Oyu Tolgoi Mine Project

IESC REPORT: OT Detailed Water Review

London Meeting: December 5th - 6th, 2017

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TABLE OF CONTENTS

Pag.

LIST OF FIGURES

ACRONYMS

ESIA	Environmental and Social Impact Assessment
IESC	Independent Environmental and Social Consultant
mbgs	meter below ground surface
MLA	Mine License Area
OT	Oyu Tolgoi
TPC	Tripartite Council
TDS	Total Dissolved Solid
TSF	Tailings Storage Facility
WMP	Water Monitoring Plan

1 INTRODUCTION

In accordance with the agreements for Oyu Tolgoi (OT) project financing the Project Lenders retain the right to request a detailed review of available water monitoring data, as specifically stated in Section 8.2 of the Water Management Plan (External Auditing). The specific language is this section is as follows:

"…the Project Lenders working with the IESC and agreed with Oyu Tolgoi can request a comprehensive presentation/discussion of the monitoring results and interpretation thereof, to be provided by the OT issue experts to coincide with one of the periodic auditing events (no more than once per year, notified at least four weeks in advance) to occur immediately before or after the site audit."

In October 2017 the Policy Lenders made a formal request to OT to receive a comprehensive presentation and discussion of current water resources monitoring results.

This request was not made due to any particular concerns regarding monitoring results; rather the request was made to due to the over-arching sensitivity of water in the South Gobi region and the recent 1 in 25-year flood event that occurred in early August 2017. This flood event resulted in a significant test of the Undai River Diversion. The constructed Undai River Diversion differs from the original design as presented in the 2011 Environmental and Social Impact Assessment (ESIA). However OT and its stakeholders have agreed to maintain the current configuration of the Undai Diversion as detailed in Notice of Change 2016-14 (approved in August, 2016).

Accordingly OT, representatives from Policy Lenders, and representatives from the Independent Environmental and Social Consultant (IESC) met in London, UK on December 5th-6th to discuss recent water monitoring results and interpretation. Key outputs from the monitoring are provided in the following sections, and summarized in the conclusions at the end of this report.

Data reviewed in preparation of this report include recent reporting output from a separate dispute resolution effort undertaken by under the International Finance Corporation (IFC) Compliance Advisor Ombudsman (CAO). Outputs from that effort are presented in the document *Multi-Disciplinary Team and Independent Expert Panel Joint Fact Finding Summary of the Expert's Reports (*JSL Consulting, Ltd., December 2016). The authors of this Detailed Water Review note that some statements and conclusions in the referenced report are not fully aligned with the IESC's position on similar matters. This could be the result of the IESC's more detailed technical review of available data and the overall OT water monitoring program.

2 UNDAI DIVERSION PERFORMANCE

Of foremost concern to OT are impacts to the Undai River system, including those to both surface water and groundwater resources. Commitments from construction phase management plans included implementation of mitigation measures in the event impacts to Undai River subsurface alluvial flows were realized. Historic water level data reflected potential localized impacts to the Undai River system, partially as a result of usage of construction camp water supply wells before the diversion was constructed. Potential impacts of operational phase open pit development were also evaluated in the Project ESIA and the Undai River Diversion Project was developed to re-route both ephemeral surface flow and continuous subsurface flow around the zone of influence of the open pit.

The Undai Diversion Project was completed in September 2013. Components of the diversion scheme included completion of upstream (northern) and downstream (southern) Undai River channel cut-off dams. These dams were designed to prevent groundwater and occasional flood waters from entering the open pit and to prevent any potential off-site migration of contamination in alluvial pathways. A surface flood diversion channel was also constructed to convey flood waters from the upgradient (northern) cut-off dam to an adjacent “Western Channel” alluvial system. The Western Channel flood waters merge with the Brown Hill River which eventually rejoins the Undai River approximately 4 km downstream of the OT mine site.

In addition to the surface water diversion, a groundwater diversion system was constructed to capture groundwater flow upgradient of the northern cut-off dam, and to convey these waters via a buried pipeline to a location in the Undai River alluvial channel just within the MLA. Two groundwater intake bores upgradient of the north cut-off dam collect Undai River subsurface flow and are functioning as anticipated. The discharge location of diverted groundwater is to two outfall bores located just within the southern fence line of the Mine License Area (MLA).

A 2013 report entitled “Oyu Tolgoi: Hydrogeological Conditions near the Mine Site” identified two key findings:

- ✓ prior to completion of any Undai River Diversion works alluvial groundwater flow between the upstream (northern) and downstream (southern) Undai River channel cut-off dams naturally “leaked” or recharged the weathered bedrock unit that underlies the Undai River shallow alluvium unit. This connectivity between units is principally constrained to an area of the Undai River channel located near the active open pit, between the mapped Western BAT and Solongo Faults; and
- ✓ the thickness of the Undai River channel alluvial unit decreases from approximately 5 – 6 meters at the location of the northern cut-off dam location to approximately 2 meters immediately below the southern cut-off dam location. This effectively decreases the capacity of the alluvial unit below the southern cut-off dam to receive diverted groundwater and return it to the subsurface, as described in the ESIA.

Within the MLA much of the groundwater flow in the Undai River system historically “leaked” into the underlying weathered bedrock unit in the vicinity of the open pit, and therefore did not continue to flow down gradient in alluvial sediments. Baseline flow was also intercepted at the Old Bor Ovoo Spring. Early in development there was some limited seepage into the open pit derived from the reach of the river that is now hydrogeologically isolated from up gradient sections of the river; this seepage has gradually diminished over time.

The current Undai River Diversion scheme should theoretically result in an increase in the volume of alluvial flow available south of the MLA as this flow is now not subject to leakage in the vicinity of Western BAT and Solongo Faults or interception at the Old Bor Ovoo Spring.

2.1 GENERAL METEOROLOGICAL TRENDS

One of the reasons for this Detailed Water Review was evaluation of the effects of the recent very high rainfall event of August 2017. A rainfall of 46.2 mm was recorded on August 1, 2017, the highest rainfall in the past five years with additional rains bringing the monthly total to 76.5 mm. This resulted in a significant flood event along the Undai River and a good test of the Undai Diversion system. Precipitation patterns since diversion construction in 2013 are shown on the Figure 2.1.

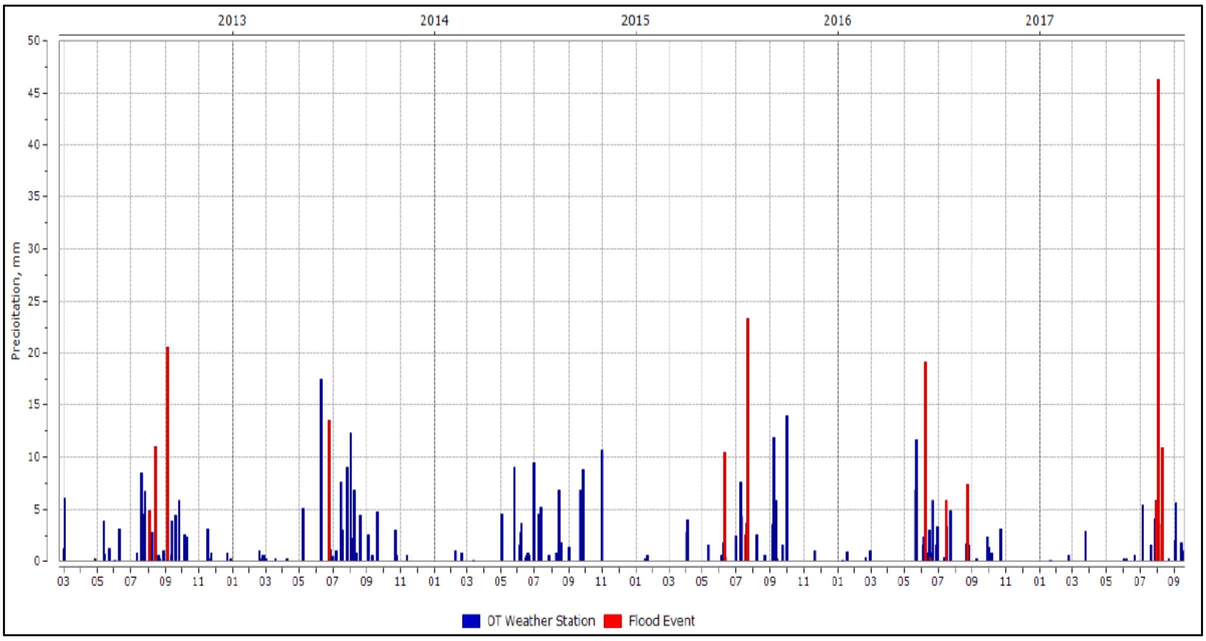


Figure 2.1: Rainfall at OT Weather Station and Flood Events

The August flood volume was measured at approximately 38 m^3/s and is classified as a 1:25 years flood event. Flood velocity was 1.13 m/s and the maximum height of water during the flood was sustained for about 60 hours. Some minor overtopping at the Central Heating Plant Road upstream of the northern cut-off dam occurred but there was no overtopping of the north cut-off dam. A 1:100 year flood event volume for comparison is estimated at 135 m^3/sec.

2.2 GROUNDWATER DIVERSION PERFORMANCE

At the groundwater discharge location there are two outfall bores consisting of the intended injection well (the "Undai Diversion Discharge Well") and an adjacent well originally used for dewatering purposes during construction of the southern cut-off dam. The Undai Diversion Discharge Well was intended to be the sole source of recharge of diverted groundwater back to the subsurface. Instead some injected flow from the subsurface diversion pipeline migrates up to the surface via the permeable gravel packs of Undai Diversion Discharge Well and adjacent dewatering well resulting in surface flow. The observed behaviour at the discharge point is due to a combination of several factors:

- ✓ permeability of receiving alluvial sediments downgradient of the MLA;
- ✓ the presence of a thin unsaturated zone immediately below the southern cut-off dam, ranging from only 0 to 1.2 m below ground surface (reflecting a limited storage capacity); and
- ✓ the likelihood that the current rate of diverted groundwater flow at the outfall location exceeds the historical rate of groundwater flow in the alluvial channel of the Undai River at this same location. This is suggested by the thinner alluvial thicknesses present at the outfall location and the fact that the Undai

Diversion now routes alluvial flow away from leaking impact of cross-cutting faults and Old Bor Ovoo Spring, as discussed above.

In May 2014 an in-line flow meter was installed in the groundwater diversion pipeline. Data obtained since that time is provided in Figure 2.2. These data provide an opportunity to assess performance of the groundwater diversion system with varying climatic conditions and as a function of the rate of diverted groundwater flow. During the relatively dry time periods of 2014 and the first half of 2015 there were no floods and there was a decrease in available groundwater in the Undai River system, resulting in a declining trend in diverted groundwater flow to below 0.5 l/s (or below approximately 45 m^3/day). As a result of summer 2015 and 2016 floods the Undai River system was significantly recharged, leading to an increase in diverted groundwater flow rates of up to approximately 8.7 l/s (or approximately 750 m^3/day). This pattern was also repeated in the recent flood event from the summer of 2017.

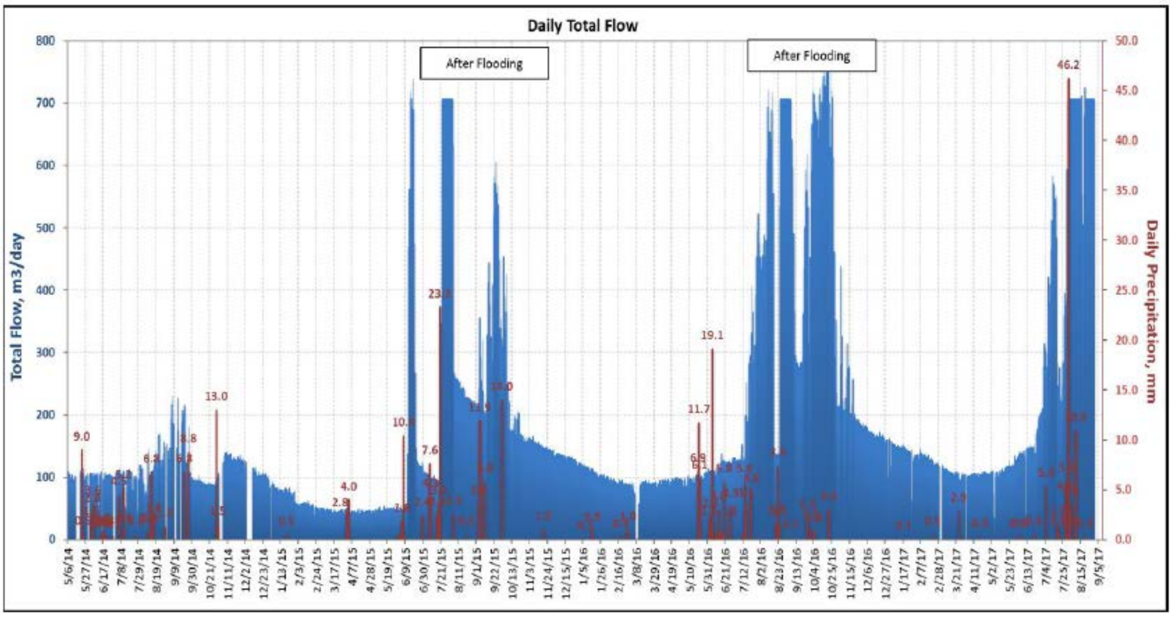


Figure 2.2: Flow Rates through the Groundwater Diversion Pipeline

Since September 2013 OT has monitored, via a constructed V-notch, the rate of diverted groundwater flow returned as surface flow at the outfall bore location (Figure 2.3). Some percentage of diverted groundwater flow is returned to the subsurface as originally intended, with the balance of diverted groundwater manifesting as surface flow. This rate fluctuates as a function of climatic conditions. During winter months water discharged to the ground surface freezes forming an expanding ice sheet; in spring the ice sheet thaws forming a pond.

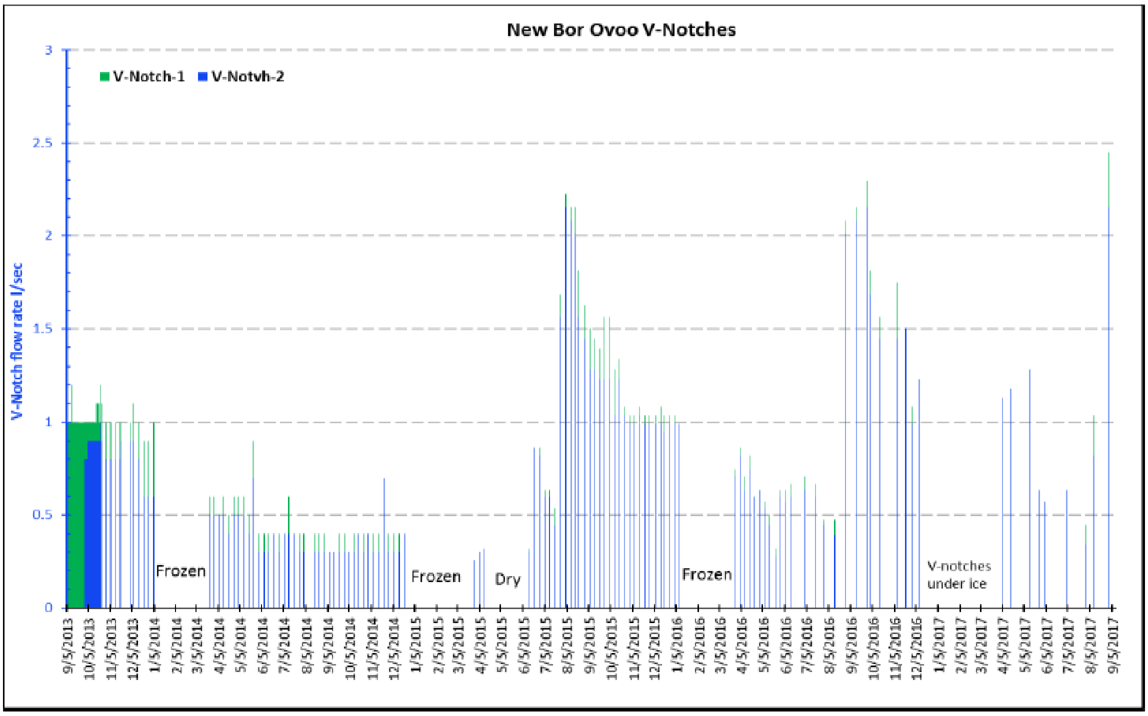


Figure 2.3: Surface Flow Rates at the New Bor Ovoo Spring

Empirical measurements indicate that a minimum flow of 0.5 l/s is needed in the groundwater diversion pipeline to produce surface flow at the New Bor Ovoo spring. At flow rates less than this all discharge goes directly into subsurface alluvials with no surface flow.

Measurement of surface flow allows approximations of the volume of water returned to the Undai River alluvial groundwater system. After the August 2017 flooding the surface discharge measured at the V-notch weirs was 2.5 l/s. Given that the rate of diverted flow through the pipeline was 8.7 l/s, the recharge rate to the alluvials was 6.2 l/s.

The surface flow just down gradient of the MLA fence line has created an artificial spring, the “New Bor Ovoo”, that is heavily used by wildlife as well as herders and their livestock. This surface flow freezes in the winter and the large ice sheet that develops in the winter gradually melts in the spring providing significant recharge to the Undai River system. For historical context the 2011 OT Project River Diversion Detailed Design Report – Final estimated the surface area of the historic Bor Ovoo Spring at an average of approximately 40 m^2. Hydrogeological data and regular photography of the “new” Bor Ovoo spring demonstrate that the surface area of the new Bor Ovoo Spring is larger than that recorded at the historic Bor Ovoo Spring (Figure 2.4) peaking at over 24,000 m^2.

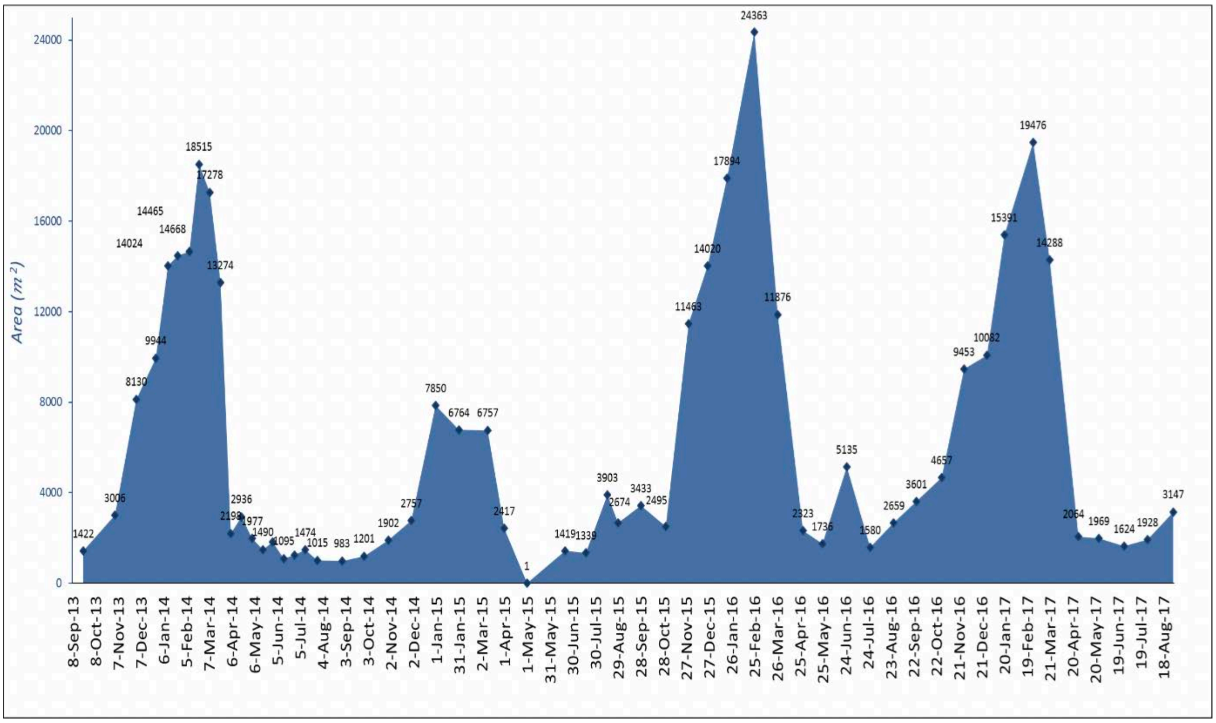


Figure 2.4: Surface area of New Bor Ovoo spring since 2013

2.3 HYDROGRAPHS WITHIN AND DOWN GRADIENT OF THE MINE LICENSE AREA

The flood events of August 2017 have been the first real test of the Undai Diversion and differing hydrogeological regimes since the diversion system was installed in 2013. Water level monitoring records are reviewed in detail in order to assess the performance of the diversion system in relation to groundwater flow as this is an important control on water levels in downstream herders’ wells. Monitoring points in the Undai version sub-monitoring program are shown in Figure 2.5. Additional drive points installed in 2015 along the Undai River channel between the south cut-off dam and Budagt Spring are not shown here but provided in Figure 2.10.

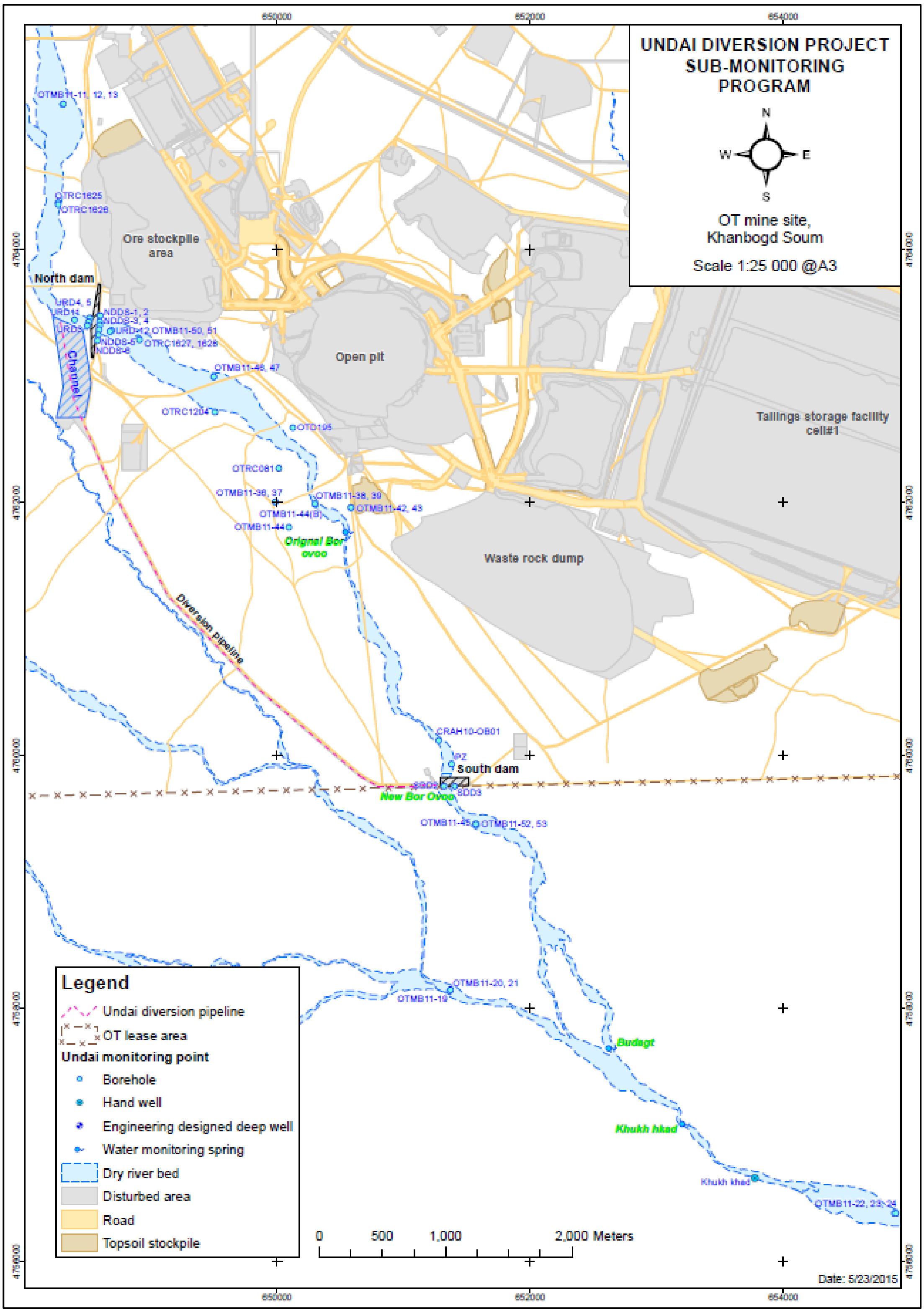


Figure 2.5: Undai Diversion Monitoring Network

2.4 UNDAI RIVER UPSTREAM OF NORTH CUT-OFF DAM

The hydrograph for URD 11 upstream of the north cut-off dam shows the natural rise and fall of water level in response to flood events and periods of no recharge (see Figure 2.6). The water level was 0.5 m above ground level during the August 2017 flood. There has been no change in the hydrogeological regime upstream of the Undai Diversion.

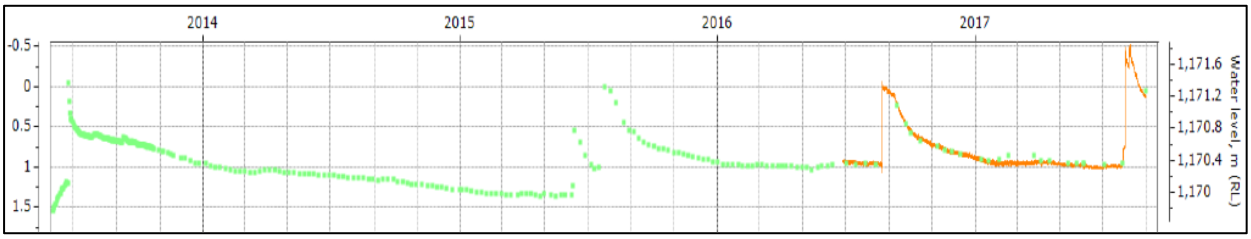


Figure 2.6: Water Depth and Water Table Elevation at Urd-11 Upstream Of North Cut Off Dam

2.5 UNDAI RIVER DOWNSTREAM OF NORTH CUT-OFF DAM, UPSTREAM OF SOUTH CUT-OFF DAM

OTMB11-50/51 is immediately downstream of the north cut off dam. Water levels decrease beginning in mid-2013 during dewatering for Undai Diversion construction (see Figure 2.7). The water table has declined progressively since that time with general stabilization around 3.2 m depth or 1,167 meters above sea level since year 2015. Minor variations in water levels are now typically caused by local ponding of water or slight seepage below the North Cut Off dam (as seen during August 2017 flooding).

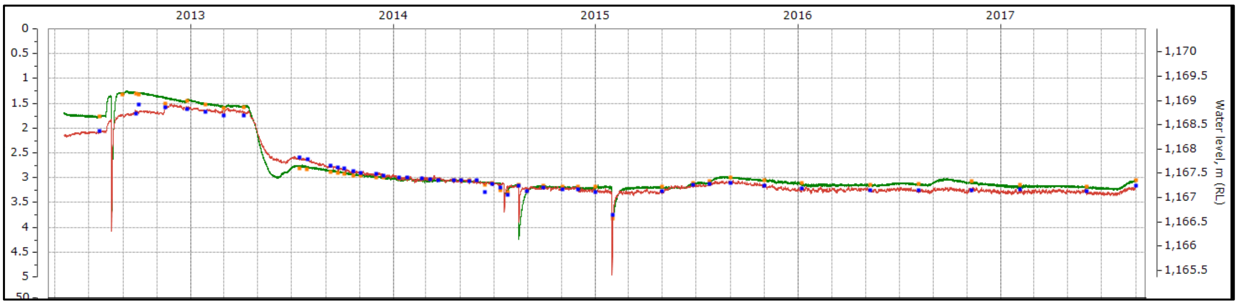


Figure 2.7: Hydrograph of OTMB11-50/51 from 2012 to 2017

Further downstream of OTMB11-50/51 the steeper water level decline observed in OTMB11-46/47 is attributed to development of the open pit and associated dewatering, in addition to the lack of flood recharge and diminished baseline flow (Figure 2.8).

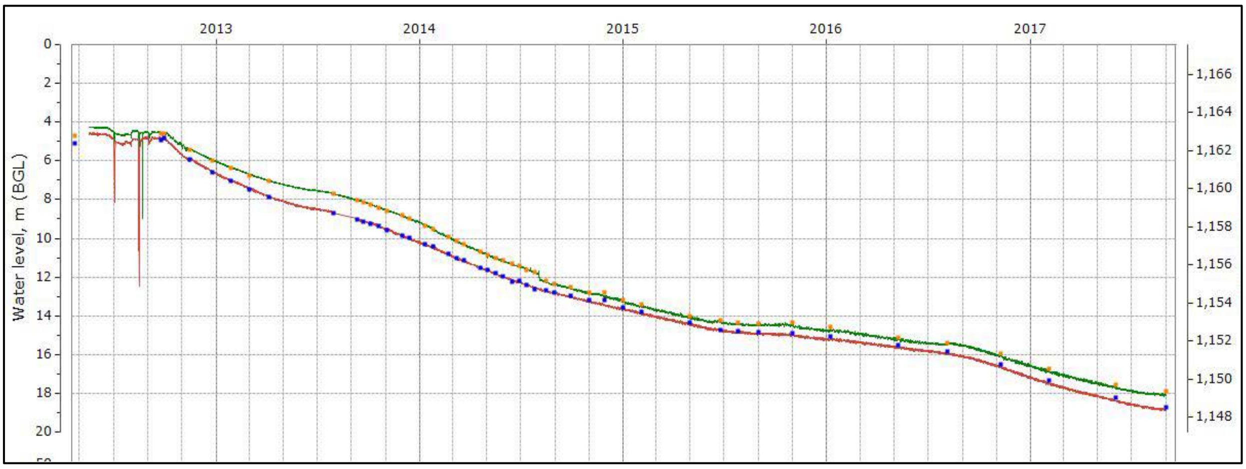


Figure 2.8: Hydrograph of OTMB11-46/47 near open Pit

Directly upstream of the south cut-off dam a significant declining trend in water level is also apparent due to the interception of baseline flow. Open pit dewatering appears to have a more localised impact. Occasional small kicks in the hydrograph are related to ponding of water (Figure 2.9).

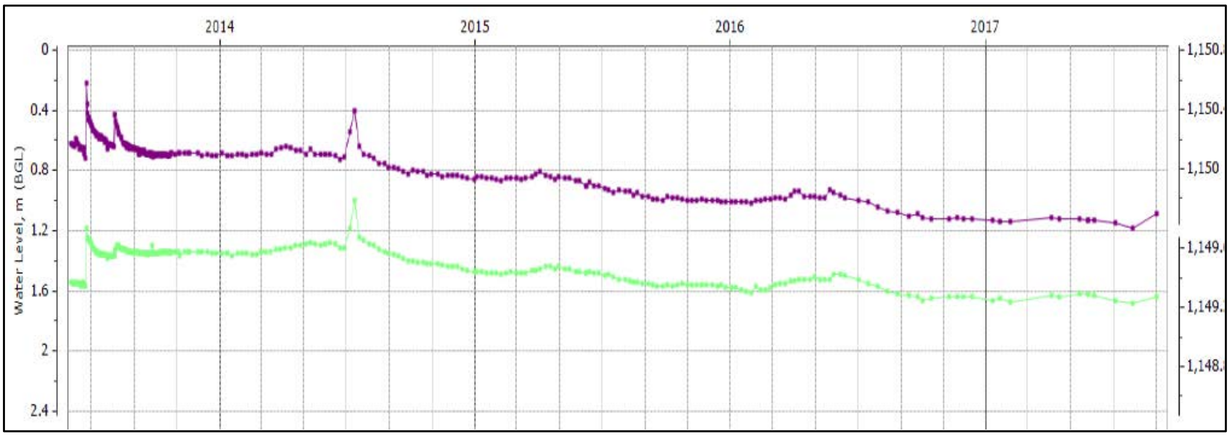


Figure 2.9: Hydrographs of CRAH10-OB01 and PZ Directly Upstream of South Cut-Off Dam

2.6 DOWNSTREAM OF SOUTH CUT OFF DAM

A more detailed map of monitoring points below the New Bor Ovoo spring is shown as Figure 2.10. The hydrographs of monitor wells and drive points downstream of the New Bor Ovoo Spring all show a rising water level trend with levels approaching 0.2 m below ground surface. This is the approximate depth below which evaporation impacts on water level are greatly reduced.

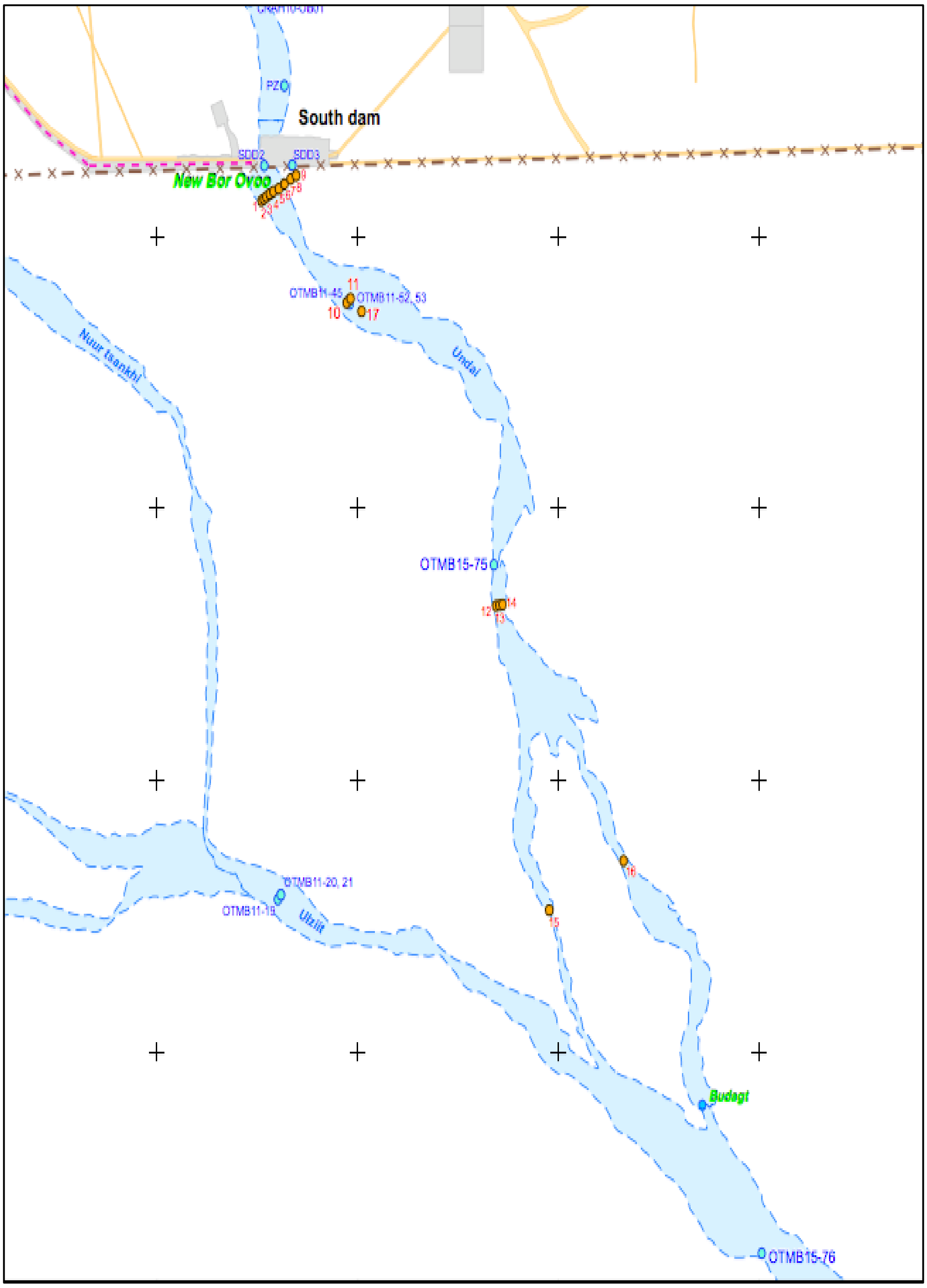


Figure 2.10: Monitoring Locations South of New Bor Ovoo Spring, including Drive Points

Drive Points DP1 to DP9 are installed across the Undai River bed just below the New Bor Ovoo Spring location (Figure 2.11). Recent water level measurements reflect mounding in the riverbed alluvials with water above ground level on the western margin in the area of lowest topographic elevation dropping to a maximum of 1 m depth in the eastern two-thirds of the channel (Figure 2.12).

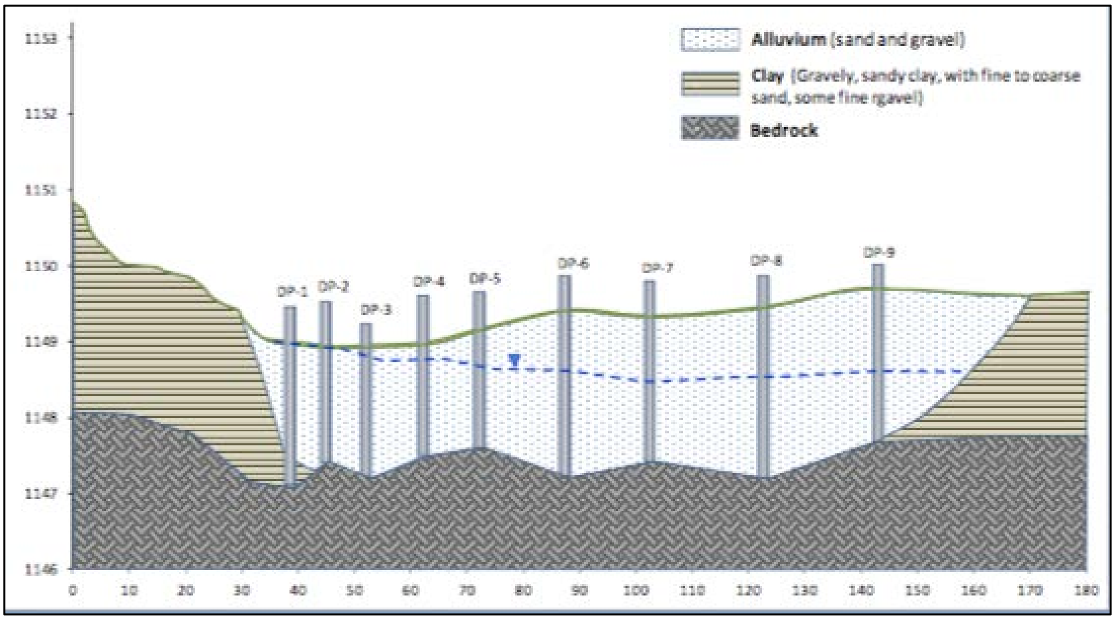


Figure 2.11: Drive Points DP-1 to 9 across Undai River at New Bor Ovoo Spring

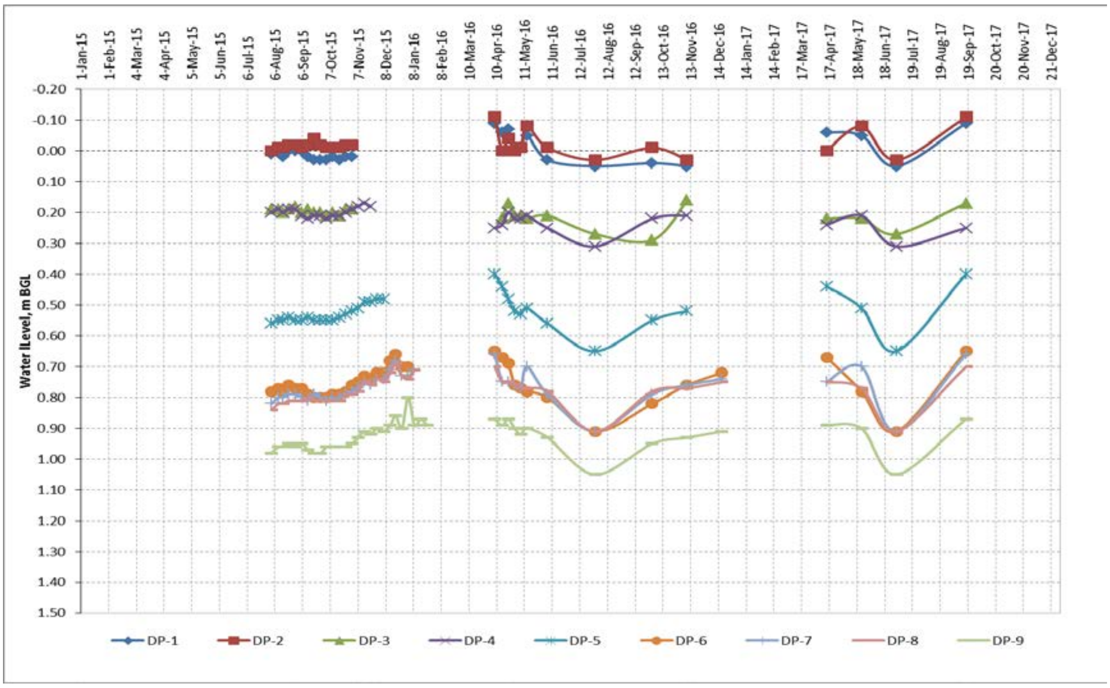


Figure 2.12: Drive Points DP-1 to 9 across Undai River at New Bor Ovoo Spring.

A key monitoring point in the Undai River channel is located approximately 400 meters to the south of the southern cut-off dam (OTMB11-45). Available monitoring data from OTMB 11-45 is presented in Figure 2.13

(from May 2012 – current). A sharp increase in water level is observed beginning in April 2013 at the initiation of construction works. At that time subsurface flow from the Undai River alluvial channel was diverted up-gradient of the northern cut-off dam, routed through a subterranean pipeline, and ultimately discharged through an overland hose to the Undai River alluvial surface at a location just south of the MLA. Initial dewatering discharge rates during construction were approximately 6 l/s, peaking at approximately 8.4 l/s in May, 2013.

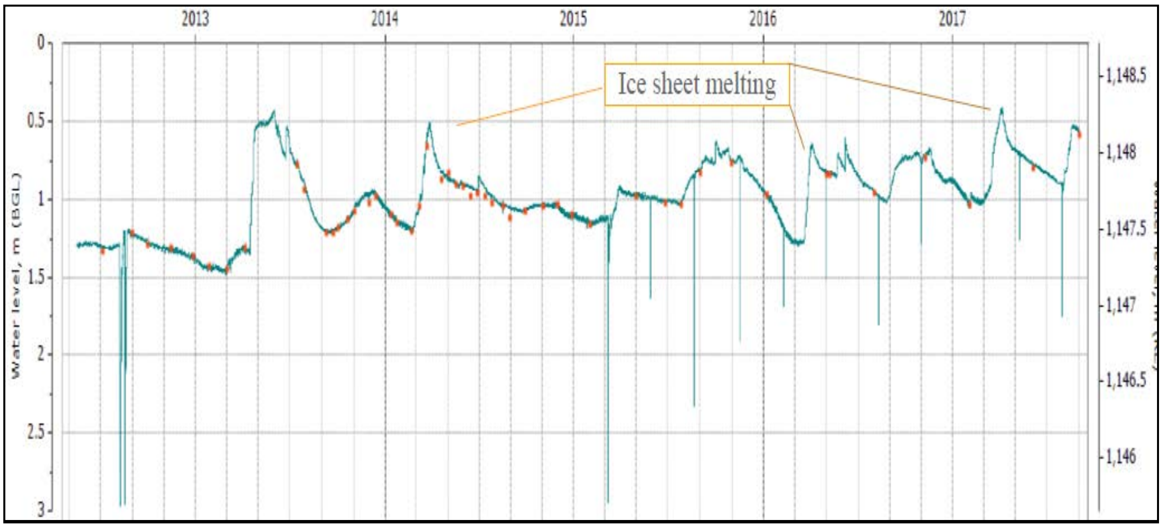


Figure 2.13: Hydrograph of OTMB11-45 approximately 400 Meters Down Gradient of New Bor Ovoo Spring

Continued springtime increases in OTMB 11-45 water levels reflect thawing of surface ice, which creates a slug of recharge to the alluvial aquifer. Summer precipitation events can also lead to an increase in water levels if such rain is falling directly at the monitoring location. Data from post-construction monitoring reflect general stabilization of groundwater levels at approximately 0.5 - 1 meter below ground surface (mbgs), with fluctuations caused by variations in climatic conditions and the melting ice sheets.

Drive points further downstream (DP13 to DP15) and in a constricted section of the Undai River alluvials also show an increasing trend (Figure 2.14), as do drive points DP16 and DP17 still further downstream in a braided section of the river channel upgradient of Budagt Spring (Figure 2.15). The water table level in DP16 has risen to only 0.3 mbgs and shows a seasonal trend which is similar to the variation in baseflow discharge at the New Bor Ovoo Spring more than 3 km upstream.

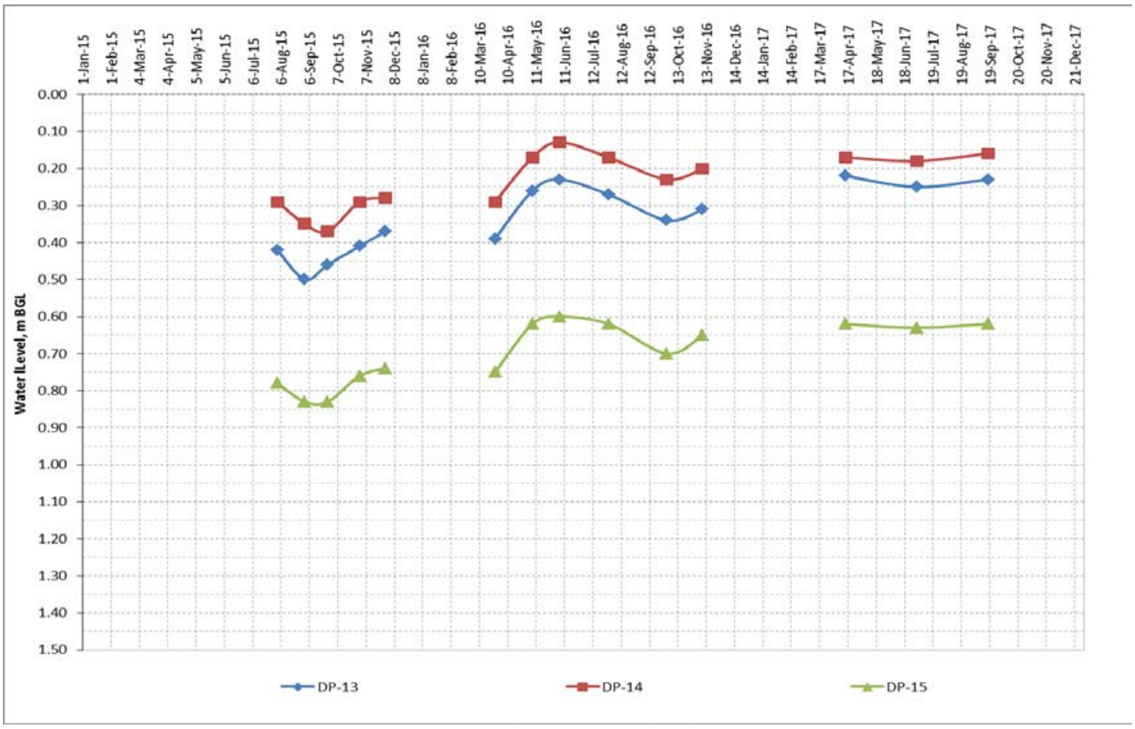


Figure 2.14: Drive Points DP13 – 15 across in Undai below New Bor Ovoo Spring

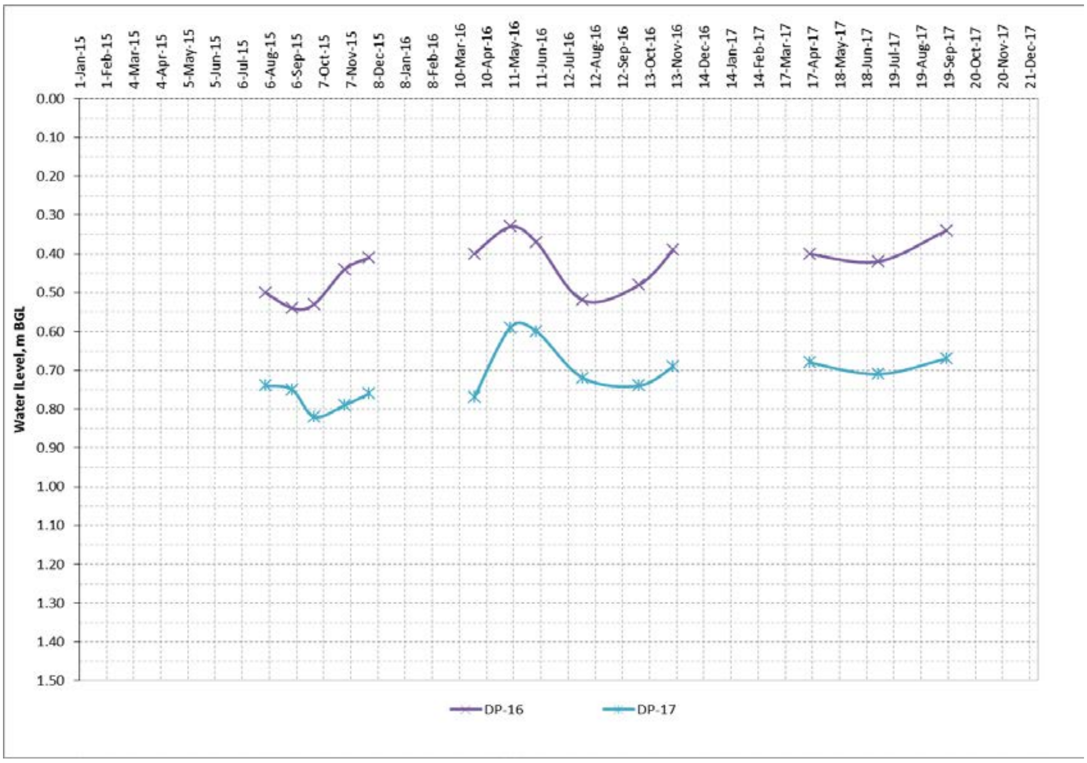


Figure 2.15: Drive Points Dp16 (Western Braided Channel) and Dp17 (Eastern Braided Channel) Upstream of Budagt Spring

The positive result apparent from these hydrographs is that recharge along the old Undai River channel downstream of the New Bor Ovoo Spring, which does not now receive recharge from flood events, has been enhanced due to the diversion system. This has resulted in more plentiful groundwater supply extending downstream for the full 4 km of the isolated riverbed as far as the Budagt Spring. There has been no adverse impact on herders wells or springs down gradient of the Mine License Area as evidenced by the above hydrographs.

3 SPRING MONITORING

The Budagt Spring is located in the old Undai River channel slightly upstream of its confluence with the Brown River. It was originally hypothesized that the Undai Diversion could negatively impact the Budagt Spring as the spring location no longer receives episodic flooding. However as shown in the recent picture provided as Figure 3.1 the spring is doing very well, in likelihood from increased groundwater flow in the cut-off portion of the Undai Channel due to enhanced baseflow recharge deriving from the Undai Diversion System.

Figure 3.1: Budagt Spring in September 2017

The ultimate success of the Undai River Diversion will be assessed based on the long-term viability of springs located down gradient of the OT site (Khukh Khad, Budagt, Buural and Maanit), and long-term depth to groundwater provided from Undai River monitoring points. To date no negative impacts have been observed at these locations. The success of the project must also be evaluated against the backdrop of climate variations, for example normal episodic drought years, as well as the overprint of any potential activities up gradient of the OT site. To date no negative impacts have been realized to the Undai River channel down gradient of the MLA.

4 PERFORMANCE OF TSF

Tailings Storage Facility (TSF) Cell #1 has been receiving tailings since March 2013. Most of the TSF foundation overlies thick natural clays; however an engineered 1 m thick compacted clay liner was constructed in the southeast corner of Cell #1 at a location with no naturally occurring clays. Tailings depth in Cell #1 has reached approximately 20 m with the crest of the dam wall approximately 10 m over this level. Figure 4.1 provides a general layout of the TSF along with associated monitoring points.

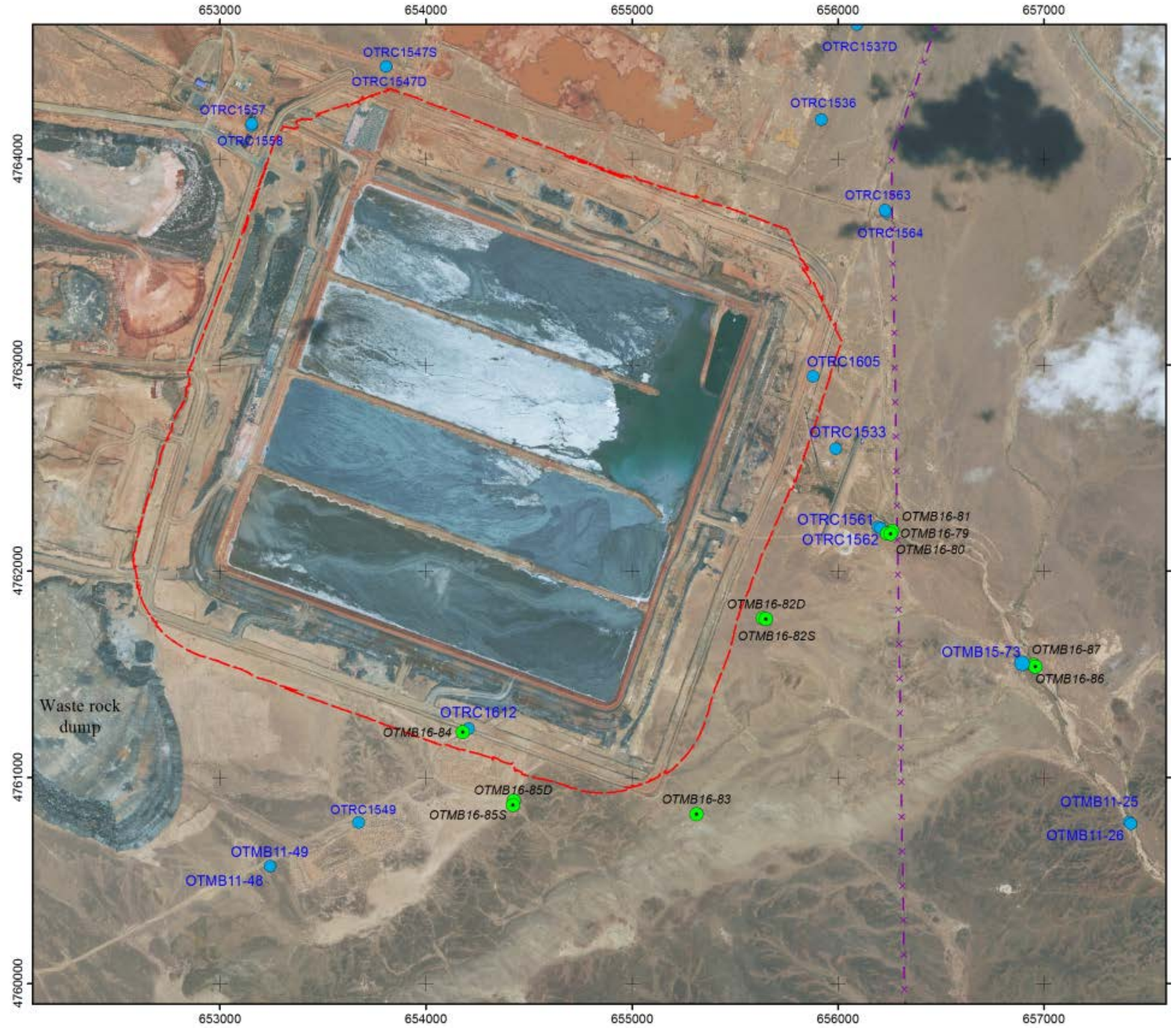


Figure 4.1: TSF with Khaliv Drainage Cross Footprint in Extreme Northeast. Monitoring array also shown

The northeast corner of Cell #1 is a topographic low where the ephemeral Khaliv River and its major tributary, the Dugt River, cross the TSF footprint allowing rises in groundwater level to flow along these preferential pathways. Surface flows in these channels report to an engineered trench that conveys non-contact runoff water around the TSF. Flows collected in this trench are then discharged back to the Khaliv River alluvial system just down gradient of the TSF. A down gradient cut-off dam has been constructed just to the east of the TSF in the Khaliv River alluvial channel. This dam (the “East Toe Collection Dyke”) was installed specifically for the purpose of collecting any seepage so that it can be contained and pumped back the TSF. The Khaliv drainage eventually joins the Bor Khoshuu riverbed for a short distance before forming the Budaa River.

Weathered bedrock and residual soils are present beneath the clays underlying the TSF and overlying bedrock. The bedrock sequence is variably weathered to a depth of 15 to 30 m. The reported hydraulic conductivity of the intact bedrock across the TSF is very low, ranging between 5 x 10^{-8} m/s to 7 x 10^{-11} m/s.

All monitoring wells at the TSF are screened in weathered bedrock, some directly beneath the water table and others at the base of the weathered bedrock. Some wells are screened in the unweathered bedrock as deep as 127 m. These deep wells are of limited evaluation value given the very low permeability of the bedrock and the lack of hydraulic connection to the shallower groundwater.

4.1 VISIBLE SEEPAGES

There are two geochemically distinct seepages present at the eastern toe of Cell #1, with a third seepage present at the northern toe. These seepages have collectively resulted in visible surface flow of approximately 1 – 1.25 L/s as measured with constructed V-notches. This seepage has always been anticipated as alluvial sediments of the Khaliv River system underlie the TSF at these locations. As such a pumping system exists to collect this seepage and return it to the TSF.

In addition and as a preventative measure the East Toe Collection Dyke has been constructed downgradient of the seepage collection system and extending across the breadth of the Khaliv River alluvials. This allows interception of seepage that could bypass the collection system. Additional monitoring points down gradient of the dam allow monitoring of any seepage that could short-circuit the East Toe Collection Dyke. There is no discernible impact to the environment from these known seepages on the northern and eastern margin of the TSF, as reflected by reviewed data from the network of downstream monitoring wells..

4.2 BEHAVIOUR TO THE SOUTH OF THE TSF

Monitoring bore OTRC 1612 is located to the south of Cell #1 and screened from 21 to 28 m below ground surface in tuffaceous sandstone. Data from this monitoring point reflect an approximate 6.5 m rise in water levels since early 2014 (see Figure 4.2). This gradual increasing trend in water levels since mid-2014 coincides with commencement of tailings deposition in this part of the cell. This parallel and equivalent rise is likely attributed to increasing head of tailings pressurising the groundwater in the aquifer approximately 20 m below the floor of the TSF.

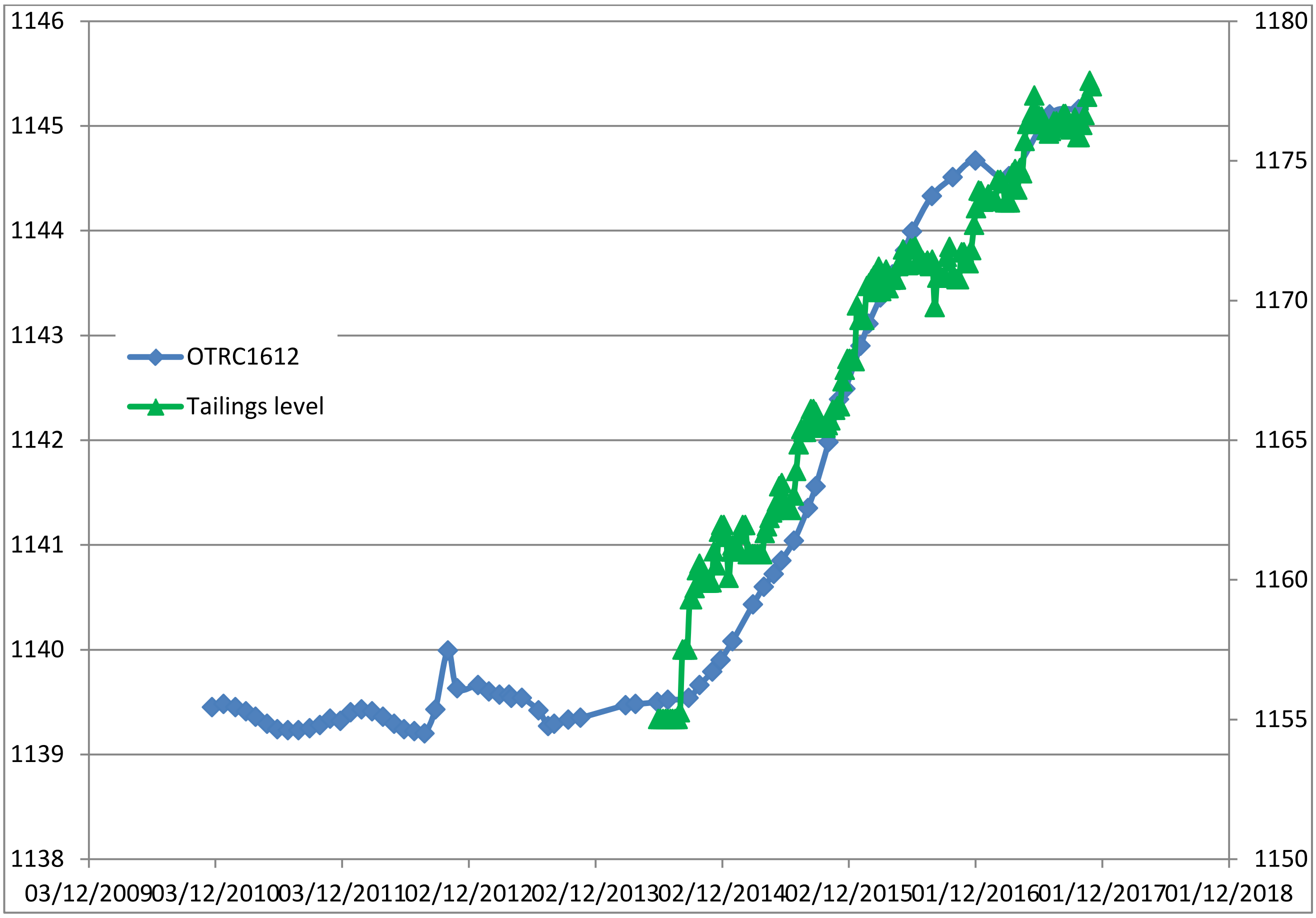


Figure 4.2: Water Levels in TSF and Monitor Well OTRC 1612 since Tailings Deposition Commenced in August 2014 (Right Vertical Axis Level of Tailings, Left Vertical Axis Water level of OTRC 1612)

In Q3 of 2016, OT substantially improved the monitoring array available in the immediate vicinity of OTRC 1612 including nested monitoring points located in alluvial, weathered bedrock, and bedrock units (OTMB16-84, OTMB16-85 Deep and Shallow, and OTMB 16-83). These boreholes have been installed at depths of between 1.5 to 30 m specifically for the purpose of monitoring groundwater and potential seepage behaviour at this location. These complement other available monitoring points including OTRC 1549 and three vibrating wire piezometers installed at the dam (DH12-01, DH12-02 and DH12-03).

Monitor well OTMB16-84 was installed adjacent to OTRC 1612 and screened in weathered bedrock from 2.5 to 8.2 m below ground surface. Recorded water levels since that time generally mirror those of OTRC1612 suggesting relatively permeable bedrock being pressured by the increasing head of tailings in the TSF. The pH recorded in this well is as high as 13.34 with EC up to 6948 mS/cm; this EC is associated with high cations (Ca, Na and K) and anions (Cl, CO_3/HCO_3 and SO_4) reducing progressively from October 2016 to July 2017. This is a clear indication of contamination by drilling fluids and cement during well construction as observed in other monitor wells constructed in 2016.

Three other monitor wells were installed further to the southeast of the TSF. Monitoring points OTMB1685 Deep and Shallow are approximately 0.6 km south of the TSF and OTMB1683 is approximately 0.7 km to the southeast. The OTMB1685 hydrographs, albeit of limited duration, show an increasing water level trend (Figure 4.3) whereas OTMB1683 further to the east does not (Figure 4.4). It has been observed that after purging and sampling the water levels in some monitor wells can take up to 2 years to recover because of very low permeabilities. Low permeabilities are associated with high TDS, in OTMB-1687 for example the TDS is up to 15,000 mg/l.

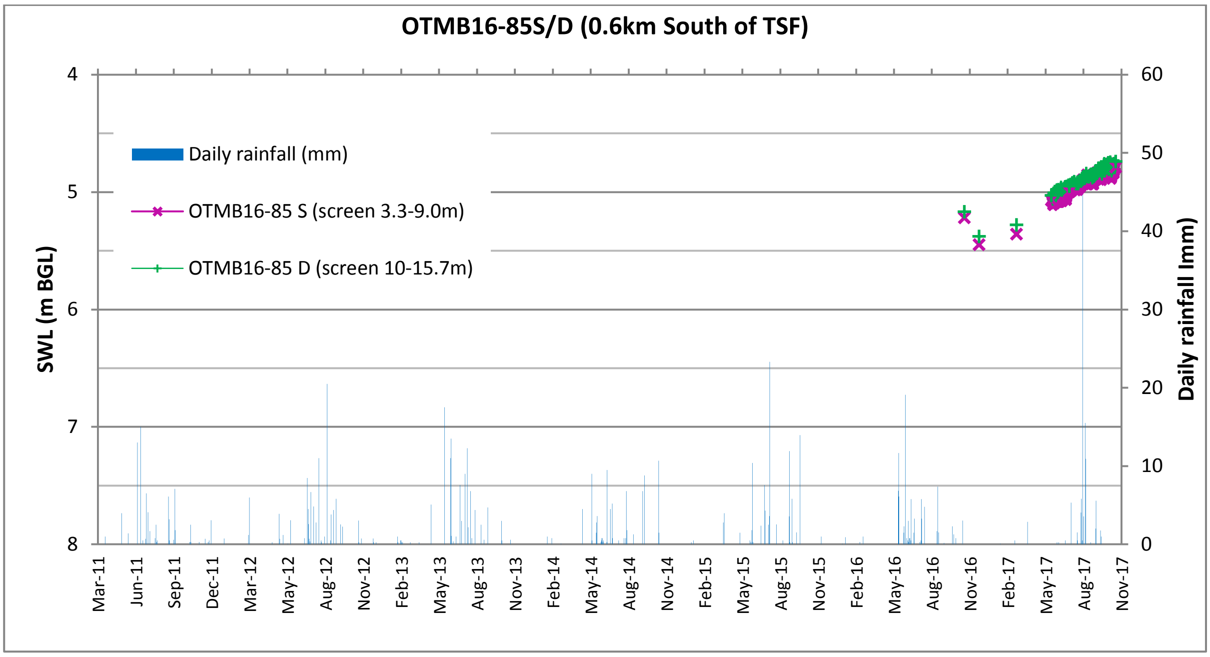


Figure 4.3: Water Levels in New Monitor Well OTMB 16-85 Shallow and Deep

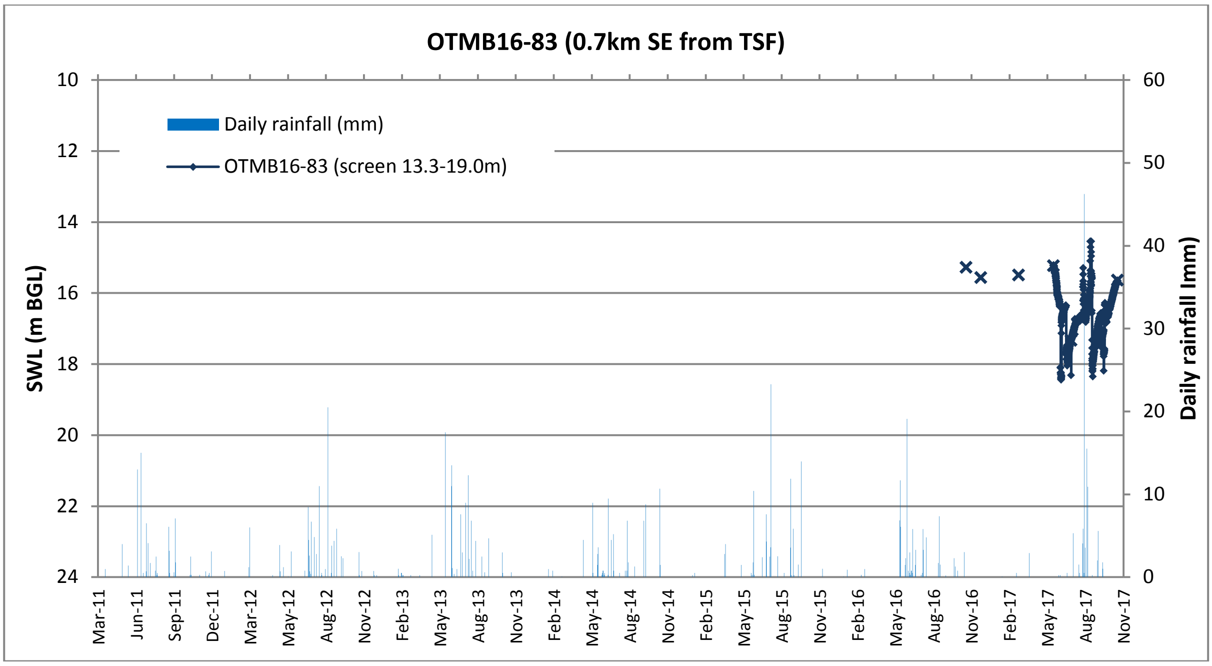
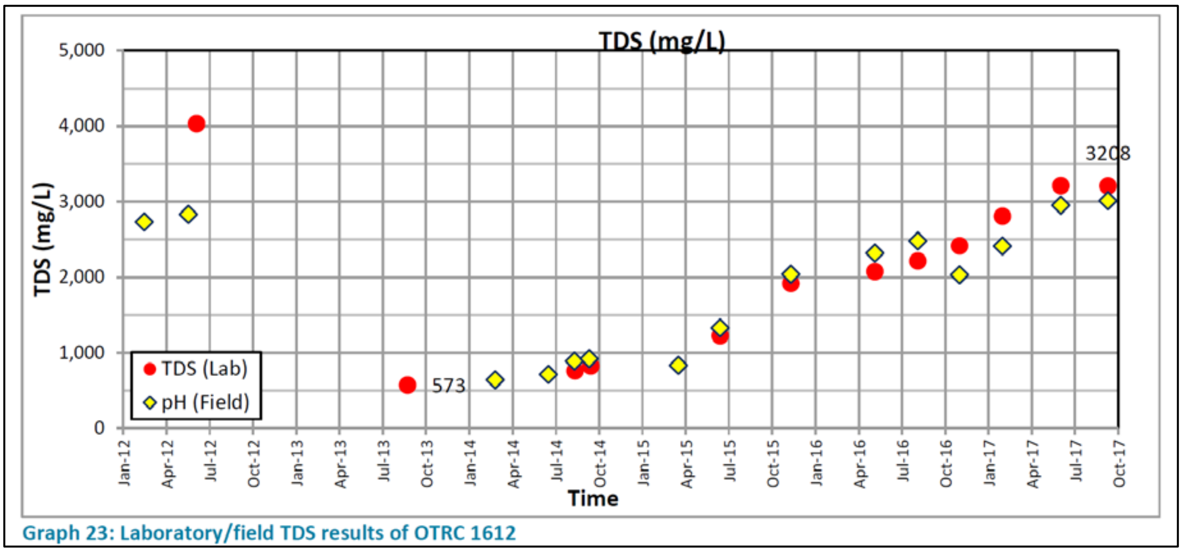


Figure 4.4: Water Levels in New Monitor Well OTMB 16-83

4.3 GEOCHEMISTRY

The water level rise at OTRC 1612 corresponds with an increase in total dissolved solid (TDS) concentrations from 573 mg/L in 2013 to 3,208 mg/L in October 2017 (Figure 4.5). Hardness, SO_4, Cl, Na, Ca, Mg and Sr also increased at proportionate rates. The relatively high salinity of 4,034 mg/L measured in 2012 at time of installation, albeit from a single measurement only, could be related to contamination with drilling fluids with this effect dissipating within a year.



Graph 23: Laboratory/field TDS results of OTRC 1612

Figure 4.5: Increase in TDS (lab and field measurements) at OTRC 1612

The Total Dissolved Solid (TDS) in the TSF barge water is variable but averages 6,154 mg/l. Although the majority of the parameters recorded with increasing concentration in OTRC 1612 reflect trend towards barge water quality, there are discrete hydrogeochemical differences as shown in Figure 4.6. The K/Na and Mg/K ratios are markedly different and more representative of naturally occurring high salinity groundwaters as sampled in the area prior to TSF construction.

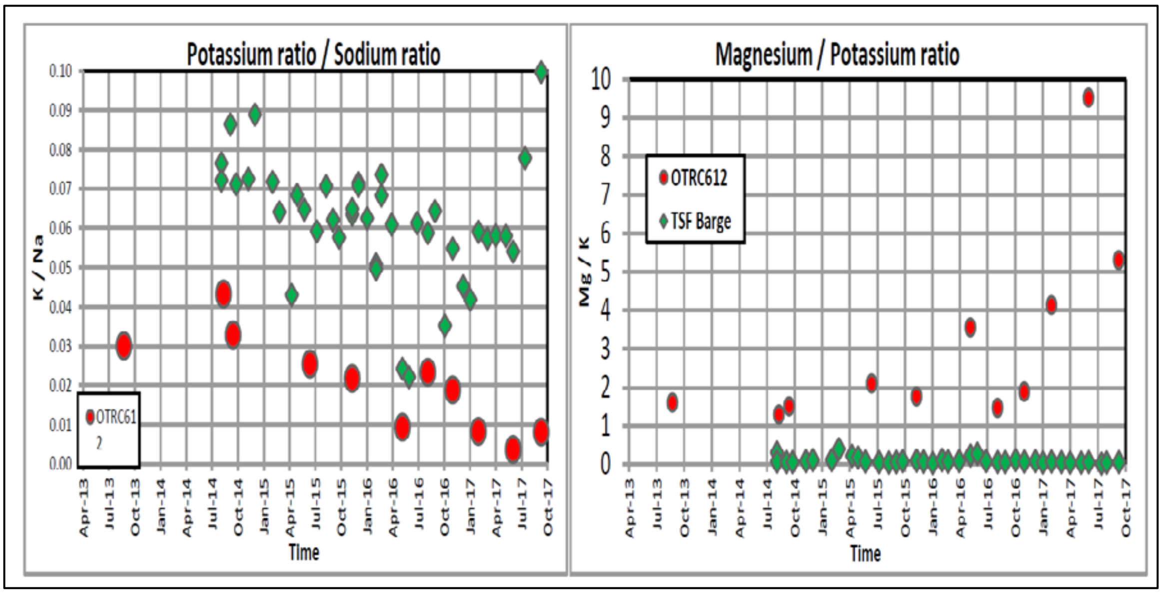


Figure 4.6: Differing K/Na and Mg/K Ratios of OTRC 1612 from those of Barge Water

Overall the geochemistry of OTRC 1612 is indicative of natural ground waters and differs in several respects to that of barge water quality. OTRC 1612 water quality is evolving trend towards Na-Cl-SO_4 and Na-Cl type. This is similar to existing monitoring bores in the TSF area (OTRC1533A, OTRC 1549A, OTMB 1126A and OTRC 1562). The observed geochemical behaviour appears related to hydraulic/physical loading (pressurization) from tailings deposition in Cell 1A. However given the potential for Cation Exchange Capacity (Ca, Mg and K) in the groundwaters due to interaction with bentonite and TSF clay liners and similar cation exchanges with clays used in drilling fluids it is suggested that the trends and differences observed between barge water and groundwater could also be partially influenced by cation exchange.

Unfortunately drilling fluids or cement has contaminated the groundwater from some of the wells constructed in 2016. Little value can be attached to the data from these wells (OTMB 1680, OTMB 1683 and OTMB 1684). The pH for example is very high and remains high despite frequent purging. In OTMB1683 the pH ranges between 11.6 and 13.4. Although the water level data collected from these new wells is useful they are not returning important geochemical data. As such these wells should be replaced if contamination remains persistent.

Water quality trends in OTRC 1612 are difficult to precisely parse, however there is a trend towards background groundwater quality. This would suggest observed behaviors at this location reflect increased pressurization from tailings deposition forcing displacement of natural groundwaters into the monitoring bore location. However there may also be some impact from seepage of the TSF, as some seepage will occur over time and this location corresponds to relatively thin underlying engineered clay low permeability barrier.

l Natural groundwater salinities are high and bear a hydrogeochemical signature similar to the rising salinities observed in the OTRC 1612 groundwater but both exhibit several marked differences to the cation ratios in the TSF barge water.The trend will continue to be evaluated. There are no groundwater receptors of concern, such as herders wells, near the southern margin of the TSF and the saline nature of the natural groundwaters renders it unsuitable for livestock use whether influenced by TSF seepage or not. The less saline shallow groundwater present in Undai alluvial channel is located several kilometers downgradient.

At the depth of the screens in OTRC1612 (21 to 28 m below ground level) the observed sudden rise in water level is likely a tailings head loading effect. It is considered unlikely that there is an abandoned borehole providing direct access between the TSF and the tuffaceous sandstone aquifer so that direct seepage would not be observed at the location of OTRC1612 in such a short period of time. It also suggests that this immediate area is a zone of higher permeability than that observed over the major part of the TSF footprint.

Recommendations

- ✓ Review drilling fluids (Ca-bentonite or Na-bentonite) and cement used for monitor well construction to avoid contamination of groundwaters;
- ✓ replace monitoring wells OTMB 1680, OTMB 1683 and OTMB 1684 if they continue to demonstrate contamination from well construction materials;
- ✓ include field temperature readings when groundwater sampling to determine if it could be a potential indicator of barge water seepage;
- ✓ discontinue geophysical resistivity profiling as the results have proved inconclusive;
- ✓ review and incorporate the groundwater monitoring data contained in the RPS groundwater monitoring report of 2014 and any relevant groundwater data collected during the TSF investigation by Klohn Crippen in 2010. Detailed review of this existing data will provide more credible information on baseline groundwater quality in this southeastern part of the TSF and allow more refined understanding of the initial low salinity and indicated high permeability at OTRC-1612.

5 PERFORMANCE OF GUNII HOOLOI AQUIFER

The OT Project is permitted to withdraw water from 28 production wells installed in the regional Gunii Hooloi (GH) aquifer, which is brackish, at a rate of 918 L/s or approximately 79,315 m^3/day. This represents an increase over the prior 2015 approved rate of 870 L/s. In December 2015 the State Water Reserve Council approved this slight increased usage based on review of available hydrogeological data and observed draw down rates. The Ministry of Environment confirmed these results via issuance in May 2016 of a Long Term Water Contract. This Long Term Water Contract is described in the Investment Agreement and is now valid through Year 2040. Within the Long Term Water Contract limits are imposed on the percentage of groundwater stored in the aquifer that can be withdrawn and on maximum drawdown levels.

OT withdrew 15,905,059 m^3 of water from the GH aquifer in calendar year 2016 (43,575 m^3/day). This was approximately 10% more than the volume extracted by OT in year 2015, which was 14,535,599 m^3, or 39,824 m^3/day. Even with this increased pumping overall usage in 2016 was approximately 55% of the permitted amount approved by the Ministry of Environment under the Long Term Water Contract.

The original OT target raw water usage rate was predicted at 696 L/s (60,134 m^3/day). The project has been below this target pumping rate since the beginning of open pit operations. Average consumption rate in 2016 was 504 L/s. Consumption rates vary throughout the year primarily due to freezing and thawing cycles at the TSF. Maximum monthly water raw water usage is highest in winter when much of available water at the TSF is locked up as ice. The concentrator circuit is by far the biggest user of water at the site, using almost 90% of all make-up supply, and as such is the focus of water recycling efforts.

In 2016 OT achieved an 86.6% water recycling efficiency rate. This represents steady improvement over the 2015, 2014 and 2013 water recycling efficiency rates of 85.6%, 84.7% and 83.3%, respectively. Water recycling rate to date in 2017 is 86.1%. All of these values demonstrate recycling efficiencies above the 80% threshold minimum criteria recycling rate included as a key performance indicator (WR-KPI-03). On-going success has been realized in optimizing water management at the TSF, with improvement in tailings solids density from 55% to approximately 61%, and an increase in tailings beach slope from 0.3 to 0.6 percent.

In 2016 OT achieved a 423 L of water consumed/ton of ore produced ratio. Values are below the target of 547 L/ton-ore (WR-KPI-04), and less than half of the global average usage rate of 1,220 L/ton-ore for similar scale mines. Steady improvements in this important metric are primarily related to more effective beaching inside the TSF and on-going efficiency modifications in the process recycling circuit.

5.1 GUNII HOOLOI PERFORMANCE

The performance of the GH aquifer is assessed by measuring drawdowns at various depths in the aquifer and adjacent aquitards from a network of groundwater monitoring wells. These drawdown levels are then periodically used to calibrate the numerical model that has been developed to evaluate past and future aquifer performance.

Production well arrays include five clusters, each containing five production wells. Three clusters in the northeast well field provide 95% of total demand and two clusters in the southwest provide the remaining t 5% (Figure 5.1).

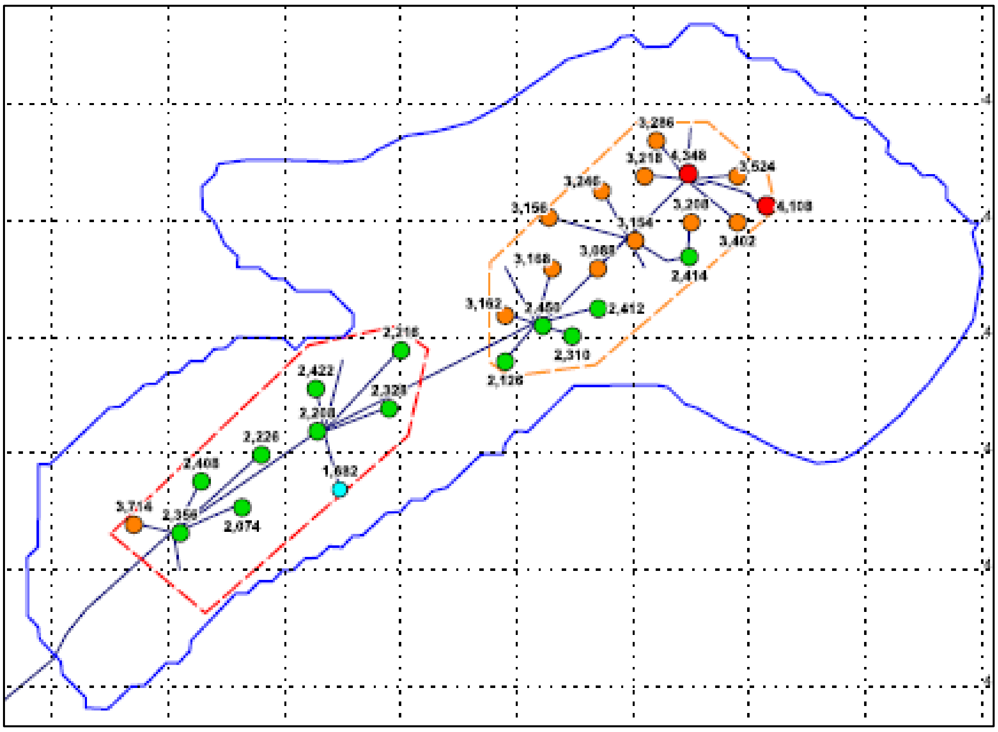


Figure 5.1: Gunni Hooloi Production Wells

Groundwater quality is variable between the various production bores but is always brackish. Produced water quality is relatively stable. A rising trend in pH and sulphate noted in some bores is not significant in terms of evaluating aquifer performance.

This discussion is based on findings contained in two recent reports:

- ✓ 2015 Groundwater Model Update of 2012 Model (Groundwater Solutions, 2016);
- ✓ 2015 – 2016 Hydrogeologic Data Review (Groundwater Solutions, 2017).

The 2016 review by Groundwater Solutions was an update of the previous review that used six years of data from 2004 to 2010. Additional multi-level piezometers have since been installed at four sites but overall the groundwater monitoring network has contracted by about 25% (161 bores down from 219 previously) due to decommissioning of a number of old exploration bores and some losses from damage. The monitoring network now comprises:

- ✓ 44 herder wells;
- ✓ 11 shallow bores typically 5 to 20 m deep;
- ✓ 19 intermediate bores;
- ✓ 22 aquitard bores;
- ✓ 19 composite bores;
- ✓ 18 deep, main aquifer bores; and
- ✓ 28 production bores.

A general schematic of the GH monitoring program is shown on Figure 5.2.

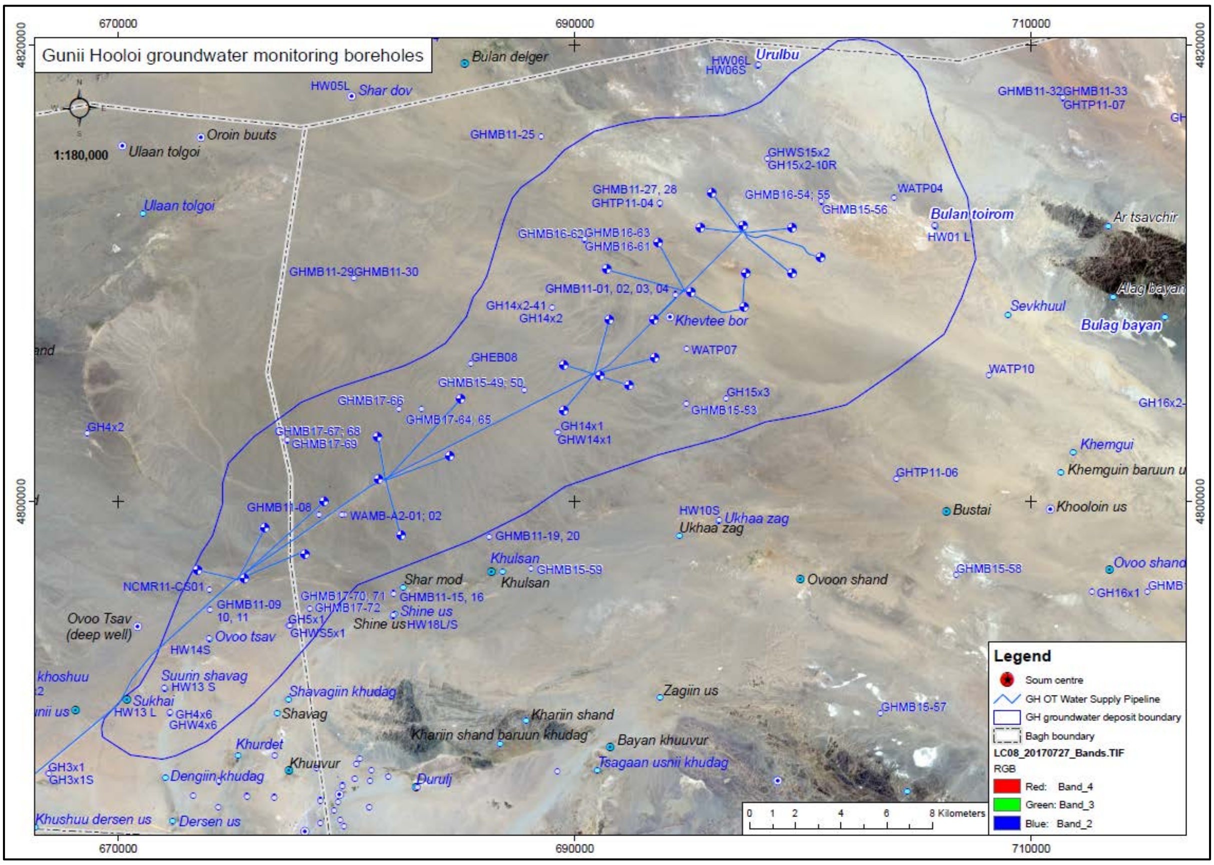


Figure 5.2: Aerial View of Gunii Hooloi Water Monitoring Locations, including Herder Wells

The groundwater monitoring programme for the well field and for the regional monitoring network has been reviewed separately and recommendations made for optimising the frequency of monitoring and the collection and analysis of groundwater samples. Such optimisation is standard best practice after a lengthy data set has been made available for review.

A significant focus is always on the shallow alluvial aquifers that support herder wells. It had been previously assumed that these shallow aquifers were separated from the main aquifer by relatively thick aquitards and no adverse impact would result from the wellfield abstraction apart from a potential impact to the northeast of the main aquifer. All herder wells monitored returned seasonal water level fluctuations related entirely to recharge from stream floods and runoff from bedrock massifs with discharge by evapotranspiration and livestock usage similar to the trends observed in this area commencing 2003. No adverse impacts to herders wells have been identified.

Hydrographs for Bulag bayan (HW07 and Figure 5.3), Bulan Toirom (HW01 and Figure 5.4) and Urubu melkhii (HW06 and Figure 5.5), the three herders wells northeast of the northeast wellfield in the area considered potentially at risk from groundwater abstraction confirm that there are no adverse impacts to date in that area. Precipitation totals at the OT mine site were significantly higher than totals received in the Gunnii Hooloi region.

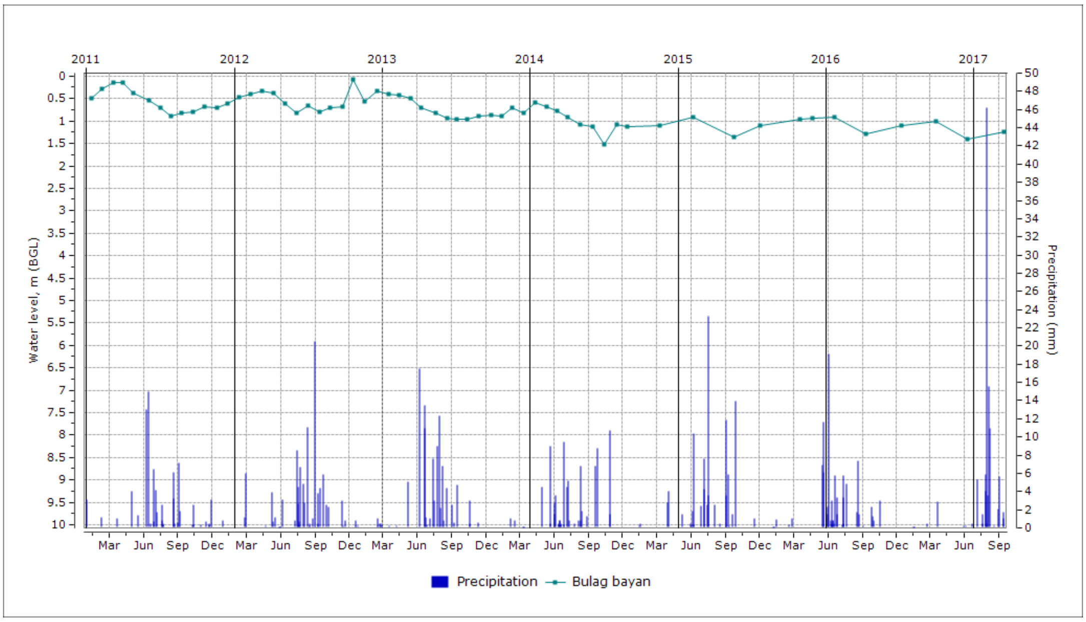


Figure 5.3: Hydrograph of Bulag Bayan (HW07) Herders Well

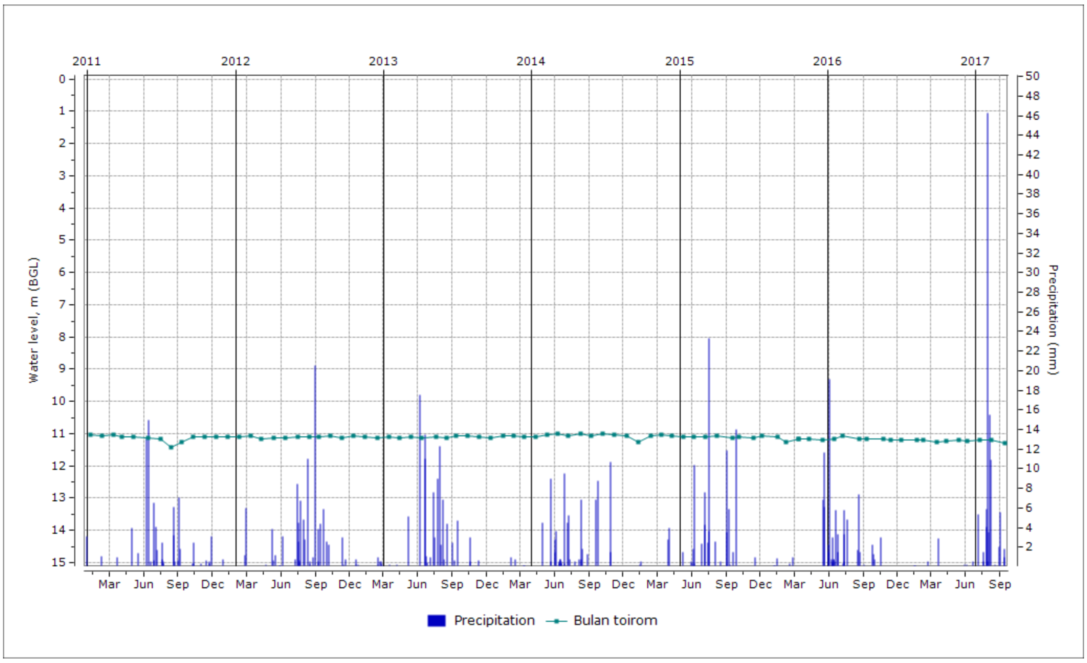


Figure 5.4: Hydrograph of Bulan Toirom Herders Well

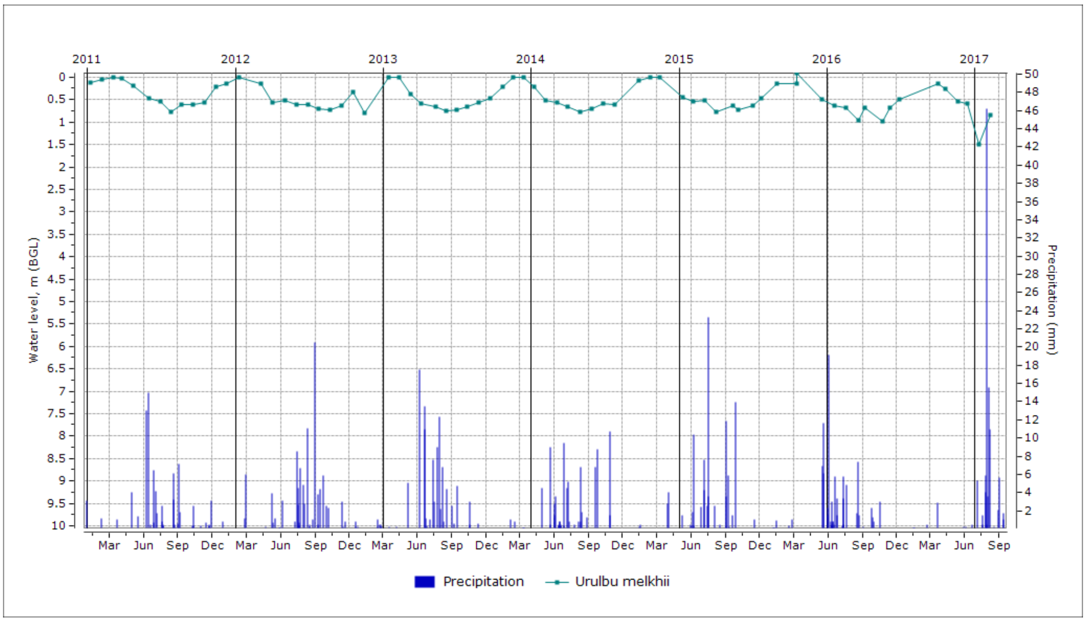


Figure 5.5: Hydrograph of Urulbu (HW06) Herders Well

In the deep aquifer there is no evidence of any recharge and the minor fluctuations that have been observed are related to variations in barometric pressure. Drawdowns are being experienced in the aquitards in response to groundwater abstraction from the deep aquifer and is an indication of leakage to the aquifer that ultimately will increase the groundwater reserves available. This may ultimately lead to some compaction in the clayey aquitards that would then, over a long period time, be transmitted to the surface and result in some subsidence over the footprint of the well fields.

6 GROUNDWATER MODEL UPDATE

The groundwater model is an essential tool for prediction of future water level drawdowns under various abstraction scenarios. As more monitoring data becomes available it allows the model to be calibrated and refined to provide progressively more precision to predictions. Modelling of the Gunii Hooloi aquifer should always be considered as a work in progress.

The latest iteration of the model incorporated improved definition of the aquifer and its transmissivity distribution, a transient model set-up and calibration to historical water levels during well field operation between July 2011 and December 2014; and predictions for groundwater abstraction for the period 2015 to 2054. In general the model follows the 2012 Australian Groundwater Modelling Guidelines commissioned by the Australian Water Commission on Key Water Issues but a robust assessment of the model against these Guidelines has not been conducted as part of this detailed water review.

It is noted that recharge to the aquifer on the margins of the sedimentary basin where runoff from the bedrock areas can be expected to generate some recharge, has been included in the model and creates some uncertainty. Recharge values of up to 29.2 mm annually are shown, for example, south of the south western well field, equivalent to about 30% of rainfall. As a corollary if recharge occurs on the margins of the basin drawdown can also occur.

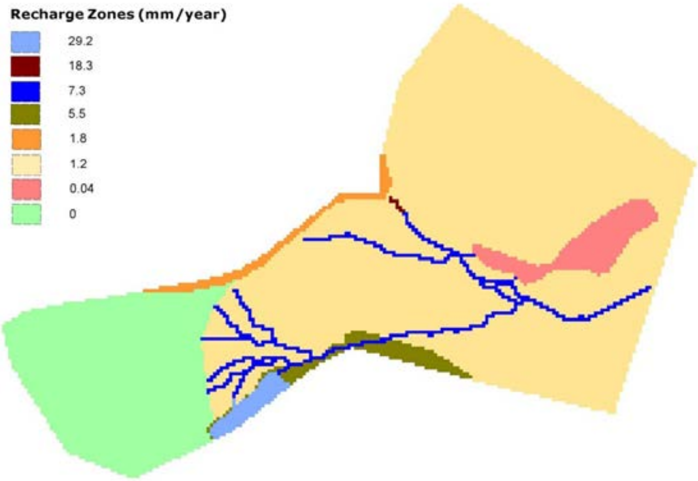


Figure 6.1: 2015 Model: Recharge Areas and Rates

It is noted that hydrographs for herders wells (eg Khurdet and Dengu Khudag) on the SE margin of the basin in the area of indicated high recharge in the numerical model are relatively flat showing limited response to recharge and no response to abstraction from the aquifer. This is the opposite of what would be expected. The only herders well to show appreciable recharge response and a progressive decline in water level is Murui on the NW margin of the basin supporting the numerical model prediction of some limited recharge in that area.

The model prediction of water levels agrees well with observed water level drawdowns in the aquifer supporting the ability of the aquifer to meet the project’s long term demand. The only potential impact to shallow aquifers predicted in the model is in a small area to the northeast of the well field where herder well hydrographs do not indicate impact from GH pumping by the project.

The hydrogeological monitoring network in the vicinity of the Gunii Hooloi Wellfield is comprehensive and fully representative of the different aquifers and aquicludes in that area. To date no adverse impacts on herders wells have been identified although there is some question of potential future impact to the northeast of the northeast well field. This area should be an area of focus for future model updates and calibration.

In the main aquifer where abstraction rates are markedly lower than previously projected because of successful water management and conservation on site the observed drawdowns have been successfully replicated in the numerical model. The water demand for the life of the project is validated.

Recommendation

- ✓ It is best practice to conduct a detailed review of numerical models against the Groundwater Modelling Guidelines developed by the Australian National Water Commission. Given the importance of the Gunii Hooloi numerical model as water management and prediction tool it is recommended that at some point an internationally recognised groundwater modelling expert conduct such a review. It is also recommended that the predictions of recharge to the main aquifer on the SE and NW basin margins be further reviewed as the predictions on the SE margin seem too high and are not supported by hydrographs in that area.

7 KEY CONCLUSIONS OF DETAILED WATER REVIEW

A 1 in 25 year flood event occurred along the Undai River in August 2017, the first significant flood since the Undai diversion was commissioned in 2014. This has allowed a detailed review of the Undai diversion performance in respect to the effectiveness of the baseflow interception and diversion, the integrity of the north and south cut-off structures, the surface diversion channel, the New Bor Ovoo Spring, and downstream water level trends in springs and herders wells.

Since 2015 shallow groundwater levels have been observed to be stable or rising along the reach of the Undai River channel between the New Bor Ovoo Spring and its intersection with the Brown River. This reach of the Undai River is approximately 4 km in length and now no longer receives episodic flooding. This observed trend appears related to an overall increase in the volume of subsurface groundwater flow derived by the subsurface diversion system and associated New Bor Ovoo Spring discharge compared with the pre-diversion condition that relied on episodic flooding. At present there are no adverse impacts to alluvial water levels from isolation of the channel to periodic flood recharge events.

As designed, the Undai surface diversion system has successfully transmitted several runoff events, including the recent 1 in 25 year flood, around the mine and back into the original Undai channel downstream. There have been no observed adverse impacts to springs or herder wells located down gradient in the Undai channel subsequent to the diversion. In fact springs and herder wells received significant recharge from the August 2017 flood event.

OT continues to monitor erosional behaviour at locations potentially impacted by the Undai River diversion and also within the project’s larger area of influence. The most recent 2017 Annual Erosion Monitoring Report did not identify any key concerns. However it is noted that the Tsankhi riverbed, which receives diverted surface flow from the Undai Diversion, is widening in response to the increased flood flows relative to historic patterns. This behaviour is anticipated and OT continues to monitor the system as it adjusts to the new flow regime.

After four years of operational water abstraction from the Gunii Hooloi aquifer, water level monitoring in the deep aquifer and overlying aquitard has confirmed the capacity of the deep aquifer to meet project demand. There have been no observed negative impacts to herder wells within the Gunii Hooloi basin.

Higher than projected recycling rates in the tailings/process water circuit have led to a reduced water demand, directly translating to lower abstraction rates from the Gunii Hooloi aquifer. Benchmarked globally against other similar copper mines, Oyu Tolgoi ranks very favorably in terms of water consumption per ton of ore processed.

TDS and water level has risen markedly in one monitoring bore adjacent to the south side of the TSF. This is also the location of relatively thin impermeable geologic materials within the TSF footprint. These changes do not currently represent an environmental concern given that process water quality is similar to some natural bedrock groundwaters in the area, the changes are occurring well within the operational footprint, and shallow alluvial aquifers are much further downgradient. This said it is likely that most of the changes in the well’s water level and TDS concentrations reflect the movement of naturally occurring high TDS groundwater induced by loading pressure of active deposition in the TSF. Oyu Tolgoi should and has committed to the continued monitoring and assessment of the water level and geochemical trends in this area. This is evidenced by the recent installation of additional monitoring points to the south of the TSF.

Given the improved understanding of the natural systems and Oyu Tolgoi’s potential impacts, the water monitoring program can be refined to improve efficiency of the program without compromising its integrity. These proposed changes will be sought through the existing NoC process.

In the 2017 field season OT completed installation of the additional monitoring bores in the Guuni Hooloi region (nine monitoring points across three sites). Drilling and installation of supplementary monitoring bores, as discussed in the Water Monitoring Plan (WMP), has been fully implemented. The previous associated non-conformance (M2.3) can now be considered closed.

There are 20 exploration boreholes remaining that will be sealed by OT as part of a 2018 work program. Although these boreholes extend through the shallow and deep aquifers of the groundwater system they do not represent a risk of inter-aquifer connection as they are cased along their entire lengths. Nevertheless in accordance with best practice the boreholes will be sealed as they are no longer of utility. Additional details on the historic sealing of cascading/interconnected bores is presented in publicly available periodic audit reports as issued by the IESC (see section 5.1.2.8 of the IESC Audit Report of August, 2017).

OT is engaged in several water-related projects in coordination with the Tri-Partite Council (TPC) and Herders' Complaints Resolution Agreements #1 and #2. Although outside the scope of this technical review OT reports that actions of Detailed Implementation Plans associated with these Resolution Agreements are on track.