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CELL DEVELOPMENT AND CLOSURE PLAN – SEVEN MILE WASTE DISPOSAL FACILITY

This document is to be used as a guide for the ongoing development, closure and rehabilitation of landfill areas at the Seven Mile Waste Disposal Facility.


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TABLE OF CONTENTS

1	Executive Summary.....	9
2	Introduction	10
2.1	Seven Mile Waste Disposal Facility.....	10
2.2	Guidance Documents.....	10
2.3	Compliance	10
2.4	Cell Development and Closure Plan.....	10
2.5	Landfill Location	10
2.6	Surrounding Land Uses	11
2.7	Climate and Meteorology	11
2.8	Topography	11
2.9	Geology and Hydrogeology.....	11
2.10	Groundwater.....	11
2.11	Landfill Infrastructure	12
2.12	Operating Hours.....	13
2.13	Landfill Users.....	13
3	Lined Landfill Cell Location.....	14
3.1	Protection of Groundwater.....	14
3.2	Earthworks Quantities	14
4	Landfill Life Expectancy	16
4.1	Landfill Capacity	16
4.2	Top of Waste Profile	16
4.3	Airspace Modelling Criteria.....	17
4.4	Landfill Capacity	17
4.5	Capital Cost for Cell Construction	19
5	Landfill Liner System	21
6	Leachate.....	22
7	Landfill Gas.....	23
8	Rehabilitation and Aftercare.....	24
8.1	Progressive Rehabilitation	24
8.2	Landfill Cap.....	24



8.3	Proposed Landfill Caps.....	25
8.4	Topsoil on Landfill Cap	26
8.5	Vegetation.....	27
8.6	Landscaping.....	28
8.7	Aftercare	28
8.8	Landfill Completion	29
9	References	30
10	Drawings	31



LIST OF FIGURES

Figure 1	Future Landfill Liner Detail	21
Figure 2	Seven Mile Waste Management Facility Landfill Cap Designs	26

LIST OF TABLES

Table 1	Groundwater Monitoring Bores	12
Table 2	Area for Each Cell of Landfill Development	15
Table 3	Area for Each Cell of Landfill Development	16
Table 4	Estimate of Remaining Airspace in Current Landfill Area	18
Table 5	Proposed Landfill Cell Construction Program	20
Table 6	Contingency Plan for Excessive Leachate Levels within the Landfill	22
Table 7	Contingency Plan for Excessive Leachate Levels within the Landfill	27
Table 8	Contingency Plan for Excessive Leachate Levels within the Landfill	28

TABLE OF DRAWINGS

DRAWING NO	REVISION	DESCRIPTION
SML – SK01	A	Site Layout Plan
SML – SK02	A	Existing Landfill Top of Waste Surface Layout Plan
SML – SK03	A	Proposed Existing Landfill Sections
SML – SK04	A	New Landfill Earthworks Layout Plan
SML – SK05	A	New Landfill Top of Waste Surface Layout Plan
SML – SK06	A	New Landfill Top of Waste Surface Sections
SML – SK07	A	Landfill Top of Cap Surface Layout Plan
SML – SK08	A	Landfill Catchment Layout Plan & Calculations
SML – SK09	A	Landfill Details



ABBREVIATIONS

AHD	Australian Height Datum
Consultant	Bowman & Associates Pty Ltd
City	City of Karratha
DER	Department of Environment Regulation
EP	Environmental Protection
EPA	Environmental Protection Authority
HDPE	High Density Polyethylene
Licence	Seven Mile Waste Disposal Facility Licence No. L7021/1997/14
Shire	Shire of Roebourne

UNITS OF MEASURE

\$	Australian Dollars (AUD)
ha	hectare
km	kilometre
kg/m³	kilogram per cubic metre
mm	millimetre
m	metre
m²	square metre
m³	cubic metre
m/s	metre per second
t	tonne
tpa	tonne per annum



1 Executive Summary

In 2012 the Shire of Roebourne, and now known as the City of Karratha (City), engaged Bowman & Associates to investigate and prepare a plan for the continued development, rehabilitation and final closure of the landfill operations undertaken at the City's Seven Mile Waste Disposal Facility. The resulting plan, titled *Proposed Land Use Strategic Filling Plan – 7 Mile Waste Disposal Facility*, Version 3, Bowman & Associates, was released on 8 June 2012.

The City has now engaged Bowman & Associates to further review and prepare guidance for the development of new landfill cells, rehabilitation and closure of completed landfilled areas. The *Proposed Land Use Strategic Filling Plan – 7 Mile Waste Disposal Facility* has now been superseded by this document, *Cell Development and Closure Plan – Seven Mile Waste Disposal Facility* (Plan).

The current unlined area of the landfill has a remaining capacity of approximately 435,000 m³ necessitating a new area for landfilling to be developed and ready to accept waste in the 2016/17 period. The Department of Environment Regulation (DER) requires all new landfill areas to be constructed in accordance with the Victorian EPA, 2014, *Best Practice Environmental Management: Siting, Design, Operation and Rehabilitation of Landfills Guideline* (VIC-BPEM). This involves the use of a barrier system beneath (liner) the waste and a sealed capping system on top of the waste once landfilling is completed.

This Plan is prepared as a guidance document to be used by the City for scheduling, designing, closing and rehabilitating landfill cells at the Seven Mile Waste Facility. Waste quantities to landfill were modelled assuming that the combustible portion of the waste stream will be diverted from landfill in 2017/18 and sent to the proposed waste to energy facility planned for construction near Port Hedland.

The modelling suggests that over the next twenty five (25) years 940,569 tonnes of waste will be required to be landfilled at Seven Mile Waste Disposal Facility. Landfill cells will be progressively constructed to provide timely airspace availability over this period.

This Plan provides a concept design for six (6) lined landfill cells which, provided combustible waste is diverted away from the site for off-site gasification, will provide landfill airspace up to 2040. There is sufficient land available at the site to develop further landfill cells beyond the six (6) cells proposed allowing landfilling to extend well into the later part of this century.

It is estimated that capital expenditure of \$8,944,000 will be required over the next twenty five (25) years for landfill cell construction. This equates to \$9.51 per tonne for every tonne of waste landfilled at the Seven Mile Waste Disposal Facility over the next twenty five (25) years.



2 Introduction

2.1 Seven Mile Waste Disposal Facility

The Seven Mile Waste Disposal Facility is situated on Crown Land and has been used as a landfill by the City circa 1992. The site is owned by the Crown and vested in the City. There are no conditions in the vesting order which impact on the long term use of the land as a landfill by the City.

2.2 Guidance Documents

The key guiding documents for the preparation of the Filling Plan have been:

- Bowman & Associates, 2013, *Operational Management Plan – 7 Mile Waste Disposal Facility*, Version 1,
- Department of Environment Regulation, 2012, Licence Number L7021/1997/14, *Licence for Prescribed Premises, Seven Mile Waste Disposal Facility*,
- Western Australia, 1986, *The Western Australian Environmental Protection Act 1986*,
- WA EPA, 2005, *Separation Distances between Industrial and Sensitive Land Uses*,
- Department of Environment and Conservation, 2009, *Landfill Waste Classification and Waste Definitions 1996* (As amended December 2009), and
- The Victorian EPA, 2010, *Best Practice Environmental Management: Siting, Design, Operation and Rehabilitation of Landfills Guideline*.

2.3 Compliance

The Seven Mile Waste Disposal Facility is licenced by the DER in accordance with the *Environmental Protection (EP) Act 1986*. The DER licence reference number is L7021/1997/14 (Licence). The Licence permits the City to operate its Seven Mile Waste Disposal Facility as:

- Category 57 Used Tyre Storage,
- Category 62 Solid Waste Depot,
- Category 64 Class II putrescible landfill, and
- Category 61 Liquid Waste Facility.

Landfill operations must comply with the *EP Act 1986*, its regulations and relevant environmental protection policies.

2.4 Cell Development and Closure Plan

This Plan has been prepared by Bowman & Associates in order to provide guidance to the landfill staff for the ongoing landfilling of waste, rehabilitation and then closure the City's Seven Mile Waste Disposal Facility.

2.5 Landfill Location

The Seven Mile Waste Disposal Facility is located approximately 8 km (12 km by road) west - south



west of Karratha on Crown Reserve numbers 32987 and 33135 on Lots 85 and 552, Seven Mile Road, Gap Ridge, Karratha WA 6714. The site totals approximately 100 hectares (ha) and has waste disposal activities that are undertaken throughout the site. The main access to the site is along Exploration Drive, off Dampier Road and located at the rear of the Gap Ridge Industrial Estate.

2.6 Surrounding Land Uses

The Seven Mile Waste Disposal Facility is surrounded by land largely covered with low scrub; the area to the west is occupied by Rio Tinto's rail network. To the north lies the Gap Ridge Industrial Estate. Located east of the landfill site is low scrub, around 500 m further to the east is a watercourse, and 1.2 km to the east is the Water Corporation Waste Water Treatment Plant.

The closest residence is situated 2.5 km from the northern east boundary of the site within the residential area of Madigan Estate.

2.7 Climate and Meteorology

The Karratha region has a climate of hot summers with cyclonic weather from November to March, and mild, dry winters.

Seasonal temperature variations range from mean daily maximum and minimum temperatures of 36°C and 26°C respectively in summer (January) to a mean daily maximum and minimum temperature of 27°C and 13°C respectively in winter (July).

Long term climatic data obtained from the Karratha Airport, approximately 5.7 km north of the facility, indicated that the long term average annual rainfall is 289 mm, which falls usually over the summer months. The wettest month is normally February, with an average rainfall of 80 mm.

2.8 Topography

The area is relatively flat with a slight fall across the site from the western boundary to the eastern boundary. Elevation ranges from approximately 25 m above the Australian Height Datum (AHD) in the western portion of the site to approximately 16 m AHD along the north east boundary. The surrounding vegetation is native scrubland.

2.9 Geology and Hydrogeology

There are no surface water bodies present on the site; the nearest water body is 4.5 km to the west which are salt evaporation ponds, Hampton Harbour, and located 9 km to the north is Nickol Bay.

The geology beneath the landfill site is typically red shallow sand, pindan sands, with granite and laterite gravel deposits in the south west corner of the site.

2.10 Groundwater

Several groundwater monitoring bores exist on the landfill site and are located in strategic locations



around the landfill and wastewater treatment areas (**Drawing SML-SK01**). The Licence refers to eight (8) groundwater monitoring bores on the site. A further four (4) bores have been installed around the site. These additional bores, Bores 2, 3, 4 and 6, are not referred in the Licence and do not included in the annual compliance report submitted to the DER. Typical levels from groundwater monitoring undertaken by the City are shown in **Table 1**. These groundwater levels have been used for the concept modelling of the future lined landfill cells.

Table 1 Groundwater Monitoring Bores

MONITORING SITE	GROUNDWATER DEPTH (m) AHD	COORDINATES	
		NORTH	EAST
MW01	9.8	7703777.251	475790.783
MW02	10.0	7703754.210	475551.593
MW03	10.2	7703628.291	475356.412
MW04	10.8	7703228.608	475339.783
MW05	10.7	7703299.165	475575.546
MW06	11.8	7702789.739	475382.341
MW07	11.2	7702626.774	475851.024
MW08	12.5	7702338.145	475456.224
Bore 2	9.6	7703581.056	476042.135
Bore 3	10.1	7703248.650	476073.941
Bore 4	10.6	7702925.991	476205.418
Bore 6	10.9	7702569.037	476240.016

2.11 Landfill Infrastructure

The landfill site infrastructure includes:

- Perimeter fencing,
- Entrance and site access roads,
- Weighbridge office and weighbridge,
- Vehicle parking and hardstand area,
- Administration office and ablutions,
- Recycling drop off area,
- Light vehicle waste transfer station,
- Workshop,



- Landfill areas,
- Effluent ponds, and
- Landfill plant equipment.

2.12 Operating Hours

The Seven Mile Waste Disposal Facility's operating hours for waste acceptance is Monday to Sunday: 7.30 am to 4.30 pm (excluding New Year's Day, Good Friday and Christmas Day).

2.13 Landfill Users

The landfill is used by the City and is also open to both commercial users and the general public.



3 Lined Landfill Cell Location

To the south of the current landfill area within the Seven Mile Waste Disposal Facility is an expanse of land of approximately 40 ha (**Drawing SML-SK01**). Within this area are located the below ground hazardous waste pits and a prior above ground landfill that cannot be disturbed. A hard rock deposit is located at the south west corner of the site. A large portion of this land can however be excavated and the resultant void be used for future landfilling. **Drawing SML-SK01** shows the proposed future landfill cells which will allow landfilling up to circa 2040.

The area covered by the six (6) proposed lined landfill cells is 6.88 ha providing ample room further south on the site for further expansion of the landfill beyond 2040. The current unlined landfill covers an area of almost 11 ha and with the proposed lined landfill area a total area of 17.88 ha of landfill is proposed.

3.1 Protection of Groundwater

The Licence requires an undisturbed separation distance of 3.0 m between the base of the landfill (waste) and the highest level of groundwater. Therefore any future excavation for landfill should be kept 3.0 m above the groundwater table. Shown 'in blue' on **Drawing SML-SK01** is the inferred location of the groundwater table beneath the Seven Mile Waste Disposal Facility.

Drawing SML-SK04 shows the area of the future lined landfill divided into six (6) cells. A leachate well is shown in the lowest point within each cell. For concept design purposes, the depth of the unsaturated zone beneath the lowest point of each cell's waste has been modelled at not less than 3.0 m. With confirmation of the location of the groundwater table at the time of cell development the maximum depth of excavation can be updated to ensure the 3.0 m minimum clearance is achieved.

3.2 Earthworks Quantities

Each cell will be constructed when the previous cell is approaching capacity. The total earthworks required over the six (6) cells of the proposed lined landfill have been estimated to be cut, 28,800 m³ and fill, 51,400 m³ (**Drawing SML-SK04**). These estimates are based on survey data available to the Consultant in 2014.

Table 2 below provides an estimate of the areas covered by the various landfill cells.



Table 2 Area for Each Cell of Landfill Development

LANDFILL	CELL	SURFACE AREA (M²)
Existing Unlined Landfill		109,650
Future Lined Landfill	1	13,000
	2	11,900
	3	10,200
	4	13,000
	5	11,700
	6	9,000
Total Surface (Future Lined Landfill)		68,800
Total Landfill Footprint		178,450



4 Landfill Life Expectancy

4.1 Landfill Capacity

The available airspace for the current unlined landfill and the future six (6) lined landfill cells is calculated at 1,425,000 m³. The airspace is made up of:

- 435,000 m³ in the existing unlined landfill,
- 782,000 m³ in the future lined landfill area, and
- 208,000 m³ over on the southern batter of the old landfill due to the development of adjacent lined landfill cells.

Table 3 below provides an estimate of the areas covered by the various landfill cells.

Table 3 Area for Each Cell of Landfill Development

DESCRIPTION	TOTAL CAPACITY (VERTICAL JOIN BETWEEN CELLS) (M ³)	USABLE CAPACITY (CELLS FILLED TO 1:3 BATTER SLOPES AND EXTERNAL BATTERS TO 1:5) (M ³)
Existing Unlined Landfill	435,000	435,000
New Landfill (Cell 1)	156,600	156,000
New Landfill (Cell 2)	213,800	275,000
New Landfill (Cell 3)	109,500	140,000
New Landfill (Cell 4)	110,600	125,000
New Landfill (Cell 5)	118,000	180,000
New Landfill (Cell 6)	73,500	114,000
Southern Batter of Unlined Landfill	208,000	
Totals	1,425,000	1,425,000

4.2 Top of Waste Profile

Drawings SML-SK02 and SML-SK04 show the shape of the final landforms following waste placement. The levels shown are 'top of waste' and the final landfill cap will be placed over the landfilled waste.

The design criteria for modelling the top of waste surface are:

- Maximum Height of waste placement to be 33.5 m AHD,
- Maximum gradient for the final landfill top of waste surface at 1:5, and
- Minimum gradient for the final landfill top of waste surface to reduce ponding at 1:20.



4.3 Airspace Modelling Criteria

Modelling of waste quantities was carried out based on:

- Waste tonnage records from the 2010-14 periods¹,
- Population growth predictions for the period 2014-17², and
- Waste volumes with New Energy's waste to energy plant operating³.

Assumptions made in determining the life expectancy of the landfill include:

- | | |
|--|-------------------------|
| – Compacted density of waste in landfill | 750 kg/m ³ |
| – Compacted density of landfill cover material | 1,600 kg/m ³ |
| – Depth of landfill earthen cover | 230 mm |
| – Overall landfill density | 848 kg/m ³ |

Assumptions made for the design of the excavation for the future lined landfill area include:

- | | |
|---|-------|
| – Minimum thickness of unsaturated zone beneath the waste | 3.0 m |
| – Minimum gradient of the leachate pipes to the wells | 1:100 |
| – Minimum fall on the landfill base to the leachate pipes | 1:33 |
| – Maximum gradient on internal cut and fill batters | 1:3 |

Assumptions made for the placement of waste include:

- | | |
|--|-----|
| – Maximum gradient of internal waste batter slopes | 1:3 |
| – Maximum gradient of external waste batter slopes | 1:5 |

4.4 Landfill Capacity

Table 4 provides predictions for the consumption of airspace in the landfill. The Table shows that airspace in the existing unlined landfill will be depleted by 2016/17 and that Cell 1 of the future lined landfill will be required to be ready to accept waste by 2016-17.

¹ City of Karratha, Steve Wachter, email, 6.10.14

² City of Karratha, <http://forecast.id.com.au/karratha>

³ City of Karratha, Steve Wachter, 12.01.15, File: NCR12822 Final LTFP NEC.xlsx.



Table 4 Estimate of Remaining Airspace in Current Landfill Area

YEAR	YEAR	TONNES LANDFILLED PER ANNUM (TONNES PER YEAR)	NEW AIRSPACE CREATED (APPROX) (M ³)	AIRSPACE CONSUMED PER ANNUM (M ³ PER YEAR)	AVAILABLE AIRSPACE (M ³)
1	2014/15	83,246		125,461	309,539
2	2015/16	85,468		128,809	180,729
3	2016/17	89,711	156,000	135,204	45,525
4	2017/18	25,385*		38,259	163,267
5	2018/19	25,751		38,810	124,457
6	2019/20	26,122	275,000	39,369	85,087
7	2020/21	26,499		39,937	320,150
8	2021/22	26,882		40,514	279,636
9	2022/23	27,270		41,099	238,537
10	2023/24	27,664		41,693	196,844
11	2024/25	28,064		42,296	154,549
12	2025/26	28,470		42,907	111,641
13	2026/27	28,882	140,000	43,528	68,113
14	2027/28	29,300		44,159	163,954
15	2028/29	29,725		44,799	119,156
16	2029/30	30,156	125,000	45,448	73,708
17	2030/31	30,593		46,107	152,601
18	2031/32	31,037		46,776	105,825
19	2032/33	31,487	180,000	47,455	58,370
20	2033/34	31,737		47,831	190,539
21	2034/35	32,048		48,300	142,239
22	2035/36	32,364	114,000	48,776	93,463
23	2036/37	32,684		49,259	158,205
24	2037/38	33,009		49,749	108,456
25	2038/39	33,340		50,246	58,209
26	2039/40	33,675		50,751	7,458
Totals		940,569	990,000	1,417,542	

The modelling suggests that over the next twenty five (25) years 940,569 tonnes of waste will be required to be landfilled at Seven Mile Waste Disposal Facility. Landfill cells will be progressively constructed to provide timely airspace availability over this period.



The life of the landfill cells will be dependent on:

- Actual tonnages received,
- Waste diverted from landfill via adopted recovery systems, and
- Potential changes in licence conditions and approvals.

These changes have the potential to recast the life of the six (6) lined cells. It is anticipated that this modelling will be reviewed from time to time by the City e.g when a new cell is to be established.

4.5 Capital Cost for Cell Construction

A conservative figure of \$130.00 per m² of landfill cell has been used for the capital cost modelling. **Table 5** shows the expected timing for the construction of each of the six (6) new lined landfill cells and the corresponding capital expenditure required. It is estimated that capital expenditure of \$8,944,000 will be required over the next twenty five (25) years for landfill cell construction. This equates to \$9.51 per tonne for every tonne of waste landfilled at the Seven Mile Waste Disposal Facility over the next twenty five (25) years.



Table 5 Proposed Landfill Cell Construction Program

YEAR	YEAR	CELL	CELL AREA (M ²)	CELL DEVELOPMENT COST (\$)
1	2014/15			
2	2015/16			
3	2016/17	1	13,000	\$ 1,690,000
4	2017/18			
5	2018/19			
6	2019/20	2	11,900	\$ 1,547,000
7	2020/21			
8	2021/22			
9	2022/23			
10	2023/24			
11	2024/25			
12	2025/26			
13	2026/27	3	10,200	\$ 1,326,000
14	2027/28			
15	2028/29			
16	2029/30	4	13,000	\$ 1,690,000
17	2030/31			
18	2031/32			
19	2032/33	5	11,700	\$ 1,521,000
20	2033/34			
21	2034/35			
22	2035/36	6	9,000	\$ 1,170,000
23	2036/37			
24	2037/38			
25	2038/39			
26	2039/40			
			178,450	\$8,944,000

5 Landfill Liner System

The current unlined landfill relies on the *in situ* Pindan clay material to function as an environmental barrier. The DER requires landfills to be designed and operated in accordance with the Vic-BPEM which requires landfills accepting putrescible waste are to be lined with an environmental barrier comprising of a composite liner system.

It is proposed that the construction of future putrescible landfill cells will adopt an environmental protection barrier to the standard of a Class II landfill liner in the form of a geosynthetic clay liner (GCL) overlaid with a 2.0 mm thick High Density Polyethylene (HDPE) geomembrane liner.

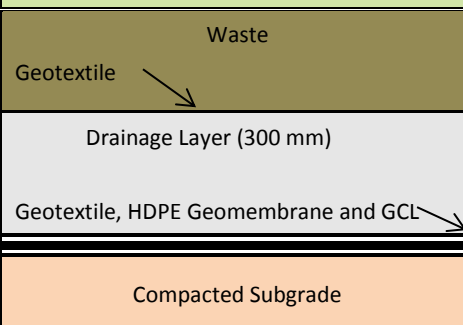
GCL is to be installed as the first layer of the composite liner system on a prepared sub-grade and on the side slopes of the cell excavation. The GCL inherently has a hydraulic conductivity of less than 1×10^{-9} m/s.

A second environmental barrier is to be placed over the GCL. HDPE geomembrane of minimum 2.0 mm thickness is to be placed over the GCL, continuously seam welded and covered with a non woven geotextile protection layer to prevent damage from above. When installed correctly the HDPE liner will have a hydraulic conductivity of less than 1×10^{-9} m/s.

A 300 mm drainage layer of crushed single sized aggregate, less than 50 mm and greater than 20 mm, is to be placed over the geotextile protection layer to provide further protection and provide drainage of leachate to the leachate well. Above the drainage layer is placed a light weight separation geotextile layer to prevent waste from entering and blocking the drainage layer.

Figure 1 describes the proposed liner for use in the construction of future lined landfill cells at the Seven Mile Waste Disposal Facility.

Figure 1 Future Landfill Liner Detail

LANDFILL TYPE	LINER PERFORMANCE	INDICATIVE LINER DESIGNS
Class II Putrescible Landfill	Uses best available technology to control seepage to an amount not exceeding 10 L/ha/day.	 <p>The diagram illustrates the vertical stack of the landfill liner system. From top to bottom, the layers are: Waste (dark brown), Geotextile (light brown), Drainage Layer (300 mm) (light grey), Geotextile, HDPE Geomembrane and GCL (light green), and Compacted Subgrade (orange). Arrows indicate the flow of leachate from the waste through the geotextile and drainage layer into the GCL/HDPE layer, and finally down to the subgrade.</p>

The minimum grade across the liner is to be 1:33 (3%) and the minimum grade of the drainage invert running towards the leachate well is to be 1:100 (1%). Additional wells will be required for future cells and the maximum height of groundwater is to be taken into consideration during cell construction design.

6 Leachate

Leachate management is undertaken to prevent any contamination of ground or surface waters. The liner beneath the landfill acts as a barrier to prevent the leachate from penetrating into the groundwater table. Leachate generated in the new lined landfill will percolate down through the emplaced waste and be collected on the liner. Once at the liner, leachate will flow to a leachate well located at the low point of each lined landfill cell where the leachate is monitored for quality and quantity and extracted if required.

To maintain the maximum required depth of leachate (no more than 300 mm) over the liner adjacent to the leachate well surplus leachate is pumped to the leachate pond (**Drawing SML-SK01**). During the warmer months leachate is evaporated from the leachate pond. Leachate is returned to the landfill in a controlled manner from the leachate pond and recirculated into the emplaced waste to increase the moisture content of the landfill, aiding decomposition of the waste.

Leachate recirculation is a process of finite capacity as rainfall on the cells and leachate pond increases the total volume of leachate in the leachate system. The total quantity of leachate being recirculated and stored in the lined landfill and leachate pond should be closely monitored. Following closure and final capping of the lined landfill all leachate will be required to be removed from the lined landfill and either evaporated, alternatively treated or transferred off site for treatment and disposal.

The level of leachate head on the liner must be minimised to ensure the liner keeps its integrity. In accordance with the (Vic-BPEM), a 300 mm leachate head is the maximum allowable head over a landfill liner adjacent to the leachate well. Following is the proposed contingency action plan if excessive leachate is observed in the leachate well.

Table 6 Contingency Plan for Excessive Leachate Levels within the Landfill

MONITORING REGIME	ASSESSMENT CRITERIA	CAUSE OF SCENARIO	CONTINGENCY ACTION
Leachate head on the base of the landfill is measured on a monthly basis from the leachate well.	Leachate level within the landfill exceeds 300 mm in more than 50% of the measurements in a three month period.	Stormwater infiltration.	<p>Increase leachate pumping rates from the base of the landfill.</p> <p>Check the efficiency of the leachate removal system.</p> <p>Check stormwater diversion drains to ensure stormwater is not entering the landfill.</p> <p>Check condition of landfill cap for subsidence, ponding of stormwater and/or surface cracking.</p>



7 Landfill Gas

Landfill gas is the gas given off during the decomposition of waste through microbiological processes. Landfill gas is an almost even mix of Carbon Dioxide (CO₂) and Methane (CH₄) and is normally treated by capturing the gas using a gas extraction system and combusting using either a flare or a combustion engine.

Generation for landfill gas at the Seven Mile Waste Disposal facility landfill is expected to be low due to:

- The original landfill being unlined,
- The arid dry weather is not conducive to the generation of leachate, and
- The dry nature of waste which slows down the metabolic rate of decomposition.

By 2017/18 it is expected that all combustible waste will be transferred to the waste to energy plant located near Port Hedland for incineration. This will remove all putrescible wastes from the landfill waste stream reducing the landfills ability to generate landfill gas. For these reasons installation of gas wells for the removal of landfill gas is not considered necessary at the Seven Mile Waste Disposal Facility.



8 Rehabilitation and Aftercare

Many of the chronic impacts of landfilling occur long after the landfill has closed, and while these can be mitigated against by good design and operation of the landfill, best practice rehabilitation and long-term aftercare of the site will further minimise the potential of any detrimental impacts from the landfill.

The primary objective for rehabilitation is to minimise environmental impacts resulting from permanent change to ecosystems. This requires the return of rehabilitated areas to self-sustaining and functional ecosystems comprised of local provenance species.

Best practice for rehabilitation and aftercare should be considered very early in the design and operation phase of the landfill.

There are two main aspects to site rehabilitation and aftercare:

- Site capping and revegetation, and
- Post-closure monitoring and maintenance.

8.1 Progressive Rehabilitation

Due to the nature of the landfill design and construction operating on a cellular basis, progressive rehabilitation is able to occur. While waste placement and compaction occurs in a new area, the old area can be rehabilitated.

Landfill rehabilitation considers:

- Operational requirements, to ensure that the highest after-use value can be achieved,
- Identify the potential after-uses for the site, taking into consideration trends in the surrounding area,
- Measure surface contours before and after settlement,
- Specifications and materials be used in the final cap, and

Preservation/installation of environmental performance control or monitoring features.

8.2 Landfill Cap

The (Vic-BPEM) states that a key element of rehabilitation is the final capping of the landfill. The design objectives for the final landfill surface or capping are:

- Minimising infiltration of water into the waste, ensuring that the infiltration rate does not exceed 75% of the seepage rate through the base of the landfill,
- Providing a long-term, stable barrier between waste and the environment in order to protect human health and the environment,
- Preventing the uncontrolled escape of landfill gas, and



- Providing land suitable for its intended after use.

The landfill cap provides long-term protection of the groundwater environment. A cap that is designed so that the infiltration through the cap does not exceed 75% of the calculated seepage rate through the landfill basal liner avoids the so-called landfill ‘bathtub’ effect, in which leachate levels within the landfill build up.

The Environmental Protection Authority (EPA) requires that rehabilitation be based on clear objectives and targets which can be effectively monitored and audited to conform to objectives as outlined in the EPA (2006) *Guidance for the Assessment of Environmental Factors (No. 6)*. The objective of the landfill cap is to ensure that landfills are rehabilitated in a manner that minimises seepage of stormwater into the landfill. The DER requires that landfill caps are to be designed in compliance with the (Vic-BPEM).

8.3 Proposed Landfill Caps

It is proposed that the Seven Mile Waste Disposal Facility will have two designs for the final landfill cap. For the existing unlined landfill it is proposed to use the Class I cap design. By engineering the placement of cap materials to comply the hydraulic properties of low permeable clay, the Vic-BPEM requirement for 75% seepage rate through the base liner will be achieved as the underlying pindan clays beneath the unlined landfill exhibit permeability in excess of 1×10^{-7} m/s.

For the future lined landfill the Class II composite cap is proposed using low permeability clays and a geomembrane. Due to differential settlement across the final surface of the landfill a highly flexible Linear Low Density Polyethylene (LLDPE) material of 1.5 mm thickness is proposed.

Figure 2 below demonstrates the two types of liners proposed for the Seven Mile Waste Disposal Facility.

Figure 2 Seven Mile Waste Management Facility Landfill Cap Designs

LANDFILL TYPE	CAP PERFORMANCE	INDICATIVE LANDFILL CAP	
Class II Future Lined Putrescible Landfill	75 per cent of the anticipated seepage rate through the liner.	Topsoil / Mulch	>1.0 m
		Soil Sub-base	
		Geotextile and LLDPE Geomembrane Low Permeability Clay	> 0.6 m
		Earthen Cover	0.3 m
		Waste	
Existing Unlined Putrescible Landfill	75 per cent of the anticipated seepage rate through the liner.	Topsoil / Mulch	0.5 m
		Soil Sub-base	
		Low Permeability Clay	0.5 m
		Earthen Cover	0.3 m
		Waste	

The construction and maintenance of a low permeability clay layer for a cap is difficult for a number of reasons, including:

- The spongy foundation of waste on which it is built,
- Differential settlement of the waste causing cracking of the clay, and
- Desiccation of the clay from above due to evapotranspiration and below due to heat released from the landfill.

All of the above significantly increase the effective hydraulic conductivity of the clay. The use of the LLDPE within the cap will significantly reduce seepage rates through the cap.

8.4 Topsoil on Landfill Cap

The top-most layer of the landfill cap must be able to support vegetation and be of sufficient depth to ensure that roots do not penetrate the cap and providing a conduit for water into the landfill and leachate out of the landfill.

The surface layer should reflect the type and depth of topsoils normally found in the local area. Where it is not possible to duplicate the local topsoil conditions or the natural soil is too thin to support adequate vegetation for erosion control, then an appropriate mix of soils 200 to 300 mm

thick should be used provided it is capable of sustaining vegetation. Any mulch used in the cap should be pasteurised to remove weed seeds, plant pathogens and pests.

8.5 Vegetation

Introduced plantings on the landfill should not include any noxious weed varieties for that area, nor should the landfill provide a haven for weeds migrating from the surrounding area. Planting is to be restricted to species indigenous to the area and of local provenance to:

- Avoid inappropriate planting,
- Ensure the species are adapted to the local climate, and
- Enhance the local habitat.

The proposed rehabilitation and aftercare has been developed to meet the requirements of the City and the DER. The species proposed for use on the landfill cap are shown in **Table 7**.

Table 7 Contingency Plan for Excessive Leachate Levels within the Landfill

TYPE	APPLICATION RATE KGS/HA
Acacia ancistrocarpa	1.0
Acacia colei	1.0
Acacia coriacea ssp pendens	1.0
Gomphrena canescens	1.0
Grevillea wickhamii	0.3
Ptilotus exaltatus	1.0
Senna artemisioides	1.0
Swainsona formosa	0.5

Alternative species proposed for use on the landfill cap are shown in **Table 8**.



Table 8 Contingency Plan for Excessive Leachate Levels within the Landfill

TYPE	APPLICATION RATE KGS/HA
Acacia ampliceps	1.0
Acacia inaequilatera	1.0
Acacia sclerosperma	1.0
Acacia tumida	1.0
Atalaya hemiglauca - pure	1.0
Codonocarpus cotinifolius	1.0
Crotalaria cunninghamii	0.25
Ipomoea muelleri	0.5
Ptilotus polystachyus	1.0
Ptilotus macrocephalus	0.35
Senna notabilis	1.0
Solanum lasiophyllum	0.5

8.6 Landscaping

Landscaping and site improvement will be carried out on a continual basis throughout the landfill operation. The landscape works are undertaken to achieve the following objectives:

- To provide surface stability to areas disturbed by site activities,
- To provide additional screening of landfill operations and associated infrastructure from potential external view, and
- To enhance vegetation diversity and wildlife habitat associated with the site.

The landscape works are to be developed in consultation with DER, the City's Parks and Gardens crew and if used, a Contractor.

8.7 Aftercare

The aftercare management of the site will include the following:

- Maintenance of landfill cap to:
 - Prevent and control erosion,
 - Fill in areas of subsidence,



- Repair cracks in the surface of the cap to minimise the entry of water,
 - Manage weeds and vegetation,
- Maintenance and operation of leachate collection system, and
- Environmental monitoring of groundwater, surface water, leachate, and settlement.

The discharge of the City's environmental responsibility for the site will only be considered when monitoring confirms that the site is stable and non-polluting (inert). Discharge of responsibility will be in the form of a Certificate of Completion, issued by the DER.

8.8 Landfill Completion

When sufficient evidence can be provided that the landfill is stable and non-polluting, the City may seek to complete all obligations by submitting to the DER a certified statement of completion to the effect that site remediation work has been completed and further environmental management of the premises is not required.

Generally, this statement will be expected to show that:

- Waste stabilisation has completed and is effectively inert. This would be documented by the composition of the leachate changing to a low level of contamination, and posing no threat to the environment,
- Groundwater monitoring has indicated no failure of the landfill liner and no groundwater contaminants that would pose a threat to environmental health,
- The landfill capping has been fully revegetated and does not experience erosion from wind and stormwater,
- Generation of leachate has slowed to the point that it no longer requires removal,
- Survey over time shows that the settlement of the landfill is complete, and
- Documentation has been maintained to demonstrate that all functions in the rehabilitation and aftercare phase have been followed and completed.

Once the DER has approved the certified statement of completion, the City can cease the maintenance and monitoring of the site.

9 References

Bowman & Associates, 2013, *Operational Management Plan – 7 Mile Waste Disposal Facility*, Version 1.

Department of Environment Regulation, 2012, Licence Number L7021/1997/14, *Licence for Prescribed Premises, Seven Mile Waste Disposal Facility*.

Western Australia, 1986, *Environmental Protection Act 1986*.

EPA Western Australia, 2005, *Separation Distances between Industrial and Sensitive Land Uses*.

EPA Western Australia, 2006 *Guidance for the Assessment of Environmental Factors (No. 6)*.

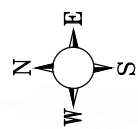
Victorian EPA, 2010, *Best Practice Environmental Management: Siting, Design, Operation and Rehabilitation of Landfills Guideline*.



10 Drawings







MW 1
BORE R.L. 16.848
G.W.L. 9.800 (DEC 13)
E 475790.783
N 7703777.251

MW 2
BORE R.L. 17.838
G.W.L. 10.000 (DEC 13)
E 475551.593
N 7703754.21

MW 3
BORE R.L. 13.355
G.W.L. 200 (DEC 13)
E 475558.417
N 7703628.267

MW 4
BORE R.L. 20.268
G.W.L. 10.000 (DEC 13)
E 475330.783
N 7703228.608

MW 5
BORE R.L. 12.268
G.W.L. 10.000 (DEC 13)
E 475558.417
N 7703628.267

Bore 3
BORE R.L. 15.883
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Bore 4
BORE R.L. 15.803
G.W.L. 10.000 (DEC 14)
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Bore 5
BORE R.L. 17.348
G.W.L. 10.000 (DEC 14)
E 476240.116
N 7702573.337

MW 7
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G.W.L. 11.25 (DEC 13)
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MW 8
BORE R.L. 23.555
G.W.L. 12.00 (DEC 13)
E 475558.417
N 7702338.645

MW 6
BORE R.L. 21.007
G.W.L. 11.00 (DEC 13)
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N 7702785.739

NOTE:
SURVEY PROVIDED BY LANDSURVEYS (KARRATHA - 08)91431744.)
SURVEY DATUM IS AHD AND MGA.

PRELIMINARY
14 MARCH 2015

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1 : 2,000 (A1), 1 : 4,000 (A3)



Bowman and Associates Pty Ltd

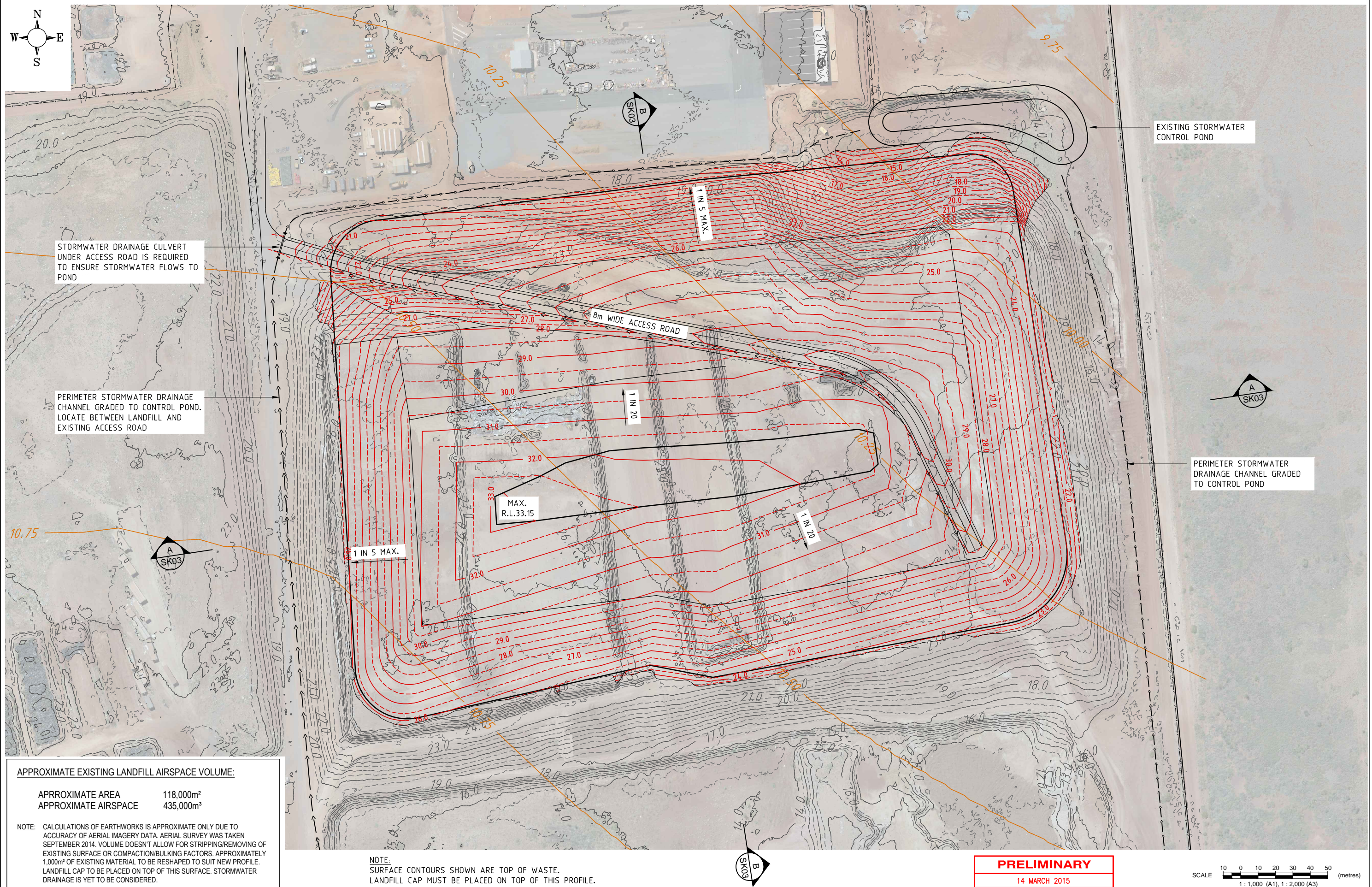
ABN: 22 112 399 514

Mail: PO Box 2059, Rossmyrne WA 6148
Office: 8/640 Beelihar Drive, Success WA 6164
Phone: (08) 9414 9670
Web: www.bowmanassociates.com.au

Project Seven Mile Waste Disposal Facility			
Date Drawn 14/03/2015	Design By B.B.	Drawn By S.B.Y.	Checked By B.B.

Location Seven Mile Road, Gap Ridge Karratha WA 6714
Client City of Karratha

Drawing Title Site Layout Plan		
Drawing Number SML - SK01	Revision A	Drawing Size A1



APPROXIMATE EXISTING LANDFILL AIRSPACE VOLUME:

APPROXIMATE AREA 118,000m²
APPROXIMATE AIRSPACE 435,000m³


NOTE: CALCULATIONS OF EARTHWORKS IS APPROXIMATE ONLY DUE TO ACCURACY OF AERIAL IMAGERY DATA. AERIAL SURVEY WAS TAKEN SEPTEMBER 2014. VOLUME DOESN'T ALLOW FOR STRIPPING/REMOVING OF EXISTING SURFACE OR COMPACTION/BULKING FACTORS. APPROXIMATELY 1,000m³ OF EXISTING MATERIAL TO BE RESHAPED TO SUIT NEW PROFILE. LANDFILL CAP TO BE PLACED ON TOP OF THIS SURFACE. STORMWATER DRAINAGE IS YET TO BE CONSIDERED.

NOTE: SURFACE CONTOURS SHOWN ARE TOP OF WASTE. LANDFILL CAP MUST BE PLACED ON TOP OF THIS PROFILE.

PRELIMINARY

14 MARCH 2015

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1 : 1,000 (A1), 1 : 2,000 (A3)



Bowman and Associates Pty Ltd

ABN: 22 112 399 514

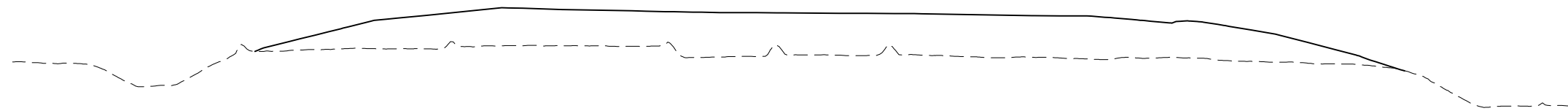
Mail: PO Box 2059, Rossmyrne WA 6148
Office: 8/640 Beelihar Drive, Success WA 6164

Phone: (08) 9414 9670
Web: www.bowmanassociates.com.au

Project			
Seven Mile Waste Disposal Facility			
Date Drawn	Design By	Drawn By	Checked By
14/03/2015	B.B.	S.B.Y.	B.B.

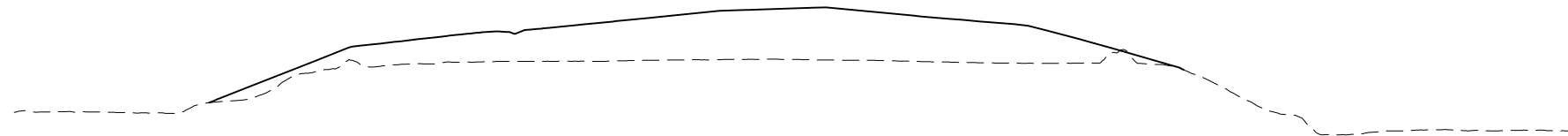
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Seven Mile Road, Gap Ridge Karratha WA 6714	
Client	
City of Karratha	

Drawing Title		
Existing Landfill Top of Waste Surface Layout Plan		
Drawing Number	Revision	Drawing Size
SML - SK02	A	A1



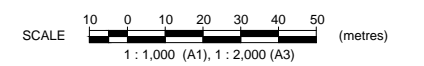
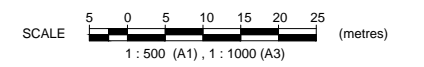
DATUM R.L. 0.000

SECTION A
SCALE H 1 : 1,000
V 1 : 500
SK02



DATUM R.L. 0.000

SECTION B
SCALE H 1 : 1,000
V 1 : 500
SK02



PRELIMINARY

14 MARCH 2015



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Project

Seven Mile Waste Disposal Facility

Date Drawn

14/03/2015

Design By

B.B.

Drawn By

S.B.Y.

Checked By

B.B.

Location

Seven Mile Road, Gap Ridge Karratha WA 6714

Client

City of Karratha

Drawing Title

Proposed Existing Landfill Sections

Drawing Number

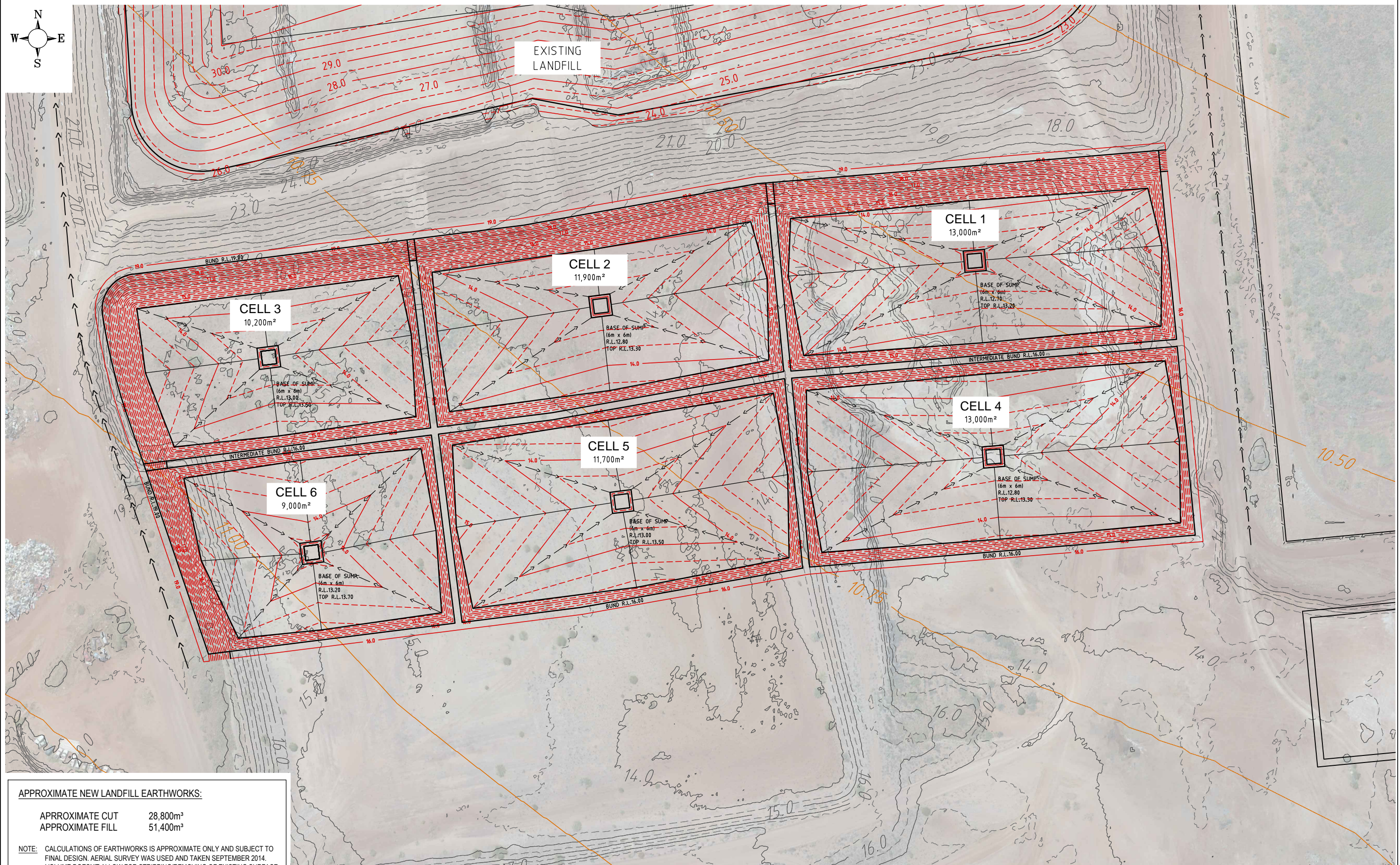
SML - SK03

Revision

A

Drawing Size

A1



APPROXIMATE NEW LANDFILL EARTHWORKS:

APPROXIMATE CUT 28,800m³
APPROXIMATE FILL 51,400m³

NOTE: CALCULATIONS OF EARTHWORKS IS APPROXIMATE ONLY AND SUBJECT TO FINAL DESIGN. AERIAL SURVEY WAS USED AND TAKEN SEPTEMBER 2014. VOLUME DOESN'T ALLOW FOR STRIPPING/REMOVING OF EXISTING SURFACE OR COMPACTION/BULKING FACTORS. NEW LANDFILL PROFILE DOESN'T ALLOW FOR PERIMETER BATTER/TIE-IN SO ADDITIONAL EARTHWORKS ARE REQUIRED. STORMWATER DRAINAGE HAS NOT BEEN CONSIDERED.

NOTE: SURFACE CONTOURS SHOWN ARE EARTHWORKS SURFACE. LANDFILL LINER MUST BE PLACED ON TOP OF THIS PROFILE.

PRELIMINARY

14 MARCH 2015

SCALE 5 0 5 10 15 20 25 (metres)
1 : 500 (A1) , 1 : 1000 (A3)



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Project

Seven Mile Waste Disposal Facility

Location

Seven Mile Road, Gap Ridge Karratha WA 6714

Date Drawn

14/03/2015

Design By

B.B.

Drawn By

S.B.Y.

Checked By

B.B.

Client

City of Karratha

Drawing Title

New Landfill Earthworks Layout Plan

Drawing Number

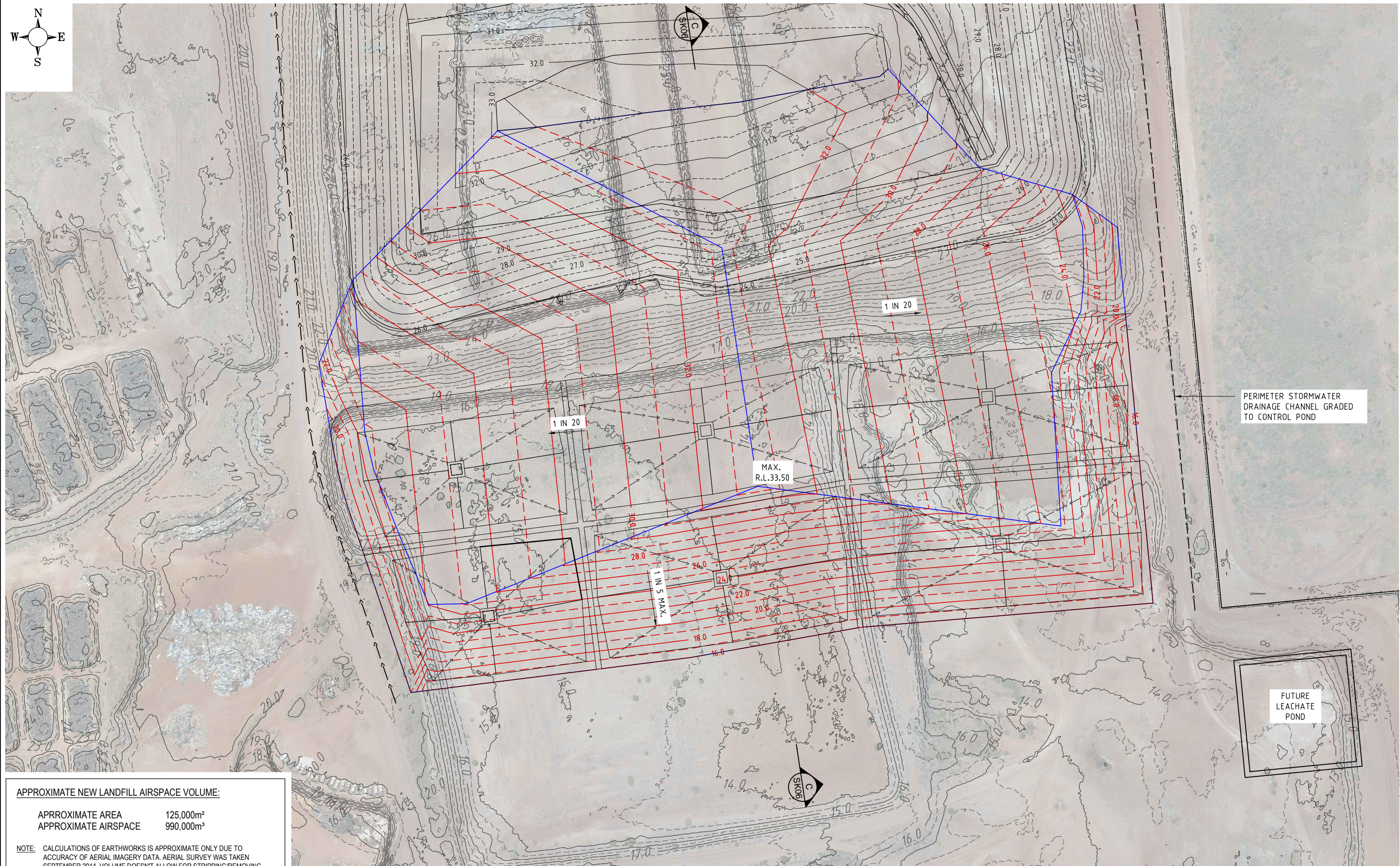
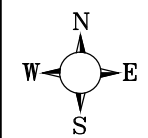
SML - SK04

Revision

A

Drawing Size

A1



APPROXIMATE NEW LANDFILL AIRSPACE VOLUME:

APPROXIMATE AREA 125,000m²
APPROXIMATE AIRSPACE 990,000m³

NOTE: CALCULATIONS OF EARTHWORKS IS APPROXIMATE ONLY DUE TO ACCURACY OF AERIAL IMAGERY DATA. AERIAL SURVEY WAS TAKEN SEPTEMBER 2014. VOLUME DOESNT ALLOW FOR STRIPPING/REMOVING OF EXISTING SURFACE OR COMPACTION/BULKING FACTORS. LANDFILL CAP TO BE PLACED ON TOP OF THIS SURFACE. STORMWATER DRAINAGE IS YET TO BE CONSIDERED.

NOTE:
SURFACE CONTOURS SHOWN ARE TOP OF WASTE.
LANDFILL CAP MUST BE PLACED ON TOP OF THIS PROFILE.

CONCEPT ONLY

02 MARCH 2015

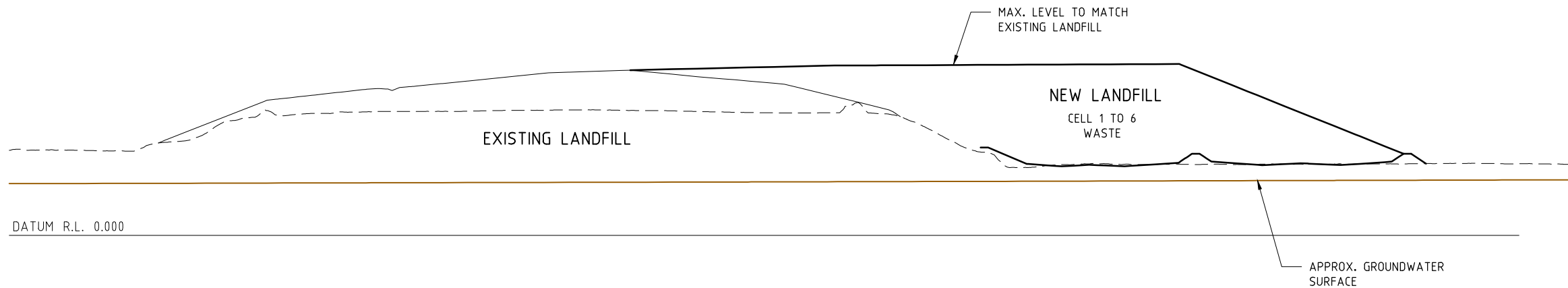
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Project			
Seven Mile Waste Disposal Facility			
Date Drawn	Design By	Drawn By	Checked By
14/03/2015	B.B.	S.B.Y.	B.B.

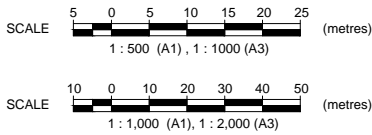
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Seven Mile Road, Gap Ridge Karratha WA 6714	
Client	
City of Karratha	

Drawing Title		
New Landfill Top of Waste Surface Layout Plan		
Drawing Number	Revision	Drawing Size
SML - SK05	A	A1



SECTION C
SCALE H 1 : 1,000
V 1 : 500
SK05

7 MILE WASTE FACILITY			
SMWF MONITORING BORE LOCATIONS			
BORE IDENTIFIER	EASTING	NORTHING	ELEVATION
BORE_2	476042.135	7703581.056	15.484
BORE_3	476073.941	7703248.65	15.883
BORE_4	476205.418	7702925.991	15.803
BORE_6	476240.016	7702569.037	17.245
MW_1	475790.783	7703777.251	16.848
MW_2	475551.593	7703754.21	17.825
MW_3	475356.412	7703628.291	19.354
MW_4	475339.783	7703228.608	20.268
MW_5	475575.546	7703299.165	19.543
MW_6	475382.341	7702789.739	21.567
MW_7	475851.024	7702626.774	20.686
MW_8	475456.224	7702338.145	23.555
Note: All locations observed to top of bore cap Locations surveyed by GPS methods on 16th October 2014 Elevations accurate to +/- 0.02m			



PRELIMINARY

14 MARCH 2015



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Project

Seven Mile Waste Disposal Facility

Date Drawn

14/03/2015

Design By

B.B.

Drawn By

S.B.Y.

Checked By

B.B.

Location

Seven Mile Road, Gap Ridge Karratha WA 6714

Client

City of Karratha

Drawing Title

New Landfill Top of Waste Surface Sections

Drawing Number

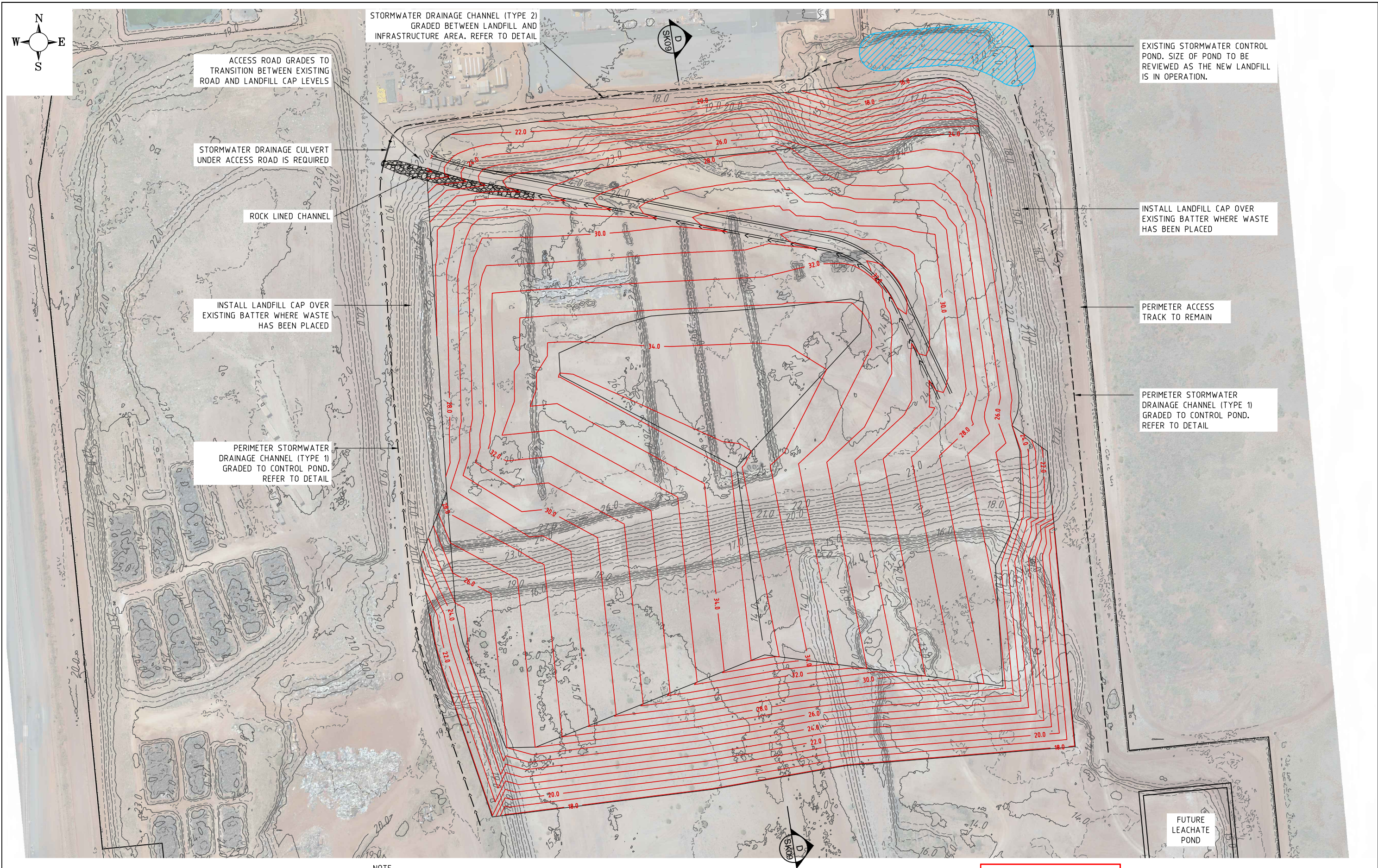
SML - SK06

Revision

A


Drawing Size

A1



CONCEPT ONLY
19 MARCH 2015

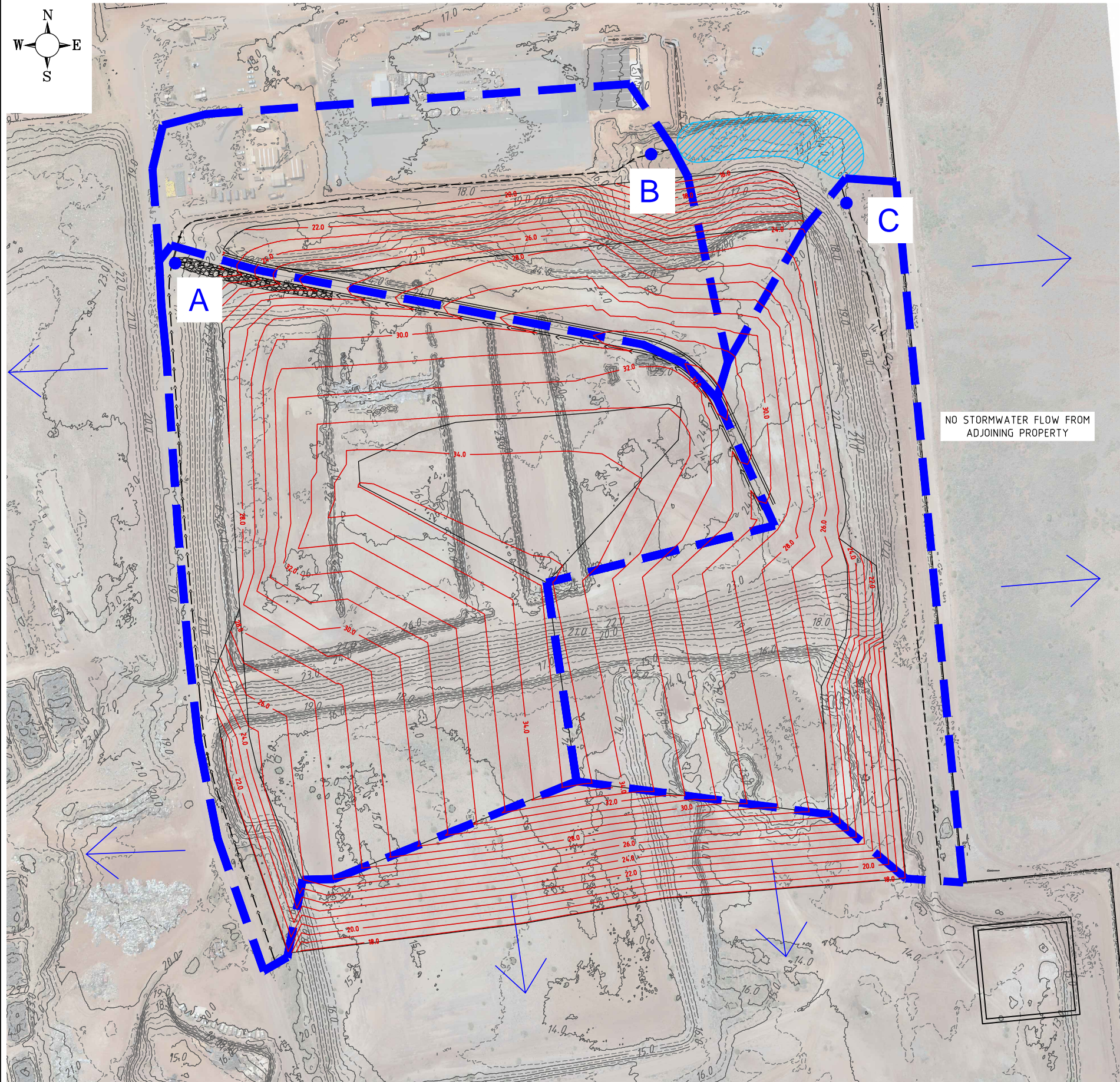
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Project			
Seven Mile Waste Disposal Facility			
Date Drawn	Design By	Drawn By	Checked By
19/03/2015	B.B.	S.B.Y.	B.B.

Location	
Seven Mile Road, Gap Ridge Karratha WA 6714	
Client	
City of Karratha	


Drawing Title		
Landfill Top of Cap Surface Layout Plan		
Drawing Number	Revision	Drawing Size
SML - SK07	A	A1



NOTE:
SURFACE CONTOURS SHOWN ARE TOP OF CAP.

STORMWATER DRAINAGE CALCULATIONS

LOCATION	CATCHMENT AREA (km ²)	TIME OF CONC. (mins)	FLOW (m ³ /s)					COMMENTS
			Q2	Q5	Q10	Q20	Q50	
A	0.114	20	0.15	0.33	0.59	2.54	4.4	Western side of landfill
B	0.164	23	0.21	0.45	0.81	3.49	6.17	Northern side of landfill
C	0.072	16	0.08	0.17	0.25	1.33	2.35	Eastern side of landfill



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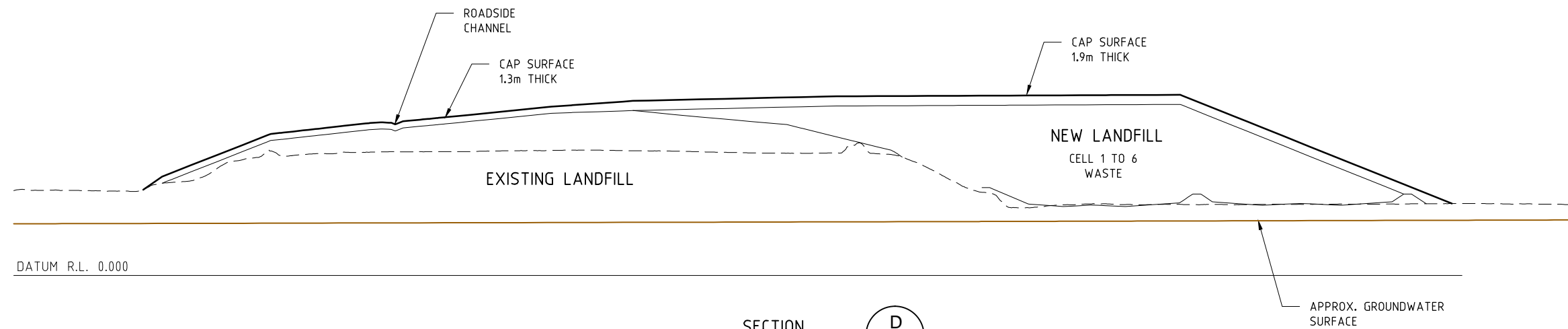
Project			
Seven Mile Waste Disposal Facility			
Date Drawn	Design By	Drawn By	Checked By
19/03/2015	B.B.	S.B.Y.	B.B.

Location	
Seven Mile Road, Gap Ridge Karratha WA 6714	
Client	
City of Karratha	

CONCEPT ONLY
19 MARCH 2015

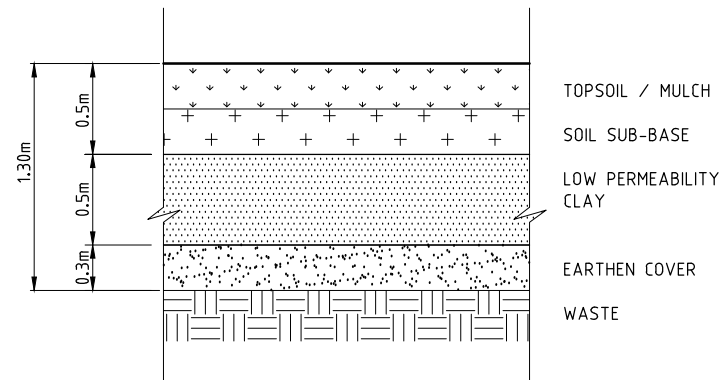
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Drawing Title		
Landfill Catchment Layout Plan & Calculations		
Drawing Number	Revision	Drawing Size
SML - SK08	A	A1

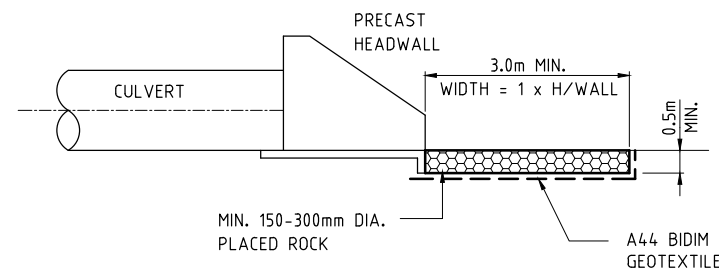


SECTION
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V 1 : 500

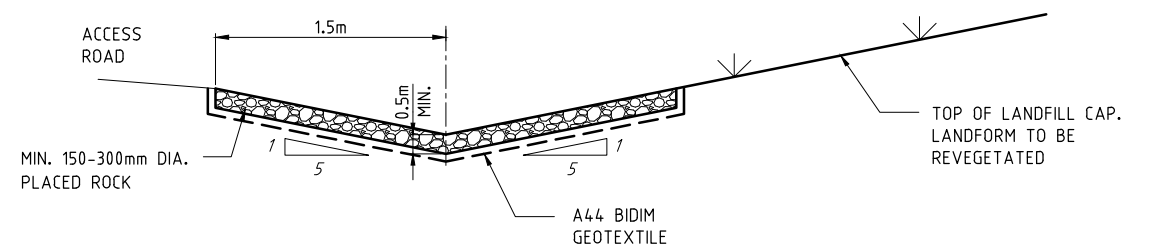
D
SK07



INDICATIVE LANDFILL CAP DETAIL - EXISTING LANDFILL
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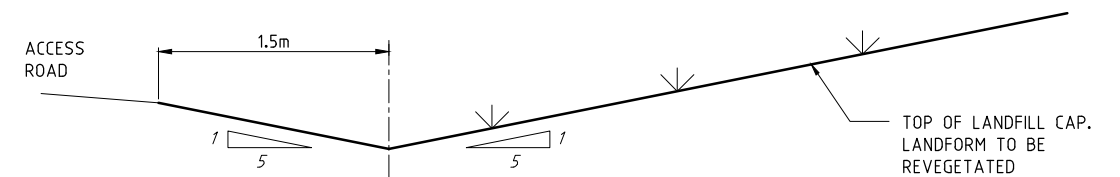


STORMWATER INLET/OUTLET PROTECTION DETAIL
NOT TO SCALE



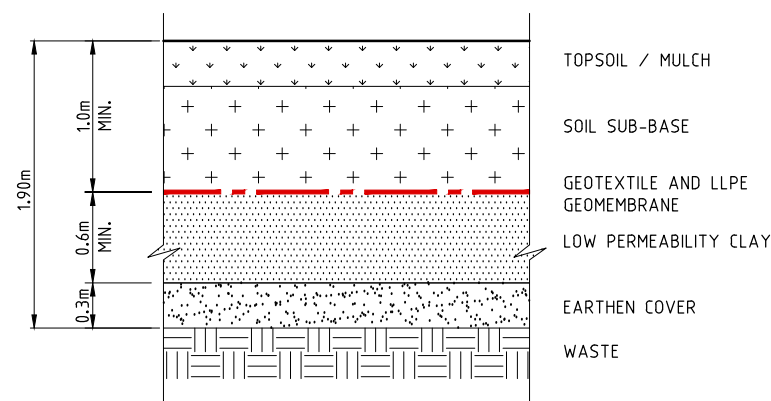
TYPICAL ROADSIDE ROCK LINED CHANNEL DETAIL
NOT TO SCALE

NOTE:
ROADSIDE CHANNEL WHERE
GRADES EXCEED 3%

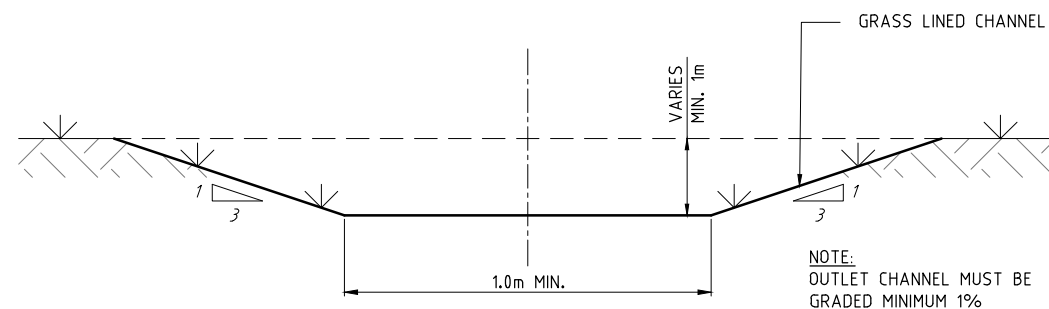


TYPICAL ROADSIDE CHANNEL DETAIL
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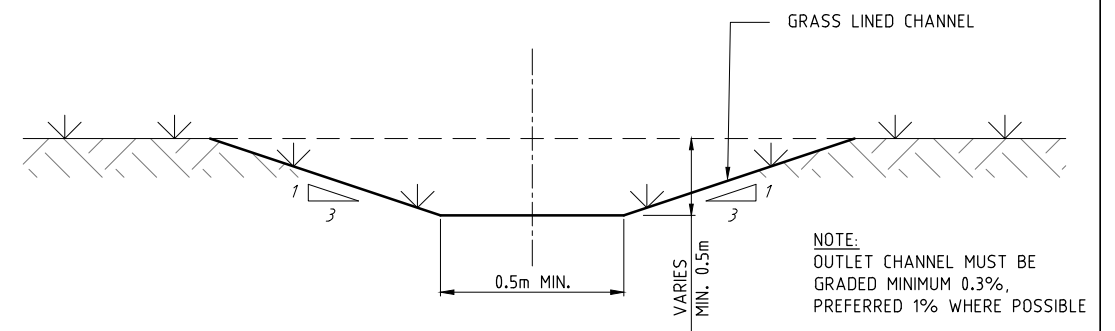
NOTE:
ROADSIDE CHANNEL
MAXIMUM GRADE UP TO 3%



INDICATIVE LANDFILL CAP DETAIL - NEW LANDFILL
NOT TO SCALE



TYPICAL LANDFILL PERIMETER STORMWATER
DRAINAGE CHANNEL DETAIL - TYPE 2
NOT TO SCALE



TYPICAL LANDFILL PERIMETER STORMWATER
DRAINAGE CHANNEL DETAIL - TYPE 1
NOT TO SCALE

CONCEPT ONLY

19 MARCH 2015

SCALE 10 0 10 20 30 40 50 (metres)
1 : 1,000 (A1), 1 : 2,000 (A3)



Bowman and Associates Pty Ltd

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Phone: (08) 9414 9670
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Project

Seven Mile Waste Disposal Facility

Date Drawn

19/03/2015

Design By

B.B.

Drawn By

S.B.Y.

Checked By

B.B.

Location

Seven Mile Road, Gap Ridge Karratha WA 6714

Client

City of Karratha

Drawing Title

Landfill Details

Drawing Number

SML - SK09

Revision

A

Drawing Size

A1