Clover Creek Flood Study
Engineering Report

Prepared for
City of Lakewood
Lakewood, WA
February 2023

Acknowledgements

Brown and Caldwell acknowledge the valuable contributions made by the City of Lakewood in conducting the Clover Creek Flood Study. Specifically, the project team recognizes the following City personnel for their efforts:

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1D	one-dimensional
2D	two-dimensional
BC	Brown and Caldwell
BCE	business case evaluation
BNSF	Burlington Northern Santa Fe
BRIC	Building Resilient Infrastructure and Communities
CIP	capital improvement program
City	City of Lakewood
CPOD	Comprehensive Plan of Development
DEI	diversity, equity, and inclusion
Ecology	Washington State Department of Ecology
FCAAP	Flood Control Assistance Account Program
FCZD	Flood Control Zone District
FEMA	Federal Emergency Management Agency
FMA	Flood Mitigation Assistance
HEC-RAS	Hydrologic Engineering Center River Analysis System
I-5	Interstate 5
JBLM	Joint Base Lewis-McChord
LOMR	Letter of Map Revision
MCDA	Multi-Criteria Decision Analysis
NOI	Notice of Intent
TMDL	total maximum daily load
USACE	United States Army Corps of Engineers
USEPA	Unites States Environmental Protection Agency
WIFIA	Water Investment in Federal Infrastructure Act
WSE	Watershed Science & Engineering
WSDOT	Washington State Department of Transportation

Executive Summary

The City of Lakewood (City) initiated this study and developed this Engineering Report to generate and evaluate project alternatives to mitigate 100-year flood risk along Clover Creek within the City limits. Federal Emergency Management Agency (FEMA) mapping reveals that the predicted 100-year flooding event would inundate portions of the City east of Interstate 5 (I-5) and north of Clover Creek. The intent of this engineering report is to evaluate potential alternative mitigation measures and determine the preferred alternative based on criteria developed as part of the study, engage stakeholders and the community, and utilize the existing hydrologic and hydraulic model to inform potential alternative flood reduction.

The hydrologic and hydraulic flood model was updated in 2019 for Clover Creek, which revealed a significant increase to the area impacted by floodwater when compared to the previous FEMA effective map of inundation for the 100-year event. The updated model suggests a significant portion of the City of Lakewood could be impacted by the floodwaters, including I-5. The flooding to I-5 could potentially result in significant new regulatory constraints placed on I-5. The City paused further coordination with FEMA to explore flood mitigation alternatives to reduce these potential impacts to the City and I-5. Refer to Section 3 for an in-depth discussion of the modeling results.

This report documents the potential flood mitigation alternatives that were developed and evaluated as part of this study and the resulting preferred alternative. This study and report provide the City and stakeholders with the information necessary to move forward with next steps to secure the funding and generate political support to proceed with the planning, design, and construction of the preferred alternative. See Section 2 for a full discussion of the alternative development, screening, and prioritization process and results.

This study considered many potential alternatives to mitigate flooding from Clover Creek. Four were evaluated in greater depth following an initial screening and prioritization of potential options:

- Do Nothing
- Stream and Channel Enhancements
- I-5 Levee
- Levee

The Do Nothing alternative would maintain the current floodplain and I-5 inundation risk as documented by FEMA and include the new areas shown to be inundated with the latest model updates.

The Stream and Channel Enhancement alternative would explore locations and areas where the Clover Creek riparian area and floodplain could be expanded to enhance the capacity of the creek and reduce flooding. This alternative would also put an emphasis on restoration activities that would benefit water quality in addition to salmon and other native species.

The I-5 Levee alternative would provide flood blockage such that I-5 and areas of the city west of I-5 would not be inundated. Much of the land east of I-5 would remain within the floodplain.

The Levee alternative would place a flood blocking structure along or setback from Clover Creek that would block nearly all flood water from the city. This alternative provides the most comprehensive flood mitigation benefit.

The preferred alternative is the Levee. However, significant elements of stream restoration and habitat enhancement should be considered as part of the preferred alternative to provide the greatest benefit to the creek and the community. Section 4 provides a full discussion of the alternative evaluation.

Local, state, and federal funding options including grants, loans, and partnering opportunities have been reviewed and evaluated as part of this study. Each funding option has been documented with steps for applying for and advancing each opportunity. Funding options and recommendations, including an approach and basic timeline, are detailed in Section 5.

Public engagement included developing a stakeholder committee and engaging with the community of Lakewood. The project team engaged key stakeholders to secure their involvement, meeting with the committee four times to share the study progress and receive feedback and input. The community of Lakewood participated in two meetings where the project status was shared and allowed time for questions. Section 6 highlights the outreach completed as part of this study.

Section 1

Project Background

This engineering report outlines the development and evaluation of potential flood mitigation alternatives and recommends a preferred alternative. This work was initiated based on updated floodplain modeling. The impetus for updating the flood modeling and initiating this study began with the City reviewing the effective Federal Emergency Management Agency (FEMA) flood maps and suspecting the maps may be over-predicting the flood inundation. The City contracted Watershed Science & Engineering (WSE) to update the hydrology and hydraulic model to better predict the 100-year flood extent. The updated model results revealed an increase to the 100-year flood extent.

The updated 100-year floodplain was presented to regulators for consideration. The updated floodplain would significantly increase risk to the City, its infrastructure, and private property and impose significant cost to property owners in the form of flood insurance. Additionally, the FEMA designated floodway would increase within the Clover Creek riparian area but also be designated in areas outside of the creek and across Interstate 5 (I-5). A floodway designation by FEMA limits development and structural changes to the floodway and has significant flood insurance implications.

Based on this information, City leaders requested to pause any further update to the 100-year floodplain with FEMA so that a study could be performed to evaluate potential mitigation alternatives that could reduce the impact of an updated floodplain designation and the likelihood of flood impacts.

The study area along Clover Creek begins at the Burlington Northern Santa Fe (BNSF) railroad to the east, which runs north—south and extends to Steilacoom Lake where Clover Creek terminates (Figure 1.)

1.1 Flooding History

Clover Creek has a history of flooding, most recently in 1996 when the Gen-Villa Apartments were flooded. Flooding has also occurred over the years downstream of the Gen-Villa Apartments along 58th Avenue SW and the surrounding properties. Flooding can be characterized as ‘nuisance flooding’ and localized flooding may occur a few times per year or not at all, depending on the winter. There is no record or observation of a larger flood that has inundated the area in the way a 100-year event would impact Lakewood.

Lakewood and the surrounding region are characterized by unusual geology and hydrogeology due to past continental and alpine glaciation. The subsurface geology can absorb and move water from upstream to downstream locations. The groundwater/surface water interface is most prominent in the Graham, Frederickson, and Spanaway communities where groundwater reaches the surface and can flood areas for weeks, as it did in the winter of 2017. Similarly, 123rd Street SW in Lakewood experiences similar groundwater flooding that can occur weeks after rain events and last for weeks. This unusual geology creates unique challenges to managing flooding in the region.

1.2 Previous Studies

Clover Creek has been studied over the years to characterize the potential hazard of flooding and to mitigate the threat of flooding. These studies are highlighted below.

1.2.1 Effective FEMA Flood Insurance Study

Effective FEMA flood hazard mapping for Clover Creek is based on a 2006 Flood Insurance Study that applied one-dimensional (1D) Hydrologic Engineering Center River Analysis System (HEC-RAS) hydraulic modeling and Hydrological Simulation Program—Fortran hydrologic modeling Northwest Hydraulic Consultants (NHC, 2006). Flood hazards determined within the City at that time included 100-year breakout flooding along 58th Avenue downstream from Pacific Highway and overbank flooding between Joint Base Lewis-McChord (JBLM) and Bridgeport Way that would overtop I-5 and inundate downstream areas.

1.2.2 2003 Brown and Caldwell Study

This study was initiated following the flooding of Gen-Villa Apartments in 1996 to explore mitigation options to alleviate flooding in the area. The study included the evaluation of four alternatives: storage in new off-channel ponds at two sites upstream of the flooding, diversion piping, increased bank elevations, and off-channel conveyance improvements. The final report outlines a preferred alternative, which focuses on off-channel conveyance improvements and the most likely alternative to mitigate flooding while considering costs, permitting, and overall performance. The recommended improvements have not been implemented to date.

1.2.3 2019 Flood Hazard Analysis

In 2019, WSE completed a study to refine FEMA flood hazard mapping for Clover Creek within the City (WSE, 2020). The resulting FEMA HEC-RAS 1D hydraulic model was updated by adding a two-dimensional (2D) flow area to route overbank flow. The resulting 1D/2D model was run in the unsteady mode to simulate the 100-year flood event to support updated floodplain mapping.

During the study, a berm along Clover Creek was identified as a non-accredited levee. The berm is located on the right bank of the creek just downstream of the BNSF-McChord railroad crossing. WSE followed FEMA guidelines to complete a levee failure analysis by running an additional 100-year model simulation with the levee removed from the model geometry.

Mapped flood hazard areas and base flood elevations from the 2019 study reflect a combination of worst-case scenarios, both with and without levee simulations. Flood inundation extents are similar to effective mapping boundaries, and results confirm the risk of a 100-year flood overtopping I-5. Failure of the unaccredited levee results in significant flow in the overbank, and the FEMA floodway would no longer be contained to the channel without creating a 1-foot surcharge. A revised floodway was not developed as part of the 2019 study but would need to extend through the overbank and over I-5 to meet surcharge requirements. The WSE 2020 memorandum is provided as Appendix A with additional detail.

1.3 2022 Flood Mitigation Evaluation

Based on the 2019 100-year floodplain evaluation completed by WSE, the City chose to evaluate mitigation alternatives prior to updating the base flood elevations for the 100-year floodplain and include I-5 as part of the floodway. The resulting alternative development, evaluation, and suggested preferred alternative are included in this engineering report.

Section 2

Flood Mitigation Alternatives

The development of flood mitigation alternatives included a comprehensive, holistic review of the watershed and how it functions to determine how the 100-year flood could be mitigated in Lakewood. A broad suite of alternatives was initially proposed, which were processed through various screening and modeling evaluations to narrow the list down to four viable alternatives, including the Do Nothing alternative. These four alternatives were further evaluated in finer detail to determine the preferred alternative. The evaluation process and steps are described in more detail below and in Section 4.

Goals for flood mitigation include removing as much land from the 100-year floodplain as possible and removing floodwaters from overtopping I-5. If an alternative accomplished this goal, while creating higher flows in the creek, mitigation measures for these downstream impacts were also included in the alternative, through floodplain creation or the construction of flood walls, to keep Clover Creek within its banks.

2.1 Flood Mitigation Alternative Development

To develop a comprehensive list of potential alternatives, the consultant team reviewed modeling results for the existing conditions to identify potential mitigation measures. The team developed the following five categories of solutions to help guide the creation of the potential alternatives list:

- Do nothing
- Levee or block the flooding
- Create flood storage
- Enhance the watershed and/or riparian-zone restoration
- Improve capacity

The consultant team developed a comprehensive list of potential alternatives and then conducted a broad review and analysis of the watershed. This historical review included reviewing historical aerials, discussing development patterns with the City, evaluating historical flooding events, and reviewing the surficial and groundwater hydrology patterns in the watershed. Due to site conditions, including limited space, and concerns of high groundwater, some alternatives were quickly dismissed but have still been included here for documentation purposes.

Based on the five categories above, the team developed 12 potential alternatives, which are presented below in Table 2-1. Each of these potential alternatives was evaluated to estimate the potential for flood mitigation and ranked as high, medium, or low. The engineering and implementation considerations for each of these alternatives have also been considered. The estimated mitigation ranking, engineering, and implementation considerations are included in the full table included in Appendix B.

Table 2-1. Potential Flood Mitigation Alternatives

Alternative	Name	Type	Description
A1	Do nothing	–	Continue business as usual with inherent risk of FEMA mapped floodplains containing I-5 and other local businesses and residential buildings.
A2	Regional storage	Storage	Create regional storage facilities throughout the watershed. Storage could be inline/offline or floodplain benching.
A3	Bypass pipe	Capacity improvements	Construct a pipe/channel capable of rerouting/bypassing high flows downstream.
A4	Set back levee or flood wall	Storage/capacity/ blockage	Set back levee along the north bank to limit flooding. Location of levee to be determined.
A5	Levee or flood wall along creek	Flood blockage	Levee along the creek to block floodwaters from exiting the channel.
A6	Creek restoration/capacity enhancements	System improvements/capacity	Upstream and downstream restoration of Clover Creek to include habitat improvements, flood mitigation and storage, bank stabilization, and the implementation of low impact development to improve water quality.
A7	WSDOT ditch blockage or flood wall along I-5	Flood blockage	Flood propagation begins at the creek and moves north mostly west of 47th Ave. The drainage ditch along I-5 would be blocked and would not allow drainage or floodwater to move north or south along the east side of I-5.
A8	Watershed wide management study	Upstream improvements	Implement a feasibility study to measure and monitor flows from the upstream watershed and determine watershed-wide actions to help mitigate peak flows.
A9	Raise profile I-5	Flood blockage	Elevating the northbound lanes of I-5 would effectively remove the roadway from the floodplain and block floodwater from the western side of I-5.
A10	TMDL integration	Integrated approach	Integrate TMDL operations to also consider flood mitigation throughout the watershed.
A11	Fill Low areas along Clover Creek	Flood blockage	Fill areas along the creek to effectively raise the bank elevation while still enabling development to occur.
A12	Creation of floodplain	Capacity improvements	Purchase property and establish easements for the creation of intentional floodplain storage areas with flooded area as well as upstream and downstream.

TMDL = total maximum daily load

WSDOT = Washington State Department of Transportation

These twelve alternatives were discussed in detail during a regular project meeting with the City to reduce the number of alternatives based on the information available, including feasibility, effectiveness, stakeholder input, and ability for alternative to meet flood mitigation goals. This early alternative reduction resulted in eight alternatives considered as likely candidates for implementation. Alternatives A1, A3 through A7, A9 and A11 were included in the next stage of screening.

Table 2-2, below, provides additional information about each of the eight alternatives and some of the rationale or challenges associated with implementation.

Table 2-2. Alternatives and Engineering Considerations

Alternative	Name	Engineering and Implementation Considerations
A1	Do Nothing	The economic impacts associated with flood risks include damage and closures to local businesses, damage to residential buildings, and the potential closure of I-5.
A3	Bypass pipe	Involves the design and construction of miles of new infrastructure. Project will be expensive and finding an acceptable alignment to minimize utility conflicts will be challenging. Estimate of roughly 2 miles of pipe to Steilacoom Lake.
A4	Set back levee or flood wall	The displacement of floodwaters may trigger a no-rise analysis or other permitting requirements. Downstream capacity and flooding would also require consideration or attention.
A5	Levee or flood wall along creek	Private property and structures along the north bank may add complexity along with permitting challenges such as a no-rise analysis.
A6	Creek restoration/capacity enhancements	Project will require an extensive study of the Clover Creek watershed, which will likely include stream flow and quality monitoring.
A7	WSDOT ditch blockage or flood wall along I-5	Construction and/or hydraulic modifications within the floodway may trigger a no-rise analysis or other FEMA permitting requirements.
A9	Raise profile of I-5	Changing the profile of a federal highway will likely have significant unforeseen challenges. Changing the vertical profile of I-5 will have practical challenges; however, construction to elevate the roadway may be more feasible.
A11	Fill low areas along clover creek	The feasibility of relocating current occupants, both businesses and residents, poses challenges. Purchase of easements/property may be costly.

Once these eight alternatives were identified and evaluated in a qualitative way, they entered the initial screening process described in Section 2.2 below.

2.2 Flood Mitigation Initial Screening Criteria Development

Screening criteria for the eight alternatives were developed for further evaluation and consideration of the suitability and ability of each alternative to address multiple criteria while mitigating flooding to various degrees. The criteria were developed based on the following four overarching elements:

- Environmental
- Community
- Implementation
- Cost

Seventeen specific criteria were developed within these four key elements. The environmental element of the screening criteria includes three specific criteria: community includes five specific criteria; implementation includes three specific criteria; and cost includes six specific criteria. Each of the 17 criteria have been scored with a zero, five, or ten. Table 2-3 details the scoring criteria definitions for each of the seventeen specific criteria.

Table 2-3. Screening Criteria Definition for Scoring

Element	Criteria	Scoring Definition		
		0	5	10
Environmental	Stream water quality impact	Alternative provides no significant water quality benefits	NA	Alternative provides some water quality treatment or passive improvement in stream water quality
	Stream health/fisheries benefits	Alternative provides no added benefit	Alternative provides moderate improvement at only the project site	Significant improvement at project site and along the stream corridor
	Natural wetland and species impacts	Alternative decreases effective wetland area	Alternative maintains current wetland area	Alternative creates a measurable area of new significant wetland area
Community	Diversity, equity, and inclusion (DEI)	Alternative negatively impacts DEI in some way	Alternative is neutral with respect to DEI, neither positive nor negative	Alternative acknowledges marginalized or underserved groups in the community and addresses past inequities
	Community impact (non-specific general disruption)	Alternative has high community impact	Alternative has moderate impact on the community	Alternative has little impact on the community
	Emergency response	Alternative has no significant impact on emergency response	Alternative improves emergency response in the area by reducing flooding and increasing flood risk awareness in the area	Alternative improves emergency response in the area by significantly reducing/eliminating flooding and increasing flood risk awareness in the area
	Transportation impact	Alternative provides no significant improvements to transportation impacts due to flooding	Alternative provides access to all major corridors with some interruption during flooding events	Alternative largely mitigates flooding impacts to transportation infrastructure
	Safety from flooding (structure flooding)	Alternative has no influence on the number of structures impacted	Alternative provides more than a 30% reduction in the number of structures impacted	Alternative provides more than a 70% reduction in the number of structures impacted
Implementation	Feasibility	Alternative requires significant regulatory hurdles due to major mitigation or compensatory impacts	Alternative requires significant mitigation of implementation impacts	Alternative requires a reasonable level of mitigation of implementation impacts
	Community enhancement	Alternatives provides minimal flood impact improvements for the community	Alternative provides community enhancement through flood reduction and safety improvements	Alternative enhances the community through the creation of open/green space, low-impact development, or transportation improvements
	Timeline for full implementation	Effective in more than 20 years	Effective in 10 to 20 years	Effective in less than 10 years
	Maintainability	Alternative is anticipated to require monthly (or more frequent) inspection and maintenance	Alternative is anticipated to require quarterly inspections and some maintenance	Alternative requires inspection after large rainfall events and minimal maintenance and upkeep

Table 2-3. Screening Criteria Definition for Scoring				
Element	Criteria	Scoring Definition		
		0	5	10
Cost	Land acquisition or easement need	Alternative is likely to have significant land needs—more than 10 acres	Alternative is likely to have some land needs—between 5 and 10 acres.	Alternative is likely to have little land needs—less than 5 acres.
	Relative implementation cost	Anticipated alternative implementation cost is relatively high—greater than 25 million	Anticipated alternative implementation cost is moderate—between 10—25 million.	Anticipated alternative implementation cost is relatively low, less than 10 million
	Undeveloped land within floodplain	Alternative has no impact on floodplain extents	Alternative removes up to 20 acres from the floodplain for potential development	Alternative removes 20 or more acres from the floodplain for potential development
	Transportation interruptions	Alternative reduces transportation cost impacts by less than 10 percent	Alternative reduces transportation cost impacts by up to 50 percent	Alternative reduces transportation cost impacts by more than 50 percent
	Local business impacts	Alternative provides no significant reduction in flood-related business costs	Alternative provides moderate reduction in flood-related business costs	Alternative provides significant reduction in flood-related business costs
	Residential building impacts	Alternative provides no significant reduction in flood related recovery costs	Alternative provides moderate reduction in flood related recovery costs	Alternative provides the most reduction in flood related recovery costs

2.3 Flood Mitigation Alternative Initial Screening

Each alternative received the following scores using the criteria described above:

- 0.72: Set Back Levee
- 0.53: Creek Side Levee
- 0.47: Washington State Department of Transportation (WSDOT) Ditch Blockage or Flood Wall along I-5
- 0.39: Raise Profile I-5
- 0.36: Creek Restoration/Capacity Enhancements
- 0.23: Fill Low Areas Along Clover Creek
- 0.12: Bypass Pipe

Figure 2-1 provides a graphical representation of the scoring along with the relative score for each of the criteria listed in Table 2-3. This figure shows the relative score of one element compared to others for each of the seven alternatives.

For example, the Set Back Levee scored well for the environmental criteria (shown in green) compared to the Creek Side Levee. This difference is the primary reason the Set Back Levee scored higher than the Creek Side Levee.

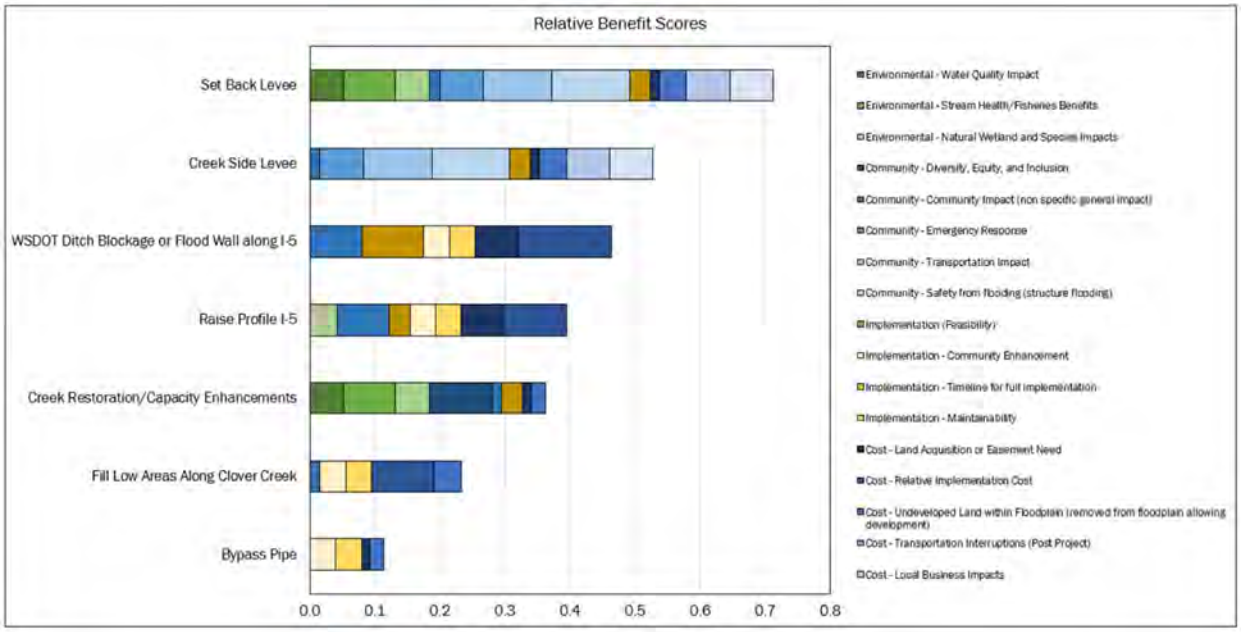

Figure 2-1. Mitigation alternative relative benefit scores

These seven alternatives were evaluated and screened based on the scoring shown in Figure 2-1 to further narrow down the number of potential alternatives. Several alternatives were either removed or combined over the span of several meetings to review and discuss the alternatives as a team.

The bypass pipe (Alternative A3) was determined to not be a reasonable alternative due to its low relative benefit score and was removed for any further study.

The first two alternatives, Set Back Levee and Creek Side Levee were combined to form a Levee alternative that could include either alternative to remain flexible in how the levee alternative is applied.

Alternatives three and four, WSDOT Ditch Blockage/Flood Wall along I-5 and Raise Profile I-5, both addressed the specific goal of removing floodwaters on I-5 and were thus combined to provide a second final alternative.

The third final alternative combined the Creek Restoration/Capacity Enhancements and Filling Low Areas Along Clover Creek. These two alternatives mitigate flooding through modifications to the local topography around the creek, while providing riparian enhancements, and were therefore combined.

This approach of combining the top six scoring alternatives into three alternatives allowed for each alternative to remain broad and flexible, with the City and other stakeholders given the freedom to later determine project extent and the degree of implementation. Based on this approach the final four alternatives are listed below:

- Do Nothing
- Channel and Capacity Enhancement
- I-5 Levee
- Levee

For more detail on the analysis of these four alternatives see Section 3.

2.4 Final Flood Mitigation Alternatives

The following section describes the final four flood mitigation alternatives that were chosen for in-depth analysis, including hydraulic modeling, cost estimation, and multi-criteria decision analysis (MCDA). Elements common to each of the three mitigation alternatives include the certification of an existing (uncertified) levee west of the BNSF railroad tracks and improvements downstream of I-5 that might include creek-side embankments or levee improvements. These two elements and the four mitigation alternatives are discussed in greater detail in the following sections.

2.4.1 Do Nothing Alternative

The Do Nothing alternative includes continuing business as usual, acknowledging the existing flood hazard, and proceeding to update FEMA flood mapping based on the results of the 2019 flood hazard analysis. This alternative would include submitting a Letter of Map Revision (LOMR) to adjust the regulatory floodplain boundary to include the levee failure scenario, likely resulting in floodwaters overtopping I-5 and subjecting I-5 to regulations associated with FEMA floodway regulations. Submitting a LOMR will also result in more properties inside the 100-year floodplain that would then be required to secure floodplain insurance. The 100-year flood extents for this alternative are shown in attached Figure 2.

2.4.2 Channel and Capacity Enhancement Alternative

The channel and capacity enhancement alternative would add or expand floodplain benches along the existing channel to increase flood storage and conveyance capacity to reduce the extent and duration of overbank flooding. To simulate this alternative, the model was updated to cut floodplain benches at the 2-year flood elevation where it appeared feasible to do so. The actual implementation of this alternative is uncertain. Much of the land adjacent to the creek is private property. Channel capacity improvements would occur within the reach of Clover Creek extending approximately 1 mile from the BNSF railroad tracks west of JBLM to the end of Clover Park Drive SW, where the banks of the creek are elevated. Areas of floodplain benching would also be considered for stream bank enhancement and habitat creation for instream and riparian benefit. Habitat improvements have not been quantified but would be a major element of this alternative. The 100-year flood extents for this alternative are shown in Attached Figure 3.

Results assume that the existing non-accredited levee at the upstream model extent would be certified as providing 100-year flood protection. Inundation results in attached Figure 3 also assume that high ground along the channel reach downstream from I-5 would be elevated using fill, short levee segments, flood walls, or some alternative mechanism to prevent breakout flow.

2.4.3 I-5 Levee Alternative

The I-5 Levee alternative would construct a levee to limit flood extents and prevent flooding of I-5. The levee would begin at 47th Ave SW and extend west along 120th St SW to the I-5 on-ramp where it would extend southwest until it reaches high ground, at approximately 121st St SW. The levee would be approximately 950 feet long with an average height of approximately 4 feet and a maximum height of approximately 6 feet in order to provide adequate freeboard (3 ft) and tie-ins to meet FEMA requirements for a certified levee.

Habitat improvements would be identified along the entire stretch of Clover Creek to improve instream, riparian, and upland conditions. No specific locations have been identified at this time. The hydraulic model was updated to simulate the levee alignment described above. The 100-year flood extents and approximate location of the proposed levee for this alternative are shown in attached Figure 4.

Results assume that the existing non-accredited levee at the upstream model extent would be certified as providing 100-year flood protection. Inundation results shown in Figure 4 also assume that high ground along the channel reach downstream from I-5 would be elevated using fill, short levee segments, flood walls, or some alternative mechanism to prevent breakout flow.

2.4.4 Levee Alternative

This alternative would construct a levee to contain Clover Creek flood extents between JBLM and I-5. The exact alignment of the levee has not been defined; however, preliminary modeling placed the levee beginning at high ground near the BNSF railroad and extending west along the south side of the Tacoma Power electrical station and Carlyle Court Apartments. The levee then continues west along the southern boundary of the James Apartments where it ends at high ground along Bridgeport Way SW. The levee will need to terminate at natural high ground and provide at least 3 feet of freeboard to meet FEMA requirements for a certified levee.

Areas of potential habitat restoration would be identified along the entire stretch of Clover Creek to improve instream, riparian, and upland conditions. No specific locations have been identified at this time; however, if the levee is set back from the creek, there may be significant area available for habitat restoration. Simulated 100-year flood extents and approximate location of the proposed levee for this alternative are shown in attached Figure 5.

Inundation results in attached Figure 5 assume that high ground along the channel reach downstream from I-5 would be elevated using fill or short levee segments to prevent breakout flow downstream, along 58th Avenue.

Section 3

Hydraulic Modeling and Analysis

The modeling performed for this study is an extension of the work previously completed by WSE, documented in the report *Clover Creek LOMR Hydraulic Modeling and Mapping* (2020). The modeling completed and discussed below was done in support of alternative evaluation for flood mitigation. The existing model was used with slight modifications to test or evaluate the flood mitigating capacity of each alternative.

3.1 Existing Model/Do Nothing Alternative

The current flood mapping shows inundation along the north bank of Clover Creek and east of I-5 for the 100-year event. The current 500-year flood extents include portions of the city west of I-5 including Pacific Highway and Sound Transit rail.

3.1.1 Effective FEMA model

The current effective FEMA flood map shows most of the flooding occurring on the east side of I-5 with some flooding downstream along the creek west of I-5.

The current effective FEMA hydraulic model is a 1D steady state HEC-RAS model. Hydrology is based on Hydrological Simulation Program—Fortran modeling of the basin (Northwest Hydraulic Consultants, 2006). The effective FEMA model flood inundation maps and flood insurance study are available from the FEMA website at https://msc.fema.gov/portal/home.

3.1.2 City of Lakewood Clover Creek 1D/2D Study Update 2019

One-hundred-year inundation results were refined as part of the City mapping update in 2019 and documented in the WSE report (2020). WSE updated the effective FEMA HEC-RAS 1D hydraulic model by adding a 2D flow area to route overbank flow escaping the main channel. The resulting 1D/2D model was run in unsteady mode to simulate the 100-year flood event to support updated floodplain mapping. A levee failure simulation was also included to capture the potential for the uncertified levee to fail near the upstream portion of the study reach near BNSF railroad, as described in Section 2.4. The resulting flood map is a composite of the worst case for model runs with and without levee failure 100-year flooding (Appendix A). For a more detailed report of the modeling and results please refer to the report *Clover Creek LOMR Hydraulic Modeling and Mapping (*2020).

3.2 Preferred Alternative Model Development and Analysis

Utilizing the updated flood model, the project team evaluated the potential alternatives. The hydraulic model was modified for each alternative with general assumptions for the location and extent of each alternative. This process provided model output showing flood extent and depth for each alternative.

3.2.1 Do Nothing Alternative

The 2019 1D/2D model of Clover Creek represents the Do Nothing alternative and would be represented by the composite flooding as discussed above in Section 3.1.2.

3.2.2 Channel and Capacity Enhancement Alternative

Channel and capacity enhancements were simulated within the 1D/2D model by adding or expanding floodplain benches. Modifications were made within the 1D channel cross sections at approximately the 2-year water surface elevation. The 1D cross sections were modified to extend or add a bench away from the creek for up to 30 feet at the 2-year water surface elevation. These modifications were made to undeveloped land adjacent to the channel.

Modeling for this scenario assumed that the existing non-accredited levee at the upstream model boundary would be certified; therefore, no levee failure simulations were completed. Existing lateral structures that represent the connection between the 1D channel and 2D overbank areas of the model were raised downstream of I-5 to prevent flow from leaving the channel and flooding areas along the right overbank. Refer to attached Figure 6 for the area of potential enhancement.

3.2.3 I-5 Levee Alternative

A levee was simulated to block flow from entering the I-5 roadside ditch, allowing floodwaters to travel north and overtop I-5. A levee was added within the 2D portion of the model by adding an embankment along the levee alignment to prevent flows from overtopping I-5. It is assumed the levee would be accredited with the United States Army Corps of Engineers (USACE) to provide 100-year flood protection; therefore, no levee failure simulations were completed. Existing lateral structures, along the creek, that represent the connection between the 1D channel and 2D overbank areas of the model were elevated downstream of I-5 to prevent flow from exiting the channel and flooding areas along the right overbank, simulating a small levee or flood walls. Refer to attached Figure 4 for the levee location.

Modeling for this scenario also assumed the existing non-accredited levee at the upstream model boundary would be certified with the USACE; therefore, no levee failure simulations were completed.

3.2.4 Levee Alternative

A levee was simulated to reduce right overbank flooding between the BNSF railroad, at the east end of the project area, and I-5, which splits the project area roughly in half. The levee was added within the 2D portion of the model by adding an embankment along the levee alignment to prevent flooding. The embankment was elevated to a height that eliminated any flooding to the north or into the right bank. It is assumed that the levee would be accredited by the USACE to provide 100-year flood protection; therefore, no levee failure simulations were completed. Existing lateral structures, along the creek, that represent the connection between the 1D channel and 2D overbank areas of the model were elevated downstream of I-5 to prevent flow from exiting the channel and flooding areas along the right overbank, simulating a small levee or flood walls. Refer to attached Figure 5 for the levee location.

Modeling for this scenario also assumed the existing non-accredited levee at the upstream model boundary would be certified with the USACE; therefore, no levee failure simulations were completed.

Section 4

Alternatives Analysis

The three preferred alternatives and the Do Nothing alternative were evaluated through an abbreviated business case evaluation (BCE). The abbreviated BCE of the four alternatives included criteria that had the potential to demonstrate meaningful differences between the four options. The criteria included qualitative and quantitative elements and financial impacts.

4.1 Development of Planning Level Evaluation Criteria and Scoring

To provide a recommendation for a preferred flood mitigation alternative, Brown and Caldwell (BC) leveraged a decision-support framework that includes engagement with stakeholders and the community in the decision-making process. The steps of the decision-support process and groups engaged in each step are outlined in Figure 4-1. This process is often referred as a multiple criteria decision analysis (MCDA).

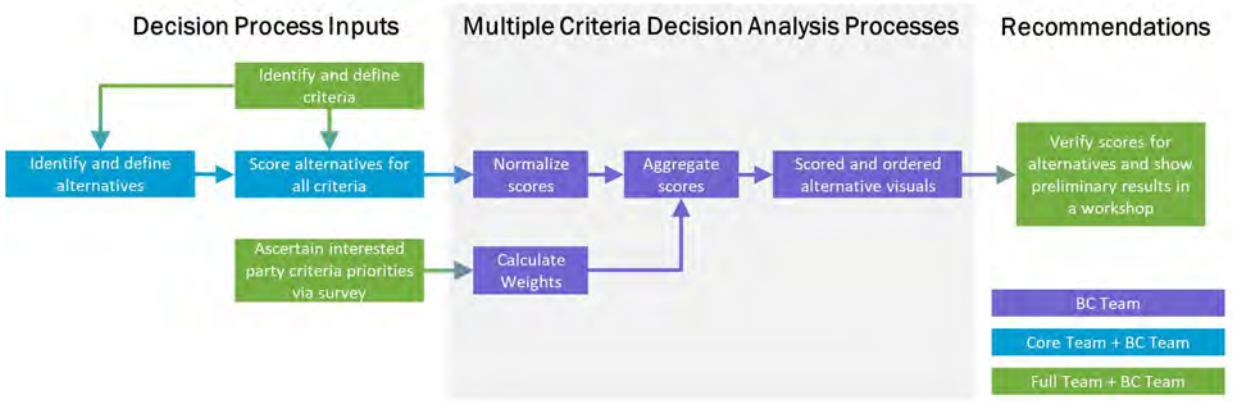

Figure 4-1. Decision-support process flow diagram

4.1.1 Criteria Selection

Decision criteria were identified to differentiate and prioritize the four alternatives presented. Non-monetary criteria are critical to project success and require a defensible, repeatable approach that makes use of project information available at the time.

BC formulated an initial set of 31 criteria during scoping and in a project team screening criteria identification working session. Criteria were grouped based on overlapping mechanisms (e.g., environmental factors versus environmental water quality impact). This exercise was conducted by BC and vetted by the City project team. The final list of eight decision criteria was formulated to highlight the benefits associated with project alternatives compared to one another and together represent non-monetary benefits. The descriptions associated with decision criteria are shown in Table 4-1. Due to the importance of capital and flood impact costs, those variables were considered against non-monetary benefits, where monetary cost and non-monetary benefits were plotted against one another to highlight project alternatives with high benefit and low cost.

Table 4-1. Decision Criteria and Associated Descriptions	
Criterion	**Description**
Water quality and habitat	Habitat and water quality conditions that are either supportive or detrimental to aquatic species.
Community flood reduction benefits	Spatial extent of flooding to approximate impacts of flooding that are not captured in flood cost analysis (e.g., business development in region, business downtime, community perception, traffic impacts to immediate and surrounding area).
Community safety	Magnitude of population that could be adversely affected by flooding and/or associated emergency response capability, including hospital access.
Community improvement—greater community	Community benefits not related to flooding, including nature-based solutions and/or educational opportunities, green spaces, parks, and setbacks.
Community improvement—DEI	Investments in and impacts to traditionally underserved neighborhoods.
Shovel readiness	Time to fully implement an alternative. This effectively encompasses funding time, political buy-in, land acquisition, permitting, construction, etc.
Ease of operation	Maintenance/operational upkeep requirements.
Leverages City land	An alternative leverages City-owned land versus requiring coordination with private landowners.

4.1.2 Criteria Weightings

The City provided an initial set of category weightings in association with the updated criteria list (Figure 4-2). The weights reflected the importance of benefiting the community and environment, with a minimized focus on technical logistics.

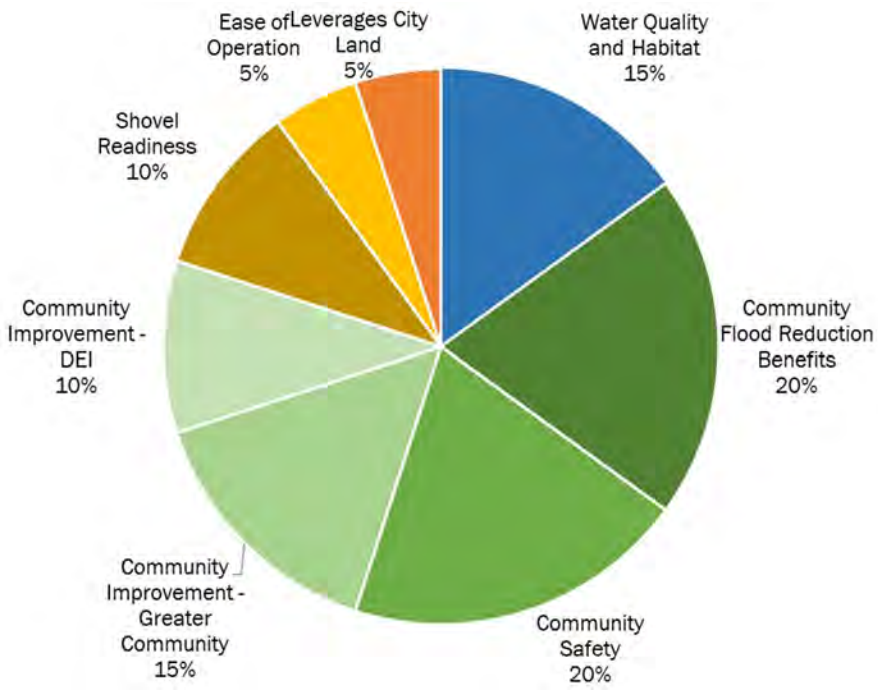

Figure 4-2. Category weights as specified by the City on September 15, 2022

4.1.3 MCDA Scoring Methodology

The eight criteria identified and defined in Section 4.1.1 were used to score each of the four alternatives under consideration. Details on scoring methods and alternatives scores are discussed

and shown in subsequent sub-sections. Quantitative criteria, e.g., flood inundation data, were characterized using data gathered during alternative development.

Quantitative scores were normalized using Equation 1 below per MCDA literature (Marler and Arora, 2004; Cinelli et al., 2020). The equation is used to normalize scores across criteria bounding them between 0, the least relative benefit, and 1, the most relative benefit. This process orients the analysis so maximum normalized scores are associated with maximum benefit. Qualitative scores were normalized by determining the percentile of a selected project's benefits compared to other projects for each qualitative criterion, thus avoiding pitfalls associated with qualitative criteria. This approach allowed for differentiation of relative project performance, which highlights benefits across each of the project alternatives. In cases where lower numbers represent higher benefit, the normalized scores were deducted from 1 to re-orient the normalized score so a larger number resulted in a lower normalized relative score (Equation 1).

Normalized scores were multiplied by their component weights and summed to represent their aggregate benefit. Alternatives were ranked and then ordered from highest benefit to lowest benefit.

$$N_{score,i} = \frac{r_i - r_{min,benefit}}{r_{max,benefit} - r_{min,benefit}} \quad or \quad N_{score,i} = 1 - \frac{r_i - r_{min,detriment}}{r_{max,detriment} - r_{min,detriment}} \qquad \text{Equation 1}$$

Where:

$N_{score,i}$ = Normalized criterion score for ith criterion
r_i = Raw criterion score for ith criterion
$r_{max,benefit}$ = Maximum benefit raw criterion score
$r_{max,detriment}$ = Maximum detriment raw criterion score
$r_{min,benefit}$ = Minimum benefit raw criterion score
$r_{min,detriment}$ = Minimum detriment raw criterion score

Water Quality and Habitat

Water quality and habitat benefits was scored by considering the likelihood of new areas to be created or made available by the proposed alternatives and the proximity of those areas to the creek and existing habitat. Water quality would be provided by new areas being made available for wetlands and riparian zones. The total new area potentially made available for habitat and water quality was estimated and used for scoring. The Do Nothing alternative provides no new area and does not change the current opportunities and therefore scores a 0. The Channel and Floodplain Enhancement alternative provides the greatest opportunity, which results in a normalized score of 1. The two levee alternatives scores fall between the others and have the same normalized score. The criteria and scores are presented below in Tables 4-2 and 4-3.

Table 4-2. Water Quality and Habitat Scoring Bins

Score	Differentiating Details
1	Does not improve and may decrease habitat and water quality benefits compared to existing condition
2	Maintains status quo habitat and water quality benefit
3	Provides habitat and water quality benefits via channel widening/vegetation/wetland creation, etc. compared to existing condition
4	Significantly improves habitat and water quality benefits via channel widening/vegetation/wetland creation, etc. compared to existing condition

Table 4-3. Alternative Scores for Water Quality and Habitat		
Alternative	Score	Normalized Score
Do Nothing	2	0.00
Levee	3	0.33
I-5 Levee	3	0.33
Channel and Floodplain Enhancements	4	1.00

Community Flood Reduction Benefits

Community flood reduction benefits was scored by considering the total flood reduction area associated with a flood reduction alternative during an anticipated flood event (Table 4-4). This scoring mechanism was assumed a proxy for parameters that are challenging to monetize such as business development within region, business downtime, and community perception. While numerically the I-5 Levee alternative reduces flooding to a similar degree as the Levee alternative, spatially and visually there is a significant difference in modeled flooding to the south of I-5 between those two alternatives. For this reason, this criterion used the I-5 Levee raw score as the $r_{min,benefit}$ value in Equation 1. As a reference point to understand the benefit of each alternative, $r_{min,benefit}$ was set to 0 acres representing the Do Nothing alternative, which was also considered for completeness and shown in Figure 3.

The area, considered a proxy, for the community flood reduction was calculated by computing the overlap between modeled flood extents and City provided parcels information in Esri's ArcGIS Pro. The total area of flooding for the Do Nothing condition was used as a baseline, and the total flooding areas were calculated for each alternative and subtracted from the baseline to calculate total flood reduction area (Table 4-4).

Table 4-4. Alternative Scores for Community Flood Reduction Benefits		
Alternative	Flood Area Mitigated (Acres)	Normalized Score
Do Nothing	0	0.00
Levee	164	1.00
I-5 Levee	120	0.00
Channel and Floodplain Enhancements	129	0.19

Community Safety

Community safety was scored by considering how many road miles would be inundated in an anticipated flood event (Table 4-5). Roadway inundation was assumed a proxy for emergency response and emergency service access and, therefore, community safety. Because a higher inundation number is worse for this criterion, the equation oriented around detriment was used for normalization (Equation 1). The Do Nothing alternative was associated with the most roadway flooding while flood reduction alternatives all minimized safety impacts due to roadway flooding to a high degree. Figure 4-3provides the flood reduction calculations associated with each alternative.

The length of road flooded for each alternative was calculated using a similar process as for community flood reduction benefits, but instead of looking at flooded parcels, only public rights-of-way were considered, which represented flooded roadways. The total area was calculated for each alternative and then divided by 11 feet to represent a typical lane-width, which provides an estimate of lane-miles flooded.

Table 4-5. Alternative Scores for Community Safety		
Alternative	Remaining Flooded Roadways (Road Miles)	Normalized Score
Do Nothing	34.4	0.00
Levee	1.5	1.00
I-5 Levee	7.6	0.81
Channel and Floodplain Enhancements	6.9	0.84

Community Improvement—Greater Community

Community improvement—greater community was scored using the expected area that would be improved for community use (e.g., parks, greenspace) (Table 4-6). Areas were identified by visually identifying open areas where parks exist and can be expanded, or where vacant lots were pulled out of the floodplain, presenting an opportunity for community enhancement. The following table provides the total areas estimated to be available for public space when flood reduction benefits of each alternative are realized. The Levee alternative demonstrated the most potential for added community spaces, while the other alternatives provide a variety of potential with the Do Nothing alternative providing none.

Table 4-6. Alternative Scores for Community Improvement – Greater Community		
Alternative	Community Improvement Area (Acres)	Normalized Score
Do Nothing	0	0.00
Levee	13.6	1.00
I-5 Levee	7.6	0.56
Channel and Floodplain Enhancements	7.6	0.56

Community Improvement—DEI

Community improvement is specifically related to diversity, equity, and inclusion (DEI) and is a multifaceted subject, and flood mitigation projects have the potential to impact this criterion in several ways. Flood reduction intrinsically provides benefits to those who are traditionally disadvantaged (and live in the existing floodplain) by reducing risk to their property and increasing the value of their land. These benefits are complex in that they both benefit a traditionally underserved population and present potential unintended consequences, such as gentrification. Other implications may include updated zoning or use of private land to implement an alternative, both of which have the potential for displacement. Due to the complexities in benefits and unintended consequences of flood mitigation alternatives, each alternative was scored equally for this criterion. A case where the Do Nothing scored a 1 and the Levee alternative scored a 3 was also considered to emphasize benefits of flood mitigation to underserved communities for completeness. The results of the scoring are provided in Tables 4-7 and 4-8.

Table 4-7. Community Improvement—DEI Scoring Bins	
Score	Differentiating Details
1	No improvement or investment
2	Some negative and positive improvements (net benefit positive or neg)
3	Improvement or investment

Table 4-8. Alternative Scores for Community Improvement—DEI		
Alternative	Score	Normalized Score
Do Nothing	2	0.00
Levee	2	0.00
I-5 Levee	2	0.00
Channel and Floodplain Enhancements	2	0.00

Shovel Readiness

The shovel-readiness criterion was established to provide a high-level comparison between how long it would take to plan, design, and construct each of the alternatives. Time to implementation was estimated from multiple projects of similar purpose, scope, and scale. Because a higher inundation number is worse for this criterion, the equation oriented around detriment was used for normalization (Equation 1). The Levee alternatives are expected to take the most time to implement whereas the Channel and Floodplain Enhancements would take less time, and the Do Nothing alternative would not require any implementation time.

Table 4-9. Alternative Scores for Shovel Readiness		
Alternative	Time to Implementation (Years)	Normalized Score
Do Nothing	0	1.00
Levee	10	–
I-5 Levee	10	–
Channel and Floodplain Enhancements	5.5	0.45

Ease of Operation

Ease of operation was scored qualitatively using two layers of operational requirements. The first layer is related to inspecting the channel to ensure that any modifications to the channel or nearby locations result in channel stability (U.S. Fish and Wildlife Service, 2006). The second layer of operational requirements occur with added inspection and maintenance tasks (e.g., vegetation management) related to maintaining channel adjacent flood mitigation infrastructure on a regular basis (Pierce County, 2016 and King County, 2015). The Levee alternatives were expected to require both layers of operational requirements, the Channel and Floodplain Enhancements alternative is expected to only require the first layer, and the Do Nothing does not require any added operational tasks. Tables 4-10 and 4-11 provide the scoring criteria and scores.

Table 4-10. Ease of Operation Scoring Bins	
Score	Differentiating Details
1	Annual inspection + regular action plan tasks (asset management program, maintenance, vegetation management)
2	Annual inspection (inspection of erosion and associated channel stability metrics)
3	No added operational requirements

Table 4-11. Alternative Scores for Ease of Operation		
Alternative	Score	Normalized Score
Do Nothing	3	1.00
Levee	1	0.00
I-5 Levee	1	0.00
Channel and Floodplain Enhancements	2	0.67

Leverages City Land

Leverages city land was scored qualitatively based on the project team's estimation of higher participation needs from private landowners to enact an alternative. Each alternative to decrease the flood extent will require participation of private land. The extent is unknown; therefore, each of these alternatives score the same, as shown in Tables 4-12 and 4-13.

Table 4-12. Leverages City Land Scoring Bins	
Score	Differentiating Details
1	Requires significant participation from private property owners
2	Does not require significant participation from private property owners

Table 4-13. Alternative Scores for Leverages City Land		
Alternative	Score	Normalized Score
Do Nothing	2	0.33
Levee	2	0.33
I-5 Levee	2	0.33
Channel and Floodplain Enhancements	1	0.00

4.1.4 Alternative Development Cost Estimates

Class 5 cost estimates were developed for each alternative. Unit costs were developed from previous planning projects completed in the region, in consultation with RS Means, and from reviews of similar projects previously funded by the USACE. Because the exact configuration and implementation of the alternatives is currently unknown, quantities were estimated using best engineering judgement. The major items accounted for in the cost estimates include earthwork and excavation, clearing and grubbing, dewatering, channel restoration, levees, and floodwalls. The cost estimates also include contingencies to attempt to capture the uncertainties around contractor mobilization, erosion and sediment control, traffic control and utility relocation, and a general contingency of 40 percent. See the following table for cost estimates, including ranges of uncertainty, and Appendix C for the detailed estimates.

Table 4-14. Alternative Costs			
Alternative	Cost (-50%)	Cost	Cost (+100%)
Levee	$10,308,000	$20,615,000	$41,230,000
I-5 Levee	$9,110,000	$18,220,000	$36,440,000
Channel and Floodplain Enhancements	$10,812,000	$21,624,000	$43,248,000

4.2 MCDA Results

As discussed in Section 4.1, scores and weights were aggregated using a weighted sum approach to identify alternatives that demonstrated the most benefit across all criteria. Alternatives that effectively address decision criteria that were deemed important (i.e., highly weighted), represent the most potential for benefits. The Levee was associated with the most non-monetary benefits for community flood reduction benefits, community safety, and community improvement—greater community and no benefits to shovel readiness and ease of operation. Channel and Floodplain Enhancements had the most benefits for water quality and habitat, high benefits for community safety, and the least benefit for leverages City land. Both the I-5 Levee and Do Nothing alternatives represented minimal benefits to multiple criteria because the I-5 Levee is not expected to reduce flood-related impacts as significantly as other flood reduction alternatives, and the Do Nothing only demonstrates benefits to criteria relating to project implementation.

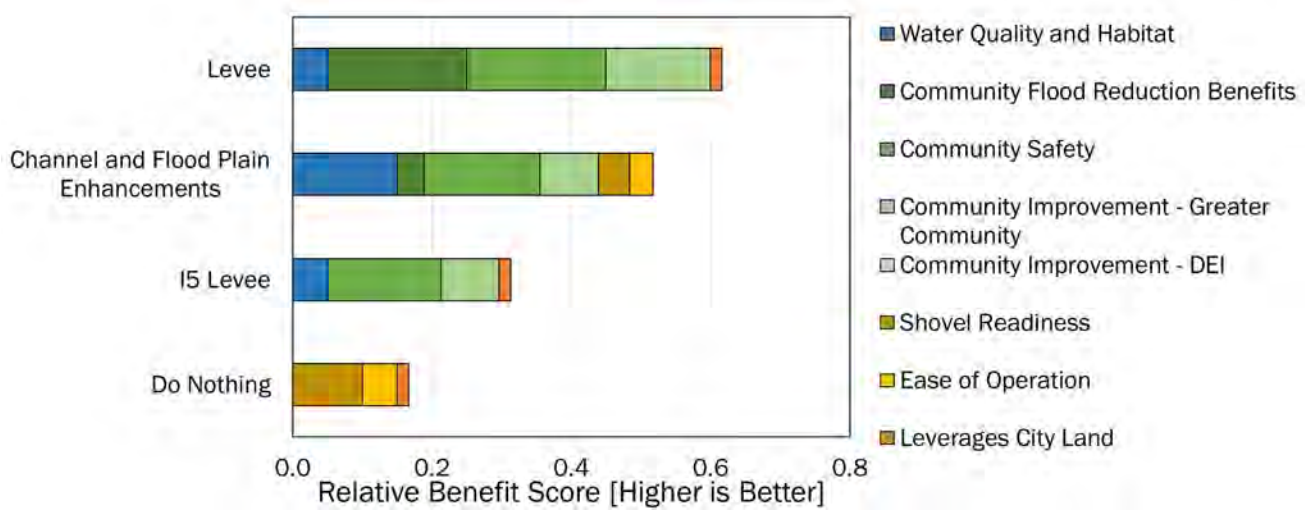

Figure 4-3. Aggregated relative benefit scores that represent non-monetary benefits of alternative

Note: Benefits associated with Do Nothing alternative result from not having to do or pay for project

4.2.1 Benefit Score versus Development Cost Estimates

While non-monetary benefits are important for characterizing which alternatives may be associated with the highest relative benefits, they must be considered against cost factors to identify which alternatives present significant value. When relative benefit scores were plotted against project costs, the three flood reduction alternatives demonstrate similar costs, and the Levee and Channel and Floodplain Enhancement alternatives were associated with higher benefit than the other two alternatives (Figure 4-4). While the Do Nothing alternative may look attractive from a project cost perspective, it is expected to be the costliest alternative related to anticipated flood costs, where the Levee alternative is associated with the least anticipated flood costs (Figure 4-5).

When relative benefit was plotted against project cost plus anticipated flood cost, the Levee alternative demonstrates the most benefit per cost, namely because its total costs are anticipated to be roughly half of the next least costly alternative (Figure 4-6). Channel and Floodplain Enhancements demonstrated similar non-monetary benefits as the Levee alternative (Figure 4-3) but at higher anticipated cost. The I-5 Levee alternative had similar anticipated costs to the Channel and Floodplain Enhancements with less non-monetary benefit, and the Do Nothing alternative was associated with the highest costs and lowest relative benefits (Figure 4-6).

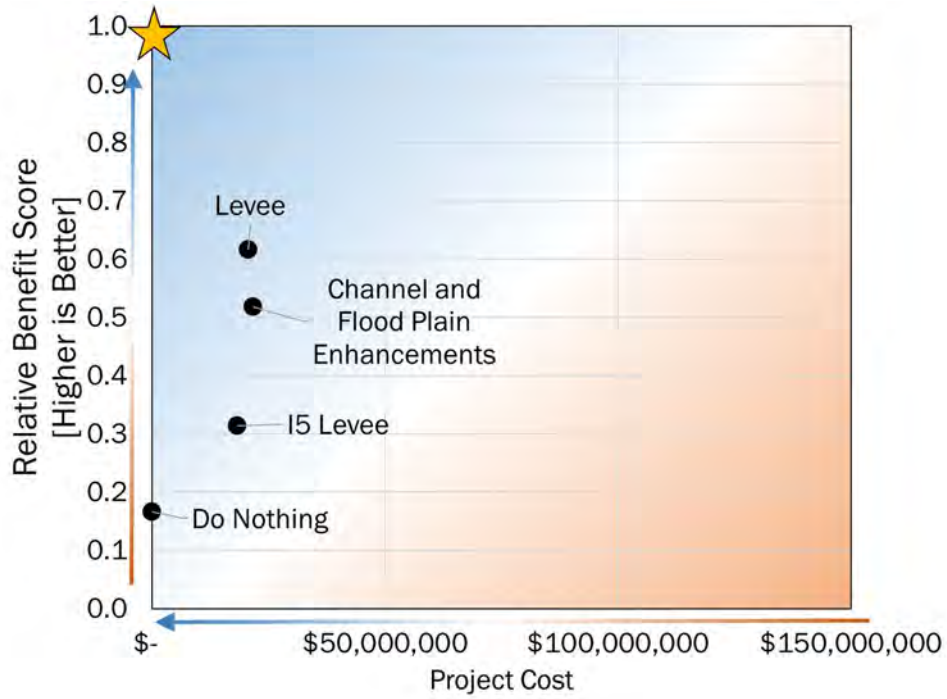

Figure 4-4. Aggregate relative benefit scores from Figure 4-3 versus project cost

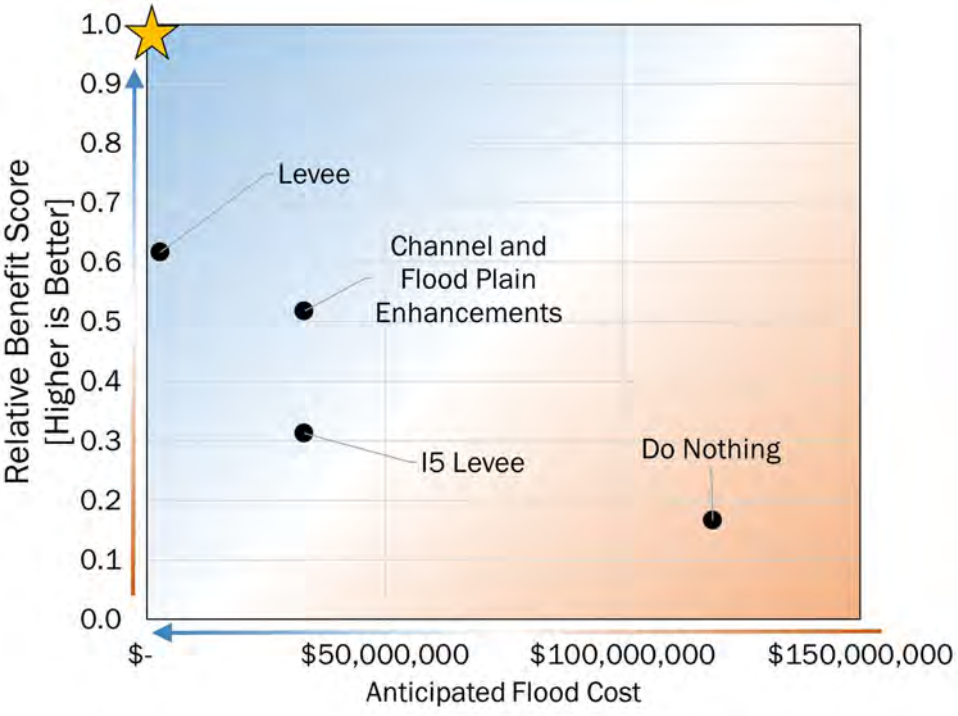

Figure 4-5. Aggregate relative benefit scores from Figure 4-3 versus anticipated flood cost

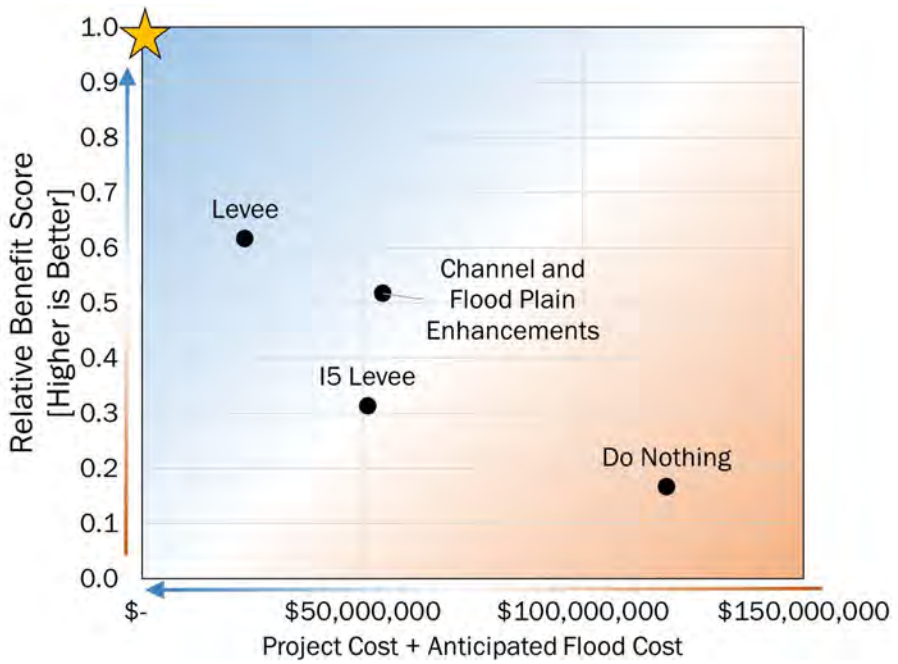

Figure 4-6. Aggregate relative benefit scores from Figure 4-3 versus project cost plus anticipated flood cost

4.3 Discussion

Similar benefit scores between the Levee (0.62) and Channel and Floodplain Enhancements (0.52) alternatives suggest a hybrid approach where both would be pursued to achieve greater benefit than if only one alternative were completed on its own. For example, the Levee may provide the most significant community benefits due to its significant flood reduction, whereas the Channel and Floodplain Enhancements could provide added benefits to water quality and habitat, shovel readiness, and ease of operation while still working towards flood reduction. Therefore, pursuing the Levee alternative to meet community benefit goals could be well served by including Channel and Floodplain Enhancements to some degree to provide a project that provides multiple benefits to the greatest extent possible.

Section 5

Funding Strategy

Funding support will be essential for the City to design and implement the selected alternative or combination of alternatives for flood mitigation. This section describes potential funding opportunities in addition to application details and timelines. A funding strategy has been developed to support the City in selecting the best funding options and how to best leverage application materials and timelines.

5.1 Funding Alternatives

The following funding alternatives include local, state, and federal funding programs that provide grants and loan opportunities. Each of the funding alternatives are described in detail below. A comprehensive funding strategy has been developed in Section 5.2.

5.1.1 Local Funding Sources

The City of Lakewood Surface Water Management Funds and the Pierce County Flood Control Zone District (FCZD) are two local funding opportunities that could potentially contribute to funding flood mitigation projects for the City. Local funding programs tend to have a smaller applicant pool than state or federal programs and potential economic implications to the regional economy.

5.1.1.1 City of Lakewood Surface Water Management Funds

The City of Lakewood established a Surface Water Management Fund. The Surface Water Management Fund was created to administer and account for receipts and disbursements related to the City's surface and stormwater management system. All service charges are deposited into the fund to maintain and operate surface and stormwater management facilities.

5.1.1.2 Pierce County FCZD

The Pierce County Council authorized Ordinance 2011-95s to create the FCZD to address flood prevention and management needs in the county. The FCZD is governed by a Board of Supervisors and Executive Committee and receives input from an Advisory Committee. The Department of Planning and Public Works reviews and approves projects and programs. The FCZD's budget covers funding for capital projects in addition to maintenance of levees and other flood control infrastructure. The budget also provides funding opportunities for local projects.

Capital Improvement Program

The Pierce County FCZD Advisory Committee reviews and recommends an annual capital budget, including capital improvement projects and funding levels. The capital improvement program (CIP) covers a 6-year cycle and is revised annually. The funding range for the capital improvement projects is variable. Projects adopted in the capital improvement plan must be included within the District's Approved Comprehensive Plan of Development (CPOD) and have received an initial project ranking number. Project sponsors wanting to construct a project ranked within the CPOD may formally request to place the project in the CIP. Requests to be included in the CIP are due to the District Administrator no later than March 1 each year. New projects must include the following information in their request: project description, location, funding plan, information on stakeholder support, and

explanation of readiness for construction. The District Administrator then determines eligibility and ranks each of the projects. The District Administrator relies on the CPOD ranking and applies the following four additional criteria:

- Ability to leverage other funds
- Readiness for construction
- Avoidance of ongoing maintenance costs or repairs
- Stakeholder support

The Advisory Committee considers the capital budget scenarios over the following months and provides a recommendation to the Executive Committee of the Board. The Executive Committee of the Board recommends a capital budget in October and holds a public hearing.

Opportunity Fund

Funding for the FCZD Opportunity Fund comes from a county-wide property levy. As of 2022, the levy is approximately $0.10 per $1,000 of assessed value with a total of $15,900,000. Ten percent of the Pierce County Flood Control District's levy proceeds are set aside in an Opportunity Fund that is accessible for local jurisdictions. This fund is made available to jurisdictions on a proportional basis, based on assessed valuation. The Opportunity Funds can be used for the following purposes:

- Flood control or stormwater control improvements (whether extended, enlarged, acquired, or constructed).
- Maintenance and operation of flood control and stormwater system improvements that were constructed or acquired by the jurisdiction.
- Studies and plans for flood control or stormwater control improvements that will be constructed or acquired by the jurisdiction.
- Watershed management projects, studies, plans, and activities that are developed for water supplies, water quality improvement, and water resource and habitat management.
- Major equipment used for stormwater control or water quality protection.

The FCZD announces the availability of the Opportunity Fund each April for the subsequent fiscal year. To request funds, jurisdictions need to submit a Notice of Intent (NOI) to indicate if they will expend or store and bank their allocation. If a jurisdiction chooses to expend its allocation, it must submit details of the specific project that will be funded by attaching a Project Scope of Work form. The NOI to Request Funds should be submitted along with a fully executed Interlocal Agreement. During October, the FCZD reviews the NOI to Request Funds for completement and compliance. Eligible projects are presented and adopted by the Board of Supervisors in November. If the jurisdiction needs to receive advanced funding for any reason, it is required to submit a Request for Advanced Funds form that explicitly states the amount of funds being requested. If funding is granted, then jurisdictions are required to provide the FCZD with regular updates to project status and the final report within 90 days of project completion. Annual progress reports are due by December 31 each year.

Economic Stimulus Grant Program

The FCZD also has an Economic Stimulus Grant Program. During the last application cycle, $3.5 million was available for projects that reduced flood risk. Up to $1 million per construction project and $125,000 for a study or plan can be allocated through this program. Eligible projects include the following types:

- Flood control or stormwater control improvements
- Community flood resiliency projects

- Habitat projection and management projects
- Culvert improvements
- Watershed management projects
- Structure demolition that supports a larger flood risk project
- Purchase of equipment for flood risk reduction

To apply for the program, a pre-application is due to determine eligibility. During the last application cycle, pre-applications were due by March 31, 2022. Successful applicants were then asked to submit a full application by July 31, 2022. For construction projects, the full application requires preliminary engineering studies, State Environmental Policy Act determinations and plans, cost estimates, and a full description of project benefits. For studies and plans, the full application requires a draft scope, budget, and project timeline.

5.1.2 State Funding Opportunities

The Water Quality Combined Funding Program, Washington Department of Transportation (WSDOT), Floodplains by Design, and the Flood Control Assistance Account Program are four potential funding opportunities through the State of Washington for potential Clover Creek flood mitigation projects.

5.1.2.1 Water Quality Combined Funding Program

The State of Washington has created the Water Quality Funding Program, which is an annual single-application process to apply for funding from multiple sources at once. These sources of funding are intended for eligible projects that improve and protect water quality. Funding is available from the following funds and programs:

- Clean Water State Revolving Fund
- Stormwater Financial Assistance Program
- The Centennial Clean Water Program
- The Clean Water Act Section 319 Nonpoint Source Grant Program

For stormwater and flood facility projects, applications may receive funding for projects that provide flood flow control or water quality benefits for stormwater generated from impervious surfaces associated with urban development. Grants from these funds may be provided for various steps of the project, including planning and prioritization, design, construction, and small project design/construction. Stormwater projects that provide water quality benefits through behavior change and management actions may also receive grants or funding.

The application period for the Water Quality Combined Funding Program is approximately two months extending from August to October each year. The Washington State Department of Ecology (Ecology) also conducts workshops during the beginning of the application period to assist the applicant. Applications must include the following items:

- Detailed budget spreadsheet
- Project schedule
- Photos
- Maps
- Letters of support from stakeholders or partners
- Other small support documents

Large support documents such as total maximum daily loads and watershed plans should not be uploaded to the application, but links may be provided.

Once the application materials are prepared, only an authorized official may submit the application. Ecology reviews and ranks the projects and assigns funding based on project rank and available funding. The application period usually closes in mid-October. Future opportunities can be found on Ecology's website.

5.1.2.2 Floodplains by Design

Floodplains by Design grant program was created by Ecology to help communities better manage and live within their floodplains. Floodplains by Design is a competitive grant program that is a component of a public-private partnership led by Ecology, the Nature Conservancy, the Bonneville Environmental Foundation, and the Puget Sound Partnership. Floodplains by Design projects are focused on re-establishing floodplain functions in Washington's major river corridors and reducing flood risk, including those that accomplish the following goals:

- Improve flood protection for communities that live and work in the floodplain
- Conserve and restore habitat for salmon and other important aquatic species
- Improve water quality
- Enhance outdoor recreation

The application process for the Floodplains by Design grant includes a pre-application in which a Request for Proposals is released. Pre-applications are then submitted, and if the project is deemed a good fit, the applicant will be asked to give a presentation. Once the project presentation is complete, the full application must be filled out and submitted. The application must include the following items:

- Table of project outcomes and measurements
- Description of community support and stakeholder involvement
- Description of how funds will be spent
- Indication that the project is ready to proceed (could include project scope, completion of environmental reviews, permits, or Landowner Acknowledgement form)

Projects are then evaluated and scored by a panel of technical experts. The applicants are notified when the proposed funding list is reviewed. The 2025–2027 funding cycle will start in November 2023.

5.1.2.3 Flood Control Assistance Account Program

The Flood Control Assistance Account Program (FCAAP) was established by the Washington Legislature to assist local jurisdictions with comprehensive floodplain management planning and to implement projects that mitigate flood hazards. In the previous biennium (2021–2023), approximately $1.5 million was available for floodplain planning projects and $150,000 was available for emergency projects. Projects that are eligible for this funding resources are listed below:

- Comprehensive flood hazard management plans
- Feasibility studies
- Match for federal projects that lead to Comprehensive Flood Hazard Management Plans (i.e., federal general investigations)
- Flood control maintenance projects

Applications are submitted to Ecology and must include the following information:

- Scope of work, schedule, and budget
- Documentation of stakeholder engagement process including DEI

- Description of benefits of the projects
- Identifications of flooding issues

Planning projects are competitively evaluated and awarded. Conversely, emergency projects are funded on a first come, first served basis. The 2023–2035 funding cycle for FCAAP is expected to start in April 2023.

5.1.3 Federal Flood Management Funding Opportunities

Flood risk management is considered a shared responsibility between several agencies, including the USACE, FEMA, and other federal agencies. There are several programs to assist communities with reducing flood damage and promoting flood risk reduction. There are multiple federal grant programs available, including the Building Resilient Infrastructure and Communities (BRIC) Grant Program, Flood Mitigation Assistance, Pre-Disaster Mitigation Grant Program, Water Investment in Federal Infrastructure Act (WIFIA), and Water Resources Development Act. Federal funding programs tend to offer larger grants than state or local funding programs, but federal grants are also generally more competitive.

5.1.3.1 FEMA BRIC Grant Program

BRIC is a grant program that supports states, communities, and tribes with hazard mitigation projects that reduce the risk of natural disasters and hazards. BRIC funds may be used for a variety of projects in the following categories:

- Capability and capacity building activities
- Flood and climate-related mitigation projects
- Project management costs

Projects must also be cost-effective; reduce or eliminate risk and damage from future natural hazards; meet either of the two latest published editions of relevant consensus-based codes, specification, and standards; align with the applicable hazard mitigation plan; and meet all the Environmental and Historic Preservation requirements.

During fiscal year 2022, FEMA distributed $2.3 billion through the BRIC program. State and territories were allocated $112 million with up to $2 million per application, $50 million was set aside for tribal communities, and the remaining $2.1 billion was included in the national competition for mitigation projects. Each agency applying for the funding may only submit one BRIC application to FEMA, but an application can be made up of an unlimited number of sub-applications.

To apply, agencies should include the following information in their applications:

- Description of how the project would be cost-effective and technically feasible
- Description of the strength of the proposed project
- Compliance with all applicable Environmental and Historic Preservation laws, executive orders, and regulations
- Benefit-cost analysis

Applicants may work with their FEMA region, and sub-applicants may work with their respective applicant (state, tribe, or territory) to submit their application. Once applications are submitted, FEMA will conduct a review and provide each applicant/sub-applicant with a status update. If an application is selected for further review, then applicants must work with a FEMA Regional Office to complete the pre-award activities and Environmental and Historic Preservation compliance review. Awards will be given to the applicants and subject to the availability of funds. If applicants accept an award, the recipients agree to participate in monitoring and evaluation of the grant.

Pre-applications for BRIC are due in September with applications due in November each year. In past years, applicants selected for further review have been announced between May and July.

5.1.3.2 FEMA Flood Mitigation Assistance

The Flood Mitigation Assistance (FMA) Program is a competitive grant program that provides funding to states, local communities, and federally recognized tribes and territories to reduce or eliminate the risk of repetitive flood damage to buildings and structures. Projects that receive funding must reduce or eliminate the risk of repetitive flood damage to buildings insured by the National Flood Insurance Program. In fiscal year 2022, FMA obligated $800 million with $60 million allocated for capability and capacity building activities, $340 million allocated for flood risk reduction projects, and $400 million allocated to individual flood mitigation projects.

Applicants submit their application to FEMA with the following information:

- Lobbying forms, certification regarding lobbying
- Budget information
- Standard assurances
- Disclosure of lobbying activities
- Indirect cost agreement or proposal
- Benefit-cost analysis

FEMA ranks each applicant using scoring criteria and selects recipients based on a cumulative score. Recipients are required to submit various financial and programmatic reports as a condition of award acceptance. The application period for FEMA's FMA grant closes on January 27, 2023. In past years, applicants selected for further review have been announced between May and July. FMA funds for fiscal year 2024 are expected to be announced in September 2023.

5.1.3.3 Pre-Disaster Mitigation Grant Program

The Pre-Disaster Mitigation Grant Program was created by FEMA to provide annual funding to state, local, and territorial governments for projects that develop hazard mitigation plans that reduce safety risk and mitigate flooding prior to a disaster. The goal is to protect human health and safety while reducing funding requirements for future flood events.

The total amount of funds that were allocated to 68 congressionally directed projects was $153,922,408 for fiscal year 2022. A non-federal cost share is required for all projects funded through the Pre-Disaster Mitigation Grant Program. The non-federal cost share may consist of any combination of cash, donated or third-party in-kind services, or materials. The cost share is generally 75 percent federal and 25 percent non-federal cost share.

Each state, territory, or federally recognized tribal national with a project identified in the Pre-Disaster Mitigation funding opportunity shall designate one agency as the grant applicant. Local and tribal governments may apply as a sub-applicant. The following programmatic requirements must be met to receive funding:

- Develop a Hazard Mitigation Plan
- Demonstrate cost effectiveness (benefit-cost analysis or other documentation)
- Demonstrate technical feasibility and effectiveness (accepted engineering practices, established codes, standards, modeling techniques, or best practices)
- Comply with all applicable Environmental Planning and Historic Preservation laws

Last application cycle, applications opened on May 25, 2022, and closed on June 24, 2022. After the cycle closed, FEMA reviewed the applications to ensure each met eligibility requirements and announced awards.

5.1.3.4 USACE Flood Risk Mitigation Program and Planning Assistance to States

The USACE's Flood Risk Mitigation Program partners with state, tribal, territorial, and local governments with flood risk reduction, including traditional structures such as levees and floodwalls in addition to alternatives such as land acquisition and flood proofing. The main goals of this program are to reduce the safety risk, reduce economic damage to the public and private sectors, and provide benefit to the natural environment.

The USACE is a partner in flood risk management but does not have a specific grant funding through the Flood Risk Mitigation Program. The USACE can support projects with technical assistance and cooperate with non-federal public sponsors to provide 50 percent of the project cost (up to $2 million) for planning efforts but cannot be used for design or construction.

Planning Assistance to States funding from the USACE can be used for studies and planning purposes. This funding could be a source to perform the studies required and generate the preliminary materials needed to pursue funding.

5.1.3.5 U.S. Environmental Protection Agency (USEPA) Water Investment in Federal Infrastructure Act (WIFIA)

The WIFIA loan program was established in 2014 by the Water Infrastructure Finance and Innovation Act. WIFIA is administered by the USEPA and provides federal credit for water, wastewater, and stormwater infrastructure projects. Eligible projects are listed below:

- Projects that are eligible for Clean Water State Revolving Fund
- Projects that are eligible for the Drinking Water State Revolving Fund
- Enhanced energy efficient projects at drinking water and wastewater facilities
- Brackish or seawater desalination, aquifer recharge, alternative water supply, and water recycling projects
- Drought prevention, reduction, or mitigation projects
- Acquisition of property if it is integral to the project or will mitigate the environmental impact of a project
- A combination of projects secured by a common security pledge or submitted under one application by a State Revolving Fund program

The funding range for projects is as follows:

- $20 million: minimum project size for large communities
- $5 million: minimum project size for small communities (population of 25,000 or less)

WIFIA funding will be provided as a loan with an interest rate equal to or greater than the U.S. Treasury rate of a similar maturity. WIFIA can fund up to 49 percent of eligible project costs, with total federal assistance not exceeding 80 percent of project costs.

The USEPA announced WIFIA funding as a Notice of Funding Availability published in the Federal Register and on the WIFIA program website. WIFIA funding is announced, and applicants must submit a letter of interest to the USEPA on a rolling basis. The USEPA will then review projects based on the budgetary scoring rules and select projects for funding. Applicants that are selected must then apply for the WIFIA loan. The WIFIA program then conducts a detailed financial and engineering review and negotiates the terms and conductions of the loan with the applicant.

WIFIA funding is currently available, and Letters of Interest can be submitted as of October 2022. As of fiscal year 2022, the USEPA accepts Letters of Interest on a rolling basis from the date listed for the Notice of Funding Opportunity.

5.2 Funding Strategy

The funding alternatives detailed in Section 5.1 include a combination of grant and loan programs to provide funding for project implementation and planning activities. Grant funding may be sourced from local, state, or federal agencies to provide one-time funding for projects. Grant programs require no repayment, which is a great advantage, and the amount of funding can be significant. The disadvantages of grant programs are the competitive nature of the application process, large pool of applicants, and matching fund requirements. Another source of funding for flood mitigation and prevention projects is federal and state loans. Loan programs such as WIFIA and the State of Washington State Revolving Fund are often targeted toward drinking water or wastewater projects but can be leveraged for flood projects. Loans can fund flood control activities as a lower cost debt financing option. Federal and state loan programs require full repayment from the recipient but may be offered at low or no interest rates, depending on the program.

Grants and loans can be sourced from various local, state, and federal agencies. The type of funding agency is another item to consider when applying for funding opportunities. Federal funding programs often offer larger grant amounts but are open to a larger applicant pool, making them more competitive than local or state funding programs. In addition, due to the large number of applicants, federal funds are often slow to become available, involve significant upfront transaction effort, and require ongoing reporting and documentation. Local and state funding programs do not offer as much grant funding as federal programs but are less competitive.

The recommended funding strategy includes applying to a combination of grants and loans from local, state, and federal programs to diversify the funding opportunities. Successful project funding will be facilitated with a cohesive team leveraging articulate and compelling materials for multiple funding opportunities.

The recommended funding strategy is a stepwise approach as follows:

1. Charter a team of internal Clover Creek flood mitigation champions.
2. Clearly articulate and define the problem statement and No Action alternative.
3. Develop compelling project descriptions and details of decision-making process.
4. Ensure stakeholders and public participate in the journey and have opportunities to provide feedback.
5. Use background materials and alternatives analysis (MCDA) results to build a network of regional project partners.
6. Charter the Clover Creek Mitigation Partnership Team and generate commitment and enthusiasm.
7. Create internal and external communication plans.
8. Prepare preliminary concept/design materials for the preferred alternative.
9. Develop compelling materials required for Letters of Interest for most grant applications.
    - Project description and Location maps
    - Project purpose
    - Project cost estimate
    - Population demographics and socio-economic details

- Preliminary Engineering Report
- Planning documents
- Environmental information
- Resource-Specific technical reports (i.e., biological or cultural)
- Lakewood financial information (credit rating)
- Economic impacts
- Social impacts
- Environmental impacts

10. Evaluate funding opportunities with partners and select the best opportunities.
11. Use the timeline below to submit Letters of Interest and application materials.

5.2.1 Recommended Approach and Timeline

The most likely programs and pathways for funding this project are detailed in this section. In the next phase of this project, a decision will be necessary around which programs to focus on within this set of opportunities. A timeline of application activities for available funding programs is detailed in Figure 5-1. The application due dates, along with any milestones in the application process, are noted in the chart, based on available information and past applications cycles.

The FEMA BRIC Grant Program and the FEMA FMA Grant Program have application periods typically September 30 through January 27 of each year. The first round of applicants selected are announced between May and June. To be considered for this funding source, this project must submit applications in the fall/winter of 2023 with a potential notification of award in May or June of 2024.

To be included in the Pierce County Flood Zone District CIP for the upcoming year, requests are due by March 1. For the Pierce County Flood Zone District Opportunity Fund, applicants must adopt the Interlocal Agreement before April 1. Program funding will be announced on April 1 each year. NOIs are expected to be due by August 1 each year. NOIs are then reviewed by the district and eligible projects are announced in November. To submit for this funding, the project must submit an NOI in August of 2023 and subsequently submit the request by March 1 of 2024.

In October of 2022, WIFIA announced a rolling application basis for funding. Applicants can submit applications for WIFIA funding at any time throughout the year.

The FCAAP and Floodplains by Design Program are expected to open during 2023. FCAAP funding will be announced in April 2023 and Floodplains by Design funding will be announced in November 2023.

Funding by direct allocation of the State budget is a less formal process without specific milestones apart from securing an intent to fund towards the end of 2024. As such, it is not shown in Figure 5-1. That funding opportunity will not be available until the 2025 legislative session, which will take place between January and April of 2025.

	2023 (or 2024 for steps initiating in Q1 2024 to the right)									2024		
	April	May	June	July	August	September	October	November	December	January	February	March
Pierce County Flood Control Zone District CIP												
Complete Request for CIP												* 3/1
CIP Requests Due												
Pierce County Flood Control Zone District Opportunity Grant												
Complete ILA												
ILA Due	*4/1											
Announcement of Funds												
Complete Notice of Intent												
Submit Notice of Intent					*8/1							
District Review of Notice of Intents												
Eligible Projects Adopted by Board of Supervisors												
Floodplains by Design												
Announcement of Funds												
Flood Control Assistance Account Program												
Announcement of Funds												
Building Resilient Infrastructure and Communities Funds												
Complete Application												
Application Due											*1/27	
FEMA Review												
First Round of Subapplicants Selected												
Flood Mitigation Assistance Grant												
Complete Application												
Application Due											*1/27	
FEMA Review												
First Round of Subapplicants Selected												
WIFIA - Rolling Application												
Application Due - Rolling Application												

Figure 5-1. Funding application strategy submittal timeline

5.3 Funding Framework

The table below provides a summary of funding options and is populated with detailed information on each of the opportunities described above. This table summarizes the funding options and provides contact names for each program in addition to funding details, application requirements, and deadlines. This summary table can be used to guide decision making.

Table 5-1. Funding Options Summary

	Lead Agency	Description	Point(s) of Contact	Funding Type	Funding Range	Applicant Requirements	Deadlines
Local							
City of Lakewood Surface Water Management Fund	City of Lakewood	All service charges are deposited into this fund for the purpose of paying the expense of maintaining and operating surface and stormwater management facilities.	• City of Lakewood	N/A	N/A	• N/A	N/A
Pierce County FCZD	Pierce County	The FCZD was created by the Pierce County council to address flood management needs. The flood district's budget covers funding for capital projects, maintenance of levees and other existing flood related infrastructures, as well as the district's administrative costs.	• Brynne Walker rynne.walker@piercecountywa.gov	CIP	Funding range is variable. In 2020, the budget was $6,492,586.	• Project proposed in District's Comprehensive Plan • Comprehensive Plan • Project description • Project location • Funding plan • Stakeholder support • Explain readiness for construction	To be included in the CIP process, submit request by March 1.
				Opportunity Fund	• Under $50,000 total allocation = up to 80% of advance amount. • Between $50,000 to $100,000 total allocation = up to 50% of advance amount. • Over $100,000 Total allocation = up to 30% of advance amount.	• Adopt Interlocal Agreement • Submit Notice of Intent • Submit proposed scope of work • Submit progress reports and reimbursement requests • Submit final payment and project completion report	Adopt Interlocal Agreement before April to be considered for the Opportunity Fund.
				Economic Stimulus Grant Program	Up to $1M for construction projects and max of $125,000 for study/plan.	For construction projects: • Preliminary engineering study • State Environmental Policy Act determinations and plans • Cost estimate • Description of project benefits For Studies and Plans: • Draft scope • Draft budget • Project timeline	Application cycle is closed. Check the back in 2023 for future opportunities.
State							
Water Quality Combined Funding Program	Washington State Department of Ecology	The Water Quality Combined Funding program is an annual single-application process to apply for funding from multiple sources all at once for eligible projects that benefit water quality.	• Financial Management Section P.O. Box 47600 Olympia, WA 98504-7600 360-407-6510 • Eliza Keeley-Arnold Water Quality Combined Funding Planner eliza.keeley-arnold@ecy.wa.gov 360-628-1976	Grants and loans	Funding range is variable based on funding program.	• Develop a detailed budget spreadsheet • Develop a project schedule • Add compressed photos • Include a map • Include letters of support • Upload supporting documents	The application cycle closed on October 12, 2022. Check the back in 2023 for future opportunities.

Table 5-1. Funding Options Summary

	Lead Agency	Description	Point(s) of Contact	Funding Type	Funding Range	Applicant Requirements	Deadlines
Floodplains by Design	Washington State Department of Ecology	Floodplains By Design is a competitive grant program and a component of a public-private partnership led by Ecology, the Nature Conservancy, Bonneville Environmental Foundation, and the Puget Sound Partnership. It is focused on re-establishing floodplain functions in Washington's major river corridors, as well as reducing flood risk.	• Scott McKinney Floodplains by Design Grant Program Lead scott.mckinney@ecy.wa.gov 360-918-3428 • Amelia Petersen Floodplains by Design Planner amelia.petersen@ecy.wa.gov 360-480-3298 • Lisa Nelson Northwest Washington Grant Manager lisa.nelson@ecy.wa.gov 425-213-4843	Grant	Funding range is variable and determined by the state legislature. The grant lasts 3–4 years. fiscal years 21–23, the range of funding was $341,000 to $10 M. The total funding for this fiscal year was $50 M.	• Prepare a table of project outcome measurements • Describe community support and stakeholder involvement • Show how funds will be spent • Illustrate that the project is ready to proceed (scope, environmental reviews are complete, permits are obtained, and Landowner Acknowledgement form is complete)	Funding is closed at this time. The 2025–2027 funding cycle will start in November 2023.
FCAAP	Washington State Department of Ecology	The Washington Legislature established the FCAAP to assist local jurisdictions with comprehensive floodplain management planning and implementing actions to mitigate flood hazards.	• Dawn Drake Agency Grant and Loan Coordinator dawn.drake@ecy.wa.gov	Grant	About $1.5 M for planning projects and $100,000 for emergency flood response projects. Amount of matching funds required: 25% for planning projects and 20% for emergency flood response.	• Prepare scope, schedule, and budget • Document stakeholder engagement process include DEI • Describe benefits for the project • Identify flood issues	Funding is closed at this time. The 2023–2025 funding cycle will start in April 2023.
Federal							
FEMA BRIC	FEMA	BRIC will support states, local communities, tribes, and territories as they undertake hazard mitigation projects, reducing the risks they face from disasters and natural hazards.	• State Hazard Mitigation Officer Tim Cook (253) 512-7072 tim.cook@mil.wa.gov	Grant	Fiscal year 22, FEMA will distribute up to $2.3 B: $112 (up to $2 M per applicant) is allocated to states, $50 M is allocated to tribes, and the remaining $2.133 B will be included in the national competition.	• Show how the project is cost-effective and technically feasible • Describe strengths of the proposed project • Show compliance with all applicable Environmental Planning and Historic Preservation laws, executive orders, and regulations • Provide benefit-cost analysis	Application period closes on January 27, 2023.
FMA	FEMA	The FMA Program is a competitive grant program that provides funding to states, local communities, federally recognized tribes, and territories. Funds can be used for projects that reduce or eliminate the risk of repetitive flood damage to buildings insured by the National Flood Insurance Program.	• State Hazard Mitigation Officer Tim Cook (253) 512-7072 tim.cook@mil.wa.gov	Grant	$800 M for fiscal year 22. $60 M is allocated for capability and capacity building activities, $340 M is allocated to localized flood risk reduction projects, and $400 M is allocated to individual flood mitigation projects	• Lobbying forms, certification regarding lobbying • Budget information (construction/non-construction/both) • Standard assurances (construction/non-construction/both) • Disclosure of lobbying activities • Indirect cost agreement or proposal • Benefit-cost analysis	Application period closes on January 27, 2023
USACE Flood Risk and Mitigation Planning Assistance to States	USACE	The USACE can provide states, local governments, other non-federal entities, and eligible Native American Indian tribes assistance in the preparation of comprehensive plans for the development, utilization, and conservation of water and related land resources.	• Planning Assistance to States Program Manager Barbara Blumeris 978-318-8737 barbara.r.blumeris@usace.army.mil	Assistance program	The USACE can support projects with technical assistance and cooperate with non-federal public sponsors to provide 50% of the project cost (up to $2 M) for planning efforts but cannot be used for design or construction.	• Officially request USACE assistance under the program • Work with USACE to develop a scope of work • Prepare and sign cost sharing letter agreement • Begin study, subject to the availability of both federal and local funding.	N/A
USEPA WIFIA	USEPA	The WIFIA of 2014 established the WIFIA program, a federal credit program administered by the USEPA for eligible water and wastewater infrastructure projects.	• wifia@epa.gov	Loan	• $20 M: minimum project size for large communities. • $5 M: minimum project size for small communities (population of 25,000 or less). • 49%: maximum portion of eligible project costs that WIFIA can fund. • Total federal assistance may not exceed 80% of a project's eligible costs.	• Fill out WIFIA Letter of Interest • Fill out WIFIA application	Funding is still available and Letters of Interest can be submitted starting September 6, 2022. Rolling basis deadline.

Section 6

Public Involvement

This document outlines community and stakeholder involvement efforts throughout the project to promote meaningful engagement and raise awareness of this study within Lakewood. Community support will push agencies to secure appropriate funding and permitting for engineering projects that address flooding. The full Public Engagement Plan can be found in Appendix D.

6.1 Community Engagement Overview

Outreach and engagement activities were designed to reach the following audiences that have interest in the Clover Creek Flood Mitigation Study:

- Public
- Local businesses and business associations
- Community and nonprofit organizations
- Appointed and elected officials
- Regional stakeholders

Activities included four stakeholder committee meetings, a series of individual stakeholder interviews, and two community meetings.

6.2 Engagement Schedule

Figure 6-1 includes the engagement schedule used to reach the community and stakeholders involved throughout the project.

Activity	Timeline
Stakeholder Committee Meeting #1	March 10, 2022
Individual Stakeholder Interviews	March 14–April 6, 2022
Community Meeting #1	April 12, 2022
Stakeholder Committee Meeting #2	April 21, 2022
Stakeholder Committee Meeting #3	July 14, 2022
Stakeholder Committee Meeting #4	October 6, 2022
Community Meeting #2	November 10, 2022

Figure 6-1. Project engagement schedule

6.3 Community Input

Following the first community meeting and with feedback received via the website, email, and social media, the public's comments reflected the following themes:

- **Concern and desire for more information:** For those with properties that fall within the 100-year floodplain, members of the public expressed a need to track the project closely and a desire to understand more. They expressed interest in how the City is currently managing flows and groundwater with respect to the City's long-term goals.

- **Information apprehension:** Many community members expressed criticism and a lack of confidence in the maps used, citing that it had not flooded during their lifetime. This feedback reflects the need for increased education regarding the meaning of a 100-year flood and its potential impact
- **Unease about new and future developments and impact on impervious covers:** Some members of the public expressed concern about new development in the City, specifically those in Springbrook and along South Tacoma Way and along sensitive areas. They shared that the new development contributes to an increase in impervious surfaces
- **Request to utilize natural systems in mitigation efforts:** The Clover Creek Watershed Group shared a letter requesting that natural systems be the top priority in mitigation efforts and to incorporate green infrastructure in planning efforts. Examples listed included policies and design standards to minimize the development of impervious surfaces, increasing open spaces, retaining riparian areas, constructing rain gardens, and coordinating with other entities on long-term sustainability.

6.4 Stakeholder Input

Following the stakeholder meetings, the stakeholders' comments reflected the following themes:

- **Desire to integrate alternatives**: Stakeholders showed strong support to integrate the preferred alternatives as the final alternative is refined and adapted. They shared that the alternatives are not mutually exclusive, and integration would lead to the best possible outcome.
- **Strong interest in refinement process**: Stakeholders expressed strong interest in further refinement in the process and design of the final alternative as it combines ideas from all three preferred alternatives. As the final alternative is refined and identified, stakeholders expressed concern about changes to the cost estimates given the unknowns that still exist at this point in the process.
- **Desire to apply a contextual understanding**: Throughout the process, stakeholders shared information of other systems affected by this study and other related studies occurring. Stakeholders asked questions about where the water volume in the shrinking floodplain would go. They expressed concerns about water potentially propagating upstream. They also shared a desire to consider related studies, such as the TMDL Water Quality Improvement Plan being developed with Pierce County, the City, and JBLM,

6.5 Outreach and Engagement Activities

The project team actively engaged the stakeholders and community to ensure a transparent process and provided a mechanism for questions and feedback.

6.5.1 Stakeholder Committee Members

The stakeholder committee members were selected based on their understanding of the system, regulatory guidance, being directly impacted by the flooding, and potential financial partners.

- Luke Assink, WSDOT
- Rod Chandler, Pierce Transit
- David J. Fulmer, JBLM,
- Matthew Gerlach, Ecology
- Meseret Ghebresllassie, JBLM
- Donovan Gray, Ecology
- Russ Ladley, Puyallup Tribe
- Andrew Larson, WSDOT
- Anne-Marie Marshall-Dody, Pierce County Surface Water Management and Flood District
- Tom Kantz, Pierce County Surface Water Management and Flood District (Sub for Anne-Marie Marshall-Dody)
- Darrin Masters, Washington Department of Fish and Wildlife
- Rebecca McAndrew, Sound Transit,
- Char Naylor, Puyallup Tribe (sub for Russ Ladley)
- Helmut Schmidt, Pierce County
- Jacob Tennant, WSDOT
- David Troutt, Nisqually Tribe
- George Walter, Nisqually Tribe

6.5.2 Stakeholder Meetings

The project team led four interactive virtual interactive meetings with the Stakeholder Committee members throughout this project. These meetings included presentations and opportunities to introduce stakeholders to the project; provide feedback on the potential alternatives, prioritization process, and preliminary model results; share final preferred alternatives; and seek partnering commitments both politically and financially. The meeting summaries can be found in Appendix E.

6.5.2.1 Meeting One Summary

Held on March 10, 2022, the first meeting had the following purpose:

- Introduce the project and purpose of the Stakeholder Committee
- Share the project's scope, objectives, timeline, and milestones
- Present the problem the study will address
- Increase awareness of issues with respect to flooding occurrences, FEMA mapping, and impacts of flooding

The Stakeholder Committee members introduced themselves and asked questions to clarify the project overview, discuss potential study opportunities within the flood mitigation alternatives, share information on related projects, and understand next steps and the overall project schedule. The PowerPoint presentation slides are available in Appendix F.

6.5.2.2 Meeting Two Summary

Held on April 21, 2022, the second meeting had the following purpose:

- Present a list of five alternative categories to mitigate flooding

- Gather feedback on additional potential alternatives previously not considered
- Gather input on any fatal flaws of any alternatives presented

The Stakeholder Committee members provided information on related projects and key contacts, additional alternative approaches, and potential mitigation risks for consideration. The PowerPoint presentation slides are available in Appendix G.

6.5.2.3 Meeting Three Summary

Held on July 14, 2022, the third meeting had the following purpose:

- Share finalized flood mitigation alternatives, prioritization process and results, and preliminary model results for the three preferred alternatives
- Hear feedback on the alternatives to inform the next phase of work
- Outline next steps to support BCE process

The Stakeholder Committee members compared the final flood mitigation alternatives' opportunities and challenges and discussed the prioritization process. The committee and project team expressed a desire to find a solution that blends the preferred alternatives. The PowerPoint presentation slides are available in Appendix H.

6.5.2.4 Meeting Four Summary

Held on October 6, 2022, the fourth meeting had the following purpose:

- Share MCDA criteria and scoring, summary of results, result graph, and alternative scoring versus costs
- Hear feedback on the MCDA process and results
- Identify potential areas where refinement may be possible
- Outline next steps including an opportunity to seek partnering commitments both politically and financially

The Stakeholder Committee members discussed considerations in the prioritization process, the final alternatives, shared feedback on the MCDA scoring process, and final thoughts. The project team shared next steps as the initial project wraps up. The City is seeking stakeholders interested in partnering in the next stage of the project to provide funding and construction support. The PowerPoint presentation slides are available in Appendix I.

6.5.3 Community Meetings

The City hosted two in-person informational community meetings, promoted through mailers, project website updates, and social media. These meetings introduced the public to the project, gathered early input on alternatives from the public, and informed the public on project progress.

- **Meeting One:** The first public meeting presented the problem and brought awareness with respect to the historical flooding events, existing FEMA mapping, potential impacts of flooding, and the scope for this study. The overall project tasks and events were outlined for public knowledge.
- **Meeting Two:** The second public meeting provided information on the development of the flood mitigation alternatives, the process for reducing the alternatives to the preferred concepts, the results of the BCE process, and the final preferred alternatives.

6.5.3.1 Promotion

To reach the public, the City sent a fact sheet mailer 2 weeks prior to each community meeting, shared updates on the project website, and promoted the event on social media. The City distributed 596 mailers to zip code 98499. The mailer is provided in Appendix J and includes an overview of information about the project, status, key issues, and ways to participate.

The City also promoted the meetings on the website (https://cityoflakewood.us/clover-creek-floodplain/) and with the quarterly City magazine, Connections (https://cityoflakewood.us/?s=connections).

6.5.3.2 Community Meeting One Summary

Meeting details: April 12, 2022 | 7:00–8:30 pm | City Hall Council Chambers

Attendance: 13 members of the public attended the meeting.

The meeting initiated with a discussion of what the problem was and how the City determined that the existing FEMA mapping does not accurately reflect the degree of flooding anticipated during a 1 percent probability flood event, commonly called the 100-year flood. The PowerPoint presentation slides for the first community meeting are available in Appendix L.

Public Works Engineering Director, Paul Bucich, addresses the meeting attendees.

Lakewood residents ask questions during the meeting

Brown and Caldwell Project Manager, Ryan Retzlaff, addresses questions from the community

Lakewood residents review floodplain poster

The City stepped through the previous analysis at a high level then discussed with the public the current process to evaluate potential engineering options that will alleviate or eliminate the flood risk potential.

The City reiterated that a flood like this is a low probability event, 1 percent for any year, but the consequences are high for the residents, businesses, and travelling public.

The City shared the members of the stakeholder committee, the purpose of the committee, and when the public can expect to receive an update.

Questions asked by members of the community:

- I-5 has never flooded here in my lifetime, and I know there are culverts and such. What makes you so confident in this map?
  - This study used cutting-edge technology that gives us a better understanding of the land than we've ever had. Water follows the land, and this data shows us where that will be. These 1 percent flood events are rare but more probable than impossible. It will happen at some point. It would be wrong to turn a blind eye.
- How do you know that this flood would happen once every 100 years?
  - I don't love the term "100-year flood." It's more about odds than timing. Floods happen under a mix of conditions. Rainfall is the most important factor, but there are others. Ground saturation, stream water levels, and other factors matter. Local floods in the 1990s involved rainfall on snow, for example. Models show a 1 percent chance in any year that environmental factors will conspire to produce flooding at this level.
- There are new developments in Springbrook and along South Tacoma Way. Do these impervious surfaces add to the risk?
  - The water that would flood this area is surface water that originates upstream elsewhere in Pierce County. Development regulations upstream may be a solution. Some unused areas of Springbrook might become undevelopable for compensatory storage. Our soil takes in water very well, so recent local developments don't have much to do with Clover Creek flows.
- There's a lot of talk about JBLM and I-5, are they more important than the property owners and residents?
  - No, of course not. A major flood would be a threat to military readiness and to statewide transportation. WSDOT and JBLM will be important partners in any solution. They also have the financial might to help us engineer the best solution for Lakewood residents (and their interests).
- What is being done to track creek flows and groundwater?
  - The City does track creek flows, but that only establishes a baseline for the stream. Groundwater is a factor, but it wouldn't be the catalyst for a major flood. We've seen small groundwater floods in Springbrook from time to time, surface water would be the catalyst in a major flood.

Next Steps

No additional follow-up was needed beyond keeping the public informed and updating the web page with project progress.

6.5.3.3 Community Meeting Two Summary

Meeting details: November 10, 2022 |7:00–8:30 pm | City Hall Council Chambers

Attendance: 12 members of the public attended the meeting.

Brown and Caldwell Project Manager, Ryan Retzlaff, shares the latest work with the community

Public Works Engineering Director, Paul Bucich, speaks to questions asked by the public

Clover Creek alternative posters

The City provided a summary of the previous community meeting and an update on the flood mitigation alternatives process. This update included sharing the four alternatives that were evaluated with the hydraulic model and evaluated based on multiple criteria to determine the most appropriate. Posters were provided showing the model results and flood extent for all four alternatives. The PowerPoint presentation slides for the second community meeting are available in Appendix M.

Questions asked by members of the community:

- What is the area that would be restored as part of a stream restoration?
  - From the railroad east approximately 1 mile downstream to the end of Cloverdale Ct SW. Also, some of the fish barriers downstream would be evaluated for improvement.
- How will Pierce County assist with funding?
  - Pierce County has two groups that could assist with funding, including the surface water group and flood protection group. Both of these groups have been represented at our stakeholder meetings.
- Will private property be needed to implement proposed flood mitigation alternatives?
  - That is unknown at this time as the details of any alternative have yet to be formalized. There are likely to be some improvements along the creek downstream of Pacific Hwy and I-5 to limit break out flow from the creek onto private property and flood roadways.
- What is the timeline moving forward?
  - The discussion and questions asked here (community meeting on November 10, 2022) will be integrated into our alternatives. The finalization of the preferred alternative will be completed, and the entire process will be documented in an engineering report and a PowerPoint. Final outcome and path forward will be presented to council in late January or February.
- Does Steilacoom Lake impact Clover Creek flows.
  - No.
- Can the land around JBLM be used for storage or flood management?
  - This land is already very wet during the winter and most of it is wetland. Identifying areas within this space that would be suitable for storage is unlikely. Additionally, federal land and

federal agencies are very challenging to work with and are likely not interested in addressing non-federal concerns on federal land.

Next Steps

No additional follow-up was needed beyond keeping the public informed and updating the web page with project progress.

6.5.4 Website, Social Media, and Email Engagement

At the start of the project, the City created a project webpage at https://cityoflakewood.us/clover-creek-floodplain/. Designed to align with the consistent project identity to support public awareness and increase visibility for the project, the website had information about public involvement activities and a comment box. The City's social media aligned with the project identity and updates.

6.5.5 Public Feedback

Members of the public submitted comments through the website. The posts and social media stories regarding the project yielded low engagement in comparison to other City topics. The comments received through engagement reflect a gap in understanding between the public and the stakeholders involved. General feedback received on the website and via social media include the following comments:

- "Why is the City allowing development in this area?"
- "Why is the City making people buy flood insurance?"
- "This isn't a big deal like you're pretending it is—there's never been any flooding here."
- "It must be the City's development strategy and new impervious surfaces causing this risk."
- "The City gentrified other neighborhoods and made people of color move where the flooding will be."

Section 7

Summary and Recommendations

A floodplain model update to the hydrologic and hydraulic flood model for Clover Creek, completed in 2019, revealed a significant increase to the area impacted by floodwater than the current FEMA effective map of inundation for the 100-year event. The updated model suggested a significant new portion of the City would be impacted by the floodwaters, including I-5. The flooding could potentially result in significant new regulatory constraints placed on area. The City paused further coordination with FEMA to explore flood mitigation alternatives to reduce new impacts to the City and I-5.

The potential flood mitigation alternatives and preferred alternative developed as part of this study and outlined in this report provide the City and stakeholders with the information necessary to move forward with the next steps to secure the funding, advance the design, and build the political will to construct the preferred alternative. The preferred alternative is a levee that extends from Bridgeport Way to JBLM along the north side of Clover Creek. This levee should not only protect I-5 from flooding, but will also protect existing homes and businesses. USACE certification of this levee would allow protected and undeveloped land behind the levee to be developed. This alternative is preferred as it provides the most comprehensive flood protection, requires the least amount of private property acquisition while leveraging City owned land, and is feasible to construct relative to the other alternatives. The flood protection benefit to the City relative to just protecting I-5 more than justifies the 13% cost increase of the preferred alternative over the I-5 levee alternative.

This report recommends three focus areas be advanced to move this project forward from concept to a fully funded project with broad support. Those focus areas and their strategy are listed below.

1. Funding Strategy: Due to the nature of the problem this project is aiming to solve and the magnitude of the preliminary cost, this report recommends three primary funding pathways. The majority of funding, especially for construction costs, could come from an allocation in the State of Washington's biennium budget. This could be achieved by creating local momentum and thoughtfully engaging political leaders. That funding could be supplemented with grants to cover design costs and specific applicable project elements in construction. Finally, the formation of public-private partnerships could provide additional funding in addition to signalling to the State that there is local support in the form of financial backing.
2. Outreach and Engagement: Engaging residents, the business community, local and state agency stakeholders, as well as legislators and committees in Olympia will be critical to gain insight into how to advance the technical design as well as building consensus and support for the project. A strategic engagement framework would create consistency in messaging and a centralized approach to synthesizing external feedback.
3. Technical Refinement: The technical refinement should be a two-step process. First, technical refinement should focus on ground truthing the concept with survey and geotechnical exploration to ensure the concept is reasonably constructable. That advanced concept will serve as the centerpiece of the outreach so that stakeholders have something to provide feedback on. The advanced concept should be advanced to a 30% Design level of definition so that a funding request from the State has reasonable accuracy.

An example of the potential timeline for the next 3 years as it relates to these three major elements is outlined below.

- 2023: develop funding business case, advance engineering concept, submit grant funding applications, identify stakeholders and build strategic engagement framework and begin outreach.
- 2024: conduct stakeholder outreach, continue conversations with political leaders to gain support, advance engineering design to 30%, secure letters of recommendation and build public-private partnerships
- 2025: secure funding to fully fund remaining design and construction, continue to engage public and political leaders to maintain and gain support, complete design and acquire necessary permits.

Section 8

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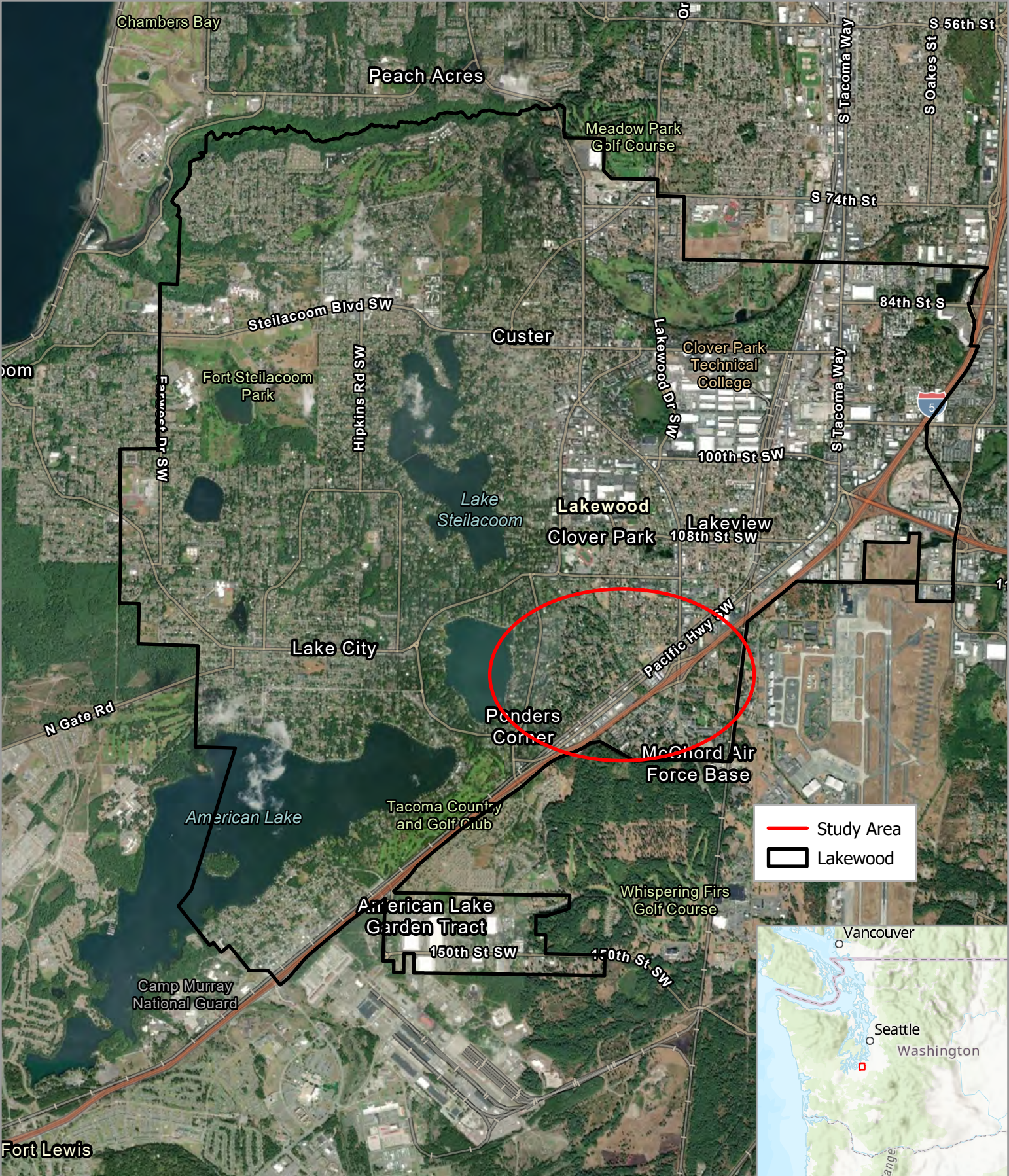

City of Lakewood
Clover Creek Flood Study Engineering Report

Date: 12/12/2022 11:23 AM

Figure 1 Study Area

N

0 0.25 0.5 1 Miles

*Scale for main map

City of Lakewood
Clover Creek
Flood Study
Engineering Report

Date: 12/12/2022 11:23 AM

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Brown AND Caldwell
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Figure 2: Do Nothing Modeled Flood Extents

N

0 0.05 0.1 0.2 0.3
Miles

City of Lakewood
Clover Creek
Flood Study
Engineering Report

Date: 12/12/2022 11:23 AM

Figure 3: Channel Enhancements Modeled Flood Extents

N

0 0.05 0.1 0.2 0.3 Miles

City of Lakewood
Clover Creek
Flood Study
Engineering Report

Date: 12/12/2022 11:23 AM

Figure 4: I-5 Levee
Modeled Flood Extents

N

0 0.05 0.1 0.2 0.3
Miles

City of Lakewood
Clover Creek
Flood Study
Engineering Report

Date: 12/12/2022 11:23 AM

Brown AND Caldwell
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Figure 5: Setback Levee Modeled Flood Extents

N

0 0.05 0.1 0.2 0.3 Miles

City of Lakewood
Clover Creek
Flood Study
Engineering Report

Date: 12/12/2022 11:23 AM

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Figure 6: Channel / Floodplain Enhancements

N

0 0.05 0.1 0.2 0.3 Miles

Appendix A: WSE 2020 Memorandum

Memorandum

To: Paul Bucich, City of Lakewood Public Works

From: Sarah Parker, P.E., and Chris Frei, P.E., Watershed Science & Engineering

Date: January 27, 2020

Re: Clover Creek LOMR Hydraulic Modeling and Mapping

1.0 INTRODUCTION

Watershed Science & Engineering (WSE) was hired by the City of Lakewood Public Works Engineering Department (Lakewood) to refine FEMA flood mapping of Clover Creek within the City of Lakewood. WSE updated the effective one-dimensional (1D) FEMA HEC-RAS hydraulic model by adding a two-dimensional (2D) flow area to route overbank flow escaping the main channel. The resulting 1D/2D model was run in unsteady mode to simulate the 100-year flood event to support updated floodplain mapping. This memorandum summarizes work completed by WSE including; hydraulic model updates, unsteady flood hydrology, and updated flood mapping. Results of this study were used to support application for a Letter of Map Revision to update effective Flood Insurance Rate Maps (FIRMs).

2.0 LOCATION

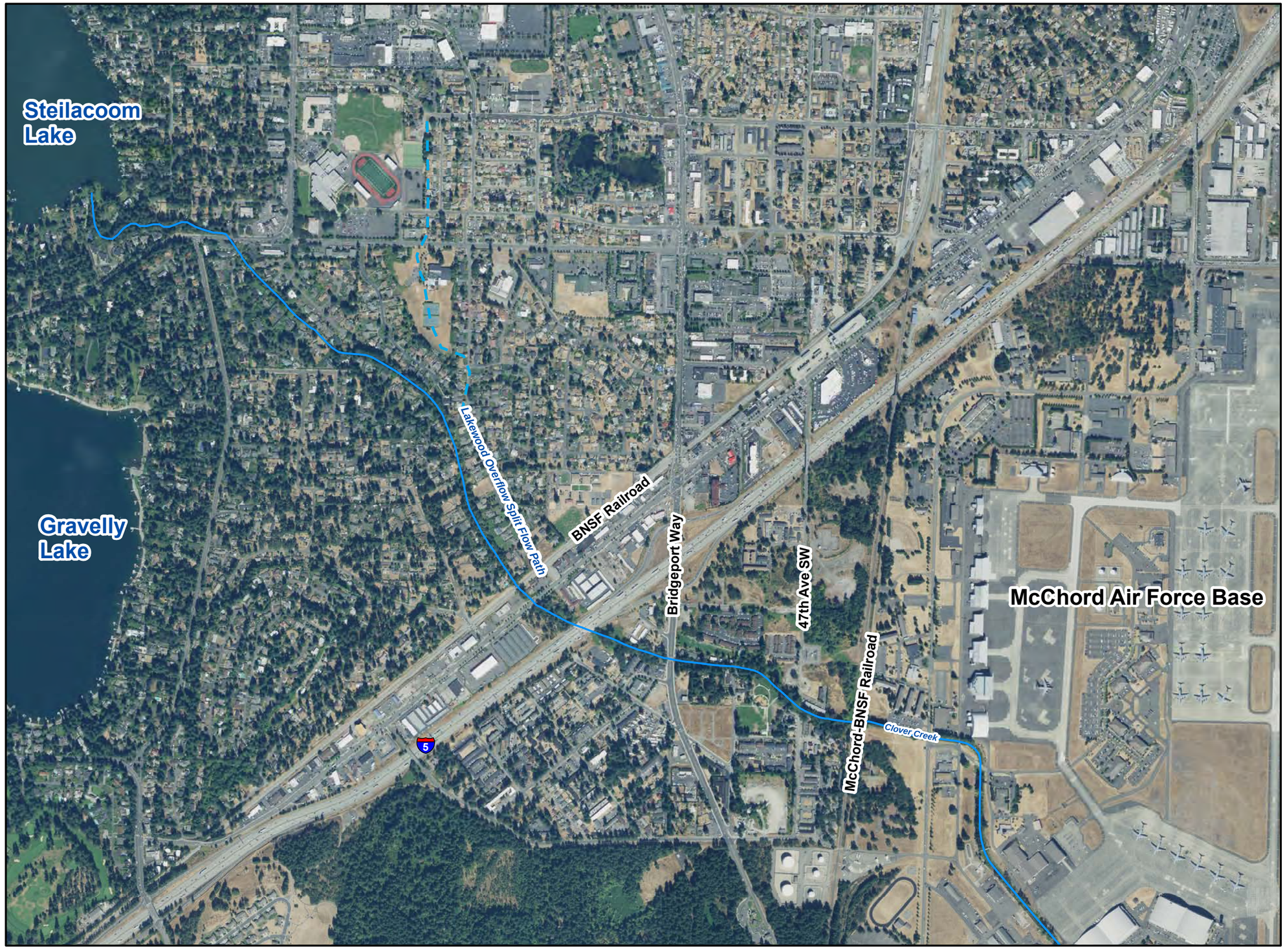
Figure 1 shows the study area, which covers the mainstem of Clover Creek between the Burlington Northern Santa Fe (BNSF) Railroad just west of McChord Air Force Base (McChord AFB) to Steilacoom Lake in Lakewood, WA. The primary focus of this investigation is the right (north) overbank area between the BNSF-McChord Railroad and I-5.

3.0 BACKGROUND

Effective FEMA mapping for Clover Creek (Figure 2) is based on 1D steady state HEC-RAS modeling (NHC 2006). The right (north) overbank area between the BNSF-McChord Railroad and Interstate 5 (I-5) is represented in the effective model as an ineffective flow area (River Stations AM to AT, Figure 2), and resulting FIRMs indicate deep ponding in that region. The City of Lakewood hired WSE to revise the floodplain modeling and mapping in this area to more accurately route overbank flow and better represent existing flood hazard. WSE updated the effective FEMA model by trimming the 1D cross sections at natural high ground along the main channel bank and converting the right overbank to a single 2D area to route flow escaping the main channel. WSE extended the 2D area across I-5, Pacific Highway, and mainline BNSF to encompass the upstream portion of the 1D Lakewood Overflow split flow reach from the effective model (see Figures 1 and 2).

Initial review of the effective FEMA study found that the effective FEMA hydraulic model for Clover Creek indicates 100-year overtopping of I-5. Lakewood was not aware of this potential because effective FIRMs (Figure 2) map this area using a Zone X designation which can represent either 0.2% chance hazard area or 1% chance flood with average depth less than 1 foot.

Updated 1D/2D modeling confirmed the potential for the 100-year flood to overtop I-5 and the City of Lakewood held a meeting with representatives from the Washington State Department of Transportation (WSDOT), Pierce County, WSE, and FEMA Region X on August 21, 2019 to discuss preliminary mapping and results. Following this meeting, FEMA conducted an informal review of preliminary modeling and mapping and provided feedback through an in-person discussion of modeling and an email discussion of hydrology (attached). FEMA's comments have been addressed for this LOMR submittal by refining modeling and mapping, and through expanded discussion of modeling and hydrology within this write-up.



Clover Creek Location Map

Legend

- Clover Creek Centerline
- Lakewood Overflow Split Flow Path

Pierce County, WA

0 650 1,300 Feet

N

Scale: 1:12,000
NAD 1983 HARN
StatePlane Washington
South FIPS 4602 Feet

04 Sep 2019

WATERSHED SCIENCE & ENGINEERING

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Figure 1

Clover Creek FEMA Effective Mapping

Steilacoom Lake

Gravelly Lake

Lakewood Overflow Split Flow Path

Bridgeport Way

Shallow flooding/500-year flooding over I-5

BNSF Railroad

Pacific Highway

47th Ave SW

McChord-BNSF Railroad

McChord Air Force Base

Clover Creek

Overbank area for revision

262

265

268

274

275

276

Legend

- Base Flood Elevations
- Effective Cross Sections
- Regulatory Floodway
- 1% Annual Chance Flood Hazard Area (Zone AE)
- 0.2% Annual Chance Flood Hazard Area or 1% annual chance flood with average depth less than one foot or with drainage areas of less than 1 square mile (Zone X)

Pierce County, WA

0 510 1,020 Feet

N

Scale: 1:12,000
NAD 1983 HARN
StatePlane Washington
South FIPS 4602 Feet

05 Sep 2019

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Figure 2

4.0 HYDROLOGY

WSE reviewed and updated effective FEMA hydrology to develop a 100-year flood hydrograph to facilitate unsteady 1D/2D modeling.

4.1.1 Effective Hydrology

Effective hydrology for the Clover Creek FIS is based on an HSPF model simulation of stream flows from October 1, 1948 to September 30, 1999 (NHC, 2006). Figure 3 shows a schematic of the HSPF model (NHC 2005). Model output locations within the current study area include RCHRES 23 (Bridgeport Way) and RCHRES 24 (Lake Steilacoom). Effective HSPF model development is detailed in the study hydrology memo (NHC, 2003) which was included as an appendix to the 2006 FIS study report (NHC).

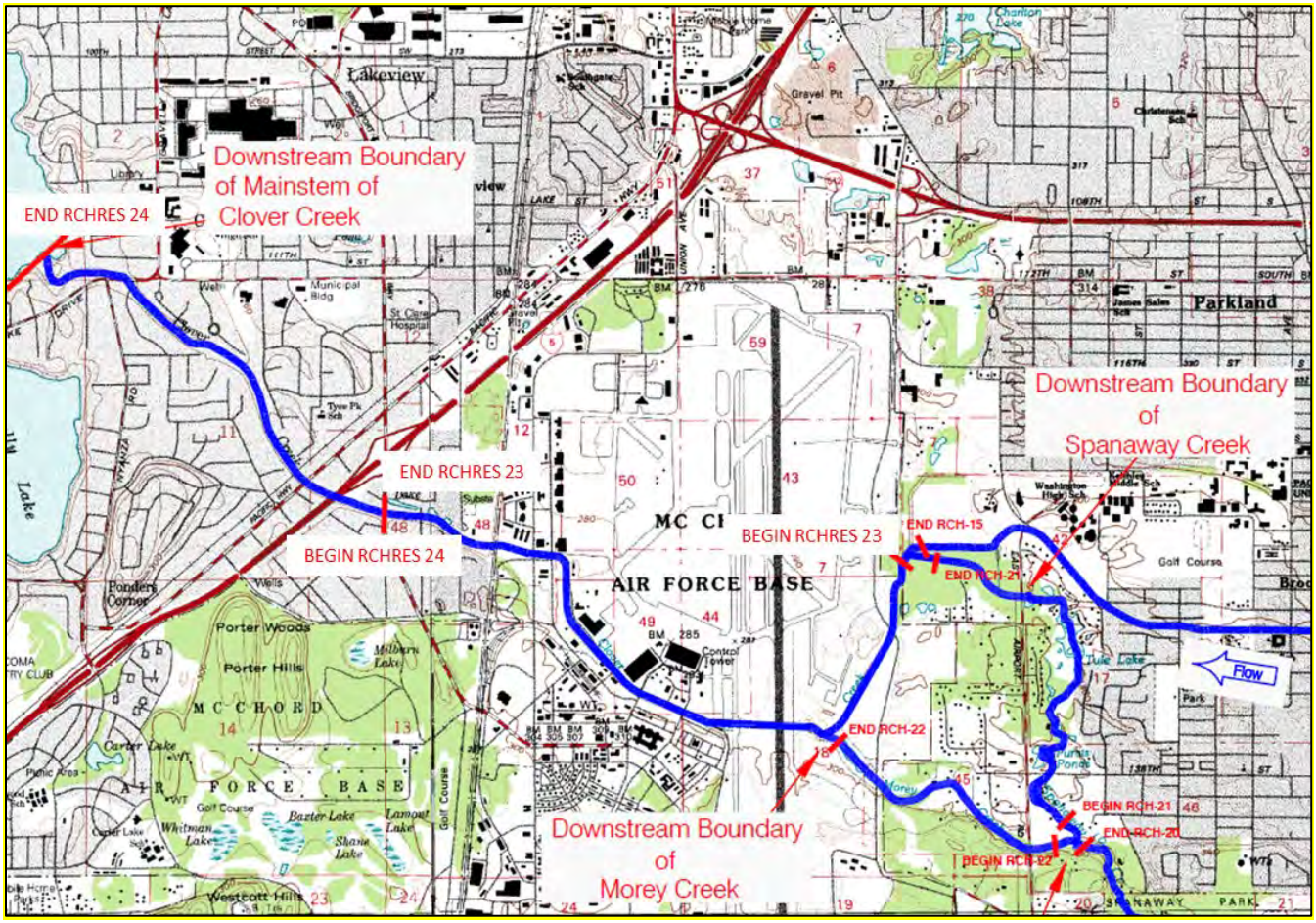

Figure 3. HSPF layout map from 2006 hydrology update (from NHC 2005)

4.1.2 Updating Hydrologic Data

WSE updated the effective HSPF analysis by extending the precipitation record through September 30, 2009 using new data recorded at the McMillin Reservoir precipitation gage. Gaps in the McMillin gage record were infilled with data from the SeaTac precipitation gage. Precipitation data for both the McMillin and SeaTac gages were downloaded from NOAA (https://www.ncdc.noaa.gov/cdo-web/) and input to the model at an hourly timestep. To be consistent with the effective model; no scalar was applied to the SeaTac data used to supplement McMillin precipitation record, the evaporation record

was extended using monthly average evaporation values, and the extended HSPF model was run at a 15 minute time step.

WSE completed flood frequency analysis on streamflow output from the extended HSPF model using the methods of Bulletin 17C to estimate 10-, 50-, 100-, and 500-year peak flows at Bridgeport Way (RCHRES 23) and Lake Steilacoom (RCHRES 24). Table 1 compares the updated peak flow estimates to peak flows from the effective FIS.

Table 1. Peak Flow Frequency from Extended Model and Effective FIS

Source	10-year Peak Flow (cfs)	50-year Peak Flow (cfs)	100-year Peak Flow (cfs)	500-year Peak Flow (cfs)
Bridgeport Way (RCHRES 23)				
Effective FIS Hydrology	291	434	501	677
Updated Flow Frequency Analysis	294	415	466	584
% Difference	+1%	-4%	-7%	-14%
Steilacoom Lake (RCHRES 24)				
Effective FIS Hydrology	297	439	506	680
Updated Flow Frequency Analysis	299	425	479	606
% Difference	+1%	-3%	-5%	-11%

The updated 100-year peak flows were within 7% of the effective FIS peak flows. It was decided that this difference was too small to pursue updating the effective flows; therefore, the peak flow values from the effective FIS were maintained for the current study. Results from the extended HSPF analysis were, however, used to calculate 100-yr flood volumes and to select a pattern 100-yr event hydrograph as described in Section 4.1.3.

4.1.3 Selecting Pattern Event Hydrograph

WSE completed an event volume analysis to help define the shape of the 100-year flood hydrograph. First, a flow frequency analysis was completed to calculate the 100-year 24-hour, 3-day, and 7-day flows at RCHRES 23 (Bridgeport Way) based on mean daily flows the extended HSPF model. Results were used to determine the 100-year 24-hour, 3-day, and 7-day volumes shown in Table 2.

Table 2. Volume Analysis

Event	Instantaneous Peak Flow (cfs)	24-Hour Volume (ac-ft)	3-day Volume (ac-ft)	7-day Volume (ac-ft)
100-year (Effective FIS @ RCHRES23)	501	917	2,529	5,207

WSE patterned the 100-year inflow hydrograph after the Feburary 1996 flood event recorded at USGS 12090500 - Clover Creek near Tillacum, WA. The gage is located at Pacific Highway several hundred feet downstream from Bridgeport Way. The February 1996 flood had a peak flow recurrence of

approximately 50 years (418 cfs) and was the largest event for which short interval (15-min) flow data was available. WSE scaled the gage data by a uniform scalar of 1.30[1] and input the resulting hydrograph at the upper model boundary of the project HEC-RAS model (described in section 5). The HEC-RAS model was then run, and simulated flow peak and flood volumes were extracted at Bridgeport Way - which corresponds to the effective FIS flow location and HSPF RCHRES 23. Table 3 shows a comparison of the simulated values to the FEMA 100-year flow peak and calculated flood volumes (from Table 2). This comparison indicates that simulated values are within 5% of reported/calculated values for both peak flow and flood volumes. Figure 4 provides a graphical comparison of the 1996 flood hydrograph, the scaled 100-year model inflow hydrograph, and the routed 100-year hydrograph at Bridgeport Way.

Table 3. Inflow Hydrograph Scalar Results

Event	Scalar	Q_{peak} (cfs)	24-Hour Volume (ac-ft)	3-day Volume (ac-ft)	7-day Volume (ac-ft)
100-year Event @ RCHRES23/Bridgeport Way	-	501	917	2,529	5,207
Scaled February 1996 Routed. Results at Bridgeport Way (RS 1.5947)	1.30	476	924	2,577	5,136
% Difference		-5.1%	+0.7%	+1.9%	-1.4%

[1] The final scaling factor was determined through an iterative (trial and error) process of running model simulations and checking output at Bridgeport way for agreement with 100-year peak flow and flood volumes.

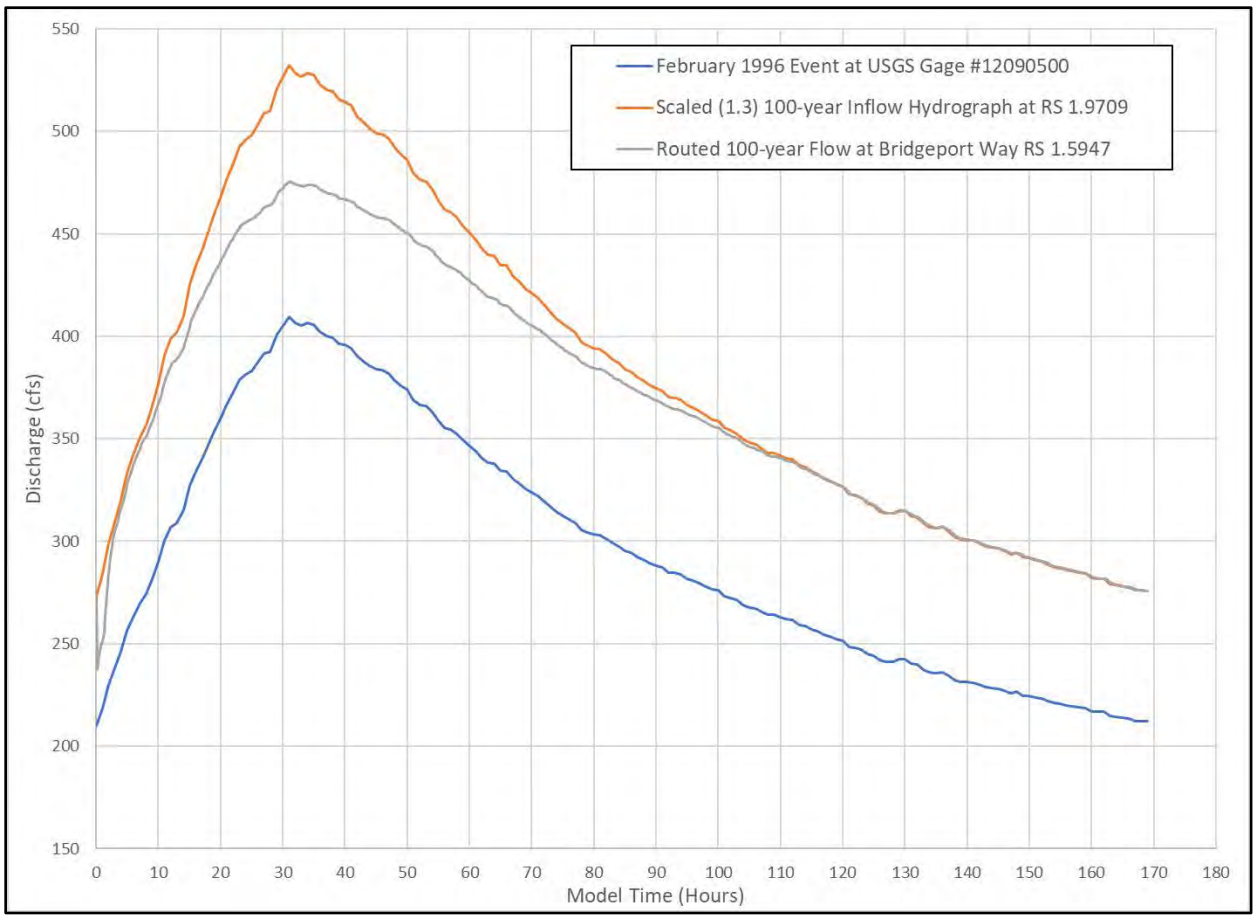

Figure 4. February 1996 hydrograph, 100-year model inflow hydrograph (1.3 times Feb 1996), and routed 100-year flow hydrograph at Bridgeport Way.

4.1.4 Use of USGS Gage Data

FEMA Region X reviewed proposed LOMR hydrology and compared results to flood frequency analysis completed on peak flow data from USGS gage 12090500 Clover Creek at Pacific Highway SW (Ana Simones, FEMA Region X, Personal Comm.). As a point of clarification – hydrology for this LOMR is based off the effective HSPF analysis and not the gage data for the following reasons:

1. Data that was recorded at gage 12090500 before 2000 does not reflect current attenuation of North Fork Clover Creek peaks by two regional detention ponds. These ponds are represented in the FIS hydrologic model (NHC, 2006).
2. Consistency with the effective FIS, which applied HSPF to determine flows for the entire Clover Creek Study area. The HSPF model was developed, calibrated, and validated using several long term USGS sites as well as short term meteorological and stream gaging sites (NHC, 2006).

5.0 2D HYDRAULIC MODELING AND ANALYSIS

WSE converted the effective FEMA model to run in HEC-RAS 2D (v 5.07) and truncated the model to remove cross sections above the BNSF-McChord Railroad crossing at River Station 1.9707 (see Figure 5). Model updates included incorporating new overbank topography using 2011 LiDAR (Watershed

Sciences, 2011), adding the Springbrook Park Pedestrian Bridge (constructed in 2016), converting the model from steady state to an unsteady flow analysis, and replacing the right overbank area and Lakewood Overflow split flow reach with a single 2D area.

5.1.1 Geometry Development and 2D computational Mesh

The updated model was run as a combined hybrid 1D/2D model. The main reach of Clover Creek is represented as a 1D channel, but WSE trimmed the effective cross sections at natural high ground along the right channel bank and added a 2D area to route flow escaping the main channel (see Figure 5). WSE defined lateral weirs to connect the 1D channel reach and cross sections to the right overbank 2D area, from HEC-RAS River Station 1.9709 to midway between River Stations 0.9055 and 0.7651. Lateral weir elevation data was based on LiDAR topography. This incorporated the Lakewood Overflow split flow path from the effective model into the 2D flow area. The downstream boundary condition used for the Lakewood-Overflow split flow path was set to normal depth with a slope of 0.0084 ft/ft to be consistent with the effective FIS model.

Clover Creek Updated Model Layout

Legend

- Split Flow Path Downstream Boundary
- Bridges
- Cross Section
- Lakewood Overflow Split Flow Path
- Clover Creek Centerline
- Lateral Weir
- 2D Area Boundary

Pierce County, WA

0 500 1,000 Feet

N

Scale: 1:12,000
NAD 1983 HARN
StatePlane Washington
South FIPS 4602 Feet

22 Jan 2020

WATERSHED SCIENCE & ENGINEERING

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Figure 5

5.1.2 Updated Topography

The updated model maintained in-channel data from the effective cross sections. Left and right overbank topography was updated using LiDAR collected in 2011 for Pierce County (Watershed Sciences, 2011).

5.1.3 Roughness

WSE set Manning's 'n' roughness values in the 2D right overbank area based on land cover observed in 2017 National Agriculture Imagery Program (NAIP) satellite imagery and site observations. A land use layer was created in GIS and imported into HEC-RAS to define spatially varying Manning's n values. Table 4 summarizes the Manning's 'n' values assigned to each land use classification in the layer.

A GIS layer of building footprints was downloaded from the City of Lakewood's GIS ftp site. This layer was incorporated in the land use layer. Building footprints were set to a very high manning's n value to simulate no flow being allowed through buildings (0.99)

A manning's n value of 0.075 was chosen for the immediate right over bank and other moderately treed areas. This is consistent with the manning's n value used in the 2006 HEC-RAS model for the right overbank.

Table 4. Manning's n Roughness Values

Land Use/Land Cover Classification	Manning's n Value
Residential	0.045
Commercial	0.02
Fields	0.06
Roads	0.02
Railroad Berm	0.025
Forested Areas	0.075
Open Water	0.02
Buildings	0.99

5.1.4 Springbrook Park Pedestrian Bridge

The Springbrook Park Pedestrian Bridge located on Clover Creek between the BNSF-McChord Railroad crossing and Bridgeport Way SW was constructed 2016 and therefore not included in the 2006 HEC-RAS model. WSE incorporated this new bridge into the HEC-RAS model based on 7/20/2016 construction drawings provided by the City of Lakewood.

The bridge was added to the model by first adding two cross section at the upstream and downstream bridge faces (River Stations 1.824 and 1.820, respectively). Bridge deck elevations, low chord elevations, and in-channel topography for the bridge face cross sections were taken from the construction drawings provided by the City of Lakewood. The bridge railing was not simulated in the HEC-RAS model because both the 100-year and 500-year water surface elevations do not get this high.

5.1.5 Upstream Inflow

As described in Section 4.1.3, the February 1996 event was selected as the 100-year pattern hydrograph. The peak 7-day hydrograph from the February 1996 event was scaled by 1.30 and input into the HEC-RAS at the upstream end of the model (RS 1.9709).

5.1.6 Levee Failure Run

One section of the bank along Clover Creek appears to be a berm that is acting as a non-accredited levee. This berm is located on the right bank of Clover Creek just downstream of the BNSF-McChord railroad crossing (See Figure 5). WSE completed a levee failure run by removing approximately 130 feet of berm from the topographic surface and re-running the model to simulate the 100-year and 500-year flood events. The mapped flood hazard areas and BFEs from this study reflect a combination of worst case with and without levee failure runs.

5.1.6 Floodway

The effective Clover Creek floodway was maintained for this LOMR study. Floodway encroachments were applied by setting blocked obstructions at effective floodway stations. The floodway contains all flow within the mainstem (1D) channel and does not require a floodway along the Lakewood Overflow reach. Table 5 presents the updated floodway properties. Both Base Flood Elevations (BFEs) and encroached floodway elevations changed throughout the revised reach, however the floodway water surface elevations did not increase by more than 1 foot over BFEs.

Table 5: Floodway Data Table: Clover Creek Main Stem

Flooding Source		Floodway			Base Flood Water Surface Elevation		
Cross-Section	Distance (ft from outlet at Lake Steilacoom)	Width (ft)	Section Area (sq ft)	Mean Velocity (ft/s)	Without Floodway (ft)	With Floodway (ft)	Increase (ft)
P	2384	52	224	2.2	261.4	262.0	0.6
Q	2865	54	194	2.6	261.8	262.5	0.7
R	3552	28	93	5.4	263.1	263.8	0.7
S	4251	48	172	3.7	265.4	266.3	0.9
T	4992	45	144	4.2	266.7	267.5	0.8
U	5583	40	165	3.8	268.0	268.7	0.7
V	6279	29	161	3.2	269.1	269.7	0.6
W	6619	23	108	4.7	269.6	270.3	0.7
X	6826	46	162	3.5	270.2	271.0	0.8
Y	6845	47	172	3.5	270.2	271.0	0.8
Z	6862	44	178	3.0	270.4	271.1	0.8
AA	6879	38	158	4.5	270.2	271.0	0.8
AB	6934	29	128	4.3	270.5	271.1	0.6
AC	7032	40	156	3.5	270.7	271.4	0.7

Table 5: Floodway Data Table: Clover Creek Main Stem							
Flooding Source		Floodway			Base Flood Water Surface Elevation		
Cross-Section	Distance (ft from outlet at Lake Steilacoom)	Width (ft)	Section Area (sq ft)	Mean Velocity (ft/s)	Without Floodway (ft)	With Floodway (ft)	Increase (ft)
AD	7112	39	151	3.6	271.0	271.7	0.7
AE	7121	47	175	3.2	271.0	271.7	0.7
AF	7167	44	194	3.2	271.1	271.8	0.7
AG	7256	37	165	3.7	271.2	271.9	0.6
AH	7548	25	110	4.7	271.8	272.4	0.6
AI	7768	29	111	4.9	272.4	273.0	0.6
AJ	8009	74	266	2.1	273.1	273.6	0.5
AK	8196	37	170	3.1	273.2	273.7	0.5
AL	8537	26	113	4.4	273.7	274.2	0.5
AM	8566	36	162	3.2	273.8	274.4	0.6
AN	8631	35	145	3.9	273.8	274.4	0.6
AO	8675	32	125	4.7	274.0	274.5	0.5
AP	9303	41	181	3.0	275.3	276.0	0.6
AQ	9688	36	184	3.2	275.7	276.4	0.7
AR	9984	36	196	2.7	275.9	276.6	0.7
AS	10413	26	114	2.8	275.9	276.6	0.7
AT	10617	62	355	2.9	276.0	276.7	0.7
AU	10699	44	277	1.8	277.1	277.8	0.7
AV	10903	46	295	1.7	277.3	278.0	0.7
AW	11068	52	246	2.0	277.4	278.2	0.7
AX	11248	53	314	1.6	277.7	278.4	0.7
AY	11381	62	316	1.6	277.9	278.5	0.6
AZ	11475	57	328	1.5	278.2	278.8	0.6

6.0 MODEL RESULTS

Figure 6 and 7 show inundation extents and depths from the updated 100-year model run and 100-year levee failure run, respectively. In both cases, water overtops the right bank of Clover Creek and fills up low lying areas between the BNSF-McChord Railroad crossing and I-5. Results indicate that flooding would overtop I-5 with a maximum water surface elevation of 274.3 feet in the 100-year run and 274.9 feet in the levee failure run compared to a controlling roadway elevation of approximately 272.9 ft. Overtopping flow continues northwest past Pacific Highway and the downstream mainline BNSF railroad crossing before joining the Lakewood Overflow split flow path. Levee failure sends more water into the

right overbank at the levee location near the upstream model extent, resulting in greater inundation depths and larger overall overbank inundated area compared to the no levee failure case.

6.1.1 Floodplain Mapping

Proposed mapping updates contained in this LOMR are presenting in the attached floodplain workmap (pdf in Digital Data Submittal). 500-year floodplain extents, 100-year floodplain extents, and 100-year base flood elevations represent the composite of levee failure and no levee failure simulations. The workmap depicts both proposed and effective mapping including tie in locations.

6.1.2 Mapping Tie-in Locations

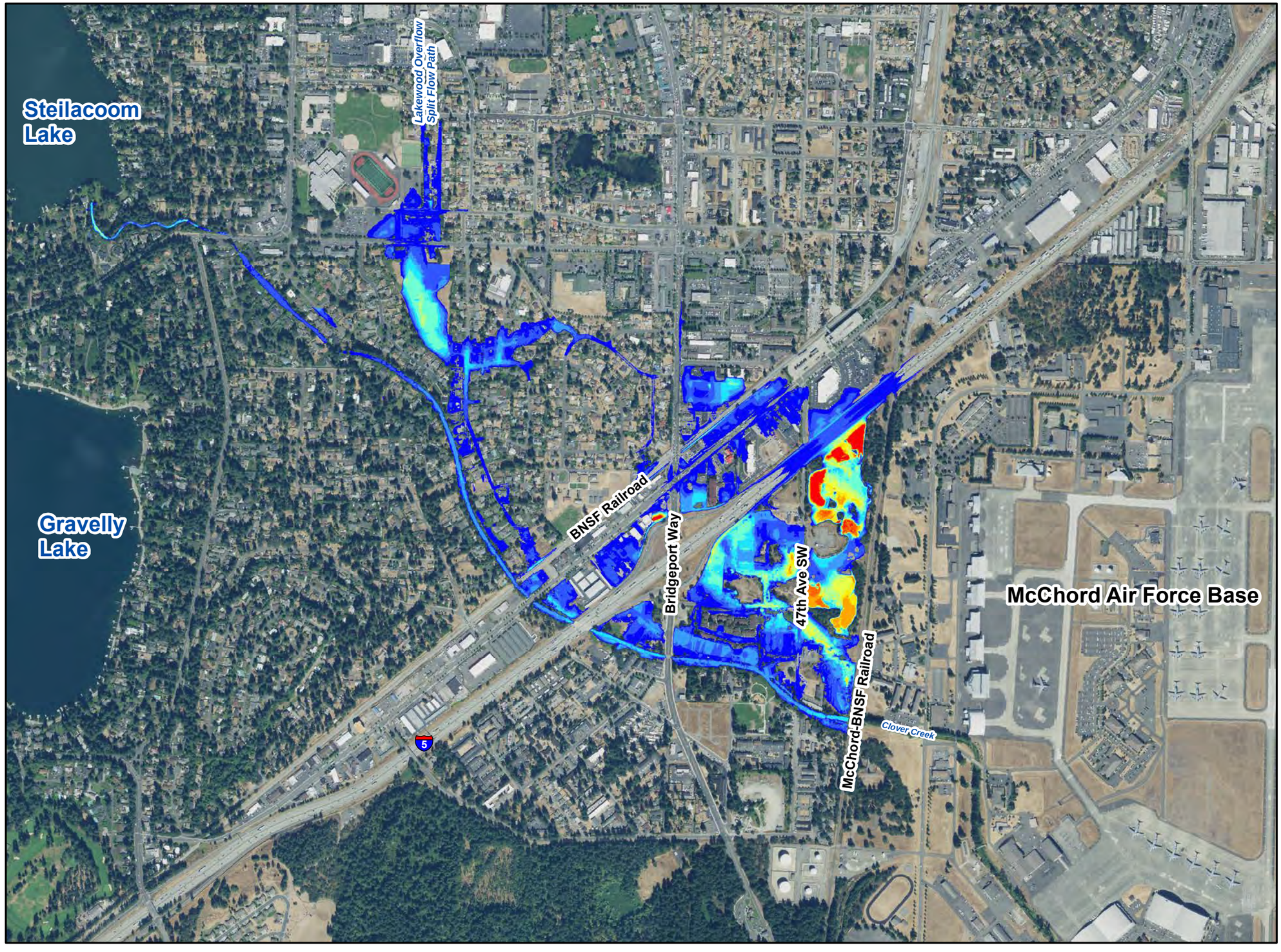
The downstream LOMR extent along the mainstem channel is effective FEMA XS S, approximately 116th Ave SW. The upstream model extent is the downstream face of the BNSF Bridge (FEMA XS AT). Along the Lakewood Overflow reach mapping was tied in 112th St SW (FEMA XS D). The upper portion of the overflow reach was replaced with a 2D area. Proposed base flood elevations at the tie in locations match effective elevations within 0.5 feet.

6.1.3 Flood Profile

Updated flood profiles are included at the end of this memo for the mainstem of Clover Creek including the 10-, 50-. 100-, and 500-year flood profile. Profiles represent the no levee failure simulation, which is the worst-case scenario for in-channel flood elevations.

6.2 LOMR MAPPING

Results of the updated modeling and mapping are provided as a Letter of Map Revision request.



100-year Flooding Depth Non Levee Failure

Legend

Maximum Water Depth

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 7
- 7 - 8
- 8 - 9
- 9 - 10
- 10+

Pierce County, WA

0 500 1,000 Feet

N

Scale: 1:12,000
NAD 1983 HARN
StatePlane Washington
South FIPS 4602 Feet

22 Jan 2020

WATERSHED SCIENCE & ENGINEERING

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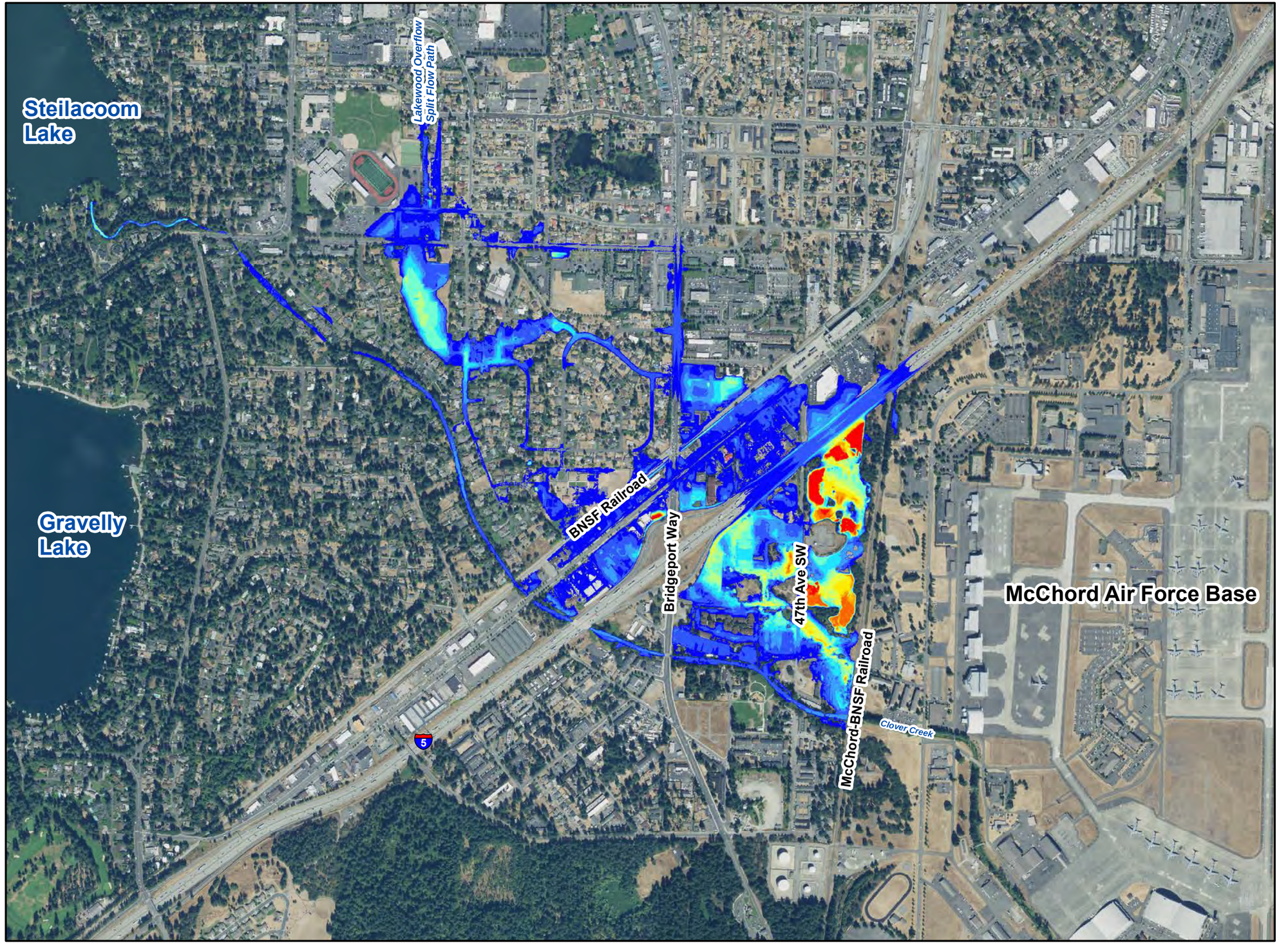
Figure 6



100-year Flooding Depth With Levee Failure

Legend

Maximum Water Depth

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 7
- 7 - 8
- 8 - 9
- 9 - 10
- 10+

Pierce County, WA

0 500 1,000 Feet

N

Scale: 1:12,000
NAD 1983 HARN
StatePlane Washington
South FIPS 4602 Feet

22 Jan 2020

WATERSHED SCIENCE & ENGINEERING

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Figure 7

7.0 REFERENCES

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NHC (2003) *Hydrology for 2002 Floodplain Mapping Study of Pierce County, Washington Streams: Clover Creek, Spanaway Creek, and North Fork Clover Creek* , Prepared by northwest hydraulic consultants, inc, July 17, 2002 (revised October 30, 2003).

NHC (2005) *Hydrology Memorandum Figure 1 Location Map Revised* October 5, 2005.

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Watershed Sciences. (2011) *LiDAR Remote Sensing – Pierce County, Washington.* Downloaded from http://pugetsoundlidar.ess.washington.edu/lidardata/restricted/nonpslc/pierce2010/pierce2010.html on 5/17/2019.

WATERSHED SCIENCE & ENGINEERING

Chris Frei <chris@watershedse.com>

Clover Creek Hydrologic analysis, updated floodplain mapping, City of Lakewood

10 messages

Simoes, Ana P <Ana.Simoes@atkinsglobal.com> Thu, Nov 21, 2019 at 3:04 PM
To: Chris Frei <chris@watershedse.com>, Paul Bucich <pbucich@cityoflakewood.us>, Greg Vigoren <GVigoren@cityoflakewood.us>, Sarah Parker <sarah@watershedse.com>
Cc: "Crowley, Josha" <Josha.Crowley@atkinsglobal.com>, Ted Perkins <Dwight.Perkins@fema.dhs.gov>

Hello,

I reviewed WSE's Clover Creek Hydrologic analysis. Estimates for 100-yr flows seem fine but the 100-yr hydrograph may need to be revised as some assumptions made aren't clearly documented, which may lead to a different outcome, perhaps less conservative. Here is a summary:

1. Clover Creek and WSE approach:
   - About Clover Creek: urban watershed, over 25% impervious cover. There is a USGS unregulated gage near Tillicum (12090500), right upstream of I-5, draining 7 sq.mi., with 40 years of records. Since the watershed is urban, WA regional regression equations are not applicable. A well calibrated continuous hydrologic model is certainly adequate to describe the watershed;
   - 100-yr peak flow: WSE extended the climatological series and ran the effective HSPF model developed by NHC. Updated results were slightly lower than effective flows, which consequently were not revised;
   - 100-yr hydrograph (for 2D model input) – WSE used frequency analysis of simulated volumes and the 1996 event 15-min observed hydrograph (peak at 418 cfs) to develop the 100-yr hydrograph.

2. Gage analysis check:
   - I used HEC-SSP to perform Bulletin 17C frequency analysis on the records from the gage near Tillicum and compared against 100-yr effective flows and HSPF model results for Bridgeport Way / RCHRES 23. Estimated 100-yr flow is 571 cfs with a 68% interval of 488 to 827 cfs – so, effective flow (501 cfs) is within the 68% confidence interval while WSE estimated flow is just outside (466 cfs).

3. Overall comments:
   - Flood frequency analysis – the WSE report states that they "completed flood frequency analysis on streamflow output from the extended HSPF model using the methods of Bulletin 17C", and then present a table with flows for selected intervals, no input/output files are provided, no frequency curves. Which software was used in the analysis – SSP, PeakFQ or WSE-developed? Only HEC-SSP and PeakFQ are FEMA approved. Was B17C or B17B followed? What are the assumptions regarding skew coefficient? Was frequency analysis performed only at one location or multiple locations?
   - Hydrograph development – it was not explicit how the scaling factor (1.35) was derived. Also, since there is a gage with daily records, the volume frequency analysis results should probably be compared with similar results from gage data instead of the 1996 event. Finally, the hydrograph 24-hr, 3-day, and 7-day volumes should probably represent their respective 100-yr estimates (not the mean), similar to the USACE balanced hydrograph approach. Having some of the calculation sheets would be helpful;
   - Hydrograph plots – plots of the 1996 event vs. the 100-yr hydrograph would provide a useful comparison;.
   - Calibration – there is no mention of such, so assumption seems to be that effective model is fine, which may not be the case. It would also be good to see hydraulic model results for the observed 1996 event – was that run and compared to information on flood damages, historical reports, aerial photos, etc., for a qualitative comparison? It doesn't look like that was done.

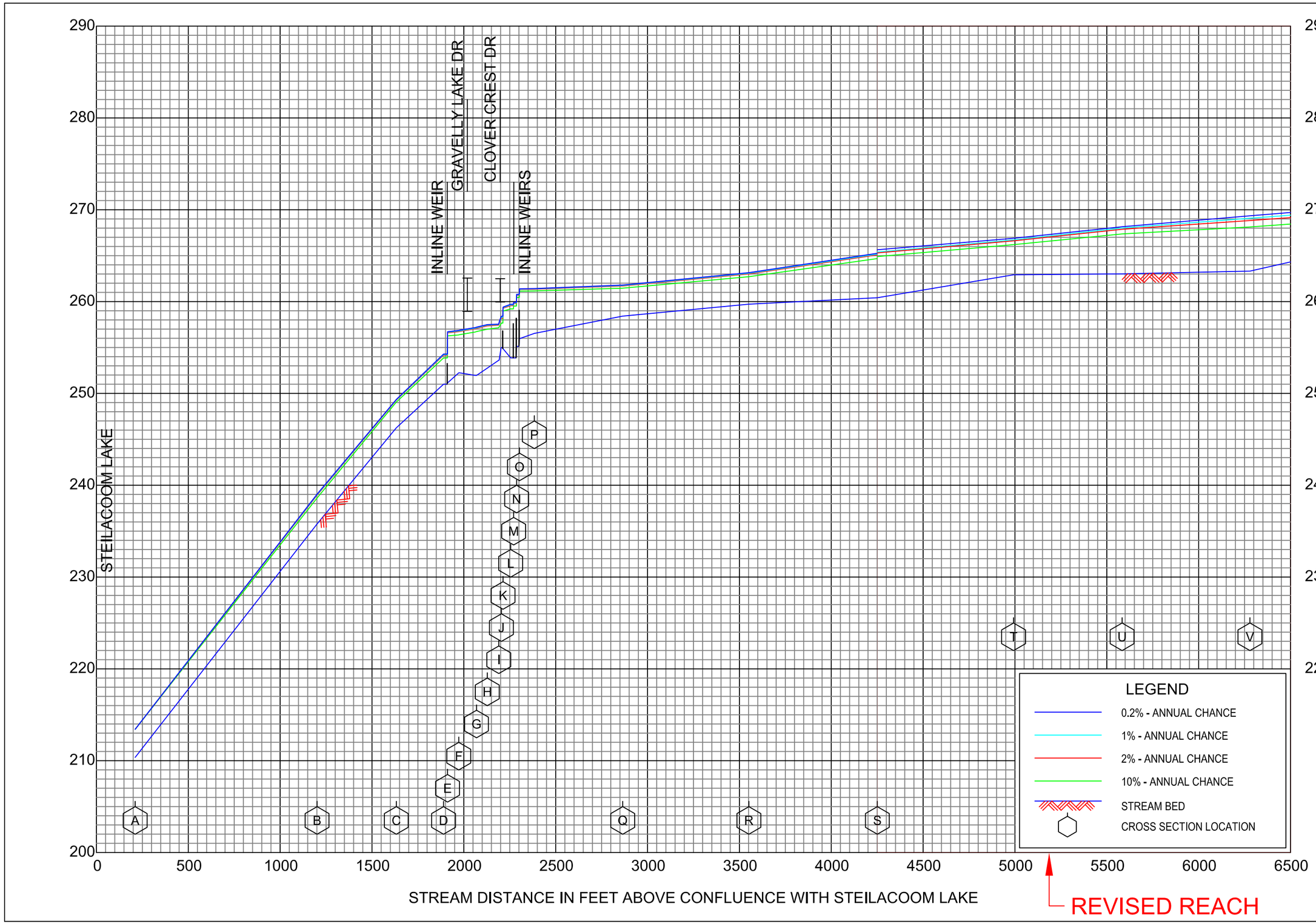
Please do not hesitate to contact me if you need additional information or have any questions.

Best regards,

Ana.

Ana Paula Simões, Ph.D., PH, CFM

Sr. Hydrologist | STARR II - FEMA Region X Service Center



FLOOD PROFILES

CLOVER CREEK

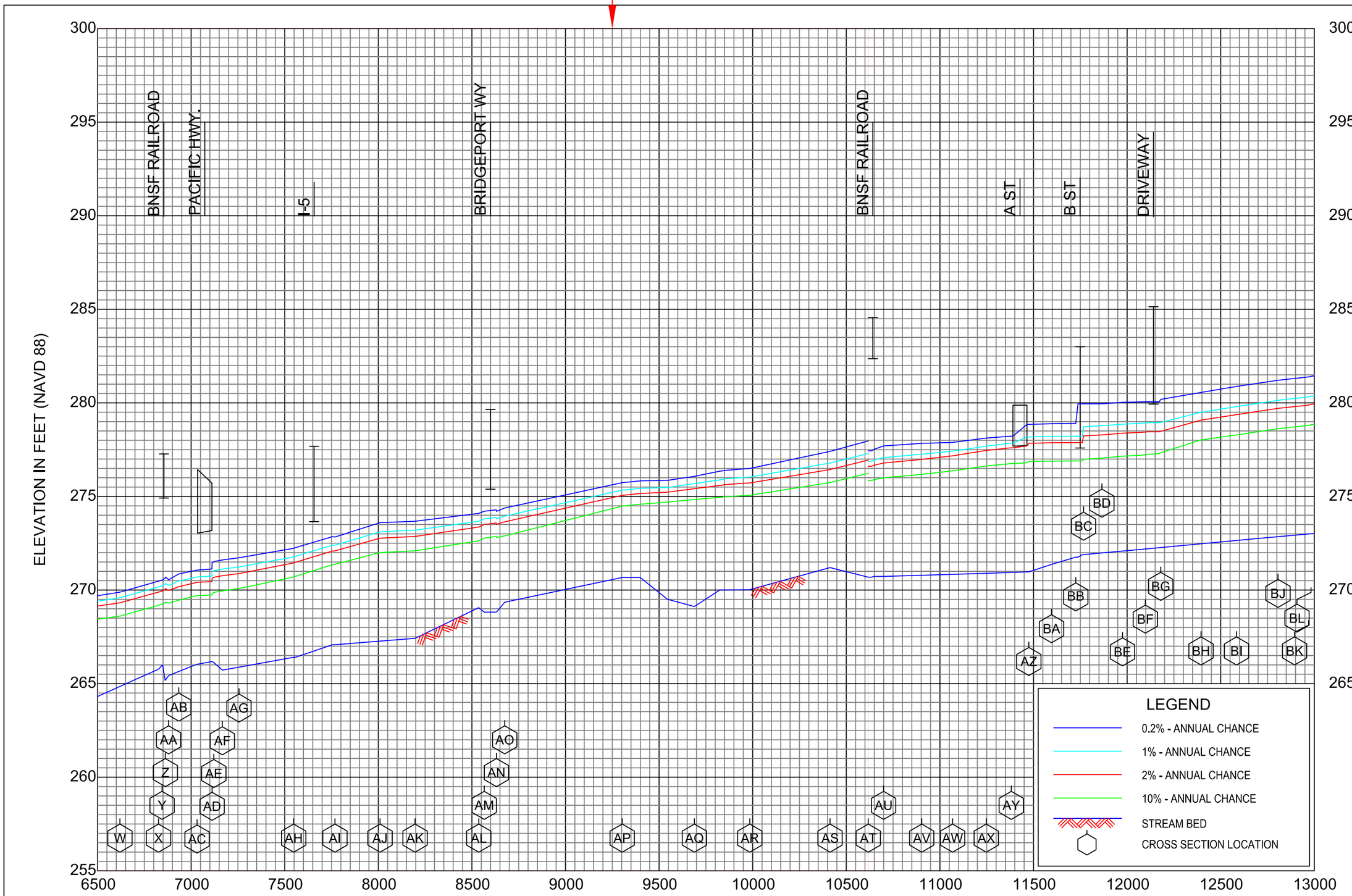
FEDERAL EMERGENCY MANAGEMENT AGENCY

PIERCE COUNTY, WA

& INCORPORATED AREAS

1.1

REVISED REACH



FLOOD PROFILES

CLOVER CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

PIERCE COUNTY, WA

& INCORPORATED AREAS

1.2

Effective Zone X
Not associated with Clover Creek

2D LOMR model ties to effective 1D Lakewood Overflow reach at cross section D near 112th Street SW

Effective Zone X

Cross Sections D through L removed. Now part of 2D area.

Effective 1D model retained downstream from Cross Section S

Cross Sections X through AT truncated at 1D/2D boundary line on right bank.

Cross section orientation from effective model was maintained where it differed from effective mapping

Effective floodway was maintained for LOMR study

Effective 1D model retained upstream from Cross Section AT

Cross sections added to promote model stability

Clover Creek

Cross sections added to represent Springbrook Bridge

PRIVATE
69TH
GRAVELLY LAKE DRIVE SW
DOUGLAS DR SW
WESTWOOD DR SW
RUSSELL RD SW
DOTEN DR SW
108TH ST CT SW
109TH ST SW
58TH AVE CT SW
59TH AVE SW
BRIAR RD SW
DAVISSON RD SW
VILLA LN SW
110TH ST SW
CARAWAY DR SW
111TH ST SW
OCCIDENT ST SW
ADDISON ST SW
FREIDAY ST SW
47TH AVE SW
ALLEY
KENDRICK ST SW
KLINE ST SW
114TH ST SW
60TH AVE SW
HIGHLAND AVE SW
55TH AVE SW
112TH ST SW
CLOVERDALE CT SW
CLOVER PARK DR SW
LOMA PL SW
LOCH LEA DR SW
ARROWHEAD RD SW
114TH ST CT SW
115TH ST SW
115TH ST CT SW
56TH AVE SW
116TH ST SW
MOUNTBROOK LN SW
117TH ST SW
55TH AVE SW
SEMINOLE RD SW
PAWNEE DR SW
TOMAHAWK RD SW
CREEKWOOD LN SW
119TH ST SW
CLOVER CREEK DR SW
CREEKSIDE DR SW
58TH AVE SW
120TH ST SW
COCHISE LN SW
BRIDGEPORT WAY
CLINE RD SW
121ST ST SW
122ND ST SW
48TH AVE SW
LINDALE LN SW
PACIFIC HIGHWAY
SEATTLE AVE SW
123RD ST SW
124TH ST CT SW
SOLBERG DR SW
ADDISON ST SW
47TH AVE SW
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I-5

Legend

- Creek Centerline
- Proposed Cross Sections
- Effective Cross Sections
- Proposed Base Flood Elevation
- Effective Base Flood Elevation
- Roads
- 1D/2D Connection Gutterline
- LiDAR 1ft Contour
- LiDAR 10ft Contour
- Proposed Clover Floodway
- Proposed Clover 100yr Floodplain
- Proposed Clover 500yr Floodplain
- Effective Floodway
- Effective Zone A
- Effective Zone AE
- Effective Zone X

CLOVER CREEK
PIERCE COUNTY, WA
LOMR WORKMAP

Effective FIRM Panels:
53053CO313E
53053CO294E

Vertical Datum: NAVD 88

Notes:

Effective flood hazard boundaries are shown as solid lines proposed LOMR revisions as solid polygons.

Background Topography shows 1-ft Contours based on Pierce County LiDAR (2011).

Pierce County, WA

CHRISTOPHER MICHAEL HERE
STATE OF WASHINGTON
46360
REGISTERED
PROFESSIONAL ENGINEER

Clover Creek LOMR Workmap

EXHIBIT 1

Scale: 1:3,000
NAD 1983 HARN StatePlane Washington South FIPS 4602 Feet

22 Jan 2020

WATERSHED SCIENCE & ENGINEERING

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Appendix B: Estimated Mitigation Ranking, Engineering, and Implementation Considerations Table

Clover Creek Engineering Alternatives Evaluation Study
Final Alternatives Matrix

Alternative	Name	Type	Description	Estimated Mitigation level	Estimated relative level of effort	Engineering/Implementation considerations
A1	Do Nothing	-	Continue business as usual with inherent risk of FEMA mapped floodplains containing I-5 and other local businesses and residential buildings.	-	-	The economic impacts associated with flood risks include damage and closures to local businesses, damage to residential buildings, and the potential closure of I-5.
A2	Regional Storage	Storage	Create a regional storage facility's throughout the watershed. Storage could be inline/offline or flood plain benching.	High	High	Storage will likely need to be mostly in the upperwatershed as the areas near I5 have high groundwater during the rainy season and therefore have limited opportunity for storage.
A3	Bypass Pipe	Capacity Improvements	Construct a pipe/channel capable of rerouting/bypassing high flows downstream.	High	High	Involves the design and construction of miles of new infrastructure. Project will be expensive, and finding an acceptable alignment to minimize utility conflicts will be challenging. Estimate of roughly 2 miles of pipe to Steilacoom Lake.
A4	Set Back Levee or Flood Wall	storage/ Capacity/ blockage	Set back levee along the north bank to limit flooding. Location of levee to be determined.	Medium	Medium	The displacement of flood waters may trigger a no-rise analysis or other permitting requirements. Downstream capacity and flooding would also require consideration or attention.
A5	Levee or Flood Wall along creek	Flood Blockage	Levee along the creek to block flood waters exit from the channel	Medium	Medium	Private property and structures along the north bank may add complexity along with permitting challenges.
A6	Creek Restoration/Capacity Enhancements	System Improvements/Capacity	Upstream and downstream restoraton of Clover Creek to include habitat improvements, flood mitigation and storage, bank stabilization, and the implementation of LID to improve water quality.	Medium	Medium	Project will require an extensive study of the Clover Creek watershed which will likely include stream flow and quality monitoring.
A7	WSDOT Ditch Blockage or Flood Wall along I-5	Flood blockage	Flood propagation begins at the creek and moves north mostly west of 47th Ave. The drainage ditch along I-5 would be blocked and would not allow drainage or flood water to move north or south along the east side of I-5.	Medium	Low	Construction and/or hydraulic modifications within the floodway may trigger a no-rise analysis or other FEMA permitting requirements.
A8	Watershed Wide Management Study	Upstream improvements	Implement a feasibility study to measure and monitor flows from the upstream watershed and determine watershed-wide actions to help mitigate peak flows.	Low	Low	This is a recommendation for further study to understand the watershed dynamics and if a watershed wide approach could be effective.
A9	Raise Profile I-5	Flood Blockage	Elevating the North bound lanes of I-5 would effectively remove the roadway from the flood plain and block flood water from the western side of I-5	Medium	medium	Project may result in the displacement of flood water resulting in permitting challenges. Realignment of the roadway profile may require retrofits of on-ramps, off-ramps, and utility relocation.
A10	TMDL Integration	Integrated Approach	Integrate TMDL operations to also consider flood mitigation throughout the watershed.	Low	Low	Partner with larger TMDL implementation plan to target flood mitigation in additional to TMDL targets.
A11	Fill Low Areas Along Clover Creek	Flood Blockage	Fill areas along creek to effectively raise the bank elevation while still enabling development to occur	Medium	Medium	Filling in an existing mapped FEMA flood plain would require a no rise evaluation and may trigger other requirements. May result in filling existing wetland which could be a challenging permitting process. Down stream impacts may be a concern.
A12	Creation of Floodplain	Capacity Improvements	Purchase property and establish easements for the creation of intentional floodplain storage areas with flooded area as well as upstream and downstream.	High	High	Feasibility of relocating current occupants, both businesses and residents poses challenges. Purchase of easements may be costly.

Appendix C: Alternative Cost Estimates

Setback Levee				
Key Project Elements ~ Construct 2,000' of setback levee from RR tracks at JBLM to Bridgeport Way ~ Construct up to 4,000' of floodwall downstream of Bridgeport Way to protect from breakout flooding ~ Existing downstream weirs, culverts, fish ladders etc that impede the movement of fish would be removed or improved down to Steilacoom Lake ~ Wetlands, water quality, habitat improvements will be constructed as appropriate where there are opportunities				
Item	**Unit**	**Unit Cost (2022)**	**Quantity**	**Total Cost**
General				
Construction Access	LS	100,000	1	$100,000
Earthwork				
General Earthwork/Excavation	CY	25	0	$0
Clearing and Grubbing	AC	16,000	14	$200,000
Dewatering	LS	1,000,000	1	$1,000,000
Structure Installation				
Levee (6' height)	LF	840	2,000	$1,700,000
Floodwall (5' height)	LF	1,200	4,000	$4,800,000
Project Sub-Total				$7,800,000
Contingencies and Multipliers				
Mobilization	LS	10%		$800,000
Erosion and Sediment Control	LS	3%		$200,000
Contingency	LS	40%		$3,100,000
Traffic Control/Utility Relocation	LS	5%		$400,000
Easements	LS			$3,500,000
Capital Expense Total (including contingency)				$15,800,000
Design/Construction Administration/Public Involvement (%)	LS	15%		$2,400,000
Engineering and Permitting (%)	LS	15%		$2,400,000
			TOTAL	**$20,600,000**
			-50%	**$10,300,000**
			+100%	**$41,200,000**

I-5 Levee				
Key Project Elements ~ Construct 1055' of levee at 47th Ave SW and extends west along 120th St SW to the I-5 on-ramp where it would extend to the southwest until it intersects with high ground, approximately where the levee would cross 121st St SW. ~ Construct 275' of levee at existing RR tracks near JBLM to prevent breakout flooding ~ Construct up to 4,000' of levee/floodwall downstream of Bridgeport Way to protect breakout flooding ~ Existing downstream weirs, culverts, fish ladders etc that impede the movement of fish would be removed or improved down to Steilacoom Lake ~ Wetlands, water quality, habitat improvements will be constructed as appropriate and where there are opportunities				
Item	**Unit**	**Unit Cost (2022)**	**Quantity**	**Total Cost**
General				
Construction Access	LS	100,000	1	$100,000
Earthwork				
General Earthwork/Excavation	CY	25	0	$0
Clearing and Grubbing	AC	16,000	12	$200,000
Dewatering	LS	1,000,000	1	$1,000,000
Structure Installation				
Levee (6' height)	LF	840	1330	$1,100,000
Floodwall (5' height)	LF	1,200	4000	$4,800,000
Project Sub-Total				$7,200,000
Contingencies and Multipliers				
Mobilization	LS	10%		$700,000
Erosion and Sediment Control	LS	3%		$200,000
Contingency	LS	40%		$2,900,000
Traffic Control/Utility Relocation	LS	5%		$400,000
Easements	LS			$2,600,000
Capital Expense Total (including contingency)				$14,000,000
Design/Construction Administration (%)	LS	15%		$2,100,000
Engineering and Permitting (%)	LS	15%		$2,100,000
			TOTAL	**$18,200,000**
			-50%	**$9,100,000**
			+100%	**$36,400,000**

Channel and Flood Plain Enhancement				
Key Project Elements ~ Channel widening and floodplain benching up to 30' wide on either side of creek or up to 55 feet total from at 2-year WSEL ~ Approximately 0.6 miles of channel widening and floodplain benching ~ Widening and benching would begin at the 2-year WSEL, which approximates bankfull elevation ~ Benching would be completed on a site-by-site basis primarily on the north side (right bank) of the creek, with limited benching on the left bank. ~ Instream improvements such as wood, spawning substrate, complexity, riffle/pool, would be implemented ~ Existing downstream weirs, culverts, fish ladders etc that impede the movement of fish would be removed or improved down to Steilacoom Lake ~ Wetlands, water quality, habitat improvements will be constructed as appropriate and where there are opportunities				
Item	**Unit**	**Unit Cost (2022)**	**Quantity**	**Total Cost**
General				
Construction Access	LS	100,000	1	$100,000
Earthwork				
General Earthwork/Excavation	CY	25	33300	$800,000
Clearing and Grubbing	AC	16,000	100	$1,600,000
Dewatering	LS	500,000	1	$500,000
Channel and Flood Plain Enhancement				
Channel Restoration	LF	570	1580	$900,000
Extensive Channel Restoration	LF	1,710	1740	$3,000,000
Project Sub-Total				$6,900,000
Contingencies and Multipliers				
Mobilization	LS	10%		$700,000
Erosion and Sediment Control	LS	3%		$200,000
Contingency	LS	40%		$2,800,000
Traffic Control/Utility Relocation	LS	5%		$300,000
Easements	LS			$5,700,000
Capital Expense Total (including contingency)				$16,600,000
Design/Construction Administration (%)	LS	15%		$2,500,000
Engineering and Permitting (%)	LS	15%		$2,500,000
			TOTAL	**$21,600,000**
			-50%	**$10,800,000**
			+100%	**$43,200,000**

Appendix D: Public Engagement Plan

Clover Creek Flood Mitigation Study

Public Engagement Plan

Introduction

Purpose and Need of the Clover Creek Flood Mitigation Study

The City of Lakewood is evaluating a portion of Clover Creek through the Clover Creek Flood Mitigation Study. Points along the Clover Creek alignment have experienced flooding during large storm events, particularly in the area between Joint Base Lewis-McCord and I-5, as well as northwest of I-5 along Pacific Highway. This Study will

- Develop conceptual alternatives and flood mitigation strategies,
- Evaluate flood mitigation concepts,
- Engage stakeholders throughout the study, and
- Provide funding alternatives.

The Study is expected to take 12 months. This document outlines community and stakeholder involvement efforts throughout the project to promote meaningful engagement and raise awareness of this Study within Lakewood. Community support will push agencies to secure appropriate funding and permitting for engineering projects that address flooding.

Community Demographics

Race / Ethnicity

As of 2020, Lakewood is a community of about 63,612 people. It is diverse, with 51% identifying as White alone, and 47% identifying as another race, including Hispanic (17%), Black (13%), and Asian (9%). In comparison, Pierce County overall is 66% White. The City's share of people of Hispanic ethnicity is almost 17%, higher than Pierce County at 12% (US Census 2020). Lakewood also has a higher percentage of foreign born people—approximately 16%—compared to Pierce County's 10%.

Reflecting citywide patterns, the Clover Creek study area is diverse both racially and ethnically. See **Exhibit 2.** Outreach and engagement strategies will be designed to reach an inclusive set of community members.

Language Spoken at Home

About 22% of Lakewood residents speak a language other than English at home, including Spanish and Asian and Pacific Islander languages. Anecdotal data show that of Asian and Pacific Islander languages, Korean is the more common language spoken by residents who speak a language other than English at home. Outreach and engagement will incorporate methods and strategies that reach those who speak Spanish and Korean.

Household Income

While Pierce County's median income is about $72,113, Lakewood's is substantially lower at $51,972. (2015-2019 American Community Survey). The Study Area itself includes a range of income levels. See **Exhibit 3.** Given this variety of income levels, engagement and outreach will include methods targeting community members from a broad spectrum of socioeconomic backgrounds. Given its location near commercial areas along I-5, outreach and engagement activities will also target small businesses.

Outreach and Communications Tools and Materials

This Public Engagement Plan is designed to reach audiences that have interest in the Clover Creek Flood Mitigation Study, including but not limited to:

- Public
- Local businesses and business associations
- Community and nonprofit organizations
- Appointed and elected officials
- Regional stakeholders

Communication Materials

The following materials will support outreach:

- **Project Identity:** A simple project logo and templates will create a consistent project identity that supports public awareness by increasing visibility for the project.
- **Fact Sheet Mailer:** This will include overview of information about the project, status, key issues, and ways to participate. The fact sheet will be mailed to the community.
- **Project webpage content:** At the beginning of the project, information about public involvement activities will be added to the City's project webpage at https://cityoflakewood.us/clover-creek-floodplain/
- Throughout the project, materials from community and stakeholder meetings will be posted for public review. City staff will lead website updates as well as receive, track, and respond to comments/questions from the website.
- **Public Engagement Plan (PEP).** This "living" document guides engagement and communication throughout the development of the study.
- **Print and social media.** Information will be advertised through the City's Facebook, Twitter, and Instagram accounts, media partnerships, as well as through print mailings and newsletters. Press releases may be issued for public meetings and at project milestones. Videos and pre-recorded, narrated PowerPoint slides may also be used as communications tools.
- **Translation.** Translation of print materials will be available as needed to ensure outreach and engagement with those who speak a language other than English.

Equity Focus

The Clover Creek Flood Migation Study ought to be inclusive of all voices in Lakewood. To achieve inclusivity, community outreach should proactively engage with and conduct outreach to communities that have been historically excluded from the public process. To avoid transactional engagement, this involves investing time and resources in building relationships with community leaders and the public, providing options for non-time-intensive participation, and communicating how the analysis is impactful to the community and its future.

Outreach Channels and Partners

Lakewood is a diverse community, home to businesses and residents of different ethnicities and who speak different primary languages, such as Spanish, Korean. The following partner organizations and community leaders, online outlets, and physical locations throughout the community can assist with project notifications.

Given the project's study area and emphasis on engaging with those historically not included in the public process, outreach will focus on the following partner organizations. See the Appendix for a list of city-wide organizations that can be contacted for broader notification outreach.

The list below suggests organizations and outlets the City might reach out to:

City outlets

- Quarterly Magazine (Connections)
- Email newsletter
- Community publications – News Tribune, The Suburban Times
- Utility bills
- "Community Coffeehouse" – Bimonthly conversations sessions with Lakewood's new mayor. Held every other month on the fourth Thursday of the month.
- Lakewood JBLM WA Patch

Community and Faith-Based Organizations

- Chambers-Clover Creek Watershed Council
- Lakewood Family YMCA
- Latino Partnership Group

Employers

- St. Clare Hospital
- JBLM
- Businesses within ¼ mile

Education

- Clover Park High School

Neighborhood Associations

- North East Neighborhood Association
- Springbrook Neighborhood Association
- Springbrook Connections

Tribes, Governments, Regional

- Nisqually Tribe
- Puyallup Tribe
- Pierce County
- South Sound Military & Communities Partnership
- Tacoma-Pierce County Health Department
- WSDOT

Special Interest Groups

- Lakewood Chamber of Commerce
- Lakewood Community Foundation
- Tacoma-Pierce County Chamber of Commerce

City Advisory Boards

- Planning Commission
- Parks and Recreation Advisory Board
- Community Services Advisory Board

Engagement Tools and Activities

Stakeholder Committee Meetings

A group of 10-15 stakeholders will form the Stakeholder Committee for this project. This group will meet four times during the course of the project. Meetings will be virtual and include presentations and opportunities for participants to provide feedback on materials. Meetings will introduce stakeholders to the project, gather early input on alternatives, share final alternatives, generate support and discuss funding. The anticipated topics of the meetings are described below.

- **Meeting 1:** The first stakeholder meeting will present the problem and promote issues awareness with respect to flooding occurrences, FEMA mapping, impacts of flooding and scope for this study.
- **Meeting 2:** The second stakeholder meeting will present a list of potential alternatives to mitigate the flooding. This will include a table including narrative, anticipated flood reduction and exhibits showing the relative spatial extent of the alternative. The BC team will request feedback from the stakeholder group to provide additional potential alternatives previously not considered. Lastly, with an updated comprehensive list of alternatives, the group will be asked to consider fatal flaws of any alternatives presented.
- **Meeting 3:** The third stakeholder meeting will present the four preferred concepts, including the option to 'do nothing'. The screening criteria and screening of alternatives will provide context to how the preferred concepts were determined.
- **Meeting 4:** The fourth stakeholder meeting will present the final preferred alternative outlining the results of the Business Case Evaluation (BCE) process, scoring, and model results. As the final meeting with the stakeholders, this will be an opportunity to seek partnering commitments both politically and financially.

Members include:

- **Luke Assink**, WSDOT
- **Mark Davila/Rod Chandler**, Pierce Transit
- **Donovan Gray**, Ecology
- **Char Naylor**, Puyallup Tribe
- **Andrew Larson**, WSDOT
- **Anne-marie Marshall-Dody**, PCSWM and Flood District
- **Rebecca McAndrew**, Sound Transit
- **Jacob Tennant**, WSDOT
- **David J. Fulmer**, JBLM
- **Matthew Gerlach**, Ecology
- **Russ Ladley**, Puyallup Tribe
- **Darrin Masters**, WDFW
- **David Trout**, Nisqually Tribe
- **George Walter**, Nisqually Tribe

Stakeholder Interviews

Potential interviewees include:

- Washington Department of Transportation
- Pierce County
- Tribal groups
- Other key stakeholders and potential partners

Community Meetings

Two informational community meetings will introduce the public to the project, gather early input on alternatives and inform the public on project progress. Meetings are anticipated to be virtual.

- **Meeting 1**: The first public meeting will present the problem and bring awareness with respect to the historic flooding events, existing FEMA mapping, potential impacts of flooding and the scope for this study. The overall project tasks and events will be outlined for public knowledge.
- **Meeting 2**: The second public meeting will provide information with regard to the alternative development, the process for reducing the alternative to the preferred concepts, the results of the BCE process and final preferred alternative.

Online Survey

In addition to community meetings, a brief survey advertised across communications channels will invite input from a wide range of community members when the final preferred alternative is ready. This survey will create an informational feedback loop to inform the community about findings from the study, how their input shaped alternatives, and ways that the community can stay involved.

Schedule

The following table provides a schedule of anticipated engagement and milestones throughout the study. The schedule is approximate and subject to change.

Exhibit 1: Schedule of Engagement

Activity	Anticipated Timeline	Lead
Public Engagement Plan	2/1/22 (Draft) 2/14/22 (Final)	BERK
Communication Materials	2/14/22	BERK & City
Public Launch of project webpage	3/1/22	City
Stakeholder Committee Meeting #1:	3/10/22	BERK & BC
Individual Stakeholder Interviews	3/14/22 – 4/6/22	City
Community Meeting #1	4/12/22	BERK
Stakeholder Committee Meeting #2:	4/21/22	BERK & BC
Stakeholder Committee Meeting #3:	7/14/22	BERK & BC
Stakeholder Committee Meeting #4:	10/06/22	BERK & BC
Community Meeting #2	11/9/22	BERK
Engagement Summary	9/21/22 (Draft) 12/22/22 (Final)	BERK

Appendix A: Demographic Maps

- Persons of Color: Those whose race is not "White Alone" and anyone who is Hispanic and not White in the 2020 Census data.
- Median Family Income: 2020 Census data.

Exhibit 2. Percent People of Color, 2022

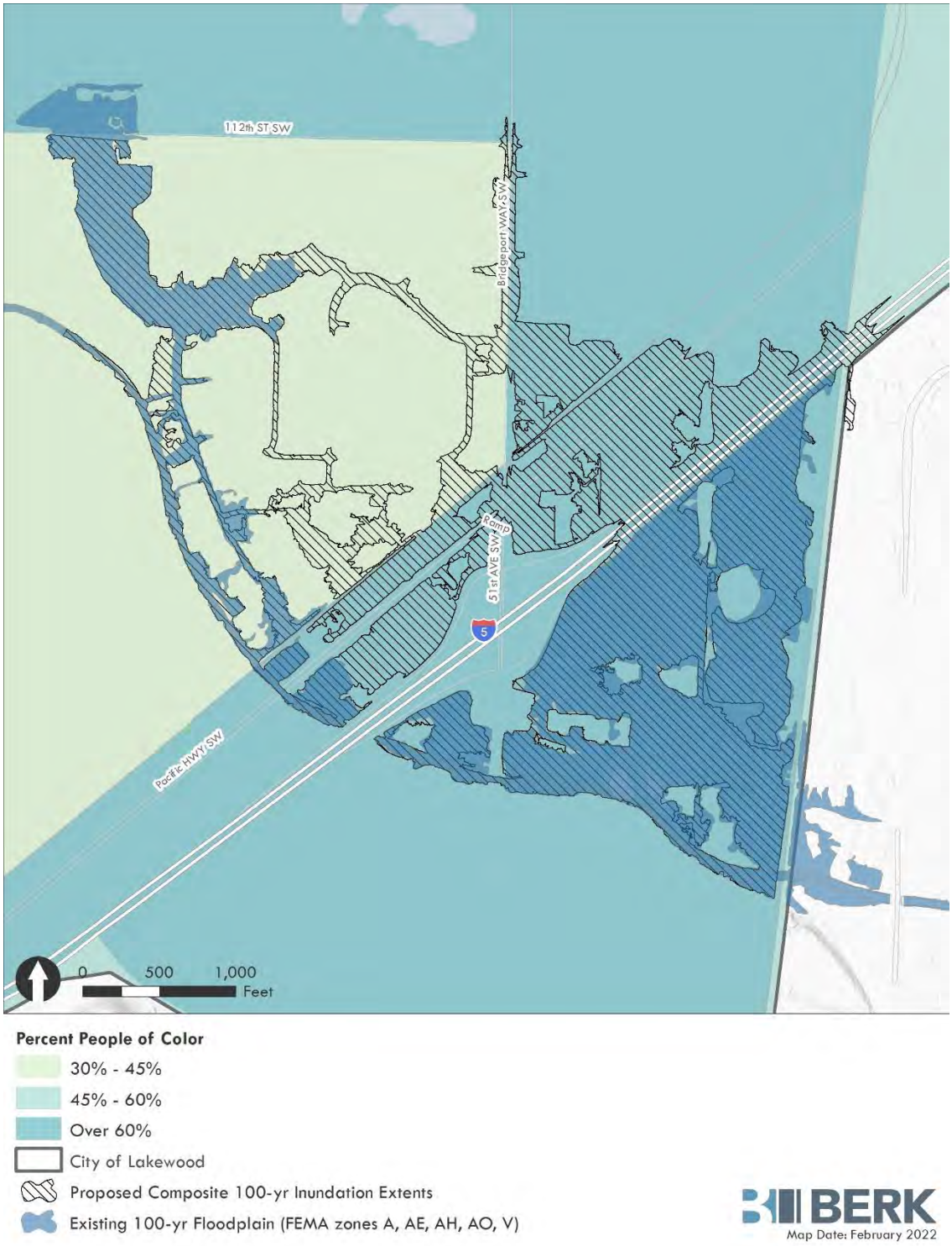
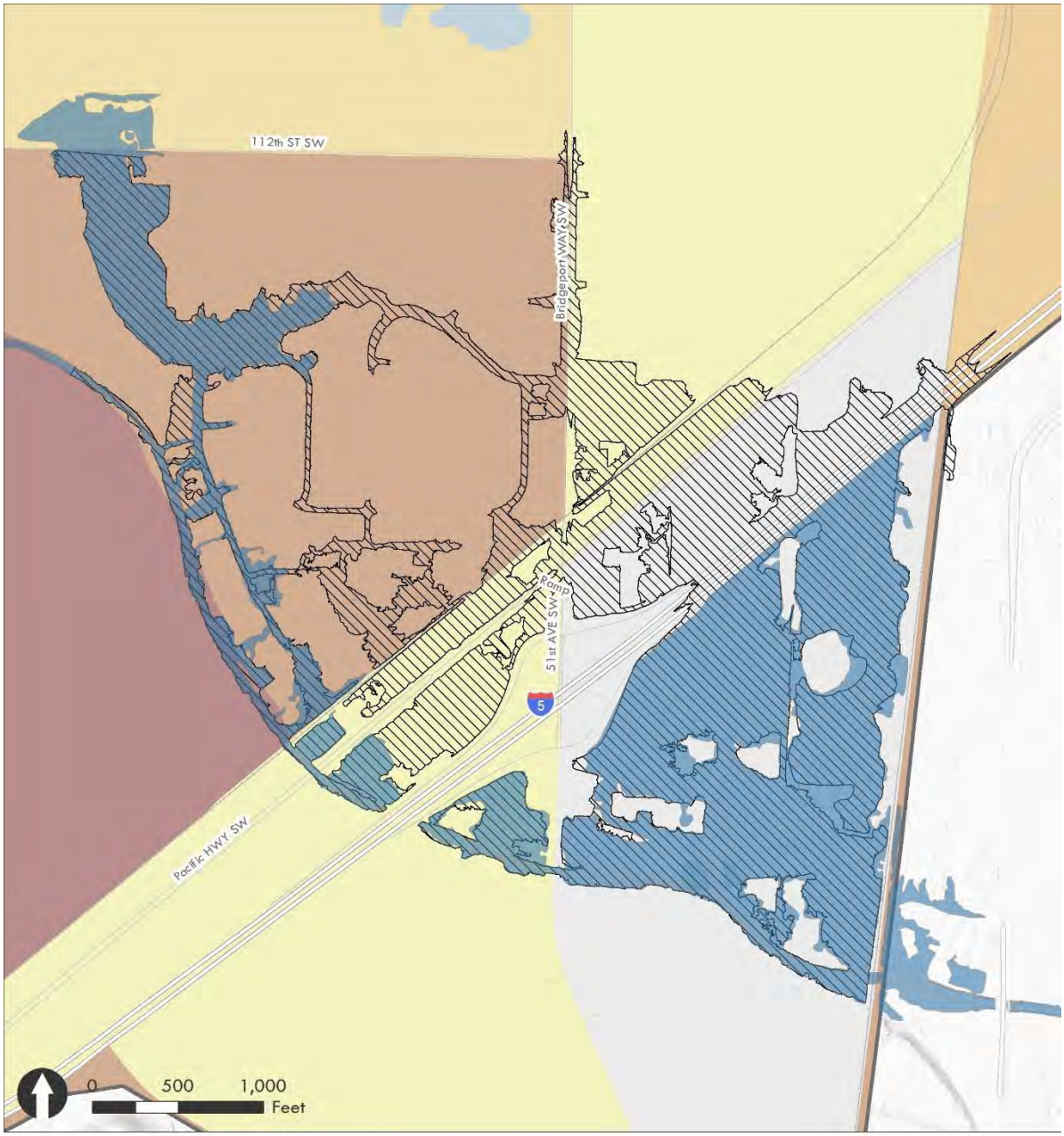


Exhibit 3. Median Household Income, 2022



Median Household Income

- Less than $35,000
- $35,000 - $45,000
- $45,000 - $55,000
- $55,000 - $65,000
- Greater than $65,000
- No Data

- City of Lakewood
- Proposed Composite 100-yr Inundation Extents
- Existing 100-yr Floodplain (FEMA zones A, AE, AH, AO, V)

BERK

Map Date: February 2022

Appendix E: Stakeholder Meeting Summaries

Stakeholder Committee Meeting Summary

12/8/2022

Meeting details: March 10, 2022 |10:00-11:30 am | Teams

Purpose

The purpose of this first Stakeholder Committee meeting was to

- Introduce the project and role of the Stakeholder Committee;
- Share an overview of the project scope, objectives, timeline, and milestones;
- Present the problem the study will address; and
- Increase awareness of issues with respect to flooding occurrences, FEMA mapping, and impacts of flooding.

Staffing

City of Lakewood

Paul Bucich
Weston Ott

Consultant Team

Ryan Retzlaff, Brown & Caldwell
Chris Frei, Watershed Science
Radhika Nair, BERK
Rebecca Fornaby, BERK

Participants

Luke Assink, WSDOT
Mark Davila (sub for Rod Chandler), Pierce Transit
Donovan Gray, Ecology
Char Naylor, Puyallup Tribe
Andrew Larson, WSDOT
Anne-marie Marshall-Dody, PCSWM and Flood District
Rebecca McAndrew, Sound Transit
Jacob Tennant, WSDOT

Unable to attend

David J. Fulmer, JBLM
Matthew Gerlach, Ecology
Russ Ladley, Puyallup Tribe
Darrin Masters, WDFW
David Trout, Nisqually Tribe
George Walter, Nisqually Tribe

Agenda

10:00 Welcome

10:05 Introductions

10:15 Meeting Purpose and Agenda

10:20 Project Overview

10:25 Project Timeline & Milestones

10:35 FEMA Mapping

10:50 Discussion

11:25 Next Steps

11:30 Adjourn

What We Heard

Comments and questions heard during the discussion portion of the meeting are summarized in bullets below. Where available, project team responses follow in an indented bullet.

Clarifying Questions

- **What do the colors on the floodplain map indicate?**
  - The difference between each shade is foot increments. Most flooding in these areas is in the one- to two-foot range, and over I-5 it reaches about two feet. The red areas are pockets on the former Pierce County gravel pit.
- **When this happens, how long is the water going to sit there?**
  - Probably three to five days. Flooding is driven out of the area by duration and volume of flood water, so it has to do with how fast it fills up and how fast it drains, which will both be slow.
- **Does flood mapping take climate change into account?**
  - This flood mapping does not take climate change into account.
- **The new project that JBLM just finished where they daylighted the stream—is the impact modeled here?**
  - It would not have impacted our analysis. They replaced the culverts under the runway, which did not create any additional flow or drain the wetland.
- **What is your primary goal for this project?**
  - Our primary goal is to protect property, life, and limb—to protect individuals from floodwater. We would also like to be able to free up more land for the industrial development that the region is looking for. Ideally, we will eliminate all flooding from Clover Creek.
- **Are there any past smaller flood events that you can compare to the model?**

- We looked at the 1996 event but there is not a lot of data about past flooding events. There have not been floods of this magnitude to compare to. We have looked at 10-year flood events which do not show water over I-5.

- **Where is this unaccredited levee?**
  - The levee is on small segment of Clover Creek at the end of the upstream end of our study reach (under the railroad). It is significant because the ground on the landward side is lower than the channel. We know that Clover Creek and this reach were completely relocated. In 1800s it used to sit where City Hall is, run through town center, and connect through to Ponce De Leon Creek. That levee was likely put in to help water stay in new constructed channel.
- **If the unaccredited levee does not fail, would there be less flooding?**
  - Slightly. It takes longer to fill but still fills and spills over I-5, demonstrating that a levee system could mitigate flooding, though levees do have large footprints.

Opportunities and Potential Next Steps

- **Are you going to fly a drone during the atmospheric river next week? Could you observe flooding and develop tiered solutions based on the flooding footprints for 10- and 50-year interval flooding?**
  - We were not planning to fly the drone—the size of the rain event will not likely cause problems. The times we have had issues have been rain-on-snow events with a fast melt. One of the biggest challenges dealing with a 100-year model event is that people haven't experienced the flooding. Good suggestion to develop tiered solutions based on smaller flood events.
- **Riparian restoration could mitigate flooding—we are looking forward to thinking about solutions that address flooding concerns as well as water quality and salmon habitat issues. There may be opportunities outside Lakewood as well but given the nature and terrain there is likely opportunity at JBLM.**
  - We know that the middle and lower reaches of this watershed are densely developed with limited opportunities for restoration, but to the degree possible we should look for solutions that not only address flooding.
- **Pierce County is leading a "TMDL alternative" effort with Ecology that aims to achieve the same effect as following a traditional TMDL pathway while avoiding resource intensive modeling so restoration can start sooner.**
  - One of our tools upstream could be a longer-term partnership with this TMDL plan. We could collaborate with jurisdictions beyond Lakewood and combine flooding issue with larger environmental needs. We have a lot of businesses that would be inundated, including a gas station, creating opportunity for more contaminants to enter the Creek.
- **I recommend reaching out to Tim McCall with the WSDOT/JBLM group focused on I-5.**
  - We'll also be talking offline with SSMCP to learn what they are doing.
- **Consider a combination of upstream improvements and strategically placed floodwalls.**

- Yes, we will need flood walls downstream where there are homes and no room for a levee. Upstream there is some undeveloped land that the City would have to acquire.

- **Would it be possible to raise I-5?**
  - Unlikely, that would cause water to build up on one side of the corridor.
- **Would it be possible to put in a flood wall on the upstream side of I-5?**
  - Unlikely, that would cause all the flooding to affect residents.

Next Steps

The project team will share graphics showing the 10- and 50-year flood events, the presentation shown today, the flood study, and the project mailer. The next meeting will be on April 21, where we will share preliminary concepts for flood mitigation.

Stakeholder Committee Meeting Summary

4/21/2022

April 21, 2022 | 10:00-11:30 am | Teams

Purpose

The purpose of this second Stakeholder Committee meeting was to

- Present a list of potential alternatives to mitigate flooding,
- Gather feedback on additional potential alternatives previously not considered, and
- Gather input on any fatal flaws of any alternatives presented.

Staffing

City of Lakewood

Paul Bucich
Weston Ott

Consultant Team

Ryan Retzlaff, Brown & Caldwell
Chris Frei, Brown & Caldwell
Radhika Nair, BERK
Rebecca Fornaby, BERK

Participants

Rod Chandler, Pierce Transit
Donovan Gray, Ecology
Russ Ladley, Puyallup Tribe
Anne-marie Marshall-Dody, PCSWM and Flood District
Rebecca McAndrew, Sound Transit
Jacob Tennant, WSDOT
George Walter, Nisqually Tribe
Meseret Ghebresllassie, JBLM

Unable to attend

Luke Assink, WSDOT
David J. Fulmer, JBLM
Matthew Gerlach, Ecology
Andrew Larson, WSDOT
Darrin Masters, WDFW
David Trout, Nisqually Tribe

Agenda

10:00 Welcome & Meeting Purpose

10:20 Potential Alternatives to Mitigate Flooding & Discussion

10:50 Details about Potential Alternatives & Discussion

11:25 Next Steps

11:30 Adjourn

What We Heard

Comments and questions heard during the discussion portion of the meeting are summarized in bullets below. Where available, project team responses follow in an indented bullet.

General Comments

- **"Is this group aware that the WA State EMD put out a call for applications for a Hazard Mitigation Grant to address flooding and mudslides? Applications are due June 3, 2022. If you have an approved Region 5 Hazard Mitigation Plan through FEMA you are eligible to apply. If interested let me know and I would be happy to send you the info."** – Rodney Chandler
- **"JBLM has substantial groundwater monitoring wells in Springbrook area—if you want any information about those we monitor for contamination and can share data. Also, if you share the location of the uncertified levee I can try to learn more about it for you."** – Meseret Ghebresllassie
- **"I recommend working with Tim Hagan at Pierce County." – Paul Bucich**

Clarifying Questions

- **Has Clover Creek been channelized? Has capacity been reduced? Is it possible to restore it to a more natural-looking channel?**
  - It is a highly modified urban stream—we will make the existing channel as natural as possible within the constraints. The linear length of the creek has a lot of homes that back up to it and roads that cross it. We would explore opportunities to add benching and planting with appropriate vegetation.
- **Is there anything that could impact the JBLM's mission to "Be ready at all times?"**
  - Flooding would threaten the base's ability to be ready at all times. The "do-nothing" solution will block one of the main access points to JBLM at the former McChord point and shut down ability to move materials down I-5 to Tacoma for shipping.
- **When is the last time we had a significant event in this area?**
  - There was a 19-inch rainfall in 1933 that caused the creek to resume its old flood path. We have also had a series of 10-year floods in the 1990s.
- **Could a major earthquake cause this kind of long-term flooding?**

- Yes, and it would be more than a regional issue because of impacts to I-5.

Are there any additional alternatives we should consider? Do you see any fatal flaws with the alternatives?

- **Would there be a combination of development and restoration in the setback area?**
  - Any solution we end up with will be a combination of approaches. The Lakewood City Council rezoned the setback area for more industrial application and the County gravel pit has been sold. We are talking to developers who are developing in accordance with floodplain regulations. It will be hard to acquire that land in the immediate future.
- **What opportunities exist to get water in the ground and apply these findings to building code? There are big implications on viability of streams to provide fish habitat. It would benefit everyone to make for a more unified discharge of the stream year-round.**
  - There is quite a bit of infiltration in most of the watershed that is being used extensively because of the nature of the geology in the area.
- **Has the study done a water budget and determined what portion of the total precipitation is discharging through the ground as opposed to over the surface? Are hardened surfaces hindering infiltration and increasing surface discharge?**
  - No water budget has been completed. Impervious surfaces are directed to infiltrate where appropriate. As a result, new development may have some impact on surface discharge but is likely mostly mitigated.
- **The flooding we are most concerned about may occur when the aquifer is full. We need to mitigate flooding when it is just the result of there being nowhere for the water to go.**
  - Pierce County has an unofficial project with the USGS to develop an interactive, live monitoring system of shallow water wells within the Clover Chambers Watershed to help them determine where groundwater flooding is going to occur.
  - Pierce County is trying to convert as much runoff into infiltration as possible. We know there is 40-50% more water available that must go somewhere. That is why people are trying to reduce the footprint of impervious surfaces through development regulations.
  - From a watershed health and flooding perspective, groundwater plays a more significant role in this system than it would in a system with different geology.
- **Where possible, we should figure out a solution that helps with water quality restoration. Some areas in the upper reaches may have greater potential for restoration.**
- **Consider long-term actions, like property acquisition.**
- **It can be hard to know if expensive infrastructure will solve the problem. If you do something for the environment, any associated cost would be beneficial while also solving other problems like water quality and fish habitat. Infrastructure alternatives only benefit if a rare event occurs.**
- **Has there been review of preferred acquisitions that would lend themselves to this concept?**
  - Once we see how effective the various potential solutions might be we will investigate the implementation further.

Next Steps

The project team will share the presentation shown today. The next meeting will be on July 14th.

Stakeholder Committee Meeting #3 Summary

7/14/2022

July 14, 2022 | 10:00-11:30 am | Teams

Purpose

The purpose of this third Stakeholder Committee meeting was to

- Share finalized flood mitigation alternatives, prioritization process and results, and preliminary model results for the three preferred alternatives,
- Hear feedback on the alternatives to inform the next phase of work, and
- Outline next steps to support business case evaluation (BCE) process.

Staffing

City of Lakewood

Paul Bucich
Weston Ott

Consultant Team

Ryan Retzlaff, Brown & Caldwell
Chris Frei, Brown & Caldwell
Radhika Nair, BERK
Michelle Ellsworth, BERK

Participants

Anne-Marie Marshall-Dody, PCSWM and Flood District
Rod Chandler, Pierce Transit
Darrin Masters, WDFW
Donovan Gray, Ecology
Luke Assink, WSDOT
Rebecca McAndrew, Sound Transit

Unable to attend

Russ Ladley, Puyallup Tribe
Jacob Tennant, WSDOT
George Walter, Nisqually Tribe
Meseret Ghebresllassie, JBLM
David J. Fulmer, JBLM
Matthew Gerlach, Ecology
Andrew Larson, WSDOT
David Trout, Nisqually Tribe

Agenda

10:00 Welcome & Meeting Purpose

10:10 Final Flood Mitigation Alternatives and Prioritization Process

10:50 Preferred Alternatives and Their Model Results

11:25 Next Steps

11:30 Adjourn

What We Heard

Comments and questions heard during the discussion portion of the meeting are summarized in bullets below. Where available, project team responses follow in an indented bullet.

Prioritization Process

- **The Creek is in bad shape and deteriorating in terms of the salmon habitat. Hopefully we can work to come up with a plan to benefit salmon restoration.**
  - Whatever solution we end up with, we hope for a minimum or neutral impact. It's important to look at what options will keep the flow and protect the built environment. The final recommendation will include next steps to encompass the creek's current condition, and potential steps for improvement and restoration.
- **With minimal to no environmental impacts, hopefully the creek side levee alternative gets weeded out.**
  - We expect to see a blend of the alternatives used to satisfy as many objectives as possible. The solution must be beneficial to the built environment and the natural environment. These evaluations are to identify what is worth pursuing further. But one solution will not fix everything. We expect to apply a combination of solutions and tools in the final recommendation.
- **Two alternatives show no environmental benefits. Does the absence of benefits mean that the alternative is neutral or that it has a detrimental effect? The scoring may be misleading, as it does not show the alternatives that cause a degradation effect. The alternatives do not appear harmful at first glance, but some could be detrimental, which is important information to consider in decision making.**
  - That is a fair observation that the criteria weighting does not account for an alternative's detrimental impact. This input is helpful to help guide and account for those elements that cause degradation.

Clarifying Questions

- **Describe the channel modifications downstream and if they can be extended.**
  - In the Channel Enhancement modification, the main channel diverges from the channel where the flow is escaping. The flow downstream becomes more channelized and can handle an increased

capacity. At this path divergence, we did not add channel modifications. Instead, the channel modifications focused on areas where the flow is escaping and where the creek is flatter.

Discussion: What opportunities and/or challenges does each alternative present?

- **General**
  - **Is it possible to meld the three alternatives?**
    - That is where we are likely to end up.
- **Alternative – Do Nothing**
  - **Would we expect to see degradation downstream in the main channel?**
    - Although the flow is extreme, we expect to see increased channel flows due to levee failure only every 50 to 100 years, which would impact degradation. While there will be impacts from those events, we do not expect to see similar degradation impacts from typical channel forming flows.
  - **Due to climate change, we anticipate that 100-year events will increase in frequency.**
    - If the frequency of 100-year events increases, the environmental impact of increased channel flow would be a consideration. It is something to evaluate in the next phase.
  - **Given the stakes, it does not seem ethical to do nothing. Do not "do nothing." It does not meet the project purpose. It is not a good alternative.**
    - We agree that Do Nothing is not a great alternative. Our goal is to find solutions to help alleviate the flooding challenges.
- **Alternative – Levee**
  - **I prefer this alternative. I assume that it is a certified levee that receives ongoing maintenance. However, we should look at the financial feasibility of ongoing maintenance for this levee.**
    - Setback levees are maintained by Pierce County. The advantage of this project is that the creek is limited in length. So, the ability to maintain it would seem likely.
  - **I like this option as it is the best opportunity to not displace as many people.**
  - **This option opens up the potential for habitat improvement and restoration, particularly for juvenile salmon.**
  - **The levee is good, but I have mixed feelings about the additional fill. Property acquisition may be difficult due to the dense development that has already occurred.**
  - **Is the area between the creek and the levee going to be restored?**
    - The model did not assume a change to modeling, but we can assume some restoration. However, the exact levee location has not been determined. What is seen in the model is only for modeling purposes.

- **<u>Alternative – I-5 Blockage</u>**
  - **Would the additional flow along the bank require permitting? I'm seeking the least impacting alternatives and options.**
    - The area simulated would prevent breakout flow downstream of I-5 but would see increased channel flow downstream.
  - **This option shows the lowest increase of flow downstream. So, we might see less impact on road crossing and eroding during flooding events.**
  - **This option is not my favorite due to social justice considerations. Those who are low-income would experience a greater displacement impact.**
- **<u>Alternative – Channel Enhancement/Capacity</u>**
  - **This option adds more function and has an increased flow.**
  - **This option is good for fish**
  - **It is my preferred option. However, property acquisition may be challenging.**
  - **This is my second favorite option.**

Next Steps

The project team will evaluate the four alternatives using a multi-criteria evaluation. The next stakeholder committee meeting will be on October 6th.

Stakeholder Committee Meeting #4 Summary

10/6/2022

October 6, 2022 | 10:00-11:30 am | Teams

Purpose

The purpose of this fourth Stakeholder Committee meeting was to

- Share Multi Criteria Decision Analysis (MCDA) criteria and scoring, summary of results, result graph, and alternative scoring vs. costs,
- Hear feedback on the MCDA process and results,
- Identify potential areas where refinement may be possible, and
- Outline next steps.

Staffing

City of Lakewood

Weston Ott, City of Lakewood

Consultant Team

Ryan Retzlaff, Brown & Caldwell
Christopher Jones, Brown & Caldwell
Nicolas Brouillard, Watershed S&E
Chris Frei, Watershed S&E
Radhika Nair, BERK
Rebecca Fornaby, BERK
Michelle Ellsworth, BERK

Participants

Donovan Gray, WA Dept. of Ecology
Tom Kantz, PCSWM and Flood District
Rebecca McAndrew, Sound Transit
Char Naylor, Puyallup Tribe
Helmut Schmidt, Pierce County
Jacob Tennant, WSDOT

Unable to attend

Luke Assink, WSDOT
Paul Bucich, City of Lakewood
Rod Chandler, Pierce Transit
David J. Fulmer, JBLM
Matthew Gerlach, Ecology
Meseret Ghebresllassie, JBLM
Russ Ladley, Puyallup Tribe
Andrew Larson, WSDOT
David Troutt, Nisqually Tribe
George Walter, Nisqually Tribe

Agenda

10:00 Welcome & Meeting Purpose; Recap previous meeting

10:10 MDCA Criteria, Scoring Method and Weighting; Summary Results, Results Graph, Costs and Monetary Results

10:40 Feedback on the MCDA Process and Results

11:00 Potential Areas for Refinement

11:25 Next Steps

11:30 Adjourn

What We Heard

Comments and questions heard during the discussion portion of the meeting are summarized in bullets below. Where available, project team responses follow in an indented bullet.

Prioritization Process

- **Does cost reflect mitigation? Was rise calculated as well? Where does the shrinking flood plain go?**
  - That was not used as criteria within the cost analysis. To calculate rise requires refinement of the runs and an additional level of detail. Within the analysis, there is a combination of levee failure run and non-levee failure run. Part of the analysis is addressing the worst-case scenario. Looking at results, there may some rise in the channel but that rise should be mitigated with certified levee options. It would then need to go through the CLOMR process in FEMA.
- **Are mitigation costs reflected in implementation? Specifically, do the mitigation costs reflect the cost of land acquisition for easements to accommodate the change in the base flood elevation on impacted properties?**
  - Given that this is a prioritization process relative to other alternatives, the modeling is high-level, and the specific alignments are not known. The modeling is to understand the system reaction with these possible mitigation alternatives. This high-level modeling can narrow down to three preferred alternatives.
- **Does the prioritization process account for stakeholders' interest in involvement? Alternatives that affect WSDOT appear high on the prioritization list.**
  - Organizations' involvement interest is not considered at this stage. Given the impacts to I-5, we hope WSDOT is interested in being involved.

Preferred Alternatives

- **Does the I-5 Levee alternative cause the water system to back up upstream? Where does the volume go?**
  - One key assumption is that the existing levee upstream is certified and does not fail. There are ways the levee can be rebuilt or realigned with natural hills. Also, the water channel does deepen behind the levee, as shown in yellow. The graphic map is specifically showing the areas where the floodplain is extended.
- **With the shrinking floodplain, would water propagate on the other side of the railroad tracks?**
  - Looking at existing conditions, the water would be closer to Bridgeport Way and seeping into ponds next to the channel. Over a long duration of flooding, it may eventually spill over I-5. But the analysis is not showing upstream impacts up to the base.

Costs and Monetary Results

- **I want to ensure that water does not propagate upstream and impact county infrastructure and properties. The County has made significant changes to the system.**
  - Upstream is the base. With the preferred alternatives identified, more refined modeling can occur to provide deeper analysis. The detailed analysis will help us look at the whole system and understand if new problems are being created with these alternatives. There are flood mitigation actions that must occur downstream to ensure flooding does not increase. Similar actions could happen upstream, but it is less likely due to the nature of gravity.
- **What is the process if an alternative's cost estimations change? At what point is the approach changed? What are the thresholds? This project has cost unknowns, such as property acquisition. For reference, FEMA has a BCA Toolkit to help perform an analysis of cost-effectiveness.**
  - It is hard to quantify the cost impact of a flood and its short- and long-term implications. At this time, a specific framework does not exist, but that option can be explored as this process moves forward. Stakeholders can help identify the cost-benefit thresholds.

Discussion

Impressions or feedback on the MCDA process and results? The alternative selected?

- **Have different setback levee widths been discussed or determined?**
  - The analysis conducted thus far focused on the positives and negatives of a levee closer to the creek and a setback levee. More analysis is required to determine the exact placement and levee width, and the resulting impacts to property owners and development. More analysis is also needed to understand potential displacement of low-income community members caused by a setback levee.

- **It is good to see channel improvements and wetland restoration. A setback levee 100 feet away is different from a levee right at the edge of the creek. The farther the levee is from the creek, the better.**
    - There are positive and negative impacts throughout flood mitigation. At this time, we do not have the analysis to determine the exact location of the levee and its resulting impact. But certain assumptions can be made based on scoring criteria.
- **As options are refined, the alternatives that involve WSDOT may warrant further conversations with them to gauge their involvement.**
- **I am looking forward to the refinement of the process and design.**
    - As the initial analysis process wraps up, the City of Lakewood is seeking stakeholders interested in partnering on the next stage. The goal of this study is to build momentum and share information so other organizations can partner with the City of Lakewood and provide support with funding and construction.
- **I am pleased that the levee setback and channel enhancement options are not mutually exclusive. I encourage all those involved to consider how to best integrate these two alternatives as much as possible.**
- **This project and its resulting solution exist within a larger context. It would be beneficial if the alternative selected also considers the context of water quality. Pierce County is currently developing a TMDL (Total Maximum Daily Load) water quality improvement plan with JBLM and the City of Lakewood. Ideally, the alternative selected for this current project helps the City of Lakewood improve high water quality standards that offset the costs of complying with the TMDL, should one be imposed.**
    - Leveraging water quality has been discussed, and the City is not opposed to this kind of alignment. TMDL implementation will be a satellite criterion, likely with limited overlap. This project is focused on flood mitigation and has a shorter time scale than implementation of TMDL measures.

Next Steps

There will be a community meeting on November 10. The engineering report and a final report will be finalized by this winter.

Appendix F: Stakeholder Meeting 1 Presentation

Clover Creek
FLOOD MITIGATION STUDY

Stakeholder Committee | March 10, 2022

Project Team

City of Lakewood
Paul Bucich
Weston Ott

Brown & Caldwell
Ryan Retzlaff
Chris Frei

BERK Consulting
Radhika Nair
Rebecca Fornaby

Introductions

Share your name, Organization, and one thing you're looking forward to as spring arrives.

Agenda

1. Introductions
2. Meeting Purpose and Agenda
3. Project Overview, Timeline, and Milestones
4. Current flood mapping and modeling
5. Discussion
6. Next Steps

MEETING PURPOSE

- Introduce the project, project team, and purpose of the Stakeholder Committee
- Share an **overview of the project**, including scope, objectives, timeline, and milestones
- **Present the problem** the study will address
- Increase **awareness of issues with respect to flooding occurrences, FEMA mapping, and impacts of flooding**

STAKEHOLDER COMMITTEE MEETING ARC

The role of Stakeholder Committee members, individually and as a body, is to:

- **Increase awareness** of the impacts of the do nothing alternative on your organizational missions
- **Actively engage in the development of alternatives** based on a clear understanding of data
- **Represent the mission of their organization to the best of their ability with respect to** the development of flood reduction strategies

STAKEHOLDER COMMITTEE

The Stakeholder Advisory Committee will meet up to **four times** to advance the Clover Creek Flood Feasibility Study.

I

CONTENT

Kickoff

Discussion Topics

- Present the problem
- Promote issues awareness with respect to flooding occurrences, FEMA mapping, impacts of flooding
- Scope for this study

II

CONTENT

Preliminary Alternatives

Discussion Topics:

- List of potential alternatives to mitigate the flooding

III

CONTENT

Screening criteria , Four concepts

Discussion Topics

- Four preferred concepts, including the option to 'do nothing'

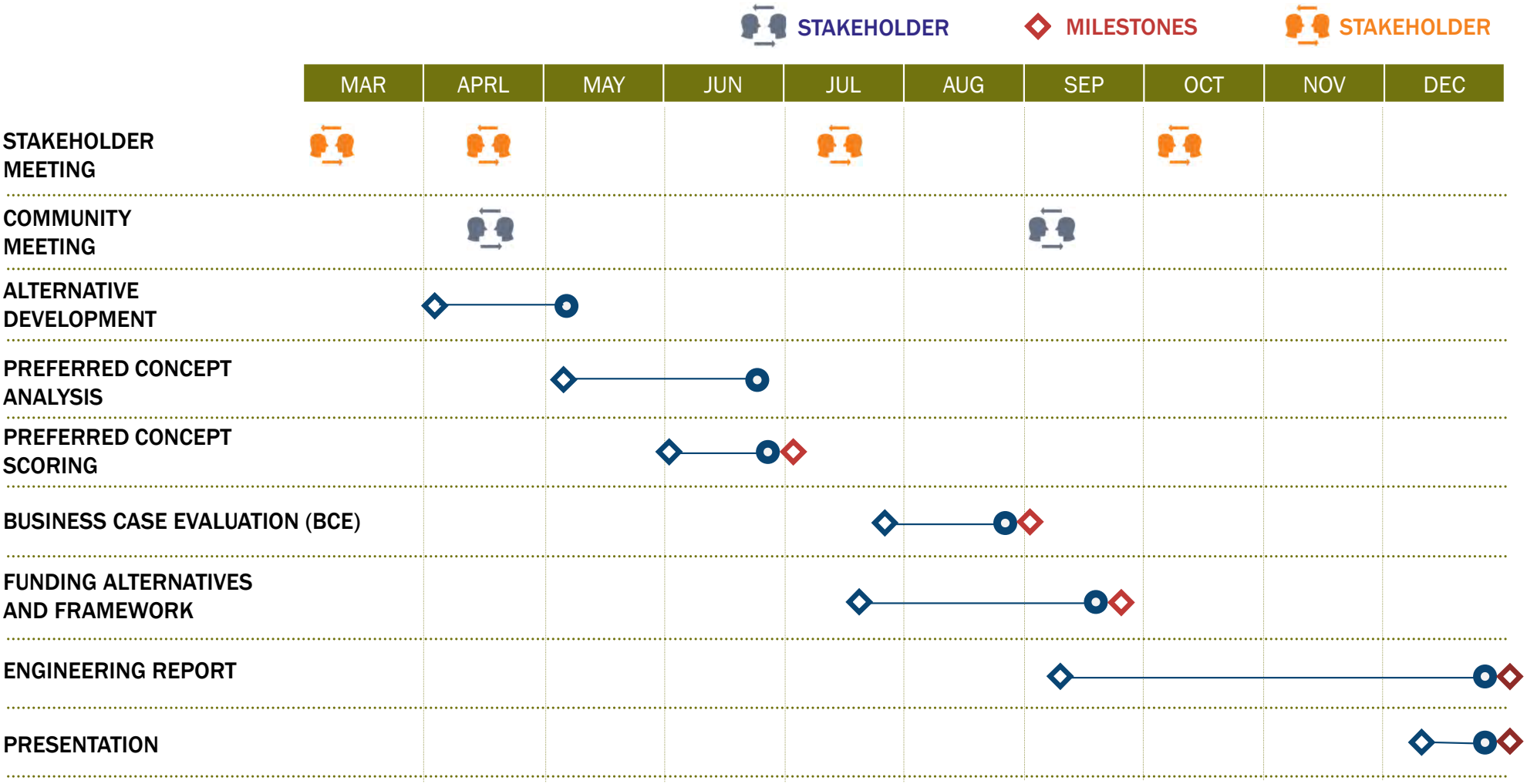
IV

CONTENT

Business Case Evaluation (BCE) process, scoring, and model results

Discussion Topics

- Final preferred alternative
- Potential partnerships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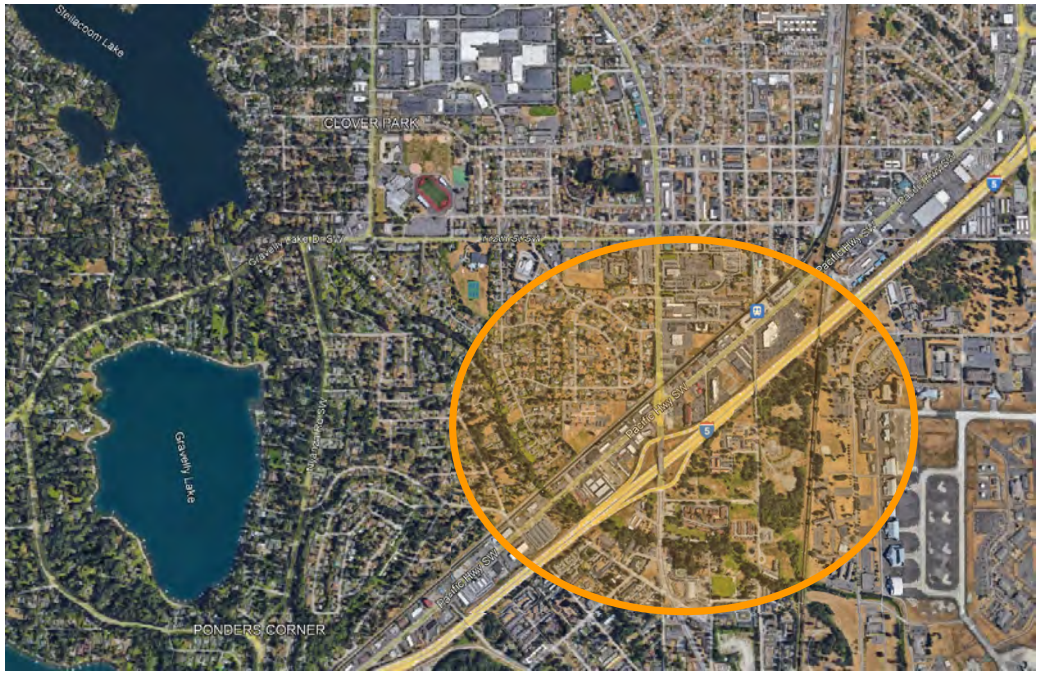
STAKEHOLDER MEETING
COMMUNITY MEETING
ALTERNATIVE DEVELOPMENT
PREFERRED CONCEPT ANALYSIS
PREFERRED CONCEPT SCORING
BUSINESS CASE EVALUATION (BCE)
FUNDING ALTERNATIVES AND FRAMEWORK
ENGINEERING REPORT
PRESENTATION

Questions?

PROJECT OVERVIEW

- Recent flood modeling revealed a greater floodplain than FEMA mapping indicated
- New mapping highlighted multitude of issues affecting many
- Project will explore alternatives to minimize flooding
- Public and Stakeholder engagement critical
- Engineering Report and presentation will document findings



Area of primary Study

FLOOD MAPPING AND MODELING

- Presentation Overview
  - Effective Clover Creek FEMA Mapping
  - 2019 Clover Creek Restudy
  - 2019 Study Results/Outcomes
    - Updated 100-year Flooding Extents
    - Identification of Unaccredited Levee
    - Impacts to FEMA Flood Risk

FLOOD MAPPING AND MODELING

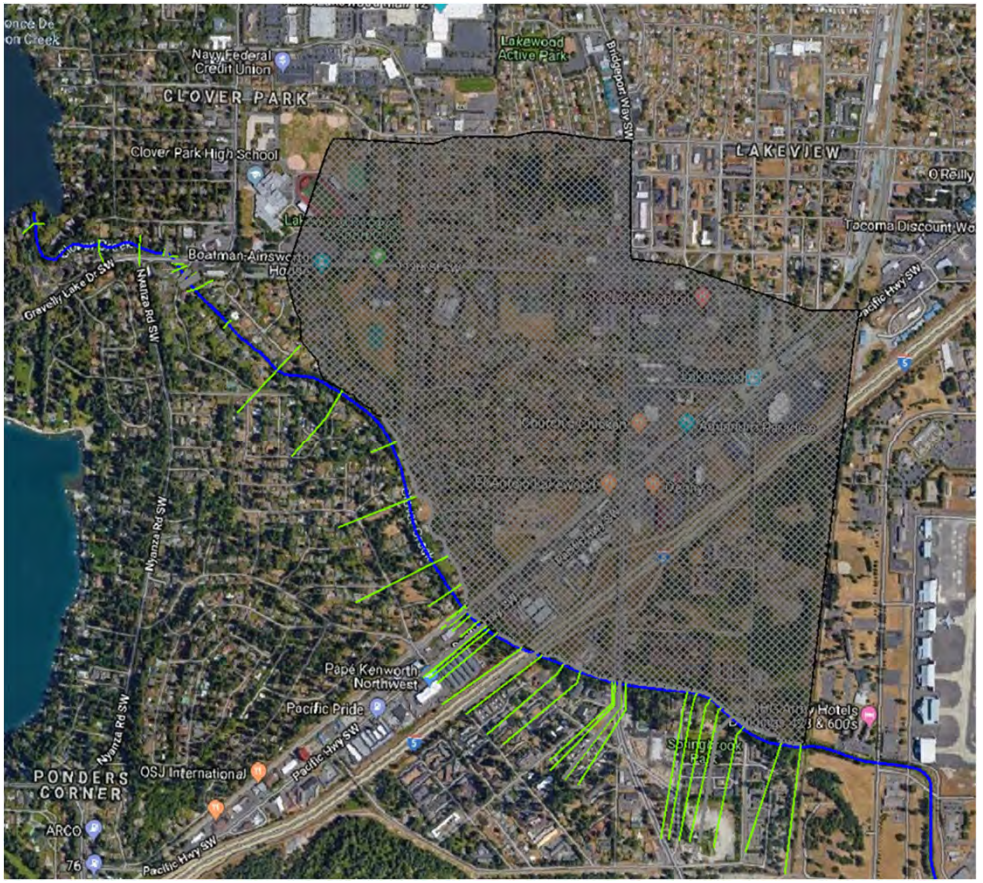
- Effective Clover Creek FEMA Mapping (ca 2006)
  - Blue is 100-yr floodplain
  - Orange is 500-yr or shallow 100-year (<1ft)

FLOOD MAPPING AND MODELING

- Clover Creek Restudy (2019)
  - Area where effective maps show deep 100-year flooding
  - City has not observed significant flooding
  - Effective floodplain impacted by 1D assumption

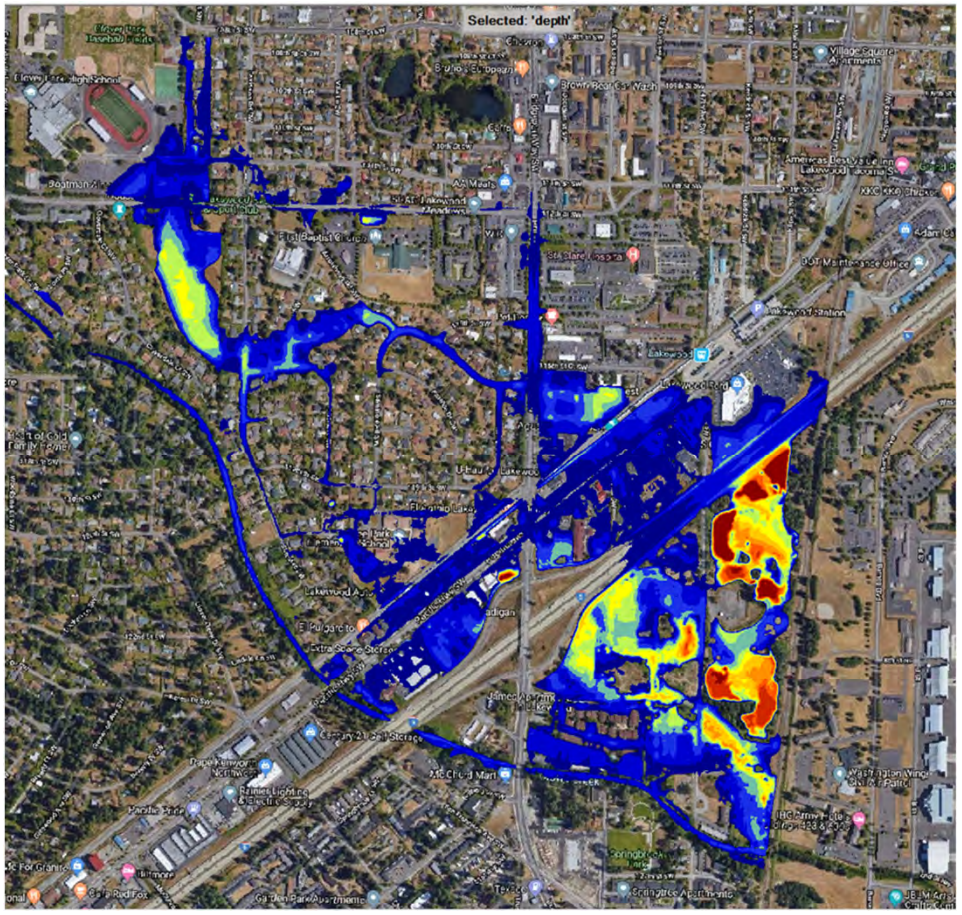
FLOOD MAPPING AND MODELING

- Clover Creek Restudy (2019)
  - WSE updated FEMA model using 2D elements to route overbank flow
  - Extended effective hydrologic model and developed unsteady inflow hydrographs
  - FEMA provided unofficial review of model and hydrology



FLOOD MAPPING AND MODELING

- Restudy 100-yr Event
  - Unaccredited levee incorporated
  - Increased overbank flooding
  - Increased flooding over I-5
  - Floodway cannot be confined to channel



FLOOD MAPPING AND MODELING

- Outcomes of Clover Creek Restudy (2019)
  - Applied 2D model and unsteady hydrology to improve accuracy of inundation mapping
  - Confirmed flood overtopping of I-5 and recognized 100-year flood risk downstream
  - Identified unaccredited levee and followed FEMA procedures to assess risk behind levee
  - Submitted Letter of Map Revision (LOMR) request in 2020
  - Rescinded LOMR when it was determined that updates would require floodway to extend over I-5

QUESTIONS & DISCUSSION

- Questions regarding stakeholder group involvement?
- Questions regarding modeling?
- Potential flood reduction strategies?
  - Do nothing?
  - Levee or set back levee?
  - Stream enhancement?
  - Alternative conveyance?
  - Upstream/upland improvements?
  - What additional ideas would this group put forward for consideration?

NEXT STEPS

- Community Meeting on 4/12
- Stakeholder Committee Meeting 4/21

Thank you.

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Appendix G: Stakeholder Meeting 2 Presentation

Clover Creek
FLOOD MITIGATION STUDY

Stakeholder Committee | April 21, 2022

Project Team

City of Lakewood
Paul Bucich
Weston Ott

Brown & Caldwell
Ryan Retzlaff
Chris Frei

BERK Consulting
Radhika Nair
Rebecca Fornaby

Introductions

Share your name, Organization, and your favorite way to enjoy nature.

Slide 3

RR0 BERK - same slide here with a new question for ice breaker? please update.
Ryan Retzlaff, 2022-04-19T03:11:48.519

Agenda

1. Introductions
2. Meeting Purpose and Agenda
3. Review previous meeting
4. Potential flood mitigation alternatives
5. Round robin discussion - Alternatives
6. Detailed mitigation alternatives
7. Round robin discussion – Fatal flaws
8. Next steps

MEETING PURPOSE

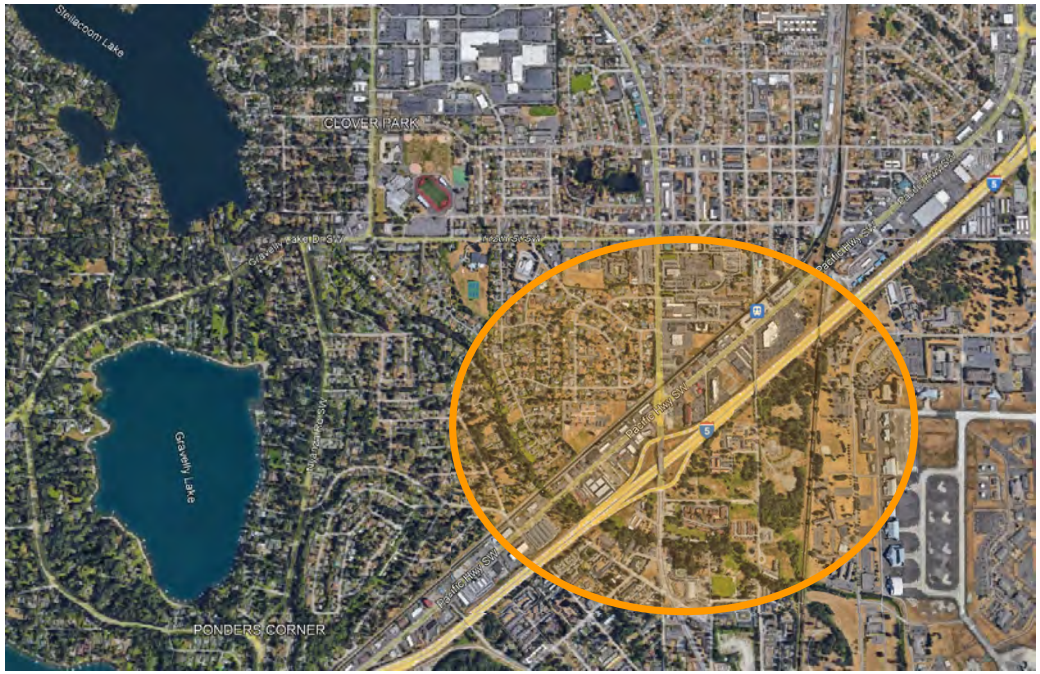
- Review previous meeting
- Share general and detailed flood mitigation alternatives
- Gather feedback and perspective from Stakeholders regarding potential alternatives
- Provide a space for Stakeholder engagement and understanding from the project team
- Outline next steps and how Stakeholders can stay engaged

STAKEHOLDER MEETING ONE - REVIEW

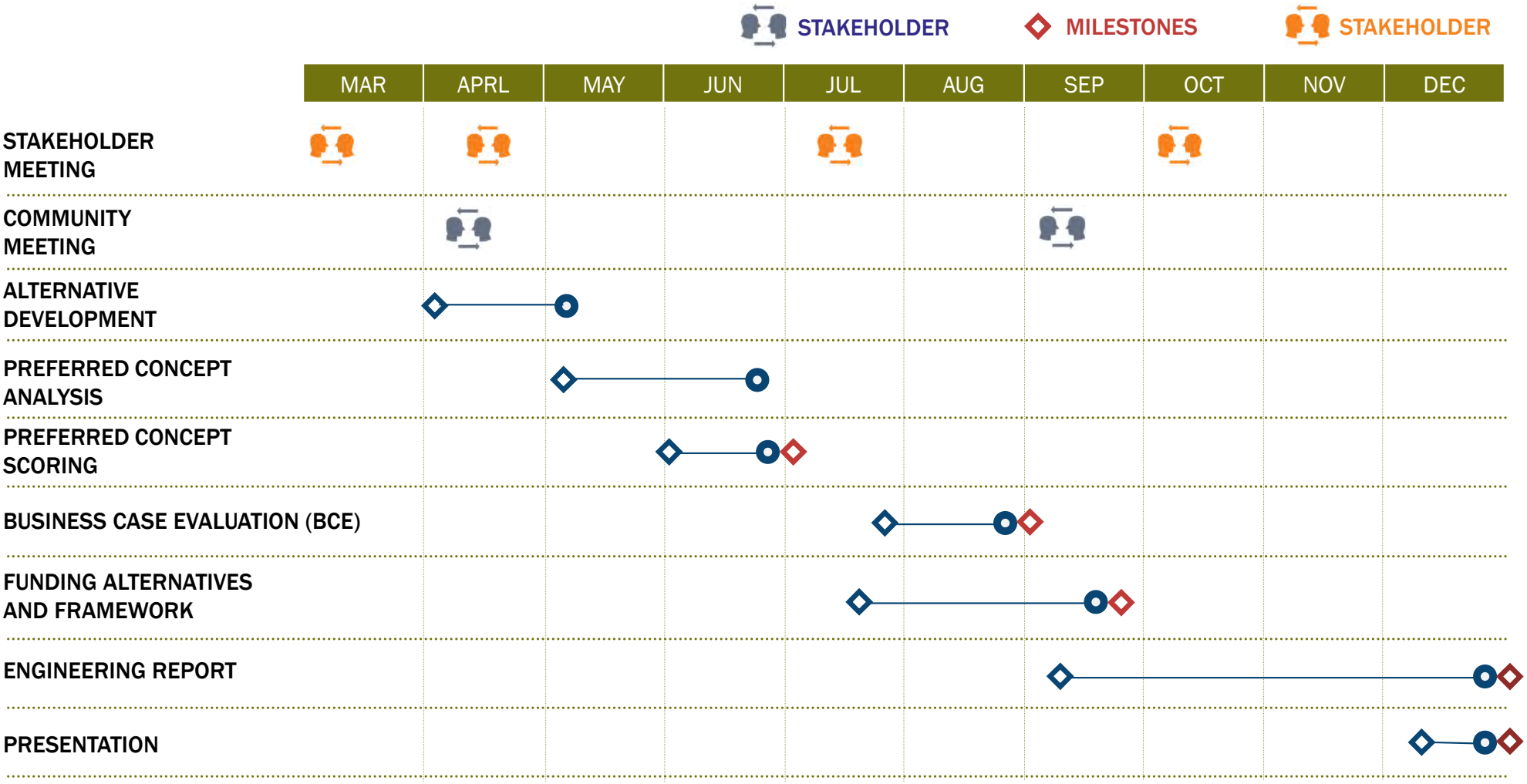
- Introduced the project and role of the Stakeholder Committee
- Shared an overview of the project scope, objectives, timeline, and milestones
- Presented the problem the study will address and
- Increased awareness of issues with respect to flooding occurrences, FEMA mapping, and impacts of flooding.

STAKEHOLDER MEETING ONE – PROJECT OVERVIEW

- Recent flood modeling revealed a greater floodplain than FEMA mapping indicated
- New mapping highlighted multitude of issues affecting many
- Project will explore alternatives to minimize flooding
- Public and Stakeholder engagement critical
- Engineering Report and presentation will document findings



Area of primary Study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STAKEHOLDER MEETING
COMMUNITY MEETING
ALTERNATIVE DEVELOPMENT
PREFERRED CONCEPT ANALYSIS
PREFERRED CONCEPT SCORING
BUSINESS CASE EVALUATION (BCE)
FUNDING ALTERNATIVES AND FRAMEWORK
ENGINEERING REPORT
PRESENTATION

POTENTIAL FLOOD MITIGATION ALTERNATIVES

- Five alternative categories identified

1. Do nothing
2. Levee or Blocking flooding
   - Full levee, setback levee, partial levee, railway levee
3. Storage
   - Instream, upstream, within larger Clover Creek watershed
4. Watershed or Creek Enhancement
   - Flood plain enhancement, restoration, stormwater controls, etc
5. Capacity improvements
   - Instream, or high flow bypass

Discussion

Are there any additional alternatives we should consider?

POTENTIAL FLOOD MITIGATION ALTERNATIVES

Alternative	Name	Type	Description
A1	**Do Nothing**		▪ Continue business as usual with inherent risk of FEMA mapped floodplains containing I-5 and other local businesses and residential buildings.
A2	**Regional Storage**	Storage	▪ Create regional storage facilities throughout the watershed. Storage could be inline/offline or flood plain benching.
A3	**Bypass Pipe**	Capacity Improvements	▪ Construct a pipe/channel capable of rerouting/bypassing high flows downstream.
A4	**Set Back Levee or Flood Wall**	storage/ Capacity/ blockage	▪ Set back levee along the north bank to limit flooding. Location of levee to be determined.
A5	**Levee or Flood Wall along creek**	Flood Blockage	▪ Levee along the creek to block flood waters exit from the channel
A6	**Creek Restoration/Capacity Enhancements**	System Improvements/Capacity	▪ Upstream and downstream restoration of Clover Creek to include habitat improvements, flood mitigation and storage, bank stabilization, and the implementation of LID to improve water quality.
A7	**WSDOT Ditch Blockage, raise profile of I-5 or Flood Wall along I-5**	Flood blockage	▪ Flood propagation begins at the creek and moves north mostly west of 47th Ave. The drainage ditch along I-5 would be blocked and would not allow drainage or flood water to move north or south along the east side of I-5.
A12	**Creation of Floodplain**	Capacity Improvements	▪ Purchase property and establish easements for the creation of intentional floodplain storage areas with flooded area as well as upstream and downstream.

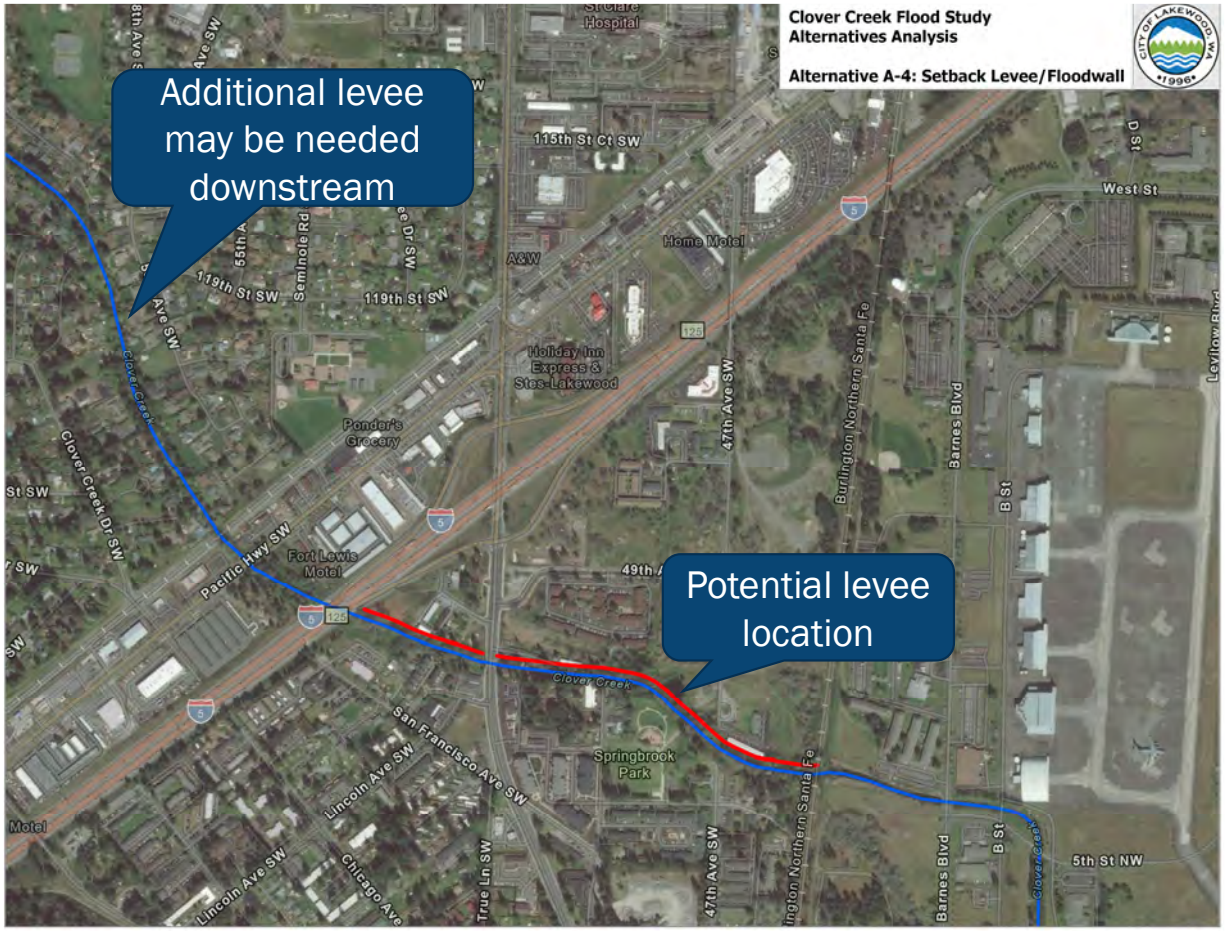
POTENTIAL FLOOD MITIGATION ALTERNATIVES

Alternative	Name	Estimated Mitigation level	Estimated relative level of effort	Engineering/Implementation considerations
A1	Do Nothing	-	-	▪ The economic impacts associated with flood risks include damage and closures to local businesses, damage to residential buildings, and the potential closure of I-5.
A2	Regional Storage	High	High	▪ Storage will likely need to be mostly in the upper watershed as the areas near I5 have high groundwater during the rainy season and therefore have limited opportunity for storage.
A3	Bypass Pipe	High	High	▪ Involves the design and construction of miles of new infrastructure. Project will be expensive and finding an acceptable alignment to minimize utility conflicts will be challenging. Estimate of roughly 2 miles of pipe to Steilacoom Lake.
A4	Set Back Levee or Flood Wall	Medium	Medium	▪ The displacement of flood waters may trigger a no-rise analysis or other permitting requirements. Downstream capacity and flooding would also require consideration or attention.
A5	Levee or Flood Wall along creek	Medium	Medium	▪ Private property and structures along the north bank may add complexity along with permitting challenges such as a no-rise analysis.
A6	Creek Restoration/Capacity Enhancements	Medium	Medium	▪ Project will require an extensive study of the Clover Creek watershed which will likely include stream flow and quality monitoring.
A7	WSDOT Ditch Blockage, raise profile of I-5 or Flood Wall along I-5	Medium	Low	▪ Construction and/or hydraulic modifications within the floodway may trigger a no-rise analysis or other FEMA permitting requirements.
A12	Creation of Floodplain	High	High	▪ Feasibility of relocating current occupants, both businesses and residents poses challenges. Purchase of easements/property may be costly.

POTENTIAL FLOOD MITIGATION ALTERNATIVES

- Construct a pipe/channel capable of rerouting/bypassing high flows downstream
- Involves the design and construction of miles of new infrastructure. Project will be expensive and finding an acceptable alignment to minimize utility conflicts will be challenging.
- Estimate of roughly 2 miles of pipe to Steilacoom Lake.

POTENTIAL FLOOD MITIGATION ALTERNATIVES

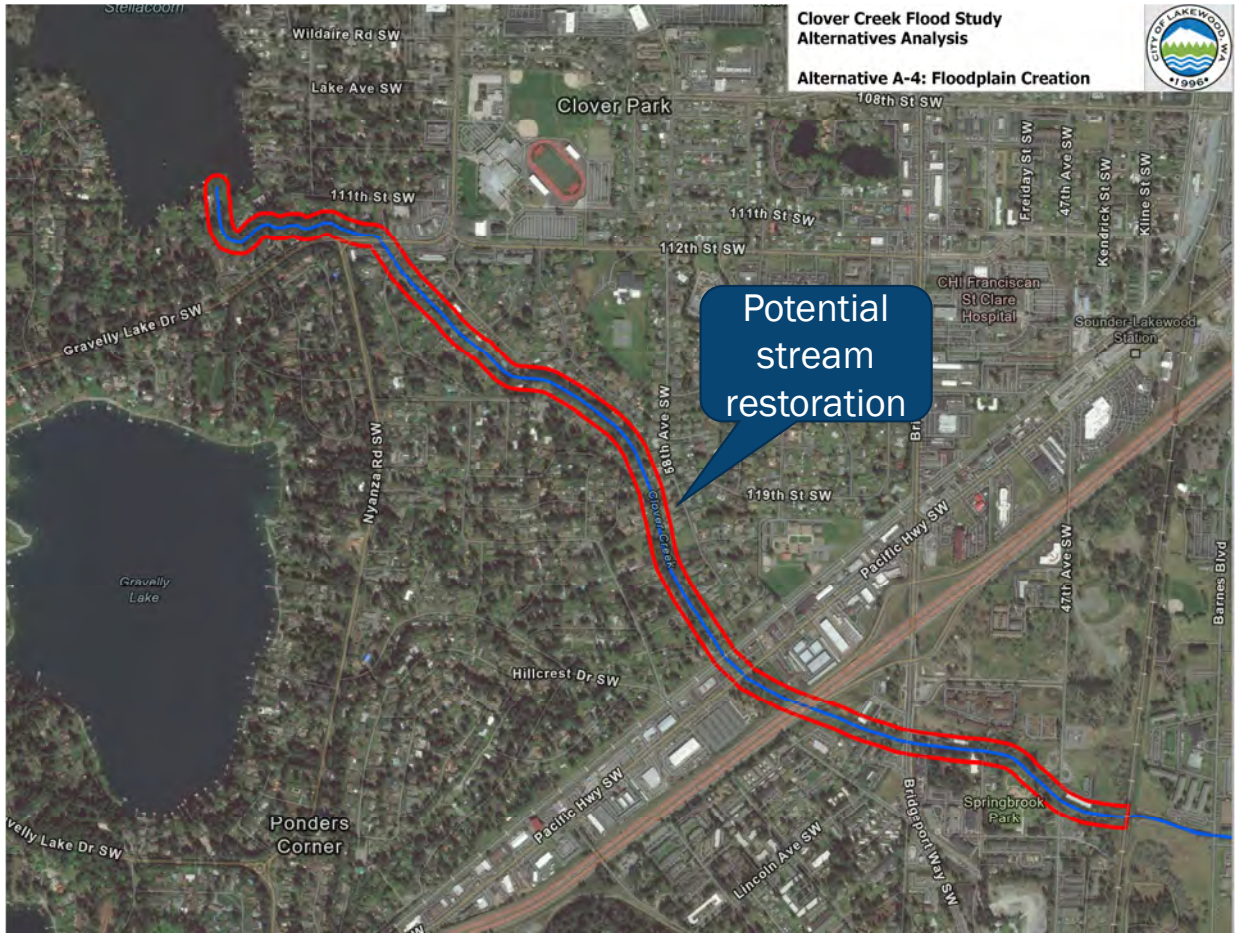


- Set back levee along the north bank to limit flooding. Location of levee to be determined and may be needed downstream.
- The displacement of flood waters may trigger a no-rise analysis or other permitting requirements.
- Downstream capacity and flooding would also require consideration or attention.

POTENTIAL FLOOD MITIGATION ALTERNATIVES

- Banks are breached west of 47th Ave and flood water propagate north. The drainage ditch along I-5 would be blocked along with a floodwall and would not allow drainage or flood water to move north or west across I-5.
- Construction and/or hydraulic modifications within the floodway may trigger a no-rise analysis or other FEMA permitting requirements.

POTENTIAL FLOOD MITIGATION ALTERNATIVES



- A holistic approach to managing flooding by increasing capacity, habitat, flood plain storage, etc.
- The stream is currently encroached upon by development including road, homes, and businesses. The developed nature of this system complicates this approach in many ways.

Discussion

Do you see any fatal flaws with the alternatives?

NEXT STEPS

- Stakeholder Committee Meeting 7/14
- Individual stakeholder meetings – as needed
- Community meeting in September

Thank you.

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Appendix H: Stakeholder Meeting 3 Presentation

Clover Creek
FLOOD MITIGATION STUDY

Stakeholder Committee | July 14, 2022

Project Team

City of Lakewood
Paul Bucich
Weston Ott

Brown & Caldwell
Ryan Retzlaff

Watershed Science & Engineering
Chris Frei

BERK Consulting
Radhika Nair
Michelle Ellsworth

Introductions

In the chat, share your **name**, **organization**, and **favorite thing to bring to a summer barbeque or potluck.**

MEETING PURPOSE

- Recap previous meeting
- Share finalized flood mitigation alternatives, prioritization process and results, and preliminary model results for the three preferred alternatives
- Hear feedback on the alternatives to inform the next phase of work
- Outline next steps to support business case evaluation (BCE) process

Agenda

1. Recap previous meeting
2. Final flood mitigation alternatives
3. Prioritization Process
4. Preferred Alternatives
5. Preferred Alternative Model Results
6. Next steps

RECAP OF STAKEHOLDER MEETING 2

- Shared general and detailed flood mitigation alternatives
- Gathered feedback on potential alternatives

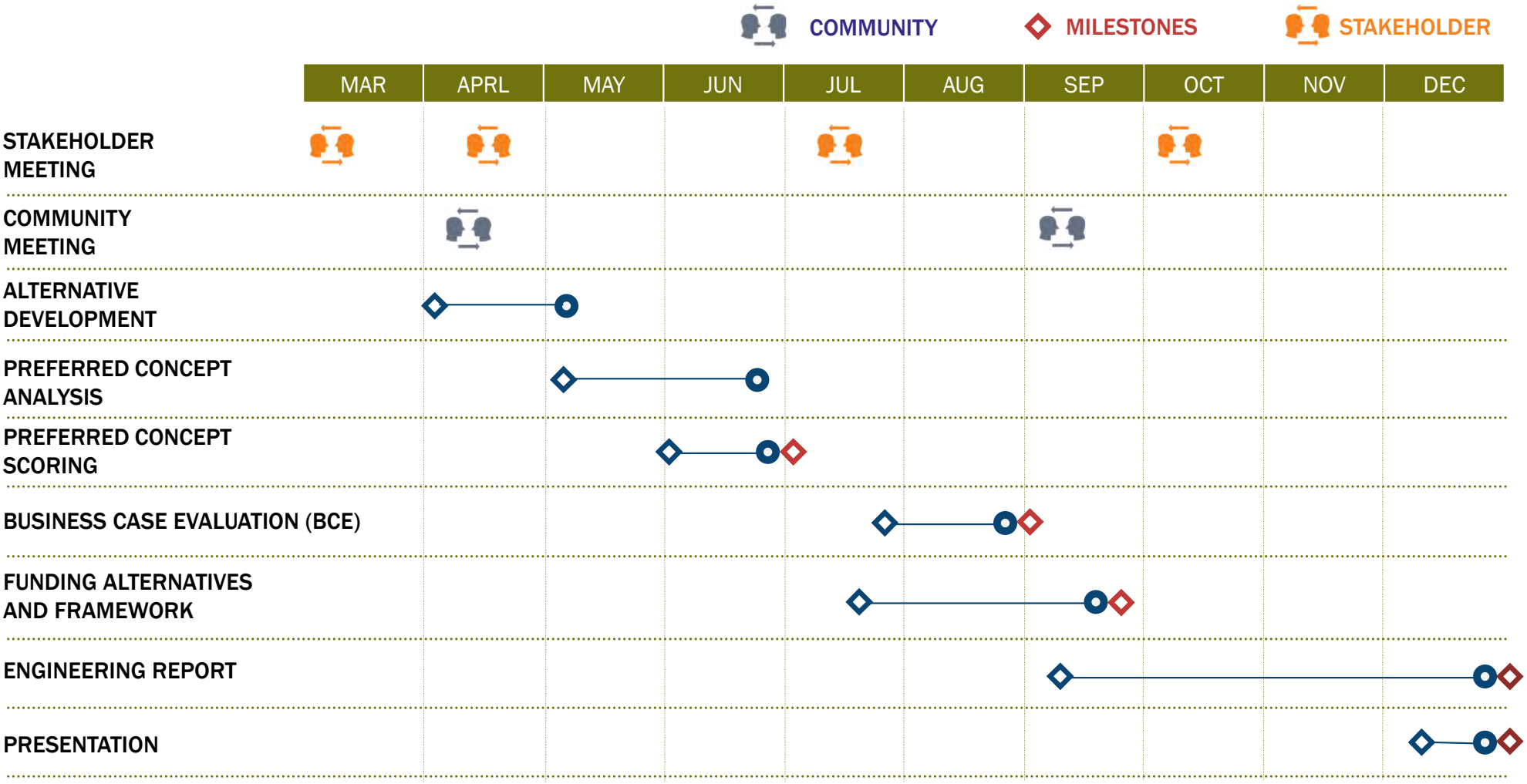
STAKEHOLDER MEETING 2 – MITIGATION ALTERNATIVES OVERVIEW

Five alternative categories have been identified.

1. Do nothing
2. Levee or Blocking Flooding
   - Full levee, setback levee, partial levee, railway levee
3. Storage
   - Instream, upstream, within larger Clover Creek watershed
4. Watershed or Creek Enhancement
   - Flood plain enhancement, restoration, stormwater controls, etc.
5. Capacity improvements
   - Instream, or high flow bypass

STAKEHOLDER MEETING 2 – MITIGATION ALTERNATIVES OVERVIEW

Alternative	Name	Type	Description
A1	**Do Nothing**		▪ Continue business as usual with inherent risk of FEMA mapped floodplains containing I-5 and other local businesses and residential buildings.
A2	**Regional Storage**	Storage	▪ Create regional storage facilities throughout the watershed. Storage could be inline/offline or flood plain benching.
A3	**Bypass Pipe**	Capacity Improvements	▪ Construct a pipe/channel capable of rerouting/bypassing high flows downstream.
A4	**Set Back Levee or Flood Wall**	storage/ Capacity/ blockage	▪ Set back levee along the north bank to limit flooding. Location of levee to be determined.
A5	**Levee or Flood Wall along creek**	Flood Blockage	▪ Levee along the creek to block flood waters exit from the channel
A6	**Creek Restoration/Capacity Enhancements**	System Improvements/Capacity	▪ Upstream and downstream restoration of Clover Creek to include habitat improvements, flood mitigation and storage, bank stabilization, and the implementation of LID to improve water quality.
A7	**WSDOT Ditch Blockage, raise profile of I-5 or Flood Wall along I-5**	Flood blockage	▪ Flood propagation begins at the creek and moves north mostly west of 47th Ave. The drainage ditch along I-5 would be blocked and would not allow drainage or flood water to move north or south along the east side of I-5.
A12	**Creation of Floodplain**	Capacity Improvements	▪ Purchase property and establish easements for the creation of intentional floodplain storage areas with flooded area as well as upstream and downstream.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PREFERRED CONCEPT SCORING
BUSINESS CASE EVALUATION (BCE)
FUNDING ALTERNATIVES AND FRAMEWORK
ENGINEERING REPORT
PRESENTATION

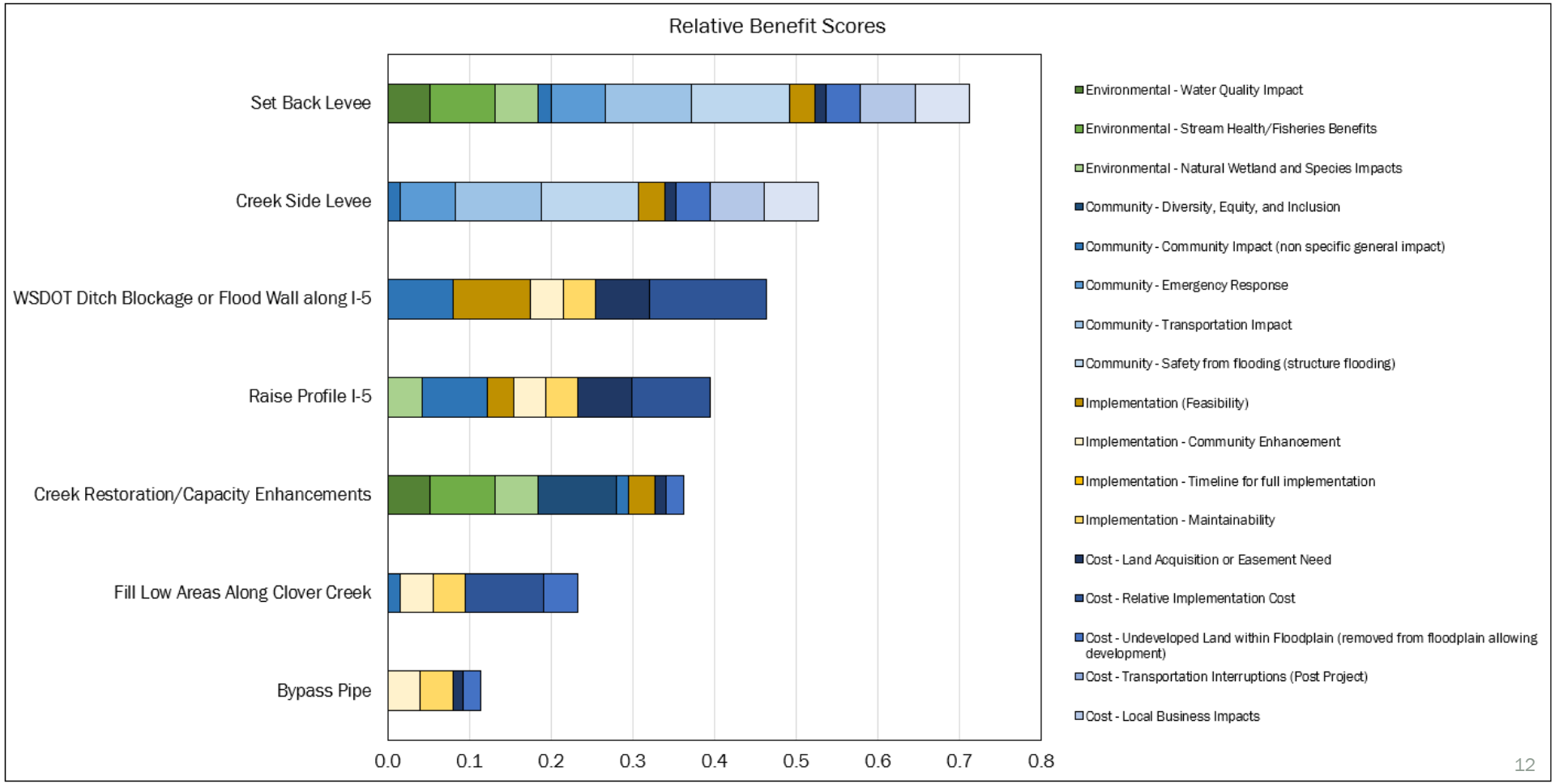
Final Flood Mitigation Alternatives

1. Set Back Levee
2. Bypass Pipe
3. WSDOT Ditch Blockage or Flood Wall Along I-5
4. Raise Profile I-5
5. Creek Restoration/Capacity Enhancements
6. Fill Low Areas Along Clover Creek
7. Creek Side Levee

Prioritization Process

- Qualitative Criteria Development – 17 Criteria
  - Environmental (3), Community (5), Implementation (3), Cost (6)
- Alternative Scoring for each criteria
  - 0, 5, 10
- Criteria Weighting
  - 1, 2, 3

Prioritization Process



Questions?

Preferred Alternatives

- Three Alternatives Considered
- Alternatives 'lumped' Together as Preferred for Evaluation
  1. Set Back Levee/Creek Side Levee
  2. WSDOT Ditch Blockage or Flood Wall Along I-5/Raise Profile I-5
  3. Creek Restoration/Capacity Enhancements
- Preliminary Model Results Discussion

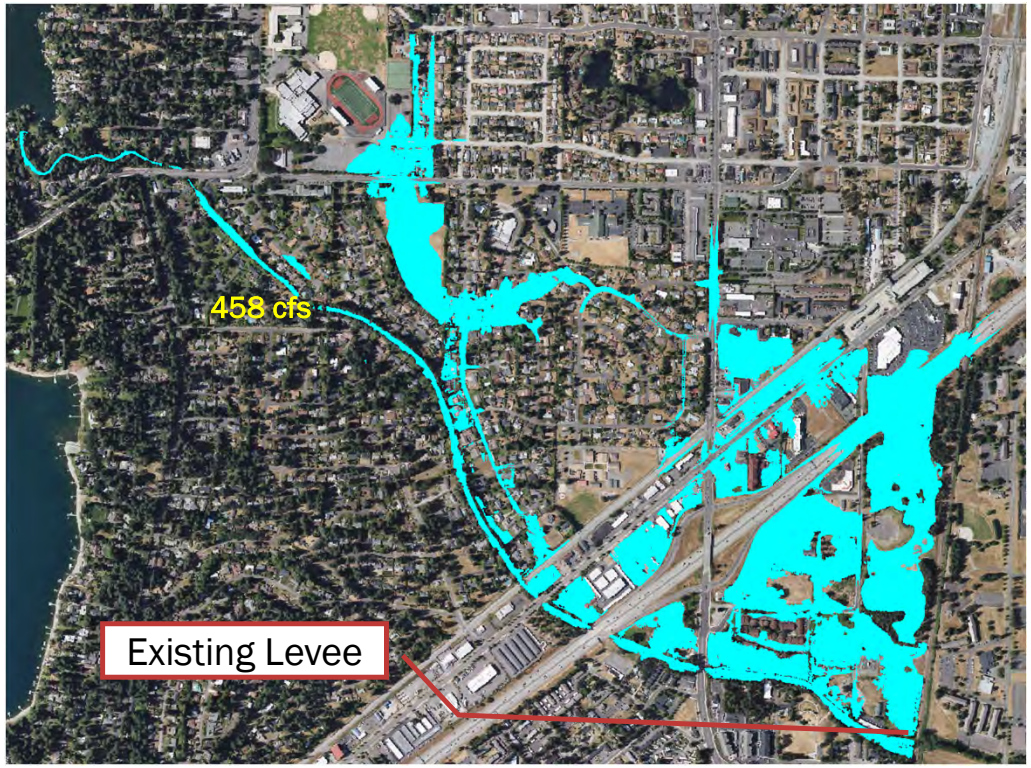
Questions

Discussion

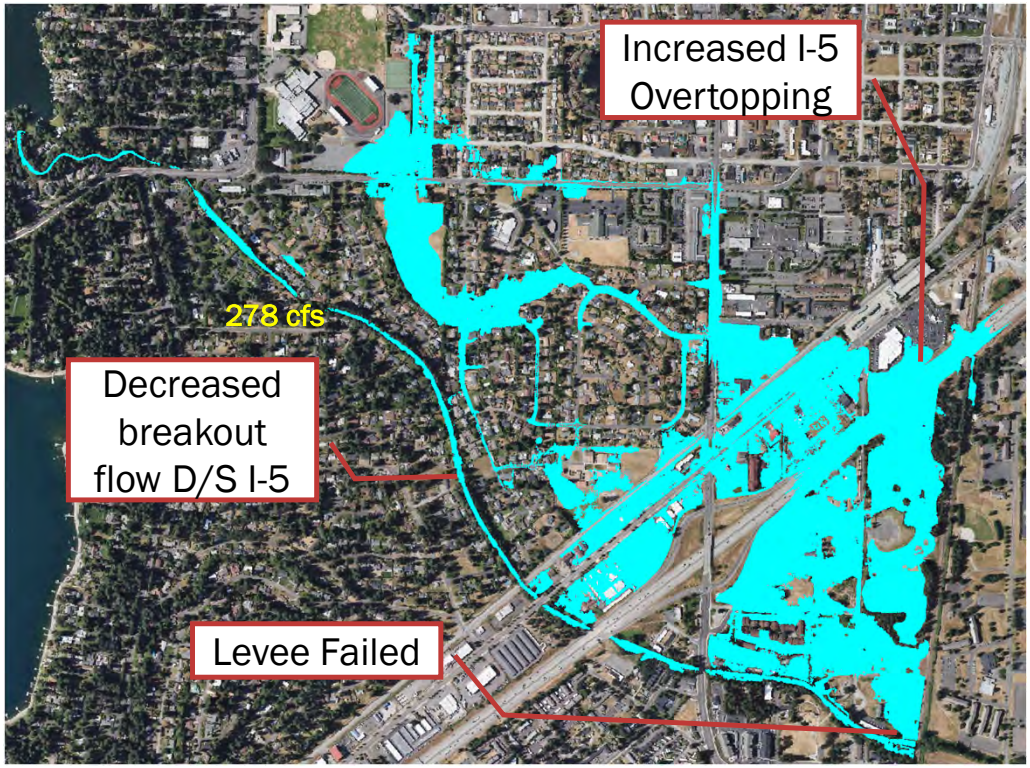
- Initial impressions or feedback?
- Do these alternatives capture a reasonable range of possible approaches?
- Are there fatal flaws in these three alternatives?

Existing Conditions – FEMA Mapping Composite

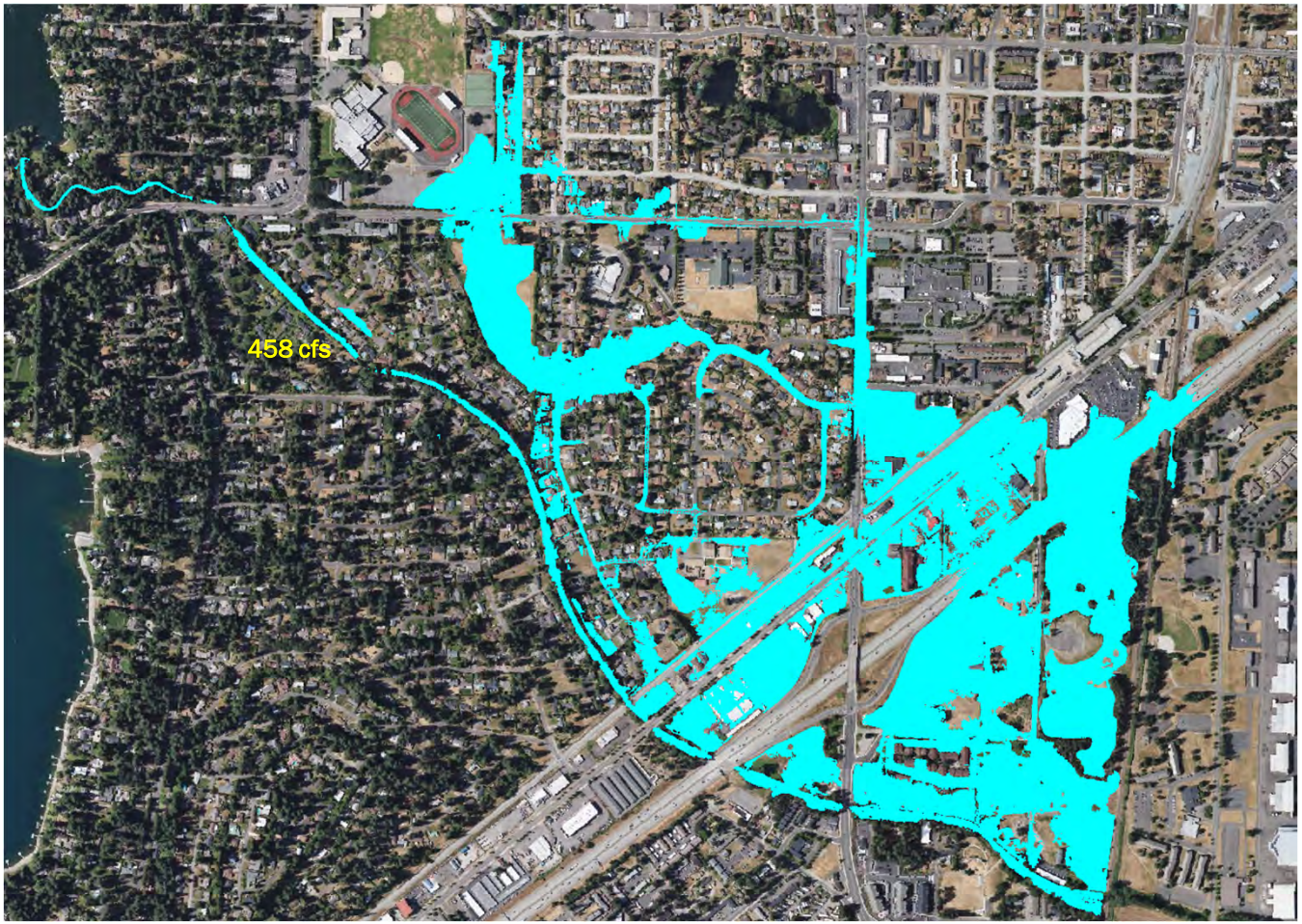
Levee in Place



Levee Failure

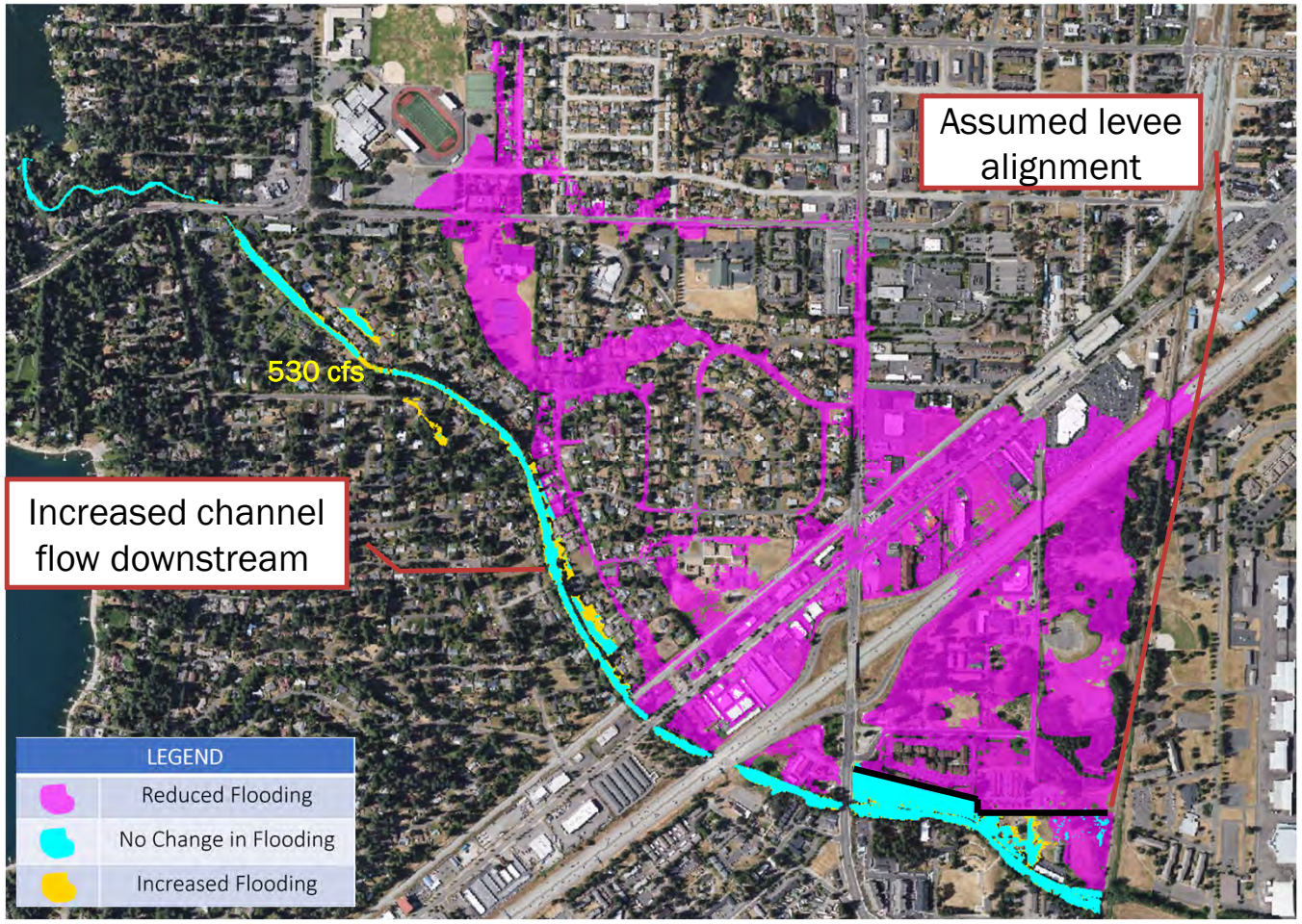


Do Nothing – FEMA Mapping Composite



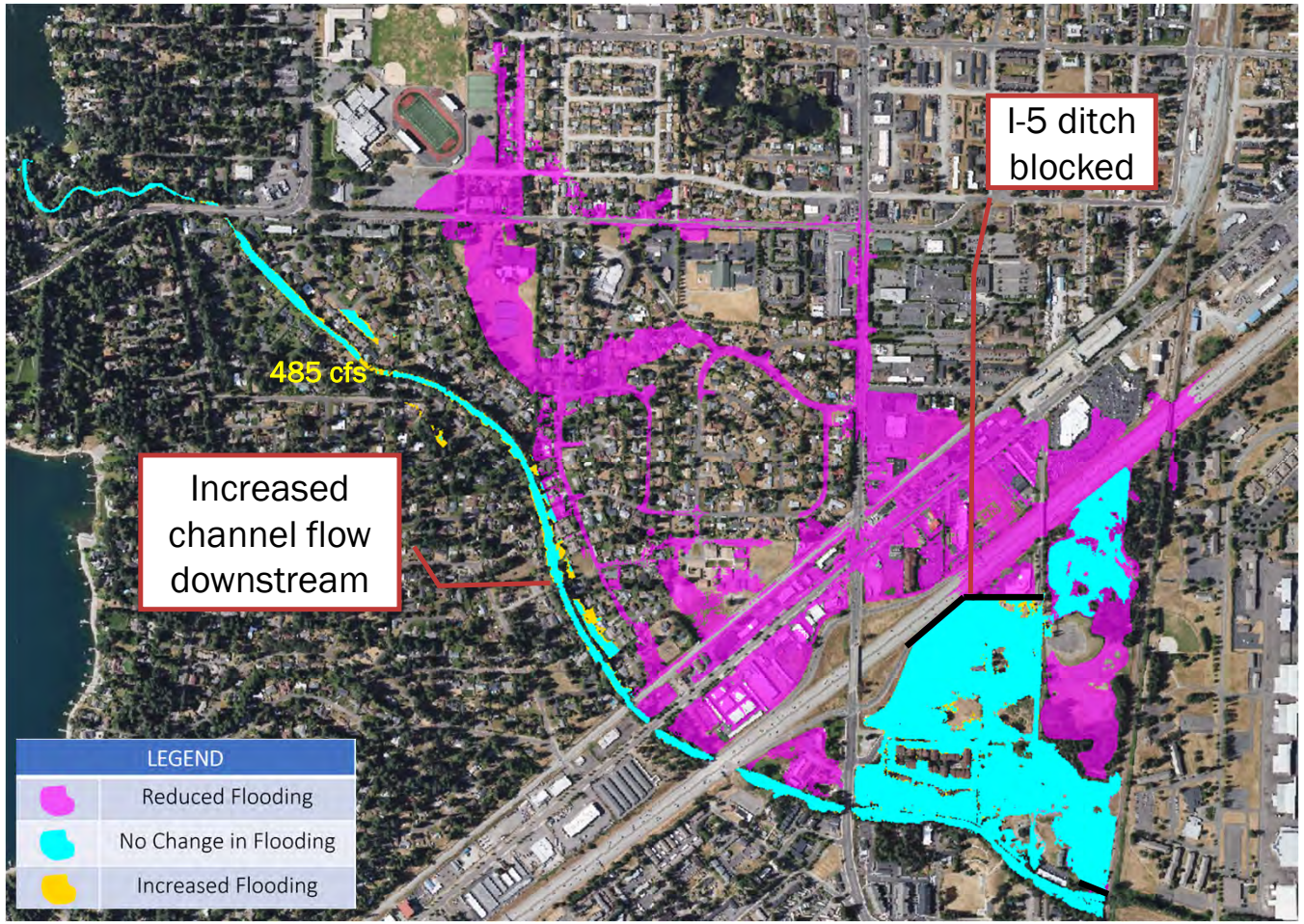
- FEMA 100-year flood extents combines w/ and w/o levee failure results.

Alternative - Levee



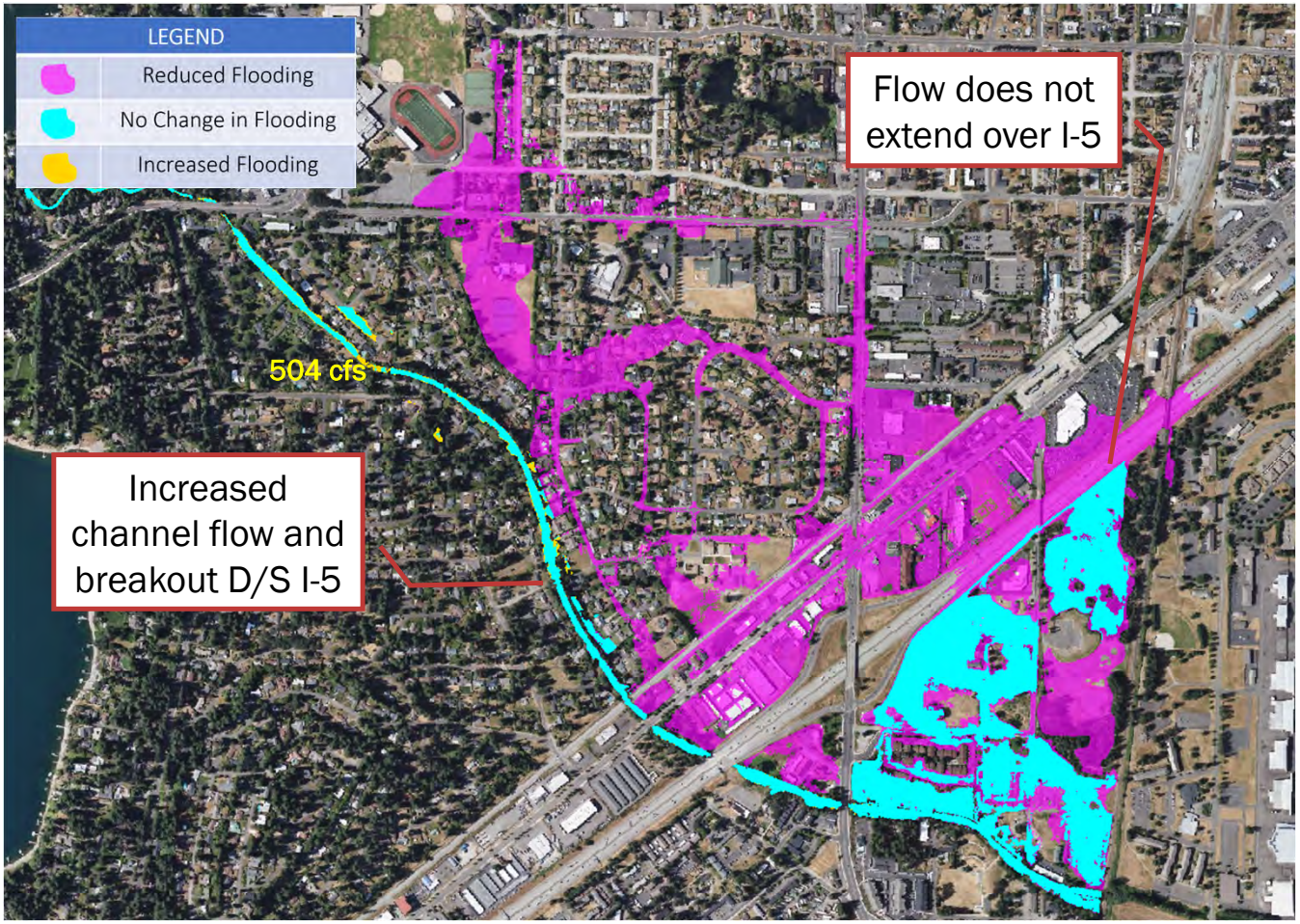
- Levee setback upstream from Bridgeport Way
- Additional fill along channel bank to prevent breakout flow d/s I-5
- Assumes existing levee is certified

Alternative - I5 Blockage



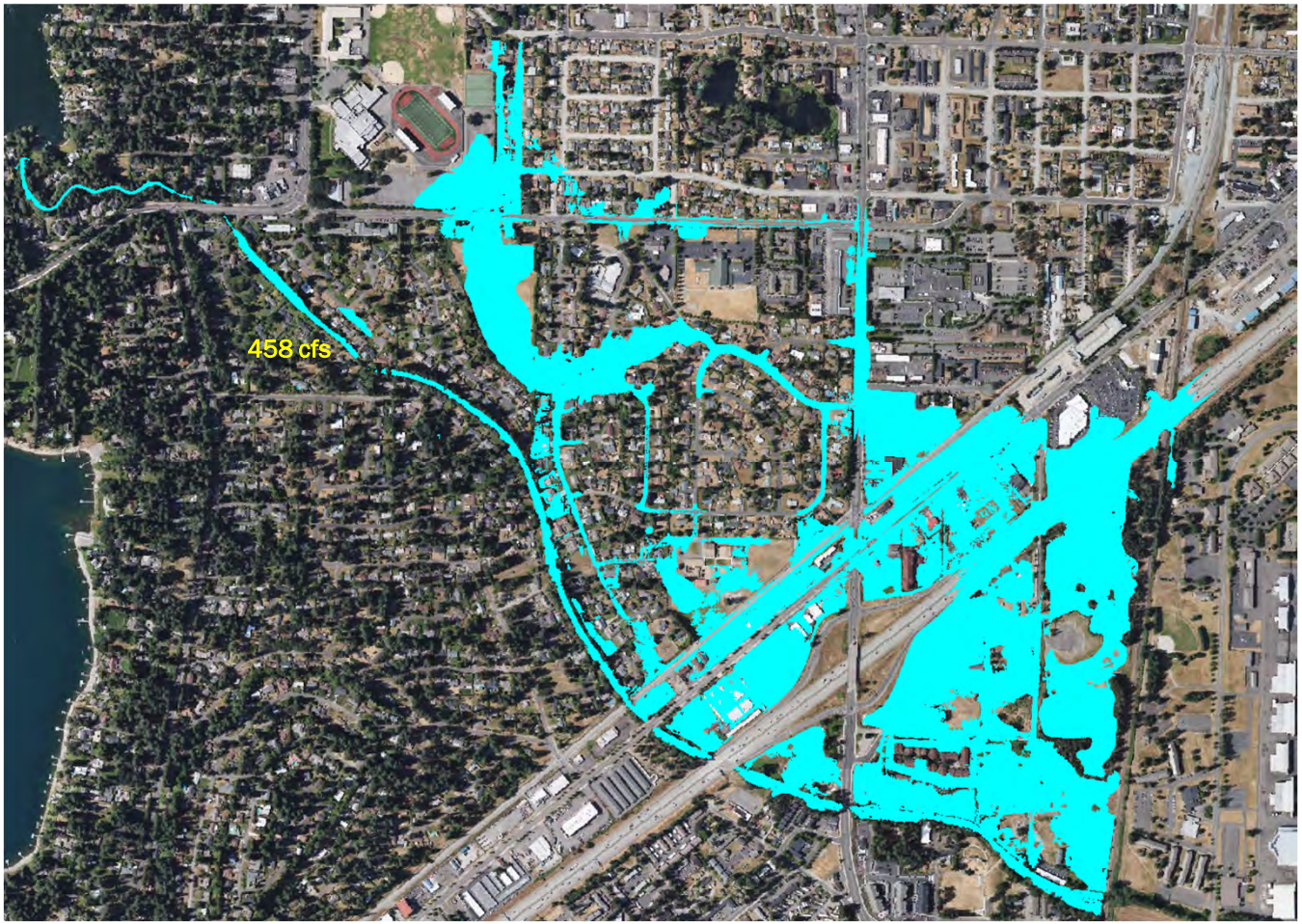
- Levee/blockage preventing flow over I-5
- Additional fill along channel bank to prevent breakout flow d/s I-5
- Assumes existing levee is certified

Alternative - Channel Enhancement/Capacity



- Channel overbank benches added at 2-year flood elevation
- Assumes existing levee is certified
- Additional fill along channel bank to prevent breakout flow d/s I-5

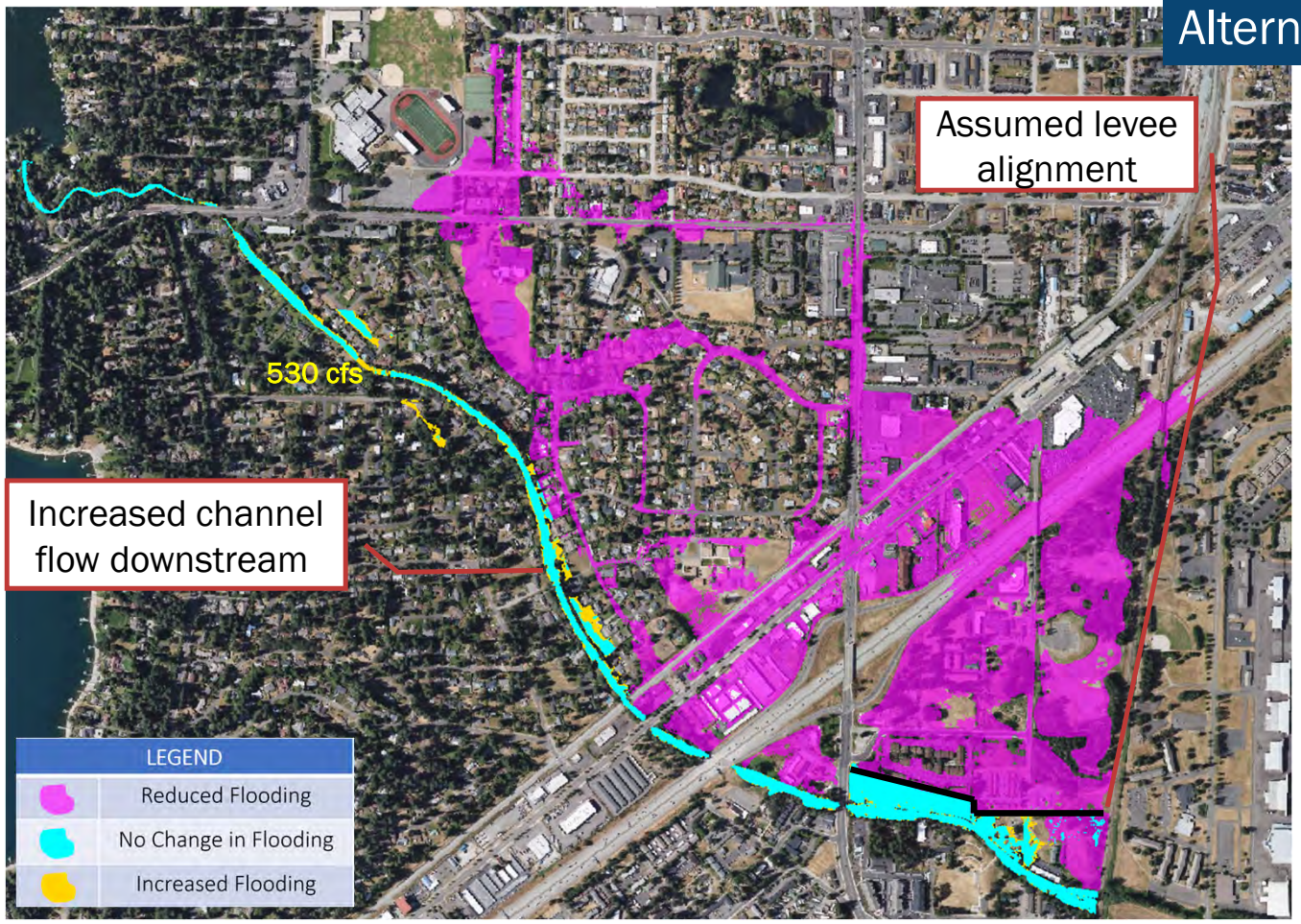
Do Nothing – FEMA Mapping Composite



- FEMA 100-year flood extents combines w/ and w/o levee failure results.

What opportunities and/or challenges does the Do Nothing Alternative present?

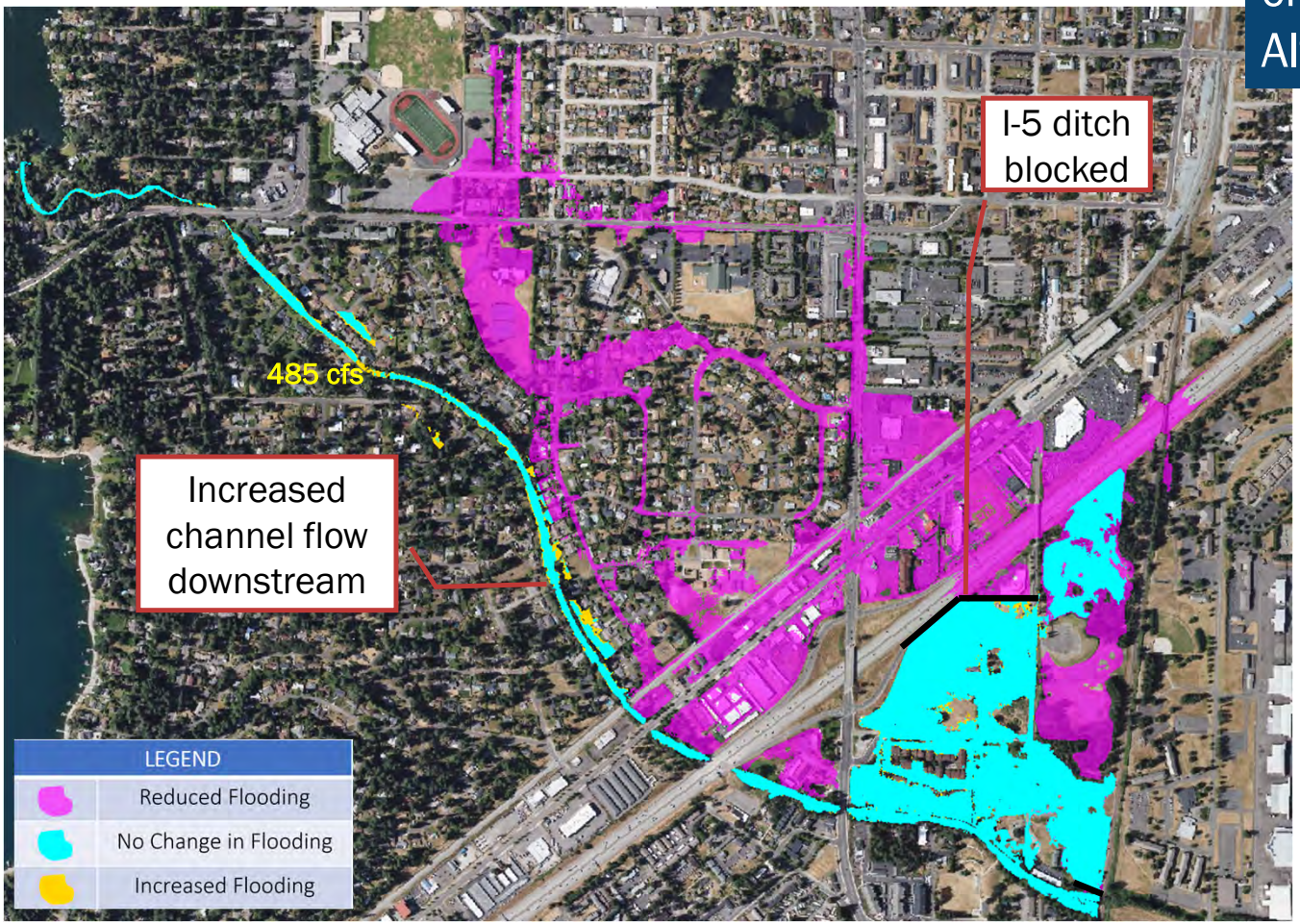
Alternative - Levee



What opportunities and/or challenges does the Levee Alternative present?

- Levee setback upstream from Bridgeport Way
- Additional fill along channel bank to prevent breakout flow d/s I-5
- Assumes existing levee is certified

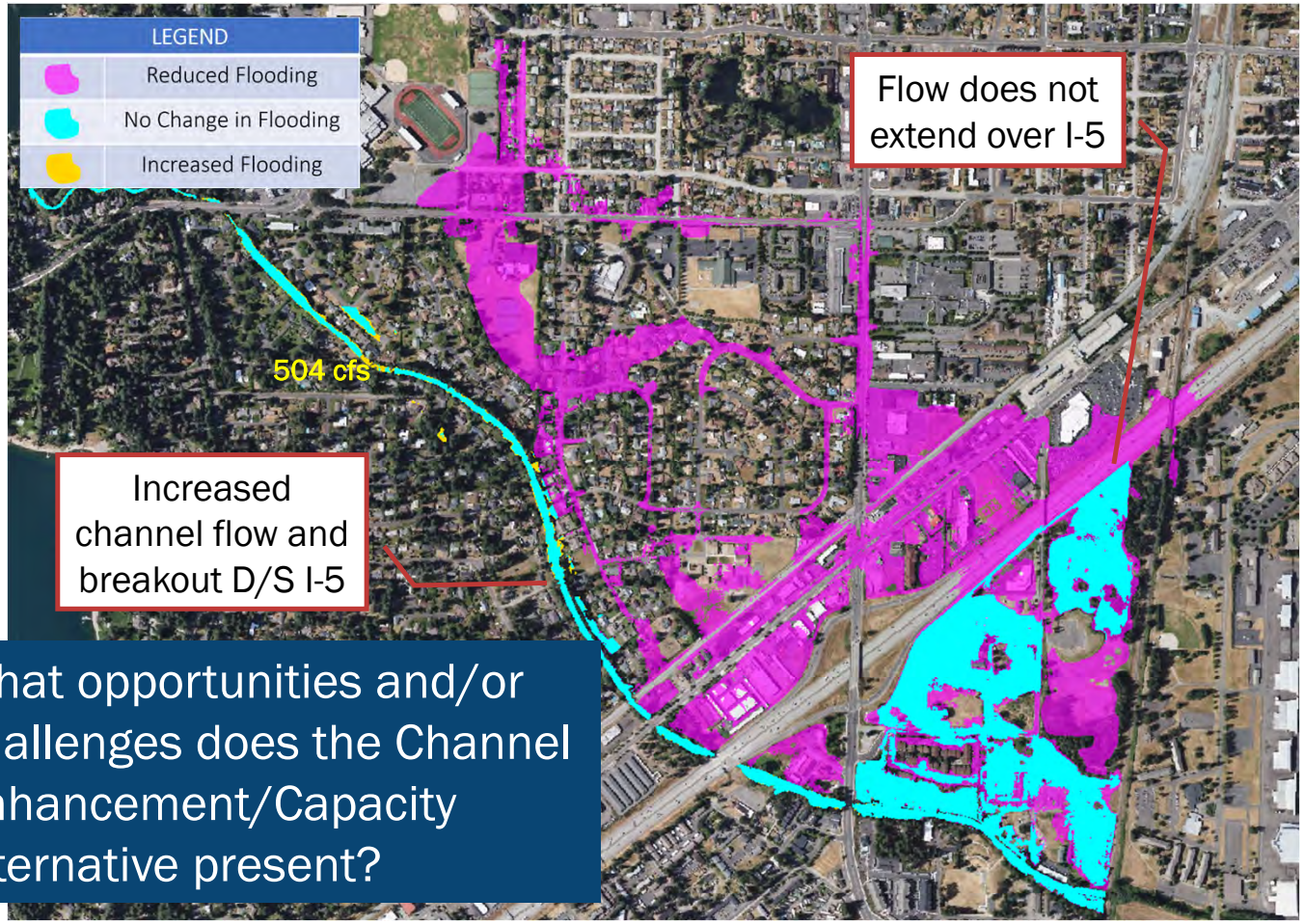
Alternative - I5 Blockage



What opportunities and/or challenges does the I-5 Alternative present?

- Levee/blockage preventing flow over I-5
- Additional fill along channel bank to prevent breakout flow d/s I-5
- Assumes existing levee is certified

Alternative - Channel Enhancement/Capacity

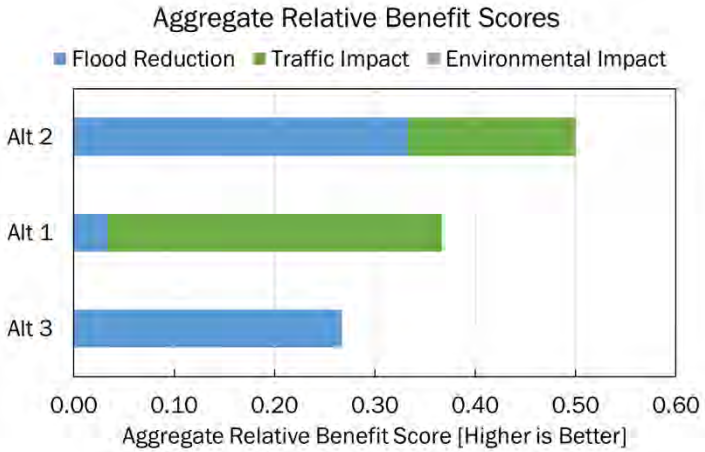


What opportunities and/or challenges does the Channel Enhancement/Capacity Alternative present?

- Channel overbank benches added at 2-year flood elevation
- Assumes existing levee is certified
- Additional fill along channel bank to prevent breakout flow d/s I-5

Business Case Evaluation (BCE) Process

- Evaluate four alternatives
  - Do Nothing, Levee, I-5 Blockage, Channel Enhancement/Capacity
- Multi criteria evaluation including relative cost
- Visual to aid in decision making



NEXT STEPS

- Community meeting in September
- Individual stakeholder meetings – as needed
- Stakeholder Committee Meeting on October 6

Thank you.

Paul Bucich
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Ryan Retzlaff
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Chris Frei
Chris@watershedse.com

Radhika Nair
Radhika@berkconsulting.com

Appendix I: Stakeholder Meeting 4 Presentation

Clover Creek
FLOOD MITIGATION STUDY

Stakeholder Committee | October 6, 2022

Project Team

City of Lakewood
Paul Bucich
Weston Ott

Brown & Caldwell
Ryan Retzlaff
Dan Shapiro
Erin Cox
Topher Jones

Watershed Science & Engineering
Chris Frei

BERK Consulting
Radhika Nair
Michelle Ellsworth

Introductions

In the chat, share your **name**, **organization**, and **your favorite part about autumn**.

ME0

Slide 3

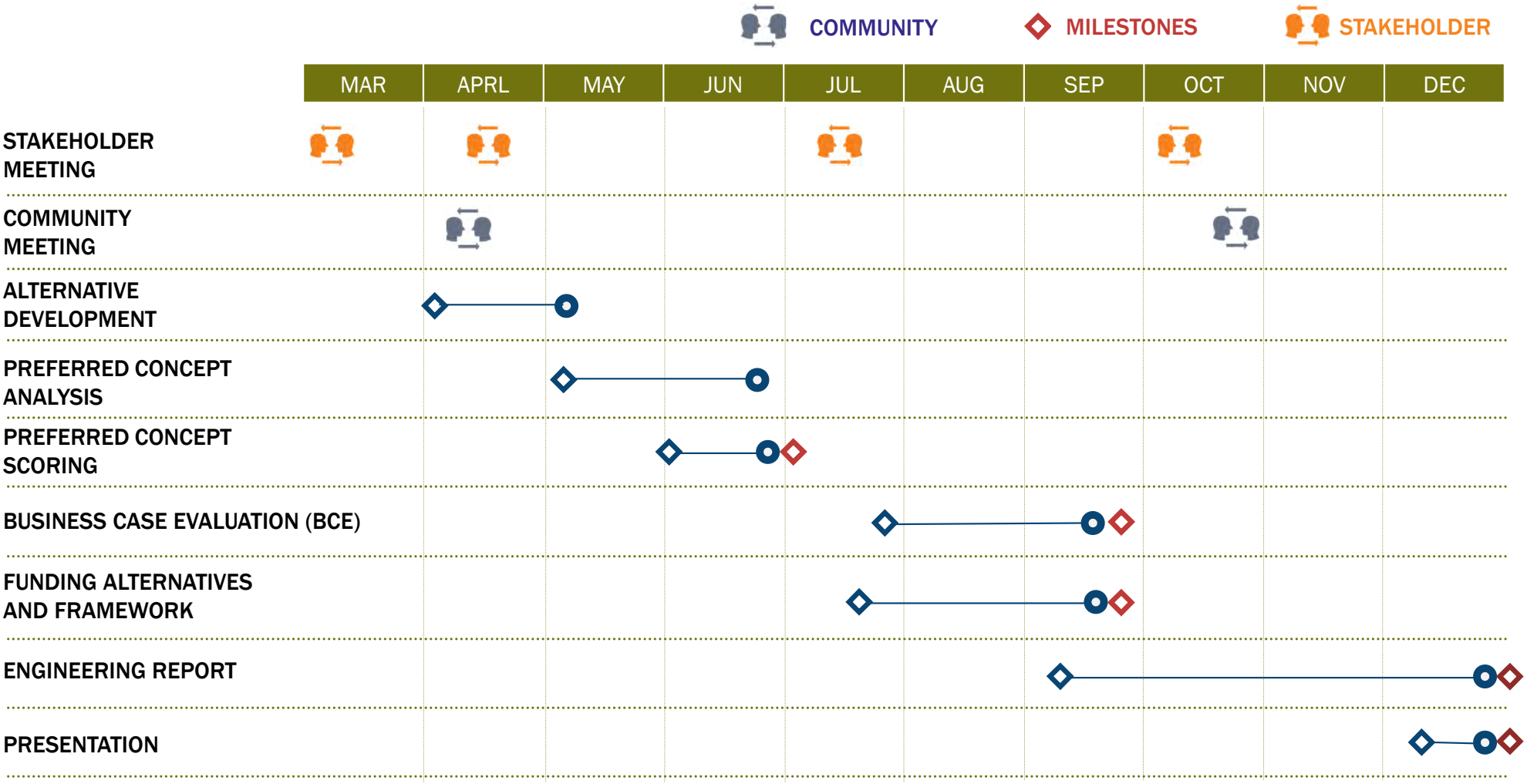
ME0 Hi RN, Updated question.

Other ice breaker ideas include:
- favorite Halloween costume
- favorite Halloween treat / candy
- favorite scary movie
- if you prefer a cool, crisp fall day or would rather go back to the summer heat,
- if you'd rather watch football, baseball, or something else.
(Trying to tap into the Mariners getting into the playoffs)

Michelle Ellsworth, 2022-10-04T00:16:22.531

MEETING PURPOSE

- Recap previous meeting
- Share MCDA criteria and scoring, summary of results, result graph, alternative scoring vs. costs
- Hear feedback on the MCDA process and results
- Identify potential areas where refinement may be possible
- Outline next steps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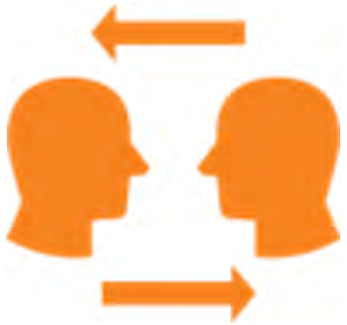
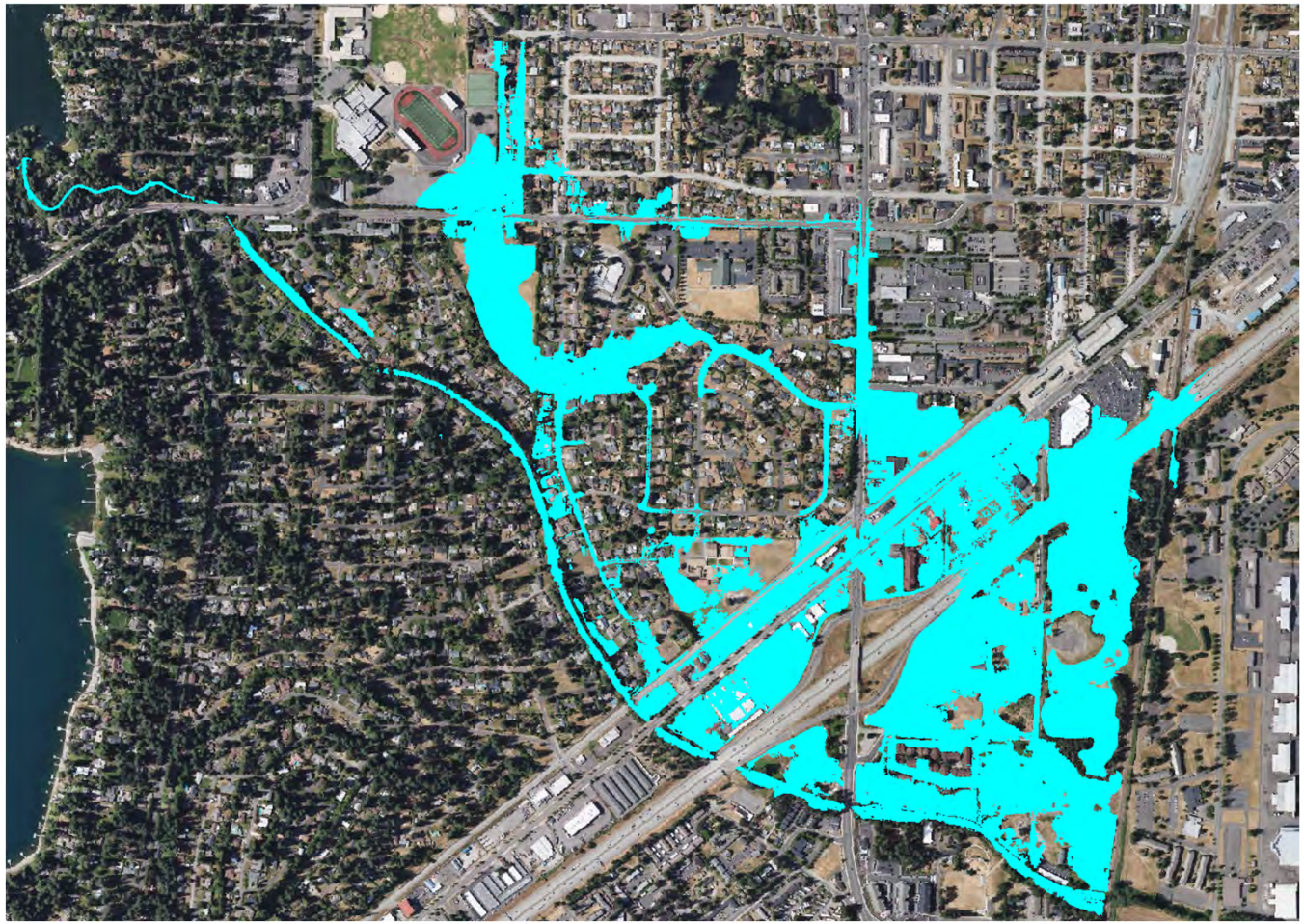
COMMUNITY MEETING
ALTERNATIVE DEVELOPMENT
PREFERRED CONCEPT ANALYSIS
PREFERRED CONCEPT SCORING
BUSINESS CASE EVALUATION (BCE)
FUNDING ALTERNATIVES AND FRAMEWORK
ENGINEERING REPORT
PRESENTATION

RECAP OF STAKEHOLDER MEETING 3

- Shared finalized flood mitigation alternatives, prioritization process and results, and preliminary model results for the three preferred alternatives
- Hear feedback on the alternatives to inform the next phase of work
- Outline next steps to support business case evaluation (BCE) process



Do Nothing – FEMA Flood Extents

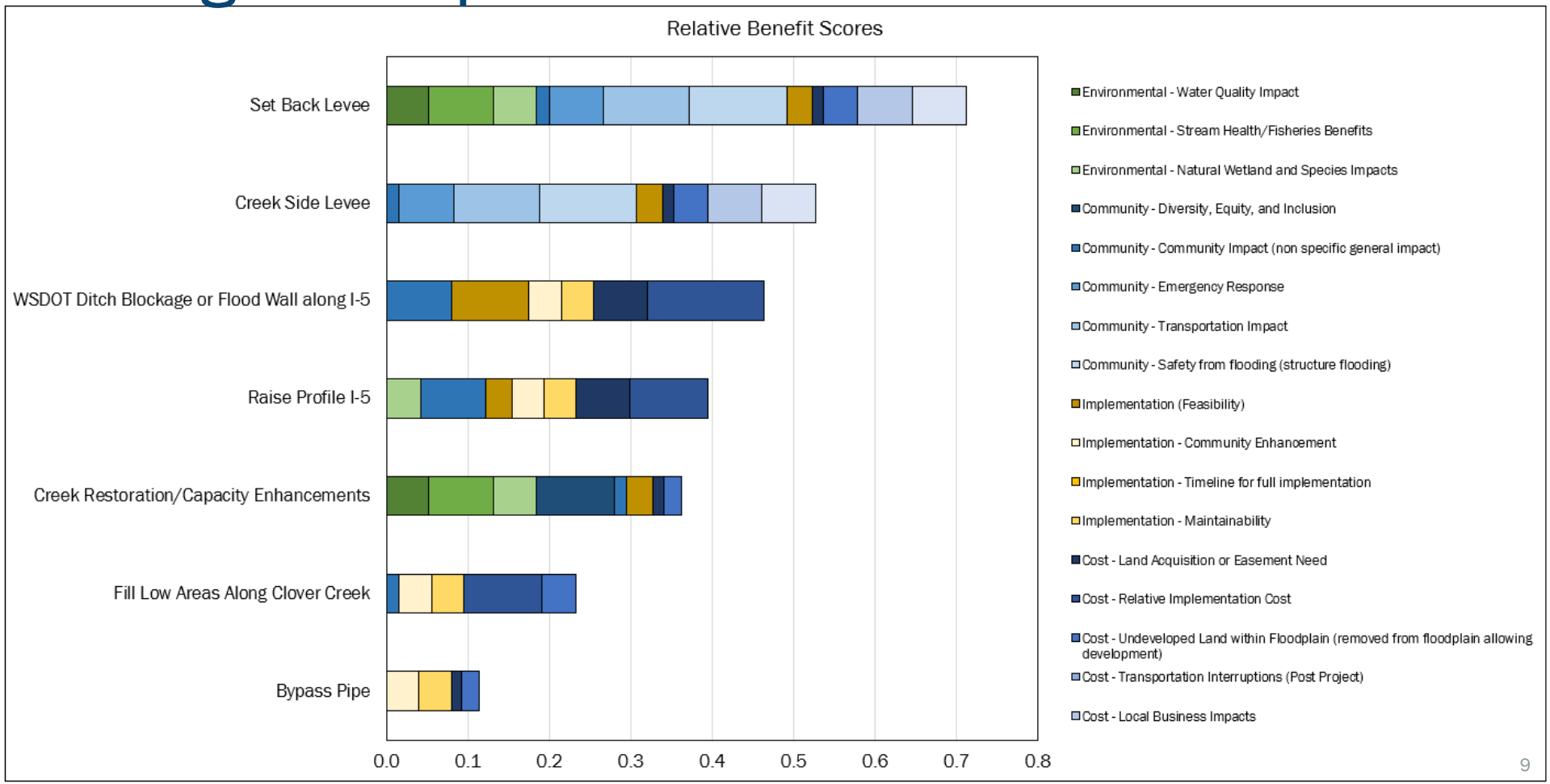


- FEMA 100-year flood extents

Meeting 3 Recap - Final Flood Mitigation Alternatives

1. Set Back Levee
2. Bypass Pipe
3. WSDOT Ditch Blockage or Flood Wall Along I-5
4. Raise Profile I-5
5. Creek Restoration/Capacity Enhancements
6. Fill Low Areas Along Clover Creek
7. Creek Side Levee

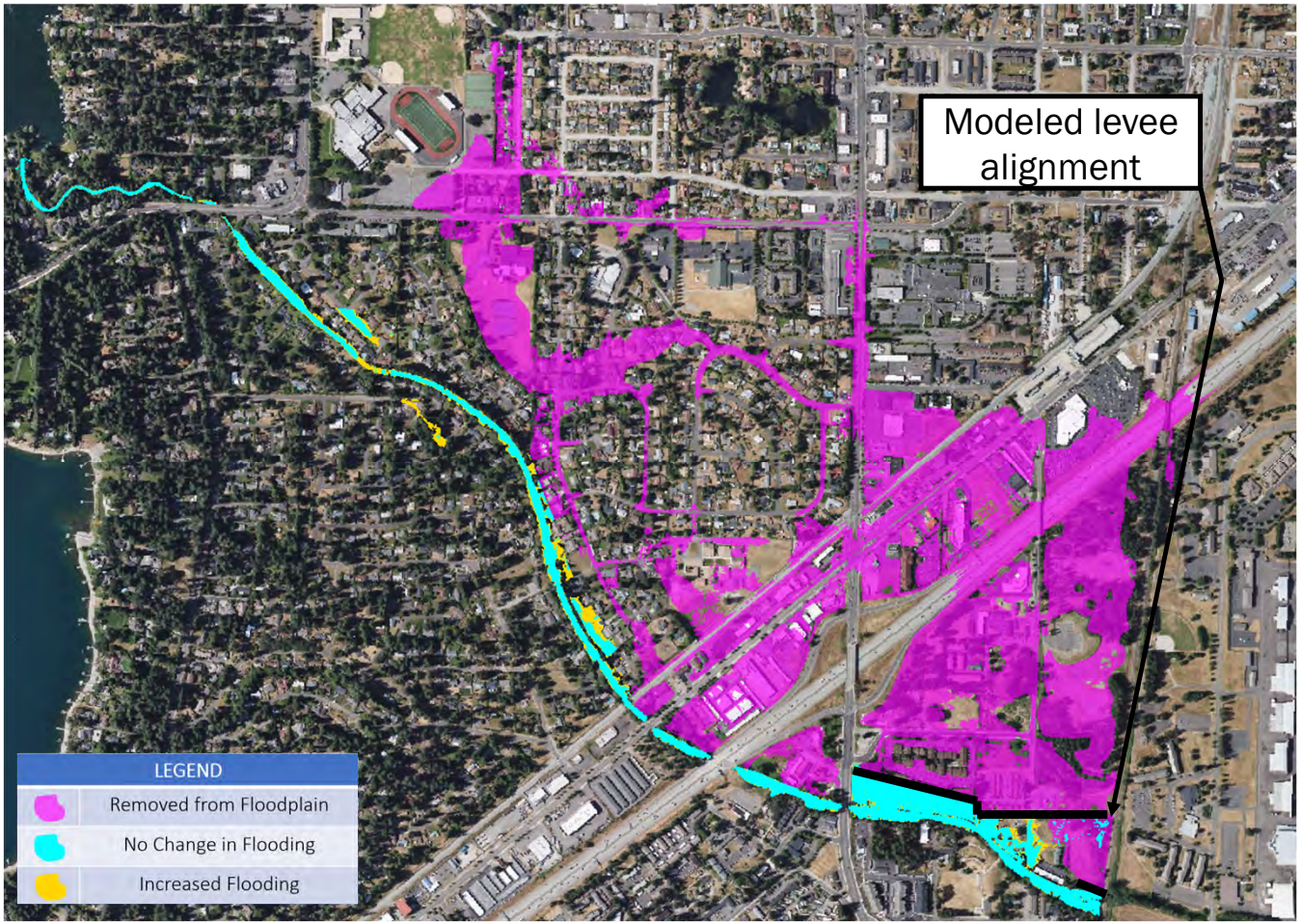
Meeting 3 Recap - Prioritization Process



Meeting 3 Recap - Preferred Alternatives

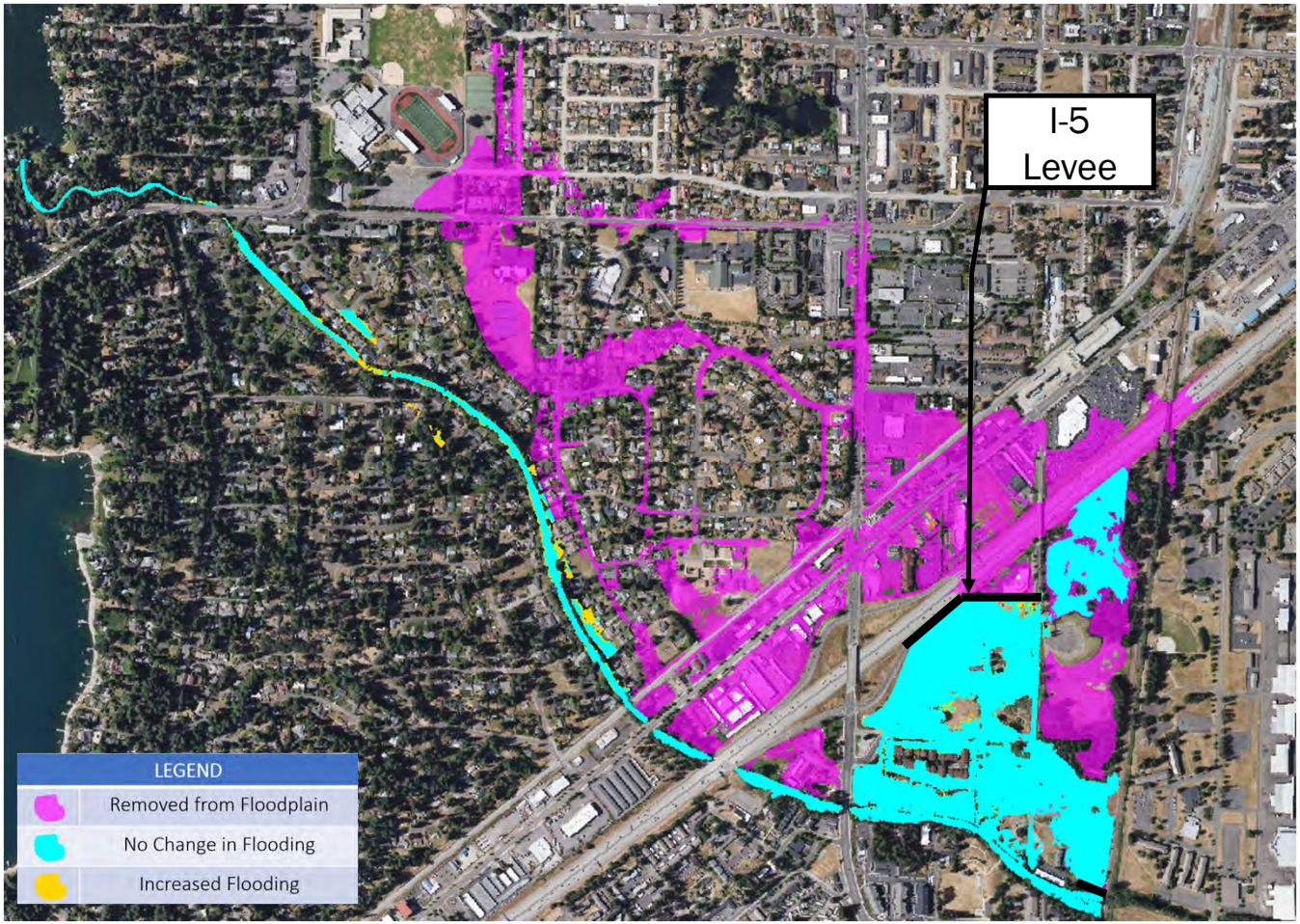
- Three Alternatives Considered
- Alternatives 'lumped' Together as Preferred for Evaluation
  1. Set Back Levee/Creek Side Levee
  2. WSDOT Ditch Blockage or Flood Wall/Levee Along I-5
  3. Creek Restoration/Capacity Enhancements
- Preliminary Model Results Discussion
- Outlined Next Steps
  - Business Case Evaluation (BCE)
  - Utilizing Multiple Criteria Decision Analysis (MCDA) process

Alternative - Levee



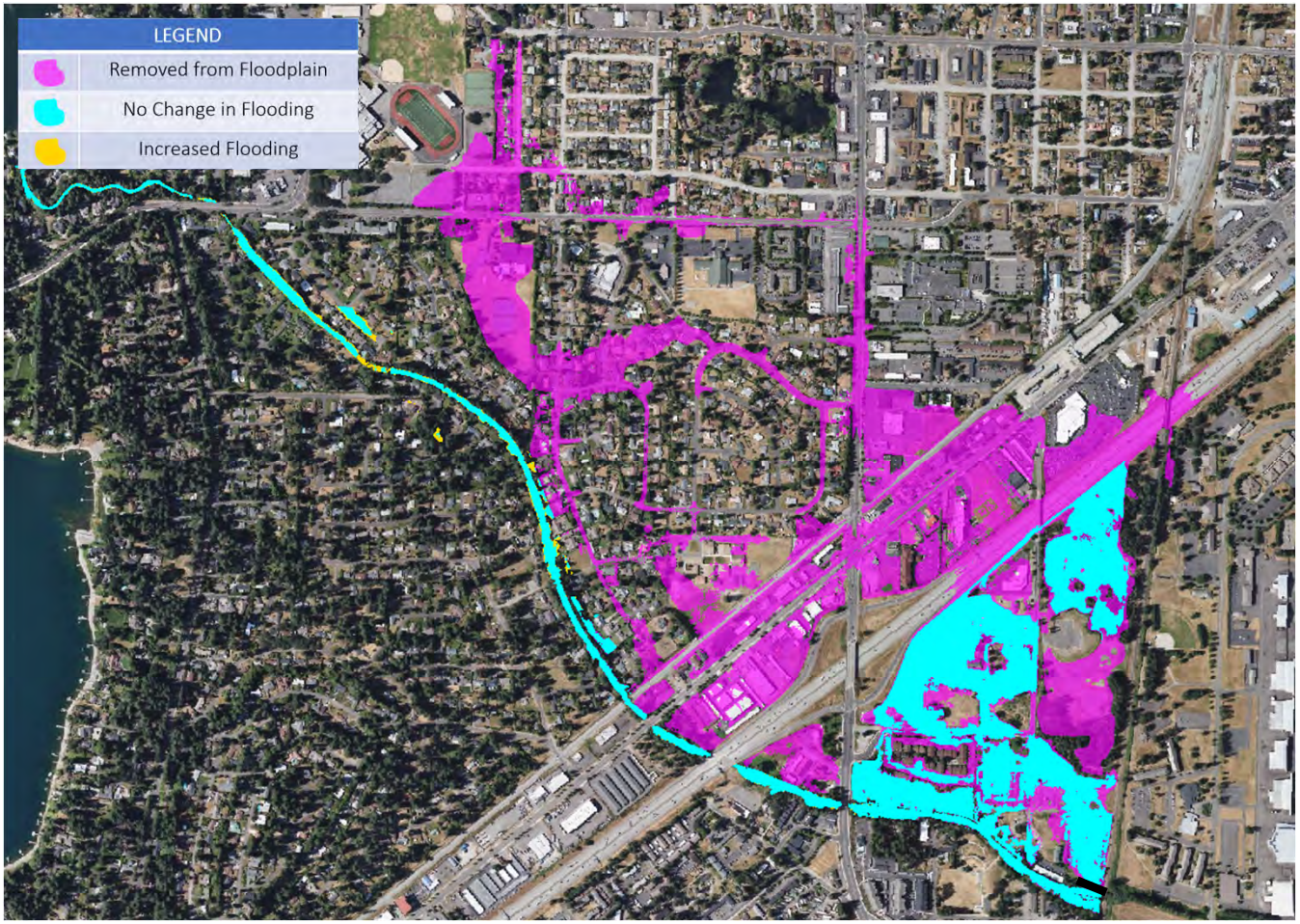
- Levee setback upstream from Bridgeport Way

Alternative - I5 Levee



- Levee preventing flow over I-5

Alternative - Channel Enhancement/Capacity



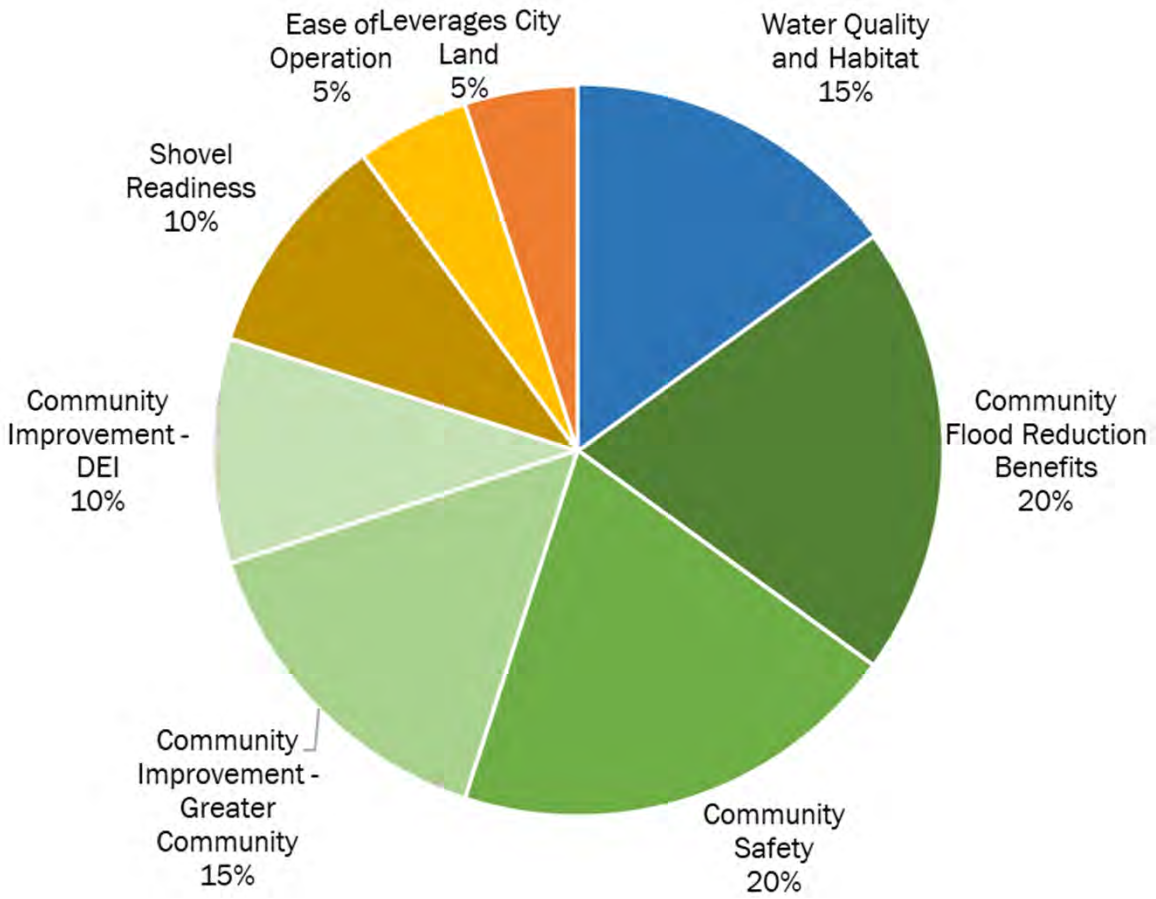
- Channel overbank benches added at 2-year flood elevation

Questions

MCDA Criteria and Scoring Methods

Criteria	Description
Water Quality and Habitat	Habitat and water quality conditions that are either supportive or detrimental to aquatic species
Community Improvement - Greater Community	Community benefits not related to flooding: • nature-based solutions, and/or educational opportunities • green spaces, parks, and setbacks
Community Improvement - DEI	Investments in traditionally underserved neighborhoods
Community Flood Reduction Benefits	Spatial extent of flooding to approximate impacts of flooding that are not captured in flood cost analysis: • business development in region, business down-time • community perception • traffic impacts to immediate and surrounding area
Community Safety	Magnitude of population that could be adversely affected by flooding and/or associated emergency response capability, including hospital access
Shovel Readiness	Time to fully implement an alternative. This encompasses funding time, political and community acceptance, land acquisition, permitting, design, construction etc.
Ease of Operation	Maintenance/operational upkeep requirements
Leverages City Land	Minimizes impact to private property owners

Greatest Criteria Weighting = Meeting Project Goals

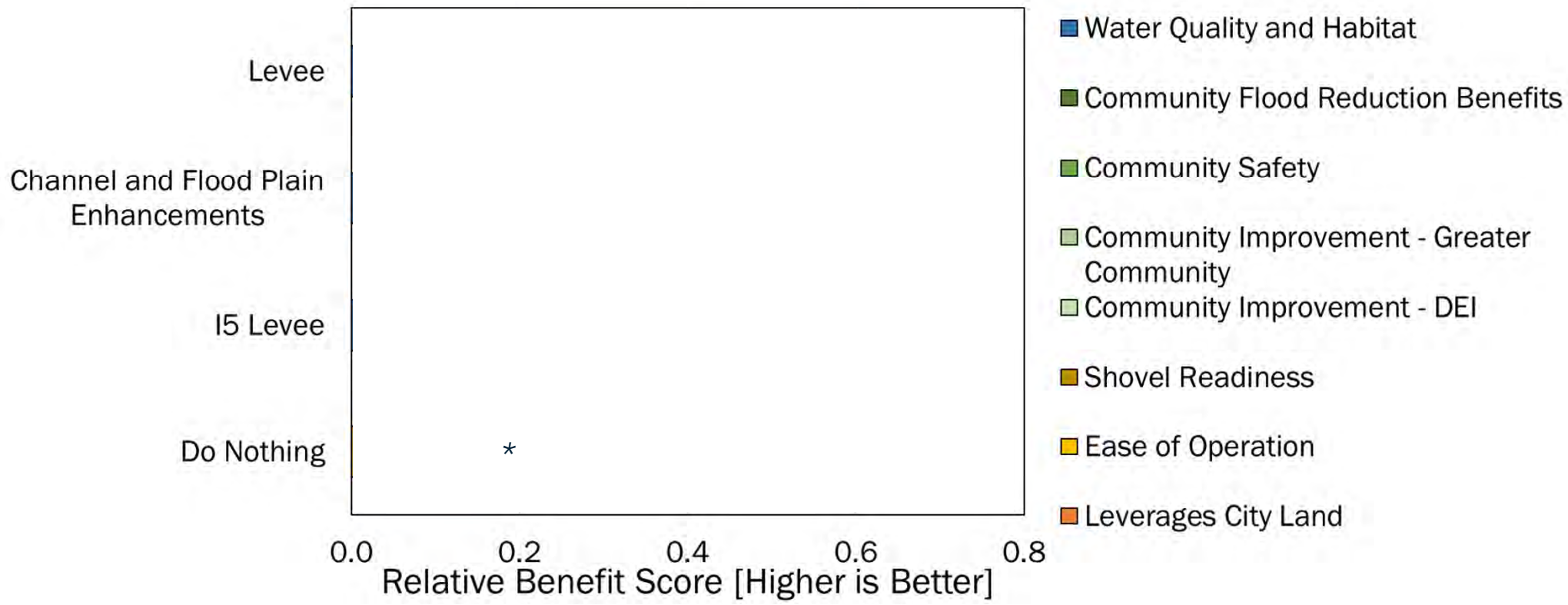


MCDA Summary Results

Key benefits associated with each alternative

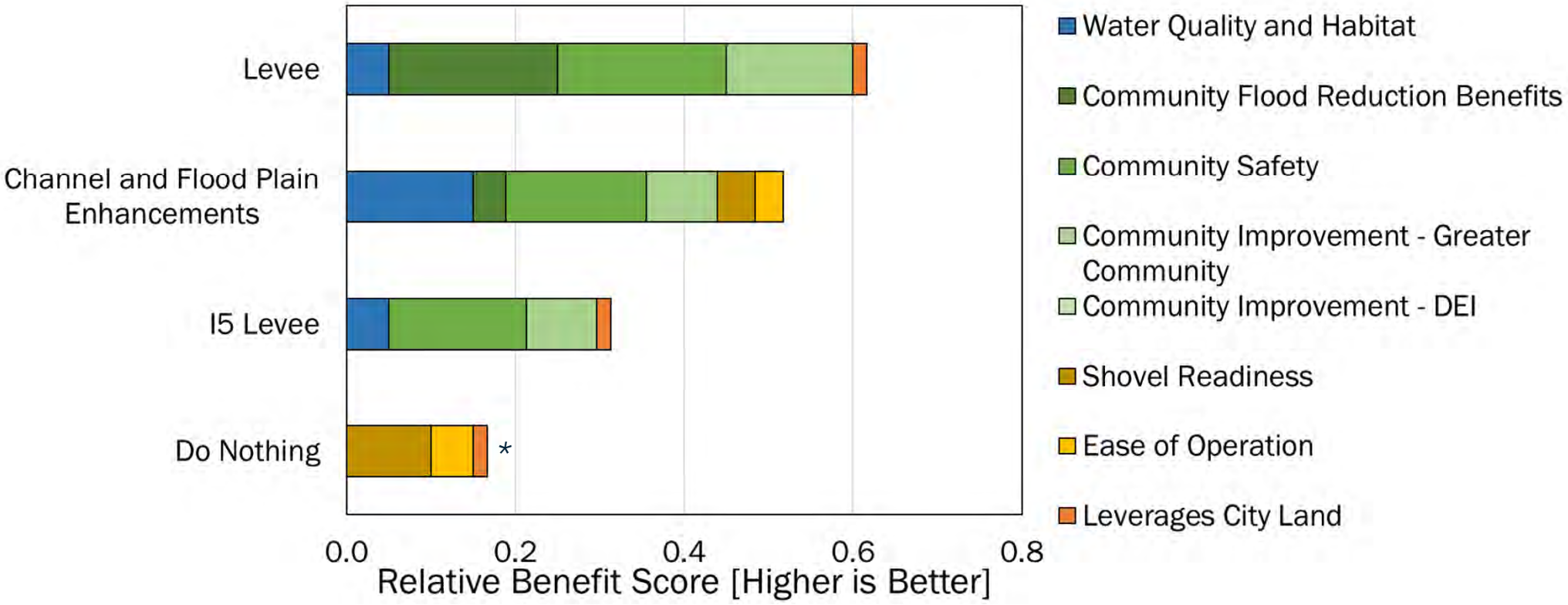
Alternative	Water Quality and Habitat	Community Improvement - Greater Community	Community Flood Reduction Benefits	Community Safety	Community Improvement - DEI	Shovel Readiness	Ease of Operation	Leverages City Land
Do Nothing	None	None	None	None	Varies	High	High	Medium
Levee	Medium	High	High	High	Varies	Low	Low	Medium
I5 Levee	Medium	Medium	Medium	Medium	Varies	Low	Low	Medium
Channel and Flood Plain Enhancements	High	Medium	Medium	Medium	Varies	Medium	Medium	Low

Benefits Discussed Previously Pulled into Multiple Criteria Decision Analysis (MCDA) Framework



** Benefits associated with do nothing come from not having to do anything*

Benefits Discussed Previously Pulled into Multiple Criteria Decision Analysis (MCDA) Framework



** Benefits associated with do nothing come from not having to do anything*

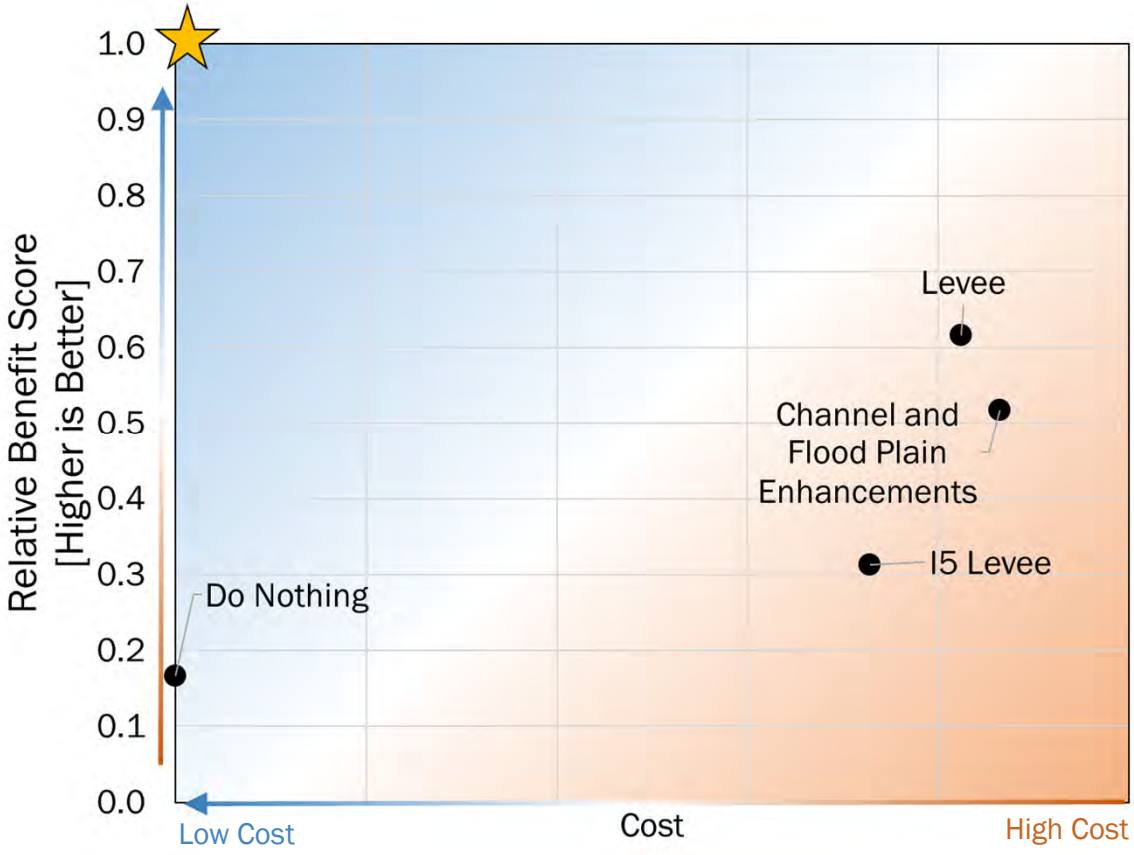
Alternative Costs

Estimated Cost of 100-Yr Flood	
Do Nothing	$88,900,000
Levee Alternative	$2,800,000
I5 Levee Alternative	$2,900,000
Channel Enhancement Alternative	$2,900,000

Estimated Alternative Cost	
Levee Alternative	$20,600,000
I5 Levee Alternative	$18,200,000
Channel Enhancement Alternative	$21,600,000

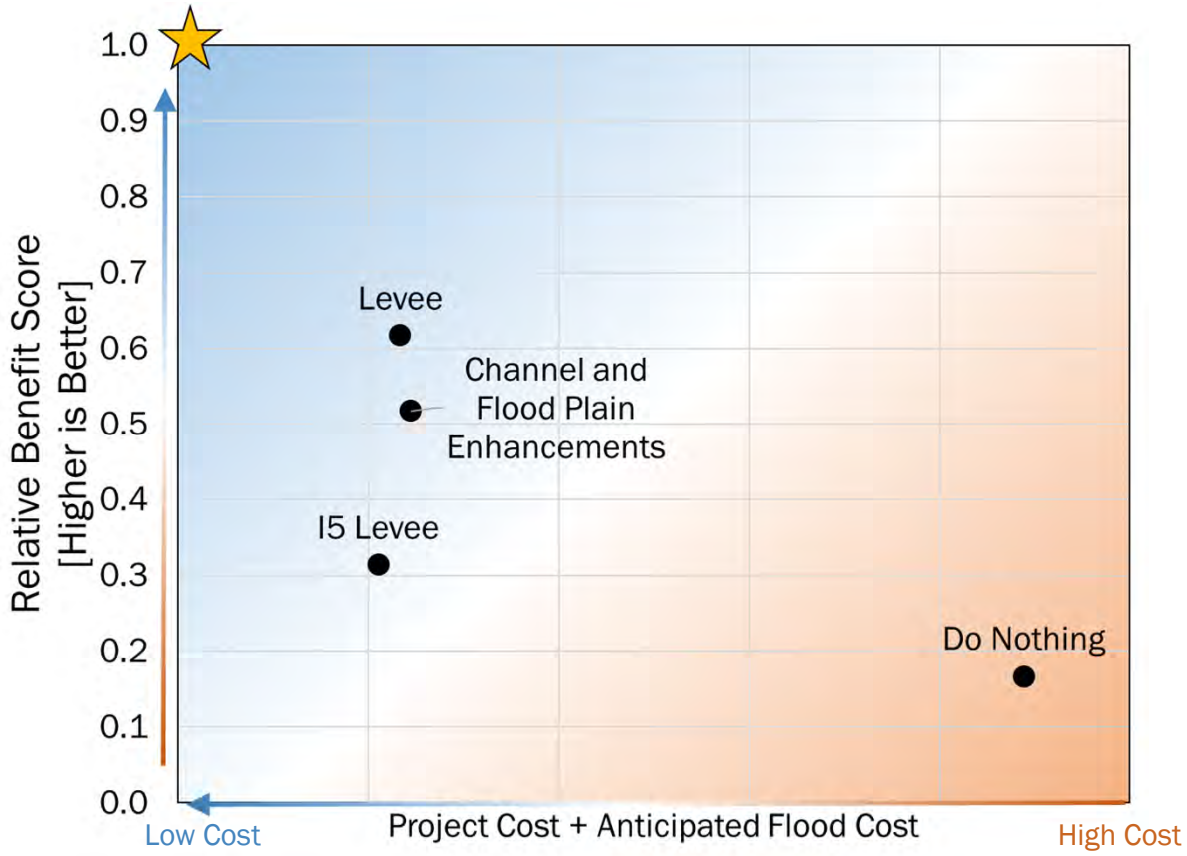
Capital costs Vs Benefit

(*Closer to the star is better)



Capital and Flood Cost Vs Benefit

(*closer to the star is better)



Summary

- The levee alternative has risen to the top as the primary and most likely alternative that best meets the criteria and objectives set forth through this evaluation.
- The levee alternative will be the recommendation moving forward
- Improvements to stream habitat, overall environmental uplift that may be associated with the development of a project could include the following:
  - Creation of flood plain, riparian zone and off channel wetlands
  - Removal of obstructions downstream of project area IE weirs.
  - Parks and green spaces with interactive space
  - Stormwater treatment to enhance local water quality

Discussion

- Impressions or feedback on the MCDA process and results? The alternative selected?
- Are there potential areas for refinement?

ME0

Slide 24

ME0 Hi RN, updated to reflect the questions outlined in the agenda objectives.
Michelle Ellsworth, 2022-10-04T00:22:21.481

NEXT STEPS

- Community meeting on November 10
- Individual stakeholder meetings (as needed)
- Approach refinement based on Stakeholder and Community feedback
- Finalization of engineering report and presentation, scheduled for this winter

Thank you.

Paul Bucich
pbucich@cityoflakewood.us

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rretzlaff@brwncald.com

Chris Frei
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Radhika Nair
Radhika@berkconsulting.com

Appendix J: Community Meeting Mailer

Clover Creek
FLOOD MITIGATION STUDY

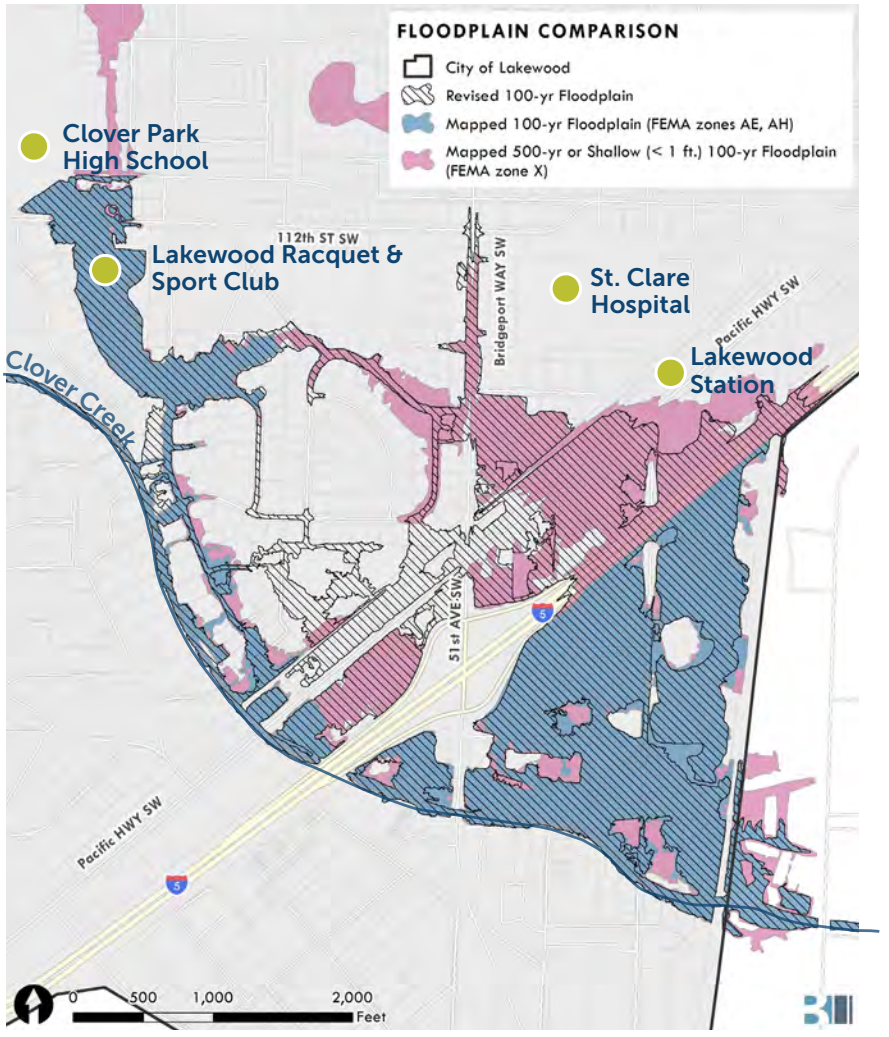
Mild flood risk to Springbrook and Hillside neighborhoods

What is the issue? If a 100-year flood were to occur, water might reach your neighborhood. The City is studying how to reduce the risk.

Why should you care? If the City does nothing, the "100-year floodplain" will grow. Properties inside the floodplain may need flood insurance. Development may have increased regulatory requirements.

What is the City doing about this? The City is working with local, state, and federal partners to find ways to reduce flooding.

What can I do? Do you support City efforts to address this flood risk? Visit the link to ask questions or state your opinion.



Learn more at the **community meeting** on
April 12 from 7 - 8:30 pm at City Hall Council Chambers
Or visit **CityofLakewood.us/clover-creek-floodplain**

Appendix K: Community Meeting 1 Presentation

Clover Creek
FLOOD MITIGATION STUDY

Community Engagement | April 12, 2022

Agenda

1. Introductions
2. Meeting Purpose and Agenda
3. Current flood mapping and modeling
4. Project Overview, Timeline, and Milestones
5. Poster Viewing / Q & A

Introductions

City Staff:

Paul Bucich, Public Works Engineering Director

Weston Ott, Engineering Services Manager

Jim Kopriva: Communications Manager

Consultant Staff:

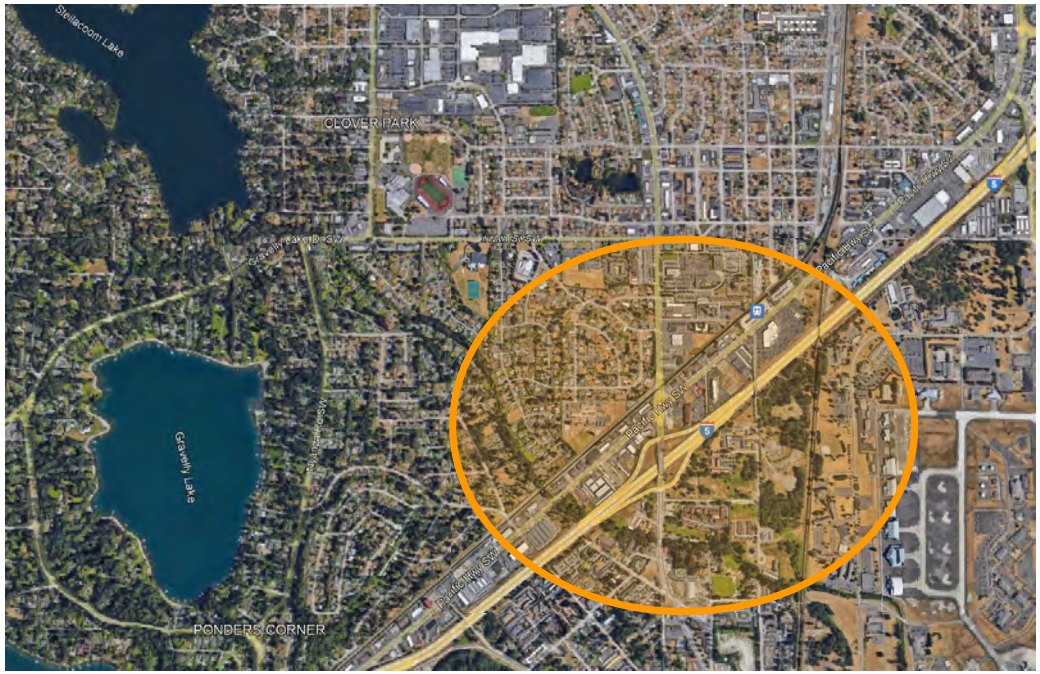
Ryan Retzlaff, Brown and Caldwell

COMMUNITY MEETING PURPOSE

- Introduce the project, project team, and purpose of this meeting
- Share an **overview of the project**, timeline, and milestones
- **Share the problem** the study will address
- Provide an opportunity for Community feedback

PROJECT OVERVIEW

- Recent flood modeling revealed a greater floodplain than current FEMA mapping indicates
- New flood modeling highlights a multitude of issues potentially affecting the community
- This project will explore alternatives to minimize flooding
- Engineering Report and presentation will document findings



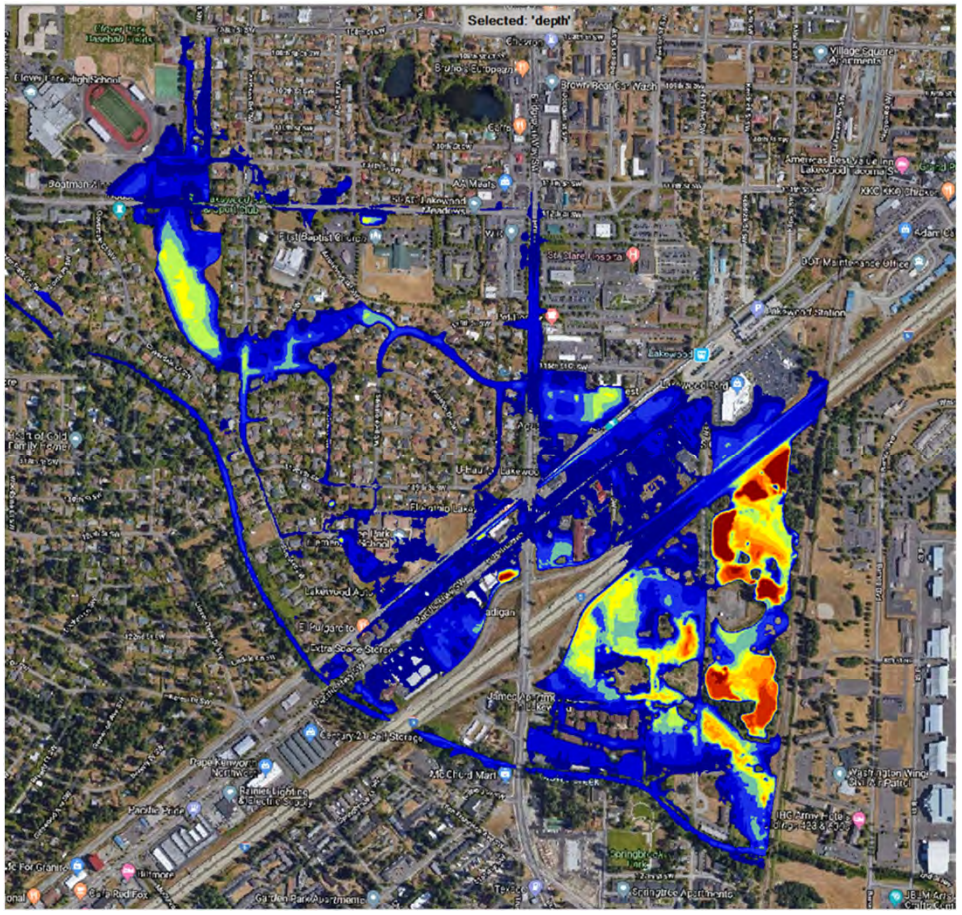
Area of primary Study

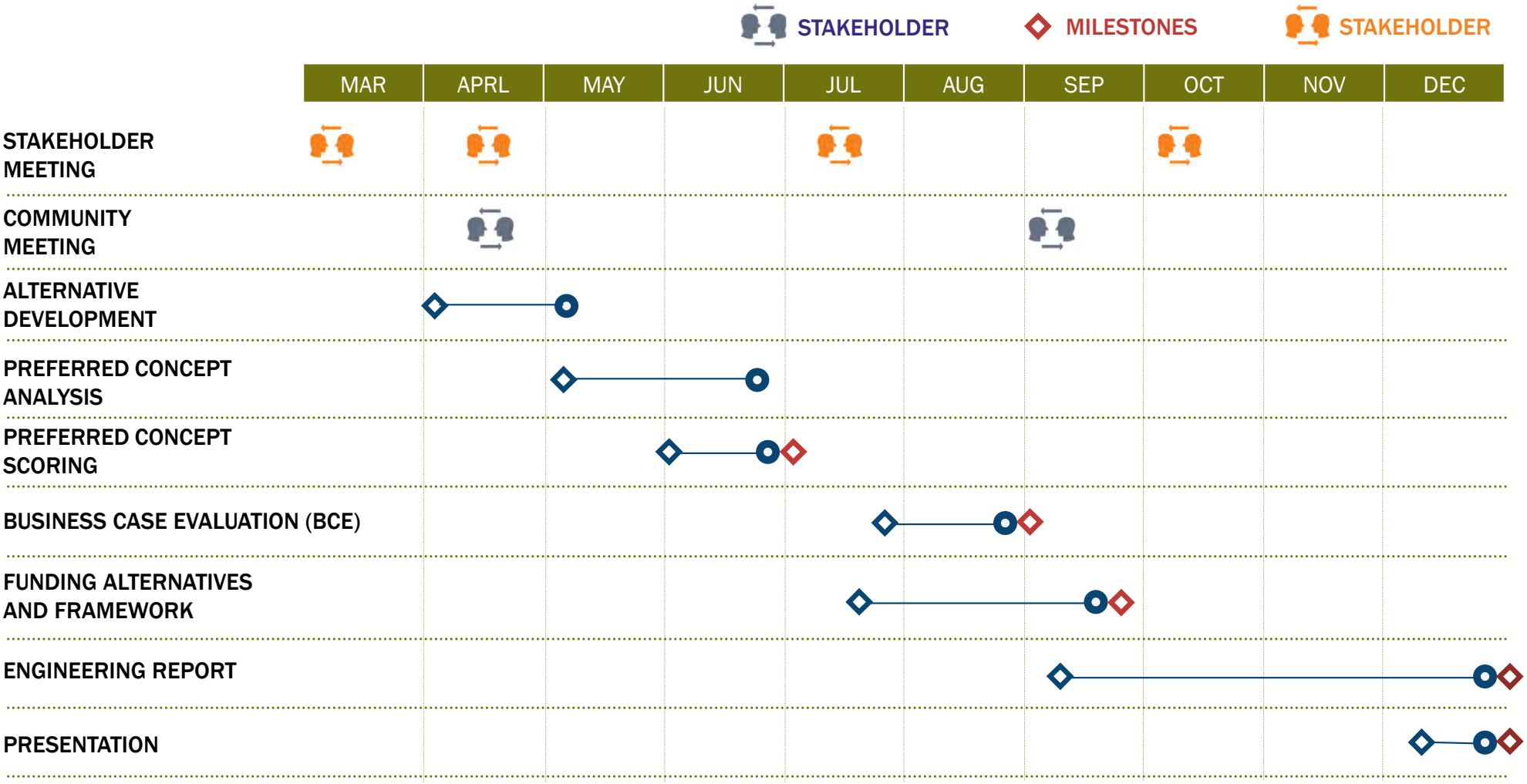
FLOOD MAPPING AND MODELING

- Clover Creek FEMA Mapping
  - Area where effective maps show 100-year flooding (Blue)
  - Area of 500-year flooding (Brown)
  - City has not observed significant flooding

FLOOD MAPPING AND MODELING

- Restudy 100-yr Event (2019)
  - Increased overbank flooding
  - Increased flooding over I-5
  - Floodway cannot be confined to channel
  - Increased 100-Year flooding on west side of 1-5

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COMMUNITY MEETING
ALTERNATIVE DEVELOPMENT
PREFERRED CONCEPT ANALYSIS
PREFERRED CONCEPT SCORING
BUSINESS CASE EVALUATION (BCE)
FUNDING ALTERNATIVES AND FRAMEWORK
ENGINEERING REPORT
PRESENTATION

CURRENT OPTIONS

- Potential flood reduction strategies
  - Do nothing
  - Levee or set back levee
  - Stream enhancement
  - Alternative conveyance
  - Upstream/upland improvements

QUESTIONS

- Poster viewing
- 3 X 5 cards available for questions

- Pbucich@cityoflakewood.us
- Wott@cityoflakewood.us

NEXT STEPS

- Stakeholder's meetings (regulatory agency staff & critical partners)
- Individual one-on-one discussions
- Next community meeting will be held in September
- Analysis wrapped up in late Fall
- Analysis presented to City Council in January 2023

Thank you.

Paul Bucich
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Weston Ott
wott@cityoflakewood.us

Appendix L: Community Meeting 2 Presentation

Clover Creek
FLOOD MITIGATION STUDY

Community Engagement | November 10, 2022

Agenda

1. Introductions
2. Present meeting purpose and agenda
3. Review previous meeting information
4. Share alternative development/evaluation
5. Discuss model results and best alternative
6. Poster viewing and Q & A

Introductions

City Staff:

- Paul Bucich, Public Works Engineering Director
- Weston Ott, Engineering Services Manager
- Brynn Grimley: Communications Manager

Consultant Staff:

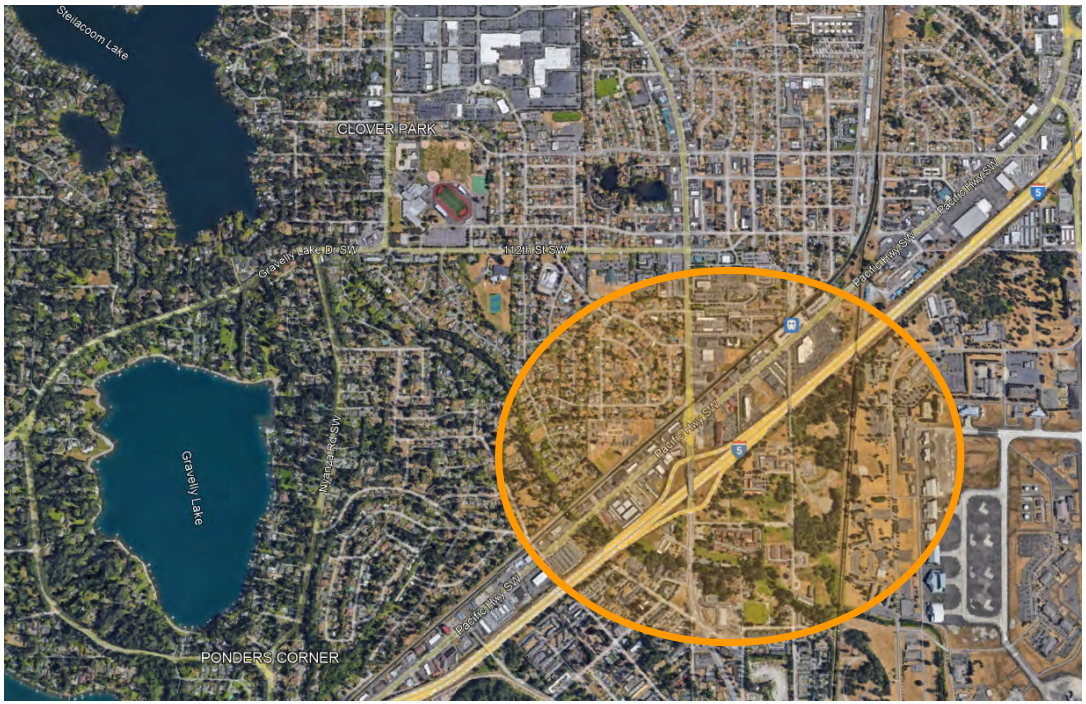
- Ryan Retzlaff, Brown and Caldwell

Community Meeting Purpose

- Introduce the project, project team, and purpose of this meeting
- Share an overview of the project, timeline, and milestones
- Share the problem the study will address
- Share potential alternative solutions
- Share process of alternative solution evaluation
- Provide an opportunity for Community feedback

Project Overview

- Recent flood modeling revealed greater floodplain than current FEMA mapping indicates
- New flood modeling highlights a multitude of issues potentially affecting the community
- This project will explore alternatives to minimize flooding
- Engineering Report and presentation will document findings



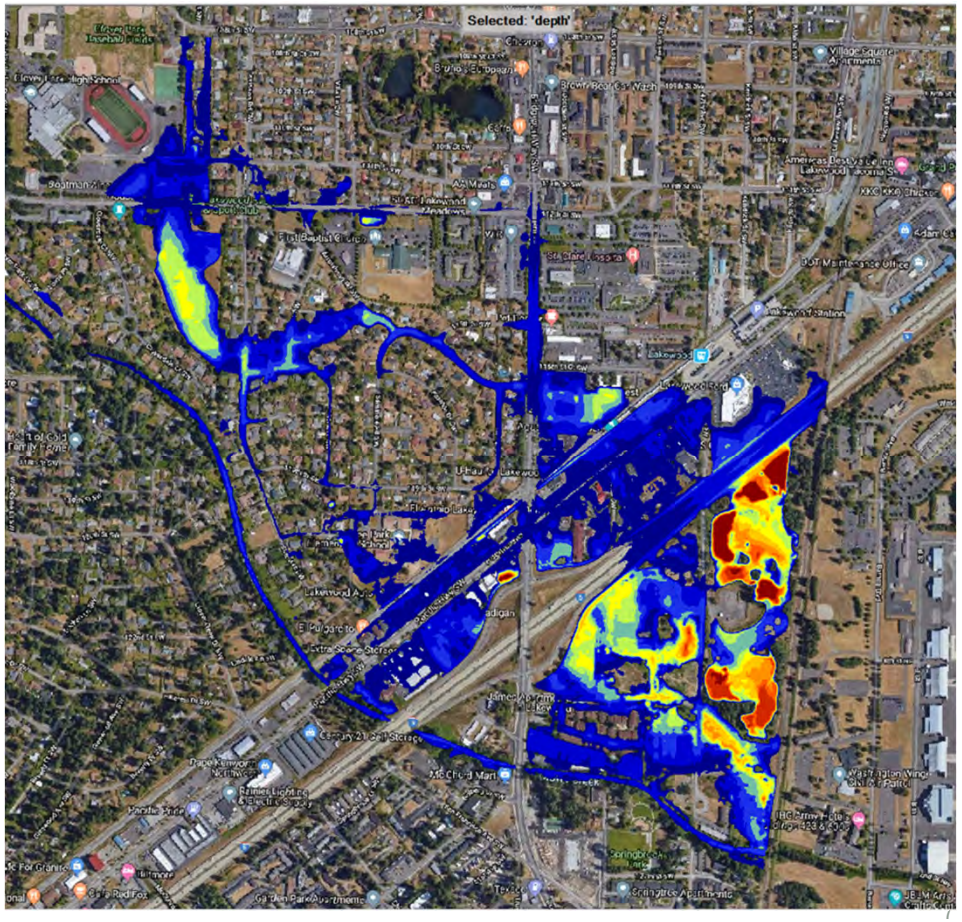
Potentially Impacted Area of Study

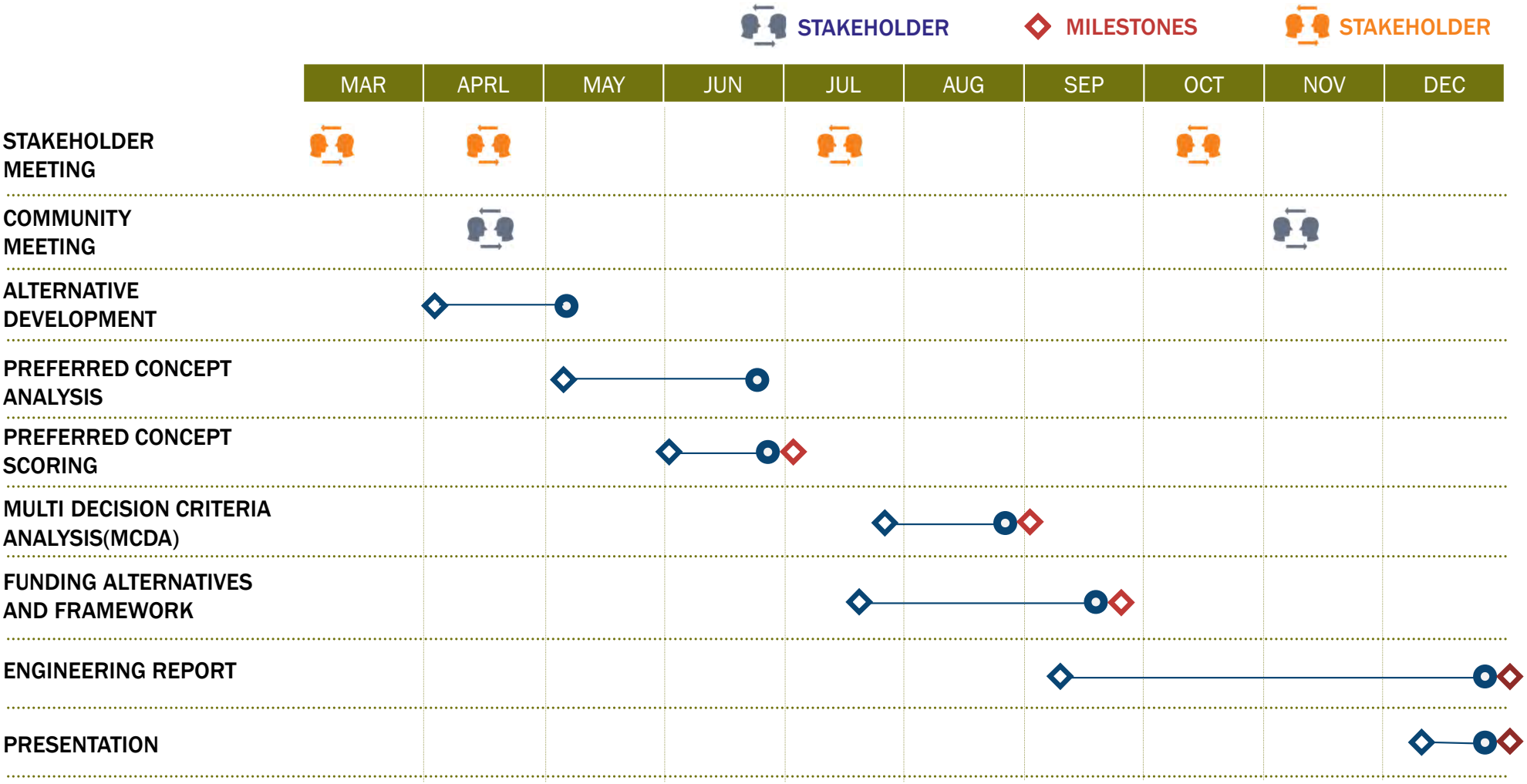
Flood Plain Mapping and Modeling

- Previous Clover Creek FEMA Mapping
  - Area where effective maps show 100-year flooding (Blue)
  - Area of 500-year flooding (Brown)
  - City has not yet observed significant flooding

Flood Plain Mapping and Modeling

- Review and Update 100-yr Storm Event (2019)
  - Increased overbank flooding
  - Increased flooding over I-5
  - Floodway is not confined to channel
  - Increased 100-Year flooding west of 1-5

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STAKEHOLDER MEETING
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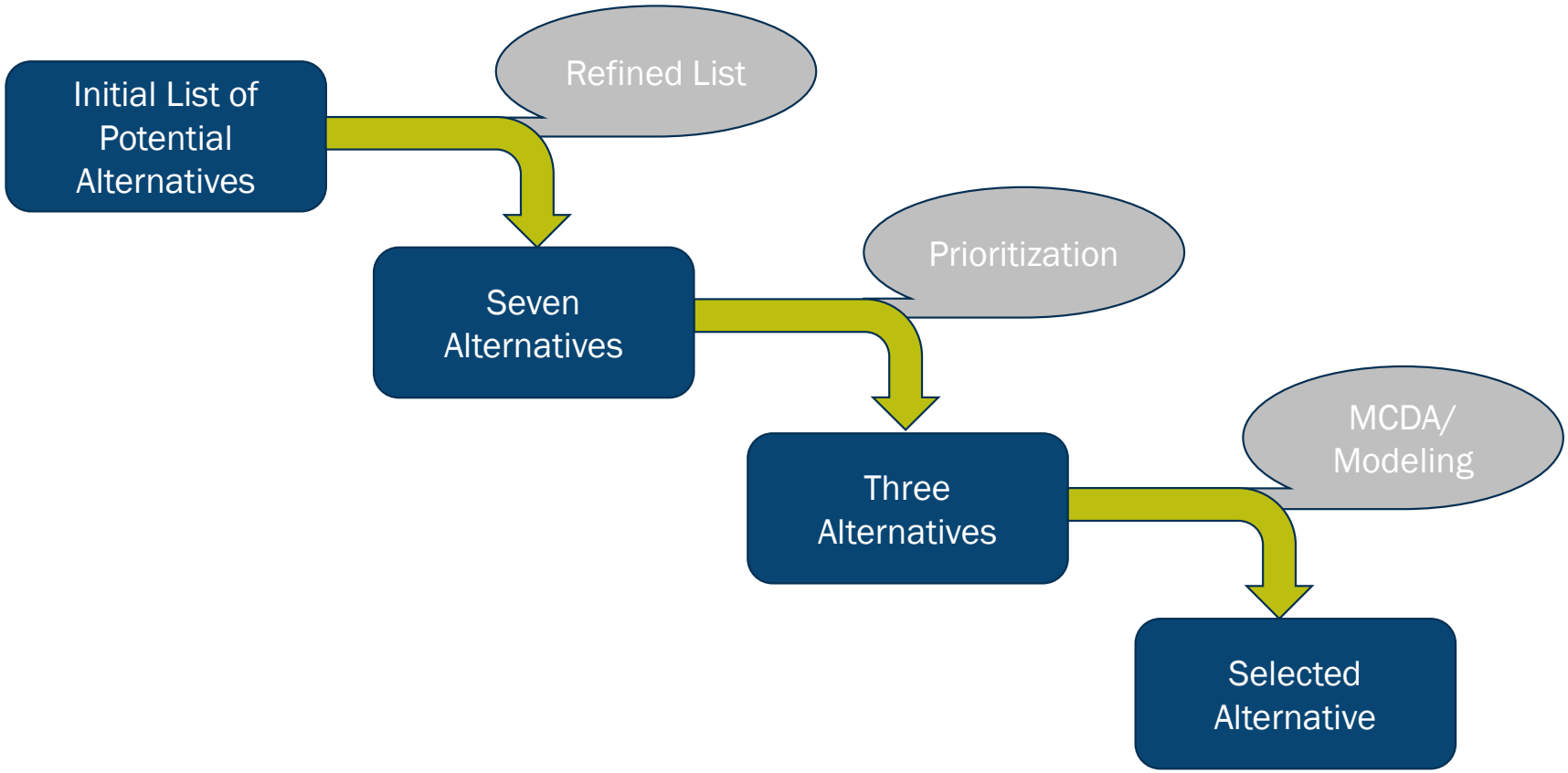
MULTI DECISION CRITERIA ANALYSIS(MCDA)
FUNDING ALTERNATIVES AND FRAMEWORK
ENGINEERING REPORT
PRESENTATION


Initial List of Potential Alternatives
Refined List
Seven Alternatives
Prioritization
Three Alternatives
MCDA/ Modeling
Selected Alternative

Flood Mitigation Alternatives

Five major alternative categories identified

1. Do Nothing
2. Levee or Blocking Flooding
3. Storage
4. Watershed or Creek Enhancement
5. Capacity Improvements

- Initial list of alternatives included roughly 17 unique alternatives
- The list was refined through high level evaluation

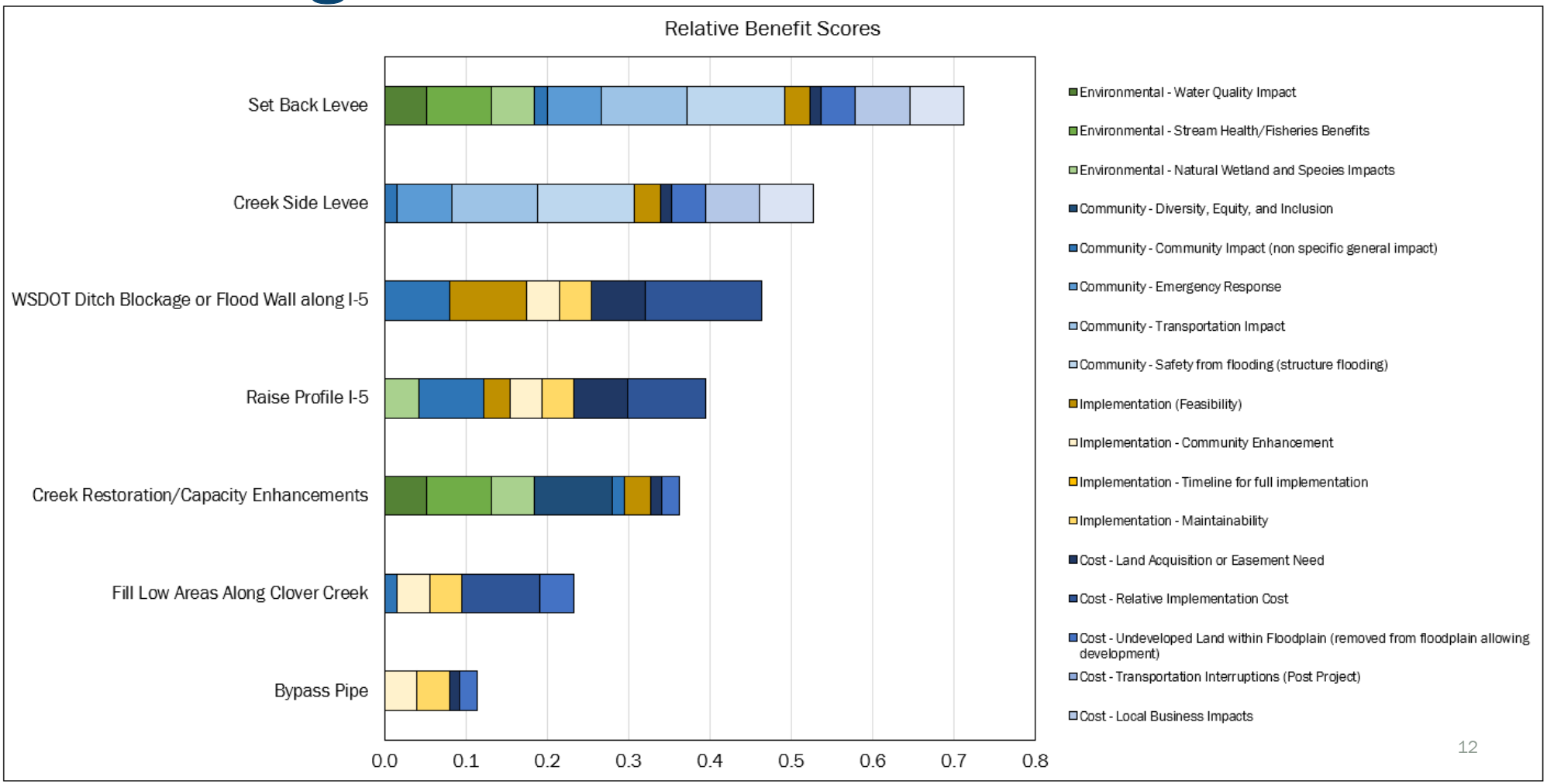
Flood Mitigation Alternatives

Seven alternatives include the following:

1. Set Back Levee
2. Bypass Pipe
3. WSDOT Ditch Blockage or Flood Wall Along I-5
4. Raise Profile I-5
5. Creek Restoration/Capacity Enhancements
6. Fill Low Areas Along Clover Creek
7. Creek Side Levee

Seven alternatives were evaluated and scored, resulting in reduction to three most viable alternatives

Flood Mitigation Alternatives



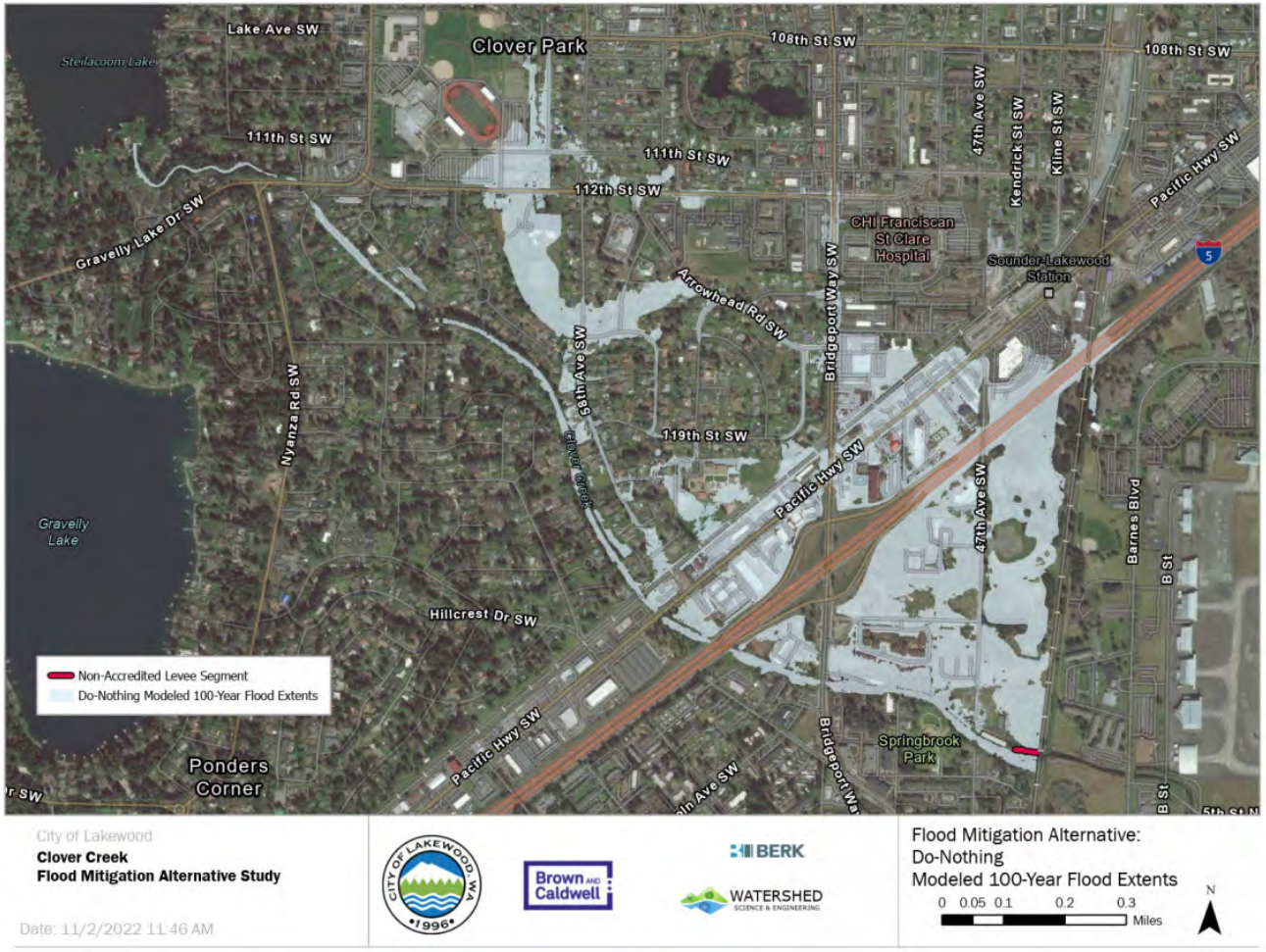
Flood Mitigation Alternatives

List of four alternatives include the following:

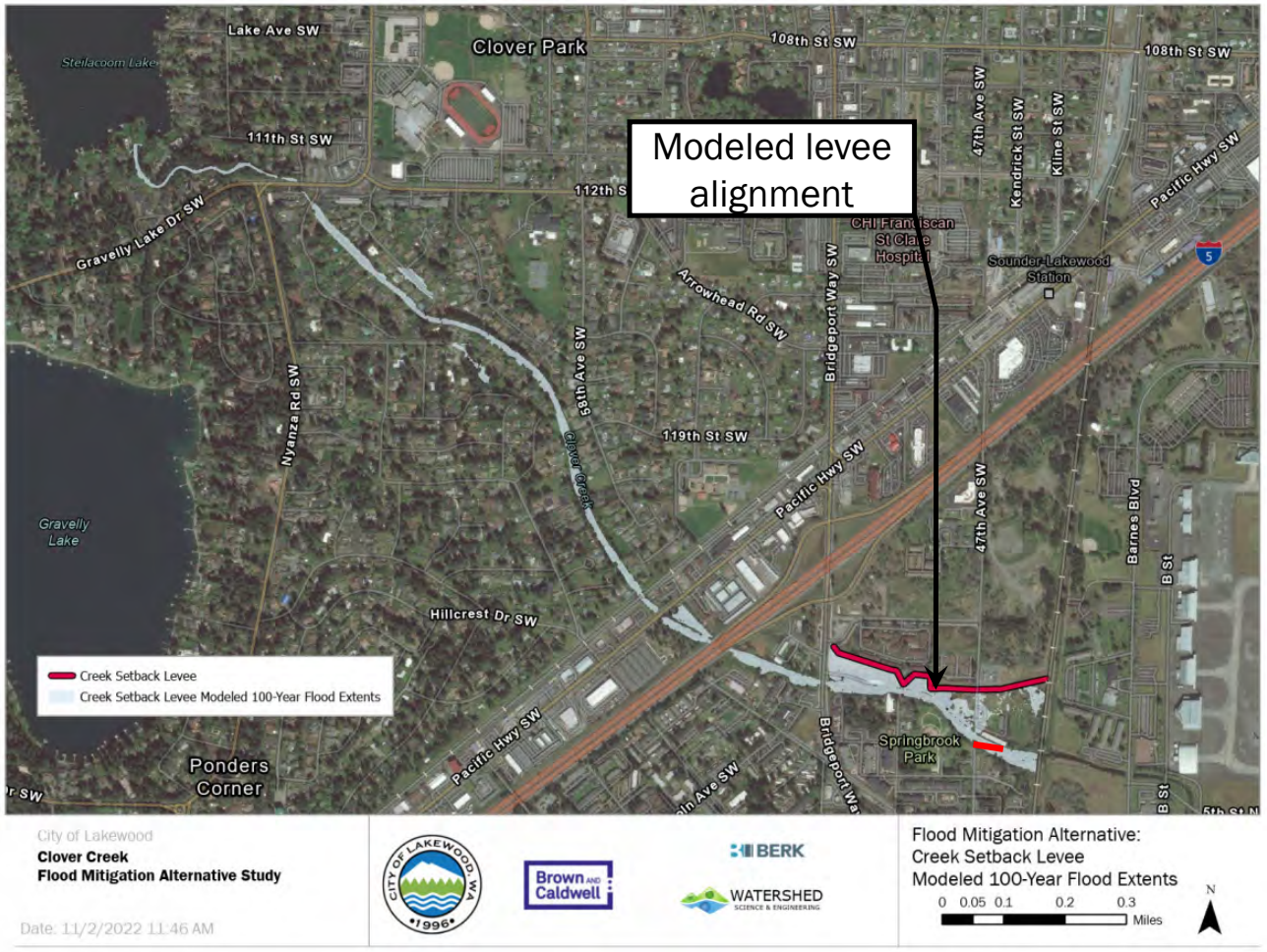
1. Do Nothing
2. Levee
3. I-5 Levee
4. Creek Restoration and Capacity Enhancements

Four Alternatives were evaluated further and scored to determine most economical and effective alternative for the City of Lakewood

Flood Mitigation Alternatives - Do Nothing



Flood Mitigation Alternatives - Levee



Flood Mitigation Alternatives – I-5 Levee

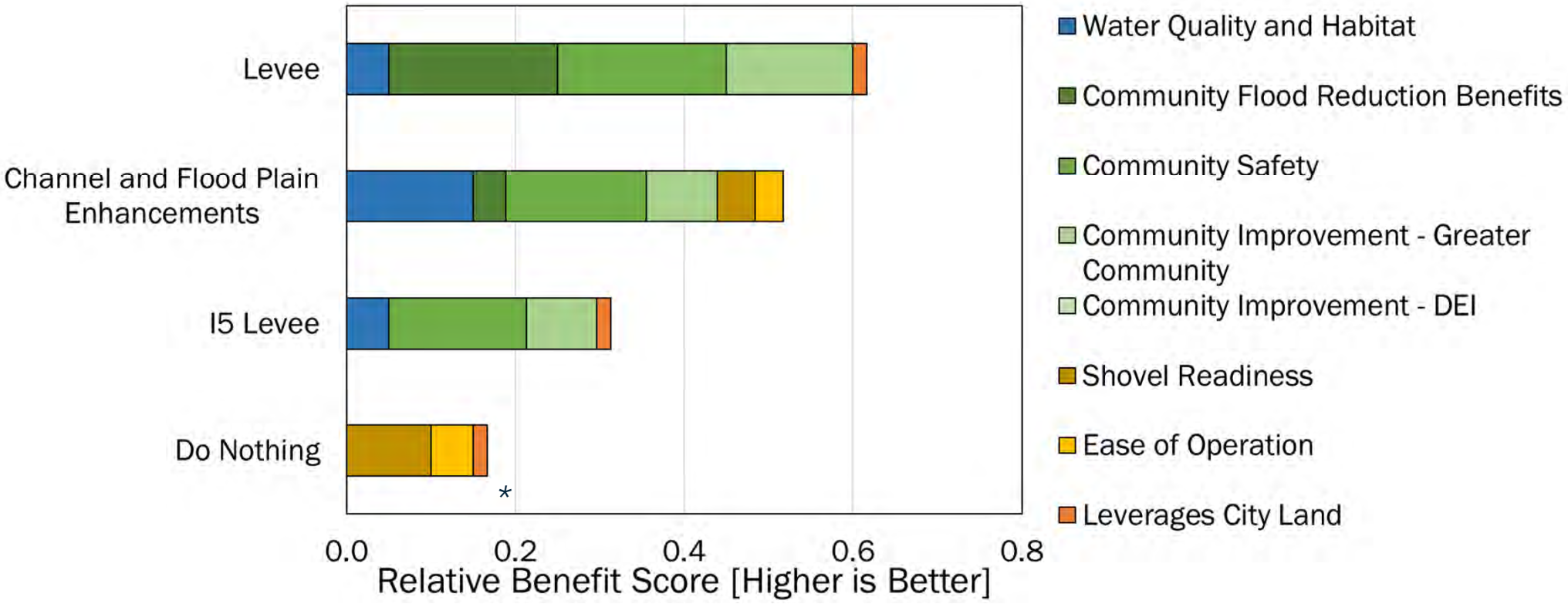
Flood Mitigation Alternative - Channel Enhancement

Flood Mitigation Alternatives

Key benefits associated with each alternative

Alternative	Water Quality and Habitat	Community Improvement - Greater Community	Community Flood Reduction Benefits	Community Safety	Community Improvement - DEI	Shovel Readiness	Ease of Operation	Leverages City Land
Do Nothing	None	None	None	None	Varies	High	High	Medium
Levee	Medium	High	High	High	Varies	Low	Low	Medium
I5 Levee	Medium	Medium	Medium	Medium	Varies	Low	Low	Medium
Channel and Flood Plain Enhancements	High	Medium	Medium	Medium	Varies	Medium	Medium	Low

Flood Mitigation Alternatives



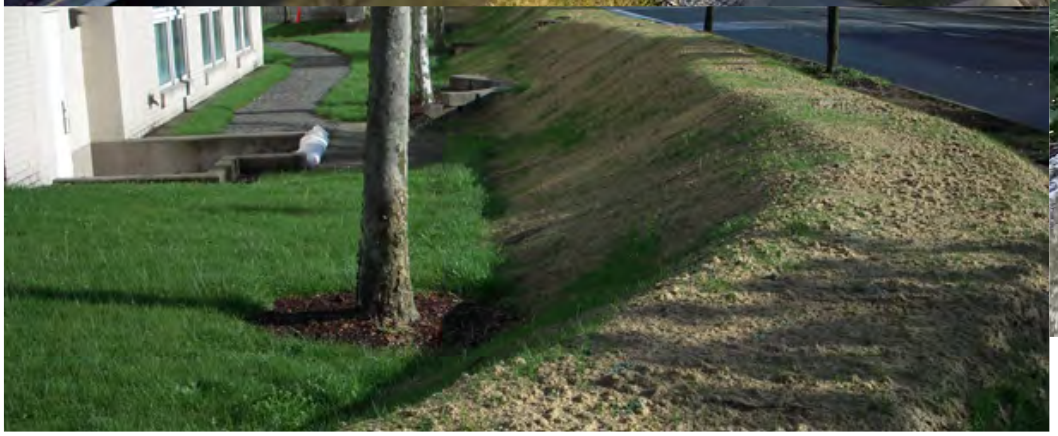
** Benefits associated with do nothing come from not having to do anything*

Alternative Costs

Estimated Cost of 100-Yr Flood	
Do Nothing	$119,384,000
Levee Alternative	$2,800,000
I5 Levee Alternative	$33,400,000
Channel Enhancement Alternative	$33,400,000

Estimated Alternative Cost	
Levee Alternative	$20,615,000
I5 Levee Alternative	$18,220,000
Channel Enhancement Alternative	$21,624,000

Levee and Flood Wall Examples



Next Steps

- Community input on alternatives
- Craft final Engineering Report on Alternatives with strategy for funding
- Present to City Council in early 2023
  - Present recommended alternative
  - Pursue partnerships on recommended alternative
  - Pursue next phase of engineering work and funding
- Initiate next phase of engineering in support of environmental work and funding needs.

Questions

- Poster viewing
- 3 X 5 cards available for questions

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Thank you

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