STATE OF OUR AQUIFERS

Regional District of Nanaimo

Aquifer 217

Prepared for:

Regional District of Nanaimo

Prepared by:

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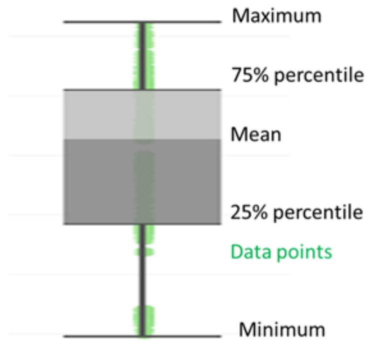
Glossary

Aquifer	An underground layer of water-bearing permeable rock, rock fractures or unconsolidated materials (gravel, sand) from which groundwater can be extracted using a water well. (See also confined aquifers and unconfined aquifers.)**.** Aquifers can be interconnected to other aquifers and surface water and can be present at various depths.
Aquifer classification number	Assigned by government to developed, unconsolidated and bedrock aquifers, classified by their level of development and vulnerability.
Aquifer map database	Aquifers are mapped by the Province of British Columbia using data from the WELLS database. The map based Aquifer Classification System was developed in 1994, and approximately 1129 aquifers have been mapped and classified as of May, 2017.
Aquifer type	Describes the general lithology and origin of the aquifer materials.
Aquitard	An aquitard is a zone in the ground or bedrock that restricts the flow of groundwater from one aquifer to another, or from the surface to the subsurface. Aquitards are usually comprised of silt, clay, or non-porous rock of low hydraulic conductivity.
Bedrock aquifer	In solid rock, groundwater is stored in the fractures, joints, bedding planes and cavities of the rock mass. Despite the potential for having voids (known as porosity), a rock can only act as an aquifer if those voids are saturated and connected via conduits such as fractures.
Box-and-whisker plot	A graphic way to display the median, quartiles, and extremes of a data set on a number line to show the distribution of the data. The whiskers represent the minimum and maximum values recorded and the box represents the values between the 25% and 75% percentiles, with the median illustrated by the light /dark boundary in the box as shown in the diagram below:

	 For example, if a new groundwater level reading for a given month falls below the 25th percentile, that would indicate that more than 75% of readings for that month have been higher.
Confined aquifer	A confined aquifer is a fully saturated layer of permeable material that has a “confining” layer of low permeability material (aquitard or aquiclude) above it. The low permeability confining layer causes the aquifer to be under pressure so that when the aquifer is penetrated by a well, the water will rise above the top of the aquifer.
Confinement	Refers to the degree of aquifer confinement; limited in this report to confined, unconfined and partially confined aquifer for unconsolidated materials.
Confining layer	A zone in the subsurface that prevents the movement of groundwater. A confining layer is synonymous with a material being impervious to the flow of water. A thick layer of clay is a confining layer.
CPD - Cumulative precipitation departure from average	The CPD graph is a derivative of the precipitation data. The mean monthly precipitation over the considered period is determined and the departures from the average of the actual monthly precipitation are summed and plotted. Sums mathematically return to zero difference with the last reading. The cumulative precipitation departure (CPD) from average is a concept utilized to evaluate the temporal correlation of precipitation with surface water or groundwater levels.

Demand	Demand refers to the present level of groundwater use. Demand is one of the seven criteria used to rank the relative importance of an aquifer. Demand may be light, moderate or heavy.
Elevation	Elevation is given in meters above sea level. Ground elevations were projected/interpolated from a 2m Digital Elevation Model (DEM) provided by the Regional District of Nanaimo (RDN) for the current project.
Groundwater	Groundwater is water found in the soil or rock below the surface where the pores and openings are filled with water.
Hydrogeology	The science of groundwater.
Latitude and longitude	Geographic coordinates that specify the north–south (latitude) and east-west (longitude) position of a point on the Earth's surface.
Partially confined	An aquifer where, due to heterogeneities in some part of the aquifer, there is a lack of confining layer or the overlaying confining layer allows the recharge and discharge of groundwater.
Precipitation	The fall of water, ice, or snow deposited on the surface of the Earth from the atmosphere. Local daily precipitation was obtained from weather station records on the Environment Canada website (http://climate.weather.gc.ca). Weather station locations were paired primarily based on proximity and best possible match for years of record considered. The weather station named on the graph precipitation vs water levels, matches the name found on the Environment Canada website.
Productivity	Productivity describes an aquifer's ability to yield water and is inferred from aquifer transmissivity values, specific capacity of wells, well yields, description of aquifer materials and sources of recharge (e.g., rivers or lakes), or a combination of all of these factors. Productivity is one of the seven criteria used to rank the relative importance of an aquifer.

Screen top and screen bottom	Indicates the reported depth the screen was installed ("Top" starting depth and "Bottom" ending depth). Wells completed in bedrock are generally open-hole, so no screen information would be provided.
Surface water	Surface water is water that can be seen on land and is usually freshwater. It includes lakes, rivers, streams, creeks, ponds, and wetlands.
Total dissolved solids (tds)	Concentration of total dissolved solids (TDS) in groundwater expressed in milligrams per litre (mg/L), is found by evaporating a measured volume of filtered water sample to dryness and weighing this dry solid residue. TDS includes common salts such as sodium, chloride, calcium, magnesium, potassium, sulphates and bicarbonates. The most common source of dissolved solids in water is from the weathering of sedimentary rocks and the erosion of the earth's surface. Groundwater usually has higher levels of TDS than surface water, since it has a longer contact time with the underlying rocks and sediments. However, if groundwater's TDS is low it suggests connection to surface water or recharge happens close to the measuring point. The change in TDS could be attributed to agriculture, land development, industrial processes (waste water, cooling towers, food processors), salt water intrusion, change in natural groundwater gradient due to excessive pumping and so on.
Unconfined aquifer	Where no aquitards overlie the aquifer, the aquifer is said to be "unconfined" and is vulnerable to impacts from human activities at the land surface, particularly if the water table is shallow. Knowing which areas of the aquifer are most vulnerable will allow you to put the greatest effort into the areas that need the most protection.
Vulnerability	Vulnerability of an aquifer to contamination is based on type, thickness and extent of geologic materials above the aquifer, depth to water table (or to top of confined aquifer) and type of aquifer materials. Vulnerability is one of the seven criteria used to rank the relative importance of an aquifer. Vulnerability may be high, medium or low. Land use activities are not considered in determining an aquifer's vulnerability.
Water level slope	Water level slope is the magnitude of the water level trend. It is expressed in meters per year of increasing water level (positive) or declining water level (negative).

Water level trend	Trend analysis was conducted using daily groundwater levels from each groundwater observation well that had more than five years of continuous data. Two groups of timespans were considered for the trend analysis: for the last five years of data and for the entire historical data (>5 years). The analytical method used was linear analysis. Tableau package was used to determine the slope and trend results. Three types of water level trends were defined based on the trend slope: 1) stable, 2) increasing and, 3) declining trend.
Water level trend category	Five trend categories were defined based on the estimated slope: Stable (less than 0.03 m per year), moderate rate of decline (slope between -0.03 to -0.10 m per year), large rate of decline (< -0.10 m per year), moderate rate of increase (slope between +0.03 to +0.10 m per year) and large rate of increase (>+0.10 m per year).
Watershed	A watershed is the area of land that, due to its topography, collects water from precipitation and drains into a receiving surface water body (a river, a lake, a foreshore). Every piece of land is part of a watershed.
Well depth	The total penetrated depth for the well as found on the original well record, and not necessarily the completed well depth.
Well screen	Part of a water well where groundwater from the aquifer enters the well. It provides mechanical stability by preventing fine particles from entering the well. It should also offer enough opened area to allow groundwater to flow as freely as possible into the well.
Well tag number	A unique database number automatically assigned to water wells when the well is entered in to the government database. It can be used to find more information about each well.
Wells database	The water wells database is maintained by the by the Province of British Columbia. The submission of water well information is voluntary and consequently many existing wells may not be found in the database or the location may vary. There are over 108,000 water wells registered within the wells database as of May, 2017.

Yearly amplitude	For groundwater, yearly amplitude is the seasonal water level fluctuation. It is reported in meters as ranges when more than one year of data is available (minimum to maximum amplitude) including the average amplitude estimated within the study period.

Aquifer 217 IB (14)

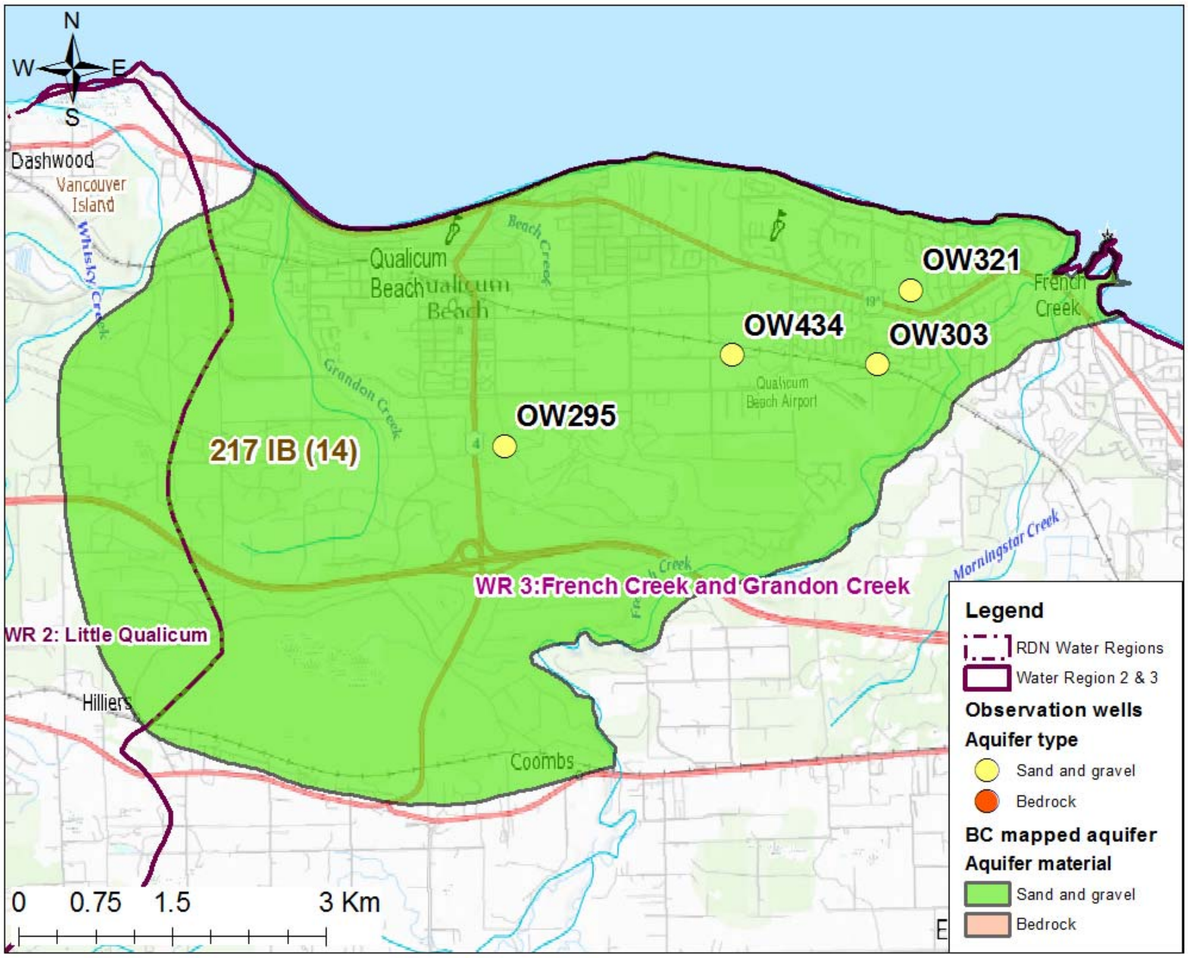


Figure 1. Location of mapped aquifer and observation wells

AQUIFER REPORT

Aquifer classification number:	**217 IB (14)**	**Comments**
Location:	*Qualicum*	
RDN Water region(s):	*WR 3: French Creek and Grandon Creek*	
Observation well(s):	*OW295, OW303, OW321, & OW434*	
Aquifer type:	*Sand and Gravel*	
Confinement:	*Partially confined to confined*	
Lithology/Stratigraphic unit(s):	*Quadra Sand*	BC MoE
Demand:	*Moderate*	BC MoE rating
Vulnerability:	*Moderate*	BC MoE rating
Productivity:	*Moderate*	BC MoE rating
Aquifer area (km^2):	42.0	BC MoE

WATER LEVEL ANALYSIS

Last five years of data (2012-2016)		
Yearly amplitude (m):	*0.1 to 6.9*	
Month(s) of minimum water level:	*June - September*	
Month(s) of maximum water level:	*November - July*	
Water level trend:	*Declining*	
Water level slope (m per year):	*-0.095 to -0.68*	
Water level trend category:	*Moderate to large rate of decline*	

Factors influencing water level for the last five years

Factor	**Influence on water level**
1. Precipitation	Moderate influence. There is a decreasing trend in precipitation happening since 2008. The last five years (2012-2016) the declining trend in water level coincides with the trend in precipitation.
2. Groundwater extraction	Unknown. Over 10 wells were drilled in the aquifer during 2012-2016.
3. Surface water interaction	It is likely not directly influenced; however, along waterbodies (i.e. French, Grandon, and Whisky Creeks) the water level in the aquifer may be directly influenced by surface water level.
4. Land use	Unknown.

Comments: Avg. TDS during 2012-2016 is 180 mg/L.

Historical data (greater than five years)		
Yearly amplitude (m):	*2.1 to 7.1*	
Month(s) of minimum water level:	*May - September*	
Month(s) of maximum water level:	*October - July*	
Water level trend:	*Declining - increasing*	
Water level slope (m per year):	*-0.091 to -0.31 and 0.34*	

Water level trend category:	*Moderate to large rate of decline and large rate of increase*	Moderate to large rate of decline, except near center as observed at OW 295
Factors influencing historical water level		
Factor	**Influence on water level**	
1. Precipitation	Slight to moderate influence. There is an increasing trend in precipitation happening up to 2008 coinciding, in some parts of the aquifer, with the increasing water level. In other parts of the aquifer the opposite is observed, suggesting other factors are influencing the decreasing water level (i.e. groundwater extraction). Finally, after 2008 the decreasing trend in precipitation does not totally coincide with the stable to slightly decreasing trend in water level, suggesting there may be a delay in water level response to precipitation, among other factors.	
2. Groundwater extraction	Slight to moderate influence. Most of the wells (75%) in the aquifer were drilled prior 1994.	
3. Surface water interaction	It is likely not directly influenced; however, along waterbodies (i.e. French, Grandon, and Whisky Creeks) the water level in the aquifer may be directly influenced by surface water level.	
4. Land use	Unknown. Less than 20% of the surface of the aquifer has experienced forest loss between 2000 to 2015 that could potentially affect groundwater recharge.	
Comments: Avg. TDS between 1987 to 2016 is 176 mg/L		

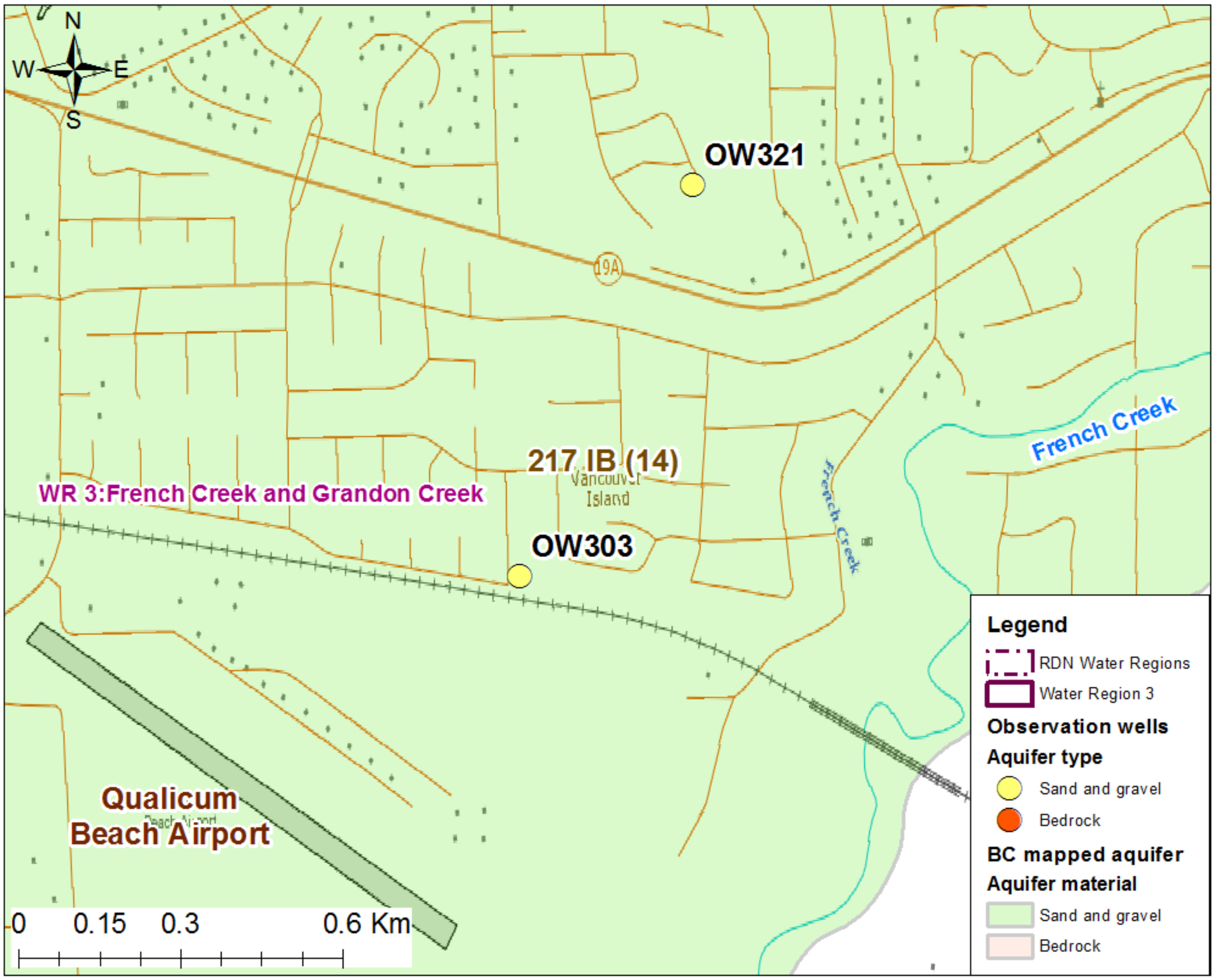


Figure 2. Location of observation wells OW303 and OW321

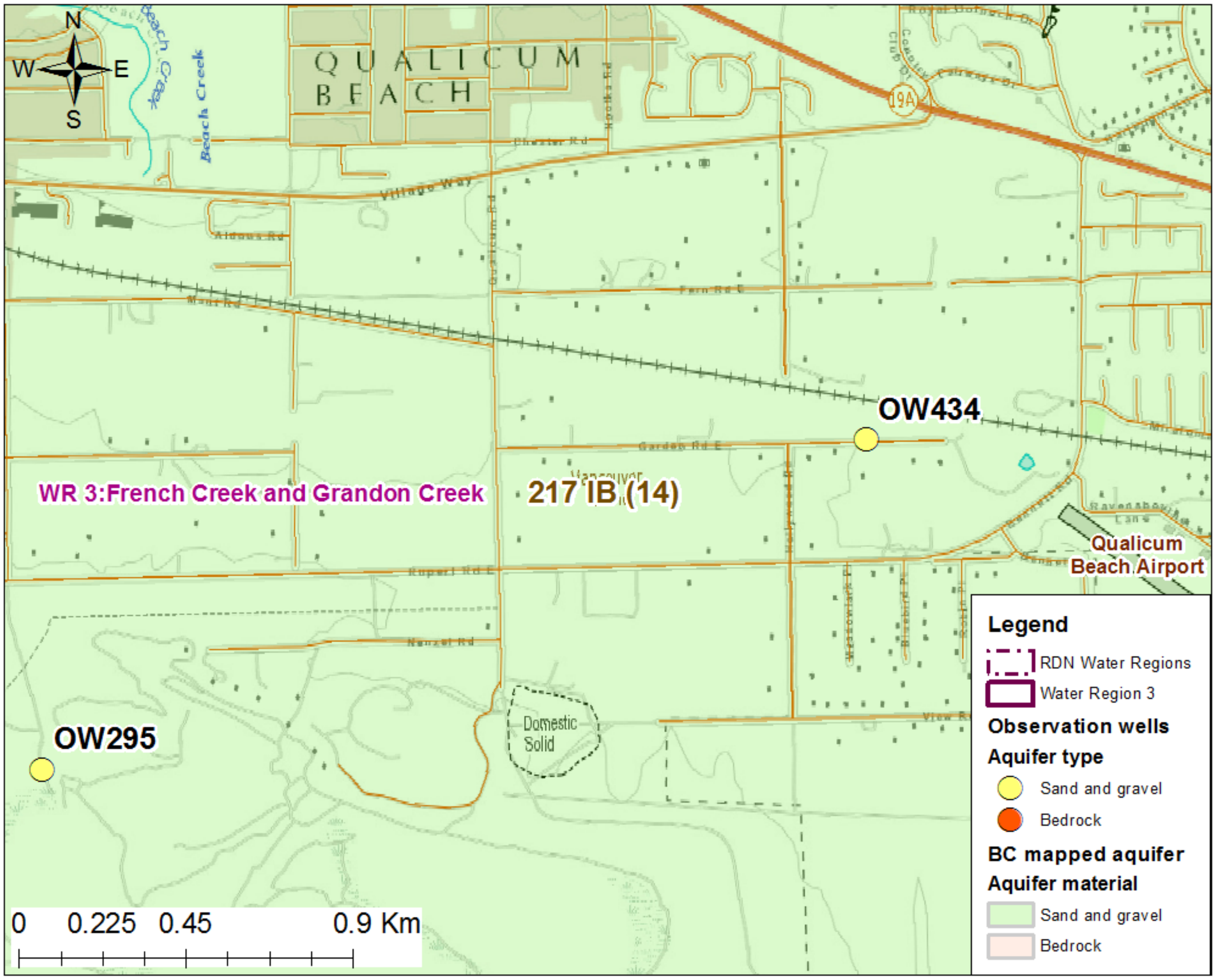


Figure 3. Location of observation wells OW295 and OW434

OBSERVATION WELL INFORMATION

Station ID:	OW295	Comments
Observation well group:	Provincial Groundwater Observation Well	
Aquifer type:	Sand and Gravel	
Confinement:	Partially confined	
Aquifer classification number:	217 IB (14)	
RDN Water region:	WR 3: French Creek and Grandon Creek	
Water level period of record available:	1986-2017	
Water level period of record considered:	1986-2016	
Water level period considered (years):	30.1	
Well Tag Number:	13653	
Well depth (m below ground surface):	27.7	
Screen top depth (m below ground surface):	19.8	Estimated from drilling log
Screen bottom (m below ground surface):	23.5	Estimated from drilling log
Location:	Memorial Ave (Qualicum)	
Latitude:	49.334759	
Longitude	-124.437991	
Elevation (m):	75.0	

WATER LEVEL ANALYSIS

Last five years of data (2012-2016)		
Yearly amplitude (m):	*3 to 4 (avg. 3.3)*	
Month(s) of minimum water level:	*August*	
Month(s) of maximum water level:	*April - July*	
Water level trend:	*Declining*	
Water level slope (m per year):	*-0.095*	
Water level trend category:	*Moderate rate of decline*	

Factors influencing water level for the last five years

Factor	Influence on water level
1. Precipitation	Moderate influence. There is a decreasing trend in precipitation happening since 2008. The declining trend in water level coincides with the trend in precipitation during 2012-2016.
2. Groundwater extraction	Unknown. Within 1 km from obs well, only one more well was drilled during 2012-2016.
3. Surface water interaction	It is likely not directly influenced.
4. Land use	Unknown.

Comments: Avg. TDS in 2015 is 168 mg/L.

Historical data (greater than five years)		
Yearly amplitude (m):	*2.1 to 5.8 (avg. 3.7)*	Data from 2003 to 2016
Month(s) of minimum water level:	*May - September*	Data from 2003 to 2016
Month(s) of maximum water level:	*October - July*	Data from 2003 to 2016
Water level trend:	*Increasing*	
Water level slope (m per year):	*0.34*	
Water level trend category:	*Large rate of increase*	

Factors influencing historical water level	
Factor	**Influence on water level**
1. Precipitation	Slight to moderate influence. There is an increasing trend in precipitation happening up to 2008 coinciding with the increasing water level until 2002. However, between 2003 and 2006 there are signs of other factors influencing the decreasing water level (i.e. groundwater extraction). Finally, after 2008 the decreasing trend in precipitation does not coincide with the increasing trend in water level, suggesting there may be a long-term delay of the water level to react to precipitation.
2. Groundwater extraction	Slight to moderate influence.
3. Surface water interaction	It is likely not directly influenced.
4. Land use	Unknown.
Comments: Avg. TDS prior 2000 is 136 mg/L and after 2000 avg TDS is 166 mg/L suggesting there are other factors influencing water level after 2000.	

OBSERVATION WELL INFORMATION

Station ID:	OW303	Comments
Observation well group:	Provincial Groundwater Observation Well	
Aquifer type:	Sand and Gravel	
Confinement:	Partially confined	
Aquifer classification number:	217 IB (14)	
RDN Water region:	WR 3: French Creek and Grandon Creek	
Water level period of record available:	1988-2017	
Water level period of record considered:	1988-2016	
Water level period considered (years):	28.3	
Well Tag Number:	43750	
Well depth (m below ground surface):	48.8	
Screen top depth (m below ground surface):		No information but probably somewhere from 23 m
Screen bottom (m below ground surface):		No information but probably somewhere to 39 m
Location:	Yambury Road (Qualicum)	
Latitude:	49.341224	
Longitude	-124.387477	
Elevation (m):	40.0	

WATER LEVEL ANALYSIS

Last five years of data (2012-2016)		
Yearly amplitude (m):	*3.6 to 4.8 (avg. 4)*	
Month(s) of minimum water level:	*June - August*	
Month(s) of maximum water level:	*November - March*	
Water level trend:	*Declining*	
Water level slope (m per year):	*-0.11*	
Water level trend category:	*Large rate of decline*	

Factors influencing water level for the last five years

Factor	Influence on water level
1. Precipitation	Moderate influence. There is a decreasing trend in precipitation happening since 2008. The declining trend in water level coincides with the trend in precipitation during 2012-2016.
2. Groundwater extraction	Unknown. Within 1 km from obs well, only two wells were drilled during 2012-2016.
3. Surface water interaction	It is likely not directly influenced.
4. Land use	Unknown.

Comments: Avg. TDS in 2016 is 257 mg/L.

Historical data (greater than five years)		
Yearly amplitude (m):	*3.6 to 6.5 (avg. 4.4)*	Data from 2003 to 2016
Month(s) of minimum water level:	*June - August*	Data from 2003 to 2016
Month(s) of maximum water level:	*October - April*	Data from 2003 to 2016
Water level trend:	*Declining*	
Water level slope (m per year):	*-0.091*	
Water level trend category:	*Moderate rate of decline*	

Factors influencing historical water level

Factor	Influence on water level
1. Precipitation	Slight to moderate influence. There is an increasing trend in precipitation happening up to 2008 opposite to the declining water level until 2003. This suggests there are other factors influencing the decreasing water level (i.e. groundwater extraction). Finally, after 2008 the decreasing trend in precipitation does not totally coincide with the stable to slightly decreasing trend in water level, suggesting there may be a delay in water level response to precipitation.
2. Groundwater extraction	Slight to moderate influence. Most of the wells (75%) within 1 km were drilled prior 1981.
3. Surface water interaction	It is likely not directly influenced
4. Land use	Unknown.

Comments: Avg. TDS prior 2003 is 180 mg/L and after 2003 avg TDS is 217 mg/L suggesting there are other factors influencing water level after 2003.

OBSERVATION WELL INFORMATION

Station ID:	OW321	Comments
Observation well group:	Provincial Groundwater Observation Well	
Aquifer type:	Sand and Gravel	
Confinement:	Confined	
Aquifer classification number:	217 IB (14)	
RDN Water region:	WR 3: French Creek and Grandon Creek	
Water level period of record available:	1992-2017	
Water level period of record considered:	1992-2016	
Water level period considered (years):	24.1	
Well Tag Number:	48458	
Well depth (m below ground surface):	42.1	
Screen top depth (m below ground surface):	39.6	Estimated from drilling log
Screen bottom (m below ground surface):	41.1	Estimated from drilling log
Location:	Leewaroad Way (Qualicum)	
Latitude:	49.347694	
Longitude	-124.382812	
Elevation (m):	23.0	

WATER LEVEL ANALYSIS

Last five years of data (2012-2016)	
Yearly amplitude (m):	*4.2 to 6.9 (avg. 5.8)*
Month(s) of minimum water level:	*June - September*
Month(s) of maximum water level:	*December - April*
Water level trend:	*Declining*
Water level slope (m per year):	*-0.68*
Water level trend category:	*Large rate of decline*

Factors influencing water level for the last five years

Factor	Influence on water level
1. Precipitation	Moderate influence. There is a decreasing trend in precipitation happening since 2008. The declining trend in water level coincides with the trend in precipitation during 2012-2016.
2. Groundwater extraction	Slight to moderate influence.
3. Surface water interaction	It is likely not directly influenced.
4. Land use	Unknown.

Comments: Avg. TDS in 2014 is 176 mg/L.

Historical data (greater than five years)		
Yearly amplitude (m):	*3.3 to 7.1 (avg. 5.7)*	Data from 2004 to 2016
Month(s) of minimum water level:	*June - September*	Data from 2004 to 2016
Month(s) of maximum water level:	*December - April*	Data from 2004 to 2016
Water level trend:	*Declining*	
Water level slope (m per year):	*-0.31*	
Water level trend category:	*Large rate of decline*	

Factors influencing historical water level	
Factor	**Influence on water level**
1. Precipitation	Moderate influence.
2. Groundwater extraction	Moderate to large influence. There is an increasing trend in precipitation happening up to 2008; however, there is decreasing trend in water level suggesting a large groundwater extraction. After 2008 the decreasing trend in precipitation coincides with the decreasing trend in water level. In addition, approximately 95% of the wells within 1km were drilled prior to 1997.
3. Surface water interaction	It is likely not directly influenced.
4. Land use	Unknown.
Comments: Avg. TDS from 2002 to 2014 is 182 mg/L	

OBSERVATION WELL INFORMATION

Station ID:	OW434	Comments
Observation well group:	Provincial Groundwater Observation Well	
Aquifer type:	Sand and Gravel	
Confinement:	Partially confined	
Aquifer classification number:	217 IB (14)	
RDN Water region:	WR 3: French Creek and Grandon Creek	
Water level period of record available:	2013-2017	
Water level period of record considered:	2013-2016	
Water level period considered (years):	3.7	
Well Tag Number:	108125	
Well depth (m below ground surface):	53.6	
Screen top depth (m below ground surface):	50.7	Reported in well log
Screen bottom (m below ground surface):	53.6	Reported in well log
Location:	Garoaden Road East (Qualicum)	
Latitude:	49.342318	
Longitude	-124.407139	
Elevation (m):	56.3	

WATER LEVEL ANALYSIS

Last five years of data (2012-2016)		
Yearly amplitude (m):	*0.1 to 0.2 (avg. 0.2)*	Difficult to determine amplitude. Water level influence by the pump
Month(s) of minimum water level:	*August - September*	
Month(s) of maximum water level:	*January - February*	
Water level trend:		Not enough; however, water level is stable (-0.01m/year).
Water level slope (m per year):		
Water level trend category:		

Factors influencing water level for the last five years

Factor	Influence on water level
1. Precipitation	Unknown.
2. Groundwater extraction	Unknown. Within 1 km from obs well, less than 10 wells were drilled during 2012-2016. Additionally, 75% of the wells within 1 km were drilled prior 1986.
3. Surface water interaction	It is likely not directly influenced.
4. Land use	Unknown.

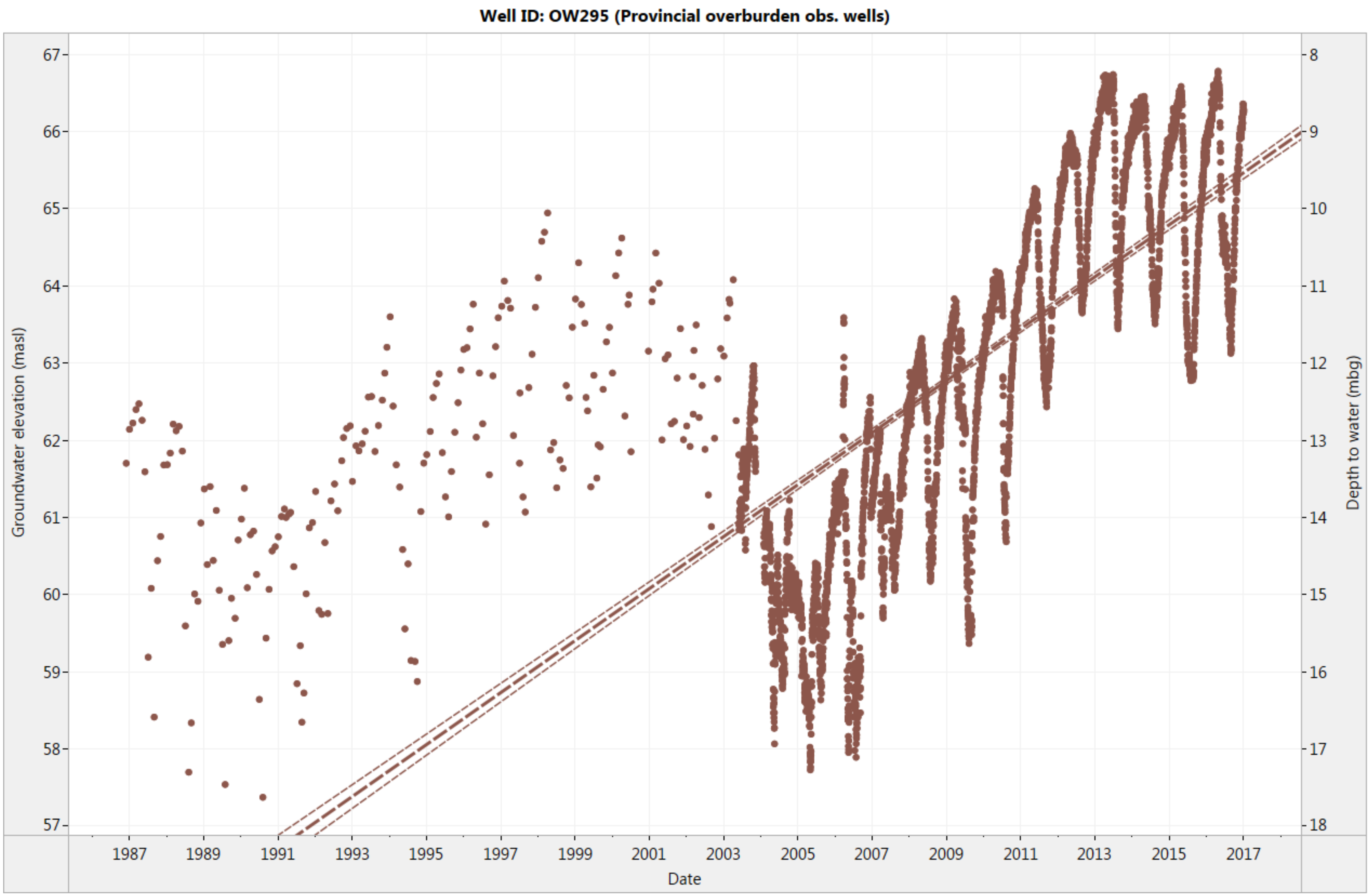


Figure 4. OW295: Historical daily water level (1986-2016) and trend line estimation (1986-2016)

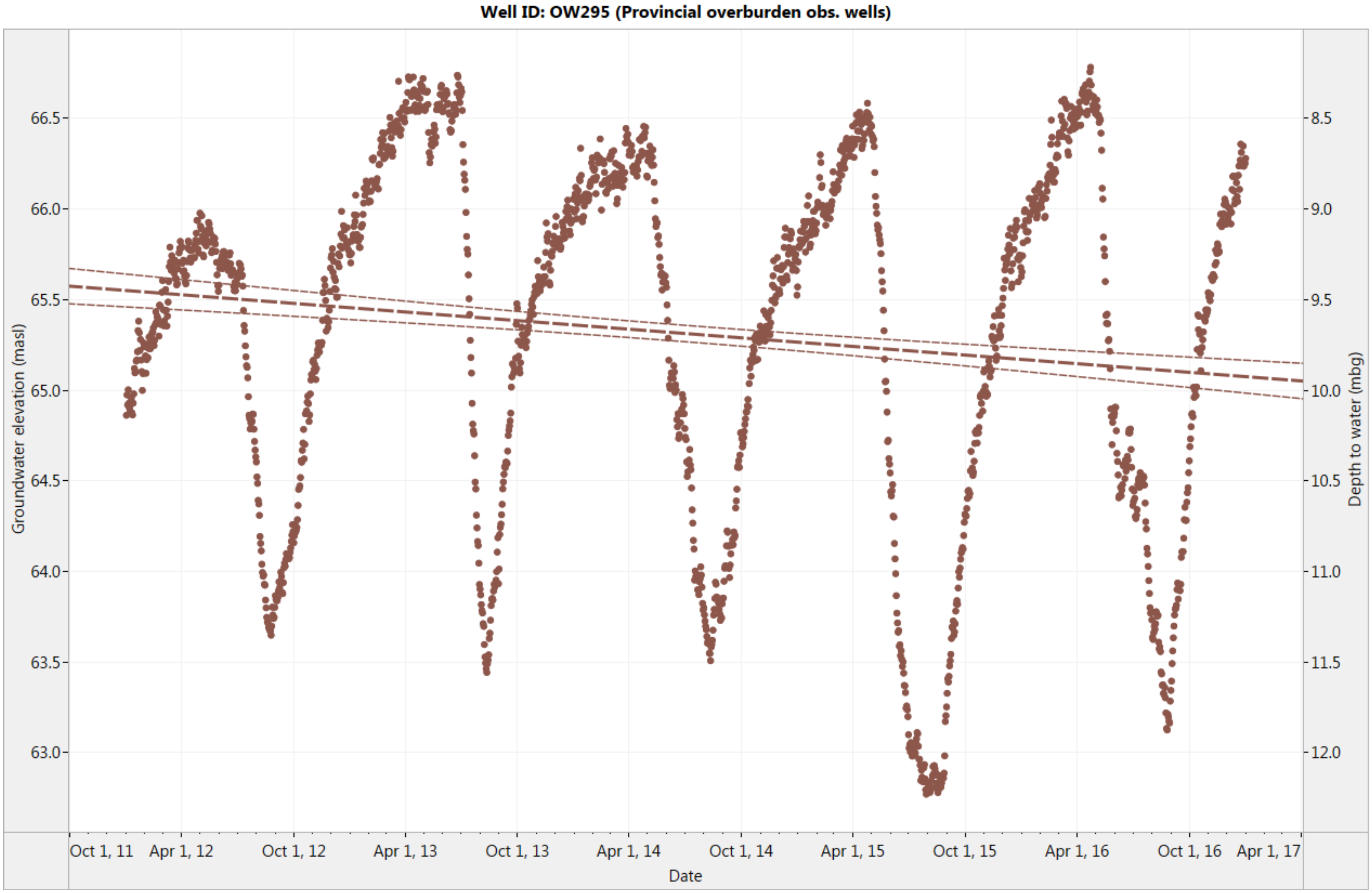


Figure 5. OW295: Water level and trend line estimation for the last five years (2012-2016)

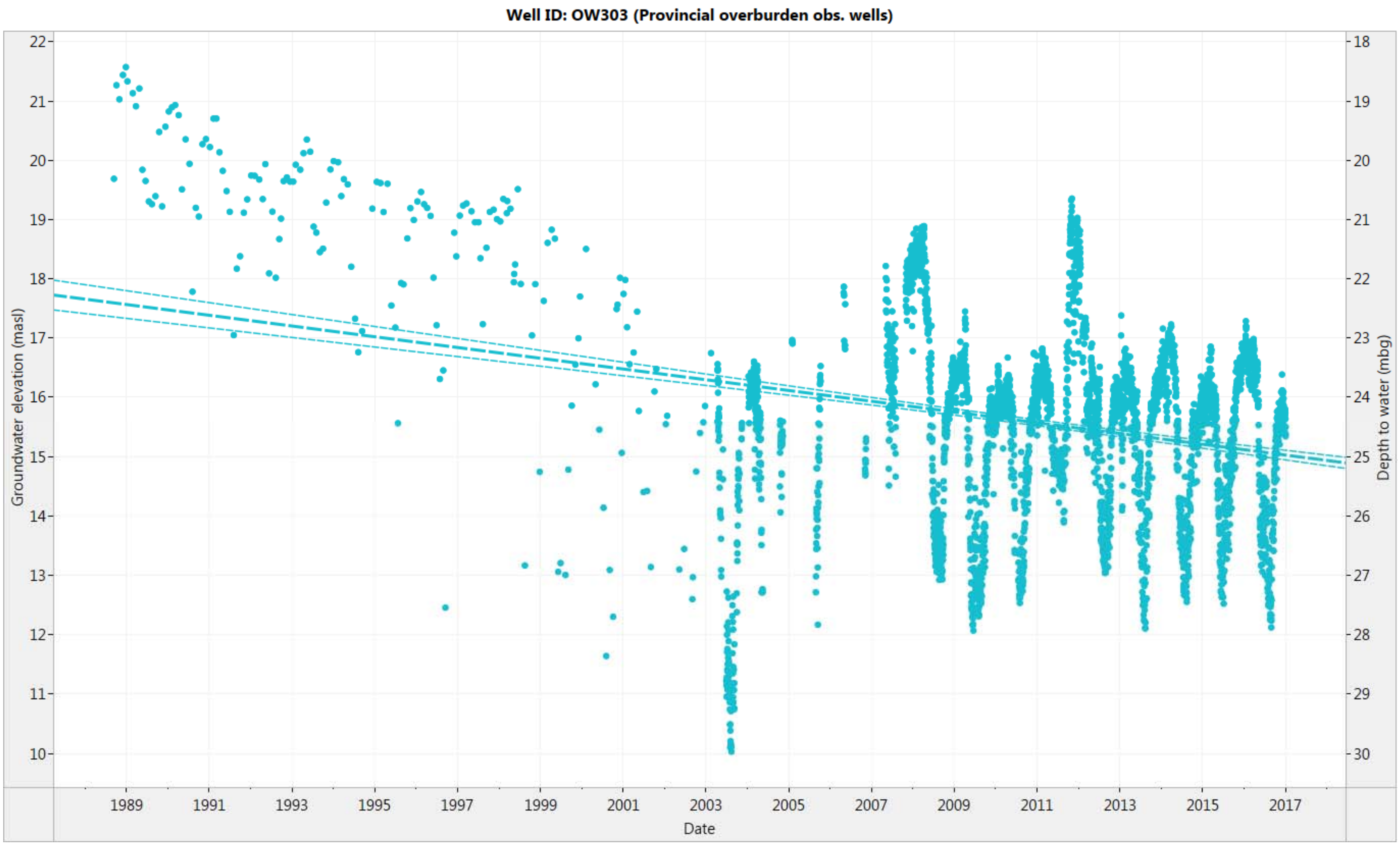


Figure 6. OW303: Historical daily water level (1988-2016) and trend line estimation (1988-2016)

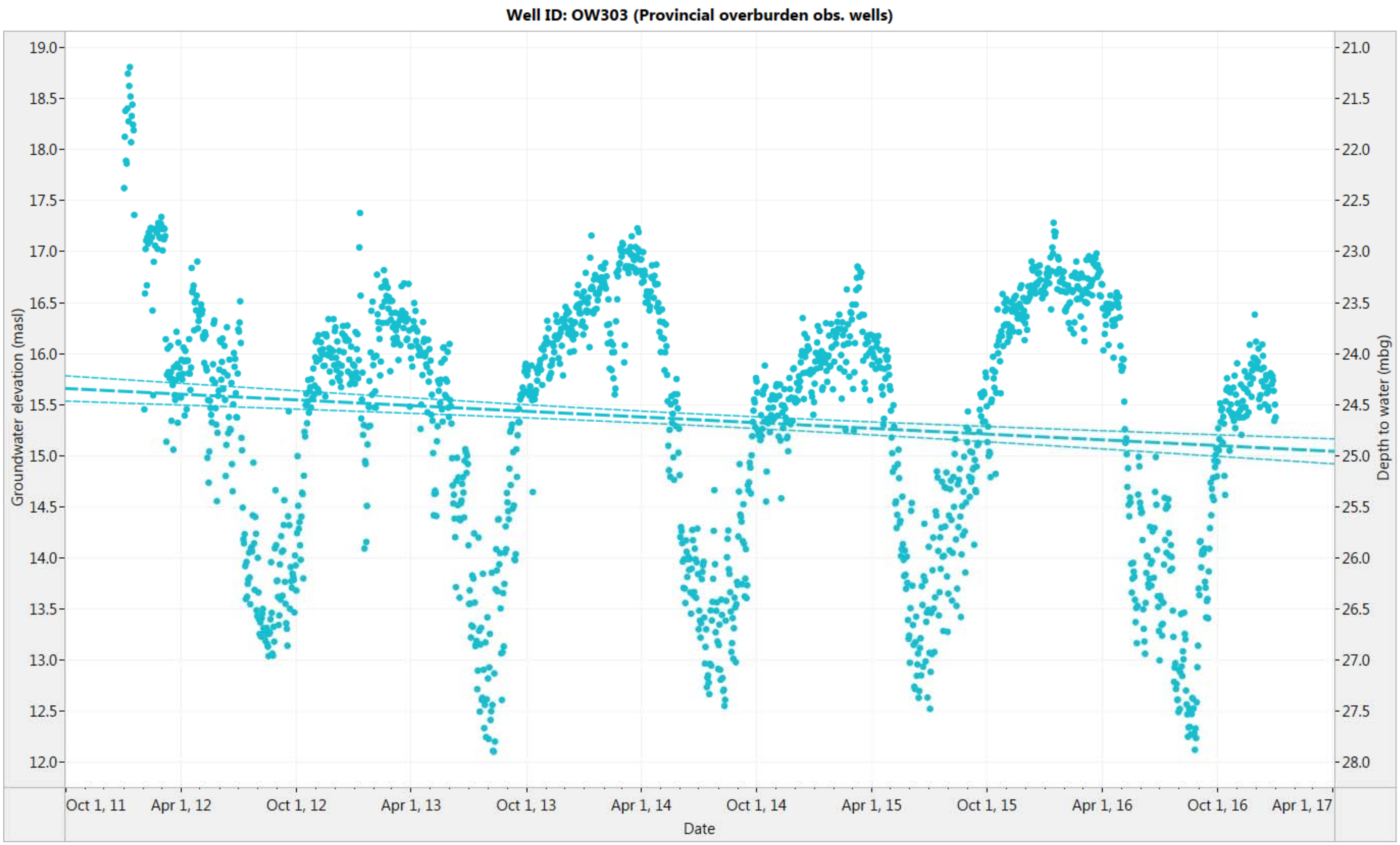


Figure 7. OW303: Water level and trend line estimation for the last five years (2012-2016)

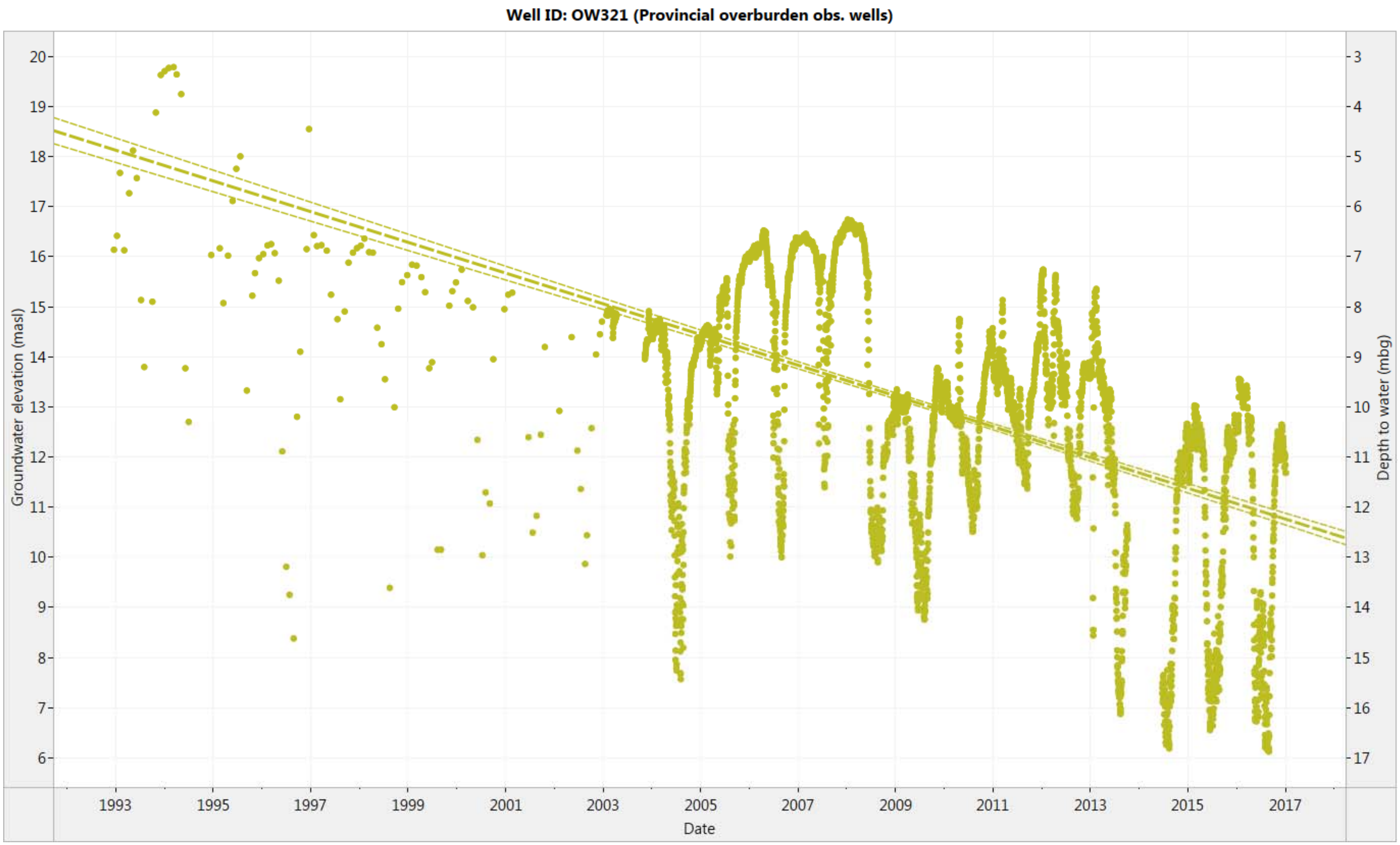


Figure 8. OW321: Historical daily water level (1992-2016) and trend line estimation (1992-2016)

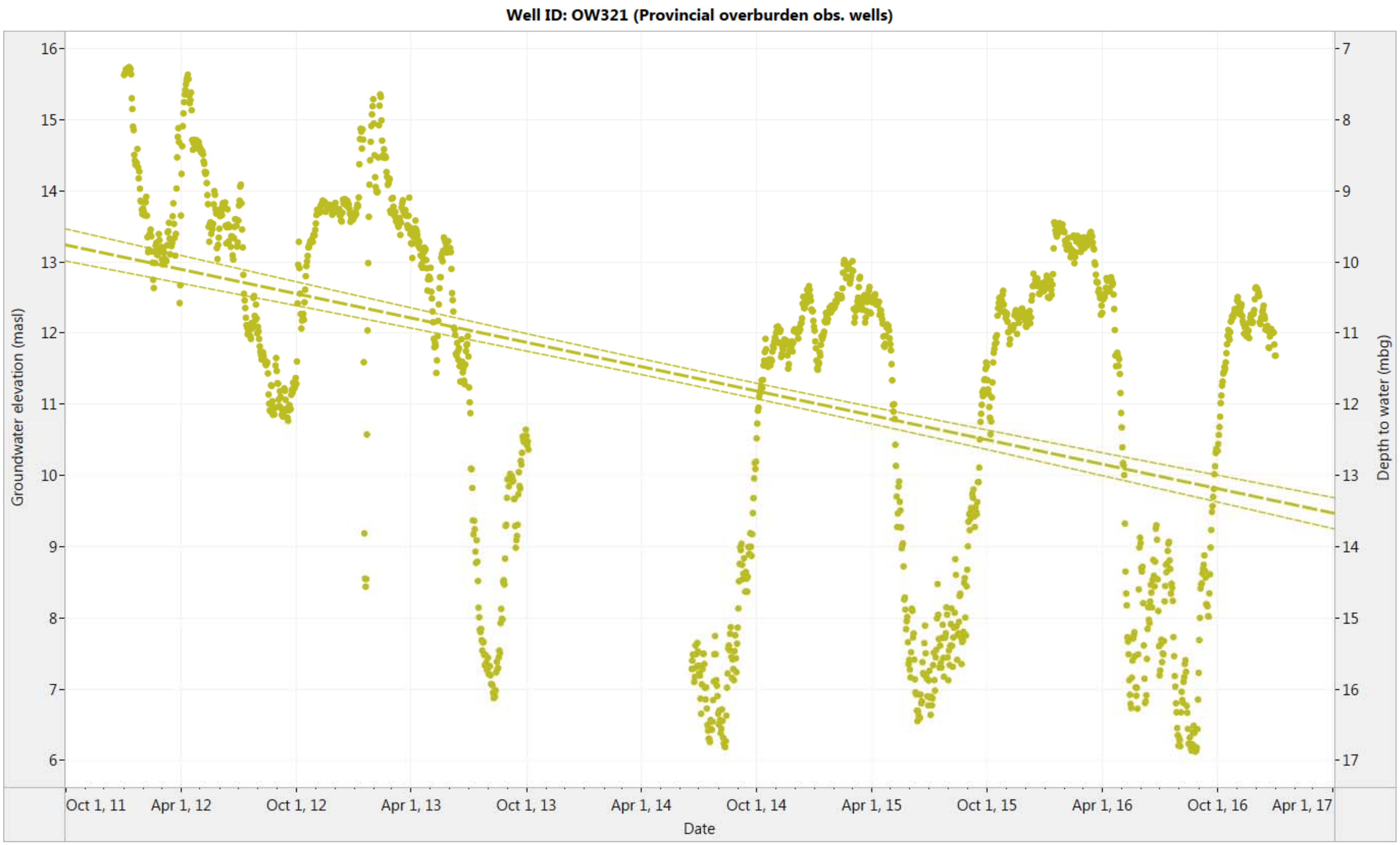


Figure 9. OW321: Water level and trend line estimation for the last five years (2012-2016)

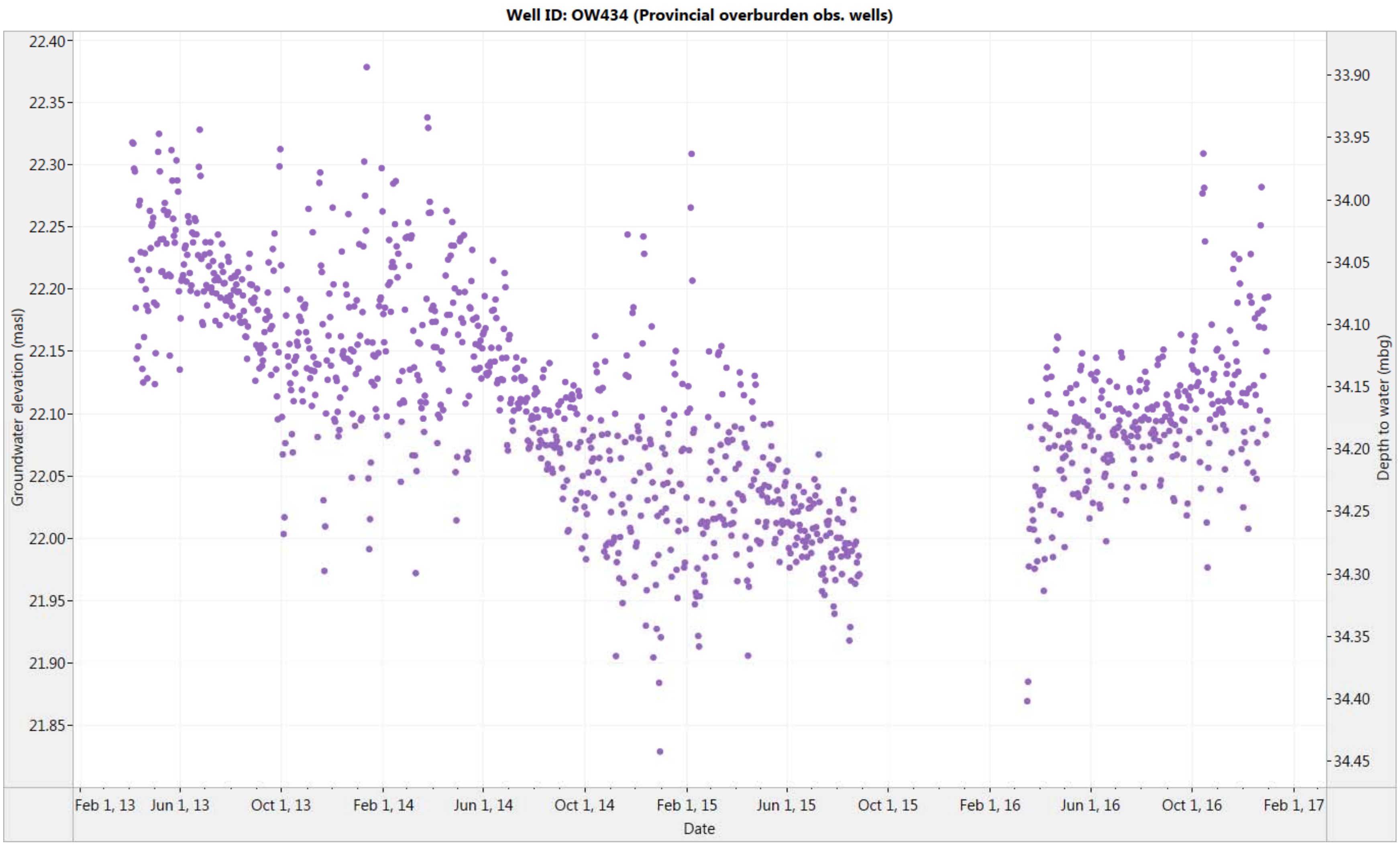


Figure 10. OW434: Historical water level (2013-2016)

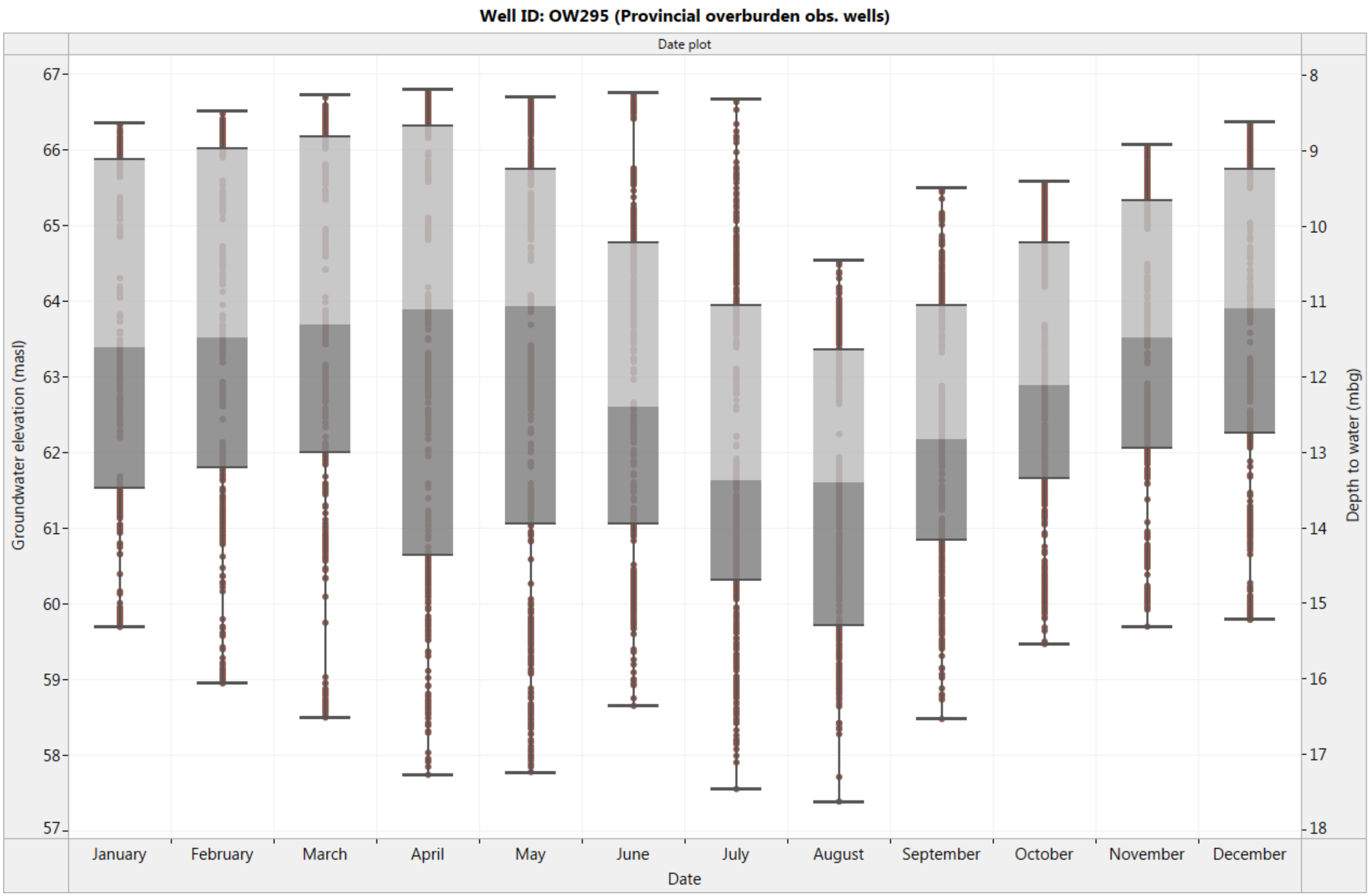


Figure 11. OW295: Box and Whisker diagram for historical monthly groundwater level fluctuation (1986-2016)

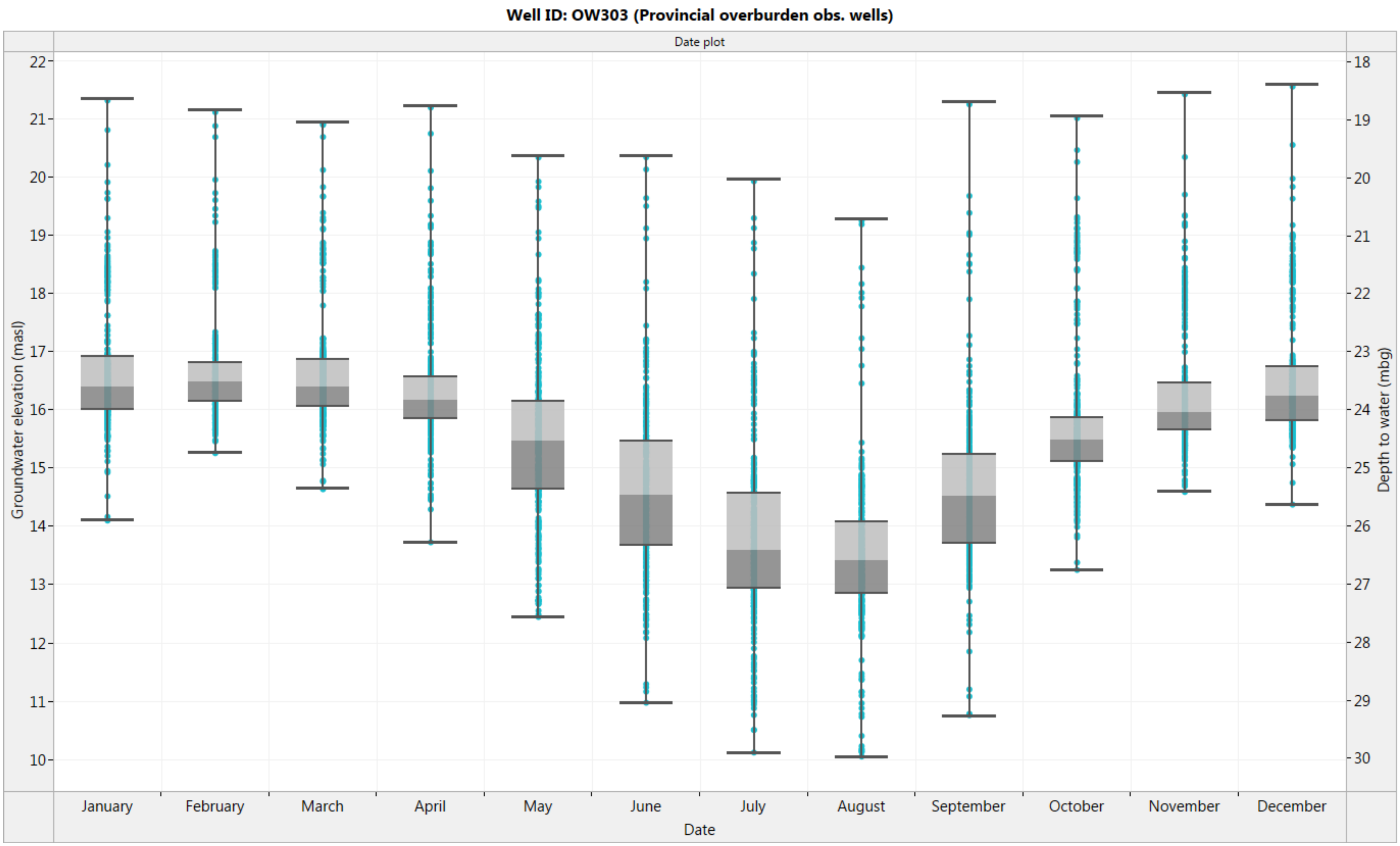


Figure 12. OW303: Box and Whisker diagram for historical monthly groundwater level fluctuation (1988-2016)

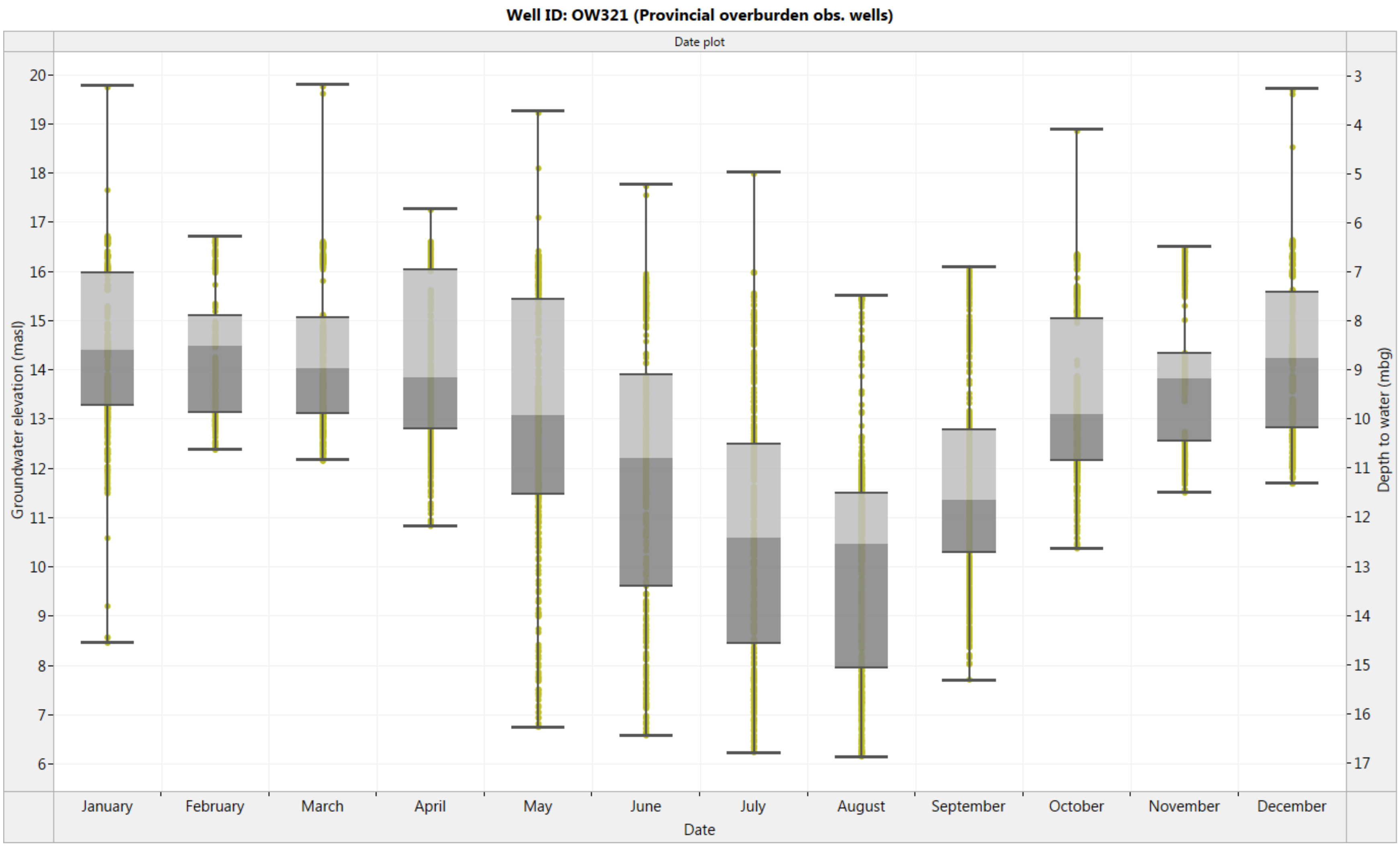


Figure 13. OW321: Box and Whisker diagram for historical monthly groundwater level fluctuation (1992-2016)

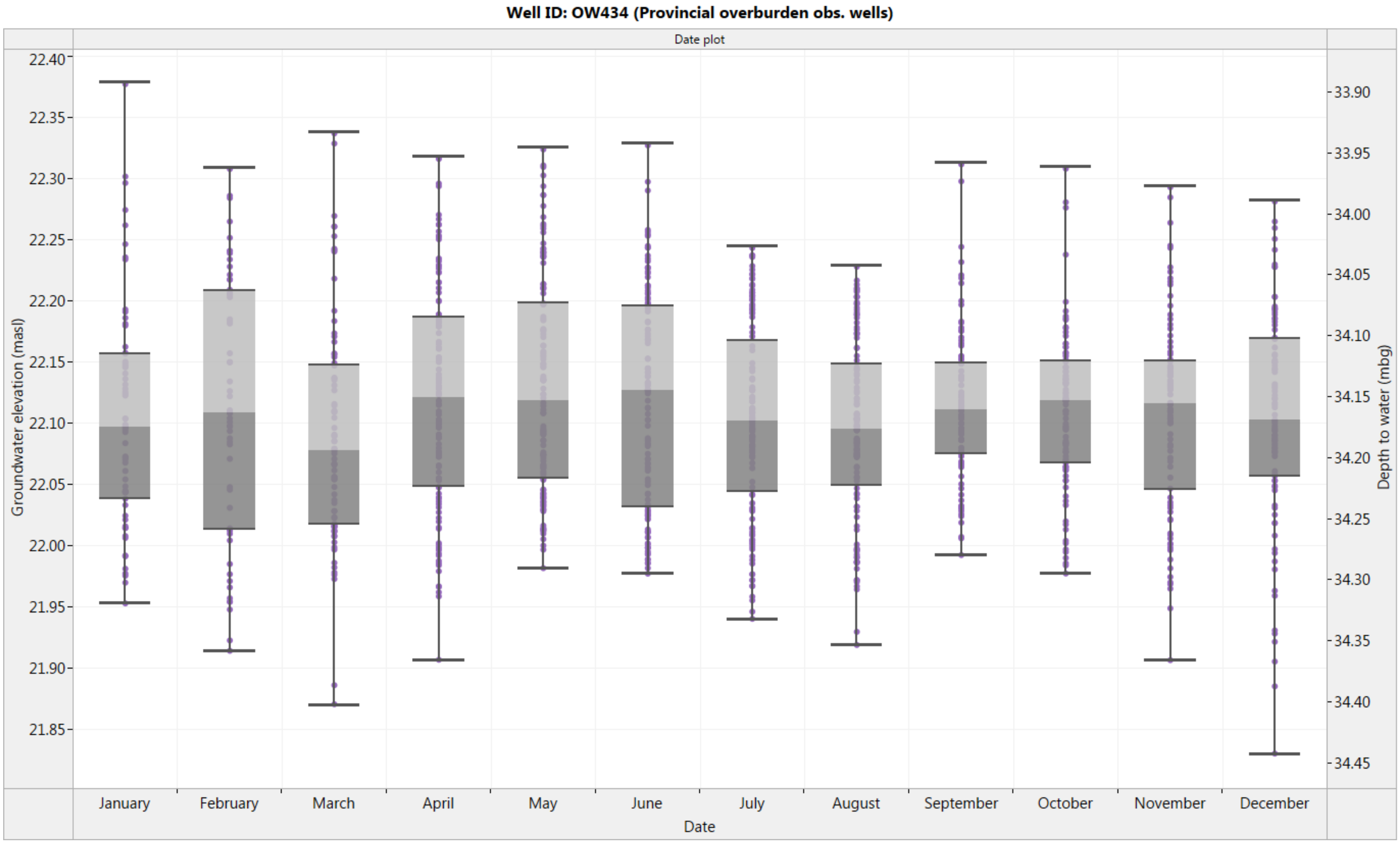


Figure 14. OW434: Box and Whisker diagram for historical monthly groundwater level fluctuation (2013-2016)

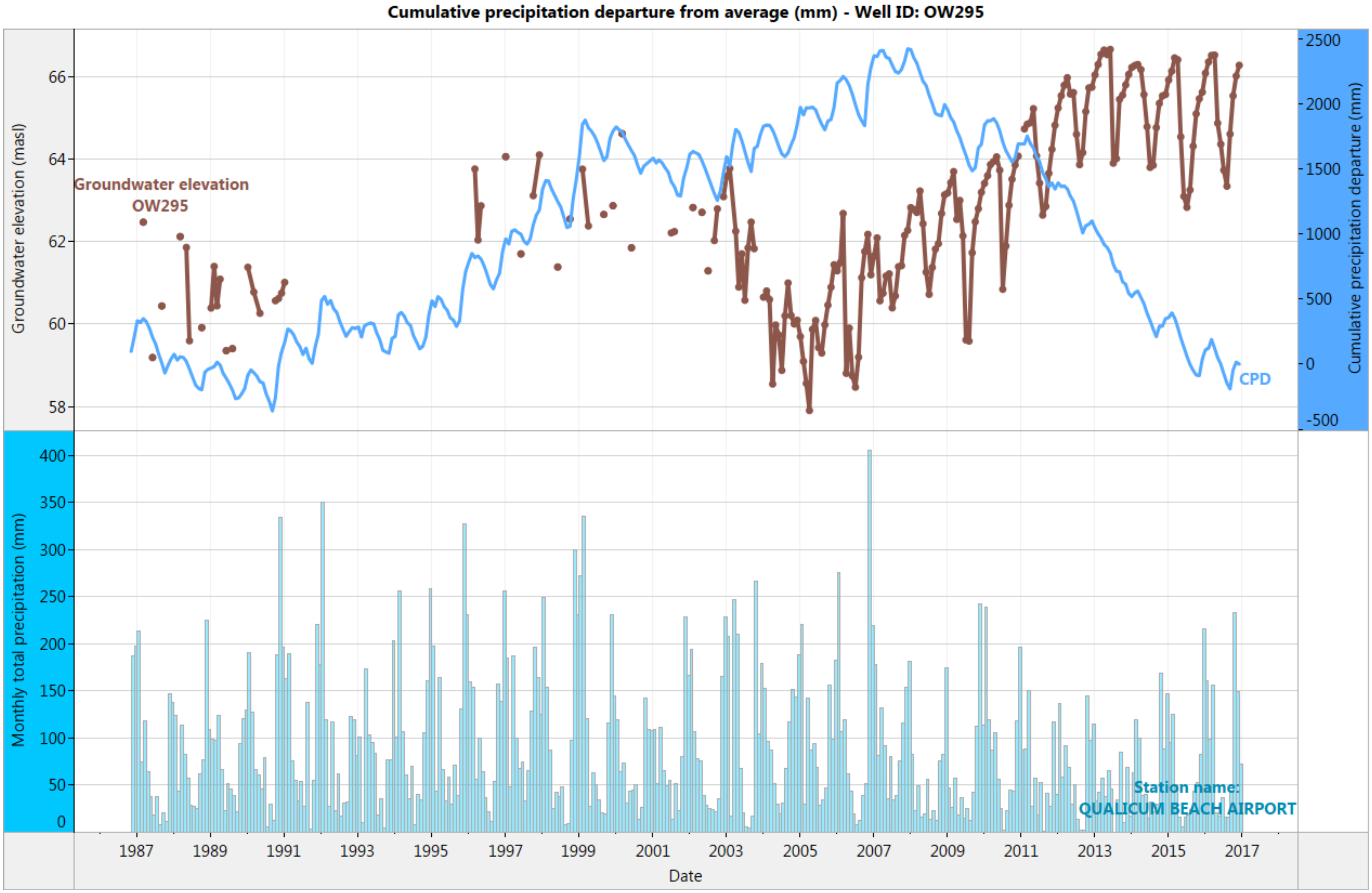


Figure 15. OW295: Month end groundwater levels compared to cumulative precipitation departure curve and total monthly precipitation (1986-2016)

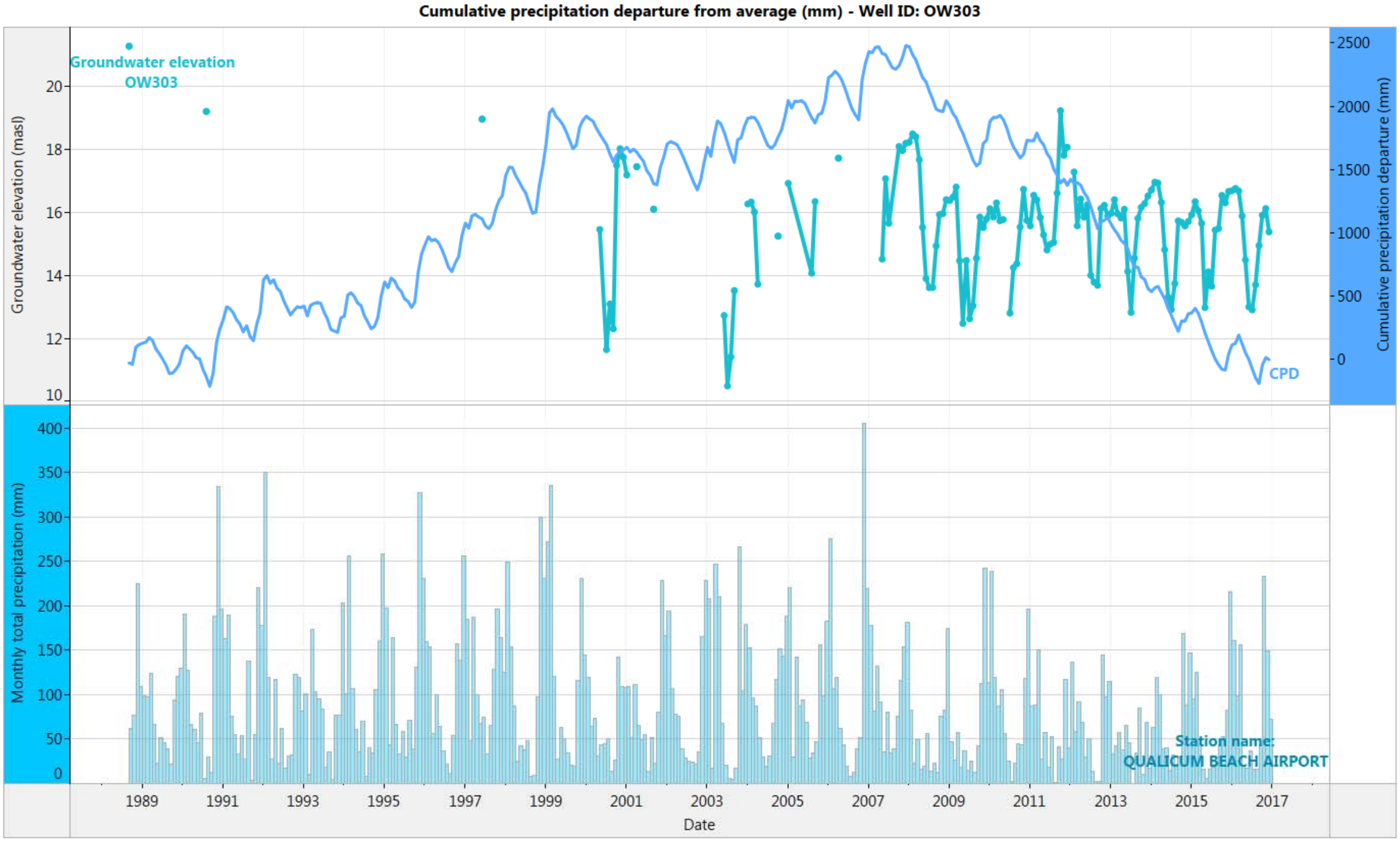


Figure 16. OW303: Month end groundwater levels compared to cumulative precipitation departure curve and total monthly precipitation (1988-2016)

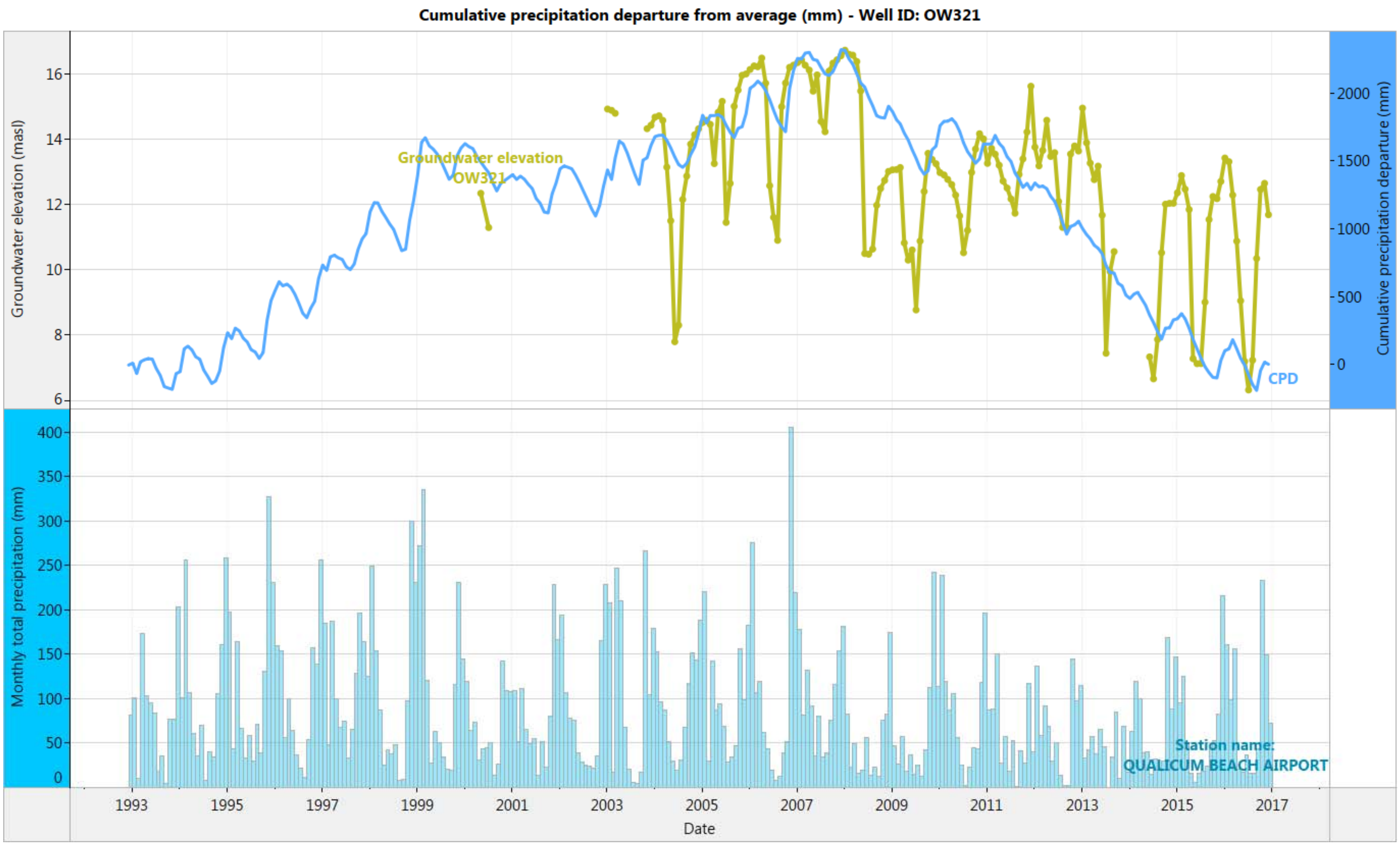


Figure 17. OW321: Month end groundwater levels compared to cumulative precipitation departure curve and total monthly precipitation (1992-2016)

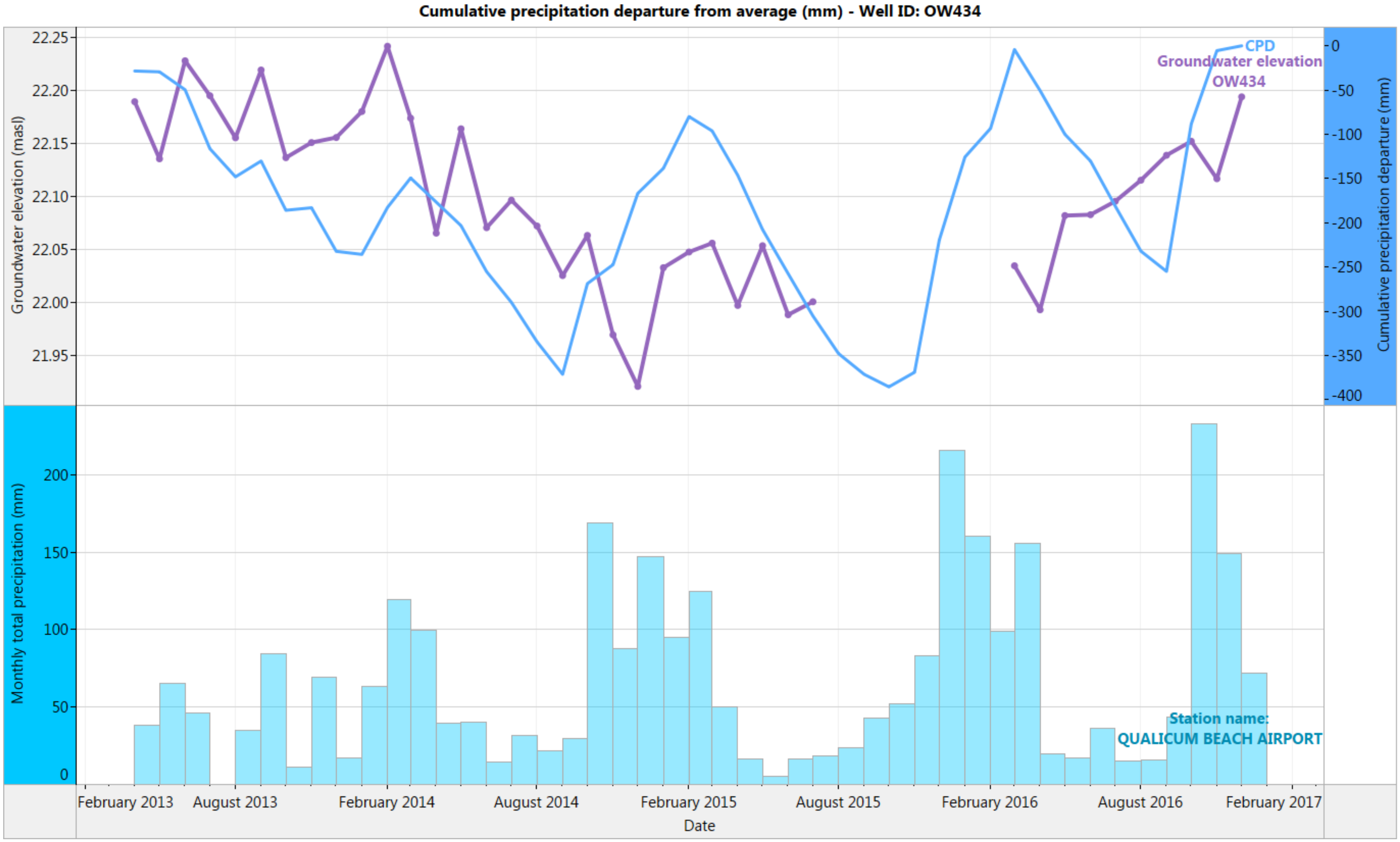


Figure 18. OW434: Month end groundwater levels compared to cumulative precipitation departure curve and total monthly precipitation (2013-2016)

Study Limitations

This document was prepared for the exclusive use of the Regional District of Nanaimo (the client). The inferences concerning the data, site and receiving environment conditions contained in this document are based on information obtained during investigations conducted at the site by GW Solutions and others, and are based solely on the condition of the site at the time of the site studies. Soil, surface water and groundwater conditions may vary with location, depth, time, sampling methodology, analytical techniques and other factors.

In evaluating the subject study area and water quality data, GW Solutions has relied in good faith on information provided. The factual data, interpretations and recommendations pertain to a specific project as described in this document, based on the information obtained during the assessment by GW Solutions on the dates cited in the document, and are not applicable to any other project or site location. GW Solutions accepts no responsibility for any deficiency or inaccuracy contained in this document as a result of reliance on the aforementioned information.

The findings and conclusions documented in this document have been prepared for the specific application to this project, and have been developed in a manner consistent with that level of care normally exercised by hydrogeologists currently practicing under similar conditions in the jurisdiction.

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If new information is discovered during future work, including excavations, sampling, soil boring, predictive geochemistry or other investigations, GW Solutions should be requested to re-evaluate the conclusions of this document and to provide amendments, as required, prior to any reliance upon the information presented herein. The validity of this document is affected by any change of site conditions, purpose, development plans or significant delay from the date of this document in initiating or completing the project.

The produced graphs, images, and maps, have been generated to visualize results and assist in presenting information in a spatial and temporal context. The conclusions and recommendations presented in this document are based on the review of information available at the time the work was completed, and within the time and budget limitations of the scope of work. For instance, aquifer reports based only in one observation well may not represent the condition of the entire aquifer due to lateral and vertical heterogeneities, localized groundwater conditions, ambiguities in aquifer boundary mapping among other factors. Therefore, extra care should be taken when applying results to the entire aquifer.

The client may rely on the information contained in this memorandum subject to the above limitations.

CLOSURE

Conclusions and recommendations presented herein are based on available information at the time of the study. The work has been carried out in accordance with generally accepted engineering practice. No other warranty is made, either expressed or implied. Engineering judgement has been applied in producing this letter-report.

This letter report was prepared by personnel with professional experience in the fields covered. Reference should be made to the General Conditions and Limitations attached in Appendix 1.

GW Solutions was pleased to produce this document. If you have any questions, please contact me.

Yours truly,

GW Solutions Inc.

K. Antonio Barroso, Msc.
Project Hydrogeologist

Gilles Wendling, Ph.D., P.Eng.
President

APPENDIX 1

GW SOLUTIONS INC. GENERAL CONDITIONS AND LIMITATIONS

This report incorporates and is subject to these "General Conditions and Limitations".

1.0 USE OF REPORT
This report pertains to a specific area, a specific site, a specific development, and a specific scope of work. It is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site or proposed development would necessitate a supplementary investigation and assessment. This report and the assessments and recommendations contained in it are intended for the sole use of GW SOLUTIONS's client. GW SOLUTIONS does not accept any responsibility for the accuracy of any of the data, the analysis or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than GW SOLUTIONS's client unless otherwise authorized in writing by GW SOLUTIONS. Any unauthorized use of the report is at the sole risk of the user. This report is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of GW SOLUTIONS. Additional copies of the report, if required, may be obtained upon request.

2.0 LIMITATIONS OF REPORT
This report is based solely on the conditions which existed within the study area or on site at the time of GW SOLUTIONS's investigation. The client, and any other parties using this report with the express written consent of the client and GW SOLUTIONS, acknowledge that conditions affecting the environmental assessment of the site can vary with time and that the conclusions and recommendations set out in this report are time sensitive. The client, and any other party using this report with the express written consent of the client and GW SOLUTIONS, also acknowledge that the conclusions and recommendations set out in this report are based on limited observations and testing on the area or subject site and that conditions may vary across the site which, in turn, could affect the conclusions and recommendations made. The client acknowledges that GW SOLUTIONS is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the client.

2.1 INFORMATION PROVIDED TO GW SOLUTIONS BY OTHERS
During the performance of the work and the preparation of this report, GW SOLUTIONS may have relied on information provided by persons other than the client. While GW SOLUTIONS endeavours to verify the accuracy of such information when instructed to do so by the client, GW SOLUTIONS accepts no responsibility for the accuracy or the reliability of such information which may affect the report.

3.0 LIMITATION OF LIABILITY
The client recognizes that property containing contaminants and hazardous wastes creates a high risk of claims brought by third parties arising out of the presence of those materials. In consideration of these risks, and in consideration of GW SOLUTIONS providing the services requested, the client agrees that GW SOLUTIONS's liability to the client, with respect to any issues relating to contaminants or other hazardous wastes located on the subject site shall be limited as follows:
(1) With respect to any claims brought against GW SOLUTIONS by the client arising out of the provision or failure to provide services hereunder shall be limited to the amount of fees paid by the client to GW SOLUTIONS under this Agreement, whether the action is based on breach of contract or tort;
(2) With respect to claims brought by third parties arising out of the presence of contaminants or hazardous wastes on the subject site, the client agrees to indemnify, defend and hold harmless GW SOLUTIONS from and against any and all claim or claims, action or actions, demands, damages, penalties, fines, losses, costs and expenses of every nature and kind whatsoever, including solicitor-client costs, arising or alleged to arise either in whole or part out of services provided by GW SOLUTIONS, whether the claim be brought against GW SOLUTIONS for breach of contract or tort.

4.0 JOB SITE SAFETY
GW SOLUTIONS is only responsible for the activities of its employees on the job site and is not responsible for the supervision of any other persons whatsoever. The presence of GW SOLUTIONS personnel on site shall not be construed in any way to relieve the client or any other persons on site from their responsibility for job site safety.

5.0 DISCLOSURE OF INFORMATION BY CLIENT

The client agrees to fully cooperate with GW SOLUTIONS with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site. The client acknowledges that in order for GW SOLUTIONS to properly provide the service, GW SOLUTIONS is relying upon the full disclosure and accuracy of any such information.

6.0 STANDARD OF CARE
Services performed by GW SOLUTIONS for this report have been conducted in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided. Engineering judgement has been applied in developing the conclusions and/or recommendations provided in this report. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of this report.

7.0 EMERGENCY PROCEDURES
The client undertakes to inform GW SOLUTIONS of all hazardous conditions, or possible hazardous conditions which are known to it. The client recognizes that the activities of GW SOLUTIONS may uncover previously unknown hazardous materials or conditions and that such discovery may result in the necessity to undertake emergency procedures to protect GW SOLUTIONS employees, other persons and the environment. These
procedures may involve additional costs outside of any budgets previously agreed upon. The client agrees to pay GW SOLUTIONS for any expenses incurred as a result of such discoveries and to compensate GW SOLUTIONS through payment of additional fees and expenses for time spent by GW SOLUTIONS to deal with the consequences of such discoveries.

8.0 NOTIFICATION OF AUTHORITIES
The client acknowledges that in certain instances the discovery of hazardous substances or conditions and materials may require that regulatory agencies and other persons be informed and the client agrees that notification to such bodies or persons as required may be done by GW SOLUTIONS in its reasonably exercised discretion.

9.0 OWNERSHIP OF INSTRUMENTS OF SERVICE
The client acknowledges that all reports, plans, and data generated by GW SOLUTIONS during the performance of the work and other documents prepared by GW SOLUTIONS are considered its professional work product and shall remain the copyright property of GW SOLUTIONS.

10.0 ALTERNATE REPORT FORMAT
Where GW SOLUTIONS submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed GW SOLUTIONS's instruments of professional service), the Client agrees that only the signed and sealed hard copy versions shall be considered final and legally binding. The hard copy versions submitted by GW SOLUTIONS shall be the original documents for record and working purposes, and, in the event of a dispute or discrepancies, the hard copy versions shall govern over the electronic versions. Furthermore, the Client agrees and waives all future right of dispute that the original hard copy signed version archived by GW SOLUTIONS shall be deemed to be the overall original for the Project. The Client agrees that both electronic file and hard copy versions of GW SOLUTIONS's instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except GW SOLUTIONS. The Client warrants that GW SOLUTIONS's instruments of professional service will be used only and exactly as submitted by GW SOLUTIONS. The Client recognizes and agrees that electronic files submitted by GW SOLUTIONS have been prepared and submitted using specific software and hardware systems. GW SOLUTIONS makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.