APPENDIX B

Details of Water Barriers and Dewatering Volumes
The following report outlines the design and results of water barrier trials conducted in 2011 and the resultant determination of dewatering rates and groundwater management during mining.

1 Water Barrier Trials

1.1 Background

Groundwater control during mining of Centipede and Lake Way deposits will be critical for safe operations and to enable effective ore extraction. As part of the ongoing technical studies to support the Project proposal, a water barrier trial was undertaken in September 2011. Two barrier types were tested: a compacted clay barrier and a high density polyethylene (HDPE) liner in calcrete and clay ore zones.

The results will be used to inform the selection of the final dewatering method and mine pit design.

1.2 Sump 1 – Clay Barrier in Clay Area

The clay barrier around Sump 1 was approximately 40m x 40m. The average depth of the trench was 4.5m to 5m. Trench excavation was trouble-free as the majority of the material was clay and not calcrete. Stability and integrity of the open trench was very good and no wall collapse was noted at any point when the trench was open.

The trench was completed on the same day and was dewatered overnight to allow the backfilled clay to be compacted. Compaction was done using the bucket of the excavator, and although good compaction was achieved, this could be improved through the use of plate compacting attachments for excavators.

Clay from the earlier excavation of Sump 1 was used to backfill the trench, as it was dry and enabled good compaction to be achieved. Clay excavated from the trench could not be used because it was wet. The compacted backfill began at the north corner and construction was progressed rapidly. Dewatering was carried out continuously, which allowed the clay to be compacted.

Figure 1 shows Sump 1 with the trench installed.

When the construction of the compacted clay barrier was approximately 70% complete, dewatering of the trench began to exceed the capacity of the pumps and water level rose rapidly to approximately 2-3 metres above the trench floor. Discharge of this water was not possible due to high turbidity levels. This resulted in the last 30% of the barrier being constructed in very wet conditions. In particular, the western corner of the barrier was poorly compacted due to the wet conditions. A schematic diagram of the quality of the barrier is shown in Figure 2.
Figure 1: Trench around Sump 1

Figure 2: Approximate representation of barrier quality at Sump 1

Legend:
- Green – Fully Effective
- Orange – Partially Effective
- Red – Low Effective
1.3 Sump 1 results

Key results:
- Water inflow cut off by 75%-80%;
- Water ingress was visibly stopped in all areas, except for the corner where the barrier was poorly constructed;
- Water drawdown time was 50% faster after the barrier had been installed;
- Sump recharge time was 400% longer after the barrier had been installed; and
- Poorly constructed barrier on the west corner may have contributed up to 70% of the water inflow after the barriers had been installed. Barrier performance would have been better if it wasn’t for this corner.

The pump test at Sump 1 yielded excellent results. Water was pumped out consistently at 25L/sec and after six hours the sump was dry, which was near the minimum time required based on the estimated volume of water in the sump. This was significantly less than the 12 hours required before the clay barrier was installed. Visually, the water inflow stopped in all areas, with a few pockets of small water inflow from the north side. A significant flow of water was entering the pit from the western corner, where the barrier was poorly constructed. Water recharge time was approximately 4 days. Water ingress into sump 1 is shown in Figure 3.

Figure 3: Reduced water ingress at Sump 1
1.4 Sump 1 Water level curves

Figure 4: Draw down and Recharge curve for Sump1 (m)
1.5 Sump 2 – HDPE liner in calcrete area

The trench around Sump 2 was 40m x 40m. The depth of the trench was on average 4.5m but in some areas was only 3m deep. Trench stability was very good with very little possibility of wall collapse. Difficulty was experienced in penetrating the calcrete layer and hence some areas were not dug to full depth. Water inflow in this area was high, and attempts to dewater the trench were initially unsuccessful due to inability to pump sufficiently and still meet discharge requirements.

The HDPE liner used was 0.5mm thick and 7m wide. A 180 m length of liner was used which was sufficient to provide a continuous liner to be placed in the trench. Installation was difficult due to the rigidity of the liner material, in particular around the corners. This was further affected by the inconsistent depth of the trench. Liners were pegged at the top of the trench using star pickets to prevent the line from sliding into the trench.

While the liner was eventually placed in the trench successfully (see Figure 5), backfilling of the HDPE lined trench was far from ideal. As the trench was being backfilled, the liner was firstly dragged into the trench, then the compression of the earth being installed in the trench caused the HDPE liner to tear. More than 50% of the liner is estimated to have suffered damage during the backfill.

It should be noted that the backfill material used was mostly calcrete mixed with a bit of clay. This was to ensure that clay was not a factor in the barrier performance. However, the use of calcrete may have also contributed to the damage of the HDPE liner.

Figure 5: HDPE liner installed in the trench before the backfill
1.6  Sump 2 Results

Key results:
- Results were poor due to installation issues;
- Water inflow was reduced by 20%;
- Water inflow was visible from all sides of the sump; and
- Thicker HDPE liner required to reduce possibility of cut-off wall damage.

The pump test at Sump 2 was performed for approximately 6 hours. The test was stopped early because of poor water quality as the result of some clay being used in the backfill. It should be noted that the pump used during the barrier pump test was a larger unit. Total pump rate was approximately 25% faster during the barrier pump test.

Results of the test were poor. Water inflow was visible on all sides of the sump, with no obvious sign of water suppression. However, data show that water recharge time was approximately 20% longer. This indicates that the liner did have a minor effect in reducing water inflow.

The poor result was attributed to the condition of the liner. It was evident during construction that damage to the liner had occurred on all sides and in particular around the corners. Water in the trench made it impossible to assess the liner and to document the extent of the damage. Similarly, it was not possible to identify the locations of the tears in the HDPE liner.
1.7 Sump 2 water level curves

Figure 6: Drawdown and Recharge curve for Sump 2 (m)
1.8 Sump 3 – Clay barrier in calcrete area

The trench around Sump 3 was 40m x 40m. There was more difficulty in digging this trench than Sump 2. The north-west side of Sump 3 had a particularly hard calcrete cap at about 2.5 m deep which could not be penetrated by the excavator. The depth of the trench was an average 4 – 4.5m but there are sections on the north-west side where only 2.5m was achieved. Not surprisingly, wall stability of the trench was very good and there was no trouble with wall collapse during the construction process.

The material excavated from Sump 3 was both rocky and coarse, making it unsuitable for compacted backfilling. Clay was carted from the area around Sump 1 and was used to backfill the trench instead (Figure 7). Quality of the clay was very good and it was reasonably dry making it suitable for compaction. There was an attempt to dewater the trench before backfilling. However because the water quality was very poor and discharge was not possible, dewatering was terminated before the trench was completely dry (Figure 6). As a consequence, the clay barrier was constructed with water in the trench, and little compaction of clay could be achieved which severely affected the quality of the clay barrier.

It is important to note that Sump 3 had a depth of 6m. However, the depth of the clay barrier was only 4.5m on average which also affected the effectiveness of the barrier.

Figure 7: Clay was transported from Sump 1 to Sump 3
1.9 Sump 3 Results:

Key points

- Results were promising;
- Water inflow was reduced by 40%;
- Visual observation showed that water ingress from the top layer (within the barrier zone) had stopped. Clay was visibly obstructing the water inflow;
- Majority of the water inflow was from the lower layer (below the barrier zone); and
- Depth of barrier (4.5m) and depth of Sump 3 (6m) have adverse effects on the effectiveness of the barrier.

The pump test at Sump 3 ran for approximately five hours at approximately 50L/sec reducing to approximately 31L/sec in the latter stages. Pumps were turned off after poor water quality was detected at the discharge point prior to discharge. The barrier results were encouraging. When comparing drawdown rates, water drawdown time was four hours compared to more than 12 hours without the barriers in place.

There was clear evidence of clay moving through the water ingress layer which was congesting the water inflow during the pump test (Figure 9). Most importantly, observation of the sump walls after four hours showed nearly all shallow water ingress (~2m depth) had stopped.

The vast majority of the water ingress was from depths of 5 – 6m, which may indicate that water was moving below the barrier. This almost certainly would have impacted on the effectiveness of the barrier.
Figure 9: Clay ingress during the pump test
1.10 Sump 3: Water level curves

Figure 10: Drawdown and Recharge curve for Sump 3 (m)
2 Summary

2.1 Barrier Construction

The water barrier trials confirmed that the compacted clay barrier is a viable and effective water barrier. On the other hand, the HDPE liner performed relatively poorly, although this can be attributed to the damage caused during construction. Results of the trials are given in Table 1 below.

<table>
<thead>
<tr>
<th>Description</th>
<th>Reduction of water inflow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sump 1 – Clay barrier in clay area</td>
<td>75% - 80%</td>
</tr>
<tr>
<td>Sump 2 – HDPE liner in calcrete area</td>
<td>20% - 25%</td>
</tr>
<tr>
<td>Sump 3 – Clay barrier in calcrete area</td>
<td>35% - 40%</td>
</tr>
</tbody>
</table>

Table 1: Results of water barrier performance trials

Observations during the trial indicate that the probability of the trench caving in during a barrier construction is very unlikely. Instead, hard ground conditions, particularly where calcrete occurs, will affect the ability to install trenches and barriers. Overall, the construction of the clay barrier was relatively simple compared to the HDPE liner barrier. The result of the pump tests also showed that the clay barrier would perform well, especially if constructed properly. The HDPE liner may also be effective, if the issues arising during installation can be overcome.

Based on observations and test results, it is also recommended that the barrier have the following properties to be fully effective:

- barrier must be constructed to full depth;
- The trench must be fully dewatered before backfilling;
- Good quality clay or heavy HDPE liner must be used, calcrete is not suitable;
- The clay should be reasonably dry before backfilling; and
- Proper compaction will greatly increase the effectiveness of the barrier.

Barrier construction would be consistent with the structures outlined in Figure 11. Figure 12 shows the approximate location and sequence of barrier installation at Centipede.

Barrier A is compacted backfill. Barrier B has a high-density polyethylene liner. The barriers would be placed in either calcrete or clay dominant ore mining zones at a depth of one to two metres below the mine pit floor. Further design of the barriers would be based on geotechnical engineering and detailed in the Mining Proposal to be submitted for the assessment of the Western Australian Department of Mines and Petroleum.
Note: The water barriers are non-structural barriers constructed underground to minimise the flow of groundwater. Hence the set back distance of the wall from the pit, Dimension "R", and the pit batter angle, Angle "B", shall be determined by the site Geotechnical Engineer and shall be based on an assessment of the ground conditions applicable to the area.

Figure 11: Diagrammatic cross section of water barriers
Figure 12: Conceptual groundwater barrier location and schedule
2.2 Dewatering Rates

The total predicted dewatering volume from pit dewatering at both Centipede and Lake Way with barriers in place is estimated to be approximately a total of 4.8 GL (Centipede 2.2GL and Lake Way 2.6GL) over 11 years of dewatering (ERMP Part 1. pp 6-62 and 6.64) based on 100% effectiveness of the barriers. Table 5.6 in the RPS Aquaterra report in Appendix G of the ERMP showed that with the perimeter barrier in place, a maximum of about 0.8 GL of groundwater would be intercepted in any given year (maximum water recovery is predicted to occur in Year 2). However, these dewatering studies have now indicated that the maximum amount is likely to be 1.3 GLpa.

As shown in the Project water balance (Table 2), when the perimeter barrier is in place there would be no excess water (ie water that cannot be used in the ore processing operation or other mining activities) in any year during the life of mine.

With no barriers in place, there would be sufficient water for the first two years of operation, and an excess of 0.2 GL during Year 1. This excess would be captured as part of the early Project operations for later use and/or evaporation, and would not be discharged. Should the predicted dewatering rates be realised, additional water supply would be required after Year 2 of operations.

<table>
<thead>
<tr>
<th>Year*</th>
<th>Water Requirement (2.5GLpa)</th>
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<tbody>
<tr>
<td></td>
<td>Mine Dewatering (GLpa)</td>
</tr>
<tr>
<td></td>
<td>Max</td>
</tr>
<tr>
<td>1</td>
<td>2.0</td>
</tr>
<tr>
<td>2</td>
<td>1.8</td>
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<td>Total</td>
<td>15.0</td>
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Average GLpa 1.3 0.4

*Modelling has been completed for only 12 years of project life, as the predicted mine life is between 10 – 14 years dependent on ore grade

Table 2: Mine Dewatering Rates
The quality of water that will be intercepted by pit dewatering (ie hypersaline) has now been determined to not be a barrier to use in ore processing. Therefore, should barrier walls be breached during operations, Toro would be able to reduce the draw of water from other sources (such as the West Creek borefield) to ensure that the maximum water is drawn from mine dewatering. These trial flow rates indicate that even with no or completely ineffective barriers in place (such as a breach of barrier), the ore processing operations would be able to use all of the water produced from mine dewatering. As a further conservative measure, temporary water storage (and evaporation) may be considered. As was explained in the ERMP, any water storage to provide temporary containment would be constructed within the planned mine disturbance footprint to avoid unnecessary land disturbance.

Water from pit dewatering is predicted to be less than the amount required by Toro for its ore processing. Routine discharge to the environment is not necessary or proposed. If extreme weather conditions result in unexpected inflows to the pit at a rate that could not be accommodated in the process circuit, or if upset conditions in the plant prevent use of water from pit dewatering, Toro would, in the first instance, direct surplus water to a temporary holding pond or empty pit within the approved project disturbance area. The surplus water would be retained until it could be used in the plant and/or discharged to the environment after detailed testing had confirmed the suitability of the water for discharge.