Participant Package

Flood Mitigation Engagement Sessions

October – November 2016

Help build Calgary's resiliency to flooding

Since the 2013 floods, The City of Calgary has placed considerable attention on flood resiliency and mitigation. Building flood resiliency takes the whole community working together. A key piece of The City's work is engaging with citizens to gather input and perspectives on potential flood mitigation measures.

This Participant Package contains background information to add to your perspective on the social, environmental and economic impacts of flood mitigation measures.

This public input will inform recommendations that will be put forward to Council in early 2017. These recommendations will detail the best mitigation measures for Calgary to pursue, based on technical data, citizen perspectives and environmental, social and economic factors.

How Calgary has recovered since 2013

Since the 2013 flood, The City of Calgary has committed over $150 million for various flood mitigation and resilience projects throughout Calgary. Mitigation work that is already complete or is ongoing now has reduced Calgary's exposure to flood damage by about 30 per cent compared to 2013.

City teams have also conducted studies to better understand our waterways, the extent of our flood risk, and changes to the rivers after the 2013 flood. All of this work is vital to building long-term resilience throughout Calgary.

River floods affect us all

Calgary was established at the confluence of the Bow and the Elbow Rivers. As such, the city is vulnerable to river flooding. Historic communities, a diverse population and much of the commercial downtown reside within the floodplain. The impacts of floods, such as in 2013, can be devastating.

Reducing potential flood damage

Calgary's potential exposure to flood damage is over one hundred million dollars per year. The City takes this risk seriously, and considers all mitigation measures that could help protect communities. We want to make decisions about mitigation that will be effective and adaptable into the future, consider the entire watershed, and will not become tomorrow's problems.

A long list of flood mitigation options was previously assessed for feasibility and cost effectiveness. Several options were removed from the list including a tunnel to divert water from the Elbow River to the Bow River in south Calgary and dredging of the Glenmore Reservoir, which were both found to be unfeasible.

After the initial assessment, feasible options for Calgary include reservoirs, flood barriers, and policy and land use regulation. These options can be combined in many ways, and The City is assessing several combinations or scenarios for cost effectiveness and social/environmental impact. We are seeking public input on these measures, as described in the following pages.

Mission Bridge, 1923 flood. Glenbow Library Archives NA-2365-26

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Flooding in Calgary

The purpose of this engagement project is to talk primarily about river flooding. In Calgary, river floods are most likely to happen between May and July. This is when snowmelt in the mountains and the chance of heavy precipitation are both at their peak. However, floods can happen any time of year, and in winter, floods can happen when blocks of river ice pile up and block flow.

Stormwater flooding can also occur with heavy rains within Calgary. Stormwater systems are designed to convey runoff on streets during large rainfall events to reduce flooding of buildings and basements. Water may backup into streets or basements due to overwhelmed drainage systems, improper grading, or rising groundwater.

The City is pursuing drainage improvements across Calgary, particularly in older communities, that were designed without the benefit of modern data and techniques, simultaneous to river flood mitigation work.

Flooding and nature

River flooding is a natural process that benefits the floodplain environment. It brings water and nutrients to vegetation growing near the river and regenerates the ecosystem for new trees and shrubs to grow.

Rivers naturally move and change course over time. During high flows, the power of the river can carve new channels, changing its course, or deposit gravels, creating gravel bars that will change the river's pattern of flow.

These natural processes benefit the river valley, and are part of a healthy river system. In urban environments, both the river and development must be wisely managed to reduce flood-people conflict, while acknowledging and giving room to the river to allow for natural processes wherever possible.

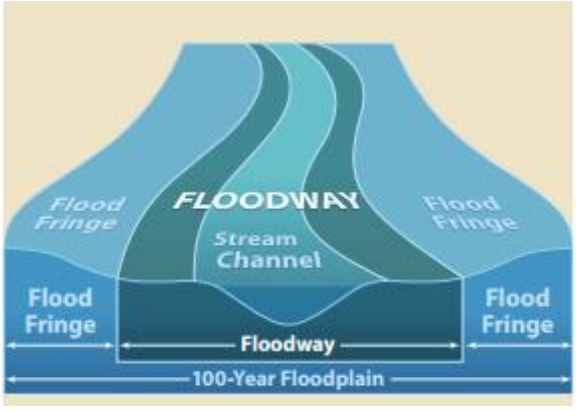
Flood Zones

In 1983 (with updates in 1996), the Province created maps showing the Flood Hazard Area (FHA) in Calgary. The FHA was divided into three zones:

Floodway – the river channel and some areas just out of the channel, where the flood water is deepest and fastest. Most of the flood water flows through the floodway.

Flood Fringe – areas along the river that flood, but where the water is not as deep or as fast as in the floodway.

Overland Flow Zone – Areas where water leaves the river channel, flows over land through streets or communities, and eventually flows back into the river somewhere downstream.



The provincial flood hazard map is the basis of the flood policy and zones in Calgary's Land Use Bylaw. Development and flood proofing regulations are based on these three zones. The Province is currently updating the flood hazard maps, with expected completion in 2017.

River flows and the 2013 flood

Floods are often described by how often they are statistically expected to happen. Smaller floods happen more frequently. Larger floods are rare. For example: the "one in one-hundred year flood" is a large flood that has a 1 per cent chance of occurring in any year. A "one in ten year flood" is smaller, and has a 10 per cent chance of occurring in any year.

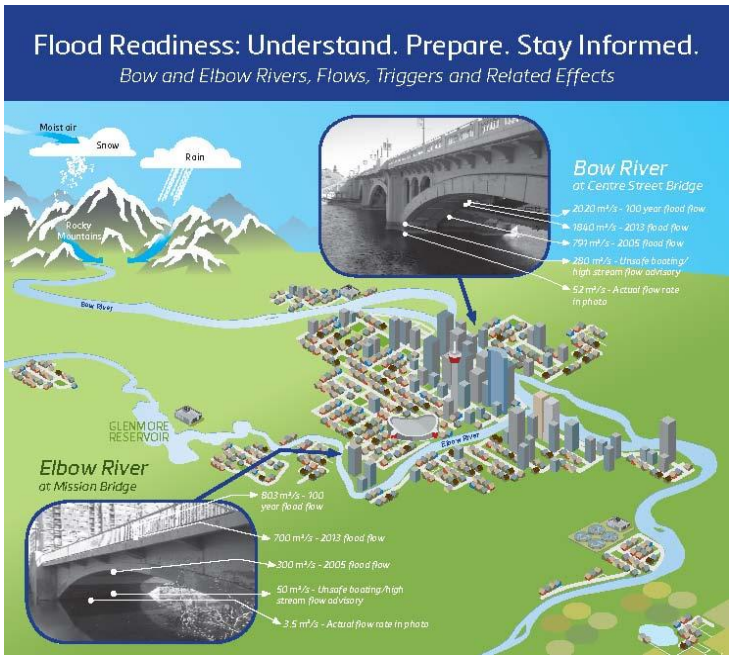
These names can be misleading – a one in one hundred year (1:100 year) flood could occur more than once in 100 years, and it is even possible for it to occur more than once in a year. Similarly, a 1:50 year flood has a 2 per cent chance of occurring in any year, and a 1:200 year flood has a 0.5 per cent chance of occurring in any year. These terms are associated with specific flow rates, and the 1:100 year flood flow rate on the Elbow River is different than the 1:100 year flood flow rate on the Bow River.

The size of a flood can be described in several ways. One way is the flow rate. River flow is measured in cubic metres per second (m^3/s or cms). Typical high spring flows in Calgary are:

- Elbow River: 30 m^3/s
- Bow River: 100 m^3/s

In 2013, the highest flows on the rivers through Calgary were:

- Elbow River: ~700 m^3/s (downstream of Glenmore Dam)
- Bow River: ~1840 m^3/s (upstream of the confluence with the Elbow River)



Understanding flood risk in Calgary

Since 2013, The City has been working hard to better understand the flow on our rivers, and how our rivers change. The Expert Management Panel on Flood Resiliency, organized by The City following the 2013 flood, included several recommendations around understanding flood risk, and it is one of The City's core strategies for building resiliency.

The flood risk in Calgary depends on:

- The flow rates we can expect on our rivers during future floods.
- The amount and type of development within the floodplain.

Historically, the damage caused by flooding did not outweigh the benefits of developing in the floodplain. However, the amount and type of development within the floodplain has changed. Today, there is a significant amount of property and infrastructure within the Bow and Elbow floodplains, including much of the downtown core.

As recommended by The Expert Management Panel on Flood Resilience, The City has undertaken several studies to better understand our flood risk, including studies on river morphology, permanent barriers, and groundwater. Understanding the amount and type of damage floods cause, we can assess what mitigation measures best address the flood risk for Calgary.

The Flood Mitigation Measures Assessment

The Flood Mitigation Measures Assessment project is being completed in three phases. During the first phase The City updated flood damage models created by the Province to include the most up-to-date technical information as well as social and environmental factors of a triple bottom line analysis, which was not included in the Province's 2014 Flood Damage Assessment Study.

The damage was added up for all potential floods that could happen over 100 years. On average, if you paid out the flood damages evenly as yearly payments, floods cost Calgary about $170 Million per year ("average annual damage"). This is the total exposure to flooding if no mitigation existed (that is if none of the mitigation done since 2013 was in place).

The second phase is underway. It includes the assessment of costs and benefits of mitigation measures. The City is working with citizens, community groups, consultants and the Province to develop and analyze all upstream, local, and policy measures, taking into account community needs and levels of protection, to determine the most feasible approach to long-term mitigation. Many mitigation measures will change the way our communities and rivers look, feel and behave. The third phase, to be completed in 2017, will be to finalize recommendations to Council.

Current flood mitigation

Calgary has many flood mitigation projects already in place to reduce damages when flooding happens. The Glenmore Reservoir can be operated to mitigate flood impacts, and some flood barriers existed along the Bow and Elbow before the 2013 flood. Since 2013, the gates at the Glenmore dam are being raised and several barriers have been built. The City has also repaired and strengthened the river banks at 37 sites eroded in 2013, rebuilt 72km of pathways, 3 pedestrian bridges and hundreds of sinkholes and conducted a river debris removal program. Hundreds of identified stormwater outfalls are continually being repaired and upgraded with gates to prevent river back-up into communities.

The City recently approved construction of several barriers at strategic locations throughout Calgary, including West Eau Claire, Heritage Drive, Bonnybrook Wastewater Treatment Plant and Centre Street Bridge, with funding support from the Government of Alberta. Once all this work is completed, the average annual damage that Calgary is exposed to from flooding will decrease to about $115 Million per year – about a 30 per cent decrease in potential damage.

The river flood mitigation projects completed or currently in progress are shown on the map on Page 7. The projects shown on this map only include river bank stabilizations and flood protection projects.

Flood mitigation jurisdictions

Some mitigation measures are fully within the jurisdiction of The City to implement, such as building barriers along our rivers.

Other measures are Provincial jurisdiction. The City continues to coordinate flood mitigation with the Government of Alberta, and we have worked together on several flood mitigation projects.

- The City is participating as a stakeholder on the design of the Province's Springbank Reservoir on the Elbow River.
- The Province and The City co-chair the Bow River Advisory Committee and participate in the Bow River Working Group, which are investigating the potential for new reservoirs on the Bow River upstream of Calgary.
- The Province has negotiated a 5-year agreement with TransAlta to operate the Ghost Reservoir upstream of Calgary for improved flood mitigation. It is the Government of Alberta's jurisdiction to manage this agreement.

The federal government also has a responsibility for flood mitigation. The City has been working with Public Safety Canada and Natural Resources Canada on flood risk, mapping and mitigation issues.

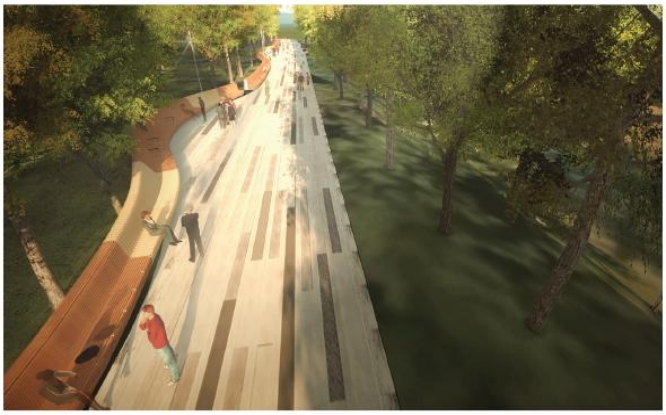
Additional tools to manage flood risk include disaster assistance payments and private overland flood insurance. Work is ongoing between all orders of government to understand the future role of these tools in combination with flood mitigation measures.

Next Steps

The technical studies and public engagement activities conclude at the end of November. The City will be reporting back to citizens and Council about what was heard through the public engagement program. The findings of the technical studies, citizen's input and a social/environmental analysis will be used to inform a final report to City Council with recommendations for flood mitigation, in early 2017.

To stay informed on flood resiliency and mitigation:

www.calgary.ca/floodinfo



Conceptual drawings for flood barrier at West Eau Claire

Glossary of flood terms

Design Flood – The size of flood that flood-related policies and structures are designed to protect against. In Alberta, flood-related policies, such as Calgary bylaws, are based on a 1:100 year flood.

Drought – Is a temporary or prolonged shortage of precipitation (either rainfall and/or snow) which may create low-water levels in surface waters.

Flood – A flood is an overflowing of water onto land that is normally dry. Floods can happen in Alberta during heavy rains, when snow melts too fast, or when dams or reservoirs break. Floods are the most common and widespread of all weather-related natural disasters.

- River flooding refers to flooding caused by the river exceeding its banks.

Flood mitigation – Includes policies or structures that reduce the risk of floods to a community, either by preventing floodwater from entering the community or by reducing the potential damages or threats to public safety when flooding does occur.

Flood barrier – Is an earthen embankment (known as a berm or a dyke), flood wall, or a temporary wall constructed of sand bags or other materials built to provide protection from floods.

Flood wall (or **floodwall**) – Is a primarily vertical artificial barrier designed to temporarily contain the waters of a river or other waterway, which may rise to unusual levels during seasonal or extreme weather events.

Flood hazard mapping – Flood hazard mapping shows flood hazard areas along streams and rivers.

Flood Hazard Area – In Alberta, the flood hazard area is the area that would be flooded in a 1:100 year flood. It is typically divided into two zones: floodway and flood fringe. In some areas, such as Calgary, there may also be a third zone, called the overland flow zone, which is considered a special part of the flood fringe.

Floodway – The floodway includes the channel of a river and, in some places, the land next to the river. The floodway carries the bulk of the floodwater downstream. Flow is usually fastest and deepest in the floodway.

Floodplain - The area next to a river which can flood when river flows are high.

Flood fringe – The area outside of the floodway that is flooded in a 1:100 year event, but where flows are not as deep or fast as in the floodway.

Groundwater – is the water found underground in the cracks and spaces in soil, sand and rock. It is stored in and moves slowly through geologic formations of soil, sand and rocks called aquifers. Groundwater can rise and contribute to flooding.

Inundation – flooding.

Mitigation measures – Structural measures keep river flood water out of communities to a specified water level, reduce property damage and increase public safety. Examples of physical structures are dams and reservoirs, as well as barriers.

- **Upstream physical measures** such as dams and reservoirs are built to control or slow the flow of the river to reduce the risk of flooding to a community as a whole.
- **Local physical barriers**, such as dykes and barriers are placed where the river banks need to be raised to prevent flooding at specific locations and providing protection to specific communities/areas.

Non-structural measures – Are mitigation measures based in knowledge, practice, or agreement to reduce risk and improve resiliency. These measures include policies, land use planning, development regulations, emergency response and public training and awareness.

1 in 100 year flood – A flood that has a one per cent chance of occurring (or being exceeded) in any given year. It can also be called a 1 per cent-flood, a 100-year flood, and is often written as “1:100 year flood”. Although called a “1 in 100 year flood” there will not necessarily be one every 100 years. It is even possible to have more than one 1 in 100 year flood in the same year.

Overland Flow Zone – Part of the flood hazard area outside of the floodway, where in a flood water leaves the river channel, flows overland and then flows back into the channel somewhere downstream. Overland flow zones are considered special areas of the flood fringe.

Reservoir - Is a storage place for water created by construction of a dam in a river valley, and from which the water may be withdrawn for such purposes as irrigation, power generation or water supply.

Residual risk – The risk that remains after efforts have been made to reduce or eliminate the hazard.

Resiliency – The capacity of any entity – an individual, a community, an organization or a natural system – to prepare for disruptions, to recover from shocks and stresses and to adapt and grow from a disruptive experience." (Judith Rodin, President, the Rockefeller Foundation)

Riparian – Transition zones between the water and land. Riparian zones play an important role in protecting the river; they prevent excessive erosion, act as natural floodplains, provide river bank stabilization and also offer aesthetic, economic and recreational benefits.

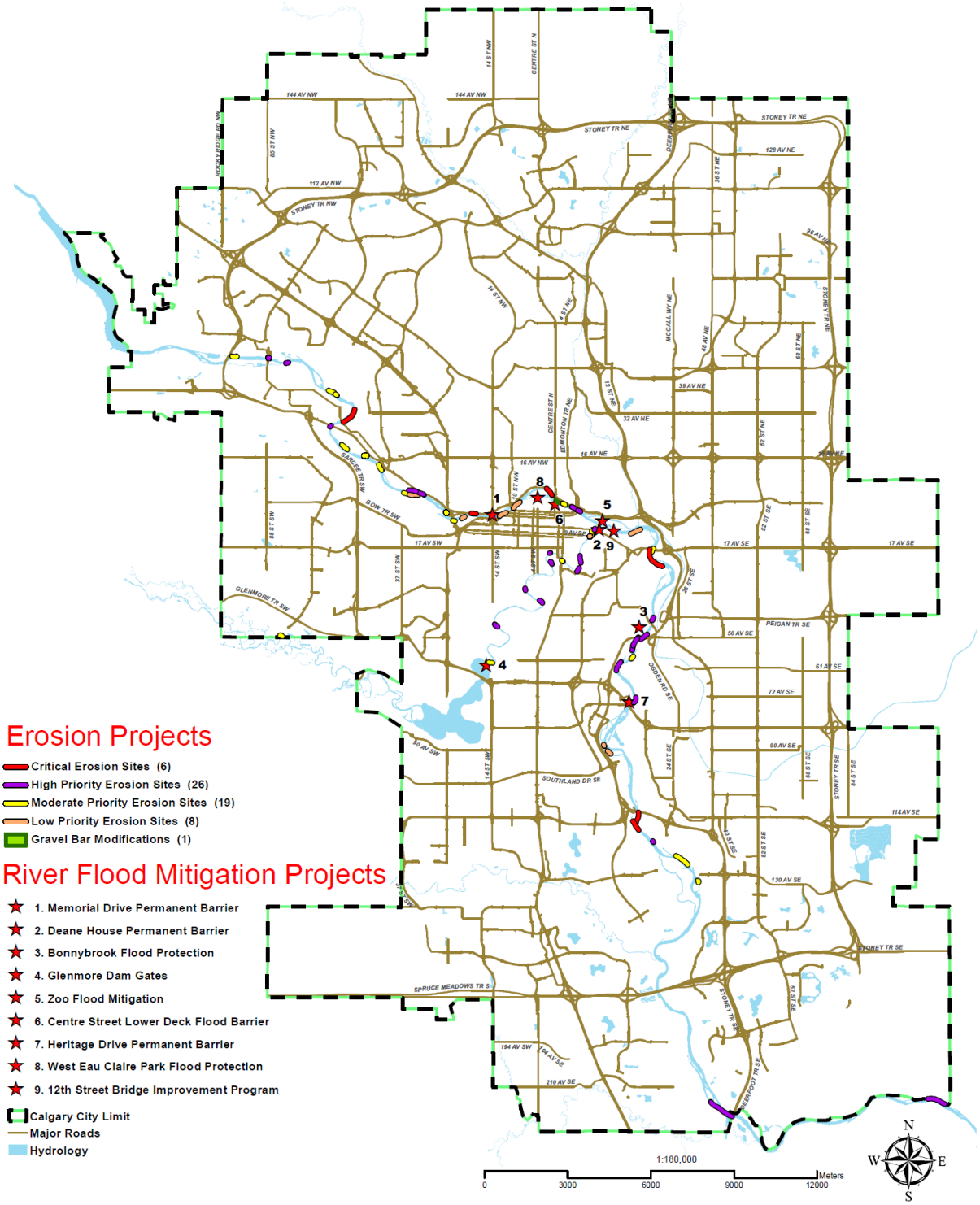
Stormwater – Stormwater is the water from rainstorms or melting snow that goes into the storm drains in the road through an underground pipe system to the river. The stormwater system includes storm drains, overland and underground systems, ponds, outfalls, and low impact development.

Triple Bottom Line - Is an approach that considers economic, social, and environmental implications in the decision making process. Triple Bottom Line is common in both the public and private sector. It is a departure from making decisions based solely on the financial bottom-line and reflects a greater awareness of the impacts of our decisions on the environment, society and the external economy.

Upstream – Toward or in the higher part of a stream. For example, a reservoir to mitigate river flows would be built upstream of Calgary on the Bow or Elbow Rivers.

Watershed – The entire land area or region that catches precipitation and drains into a region, river system or other bodies of water. Calgary gets its water from both the Elbow River and Bow River watersheds.

Calgary's River Flood Mitigation Projects to Date



Conceptual Mitigation Measures for Discussion

City teams have conducted a number of technical studies to better understand our waterways, the extent of our flood risk, and changes to the Bow and Elbow rivers after the 2013 flood. As part of this work we are conducting public engagement on four mitigation concepts as part of the Flood Mitigation Measures Assessment project. This input will inform the final mitigation recommendations that will presented to City Council in 2017.

The mitigation concepts presented here are ***preliminary concepts for discussion and feedback*** during The City's public engagement process. The City and its consultants, through the technical analysis of the Flood Mitigation Measures Assessment project, developed these concepts based on community needs, levels of protection, and the feasibility of mitigation measures.

These concepts for public discussion include a variety of upstream and local infrastructure, operational strategies, land use regulation and building policy to manage flood risk on the Bow and Elbow Rivers.

There are four concepts presented for public discussion, including:

1. Springbank Off-Stream Reservoir (SR1) on the Elbow River and a new reservoir on the Bow River
2. Barriers along the Bow and Elbow Rivers
3. Springbank Off-Stream Reservoir (SR1) on the Elbow River, and barriers on the Bow River
4. Non-Structural measures – examining policy measures to address flood risk

Our analyses of these concepts are ongoing, and neither The City nor other orders of government have committed to them. To enable assessment of these concepts, significant background work has been done to assess the cost, benefit and basic lay-out, for various levels of protection. However, detailed design work has not started on the concepts, nor has funding been put in place, with the exception of the Springbank Off-Stream Reservoir and the barriers mentioned previously and included on the map of projects to date.

The barrier examples in Concepts 2 and 3 provide an idea of the look and feel of designs that would be necessary in typical locations along the Bow and Elbow Rivers. The barrier maps for Concepts 2 and 3 show ***estimates only*** of all possible locations where barriers would be needed to mitigate flooding. Not all barriers are cost-effective on their own, and not all may be feasible.

While The City has analyzed barrier designs at several protection levels, the maps show the barriers that would be necessary to fully mitigate a 1:200 year flood. This level was selected to provide consistency across mitigation concepts presented and to explore the feasibility of protecting to a higher level than the historical 1:100 year standard. If any barriers are pursued, further refinement of barrier design, protection level, locations, features and costs would occur and would include further public engagement.

The idea of a new reservoir on the Bow River upstream of Calgary is in the conceptual stage with the Bow River Working Group. No commitment, location, funding or design work for this idea has been confirmed by the Government of Alberta.

After three years of on-the-ground flood repair and mitigation work, and study of our dynamic urban river system, we have a lot of information to share. The City is committed to moving forward with flood mitigation. At this time, we are reaching out to citizens to gather perspectives on what you like and don't like about each of the mitigation concepts. What we hear back will help us design solutions that build a flood-resilient Calgary that its citizens feel proud of.

The City takes citizen voices seriously, and is accountable to incorporate citizens' perspectives into decisions. The information presented in this package and discussed during engagement sessions is for the purpose of informing and improving decisions. Presentation of these concepts does not guarantee commitment by The City to any one of these mitigation concepts, or to any specific locations.

Concept 1: Springbank Off-Stream Reservoir (SR1) on the Elbow River and a new reservoir on the Bow River

Background

On March 3, 2015, the Government of Alberta confirmed it would proceed with the development of a dry-storage reservoir at Springbank. The project site is located just west of Calgary approximately 18.5 km upstream of the Glenmore Reservoir. This project, in combination with operation of new gates on The Glenmore Dam would be able to mitigate damage caused on the Elbow River by a flood event similar to 2013. The Springbank Reservoir is currently undergoing a federal Environment Impact Assessment.

The City is participating on the Government of Alberta's Bow River Working Group, which is exploring flood mitigation opportunities upstream on the Bow River. One of the ideas being investigated is building a new reservoir on the Bow River upstream of Calgary to mitigate flooding in Calgary and other communities. This idea is at the conceptual stage. No commitment, location, funding or design work for this idea has been confirmed by the Government of Alberta.

An overview map of the structures is provided on Page 12.

Concept 1 is presented in combination with:

- New Gates on Glenmore Dam
- Current TransAlta Operation of Ghost Dam (Provincial agreement)
- Emergency Preparedness and Response
- Stormwater Drainage Improvements
- Flood Forecasting

Cost summary

Costs are preliminary estimates. The following numbers include benefits, capital and operating costs over a 100 year period.

- Cost: $1.9 billion
- Benefits: $2.6 billion
- Benefit-cost ratio (=benefits/costs): 1.4
- Estimated remaining damages (average annual damage): $34 million per year

What does this concept achieve?

- Reservoirs are used to store water and control flow downstream of the dam.
- The Springbank Off-Stream Reservoir (SR1) is a "dry reservoir" that is usually a field, and only holds water during flood events. During a flood, some water is diverted from the Elbow River into SR1. The rest of the water in the Elbow River will flow downstream to Glenmore Reservoir. The water held in SR1 during the flood will be slowly released back into the Elbow River when the event has passed.
- Together, SR1 and the new gates at Glenmore Dam are intended to be able to store a 2013-sized event without overland flooding along the Elbow River downstream of Glenmore Dam.
- A new reservoir on the Bow River would likely be a "wet reservoir", which has water in it year-round. It would increase the water supply available during a drought, including for drinking water

and irrigation. Hydro-electric energy generation would be explored as an option. A new reservoir might also provide new recreational opportunities for the region.

- Reservoirs can provide some reduction in groundwater flooding during a river flood, by lowering river levels during the flood event.
- For floods smaller than the event the reservoir was designed for, communities downstream would not necessarily need to be evacuated.

What are the drawbacks of this concept?

- The decision to build dams and reservoirs is the responsibility of the Province.
- Dams and reservoirs can take a long time to approve and build.
- Dams and reservoirs require environmental impact assessments and technical feasibility assessments. Currently, SR1 is undergoing a provincial and federal level environmental assessment.
- The construction of the dams and reservoirs would have significant environmental impacts.
- The location and size of a new reservoir on the Bow River, if feasible, are yet to be determined.
- While a reservoir upstream on the Bow River would provide some protection to all communities along the Bow River, additional protection may be needed for some locations.
- The land needed to build dams and reservoirs requires the acquisition of land outside of The City of Calgary's boundaries.
- While rare, there is the risk that dams can fail, which could cause catastrophic flooding.
- Dams can hold a certain amount of water. For extreme events that bring more water than the dam can hold, water needs to be released from the reservoir. These events, which are larger than the reservoir is designed for, may result in flooding downstream but would be less than if the dam was not in place.

Concept 1 Map: Springbank Off-Stream Reservoir on the Elbow River and a new reservoir on the Bow River (feasibility and location currently undecided)

NOTE: The Government of Alberta confirmed its commitment to the Springbank Off-Stream Reservoir in March 2015. In combination with the operation of new gates on the Glenmore Dam, this project would mitigate damages caused by a flood similar to what was experienced on the Elbow River in 2013. The Bow River Working Group is currently investigating flood mitigation options on the Bow River, including the feasibility of a dam upstream of Calgary.

Concept 2: Barriers along the Bow and Elbow Rivers

Background

Infrastructure on both the Bow and Elbow rivers provides Calgary with some flood protection. The existing dams and permanent barriers were critical in allowing evacuation time and reducing some of the damage from the 2013 flood. The City also recently approved construction of several barriers at West Eau Claire, Heritage Drive, and Centre Street Bridge with funding support from the Government of Alberta.

The City has completed a Flood Protection Conceptual Design study to identify potential spill points where floodwaters would inundate communities and to identify the feasibility of preventing them with permanent barriers, such as berms or walls, at specific locations along the Bow and Elbow rivers.

Concept 2 illustrates how permanent barriers can prevent damage during flooding, and the examples of what barriers could look like. An overview map and illustrations of typical barriers are provided on the following pages. Note that the examples of types of barriers shown may not be feasible for all locations. Most of the barrier locations are conceptual and detailed design work has not been undertaken, with the exception of the barriers identified above. No commitment or funding for the other barriers shown has been confirmed.

An overview map is provided on Page 15.

Concept 2 is presented in combination with:

- New Gates on Glenmore Dam
- Current TransAlta Operation of Ghost Dam (Provincial agreement)
- Emergency Preparedness and Response
- Stormwater Drainage Improvements
- Flood Forecasting

Costs summary

This calculation includes benefits, capital and operating costs over a 100 year period.

- Cost: $ 1.8 billion
- Benefits: $1.9 billion
- Benefit-cost ratio (= benefits/costs): 1.1
- Estimated remaining damages (average annual damage): $57 million per year

What does this concept achieve?

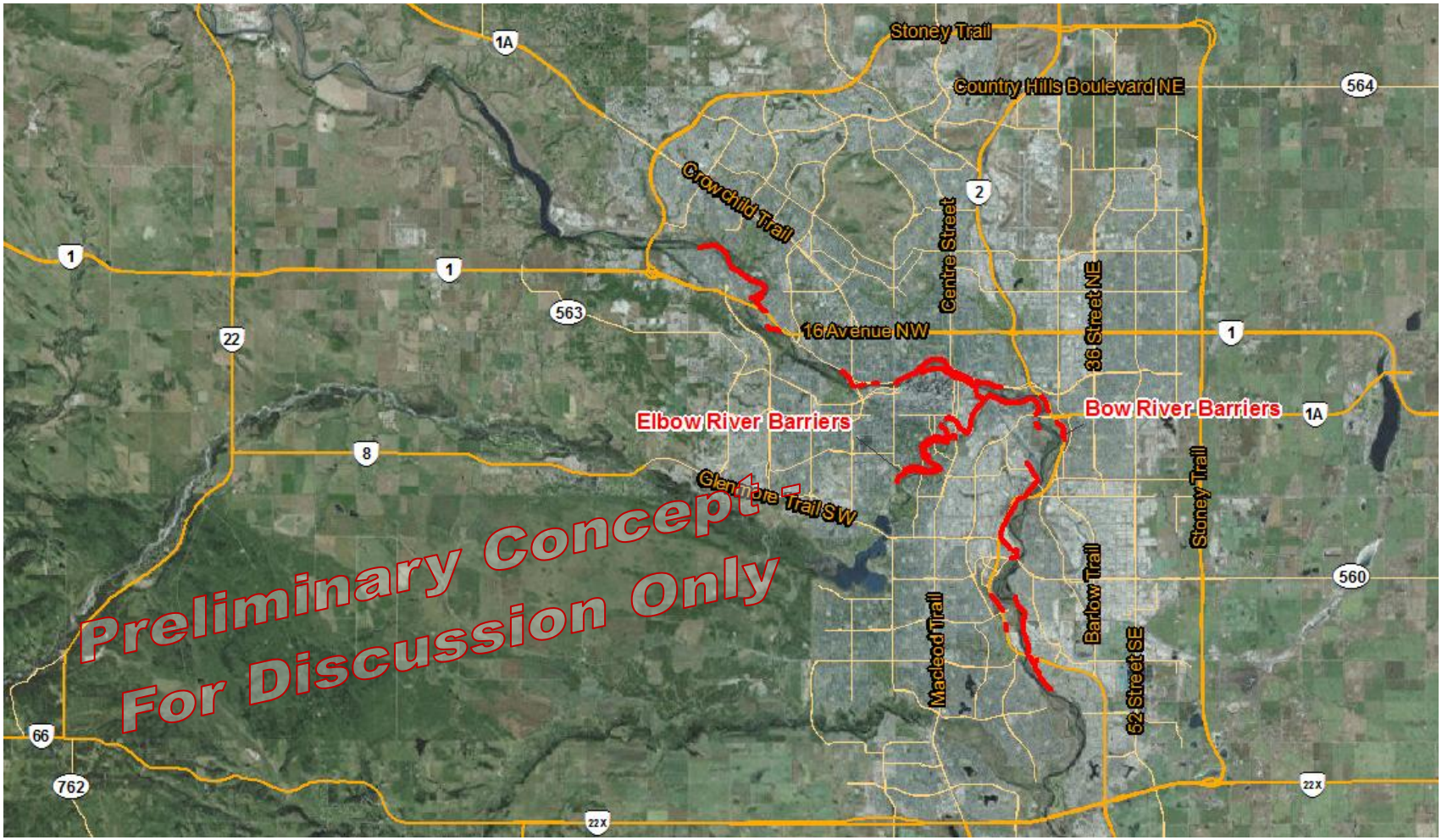
- Barriers are built along a river's edge to prevent water from entering communities.
- Barriers can be earth berms, or concrete or metal walls.
- Building barriers within the city limits can be undertaken by a municipality.
- Extending the barriers underground to protect against groundwater flooding from the river is possible, but costly. It could double the cost of the barrier.

What are the drawbacks of this concept?

- It will take time to approve and build all the barriers.
- The length and height of barriers required to protect all at-risk communities are significant.

- The height of the barrier depends on the size of flood event from which the community is being protected.
- Many barriers will require purchase of land along the river where space is needed to build the barrier.
- Barriers will change the visual aesthetics of the river and nearby communities, and may affect the location and number of access points for recreational activities.
- There is significant impact to the natural riverbank environment, including drainage and interactions between the river and floodplain areas.
- Barriers do not provide any additional benefits to the watershed, such as drought management, energy generation or recreation.
- While rare, barriers can fail. If an event larger than they were designed for occurs, water will flow over the barrier. These situations would cause water to flow into communities that were considered protected. Having the barrier in place may make damages worse, as once the river level goes down, the water cannot drain out of the community as quickly.
- Depending on the size of a flood event, communities protected by barriers may still need to be evacuated for safety.
- This combination of measures prevents the least amount of flood damage, and has the greatest physical changes to the look and feel of the river-facing communities.

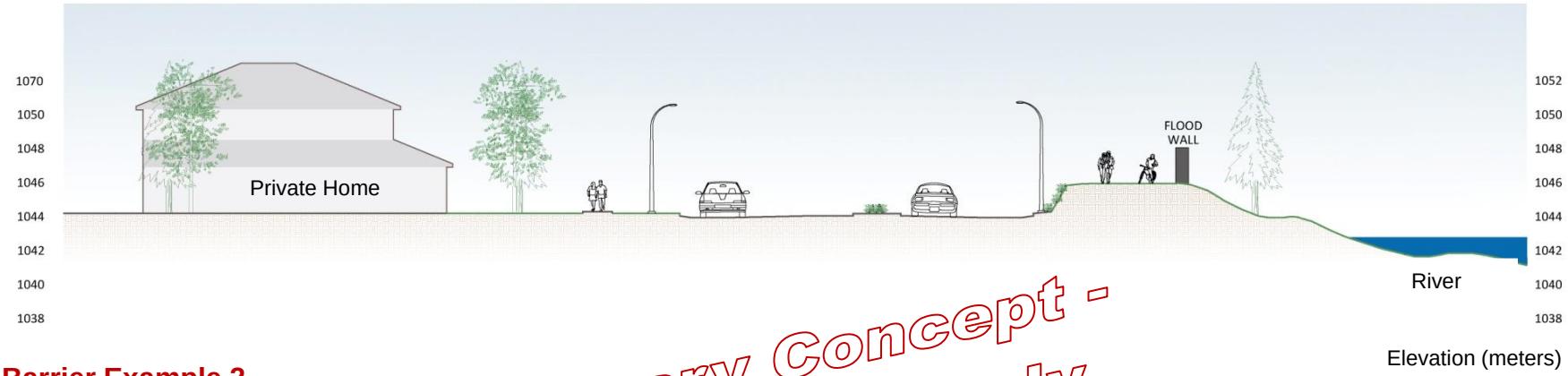
Concept 2: All possible barriers along the Elbow and Bow Rivers



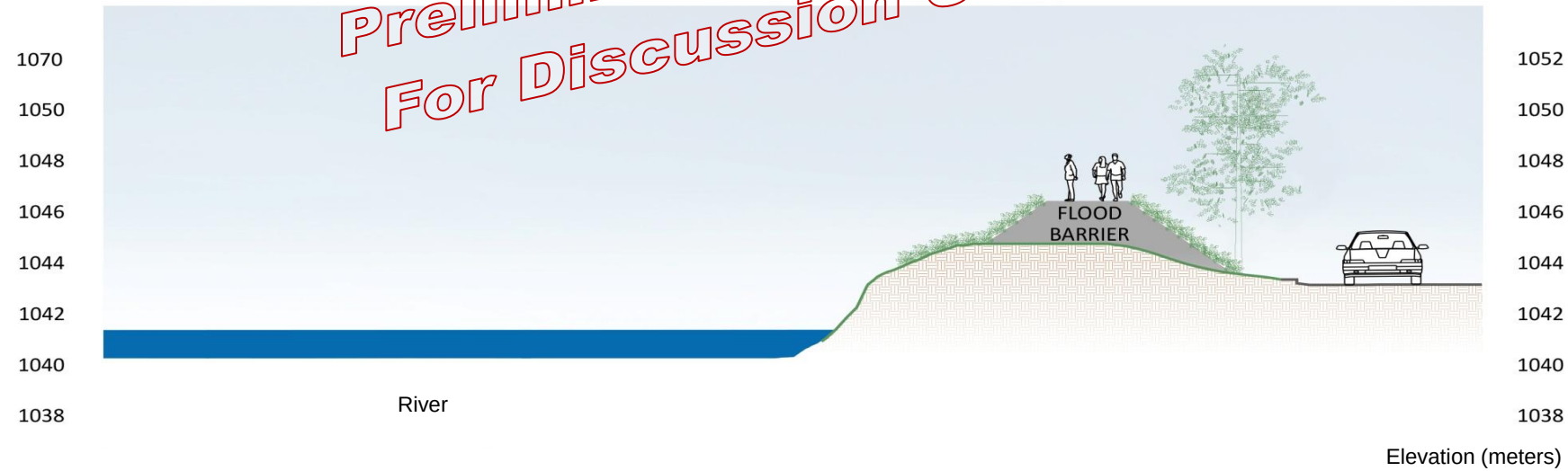
NOTE: The red lines on this map show ***location estimates only*** of where barriers would be needed to mitigate a 1:200 year flood event throughout Calgary along the Bow River (2390 m^3/s) and the Elbow River (1130 m^3/s). Barrier locations and cost-benefit estimates have been assessed for a range of protection levels. Presentation of this conceptual map does not guarantee commitment by The City to any one of these barrier concepts, or to any specific locations.

Concept 2: Types of possible flood barriers

Barrier Example 1



Barrier Example 2



NOTE: These examples represent the estimated heights and widths of barriers required in Calgary to protect communities at the 1:200 year flood level. Not all barrier examples are applicable or feasible for all locations or communities.

Barrier Example 3

Barrier Example 4

NOTE: These examples represent the estimated heights and widths of barriers required in Calgary to protect communities at the 1:200 year flood level. Not all barrier examples are applicable or feasible for all locations or communities.

Concept 3: Springbank Off-Stream Reservoir (SR1) on Elbow River and Barriers on Bow River

Background

On March 3, 2015, the Government of Alberta confirmed it would proceed with the development of a dry-storage reservoir at Springbank. The project site is located just west of Calgary approximately 18.5 km upstream of the Glenmore Reservoir. This project, in combination with operation of new gates on the Glenmore Dam would be able to mitigate damage caused by a flood event similar to 2013.

Infrastructure on both the Bow and Elbow rivers provides Calgary with some flood protection. The existing dams and permanent barriers were critical in allowing evacuation time and reducing some of the damage from the 2013 flood. The City also recently approved construction of several barriers at West Eau Claire, Heritage Drive, and Centre Street Bridge with funding support from the Government of Alberta.

The City has completed a Flood Protection Conceptual Design study to identify potential spill points where floodwaters would inundate communities and to identify the feasibility of preventing them with permanent barriers, such as berms or walls, at specific locations along the Bow and Elbow rivers.

Concept 3 presents Springbank off-stream reservoir for flood mitigation on the Elbow and permanent barriers to offer protection on the Bow River. The barrier locations are the same as those presented for the Bow River in Concept 2. An overview map and illustrations of typical barriers are provided on the following pages. Note that the examples of types of barriers shown may not be feasible for all locations. Most of the barrier locations are conceptual and detailed design work has not been undertaken, with the exception of the barriers identified above. No commitment or funding for the other barriers shown has been confirmed.

An overview map of the structures is provided on Page 21.

In combination with:

- New Gates on Glenmore Dam
- Current TransAlta Operation of Ghost Dam (Provincial agreement)
- Emergency Preparedness and Response
- Stormwater Drainage Improvements
- Flood Forecasting

Cost summary

This calculation includes benefits, capital and operating costs over a 100 year period.

- Cost: $ 1.01 billion
- Benefits: $2.5 billion
- Benefit-cost ratio (=benefits/costs): 2.4
- Estimated remaining damages (average annual damage): $37 million per year

What can this concept achieve?

- Reservoirs are used to store water and control flow downstream of the dam.

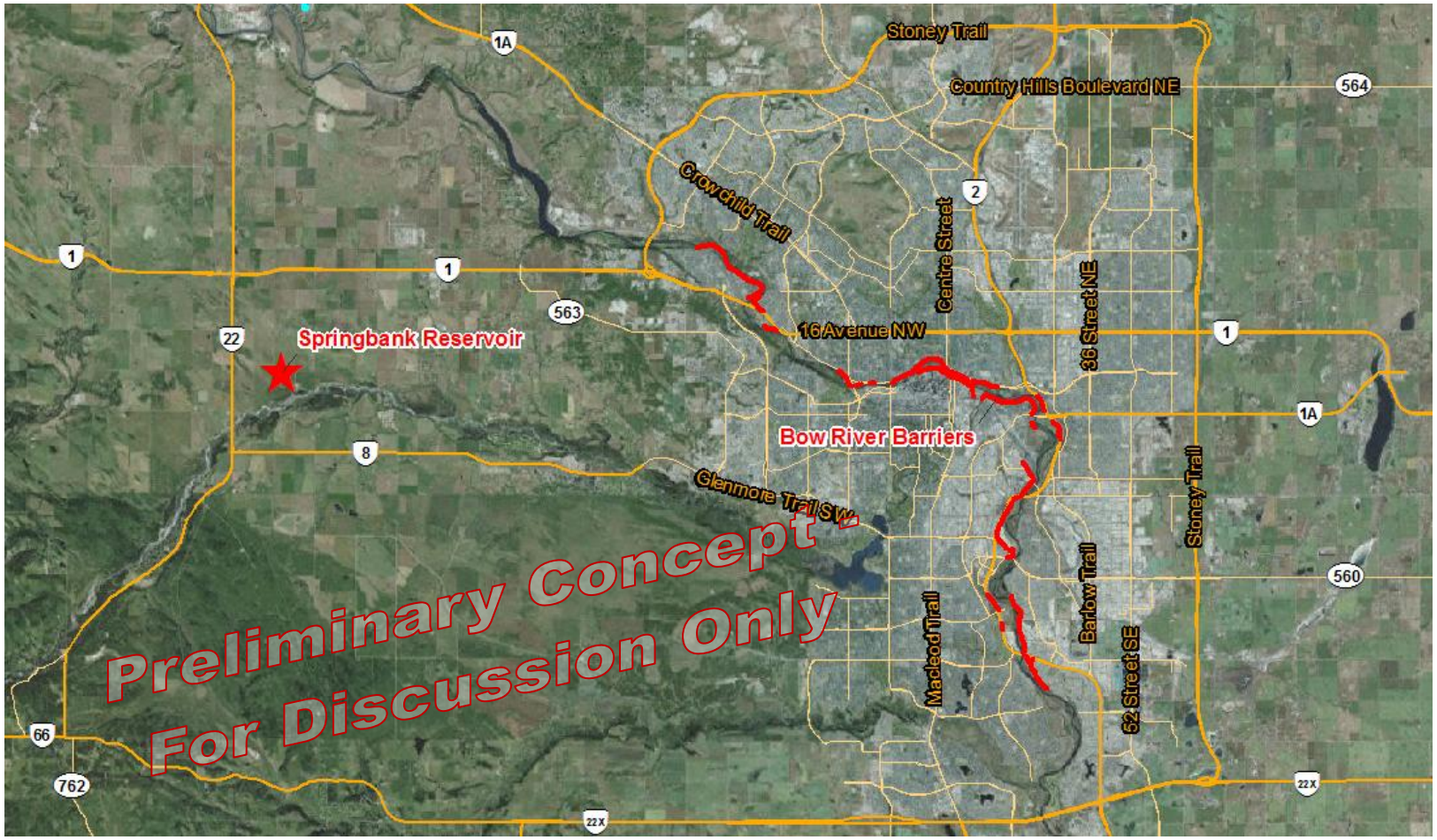
- The Springbank Off-Stream Reservoir (SR1) is a “dry reservoir” that is usually a field, and only holds water during flood events. During a flood, some water is diverted from the Elbow River into SR1. The rest of the water in the Elbow River will flow downstream to Glenmore Reservoir. The water held in SR1 during the flood will be slowly released back into the Elbow River when the event has passed.
- Together, SR1 and the new gates at Glenmore Dam are intended to be able to store a 2013-sized event without overland flooding along the Elbow River downstream of Glenmore Dam.
- Reservoirs can provide some reduction in groundwater flooding during a river flood, by lowering river levels during the flood event.
- For floods smaller than those the reservoirs were designed for, communities downstream would not necessarily need to be evacuated.
- Barriers are built along a river’s edge to prevent water from entering communities.
- Barriers can be earth berms, or concrete or metal walls.
- Building barriers within the city limits can be undertaken by a municipality.
- Extending the barriers underground to protect against groundwater flooding from the river is possible, but costly. It could double the cost of the barrier.

What are the drawbacks of this concept?

- The decision to build dams and reservoirs is the responsibility of the Province.
- Dams and reservoirs can take a long time to approve and build.
- Dams and reservoirs require environmental impact assessments and technical feasibility assessments. Currently, SR1 is undergoing and federal level environmental assessment.
- The construction of the dams and reservoirs would have significant environmental impacts.
- The land needed to build dams and reservoirs requires the acquisition of land outside of The City of Calgary’s boundaries.
- While rare, there is the risk that dams can fail, which could cause catastrophic flooding.
- Dams can hold a certain amount of water. For extreme events that bring more water than the dam can hold, water needs to be released from the reservoir. These events, which are larger than the reservoir is designed for, may result in flooding downstream but would be less than if the dam was not in place.
- It will take time to approve and build all the barriers.
- The length and height of barriers required are significant.
- The height of the barrier depends on the size of flood event from which the community is being protected.
- Many barriers will require purchase of land along the river where space is needed to build the barrier.
- Barriers will change the visual aesthetics of the river and nearby communities, and may affect the location and number of access points for recreational activities.
- There is significant impact to the natural riverbank environment, including drainage and interactions between the river and floodplain areas.
- Barriers do not provide any additional benefits to the watershed, such as drought management, energy generation or recreation.

- While rare, barriers can fail. If a larger event occurs than they were designed for, water will flow over the barrier. These situations would cause water to flow into communities that were considered protected. Having the barrier in place may make damages worse, as once the river level goes down, the water cannot drain out of the community as quickly.
- Depending on the size of a flood event, communities protected by barriers may still need to be evacuated for safety.

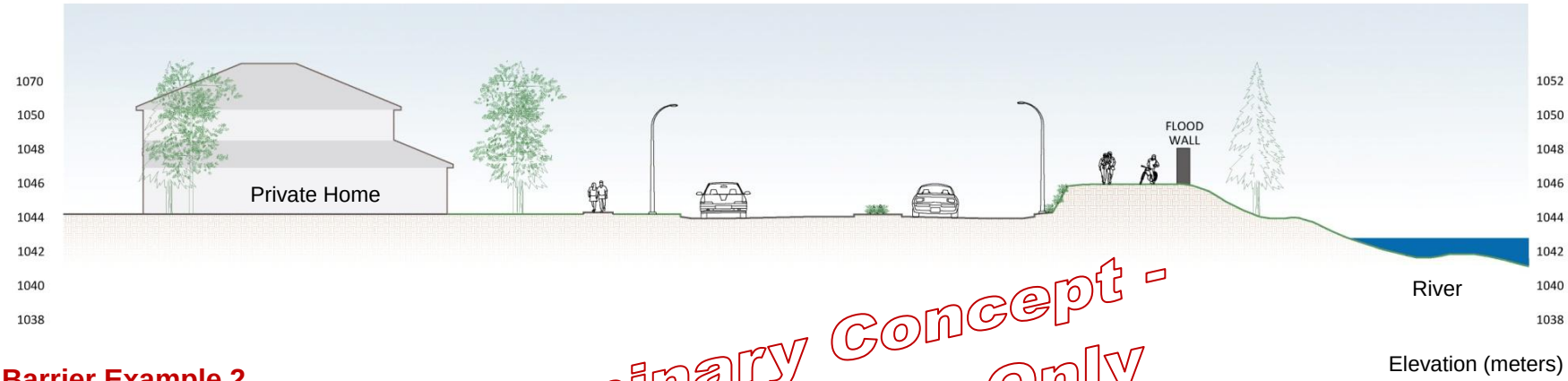
Concept 3: Springbank Off-Stream Reservoir on the Elbow River, Barriers on Bow River



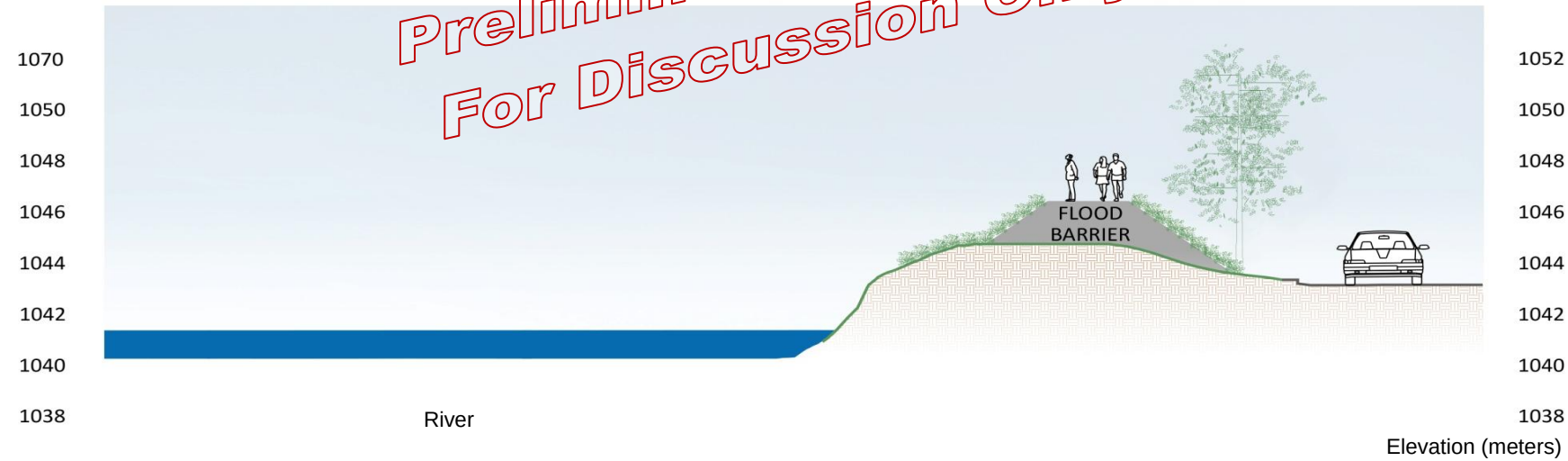
NOTE: The Government of Alberta confirmed its commitment to the Springbank Off-Stream Reservoir in March 2015. In combination with the operation of new gates on the Glenmore dam, this project would mitigate damages caused by a flood similar to what was experienced on the Elbow River in 2013. The red lines on this map show ***location estimates only*** of where barriers would be needed to mitigate a 1:200 year flood event along the Bow River (2390 m^3/s). Barrier locations and cost-benefit estimates have been assessed for a range of protection levels. Presentation of this conceptual map does not guarantee commitment by The City to any one of these barrier concepts, or to any specific locations.

Concept 3: Types of possible flood barriers

Barrier Example 1

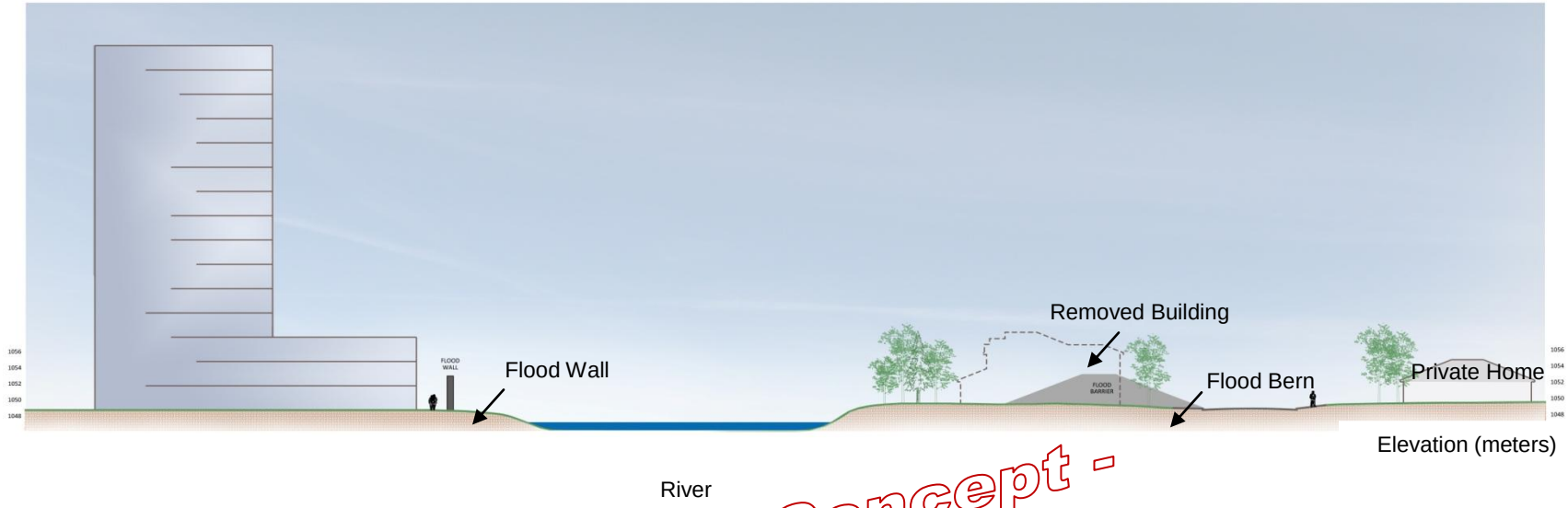


Barrier Example 2

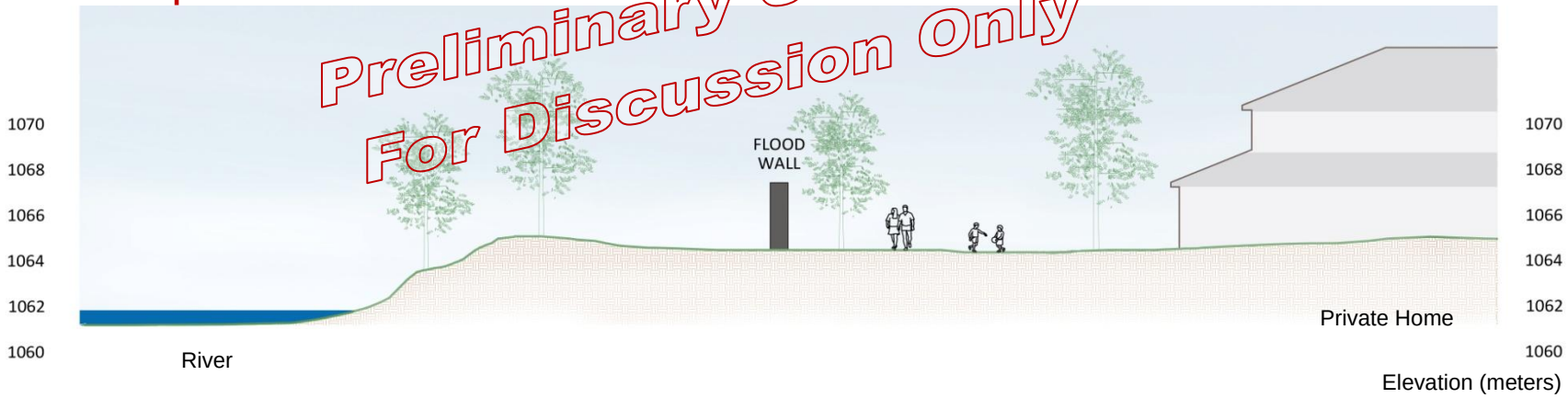


NOTE: These examples represent the estimated heights and widths of barriers required in Calgary to protect communities at the 1:200 year flood level. Not all barrier examples are applicable or feasible for all locations or communities.

Barrier Example 3



Barrier Example 4



NOTE: These examples represent the estimated heights and widths of barriers required in Calgary to protect communities at the 1:200 year flood level. Not all barrier examples are applicable or feasible for all locations or communities.

Concept 4: Non-Structural measures

Background

Non structural measures include policies, by-laws and land use regulation, building codes and requirements, operating procedures, emergency response plans and river forecasting models that are designed to reduce the extent of damage to property and increase public safety. Non-structural measures and community-scale structural flood protection can be combined in many ways to increase a community's resilience to flood.

The City of Calgary's Municipal Development Plan (MDP)

The MDP gives high level policy direction guiding development in Calgary. In 2014 the MDP was updated with four flood policy priorities: increase public safety, reduce property damage, increase city flood resiliency and achieve Provincial standards at a minimum.

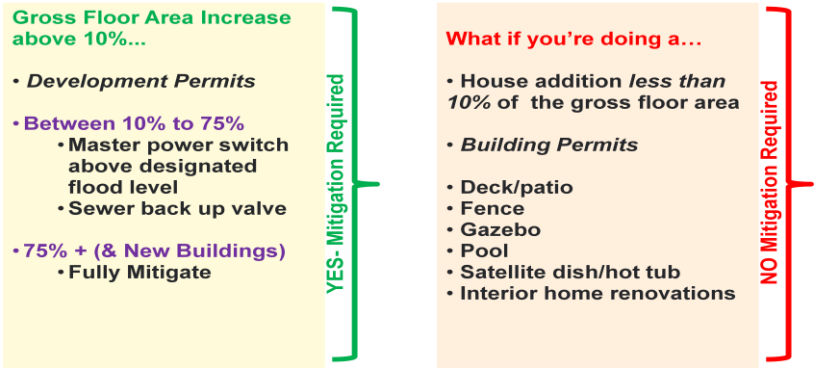
The following is a summary of the current MDP policy direction:

- Endorses a graduated approach to development in the flood hazard area (FHA), where areas of higher risk are regulated to a higher degree.
- Allows for discretionary redevelopment in the floodway on the same footprint.
- Where possible, buildings should be moved from the floodway to the flood fringe.
- The City can consider relaxation of Land Use Bylaw rules to accommodate better flood protection in buildings. Traditional built form in neighbourhoods may change as a result.
- The City can consider relaxation of Land Use Bylaw rules for buildings in areas that are covered by community scale mitigation measures.

Land Use Bylaw

The 2014 changes to the Land Use Bylaw introduced two important steps:

- The removal of 'grandfathering' rules whereby buildings built before a certain date could be re-built without following the current flood proofing rules.
- A 'sliding scale' approach where the degree of required flood proofing in a building is commensurate to the degree of building expansion. These rules are summarized below:



The current Land Use Bylaw rules do:

- Make development in the Flood Fringe and Overland Flow areas follow the same rules regardless of the parcel history.
- Make required mitigation proportionate to the degree of change to a building.
- Moves towards more resilient housing in the community.

The current Land Use Bylaw rules do not:

- Eliminate the right to develop in areas at risk of flooding.
- Change the distance buildings must be away from the river.
- Require flood mitigation be put in place in every redevelopment situation.
- Force mitigation or increase resilience if no development permit is submitted.

Residual risk will remain regardless of which flood mitigation measures are put in place because of:

- The time required to have infrastructure approved, designed and built.
- The natural changes to rivers and the environment that affect river channels and river flows, and may change the way mitigation structures perform or the areas at risk of flooding.
- There is always the risk of infrastructure failures.
- Groundwater coming from the river or from community drainage during a flood/rainfall event, which can flood basements. Groundwater flooding causes a significant amount of damage.

Additional non-structural measures

There are a number of non-structural measures that could be used in combination with structural measures to address residual risk. Having such measures in place would further reduce the risk of damage to property and building contents, as well as reduce risks to public safety and distress.

Such potential measures include:

- Removing some or all buildings from the floodway.
- Increasing restrictions on how buildings are re-developed in the flood hazard area.
- Not allowing basements in new developments within the flood fringe.
- Not allowing basement secondary suites within the flood hazard area.
- Prohibiting or restricting land uses within the flood hazard area that pose an increased safety risk during flood emergencies (e.g. hospitals, assisted living, protective and emergency services).
- Stricter flood proofing regulations in the flood hazard areas.

What would these measures strive to achieve?

- Increase community resilience and reduce damage to structures, contents and safety risks in flood events.
- Creates more room for flood water to move through the floodway.

How might these possible measures impact communities and property owners?

- Restricts the way properties are redeveloped and used in some communities to a greater extent than in other communities.
- Moving properties out of the floodway may be disruptive to community fabric, and may not retain existing community architecture, building form/design.

- The cost of flood proofing measures and development requirements would be the responsibility of the property owner.
- May reduce rental housing availability.
- Restrict new hospitals, assisted living, protective and emergency services in some communities.