CCE AWARD SUBMISSION

RECOVERY & RESILIENCE
FLOOD MITIGATION INNOVATION

Golder Associates

PROJECT OUTLINE

In June 2013, large scale flooding in southern Alberta rearranged river beds, moved material on a large scale, eroded banks and in some cases altered river alignment. Amid extensive recovery efforts, the City of Calgary challenged Golder Associates to improve existing methods of interpolating river data. A custom interpolation method and tool were created, where none previously existed. The resulting flood maps are an essential risk mitigation tool in managing future flooding.

PROJECT HIGHLIGHTS

Innovation and Technical Excellence

Golder Associates (Golder) conducted a post-flood river survey of the Bow and Elbow Rivers, updated hydraulic models (a computer model of a segment of river) for inundation mapping (flood maps) and interpolated river survey data. Previous interpolation methods were not considered sufficient to accurately capture the river banks. The City of Calgary (the City) required high quality interpolated river data to ensure accurate one-dimensional hydraulic modelling, allow for construction and erosion protection design, fish habitat assessment, morphodynamic and bank stability modelling and potential future two-dimensional hydraulic modelling. To address the City's request, Golder created a custom interpolation method and implemented the approach as a GIS-based tool.

Golder had previously (2009 to 2012) conducted comprehensive surveys of the rivers in Calgary and produced one-dimensional hydraulic modelling used to update flood maps. The floodwaters of 2013, however, rearranged the river beds, moved material on a large scale, eroded banks and shorelines and in some cases altered the river alignment. Several bridges were closed, or impacted as a result of rising water levels as seen in Photo 1, below.

Research revealed that there was no existing tool capable of meeting the City's requirement. In order to create the required, high-quality data, Golder needed to rethink the existing method of data interpolation. As such, a technique was devised and applied that only existed in theory: that a fishnet pattern would more accurately fit on a continuous irregular path (a river).

Due to resource and accessibility constraints, rivers are often surveyed in cross-sections. Typically, one-dimensional models are based on surveys conducted at cross-sections at regular intervals (for example every 200 meters along the river) under the assumption that a series of cross sections provides a representative approximation of the channel geometry. However, the City was planning to use the data generated by Golder for other applications that require bathymetry (the shape of river beds, ocean or lake floors) along a continuous path.

The approach developed for this project proved to be the solution. By using a fishnet method (a grid with lines drawn in longitudinal and cross-river direction) that was fitted in the river channel, creation of a continuous dataset was now possible.

Photo 1 - Calgary's historic Centre Street bridge was inundated by the rising Bow river.

Complexity

The project required the interpolation of continuous bathymetry as illustrated in Figure 1, along the Bow and Elbow Rivers. Common commercially available interpolation methods are GIS-based (Geographical Information System) and include inverse distance weighting, spline natural neighbor and kriging. The majority of these interpolation methods are isotropic, (interpolation is indifferent to direction) but river bathymetry is shaped by the flow of the water and is anisotropic (directionally-dependent). Isotropic interpolation is useful when survey points have been collected densely and at an even distribution. However, it will not yield appropriate results when cross-section surveys are used as input.

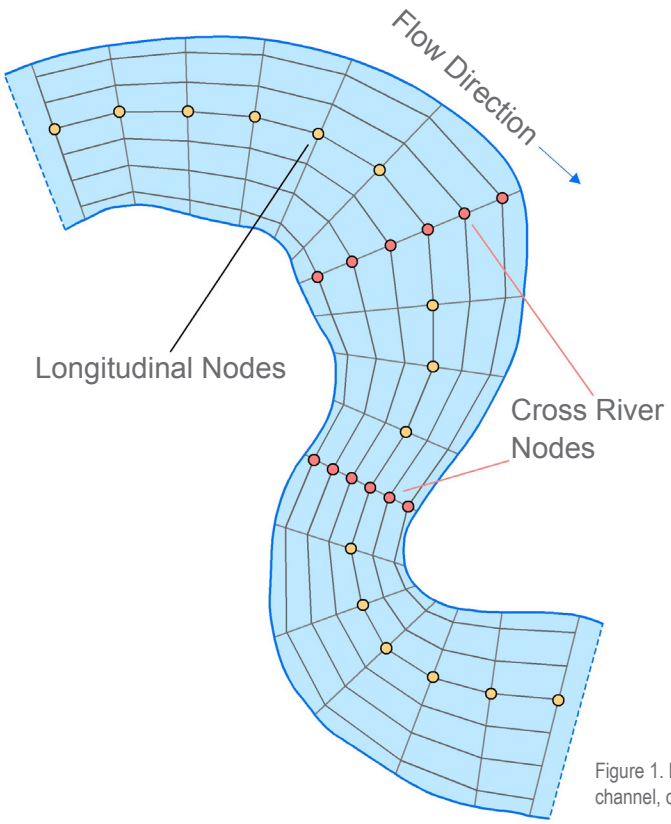


Figure 1. By using a fishnet method that was fitted in the river channel, creation of a continuous dataset was now possible.

Though anisotropic bathymetry interpolation is available off-the-shelf as part of hydraulic modelling packages, these tools interpolate between cross-sections and take into account only the general alignment of the river. This results in a bathymetry surface that is unable to be seamlessly integrated into the terrain surrounding the river.

The results from previous interpolation approaches proved unable to seamlessly integrate the irregular, meandering shape of the rivers with surrounding topography. With this latest advancement, the quality of data produced by the fishnet interpolation method now allows for more accurate one-dimensional modelling. It has also enabled the City to use the products for a variety of additional applications, such as fish habitat assessment and bank stability modelling, therefore allowing for a greater understanding of the powerful Bow and Elbow Rivers.

Social and/or Economic Benefits

Thousands of people were displaced from their homes, residential and commercial property was damaged and four people lost their lives in what was the worst flooding in southern Alberta in decades. Much of Calgary's downtown, headquartering multiple multi-national, sizable corporations, was inaccessible for almost a week. Statistics Canada estimates, "The Alberta private sector lost $485.3 million in real GDP from the net working hours lost during the last two weeks in June. Factoring in public sector working losses, we would estimate approximately $500 million in economic impacts."[1]

This project contributed to more sophisticated flood maps. These maps are the prediction of the areas of the City that will be affected by floodwaters at a given amount of rain and snowmelt.

Flood mapping serves two main purposes:

1. It helps to quantify risk and increases awareness of potential hazards.
2. It aids the planning of flood mitigation measures, including emergency plans (evacuation), community urban planning (making sure new communities are not built in areas prone to flooding) and engineered flood protection (berms and floodwalls).

[1]Parkatti, Michael "Economic Commentary: Impact of Southern Alberta Flooding on Hours Worked and GDP" September 6, 2013 http://www.albertacanada.com/files/albertacanada/SP-Commentary_09-06-13.pdf

Golder Associates

The update to the inundation mapping (a map detailing the area that would be flooded), as well as the improvement in data creation in order to enable further applications, provides an in-depth knowledge of the river needed to minimize the social and economic consequences to people and property of future flood events. Photo 2 and Photo 3 are examples of the extent of damage to infrastructure and communities as a result of the 2013 flood. The interpolation approach, using a fishnet pattern to more accurately fit on a continuous irregular path, has been converted into a tool that will have ongoing use in flood mitigation and can be applied to model any river.

Environmental Benefits

In reality rivers have varying depths. The Bow River has gravel banks in several places that cause various water level depths on either side of the channel, for example. River velocity varies at different depths. Shallower depths often have slower moving water and less velocity. Deeper water often has higher velocity. Understanding river velocity is beneficial in protecting the environment.

Fish prefer different water beds depending on the activity e.g., spawning, resting or migration. Flow velocities can be used to map fish habitats according to the activity. Fish that are spawning prefer slower, shallower water.

The results of the fishnet interpolation method can be used in applications such as river engineering and the mapping of fish habitats. With a better understanding of flow velocities, river engineering such as the development of bank protection, protecting against scouring (deep erosion forming holes), bank failure and erosion, is possible. Photo 4 below, shows the extent of inundation as a consequence of the 2013 flood.

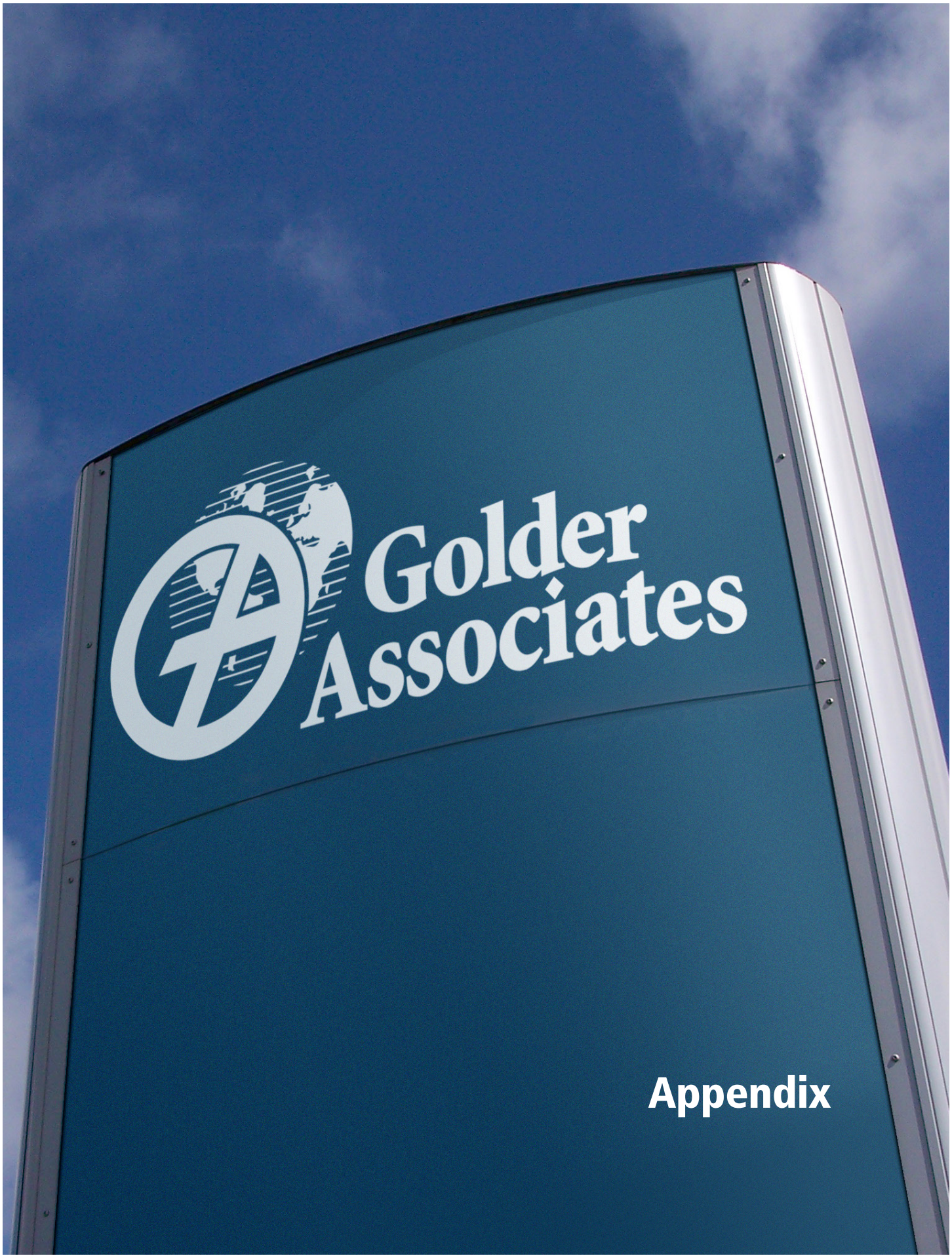
Photo 2 - Neighborhood under water. Several communities were evacuated during the flood, leaving many families displaced for days.

Photo 3 - Road washout after the flood.

Meeting Client's Needs

The City of Calgary was looking for a high-quality river bathymetry surface, able to be integrated seamlessly into the surrounding topography. Well integrated surfaces consisting of bathymetry and topography allow for accurate modelling of flood events of all sizes. This data is being applied in current project work for the City involving hydraulic modelling and inundation mapping. With this innovation in interpolating river data, the City of Calgary can better plan long-term mitigation strategies and tactics, and put additional emergency response measures into place.

Photo 4 - Stranded vehicles in one of many flooded communities.



Appendix

Summary

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CATEGORIES A-F

Innovation

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