Appendix G

Balannup Pressure Main Groundwater Assessment (RPS ,2014)

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RPS

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Our Ref: I1420001

Email: carl.davies@rpsgroup.com.au
Date: 13 November 2014

Bree Atkinson
Environmental Scientist
Water Corporation
629 Newcastle Street
LEEDERVILLE WA 6007

Dear Bree

BALANNUP ROAD PRESSURE MAIN- GROUNDWATER ASSESSMENT

Objective

This report has been prepared to address Environmental Protection Authority (EPA) correspondence related to the installation of the Balannup wastewater pressure main (EPA Ref CMS 14335; AC01-2014-0150, 28 October 2014). The EPA correspondence identifies that the following additional information is required to make a determination on significance and appropriate level of assessment for the proposal:

- Further information in relation to the predicted hydrological changes that may occur as a result of the installation of the pipeline are required to demonstrate that the EPA's objective for hydrological processes which is *to maintain the hydrological regimes of groundwater and surface water so that existing and potential uses, including ecosystem maintenance, are protected*, can be met, following construction.

- Based on existing knowledge and available information regarding hydrology and stratigraphy for the Keane Road section (Bush Forever 342) the referral document needs to

    - Clearly demonstrate that the proposal would not have significant direct and indirect impacts on the subsurface flows at the site. This includes describing the current hydrological regimes and processes that operate at the site (at the local-scale) and how they may be disrupted due to the proposal. This could be set out for example, by using cross-sectional figures of the soil profile showing current hydrological processes/flows, compared with one showing the potential effects of the proposal.

    - Provide further discussion on whether there are any risks to ground water quality associated with the application of Aglime for neutralising soils as stated in the Draft Acid Sulfate Soil and Dewatering Management Plan (ASSDWMP).

The EPA correspondence is provided in Appendix 1. Essentially, the EPA has raised a concern that the 450 mm pressure main will form some sort of hydrological flow-barrier to groundwater (once installed), and that this might cause an impact on proximate wetland vegetation.

Scope

In order to address the EPA comments, the work scope includes preparation of a visual representation of the groundwater conditions before and after pressure main construction, based on outputs generated from a groundwater model. The modelling approach consists of the preparation of simple numerical "box models" to represent three scenarios that are based on natural site conditions:

1. 450 mm pressure main located within the Bassendean Sand unit (being approximately 2.5 m thickness, above clay)

2. 450 mm pressure main located within the Bassendean Sand, directly above a clayey unit.

3. 450 mm pressure main located within the clayey unit.

The box models include relevant hydrogeological parameters such as groundwater recharge (from rainfall), evapotranspiration (ET), groundwater inflow and outflow, and soil parameters such as hydraulic conductivity (K) and storage. The above scenarios capture the general geological conditions along the alignment.

Groundwater level changes have in turn been compared with generic ecological water requirements (EWRs) for wetlands of the Swan Coastal Plain. These generic EWRs relate to maximum drawdown limits and rate of change limits for wetlands and can be used to provide "risk of impact" categories for wetlands.

This approach was approved in principle by the EPA (pers. comm. Amy Sgherza, 3 November 2014), provided that suitable, up to date information was used in the model. The EPA email correspondence is provided in Appendix 2.

Geology

As described in the EPA referral supporting documentation (AECOM 2014)[1], bore sampling was conducted by GHD (2013)[2] along the entire proposed alignment. Two distinct geological areas were encountered within Bush Forever Site 342. The first section is approximately 320 m in length located from Skeet Rd to the east and typically consists of Bassendean Sand to 2.5 metres below ground level (mbgl), overlying a layer of medium dense to dense silty sand. The second section is approximately 1,200 m in length and is located directly east of the first section to Anstey Road. This second section generally consists of a thin layer of Bassendean Sand (0.5 to 2 m) overlying sandy clay/ clayey sand.

Soils along the alignment outside of the Bush Forever site were highly variable which is partly due to the disturbance of soil associated with the development. It was noted by GHD (2013) that the soils west of Skeet Road contain strongly cemented coffee rock, while east of Anstey Road the pressure main may intersect strongly cemented clayey sand, however much of this layer may be below the depth of the proposed pipeline.

[1] AECOM 2014. Balannup Wastewater Pressure Main. Supporting Documentation
[2] GHD. 2013. Water Corporation Balannup A WWPS and Keane Road Pressure Main Report on the Geotechnical, ASS and Contaminated Sites Investigation

The pressure main is proposed to be installed to 1.5 m depth. It is expected to be wholly in Bassendean Sand at the western part of the alignment, which extends to 2.5 mbgl in this area. The pressure main is expected to penetrate into the sandy clay/ clayey (Guildford Formation) along the eastern part of the alignment, which is located at depths of between 0.5 and 2 mbgl.

Groundwater

Groundwater in the immediate area is generally shallow, and encountered in Bassendean Sands overlying lower permeability Guildford Formation soils. Groundwater and surface water drainage in the area is facilitated by numerous open drains which have a controlling influence on groundwater levels.

Groundwater monitoring along the proposed pressure main alignment indicates groundwater to the southeast of the alignment migrates in a west to north-westerly direction towards the Jandakot Regional Park wetland area (approximately 23 m AHD at the south-east end of the alignment to the wetland). Conversely, groundwater to the north-west of the alignment migrates in an east to south-easterly direction towards the wetland area (approximately 25 m AHD at the north-western end of the alignment to the wetland), indicating the wetland acts as a local discharge area for groundwater. Appendix 3 provides groundwater elevation information, including levels along the alignment and regional flow patterns as provided by Department of Water (DoW 2014)[3].

Groundwater Modelling

Groundwater modelling was undertaken to predict groundwater impacts associated with the pressure main installation for the three scenarios described previously, i.e. pressure main within sand (Scenario 1), pressure main located on the clayey sand surface (Scenario 2) and pressure main within the clayey sand (Scenario 3). Two separate model grids were created to take into account the variable groundwater flow direction and geology between the western and eastern parts of the alignment.

The modelling predicted minimal (< 5 cm) of groundwater level change immediately adjacent to the pressure main for all three scenarios, indicating pressure main installation has a negligible influence on groundwater flows. Details of the modelling methodology and results are provided in Appendix 4.

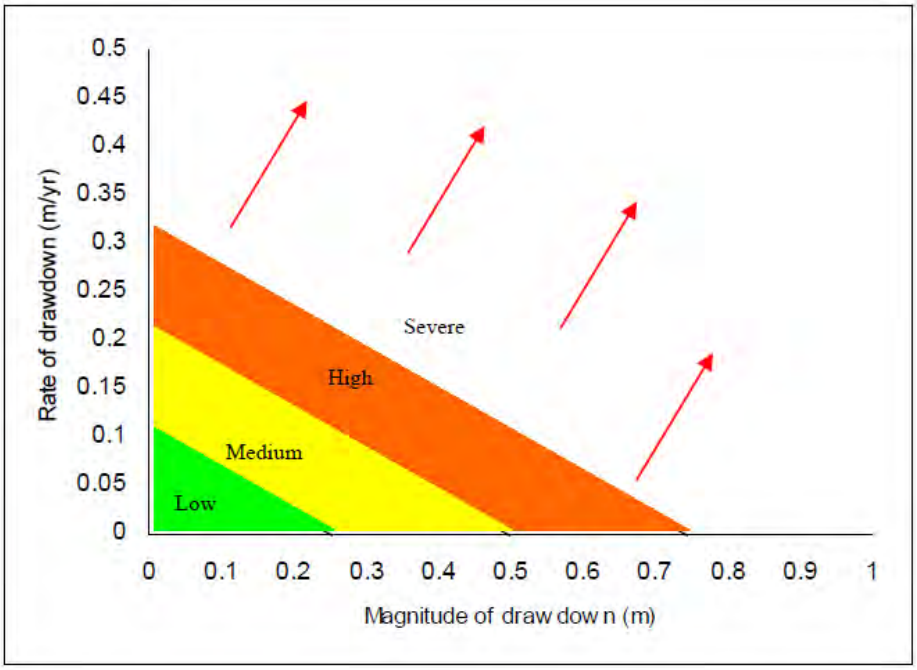
Wetland Ecological Water Requirements

The risk of impact associated with water level changes can be provided by comparison with generic Ecological Water Requirements (EWRs) established by DoW for the Swan Coastal Plain and Blackwood region (Hyde 2006). These generic EWRs relate to maximum drawdown limits and rate of change limits for wetlands and phreatophytic vegetation. The DoW document includes "risk of impact" categories for wetlands that were developed by Froend and Loomes (2004)[4].

[3] DoW (2014). Perth Groundwater Atlas

[4] Froend, R. and Loomes, R. 2004. Approach to determination of ecological water requirements of groundwater dependent ecosystems in Western Australia – A report to the Department of Environment, Edith Cowan University, Perth.

As stated in Hyde (2006)[5], the categories were developed based on the results of research into the response of vegetation to groundwater decline. The cumulative rate and magnitude of the predicted groundwater drawdown is defined and the possible ecological responses to the varying degrees of drawdown are described broadly as either low, moderate, high or severe in terms of probability of noticeable impact from groundwater level change. The risk categories for wetlands are shown on Graph 1.



Froend and Loomes 2004

Graph 1: Risk of Impact for Wetland Vegetation based on Magnitude of Groundwater Level Change

On this basis, the model predicted water level change associated with pressure main installation is expected to result in a low risk of impact to wetlands.

Aglime Impact to Groundwater Quality.

The application of aglime to neutralise acid sulfate soils (ASS) is not considered to pose a significant risk to groundwater given its low solubility and weak base nature. Aglime is considered the industry standard for treating ASS and acidic dewatering effluent as described in *Treatment and Management of Soils and Water in Acid Sulfate Soil Landscapes* (DER July 2011) and is also generally not harmful to plants, livestock, humans and most aquatic species. As such it is considered suitable for use near water bodies.

Due to aglimes' low solubility, weak basic nature and its low dissociation constant, any impact on the chemistry of groundwater would be very slow and as a result the groundwater system is likely to be able to buffer any addition of bicarbonate to the system. Thus the buffering capacity of the groundwater and the low solubility of the aglime results in minimal potential for the pH to rapidly change and increase to highly basic. As such the aglime is not considered to pose a significant risk to groundwater.

[5] Hyde, N.L. (2006). A summary of investigations into ecological water requirements of groundwater-dependent ecosystems in the South West groundwater areas.

Furthermore, given the aglime is being applied to ASS, the aglime is expected to protect the groundwater from potential acidification impacts as a result of ASS oxidation during earthworks. These acidification products pose a greater risk to groundwater, should they not be managed, than the use of aglime to manage the potential acidification products. Any generated acidification products will react with the aglime and be neutralised and thus consume the aglime, reducing the concentration of aglime in the soil. As a result, the aglime concentration will decrease over time and therefore the potential for any impacts will be further decreased. It should be noted that the treatment of the ASS should result in an excess of aglime being added to the soils and as such more neutralising capacity will be added to the soils than required. However as previously stated this is considered to pose a smaller potential environmental risk than not treating the ASS.

Conclusion

Groundwater modelling has been undertaken to estimate the impact of the Balannup pressure main on nearby hydrological processes. The models utilised site specific hydrogeological information and the results indicate the pressure main will not have significant direct or indirect impacts on the subsurface flows at the site. This meets the EPA's objective which is to maintain the hydrological regime so that existing and potential uses, including ecosystem maintenance, are protected. In relation to groundwater quality, the use of aglime is the recommended option for treating ASS and its use is not expected to result in any risk to groundwater quality.

Yours sincerely
RPS

CARL DAVIES
Principal Hydrogeologist

ATTACHMENTS

Appendix 1: *EPA Referral Comments*
Appendix 2: *EPA Email Correspondence*
Appendix 3: *Groundwater Elevation Information*
Appendix 4: *Groundwater Modelling*

APPENDIX 1

EPA Referral Comments

Mr Rupert Duckworth
Manager EIA and Approvals
Environment and Aboriginal Affairs Branch
Water Corporation
PO Box 100
LEEDERVILLE WA 6902

Your Ref: *JT1 2011 12136v01*
Our Ref: *CMS 14335; AC01-2014-0150*
Enquiries: *Amy Sgherza, 6145 0818*
Email: *amy.sgherza@epa.wa.gov.au*

Attention: Ms Bree Atkinson

Dear Mr Duckworth

NOTICE REQUIRING FURTHER INFORMATION
s38A of the *Environmental Protection Act 1986*

PROPOSAL: **BALANNUP WASTEWATER PRESSURE MAIN**
PROPONENT: **WATER CORPORATION**

Thank you for your letter dated 3 October 2014 referring the above proposal to the Environmental Protection Authority (EPA) under section 38 of the *Environmental Protection Act 1986* (EP Act).

This means that the EPA is required to:

- determine the significance of the effect on the environment of the proposal, if implemented, and
- make a decision on whether or not to assess the proposal and, if the decision is to assess, the level of assessment.

The EPA considers that it does not have enough information about the proposal to enable it to make decisions on significance and appropriate level of assessment. Accordingly, the EPA requests that you, as the proponent, provide it with the following additional information about the proposal:

- Further information in relation to the predicted hydrological changes that may occur as a result of the installation of the pipeline are required to demonstrate that the EPA's objective for hydrological processes which is *to maintain the hydrological regimes of groundwater and surface water so that existing and potential uses, including ecosystem maintenance, are protected*, can be met, following construction.

- Based on existing knowledge and available information regarding hydrology and stratigraphy for the Keane Road section (Bush Forever 342) the referral document needs to:
    - clearly demonstrate that the proposal would not have significant direct and indirect impacts on the subsurface flows at the site. This includes describing the current hydrological regimes and processes that operate at the site (at the local-scale) and how they may be disrupted due to the proposal. This could be set out for example, by using cross-sectional figures of the soil profile showing current hydrological processes/flows, compared with one showing the potential effects of the proposal; and
    - provide further discussion on whether there are any risks to ground water quality associated with the application of AgLime for neutralising soils as stated in the Draft Acid Sulphate Soil and Dewatering Management Plan (ASSDWMP).

Should you have any enquiries please contact the person cited above.

Your response to this request for additional information is required by 17 November 2014. Please respond with either:

a) the information requested; or

b) advice that further information is not available and/or cannot be obtained.

Please note that the EPA has also sought additional information about the proposal from the Department of Parks and Wildlife, the Department of Water, the City of Armadale and the Department of Planning.

Your response should be sent by email to registrar@epa.wa.gov.au marked for the attention of the person cited above, or by post to the Office of the Environmental Protection Authority, Locked Bag 10, East Perth WA 6892. Please quote the above "Our ref" on any further correspondence.

It should be noted that, under the EP Act, the EPA has 28 days in which to make a decision on whether or not to assess a proposal, and if assess, the appropriate level of assessment. The 28-day period will start to run either on 17 November 2014, i.e. the expiration of the specified period, or on receipt of the requested information, whichever occurs first. However, if the information is not received within the specified period, or if it becomes apparent that such information is not available, the EPA can proceed (at the expiration of the specified period) to make its decision on whether or not to assess and if assess, the appropriate level of assessment, based on information derived from its own investigations and inquiries.

You would be notified once the EPA has made a decision.

Yours sincerely

Anthony Sutton
Director
Assessment and Compliance Division

For the Chairman of the Environmental Protection Authority
Under Notice of Delegation No. 33 dated 6 December 2013

28 October 2014

APPENDIX 2

EPA Email Correspondence

Doris Clarke

From: Bree Atkinson <Bree.Atkinson@watercorporation.com.au>
Sent: Monday, 3 November 2014 4:04 PM
To: Carl Davies
Cc: Carl Barbato
Subject: FW: Balannup - Proposal

FYI comments from the oEPA regarding their review of the scope of works.

Thanks
Bree

From: Amy Sgherza [mailto:Amy.Sgherza@epa.wa.gov.au]
Sent: Monday, 3 November 2014 3:50 PM
To: Bree Atkinson
Subject: RE: Balannup - Proposal

Hi Bree,

I provide the following comments in relation to the proposed scope of works (RPS).

In general, the scope of works is adequate, but please be aware that the model output is only going to be as good as the information inputted, so please ensure that the most up to date available information is utilised. Also, once the models are generated it will be necessary to then relate the results back to the EPA's objective for Hydrological Processes with a discussion on whether this objective will be met.

Thank you. Any questions please do not hesitate to contact me. I will be back in the office on Wednesday.

Kind regards

Amy Sgherza
Environmental Officer
Office of the **Environmental Protection Authority**
The Atrium, Level 8, 168 St Georges Terrace, Perth
Locked Bag 10, East Perth WA 6892
direct: 08 6145 0818| reception: 08 6145 0800 | fax: 08 6145 0895
email: amy.sgherza@epa.wa.gov.au | web: http://www.epa.wa.gov.au
@EPA_WA

Please note new postal address and phone and fax numbers.

Office of the
Environmental Protection Authority

From: Bree Atkinson [mailto:Bree.Atkinson@watercorporation.com.au]
Sent: Friday, 31 October 2014 1:59 PM
To: Amy Sgherza
Subject: Balannup - Proposal

Hi Amy

I really appreciate you agreeing to have a look at RPS's proposal (attached)

We will also address the potential impact of adding aglime to manage Acid Sulfate Soils.

Thanks for your help

Bree Atkinson
Environmental Scientist
Environment & Aboriginal Affairs
Water Corporation
T: (08) 9420 2893
629 Newcastle Street, Leederville, WA 6007
PO Box 100, Leederville, WA 6902

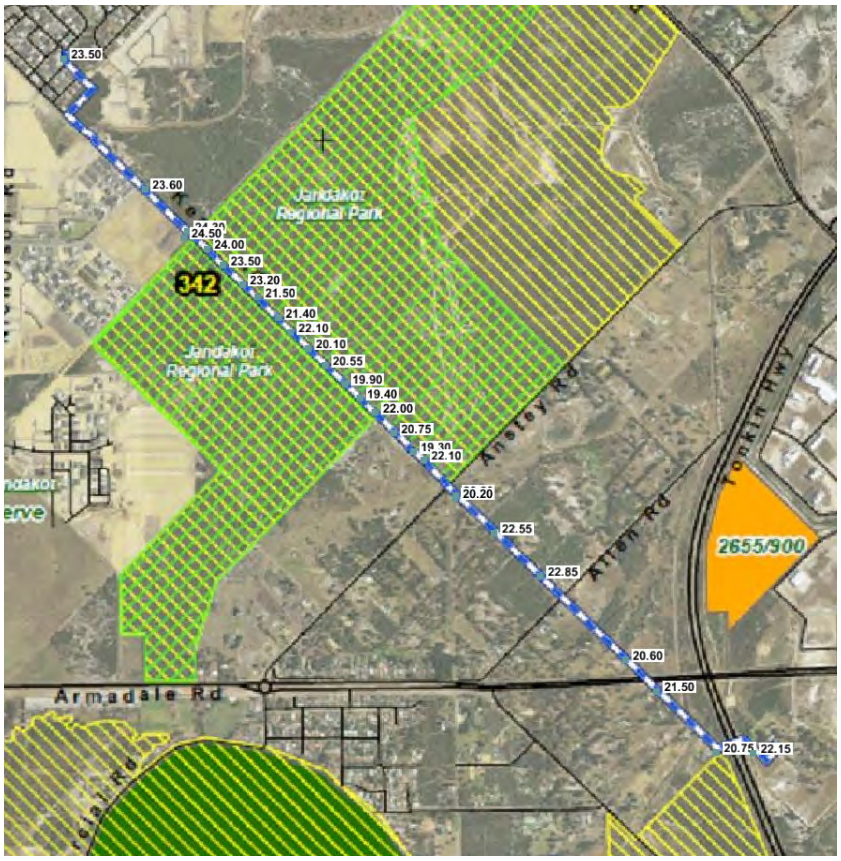
APPENDIX 3

Groundwater Elevation Information

APPENDIX 3: GROUNDWATER ELEVATION INFORMATION

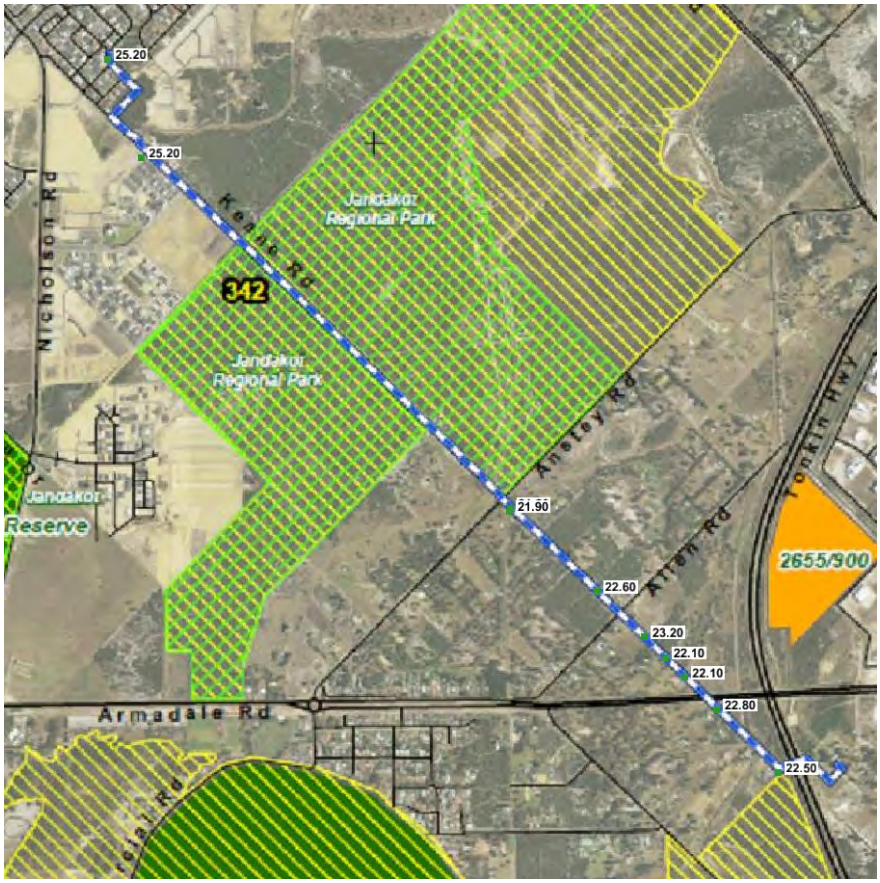
Table A3-1 Groundwater Monitoring Data (Modified from GHD 2013)

Bore	Chainage (m)	x	y	Topo Elevation (mAHD)	Depth achieved (mAHD)	Estimate GW Depth (June-July 2013)- mbgl	Bore Installed?	GWL June-July 2013_(mAHD)	GWL August 2013_(mAHD)
BH01	47	398909	6445341	26.8	3.45	3.3	Yes	23.5	25.2
BH02	353	398919	6445115	26.5	3.45	-	No		
BH03	570	399047	6444936	27	3.45	-	Yes		25.2
BH04	819	399252	6444789	25.5	3.45	1.9	No	23.6	
BH05N	1073	399432	6444610	25.5	2.86	1.2	Yes	24.3	
BH05S	1080	399417	6444584	25.4	2.5	0.9	Yes	24.5	
BH06N	2667	400565	6443495	22	6	1.8	Yes	20.2	21.2
BH06S	2674	400563	6443483	22.5	6.45	2.3	Yes	20.2	21.9
BH07	2895	400728	6443335	23.75	3.45	1.2	No	22.55	
BH08	3161	400922	6443153	24.25	2.8	1.4	Yes	22.85	22.6
BH09	3432	401117	6442965	24.3	3.45	-	No		23.2
BH10	3665	401281	6442799	23.4	4.5	2.8	Yes	20.6	22.1
BH11	3853	401414	6442667	23.5	4.5	2	Yes	21.5	22.8
BH12	4199	401666	6442408	23.75	4.5	3	Yes	20.75	22.5
BH13	4395	401821	6442405	24.75	4.5	2.6	Yes	22.15	
BH14	1183	399514	6444537	24.9	6.45	0.9	No	24	
BH15	1281	399583	6444467	25	6	1.5	No	23.5	
BH16	1396	399664	6444386	24.4	6	1.2	Yes	23.2	
BH17	1480	399729	6444332	24.5	6	3	No	21.5	
BH18	1603	399815	6444245	24	6	2.6	No	21.4	
BH19	1685	399869	6444183	23.9	6	1.8	Yes	22.1	
BH20	1784	399943	6444116	23.6	6.45	3.5	No	20.1	
BH21	1886	400014	6444044	23.75	6.45	3.2	No	20.55	
BH22	2000	400097	6443966	23.8	6	3.9	Yes	19.9	
BH23	2087	400159	6443905	23.4	6.45	4	No	19.4	
BH24	2177	400226	6443844	22.9	6.45	0.9	No	22	
BH25	2293	400303	6443757	22.75	6	2	Yes	20.75	
BH26	2409	400386	6443680	22.3	6.45	3	No	19.3	
BH27	2465	400430	6443644	22.3	6	0.2	No	22.1	
BH28	3553	401204	6442881	23.25	3	-	Yes		22.1



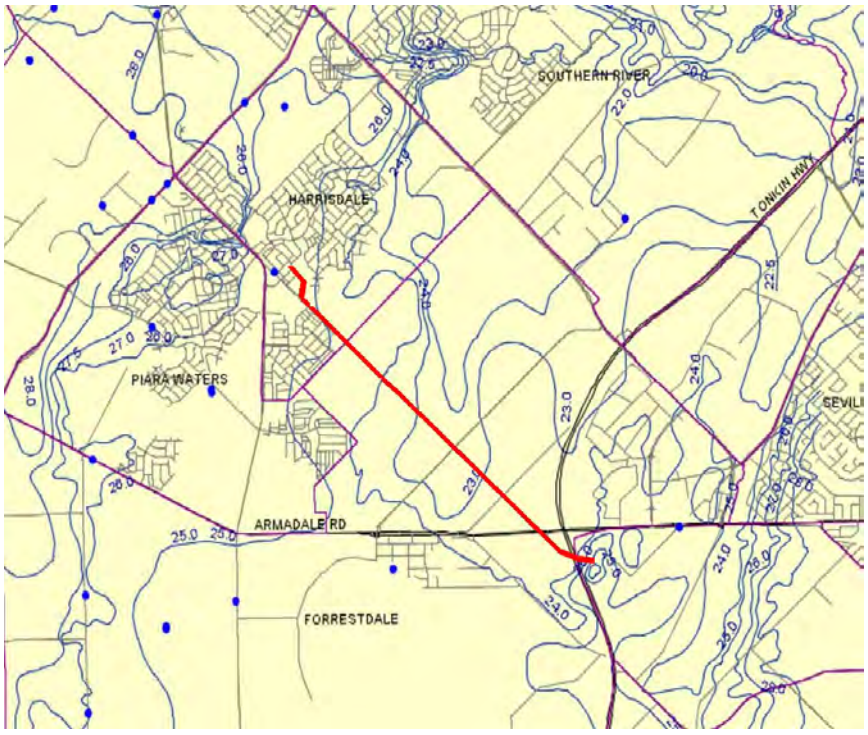
Source: GHD 2013 and AECOM 2014

Figure A3-1: Estimated Groundwater Elevation along Alignment- July 2013



Source: GHD 2013 and AECOM 2014

Figure A3-2: Estimated Groundwater Elevation along Alignment- August 2013



(DoW 2014)

Figure A3-3: Regional Groundwater Contours

APPENDIX 4

Groundwater Modelling

APPENDIX 4: GROUNDWATER MODELLING

Scenario 1: Western Model

Model Grid

Scenario 1 (pressure main located within the Bassendean Sand unit of approximately 2.5 m thickness) was simulated by constructing a model along the western side of the alignment.

A pre-installation model was initially constructed to use for comparison purposes. The model was constructed using Modflow NWT[1]. The model is approximately 1350 m × 840 m in dimension and the cell size ranges from 0.45 m along the pressure main (area of interest) and progressively increases to a maximum cell size of 20 m towards the model boundaries (Figure 1)[2]. The model has four layers with characteristics as follows:

- Layer 1 – topographic surface to top of pressure main.
- Layer 2- pressure main within sand (1.05 to 1.5 mbgl).
- Layer 3 – bottom of pressure main to top of clayey sand (1.5 to 2.5 mbgl).
- Layer 4 – clayey sand top (2.5 mbgl) to base of superficial aquifer (-7 m AHD as provided by DoW 2014[3]).

Boundaries

Specified head boundaries were used at the western (25 m AHD) and eastern (24 m AHD) ends of the model to coincide with groundwater levels as determined by measured site data (GHD 2013[4]) and DoW (2014) mapping. No flow boundaries were used along the northern and southern boundaries (Figure A4-1).

[1] Modflow NWT allows simulation of cell drying/ rewetting due to the shallow water tables in the area
[2] Small cell sizes are also shown in Figure 1 perpendicular to the drain, which is necessary as part of the model grid process.
[3] DoW (2014). Perth Groundwater Atlas
[4] GHD. 2013. Water Corporation Balannup A WWPS and Keane Road Pressure Main Report on the Geotechnical, ASS and Contaminated Sites Investigation

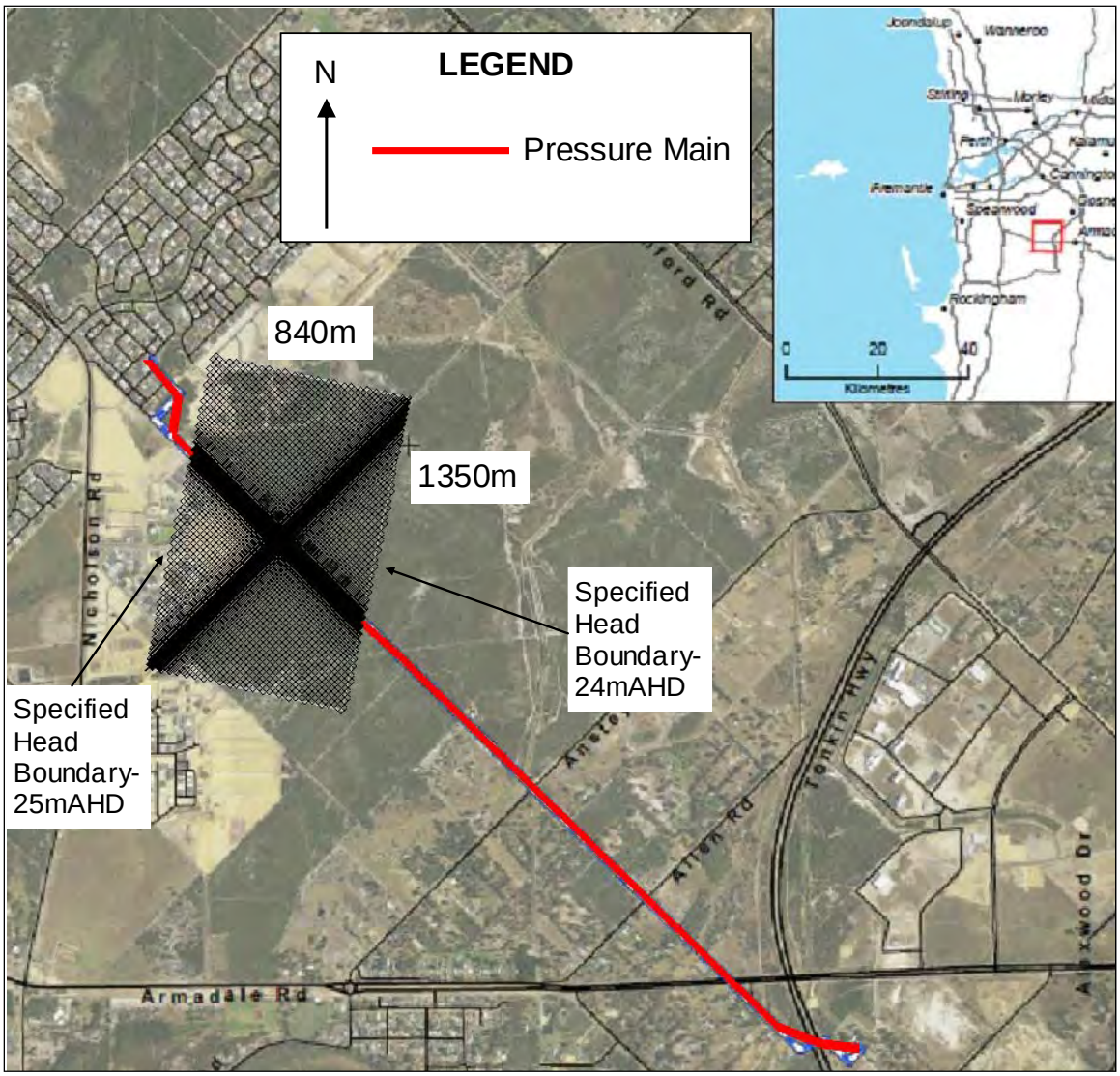


Figure A4-1: Scenario 1 Model Grid (Modified from AECOM Basemap)

Aquifer Properties

Aquifer properties were based on literature values (e.g. Davidson 1995[5]) for the geological unit, as summarised in Table A4-1.

Table A4-1: Aquifer Properties

Geological Unit	Hydraulic Conductivity (m/d)	Horizontal to Vertical K ratio	Specific Yield	Location
Bassendean Sand	15	3	0.2	Layers 1 to 3
Clayey Sand	1	10	0.07	Layer 4

[5] Davidson, W. A. 1995. Hydrogeology and Groundwater Resources of the Perth Region Western Australia. Geological Survey of Western Australia Bulletin 142.

Groundwater Recharge

The model utilises average monthly rainfall data from the Forrestdale weather station and monthly evaporation values from Medina weather station. Net recharge was simulated by applying a gross 50% rainfall recharge value with an evapotranspiration (ET) function of 0.8 pan evaporation at the ground surface that decreases linearly to zero at 1.5 mbgl.

Scenario 1 Pre-Installation Groundwater Levels

Pre-installation simulated groundwater contours are shown on Figure A4-2. Graph A4-1 shows a groundwater elevation time series for a point near the centre of the model domain, along the proposed main installation. The model simulated groundwater contours fluctuate approximately 1 m which is reasonable for the area (cf. Davidson 1995).

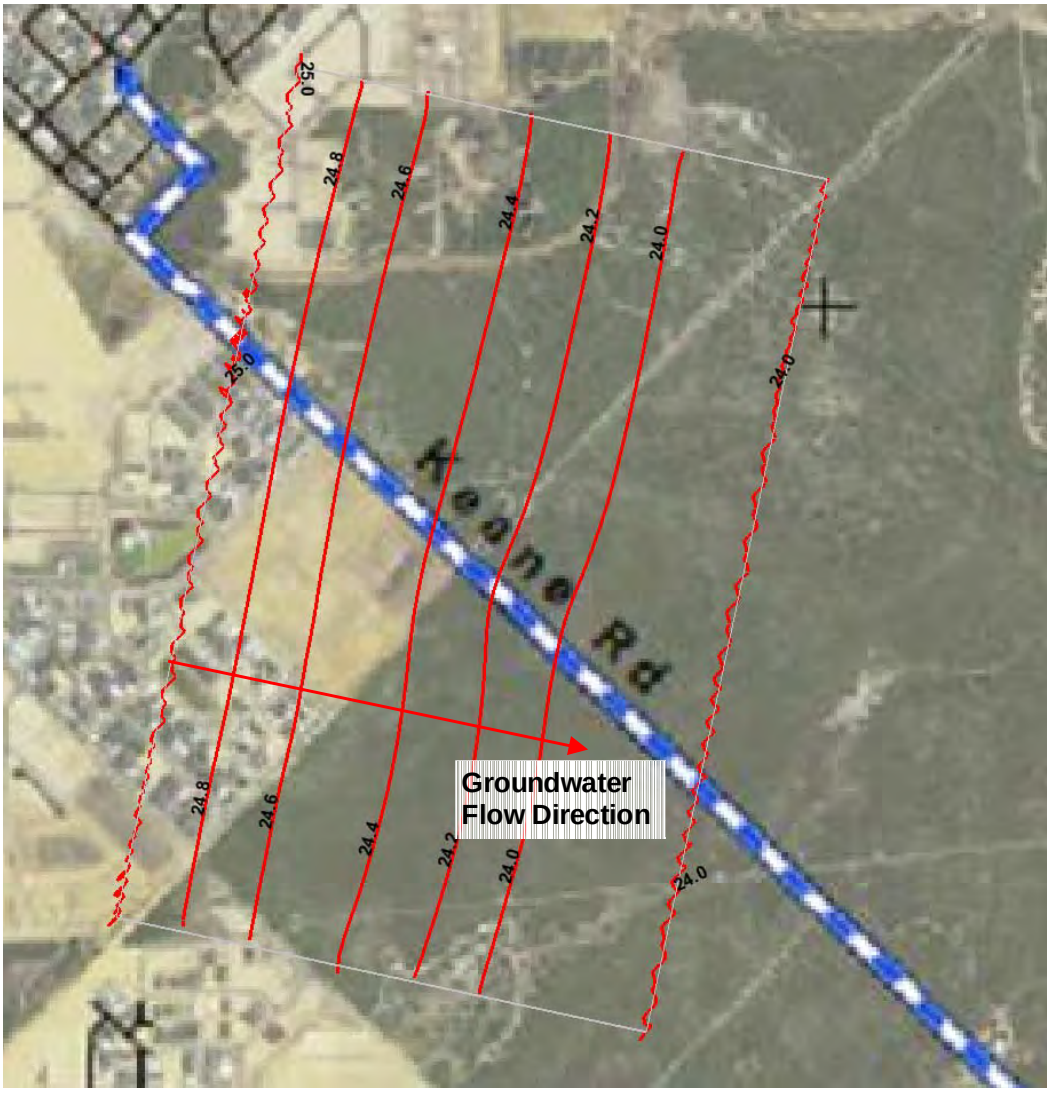
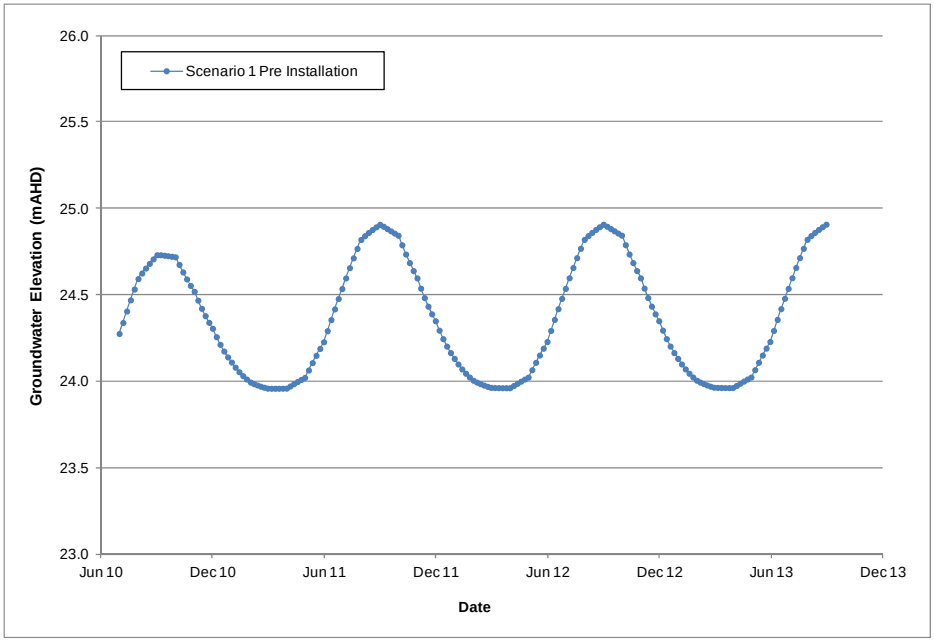


Figure A4-2: Scenario 1 Pre Installation Groundwater Contours - August 2013 (Modified from AECOM Basemap)

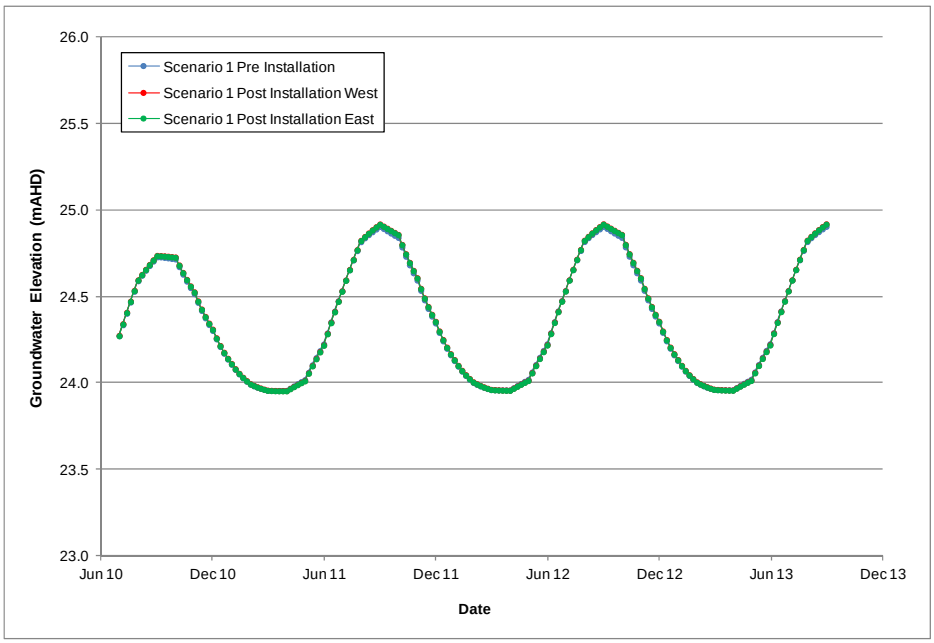


Graph A4-1: Scenario 1 Pre Installation Groundwater Elevation Time Series

Scenario 1 Post-Installation Groundwater Level Change

The pre installation model was modified to simulate the impact of the pressure main. This was undertaken by applying a low hydraulic conductivity (K) value of 10^{-8} m/d along the 0.45 m × 0.45 m cells in Layer 2 (depth of 1.05 to 1.5 mbgl).

The model simulated minimal groundwater elevation change (<1 cm) directly adjacent[6] to the pressure main for Scenario 1 (Graph A4-2).



Graph A4-2: Scenario 1 Groundwater Elevation Time Series– Adjacent to Pipe

[6] Simulated groundwater levels taken from 0.5 m cells directly adjacent to the pressure main

Scenarios 2 and 3: Eastern Model

Model Grid

Scenarios 2 and 3 (pressure main located *on* clayey sand and *within* clayey sand respectively) were simulated by constructing a model along the eastern side of the alignment. A pre-installation model was initially constructed to use for comparison purposes for Scenarios 2 and 3. The model is approximately 1675 m × 1020 m in dimension (Figure A4-3) and the cell size ranges from 0.45 m along the pressure main and progressively increases to a maximum cell size of 20 m towards the model boundaries.

The Scenario 2 model has four layers with characteristics as follows:

- Layer 1 – topographic surface to top of pressure main.
- Layer 2- pressure main located on clayey sand (1.05 to 1.5 mbgl).
- Layers 3 and 4 – clayey sand top (1.5 mbgl) to base of superficial aquifer (-7 m AHD).

The Scenario 3 model has four layers with characteristics as follows:

- Layer 1 – topographic surface to top of pressure main.
- Layer 2 – pressure main within clayey sand (1.05 to 1.5 mbgl).
- Layers 3 and 4 – clayey sand to base of superficial aquifer (-7 m AHD).

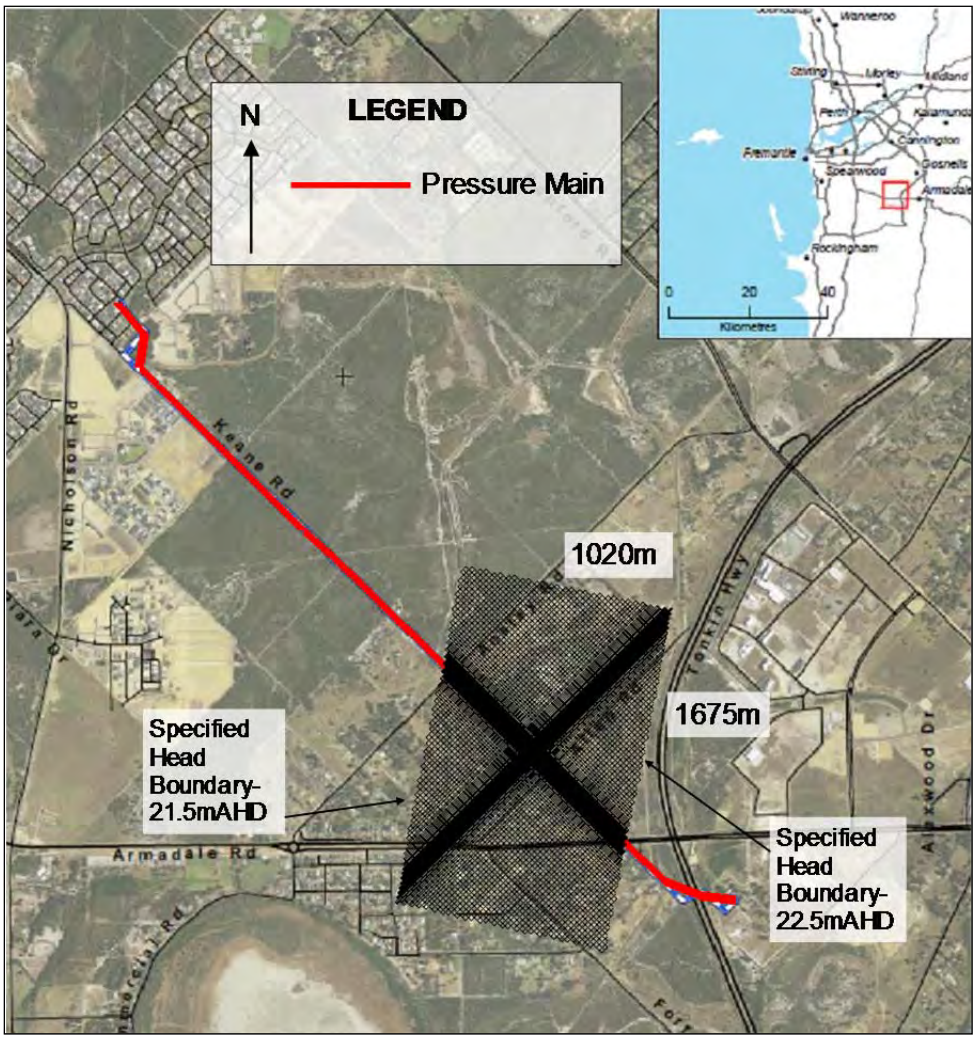


Figure A4-3: Scenarios 2 and 3 Model Grid (Modified from AECOM Basemap)

Boundaries

Specified head boundaries were used at the western (21.5 m AHD) and eastern (22.5 m AHD) ends of the model to coincide with groundwater levels as determined by measured site data (GHD 2013) and DoW (2014) mapping. No flow boundaries were used along the northern and southern boundaries.

Aquifer Properties

Aquifer properties were as per the previous model.

Groundwater Recharge

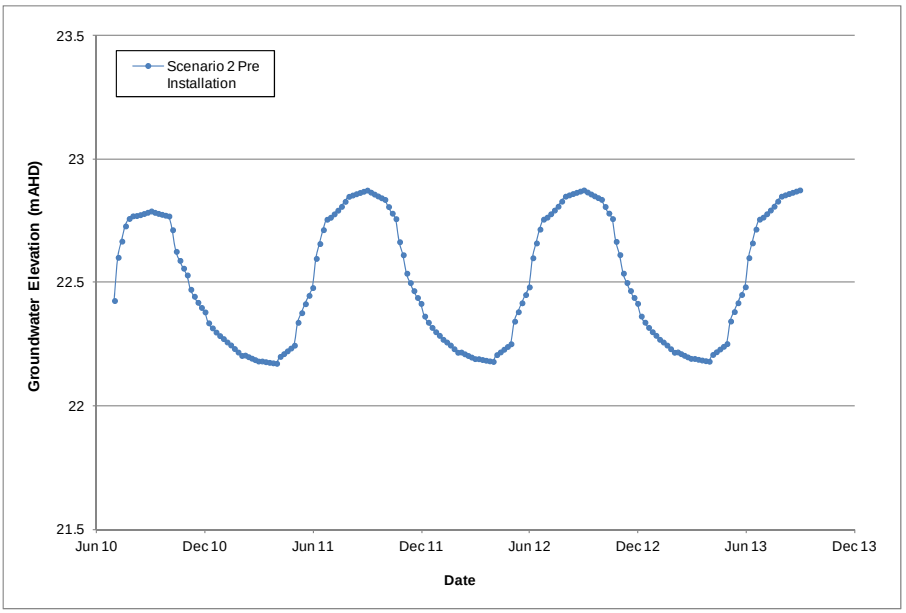
Net recharge was simulated by applying a gross 30% rainfall recharge value with an ET function of 0.8 pan evaporation at the ground surface that decreases linearly to zero at 2 mbgl.

Scenario 2 Pre-Installation Groundwater Levels

Pre-installation model simulated groundwater contours (Figure A4-4) correspond with the measured flat water table east of the open drain (which is in close proximity to the western

boundary). Graph A4-3 shows a groundwater elevation time series for a point along the proposed main installation, near the centre of the model domain. The model simulated groundwater contours fluctuate approximately 0.8 m which is reasonable for the area.

Figure A4-4: Scenario 2 Pre-Installation Groundwater Contours - August 2013 (Modified from AECOM Basemap)

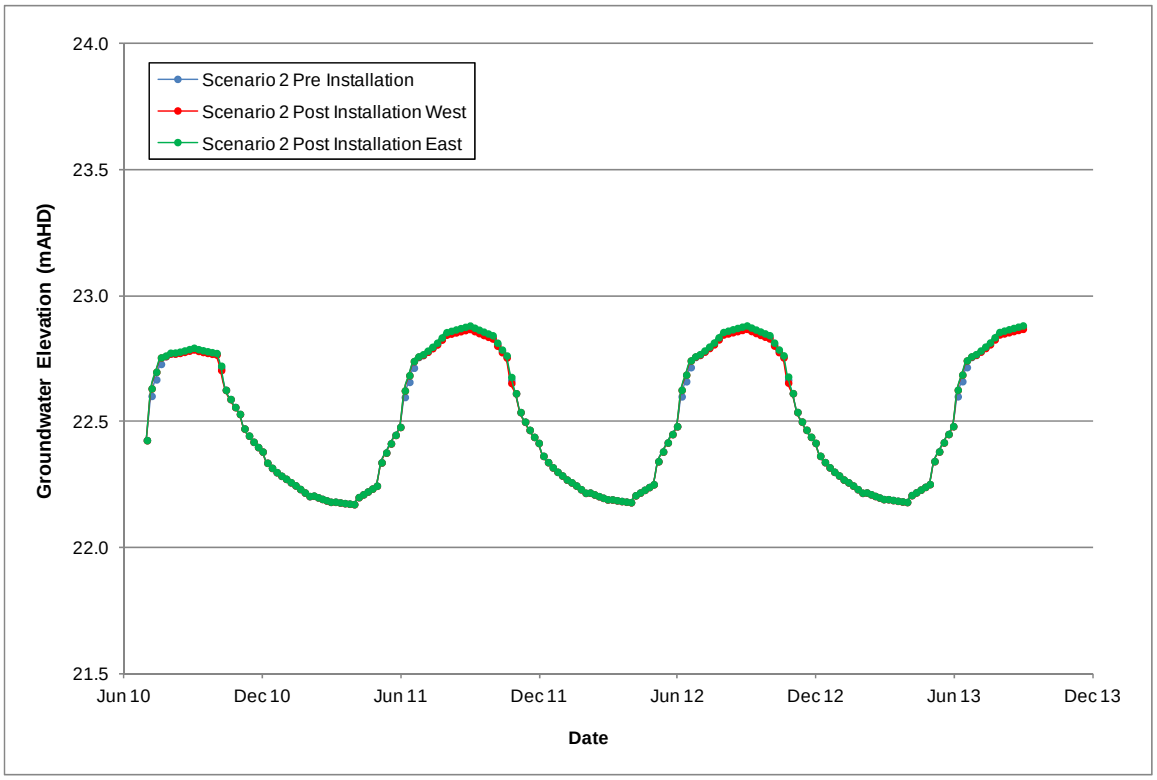


Graph A4-3: Scenario 2 Pre-Installation Groundwater Elevation Time Series

Scenario 2 Post-Installation Groundwater Level Change

The pre-installation model was modified to simulate the impact of the pressure main. This was undertaken by applying a low hydraulic conductivity (K) value of 10^{-4} m/d[7] along the 0.45 m × 0.45 m cells in Layer 2 (depth of 1.05 to 1.5 mbgl).

The model simulated minimal groundwater elevation change (maximum 3 cm) directly east and west of the pressure main for Scenario 2 (Graph A4-4).



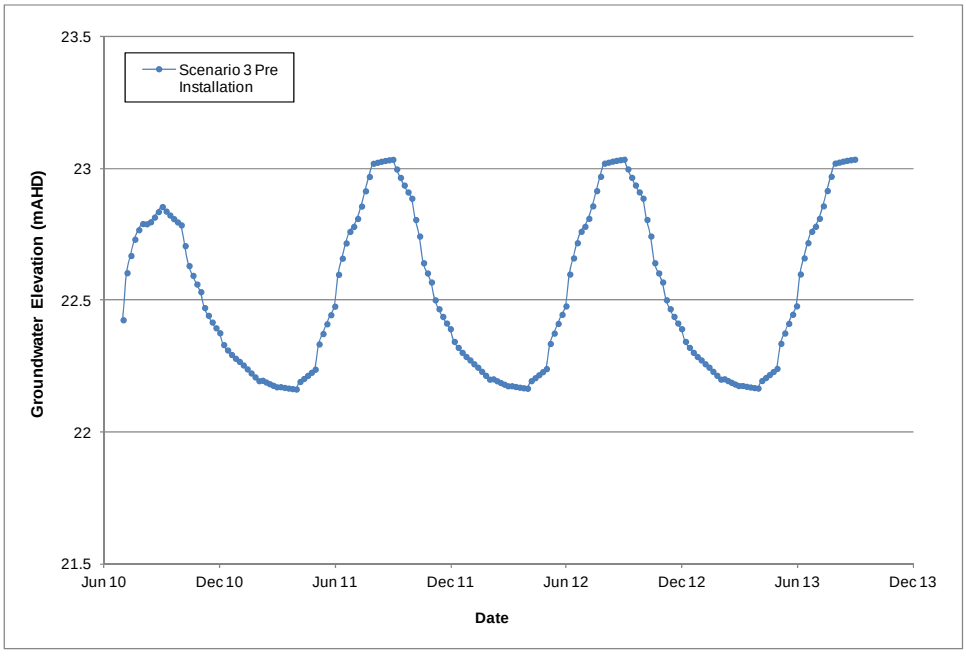
Graph A4-4: Scenario 2 Groundwater Elevation Time Series – Adjacent to Pipe

Scenario 3 Pre-Installation Groundwater Levels

Pre-installation model simulated groundwater contours (Figure A4-5) correspond with the measured flat water table east of the open drain (which is in close proximity to the western boundary). Graph A4-5 shows a groundwater elevation time series for a point along the proposed main installation, near the centre of the model domain. The model simulated groundwater contours fluctuate approximately 1 m which is reasonable for the area.

[7] A lower value was not used due to model convergence issues. This value is still 10,000 times less than the clayey sand K value and 150,000 times less than the sand K value.

Figure A4-5: Scenario 3 Pre-Installation Groundwater Contours - August 2013 (Modified from AECOM Basemap)

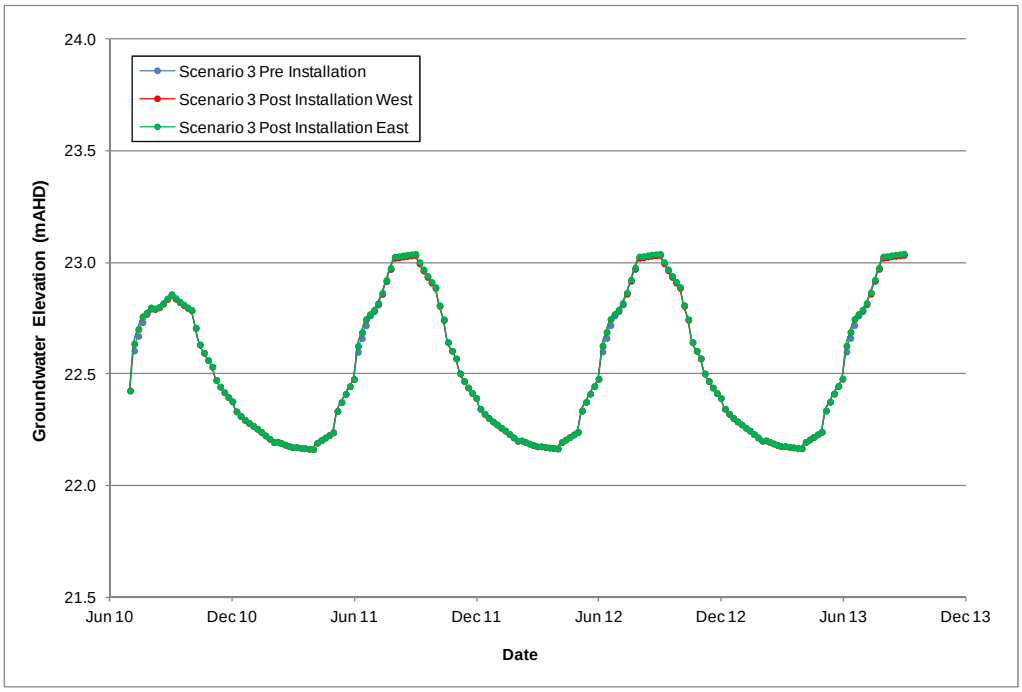


Graph A4-5: Scenario 3 Pre-Installation Groundwater Elevation Time Series

Scenario 3 Post-Installation Groundwater Level Change

The pre-installation model was modified to simulate the impact of the pressure main. This was undertaken by applying a low hydraulic conductivity (K) value of 10^{-4} m/d along the 0.45 m × 0.45 m cells in Layer 2 (depth of 1.05 to 1.5 mbgl).

The model simulates minimal groundwater elevation change (maximum ~3 cm) directly east and west of the pressure main for Scenario 3 (Graph A4-6).



Graph A4-6: Scenario 3: Groundwater Level Change Time Series– Adjacent to Pipe

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