C I T Y O F B O U L D E R
WATER RESOURCES ADVISORY BOARD
AGENDA ITEM

MEETING DATE: June 20, 2016

AGENDA TITLE: Information Item - Update on the Bear Canyon Creek Flood Mitigation Plan

PRESENTERS:
Jeff Arthur, Director of Public Works for Utilities
Annie Noble, Acting Principal Engineer for Flood and Greenways
Ward Bauscher, Engineering Project Manager
Christin Shepherd, Flood and Greenways Engineer

EXECUTIVE SUMMARY:

The purpose of this memorandum is to provide an update on the progress and current status of the Bear Canyon Creek Flood Mitigation Plan. Over time, flood improvements have been made at various locations along this drainageway, but the September 2013 flood highlighted areas of hydraulic limitation that prompted the public to request additional flood mitigation. Bear Canyon Creek was analyzed with several modeling techniques and mitigation opportunities were identified.

Staff has established several recommended improvements and is seeking input and feedback before completing a benefit cost analysis and finalizing the recommended alternative to be presented to the Water Resources Advisory Board (WRAB) in October of 2016. Pending acceptance of the mitigation plan and the plan's recommended alternative in October, staff will submit the final mitigation plan for acceptance by City Council. The study area for this mitigation plan is shown in **Attachment A**.

BOARD AND PUBLIC FEEDBACK

Information items providing status updates of the Bear Canyon Creek Mitigation Plan were submitted to WRAB in April and November of 2015. There have been three open houses for the Bear Canyon Creek Mitigation Plan held on July 1, April 27, and August 20 of 2015. An additional open house will be held prior to the WRAB meeting on June 20, 2016. Notification postcards were mailed to property owners in the study area, emails were sent to parents of children attending elementary schools in the study area, and a project web site has been developed to provide information (https://bouldercolorado.gov/flood/bear-canyon-creek-flood-mitigation-project).

Forty-eight comments have been received via the website comment tool to date. Generally, the public supported potential mitigation alternatives and sought their implementation. Other general themes that appeared are listed and addressed below:

General Theme	Response
Remove steel culvert at Ithaca Drive	Included in recommended alternative
Do not decrease traffic lanes on Table Mesa Drive	The recommended alternative increases capacity at the Lehigh Street and Harvard Lane culverts without altering the number of traffic lanes on Table Mesa Drive. This approach reduces flows in the roadway and would not increase vehicular congestion to and from Bear Creek Elementary School.
Increase capacity at Saint Andrew Church driveway	Included in recommended alternative
Do not remove habitat, vegetation and trees	Increased channel capacity can sometimes require removal of vegetation and trees, but it is also essential to the success of the recommended alternative. Every effort will be made to protect the natural habitat during design and construction of the recommended alternative.
Remove trees and vegetation	
Deepen the channel	
Provide a concrete lined channel	Concrete lined channels technically stabilize against erosion, but would not work to create natural streams and well-vegetated floodplains that are physically and biologically healthy. Concrete lined channels remove vegetation and habitat, increase flow velocity and can create negative impacts to property and habitat downstream.

BACKGROUND

Since initial development, Bear Canyon Creek has undergone numerous improvements and continues to benefit from good maintenance within the improved reaches. The flooding of September 2013 brought to light some key issues which contributed to property damage and safety concerns. In general, problems stemmed from areas of hydraulic limitation where the creek experiences limited conveyance capabilities, debris blockage or lack of effective flow return zones. These points of hydraulic limitation are illustrated in **Attachment B** and are the main focus of this mitigation plan's alternative analysis.

After the 2013 flood, the community expressed a strong desire for flood mitigation improvements along Bear Canyon Creek. AMEC Foster Wheeler (AMEC) was selected as the engineering consultant team to help develop flood mitigation alternatives and the

mitigation plan. In order to fully analyze flows and potential improvements in the area of Bear Canyon Creek, a complete model of the entire drainageway was needed.

During a major storm event, Bear Canyon Creek overtops at several major crossings, most notably Broadway and Baseline Road. Spills from these areas become hydraulically disconnected from the main channel, flow overland through streets and neighborhoods and then rejoin the floodplain downstream. It was determined that the city's current two-dimensional model (FLO-2D) approach would be used to define these major flow paths and spill flows. Traditionally, regulatory models are developed in HEC-RAS, which is a one dimensional model that analyzes flow only in the longitudinal direction and represents the terrain in a sequence of cross sections. In two dimensional models, such as FLO-2D, flows are allowed to move in both the longitudinal and lateral directions. FLO-2D utilizes the latest technology to measure and incorporate real-world topography that makes it ideal for identifying flow paths that split away from the main channel.

In general, the FLO-2D model confirmed regulatory model flood extents while identifying spill flows similar to what was observed during the September 2013 storm event. The FLO-2D model also confirmed the areas to focus efforts for the mitigation plan. Development of the HEC-RAS and FLO-2D models is outlined in **Attachment C.**

ANALYSIS

Typically, flood mitigation plans are developed with the intent to adequately convey a 100-year storm event, consistent with the policies of the Boulder Valley Comprehensive Plan, the Comprehensive Flood and Stormwater Utility Master Plan and the Urban Drainage and Flood Control District (UDFCD) Drainage Criteria Manual. However, 100-year capacities for culverts and channels are not always economically feasible. Staff and AMEC analyzed alternatives based on a bookend approach, evaluating the least costly mitigation (maintenance) and the most costly (a capital improvement alternative selectively increasing culvert capacity at major intersections to accommodate the 100-year storm).

The maintenance alternative analyzed sediment and debris removal within all culverts, invasive species removal at various locations along the channel and improving culvert inlet/outlet conditions by grading and clearing. It did not include any structural modifications to the channel or increases in culvert capacity. The maintenance alternative would not convey the 100-year storm throughout the channel and key hydraulic limitation points and spill areas would remain.

Within the study reaches, a capital improvement alternative, which increased culvert and channel capacity to pass the 100-year storm event, was created and analyzed. It was discovered that the Baseline Road and Gilpin Drive culverts were the primary hydraulic limitation points for Bear Canyon Creek north of US 36. Improvements at these two culverts and surrounding channel area need to be combined with improvements in Reach 3A (between US 36 and Baseline Road) in order to provide a 100-year flood mitigation benefit.

The recommended alternative is a combination of the maintenance and capital improvement alternatives and includes sediment and debris removal, channel grading and increasing culvert capacity as described in the following table:

Study Reach	Improvement Location	Recommendation
Reach 1	Wildwood Road	Remove sediment in culvert, including gravel bars and vegetation blocking inlet and outlet
	Wildwood Road	Grade channel and widen floodplain downstream of culvert
	Ithaca Drive	Remove steel culvert and grade channel in conjunction with stormwater improvement project at Ithaca Drive
Reach 2A	Lehigh Street	Increase culvert size to 7.5ft x 28ft concrete box
	Lehigh Street	Increase channel capacity upstream and downstream of culvert
	Table Mesa Drive	Remove sediment in culverts at Ithaca Drive, Yale Road and Gillaspie Drive, including gravel bars and vegetation blocking inlet and outlet
	Stanford Avenue	Continue good maintenance
	Stanford Avenue	Increase channel capacity from Stanford Avenue to Harvard Lane
	Harvard Lane	Increase culvert size to (2) 7.5ft x 10ft concrete boxes
Reach 2B	Broadway	Increase culvert size to 8.6ft x 23ft concrete box
	Broadway	Sediment and debris removal from Broadway to Martin Drive
	Martin Drive	Continue good maintenance
Reach 3A	Moorhead Avenue	Continue good maintenance
	US 36	Reconfigure pedestrian separator wall in underpass and grade multi-use path and channel downstream to improve the inlet and outlet condition
	University of Colorado	Increase channel capacity in conjunction with CU Master Plan
	Saint Andrew Church	Replace culverts with 24ft wide driveway bridge
Reach 3B	Baseline Road	Increase culvert size to 7.5ft x 28ft concrete box
	Baseline Road	Increase channel capacity from Baseline Road to Gilpin Drive
	Gilpin Drive	Increase capacity and improve outlet condition

A map outlining the Recommended Alternative can be found in **Attachment D.**

NEXT STEPS:

Staff and AMEC will continue to prepare a draft mitigation plan. Next steps include:

- Gather input from the public and the WRAB about the recommended alternative.
- Create a benefit cost analysis (BCA) for all alternatives.
- Refine and prepare the mitigation plan.
- Present the mitigation plan to the WRAB for consideration in October, 2016.

- If recommended by WRAB, the mitigation plan will be presented to City Council for acceptance.
- Once accepted by City Council, recommended alternatives in the Bear Canyon Creek Mitigation Plan will be programmed as capital improvements for construction as funding is available.

ATTACHMENTS

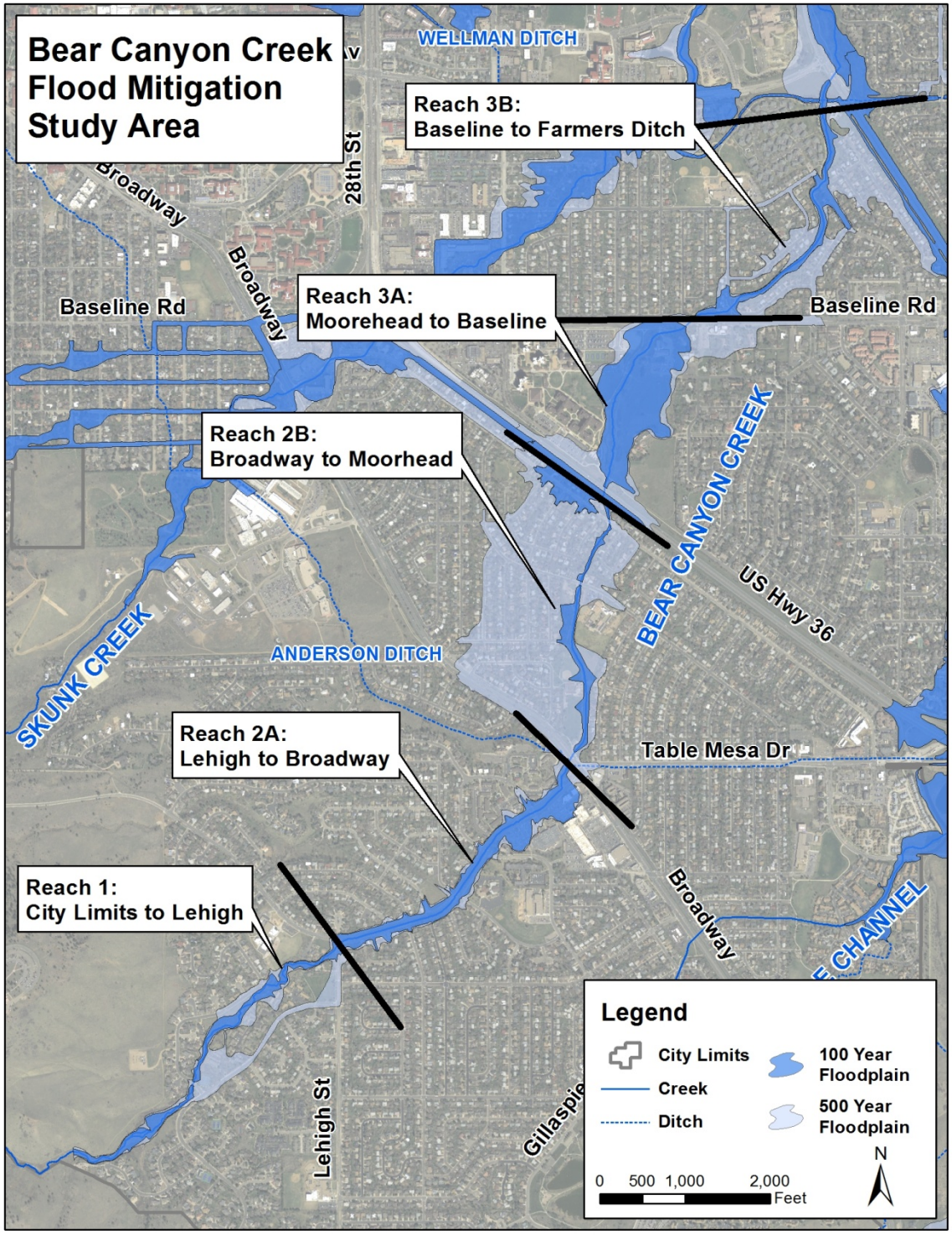
Attachment A: Study Area

Attachment B: Locations of Hydraulic Limitation

Attachment C: Development of Models

Attachment D: Recommended Alternative Figure

ATTACHMENT A: Study Area



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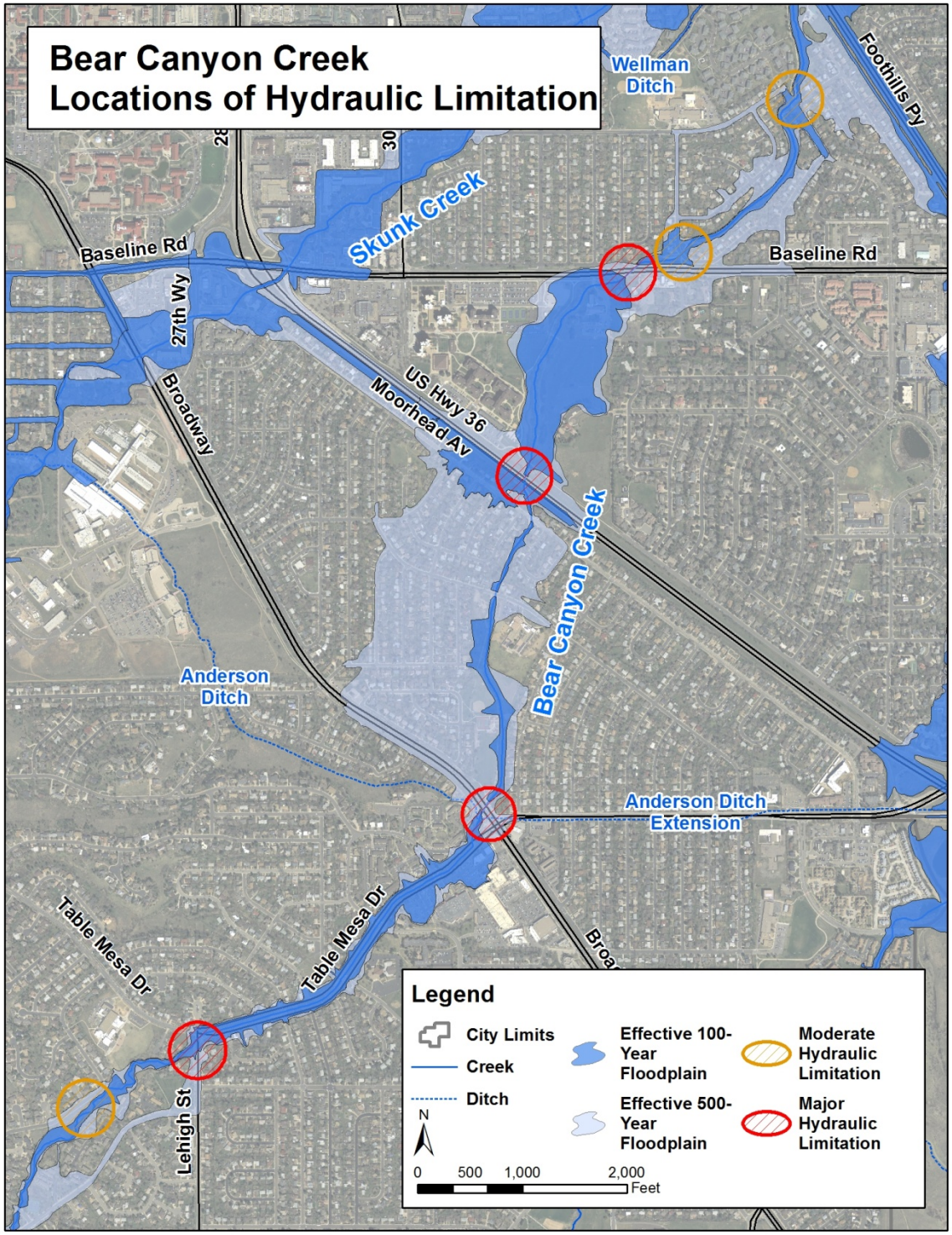


ATTACHMENT C: Development of Models

In April of 1985, a Flood Insurance Study (FIS) was conducted that produced detailed hydrologic and hydraulic information for the City of Boulder and its vicinity. In May of 1987, Greenhorne & O'Mara, Inc. developed a final Hydrologic Analysis Report that developed and delineated flood hazard areas for Bear Canyon Creek. These reports did not result in a complete hydraulic model for the entire stretch of Bear Canyon Creek (from City Limits to its confluence with Boulder Creek). Smaller hydraulic models had been developed for segments of Bear Canyon Creek, but did not seamlessly connect as one cohesive model. In order to fully analyze flows and potential improvements in the area of Bear Canyon Creek, a hydraulic model of the entire drainageway was needed.

The city and the Urban Drainage and Flood Control District (UDFCD) transferred all available modeling data to AMEC who developed a "Best Available Information" existing conditions model. UDFCD has informed the city that, when no complete model exists, a Best Available Information model is acceptable to use for planning and mitigation purposes.

While refining the Best Available Information model and comparing it to actual inundation areas from 2013, AMEC and city staff noted the need for further refinement in areas where spill flows occur. During a major storm event, overtopping of Bear Canyon Creek is present at several major crossings along this creek, most notably Broadway and Baseline Road. Spills from these areas become hydraulically disconnected from the main channel, flow overland through streets and neighborhoods and then rejoin the floodplain downstream. It was determined that the city's current two-dimensional model (FLO-2D) approach to define major flow paths and spill flows should be used. FLO-2D utilizes the latest technology to measure and incorporate real-world topography that makes it ideal for identifying flow paths that split away from the main channel.

Flood mitigation master plans rely on sound hydrologic analysis and hydraulic modeling to identify and evaluate flood mitigation measures. The Greenhorne & O'Mara analysis applied hydrographs at design points along the drainageway itself, but the first iteration of FLO-2D output did not reflect spill flow paths observed during the September 2013 flood. Adjustments were made to two hydrological design points:

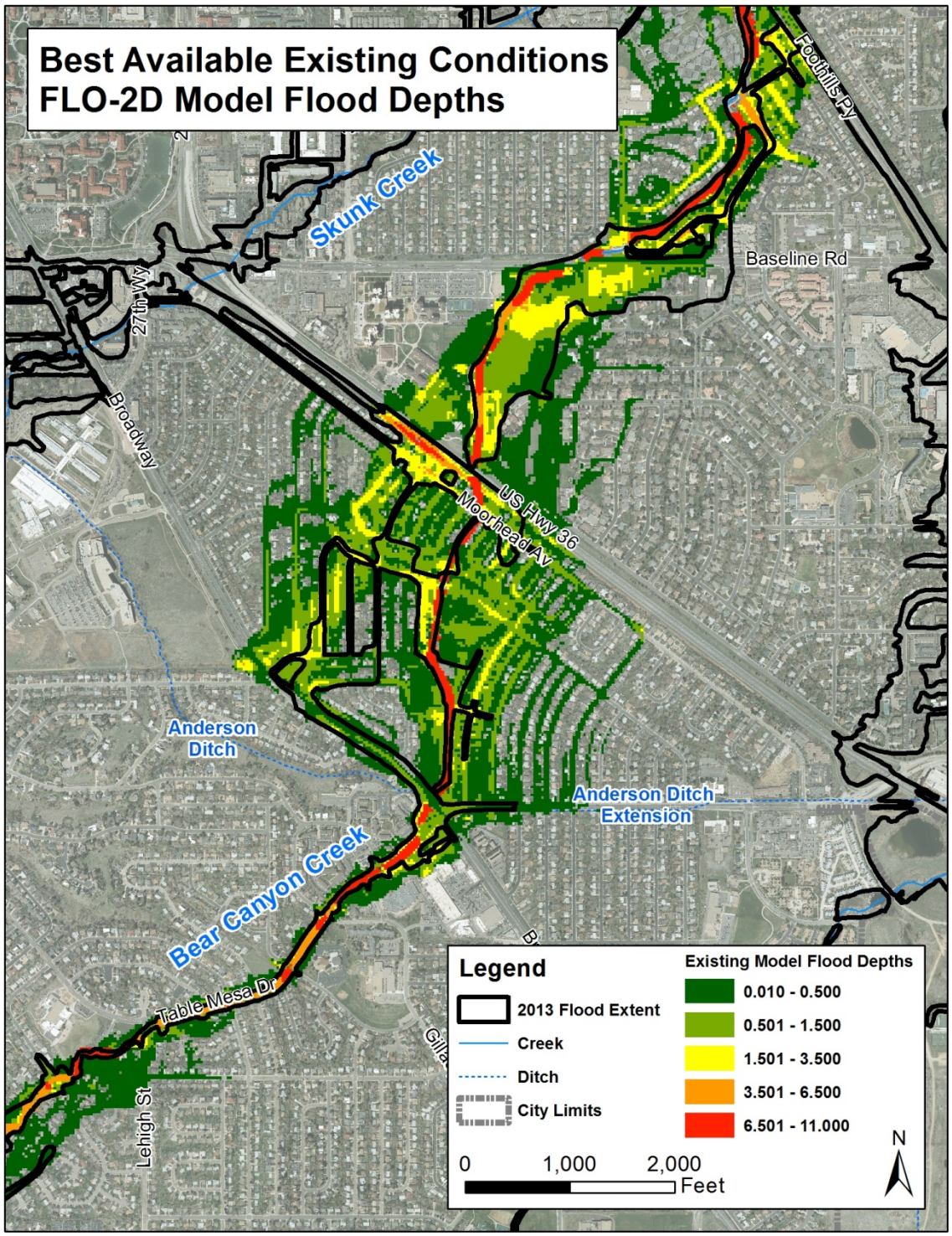
- **Design Point 402**: peak discharge for this design point (1,600cfs) was originally applied at the upstream limit of the Flood Insurance Study (FIS), which yielded highly conservative flows upstream of Lehigh. In the Best Available Information model, Design Point 402 was applied at Table Mesa Drive and Yale Road, assigning the corrected flow of 1,063cfs at the upstream limit.

- **Design Point 405:** peak discharge for this design point (540cfs) is applied near Moorhead Avenue along Bear Canyon Creek and represents of a 240-acre sub-basin near Baseline and Dartmouth. In the Best Available Information model, Design Point 405 was applied at the outlet of its sub-basin.

Staff also questioned whether flows from Skunk Creek, located north and west from Bear Canyon Creek, had any effect on Bear Canyon Creek flows. The effective 100-year flood

mapping for these two drainageways shows a branch of Skunk Creek that extends into Bear Canyon Creek along US 36 and Moorhead Avenue. The topography in this area, however, creates a high point between the two creeks, indicating that this connection arm is not caused by overflow of either drainageway. The flooding experienced in this area is most likely due to surface runoff from Design Point 405 (mentioned above), located near Dartmouth Avenue and indicated on the figure below. In addition, Bear Canyon Creek and Skunk Creek experience peak runoff events that occur approximately one hour apart.

In general, the FLO-2D model confirmed regulatory model flood extents while identifying spill flows similar to what was observed during the September 2013 storm event. The FLO-2D model also confirmed the areas to focus efforts for the mitigation plan.


Best Available Existing Conditions
FLO-2D Model Flood Depths
Skunk Creek
Baseline Rd
Foothills Py
27th Wy
Broadway
US Hwy 36
Moorhead Av
Anderson Ditch
Anderson Ditch Extension
Bear Canyon Creek
Table Mesa Dr
Lehigh St
Legend
2013 Flood Extent
Creek
Ditch
City Limits
Existing Model Flood Depths
0.010 - 0.500
0.501 - 1.500
1.501 - 3.500
3.501 - 6.500
6.501 - 11.000
0
1,000
2,000
Feet
N

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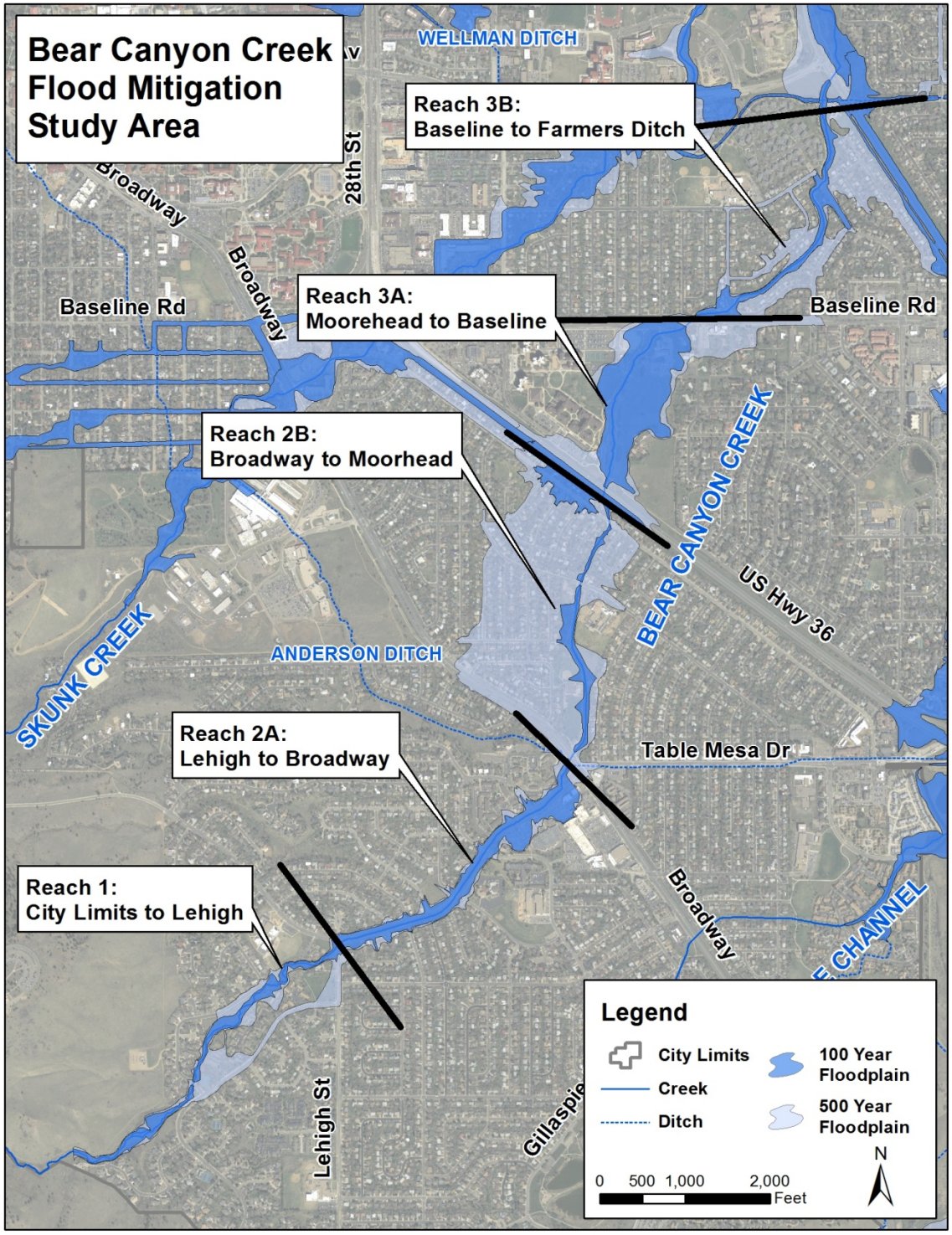

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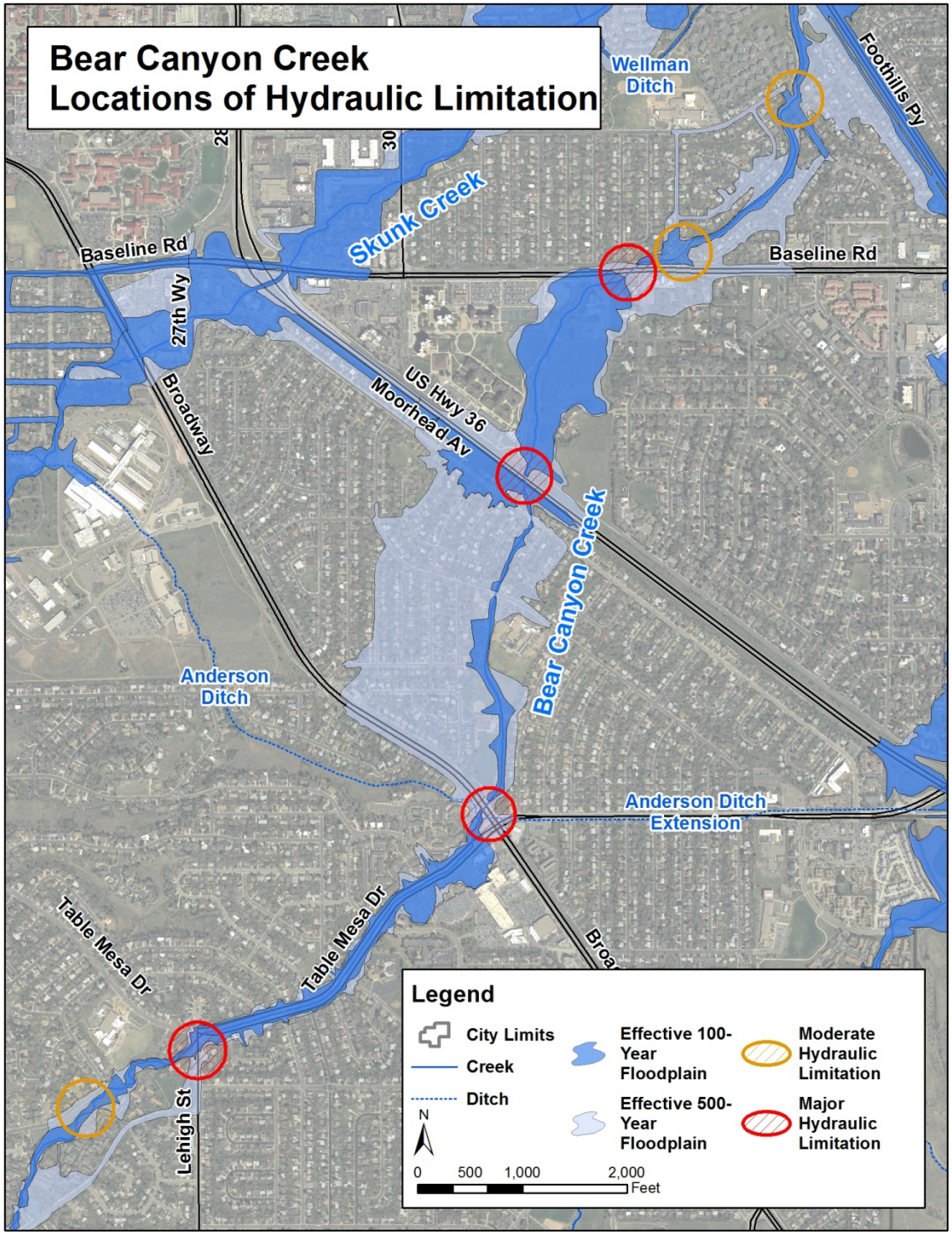

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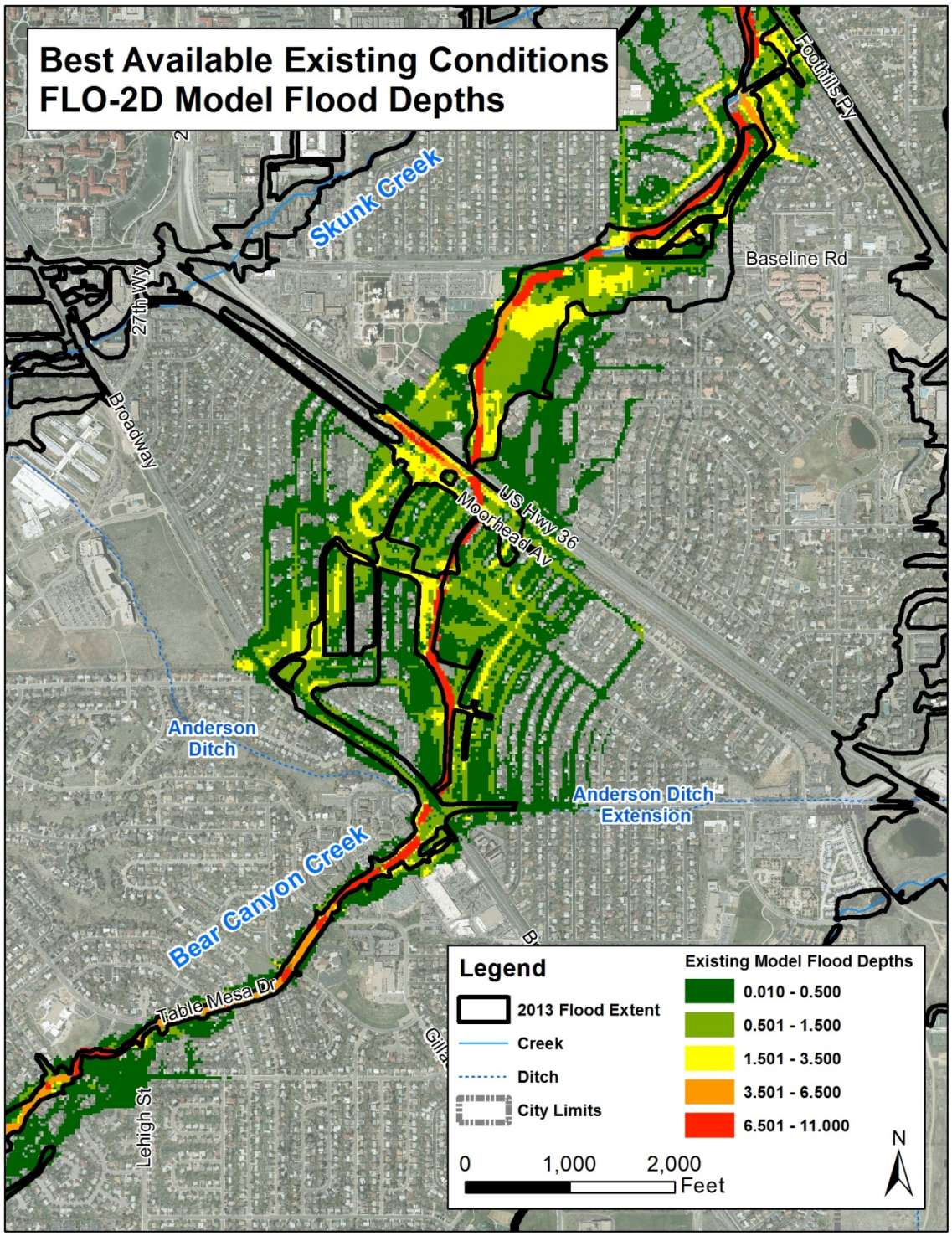
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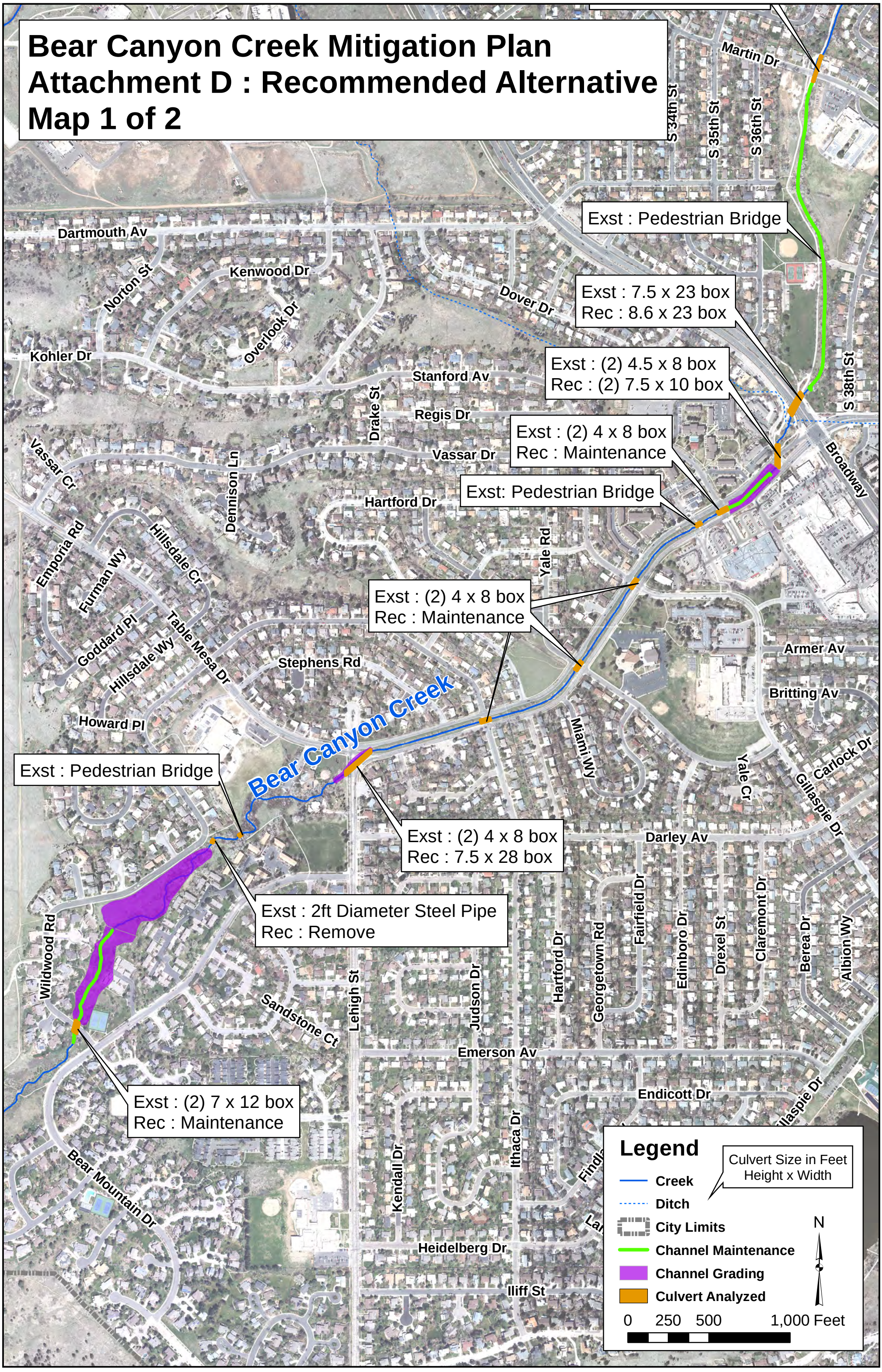
Bear Canyon Creek Mitigation Plan
Attachment D : Recommended Alternative
Map 1 of 2



Bear Canyon Creek Mitigation Plan
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Map 2 of 2