

**CITY OF BOULDER  
WATER RESOURCES ADVISORY BOARD  
AGENDA ITEM**

**MEETING DATE: March 16, 2015**

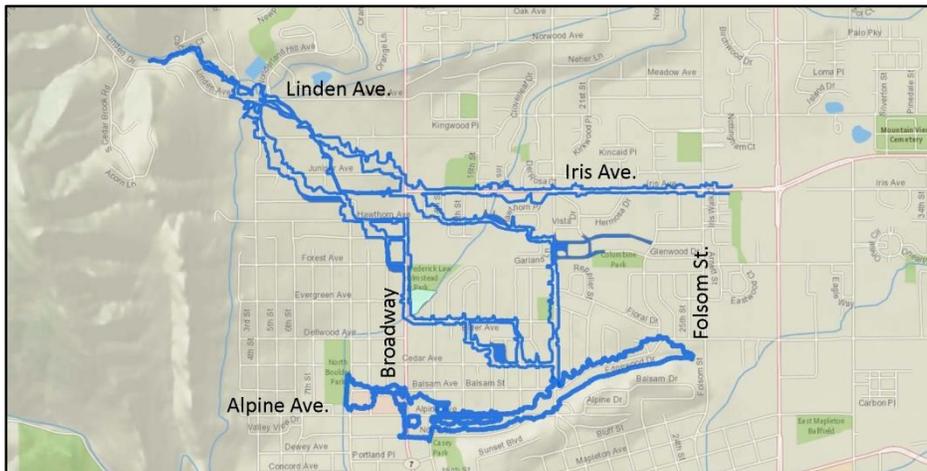
**AGENDA TITLE:** Public hearing and consideration of a recommendation to City Council regarding the Upper Goose Creek and Twomile Canyon Creek Floodplain Mapping Update.

**PRESENTER/S:**

Jeff Arthur, Director of Public Works for Utilities  
Annie Noble, Acting Principal Engineer for Flood and Greenways  
Kurt Bauer, Engineering Project Manager

**EXECUTIVE SUMMARY:**

The purpose of this memorandum is to provide a brief summary of the history and revised results of the Upper Goose Creek and Twomile Canyon Creek floodplain remapping study and request a motion from the WRAB to recommend to City Council to adopt the mapping. The study includes the area located west of Folsom Street to the city limits as shown by the blue areas in the figure below:



The Upper Goose Creek and Twomile Canyon Creek floodplain mapping update began in 2011. The initial draft revised mapping was presented to WRAB in May 2013. Based on a WRAB recommendation, the mapping was remodeled using the new city LiDAR topographic mapping information and presented to WRAB on November 17, 2014. The maps have been further revisited and revised to address issues raised by the public and the WRAB including changes to the High Hazard Zone, Conveyance Zone and limited

changes to the 100-year floodplain. As a result of these changes, no structures would be located in the revised draft High Hazard Zone, 13 structures would no longer be added to the Conveyance Zone and 15 structures would no longer be added to the 100-year floodplain. The proposed Upper Goose Creek and Twomile Canyon Creek floodplain mapping would result in a net:

- Decrease of 130 structures identified in the 100-year floodplain;
- Decrease of 97 structures identified in the Conveyance Zone and;
- Decrease of 64 structures identified in the High Hazard Zone.

The WRAB review of the floodplain mapping update does not require board members to verify the analysis and calculations, but accepts the overall mapping study process and that results are reasonable and acceptable. The WRAB is being asked to make a recommendation to City Council on whether to adopt the mapping update and forward it for consideration by FEMA.

**STAFF RECOMMENDATION:**

Staff requests Water Resources Advisory Board consideration of this matter and action in the form of the following motion:

Motion to recommend that City Council adopt the Upper Goose Creek and Twomile Canyon Creek floodplain mapping update.

**BOARD AND COMMISSION FEEDBACK:**

The initial draft revised mapping was presented to WRAB in May 2013. As a separate effort, in 2012 the city initiated collection of new topographic mapping using LiDAR to provide more accurate city-wide base mapping. During the May 2013 meeting, the Board and public voiced concern over the dramatic differences between the existing 1994 single-flow-path floodplain and the proposed split-flow-condition floodplain. Based on Board and public feedback, the floodplain mapping update was delayed until the new LiDAR topographic information was available and could be used to verify or update the study hydraulic models.

The WRAB made the following motion (4-0) at the May 20, 2013 meeting:

Move to table recommendation of adoption of Upper Goose Creek and Twomile Canyon Creek floodplain remapping study to Council, pending further information, evaluation of the study and additional public process with an emphasis on differences between current and prior studies.

The revised mapping was remodeled using the new city LiDAR topographic mapping information and presented to WRAB on November 17, 2014. The WRAB was not asked to make a motion at that meeting, but issues were raised by the Board and public concerning some of the draft High Hazard Zone, Conveyance Zone, shallow flooding and

100-year delineations. The mapping was revisited and revised to address the issues and concerns.

### **PUBLIC FEEDBACK:**

The following provides a summary of the public process and corresponding feedback:

- The initial remapping results were presented at a public open house on March 20, 2013. Sixty people attended the initial open house and the city received 11 written comments;
- City and consultant staff conducted an extensive site visit of the study area following the 2013 flood event and conducted a post-flood open house to collect post-flood information; and
- Revised mapping that incorporated the new LiDAR data was presented to the public at an open house on November 13, 2014 and at the November 17, 2014 WRAB meeting. Issues were raised by the Board and public concerning some of the draft High Hazard Zone, Conveyance Zone, shallow flooding and 100-year delineations at these meetings.

In addition, the public will have opportunities to provide comments at the March 16, 2015 WRAB meeting, the City Council meetings and during the FEMA 90-day public comment period. Following map adoption by FEMA, the public can also submit a request to be removed from the floodplain based on site specific survey information using the FEMA Letter of Map Amendment (LOMA) process.

### **BACKGROUND:**

Floodplain maps (Flood Insurance Rate Maps (FIRMs)) provide the basis for flood management by identifying the areas subject to the greatest risk of flooding. This information is essential for determining areas where life safety is threatened and property damage is likely, and forms the basis for floodplain regulations and FEMA's National Flood Insurance Program. Once adopted by FEMA, the FIRMs are the official maps used to determine flood insurance requirements and therefore the methodology to develop these maps is prescribed by FEMA. In addition, these maps are used to implement the city's land development regulations and help the city identify and prioritize opportunities for flood mitigation projects.

This mapping study area includes Upper Goose Creek and Twomile Canyon Creek west of Folsom Street to the city limits. The existing regulatory floodplain maps date back to 1994 and were based on analysis conducted in 1987. The 1994 floodplain maps show one major flow path along Twomile Canyon Creek. The original modeling was based on two-foot contour interval topographic mapping and 1-dimensional hydraulic models. One-dimensional models simulate flow in only one direction and therefore make it difficult to accurately define spill flow conditions (areas where stormwater overtops the main creek channel and flows downstream along one or more flow paths) along creek systems. While the land use has not changed significantly in the nearly 25 years since the original mapping, hydrologic and hydraulic modeling capabilities and topographic mapping technologies have changed dramatically.

In 2011, the city hired ICON Engineering to conduct an updated study. The study, co-funded by the Urban Drainage and Flood Control District (UFCD), was conducted in the following three phases:

1. Hydrologic analysis
2. Field survey and investigation
3. Hydraulic analysis

As a separate project, the city in 2012 initiated collection of new topographic mapping using state-of-the-art Light Detection and Ranging (LiDAR) technology to provide more accurate city-wide base mapping. The initial floodplain remapping results were presented to the public and WRAB in early 2013. Based on Board and public feedback, the floodplain mapping was revised using the new LiDAR mapping.

In September 2013, major flooding occurred along Twomile Canyon Creek. The flood resulted in overtopping of the creek and spilled similar to what was shown in the draft floodplain mapping presented in May 2013. City and consultant staff conducted an extensive field investigation of the project area following the flood to document flow paths, flood limits and collect information from residents.

Following the flood, the city also contracted with Wright Water Engineers to estimate how the 2013 storm correlates with the theoretical design storm used to develop the regulatory FEMA floodplains for all of the city's 15 major drainageways. The 2013 storm was a long-duration storm that did not have very high rainfall intensities. FEMA floodplain mapping is based on prescribed design storm characteristics that reflect a short-duration, high intensity theoretical thunderstorm. For this reason, Wright Water Engineers estimates that many of the city's major drainageways did not see peak flows from the 2013 storm as great as the theoretical 100-year design storm. One exception is the Twomile Canyon Creek system that had received close to or even slightly higher estimated peak flows in 2013 than the 100-year design storm. This information was compared to the draft floodplain mapping to identify areas requiring additional analysis. It should be noted, however, that no two storm events are exactly the same and therefore the refined results will still differ slightly from the 2013 flood event.

Anderson Consulting Engineers was hired to perform a peer review of ICON Engineers work. The peer review was conducted on the initial model parameters, hydrologic analysis, hydraulic modeling and proposed mapping delineations in November 2012. Anderson Engineering then conducted a second peer review in October 2014 of the revised modeling. Both sets of review comments were addressed by ICON Engineering and approved by the city and UDFCD.

The revised floodplain mapping using the LiDAR information was then presented to the public and WRAB in November 2014. The mapping has since been refined based on comments from WRAB and the public. These changes and the methodology for making these changes are described below in the Analysis Section. Information about the city's

floodplain management program, floodplain regulations and flood insurance can be found at: [Flood Management Program Overview](#).

### **ANALYSIS:**

ICON Engineers has revisited the revised draft floodplain mapping presented to WRAB and the public in November 2014 based on issues raised concerning some of the draft High Hazard Zone, Conveyance Zone, shallow flooding and 100-year delineations. The following provides a summary of the changes that have been made by issue.

**Attachment A** shows the areas of change from the mapping presented in 2014.

#### **High Hazard Zone Delineations**

Due to the potential for spill flows to occur along Twomile Canyon Creek, it was decided to develop both a 1-dimensional and 2-dimensional hydraulic model for this floodplain remapping study. A 2-dimensional model (FLO-2D) was developed for Twomile Canyon Creek to better define spill flow conditions and corresponding flow paths. A traditional 1-dimensional hydraulic model (HEC-RAS) which will be used for regulatory purposes, was then developed for the entire creek system (both Twomile Canyon Creek and Upper Goose Creek) with channel alignments mimicking the major flow paths identified by the 2-dimensional model.

Draft delineations of the High Hazard Zone (HHZ) were initially defined based solely on the 1-dimensional model results, an approach typically used in previous studies. The initial draft delineations resulted in very small and isolated HHZ areas along Twomile Canyon Creek. Review of the 2-dimensional model results indicate that other isolated areas of HHZ would exist due to the model detail. To eliminate isolated pockets of HHZ that do not likely reflect a significant risk to life and safety, it was therefore decided to revise the mapping to delineate High Hazard Zones only in areas where results from both the 2-dimensional and 1-dimensional models indicate HHZ are coincident. As a result, no structures are shown to fall within the HHZ in the revised mapping.

#### **Conveyance Zone Delineations**

The Conveyance Zone is synonymous with FEMA's Floodway and is defined as the areas in the floodplain that are reserved for the main passage of the entire 100-year flood flow when the 100-year floodplain is artificially narrowed until a maximum six-inch increase in flood water depth is created. This zone is delineated to allow development in areas of the floodplain and still provide passage of 100-year storm flows.

The 2014 draft floodplain maps showed 15 structures falling just inside the proposed Conveyance Zone. The Conveyance Zone was delineated based on interpolating model results between cross sections. Each of these 15 structures were revisited and additional model cross-sections and/or split flow paths added. As a result of adding more modeling detail, 13 of the 15 structures are no longer located in the revised draft Conveyance Zone.

## **Shallow Flooding and 100-year Delineations**

Comments were received during the 2014 public process regarding: 1) how the draft mapping showed flood risk at Foothills Elementary School; 2) structures falling just inside the revised 100-year floodplain; and 3) some areas in the floodplain showing sharp bends at certain street intersections. The following summarizes how each of these issues have been addressed.

### **1) Foothills Elementary School**

The 2014 draft floodplain mapping only showed shallow flooding (Zone X) at the Foothills Elementary School site. This was based on averaged flood depths over the entire school site. The 2015 revised draft now shows areas of shallow flooding (Zone AO 1') in addition to the Zone X shallow flooding. This change was based on information from the 2-dimensional hydraulic model. Unlike the Zone X shallow flooding zone that is regulated by the city under the recent Critical Facilities Ordinance, the Zone AO 1' would be regulated as 100-year floodplain by FEMA.

### **2) 100-Year Floodplain Delineations**

Numerous structures located along 19<sup>th</sup> Street between Evergreen Avenue and Cedar Avenue and along 17<sup>th</sup> Street between Elder Avenue and Cedar Avenue were shown in the 2014 draft as falling just inside the revised 100-year floodplain. Model refinements in these areas included defining additional split flows in the model at Broadway and 13<sup>th</sup> Street and along 19<sup>th</sup> Street at Grape Avenue, Glenwood Drive, Floral Drive, and Evergreen Avenue. The added model detail resulted in 11 structures no longer shown to be touched by the 100-year floodplain.

### **3) Bends in Floodplain Delineations**

The draft floodplain mapping shows 100-year floodplain delineations taking sharp turns at several intersections within the modeled area. These turns were questioned during the public process, particularly the one shown at the intersection of Broadway and Elder. **Attachment B** shows detailed information at Broadway and Elder and why the revised 100-year floodplain is shown to take a sharp bend at this intersection. At this location, the 100-year discharge splits between flow continuing south on Broadway and that continuing east on Elder and is based on the percentage of discharge originating west and east of the Broadway roadway crown and gradient changes through the intersection. The flow distribution was further supported by the 1-dimensional HEC-RAS model update. Other areas showing sharp turns have been similarly confirmed with by the LiDAR topographic and modeling information.

## **Summary of Results**

The Twomile Canyon Creek watershed is an alluvial floodplain with sections where no channel exists. During major storm events the creek overtops its banks and spills south and east along many flow paths through the watershed. While the proposed mapping is based on criteria established by FEMA for a design storm, the level of detail to model spill flows is not prescribed. The proposed revisions to the draft floodplain mapping along Twomile Canyon Creek differ in the level of modeling detail from what has been done in the past for city floodplain remapping studies. Typically only large spill flows are

modeled within a watershed. The inclusion of the LiDAR topographic mapping and 2-dimensional modeling has allowed us to define smaller spill flows (down to 50 cfs) within the Twomile Canyon Creek watershed. The revised Twomile Canyon Creek floodplain remapping study also differs from previous studies in the method used to define the High Hazard Zone. Typically the High Hazard Zone is delineated from the 1-dimensional model only. The High Hazard Zone for this revision was delineated in areas only where it was identified in both the 1- and 2-dimensional models.

These changes in modeling approach have resulted in narrower flood zone delineations and correspondingly fewer structures identified in the flood zones. While these changes result in fewer properties being burdened with regulatory restrictions and flood insurance requirements, this more detailed modeling approach has potential implications. The less conservative delineation (narrower) of flood zones may lead residents and visitors to believe there is a more limited flood risk. No two storms are alike and an individual major storm event will likely not manifest itself in exactly the way depicted by the flood zones defined by the FEMA theoretical design storm. Human intervention, sediment and debris can also greatly impact flow paths and result in flooding outside of mapped zones. In addition, floodplain mapping provides the basis for the city's flood mitigation studies. As a result, this less conservative mapping approach might affect future mitigation planning alternatives and priorities. Considering these potential implications, staff still recommends the revised mapping approach due to the more detailed topographic mapping using LiDAR and the thorough evaluation using both the 1- and 2-dimensional modeling. It should, however be understood that ultimately FEMA will be reviewing the mapping and may not concur with this less conservative modeling approach.

In summary, if adopted, the 2015 revised Upper Goose Creek and Twomile Canyon Creek floodplain mapping would result in the following net changes from the current FEMA regulatory floodplains:

- Decrease of 130 structures identified in the 100-year floodplain;
- Decrease of 97 structures identified in the Conveyance Zone and;
- Decrease of 64 structures identified in the High Hazard Zone.

Additional background information for this study can be found on the project web site: [Upper Goose Creek and Twomile Canyon Creek Floodplain Mapping Update](#). The following attachments present the revised 2015 floodplain maps for Twomile Canyon Creek and Upper Goose Creek:

- **Attachment A** - Areas of change from mapping presented in 2014.
- **Attachment B** - Detailed information at Broadway and Elder showing reasons for sharp bend in 100-year floodplain
- **Attachment C, D and E** - Revised (2015) 100-year floodplains, Conveyance Zones and High Hazard Zones respectively for both creeks in comparison to the existing regulatory FEMA floodplain. Each of these figures show the structures (including summary numbers) that would be identified to be in the revised flood zones, those that would remain in the flood zones and those that would be removed should this revised mapping be approved. All of the map attachments

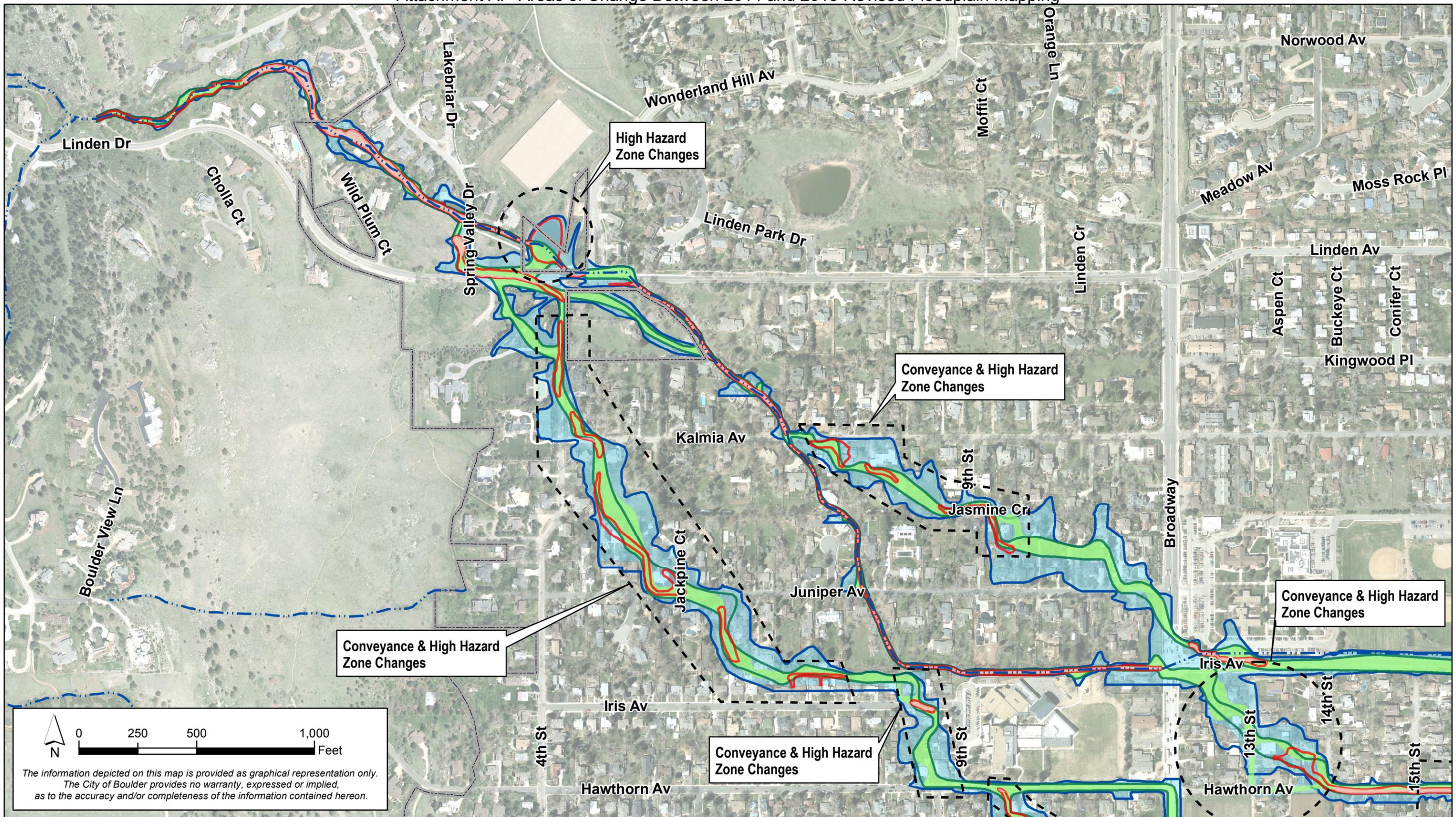
can be accessed on the project website and via the hyperlinks below for better viewing capabilities.

**NEXT STEPS:**

Following a formal recommendation from WRAB, the mapping study will be presented to City Council in early 2015. If City Council adopts the study, the city will forward the mapping to FEMA for review. The FEMA adoption process includes a 90-day appeal process. During the FEMA review and approval process (which can take from six months to four years to complete), it is recommended that the more restrictive of the existing and proposed mapping be used for regulatory purposes. This means that development within newly identified flood zones would be subject to the city's floodplain regulations. In order to comply with FEMA requirements, development within areas that are being removed from the floodplain would still be subject to the city's floodplain regulations until FEMA officially adopts the new floodplain mapping. Following formal adoption by FEMA, the city would regulate solely based on the new mapping.

**ATTACHMENTS:**

- A. [Areas of Change Between 2014 and 2015 Revised Floodplain Mapping](#)
- B. [Existing FEMA and Revised \(2015\) Proposed 100-Year Floodplain](#)
- C. [Existing FEMA and Revised \(2015\) Proposed Conveyance Zone](#)
- D. [Existing FEMA and Revised \(2015\) Proposed High Hazard Zone](#)



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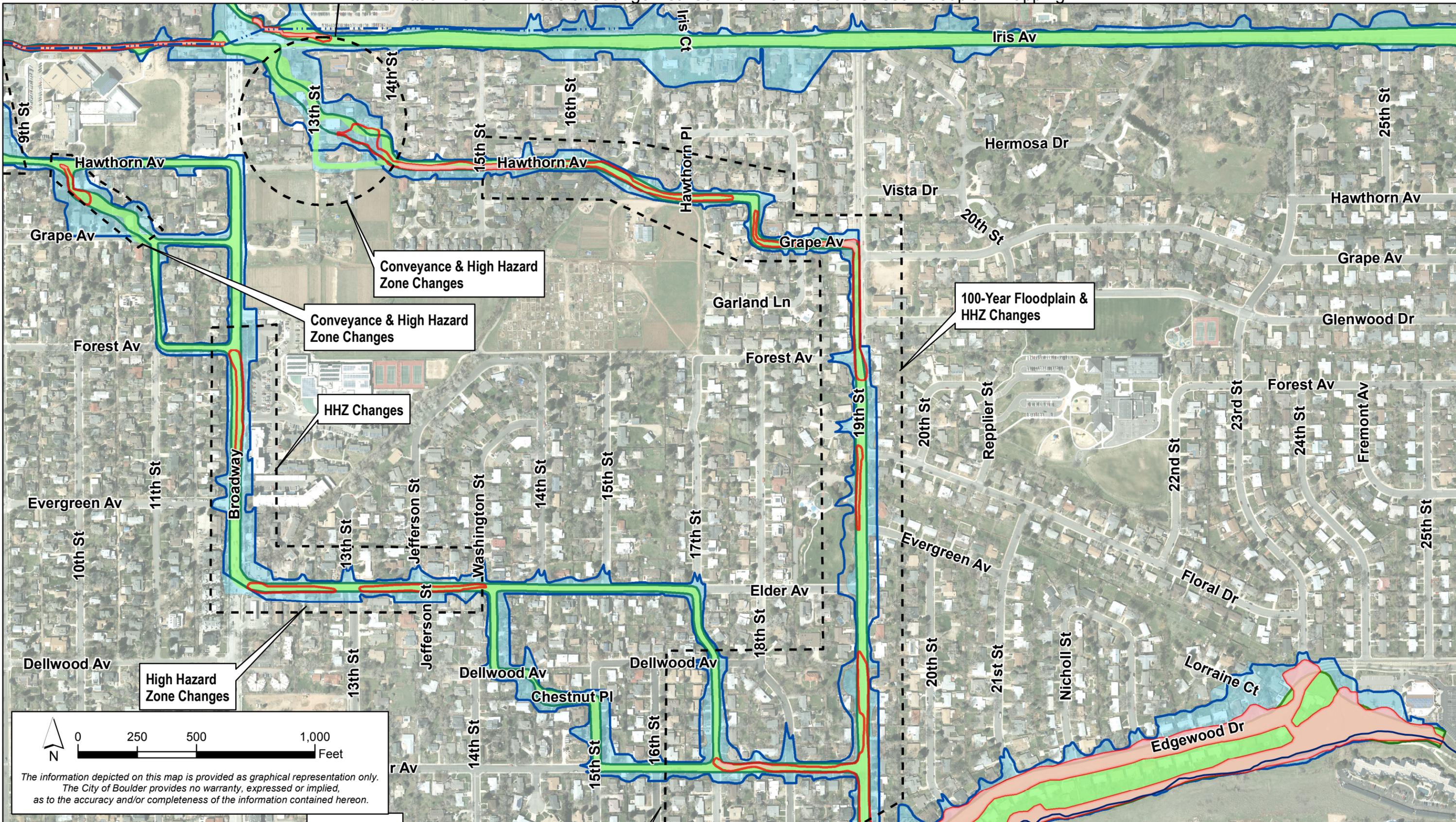
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<b>Legend</b>		Draft Proposed (2014) 100 Year Floodplain		Draft Proposed (2014) Conveyance Zone		Draft Proposed (2014) High Hazard Zone		Areas of Significant Change From 2014 to 2015 Proposed Mapping
		Proposed (2015) 100 Year Floodplain		Proposed (2015) Conveyance Zone		Proposed (2015) High Hazard Zone		City Limits

### Twomile Canyon & Upper Goose Creek

Areas of Significant Changes  
From 2014 to 2015 Proposed Mapping

Rev: 3/3/2015



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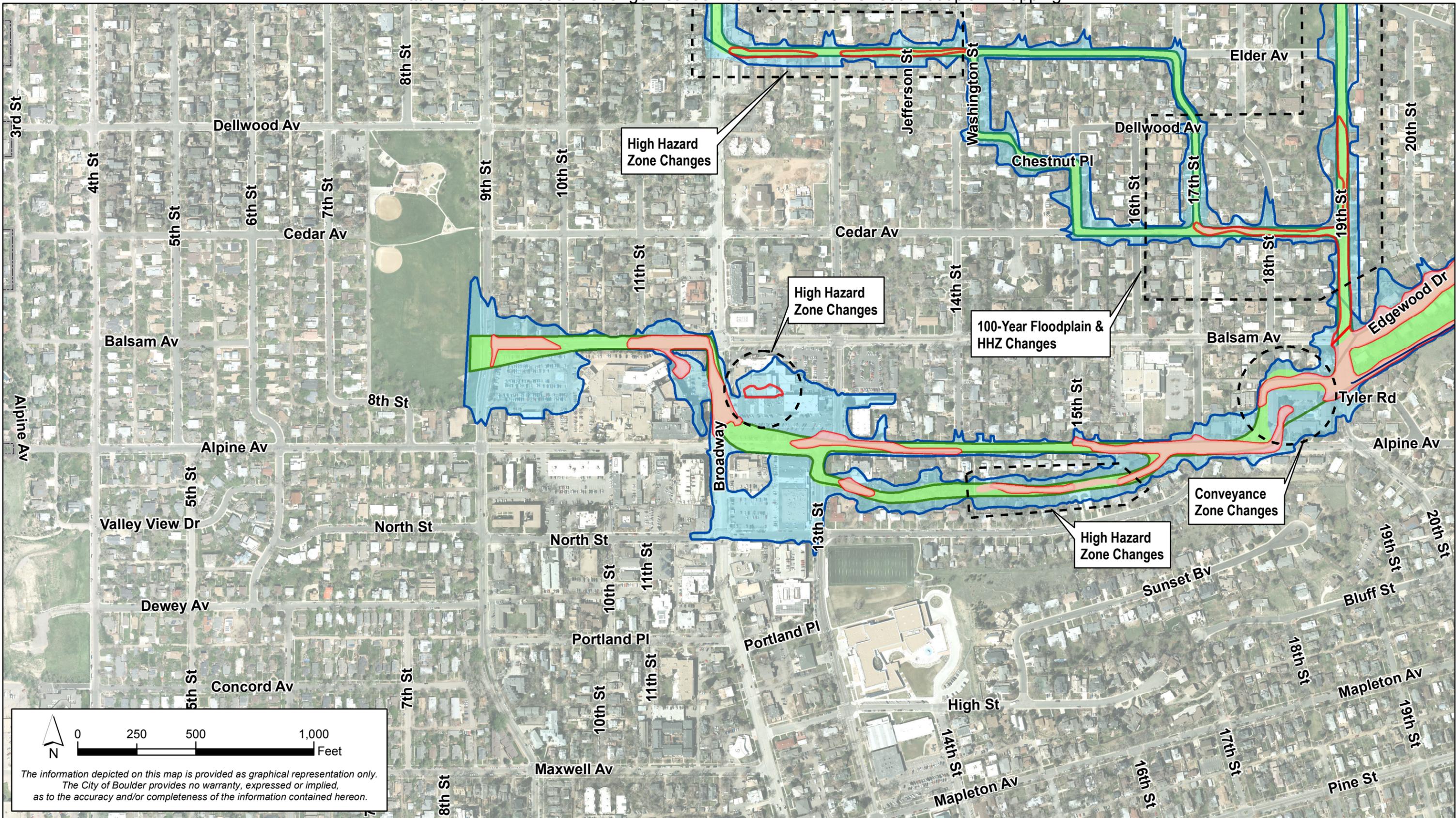
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### Twomile Canyon & Upper Goose Creek

Areas of Significant Changes  
From 2014 to 2015 Proposed Mapping

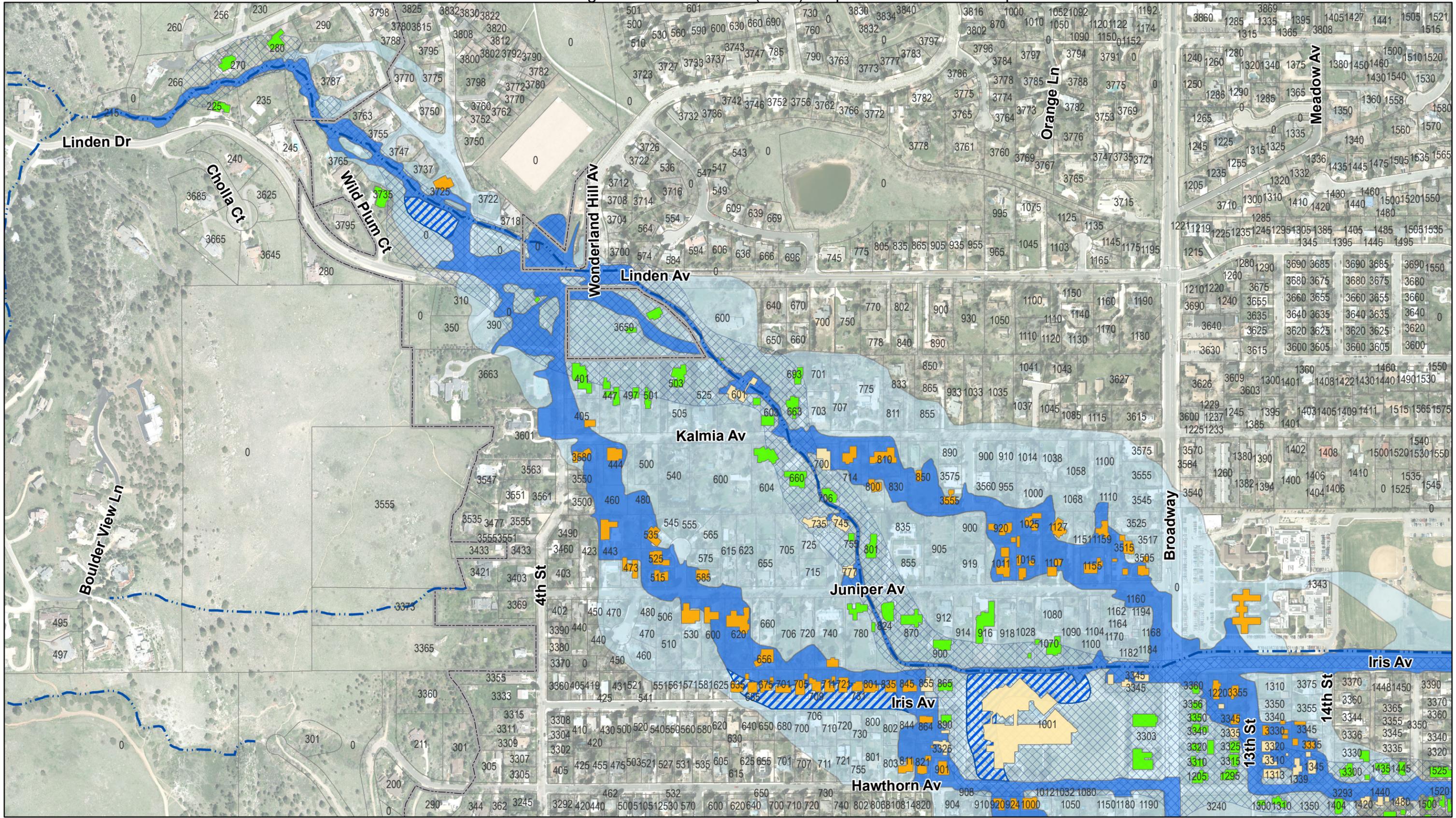
Rev: 3/3/2015



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		Proposed (2015) 100 Year Floodplain		Proposed (2015) Conveyance Zone		Proposed (2015) High Hazard Zone		City Limits



**Legend**

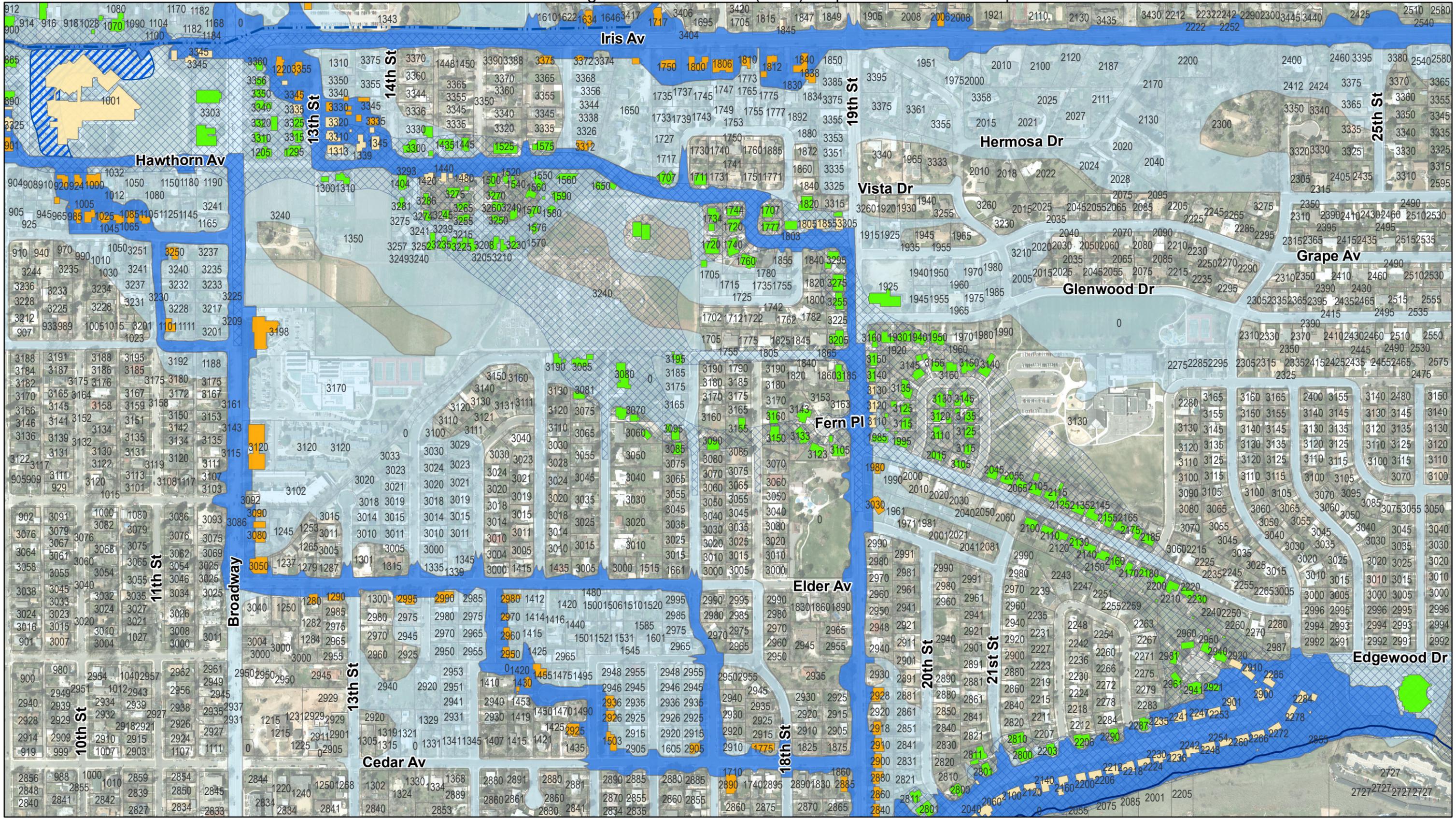
- Proposed (2015) 100 Year Floodplain
- Proposed (2015) Shallow Flooding (unregulated)
- Buildings Added to the 100 Year Floodplain (145)
- Buildings Remaining in the 100 Year Floodplain (133)
- Buildings Removed from the 100 Year Floodplain (275)
- FEMA Effective 100 Year Floodplain
- City Limits

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**Twomile Canyon & Upper Goose Creek**  
 Structures Affected by Proposed Mapping Compared to Existing FEMA 100-Year Floodplain

Rev: 3/3/2015

Attachment B. Existing FEMA and Revised (2015) Proposed 100-Year Floodplain



**Legend**

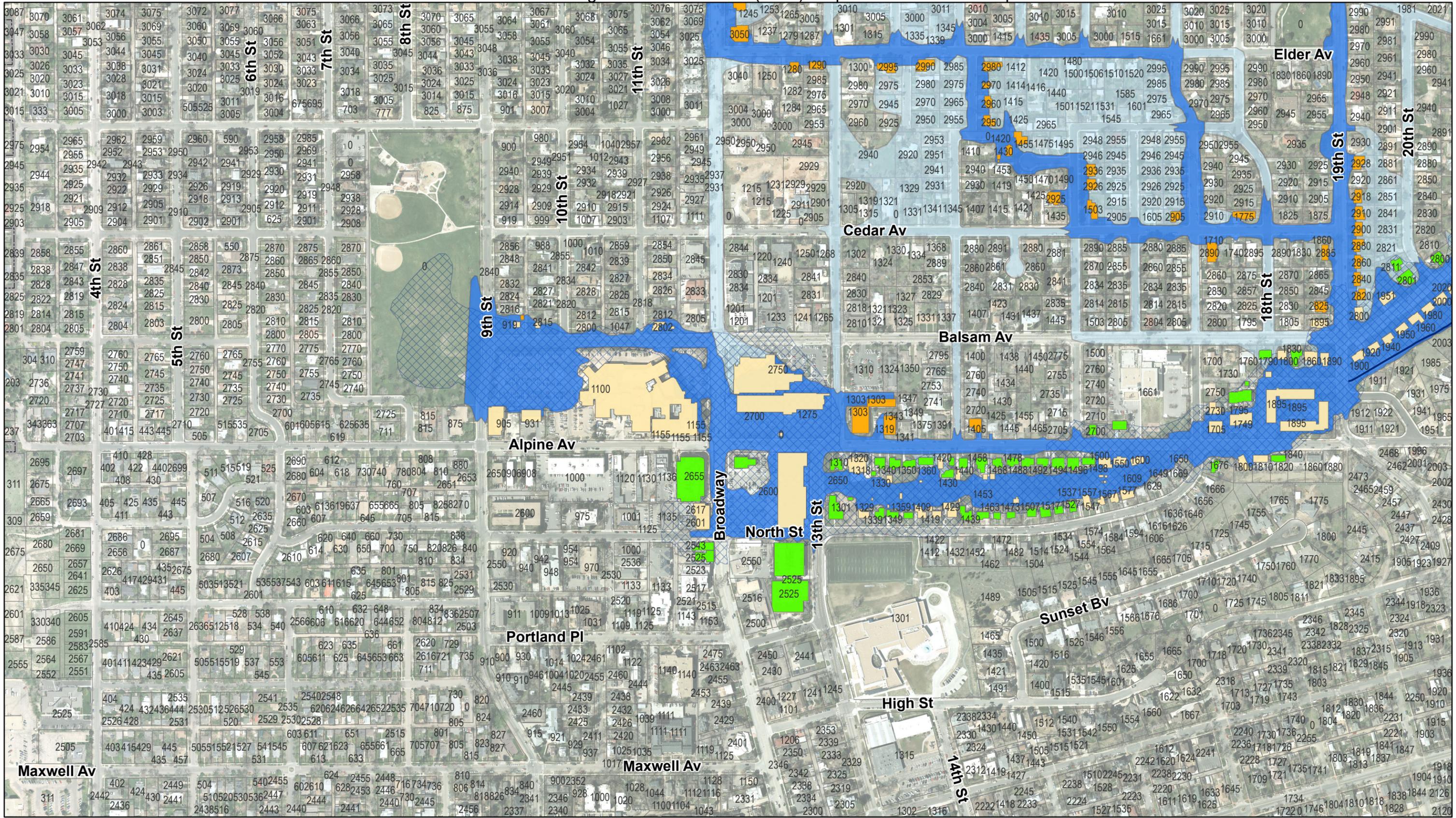
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- Buildings Added to the 100 Year Floodplain (145)
- Buildings Remaining in the 100 Year Floodplain (133)
- Buildings Removed from the 100 Year Floodplain (275)
- Proposed (2015) 100 Year Floodplain (Zone AO) Flood Depth 1' to 2'
- FEMA Effective 100 Year Floodplain
- City Limits

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**Twomile Canyon & Upper Goose Creek**  
 Structures Affected by Proposed Mapping Compared to Existing FEMA 100-Year Floodplain

Rev: 3/3/2015

Attachment B. Existing FEMA and Revised (2015) Proposed 100-Year Floodplain



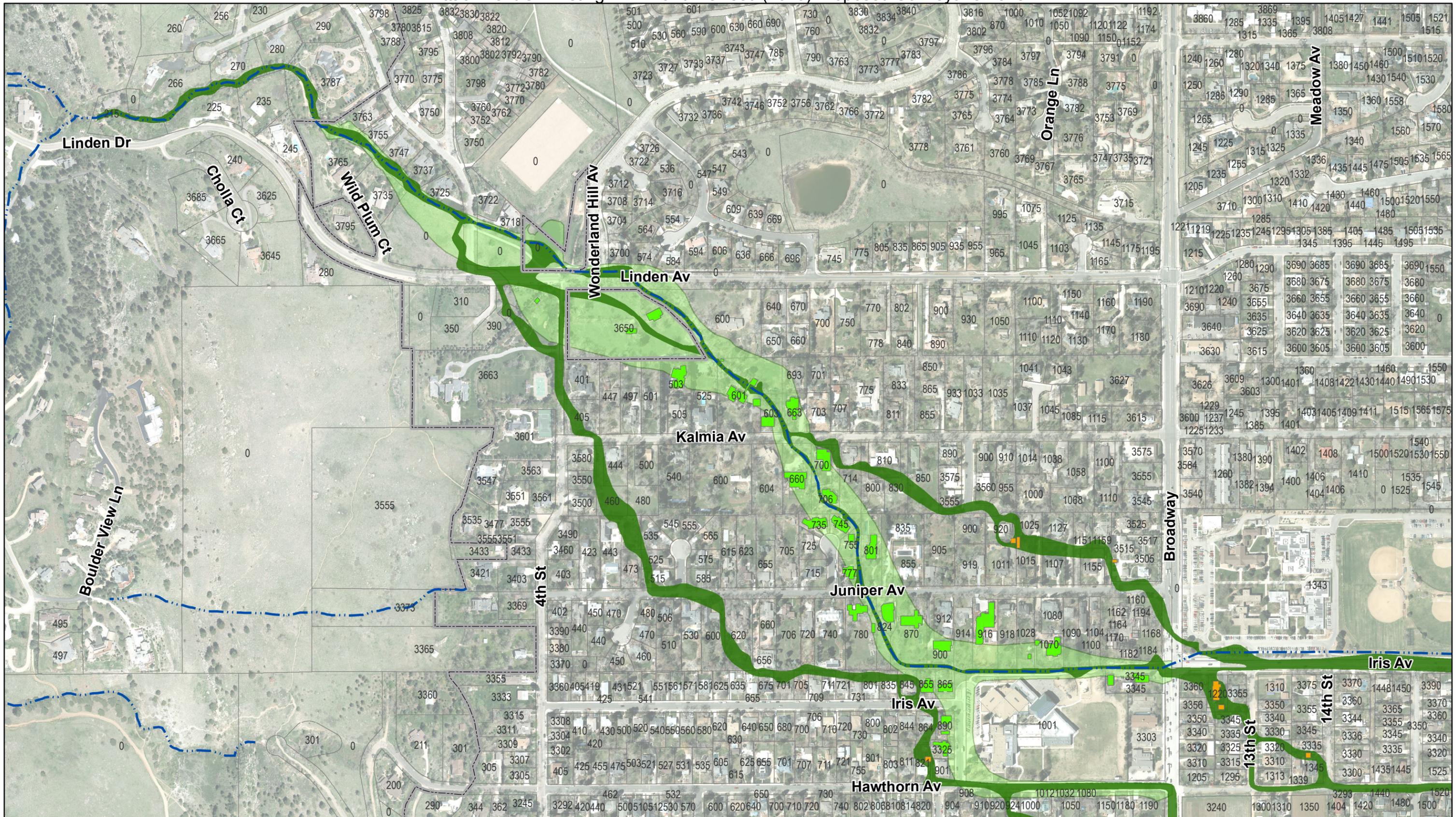
**Legend**

- Proposed (2015) 100 Year Floodplain
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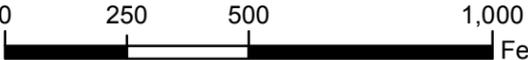
**Twomile Canyon & Upper Goose Creek**  
 Structures Affected by Proposed Mapping Compared to  
 Existing FEMA 100-Year Floodplain

Rev: 3/3/2015



**Legend**

-  Proposed (2015) Conveyance Zone
-  FEMA Effective Conveyance Zone
-  City Limits
-  Buildings Added to the Conveyance Zone (9)
-  Buildings Remaining in the Conveyance Zone (42)
-  Buildings Removed from the Conveyance Zone (107)

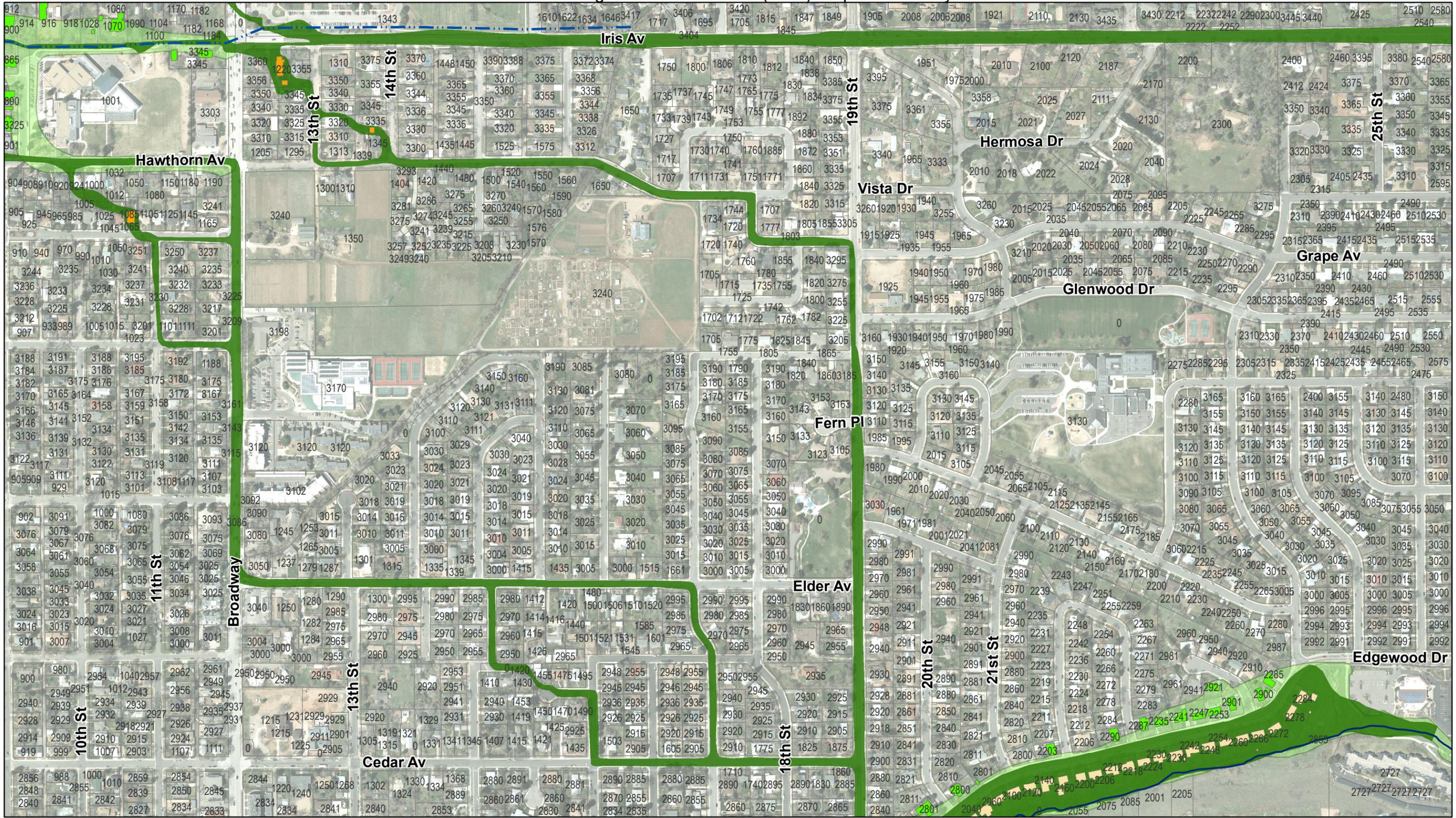



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**Twomile Canyon & Upper Goose Creek**  
*Structures Affected by Proposed Mapping Compared to Existing FEMA Conveyance Zone*

Rev: 3/3/2015

Attachment C. Existing FEMA and Revised (2015) Proposed Conveyance Zone



**Legend**

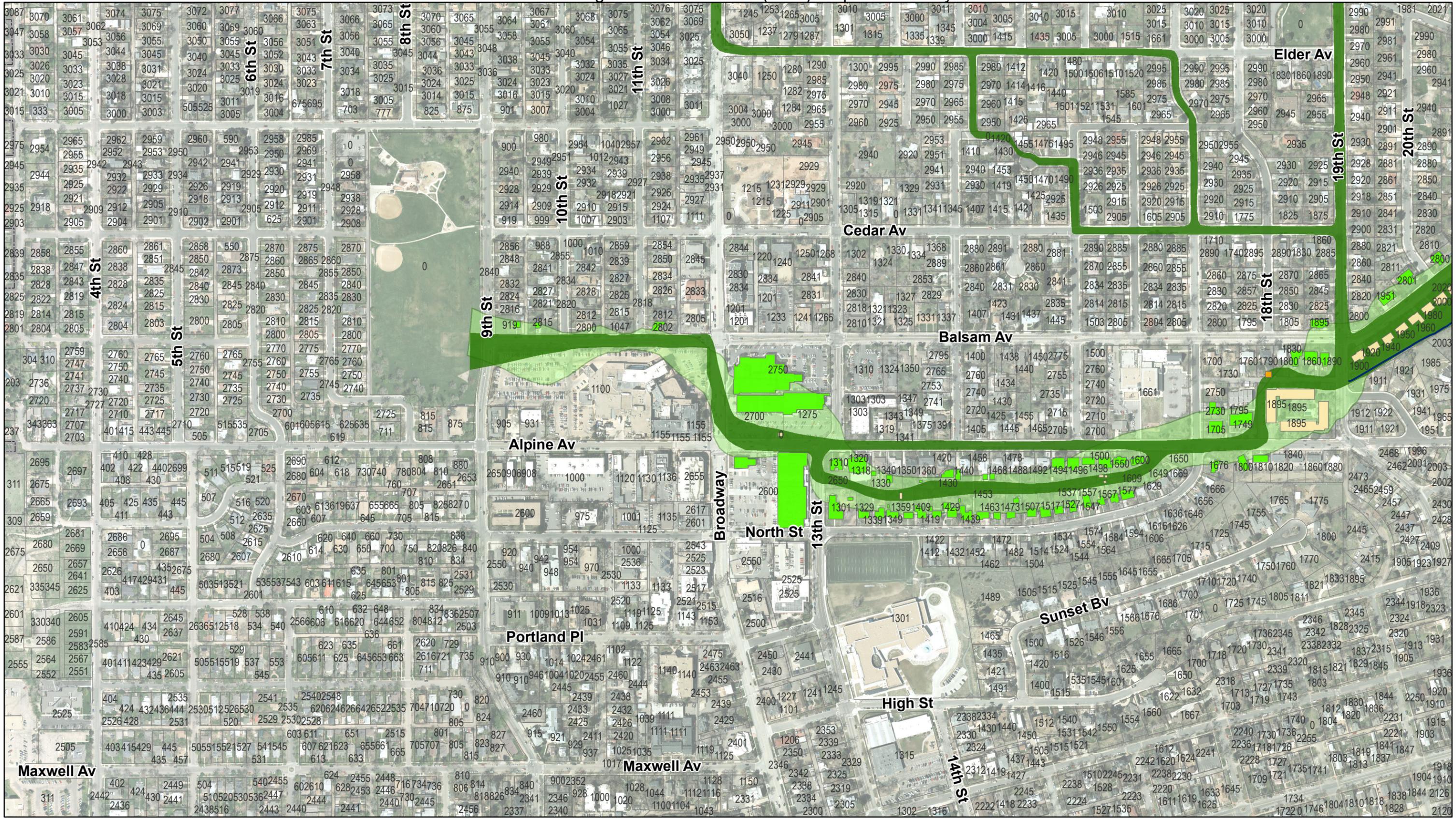
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- FEMA Effective Conveyance Zone
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**Twomile Canyon & Upper Goose Creek**  
 Structures Affected by Proposed Mapping Compared to  
 Existing FEMA Conveyance Zone

Rev: 3/3/2015

Attachment C. Existing FEMA and Revised (2015) Proposed Conveyance Zone



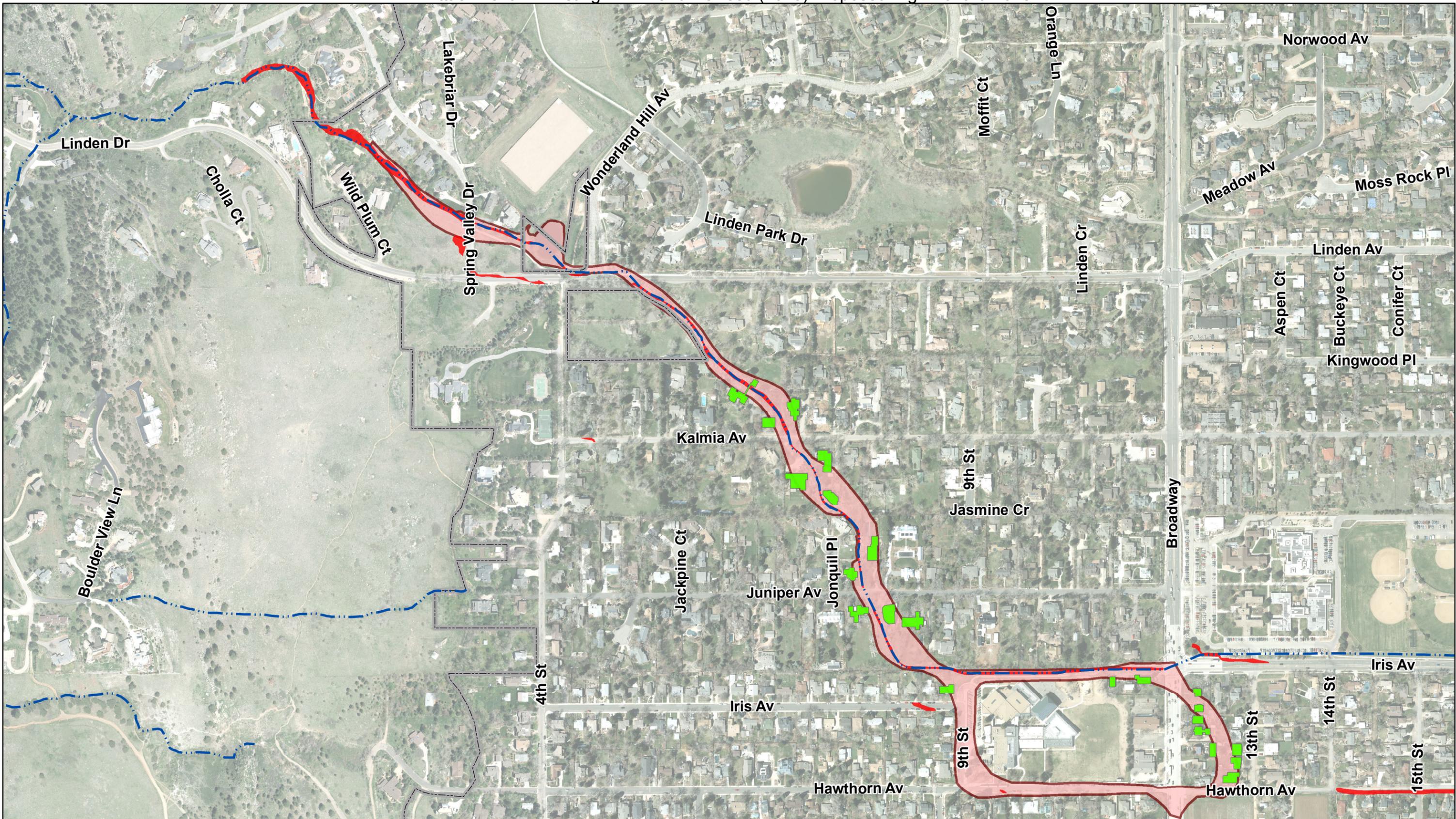
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- FEMA Effective Conveyance Zone
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**Twomile Canyon & Upper Goose Creek**  
 Structures Affected by Proposed Mapping Compared to  
 Existing FEMA Conveyance Zone

Rev: 3/3/2015



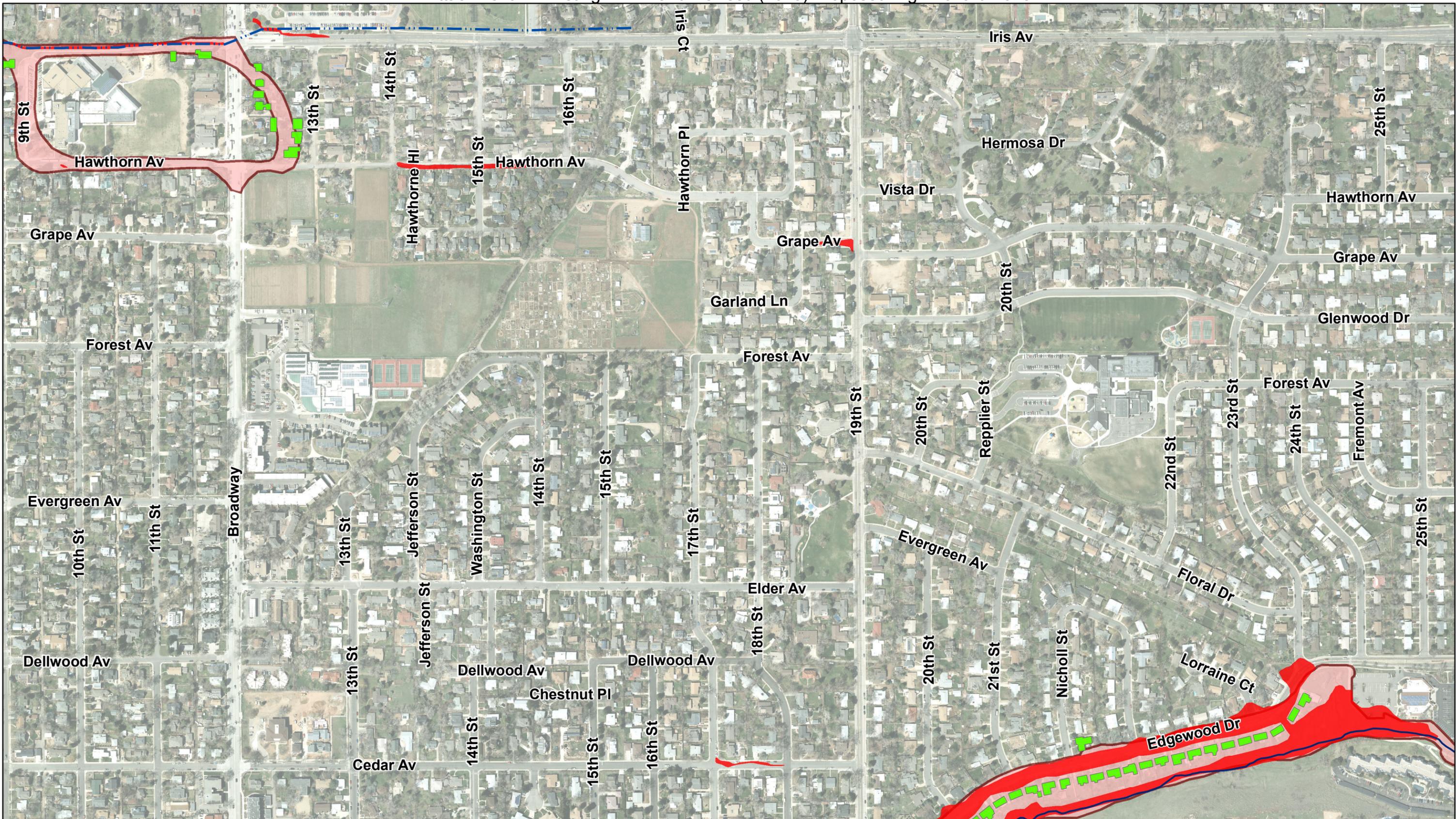
**Legend**

-  Proposed (2015) High Hazard Zone
-  Effective High Hazard Zone
-  City Limits
-  Buildings Added to the High Hazard Zone (0)
-  Buildings Remaining in the High Hazard Zone (0)
-  Buildings Removed from the High Hazard Zone (65)




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**Twomile Canyon & Upper Goose Creek**  
*Structures Affected by Proposed Mapping Compared to Existing High Hazard Zone*



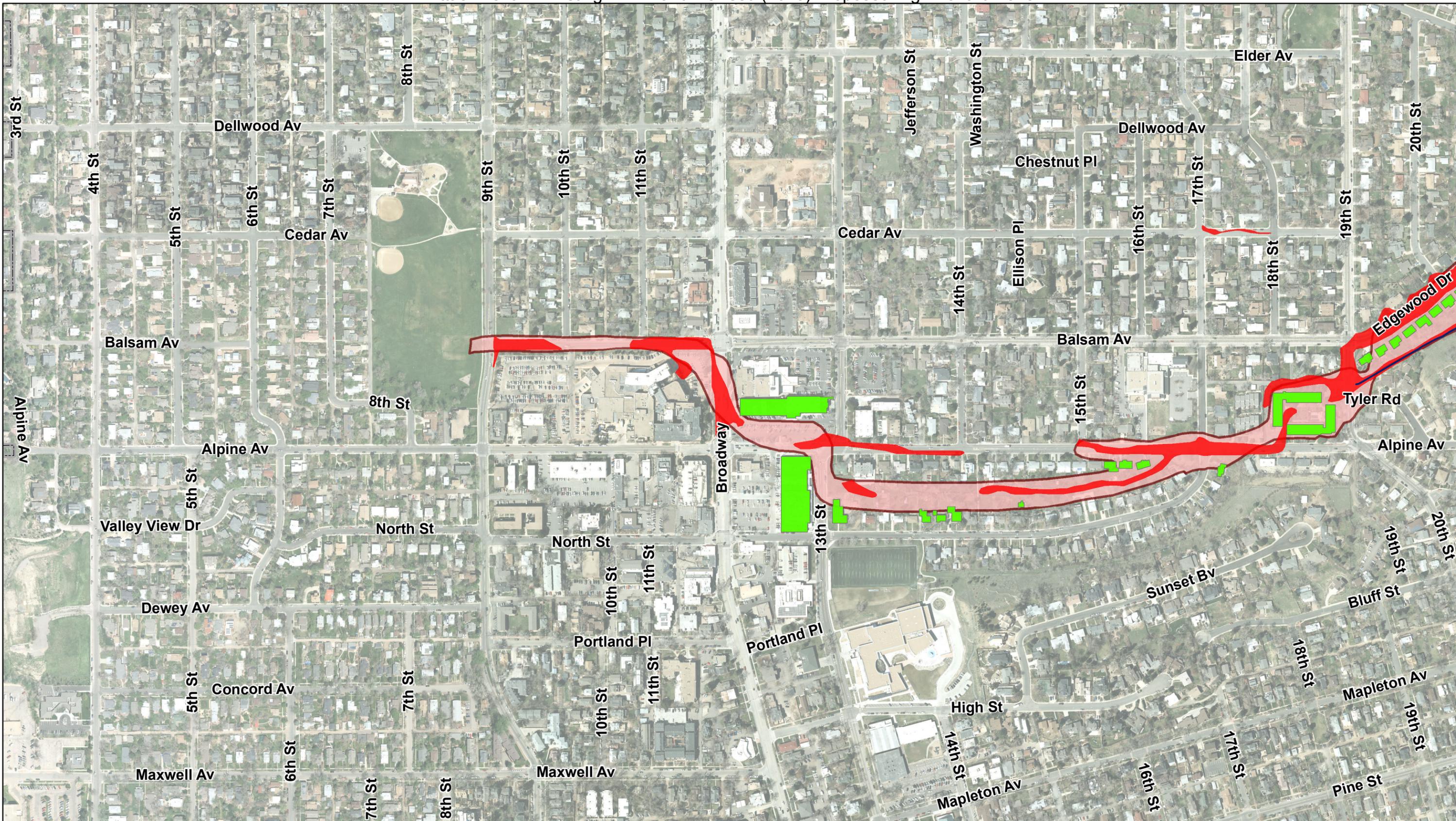
**Legend**

-  Proposed (2015) High Hazard Zone
-  Effective High Hazard Zone
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**Twomile Canyon & Upper Goose Creek**  
*Structures Affected by Proposed Mapping Compared to Existing High Hazard Zone*



**Legend**

-  Proposed (2015) High Hazard Zone
-  Effective High Hazard Zone
-  City Limits
-  Buildings Added to the High Hazard Zone (0)
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**Twomile Canyon & Upper Goose Creek**  
*Structures Affected by Proposed Mapping Compared to Existing High Hazard Zone*