



MORFA LANDFILL RECHARGE TRENCH

Review of Progress

Report Number 2040r1v1d1020

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1 INTRODUCTION

The conceptual hydrogeological model of the Morfa landfills indicates that if recharge to groundwater becomes depleted, groundwater flow rate and groundwater elevation along the Moors would be expected to fall. In response, The Countryside Council for Wales (CCW) indicated at the time of Permit issue, that as the groundwater-fed springlines along the edge of Margam Moors are afforded statutory protection as a SSSI (Site of Specialist Scientific Interest), any depletion in groundwater flows was considered likely to lead to a derogation of the wet alkaline patches which support this vegetation. Consequently, the concept of a recharge scheme was agreed that was aimed at restoring any shortfall in groundwater flow that might result from landfill capping and development.

Since this time, two sections of the recharge trench have been constructed and additional monitoring data is now available. The infrastructure installed includes the supply ponds on the surface of the capped landfill and associated pipework, subterranean pipelines, control chambers, wind turbines, electrical power and batteries. Much of this infrastructure is still in place but has unfortunately suffered significant vandalism and theft. This has resulted in parts of the system becoming inoperable and others working under gravity and passive means. This has led to the current position where the system is not working as originally designed.

In this context, Geotechnology has been asked to undertake a review of the original design with the benefit of more monitoring data and of the current situation to help determine potential next steps.

2 OVERVIEW OF SITE

Tata (UK) Limited operates the Morfa Landfills which are situated at the southern end of the Port Talbot steel plant (see Figure 1). One of the landfills accepts hazardous wastes and another accepts non-hazardous wastes. Both facilities are subject to requirements of an Environmental Permit issued by the Environment Agency. The landfills both operate in a cellular manner with the site footprint being progressively covered with discrete landfill cells. This systematic method of working minimises leachate generation and environmental impact and offers the opportunity of progressive site restoration. A large part of the Morfa site is also occupied by a closed landfill which was filled prior to the use of containment cells.

2.1 Location

The centre of the site is located at National Grid Reference SS781 838. The site currently comprises a mixture of casually over-tipped land, landfills constructed in accordance with the current Landfill Directive since 2004 (MNHL and MHL), the unlined MCL, partially excavated sand dunes and pristine dune fields. Key features and boundaries are indicated on Figure 2.

The site was granted planning consent for sand extraction and waste disposal in 1973 and has been used in part for these purposes since. The planning boundary covers a large area (as shown on Figure 2), though restrictions within the conditions required a stand-off to be observed between the landfill site and the River Kenfig to the south and Margam Sands to the west. Tata also adopted a voluntary stand-off between the development of MNHL and MHL and the Margam Moors, which was designated a SSSI in 1984, 11 years after planning consent for the landfill had been granted.

The site occupies a coastal location, adjacent to the dune system behind Margam Sands. The ground is generally flat with only 2 metres of relief between 6m and 8m AOD, though the western edge of the development encroaches into the dune system, where elevation rises to 14m AOD. The western edge of the site is the coastal dune field over its entire length and is roughly parallel to the beach which lies 75 metres further to the west. The southern edge of the site is occupied by MCL with the eastern edge following the fence line at the western edge of Margam Moors. The central part of the site is occupied by the current MNHL while the northwestern corner is occupied by MHL. The northern edge of the site is defined by a disused access track crossing from the coast road to the edge of the moors.

The site is remote and located at the southern end of the Port Talbot steel plant. It is surrounded by land entirely owned by the company. The adjacent Margam Moors as far as the railway line to the east is owned by Tata (UK) Ltd as is the site as far south as the River Kenfig. KNNR is located to the south of the River Kenfig and is bound by the southern bank of the River Kenfig.

There are no inhabited buildings within 1.9km and the nearest industrial buildings are close to 1km from the site. There are no public roads within 1km of the site and the adjacent beach is also under the private ownership of Tata (UK) Ltd. There are no services crossing the site. One public footpath crosses the moors close to the site.

2.2 Geology

Much of the site is underlain by an irregular sheet of wind-blown sand which extends from the ground surface down to an organic/alluvial clay layer. The sand deposit is typically several metres thick, though this locally increases due to sand dune topography. Being wind-blown, the dune sand is poorly graded, with a very uniform grain size throughout. The sand has blown inland from Margam Beach which lies to the west. Locally, the wind-blown sand is overlain by made ground comprising steel making wastes. The small woodland patches along the base of the northeastern flank of the site appear to be dune migration barriers and mark the extent of the blown sand.

Underlying the wind-blown sand is an organic and alluvial clay layer of up to 2.8m thickness. The alluvial clay layer is continuous with the clays found at the surface on the adjacent Margam Moors and therefore this layer represents the moorland surface prior to the deposition of the wind-blown sands. This clay layer is absent in the south, possibly being washed away by the meandering River Kenfig.

Where present, the clay layer overlies an estuarine alluvium sequence, comprising principally dirty sands with shell fragments. Locally, finer lenses are seen and on occasions the upper surface of the estuarine fines layer supports a thin organic layer. In the extreme north of the site, the estuarine fines dominate the sequence, with the upper 10m of the stratum comprising sandy silt and clays. Locally, within the estuarine deposits, gravels and even cobbles are noted occurring in bands, with one of these traceable between Boreholes 14 and 15.

The estuarine sands overlie glacial gravels at depth, which have been encountered in nearby deep boreholes. None of the investigation boreholes drilled at the site have continued sufficiently deep to intersect these strata. The glacial gravels, which also crop out beneath the seaward edge of the coastal barrier dunes, extend inland for some distance. Coal Measures Bedrock underlies the glacial gravels at a depth of approximately 26m at the nearby Newlands Colliery.

2.3 Hydrogeology

2.3.1 Shallow Aquifer

The shallow aquifer is the wind-blown sand deposit with vertical downward percolation eliminated or restricted by the presence of the underlying clay. Permeability tests have been undertaken (rising head tests), and these reveal a variation in permeability ranging from $2 \times 10^{-3} \text{ms}^{-1}$ to $5 \times 10^{-5} \text{ms}^{-1}$, with an average permeability of $2.3 \times 10^{-4} \text{ms}^{-1}$. Due to the sand deposits limited thickness, the aquifer is thin, with perched water depths typically around 2 to 3 metres, extending from close to ground surface down to the underlying clay layer.

2.3.2 Deep Aquifer

Beneath the alluvial clay layer, the estuarine sands are saturated and piezometric levels are higher than the base of the clay. The water in the lower aquifer is therefore confined by the clay layer, where present. Rising head permeability tests have been undertaken in many of the boreholes, and these reveal that the lower aquifer is of lower permeability than the upper aquifer, with permeabilities ranging from $5.2 \times 10^{-4} \text{ms}^{-1}$ to $1.5 \times 10^{-7} \text{ms}^{-1}$. This is consistent with descriptions of the lower aquifer stratum as being silty sand.

Locally, thicker deposits of estuarine fines are found inter-bedded with the sands, with one principal fines stratum shown on the geological sections. At the northern edge of MHL, Boreholes 26 and 27 intersected a sequence dominated by silts and clays, with sand occurring as a minor constituent. Permeabilities here are expected to be accordingly smaller.

2.4 Hydrology

The site is surrounded by a sand dune field and there are no surface water courses within the site, or at its immediate perimeter. Surface water features in the vicinity of the site comprise the River Kenfig to the south, the Margam Moors ditch system to the north and the Bristol Channel to the west. A small number of isolated ponds are found on the low lying area to the north of MCL in an area that will be developed as part of MNHL.

Margam moors is a flat, poorly drained moorland which has been artificially managed over many centuries with a ditch or reen system. Precipitation is slow to run-off and the poor vegetation cover supports a small livestock rearing effort. The moors are characterised by the deep man-made reed filled ditches which allow the moors to drain water northwards where it is collected and pumped into the steel plant to be used as process water.

The flat lying moors have been managed for centuries and their configuration has been developed to address local ground conditions. The ditches are at their densest along the southern and western edge of the moors where there is a need to drain surface water originating from a pronounced springline. This springline is thought to be the result of the upper clay surface directing shallow groundwater in the upper aquifer to this area, as revealed by the topography of the upper clay layer shown in Figure 3. All the ditches feed into the Mother Ditch which flows northward to a single gauged collection point. From here the entire flow of water is abstracted into the works for use as process water. The pumping is carried out after the water discharges over a weir, and therefore pumping cannot affect water levels in the ditches.

The River Kenfig drains a small catchment to the east of the site to the sea at Margam Beach. This is the principal watercourse in the area and separates the site from Kenfig National Nature Reserve which is bound by the southern bank of the Kenfig. The river has a 95 percentile low flow of 950 litres/sec.

2.5 Ecological Setting

The site lies in an area of great ecological interest. Some 40m to the south of MCL, on the opposite side of the River Kenfig is the Kenfig National Nature Reserve, a SAC. The site shares a common boundary to the east with the Margam Moors which has also been granted statutory protection by its SSSI designation. There are also significant ecological features on site, some of which are a direct consequence of the restoration activities undertaken by Tata to date, particularly on the restored surface of MCL.

2.5.1 Kenfig National Nature Reserve

The northern boundary of Kenfig National Nature Reserve (KNNR) follows the southern bank of Kenfig River which flows to within 40m of the southern edge of MCL, as shown on Figure 2. KNNR is a Special Area of Conservation (SAC), designated because of:

-
1. Fixed dunes with herbaceous vegetation (grey dunes).
 2. Dunes with *Salix repens* subsp. *argentea* (*Salicion arenariae*).
 3. Humid dune slacks.
 4. Atlantic salt meadows (*Glauco-puccinellietalia maritima*).
 5. Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp.

Animal and plant species of community interest whose conservation requires the designation of Special Areas of Conservation; these are included on Annex II of the European Communities Council Directive on the Conservation of Natural Habitats and Wild Fauna and Flora:

1. Fen orchid *Liparis loeselii*
2. Petalwort *Petalophyllum ralfsii*

KNNR is also included under the following United Kingdom designations:

- Sites of Special Scientific Interest (United Kingdom)
- National Nature Reserves (United Kingdom).

2.5.2 Margam Moors SSSI

The western part of Margam Moors lies within 40m of the active MNHL and is shown on Figure 2. Margam Moors is a Site of Special Scientific Interest (SSSI) designated because of the mosaic of drainage ditches. In a Welsh context, only the extensive Wentlooge Levels support a similar assemblage of habitats and species.

2.5.3 On-site Ecological Features

Surveys of the ecological features on site have recently been undertaken as part of the review of mineral planning. Several significant ecological habitats were identified on site:

- Wet Woodland
- Reedbeds
- Ponds
- Coastal sand dunes
- Coastal vegetated shingle

Seven Nationally Scarce (BSBI Red List) and three Regionally Scarce plant species have also been recorded with the landfill site application boundary. A total of 35 Priority and Contributory sand dune specialists have been recorded to date with a further 37 species not confined to sand dunes but considered to be of local importance, as they are either important components of other valuable habitats, support scarce invertebrates or are locally scarce.

Plans showing the location of these features are set out in the Ecological Monitoring Plan.

3 TRENCH DESIGN AND OPERATION

3.1 Background

The conceptual hydrogeological model for the site reveals that shallow groundwater flows northward beneath the unlined MCL to discharge on the edge of Margam Moors. The thin wind-blown sand aquifer also receives rainfall recharge and the spring lines along Margam Moors are therefore dependent upon groundwater flow and rainfall recharge. If either recharge source becomes depleted, groundwater flow rate and groundwater elevation along the Moors would be expected to fall.

The Countryside Council for Wales (now known as Natural Resources Wales or NRW) indicated at the time of Permit application in 2004 that the groundwater fed spring lines along the edge of the Margam Moors support a soligenous fen ecology that is afforded statutory protection as a SSSI (Site of Specialist Scientific Interest). The relevant boundary of the SSSI in proximity to the Morfa site is shown on Figure 2. Any depletion in groundwater flows is likely to lead to a derogation of water levels in the Moors which in turn may affect the assemblage of flora and fauna. Consequently, the Permit was issued to Tata subject to the requirement to design a recharge scheme to restore any shortfall in groundwater flow that might result from the development.

Several reports have been approved by NRW that detail the design of the recharge trench:

- Geotechnology report 495.1/0/1206. Recharge Trench Design Report. 18 December 2006
- Geotechnology letter response (ref: 542/Recharge Trench Report/lt1 (Note: This letter was incorrectly dated 11 July 2006 – should have read 2007).
- Geotechnology Report: Morfa Non Hazardous Landfill Cell 1 Restoration Scheme Report Number 629.1/0/1207 December 07.

A summary is provided here.

3.2 Restoration Objectives

Restoration of the final landfill landform is required to comply with legal obligations set out in the Planning Consent and Permit. Whilst these documents specify restoration in broad terms, Geotechnology and Tata staff consulted widely to elicit a series of design objectives for the scheme at the time of Permit application. The identified design objectives for the restoration are:

- To achieve an acceptable landform that sits comfortably in its surroundings
- To control the infiltration of rainfall into the waste mass, thereby controlling the production of leachate
- To maintain groundwater levels at their historically recorded levels
- To create a finished surface that is similar to the dune system lost by the development of the landfill
- To improve groundwater quality by progressively replacing percolating leachate with clean surface run-off
- To maintain surface water chemistry as close to the surrounding natural water chemistry as practical

-
- To achieve a low maintenance restoration system that is easily inspected and maintained
 - To maximise the ecological opportunity offered by the scheme

The design and consultation process was iterative and during its evolution the interested parties considered many options. The approved final design is based on consultation with the statutory bodies and offers the potential to achieve each of the design objectives. The scheme uses readily available materials that can be placed quickly using techniques considered conventional in the landfill and construction industries.

3.3 Approved Design Concept

The concept of the recharge trench, as part of the site wide restoration scheme, is relatively simple and outlined in Figure 4.

Rainwater falling on the restored areas would be diverted to a series of storage ponds by gravity. The water from the ponds would then be fed by pipework down to the trenches running alongside the toe of MCL and MNHL. The timing of water supply and the amount required would be automated using a series of logic control valves connected to a low voltage wind-power supply and controlled by a PLC (programmable logic controller). This would divert water from the ponds to the trenches as demand, whilst ensuring that the ponds are not allowed to fully drain. Each element of the design is briefly outlined in the following sections.

3.4 Storage Pond Design

Storage ponds or any water bodies are generally discouraged on landfill caps as a failure in the lining system would result in additional leachate production. However, in this case, the need for an ecologically sensitive restoration together with a series of "header tanks" for the recharge system resulted in their acceptance.

On the restored surface of MCL, water will be collected in the drainage layer beneath the restoration sand and directed under gravity to a series of ponds. The design is outlined in Figures 4 and 5.

In total, the ponds cover a surface area of 16,378m² providing a total capacity of 24,567m³. However, it was the intention to preserve at least 0.5m of water in the ponds at any one time to ensure that their ecology is not compromised. Therefore, the scheme was intended to offer a useable capacity of 16,378m³. This figure was calculated to exceed the 8,431m³ shortfall caused by the recharge shadow. The 7,947m³ additional capacity provides contingency for the supply of water to both MNHL and MCL recharge trenches.

Leakage control from the ponds is of paramount importance and therefore the design comprises a 2mm welded double rough sided HDPE fml (flexible membrane liner) directly overlying a 300mm compacted BES or natural clay layer. The high specification of the composite barrier together with the control of water levels by weir outlets will limit leakage to very small quantities.

3.5 Trench Design

Alongside MCL and MNHL, recharge trenches comprising buried perforated pipes and associated inspection chambers will receive the water from the storage ponds on the surface of the restored landfill. The layout of the trenches is shown on Figure 5.

The recharge trench is to be excavated not as a single trench but as a series of trenches. This arrangement is required as the natural groundwater surface is not flat, but slopes along the trench alignment. Construction as a series of trenches also allows a greater degree of control over the water levels along the edge of Margam Moors. Each recharge trench is labelled separately for identification purposes, with Recharge Trench A at the southeastern end of the alignment (adjacent to Morfa Closed Landfill) and Recharge Trench F2 at the northwestern end. The trenches work as a series of pairs, with each pair being controlled from a single stand-alone controller. Construction of the recharge trench system will be carried out in two phases, with the MCL trench constructed first. The trench alongside MNHL will be placed in sections as the landfill construction proceeds. Progressive construction will keep pace with the development of the landfill but will follow the restoration phasing.

The trench is to be excavated using conventional earth moving plant to a target depth 0.5m below the lower water level. A filter geotextile will be placed into the trench once fill depth is achieved and onto this a layer of limestone sourced pipe bedding will be laid. Into the pipe bedding a single 250mm diameter hdpe twin wall perforated pipe will be laid and this will be covered in pipe bedding. The trench will be backfilled to the upper water level with a clean limestone crushed rock comprising 95% between 20mm and 45mm. Upon achieving the finished level, the filter fabric will be folded over aggregate and fixed in place with an additional layer of aggregate.

3.6 Recharge Chambers

Each recharge trench will be fitted with a stilling chamber at the discharge of each pond outlet pipe. These will receive the water from the pipelines such that the energy is dissipated within the chamber. A baffled section of the stilling chambers will contain the level transducers which will record water levels whilst also controlling the penstocks. The penstock valves will be fitted within the stilling chamber.

It is envisaged that each chamber will be fitted with a multi-channel data-logger to record the key parameters identified in this report.

3.7 System Control

Control sensors within the chambers will be set at the design levels and will open and close valves depending on whether water is required or not. Programmable control logic would demand water from the ponds water when needed and shut off water supply valves when water is not needed, throughout the seasonal cycle. This system would be powered by wind-power connected to batteries and provided with a back-up generator.

3.8 Targets

As part of their management of the Moors, NRW has developed a Site Management System (SMS) that set's out the objectives to be achieved through managing the Moors. The SMS identifies that the *100 hectare coastal grazing marsh comprises a relatively large Fen-Marshy*

Grassland area with adjacent neutral grassland fields, criss-crossed by man-made ditches with Standing Water. The collection of water within the ditches supports submerged, floating and emergent plant communities, with regionally rare species, in addition to a rich Aquatic Invertebrate Assemblage. The dune-influenced grassland areas, nearest the coast, support the vulnerable Shrill Carder Bee, which is currently only known from one other location in Wales and is thought to be on the verge of extinction in the UK.

The Fen-Marshy Grassland mosaic is present along the south and southwest margins of the site, largely separated from the rest of the site by the Lower Mother Ditch, receiving waters from under the base of the dune system and landfill, which lies on the former Margam Burrows.

3.8.1 Waterlevels

The SMS developed by CCW does not set water levels to be achieved at specific points within the Moors. Rather, the SMS states that '*water levels in the ditches need to be maintained to ensure the plants and invertebrates are able to persist*'.

The SMS also recognises that the water in the Mother Ditch ultimately drains into the Tata site where it is controlled by a weir system.

The SMS also indicates that periodic clearance of the ditches to remove dead plant material and accumulated soils that would otherwise infill the ditches is required to maintain the water levels.

The recharge trench system is designed at therefore maintaining groundwater levels to those experienced previously. Based on a review of data at the time, the target water levels to be maintained in recharge trenches were set as follows:

Design elevations for the western MNHL recharge trench are:

Upper Level	5.75m AoD
Lower Level	5.05m AoD
Trench Floor	4.5m AoD

The design elevations for the MCL recharge trench are

Upper Level	6.50m AoD
Mid Level	6.15m AoD
Lower Level	5.80m AoD
Trench Floor	5.75m AoD

It was recognised at the design stage that the waterlevel targets were based on historical monthly groundwater level variations and that the levels may need to be changed based on the results of future monitoring following the implementation of the recharge trench scheme and potential changes in climate.

3.8.2 Hydrochemical Requirements

The SMS does not set emission limits for water draining into the Moors. According to the SMS, the aim is to maintain good water quality passing through Margam Moors. The water should be nutrient poor with a neutral pH. In relation to the Morfa Site, the SMS indicates

that the '*landfill should ensure waters draining into the site are not enriched and are of suitable pH*'.

Although the SMS does not set any specific emission limits for the waters draining into the Moors, target levels have been agreed with NRW.

4 PROGRESS TO DATE

4.1 Restoration of Morfa Closed Landfill (MCL)

In the early 1970's, Morfa Landfill was constructed as an ad-hoc deposition of wastes onto natural ground. No basal liner was placed beneath the deposited wastes and there is no leachate collection or leachate management system. This has resulted in leachate from the wastes infiltrating shallow groundwater. In areas where the clay aquitard is absent, this leachate is also potentially recharging the deep aquifer, if and when, the head differential is suitable. There is limited evidence of such recharge.

MCL accepted all the waste originating within the steel plant between the mid 1970's and 2004. Since December 2004, no additional waste has been deposited. During the landfill operation, the waste comprised the principle sources listed in Table 4-1. The total tonnage deposited is approximately 10 million tonnes. The waste is dominated by BOS and BF slag.

Table 4-1 Estimated Waste Composition of MCL

Waste Material	Percentage of Total Waste
BOS and BF Slag, Refractory material and Rubble	89%
Water treatment solids, mill scale, wood and general commercial waste	7%
Canteen and Horticultural waste	0.3%
Filter Cake	3.7%
Asbestos	0.002%

Restoration of unlined MCL was completed in phases between 2004 and 2013. The restoration involved the placement of site won dune sand over the plateau and parts of the re-profiled slopes. Below the sand, the restoration scheme involved placement of geomembranes which, in combination, provide gas and surface water management as well as providing barriers to precipitation ingress and gas egress. The sympathetic restoration also involves the placement of sand on top of the geomembranes, creating dune morphology like the surrounding land. Rainwater falling onto the restoration surface infiltrates through the restoration sand layer, encountered the geomembranes and then drains to the ponds shown on Figure 5 and Plate 4-1. The restoration scheme has been complete since 2013 and subject to ongoing maintenance and aftercare.



Plate 4-1 Typical restoration profile on surface of MCL

4.2 MCL Trench Construction

As part of the restoration of MCL, recharge Trenches A and B, together with pipe trenches, chambers and cable runs from Ponds 2 and 3 have been constructed (see Figure 6).

Recharge trenches A and B were constructed at the toe of the northeastern edge of MCL in August and September 2102. The pipe and cable trenches, pipe and chamber placement together with geomembrane remediation works was completed during November 2014. Photographs of some elements of the work are provided in Plates 4-2 to 4-5.

As part of the works, the wind turbine and associated cabling was installed along with required control valves, control systems, battery packs, programmable controller unit, control cables and power cables were also installed.



Plate 4-2 Pipework in trench along toe of MCL



Plate 4-3 Intake chamber in Pond 3



Plate 4-4 One of the two recharge chambers at toe of MCL



Plate 4-5 Pipework chamber in valley between MCL and Biocell

4.2.1 Vandalism

Despite patrols by Tata security personnel and the landfill operator, the current trench alongside MCL is not operating as designed due to significant vandalism and theft. As shown in Plate 4-6, one of the blades of the wind turbine is no longer in place, and appears to have been shot off, and the control room has been forcibly entered, all contents removed and vandalised. As a consequence, the system has no power, batteries or control systems. This has resulted in the system solely working by passive means. Figure 6 illustrates the location of the main emission points of surface run-off from the cap.



Plate 4-6 Damaged wind turbine and control room

4.3 MNHL Trench Construction

Installation of the MNHL trench is coupled to the ongoing development of the landfill and the progressive restoration of completed cells. To date, progressive restoration has not yet been initiated and trench construction has not yet been commenced. However, the current Permit requires Tata to restore part of the biodegradable waste cells by December 2021.

Since issue of the Permit, four cells have been constructed; two biodegradable cells used for the deposition of wastes with a gassing potential and two cells for the deposition of non-hazardous waste without a significant gassing potential. The extent of these areas are outlined on Figures 2 and 6.

Since 2007, Tata has operated a waste treatment centre that comprises recycling, screening, sorting and bailing facilities, together with areas for the storage of processed and

unprocessed materials prior to recovery. The facility mostly treats general wastes comprising plastics, paper, timber, glass, brick and concrete. Consequently, these wastes are diverted from landfill. Tata has also diverted several other waste streams from landfill resulting in a significant decline in the rate of waste disposal, as summarised in chart below.

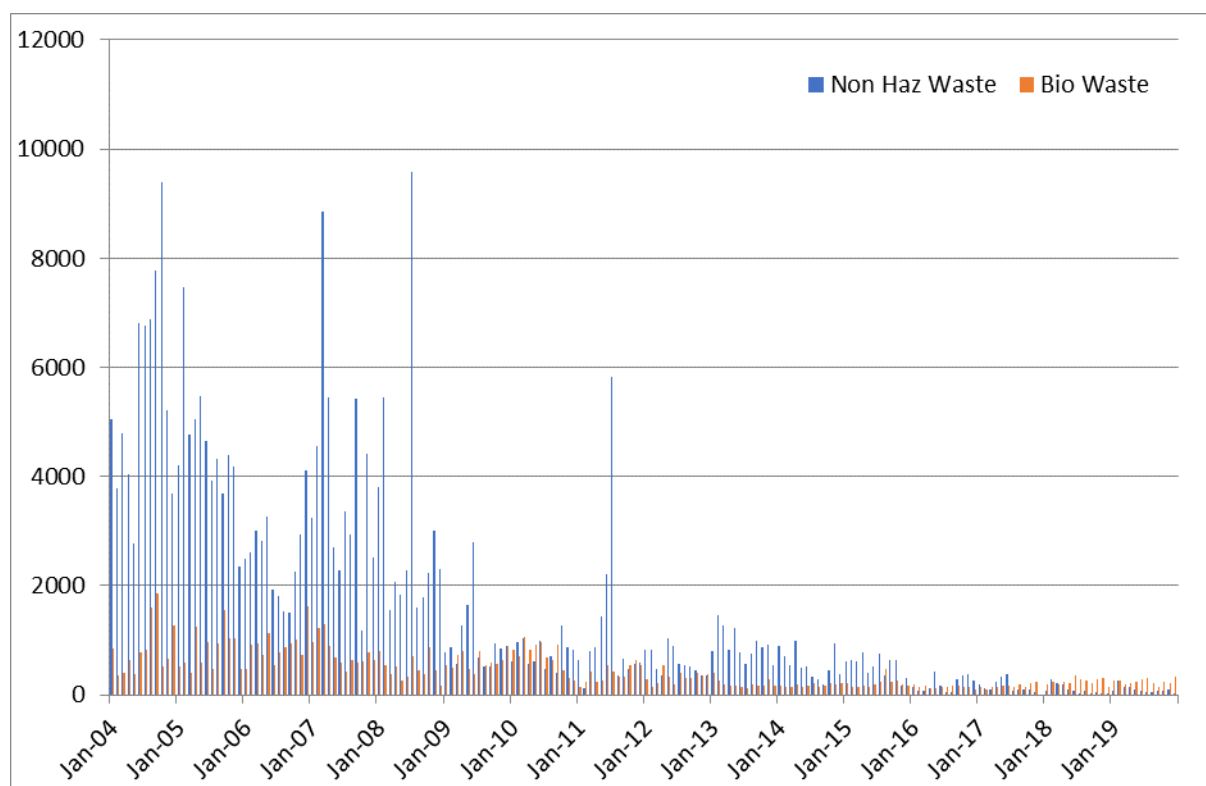


Chart 4-1 Tonnes of waste deposited each month

Despite diminishing inputs, the existing biodegradable waste cell (Biocell) is now very close to capacity, though there is large remaining industrial waste capacity in non-hazardous Cell 2. To address the imminent Biocell shortage, NRW has approved extending the Biocell capacity by recovering waste from Cell 1.

The existing Biocell is separated from non-hazardous Cell 1 by a deep narrow valley where the opposing south flank of Cell 1 meets the north flank of the Biocell, as shown in Plate 4-7. The approved restoration contours for the landfill, shown in Figure 5, require that this valley is infilled to produce a single elevated landform. To secure additional biodegradable void space, NRW has approved a cut into the upper part of the southern flank of Cell 1 and extension of the biodegradable waste cell lining system into the void to provide sufficient biodegradable waste capacity to 2028. Once the new cell area is available for waste disposal, the completed areas of the Biocell must then be restored by December 2021.

When disposal activities are complete, the entire MNHL site is to be covered with an engineered barrier in order to restrict the ingress of surface water into the waste. This is necessary to control the formation of leachate. The cap is designed to be placed progressively over the waste, with previous cells capped during the operation of the subsequent cell. This strategy offers the optimum control on the formation of leachate and therefore the flux of potential contaminants.

In each cell, the finished waste mass is to be covered with an intermediate cover layer of selected BOS slag to contain the wastes and control litter, dust, odour and vermin. When

the entire cell is available for capping, this intermediate cover layer will be proof rolled to provide a hard unyielding surface and also to assist the passage of landfill gas toward the gas vents. During this operation, any hollows or voids that develop are to be filled with slag and rolled until an acceptable surface is produced. The capping system placed over each cell will then comprise several elements placed in the following sequence:

1. A FML (flexible membrane liner) moisture barrier
2. A drainage geocomposite
3. Restoration soils (aeolian sand) and ponds

Restoration materials are to be placed above the drainage composite to provide a new ecosystem to off-set the losses caused by the landfill development.

The current planning permission for the site requires full restoration by 21 February 2044, followed by a 5 year period of aftercare.



Plate 4-7 View north towards Non-hazardous Cell 1, valley feature and Biocell

4.4 Aftercare to date

Morfa Closed Landfill has been fully restored and is in Aftercare. Since completion of the restoration of MCL, Tata has undertaken maintenance of the restored surface. This has primarily involved placing site won sand over areas where the original restoration sand has been shifted by the prevailing wind resulting in the underlying lining systems becoming partly exposed. In some areas this has been exacerbated by trespassing motorcyclists.

The current Ecological Management Plan (EMP) for the site sets out a programme of works to be implemented at set routine intervals. The work is largely focussed on enhancing and retaining habitats. A summary of the programme is provided in Table 4-3 with the full schedule set out in the EMP. One of the main elements of the work is regular scrub control. This is a fundamental requirement if open sand dune vegetation is to be kept in favourable condition for maintaining a high level of biodiversity.

With approval from the ecologist and Technical Working Party, scrub vegetation is to be used to help stabilise parts of the MCL flanks prone to wind erosion. The vegetation will be placed to reduce and halt the localised movement of sand so that self-seeding vegetation has time to colonise.

Some of the sand moved around the site by the wind has ended up in the topographic low points occupied by the ponds. As shown by the aerial image in Figure 6 and Plates 4-8 to 4-9, some of the ponds are significantly infilled. This sometimes results in localised over-topping of the linear pond arrangements resulting in wider, shallower littoral zones.



Plate 4-8 Partially infilled pond on surface of MCL



Plate 4-9 Overspilling of Pond 7

Table 4-2 Planned Ecological Aftercare

Year	Year #	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Prescription	ROMP conditions	Days	Method
2020	4							M	M	R				Monitoring	26: f & g	0.5	Surveyor
	4													Landfill embankment Cmpts D10 & D11: Partial scrub clearance	26: a, b, e & g	1	Cutting & treating stumps
	4													Landfill Cmpts D2 & D5: Top all vegetation	26: a, e & g	1	Tractor-mounted mower
	4													Re-scape borrow-pits: Southern half of D17 & D18:	26: a, b, d & e	1	Bulldozer/Excavator
	4													Pond clearance - outer half of P4, P6 & all of P8:	26: a, d & e	2	Tracked excavator
2021	5							M	M	R				Monitoring	26: f & g	0.5	Surveyor
	5													All areas: Monitor for & Control any regrowth	26: a, b & e	1	Cutting & treating stumps
	5													Landfill Cmpts D3, D7 & D8: Top all vegetation	26: a, e & g	1	Tractor-mounted mower
	5													Pond clearance - inner half of P7 & P9:	26: a, d & e	2	Tracked excavator
2022	6							M	M	R				Monitoring	26: f & g	0.5	Surveyor
	6													Landfill Cmpts D4 & D6: Top all vegetation	26: a, e & g	1	Tractor-mounted mower
	6													Re-scape borrow-pits: Northern half of D17 & D18:	26: a, b, d & e	1	Bulldozer/Excavator
	6													Pond clearance - inner half of P2, P3 & P5:	26: a, d & e	2	Tracked excavator
2023	7							M	M	R				Monitoring	26: f & g	0.5	Surveyor
	7													Landfill embankment Cmpts D1 & D9: Partial scrub clearance	26: a, b, e & g	1	Cutting & treating stumps
	7													Landfill Cmpts D2 & D5: Top all vegetation	26: a, e & g	1	Tractor-mounted mower
	7													Pond clearance - inner half of P4, P6 & all of P8:	26: a, d & e	2	Tracked excavator
2024	8							M	M	R				Monitoring	26: f & g	0.5	Surveyor
	8													All areas: Monitor for & Control any regrowth	26: a, b & e	1	Cutting & treating stumps
	8													Landfill Cmpts D3, D7 & D8: Top all vegetation	26: a, e & g	1	Tractor-mounted mower
	8													Pond clearance - outer half of P2, P3 & P5, plus outer half of P7 & P9:	26: a, d & e	2	Tracked excavator

5 IMPACT OF WORKS TO DATE

5.1 Recharge Shadow Development

The current recharge shadow has developed over a decade, as shown in the timeline of key events summarised in Table 5-1. Restoration and capping of MCL and the development of cells at MNHL has resulted in direct rainwater infiltration being prevented in these areas. The full extent of the area where this recharge shadow is currently cast is shown on Figures 6 and 7. Also shown on Figure 7 is the predicted full extent of the recharge shadow based on the construction of further landfill cells. This was the extent of the recharge shadow used to underpin the original design of the recharge trench system.

Table 5-1 Summary of site activity to date

Activity	Start	Finish	Current Recharge Shadow Development
Construction of MNHL Cell 1	1 June 2004	19 October 2004	START
Construction of MHL Cell 1	1 June 2004	19 October 2004	
Start restoration of MCL surface	September 2004		
Construction of MNHL Biocell A	14 June 2004	8 September 2004	
Construction and operation of waste treatment centre	5 December 2006	Ongoing	
Construction of MNHL Biocell B	August 2007	13 October 2007	
Construction of MNHL Cell 2	6 May 2008	31 July 2009	
Construction of MHL Cell 2	October 2011		
Construction of recharge trench sections A & B	30 Aug 2012	12 Oct 2012	
Completion restoration of MCL surface		June 2013	COMPLETE
Ditch clearance in Margam Moors by NRW & Tata	February 2019	March 2019	

5.2 Water Levels

Tata monitors groundwater and surface water levels around the site at a series of shallow piezometers, groundwater wells and surface water gauging posts, as indicated on Figure 8. Monthly monitoring has been ongoing for the past 16 years and the data provides a reliable record for tracking and evaluating the current influence of the recharge shadow caused by the capping and lining schemes.

5.2.1 Groundwater Levels

Examination of the shallow groundwater surface shown in contour plans included in Appendix 1 shows that it is domed and has been largely stable for the past decade, with a concentric series of groundwater elevation contours centred on the highest elevation, close to the centre of the site (typically around BH19).

Groundwater flows in response to head loss and accordingly, flow lines will be normal to the contours, radiating outwards from the dome. This radial flow pattern is a response to groundwater recharge in the shallow aquifer, which has very limited extent, following almost exactly the footprint of the site. Clearly, shallow groundwater flow from beneath the site would be expected toward Margam Moors, Margam Beach, the River Kenfig and the railway sidings – the vector arrows included on the plots in Appendix 1 help illustrate these groundwater movement patterns.

Despite the full extent of the current recharge shadow being in place since 2013, and having started in 2004, groundwater flow patterns are largely unchanged. This is clearly highlighted in the selected chart 5-1.

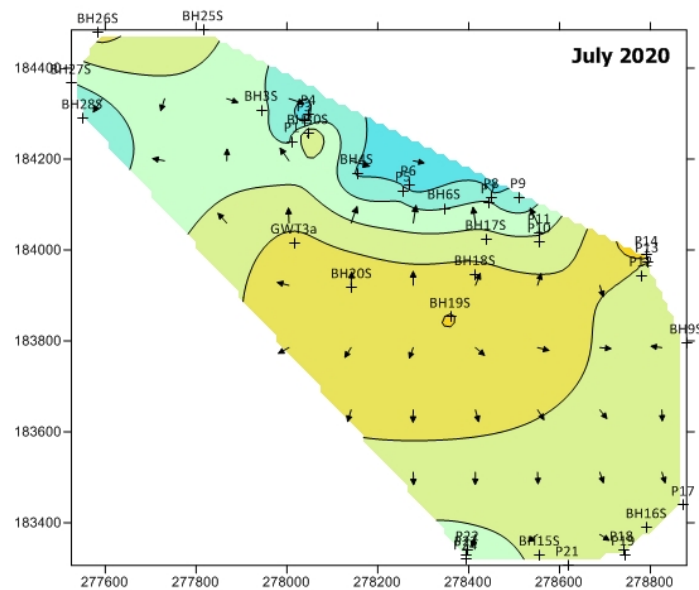
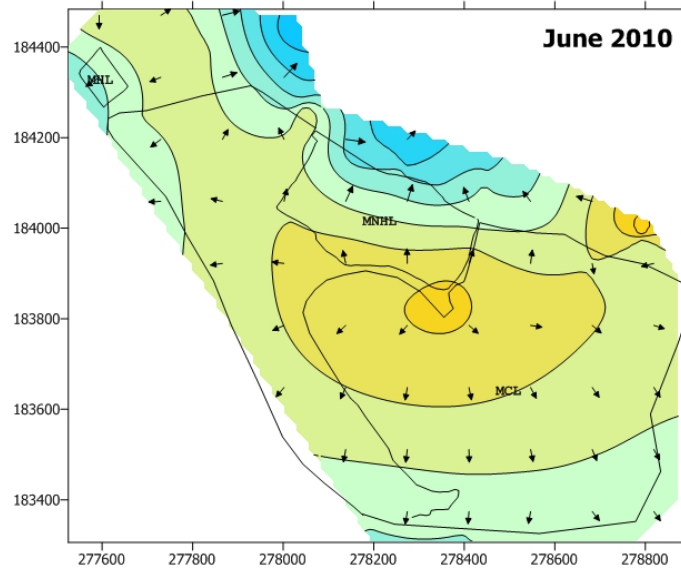
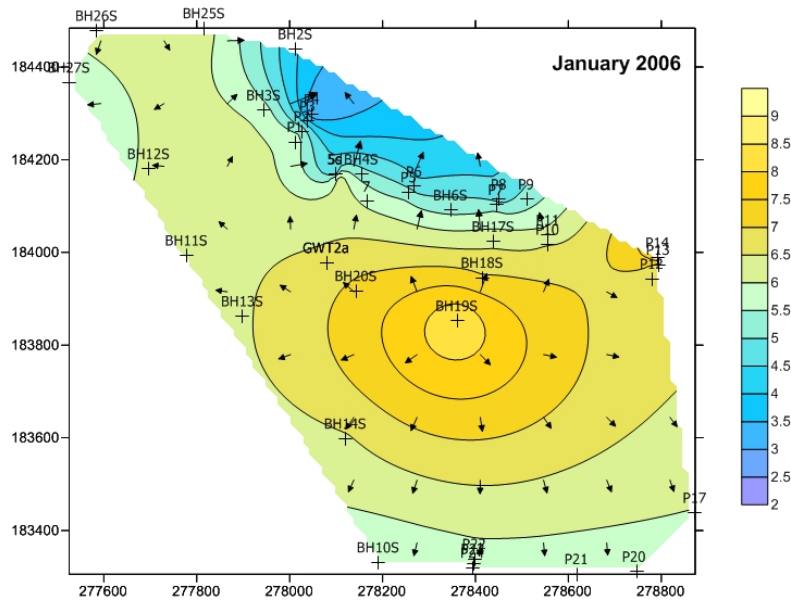


Chart 5-1 Groundwater contours

The reason that groundwater flow patterns have not altered significantly is that groundwater levels and surface water levels measured in the monitoring network have largely remained unchanged throughout the monitoring period that extends from 2005 to the current time. This is revealed by the temporal plots in Appendix 2, with key plots reproduced in /chart 5-2 to 5-4.

The selected plots show the waterlevels at the following key locations:

- Chart 5-2 - Mother Ditch in Margam Moors SSSI (Gauges 1 and 2)
- Chart 5-3 - River Kenfig (Gauges 6 and 7)
- Chart 5-4 - Groundwater levels in and close to Margam Moors SSSI (BH1, BH3 and BH17)

Each of these locations are shown on Figure 8.

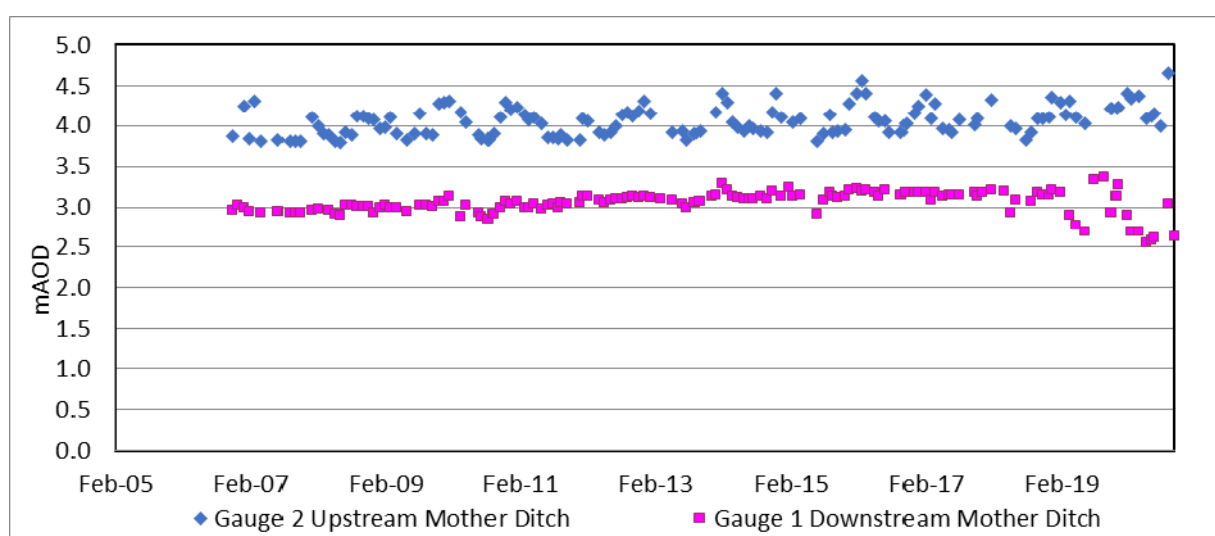


Chart 5-2 Water levels in Margam Moors SSSI Mother Ditch

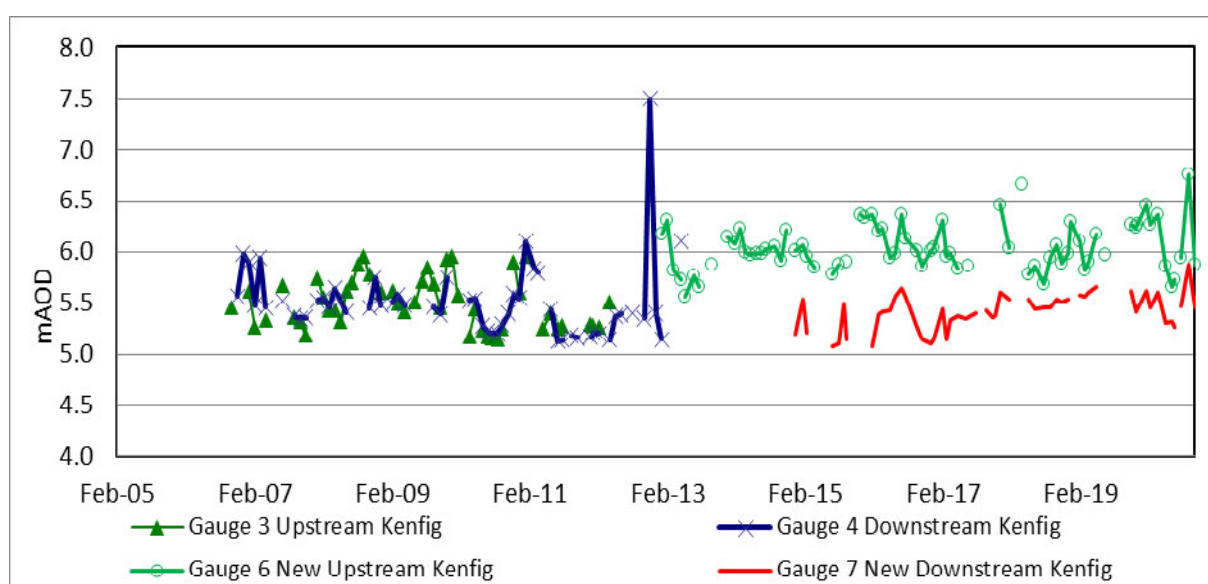


Chart 5-3 Water levels in River Kenfig

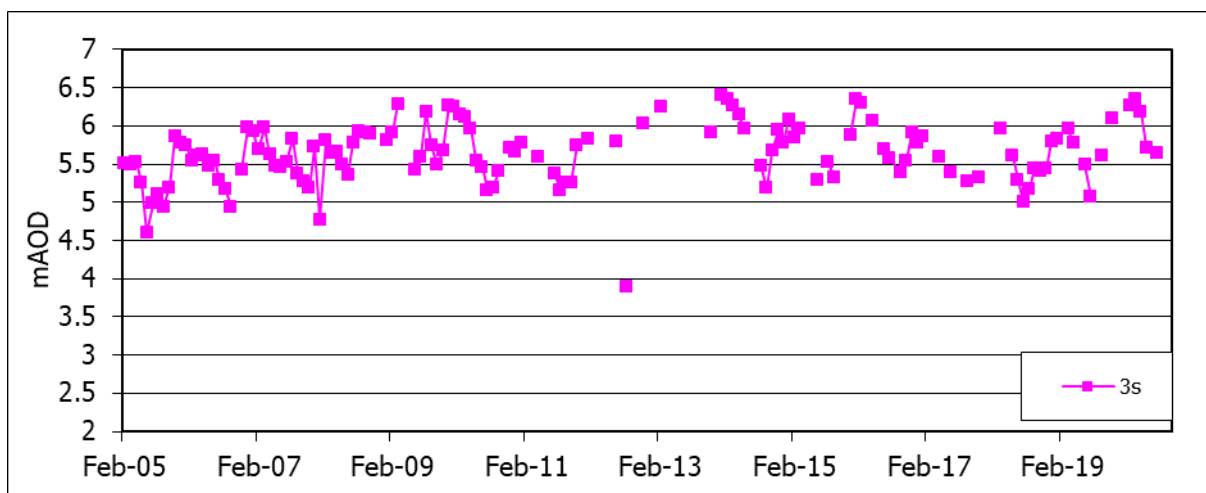
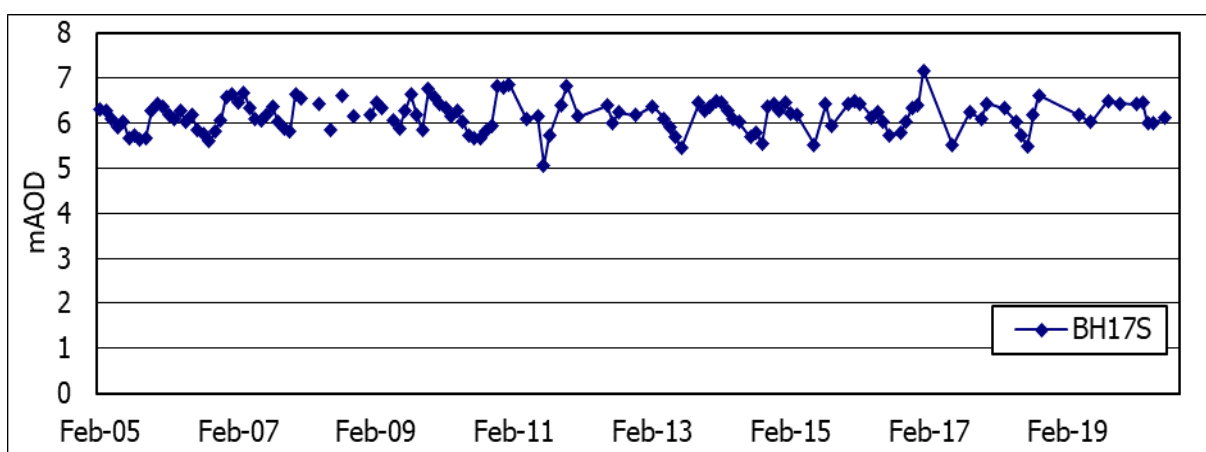
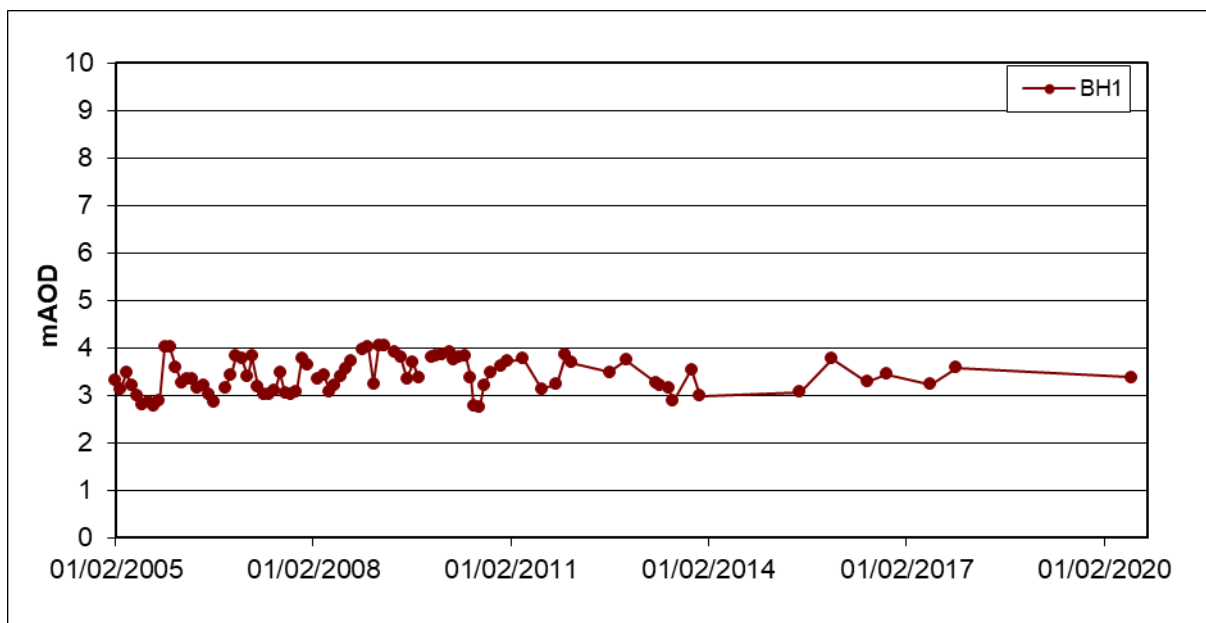


Chart 5-4 Selected groundwater in and along edge of Margam Moors SSSI

These charts clearly illustrate that short-term seasonal variations are still evident but that there are no significant long-term trends in water levels. Critically, summer waterlevels have not declined. This is important and means that radial groundwater flow to the sensitive surrounding ecological features is still occurring and that groundwater and surface water levels in and around these sensitive receptors has been sustained throughout the capping and lining works to date.

Interestingly, the impact of ditch clearance in early 2019 on surface water levels in the Mother Ditch appears to be clearly evident in the monitoring data (see Chart 5-1). This highlights the importance, and influence, of SSSI maintenance.

6 NEXT STEPS

6.1 Restoration Success

The reason that water levels have been maintained is that the recharge scheme has been operating but via passive means. The system has been recharging shallow groundwater but the automated control originally intended has not occurred, principally because of the significant vandalism that has occurred.

Inspection of the site reveals that recharge is occurring at several key principle emission locations, where rainfall captured on the surface of MCL is being passed to the wider environment. These areas are indicated on Figure 6 with further photographs of the processes occurring provided in Plates 6-1 and 6-2.



Plate 6-1 Surface water ponding between toe of MCL (left) and Biocell (on right). Partly being caused by drainage channel overtopping at toe of MCL in foreground.



Plate 6-2 Emission from Pond 2 (left) at toe of MCL draining northwards towards P10/P11 (Note recharge chamber on right of photo)

In these recharge zones, indicated on Figure 6, rainwater from the restored surface of MCL is draining under gravity through the installed pipework and infiltrating to the shallow aquifer. In some areas, at some times, this is leading to inundation and localised temporary ponding. Run-off is also draining off the cap along constructed drainage channels, as shown in Plate 6-1. The process is conceptually illustrated in Figure 9.

6.2 Potential Modified Approach

The sustained waterlevels and ecological features of interest noted on the MCL restoration surface indicate that the MCL capping scheme and recharge trench concept have proved successful to date and that the restoration objectives are being achieved. Subject to approval from NRW, the success to date potentially paves the way to alter the way that the system was intended to be operated and managed and potentially also offers the opportunity of refining the design of future recharge elements. Such changes could be short-term or permanent dependent upon ongoing observational monitoring results.

The alternate approach would require several interventions and modifications to the existing system and modified designs for future recharge trenches. If the principle of this approach is acceptable to NRW, much of this work can be presented during the imminent design of the Biocell capping scheme with the intervention works undertaken alongside the planned progressive restoration of the Biocell, scheduled to be completed by 2021.

The interventions that are considered necessary include:

- Careful removal of wind-blown sand from all of the ponds on the restored surface of MCL. This sand could be used to protect elements of the restoration surface exposed due to wind erosion. This should be coordinated with NRW and the Technical Working Party. Consideration should be given to the ecological importance of the dune ponds and potentially rotational clearance.
- Close examination and maintenance of all of the currently installed pipework and drainage channels. Localised scouring and erosion needs to be controlled.
- Raising headworks of monitoring infrastructure around toe of MNHL / MCL (GA7, GA16, BH17, BH15)

The interventions would be aimed at maintaining the status-quo and, like any future modified trench designs, enable the system to become automated (as originally intended) if future observational monitoring indicates undermining of the restoration objectives. If future cells of MNHL are constructed, the area of reduced infiltration will expand. In the original design, the water harvested from the restored cap of MNHL was calculated to be insufficient to fully recharge the trenches alongside and so the design included water being drawn from the ponds of MCL which has a significant spare design capacity. This element of the water balance will need to be further scrutinised if, and when, the footprint of the landfill extends. Critically, the suggested interventions and modified approach would not undermine this potential hydraulic connection or the full construction of the original design philosophy.

7 SUMMARY

One of the key objectives of the SMS for Margam Moors is to maintain waterlevels in the ditches. Based on the available information, the recharge scheme installed as part of site restoration is proving successful at meeting this objective. As the current scheme operation is enabling the objectives to be met, an alternate strategy could be adopted provided this is acceptable to NRW. The new approach would retain all of the main elements of the recharge trench system that have proven to be successful but would require several interventions in the short-term and ongoing observational monitoring. The interventions could be undertaken at the same time as the bio-cell restoration.

References

Morfa Landfill Site Recharge Trenches A & B Specification. Report Number 1088r1v1d1011.

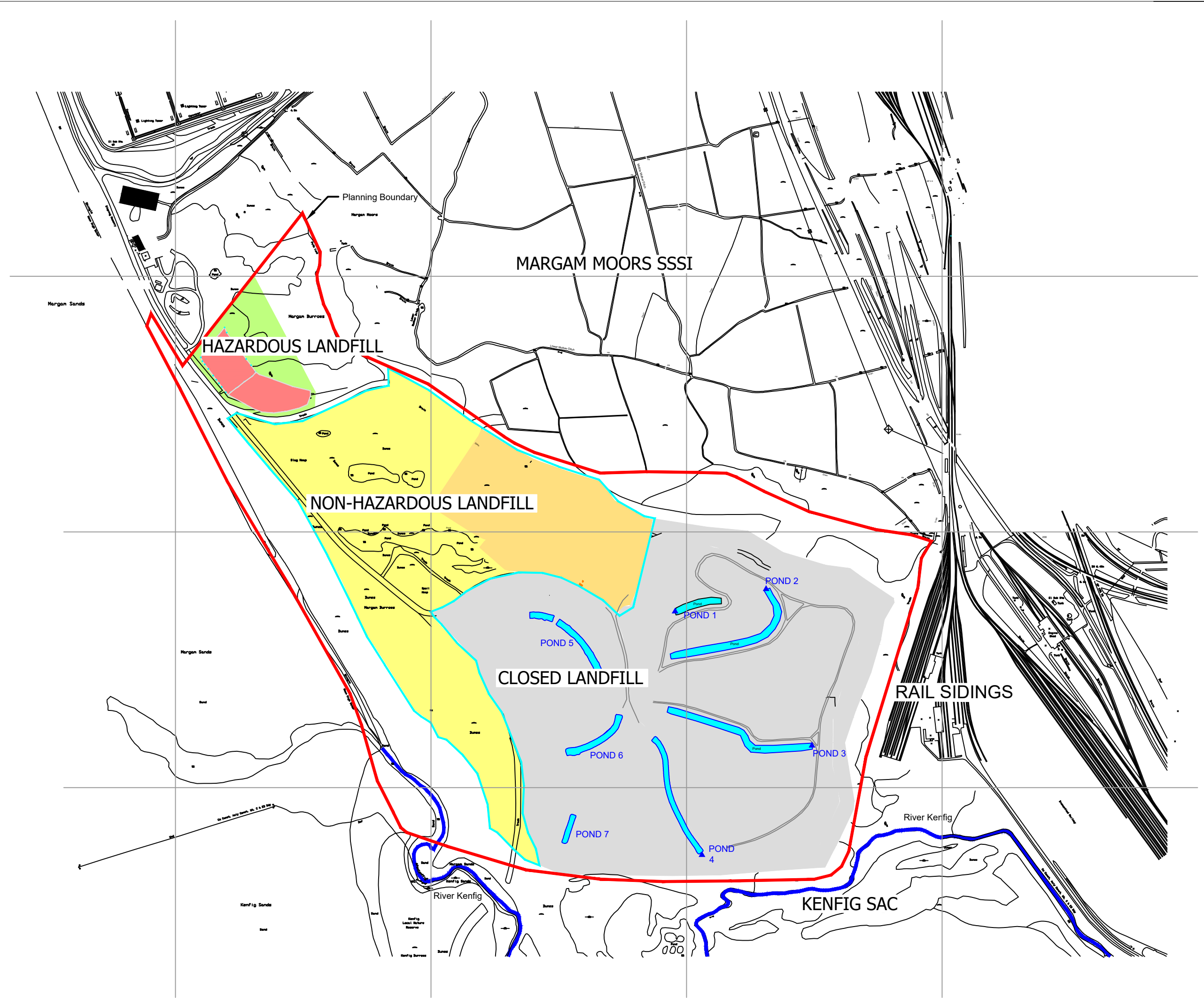
Morfa Closed Landfill Port Talbot, Permit EPR/3292LT, Recharge Trench Design Targets. Report Number 1085r1v1d0811.

Morfa Non-Hazardous Landfill, Cell 1 Restoration Scheme. Report Number 629.1/1/1207.

Figure 1 Site Location Plan



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Drawing Number 2040/2

- Legend
- Undeveloped Part of MHL
 - Developed Part of MHL
 - Developed Part of MNHL (2 bio cells & 2 non-haz cells)
 - Undeveloped Part of MNHL
 - Restored Extent of MCL

Notes

Rev	Date	Status/Ammendments
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CLIENT	Tata Steel Ltd	
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PROJECT	Morfa Landfill Recharge Trench	
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TITLE	Detailed Site Plan	
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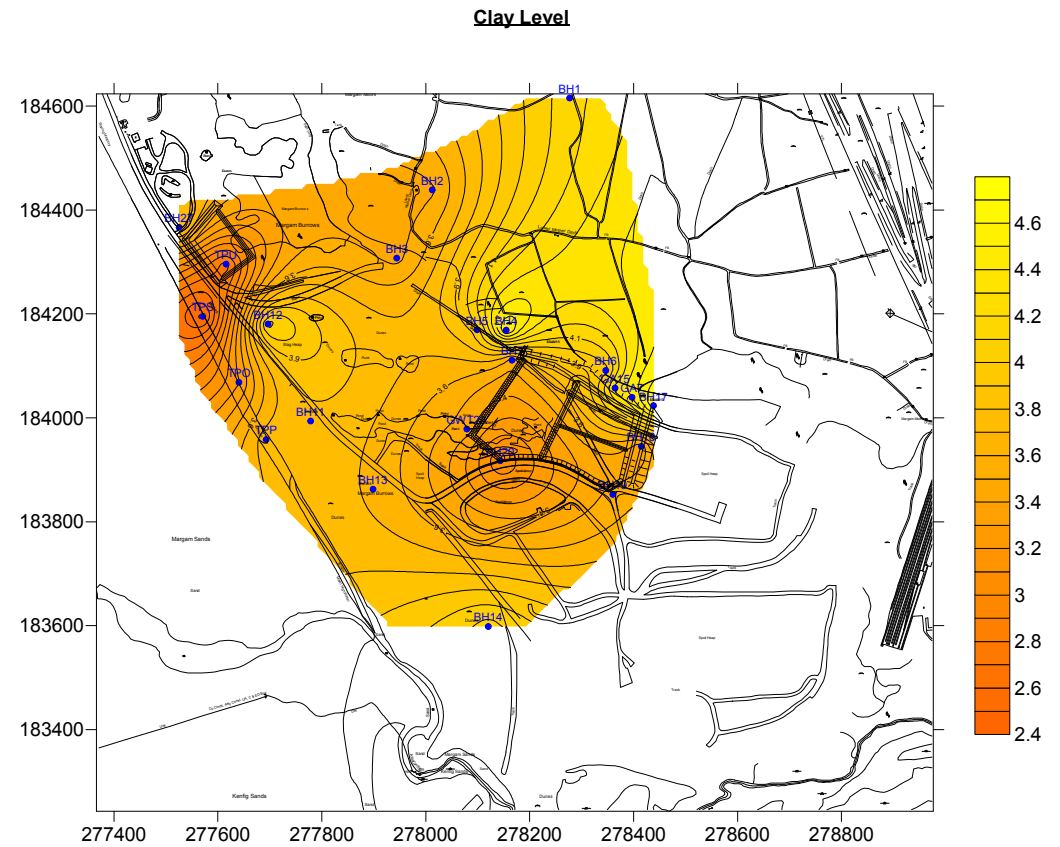
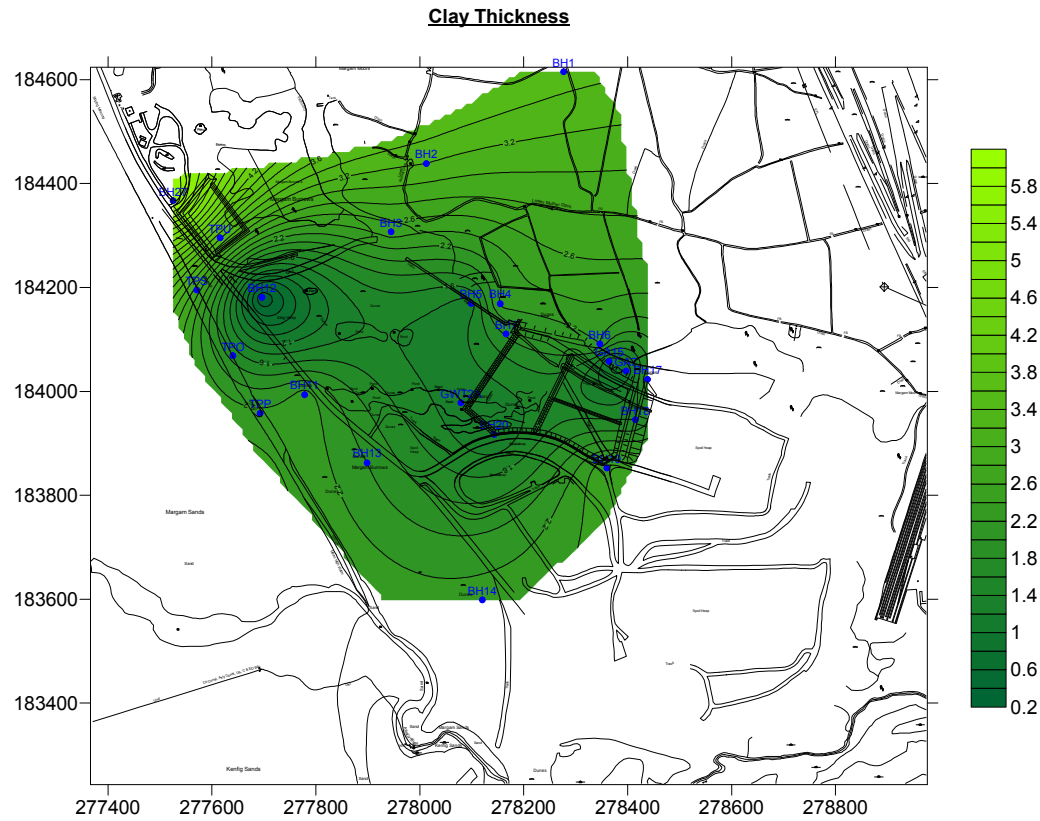
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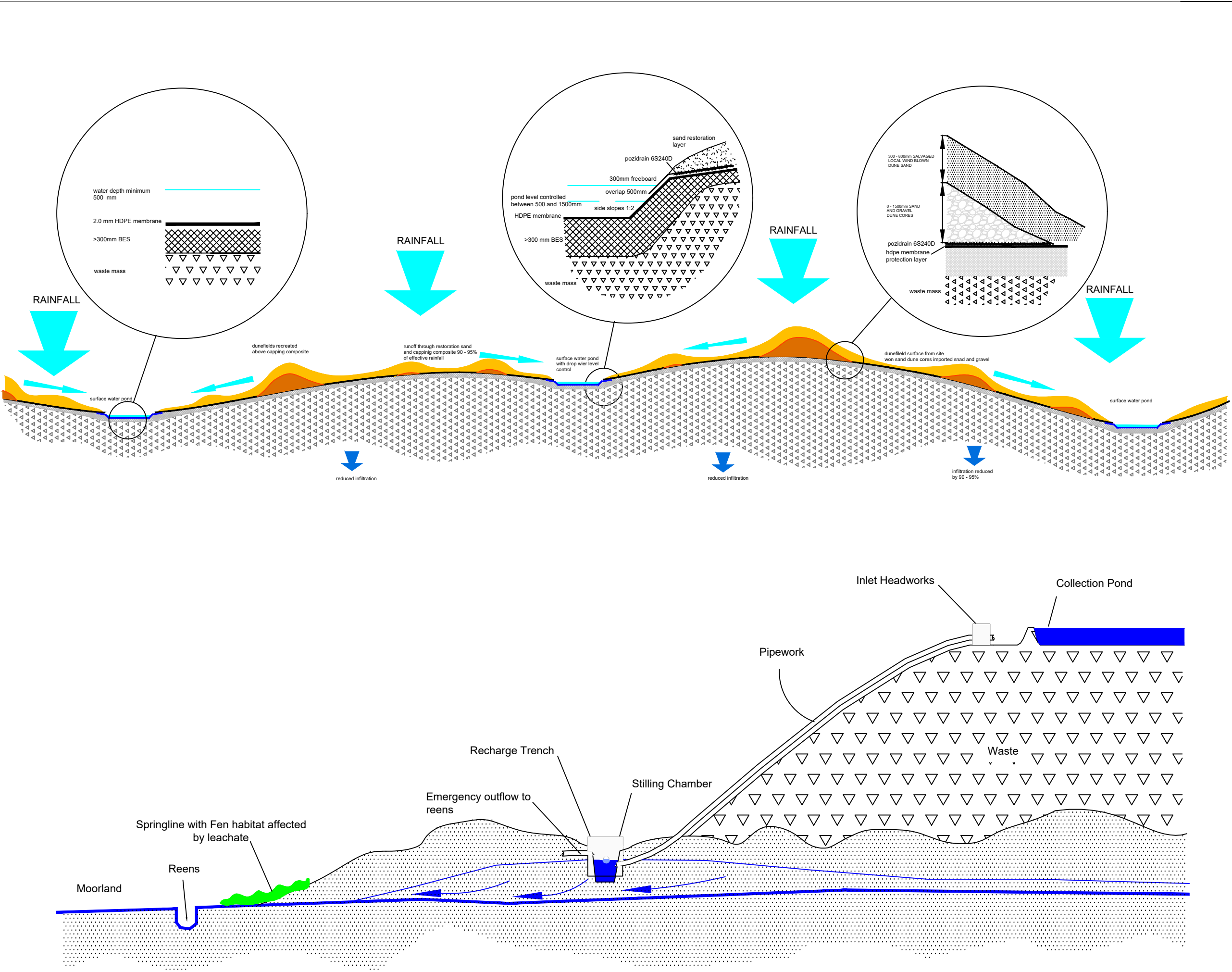
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Aberdulais, Neath
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01639 775293
www.geotechnology.net



Figure 3. Clay Layer Topography





Drawing Number 2040/4

Legend

Notes

Rev	Date	Status/Ammendments

CLIENT
Tata Steel Ltd

PROJECT
Morfa Landfill Recharge Trench

TITLE
Capping System Cross Sections

DRAWING NUMBER 2040/4			REVISION 0
DATE 10.20	DRAWN KJT	CHECKED	SCALE AT A3 NTS

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CLIENT	Tata Steel Ltd
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TITLE

Recharge Trench Design Layout

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Legend

 Recharge zone

----- Extent of lost recharge to Margam Moors

 Point Source Surface Runoff

 Springline in Moors

 Ponds in undeveloped areas of MNHL

Notes

Notes		

Rev	Date	Status/Ammendments
CLIENT		

TATA STEEL UK LIMITED

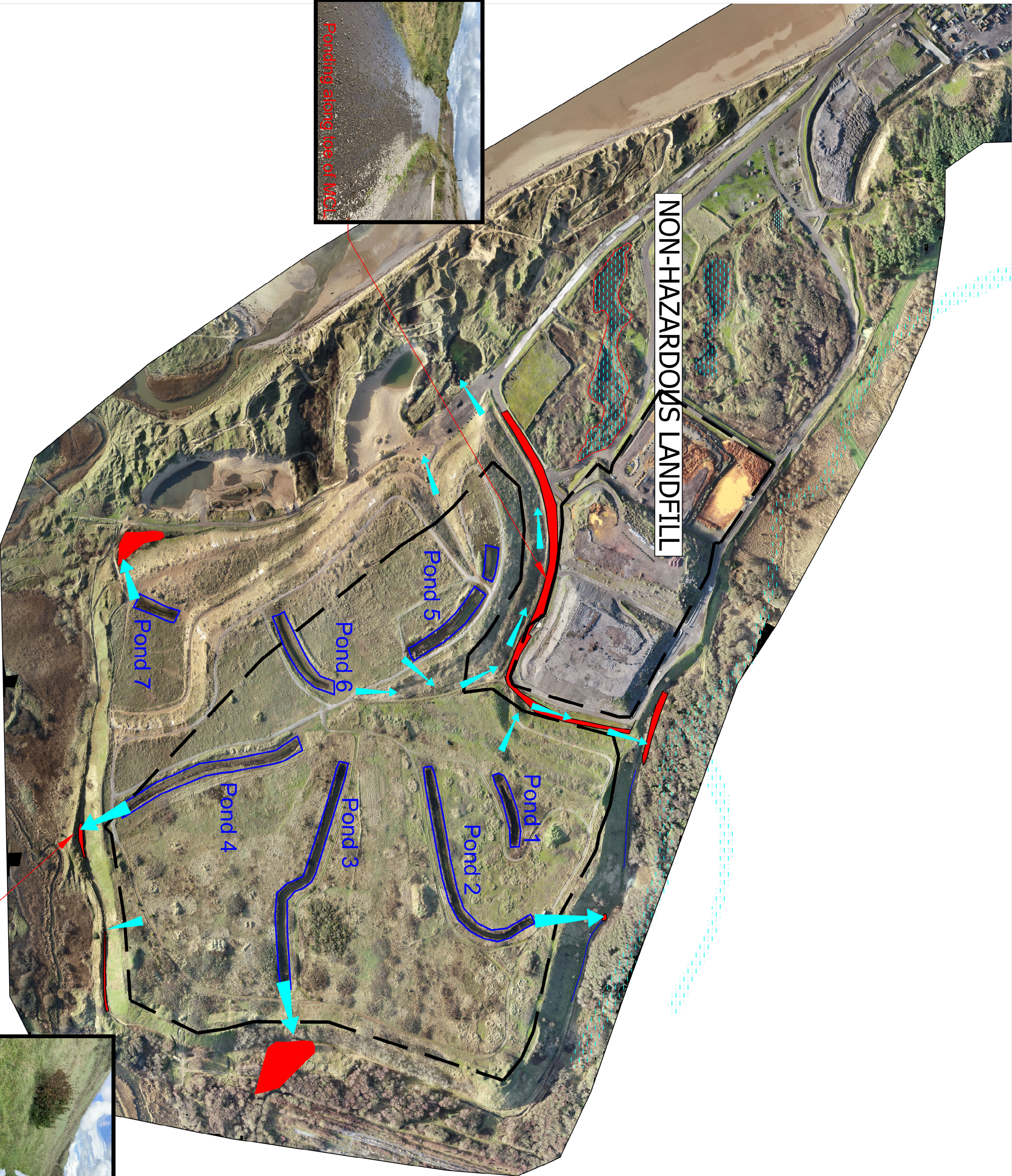
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Morfa Landfill Recharge Trench

TITLE

Aerial Image of Key Features

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NON-HAZARDOUS LANDFILL



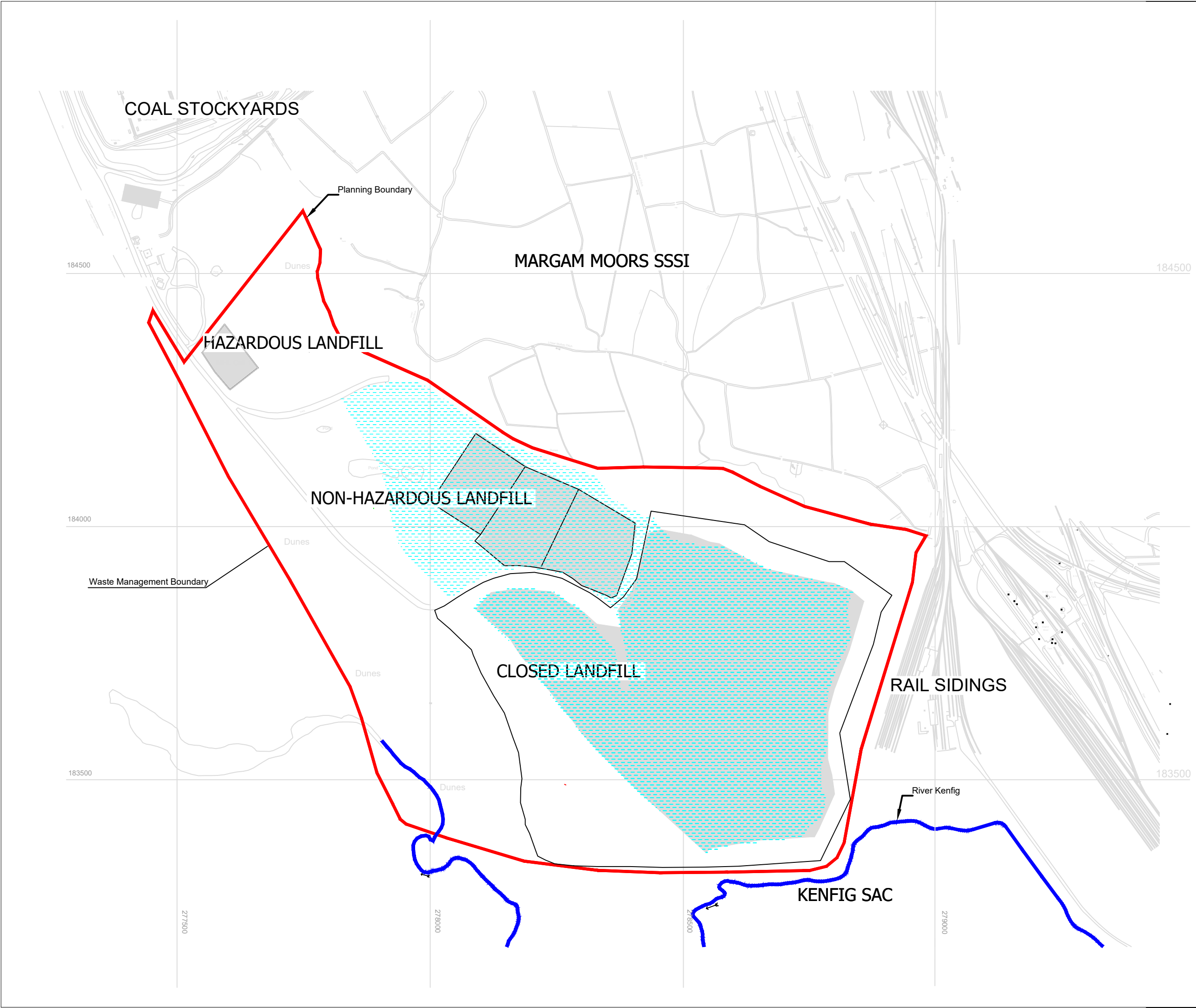
Ponding along toe of MGL



Runoff from Pond 3



Discharge from Pond 4 and surface ponding



Drawing Number 2040/7

Legend

Predicted full extent of rainfall shadow

Current extent of rainfall shadow

Notes

Rev	Date	Status/Ammendments

CLIENT

Tata Steel Ltd

PROJECT

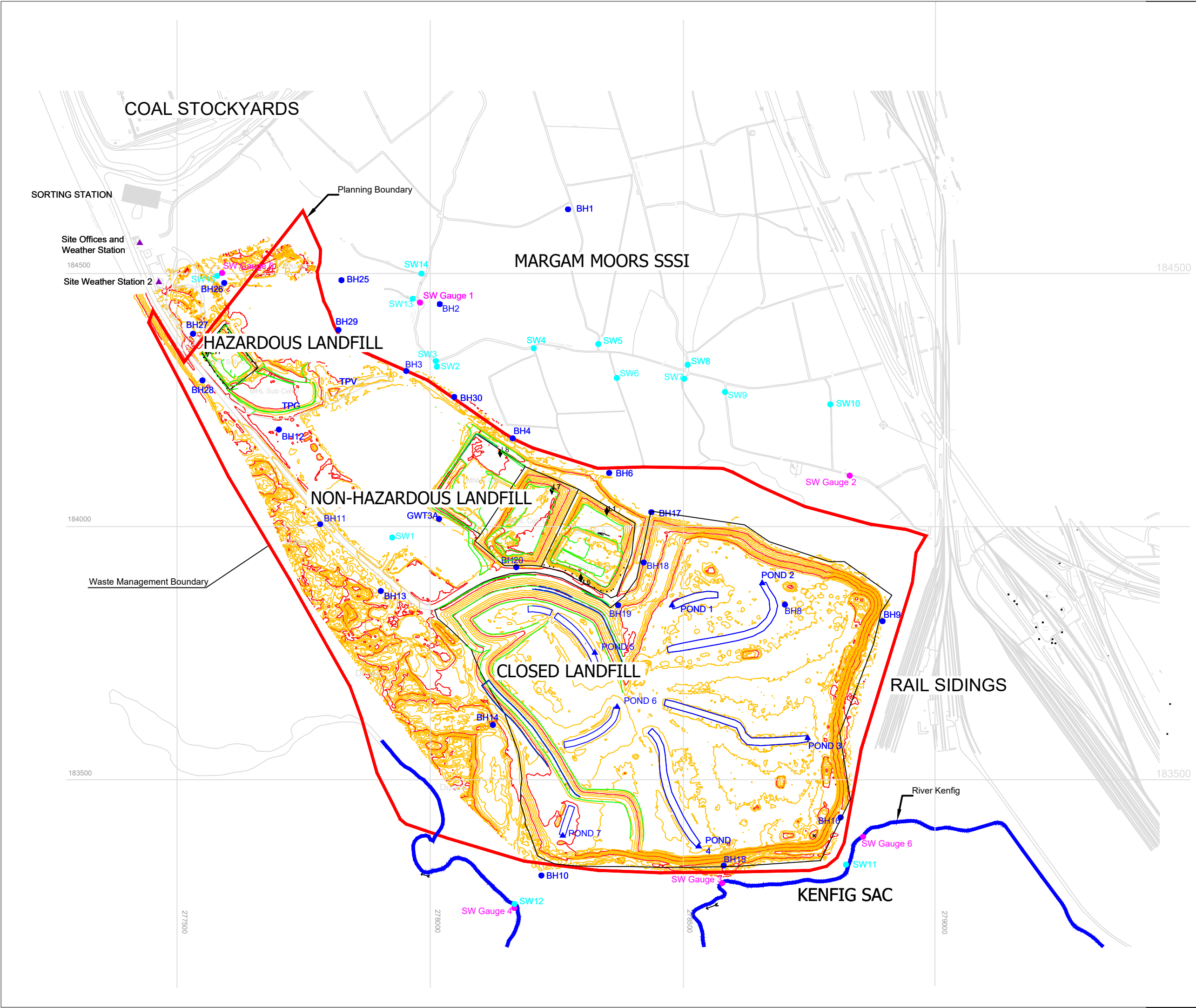
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Drawing Number 2040/8

Legend

- Gas Vent
- Leachate Collection Sump
- Weather Station
- Groundwater Well
- Surface Water Sample Point
- Surface Water Gauge Boards
- Pond Gauging and Sampling Point

Notes

Rev	Date	Status/Ammendments
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CLIENT
Tata Steel Ltd

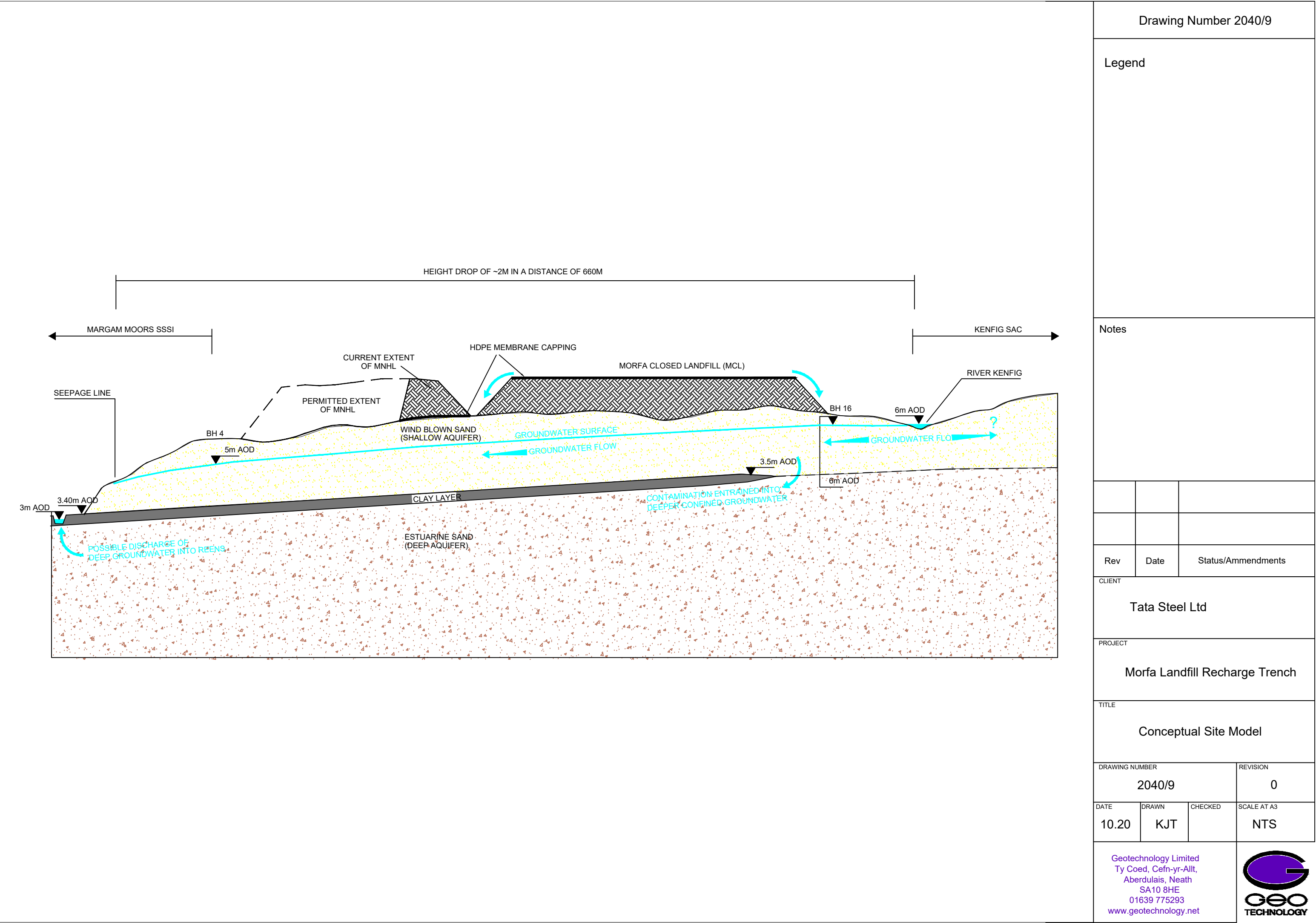
PROJECT
Morfa Landfill Recharge Trench

TITLE
Available Monitoring Network

DRAWING NUMBER 2040/8		REVISION 0	
DATE 10.20	DRAWN KJT	CHECKED	SCALE AT A3 NTS

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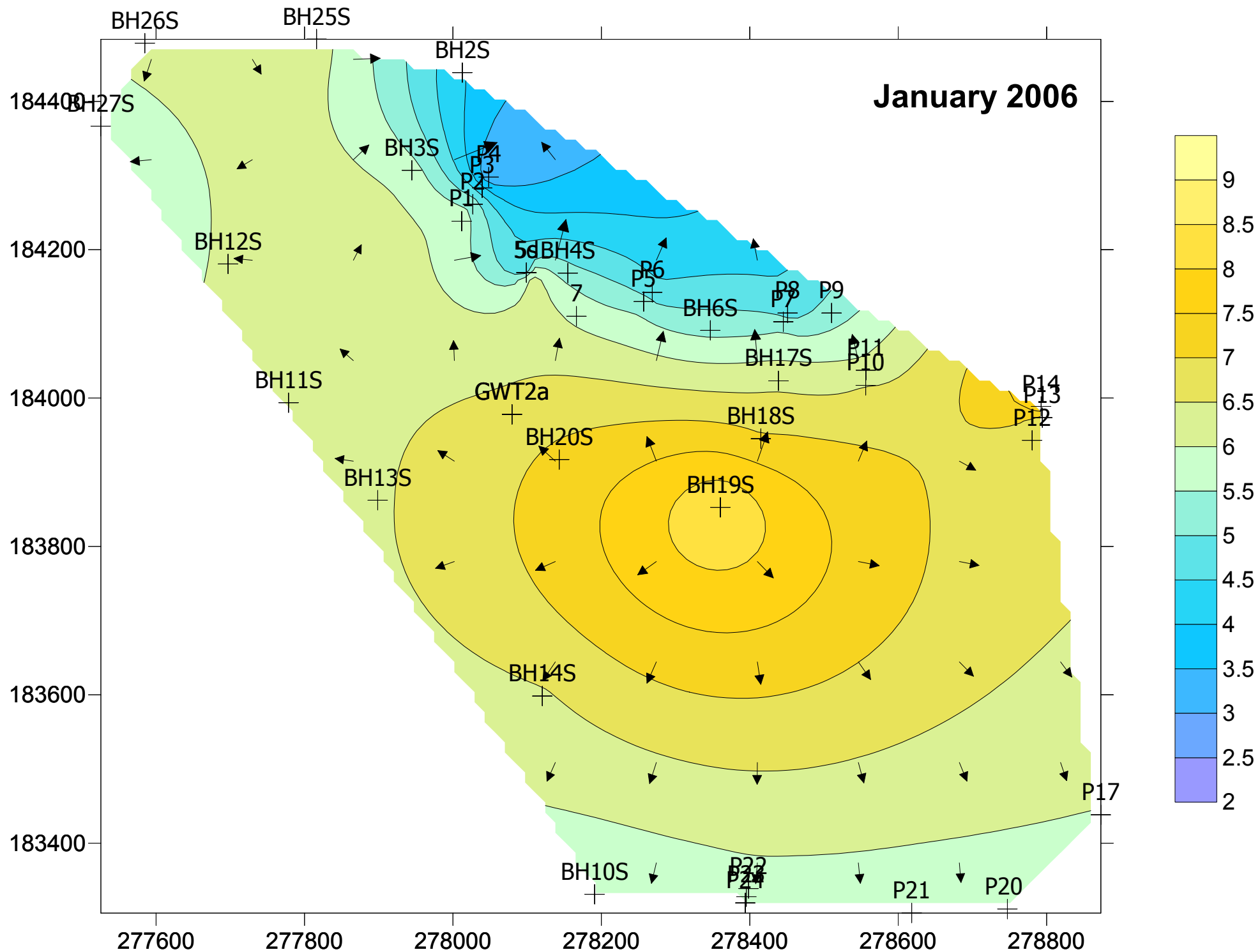
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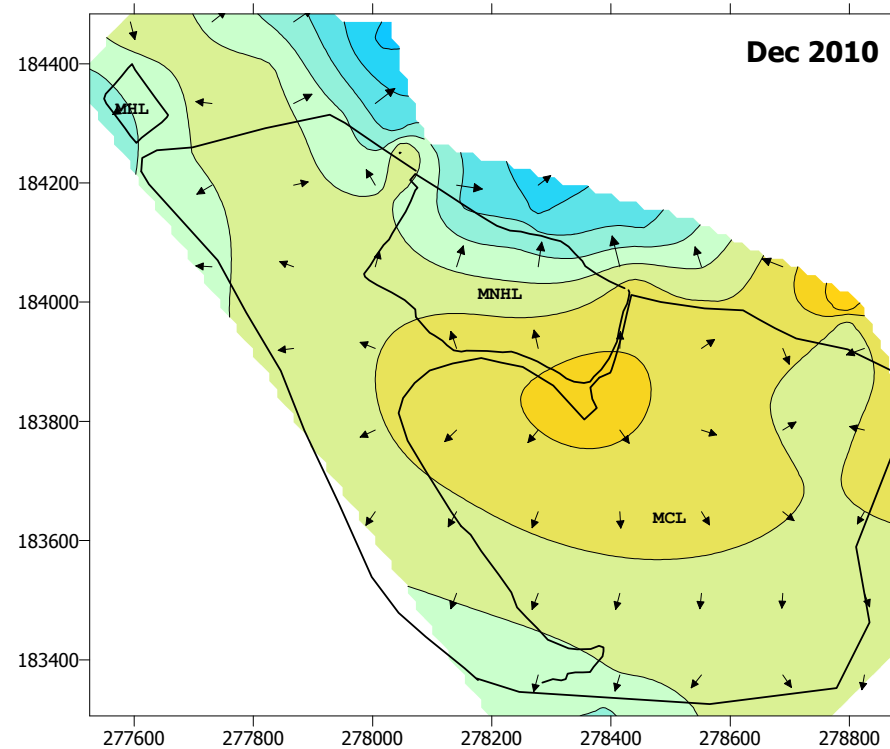
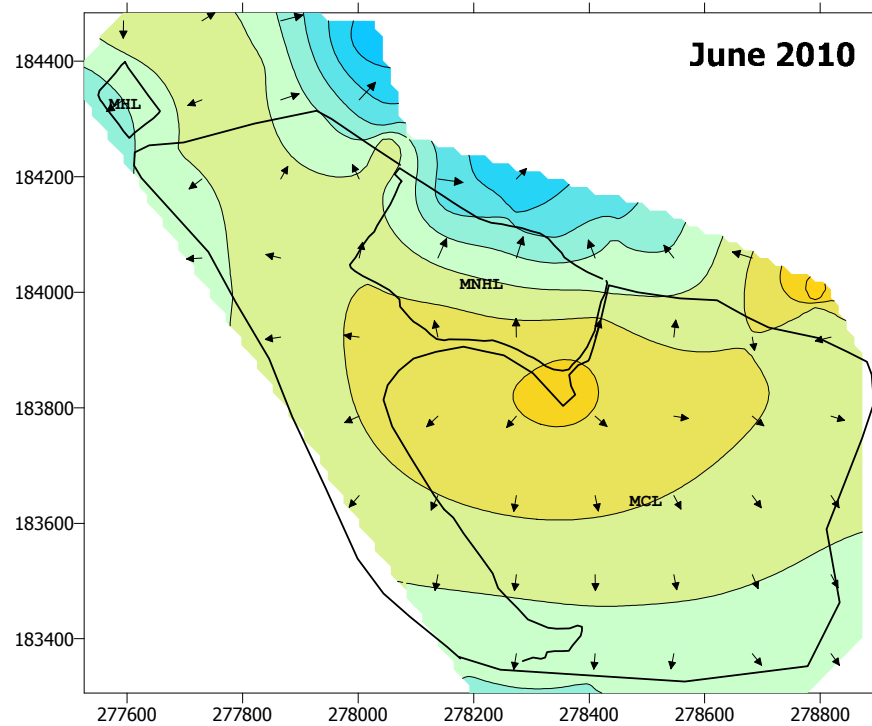
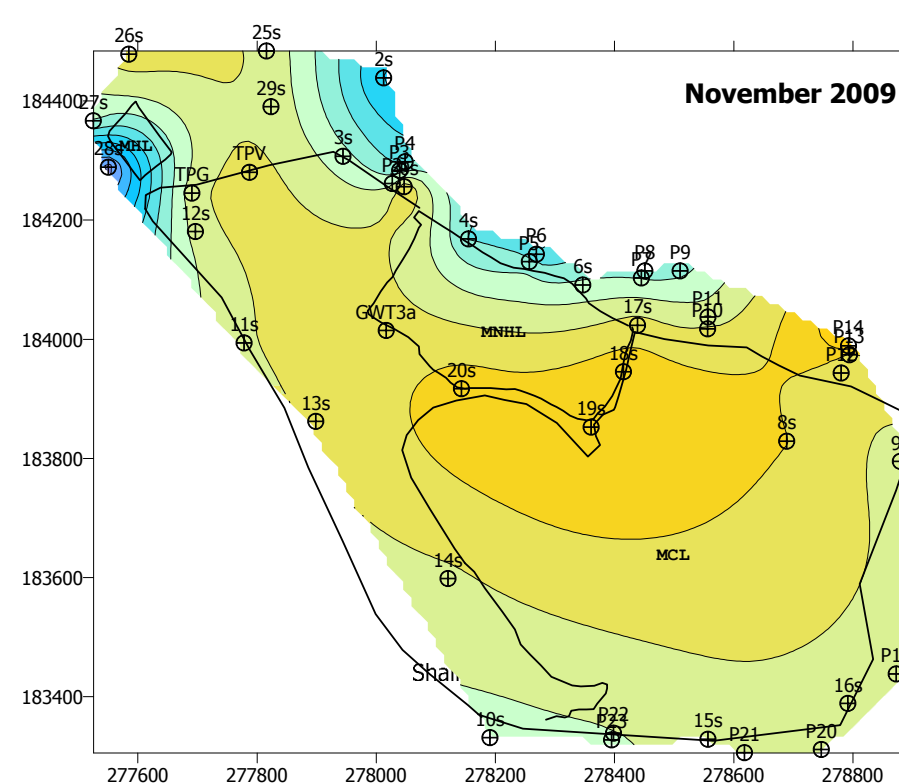
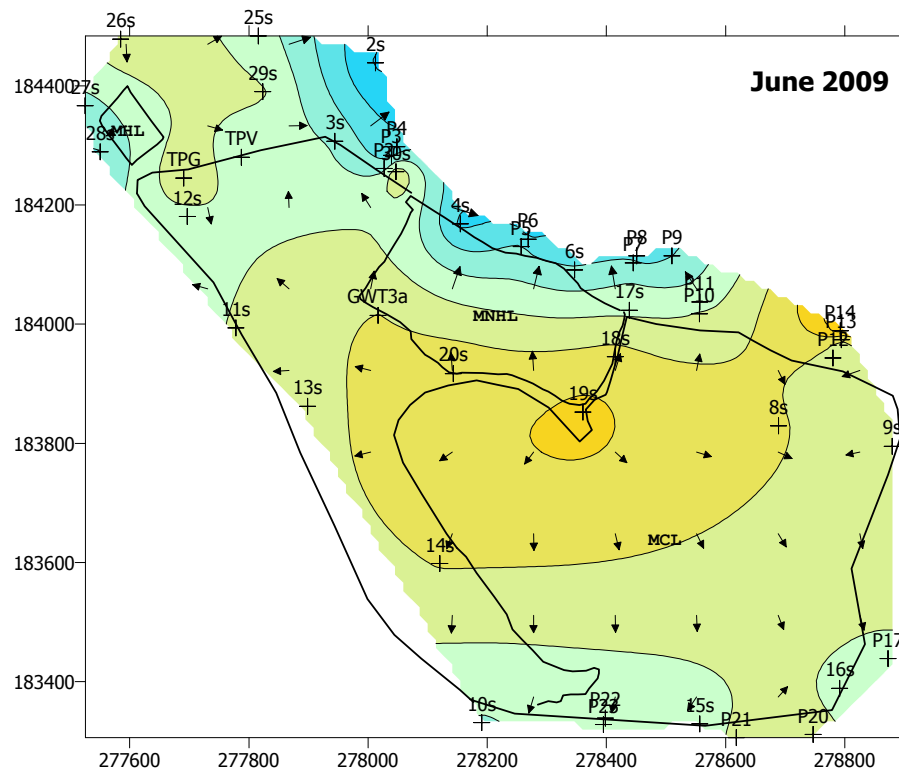
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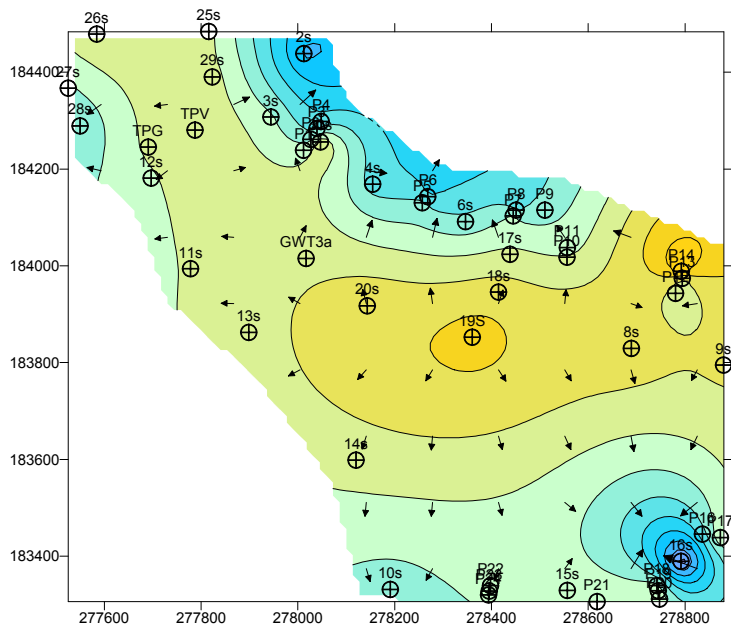
Appendix 1 Groundwater Contours

Report Number 2040r1v1d1020

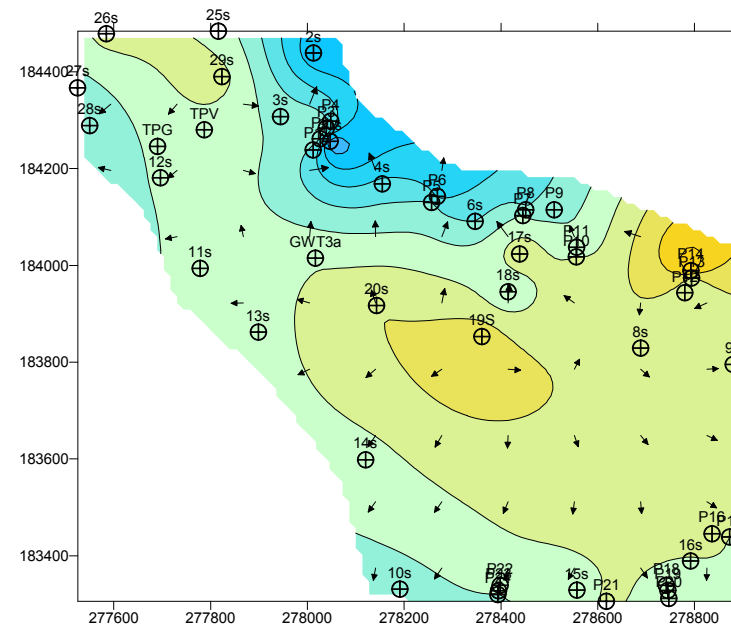
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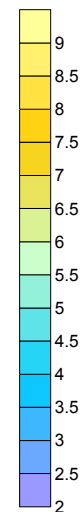
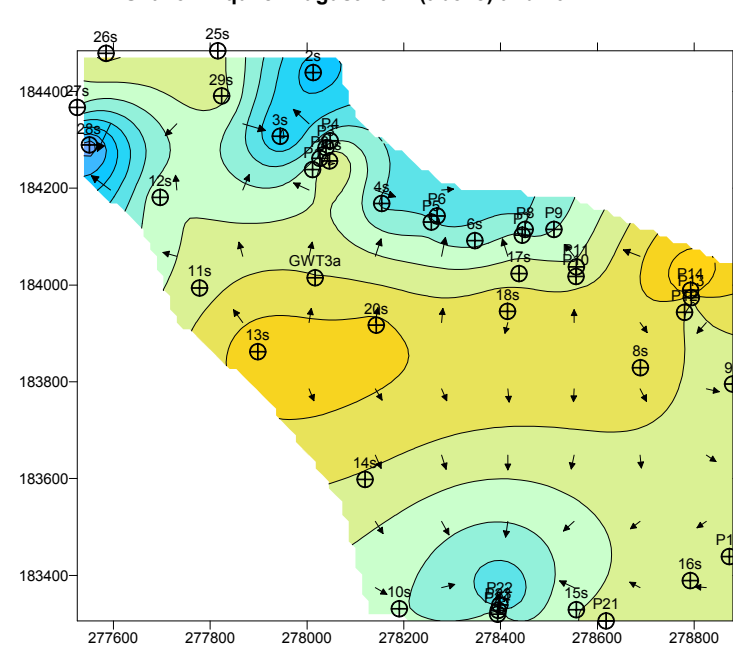
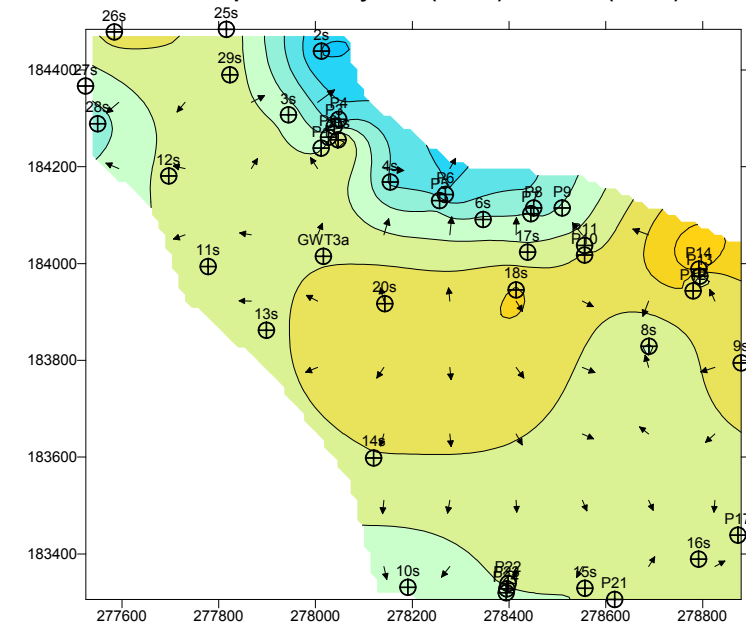


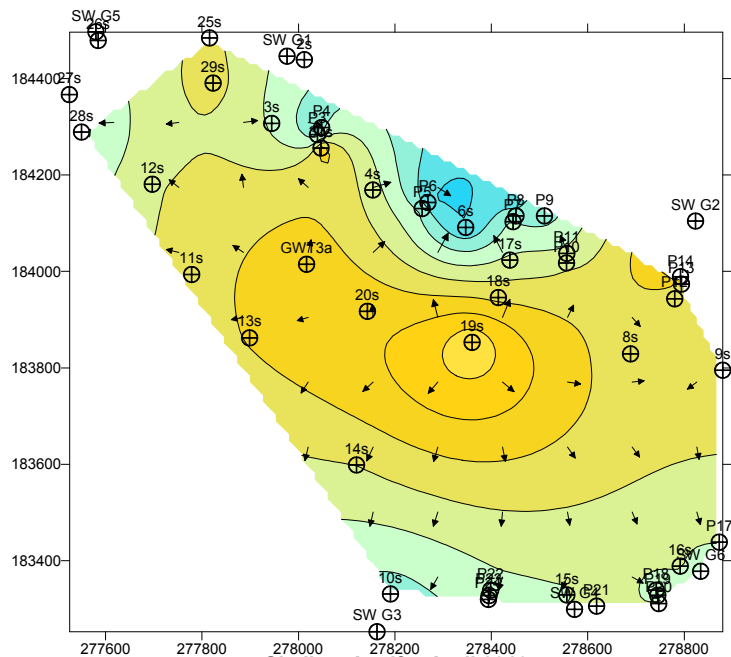


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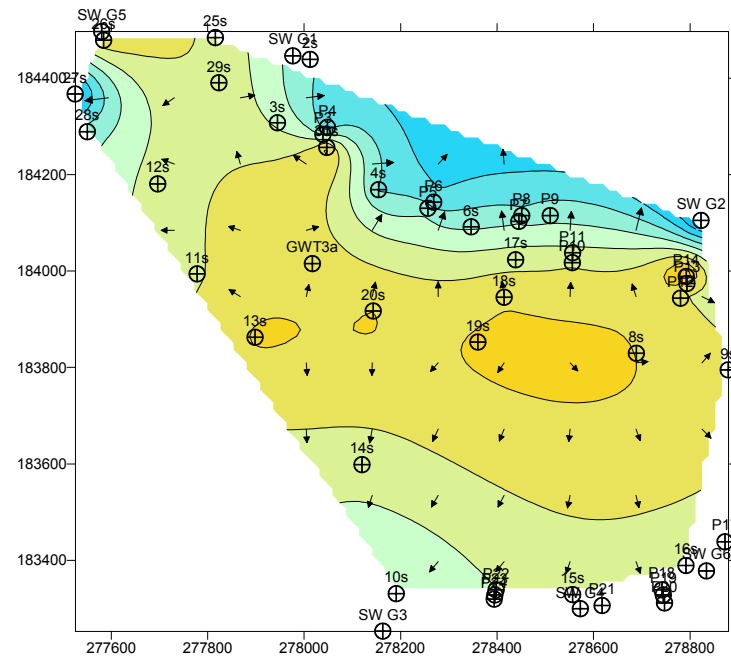


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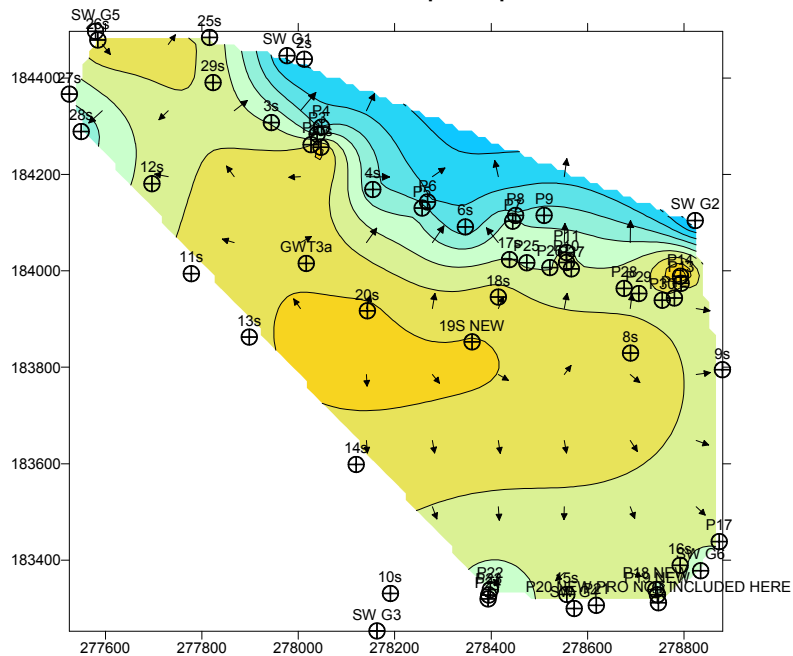




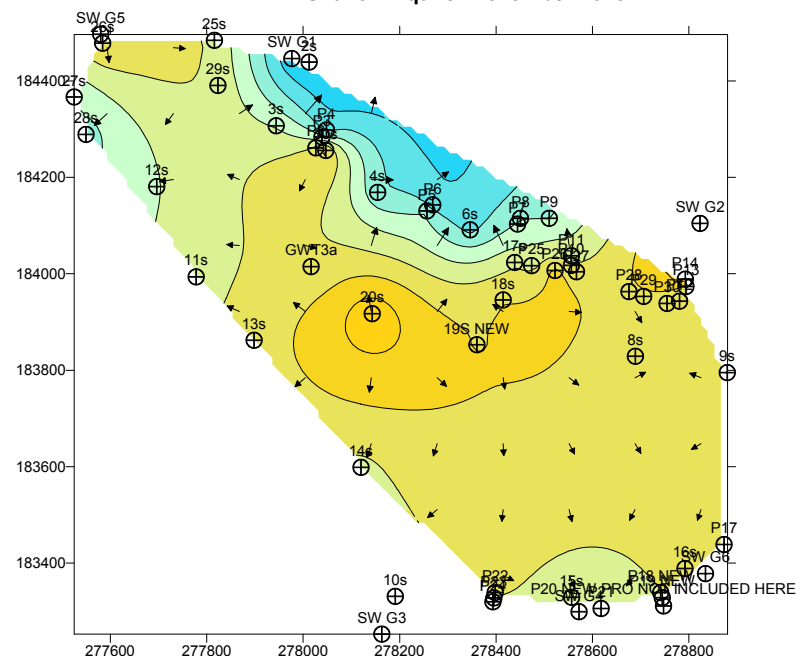
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Shallow Aquifer November 2013

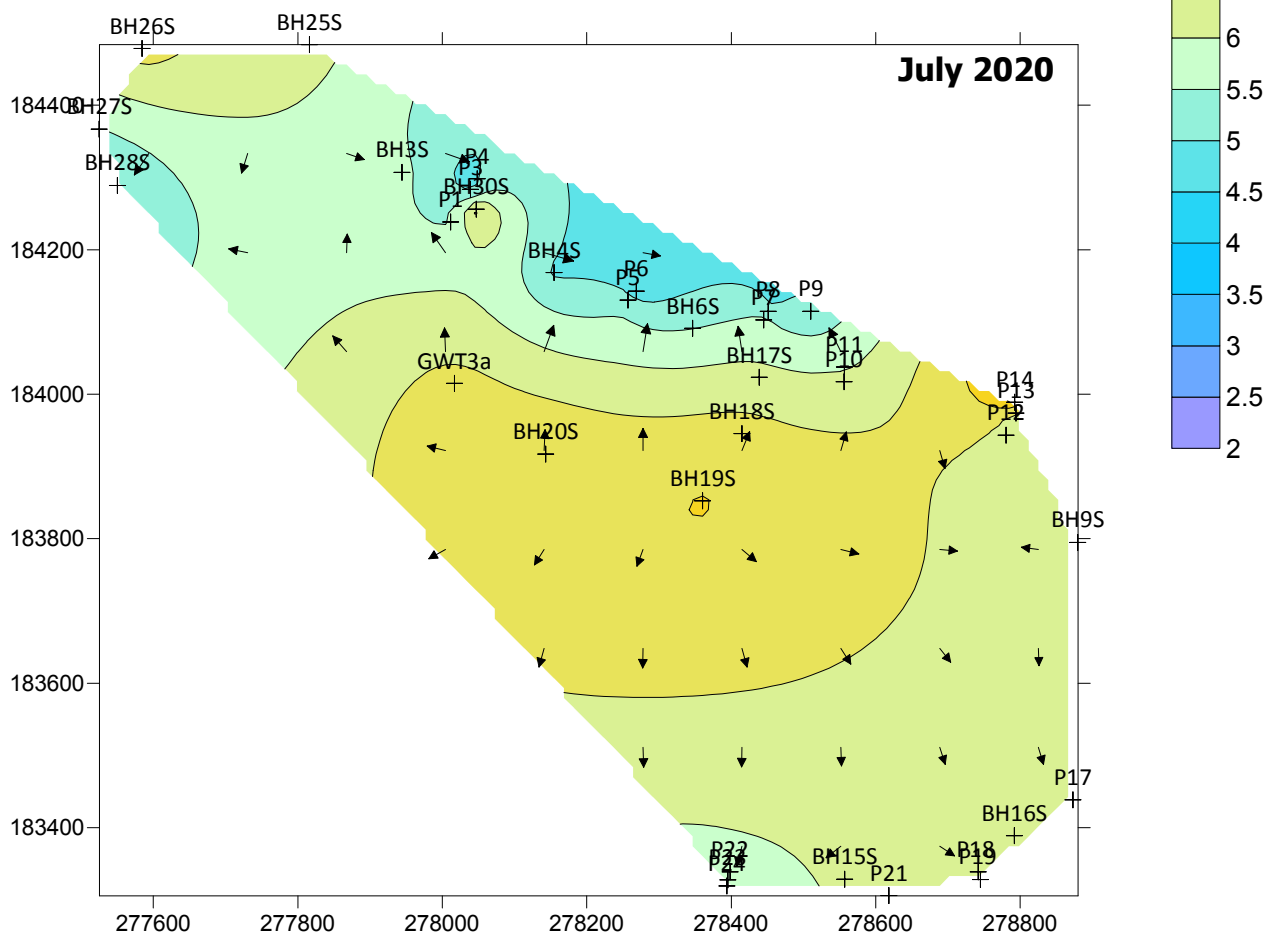
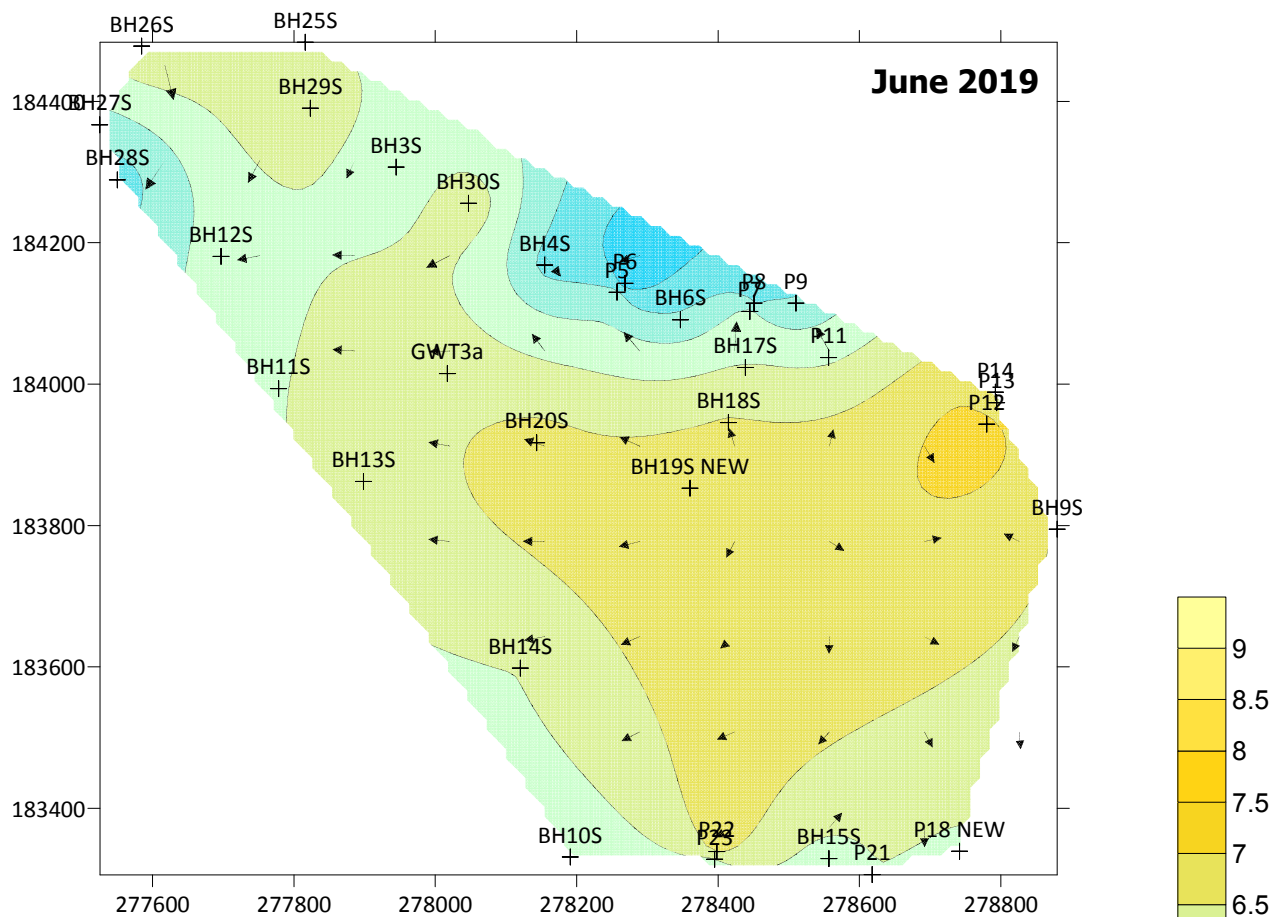


Shallow Aquifer May 2014



Deep Aquifer November 2014

The figure is a map of the study area, showing the location of the study area, the location of the study area, and the location of the study area. The map includes a coordinate system with latitude and longitude values. The study area is defined by a boundary, and the location of the study area is indicated by a shaded region. The map also shows the location of the study area, the location of the study area, and the location of the study area.

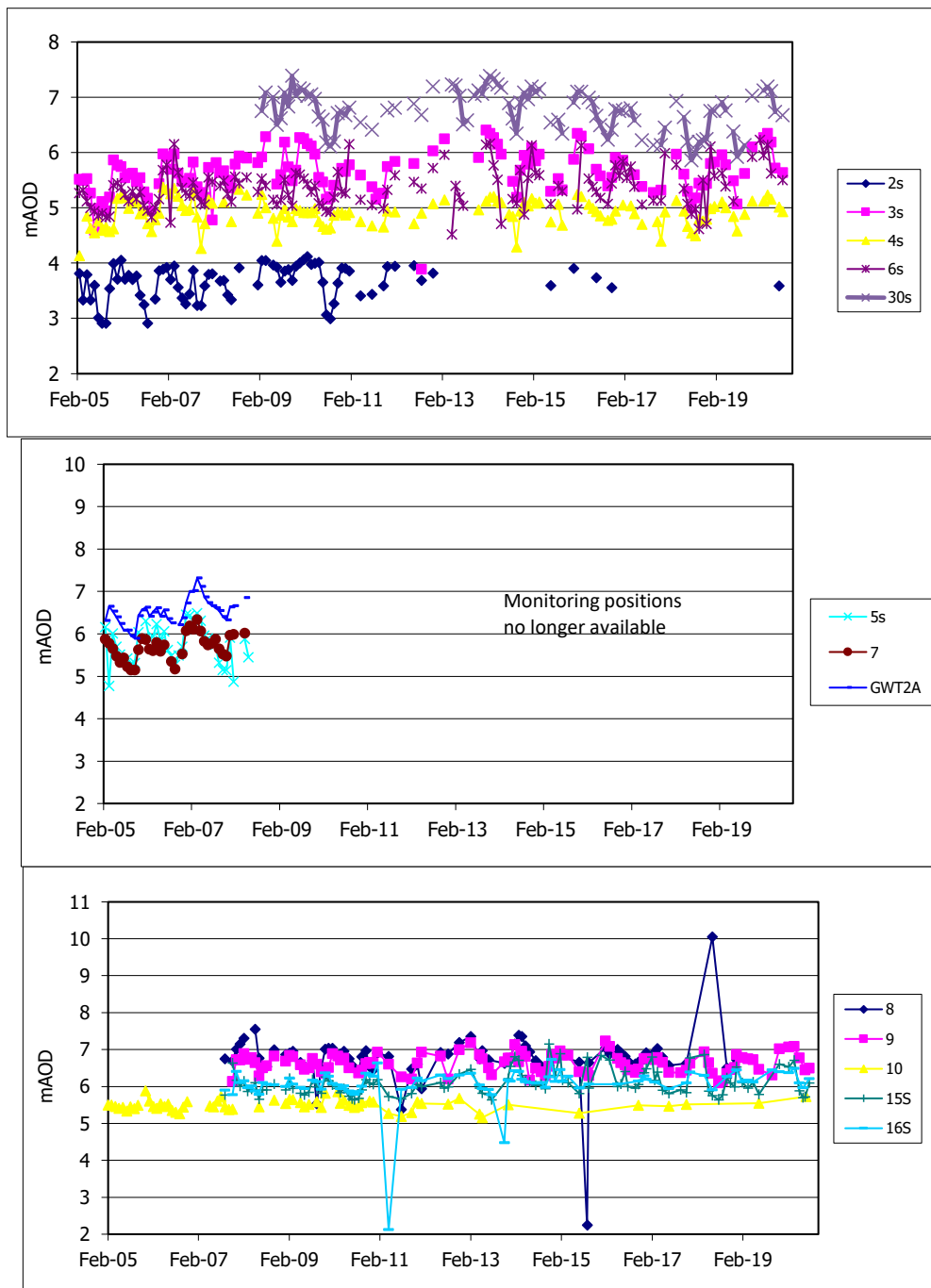


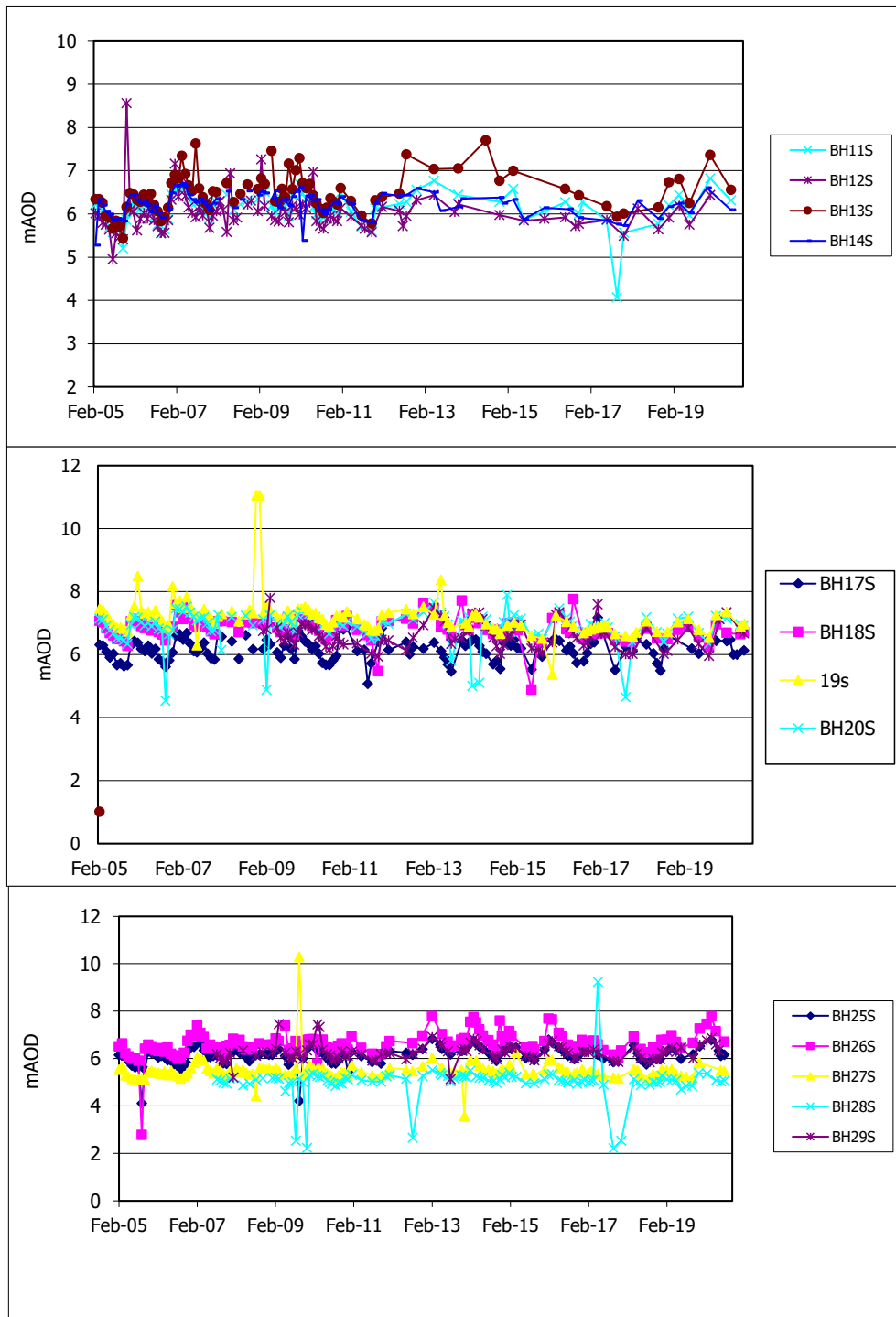
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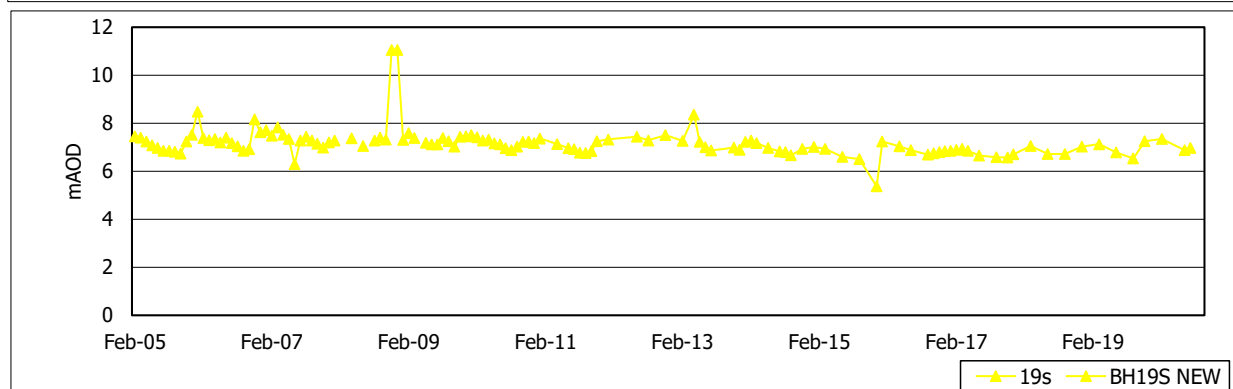
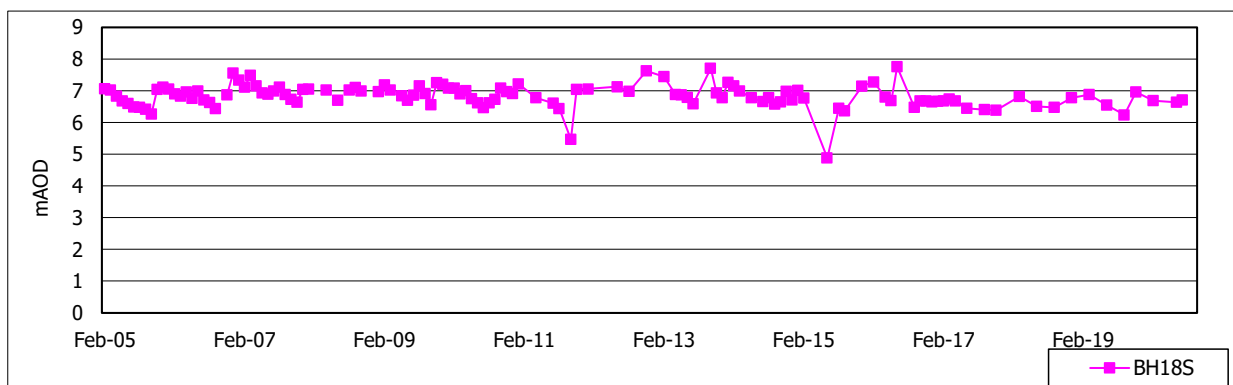
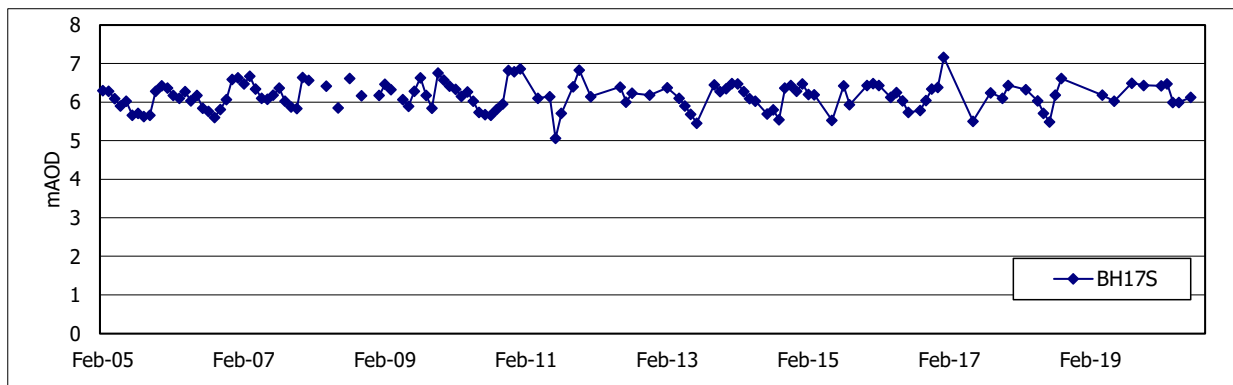
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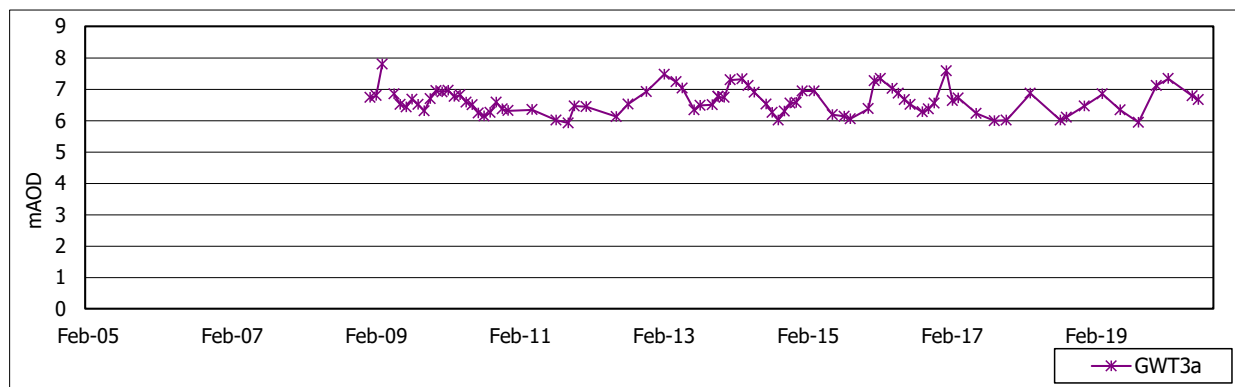
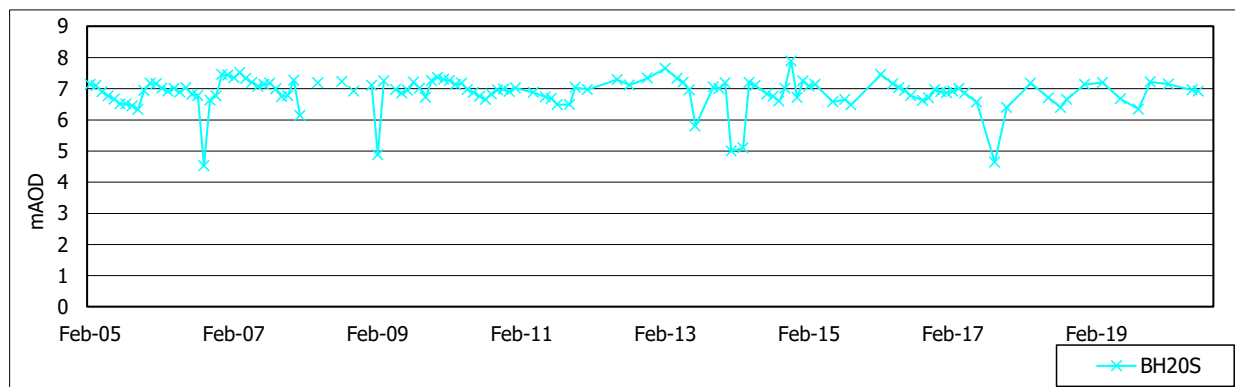
Appendix 2 Temporal Plots of Groundwater Levels

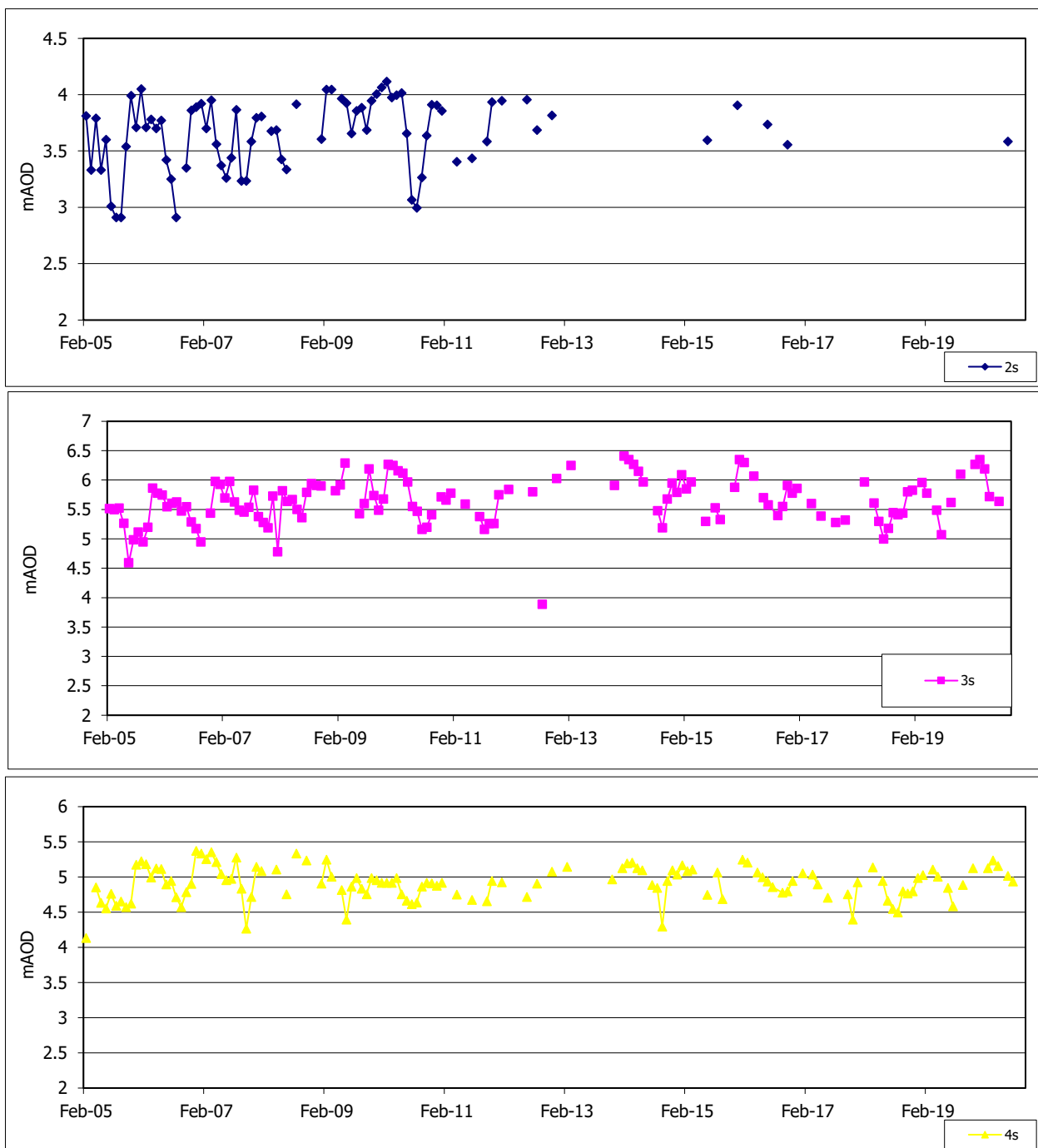
Report Number 2040r1v1d1020

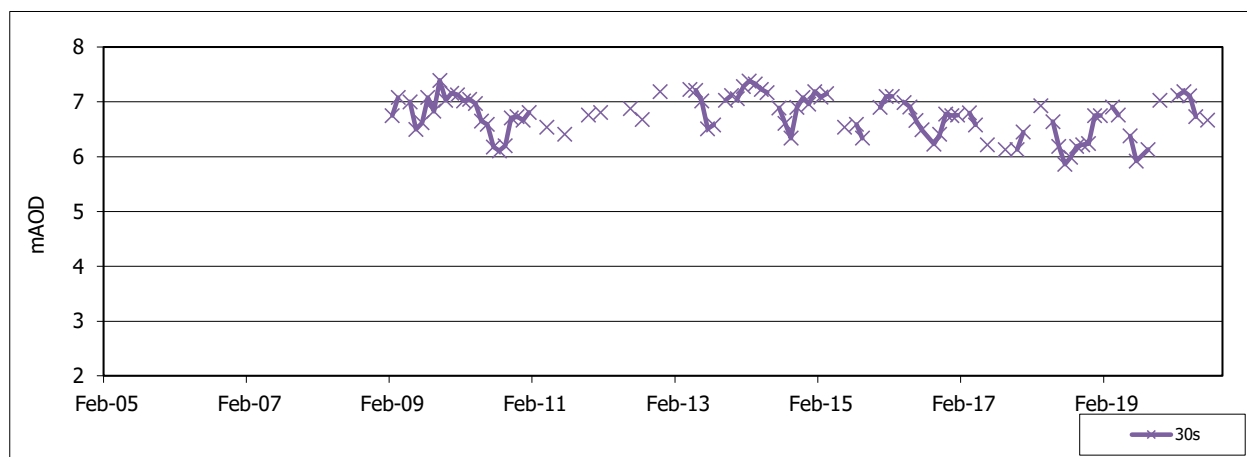
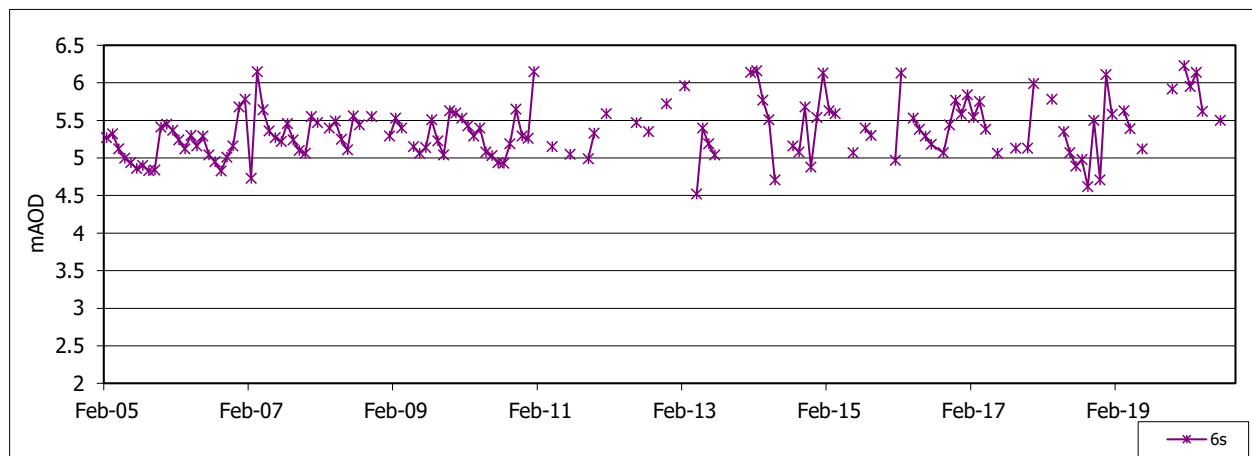


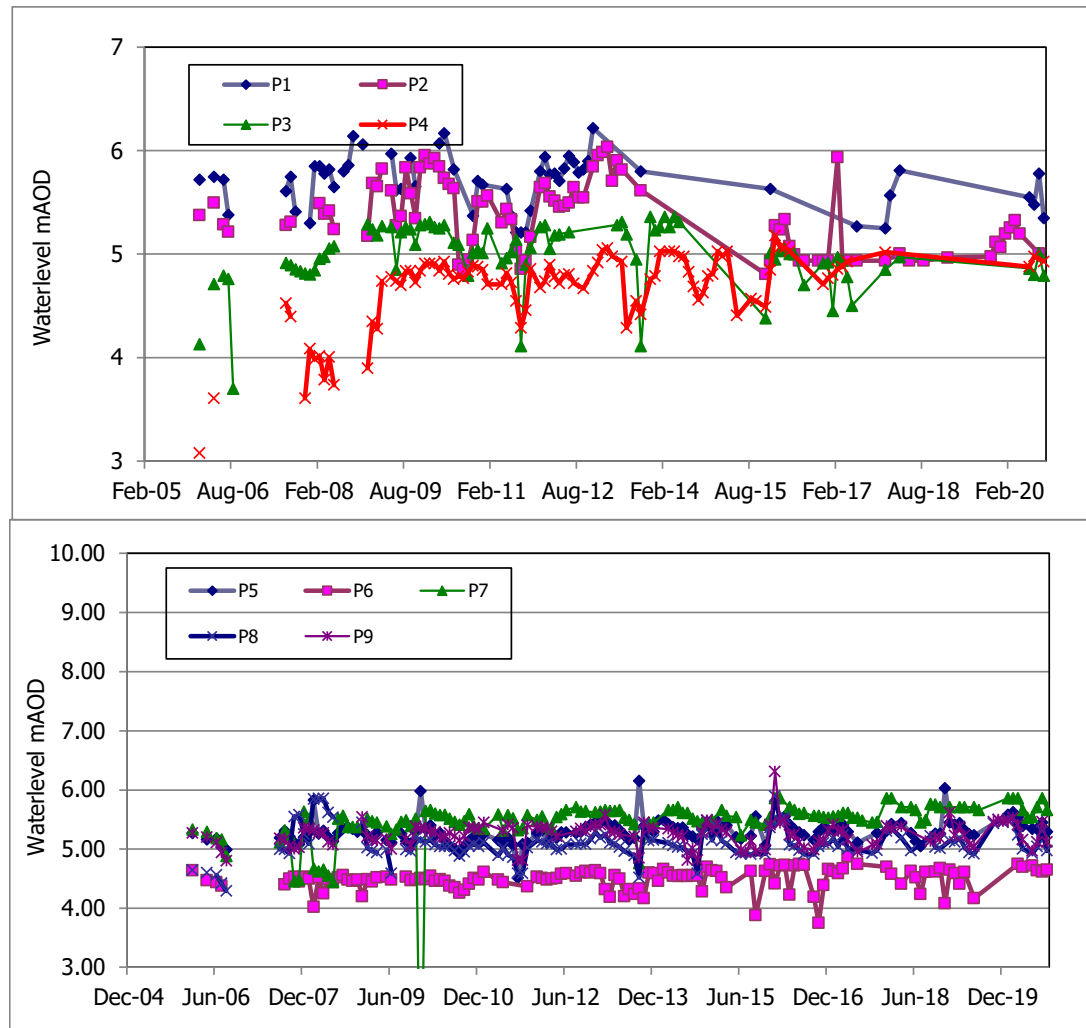


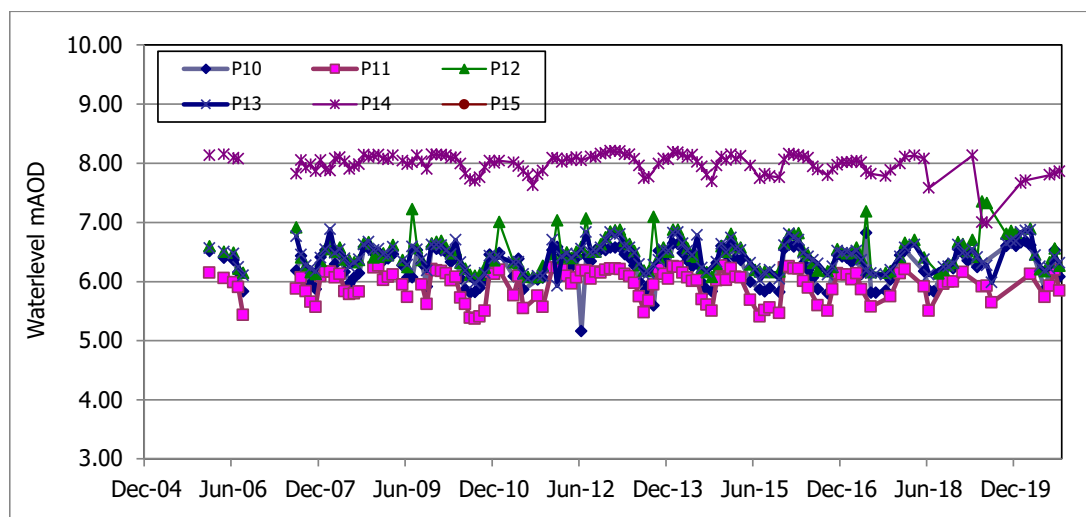


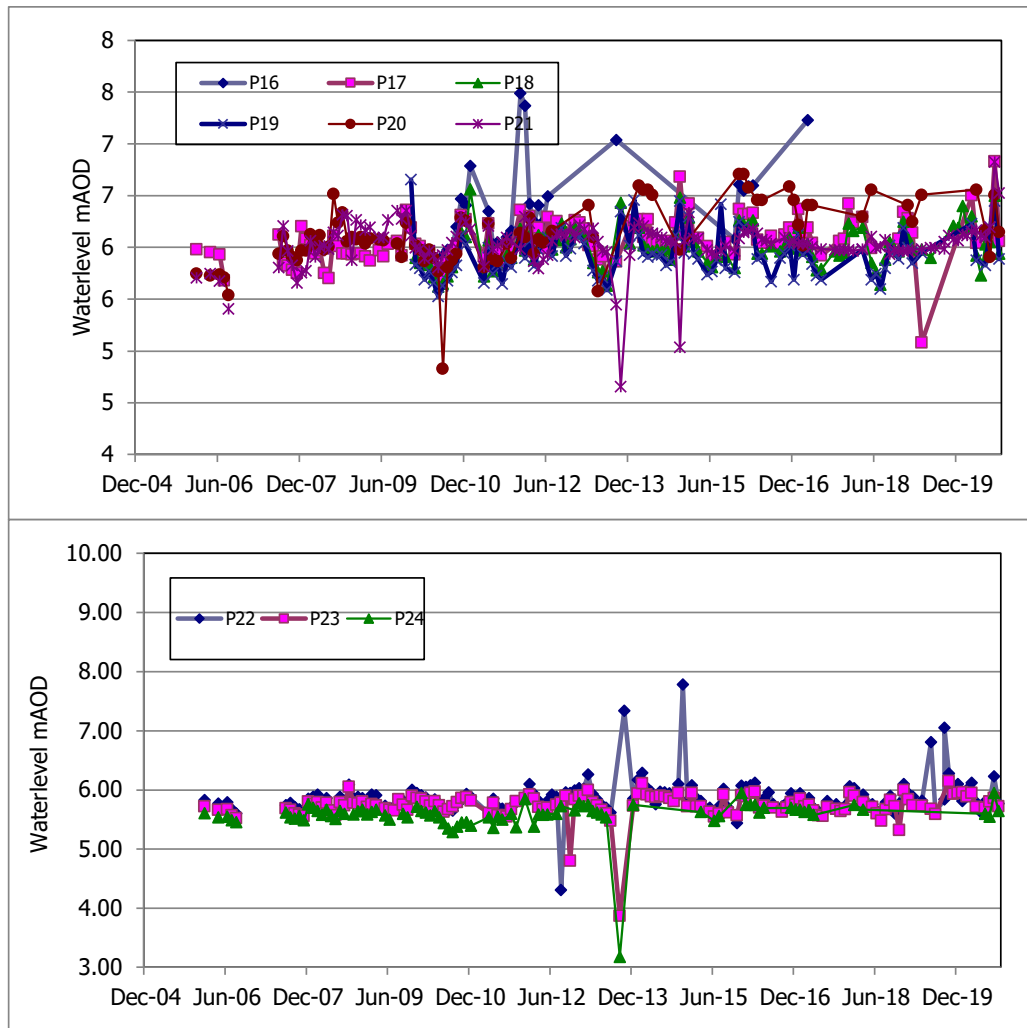


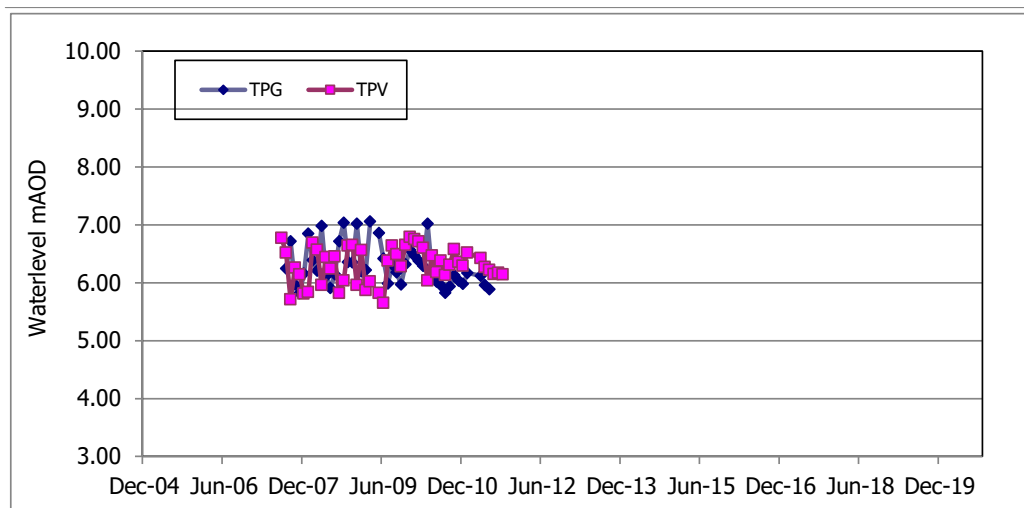


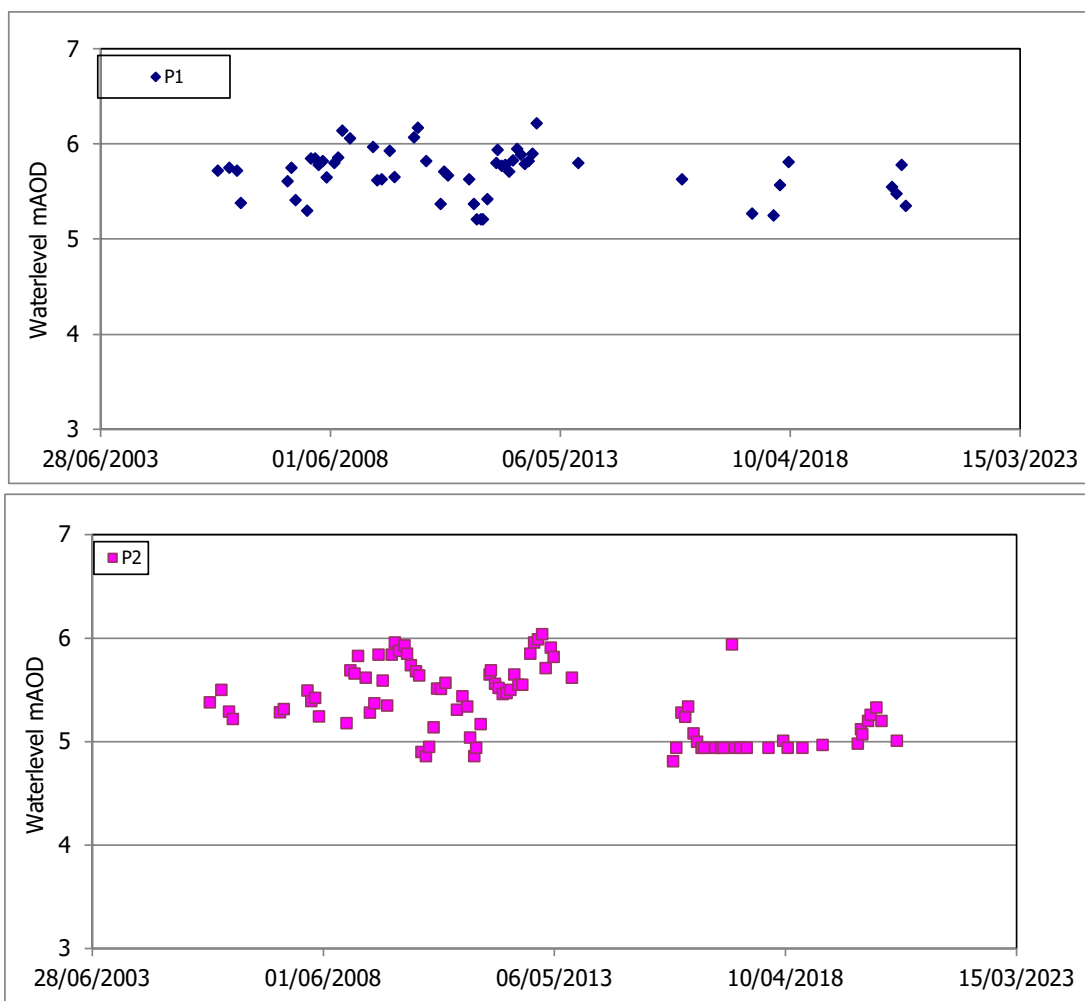


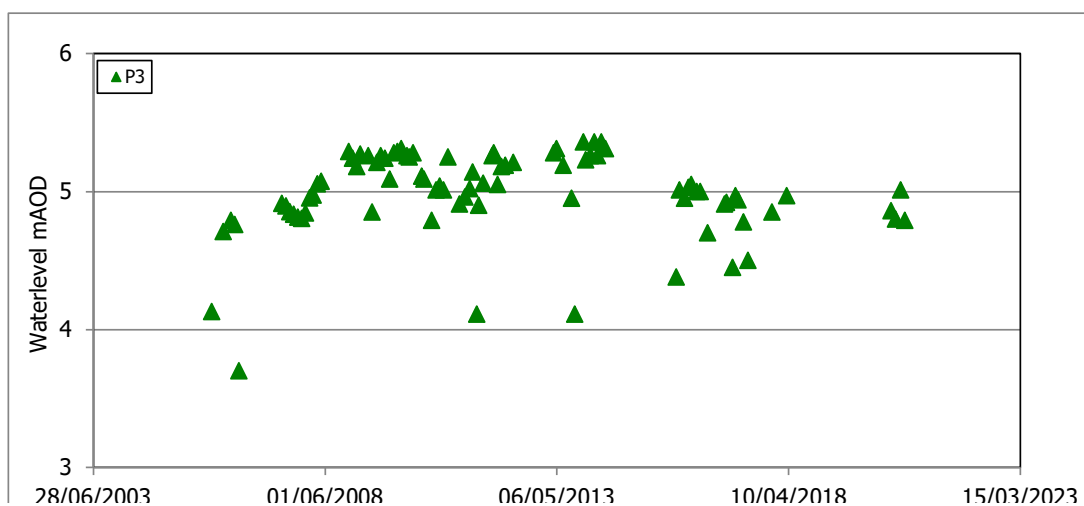














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