

SECTION C: IMPACT ASSESSMENT

CHAPTER C5: WATER

Contents

5 WATER RESOURCES	3
5.1 INTRODUCTION	3
5.2 OVERVIEW OF KEY ISSUES ADDRESSED	3
5.2.1 <i>Fossil Groundwater Resources of the South Gobi</i>	4
5.3 SCOPE OF THE ASSESSMENT	5
5.3.1 <i>Spatial Scope</i>	5
5.3.2 <i>Technical Scope</i>	5
5.3.3 <i>Temporal Scope</i>	6
5.4 IMPACT ASSESSMENT	6
5.4.1 <i>Summary of Impacts</i>	6
5.4.2 <i>Surface Water Diversions and Crossings in Mine Licence Area</i>	7
5.4.3 <i>Surface Water Impacts outside the Mine Licence Area</i>	14
5.4.4 <i>Groundwater Abstraction and Dewatering in Mine Licence Area and Galbyn Gobi</i>	18
5.4.5 <i>Gunii Hooloi Abstraction</i>	27
5.4.6 <i>Impacts to Herder Wells</i>	33
5.4.7 <i>Groundwater & Surface Water Contamination</i>	39
5.4.8 <i>Increased Khanbogd Groundwater Supply Demands</i>	41
5.4.9 <i>Operation of Tailings Storage Facilities</i>	42
5.4.10 <i>Waste Rock Dump Construction and Operations</i>	47
5.5 MONITORING AND PERFORMANCE	53
5.5.1 <i>Water Conservation</i>	53
5.5.2 <i>Monitoring and Key Performance Indicators</i>	58
5.6 SUMMARY OF RESIDUAL IMPACTS	59

Figures

Figure 5.1: Undai Diversion around South Pit	9
Figure 5.2: Illustrative Cross Section through Undai at the location of the Diversion Dam.	11
Figure 5.3: Gunii Hooloi Borefield, Pipeline and Relationship to Ephemeral Watercourses	14
Figure 5.4: Saxaul Disturbance in the Borefield	16
Figure 5.5: Oyu Tolgoi Construction Phase Water Supply Wells adjacent to Proposed South Pit	20
Figure 5.6: Oyu Tolgoi to Gashuun Sukhait Water Supply Boreholes	26
Figure 5.7: GH4x6 Water Well and Monitoring Wells	30
Figure 5.8: GH4x6 Well Location	31
Figure 5.9: Gunii Hooloi Groundwater levels – 40 years (using a 110,000tpd base case)	32
Figure 5.10: Map of Winter Herder Camps and Wells along the Gunii Hooloi Water Supply Route	34
Figure 5.11: Map of Winter Herder Camps and Wells and Ephemeral Watercourse along the Road Route	35
Figure 5.12: Location of Herder Wells which may be Impacted by Dewatering	36
Figure 5.13: Drilling Rig and Infrastructure including mud pits	41
Figure 5.14: SSW-NNE Section through Budaa TSF illustrating Surficial Materials and Shallow Geology	43
Figure 5.15: Location of Clay Liner beneath Cell 1 of TSF	45
Figure 5.16: Seepage and Diversion Ditches for the TSF	46
Figure 5.17: Generalised Subsoil and Outcrop Conditions below the WRD	48
Figure 5.18: General Orientation of Drainage below WRD Footprint	50
Figure 5.19: Generation of NAF and PAF materials during initial years of mine life	51
Figure 5.20: Plan of exterior slope of dump	52
Figure 5.21: Construction Water Supply Demand model January 2010 – December 2012	54
Figure 5.22: Water Losses as a Percentage	55
Figure 5.23: Simplified Water Balance for the 100,000 tpd Case	56

Tables

Table 5.1: Road Construction Supply Requirements	25
Table 5.2: Summary of Waste Rock Types	47

Table 5.3: Available NAF and Placement Options	50
Table 5.4: Per Capita Water Allowance	53
Table 5.5: Estimated Maximum and Minimum Personal Water Use.....	53
Table 5.6: Key Monitoring Measures and Key Performance Indicators	58
Table 5.7: Summary of Impacts: Water Resources	61

5 WATER RESOURCES

5.1 INTRODUCTION

This chapter of the ESIA describes the potential environmental and social impacts related to surface and groundwater resources which could result from the construction and operation of the Project. The impacts on water arising from the Project can affect the natural environment, the sustainability of the livelihoods of the local population, and also the future resources and carrying-capacity of the Project Area of Influence. The different impacts on water resources are assessed in terms of likelihood and significance and appropriate mitigation measures are developed. This is in keeping with the terms of the Investment Agreement which requires Oyu Tolgoi to take necessary measures to eliminate any material adverse impact on water resources detected by its monitoring regime¹. The assessment takes a precautionary approach and includes aspects where there is currently insufficient data to confirm that there is no impact or likely to be only a negligible impact.

The assessment also includes an assessment of the cumulative and residual impacts, long term management issues and monitoring requirements through the various Project phases and these are developed in *Chapter D7: Water Resources Management Plan*. The impacts and their significance are summarised in a table at the end of this Chapter.

5.2 OVERVIEW OF KEY ISSUES ADDRESSED

Based on an appraisal of the baseline conditions and sensitivities which are discussed in *Chapter B6: Water Resources*, the follow key issues were identified:

- The impact of the various elements of the Project on surface water systems, including ephemeral watercourses and ephemeral and permanent springs. These impacts could affect water quantity, quality or the length of time an ephemeral watercourse sustains surface or groundwater flows over the course of a year;
- The impact of the Project's water demand on the deep aquifer water resources of Gunii Hooloi and its significance to the overall water resources of the region and impacts on potential future water use; and
- The impact of the Project on shallow aquifer resources across the Project Area of Influence.

These key aspects of surface water systems, deep groundwater resources and shallow groundwater resources are influenced by a variety of interactive impacts, including:

- Impacts on flora and fauna due to potential disruptions to ephemeral surface water and groundwater flows and springs, and access to these water sources by wildlife;
- The impact of the diversion of the Undai on downstream springs and water users and risks to the Undai diversion from the adjacent waste rock dump and other infrastructure, including the quality of the water that drains from these features;
- The impact of the mine site water abstraction (for the construction water supply and dewatering incurred by the excavation and operation of the open pit and underground workings) on the surficial aquifers and on local ephemeral watercourses;
- The impact of water abstraction for construction purposes from locations outside the Mine Licence Area;
- The impact of the abstraction of deep aquifer water resources which are generally non-potable on shallower potable water aquifers including the surficial aquifers along the ephemeral watercourses used by herders and wildlife;
- Impacts on herder water supplies, particularly at their winter camps, which are critical for the maintenance of their livelihoods; and

¹ Investment Agreement between The Government of Mongolia and Ivanhoe Mines Mongolia Inc LLC and Ivanhoe Mines Ltd, and Rio Tinto International Holdings Limited, 6th October 2009, Clause 6.10.

- The impact of the increased water demand due to the known and predicted future increase in population of Khanbogd *soum* centre.

The impacts on the aquifers in the Gunii Hooloi basin are influenced by the Project water demand. Minimising the Project's water demand is a key performance indicator which has been at the forefront of the design of the Project. This assessment of the impacts of the Project on the water resources of the area, includes a review of the water minimisation measures which have been incorporated and the Project's targets for water conservation and recycling (see *Section 5.5.1*). Oyu Tolgoi is engendering a culture of water conservation throughout the company, its employees and contractors. This is illustrated by active management by Oyu Tolgoi to drive water conservation at all levels of the Project; reflected in initiatives such as Oyu Tolgoi's use of water conservation initiatives from choice of sanitary ware through to use of treated and recycled wastewater in the concrete batch plant.

5.2.1 Fossil Groundwater Resources of the South Gobi

The location and national water resources in Mongolia are discussed in *Chapter B6: Water Resources Baseline* the appreciation of the impacts that could arise from the Oyu Tolgoi Project are considered in the context of this national water setting. This section presents an overview of the extent of fossil groundwater resources present in the South Gobi and against which Oyu Tolgoi has evaluated the Project impacts.

The Approach of Oyu Tolgoi to the use of Fossil Groundwater Resources

Oyu Tolgoi has discovered and defined the deep Gunii Hooloi aquifer system and its exploration work has also improved definition of the known Galbyn Gobi aquifer system. Neither of these were previously identified as resources for mining projects and there are currently no other projects planned in the vicinity which could exploit these groundwater resources.

Oyu Tolgoi is currently permitted by the Government of Mongolia to take approximately 70,000 m³/day of water from the Gunii Hooloi deep aquifer. Given the positive economic impact the Project will have on Mongolia (30-40% increase in GDP at Project commencement), the use of the fossil groundwater in Gunii Hooloi is considered to be justified given the economic return to Mongolia from the use of this water; however the use of the water still needs to be undertaken in a responsible manner which maximises the return per unit of water used. The current models of the Gunii Hooloi aquifer demonstrate that it can be exploited by Oyu Tolgoi at a rate which maintains its confined nature for approximately 40 years².

Potential future expansion of Oyu Tolgoi's ore production capacity to allow the processing of additional reserves may result in production rates of up to 160,000 t/day. Such an expansion might require additional sources of water beyond the Gunii Hooloi, such as the Galbyn Gobi or Gunii Hooloi East areas. The impact of any such increase would be evaluated through specific modelling, impact assessments and negotiations with the Government of Mongolia and local stakeholders.

The extent to which mining abstraction will compete with other uses such as livestock, rural and urban public supply - depends on the specific characteristics of the aquifer that any individual mine utilises. The detailed studies of the Gunii Hooloi aquifer undertaken by Oyu Tolgoi have demonstrated that it is not strongly connected to shallow aquifers, and the use of the water is unlikely to have a significant impact on either the herders' wells or plants such as saxaul (*Haloxylon ammodendron*) that depend on the shallow surface water table in the area. These assumptions continue to be tested by Oyu Tolgoi and the on-going modelling and monitoring will be used to minimise any impacts and allow Oyu Tolgoi to address proactively any issues that arise (be they directly linked to Oyu Tolgoi's activities or not).

Given the importance of water to the South Gobi region's development and for the continued operation of the Oyu Tolgoi Project, Oyu Tolgoi will take a proactive leadership position on this issue to safeguard water resources and maximise water use efficiency for the Project and the South Gobi region, allowing the Project to operate over both the short and medium-term.

² Aquaterra, 2007. Referenced in Tuinhof, A. and Buyanhisnig, N. 2010. *Groundwater Assessment of the Southern Gobi Region*. Mongolia Discussion Papers, East Asia and Pacific Sustainable Development Department. Washington, D.C.: World Bank.

This leadership position will require Oyu Tolgoi to work closely with the Government of Mongolia, other water users (both private and public), NGOs and donors to:

- Improve the knowledge base and understanding of the area's groundwater resources;
- Develop a water use, treatment and efficiency model that maximises water use efficiency in the region;
- Work with other industrial water users to coordinate activities to improve resource efficiency to support the economic development of the South Gobi region and Mongolia;
- Seek to develop alternative water supplies;
- Educate consumers on efficient water use; and
- Develop a common understanding of available water resources and the priority uses for that water.

The aim is to develop a sustainable model for water use in the South Gobi region of Mongolia. The South Gobi Regional Development Council is likely to be central to this process.

Summary

Oyu Tolgoi fully understands and appreciates the critical importance of water to the on-going development of the South Gobi region. Oyu Tolgoi is committed to playing a leadership role together with other public and private sector partners to develop a model of water use for the region that is as efficient and as sustainable as possible.

5.3 SCOPE OF THE ASSESSMENT

5.3.1 Spatial Scope

The spatial scope of the water impact of the Project covers all surface and groundwater in the overall Project Area of Influence which includes the following:

- The mine operations and infrastructure within the Mine Licence Area, and the aquifers associated with the these;
- The ephemeral watercourse systems passing through and downstream of the Mine Licence Area, which will be subject to diversion and change;
- The infrastructure corridor from Oyu Tolgoi to Gashuun Sukhait, and the ephemeral watercourse and aquifers along this route;
- The Temporary and Permanent Airport and the ephemeral watercourse and aquifers around this; and
- The operational water supply system including the basin-wide aquifer that this will exploit, and the overlying aquifers and ephemeral watercourse.

In addition, the assessment covers the impacts on the shallow aquifer at Khanbogd. This will be impacted by increased water demand caused by the migration of Oyu Tolgoi workers and service workers and their families into the community.

The impact on springs is considered as part of the impact on groundwater (rather than surface water) given that these are directly supported by groundwater.

The impact assessment considers the broader impacts on the groundwater resources in this region of the South Gobi, implications for future users, and potential cumulative impacts caused by demands from other projects.

5.3.2 Technical Scope

The technical scope covers the construction and operational activities as they impact on water resources. This includes the following:

- The requirement to divert and culvert ephemeral watercourses and the impacts on base flow in the associated alluvial aquifers;

- Abstraction from the shallow aquifers within the Mine Licence Area for construction-phase supplies;
- Groundwater drawdown around the open pit and block cave during operations;
- Abstraction from the deep Gunii Hooloi Cretaceous aquifer during operations;
- Local short-term abstraction associated with construction-related activities in the Gunii Hooloi area and along the Oyu Tolgoi to Gashuun Sukhait infrastructure corridor;
- Risks to surface and groundwater posed by contamination from the Project, such as the waste management facilities (construction and operations), waste rock dump and tailings storage facility;
- Risks to surface and groundwater from the construction and operation of the Temporary Airport and Permanent Airport; and
- Abstraction from the Cretaceous aquifer adjacent to Khanbogd for Khanbogd's potable water supply.

Impacts during closure will relate to legacy issues associated with the long-term groundwater drawdown around the open pit and the block cave subsidence zone, the local influences on surface flows, and the drawdown in the Gunii Hooloi Cretaceous aquifer at the end of the Project's water abstraction period.

5.3.3 Temporal Scope

The scope covers the Project cycle from construction through operations to closure. The spatial scope varies slightly over these phases, for example the water supply for the workers in Khanbogd becoming more important in the operational phase of the Project when workers settle with their families in the community rather than being in single accommodation in the camp. In addition, any impacts on herder wells in the Gunii Hooloi basin, if these occur, may take decades to be expressed and potentially not occur until after closure.

5.4 IMPACT ASSESSMENT

5.4.1 Summary of Impacts

The potential impacts on the surface and groundwater arising from the construction, operation and closure of the Project can be summarised as follows:

- Impacts resulting from diversion of ephemeral watercourses in the Mine Licence Area, including the Undai and the loss of the Bor Ovoo spring;
- Impacts associated with open pit and block caving mining activities on local surface and dewatering of the aquifers in and immediately around the Mine Licence Area;
- Potential contamination resulting from construction of mine infrastructure including tailing storage facilities (TSF) and waste rock dump (WRD);
- Demands placed on local water resources as a result of the construction of the Project Infrastructure including linear features such as the Oyu Tolgoi to Gashuun Sukhait road and power line (including borrow pits); and
- Impacts of the dewatering of the Cretaceous Aquifer in the Gunii Hooloi Basin, including potential subsidence impacts of the area overlying the Gunii Hooloi aquifer.

Potential impacts during closure will relate to legacy issues associated with the open pit, block cave subsidence area, TSF, WRD and potential settlement associated with the drawdown in the deep aquifer used to supply the Project's operational water requirements. Whilst the scope here assesses the closure at the end of the Project for which a preliminary closure plan has been prepared³, the potential for early or forced closure is also considered by Oyu Tolgoi annually and the forced closure requirements are

³ Oyu Tolgoi (2010), Preliminary Mine Closure Plan for Mongolian Feasibility Study. AMEC, 2010.

presented in the annual closure liability assessment report for the Project. This is discussed in further detail in *Chapter D21: Mine Closure and Rehabilitation Framework*.

The potential impacts to the water resources in the area are summarised in *Table 5.7* at the end of this document. The remainder of this Chapter describes potential impacts on the local water resources, and the specific design and other mitigation measures which Oyu Tolgoi is implementing or proposing to implement.

Mitigation through Design

As discussed in *Section 5.2* above, Oyu Tolgoi has sought to mitigate the impact of its operations through appropriate and careful design and planning. This has been assisted by detailed groundwater monitoring and modelling which for instance has influenced the design of the Gunii Hooloi borefield. Where impacts are unavoidable, such as the requirement to divert the Undai because of the extension of the pit across the watercourse and necessary removal of the associated alluvial aquifer, mitigation measures have been developed, and are incorporated via detailed design engineering.

5.4.2 Surface Water Diversions and Crossings in Mine Licence Area

Nature of Impact

The most significant ephemeral watercourses associated with the Oyu Tolgoi Project pass through the Mine Licence Area, and include the Undai, its tributaries (e.g. the Budaa) and associated springs including the Bor Ovoo spring. The diversion of these ephemeral watercourses and loss of the Bor Ovoo (which will be covered by the waste rock dump) represent significant Project impacts on surface water features, leading to potentially increased evaporative losses, significant changes in the sedimentation and/or erosion in the downstream sections of the watercourses. Diversion of the watercourse may also result in changes to the recharge regime in the downstream aquifers; any decrease in the recharge to aquifers downstream could impact the sustainability of local springs and herder wells as well as impacting local fauna and groundwater dependant flora.

The impacts on fauna and flora as a consequence of the diversion, and more significantly the development of the pit, WRD and associated haul roads, are covered in *Chapter C6: Biological Resources and Ecosystem Services*, and the social impacts are included in the assessment of the impact of the mine development on the local communities (*Chapters C7 to C12*).

The potential impacts that could arise downstream from the Undai diversion are associated with interruptions or restriction to the groundwater flow in the Undai alluvial sediments during the construction works. This groundwater flow in the Undai sediments is considered to be an essential component of the groundwater flows which sustain the springs downstream of the Mine Licence Area and the herders, fauna and flora which depend on them. The simplest engineering option would be to construct a lined channel to accommodate all of the flow as surface water; however, this would result amongst other impact the evaporation of all if not the majority of the base flow as it was brought to the surface with associated impacts on the downstream aquifers and springs, loss of the Bor Ovoo spring, and also increased velocities of flood events all of which are considered to be unacceptable. Therefore Oyu Tolgoi proposes a more complex and expensive option of the engineered diversion, and subsurface pipeline for subsurface flow and creation of an artificial spring in order to avoid all these possible impacts.

Outside of the Mine Licence Area the impacts on surface water by the Project are considered to be negligible as these will be limited to the construction of culverted crossings and some more permanent unsealed fords. Such culverts and fords have been designed to accommodate the anticipated surface water ephemeral flows and ensure flow events in the watercourses are not interrupted by these crossings. The Temporary and Permanent Airport locations are both in areas with minor ephemeral watercourses and there will be negligible impacts on the surface water regime with any flood event being diverted around the airport or allowed to drain off it. The mitigation measures employed by Oyu Tolgoi to manage these surface water impacts are described below and presented in more detail in the *Chapter D7: Construction Phase Water Resources Management Plan*. These mitigation measures, and the management plan developed to ensure they are implemented, aim to minimise Oyu Tolgoi's impacts on the local water resources and to enable any impact to be quantified so that remedial measure can be implemented as required to address any significant impacts.

Mitigation & Management Measures

Undai Watercourse

The Undai is one of the most significant ephemeral watercourses within the Project Area of Influence, of equal importance are the subsurface flows in the sediments of the Undai and the occasional surface flows which recharge the Undai sediments along the course of the watercourse where they flow. The Southern Oyu Pit excavation will extend into the Undai flood plain and the WRDs are planned to lie across the course of the Undai. Therefore given the size of the Undai and the operational (flooding) risks involved in retaining the current route of the water course around the large open pit, Oyu Tolgoi has determined that the best solution will be to divert the watercourse to the south of the operations into an adjacent watercourse (termed the “Western Channel” or Nuur Tsangi) which flows into the Khuren Tolgoi (or “Red River”) which is one of the Undai’s tributaries, The Western Channel is an minor ephemeral water course which, during significant flood events in the Undai, acts as an overflow for excess flows in the Undai.

This diversion will allow flood water in the Undai to pass safely around the mine operations area and to re-join the course of the Undai approximately 1,800 m south of the Mine Licence Area. The catchment of the Undai up stream of the diversion is approximately 460 km² whereas the Western Channel’s catchment (at its confluence with the Brown Hill River) is 75 km². The catchment of the Brown Hill River is approximately 560 km².

The current flood plain of the Undai, the diversion dam, low flow channel and diversion channel are illustrated in *Figure 5.1*.

The diversion of the Undai River will result in the 6.8 km section of the Undai, between the diversion dam and the junction with the Khuren Tolgoi (a tributary of the Undai), becoming dry. This section includes the location of the Bor Ovoo Spring. The majority (over 90%) of this 6.8 km section will be lost as a consequence of the development of the open pit, the placement of the WRD (which will cover the section with the Bor Ovoo spring) and other infrastructure such as the haul roads. A cut-off wall will be installed to the south of the WRD to prevent seepage from the WRD passing downstream in the Undai sediments, and thereby protecting downstream springs and groundwater users. The remaining short dry section of the Undai between this cut-off wall and the confluence of the Khuren Tolgoi and Undai (where the diverted surface water flows re-join the Undai), has been chosen as the location of a Bor Ovoo replacement spring. This artificial spring will be supplied by the diverted subsurface flow in the Undai and has been designed to be accessible to a wide range of fauna species.

Detailed engineering design for the diversion was completed in 2011⁴ and it is expected that construction work will start on the diversion in by 2013, following Mongolian permitting approvals.

The key design components of the diversion developed to address the potential impacts are:

- A 500 m Diversion Embankment and Cut-off Wall; this will be toed into the bedrock and will prevent flood water continuing down the original Undai watercourse and underground flows in the alluvial gravel from flowing eastwards and interacting with the open pit mine and waste rock dump. Toeing the cut-off wall into the bedrock will reduce flow through the upper part of the weathered zone with hydraulic conductivities in the less weathered bed rock expected to be between 0.001 and 1 m/d⁵. The final depth of the cut-off wall will be determined by geophysics and geotechnical drilling to establish an appropriate depth for the cut-off wall;
- A Diversion Channel; which diverts flood events into an adjacent natural tributary channel (the ‘Western Channel’). Low flow events would be focused in a central low flow channel which will join with the Western Channel and ensure minimum flood water is lost from the channel;
- Subsurface Flow Diversion Pipe; which comprises a buried pipe which captures and diverts the continuous subsurface flows in the Undai alluvium, passes it around the Oyu Tolgoi mine, and discharges it directly to the Undai down-gradient of the embankment to the south of the WRD

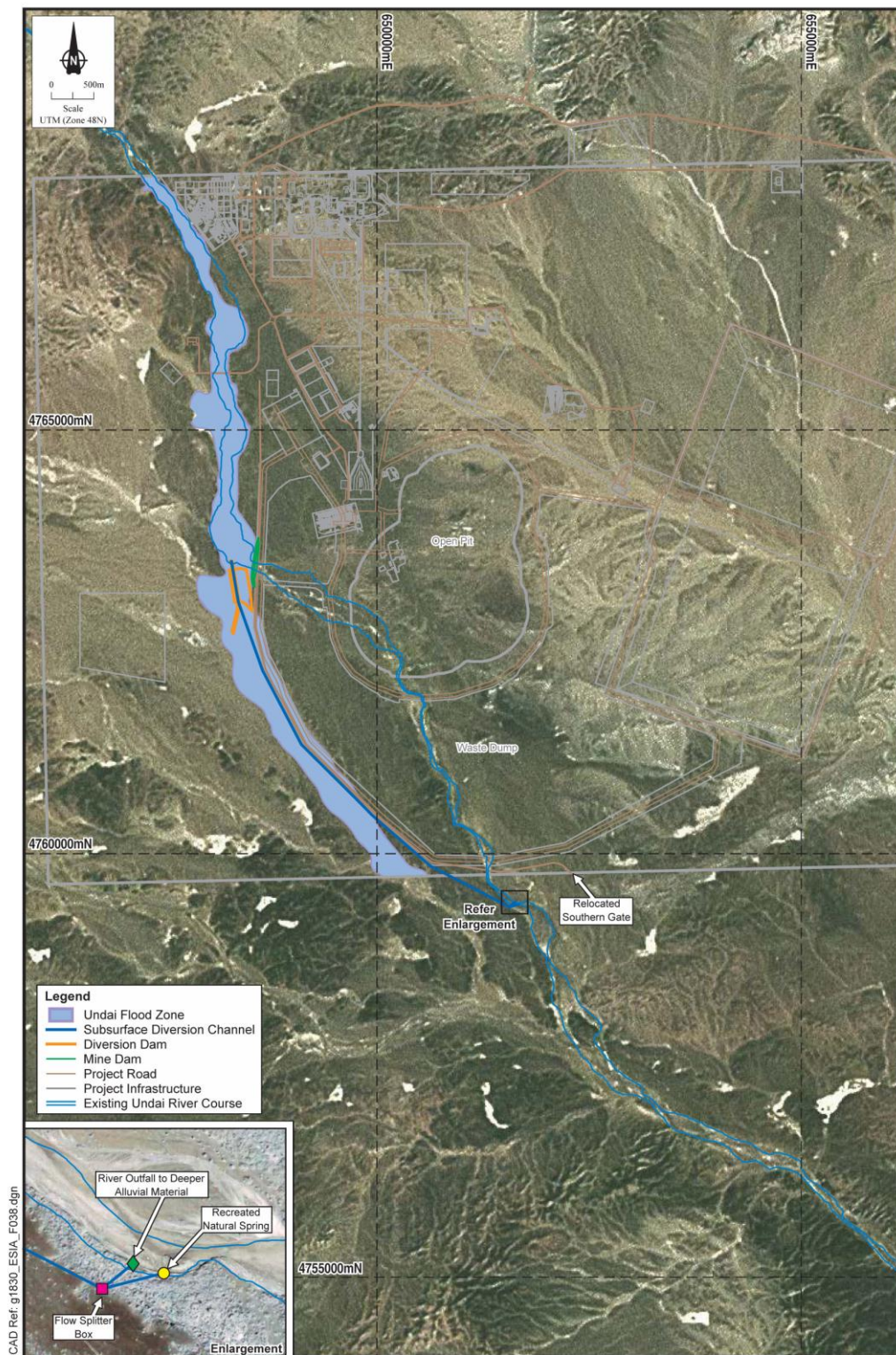
⁴ SMEC, 2011, Oyu Tolgoi Project: River Diversion Detailed Engineering. Detailed Design Report – Final. A2MW-90-K. 5 September 2011

⁵ Aquaterra 2010; Oyu Tolgoi Mine Site Hydrological Assessment, Ref U25D/111c date 9th December 2010

within the southern Mine Licence Area. This diverted water will be used to create a new ephemeral spring and sustain groundwater flow in the Undai sediments down-gradient; and

- A road crossing; which allows the Project continuous access across the Undai except during periods of high intensity floods.

Figure 5.1: Undai Diversion around South Pit



Data Source: Undai River Diversion Basic Engineering, Final Report, SMEC February 2007

The overall objective of the design of the diversion is to minimise and manage the impact of the diversion by ensuring that the diverted flows are returned efficiently to the river bed downstream so as to maintain surface and subsurface water flows within the local ephemeral watercourse network. In particular the design of the subsurface flow ensures that there are no groundwater losses through evaporation caused by the diversion between the inlet and replacement spring.

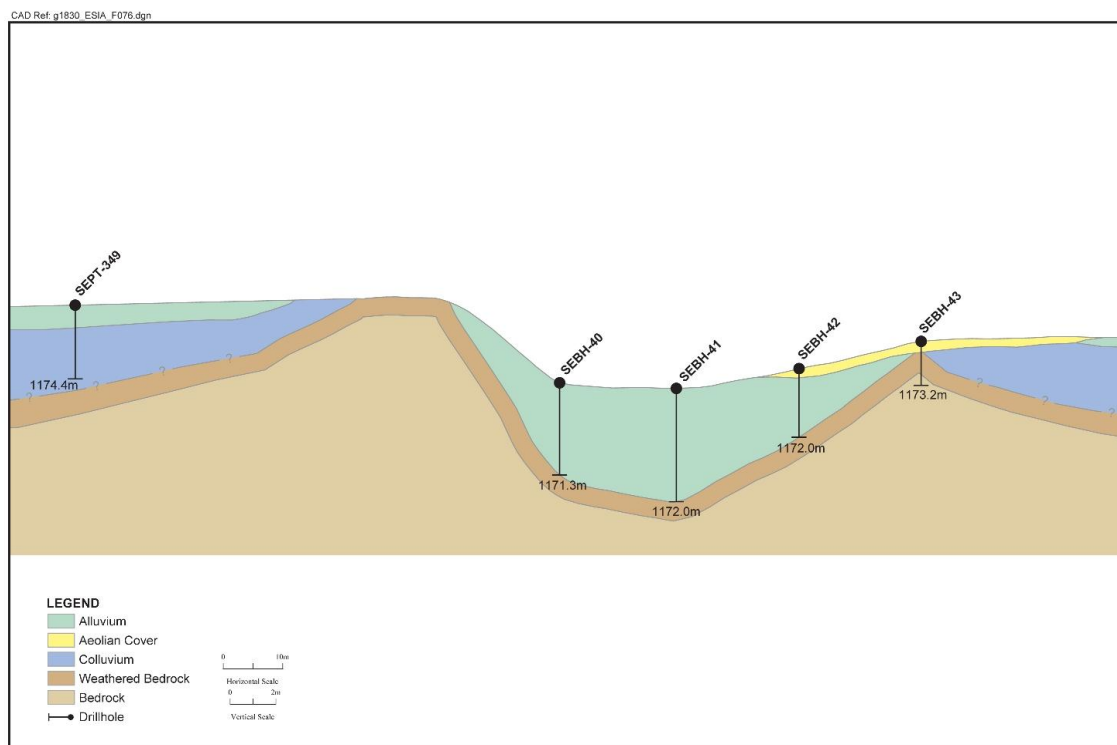
The Diversion Embankment and Cut-Off wall will be located at a natural constriction in the Undai (see *Figure 5.1*), where the flood channel narrows to about 100 m compared with the typical width of the Undai flood channel of 300 m to 400 m. The diversion dam will be founded into the bedrock and raised approximately 2.5 m above the Undai alluvial sediments, and is designed to meet the 1 in 1,000 year flood event. Founding the dam in the bedrock will ensure that groundwater flowing through the Undai sediments which are up to 5.1 m thick (see *Figure 5.2*) is prevented from flowing towards the open pit. The final depth of the dam and detailed design are being finalised as part of the detailed design of the diversion system, and will draw on the results of a planned seismic survey and additional drilling investigation of the area. The Diversion Embankment and Cut-Off Wall will comprise a clay core, a nominal 5 m wide with filter zones on either side, protected by an outer rock fill which forms the embankments to the Cut-Off Wall. The emplacement of the dam will be take place after the completion of the diversion channel and Diversion Pipe, and will be achieved through the construction of walls and dewatering of the excavation (predicted to take up to 90 days. The use of the grout curtain will minimise the impact of the dewatering on the surrounding Undai aquifer and influences on the water passing through the diversion the Diversion Pipe. Water abstracted will be discharged over 1,000 m of the excavation to avoid the potential for it to flow back to the abstraction, as appropriate water may be pumped to the head of the Diversion Pipe to maintain flow.

The diversion channel which will be excavated into the thin cover and bedrock will connect the Undai with the Western Channel to the south comprises:

- A 20 m wide low flow channel extending from the bed of the Undai to the bed of the western channel; the channel is approximately 800 m long and has a grade around 1 in 400; and
- A 200 m wide, 400 m long main channel to cater for heavy flood events located approximately 1 m above the level of the low flow channel; this channel has a grade of 1 in 400.

The diverted floodwaters will flow through the diversion channel and discharge into the Western Channel and flow south-eastwards to the west of the WRD before entering the Khuren Tolgoi and then the Undai. The course of the diverted watercourse is estimated to be 200 to 300 m longer than the original Undai course (circa 3-4% further), which will not result in any measurable increase in evaporative losses from the flood water compared to the original Undai watercourse.

Figure 5.2: Illustrative Cross Section through Undai at the location of the Diversion Dam.



Source: *Undai River Diversion Basic Engineering, Final Report, SMEC February 2007*

Note: The detailed profile of alluvium and weathered rock across the Undai will be gained through a geophysical survey verified with intrusive works as part of the detailed design of the diversion dam

The peripheral road around the WRD will form the eastern bank for a section of the course of this Western Channel floodplain. This peripheral road will comprise an elevated 45 m road built to carry the dump trucks with the concentrate export road running parallel. The western side of the peripheral road will have rock armoured with non-acid forming rock to ensure that there is no erosion of the road in the event of a significant flood (1 in 1,000 year) event in the Western Channel.

The crest of the road will be approximately 30 m from the floodplain and the WRD 18 m to the east of it. When the WRD is closed and slopes reshaped and rehabilitated the toe of the WRD will abut the eastern side of the road. This layout is illustrated in *Figure 5.1*.

The 1 in 1,000 year flood height calculated by SMEC and the Hydrology Section, Mongolian Institute of Meteorology and Hydrology⁶ used hydrological models based on over 40 years of rainfall data. In addition the estimated peak flows were also calibrated against the known flood levels from 2005 and 2006, both of which were reported to be years with exceptional flow conditions (the 2006 flood reportedly made the Undai impassable for three days due to the water flow). The calibration with the 2005 flood data was the most critical as this represented a major flood that was not recorded at the meteorological station at Oyu Tolgoi or at any other station in Omnogovi (illustrating the localised and intense nature of some of the rainfall events). The result of this assessment led to the revision of the model input with regard to roughness and runoff coefficients and the upward revision of the estimated peak flow event with 100 year and 1,000 year return periods.

Hydraulic modelling indicates that within the low-flow channel the flow velocities will be in excess of 1 m/s, and it is anticipated that once the low-flow channel is established it will erode and stabilise at a width comparable to that of the existing Undai channel. The degree of erosion will depend on whether the channel at any one point is founded in weather bedrock or sediments. Similarly the Western Channel will experience erosion and stabilisation as the channel width is expanded through erosion to one more

⁶ SMEC (2007) *Undai River Diversion Basic Engineering, Final Report, February 2007*

similar to the Undai. Within the Western Channel the flow is anticipated to increase from approximately 12 m³/s to 256 m³/s and velocities will increase from the range of 0.5 to 1,2 up to 2,21 m/s in one location.

At present the western channel contains a relatively thin layer of sediments comprising up to 1.1 m of alluvium (sands with trace gravels) and up to 2.4 m of residual Cretaceous sediments (silty clays) over bedrock. This alluvium thins away from the Western Channel with bedrock encountered at shallow depths along the periphery of the channel. Any additional erosion within the Western Channel as a consequence of the diversion of Undai flood flows will be focused on the current alignment of the channel and constrained by the shallower bedrock on the periphery of the channel. Given the surrounding shallow bedrock the river course will not move outside the current natural channel alignment.

The diversion will maintain flows downstream in the Undai and importantly maintain the Undai's contribution to groundwater flow in the alluvial sediments which feeds the Khukh Khad and other springs in the Undai downstream of the Mine Licence Area. There will be no impacts on surface water (i.e. springs or flood events) upstream of the mine. As the sediments in the diversion and Western Channel are significantly thinner than the current course of the Undai watercourse and in parts of the diversion will be absent where there is shallow bedrock present. Infiltration along the diversion will be significantly less than in the Undai and therefore a greater proportion of the floodwaters will be delivered into the Undai below the Mine Licence Area. This is anticipated to have a positive impact on the amount of infiltration, as a result of increased flow and potentially flow duration, that can occur in this lower section of the Undai and the sustainability of the springs and herder wells through the dry season.

The Undai diversion will be a permanent feature and annual flood events in the Undai will result in the geometry of the receiving watercourse evolving to accommodate the increased flows, and developing a natural sedimentation and erosion regime along the diversion. During operations Oyu Tolgoi will monitor the diversion to ensure that it performs to specifications and there are no issues with regard erosion of sedimentation. If issues are identified Oyu Tolgoi will implement remedial measures to address them. At the end of operations any intervention by Oyu Tolgoi would be expected to be negligible with actions having been taken early on to address any non-performance of the surface and subsurface flow diversions. Monitoring of this system will continue following closure but no additional impacts are expected.

Diversion of Minor Channels in the Mine Licence Area

While the Undai is the main ephemeral watercourse within the Mine Licence Area, across the eastern part of the Mine Licence Area there are numerous smaller watercourses which exhibit surface flows during significant rainfall events in their catchments (see *Section B6.4.1*). The water from these watercourses currently drains to the southeast into the Budaa watercourse and ultimately joins the Undai down-gradient of the Mine Licence Area. The construction of the TSF will require the removal of these channels. In order to manage the flood water in these minor watercourses and maintain flows in the Budaa watercourse, Oyu Tolgoi will construct a diversion channel around the northern side of Cell 2 of the TSF which captures the floodwaters from the individual ephemeral watercourses (e.g. the Khaliv).

The surface water flows collected and diverted via the diversion channel around the TSF will re-join the Budaa ephemeral watercourse below the TSF seepage collection system. Storm water run-off collected in the pit, will be used for dust suppression around the mine area. As required depending on the area affected by the block cave subsidence, local ephemeral watercourses will be diverted to minimise the run-off into the area of subsidence. The design of the diversions will be developed during the operational phase as the subsidence zone is defined.

Run-off from the waste rock dumps will be either collected in the mine pit (for northerly run-off) or in perimeter drains, and transferred to settlement ponds for use as process make-up water or ultimately discharged to the pit. A clay cut-off wall installed across the Undai watercourse immediately downstream of the WRD will ensure that there is no potential acid rock drainage southwards into the active part of the Undai into which the diverted waters will flow.

Storm water may be collected from the impermeable areas of the plant including building roofs and areas of hard-standing and will be directed either to the box-cut or other sumps for collection and subsequent use for dust suppression. Rainwater in bunded areas (such as the fuel tank farm) will be checked for contamination before use for dust suppression. No run-off from the site into ephemeral watercourses will be permitted without these storm water flows passing through a retention pond where it will be monitored to ensure that the water is clear of contamination (see *Section C5.4.7*).

Closure

Upon closure the remaining impacts on surface water will be negligible for the majority of the Project footprint with all permanent watercourse diversions continuing after the mine closes. The removal of hazardous materials and demolition of the majority of the site infrastructure will have a positive impact through the removal of the risks of surface water contamination. Leachate from all but the last active cell of the TSF will be minimal by the end of the mine life and the early cells will have been closed, rehabilitated and their seepage profile modelled in detail. The planned management of the placement of NAF cover over the tailings is intended to create a neutral pH tailings material which will minimise the potential to generate acidic leachate which would require long term management to ensure there were no impacts to surface water quality.

The main legacy of the mine following closure will be a permanent water body at the bottom of the open pit. The exact level of the water will be dependent on the rate of infiltration of groundwater and, to a much lesser degree, the periodicity of the storm events which would need to occur immediately around and over the pit to contribute water to the pit. The water in this pit will become saline through evaporation, will not be suitable for animals, and given the absence of acid rocks in the pit, are expected to have an approximately neutral pH. The internally draining area caused by the subsidence over the block caving is not anticipated to contain any surface water except potentially after a significant rainfall event, after which it will evaporate. This internally draining basin may, if seasonal rainfall is sufficiently consistent, provide a new habitat in the area being able to sustain more groundwater dependent plants.

The drawdown around the pit will have reached equilibrium with the surrounding sediments and the areas of influence well defined and understood before closure; therefore any necessary mitigation measures (such as adjustments to the discharge point for the Undai diversion) will have been taken before closure. The majority of the seepage (if any) from the WRD will drain towards the pit, if significant seepage collects to the south of the WRD in the sump behind the cut-off wall; Oyu Tolgoi will consider the use of directional drilling to create a positive drainage path for this seepage back to the pit.

Outside of the main operations (essentially the Mine Licence Area and the water resources immediately downstream of it), the impacts to water resources will be from non-routine operations such as spills during the decommissioning works.

Monitoring

Given the short duration of any flood events, surface water monitoring will be focused on monitoring the quality of the shallow groundwater and more permanent surface water resources across the Project Area of Influence (e.g. in the springs downstream of the Mine Licence Area). This will enable any impacts to water quality if they occur, to be identified and additional mitigation/remedial measures to be developed and implemented. The monitoring regime for the springs is described in *Chapter D7: Water Resources Management Plan* and is considered to be part of the groundwater monitoring as the springs are integrally linked with groundwater levels and quality. In the event that there is an incident that results in the release of hazardous materials to the local environment, this would be dealt with through Oyu Tolgoi's *Emergency Response Plan* (see *Chapter D20*).

The surface water monitoring regime in place through the construction and operational phases will be continued after the mine has closed to evaluate the impacts on water levels and chemical composition. The duration of the monitoring phase post-closure will be defined in the finalised closures management plan which will be agreed with the MNET, but is expected to be at least 5 years. This is considered adequate to have proven the long term post closure impacts of features such as the Undai diversion and seepage from the WRD and TSF.

This monitoring will enable Oyu Tolgoi to assess whether there are any unanticipated impacts to surface water quality arising from the operations (e.g. seepage from the TSF or from the engineered landfill).

Impact Significance

Impacts to surface water will be greatest in the construction phase when there is significant work within the Mine Licence Area associated with the diversion of the ephemeral water courses. The disturbance associated with the ephemeral water courses will be largely completed in the dry season and therefore the impacts are associated with the groundwater flow and springs. Any such impacts should be **short-term** in nature, although the diversion is **permanent**. With appropriate design the long-term impacts through operations and closure should be **negligible**. The loss of the Bor Ovoo spring is **permanent**, and careful design of the replacement spring is critical to deliver an artificial spring that fulfils the same

functionality as the lost spring; overall the impact is considered to be **minor adverse**, which through management of the spring during, operations Oyu Tolgoi aim to reduce to **negligible**.

5.4.3 Surface Water Impacts outside the Mine Licence Area

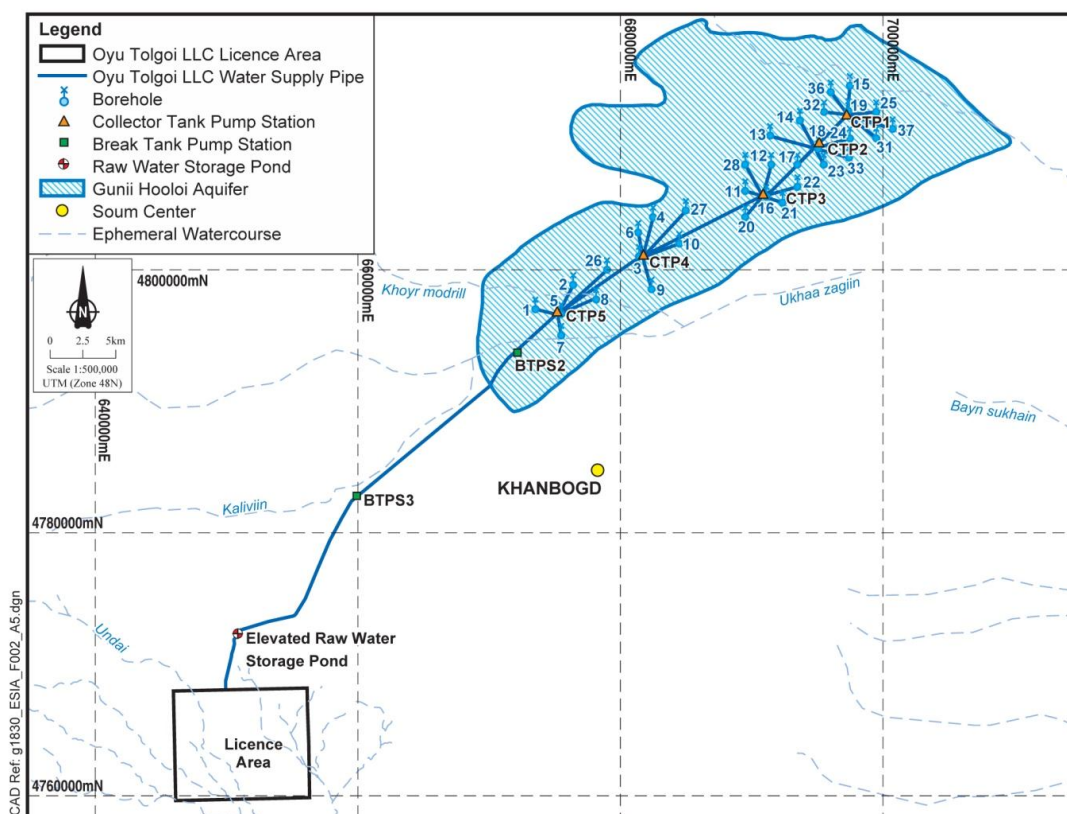
Nature of Impact

The area encompassed by the Gunii Hooloi borehole network is crossed by a number of ephemeral watercourses. The largest ephemeral watercourse passing through the borefield is the Khoyr modrill in the southern part of the borehole field, which is a tributary of the larger easterly flowing Ukhaa zagiin (see *Figure 5.3* and *Baseline Section B6.4.2*). The Ukhaa zagiin, is located to the south of the borehole network, and ultimately flows to the internally-draining Duut Torim basin to the east. The buried pipeline linking the borehole field and the elevated Raw Water Storage Pond needs to cross some of these ephemeral watercourses, including Ukhaa zagiin.

The construction of the pipeline will require the excavation of a trench through the alluvial aquifers in the ephemeral water courses and installation of the pipeline. The disturbance of the alluvial aquifer and installation of the pipeline could potentially disrupt shallow groundwater flow through the creation of a low permeability barrier. Any interruption to the groundwater flow could impact the sustainability of downstream herder wells (e.g. the herder wells Shine us and Ovoo tsav) and the herders ability to reside in the area. The pipeline construction will also disturb some areas of flora including areas of saxaul along the route.

Any construction activities in the area particularly when they occur in or adjacent to the could result in additional turbidity in the local watercourses during a storm event, leading to increased erosion and sedimentation in the adjacent ephemeral watercourses and potential increase the potential for floods to impact local herder wells. Hazardous materials associated the construction activities (such as fuels) have the potential to impact surface watercourses if these are spilt or washed into the watercourse during a storm event. Any such spills could contaminate surface water quality, and more significantly groundwater quality in the downstream alluvial aquifers.

Figure 5.3: Gunii Hooloi Borefield, Pipeline and Relationship to Ephemeral Watercourses



The abstraction of water from the Gunii Hooloi aquifer will result in the reduction of the piezometric head (standing water level) of the Cretaceous aquifer of between 40 and 75 m in the centre of the borefield. This water currently maintains a pore pressure in the aquifer which may support the structure of the aquifer and the overlying sediments. As water is removed, the reduced pore pressure may result in settlement of the sediments and compression of silt and clay layers. Any such subsidence would be permanent and irreversible as any future recharge of the aquifer would not result in the reversal of the settlement and compression of the sediments. The subsidence, if it were to occur, would be across the area underlain by the aquifer. The current estimate based on Plaxis modelling is that this could amount to a 0.7 m subsidence (approximately 0.01 m/yr over a 40 year period). This modelling indicates that this could be reflected in a maximum 0.03% variation in the surface gradient in the central part of the basin⁷ (see *Chapter C4: Topography, Geology and Soils Impact Assessment* for a discussion of the potential implications of this on topography)

Mitigation and Management Measures

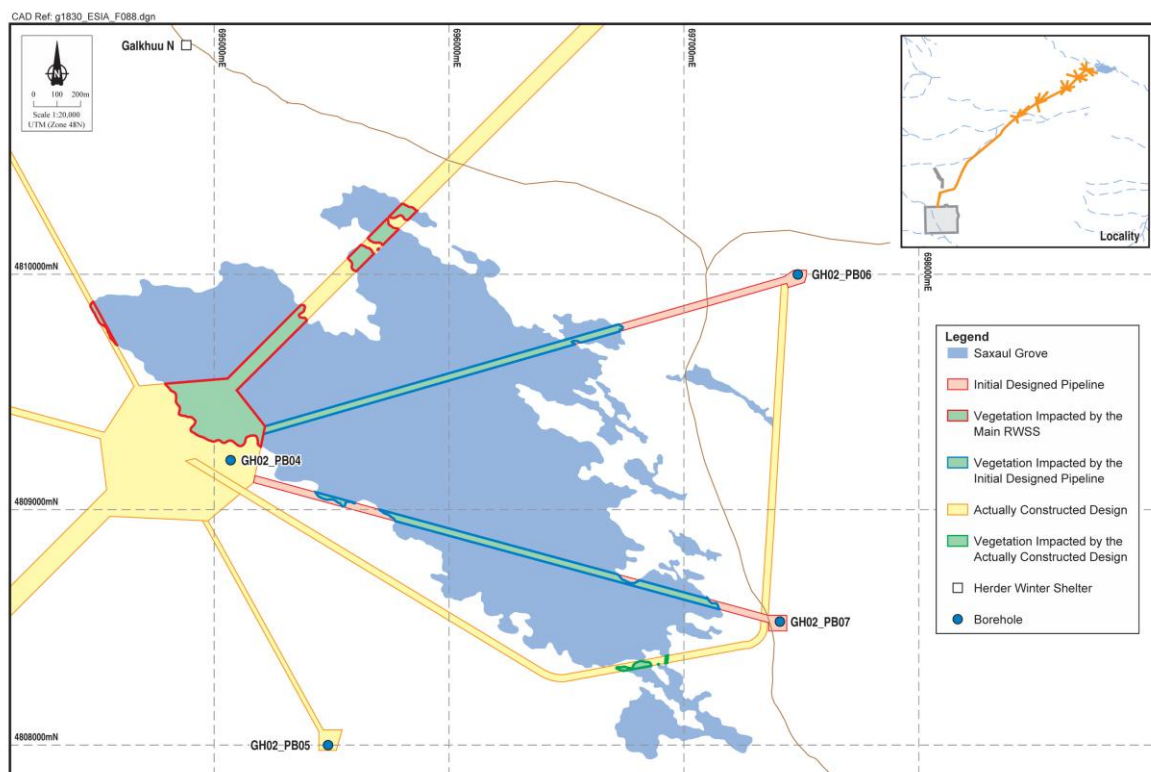
Pipeline Construction and Infrastructure

To minimise the potential for impacts to surface water flows and also groundwater flow in the shallow alluvium, the Gunii Hooloi pipeline will be buried whenever feasible beneath the surficial aquifer in the watercourses and, once installed, the sediments reinstated. Sediments replaced over (or around) the pipeline will be of the same or greater permeability to those of the original watercourse. In addition low permeability barrier will be installed within the pipeline trench, either side of the ephemeral watercourse to prevent subsurface flows entering into the backfilled trench and draining the ephemeral aquifer. No materials with the potential to impact surface water will be stored near these watercourses to minimise the potential for contamination of the ephemeral aquifer and any surface flood events. Overall the main components of the Gunii Hooloi borefield are located on an elevated area between the main easterly draining ephemeral watercourses in the Gunii Hooloi valley and therefore the surface features of the system (e.g. pump houses) will not interfere with or be affected by any flood events in the area.

Although not a direct impact on surface watercourses, there is an area of the borehole field in which there is an area of saxaul. The borehole main pipeline and infrastructure was planned to pass through this area. In order to reduce the impact of the borehole delivery pipeline construction on the local flora and also any surficial pooling of water in a storm event Oyu Tolgoi is making an application to link two of the delivery pipelines and route the combined flow around the majority of the saxaul area. This will result in less disturbance to the saxaul and soils in the area as illustrated in the following Figure.

⁷ Maison Whorley Parsons (2010) Assessment of Subsidence on Pipeline for Raw Water Supply System, Document No. A2MW-6100-00-EV043, Rev. B, 16 October. 2010

Figure 5.4: Saxaul Disturbance in the Borefield



Settlement over the Gunii Hooloi Aquifer

If there is compression of the aquifer as pore pressures are gradually reduced, given that the sediments are soft, the potential for the creation of any surface cracks or crevasses is considered negligible. In the case where cracks develop beneath surface water features, the presence of clayey sediment means these will 'self-seal' as they form⁸. Therefore the impact of this cracking, if it were to occur, on surface water (or groundwater) flow is considered to be negligible.

Given the anticipated slow and gentle nature of any subsidence that occurs, it is considered unlikely that the subsidence will result in any noticeable impact on surface water flow in the vicinity of the extraction zone. Equally the erosion rates in the ephemeral watercourse are unlikely to increase due to any subsidence, beyond the range of natural variability of the erosion in the watercourse during a flood event.

Although impacts on surface watercourse are considered to be negligible, Oyu Tolgoi is undertaking long term monitoring of the topography in Gunii Hooloi through the establishment of a series of height datum points at the groundwater monitoring bores throughout Gunii Hooloi. The elevation of the datum points will be monitored on an annual basis, to determine whether there are any changes in surface elevation due to the long term water extraction. In conjunction with the topographic monitoring the following will be undertaken:

- Monitoring baseline environmental conditions on an annual basis during periods of stream flow where they pass through the Project Area of Influence; and
- Identifying and monitoring any valuable land located near major drainage features, or any feature in other areas where groundwater is shallow and could be influenced by changes in topography.

The planned monitoring will help early identification of potential risks and unexpected response (if any) to any settlement so that remedial plans where required can be developed in a responsible and timely manner. If there is any impact on ephemeral watercourse gradients which have a significant impact on the downstream water flow and users then a potential remedial measure would be for Oyu Tolgoi to

⁸ MaisonWorleyParsons 2010; Assessment of subsidence on pipeline for raw water supply system, Ref: A"MW-6100-00-EV043, Rev_B, 16th October 2010

implement an appropriate engineering solution, drawing on experience and lessons learnt from the Undai diversion.

Construction Activities

Construction activities, wherever they occur across the Project Area of Influence, if they are within an ephemeral watercourse at a time of surface water flow, may result in increased sediment load. Given that when these short-duration flood events occur they are typically naturally high in suspended sediments, any construction-related impacts on sediment levels are likely to be negligible over and above naturally-occurring sediment levels. The Oyu Tolgoi to Gashuun Sukhait road design includes a series of culverts which will permit flood waters to pass through and avoid any significant increase or decrease in erosion downstream of the culvert. The design of these culverts includes consideration of the potential for migration of the watercourse overtime. There will be culverts installed at 129 locations along the route, the majority (103) of which will be single or occasionally twin 1 m diameter circular culverts, and 18 will comprise single or occasionally twin 1.5 m diameters circular culverts. There will be 8 locations where larger (2.0 or 2.5 m square culverts) are installed either as single units or on the largest crossing as three 2.5 m square culverts.

All these large culverts are located on the road section which extends through the small hills of the SGSPA to the Chinese border. By using these large culverts Oyu Tolgoi will be able to replace the current fords across the ephemeral watercourses with “bridges”, reducing the potential for accidents when they are in flood, and allowing the free flow of water and, in the dry season, animals, along the watercourse. The size of the culvert required was based on calculations of flood flows taking account of the catchment above the crossing point, and the character of the watercourse.

One of the most significant earthworks associated with the construction phase outside of the Mine Licence Area is the Elevated Raw Water Storage Pond for the water supply system (see *Figure 5.3*). This is an area with no springs and, given its elevated situation, only very minor ephemeral watercourses, as a result impacts on surface water will be negligible.

Oyu Tolgoi will require the use of materials and chemicals (e.g. reagents, hydrocarbon fuels and lubricants) which have the potential, in the event of a spill, to impact the surface water resources in the area. The main potential for such impact is at construction camps and operations off-site and from accidents on supply routes to the Project. The risks of an impact are greatest during a rainfall event and when the ephemeral watercourses are in spate (see *Section C5.4.7*). The potential for any significant impacts to arise from these hazardous materials is considered to be unlikely and will be managed through Oyu Tolgoi's Hazardous Materials Management Plan (see *Chapter D12: Hazardous Materials Management Plan*). Any hazardous materials will be stored in appropriately bunded and covered areas and at locations away from the immediate vicinity of watercourses. The design of this storage will consider international good practise and applicable EU directives.

Closure

Upon closure the remaining impacts on surface water will be negligible for the majority of the Project Area of Influence outside of the Mine Licence Area, with all permanent watercourse crossings continuing after the mine closes. The removal of hazardous materials and demolition of the majority of the off-site infrastructure will have a positive impact through the removal of the risks of surface water contamination. The potential impacts to water resources during the decommissioning works will be from non-routine operations such as spills.

Monitoring

Given the short duration of any flood events, surface water monitoring will be focused on monitoring the quality of the more permanent surface water resources across the Project Area of Influence (e.g. in the springs downstream of the Mine Licence Area). This will enable any impacts to water quality if they occur, to be identified and addressed, the monitoring regime for the springs is described in *Chapter D7: Water Resources Management Plan* and is considered to be part of the groundwater monitoring as the springs are integrally linked with groundwater levels and quality. In the event that there is an incident that results in the release of hazardous materials to the local environment, this would be dealt with through Oyu Tolgoi's *Emergency Response Plan* (see *Chapter D20*).

The surface water monitoring regime in place through the construction and operational phases will be continued after operations have closed to evaluate the impacts on water levels and chemical composition. At the time of closure Oyu Tolgoi will have been monitoring surface and groundwater for many years and

the behaviour of these and the influence of the pit and block caving in the Mine Licence Area will be well understood, and enable clear long term post closure monitoring plans to be established. The duration of the monitoring phase post-closure will be defined in the finalised closures management plan which will be agreed with the MNET, but is expected to be at least 5 years, (note impacts on groundwater in the Gunii Hooloi aquifer, which are considered below in *Section 5.4.5*, are likely to take a significantly longer time to manifest themselves and this requires a longer term approach).

Impact Significance

Impacts to surface water will be greatest in the construction phase when there is significant work around the ephemeral water courses. The disturbance associated with the ephemeral water courses will be completed in the dry season and therefore the impacts are associated with the groundwater flow and springs rather than surface flows. Any such impacts should be **short-term** in nature. With appropriate design the long-term impacts through operations and closure should be **negligible**.

5.4.4 Groundwater Abstraction and Dewatering in Mine Licence Area and Galbyn Gobi

Nature of Impact

During the construction and operation of the mine and associated infrastructure, there will be a number of direct and indirect impacts on the groundwater resources in the Mine Licence Area and in the Project Infrastructure corridor between the Mine Licence Area and the Mongolia/China border. These include water abstraction to support construction, operations and camp requirements, as well as other potential impacts such as contamination of the aquifers from the use of hazardous materials. In addition relatively minor volumes of water will be required for the construction of the road.

The diversion of the Undai will interrupt the groundwater flow through the alluvium associated with the watercourse which is considered critical for the sustainability of the springs and herder wells downstream of the Mine Licence Area. Any such interruption would be very short term and mitigated by the creation of the subsurface diversion pipe.

At closure the principle impact will be the influence of the cone of depression associated with the open pit and ultimately the block caving (when fractures reach the surface).

Mitigation Measures

Maintaining Subsurface Flows along Undai

Due to the requirement to divert the Undai within the Mine Licence Area, the subsurface flows in the Undai alluvium which contribute to sustaining the springs downstream of the Mine Licence Area have the potential to be impacted. To mitigate this and to ensure the continuity of flow, these flows will be diverted via an underground pipeline, with the following principal features:

- 200 mm internal diameter HDPE pipe designed to accommodate the full subsurface flow (estimated⁹ based on grain size and analysis and the gradient to be 2.3 m³/hr) with a significant additional contingency capacity;
- 6 km length extending from the Undai beneath the diversion channel, skirting the western edge of the waste rock dump (see *Figure 5.1*) and re-entering the Undai immediately south of the cut off wall installed downstream of the WRD on the southern margin of the Mine Licence Area to create a semi-permanent surface water feature similar to the existing Bor Ovoo spring;
- inlet and outlet structures located within the Undai alluvium; and
- 16 inspection pits along the pipeline length.

The diameter of the pipe was chosen in recognition of the fact that although the calculated flow could be accommodated in a 100 mm diameter pipe, given the length of the route, even allowing for laser guided pipe laying, undulations in the pipe are likely to occur. Such undulations could result in local siltation if fine sediments managed to enter the pipeline; therefore the larger diameter was chosen as this has the

⁹ Knight Piésold Pty Limited, 2005; Oyu Tolgoi Project, Feasibility Study, Undai River Diversion, May 2005, Ref: PE601-0001/18, Revision 1.

ability to tolerate sediment build-up without affecting performance. To minimise the potential for sediment to enter the pipeline the inlet design includes the following features:

- a perforated section of pipe extending across the width of the river at both the upstream and downstream ends of the pipeline. The pipeline incorporates a self-flushing system, and the perforations comprise a series of 50 mm diameter inlets instead of slots to provide adequate hydraulic capacity;
- a gravel zone with a cobble core (nominal 150 mm) surrounding the perforated section of pipe; the zone would have a permeability substantially greater than the 10^{-4} m/s of the alluvium generally;
- the gravel will be encased in a filter surround to guard against inflow of sediment into the pipe system. The filter will comprise clean sandy gravel/gravelly sand obtained from the river alluvial deposits and which will be more permeable than the Undai alluvium generally (which can have of the order of 10% fines). This filter will be a nominal 0.5 m wide;
- at the base of the river, a local excavation 1 m deep is included to increase the effective area of the inlet and outlet; and a 1 m thick cover of rock protection beneath the river bed to guard against local scour and damage; and
- the end of the pipe will be fitted with a splitter box which allowed water to flow to an artificial spring in the summer and during the winter, when the ground is frozen, discharge the flow to the alluvial aquifer in the Undai. .

Management and Monitoring of Dewatering in Mine Licence Area

A shallow groundwater system is present within the surface materials and weathered bedrock across the Mine Licence Area. The degree of connectivity between the surface materials, including the Undai gravel aquifer (which forms a ribbon aquifer along the watercourse), sands and clays, and the underlying weathered and fractured bedrock is variable and generally limited by the low permeabilities of the weathered bedrock. To date there has been localised dewatering of the weathered bedrock.

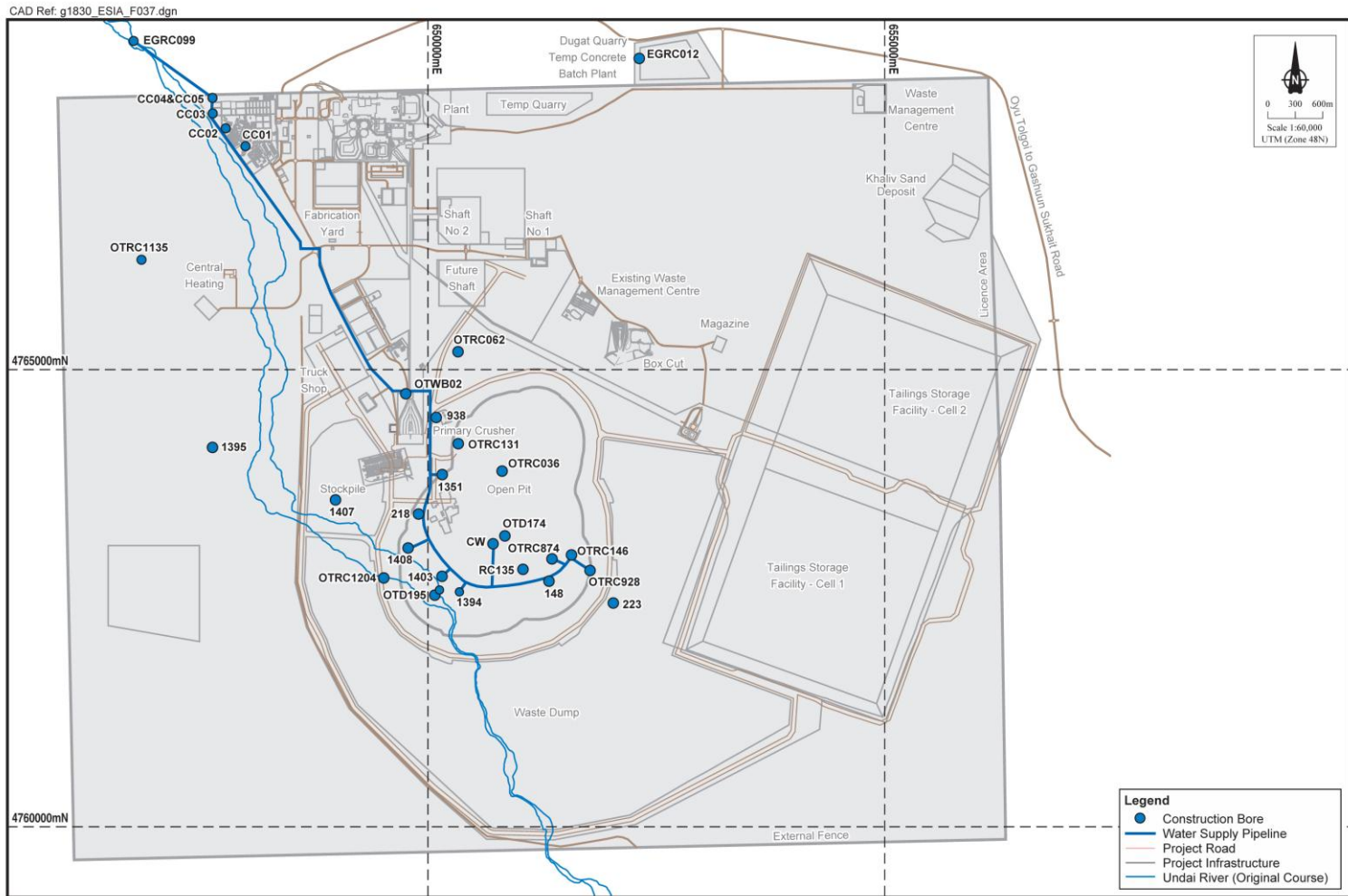
Modelled Groundwater Area of Influence

As the Project moves into operations, the creation of the open pit will result in more extensive dewatering of the quaternary and recent sediments and the underlying weathered and fractured bedrock in the area of the pit, some of which form surficial aquifers. Initial studies were undertaken in 2004-6¹⁰ to assess the potential impact of the pit and underground mine on the groundwater, using the limited hydrological data available, to provide Oyu Tolgoi with an assessment of the potential worst case water inflows to the pit and assess the area of influence. The modelling used a number of scenarios, which took account of the possibility of subsidence around the underground block caving which could cause the surficial groundwater to flow into the block caving. These models, which used conservative assumptions (e.g. no internal flow barriers and just four modelled units – alluvial, soil, weathered bedrock and bedrock¹¹), predicted an ellipsoid cone of depression which was approximately 10 km by 8 km for the 1 m drawdown contour. The 1 m contour was, given the conservative nature of the model, taken as equivalent to the maximum areal extent of any potential drawdown as it was considered to overestimate the extent of any zone of influence of the pit dewatering. This initial information along with other factors, such as anticipated dust emissions, was used to define the 10 km zone designated for herder relocation (see *Chapter C10: Land Use and Displacement*).

¹⁰ Ecotrade (2006), Detailed Environmental Impact Assessment Report for the Oyu Tolgoi Project, Mining and Processing, May 2006.

¹¹ Horizontal hydraulic conductivities used were 1, 0.08, 0.005, and 0.0005 m/d respectively and vertical were an order of magnitude less.

Figure 5.5: Oyu Tolgoi Construction Phase Water Supply Wells adjacent to Proposed South Pit



Note: Construction water supply locations superimposed on the anticipated pit and waste rock dump layout

Since this initial modelling there have been a significant number of additional boreholes drilled, including those used for the construction water supply, which has provided a better appreciation of the layering of the sediments and their relative hydraulic conductivities. Oyu Tolgoi has commissioned a revision of the groundwater model for the mining licence which will include undertaking hydraulic testing on the various formations and other geotechnical testing. This work is underway and a new model will be developed in 2012. As an interim step the original simplistic model has been revisited and re-run using more realistic (lower) hydraulic conductivities based on recent hydraulic testing data gathered from the Mine Licence Area.

This re-run of the model predicted a smaller cone of depression, with the 1 m drawdown contour being approximately 5 km from the mine at the end of the open pit mining¹² extending beneath the WRD and a section of the Undai and its diversion, and the majority of the TSF. The 1 m drawdown contour in the interim model is also used as an approximation to the maximum extent of any drawdown as the hydrogeological data used in this model is insufficient to refine the outer edge of the groundwater area with greater confidence. Within this area there are no other groundwater users such as herders or springs (other than the Bor Ovoo) or any groundwater dependant flora (see *Chapter B7A: Biodiversity Baseline*); this reflects the fact that herder wells were relocated from within the area covered by the initial model when a larger area of influence was modelled.

It is anticipated that when further layers are put in the model in 2012, together with more representative hydraulic conductivities and definitions of their geometries, the modelled cone of depression will be smaller in extent and irregular in shape and therefore will better reflect the local geology and structures in the Mine Licence Area. This will provide Oyu Tolgoi with a model with a higher degree of confidence on which to evaluate the potential impacts of the drawdown on the different aquifers, including the wider spread weathered and fractured bedrock aquifer, and the linear aquifers associated with the ephemeral watercourses.

Importantly the revised groundwater model in 2012 will enable Oyu Tolgoi to review critically the area of influence of the cone of depression and verify that impacts will not extend to any of the herders around the Mine Licence Area or Undai diversion; Oyu Tolgoi will present this data to the herding community through the various forums such as the participatory environmental monitoring programme (discussed later in this Chapter).

Monitoring of Impacts on Undai

The current monitoring network does not enable a robust assessment of the influence of the drawdown from the construction water supply wells abstracting from the weathered bedrock adjacent to the Undai and the water levels in the shallow linear aquifer associated with the Undai. However, there are measured groundwater drawdowns in the weathered bedrock which is inferred to extend beneath a section of the Undai, and this has coincided with low water levels in the Bor Ovoo spring. Although no direct impact has been proven, Oyu Tolgoi has taken the precautionary approach and assumed the impact may be due to the dewatering and is supplementing the spring (by providing water troughs) to maintain water availability until the replacement spring is constructed. Further works are scheduled for later 2011/2012 to assess in greater detail the degree of connectivity between the alluvial sediments and the weathered bedrock. This data will be used in the development of the new mine model, which will enable the assessment of conductivity between lithological units in greater detail and in particular appraise the potential for induced leakage from these alluvial sediments. This monitoring combined with the piezometric data will enable Oyu Tolgoi to assess the effectiveness of the Undai cut-off wall and whether there is any significant leakage from the Undai occurring upstream of the diversion.

In the event that there is significant induced leakage from the alluvial sediments of the Undai indicated by the model and verified by the monitoring network, which could have an impact on the inflows to the diversion pipe, downstream springs and/or groundwater users, Oyu Tolgoi would implement changes to the diversion pipeline intake. Indications of an impact would be manifest by evidence of the cone of depression initially encroaching on the Undai gravels upstream of the diversion pipeline, and there being a subsequent reduction in water levels and a measurable reduction in flow through the diversion pipeline, which is not seasonally driven. If there was evidence of an impact, Oyu Tolgoi would verify the observations and evaluate the degree of impact through a more sophisticated model of the Undai and

¹² *Pers comm.* Aquaterra November 2010

interactions with the pit to establish the appropriate engineering solution. Oyu Tolgoi recognises that if an impact is detected, as the cone of depression develops, the degree of impact is likely to increase as the head difference between the underlying fractured bedrock and the alluvium increases, and therefore the development of the solution would need to take this into account.

The Bor Ovoo spring will be lost due to the diversion of the Undai and the construction of the WRD across 2.5 km of the original Undai watercourse. To mitigate the loss of this spring a replacement spring will be located in the original Undai watercourse to the south of the cut-off embankment below the WRD. The objective of the cut-off embankment is to ensure that there will be minimal seepage from this new spring back towards the open pit and also minimise the potential for leachate from the WRD to impact the spring or associated groundwater in this section of the Undai. The existing Bor Ovoo spring occupies an area of approximately 40 m², although only a small percentage of this contains surface water for drinking (much of the 40 m² is space around the spring which animals use whilst drinking). To replicate this three artificial “drinker” units would be installed, each of which 13 m² and would give approximately the same area as the existing Bor Ovoo Spring. As well as open water, these drinkers would have rocks placed in them to allow smaller animals to access the water without the risk of drowning¹³.

The detailed engineering design for the replacement Bor Ovoo spring is part of the detailed engineering design for the Undai River diversion and associated works which are currently scheduled to be implemented by Q3 2012. The key design criteria with respect to the replacement spring, is for it to be provided with a natural occurring flow of water from the diversion pipeline and for it to be accessible to wild animals and livestock. The goal is for the replacement Bor Ovoo Spring, and all springs and wells downstream of it to have at least the same level of reliability as currently exists. The location of the replacement spring has been chosen in consultation with the Rapid Biodiversity Assessment team and herders and is located adjacent to a bend in the Undai which has a similar topography to the existing location and is a suitable distance downstream of the WRD and cut-off wall that disturbance will be minimised. The design will include a 1:4 ramp, no steps, and be sand backfill to 50mm50 mm below lip of trough to provide easy access and a firm footing for animals using this artificial spring.

Once installed the flux through the groundwater diversion pipe will also be monitored to ensure that the system is functioning correctly and if required remedial engineering works can be undertaken to maintain the water transfer efficiency of the diversion system. Oyu Tolgoi will in essence be actively managing the groundwater through-flow in the Undai diversion, and given the longevity of the underground mine, any impacts from the open pit would be manifest while Oyu Tolgoi was in operations and had the necessary earth moving equipment on site to rectify the situation. In addition, although considered very unlikely, if the cone of depression resulted in significant impacts (i.e. affecting the effectiveness of springs and wells) downstream of the diversion, Oyu Tolgoi would move the outlet further downstream so that groundwater would be effectively transferred to a point down-gradient of the area of influence of the pit. Towards the end of the pit life and certainly before the completion of the block caving, the cone of depression around the open pit will have reached equilibrium. Any drawdown cone around the underground working will gradually decrease once the underground workings are flooded post closure and will ultimately cease to be a draw on local groundwater; the timing of this will be modelled in 2012 and refined based on the modelling data gathered over the life of the mine.

The design of the proposed diversions for the Undai and tributaries of the Budaia will mitigate any impact on the surface and basal flows within the ephemeral watercourses. The effectiveness of the diversions will be monitored through Oyu Tolgoi's current monitoring regime which covers both the springs, herder wells, and the shallow alluvial aquifers. In addition further piezometers and stream flow gauges (to capture maximum flood levels) are planned to be installed in early 2012 to assist with the revision of the groundwater model for the Mine Licence Area; these new data points will allow Oyu Tolgoi to measure the flows coming into and exiting the diversion and provide additional information on the influence of these flood events on the groundwater levels in the Undai sediments. These studies on the ephemeral watercourses will, as well as providing information for the groundwater model, provide detailed river profile information which can be used to assess variations overtime in erosion and sedimentation. In the cases of the Undai diversion this will allow an assessment of the impact on sedimentation downstream of the diversion. The maximum flow velocities at the entrance of the diversion channel calculated to be

¹³ SMEC 2011; Oyu Tolgoi Project: River Diversion Detailed Engineering Report, Ref A2MW-90-K487, 5th September 2011

about 1.2 m/s under the design condition with a maximum flow of 241 m³/s. As some sections of the diversion channel are located on top of rocks as shown in the geophysical survey undertaken by SMEC and the standard annual flow condition velocities are expected to be much less than the design condition, erosion protection works for the diversion channel are not required.

As part of the Environmental Protection Plan, commitments were made by Oyu Tolgoi within the DEIA for mine and processing facilities to ensure that downstream water supplies were not adversely impacted and to minimise impacts on wells or to provide alternative water supplies¹⁴. Oyu Tolgoi is committed to maintaining water quality and quantity in the Undai downstream of the Mine Licence Area and will monitor the performance of the Undai diversion to ensure that water is being effectively diverted and that downstream uses are not adversely impacted. This includes the re-establishment of a surface water source to replace the Bor Ovoo spring in the Undai watercourse south of the WRD; and commitment to replacing this if it does not adequately replicate the existing spring performance, or becomes impacted by the Project.

Springs

The monitoring of the springs during operations, which will be undertaken as part of the monitoring of water resources, will include the monthly photographic record of the springs (allowing a visual assessment of the quantity of water available in the spring) and quarterly water quality sampling (when water is present and/or not frozen) including the field testing of electrical conductivity and pH, and laboratory testing of physio-chemical parameters, major ions and common metals. An impact would be considered to be occurring if there was a significant¹⁵ variation (e.g. decrease) in spring levels which could not be accounted by other influences such as drought or changes to herd drinking regimes at the spring, or a change in pH or concentrations of metals. Where impacts to the sustainability of any water features is occurring Oyu Tolgoi will seek to understand the reasons for the impact and provide an engineered solution to rectify any impacts occurring as a consequence of Oyu Tolgoi's activities.

Any solutions proposed will be discussed and agreed with the local herding community; where the impact on the spring is considered to be naturally occurring (such as decreasing rainfall) Oyu Tolgoi will consider options for enhancing the spring to restore its functionality and duration of supply. The assessment of the behaviour of the springs will be closely linked to the monitoring of the local groundwater levels and levels in herder wells; as well as river gauging stations. This holistic approach to monitoring of water resources will enable a more considered assessment of any changes to spring water levels (positive or negative) and better appreciation of whether the impact on a spring is unique or representative of a greater area of impact or external regional change. This approach will also be important in assessing whether there may be an impact on shallow groundwater away from the springs which may be relied on by wildlife.

Participatory Environmental Monitoring (Water)

The primary objectives of the Participatory Environmental Monitoring (PEM) programme run by the Communities and Social Performance Department (CSP), is to involve the local community in environmental monitoring, and to present the environmental activities of the Oyu Tolgoi Project more clearly for the local community, with the overall objective of increasing the environmental knowledge of the local community. A key component of the PEM programme is the Participatory Water Monitoring (PWM) programme which started in mid 2011 with an initial 9 herders and has subsequently increased to 26. These herders are all measuring water levels of their own wells with equipment supplied by Oyu Tolgoi. These herders are located in the vicinity of Oyu Tolgoi and Gunii Hooloi areas where monitoring by the herders started in 2008. These herders are trained in taking the groundwater level measurements and the results are discussed with them and other stakeholders every three months, and reviewed in the context of the results from Oyu Tolgoi's broader monitoring programme. This allows them to understand Oyu Tolgoi's programme and place greater trust and confidence in the data. The monitoring undertaken by the herders is subject to the same QA/QC as the Oyu Tolgoi monitoring with results (e.g. levels) compared against previous data so that any significant change can be validated and assessed appropriately. The herder data which include measurements of groundwater levels before and after

¹⁴ Oyu Tolgoi Project Volume III: Oyu Tolgoi Mining and Processing Facilities. May 2006. Eco-Trade Ltd.

¹⁵ A significant variation is considered to be when there is a chance of greater than 2 standard deviations in the data.

watering their animals supplements Oyu Tolgoi's data and provide a level of detail which would not be collected in the normal monitoring programme

In addition to the monitoring by the herders, the 8th grade students of Khanbogd *soum* secondary school are engaged in the implementation of joint water monitoring as expansion and practical work of their school subjects such as chemistry, biology and physics, having joined as members of www.worldwatermonitoringday.org, www.worldwatermonitoringday.org (WWMD). To assist this initiative Oyu Tolgoi purchased a number of sets of the study tools through the official website, and students have been undertaking quality studies of domestic water wells and surface water in Khanbogd as their summer assignment. Oyu Tolgoi is assisting with the compilation of the data at the start of the academic year and will send this to the WWMD network on behalf of the students, enabling the students to compare water quality in other countries with that used in our daily life.

The monitoring of the success of the diversion and the new spring that is created will form part of this PEM Programme. This will ensure that monitoring of springs and downstream herder well water levels and quality is undertaken in a transparent manner that builds and maintains trust between the Project and local herders. This monitoring will include the assessment of usage of the spring by herd animals and wildlife. If issues are identified, Oyu Tolgoi will work with local potentially affected herders to develop, implement and monitor a mutually-acceptable solution (such as the provision of an alternative water supply through the drilling of a new water borehole). If the monitoring identifies any significant issues Oyu Tolgoi is fully committed to redesigning and re-engineering aspects of the diversion as necessary.

As a result of the current herder well monitoring regime the natural fluctuations in herder water levels are being established, including the speed and magnitude of a response of water levels to a flood event and the decay curve as the local aquifer dewateres (see *Section B6.5.1*). This data provides key information on the natural behaviour of the herder wells so that influences of the Project, which result in faster decay curves or lowering of base water levels can be indicated. If issues are identified (impacts may be Project related, or caused by drought, climate change, siltation etc.), Oyu Tolgoi will act as a responsible neighbour and work with the herders to address any concerns over water levels or quality, and as appropriate develop a response to providing an alternative supply. This approach will be undertaken alongside other initiative in the PEM Programme, which will look at assessing broader climate change influences and discussing these with the herders. Oyu Tolgoi's aim is to work with the herders to ensure that their water supplies for them and their herd animals are sustained at the levels they are used to.

Closure

The monitoring regime established and refined during the operational phase of the Project will be continued during the decommissioning and closure period. Once the Project has closed the monitoring regime will be adapted as appropriate to monitor the changes in the groundwater regime and ensure that there are no additional significant impacts on groundwater quality or quantity. This will include the regular monitoring of herder and monitoring wells. The period of this will be determined based on the stability of the preceding data but is considered likely to be quarterly. This monitoring will continue to be part of the participatory monitoring programme, the duration of this monitoring will be defined during the later parts of the operational phase in consultation with all stakeholders, and based on the historical monitoring data. Oyu Tolgoi recognises that the impact of the dewatering can take a significant period of time, decades or longer to manifest itself at the shallowest horizons. Oyu Tolgoi is committed to setting up the appropriate monitoring regime and duration during closure and holding a contingency for implementing mitigation measures should they be required.

Dewatering Associated with Construction Outside the Mine Licence Area

The Project will require limited abstraction outside the Mine Licence Area during construction; this will include:

- water for the construction camps in the infrastructure corridor, and the camp for the borefield and pipeline installation;
- make-up water for the polymer based drilling mud; and
- water for the road construction.

The total length of the road alignment is 96.8km8 km, and has been divided into four construction zones (from north to south):

- Zone 4: 19.4 km (northern-most section);

- Zone 2A: 27 km (central section);
- Zone 2B: 27 km (central section); and
- Zone 3: 23.4 km (southern-most section).

Water supply requirements have been calculated for each of the Zones along the alignment, assuming the nominal 25% of total construction water demand for dust suppression. Based on this assumption two potential water supply scenarios:

- Majority of water demand / consumption within the first six months of construction (i.e. May-November 2011); and
- Constant demand throughout the entire 12 month construction period.

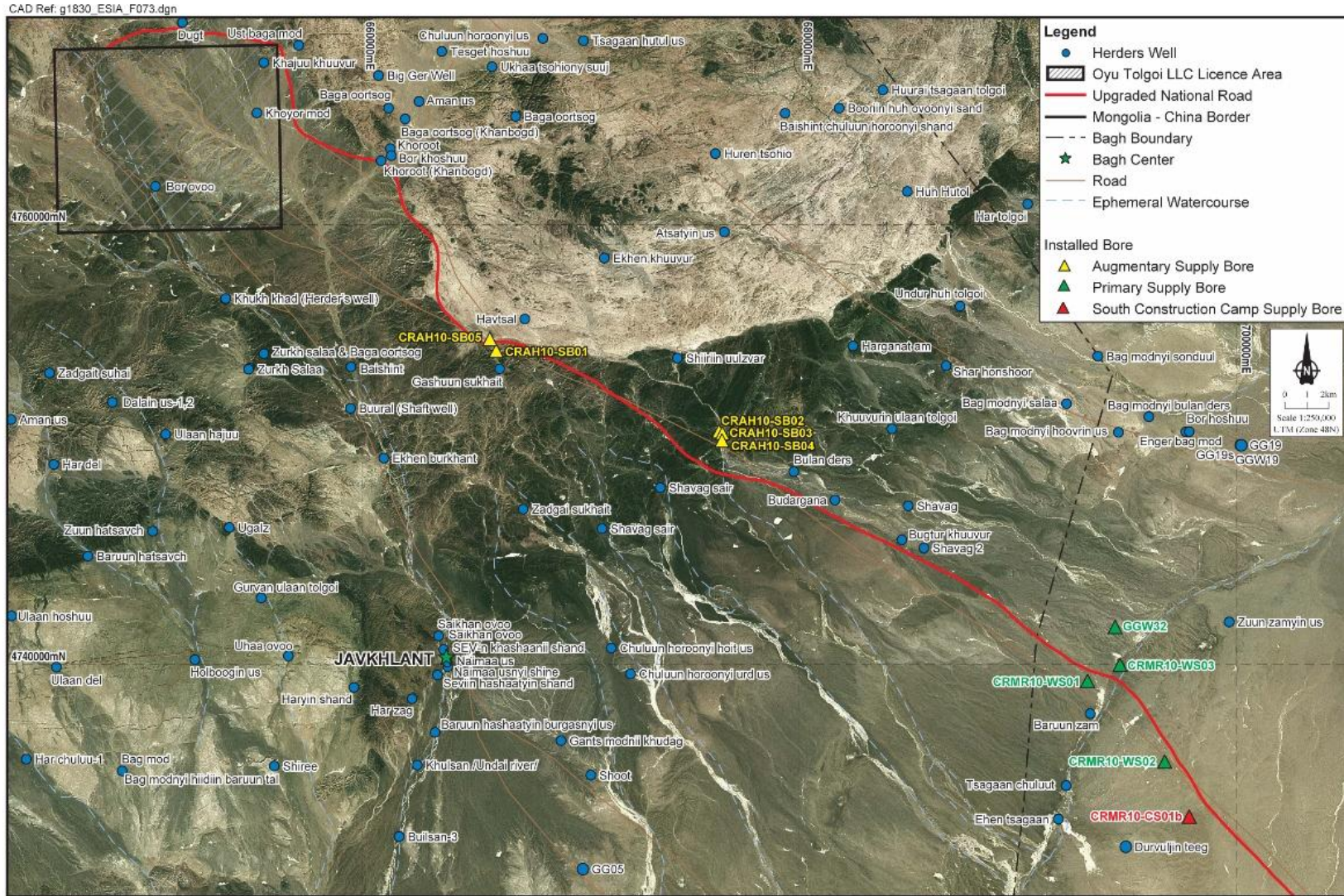
It has been assumed that bore pumping will be continuous (i.e. 24 hours), with discharge pumped into a storage facility (nominal 500 m³ volume), to maintain the requisite immediate operational demand which the construction will require. The estimated demand for both scenarios is presented in *Table 5.1* below:

Table 5.1: Road Construction Supply Requirements

Zone	Total Demand (m ³ ; incl. addition of nominal 25% for dust suppression)	Six Month Supply Requirement (L/s)	12 Month Supply Requirement (L/s)
Zone 4	65,926	4.2	2.1
Zone 2A	66,914	4.2	2.1
Zone 2B	67,120	4.3	2.2
Zone3	57,371	3.6	1.8
Total	257,331	16.3	8.2

The construction water supply will require the installation of a number of temporary water supply wells and also the utilisation of some of the exploration boreholes installed by Oyu Tolgoi in the Galbyn Gobi. The use of these has been permitted by the Water Agency. Seventeen potential water supply boreholes locations were identified along the first 32 km of road south of Oyu Tolgoi, and subsequently drilled and tested. Based on the results and consideration optimum location of the construction camp for the road in the central Galbyn Gobi, Oyu Tolgoi has determined that the water to be used for the construction camp will be taken from Galbyn Gobi exploration well GG32 (circa 9.3 km from the construction camp) and two new exploration wells CRMR10-WS02 and CRMR10-WS03 (see *Figure 5.6*). In addition should they be required for logistical reasons, five supplemental wells have been installed.

Figure 5.6: Oyu Tolgoi to Gashuun Sukhait Water Supply Boreholes



Well yields for these boreholes range from 4.5 to 15 L/s, while the supplemental boreholes (if used) range between 0.6 and 2.5 L/s. The wells in the Galbyn Gobi will exploit water from a depth of 200 to 220 m and are approximately 9 km south of the nearest herder well (Engenbad mod). The supplemental boreholes will abstract from fractured bedrock aquifers at a depth of 90 to 120 m with limited primary permeability. Once construction is completed any additional boreholes will be capped and/or sealed, and form standby water wells and/or be provided to the local herder. There will be no water abstraction from other locations along the road and no abstraction inside the SGSPA. Water for the road construction near to the Mine Licence Area will be taken from the construction water supply (comprising the water from the Gunii Hooloi borefield).

In all cases the volume of water required and these activities will have a negligible impact on local water resources given the volume of the resource present in the Galbyn Gobi; nonetheless Oyu Tolgoi will aim to use the minimum water necessary to construct the road.

Impact Significance

The dewatering in the Mine Licence Area will result in the development of a **permanent** cone of depression in the local aquifers around the open pit. There are no groundwater users in this area or groundwater dependent vegetation and therefore the overall impact is considered to be **minor-adverse**. The diversion of the groundwater flow in the alluvial aquifers associated with the Undai will ensure that impacts on the springs and wells downstream of the Mine Licence Areas are minimised and the potential impacts are considered to be **minor-adverse**. The volume of water required during construction of the road and the Gunii Hooloi supply pipeline are considered to be **negligible** in the context of the volume of water available in these aquifers, and given the distance from the nearest herder wells and the fact that these wells will exploit a deeper aquifer than that used by the herders the impacts on herders are considered to be **negligible**.

5.4.5 Gunii Hooloi Abstraction

Nature of Impact

Outside of the Mine Licence Area and its immediate environs, the most significant impact on the water resources of the Project Area of Influence will be the abstraction of water from the deep Cretaceous age aquifers of the Gunii Hooloi basin. The key impacts which may arise from this abstraction will be:

- Loss of Regional Water Resource; and
- Potential impacts on shallow groundwater and herder wells.

This water will be abstracted through the network of wells to be installed as part of the water supply network which extends some 75 km northeast of the mine.

The baseline studies of the Gunii Hooloi basins and aquifer characteristics (See *Chapter B6: Water Resources*) have demonstrated that the deeper aquifer resource at Gunii Hooloi is generally unsuitable for use as potable water due to its salinity but that the quality in some areas is acceptable for livestock watering. The water has a salinity (Total Dissolved Solids) of 1,600 – 3,100 mg/l. This water resource was discovered by Oyu Tolgoi and given its depth (typically over 30 m to the piezometric head and 60 m or deeper to the aquifer unit reflecting its confined nature) is not currently used by other users¹⁶. There are also no areas where the Cretaceous aquifer discharges to the surface, and therefore there are no surface water features (e.g. springs) or deep rooted groundwater dependent vegetation which rely on this deep groundwater¹⁷.

The actual and potential impacts of the abstraction comprise the resultant groundwater drawdown and its impact on the regional resource capacity and the potential for the drawdown to increase “leakage” from the upper near-surface aquifers and impact water levels in the shallow alluvial aquifer associated with the ephemeral watercourse. The pumping regime (average of 696 L/s– see *Chapter A4: Project Description*)

¹⁶ This self-discovered water resource is for the exclusive commercial use of Oyu Tolgoi as described in the Investment Agreement (2009) Clause 6.13.1; but Oyu Tolgoi will make these water resources available for household purposes, herder families and agricultural activities of the local *soum* communities (Clause 6.13.3).

¹⁷ Aquaterra (2008), Gunii Hooloi Aquifer, Groundwater Investigation and Resource Assessment – 2007 (Revised Water Demand), Section 5.3.4, pg 34, March 2008

will result in the reduction of the piezometric heads in the deep aquifer of up to 40 m over the 27 year life of the mine, throughout which the aquifer will remain confined¹⁸. The greatest drawdowns are in the north-eastern part of the borehole field where the highest hydraulic conductivities are encountered and the greatest pumping is planned. The presence of the edge of the Cretaceous sedimentary basin to the south of the borefield results in edge effects and slightly accentuated drawdown at these boundaries. The modelling planned for 2012 will consider further the boundary conditions used in the original model, and as some of the boundaries will now be modelled with a degree of flow across them based on changes to the basin concept, the revised model is likely to indicate a slight reduction in drawdown across the basin. In all cases the aquifer remains in a confined state which is in compliance with approved permitting conditions.

Khanbogd is located to the south of the main Gunii Hooloi valley, and the shallow aquifers currently exploited for Khanbogd's water supply, have a negligible connection with the main Gunii Hooloi aquifer and will not be influenced by Oyu Tolgoi's Gunii Hooloi abstraction (see also *Section C5.4.8*). In the water perception study commissioned by Oyu Tolgoi it was recognised that a significant number of people in the Project Area of Influence¹⁹ thought that the near-surface aquifers were linked with the deeper aquifers, as well as with ephemeral watercourse sediments. The results of this perception study illustrated the limited understanding of the interaction between the different aquifer systems in the region and also the reliance of the communities on, and importance of, the shallow aquifers. As part of Oyu Tolgoi's community relations programme, the PEM programme and the baseline data (such the differences in their chemistry and standing water levels) will be used to address these perceptions and demonstrate that these are separate hydrogeological units.

Assessment of Potential for Impacts

Impacts from the dewatering of the Gunii Hooloi aquifer on the shallow and near-surface aquifers will occur only if there is sufficient hydraulic connection between the localized shallow and the regional deep aquifer. The impact could occur through enhanced vertical leakage through the overlying low permeability formations. Similarly impacts could occur where there is a connection created by a borehole (either deep, and screened through shallow sediments, or shallow and penetrating the deeper, upper aquifer horizon).

The modelling undertaken by Oyu Tolgoi has taken account of leakage from the upper formations into the main aquifer to assess water supply potential, and will be refined further during 2012 to assess leakage through the whole upper formation to the surface. This will allow the influence of the pumping on the very shallow aquifers in the ephemeral systems used by the herders to be included in the model. Given the thick sequences of relatively low permeability clays at basin margins, the current conceptualisation indicates that there is unlikely to be significant leakage from the shallow alluvial aquifers used by the hand-dug herder wells, and where any such leakage occurs it will induce water level changes which are orders of magnitude less than that caused by the herders use and seasonal recharge of the shallow sediments within the stream beds. The exception to this is the single deeper drilled well at the eastern extent of the system, and given the depth in this well and more limited aquicludes system, there may be an impact²⁰ and this will require close monitoring and management (see *Section C5.4.6* for a more detailed discussion of potential impacts on herder wells).

Given that the effects of any impact on the shallow aquifers used by the herders are likely to be very subtle in the first instance and easily masked by seasonal recharge, Oyu Tolgoi recognise there is the need for a robust groundwater monitoring regime. This monitoring has been on-going for a number of years with, at many locations, water level data records extending back to 2003; this provides Oyu Tolgoi with a substantial historical data set against which to evaluate future fluctuations. It is also recognised that the influence of the water abstraction from the deep aquifer may take a considerable period (10s to 100s of years) before it would manifest at the surface and therefore an on-going post closure monitoring programme is necessary. This will be planned later in the Project life and will be designed to take

¹⁸ A "confined aquifer" is sandwiched between confining beds (layers of impermeable materials such as clay which impede the movement of water into and out of the aquifer).

¹⁹ CPR (2007) Perceptions Study on Water Use

²⁰ Aquaterra (2008), Gunii Hooloi Aquifer, Groundwater Investigation and Resource Assessment – 2007 (Revised Water Demand), Section 5.3.2, pg 33, March 2008

account of the behaviour of the aquifers up to that point. This monitoring will be combined with the PEM to ensure that herders are informed and involved and that all data collection is transparent and open.

The borefield is situated in an area where there are no shallow alluvial aquifers and therefore there is no potential for these to create linkages between the shallow alluvial aquifers used by the herders and the deeper aquifer. However, given the depth of the wells and the extensive screened intervals in some of the exploration wells drilled in 2004; it is recognised by Oyu Tolgoi that there is the potential that hydraulically unconnected aquifers at intermediate depths (20-100 m) could be connected via the well screen. None of these wells are screened across the shallow aquifer (0-10 m) used by the herders.

Oyu Tolgoi has identified one well where there is evidence that there is an impact of the exploration wells on a shallower water level in the overlying Cretaceous sequence; this is in the GH4x6 group of wells (*Figure 5.7* and see discussion below) located to the southwest of the planned borehole field. There is no evidence of any impact on the aquifers used by the herders.

GH4x6 Boreholes

The potential impact on shallower aquifer units in the Cretaceous sequence is illustrated by the situation in the GH4x6 group of boreholes (see *Figure 5.7*). These boreholes were installed in 2004 as part of the Gunii Hooloi investigation in the south-western part of the Gunii Hooloi (see *Figure 5.8*). GH4x6 is located 9 km northeast of Khanbogd approximately 1 km from the nearest herder well which has a total depth of 7 m and a water level of approximately 2.8 m. The main well (GHWx6) does not form part of the Gunii Hooloi borefield, and since installation has been used as a water level monitoring well. Three types of bore were established at the location GH4x6, these are:

- GHW4x6 - A medium diameter pump “test bore”, into which a pump was inserted and hydrogeological pump tests were undertaken;
- GH4x6 - A small diameter “observation bore”, which was used to monitor the effect of pump testing at a distance of ~30m away from the main “test bore”; and
- GH4x6s – A small diameter “shallow observation bore”, which was used to monitor the effect that pump testing would have on the identified layer of shallow water.

The geological sequence encountered during drilling of these boreholes comprised an initial layer of sandy gravely sediments in which the identified shallow water exists up to approximately 11 m depth followed by a series of predominantly impermeable clayey layers up to approximately 96 m depth and then followed by a series of predominantly water bearing layers until bedrock was encountered at 265 m depth.

In 2007, a cascading noise was noticed in the main GHW4x6 “test bore” that raised the concern that water may be “leaking” from a shallow aquifer to the deep aquifer, potentially leading to a loss of water in the shallow aquifer. Given that herders rely on shallow aquifers Oyu Tolgoi recognised that this could potentially lead to an impact on the shallow aquifer (11 m depth) and then potentially the higher separate shallower aquifer exploited by the hand dug herders’ wells (upper 5 m). All of the GH4x6 bores have been subject to routine monitoring since they were constructed and a comprehensive database of information now exists covering a period of over 6 years. This monitoring set includes water monitoring of the nearby herder wells of Dersen us and Denglin khudeg which are up-gradient and Suurin shavag which is approximately downstream. This herder wells monitoring was complemented in 2008 by the installation of specific herder monitoring boreholes at Suurin shavag as part of Oyu Tolgoi’s basin wide herder well monitoring programme.

The monitoring data clearly demonstrates that the groundwater level in the shallow aquifer in GH4x6S has remained stable since the GH4x6 bores were constructed, with the main fluctuations being due to occasional flood events along the water course recharging the shallow aquifer. These flood events appear to occur, or are significant enough to influence water levels approximately every two years, with water rises of approximately 0.6 m.

The data for herder wells up-gradient of GH4x6 and in the same ephemeral water course show similar fluctuations in water levels in the very shallow alluvial aquifer which these wells exploit. This is to be expected given they would be as sensitive to recharged from any small floods.

Figure 5.7: GH4x6 Water Well and Monitoring Wells

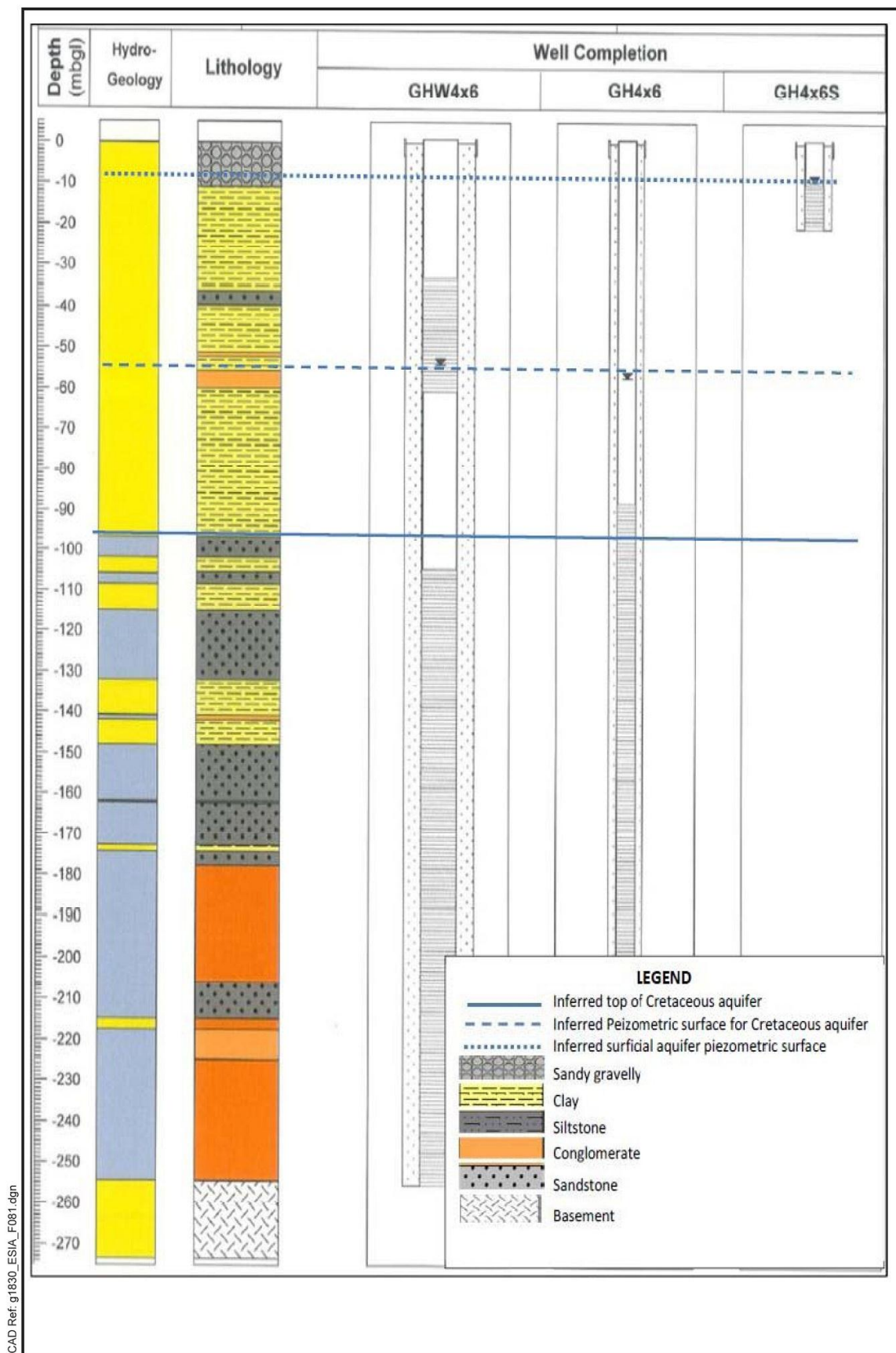
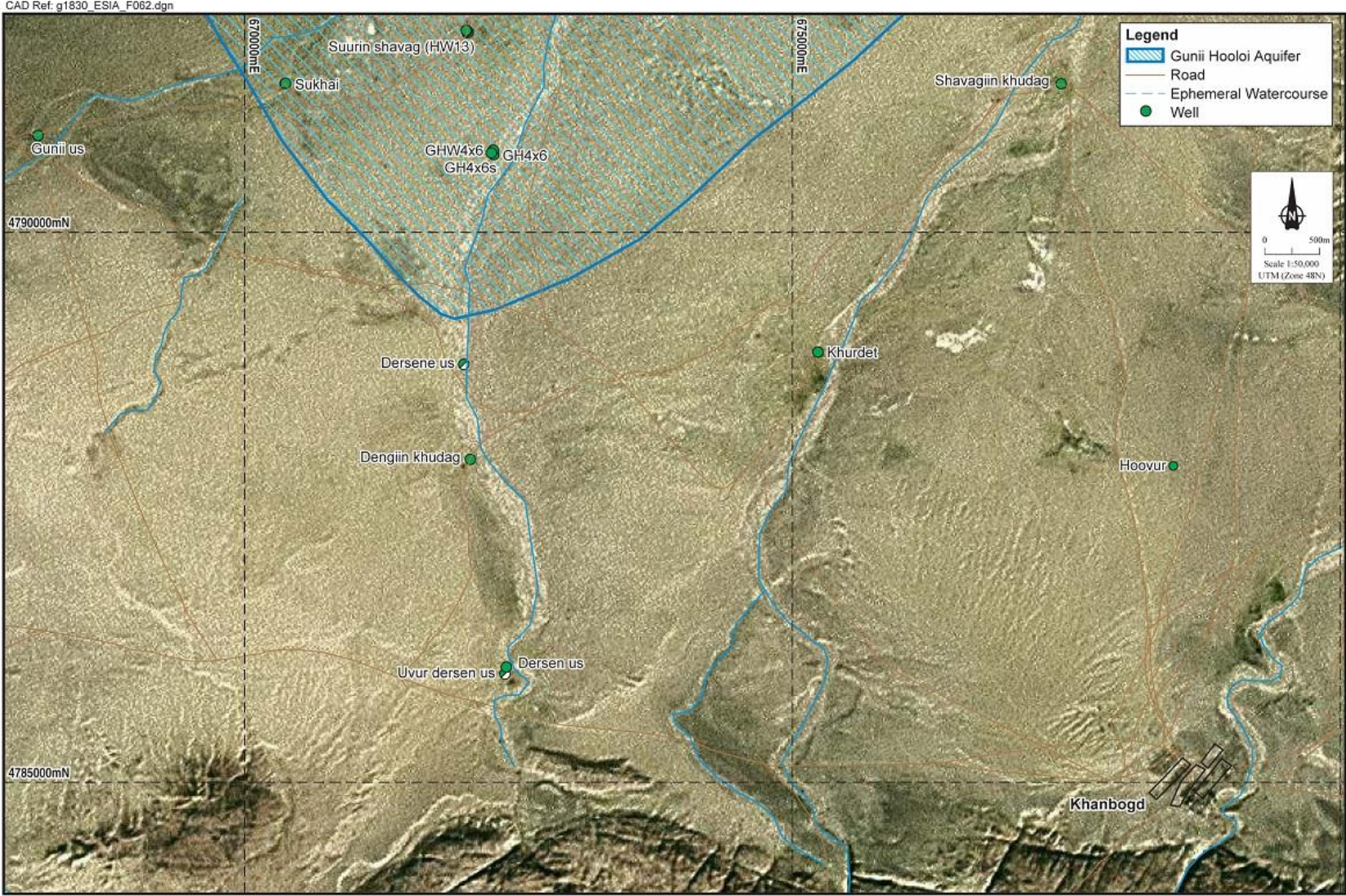


Figure 5.8: GH4x6 Well Location

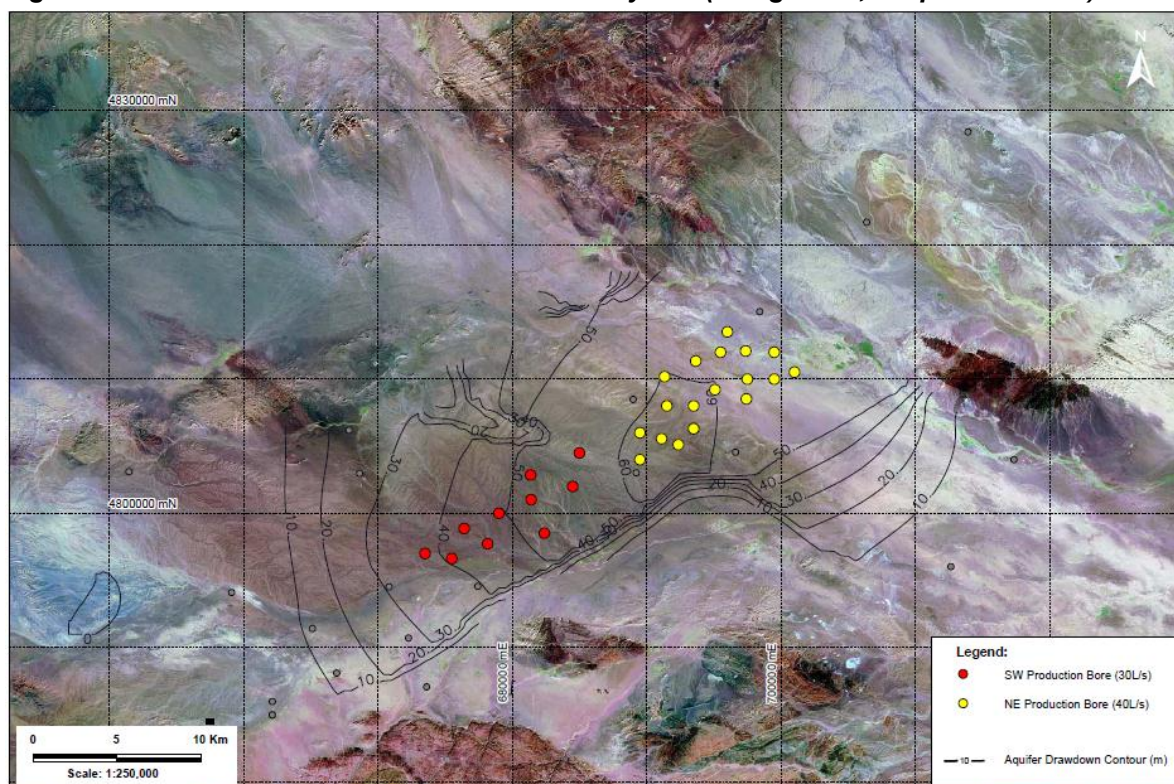


Whilst monitoring data demonstrates that no observable impact has been caused on the shallow aquifer monitored by GH4x6S by the “leaking” of the shallower aquifer into the deep aquifer, there has been a rise in the groundwater in GHW4x6 indicating that water is moving between Cretaceous aquifer horizons. The inference is that the thin sandy horizon between 38 and 40 m depth is leaking water into GHW4x6. Furthermore, it is recognized that public concern does exist, that this “leaking” may have an impacts on the water resources available to herders and even potentially local vegetation.

Mitigation Measures

The closure of the operations will result in the cessation of pumping from Gunii Hooloi which will result in a decrease in the local cone of depression around each pumping well, and the equilibration of water levels across the aquifer over the subsequent years. The final modelled groundwater levels in the Gunii Hooloi aquifer at the cessation of pumping (on a conservative 40-year horizon) are shown in *Figure 5.9* which illustrates that the centre of the drawdown is within the eastern part of the well field with the aquifer remaining confined. Where groundwater contours are shown as open-ended to the north-east, this indicates the fixed head boundary assumed with the Gunii Hooloi NE Basin to the east. The next phase of model refinement will be reviewing the assumptions in this area, and it is expected that this will result in a reduction in the amount of depletion of the natural piezometric head. Following closure the aquifer will gradually recover; however given the limited connection of the aquifer with areas of recharge (considered to be in the western part of the Gunii Hooloi valley), is recovery anticipated to be of the order of 200 years.

Figure 5.9: Gunii Hooloi Groundwater levels – 40 years (using a 110,000tpd base case)



Source: Gunii Hooloi Aquifer Groundwater Investigation and Resource Assessment – 2007 (Revised Water Demand) Prepared for Ivanhoe Mines Mongolia. Ref 658/F/331a, March 2008.

The water supply network for the Project will require the removal of pumps, motors and other electrical infrastructure for recycling. Subject to approval from the *Soum* Governor and Water Agency the wells will be plugged and abandoned to protect the deep aquifer from any surface contamination. It is considered impractical to leave the pumps in the ground for use by herders as the pumping capacity will be significantly greater than their needs and it will be beyond their means to maintain them, and the water is typically unacceptable for potable use potentially of limited use for herd animals. Herders will not have had access to the Project water supply unless absolutely necessary, and therefore no reliance on the infrastructure will have been developed. Any remedial measures to address impacts to herder wells will, where possible, have been achieved through standalone solutions such as a replacement well with hand-

operated pump. The aim is that decommissioning will have no impact on the water supply for the herders or their wells.

If the community of Khanbogd wished to adopt part of the system this would require a new pipeline connecting the community with the well bores and parallel power supply. This is however unlikely as a potential good local resource has been identified significantly closer to Khanbogd which is subject to a joint Oyu Tolgoi/ADB plan to provide a water supply to Khanbogd.

Oyu Tolgoi plans to convert GHW4x6 to a piezometer and install a cement plug across the shallow aquifer in order to help prevent any further leakage from the shallower aquifer horizon and resolve any on-going herder concerns. This is in line with plans to undertake similar work on the majority of the 2004 exploration boreholes. The plan for GHW4x6 has been conveyed to the local Khanbogd *soum* governor, and it was also discussed with the representatives of the *soum* community at a meeting on the 12th April 2010 organised by CSP and in further discussions in November 2010 with the Khanbogd community and herders. Following this there was an initial instruction from the local Khanbogd *soum* governor to postpone the work until a more detailed review of the monitoring data has been completed by the Water Agency.

Impact Significance

The abstraction from the Cretaceous aquifers in the Gunii Hooloi will result in the development of essentially a **permanent** cone of depression centred on the borehole field. This abstraction will result in a decrease in the groundwater resources of the region, although the aquifer will remain confined and full of water, this is considered to represent a **moderate-adverse** impact. The leakage caused by the long casing lengths used in the initial groundwater exploration wells has been demonstrated not to be having any measurable impact on the shallow aquifers relied on by the herders, and the overall impact is considered to be **negligible**.

The loss of water from the main Cretaceous aquifers has been estimated to take approximately 200 years to replace as there is limited recharge to the aquifer; this will represent a loss of part of the resource for future generations and is considered to be a **moderate-adverse** impact. However, it is estimated that the Project will result in the removal of less than 20% of the available groundwater resource of the aquifer, i.e. leaving a significant resource for future requirements in the area.

5.4.6 Impacts to Herder Wells

Nature of Impact

An impact to a herder well is considered to be unacceptable as it can result in immediate hardship to the herder family and their animals and force them to leave their traditional living area and grazing. The groundwater flow in the sediments of the ephemeral watercourses across the Project Area, where these sediments are sufficiently developed, provides the water for the shallow wells used by herders for their domestic water and watering of livestock. Any decrease in the recharge to these surficial aquifers or increased leakage from them to deeper sediments will result in reduced water availability in the herder wells with significant impacts on the herders' livestock and livelihoods²¹.

Mitigation & Management Measures

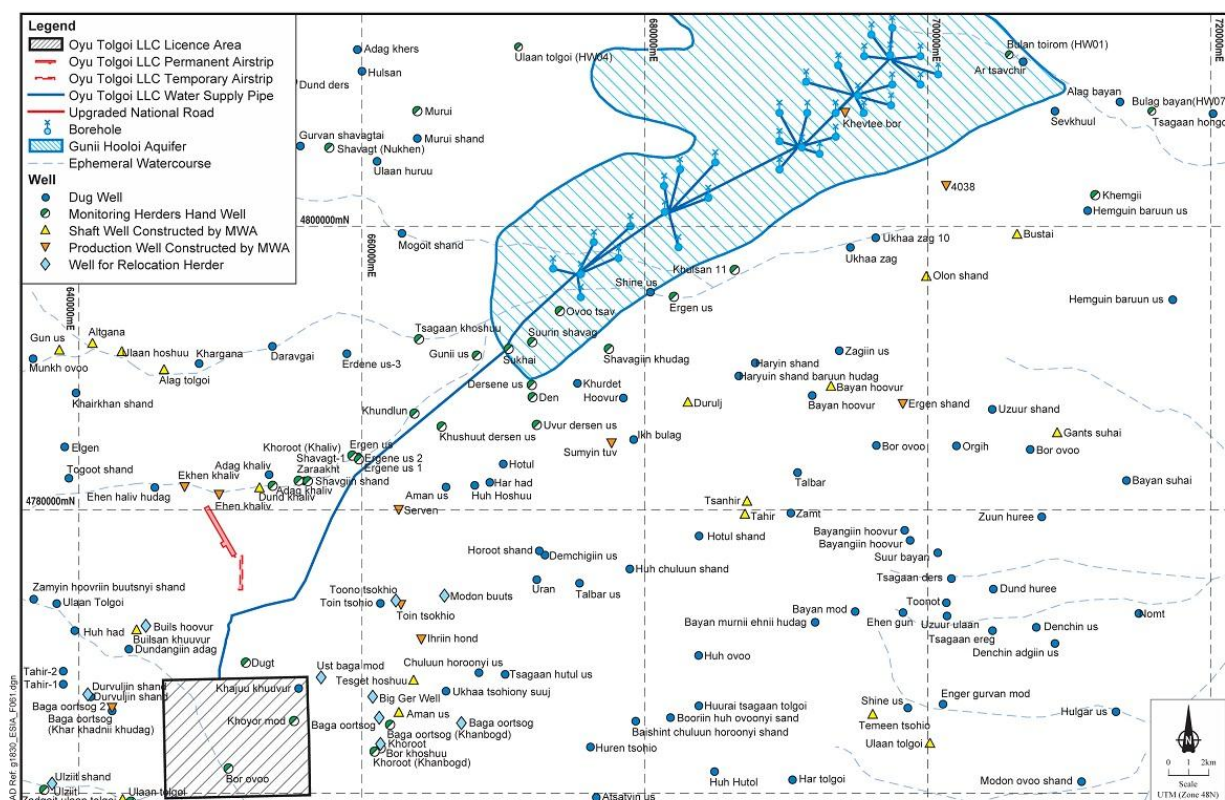
Herder winter camps within a 10 km radius of the mine site were part of a resettlement programme to address environmental and health and safety concerns for herders arising from the Mine Licence Area. This included concerns regarding impacts on the groundwater supply to herder wells. As a result there are no herder wells within the Mine Licence Area which are relied on as their primary supply, and the nearest winter shelter wells used by the herders are approximately 1,200 m from the northeast corner of the Mine Licence Area, with another a similar distance from the southwest corner. Both wells are located in ephemeral streams up-gradient of the Mine Licence Area. These wells are considered to be outside the radius of influence of the potential drawdown modelled for the operations in the Mine Licence Area.

Based on the groundwater monitoring undertaken and the assessment of the limited area of influence of the current pumping regime, the water abstraction within the Mine Licence Area through the construction phase will not result in any impacts on herder wells or the springs they rely on (other than Bor Ovoo – see

²¹ Oyu Tolgoi has made a commitment in the Investment Agreement not to reduce from the current levels the quality or quantity of the existing potable and livestock water supplies (Investment Agreement (2009) Clause 6.19.2)

Section C5.4.2). The monitoring and aquifer test data gathered by Oyu Tolgoi since the initial groundwater model in 2004 will be further enhanced by additional testing, and this data will be used to develop a new groundwater model in 2011/12. This model will be used to develop a more accurate assessment of the likely groundwater drawdowns in the operational phase and will allow Oyu Tolgoi to assess the impact of the open pit on the groundwater of the Mine Licence Area. Importantly this revised groundwater model will be used to assess whether there could be any potential impacts on herder wells or springs around the Mine Licence. If there are any potential impacts identified Oyu Tolgoi would adopt a precautionary approach and undertake a more detailed assessment to establish whether there was a requirement for mitigation action such as installation of replacement deeper wells or resettlement. Based on the current data, the likelihood of any such impacts occurring on the herders, their animals or their livelihoods is considered very unlikely.

Figure 5.10: Map of Winter Herder Camps and Wells along the Gunii Hooloi Water Supply Route



Note: Well shown in Gunii Hooloi bore field is abandoned mineral prospecting well, not a herder well.

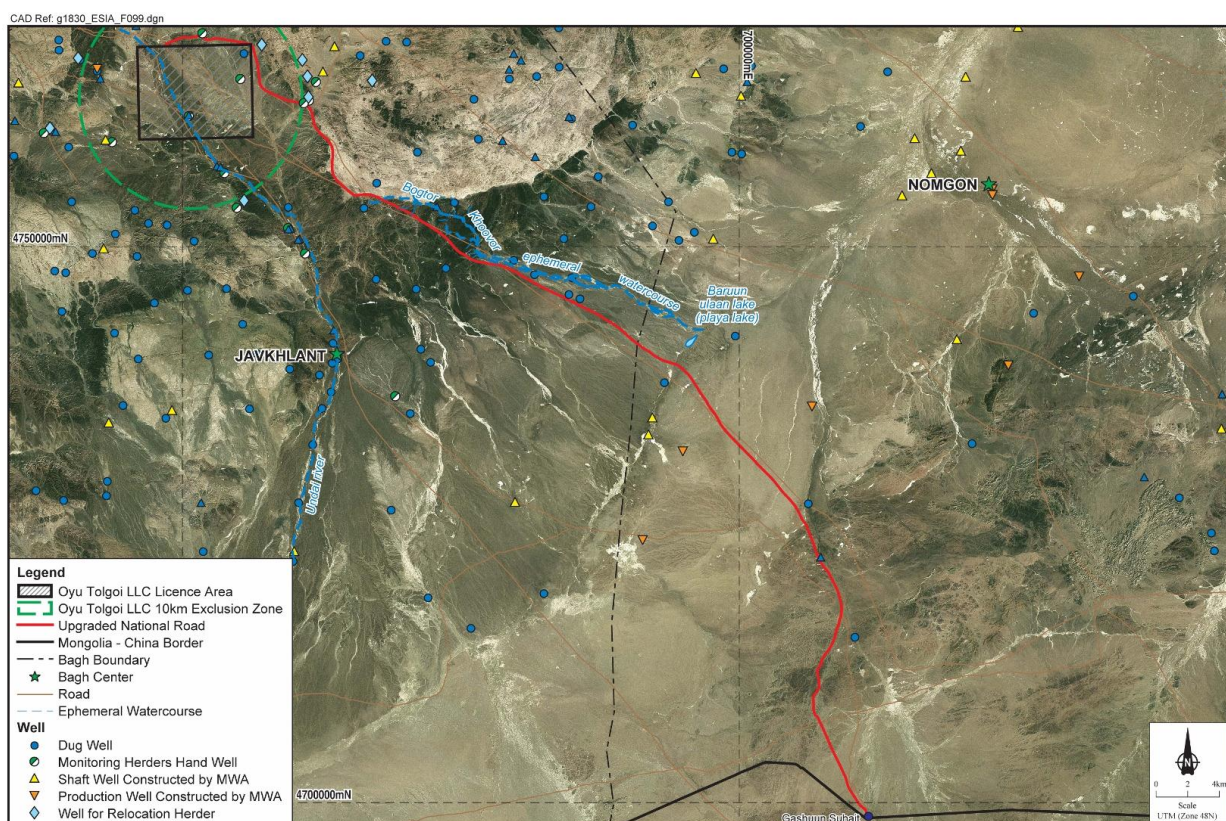
Outside of the Mine Licence Area the water abstraction volumes during construction will have a negligible impact on herder water resources given that these are being abstracted from the main Galbyn Gobi and Gunii Hooloi aquifers and not from the more limited shallow alluvial aquifer systems. The groundwater abstraction for the road construction is to be sourced from boreholes in the central Galbyn Gobi which are abstracting from deeper aquifers not used by the herders, and are also over 9 km away from and therefore significantly outside of the area of influence of any existing herder well, or from deep boreholes abstracting from fractures bedrock. Other than the continuation of Oyu Tolgoi’s regional groundwater monitoring programme, which includes monitoring of selected herder wells, no additional mitigation measures are required.

Along the infrastructure route there are 16 herder wells located between 200 m and 1,700 m from the planned road alignment as shown in Figure 5.6. None of these wells are anticipated to be impacted by the proposed road or power line route. Access to one herder’s summer well at the North East corner of the Mine Licence Area was impacted by temporary access road construction as the herder’s family had to cross the road to access the well. Although this route will not have a significant volume of traffic Oyu Tolgoi has undertaken a hydrogeological investigation (including using geophysical surveys) to identify a replacement well close to the herder’s family, which would provide the herder family with an acceptable solution. This well has been constructed and is now commissioned, while the original well remains available for the herder.

Herder Well Impacts in the Gunii Hooloi during Operations

There are also no herder wells closer than 500 m to the route of the water supply system (see *Figure 5.10*). As illustrated by *Figure 5.10*, the majority of the area of the Gunii Hooloi borefield is remote from any shallow aquifers and therefore is only able to be grazed by camels, as these can forage a significant distance from their water supplies. The exception to this is the area of the borefield closest to the Mine Licence Area where there are two ephemeral watercourses passing through or close to the borefield, where there are herder wells approximately 5 km downstream.

Figure 5.11: Map of Winter Herder Camps and Wells and Ephemeral Watercourse along the Road Route

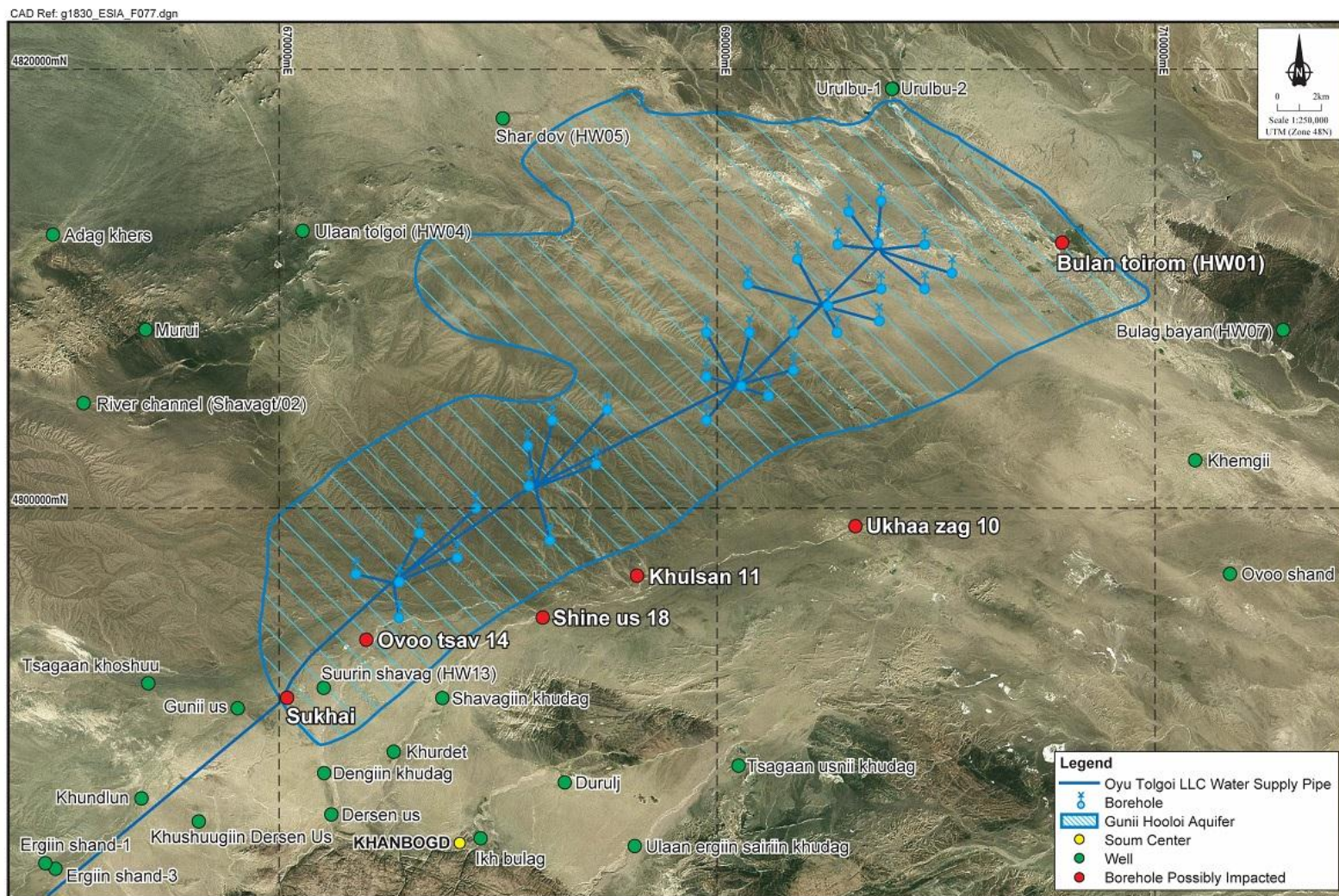


Note: Symbol size of wells and herder camps is approximately 1 km in diameter.

Based on the modelling undertaken²², there is considered to be only one herder well (Bulan toirom – see *Figure 5.12*) where there is a reasonable potential for impacts from the operation of the borefield abstraction. This located at the eastern extent of the Gunii Hooloi basin, and is only used in the summer when there is sufficient grazing vegetation in the area. This well is unusual as it is a drilled well (rather than hand dug) dating from earlier water exploration in the basin. It has a total depth of 12.3 mbgl and a water level of approximately 11.1 mbgl, and due to its depth the herder utilises a diesel pump to extract groundwater. The piezometric head in the deeper aquifer based on the nearest well drilled by Oyu Tolgoi is estimated to be 25 to 30 m and the concern is that additional drawdown of this piezometric head could induce leakage in the overlying sediments and reduce the water level in this herder well below the base of the well.

²² Aquaterra (2008), Gunii Hooloi Aquifer, Groundwater Investigation and Resource Assessment – 2007 (Revised Water Demand), Section 5.3.2, pg 33, March 2008

Figure 5.12: Location of Herder Wells which may be Impacted by Dewatering



There are a further three herder hand dug wells with depths of between 3.5 and 6.4 m and water levels around 2.5 to 2.9 m which are located in the easterly trending ephemeral water course 3 to 7 km south of the pipeline route (see *Figure 5.12*). The aquifer modelling shows these wells to be within the radius of influence of the drawdown caused by the Project, with drawdowns of up to 20 m. Two further wells are within the outer limits of the modelled drawdown will be similarly part of the monitoring although there is little potential for impacts. These herder wells are located along the southern boundary of the cone of depression, where the Cretaceous clastic sedimentary sequence abuts the hard bedrock with forms the structure of the basin. The surficial aquifers which support the herder wells are supplied by flood waters and groundwater flow in the alluvial aquifers flowing from the high areas around the basin which are outside of the area of drawdown.

These herder wells along with others are being monitored through pairs of adjacent boreholes installed by Oyu Tolgoi which are at a shallow (equivalent to the depth of the herder well with a screen 3-5 m) and deeper depth (typically screened 38-50 m) (Aquaterra March 2008). These monitoring boreholes at the herder locations have demonstrated the presence of low permeability clay rich sediments underlying the alluvial gravels (see *Section B6.5.3*). Based on this data the potential for significant leakage through these underlying low permeability sediments, which could impact the surficial aquifers, is considered to be unlikely.

Monitoring and Mitigation of Aquifer Abstraction Impacts

The baseline studies (reported in *Chapter B6: Water Resources*) have established the likely relationships between the local groundwater and surface water - linking changes in groundwater levels to rainfall variability associated with summer rainfall events. However, at an individual well level, the lack of very local rainfall data means that the ability to quantify the relationship between rainfall, flood events and recharge is limited and relies on data from the nearest rain gauge and/or anecdotal evidence provided by local herders. Oyu Tolgoi recognise the need to better understand these surface flow systems in order to establish the long-term seasonal dynamics occurring in the shallow aquifers of the Gunii Hooloi valley that are used by the herders. The flow data along with Oyu Tolgoi long-term groundwater baseline information will enable any seasonal impacts (as well as any potential impacts from the Gunii Hooloi pumping) to be evaluated and strategies developed to reduce the impact on the herder wells; be they natural or due to Oyu Tolgoi. This data will also be valuable in addressing perceptions in the community concerning the relationships between surface water, wells and the various aquifers.

The depth of water in the herder wells varies between wells, but at an individual level, a sustained drop in the depth of water in a well could represent a significant impact for herders where the wells is shallow and/or in an area where the aquifer has a low permeability. Oyu Tolgoi recognises that herder well performance may reduce or fail due to a number of reasons including:

- Natural variation in recharge leading to the water level dropping;
- Increased demands by the herder;
- Physical failure of the well e.g. silting-up;
- Reduction in alluvial water levels due to Oyu Tolgoi Operations; and
- Exploitation of, or impact on, the aquifer from other users (herders, *soum* centre).

Herder well performance will be continuously assessed as part of routine water monitoring activities with an aim of proactively identifying potential impacts. Potential impacts may also be identified by herders via local Oyu Tolgoi Communities and Social Performance Department contact points. In accordance with the CSP Grievance Management Procedure, any herder well potential impacts reported within potential impact zone will be investigated by an investigation team, including professional hydrogeologists to assess the likely reason of the failure. This will include:

- Review of rainfall data;
- Historical water level trends in this well and surrounding wells based on Oyu Tolgoi's monitoring;
- Information collected by the herder and or PEM;
- Review of well construction and depth of the well (and comparison with historical information); and
- Assessment of cause of impact, if any, and recommendations for mitigation.

The result of the study will be discussed with the herder. If the herder is dissatisfied with the results of the investigation, appropriate follow up will be undertaken, including:

- On-going contact with the herder to clarify reasons for dissatisfaction; and
- Referring the case to the Local Advisory Body (mediation body) chaired by the *soum* governor and potentially including the Khanbogd Environment Officer, related NGOs, Herders and Oyu Tolgoi (Environment Officer, Community Officer).

If the issue(s) associated with a herder well is identified as a being potentially due to Oyu Tolgoi's activities by the Local Advisory Body. Oyu Tolgoi will agree with the herder and the Local Advisory Body an acceptable solution. This solution may include:

- Deepening or otherwise rehabilitating the existing well;
- Placing a new well in an alternative location within the herders pasturelands; and
- Providing water by truck to the herder.

Any solution will provide the herder with a water supply of similar quantity and quality as the well which has failed; so that it can support the requirements of the herder family and animals.

The involvement of the herders in the Oyu Tolgoi PEM Programme will be an important aspect of the monitoring going forwards, enabling full and open discussion of monitoring data and providing Oyu Tolgoi access to the insight of the herders into changes in the environment and well performance that may not be apparent from the regular monitoring data. Oyu Tolgoi will take a proactive approach to changes in herder well performance and take responsibility for ensuring that any impact on well performance is rectified and wells are returned to use and are able to provide the same volumes and quality of water as before. These actions will be taken whether Oyu Tolgoi is responsible for the impact or not. This approach is already in place with Oyu Tolgoi assisting a herder near the airport with the renovation of a well which was silting up in late 2010.

Although, with the exception of the single deeper herder well, any impact on the shallow groundwater aquifers (and herder wells) is considered unlikely. Nonetheless, the development of Gunii Hooloi borefield and groundwater drawdown management has included appropriate mitigation measures to address potential areas of concern as follows:

- The Gunii Hooloi borefield layout has been designed to minimise the potential drawdown in the vicinity of the local surface water systems in north eastern Gunii Hooloi. The design will result in a groundwater drawdown of between 15 and 40 m beneath this un-named surface saline playa in north eastern Gunii Hooloi, which is immediately east of the proposed borefield. The available evidence suggests that this system is not a major surface water feature during average rainfall seasons and there is no evidence that any groundwater dependent vegetation in the Gunii Hooloi area are reliant on discharges of groundwater from the Cretaceous aquifers.
- Positioning of the Gunii Hooloi borefield away from the majority of shallow wells. As a consequence there are only two wells located within the 30 m drawdown contour, two wells are located within the 20 m drawdown contour and two wells within the 5 to 10m drawdown contour. The area of maximum regional aquifer drawdown is located where there is no shallow groundwater. The potential impact on the shallow aquifer and wells is considered likely to be negligible.

With regards to the potential impact on the 12.3 m deep herder well, if the predicted impacts on this bore do occur, an alternative water supply would need to be provided to sustain their summer grazing in this area. This will be subject to a detailed review of the local shallow groundwater system and negotiation with the relevant herders to establish the appropriate location of an alternative groundwater supply. Oyu Tolgoi is committed to ensuring the continuity of supply for all herders around the Gunii Hooloi borefield as detailed in the Environmental Protection Plan in the Gunii Hooloi DEIA²³.

²³ JEMR Consulting LLC (2010), Amendment Detailed Environmental Impact Assessment Report on use of Gunii Hooloi underground water resource for Oyu Tolgoi Project, Table 5.1, pg 74, October 2010

Monitoring of the groundwater in the selected monitoring wells installed by Oyu Tolgoi and selected herder wells in the area will continue on a monthly basis through the Project life, with annual sampling of selected wells for chemical analysis. This groundwater analysis will allow any variation in groundwater chemistry to be established (e.g. increasing salinity) which may be an indicator for other changes occurring in the aquifer system (e.g. reduced recharge or increased leakage).

The detailed relationship between the recharge events from seasonal rainfall and potential losses from the surface aquifer to deeper formations through vertical permeability has been partially characterised. Further long-term monitoring of flow events, stream sediment storage characteristics tied to monitoring water levels in all aquifers including in the near-surface aquifers used by the herders hand dug wells will be undertaken by Oyu Tolgoi. The results of this monitoring will enable Oyu Tolgoi to improve understanding of the relationship between near-surface aquifers and rainfall and whether there are any drawdown impacts measurable in this shallow aquifer. This detailed baseline information will enable the Company, herders and other stakeholders to assess objectively any claims of impacts to herder wells.

The trigger to undertake mitigation measures on a well will vary from well to well and will be dependent on the standing water level, depth of the borehole, and pumping method. Oyu Tolgoi's monitoring regime will enable the early identification of potential impact and then ensure that there is sufficient time to agree the design of a replacement supply with the herder, such as a new well or deepening the existing well, and ensure the herder's water supply is uninterrupted.

Impact Significance

The potential for the abstraction to impact the Bulan toirum (the 12.3 m deep herder well) is considered to be **likely**, as this well utilises a diesel pump to abstract water when the herder is using it in the summer (i.e. it is not a winter camp well). It is considered that a replacement supply could be readily provided (e.g. a deeper well) and the overall impact is considered to be **minor-adverse**. The potential to impact other herder wells is considered to be **unlikely** and the impact to be **minor-adverse**.

5.4.7 Groundwater & Surface Water Contamination

Nature of Impact

The Oyu Tolgoi Project will require the use of significant quantities of hazardous and non-hazardous chemicals which could have the potential to impact groundwater and surface water quality. This could arise from the storage and handling of hazardous materials or from the disposal of waste materials that cannot be recycled. In addition the Project will be generating wastewaters, such as from the wastewater treatment plant that could have an impact on groundwater and surface water quality if inadequately treated or handled.

Mitigation Measures

These potential impacts will be mitigated through the use of appropriate storage facilities, and management procedures including Emergency Response Procedures (see *Chapter D12: Hazardous Materials Management Plan* and *D20: Emergency Response Plan*). The most significant hazardous material stored on site with the potential to impact the groundwater is diesel fuel for the diesel power plant, back-up generator and site vehicles. This fuel will be stored in bunded compounds which will retain any leaks or spills, all pipe-work will be, where possible, above ground or where underground subject to regular testing regimes. Emergency response procedures will be in place to deal with any incident that could result in contamination of groundwater and spill kits will be available around the site to respond to any spill incident.

The site currently operates an interim waste management facility, which includes a recycling area and is located on the Mining Licence Area close to Shaft No. 2. During the construction phase a permanent waste management facility (WMF) will be constructed in the north-eastern part of the mining Licence, outside of the anticipated subsidence zone associated with the block caving operations. This site, which overlies the Cretaceous clay, will comprise a lined landfill cell and two leachate evaporation ponds. Once the new facility is constructed, the interim waste management facility will be closed, the land cleared and pit capped with clay, and any necessary remediation undertaken. On-going additional landfill cells and leachate evaporation ponds will be constructed during operational phase as required. Oyu Tolgoi's aims is to minimise the volume of waste material going to landfill through a robust materials management strategy comprising the "reduce, reuse, recycle" philosophy. Non-recyclable combustible hazardous materials (including medical wastes) will be disposed of via the site's incinerator; any non-recyclable

hazardous waste (e.g. fluorescent tubes) will be carefully stored until an appropriate disposal route has been identified.

Monitoring wells are planned for this area to provide an assessment of groundwater condition around the interim waste management facility and closed disposal pits. These will be used to ensure there are no legacy issues associated with contamination from the interim landfill with appropriate remedial measures taken if significant contamination is identified.

It is noted that during the operational phase any contaminated groundwater would be most likely to be captured within the cone of depression caused by the operations and therefore captured in the mine workings. However, this fact will not be used as a mitigation measure by Oyu Tolgoi with all contamination risks prevented by appropriate management procedures and any incidents resulting in spills being remediated promptly and appropriately. The Project's groundwater monitoring network will include wells around the WMF which will be analysed regularly to assess whether there are any impacts to local groundwater quality and remedial measures implemented if any significant impact was encountered.

Across the other aspects of the Project such as the operation of the airport and infrastructure corridor the risks of contamination are considered to be negligible as no significant volumes of chemicals will be stored in these areas. There is the potential for impact to arise from non-routine events, such as fuels spills or road traffic incidents. These could result in soil and groundwater impacts, or in the event that there was a coincident flood event, surface water impacts.

The drilling of the water abstraction boreholes and the cut and fill installation of the underground water supply pipeline have the potential to impact near-surface aquifers where they are present through the impacts from spills of hazardous materials.

To reduce the potential for impacts from these activities, hazardous materials and waste materials handling procedures will be adopted (see *Chapter D12: Hazardous Materials Management Plan*) and domestic and industrial waste will be removed from the area on completion and disposed of through the Project waste management facility (see *Chapter D8: Waste Management Plan* which also describes the design criteria used). This will include any contaminated soils created by the construction works.

When drilling the water abstraction boreholes, the operations will use water-based polymer drilling mud, the cuttings and excess mud will be collected in local mud pits (see *Figure 5.13*) and upon completion of the works the mud pits will be allowed to evaporate and will then be covered and the areas restored. It is anticipated that the mud pits will be closed when or soon after the rig is dismantled and would either have almost dried out or be close to this; therefore the ponds will not be left open and untended with liquids in them and will not present a hazard to herders, herd animals and wildlife including any birds.

The site wastewater treatment plant (WWTP) treats the sewage and other wastewater from the construction camps within the Mine Licence Area. Treated wastewater is used for dust suppression and also used in the concrete batch plant (see *Chapter D7: Water Resources Management Plan*).

Given the size of the road and pipeline construction camps (circa 1,500 people in each, which assuming 150 L/person/day, each camp would use approximately 225 m³/day and produce a slightly lesser volume of wastewater) temporary mobile wastewater plants may be used, rather than transporting wastewater back to the central WWTP in the Mine Licence Area. The final design for these (if used) is yet to be determined but is likely to be a lined containerised system. The treated wastewater will not be discharged to any surface water body or soakaway, but rather reused in the mining process or would be used for dust suppression and sludges transported to the central waste treatment centre on the mine site. It is a mandatory requirement that all sewage treatment plants shall perform to applicable Mongolian discharge standards²⁴ which are designed for the protection of surface water and groundwater.

²⁴ MNS 6148:2010

Figure 5.13: Drilling Rig and Infrastructure including mud pits



In addition the increase in the population of Khanbogd will result in an increase in sanitary waste in Khanbogd. At present there is limited sanitary treatment in Khanbogd. As part of the development of the community infrastructure in Khanbogd, Oyu Tolgoi will be providing assistance to the development of a sustainable reticulated water supply system, and is in detailed discussion with the local administration and other donors on how this will be developed.

To mitigate the risk of contamination of the surface water resources, all hazardous materials will be stored in bunded facilities in accordance with Oyu Tolgoi's hazardous handlings and storage procedures (see *Chapter D12: Hazardous Materials Management Plan*) and waste management procedures (see *Chapter D8: Waste Management Plan*). Any accidental spills which occur will be addressed promptly through Oyu Tolgoi's emergency response procedures (see *Chapter D20: Emergency Response Plan*), followed by an appropriate validation and monitoring programme to ensure that the remediation was successful. The potential for a significant impact is considered unlikely and with the mitigation measures this likelihood is reduced to unlikely.

If there was any spill which could not be completely remediated, Oyu Tolgoi would instigate a remedial programme along with an environmental monitoring programme to ensure that the impact was dealt with effectively and efficiently.

Monitoring of the groundwater quality across the Project will be undertaken to assess and identify early any degradation in groundwater quality. In the event that such contamination is detected appropriate remedial measures will be implemented which could comprise engineering solutions or revisions to Oyu Tolgoi management procedures.

Impact Significance

The potential for a significant contamination impact on surface and groundwater to arise from Oyu Tolgoi operations, given the management procedures in place to manage hazardous materials and waste, is considered to **unlikely**, and the potential significance to be **negligible**.

5.4.8 Increased Khanbogd Groundwater Supply Demands

Nature of Impact

At Khanbogd the community water supply is envisaged to move from individual and community wells towards a reticulated system which draws water from the local shallow aquifer, and water demands will increase as the population of the community grows and economic activity increases. This will result in an increasing demand on the groundwater resources of the area.

Mitigation Measures

Oyu Tolgoi is working with the Water Authority and Governor of Khanbogd and other organisations to identify and develop an alternative water supply for Khanbogd²⁵. The optimum location of the supply wells is currently the subject of on-going studies by Oyu Tolgoi, as part of this programme three wells have been drilled approximately 6 km to the northeast of Khanbogd and have proven a significant groundwater resource (see *Section B6.10*). This basin containing this water resource is inferred to be recharged annually by rainfall and bedrock flows from the Khanbogd Massif to the south and Durulj Mountain to the north. Oyu Tolgoi is currently defining this resource and agreeing the resource estimate with the Water Authority. Oyu Tolgoi is also assisting develop plans for the water reticulation system in conjunction with the Water Authority and Governor of Khanbogd, Asian Development Bank and others. The first phase of the development of the *soum* water supply is designed to deliver 30 l/s, and will have the capacity to increase this in the future as Khanbogd demand grows through development and influx. Tied into the water supply will be a wastewater treatment plant which will seek to recycle/reuse water once treated; work on this area is still under development.

This monitoring will be directed and undertaken by Oyu Tolgoi's Environment Department in conjunction with the Communities and Social Performance Department (CSP) who will provide any anecdotal information on water well quality and water levels from the herders to the Environmental Department.

Similar to the Gunii Hooloi aquifer the Khanbogd aquifer is significantly deeper than the surficial aquifers exploited by the herders, with the wells penetrating to a depth of 188 m. Nonetheless, the design of the boreholes and their layout will aim to avoid impacts on local herder wells (the nearest herder well (Durulj, which has been monitored since 2004) is approximately 5 km to the northeast. The baseline monitoring data on the herder wells in this area which form part of the baseline monitoring for the Gunii Hooloi basin, will continue to be collected by Oyu Tolgoi and the information provided to the Khanbogd Governor to enable them to use the data to assess any impact caused by the *soum* centre's abstraction of the groundwater from this basin for the reticulated water supply.

Plans for the development of community water supplies in Khanbogd are still under development, but the key strategies and objectives are set out in *Chapter D16: Influx Management Plan* and development will be conditional on the identification and development of a sufficient and sustainable water supply for Khanbogd.

Impact Significance

The impact of dewatering on any herder well has the potential to be major, however as the likelihood of the impact occurring is considered to be **unlikely** given the depth to the groundwater and the mitigation measures planned the residual significance is considered to be **minor-adverse**. The lack of sufficient water for Khanbogd would have a major impact on the community; however the initial work undertaken and early indications from the drilling investigation indicated that there is a significant water resource available and the residual significance is judged to be **minor-adverse**.

5.4.9 Operation of Tailings Storage Facilities

Nature of Impact

The operation of the TSF has the potential to impact water resources through saline and, potentially acidic, leachate from the TSF into the underlying aquifer and run-off from the TSF into the local water courses during a flood event. The potential for any surface run-off from the operational area of the TSF is considered negligible as the void space in the supernatant pond will be sufficient to capture any storm water event. Any storm water would be promptly pumped back to the process water pond to minimise evaporative losses and subsequently used in the process.

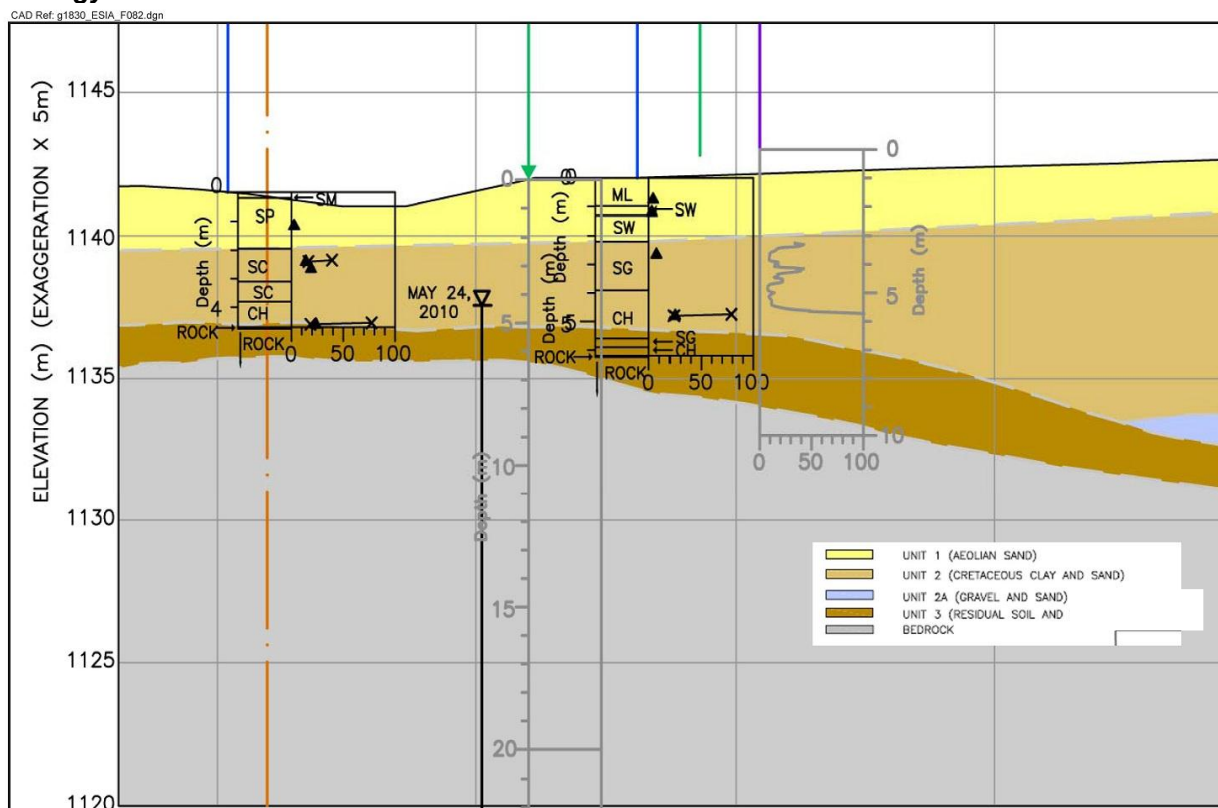
Mitigation Measures

The operation of the TSF is designed to minimise the volume of water remaining in the tailings so as to maximise the recycling, minimise water loss due to evaporation and reduce the demands on the groundwater; this in turn will limit the amount available for seepage. There have been extensive

²⁵ This reflects the commitment to support the Government in the establishment of safe drinking water for the local *soum* centre directly impacted by the Oyu Tolgoi Project – Clause 6.15 of the Investment Agreement (2009)

investigations below the TSF footprint. Cell 1 of the proposed TSF is predominantly underlain by the Cretaceous clay rich deposits, with the exception of the southeast corner where it is absent and the area underlain by more permeable residual soils and weathered bedrock. The Cretaceous deposits vary in thickness from 0 to 9 metres (in the northwest and southwest corners). Cell 2 of the proposed TSF is entirely underlain by the Cretaceous deposits, which varies in thickness between 2.5 metres (in the southeast corner) to over 25 metres (in the northwest corner). Material from thicker clay areas to the northwest will be redeposited in the southwest area of Cell 1 to create a minimum of a 1 m thick clay liner across the full extent of the TSF.

Figure 5.14: SSW-NNE Section through Budaa TSF illustrating Surficial Materials and Shallow Geology



Source: Klohn Crippen Berger, 27 April 2010. Oyu Tolgoi Tailings Site Reassessment.

All loose aeolian deposits will be stripped below all TSF structures and key trenches will be installed to cut-off seepage through the deeper fluvial deposits. Loose fluvial deposits will also be stripped below the tailings embankments (residual soils have a median permeability of 6.65×10^{-6} m/s).

The Cretaceous deposits generally comprise beds of clayey sands or sandy clays and inorganic high plasticity clays with occasional beds of well gravels or sands generally less than a metre thick with a permeability of 2.3×10^{-7} m/s. A typical cross section of the geological sequences underlying the TSF site is provided in Figure 5.14 below. This illustrates the relative shallowness of the Cretaceous clay (typically approximately 2 m below the surface) which will form the foundation and sealing horizon for the TSF. The cross section also illustrates how the aeolian sands are eroded in the ephemeral watercourse, and there is no thinning of the Cretaceous clay beneath the watercourse. The interpreted hydraulic conductivity values for the Cretaceous Clay are in the order of 1.23×10^{-10} m/s and 6.48×10^{-10} m/s, and are in-line with values expected for this type of lithological unit.

The Cretaceous clay within the Mine Licence Area is a high plasticity material which is suitable for use as a low permeability liner when compacted. Natural permeabilities of the clay range from 3.24×10^{-6} to 1.3×10^{-9} m/s (2.10×10^{-7} to 4.5×10^{-7} m/s are 25 and 75 percentiles). The area where this 3 m clay liner will be placed is illustrated in Figure 5.15, the remainder of the cell is underlain by in-situ clays from which the overlying superficial sediments will be removed, and therefore no additional clay is required to be placed in this area. The clay fill will be taken from thicker deposits of Cretaceous clay primarily in Cell 2 area, although external sources may also need to be used. The clay fill will be placed in loose thickness

lifts of 300 mm and then compacted to 95% of Standard Proctor maximum density and between -3% and +2% of optimum moisture content²⁶. The upstream edge of the liner will be keyed into the natural Cretaceous clay (with a minimum thickness of 1 m) to maintain continuity. The downstream edge of the liner will be tied into the starter dam Zone A low permeability zone. The clay liner will also extend beneath the reclaim pond in Cell 1. *Figure 5.15* shows the plan of Cell 1 of the TSF in year one with the associated seepage collection ditches and surface water diversion channel.

Settling tests and consolidation tests indicate the tailings exhibit good settling and consolidation characteristics, with initial settled densities of 1.28 t/m³ to 1.39 t/m³. Therefore for design purposes, an average density of 1.4 t/m³ has been assumed for sizing of the starter facilities and 1.5 t/m³ for the ultimate facility. The hydraulic conductivity of the consolidated tailings is estimated to vary from 1 x 10⁻⁷ m/s at shallow depth to 5 x 10⁻⁹ m/s at the pile base. This low hydraulic conductivity will limit seepage through the base of the TSF.

Numerical modelling indicates the total seepage from the TSF will be in the order of 20 L/s to 40 L/s. The vast majority of the seepage will exit through the outer tailings embankments and within the near surface fluvial deposits and weathered bedrock horizons (permeabilities from 2 x 10⁻⁵ m/s to 3 x 10⁻¹⁰ m/s). This seepage will be intercepted by the perimeter collection ditches. Groundwater losses into the deeper bedrock are limited by the low permeability of this rock (permeabilities from 5 x 10⁻⁸ m/s to 7 x 10⁻¹¹ m/s).

Minimal reshaping of the basin (low-lying area) will be required, as the natural topography will be utilised as far as practicable to generate a positive slope on the seepage collection network, and the natural clays used to line the seepage pond. A 4 m deep ditch will be excavated at the toe of the tailings embankments to collect seepage and precipitation falling on the downstream slopes of the embankments. Two seepage collection ponds (East and West) will be constructed on the east and west sides of the TSF to contain the seepage flows and runoff from a 100-year 24-hour storm. The base of the ditches will be founded in low permeability Cretaceous clay or intact bedrock. Where the depth of these units exceeds 4 m, seepage cutoffs will be constructed to reach low permeability stratum. Any seepage from the TSF collecting in the seepage collection ponds will be directed back to the supernatant pond within the TSF and returned to the processing facility for re-use. The preliminary design for the seepage collection and the diversion of the ephemeral water course around the cells is illustrated in *Figure 5.15*.

Tests²⁷ of the mineralised zones show that the majority of the tailings will be Non Acid Forming (NAF) and any Potentially Acid Forming (PAF) tailings which are encountered will be easily encapsulated (by NAF tailings). The design of the TSF will take account of the source of the tailings such that the capping layer is of NAF tailings which will provide a potential grow medium for future restoration. If PAF needs to be placed on the upper layer then NAF waste rock will need to be placed over the cell on closure. Oyu Tolgoi's groundwater monitoring network installed around the TSF provides a robust baseline data set, against which the groundwater chemistry of the TSF can be monitored going forwards to assess the efficiency of the seepage collection and as required enable Oyu Tolgoi to take proactive measures to address any concerns. Current modelling of the chemistry of the supernatant water likely to present indicate that some metals (e.g. copper, iron and lead) could be elevated above potable standards although supernatant analyses do not necessarily reflect tailings water seepage quality under operational or closure conditions.

During the operational phase the TSF will sit partially or wholly over the cone of depression in the groundwater caused by the mining operations and therefore any seepage which is not captured by the seepage collection system in these areas will be directed towards the mine and pit operations. This provides a secondary risk mitigation feature for addressing any seepage; however Oyu Tolgoi will be reliant on the primary controls of adequate clay liners and seepage collection. The exact shape of the cone of depression will be re-evaluated in 2012 when the hydrogeological model for the mine is rerun.

²⁶ : Klohn Crippen Berger 2011, Tailings Storage Facility 2010 Feasibility Study Update report

²⁷ EGI (2008), Oyu Tolgoi Project Acid Rock Drainage Review and Recommended Investigation Programme, for Ivanhoe Mines Mongolia Inc, by Environmental Geochemistry International Pty Ltd, May 2008

Figure 5.15: Location of Clay Liner beneath Cell 1 of TSF

CAD Ref: g1830_ESIA_F083.dgn

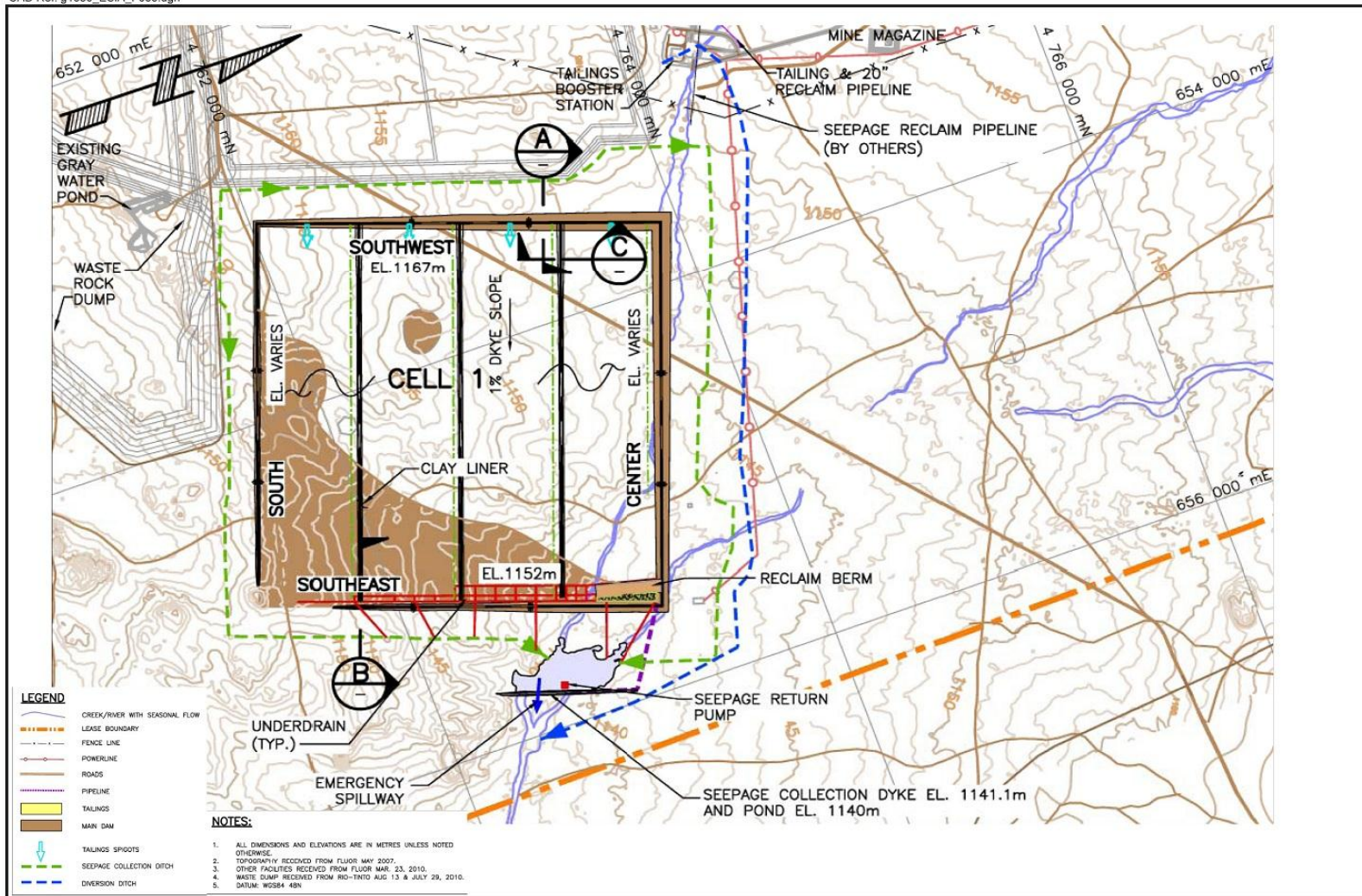
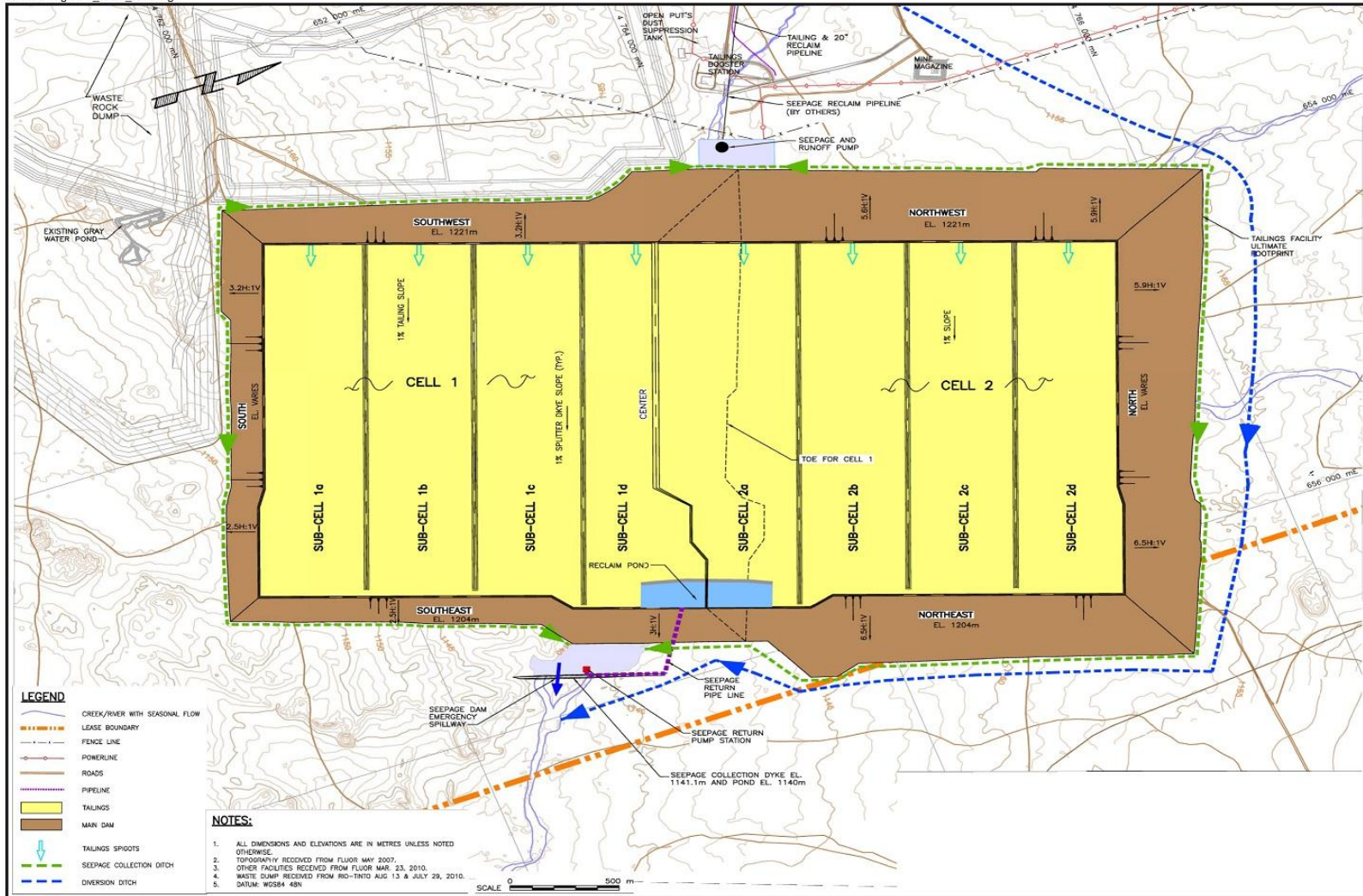


Figure 5.16: Seepage and Diversion Ditches for the TSF

CAD Ref: g1830_ESIA_F084.dgn



Source: Klohn Crippen Berger, 5 August 2011. Oyu Tolgoi Tailings Storage Facility 2010 Feasibility Study Update.

Impact Significance

The installation of an engineered clay liner and utilisation of the in-situ clays beneath the TSF will reduce the potential impact of the TSF on groundwater to **minor-adverse** (and potentially **negligible**). The seepage collection system is designed to collect the majority of the seepage arising from the TSF and return this ultimately to the process water pond which will contribute to reducing the demands on the Gunii Hooloi aquifer. The potential impact of the TSF on the surface water systems is considered to be **minor-adverse**.

5.4.10 Waste Rock Dump Construction and Operations

Nature of Impact

The waste rock from the open pit will be placed on the WRD. Once the open pit is mined-out no significant further waste rock will be generated, and the WRD will be closed as all the rock taken from the underground block caving will be ore for processing and no waste rock will be generated. The waste rock from the open-pit includes rock that has the potential to generate acidic leachate if there is sufficient moisture, and if generated this would be likely to contain other contaminants including metals. This acidic leachate if generated has the potential to impact the underlying and down-gradient sediments, groundwater and surface water. If acidic leachate was generated and was uncontrolled, this could have a significant impact on down-gradient springs and wells in the Undai south of the Mine Licence Area.

Mitigation & Management Measures

The potential for the waste rock to generate acid rock drainage has been assessed by a series of studies since 2002, and column tests have been on-going since 2004, with further refinement of these studies still on-going. The results of these studies indicate that the majority of the non-host lithologies will be NAF and that the host rock mineralisation means that it has the PAF or NAF depending on the relative content of acid generating (mainly pyrite) and acid neutralising (calcite and dolomite) phases. When the non-host material is separated, the majority of host materials is PAF. Based on these studies, the South West Oyu appears to have significant quantities of NAF host rock. The geochemical investigations indicate that based on the current mine plans of the estimated 1,800 Mt of waste rock that will be generated from the pit, 57% will be PAF which will be dealt with through the operational waste rock management plans which will be developed before commencement of commercial operations. The types of waste rock which will be generated are summarized in *Table 5.2* below.

Table 5.2: Summary of Waste Rock Types

Waste Type	Description	Mt	Volume M m ³	Loose Volume M m ³
NAF	Oxide	179	73	95
	Sediment	241	92	120
	Not oxide, sediment or SOM	250	93	121
	Segregated Oxide Material (SOM)	107	42	54
PAF	Not oxide or SOM	972	355	461
	Oxide	18	7	9
	SOM	33	12	16
Total NAF		777	301	391
Total PAF		1,023	374	486
TOTAL		1,800	675	877

The waste rock that is generated will comprise approximately 301 million m³ of NAF and 374 million m³ of PAF²⁸. Of this material it is envisaged that 207 million m³ of NAF will be used to construct the TSF with

²⁸ Pers Comm. Oyu Tolgoi, November 2010.

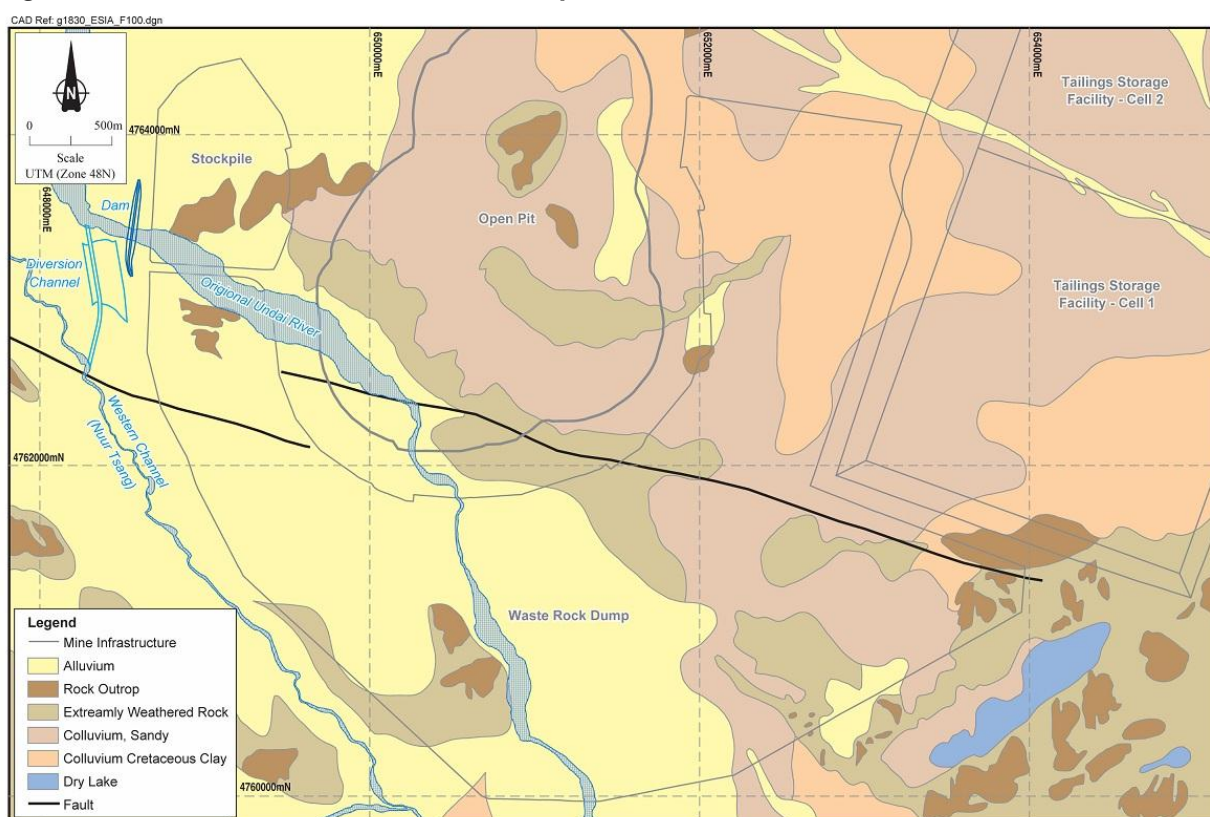
the balance used for haul roads, and for a 10 m thick capping layer over the side of the completed WRD and 3 m capping layer over the top.

The WRD overlies three general types of subsurface conditions (described from NE to SW):

- Cretaceous clay, which forms a low permeability layer below the dumps ranging from 0 to 15 m in thickness;
- A zone of shallow bedrock (or bedrock covered by thin mantle of Aeolian soil) located between the southern edge of the Cretaceous clay and the present Undai channel. The bedrock is primarily weathered Andesite and basalt with moderate to low permeability; and
- The southwest portion of the dumps is underlain by Undai River and other alluvial deposits. These deposits are typically a few metres in thickness but in places can reach up to 10 m in total thickness. The alluvium is in turn underlain by weathered bedrock.

A generalised foundation map is presented in *Figure 5.17* below.

Figure 5.17: Generalised Subsoil and Outcrop Conditions below the WRD



The entire area underlying the WRD has variable thicknesses of shallow sands, silts and gravels of either alluvial or colluvial origin. These deposits do not present stability or other concerns below the WRD given their shallow depth. Following the initial soil stripping (where sufficient soil is present to warrant stripping) and preparation, the WRD will be situated on low permeability Cretaceous clay or generally low permeability weathered rock materials. Special foundation treatment of these materials is not considered to be warranted due to the very low expected seepage through the WRD.

The data presented above indicates that the permeability of the Cretaceous sediments range between 4.0×10^{-6} m/sec and 6.5×10^{-11} m/sec, with the higher values representing slightly sandy horizons. Additional testing of the Cretaceous materials indicated an average permeability of 1.1×10^{-8} m/sec. The permeability for the underlying weathered bedrock ranges from 1.8×10^{-6} m/sec and 2.2×10^{-10} m/sec and the bedrock ranges from 4.6×10^{-8} m/sec to 1.6×10^{-10} m/sec. It should be noted that actual permeability is likely to be lower as field testing such low permeability materials is difficult and can result in false elevated readings.

The area of the WRD where there is a significant thickness of alluvial sediments is within the Undai channel. These alluvial gravels along the Undai channel represent a source of granular material for Oyu Tolgoi and also in their present state represent a thin shallow alluvial aquifer. Leaving such alluvial materials in place below the WRD poses a number of issues:

- The loss of the beneficial utilisation of the granular materials (such as for building materials);
- Any interaction between the infiltration through the WRD and/or inundation of the PAF at the base of the WRD could result in the underlying aquifer within the Undai sediments becoming acidic; and
- Some of the sand and gravel deposits are expected to be loose and if saturated could present a geotechnical risk. Removal of the gravels will also remove any liquefaction concerns with the gravels and sands below the dumps (these are the only sediments where liquefaction is a concern due to their water content).

For these reasons, it is preferred that the majority of the alluvial gravels be removed from below the WRD. The removal of the alluvial gravels will create a depression which represents additional volume for the WRD, but will need to be backfilled with NAF so that in the future if there is any pooling of water this does not become acidic.

In the northern parts of the WRD, the alluvial gravels and subsurface topography will result in natural drainage along the base of the clastic materials towards the open pit. In these areas no special treatment (removal) of the gravels is warranted and the decision on whether to utilise the resource or leave them in place is an economic decision. NAF materials will be used preferentially used to backfill any void created where gravels are excavated, where gravels are left in place to reduce the potential for any contact between water in the alluvium (if present) and PAF which could result in the development of acidic drainage.

The general direction of surface drainage flow, based on current topography, is shown in *Figure 5.18*. The majority of the topography underlying the WRD slopes towards the Undai channel. Should surface runoff from flash rain storm events occur, some sediment is expected to run off the WRD face and a minor amount may infiltrate the top of the WRD. Since the WRD materials are expected to be at least one or more orders of magnitude higher in permeability than the underlying sediments, water percolating through the WRD will also find its way towards the original Undai channel and then flow to the pit or the toe collection ditch established around the southern perimeter of the WRD.

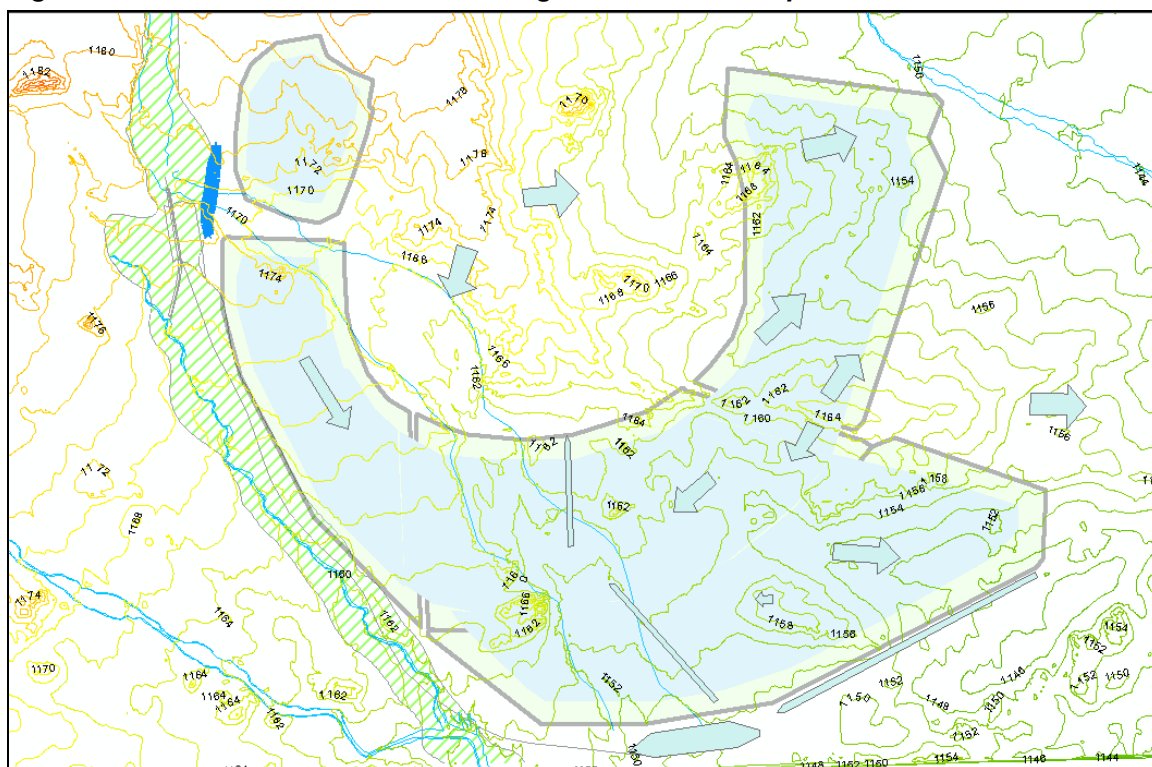
The natural drainage at the base of the eastern part of the WRD is from the northwest down to the southeast at an average gradient of approximately 0.5 percent. In the north-eastern section of the WRD, drainage is towards the east-northeast, and beneath the southeast WRD area flows eastward. Both of these are essentially towards Cell 1 of the TSF. A surface water collection and interception ditch will be established on the north side of the TSF and a toe collection ditch will be established around the entire perimeter of the TSF into which the south-eastern WRD toe collection ditch will then tie and any water ultimately captured in the TSF toe collection pond on the east side.

A toe ditch will be established along the southern perimeter of the WRD. This will continue southwest along Undai, with a 45 m offset from the relocated river providing sufficient room for an (elevated) roadway, toe collection ditch (10 m width with slopes) and monitor well pads (set off roadway), and lead to the Undai channel collection basin. Any surface run off from the southern face of the WRD face will be collected in a seepage collection basin to be established across the current Undai channel. This will be established to the north of a cut-off constructed of separated Cretaceous clay. The timing of this construction is dependent on the WRD advance and is only needed when surface collection ditches can no longer route run off to the TSF collection pond.

The quality of seepage or surface runoff collecting in the collection basin at the southern side of the WRD will be evaluated against Mongolian water discharge standards. Based on column testing the PAF is likely to exhibit various lag times before the onset of acid drainage if this occurs, if acid drainage occurs the column test have demonstrated that this leachate may have elevated concentrations of Al, Co, Cu, Fe, Mn and Zn and Ni. Any water collecting in the basin will be analysed to assess its compliance with Mongolian water discharge standards with respect to these metals and other parameters, and if compliant with these will be released to the Undai. Water exceeding these standards will be either allowed to evaporate or trucked back to the main facility and used for dust suppression or process make-up water.

In the longer term if considered to be required directional drilling will be used to create a positive flow of any pooled seepage water back to the open pit.

Figure 5.18: General Orientation of Drainage below WRD Footprint



Source: Oyu Tolgoi

Several sensitivity analyses have been completed by Oyu Tolgoi to evaluate how much NAF is available to cover the WRD and TSF. The minimum WRD NAF cover is expected to be 3 m on the top. The minimum NAF covering the TSF is less than 1 m (where PAF tailings are placed) and is essentially a wind erosion cover. Order of magnitude estimates of the availability of NAF for the 15 year mine plan are as follows:

Table 5.3: Available NAF and Placement Options

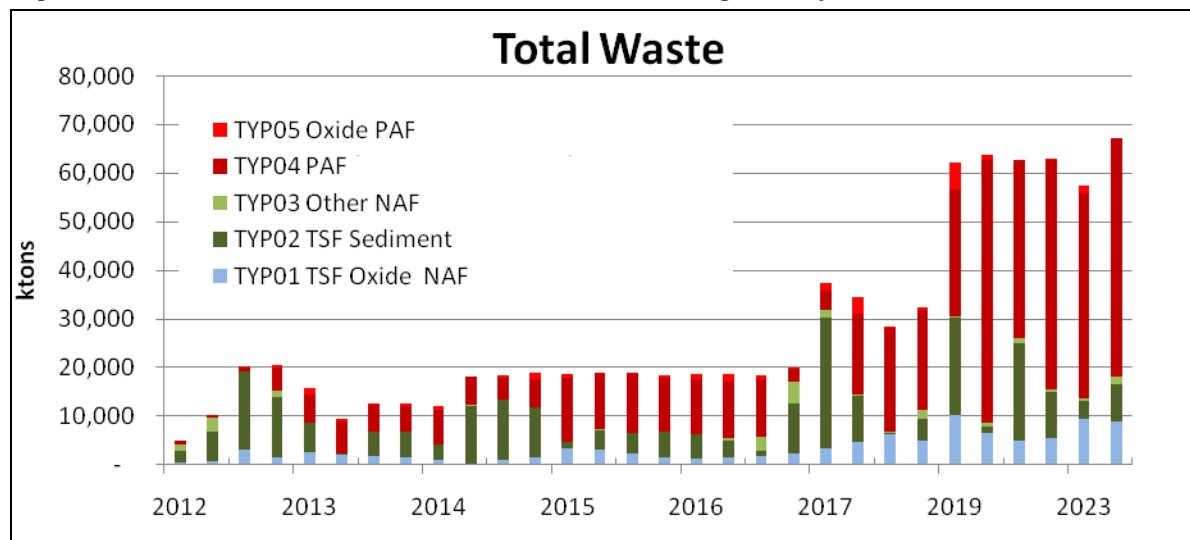
Option	WRD slope Cover, m	WRD Top Cover m	TSF Top Cover m	Remaining NAF (Mtons)
1	20	3	1	250
2	10	3	1	423
3	30	5	1	62

It is observed that up to 30 metres of NAF would be available to place on the perimeter of the WRD. However, it would be desirable to allow for sufficient NAF to be stockpiled for future usage on TSF cells 3 and 4 or to provide additional cover in the future should some areas of the WRD become acidic. In addition, the future (Hugo underground) tailings are expected to be more acid generating and NAF will be needed to cover these materials. For these reasons, Oyu Tolgoi has selected Option 2 and will stockpile NAF for future usage and provides such an “extra NAF” allowance.

During the initial mine production, it is expected that most of the pre-strip NAF will go to either to an intermediate WRD for later transfer to the TSF or directly to the TSF for embankment construction. PAF materials will begin to be developed from the pit in mid 2012. A semi-permanent ramp system will be constructed that extends to the end of the ultimate WRD. This ramp will be used to provide access to several WRD lifts over the mine life. Secondly, the ramp will allow access to the dump exterior, so that when NAF materials are available they can be placed closer to their final resting position (versus

rehandling NAF at closure). The WRD types generated during the initial 5 year mine plan are shown in *Figure 5.19* below; illustrating the fact that NAF and PAF are generated in parallel, with the majority of NAF in the early years being designated for the development of the TSF.

Figure 5.19: Generation of NAF and PAF materials during initial years of mine life



The dumps will be constructed to an ultimate notional height of 90 using 2 to 15 m high angle of repose lifts. NAF material will be placed along the outer slopes to provide a closure cover. A variable set back distance of 35 to 50 m will be used between individual 30 m lifts. This will allow future flattening of the slopes to a pseudo concave shape with overall slopes of approximately 2.5:1. Slopes will be flattened by dozer push, resulting in NAF materials being spread along the outer portion of the WRD. Intermediate benches to capture surface run off and provide access will be provided. The intermediate and final WRD slope configuration is shown in *Figure 5.20*, which also shows the 3 m thick layer of NAF at the base and 10 m thick cover of NAF over the top of the WRD. The beneficial use in the base of NAF are still being evaluated as the use of the 3 m thick layer of NAF at the base may not have any environmental benefits and could be better used on the upper layers or elsewhere. The reasons for this are: because:

- The NAF is not demonstrated to have or improve attenuation capacity;
- The WRD footprint is currently NAF, so one would just be raising grade at considerable cost; and
- In some cases, NAF may be lower K, which would inhibit free drainage of dump.

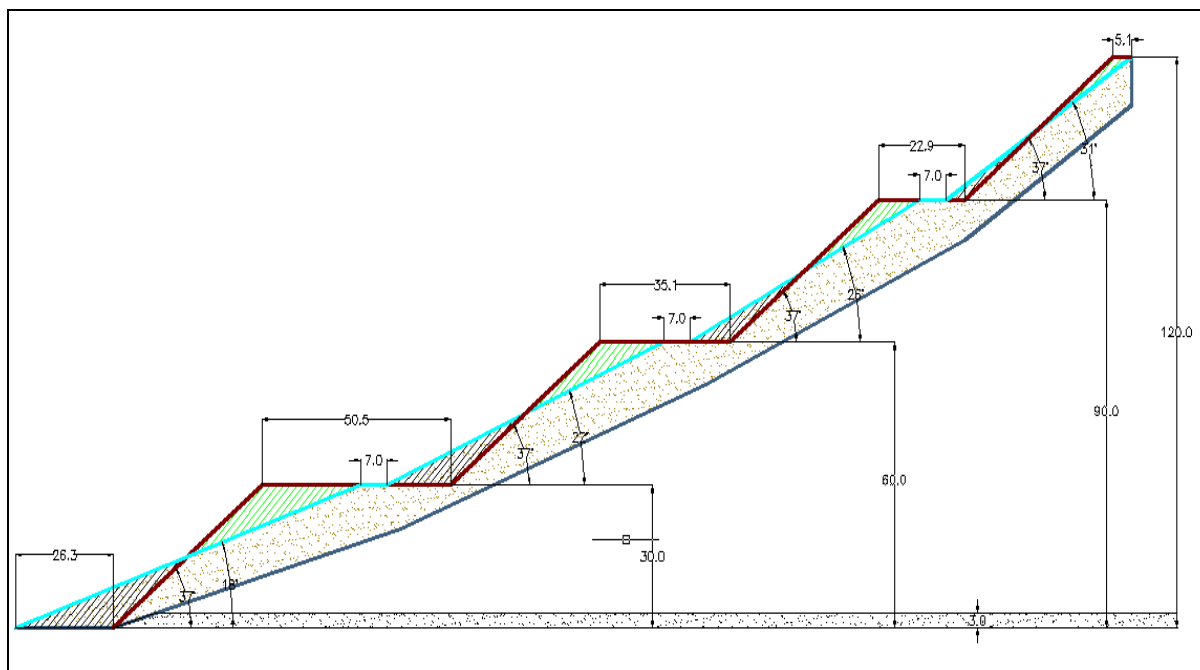
Oyu Tolgoi will further evaluate this before making a decision.

The WRD will be designed to achieve the following minimum factors of safety (FS), although actual factors of safety are likely to be higher as a consequence of other design factors:

- Static: FS > 1.5 (long term, drained);
- Static: FS > 1.3 (undrained, construction condition); and
- Seismic FS > 1.2 (1,000 yr return).

The strength properties of the Cretaceous clay and soils underlying the TSF are similar to those underlying the WRD. In addition, the highly plastic clay also acts as an aquiclude preventing migration of surface water migrating through the WRD seeping into the subsurface. Stability of the WRD on the bedrock and alluvium is not a concern, provided that any areas of alluvial gravel and sands which are left in place are proven to be non-liquefiable.

Figure 5.20: Plan of exterior slope of dump



Key: Black horizon represents the construction topography, light blue horizon represents the closure topography and dark blue line the base of the protective NAF layer covering the WRD.

Note: The top 120 m bench is illustrative and unlikely to be used.

Mitigation and Monitoring of Water Resource Contamination Impacts

The potential issues associated with acid rock drainage from the WRD will be dealt with through the development of detailed designs for the WRD which include the collection system and the methodology for the identification of PAF and its placement in the WRD. In addition a cut-off wall will be installed across the Undai down-gradient of the WRD which will prevent any migration of groundwater through the alluvial sediments and cause it to flow back to the open pit. Additional monitoring wells will also be installed along the re-routed Undai channel, downstream of the seepage collection pond, and down slope of the southeast section of the WRD to enable Oyu Tolgoi to monitor the effectiveness of the cut-off wall and respond early to address any seepage if this passes past the cut-off wall. Direction drilling may be used to create a gravity-based flow channel into the pit if the long term management of the leachate indicates that this is necessary. The detailed *Waste Rock Management Plan* will be developed before the start of commercial operations with the aim to ensure that environmental controls minimise the potential for acid generation and capture any discharges from the WRD. The design of the WRD and management of leachate management will take account of applicable international standards such as those in the EU (e.g. Mine Waste Directive 2006/21/EC).

Impact Significance

The use of a 10 m thick layer of NAF over the WRD will reduce the potential for storm water to contact PAF waste rock and minimise the potential for acid generation. The installation of drainage ditches around the WRD and the placing of a cut-off wall across the Undai down-gradient of the WRD will reduce the potential impact of the WRD on groundwater in the superficial aquifers and particularly the Undai sediments to **minor-adverse**. Although seepage is expected to be minimal, the seepage collection system on the eastern part of the WRD is designed to collect all seepage arising from this part of the WRD and deliver it to the TSF area and deliver it ultimately to the process water pond which will contribute to reducing the demands on the Gunii Hooloi aquifer. The potential impact of the WRD on the surface water systems is considered to be **minor-adverse**.

5.5 MONITORING AND PERFORMANCE

5.5.1 Water Conservation

Minimising water use throughout all the operational aspects of the Project is a key focus of Oyu Tolgoi which aims to minimise its impacts on the water resources of the area. Oyu Tolgoi recognises that it has a responsibility to the local community and Mongolia to manage the water resources it uses carefully and efficiently. The conservation of water will be an ethos of the Oyu Tolgoi's operations²⁹ which is instilled in its workforce, and is currently a focus of education during the construction phase as reflected in the signage around washing and other areas.

Although the construction phase will be utilising water, the volumes are relatively insignificant compared to the operational phase; furthermore the dewatering on the mining Licence is a useful precursor to the dewatering that will be required for the opening of the pit. The conservation of water through the construction phase is focused on minimising water use (e.g. in washrooms) and recycling water (e.g. the use of effluent from the wastewater treatment plant as makeup water for the concrete batch plant). Due to the dynamic nature of the construction efforts there have been no KPIs developed, as there will for the operational phase.

The construction water supply usage has been calculated on a per capita basis which has been verified through metering of water into the camp and water received at the WWTP. Based on this the per capita allowance has been calculated as follows:

Table 5.4: Per Capita Water Allowance

Usage	Per Capita Allowance
Personal Use Only	214 L/p/day
Kitchen & Laundry	36 L/p/day
Total Usage within Camp	240 L/p/day

This calculated allowance was cross-checked against observed usages and measured flow rates at a system level as presented in *Table 5.5*, which indicated that the average per capita allowance was adequate.

Table 5.5: Estimated Maximum and Minimum Personal Water Use

Unit	Volume/Use (Litres)		Times per day		Daily Usage (Litres)	
	Min	Max	Min	Max	Min	Max
Hand Basin ¹	1	15	3	8	3	120
Hand Basin private washroom ²	0	25	0	1	0	25
Shower ³	10	90	1	1	10	90
WC Full Flush	6	6	1	2	6	12
WC Half Flush ⁴	3	6	4	6	12	36
Total					31	283

Notes: ¹ max flow based on 0.5L/sec for 30 sec without using plug

² min is those who don't use hand basin for private washing, max based on 5 L/min for 5 min

³ max shower flow rate about 18L/min, min comfortable rate would be about 10L/min

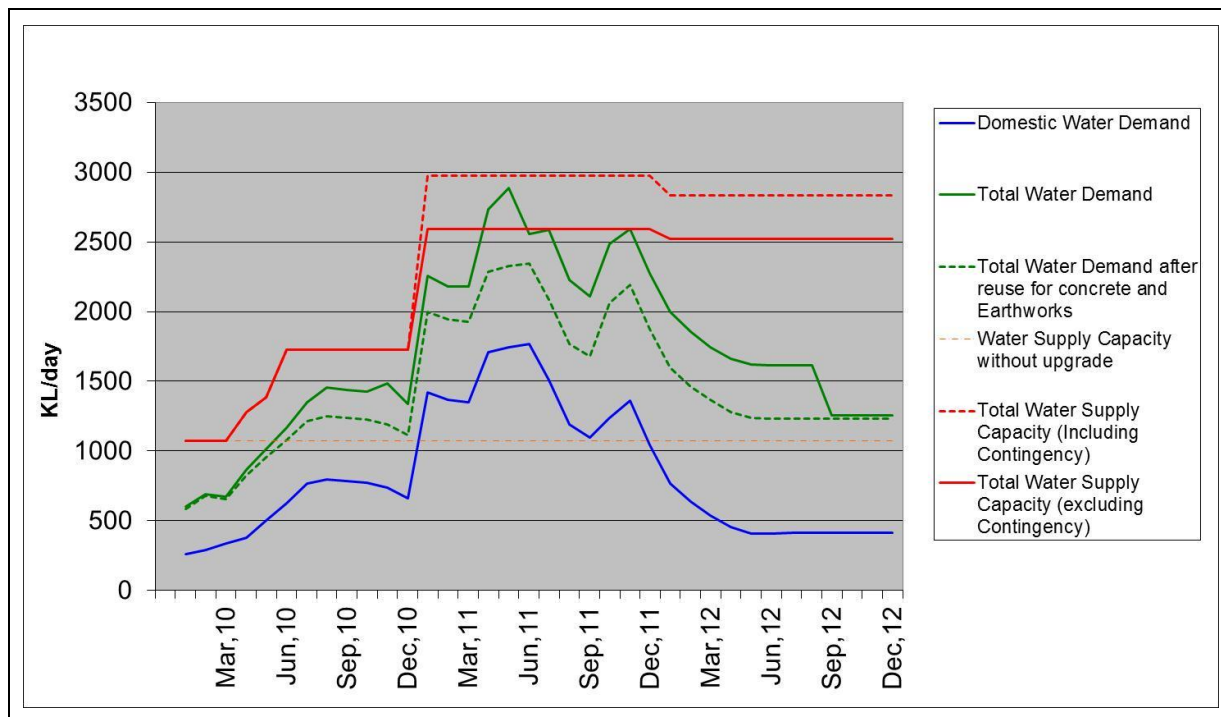
⁴ max based on not using half flush

This appraisal of water use on a personal level allows Oyu Tolgoi to focus efforts on efficient sanitary equipment. The option of using recycled water for toilets has been considered and subsequently rejected as its use in the concrete batch plant is equally valuable (in terms of water conservation measures) and less technically challenging.

²⁹ This is emphasised in the Investment Agreement (2009) Clause 6.20; where Oyu Tolgoi is committed to applying modern technology and procedures to minimise the volume of water used.

The water demands for the construction phase are presented in *Figure 5.21*, which illustrates peak in water demand through construction in the second quarter of 2011. The reduction in water demand as a result of using the treated wastewater as part of the water feed for the concrete batch plant and earthworks is also illustrated in *Figure 5.21*. Overall Oyu Tolgoi has achieved very high recycling rates with the result that 96% of the water demand is for the camps and almost all the water for the concrete plant and dust suppression comes from treated wastewater from the waste treatment plant.

Figure 5.21: Construction Water Supply Demand model January 2010 – December 2012



The late construction and operational phase of the Project will utilise the water from the Gunii Hooloi borefield with the main water use during operations being in the production plant (i.e. the concentrator).

The approximate water balance for the operational phase of the Project is presented in *Table 5.4*. This water balance is being refined but the key features this illustrates are the volume of water that is recycled back to the Process Water Pond; primarily from the tailings thickener and pond, but also the significant recovery percentages from the wastewater and the grinder cooling.

The features of the water recycling during the operations based on the current plans are:

- 83% of production water will be recycled with the 17% of additional water required being will be supplied from the ground water reserves in Gunii Hooloi (in reality some of this 17% will be provided from the water captured in the pit);
- 80% of drinking and public use water will be treated and recycled into the production water with the remainder put to useful purposes as Oyu Tolgoi has also adopted a policy that no wastewater will be directly discharged to the environment; and
- 50% of water used for cleaning machinery and equipment will be re-used.

These recycling figures will be further refined and improved wherever possible³⁰, these recycling figures will form a key performance indicator for Oyu Tolgoi. The greatest loss of water from the system, is through the water retained in the tailings which equates to approximately 66% of the total as illustrated below.

³⁰ Currently the percentage of recycling is rounded to the nearest full number, Oyu Tolgoi recognise that fractional improvements will, particularly when considered over the life of the mine, result in a significant water saving leaving more water in the Gunii Hooloi aquifer for future users.

Figure 5.22: Water Losses as a Percentage

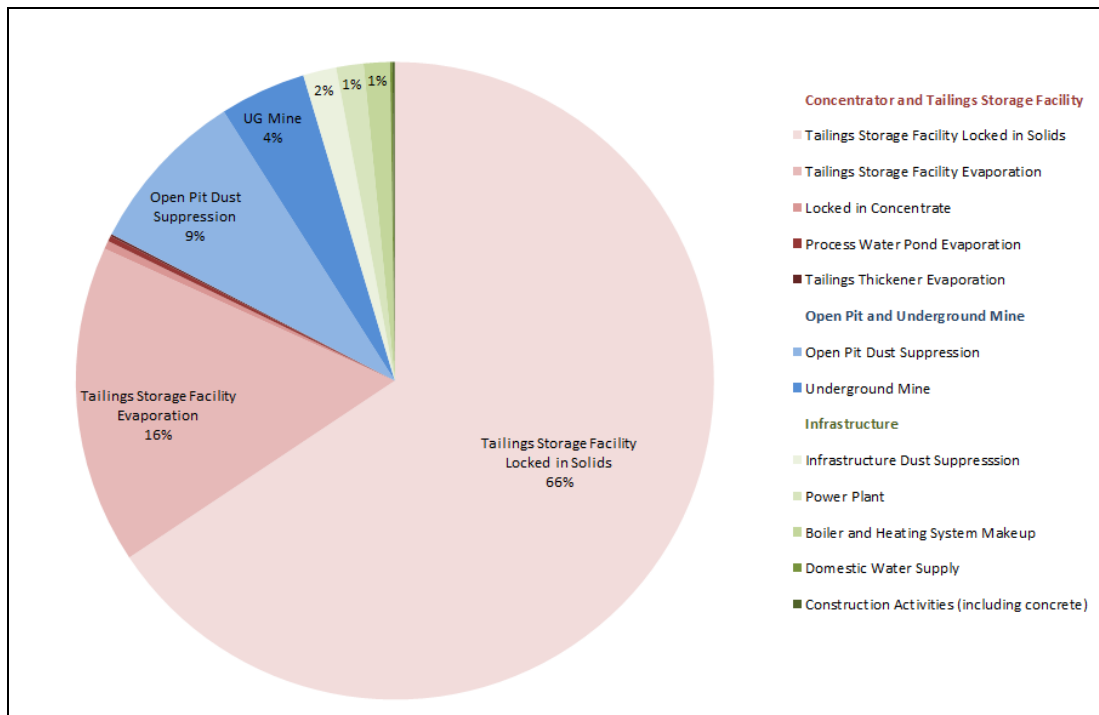
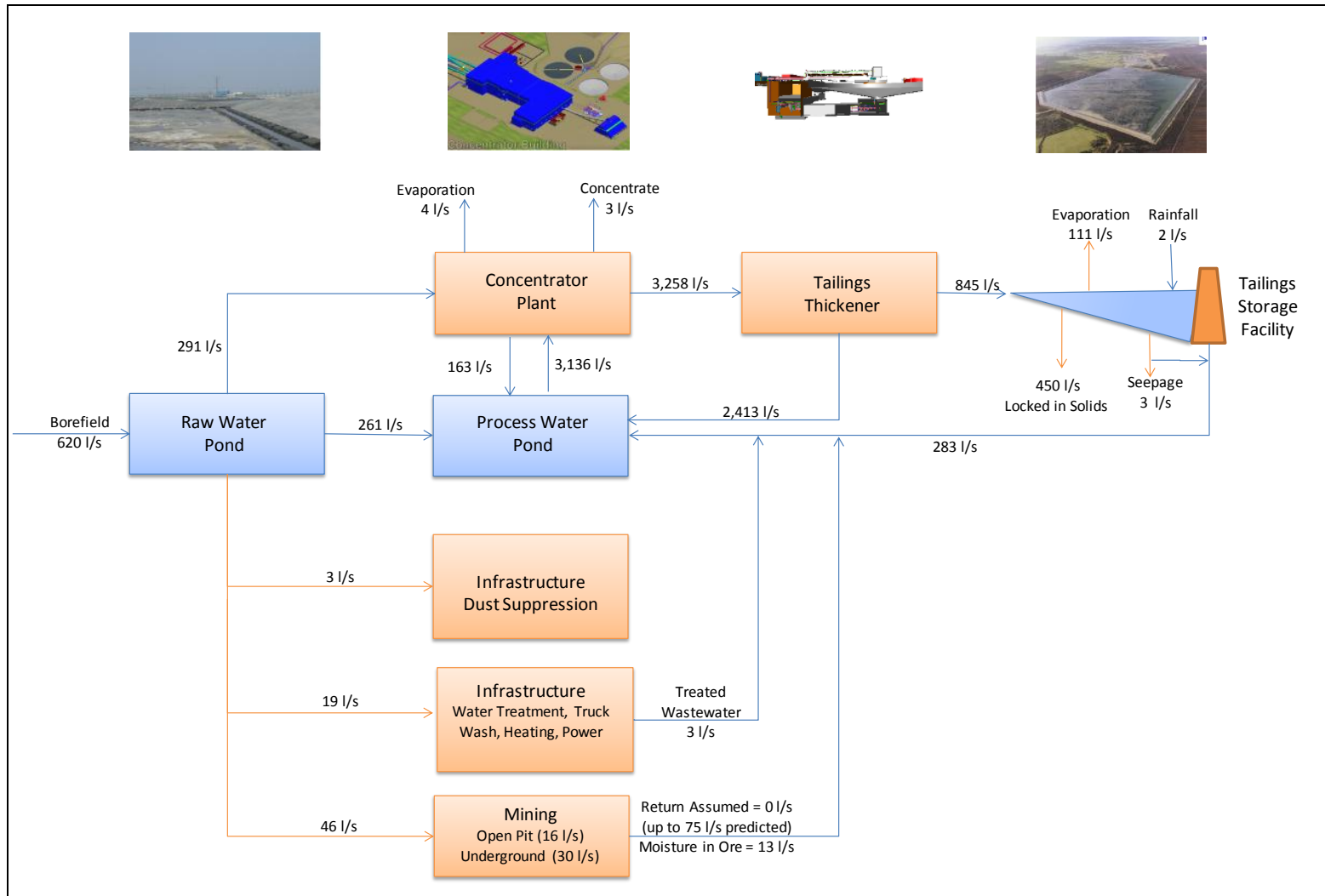


Figure 5.23: Simplified Water Balance for the 100,000 tpd Case



Note: Values in litres per second. Seepage from TSF is for active cell only

Oyu Tolgoi is a world class Project and will measure itself against other world class mines, this will include assessing factors such as litres of water used per tonne (L/T) of ore processed. The current assessment is that the Project will use 750 L/T. Which compares favourably with other comparable sized operations in similarly arid conditions such as Chuquicamata, operated by Codelco in Chile. The division of Codelco containing Chuquicamata achieves a water use of 800 L/T³¹ processed and water recycling rate of 73% (compared to Oyu Tolgoi's better rate of 83%). Oyu Tolgoi will seek further comparable international operations with which to develop a benchmarking exercise, this is underway and initial indications are that Oyu Tolgoi is within the top quartile with respect to water efficiency by comparison to the mines in Chile (average Chilean Concentrator use is 810 L/T). This data is subject to more detailed assessment to ensure that the comparison is a like for like comparison, and that all the water usage includes rainfall contribution and site admin needs and excludes other water demands (such as for a smelter). This detailed analysis may also allow Oyu Tolgoi to identify further best practise which it can implement.

Overall, Oyu Tolgoi aims to be the most efficient mine of its type worldwide in terms of the volume of water used per tonne of processed ore. With this goal in mind, the following water conservation initiatives have already been implemented as part of mine planning and design:

- **High-efficiency Tailings Thickeners:** Recent design improvements in tailings thickening techniques have enabled an increase in tailings solids content to 64%, which represents high-density tailings and which significantly reduces the amount of water sent to the tailings storage facility (TSF). These design modifications greatly reduce the amount of reclaim required from, and the evaporative losses that would occur in, the TSF;
- **High-efficiency TSF Reclaim:** The TSF has been designed so that tailings are deposited in discrete cells, rather than broadly across the facility, to reduce evaporative losses. The entire base of the TSF rests on natural or installed clay and includes a seepage collection system to minimise seepage losses. The TSF reclaim system has been designed to ensure that all supernatant water and collected seepage is returned to the process plant for reuse;
- **100% Cooling Water Reuse:** Within the concentrator, the areas of greatest water use are the grinding mills and air compressors, where clean raw water is required for cooling. All discharge from the cooling systems is sent to other areas that require clean water, such as pump gland seal water, reagent mixing, the tailings booster pumps, and spray water for dust suppression;
- **100% Mine Water Recovery:** All water encountered in the underground and open pit mines will be recovered via the TSF reclaim system for use as process water or for dust suppression. Recovery of mine water will help reduce site demand for raw water from the Gunii Hooloi aquifer;
- **100% Treated Wastewater Reuse:** All treated wastewater produced in the site wastewater treatment plant has been designed to be reused. During the construction period, treated wastewater is planned to be used for road dust suppression and for concrete production. During operations, all treated wastewater will be reused in the process plant;
- **100% Truck Wash Water Reuse:** A comprehensive water treatment system has been designed at the Project mine truck washing facility to allow all truck wash water to be continuously recycled and reused;
- **Lagoon Floating Cover:** A floating cover will be placed over the entire raw water storage to eliminate evaporative water losses and prevent the accumulation of dust within the lagoon; and
- **Proactive choice of low or zero water equipment:** Examples of this include the incinerator and air cooled central heating plant.

In support of the water conservation policy, further innovative water conservation measures will continue to be investigated and implemented during the Project operations period. Recognising that water lost to the tailing facility is the most significant element Oyu Tolgoi is working on a number of strategies which are aimed at firstly reducing the volume of water going to the tailing, secondly increasing the recovery of water from the TSF and thirdly reducing evaporation from the TSF to increase recovery. Other initiatives

³¹ Codelco Norte sulphides and oxides - Codelco Sustainability Report 2010

include reducing the slimes quantity, and SAG mill pebble sorting. The use of advanced dust suppressants are being assessed in order to reduce the amount of water used.

Should there be a future expansion of the plant to 160,000 t/day the water demand is likely to increase to approximately 900 l/s (provisional estimate which includes contingency), which is greater than the permitted 870 l/s. This additional water supply if required may be achieved through the implementation of some of the innovative water saving proposals outlined above; or if this cannot be achieved then through expansion of the drilling in the Gunii Hooloi, development of Galbyn Gobi or Gunii Hooloi NE basins .

If there is a future water demand for a power plant on the site, this will be air cooled to minimise the water requirements and would be expected to require an additional 20 l/s.

5.5.2 Monitoring and Key Performance Indicators

The monitoring and key performance indicators presented in *Table 5.6* below draw on the key points raised in this Chapter and recognise the importance of water both at the local level but also as a strategic country resource. Oyu Tolgoi is committed to ensuring the continuity of supply for other water users around the Project and this is documented in the Environmental Protection Plans in the various Detailed Environmental Impact Assessments. Oyu Tolgoi will also take a proactive approach to any issues that arise with herder wells, and take responsibility for assisting them to rectify any issue and restore their supply even if there is no direct connection with the activities of Oyu Tolgoi. All such works will be to restore the same level of supply and not notably increase the herders supply, thus ensuring that the current balance between herd numbers and pasture stresses is not negatively affected.

Oyu Tolgoi's monitoring and key performance indicators are summarised below in *Table 5.6*.

Table 5.6: Key Monitoring Measures and Key Performance Indicators

Potential Impact	Management, Mitigation & Improvement	Key Monitoring Actions	Key Performance Indicators
Dewatering of the Gunii Hooloi aquifer	<ul style="list-style-type: none"> ■ The partial dewatering of the Gunii Hooloi aquifer is an inevitable result of the Project. ■ Water reduction, recycling and management will be a core focus of the Project through all phases. ■ Regular review of water efficiency measures to seek continual improvement. ■ All water use figures to be published to allow public scrutiny. 	Water use monitoring throughout operations	<p>Core KPI: water use per tonne of concentrate produced.</p> <p>Subsidiary KPI for water recycling on key plant including and not limited to tailing thickener, tailings pond, wastewater treatment plant, and grinder cooling water.</p>
Dewatering of herder wells	<ul style="list-style-type: none"> ■ Regular monthly monitoring of herder wells, monitoring wells and rainfall/snowfall. ■ Critical QA/QC and review of water level fluctuations to determine the driver(s) for variations. ■ Critical review of monitoring programme to ensure it delivers the monitoring data required to provide Oyu Tolgoi with a robust appreciation of the shallow aquifer behaviour. ■ Participation of community/herders in monitoring and presentation of base data to those who request it. ■ Development of detailed action plan to address any impacts on water levels (due to climate change, actions of Oyu Tolgoi or other factors). ■ Commitment to continuity of supply for all water users around the Project. 	Monthly water monitoring across herder wells and monitoring network	<p>Constant base water levels in herder well with fluctuations above this only due to seasonal recharge.</p> <p>No complaints regarding water depletion of shallow aquifer.</p>
Early drying up of springs	<ul style="list-style-type: none"> ■ Ensure Undai diversion is effective and permanent solution. ■ Continuation of monthly monitoring of spring levels and regular water quality monitoring 	Monthly qualitative water monitoring across all springs downstream of mining Licence and	<p>Regular season fluctuations in water levels in springs following pattern observed since monitoring began.</p> <p>No complaints regarding springs</p>

Potential Impact	Management, Mitigation & Improvement	Key Monitoring Actions	Key Performance Indicators
	including the participatory monitoring programme. <ul style="list-style-type: none"> ■ Creation of new spring to replace the Bor Ovoo spring lost due to the diversion of the Undai and construction of the WRD. ■ Development of mitigation measures to address unseasonal falling spring water levels, including as required re-engineering of Undai diversion. ■ Commitment to continuity of supply for all water users around the Project. 	also baseline springs outside of Project influences e.g., around Khanbogd Massif	drying prematurely or permanently.
Impact on groundwater dependant vegetation	<ul style="list-style-type: none"> ■ Regular surveys of indicator species such as Siberian Elms. ■ Monitoring of water levels in selected ephemeral watercourses. ■ Development of mitigation measures to address unseasonal decreases in groundwater levels in shallow alluvial aquifers. 	Monitoring of indicator species	No un-natural die back of groundwater dependent vegetation.
Contamination of Groundwater from TSF and WRD	<ul style="list-style-type: none"> ■ Compliance with detailed engineering designs for the TSF and WRD to ensure that any potential seepage is captured and either recycled or proven to be acceptable for release to the environment. ■ Monitoring of seepage, surface water and groundwater, with critical analysis of the data to ensure early identification of any potential issue. 	Detailed monitoring programme around the WRD and TSF	No ARD impacts to surface or groundwater.

It is recognised that the KPIs for water will be used for internal focus and improvement; and also a source of information and debate with the local community and national organisations. Therefore the KPIs will be further developed to respond to and address as appropriate any additional information which is sought by others. The KPIs are reflected in the water and wastewater management plans (see *Chapter D7: Water Resources Management*)

5.6 SUMMARY OF RESIDUAL IMPACTS

The baseline studies and modelling of the surface and groundwater levels and quality undertaken by Oyu Tolgoi have provided an extensive and defensible appreciation of the potential impacts of the Project on the water resources of the area and their users. The relocation of the herder winter camps from within the mining Licence in 2004 (see *Chapter D15: Resettlement Action Plan*) has reduced the potential for impacts on the herder water supplies during the operational and closure phases. Underlying all of Oyu Tolgoi's approach to potential impacts is the commitment to the continuity of water supply for the herders, their herds and the local fauna and flora. A key aspect of this is the proactive approach Oyu Tolgoi is taking to any issues raised with water supply, where it takes responsibility for assisting the impacted herders to re-instate their water supply (such as the current work with the herder near the airport) even if there is no direct linkage between the water supply issues and Oyu Tolgoi's activities.

The Project will exploit a deep aquifer for its water supply which will not be recharged quickly; however the Project will only require approximately 15% of the available water resources, leaving water for other users in the future. The modelling to date has indicated that there is potential, although limited, impact on one herder well, with a further three wells identified with a low likelihood of impact. The water and environmental monitoring regime in place, and other initiatives such as the participatory monitoring programme will enable early detection of any impacts and the design of appropriate mitigations to ensure that the livelihoods of the herders and their local herding patterns are unaffected. The current refinements of the groundwater model will also enable Oyu Tolgoi to better understand the potential magnitude (if any) and timing of impacts on these herder wells.

The PEM Programme is the programme which Oyu Tolgoi will implement with local potentially affected herders to ensure that monitoring of herder well water levels and quality is undertaken in a transparent manner that builds and maintains trust between the Project and local herders. If issues are identified, Oyu Tolgoi will work with local potentially affected herders to develop, implement and monitor a mutually-acceptable solution (such as the provision of an alternative water supply through the construction of a new water borehole). Such mitigation measures are simple and achievable.

The diversions to the ephemeral watercourses, such as the Undai, will be permanent and will be designed to provide a sustainable permanent solution which will not require future maintenance, and will protect the watercourse and the associated linear aquifers from impacts.

The work being commissioned by Oyu Tolgoi to identify a sustainable water source to support the expansion of Khanbogd will, in conjunction with others (e.g. Asian Development Bank), result in a much improved water supply to the *soum* centre. The objective is to develop a groundwater resource which is at a sufficient distance from the community that the risk of contamination (such as from sewage) is minimal and thus will provide a supply which will require minimal treatment before it enters the reticulation system.

Throughout the Project phases the continuation of the baseline monitoring, with additional monitoring added where necessary will ensure that the Oyu Tolgoi's appreciation of the potential impacts is developed further and appropriate mitigation measure can be developed to maintain the surface water resources of the areas for the local people, fauna and flora.

Table 5.7 below provides a summary of likely impacts on Water Resources.

Table 5.7: Summary of Impacts: Water Resources

Impact	(1)Receptor/ Beneficiary	(2) Phase	(3) Impact Categorisation	(4) Potential Significance	Design and Mitigation Measures	Management Plan	Residual Significance
Loss of surface flow, and subsurface flow of 6.8 km in Undai due to the Diversion	Herders, fauna and flora	C, O, D	Scale: Local Duration: Permanent Type: Negative	Consequence: Moderate Likelihood: Certain Significance: Moderate Adverse	<ul style="list-style-type: none"> Installation of a diversion that effectively diverts the surface and groundwater flows in the Undai around the mine, and ensures that the lower reaches remain unaffected. Design by an internationally recognised consultant with international experience in river diversion systems. Sequencing of the installation of the diversion and use of grout curtains to minimise disruption of surface and/or groundwater during construction. Designed so that erosion and sedimentation in the Western Channel will result in the creation of a dynamic river system similar to the Undai. 	Water Resources Management Plan (<i>Chapter D7</i>)	Minor Adverse
Loss of Bor Ovoo Spring	Herders, fauna and flora	C, O, D	Scale: Local Duration: Permanent Type: Negative	Consequence: Moderate Likelihood: Certain Significance: Moderate Adverse	<ul style="list-style-type: none"> Creation of new spring in the Undai downstream of the site which replicates the size, nature, water availability and water quality of the Bor Ovoo. Open and transparent monitoring of success of new spring and other downstream springs and wells through participatory environmental monitoring programme. Monitoring of the effectiveness of the new replacement spring through monitoring its use by herd animals and wildlife. 	Water Resources Management Plan (<i>Chapter D7</i>)	Minor Adverse
Impacts on Khukh Khad, Maanit and Burkhant springs from diversion	Herders, fauna and flora	C, O	Scale: Local Duration: Short Term Type: Negative	Consequence: Moderate Likelihood: Unlikely Significance: Moderate Adverse	<ul style="list-style-type: none"> Diversion of the alluvial groundwater flow in Undai around the mine into lower reaches of the Undai to ensure that any impact on groundwater flow to the springs is negligible. Monitoring of water quality and quantity in springs to ensure that there is no significant variation in quality or quantity as a consequence of the diversion. Monitoring of flows through the diversion pipeline to ensure that it is working effectively and contributing to groundwater recharge upstream of these springs. Implement effective remedial measures if any monitoring indicates that the engineered 	Water Resources Management Plan (<i>Chapter D7</i>)	Minor Adverse

Impact	(1)Receptor/ Beneficiary	(2) Phase	(3) Impact Categorisation	(4) Potential Significance	Design and Mitigation Measures	Management Plan	Residual Significance
					solution is not effective and may have a significant impact on the springs.		
Degradation or losses of surface water resources in the Undai and Budaa due to the diversions	Herders, fauna and flora	C, O, D	Scale: Local Duration: Long Term Type: Negative	Consequence: Moderate Likelihood: Unlikely Significance: Moderate Adverse	<ul style="list-style-type: none"> Detailed engineering solutions to the diversions to ensure that they are robust and sustainable, and ensure that surface water resources are not degraded, but passed effectively around Oyu Tolgoi's operations, including the subsidence zone. Monitoring of the physical behaviour of the diversion to ensure that it is effective, and is achieving the design criteria. Undertake any necessary improvements to the design identified by the monitoring, quickly and efficiently. 	Water Resources Management Plan (<i>Chapter D7</i>)	Negligible
Contamination of surface water from hazardous chemicals, fuel spills, leaks and uncontrolled storm water release	Surface water	C, O	Scale: Local Duration: Short Term Type: Negative	Consequence: Minor Likelihood: Unlikely Significance: Minor Adverse	<ul style="list-style-type: none"> Use of appropriate storage, of hazardous materials and regular disposal of wastes to Oyu Tolgoi's waste management facility. Diverting storm water around plant areas and capturing contact water for settlement and testing before release or use in the process. 	Hazardous Materials Management Plan (<i>Chapter D12</i>) and Waste Management Plan (<i>Chapter D8</i>)	Negligible
Dewatering of shallow quaternary and alluvial aquifers around the open pit and block caving	Herders, fauna and flora	C, O, D	Scale: Local Duration: Permanent Type: Negative	Consequence: Moderate Likelihood: Certain Significance: Moderate Adverse	<ul style="list-style-type: none"> Development of a refined groundwater model to verify that there are no users of this groundwater within the groundwater cone of depression created. If there are any springs or wells then mitigation measures will be developed. Diversion of the Undai away from the central cone of depression and positioning of the groundwater pipeline inlet and outlet, outside of the area of significant drawdown. Participatory environmental monitoring to ensure local stakeholders are involved in developing necessary mitigations. Monitoring of drawdown will be undertaken to evaluate impacts and ensure that there are no impacts on local herder wells outside of the area or springs. Evaluated any impacts detected and where necessary implement alternative permanent 	Commitment to continuity of supply in accordance with EPP in DEIA Water Resources Management Plan (<i>Chapter D7</i>)	Minor Adverse

Impact	(1)Receptor/ Beneficiary	(2) Phase	(3) Impact Categorisation	(4) Potential Significance	Design and Mitigation Measures	Management Plan	Residual Significance
					solutions.		
Pollution of shallow groundwater aquifer from spills or leaks of fuel, oil, chemicals or sewage water	Groundwater	C, O	Scale: Local Duration: Short Term Type: Negative	Consequence: Minor Likelihood: Unlikely Significance: Minor Adverse	<ul style="list-style-type: none"> Use of appropriate storage, of hazardous materials and regular disposal of wastes to Oyu Tolgoi's waste management facility. 	Hazardous Materials Management Plan (<i>Chapter D12</i>) and Waste Management Plan (<i>Chapter D8</i>)	Negligible
Increased sediment load in flood events due to construction works in watercourses	Surface Water and flora	O	Scale: Local Duration: Short Term Type: Negative	Consequence: Negligible Likelihood: Likely Significance: Negligible	<ul style="list-style-type: none"> Avoid working in watercourses when flash floods may occur and restore areas to avoid increased erosion of sediments. Culverts to be designed to accommodate 1 in 1,000 year floods and allow the passage of flood water with minimal interruption and minimum increased scouring. 	Water Resources Management Plan (<i>Chapter D7</i>)	Negligible
Reduction in connectivity and conductivity of alluvial aquifers crossed by the pipeline excavation and subsequent impact on downstream groundwater levels	Groundwater, Herders	C.O	Scale: Local Duration: Long Term Type: Negative	Consequence: Moderate Likelihood: Unlikely Significance: Moderate Adverse	<ul style="list-style-type: none"> Backfilling of pipeline excavations with materials which have the same or higher permeability that the existing sediments. Design the crossing point so that the pipeline does not act as a barrier to groundwater flow. Where feasible burying the pipeline into lower permeability sediments beneath the surficial alluvial aquifer. 	Design measures Water Resources Management Plan (<i>Chapter D7</i>)	Negligible
Dewatering of aquifers associated with the construction of the Oyu Tolgoi to Gashuun Sukhait Road and the Gunii Hooloi pipeline and borefield	Groundwater, Herders	C	Scale: Local Duration: Short Term Type: Negative	Consequence: Minor Likelihood: Unlikely Significance: Minor Adverse	<ul style="list-style-type: none"> Ensure that groundwater abstraction is from aquifers deeper than those used by the herders. Conserve water wherever possible to make most effective use of the resources available. Cap or seal wells which are not required for later operations. 	Water Resources Management Plan (<i>Chapter D7</i>)	Negligible
Impacts of leachate from the Tailings Storage Facility (TSF) and Waste Rock Dumps (WRD) on	Surface and groundwater	O, D	Scale: Local Duration: Long Term Type: Negative	Consequence: Moderate Likelihood: Unlikely Significance: Moderate Adverse	<ul style="list-style-type: none"> Installation of a clay liner beneath all of the TSF. Use of seepage collection system at the TSF to capture seepage and return this to the TSF for recycling in the processing plant. 	Tailings Management Plan Waste Rock Management Plan (<i>Chapter D8</i>)	Minor Adverse

Impact	(1)Receptor/ Beneficiary	(2) Phase	(3) Impact Categorisation	(4) Potential Significance	Design and Mitigation Measures	Management Plan	Residual Significance
surface and groundwater quality					<ul style="list-style-type: none"> Capping of TSF with NAF tailings or covering with NAF waste rock. Encase WRD with 10 m of NAF to minimise contact with rainwater. Installation of cut-off trench in Undai down-gradient of the WRD. 		
Loss of regional groundwater resources through groundwater abstraction from of the Gunii Hooloi aquifer	Soum residents	O, D	Scale: Local Duration: Long Term Type: Negative	Consequence: Moderate Likelihood: Certain Significance: Moderate Adverse	<ul style="list-style-type: none"> Minimise water use through ensuring that plant is operated efficiently to minimise water use. Recycle and reuse water wherever possible. Use water reduction as a core KPI. 	Water Resources Management Plan (<i>Chapter D7</i>)	Moderate Adverse
Impact on shallow aquifers due to leakage in early groundwater exploration wells	Herders	C, O, D	Scale: Local Duration: Long Term Type: Negative	Consequence: Minor Likelihood: Certain Significance: Minor Adverse	<ul style="list-style-type: none"> Monitor wells to establish which boreholes exhibit leakage. Seal wells where leakage is identified. 		Negligible
Dewatering of the Gunii Hooloi aquifer causing an impact on surficial aquifers used by herders	Herders	O, D	Scale: Local Duration: Long Term Type: Negative	Consequence: Major Likelihood: Unlikely Significance: Moderate Adverse	<ul style="list-style-type: none"> Control of pumping rates to ensure drawdown in aquifer kept as low as feasible beneath herder wells. Provision of a commitment to the continuity of supply. Full engagement with participatory environmental monitoring to ensure anecdotal as well as actual data is evaluated fully by all stakeholders. Continue long term monitoring to enable early impacts to be identified. Open dialogue and consultation with herders through CSP. Identification and provision of alternative supplies if impacts occur. 	Water Resources Management Plan (<i>Chapter D7</i>)	Minor Adverse
Subsidence over Gunii Hooloi aquifer due to dewatering	Oyu Tolgoi, Herders	O, D	Scale: Local Duration: Long Term Type: Negative	Consequence: Negligible Likelihood: Unlikely Significance: Negligible	<ul style="list-style-type: none"> Control of pumping rates to ensure even drawdown in aquifer. Monitoring of topography to identify if subsidence is occurring and plan mitigation. In the unlikely event that there is a significant impact on the gradient or flows of ephemeral watercourses, Oyu Tolgoi to design 	Design Measures Only	Negligible

Impact	(1)Receptor/ Beneficiary	(2) Phase	(3) Impact Categorisation	(4) Potential Significance	Design and Mitigation Measures	Management Plan	Residual Significance
					engineered solution if appropriate in consultation with local <i>soum</i> and community.		
Dewatering of the shallow aquifer beneath Khanbogd and impact on herder wells	Herders	O,D	Scale: Local Duration: Long Term Type: Negative	Consequence: Major Likelihood: Unlikely Significance: Moderate Adverse	<ul style="list-style-type: none"> Design of the water supply system to avoid impacts on herder wells. Objective is for the system to be sustainable and recharged annually by rainfall on Khanbogd mountain and surround areas. If impacts on herder wells occur replacement water supplies will be established, these may comprise deepening the wells, replacing pumps, or drilling new wells. 	Water Resources Management Plan (<i>Chapter D7</i>)	Minor Adverse
Insufficient groundwater supply for Khanbogd from the identified basin	<i>Soum</i> Residents	O, D	Scale: Local Duration: Long Term Type: Negative	Consequence: Major Likelihood: Unlikely Significance: Moderate Adverse	<ul style="list-style-type: none"> Development of detailed groundwater model based on the results of the aquifer testing. Model to take account of potential future variations in recharge due to climate change. Development of detailed plan for sustainable groundwater development, which identifies future expansion. Assessment of groundwater quality and treatment requirements for potable water supply. 	Water Resources Management Plan (<i>Chapter D7</i>)	Minor Adverse
Creation of saline lake at the base of the open pit	Herders, fauna and flora	D	Scale: Local Duration: Permanent Type: Negative	Consequence: Minor Likelihood: Certain Significance: Moderate Adverse	<ul style="list-style-type: none"> Monitoring of the water quality to monitor how the pit water chemistry develops and what level the pit waters stabilise at. If pit water is acidic need agreement with Water Agency, MNET and Local Governor over the acceptable solution. Make safe the sides of the pit taking account of the level the pit water stabilises at. 	Mine Closure Framework (<i>Chapter D21</i>)	Minor Adverse