

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

MEETING DATE: November 17, 2014

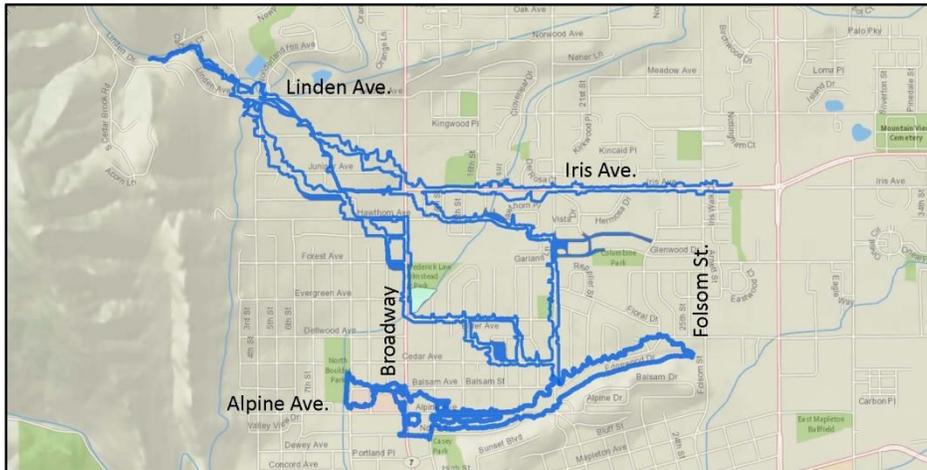
AGENDA TITLE: Information Item - Upper Goose Creek and Twomile Canyon Creek Floodplain Mapping Update

PRESENTER/S:

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

EXECUTIVE SUMMARY:

The purpose of this memorandum is to provide a general summary of the history and revised draft results of the Upper Goose Creek and Twomile Canyon Creek floodplain remapping study. 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 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 and were based on what are now dated topographic mapping and hydraulic modeling techniques. Field surveys conducted in 2011 and documentation of historic flood events indicate that Twomile Canyon Creek will overtop with resultant spills flowing along several paths. The Twomile Canyon Creek and Upper Goose Creek floodplain mapping update began in 2011.

The 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 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.

In September 2013, major flooding occurred along Twomile Canyon Creek. The flood resulted in overtopping of the creek and spill flows similar to what was shown in the draft floodplain mapping presented in May 2013. The revised mapping presented in this memorandum includes several spill flows and is slightly different than the mapping presented in May 2013 as it is now based on the new LiDAR topographic mapping data and considers information collected before and after the September 2013 flood event.

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 November WRAB meeting is an opportunity for the board to provide input and request clarification. A follow up agenda item and public hearing, where WRAB will be asked to vote on a recommendation to City Council, is currently scheduled for January 26, 2015.

BOARD AND COMMISSION FEEDBACK:

The Upper Goose Creek and Twomile Canyon Creek remapping study was presented to the WRAB as an information item at a public hearing held on May 20, 2013. The Board made the following motion (4-0):

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 [May 2013 WRAB memorandum](#) and [meeting minutes](#) can be accessed via their respective hyperlinks and on the [project website](#).

PUBLIC 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 along Twomile Canyon Creek and Upper Goose Creek following the September 2013 storm to document flow paths and flood limits. During this site visit, staff talked to numerous residents to collect additional information on the flood event. A post-flood open house was conducted on October 17, 2013 to present draft flood inundation limits, collect information about damages and

problem areas and provide flood recovery information. The revised mapping that incorporates the new LiDAR data will be presented to the public at an open house on November 13, 2014. Post cards were mailed to owners and residents of every parcel located within the existing and proposed 100-year floodplain notifying them of the proposed changes, specifics of the open house and WRAB meetings. Electronic notifications were sent to people who had previously provided email addresses and posters were placed in various locations within the project area providing specifics about the 2014 public process meetings. The public will have opportunities to provide comments at the upcoming open house and WRAB meetings, the City Council public hearing and during the FEMA 90-day public comment period. In addition, following map adoption by FEM, the public can 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:

The risk of flash flooding is an important issue for the City of Boulder primarily due to its location at the mouth of Boulder Canyon and other canyon creeks. Approximately 13 percent of the city is located within the 100-year floodplains of Boulder Creek and its 14 tributaries. Nearly 2,600 individual structures are located within this flood zone. The city has a comprehensive floodplain management program designed to identify flood risks, mitigate the risks of flooding, minimize loss of life and property damage and support recovery following a major flood event. Floodplain mapping provides the basis for the city's floodplain management program 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 is the basis for floodplain regulations and the National Flood Insurance Program (NFIP). The city's floodplain maps are periodically updated to reflect changes in the floodplain resulting from land development, flood mitigation improvements, new topographic mapping information and new mapping study technologies. Additional information about the city's floodplain management program, floodplain regulations and flood insurance can be found at: [Flood Management Program Overview](#).

The city delineates four flood zones:

500-year floodplain: The 500-year floodplain delineates the flood limits resulting from a storm that has a 0.2 percent chance of occurring in any given year.

100-year floodplain: The 100-year floodplain delineates the flood limits resulting from a storm that has a one percent chance of occurring in any given year (26 percent chance over a 30-year mortgage).

Conveyance zone: The conveyance zone 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.

High hazard zone: The high hazard zone defines the area of the floodplain where water depth and velocity pose a threat to life and safety. This area is delineated for areas in the floodplain where water depths are four feet or greater or where the water velocity multiplied by water depth equals or exceeds the number four.

ANALYSIS:

The study area includes Upper Goose Creek and Twomile Canyon Creek west of Folsom Street to the city limits. The 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 path) 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.

The city hired ICON Engineering in 2011 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 city's new LiDAR mapping provides a minimum of 16 elevation points per square meter and has a minimum vertical accuracy of 0.6 feet. The Upper Goose Creek and Twomile Canyon Creek revised draft remapping study results were presented to the WRAB as an information item at a public hearing held on May 20, 2013. The Board and public voiced concern over the dramatic differences between the 1994 single flow path floodplain and the proposed split flow condition floodplain. Based on the Board motion and public feedback, the floodplain remapping update was delayed until the new LiDAR topographic information was available and could be used to update the study hydraulic models.

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 while the city's design storm is based on 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 Two Mile Canyon Creek system that had received close to or even slightly higher estimated peak flows in 2013 than the 100-year design storm.

ICON Engineers has now revised the hydraulic models and associated floodplain maps for the project. The following summarizes each of the project phases along with a description of the peer reviews for the study. The summary includes a description of the changes made to the initial analysis and draft floodplain maps. Additional background information for this study can be found on the project web site: [Upper Goose Creek and Twomile Canyon Creek Floodplain Mapping Update](#).

Hydrologic Analysis

A hydrologic analysis was conducted in late 2011 with minor revisions in 2012 using updated land use and current modeling software. The updated analysis refined the area of land tributary to the study creeks, resulting in a slightly smaller watershed area (a portion of land located east of Broadway and north of Iris Avenue was determined to be tributary to Elmer's Twomile Canyon Creek and therefore excluded from the study area). Results from the updated analysis were compared to the 1994 regulatory mapping study results, regional regression equations and comparisons to similar Front Range drainage basins. The average 100-year peak flows from the updated hydrology are approximately two percent lower than those in the 1994 study. The hydrologic analysis was documented in a report that can be reviewed using the following link: [Hydrology Verification Report](#). Hydrology for this study has not been modified from the 2012 Hydrology Verification Report.

Field Survey and Investigation

ICON Engineering conducted a field survey in late 2011 to document existing conditions within the study area. This information was used to:

- Identify sizes and characteristics of existing culverts and other creek crossings
- Assign hydraulic model parameters (roughness coefficients, debris blockage values and contraction and expansion values). Debris blockage values were developed based on the size of the existing culvert, by rainfall recurrence intervals and assumed conditions during those events. The smaller the existing pipe or culvert and the larger the rainfall event the greater the estimated blockage factor. **Attachment A** presents a summary of the estimated debris blockages by channel crossing and rainfall event.
- Collect select topographic survey information to supplement the city's topographic mapping

The field investigation was documented in a report that can be reviewed using the following link: [Field Documentation Memorandum](#).

City and consultant staff conducted an extensive site visit along Twomile Canyon Creek and Upper Goose Creek following the September 2013 storm to document flow paths and flood limits during that specific storm event. During this site visit, staff talked to numerous residents to collect additional information on the flood event. This information was used to identify discrepancies between the draft floodplain mapping and the 2013 flood limits and flow paths. This comparison is more relevant in this watershed since the 2013 storm was estimated to have resulted in somewhat similar peak flows as the FEMA design storm used to develop the floodplain maps.

Hydraulic Analysis

The 1994 floodplain maps show one major flow path along Twomile Canyon Creek. Findings from the 2011 field survey and documentation of historic flood events indicate that Twomile Canyon Creek will overtop with spill flows along several paths. It was therefore decided early in the study process to develop two hydraulic models for the study area. A separate 2-dimensional model was developed for just Twomile Canyon Creek. Data from this model was used to determine the major floodplain flow paths. A traditional 1-dimensional hydraulic model 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. Floodplains were delineated for the 10-, 25-, 50-, 100-, and 500-year events.

The initial round of modeling that was presented to WRAB in May, 2013 used the city's one-foot contour topographic mapping. The draft model results indicated spill flows would occur during a major storm event, similar to what was observed during the September 2013 flood. The revised models use the city's new LiDAR Topographic mapping information that provides a minimum of 16 elevation points per square meter. The LiDAR mapping was collected before the September 2013 flood. As a result of the September 2013 flood, the project area north and west of Linden Avenue and Wonderland Hill Avenue was vastly changed due to sediment deposition and channel erosion. In addition, the Urban Drainage and Flood Control District assisted the city in restoring the segment of Twomile Canyon Creek upstream and downstream of Spring Valley Road after the September 2013 storm redirected and/or filled in the original channel segment. As a result, hard survey was collected in early 2014 to define this affected area for the revised hydraulic models.

In order to help verify the study models, ICON Engineering, in coordination with Wright Water Engineers simulated the 2013 storm event in the study models. Results correlated well with the flood limits documented on the ground. The study models were then run with the FEMA 100-year design storm with the more detailed LiDAR topographic mapping. The results were compared to the 2013 documented flow paths and flood limits. **Attachment B** shows how the model was modified from the original version based on the new topographic mapping data and the 2013 flood documentation. The revised 2014 hydraulic analysis was documented in a report that can be reviewed using the following link: [Hydraulic Report](#).

Peer Review

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 effort with the exception that the hydrology was not changed and therefore not reviewed. Both sets of review comments were addressed by ICON Engineering and approved by the city and UDFCD.

Results

The mapping presented in May 2013 showed several spill flow paths from Twomile Canyon Creek. These major spill paths were substantiated during the September 2013 flood. The revised 2014 floodplain mapping has been refined using the city's new LiDAR topographic mapping in the hydraulic models and information collected from the 2013 storm. It should, however, be noted that no two storm events are exactly the same and therefore the refined results still differ slightly from the 2013 flood event. These discrepancies can be due to the following:

- Storm deposited flood debris, sediment and erosion;
- Impacts to flow paths from human induced emergency flood response; and
- Runoff from side tributaries and minor drainages not directly attributed to the study creek system.

The following attachments present the revised floodplain maps for Twomile Canyon Creek and Upper Goose Creek:

- **Attachment C** presents the revised mapping (2014) in comparison to the initial draft 100-year floodplain (2013).
- **Attachment D** presents the revised mapping (2014) in comparison to the documented 2013 storm flood limits.
- **Attachment E, F and G** present the revised (2014) 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 shows the structures (including summary numbers) that would be identified to be in the 100-year floodplain, those that would remain in the floodplain 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.

It should be noted that while the city used the 2013 LiDAR topographic data that provides a minimum of 16 elevation points per square meter at a minimum accuracy of 0.6 feet to develop the revised floodplain maps, residents can submit site specific survey data collected by a professional surveying for their property. If submitted before 2015, the city will incorporate this information into the remapping study model.

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 are still subject to the city's floodplain regulations until FEMA officially adopts the new floodplain mapping. Following formal adoption by FEMA, the city regulates solely based on the new mapping.

ATTACHMENTS:

- A. Summary of Estimated Debris Blockages by Channel Crossing and Rainfall Event
- B. 2013 Flood Limits and Changes to Initial Hydraulic Model
- C. [Revised Mapping \(2014\) Compared to Initial Draft 100-year floodplain \(2013\)](#)
- D. [Revised Mapping \(2014\) Compared to 2013 Flood Limits](#)
- E. [Existing FEMA and Revised Proposed 100-Year Floodplain](#)
- F. [Existing FEMA and Revised Proposed Conveyance Zone](#)
- G. [Existing FEMA and Revised Proposed High Hazard Zone](#)