UBC Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

Analysis of Campus Water Base Flows Using Metering Data

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CIVL 592F

Themes: Water, Buildings

September 6, 2018

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ANALYSIS OF CAMPUS WATER BASE FLOWS USING METERING DATA

UBC SEEDS Directed Studies Research Report

By Aina Crozier

Sept. 6th, 2018

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Research focuses on tools to help inform and assist decision making in urban water system planning and management.

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EXECUTIVE SUMMARY

Water consumption in all buildings equipped with high-resolution meters has been analyzed in detail in this study, with focus on their contribution to the high campus base flow (minimum) consumption, estimated at 50 % of total annual consumption. A systematic approach has been applied to estimate the base flow by assuming that whatever is consuming water when occupancy is minimal during the non-irrigation season is running continuously. Buildings have been identified and ranked accordingly.

Since data was not easily acquired and there has been limited previous analysis, a lot of the time was spent on organizing, cleaning and exploring the data, as well as gaining confidence by discussing findings with stakeholders. The 55 primary buildings for which good quality data was available for the study period from July 2017 to July 2018 (the majority Core buildings), consume 24 % of the Campus total supply and 35 % of the Campus base flows. This translated to current high-resolution metered base flow consumption of ~660,000 cubic meters annually, or potential annual cost savings of almost $600,000 (17 % of total water costs) if eliminated completely. It was also found that, as expected, Core buildings with Lab as primary usage have the highest water usage intensities and contribute more to campus base flows. Further, it is stated that more than 70% of the Campus water consumption is currently not accounted for in high resolution (Skyspark data).

Recommendations from this study are to investigate whether the already high-resolution metered base flow water consumption in buildings can be reduced, by, first, clearing up any confusions regarding where meters are located and the area and purpose they cover, and, second, evaluating the cost and feasibility of conserving the water. Further, the recommendation is to make sure that already installed high-resolution meters are working properly and connected, and then prioritize additional meters in buildings with significant lab usage, as well as separate irrigation systems to help investigate potential leaks.

Additionally, a number of recommendations related to improving data availability and quality are listed in this report, as the overall impression is that there should be substantial opportunity for water conservation in buildings and other systems if reliable data is available. As a contribution to this goal, the report is accompanied by an Excel spreadsheet containing all numerical and descriptive data that have been gathered in this study, including various statistics, metrics and charts to help provide a deeper understanding at the building level.

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BACKGROUND

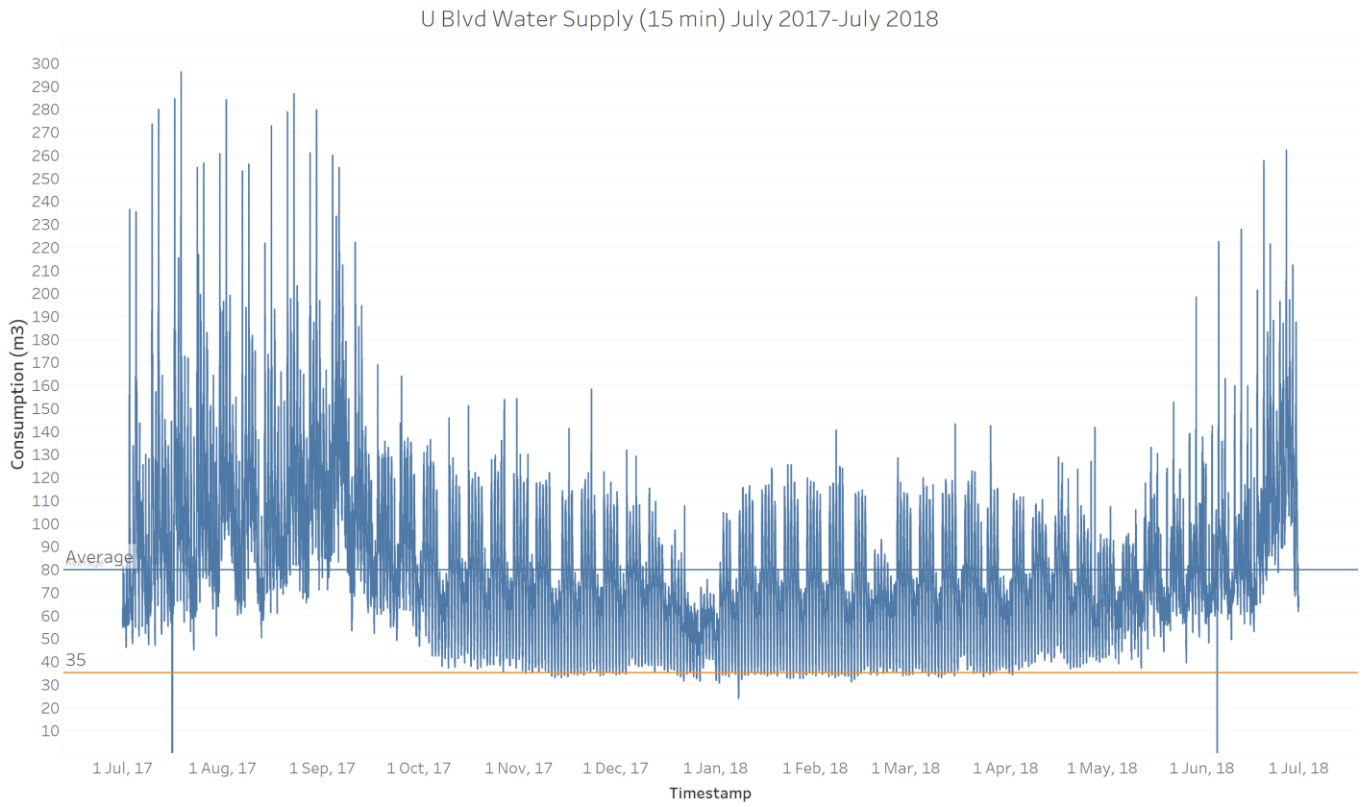
Introduction

Bud Fraser UBC Sustainability

Senior Planning & Sustainability Engineer

"Campus supply water meter data indicates base (minimum) water flows that approach 50% of average flows.

This indicates that there are buildings or systems that are consuming large amounts of water during the night when academic building occupancy is at a minimum."



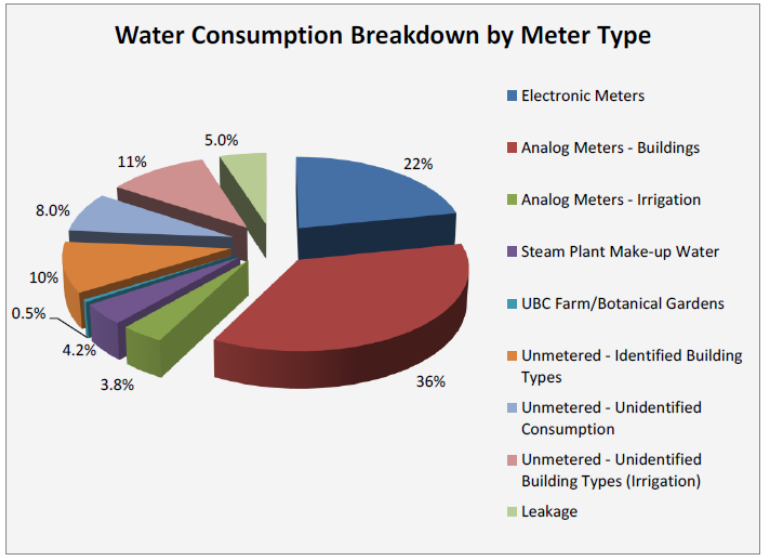
PREVIOUS WORK

UBC Water Base Flow Analysis (2011)

- Stantec Consulting engaged by Campus Sustainability Office (CSO)
- Defined baseflow as the lowest and most consistent water flow for a building at any one point during the study period (Sept 2010 to Sept 2011).
- Extensive study covering data from campus main supplies and sewer, buildings with digital meters (78) and analog meters (298), analog irrigation meters, and various manual readings.

Total and Base Water Consumption of the Entire Campus (Stantec Consulting)

	Annual Water Consumption (m^3)	Estimated Annual Base Flow Water Consumption (m^3)	Base Flow/Annual Consumption (%)
16th Ave Meter	404,000	315,000	78%
Powerhouse Meter	3,500,000	1,730,000	50%
Total	3,900,000	2,050,000	53%



Breakdown of the Campus Annual Water Consumption by Meter Type (Stantec Consulting)

STATUS

Estimated base flow percentage of annual consumption is still around 50%.

Water is relatively cheap compared to electricity, which explains why efforts to reduce consumption may have been down-prioritized.

UBC Water Action Plan (2018) – Renewed sustainability effort to conserve water.

"Maintain UBC total water consumption at or below 2017 levels despite anticipated growth of 2%"

Makes sense to investigate sources of base flow (low-hanging fruit).

Price of water per cubic meter: $0.891
(Increasing 5% annually)

2011 2018	Water Consumption (m^3)	Estimated Baseflow (m^3)	Baseflow/Annual Consumption (%)
16 Avenue Meter	404,000* 970,895	315,000* 403,103	78%* 42%
U Blvd Meter	3,500,000* 2,799,096	1,730,000* 1,483,914	50%* 53%
Total	3,900,000* 3,769,991	2,050,000* 1,887,017	53%* 50%

*Stantec Consulting: Total and Base Water Consumption of the Entire Campus

Cost of base flow:

$1,298,095 (2011)
$1,681,332 (2018)

OBJECTIVES

1. Gain a deeper understanding of water consumption across campus buildings by analyzing Skyspark high-resolution data along with data from campus main supply meters.
   - Identifying and ranking buildings with the largest contribution to campus base flow rates.
   - Identifying potential sources of the base flows.
2. Estimate how much of the total water flow within core academic buildings on campus is metered and if possible, provide recommendations for additional metering locations.

These evolved from the various actions listed in the new UBC Water Action Plan.

CHALLENGES & TIME SPENT

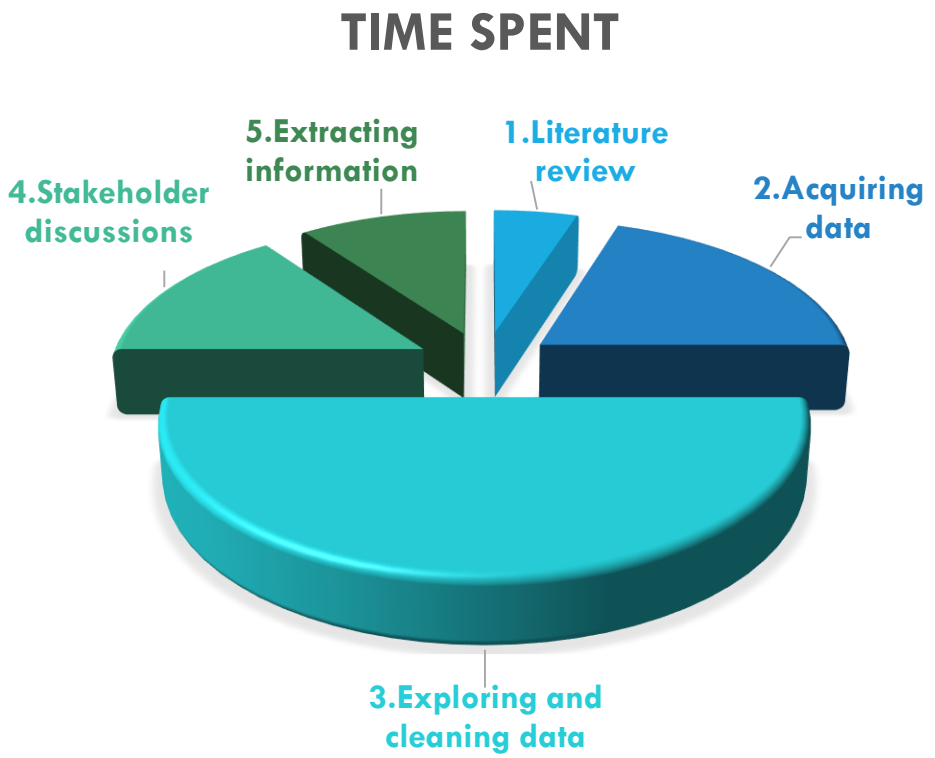
Systematic approach instead of reading off base flow graphically:

- Easier to reproduce and update numbers.
- Apply analytical technique to get deeper understanding of characteristics and trends for building consumption.

Acquiring, exploring and cleaning data (gaining confidence) took longer than anticipated and triggered many questions.

Data has been organized in single spreadsheet, providing a good baseline for further analysis.

Summary of data availability and quality, methods, results and recommendations are presented in the following slides.



DATA AVAILABILITY

Approach

Time period: July 1st 2017 – July 1st 2018

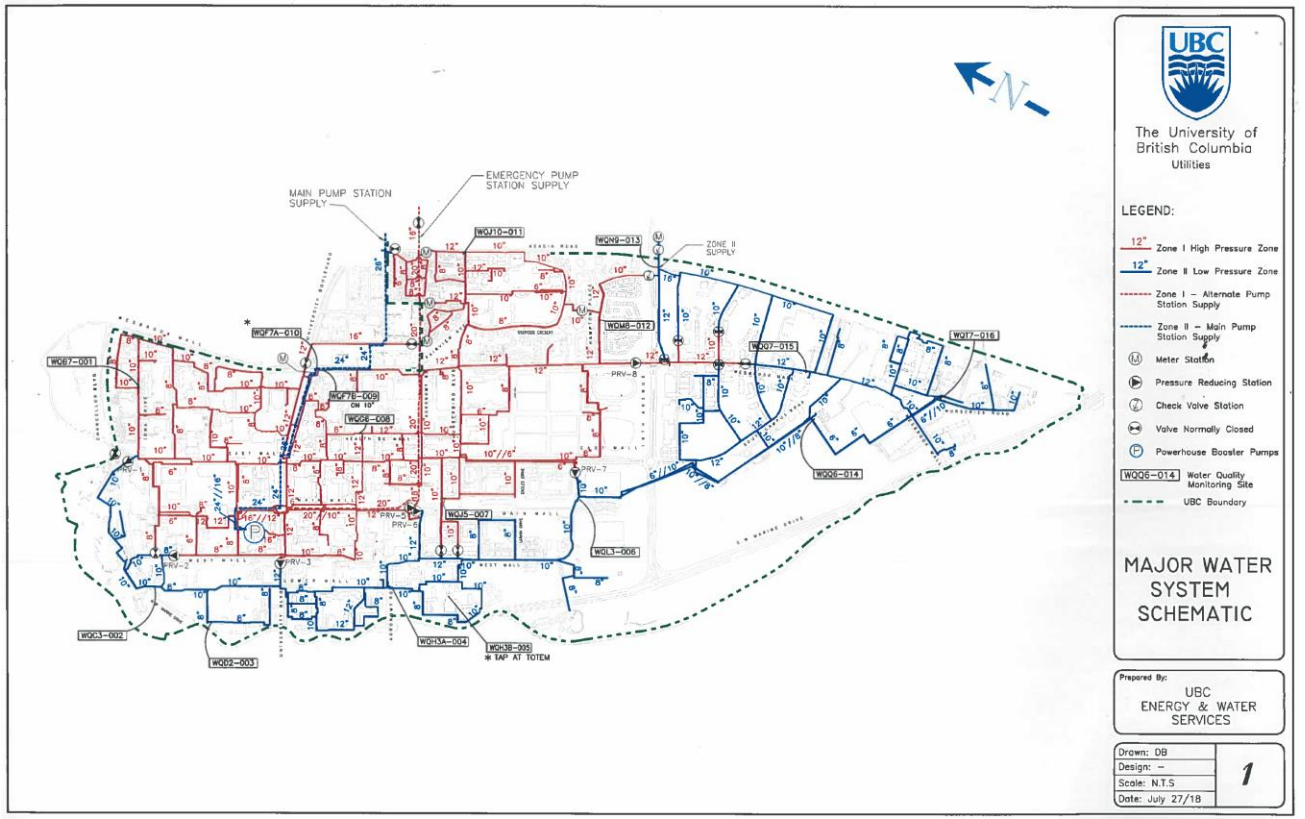
- Steam boiler in Power House shut down on June 7th 2017

Campus Water Supply:

- No direct access to data (TrendReader)
- 15 min resolution data
- U Blvd and 16th Ave supplies (high- and low-pressure zones)
- Available as average flow rates (liters per second)
- Consumption readings Sept 27th, Dec 20th and March 28th (cubic feet for 16th Ave and cubic meters for U Blvd)

Building Water Consumption:

- Access to Skyspark platform
- 15 min resolution data
- 80 buildings listed with water consumption data
- Available as cumulative consumption (cubic meters)



Campus Water Schematics indicating Main Supplies, Distribution Pipes, Pressure Zones, PRVs, etc. (EWS)

DATA QUALITY: CAMPUS SUPPLY

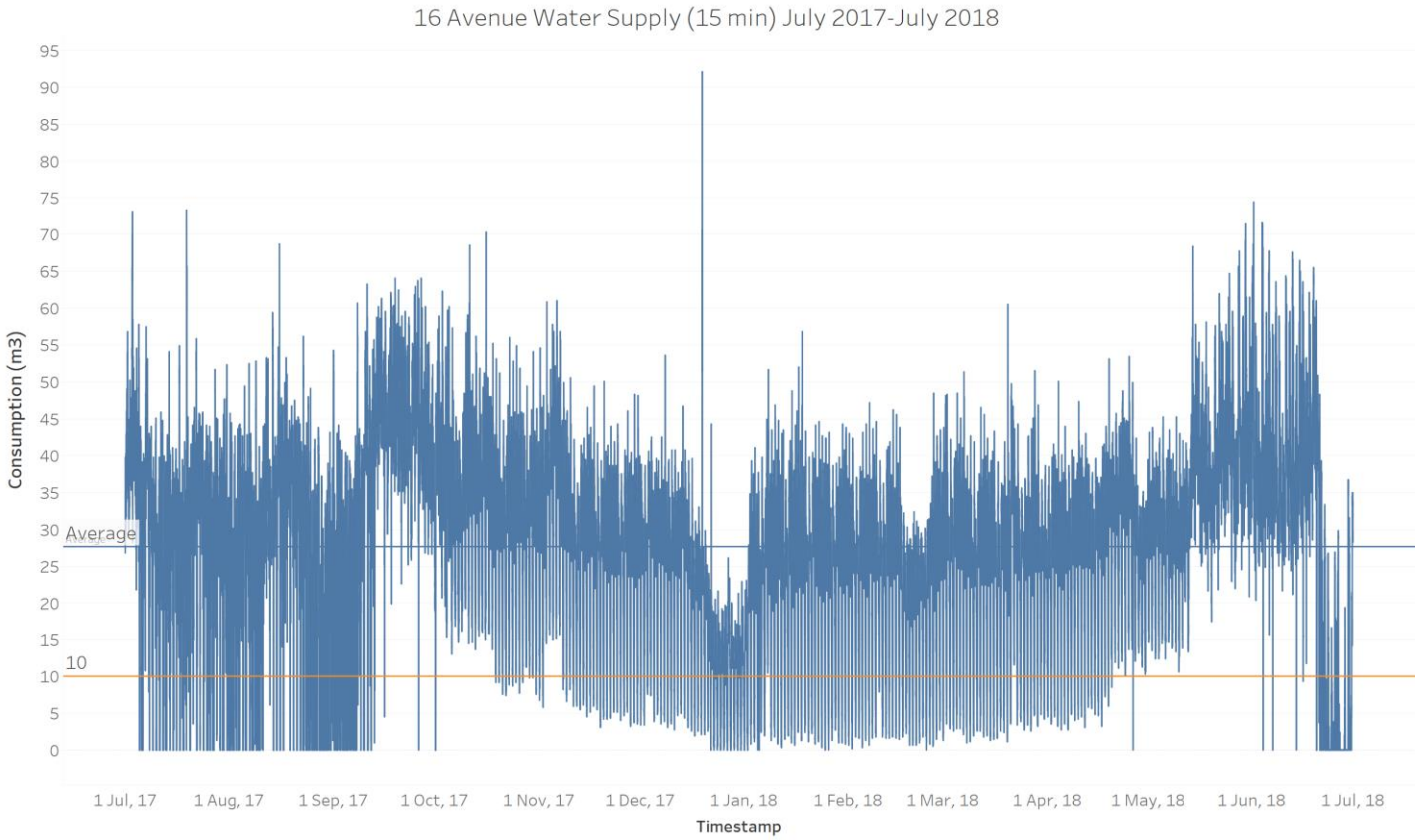
Approach

Interpretation challenging due to automated interaction between high and low-pressure zones through seven pressure-reducing values (PRVs).

Uncertainties & Sources of Error:

- When and how much of U Blvd supply feeds low-pressure zone.
- Offset between consumption computed from flow rate measurements and manual readings.
- Conversion between metric and imperial units.

See Appendix 2: Technical Work for more details on how these were handled.



DATA QUALITY: BUILDING CONSUMPTION

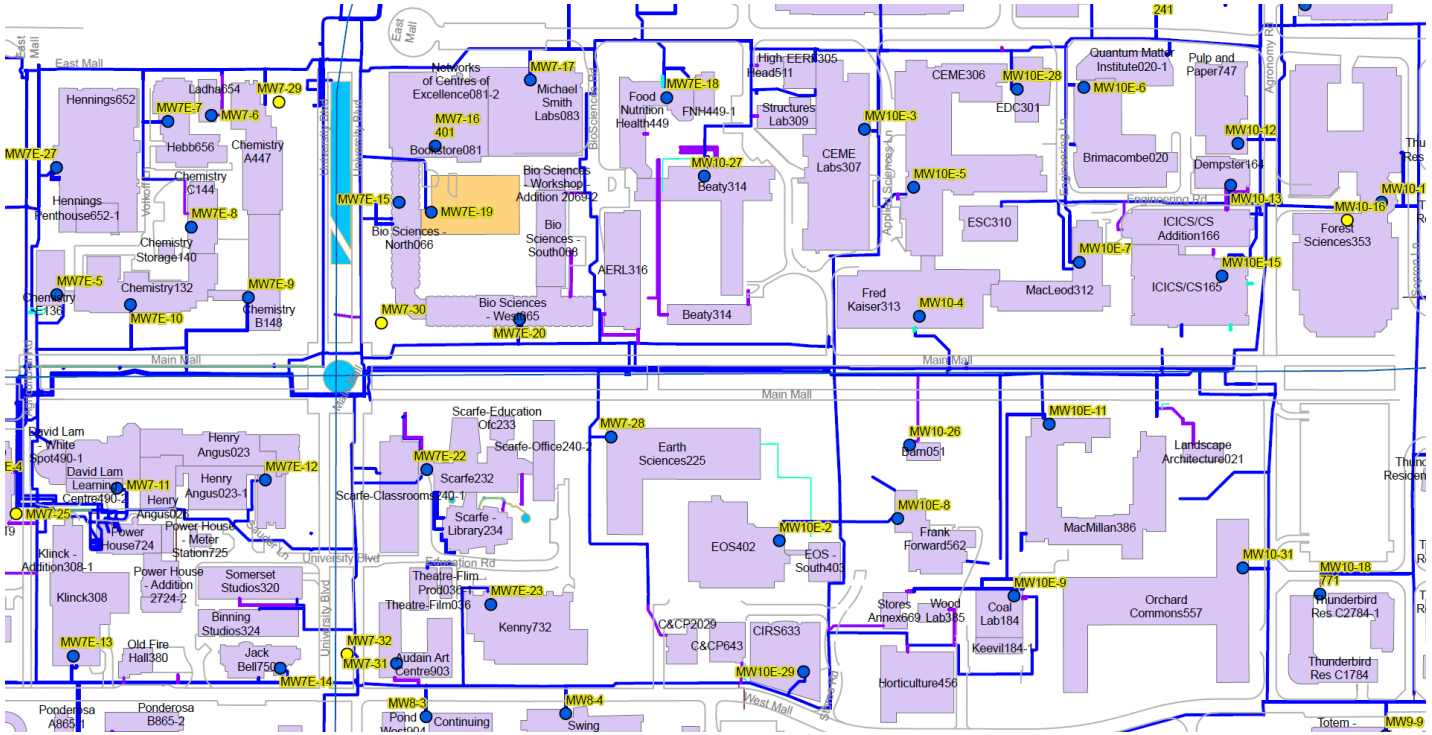
Approach

Main challenge is understanding where data is coming from and how it has been acquired and treated before being presented in Skyspark.

Uncertainties & Sources of Error :

- Understanding which meter the data is coming from.
- Ensuring correct area and space usage of buildings due to sub-fed buildings.
- Missing data and confidence factors (communication issues water meter/ION meter/server).
- Interpreting and handling consumption spikes (cumulative consumption or calculation error).
- Interpreting zeros (malfunctioning meter or accounted for in following datapoints).

See Appendix 2: Technical Work for more details on how these were handled.

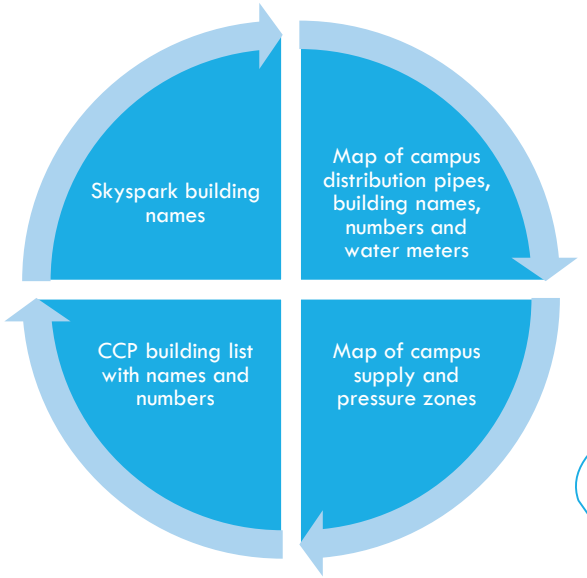


Sample of Map indicating Campus Water Distribution Pipes, Buildings and Water Meters. (EWS)

TECHNICAL & ANALYTICAL METHODS

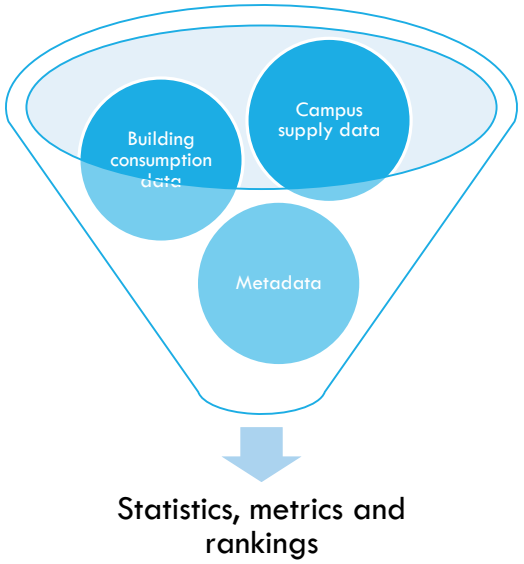
Approach

1. Organized data in single Excel spreadsheet[1].
2. Included metadata by cross-referencing different sources.
3. Cleaned and updated data [2]:
   - Building usage and total areas adjusted for meters covering sub-fed buildings
   - Consumption spikes after missing data removed from the dataset
   - Confidence factors and zero percentages used to filter out poor quality data
4. Computed statistics and metrics to get building ranking



Base flow consumption estimate found by extracting nighttime consumption in non-irrigation months and scaling up to the whole year.

Assuming that whatever is consuming water when occupancy is minimal in non-irrigation season, is running continuously.



[1] See Appendix 1: Spreadsheet for more details.
[2] See Appendix 2: Technical Work for more details.

SUMMARY SHEET WITH METADATA, STATS AND METRICS

Results

Primary Building	Subfed Buildings	Skyspark Name	Category	Primary Usage	Const/Renov Ye	Total Area m3	Total Lab %	Total Residential %	Pressure Zone	Meter Number	Data Extract	Data Column	Resolution	Unit
797		Alumni Centre	Ancillary	Other	2015	3730	0%	0%	High	MW6-21 777	July 1st 2017-June 30th 2018	E	15 min	m^3
795		AMS Nest	Mix	Other	2015	20282	0%	0%	High	MW6-20	July 1st 2017-June 30th 2018	F	15 min	m^3
213		Aquatic Centre	Ancillary	Athletics	2017	8041	0%	0%	High		July 1st 2017-June 30th 2018	G	15 min	m^3
316		Aquatic Ecosystems Research Laborator	Core	Office	2005	5150	5%	0%	High		July 1st 2017-June 30th 2018	H	15 min	m^3
46		Asian Centre	Core	Library	1975	4926	3%	0%	Low	MW1E-1	July 1st 2017-June 30th 2018	I	15 min	m^3
314		Beaty Biodiversity Centre	Core	Lab	2009	12061	21%	0%	High	MW10-27	July 1st 2017-June 30th 2018	J	15 min	m^3
68		Biological Sciences Building South	Core	Lab	2011	5441	42%	0%	High		July 1st 2017-June 30th 2018	K	15 min	m^3
65		Biological Sciences Building West	Core	Lab	2011	7846	36%	0%	High	MW7E-20	July 1st 2017-June 30th 2018	L	15 min	m^3
461		Biomedical Research Centre	Core	Lab	1987	4530	47%	0%	High	MW11E-3	July 1st 2017-June 30th 2018	M	15 min	m^3
20	20-1	Brimacombe-QMI	Core	Lab	1995	13781	28%	0%	High	MW10E-6	July 1st 2017-June 30th 2018	N	15 min	m^3
121-2	121-1,121-3	Buchanan A,B,C	Core	Classroom	2009	10660	4%	0%	High	MW2E-8	July 1st 2017-June 30th 2018	O	15 min	m^3
122-1	122-2	Buchanan D,E	Core	Classroom	2007	6707	1%	0%	High	MW2E-9	July 1st 2017-June 30th 2018	P	15 min	m^3
120		Buchanan Tower	Core	Office	1972	9985	1%	0%	High	MW2E-6	July 1st 2017-June 30th 2018	Q	15 min	m^3
478		C.K. Choi Building	Core	Office	1996	2710	3%	0%	High		July 1st 2017-June 30th 2018	R	15 min	m^3
465		Centre for Brain Health	Tenant	Lab	2014	14395	14%	0%	High	MW11-16	July 1st 2017-June 30th 2018	S	15 min	m^3
57		Centre for Comparative Medicine	Core	Lab	2011	10367	52%	0%	Low	MW25-5	July 1st 2017-June 30th 2018	T	15 min	m^3
130		Chan Centre	Core	Other	1997	8214	0%	0%	High		July 1st 2017-June 30th 2018	V	15 min	m^3
300		Chemical & Biological Engineering	Core	Lab	2005	13182	33%	0%	High	MW11-9	July 1st 2017-June 30th 2018	W	15 min	m^3
132		Chemistry Centre	Core	Lab	1925	7139	37%	0%	High	MW7E-10	July 1st 2017-June 30th 2018	X	15 min	m^3
144		Chemistry East	Core	Lab	2008	3561	49%	0%	High	MW7E-8	July 1st 2017-June 30th 2018	Y	15 min	m^3
136		Chemistry North	Core	Lab	2006	2797	53%	0%	High	MW7E-5	July 1st 2017-June 30th 2018	Z	15 min	m^3
447		Chemistry Physics	Core	Lab	1989	7631	45%	0%	High	MW7-29	July 1st 2017-June 30th 2018	AA	15 min	m^3
148		Chemistry South	Core	Lab	1959	5239	42%	0%	High	MW7E-9	July 1st 2017-June 30th 2018	AB	15 min	m^3
633		CIRS	Core	Office	2011	5264	4%	0%	High	MW10E-29	July 1st 2017-June 30th 2018	U	15 min	m^3
306		Civil & Mechanical Engineering	Core	Lab	1976	8773	29%	0%	High	MW10E-5	July 1st 2017-June 30th 2018	AD	15 min	m^3
307		Civil & Mechanical Engineering Labs	Core	Lab	1971	5636	48%	0%	High	MW10E-3	July 1st 2017-June 30th 2018	AE	15 min	m^3
625		Cunningham	Core	Lab	1960	4901	0%	0%	High	MW6E-12	July 1st 2017-June 30th 2018	AF	15 min	m^3
490-2	490, 490-1	David Lam	Core	Library	1992	6444	1%	0%	High	MW7-11	July 1st 2017-June 30th 2018	AG	15 min	m^3
199		David Strangway	Mix	Office	2005	12209	0%	0%	High	MW6-11	July 1st 2017-June 30th 2018	AH	15 min	m^3
732		Douglas Kenny	Core	Lab	1983	8742	31%	0%	High	MW7E-23	July 1st 2017-June 30th 2018	AI	15 min	m^3
402	403	Earth and Ocean Sciences	Core	Lab	1971	10570	47%	0%	High	MW10E-2	July 1st 2017-June 30th 2018	AJ	15 min	m^3
225		Earth Sciences Building	Core	Lab	2012	15910	22%	0%	High	MW7-28	July 1st 2017-June 30th 2018	AK	15 min	m^3
301		Engineering Design Centre	Core	Lab	2011	2009	45%	0%	High	MW10E-28	July 1st 2017-June 30th 2018	AL	15 min	m^3
337		First Nations Longhouse	Core	Office	1993	2282	0%	0%	Low	MW8E-1	July 1st 2017-June 30th 2018	AM	15 min	m^3
449	449-1	Food, Nutrition and Health	Core	Lab	1982	5740	26%	0%	High	MW7E-18	July 1st 2017-June 30th 2018	AN	15 min	m^3
353		Forestry Sciences	Core	Lab	1998	22459	31%	0%	High	MW10-17	July 1st 2017-June 30th 2018	AO	15 min	m^3
562		Frank Forward	Core	Lab	1968	7542	29%	0%	High	MW10E-8	July 1st 2017-June 30th 2018	AP	15 min	m^3
313		Fred Kaiser	Core	Lab	2005	11798	32%	0%	High	MW10-4	July 1st 2017-June 30th 2018	AQ	15 min	m^3
28		Frederic Lasserre	Core	Office	1962	4572	23%	0%	High	MW2E-7	July 1st 2017-June 30th 2018	AR	15 min	m^3
523-2	525-2	Friedman	Core	Lab	2008	5867	24%	0%	High	MW6E-18	July 1st 2017-June 30th 2018	AS	15 min	m^3

BUILDING CONSUMPTION ANALYSIS SHEET

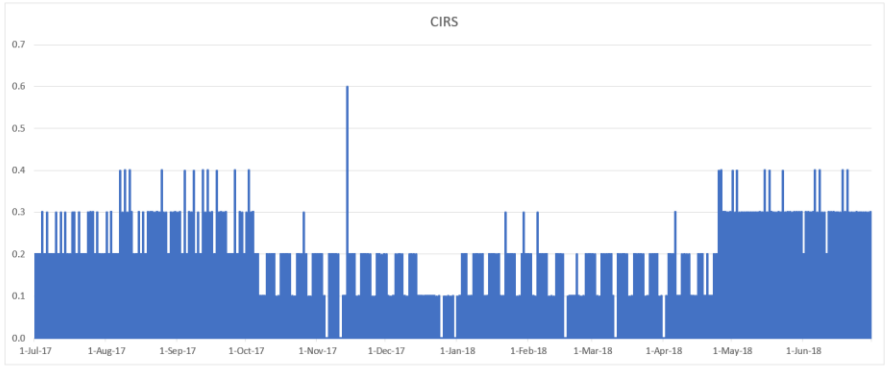
Results

	Drop-down list	Data Column
Select Building	CIRS	U

Primary Building	Subfed Buildings	Skyspark Name	Category	Primary Usage	Const/Renov Y	Total Area m3	Total Lab %	Total Residenti	Irrigation	Pressure zone
633.0	0	CIRS	Core	Office	2011	5264	4.3%	0.0%	Yes	High

Meter Number	Data Extract	Data Column	Resolution	Unit	Timestamps	Datapoints	Missing Datapoin	Confidence	Zeros	Zero Percentage	Quality
MW10E-29	July 1st 2017-June 30th 2018	U	15 min	m3	35040	34982	58	99.8%	21273	60.8%	Good

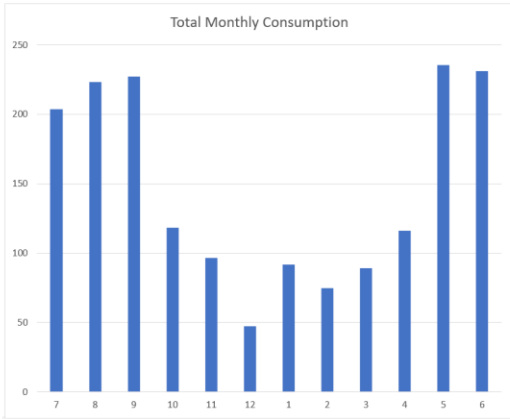
Average 15 min	0.1
Min 15 min	0.0
Max 15 min	0.6
Sec largest 15 min	0.5
Std Dev 15 min	0.1
Outlier?	7.8
Total Consumption	1755
WUI	0.3
% Campus supply	0.05%
% High zone supply	0.06%
Sum night consumption (0-6am)	342
% Total Consumption	19.50%
% Campus night supply	0.04%
% High zone night supply	0.06%
Sum non-irr night consumption (0-6am)	33
% Campus non-irr night supply	0.01%
% High zone non-irr night supply	0.02%
Estimated baseflow	226
%Total Consumption	13%
Ave night consum non-irr months	4.7
Ave night consum irr months	61.9
Ave hourly night consumption	0.2

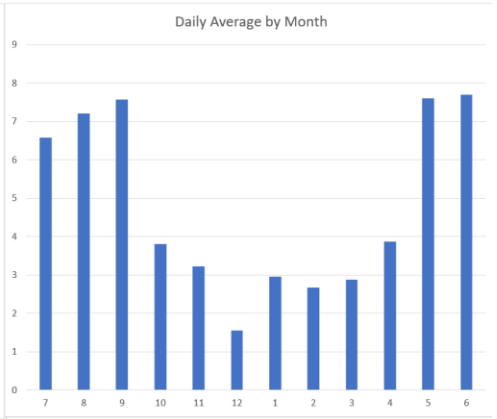


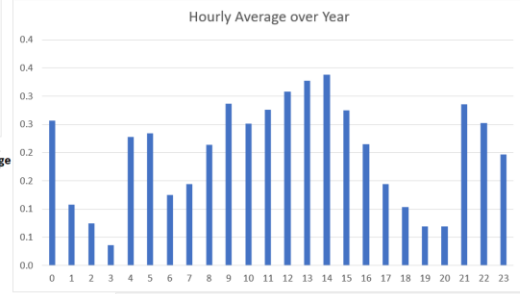
Month	Total Consumption	15 min Average	Min	Max	Second largest	Std. Dev	Count	Days	Correct count	Blanks	Zeros	Daily Average
7	203.80	0.07	0.00	0.30	0.30	0.07	2976	31	2976	0	1367	6.57
8	223.40	0.08	0.00	0.40	0.40	0.08	2976	31	2976	0	1300	7.21
9	227.10	0.08	0.00	0.40	0.40	0.08	2880	30	2880	0	1248	7.57
10	118.20	0.04	0.00	0.40	0.30	0.06	2976	31	2976	0	2003	3.81
11	96.70	0.03	0.00	0.60	0.50	0.06	2884	30	2884	0	2044	3.22
12	47.20	0.02	0.00	0.20	0.20	0.04	2923	31	2976	53	2466	1.55
1	91.80	0.03	0.00	0.30	0.30	0.05	2976	31	2976	0	2171	2.96
2	75.00	0.03	0.00	0.30	0.20	0.05	2688	28	2688	0	2011	2.68
3	89.00	0.03	0.00	0.20	0.20	0.05	2967	31	2972	5	2160	2.88
4	116.20	0.04	0.00	0.40	0.40	0.07	2880	30	2880	0	1943	3.87
5	235.70	0.08	0.00	0.40	0.40	0.09	2976	31	2976	0	1342	7.60
6	231.00	0.08	0.00	0.40	0.40	0.08	2880	30	2880	0	1218	7.70
	1755.10											

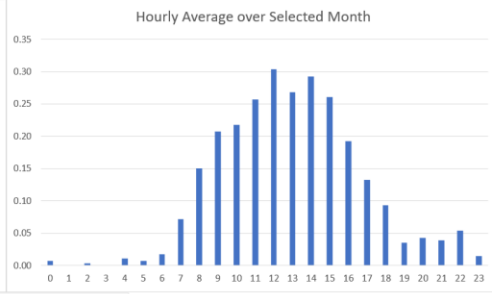
Counts adjusted for:
Daylight Saving Nov 5th 2017 (1am data double)
Daylight Saving March 11th 2018 (2am data missing)

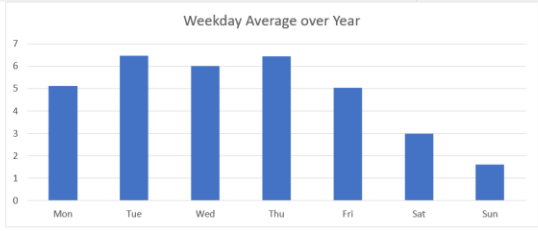
Weekday	Total Consumption	15 min Average	Min	Max	Second largest	Std. Dev	Count	Equiv. Days	Daily Average
Mon	267.00	0.05	0.00	0.40	0.40	0.07	4992	52.00	5.13
Tue	335.90	0.07	0.00	0.60	0.50	0.08	4992	52.00	6.46
Wed	313.20	0.06	0.00	0.40	0.40	0.07	4992	52.00	6.02
Thu	335.30	0.07	0.00	0.40	0.40	0.08	4992	52.00	6.45
Fri	262.60	0.05	0.00	0.40	0.40	0.07	4992	52.00	5.05
Sat	156.70	0.03	0.00	0.30	0.30	0.06	5030	52.40	2.99







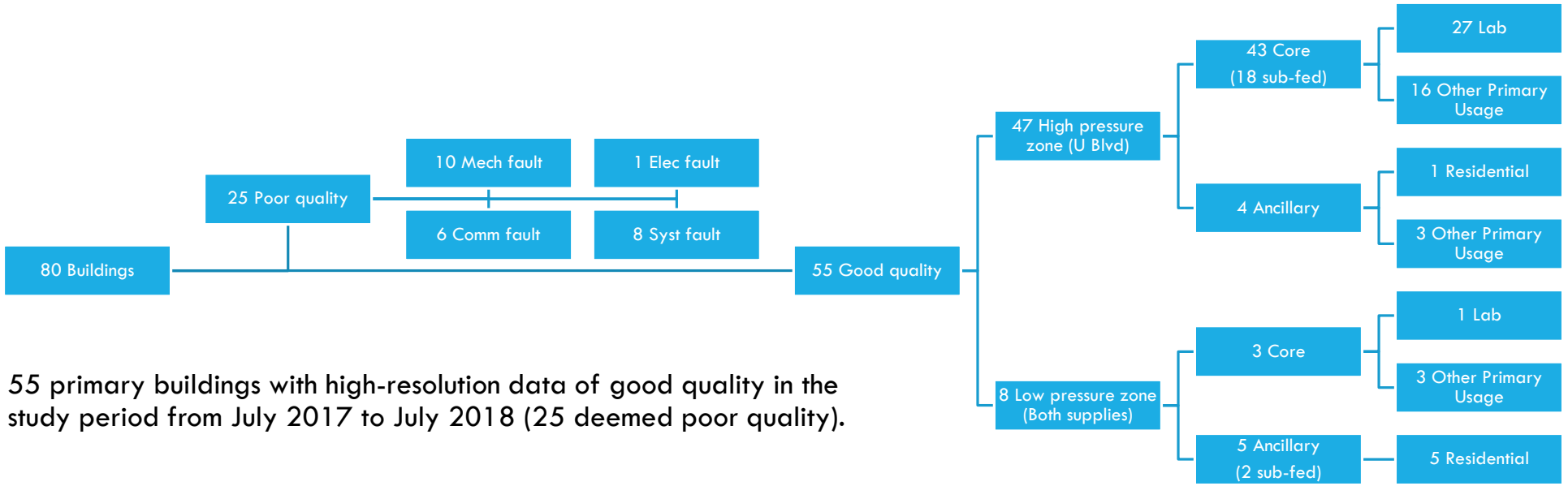




Choose month	2

SKYSPARK BUILDING DATA

Results



- 55 primary buildings with high-resolution data of good quality in the study period from July 2017 to July 2018 (25 deemed poor quality).
- The majority are Core buildings located in the High pressure zone, consuming water from the U Blvd campus supply only.
- 64 of the 218 core buildings on campus are metered with high resolution when including sub-fed buildings into the count.

TOP 10 WATER CONSUMERS

Results

High-resolution metered buildings account for 24 % of total campus supply and Top 10 buildings account for 14%.

If only considering buildings located in the high-pressure zone (47 buildings), these account for 29% of the U Blvd supply.

Skyspark Name	Category	Primary Usage	Meter Number	Subfed Buildings	Pressure Zone	m3/yr
Biological Sciences Building South	Core	Lab	Null	Null	High	121,891
Orchard Commons	Ancillary	Residential	MW10-31	Null	High	80,066
Forestry Sciences	Core	Lab	MW10-17	Null	High	69,927
Life Science Centre	Core	Lab	MW11-8	Null	High	59,502
Earth and Ocean Sciences	Core	Lab	MW10E-2	403	High	41,673
Ponderosa North	Ancillary	Residential	MW8E-2 783	Null	Low	34,743
Robert F. Osborne Centre 1	Core	Lab	Null	Null	High	33,850
Aquatic Centre	Ancillary	Athletics	Null	Null	High	28,964
AMS Nest	Ancillary	Other	MW6-20	Null	High	24,890
Hennings	Core	Lab	MW7E-27	652-1	High	22,294

Metered Core buildings account for 18 % of total campus supply and Top 10 Core buildings account for 11%.

If only considering core buildings with lab as primary usage (28 buildings), these account for 15 % of total campus supply.

Skyspark Name	Category	Primary Usage	Meter Number	Subfed Buildings	Pressure Zone	m3/yr
Biological Sciences Building South	Core	Lab	Null	Null	High	121,891
Forestry Sciences	Core	Lab	MW10-17	Null	High	69,927
Life Science Centre	Core	Lab	MW11-8	Null	High	59,502
Earth and Ocean Sciences	Core	Lab	MW10E-2	403	High	41,673
Robert F. Osborne Centre 1	Core	Lab	Null	Null	High	33,850
Hennings	Core	Lab	MW7E-27	652-1	High	22,294
Civil & Mechanical Engineering	Core	Lab	MW10E-5	Null	High	22,200
Chemistry South	Core	Lab	MW7E-9	Null	High	21,038
Wesbrook Building	Core	Lab	MW6E-10	Null	High	19,824
Earth Sciences Building	Core	Lab	MW7-28	Null	High	17,784

Added to the list when only considering core buildings.

More than 70% of campus consumption is not accounted for in high resolution (Skyspark).

WUI BENCHMARK

Results

- Water Usage Intensity (WUI) is defined as annual consumption divided by total area (m3/yr/m2).
- Biological Sciences Building South stands out even more as Orchard Commons drops to the bottom.
- Chemistry South, CEME, Biomedical Research Centre and Frank Forward (all Lab buildings) replace other buildings.
- Buildings with Lab as primary usage have highest WUI.

Building Type	WUI Average (m3/yr/m2)	WUI Range (m3/yr/m2)
Core (excl. Bio Sci South)	1.8 (1.4)	0.2-9.8
Core Lab (excl. Bio Sci South)	2.5 (1.7)	0.2-9.8
Ancillary	1.3	0.4-3.6
Ancillary Residential	1.0	0.4-2.0

Top 10 Water Intensive Consumers

Skyspark Name	Category	Primary Usage	Meter Number	Subted Buildings	Pressure Zone	WUI
Biological Sciences Building South	Core	Lab	Null	Null	High	22.40
Robert F. Osborne Centre 1	Core	Lab	Null	Null	High	9.85
Chemistry South	Core	Lab	MW7E-9	Null	High	4.02
Earth and Ocean Sciences	Core	Lab	MW10E-2	403	High	3.94
Aquatic Centre	Ancillary	Athletics	Null	Null	High	3.60
Forestry Sciences	Core	Lab	MW10-17	Null	High	3.11
Civil & Mechanical Engineering	Core	Lab	MW10E-5	Null	High	2.53
Biomedical Research Centre	Core	Lab	MW11E-3	Null	High	2.40
Frank Forward	Core	Lab	MW10E-8	Null	High	2.25
Orchard Commons	Ancillary	Residential	MW10-31	Null	High	2.01

Metered consumption most likely includes water usage in Biological Sciences Building West, thus the area should be more than doubled.

NIGHTTIME CONSUMPTION

Results

- 23% of campus total nighttime supply metered with high resolution (14% in Top 10)
  - Metered buildings contribute similarly as for whole year.
- 35% of campus total nighttime supply metered in non-irrigation season (23% in Top 10)
  - Metered buildings contribute more to nighttime consumption outside of irrigation season.
  - Separate irrigation systems thus account for 12% of nighttime consumption during irrigation season? *
- CEME and H.R. Macmillan replace AMS Nest and Hennings in Top 10 consumers.

Top 10 Nighttime Consumers Non-Irr Season

Skyspark Name	Category	Primary Usage	Meter Number	Subted Buildings	Pressure Zone	m3/yr
Biological Sciences Building South	Core	Lab	Null	Null	High	17,235
Orchard Commons	Ancillary	Residential	MW10-31	Null	High	11,128
Forestry Sciences	Core	Lab	MW10-17	Null	High	8,074
Earth and Ocean Sciences	Core	Lab	MW10E-2	403	High	5,740
Robert F. Osborne Centre 1	Core	Lab	Null	Null	High	5,015
Life Science Centre	Core	Lab	MW11-8	Null	High	3,975
Ponderosa North	Ancillary	Residential	MW8E-2 783	Null	Low	3,339
H.R. Macmillan	Core	Lab	MW10E-11	Null	High	3,096
Aquatic Centre	Ancillary	Athletics	Null	Null	High	3,074
Civil & Mechanical Engineering	Core	Lab	MW10E-5	Null	High	2,829

Nighttime is here defined as time period between midnight and six in the morning and irrigation season as beginning of May to end of September.

- 41% of U Blvd nighttime supply metered in high pressure zone in non-irrigation season (29% in Top 10)
  - Almost 60% not captured (some in low-pressure zone) .
  - Metered consumption accounts for almost 90,000 cubic meters.

Potential annual savings of 616,000 cubic meters or $550,000 (16% of annual water costs) if currently metered base flow consumption in high-pressure zone is eliminated completely.

* *In range of Stantec Consulting estimate in 2011.*

ESTIMATED BASE FLOW CONSUMPTION

Results

Main assumption: whatever is consuming water when occupancy is minimal in non-irrigation season, runs continuously.

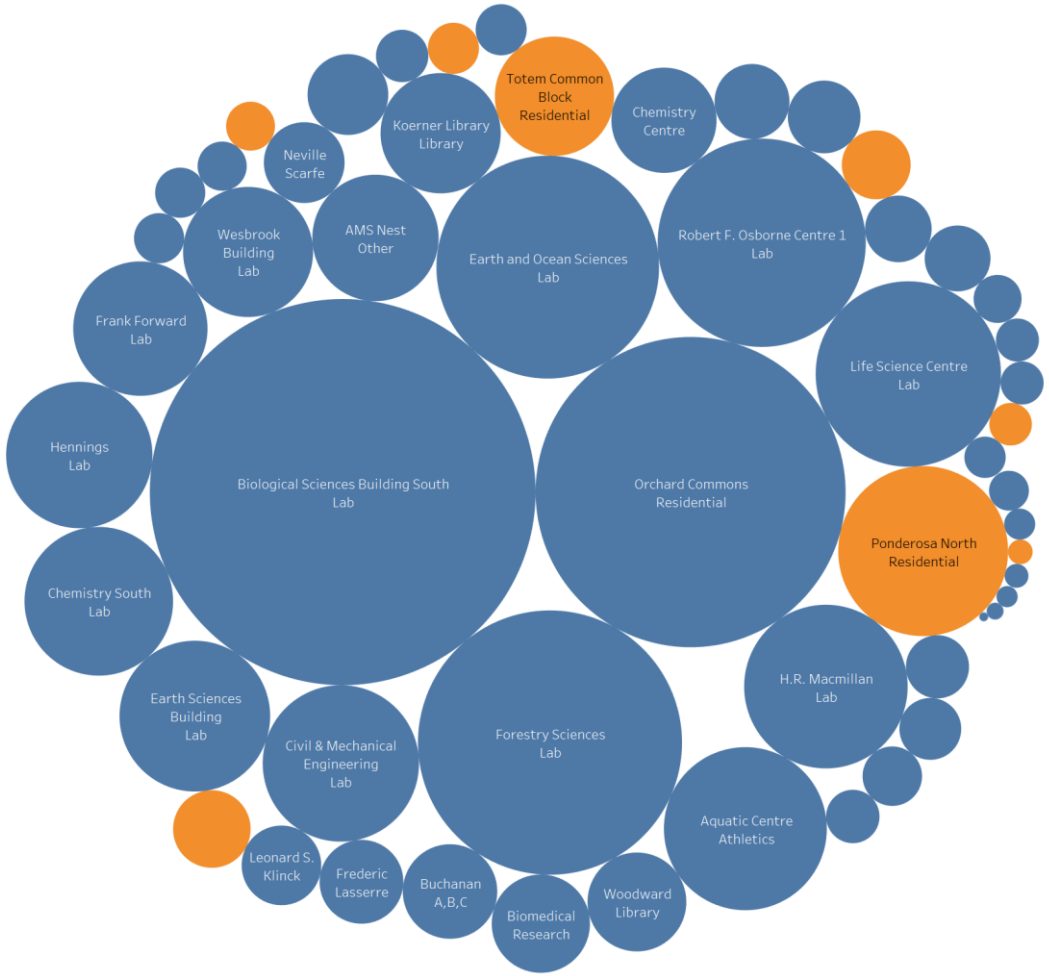
35% of estimated campus base flow consumption metered (664,105/1,887,017 m3).

Almost $600,000 annually already metered (Campus total $1,681,332).

Uncertainty related to absolute values from scaling, but relative size indicates base flow contribution.

Except for Orchard Commons, Ponderosa North and the Aquatic Centre, Core Lab buildings are the biggest contributors.

Need to investigate Aquatics Lab in Biological Sciences Building South and the distribution of dechlorinated water to the Building West.

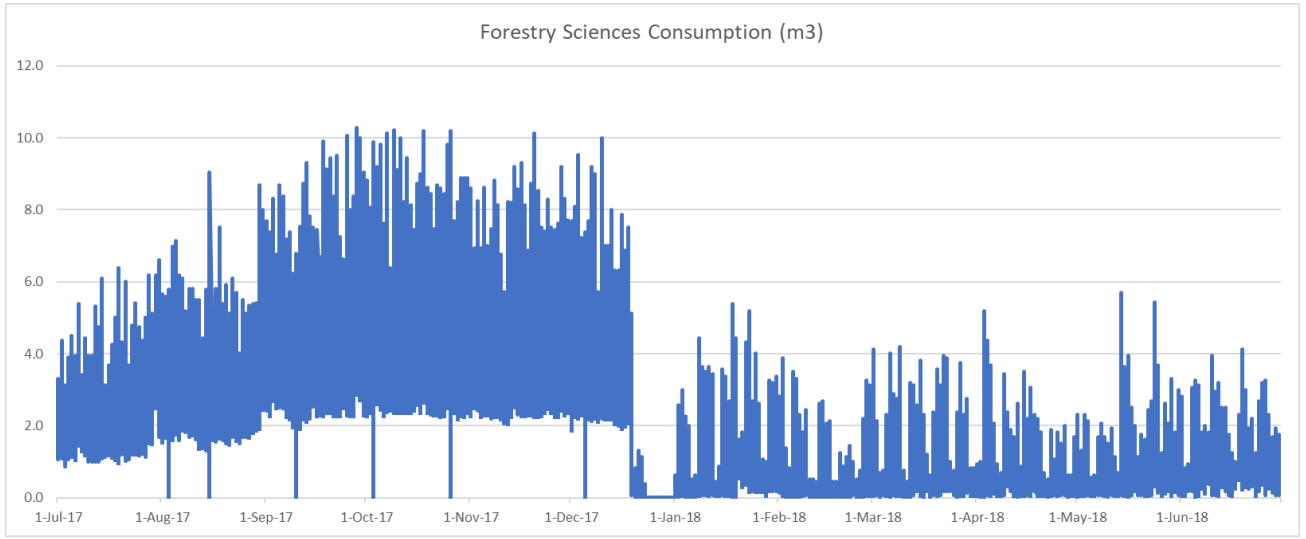


Colors indicate high and low pressure zones.

EXAMPLE: FORESTRY SCIENCES

Results

- The Aquatic Ecology Lab (fish tank) has a flow-through water system.
- Lab had an incident that put it out of operation at the end of last year.
- In operation the minimum consumption of 2 cubic meters every 15 minutes converts to 70,000 cubic meters annually.
- Indicates annual cost of $62,000 to EWS for running the lab – compare to cost of installing recirculating system.



FINDINGS SUMMARY

Conclusions

- Total Campus base flow is estimated at 1,887,017 cubic meters (~50% of annual consumption).
  - U Blvd main supply accounts for 1,483,914 cubic meters of base flow alone (78 %).
- 55 of the 80 buildings listed with water consumption data in Skyspark are deemed good quality and considered in this study.
  - The majority are Core Buildings located in the High pressure zone and consume water from the U Blvd campus supply only.
  - 18% of campus total supply is metered in core buildings (64 of the 218 core buildings when considering sub-fed buildings)
- High-resolution metered buildings account for approx. 24% of campus total supply (14% in Top 10 consumers).
- Outside of irrigation season, the contribution to nighttime consumption increases to 35 % (23% in Top 10 consumers).
  - 41% of U Blvd supply when only considering buildings located in high-pressure zone (29% in Top 10 consumers)
- If main assumption holds, this converts to 664,105 cubic meters of annual base flow consumption.
  - High-pressure zone (Core building area) annual base flow estimate alone is 616,000 cubic meters.
- **Potential annual savings of almost $600,000 (17% of total water costs) if currently metered base flow consumption is eliminated completely.**
- Core Lab buildings have the highest water usage intensities and contribute more to campus base flows.
- More than 70% of the Campus water consumption is currently <u>not</u> accounted for in high resolution (Skyspark).

RECOMMENDATIONS

- **Clear up any confusions regarding where meter is located and the area/purpose it covers.**
- Investigate whether already-metered base flow consumption can be reduced (cost and feasibility).
- Make sure already installed high-resolution meters are working properly and connected.
- Prioritize installing high-resolution meters in buildings with lab space and separate irrigation systems.

- Improve data access:
  - High-resolution data download of all buildings less time-consuming.
  - Direct access to campus water supply and sewer data. (PRV data available?)
  - **Include descriptions (metadata) on meters, logging, conversions, areas and buildings covered etc.**
  - Gather data from already installed high-resolution meters on campus irrigation systems, if any.

- Improve data quality:
  - Investigate why campus supply flow rates are off by 10% when compared to consumption readings.
  - **Minimize uncertainties regarding missing data, zeros and consumption spikes for building meter data.**

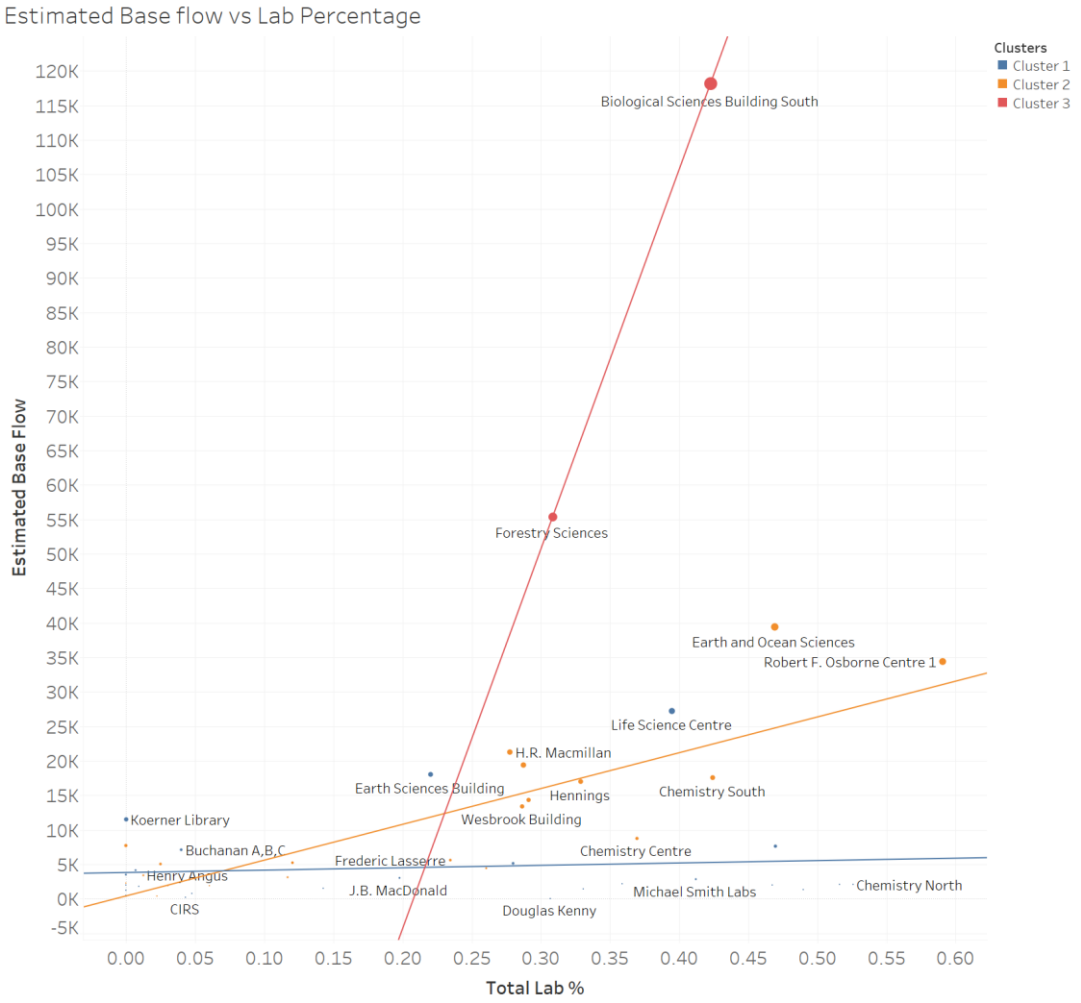
- Include some of the metrics used in this study in further development of Skyspark.

POTENTIAL PROJECTS

Should be substantial opportunity for water conservation and system optimization if reliable data at hand:

1. Explore correlations and establish building benchmarks when utilizing water consumption and occupancy data along with building specifics and seasonality.
2. Create map visualizations of building consumption for easier analysis and interpretations.
3. Investigate potential leaks by analyzing high-resolution campus supply, sanitation, building and irrigation data.
4. Apply clustering technique and machine learning to predict performance and highlight abnormalities.
5. Multi-objective optimization of complete system (PhD research goal).

Conclusions



REFERENCES & RESOURCES

1. Stantec Consulting (2011) "UBC Water Base Flow Analysis" Final Report.
2. UBC Water Action Plan (TBC 2018): Bud Fraser (Senior Planning & Sustainability Engineer, S&E)
3. Water Consumption in Buildings:
   - Water Meters: Colin Mingus (Climate & Energy Engineer, EWS)
   - Data Logging: Blair Antcliffe (Energy Engineer, EWS)
   - Skyspark Platform: Arthur de Robert (Energy Data Analyst, EWS)
   - Maps and Schematics: Erin Kastner (Geospatial Information Manager, EWS)
4. Water Supply on Campus:
   - Water Mains Data: Jenny Liu (Mechanical Utilities Engineer, EWS)
   - Operational Questions: Aleks Paderewski (Mechanical Utilities Manager, EWS)
5. Spreadsheet "Campus Building Data v9.0 2018 working_20180418_NM": Nicole Montgomery (Coordinator, Reporting, Monitoring & Systems Review, S&E)

APPENDIX 1: SPREADSHEET

The accompanying "**Building Consumption Data Analysis**" spreadsheet (~70 MB) contains the following:

Summary & Rankings: Summary of metadata, statistics and metrics for each listed building in Skyspark (each water meter).

Building Analysis: The option to choose one Skyspark listed building (water meter) to see summary and additional charts for detailed analysis.

Campus Analysis: Data and cost analysis for the campus water supplies.

Data: Gathered and treated data from the Skyspark Buildings App (under Building Utilities) for the time period July 1st 2017 to June 30th 2018.

16th Ave Supply: Gathered data on flow rate measurements and computed consumption for the campus supply for same time period.

U Blvd Supply: Gathered data on flow rate measurements and computed consumption for the campus supply for the same time period.

CCP Building List: Data extracted from the spreadsheet "Campus Building Data v9.0 2018working_20180418_NM" by filtering on existing buildings only.

One can find a number of comments explaining more details in the spreadsheet.

APPENDIX 2: TECHNICAL WORK

Campus Supply Data:

- When comparing consumption computed from average flow rate measurements and the manual readings, a constant error of ~10% was found. Assuming that the offset origins from the flow rate measurements or conversion factors, the error was corrected for by adding 10% to every datapoint for the computed consumption.

Building Consumption Data:

- Initially, building area and usage percentages were gathered from Skyspark, but encountering inconsistencies between these numbers and the CCP Spreadsheet that was used as input, it was decided to use this list directly. A lot of manual work was required by cross-referencing buildings with campus map of meters and distribution pipes, to make sure that the complete area covered by each meter (due to subfed buildings) was included, as well as usage percentages updated accordingly.

- All water meters are configured to send a pulse to the ION meter (data logger) when 0.1 cubic meters of water has been consumed. A server communicating with the ION meters, converts the pulse count into accumulated consumption with a resolution of 15 minutes, which is the data made available in Skyspark. If communication issues are experienced in the data logging process, this result in missing datapoints during the affected time period, and depending on the cause behind, the first datapoint recorded may represent cumulative consumption during the missing time period or it could be a pulse count conversion error. Since there is no way of easily determining the case, and the timing of the consumption is relevant for this study, it was decided to remove all consumption spikes after a period of missing data.

- It was discovered that some meters had a very high percentage of zero measurements, which can be due to malfunction meter or low consumption (less than 0.1 cubic meters in 15 minutes). Further, in some cases large spikes in consumption were identified after a longer period of zeros and these were removed using the same rationale as for first record after missing datapoints above. Overall, distinguishing these events is not straight forward, and again, since timing of consumption is relevant for this study, the percentage of zero measurements was used along with confidence factors (missing datapoints) to determine the quality of the data. Manually adjusting and reviewing the results, the requirement for Good quality data was set to confidence above 85% and percentage of zeros during the day less than 75%. The latter translates to minimum hourly data resolution.