FRANCES CREEK PROJECT, NORTHERN TERRITORY: SURFACE HYDROLOGY STUDY

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PREPARED FOR

TERRITORY IRON LTD

BY

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1. INTRODUCTION

Territory Iron Limited is proposing to extract iron ore from a series of open cut pits in the vicinity of Frances Creek. Ore will be crushed and screened and the resulting products transported via the Alice to Darwin Railway line to Darwin Port for export. Some waste rock stockpiles will be constructed outside the pits.

As shown in Figures 1 and 2, the project area is located 180 kilometres south-east of Darwin, 30 kilometres north of Pine Creek and 100 kilometres north-west of Katherine in the Northern Territory. The project area occurs within the upper catchment of Mary River, 30 kilometres south of Mary River National Park and 18 kilometres west of the western boundary of Kakadu National Park.

The proposed operations will involve the development of several open cut mine pits, a crushing and screening plant, stockpiles, haul roads and a rail loading facility. Much of the development will make use of infrastructure remaining from previous iron ore mining in the area, which ceased in 1974. The layout of the proposed operations are shown in Figure 2. The mining and processing area other than Ochre Hill pit are shown in greater detail in Figure 3.

The proposed operations will have a total footprint area of about 170 hectares, of which about 80 hectares was cleared for previous mining 30 years ago.

2. OBJECTIVES

The objective of this report is to provide relevant surface water information to meet the requirements of the Public Environmental Report document being prepared for the Frances Creek project. This will consist of the following:

- Describe the site and regional surface water systems including rivers, creeks and streamlines.
- Discuss the significance, current uses and beneficial uses of all surface water systems.
- Acquire available regional and local data on stream flows.
- Estimate average and flood flows for surface water systems associated with the project using local data and regional methods.
- Discuss water quality based on field observations, sampling and historical data where available.
- Describe potential impacts of the project on water quality, water quantity, diversion of waters and aquatic flora and fauna.
- Describe current downstream water users and their requirements.
- Document requirements for water licensing.
- Propose management measures for treatment, and disposal of water, separation of clean and contaminated water and management of extreme rainfall events.
- Identify water monitoring requirements before, during and after mining.

3. CATCHMENT DESCRIPTION

The Frances Creek project area is located in the headwaters of the upper Mary River catchment. The Mary River catchment covers an area of 8,000 square kilometres, draining north-west into the ocean at Van Diemen Gulf, about 100 kilometres east of Darwin (Figure 1). Approximately 1,987 square kilometres of the catchment is upstream of the confluence of Frances Creek and the Mary River. The upper catchment of Mary River is defined as that upstream of its major tributary, the McKinlay River, which joins Mary River about 100 kilometres from the ocean. The upper Mary River catchment is characterised by channel flow, while the lower catchment is dominated by sheet flow, with large areas of floodplain seasonally inundated, during the wet season, receding to a series of large pools of permanent water "Billabongs" in the dry season.

Plate 1: Frances Creek in Project Area, December 2005 (early wet season).

Frances Creek is located about 20 kilometres north of the southern boundary of the Mary River catchment and the discharge point of Mary River to the ocean is 150 kilometres north of Frances Creek. The major drainage divide within the project area is between the Frances Creek and Maude Creek catchments (Figure 2). Frances Creek arises within the project area and discharges into the Mary River some 20 kilometres downstream. It has a catchment area of 158 square kilometres. Maude Creek is located about 20 kilometres north of and parallel to Frances Creek and is also a tributary of the Mary River. It has a catchment area of 223 square kilometres.

The majority of the project area lies within the catchment of Frances Creek. The northern portion around Ochre Hill drains east into the Mary River via Maude Creek. Part of the haul route drains into the Mary River via Nelly Creek and some drains west into the McKinlay River (1812 square kilometres total, 367 square kilometres at Watts Ck Confluence) either directly or via Watts Creek. (80 square kilometres) The highest point in the project area is about 292 metres AHD (Australian Height Datum) on the eastern edge of MLA 24727, the lowest point is around 150 metres AHD at the point where Frances Creek leaves the project area to the north-east. Plate 1 shows low early wet season flow in December 2005 at three locations in Frances Creek within the project area.

Three large dams exist on the upper part of Frances Creek as shown in Figure 3. These were constructed for the previous Frances Creek mining operation and were completed in about 1971 (Barrie, 1999). The Dam walls consist of:

- An upper dam wall, which acts as the Helene 9 dam and an upstream embankment for the Tailings Storage Facility from pre 1974 mining operations (TSF).

- A lower TSF dam wall that creates the Helene 11 Dam, which would have been a water recovery dam during operation of the TSF.
- The lower dam wall, which creates the largest dam, Main Frances Creek Dam, downstream of the TSF

Helene 9 dam covers approximately 0.170 square kilometre and Main Frances Creek dam covers 0.258 square kilometre. The maximum depth of all dams is about 6 to 8 metres, and they have catchment areas of 1.95 square kilometres (Helene 9) 2.55square kilometres (Helene 11) and 2.40square kilometres (Main Frances Creek) a total of 6.9square kilometres. Approximate volumetric capacity is 1300 megalitres for Main Frances Creek dam, 250 megalitres for Helene 11 Dam and 450 megalitres for Helene 9 Dam.

The old TSF lies between the two dams, but the upper dam spillway is through a saddle allowing overflows to bypass the old TSF and flow directly to Helene 11 dam.

The dam walls are all less than eight metres in height so the dams are not classed as large dams by the Australian National Committee on Large Dams Inc (ANCOLD, 2004). The spillway of the main Frances Creek Dam was eroded by record rainfall in early 2006 and requires maintenance before the 2006/7 wet season.

There are also two much smaller dams in the project area:

- Helene 6 dam is created by the TSF blocking a small tributary, and covers an area of one hectare with a catchment of 0.78 square kilometres.
- Helene 4 Dam is created by the main haul road damming a catchment to the east and covers about 1.5 hectares with a catchment area of 0.44 square kilometres.

These two dams are likely to dry out completely in most years during the dry season.

4. DOWNSTREAM WATER USERS

Three main Beneficial Uses of surface water in the Mary River catchment, have been declared under Beneficial Uses legislation under the *NT Water Act (1992)*. These are:

- Cultural (including aesthetic and recreational).
- Environmental (the maintenance of healthy aquatic ecosystems).
- Riparian use (public rights to extract water for domestic/stock purposes).

These uses are the basis for waste discharge licences and water quality planning - potential waste discharge or water extraction which detrimentally impacts on these Beneficial Uses will not be permitted under the Water Act.

There are no townships within the Mary River Catchment, and the resident population was estimated at less than 200 in 2002 (Armstrong *et al*, 2002). Some recreational use has been made of water on the main Frances Creek dam within the project area, primarily in the form of water skiing and swimming. The main uses within the project area are environmental. The area is not currently used for grazing, but as it is part of Ban Ban Springs pastoral lease there is potential for riparian use for stock purposes.

Immediately downstream of the project area, Frances Creek passes through Ban Ban Springs and Mary River East Pastoral Leases. The major uses in these leases are also environmental and riparian for stock use. Frances Creek joins the Mary River next to Mary River Station and Mary River Roadhouse. This is the nearest residence downstream of the project area.

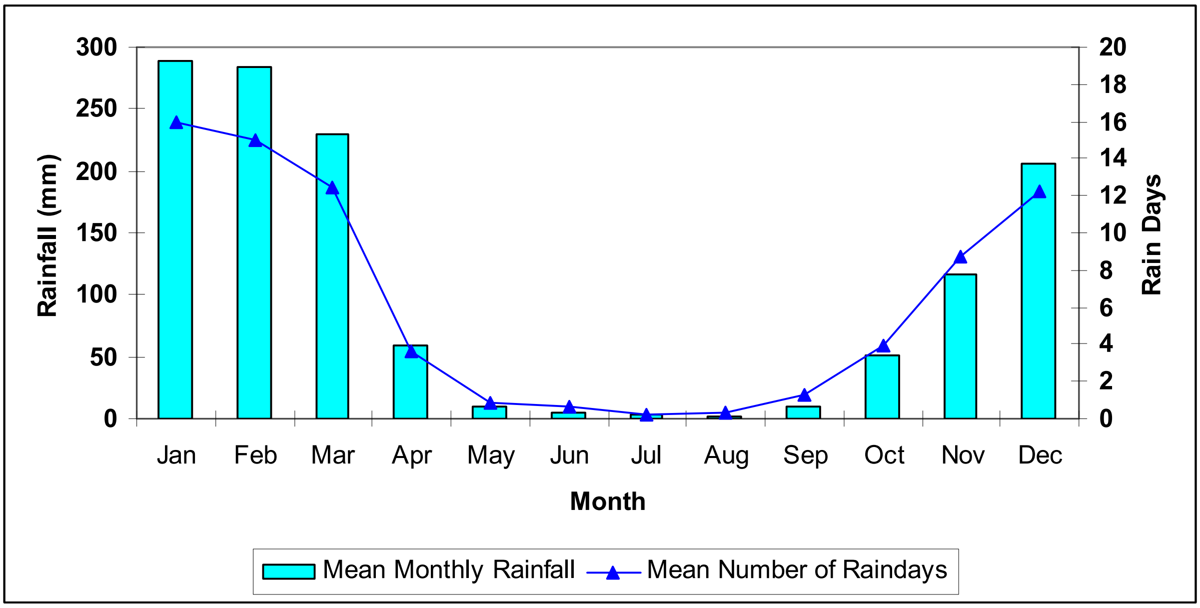
The Mary River forms a portion of the boundary of Kakadu National Park where Frances Creek joins it, about 20 kilometres downstream of the project area. The Kakadu National Park diverges from the Mary River about 40 kilometres downstream, and Mary River does not flow into the park, so there is minimal use of Mary River water in Kakadu. Mary River National Park covers the majority of the Mary River downstream of Kakadu. The final 40 kilometres before the ocean includes some pastoral and leasehold land. Fishing and Boating are promoted as major recreational attractions of the National Park so recreation use as well as environmental use is significant in Mary River National Park.

5. RAINFALL AND CLIMATE

The climate of the Frances Creek area is tropical monsoonal, with a pronounced wet season consisting of a hot, humid summer from November to March. Conditions are typically cooler and dry from May to September. October and April are transitional months with some rainfall.

Average rainfall in the region is 1,100 to 1,300 millimetres and falls mainly during the period between October and April, especially during the months of January to March, when the area is subject to tropical cyclones and associated tropical low pressure systems and monsoon troughs. The nearest long term rainfall records available are from Burrundie Railway Station (15 kilometres west of the project area) and averages from this location are shown in Chart 1.

Chart 1: Burrundie Railway Station Monthly Rainfall Data (1889-1974)



Mean annual average rainfall for Burrundie Railway Station is 1,263 millimetres, over 98% of which falls between October and April. The highest average monthly rainfall occurs in January (288 millimetres). Pine Creek, 25 kilometres south of the project area, has slightly lower rainfall, with an average annual rainfall of 1,149 millimetres for the period 1874 to 2000.

Air temperatures are relatively high and consistent from year to year. During the coolest time of the year (June to July), the mean monthly temperature for Pine Creek ranges from a minimum of 10 to 13 degrees Celsius to a maximum 20 to 32 degrees Celsius. In the hottest part of the year (October to November) the mean monthly temperature ranges from a minimum of 24 to 27 degrees Celsius to a maximum of 37 to 41 degrees Celsius. The lowest recorded overnight temperatures are below five degrees Celsius.

Humidity measured at Pine Creek averaged 49% in September 2004 and 79% in February 2005 (Bureau of Meteorology, 2006). Evaporation at Pine Creek is estimated at 2,775 millimetres per year (Bureau of Meteorology, 2003). Average evaporation is therefore more than double the average rainfall.

Rainfall intensity-frequency-duration (IFD) data for design can be derived from the data and methods in Australian Rainfall and Runoff (Pilgrim, 1998). Values for the Frances Creek site were calculated using the computer program AUSIFD version 2.0 from the rainfall factors published in Pilgrim (1987). Table 1 summarises the rainfall depths for standard design storm durations and probabilities for the project area.

Table 1: Design Rainfall Intensity-Frequency-Duration Values for Frances Creek

Duration (hrs)	1 Year ARI (mm)	2 Year ARI (mm)	5 Year ARI (mm)	10 Year ARI (mm)	20 Year ARI (mm)	50 Year ARI (mm)	100 Year ARI (mm)
0.5	30.0	38.0	47.0	52.5	60.0	70.0	78.0
1.0	42.2	54.0	66.0	73.0	83.0	97.0	108.0
3.0	54.6	69.3	85.2	94.8	108.3	126.6	141.0
6.0	63.6	81.0	99.6	111.0	126.6	148.2	165.6
12.0	73.9	94.4	116.5	129.6	148.8	174.0	194.4
24.0	95.0	122.4	154.3	174.2	201.6	239.3	268.8
48.0	119.0	154.6	199.7	228.5	267.4	320.6	363.8
72.0	132.5	172.8	226.1	260.6	307.4	372.2	424.8

6. AVERAGE AND FLOOD FLOWS

Watercourses in the project area are ephemeral and dry up during the dry season but have regular flows during the wet season.

6.1 REGIONAL STREAMFLOW DATA

A flow monitoring station on Frances Creek was operated near the minesite from 1961 to 1967. Six years of water level data were collected but a reliable rating curve is not available to translate the level measurements to flow measurements. It is likely the station was established to collect data for the dam construction and was flooded when the dams were completed. There are four other flow gauging sites within a 60 kilometre radius of the project area.
The available stream gauging data is summarised in Table 2.

Table 2: Stream Gauging Data Summary

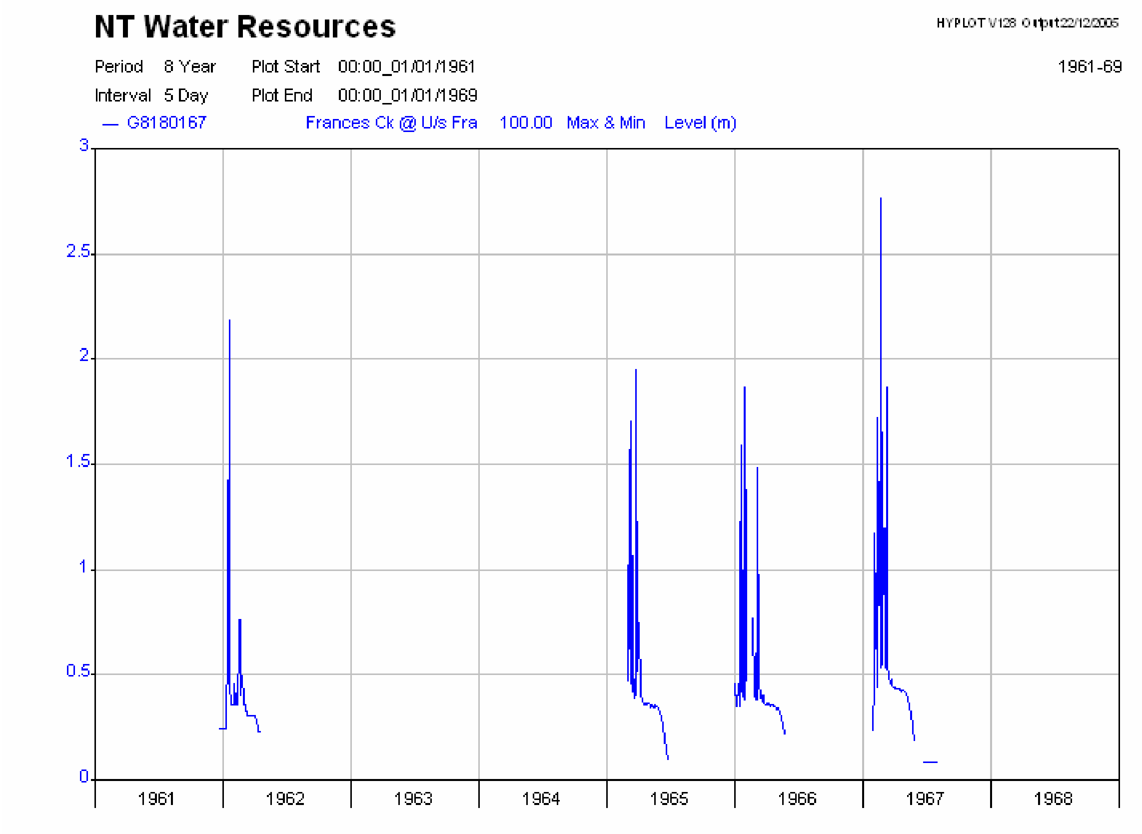
Gauging Station	Distance (km)	Start Year	End Year	Period (Years)	Catchment Area (km^2)	Bad Records	MGA94 Zone	Easting	Northing
G8180026 - Mary River At El Sherana Road Crossing	40	1960	2005	45	466	5.7%	53	199180	8494660
G8180069 - Mckinlay River At Near Burrundie	16	1957	2005	48	352	12.4%	52	794186	8502406
G8180167 - Frances Creek At Upstream Frances Creek Mine	0	1961	1967	6	7*	76.6%	53	278309	8497580
G8180252 - Harriet Creek At Downstream El Sherana Road	17	1965	2005	40	122	40.3%	52	823159	8486119
G8200044 - Goodparla Creek At Coirwong Gorge	52	1973	1993	20	161	26.2%	53	191244	8535458

* Estimated catchment area, no record of precise site location could be found.

6.1.1 Frances Creek Streamflow Data

Chart 2 shows the water level data available for Frances Creek. Reasonably complete wet season records were only obtained for 1962, 1965, 1966 and 1967. Of these 1962 was a very dry year (741.4millimetres - less than 10th percentile), and 1965 to 1967 were about average rainfall. The highest water level recorded was 2.766 metres in February 1967. Around 2 metres appears to be a typical wet season maximum flow depth prior to construction of the Frances Creek Dams.

Chart 2: Water levels in France Creek 1962 to 1967



Relatively complete records for the 1961-62 and 1965-1967 wet seasons indicate Frances Creek Flowing consistently from December to May. These years had close to average rainfall except 1961 to 1962 which was a very low rainfall year. Annual rainfall figures from 1961 to 1967 are shown in Table 3.

Table 3: Pine Creek Annual Rainfall Records 1961 to 1965 (Bureau of Meteorology)

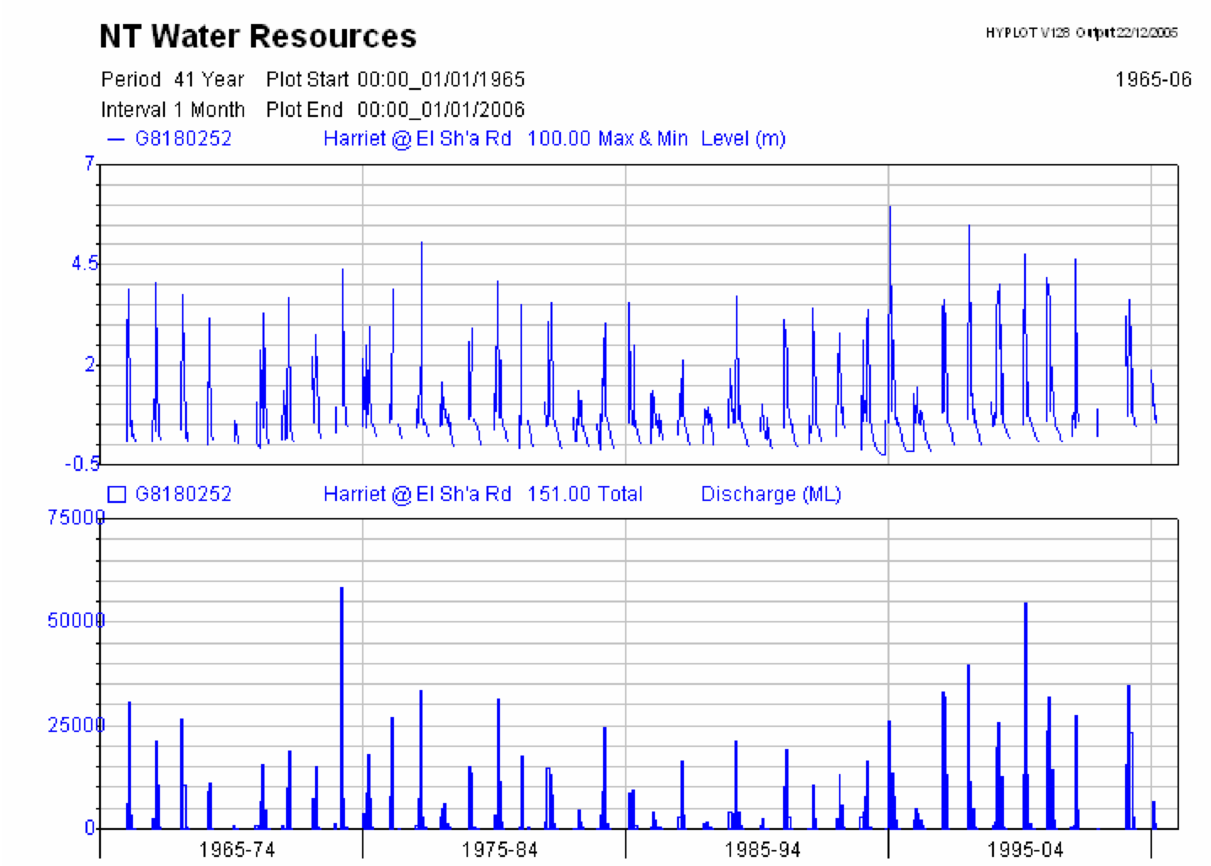
Year	Annual Rainfall	Rainfall Description
1961	939.9	below average
1962	741.4	very low
1963	1286.2	above average
1964	1376.8	well above average
1965	1105.7	average
1966	1253.4	above average
1967	1082.1	below average

The missing streamflow years of 1963 to 1964 had relatively high rainfall. It is possible that damage or access issues associated with flooding contributed to the lack of records for those years.

6.1.2 Harriet Creek Streamflow Data

Chart 3 shows the stream flow and volume data from Harriet Creek gauging station G8180252. The expected seasonal pattern of high flows in the wet season and no flow in the dry season can be seen, with substantial flows in almost all years.

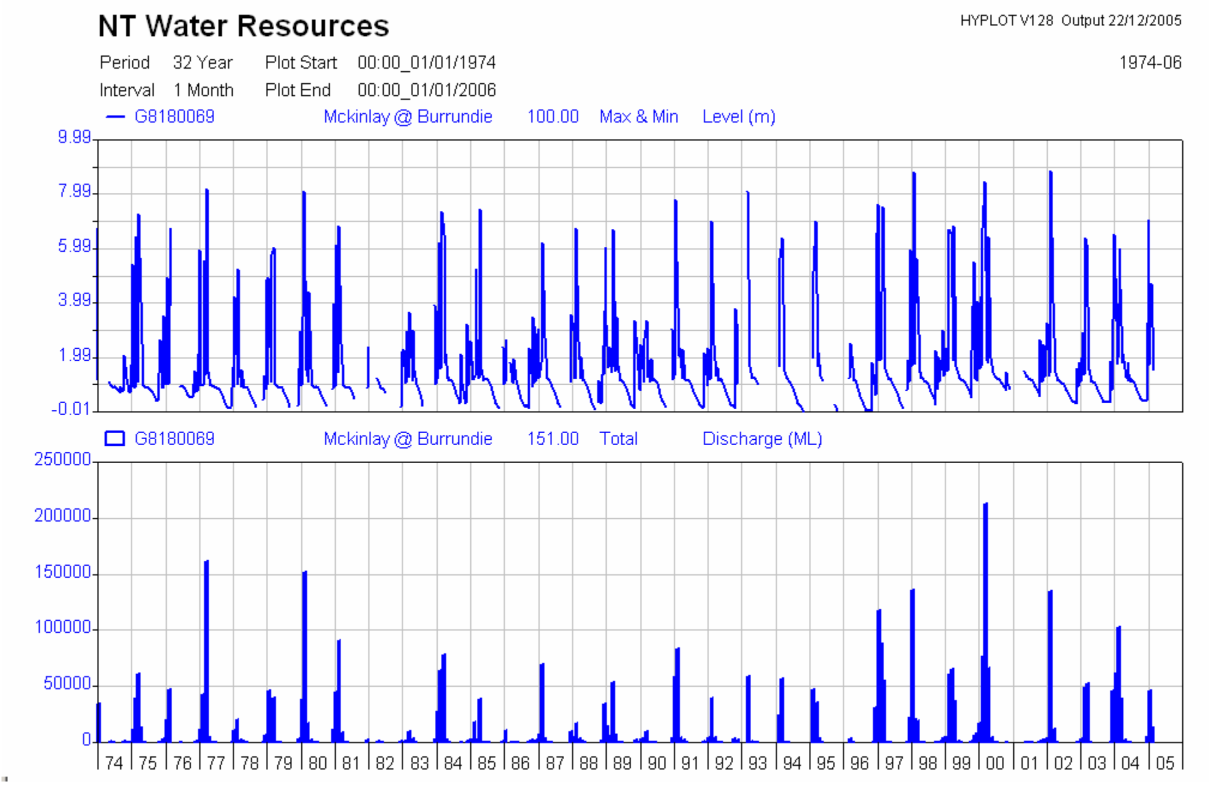
Chart 3: Flow and Volume Records from Harriet Creek Downstream El Sharana Road Gauging Station (G8180252).



6.1.3 McKinlay River Stream Flow Data

Chart 4 shows the stream flow and volume data from McKinlay River gauging station G8180069. As in Harriet creek, the expected seasonal pattern of high flows in the wet season and no flow in the dry season can be seen, with substantial flows in almost all years.

Chart 4: Flow and Volume Records from McKinlay River at Burrundie Gauging Station (G8180069)



6.1.4 Average Streamflow Data for Region

Chart 5 shows flow statistics per square kilometre for the McKinlay River (Burrundie, G8180069) and Harriet Creek (El Sharana, G8180252) gauging stations. The units are megalitres per square kilometre, which are equivalent to millimetres of rainfall runoff. It can be seen from this graph that the very little runoff occurs between May and September. Runoff is consistently high in January and February in Harriet Creek and from January to March in the larger McKinlay Catchment. Substantial runoff events have also occurred in the months of October, November, March and April. The highest recorded flow on McKinlay River occurred in the month of March. Since this data was extracted a late cyclone in April 2006 created very high April flows in the district.

The records available for Frances Creek indicate a closer match with the McKinlay River catchment, as Frances Creek flows regularly extend into April and May. This is likely due to the higher rainfall in the Frances Creek catchment than Harriet Creek.

Chart 5: Mean, Decile 9 and Maximum Monthly Runoff per square kilometre of Catchment for Harriet Creek (downstream El Sharana Road) and McKinlay River (Burrundie) Catchments.

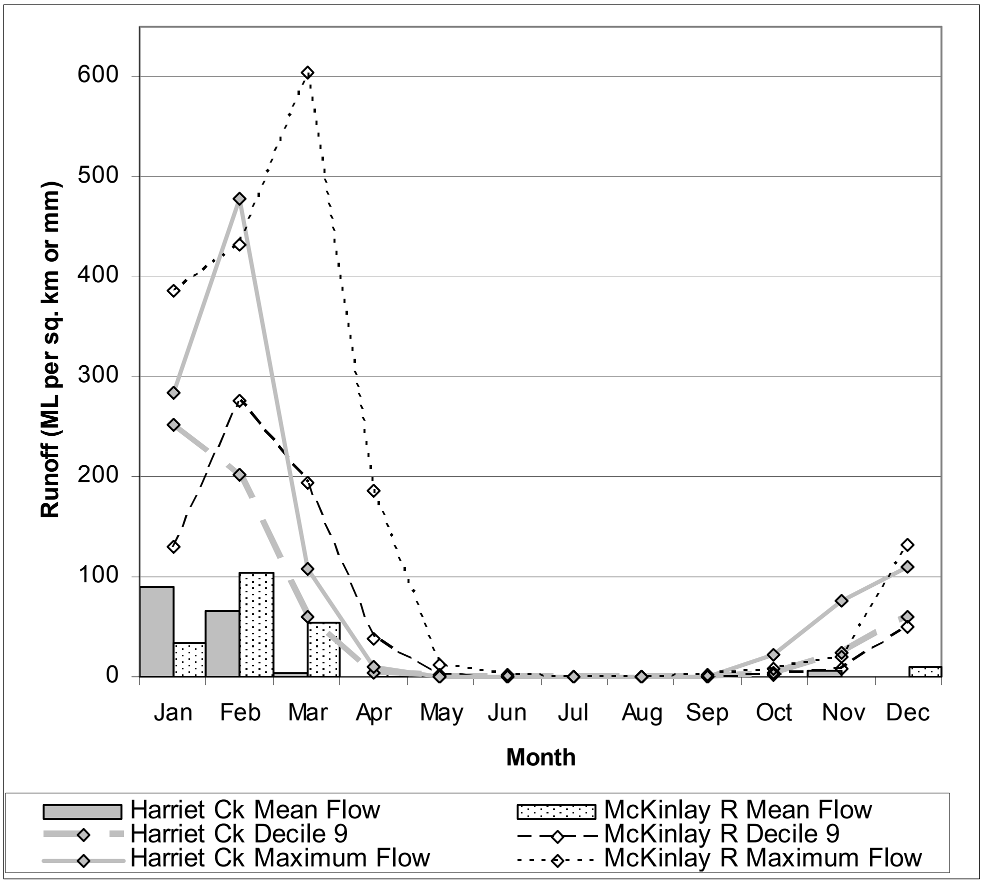


Chart 5 shows the mean, maximum, and decile 9 monthly flows. Decile 9 flows are equivalent to 90th percentile, and can be interpreted as the flow which is exceeded on average only once in ten years.

6.2 ESTIMATED AVERAGE AND FLOOD FLOWS FOR PROJECT AREA.

Based on the available stream flow data and regional flood estimation methods, estimates have been made of average peak flows and annual volumes, and flood peak flows for relevant catchments within the project area.

Results of these calculations are shown in Table 4 and Table 5. The figures in Table 4 for annual volumes are derived by scaling monitoring data from McKinlay river at Burrundie by catchment area.

Table 4: Estimated Annual Flow Volumes for Frances Creek Catchments

	Catchment Area (km^2)	10th Percentile Annual Flow (ML)	Median Annual Flow (ML)	Mean Annual Flow (ML)	90th Percentile Annual Flow (ML)	Maximum Annual Flow (ML)
Helene 9 Dam	1.95	103.7	527.7	614.1	1137.8	2181.1
Helene 11 Dam	1.6	85.1	433.0	503.9	933.6	1789.7
Frances Creek Main Dam	2.4	127.7	649.5	755.9	1400.4	2684.5
Helene 6 Dam	0.78	41.5	211.1	245.7	455.1	872.5
Helene 4 Dam	0.44	23.4	119.1	138.6	256.7	492.2
Ochre Hill Crossing - Dams	4.08	217.1	1104.1	1285.0	2380.7	4563.6
Ochre Hill Crossing - All	6.39	339.9	1729.3	2012.5	3728.6	7147.4
Thelma-Rosemary Dump US	0.15	8.0	40.6	47.2	87.5	167.8
Thelma-Rosemary Dump Total	0.48	25.5	129.9	151.2	280.1	536.9
Helene 6/7 WRS	0.224	11.9	60.6	70.5	130.7	250.6

The peak flows in Table 5 were calculated by the method developed for the Alice Springs to Darwin Railway design by Weeks *et. al*. (2002). Details of calculations are given in Appendix A.

Table 5: Estimated Peak Flow Rates for Frances Creek Catchments

	Catchment Area (km^2)	5 Year ARI Peak Flow (m^3s^{-1})	10 Year ARI Peak Flow (m^3s^{-1})	20 Year ARI Peak Flow (m^3s^{-1})	50 Year ARI Peak Flow (m^3s^{-1})
Helene 9 Dam	1.95	9.1	12.8	16.7	28.9
Helene 11 Dam	1.6	7.9	11.1	14.4	25.3
Frances Creek Main Dam	2.4	10.6	14.9	19.4	33.2
Helene 6 Dam	0.78	4.6	6.5	8.5	15.7
Helene 4 Dam	0.44	3.0	4.3	5.6	10.7
Ochre Hill Crossing - Dams	4.08	15.7	22.0	28.8	47.3
Ochre Hill Crossing - All	6.39	21.9	30.7	40.0	63.7
Thelma-Rosemary Dump US	0.15	1.4	1.9	2.5	5.2
Thelma-Rosemary Dump Total	0.48	3.2	4.6	5.9	11.3
Helene 6/7 WRS	0.224	1.8	2.6	3.4	6.8

Table 4 shows that the average annual stream flow for the dams on site is over half the storage capacity, and dams are likely to overflow most years. Table 5 shows the maximum flows that diversion structures will be required to cope with will be of the order of 10 cubic metres per second.

7. WATER QUALITY

7.1 REGIONAL WATER QUALITY.

Table 6 is a summary of water quality information for the Mary River Catchment extracted from the report Water Quality of the Rivers and Streams of the Mary River Catchment (N.T.) (Schultz *et al*, 2002).

Table 6: Water quality characteristics of 40 sites in the Mary River Catchment

Element	Units	Number of sites	Median	Range	10th percentile	90th percentile	ANZECC 95% trigger
pH		40	6.3	6.1 - 7.8	6.2	6.8	6.0-7.5
EC(2000)	µS/cm	40	53	12 - 342	32	119	20-250
Nitrate & Nitrite	mg/L	35	<0.001	<0.001-0.006	<0.001	0.004	0.030
NH_3 Nitrogen	mg/L	40	<0.01	<0.01-0.02	<0.01	0.01	na
Total Kjeldahl Nitrogen	mg/L	40	0.06	0.03 - 0.32	0.03	0.12	na
Total Nitrogen	mg/L	35	0.06	<0.03 - 0.32	0.03	0.13	0.15
Total Phosphorus	mg/L	40	0.007	0.004-0.013	0.005	0.011	0.01
Filterable Reactive Phosphorus	mg/L	35	0.001	<0.001-0.009	<0.001	0.003	0.005
Turbidity	NTU	40	5.7	0.7 - 15.0	3.8	13	2 - 15
Total Suspended Particulates	mg/L	40	1.95	0.40 - 8.76	0.85	4.46	

Table 6 shows that the catchment in general has slightly low pH compared to the relevant ANZECC trigger values for protection of aquatic ecosystems (ANZECC, 2000). The electrical conductivity is towards the upper end of the ANZECC trigger value range. Other studies confirm the upper Mary River catchment has elevated conductivity compared to the upper Katherine and East Alligator Rivers, (which have electrical conductivities of 38 and 22 microsiemens per centimetre respectively) but is low in comparison to other rivers in the top end of the NT such as the Daly and Roper Rivers (conductivities of approximately 600 and 1000 microsiemens per centimetre respectively). The higher conductivity is likely to be due to different geology (Schultz *et al*, 2002). Nutrients (Nitrogen and Phosphorous) are low, generally below ANZECC trigger values. Turbidity is within the range of ANZECC trigger values.

Table 7 shows Electrical Conductivity and turbidity from Schultz *et al* (2002) for the catchments in the study area containing active mines. It can be seen that both are significantly higher in these catchments. This may be contributed to by the mineralised geology of the catchments and/or discharge from mining operations.

Table 7: Water Quality Characteristics of Active Mine Catchments of the Mary River Catchment

Element	Units	Number of sites	Median	Range	10th percentile	90th percentile	ANZECC 95% trigger
EC(Active Mines)	mg/L	2	163	115 - 210	125	201	21
Turbidity-Active mines	NTU	2	7.2	2.3 - 12.0	3.3	11	2 - 10

Table 8 is a summary of metal concentrations for the Mary River Catchment extracted from the report "Water Quality of the Rivers and Streams of the Mary River Catchment (N.T.) (Schultz *et al*, 2002). Water samples were taken from 42 sites and a second sampling taken at 5 of these sites for a total of 47 samples.

Table 8: Metal concentrations (µg/L) at 42 sites in the Mary River Catchment

Element	% of sites with measurable concentrations	Median	Range	10th percentile	90th percentile	ANZECC 95% trigger
Aluminium	96	**60**	<5-**260**	12.6	150	55
Arsenic	55	1	<1-18	<1	3.32	37
Cadmium	6	<1	<1-**3**	<1	<1	0.2
Cobalt	4	<1	<1-5.9	<1	<1	ID
Chromium	0	<1	<1-<1	<1	<1	1
Copper	11	<1	<1-**12**	<1	0.44	1.4
Iron	100	620	44-1200	186	954	ID
Magnesium	100	2700	460-17000	1048	8100	-
Manganese	100	27	3.8-390	9.6	119.4	1900
Molybdenum	2	<1	<1-15	<1	<1	ID
Nickel	30	<1	<1-**16**	<1	4.62	11
Lead	0	<1	<1-<1	<1	<1	3.4
Selenium	0	<1	<1-<1	<1	<1	ID
Uranium	2	<1	<1-1.3	<1	<1	ID
Vanadium	2	<1	<1-1.2	<1	<1	ID
Zinc	60	1.6	<1-**200**	<1	**84.8**	8

It can be seen from Table 8 that the median aluminium concentration is above the ANZECC trigger value. The median concentration of all other metals analysed is below trigger values, but at least one sample exceeded the trigger values for each of Cadmium, Copper, Nickel and Zinc.

Further analysis focusing on upper tributaries within the Pine Creek Geosyncline such as Frances Creek indicates significantly higher concentrations of metals in runoff from these areas (Schultz *et al*, 2002).

The high concentrations of aluminium observed suggest that biota in the area has had an extended period to adapt to the high aluminium concentrations in the area (Schultz *et al*, 2002). The ANZECC trigger values are therefore likely to be too conservative to be applied to protection of ecosystems in the Mary River catchment. More appropriate limits will need to be developed based on the local natural water quality.

7.2 PROJECT AREA WATER QUALITY

7.2.1 Project Area Water Quality

Surface water samples were taken within the project area during April, November, and December 2005. The Frances Creek Waste Characterisation Study (MBS Environmental, May 2006) includes a detailed analysis of all surface water samples within the project area.

Data available includes:

- EC Turbidity and pH data from the main Frances Creek, Helene 9 and Helene 11 Dams and Helene 6/7 open pit sourced from Territory Iron.
- Water quality data from the Helene 9 Dam (unaffected by dewatering) sourced from Territory Iron and the Helene 4 Dam (Sample F6) - sourced through MBS Environmental (MBS). This data is considered representative of background surface water.
- Water quality data from the Helene 4 (sample F6), Jasmine (sample F2) and Thelma 2 (sample F3) open pits (unaffected by dewatering) - sourced through MBS.
- Surface ponds sourcing run-off water from un-mineralised Wildman Siltstone (sample F5) and pristine Mundogie Sandstone (sample F1) - sourced through MBS.
- Stream channel flow waters from basically un-mineralised ground (samples M2, M3, M5, M6) - sourced by MBS.
- Stream channel flow waters from mineralised ground (samples M4, M7, M8) - sourced by MBS.
- A stagnant pool on an old ore stockpile (sample M1) - sourced by MBS.

The locations water samples were taken from are shown in Figure 3. The most relevant surface water quality data is summarised in Table 9. Water quality in the project area is generally good, with significantly enhanced metal content in some areas. All water is fresh, with some higher electrical conductivity observed in areas subject to evaporation over the dry season. All samples were taken early in the wet season (November to December 2005) with the exception of Helene 9 Dam (April - early dry season) and the Frances Creek Dam (July - dry season). It is expected that water during the wet season will more closely resemble rainwater and have lower electrical conductivity.

Table 9: Frances Creek Project Area Surface Water Quality

Sample	Location	EC (µS/cm)	pH	Other Characteristics (µg/L)
Frances Creek Tributaries				
F5	Helene 6 Dam upper Frances Creek Tributary Catchment includes old Helene waste rock stockpiles	306	4.8	Enhanced beryllium (0.35), cobalt (45), soluble iron (1800), nickel (**50**) and sulfate (105,000). Enhanced sodium (19,900) and chloride (17,300) indicates likely concentration through evaporation. Beryllium level is likely due to granite geology of upper catchment.
F4	Tailings Swamp, catchment includes tailings surface and old stockpile area	121	7.2	Trace of zinc (**30**).
Helene 4 Dam	Small tributary upstream of disturbances	34	6.6	No elements exceeding guidelines.
M3	Tributary undisturbed catchment between Helene 2 and Thelma	36	6.0	Slightly enhanced aluminium (500), reduced iron (340).
M7	Diversion around Jasmine Pit	50	6.4	Trace of reduced iron (200), sulfate (4,900) almost high enough to account for acidity
Frances Creek				
Helene 9 Dam	Upstream of all disturbances	26	6.7	Significant aluminium (**21,800**), little reduced iron (60), extremely low sulphate (400) and negligible contents of toxicants.
Main Frances Creek Dam*	Downstream of TSF and stockpile area. Handheld meter readings	100	8.1	Moderate EC. No analysis of toxicants. Higher pH likely due to hand held meter versus lab analysis.
M4	Downstream of Main Dam	596	7.5	High in nitrates (**75**) and highest in both calcium (37,600) and sulphate (172,000). Exceeds Uranium Trigger Value (0.66 vs 0.50).
M8	Upstream of Ochre Hill crossing	132	6.9	No enhanced elements, red colour from road runoff.
M6	Waterhole, not flowing, downstream of all except Jasmine Pit	36	6.9	Slightly enhanced aluminium (**600**), reduced iron (600)
Maude Creek Tributaries				
M5	3 kilometres downstream of Ochre Hill	45	6.1	Slightly enhanced aluminium (**500**), reduced iron (400)
F1	7.5 kilometres north of Ochre Hill, northern tributary of Maude Creek unaffected by project	45	6.6	Significantly enhanced soluble Aluminium (**10,200**), Beryllium (0.20), Cobalt (5), Copper (**10.0**) soluble Iron, Lead (**4,150**), Thallium (0.01), Uranium (0.005), Vanadium (**20**) and Zinc (**30**) when compared against Fresh Water Trigger Values.

Note: Bold text indicates values exceeding ANZECC 2000 trigger values (see Table 6).

The highest concentrations of metals generally occurred in upper catchments without mining disturbances, and concentrations are often lower in samples downstream of those with high concentrations. Aluminium is elevated in all samples, as it is in the upper Mary River catchment generally (Schultz *et al*, 2002). The highest recorded levels of metals were in sample F1, taken from an undisturbed mineralised catchment in a Territory Iron exploration area 7.5 kilometres north of the proposed project area. The highest aluminium levels observed were from Helene 9 Dam, which has a largely undisturbed catchment.

The high levels of some metals in natural runoff in the area means it will be important to monitor flows upstream of operations to distinguish natural levels of metals from any influence of mining.

8. PROJECT IMPACTS

8.1 WATER DIVERSION

All the proposed open cut pits are located high in the landscape, on or near hill tops and will not require diversion of surface water. Pits will intercept direct rainfall, slightly reducing runoff to the local area.

Waste Rock Stockpiles will also be located high in the landscape and will not require diversion of runoff with the exception of the Helene 5, Helene 6/7 and Thelma Rosemary Waste Rock Stockpiles.

The Helene 5 Waste Rock Stockpile will be constructed on the former stockpile area and tailings storage facility (Figure 3). Construction of a low perimeter bund or drain to direct runoff from the upstream catchment around the waste rock stockpile over the rehabilitated tailings surface is desirable for this location (Figure 4). All runoff from the waste rock stockpile will flow to the Helene 11 Dam where it will mix with dewatering water and be available for reuse. Overflows from the Helene 11 Dam will flow into Main Frances Creek Dam where further settling and mixing will occur before potential flow into Frances Creek and off the mining lease, which will occur only when Main Frances Creek Dam overflows.

Helene 6/7 Waste Rock Stockpile will be constructed partly on top of the previous waste rock stockpiles for this pit and extended to the south. The southernmost extent of the dump will impinge on a watercourse draining a small catchment. A diversion drain will be required to carry flow from this watercourse around the toe of the dump (Figure 4). From the exit of the diversion water will flow under the haul road to the small Helene 6 dam. Overflows from Helene 6 dam will flow to the old TSF surface and Helene 11 Dam where it will mix with dewatering water and be available for reuse.

The Thelma Rosemary waste rock stockpile will be constructed in a gully extending from the Thelma Rosemary pit to near the haul road and covering the existing Thelma 2 waste rock stockpile. The head of the valley forms a 15 hectare catchment, runoff from which will be blocked by the stockpile. The catchment has been cut off further downstream by the Thelma 2 waste rock stockpile for 30 years without apparent detrimental effects. The catchment area is small enough that allowing runoff to percolate under the dump is not likely to cause any harm. Alternatively contour drains could be established around the perimeter of the WRS to direct runoff from adjacent hillsides around the dump to Frances Creek as indicated in Figure 4. A suitable sedimentation basin would be required at the exit of these drains.

Construction of this waste rock stockpile either with or without diversion drains will have the effect of substantially reducing the amount of runoff dammed at the toe of the Thelma 2 waste rock stockpile.

8.2 RUNOFF FROM DISTURBED AREAS

Haul roads will generate higher runoff than natural surfaces. Road runoff will have elevated levels of sediments. It is recommended that sedimentation basins should be constructed on roadside drains to reduce sediment load to water courses.

Waste rock stockpiles that have not yet been revegetated are likely to generate higher sediment loads than naturally vegetated areas. Runoff collection bunds should be installed at the toe of waste rock stockpiles to slow runoff and allow settling of suspended sediments. The waste characterisation report (MBS Environmental, May 2006) indicates that leachate from the stockpiles will not cause acidity or toxicant problems.

8.3 DEWATERING

Water from Helene 6/7 pit was sampled and analysed during dewatering for exploration in April 2005. The water sampled was immediate inflow, not accumulated pit water, and is representative of expected discharge during mining operations. A summary of the results of analysis and comparison with local surface water is shown in Table 10. Full details of laboratory analysis are included in the Waste Rock Characterisation Report (MBS Environmental, May 2006).

It can be seen from Table 10 that the water sourced from Helene 6/7 dewatering is of good quality, comparable to natural surface waters in the area. It is of suitable quality for reuse and meets standards for raw water for drinking water supply use. The main impact on receiving waters will be due to elevated turbidity and suspended solids created by the pumping process.

The water is slightly alkaline with extremely low sulfate, so there are no acid drainage issues. The only substance exceeding ANZECC default trigger values for protection of aquatic ecosystems is aluminium, which is relatively high at 6,800 micrograms per litre. Although well above guidelines it is within the range of values observed in surface water sampling in the project area. The highest observed value in the project area is the Helene 9 dam, which receives runoff from a mostly undisturbed catchment, and has four times more aluminium than the Helene 6/7 dewatering discharge.

Estimated quantity of dewatering is 24 megalitres per month. At the end of the dry season the Helene 11 Dam water is estimated to be a mix of about 50% dewatering discharge and 50% natural runoff water. Overflow from Helene 11 will be further diluted in the main Frances Creek Dam. Dewatering discharge would be diluted by a factor of around 10 to 1 in any discharge from the Main Frances Creek Dam.

Table 10: Discharge Water Quality

Element	Units	Helene 6/7 Dewatering Sample	Range observed in Frances Creek Project Area	Range observed in Mary River Catchment Study (Shultz *et al* , 2002)	ANZECC Default Trigger Value
pH	none	7.9	3.5-8.1	6.1 - 7.8	6.0-7.5
EC(2000)	µS/cm	106	17-596	12 - 342	20-250
NO3 Nitrogen	mg/L	<0.005	5-290	na	na
NH3 Nitrogen	mg/L	0.005	5-2,610	<0.01-0.02	na
Sulphate	mg/L	1.2		na	na
Turbidity	NTU	5	na	0.7 - 15.0	2 - 15
Aluminium	µg/L	**6,800**	**20-21,800**	<5-**260**	55
Arsenic	µg/L	1.05	0.4-7.7	<1-18	37
Cadmium	µg/L	<0.02	0.02-0.16	<1-**3**	0.2
Cobalt	µg/L	0.1	0.04-45	<1-5.9	na
Chromium	µg/L	0.2	0.2-**1.6**	<1-<1	1
Copper	µg/L	1	0.78-**35**	<1-**12**	1.4
Iron	µg/L	60	60-4,150	44-1200	na
Magnesium	µg/L	9,200	300-35,500	460-17,000	-
Manganese	µg/L	11	0.68-870	3.8-390	1900
Molybdenum	µg/L	0.20	0.05-0.85	<1-15	na
Nickel	µg/L	1.77	0.36-**110**	<1-**16**	11
Lead	µg/L	0.06	0.03-7	<1-<1	3.4
Selenium	µg/L	<0.2	0.2-4.8	<1-<1	na
Uranium	µg/L	0.05	0.01-3.11	<1-1.3	na
Vanadium	µg/L	0.5	0.2-**500**	<1-1.2	100
Zinc	µg/L	7	0.2-**195**	<1-**200**	8

Dilution will continue downstream and by the time water leaves the mining tenements the dewatering discharge component will be less than 4% of Frances Creek flows. At the confluence with the Mary River it will make up less than 1% of the total Frances Creek flow.

8.3.1 Pit Stormwater Discharge

Whilst groundwater dewatering will only be required at Helene 6/7 pit, all open pits will accumulate stormwater during rainfall events. The pits are located on ridge lines and have little or no contributing catchment other than the pit itself, but will still collect substantial volumes of water in the wet season due to the high rainfall climate of the area. Table 11 shows estimated volumes of stormwater that would be collected for various rainfall scenarios. These volumes are too large to be accommodated within the pits without compromising mining operations.

Table 11: Annual Stormwater Flow to Open Pits (kilolitres)

Rainfall	Helene 5	Helene 6/7	Jasmine E	Ochre Hill	Thelma Rosemary
10th Percentile Annual Rainfall (826.8mm)	70113	57545	17197	42332	68128
Mean annual rainfall (1262.7mm)	107077	87884	26264	64650	104046
Median annual rainfall (1225.3mm)	103905	85281	25486	62735	100965
90th Percentile Annual Rainfall (1812.6mm)	153708	126157	37702	92805	149358

To allow mining during the wet season it is proposed to pump excess stormwater out of the southern four pits to the following locations:

- Water from Jasmine East Pit will be pumped to Jasmine central pit.
- Water from Thelma Rosemary Pit will be pumped to Thelma 2 pit.
- Water from Helene 5 and Helene 6/7 pits will be pumped to the old TSF and Helene 11 dam combined with groundwater dewatering flows.

Proposed discharge routes are shown in Figure 4.

To avoid potentially contributing to overflow of water accumulated in the Thelma 2 and Jasmine East pit voids, water should only be pumped to these pits while there is sufficient freeboard to allow for a 1:100 year 72 hour rainfall event (424 millimetres).

There are no suitable areas nearby to contain Ochre Hill stormwater, so it will have to be discharged to nearby water courses after passing through a suitable sedimentation pond. Water pumped from Ochre Hill pit is expected to meet discharge criteria as it is rainwater with only brief exposure to fresh rock in the pit, and ore and waste analysis indicates no problems due to exposure of water to these materials are likely. Discharges will only be required following rainfall so discharges are likely to be made into flowing watercourses, ensuring dilution of the discharge. The estimated pit life of Ochre Hill is less than two years, so discharges will only occur over one or two wet seasons.

Water quality should be monitored prior to discharge to ensure it meets relevant water quality criteria and will not be harmful to the environment.

8.4 PIT VOIDS

Of the proposed pits only Helene 6/7 is likely to have a final pit lake. Exploration drilling in other pits has not encountered water above the final pit depth. Water quality in Helene 6/7 pit is suitable for all purposes including use by wildlife and this is not likely to be changed by deepening of the pit.

9. LICENSING REQUIREMENTS

Use storage, discharge and management of water within the mining tenements is covered by the conditions of the Mining Management Plan under the *NT Mining Management Act 2001,* administered by DPIFM.

Products of dewatering from Helene 6/7 are likely to be discharged from the mining tenements via the Main Frances Creek Dam and Frances Creek. Excess stormwater from Ochre Hill Pit will need to be discharged to a tributary of Maude Creek. A water discharge licence is required for such discharge under the sections 74 and 75 of the *NT Water Act*. Such a licence should be applied for following approval of the PER.

10. WATER MANAGEMENT MEASURES

The following water management measures are recommended:

- All discharge from dewatering should pass through the former Helene 11 Dam and Frances Creek Main Dam for settling of sediments and dilution before release to Frances Creek.
- Water for dust suppression should be sourced from dewatering discharges via the Helene 11 Dam or from pit sumps.
- Waste Rock Stockpiles should have low perimeter bunds constructed around their bases to slow runoff and permit settling of suspended material.
- Waste Rock Stockpiles should be progressively rehabilitated to reduce the amount of unvegetated area contributing to runoff at any time.
- A diversion channel/bund should be constructed around the Helene 5 waste rock stockpile to prevent catchment runoff from coming into contact with the dump base.
- All runoff from disturbed areas should pass through settlement basins prior to discharge to natural watercourses.
- If stormwater is pumped to existing pit voids, the water level in the voids should be monitored and pumping should cease whilst sufficient freeboard remains to prevent overflow of pit waters.

Figure 4 shows the location of proposed diversions, culverts and settlement basins to manage water on the site.

11. WATER MONITORING REQUIREMENTS

Water quality should be monitored up and downstream of impacts. Water quality analysis should include elements known to occur at high levels naturally in the area and those likely to be impacted by mining. These would include pH, electrical conductivity, nitrate, beryllium, copper, lead, thallium, uranium, vanadium, nickel and zinc.

Water in locations likely to require discharge to the environment (Helene 6/7 and Ochre Hill pit) should be analysed before release is imminent to ensure discharge requirements will be met.

Quantity of water discharge should be monitored through daily level readings at Helene 11 Dam and the Frances Creek Dam spillway level or automated monitoring system. The dam spillways will need to be surveyed and level boards installed to facilitate this.

Flow meters should be installed on dewatering and stormwater discharge pipelines and daily records kept of discharge volumes. Water volumes taken from the decant pond for site use should also be monitored.

12. REFERENCES

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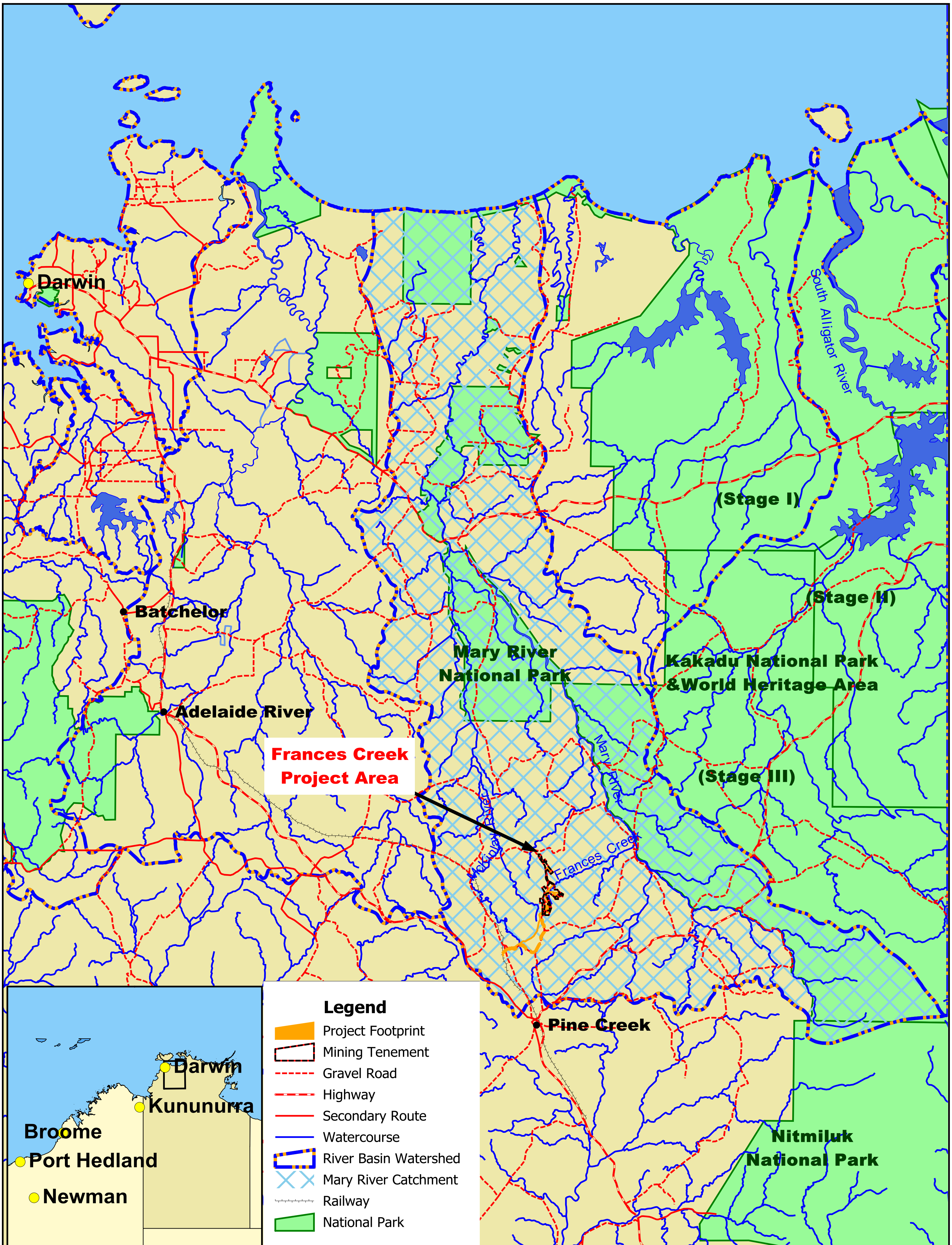
FIGURES



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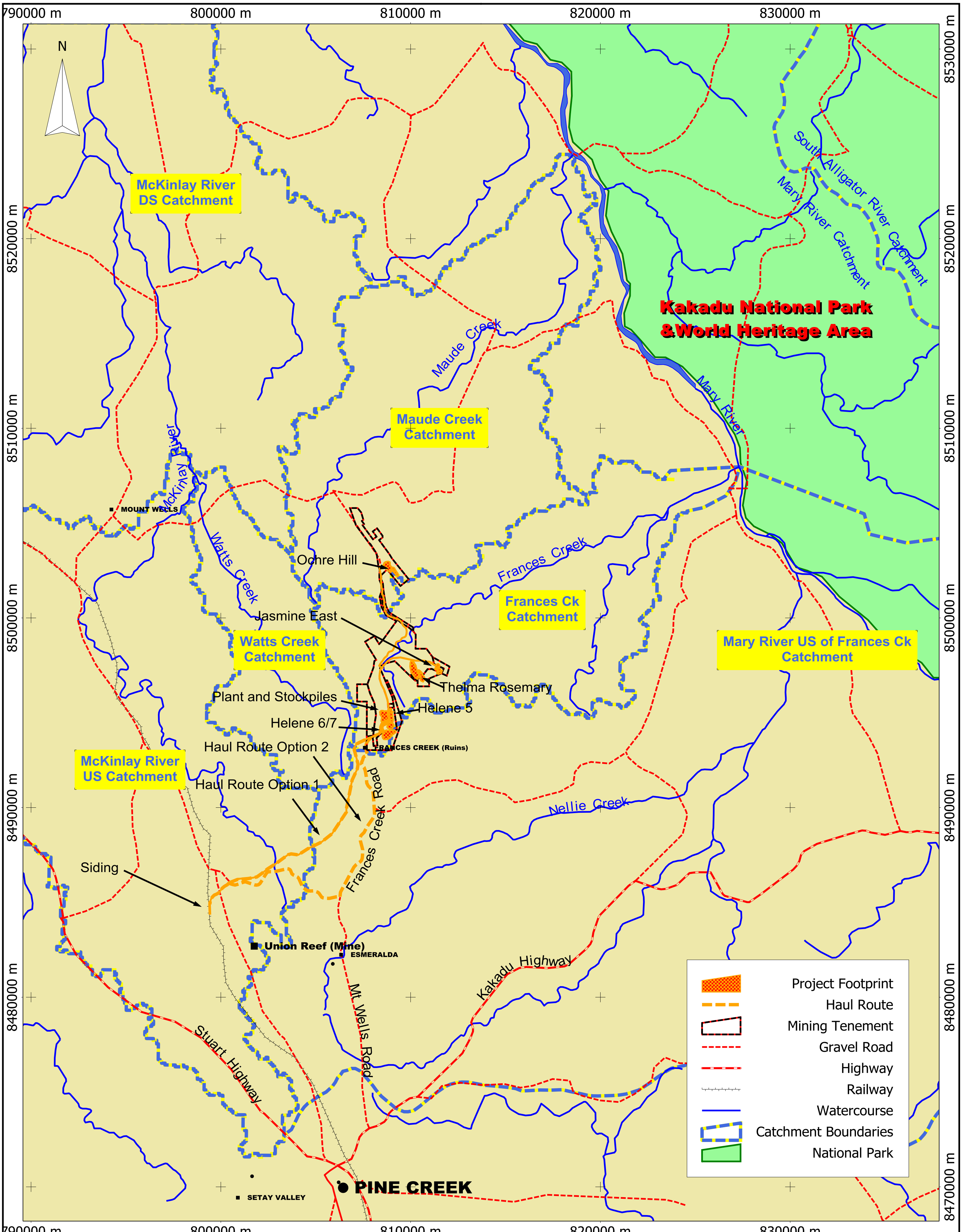
Territory Iron Limited
Frances Creek Mine

Location Plan and Regional Catchments

Figure 1



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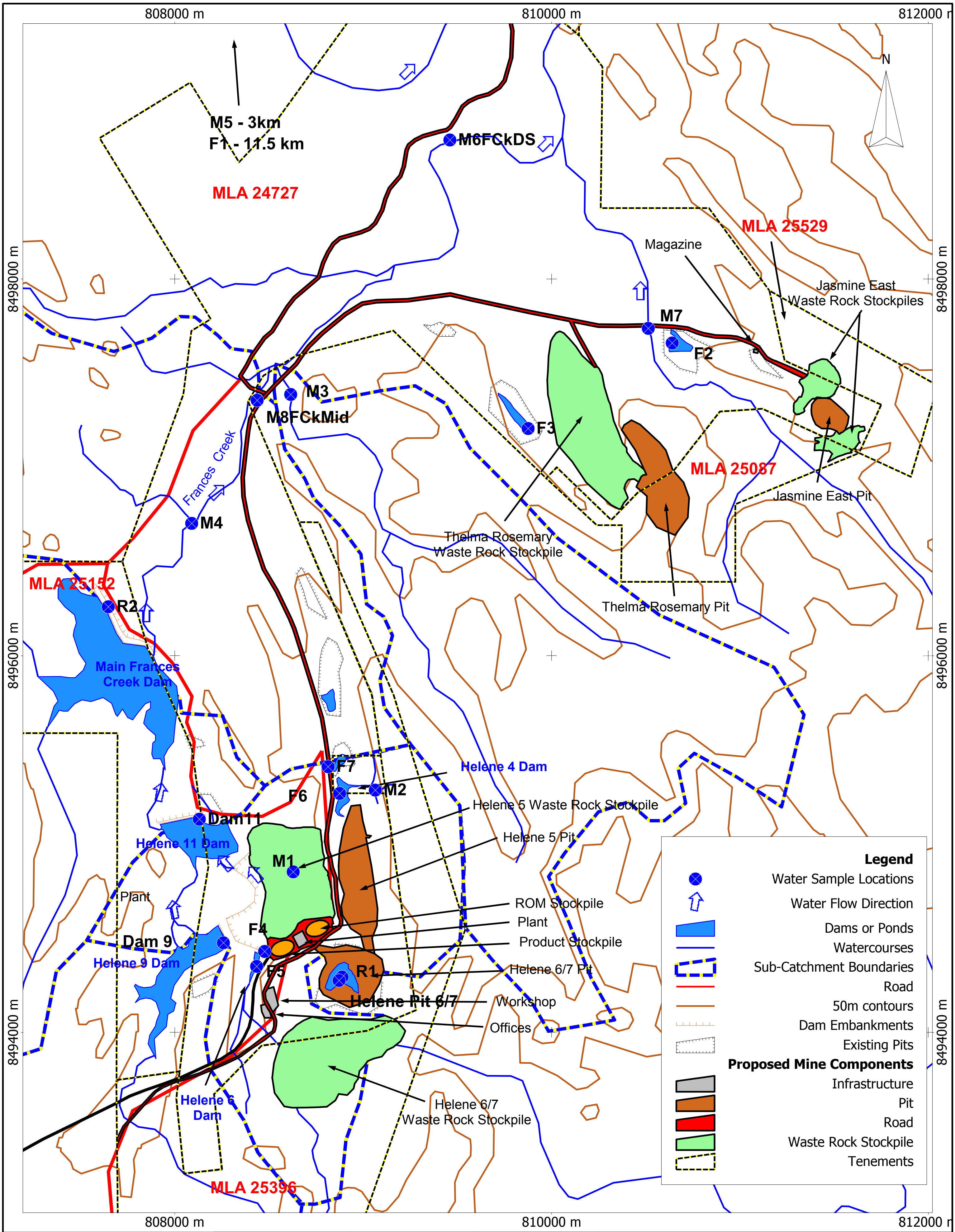

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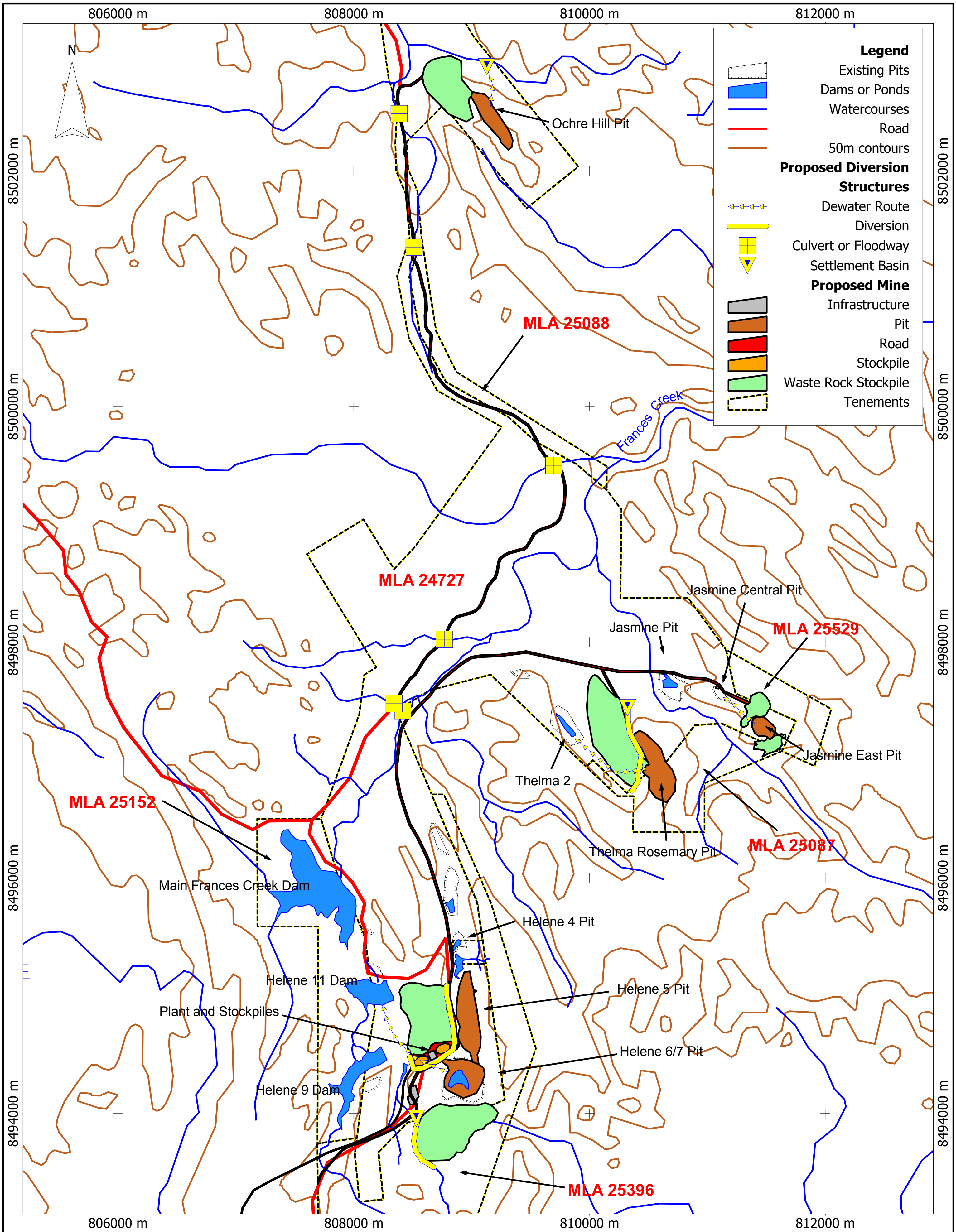

MBS ENVIRONMENTAL Environmental + Water Resource Consultants 4 Cook St West Perth WA 6005 Telephone: + 618 9226 3166 Facsimile: + 618 9226 3177 info@mbsenvironmental.com.au	Scale: 1:40000 Original Size: A4 Air Photo Date Datum: Australian Geocentric 1994 (GDA94) 0 1 km	Territory Iron Frances Creek Mine	Location of Proposed Water Diversions, Culverts and Floodways Figure 4

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APPENDIX A
STREAMFLOW CALCULATIONS

Streamflow Calculations

A1. Peak Flow Calculations

Peak flow estimates were made using the regional techniques described in Weeks *et al.* (2002). These methods were developed by statistical analysis from gauged catchments, and used in design of the Alice Springs to Darwin Railway.

For the Katherine area the relationships developed are:

$Q_5 = 6.43A^{0.627}$
$Q_{10}=9.20\ A^{0.63}$
$Q_{20}=10.2A^{0.737}$
$Q_{50}=18.5\ A^{0.657}$

Where Q_Y is the peak discharge in cubic metres for a Y year average recurrence interval rainfall event, and A is the catchment area in square kilometres.

Application of the above equations to catchments in the Frances Creek project area provides the results shown in Table A1.

Table A1: Estimated Peak Flows for Frances Creek Catchments

	Catchment Area (km^2)	5 Year ARI Peak Flow (m^3s^{-1})	10 Year ARI Peak Flow (m^3s^{-1})	20 Year ARI Peak Flow (m^3s^{-1})	50 Year ARI Peak Flow (m^3s^{-1})
Helene 9 Dam	1.95	9.1	12.8	16.7	28.9
Helene 11 Dam	1.6	7.9	11.1	14.4	25.3
Frances Ck Main Dam	2.4	10.6	14.9	19.4	33.2
Helene 6 Dam	0.78	4.6	6.5	8.5	15.7
Helene 4 Dam	0.44	3.0	4.3	5.6	10.7
Ochre Hill Crossing - Dams	4.08	15.7	22.0	28.8	47.3
Ochre Hill Crossing - All	6.39	21.9	30.7	40.0	63.7
Thelma-Rosemary Dump US	0.15	1.4	1.9	2.5	5.2
Thelma-Rosemary Dump Total	0.48	3.2	4.6	5.9	11.3
Helene 6/7 WRS	0.224	1.8	2.6	3.4	6.8

A2. Volume Calculations

Comparison of the limited available flow records for Frances Creek with nearby gauging stations indicated that monitoring data from station G8180069 on the McKinlay River at Burrundie was the most representative of flows in Frances Creek. Estimated annual flow volumes for Frances Creek have been calculated by scaling the statistical data available for McKinlay River at Burrundie by catchment area.

The calculations are a rough approximation; especially as no the Frances Creek catchments are a hundred times smaller than the catchment of G8180069. No local data is available for very small catchments however, so the data used is the best available.

The results of these calculations are shown in Table A2.

Table A2: Estimated Annual Flow Volumes for Frances Creek Catchments

	Catchment Area (km^2)	10th Percentile Annual Flow (ML)	Median Annual Flow (ML)	Mean Annual Flow (ML)	90th Percentile Annual Flow (ML)	Maximum Annual Flow (ML)
Helene 9 Dam	1.95	103.7	527.7	614.1	1137.8	2181.1
Helene 11 Dam	1.6	85.1	433.0	503.9	933.6	1789.7
Frances Ck Main Dam	2.4	127.7	649.5	755.9	1400.4	2684.5
Helene 6 Dam	0.78	41.5	211.1	245.7	455.1	872.5
Helene 4 Dam	0.44	23.4	119.1	138.6	256.7	492.2
Ochre Hill Crossing - Dams	4.08	217.1	1104.1	1285.0	2380.7	4563.6
Ochre Hill Crossing - All	6.39	339.9	1729.3	2012.5	3728.6	7147.4
Thelma-Rosemary Dump US	0.15	8.0	40.6	47.2	87.5	167.8
Thelma-Rosemary Dump Total	0.48	25.5	129.9	151.2	280.1	536.9
Helene 6/7 WRS	0.224	11.9	60.6	70.5	130.7	250.6