CANADIAN CONSULTING ENGINEERING AWARDS 2023

CALGARY CITY-WIDE STORMWATER MAPPING AND MODELLING

LOCATION: CALGARY, AB
CLIENT/OWNER: THE CITY OF CALGARY
LEAD CONSULTANT: ASSOCIATED ENGINEERING

Associated Engineering

CANADIAN CONSULTING engineer

ASSOCIATION OF CONSULTING ENGINEERING COMPANIES | CANADA

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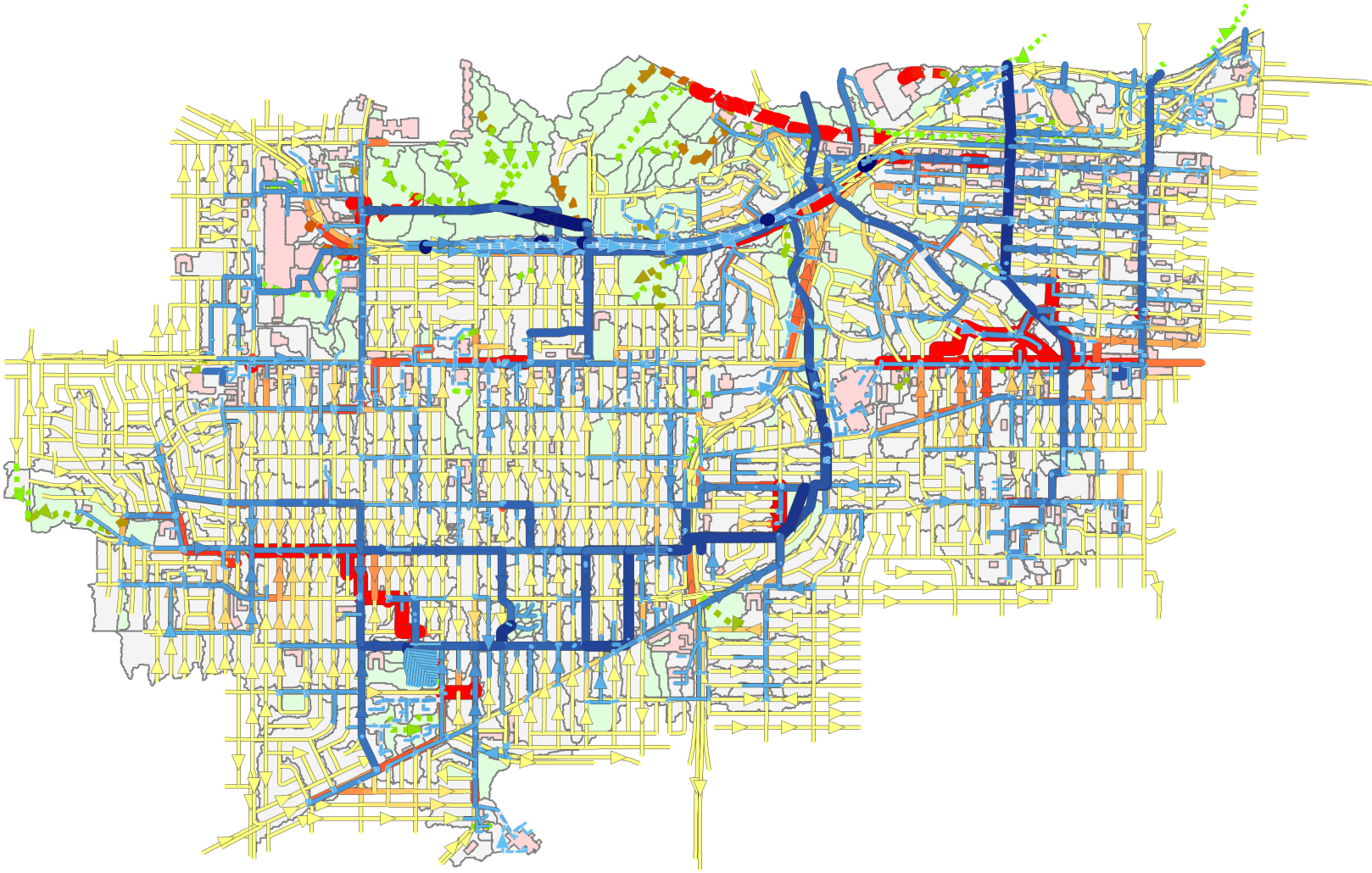

CALGARY CITY-WIDE STORMWATER MAPPING AND MODELLING

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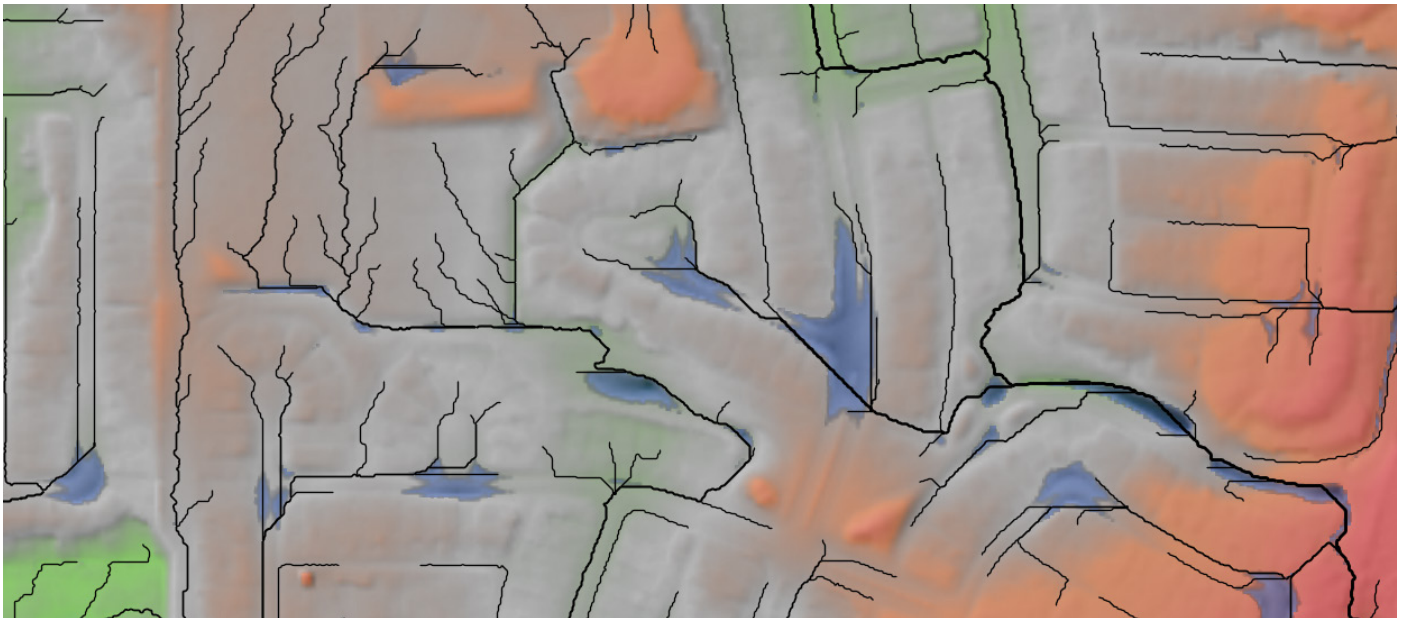
PROJECT SUMMARY

The City of Calgary engaged Associated Engineering to develop GIS mapping and stormwater models of neighbourhoods that experienced flooding during heavy rainfall. The Associated Engineering team used automation and spatial programming to deliver highly detailed stormwater models and detailed overland drainage maps with City-wide coverage. City staff can now respond quickly to concerns and make informed decisions to reduce flood risks, protecting public safety, property, and the environment.



INNOVATION

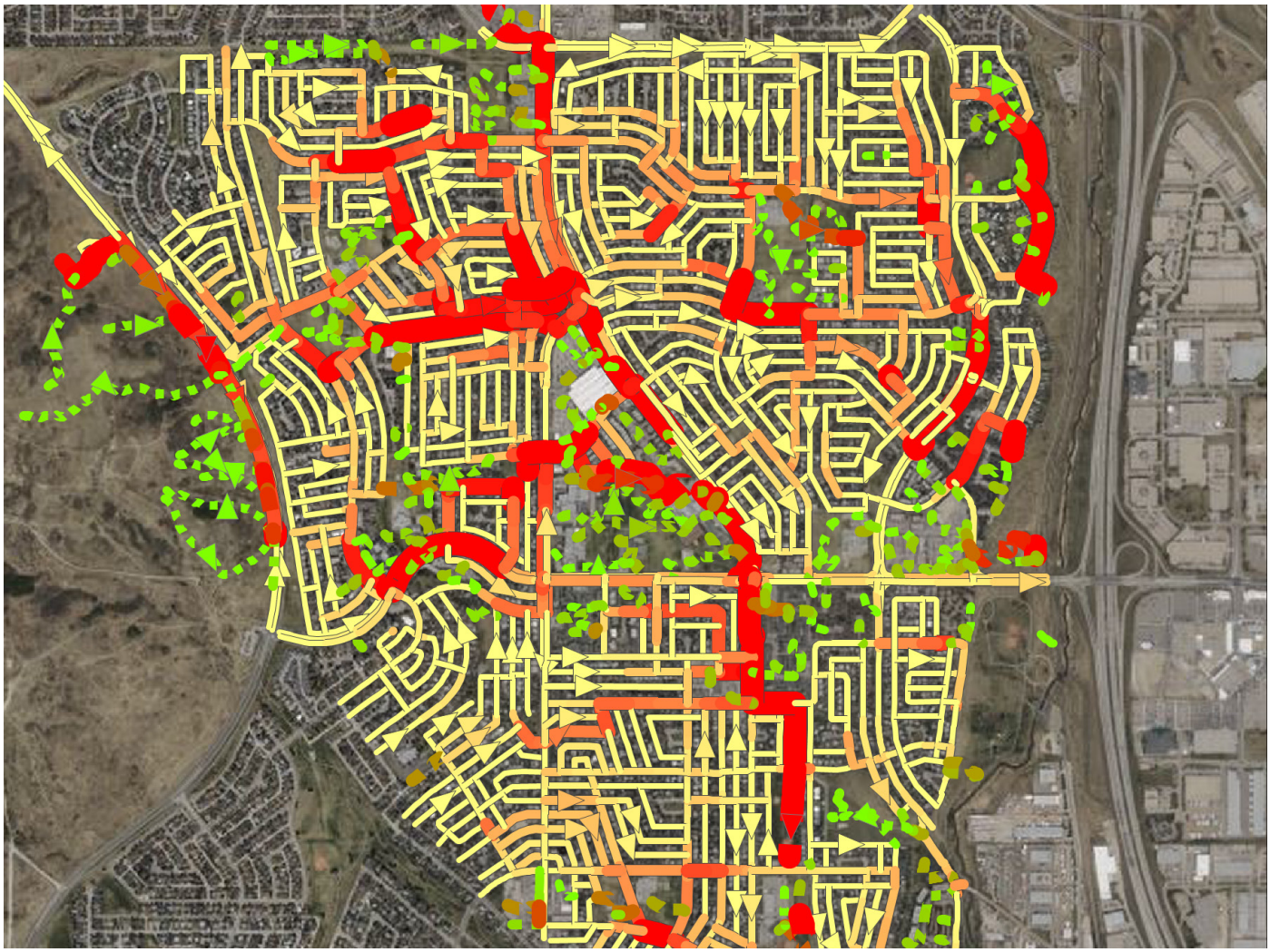
The City of Calgary engaged Associated Engineering to develop flood mapping and stormwater models with City-wide coverage. The goals of the study were to: create topologic mapping of depressions (trap lows) and overland flow routes (streamlines); develop a dual drainage (piped and overland) stormwater modelling specification; and build detailed stormwater models to the modelling specification. The scale of the assignment was unprecedented and required a significant amount of programming to yield the maximum value to The City.

Trap Low Data: Trap lows store stormwater, slowly releasing it into the piped system; however, they can pose a risk or liability when improperly designed. Using advanced spatial routines, Associated Engineering rapidly delineated thousands of trap lows to identify areas at risk. Leveraging The City's newly acquired LiDAR survey, Associated Engineering employed a vector-based approach for the analysis. The analysis was programmed in a GIS which allowed additional information (depth, volume, spill elevation, and bottom elevation) to be associated with each depression.

Streamline Data: Streamlines represent overland flow paths and show the spill direction between trap lows. Together with the trap lows, streamlines are used to create the major system of the stormwater models. However, streamlines can also identify houses at risk when overland flow is predicted to spill between houses. The ultimate deliverable included GIS attributes, such as upstream area and rank attribute, to characterize the potential for overland flow.

1D Model Building: The scope of the project included creating "as many models as possible". This unconventional approach required development of a comprehensive specification to determine the level of detail within each model. Despite requiring a large number of models, The City also required a high level of detail. To achieve these goals, Associated Engineering engaged with The City extensively on the specification, then programmed it in a GIS environment. The advanced automation allowed team members to rapidly produce highly detailed stormwater models to the agreed upon specification.

The unique project approach allowed Associated Engineering to significantly exceed The City's expectations. To date, 33 stormwater models have been completed alongside the City-wide trap low and streamline deliverables. Using this data, City engineers have significantly improved response times to drainage issues and have a far better understanding of their stormwater system.



COMPLEXITY

The main challenge encountered was the scale of the analysis and the size of the LiDAR information. The nature of the mapping assignment required that the entire City (850 square kilometres) be processed at once without dividing the data into smaller pieces. Traditional GIS software would either be prohibitively slow or crash under the data size.

To manage the magnitude of the assignment, Associated Engineering used a brand-new GIS software, Manifold 9. The software was built fully parallelized and indexed, which significantly sped up the analysis. With faster software, we invested in a powerful supercomputer to further upscale the analysis to the point where the mapping analysis could be conducted on the entire city at once. Code written in spatial SQL was also optimized for speed on large datasets.

Another significant challenge was programming the specification into our GIS software. Numerous challenges had to be overcome and programmed in a transparent manner. For example, the project team needed to develop code to snap thousands of pipes into a network and interpolate/extrapolate missing inverts which could constitute up to 70% of the network. Further complicating the matter was the presence of erroneous data in The City's GIS databases. Associated Engineering developed routines to flag and remove probable GIS errors, which were often the result of manual user entry.

Other examples of challenges included: merging streamline data with street centerlines; adding highs and lows into the street network; developing a hydraulically stable specification; and developing catch basin inlet curves.

SOCIAL AND ECONOMIC BENEFITS

Prior to this project, The City of Calgary responded to drainage complaints, sometimes with little to no information. Often, they were required to hire a consultant to undertake a drainage study to identify problems and solutions. This process could take years and resulted in an inequitable level of service across Calgary.

The information developed as part of this project has allowed The City to triage and analyze drainage issues in-house, thus significantly speeding up customer response times. City engineers use the GIS mapping information on a daily basis to advise redevelopment, identify stormwater risks, and explain drainage issues to internal and external stakeholders.

The stormwater models are now used as the basis for design and construction projects across Calgary. Their consistent specification and standardized nature have provided uniformity and given The City confidence in the stormwater modelling. The availability of the models has also reduced costs for The City, as model development has traditionally been a costly exercise. Previous to this project, development of a model could have been prohibitively expensive for a small project.

The GIS information is now being used for a variety of risk assessments. One example is an operation and maintenance plan to prioritize boiler truck maintenance on frozen catch basins during spring chinook and snow melt events. Another example is how the data has been used to identify homes at risk, prioritize future drainage studies, and inform long-scale redevelopment. The comprehensive data helps The City reduce flood risk and protect public safety.

ENVIRONMENTAL BENEFITS

The trap low and streamline deliverables were used by Associated Engineering to support the development of a natural asset inventory as part of a separate project. Using GIS means, the data was overlaid with natural assets to monetize their ability to retain stormwater runoff. Without the hydraulic attenuation of these natural assets, a significant amount of grey infrastructure would be required to mitigate the effects of higher runoff and peak flows downstream.

The stormwater modelling specification was designed to be flexible to accommodate the future impacts of climate change. The models were setup with future IDF curves, and climate data such that the resiliency of existing and future infrastructure could be tested. Associated Engineering will use these models and their future IDF curves to stress test infrastructure on the Lift Station 4 and RT Alderman community drainage improvement projects.

Associated Engineering also used the models created as part of this project in the Local Area Planning program to assess the downstream environmental impacts of redevelopment. The effects of increased impervious area due to infilling and urban redevelopment can now be quantified across Calgary. The City's river engineering group is using these models to quantify the effects of urban runoff on the sensitive water body of Nose Creek.

City staff are now able to make informed decisions to improve its stormwater system, as Calgary grows with land development and responds to urban drainage problems. The City is now able to quantify the impacts on the land, riparian areas, rivers, and streams.

MEETING CLIENT'S NEEDS

Associated Engineering delivered state-of-the-art, City-wide stormwater models, including 33 of an anticipated 46 models covering 70% of the pre-1988 City boundary or 63% of The City's total model area, and a GIS relational database for the trap lows, streamlines, and risk analysis.

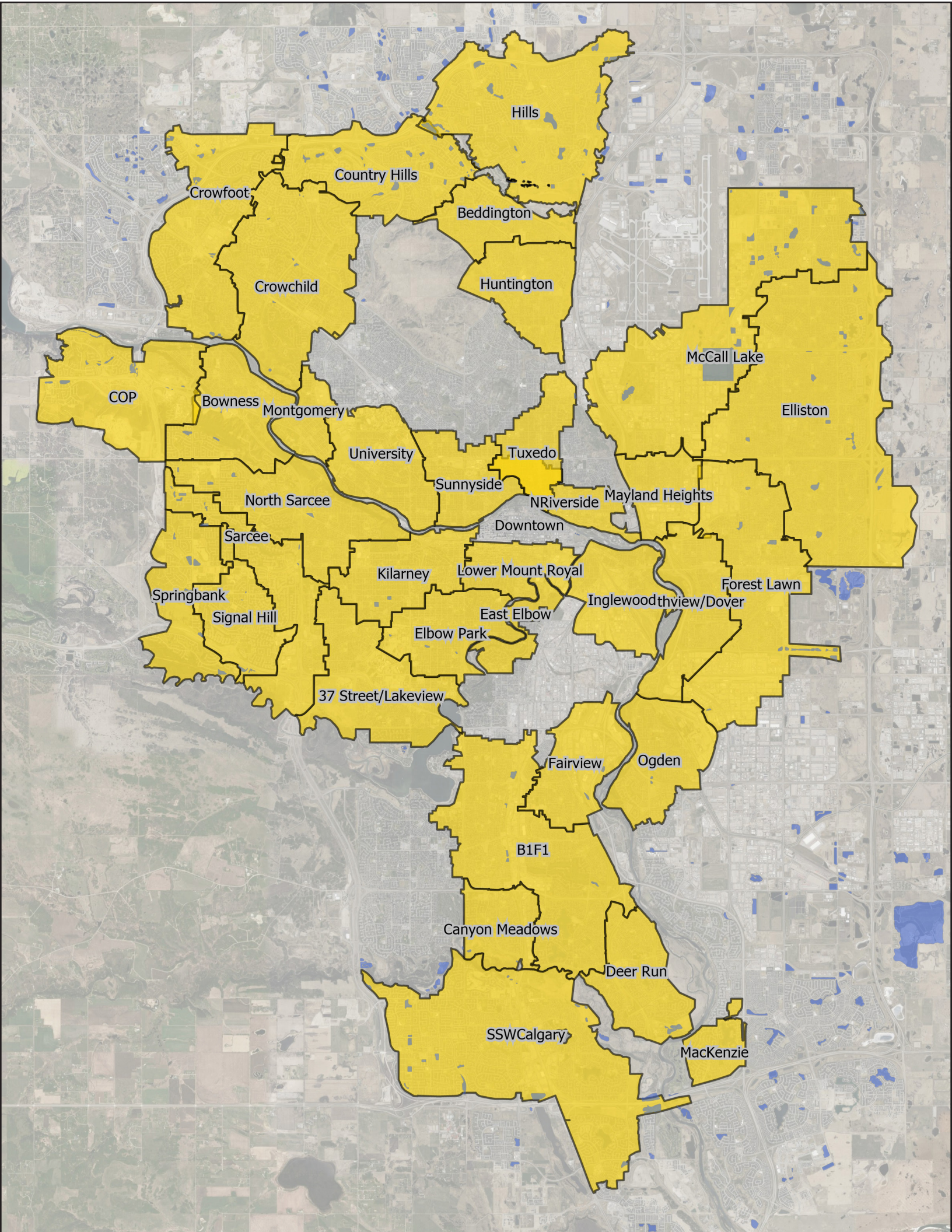
The models revolutionize stormwater analysis for The City of Calgary. Associated Engineering's automated model generation allows The City to significantly reduce the time required to respond to Calgarians' concerns during heavy rainfall and snowmelt events. City staff are equipped to rapidly assess 311 drainage notifications and conduct their own preliminary modelling. They can also efficiently evaluate the impacts of future growth on the stormwater system. Feedback from City staff indicate that the GIS products have become crucial to daily operations.

The City has distributed these models on a variety of projects, ranging from watershed modelling to planning to drainage improvements. These models have reduced costs for The City, as it no longer has to prepare new models on every project.

The model specifications are consistent; model methodology was transparent and comprehensive; and development employed modern software, giving users confidence with the models.

In June 2020, a heavy rainfall event offered a unique opportunity to validate the models. This partial validation provided assurance to the City that the models predict reasonable results and are appropriate for general use.

The City-wide stormwater models cover a broader geographic area than before, helping City staff make more informed decisions on maintenance and operational activities, while protecting public safety, property, and the environment.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