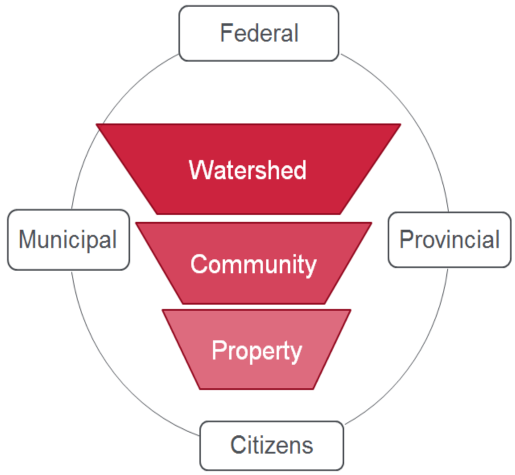
FLOOD MITIGATION MEASURES ASSESSMENT

Analysis and recommendations for future flood mitigation measures

SUMMARY OF FINDINGS AND RECOMMENDED APPROACH

Protecting Calgary from flood risk is a shared responsibility of all orders of government and citizens. In 2016, The City of Calgary undertook a Flood Mitigation Measures Assessment to provide a recommended direction on the future of Calgary's flood mitigation and resiliency. Following the assessment, The City developed recommendations considering its principles and priorities regarding flood resiliency:

- Public safety
- Sustainable watershed management
- Cost beneficial investments
- Adaptability and flexibility
- Equitable protection on both rivers
- Community receptivity and shared responsibility



BUILDING FLOOD RESILIENCY THROUGH INTEGRATED LEVELS OF FLOOD PROTECTION

The recommended approach was developed through technical assessment, sustainability analysis, and community engagement. It includes a combination of watershed, community, and property level mitigation solutions to create a flexible and adaptable flood mitigation program.

The Flood Mitigation Measures Assessment showed:

- Investment in flood mitigation in Calgary has decreased flood damage risk by 30 per cent. However, significant flood risk remains for Calgary until upstream mitigation is built.
- The Province's Springbank Off-Stream Reservoir project and improved Glenmore Dam gates will protect the Elbow River to an event similar to 2013. No further structural mitigation is proposed for the Elbow River.
- A new upstream reservoir, TransAlta operations, and complementary barriers are required on the Bow River to protect to an event similar to 2013.
- A new reservoir on the Bow River would deliver multiple benefits: water security, drought management, climate adaptability, and benefit for downstream communities.
- A barrier implementation plan must be adaptable to Provincial policy decisions and include extensive community engagement.
- The Provincial-TransAlta agreement provides significant flood mitigation for Calgary.
- Any future policy changes must align with potential Provincial flood hazard area regulations, federal guidelines, and structural mitigation that is put in place.
- Property level mitigation can significantly reduce risk of flood damage. The City should explore the development of a property level mitigation program for property owners.

1. BACKGROUND

In 2013, Calgary experienced its largest flood since 1932. The 2013 floods resulted in approximately $5 billion in damages across Alberta and an estimated $400 million to The City of Calgary's infrastructure. Floods are natural events and have occurred periodically throughout Calgary's history, with some exceeding the 2013 flood in scale. Though The City has taken many steps to rebuild and become more resilient since 2013, flooding continues to be a significant risk. While the risk of flooding can be reduced, it can never be eliminated. It is anticipated that climate change will result in more frequent and intense weather events, potentially leading to larger floods and extreme drought in the future.

In the wake of the 2013 event, The City formed an Expert Management Panel on River Flood Mitigation to identify opportunities to reduce Calgary's flood risk and build resilience. The Panel delivered 27 recommendations to Council aimed at achieving a safer, more flood resilient Calgary. Since 2014, The City has been working through these recommendations. To fulfill several Expert Panel recommendations, The City conducted the Flood Mitigation Measures Assessment (the Assessment) project throughout 2015 and 2016. While the Assessment focused on river flooding, The City recognizes storm water flooding as an additional concern. It was determined that a combination of watershed, community, and property level flood mitigation measures is the best approach to reduce Calgary's river flood risk.

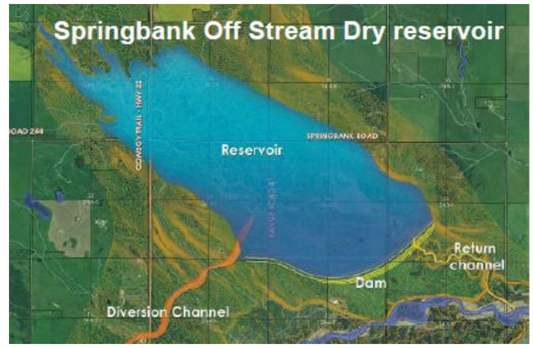
Current flood mitigation and resiliency in Calgary

Since 2013, The City developed and published updated flood inundation maps, and repaired and strengthened the riverbanks that eroded in 2013. The City also restored river pathways, pedestrian bridges and sinkholes, and removed debris from the rivers. In 2014, the Land Use Bylaw removed rules that allowed buildings built before a certain date to be rebuilt without following the current flood-proofing rules. Renovations and new buildings also now require stricter flood-proofing measures. Additionally, The City strengthened river flood forecasting, upgraded emergency response planning and expanded public education to help citizens prepare for events.

With funding support from the Province, construction of larger gates at the Glenmore Dam for additional water storage and flood protection has begun. The City is also constructing several barriers at strategic locations on the Bow River, including West Eau Claire, Bonnybrook Wastewater Treatment Plant, Montgomery, Heritage Drive, the Calgary Zoo and Centre Street Bridge. Hundreds of identified storm water outfalls are being upgraded to prevent floodwater back-up into communities. Once all this work is completed, the average annual damage from flooding that Calgary is exposed to is anticipated to decrease to about $115 million per year, about a 30 per cent decrease in potential damage compared to if no mitigation was in place.

Provincial commitments

The Province confirmed it would proceed with the development of the Springbank Off-stream Reservoir on the Elbow River approximately 18.5 km upstream of the Glenmore Dam. This project, in combination with operation of new gates on The Glenmore Dam will manage flood events similar to the 2013 flood along the Elbow River**.** The Province also entered into a five-year operational agreement with TransAlta, which will be in place until 2021. This agreement provides significant flood mitigation on the Bow River. The Province also initiated the Bow River Working Group and Advisory Committee. This process includes taking a watershed management approach to examine the feasibility of upstream reservoirs and operational changes to manage flooding on the Bow River and the impacts of drought. A report from the Working Group is expected in Q2 of 2017.



2. FLOOD MITIGATION MEASURES ASSESSMENT

The City of Calgary retained IBI Group and Golder Associates to undertake a Flood Mitigation Measures Assessment for The City of Calgary. The project included updating of the Government of Alberta's 2014 Flood Damage Assessment Study to incorporate the most up-to-date hydrology as well as social and environmental costs of flooding into a damage model. Using the results from the updated damage model, the Assessment evaluated a number of mitigation scenarios, including:

- Watershed-level structural flood mitigation measures – operations and new reservoirs upstream of Calgary on the Bow and Elbow rivers.
- Community-level structural mitigation – operations and new barriers located within Calgary.
- Property level and policy-based mitigation measures.

A number of scenarios based on combinations of the above measures were evaluated to determine the best future flood mitigation approach for Calgary and were analyzed considering the measures already in place. A comprehensive sustainability analysis was conducted on the mitigation scenarios and community engagement was undertaken to understand citizen views and to inform recommendations on future flood mitigation and resiliency measures. See the Appendix for details on community engagement and the sustainability analysis.

3. RECOMMENDED APPROACH

Based on the results of the Assessment, a combination of watershed and community level mitigation should be pursued that allow flexible and adaptable flood mitigation solutions to manage flood risk. Non-structural solutions, such as policy, regulations, education, incentives for property owners, etc. should be explored to complement structural measures. The Assessment identified mitigation to a 1:200 flood event on both the Bow and Elbow Rivers as the recommended approach. A 1:200 protection level provides mitigation beyond the current Provincial standard, and balances future climate uncertainty with cost beneficial protection that is technically, socially, and financially feasible.

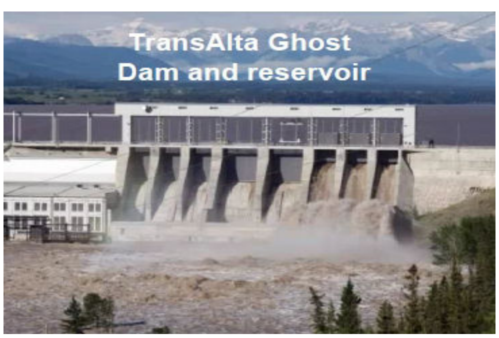
3.1 ELBOW RIVER MITIGATION

The Assessment confirmed that the Provincial Springbank Off-Stream Reservoir combined with operation of larger gates at the Glenmore Dam will mitigate a flood similar to what Calgary experienced in 2013. This scenario had a high benefit-cost ratio and had a strong ranking in the sustainability analysis. It is estimated the new gates will mitigate approximately 25 per cent, and the Springbank Off-stream Reservoir project will manage approximately 75 per cent of a 2013 level flood on the Elbow River.

The Glenmore gates enhancements are expected to be complete by 2020. The Springbank Off-stream reservoir project is currently undergoing federal and provincial environmental assessment and is working towards project completion in 2020, though current timelines are subject to change. The City is working closely with the Province to provide technical input to this process. As part of The City's ongoing work, two gravel bars located in the community of Mission have been identified that, if removed, will help ensure that the Springbank Off-stream reservoir and Glenmore gates continue to provide the expected level of mitigation on the Elbow River.

The Assessment concluded that the mitigation provided by the Springbank Off-stream Reservoir project cannot be replaced by fortification through community-level barriers along the length of the Elbow River. The barriers are not considered feasible, as they would require significant land acquisition, which would dramatically disrupt community function and aesthetics given the height and footprint required for protection at this level. Consequently, fortification of the Elbow River with barriers ranked poorly in the sustainability analysis, and was viewed unfavourably during community engagement.

3.2 BOW RIVER MITIGATION



The Assessment confirmed that to provide an equitable level of service on the Bow as on the Elbow, a new reservoir on the Bow River upstream of Calgary is recommended, along with complementary barriers in select communities and continuation of the Provincial-TransAlta operational agreement. This scenario has a positive benefit-cost and ranked high in the sustainability analysis. Together, these measures will provide mitigation similar to a 2013 flood on the Bow River.

3.2.1 WATERSHED LEVEL MITIGATION

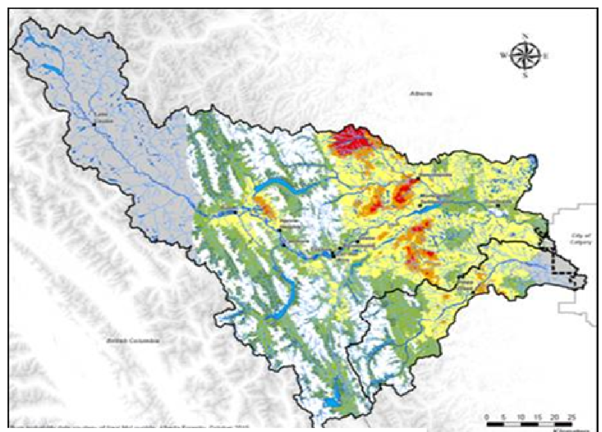
Based on overall damage reduction, benefit-cost ratios, sustainability analysis criteria, and citizen feedback, upstream mitigation on the Bow has the potential to provide benefits in addition to flood mitigation that barriers alone cannot provide. These include:

- Provides some level of mitigation for all floods, including floods larger than 2013.
- Climate adaptability benefits, such as additional water supply storage.
- Opportunities for drought and irrigation management, energy generation, and recreation.

- Community fabric is maintained and smaller complementary barriers are required, minimizing disruption.
- Reduced impacts from stormwater and groundwater during flooding.
- Downstream communities will benefit from mitigated flows and water storage.

The City co-chairs the Bow River Advisory Committee with the Province, and participates on the Bow River Working Group, which conducted a high level feasibility assessment of upstream operational and structural mitigation on the Bow River. This work is currently at the conceptual stage and the Province has not committed to any location, funding or design work of any potential new reservoirs. It is expected that the Bow River Working Group will make their findings available to the public in Q2 2017 and will recommend which potential sites should be analyzed further for feasibility. The working group includes stakeholders such as irrigators, environmental groups, TransAlta, municipalities and First Nations.

A new reservoir on the Bow River would have a relatively high cost of construction and a relatively long timeline, leaving communities along the Bow River at risk until the reservoir is completed. A site for the reservoir has not yet been recommended, which will also potentially affect the final design and service level achieved. The proposed recommendations work to limit these risks through the implementation of complementary barriers to provide some benefits until upstream mitigation is completed.



on for a new
entified.

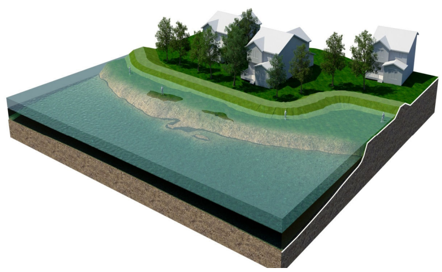
The current operational agreement between TransAlta and the Province provides significant mitigation benefits on the Bow River. The current five-year operational agreement is in place until 2021, and The City must advocate for a continued agreement beyond 2021 to ensure flood protection with operational management on the Bow.

3.2.2 COMMUNITY-LEVEL MITIGATION

Upstream mitigation is beyond The City's jurisdiction, limiting control over mitigation on the Bow River. Mitigation to a 2013 event is also unlikely to be achieved with a single upstream reservoir and operational measures. Some low-height complementary barriers along the Bow River are required to provide an equitable level of service to what is committed to on the Elbow River, as well as removal of gravel bars and stormwater enhancements for some communities. Barriers present some challenges as a form of flood mitigation, including:

- Need for negotiation of several private property easements for some sites.
- Lack of adaptability for other climate considerations such as drought and water supply.
- Would not provide any mitigation during larger flood events.
- May not provide the groundwater or stormwater protection required in some cases.

- Community disruption during construction.



1:20 barrier concept in the community of Bowness

Based on technical analysis and the community risk profiles provided as part of the Flood Mitigation Measures Assessment, four sites were identified on the Bow River where construction of barriers in combination with an upstream reservoir would be cost beneficial, and would be required for a 2013 service level:

- Bowness
- Downtown
- Sunnyside
- Pearce Estates-Inglewood

The proposed barrier sites are consistent with the areas identified in the Flood Mitigation Measures Assessment as those that flood the most frequently and/or have high risk of flood damage. The proposed barrier heights are relatively low, averaging between 0.6 m to a maximum of 1.1 m in height. The downtown barrier is designed to a 1:200 level. The remaining barrier sites protection level of approximately 1:20 increases to approximately 1:50 level with TransAlta operations, and construction of the barriers could be supported through remaining Alberta Community Resiliency Program funds allotted to The City. Because of unique circumstances for the community of Sunnyside, the proposed barrier includes groundwater protection.

In most cases, barrier sites are located on City-owned lands. However, construction of a barrier in Bowness would affect approximately 90 or more privately owned parcels of land. Throughout The City's engagement process, Calgarians cited community disruption, river access, and environmental impacts as potential negative aspects of implementing barriers. Many residents noted support for lower height barriers that would provide mitigation for small floods, particularly if developed in combination with upstream mitigation on the Bow River (see Appendix).

If a new Bow reservoir is not built, fortification of the Bow River by barriers is not desirable, as it would require higher barriers with large footprints along the length of the Bow River within Calgary, resulting in dramatic impacts on the community.

Bow River mitigation scenarios

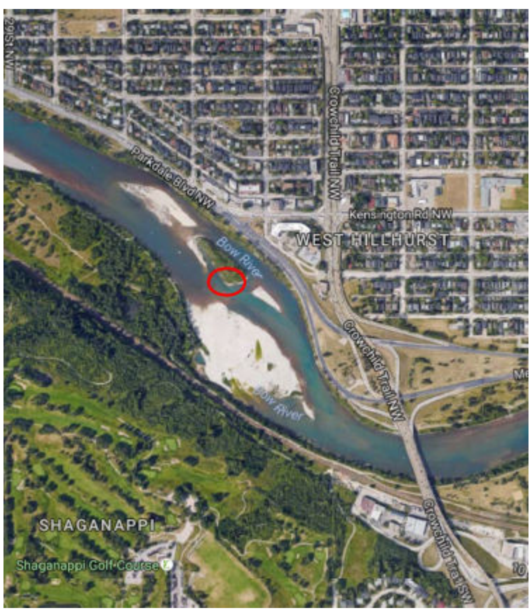
Initiative	Cost estimate (millions)	Timeline estimate	Average height range (metres)	Protection level	Sustainability Ranking
Fortification of the Bow River by barriers	$350 M to $650 M	Up to 30 years	1.1 m - 2.2 m	1:200	Rated low
New Bow reservoir + Complementary barriers	$700 M + $30 M to $75 M	Within 30 years Within 15 years	0.6 m - 1.1 m	1:200	Rated high

Note: Scenarios include Provincial-TransAlta agreement operations and other existing mitigation measures.

The proposed four low-height barriers will be designed to function in tandem with upstream mitigation from TransAlta operations and a new reservoir on the Bow River to provide mitigation to an event similar to 2013. The City can begin staged implementation of the four barriers immediately. These complementary barriers in key locations will reduce flood damage risk for more frequent smaller flood events, and will enhance the effectiveness and operational flexibility of a new reservoir on the Bow River.

Additional work beyond the Flood Mitigation Measures Assessment was identified that will provide further mitigation on the Bow River. These projects provide significant benefits in addition to the complementary barriers identified above.

- Five gravel bar removals:
    - Centre Street Bridge
    - 10th Street Bridge
    - Crowchild Trail
    - Carburn Park
    - Inglewood
- Separation of part of the Hillhurst-Sunnyside stormwater system from communities at a higher elevation (the upper plateau) to mitigate flooding during high river levels.



Identified gravel bar site at Crowchild Trail NW

Though the Upper Plateau Separation project is identified in The City's Community Drainage Improvement Program and primarily deals with stormwater flooding, the communities of Sunnyside and Hillhurst experience river flood risk complications caused by the existing stormwater system. Separation of their system of the upper plateau has been identified as providing significant river flood mitigation for the communities and may be eligible for external flood resilience funding not available to other Community Drainage Improvement projects.

It is estimated that the Upper Plateau separation project would cost an estimated additional $37M to complete. Gravel bar removals are an estimated additional $15M to $20M and are not eligible for external funding.

3.3 PROPERTY LEVEL AND POLICY MEASURES

In addition to structural mitigation, the Assessment recommended that The City investigate property level and policy measures further. These include policies, bylaws, land use regulations, building codes, incentive programs, and public education. These tools can be used to help mitigate residual risk that cannot be eliminated by structural mitigation.

Land use policy and regulations
Council approved revisions to the Municipal Development Plan and Land Use Bylaw 1P2007 in 2014. These changes were The City's initial steps to enhance flood resiliency through planning regulations.

Analysis of policy measures must align with structural mitigation once implemented, as well as forthcoming information from the Province regarding new Flood Hazard Area mapping and new floodway regulations and policy. Clarification on the implementation of upstream structural mitigation and further public consultation will inform the extent and nature of the policy mitigation measures recommended for implementation in the future.

Land-use policies for further analysis include, but are not limited to:

- Restricting certain sensitive uses within the flood fringe (e.g. daycares, assisted living facilities, protective and emergency services, basement secondary suites etc.).
- Strategic acquisition of some buildings in the floodway and/or flood fringe to allow river water to move unimpeded.
- Examining the way basements in high-risk areas are developed, including exploring the use of flood-resistant materials and elevating mechanical/electrical systems.
- Exploring restrictions to greenfield development in the flood fringe.

Buyouts
Buyout of all properties in the floodplain would cost billions, and is considered a financially and socially infeasible solution. Buyout of all 980 residential buildings in the floodway was considered as part of the Assessment. This scenario had a negative benefit-cost ratio and ranked poorly in the sustainability analysis. It would alter communities significantly while significant structural and operational measures would still be required to protect communities in the flood fringe. Therefore, this is not an economically or socially viable option for Calgary.

Property level protection and education programs
Exploration of property level mitigation is recommended in combination with structural measures, and can significantly reduce private property damage from groundwater, sewer back-up and overland flooding. Public engagement demonstrated an interest from Calgarians for more public education on reducing flood risk and financial incentives for private landowners to flood proof homes and other buildings. The Assessment recommended that The City explore the development an incentive program for property level measures with an education program for property owners. The feasibility of an incentive program for residential sump pumps and backflow valves is being investigated to complement an educational resource program for property owners.

4. NEXT STEPS

The proposed approach uses a combination of watershed, community, and property level mitigation solutions to create a flexible and adaptable flood mitigation program. While The City of Calgary can implement some mitigation measures within its jurisdiction, it is essential that upstream mitigation is put in place to provide the level of protection needed for Calgary.

The City must take the following actions to implement the proposed approach:

Watershed level mitigation

- Continue to provide technical support to the Provincial Springbank Off-stream Reservoir project through the technical committee and advocate for timely implementation of this project.
- Continue to advocate for a commitment from the Province for an upstream reservoir on the Bow River, including continued work on recommendations in the Bow River Working Group Report.
- Advocate for continuation of the TransAlta utilities operational agreement beyond 2021.

Community-level mitigation

- Develop an implementation plan for a complementary barrier package for the Bow River, Upper Plateau Separation project, and gravel bars on the Elbow and Bow rivers, including construction sequence, funding approach, design, and community engagement planning. Pursue potential funding sources for all projects.
- Begin engagement with communities potentially affected by the complementary low-height barriers.
- Continue working with the Province regarding funding and applications for eligible projects and pursue Federal funding sources.
- Continue to invest in and improve flood forecasting and warning systems.
- Continue to review, assess, and refine emergency operations measures.

Property level mitigation

- Explore the development of a property level mitigation program for Calgarians. This may include incentive and education programs for building resiliency at the property level.
- Continue advocating for appropriate Provincial flood policy and Federal guidelines through engagement with the Province and participation in national floodplain guideline discussions.
- Conduct further research of policy development for areas prone to flooding in alignment with future Provincial flood policy and Federal guidelines.

APPENDIX

COMMUNITY AND STAKEHOLDER ENGAGEMENT

Significant community and stakeholder engagement work was undertaken to inform the direction of future mitigation work through a Community Advisory Group, a telephone survey and public engagement sessions. The City also reconvened with the Expert Management Panel on River Flood Mitigation to gather their perspectives on how the recommended approach aligned with their original vision.

Community Advisory Group

In January 2016, The City created a Flood Mitigation Measures Assessment Community Advisory Group (CAG) to review mitigation measures, examine the trade-offs and provide input into optimizing solutions to meet community needs. The CAG was not a decision-making group nor was it expected to reach a consensus on solutions. The input from the CAG was used to confirm, modify or enhance the assessment of flood mitigation options.

The nineteen members of the CAG represented the following groups:

- Calgary River Communities Action Group (CRCAG)
- Elbow and Bow River communities
- Sunnyside Flood Task Force
- Bow River Basin Council
- Flood affected citizens
- Non-flood affected citizens
- Business community
- Vulnerable populations

Telephone Survey

A telephone survey was conducted by IPSOS Public Affairs in 2016 April to gauge citizens' opinions on the value of the river to our community and flood mitigation. A survey sample of 300 citizens from the general population and an additional 200 citizens from flood-affected communities was used. Key findings in the survey were that citizens:

- Place a high value on a drinking water supply and a healthy ecosystem.
- Are concerned about the damage to the river and ecosystem from river floods.
- Are concerned about the impacts of flooding on major infrastructure and public property.
- Indicated flood mitigation plans should protect the river, critical infrastructure and the downtown, and provide citizens access to the river.
- In flood-affected areas believe that mitigation plans should also protect private property.

Community and stakeholder feedback

The City held community events and online engagement to gather input from citizens on proposed flood mitigation concepts. Input was gathered from six community workshops, two open houses, one targeted stakeholder group workshop, and online opportunities between 2016 October and 2016 November to gather feedback on how the proposed flood mitigation measures would:

- Affect the way their communities would look, feel, and move.
- Reduce damages from river flood and impact personal property, business operation, and public safety.
- Impact the amenities and services in communities.
- Protect Calgary's economic core.
- Affect the city as a whole.

The "What We Heard" report from the public engagement session provides the full summary of citizen input. The input was categorized into key themes for both structural and non-structural measures.

The dominant themes heard from participants on structural measures include:

- Expedite implementation of flood mitigation measures to enhance flood protection.
- A combination of reservoirs and berms/barriers are required to provide sufficient flood protection.
- Berms are preferred to floodwalls as they are more aesthetically pleasing.
- With the high costs of implementation, it is important to ensure that structural flood protection has a positive return on investment for everyone it seeks to protect (online respondents).

Major themes heard from participants on non-structural measures include:

- Restrict/limit vulnerable uses in flood hazard areas as appropriate to reduce flood risk.
- Structural measures need to be combined with non-structural measures.
- Non-structural measures should only be implemented once structural measures have been implemented.
- More public education on reducing flood risk is needed: financial incentives, compensation programs, and cost-sharing between government and private landowners to flood proof homes and other buildings should be considered.
- Non-structural measures have the potential to affect the look, feel and vibrancy of established, river communities in Calgary (online respondents).

Additional themes highlighted by participants include:

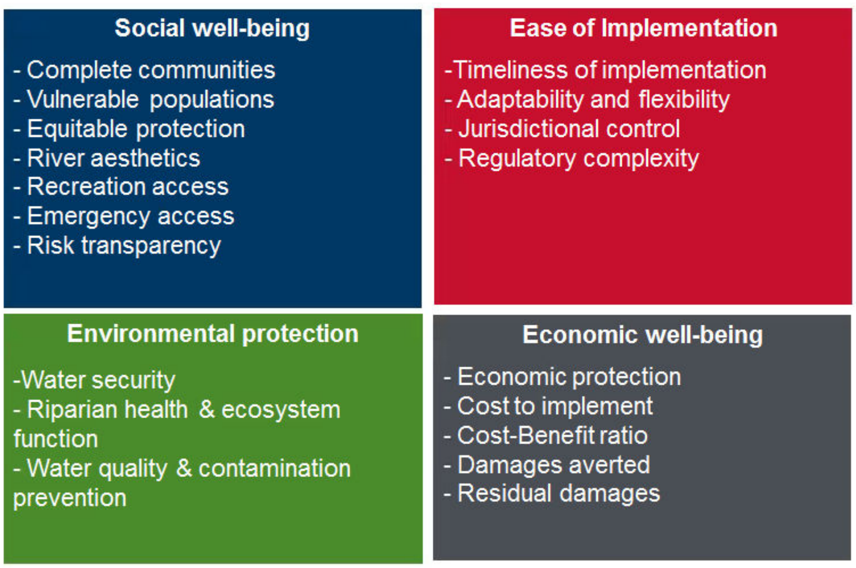
- Concern about the costs related to both structural and non-structural flood mitigation and where the money for mitigation is going to come from.
- The City has a responsibility to protect flood prone communities.
- Property owners have to accept the risk associated with living in a flood-prone areas.
- A fair process to decide which combination of measures to implement should be considered in order to provide flood mitigation across the province (online respondents).

SUSTAINABILITY ANALYSIS

The sustainability analysis evaluated each flood mitigation scenario in the areas of social well-being, environmental protection, economic well-being and ease of implementation. Each theme area was equally weighted, and the criteria within each area were assigned individual weightings based on:

- Input from the Community Advisory Group
- Input from the public telephone survey
- Feedback from the public engagement workshops
- The City's Triple Bottom Line Policy, Sustainability Direction, and watershed goals
- Best practices in sustainability analyses

Sustainability analysis criteria – Four themes



*Equal weight applied to each theme

Watershed level mitigation in general scored high due to the potential climate adaptability and water security benefits provided relative to barriers, geographical extent and equitability of protection along the entire river, as well as the lower level of community disruptions caused by upstream mitigation compared to barriers. Scenarios including watershed level mitigation and complementary barriers scored higher than fortification of the rivers by barriers alone and watershed level protection alone.