FERRAUS PILBARA PROJECT: ENVIRONMENTAL SURFACE WATER ASSESSMENT

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EXECUTIVE SUMMARY

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1. INTRODUCTION

1.1 Project Background and Location

The FerrAus Pilbara Iron Ore Project (FPP) is located on the eastern margin of the Hamersley Province in the Pilbara region of Western Australia, approximately 75km east of the township of Newman, on the northern border of the Jigalong Aboriginal Reserve (Figure 1). The project is located within Exploration Licence E52/1630 and E52/1658 and is subject to Mining Lease applications M52/1034 and M52/1043. All tenements are held by Australian Manganese Pty Ltd, a wholly owned subsidiary of ASX listed company FerrAus Limited (FerrAus).

The FPP currently comprises three main areas of development, Robertson Range, Davidson Creek and Mirrin Mirrin.

The ore bodies are hosted in the Hamersley Group Marra Mamba Iron Formation and, more specifically, in the uppermost Mount Newman Member.

The Robertson Range project area is located within the Lake Disappointment catchment. There are no significant surface water features within the project area.

The Davidson Creek and Mirrin Mirrin project areas are located within the Upper Fortescue catchment. There are two surface water drainage features of significance within the project area, namely 13 Creek and Davidson Creek.

1.2 FPP – Planned Operations

The general arrangement of the project is shown on Figure 2.

The key planned components and activities associated with the Project are as follows:

- Hard rock mining of iron ore from above and below the water table at Robertson Range, Davidson Creek and Mirrin Mirrin using conventional open pit mining methods.
- Trucking of ore to crushers, where ore will be crushed and wet screened to a size suitable for beneficiation. Water used in the beneficiation plant will be sourced from the local aquifer through pit dewatering.
- Rejects waste from the beneficiation plant will be pumped to residue storage facility (RSF). Decant water from the RSF will be returned to the processing plant for re-use.
- Waste rock dumps will be established initially adjacent to the pits, with in-pit waste disposal employed once mined-out pit voids become available.
- Finished product will be stockpiled in a storage area on site and reclaimed for loading into trains for transport.
- A loading facility will be constructed consisting of a train loop and product reclamation systems for the loading of iron ore product from the product stockpile onto trains for transport.
- Progressive construction of haul roads and light vehicle access roads to mine areas, waste dumps, RSF and other mine infrastructure as required over the life of the mine.
- Construction of dewatering bores, pipelines and pumping systems to dewater the planned pits, supply water to the Project and discharge excess water to the environment and/or aquifer reinjection.
- Construction and operation of on-site support facilities including: mine offices; workshop and wash bays; topsoil and subsoil stockpiles; explosive stores; fuelling facilities; water supply; electricity supply; water treatment plant and waste handling facilities.
- Construction of accommodation village and airstrip.
- Progressive rehabilitation of areas disturbed by the Project.

1.3 Scope of this Assessment

The scope of works for this assessment comprises:

- Characterisation and description of baseline drainage conditions from both a regional and local project-area perspective;
- Assessment of potential project impacts on natural drainage systems and of the drainage systems impacts on the proposed project infrastructure; and
- Develop strategies to minimise the impact of the project on the natural drainage systems.

2. HYDROLOGY

2.1 Climate

Western Australia has three broad climate divisions. The northern part which includes the Pilbara has a dry tropical climate. The south-west corner has a Mediterranean climate, with long, hot summers and mild wet winters. The remainder is mostly arid land or desert climates.

The Pilbara region is characterised by an arid-tropical climate resulting from the influence of tropical maritime and tropical continental air masses, receiving summer rainfall. Cyclones can occur during this period, bringing heavy rain, causing potential destruction to coastal and inland towns.

2.2 Temperature

The Pilbara region has an extreme temperature range, rising up to 50 degrees Celsius (°C) during the summer, and dropping to around 0°C in winter (Bureau of Meteorology [BOM], 2010). The nearest BOM climatic station (temperature) to the project area is at Newman (Site Numbers 007151 and 007176 – approximately 70km to the west). Mean monthly maximum temperatures at Newman range from 39°C in January to 23°C in July, while mean monthly minimum temperatures range from 25°C in January to 7°C in July (BOM, 2011). The average monthly temperatures at Newman are given in Table 2.1. High summer temperatures and humidity seldom occur together, giving the Pilbara its very dry climate. Light frosts occasionally occur during the winter season.

Table 2.1: Newman - Average Monthly Temperatures

Average Temperature	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Maximum [^{o}C]	39.2	37.1	35.6	31.7	26.4	22.6	22.5	25.1	29.5	34.0	36.8	38.6
Minimum [^{o}C]	25.2	24.3	22.1	18.1	12.6	8.7	7.4	9.3	13.1	17.7	21.2	23.8

2.3 Rainfall

The Pilbara region has a highly variable rainfall, which is dominated by the occurrence of tropical cyclones mainly from January to March. The moist tropical cyclones from the north bring sporadic and drenching rainfall events. With the exception of these large events, rainfall can be erratic, and localised, due to thunderstorm activity. Therefore, rainfall from a single site may not be representative of the spatial variability of rainfall over a wider area.

During winter, cold fronts move in an easterly direction across Western Australia and sometimes reach the Pilbara region producing light winter rains.

The nearest rainfall gauging stations to the project area are at Sylvania (Site Number 007079 – approximately 49km to the south-west) and at Ethel Creek (Site Number 005003, – approximately 68km to the north-west). The annual average rainfall recorded at Sylvania and Ethel Creek is 261mm and 268mm respectively (BOM, 2011).

This is slightly lower than at Newman Aerodrome, which has an annual average rainfall of 319mm (BOM, 2011). Average monthly rainfall totals for Newman Aerodrome are shown in Table 2.2. On average the driest period is August to November, with September and October historically being the driest months. Typically, January and February are the wettest months. However, variability is high with recorded annual rainfall at Newman varying between 153mm (1976) and 619mm (1999). The highest recorded annual rainfall at Sylvania and Ethel Creek was 713mm (1998) and 814mm (1942) respectively.

Table 2.2: Newman - Average Monthly Rainfall

Average Rainfall	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Rainfall [mm]	57.3	78.8	40.3	19.6	18.1	14.2	14.9	8.0	4.6	4.9	10.3	37.6

2.4 Rainfall Intensity

Design rainfall intensity data for the project area for selected rainfall durations and average recurrence interval (ARI) events are given in Table 2.3 (Institution of Engineers Australia 1987 and BoM, 2011). This data can be used for waterway designs.

Table 2.3: Davidson Creek Area - Design Rainfall Intensities [mm/hr]

Rainfall Duration	5 Year ARI	10 Year ARI	20 Year ARI	50 Year ARI	100 Year ARI
1 hour	31.2	36.5	43.3	52.6	59.8
3 hours	15.1	18.2	22.2	27.7	32.1
6 hours	9.3	11.5	14.3	18.3	21.6
12 hours	5.8	7.4	9.2	12.0	14.3
24 hours	3.6	4.6	5.9	7.7	9.2
48 hours	2.2	3.0	3.6	4.7	5.7
72 hours	1.6	2.1	2.6	3.5	4.2

2.5 Evaporation

The mean annual pan evaporation rate as measured by a Class A pan at Jigalong (around 34km to the east) is 4,066mm and at Newman is 3,733mm (Department of Agriculture, 1987). These average evaporation rates at Jiggalong vary between 176mm in June and 497mm in January/December. The average monthly pan evaporation rates for Jiggalong are shown in Table 2.4. Evaporation rates at the project site would be expected to be similar to the evaporation averages at Jiggalong.

Table 2.4: Jiggalong - Average Monthly Evaporation

Average Evaporation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Evaporation [mm]	497	406	397	326	211	176	180	229	301	396	450	497

Comparing the average rainfall rates at Newman to the average evaporation rates at Jiggalong, average evaporation exceed average rainfall for every month of the year and annual average evaporation exceeds annual average rainfall by about 3,700mm. However, as discussed above, annual rainfall variability is high.

2.6 Streamflow

Streamflow in the Pilbara region is typically correlated to rainfall, with the majority of streamflow occurring during the summer months of December through to March. Streamflow in the smaller flow channels is typically short in duration, and ceases soon after the rainfall passes. In the larger river channels which drain the larger catchments, runoff can persist for several weeks and possibly months following major rainfall events such as those resulting from tropical cyclones.

Streamflow gauging stations are widely spaced in the Pilbara region, with none located in the immediate vicinity of the project area. The nearest Department of Water (DoW) gauging station is at Newman, on the Fortescue River (Site Number 708011), located approximately 70km west of the planned mine site. This gauging station records streamflow from the Fortescue River Upper catchment which has an area of 2,822km^2 area above the gauging station. In comparison, the Davidson Creek project area is intercepted by two creeks; Davidson Creek and 13 Creek. The combined sub-catchment areas of Davidson Creek and 13 Creek upstream of the project area is approximately 320km^2.

Available gauging data for Fortescue River covering the period from 1980 to 2010 indicates an average annual runoff volume of about 4.8% of the annual rainfall recorded in that area (at DoW rainfall gauging station 507005 at Newman). However the variability of annual runoff volume is high with annual runoff varying between 0 to 23% of the annual rainfall. A similar analysis of Marillana Creek at Flat Rocks gauging station (DoW Site Number 708001) indicates an average annual runoff volume of about 2.2% of the annual rainfall recorded in that area. Due to relative catchment sizes, streamflow data recorded at these stations do not necessarily represent runoff within the Davidson Creek project area.

Peak streamflow discharges from ungauged catchments in the Pilbara region can be estimated using empirical techniques, such as those recommended in “Australian Rainfall and Runoff” (Institution of Engineers, 1987).

2.7 Climate Change

Climate change is generally defined as a change in average, long term, global weather patterns, and is especially associated with increases in temperature, precipitation and occurrences of extreme weather events.

Climate change is possibly contributing to increased rainfall in north-west Australia. Rainfall trends in the area have shown a substantial increase since 1950 (Department of Climate Change, 2008).

Increases in extreme storm events and flash flooding are predicted, along with more frequent and severe droughts. Increased rainfall would lead to increased runoff in the river and creek systems.

Since 1950, records have shown Australian average temperatures have increased 0.9^{o}C and the frequency of hot days and nights has increased. Climate projections indicate that annual temperatures are likely to continue to increase in Western Australia with North Western Australia becoming warmer with more hot days and less cold nights.

3. EXISTING ENVIRONMENT

3.1 Regional Surface Water Hydrology

3.1.1 Robertson Range Project

The proposed Robertson Range project lies within the Lake Disappointment catchment, an inwardly draining salt lake catchment with an area of approximately 145,100km^2. The project area lies very closely to the boundary of the Upper Fortescue catchment area (Figure 3). The main feature of Lake Disappointment catchment is Lake Disappointment, of which the main tributary is Savory Creek. The project area drains to Bobbymia Creek, a tributary of Savory Creek, which lies approximately 40km to the south-east.

Savory Creek is 280km long and flows in an easterly direction, into Lake Disappointment. Savory Creek is an extensive creek 150m wide at its maximum, though it may occasionally flood out to a width of 2km. The upper and middle reaches of the river are characterised by a well-defined braided channel, incised to a depth of 20m in places. For the last 50km (east of the McFadden Range), the river divides into several widely separated saline channels up to 10m deep and many minor salt lakes, claypans and saline swamps. Savory Creek starts fresh, but becomes saline east of the McFadden Range. The creek has been disturbed by feral cattle and donkeys (Water and Rivers Commission [WRC], 2003).

3.1.2 Mirrin Mirrin and Davidson Creek Projects

The proposed Mirrin Mirrin and Davidson Creek projects are located within the Upper Fortescue catchment, which comprises an area of approximately 29,800km^2 (Figure 4). The main feature of the Upper Fortescue catchment is the Fortescue Marsh.

The marsh area is in the physiographic unit known as the Fortescue Valley, and occupies a trough between the Chichester and Hamersley Plateaux (Beard, 1975).

The Goodiadarrie Hills, located on the valley floor just west from the marsh rail crossing, effectively cuts the Fortescue River into two separate river systems. West from the Goodiadarrie Hills, the Lower Fortescue River Catchment drains in a general north-westerly direction to the coast, whereas east of the hills the Fortescue Marsh receives drainage from the Upper Fortescue River Catchment.

Several large creek systems discharge to the Fortescue Marsh. These systems include the Fortescue River, Weeli Wolli Creek, Marillana Creek, Caramulla Creek and Jigalong Creek. The alluvial outwash fan from the Weeli Wolli Creek and other smaller creek systems abutting the Goodiadarrie Hills is believed to be partially responsible for this obstruction to the Fortescue River and forming the Fortescue Marsh. The DoW considers the upper portion of the Fortescue River which drains to the Marsh as a closed system.

The Fortescue Marsh is an extensive intermittent wetland acting as a flood storage and occupying an area around 100km long by typically 10km wide, located on the floor of the Fortescue Valley. The marsh has an elevation around 400m AHD. To the north, the Chichester Plateau rises to over 500m AHD, whereas to the south the Hamersley Ranges rises to over 1000m AHD. Following significant rainfall events, runoff from the creeks drains to the marsh. For the smaller runoff events, isolated pools form on the marsh opposite the main drainage inlets, whereas for the larger events the whole marsh area has the potential to flood.

Published topographical mapping indicates that the lower bed levels in the Fortescue Marsh predominantly lie between 400m and 405m AHD. Data provided by the DoW states that the flood level in the marsh would need to be marginally higher than 413m AHD to overspill westwards past the Goodiadarrie Hills. No published flood level data are available for the marsh. Anecdotal evidence suggests that over the last 50 years, following major cyclonic events, flood levels of approx 410m AHD have occurred.

Surface water runoff to the marsh is of low salinity and turbidity, though the runoff turbidity typically increases significantly during peak periods of flooding (WRC, 2000). Following a major flood event (that flooded the whole marsh area), anecdotal data indicates that the water could pond up to 10m depth in the lowest elevation marsh areas. Water stored in the marsh slowly dissipates through the processes of seepage and evaporation. During the evaporation process, the water salinity increases and as the flooded areas recede, traces of surface salt can be seen. During the seepage process, the increasingly more saline water is believed to seep into the valley floor alluvial deposits.

3.2 Local Surface Water Hydrology

The surface water catchments that impact on the project are presented in Figure 5.

3.2.1 Robertson Range Project

The Robertson Range project area is flat to gently sloping with a prominent hill rising some 40 to 50m above the surrounding plains immediately northwest of the proposed pit.

The Robertson Range catchment is approximately 12km^2, and has no defined creek beds.

3.2.2 Davidson Creek Project

The Davidson Creek and 13 Creek catchments which impact on the Davidson Creek project are approximately 170km^2 and 150km^2 respectively. The creeks are around 25km in length upstream of the mining area, have generally relatively flat average bed gradients of around 0.2%, and drain mainly in a northerly direction towards the mining area.

There is a low ridge orientated in an east-west direction immediately to the south of the proposed pits, through which 13 Creek and Davidson Creek flow. In the vicinity of the proposed pit areas, 13 Creek generally has a well defined channel approximately 20 to 30m wide (from aerial photography) and is approximately 1m deep. Davidson Creek also has a defined flow channel, although the creek bed is generally braided and narrower than 13 Creek (from aerial photography).

During rare flood events, it is likely that 13 Creek overflows into the adjacent western (Mirrin Mirrin) catchment downstream of the proposed mining area.

Immediately downstream from the planned mine development area, the 13 Creek gradient reduces with wide flow zones and relatively flat gradients that tend to attenuate runoff and reduce peak discharges. Flood flows through this area would typically be shallow and relatively slow moving. Around 15km downstream of the mining area, the incised main channel of 13 Creek diffuses, and flows from here would be solely as sheetflow.

13 Creek and Davidson Creek merge around 5km downstream of the mining area, and continue as 13 Creek for about 70km before joining Caramulla and Jimblebar Creeks just upstream of the Fortescue River. Jigalong Creek also merges in the same general area (Figure 4). In this merger zone, the natural ground levels are extremely flat and the main flow channels become braided and less defined. Discharges from these main river/creek systems tend to disperse into a wide floodplain and travel via smaller flow channels and as overland flow. Mapping indicates that this floodplain is many kilometres wide. Overall, the Fortescue Marsh is around 135km downstream of the mining area.

The peak flows at the proposed development areas for the 100 year ARI event have been estimated at 375m^3/s for Davidson Creek and 340m^3/s for 13 Creek (using the RORB rainfall routing model).

3.2.3 Mirrin Mirrin Project

The Mirrin Mirrin catchment is approximately 85km^2, and typically has no defined incised creek bed, particularly adjacent to the proposed Mirrin Mirrin pit. As such, flow through the catchment is more likely to be in the form of sheet flow and with flow only during major rainfall events. As described above, during rare flood events, this catchment may receive overflows from the adjacent 13 Creek catchment.

Downstream of the mining area, flow is generally in a northerly direction, towards the general 13 Creek flood plain area.

The peak flows for the 100 year ARI event have been similarly estimated at 200m^3/s.

3.2.4 Accommodation Village

The catchment for the proposed accommodation village is located on the eastern side of a localised hill, and comprises an area of approximately 1km^2, with a fall of up to 23m from the highest to lowest contours. Direction of surface flow is generally in a north-easterly direction. The upper sections of the catchment have a slope of about 10% at their steepest, flattening out to around 1% at the bottom. There are no drainage features of significance through the site.

3.2.5 Airstrip

At the proposed airstrip, the area consists of broad, wide flowpaths and sheetflow, rather than well defined, incised creeklines, with the topography sloping down gradient in a generally north-westerly direction. In general the catchment slopes are around 0.5% close to the air strip.

3.2.6 Haul Roads

A haul road is to be constructed between the Mirrin Mirrin and Davidson Creek project areas and similarly between the Robertson Range and Davidson Creek project areas project areas.

The haul road between Robertson Range and Davidson Creek will be approximately 25km long and will follow a broadly easterly direction initially from Davidson Creek before turning in a south-easterly direction towards Robertson Range. Around half the proposed haul road length will follow the alignment of an existing unsealed track between the Jiggalong Mission road and Davidson Creek. The haul road is broadly aligned parallel to surface water flowpaths, although it will require one creek crossing of significance at Davidson Creek, and a small number of minor creek crossings.

The final alignment of the haul road between Mirrin Mirrin and Davidson Creek is to be confirmed, but will require a creek crossing of 13 Creek. The haul road will be around 5km long.

3.3 Overland Flow

Where the defined drainage channels from steeper slopes enter the lower slope areas, the channels typically have a reduced discharge capacity and in many instances become less well defined and braided or may even completely disperse in flat areas. In these reducing slope channels, runoff tends to overspill the main channel flow zones and spread over a wider front. This overland flow can be important for supporting vegetation communities which rely upon enhanced soil moisture replenishment.

3.4 Existing Surface Water Quality

There is no published water quality data for the project area. However, consistent with surface water quality in nearby catchments following rainfall events, it is expected that surface water run-off would generally be of potable quality, though turbid.

4. PROPOSED DEVELOPMENT

The general arrangement of the project is shown on Figure 2. The key planned components and activities associated with the Project are as follows:

- Hard rock mining of iron ore from above and below the water table at Robertson Range, Davidson Creek and Mirrin Mirrin using conventional open pit mining methods.
- Trucking of ore to crushers, where ore will be crushed and wet screened to a size suitable for beneficiation. Water used in the beneficiation plant will be sourced from the local aquifer through pit dewatering.
- Rejects waste from the beneficiation plant will be pumped to residue storage facility (RSF). Decant water from the RSF will be returned to the processing plant for re-use.
- Waste rock dumps will be established initially adjacent to the pits, with in-pit waste disposal employed once mined-out pit voids become available.
- Finished product will be stockpiled in a storage area on site and reclaimed for loading into trains for transport.
- A loading facility will be constructed consisting of a train loop and product reclamation systems for the loading of iron ore product from the product stockpile onto trains for transport.
- Progressive construction of haul roads and light vehicle access roads to mine areas, waste dumps, RSF and other mine infrastructure as required over the life of the mine.
- Construction of dewatering bores, pipelines and pumping systems to dewater the planned pits, supply water to the Project and discharge excess water to the environment and/or aquifer reinjection.
- Construction and operation of on-site support facilities including: mine offices; workshop and wash bays; topsoil and subsoil stockpiles; explosive stores; fuelling facilities; water supply; electricity supply; water treatment plant and waste handling facilities.
- Construction of accommodation village and airstrip.
- Progressive rehabilitation of areas disturbed by the Project.

5. POTENTIAL IMPACTS

5.1 Potential Impacts from Mining Activities

Potential surface water impacts associated with the planned FPP mining activities include:

- Interruption to existing surface water flow patterns;
- Runoff loss to downstream environment;
- Increased risk of erosion and sedimentation;
- Contamination of surface water by chemicals or hydrocarbons.

5.2 Interruption to Existing Surface Water Flow Patterns

The interruption of surface water flow patterns has the potential to reduce and in some cases, increase the surface water runoff volumes.

The sub-catchment boundaries and flowpaths through the planned FPP are shown on Figure 5.

Both 13 Creek and Davidson Creek flow through the Davidson Creek project area. Davidson Creek naturally drains into 13 Creek immediately north (downstream) of the development area, from where it drains naturally towards the Fortescue River and eventually to the Fortescue Marsh.

The main flow path draining through the Mirrin Mirrin project area (referred to as Mirrin Mirrin Creek for the purposes of this report) flows in a northerly direction towards 13 Creek downstream of the merger of 13 Creek and Davidson Creek (and eventually to the Fortescue Marsh).

Surface water flows at the Robertson range project area are generally in a south-easterly direction from the area of higher ground located to the north-west of the development area. There are no defined flow paths of significance.

The proposed pits, waste dumps, stockpiles and RSF will intercept / block natural drainage paths within each sub-catchment. The proposed Davidson Creek / Mirrin Mirrin developments will potentially reduce discharges flowing northwards and on to the Fortescue Marsh, and similarly the proposed Robertson Range development will potentially reduce discharges flowing towards Lake Disappointment.

There will be a requirement to divert a section of 13 Creek around the western side of the proposed Davidson Creek pit development. The diverted flows will discharge back into the original 13 Creek alignment downstream of the development. The proposed diversion is discussed later in this document.

There is no requirement for a diversion of Davidson Creek as part of the development, although flood protection bunding will be required to prevent inflows to the mining area.

A minor diversion of Mirrin Mirrin Creek is required around the western side of the proposed waste dump and pit. The diversion discharges back into its original alignment downstream of the development.

To prevent flooding of the mine pits and associated infrastructure, bunding and minor diversion drains will be required to manage these flows (in addition to the diversion of 13 Creek and Mirrin Mirrin Creek). Indicative locations of the required bunding and diversion drains are shown in Figures 6 and 7. The operational life of diversion drains and bunds will vary from a few years to permanent structures. The drains and bunds will be designed based on an Average Recurrence Interval (ARI) flood event selected with consideration to the expected life and consequences of failure. Diversions will be designed to re-route flows back into their original drainage paths downstream of the development, or via minor channels and overland flow.

The proposed diversion of 13 Creek, constructed around the proposed development areas will intercept an overland flow zone. The diversion of this overland flow into a diversion drain/bund could potentially impact vegetation located downstream of the mine development area and upstream from the diversion discharge zone, by reduced soil moisture recharge. This potentially impacted zone extends for around 1,000m downstream from the pit development area.

Diversion works will be required at the proposed airstrip (Figure 8). The airstrip will be constructed across surface water flowpaths in a predominantly sheetflow area, and will cause a downstream surface water shadowing effect, and therefore has the potential to negatively impact downstream vegetation.

The catchment for the proposed accommodation village is shown on Figure 8. Where practical, flows upstream of the village will be diverted around the village, although these are likely to be minor due to the location of the village within the catchment. The construction of the village will intercept overland flow through the area.

The haul road route between the Davidson Creek and Robertson Range project areas is shown on Figure 9. The haul road has the potential to intercept areas of overland flow, depending on the final design. A significant creek crossing will be required at Davidson Creek, as well as a number of other minor creek crossings.

All excess runoff from internal catchments (i.e. plant, waste dumps, etc) will be treated to reduce sediment levels prior to controlled discharge to the downstream zones.

5.3 Runoff Loss to Downstream Environment

The loss of catchment area contributing runoff to the downstream drainage systems, due to the planned mining development works, may have an impact on the downstream environment. Runoff volume is likely to decrease from areas containing pits, waste dumps and upstream catchments blocked by these works.

However, runoff volumes from upstream flowpaths diverted through or around planned mine development works are considered to be largely unchanged by the planned works. This includes 13 Creek, Mirrin Mirrin Creek, and Davidson Creek, all of which impact on the mining development. Planned diversion of 13 Creek and Mirrin Mirrin Creek would redirect the flow downstream and a decrease in runoff volumes from the upstream catchments is not expected. It is possible that where discharges are fully contained within diversion drains a slight increase in the runoff quantity will occur, due to the more direct flow path and reduction in overland flow.

Locally, within pit areas, internal stormwater runoff would collect at the pit base and typically be removed by sump pumping, with discharge of excess water to the environment after sediment treatment. Within the waste dump, stockpile and ROM areas, internal runoff will collect at the perimeter bunding and be discharged via a sediment basin to the downstream environment. Overall loss of runoff volume from pit and waste dump development areas is estimated at a maximum 50% of the pre-development runoff volume and accounts for the losses to the downstream environment from non-recovered runoff from the pit and waste dumps.

It is assumed that all direct rainfall on the RSF will be lost to the environment as it will be fully contained within the RSF, and would presumably be re-used as process water. However, excess water in the RSF would reduce the requirement for make-up water from the borefields.

Runoff volumes to the downstream environment from some infrastructure areas (e.g. roofs, hardstands, access route) may be increased, whereas from other infrastructure development areas (e.g. ponds, stockpiles) runoff volumes may be reduced. Overall runoff volumes from infrastructure and stockpile areas are considered to be effectively unchanged by the planned works.

The planned pit development areas and their estimated maximum catchment areas intercepted are provided in Tables 5.1 and 5.2 below.

Table 5.1: Davidson Creek & Mirrin Mirrin Catchment Area Losses

Location	Development Area (km^2)	Adopted Runoff Loss	Effective Catchment Area Loss Estimate (km^2)
Pits	5.7	0.5	2.9
Waste Dumps	10.0	0.5	5.0
RSF	3.1	1.0	3.1
Total	18.8		11.0

Table 5.2: Robertson Range Catchment Area Losses

Location	Development Area (km^2)	Adopted Runoff Loss	Effective Catchment Area Loss Estimate (km^2)
Pits	1.4	0.5	0.7
Waste Dumps	1.3	0.5	0.7
RSF	0.4	1.0	0.4
Total	3.1		1.8

The development areas for the Davidson Creek and Mirrin Mirrin project areas, as distinct to the diverted catchment areas, total 18.8km^2 in the Upper Fortescue catchment (Table 5.1). This corresponds to approximately 0.06% of the total natural catchment to Upper Fortescue catchment (approximately 29,800km^2).

Based on the adopted runoff loss in Table 5.1, the effective catchment loss from the Upper Fortescue catchment is estimated at 11.0km^2, which represents a maximum 0.03% of the total catchment. Therefore, the effects of planned mine developments at the Davidson Creek and Mirrin Mirrin projects are a potential decrease in runoff volume to the Upper Fortescue catchment by up to 0.04%. These changes are not significant to the overall hydrological system, particularly in comparison to the natural seasonal variations in catchment runoff.

Similarly, for the Robertson Range mine development (Table 5.2) the potential decrease in runoff volume to Lake Disappointment would be extremely low (less than 0.01%) based on a catchment area of approximately 145,100km^2.

5.4 Increased Risk of Erosion and Sedimentation

Runoff from the planned waste dump and other disturbance areas has the potential to significantly increase erosion and sediment loads in the natural drainage systems, if appropriate management measures are not implemented.

The concentration of flows from overland flow into diversion drains/bunds has the potential to increase peak flow rates and consequently increase the potential for erosion and sedimentation at locations with increased or decreased velocities.

5.5 Contamination of Surface Water by Chemicals or Hydrocarbons

Spillage of chemicals or hydrocarbons from storage and/or transfer areas is possible, if appropriate control measures and operating procedures are not used.

6. SURFACE WATER MANAGEMENT

6.1 Surface Water Management Objectives

The overall surface water management objectives are as follows:

- To prevent or minimise impacts on the quality of surface water resulting from mining operations and contain any contaminated water on site;
- To ensure that the quality of water returned to local and regional surface water resources will not result in significant deterioration of those resources;

The following sub-sections describe management strategies that will be used by FerrAus to meet the above management objectives, and to minimise the potential impacts identified in Section 5.

6.2 General Water Management Strategies

The planned development of the FPP would have a localised effect on the surface water runoff through the redirection of flow and the development of bunded off areas which may intercept minor drainage lines and collect some surface water. The implementation of the general surface water management strategies outlined below is expected to effectively manage mining related impacts on the existing hydrology so that the Project will have negligible impact on local surface water resources.

- Vehicle Movements: Vehicle movements will be kept to the minimum necessary and existing tracks will be used where possible;
- Buffer Zones: Where possible, adequate buffer zones will be provided between the areas of disturbance and the natural drainage lines to protect the drainage lines from impacts resulting from construction activities;
- Limiting Clearing: Vegetation is the most effective method of minimising erosion and sedimentation. Initial clearing will be limited to areas of workable size actively being used for construction;
- Topsoil Storage: Topsoil storages will be located away from drainage lines and upstream of sediment basins. Topsoil will be stored such that it is protected from internal rainfall and runoff using temporary vegetation or mulching, and protected from external runoff using diversion banks/drains;
- Dry Season Construction: Construction on or near natural flowpaths will be planned for the dry season where practicable. Temporary stabilisation measures will be used in areas where there is a high risk of erosion;
- Internal Stormwater Provisions: Internal stormwater runoff in the development areas may cause localised flow velocities to increase around the mine infrastructure, as water is concentrated in diversion channels, or alongside flood bunds or raised pads. This flow is to be handled by the internal stormwater provisions for the developed areas. Formalised drainage networks are to be installed in plant site areas;
- Flow Dispersion: If it is necessary for concentrated flow diversions to discharge to sheet flow zones, the diverted surface water will be discharged over spreader mechanisms to encourage the flows to slow and disperse;
- Separate Flowpaths: Flows from undisturbed areas will be kept separate from disturbed areas;
- Bunding: All waste dumps and stockpiles have the potential to generate sediment laden runoff water which may require treatment in sediment basins prior to discharge to the environment. Bunding will be provided as appropriate to contain internal surface water runoff for treatment, plus to divert external surface water runoff;
- Temporary Works: Surface runoff from disturbed areas will typically contain some sediment, and may also include pollutant loads such as oil and grease. Temporary erosion and sediment control structures will be provided such as diversion banks, drains and sediment traps;

- Hydrocarbon Management: Hydrocarbon storage areas are to be bunded to prevent uncontrolled release. Potentially hydrocarbon polluted runoff such as from workshop areas will be directed to basins fitted with baffle mechanisms to trap possible pollutants before discharge to the downstream environment.

6.2.1 Surface Water Diversions

The following criteria should be adopted with regards to surface water diversions:

- Reduce the volume of run-off lost from the natural drainage systems;
- Reduce the likelihood of flooding of the mine areas due to surface water inflow;
- Reduce the volume of surface water entering the active mine areas;
- Reduce the volume of surface water which could potentially be contaminated as a result of contact with mining activities;
- Reduce the potential for erosion and sedimentation in the natural drainage systems;
- Where possible a diverted water course will be directed into the original water course at a point downstream or to the downstream water course.

Diversions require a combination of bunding and excavated channels to carry floodwaters via a flowpath different from the natural water course. The diverted water is directed into a defined water course, preferably the original water course at a point downstream. Energy may need to be removed from the flow at the entry point (e.g. riprap lining) to match the receiving channel characteristics.

The design capacity selected for the constructed diversion depends on the impacts of failure of the diversion. If there are potential adverse impacts of flow in areas that are normally flood free, or negatively impact on mine infrastructure or the environment, then diverted water needs to remain confined within its diversion flowpath (e.g. 100 year ARI capacity). If flow in areas that are normally flood free is acceptable or otherwise only represents nuisance flow, then a lesser ARI capacity and less costly diversion (e.g. 2 year ARI capacity) may be suitable.

Where diversion structures are required, bunding should typically consist of a level top section (minimum) 3m wide with side batters of 1:2.5, and be built to an engineering specification using competent materials. Bunding dimensions and the diversion channel should be capable of containing or diverting runoff flows up to the design flood event, plus a freeboard allowance. Excavated channels should typically have side batters of 1:2 and be of sufficient bottom width and depth to contain the design flood event. Larger flows would overtop the channel and potentially become overbank flow.

6.2.2 Bunding

It is a general requirement to bund the perimeters of the waste dumps, waste dumps, stockpiles, RSFs and other disturbed areas as appropriate to prevent natural runoff from outside the disturbed areas from mixing with internal site runoff. Internal runoff would be collected and treated in a sediment basin to remove sediments prior to release to the natural environment. Where possible, diversion bunding would also act as perimeter (diversion) bunding to minimise the quantities of earthworks required.

Although the diversion works discussed above would serve to protect the pits from flooding, local perimeter bunding would also be installed at the pits as appropriate to prevent unnecessary nuisance water entering the pit. Where nuisance water cannot be drained, it can be trapped against flood bunding and either be pumped away or allowed to dissipate by a combination of seepage and evaporation as appropriate.

The flood bunding height will vary across the site dependent on local topography, and the flood protection requirements. The bund would require construction and compaction to an engineering specification. Whilst the slopes will be dependent on the material used and the achievable compaction, indicative slopes are 1:3.

Upon completion of the waste dump, the flood protection bund can be incorporated into the toe of the waste dump at an angle appropriate to provide long term stability and then rehabilitated.

6.2.3 Sediment Basins

The planned mining operations for the FPP would potentially mobilise additional sediments to the natural drainage systems with the main potential sediment sources being the waste dumps and stockpiles. The most effective method of sediment management is to control sediment at their sources. Sediment basins are one such method, and should be constructed down slope of all waste dumps and stockpiles (as appropriate) to help manage surface water sediment. Sediment basins should be used in conjunction with erosion minimisation strategies such as vegetated batters, coarse sheeting and engineered drainage systems.

Sediment basins collect internal runoff and remove sediments to acceptable levels prior to release to the natural environment. Bunds and drainage diversion works will be constructed around the perimeter of all waste dumps and stockpile areas, to divert and separate the natural runoff outside the development sites from the internal site runoff. Basins are typically located at a low point on the infrastructure perimeter and constructed by a combination of excavation and earth bunds. Sediment basin designs are based on the removal of a target sediment size. Removal of medium sized silt particles > 0.02mm (20 micrometres [µm]) for the design storm event is commonly used. The sediment trap is then expected to be effective in removing sand and medium to coarse silt. The removal of fine silt and clay is generally not as effective.

Sediment basins should be constructed to treat the runoff from each waste dump and stockpile area in the development area. Each of these areas should be locally bunded to contain the internal runoff and direct runoff to a sediment basin prior to disposal to the main drainage system. The final locations and layouts for these bunds and sediment basins will need to be determined in association with the detailed mine plans. A conceptual layout for bunding and sediment control around a waste dump is provided in Figure 10.

6.2.4 In-Pit Stormwater Management

Following significant rainfall events, water falling within the footprint of the mine pits and minor upstream catchments that cannot be diverted would collect on the pit floor.

This stormwater will be captured and is proposed to be pumped to the plant site to supplement mine dewatering uses in the process plant and for dust suppression where practical. Any excess water will be discharged to adjacent drainage lines downstream of the mine site or reinjected within the mine tenement. Should short term sump pumping rates be greater than demand, water may be stored on site in locations such as tailings dam or non active pits for subsequent reuse, depending on the site water balance at that time.

6.2.5 Haul Road Design

Low formation or “at grade” roads have minimum earthworks and minimise modification of existing drainage patterns, facilitate the shedding of water, and limit ponding upstream of the road.

Drainage of unsealed roads is important because lower quality design, construction standards and marginal materials are generally used, making the road more susceptible to water. The road will readily concentrate runoff, so there is a need to allow for frequent and safe runoff discharge. The unsealed road surface represents a substantial exposed area unprotected by vegetation cover, batters and side drains present exposed and erodible material, and considerable quantities of sediment may be generated during rainfall events.

Regular turn-outs to lead water from side drains into stable depression areas slow flow velocities and minimise the potential for erosion of road edges.

Floodways are often more economical, with better environmental benefits than culverts, which have a greater potential for erosion and scouring. Floodways should be sited at right angles to the direction of the water flow and level with the existing stream bottom to minimise interference to the natural creek flow, and reduce bank erosion.

Often a combination of floodways and culverts is used, with culverts sized to have sufficient capacity for smaller flood events with larger events allowed to flood over the road. The final road crossing design will depend on the level of service required (i.e. floodway trafficability for a range of ARI flood events).

6.3 Specific Surface Water Management Works

Surface water management works are required at the following locations, and are discussed in more detail below:

- 13 Creek Diversion;
- Mirrin Mirrin Creek Diversion;
- General mine site bunding / diversions;
- Airstrip;
- Accommodation village;
- In-Pit Stormwater.

6.3.1 13 Creek Diversion

The main diversion works required is the 13 Creek diversion, whereby the 13 Creek will be diverted initially in a north-westerly direction around the proposed low grade waste dump, and then in a northerly and then north-easterly direction around the westernmost end of the proposed pit, and back on to its original alignment downstream of the pit area (Figure 7).

The diversion will largely comprise an excavated channel to convey the 100 year ARI flood event, with associated bunding as required to prevent flood waters from entering the plant and pit areas. Through the area of deepest cut, the excavation will be up to 4m deep. The excavated channel will in the shape of a trapezoid, with a base width of around 40m, and nominal side slopes of 1:2.5, although this may be steeper depending on the ground conditions encountered.

The diversion also includes a small bund on the western side of the diversion (between the Mirrin Mirrin waste dump and the diversion) which is required to ensure high flows are kept largely within the same catchment area and help maintain the current environmental regime.

As the 13 Creek diversion will be a permanent diversion, sand and gravel excavated from the original creek bed would be stockpiled and used to help form the re-established creek bed.

The 13 Creek diversion will be constructed early in the project, to provide the relevant protection for the plant and pits.

6.3.2 Mirrin Mirrin Diversion

A minor diversion of Mirrin Mirrin Creek is required to develop the Mirrin Mirrin deposit (Figure 7). An excavated channel is not required due to the nature of the existing overland flow regime, and the diversion would take the form of a bund around the proposed waste dump and pit.

The diverted flows would discharge back into its original alignment downstream of the pit area.

6.3.3 General Mine Site Bunding / Diversions

Indicative locations for general flood bunding / diversions consistent with the principles described in Section 6.2 are shown on Figures 6 and 7.

At the Robertson Range development area (Figure 6), a proposed diversion bund to the north and west of the plant area would intercept undisturbed surface water flows and reduce the quantities of water flowing across the plant area. Disturbed surface water within the plant area and from the low grade waste dump would be intercepted by diversion bunding and brought around to the west of the RSF where it would be passed through a sediment trap before discharging to the environment. Runoff from the western side of the RSF can be passed through the same sediment trap. The remainder of disturbed runoff from the RSF and plant would be diverted between the two pits, where it would combine with runoff from the waste dump and be similarly passed through a sediment trap before discharging to the environment.

At the Mirrin Mirrin development area (Figure 7), bunding along the north, south, and eastern side of the development would serve to separate clean water from the waste dump area, and to prevent inflows to the pit. It would also serve to divert internal runoff from the waste dump to a sediment trap before discharge to the environment. The Mirrin Mirrin Creek diversion bund would also serve to divert internal runoff from the waste dump to a sediment trap before discharge to the environment.

At the Davidson Creek development area, flood protection bunding is required either side of Davidson Creek to prevent ingress of water to the mining area (Figure 7). This bunding would also serve to divert internal runoff from the eastern half of the Davidson Creek project to sediment traps before discharge to the environment. Internal runoff from the western half of the development area will similarly be diverted to a suitable location for treatment before discharge to the environment. Generally, the discharge points are all within the same sub-catchment as the water source. Pit bunding will also be constructed at appropriate locations to prevent nuisance water from entering the pits. There are a few minor areas in the vicinity of the Davidson Creek pits that cannot drain naturally, and some minor ponding will occur against the bunds. This nuisance water can either be pumped away or allowed to dissipate by a combination of seepage and evaporation.

6.3.4 Airstrip

At the airstrip, runoff will need to be intercepted and diverted around the airstrip. The majority of the catchment will need to be diverted in a westerly and then northerly direction as shown on Figure 8, whilst the remainder of the catchment will require minor deviation works around the eastern end of the airstrip. At the diversion channel discharge point, flows will be concentrated and should be discharged over spreader mechanisms to encourage the flows to slow and disperse.

6.3.5 Accommodation Village

This external stormwater run-off from the ridge above the proposed development (Figure 8) needs to be cut off and diverted safely around the development where possible; if it is not possible to divert all water around the site, then the upstream cut-off diversion should direct stormwater to specific drainage corridors through the development.

The catchments to be diverted through the village depend on the layout of the village, but will generally follow the existing drainage pattern. Spreader mechanisms may be used as appropriate at discharge points.

6.3.6 In-Pit Stormwater

Although the diversion works discussed above will serve to protect the pits from flooding, local perimeter bunding will also be installed at the pits as appropriate to prevent unnecessary nuisance water entering the pit. Direct rainfall on the pit floor would be removed by pumping. After treatment to remove the sediments, the in-pit water would typically be used for ore processing and dust suppression, with any excess discharged to the environment under relevant licence conditions.

FerrAus would only pump in-pit stormwater to an adjacent creek following a significant rainfall event when the creeks would already be saturated or possibly still flowing. These discharges would be a short term activity and all water would be treated via a detention storage to remove sediments prior to discharge. A rock fill pad would be installed at the pipe discharge point, to dissipation energy and reduce the potential for erosion.

7. CLOSURE SURFACE WATER MANAGEMENT

7.1 Closure Surface Water Management Objectives

The post closure topography of the pit area will be formed by in-pit overburden placement into the mine voids. It is likely that some sections will be below the pre-mining level. The majority of the backfill will comprise of waste rock.

The change in topography post mine closure may potentially impact on surface water flow through the proposed disturbance area. Such potential impacts include:

- Drainage stability and erosion of mine closure landforms;
- Permanent changes to the pattern of overland and sheet flow.

To mitigate the risk of these potential impacts, it is recommended the following closure surface water management objectives are implemented:

- To restore baseline flow regimes in areas affected by mining and closure works;
- To maintain baseline surface water quality;
- To ensure stability of permanent diversions, creek reconstructions and other constructed water management works left after mine closure;
- To ensure stability of drainage from landforms created by mining.

Permanent changes to the pattern of flows due to post closure landforms are likely to result in geomorphic changes to drainage lines around and downstream of the mine site. The degree of change would depend on how post closure flows would be distributed compared to the natural distribution of flows with the aim to ensure post closure flows are as close as possible to natural conditions.

The 13 Creek diversion would remain in place as a permanent diversion.

Some of the runoff through the project area would be unable to flow along the entire length of their original drainage lines due to post closure landforms. It is proposed to construct a series of diversion drains to redirect water around or through the mine site. Once downstream of the minesite, flow would be diverted back to the original drainage course wherever possible.

Diversion channels would be designed with sufficient capacity for a nominated rainfall event, while minimising earthworks and the channel footprint. The channel would be an appropriate width and depth, and have a bed gradient and side batters to minimise channel velocities and ensure a stable channel profile. Using material similar to natural creek bed sediment and establishing local riparian vegetation on the flood plains encourages the diversion channels to behave like natural drainage lines.

8. SUMMARY AND CONCLUSIONS

9. REFERENCES

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FIGURES

%

0 50 100

Kilometers

Scale: 1:2,500,000 @A4

GDA 1994 Zone 51

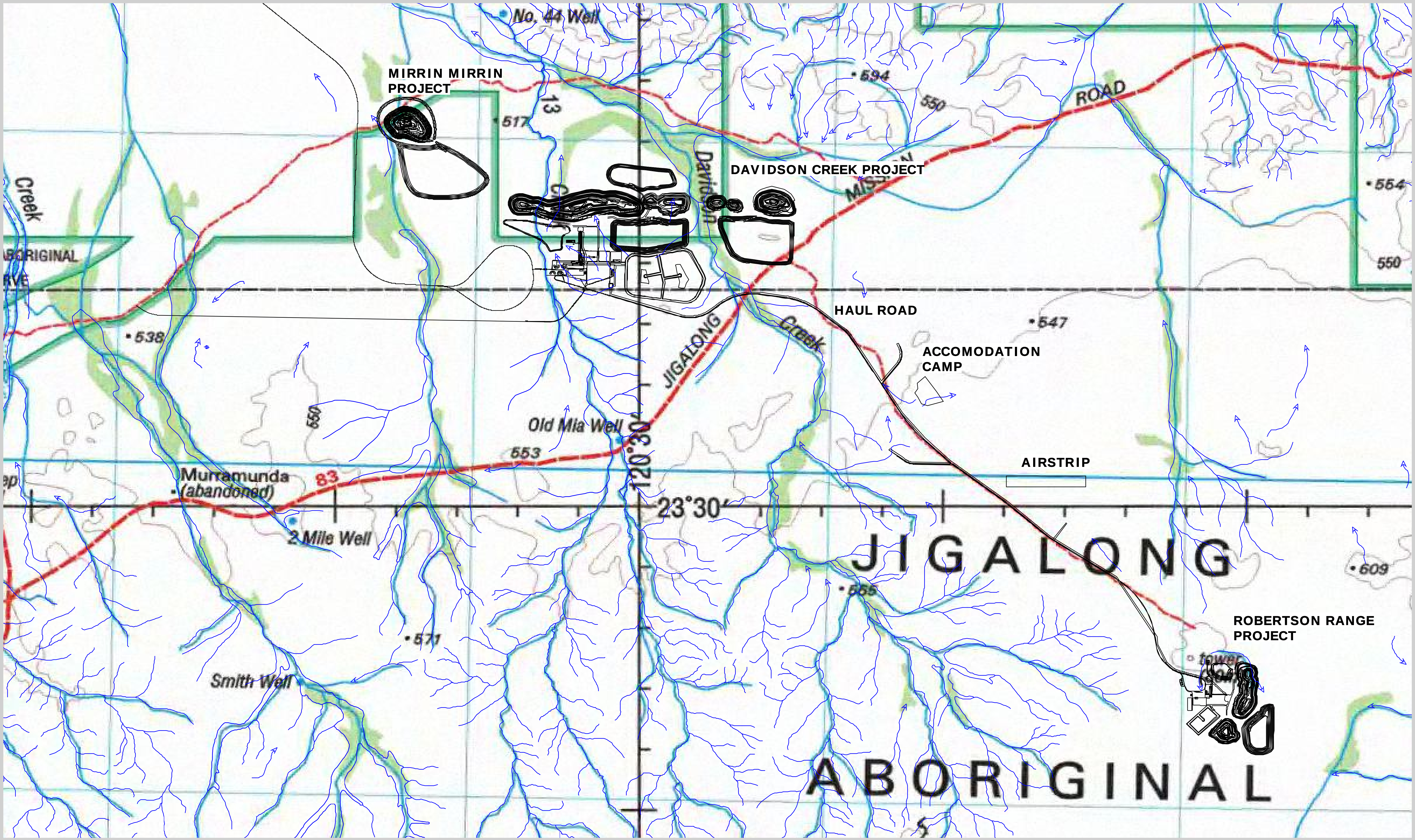
AUTHOR:	DM	REPORT NO:	023
DRAWN:	DM	REVISION:	a
DATE:	6/05/2011	JOB NO:	1297B

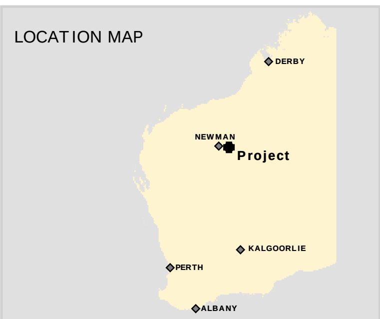
DATA SOURCES:
1:250,000 MAPPING

RPS Aquaterra

FIGURE 1
GENERAL LOCATION PLAN

Location: JOBS/1297B/REPORTING/SURFACE WATER/023





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Scale: 1:100,000 @A3

GDA 1994 Zone 51

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DRAWN: DM	REVISION: a
DATE: 6/05/2011	JOB NO: 1297B

Location: JOBS/1297B/REPORTING/SURFACE WATER/023

LEGEND

Existing Drainage Line

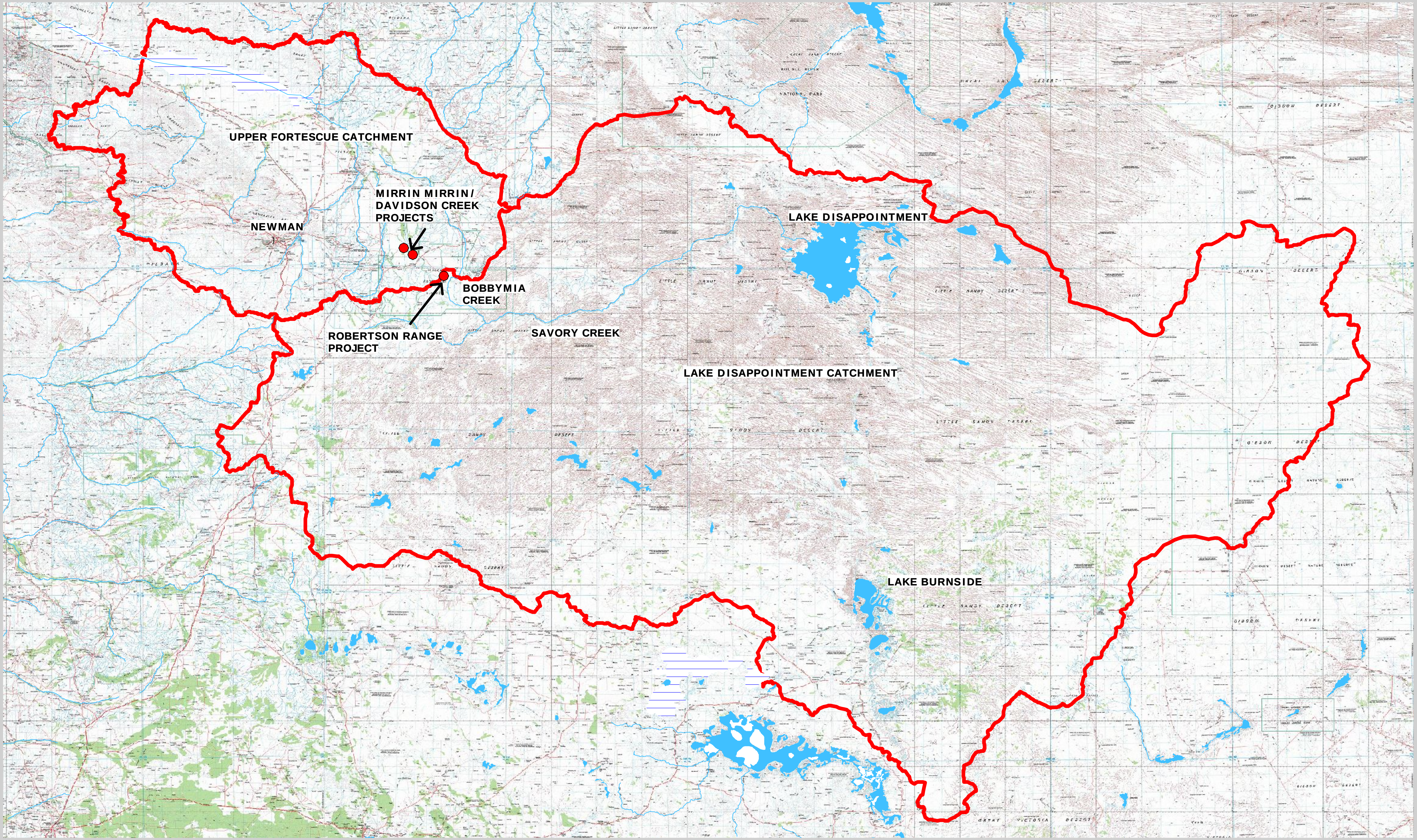
Proposed Infrastructure

DATA SOURCES:
1:250,000 Mapping

RPS Aquaterra

FIGURE 2

INFRASTRUCTURE GENERAL LAYOUT



LOCATION MAP

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Kilometres

Scale: 1:200,000 @ A3

GDA 1994 Zone 51

AUTHOR:	DM	REPORT NO:	023
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Location: JOBS/1297B/REPORTING/SURFACE WATER/023

LEGEND

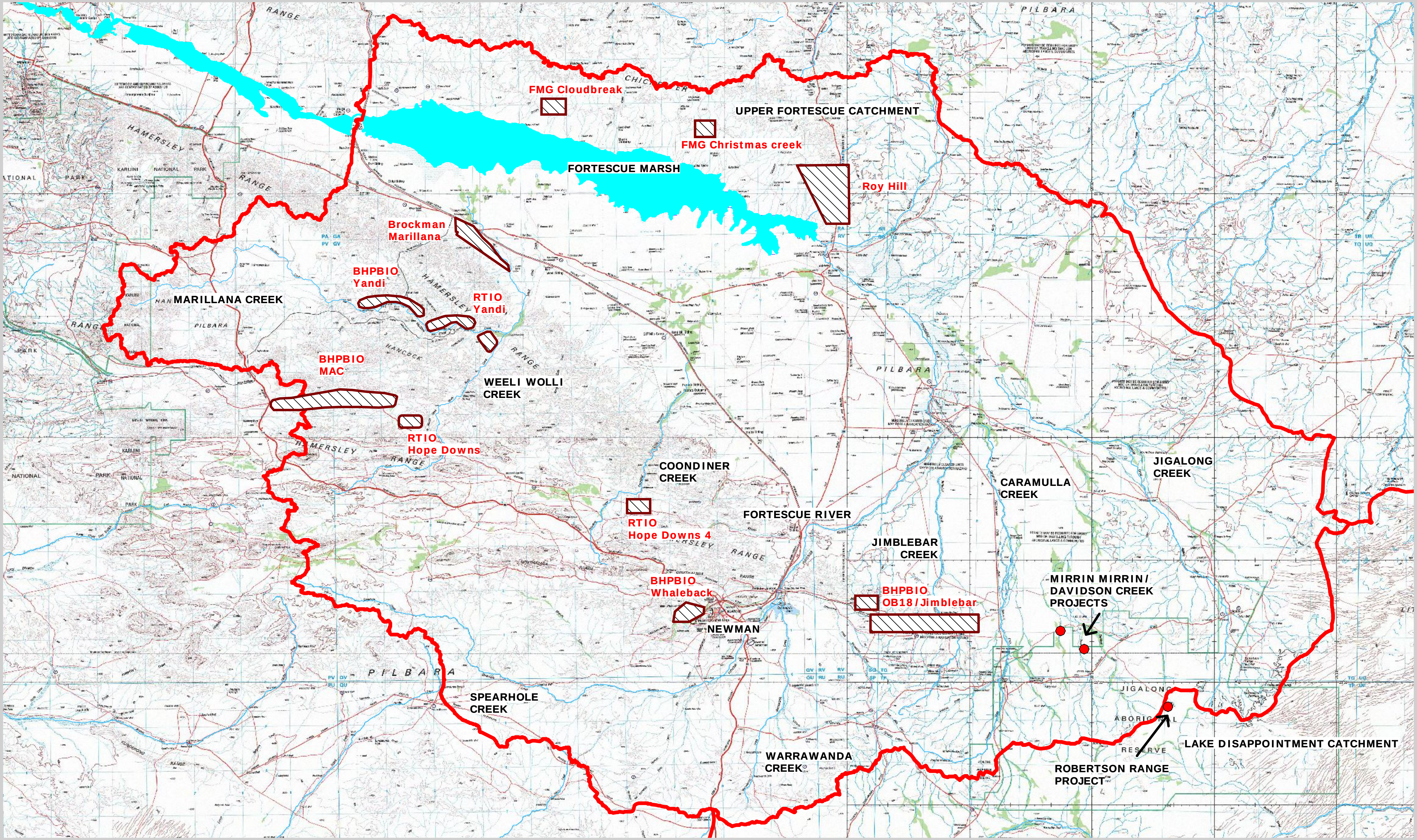
Regional Catchment Boundary

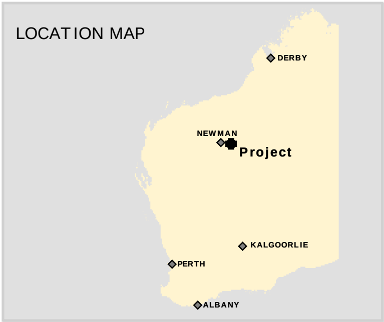
DATA SOURCES:
1:250,000 MAPPING

RPS Aquaterra

FIGURE 3

REGIONAL CATCHMENTS





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Scale: 1:750,000 @A3
GDA 1994 Zone 51

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DRAWN:	DM	REVISION:	a
DATE:	6/05/2011	JOB NO:	1297B

Location: JOBS/1297B/REPORTING/SURFACE WATER/023

LEGEND

Regional Catchment Boundary

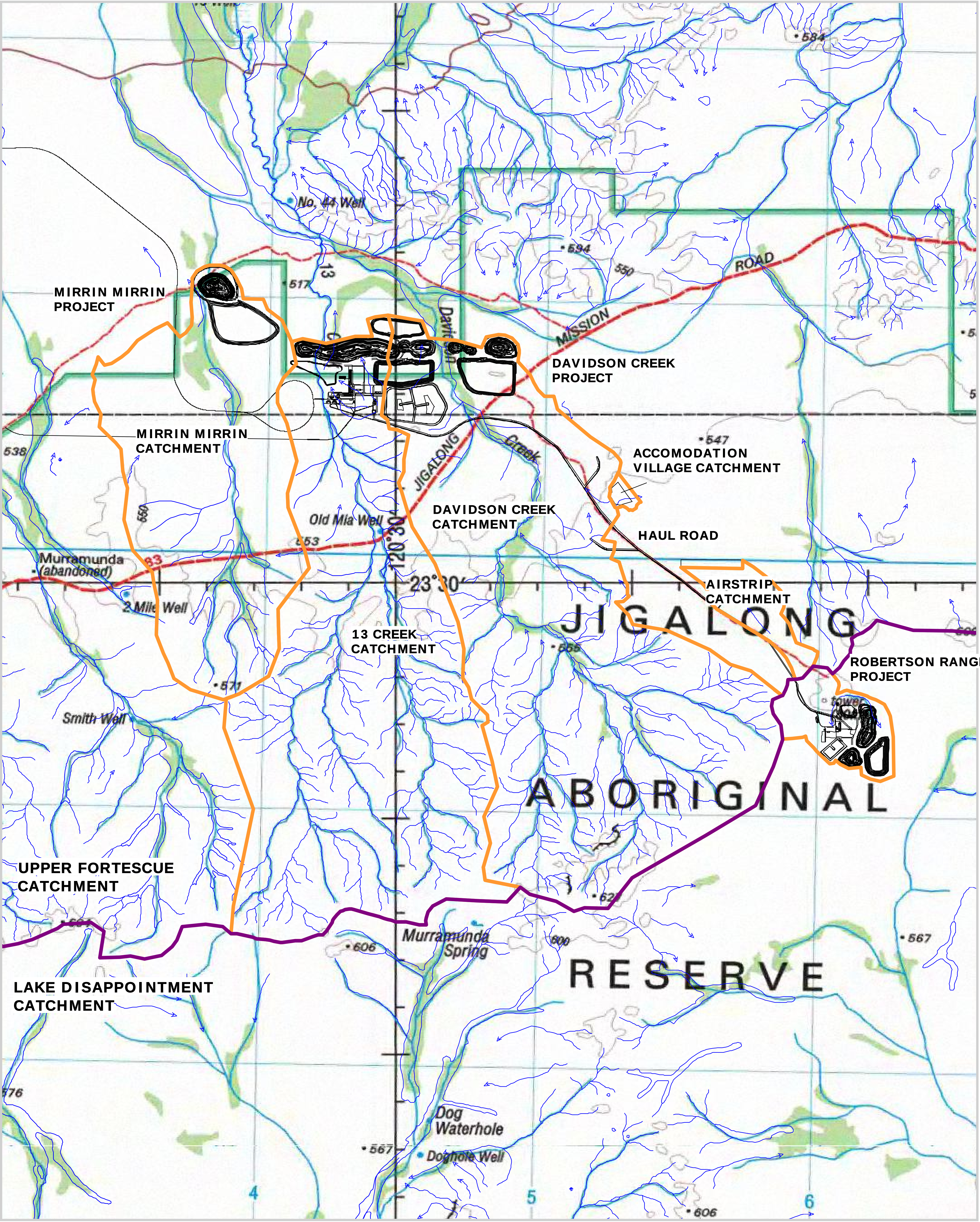
Mining Area

DATA SOURCES:
1:250,000 MAPPING

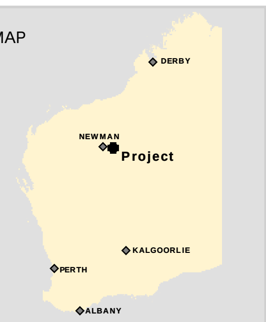
RPS Aquaterra

FIGURE 4

UPPER FORTESCUE CATCHMENT



LOCATION MAP



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Scale: 1:125,000 @A3

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LEGEND

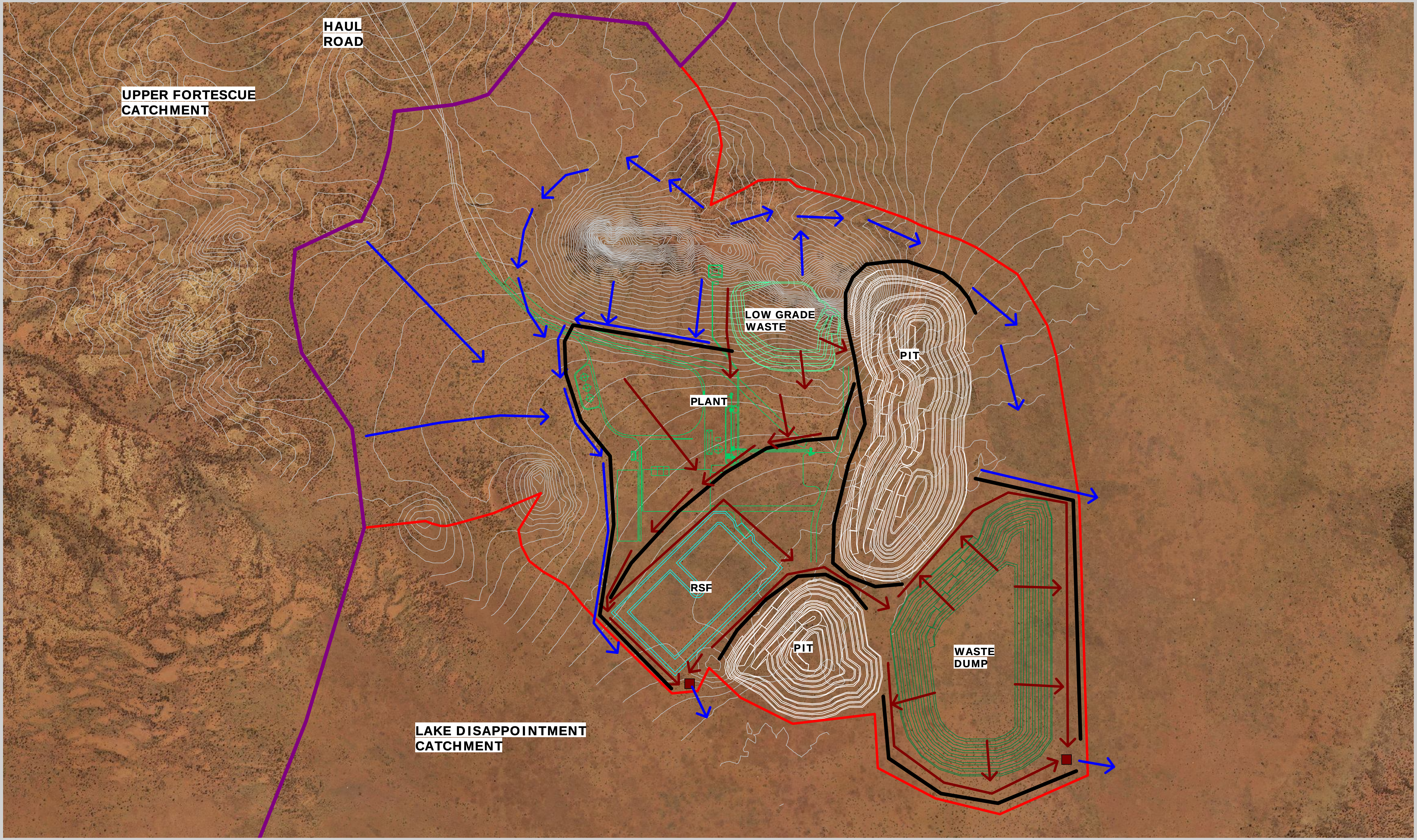
- Regional Catchment
- Local Catchment
- Existing Drainage Line
- Proposed Infrastructure

DATA SOURCES:
1:250,000 MAPPING

RPS Aquaterra

FIGURE 5
PROJECT SURFACE WATER CATCHMENTS

Location: JOBS/1297B/REPORTING/SURFACE WATER/023



LOCATION MAP

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Kilometres

Scale: 1:20,000 @A3

GDA 1994 Zone 51

AUTHOR:	DM	REPORT NO:	023
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DATE:	6/05/2011	JOB NO:	1297B

LEGEND

- Regional Catchment Boundary
- Project Catchment Boundary
- Dirty Water Flow
- Clean Water Flow
- Diversion / Flood Protection Bunding
- Sediment Trap

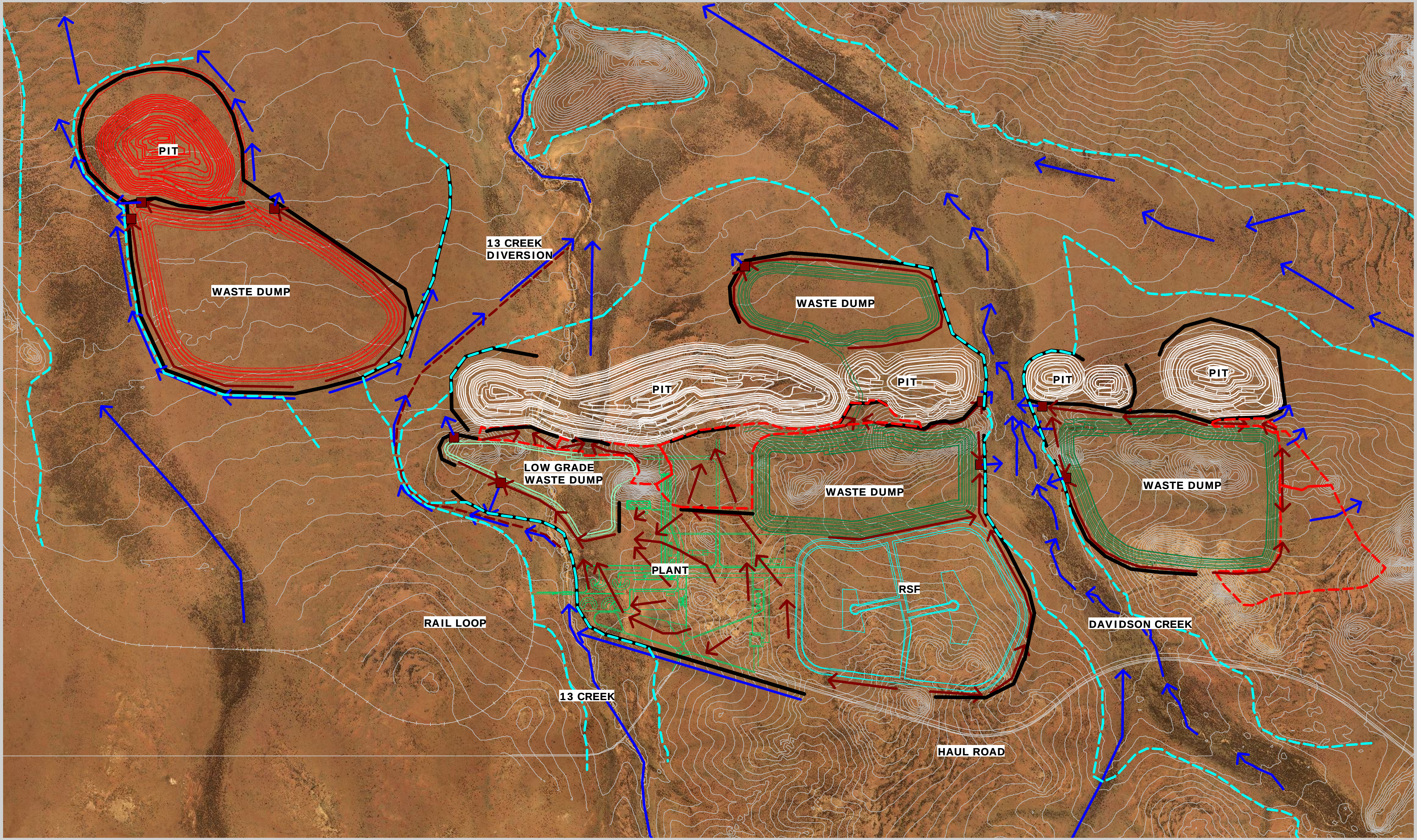
DATA SOURCES:
Client supplied aerial photography and 1m contours

RPS Aquaterra

FIGURE 6

ROBERTSON RANGE: SURFACE WATER MANAGEMENT

Location: JOBS/1297B/REPORTING/SURFACE WATER/023



Location: 1297B/REPORTING/SURFACE WATER/023

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Meters

Scale: 1:35,000 @A3

GDA 1994 Zone 51

AUTHOR:	DM	REPORT NO:	023
DRAWN:	DM	REVISION:	a
DATE:	6/05/2011	JOB NO:	1297B

LEGEND

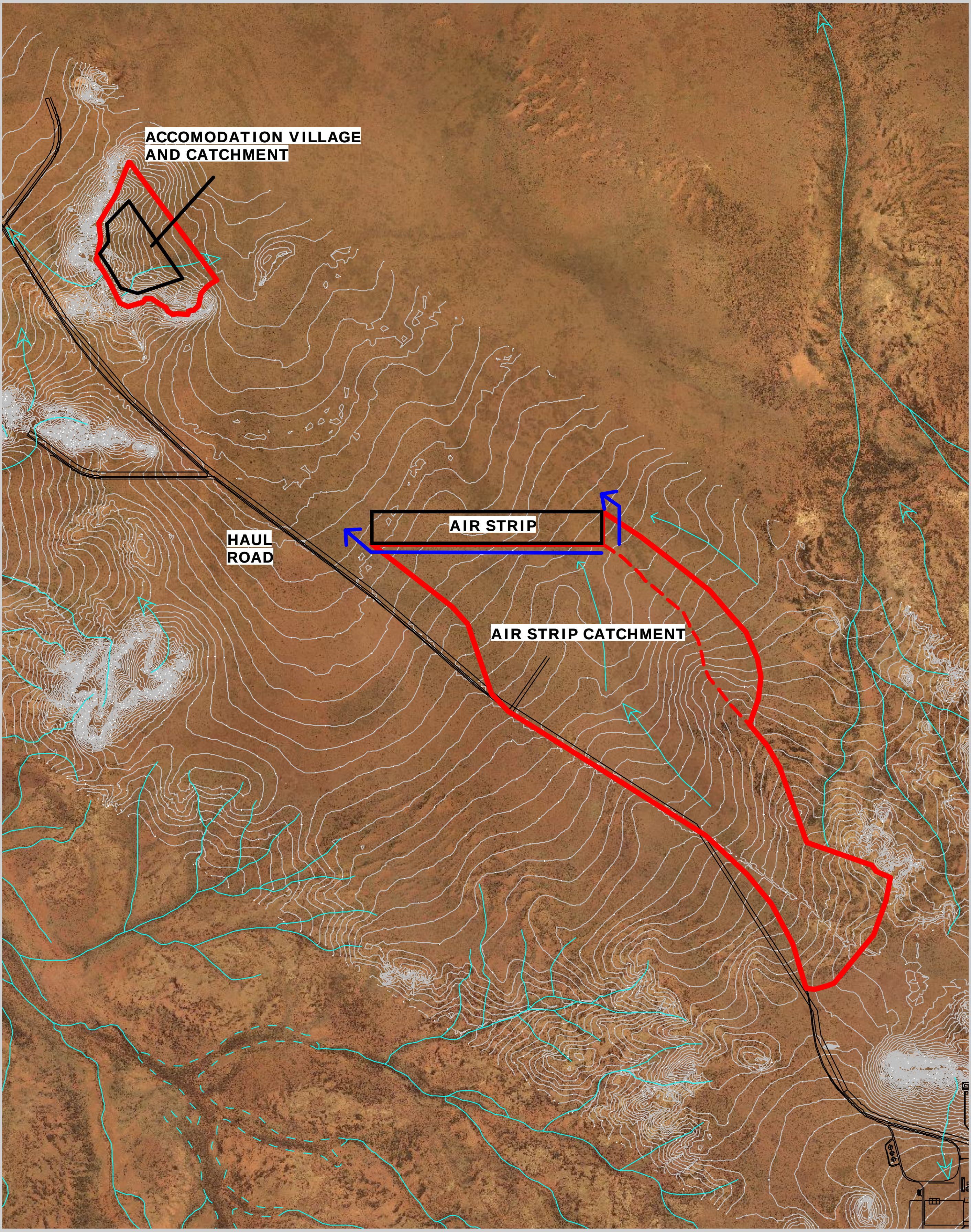
- Dirty Water Flow
- Clean Water Flow
- Diversion / Flood Protection Bunding
- Sediment Trap
- Trapped Surface Water Area
- Estimated 100 Year ARI Floodline

DATA SOURCES:
Client supplied aerial photography and 1m contours

RPS Aquaterra

FIGURE 7

DAVIDSON CREEK / MIRRIN MIRRIN AREA: SURFACE WATER MANAGEMENT



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Scale: 1:50,000 @A4

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DATE:	12/04/2011	JOB NO:	1297B

Location: 1297B/REPORTING/SURFACE WATER/023

LEGEND

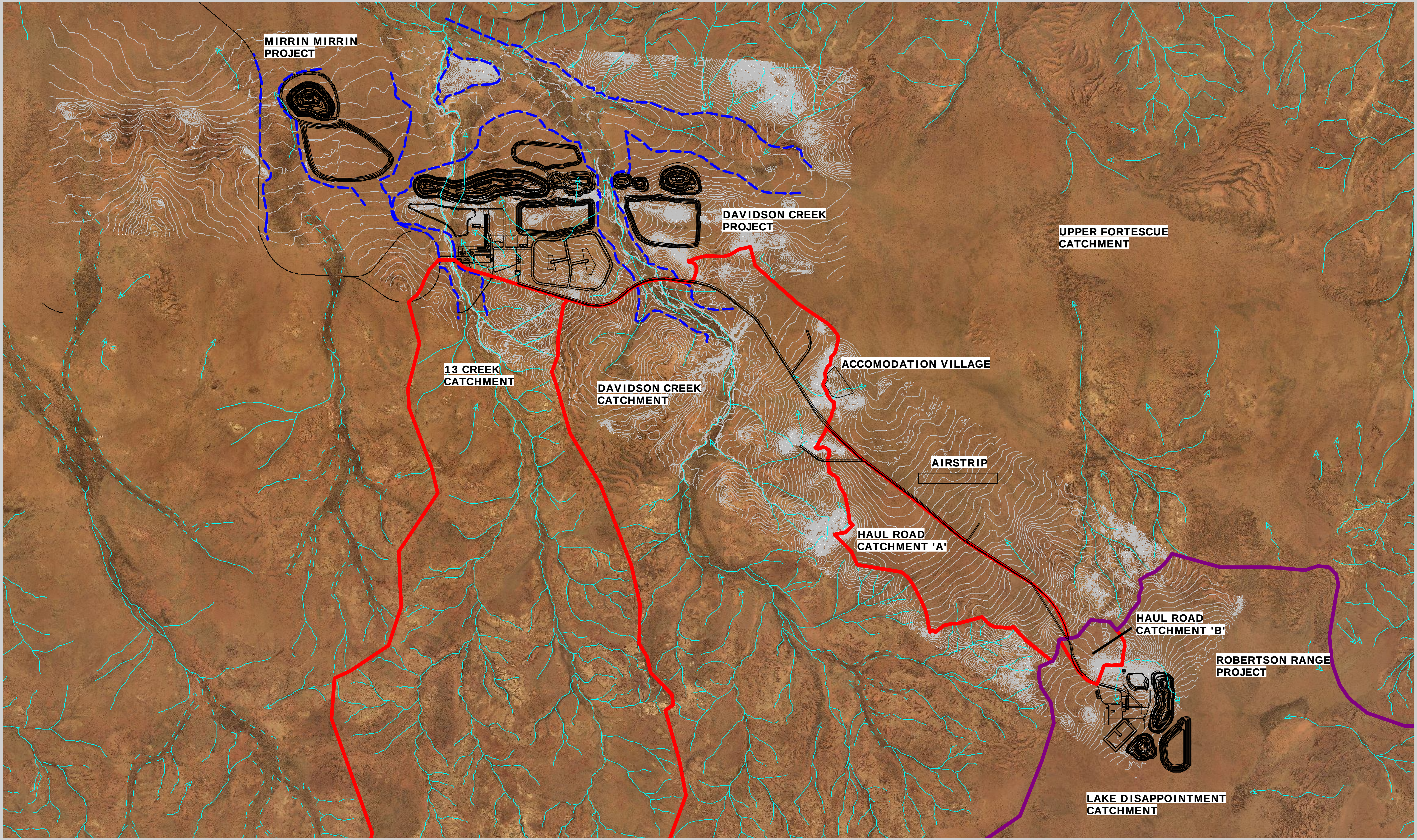
- Catchment Boundary
- Flow Direction
- Diverted Flow
- Sub-Catchment Divide
- Proposed Infrastructure

DATA SOURCES:
Client supplied aerial photography and 1m contours

RPS Aquaterra

FIGURE 8

AIR STRIP AND VILLAGE SURFACE WATER MANAGEMENT



LOCATION MAP

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Kilometers

Scale: 1:100,000 @A3

GDA 1994 Zone 51

AUTHOR:	DM	REPORT NO:	023
DRAWN:	DM	REVISION:	a
DATE:	12/04/2011	JOB NO:	1297B

LEGEND

- Catchment Boundary
- Flow Direction
- Estimated 100 Year ARI Flood levels (Post-Development)
- Regional Catchment Boundary

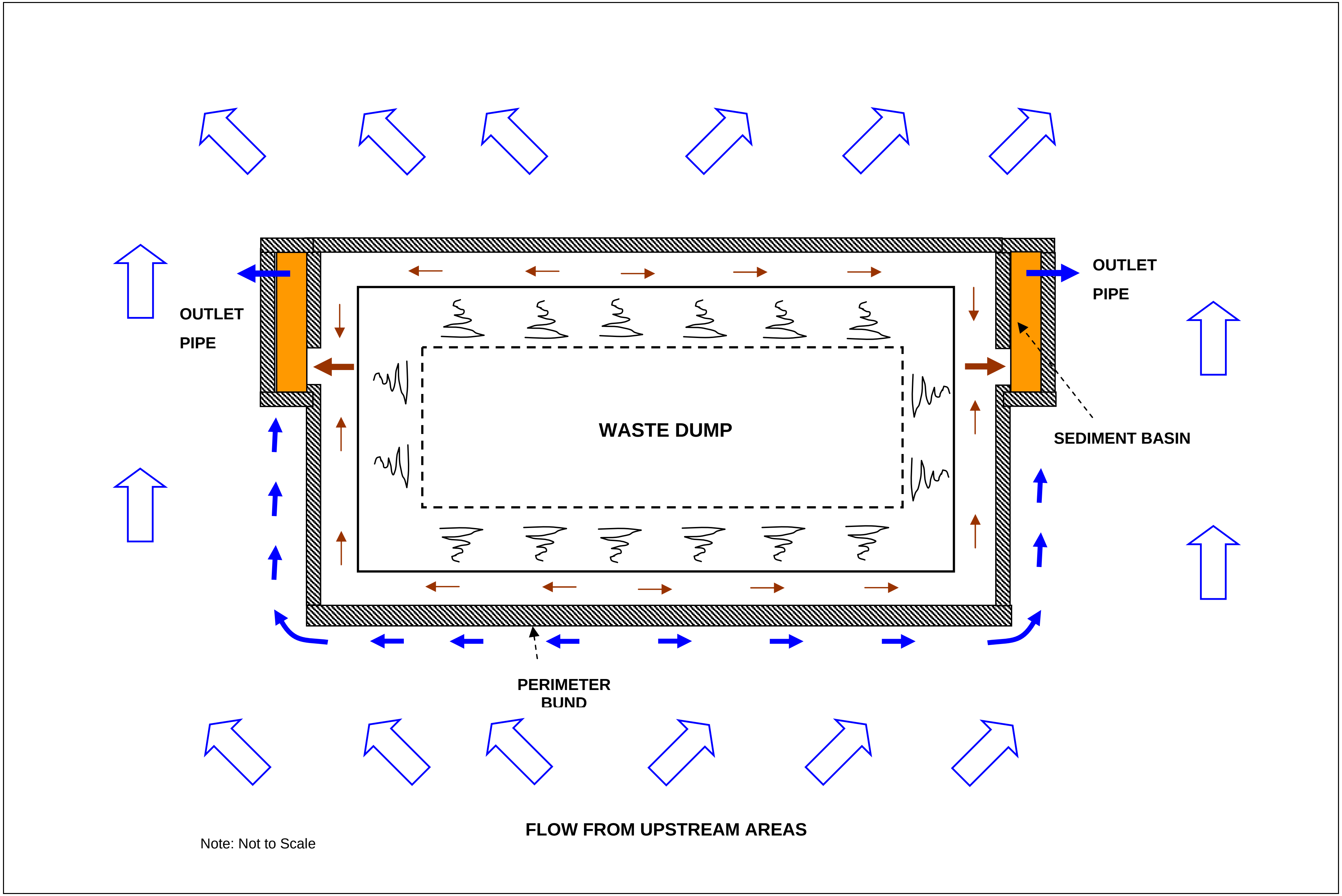
DATA SOURCES:
Client supplied aerial photography and 1m contours

RPS Aquaterra

FIGURE 9

HAULROAD CATCHMENTS

Location: 1297B/REPORTING/SURFACE WATER/023



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WASTE DUMP WATER MANAGEMENT : CONCEPTUAL LAYOUT FIGURE 10

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