Water Management at UBC

Background report for the project: Would it make sense to develop an Integrated Resource Management Strategy for UBC, using a water lens?

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UBC Program on Water Governance

Back and Front Cover Photo: UBC Steam Plant (at the Power House). Credit: Don Erhardt

Preface

This is an introductory report for a project inspired by UBC's emerging Sustainability Strategy. Experience shows that success is critically dependent on the ability to translate visionary goals to practice on the ground, and that this is easier said than done. The project was launched in January 2014 and explores if an Integrated Resource Management approach, using a water lens could help achieve the following goal in the Sustainability Strategy:

> *The integration of campus-scale energy, water, waste, and food systems is linked to improved quality of life for students, staff, faculty and campus community and to enhanced ecological integrity (UBC Sustainability, 2014a, p.6).*

The report draws on information gleaned from official UBC documents and conversations with UBC staff involved in planning, management and operation of water, as well as documents used internally by various departments. The first chapter provides a synthesis of pros and cons with integrated resource management, drawing on literature in the field.

The following four chapters describe UBC's water system from different perspectives, starting with a description of the biophysical water flows (Chapter 2), we then move to a description of the infrastructure system (Chapter 3), which is followed by a description of the management system (Chapter 4), and a description of the governance structure (Chapter 5). The sixth and last chapter presents lessons learned.

Drawing on interviews with staff, faculty and students at UBC, reports that follow will discuss what development and implementation of an "Integrated Resource Management Strategy, Using a Water Lens" might entail, in light of peer-reviewed literature on the topic.

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We would like to acknowledge and thank the UBC staff members who took the time to answer our many questions and offered their extensive knowledge, patience and enthusiasm, without which our report would not have been possible.

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Executive Summary

This introductory report is produced under a project that was launched in January 2014 that explores if it would make sense for UBC to develop an Integrated Resource Management (IRM) strategy, using a water-lens. The report provides an overview of the IRM concept and describes four central components of UBC's water management system: biophysical flows, infrastructure, management and governance. Our preliminary observations are summarized below.

Why IRM?

To move from vision to implementation is a considerable challenge, and many argue that the only way to do so is to develop a strategy inspired by theory but well-grounded in practice. IRM has developed in response to this challenge and appears to be a useful approach for an organization like UBC. There is, however, a gap between IRM in theory and in practice. Our objective is to contribute to this research – how to move from vision to implementation – while at the same time contribute to UBC's quest of becoming a leader in sustainability.

Why a Water Lens?

Even water rich locations like Vancouver are projected to face a shortage of potable water in the near future. Simply increasing the supply, as traditionally done, will not suffice. Closing the water cycle is one of UBC's radical goals, but it is not clear how this will be done or if this is indeed the most sustainable solution. UBC's new Water and Energy Services Department appears to open a window of opportunity that would allow integration of water, energy and perhaps also other resources. It seems like time is ripe to pursue the integration one step further, and for example take the relationship to other resources into account (energy, solid waste, food etc.) and maybe put the governance structure under a magnifying glass.

Sustainability

With the creation of the UBC's University Sustainability Initiative (USI) in 2010, UBC strengthened its position as one of the leaders in sustainability among academic institutions. The vision is bold and it is evident that the emerging sustainability strategy has influenced the university's strategic plan Place and Promise. The literature on IRM stresses that a shared understanding of goals and incentives is seminal to successful implementation of a strategy, as well as to efficient planning and operations. It seems as if UBC's sustainability goals are not necessarily followed through in projects on the ground. Also, even though sustainability is said to be a cross-cutting commitment, the structure and content of the strategic plan gives the impression that sustainability is not integrated across UBC's other commitments.

Energy and Water

The newly created department of Energy and Water Services is a bold step, which places UBC places among the few public institutions around the world that have taken action on the organizational level to meet the challenges posed by the water-energy nexus. This is particularly exciting as research on change management clearly show that ingrained management structures often hinder the implementation of goals and visions. It is, however, not entirely clear what the new organizational change will mean on the ground and there is no shared understanding in the organization to that end. Let's hope that it is a real and bold organizational change and not just new clothes for the emperor.

Data Management

Efficient resource management requires good knowledge about the resource itself. To know where savings can be made requires detailed knowledge about the resource flows, how these flows relate to other factors and where potential cost-savings lie. UBC does have monitoring in place but does not have a cohesive monitoring strategy for water related issues, it is not a trivial task to access the data that exists, and easily accessible data is at times conflicting. UBC is in the process of developing various monitoring systems, for example for energy consumption. Experience shows that the creation of an efficient monitoring system requires a systematic strategy as to what data to collect, why and to what end.

Vision, Operation and Human Resources

While gathering data for this report, we have several times run into situations that suggest that implementation of sustainability goals not seldom cause unexpected challenges for operations staff. This is a well-know phenomenon, generally speaking. The type of changes that are implemented under the emerging sustainability strategy will no doubt change the demands on operational staff. Yet, we have not found any action plans that specify how the strategy will impact human resources.

Next steps

"What should be integrated?" is a key-question when considering whether or not it would make sense to develop an integrated resource management strategy, using a water lens. One of the major undertakings in the next phase of this project will be to talk with faculty members across campus and in dialogue with staff in charge of planning and operations chisel out the scope for the project. We will identify key-stakeholders, and how to best engage them in the process. We will also discuss potential ways to optimize linkages among different functions at UBC. Finally, we will include an analysis of the less obvious impacts and implications of an IRM strategy on campus, specifically those pertaining to social, educational, and community values.

Table of Contents

Acronyms

BC	British Columbia
C+CP	Campus and Community Planning
DPB	Development Permit Board
GVWD	Greater Vancouver Water District
ID	Infrastructure Development
IRM	Integrated Resource Management
IRP	Integrated Resource Plan
ISMP	Integrated Stormwater Management Plan
LEED	Leader in Energy and Environmental Design
Metro	Metro Vancouver
OCP	Official Community Plan
REAP	Residential Environmental Assessment Program
SAS	Sustainability Academic Strategy
SEEDS	Social, Ecological, Economic Development Studies
UBC	The University of British Columbia
UEL	University Endowment Lands
UNA	University Neighbourhoods Association
VP Finance	Vice President of Finance, Resources and Operations

1 Introduction

1.1 Why Integrated Resource Management (IRM)?

The term Integrated Resource Management (IRM) first appeared in the literature in the 1960s. However, its roots in Canada can be traced to the beginning of the 20th century (Douglas, 1988). It was developed to help make natural resource management more sustainable by taking into account economic, social and environmental aspects. It is, however, not entirely clear what it is that is to be integrated. In 1988, the BC Ministry of Forestry defined IRM as "a decision-making process whereby all resources are identified, assessed and compared" before planning, in order to achieve optimal allocation of resource priorities and land uses (BC Ministry of Forests and Lands, 1988). In this interpretation 'resources' refers to natural resources (water, land, forests, minerals, air etc.), as well as financial resources, and 'integration' refers to the need to take various human activities into account to avoid potential land-use conflicts while optimizing the outcome.

'Integration' also refers to the need to integrate different parts of a fragmented management structure, which means that IRM can cause conflicts by bringing different preferences to the table. The underlying idea is, however, that an integrated approach will reduce conflicts in the long run for the very same reason – by bringing conflicting preferences to the table, the decision-process is believed to become more transparent, which in turn increases the possibility of identifying trade-offs. Not surprisingly, the literature on IRM stresses the need to engage all stakeholders and the broader public in the decision process. Mitchell (1990) describes IRM as the collaboration between a broad range of agencies, sharing data and using inputs from the public, and other interests, to design and implement policies, programs and projects.

Summarizing the literature, a 'full' IRM strategy includes:

- Integration across environmental assets to take into account the interrelationships between natural resources;
- Integration of environmental, social and economic considerations in the decision-making process to tackle the three dimensions of sustainability;
- Integration across time to develop a long-term vision;
- Interaction between stakeholders and involvement of the general public in the planning process to share information and expertise and to have a broader view;
- Collaboration between agencies with the development of common goals and greater communication to solve disagreements. (Klein, 2001)

There is, however, a gap between IRM in theory and in practice, especially with regards to the complexity of the approach (Hooper, 1997; Kennett, 2002; Mitchell, 2008). How to move from vision to implementation is a considerable challenge, and many argue that the only way to do so is to develop a strategy inspired by theory but well-grounded in practice (e.g. Loorbach, Frantzeskaki, & Thissen, 2011).

The objective of this project is to contribute to research on this topic – how to move from vision to implementation – while at the same time contribute to UBC's quest of becoming a leader in sustainability. This objective fits well with the idea behind UBC's 'Living lab' concept: to explore new ways of thinking and learning and to develop ideas that can change the world.

1.2 Why a Water Lens and Why at UBC?

UBC is one of Canada's leading universities and it is in the process of developing a sustainability strategy. The Point Grey Campus dates back to 1922 and is located on an erosion-prone sandstone cliff, which is surrounded by water on three sides. During the past few decades UBC has seen a dramatic change from being a regional university with no residents on campus, to university that ranks among the top-30 in the world with over 55,000 residents, and close to 60,000 students of which 10,000 are international. A fairly recent regulatory change gave UBC responsibilities that are similar to that of a municipality or a small city. In contrast to a municipality, however, UBC owns all its land and buildings, which makes it easier to carry out strategic efforts, at least in theory.

The focus on water was chosen for several reasons. Canada is one of the world's most water rich nations. In spite of this, a location like Vancouver is projected to face a shortage of potable water by 2050. The traditional solution is to increase the supply, and Metro Vancouver is presently exploring various ways to increase the supply, along with several of its member municipalities. A more progressive solution is to reduce the demand and demand management approaches in the region have increased notably during the past decade, including irrigation regulations, as well as sticks and carrots to increase the use of water saving faucets, showerheads and toilets. The most radical solution is to close the water-loop, and the past few years have seen an increase in experiments with re-use of water for irrigation, and rainwater harvesting for non-potable use.

One of UBC's goals is to close it's water cycle, which is a radical goal, but no clear strategy seems to be developed that points to how this might be realistically achieved or if this is indeed the most sustainable solution.

Figure 1: The UBC Campus in 1925.

Also, water is a very powerful resource from an educational point of view. The basics are easy to grasp and considerably less abstract than for example energy, climate change and biodiversity, and it is easy to convey the challenges involved in too little or too much water, or water of insufficient quality. At the same time, water related issues lends itself well to complex study and analysis in almost any discipline, be it political science, cultural studies or chemistry, global change, transboundary conflicts, or how to design a healthy urban environment.

The connection between water and other resources is an area that increasingly is attracting attention, and UBC is in the forefront. For instance, while others talk about the water-energy nexus, UBC is among the few public organizations in the world that is moving to action through the creation of the recently inaugurated Water and Energy Services Department. Many actions and projects, such as the new hot-water based district heating system, have been undertaken to improve water sustainability at UBC. There appears to be a window of opportunity that would allow integration of water, energy and perhaps also other resources.

Finally, it is an exciting challenge to improve water management. Water management strategies have significantly changed over years. While only water supply was taken into account some twenty years ago, approaches that include the whole water cycle are increasingly being implemented around the world, like Integrated Water Resource Management (IWRM). It seems like time is ripe to pursue the integration one step further, and for example take the relationship to other resources into account (energy, solid waste, food etc.), maybe put the governance structure under a magnifying glass or perhaps explore how one might integrate water in all of UBC's commitments.

1.3 What Might an IRM Strategy with a Water Lens at UBC Entail?

To align with UBC's strategic plan Place and Promise, an IRM framework implemented at UBC needs to be based on ambitious objectives. Indeed, the aim of the sustainability strategy is to integrate not only the planning and operating levels, but also the research and teaching. With this project, we set out to analyze in what way one might:

- Integrate of the various form of water: potable water, rainwater, wastewater, etc.
- Integrate water with others resources such as energy, greenhouse gas, food and nutrients, waste, biodiversity, etc.
- Analyze environmental and social impacts of potential improvements.
- Assess the economic viability and regulatory feasibility of preferred solutions.
- Involve all stakeholders and general public in the planning process. It includes UBC executives, management staff, operational workers, professors, students, etc.
- Identify ways to enhance cooperation and collaboration between UBC departments
- Integrate the IRM Strategy in existing or future curricula.
- Engage researchers across campus along with operational and planning staff in the development of the strategy, to enhance the approach and ease the move from theory to practice.

According to the literature, identification of the project scope is a key to develop a successful IRM approach. Consequently, the first phase of the project consists in defining the goals and the boundaries of the system. To do so, it is essential to understand and analyze the current situation before developing an action plan. In this report, we provide an overview of four sub-systems that are central components in UBC's water system: biophysical flows, infrastructure, management and governance.

2 Biophysical water flows at the UBC Vancouver Campus

We start with an overview of the biophysical water flows on the UBC Vancouver Campus, roughly outlined in

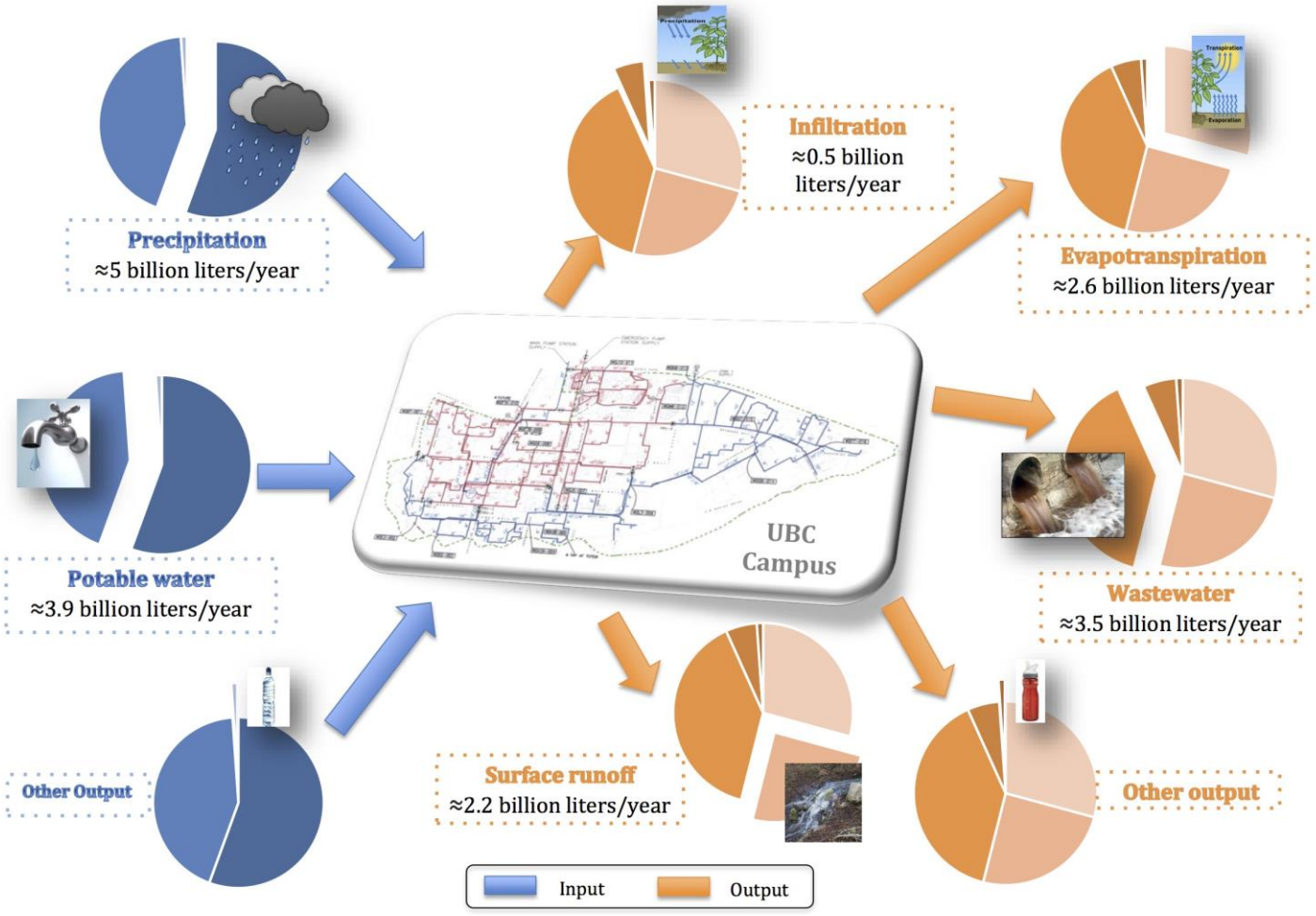

Figure 2: A rough outline of physical water flows on the UBC Vancouver Campus Input.

Approximately 9 billion litres of water flow through the UBC Point Grey Campus annually. About half of the input is precipitation (~ 5 billion L/year), slightly less is brought to the campus as piped potable water 4 billion L/year) and unknown amounts are trucked to campus as bottled drinks and groceries. The water leaves the Campus as wastewater (~ 3.5 billion L/year), evapotranspiration (~ 2.6 billion L/year), stormwater (~ 2.2 billion L/year), leaks (0.2-0.6 billion L/year), and infiltration (~ 0.5 billion L/year). As further elaborated below, the accuracy of these estimates varies dramatically, in part due that the figures are averages of flows that vary diurnally and seasonally, in part due to lack of data. The least variable and most accurate of the estimates is the amount of potable water brought to campus through the piped system managed by Metro Vancouver and the University Endowment Lands (UEL). Below we give an overview of the physical flows starting with the inputs.

2.1 Input

2.1.1 Potable Water

According to UBC's website, the annual supply to the campus is approximately 4 billion litres per year. The figure varies between reports, from 3.9 billion in the *UBC Water Balance* report (Leung & Hood, 2011) to 4.3 in the *Water Action Plan* (2009). We have consulted several staff members on campus who are involved in the operation, management and planning of water. Even so, we have not been able to deduce whether this span is due to decreased consumption or if it is an indication of how much the supply varies between years.

The supply is metered electronically at 15 minute intervals at the two main water supply points (Leung & Hood, 2011). UBC Utilities sends a breakdown of this data to UBC Sustainability and Engineering who assesses the annual water consumption for the campus (this can be seen for a number of years in Table 1). The metered data can be accessed directly online via the UBC Sustainability Remote Metering Site (ION), an online resource that displays the status and readings of electronic water meters. According to staff we spoke with, interpreting the data from this system is very difficult and we have not yet managed to decipher how to analyze it.

A water audit was conducted in 2011 by Stantec (Leung & Hood, 2011), which shows average values of the water consumption based on the UBC Utilities data. Approximately 80% of the academic buildings on the campus are metered.

2.1.2 Precipitation

Detailed precipitation data on the UBC Vancouver campus is available through climate@ubc, which is a website run by the Faculty of Land and Food Systems (LFS) and provides data from UBC's Climate Station, located on Totem Field at the Vancouver Campus. The UBC Climate Station gathers research-grade, high-quality measurements of atmospheric variables such as temperature, humidity, wind, precipitation, snow, and radiation. Most variables have been continuously measured since 1957 and every 5 minutes the latest data are automatically added to this 50-year record. UBC scientists, Operations and Campus Services are using this data to monitor local weather, climate and climate change.

Based on data from this site, we can see that the precipitation on campus varies from a 400 mm in 1997 to over 1500 mm/year in 1961, with an average of 1132 mm/year. According to UBC's Water Action Plan, the average corresponds to a deposition of approximately 5 billions L/year, with the majority as rain and a smaller amount as snow (UBC Sustainability, 2011a). The precipitation in the area shows a clear seasonal trend with 130 mm/month in June- August and 411 mm/month in November - January. In addition to the seasonal variation, the intensity also varies dramatically (how much it rains) as does the frequency (how often it rains).

Table 1: Water use at the UBC Vancouver Campus. Provided by UBC Utilities with units in billion litres.

Water use	1997	2005	2007	2010	2011	2012
Total Water Use	5.867	4.589	4.186	3.830	3.913	3.991
UBC (C+A) Water Use	5.191	3.798	3.291	2.886	2.961	2.979
Core Water Use	4.423	3.013	2.531	2.216	2.413	2.434
Ancillary Water Use	0.768	0.784	0.760	0.670	0.548	0.544
Tenant Water Use	0.676	0.792	0.894	0.936	0.952	1.012

The large natural variation among years, months and days in both frequency and intensity are of crucial importance for water management planning as it impacts the dimensions of the infrastructure needed to handle worst case scenarios. This includes both storms (eg. pressure on system to handle large amounts of water over a limited period of time) and droughts (e.g. the amount of water needed for irrigation, the amount of water available for reuse, and the fact that the need for irrigation is largest when the amount of precipitation is the lowest).

2.1.3 Other Inputs

Water is also brought to campus in commodities such as bottled drinks and food, which is typically unaccounted for in traditional water flows. Food is discussed in a number of UBC reports in terms of possible GHG emissions reductions, but not in terms of water consumption and use (SAS Working Group, 2009; UBC Sustainability, 2010).

When discussing water consumption, it is becoming increasingly common to discuss three parts, which sometimes are called blue, green and white water. The blue is the water we can see in for example rain, rivers and lakes. The green water is the water driven by the biosphere and includes evapotranspiration and the water contained in vegetation.

The white water refers to the invisible water that is 'embodied' in a product through its production process, often called the 'virtual water'. Several courses at UBC discuss this concept and an introduction is for example given on the website Virtual Water and Global Food Security: Implications for Canada. To provide some examples: the production of one hamburger consumes about 2,500 litres of water and one cup of coffee consumes about 150 liters of which 125 ml is visible in the cup, the rest is embodied in the beans. These rough estimates do not include transportation. The virtual water concept is, to our knowledge, not included in UBC's water management planning.

2.2 Consumption of potable water

As mentioned above, the consumption of potable water on the UBC Campus is approximately 4 billion litres per year. A breakdown of consumption by end-use is shown in Figure 3. The consumption of water on campus is discussed in the Integrated Water Master Plan (Urban Systems, 2010), which provides a base flow distribution between various types of water uses. Staff told us that it is possible to retrieve building specific flows for the 80% of the buildings that are metered building specific base flows. We have not yet figured out how to retrieve this information or to what extent it is possible to aggregate the data to view for example diurnal, weekly, monthly or annual patterns on building level or aggregated level for clusters of buildings.

The major areas of water consumption are described below.

2.2.1 Washroom Facilities and Showers

Washroom facilities and showers together account for almost a third of the total potable water consumption on campus, and represent the largest end user group.

2.2.2 Process Cooling and Research

More than one billion of liters is used every year for process cooling and research, corresponding to about a quarter of the potable water use (Campus and Community Planning, 2011b). To meet cooling and research demands, UBC's Green Research Program was charged with the task of identifying and implementing ways to reduce water consumption in labs. According to the website, the idea is to

> *provide labs with products, practices and information that allow for water conservation; discourage the use of open loop cooling systems; and award a Fischer Scientific Fund grant to a project implementing an alternative to water aspirators in labs (UBC Sustainability, 2014b).*

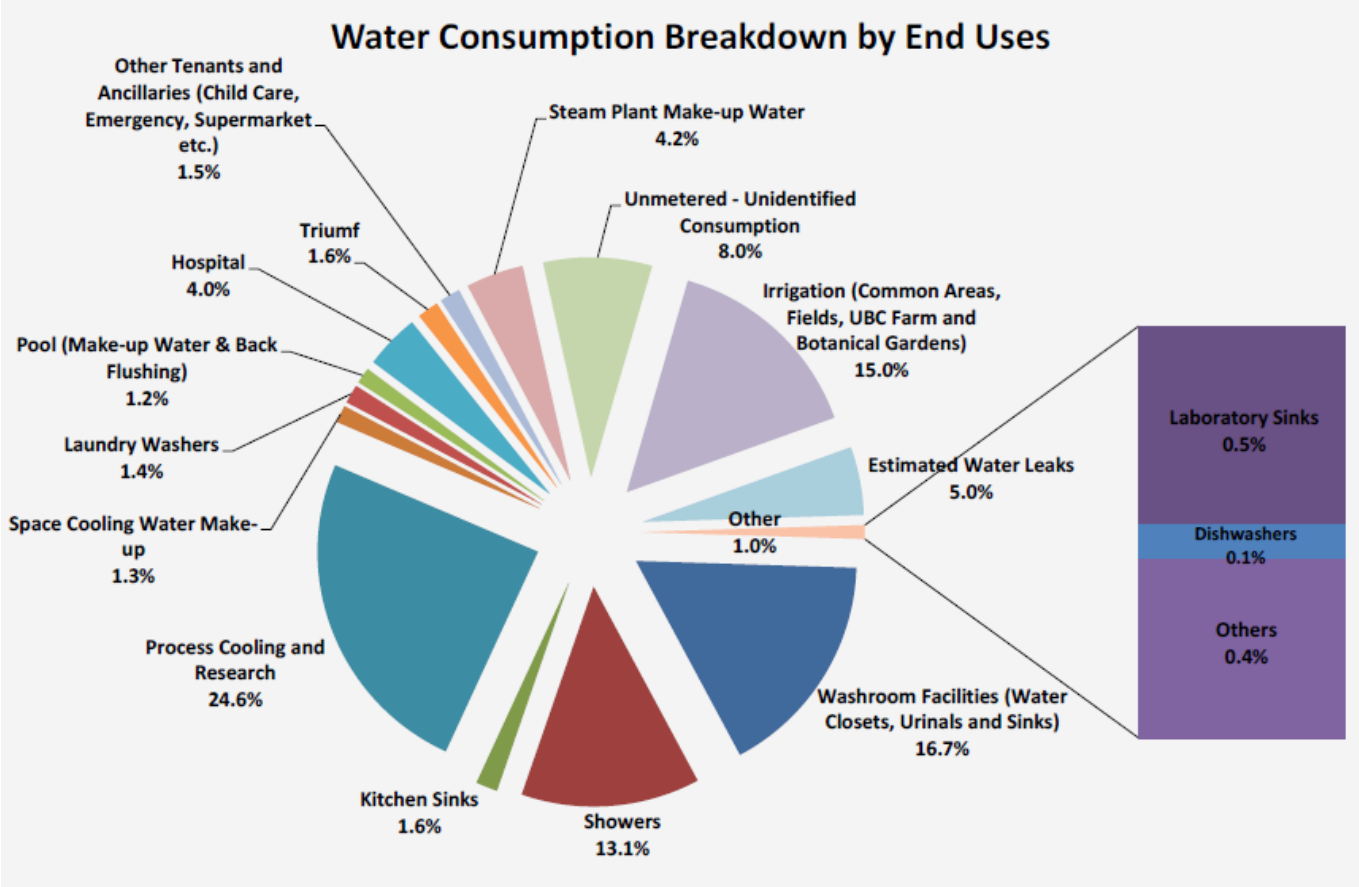

Figure 3: Water Consumption Breakdown by End User for the UBC Campus (Leung & Hood, 2011)

Initiatives to date include featuring water conservation in what is called a Virtual Green Lab Tour where researchers are encouraged to for example install pressure-reducing valves, automatic sensors and flow restrictors. Another initiative referred to on the UBC Green Research Program website is the Green Research Challenge where researchers are encouraged to take a tour to learn about "UBC laboratory solid and hazardous waste programs, water and energy reduction and green purchasing options", collect points and wind a grand prize, such as a bicycle. It is not clear whether this initiative has had an effect water consumption

We have not been able to find any detailed descriptions of water consumption for cooling or research, aside from the consumption at TRIUMF, which accounts for 1.6% of potable water consumption on campus (Leung & Hood, 2011).

2.2.3 Irrigation

According to the *Irrigation Action Plan*, the amount of water used for irrigation amounts to roughly 15% of the potable water, which corresponds to approximately 0.6 billion litres of water per year, including irrigation at the botanical gardens and the UBC Farm (Hood & Seabrooke, 2012). The same figure is given in the *UBC Water Balance* (Leung & Hood, 2011) and in the *Water Conservation Action Plan* (UBC Sustainability, 2011b).

Irrigation occurs through the months of July to September at UBC. Max day water consumption flows in September (with irrigation) were compared to max day flows in October (without irrigation). According to the *UBC Irrigation Action Plan* it appears that the irrigation flows are estimated to account for 19 L/s of total campus flows on a typical max day with irrigation (Hood & Seabrooke, 2012).

A number of UBC policies and actions are aimed at reducing the need for irrigation, for example the use of subsurface drip irrigation for trees can eliminate moisture losses due to evaporation. According to REAP (UBC Sustainability, 2009), efficient irrigation systems can reduce water consumption by 50-70% in planted areas, and overall per capita water consumption by 20-25%. It is unclear however, to what extent these policies have impacted water consumption.

2.2.4 Leaks

Leaks are inevitable. The documents we have read and the people we have talked to give a span from 5-15% (0.2-0.6 billion liters per year). Two different ways are used to assess leaks: 1. Sum up all known water consumption, compare with the water supplied by Metro Vancouver and assume that leaks account for difference. 2. Meter during the night or during a one hour period without any water use, calculate the difference between the water supplied and the amount of wastewater leaving the campus and assume that leaks account for the difference (NovaTec Consultants Inc., 2011). The lower estimate (5%) is from the *Water Action Plan* (UBC Sustainability, 2011a) and the *UBC Water Balance* (Leung & Hood, 2011), and is in both documents estimated through the first approach mentioned above. The higher estimate is from conversations with staff engaged in water planning and management, who believes that the leaks on campus are closer to 15%.

2.2.5 Heating

At present, the district steam heating system on campus is being upgraded to a hot water system. Before the conversion started, the steam system accounted for 3-4% of the potable water consumption on campus. The figures vary a bit between the reports with 4% given in the *Water Conservation Action Plan* 3% according to the *Water Action Plan Discussion Paper* (Campus and Community Planning, 2011a) and 4.2% according to the *UBC Water Balance* (Leung & Hood, 2011). The variation is smaller than one might expect, in light of the fact that the larger uncertainty in the other figures.

2.2.6 Food Services

Food Services is an auxiliary department at UBC and is the primary food provider, running restaurants, cafeterias and catering services for the campus. This is differentiated from domestic cooking by the fact that it is in itself a department at UBC that procures and imports food and drinks, processes and prepares food, as well as utilizes large-scale machinery such as industrial dishwashers that consume water.

Food services is included in the base flow calculation in the *Integrated Water Master Plan* (Urban Systems, 2010), and is relatively speaking one of the smaller consumers with a flow rate of 1.1 L/s. According to the Water Balance Report (Leung & Hood, 2011), kitchen sinks and dishwashers account for 1.6% and 0.1% of total potable water consumption on campus respectively.

2.3 Output

2.3.1 Wastewater

The amount of wastewater leaving the campus is approximately 3.5 billion litres per year. The wastewater leaves at two locations: the NW Marine Drive location accounts for approximately 2.3 billion litres, and the one at SW Marine Drive accounts for the rest (NovaTec Consultants Inc., 2011). Both locations experience diurnal and seasonal variations throughout the year, with the NW Marine Drive point experiencing considerably larger variations. Winter flows are as much as one third greater than summer flows, and maximum diurnal peak flows are roughly three times greater than minimum flow rates (NovaTec Consultants Inc., 2011). The majority of the wastewater is drained by gravity aside from a few localized wastewater catchments that are pumped. Wastewater at UBC is characteristically low in strength, which is assumed to be due to

the large volume of water used for cooling on campus (NovaTec Consultants Inc., 2011).

The two sites where the wastewater leaves the campus are metered at 15 minute intervals (Leung & Hood, 2011). The data is compiled by UBC Utilities, but the data is not readily available.

2.3.2 Surface Runoff

The terms 'stormwater' and 'surface runoff' are commonly used synonymously in urban planning when referring to water that is collected by a system of pipes (sewers) that drains roads and other impervious surfaces. Surface runoff/stormwater originates from precipitation (rain, snow, hail etc.) and is the portion that is not absorbed or evaporated by soil or vegetation. According to the *Hydrogeologic Stormwater Management Strategy* (AECOM, 2013), the annual runoff amounts to approximately 2.2 billion liters (AECOM, 2013). The amount of runoff varies with the amount of precipitation, as only a small portion of the land is designed to retain or detain stormwater on campus.

A number of policies and actions are aimed at reducing stormwater flows and thus the pressure on the stormwater infrastructure and the receiving ecosystems. For example, the land between the Museum of Anthropology and Cecil Green was landscaped to contain a significant flood: To reduce seepage-related erosion, wells were installed on the north side of the museum to drain water from the upper aquifer to the lower aquifer where it is less likely to cause concern (UBC Campus and Community Planning, 2013).

2.3.3 Evapotranspiration

Evapotranspiration is the sum of the processes that transfer water to the atmosphere from soil, water bodies (evaporation) and plants (evapotranspiration). There is little mention of evapotranspiration in the reports we have examined, despite the fact that it accounts for about a third of water leaving the campus (around 2.6 billion L/year) (AECOM, 2013), and thus ought to be a central component in storm-water management. For example, both the number and type of plants have a considerable impact on the amount of water evapotranspired. Even so, the staff we spoke with appeared to be of the opinion that evapotranspiration is a negligible factor in the water budget on campus.

2.3.4 Infiltration

Infiltration is the absorption of precipitation into deeper soil layers, a process which accounts for approximately 0.5 billion of litres of water per year at UBC (9.6% of total precipitation on the campus) (AECOM, 2013). Infiltration varies considerably with the type of soil. The infiltration capacity is zero or close to zero of impervious surfaces such as asphalt and concrete, which make up the majority of the surface on roofs and roads. Reduced infiltration leads to increased surface runoff, which in turn requires larger infrastructure to handle the excess stormwater. The limited infiltration capacity of the clay soils present in large areas of the campus is discussed in the *Integrated Stormwater Management Plan* (ISMP), which is why the plan emphasizes the need for detention and retention system optimization (UBC Campus and Community Planning, 2013).

A number of policies and action items are aimed at increasing the infiltration capacity, without inducing cliff erosion. For example, REAP prescribes a subsurface infiltration trench below permeable paving to enhance water infiltration into soils (UBC Sustainability, 2009). There is policy in place at UBC that requires that infiltration is not to be used within 300 m of the top of the cliffs (UBC Campus and Community Planning, 2013).

3 Water infrastructure at UBC

The aim of this chapter is to provide an overview of water-related infrastructure on the UBC Point Grey Campus.

3.1 Potable water

The potable water on UBC's Vancouver campus originates from Metro's three mountain watersheds-reservoirs: Capilano, Seymour and Coquitlam, which store water from rain and snow in the region. The water is piped via the City of Vancouver, to the Sasamat reservoir, which is an underground storage tank managed by the Greater Vancouver Water District (GVWD) (UBC Sustainability, 2011b). The water is then piped by the GVWD to the University Endowment Lands (UEL) and from this point, it is UEL's responsibility to distribute the water to its customers' property lines. UBC is not directly connected to the GVWD, instead, UEL provides UBC with water they have purchased from GVWD. After reaching the edge of UBC Lands, it is the responsibility of UBC Utilities to distribute the water on campus (Metro Vancouver, 2012).

Once the water arrives on campus, it is sent to two locations: the Powerhouse Booster Pump Station located on West Mall that distributes pressurized water, and the 16th Ave lower pressure zone that distributes non-pressurized water (Urban Systems, 2010). The water is piped to the various buildings on campus via a distribution network managed by UBC Utilities. There are no storage facilities for potable water on campus.

3.2 Wastewater

The wastewater system on campus is divided into two catchments. Sewage from the north side is collected in sewers that discharge at a location on NW Marine Drive while flows from the south campus are discharged at a location on SW Marine Drive. Both sewer systems discharge into larger sewers managed by Metro that convey the sewage to the Iona Island Wastewater treatment Plant in Richmond (Urban Systems, 2010).

3.3 Stormwater Sewers

The stormwater sewer system at UBC is divided into four major catchments called North, Northwest, Southwest, and South which can be seen in Figure 4 (UBC Campus and Community Planning, 2013; Urban Systems, 2010). The stormwater from streets, sidewalks, and roof leaders is directed by gravity to the sewer system. A small portion is captured for reuse as outlined below. The North catchment flows are conveyed to a vertical spiral drain outfall situated at the Cecil Green College discharging into the marine intertidal zone of English Bay. The Northwest catchment flows are conveyed to a stream at Trail 7 where it discharges into the marine water south of Wreck Beach. The Southwest catchment flows are drained along 16th Avenue to the Botanical Garden Creek that discharges into Museum Creek in Musqueam Park. The South catchment flows are collected and conveyed through ditches along then across Marine Drive to Booming Ground Creek where it is ultimately discharged into the Fraser River.

3.4 Impervious Surfaces

Impervious surfaces are a big challenge for stormwater management. Water that is not infiltrated in to the soil is led to the stormwater system as runoff, which can contribute to a number of management issues including floods particularly during storm events. On the other hand, impervious coverage hinders infiltration in the upper aquifer, which is believed to help to mitigate cliff erosion. The connection between cliff erosion and infiltration in the upper aquifer is debated, however, as evidence suggest that the impact of the waves is without comparison the dominating cause of cliff erosion.

The impervious coverage on the UBC Campus is around 50% of the total land area (Total area = 4.09 km^2) and is divided by catchment

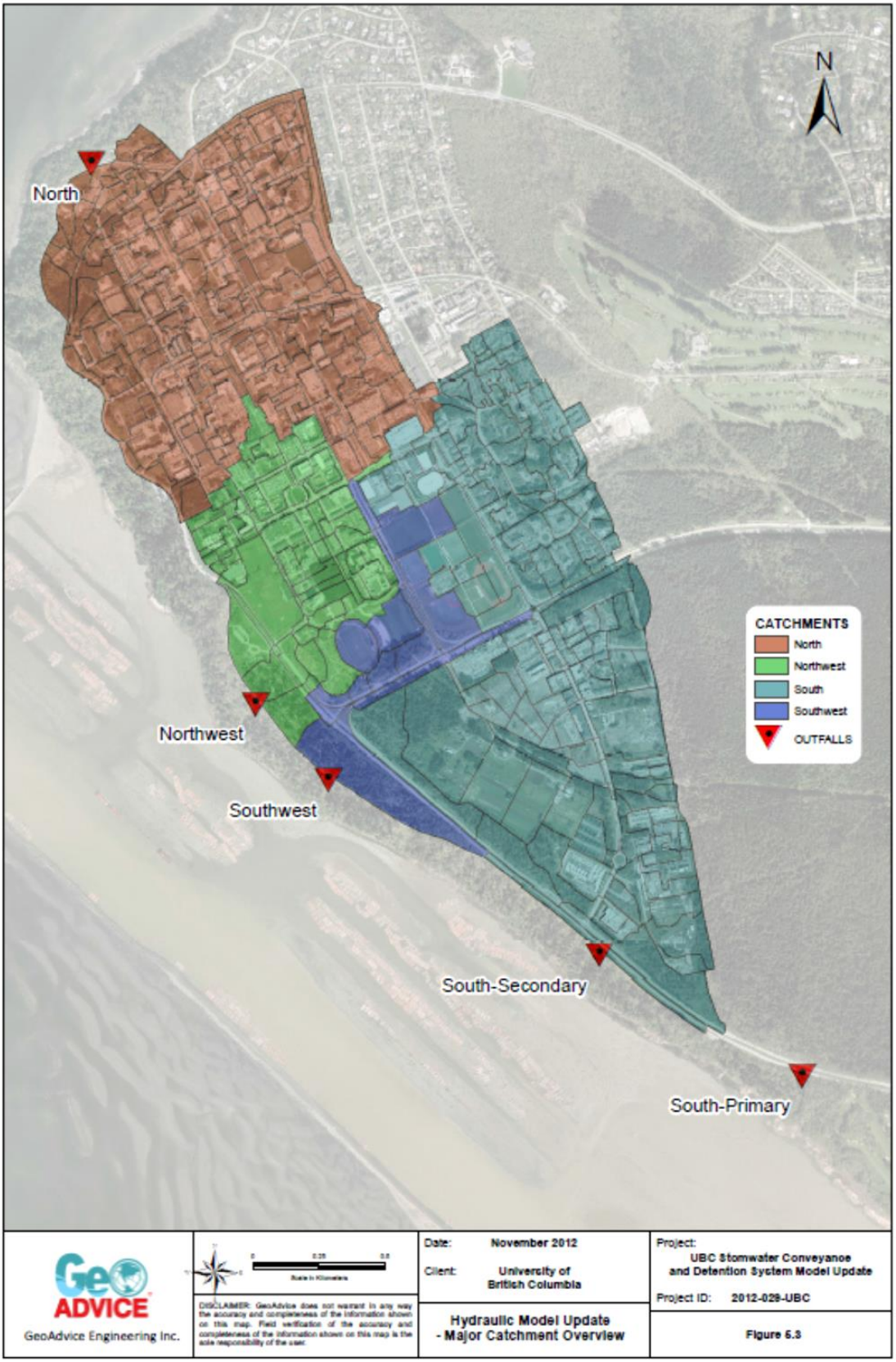

Figure 4: UBC Stormwater Major Catchments and Outfalls Overview (GeoAdvice Engineering Inc., 2012).

(GeoAdvice Engineering Inc., 2012). The impervious coverage for each catchment can be seen in Table 2. Most of the surfaces in the south campus are pervious (UBC Farm, sports fields, etc.).

As described in the Infiltration section, a number of policies outline strategies for decreasing the size of the impervious surfaces, which includes increasing green roofs, pervious paving on roads and parking lots, and increased green areas.

Table 2: UBC Stormwater Catchment Impervious Surface Coverage.

Catchment	Impervious Coverage (%)	Area (km^2)
North	65	1.4
Northwest	50	0.55
Southwest	26	0.42
South	44	1.72
Total	**50**	**4.09**

3.5 Grey, Blue and Green Infrastructure

Infrastructure is at times described as blue, green, and grey. In simplified terms, blue refers to the existence of visible or consciously used water features (fountains, creeks, wetlands, detention ponds, recycling equipment etc.) while green refers to visible or consciously used green features (trees, plantations, green roofs, green walls etc.). Green Infrastructure is typically seen as being synonymous with LID (Low Impact Development); SUDS (Sustainable Drainage Systems); and WSUDS (Water Sensitive Urban Design) (Andoh, 2011).

Grey infrastructure refers to conventional urban developments with piped drainage and water treatment systems (i.e. pipes, tanks, and conventional treatment systems including energy-intensive water treatment systems and processes such as membrane) (Andoh, 2011). Blue and green infrastructure are used to reduce health impacts, improve well-being, and decrease environmental impact of 'grey' urban developments.

When translated to building scale, blue buildings use small footprint high-efficiency devices installed and retrofitted within existing collection systems (Andoh, 2011). Green buildings use systems such as Bio-filtration, ponds, wetlands, rain gardens, and other natural land and plant based ecological treatment systems and processes.

There are a number of green buildings and infrastructure at UBC, and the number of blue features on campus has increased visibly in the past few years. A few examples are described on the following page.

C.K. Choi Building for the Institute of Asian Research

In the construction process of the C.K. Choi building in 1996, composting toilets that do not need water for flushing were installed with the aim of water conservation. Moreover, this building is equipped with a rainwater harvesting system, which collects rainwater on the roof of the building, which is used for irrigating the landscape (UBC Sustainability, 2014c).

Centre for Interactive Research on Sustainability (CIRS)

The CIRS building, opened in 2011, was designed to have a closed loop water system, which provides potable water to the building inhabitants by harvesting rainwater and conduct onsite wastewater treatment to supply water for toilet flushing and irrigation (UBC Sustainability, 2014c).

Wesbrook Place

Wesbrook Place is a residential neighbourhood in UBC lands, UTown@UBC that uses several techniques for stormwater flood control. Some examples of these practices are: rainwater retention tanks, green roofs, rain gardens and sediment control for improving water quality. Moreover, the surface water collected in outdoor pools is used for landscape irrigation at Wesbrook Place (UBC Sustainability, 2014c).

Sustainability Street

Sustainability Street or Stores Road is a pedestrian-oriented walkway on the west side of the Earth and Ocean Sciences Building connecting Main Mall to West Mall at UBC Point Grey campus. The street is presently under redevelopment and it is intended to be a show case for innovative water reuse and stormwater management principles (UBC Sustainability, 2014c).

4 Water Management at UBC

This chapter provides an overview of the different departments and units that are involved in water management at UBC. A diagram of water governance related departments at UBC can be seen in Figure 5.

4.1 Units With Main Responsibility for Water Management at UBC

Two units have until recently been carrying the main responsibility for water management at UBC: *Campus and Community Planning* (C+CP) and *Utilities*. The distribution of responsibilities will change with the creation of *Energy and Water Services*, but it is presently not entirely clear what this will mean in practice. *Sustainability and Engineering*, which is a unit under C+CP, plays a central role by being in charge of the coordination of sustainability related projects. The *University Sustainability Initiative* (USI) is the university's agent for integration of UBC's academic and operational efforts in sustainability. *Infrastructure Development* (ID) and *Properties Trust* are involved in the planning, development and implementation of larger projects.

4.1.1 Campus and Community Planning (C+CP)

C+CP is UBC's regulatory department, with a wide range of responsibilities such as: development project regulatory approvals, land use planning, campus design, green buildings, and sustainability planning. Among its responsibilities is long term planning of water related services, systems and developments. When it comes to campus growth, C+CP is responsible for ensuring that the designed systems can accommodate the development and identifies areas where predictions have not come to pass and works with UBC Utilities to resolve problems that may result.

4.1.2 UBC Utilities

UBC Utilities, which is a unit under Building Operations, is responsible for the provision of utilities such as water, electricity, steam, and gas. Building Operations "provides comprehensive facilities maintenance, operations and renovation services for lands and buildings owned by the University of British Columbia" (UBC Building Operations, 2014).

4.1.3 Sustainability and Engineering

Sustainability and Engineering, commonly called the Sustainability Office, is a unit under C+CP and is responsible for coordination of sustainability related projects. For example, UBC's Water and Zero Waste Engineer is located in this unit and is responsible for development of the Water Action Plan and the Irrigation Action Plan.

4.1.4 University Sustainability Initiative (USI)

The UBC Sustainability Initiative (USI) was established in 2010 and is a unit under the VP Academic and Provost. The role of USI is to foster partnerships and collaborations that extend beyond traditional boundaries of disciplines, sectors and geographies to address the critical issues of our time. The initiative's work is carried out under two cross-cutting themes: campus as a living laboratory and the University as an agent of change. USI reports to a Steering Committee, consisting of senior leaders at the university.

4.1.5 Infrastructure Development (ID)

Infrastructure Development is responsible for the planning and implementation of UBC's capital program. ID is made up of three core groups: Capital Planning, Facilities Planning and Project Services. Project Services is responsible for management of renovation projects between $50,000 and $2.5 million, as well as for major facility renewal projects >$2.5 million. UBC Properties Trust (see below) is engaged by Infrastructure Development to manage the design

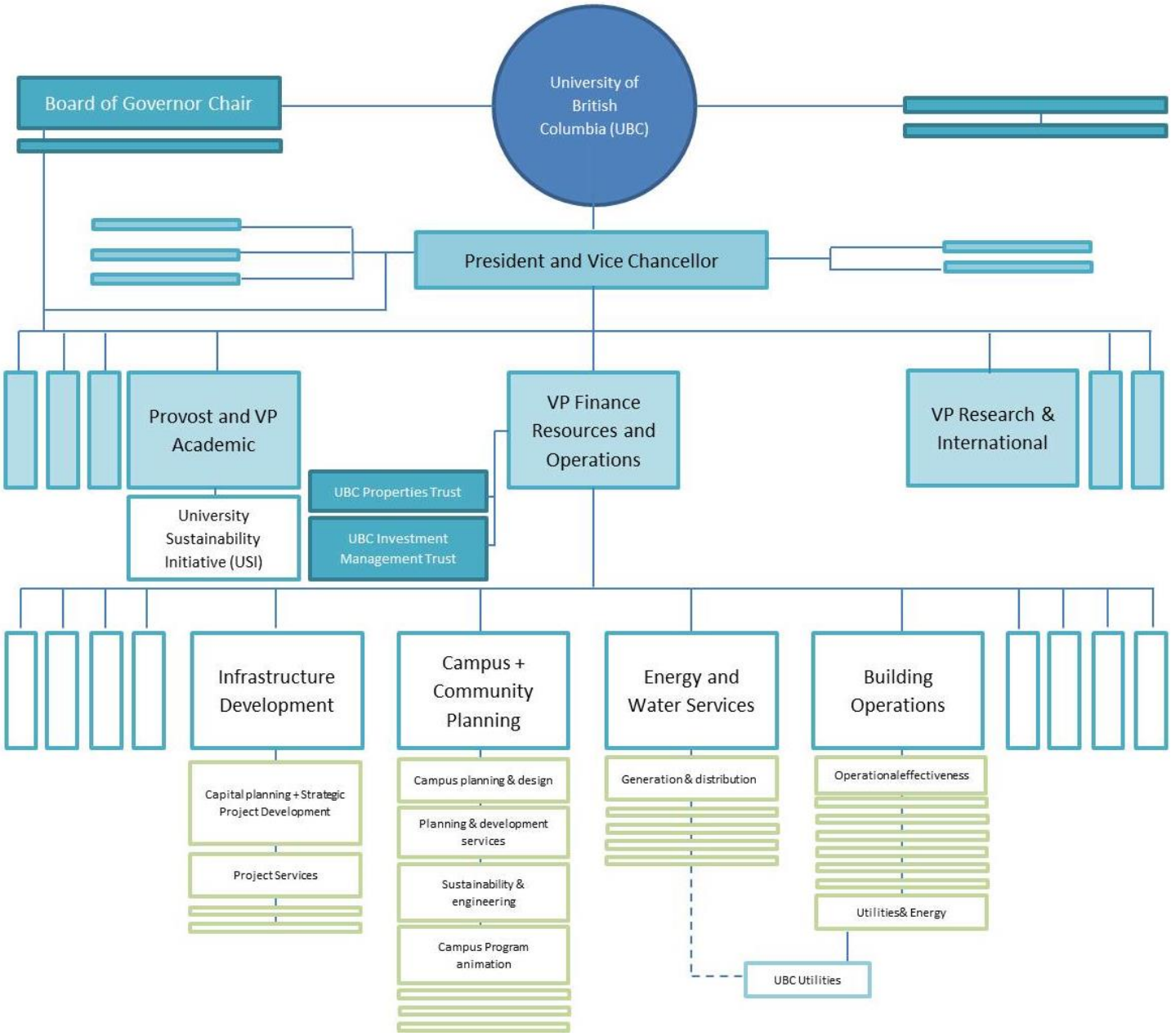

Figure 5: Departments related to water governance and management at the University of British Columbia (UBC) Vancouver Campus.

and construction of new institutional building projects. The difference between C&CP and ID is as follows: ID is the project developer and C&CP is the regulator. ID plans and develops capital projects, with essential partnership from UBC Properties Trust. C&CP regulates land use decision-making and building design standards. They review and issue development permits and building permits for capital projects put forward by Infrastructure Development/UBCPT.

4.1.6 UBC Properties Trust (UBCPT)

UBC Properties Trust is the agency responsible for managing major renovations and new constructions and works closely with ID and C+CP. UBCPT also undertakes non-institutional development projects and negotiates with private developers who lease land from UBC (UBC Campus and Community Planning, 2009).

4.2 Who is Responsible for What?

4.2.1 Renewal Projects

UBC Properties Trust manages large-scale renovations while the Construction Office manages minor renovations, which is a unit under Building Operations. For example changing toilets and small laboratory renewal in a building is considered as a small renovation to be conducted by UBC Building Operations and managed by the project managers in the Construction Office. No permits are needed for maintenance and small-scale renewal projects, such as replacing water taps. In contrast, project approval and permits are required for larger-scale renovations, such as excavation permits or lighting permits, which are provided by C+CP. Moreover, any kind of necessary inspections of development projects are managed by C+CP, which either ask UBC Utilities to conduct them, such as manhole sized sewage system inspection. External organizations are contracted if particular technology or expertise is required, such as pipe sized sewage system inspection by advanced robots.

4.2.2 Non-Institutional Development

The Neighbourhood Plan Areas is the name for seven local areas at the Vancouver campus, which accommodate family housing. C+CP in consultation with campus community and external stakeholders develop the Neighbourhood Plans and UBC Board of Governors is responsible for their approval (UBC Campus and Community Planning, 2014). Campus and Community Planning (C+CP) sets the regulations, design and technical guidelines for new constructions on campus while UBC Properties Trust manages those developments.

4.2.3 Distribution of water

The Greater Vancouver Water District (GVWD) is a legal entity that operates under Metro Vancouver (Metro) that supplies water on a wholesale basis to its member municipalities and non-member communities. The University Endowment Lands (UEL) is one of the non-member communities who Metro provides water to. UEL is administrated directly by the Province and is thus not a formal member of Metro (Chong, 2005). It is an unincorporated community with a population of nearly 4,000 people and consists of approximately 1,200 hectares that are located between the City of Vancouver and UBC (Figure 6) (University Endowment Lands Administration Office, 2014).

4.2.4 Operation and Maintenance of Different Types of Buildings on Campus

There are three different types of buildings on campus.

- Core academic buildings (such as institutional buildings and laboratories)
- Ancillary buildings (such as UBC Athletics and student housing)
- Other types of buildings (such as market housing) (UBC Sustainability, 2011b)

UBC Building Operations receives core funding for the operation and maintenance of the core academic buildings, which are the properties of the university. Ancillary buildings are also owned by UBC and maintenance of these buildings is carried out either by in-house staff within the respective ancillary (i.e. SHHS) or is provided on a contract basis to these ancillaries by Building Operations. Market housings are a number of residential communities on campus, which has their own property management teams that are responsible for building operation and maintenance.

4.3 Action Plans

One of UBC's long-term objectives are to create a campus-wide closed loop water system (UBC Sustainability, 2014c). On the path to achieve this objective, UBC is developing action plans that detail UBC's water management strategies and specific plans on campus. At this point they are all draft reports and have yet to be adopted by Campus and Community Planning (C+CP). The Discussion Paper from 2011 deals with both supply and demand and outlines conservation efforts that have financial benefits. The

Figure 6: The University Endowment Lands, the UBC Point Grey Campus and the westernmost part of the City of Vancouver (University Endowment Lands Administration Office, 2014).

Stormwater Management Plan targets flood risk management and directs financial operation. A number of consultancy reports provide the background information, as described below.

4.3.1 Water Action Plan: Discussion Paper (2011)

UBC Sustainability & Engineering is presently developing a Water Action Plan. The publically available discussion paper was released in 2011 summarizing the work until that point (UBC Sustainability, 2011a). In parallel, a *Water Conservation Action Plan* was developed (described below). Both documents stem from the same project, and support the concept of treating water as a resource (UBC Sustainability, 2011a, 2011b).

The discussion paper outlines the public consultation process leading up to the plan and it also provides a summary of a water audit that was conducted of seven institutional buildings on campus (UBC Sustainability, 2014).

A series of public consultations were held in 2011 to inform the UBC community about the development of the plan. In these events over 80 University's staff and faculty members, students and UBC community residents had the opportunity to share their ideas for long-term water conservation and management on campus. Among other things, actions required to realize the proposed concepts were also discussed among the participants. Working groups then developed the ideas that had been collected during the public consultations prioritized among the required actions. According to the available draft version of this document, UBC's five main water management strategies are:

- *Rainwater harvesting;*
- *Efficient landscape irrigation;*
- *Reduced water use and wastewater generation;*
- *Water use management in building operations; and*
- *Education and engagement* (UBC Sustainability, 2014d)

4.3.2 Water Conservation Action Plan (2011)

The *Water Conservation Action Plan* (2011) includes strategies and actions encompassing a number of water conservation aspects. Some specific strategies include replacing once through cooling units with closed loop systems or replacing older infrastructure with low-flow technologies for existing buildings, or the modification of policies and guidelines to "[promote] high efficiency and [encourage] the use of alternative water sources (eg. Rainwater and greywater)" for new buildings (UBC Sustainability, 2011b, p.1). One proposed strategy is to increase the existence of UBC-wide infrastructure, which for example by the construction of "centralized wastewater treatment and reuse facility or facilities", as well as "centralized rainwater storage and reuse system or systems" (UBC Sustainability, 2011b, p.15). It may be noted that the terms 'centralized-decentralized' refer to a different scale as compared to Metro Vancouver. In the UBC context, 'decentralized' refers to building scale and centralized refers to campus scale. In contrast, 'decentralized' refers to neigbourhood to city level in the Metro context, and 'centralized' refers to larger scale systems serving more than one city in the region.

The plan describes water infrastructure as well as inflows and outflows, along with consumption data in terms of end user and user group. If no measures are taken (business as usual scenario), the total water consumption at UBC is projected to increase 30% from the 2009 value of 4.3 billion litres per year to approximately 5.5 billion litres by 2020. The plan describes goals and targets; most notably

> *UBC is targeting a 30% and 60% reduction of potable water consumption by 2015 and 2020, respectively, from the projected business-as-usual scenario (UBC Sustainability, 2011b, p.1).*

To achieve the water conservation goals, UBC enforces construction policies that reinforce water savings. Attaining minimum Leadership in Energy and Environmental Design (LEED) Gold certification for new institutional buildings, which includes 30 percent decrease in water consumption from the baseline calculated for the building (not including irrigation) (Canada Green Building Council, 2010) and meeting Residential Environmental Assessment Program (REAP) guidelines for residential communities are some examples of the imposed construction policies (UBC Sustainability, 2009). According to REAP guidelines using low-flow fixtures, efficient irrigation and ecologically-sound planting are compulsory for all new residences (UBC Sustainability, 2009). As mentioned in the Process Cooling and Research section, there are strategies in place to reduce water consumption in the laboratories on campus, which consume significant amount of water in comparison with other buildings due to their cooling, heating and equipment requirements. It is not entirely clear if these measures will be sufficient to reduce the consumption to the projected goal. Also, it is not clear how it relates to the goal of achieving a closed water-loop.

4.3.3 UBC Integrated Stormwater Management Plan

An Integrated Stormwater Management Plan (ISMP) is presently being developed by C+CP (UBC Campus and Community Planning, 2013). The plan outlines long-term strategies and actions for stormwater quantity and quality control at UBC, using innovative approaches to improve conventional stormwater systems. A public consultation event was held in April 2014. University's staff and faculty members, students and UBC community residents were given the opportunity to share their observations and comments in relation to the emerging stormwater management plan and the suggested actions were discussed among the participants and the C+CP team. The plan will be finalized over the summer of 2014. According to the available draft version, it includes:

- *Minimizing stormwater flow outside UBC boundaries*
- *Incorporating water quality standards for stormwater leaving campus boundaries, equivalent to best practices in comparable urban areas*
- *Stormwater Management Innovations*

In contrast to previous stormwater management approaches on campus, the scope of the plan does not extend past the UBC boundaries (such as the receiving bodies), but focuses on management strategies that will minimize impacts on land, both adjacent and within the UBC boundary. According to the introduction, the main objectives of ISMP is to:

- *Reduce the impacts of flows of stormwater off of campus, through detention and other methods; and,*
- *Maintain water quality at its boundaries at a level that meets or exceeds best practices for urbanized municipalities. (UBC Campus and Community Planning, 2013a, p.3)*

Later in the document, these are specified through five additional objectives:

- *Protection from flooding and prevention of overland flooding across cliffs.*
- *Ensure that the requirements of legislation are met.*
- *Protect the campus environmental values and minimise the impact of campus discharge on neighbouring watercourses.*
- *Improve the quality of the stormwater that leaves the campus.*
- *Incorporate the natural hydrologic cycle into the stormwater system. (UBC Campus and Community Planning, 2013a, pp.3-4).*

The plan provides a background to the current stormwater management practices at UBC and identifies some key challenges for the implementation the plan. Implementation strategies and ideas are presented for each of the four catchments on the Point Grey Campus (see the Stormwater Sewers section), along with stormwater practices that are being developed, such as "green roofs, infiltration galleries and internal rainwater re-use" (UBC Campus and Community Planning, 2013a, p.14).

4.3.4 Consultancy Reports

UBC has contracted various engineering consulting firms to complete reports on various aspects of the UBC water system and its management. These documents are not generally available to the public, but used by the department that commissioned them to develop plans and strategies. The documents often provide recommended actions, which are subject to approval by UBC. For example, the *UBC Water Balance*, by Stantec details the potable water consumption at UBC. The *Integrated Water Master Plan* was completed by Urban Systems in 2010 analyze the potable water distribution system, the sanitary sewer collection system and the stormwater collection system. The report recommends that the management of the three systems be integrated. The *Hydrogeologic Stormwater Management Strategy,* completed in 2013 by AECOM to support the development of ISMP, in order to "identify areas across the four catchment areas where hydrogeological conditions are suitable for storm water infiltration into the ground" (AECOM, 2013, p.1). The *UBC Irrigation Action Plan* by Stantec in 2012 is a draft report that has not been approved by UBC. The purpose of the plan was to create an irrigation baseline and forecast, set targets for consumption reduction and suggest actions and recommendations to achieve those targets. The *UBC Campus Water Reuse Considerations Report,* completed by NovaTec in 2011, examines the potential to treat and reuse wastewater on campus.

5 Water Governance at UBC

The aim of this chapter is to provide a brief overview of the governance structure that guides water management at UBC. This structure can be seen in Figure 5 in the previous section.

The legal power to manage, govern and control the UBC campus lies with UBC's Board of Governors (Government of BC, 2014). Historically, the distribution of responsibilities was not entirely clear but in 2009, the UBC Board of Governors adopted Policy #92, "Land Use and Permitting", which states:

> *Under the University Act, the Board of Governors is vested with the power to: (a) manage, administer and control the property, revenue, business and affairs of the University, (b) make rules respecting the management, government and control of the University's real property, buildings and structures, (c) regulate, prohibit and impose requirements in relation to the use of real property, buildings, structures, and (d) generally make rules consistent with the powers conferred on the Board of Governors by the University Act. (UBC Board of Governors, 2009, p.1)*

UBC's strategic plan *Place and Promise* (UBC, 2012c) provides UBC's vision and it's six values: Academic freedom, Advancing and sharing knowledge, Excellence, Integrity, Mutual respect and equity, and Public interest. Central to the plan are UBC's three core commitments and six sub-commitments chosen to "support UBC's core mission, capitalize on strengths and focus attention on where the University most needs to grow" (Figure 7) (UBC, 2012a).

> *VISION: As one of the world's leading universities, The University of British Columbia creates an exceptional learning environment that fosters global citizenship, advances a civil and sustainable society, and supports outstanding research to serve the people of British Columbia, Canada and the world. (UBC, 2012, p.6)*

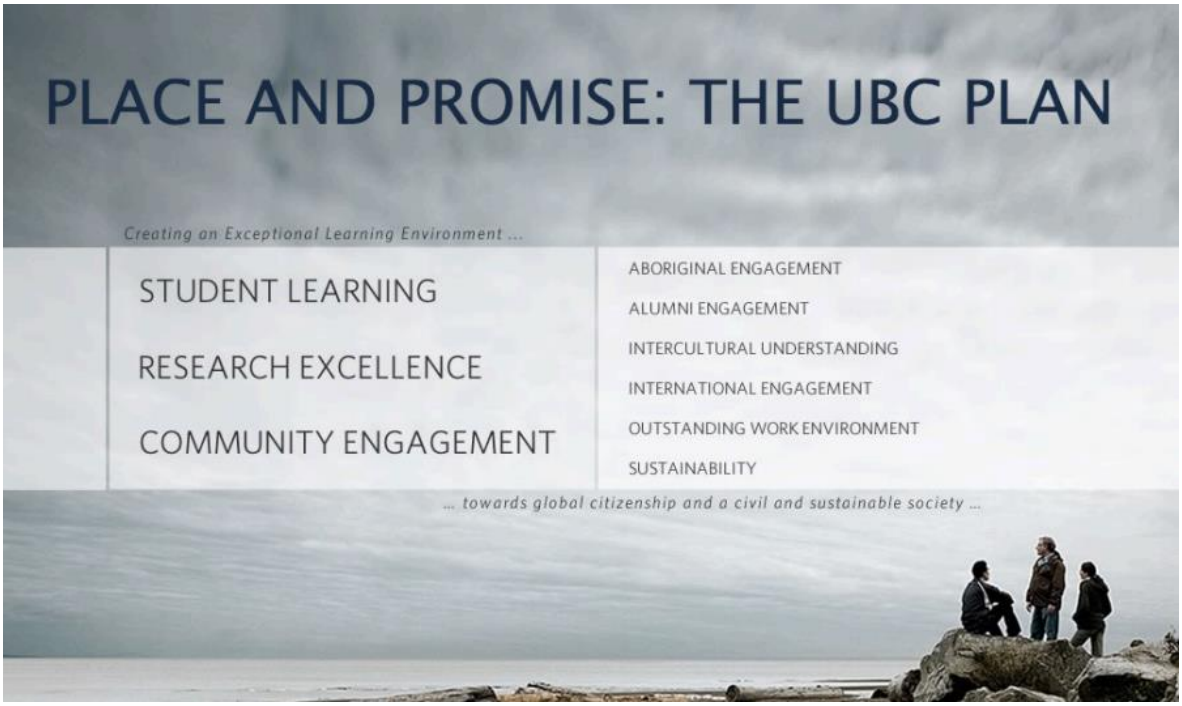

Figure 7: UBC's three commitments and six sub-commitments, as outlined in its strategic plan Place and Promise, which was adopted by the Board of Governors in 2012 (UBC, 2012b).

In the Strategic Plan, each commitment is fleshed out on a couple of pages including goals and actions that are "designed to see them through". The Strategic Plan is to guide all UBC strategies, and the intention is to create plans for each of the commitments.

In UBC's Strategic Plan, water management is explicitly mentioned under the Sustainability commitment. This commitment has the goal of "[exploring] and [exemplifying] all aspects of economic, environmental and social sustainability" (UBC, 2012, p.9), which opens up for the possibility of a truly integrated approach to water management. The specified action items related to water do, however, only deal with infrastructure planning, management and operation.

5.1 Implementation of the Vision

The *Vancouver Campus Plan* was developed as part of the process leading to the Strategic Plan and forms the basis for planning, development and growth at UBC. It consists of three parts: a synopsis (Part 1) (UBC Campus and Community Planning, 2010a), the plan itself (Part 2) (UBC Campus and Community Planning, 2010b), and design guidelines (Part 3) (UBC Campus and Community Planning, 2010c).

Policies in the campus plan are presented in six categories: Sustainability, Campus Land Use, Public Realm and Open Space, Movement and Circulation, Infrastructure and Utilities, and Campus Character. Water is discussed as part of all of the categories aside from Movement and Circulation, and Campus Character. Two areas dominate the discussion on water: rainwater/stormwater management and water efficiency. According to the plan, the latter is mainly to be achieved through decreased water consumption, even though the possibility of reuse is also mentioned. When it comes to stormwater, the plan advocates a "shift to a natural systems approach, which values rainwater as a resource" (UBC Campus and Community Planning, 2010b, p.39). Policies reinforcing those strategies are presented, such as Policy #39:

> *To the extent that the unique hydrogeology and cliff-erosion concerns at UBC's Vancouver campus allow, stormwater management strategies will incorporate a natural systems approach in managing runoff volume to mitigate downstream impacts. (UBC Campus and Community Planning, 2010b, p.40)*

Other sustainable practices such as "integrated planning for energy and water" and "Living Laboratory projects" are also mentioned (UBC Campus and Community Planning, 2010b, p.36). It is not clear what the integrated aspect of energy and water planning refers to as energy and water elsewhere are discussed separately. Coordination of water conservation strategies with waste and energy reduction strategies is mentioned, but it is not clear what this might entail.

The third part of the Campus Plan offers specific design guidelines for the implementation of strategies. It is for example stated that developments "are to collect and use rainwater and stormwater where possible for appropriate uses such as irrigation or other non-potable uses" (UBC Campus and Community Planning, 2010c, p.9) and that

> *[projects] are to minimize the consumption of potable water by eliminating its use where and when it is not necessary, and by maximizing efficiencies in its distribution and use. (UBC Campus and Community Planning, 2010c, pp.9-10)*

The Campus Plan also states that whenever it is possible,

> *public amenity will be combined with surface (ponds, swales, rain gardens) and rooftop (green roof, re-use system) stormwater facilities such that multiple benefits are realized, including potable water or energy savings, and stormwater volume reduction or flow control. (UBC Campus and Community Planning, 2010b, p.9)*

The guidelines also include infiltration limitations and allowances based on the upper and lower aquifer.

The *Land Use Plan* (adopted January 2011, amended 2012) provides goals for future development, broad land use considerations and objectives for more detailed planning (UBC Campus and Community Planning, 2012). Alongside the *Vancouver Campus Plan*, the *Land Use Plan* guides the physical planning of UBC and establishes land use policies and criteria for development on campus. The Land Use Plan conforms to Metro Vancouver's Livable Region Strategic Plan, partly through three shared cross cutting themes: Ecology, Economy, and Community. The *Land Use Plan* provides a number of policies and criteria across development areas such as Land Use, Access, and Servicing. Most pertinent to water, is the Servicing area that includes for example that "Servicing plans will need to address issues of energy conservation and demand-side management for solid water, water conservation and other services" (UBC Campus and Community Planning, 2012).

5.2 UBC's Sustainability Strategy

UBC is in the process of developing its 20-Year Sustainability Strategy, which will set the stage for the next generation of sustainability activities at UBC, across teaching, learning, research, partnerships, operations and infrastructure, and the community. Two documents predate the emerging sustainability strategy, and are directly relevant for water management: Exploring and Exemplifying Sustainability – UBC's Sustainability Academic Strategy (SAS) (2009), and Inspirations and Aspirations – The Sustainability Strategy (2007). The emerging strategy builds on SAS, and "is intended to guide decision-making at UBC's Vancouver campus with regard to sustainability" (UBC Sustainability, 2014, p.4). The strategy will be completed in 2014, but is said to be "a living document", which means that it will be subject to update over the 20-year time span in light of new discoveries or innovative practices, or changes to environmental conditions or stakeholder preferences.

6 Lessons Learned

6.1 Sustainability

With the creation of USI in 2010, UBC strengthened its position as one of the leaders in sustainability among academic institutions. The vision is bold and it is evident that the emerging sustainability strategy has influenced the university's strategic plan *Place and Promise*. The implementation of the action items appears to be on track, for example through the creation of the *Vancouver Campus Plan*, the Water Action Plan and the *Stormwater Action Plan*, which contain several radical and innovative solutions. The Campus Plan stresses integrated approaches to water management and the action plans detail solutions. The goal is to incorporate the entire water cycle and close the water loop. We note that some parts are more developed than others, for example with no strategies involving evapotranspiration even though it is one of the major drivers of the water cycle. Also, it is not entirely clear what a closed loop would mean in practice or if it indeed is the most sustainable strategy.

The literature on Integrated Resources Management stresses that a shared understanding of goals and incentives is seminal to successful implementation of a strategy, as well as to efficient planning and operations. It seems as if UBC's sustainability goals are not necessarily followed through in UBC's projects, even though they are explicitly spelled out in both the strategic plan *Place and Promise*, and the *Vancouver Campus Plan*. Even though sustainability is said to be cross-cutting, the structure and content of the other sections in the strategic plan gives the impression that planning and implementation of the six commitments is done as separate tracks. Water is only mentioned in relation to sustainability. In the development of a truly integrated strategy, it appears logical to explore how to integrate water in all UBC's commitments.

The opaqueness in the distribution of responsibilities, seem to be particularly pronounced in the sustainability field. For example, "Sustainability and Engineering" is a unit under C+CP, which is widely known as the Sustainability Office, is located in the same building as the "University Sustainability Initiative (USI)". Both offices are said to have a responsibility for the integration of sustainability issues across campus, including the integration of teaching, research and operations.

6.2 Energy and Water

With the creation of the department of Energy and Water Services, UBC places itself among the few public institutions around the world that have taken action on the organizational level to meet the challenges posed by the water-energy nexus. Research into the nexus has revealed unexpected connections. Recent studies show, for example that over 80-90 % of the energy used in the urban water cycle is used to heat water for showers, laundry and food. The energy used to produce potable water, distribute it through the network, and clean the wastewater is insignificant in comparison. The parallel development of efficient heat-exchangers that can recover up to 90% of the energy and be installed in showers opens up unforeseen opportunities for institutions like UBC, for example in relation to planning of the new Aquatic Centre and the new field house. Other examples are studies that show that regular monitoring and maintenance of pumps can save both energy, money and green-house gas emissions, as pumps commonly run on 40% or less of their capacity.

UBC is taking and exciting and bold step by creating the new department of Energy and Water Services. Research on change management and related areas clearly show that efficient management is paramount to the implementation of visions and goals.

It is a bit unsettling that there does not seem to be a shared understanding of the distribution of responsibilities and what the new organizational change will actually mean on the ground. Some believe that it is simply a new name for UBC Utilities, which is anticipated continue to operate as before. Others are of the impression that the new department will only deal with the hot-water system while responsibility for other water and energy related issues would remain where they are. It is well documented that ingrained organizational structures are one of the major obstacles to institutional change.

6.3 Data Management

Efficient resource management requires good knowledge about the resource itself. To know where savings can be made requires detailed knowledge about the resource flows, how these flows relate to other factors, such as energy, GHGs, ecosystem services, health, social well-being, and where the potential cost-savings lie.

UBC's water consumption is metered with 15-minute intervals and the amount of sewage leaving the campus is also metered. In addition, the water consumption in over 80% of the buildings is metered electronically and high quality climate data is available from a meteorological station on campus. Still, it is not a trivial task to access the data and even harder to aggregate and analyze the data over time or space. The climate data-base is an elegant tool to that end, but it is not directly accessible via UBC's website and it is not self-instructive. The other data is either not accessible or not available in a format that lends itself to analysis. Our conversations with staff across campus suggest that very few have an overview of the entire system, if anyone.

The obvious solution seems to be to create a common database, which allows analysis of the data as easily as the climate database does. Discussions are ongoing at UBC with regards to the need and design of monitoring systems, for example for energy consumption. Various experiences underline the fact that creation of an efficient monitoring system requires a systematic strategy as to what data to collect, why and to what end.

6.4 Vision, Operation and Human Resources

Previous studies suggest that implementation of sustainability goals often causes unexpected challenges for operations staff. The literature argues that all stake-holders must be involved in the planning process. UBC has taken this to heart and carried out sessions where everyone has been invited and operations staff have been involved and asked to contribute feedback to the plans. Even so, the implementation of UBCs sustainability vision has several times caused unexpected challenges for operations. It seems as if engagement in the planning process is not sufficient. What else is needed? Perhaps an action plan that identifies anticipated impact and future demands on human resources, including action items needed to meet these demands. We do not know if any such plans have been developed.

6.5 Next steps

"What should be integrated?" is a key-question when considering whether or not it would make sense to develop an integrated resource management strategy, using a water lens. Currently, UBC is taking measures to integrate the different water streams – water supply, consumption, wastewater and stormwater, with the explicit aim of creating a closed water loop on Campus. This is a progressive and promising approach. The Water Action Plan takes a broad outlook and asks bold questions. Our impression is, however, that the first step has been to develop action plans according to traditional divisions: water conservation, stormwater, and irrigation, and the integrative aspects are then added. Moreover, it is not evident that blue and

green infrastructure are strategically and systematically integrated in these plans. Furthermore, it is not clear what the effect of utilizing blue and green infrastructure practices will have on evapotranspiration or stormwater flows.

UBC has taken a giant step in the creation of the department for Water and Energy Services. It will be exciting to see how this will unfold. Would it make sense to also look at other resources such as solid waste, food and transportation? No doubt, future work is needed to better assess the links between water and other factors.

Due to the trans-disciplinary nature of the concept of IRM, this project could take a number of different directions. One of the major undertakings in the next phase will be to talk with faculty members across campus and in dialogue with staff in charge of planning and operations chisel out the scope for the project. An understanding of what 'IRM with a water lens' means, and how it can be applied to UBC is vital for the forward momentum of the project. From a governance perspective, it will be essential to determine how to involve key-stakeholders, along with the identification of potential ways to optimize linkages among different functions.

Finally, future studies in this project will include an analysis of the less obvious impacts and implications of an IRM strategy on campus, specifically those pertaining to social, educational, and community values.

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8 Appendices

8.1 External and Internal Bodies Involved in the Governance of Water at UBC

UBC *Board of Governors* manages, governs and controls development on the university's two campuses.

Campus and Community Planning (C+CP) is UBC's regulatory department, with a wide range of responsibilities such as: development project regulatory approvals, land use planning, campus design, green buildings, and sustainability planning.

Energy and Water Services was created in 2014 as "a new university department overseeing the overall management of energy and water with a mandate of fiscal efficiency, operational excellence, environmental sustainability and innovative demonstration".

The *Legislative Assembly* establishes degree-granting universities in BC (BC Laws, University Act, 2014).

Metro Vancouver (Metro) is a political body and corporate entity operating under the provincial legislation as a 'regional district' and 'greater board' that deliver regional services, policy and political leadership on behalf of its 23 municipal members. Metro was responsible for UBC Vancouver land-use approvals prior to 2010.

The *Minister of Advanced Education and Labour Market Develop*ment is consulted on land-use planning by the Ministry of Community and Rural Development.

Greater Vancouver Regional District (GVRD), Metro Vancouver's official name.

The *Provincial Minister of Community and Rural Development* approves land-use planning at the UBC Vancouver Campus.

8.2 Official Documents Guiding Water Management at UBC

The *20-Year Sustainability Strategy for the UBC Vancouver Campus*, is currently under development, but will act as a decision making guide for UBC with regard to sustainability.

Exploring and Exemplifying Sustainability – UBC's Sustainability Academic Strategy was completed in 2009, and provides a planning and decision making framework for the UBC Community.

Inspirations and Aspirations – The Sustainability Strategy 2006-2010 was completed in 2007 and set sustainability targets and goal for the University, along with implementation framework.

The *Official Community Plan* (OCP): previous name of the Land Use Plan. The name-change followed the transferal of the responsibility for approval from Metro Vancouver to the Provincial Minister of Community and Rural Development.

UBC's strategic plan *Place and Promise* (which was adopted by UBC's Board of Governors in 2012) provides the vision for the university and overrides previous strategic documents.

Policy #92, which was approved by UBC's Board of Governors in 2009, provides a municipal-like regulatory structure for the development of institutional and non-institutional development lands at the UBC Vancouver campus.

The *UBC Integrated Stormwater Management Plan* outlines long-term strategies and actions for stormwater quantity and quality control on campus. It is currently under development.

The *UBC Land Use Plan,* which was adopted January 2011, provides goals for future development, broad land use considerations and objectives for more detailed planning (UBC Development and Building Regulations, 2013).

The *UBC Leadership in Energy and Environmental Design (LEED) Implementation Guide* was released in 2013, and is to ensure sustainable building practices for the construction or major renovation of institutional buildings at UBC.

The *UBC Residential Environmental Assessment Program (REAP) Reference Guide* was published in 2009 to create a framework for ensuring sustainable building practices in residential buildings on campus.

The *UBC Vancouver Campus Climate Action Plan* was published in 2010, and outlines action and solutions for reducing emissions on campus in order to meet specified targets.

The *UBC Vancouver Campus Plan*, which was adopted in 2010, provides guidance for UBC Vancouver's academic lands.

The *University Act* is the legislation established by the Legislative Assembly of British Columbia that establishes one degree-granting universities for the province and outlines the governance of such institutions.

The *Water Action Plan: Discussion Paper* is the publically available document summarizing the work done on the Water Action Plan until that point in 2011.

The *Water Conservation Action Plan* is a draft report from 2011 that stems from the Water Action Plan that includes strategies and actions for achieving campus wide water conservation targets.

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