Uley South groundwater model scenarios 2021: Additional supply wells

Department for Environment and Water
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Government of South Australia
Department for Environment and Water

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Foreword

The Department for Environment and Water (DEW) is responsible for the management of the State's natural resources, ranging from policy leadership to on-ground delivery in consultation with government, industry and communities.

High-quality science and effective monitoring provides the foundation for the successful management of our environment and natural resources. This is achieved through undertaking appropriate research, investigations, assessments, monitoring and evaluation.

DEW's strong partnerships with educational and research institutions, industries, government agencies, Natural Resources Management Boards and the community ensures that there is continual capacity building across the sector, and that the best skills and expertise are used to inform decision making.

John Schutz
CHIEF EXECUTIVE
DEPARTMENT FOR ENVIRONMENT AND WATER

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Summary

Groundwater from the Quaternary Limestone aquifer in the Uley South Basin is the main source of municipal water supply on the Eyre Peninsula, with current extraction of ~ 5 GL/y. Low rainfall and recharge conditions and declining groundwater levels have raised the risk profile for groundwater resources in Uley South in recent years. Some town water supply (TWS) wells have been recording increases in salinity, most likely due to inflow from the underlying Tertiary Sand aquifer. While SA Water are planning to build a desalination plant to augment water supply on the Eyre Peninsula, pumping from Uley South is likely to continue in the short term. Consequently, SA Water are investigating options to reduce pumping from wells where salinity is increasing, including construction of additional TWS wells 2.5 km from the coast.

This document summarises six groundwater model scenarios which assess the impact of redistributing pumping in the basin, with the addition of three new extraction wells. The scenarios used the Uley South groundwater flow model (DEW, 2020), which simulates the position and movement of the seawater interface with the SWI2 package. The scenarios assume low rainfall/recharge conditions observed from 2015–20 persist into the future, with the five years of recharge rates repeated on a cycle from 2021 to 2040. Scenario 1 simulated a pumping rate of 5.2 GL/y from 2021-24, with pumping reducing to 3.5 GL/y for 2025-40. Scenario 2 simulated pumping 5.2 GL/y from 2021-26, with pumping reducing to 3.5 GL/y in 2027. For each scenario, a baseline was run with extraction continuing from existing TWS wells, then additional scenarios were run with extraction redistributed to proposed new TWS wells.

Results show that continued pumping of 5.2 GL/y will result in continued inland movement of the seawater interface. Under scenarios where pumping reduces to 3.5 GL/y and pumping continues from existing wells, the interface appears to stabilize. This is assuming low recharge continues persist, and that recharge does not decline further. Reduction of pumping from groundwater wells showing salinity increases will likely lead to some recovery in groundwater levels in these wells. However, it is not clear if this level of groundwater level recovery will prevent further salinity increases in these wells. Accurately predicting salinity in these wells would require more knowledge of the groundwater system than is currently available (Cook and Post, 2021). Conversely, increased pumping from new supply wells 2.5 km from the coast will lead to declines in groundwater level close to the coast, and enhance seawater intrusion.

It is recommended that SA Water consider the relative risks of increased salinity in existing wells at the current rates (3–40 mg/L/yr) against the risk posed by enhanced seawater intrusion through increased pumping close to the coast. Fluctuations in salinity in supply wells have been observed in the past, hence rising salinity may be mitigated by reduced pumping or increased recharge. However, the impact of enhanced seawater intrusion is less likely to be reversed, as scenario results show the position of the interface does not retreat when pumping is lowered from 5.2 to 3.5 GL/y. Alternative options could be to install new production wells further from the coast. If pumping increases close to the coast, it is recommended that monitoring groundwater level and salinity close to the proposed TWS wells be increased, as this area has historically been data poor. This area has historically been relatively data poor. DEW is investigating with SA Water the potential for additional seawater intrusion monitoring wells in the area of interest. Additional monitoring and drilling data could be used to further refine the model in future.

SA Water has advised DEW on scenarios that represent the maximum likely pumping rates from the new extraction wells in the basin. These are applied at the monthly scale in the model. The model results can only be considered a representative assessment of risk for these assumed pumping rates and volumes. Should pumping from the proposed wells occur at greater volumes than those detailed in these scenarios, the results of this work cannot be considered representative.

1 Introduction

1.1 Background

Groundwater is a critical source of water for the Eyre Peninsula, making up the majority of water sourced for municipal supply (EPNRMB, 2016). Groundwater from the Quaternary Limestone (QL) aquifer in the Uley South Basin provides most of this supply, with average annual extraction of approximately 5 GL (Figure 1.1). In 2018 SA Water contracted the Department for Environment and Water (DEW) to develop a groundwater flow model for the Uley South Basin. The model was used to assess the impact of various groundwater extraction and rainfall/recharge scenarios on groundwater levels in the basin (DEW 2020). The model also simulated the position and movement of the seawater interface using the SWI2 package (Bakker et al. 2013).

The model was calibrated to groundwater level measurements from 1961 to 2017. The model has recently been updated to simulate conditions up to December 2020, while low rainfall and recharge conditions have persisted, and groundwater levels have continued to decline (DEW 2021; DEW 2021a). The main risks associated with declining groundwater levels are increased salinity from two sources:

- seawater intrusion along the coastal boundary of the basin,
- increased inflow to the QL from the underlying Tertiary Sand (TS) aquifer.

Town water supply (TWS) wells 11, 12, 19 and 20, in the central part of the basin (Figure 1.2), have been showing increasing salinity at rates of 3, 6, 15 and 40 mg/L/yr (Figure 1.3). These increases are thought to be associated with increased inflow from the TS aquifer. A similar salinity increase was observed in TWS 3 in the late 1990s when extraction was higher and groundwater levels were declining. Groundwater modelling indicated that increased inflow from the TS during this period is the most likely cause for the salinity increase (DEW, 2020). TWS 3 was replaced with TWS 20 in 2014, and this well is now showing a trend similar to that in TWS 3 in the late 1990s.

A desalination plant is planned for the Eyre Peninsula, however groundwater resources in the Uley South Basin remain the main source of supply for the region until the plant is operational. A recent review of the current pumping arrangements in Uley South (Cook and Post, 2021) recommended that SA Water investigate options to reduce pumping from wells showing salinity increases.

1.2 Objectives

The objective of this report is to document model scenarios, which consider reduced pumping from TWS wells in Uley South which have shown increasing salinity. This is achieved through the inclusion of new extraction wells in the basin, 2.5km from the coast. Two future pumping scenarios are considered – continued pumping at 5.2 GL/y to 2024, and continued pumping at 5.2 GL/y to 2026. In both scenarios pumping then reduces to 3.5 GL/y through to 2040. Within these overall pumping arrangements, separate scenarios consider the impacts of pumping maximum rates of 15 and 25 L/s from the new wells.

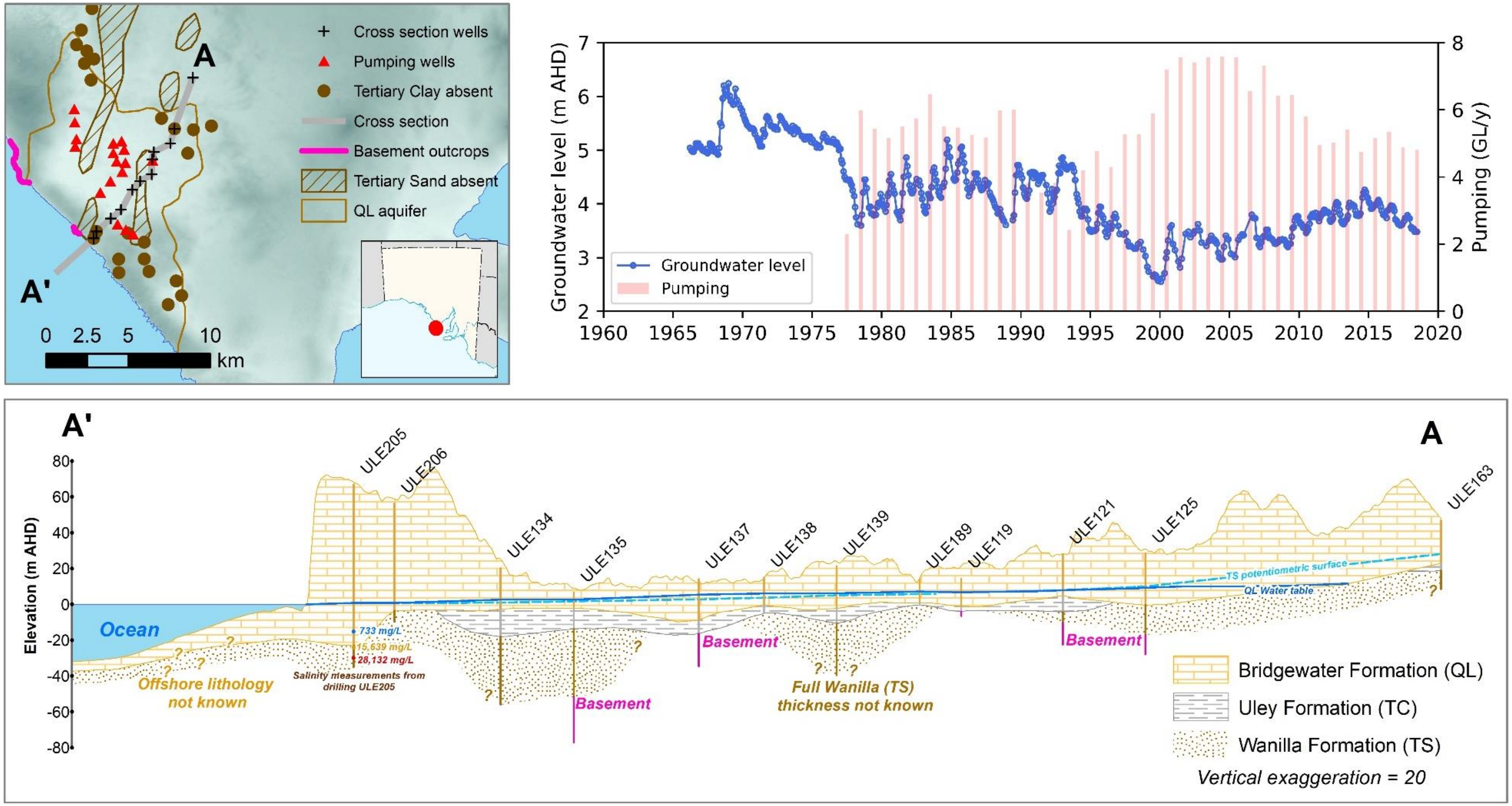


Figure 1.1. **The Uley South Basin**

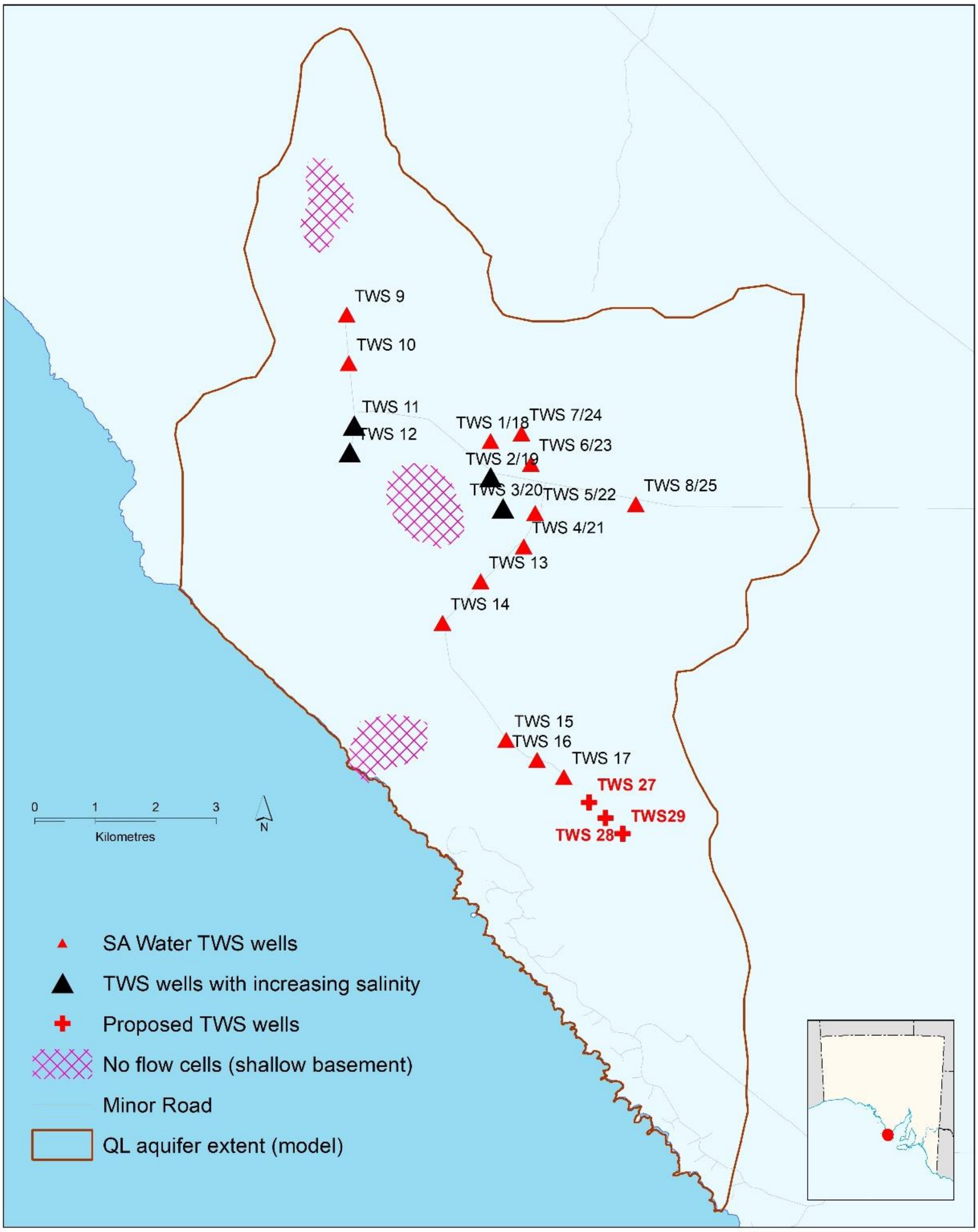


Figure 1.2. Location of existing and proposed TWS wells

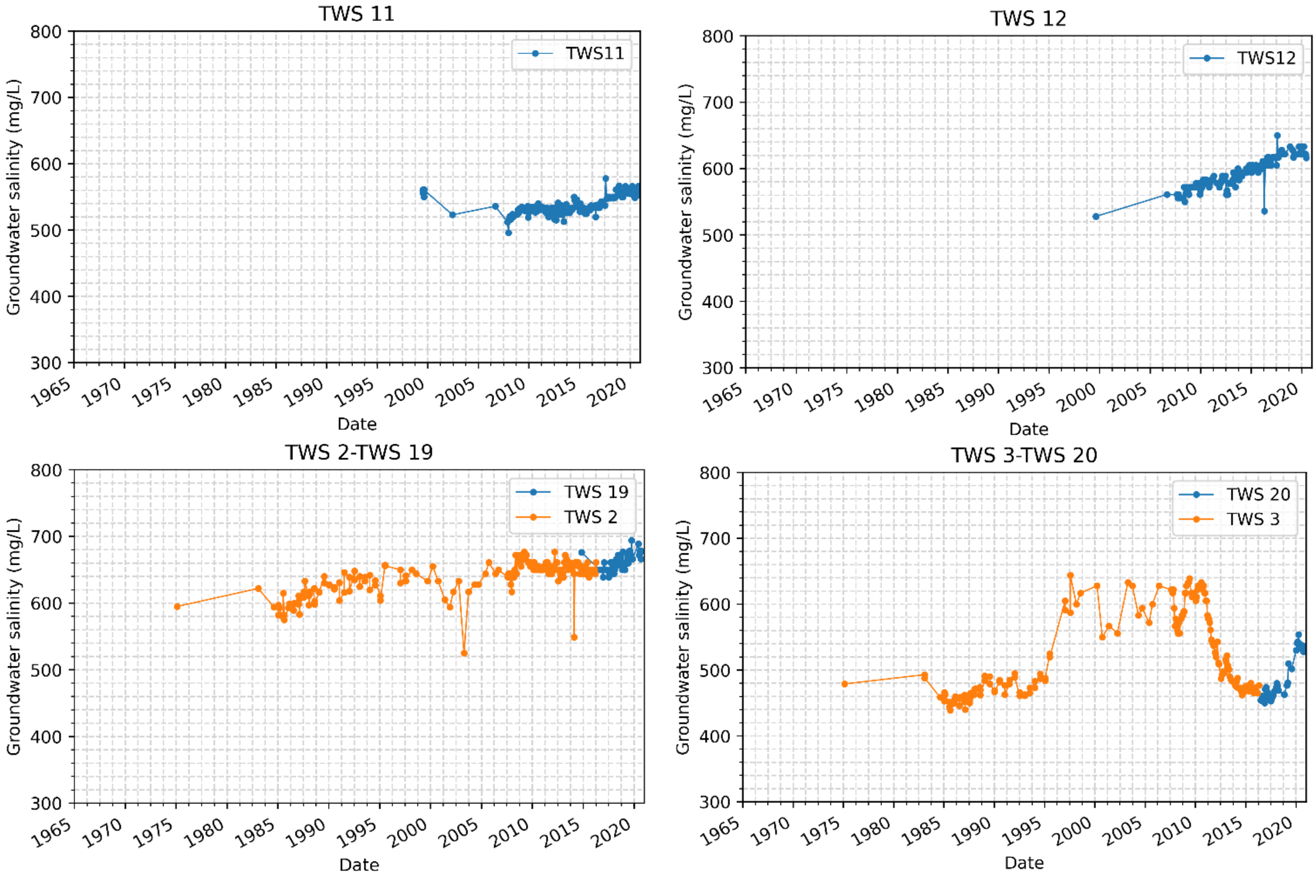


Figure 1.3. Groundwater salinity in TWS wells 11, 12, 19 and 20

2 Method

2.1 Scenarios

The simulations in this study were developed in consultation with SA Water. Two future pumping scenarios consider continued pumping at 5.2 GL/y to 2024 and 2026 separately, before pumping is reduced to 3.5 GL/y (Figure 2.1). Within these pumping arrangements, a base case is simulated where pumping continues from existing TWS wells, while two additional scenarios simulate pumping from proposed new wells while pumping from higher salinity wells reduces. This gives a total of six model scenarios (Table 2.1).

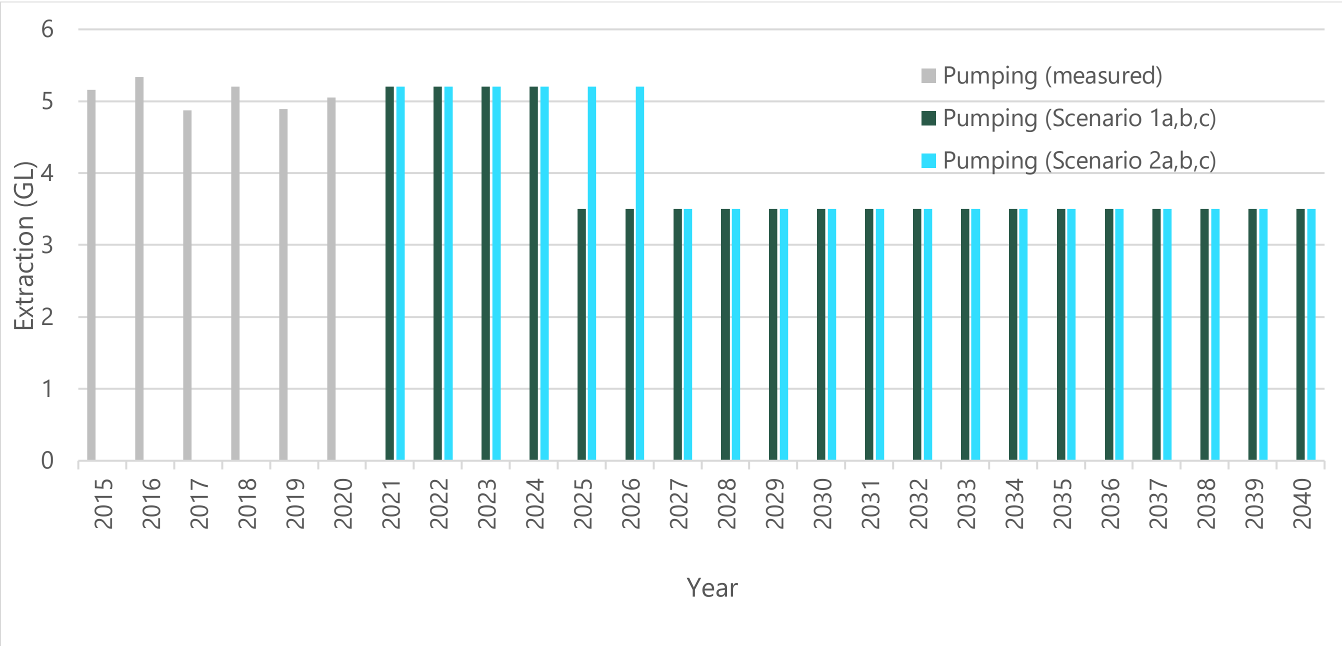


Figure 2.1. Total scenario pumping rates from all wells

Table 2.1. Model scenarios

Scenario	TWS pumping	Overall pumping volume	Pumping volume from existing wells with increasing salinity	Pumping volume from proposed new wells
1a – baseline	Pumping from existing TWS wells at rates and distribution based on metered extraction for 2017/18.	5.2 GL/y to 2024, then 3.5 GL/y to 2040	1.568 GL/y (2020–24) 1.045 GL/y (2025–40)	-
1b	Augmented supply 1: Pumping from three new TWS wells (TWS 27, 28, 29) at 15 L/s with equivalent reduction of pumping from TWS 11, 12, 19 and 20. Pumping from new wells commences in June 2021.	5.2 GL/y to 2024, then 3.5 GL/y to 2040	0.954 GL/y (2020–24) 0.636 GL/y (2025–40)	0.614 GL/y (2020–24) 0.409 GL/y (2025–40)
1c	Augmented supply 2: Pumping from three new TWS wells (TWS 27, 28, 29) at 25 L/s with equivalent reduction of pumping from TWS 11, 12, 19 and 20. Pumping from new wells commences in June 2021.	5.2 GL/y to 2024, then 3.5 GL/y to 2040	0.545 GL/y (2020–24) 0.364 GL/y (2025–40)	1.022 GL/y (2020–24) 0.681 GL/y (2025–40)
2a - baseline	Pumping from existing TWS wells at rates and distribution based on metered extraction for 2017/18.	5.2 GL/y to 2026, then 3.5 GL/y to 2040	1.568 GL/y (2020–26) 1.045 GL/y (2027–40)	-
2b	Augmented supply 1: Pumping from three new TWS wells (TWS 27, 28, 29) at 15 L/s with equivalent reduction of pumping from TWS 11, 12, 19 and 20. Pumping from new wells commences in June 2021.	5.2 GL/y to 2026, then 3.5 GL/y to 2040	0.954 GL/y (2020–26) 0.636 GL/y (2027–40)	0.614 GL/y (2020–26) 0.409 GL/y (2027–40)
2c	Augmented supply 2: Pumping from three new TWS wells (TWS 27, 28, 29) at 25 L/s with equivalent reduction of pumping from TWS 11, 12, 19 and 20. Pumping from new wells commences in June 2021.	5.2 GL/y to 2026, then 3.5 GL/y to 2040	0.545 GL/y (2020–26) 0.364 GL/y (2027–40)	1.022 GL/y (2020–26) 0.681 GL/y (2027–40)

2.2 Pumping

The scenarios listed in Table 2.1 involve pumping from new wells, where only pumping rates (L/s) are specified. This is because pumping from wells in Uley South is based on demand and a 'control philosophy', which determines the pumping rate for individual wells. Thus, the daily duration and volume of pumping from each well may fluctuate throughout the year, and the rates in Table 2.1 are potential pumping rates for a hypothetical control philosophy. The Uley South groundwater model however is set up with monthly stress periods, where pumping rates are given in m^3/d, based on metered monthly pumping volumes and the number of days per month. Thus, for the scenarios a monthly pumping volume divided into a daily rate, is needed for the proposed new wells. The following section describes the method by which future monthly pumping volumes were determined for the proposed wells, which was developed in consultation with SA Water.

The control philosophy pumping rates for the existing wells with higher salinity trends range from 16 to 35 L/s (Table 2.2). Introducing three new TWS wells with pumping rates of 15 L/s each allows for 45 L/s (3 x 15 L/s) to be subtracted from the four existing wells (11.25 L/s per well). Introducing three new TWS wells with pumping rates of 25 L/s each allows for 75 L/s (3 x 25 L/s) to be subtracted from the four existing wells (18.75 L/s per well). In the case of TWS 12, this would reduce pumping to zero, and an additional reduction can be made at the remaining existing wells. The resulting pumping rates for the seven wells for the different scenarios are summarised in Table 2.2.

Table 2.2. Maximum pumping rates (L/s) from existing and proposed wells for scenarios

	TWS 11	TWS 12	TWS 19	TWS 20	TWS 27	TWS 28	TWS 29
Base case (a) Control philosophy pumping rates (L/s) as at 9/3/2021	30	16	35	30			
New wells (b) Pumping rates (L/s) if three new wells at 15 L/s	18.75	4.75	23.75	18.75	15	15	15
New wells (c) Pumping rates (L/s) if three new wells at 25 L/s	11	0	15	10	25	25	25

In order to generate a representative pumping schedule for the scenarios, past metered extraction data was examined. Data from 2017/18 shows a total pumping volume of 5.2 GL/y, and is thus selected as a representative pumping year on which to base the model scenarios. The total extraction from existing wells 11, 12, 19 and 20 for 2017/18 is 1.57 GL. The proportional reductions in pumping rates for the scenarios (Table 2.2) are applied to the metered data for 2017/18, and the remaining volume apportioned to the new TWS wells (TWS wells 27, 28, 29). For example, Table 2.3 gives the monthly pumping volumes for the existing and proposed wells, under the scenario where total annual extraction is 5.2 GL, and the proposed new wells have a pumping rate of 15 L/s. Note in Table 2.3, pumping in TWS 20 is zero for two months. It is common for TWS wells to have no pumping for days-months, as wells are taken offline for maintenance. Data from 2017-18 has the shortest period of time during which the wells 11, 12, 19 and 20 are offline in the recent record of metered extraction.

Table 2.3. Example monthly pumping volumes from existing and proposed TWS wells (Scenario 1b)

	Pumping volume (GL)						
	TWS 11	**TWS 12**	**TWS 19**	**TWS 20**	**TWS 27**	**TWS 28**	**TWS 29**
July	1.70E-02	3.77E-03	2.22E-02	1.44E-02	1.28E-02	1.28E-02	1.28E-02
August	1.60E-02	4.75E-03	2.08E-02	1.38E-02	1.30E-02	1.30E-02	1.30E-02
September	1.87E-02	4.63E-03	2.45E-02	1.73E-02	1.47E-02	1.47E-02	1.47E-02
October	2.51E-02	6.04E-03	3.22E-02	2.20E-02	1.93E-02	1.93E-02	1.93E-02
November	2.73E-02	5.26E-03	3.76E-02	2.81E-02	2.12E-02	2.12E-02	2.12E-02
December	3.05E-02	4.50E-03	3.97E-02	2.42E-02	2.07E-02	2.07E-02	2.07E-02
January	3.73E-02	5.30E-03	4.80E-02	3.63E-02	2.65E-02	2.65E-02	2.65E-02
February	2.19E-02	4.99E-03	3.82E-02	2.87E-02	2.01E-02	2.01E-02	2.01E-02
March	2.14E-02	4.22E-03	3.78E-02	2.65E-02	1.89E-02	1.89E-02	1.89E-02
April	2.44E-02	4.15E-03	3.48E-02	1.37E-02	1.64E-02	1.64E-02	1.64E-02
May	2.37E-02	3.99E-03	2.71E-02	0	1.21E-02	1.21E-02	1.21E-02
June	2.34E-02	0	2.81E-02	0	9.12E-03	9.12E-03	9.12E-03

*Note here pumping volume is given in GL for consistency with units in Table 2.5- 1GL = 1000 ML

3 Results

3.1 Scenario 1 - groundwater level

Scenario 1 simulates continued pumping at 5.2 GL/y to 2024, before pumping reduces to 3.5 GL/y. Modelled groundwater level results are presented for a selection of observation wells located adjacent to the wells where pumping changes in the scenarios, and where the greatest change in groundwater level is likely to be observed (Figure 3.1). For locations of additional observation wells and model results, see Appendices A, B and C.

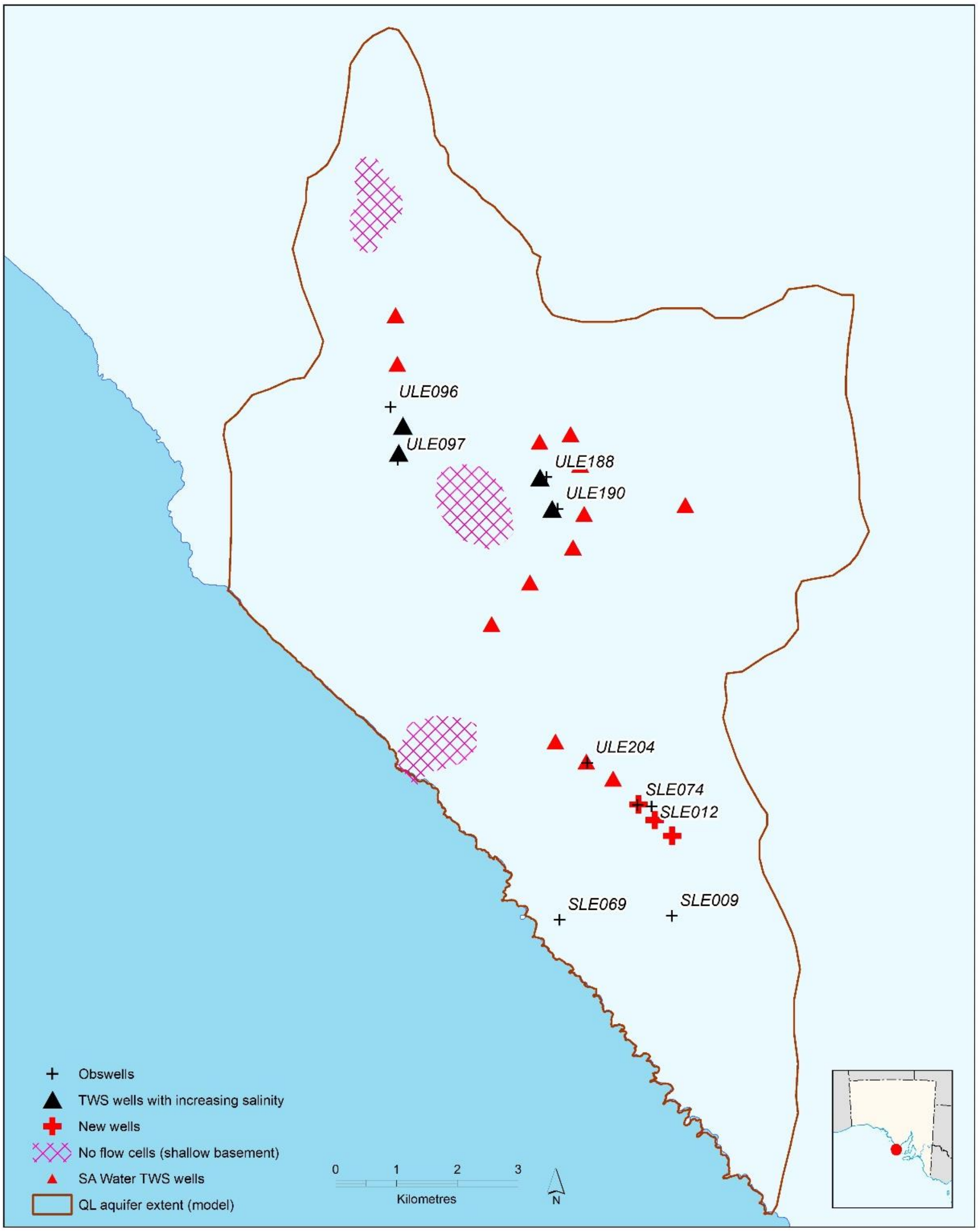


Figure 3.1. Location of observation wells near existing and proposed extraction wells where pumping may change

In scenario 1a extraction continues at 5.2 GL/y to 2024, before reducing to 3.5 GL/y to 2040, while pumping from current extraction wells continues. In scenarios 1b and c, pumping from current wells reduces as extraction from new wells commence. In all scenarios, groundwater levels surrounding existing wells show continued declines to 2024, before showing recovery and stabilization from 2025 onwards as total extraction reduces to 3.5 GL/y (Figure 3.2). Reduced pumping from existing wells does appear to assist in groundwater level recovery, however the difference is relatively small. For example, in ULE188 (adjacent to TWS 19), groundwater levels in scenario 1c are ~0.4 m higher than in scenario 1a after pumping in TWS 19 is reduced (Figure 3.2). Therefore, reduced pumping from existing TWS wells does improve groundwater level in these locations, however the difference is small compared to longer term recovery achieved by reducing pumping to 3.5 GL/y.

It should be noted that scenario groundwater levels commence in 2018 in the following figures, while observational data is plotted to 2020. In all scenarios, metered groundwater extraction is used from 2018-20, and scenario extraction used from 2020 onwards.

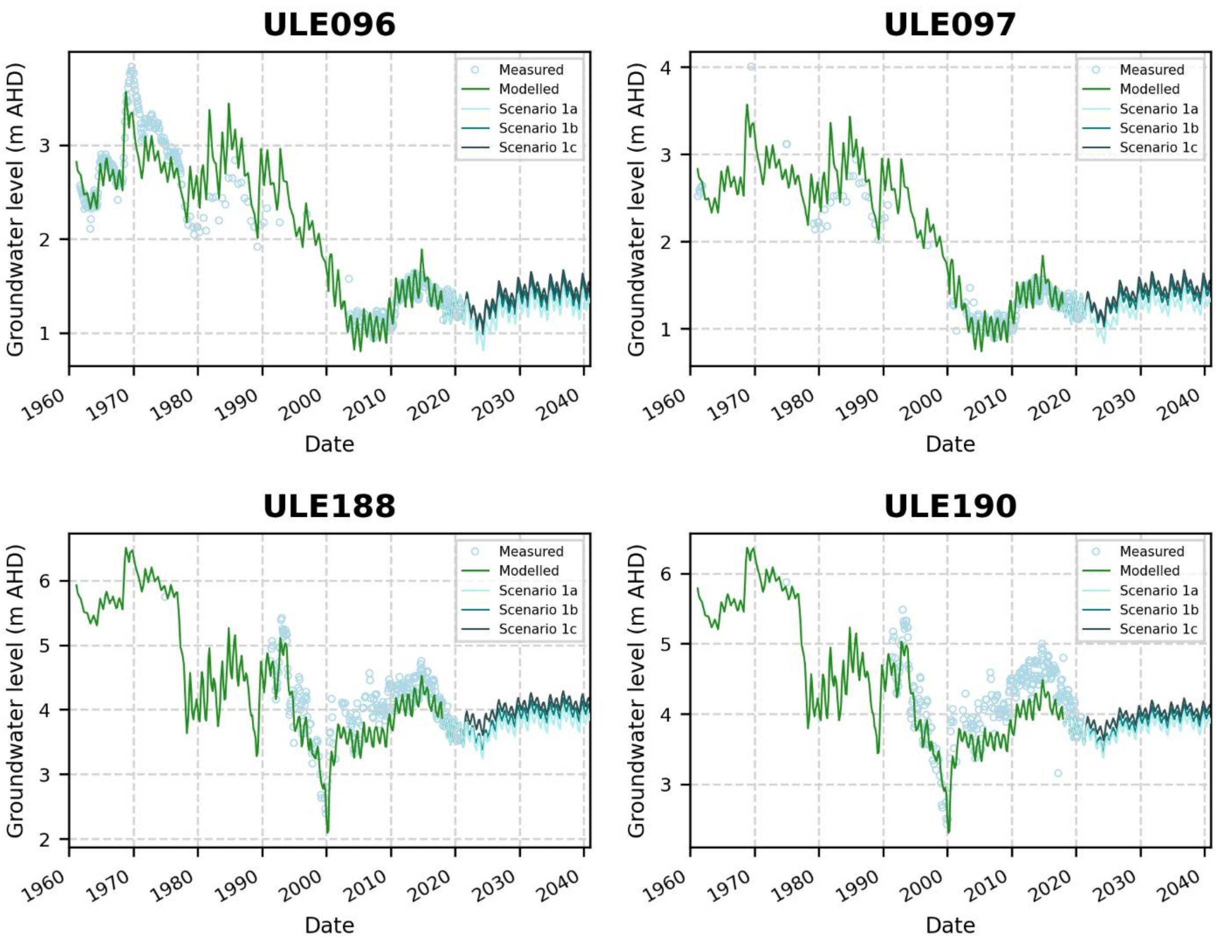


Figure 3.2. Scenario 1 a,b,c groundwater levels adjacent to existing pumping wells

Closer to the coast and the proposed new extraction wells, declines in groundwater level are greatest in scenario 1c as extraction from new wells commences at a maximum rate of 25 L/s (Figure 3.3). For example, groundwater levels in SLE074 (adjacent to proposed new well TWS 27) are ~0.75 m lower in when pumping is occurring in scenario 1c, compared to no pumping in scenario 1a. These results are the inverse of those observed in wells where extraction reduces. Given the proximity of these wells to the coast, this raises the risk profile for seawater intrusion. While groundwater levels recover following the reduction in pumping to 3.5 GL/y in 2025, in some cases groundwater levels remain below current levels.

It should be noted here that the model fit to measured groundwater level close to the proposed wells is variable compared to the fit in other parts of the basin. This is largely due to the lack of monitoring data in some locations. For example, monitoring at SLE074, adjacent to the proposed wells, commenced in March 2015. Hence there was only 2.8 years of observation data at this location to inform calibration, whereas in other parts of the basin the monitoring record extends to the early 1960s. Further model calibration work incorporating data collected since 2017 could be carried out to improve model fit in this area. However, this is considered beyond the scope of the current project.

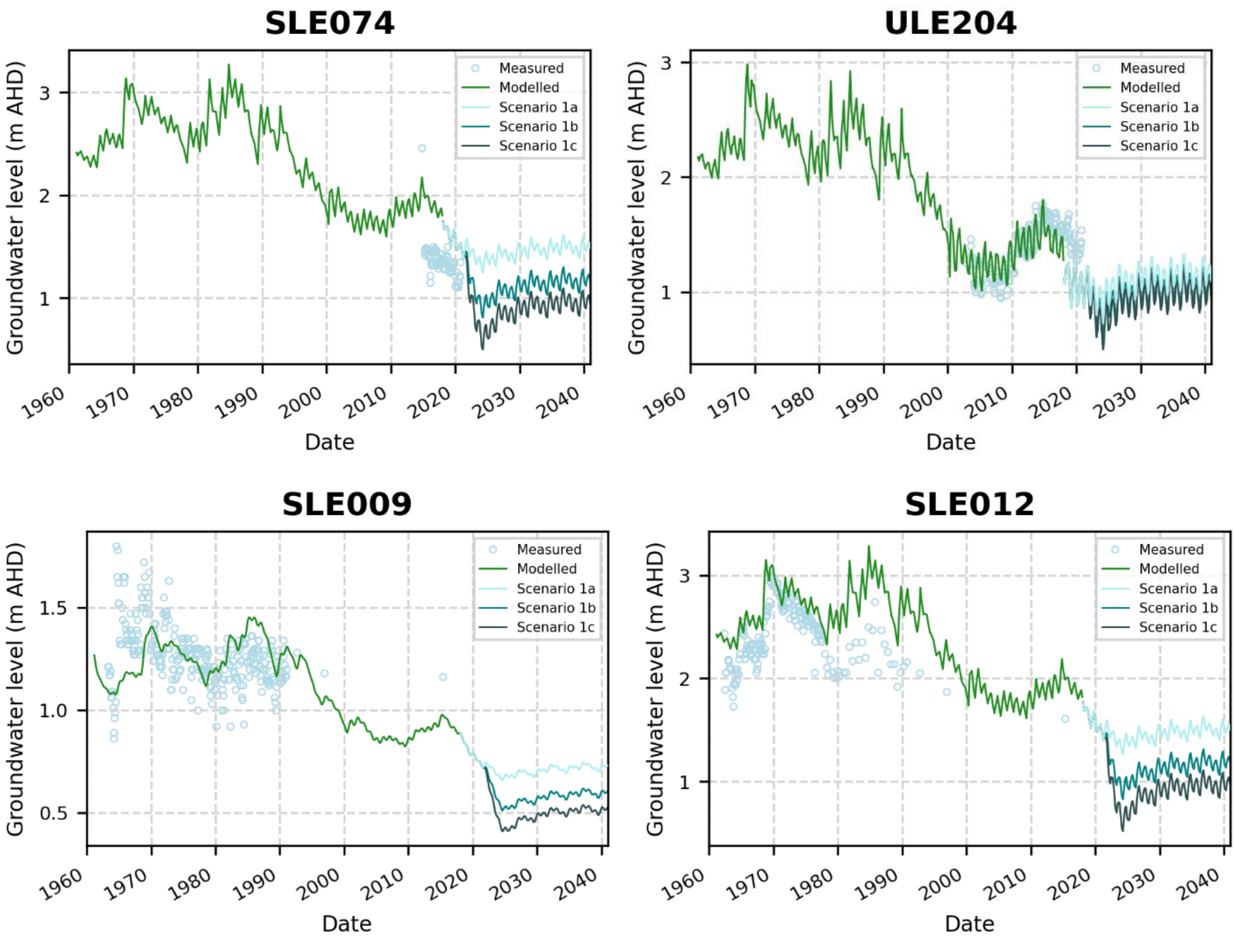


Figure 3.3. Scenario 1 a,b,c groundwater levels adjacent to proposed new extraction wells

3.2 Scenario 2 - groundwater level

Scenario 2 simulates continued pumping at 5.2 GL/y to 2026, before pumping reduces to 3.5 GL/y. The results in scenarios 2 a, b and c are similar to those in scenarios 1. There is slightly more groundwater level decline with extraction at 5.2 GL/y continuing to 2026, however groundwater levels again start to recover when extraction is reduced to 3.5 GL/y. As with scenarios 1, groundwater levels recover by ~0.4 m in wells adjacent to the existing wells (TWS 11, 12, 19 and 20), as extraction from these wells reduces (Figure 3.4). Conversely, there is increased groundwater decline of ~ 0.7m in coastal groundwater wells as extraction commences from proposed wells (Figure 3.5).

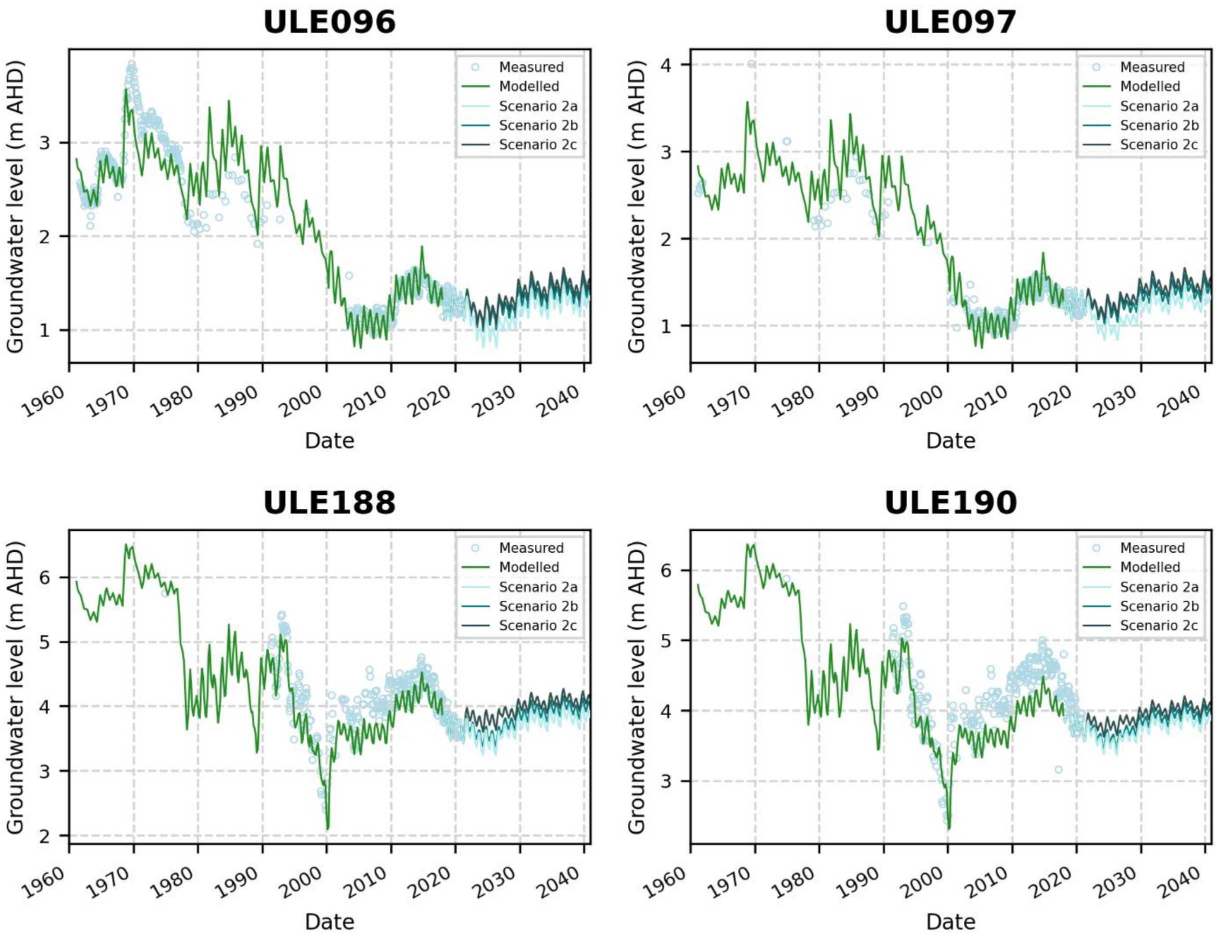
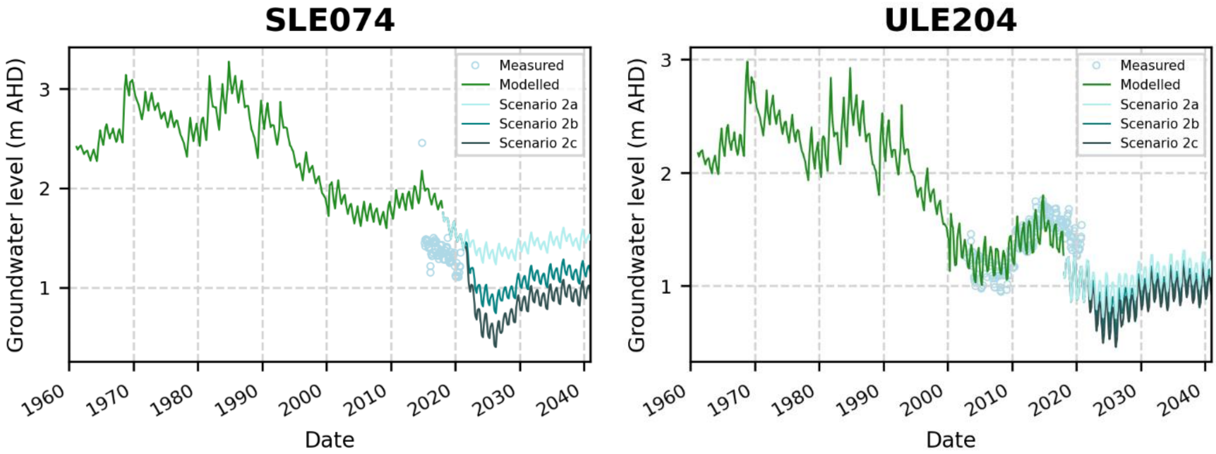


Figure 3.4. Scenario 2 a,b,c groundwater levels adjacent to existing pumping wells



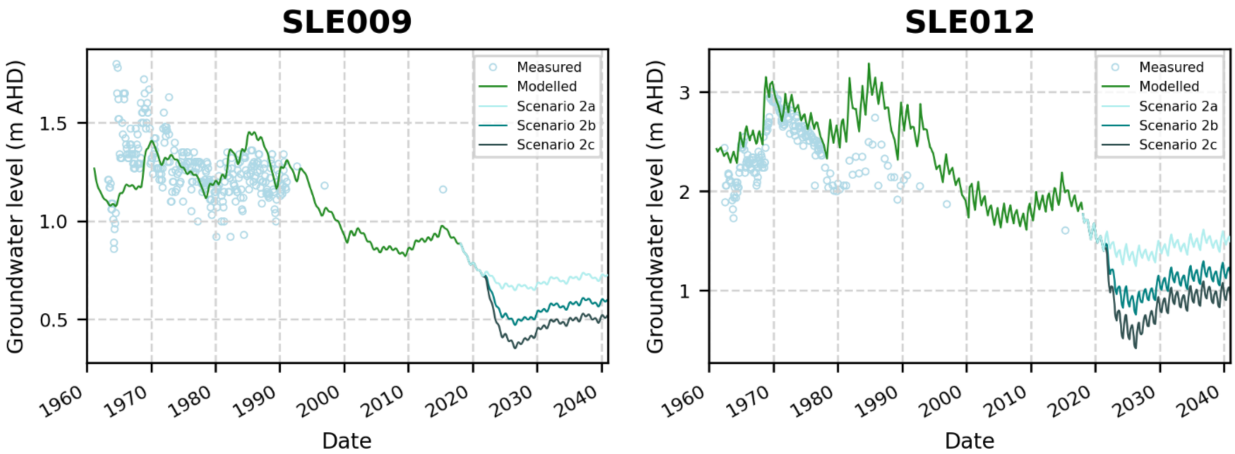


Figure 3.5. Scenario 2 a,b,c groundwater levels adjacent to proposed new extraction wells

3.3 Scenarios - seawater interface

Position and movement of the seawater interface was modelled using SWI2 (Bakker et al. 2013). Results show that for all scenarios, the seawater interface is likely to continue to move inland as pumping continues and recharge remains low. There is less seawater intrusion when pumping continues from existing wells (scenario 1a, 2a), and more intrusion when pumping from the proposed wells commences. Transient movement of the interface is greatest when pumping is at 5.2 GL/y, and reduces when pumping declines to 3.5 GL/y.

The simulated elevation of the interface in well SLE069 for scenario 1 shows a maximum increase of 4.5 m for scenario 1c (Figure 3.6), when pumping from proposed coastal wells is occurring at 25 L/s. When there is no pumping from the proposed coastal wells, the elevation of the interface increases by 2.4 m. The simulated elevation of the interface in wells SLE069 for scenario 2 shows the same results, however the increase in elevation is slightly greater (4.78 m for scenario 2c) as extraction at 5.2 GL/y continues for an additional two years (Figure 3.7).

In the south eastern part of the basin the toe of the seawater interface, the location at which the interface intersects the base of the QL aquifer, also moves further inland in all scenarios (Figure 3.8, 3.9). Movement inland is greater when pumping from the proposed new coastal wells is greater. Therefore, scenario 2c shows the greatest inland movement in the interface of up to 600m (Figure 3.10). In all scenarios where the proposed coastal extraction wells are operating (scenarios 1b, 1c, 2b, 2c), the greatest inland movement of the interface occurs parallel to coastal TWS wells.

The seawater interface does move slightly further inland in the western part of the basin (ie the area between the existing, inland wellfield and the coast) under all scenarios. However, there is no significant difference between the scenarios. Therefore, based on the model assumptions, the proposed changes in TWS well arrangements are unlikely to result in seawater intrusion in the western part of the basin, aside from the risk of intrusion associated with continued extraction and low recharge.

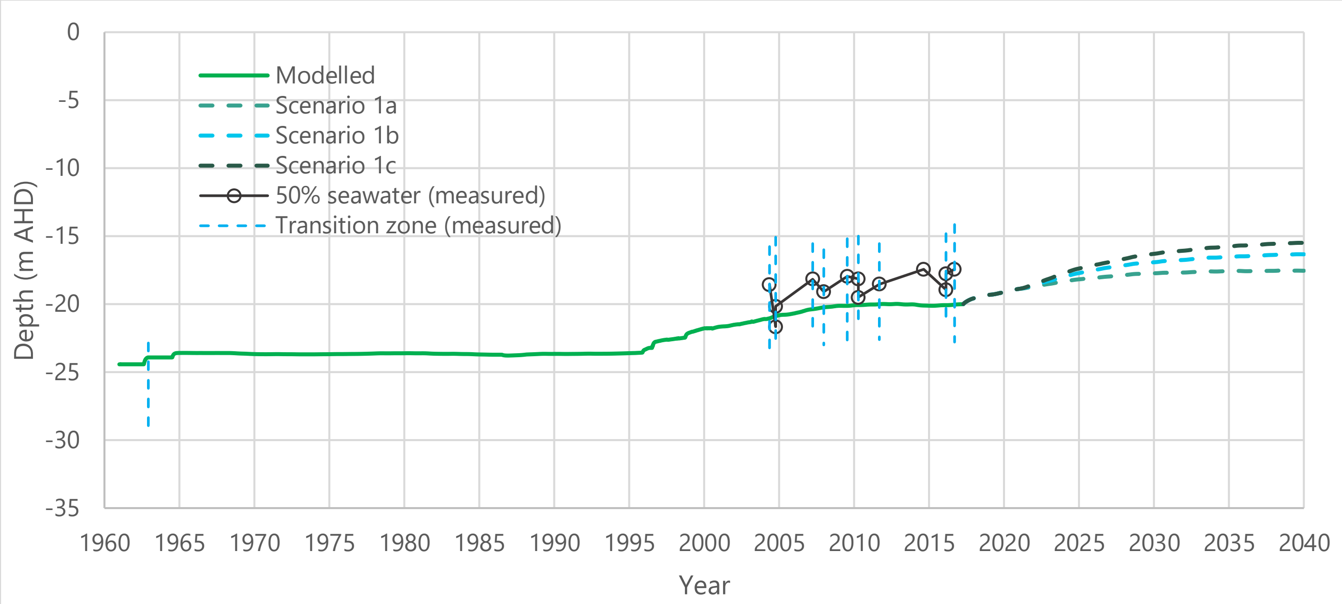


Figure 3.6. Modelled seawater interface elevation at SLE069 in Scenario 1

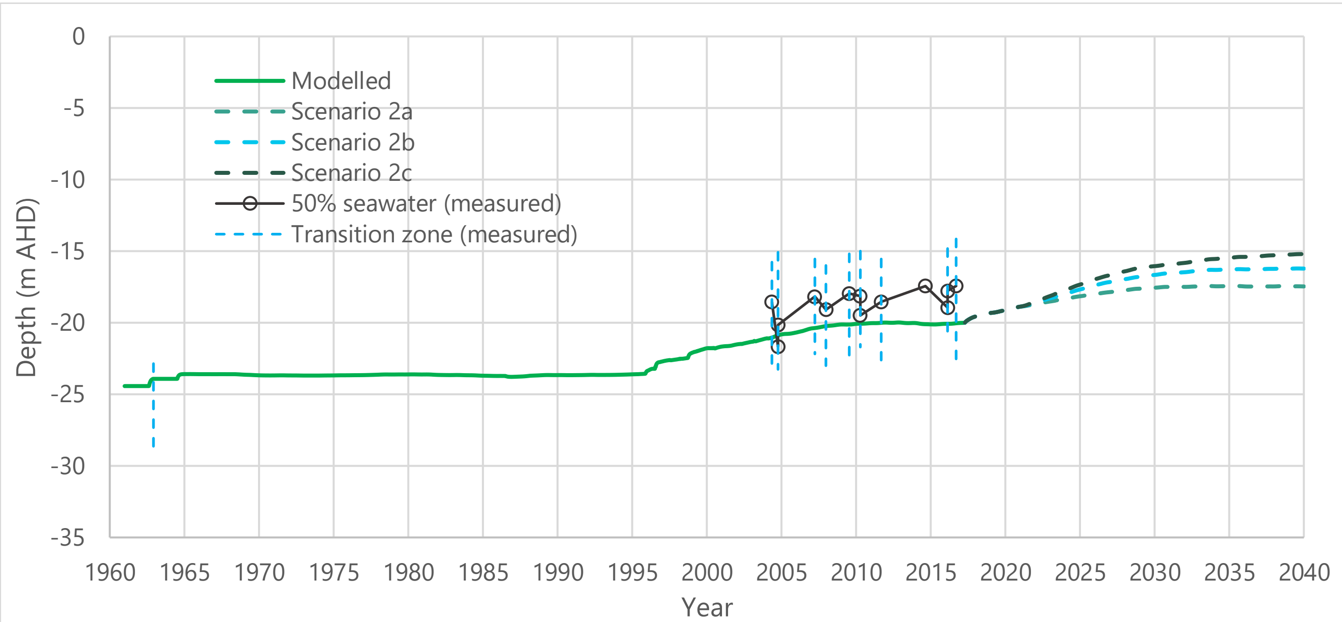


Figure 3.7. Modelled seawater interface elevation at SLE069 in Scenario 2

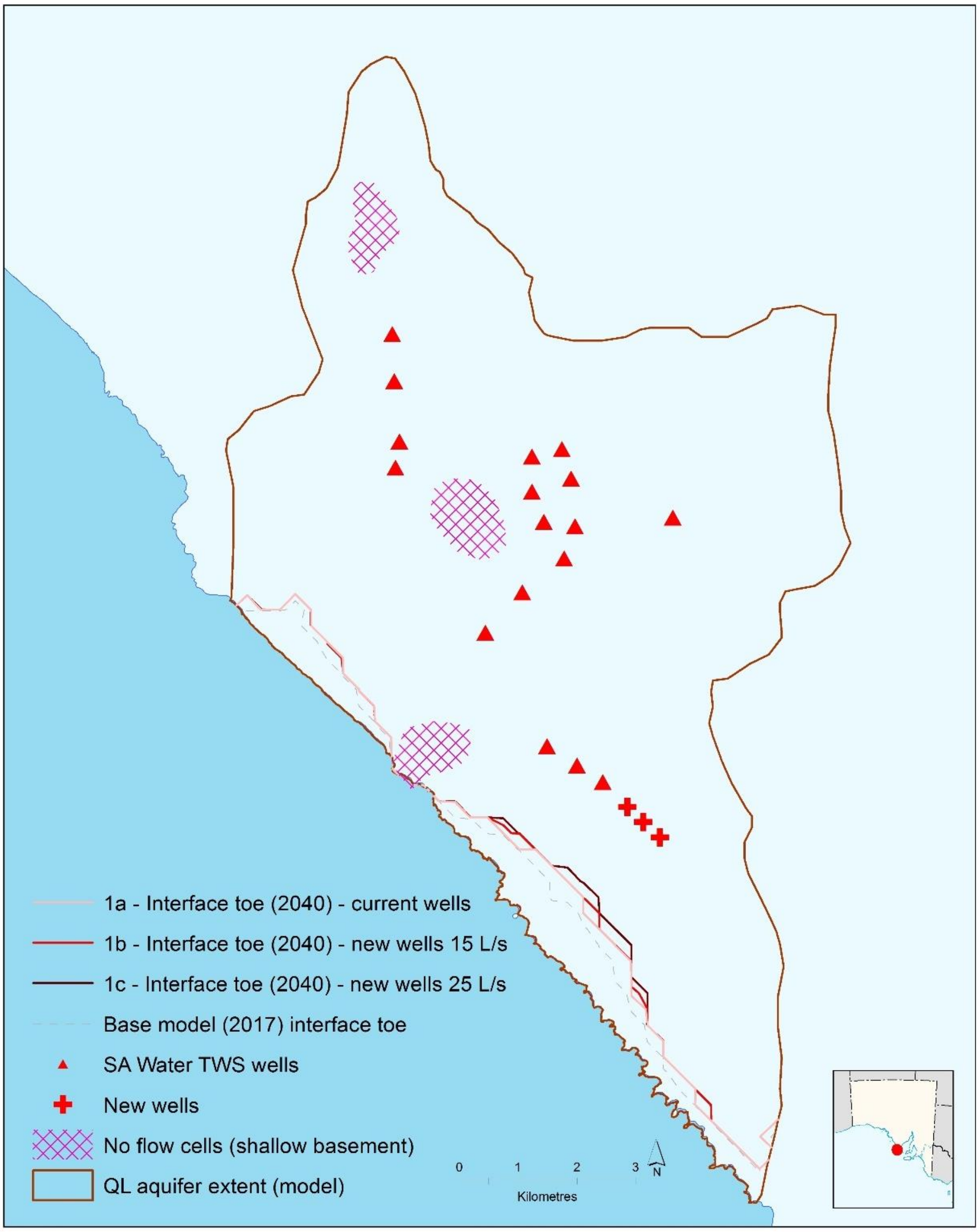


Figure 3.8. Position of the seawater interface toe Scenario 1

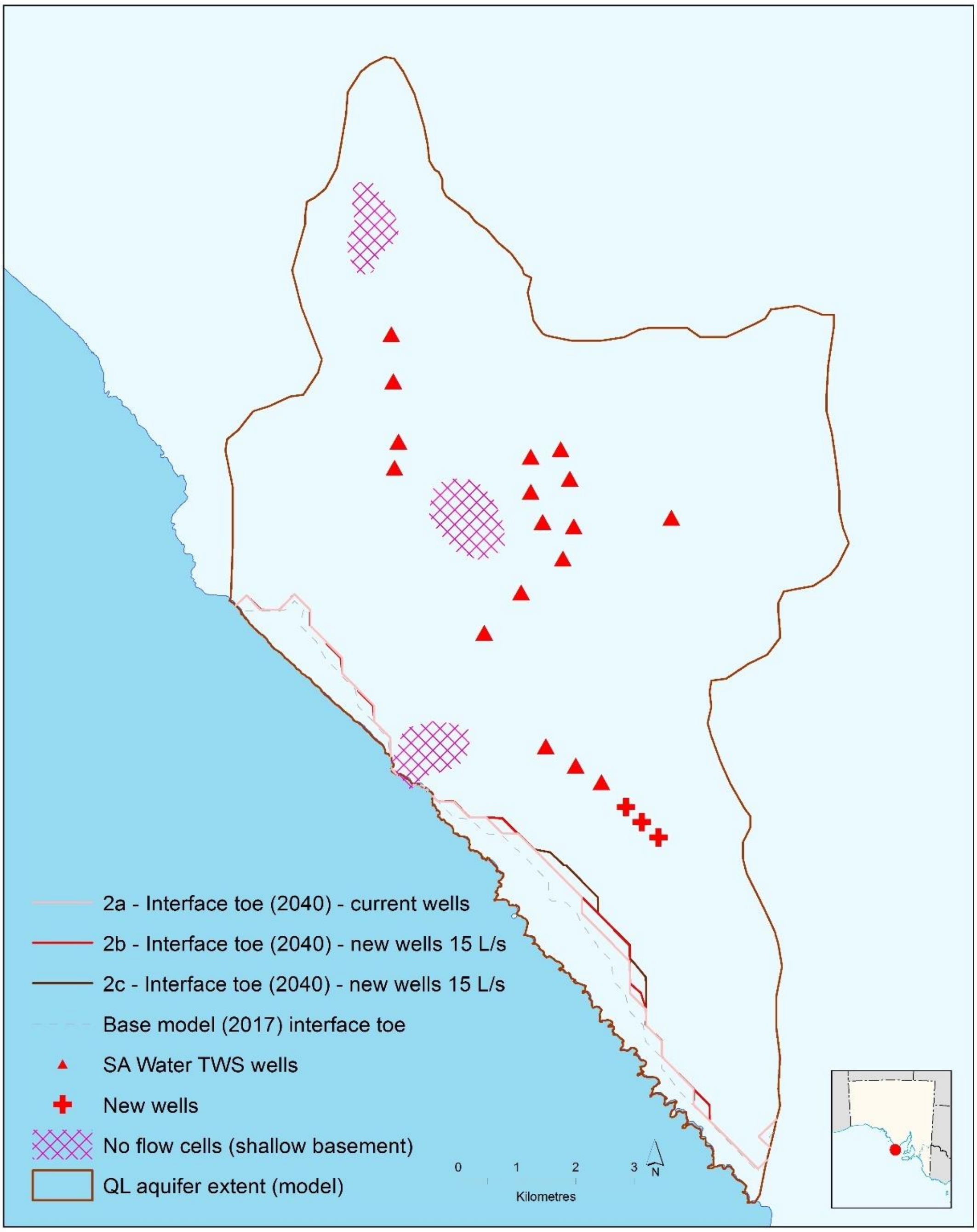


Figure 3.9. Position of the seawater interface toe Scenario 2

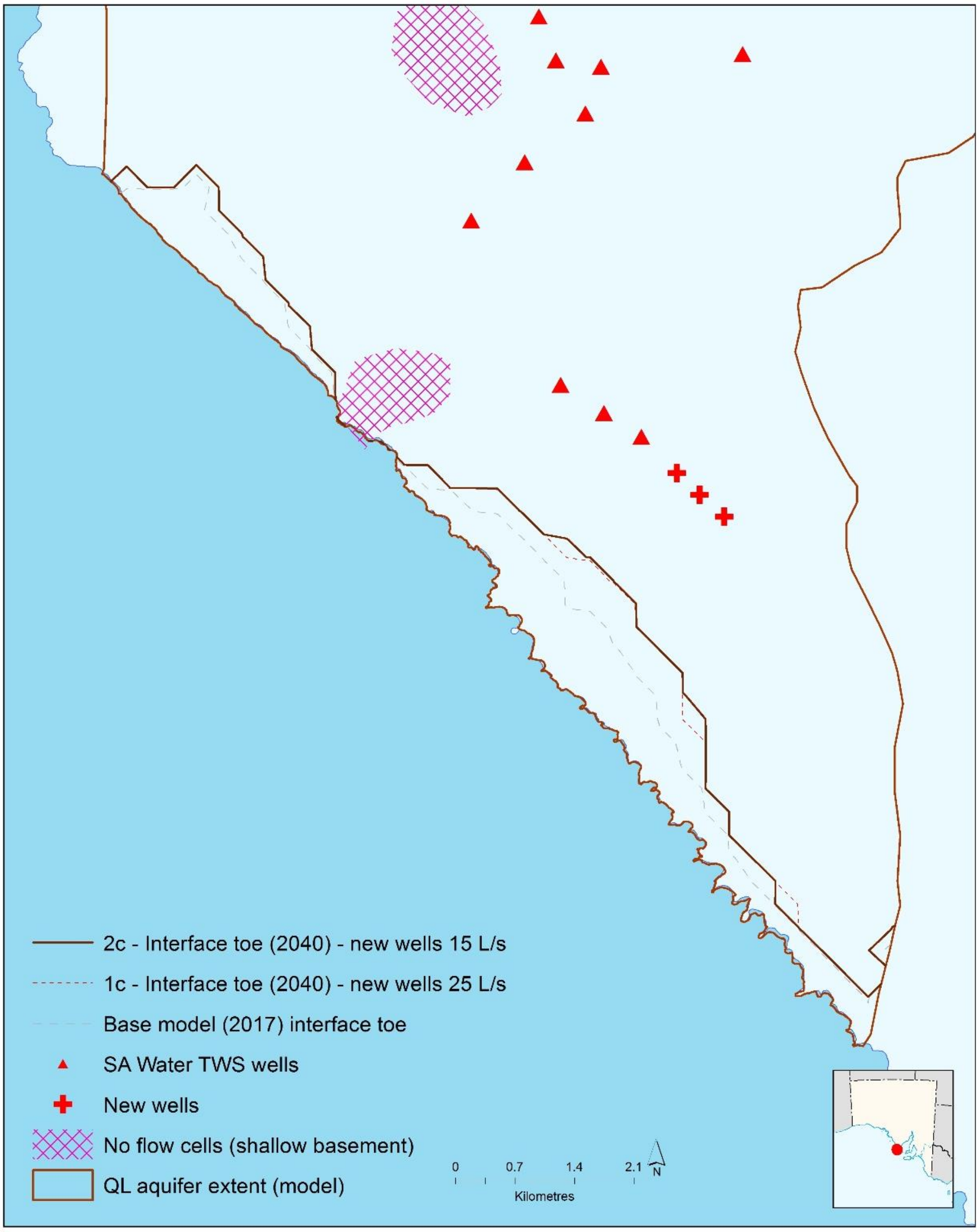


Figure 3.10. Comparison between simulated interface position in scenarios 1c and 2c

4 Conclusions and recommendations

4.1 Conclusions

Six scenarios were run with the Uley South groundwater model, to assess the impact of changes in TWS well pumping. The changes in pumping included reductions in pumping from existing wells that are showing increasing salinity trends were observed, and increased pumping from proposed new TWS wells close to the coast.

The results show that reduced pumping from inland groundwater wells showing salinity increases is likely to lead to some recovery in groundwater level at these locations, however the recovery is typically no greater than 0.4 m. It is not apparent if this will ameliorate salinity increases in these wells. Regular monitoring of salinity from these TWS bores could be used to modify pumping rates to manage salinity levels.

The modelling results show that increased pumping from proposed TWS wells in the south-east of the basin result in additional groundwater level decline up to 0.75 m in these areas. Accompanying this is further inland movement of the seawater interface, by up to 300-600 m. Therefore, increased pumping from the proposed TWS wells is likely to increase the risk of seawater intrusion in Uley South. It should be noted that this is a data poor area in the model, and these conclusions may need to be re-assessed based on results of pumping tests for any new production wells in this area. Monitoring should also be increased in this area if new supply wells are installed, to asses changes in groundwater level and salinity, and adapt pumping arrangements if necessary.

4.2 Assumptions and limitations

The Uley South groundwater model report (DEW, 2020) discusses the assumptions and limitations associated with the model in great detail. It should be reiterated here that the seawater interface is simulated using the SWI2 package in MODFLOW (Bakker et al. 2013). This package simulates a 'sharp interface', approximating the 50% seawater-freshwater isohaline, and does not simulate movement of seawater in the aquifer by diffusion or dispersion. Therefore, the results showing movement and position of the interface do not represent full dispersive mixing of seawater intruding in the aquifer, and thus results may be an underestimate of the extent of seawater intrusion for the model and scenarios considered here.

Simulated extraction from the proposed extraction wells here is a simplification of on-demand pumping, and is based on previous years extraction data. Should the total monthly extraction from proposed wells exceed those considered in this scenario, the results cannot be considered representative.

4.3 Recommendations

Recommendations that relate directly to the work in this report are:

- These scenarios are based on the assumption that current low rainfall/recharge conditions persist into the future. They do not assess the potential impact of climate change projections on rainfall into the future. Previous modelling (DEW 2020) has considered climate change impacts on groundwater recharge in the Uley South Basin, and further work in this area could be conducted.
- The scenarios simulate potential impacts for the given recharge assumptions up to 2040. Further movement of the seawater interface past 2040 may be expected if low rainfall and recharge conditions persist. Consideration should be given to simulating impacts further into the future if continued extraction from Uley South Basin past 2040 is considered likely.
- No attempt has been made to project changes in salinity in TWS wells, as a result of increased inflow from the TS aquifer, into the future. Cook and Post (2021) stated that accurate future prediction of salinity

changes in these wells would require more knowledge on the Uley South groundwater system than is currently available. Further work could be undertaken to improve understanding, such as construction of additional monitoring wells for groundwater chemistry analysis in the TS aquifer.

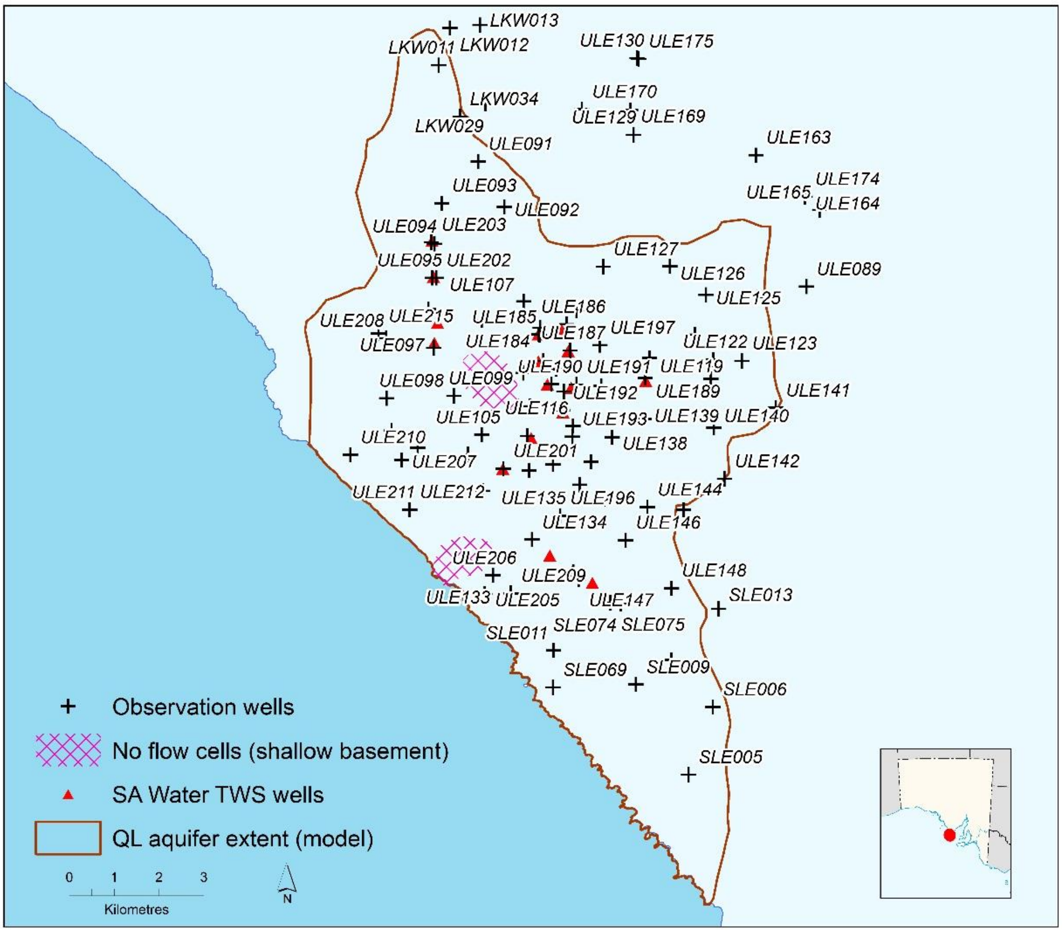
- Additional monitoring in coastal wells close to proposed TWS wells should be undertaken if plans for new extraction wells continue. For example, wells such as SLE009 and SLE012 are unlikely to be suitable for future monitoring, as they appear to be screened across both the QL and TS aquifers. It may be necessary to install additional monitoring wells in the area.

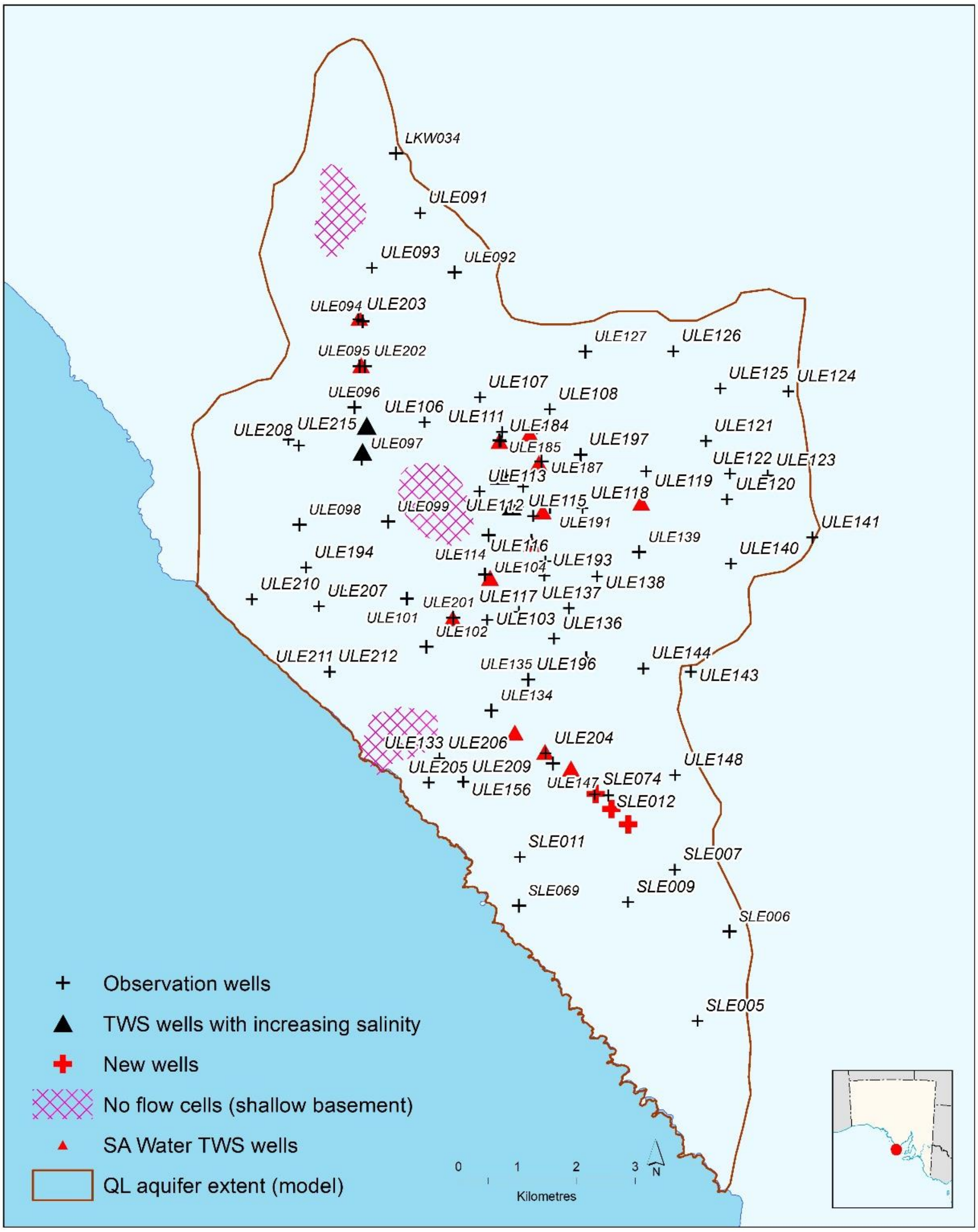
- Monitoring of the seawater interface at SLE069 is complicated by the long well screen. DEW has recently installed additional coastal monitoring wells, however data (salinity and groundwater level) from these wells is only preliminary at this stage, and will need to be updated with regular monitoring. Should the conceptual understanding of the position and movement of the seawater interface be refined or changed as a result of this new drilling, the results should feed back into the groundwater model.

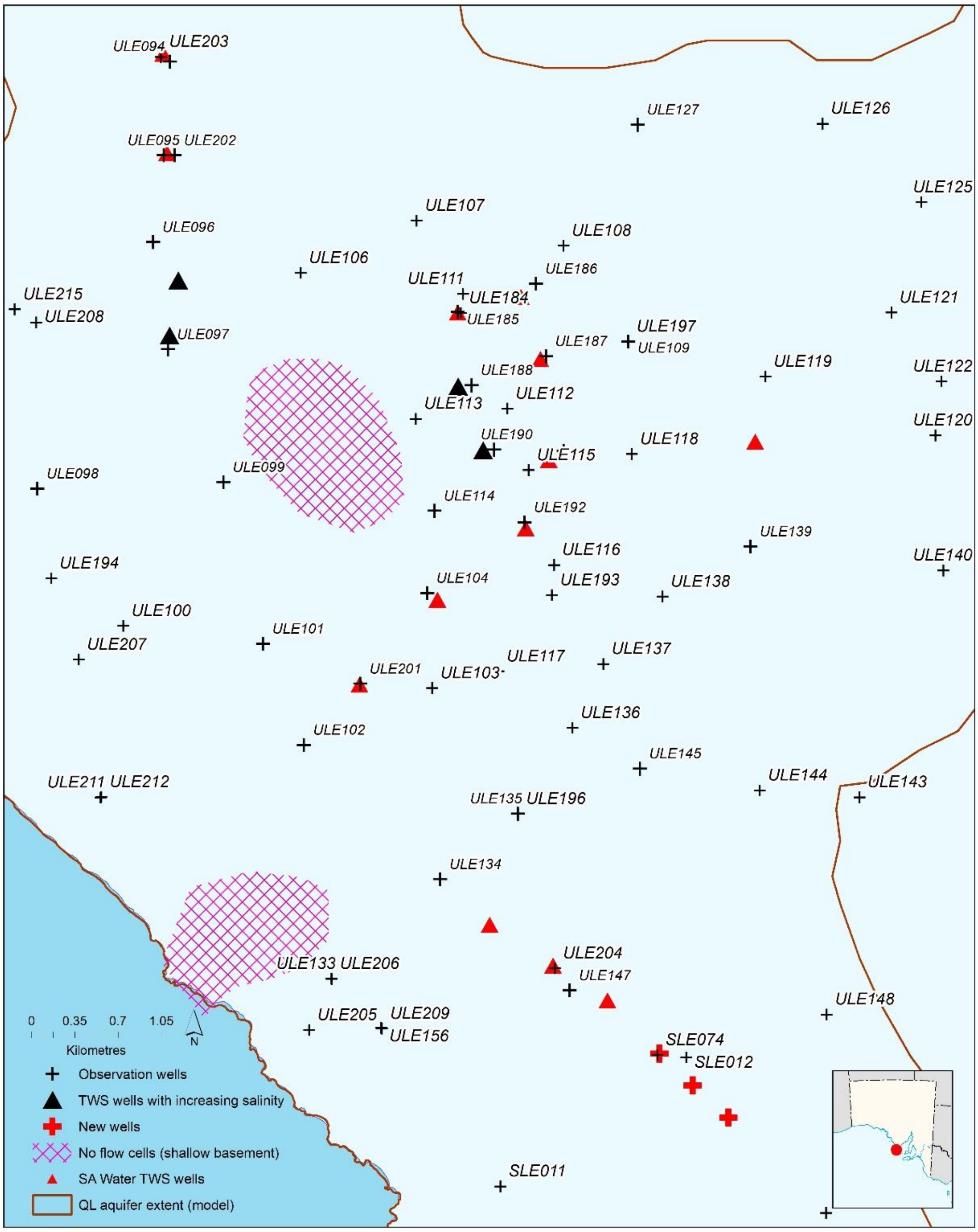
- Model calibration is generally good, but could be improved in the coastal area around the proposed extraction wells. Limited data was available in this location when the model was constructed. Model recalibration is not likely to change the overall conclusion of this work regarding model trends - that increased coastal extraction will likely still result in increased seawater intrusion. However as additional data becomes available through monitoring and drilling, model recalibration should be considered.

5 Appendices

A. Observation well locations




Observation wells
TWS wells with increasing salinity
New wells
No flow cells (shallow basement)
SA Water TWS wells
QL aquifer extent (model)
Kilometres


ULE094 ULE203
ULE095 ULE202
ULE127
ULE126
ULE125
ULE107
ULE108
ULE096
ULE106
ULE111
ULE186
ULE184
ULE185
ULE215
ULE208
ULE121
ULE097
ULE187
ULE197
ULE109
ULE119
ULE122
ULE188
ULE113
ULE112
ULE120
ULE190
ULE115
ULE118
ULE098
ULE099
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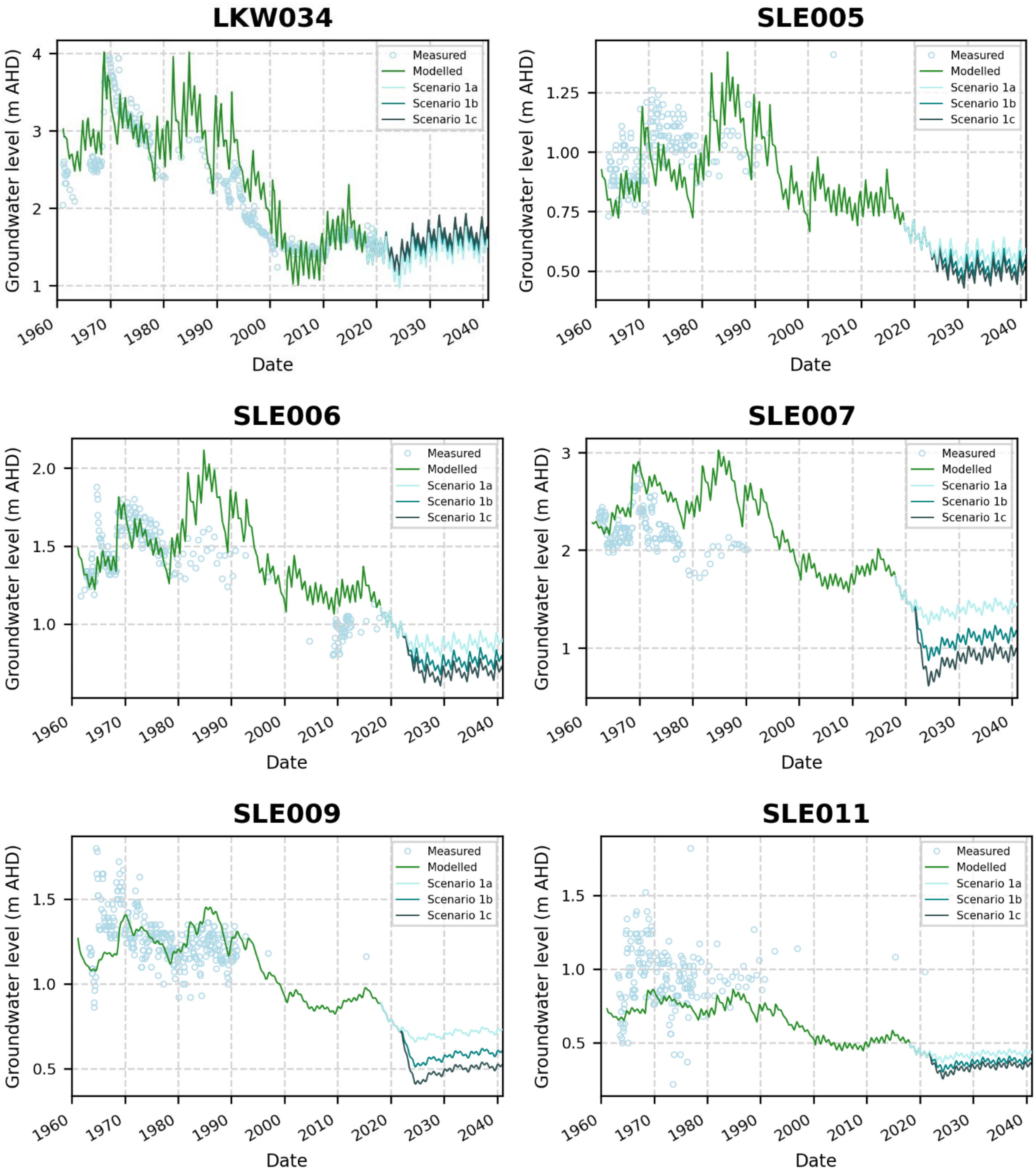
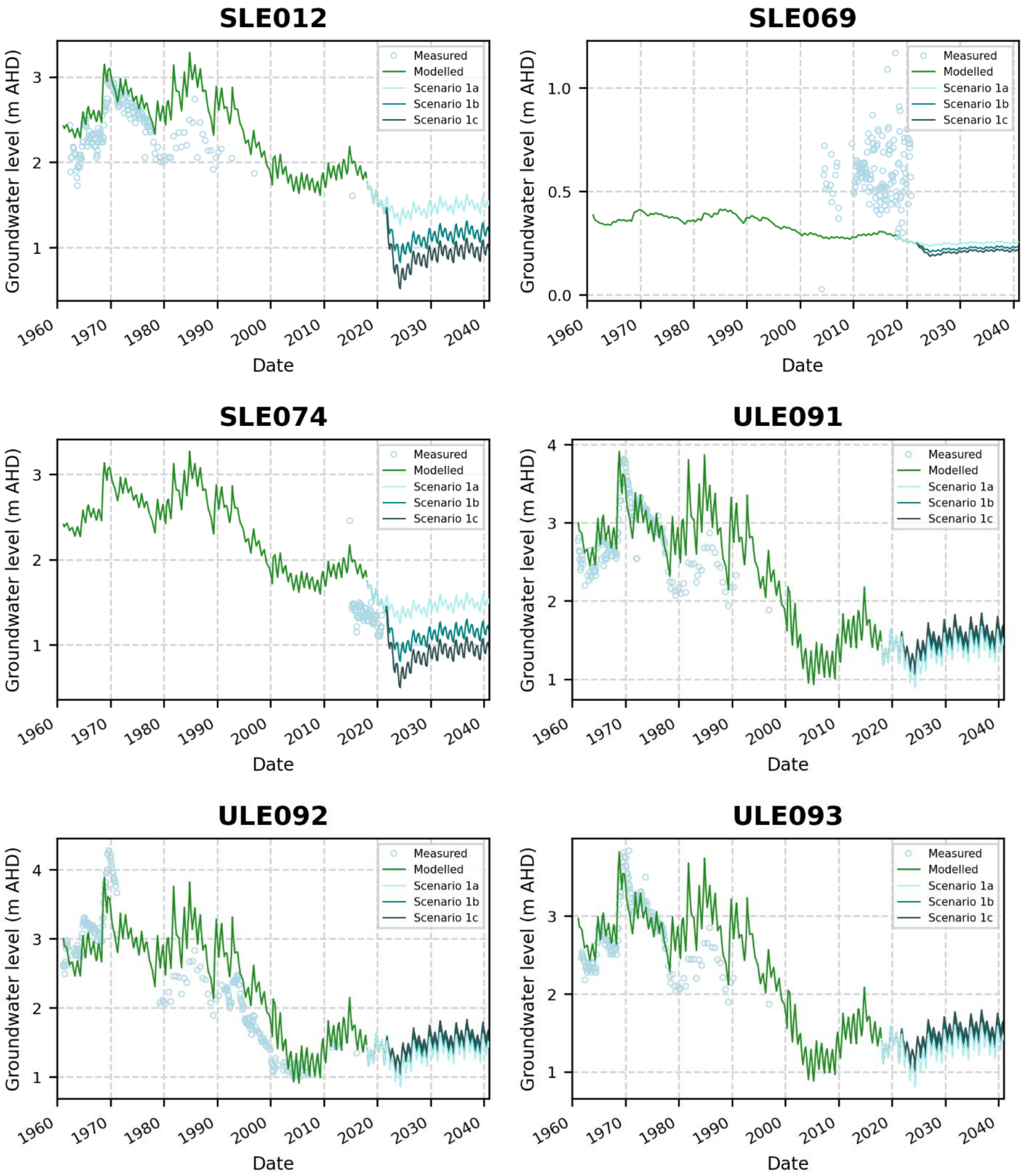
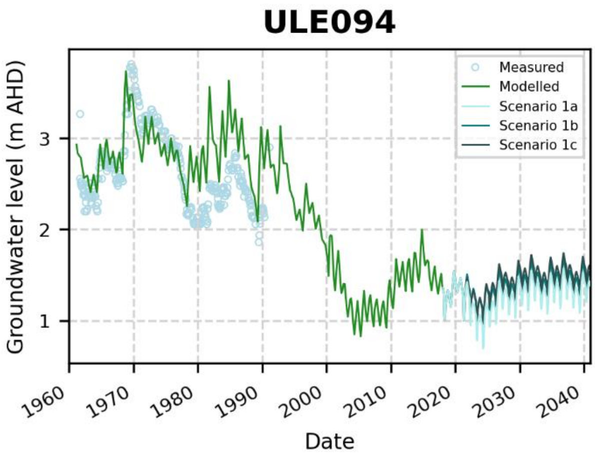
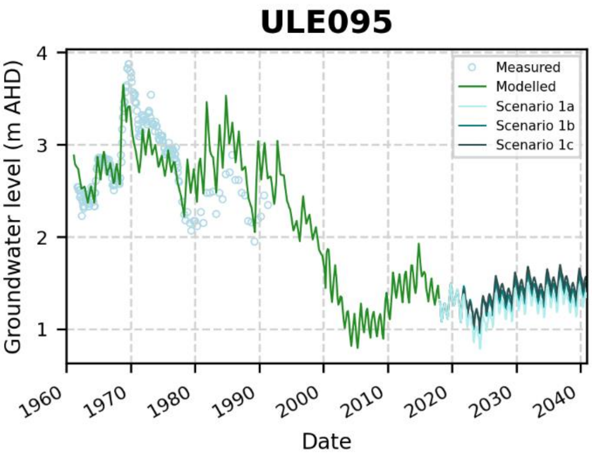
ULE192
ULE139
ULE194
ULE116
ULE140
ULE104
ULE193
ULE138
ULE100
ULE101
ULE207
ULE117
ULE137
ULE201
ULE103
ULE136
ULE102
ULE145
ULE211 ULE212
ULE144
ULE143
ULE135 ULE196
ULE134
ULE204
ULE133 ULE206
ULE147
ULE148
ULE205
ULE209
ULE156
SLE074
SLE012
SLE011
0 0.35 0.7 1.05
Kilometres
N
Observation wells
TWS wells with increasing salinity
New wells
No flow cells (shallow basement)
SA Water TWS wells
QL aquifer extent (model)

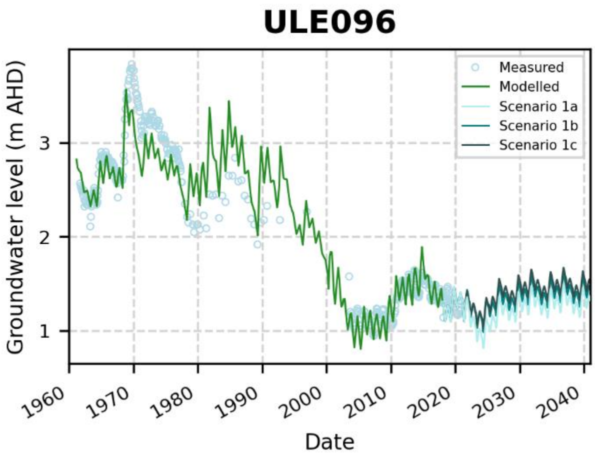
B. Scenario 1 groundwater level results

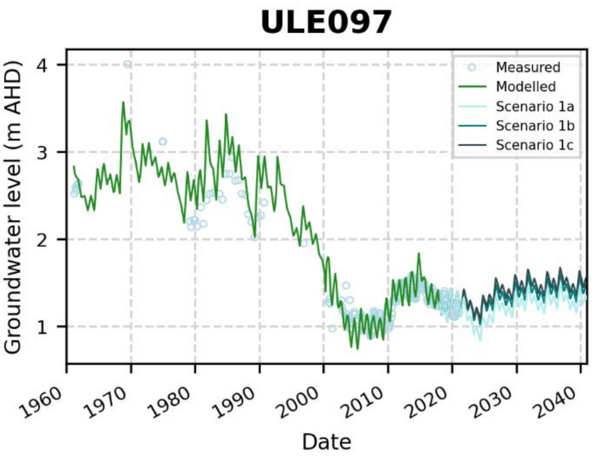


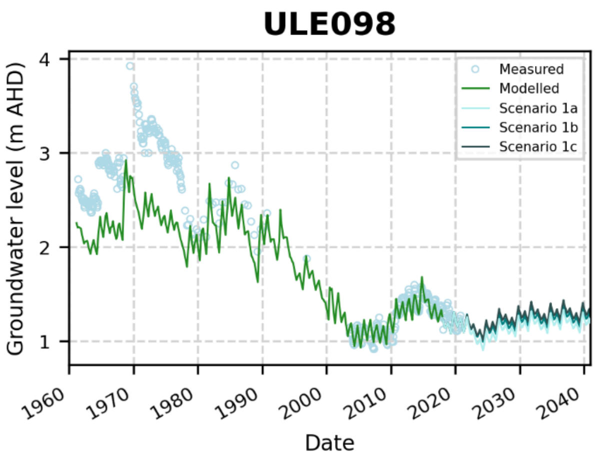

SLE012
SLE069
SLE074
ULE091
ULE092
ULE093
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c
Groundwater level (m AHD)
Date

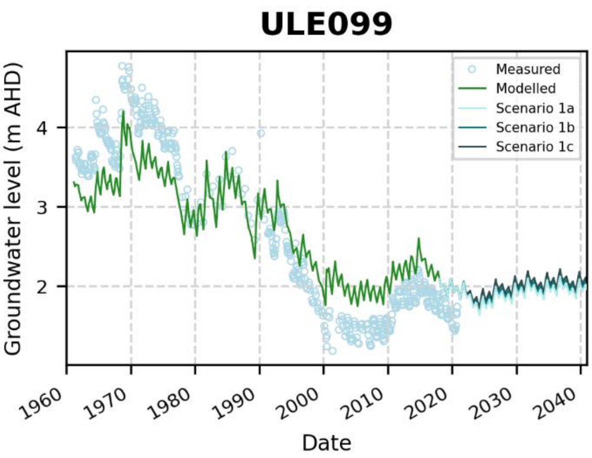

ULE094
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c
Groundwater level (m AHD)
Date

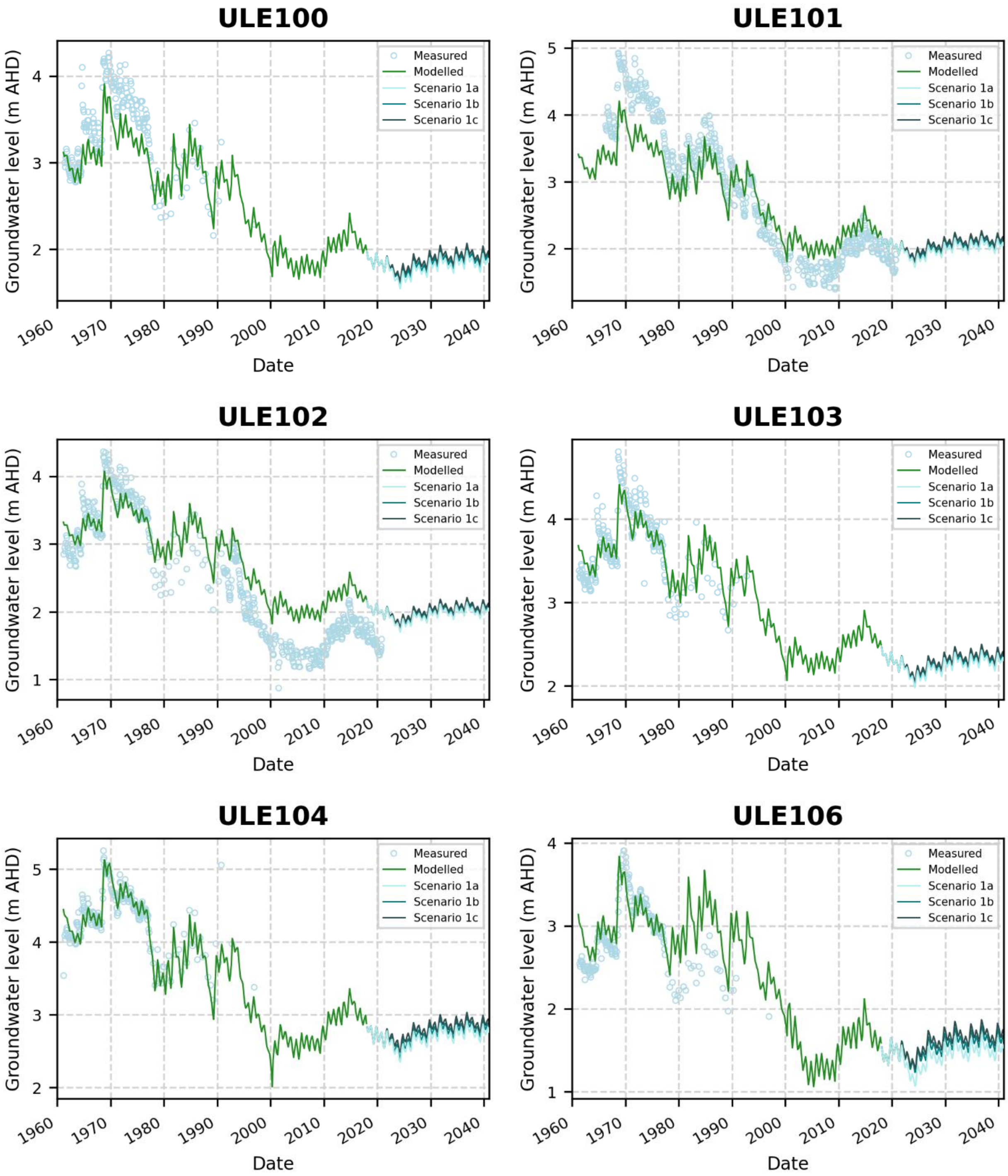

ULE095
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c
Groundwater level (m AHD)
Date

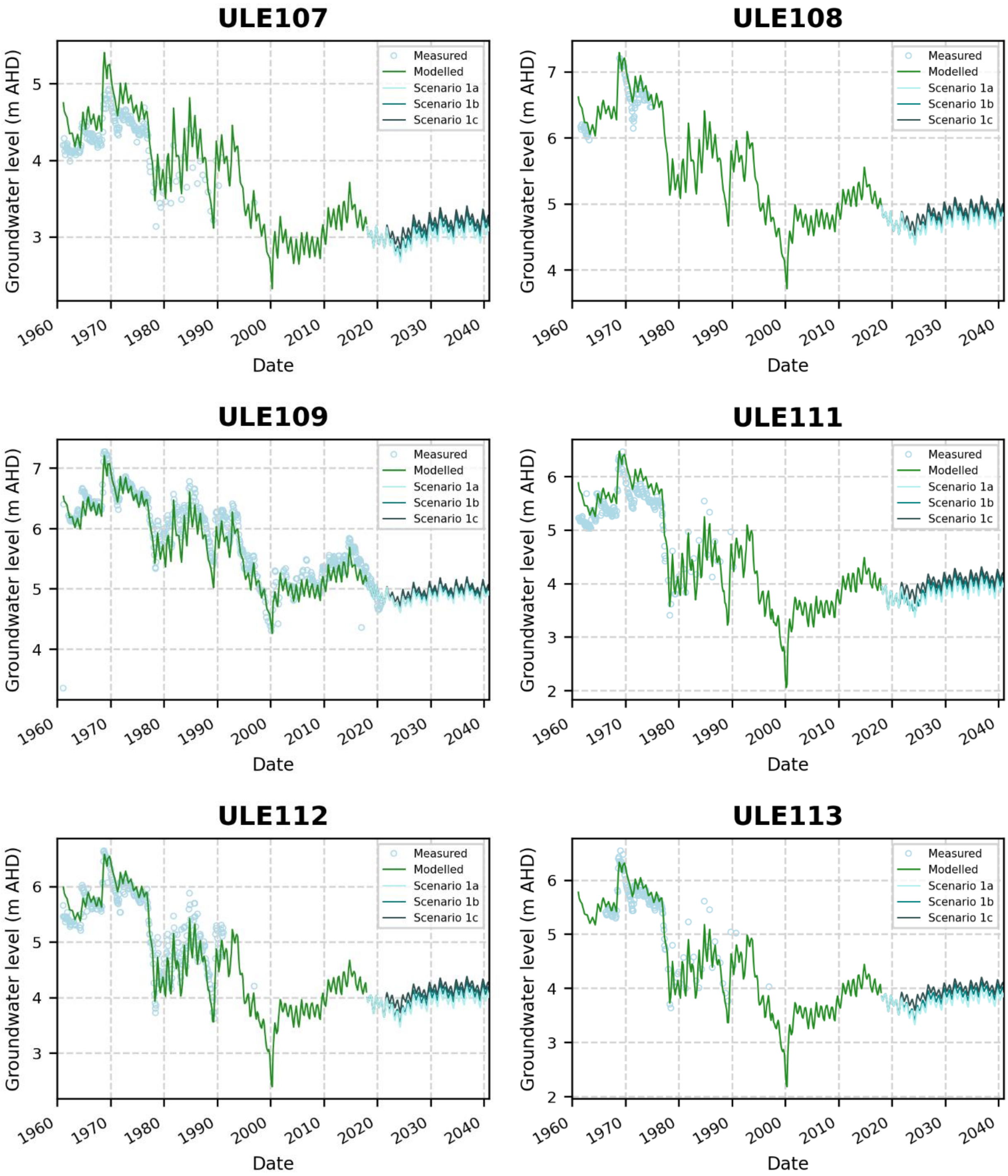

ULE096
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c
Groundwater level (m AHD)
Date

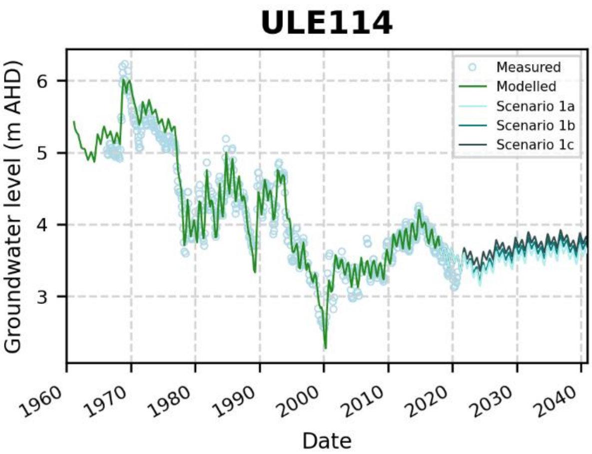

ULE097
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c
Groundwater level (m AHD)
Date

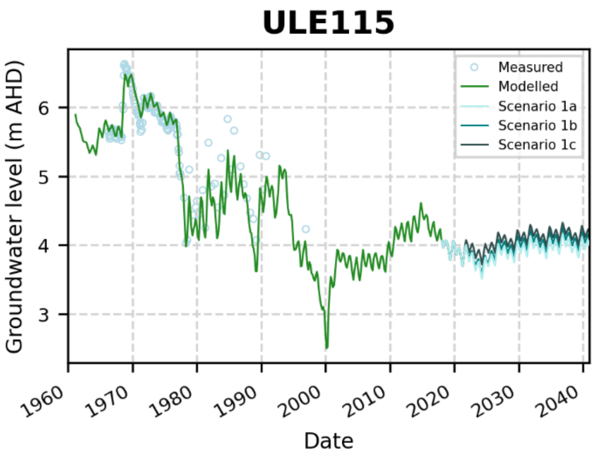

ULE098
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c
Groundwater level (m AHD)
Date

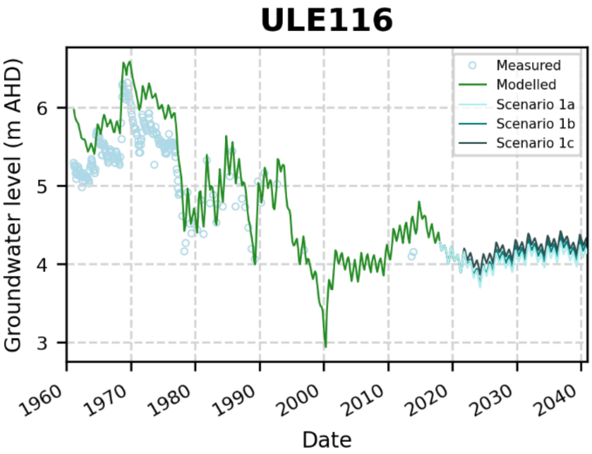

ULE099
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c
Groundwater level (m AHD)
Date

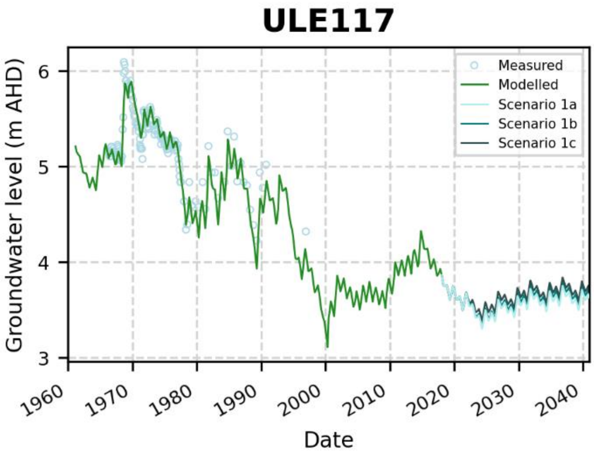

ULE100
ULE101
ULE102
ULE103
ULE104
ULE106
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c
1960
1970
1980
1990
2000
2010
2020
2030
2040

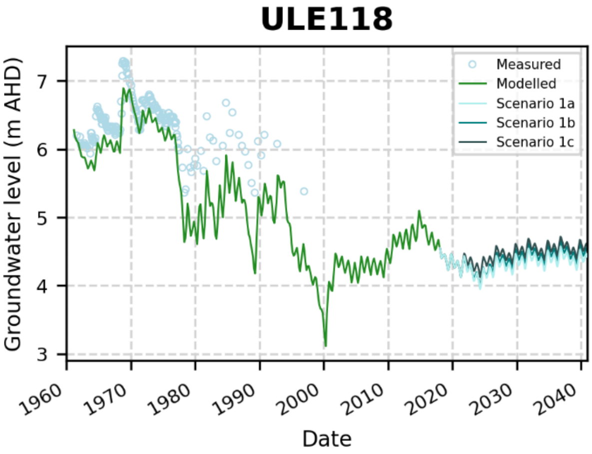

ULE107
ULE108
ULE109
ULE111
ULE112
ULE113
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c
Groundwater level (m AHD)
Date
1960
1970
1980
1990
2000
2010
2020
2030
2040

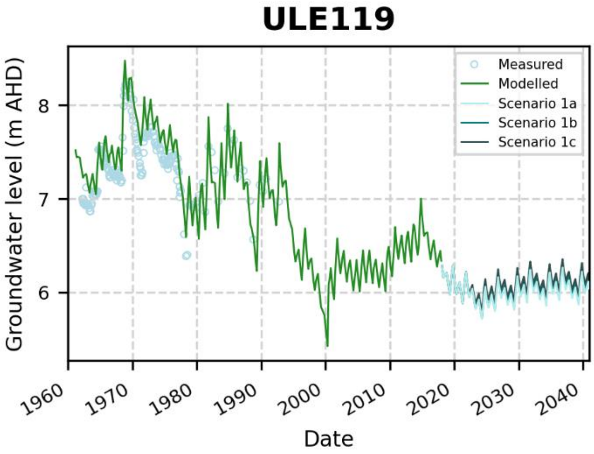

ULE114
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c

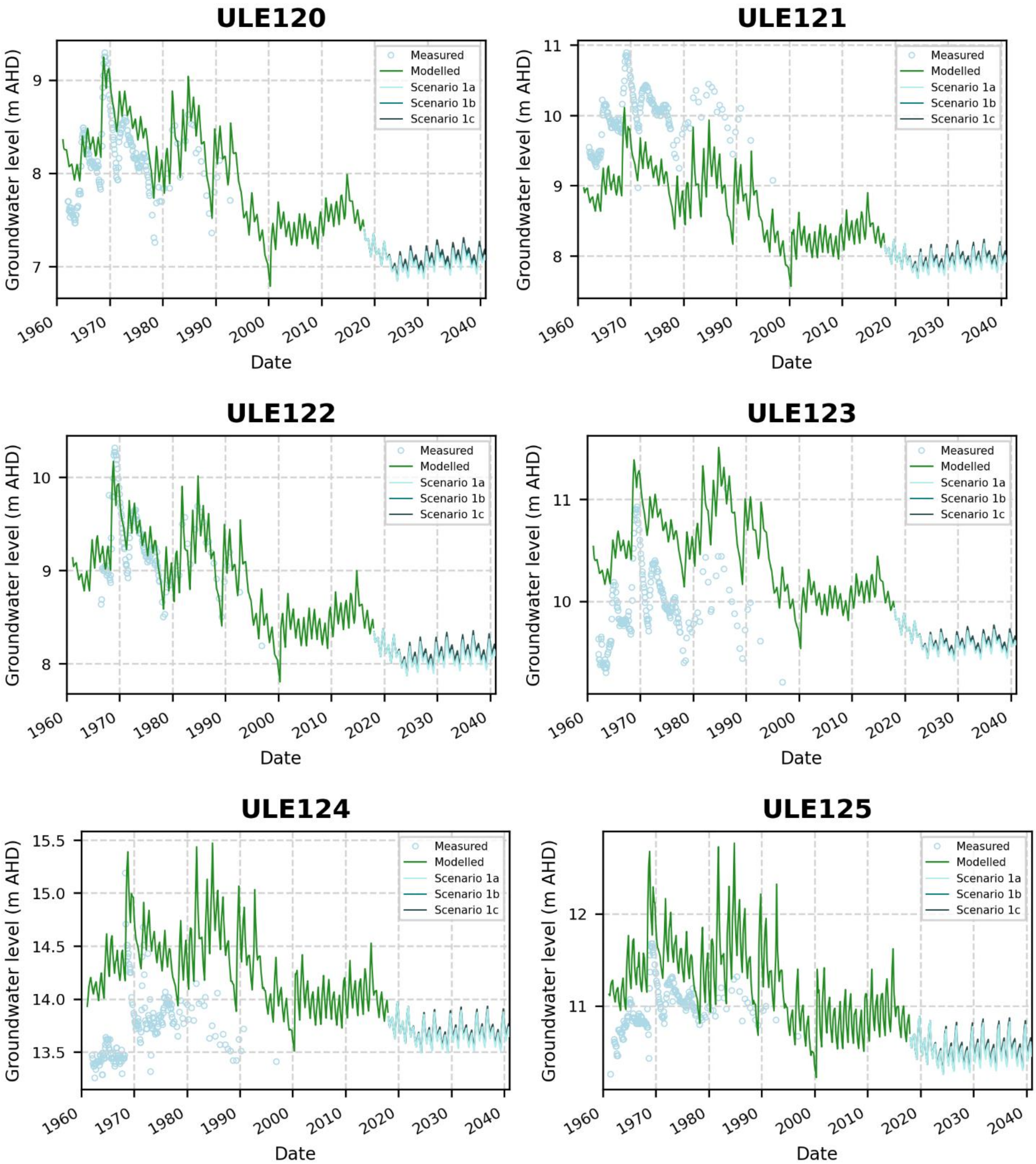

ULE115
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c

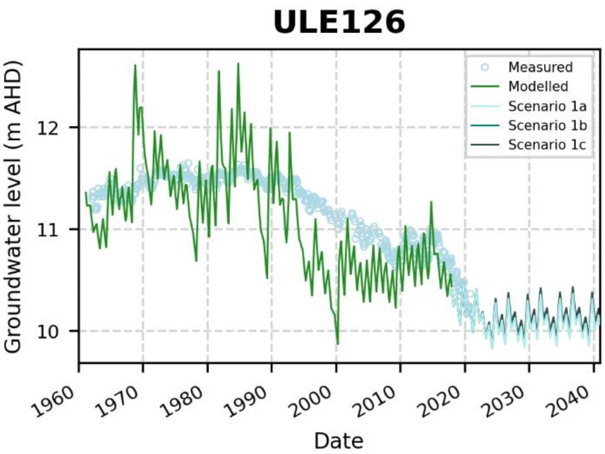

ULE116
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c

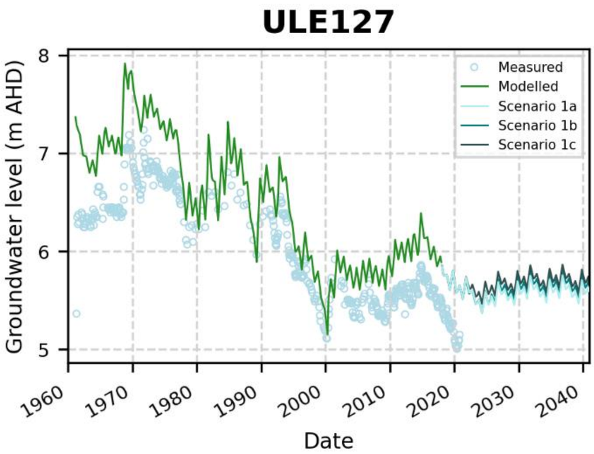

ULE117
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c

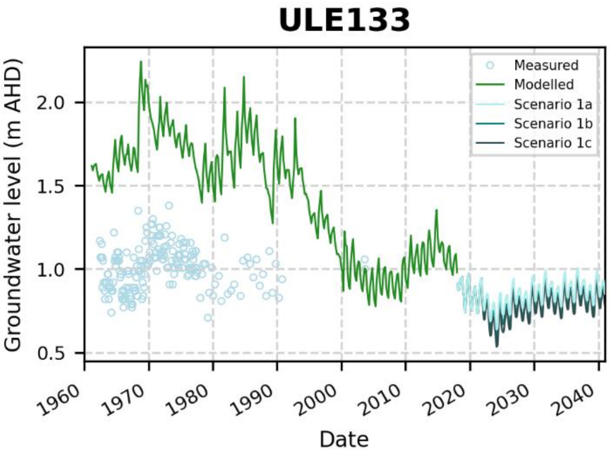

ULE118
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c


ULE119
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c


ULE120
ULE121
ULE122
ULE123
ULE124
ULE125
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c
1960
1970
1980
1990
2000
2010
2020
2030
2040


ULE126
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c


ULE127
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c


ULE133
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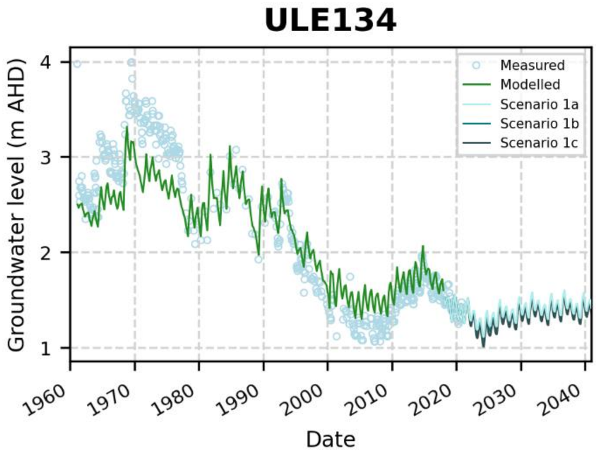
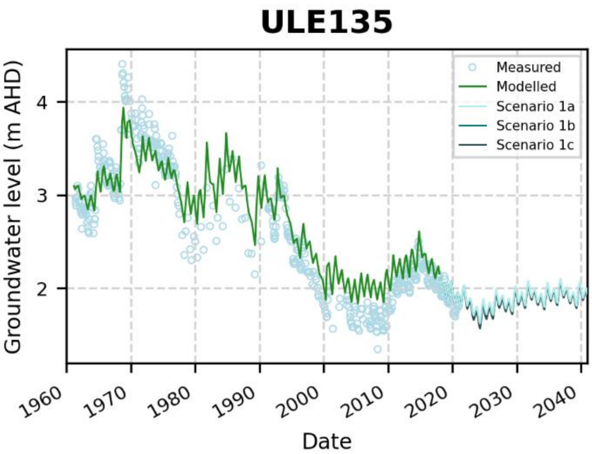
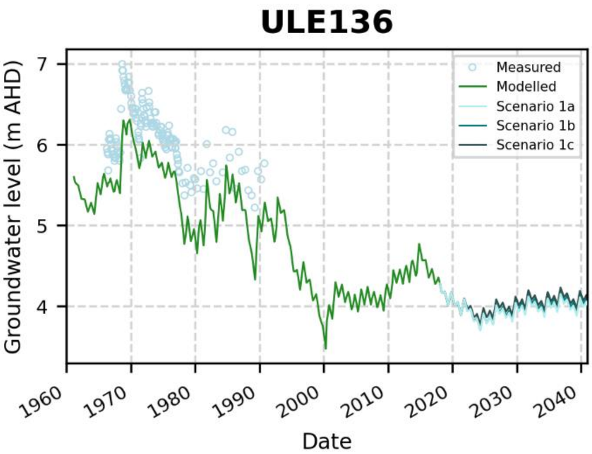
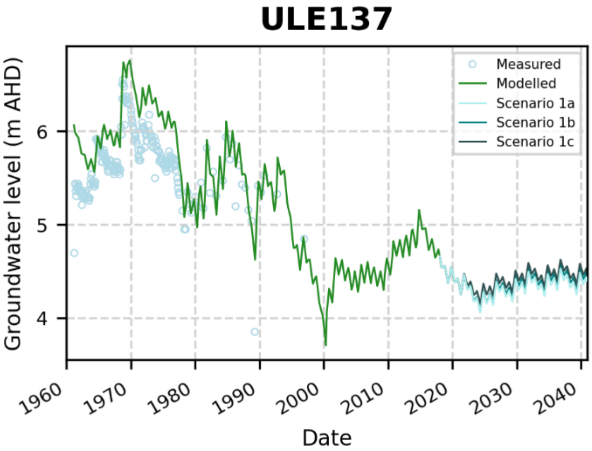
Date
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c


ULE134
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c


ULE135
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c


ULE136
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c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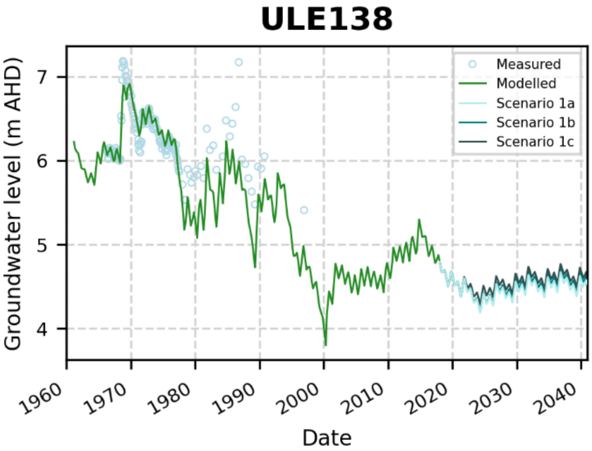
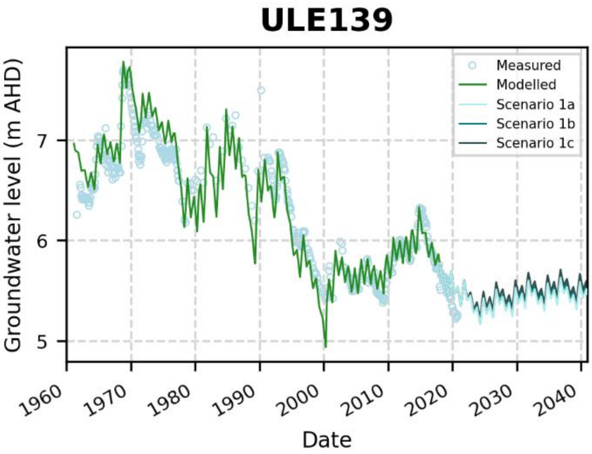
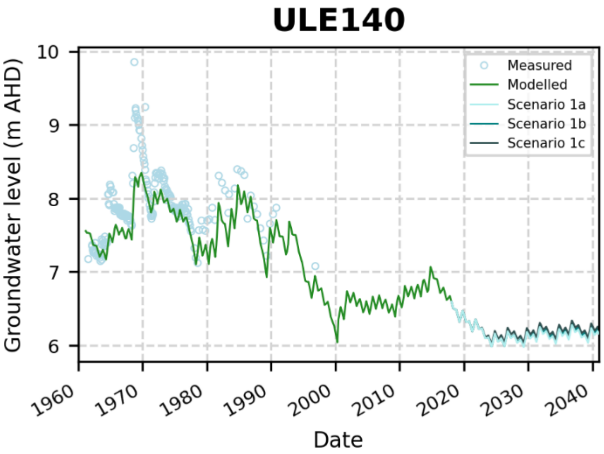
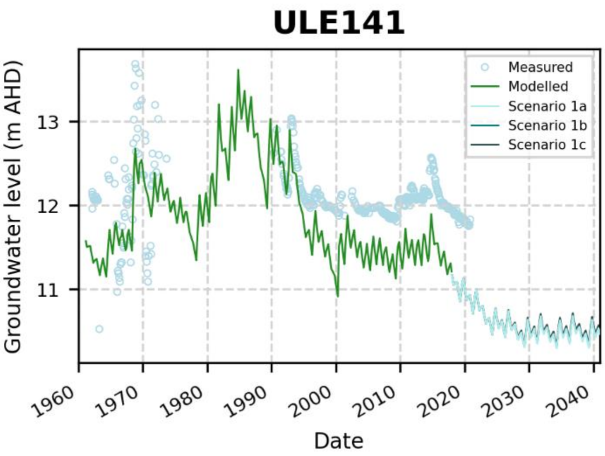
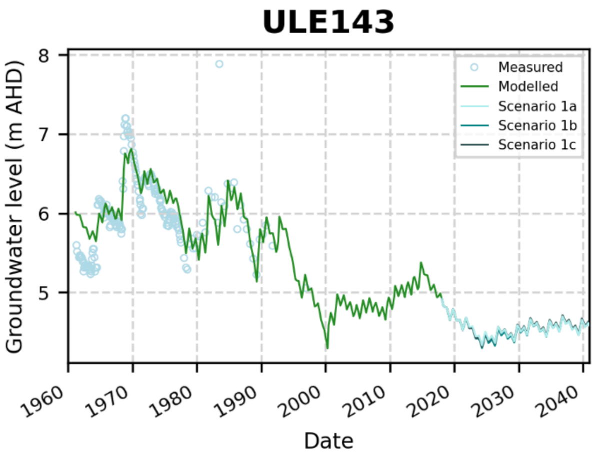
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c

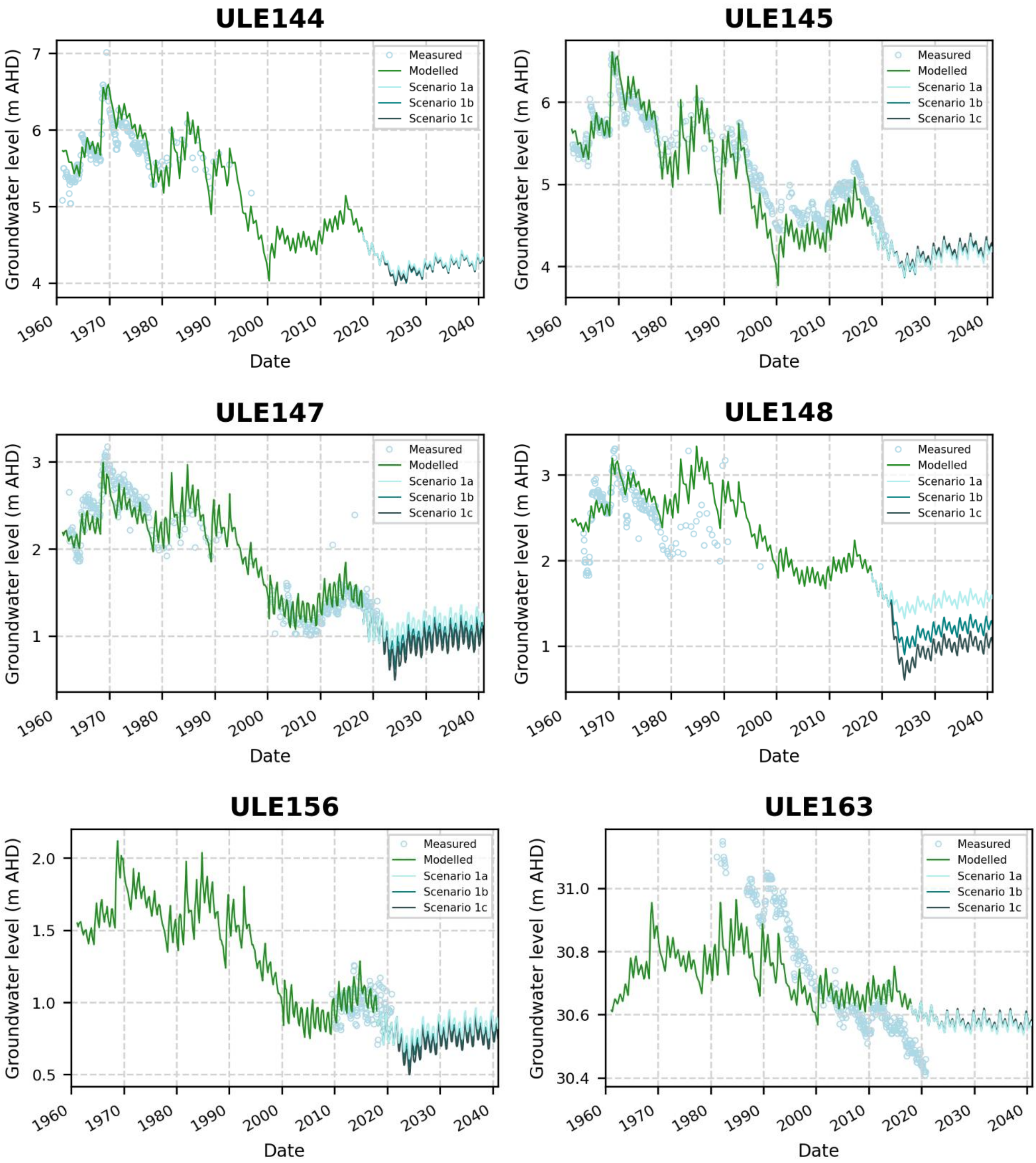

ULE138
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c

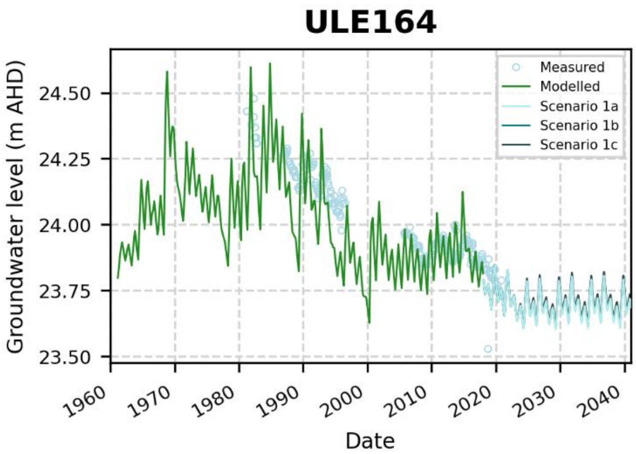

ULE139
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c

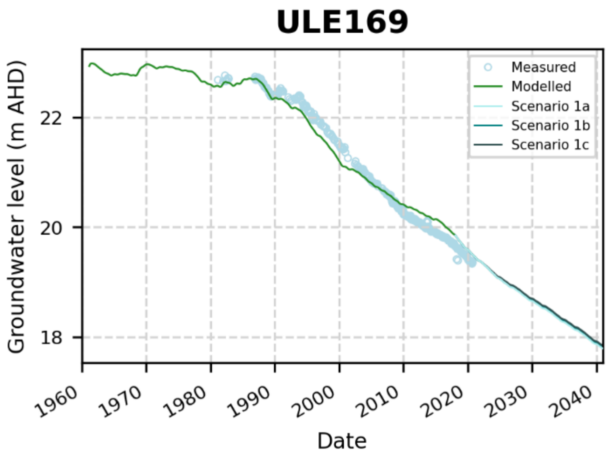

ULE140
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c

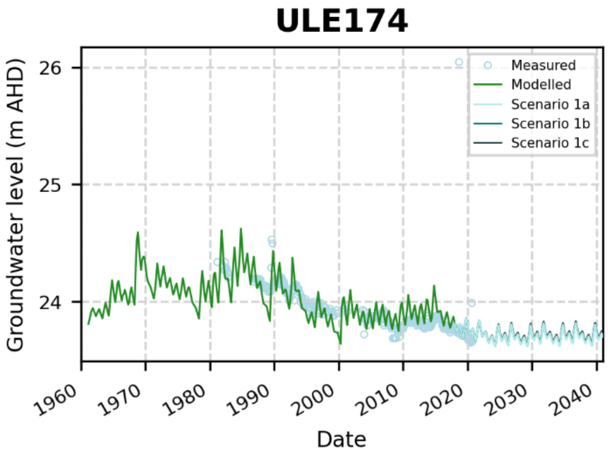

ULE141
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c

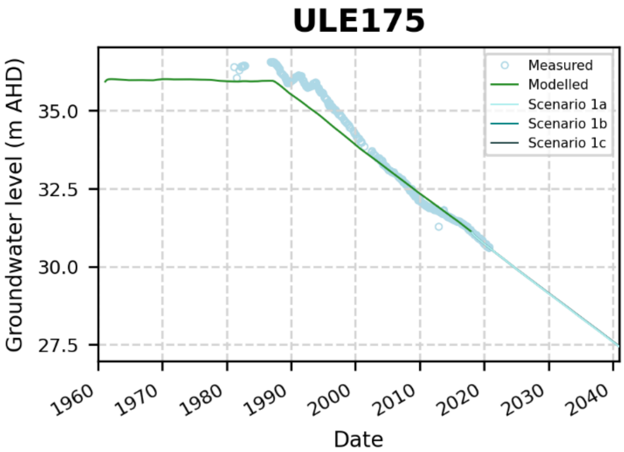

ULE143
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c

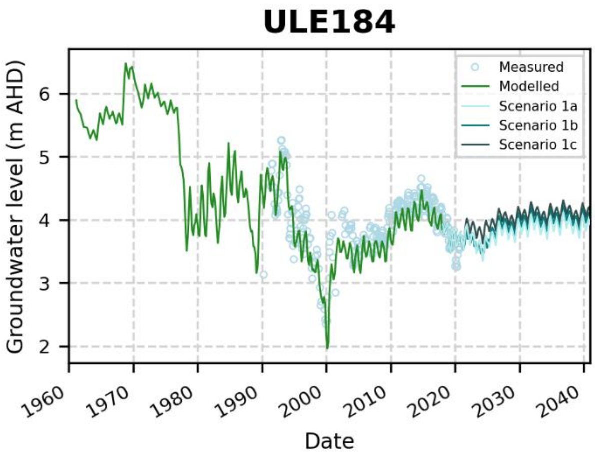

ULE144
ULE145
ULE147
ULE148
ULE156
ULE163
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c
Groundwater level (m AHD)
Date

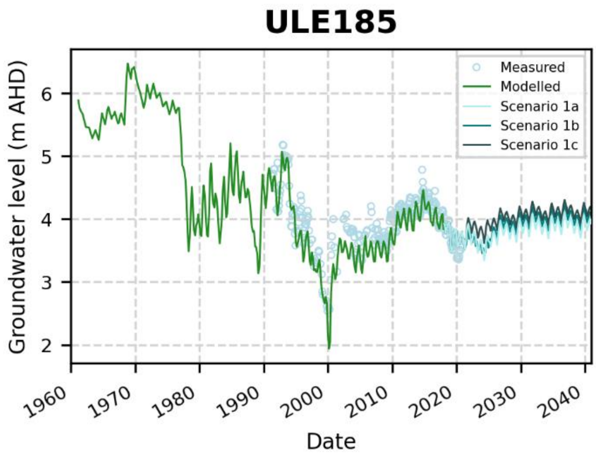

ULE164
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c
Groundwater level (m AHD)
24.50
24.25
24.00
23.75
23.50
1960 1970 1980 1990 2000 2010 2020 2030 2040
Date

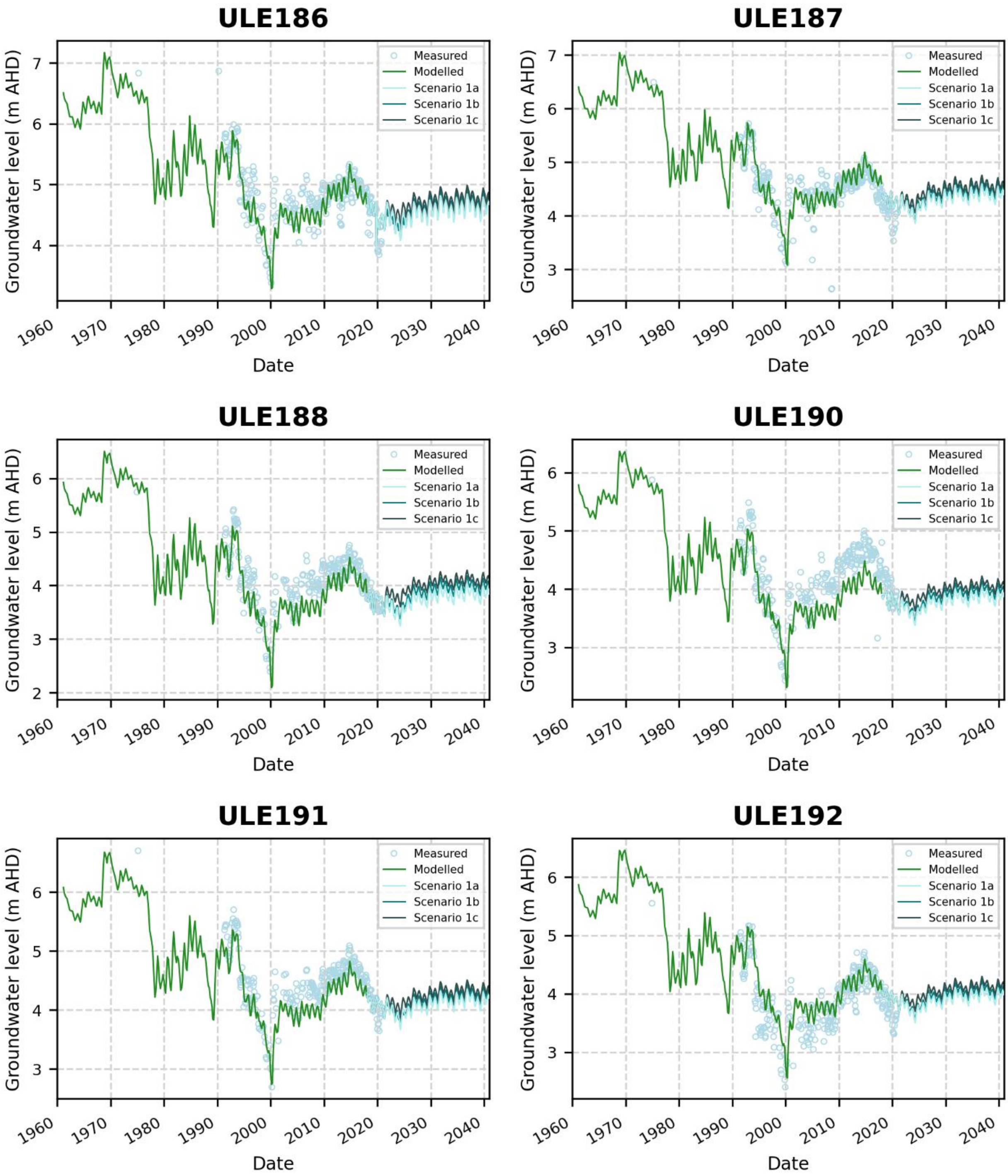

ULE169
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c
Groundwater level (m AHD)
22
20
18
1960 1970 1980 1990 2000 2010 2020 2030 2040
Date

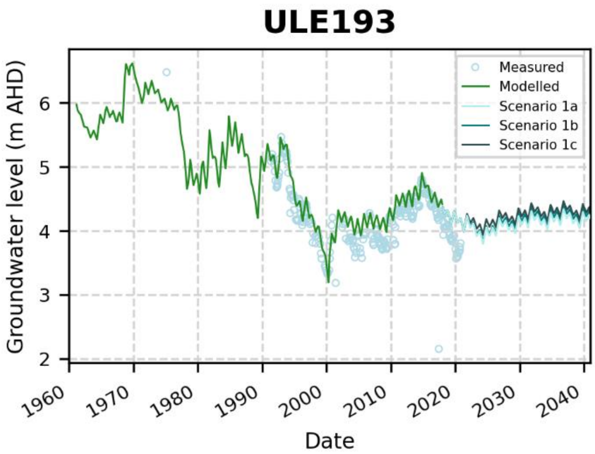

ULE174
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c
Groundwater level (m AHD)
26
25
24
1960 1970 1980 1990 2000 2010 2020 2030 2040
Date

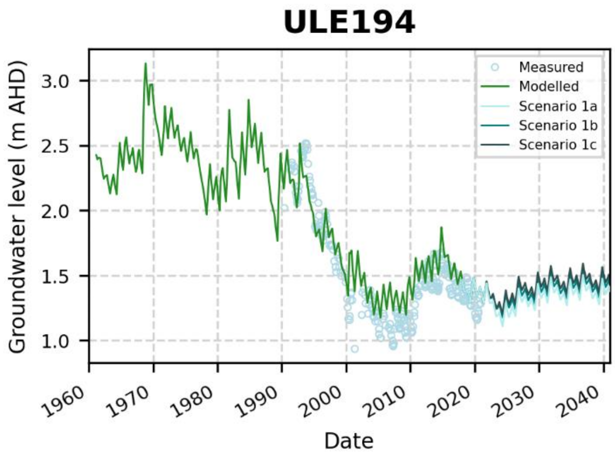

ULE175
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c
Groundwater level (m AHD)
35.0
32.5
30.0
27.5
1960 1970 1980 1990 2000 2010 2020 2030 2040
Date

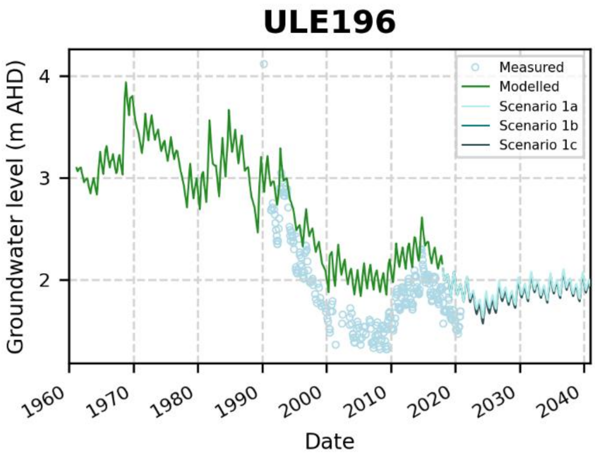

ULE184
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c
Groundwater level (m AHD)
6
5
4
3
2
1960 1970 1980 1990 2000 2010 2020 2030 2040
Date

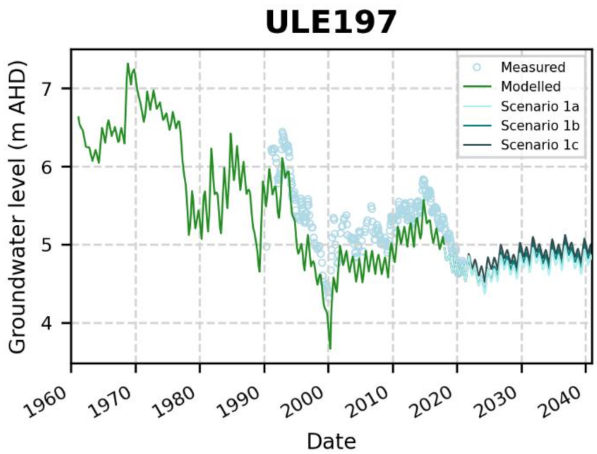

ULE185
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c
Groundwater level (m AHD)
6
5
4
3
2
1960 1970 1980 1990 2000 2010 2020 2030 2040
Date

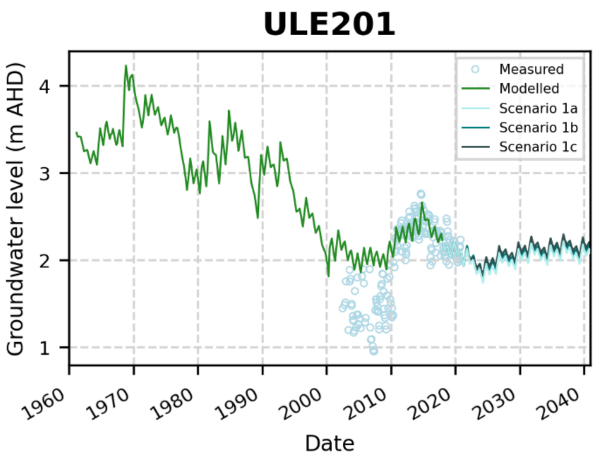

ULE186
ULE187
ULE188
ULE190
ULE191
ULE192
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c
Groundwater level (m AHD)
Date
1960
1970
1980
1990
2000
2010
2020
2030
2040

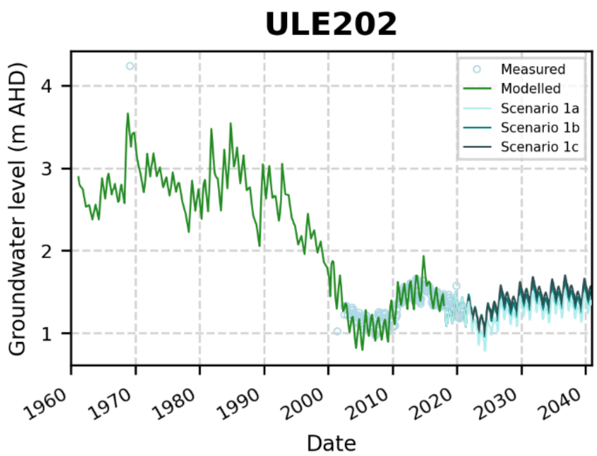

ULE193
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c
Groundwater level (m AHD)
Date

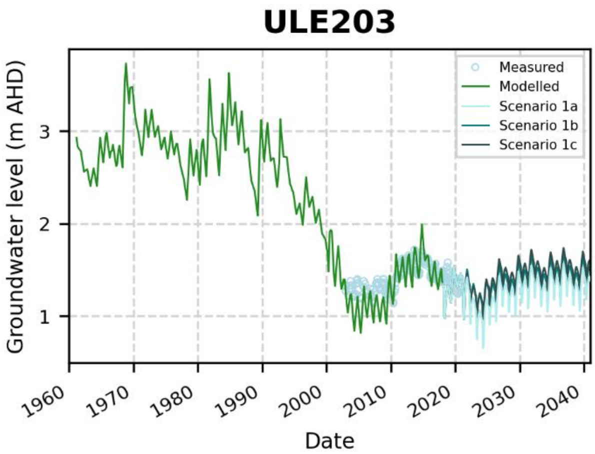

ULE194
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c
Groundwater level (m AHD)
Date

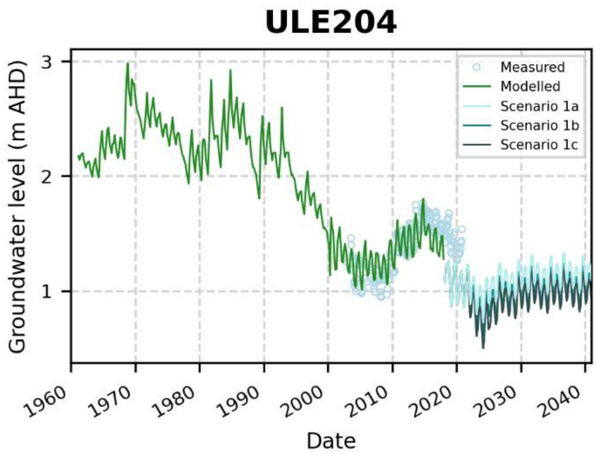

ULE196
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c
Groundwater level (m AHD)
Date

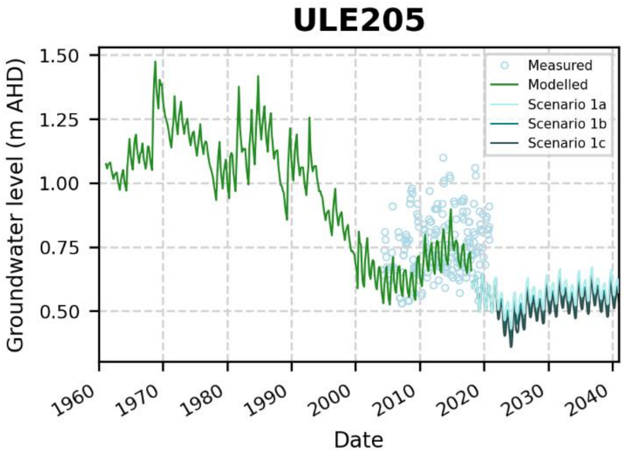

ULE197
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c
Groundwater level (m AHD)
Date

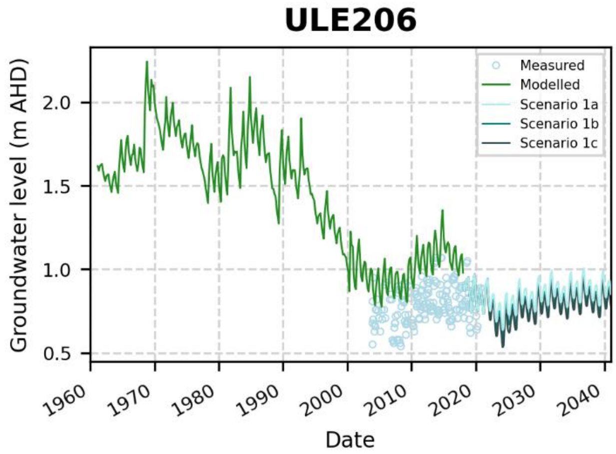

ULE201
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c
Groundwater level (m AHD)
Date

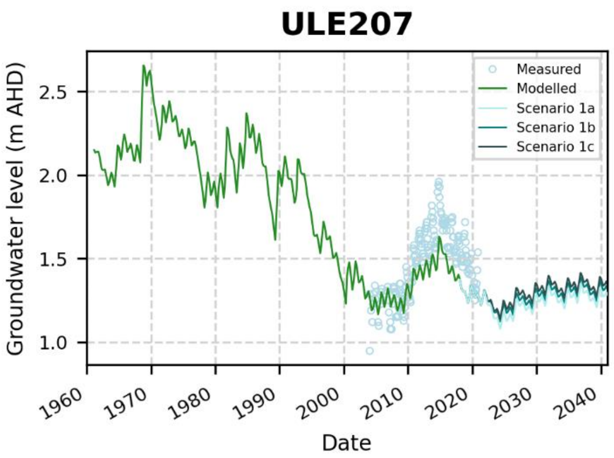

ULE202
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c
Groundwater level (m AHD)
Date

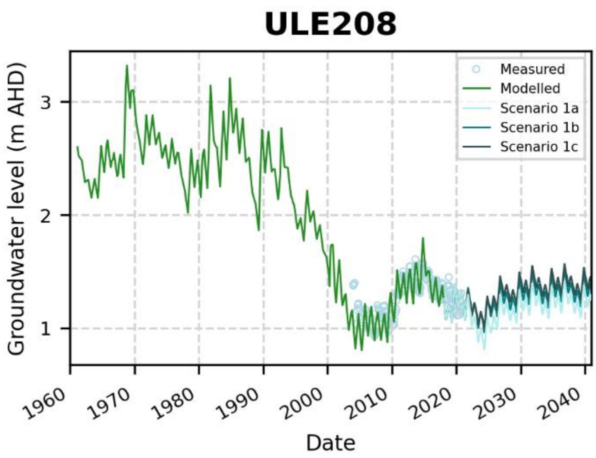

ULE203
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c
1
2
3
1960
1970
1980
1990
2000
2010
2020
2030
2040

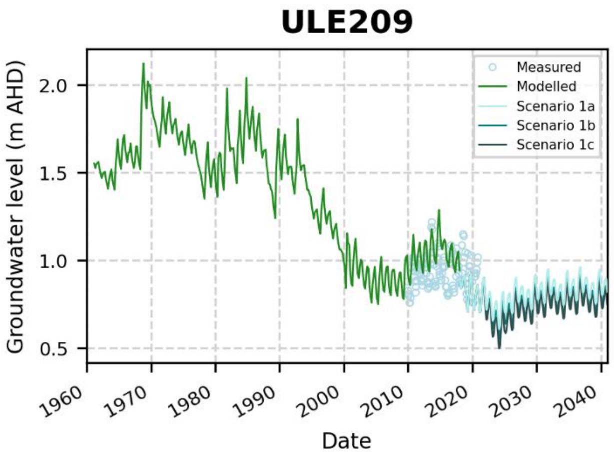

ULE204
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c
1
2
3
1960
1970
1980
1990
2000
2010
2020
2030
2040

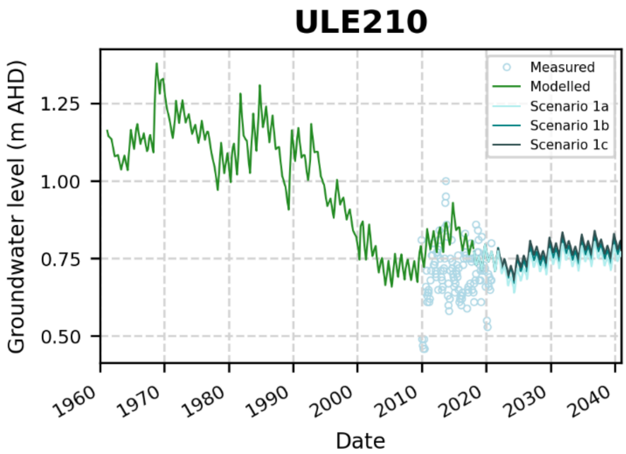

ULE205
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c
0.50
0.75
1.00
1.25
1.50
1960
1970
1980
1990
2000
2010
2020
2030
2040

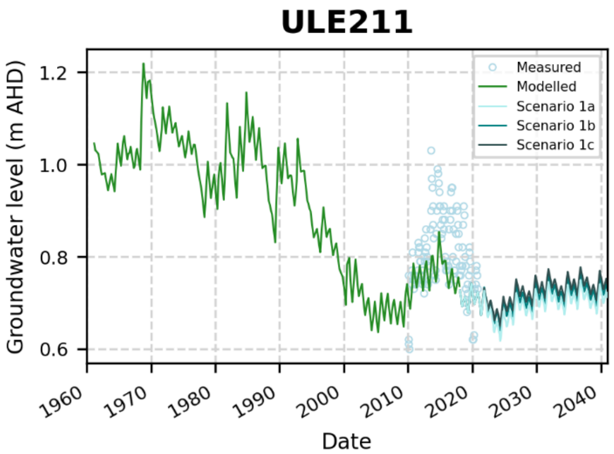

ULE206
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c
0.5
1.0
1.5
2.0
1960
1970
1980
1990
2000
2010
2020
2030
2040

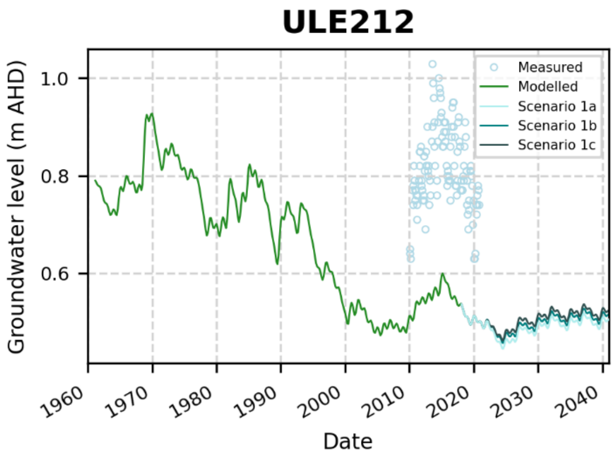

ULE207
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c
1.0
1.5
2.0
2.5
1960
1970
1980
1990
2000
2010
2020
2030
2040

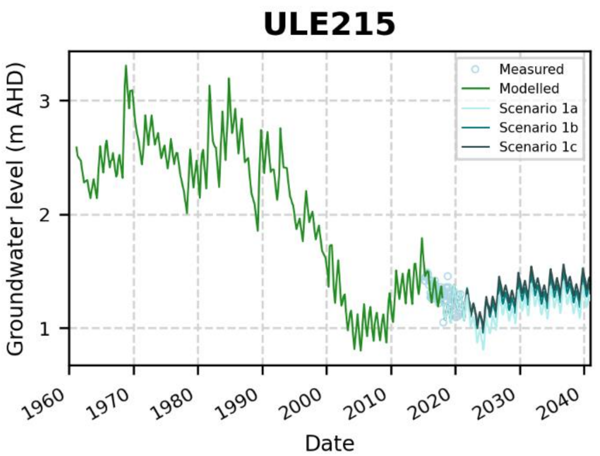

ULE208
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c
1
2
3
1960
1970
1980
1990
2000
2010
2020
2030
2040


ULE209
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c
Groundwater level (m AHD)
Date

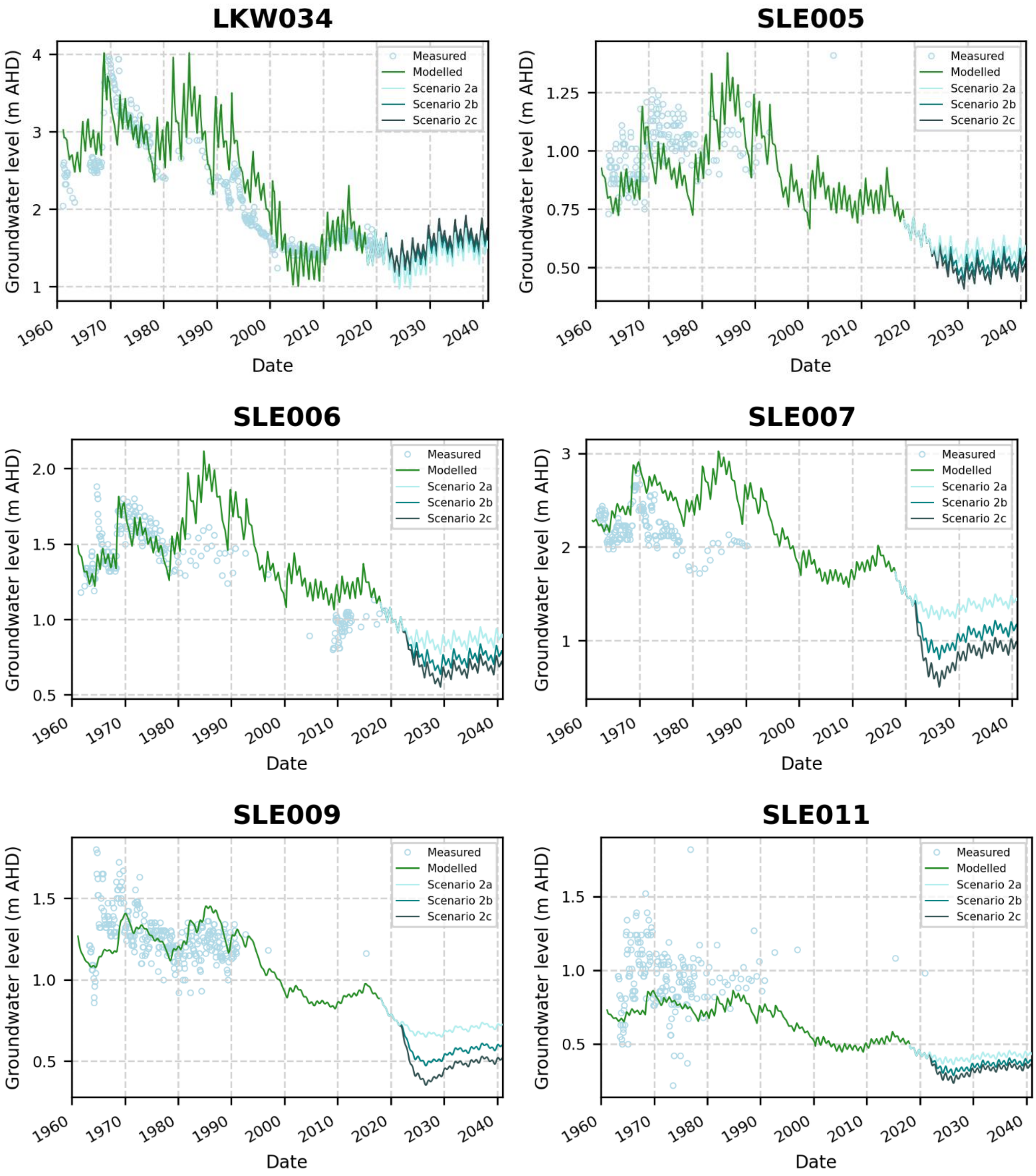

ULE210
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c
Groundwater level (m AHD)
Date

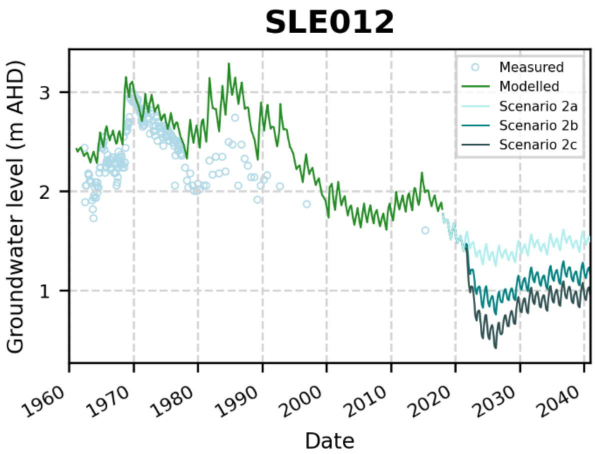

ULE211
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c
Groundwater level (m AHD)
Date

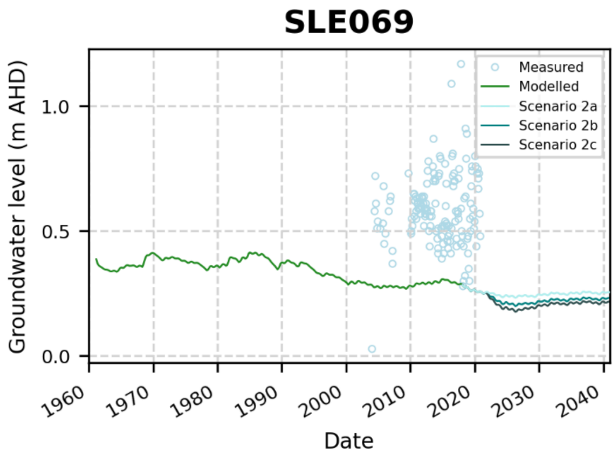

ULE212
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c
Groundwater level (m AHD)
Date

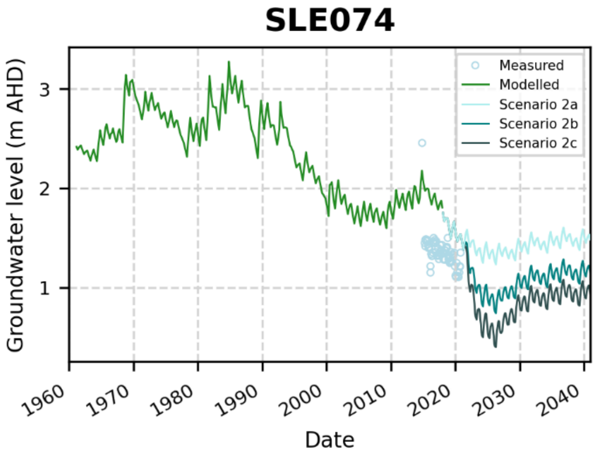

ULE215
Measured
Modelled
Scenario 1a
Scenario 1b
Scenario 1c
Groundwater level (m AHD)
Date

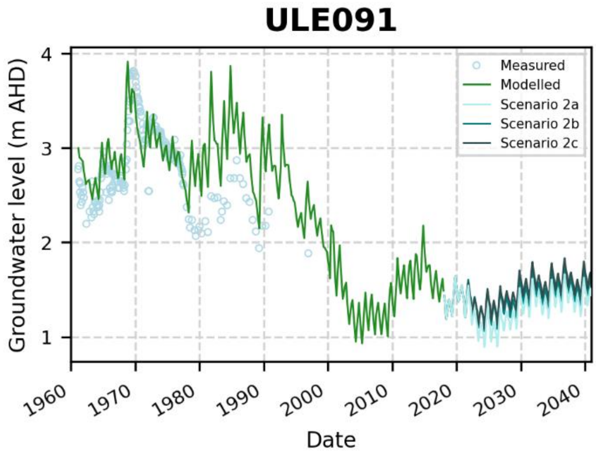
C. Scenario 2 groundwater level results

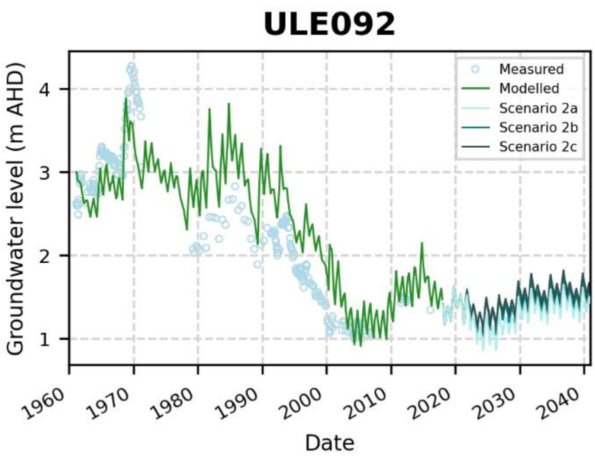


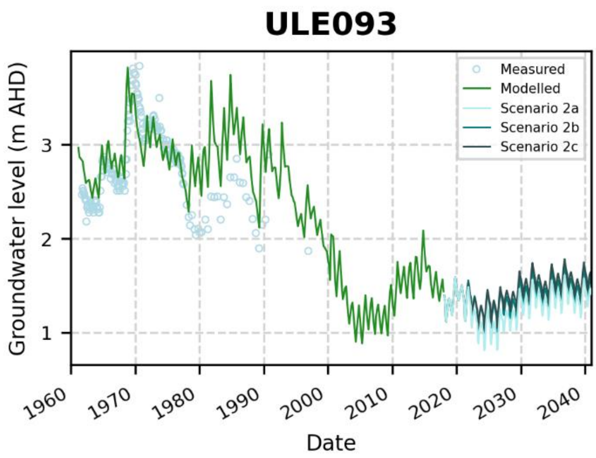

SLE012
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c

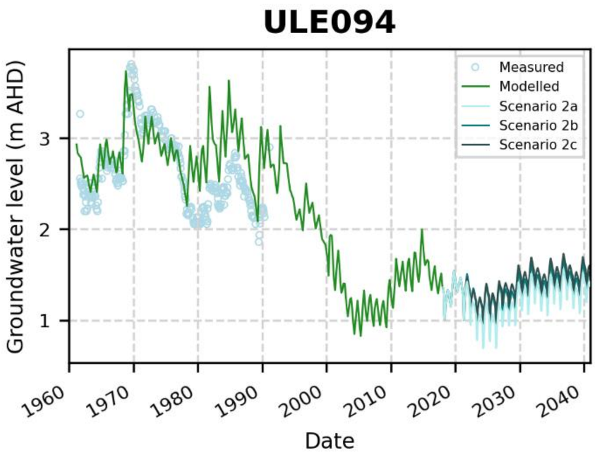

SLE069
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c

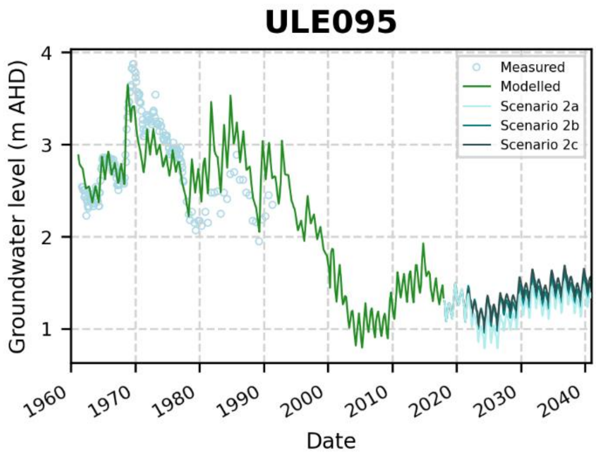

SLE074
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c

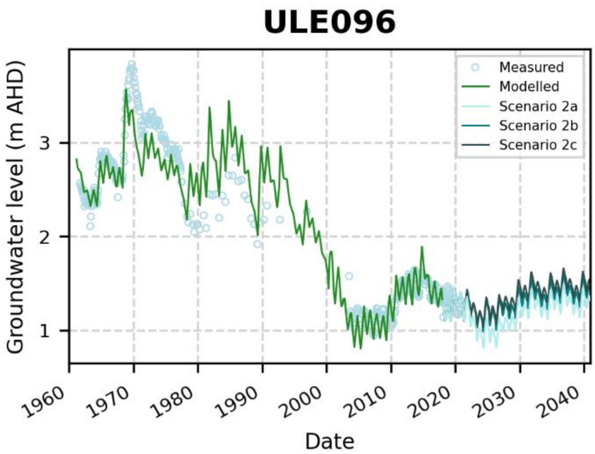

ULE091
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c

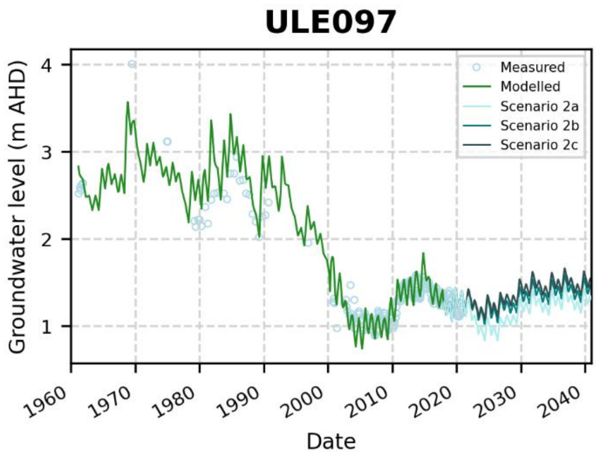

ULE092
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c

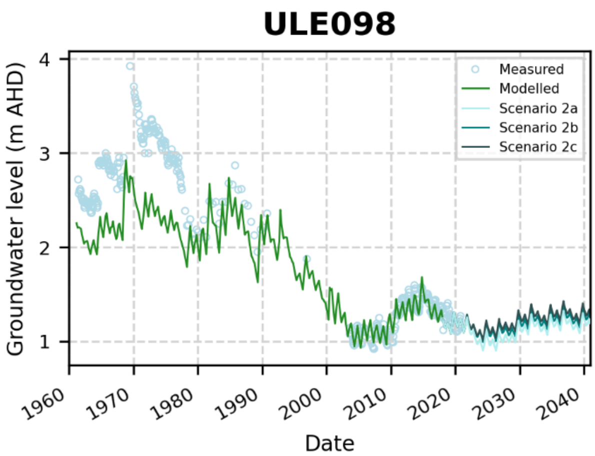

ULE093
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c

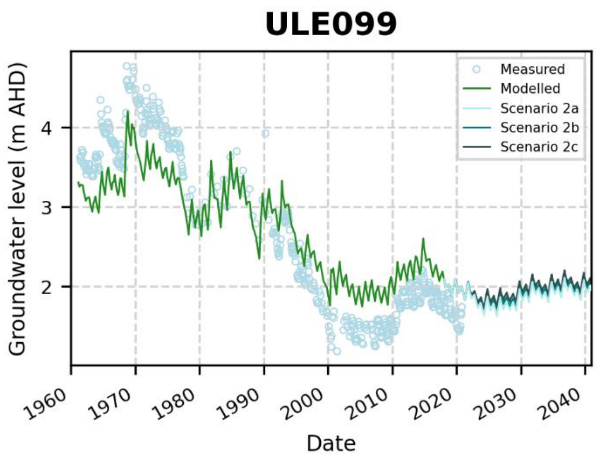

ULE094
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c

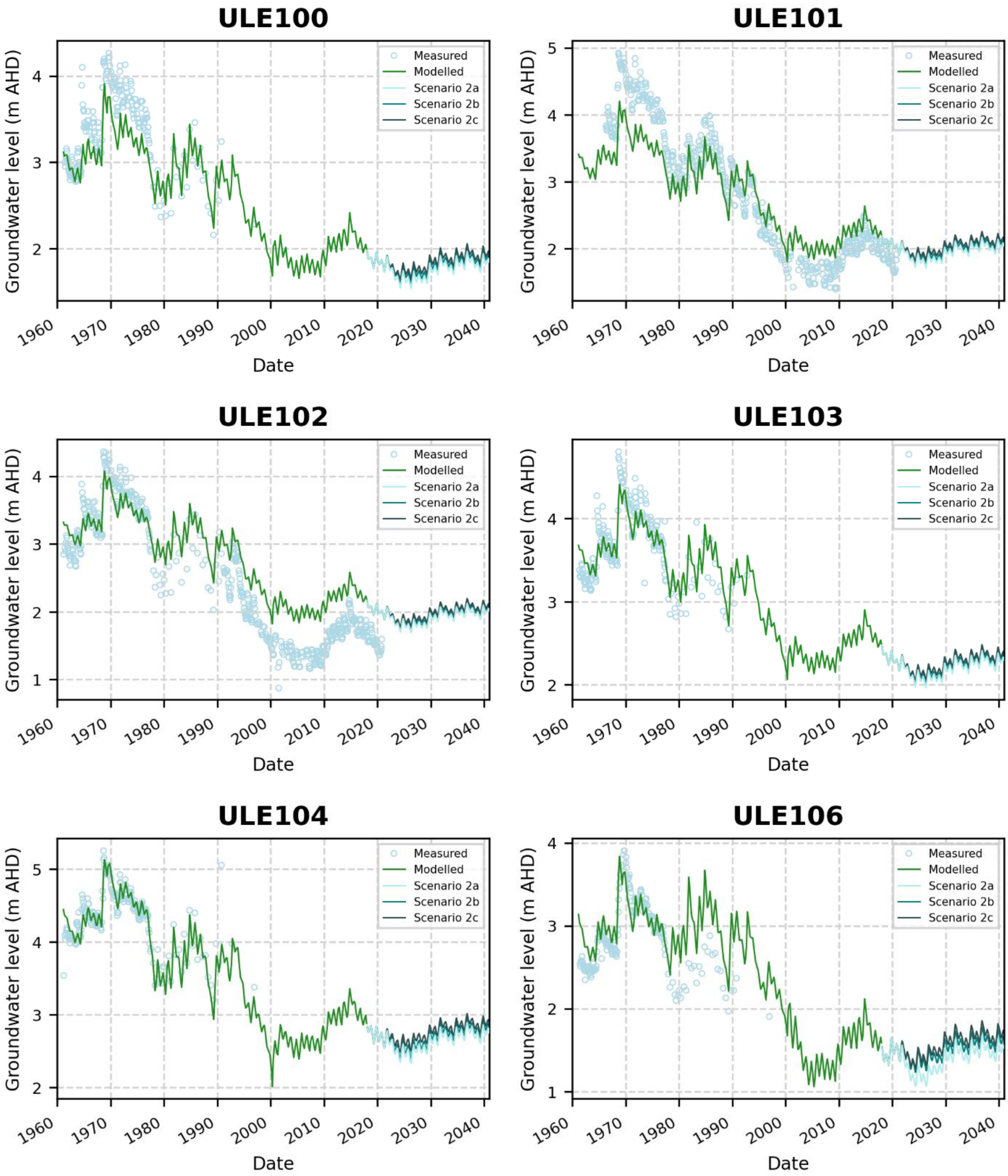

ULE095
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c

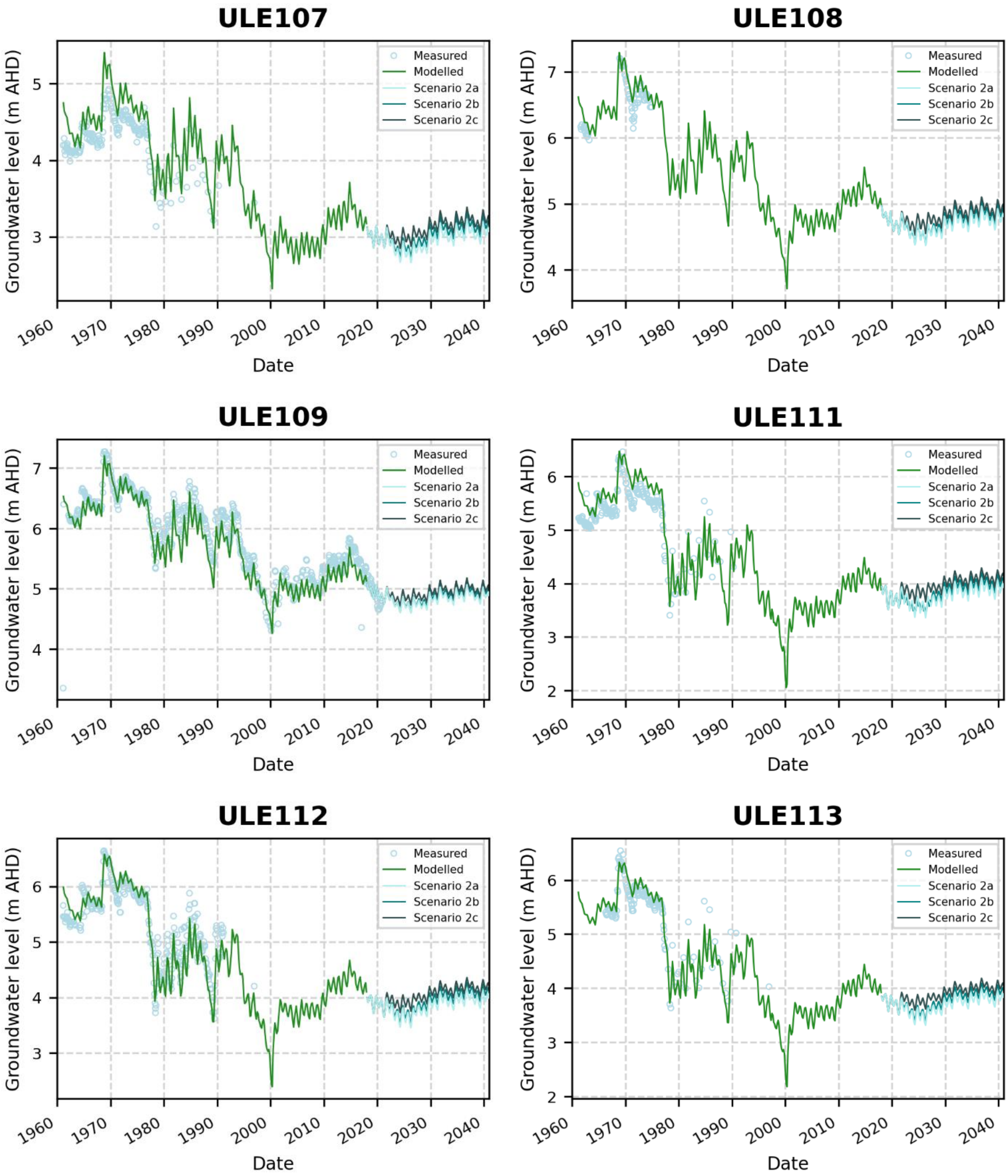

ULE096
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c

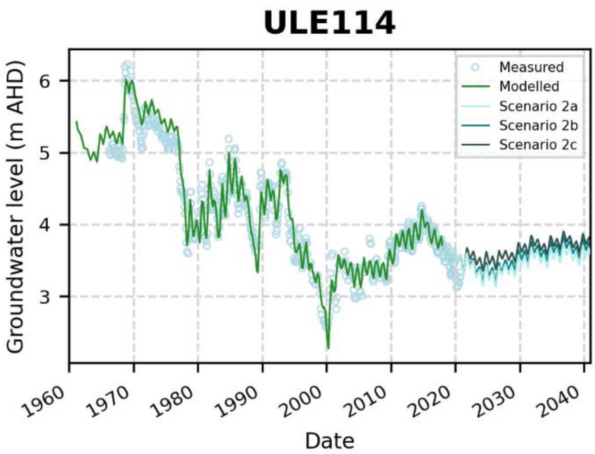

ULE097
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c

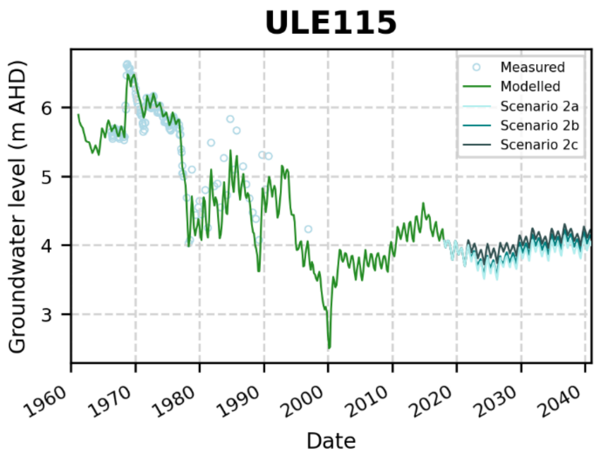

ULE098
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c

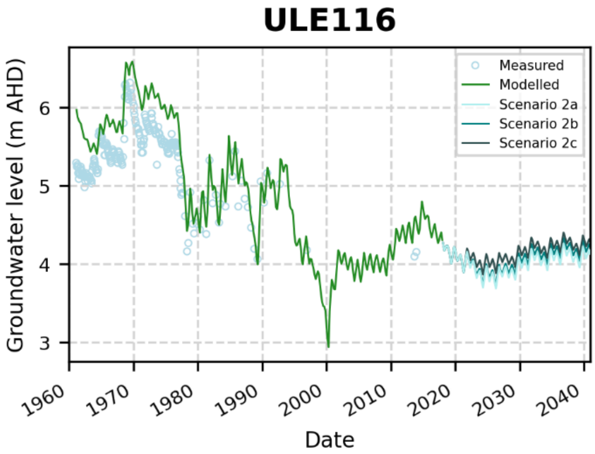

ULE099
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c

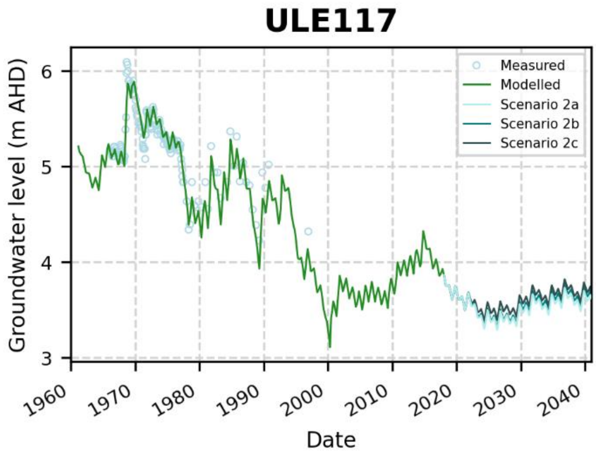

ULE100
ULE101
ULE102
ULE103
ULE104
ULE106
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c
Groundwater level (m AHD)
Date

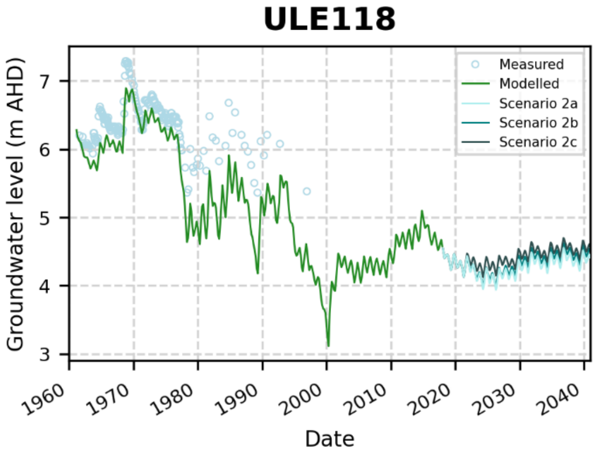

ULE107
ULE108
ULE109
ULE111
ULE112
ULE113
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c
Groundwater level (m AHD)
Date
1960 1970 1980 1990 2000 2010 2020 2030 2040

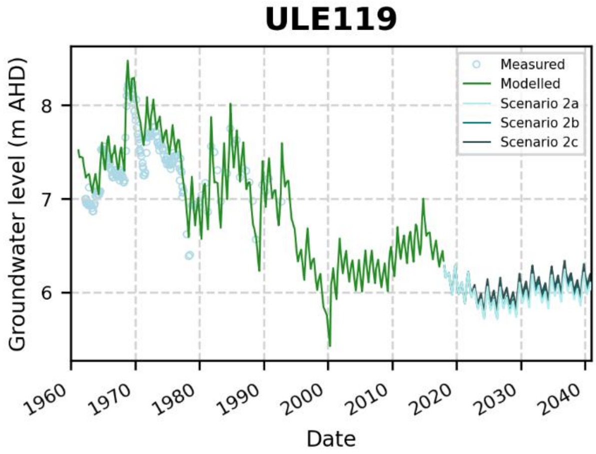

ULE114
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c
1960
1970
1980
1990
2000
2010
2020
2030
2040
3
4
5
6

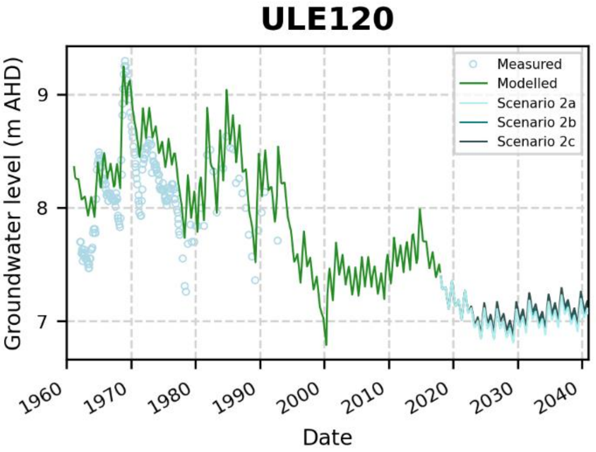

ULE115
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c
1960
1970
1980
1990
2000
2010
2020
2030
2040
3
4
5
6

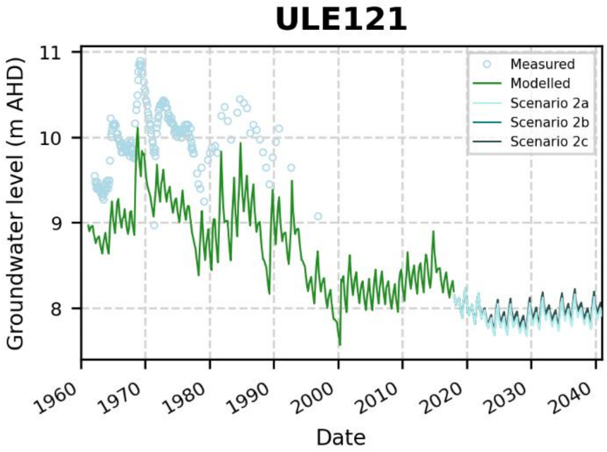

ULE116
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c
1960
1970
1980
1990
2000
2010
2020
2030
2040
3
4
5
6

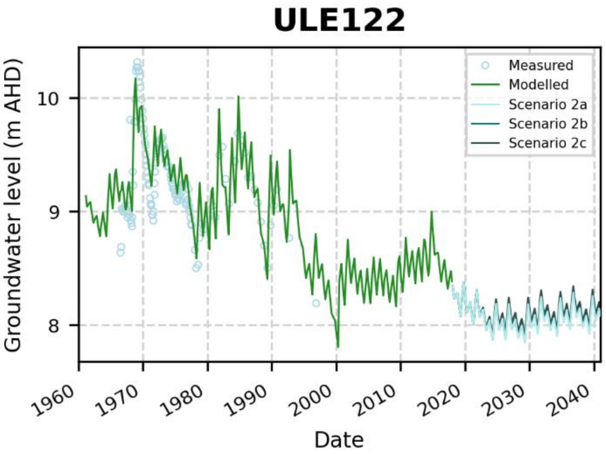

ULE117
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c
1960
1970
1980
1990
2000
2010
2020
2030
2040
3
4
5
6

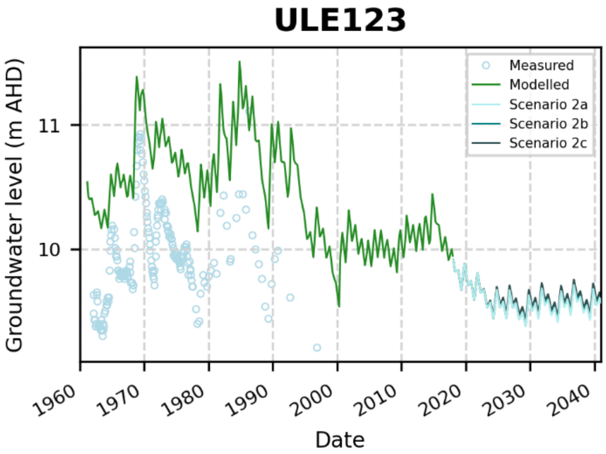

ULE118
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c
1960
1970
1980
1990
2000
2010
2020
2030
2040
3
4
5
6
7

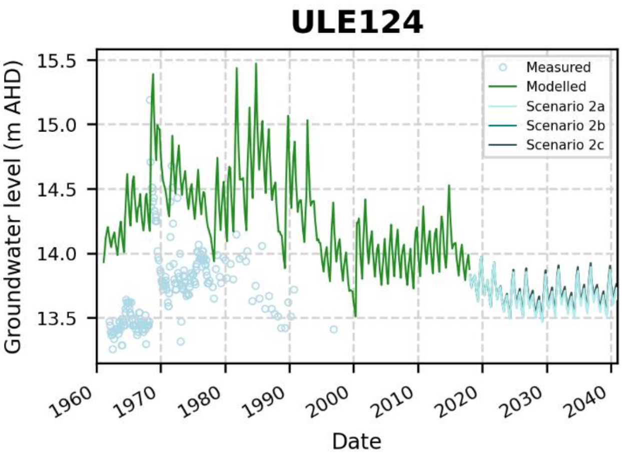

ULE119
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c
1960
1970
1980
1990
2000
2010
2020
2030
2040
6
7
8

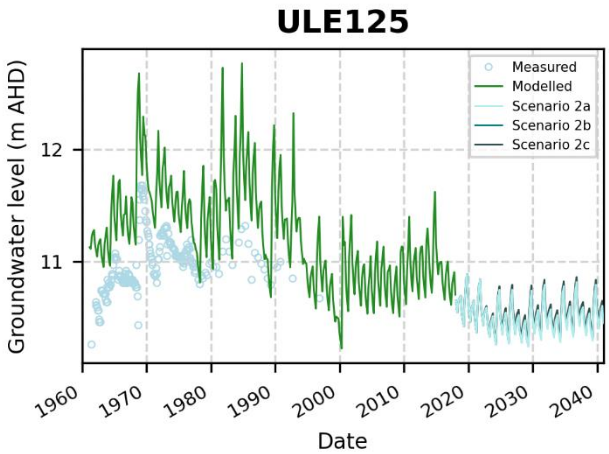

ULE120
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c
Groundwater level (m AHD)
Date

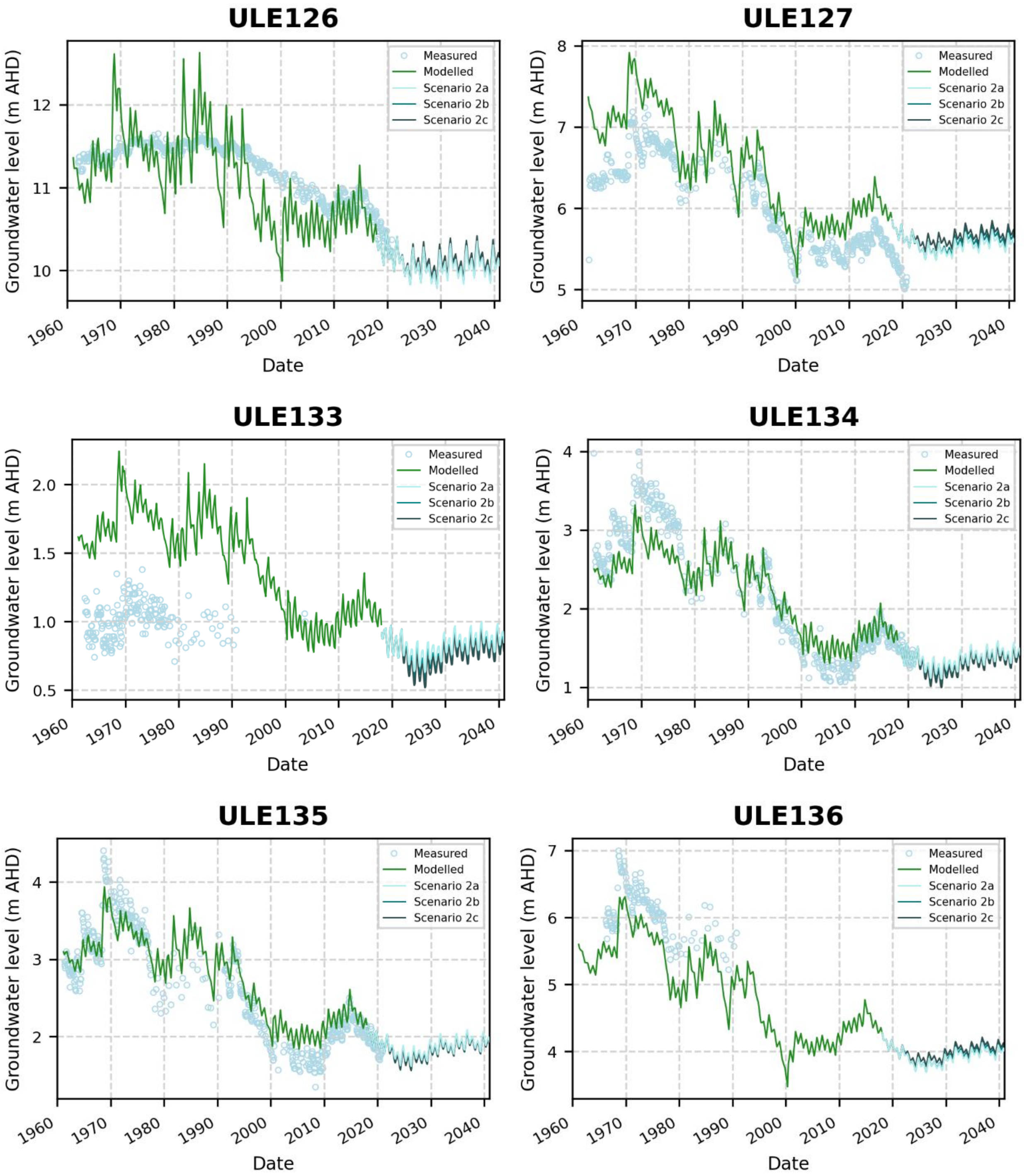

ULE121
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c
Groundwater level (m AHD)
Date

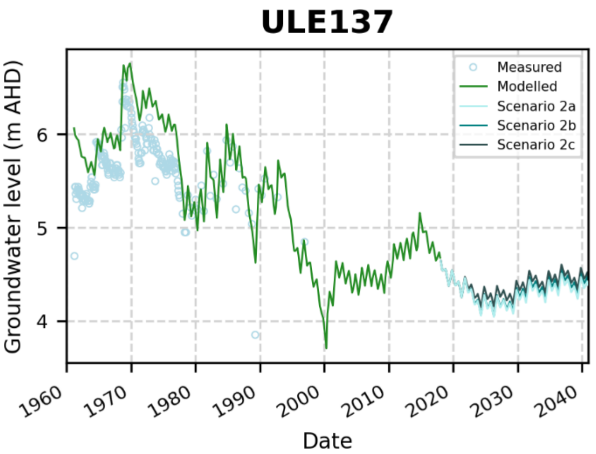

ULE122
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c
Groundwater level (m AHD)
Date

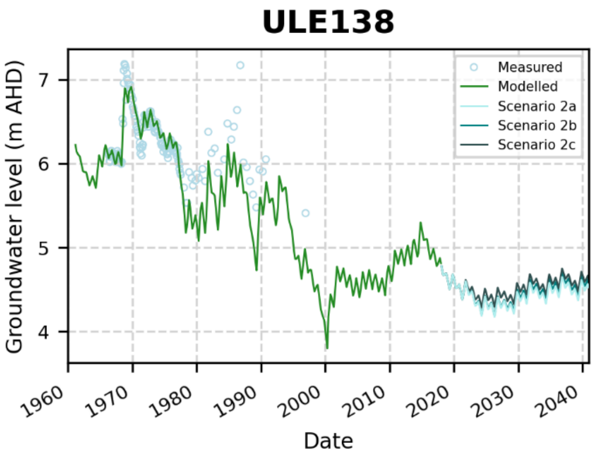

ULE123
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c
Groundwater level (m AHD)
Date

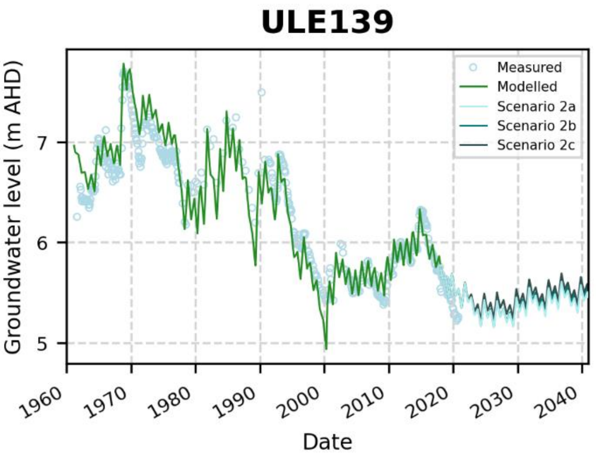

ULE124
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c
Groundwater level (m AHD)
Date

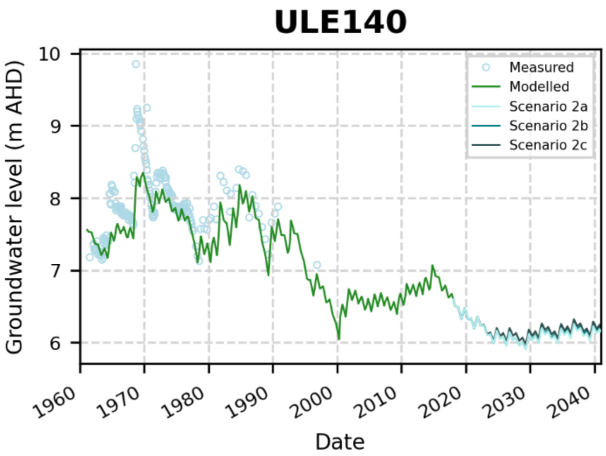

ULE125
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c
Groundwater level (m AHD)
Date

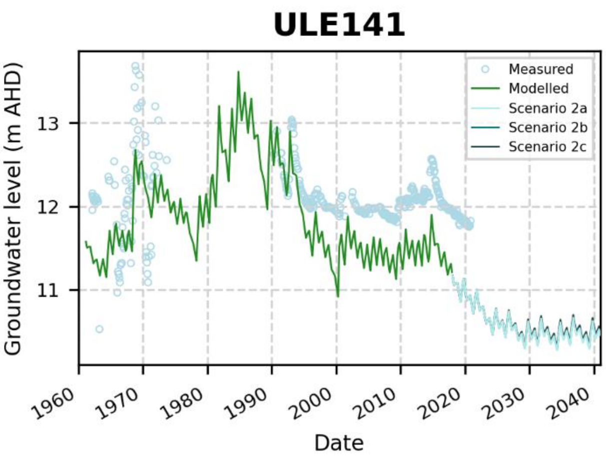

ULE126
ULE127
ULE133
ULE134
ULE135
ULE136
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c
1960
1970
1980
1990
2000
2010
2020
2030
2040

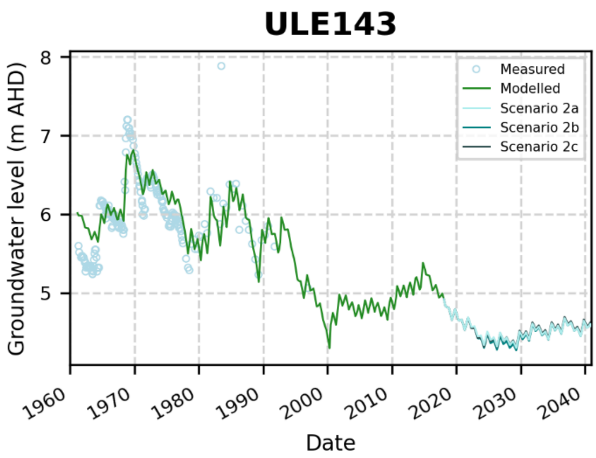

ULE137
Groundwater level (m AHD)
4
5
6
Date
1960
1970
1980
1990
2000
2010
2020
2030
2040
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c

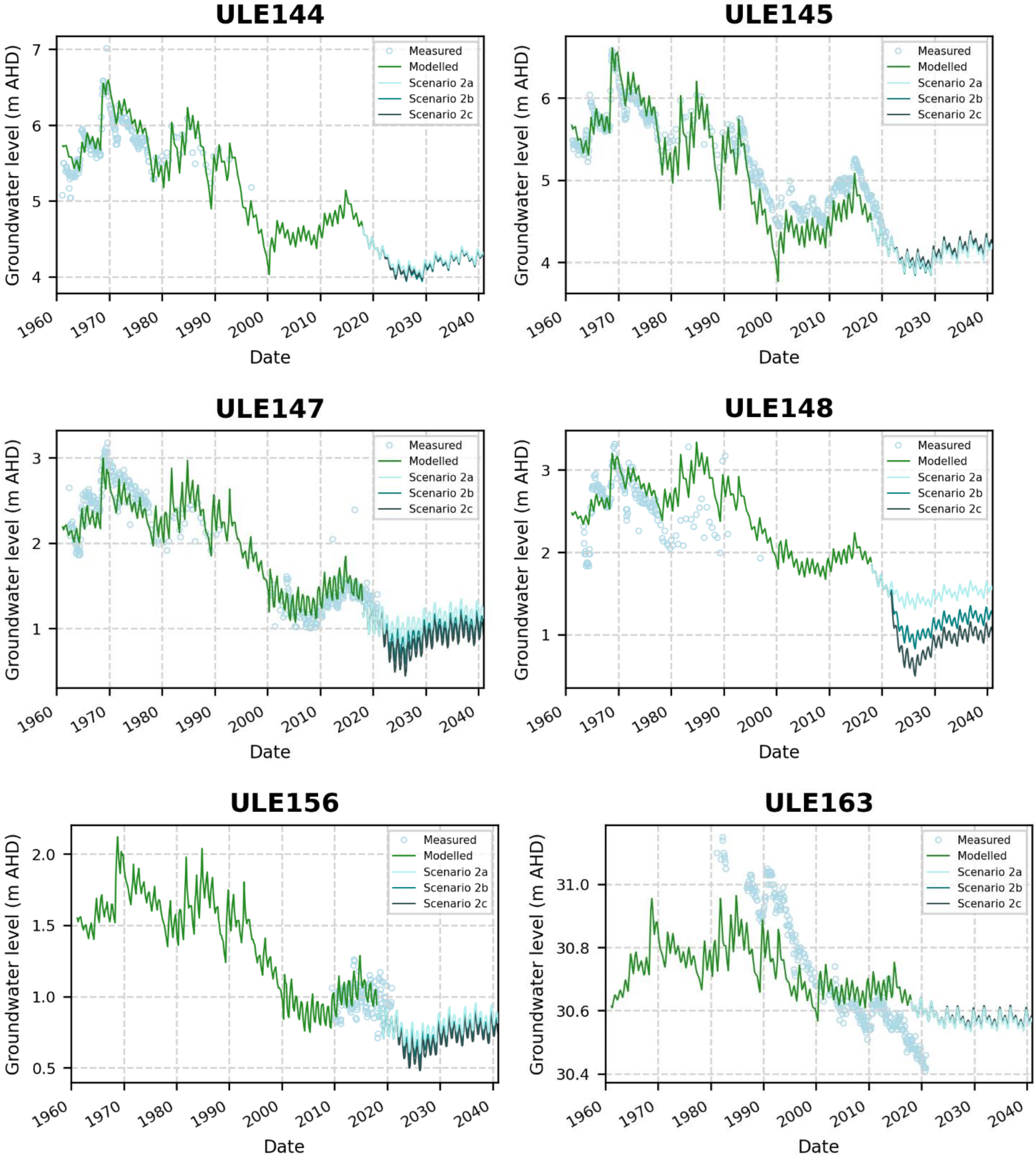

ULE138
Groundwater level (m AHD)
4
5
6
7
Date
1960
1970
1980
1990
2000
2010
2020
2030
2040
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c

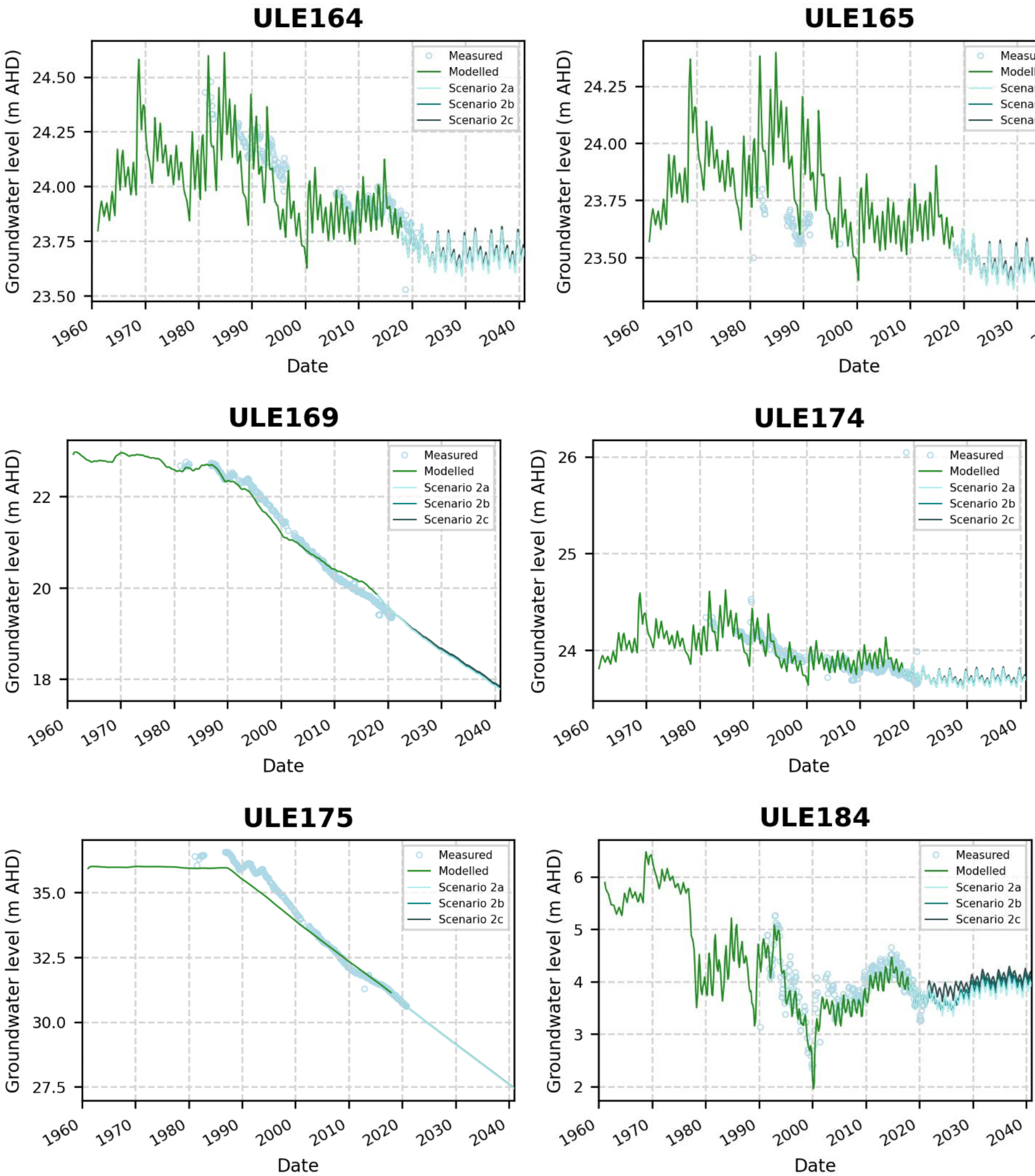

ULE139
Groundwater level (m AHD)
5
6
7
Date
1960
1970
1980
1990
2000
2010
2020
2030
2040
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c

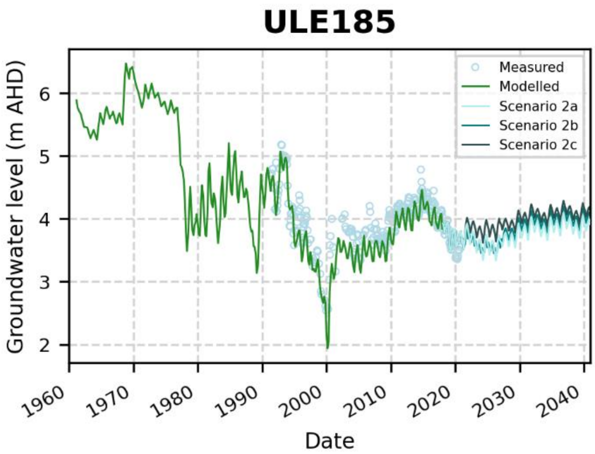

ULE140
Groundwater level (m AHD)
6
7
8
9
10
Date
1960
1970
1980
1990
2000
2010
2020
2030
2040
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c

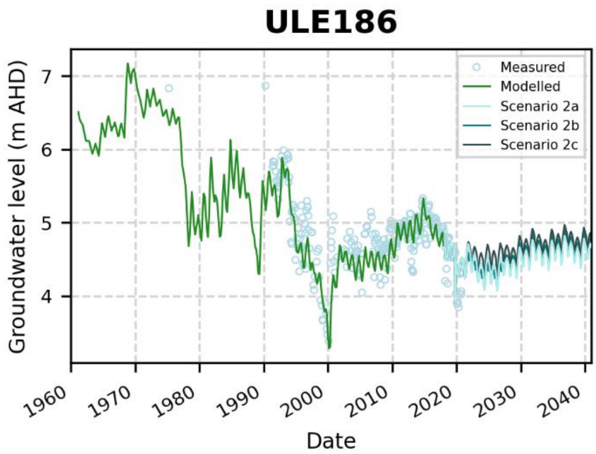

ULE141
Groundwater level (m AHD)
11
12
13
Date
1960
1970
1980
1990
2000
2010
2020
2030
2040
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c

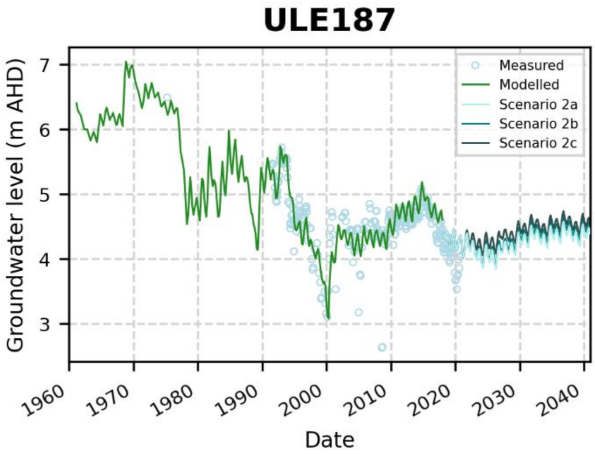

ULE143
Groundwater level (m AHD)
5
6
7
8
Date
1960
1970
1980
1990
2000
2010
2020
2030
2040
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c

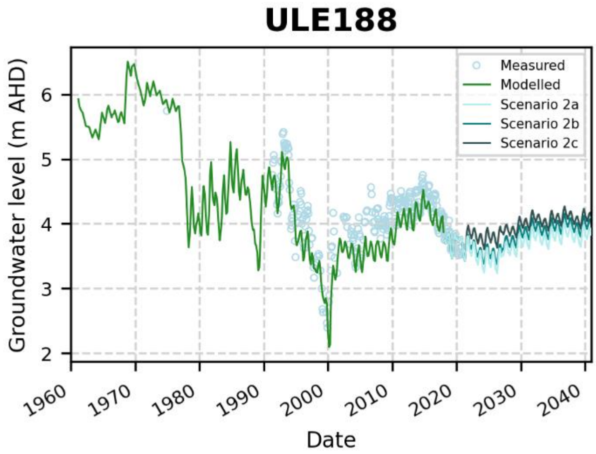

ULE144
ULE145
ULE147
ULE148
ULE156
ULE163
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c
1960
1970
1980
1990
2000
2010
2020
2030
2040

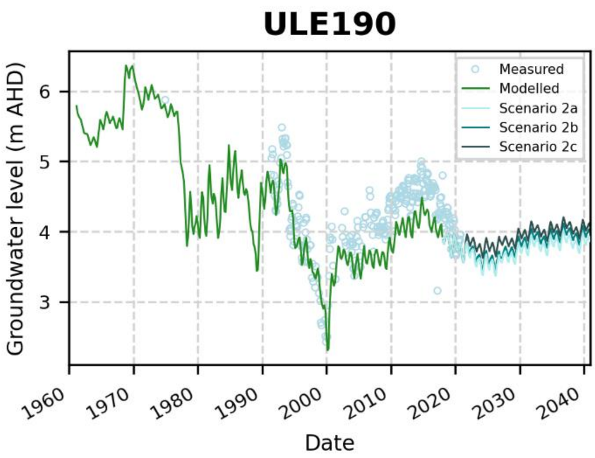

ULE164
ULE165
ULE169
ULE174
ULE175
ULE184
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c
Groundwater level (m AHD)
Date

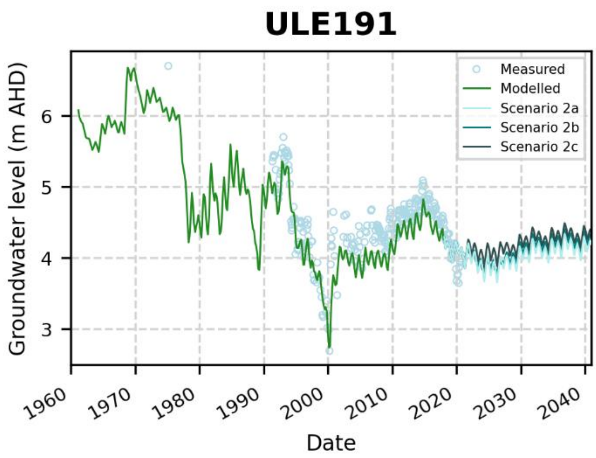

ULE185
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c

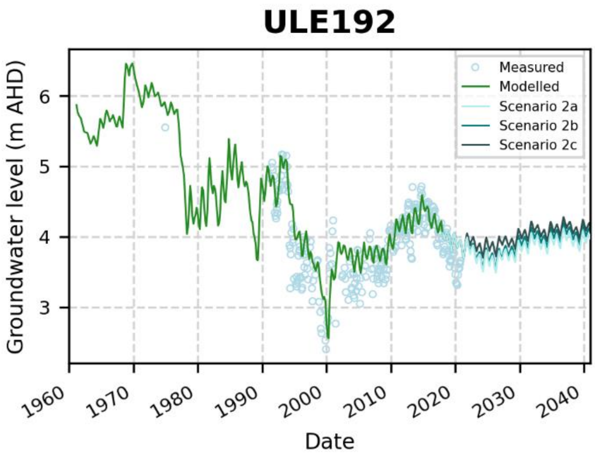

ULE186
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c

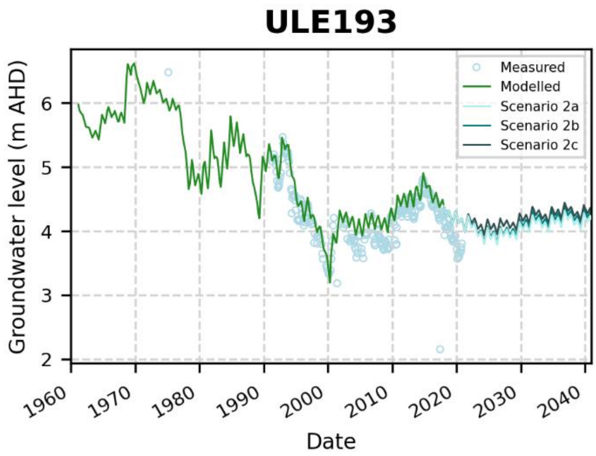

ULE187
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c

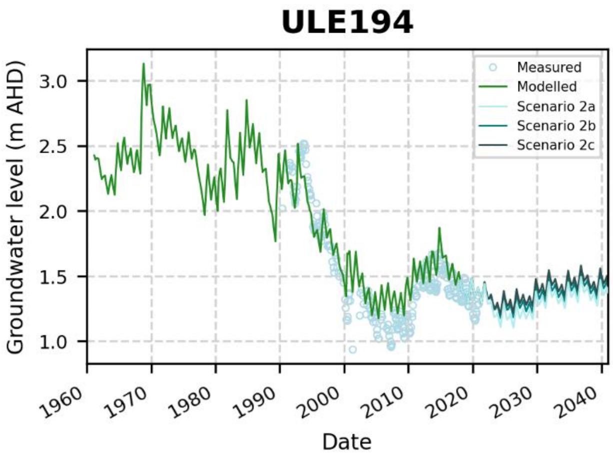

ULE188
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c

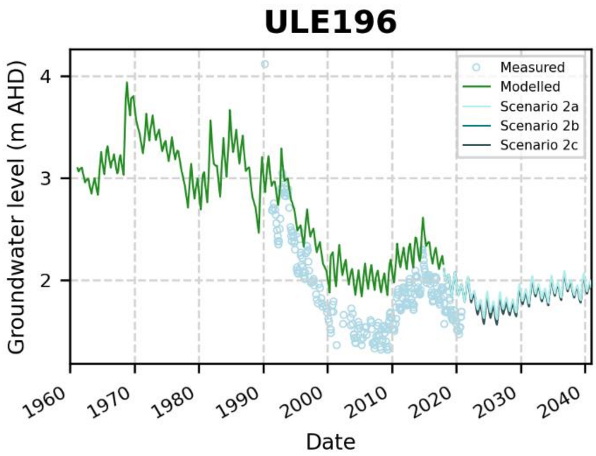

ULE190
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c

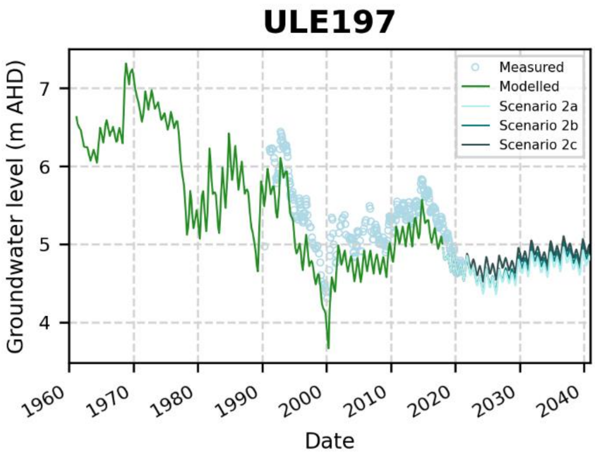

ULE191
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c

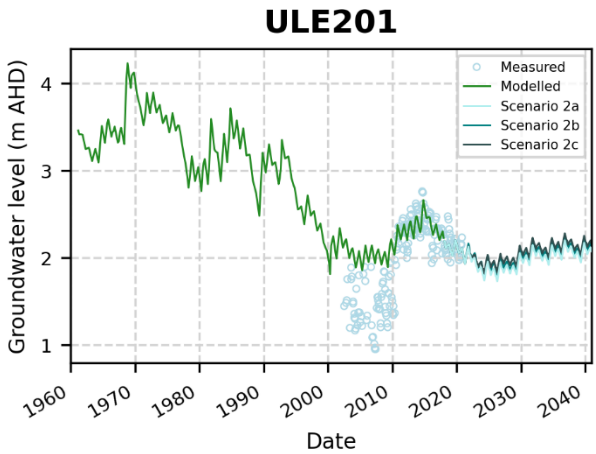

ULE192
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c
Groundwater level (m AHD)
Date

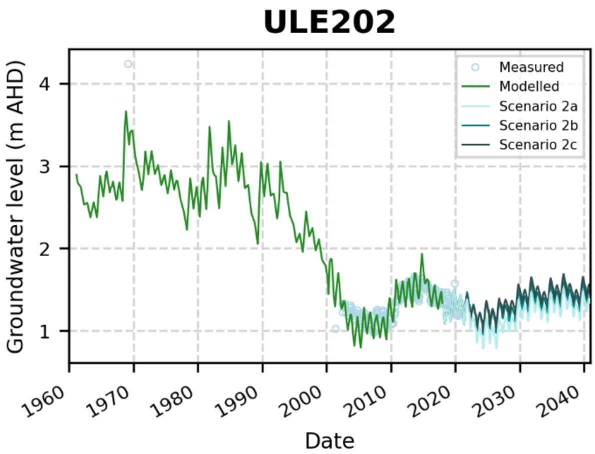

ULE193
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c
Groundwater level (m AHD)
Date

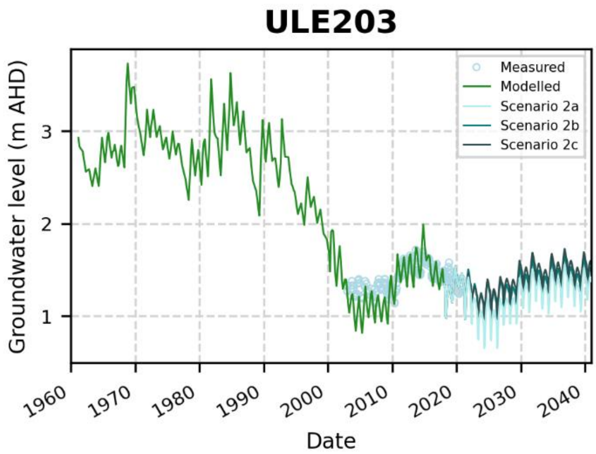

ULE194
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c
Groundwater level (m AHD)
Date

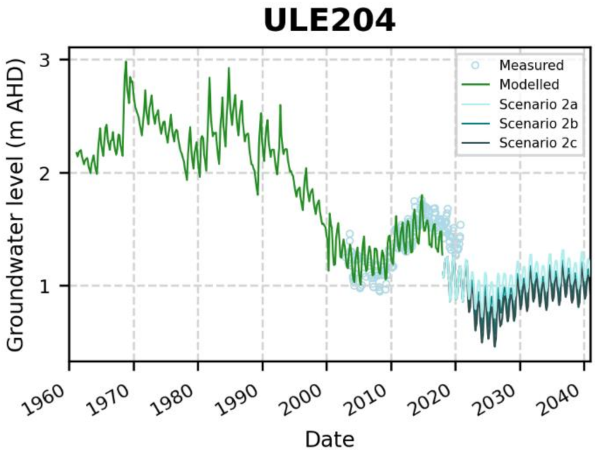

ULE196
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c
Groundwater level (m AHD)
Date

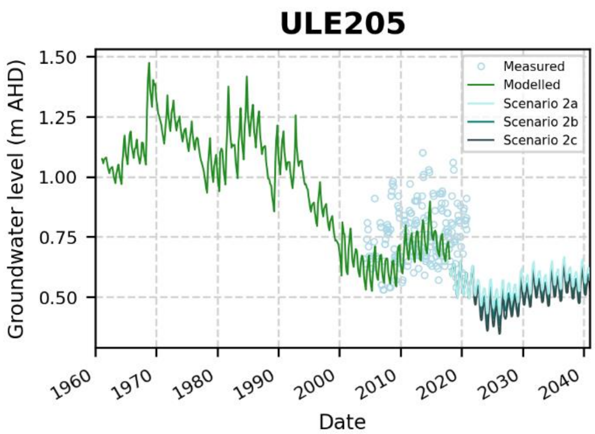

ULE197
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c
Groundwater level (m AHD)
Date

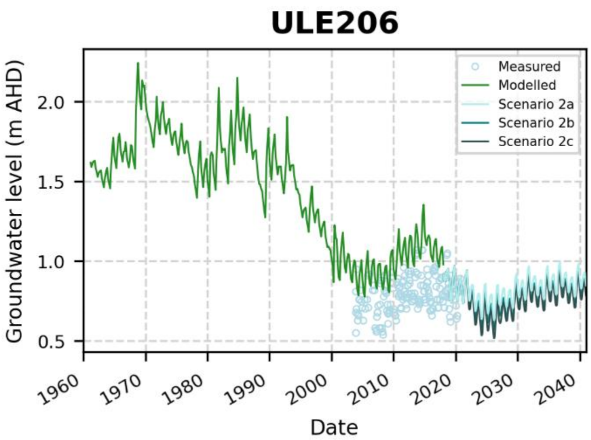

ULE201
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c
Groundwater level (m AHD)
Date

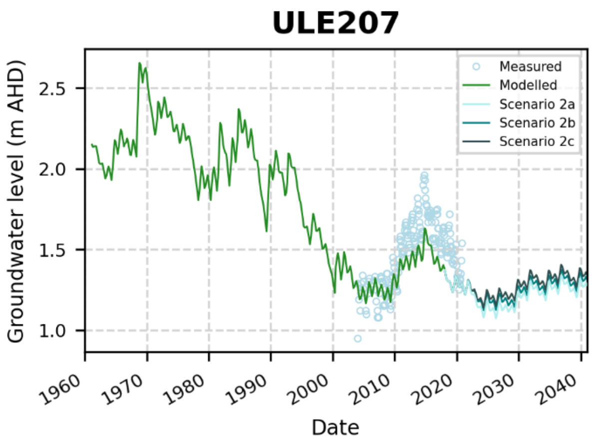

ULE202
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c
1960 1970 1980 1990 2000 2010 2020 2030 2040
1 2 3 4

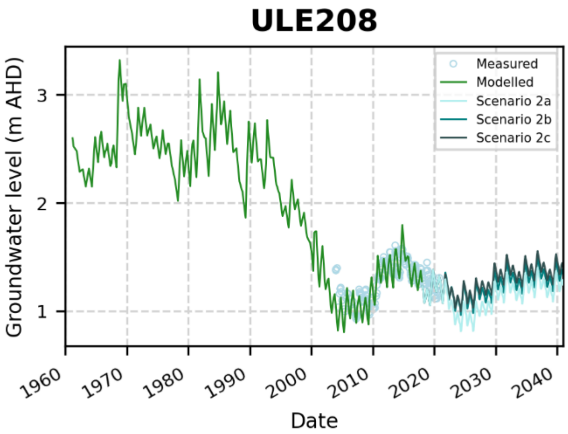

ULE203
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c
1960 1970 1980 1990 2000 2010 2020 2030 2040
1 2 3

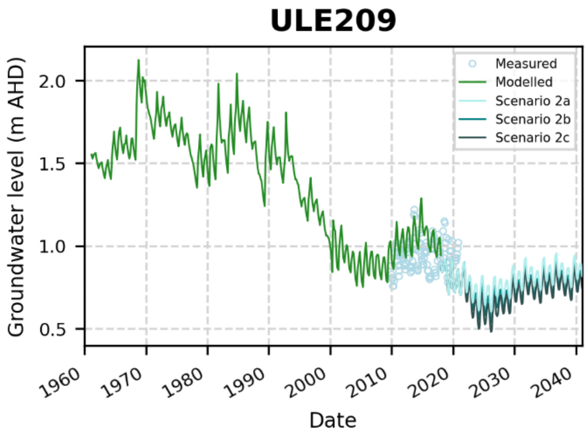

ULE204
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c
1960 1970 1980 1990 2000 2010 2020 2030 2040
1 2 3

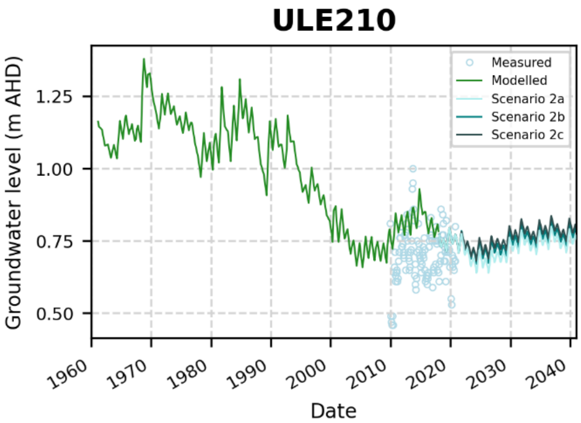

ULE205
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c
1960 1970 1980 1990 2000 2010 2020 2030 2040
0.50 0.75 1.00 1.25 1.50

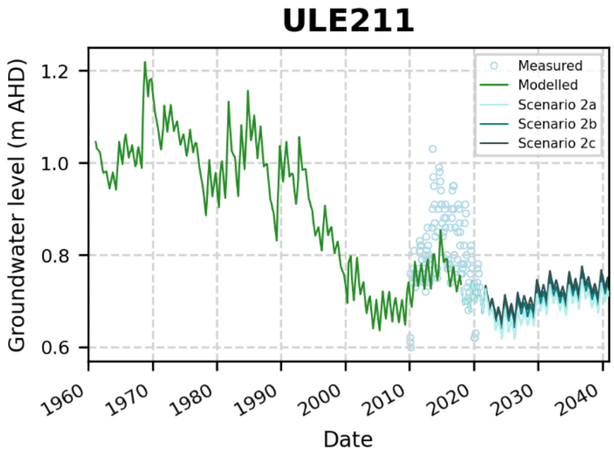

ULE206
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c
1960 1970 1980 1990 2000 2010 2020 2030 2040
0.5 1.0 1.5 2.0

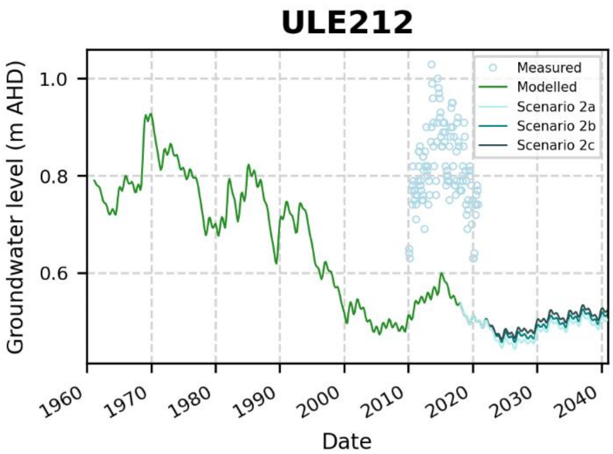

ULE207
Groundwater level (m AHD)
Date
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c
1960 1970 1980 1990 2000 2010 2020 2030 2040
1.0 1.5 2.0 2.5

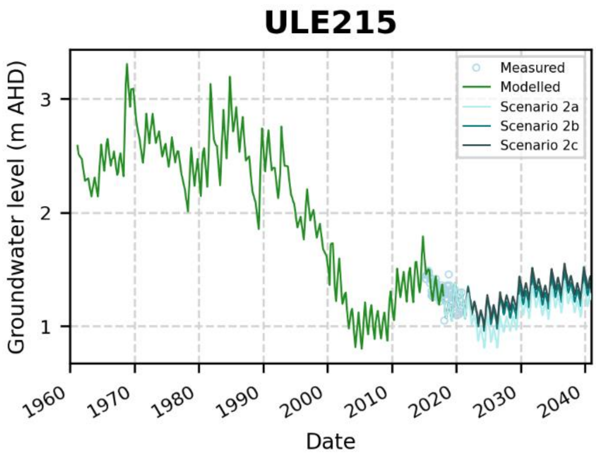

ULE208
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c
Groundwater level (m AHD)
Date


ULE209
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c
Groundwater level (m AHD)
Date


ULE210
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c
Groundwater level (m AHD)
Date


ULE211
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c
Groundwater level (m AHD)
Date


ULE212
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c
Groundwater level (m AHD)
Date


ULE215
Measured
Modelled
Scenario 2a
Scenario 2b
Scenario 2c
Groundwater level (m AHD)
Date

6 References

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