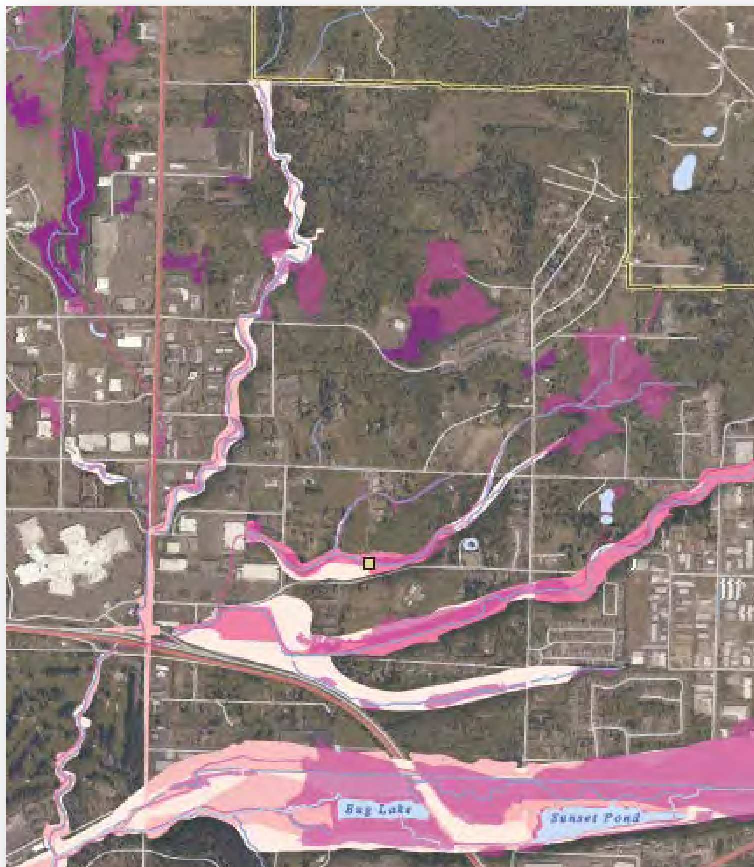
FREQUENTLY FLOODED AREAS ASSESSMENT
BEST AVAILABLE SCIENCE DOCUMENTATION
CITY OF BELLINGHAM

Submitted to Ms. Analiese Burns
August 25, 2017



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Submitted by:
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August 25, 2017

Submitted To: Analiese Burns
Habitat Restoration Manager
City of Bellingham Public Works

RE: Frequently Flooded Areas Assessment & Best Available Science Documentation

Dear Ms. Burns;

Element Solutions is pleased to present the results of our Frequently Flooded Areas assessment and mapping. The purpose of this assessment was to compile the best available science and map potential Frequently Flooded Areas for Critical Areas Ordinance regulatory review and resource planning purposes by the City of Bellingham.

Should you have any questions regarding this assessment or the associated map, please contact me at (360) 671-9172 or at ppittman@elementsolutions.org.

Sincerely,

Paul Pittman, MS, LEG
Earth and Environmental Sciences Manager - Principal

CONTENTS

1 INTRODUCTION

Purpose

Element Solutions was retained by the City of Bellingham to compile existing information and assess other areas that have been historically flooded or may be susceptible to flooding impacts. The purpose of this effort is to provide “the best available” science for “Frequently Flooded Areas” (FFA) to enable the City of Bellingham and its community to make informed development decisions, to support the environmental review of the Critical Areas Code, and to potentially identify restoration and preservation areas to support natural resource and hazard management planning.

Location and Physiography

The City of Bellingham includes several streams, relict floodplains, numerous lakes and depressional basin areas, and coastal shoreline areas that are potentially susceptible to flooding. The study area includes all mapped streams and their associated floodplain areas, lakes, marine shorelines, areas affected by dams or flood control structures, and major mapped wetland areas and basin areas within the City of Bellingham City limits and Urban Growth Area (UGA).

Bellingham Municipal Code – Frequently Flooded Areas and Best Available Science

The source for Frequently Flooded Area regulation rests with the Growth Management Act (GMA)(RCW 36.70A). Washington Department of Ecology (Ecology) and The Department of Commerce (Commerce) develop GMA guidance and oversee local jurisdiction compliance. Specific to Frequently Flooded Areas (FFAs), Ecology provides that:

> *Each local government must consider the adequacy of the **designation** and the **protection** of FFAs within their CAO. In these reviews, new information such as maps or relevant science findings needs to be integrated. Local governments will consider whether there have been updates to state statutes, other local codes or best available science that should be incorporated into the CAO. An important facet of these periodic updates is maintaining consistency with other statutes and programs. CAO reviews are also an opportunity for local governments to make enhancements of policy and regulation, particularly policies related to flood hazard management planning.*

FEMA mapping under the National Flood Insurance Program (NFIP) was designed to inform communities about flood hazards and generate flood insurance rate maps (FIRMs) for a federally supported insurance program. NFIP requirements have been integrated into state and local codes (RCW 86.16 and BMC 17.76 respectively). The “FEMA map” is often the surrogate map used for FFA regulations in lieu of other improved or updated flood mapping. As a result, FFAs are often overlooked in regulatory review as, on the surface, it appears to serve a duplicate role with FEMA regulations and has considerable overlap. Where FEMA mapping is not available, local jurisdictions often have no other sources of flooding information. The FEMA mapping information is now many decades old and an effort to modernize and increase the resolution and mapping accuracy are in various stages throughout NFIP communities, including the City of Bellingham. Ecology further recognizes that floodplain hazards also include channel migration in addition to

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flood inundation. In response, they have provided guidance to develop "Channel Migration Zones" (CMZs) to add additional flood hazard management tools for local regulatory jurisdictions.

The FFA intent is to span the hazard aspects of FEMA and the CMZ, and add a habitat consideration to assess floodplain ecological function and potential development impacts. Further, the FFA can be used to fill gaps where FEMA and CMZ mapping do not exist, as well as expand flood hazard management tools beyond the FEMA minimums where better information exists. Ecology recommends Critical Areas Ordinances consider the following standards:

New information may warrant changes to Critical Areas Ordinances policy objectives that focus on protecting property and improving habitat in floodplains. In the Puget Sound region, local governments can take steps to change how they manage their floodplains to simplify permitting for floodplain development and other activities.

- ***Habitat protection**: Increasingly, there is recognition of the importance of floodplains as vital habitat to support salmon and other species. Relevant information may be found in updates to salmon recovery plans, channel migration zone mapping or other sources. These sources should be considered in development of revised Critical Areas Ordinances provisions which better protect riparian habitat. These protections may be addressed under the FFA provisions or within the Fish and Wildlife Habitat Conservation Area provisions of a Critical Areas Ordinances. (For more information on land use planning for salmon, see the WA Department of Fish and Wildlife's land use planner's guide to salmonid habitat protection and recovery (PDF).)*
- ***Endangered Species protection:** Local governments have responsibility, under the Endangered Species Act, for preventing harm to listed fish and other species that commonly inhabit floodplains. No adverse effects to habitat function are allowed in specified areas that are vital to these species.*
- ***Address Unique Circumstances and Climate Change:** A jurisdiction may have unique risks due to the potential for tsunamis, high tides with strong winds, sea level rise or extreme weather events that it may want to address in its FFA provisions.*
- ***Flood risk reduction beyond FEMA minimums:** Ecology and FEMA encourage local governments to go beyond the FEMA minimum requirements for floodplain management. Greater protection from floods may be a policy objective that should be incorporated into the Critical Areas Ordinances. For example, some jurisdictions use the "flood of record" elevations to regulate the minimum elevation of structures, where the record flood is higher than the 100-year flood elevation used by FEMA (called the Base Flood Elevation [BFE]).*

Bellingham Municipal Code (BMC) regulates Critical Areas through BMC Chapter 16.55. Frequently Flooded Areas are designated in Section 16.55.370 as follows:

16.55.370 Designation of frequently flooded areas.

A. The purpose for the following designations, requirements and standards for frequently flooded areas shall be to:

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1. Reduce the risk to life and safety, public facilities, and public and private property that result from floods;

2. Avoid and minimize impacts to fish and wildlife habitats that occur within frequently flooded areas;

3. To assure that flood loss reduction measures protect and are consistent with retaining natural floodplain functions related to protecting riparian habitat and the natural processes that create and maintain habitat for fish;

4. To assure maintenance of hydraulic, geomorphic, and ecological functions of floodplains;

5. Controlling filling, grading, dredging, and other development activities which may increase flood damage and alter beneficial natural stream processes; and

6. Preventing or regulating the construction of flood barriers which may unnaturally divert floodwaters in such a way as to block natural channel migration, or may increase flood hazards in other areas.

B. Frequently flooded areas shall include, but are not limited to:

1. Lands as defined in Chapter 17.76 *BMC in which the floodplain is subject to a one percent or greater chance of flooding in any given year and those lands that provide important flood storage, conveyance, channel forming processes and attenuation functions, as determined by the city in accordance with WAC* 365-190-080*(3). Classifications of frequently flooded areas include, at a minimum, the 100-year floodplain designations of the Federal Emergency Management Agency and the National Flood Insurance Program;*

2. Areas Identified by the Public Works Director. Those areas of special flood hazard identified by the public works director based on review of base flood elevation, floodway data, historical data, high water marks, photographs of past flooding, or similar information available from federal, state, county, city or other valid sources when base flood elevation data from FEMA has not been provided or is not accurate;

3. The approximate location and extent of frequently flooded areas are shown on the city's critical area maps. These maps are to be used as a guide and do not provide a

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definitive critical area designation. The city shall update the maps as new hazard areas are identified and as new information becomes available. This article does not imply that land outside mapped frequently flooded areas or uses permitted within such areas will be free from flooding or flood damages. This chapter shall not create liability on the part of the City of Bellingham, or any officer or employee thereof, for any flood damages that result from reliance on this chapter or any administrative decision lawfully made hereunder. [Ord. 2016-02-005 *§ 27; amended during 2013 recodification; Ord.* 2005-11-092*].*

Currently, the City of Bellingham has no formally adopted or comprehensive compilation of flood prone or potentially flooded areas; therefore, the use of the FEMA floodplain serves as the source of mapping used to screen development for Frequently Flooded Areas review. BMC 16.55 provides for the use of "best available science" to support regulatory review as follows:

16.55.180 Best available science.

A. Protect Functions and Values of Critical Areas with Special Consideration to Anadromous Fish. Critical area reports and decisions to alter critical areas shall rely on the best available science to protect the functions and values of critical areas and must give special consideration to conservation or protection measures necessary to preserve or enhance anadromous fish, such as salmon, steelhead, cutthroat trout and their habitat.

B. Best Available Science to Be Consistent with Criteria. The best available science is that scientific information applicable to the critical area prepared by local, state, or federal natural resource agencies, a qualified scientific professional, or team of qualified scientific professionals that is consistent with criteria established in WAC 365-195-900 through 365-195-925.

C. Characteristics of a Valid Scientific Process. In the context of critical areas protection, a valid scientific process is one that produces reliable information useful in understanding the consequences of a local government's regulatory decisions, and in developing critical areas policies and development regulations that will be effective in protecting the functions and values of critical areas. To determine whether information received during the permit review process is reliable scientific information, the director shall determine whether the source of the information displays the characteristics of a valid scientific process. Such characteristics are as follows:

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1. Methods. The methods used to obtain the information are clearly stated and reproducible. The methods are standardized in the pertinent scientific discipline or, if not, the methods have been appropriately reviewed to ensure their reliability and validity;

2. Logical Conclusions and Reasonable Inferences. The conclusions presented are based on reasonable assumptions supported by other studies and consistent with the general theory underlying the assumptions. The conclusions are logically and reasonably derived from the assumptions and supported by the data presented. Any gaps in information and inconsistencies with other pertinent scientific information are adequately explained;

3. Quantitative Analysis. The data has been analyzed using appropriate statistical or quantitative methods. Data collection locations are accurately mapped or surveyed;

4. Context. The information is placed in proper context. The assumptions, analytical techniques, data, and conclusions are appropriately framed with respect to the prevailing body of pertinent scientific knowledge; and

5. References. The assumptions, analytical techniques, and conclusions are well referenced with citations to relevant, credible literature and other pertinent existing information.

D. Absence of Valid Scientific Information. Where there is an absence of valid scientific information or incomplete scientific information relating to a critical area leading to uncertainty about the risk to critical area function of permitting an alteration of or impact to the critical area, the director shall take a "precautionary approach," that strictly limits development and land use activities until the uncertainty is sufficiently resolved. [Ord. 2005-11-092].

2 METHODS

General Outline of Analysis and Interpretations Methods

The approach to identify and delineate a FFA for regulatory and planning purposes utilized the following methodologies:

- Geomorphic analysis to map "geomorphic" floodplains, shoreline areas, basins or other landforms that support flooding processes;
- Desktop integration of existing spatial hydrologic information, including FEMA mapping, independent or other sources of hydraulic modeling, public domain wetland mapping, air photo analysis, and other public domain spatial information as appropriate, including LiDAR DEM modeling;
- Research and collection of "anecdotal" or other information on historic flooding areas, events, and occurrences from Public Work staff, data records or other firsthand accounts that are discovered

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- GIS spatial mapping compilation, annotation, and geodatabase development;
- Review of other local jurisdiction FFA code and mapping for comparative purposes; and
- Summary documentation of methodologies, data sources, mapping and findings.

To complete the study, the following tasks were conducted:
- Project meetings with City Staff
- Desktop mapping, data integration, modeling, and analysis
- Map and documentation compilation and City review
- Final mapping and documentation.

Specific Task Methods

The FFA study built upon existing information to the greatest extent possible; however, digital elevation model (DEM) analysis using the City of Bellingham LiDAR data (2013) was also utilized to identify potential areas of flooding based on topographic conditions. The combined effort consisted of acquiring existing data, pre-processing the data, computer-based delineating of streams from the DEM, modeling and digitizing depressional areas, selecting areas that may be hydrologically connected to wetlands and floodplains based on the City of Bellingham open channels data and computer-based delineated streams, integrating previously mapped wetlands, and the DEM delineated streams network. These datasets were compiled for visual purposes, but remain as individual spatial datasets within the geodatabase. The geospatial data used in this study is inventoried in Table 1. Methods for the individual elements of the project are as follows below.

Table 1: Data used for desktop analysis

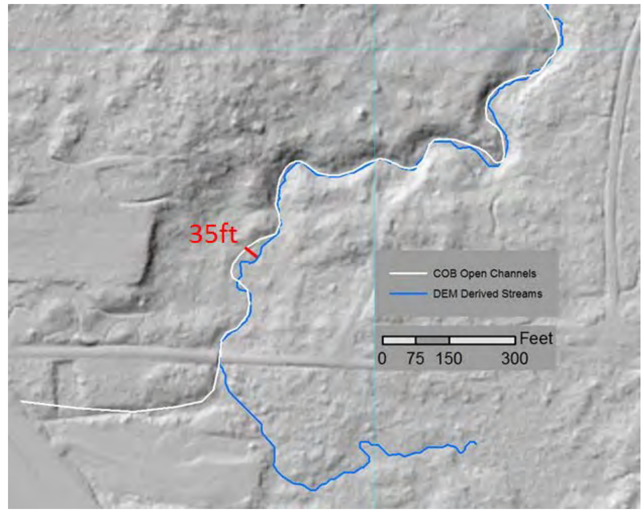
Data	Format	Date	Source
Aerial photography	SID	2013	City of Bellingham
LiDAR	Bare earth grid	2013	City of Bellingham
FEMA	Shapefile	2004	Department of Ecology
Streams	Shapefile	2012	City of Bellingham
Wetland Mapping	Shapefile	2015	City of Bellingham
Other Geospatial Environmental Mapping	Shapefile	Various	City of Bellingham
Dam Mapping & Emergency Action Plans	Paper Report	Various	Dept. of Ecology
Basin Studies	Text (paper documents)	Various	City of Bellingham

Existing Data

The existing raw data for this study was acquired through public domains hosted by the Washington State Department of Ecology and the City of Bellingham. Some data had to be projected and digitized from paper sources, such as the dam emergency action plans, as well as using data from previous projects, such as the Squalicum Creek Channel Migration Zone Study. The most recent FEMA DFIRM data was downloaded from the DOE website. The wetland data used for the study was downloaded from the City of Bellingham online GIS Data Center. The wetland datasets used are, as they appear in the GIS Data Center: Wetlands 2015 Inventory, Wetlands 2015 Site Assessment, and Wetlands Site Specific Delineations. The USFWS National

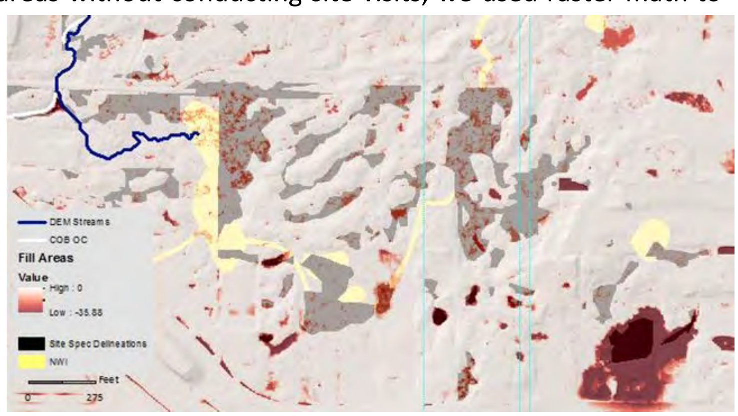
Wetland Inventory data was downloaded from the U.S. Fish and Wildlife website. All data was then projected into NAD 1983 State Plane Washington North (US Feet) then clipped to the city and urban growth area limits.

Streams and Potential Surface Water Routing



We used the City of Bellingham 2013 hydro-flattened bare earth DEM to delineate areas of water accumulation (basins) and routing (streams, ditches, or potential surface water) throughout the study area. We used the Hydrology toolset within the Spatial Analyst extension in ArcMap 10.4.1 to create a continuous and depressionless DEM raster for modeling hydrologic flow across the surface. We first filled all sinks (basins, depressions, and "low spots") in the DEM. From the fill raster, we created a flow direction and a flow accumulation raster. Within the flow accumulation raster, we set a threshold of 200,000 pixels, signifying that pixels with fewer than 200,000 pixels 'up stream' are eliminated. This eliminates areas of approximately 150,000 square feet (sf) or less, but includes areas greater than 150,000 sf as watershed areas that may be capable of routing surface water. This threshold allowed a finer level of detail over the mapped datasets but not so much detail as to be unrealistic or unreasonable. The accumulation raster was then used to create a vector file for streams for further analysis and cartographic purposes. The result is a stream network that has a higher degree of location accuracy.

Potential Ponding/Flooding Areas Using DEM Surfaces and Interpolated Depressions



To aid in mapping potential ponding areas without conducting site visits, we used raster math to identify and visualize depressions in the local topography, particularly in forested areas. We subtracted the original bare earth DEM from the fill raster created in the stream delineation. The resulting values are differences between the two surfaces showing areas that were filled in the creation of the fill raster. Larger continuous sinks were digitized, then a spatial query was performed to select only the Fill polygons that intersected the stream layers or hydrologically connected wetlands. Visual analysis and supplemental anecdotal information from property owners and city storm water maintenance employees was considered in the individual selection of some fill areas. LiDAR error was observed locally in heavily forested areas with complex topography, which is not uncommon (Mahler,

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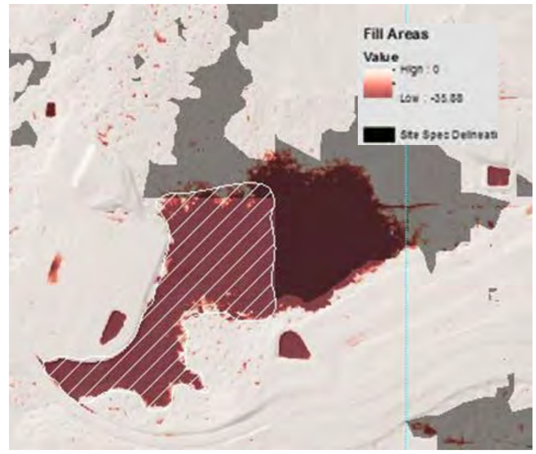
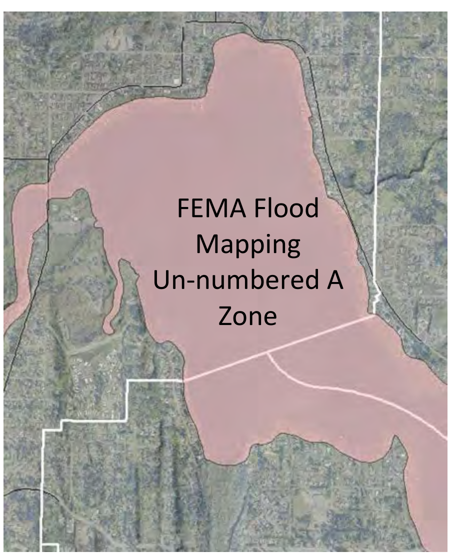
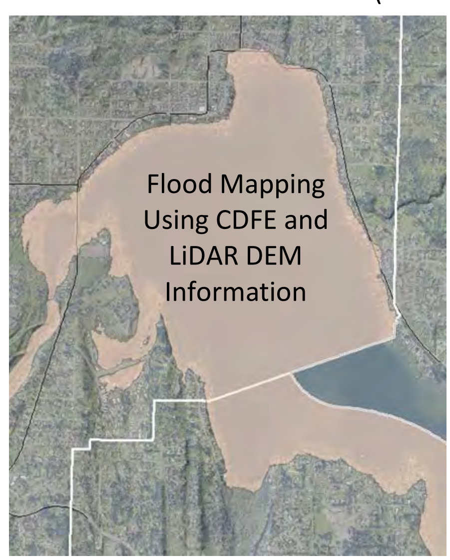
2012). Most single cell sinks and smaller sinks are also likely to be errors in the data (Gritzner, 2006). Sinks between 0 and -0.02 feet, the absolute accuracy of the acquired LIDAR data, were omitted as general error. After "cleaning" the data through the visual QA/QC process, we classified and color coded the different depths of sinks to visually assess and conduct a final review using professional judgment to confirm the method only resulted in features that appeared relevant. One of the qualitative calibration methods was to turn on the hydrologically connected wetlands layer to compare the sinks with the mapped wetlands in the areas (Gritzner, 2006). In general, we found good correlation between the delineated wetland boundaries with the DEM modeled depressions from the Fill raster (see illustration at right). We assume error of 2-3 meters between the DEM and the delineated wetland boundaries based on other similar assessment findings (Mahler, 2012). It became apparent the data was useful to identify potential unmapped depressional wetland areas where a delineation was cut off because of a parcel boundary or in improving the accuracy of National Wetland Inventory mapping. This layer was named "DEM Interpolated Depressions" for this analysis.



Lake Whatcom Community Determined Flood Elevation

The FEMA Flood Zone mapping on Lake Whatcom shows an Unnumbered A Zone and was drafted with poor resolution topography; therefore, the FEMA mapping has inaccuracies that make hazard screening difficult. The City of Bellingham uses a Community Determined Flood Elevation (CDFE) that was calculated by Whatcom County River and Flood Division using information from the dam outlet (Appendix 1). The elevation of the CDFE was established from documented elevations at the dam. The elevations reported by Whatcom County are: **319.0 Feet City Datum**; or **313.3 Feet NGVD1929 Datum**; or **317.3 Feet NAVD88 Datum**. We utilized the study datum conversions to show a Lake Whatcom CDFE inundation area of 318 feet on the 2013 LiDAR DEM (NAVD88) to be





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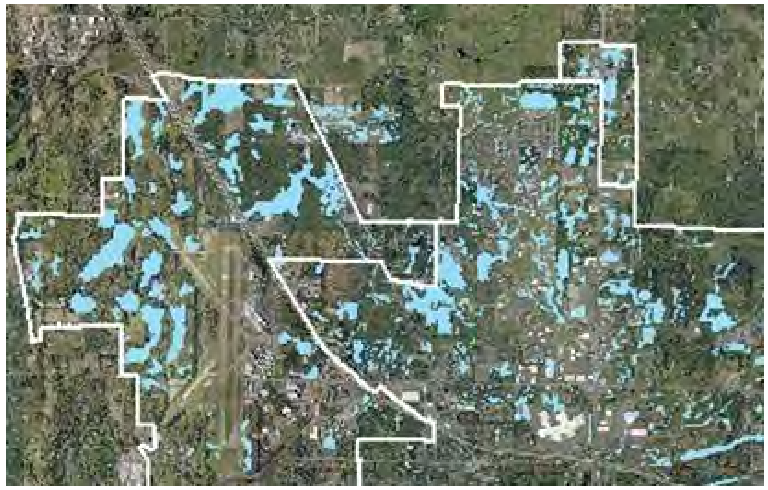
consistent with Whatcom County mapping (they map the 318.0 Feet NAVD88 contour).

Wetland Areas



Wetlands (COB mapped and DEM depressions) were assumed to be hydrologically connected to stream networks if they were proximate to stream channels (COB mapped streams and DEM derived networks). We assumed a distance of 20 feet between wetland edge and stream edge for the criteria of hydrologically connected for this analysis. No field verifications were performed to confirm this assumption. Hydrologically connected wetlands were selected by creating a model in ArcMap's Model Builder. We disassociated the city mapped wetland polygons to create multipart features and allow selection of individual wetlands. In the Site Specific Delineation layer, only wetlands indicated as "existing" in the attributes table were used for analysis. Within the model we made a spatial query of all wetlands within 20 feet horizontally from both the City's Open Channels data and the DEM Derived Streams layers. Multiple iterations (a minimum of 4) were run to select intersecting wetland boundaries between all the data layers to obtain the maximum extent of any mapped wetland. We then ran a visual QA/QC over the datasets. The result was a new layer called "hydrologically connected wetlands" within this study.

Geomorphic Migration Zone (GMZ)

The Squalicum Creek watershed and flood plain within the study is unique from the other streams and floodplains in that it flows within a relict glacial alluvial plain that was formed during glacial times when the watershed area and contributing flows were much larger. Therefore, today's channels within the Squalicum Creek watershed are "underfit stream" flowing within relict stream works. As a result, they have much broader floodplain areas. For this analysis, we utilized the geomorphic floodplain that was identified and mapped in the Squalicum Creek Watershed Channel Migration Zone Study (Element Solutions, 2016). An example of the Squalicum Creek watershed GMZ is represented as the brown areas shown in the graphic at right.

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Modeled Dam Inundation Areas

We reviewed Emergency Action Plans from the Department of Ecology concerning the dams that exist within Bellingham city limits and urban growth areas. We georeferenced and digitized areas of inundation below the dams in the event of dam failure at full capacity. We then reviewed areas of potential flooding above the dams at full capacity by digitizing contours drawn immediately above the spill point. It was determined that the dam inundation areas may not be well suited to the FFA criteria as these are engineered and controled structures and the flooding potential is low and not "frequent". However, the data exists in the geospatial database deliverable in case this interpretation changes in the future.

Frequently Flooded Area (FFA) Map

The FFA map is a merged composite of the sum of the derived polygon layers described above to create comprehensive best available science information for identifying potentially Frequently Flooded Areas. The mapped polygons include attribute fields indicating the FFA Class and the data source of individual polygons. The spatial data was provided to the City so that the map could be updated as new information becomes available. The map provided in this report only reflects a best available science "snap shot" at the time of this report. This map should only be used for planning-level purposes or regulatory screening only. No detailed analysis or ground confirmation was conducted as part of this mapping effort.

3 ANALYSIS OF OTHER JURISDICTION'S FREQUENTLY FLOODED AREAS REGULATIONS AND MAPPING

Review of other Jurisdiction's (County/Municipality) Code Concerning FFA

Almost all municipalities reviewed in Western Washington were found to adhere to the bare minimum of frequently flooded areas requirements specified in the GMA guidance by referencing the FEMA 100-year floodplain as the FFA. Many areas use different terminology within their code and often referring to FFAs as flood hazard areas or high groundwater areas. No FFA specific mapping or methodologies were identified in our review.

All information was obtained by visiting the jurisdictions web portal and searching through their code or websites. Often the information is in the critical areas section or updates to the critical areas ordinances. The following summarizes the code and FFA data source:

- King County, Chapter 21A.24.230- FEMA 100-yr Floodplain and/or Channel Migration Zones
- Thurston County, Chapter 24.20 - FEMA 100-yr Floodplain (also referenced as the high groundwater flood hazard area using the FEMA base flood elevation)
- Snohomish County, Assistance Bulletin #42 – FEMA 100yr.
- Island County, Chapter 17.02- FEMA 100-yr, only coastal storm surge.
- Skagit County Chapter 14.34.050- FEMA 100-yr.
- Pierce County, Chapter 18E.70 - FEMA Flood Areas A and V, +300 ft horizontal from base flood elevation (BFE) for mapped A and V zones, +5 ft vertical from BFE in mapped A and V zones and/or channel migration zones. Open departmental interpretations of flood maps.

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- City of Edmunds, Chapter 23.70- FEMA or per hydrologist or engineer recommendations on a case by case basis.

The outliers in definitions and mapping sources are Pierce County, the City of Edmonds and Thurston County. Pierce County outlines general FFAs by adding horizontal (+300 feet) and vertical (+5 ft) distances above the base flood elevation and defining FFAs for general or unmapped watercourses as 65-ft horizontal from edge of stream. These general watercourses do not include areas with channel migration zones. Pierce County has a list of streams where detailed CMZ studies have been done (18E.70 PCC).

The City of Edmunds uses the FEMA 100-yr flood maps and "City Discretion and Designation" (23.70.010), but formal FFA maps or detailed study were not identified. "City Discretion and Designation" appears to be at a minimum FEMA 100-year floodplain and the City's internal information and critical areas inventory is to be used as an informal guide to support the City of Edmonds' regulatory staff, project applicants and/or property owners, and the public. The internal information was not readily available online and is used on a case-by-case basis, if at all.

Thurston County regulates from the "High Groundwater Flood Hazard Area". The HGFHAs are defined by Thurston County on their Flood Hazard Area Resource Map or are delineated on a Thurston County groundwater study (14.38 TCC). The FEMA mapping appears to the basis for the flood hazard area mapping and the HGFHAs. Regulation in these areas states there are two zones; a "no development zone" and a "restricted development zone". The "no development" zone extends 50-ft horizontally from the HGFHA or 2-ft vertically, whichever is less (24.20.020 TCC). The restricted development zone extends from the outer edge of the no development zone to 2-ft vertically (24.20.025 TCC).

Other Information reviewed:

- DOE CAO Guidance for FFA
  http://www.ecy.wa.gov/programs/sea/floods/FloodedAreaGuidance.html

- FEMA Flood Zone Designations
  http://snmapmod.snco.us/fmm/document/fema-flood-zone-definitions.pdf

- WA State Coastal Atlas and Terms
  https://fortress.wa.gov/ecy/coastalatlas/tools/Flood.aspx.

4 USE OF DATA AND RECOMMENDATIONS

Additional Assessment Methods Available to Improve the Best Available Science for FFA Analysis and Mapping

The purpose of this study was to analyze and map the FFA using established methods and readily available data. The resulting mapping has limited accuracy and may not be applicable for site specific designs or even more regional hydrologic assessment. It should be used only as an information source and screening level tool for some regulatory and planning-level purposes.

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Additional assessment methods are recommended to more definitively understand, quantify and map FFAs. A few of the potential tools to improve FFA mapping accuracy, when needed include, but are not limited to:

- Hydrologic/hydraulic modeling using any number of models and higher resolution surface and infrastructure geometries. For larger streams, a regional hydraulic model could improve the prediction of areas of inundation as well as provide depth and velocity information that would provide useful information for site design and management. For smaller scale streams or watercourses, localized or site-specific hydraulic modeling may be more applicable.
- Use of LIDAR return intensity data is a measure of point returns to the scanner. This could improve the data in forested areas which compromises much of Bellingham and the urban growth and undeveloped areas. By analyzing the intensity data, fill raster and existing wetland data the accuracy of the LIDAR in a specific area could be assessed while comparing to known or suspected wetland boundaries (Lang, 2009). The use of LIDAR in classifying land cover that is inundated or non-inundated in forested areas based on digital signature from point intensity data provided a 96.7% accurate classification of inundated areas (Lang, 2009). The use of digital aerial photography in forested areas only classified 65.8% of inundated land cover accurately (Lang, 2009). This is an emerging field of study that shows promise for mapping wetlands off site and in forested areas. As the frequently flooded areas map is a preliminary screening document intended to initiate another level of investigation in the presence of a potentially flooded area and given the review of current practices involving LIDAR and depressional wetland mapping. The conservative use of the fill raster methods to expand on known wetland boundaries could be a useful tool for protecting flood storage in areas where on-site reconnaissance is unavailable or as part of cumulative impact assessment and planning efforts.

Recommendations

We recommend that the City of Bellingham use the data provided in this assessment as best available science to:

- Provide the public with a source of information as to areas that may be prone to flooding;
- Provide regulators a screening-level tool to assist with implementation of the Critical Areas Ordinance 16.55.370 and be a source of best available science;
- Provide applicants a reference tool and a starting point for assessing potential impacts from proposed development actions on potential FFAs;
- Provide planners and natural resource managers with information to help guide preservation, conservation, and restoration priorities as well as evaluate areas vulnerable given cumulative impacts from off-site projects and build-out;
- Be compliant with GMA Critical Areas requirements.

The geospatial dataset delivered with this document is dynamic and includes the sum of all information determined in the scope of work. The City has the choice about what data to include both in the public map and in the regulatory screening tool. The City also has the ability to update this dataset in the future to keep the dataset current and relevant. We believe that this document and the geospatial dataset will enable the City to meet the following objectives:

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- *Reduce the risk to life and safety, public facilities, and public and private property that result from floods;*
- *Avoid and minimize impacts to fish and wildlife habitats that occur within frequently flooded areas;*
- *To assure that flood loss reduction measures protect and are consistent with retaining natural floodplain functions related to protecting riparian habitat and the natural processes that create and maintain habitat for fish;*
- *To assure maintenance of hydraulic, geomorphic, and ecological functions of floodplains;*
- *Controlling filling, grading, dredging, and other development activities which may increase flood damage and alter beneficial natural stream processes; and*
- *Preventing or regulating the construction of flood barriers which may unnaturally divert floodwaters in such a way as to block natural channel migration, or may increase flood hazards in other areas.*

5 Closure

This report was submitted by:

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Statement of Limitations

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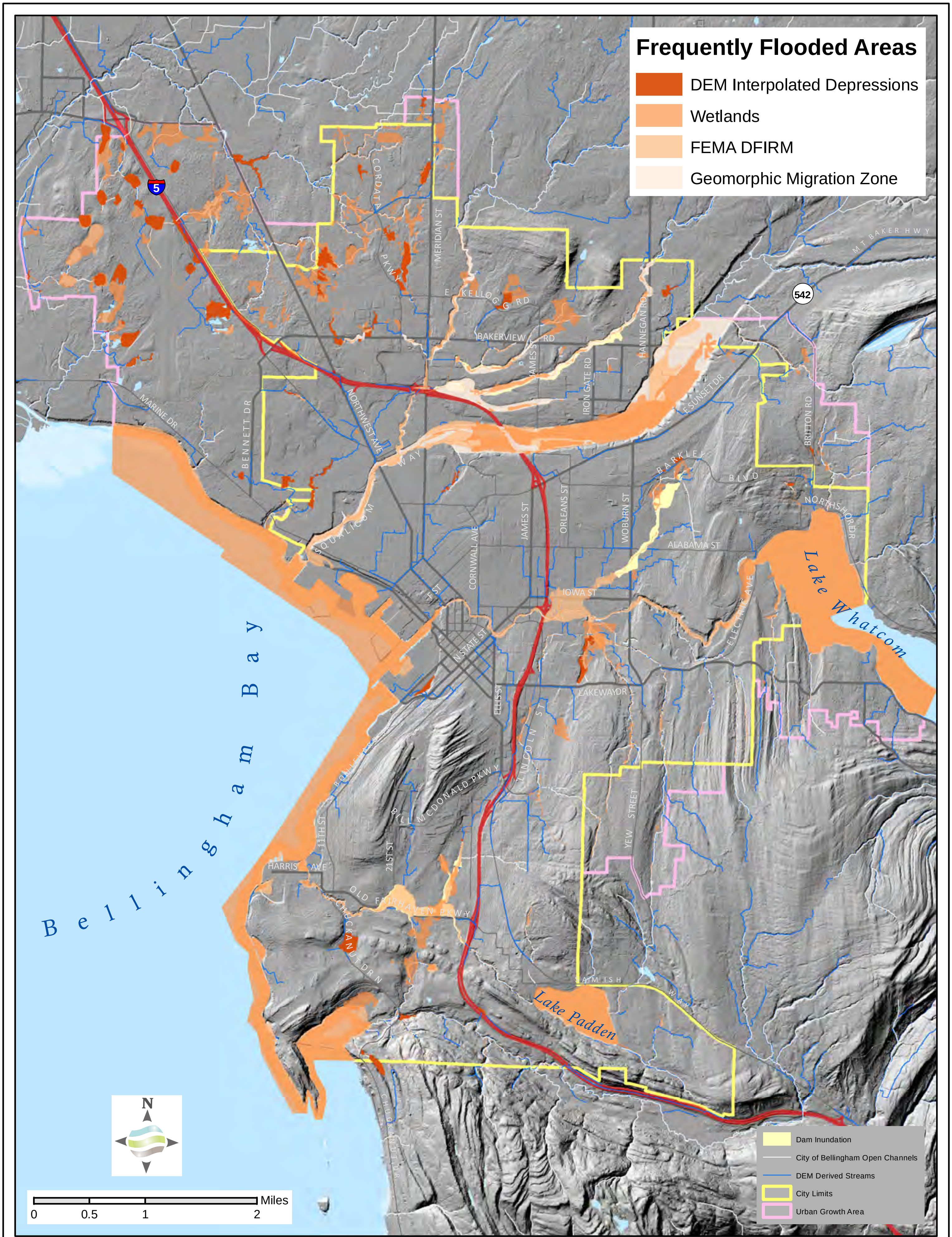

Author: Lucas Phillips. Data Credits: COB 2016, USGS 2006

APPENDIX 1: LAKE WHATCOM COMMUNITY DETERMINED FLOOD ELEVATION DATA

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LAKE WHATCOM BFE DOCUMENTATION
July 29, 2010 PJC

The Dam Safety Section (DSS) of DOE performed inspections of the Lake Whatcom dam in 1980, 1992 and 2007. The BFE was initially estimated in 1999 using information from 1992 report in conjunction with historical data on lake levels. The initial estimate was reviewed with information from the 2007 inspection report to confirm the updated data is not in conflict with the initial determination.

Bill Reilly, engineer with the City of Bellingham, provided an estimate of the highest lake level since the dam was constructed of 318 ft (City datum).

The 1992 DSS report documented the hydrologic analysis performed to assess the adequacy of the spillway. Due to the consequences associated with failure of this dam, they routed the Probable Maximum Flood (PMF) through the reservoir. This resulted in a maximum lake level of 319.7 ft (City datum).

A 2007 DSS technical memorandum documents an updated analysis of the reservoir and dam. Again the PMF was used to evaluate adequacy of the spillway. The revised analysis concluded that the peak lake level during the PMF would be 320.0 ft.

An estimated 100-year lake level of 319 ft (City datum) was considered appropriate, as the 100-year level should be higher than the highest observed level and less than the PMF.

Since the initial determination, DOE routed a 100-year event through the hydrologic model for the lake to evaluate the appropriateness of the BFE estimate. This work is documented in a memorandum dated July 14, 2010 and supports the determination of 319 ft for a BFE for Lake Whatcom.

Conversion of the elevation in the City datum to NGVD 29 requires subtracting 5.7 ft to produce a BFE of 313.7 ft (NGVD 29). Converting the NGVD 29 datum to the NAVD 88 datum yields a final BFE of 317.2 ft (NAVD 88).

The USGS LiDAR DTM was used to generate 1-foot contours and the floodplain was mapped along the 318 ft contour.

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November 16, 2015

Unnumbered A Zones – Lakes & Creeks

RE: Un-numbered "A" Zone Community Determined Base Flood Elevations (BFE) & FEMA mapping

- Lake Whatcom:
  - Community BFE= **319.0 Feet (City Datum) or 313.3 Feet (NGVD1929) or 317.3 (NAVD88)**
  - Contour Mapped= **318.0 Feet (NAVD88)**
- Lake Samish:
  - Community BFE= **275.5 Feet (NGVD1929) or 279.5 Feet (NAVD88)**
  - Contour Mapped= **280.0 Feet (NAVD88)**
- Toad Lake:
  - Community BFE= **717.1 Feet (NGVD1929) or 721.1 Feet (NAVD88)**
  - Contour Mapped= **722.0 Feet (NAVD88)**
- Wiser Lake:
  - Community BFE= **53.0 Feet (NGVD1929) or 57.0 Feet (NAVD88)**
  - Contour Mapped= **57.0 Feet (NAVD88)***
- Cain Lake:
  - Community BFE= **393.7 Feet (NGVD29) or 397.7 Feet (NAVD88)**
  - Contour Mapped= **398.0 Feet (NAVD88)****
- Reed Lake:
  - Community BFE= **401.3 Feet (NGVD29) or 405.2 Feet (NAVD88)**
  - Contour Mapped= **405.0 Feet (NAVD88)*****
- California Creek (California Trail area):
  - Community BFE= **9.3 Feet (NGVD29) or 13.2 Feet (NAVD88) ******

*****0.5-1' of safety factor is built into the BFE, this elevation fit the lake and shoreline best as shown on the current high-resolution orthophoto's (2008).

******2' was added to BFE for mapping because no survey of the outlet on file that is tied into Vertical control and lack of enough LiDAR elevations on the bridge at the outlet, this elevation fit the lake and shoreline best as shown on the current high-resolution orthophoto's (2008). Still waiting for official survey to issue more accurate Community BFE.

******* Worst case scenario BFE based on stop-logs in place, have survey/drawing on file at the dam, outlet/spillway (dated 7/9/2010) and this elevation fit the lake and shoreline best as shown on the current high-resolution orthophoto's (2008).

******** BFE based on FEMA-LOMA determination for California Trail area.

NOTE: Conversion factor from NGVD29 to NAVD88 ranged from 3.88 to 3.93 feet, 4.0 feet was used for mapping. All contours were generated using the 2006 Post-Processed USGS LiDAR…