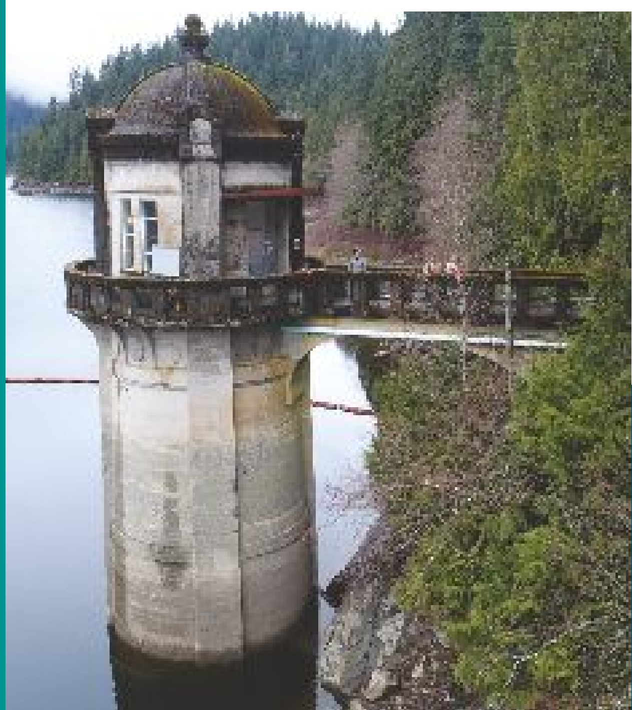
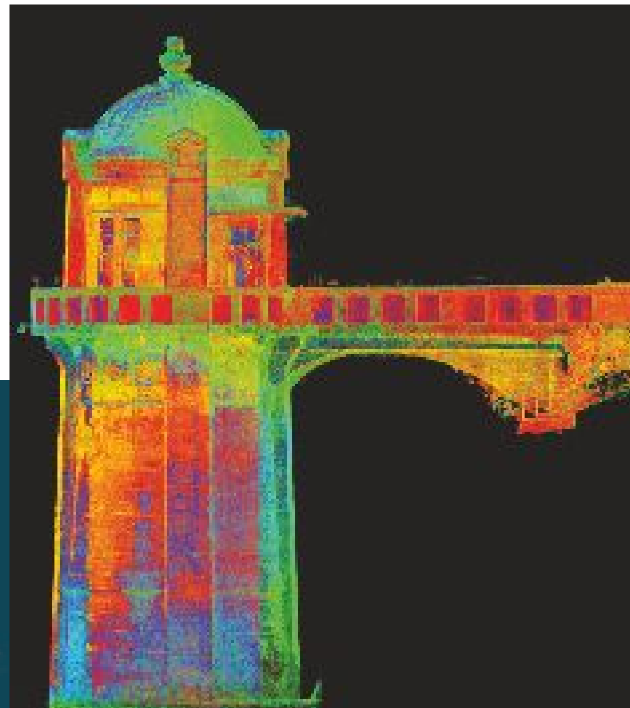
The Coquitlam Water Intake Tower's Digital Twin

Prepared for the Canadian Consulting Engineering Awards 2019

Submitted by: McElhanney

Category: F — Special Projects





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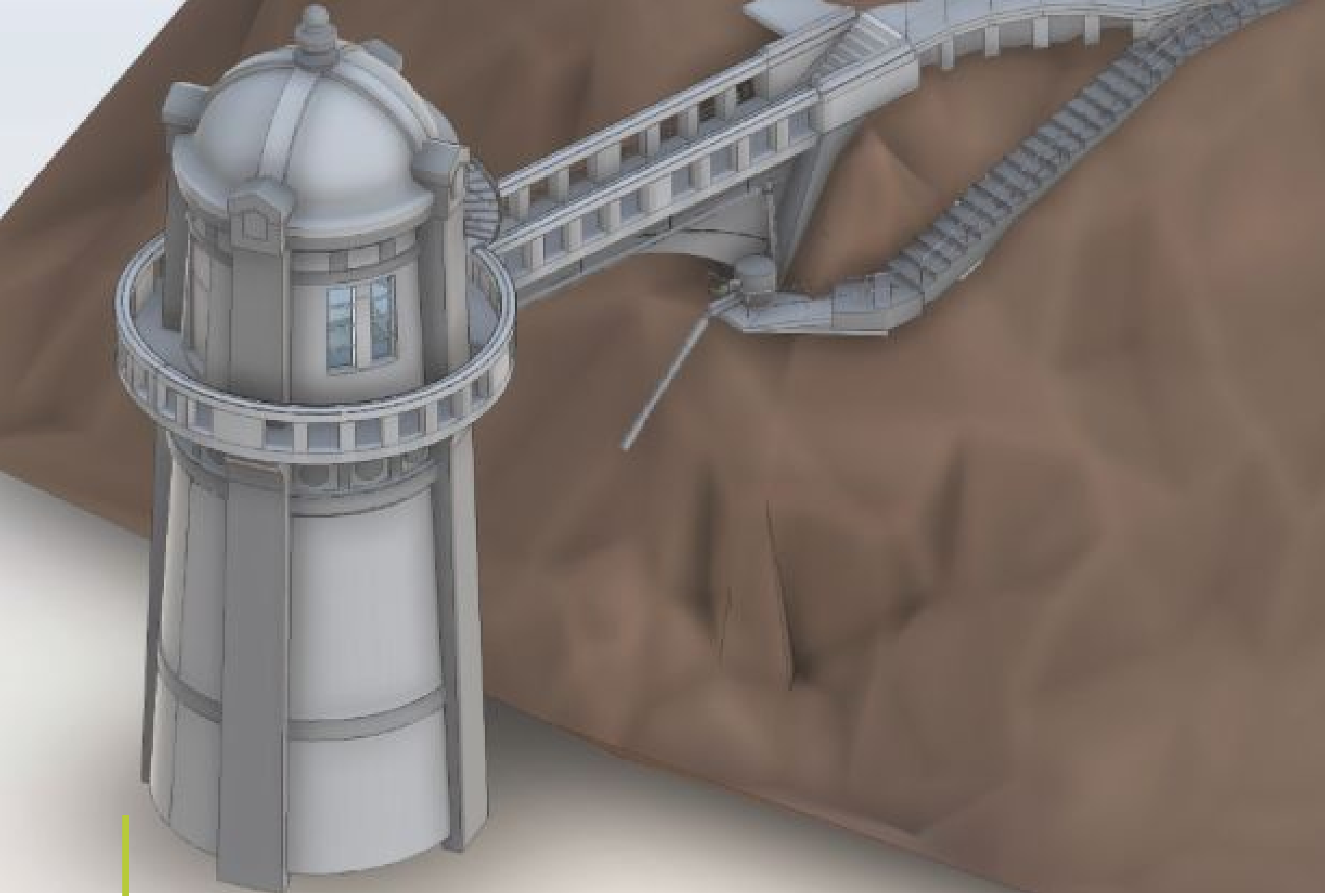
Project Outline

TAB 3

1. 75-Word Project Summary

McElhanney provided Mott MacDonald with high-definition survey data capture and 3D modelling for a structural seismic upgrade of the Coquitlam Reservoir Intake Tower, which is in the most active seismic region of Canada and provides 33% of Metro Vancouver's water supply. McElhanney used the latest tools including laser scanning, drones, and multi-beam bathymetry to produce 3D models of the tower and then uploaded into virtual and augmented reality, to optimize constructability and design.

A landmark historical structure, the tower was built in 1913. Consultant Mott MacDonald proposed to complete a seismic structural upgrade of the tower and brought McElhanney on board for high definition survey data capture with a point cloud conversion to a detailed 3D model.



McElhanney produced a 3D model of the Coquitlam Water intake tower from the data capture creating "digital twin" of the tower and surrounding terrain.

2. Project Highlights

Q1. INNOVATION

THE DIGITAL TWIN

The Coquitlam Water Intake Tower in Coquitlam, British Columbia, was due for upgrades to update, stabilize, and protect the tower in the event of seismic activity. Mott Macdonald, who was contracted to perform the upgrade, retained McElhanney to capture data. Because the tower is mostly surrounded by water and in a protected watershed, this was going to be challenging. McElhanney used high-definition survey methods to create a 3D "digital twin" of the tower that, together with high-definition photos, reduced the need for recurring site visits.

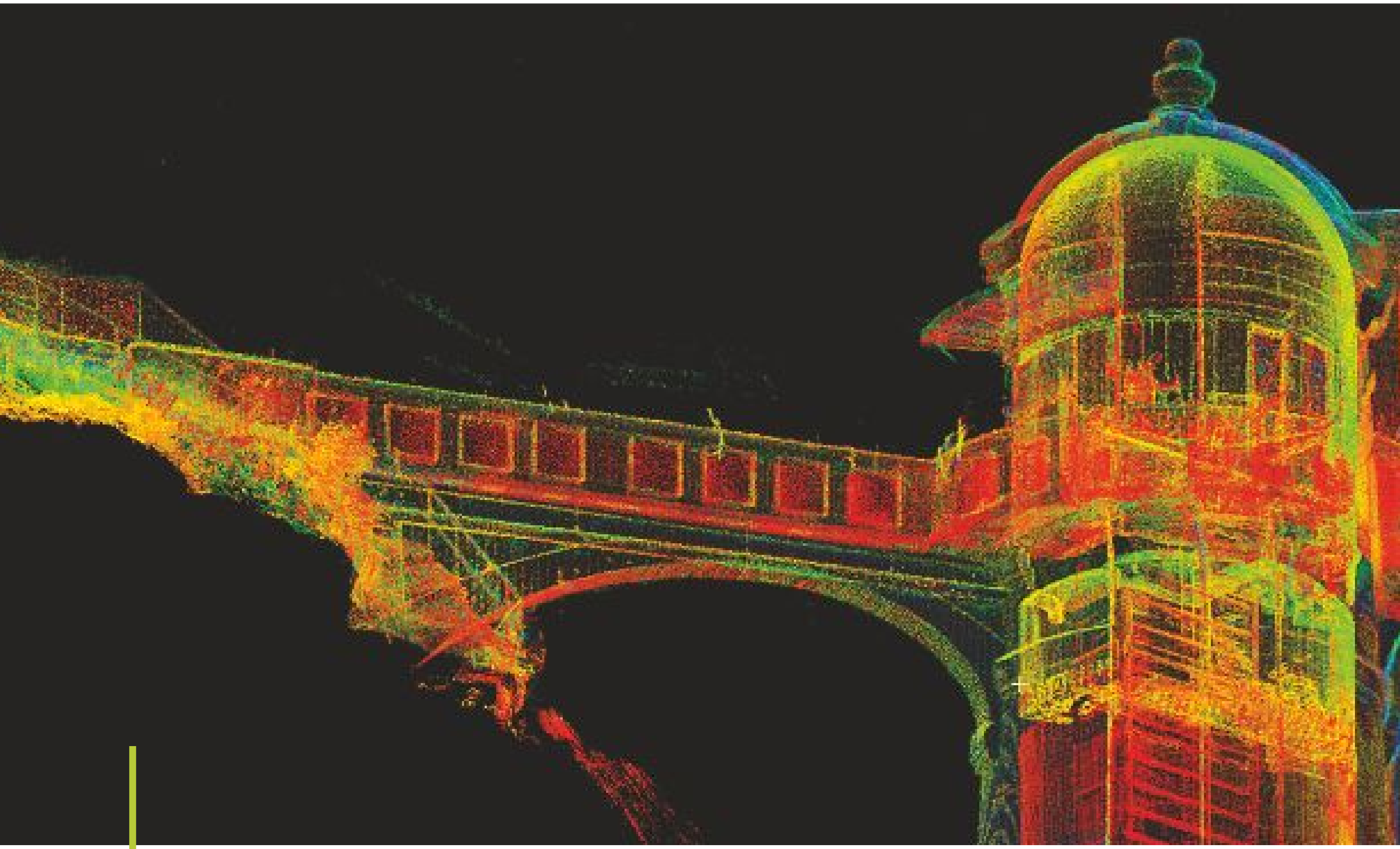
APPLICATION OF PRINCIPLES & TECHNIQUES

The data produced by McElhanney's unique use of high-definition survey methods is the foundation for the upgrade design which will stabilize this historical infrastructure in a restricted site. This project is a stellar example of how advanced technologies saved time, cost, and effort, and how technology is influencing the trajectory of the surveyor and engineer.

McElhanney used 3D laser scanning, drones, and multi-beam bathymetry to capture the data, resulting in a merged point cloud of almost 1 billion points (a point cloud is a collection of points produced by high-definition survey equipment that are capable of capturing every imperfection in a structure). Conventional surveys for similar projects might produce about 5,000 points, which means McElhanney's point cloud represented a 20 million percent increase in data density.

Above-water features were captured using 3D laser scanning which comprised 70% of the data, while drones captured the remaining 30%. Multi-beam bathymetry was used to map underwater topography. This high level of detail and density meant the data could be transformed into 3D models with a reduced margin of error when compared to relying on historical record drawings.

McElhanney's models were uploaded to augmented (AR) and virtual ¬ (VR) reality platforms to allow virtual access and minimize site visits. The advantage being that three-dimensional models do not require interpretation, like traditional two-dimensional survey plans. VR allows users to put on a headset and view the proposed design in an immersive environment, while AR overlays virtual objects in a real-world environment using either a headset or a user's smartphone or tablet. The design can then be assessed well before construction. The client accessed the point cloud and photo capture dataset via a website that functioned like Google Street View but can take measurements directly from the photo environment. Both solutions meant the design team could complete work with reduced visits to the protected site.



High resolution image capture is merged with the point dataset to create a coloured cloud. Each image pixel corresponds to a point in the data capture and provides real world colouring to the cloud.

McElhanney produced a high-definition point cloud of almost 1 billion points. Traditional survey methods may have produced 5,000 points for this project.

Q2. COMPLEXITY

Since the merged point cloud was created by stitching together different datasets, the level of complexity was high in all aspects when compared to a standard survey and required extensive in-house coordination.

For the dataset, each piece of equipment created its own point cloud with differing accuracies and the final result had to be consistent and seamless. In-house coordination between various departments and personnel was required to quality check every stage of the process before the final point cloud was produced. McElhanney used personnel from Vancouver and Surrey branches in survey and mapping to work as one team to process the data.

McElhanney also had many site complexities and safety challenges to consider. Several training certifications were required by field staff to complete the work, including watershed orientation, confined space and fall arrest training for the tower interior, and water safety training for the bathymetry work.

As a protected watershed, there were many site constraints to overcome and watershed protection regulations to follow. McElhanney coordinated the survey with other onsite activities to minimize visits to the sensitive watershed. Access was arranged and controlled by Metro Vancouver who also needed appropriate persons on site. There were also several site regulations that McElhanney's staff had to follow for the equipment being used. For example, all field vehicles needed to be disinfected to avoid introducing unwanted bacteria and McElhanney had to use an onsite water vessel not optimal for the required equipment being used.

Q3. SOCIAL & ECONOMIC BENEFITS

It is difficult to overstate the relevance of the tower to communities in the Metro Vancouver region, given its role in the supply of clean and reliable drinking water. The Coquitlam Reservoir is the largest of Metro Vancouver's three reservoirs, which each provide 33% of the region's drinking water. During peak summer months, Coquitlam's can increase to 50%. All reservoirs contains multiple pieces of infrastructure, including pipes, to get the water out, however It is only Coquitlam that has an intake tower.

The Geological Survey of Canada estimates more than 1,000 earthquakes occur in Western Canada per year, with the Pacific Coast the most active region in the country. With nearly one million residents relying on this water supply, the failure of the water intake tower during severe seismic activity would undoubtedly impact this important water supply system. The public has a huge stake in the production of the Coquitlam Reservoir Intake Tower as it is the only way for water to leave the reservoir.

The tower is highly inaccessible from a survey point of view. To address this challenge, McElhanney used 3D laser scanning, multi-beam bathymetry, and drones to perform data capture.

The Coquitlam Reservoir Intake Tower is in an environmentally-sensitive watershed with restricted access.

Q4. ENVIRONMENTAL BENEFITS

The Coquitlam watershed is a critical source of drinking water for Metro Vancouver residents, making it a sensitive ecosystem that must be protected. To minimize human impact, it is closed to the public with the exception of registered tours and any work done is heavily regulated. As such, Mott MacDonald's team relied on McElhanney to provide a highly-defined digital dataset from which to base their upgrade design and reduce footprint in the watershed.

The use of 3D model i s a sustainable solution that greatly decreases environmental impact. McElhanney's 3D base model was so detailed and accurate, the project engineers could access the information for their designs without site revisits. This was critical on this project, given the logistical challenges, time, and cost in accessing and working on the tower. McElhanney's point clouds and 3D model deliverables were able to project a fully realized model of the intake tower, imperfections included, directly in front of the design engineers. A typical conventional survey would present results as linework on a site plan. While those lines may have had elevation data, the plan itself would have been two-dimensional and required interpretation and a trained eye to visualize and understand the site. In contrast, high-definition survey methods and their resulting point clouds, like the ones McElhanney produced for this project, reproduced the physical environment in an accurate digital replica. By doing so, the site became accessible without jeopardizing the ecosystem of the reservoir.

Q5. MEETING CLIENT'S NEEDS

Mott MacDonald was looking for a client that would be able to provide comprehensive data from a protected site with minimal environmental impact. The firm approached McElhanney because of a presentation McElhanney GIS manager Brendan Walashek gave at a conference which highlighted McElhanney's expertise in various technologies. Mott MacDonald was impressed and asked McElhanney to team with them to provide data capture.

The collaboration between McElhanney surveyors and Mott MacDonald engineers demonstrated how consulting engineering is increasingly a multidisciplinary practice. McElhanney is made up of both surveyors and engineers, so McElhanney understands how to tailor survey deliverables for use, interpretation, and application by engineers.

McElhanney delivered the project ahead of schedule and under budget. McElhanney's structure and terrain modelling represented comprehensive data capture over the entire site and has therefore allowed Mott MacDonald engineers to make design changes earlier in the project, thus reducing costs and preserving schedule. The use of multiple techniques reduced field time, and the detail of the data was so comprehensive it minimized the need for return site visits, as the client could complete their design based off McElhanney's original field campaign.

McElhanney's data can be uploaded into virtual reality and augmented reality platforms, allowing the client to optimize design and assess constructibility, prior to construction.