

VanDusen Botanical Garden Water Conservation Project Report

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INTRODUCTION

One of the greatest challenges facing the modern world is the reality of our environmental impact on the planet, especially in our expanding urban centers. Falling under the broad concept of sustainability, these are issues like carbon emissions, waste disposal, environmental degradation and water usage that disrupt the biosphere and threaten the comfort and security of the future generations. With this in mind, the City of Vancouver has initiated a project known as the Greenest City 2020 Action Plan. This plan provides a comprehensive analysis of the city's current situation as well as concrete steps to move toward a sustainable future. One particular goal is to reduce the per capita consumption of potable water by 33% of 2006 levels (City of Vancouver, 2012). Strategies for reduction are targeted at residential, industrial and city park consumption. City parks make up only 4% of total city potable water consumption, but given that it is a sector that the city has direct control over, and watering practices can be quite wasteful, it is an area where major reductions can be achieved. The water consumption within these different parks is not evenly distributed, with the top 10 consumers making up 70% of all park water usage (Klein, 2015).

VanDusen Botanical Garden ranks fifth for water consumption of all city parks according to water meter data from 2015 (Klein, 2016). At 22 hectares, the park contains a beautiful variety of local and exotic plant life. Points of interest within the park include an interconnected series of water features, a defunct artificial underground reservoir and the recently opened Visitor Center that successfully achieved LEED Platinum Certification and the Living Building Challenge ("VanDusen Botanical Gardens," n.d.). In the past, efforts have been made to revolutionize park water usage by incorporating an underground reservoir that exists beneath the garden into the system. This project was never completed due to issues with funding and construction feasibility.

Currently, the City of Vancouver Parks Board and Sustainability Office have expressed interest in doing work on the park's water system in the near future.

The goal of this project is to outline the main uses of potable water within the park and investigate possible strategies to reduce current consumption, such as the feasibility of incorporating the reservoir into the current system. To achieve this goal, we created a three step strategy. Firstly, we conducted a review of existing literature on the park's water system. Secondly, a visit to the gardens themselves was done to establish ground truth on some aspects of the water system. Finally, using the information gathered, we have drafted a map of water flow and usage within the park and have several recommendations for reduction strategies. The results of this report will be useful for any future work done on VanDusen Garden.

METHODOLOGY

We initiated the project with an analysis of all available literature on the water system of VanDusen Botanical Garden, as well as several relevant blueprints and engineering plans. In particular, the EarthTech report for the Park Board on the VanDusen Botanical Garden that was written in 2004. As many changes have been made to the park since this report, we attempted to determine whether the information within the report is still relevant. Besides this, we assessed several documents for context surrounding water reduction in Vancouver city parks, such as Greenest City 2020 plan and 2014-2015 Implementation Update. In regards to the VanDusen Garden grounds itself, we assessed a number of technical drawings and maps of the area.

Next, we conducted an onsite visit led by Garden Superintendent James Warkentin. The purpose of this visit was to provide ground truthing for all researched information. A map of the

approximate locations of the water meters was provided to us by a community partner. During this visit, we cross-referenced physical locations with points marked on documents such as the water metre map, blueprints, park map and the background research. The final component of this project is the synthesis of our literature review and our field findings. All of our findings are compiled in the results section of this report.

RESULTS

Summary of Park Water Consumption

In 2004, the Vancouver Park Board hired Earth Tech (Canada) to draft a report on the water system of VanDusen Garden. Its mandate was to investigate solutions to several problems that had been identified with the current system. These problems included an outdated and inefficient irrigation system, low pond water quality during summer months, a defunct underground reservoir in unknown condition and an over-reliance on potable water that was particularly problematic during times of water restrictions. In the report, the calculated annual water consumption in the years 2001-2003 was 94 239 m³, 100 652 m³, 69 542 m³ respectively. Approximately 60% of this was used in irrigation, while the remaining 40% was used in various other outdoor and indoor uses (Earth Tech Canada, 2004). It should be noted that 2003 was a drought year in which water restrictions came into effect during the summer, and many delicate plants suffered damage because of this. We were able to obtain current city water meter data from the 6 meters that currently measure VanDusen Garden's water consumption (Vancouver Water Design Department, 2016). From this, we calculated that annual water consumption was around 57 000 m³ in 2014 and 55 100 m³ in 2015. This is around a 40% reduction from the 2003

annual usage. This massive reduction is likely due to changes that have occurred in the park during the last decade.

The report made two classes of recommendations to lower potable water consumption. The first was to decrease the demand through the modification of gardening practices and water features and the second was to increase the supply through the implementation of external water systems (Earth Tech Canada, 2004).

Irrigation

To reduce water needed for irrigation, Earth Tech recommended several changes that should be implemented. They proposed a large modernization effort to the irrigation system in both delivery and controls. This would address the inefficient sprinkler coverage and watering schedules and have to account for the different water needs of different plant species. It would have to be localized enough that each area's gardeners would have control over the delivery of the water. They also proposed a review of plant watering needs and the possibility of replacing some delicate plant species with more drought tolerant ones (Earth Tech Canada, 2004).

Our visit to the park did not reveal much new information on the irrigation system. However, given the massive reductions to the total water consumed by the park, we can assume that many of the Earth Tech recommendations were applied.

Water Features

The Earth Tech investigation of the water features revealed two main ways of water loss. Firstly, all open bodies of water suffer loss through evaporation which is particularly significant during the summer months. Secondly, some features experience water loss through leakage.

Lastly, some features did not recirculate, meaning water was being lost to the eventual outflow to the storm drains. The engineers recommended delaying the high budget repairs for the leakage and addressing recirculation as higher priority (Earth Tech Canada, 2004).

As with the gardening practices, the engineers recommended consulting with gardeners to determine to appropriate amount of water allocated to maintenance, as certain water features had downstream effects (Earth Tech Canada, 2004). Things like embankment preservation and the floating bridge between Heron Lake and Livingston Lake need a minimum water level to avoid problems.

During our visit, we discovered several changes that have been made to the water features since the time of the Earth Tech report. We will describe our findings in order of westernmost to easternmost water features, as this is the general direction of water flow. The stream that originates west of the stone garden and runs south beside the Alma VanDusen Meadow is recirculating but has a substantial amount lost to leakage. In spite of this leakage, the stream is made to run continuously year-round in order to prevent a fire ant infestation in the meadow from spreading to the rest of the park. The waterfall east of the Stone Garden flows year-round, and is partially recirculating, but due to significant losses from leakage and evaporation, it must be regularly supplemented with a potable water source. The overflow from this flows down into Shaughnessey Lake which can see low water levels in the summer months. There residents in the apartments overlooking the lake have regularly pressured garden staff to maintain a minimum water level of the lake for aesthetic purposes by increasing potable water input by the waterfall. On the east side of Shaughnessey Lake, there is a drain that leads to a catchment basin that flows to Forest Lake. We noted that the drainage from Shaughnessey seems to be far greater than what is actually reaching Forest Lake, which seems almost stagnant. This

may be an indication of some unknown obstruction or diversion of the flow from the catchment basin. Forest Lake then flows into Cascade Bend, which receives an input of stormwater diverted from a residential storm sewer that flows westward just north of the park's boundaries. At this point the water flows into Heron Lake. There is some piping that was built since the Earth Tech report that leads north for a bit before going underground. The garden superintendent says this piping then leads back toward the reservoir stops short beneath the falls and remains incomplete. Also feeding into Heron Lake, from the south, is Heather Pond, which is fed by a seasonal creek as well as runoff from the surrounding gardens. Heron Lake flows into Livingstone Lake, but is actually only one body of water insubstantially divided by the floating bridge. These two lakes must be supplemented with water during summer months as a minimum water level must be maintained to keep the bridge afloat as well as to prevent water quality concerns. The Western North American Stream is now kept flowing year-round into Livingstone Lake. It is unclear as to whether the water for this is potable municipal water or non-potable water collected by the Visitor Center. Finally, Livingstone Lake flows into Cypress Pond and from there, into a storm drain that flows north out of the park.

Indoor Water Consumption

The 2004 Earth Tech Canada's report on indoor water consumption has no information on the Visitor Center, as it was constructed in 2011. The report estimated the consumption based on urinals, toilets, sinks and taps from the bathroom and utilities in the restaurant's kitchen. The engineers recommended the installation of waterless urinals or conventional urinals with motion sensors. A cheaper option mentioned was the substitution of the 13 and 20 litre toilets with 6 litre toilets.

A new feature to the park that did not exist at the time of the Earth Tech report is the Visitor Center. Opened in 2011, the Visitor Center is a LEED Platinum Certified building with innovative features such as a green roof, grey water treatment system and a solar chimney. While the building uses municipal potable water, it attempts to be net zero on an annual basis through a variety of means. It has a system that collects rainwater from the roof and toilet sink water as grey water. Some of this is used to flush the building toilets, while overflow is fed to drip irrigation and a rock pit. The black water from the toilets is then put through a bioreactor and the water from which is directed to a percolation field (“VanDusen Botanical Gardens,” n.d.).

In spite of this, data collected show a failure to achieve annual net zero water consumption by a fairly large margin (Klein, 2015). Figure 1 shows the water consumed (blue line) and the water reclaimed (red line) over the course of 2014-2016. The water balance falls short by over 1 million litres in 2014 and 700 000 litres in 2015. The data is irregular, showing high amounts of water makeup in some months (January 2016 has a makeup of over 100% of water consumed), yet almost zero in a number of other months.

The reasons for this shortfall are not entirely clear, though two points are to be noted. Firstly, total water consumption is erratic, rising annually during summer months, when admission is high, and peaking sharply during December’s Festival of Light, which draws large crowds for a period of several weeks. This is problematic because summer months are also the time of the year with the lowest precipitation historically, meaning little water is being collected by the roof. The Festival of Lights is a very popular event that draws large crowds to the park. This has the effect of consuming huge amounts of water. In December 2015, this high consumption was matched by a high water makeup, but December 2014 had a recorded zero water makeup. The reason for this disparity is not known.

Another problem is with the water collection system on the roof. During our site visit, we observed several spots on the roof where water was spouting from and falling onto the tiles below. The design of the roof is such that it does not have gutters and this water spouting seems to be unintentional. It is significant enough that in one place, above the café patio, they have constructed a temporary measure to capture and divert one particular stream into the gardens. This is constructed out of aluminum sheeting and is very obtrusive.

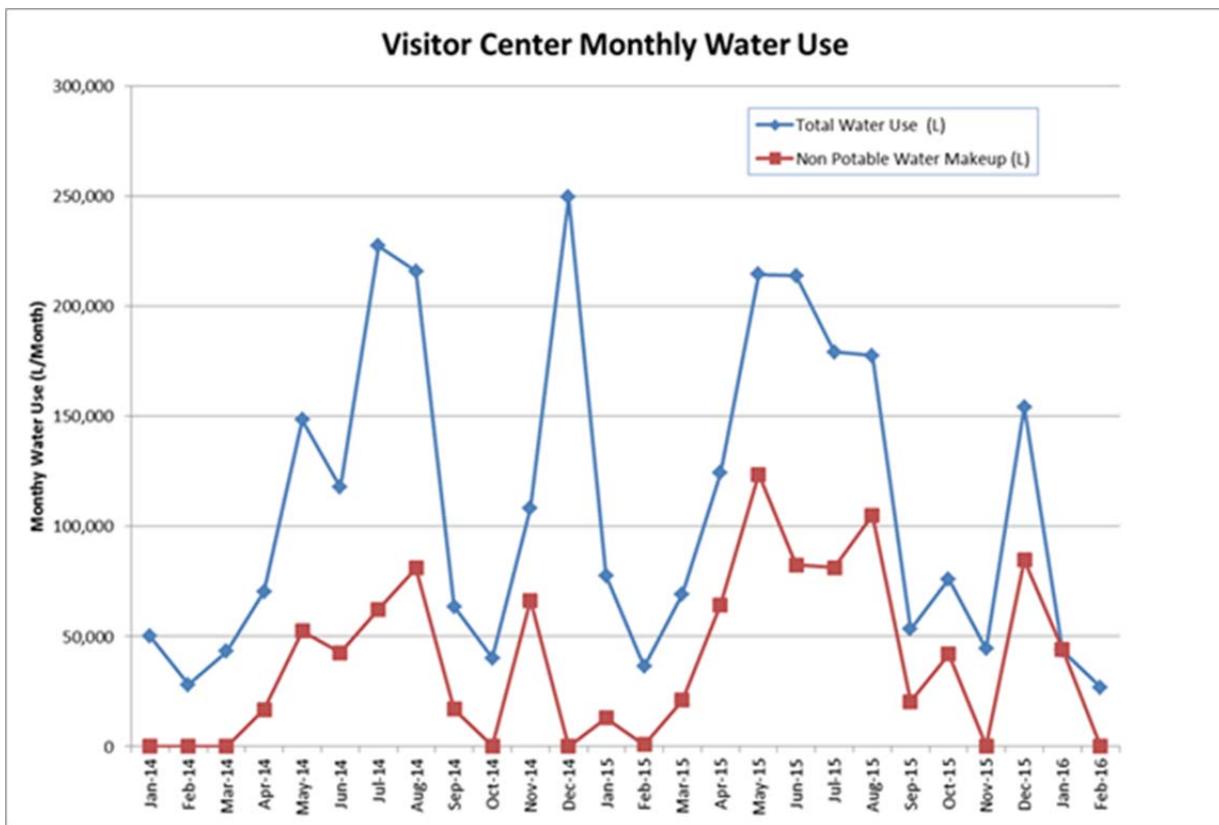


Figure 1: Visitor Center monthly water use over the course of 2014-2016. Blue line indicates total consumption of potable water. Red line indicates water makeup of non-potable water.

Stormwater Collection and the Reservoir

The Earth Tech report also drafted plans for stormwater runoff collection and storage in order to reduce potable water consumption through the introduction of stormwater as a secondary water source. As water from ponds and lakes was discharged to storm water sewers, redirecting storm water from constructed catchment sites to the ponds and lakes in excess would not create a problem.

The engineers calculated the productivity of storm water collection sectors with rainfall data from the Atmospheric Environment Services and the dimensions of the sectors. It was found the west adjacent residential area was an optimal site, in addition with the south where sanitary and storm sewers separated. The estimated total of 151 000 m³ of stormwater from the west catchment runoff of 36,000 m³ and the south catchment runoff of 115 000 m³ would be of sufficient supply for the estimated annual irrigation demand of 50 000 m³ provided a place to store it for the dry summer months existed (Earth Tech Canada, 2004).

One potential place does exist. Beneath the Stone Garden in the park, there exists the abandoned underground reservoir built in 1911 that has been decommissioned since 1960. In 2004, Earth Tech did a visual structural assessment of the reservoir. The reservoir consists of three separated cells, each accessible through its own manhole and ladder. The assessment concluded that there were no significant structural problems with the reservoir; however they were unable to do rigorous testing. Their recommendations consist of several structural tests that should be conducted should the reservoir be reopened for use. This included filling the reservoir to capacity and use X-ray and proper coring to determine safe roof load capacity. Additionally, tree roots that penetrate sections of the roof should be removed and further root growth should be discouraged (Earth Tech Canada, 2004). In light of the reservoir being constructed long before

modern earthquake safety standards, a seismic evaluation should also be conducted. Several areas of minor cracking should be sealed prior to refilling. As the single south side manhole access to each cell fails to meet modern code requirements for confined space entry, a second access must be added, preferably on the north side, before work can be done on the inside.

With this in mind, the report drafted a plan to incorporate the reservoir into the park's irrigation system, using it as a central storage facility for the proposed stormwater. The plan was to capture and treat stormwater runoff from the residential area west of the park, divert into Forest Lake, pump it into the reservoir, and from there distribute it to the rest of the grounds. At this point, there was a problem. The report calculated that with the required water for annual irrigation being 50 000 m³, even with periodic refills from precipitation based on long-term precipitation patterns, the storage capacity of the reservoir (15 000 m³) would be insufficient. A storage space of at least 37 000 m³ would be necessary. The report then recommends that the west catchment stormwater supply could also be supplemented with groundwater from wells. This would require a hydrogeological survey for groundwater wells.

During our site visit, we determined that the reservoir has remained sealed in the intervening years, and were unable to confirm if any of the recommended tests or repairs had been carried out. We did discover that some work had been done approximately 8 years ago in regards to building piping from the lower elevation water features to the reservoir. A length of pipe now runs from the north end of Heron Lake, north for a bit, before disappearing underground. This, according to the garden superintendent James Warkentin, runs all the way to the base of the waterfall in the Sino-Himalayan Gardens, but was left short of connecting to the reservoir due to several reasons, including mounting drilling costs, lack of funding, and staff changes.

DISCUSSION AND RECOMMENDATIONS

Due to the restrictions on time, resources and expertise, we were not able to investigate every aspect of the VanDusen Garden water system during our site visit. We were able to cover all the major water features, the Visitor Center and the area above and around the reservoir. We were unable to cover the southern gardens or the Meadow Ponds and the Heritage Pond. Aside from anecdotal notes from the superintendent and the water meter data, we have no direct technical information on how the new irrigation system functions. Nonetheless, using both document sources and the findings from our site visit, we are able to make several recommendations in regards to the water system of VanDusen Botanical Garden.

These recommendations are focused on reducing potable water consumption across the park in alignment with both the Greenest City 2020 goals and the stated mission of the garden to be a globally renowned leader in sustainability.

Firstly, in regards to the Visitor Center and its pursuit of annual net-zero water consumption, we would first recommend an investigation into the irregularities in monthly water makeup rates. As stated earlier, some months see a very high non-potable water makeup of over a 100%, while other months are registering zero water recovered. This seems less correlated with seasonal precipitation and more correlated with total potable water consumed within each month. Secondly, something should be done to address the rainwater that runs off the roof of the center. Whether this be an unobtrusive gutter that guides the water along the roof edge to a new collection point, or some sort of ground-level drain that captures the water. The sheer size of the roof as well as the number of areas where we noticed water coming down leads us to believe that this is a non-trivial amount of water being lost.

Another point of recommendation would be investigation into several areas of the water features experiencing water loss. The first site is the minimal water flow from Shaughnessey Lake to Forest Lake. Input into Shaughnessey Lake was intended to be diverted into Forest Lake through a catch basin and its piping. What we observed on site is that while significant water flows out of Shaughnessey Lake into the drain, Forest Lake seems to receive little of this, and remains almost stagnant. This is also obvious further downstream, where the incongruously named Cascade Bend has little more than a gentle trickle that runs between its boulders. As it had been raining several days prior to and during our visit, the flow should not have been this slow. Second, the recirculating waterfall east of the Stone Garden and the Alma VanDusen stream to the west were noted at having to be significantly supplemented with potable water due to losses from leakages. Repairing these leakages and identifying the cause of the disconnect between Shaughnessey and Forest Lake would allow for the potable water sources feeding the system to be used minimally and so allow the water meters in the area to be measuring exclusively for irrigation use.

As leakage repair is expensive and difficult to do, a temporary recommendation would be to install some type of meter to record the input of potable water at the top of the waterfall. This location is notable for its input of headwater for the Shaughnessey Lake, Heron Lake, Livingstone Lake and Cypress Pond. Potable water is introduced into the water system at this site to ideally top up all bodies of water in need of potable water downstream, and measuring this volume of water would provide the best estimate for the amount allocated to irrigation once the waterfall leakage is repaired.

We noticed through our on-site visit and the maps from the engineering report that the major bodies of water were interconnected in a unidirectional fashion. Due to the nature of the flow, any input of potable water to the streams, ponds, or lakes would be discharged into the storm sewer at the end of the system in Cypress Pond. As such, we recommend a technical analysis of whether it would be beneficial or even feasible to construct piping to redirect water entering the stormwater drain at Cypress Pond back into Heron, Forest, or even Shaughnessy Lake in an attempt to make the entire series of features partially or entirely recirculating. Installation of a filtration process would be necessary to ensure a satisfactory water quality is maintained should it be recirculated. A park-spanning recirculation system would mitigate the greatest source of water loss, drainage into the sewer, and while there would be a considerable price tag to the project, its implementation would be a significant decrease in potable water consumption. All in all, the proposal for the recirculation of the entire VanDusen water system is structured on the application of a common strategy for reducing the water loss of water features to the whole park.

Finally, the reservoir beneath the Stone Garden has long since been debated as a potential storage facility for stormwater from the residential catchments. As mentioned earlier, the reservoir alone does not have enough storage capacity to provide irrigation water throughout the summer when it is likely needed the most. When speaking to the superintendent about the current state of the reservoir and incomplete piping, he was of the opinion that completing the project at this time would be far too costly. Should the reservoir be incorporated into the water system, the final stretch of piping would need to be completed that would go through the large boulders around the waterfall to reach the reservoir. Besides this, the entire output of the reservoir would still need to be built, a pump-house created, as well as a method of integrating this into the

current irrigation system. Construction of the piping to connect the existing infrastructure to the reservoir would mean temporary or permanent damage to nearby park attractions, such as much of the original stonework that exists in the Sino-Himalayan garden. In addition, with safety protocol being far more stringent in today relative to decades past, sending workers into the reservoir for a status update demands significantly greater expenditure. Thorough safety tests and the construction of alternate access hatches to the reservoir cells would quickly increase costs before real construction even began. In light of these problems, our recommendation is to postpone the completion of the reservoir until a more cost-effective method presents itself or a severe demand for additional water storage comes to be.

CONCLUSION

The VanDusen Botanical Garden is valuable not only as place to showcase botanical and natural beauty, but also as a place to push the boundaries of sustainable practices. Using a combined method of assessing available literature, city data and our site visit, we we able to map the stocks, inputs and outputs of the main VanDusen water feature system. We were also able to provide updates on the status of elements from the Earth Tech report made back in 2004, such as the reservoir. Lastly, we found data that suggests that the Visitor Center has a long way to achieving its goal of net-zero water usage. It is in our hopes the information collected from our investigation will assist the City of Vancouver Park Board and the staff of VanDusen Garden in any future improvements to the park's water systems.

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BIBLIOGRAPHY

City of Vancouver. (2012). Greenest City 2020 Action Plan. *City of Vancouver*, 1-82. Retrieved February 8, 2016, from <http://vancouver.ca/files/cov/Greenest-city-action-plan.pdf>

Earth Tech Canada. (2004). Water Management at VanDusen Botanical Garden Final Report. *Vancouver Park Board*, 1-92. Retrieved April 15, 2016.

Klein, D. (2015). Report 3: High Water Consuming Parks. *Greenest City Scholars Program 2015*, 1-17. Retrieved January 28, 2016.

Klein, D. (2016). *VanDusen - Water Meters* [XLSX]. Retrieved January 29, 2016.

Klein, D. (2016). Visitor Center Monthly Water Use [Digital image]. Retrieved March 2, 2016.

Vancouver Water Design Department. (2016). Map of Water Meter Locations at VanDusen [Digital image]. Retrieved February 10, 2016.

VanDusen Botanical Gardens. (n.d.). About. Retrieved April 15, 2016, from <http://vandusengarden.org/about/>

APPENDIX

2016 Water Meters (2004 data from Earth Tech Canada, pg. 10, 2016 data from Tempest), Number in parentheses indicates % of total potable water consumption in 2004

