

**PLAN 597: Planning for Water Resource Management
Assignment 1: Data Analysis for the Acadia/Fairview Residence**

Clare Zemcov

University of British Columbia

PLAN 597

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Author: Clare Zemcov
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Data collected for this assignment was for the Acadia/Fairview Residential building on the UBC campus in Vancouver, BC. The data was provided by the UBC Water and Energy Department and available data spanned from January 2010 to September 2014 at a monthly frequency. Data for 10 of the 57 months was not available when the water meter measurement at the building was not collected.

The Fairview Residence building offers townhouse-style suites on the southeast portion of the UBC campus. Water saving faucets and toilets were installed within the building in the summers of 2013 and 2014.

The data available was composed of the following:

- Date the measurement was collected
- The base meter reading (usually 15 or 25 m³)
- The total cumulative meter usage reading

In order to analyze this data, it was necessary to subtract the base meter readings from the change in cumulative water consumption and convert the readings to cubic feet. An example is as follows:

Table 1. Example data for the Fairview Residence Building

Date	Base Reading (m ³)	Change in Base Reading (m ³)	Cumulative Meter Reading (m ³)	Change in Meter Reading (m ³)	Change in Water Consumption (m ³)	Change in Water Consumption (ft ³)
2014-06-17	25	10	74395	400	410	14478.93
2014-05-21	15		73995			

Black font – provided data

Blue font – Calculated data

Example Calculations:

$$\text{Base Reading (2014 - 06 - 17)} - \text{Base Reading (2014 - 05 - 21)} = 25 - 15 = 10 \text{ m}^3$$

$$\text{Change in Cumulative Meter Reading} = 74,395 - 73,995 = 400 \text{ m}^3$$

$$\text{Total Change in Water Consumption} = 10 + 400 = 410 \text{ m}^3$$

$$\text{Conversion of Change in Water Consumption to ft}^3 = 410 * 35.314475 = 14,478.93 \text{ ft}^3$$

As shown on the data attached, the following statistics were calculated:

- Mean = 18,859 ft³ = 534 m³
- Median = 18,893 ft³ = 535 m³
- Mode = 18,893 ft³ = 535 m³
- Variance = 8,745,561 ft³ = 247,648 m³
- Standard Deviation = 2957 ft³ = 84 m³

The histogram of the frequency of ranges of water consumption is show attached as Figure 1. The distribution is asymmetrically right-skewed with the most frequent water consumption ranging between 18,400-19,999 ft³ (~520 m³ – 566 m³). Therefore, there is a tendency for water consumption at the Fairview building to be located around the mean usage or less on a monthly basis. With additional data provided after the final installation of water-saving measures during

the summer of 2014, water usage should decrease and this skew may become more asymmetric and right-skewed as the mean decreases over time.

A time-series analysis was conducted for the data and is shown on Figure 2. As previously stated, the installation of water-saving faucets and toilets were installed in the summer of 2013 and 2014. In this figure, those months have been shaded in red.

In order to determine seasonal patterns a third figure was composed (Figure 3). In this figure, the yearly consumptive water use was plotted so that seasonal fluctuations could be discerned. Although there are data gaps during the summers of 2011 to 2014, general trends are observed throughout the remainder of the year. There are four months of the year that in which peak use occurs: February, April, August and October. The cycles are generally sinusoidal throughout the year.

Data between the months of January to May were available for all five years, and based on those results, a decrease in water consumption is observable from 2010 through to 2014. Since data is spotty for the remainder of the year, further observations are not possible.

Peak water use decreased from 26,132 ft³ in February 2010 to 23,130 ft³ in April 2014. That is a decrease of approximately 3,000 ft³ at the peak occurrence of the year. In addition, a sum of the total water consumption per year is as follows:

Table 2. Total Water Consumption per year between 2010 and 2014

	2010	2011	2012	2013	2014
Total Water Consumption (ft ³)	207119	196348	144966	184518	153441
Total Water Consumption (m ³)	5865	5560	4105	5225	4345
Months of data	Feb - Dec	Jan - Dec	Jan - Dec	Jan - Dec	Jan - Sep

However, this data must be used conservatively for 2010 and 2014 since only data between February and December 2010 and from January to September 2014 was collected and used in this calculation. Therefore, the total water consumption for 2010 and 2014 does not represent cumulative water consumption for an entire year and is not directly comparable to the 2011-2013 results.

Based on the total water consumption per year, and the fact that there is one remaining months worth of data for 2010 and three remaining months worth of data for 2014, there is no observable significant different between the total water consumption after the installation of the new water conserving fixtures, especially with the year 2012 having such a low total water consumption compared to the other years.

In order to statistically determine if the water conservation before and after the implementation of some of the faucets and toilets are different, a t-test value was calculated for the data. A t-test will determine if the difference between the two means in relation to the variation of the data is significant. The results provide a calculated t value of 1.89. When a t table is consulted, at p=0.05 and df=47 (round to 40), the tabulated value is 2.02. Since the calculated t value is less than the tabulated value, the means are not considered significantly different.

Table 3. Statistical t-test Analysis before and after Water Conservation Fixtures were Installed at the Acadia Fairview Residence.

	February 2010 to June 2013	June 2013 to September 2014
Mean	19358.75	17682.46
Variance	8750865.46	7280531.06
Sample Size	33	14
Variance between the two means (Sd^2)	785216	
Square root of Sd^2	886	
Calculated t value	1.89	
Tabulated t test value ($p=0.05$)	2.02	

However, since this test was completed using data from 2013 and the first half of 2014, not all of the water conserving fixtures had been installed. Therefore, with additional and complete data for the years of 2015 onwards, there is a probability that water consumption will decrease and the t test results will show that the means before and after installation are significantly different. In addition, various months within 2010 and 2014 have missing data (as discussed above), which will influence the mean values for these years. Accumulating and analyzing more data will allow for a greater accuracy in the results of further t-tests.

I appreciate the continued effort by water management team to be proactive about water conservation at UBC. Although, this data does not currently reflect a decrease in water consumption at the Fairview/Acadia Residence on the campus, the data provided for this analysis has limitations. These limitations include:

- Only four years worth of data prior to initial installation of water conserving fixtures
- The installation of water conserving fixtures over two consecutive summers.
- The final installation of these fixtures in the summer of 2014, and data only available until September 2014. Not enough data after installation was available to calculate meaningful statistical values of difference.
- Summer data not available for the years 2011 to 2013, therefore seasonal patterns were not identified during this time of year.

As the continued collection of data progresses, results will become more comprehensive and should eventually show that water conservation methods are effective to decrease the building's total water consumption. However, I would suggest that consistent monitoring of the building's water meter during the summer months should allow for any observable patterns during this time of year to be identified.

APPENDIX

Figure 1. Monthly Water Consumption

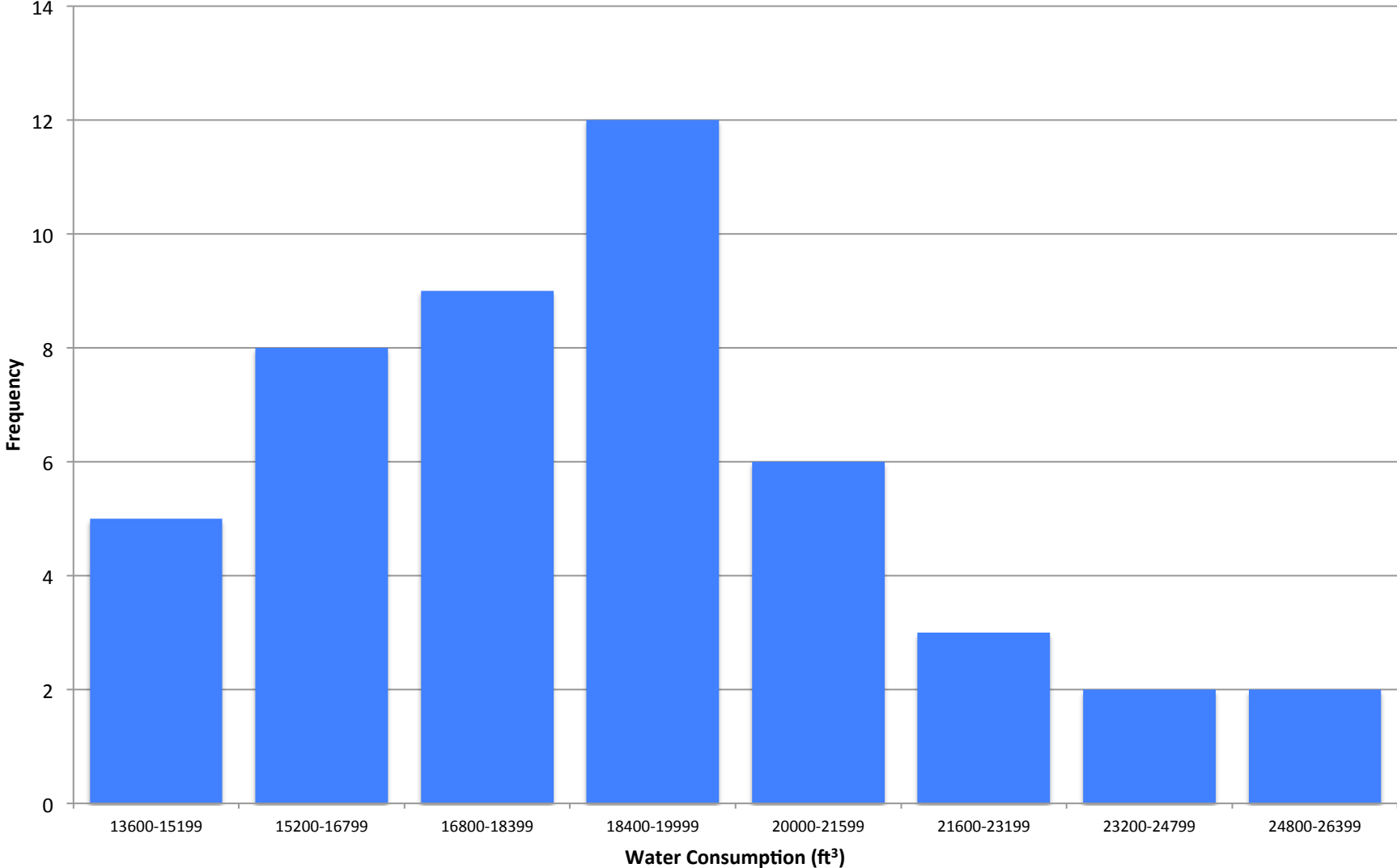


Figure 2. Time Series

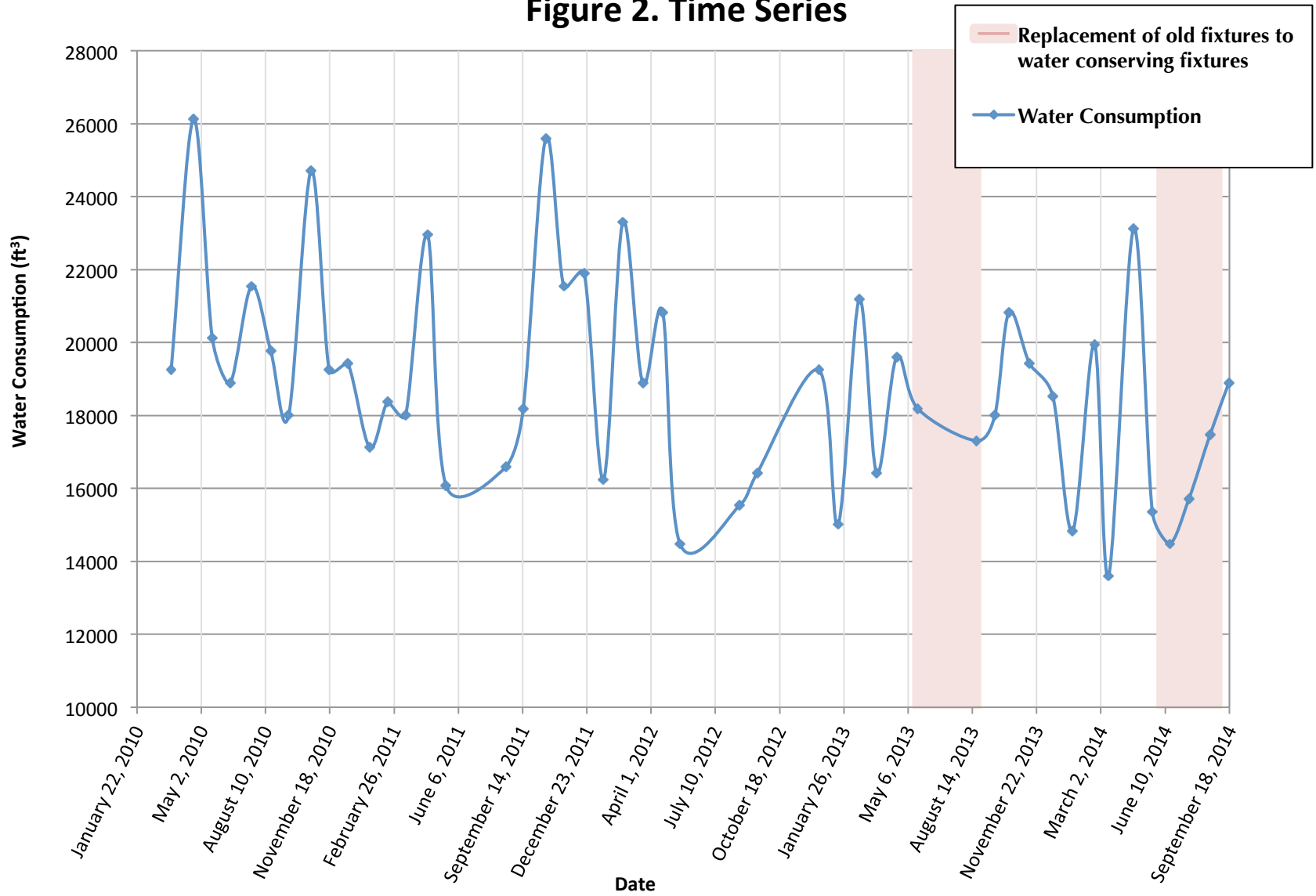


Figure 3. Yearly Water Consumption

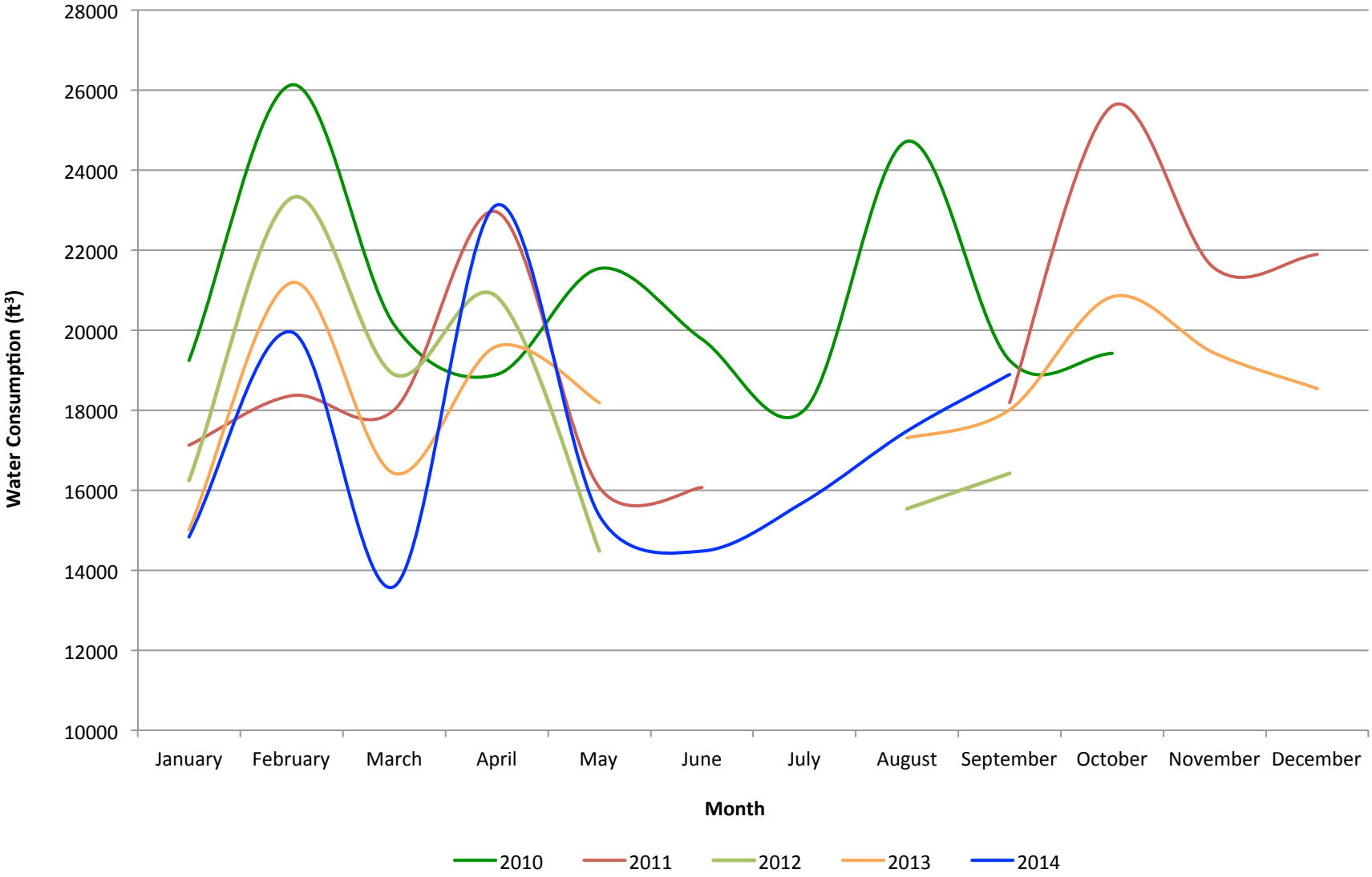


Table A1. Unmodified Data

Unmodified Data		
Date	Base Meter	Meter
	Reading (m ³)	Reading (m ³)
September 17, 2014	25	75870
August 19, 2014	25	75335
July 17, 2014	25	74840
June 17, 2014	25	74395
May 21, 2014	15	73995
April 22, 2014	15	73560
March 14, 2014	15	72905
February 20, 2014	15	72520
January 17, 2014	15	71955
December 17, 2013	15	71535
November 11, 2013	15	71010
October 10, 2013	15	70460
September 18, 2013	15	69870
August 20, 2013	15	69360
July 19, 2013	15	68870
June 14, 2013	None	None
May 21, 2013	15	67850
April 18, 2013	15	67335
March 18, 2013	15	66780
February 19, 2013	15	66315
January 17, 2013	15	65715
December 18, 2012	15	65290
November 19, 2012	15	64745
October 20, 2012	None	None
September 13, 2012	15	63460
August 17, 2012	15	62995
July 18, 2012	15	62555
June 18, 2012	None	None
May 16, 2012	15	61525
April 19, 2012	15	61115
March 19, 2012	15	60525
February 17, 2012	15	59990
January 18, 2012	15	59330
December 19, 2011	15	58870
November 17, 2011	15	58250
October 20, 2011	15	57640
September 15, 2011	15	56915
August 19, 2011	15	56400
July 21, 2011	15	55930
June 15, 2011	None	None
May 18, 2011	15	54835
April 19, 2011	15	54380
March 16, 2011	15	53730
February 16, 2011	15	53220
January 19, 2011	15	52700
December 16, 2010	15	52215
November 17, 2010	15	51665
October 20, 2010	15	51120
September 15, 2010	15	50420
August 18, 2010	15	49910
July 19, 2010	15	49350
June 16, 2010	15	48740
May 19, 2010	15	48205
April 20, 2010	15	47635
March 16, 2010	15	46895
February 17, 2010	15	46350
January 19, 2010	None	None
December 16, 2009	15	45150

Table A2. Modified Data

Modified Data						
Date	Base Meter Reading (m ³)	Change in Base Meter Reading	Meter Reading (m ³)	Change in Base Meter Reading (m ³)	Change in Water Consumption (m ³)	Change in Water Consumption (cft)
September 17, 2014	25	0	75870	535	535	18893
August 19, 2014	25	0	75335	495	495	17481
July 17, 2014	25	0	74840	445	445	15715
June 17, 2014	25	10	74395	400	410	14479
May 21, 2014	15	0	73995	435	435	15362
April 22, 2014	15	0	73560	655	655	23131
March 14, 2014	15	0	72905	385	385	13596
February 20, 2014	15	0	72520	565	565	19953
January 17, 2014	15	0	71955	420	420	14832
December 17, 2013	15	0	71535	525	525	18540
November 11, 2013	15	0	71010	550	550	19423
October 10, 2013	15	0	70460	590	590	20836
September 18, 2013	15	0	69870	510	510	18010
August 20, 2013	15	0	69360	490	490	17304
July 19, 2013	15	-	68870	-	-	-
June 14, 2013	None	-	None	-	-	-
May 21, 2013	15	0	67850	515	515	18187
April 18, 2013	15	0	67335	555	555	19600
March 18, 2013	15	0	66780	465	465	16421
February 19, 2013	15	0	66315	600	600	21189
January 17, 2013	15	0	65715	425	425	15009
December 18, 2012	15	0	65290	545	545	19246
November 19, 2012	15	-	64745	-	-	-
October 20, 2012	None	-	None	-	-	-
September 13, 2012	15	0	63460	465	465	16421
August 17, 2012	15	0	62995	440	440	15538
July 18, 2012	15	-	62555	-	-	-
June 18, 2012	None	-	None	-	-	-
May 16, 2012	15	0	61525	410	410	14479
April 19, 2014	15	0	61115	590	590	20836
March 19, 2012	15	0	60525	535	535	18893
February 17, 2012	15	0	59990	660	660	23308
January 18, 2012	15	0	59330	460	460	16245
December 19, 2011	15	0	58870	620	620	21895
November 17, 2011	15	0	58250	610	610	21542
October 20, 2011	15	0	57640	725	725	25603
September 15, 2011	15	0	56915	515	515	18187
August 19, 2011	15	0	56400	470	470	16598
July 21, 2011	15	-	55930	-	-	-
June 15, 2011	None	-	None	-	-	-
May 18, 2011	15	0	54835	455	455	16068
April 19, 2011	15	0	54380	650	650	22954
March 16, 2011	15	0	53730	510	510	18010
February 16, 2011	15	0	53220	520	520	18364
January 19, 2011	15	0	52700	485	485	17128
December 16, 2010	15	0	52215	550	550	19423
November 17, 2010	15	0	51665	545	545	19246
October 20, 2010	15	0	51120	700	700	24720
September 15, 2010	15	0	50420	510	510	18010
August 18, 2010	15	0	49910	560	560	19776
July 19, 2010	15	0	49350	610	610	21542
June 16, 2010	15	0	48740	535	535	18893
May 19, 2010	15	0	48205	570	570	20129
April 20, 2010	15	0	47635	740	740	26133
March 16, 2010	15	0	46895	545	545	19246
February 17, 2010	15	-	46350	-	-	-
January 19, 2010	None	-	None	-	-	-
December 16, 2009	15	15	45150	45150	-	-