22 June 2017

Mr. Nick Stow
City of Ottawa
110 Laurier Ave W,
Ottawa, Ontario,
K1P 1J1

Project No.: 209.40105.000000

Dear Mr. Stow:

RE: QUARRY IMPACT ASSESSMENT - FLEWELLYN SPECIAL STUDY AREA

The purpose of this letter is to report on our findings with respect to quarry discharge to the Flewellyn Wetland Complex. Phase I of the Flewellyn Wetland Study concluded that the quarries were unlikely to have affected the wetlands, however no coincident data of streamflow to quarry discharge was available to corroborate that conclusion. Coincident information has now been collected. To conduct this assessment we have compared the hydrographs from five City of Ottawa flow monitoring sites on Upper Flowing Creek and the Hobbs Drain to pumping records from the quarries discharging upstream of those stations, as well as to local precipitation records. The analysis focussed on the spring to autumn period when streamflow records match meteorological records. The time-frame of the study is from 2014 to 2015.

The analysis is intended to:

- Distinguish stream flow events specific to quarry pumping events;
- Compare the stream flows associated with quarry pumping events to stream flows associated with precipitation events and normal spring run-off (the spring freshet); and,
- Determine if stream flows associated with quarry pumping exceed flows for precipitation and run-off events or if they supplement those events to create higher flow conditions.

The objective of the project is to determine if pumping and water discharges by bedrock quarries upstream of flow monitoring stations FLW650, FLW620, HOB780 and HOB750 have the potential to contribute to the creation or expansion of wetlands downstream of the quarries.

STUDY AREA

The study area falls within the Jock River Subwatershed of the Rideau River Watershed. The Jock flows from headwaters in Montague and Beckwith Townships, through the former municipalities of Goulbourn and Nepean, and draining Barrhaven (City of Ottawa) where it outlets to the Rideau just north of Manotick. The Jock Subwatershed is very large and is subdivided into of many smaller subwatersheds that include the Hobbs Drain and Flowing Creek (Figure 1).

Phase I of the study was triggered in part by controversy regarding the identification of additional units to the Goulbourn Provincially Significant Wetland Complex located in the headwaters of the Jock River, connecting north through the Huntley Subwatershed and northeast to the Poole Subwatershed (OMNRF, 2005). Based on a review of the existing documentation, including the extent of the recent revisions to the Goulbourn Wetland Complex, the principal study area is roughly bounded by Munster Road, Mansfield Road, Huntley Road and Hazeldean/Hwy 417 extension across the north, encompassing the headwater of the Flowing Creek and Hobbs Drain. A portion of the Poole Creek watershed falls within these boundaries but drains to the northeast and therefore does not affect the wetlands of the Goulbourn complex.

EXISTING TERRAIN

The terrain in the study area is described in the Phase I study and may be summarized as thin soils overlying flat limestone bedrock. The limestone is of low permeability and restricts groundwater drainage. The relatively flat topography creates an area of poor drainage to depth and slow movement of surface water through periods with high seasonal water table conditions.

The shallow limestone bedrock is currently been quarried for aggregate in five locations within the study area. The following quarries as well as their discharge points are shown on Figure 1:

- Cavanagh Henderson Quarry;
- Tomlinson Stittsville Quarry;
- Dibblee/Lafarge Bell Quarry;
- Cavanagh Beagle Club Quarry; and,
- Goulbourn Quarry.

METHODOLOGY

The stream data from the five stream monitoring stations (FLW620, FLW650, HOB750, HOB780 and HOB850) was provided by the City of Ottawa. The data collected using a datalogger every 15 minutes over the recording period. Data was only recorded from April to October due to freezing conditions over the winter. The dataloggers were deployed after each creek thawed, and then were removed prior to the first freeze of the year. Of the five monitoring stations, two (FLW650 and HOB780) have data for 2014 and 2015, and three (FLW620, HOB750, HOB850) have data for only 2015.

The parameters that were recorded were pressure and water temperature. Each datalogger was placed into the creek a set depth, and hydraulic pressure created by the water column above the datalogger was recorded. The pressure was then converted to a water elevation by subtracting atmospheric pressure (recorded by a separate barologger), and adding it to the logger elevation (determined previously by survey). The datalogger measurements were verified by hand measurements on approximately a weekly basis. Periodic flow measurements by trained City staff were made under a variety of flow conditions to establish a rating curve (flow versus water depth). This rating curve was used by the City to determine streamflow for each datalogger point. Daily flow volumes were calculated by averaging the streamflow multiplied by each 15 minute step.

Discharge Data

For the Phase I cumulative effects study, it was identified that the five active quarries that surround the study area had the potential of pumping their excess water into the nearby streams. The amount each quarry allowed to discharge is regulated by the Ontario Ministry of Environment and Climate Change through the permit to take water process. The permit to take water process requires the daily discharge volumes to be reported on an annual basis.

The Quarry owners gave permission for this data to be released by their consultant, and the daily discharge volumes were provided by Golder Associates. This data is proprietary and is not presented numerically here. However it has been summarized in a graphical form to support the analysis herein.

Meteorological Data

The closest meteorological station to the study area was in Appleton, 11 km to the west. Where individual days were missing, the data was augmented with that from the Ottawa International Airport meteorological station, 25 km to the east.

RESULTS

Stream Data

The five flow monitoring stations are FLW650, FLW620, HOB750, HOB780 and HOB850. The data collected from the streams was analysed to determine trends in the water elevation. The water elevations were plotted against time to track the natural fluctuations in the stream levels due to climate and to determine if there were unexpected peaks that could have been cause by a quarry discharging. These hydrographs (Figures A1 to A6 inclusive) are found in Appendix A, and combine the stream level data, precipitation, and quarry discharge information on a daily basis.

Quarry Discharge Data

The daily quarry discharge data was plotted versus time to track when the potential spikes in the stream water elevations would be. The daily discharges were also compared to the maximum volume outlined in the permit to take water approval to ensure that the quarries were not exceeding their pumping rates (they were not). Out of the five quarries, only three of the quarries discharged water in 2014 and 2015. The three quarries were Tomlinson-Stittsville Quarry, Cavanaugh-Henderson Quarry and Goulbourn Quarry. The location in which each quarry discharged into is displayed on Figure 1. As described above the hydrographs plot the quarry discharge for the quarries (Stittsville Quarry on Figures A1 to A3, and Cavanagh Quarry on Figures A4 to A6) against the stream level and precipitation data (Appendix A).

Figure A3 shows the Tomlinson-Stittsville Quarry discharge in 2015, precipitation, and stream levels at FLW650, 3,300 m downstream. Figure A3 shows the same, but for the downstream station at FLW620, which is a further 2,700 m downstream (about 6,000 downstream of the quarry discharge). On these plots the rainfall events are seen as spikes in the stream hydrographs. It is also seen that the Tomlinson-Stittsville quarry discharge echoes the major rain events, showing that they respond to precipitation by pumping at the quarry. The pumping events are generally a few days later than the rainfall event, which is normal because quarry operators typically let water accumulate until they need to discharge, and are also cognizant of not pumping when streamflow is high in the receiving stream. It can also be noted that there appear to have been more rainfall events in this watershed, compared to the gauge at Appleton, 11 km to the west. Conversely there are no peaks in the hydrograph for events that occurred in the Appleton data. This is not uncommon when locations are this far apart, particularly in thunderstorm conditions. Figure A2 shows the hydrograph for FWL650 (closest to the quarry) in 2014. These same general patterns can be seen in 2014.

The same general patterns as described above can be seen in the data downstream of the Cavanagh-Henderson Quarry. Figure A6 shows the Cavanagh-Henderson Quarry discharge in 2015, precipitation, and stream levels at FLW780, 2,000 m downstream. Figure A4 shows the same, but for the downstream station at FLW750, which is a further 2,000 m downstream (about 4,000 downstream of the quarry discharge). Figure A5 shows the hydrograph for FWL780 (closest to the quarry) but in 2014.

DISCUSSION

Initially, the stream hydrographs for 2014 and 2015 were looked at to determine if there were any seasonal fluctuations present across the data. Since the data is only present from April to October, the expected trend would be to see the highest water levels in April (post-snow melt) and the lowest levels in August/September (hot-dry season). The flow station HOB850 was viewed as a ‘background’ station as it is not in a stream that has a quarry discharging directly into it. The 2015 hydrograph for HOB850, as seen in Figure A7, does show a general seasonal trend with the high water level occurring in April (expressed as an elevation, 123.1 masl) and the low occurring in August (122.6 masl), however the range is not very significant, just 0.5 m. There are also a number of peaks in water elevation that occur with each significant rainfall event.

In addition to the seasonal fluctuations, the hydrographs were examined for diurnal fluctuations. Figure A8, covering 6 days in early June of 2015 with no precipitation, demonstrates an example of the differences in diurnal fluctuations at FLW650 on a sunny day versus an overcast day. On overcast days (in this example the first two days and the last day were overcast) the water level only fluctuated about 10 mm over the day. On the sunny days, the fluctuations were 14 to 20 mm over the day. The peaks are higher and steeper on sunny days because of a variety of factors. On sunny days there is more water leaving the streams through evaporation and this means more depletion and the higher range in fluctuation. Of some interest the water levels are lowest at about 10 a.m., and then peak at about 2 p.m. These peaks are typically earlier in the day in smaller systems, however here the watershed is big enough that the transpirative uptake of the wetlands feeding the stream have a significant delay. During the six hour period of darkness there is no plant uptake and water levels rise in the wetlands, discharging to the stream by mid-morning causing the stream levels to rise at that time. It takes about four to six hours for transpiration to again erode the wetland discharges, causing the stream to drop again. Once darkness hits in the late evening and transpiration ceases, the wetlands need time to replenish so the subsequent discharge to the streams begins very slowly.

The stream hydrographs were compared to the precipitation data and to the quarry discharge data to try and determine if the peaks in the hydrographs were caused by the quarry discharge or by a rainfall event. A number of peaks were examined at the two flow stations that accept discharge water from a quarry. It was found that many of the peaks coincide with a rainfall event that has occurred a couple hours to a day prior. The few peaks that did not coincide with a rainfall event also did not coincide with a quarry discharge event. This indicates that the quarry discharge has little to no effect on the stream water level.

Figures A9 to A11 show examples of rain events followed by increases in stream water levels. These examples also have quarry discharge events occurring after the increase in water levels with no detectable effect. For example, Figure A9 shows that the increase in streamflow happened late in the day on June 24, although records indicate that the rainfall of over 50 mm began in the early afternoon. The Stittsville quarry did not pump in that period, so this hydrograph is due entirely to rainfall. They in fact pumped a full eight days later, having kept that precipitation in storage. Of most interest, Figure A9 shows no appreciable increase in stream water levels when they did pump. This is consistent with the fact that the volume of quarry water generated by rain is proportionate to the collection area of the quarry, which is substantially smaller than the watershed feeding the river. (There is very little groundwater in the quarry to augment this, as Phase I of this study demonstrated was due to the very low permeability bedrock.)

Another variable is the intensity of the rainfall. Figure A10 shows two rain events of similar total rainfall of 13 and 17 mm, on July 8 and 13 respectively. The former fell in a few short hours, whereas the latter was a slow steady rain over a 14 hour period. The stream responded to the intense event on July 8 by quickly rising by 26 mm, but responded slowly rising by only about 4 mm for the less intense event on July 13.

Figure A11 illustrates how the creek responded to a longer duration (2+ days) rainfall of 55 mm over the September 11 to 13 period. The creek rose by 33 mm over most of September 13th, and then once the rain stopped it fell over a three to four day period. Of interest the quarry discharge was begun on September 15th, and was progressively increased as the stream levels subsided. There was no corresponding rise in stream levels (due to the quarry discharge), which continued to subside during the pumping period.

Since it was determined that the peaks in the hydrographs are likely caused by rainfall events, the data was looked at in more detail to determine what might have caused the peaks that are not associated with anything. Since the nearest rainfall recording station is 11 km away, there is likely some variation in rainfall at the site. By examining precipitation records from several meteorological stations in a 50 km radius of the study area, it was found that the rainfall varied from one side of the study area to the other over the data collection period. This could account for the stream water level peak events that are not associated with any rainfall events or discharge events. An example of this is seen on the 9th of May, as shown on Figure A12.

Lastly, the water volumes were analysed to ensure that there wasn't an abundance of water entering the streams that was not being accounted for. The flow station FLW650 was used for this analysis. The rainfall was converted to a volume by multiplying the precipitation by the catchment area for each flow station. The rainfall volume, stream volume data and the quarry discharge volumes in cubic metres per day were plotted Figures A13 and A14 for 2014 and 2015, respectively). The largest volume is precipitation, with most events being under 100,000 m^3/day. Corresponding streamflow was less than 50,000 m^3/day, the difference being accounted for by evapotranspiration and temporary storage in the wetlands. A half dozen events each year fell between 100,000 and 200,000 m^3/day, generating not much more than 50,000 m^3/day. Exceptional events (mostly in 2014) reached just over 300,000 m^3/day, and corresponding streamflow reached about 90,000 m^3/day. Of note, in 2014, there is substantive streamflow, without corresponding precipitation in early April. This is attributed to the late spring melt that year. Examination of the quarry pumping volumes on these figures show that quarry discharge seldom exceeds 4,000 m^3/day. From this we conclude that the quarry contribution is relatively minor.

CONCLUSION

Based on the study results and the foregoing discussion, we provide the following conclusions.

- Examination of the stream hydrographs in comparison to precipitation events show a high correlation between stream levels and precipitation. Changes to water levels are commensurate with the rainfall duration and rainfall intensity, as would be expected. Other effects, such as seasonal conditions (wet or dry) have an influence as well. Even diurnal (daily) fluctuations follow a predictable pattern and show the influence of evapotranspiration from the wetlands flanking the watercourses.
- It is very difficult to see the effect of quarry pumping events on stream levels, and indeed analysis of water volumes show that precipitation volumes far outstrips the contribution from the quarries.
- Analysis of precipitation events shows that typically the quarries do not pump until the peak streamflow has past. There is usually a period of sustained quarry pump out early in the year to prepare the quarries for the construction season, however volumes are small in comparison to normal stream flow volumes.
- The flow generated from the quarries does not exceed flow from precipitation and run off events, and typically has little influence on stream levels.

Based on these observations we conclude that water discharges by bedrock quarries upstream of the flow monitoring stations have little to no potential to contribute to the creation or expansion of wetlands downstream of the quarries.

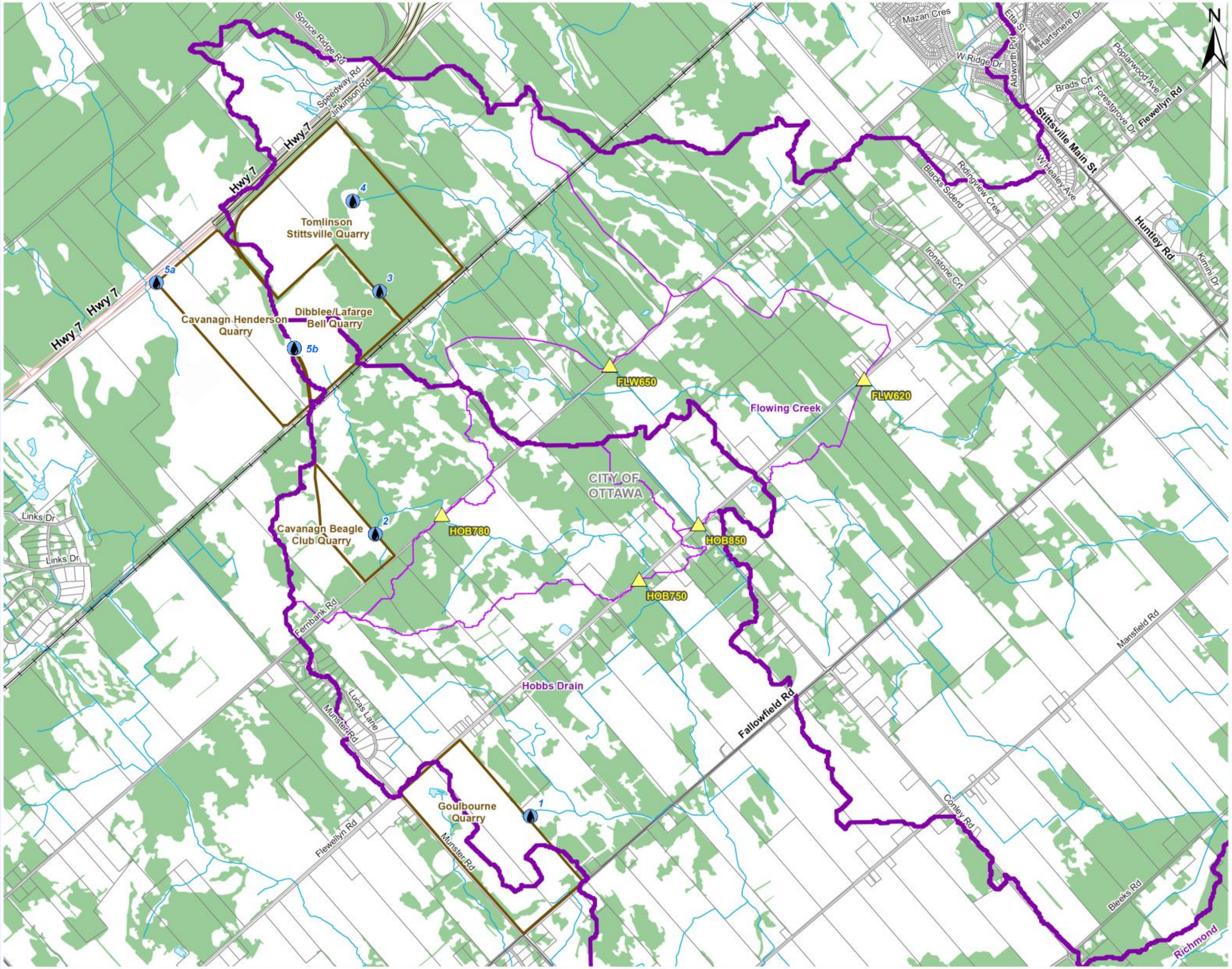
Should you or any technical reviewers have any questions, please feel free to contact the undersigned.

Yours sincerely,
SLR Consulting (Canada) Ltd.

Steven Usher, M.Sc., P.Eng., P.Geo.
Principal Hydrogeologist

cc Claire Milloy, RVCA

SU/mr



LEGEND

- Quarry Discharge Locations
- Stream Flow Station
- Jock River Reach 2 - Catchments (RVCA, 2015)
- Stream Flow Station Up Stream Catchments
- Municipal Boundary
- Quarry Property Boundaries
- Railway
- Waterbodies
- Streams (RVCA, 2015)
- Parcel Fabric
- Wooded Area

Map ID	Description
1	Goulbourn Quarry Discharge
2	Beagle Club Quarry Discharge
3	Bell Quarry Discharge
4	Stittsville Quarry Discharge
5a	Henderson Quarry (50%) Discharge
5b	Henderson Quarry (50%) Discharge

0 250 500 1,000 Meters

SCALE: 1:28,000
WHEN PLOTTED CORRECTLY AT 11 x 17
WGS 1984 Transverse Mercator

NOTES

This map is for conceptual purposes only and should not be used for navigational purposes.

Basedata: Ministry of Natural Resources, Land Information Ontario (LIO), © 2012, Queen's Printer for Ontario, Downloaded February 2013

CITY OF OTTAWA

FLEWELLYN CUMULATIVE EFFECTS STUDY

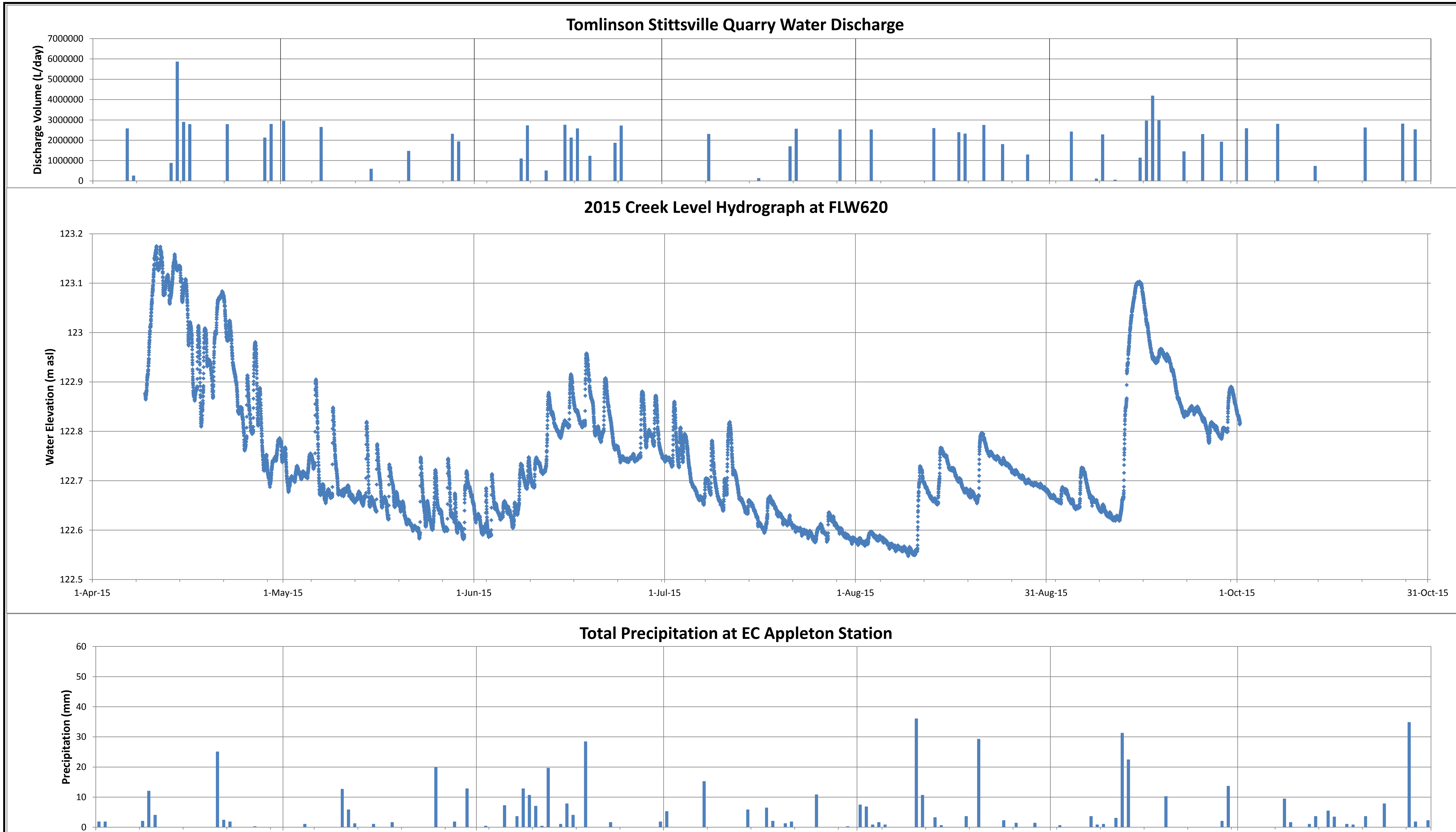
QUARRY DISCHARGE LOCATIONS

June 3, 2016	Rev 0.0	Figure No. 1
Project No.	209.40105.00000	

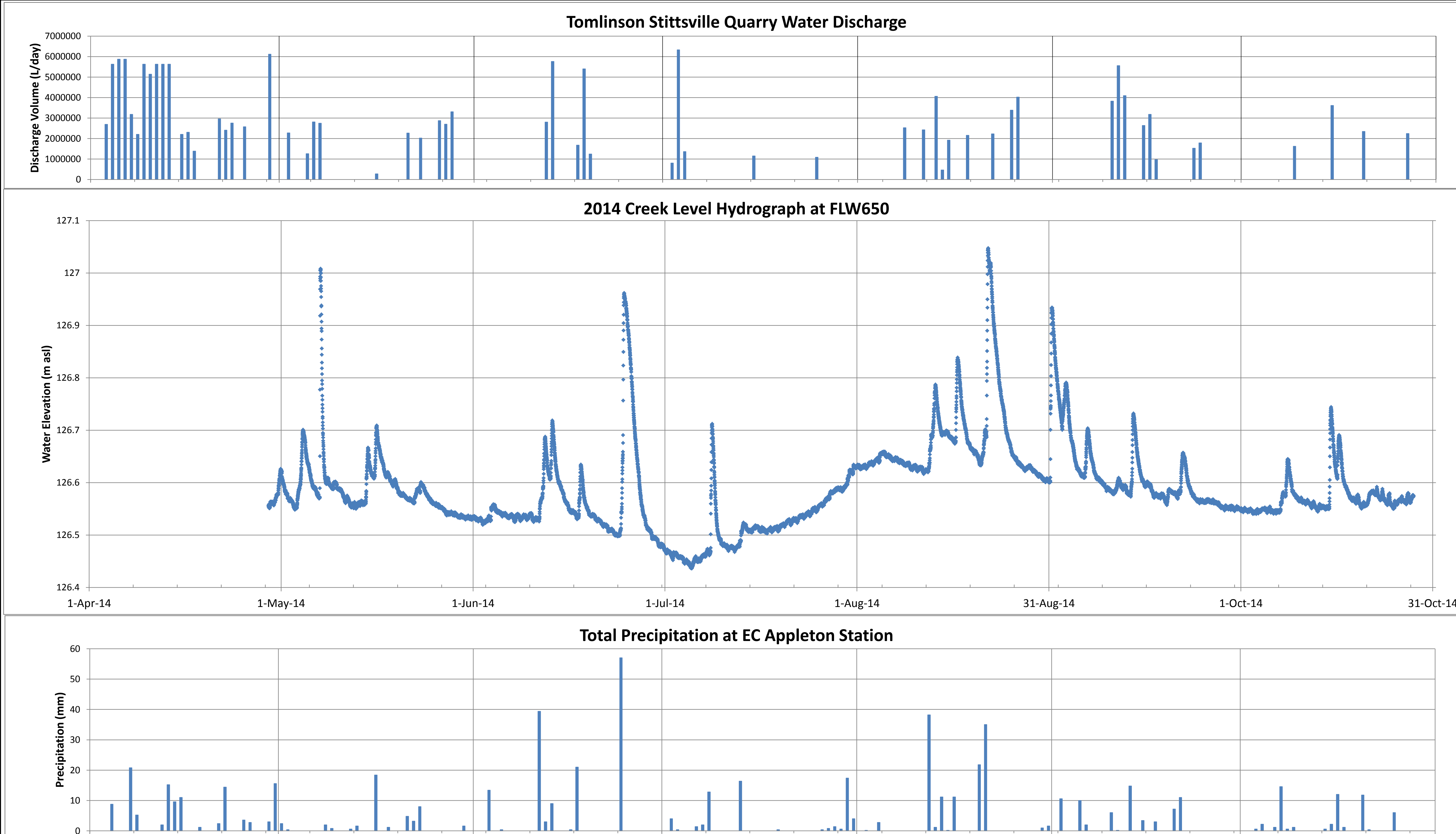
SLR global environmental solutions

APPENDIX A
Hydrographs

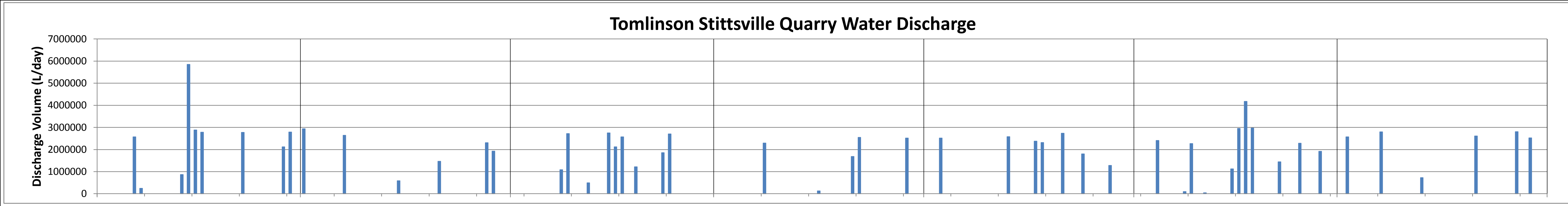
Flewellyn Wetland Assessment Phase II
SLR Project No.: 209.40105.00000

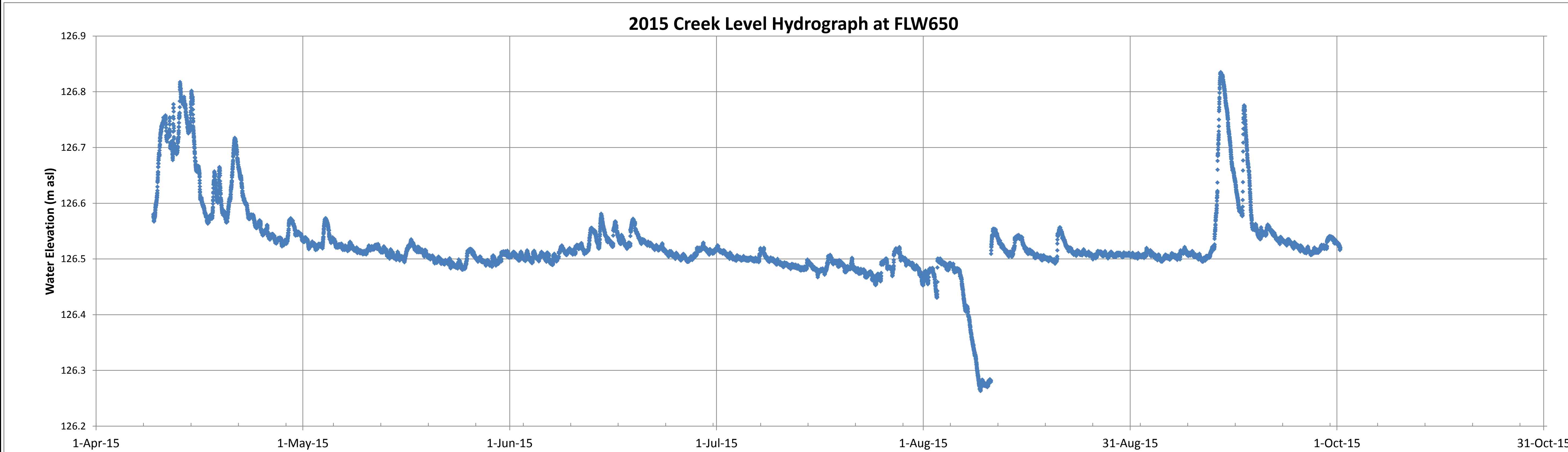


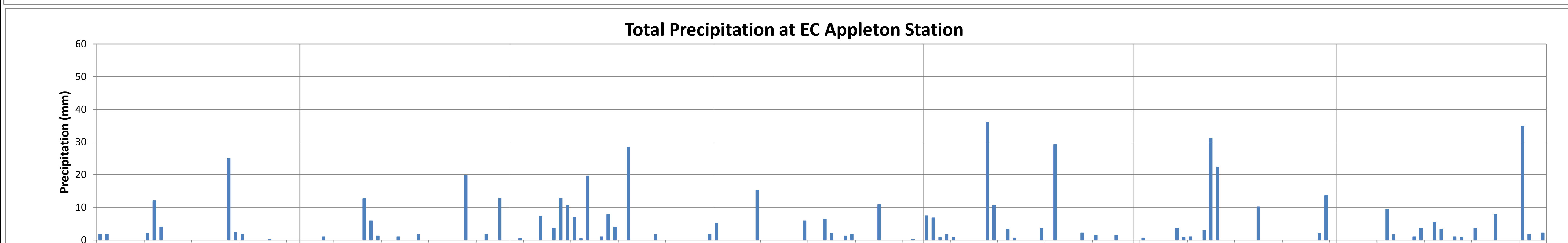
SLR	Flow Station FLW620	Figure A1
	Ottawa, Ontario	



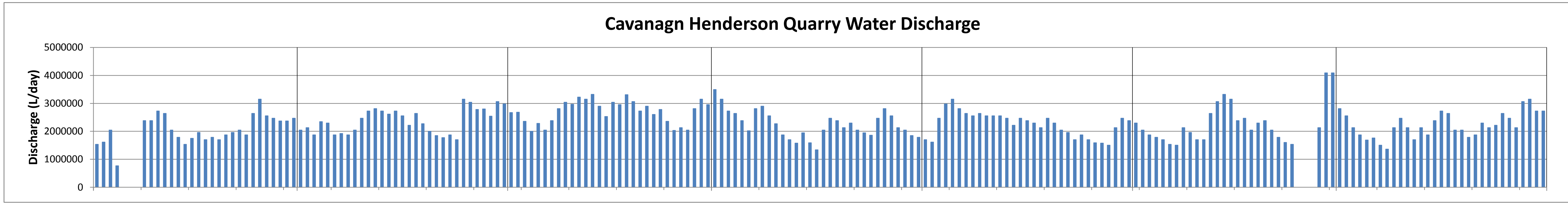
SLR	Flow Station FLW650	Figure A2
	Ottawa, Ontario	

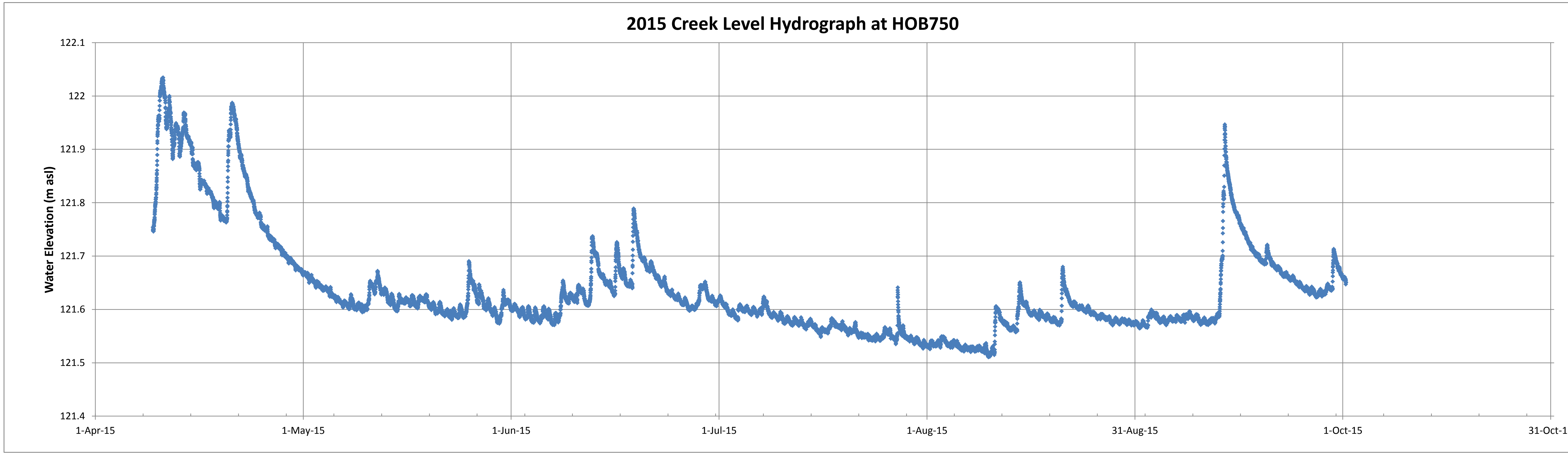


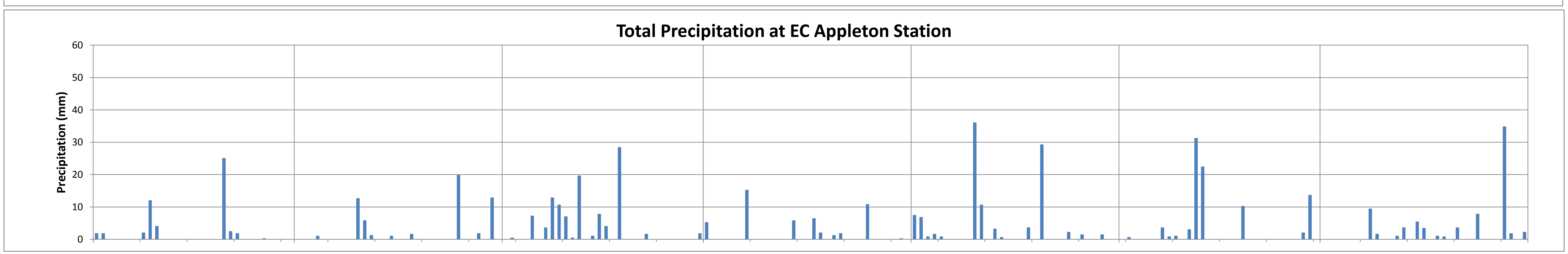




SLR	Flow Station FLW650	Figure A3
	Ottawa, Ontario	

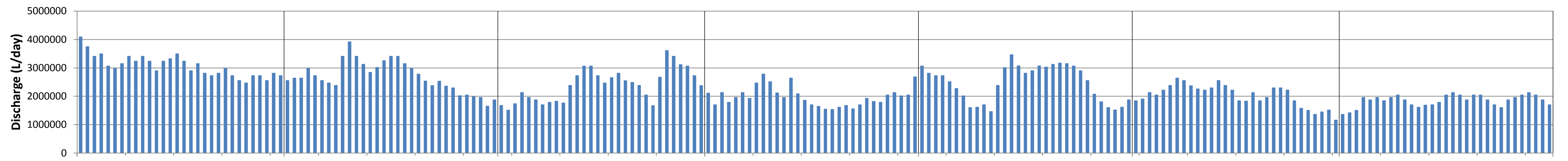




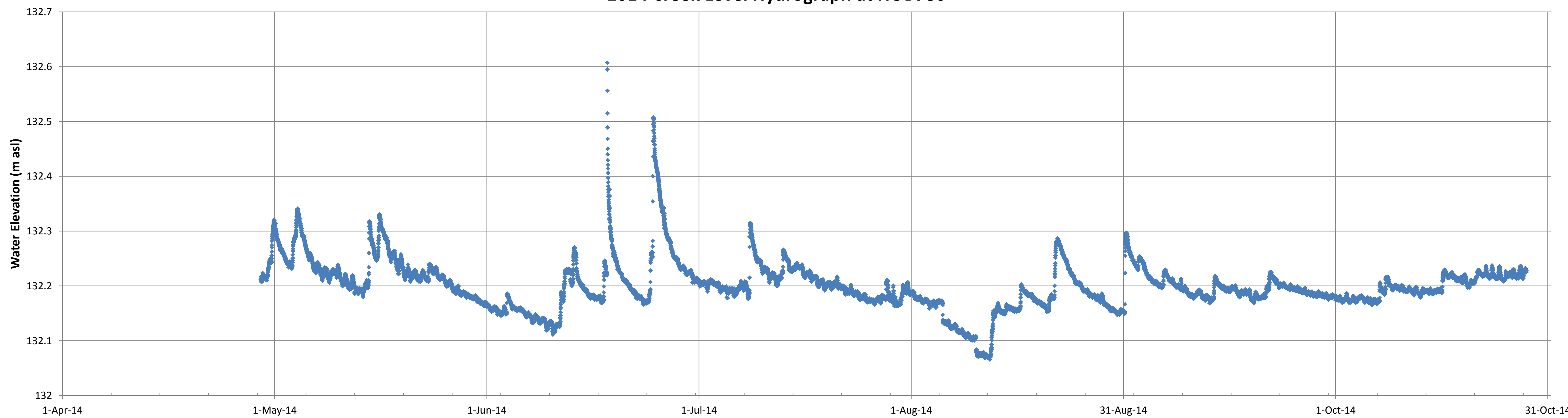


SLR	Flow Station HOB750	Figure A4
	Ottawa, Ontario	

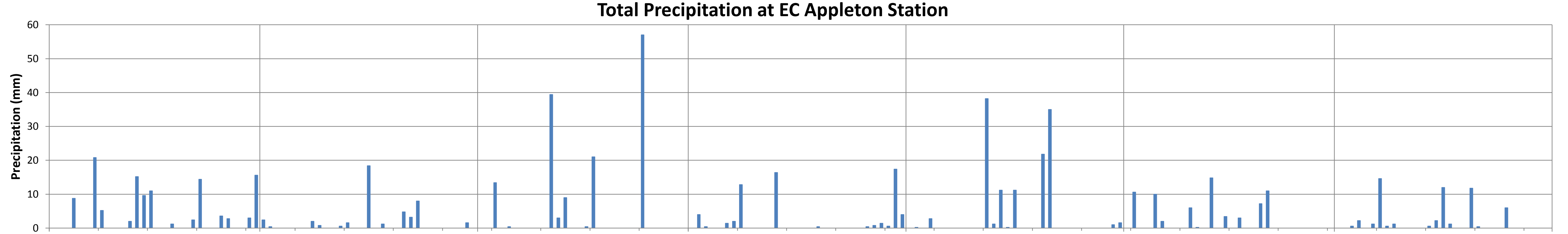
Cavanagn Henderson Quarry Water Discharge



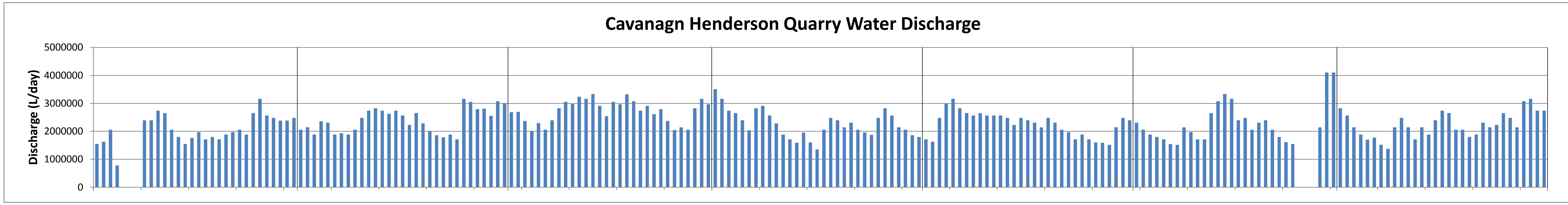
2014 Creek Level Hydrograph at HOB780

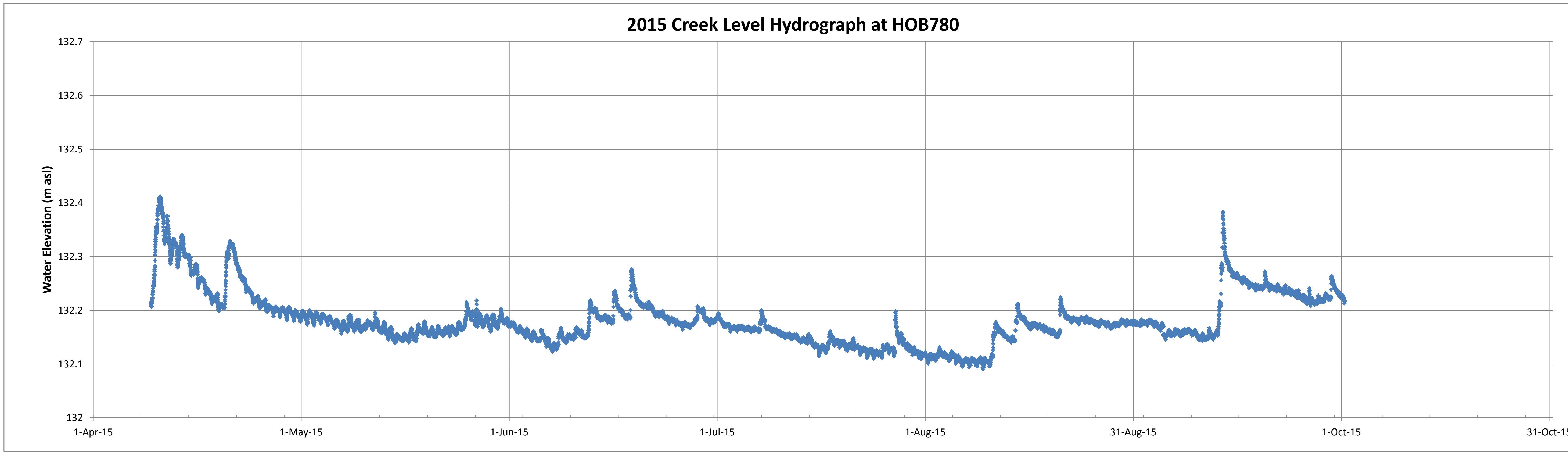


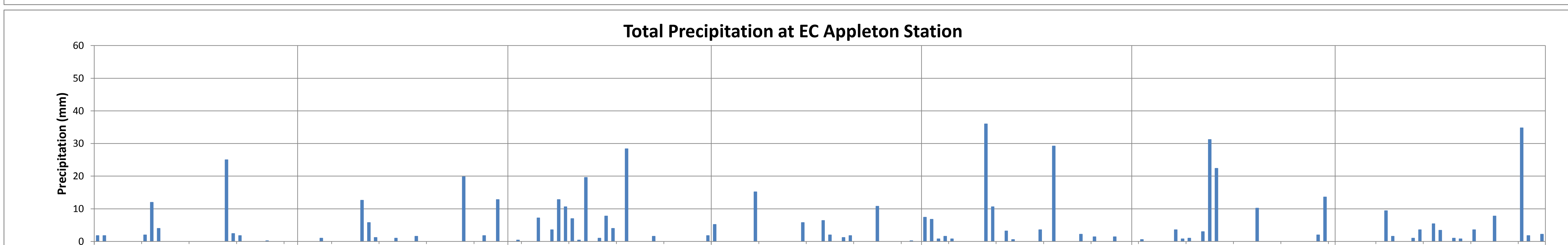
Total Precipitation at EC Appleton Station



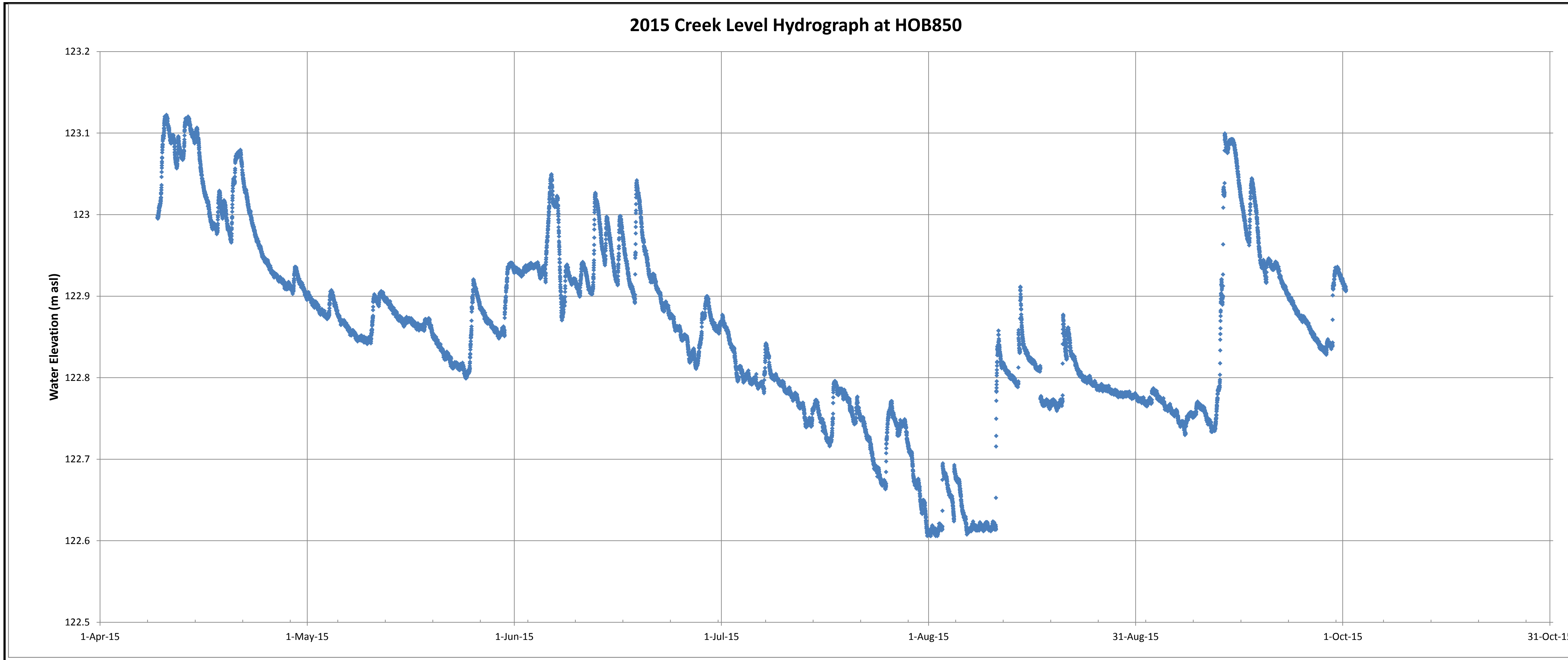
SLR	Flow Station HOB780	Figure A5
	Ottawa, Ontario	

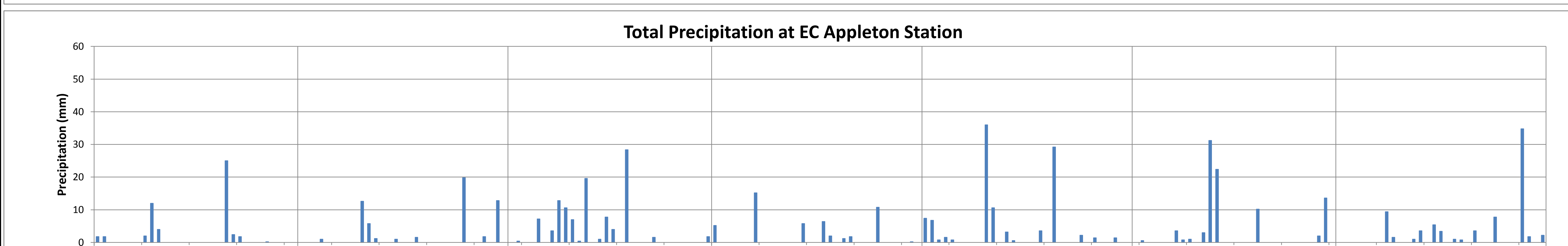




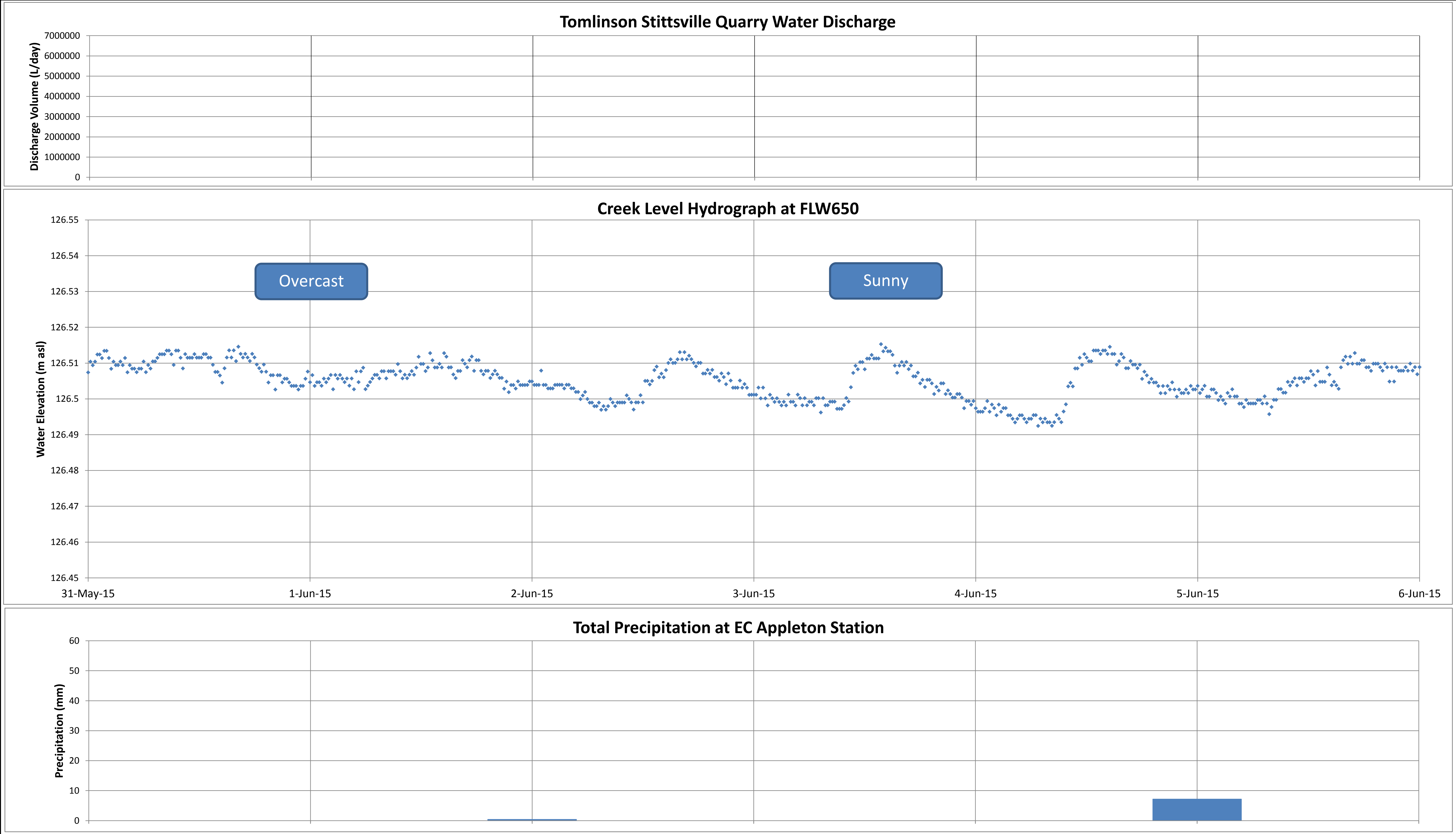


SLR	Flow Station HOB780	Figure A6
	Ottawa, Ontario	

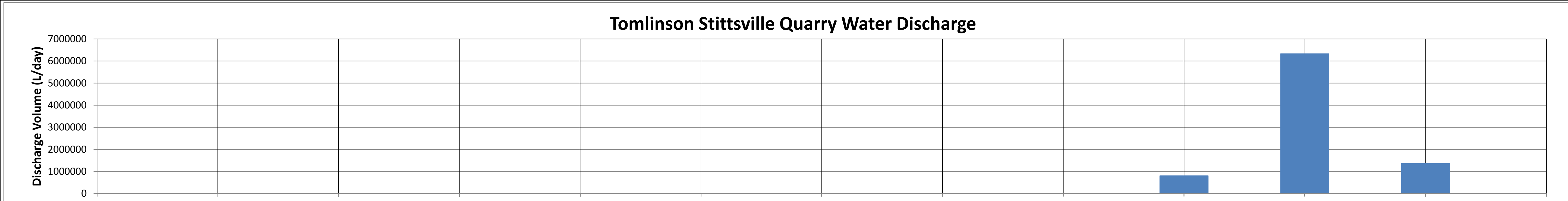


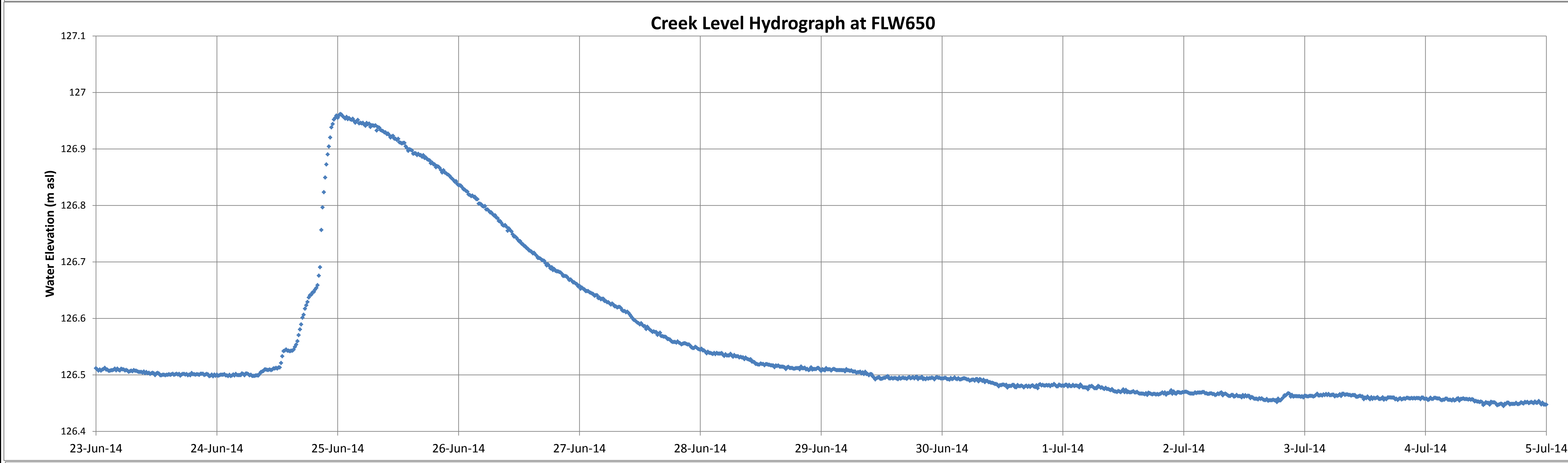


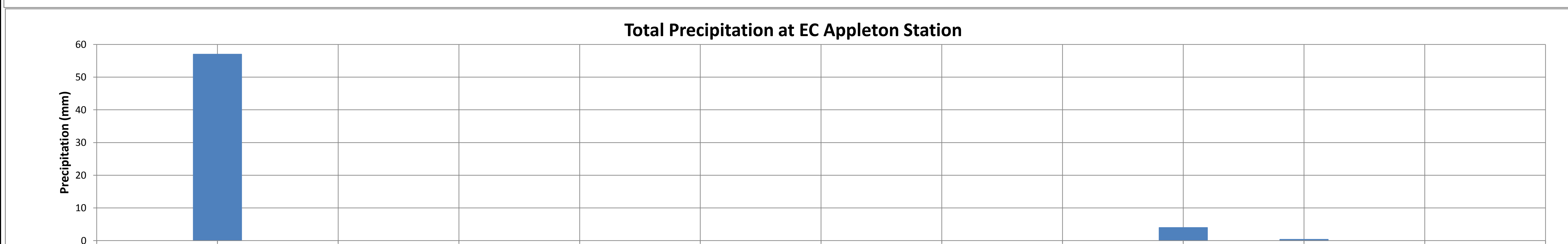
SLR	Flow Station HOB850	Figure A7
	Ottawa, Ontario	



SLR	Diurnal Fluctuations	Figure A8
	Ottawa, Ontario	

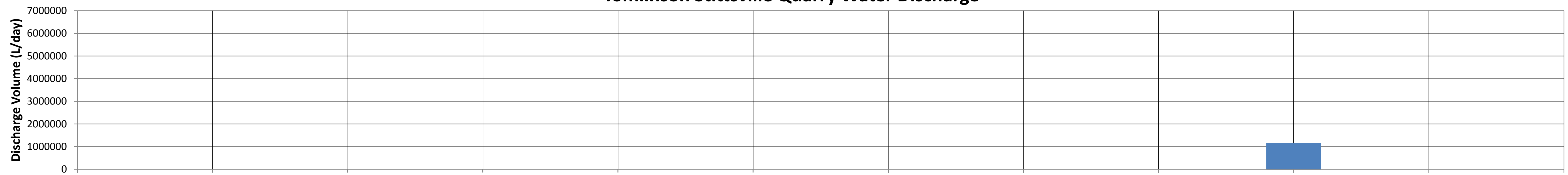




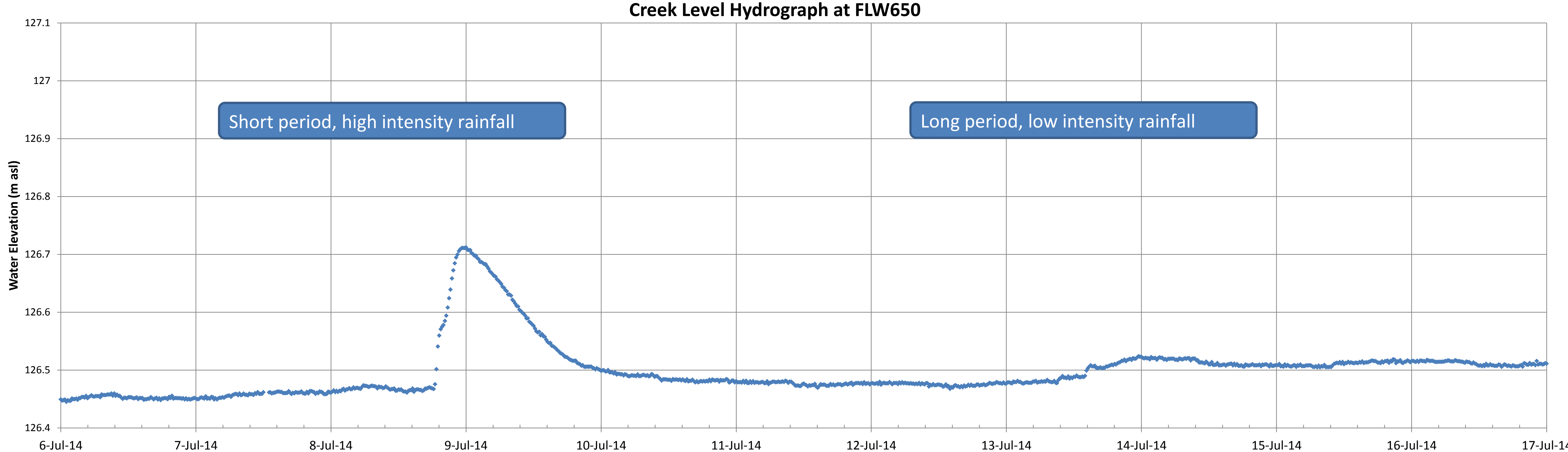


SLR	Example of Rainfall Event 1 Ottawa, Ontario	Figure A9

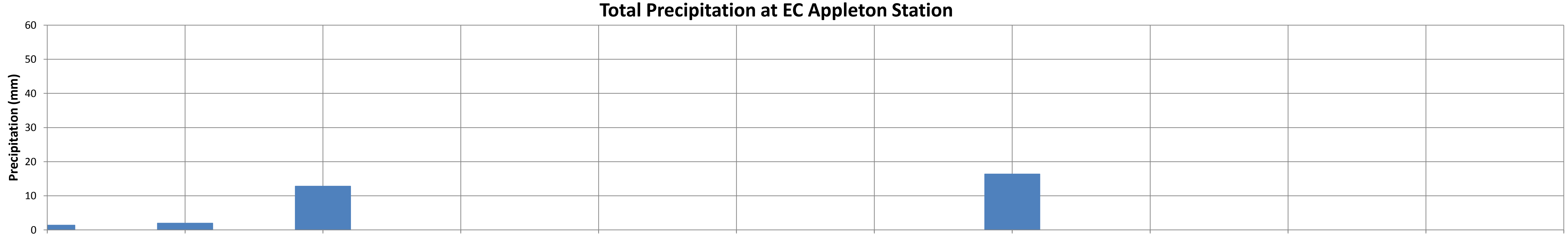
Tomlinson Stittsville Quarry Water Discharge



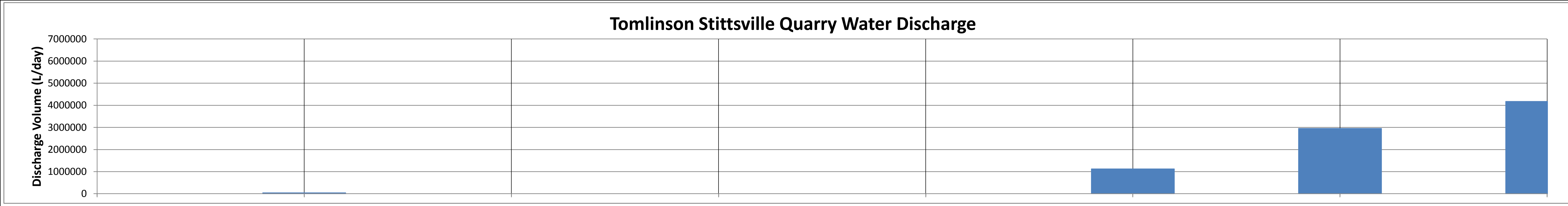
Creek Level Hydrograph at FLW650

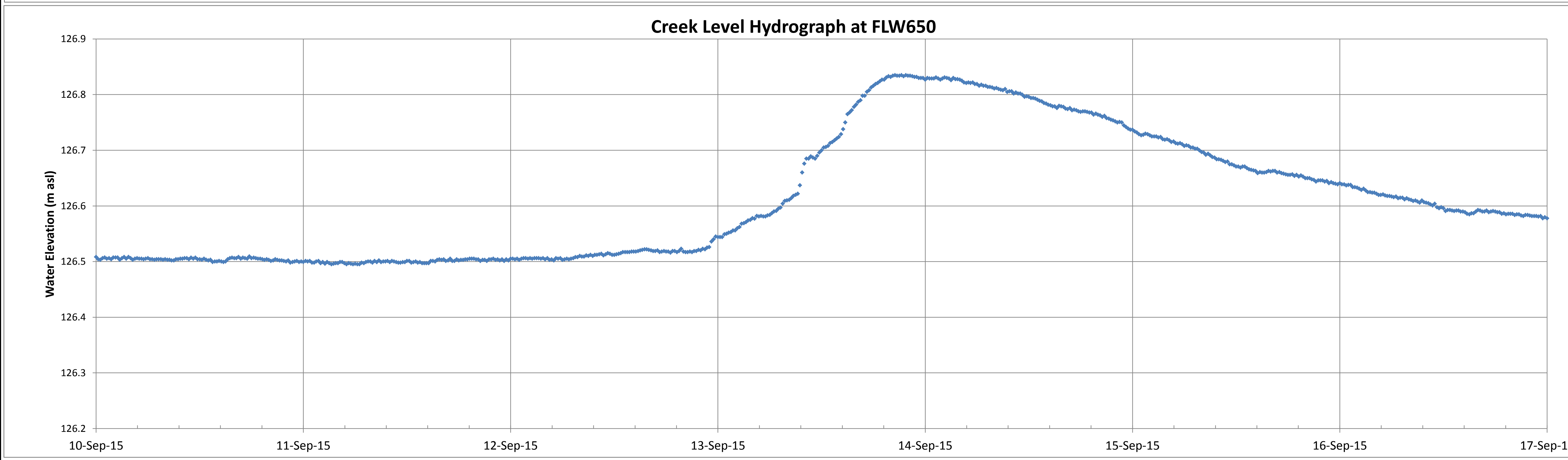


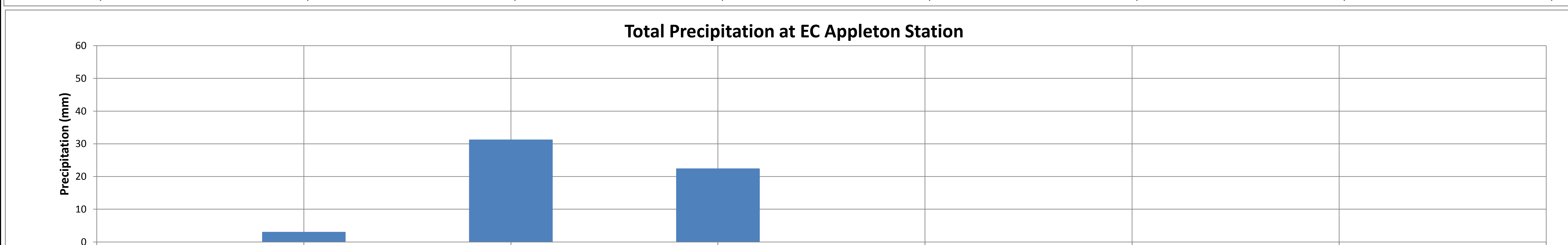
Total Precipitation at EC Appleton Station



SLR	Example of Rainfall Event 2	Figure A10
	Ottawa, Ontario	





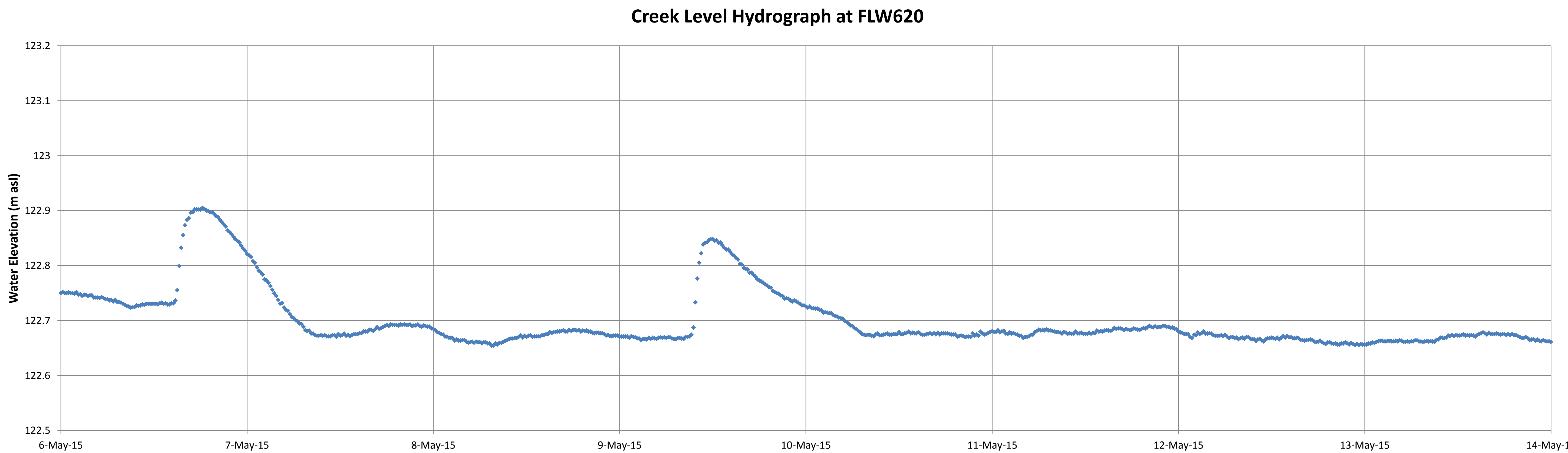


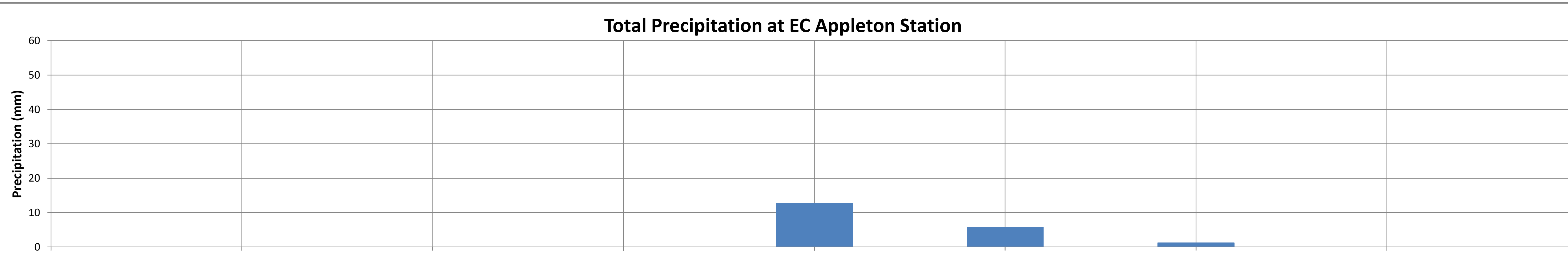
SLR

Example of Rainfall Event 3

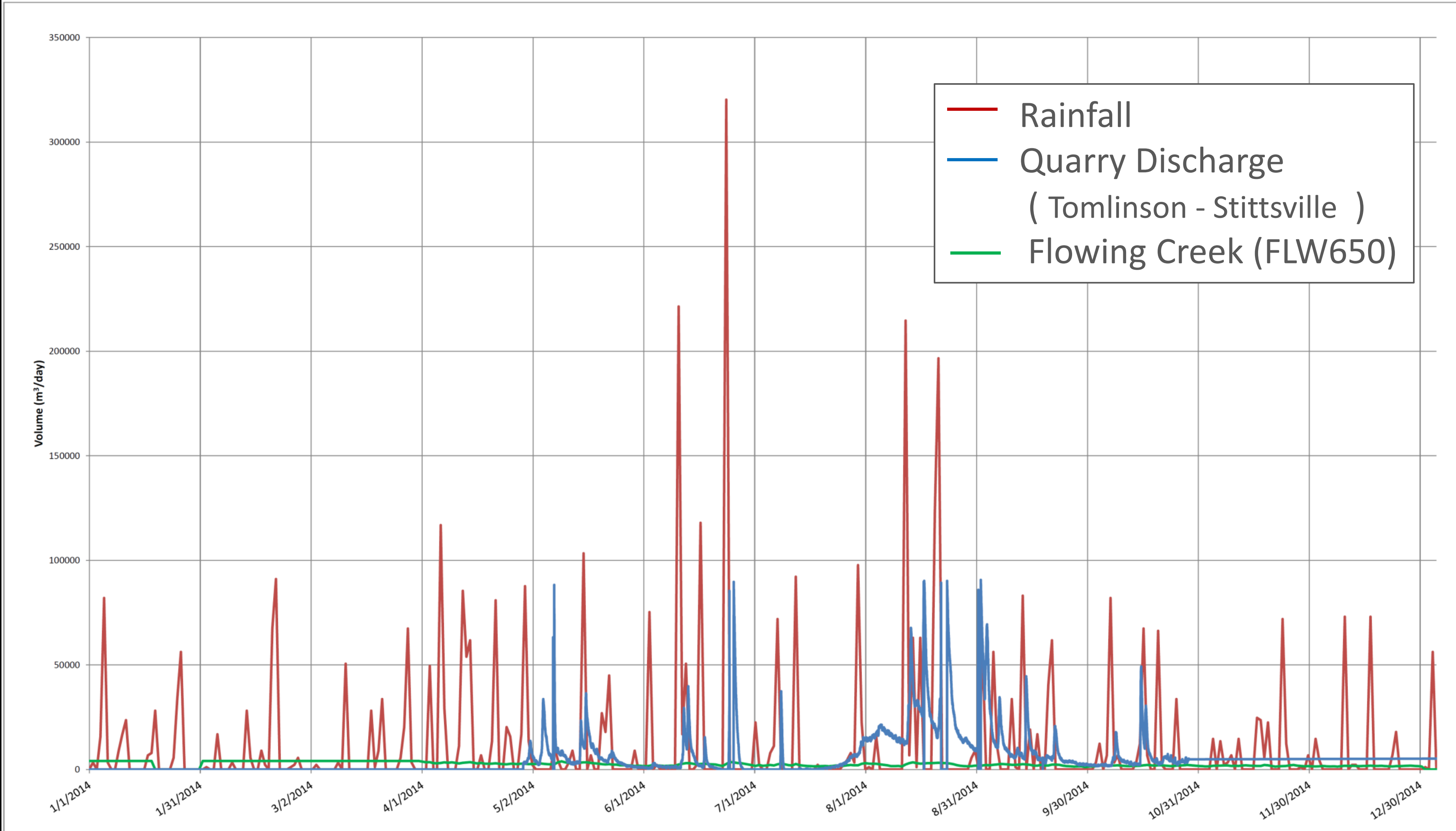
Ottawa, Ontario

Figure A11





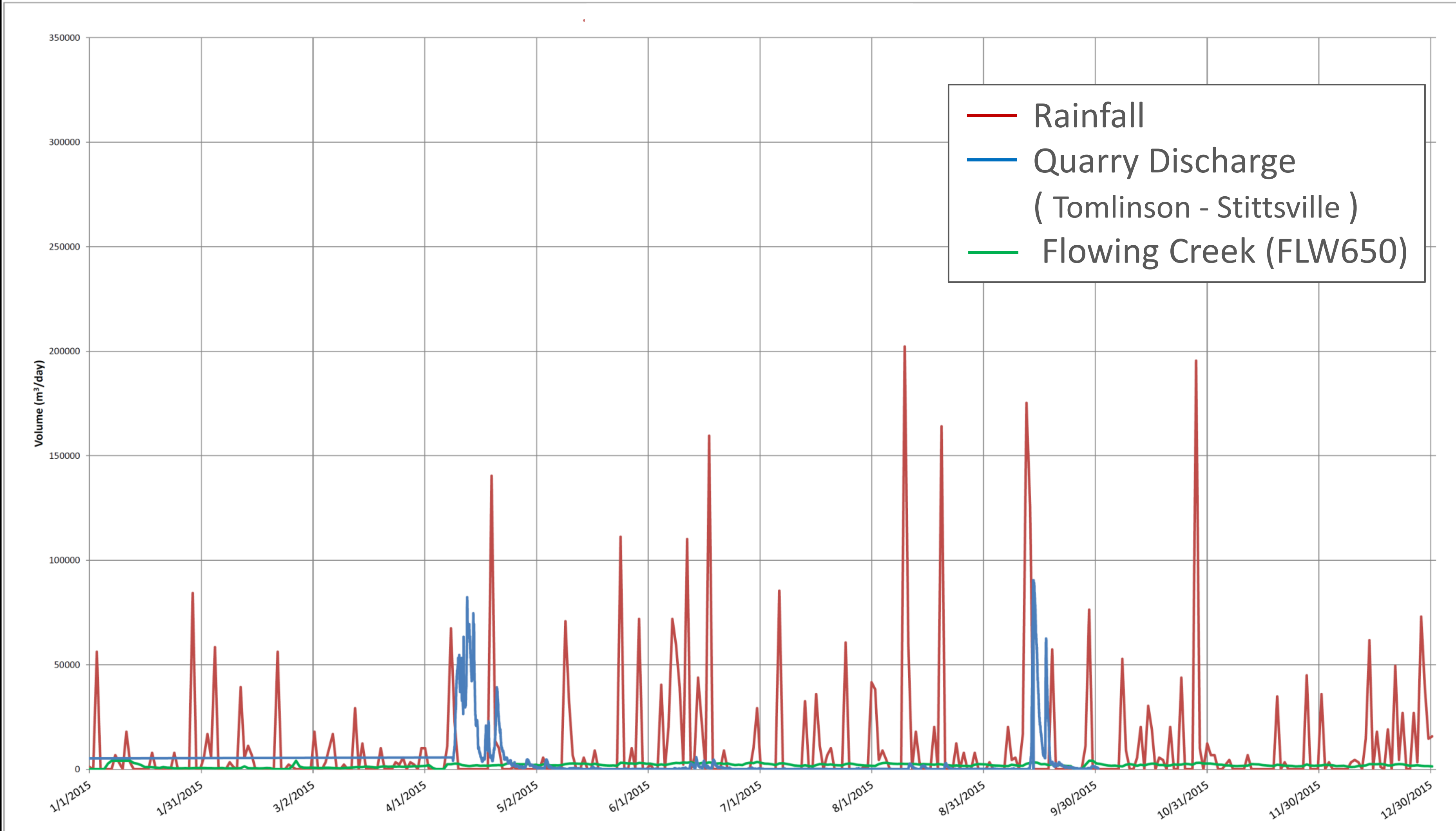
SLR	Rogue Creek Spike	Figure A12
	Ottawa, Ontario	



SLR

2014 Comparison of Daily Volume (m^3/day)

Figure A13



SLR

2015 Comparison of Daily Volume (m^3/day)

Figure A14