SEASONAL RAINFALL EFFECT ON GROUNDWATER FOR CHOMA TOWNSHIP IN SOUTHERN PROVINCE OF ZAMBIA 2009-2016

By

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A dissertation submitted to the University of Zambia in partial fulfillment of the requirements for the Post Graduate Diploma in the Integrated Water Resources Management (IWRM)

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BACKGROUND

Evaluating groundwater levels and recharge patterns is part of the sustainable management of the water resource and will help in coming up with predictions of possible water shortages in future. Southern province is found in the drought prone region of Zambia and most of the streams are non-perennial. Therefore, groundwater is increasingly relied upon as a source of portable water for rural and township populations, but seasonal and inter-annual fluctuations of groundwater levels and recharge patterns are not always known. The urgent need for portable water, combined with donor stipulations and the desire of government to meet millennium development goals, place emphasis on providing drinking water supplies through drilling of boreholes and pump installations as a priority. Scientific studies of groundwater which is a valuable and vulnerable resource are not usually taken as a priority, now however, there seems to be growing concerns in light of issues of climate change, which bring about extreme events in the form of floods or droughts and increasing population development ***(Macdonald et al., 2009; Taylor et al., 2009).***

PROBLEM STATEMENT

Lack of an understanding of groundwater under current aquifer conditions, no capacity to make limited predictions of sustainability under various future scenarios and unreliable rainfall due to climate change as stress will intensify on the development of groundwater resources when communities turn towards mechanized pump systems to deliver groundwater for agriculture and domestic use in Choma township and our country as a whole.

GENERAL OBJECTIVE

To evaluate the seasonal rainfall effects on groundwater level fluctuations and recharge to determine the potential groundwater yield in Choma township.

SPECIFIC OBJECTIVES

i. To determine the monthly and annual effects of rainfall on groundwater;

ii. To determine the year of the highest rainfall amount and the effect on groundwater;

iii. To determine the year of the greatest groundwater fluctuation;

iv. To determine the year of the lowest rainfall amount and the effect on groundwater.

RESEARCH QUESTIONS

i. Does monthly or seasonal amount of rainfall have an immediate effect on groundwater on not?
ii. Which season had the highest amount of rainfall and what was the effect on groundwater?
iii. Which year had the greatest groundwater fluctuation?
iv. Which season had the lowest amount of rainfall and what was the effect on groundwater?

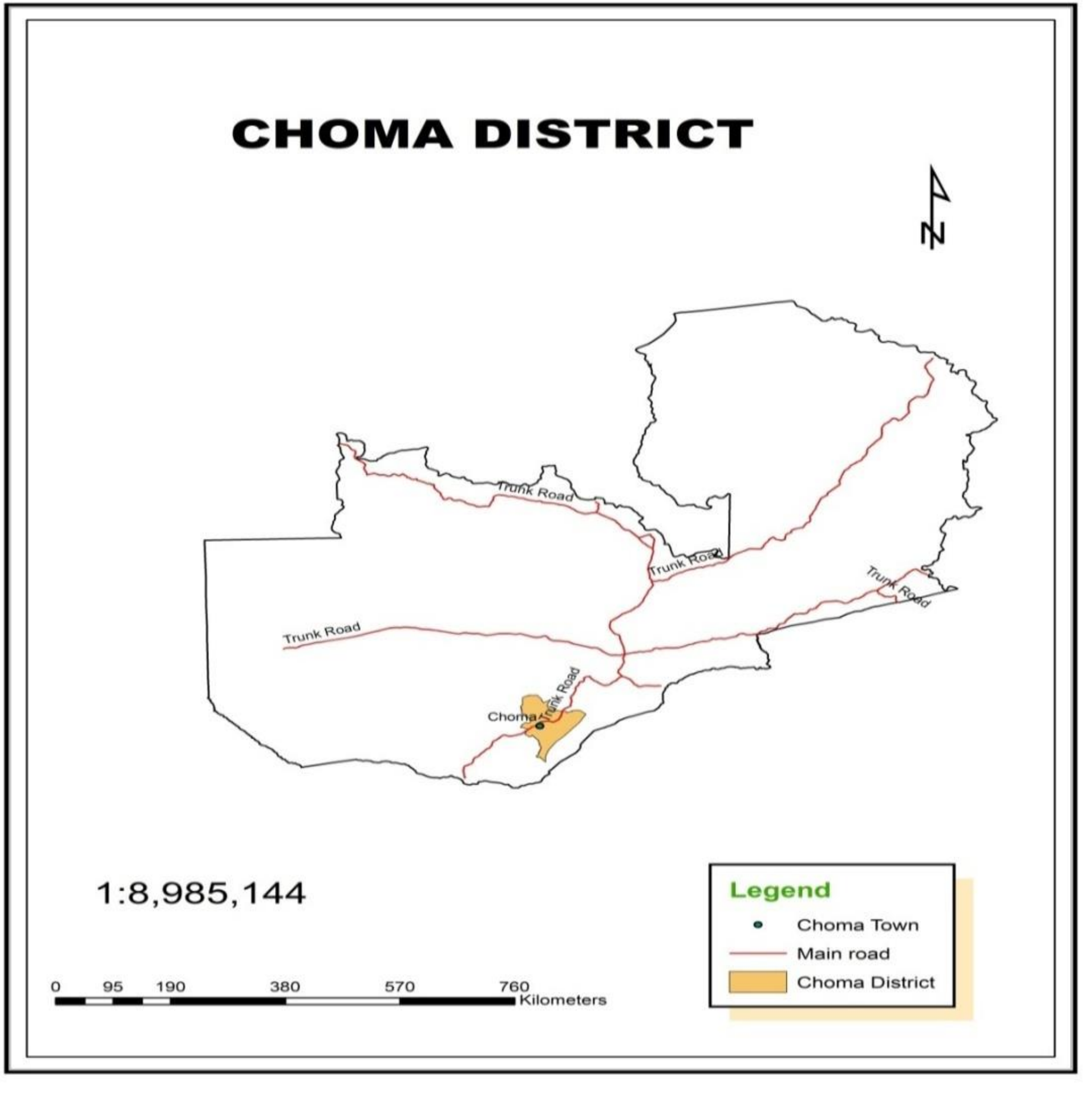
SIGNIFICANCE/RATIONALE

i. Meet groundwater demands that will grow and shift among water use sectors;
ii. Use real data to construct graphs that relate rainfall to groundwater;
iii. Analyze rainfall and groundwater recharge trends overtime;
iv. Draw conclusions from rainfall and groundwater data to make predictions;
v. Continuously monitor rainfall effects on groundwater so as to identify possible impacts of climate change on water resources;
vi. Identify trends in groundwater recharge, storage and availability; and
vii. Come up with possible solutions to the identified challenges.

METHODOLOGY

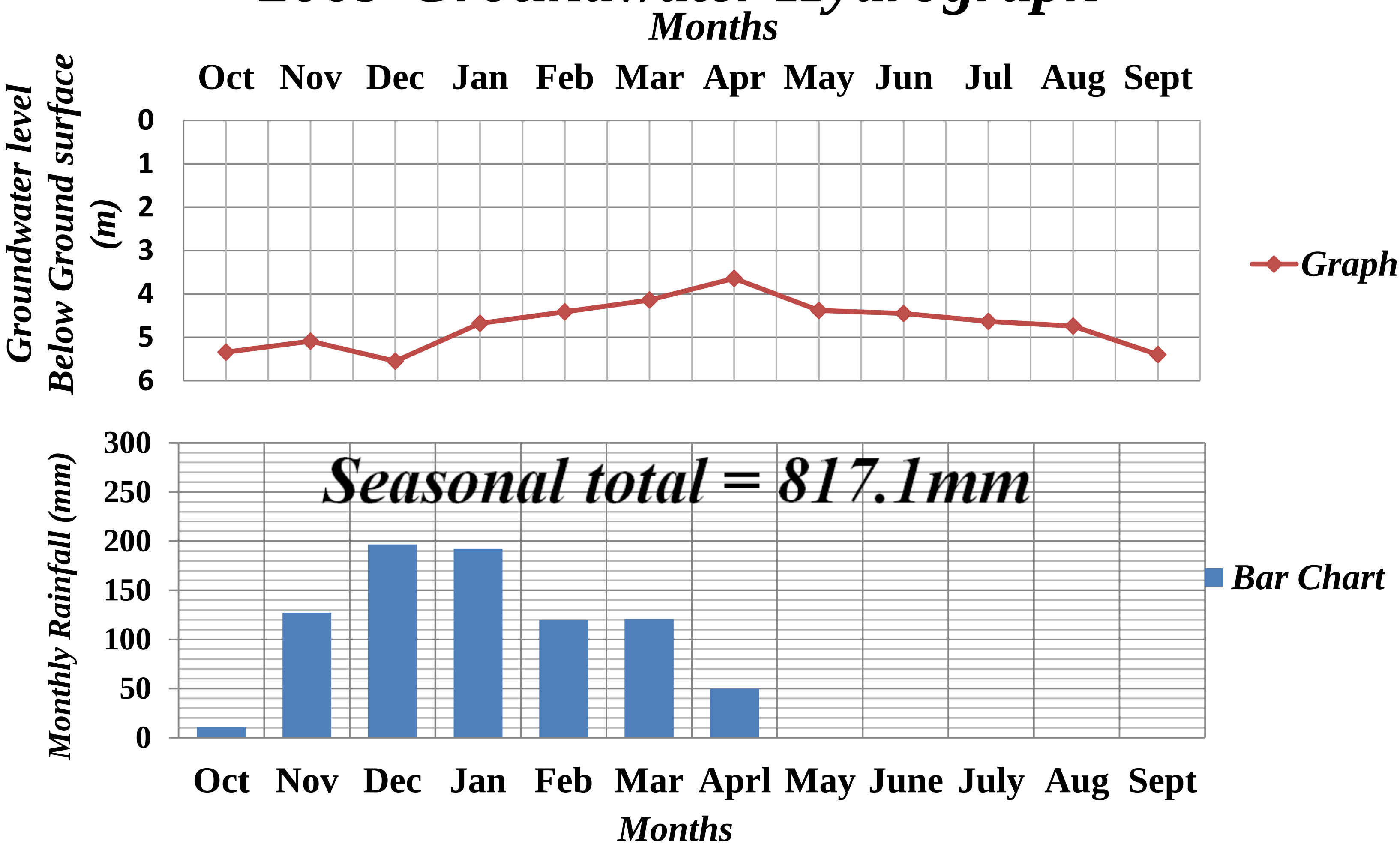
The correlation between rainfall and rise in water level between rainy season and dry season from 2009 to 2016 were examined by physical analysis of variance of individual rainfall amounts against groundwater level fluctuations. The choice of this method was guided by the objectives of the study, the available data and the possibilities to get supplementary data. Economy was also considered. The 50-year average normal rainfall of 800mm (JICA 1995) was considered.

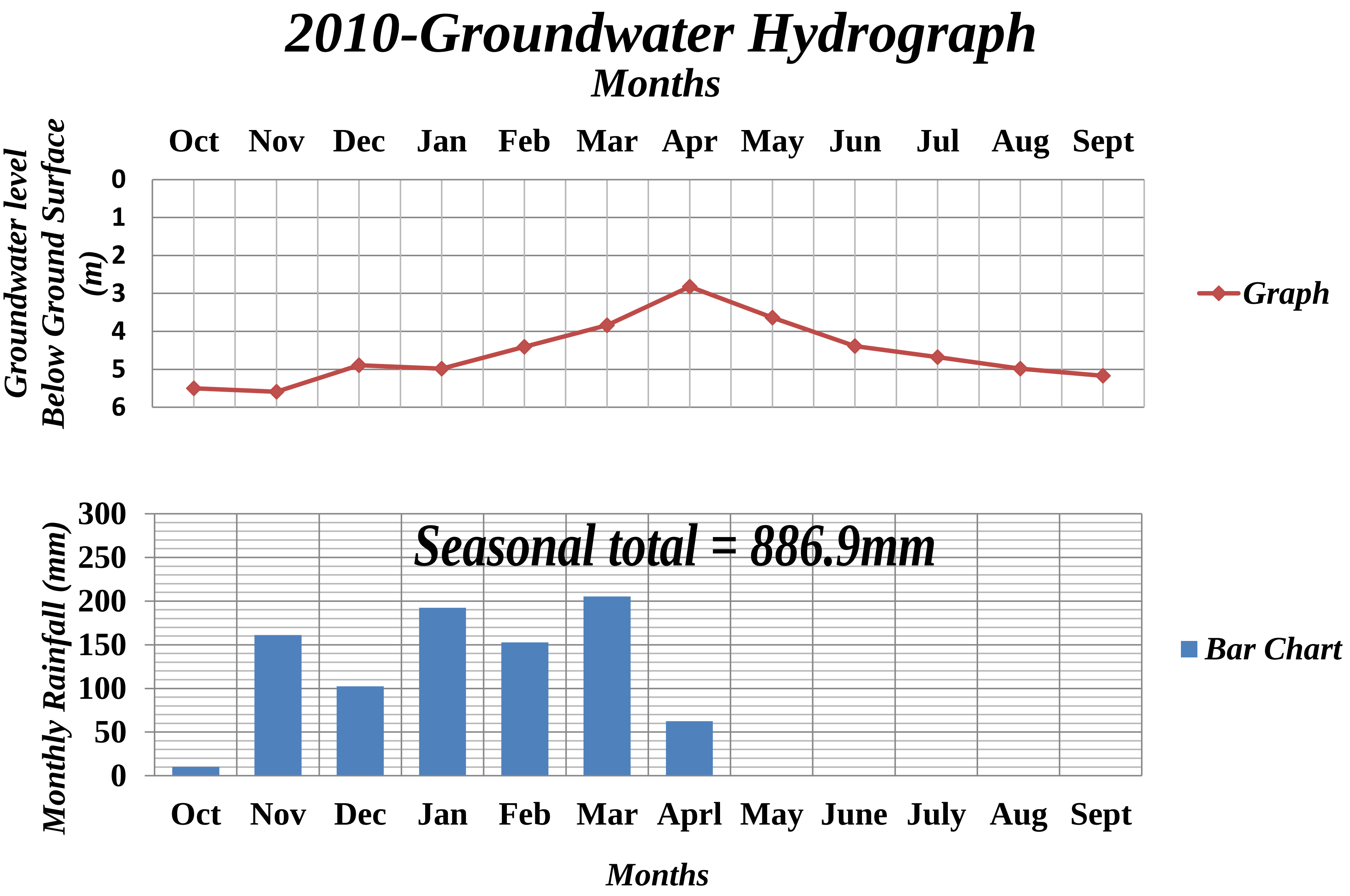
LOCATION OF THE PROJECT AREA

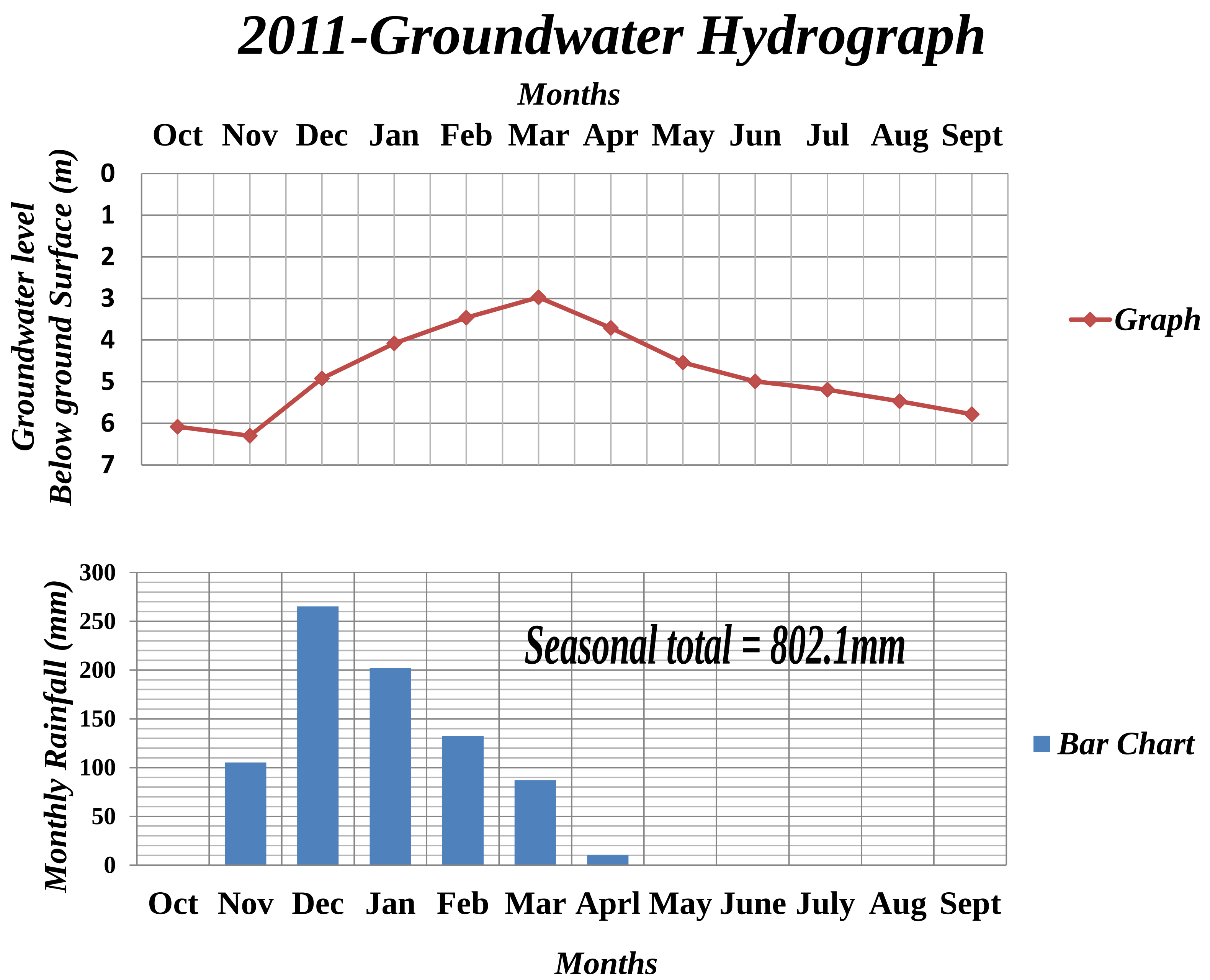


INTERPRETATION AND DISCUSSION OF RESULTS

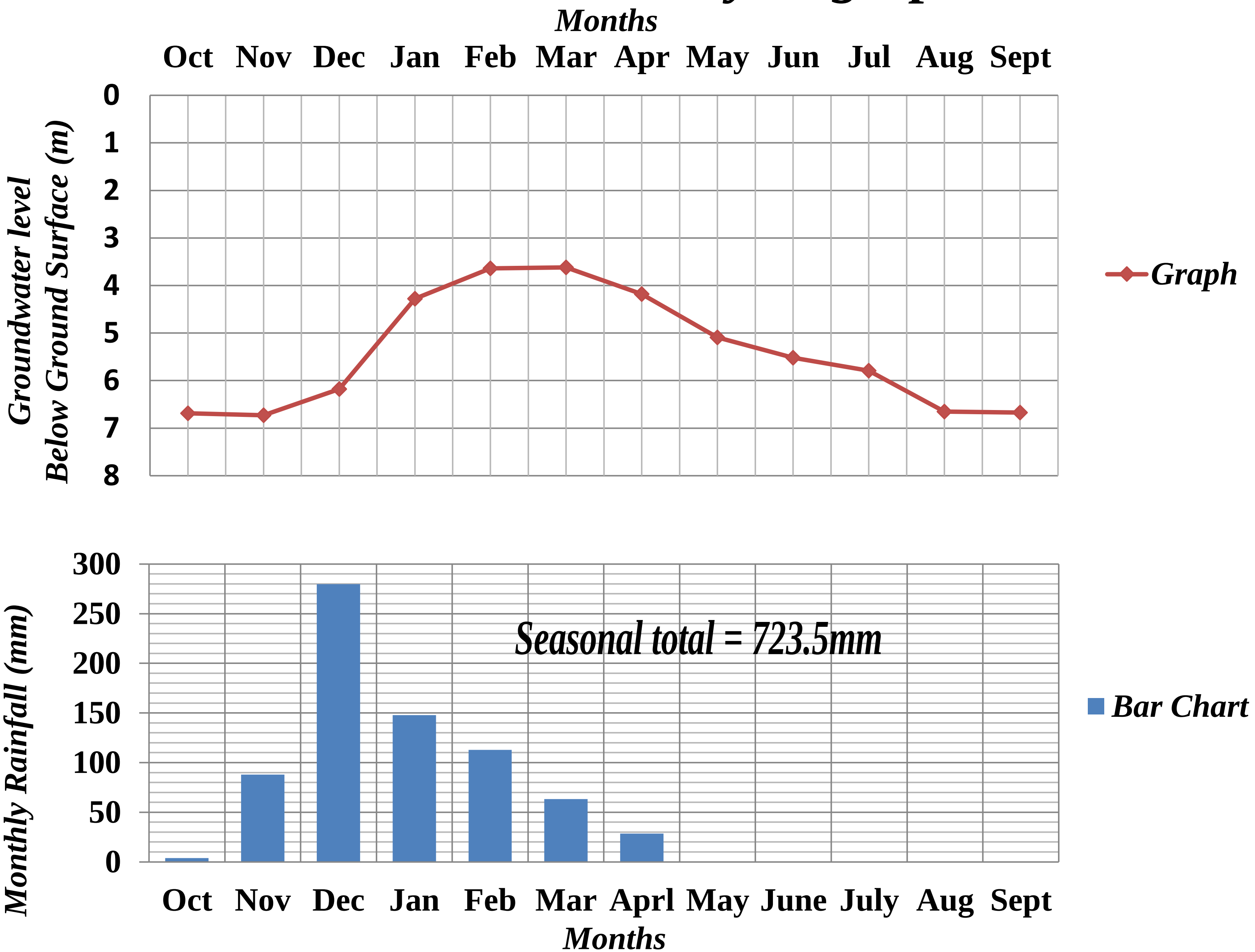
2009-Groundwater Hydrograph



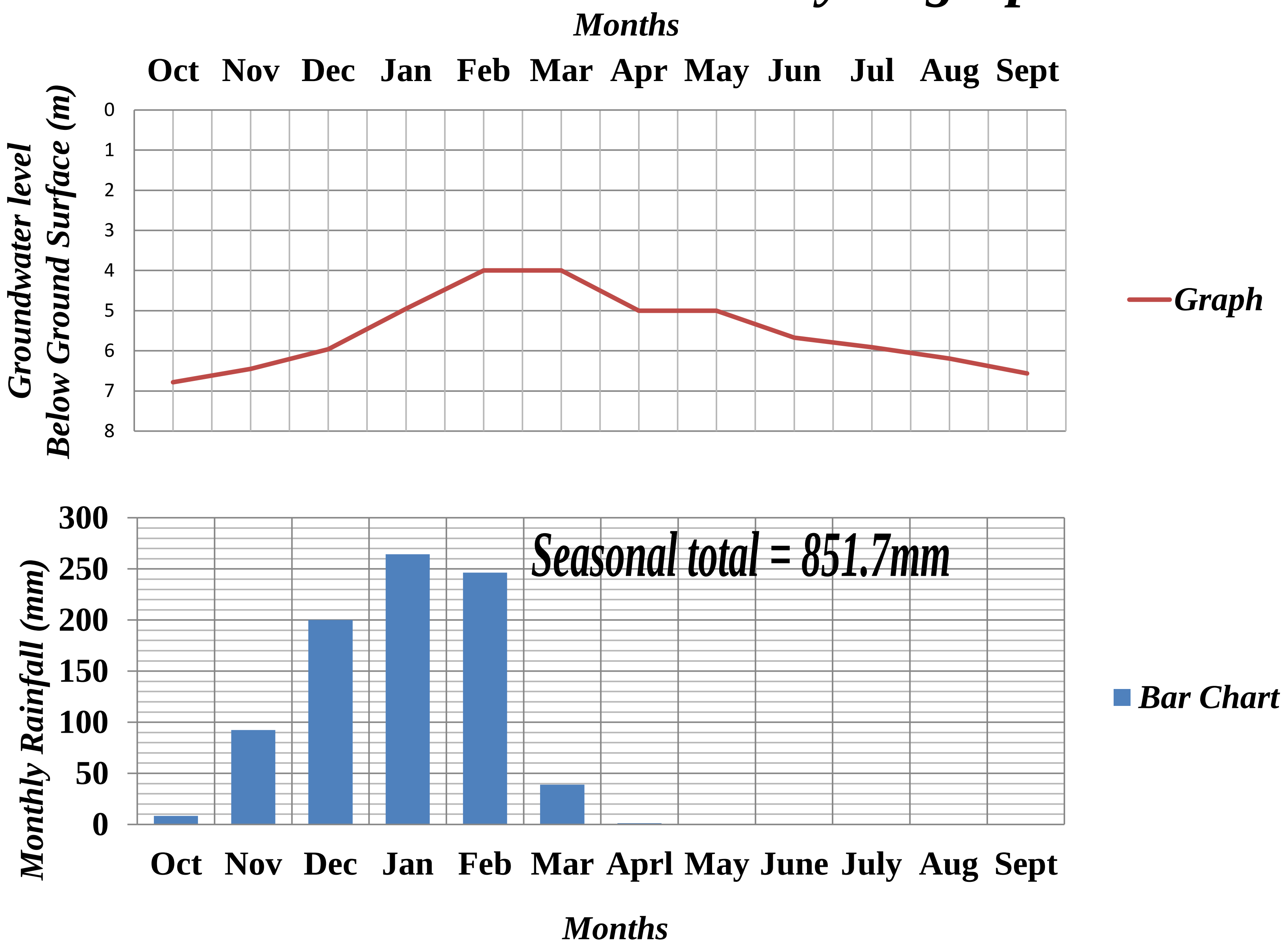

2010-Groundwater Hydrograph
Months
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sept
Groundwater level Below Ground Surface (m)
0 1 2 3 4 5 6
Graph
300 250 200 150 100 50 0
Seasonal total = 886.9mm
Monthly Rainfall (mm)
Bar Chart
Oct Nov Dec Jan Feb Mar Aprl May June July Aug Sept
Months


2011-Groundwater Hydrograph
Months
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sept
Groundwater level
Below ground Surface (m)
0
1
2
3
4
5
6
7
Graph
300
250
200
150
100
50
0
Monthly Rainfall (mm)
Seasonal total = 802.1mm
Bar Chart
Oct Nov Dec Jan Feb Mar Aprl May June July Aug Sept
Months

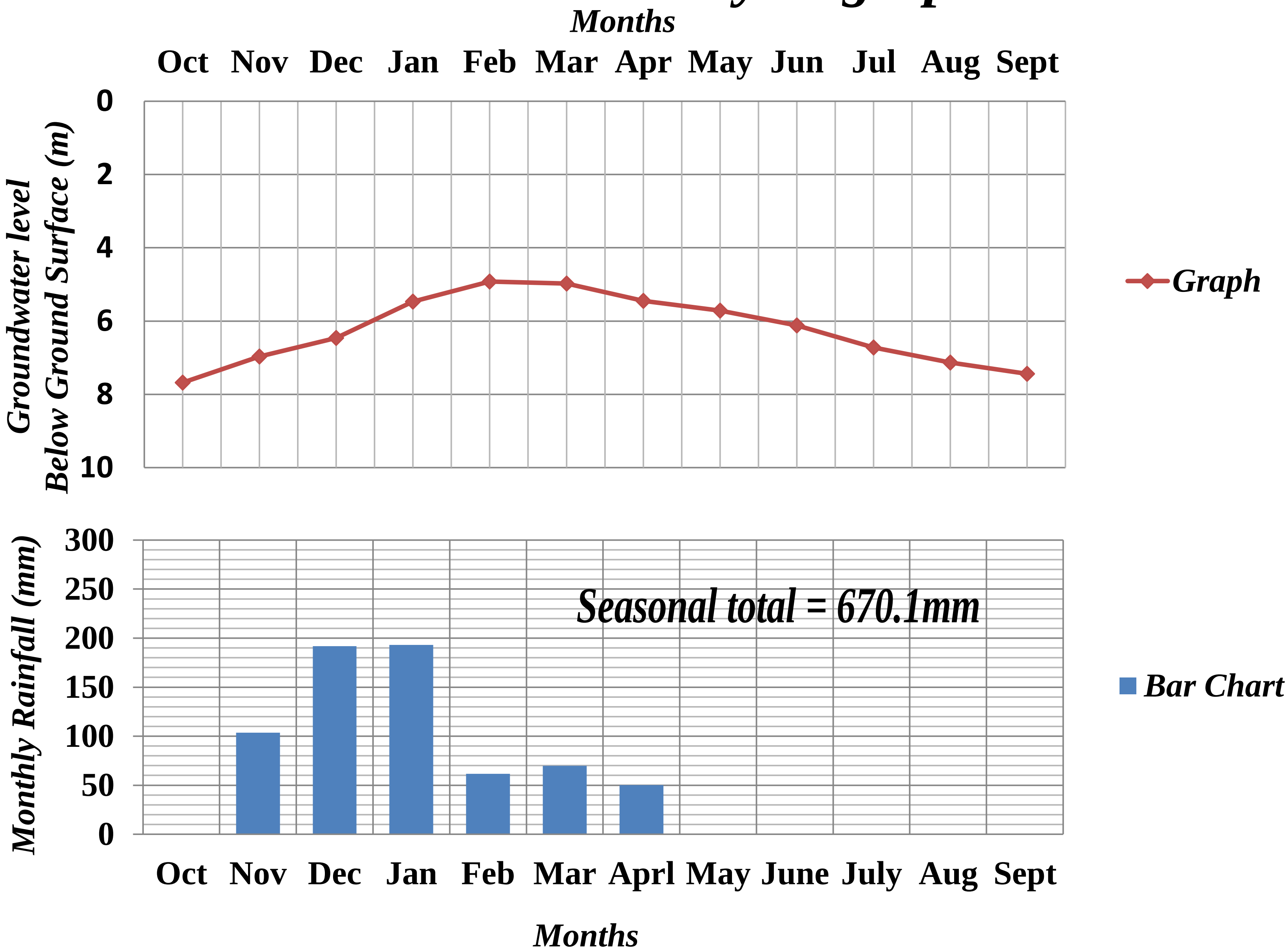
2012-Groundwater Hydrograph



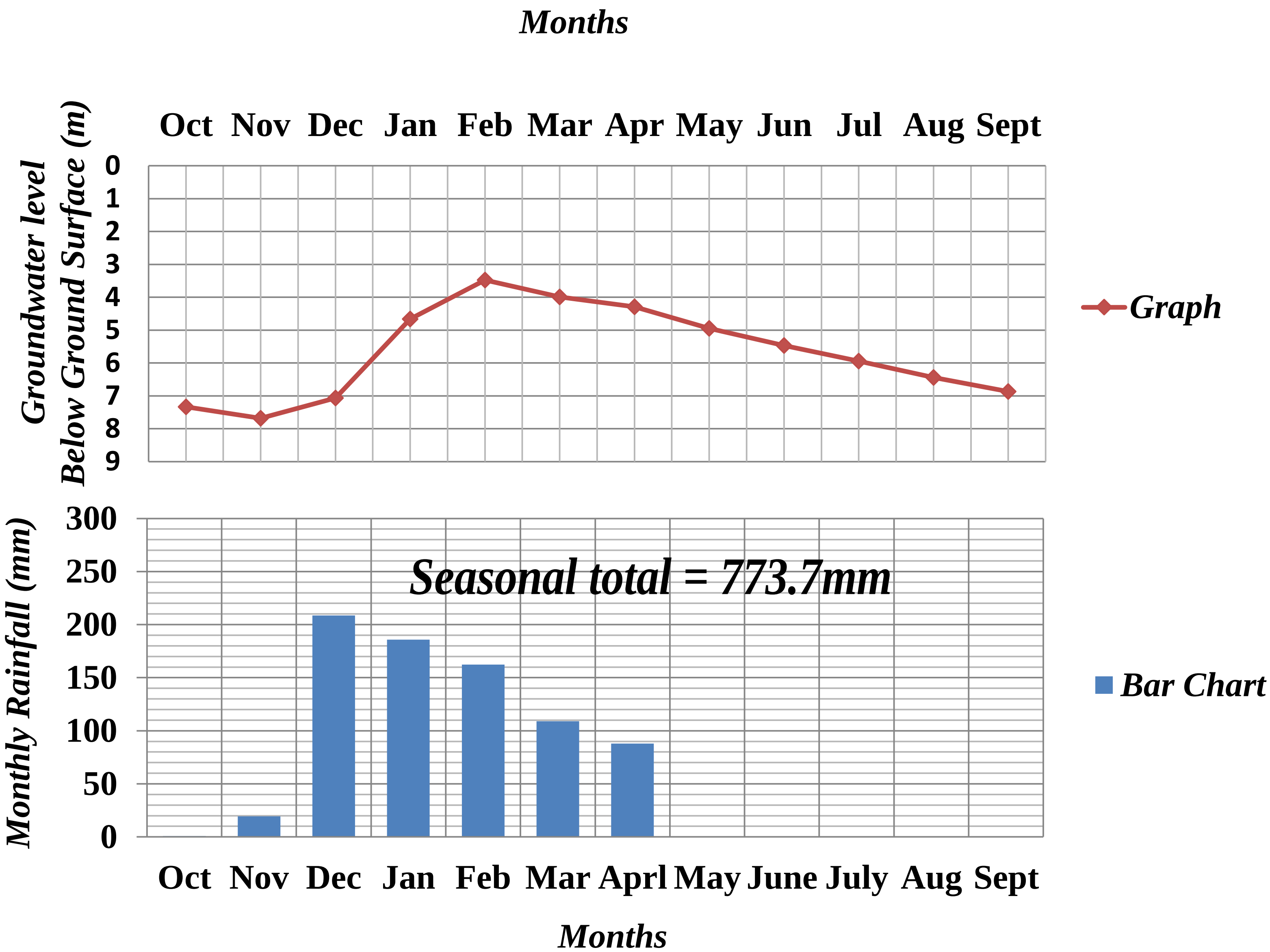
2013-Groundwater Hydrograph



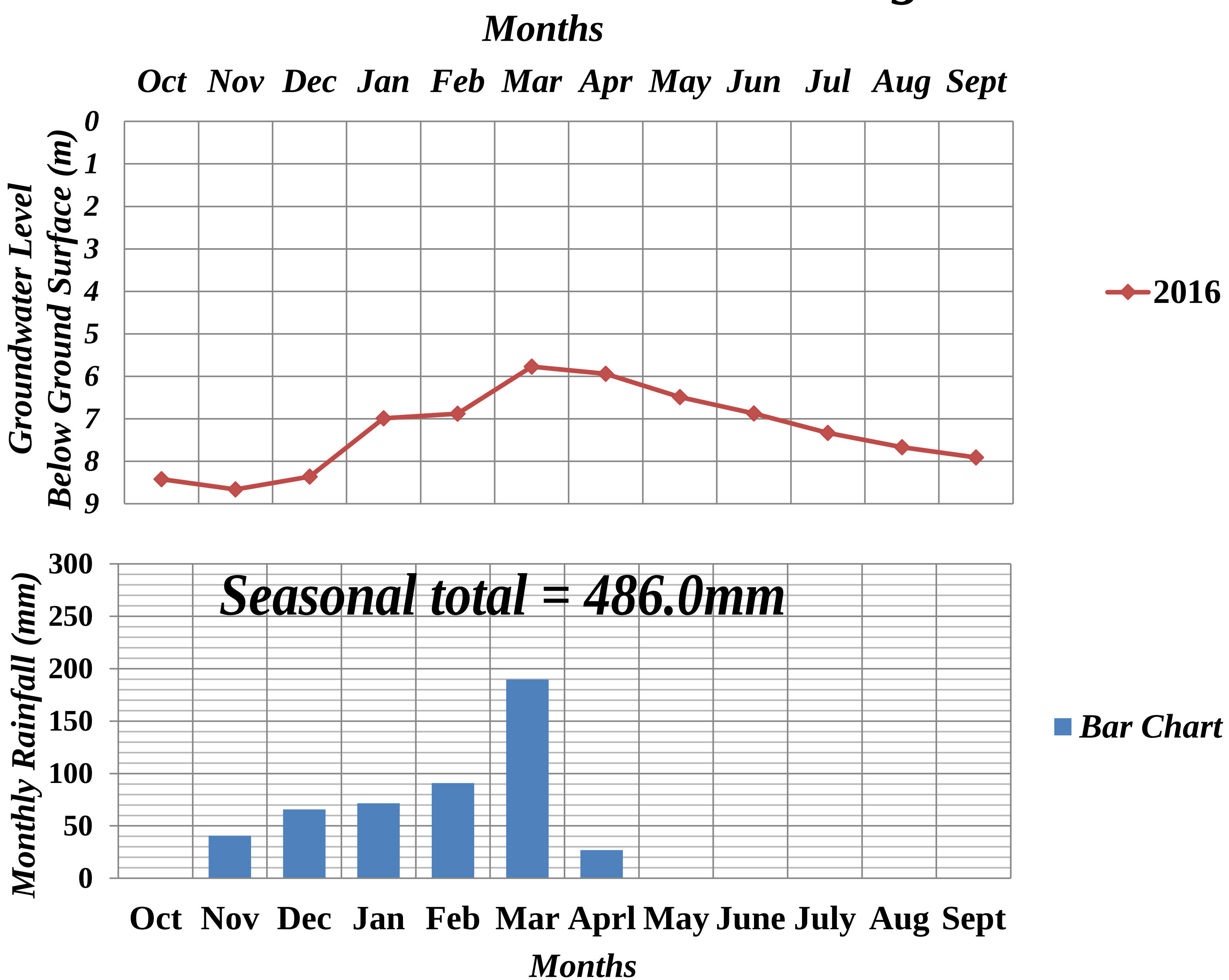
2014-Groundwater Hydrograph



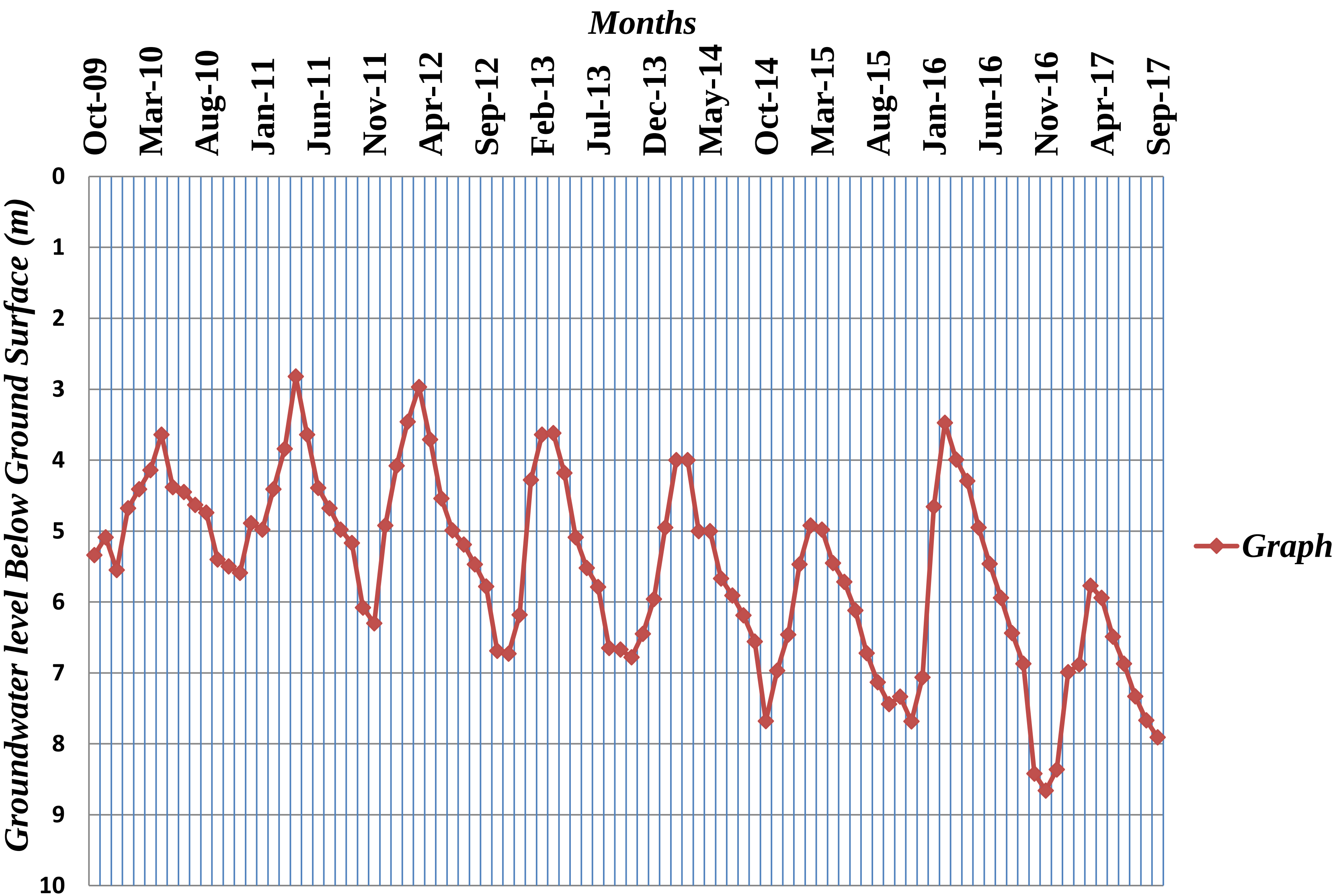
2015-Groundwater Hydrograph

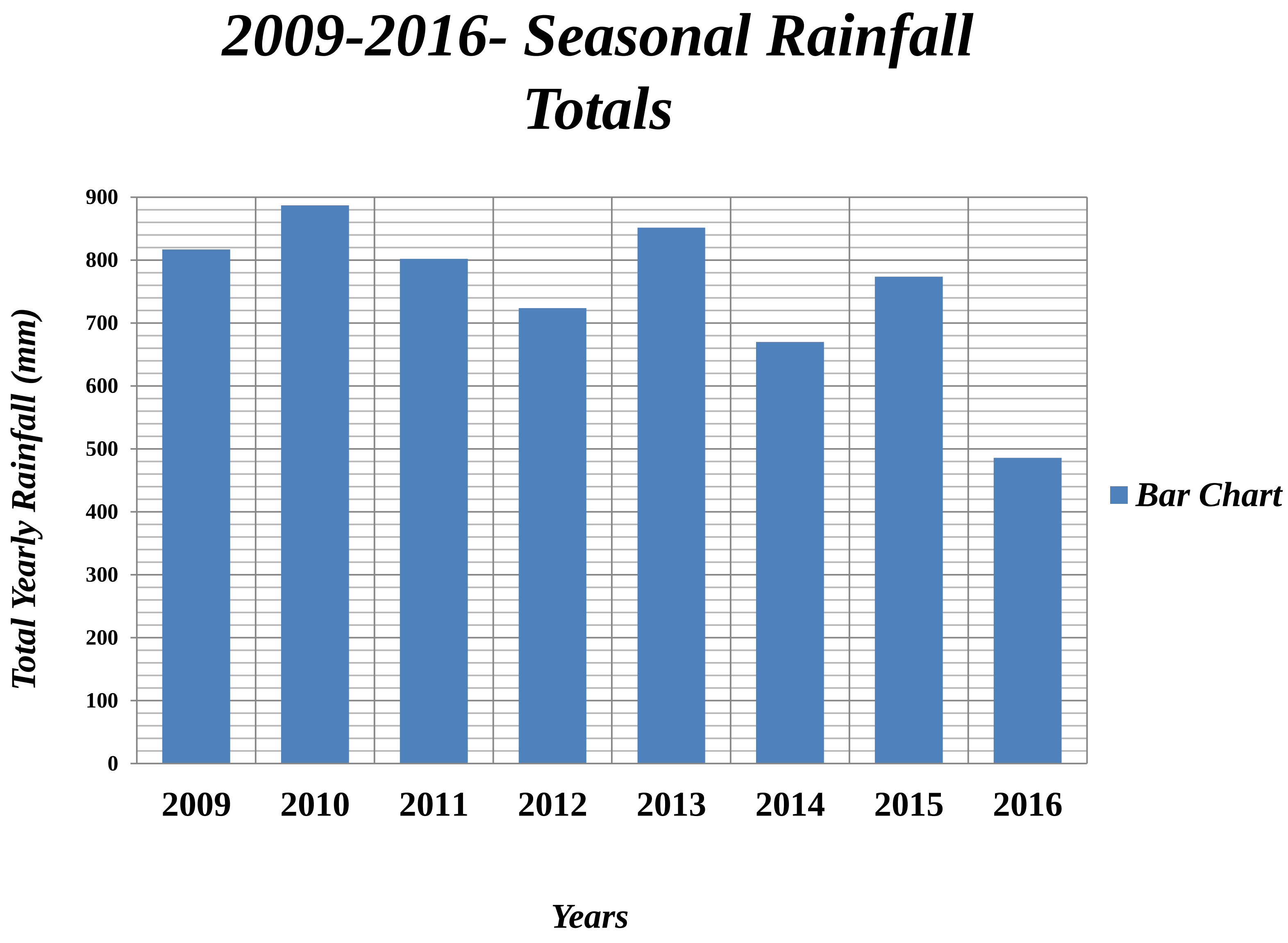


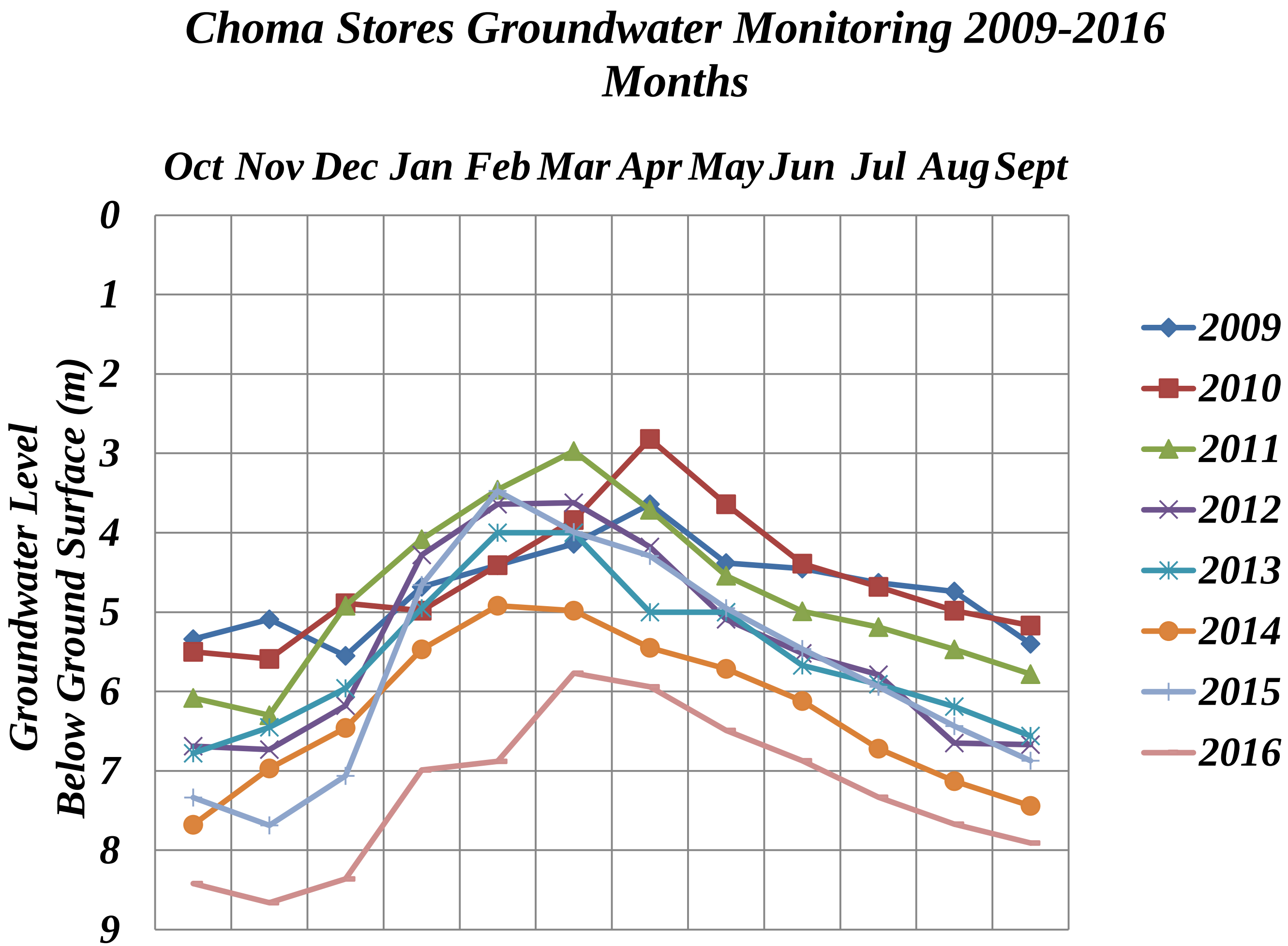
2016 Groundwater Monitoring



2009-2016-Groundwater Hydrograph

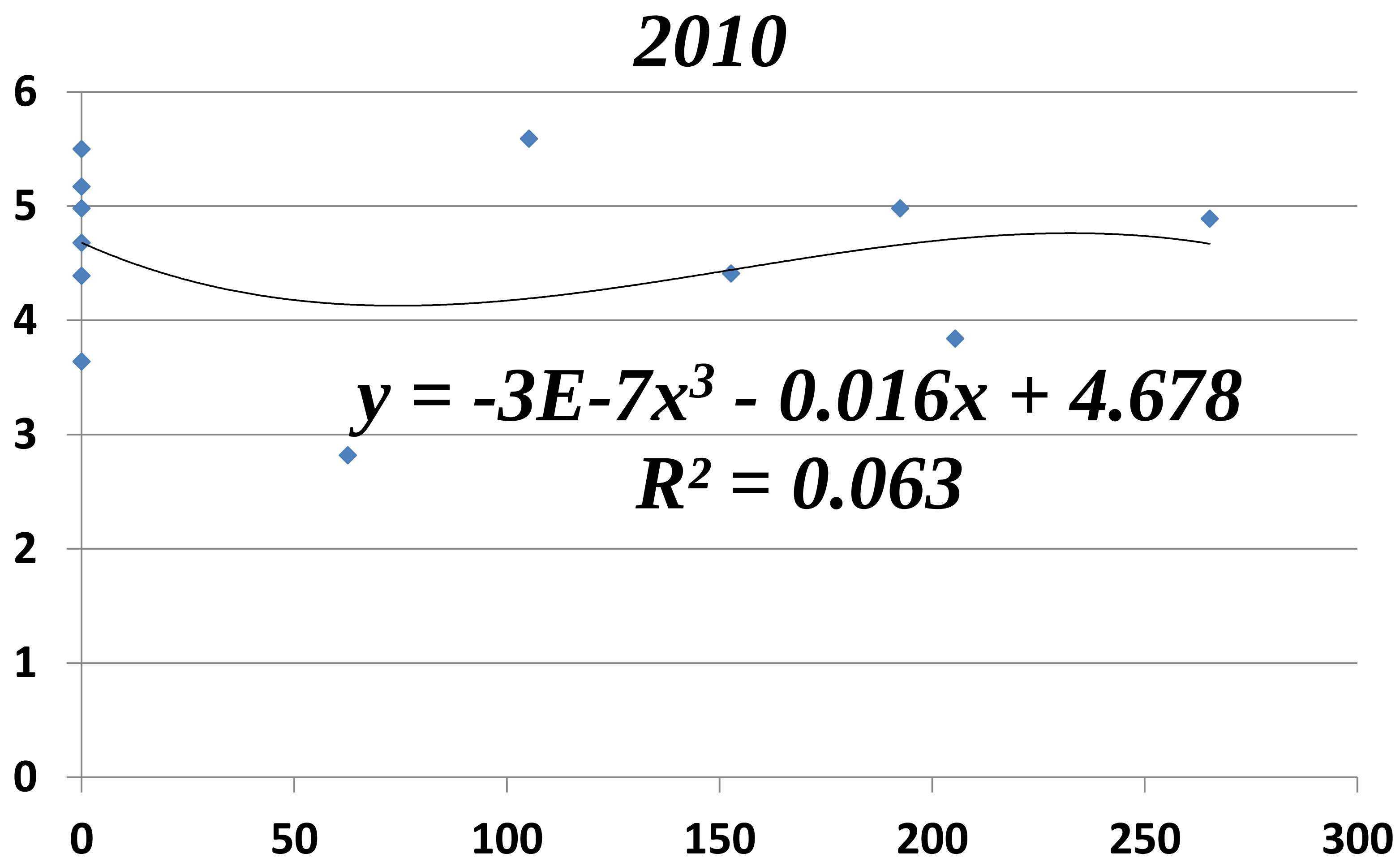



2009-2016- Seasonal Rainfall Totals
Total Yearly Rainfall (mm)
900
800
700
600
500
400
300
200
100
0
2009
2010
2011
2012
2013
2014
2015
2016
Years
Bar Chart



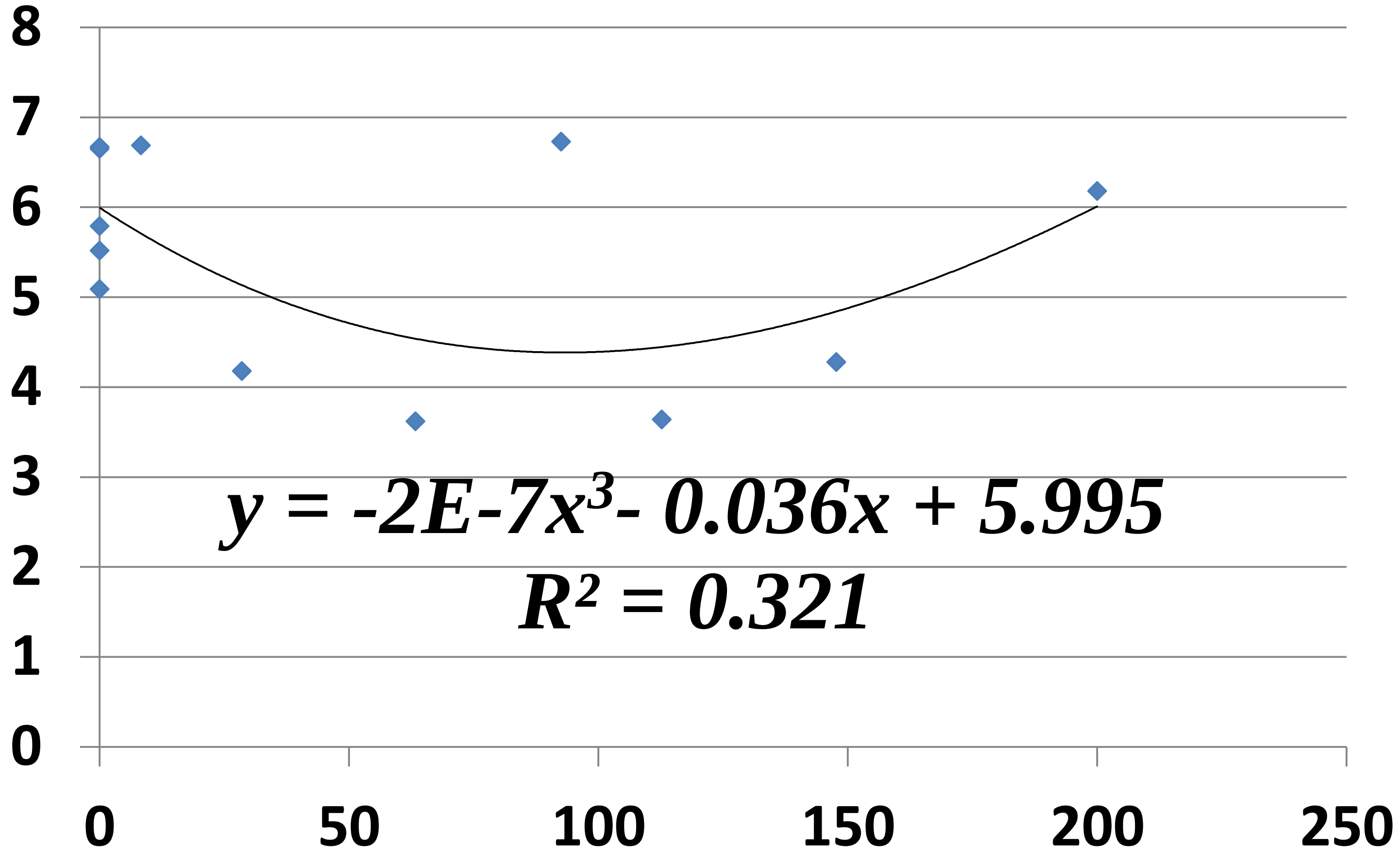
YEAR	2010	2013	2009	2011	2015	2012	2014	2016
Seasonal Rainfall(mm)	886.9	851.7	817.1	802.1	773.7	723.5	670.1	486.0
Position(#)	1	2	3	4	5	6	7	8

REGRESSION ANALYSIS OF THE DATA

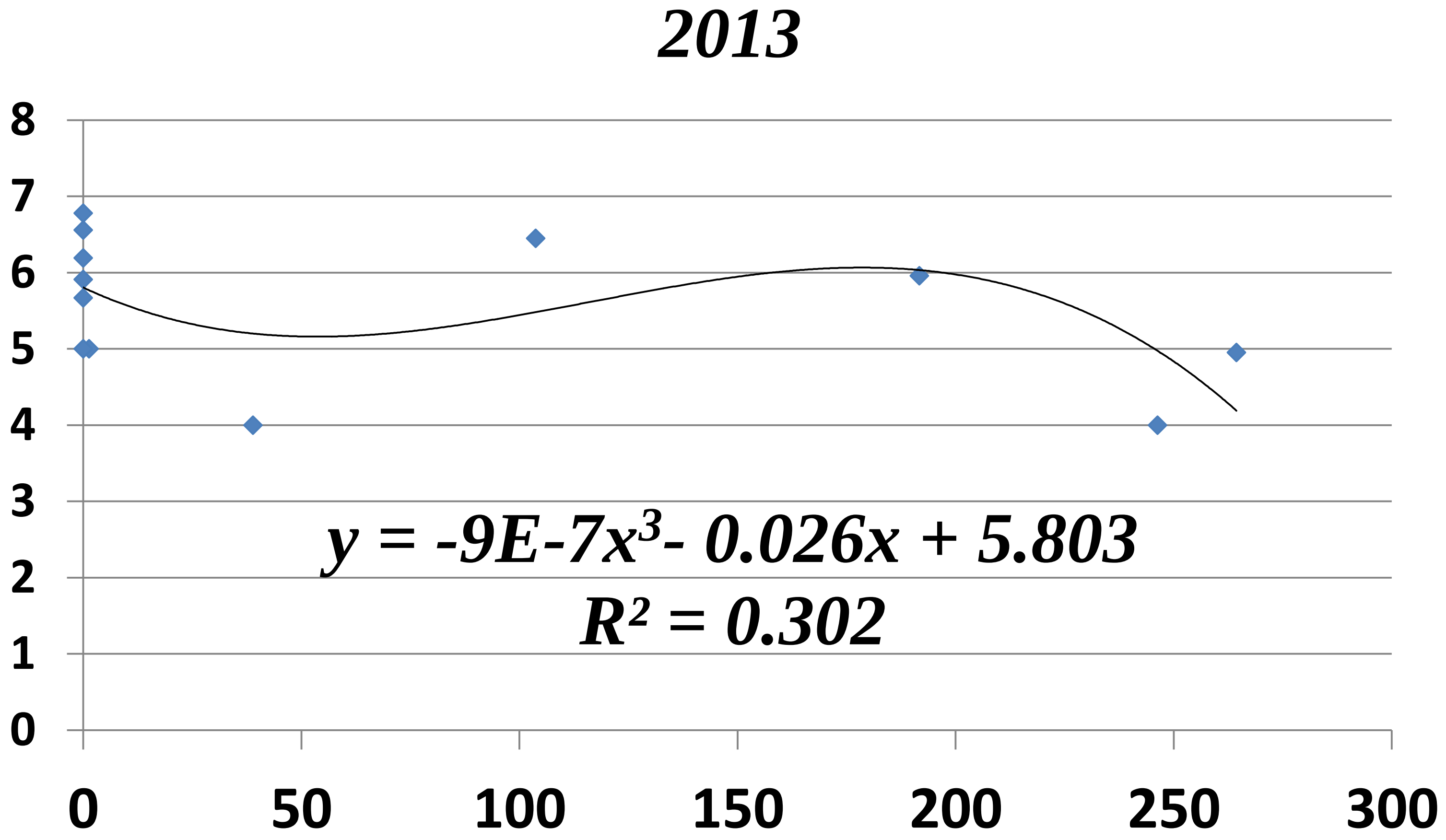


REGRESSION ANALYSIS OF THE DATA

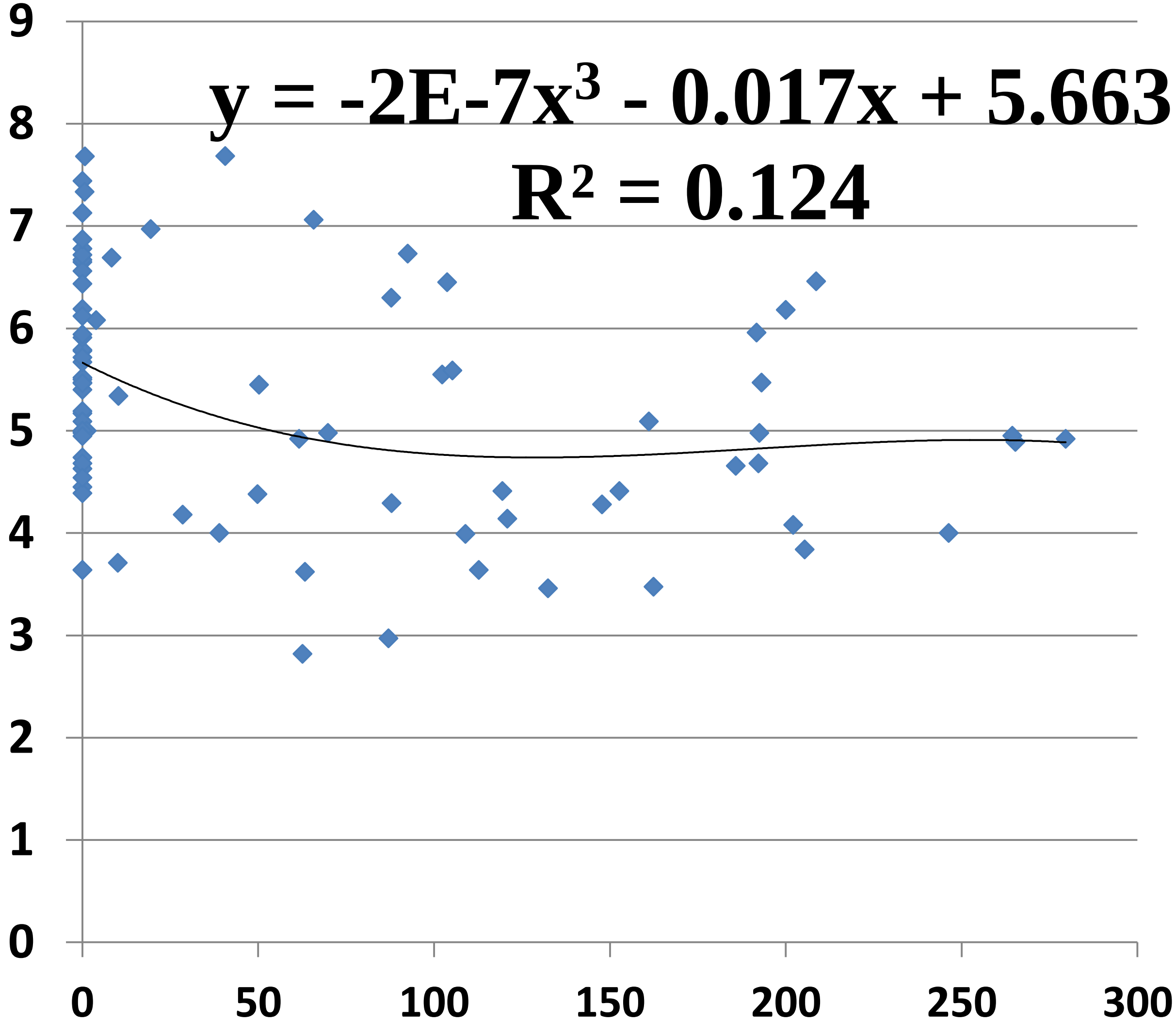
2012



REGRESSION ANALYSIS OF THE DATA



REGRESSION ANALYSIS OF THE DATA- 2009 to 2016



DISCUSIONS OF RESULTS

The season with the highest rainfall for the period was 2010 amounting to 886.9mm.

The season with the lowest rainfall amount was during the season of 2016 amounting to 486.0mm.

The lowest seasonal groundwater levels occurred during the months of October, November, December.

The peaks groundwater levels occurred in the months of February, March and April.

DISCUSSION OF RESULTS-Continues

It was observed that the highest groundwater rise was 2.8m at the point of observation in 2010.

The seasonal peak rainfalls occurred in December, January and March.

The seasons of 2009, 2010, 2011, 2013 had rainfall above average and 2012, 2014, 2015,2016 rainfall was below average.

The lowest seasonal groundwater levels are still going down and it has dropped by 3.05 metres.

In the year 2016 the groundwater levels recorded the lowest 8.6 metres below ground level.

The coefficients for Regression Analysis equations for the seasons 2010, 2012 and 2013 were negative.

CONCLUSIONS

The relationship between rainfall and groundwater level is nonlinear.

The annual potential groundwater is dependent on the amount of annual recharge observed that season and the amount of the seasonal rainfall.

The shape of the groundwater hydrograph depends on the rainfall and withdrawal patterns of that season.

The highest groundwater fluctuation was during the year 2015 and was 4.22 metres.

CONCLUSIONS continues

Since the groundwater hydrograph during rainy season raises at a steeper slope it means that there is also an immediate effect by rainfall on groundwater recharge before it reaches the peak.

Since the level of groundwater hydrograph keeps on dropping after reaching the peak even if it is still rainy season, it means that there is a certain minimum amount of rainfall required for it continue rising or start to rise. Rainfall amounts from 851.7mm and above will always be non-significant due to limited infiltration capacity of the soil.

CONCLUSIONS continues

The recharge normally happens quicker than the withdrawal hence the steeper rise to peak and a flatter graph after peak of the groundwater hydrograph.

Even if the rainfall amounts in 2009 and 2011 was above average and significant groundwater kept on going down.

The seven years average seasonal rainfall for the study period was 751.38mm, below 800mm and the overall rainfall recharge on groundwater over the period 2009 to 2016 was non-significant as shown by the regression analysis.

CONCLUSIONS continues

The seasons 2010 and 2013 had the highest rainfall amounts but the groundwater recharge was non-significant meaning that a greater amount of water went as surface run off.

Recharge depends on infiltration capacity of soil.

The groundwater levels will never recover even if rainfall amounts increased as long as the areas available for natural infiltration process are reducing, surface runoff is diverted to areas that are “out of reach” of the aquifer, groundwater abstraction keeps on increasing, droughts continue and infiltration capacity of the soil is not enhanced by artificial recharge.

CONCLUSIONS continues

From all this analysis, findings and observations I can safely say that groundwater recharge in the study area has not recovered during the period of the study.

RECOMMENDATIONS

There is need to increase the number of monitoring boreholes.

There should be a systematic, long-term monitoring of data which is crucial to the resolution of many complex water-resources issues.

There should be an iterative process of data collection, application of models or other interpretive techniques, and fine-tuning of monitoring programs over time.

All groundwater monitoring should also include rainfall monitoring in the groundwater resource assessment and management programs.

RECOMMENDATIONS cont.

There is need to come up with a deliberate artificial groundwater recharge program otherwise groundwater levels will never recover.

There is need to fully regulate groundwater abstraction as groundwater has proven to be a vulnerable resource.

These findings and recommendations should also be extrapolated to highly populated areas like Lusaka.

ENDS PRESENTATION THANK YOU