

Feasibility Study for High Line Canal Crossings

May 2014



Feasibility Study for High Line Canal Crossings

Prepared for:

Arapahoe County Open Spaces

On behalf of the High Line Canal Working Group
6934 South Lima Street, Suite A
Centennial, CO 80112

Prepared by:

Felsburg Holt & Ullevig

6300 South Syracuse Way
Centennial, CO 80111
303/721-1440

FHU Reference No. 113033-01
May 2014

ACKNOWLEDGEMENTS

High Line Canal Working Group

Arapahoe County

Nancy Sharpe, County Commissioner
Nancy Jackson, County Commissioner
Shannon Carter, Director of Open Space & Trails Program
Sharon Powers, Open Space and Trails Advisory Board

Aurora

Bob LeGare, City Councilmember
Tracy Young, Manager of Planning, Design &
Mike Rosser, Open Space Advisory Board

Centennial

Vorry Moon, City Councilmember
Laura Hoepfner, Community & Government Affairs Liaison

Cherry Hills Village

Klasina VanderWerf, City Councilmember
Jay Goldie, Public Works Director

Denver

Peggy Lehmann, City Councilmember
Jay Henke, Senior Landscape Architect – Parks & Recreation

Denver Water

Kevin Keefe, Superintendent, Source of Supply

Douglas County

Jill Repella, County Commissioner
Randy Burkhardt, Assistant Director of Community Planning & Sustainable Development

Greenwood Village

Denise Rose, City Councilmember
Jeremy Hanak, Public Works Manager – Traffic

Highlands Ranch

Carrie Ward, Director of Parks, Recreation and Open Space

Littleton

Bruce Beckman, City Councilmember
Charlie Blosten, Director of Public Services Department

South Suburban Parks & Recreation District

Dave Lorenz, Executive Director
Pam Eller, Board Member

Citizen Groups & Other Organizations

Tom Waymire, President of HLC Preservation Association
Bobbie Sheffield, South Metro Land Conservancy
Justin Spring, Program Officer – Trust for Public Land
Harriet LaMair, Cherry Hills Land Preserve

High Line Canal Crossing & Safety Task Group

Charlie Blosten, Littleton Director of Public Services Department
Jeff Brasel, Centennial Deputy Director of Community Development
Mark Brown, Arapahoe County Public Works Department CIP Engineer III
Bethany Collins, Arapahoe County Open Space & Trails Grants and Acquisitions Administrator
Brett Collins, SSPRD Director of Planning, Building Infrastructure and Construction
Megan Deffner, Arapahoe County Open Spaces Planning Assistant
Josh Garcia, Arapahoe County Open Spaces Planner
Jay Goldie, Cherry Hills Village Public Works Director
Jay Henke, Denver Parks & Recreation Senior Landscape Architect
Jeremy Hanak, Greenwood Village Public Works Manager – Traffic
Kevin Keefe, Denver Water Superintendent, Source of Supply
Dave Lorenze, SSPRD Executive Director
Brandon Ransom, Denver Water Manager of Recreation
Chris Ricciardello, Aurora Parks & Open Space Department Plans Review Coordinator
Heather Vidlock, Centennial Principal Planner
Tracy Young, Aurora Manager of Planning, Design & Construction

Project Management Team

Mark Brown, Arapahoe County Public Works Department CIP Engineer III
Josh Garcia, Arapahoe County Open Spaces Planner
Will Singleton, Singleton Strategies – Facilitator for HLCWG
Jeff Dankenbring, Felsburg Holt & Ullevig Roadway Design Engineer
Bill Marcato, Felsburg Holt & Ullevig Structural Engineer
Elliot Sulsky, Felsburg Holt & Ullevig Principal-in-Charge
Jenny Young, Felsburg Holt & Ullevig Project Manager

TABLE OF CONTENTS

	Page
EXECUTIVE SUMMARY	iv
1. INTRODUCTION	1
Purpose	1
Background	1
Report Structure	1
2. STUDY PROCESS.....	2
Oversight.....	2
Evaluation Process	2
3. SABLE BOULEVARD CROSSING	6
Existing Conditions.....	6
Crossing Alternatives	7
Evaluation of Alternatives.....	7
Recommendations and Next Steps.....	10
4. HAVANA STREET CROSSING	11
Existing Conditions.....	11
Crossing Alternatives	12
Evaluation of Alternatives.....	12
Recommendations and Next Steps.....	13
5. PARKER ROAD AT MISSISSIPPI AVENUE CROSSING	17
Existing Conditions.....	17
Crossing Alternatives	18
Evaluation of Alternatives.....	18
Recommendations and Next Steps.....	19
6. HOLLY STREET AT ILIFF AVENUE CROSSING	23
Existing Conditions.....	23
Crossing Alternatives	24
Evaluation of Alternatives.....	24
Recommendations and Next Steps.....	24
7. YALE AVENUE AT HOLLY STREET CROSSING.....	27
Existing Conditions.....	27
Crossing Alternatives	28
Evaluation of Alternatives.....	28
Recommendations and Next Steps.....	29
8. HAMPDEN AVENUE AT COLORADO BOULEVARD CROSSING.....	33
Existing Conditions.....	33
Crossing Alternatives	34
Evaluation of Alternatives.....	35
Recommendations	36

9. ORCHARD ROAD CROSSING WEST OF COLORADO BOULEVARD.....	44
Existing Conditions.....	44
Crossing Alternatives	45
Evaluation of Alternatives.....	45
Recommendations and Next Steps.....	45
10. ORCHARD ROAD CROSSING WEST OF UNIVERSITY BOULEVARD.....	48
Existing Conditions.....	48
Crossing Alternatives	48
Evaluation of Alternatives.....	49
Recommendations and Next Steps.....	50
11. BROADWAY AT ARAPAHOE ROAD CROSSING.....	53
Existing Conditions.....	53
Crossing Alternatives	54
Evaluation of Alternatives.....	54
Recommendations and Next Steps.....	55

LIST OF APPENDICES

APPENDIX A.	DAILY TRAIL AND TRAFFIC COUNTS
APPENDIX B.	PRELIMINARY GEOTECHNICAL ENGINEERING STUDY
APPENDIX C.	COST ESTIMATES
APPENDIX D.	UTILITY SUMMARY AND CONFLICTS
APPENDIX E.	MEMORANDUM REGARDING INTERCONNECTED HAWK AT BROADWAY CROSSING

LIST OF FIGURES

	<u>Page</u>
Figure 1.	Study Crossing Locations 1
Figure 2.	Sable Boulevard Crossing Trail User and Traffic Inventory..... 6
Figure 3.	Sable Boulevard Crossing At-Grade Improvements 8
Figure 4.	Sable Boulevard Crossing Underpass..... 9
Figure 5.	Havana Street Crossing Trail User and Traffic Inventory..... 11
Figure 6.	Havana Street Crossing At-Grade Improvements..... 14
Figure 7.	Havana Street Crossing Pedestrian Crossings over Canal..... 15
Figure 8.	Havana Street Crossing Underpass..... 16
Figure 9.	Parker Road at Mississippi Avenue Crossing Trail User and Traffic Inventory 17
Figure 10.	Parker Road at Mississippi Avenue Crossing At-Grade Improvements 20
Figure 11.	Parker Road at Mississippi Avenue Crossing Underpass 21
Figure 12.	Parker Road at Mississippi Avenue Crossing Pedestrian Bridge..... 22
Figure 13.	Holly Street at Iliff Avenue Crossing Trail User and Traffic Inventory 23
Figure 14.	Holly Street at Iliff Avenue Crossing At-Grade Improvements 25
Figure 15.	Holly Street at Iliff Avenue Crossing Underpass 26
Figure 16.	Yale Avenue at Holly Street Crossing Trail User and Traffic Inventory..... 27
Figure 17.	Yale Avenue at Holly Street Crossing At-Grade Improvements..... 30
Figure 18.	Yale Avenue at Holly Street Crossing Pedestrian Crossings over Canal..... 31
Figure 19.	Yale Avenue at Holly Street Crossing Underpass..... 32
Figure 20.	Hampden Avenue at Colorado Boulevard Crossing Trail User and Traffic Inventory..... 33
Figure 21.	Hampden Avenue at Colorado Boulevard Crossing At-Grade Improvements 37
Figure 22.	Hampden Avenue at Colorado Boulevard Crossing Underpass – Option A 38
Figure 23.	Hampden Avenue at Colorado Boulevard Crossing Underpass – Option B 39
Figure 24.	Hampden Avenue at Colorado Boulevard Crossing Underpass – Option C..... 40
Figure 25.	Hampden Avenue at Colorado Boulevard Crossing Underpass – Option D 41
Figure 26.	Hampden Avenue at Colorado Boulevard Crossing Pedestrian Bridge 42
Figure 27.	Hampden Avenue at Colorado Boulevard Crossing Pedestrian Bridge Profile..... 43
Figure 28.	Orchard Road Crossing West of Colorado Boulevard Trail User and Traffic Inventory 44
Figure 29.	Orchard Road Crossing West of Colorado Boulevard At-Grade Improvements..... 46
Figure 30.	Orchard Road Crossing West of Colorado Boulevard Underpass..... 47
Figure 31.	Orchard Road Crossing West of University Boulevard Trail User and Traffic Inventory 48
Figure 32.	Orchard Road Crossing West of University Boulevard At-Grade Improvements 51
Figure 33.	Orchard Road Crossing West of University Boulevard Underpass 52
Figure 34.	Broadway at Arapahoe Road Crossing Trail User and Traffic Inventory..... 53
Figure 35.	Broadway at Arapahoe Road Crossing At-Grade Improvements 56
Figure 36.	Broadway at Arapahoe Road Crossing Underpass 57
Figure 37.	Broadway at Arapahoe Road Crossing Pedestrian Bridge 58
Figure 38.	Broadway at Arapahoe Road Crossing Pedestrian Bridge Profile..... 59

LIST OF TABLES

	<u>Page</u>
Table 1.	Evaluation Criteria 4
Table 2.	Sable Boulevard Crossing Alternatives Evaluation 7
Table 3.	Havana Street Crossing Alternatives Evaluation 12
Table 4.	Parker Road Crossing Traffic Operations Comparison 18
Table 5.	Parker Road at Mississippi Avenue Crossing Alternatives Evaluation..... 19
Table 6.	Holly Street at Iliff Avenue Crossing Alternatives Evaluation..... 24
Table 7.	Yale Avenue at Holly Street Crossing Alternatives Evaluation 28
Table 8.	Hampden Avenue at Colorado Boulevard Crossing Alternatives Evaluation 35
Table 9.	Orchard Road Crossing West of Colorado Boulevard Alternatives Evaluation 45
Table 10.	Orchard Road Crossing West of University Boulevard Alternatives Evaluation..... 49
Table 11.	Broadway at Arapahoe Road Crossing Alternatives Evaluation 55

EXECUTIVE SUMMARY

The High Line Canal Trail is an important recreational amenity that provides more than 60 miles of multi-use trail through multiple communities in the Denver metropolitan area. The trail presents a unique urban and suburban recreational experience for Denver metro area citizens. Preserving and enhancing this experience as the region continues to grow is of utmost importance to the many communities served by this amenity. Arapahoe County initiated this feasibility study on behalf of the High Line Canal Working Group (HLCWG) to evaluate alternative improvements to the roadway crossings of the High Line Canal Trail at nine locations within Arapahoe County. This feasibility study represents the next step toward implementing and securing funding for crossing improvement projects. The Crossing & Safety Task Group, which includes technical staff from the various agencies represented by the HLCWG, was charged with providing technical input and oversight of this feasibility study.



Photo Credit: www.dayhikesneardenver.com

An inventory of the existing infrastructure and trail use/operations was completed at each of the nine crossing locations in order to develop and document a clear understanding of the opportunities and constraints. These opportunities and constraints at each crossing location were discussed with the Crossing & Safety Task Group, and the consulting team brainstormed with the applicable representatives of the Task Group to identify alternatives for consideration at each crossing location. The alternatives considered generally fall into one of four categories:

- ▶ At-grade improvements
- ▶ Trail realignment with pedestrian bridges over canal
- ▶ Underpasses
- ▶ Overpasses

Applicable municipal design standards were used at each crossing, depending on their locations, and were supplemented by design criteria established by CDOT, AASHTO, and MUTCD, when needed. Since the entire High Line Canal is owned and maintained by Denver Water, its design requirements were also considered at each crossing. Crossing alternatives at each location were rated based on the following nine evaluation criteria which were developed through discussions with the Task Group:

- ▶ Safety benefits
- ▶ Functionality for trail users
- ▶ Impacts to motorists
- ▶ Aesthetics/context

- ▶ Equestrian accommodation
- ▶ Constructability (utilities, phasing, design standards)
- ▶ ROW impacts
- ▶ Maintenance
- ▶ Design/construction costs

The intent of the evaluation was to facilitate the selection of the best alternative at each crossing location; not to compare or prioritize crossing locations. The Task group reviewed and discussed the evaluation results and developed recommendations and next steps for each of the nine crossing locations, which are summarized in **Table ES-1**.

Table ES-1. Summary of Recommendations and Next Steps

Crossing Location	Recommendation (Estimated Cost)	Jurisdictions	Next Steps
Sable Boulevard	Underpass (\$3.4 million)	Aurora	<ul style="list-style-type: none"> ▪ Define priority and local funding within Aurora ▪ Complete preliminary and final design ▪ Pursue grant opportunities such as the Colorado State Recreational Trails Program grant through GOCO
Havana Street	Underpass (\$3.9 million); short term signing improvements (\$21,000)	Aurora Denver	<ul style="list-style-type: none"> ▪ Define priority and local funding within Aurora ▪ Define priority and local funding within Denver ▪ Coordinate funding strategy for design and construction (Denver and Aurora) ▪ Coordinate with CDOT to implement short term signing ▪ Apply for Arapahoe County Open Space Funds as a package of at-grade improvements
Parker Road at Mississippi Avenue	Underpass (\$3.2 million)	Arapahoe County Denver	<ul style="list-style-type: none"> ▪ Define priority within Arapahoe County ▪ Define priority and local funding within Denver ▪ Coordinate funding strategy for design and construction (Arapahoe County and Denver)
Holly Street at Iliff Avenue	At-grade intersection improvements (\$79,000)	Arapahoe County Denver	<ul style="list-style-type: none"> ▪ Define priority within Arapahoe County ▪ Define priority and local funding within Denver ▪ Apply for Arapahoe County Open Space Funds as a package of at-grade improvements
Yale Avenue at Holly Street	Trail realignment with pedestrian bridges over canal and at-grade intersection improvements (\$1.05 million + ROW)	Arapahoe County Denver	<ul style="list-style-type: none"> ▪ Complete preliminary and final design in coordination with signal upgrade project ▪ Apply for Arapahoe County Open Space Funds as a package of at-grade improvements

Crossing Location	Recommendation (Estimated Cost)	Jurisdictions	Next Steps
Hampden Avenue at Colorado Boulevard	Two underpass with trail realignment (\$4.5 million); short term at-grade intersection improvements (\$350,000 + ROW)	Cherry Hills Village Denver	<ul style="list-style-type: none"> Define priority and local funding within Cherry Hills Village Define priority and local funding within Denver Coordinate funding strategy for design and construction (Cherry Hills Village and Denver) Coordinate with CDOT to design and implement short term at-grade intersection improvements (right turn lane and signalization)
Orchard Road west of Colorado Boulevard	At-grade crossing improvements and sidewalk widening/extension (\$61,000)	Centennial Greenwood Village	<ul style="list-style-type: none"> Define priority and local funding within Greenwood Village Apply for Arapahoe County Open Space Funds as a package of at-grade improvements
Orchard Road west of University Boulevard	At-grade crossing improvements (\$310,000)	Centennial Greenwood Village	<ul style="list-style-type: none"> Define priority and local funding within Centennial Define priority and local funding within Greenwood Village Coordinate funding strategy for design and construction (Centennial and Greenwood Village) Coordinate timing of project with Orchard road widening project Coordinate HAWK placement (possibly as a second phase) with Denver Water Apply for Arapahoe County Open Space Funds as a package of at-grade improvements
Broadway at Arapahoe Road	At-grade crossing improvements and sidewalk widening (\$300,000)	Centennial Littleton	<ul style="list-style-type: none"> Define priority and local funding within Centennial Define priority and local funding within Littleton Conduct study to better understand trail use patterns at all three Broadway crossings Apply for Arapahoe County Open Space Funds as package of at-grade improvements Look for opportunities to widen sidewalks along Broadway and add streetscape elements as redevelopment occurs Consider the addition of a pedestrian box culvert in combination with the Urban Drainage project near Sterne Parkway

1. INTRODUCTION

Purpose

The High Line Canal Trail is an important recreational amenity that provides more than 60 miles of multi-use trail through multiple communities in the Denver metropolitan area. The trail presents a unique urban and suburban recreational experience for Denver metro area citizens. Preserving and enhancing this experience as the region continues to grow is of utmost importance to the many communities served by this amenity. A principal element of an inviting recreational trail is the provision of a continuous system with safe roadway crossings. Arapahoe County initiated this feasibility study on behalf of the High Line Canal Working Group to evaluate alternative improvements to the roadway crossings of the High Line Canal Trail at nine locations within Arapahoe County, as shown on **Figure 1**. This feasibility study represents the next step toward implementing and securing funding for crossing improvement projects. For the purpose of identifying potential projects to pursue Great Outdoor Colorado (GOCO) grant funding in 2014, three crossing locations were placed on an expedited schedule: the Broadway crossing at Arapahoe Road, the Orchard Road crossing west of University Boulevard, and the Sable Boulevard Crossing.

Background

High Line Canal Working Group

The formation of the High Line Canal Working Group (HLCWG) in 2009 represents a significant step in regional collaboration to preserve and enhance the valued community and regional asset that is the High Line Canal. The group is composed of elected officials and staff members from 10 municipal/county governments and 12 participating entities that are served by the High Line Canal. As defined in the purpose statement, “The High Line Canal Working Group is a collaborative effort to secure funding for – and implement – projects that will help enhance and protect the unique recreation experience along the High Line Canal.”

Previous Studies

Two recent planning-level studies were completed which identify the need and set the framework for trail crossing improvements:

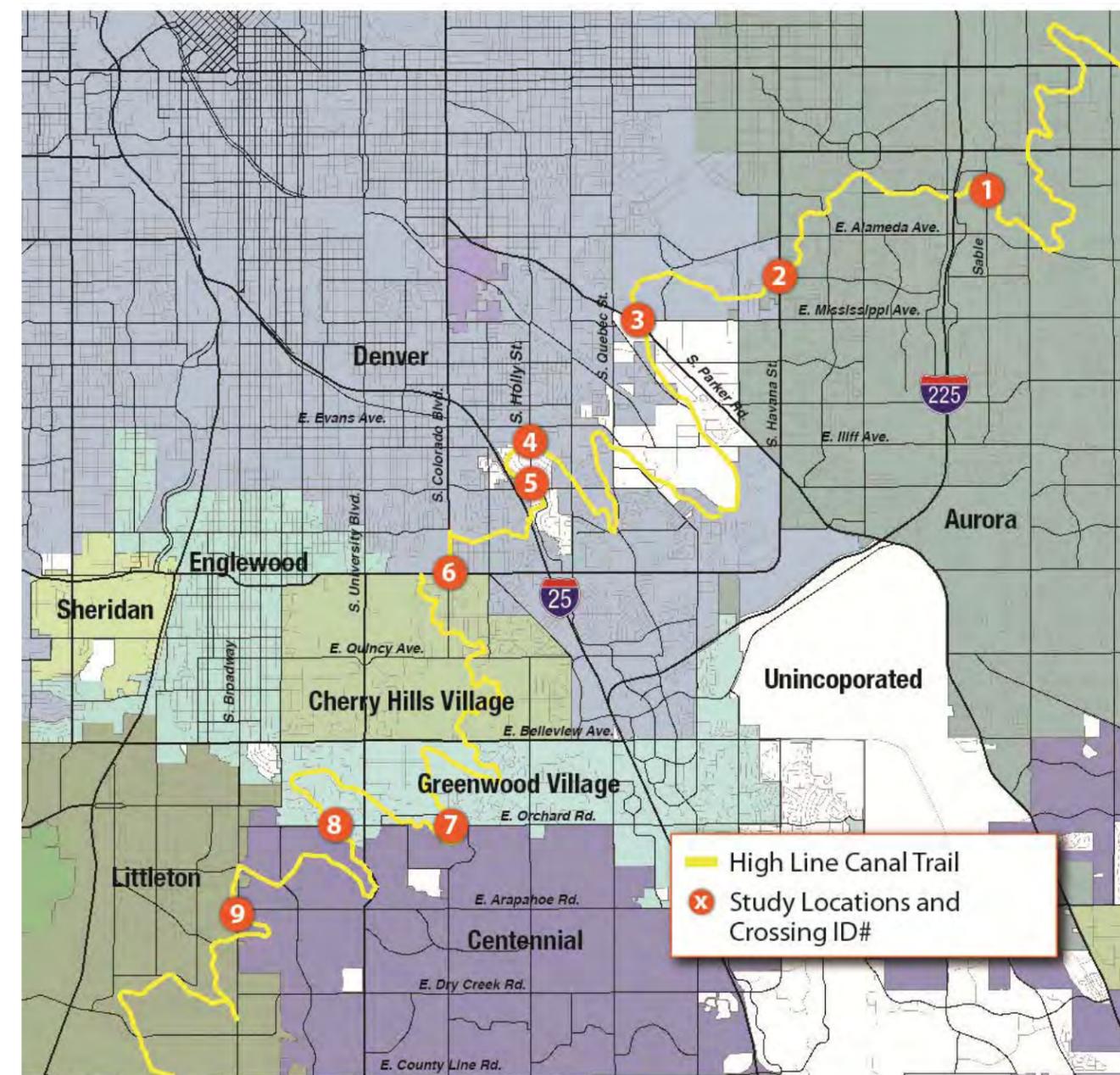
- ▶ The High Line Canal Management Plan
- ▶ The High Line Preservation and Enhancement Planning Study

The data and recommendations included in these studies were used as a starting point for this feasibility study. Similarly, many of the municipal comprehensive plans, transportation plans, trails plans, and bicycle/pedestrian plans for the communities along the High Line Canal support the vision of enhancing the High Line Canal Trail and identify the need for improved crossings. Nineteen crossings were identified through these two previous planning efforts as needing safety improvements. The High Line Canal Working Group identified the nine crossings that are the subject of this feasibility study as high priority crossings for further study; the remaining ten crossings are also in need of further study and may be evaluated in a subsequent phase.

Report Structure

The first two chapters of this feasibility study report provide introductory and process information related to the overall study. The subsequent nine chapters document the inventory, crossing alternatives, evaluation, and recommendations for each of the study crossing locations, starting with the Sable Boulevard crossing on the north and extending sequentially to the south.

Figure 1. Study Crossing Locations



2. STUDY PROCESS

Oversight

In 2013, the structure of the HLCWG was modified to create three task groups focused on specific programmatic objectives of the working group. The Crossing & Safety Task Group, which includes technical staff from the various agencies, was charged with providing technical input and oversight of this feasibility study. All work completed by the consulting team was first reviewed by the Crossing & Safety Task Group prior to presentation to the HLCWG. The Crossing & Safety Task Group provided specific recommendations for each of the nine crossing locations to the HLCWG based on the conceptual design and technical evaluation. The Crossing & Safety Task Group convened five times to review the alternatives and technical evaluation and to develop recommendations for each crossing location:

- ▶ **August 13, 2013** – Developed evaluation criteria, discussed opportunities and constraints at first three crossing locations (Broadway, Orchard west of University, and Sable)
- ▶ **September 18, 2013** – Reviewed alternatives and preliminary evaluation results at first three crossing locations and developed recommendations, discussed opportunities and constraints at remaining six crossing locations
- ▶ **November 25, 2013** – Reviewed alternatives and preliminary evaluation results at remaining six crossing locations
- ▶ **December 17, 2013** – Reviewed updates at remaining six crossing locations and developed recommendations
- ▶ **February 19, 2014** – Reviewed and discussed draft feasibility study report

To supplement the Crossing & Safety Task Group meetings, small group meetings were held periodically during the study to efficiently address key issues at certain crossing locations that primarily affected a subset of the communities along the High Line Canal.

- ▶ **October 3, 2013** – Small group meeting with Littleton, Centennial, Arapahoe County and South Suburban Parks and Recreation Department (SSPRD) to discuss Broadway crossing at Arapahoe Road
- ▶ **October 22, 2013** – Small group meeting with Denver and Arapahoe County to discuss Parker, Yale, and Holly crossings
- ▶ **November 13, 2013** – Small group meeting with Centennial, Greenwood Village, Arapahoe County, and SSPRD to discuss Orchard crossing west of University
- ▶ **November 21, 2013** – Small group meeting with Denver and Arapahoe County to discuss Yale, Holly, Parker, Havana, and Hampden crossings
- ▶ **February 13, 2014** – Small group meeting with Denver, Cherry Hills Village and Arapahoe County to discuss the Hampden crossing

The consulting team and the Crossing & Safety Task Group presented information and recommendations to the HLCWG at three of their quarterly meetings:

- ▶ **July 17, 2013** – Provided an overview of the feasibility study scope of work and schedule
- ▶ **October 16, 2013** – Presented alternatives, findings, and recommendations at the first three crossing locations
- ▶ **January 15, 2014** – Presented alternatives, findings, and recommendations at the remaining six crossing locations

Evaluation Process

Inventory

An inventory of the existing infrastructure and trail use/operations was completed at each of the nine crossing locations in order to develop and document a clear understanding of the opportunities and constraints. The physical inventory included a field survey to document the roadway cross-section, posted speeds, and sight distance in the vicinity of the trail crossings, intersection characteristics where applicable (including traffic control, lane geometry, and crosswalks), condition of existing sidewalk connections, and to locate utilities, signs, trees, etc. As-built surveys of sanitary and storm structures, manholes and inlets were compiled and included on base mapping. Mapping and potholing of known utilities was also completed at locations for which an underpass was being considered.

A subsurface geotechnical engineering study was conducted at five crossing locations for the purpose of determining subsoil and groundwater conditions in order to develop preliminary recommendations for the potential structures to be constructed at each site.

The operations inventory began with field observations at each crossing location to better understand the trail users' behavior, the level of conflict between the trail users and motorists, and the range of delay incurred by trail users at each crossing. Traffic and trail user counts were recorded at each crossing location on a weekday and a Saturday in the summer of 2013 (24-hour duration for traffic counts and 12-hour duration for trail user counts). These counts are detailed in **Appendix A**. In addition, AM, PM, and Saturday peak hour turning movement counts (including bicycle and pedestrian movements) were recorded at the signalized intersections that are currently being used as the designated trail crossing. Current signal timing was obtained from the applicable jurisdiction for the signalized intersections in order to assess the existing intersection levels of service. This baseline operation analysis was then used in evaluating the potential change in delays for motorists and trail users associated with improvement alternatives.

Accident data were obtained at each of the nine crossing locations typically for the five year time period between 2008 and 2012. The accident patterns were analyzed to understand the frequency and severity of vehicle/bicycle and vehicle/pedestrian accidents.



Traffic, bicycle, and pedestrian counts were recorded at each crossing location on a summer weekday and Saturday

Identification of Alternatives

Based on the physical and operational inventory, the opportunities and constraints at each crossing location were identified and discussed with the Crossing & Safety Task Group. The consulting team brainstormed with the applicable representatives of the Task Group to identify alternatives for consideration at each crossing location. The alternatives considered generally fall into one of four categories, as described below.

At-Grade Improvements – Improvements to the at-grade crossing can include a variety of different measures to improve the safety for bicyclists and pedestrians, reduce the delays for trail users, and make motorists aware that there are likely trail users crossing the street. While several of the trail crossings make use of an adjacent signalized intersection, others are mid-block crossings without any traffic control. Depending on the cross-street’s operational and geometric environment, crossing improvements include median refuges, Danish offsets (see photo to the right), reduction of crossing distance through the use of curb extensions, sidewalk connection improvements, crosswalks, advance markings and signing, additional traffic control equipment (such as the hybrid pedestrian signal), modification to signal timing and/or phasing to facilitate the pedestrian crossing. Some form of at-grade improvements have been considered at all nine of the crossing locations.



Example of an enhanced at-grade mid-block trail crossing with a median refuge and Danish offset



Example of a pre-fabricated pedestrian bridge crossing over a canal

Trail Realignment with Pedestrian Bridges over Canal – At several crossing locations, the High Line Canal Trail intersects the street close to, but not immediately at, a signalized intersection. At two such locations (the Yale Avenue crossing and the Havana Street crossing), a trail realignment was considered in which the trail would provide a direct connection to the nearby existing signalized intersection. Pedestrian bridges would be used to cross the trail over the High Line Canal. This configuration would typically be constructed in conjunction with at-grade improvements at the signalized intersection to enhance the safety and convenience for trail users.

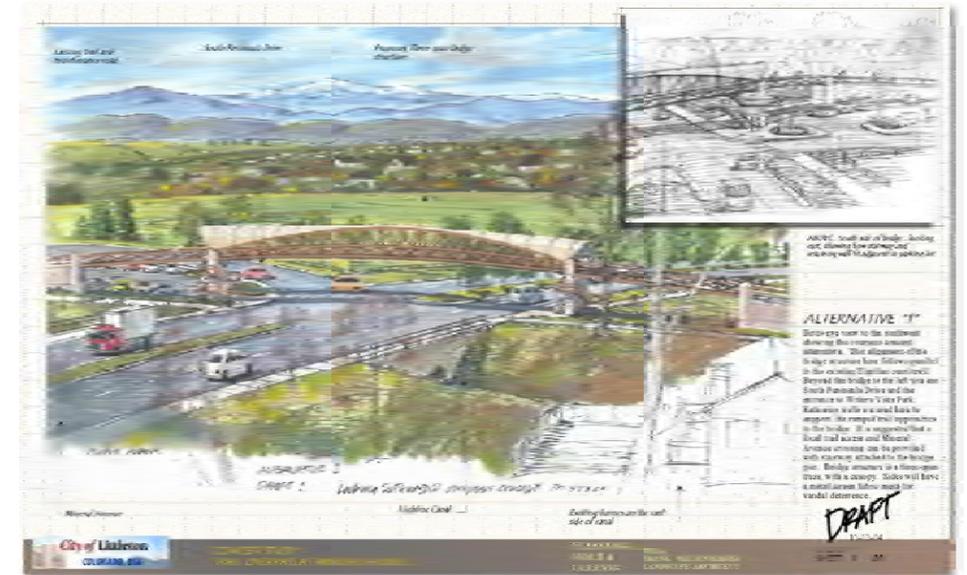


Example of an existing High Line Canal trail underpass at County Line Road in Littleton

Underpasses – In general, construction of an underpass at major roadways would greatly enhance the trail users’ experience and would eliminate conflict with traffic. Underpasses are generally more user friendly than overpasses, particularly for bicyclists. Safety enhancements for underpass structures include the effective use of lighting, as well as establishing proper structure heights and widths to help reduce tunneling effects through the underpass. The use of highly reflective finishes on the structure surfaces also help provide a more inviting and safer-looking facility. All underpass alternatives

considered in this feasibility study would involve a new box culvert, separate from the canal but generally parallel to the canal. There is a strong precedent for underpasses along the High Line Canal; the trail crosses many of the major roadways along its length via underpass. An underpass has been considered at all nine of the crossing locations.

Overpasses – Similar to an underpass, an overpass would eliminate the trail users’ conflict with traffic and would provide a safe, continuous, and uninterrupted route for trail users. Overpasses are generally more visually obtrusive than underpasses, and require a greater vertical clearance than an underpass. Maintenance and inspection requirements for overpasses also make them a less favorable alternative to underpasses. Overpasses were considered at three crossing locations (Hampden/Colorado, Parker Road, and Broadway) primarily because these major roadways have considerable utility conflicts. At the Hampden/Colorado intersection, an overpass was also considered to avoid reconstruction of recent roadway improvements with construction of an underpass.



Example of a pedestrian overpass previously contemplated at the High Line Canal Trail crossing of Mineral Avenue in Littleton

Parameters for Conceptual Design

Applicable municipal design standards were used at each crossing, depending on their locations, and were supplemented by design criteria established by CDOT, AASHTO, and MUTCD, when needed. Since the entire High Line Canal is owned and maintained by Denver Water, its design requirements were also considered at each crossing. All designs were laid out to maintain appropriate access for Denver Water equipment to the canal. The conceptual designs were laid out to have no impact on the current operation of the canal, both within and along the channel. No infrastructure has been proposed within the canal, and other proposed infrastructure alignments are such that no subsurface leakage from the canal will be introduced. The designs should not impact anticipated future uses of the canal, including its potential use as a water quality facility through construction of detention ponds and rain gardens along its alignment.

The design parameters used in determining the conceptual grade separation and at-grade crossing alternatives focused on usability, safety, and constructability. Usability was addressed through application of ADA requirements, accommodation of minimum design speeds for bicyclists, and the creation of direct and convenient paths at each crossing that would be attractive to trail users. Safety was considered first and foremost by evaluating alternatives to separate trail users from any conflict from traffic through the use of grade separations. When at-grade crossings were considered, signing, signalization, and other traffic calming measures such as roadway curb bulb-outs were considered to both provide guidance for trail users, and to provide vehicle driver awareness at the crossings.

Alignments minimizing underpass and wall lengths were developed to help reduce tunneling effects, and help provide more open and safe layouts. Drainage and maintenance of the grade separations was also considered in the proposed designs, so the facilities remain safe for users. Constructability of each crossing was evaluated by considering right-of-way constraints, utility conflicts, the presence of groundwater and other subsurface considerations such as shallow bedrock and/or expansive soils.

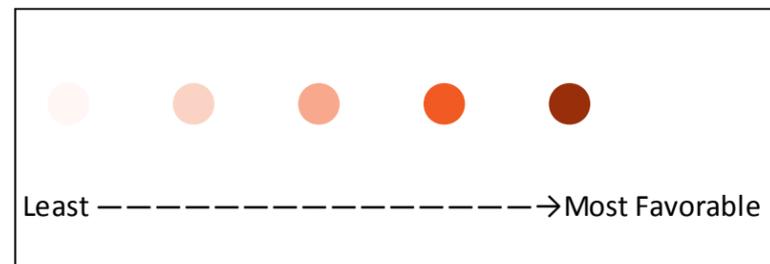
Evaluation Criteria

Crossing alternatives at each location were rated based on nine evaluation criteria which were developed through discussions with the Crossing & Safety Task Group. As listed in **Table 1**, the criteria were divided into benefits and costs.

Table 1. Evaluation Criteria

Benefits	Costs
Safety benefits	Constructability (utilities, phasing, design standards)
Functionality for trail users	ROW impacts
Impacts to motorists	Maintenance
Aesthetics/Context	Design/construction cost
Equestrian Accommodation	

The intent of the evaluation was to facilitate the selection of the best alternative at each crossing location; not to compare or prioritize crossing locations. No numerical weight has been assigned to the evaluation criteria, but the Crossing & Safety Task Group has expressed that provision of safe crossings is the single most important consideration. A general description of the basis for the ratings within each evaluation criterion is provided below. A description is provided for the best and worst rating in each category; the middle three categories represent a gradation of those ratings.



Each alternative was given a color-coded rating with the darkest color being the best – that is, the most beneficial and/or easiest to implement, and the lightest color being the worst.

Safety Benefits

- Alternative would eliminate the conflict between trail users and motorized vehicles at a crossing that is heavily used (high trail use), has high traffic volumes, and has experienced a relatively high number of bicycle and/or pedestrian related accidents.
- Alternative may only slightly improve the safety of a crossing that is not heavily used.

Note: Longer length underpasses (>150 feet) begin to score negatively, as they could be perceived as a safety risk to trail users.

Functionality for Trail Users

- Alternative would be highly functional for trail users – it would minimize required slow-downs, out of direction travel, would provide a sense of personal safety and security through the provision of lighting and minimal “tunneling effect” (for underpasses), and would benefit a high number of trail users.
- Alternative includes characteristics that result in low functionality for trail users such as out of direction travel, delays, etc.

Note: An overpass would be considered less functional for trail users than an underpass; underpasses provide the ridability advantage of providing momentum for bicyclists, riding downhill before riding uphill.

Impacts to Motorists

- Alternative would have no impacts to motor vehicles.
- Alternative would result in excessive delays to motor vehicles.

Note: At signalized intersections, impact to motorists was measured based on the intersection level of service (LOS) during the peak hours, which is a qualitative assessment ranging from LOS A to LOS F based on the average delay experienced by traffic approaching the intersection. LOS A represents nearly free-flow traffic with very minimal delays. LOS F signifies congested conditions in which motorists experience long delays.

Aesthetics/Context

- Alternative is contextually sensitive; would not create a visual distraction; and could include aesthetic enhancements through landscaping/urban design elements.
- Alternative would create a visual distraction; is not sensitive to the surrounding context; and does not include any potential for aesthetic enhancements.

Equestrian Accommodation

- Alternative would significantly improve the crossing for equestrians.
- Alternative would result in an unacceptable crossing for equestrians.

Note: An overpass would be considered unacceptable for equestrians. The best crossing for equestrians would be low-volume, low-speed at grade crossings or very short and open underpasses with minimal “tunnel effect.” Equestrians prefer soft, gravel surface.

Note: This evaluation criterion has only been applied at the crossing locations where equestrians are typically present (through the Greenwood Village and Cherry Hills Village portion of the High Line Canal Trail).

Constructability

- Alternative does not have any significant utility conflicts; construction phasing would be simple and relatively non-disruptive; and it meets all applicable design standards.
- Alternative has significant utility conflicts that would require relocation of utilities; would require complex phasing or construction; or the alternative does not meet applicable design standards.

ROW Impacts

- Alternative would not have any right of way impacts, nor would it require temporary or permanent easements.
- Alternative would have substantial right of way impacts requiring ROW acquisition.

Maintenance

- Alternative would require minimal routine maintenance.
- Alternative would result in significant additional maintenance requirements (such as lighting, snow removal, sweeping, overlays, painting, graffiti removal, etc.).

Design/Construction Cost

- Alternative would have a relatively low construction cost.
- Alternative would have a relatively high construction cost.

3. SABLE BOULEVARD CROSSING

Existing Conditions

The High Line Canal Trail crosses Sable Boulevard approximately 350 feet south of 2nd Avenue in the City of Aurora (Crossing Location #1 on **Figure 1**). Sable is a four lane road with a narrow raised median. Because the trail crosses Sable at an angle, the crossing distance is currently long (over 100 feet) and is unmarked and unprotected. The land use in the vicinity of the crossing is predominately multi-family residential.



Traffic and Trail User Counts

Sable Boulevard carries approximately 22,000 vehicles per day (vpd) and has a posted speed limit of 40 mph. The trail user counts, which are shown on **Figure 2**, provide the following insights:

- ▶ Approximately 160 trail users cross Sable on a typical summer weekday and 140 cross on a typical summer Saturday.
- ▶ Higher weekday trail activity is indicative of the trail being used for commuter travel as well as for recreational purposes.
- ▶ This section of the trail is used predominately by bicyclists (four times as many bicyclists as pedestrians).

Accident History

Over the five year time period from January 2008 through December 2012, there was one bicycle/vehicle accident in the vicinity of the High Line Canal Trail crossing of Sable Boulevard. The accident occurred on a Saturday, and there were no injuries.

Opportunities and Constraints

- ▶ The future I-225 Light Rail Transit (LRT) Station at 2nd Avenue/Abilene will be located a half mile west of the Sable crossing; increased use of this section of the trail, particularly for access to the station, is expected in the future.
- ▶ Sixth Avenue Elementary School (Aurora Public Schools) is located near Potomac Street and 6th Avenue, and the attendance area spans the Sable Boulevard crossing. The High Line Canal Trail may be a route for children to walk to and from school; a grade separation would improve the viability of its use as a safe route for children to walk or bike to school.
- ▶ Because of the presence of multi-family residential immediately surrounding the crossing, paired with the potential for this section of the trail to be used for commuting to the LRT station and as a route for children to walk or bike to school, there is a need to retain convenient local access to the trail.
- ▶ The preliminary geotechnical engineering study (detailed in **Appendix B**) revealed that the bedrock and groundwater levels are each relatively close to the bottom of the conceptual underpass, which could lead to some additional construction expense. The bedrock level was found to be potentially expansive. This may require overexcavation beneath the proposed structure, replaced with more stable, less-expansive material, thus assuring the structural performance. Additional geotechnical investigation during final design will help determine if the additional expense of overcavation/backfill will be required.

Figure 2. Sable Boulevard Crossing Trail User and Traffic Inventory



Crossing Alternatives

Two crossing alternatives were developed and evaluated at the Sable Boulevard Crossing.

At-Grade Improvements

The first alternative would provide enhancements to the existing at-grade crossing. As shown in the conceptual design (Figure 3), the trail on the east side of Sable Boulevard would be realigned to the north in order to provide a perpendicular (and shorter) crossing. The median with a Danish offset would provide a refuge for crossing bicyclists and pedestrians that positions them in a way that maximizes their visibility to on-coming traffic. The alternative also includes crosswalk markings, yield lines, and enhanced signing including pedestrian-activated Rapid Rectangular Flashing Beacons (RRFB). The estimated cost for these improvements is \$66,000 (the detailed cost estimate is included in Appendix C).

Underpass

The second alternative considered for the Sable Boulevard crossing is an underpass (Figure 4). The underpass would be a 14-foot wide and 10-foot tall box culvert north of the canal, located generally in the same alignment as the existing trail. The underpass shown in the conceptual design is approximately 160 feet. The Denver Water service road access would be maintained just to the south of the underpass; the two would be separated by a retaining wall. Stairwells on both sides of Sable Boulevard would provide convenient local pedestrian access to the underpass. Bicyclists or wheelchair users wishing to connect from the Sable Boulevard sidewalk to the underpass would use the Denver Water service road to access the trail and underpass. The underpass is estimated to cost \$3.4 million.

The site subsurface conditions noted above do not make the proposed underpass construction unfeasible. Additional site investigation is recommended, which may result in extra foundation preparation and the installation of permanent culvert underdrains. It has been assumed these items will be needed, and the expense is reflected in the underpass cost estimate. A summary of the utility conflicts is provided in Appendix D.

Evaluation of Alternatives

The two crossing alternatives for Sable Boulevard have been evaluated based on the evaluation criteria described in Chapter 2, and the results are shown on Table 2. The at-grade improvements would provide only marginal safety and trail user functionality benefits, but would be low cost and relatively easy to implement. The underpass would eliminate the conflict between trail users and motorists. Although the underpass would have a higher cost than the at-grade improvements, it could be done reasonably within the context of the surrounding area and would not be visually obtrusive.

Table 2. Sable Boulevard Crossing Alternatives Evaluation

Evaluation Criteria	At-Grade Improvements (Figure 3)	Underpass (Figure 4)
Benefits		
Safety Benefits	●	●
Functionality for Trail Users	●	●
Impacts to Motorists	●	●
Aesthetics/Context	●	●
Equestrian Accommodation	NA	NA
Costs		
Constructability (Utilities, phasing, design standards)	●	●
ROW Impacts	●	●
Maintenance	●	●
Design/Construction Cost	\$66,000	\$3,440,000

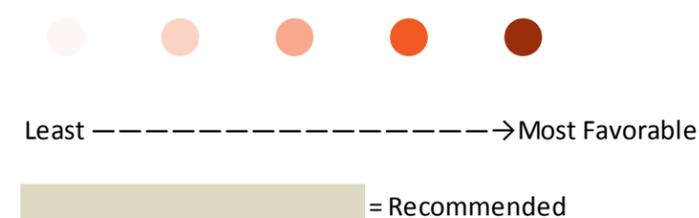
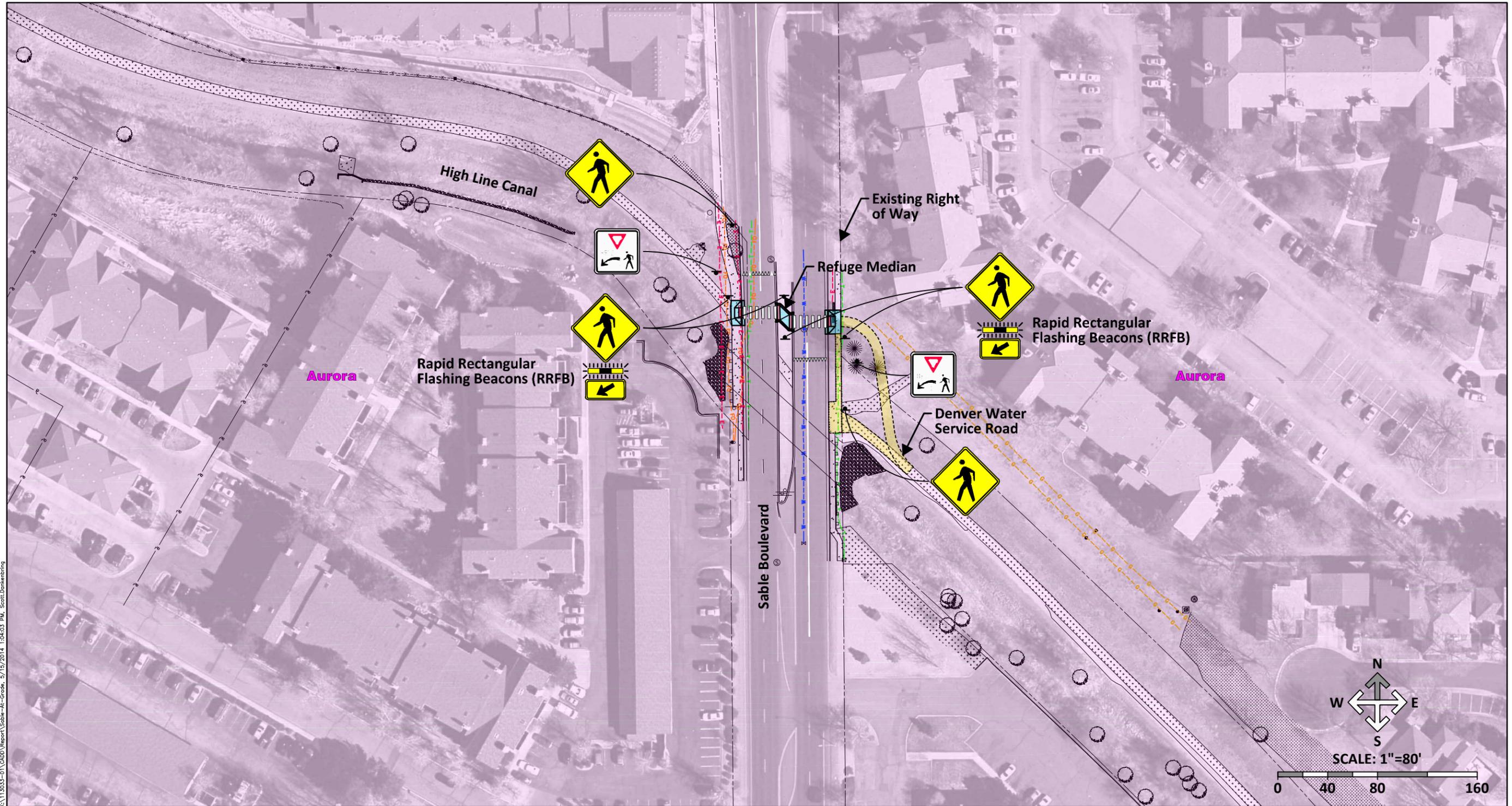
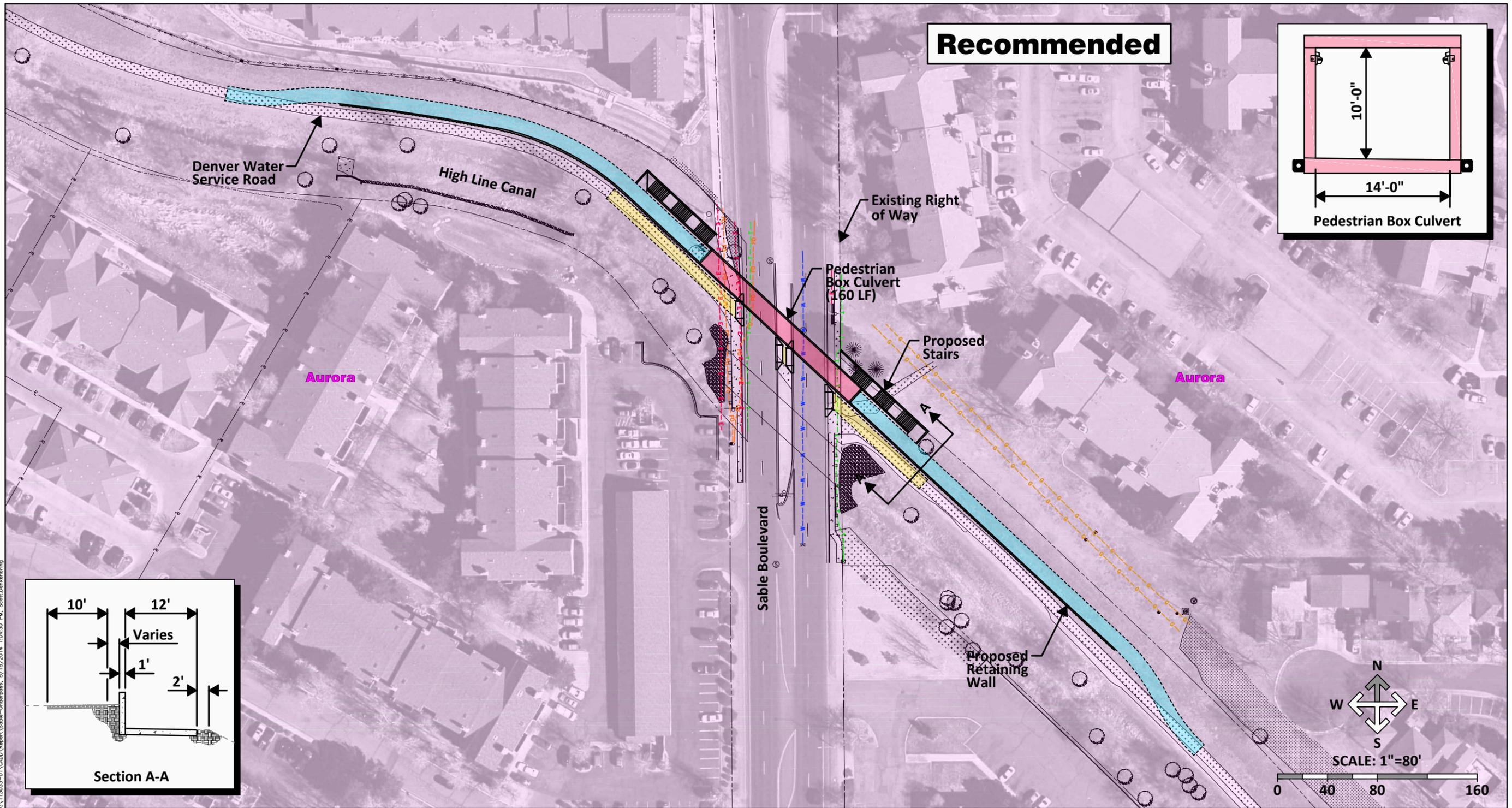


Figure 3. Sable Boulevard Crossing At-Grade Improvements



K:\113033-01\CADD\Report\Sable-At-Grade_5/15/2014 1:04:03 PM_Scott.Donkershing

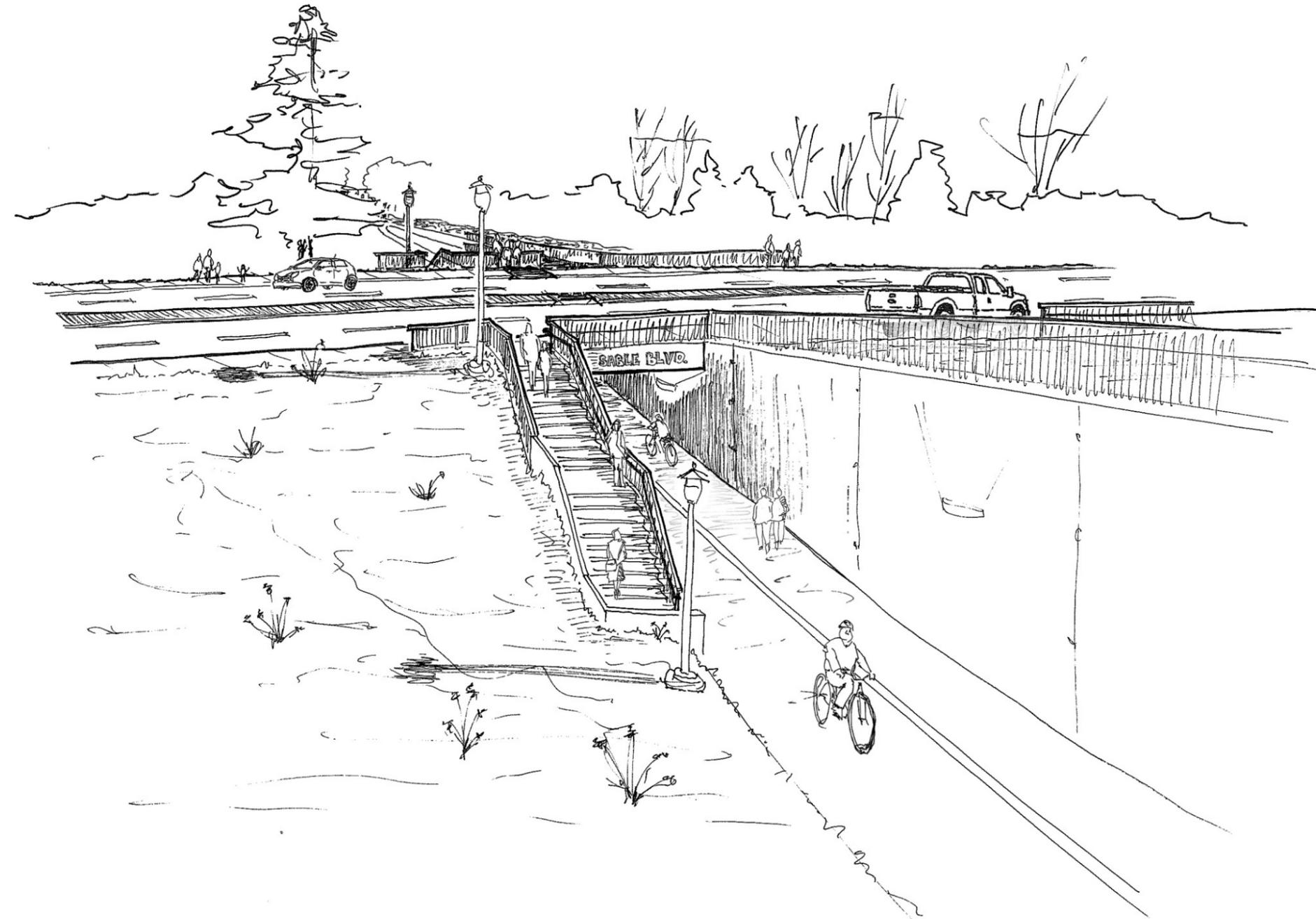
Figure 4. Sable Boulevard Crossing Underpass



K:\113033-01\CADD\Report\Sable-Underpass_5/15/2014_1:04:30 PM_Scott.Denkensring

Recommendations and Next Steps

An underpass is the recommended alternative for the Sable Boulevard crossing because of the high motor vehicle traffic, currently high use of the High Line trail by pedestrians and bicyclists, and expected increase because of nearby transit improvements. The Crossing & Safety Task Group recommends that the High Line Canal Working Group assist Aurora in obtaining funds for an underpass at this location, including advocating for Arapahoe County Open Space funds to be used as a funding source for the project, in combination with local match and other funds, such as grants. The task group recommends that the High Line Canal Working Group provide a letter of support for the project at the time of any grant applications. The City of Aurora will continue discussions to assess the priority of this project relative to other City needs.



4. HAVANA STREET CROSSING

Existing Conditions

The High Line Canal Trail crosses Havana Street approximately 100 feet north of Exposition Avenue (Crossing Location #2 on **Figure 1**). Havana is a six lane road with a painted median that carries approximately 45,000 vehicles per day (vpd) and has a posted speed limit of 40 mph. Trail users are intended to cross at the north leg of the signalized intersection of Havana Street/Exposition Avenue. The northwest quadrant of the Havana Street/Exposition Avenue intersection is in the City and County of Denver, and the remaining quadrants of the intersection are within the City of Aurora. Havana Street is a state highway (SH 30) owned and maintained by the Colorado Department of Transportation (CDOT). The land uses in the vicinity of the crossing include multi-family residential and commercial uses.



Traffic and Trail User Counts

The trail user counts (shown on **Figure 5**) are moderately high at this location and provide the following insights:

- ▶ Approximately 200 trail users cross Havana on a typical summer weekday and 230 cross on a typical summer Saturday.
- ▶ Roughly 65 percent of the trail users are bicyclists and 35 percent are pedestrians.
- ▶ Most trail users (80 – 85 percent) cross at the Exposition intersection; the remaining trail users cross at the canal alignment.

Accident History

Of the nine crossing locations being studied, this crossing location has the highest incidence of bicycle/vehicle and pedestrian/vehicle accidents. In the five year period from January 2008 through December 2012, there were four pedestrian/vehicle (two of which resulted in injuries and one of which involved a fatality) and five bicycle/vehicle accidents (two of which resulted in injuries).

Opportunities and Constraints

- ▶ The high number of injury/fatal bicycle and pedestrian accidents demonstrates a significant opportunity to improve the safety for trail users crossing at this location.
- ▶ In field observations, motorists failed to yield to crossing pedestrians, and pedestrians were required to wait for long periods before getting the walk indication at the signal (the signal operates on a 120 second cycle length during the AM and PM peak hours, and a 110 second cycle length on the weekend).
- ▶ The preliminary geotechnical engineering study (detailed in **Appendix B**) revealed that the soils are generally favorable for underpass construction, but that groundwater at this site is at a similar elevation to the bottom of the proposed underpass. The use of underdrains along the full length of the underpass will need to be considered.

Figure 5. Havana Street Crossing Trail User and Traffic Inventory



Crossing Alternatives

Three crossing alternatives were developed and evaluated for the Havana Street crossing.

At-Grade Improvements

The first alternative would provide enhancements to the existing crossing at the Havana Street/Exposition Avenue intersection. As shown on **Figure 6**, the at-grade improvements would include signing to direct trail users to the intersection and either an advance or exclusive pedestrian phase to facilitate pedestrian movements across the intersection. The intersection currently operates at level of service (LOS) A during the AM, PM, and Saturday peak hours, indicating good traffic flow with minimal delays for vehicular traffic. An advance pedestrian phase (8 seconds) would allow pedestrians to get a head start in crossing the street and would allow them to be positioned where they could clearly be seen by right turning vehicles. While an advance phase would take away a small amount of time from motorized traffic, the intersection would still operate well (LOS B during all peak hours). Similarly, an exclusive pedestrian phase of 28 seconds would allow pedestrians to cross the entire intersection before the motorists would have a green indication. With an exclusive pedestrian phase, the intersection would still operate relatively well (LOS C) during the peak hours. The pedestrian phase would be triggered only when a pedestrian activates the push button. The estimated cost for these improvements is \$21,000 (the detailed cost estimate is included in **Appendix C**).

Pedestrian Crossings over Canal

The second alternative considered for the Havana Street crossing involves trail realignments east and west of Havana Street that would provide direct connection to the crosswalk on the north leg of the Havana Street/Exposition Avenue intersection (shown on **Figure 7**). Pre-fabricated pedestrian bridges would be used to cross the trail south of the canal. Trail users would still cross at-grade, but this alternative would position the trail users in a way that highly encourages them to cross at the signalized intersection. Signing on the trail would direct trail users away from the service road and onto the pedestrian bridges. These improvements could be done in combination with an advance or exclusive pedestrian phase as described in the at-grade improvements. As noted in the conceptual design, this configuration would require approximately 2,100 square feet of right of way from the parcel in the northeast quadrant of the intersection. In order to position the trail between Exposition Avenue and the canal on the west side of Havana Street, the desired design speed of 20 mph may be compromised. The estimated cost for these improvements is \$930,000.

Underpass

The third alternative considered for the Havana Street crossing is an underpass (**Figure 8**). The underpass would be a 14-foot wide and 10-foot tall box culvert north of the canal, located slightly north of the existing trail. The Denver Water service road access would be maintained between the underpass and the canal. Due to the right-of-way constraints and the typography, retaining wall would be required on both sides of the trail on the approaches to the box culvert. The box culvert shown in the conceptual design is approximately 170 feet long. The underpass is estimated to cost \$3.9 million. A summary of the utility conflicts is provided in **Appendix D**.

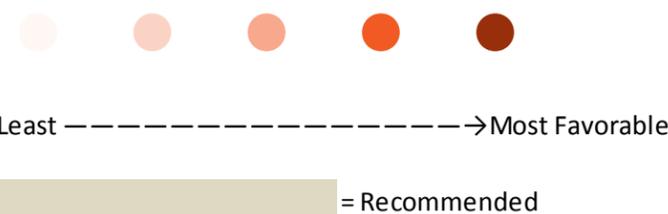
Evaluation of Alternatives

The three crossing alternatives for Havana Street have been evaluated based on the evaluation criteria described in Chapter 2, and the results are shown on **Table 3**. The at-grade improvements would provide only marginal safety and trail user functionality benefits, but would be low cost and relatively easy to implement. The trail realignment with pedestrian bridges over the canal would further discourage trail users from crossing at the canal alignment, but

would not eliminate the at-grade crossing and safety conflicts. The cost of this alternative is approximately one-quarter of the cost of the underpass. Although the underpass is the highest cost of the three alternatives, it would eliminate the conflict between trail users and motorists and would best address the considerable safety concern at this crossing location. An underpass could be constructed reasonably well within the context of the area without visual obstructions.

Table 3. Havana Street Crossing Alternatives Evaluation

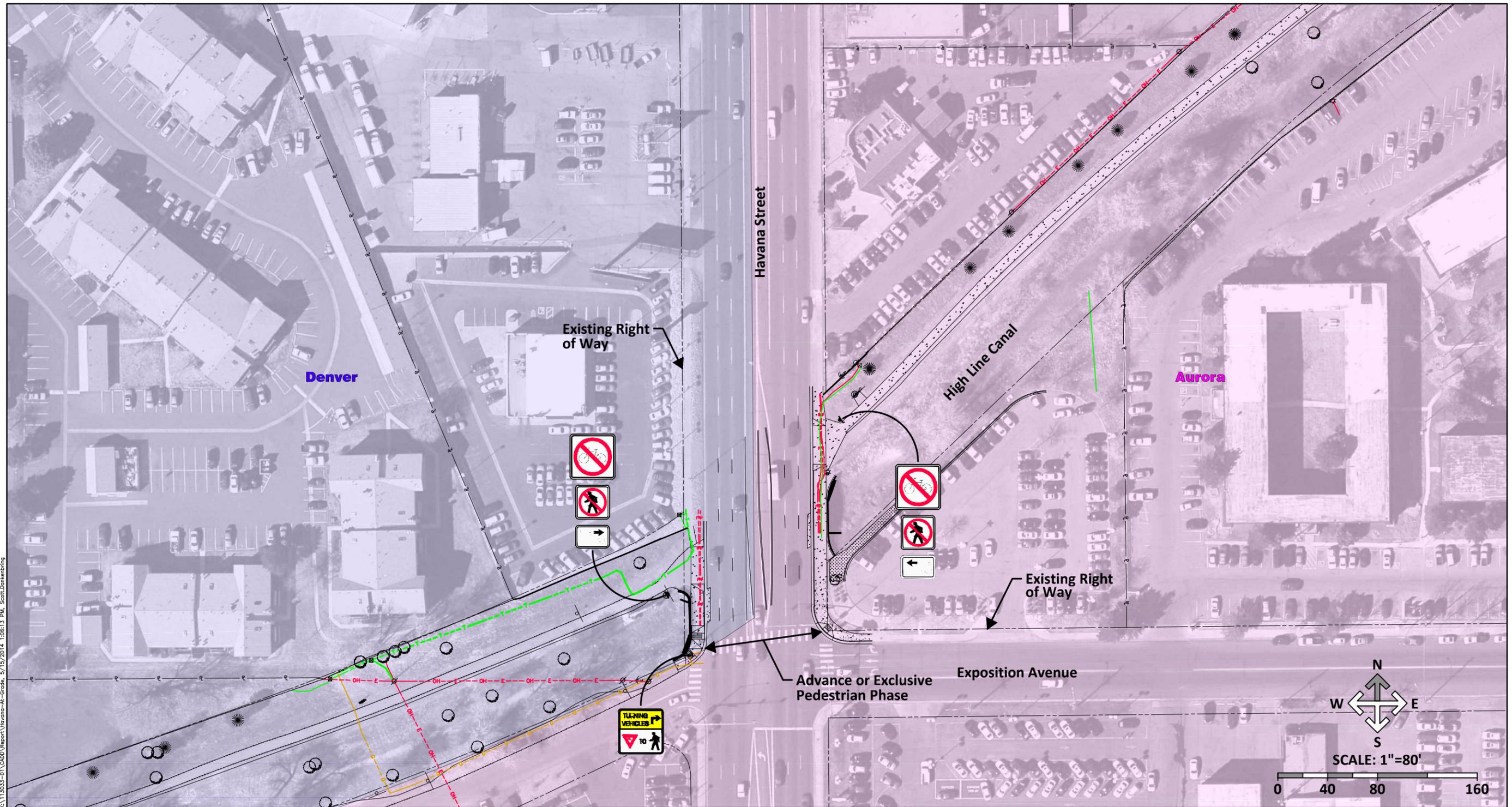
Evaluation Criteria	At-Grade Improvements (Figure 6)	Pedestrian Crossings over Canal (Figure 7)	Underpass (Figure 8)
Benefits			
Safety Benefits	●	●	●
Functionality for Trail Users	●	●	●
Impacts to Motorists	●	●	●
Aesthetics/Context	●	●	●
Equestrian Accommodation	NA	NA	NA
Costs			
Constructability (Utilities, phasing, design standards)	●	●	●
ROW Impacts	●	●	●
Maintenance	●	●	●
Design/Construction Cost	\$21,000	\$930,000	\$3,910,000



Recommendations and Next Steps

An underpass is the recommended alternative because of the high traffic volumes and speeds on Havana Street, wide crossing distance, and a history of bicycle and pedestrian accidents. The Crossing & Safety Task Group recommends that at some point in the future the High Line Canal Working Group assist Aurora and Denver in obtaining funds for design and construction of an underpass at this location. This includes advocating for Arapahoe County Open Space funds to be used as a funding source for design and construction, in combination with committed local matching funds from Denver and Aurora. Denver and Aurora will each need to have internal discussions to assess the priority of this project relative to other needs, and the two cities will need to coordinate their funding strategy to proceed with design and construction of this underpass. Until funding is obtained and an underpass is designed and constructed, the Task Group recommends installing signage to direct trail users to cross at the Havana/Exposition intersection, which will require coordination between Denver, Aurora, and CDOT.

Figure 6. Havana Street Crossing At-Grade Improvements



K:\113033-01\CADD\Report\Havana-At-Grade_5/15/2014_1:06:13 PM_Scott.Dankenberg

Figure 7. Havana Street Crossing Pedestrian Crossings over Canal

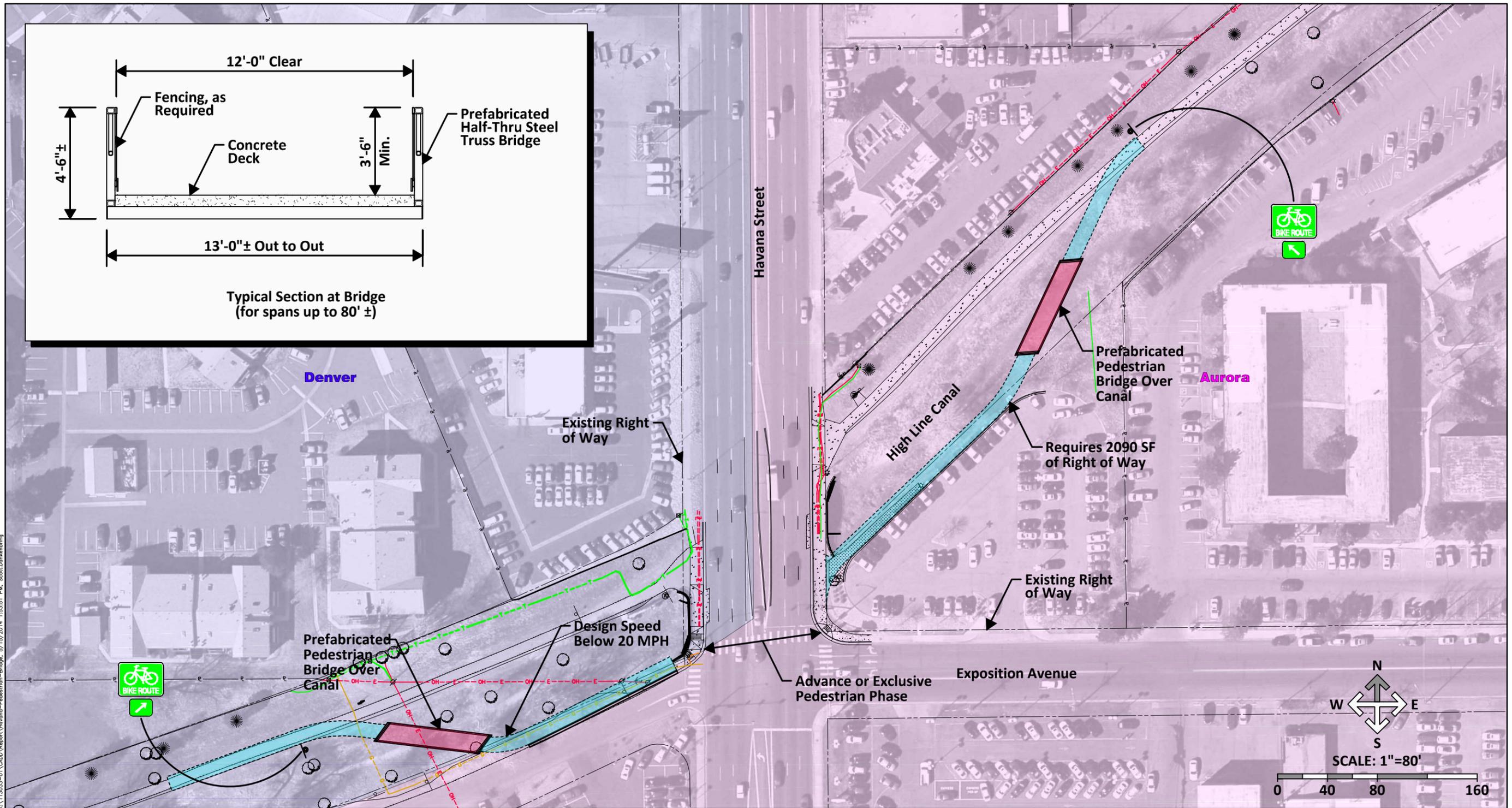
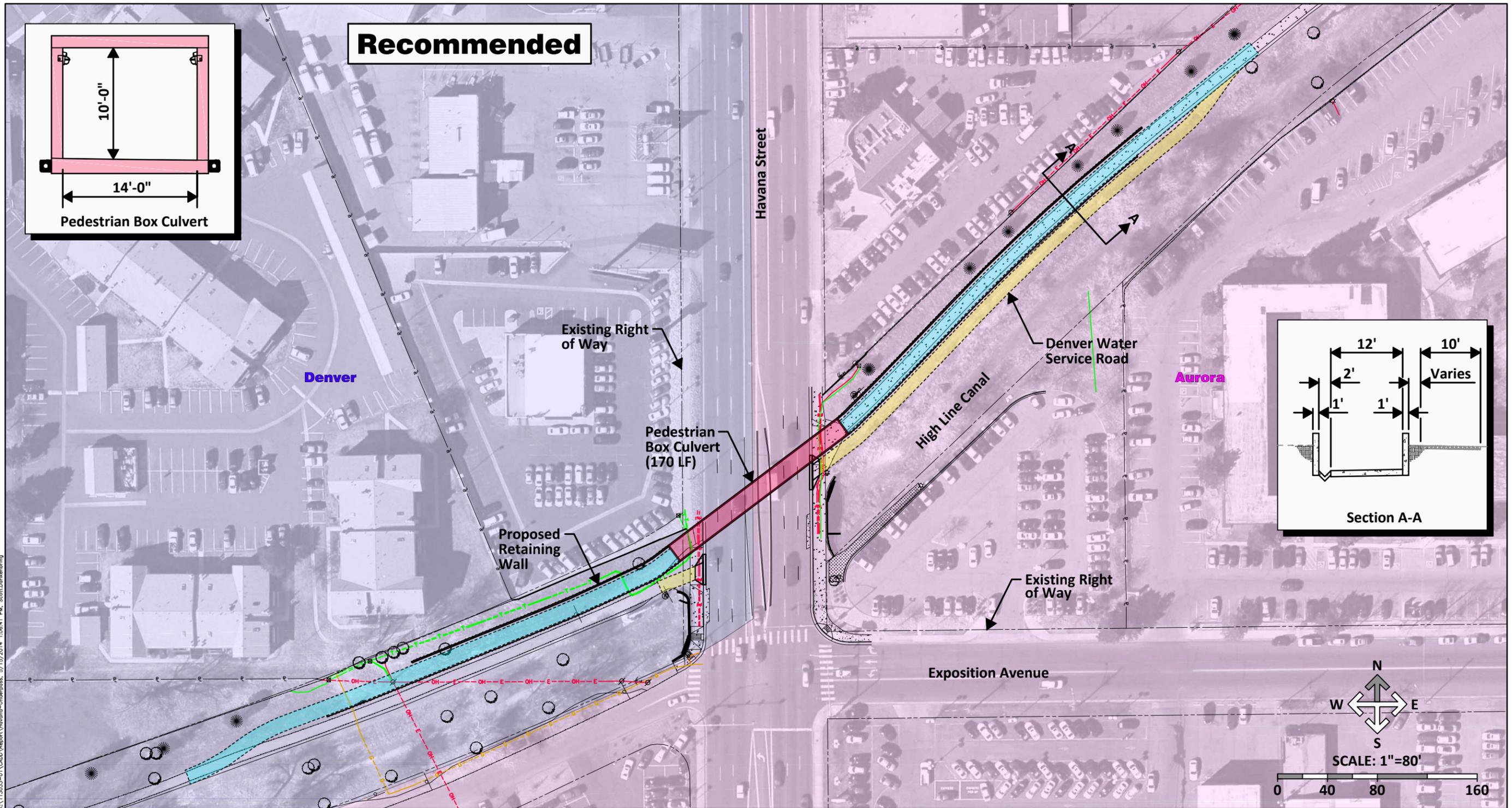


Figure 8. Havana Street Crossing Underpass



K:\113033-01\CADD\Report\Havana-Underpass_5/15/2014_1:06:41 PM_Scott.Danenberg

5. PARKER ROAD AT MISSISSIPPI AVENUE CROSSING

Existing Conditions

The High Line Canal trail crosses Parker Road near the Mississippi Avenue intersection (crossing location #3 on **Figure 1**). South of Parker, the trail ties into the west leg of the intersection; on the north side of Parker, the trail is approximately 260 feet away from the intersection and is connection via an attached sidewalk. Parker Road is a four lane road with a painted median, traffic volumes of over 41,000 vpd, and a posted speed of 40 mph. Guide signs direct trail users to cross at the north leg of the Parker/Mississippi intersection. Because of the free-flow right turn lane from Mississippi onto Parker Road, trail users must cross this high speed and heavily used turn lane, wait in a small channelization island (shown in the photo to the right), then proceed across Parker Road. The boundary between Denver and Arapahoe County approximately splits the intersection, with Denver on the northern half. Parker Road is a state highway (SH 83) owned and maintained by CDOT, although Denver operates the signal at Mississippi Avenue. The land uses in the vicinity of the crossing include a combination of commercial and multi-family residential.



Traffic and Trail User Counts

The trail user counts at the Parker Road crossing are very high, as shown on **Figure 9**:

- ▶ Approximately 360 trail users cross during a typical summer weekday and 420 cross during a typical summer Saturday.
- ▶ Roughly 85 percent of trail users at this location are bicyclists and 15 percent are pedestrians.
- ▶ The vast majority (96 percent) of trail users use the crosswalk at the Parker/Mississippi intersection (versus crossing at the trail alignment).

Accident History

During the five year period from January 2008 through December 2012, there were five vehicle/bicycle accidents and two vehicle/pedestrian accidents at this crossing. One of the pedestrian accidents involved an injury; the other bicycle and pedestrian accidents involved property damage only.

Opportunities and Constraints

- ▶ Trail users experience long delays at this intersection as a result of the long cycle length (120 seconds), and motorist failure to yield to the pedestrians, particularly when crossing the right turn lane. Bicyclists and pedestrians have been observed queuing in the small channelized island waiting to cross the remaining travel lanes.
- ▶ This section of the High Line Canal trail is heavily used by bicyclists; likely as a commuter route to access to the Cherry Creek Trail.
- ▶ The relatively high number of bicycle and pedestrian accidents demonstrates a significant opportunity to improve the safety for trail users crossing at this location.

Figure 9. Parker Road at Mississippi Avenue Crossing Trail User and Traffic Inventory



- ▶ The preliminary geotechnical engineering study (detailed in **Appendix B**) revealed that the soils are generally favorable for underpass construction, and groundwater levels are deep and will have no impact on the structure.
- ▶ The City and County of Denver plans to initiate a corridor study for the Parker /Leetsdale/Speer corridor in the near future which will likely begin at the Mississippi Avenue intersection. There may be an opportunity to pursue funding for the crossing improvements in combination with other corridor improvements.

Crossing Alternatives

Four crossing alternatives have been developed and evaluated at the Parker Road Crossing.

At-Grade Improvements

The first alternative would provide enhancements to the existing crossing at the Parker Road/Mississippi Avenue intersection. As shown on **Figure 10**, two options for at-grade improvements were considered. Option A would involve signaling the westbound right turn movement from Mississippi Avenue to Parker Road (the movement is currently free-flow, uncontrolled by the signal) such that right turns could only be made when the right turn arrow is green. Right turning vehicles would have a red arrow during the pedestrian crossing phase, resulting in a protected pedestrian movement. This modification would require modifying the signal phasing. As shown in **Table 4**, controlling the right turn movement (which is a high volume movement during AM, PM, and Saturday peak hours), would in approximately 40 additional seconds of delay for the right turning vehicles, and the overall intersection would degrade from LOS B/C with existing conditions to LOS C/C. The cost estimate for signaling the right turn movement is \$100,000 (as detailed in **Appendix C**).

Table 4. Parker Road Crossing Traffic Operations Comparison

	Peak Hour	Westbound Right Turn		Overall Intersection	
		Average Delay per Vehicle (seconds)	LOS	Average Delay per Vehicle (seconds)	LOS
Existing	AM	0	-	19.0	B
	PM	0	-	24.1	C
	Saturday	0	-	19.9	B
Option A (Signalized Right Turn)	AM	46.6	D	41.2	D
	PM	41.0	D	27.5	C
	Saturday	40.6	D	24.2	C
Option B (Interconnected Pedestrian Hybrid Signal)*	AM	142.1	F	74.8	E
	PM	84.5	F	46.5	D
	Saturday	76.0	E	35.9	D

* Traffic traveling on Parker Road would be subject to an additional 28 seconds of delay at the pedestrian hybrid signal.

The second option for at-grade improvements (Option B on **Figure 10**) includes installation of a pedestrian hybrid signal approximately 250 feet west of the Mississippi Avenue intersection in addition to signalization of the westbound right turn movement. A new sidewalk connection along the south side of Parker Road would also be needed. A High-intensity Activated crossWalk (HAWK) beacon, which is also known as a pedestrian hybrid beacon, is a special type of beacon used to warn and control traffic at an unsignalized location to assist pedestrians in crossing a street or highway at a marked crosswalk. The pedestrian hybrid signal is included in the 2009 Edition of the Manual on Uniform Traffic Control Devices (MUTCD). Because of the proximity to the signalized intersection, the pedestrian hybrid signal would be interconnected with the Mississippi Avenue. When a bicyclist or pedestrian activates the hybrid signal, the pedestrian indication at the HAWK would be illuminated during a westbound to southbound left turn phase at the Parker Road/Mississippi Avenue intersection; all other traffic would be stopped. As shown in **Table 4**, this phasing modification would result in 76-142 seconds of additional vehicular delay for the westbound right turn movement during the peak hours (LOS F during the AM and PM peak hours, LOS E during the Saturday peak hour), and would degrade the overall intersection from LOS B/C to LOS D/E. In addition, motorists traveling on Parker Road would incur additional delays (28 seconds) at the pedestrian hybrid signal when a pedestrian activates the beacon. Installation of an interconnected HAWK in addition to signalization of the westbound right turn land would cost an estimated \$800,000, would require approval from CDOT, and would have considerable adverse impacts on traffic operations.

Underpass

The third alternative considered for the Parker Road crossing is an underpass (**Figure 11**). The underpass would be a 14-foot wide and 10-foot tall box culvert north of the canal, located north of the existing trail. The Denver Water service road access would be maintained between the underpass and the canal. The High Line Canal crosses Parker Road at a sharp angle; if the underpass were to follow the alignment of the canal, it would be over 200 feet in length. The underpass shown on **Figure 11** has been aligned to shorten the pedestrian box culvert, making use of right-of-way owned by Denver along the south edge of Parker Road. This configuration results in a bend in the trail alignment where the desired design speed of 20 mph could not be achieved. The box culvert shown in the conceptual design is approximately 160 feet long. On the approaches to the box culvert, retaining wall would be needed between the trail and the service road, and for a short distance on the south side of the trail. The underpass is estimated to cost \$3.19 million. A summary of the utility conflicts is provided in **Appendix D**.

Pedestrian Bridge

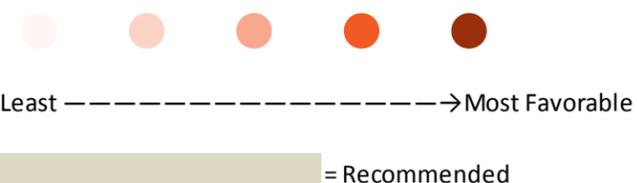
A pedestrian bridge over Parker Road was also considered, as shown on **Figure 12**. Following the alignment of the canal, the clear span of the bridge would be approximately 275 feet because it would cross Parker Road at an angle. The ramps approaching the bridge were laid out assuming ADA compliant and bike-friendly maximum grades of five percent. Design and construction of a pedestrian bridge over Parker Road is estimated to cost \$4.12 million.

Evaluation of Alternatives

The four crossing alternatives for Parker Road have been evaluated based on the evaluation criteria described in Chapter 2, and the results are shown on **Table 5**. Signalization of the right turn movement would provide only marginal safety and trail user functionality benefits, and would result in additional delay for right turning vehicles. Although the least expensive alternative, it would require coordination with CDOT. The addition of an interconnected pedestrian hybrid beacon (HAWK) would result in significant delays for traffic on Parker Road. This configuration would provide only marginal safety benefits, as trail users would still be required to cross at-grade. The City and County of Denver does not support this alternative; it would require coordination with CDOT.

Table 5. Parker Road at Mississippi Avenue Crossing Alternatives Evaluation

Evaluation Criteria	At-Grade Improvements (Signalized Right Turn) (Figure 10 Option A)	Interconnected HAWK (Figure 10 Option B)	Underpass (Figure 11)	Pedestrian Bridge (Figure 12)
Benefits				
Safety Benefits	●	●	●	●
Functionality for Trail Users	●	●	●	●
Impacts to Motorists	●	●	●	●
Aesthetics/Context	●	●	●	●
Equestrian Accommodation	NA	NA	NA	NA
Costs				
Constructability (Utilities, phasing, design standards)	●	●	●	●
ROW Impacts	●	●	●	●
Maintenance	●	●	●	●
Design/Construction Cost	\$100,000	\$800,000	\$3,190,000	\$4,120,000

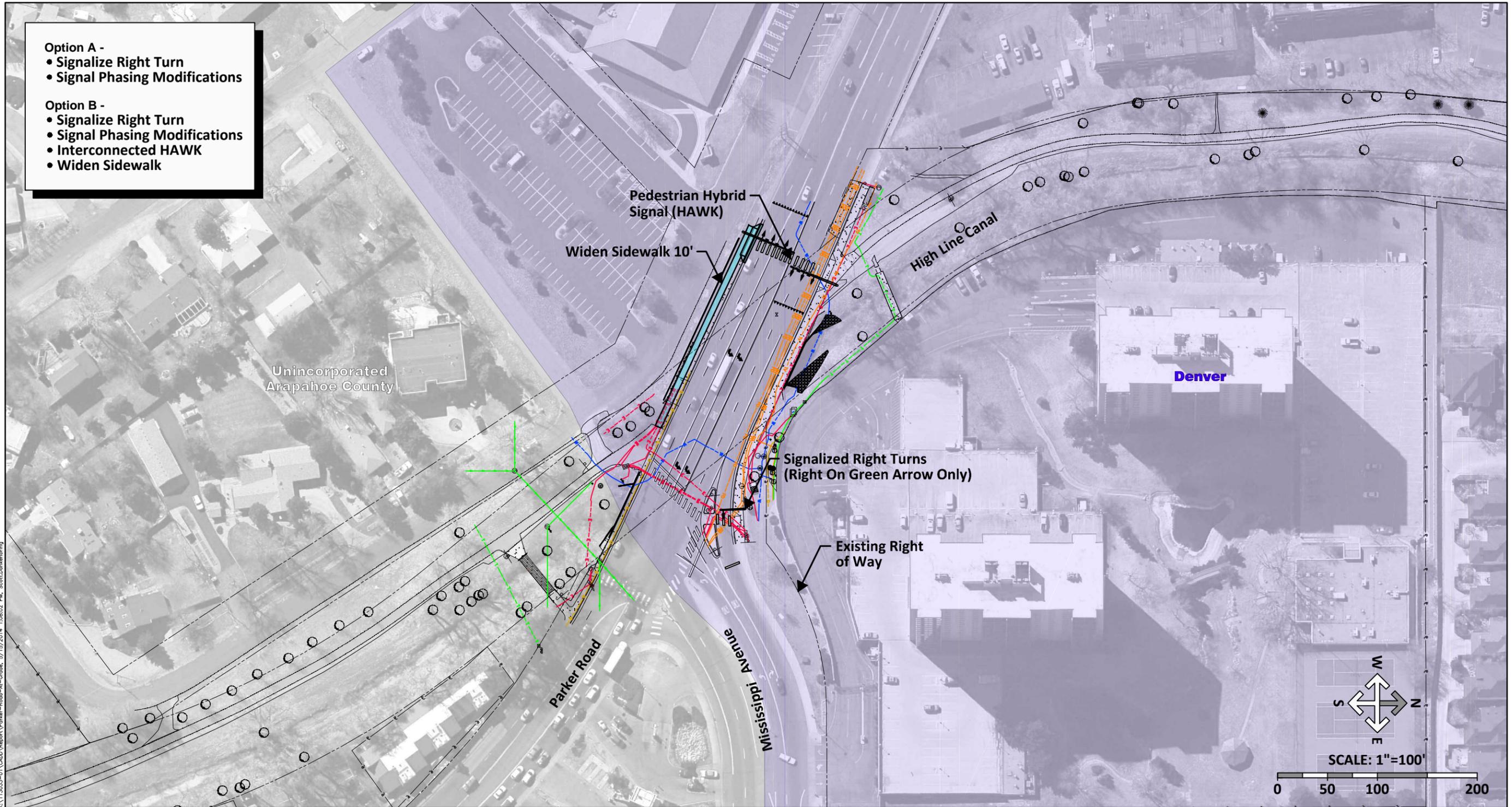


The underpass would eliminate the conflict between trail users and motorists and would best address the considerable safety concern and trail user delays at this crossing location. Although higher cost than the at-grade improvements, an underpass could be constructed reasonably well within the context of the area without visual obstructions. A pedestrian bridge would also eliminate the conflict between trail users and motorists, but it is the highest cost of the four alternatives, would be less-favored by bicyclists, and would be visually obtrusive. In addition to the cost and usability drawbacks, this alternative limits maintenance access options for Denver Water equipment. Right-of-way and topographical constraints on the north side of Parker Road appear to preclude the ability to provide an adequate and safe maintenance access to the canal.

Recommendations and Next Steps

The underpass is the recommended alternative for the Parker Road crossing because it would considerably improve the safety and comfort and minimize delays for the many trail users at this location. The underpass should be aligned to optimize the length of the pedestrian box culvert, even if desired bicycle design speeds cannot be achieved along this portion of the trail. The Crossing & Safety Task Group recommends that the High Line Canal Working Group assist Denver and Arapahoe County in obtaining funds for design and construction of an underpass at this location. This includes advocating for Arapahoe County Open Space funds as a possible funding source for the project along with local matching funds. The Task Group also recommends that this underpass be considered in combination with other recommendations in the area that may be identified in the upcoming Speer/Leetsdale corridor study that is being led by the City and County of Denver.

Figure 10. Parker Road at Mississippi Avenue Crossing At-Grade Improvements



K:\113033-01\CADD\Report\ Parker-Road-At-Grade_5/15/2014_1:08:02 PM_Scott.Dankenberg

Figure 11. Parker Road at Mississippi Avenue Crossing Underpass

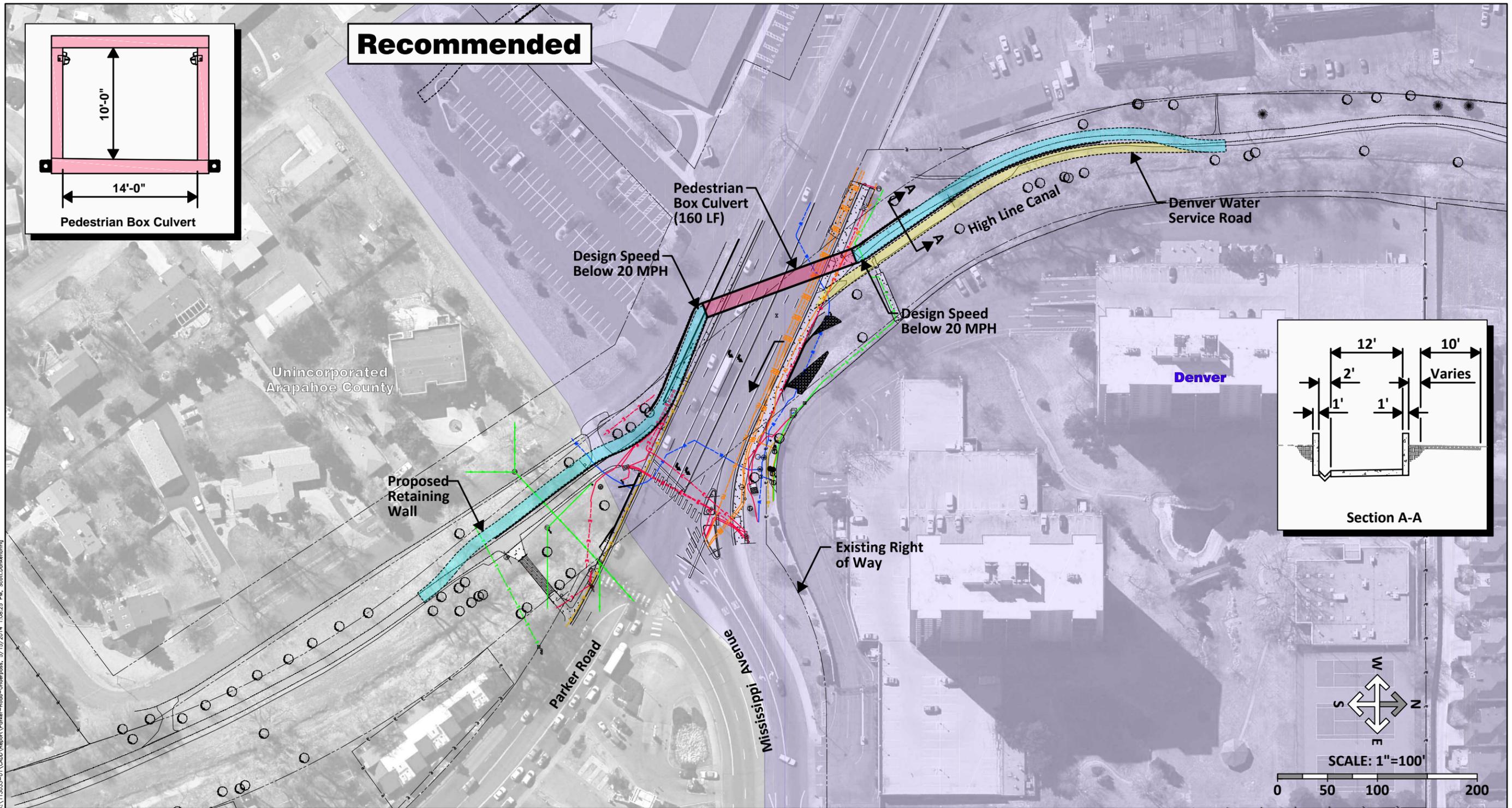
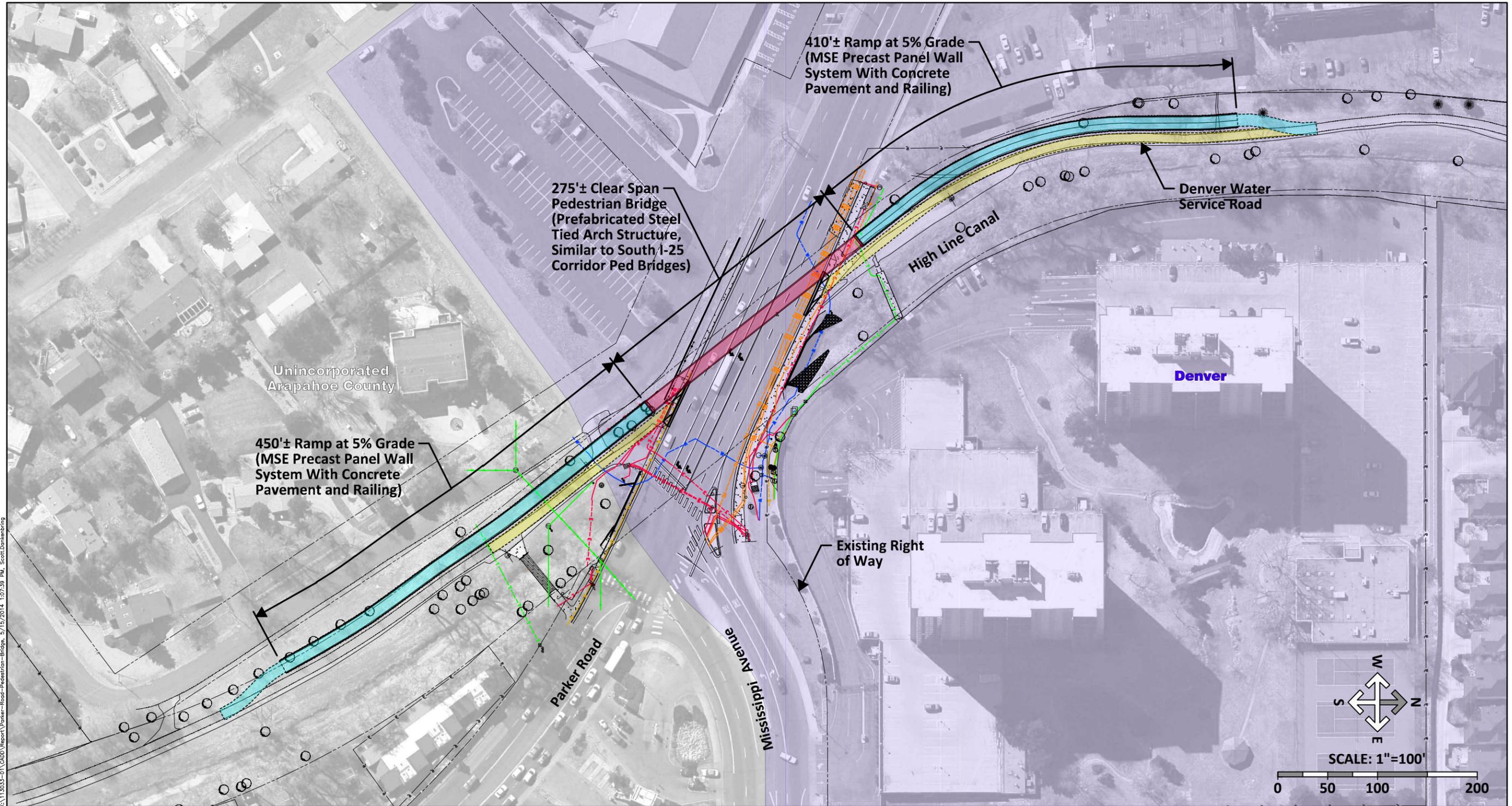


Figure 12. Parker Road at Mississippi Avenue Crossing Pedestrian Bridge



K:\113033-01\CADD\Report\Road-Pedestrian-Bridge_5/15/2014_1:07:39 PM_Scott.Dornier

6. HOLLY STREET AT ILIFF AVENUE CROSSING

Existing Conditions

The High Line Canal trail crosses Holly Street at the south leg of the intersection with Iliff Avenue (crossing location #4 on **Figure 1**). The intersection has stop sign control at Iliff Avenue; there is currently no traffic control (including any crosswalk markings or signage) on Holly Street at the trail crossing. Holly Street carries approximately 8,500 vpd and has a posted speed limit of 30 mph. This crossing is located within the City and County of Denver boundaries, but is close to the boundary with Arapahoe County. The area surrounding the crossing is primarily single family and multi-family residential with some commercial uses immediately adjacent to the Holly Street/Iliff Avenue intersection.



Traffic and Trail User Counts

As shown on **Figure 13**, the trail user counts are moderately high and provide the following insights:

- ▶ Approximately 210 trail users cross during a typical summer weekday and 180 cross during a typical summer Saturday.
- ▶ The split between bicycle and pedestrian activity is roughly equal.
- ▶ Holly Hills/Holly Ridge school boundaries span the crossing; there is potential for school-aged children to use this crossing location.

Accident History

There was one vehicle/bicycle accident at this crossing location between January 2008 and December 2012, which involved an injury.

Opportunities and Constraints

- ▶ The attendance area for Holly Hills and Holly Ridge Elementary Schools (Cherry Creek School District) spans the Holly Street crossing. The High Line Canal Trail may be a route for children to walk to and from school; crossing enhancements would improve the viability of its use as a safe route for children to walk or bike to school.

Figure 13. Holly Street at Iliff Avenue Crossing Trail User and Traffic Inventory



Crossing Alternatives

Two crossing alternatives have been developed and evaluated at the Holly Street Crossing.

At-Grade Improvements

The first alternative would provide enhancements to the existing at-grade crossing. As shown in the conceptual design (Figure 14), the at-grade improvements include crosswalk markings, yield lines, and enhanced signing to make motorists aware of the pedestrian crossing. Construction of a raised median on the south leg of Holly Street would serve as a refuge for pedestrians crossing the street. ADA-compliant curb ramps are also needed at the intersection. The estimated cost for these improvements is \$79,000 (the detailed cost estimate is included in Appendix C).

Underpass

The second alternative considered for the Holly Street crossing is an underpass (Figure 15). The underpass would be a 14-foot wide and 10-foot tall box culvert north of the canal, located generally in the same alignment as the existing trail. The underpass shown in the conceptual design is approximately 110 feet. The Denver Water service road access would be maintained just to the south of the underpass; the two would be separated by a retaining wall. Due to the right-of-way constraints and the typography, a retaining wall would also be required on the north side of the trail for a distance approaching the box culvert. On the west side of Holly Street, this retaining wall would be very close to the house just north of the trail. The underpass is estimated to cost \$3.68 million.

Evaluation of Alternatives

The two crossing alternatives for Holly Street have been evaluated based on the evaluation criteria described in Chapter 2, and the results are shown on Table 6. The at-grade improvements would provide some safety enhancements and would improve the level of comfort for trail users crossing Holly Street. These improvements would be low cost and are compatible with the level of traffic volumes, travel speeds, and short crossing distance on Holly Street. The underpass alternative would eliminate the conflict between trail users and motorists, but at a considerably higher cost than the at-grade improvements.

Recommendations and Next Steps

Although an underpass would be feasible and beneficial at this location, the cost effective at-grade improvements are recommended at this location because of relatively low traffic volume and the short crossing distance. A raised median pedestrian refuge, ADA compliant curb ramps, crosswalk markings, and improved signing will enhance the visibility of the crossing and driver expectation of trail users crossing the intersection. The Crossing & Safety Task Group recommends that the High Line Canal Working Group support Denver and Arapahoe County in implementing these at-grade improvements. Although this crossing is wholly within the City and County of Denver, improvements would benefit both Denver and Arapahoe County trail users. Denver and Arapahoe County will each need to discuss the priority of these crossing improvements relative to other city/county needs. If both agencies deem these improvements to be high priority, Denver and Arapahoe County will need to coordinate and partner in developing a funding plan, which may include the use of Arapahoe County Open Space funds in combination with local funds.

Table 6. Holly Street at Iliff Avenue Crossing Alternatives Evaluation

Evaluation Criteria	At-Grade Improvements (Crosswalk, median) (Figure 14)	Underpass (Figure 15)
Benefits		
Safety Benefits	●	●
Functionality for Trail Users	●	●
Impacts to Motorists	●	●
Aesthetics/Context	●	●
Equestrian Accommodation	NA	NA
Costs		
Constructability (Utilities, phasing, design standards)	●	●
ROW Impacts	●	●
Maintenance	●	●
Design/Construction Cost	\$79,000	\$3,680,000

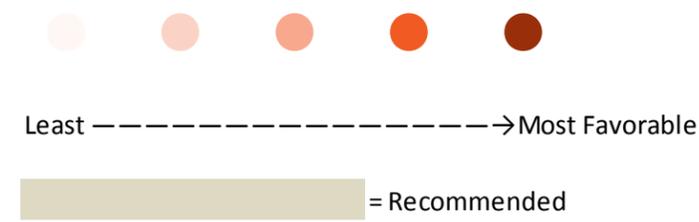
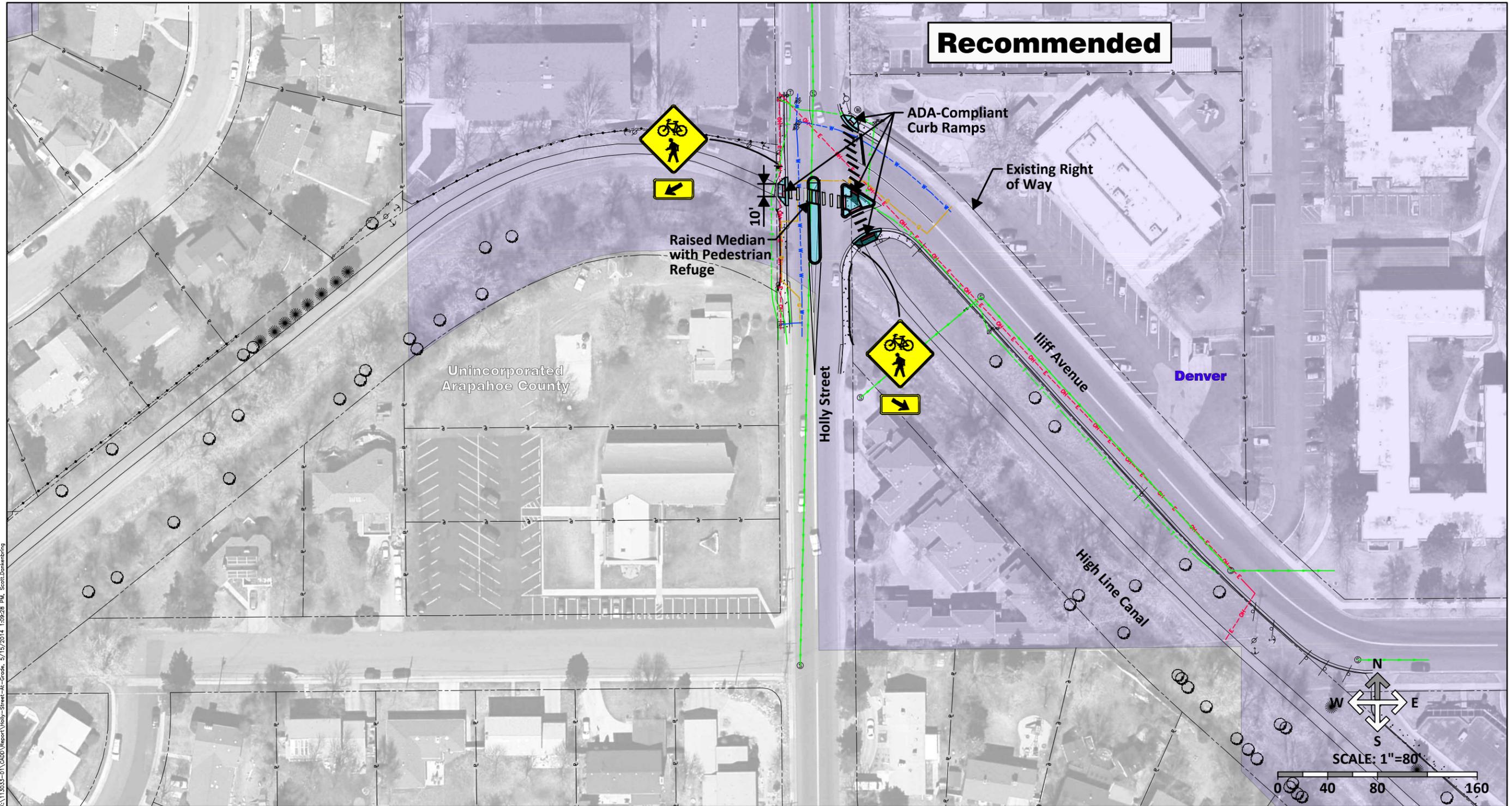
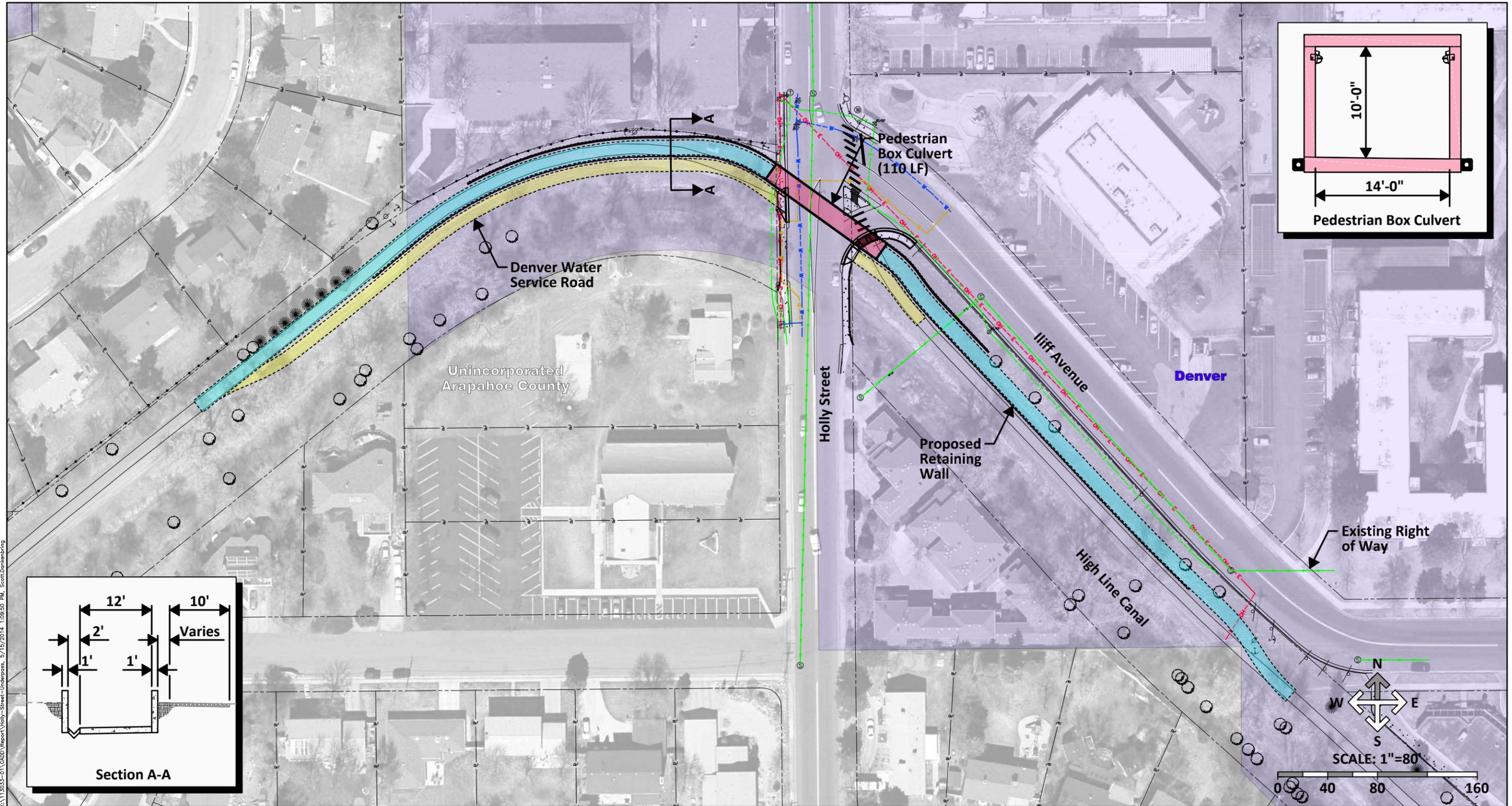


Figure 14. Holly Street at Iliff Avenue Crossing At-Grade Improvements



K:\113033-01\CADD\Report\Holly-Street-At-Grade_5/15/2014 1:09:28 PM_Scott.Dankenberg

Figure 15. Holly Street at Iliff Avenue Crossing Underpass



K:\113033-01\CADD\Report\Holly-Street-Underpass, 5/15/2014, 1:09:50 PM, Scott.Donkenbring

7. YALE AVENUE AT HOLLY STREET CROSSING

Existing Conditions

The High Line Canal trail crosses Yale Avenue at three locations; the crossing at Holly Street is the westernmost of the three (crossing location #5 on **Figure 1**). Yale has a five lane section at the trail crossing, carries approximately 23,000 vpd and has a posted speed of 30 mph. Trail users are intended to cross at the signalized intersection of Yale and Holly, which is approximately 80 feet east of the trail. This crossing is located near the boundary between Denver and Arapahoe County, and the signal is owned and operated by Denver. The land uses in the vicinity include single family residential with some commercial uses along the south side of Yale Avenue.



Traffic and Trail User Counts

This crossing location was added to the scope of work for this feasibility study in the fall of 2013. Because the high trail use summer period had passed, the study team relied on trail use counts that were obtained in the summer of 2012 for the Yale Avenue corridor study. These counts were conducted over an eight-hour period on a Saturday, as summarized on **Figure 16**. The trail user counts are moderately high and provide the following insights:

- ▶ Roughly 80 percent of the trail users are bicyclists and 20 percent are pedestrians
- ▶ On Saturday, approximately half of the trail users cross at the Holly intersection and half cross at the canal alignment
- ▶ Holly Hills/Holly Ridge school boundaries span the crossing; there is potential for school-aged children to use this crossing location

Accident History

No vehicle/bicycle or vehicle/pedestrian accidents occurred at this crossing location during the three year time period from January 2009 through December 2011.

Opportunities and Constraints

- ▶ The attendance area for Holly Hills and Holly Ridge Elementary Schools (Cherry Creek School District) spans the Yale Avenue at Holly Street crossing. The High Line Canal Trail may be a route for children to walk to and from school; crossing enhancements would improve the viability of its use as a safe route for children to walk or bike to school.
- ▶ The City and County of Denver is planning to upgrade the signal at Yale Avenue/Holly Street; there is an opportunity to coordinate the recommendations of this study such that the signal modifications do not preclude future crossing improvements.
- ▶ The sidewalks on the Yale Avenue bridge over the High Line Canal are narrow and in poor condition; future replacement of the bridge may present an opportunity to improve these sidewalks and widen the landing area at the ends of the crosswalks at the intersection.

Figure 16. Yale Avenue at Holly Street Crossing Trail User and Traffic Inventory



Crossing Alternatives

Three crossing alternatives have been developed and evaluated at the Yale Avenue Crossing.

At-Grade Improvements

The first alternative would provide enhancements to the existing crossing at the Yale Avenue/Holly Street intersection. As shown on **Figure 17**, the at-grade improvements would include signing to encourage trail users to cross at the intersection and reconstruction of the curb ramps to be ADA-compliant. The estimated cost for these improvements is \$46,000 (the detailed cost estimate is included in **Appendix C**).

Pedestrian Crossings over Canal

The second alternative considered for the Yale Avenue crossing involves trail realignments north and south of Yale Avenue that would provide direct connection to the crosswalk on the west leg of the Yale Avenue/Holly Street intersection (shown on **Figure 18**). Pre-fabricated pedestrian bridges would be used to cross the trail east of the canal. Trail users would still cross at-grade, but this alternative would position the trail users in a way that highly encourages them to cross at the signalized intersection. Signing on the trail would direct trail users away from the service road and onto the pedestrian bridges. These improvements could be done in combination with the curb ramp reconstruction described in the at-grade improvements. As noted in the conceptual design, this configuration would require approximately 3,200 square feet of right of way from the triangular parcel south of Yale Avenue between Holly Place and the High Line Canal. The estimated cost for these improvements is \$880,000 plus right of way costs, which could be in the range of \$10,000 to \$30,000. The preliminary subsurface investigation at the proposed bridge locations do not suggest any unusual conditions – the site is suitable for pedestrian bridge construction.

Underpass

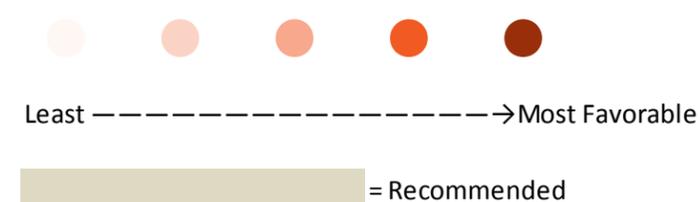
The third alternative considered for the Yale Avenue crossing is an underpass (**Figure 19**). The underpass would be a 14-foot wide and 10-foot tall box culvert north of the canal, located generally in the alignment of the existing trail. The Denver Water service road would be shifted slightly to the east. Due to the right-of-way constraints and the typography, retaining wall would be required on both sides of the trail on the approaches to the box culvert. The box culvert shown in the conceptual design is approximately 150 feet long. The underpass is estimated to cost \$3.61 million.

Evaluation of Alternatives

The two crossing alternatives for Holly Street have been evaluated based on the evaluation criteria described in Chapter 2, and the results are shown on **Table 7**. The at-grade improvements would provide marginal safety and trail user functionality benefits, but would be low cost and relatively easy to implement. Although the pedestrian bridges over the canal would not eliminate the at-grade crossing and associated safety conflicts, it would further discourage trail users from crossing at the canal alignment. This alternative is considerably less expensive than an underpass, but would require a small amount of right-of-way from the property south of Yale Avenue. The underpass alternative would eliminate the conflict between trail users and motorists, but is the highest cost of the three alternatives.

Table 7. Yale Avenue at Holly Street Crossing Alternatives Evaluation

Evaluation Criteria	At-Grade Improvements (Route to Holly) (Figure 17)	Pedestrian crossings over Canal (Figure 18)	Underpass (Figure 19)
Benefits			
Safety Benefits	●	●	●
Functionality for Trail Users	●	●	●
Impacts to Motorists	●	●	●
Aesthetics/Context	●	●	●
Equestrian Accommodation	NA	NA	NA
Costs			
Constructability (Utilities, phasing, design standards)	●	●	●
ROW Impacts	●	●	●
Maintenance	●	●	●
Design/Construction Cost	\$46,000	\$1,050,000	\$3,610,000

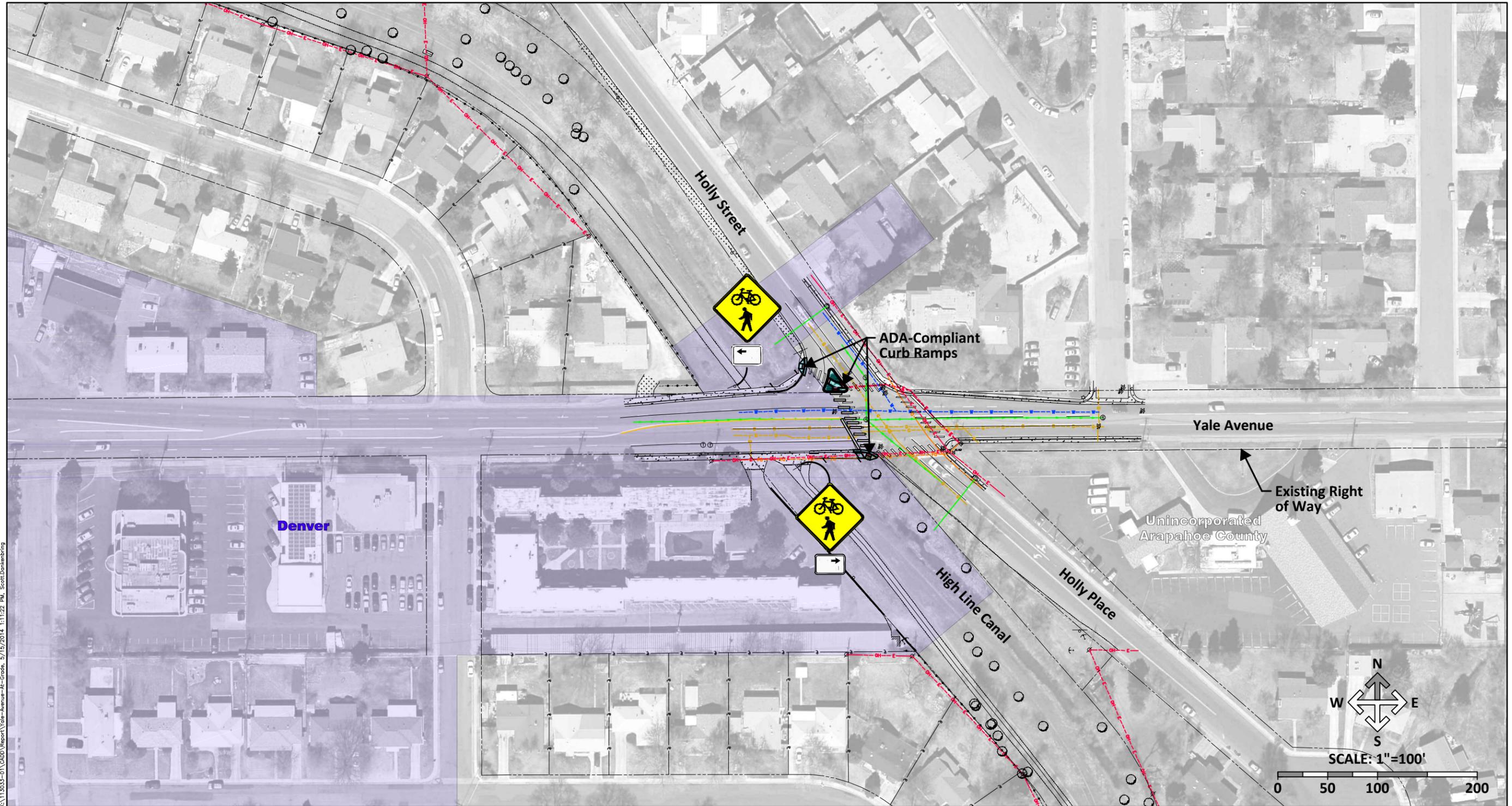


Recommendations and Next Steps

The recommended alternative for the Yale Avenue crossing includes new realigned trail segments north and south of Yale that will provide a direct connection to an improved at-grade trail crossing at the signalized intersection of Yale/Holly. Pedestrian bridges would be used to cross the trail east of the canal, and street-level crossing enhancements, including improved landing areas and ADA-compliant curb ramps, would be provided at the intersection. Although an underpass would also be feasible and beneficial at this location, the cost is estimated to be 3 ½ times that of the pedestrian bridge connections. With no history of bicycle or pedestrian accidents and a relatively short crossing distance, the realignment with an improved at-grade crossing has been deemed to be a cost effective solution. The Crossing & Safety Task Group recommends that the High Line Canal Working Group assist Denver and Arapahoe County in obtaining funds for design and construction of the trail realignment and pedestrian bridges over the canal.

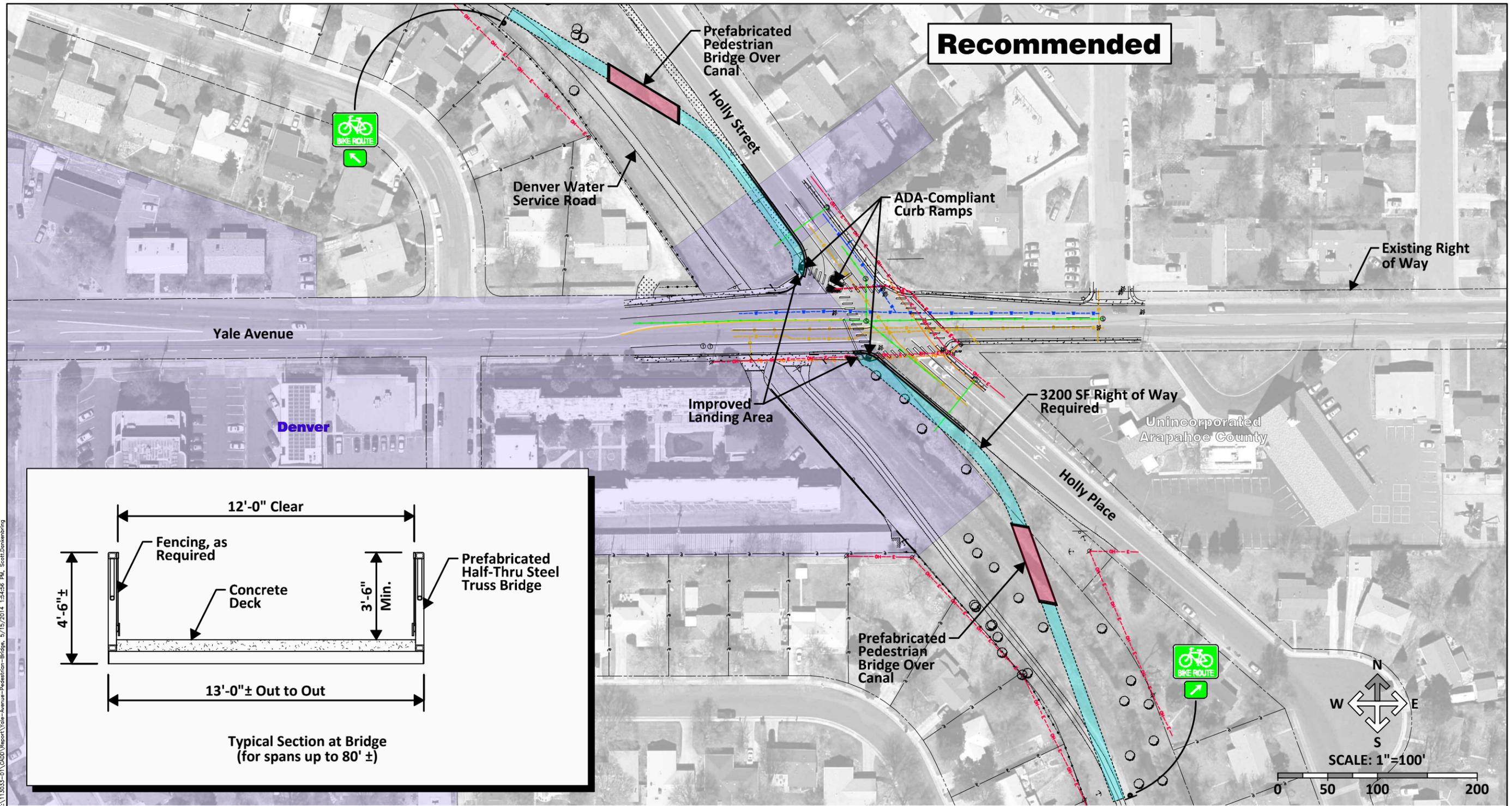
Because Denver is initiating a project to upgrade the signal at Yale/Holly, the Task Group recommends that Denver and Arapahoe County complete preliminary design of the recommended intersection and trail improvements in the short term to ensure that the signal project is compatible with the desired intersection modifications. Preliminary and final design will require coordination between Denver Public Works and Parks Departments, and Arapahoe County Public Works and Open Spaces Departments and should incorporate the recommendations of the Yale Avenue corridor study. The Task Group recommends that the involved departments from Denver and Arapahoe County coordinate to complete the preliminary and final design and develop a funding plan for construction, which may include Arapahoe County Open Space funds in combination with local matching funds.

Figure 17. Yale Avenue at Holly Street Crossing At-Grade Improvements



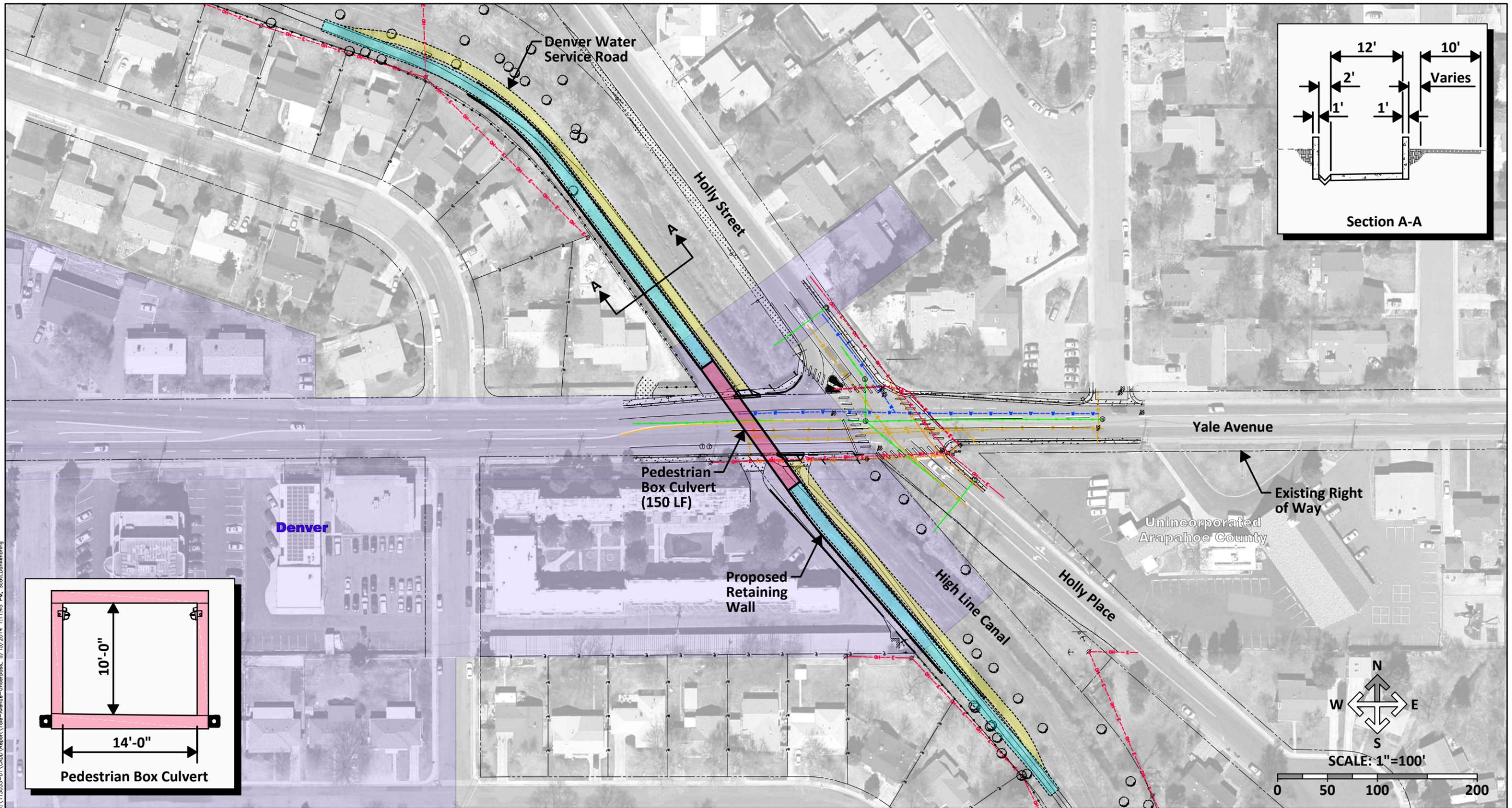
K:\113033-01\CADD\Report\Yale-Avenue-At-Grade_5/15/2014_11:12:22 PM_Scott.Dankenberg

Figure 18. Yale Avenue at Holly Street Crossing Pedestrian Crossings over Canal



K:\113033-01\CADD\Report\Yale-Avenue-Pedestrian-Bridge_5/15/2014_1:54:56 PM_Scott.Donnenberg

Figure 19. Yale Avenue at Holly Street Crossing Underpass



K:\113033-01\CADD\Report\Yale-Avenue-Underpass_5/15/2014_1:11:45 PM_Scott.Dankenberg

8. HAMPDEN AVENUE AT COLORADO BOULEVARD CROSSING

Existing Conditions

The High Line Canal extends through the Wellshire Golf Course in the northwest quadrant of Hampden Avenue and Colorado Boulevard. The trail, however, bypasses the golf course. From the south, the trail is routed onto Jefferson Avenue to Colorado Boulevard. Trail users cross the south and east legs of the Hampden/Colorado intersection, travel north along Colorado Boulevard, where they reconnect to the trail going east (crossing location #6 on **Figure 1**). Because Hampden and Colorado are both high-speed (45 mph and 40 mph respectively), heavily traveled arterial roads (Hampden carries 54,000 vpd, Colorado carries 21,000 vpd), this location is a significant barrier for recreational users. Hampden Avenue is the dividing line between Denver (to the north) and Cherry Hills Village (to the south). In addition to the golf course, the land uses in the vicinity of the crossing include single family residential, and churches in the southwest and northeast quadrants of the Hampden/Colorado intersection. Hampden Avenue (US 285) and Colorado Boulevard (SH 2) north of Hampden are owned and maintained by CDOT.



Traffic and Trail User Counts

Because Hampden Avenue and Colorado Boulevard act as a barrier to through travel on trail, the trail use at this crossing is low (as summarized on **Figure 20**):

- ▶ Approximately 35 trail users cross during a typical summer weekday and 75 cross during a typical summer Saturday.
- ▶ Roughly 80 percent of trail users at this location are bicyclists and 20 percent are pedestrians.

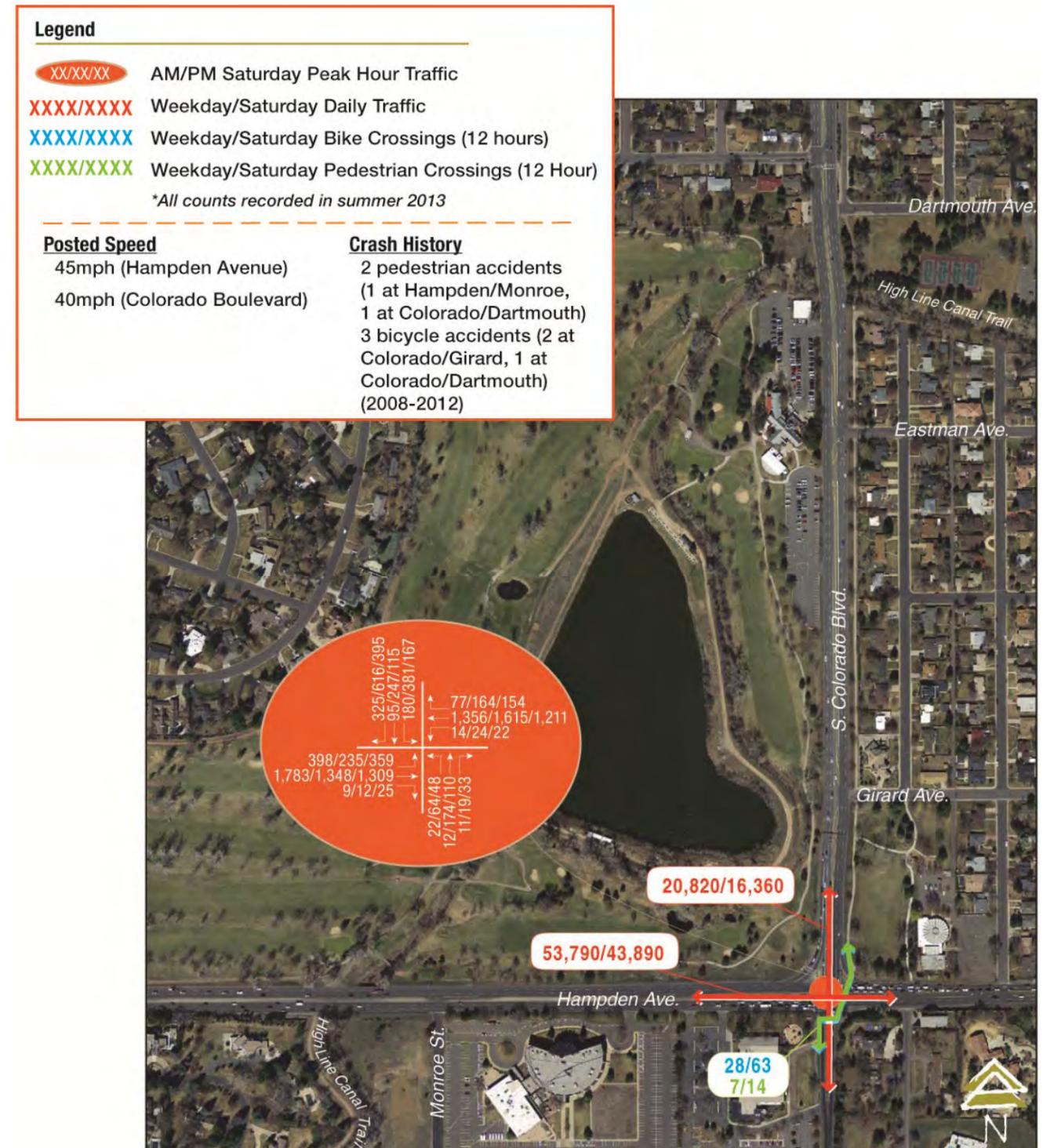
Accident History

During the five year time period from January 2008 through December 2012, there were two vehicle/pedestrian accidents – one at the intersection of Hampden/Monroe Street and one at the Colorado/Dartmouth intersection, and three vehicle/bicycle accidents – two at the Colorado/Girard intersection and one at the Colorado/Dartmouth intersection. Four of the five accidents involved an injury.

Opportunities and Constraints

- ▶ CDOT recently reconstructed the intersection of Hampden Avenue/Colorado Boulevard. Although no pedestrian crossing improvements were included in the intersection reconstruction project, CDOT has agreed to work with Denver and Cherry Hills Village to identify salutations to improve the safety for crossing pedestrians.
- ▶ Placement of bicycle and pedestrian activity close to the Wellshire Golf Course may be negatively received because of the risk of being hit by errant golf balls.

Figure 20. Hampden Avenue at Colorado Boulevard Crossing Trail User and Traffic Inventory



Crossing Alternatives

Five crossing alternatives have been developed and evaluated at the Hampden/Colorado Crossing.

At-Grade Improvements

The first alternative would provide enhancements to the existing crossing at the Hampden Avenue/Colorado Boulevard intersection. As shown on **Figure 21**, the at-grade improvements would involve signalizing the westbound to northbound right turn movement in order to provide a protected pedestrian crossing. The intersection currently operates at LOS D during the peak hours and would remain at LOS D during the AM and Saturday peak hours and LOS E during the PM peak hour with the signalized right turn, with only minor additional delays to right turning traffic. To accommodate the right turning vehicles queued at the signal, a right turn lane would also be required. The right turn lane length and taper is subject to the requirements of the State Highway Access Code because Hampden Avenue is a US highway. Figure 21 shows the deceleration and taper lengths for three different speeds (the posted speed on Hampden Avenue east of Colorado is 40 mph). To minimize impacts to the church property and parking lot, a variance may be pursued with CDOT such that the 30 mph design standard for the right turn lane be used. The estimated cost for the right turn signal and the right turn lane is \$350,000 (the detailed cost estimate is included in **Appendix C**). The project would require between 4,000 and 6,000 square feet of ROW, depending on the design (and if a variance from the State Highway Access Code could be obtained). Assuming the cost per square foot could range from \$4 - \$10, the ROW cost could range from \$16,000 to \$60,000.

Underpass Options

The project team looked at four underpass configurations. Option A (**Figure 22**) would provide an underpass of Hampden Avenue where the High Line Canal crosses Hampden. As shown on Figure 22, a substandard design speed would be required on the north approach to the box culvert in order to minimize impacts to the golf course. The box culvert would be 14 feet wide and 10 feet tall with a length of approximately 200 feet. In this alternative, a new shared use path would be constructed on the north side of Hampden Avenue between the canal and Colorado Boulevard. Trail users would then cross Colorado Boulevard at the Hampden/Colorado intersection and continue north along Colorado Boulevard to the trail. The estimated cost for the underpass and sidewalk construction is \$3.09 million. This option includes widening the Hampden Avenue bridge over the High Line Canal to accommodate the new trail connection on the north side.

As an alternative to the previously described underpass, an additional sidewalk could be constructed along the west side of Colorado Boulevard, allowing pedestrians to cross Colorado at the Dartmouth Avenue intersection, which is signalized and has a pedestrian crosswalk (as shown in Option B – **Figure 23**). This configuration would require trail users to travel approximately 1,000 feet out of direction, since Dartmouth Avenue is approximately 500 feet north of the High Line Canal. The estimated cost for the underpass, sidewalk construction, and Hampden Avenue bridge widening is \$3.46 million.

In order to eliminate at-grade crossings of both Hampden Avenue and Colorado Boulevard, Option C (**Figure 24**) includes underpasses of both streets approximately where the High Line Canal crosses each street, with a shared use path connection adjacent to the Wellshire Golf Course connecting the two underpasses. Similar to the underpass of Hampden, the Colorado Boulevard underpass would require substandard design speeds to minimize impacts to the

adjacent properties. The estimated cost for the two underpasses, sidewalk construction, and Hampden Avenue bridge widening is \$5.67 million.

A fourth underpass alternative (Option D – **Figure 25**) was conceived to address some of the concerns with the first three underpass options. Option D includes a trail realignment south of Hampden Avenue. The realigned trail would make use of the existing pedestrian bridge which connects to Covington Drive/Jefferson Avenue to cross the canal, then extend north along the east side of the canal (along property owned by the Denver First Church). This realignment would allow for an underpass of Hampden Avenue on the east side of the canal which would allow for a more user-friendly ramp on the north side of Hampden Avenue and would avoid the need to widen the Hampden Avenue bridge over the canal. This Option includes an underpass of Colorado Boulevard just north of the Hampden Avenue intersection. Between the two underpasses, the trail would extend along the south edge of the Wellshire Golf Course. East of Colorado, trail users would use the existing detached shared use path that connects to the High Line Canal at Mamie Dowd Eisenhower Park. The cost for the two underpasses and sidewalk construction is an estimated \$4.48 million.

Pedestrian Bridge

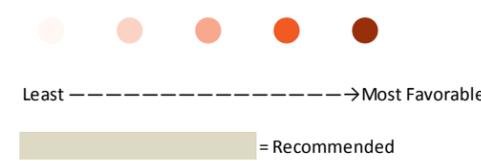
The final alternative considered for the Hampden and Colorado crossing is a pedestrian bridge over the Hampden/Colorado intersection. As shown on **Figure 26**, the bridge would diagonally span the intersection, with ramps extending west along the south side of Hampden and north along the east side of Colorado. The bridge profile, shown on **Figure 27**, includes a 225 foot main span with a 17 ½ foot vertical clearance over the intersection. Half-through trusses would be used for the ramp approaches to minimize visual obstructions. West of the structure, a new shared use path would be needed on the south side of Hampden Avenue, connecting via Monroe Street to the existing pedestrian bridge access to the trail. North of the structure, trail users would travel along the existing trail adjacent to Colorado Boulevard to the High Line Canal. A few variations of the bridge approach alignments appear to be available at the southwest quadrant of the intersection, but each may impact existing accesses in the vicinity. The estimated cost for the pedestrian bridge and associated improvements is \$4.72 million.

Evaluation of Alternatives

- ▶ At-grade improvements (add a westbound to northbound right turn lane and signalize the right turn movement)
 - Marginal safety and trail user functionality improvements
 - Would result in minimal additional delay for right turning vehicles
 - Relatively low cost, but would require some ROW and coordination with CDOT
- ▶ Underpass Option A
 - Eliminates the conflict between trail users and motorists at Hampden
 - Trail users would still be required to cross Colorado at-grade, and at the north leg of the intersection (which has higher traffic volumes than the south leg)
 - Requires the trail to run alongside the Wellshire Golf Course along Hampden Avenue
- ▶ Underpass Option B
 - Eliminates the conflict between trail users and motorists at Hampden
 - Trail users would still be required to cross Colorado at-grade at the Dartmouth Avenue intersection, which requires out of direction travel
 - Requires the trail to run alongside the Wellshire Golf Course along Hampden Avenue and Colorado Boulevard
- ▶ Underpass Option C
 - Eliminates the conflict between trail users and motorists at Hampden and Colorado
 - Trail users could bypass this barrier with a safe, continuous, uninterrupted route
 - Requires the trail to run alongside the Wellshire Golf Course along Hampden Avenue and Colorado Boulevard
- ▶ Underpass Option D
 - Eliminates the conflict between trail users and motorists at Hampden and Colorado
 - Trail users could bypass this barrier with a safe, continuous, uninterrupted route
 - Requires the trail to run alongside the Wellshire Golf Course along Hampden Avenue
- ▶ Bridge over Hampden/Colorado intersection
 - Eliminates the conflict between trail users and motorists
 - Trail users could bypass this barrier with a safe, continuous, uninterrupted route
 - High cost and visually obtrusive; incompatible with surrounding area
 - An overpass alternative could provide a fairly direct connection at this location, but the substantial size, cost, obtrusiveness, and overall maintenance required for the structure made it an unattractive solution for this site.

Table 8. Hampden Avenue at Colorado Boulevard Crossing Alternatives Evaluation

Evaluation Criteria	At-Grade Improvements (WB Right Turn Lane) (Figure 21)	Underpass Option A (Figure 22)	Underpass Option B (Figure 23)	Underpass Option C (Figure 24)	Underpass Option D (Figure 25)	Pedestrian Bridge at Intersection (Figure 26)
Benefits						
Safety Benefits	●	●	●	●	●	●
Functionality for Trail Users	●	●	●	●	●	●
Impacts to Motorists	●	●	●	●	●	●
Aesthetics/Context	●	●	●	●	●	●
Equestrian Accommodation	NA	NA	NA	NA	NA	NA
Costs						
Constructability (Utilities, phasing, design standards)	●	●	●	●	●	●
ROW Impacts	●	●	●	●	●	●
Maintenance	●	●	●	●	●	●
Design/Construction Cost	\$350,000	\$3,090,000	\$3,460,000	\$5,670,000	\$4,480,000	\$4,720,000



Recommendations

Hampden Avenue and Colorado Boulevard are both high-speed arterial roads, and this location is a significant barrier for recreational users. An underpass of both Hampden and Colorado (Option D – **Figure 25**) is the recommended alternative for this crossing because of the high motor vehicle traffic and the opportunity to provide a safe, continuous routing of the High Line Canal Trail that eliminates the existing barriers. The underpasses should be aligned to optimize the length of the pedestrian box culverts, even if desired bicycle design speeds cannot be achieved along this portion of the trail. The Crossing & Safety Task Group recommends that the High Line Canal Working Group assist Denver and Cherry Hills Village in obtaining funds for the underpasses at this location, including advocating for Arapahoe County Open Space funds to be used as a funding source for the project, in combination with local match and other funds.

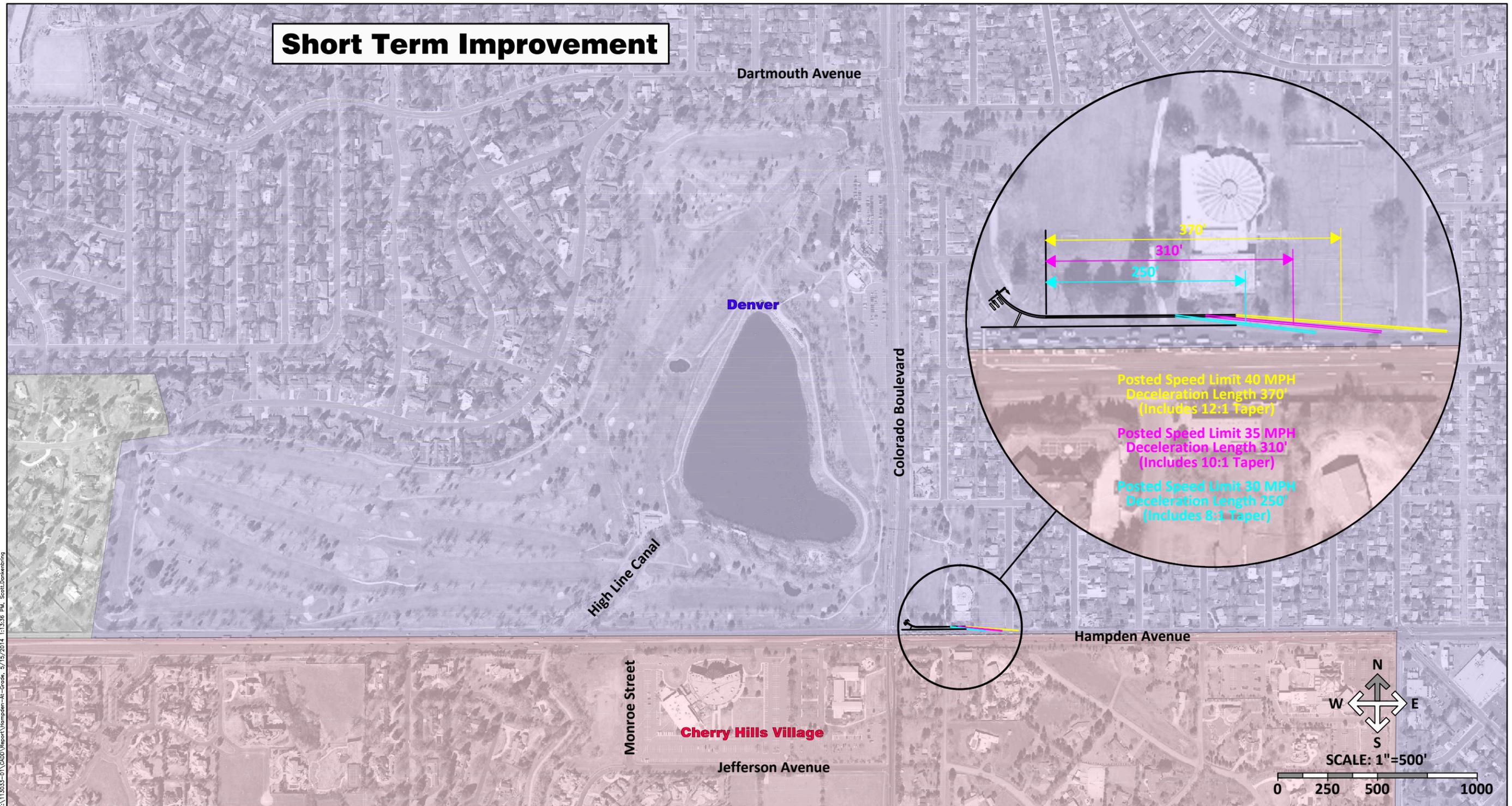
Because this recommended routing extends alongside the Wellshire Golf Course, the preliminary and final design will require considerable coordination with Golf Division of Denver’s Parks and Recreation Department. In early discussions with Denver Golf, they expressed the need to address the following considerations:

- ▶ Denver Golf would not be liable for any injuries that may result from errant golf balls
- ▶ Fencing and/or landscaping would be required to protect trail users from being hit by errant golf balls, to prevent trail users from entering onto the golf course and to prevent golf course users (especially in golf carts) from accessing the trail
- ▶ Trees along the edge of the golf course should be salvaged as possible; tree mitigation is already anticipated at this site due to the presence of Ash trees, which are vulnerable to the emerald ash borer which is present in Colorado

South of Hampden Avenue, the recommendation involves realigning the trail, making use of the existing pedestrian bridge near Covington Drive/Jefferson Avenue to cross the canal, then extending north along the east side of the canal along property owned by the Denver First Church. Cherry Hills Village should continue to coordinate with Denver First Church on the layout of their planned parking lot expansion and the future realigned trail. The expanded church parking lot may provide an opportunity for future trailhead parking and access.

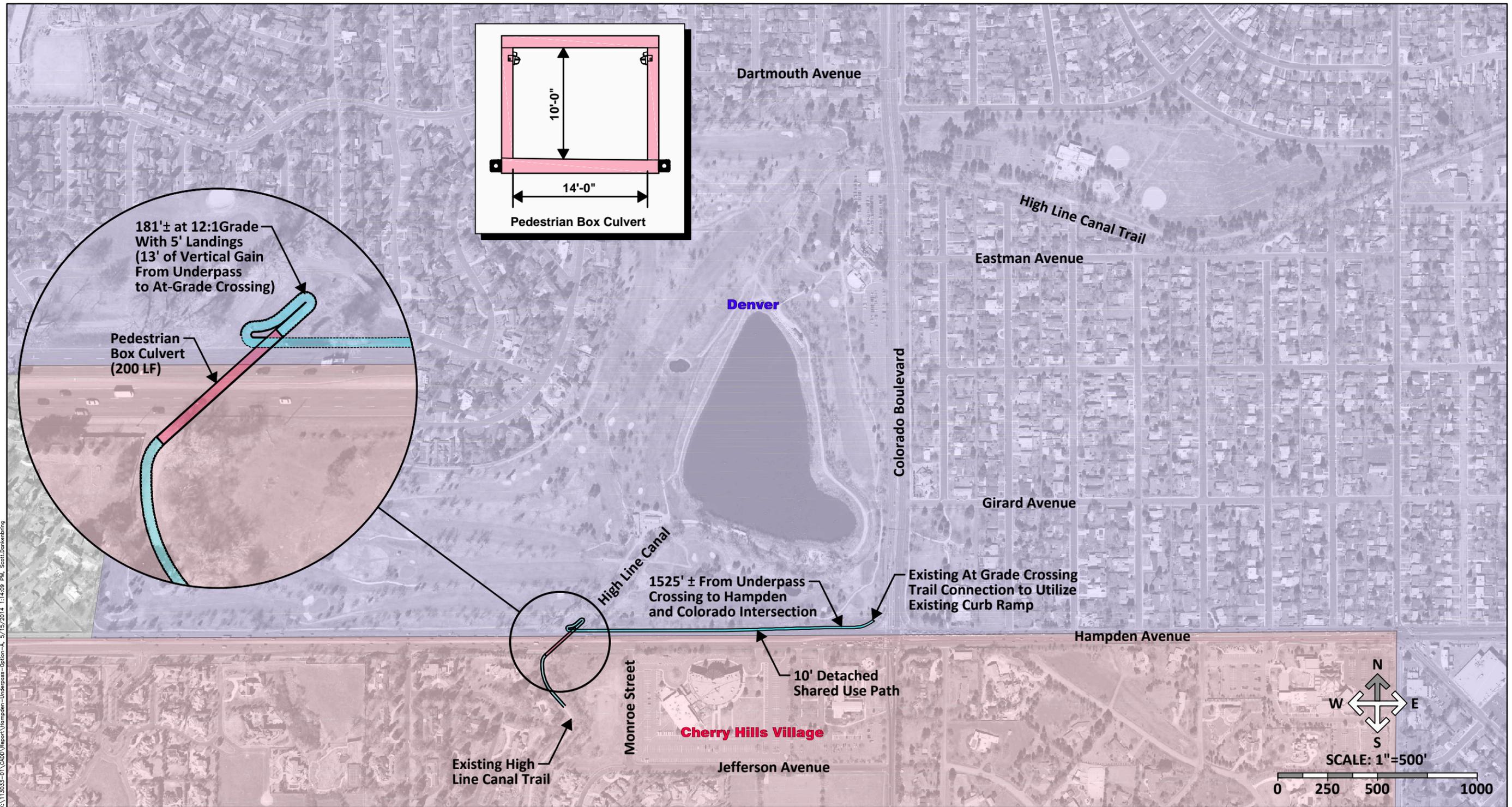
In the short term, the Task Group recommends that Denver and Cherry Hills Village work with CDOT to explore adding a westbound to northbound right turn lane and arrow at Hampden/Colorado to facilitate safe pedestrian crossings, and that the High Line Canal Working Group assist Denver and Cherry Hills Village in obtaining funds for the design, ROW acquisition and construction of the at-grade improvements. This includes advocating for Arapahoe County Open Space funds as a possible funding source for the project in combination with local matching funds.

Figure 21. Hampden Avenue at Colorado Boulevard Crossing At-Grade Improvements



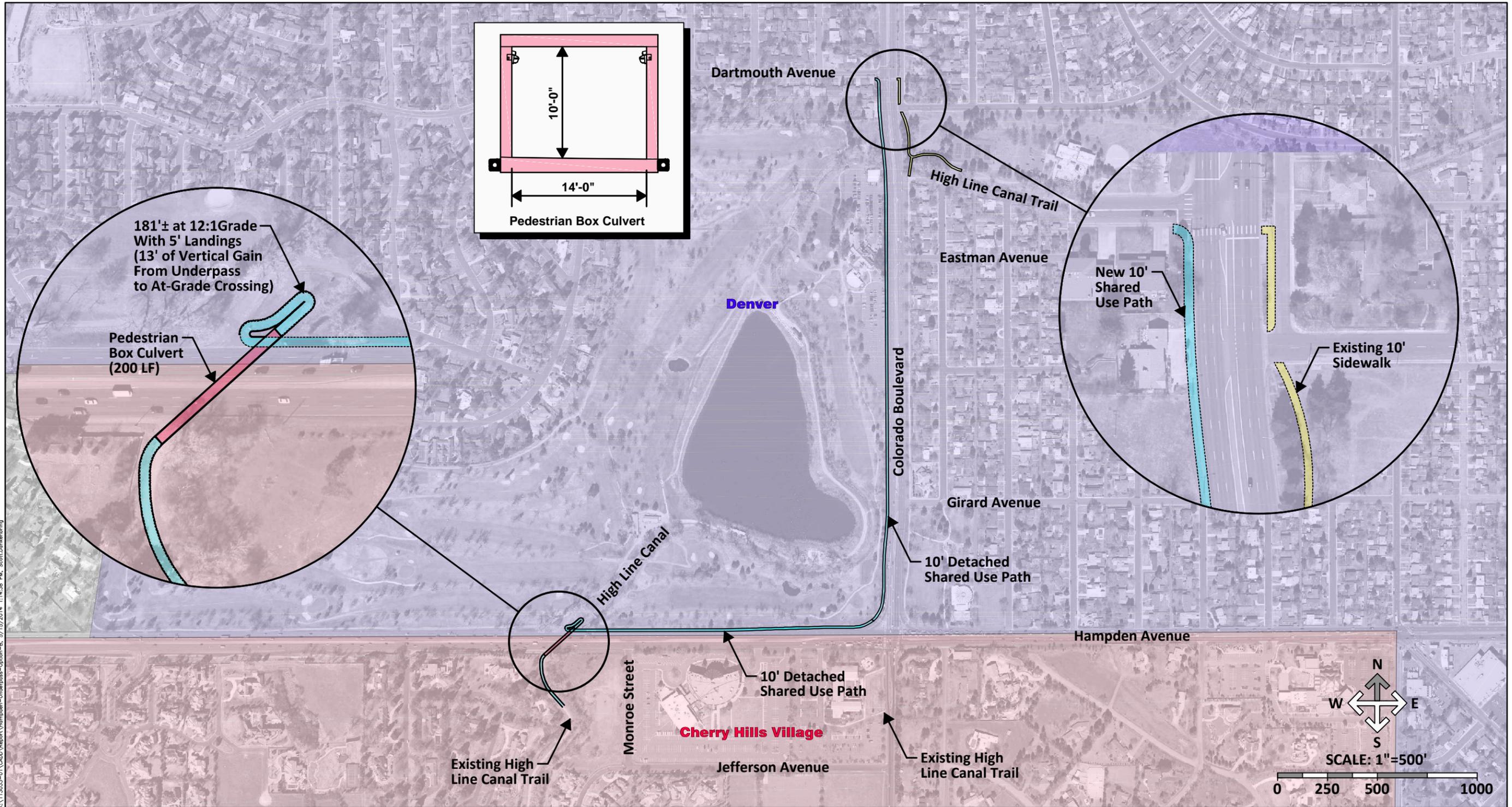
K:\113033-01\CADD\Report\Hampden-At-Grade, 5/15/2014 1:13:36 PM, Scott.Dankenberg

Figure 22. Hampden Avenue at Colorado Boulevard Crossing Underpass Option A



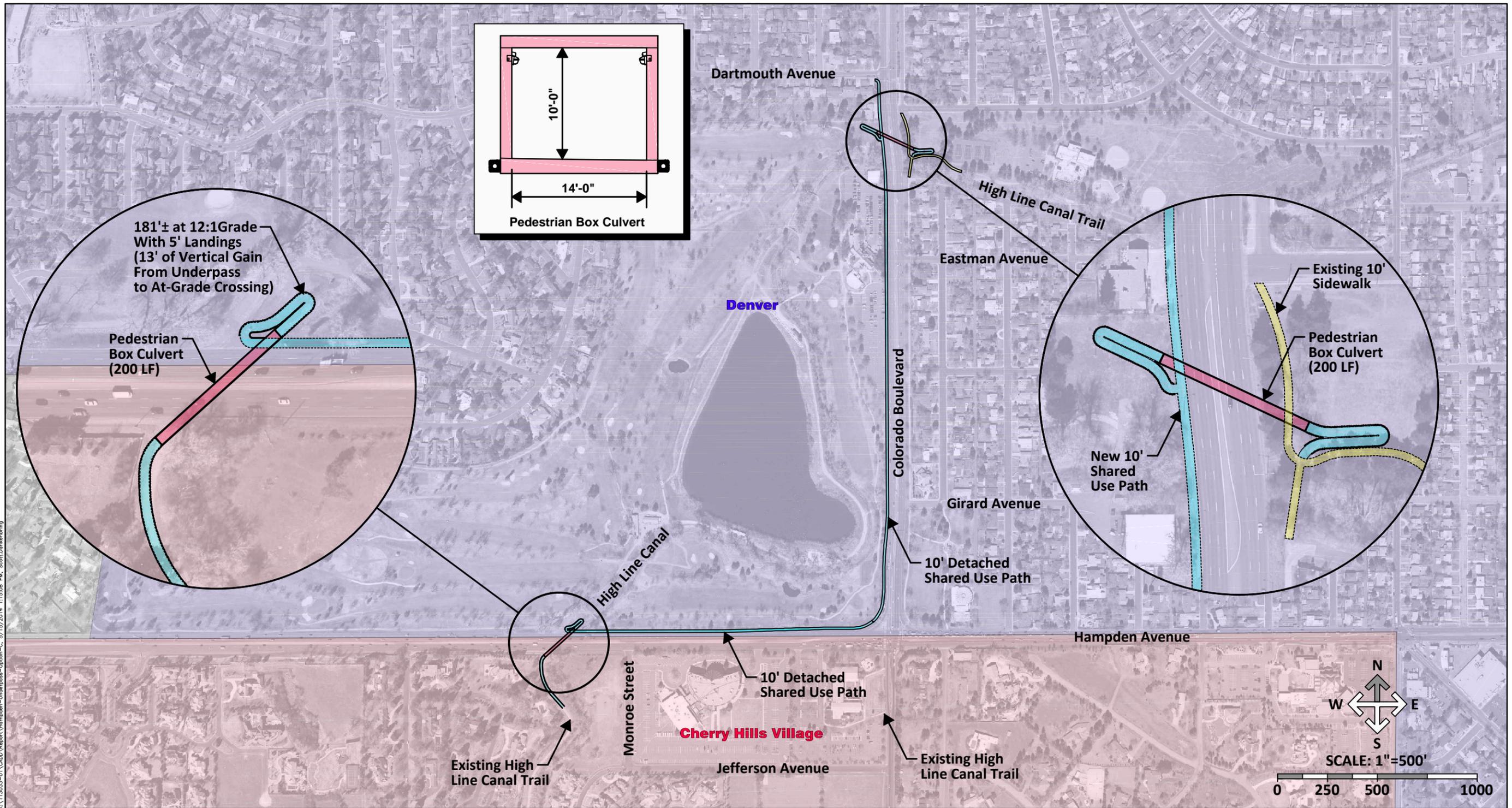
K:\113033-01\CADD\Report\Hampden-Underpass-Option-A, 5/15/2014 1:14:09 PM, Scott.Dankert@fh...

Figure 23. Hampden Avenue at Colorado Boulevard Crossing Underpass Option B



K:\113033-01\CADD\Report\Hampden-Underpass-Option-B_5/15/2014 11:43:38 PM_Scott.Donahoe.dwg

Figure 24. Hampden Avenue at Colorado Boulevard Crossing Underpass Option C



K:\113033-01\CADD\Report\Hampden-Underpass-Option-C_5/15/2014 1:15:08 PM_Scott.Donahoe

Figure 25. Hampden Avenue at Colorado Boulevard Crossing Underpass Option D

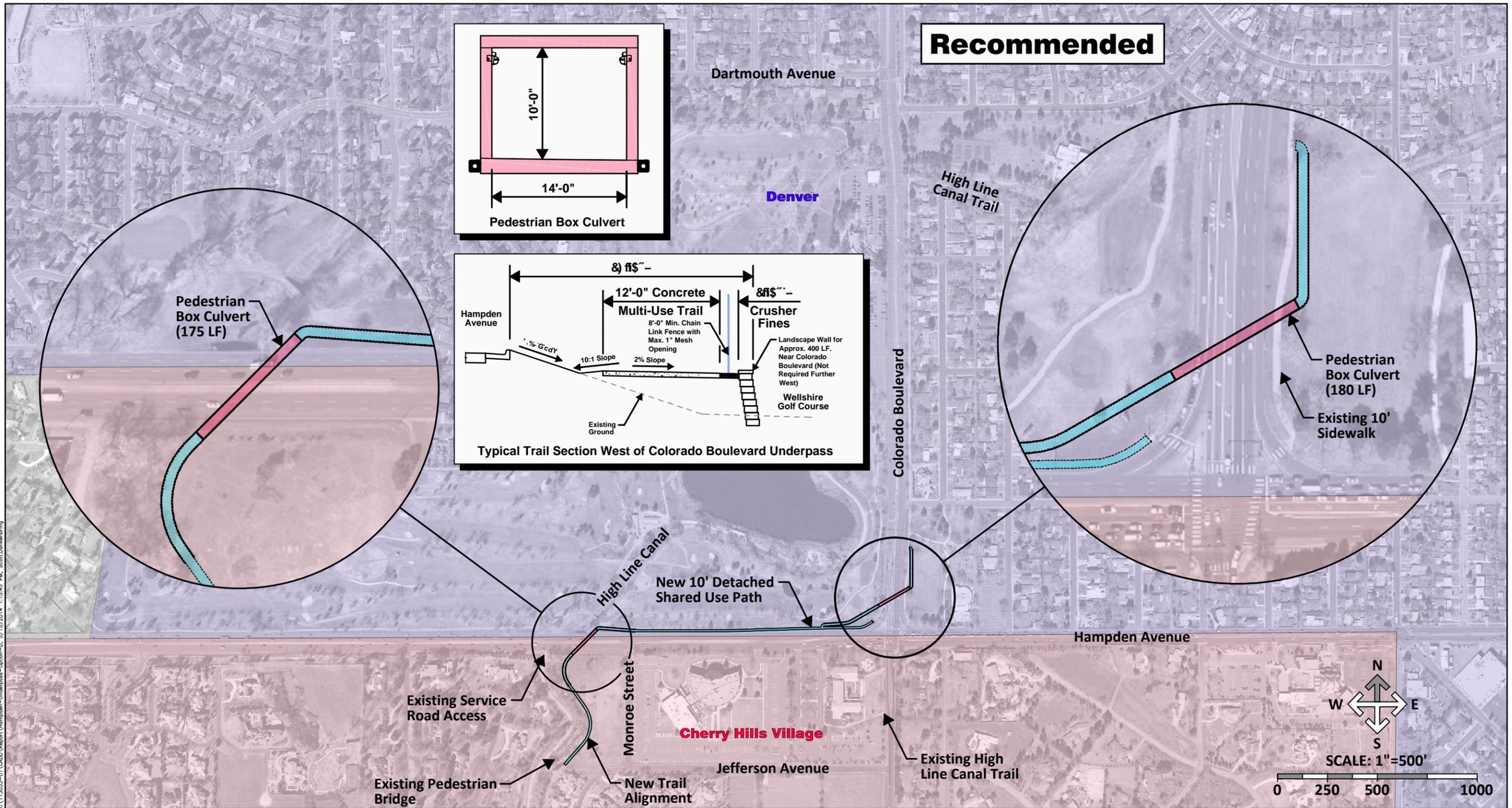


Figure 26. Hampden Avenue at Colorado Boulevard Crossing Pedestrian Bridge

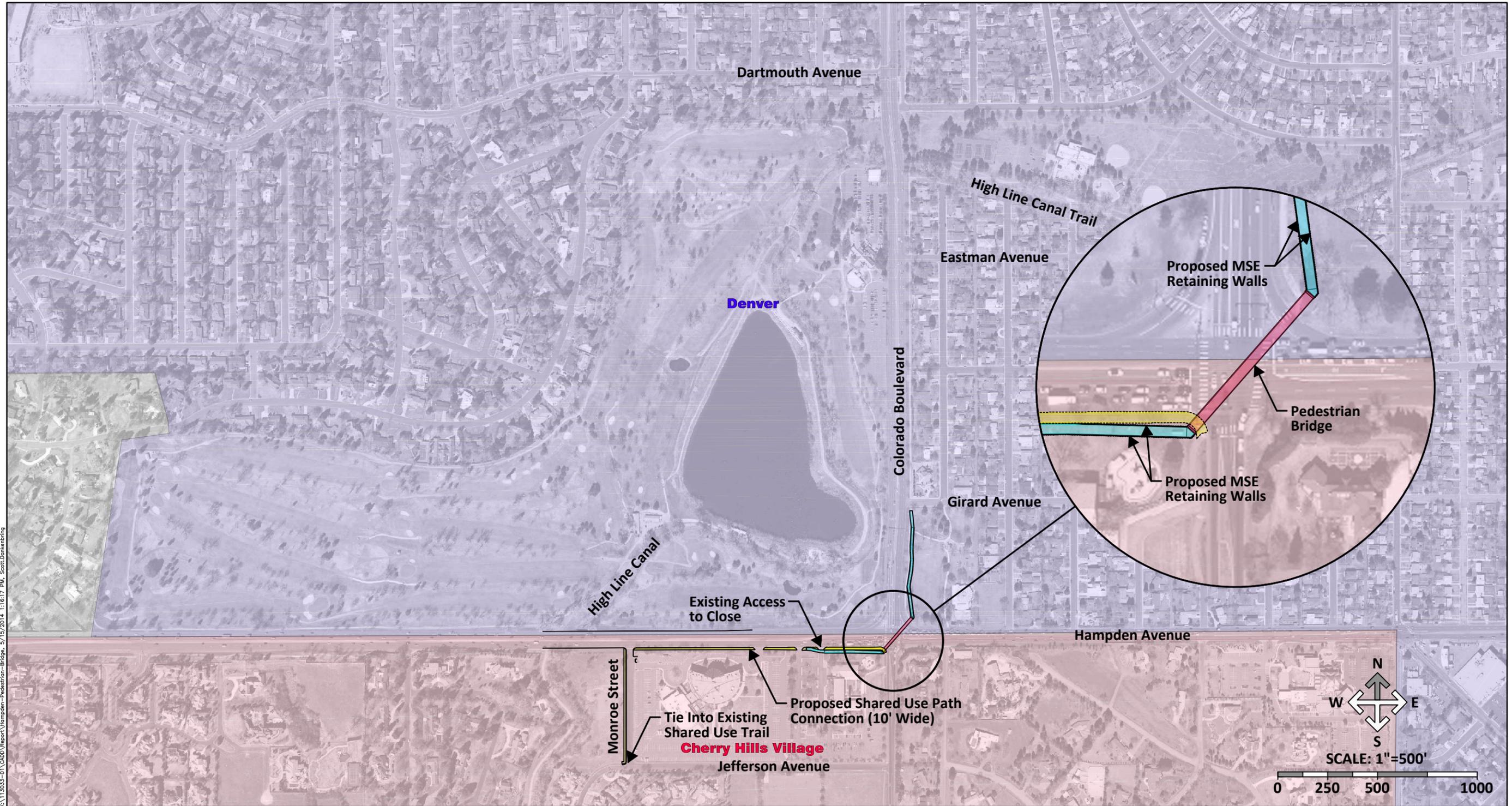
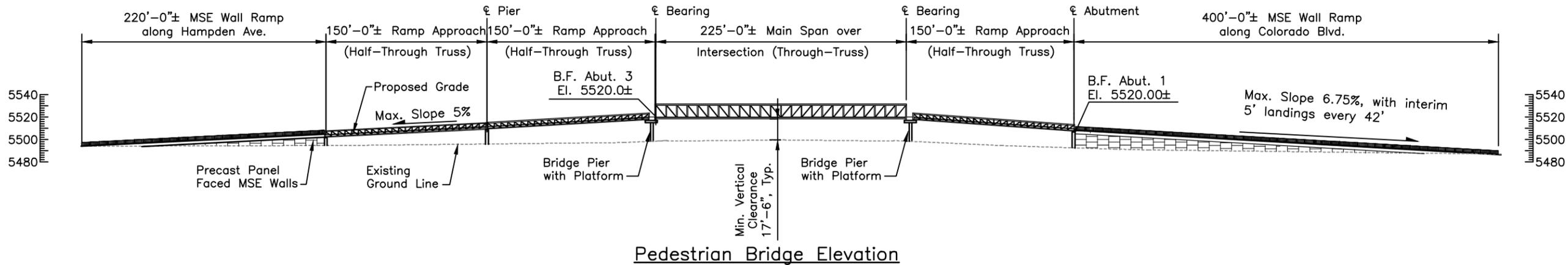
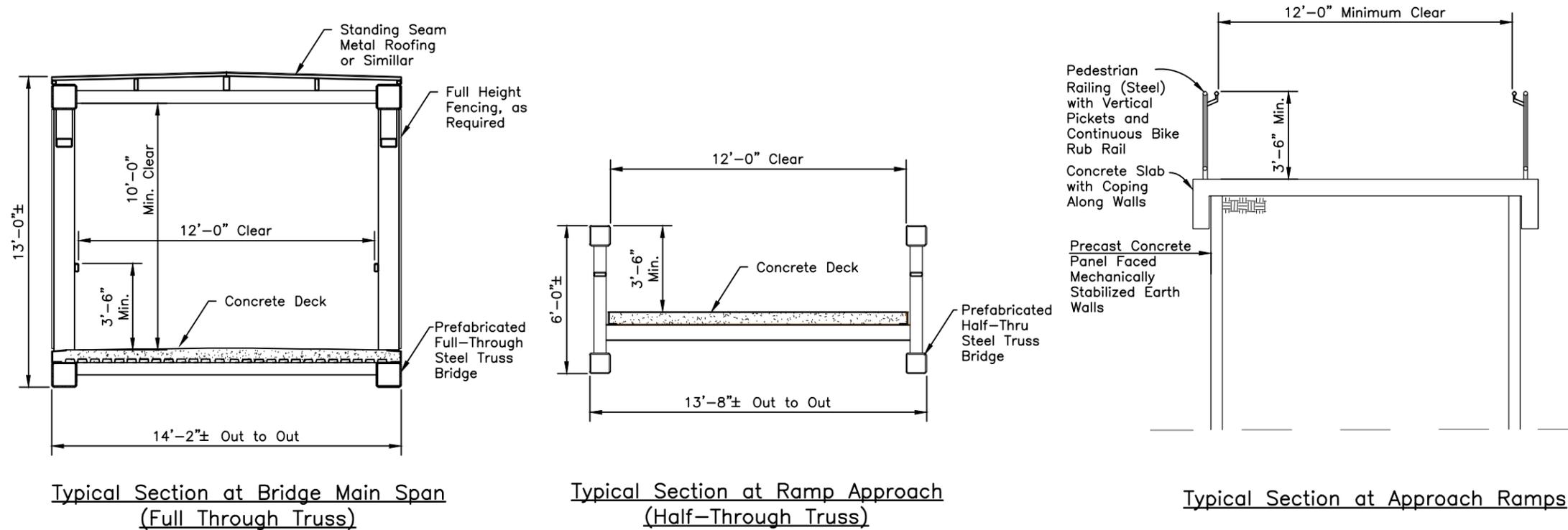


Figure 27. Hampden Avenue at Colorado Boulevard Crossing Pedestrian Bridge



9. ORCHARD ROAD CROSSING WEST OF COLORADO BOULEVARD

Existing Conditions

The High Line Canal Trail crosses Orchard Road west of Colorado Boulevard (crossing location #7 on **Figure 1**). This section of Orchard Road is a two lane road carrying 4,500 vpd and has a posted speed limit of 30 mph. West of the crossing, Orchard Road terminates, turning north as Long Road. This discontinuity results in low traffic volumes. The trail crossing currently includes crosswalk markings, signing, and recently installed pedestrian-activated rectangular rapid flashing beacons (RRFBs). Trailhead parking is located on the north side of Orchard Road and east of the High Line Canal. Orchard Road and the area to the north is within the City of Greenwood Village; the area south of Orchard Road is within the City of Centennial. The land use surrounding this crossing is large lot single family residential.



Traffic and Trail User Counts

This crossing is very heavily used by bicyclists and pedestrians, as shown on **Figure 28**:

- ▶ Approximately 410 trail users cross at this location on a typical summer weekday and approximately 430 cross on a typical summer Saturday.
- ▶ Roughly 60 percent of the trail users are bicyclists and 40 percent are pedestrians.

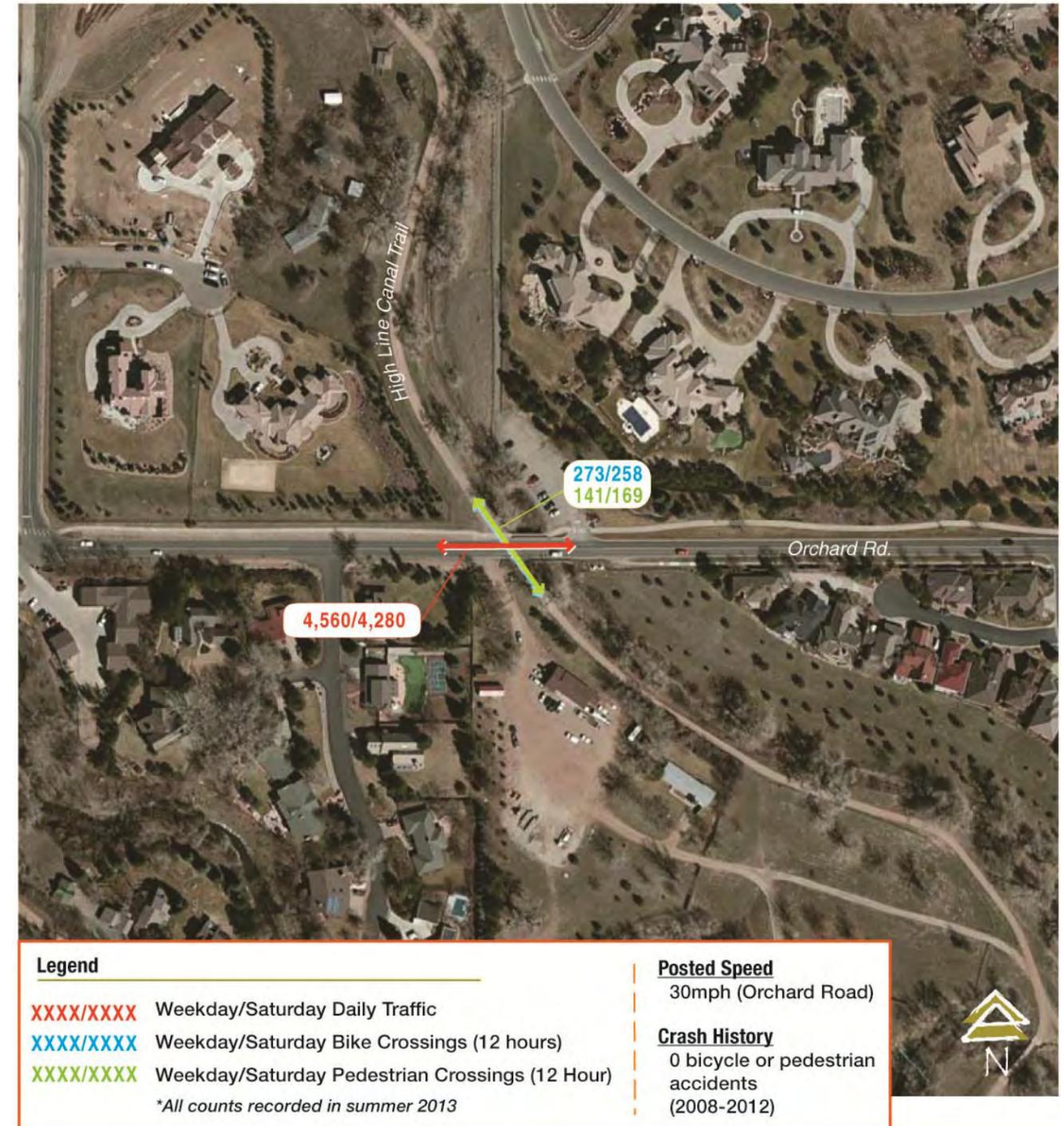
Accident History

No accidents involving a bicyclist or pedestrian occurred at this crossing during the five year period from January 2008 through December 2012.

Opportunities and Constraints

- ▶ The trailhead parking northeast of the trail crossing is heavily used.
- ▶ The sidewalks on the Orchard Road bridge over the High Line Canal are narrow, and there is a missing sidewalk connection east of the bridge on the south side of Orchard.

Figure 28. Orchard Road Crossing West of Colorado Boulevard Trail User and Traffic Inventory



Crossing Alternatives

Two crossing alternatives have been developed and evaluated at the Orchard Road Crossing.

At-Grade Improvements

The first alternative would provide enhancements to the existing at-grade crossing. As shown in the conceptual design (Figure 29), the at-grade improvements include sidewalk widening on the south side of the Orchard Road bridge and a new sidewalk connection to enhance the pedestrian connection to the east of the trail and improvements to the trail entrance to better define the trail entrance. These improvements would complement the existing crosswalk and RRFB signs. The estimated cost for these improvements is \$61,000 (the detailed cost estimate is included in Appendix C).

Underpass

The second alternative considered for the Orchard Road crossing west of Colorado Boulevard is an underpass (Figure 30). The underpass would be a 14-foot wide and 10-foot tall box culvert north of the canal, located immediately west of the existing trail. The underpass shown in the conceptual design is approximately 120 feet long. The Denver Water service road access would be maintained just to the east of the underpass; the two would be separated by a retaining wall. Due to the right-of-way constraints and the topography, a retaining wall would also be required on the west side of the trail for approximately 150 on each approach to the box culvert. The underpass is estimated to cost \$3.75 million.

Other Considerations

Members of the Crossing & Safety Task Group expressed concern about the narrowness of the sidewalk (five feet) on the north side of the Orchard Road bridge, which connects the trailhead parking to the trail. The project team was asked to prepare a cost estimate for a prefabricated pedestrian bridge connection that would provide a direct connection between the trail head parking and the trail (separate from the existing Orchard Road bridge). The pedestrian bridge would be approximately 65 feet long and 12 feet (clear) wide and is estimated to cost \$360,000 for design and construction. An alternative would be to widen the Orchard Road bridge to accommodate a 10 foot sidewalk on the north side, which would cost an estimated \$240,000 for design and construction.

Evaluation of Alternatives

The two crossing alternatives for Orchard Road west of Colorado have been evaluated based on the evaluation criteria described in Chapter 2, and the results are shown on Table 9. The at-grade improvements would be low cost and compatible with the low level of traffic volumes, low travel speed, and short crossing distance. The at-grade improvements would complement the existing crosswalk and recently installed flashing beacons. While the underpass would eliminate the conflict between trail users and motorist, it has a considerably higher cost.

Recommendations and Next Steps

The at-grade sidewalk improvements along the south side of Orchard Road are recommended to enhance the pedestrian connection to the east of the trail and to better define the trail entrance. These improvements would complement the existing crosswalk and flashing beacons, creating a more comfortable at-grade crossing. An underpass is not recommended because of cost and the relatively low traffic volumes and speeds, and short crossing distance. The Crossing & Safety Task Group recommends that the High Line Canal Working Group support

Greenwood Village in implementing these sidewalk improvements. This includes advocating for Arapahoe County Open Space funds to be used as a funding source in combination with local matching funds.

Table 9. Orchard Road Crossing West of Colorado Boulevard Alternatives Evaluation

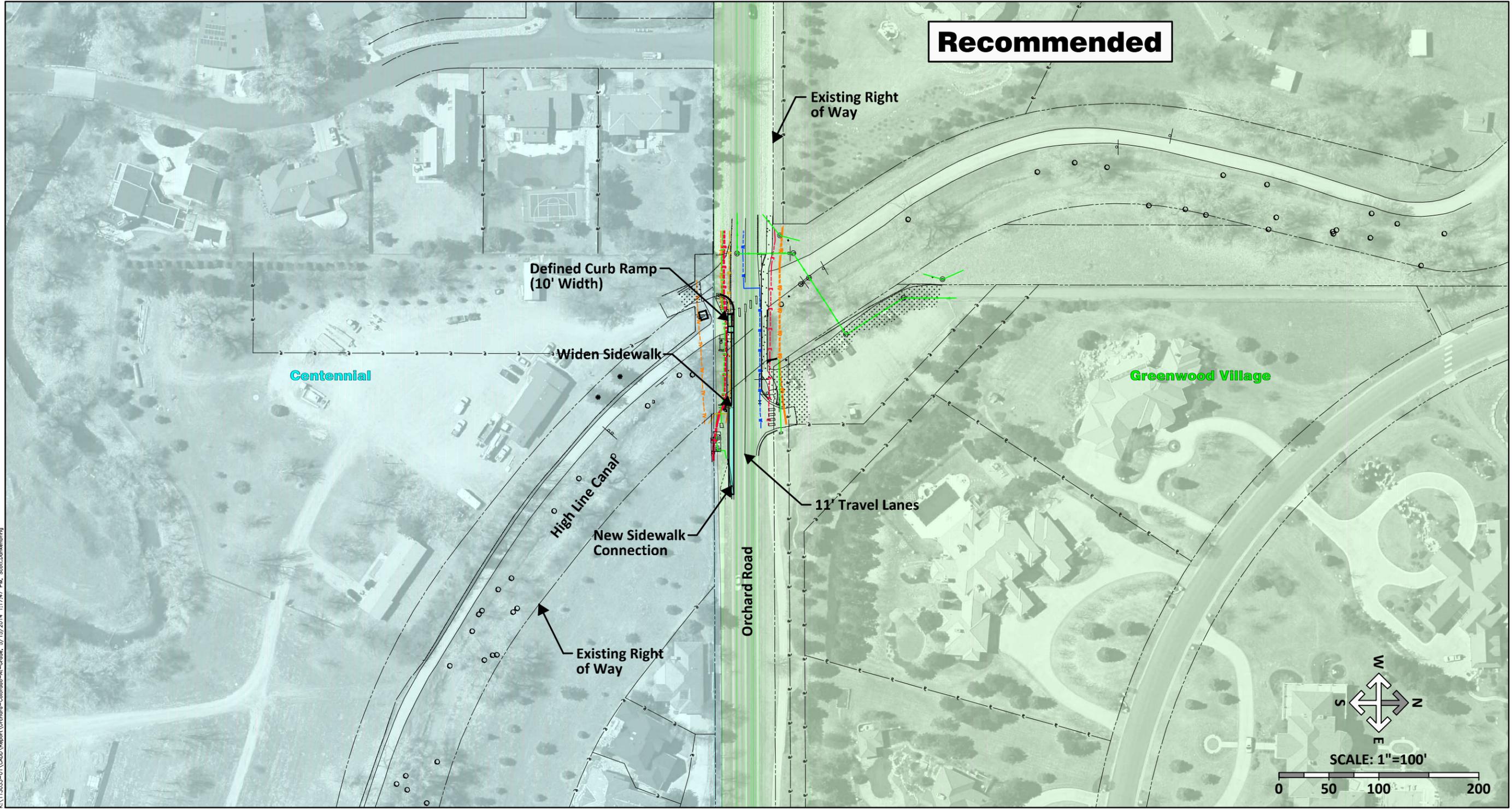
Evaluation Criteria	At-Grade Improvements (Sidewalk widening)	Underpass
Benefits		
Safety Benefits	●	●
Functionality for Trail Users	●	●
Impacts to Motorists	●	●
Aesthetics/Context	●	●
Equestrian Accommodation	●	●
Costs		
Constructability (Utilities, phasing, design standards)	●	●
ROW Impacts	●	●
Maintenance	●	●
Design/Construction Cost	\$61,000	\$3,750,000



Least ----->Most Favorable

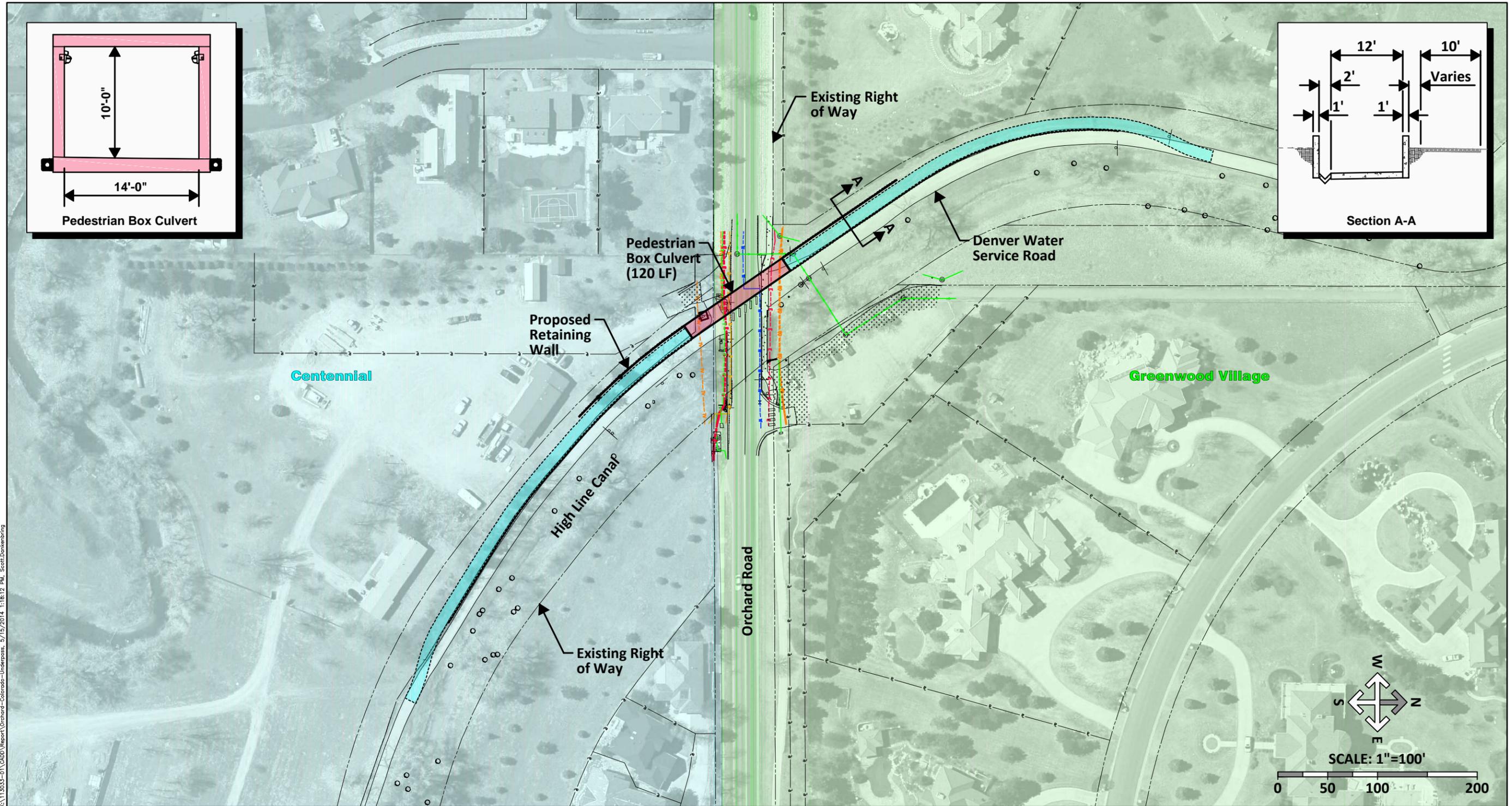
= Recommended

Figure 29. Orchard Road Crossing west of Colorado Boulevard At-Grade Improvements



K:\113033-01\CADD\Report\Orchard-Colorado-At-Grade, 5/15/2014, 1:17:47 PM, Scott.Dankert@fhwa.gov

Figure 30. Orchard Road Crossing west of Colorado Boulevard Underpass



K:\113033-01\CADD\Report\Orchard-Colorado-Underpass_5/15/2014_1:18:12 PM_Scott.Donkemberg

10. ORCHARD ROAD CROSSING WEST OF UNIVERSITY BOULEVARD

Existing Conditions

The High Line Canal trail also crosses Orchard Road west of University Boulevard (crossing location #8 on **Figure 1**). This section of Orchard is a two lane road carrying 7,000 – 9,000 vpd and has a posted speed limit of 35 mph. The trail crossing currently includes crosswalk markings, signing, and recently installed pedestrian-activated rectangular rapid flashing beacons (RRFBs). The boundary between Greenwood Village and Centennial runs approximately along the centerline of Orchard, with Greenwood Village to the north and Centennial to the south. The land use surrounding this crossing is single family residential.



Traffic and Trail User Counts

Trail use along this section of the High Line Canal trail is very high – the bicycle and pedestrian counts (shown on **Figure 31**) are the highest of the nine crossing locations studied in this feasibility study.

- ▶ Approximately 420 trail users cross at this location on a typical summer weekday and over 850 cross on a typical summer Saturday.
- ▶ The split between bicycle and pedestrian activity is roughly equal

Accident History

During the five year period from January 2008 through December 2012, there was one vehicle/pedestrian accident at this location which involved an injury.

Opportunities and Constraints

- ▶ The volume of bicycle and pedestrian activity at this crossing suggests that any improvements made at this crossing would benefit a great number of trail users.
- ▶ This section of Orchard Road is wide (approximately 48 feet) for a two lane road. Greenwood Village has plans to widen Orchard Road to a three-lane section in the future; any improvements need to be compatible with the future cross-section.

Crossing Alternatives

Two crossing alternatives have been developed and evaluated at the Orchard Road Crossing west of University Boulevard.

At-Grade Improvements

Several options were considered by the project team and the Crossing & Safety Task Group to improve the at-grade crossing of Orchard Road west of University. Each of the options were aimed at slowing traffic on Orchard Road, shortening the crossing distance, and making motorists more aware of the crossing. The options included a raised median with pedestrian refuge, a raised speed table, and curb extensions.

Figure 31. Orchard Road Crossing West of University Boulevard Trail User and Traffic Inventory



After considering the various options for at-grade improvements, the Crossing & Safety Task Group identified the curb extensions as the optimal at-grade treatment as this crossing. As shown in the conceptual design (Figure 32), the at-grade improvements include curb extensions to shorten the crossing distance and slow traffic along Orchard Road. Because no left turn lanes are needed in the immediate vicinity of the crossing, this configuration could work as a pinch point in a future three-lane section. Installation of a High-intensity Activated crossWalk (HAWK) beacon is also included in the at-grade improvements. The HAWK, which is also known as a pedestrian hybrid beacon, is a special type of beacon used to warn and control traffic at an unsignalized location to assist pedestrians in crossing a street or highway at a marked crosswalk. The pedestrian hybrid signal is included in the 2009 Edition of the Manual on Uniform Traffic Control Devices (MUTCD). This treatment would be an upgrade to the existing RRFB beacons; the driver yielding compliance is very high at HAWK. The pedestrian push button to activate the HAWK should be placed on the pedestrian’s right side as they approach to crossing to encourage use of the HAWK. Yield lines and signing are also included in this package of improvements. The estimated cost for these improvements is \$310,000 (the detailed cost estimate is included in Appendix C).

Underpass

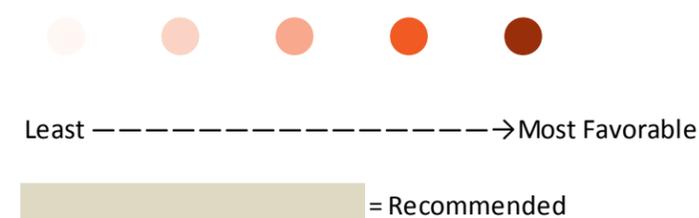
The second alternative considered for the Orchard Road crossing west of University Boulevard is an underpass (Figure 33). The underpass would be a 14-foot wide and 10-foot tall box culvert north of the canal, located immediately west of the existing trail. The underpass shown in the conceptual design is approximately 90 feet long. The Denver Water service road access would be maintained just to the east of the underpass; the two would be separated by a retaining wall. Due to the right-of-way constraints and the topography, a retaining wall would also be required on the west side of the trail for the full length of the ramp on the south side. The long, parallel wall extents would not provide a very attractive or safe-feeling facility. Stairwell accesses would provide a local access to the trail without requiring trail users to go unnecessarily out of direction. The underpass is estimated to cost \$3.43 million.

Evaluation of Alternatives

The two crossing alternatives for Orchard Road west of University have been evaluated based on the evaluation criteria described in Chapter 2, and the results are shown on Table 10. The at-grade improvements would provide some safety improvement and would enhance the level of comfort for trail users. The cost of implementing these improvements would be significantly less than the underpass, and the at-grade improvements are compatible with the level of traffic volumes using Orchard Road. The underpass would eliminate the conflict between trail users and motorists. The right-of-way constraints result in the need for retaining walls on both sides of the trail, creating a tunneling effect that is less functional for trail users and may be visually obtrusive. The cost is high for a relatively short underpass because of the need for long retaining walls.

Table 10. Orchard Road Crossing West of University Boulevard Alternatives Evaluation

Evaluation Criteria	At-Grade Improvements (Curb Extensions and HAWK)	Underpass
Benefits		
Safety Benefits	●	●
Functionality for Trail Users	●	●
Impacts to Motorists	●	●
Aesthetics/Context	●	●
Equestrian Accommodation	●	●
Costs		
Constructability (Utilities, phasing, design standards)	●	●
ROW Impacts	●	●
Maintenance	●	●
Design/Construction Cost	\$310,000	\$3,430,000



Recommendations and Next Steps

At grade improvements to the Orchard Road crossings will improve safety for High Line trail users. It is the recommended alternative rather than an underpass because an underpass would be costly and will not bring significantly higher safety conditions to the crossing. The Crossing & Safety Task Group recommends that the High Line Canal Working Group and support Greenwood Village and Centennial in implementing these sidewalk improvements. This includes advocating for Arapahoe County Open Space funds to be used as a funding source in combination with local matching funds. Centennial and Greenwood Village will each need to have internal discussions to assess the priority of this project relative to other needs, and the two cities will need to coordinate their funding strategy to proceed with design and construction of the improvements. The at-grade improvements could be phased for implementation, with the curb extensions and resetting of the Rapid Rectangular Flashing Beacons (RRFB) first and the HAWK installation at a later date, if deemed appropriate. The RRFB beacons, which were recently installed, could be reset at another pedestrian crossing location in Greenwood Village if/when a HAWK is installed. During the design process, Centennial and Greenwood Village should work with Denver Water to locate the HAWKS to be easily accessible to trail users while maintaining access to the service road. The curb extensions would act as a pinch point for traffic calming when Greenwood Village widens Orchard to a three-lane section in the future; Greenwood Village should coordinate the design for the curb extensions with the future three-lane widening project to ensure compatibility.

Figure 32. Orchard Road Crossing west of University Boulevard At-Grade Improvements

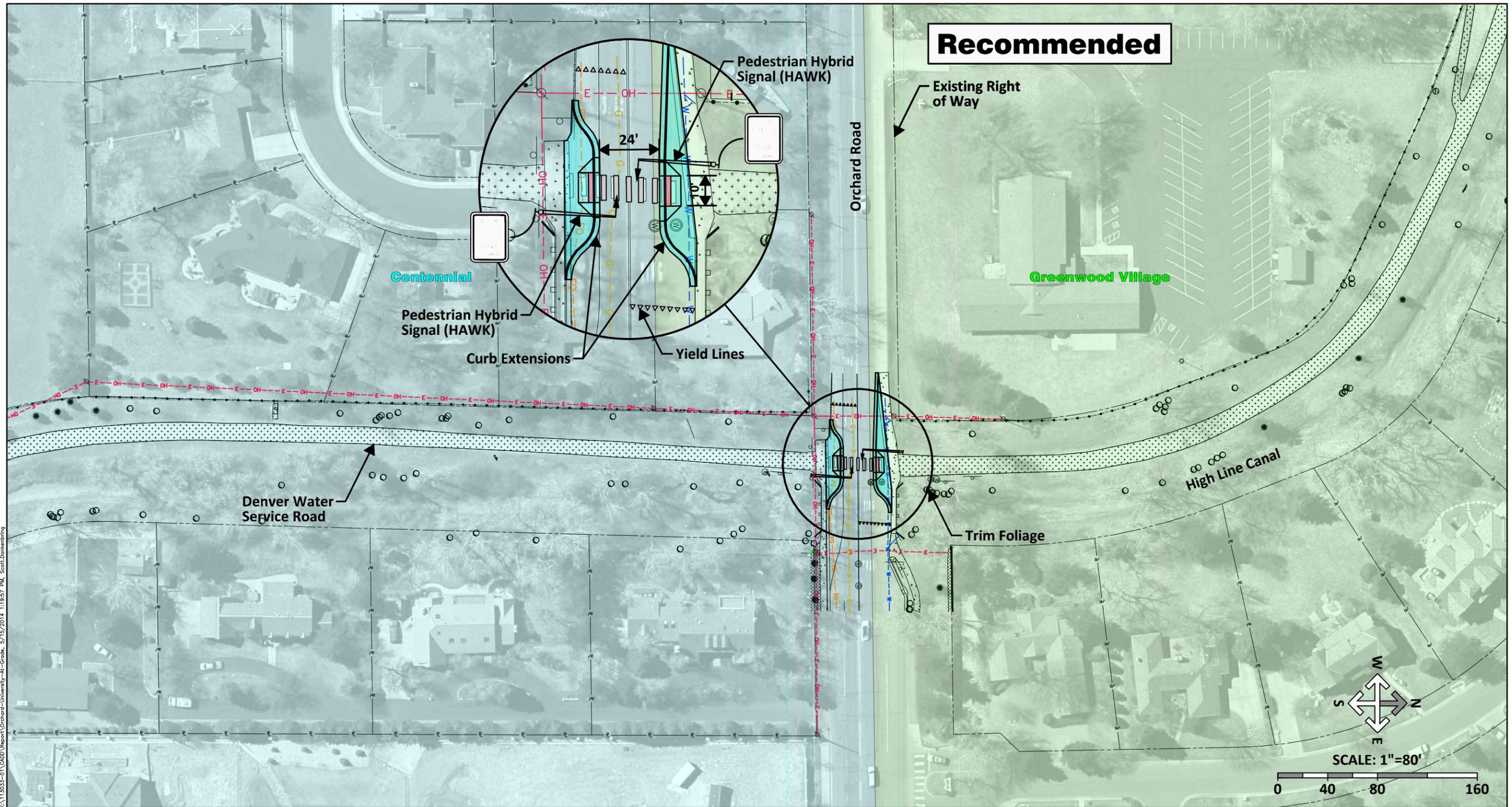
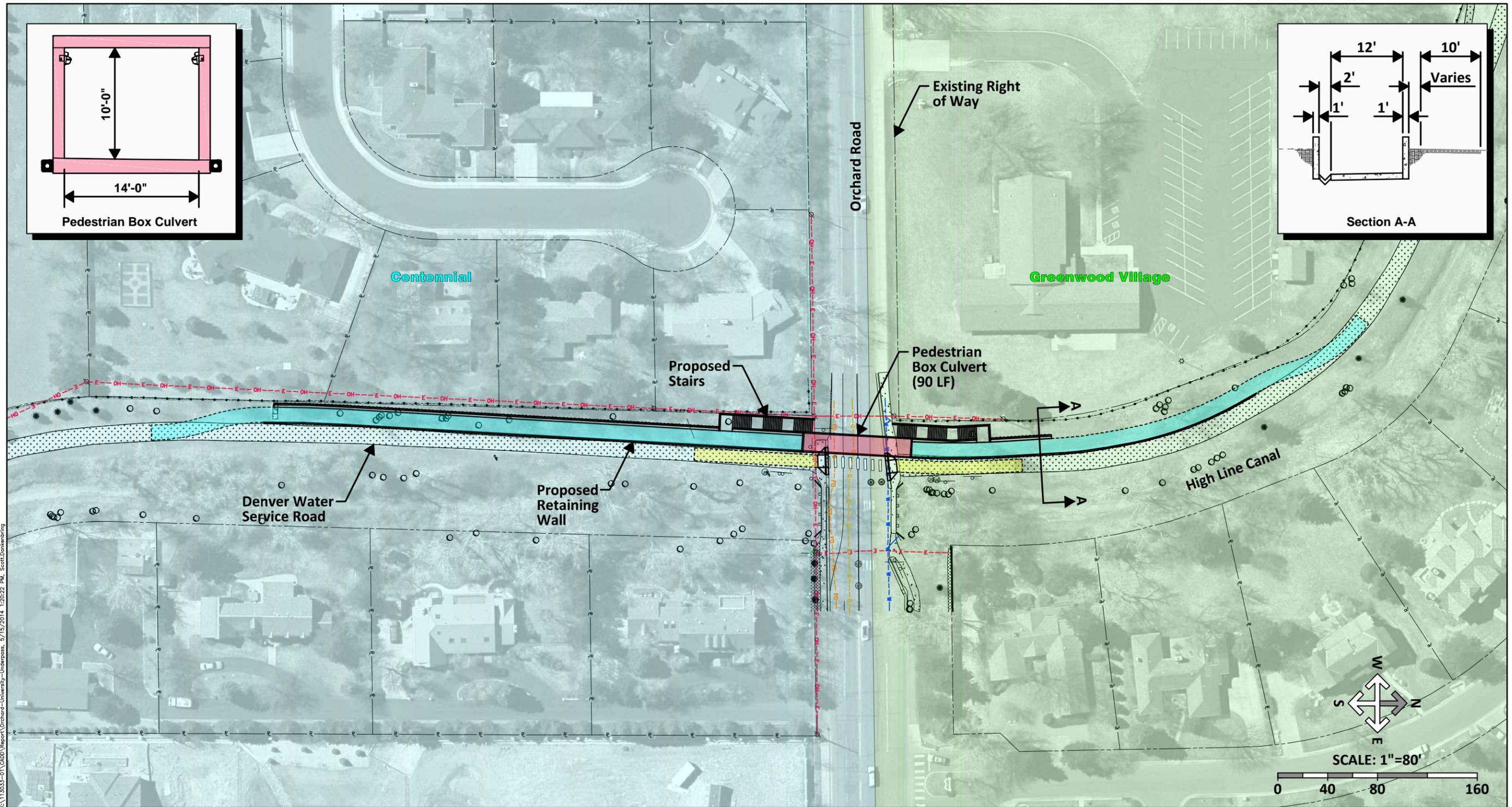


Figure 33. Orchard Road Crossing west of University Boulevard Underpass



K:\113033-01\CADD\Report\Orchard-University-Underpass-5/15/2014 1:20:22 PM Scott.Dankenberg

11. BROADWAY AT ARAPAHOE ROAD CROSSING

Existing Conditions

The High Line Canal trail crosses Broadway at three locations; the crossing at Arapahoe Road is the middle crossing of the three (crossing location #9 on **Figure 1**). Broadway is a four lane road with a painted median, carries approximately 35,000 vpd, and has a posted speed of 40 mph. Trail users are intended to cross at the signalized intersection of Broadway and Arapahoe Road, which is over 200 feet north of the High Line Canal.



Traffic and Trail User Counts

Likely because trail users must cross Broadway three times (all of which are currently at-grade), the trail use at this crossing is low, as shown on **Figure 34**:

- Approximately 30 trail users cross during a typical summer weekday and 70 cross during a typical summer Saturday.
- Roughly 60 percent more bicyclists than pedestrians cross at this location.
- On weekdays, when traffic volumes are higher, approximately 75 percent of trail users cross at the Arapahoe intersection; on Saturday, the majority of trail users (nearly 70 percent) cross at the canal alignment.

Accident History

During the 4 ½ year time period from January 2009 through June 2013, no bicycle or pedestrian accidents were recorded at this crossing location, or at the intersection of Broadway and Arapahoe Road.

Opportunities and Constraints

- ▶ Anecdotally, trail users bypass the High Line Canal trail loop east of Broadway between Ridge Road and Arapahoe Road to avoid crossing Broadway multiple times.
- ▶ Urban Drainage is planning to construct a box culvert for drainage purposes south of the subject crossing (just north of Sterne Parkway); there may be an opportunity to add a pedestrian box culvert at this location.

Figure 34. Broadway at Arapahoe Road Crossing Trail User and Traffic Inventory



Crossing Alternatives

Three crossing alternatives have been developed and evaluated at the Broadway Crossing.

At-Grade Improvements

The first alternative would provide enhancements to the existing crossing at the Broadway/Arapahoe Road intersection. As shown on **Figure 35**, the at-grade improvements would involve widening the sidewalks to 10 feet on both sides of Broadway to provide a better connection to the Arapahoe Road intersection. This could be done by widening the sidewalk into the street and narrowing the travel lanes to 11 feet. At-grade improvements would also include signing to direct trail users to the intersection and an advance pedestrian phase to facilitate pedestrian movements across the intersection. The intersection currently operates at level of service (LOS) C during the AM and Saturday peak hours and LOS D during the PM peak hour. An advance pedestrian phase (8 seconds) would allow pedestrians to get a head start in crossing the street and would allow them to be positioned where they could clearly be seen by right turning vehicles. While an advance phase would take away a small amount of time from motorized traffic, the intersection would still operate well (LOS C or D during the peak hours). An exclusive pedestrian phase of 25 seconds was also considered and would allow pedestrians to cross the entire intersection before the motorists would have a green indication. However, with an exclusive pedestrian phase, the intersection would operate with long delays (LOS F) during the peak hours. Therefore, the at-grade improvements shown on **Figure 34** include an advance pedestrian phase, which would be triggered only when a pedestrian activates the push button. The estimated cost for these improvements is \$300,000 (the detailed cost estimate is included in **Appendix C**).

Underpass

The second alternative considered for the Broadway crossing is an underpass (**Figure 36**). The underpass would be a 14-foot wide and 10-foot tall box culvert north of the canal, located south of the existing trail. The Denver Water service road access would be maintained between the underpass and the canal. The box culvert shown in the conceptual design is approximately 120 feet long. On the approaches to the box culvert, retaining wall would be needed between the trail and the service road. The underpass is estimated to cost \$3.7 million.

Pedestrian Bridge

A pedestrian bridge over Broadway was also considered, as shown on **Figure 37**. Following the alignment of the canal, the clear span of the bridge would be approximately 130 feet. The ramps approaching the bridge would be ADA compliant with a five percent grade, as detailed on the profile in **Figure 38**. Design and construction of a pedestrian bridge over Broadway is estimated to cost \$4.0 million.

Other Considerations

A subset of the High Line Canal Crossing & Safety Task Group met on October 3, 2013 to discuss the High Line Canal Trail crossing of Broadway south of Arapahoe Road. The subset included representatives from the City of Littleton, the City of Centennial, Arapahoe County, and South Suburban Parks and Recreation Department. After discussing the initial crossing improvement alternatives, the group asked the project team to evaluate the feasibility of a HAWK at the High Line Canal Trail alignment interconnected with the Broadway/Arapahoe Road signal. The project team completed an evaluation of an interconnected High-intensity Activated crossWalk (HAWK) beacon, and the findings are documented in **Appendix E**. After reviewing the evaluation and considering this option, the relevant subset of the Crossing & Safety Task Group opted to dismiss an interconnected HAWK as a viable option for this crossing.

Evaluation of Alternatives

The three crossing alternatives for Broadway at Arapahoe Road have been evaluated based on the evaluation criteria described in Chapter 2, and the results are shown on **Table 11**. The at-grade improvements would provide marginal safety and trail user functionality benefits. The at-grade improvements would be relatively low cost and, in conjunction with Littleton's plans to widen the sidewalk along Broadway to the south, would provide a cost-effective solution for trail users to bypass the multiple crossings of Broadway. Both the underpass and the pedestrian bridge would eliminate the conflict between trail users and motorists. However, either of these options would be a high cost solution with uncertain benefits – the trail use at the crossing is currently very low and it is unclear if a grade separation would induce more trail use given the context of the area with two additional at-grade crossings of Broadway in close proximity.

Table 11. Broadway at Arapahoe Road Crossing Alternatives Evaluation

Evaluation Criteria	At-Grade Improvements to Broadway/Arapahoe Intersection & Sidewalk Widening	Underpass	Pedestrian Bridge
Benefits			
Safety Benefits	●	●	●
Functionality for Trail Users	●	●	●
Impacts to Motorists	●	●	●
Aesthetics/Context	●	●	●
Equestrian Accommodation	NA	NA	NA
Costs			
Constructability (Utilities, phasing, design standards)	●	●	●
ROW Impacts	●	●	●
Maintenance	●	●	●
Design/Construction Cost	\$300,000	\$3,720,000	\$4,020,000



Least ----->Most Favorable

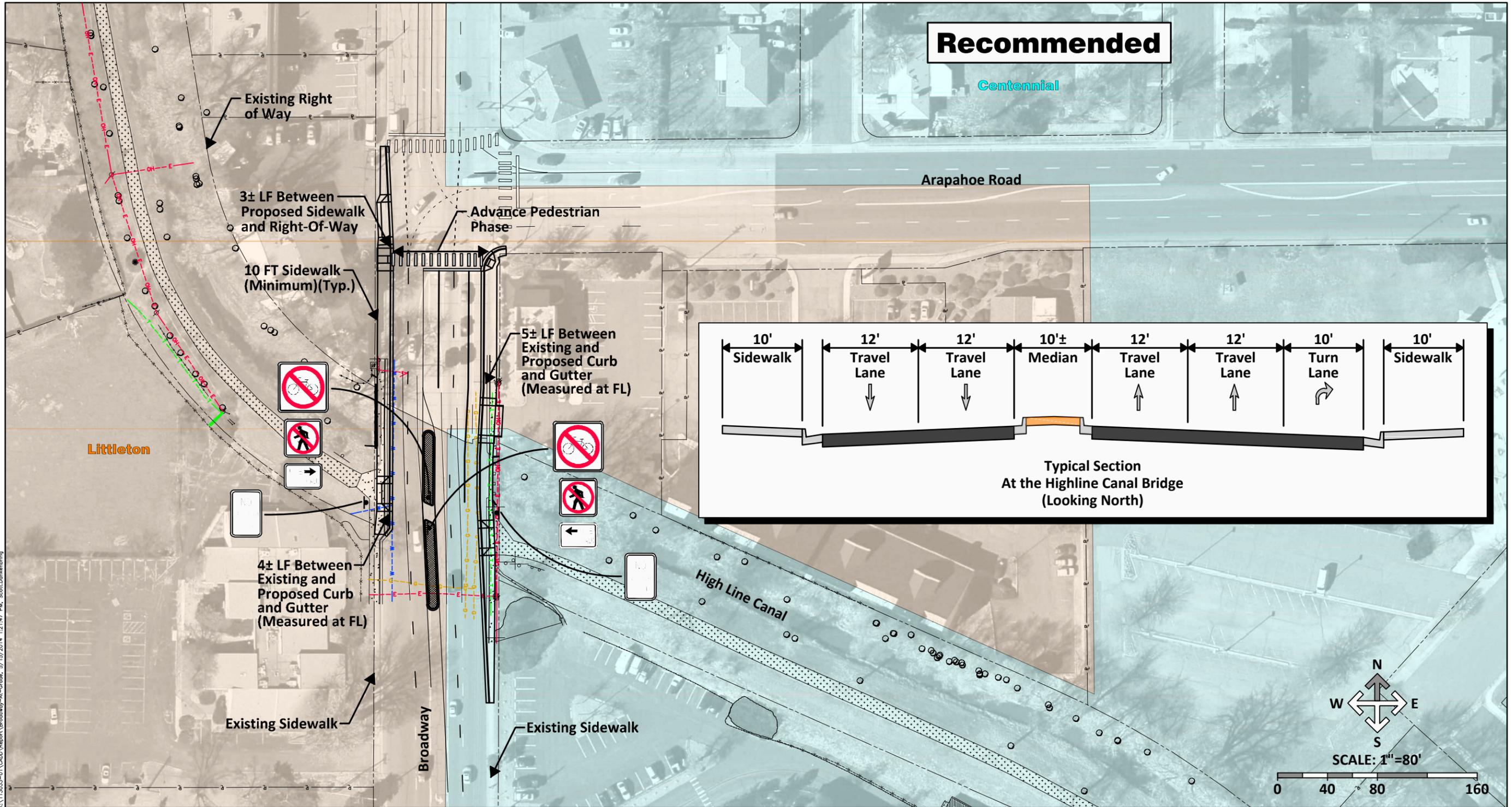
= Recommended

Recommendations and Next Steps

While an underpass crossing or pedestrian bridge are both feasible at this location, either one would require significant capital investment with uncertain benefits given the low trail use in the area. Therefore, at-grade improvements are recommended as an interim improvement to benefit the safety of the Broadway/Arapahoe crossing and the Broadway corridor as a whole. The Crossing & Safety Task Group recommends that Littleton and Centennial coordinate their efforts to widen sidewalks along both sides of Broadway from Ridge Road to Caley Avenue. This would not only improve connectivity to the Arapahoe Road intersection, but it would also improve connectivity to the Ridge Road intersection to the south and the Caley Avenue intersection to the north. The sidewalk improvements will provide trail users the opportunity to avoid crossing Broadway three times, instead allowing them to travel along Broadway and cross only once. These improvements would not preclude grade separated crossings in the future. The improvements can be implemented as phased city projects or can occur with redevelopment.

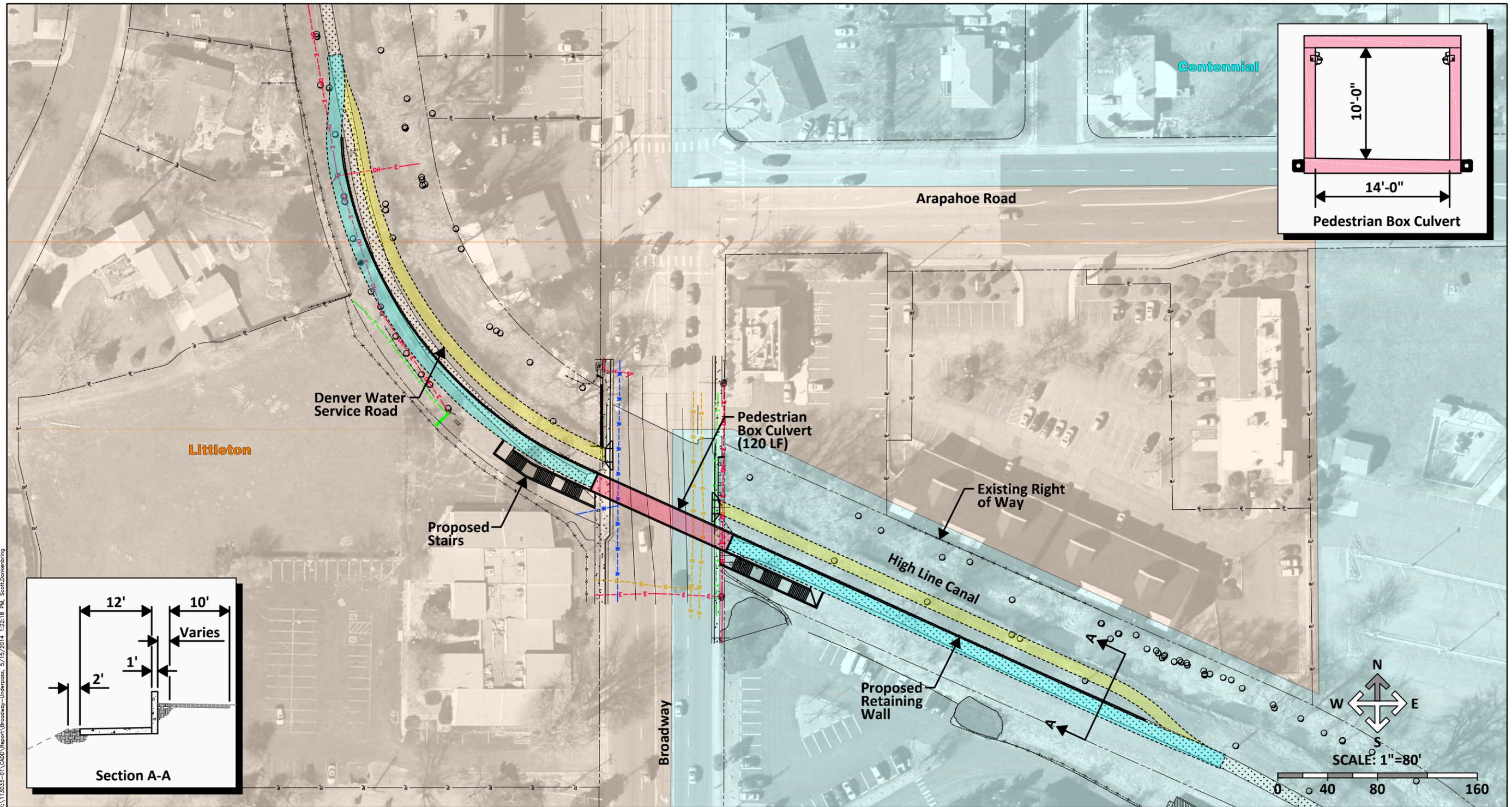
To the degree improvements can be supported by open space funds, the Task Group recommends that the High Line Canal Working Group support the use of Arapahoe County Open Space funds in combination with local matching funds to improve safety for High Line trail users. Additionally, the Task Group recommends that the trail use patterns of the Broadway corridor (as opposed to just the Arapahoe Road intersection) should be studied further. This should include studying the use of the corridor for recreational purposes versus local trips. Finally, further consideration should be given to a grade separated crossing near Sterne Parkway in conjunction with storm water improvements being considered by Urban Drainage.

Figure 35. Broadway at Arapahoe Road Crossing At-Grade Improvements



K:\113033-01\CADD\Report\Broadway-At-Grade_5/15/2014_1:21:47 PM_Scott.Dunkenshiring

Figure 36. Broadway at Arapahoe Road Crossing Underpass



K:\113033-01\CADD\Report\Broadway-Underpass_5/15/2014_1:22:18 PM_Scott.Dankenberg

Figure 37. Broadway at Arapahoe Road Crossing Pedestrian Bridge

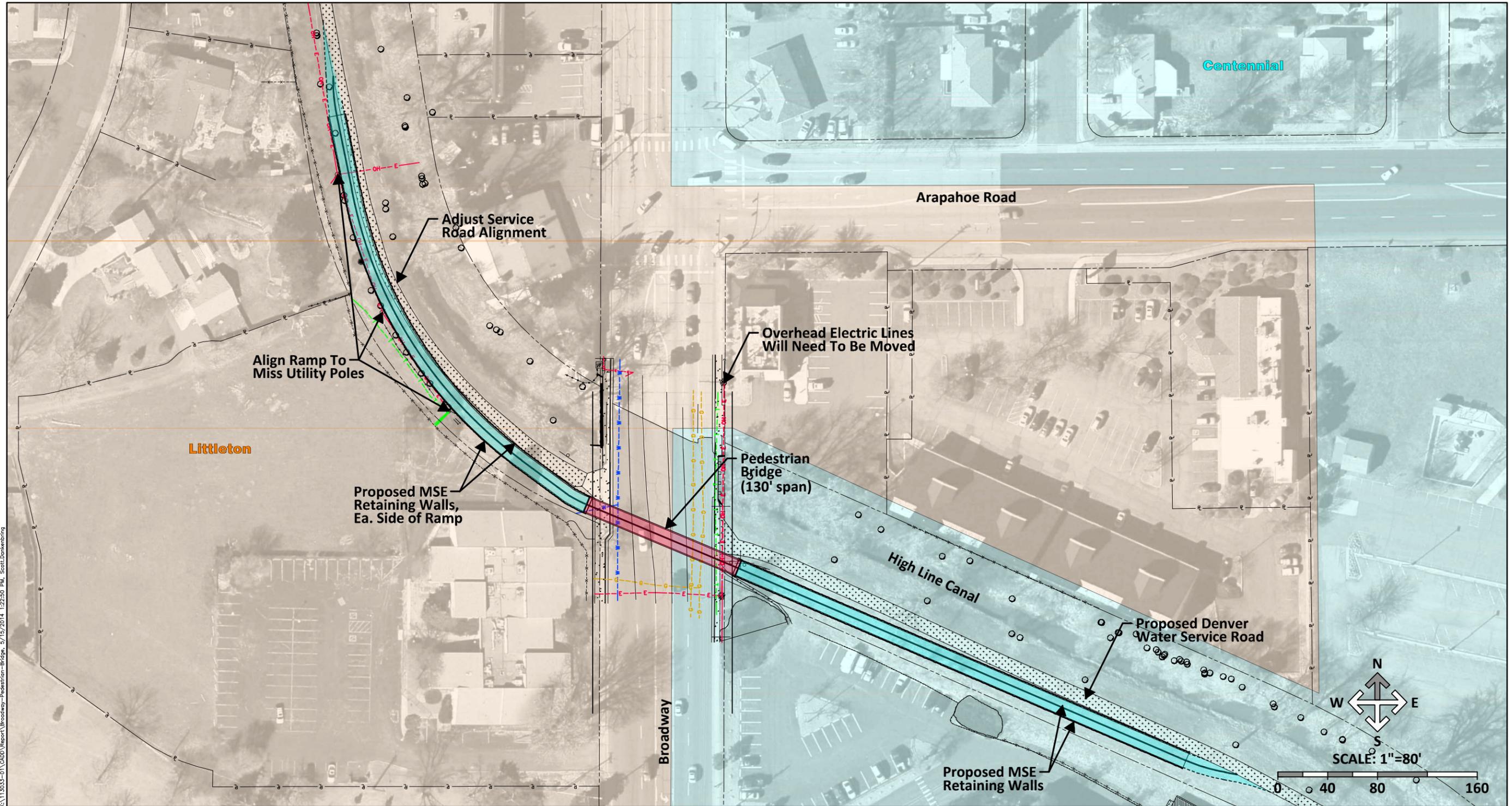
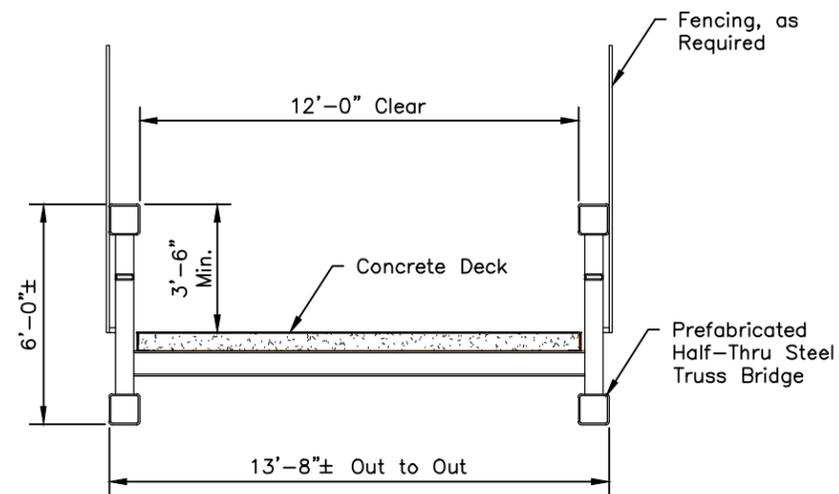
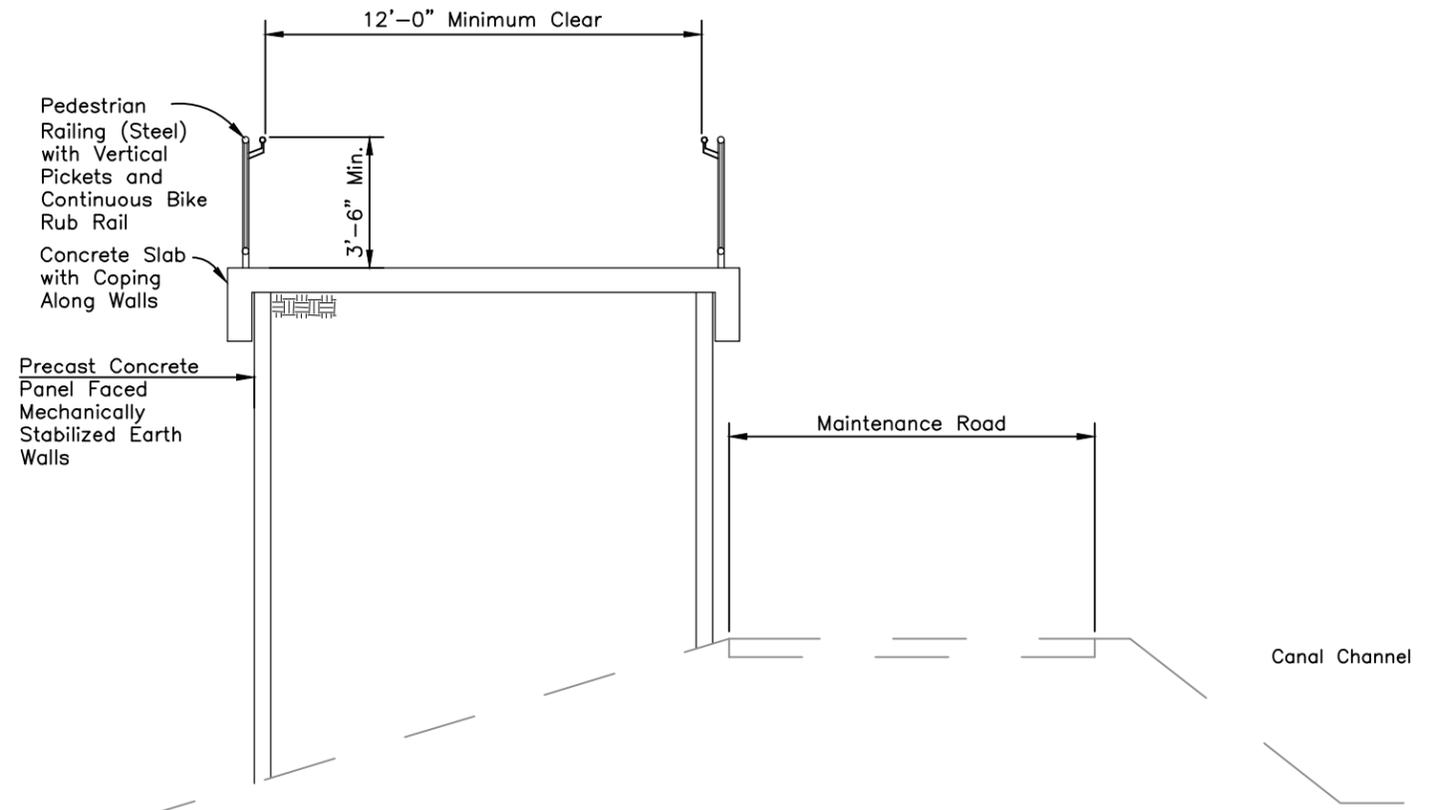


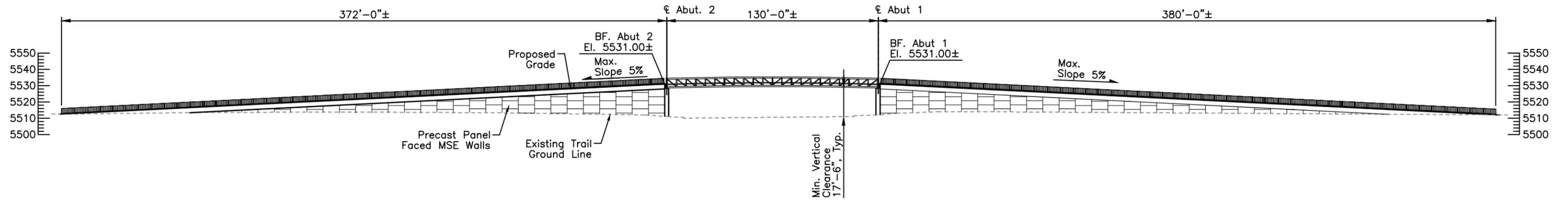
Figure 38. Broadway at Arapahoe Road Crossing Pedestrian Bridge Profile



Typical Section at Bridge



Typical Section at Approach Ramps (Facing West)



Pedestrian Bridge Elevation



6300 South Syracuse Way, Suite 600
Centennial, CO 80111 | 303-721-1440
www.fhueng.com