



## APPENDIX D-2 GOLDER ASSOCIATES BEDDING SAND FIELD INVESTIGATION



October 2009

## CONNORS RIVER DAM TO MORANBAH PIPELINE

# Stage 1 - Bedding Sand Field Investigation

**Submitted to:**  
SunWater  
Level 10  
179 Turbot St  
Brisbane QLD 4000

REPORT



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### 1.0 INTRODUCTION

In conjunction with the development of the Connors River Dam, SunWater have commenced conceptual design of a pipeline to supply water from the dam to Moranbah. The Connors River Dam (CRD) to Moranbah pipeline is approximately 145 km in length. We understand that the pipe is likely to be 1.2 m in diameter and will have an invert level at a maximum depth of approximately 3.5 m below surface. The pipeline will require approximately 340,000 m<sup>3</sup> (563,000 t) of bedding sand.

Stage 1 investigations of the bedding sand were undertaken by Golder Associates (Golder) in March 2009 and comprised a desktop study and site inspection to identify prospective areas for sand extraction. SunWater commissioned Golder to undertake a Stage 2 investigation of the bedding sand including field investigations at various locations along or close to the proposed pipeline route as identified in the desktop study. The project area is shown on Figure 1. The Stage 2 investigation was aimed at:

- Providing a more detailed visual inspection of potential resource extents;
- Collection of representative samples for analysis of particle grading curves for comparison with SunWater's grading envelope; and
- Preliminary estimation of sand volumes through limited investigation of alluvium thickness.

The findings of the Stage 2 investigations are reported here.

### 1.1 Bedding Sand Requirements

SunWater has developed a specification for granular backfill around pipes that varies from the Australian Standard (AS/NZC 3725:2007) and has been using this on previous pipeline projects. A copy of this has been provided to Golder and we understand that the following properties are typically required by SunWater for bedding sand:

- Naturally occurring gravelly sand or other granular material meeting the grading specified in Table 1;
- The grading curve shall be smooth;
- Free from cohesive material and free draining;
- Fine materials (passing 0.075 mm sieve) shall be non-plastic; and
- No angular or sharp particles such as quarry crusher fines shall be used.

**Table 1: Bedding Sand Grading Envelope**

AS Metric Sieve (mm)	Percentage Passing
19	100
4.75	90 – 100
2.36	60 – 100
1.18	30 – 97
0.425	3 – 50
0.150	0 – 5
0.075	0 – 3



### 2.0 BACKGROUND

The Stage 1 desktop study and two day field inspection undertaken by Golder identified that the site of the largest bedding sand resource is the Isaac River. It is a wide river with the main channel approximately 50 to 80 m wide and the bed can be readily accessed at a number of locations. The sand resources identified on the other rivers are typically much narrower and are accessed via steep river banks that would require significant tree clearing and earthworks to provide vehicular entry. Vegetation present in the sand would need to be cleared and organic material screened out prior to use as bedding. No single commercial supplier was identified in the vicinity of the pipeline route who could provide the quantity of sand required by the project. In fact, based on discussions with commercial suppliers, it appears that the existing allocations are insufficient to meet current commercial demands.

Full details of the Stage 1 work is included in Golder's Report (ref: 137-077632049 Rev 0) *CRD to Moranbah Pipeline - Bedding Sand Desktop Review*, dated 18 May 2009.

Following discussions with SunWater a number of rivers and creeks were identified as prospective for bedding sand extraction, including:

- Isaac River;
- North Creek;
- Harrybrandt Creek;
- Bee Creek;
- Dennison Creek;
- Funnel Creek;
- Boothill Creek; and
- Connors River.

A staged investigation of the suitability of these resources as bedding sand was recommended. The early investigation stages would be undertaken with minimal vegetation or river bank disturbance prior to more targeted detailed investigations.

### 3.0 QUARRY MATERIAL ALLOCATION NOTICES

Prior to removal of any quarry material, an application has to be made to the Department of Environment and Resource Management (DERM) for a Quarry Material Allocation Notices (QMAN) to determine the allowable volume that can be removed. The volume of material that is allocated will be based on assessments of issues such as subsidence due to long wall mining, resource replenishment rate, water course integrity, depth restriction, minimum depth from the water course's edge, and existing entitlement holders. There are also restrictions on quarrying materials below water level.

SunWater supplied information on existing entitlement holders near the proposed investigation areas to Golder. The existing entitlements information also included the total allocated volume for each holding. The locations of these are summarized in Table 2 and positions of resources near the proposed investigation sites are shown in Figures 2, 3 and 6. Using the information supplied, Golder adjusted the investigation boundary for each area to avoid infringing on existing QMANs. Investigation areas along the water courses are identified using the Adopted Middle Thread Distance (AMTD) system.





**Table 2: Existing quarry material allocation notices**

Reference	Status	Volume per annum (m <sup>3</sup> )	Subsystem Name	Approx D/S AMTD	Approx U/S AMTD	Bed Length (km)	Separation (km)
100713	Under renewal	1500	Denison Creek	30.2	30.8	0.6	
100671	Issued	2000	Harrybrandt Creek	8.0	8.5	0.5	
101029	Issued	2000	Harrybrandt Creek	8.6	9.4	0.8	0.1
300155	New application	71,000	Isaac River	116.0	135.0	19	
300132	Issued	15,000	Isaac River	185.7	189.7	4.0	50.7
300052	Issued	65,000	Isaac River	207.8	209.2	1.4	18.1
300150	New application	45,000	Isaac River	218.8	223.6	4.8	9.6
101072	Issued	6,000	Isaac River	223.8	226.8	3	0.2
300164	New application	3,500	Isaac River	232	242	10	5.2
100802	Under renewal	500	Isaac River	240	241	1	Include above

Along with the information on existing entitlements, Golder also received information on the volume of allocation remaining for the Isaac River. The volume of remaining allocation is summarized in Table 3.

**Table 3: Isaac River Volume Remaining for Allocation**

Reach No.	Volume Remaining for Allocation (m <sup>3</sup> )
Reach 6	40,000
Reach 7	87,000
Reach 8	7,000
Reach 9	45,000
Reach 10	15,000

Based on the information acquired, it was established that the investigation areas on the Isaac River were located within Reach 9, with a remaining volume of material for allocation of 45,000 m<sup>3</sup> significantly below the required volume for the pipeline construction.



## 4.0 METHODOLOGY

The Stage 2 field investigation program was developed in order to gain better understanding of the potential sand resources identified during the Stage 1 desktop study. The investigation program varied between sites and included:

- test pits and/or hand augers, all with adjacent dynamic cone penetrometer (DCP) testing;
- sample collection of surface material and at strata changes during intrusive investigation;
- photographs; and
- visual inspection.

Test pit and/or hand auger locations were spaced out as evenly as possible over the identified resource, limited by access and property boundaries, in order to investigate representative ground strata. Test pits and hand augers were logged by a Golder geotechnical engineer and geotechnician who made a visual description of the soil, collected representative samples and photographed the site. All test pits and hand auger holes were backfilled upon completion. Reports of the test pits and auger holes are presented in Appendix A with DCP results and test pit photographs. Also included in Appendix A are the following explanatory sheets that should be read in conjunction with the reports:

- Explanation of Notes, Abbreviations and Terms Used on Borehole and Test Pit Reports; and
- Method of Soil Description Used on Borehole and Test Pit Reports.

Coordinates for each investigation location were measured using a hand held Garmin GPSmap 60CX with an accuracy of  $\pm 4$ m. Table 4 summarises the investigations that were carried out at each prospective sand resource area.

**Table 4: Investigation Summary**

Location	Investigation Date	Investigation Type	Investigation Designation	Coordinates (MGA 94)		Depth (m)	Adjacent DCP Depth (m)
				Easting	Northing		
Isaac River	09/07/2009	Hand Auger	IRTP01	617322	7561199	0.8	2.31
		Test Pit	IRTP02	617058	7561064	1.1	3.11
			IRTP03	617124	7561090	0.9	2.01
			IRTP04	616615	7561280	1.9	3.90*
			IRTP05	615955	7562250	2.1	2.30
			IRTP06	616312	7561781	1.5	2.40
			IRTP07	614003	7564533	1.9	3.20
			IRTP08	613614	7564497	2.1	3.70
			IRTP09	613256	7564704	2.1	1.90
	10/07/2009	Test Pit	IRTP10	613363	7565080	2.1	2.35
			IRTP11	613554	7565425	2.0	1.90



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Location	Investigation Date	Investigation Type	Investigation Designation	Coordinates (MGA 94)		Depth (m)	Adjacent DCP Depth (m)
				Easting	Northing		
Isaac River	10/07/2009	Test Pit	IRTP12	613609	7565826	2.1	4.10
			IRTP13	613538	7566119	2.1	2.70
North Creek	13/07/2009	Hand Auger	NCAH01	634601	7569614	1.6	2.00
			NCAH02	635388	7569062	1.1	2.10
			NCAH03	635146	7571051	2.1	1.70
Harrybrandt Creek	12/07/2009	Hand Auger	HCAH01	657894	7580242	1.1	3.60
			HCAH02	656171	7580224	1.8	2.60
			HCAH03	655150	7580035	1.1	2.30
			HCAH04	650278	7580052	0.9	2.30
			HCAH05	652192	7580729	2.5	3.50
Bee Creek	11/07/2009	DCP Only	BCDCP01	662450	7578617	-	3.00
			BCDCP02	662608	7578086	-	4.00
		Hand Auger	BCAH01	664230	7581072	1.8	5.00
			BCAH02	664671	7580149	1.8	2.00
			BCAH03	662333	7578781	0.6	3.50
			BCAH04	662766	7578206	1.1	2.10
Denison Creek	14/07/2009	Hand Auger	DCAH01	683396	7583833	0.9	5.00
			DCAH02	682194	7582542	1.1	3.60
			DCAH03	682105	7581060	1.1	4.90
Funnel Creek	15/07/2009	Hand Auger	FCAH01	694594	7578173	0.8	1.70
			FCAH02	694679	7578441	0.8	1.64
			FCAH03	694341	7577908	0.8	3.50
Boothill Creek	06/07/2009	Test Pit	BHCTP02	697497	7582089	0.8	3.71
			BHCTP03	697435	7582081	2.5	1.80
	15/07/2009	Hand Auger	BHAH01	697624	7582147	0.9	3.90
			BHAH02	697347	7582020	0.9	4.00



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Location	Investigation Date	Investigation Type	Investigation Designation	Coordinates (MGA 94)		Depth (m)	Adjacent DCP Depth (m)
				Easting	Northing		
Boothill and Funnel Creek Junction	07/07/2009	Test Pit	FCTP01	693770	7580743	2.5	4.70
			FCTP02	693726	7580637	2.5	2.40
			FCTP03	693808	7580606	2.6	1.90
			FCTP04	693648	7580685	2.6	2.50
Connors River	08/07/2009	Test Pit	CRTP05	716204	7560904	2.6	0.50
			CRTP06	716230	7560943	2.6	2.10
			CRTP07	716267	7560967	2.6	0.60
			CRTP08	716298	7561009	2.5	0.60
Connors River and Sandy Creek Junction	07/07/2009	Test Pit	CRTP01	715967	7560197	2.4	0.08
			CRTP02	715891	7560290	1.8	1.40
			CRTP02A	715796	7560357	0.9	0.88
			CRTP03	715645	7560482	2.6	0.60

Photographs were taken and sketches were made at each resource investigated in order to provide an overview of the conditions at each creek and river. Representative photographs are presented in Appendix B together with hand sketches. Observations of surface conditions and access restrictions were also made.

Permission to access the creeks and rivers through occupied property was obtained from the land owner / leaser by SunWater liaison officer Keith Saunders. Aboriginal monitors were present for the test pit excavations in the Isaac and Connors Rivers and in Boothill Creek and the junction of Boothill and Funnel Creeks.

Selected material samples that were collected during the investigation were sent to Golders Mansfield laboratory for particle size distribution (PSD) testing. Testing numbers from each resource site are indicated in Table 5.



**Table 5: Summary of Particle Size Distribution Tests**

<b>Location</b>	<b>No. Samples collected</b>	<b>No. Samples tested for PSD</b>
Isaac River	29	6
North Creek	12	2
Harrybrandt Creek	14	3
Bee Creek	10	3
Dennison Creek	6	2
Funnel Creek (including the Junction)	19	5
Boothill Creek	12	3
Connors River	16	6
	<b>Total</b>	30

Results of the laboratory testing are included in Appendix C.



### 5.0 RESULTS OF INVESTIGATIONS AND PRELIMINARY ASSESSMENT

This section presents the results of the field and laboratory investigation, as well as the preliminary assessment of the materials encountered in the field for suitability as pipeline bedding material. This section also includes a rough estimate of the volume of the suitable and possibly suitable material.

A suitable material is a material that meets the bedding sand requirements as presented in Section 1.1. A possibly suitable material is a material that does not explicitly meet the requirements, but is close enough that SunWater may choose to use the material.

A summary of the estimated bedding sand volumes is presented in Table 6.

**Table 6: Summary of estimated pipeline bedding material volume**

Site	Estimated Volume of Suitable Material (m <sup>3</sup> )	Estimated Volume of Possibly Suitable Material (m <sup>3</sup> )
Isaac River Northern Site	-	250,500
Isaac River Southern Site	-	287,500
North Creek	-	57,000
Harrybrandt Creek	77,000	-
Bee Creek	87,500	-
Denison Creek	365,000	-
Funnel Creek	108,000	-
Boothill Creek	43,000	-
Boothill and Funnel Creek Junction	37,000	-
Connors River	1,500	-
Connors River and Sandy Creek Junction	1,500	-
<b>Total</b>	<b>720,500</b>	<b>595,000</b>
<b>Combined Total</b>	<b>1,315,500 m<sup>3</sup></b>	

Note that the estimated volume of materials presented above varies from the allowable volume for allocation indicated by DERM. The allocation volume would be determined by DERM upon application for a QMAN.



## 5.1 Isaac River

The Isaac River was separated into two investigation areas due to the location of existing sand dredging leases. The two areas are referred to as the Southern and Northern sites. The findings for each site are presented below.

### 5.1.1 Isaac River Southern Site

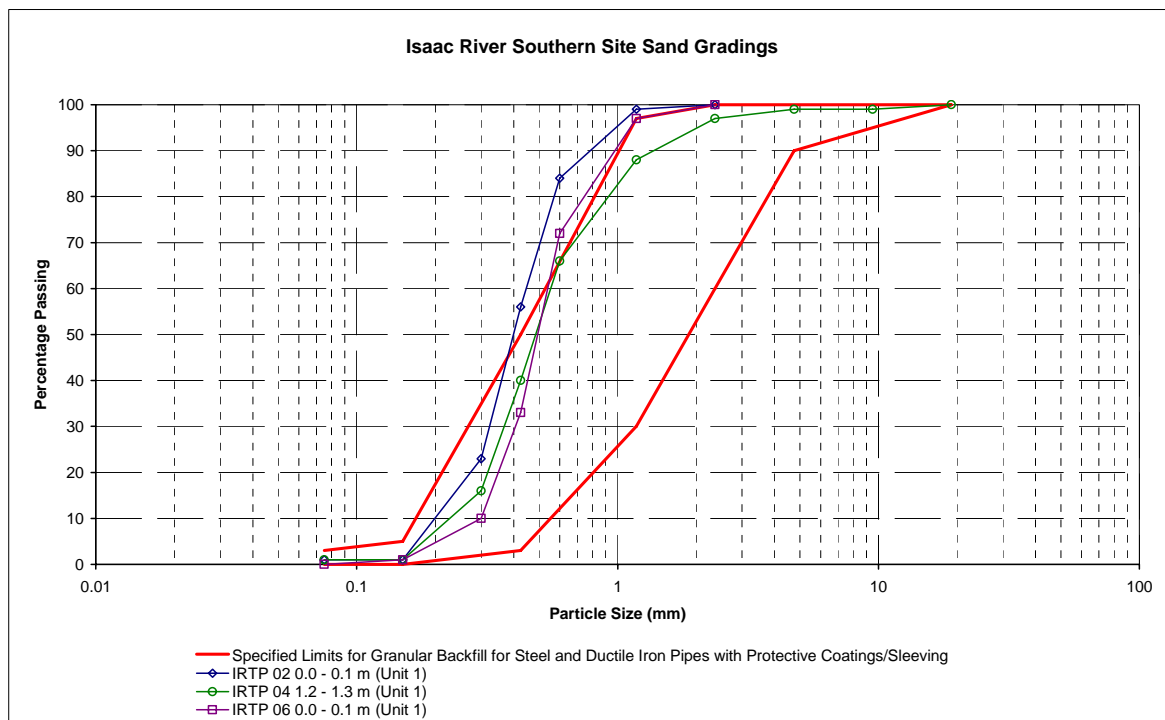
The Southern site is located near the Peak Downs Highway crossing of the Isaac River as shown in Figure 2. The investigation area is between AMTD 208.5 and AMTD 211.5 and is immediately upstream of QMAN 300052. The length of this area is 3.0 km and the bed of the Isaac River varies from 40 to 50 m in width.

One hand auger hole, designated IRTP01 and five test pits, designated IRTP02 to IRTP06, were performed at the Isaac River Southern Site on 9 July 2009. The test locations are also presented in Figure 2.

The site was accessed via an existing dirt track off the Peak Downs Highway, at the base of the bridge crossing the Isaac River. The existing track was wide enough to accommodate access of the backhoe into the riverbed. The riverbed was dry, free of vegetation and relatively flat. The riverbanks rise steeply from the riverbed up to 5 m and were heavily treed.

IRTP01 was performed at the eastern most location that could be practically accessed on foot as the ground surface was too soft for the backhoe to safely track on. Groundwater was encountered during intrusive investigations between 0.4 and 1.1 m below ground level.

Three particle size distribution (PSD) tests were performed on selected samples from the Isaac River Southern Site. The test results are plotted against the requirement curves in Plot 1.



Plot 1: Isaac River Southern Site Sand Gradings

Based on the laboratory results and the investigation carried out over the site, the ground strata is interpreted to be represented by three units. These units, along with the depth of the units encountered in each intrusive investigation are summarized in Table 7.



**Table 7: Isaac River Southern Site Units Description and Strata**

Unit Description	Strata Intervals (m)					
	IRTP01	IRTP03	IRTP02	IRTP04	IRTP06	IRTP05
Unit 1 – SAND, medium to coarse, trace fine angular gravel	0.0 – 0.3	0.0 – 0.4	0.0 – 3.2*	0.0 – 3.7*	0.0 – 2.2*	0.0 – 1.7
Unit 2 – Sandy GRAVEL, fine, angular, fine to coarse sand	0.3 – 2.3	0.4 – 2.0*	-	-	-	-
Unit 3 – Sandy Silty CLAY, fine to medium sand	-	-	-	-	-	1.7 – 2.2
Undefined strata due to limited data from intrusive investigation and laboratory testing	2.3 – 2.4*	-	-	-	-	2.2 – 2.3*

Note: \* denotes end of intrusive investigation

The investigation suggests that Unit 1 is slightly finer than acceptable pipeline bedding material but may be considered for use by SunWater. Unit 1 is present in all of the investigated hand auger and test pit locations. Based on the interpreted strata, an average riverbed width of 45 m and the investigated river section length of approximately 2.1 km, it is estimated that the Isaac River Southern site stores 230,000 m<sup>3</sup> of Unit 1 material which is possibly suitable for use for the pipeline construction.

Unit 2 is likely to be within the required grading envelopes, however it was only located in two investigations at the eastern end of the area and its grading was not assessed by laboratory testing. It is estimated that 20,500 m<sup>3</sup> of Unit 2 may be available.

### 5.1.2 Isaac River Northern Site

The Northern site is located 3 km east of the Moranbah township. The investigation area is between AMTD 216.3 and AMTD 219.3 with the northern investigation limit bordering with QMAN 300150. The length of this area is 3.0 km and the riverbed width varies between 45 to 80 m.

The Isaac River Northern Site was accessed by trekking the backhoe north along the Isaac River after performing the investigation at the Southern Site. The backhoe had to be trekked in as a gate was locked along the planned access route which followed an existing stock route. The river bed was free of vegetation and relatively flat. The left bank rises to 9 m above the riverbed and the right bank rises to 5 m. Both banks are heavily treed. There is an existing river crossing near IRTP11 as illustrated in Figure B2, Appendix B.

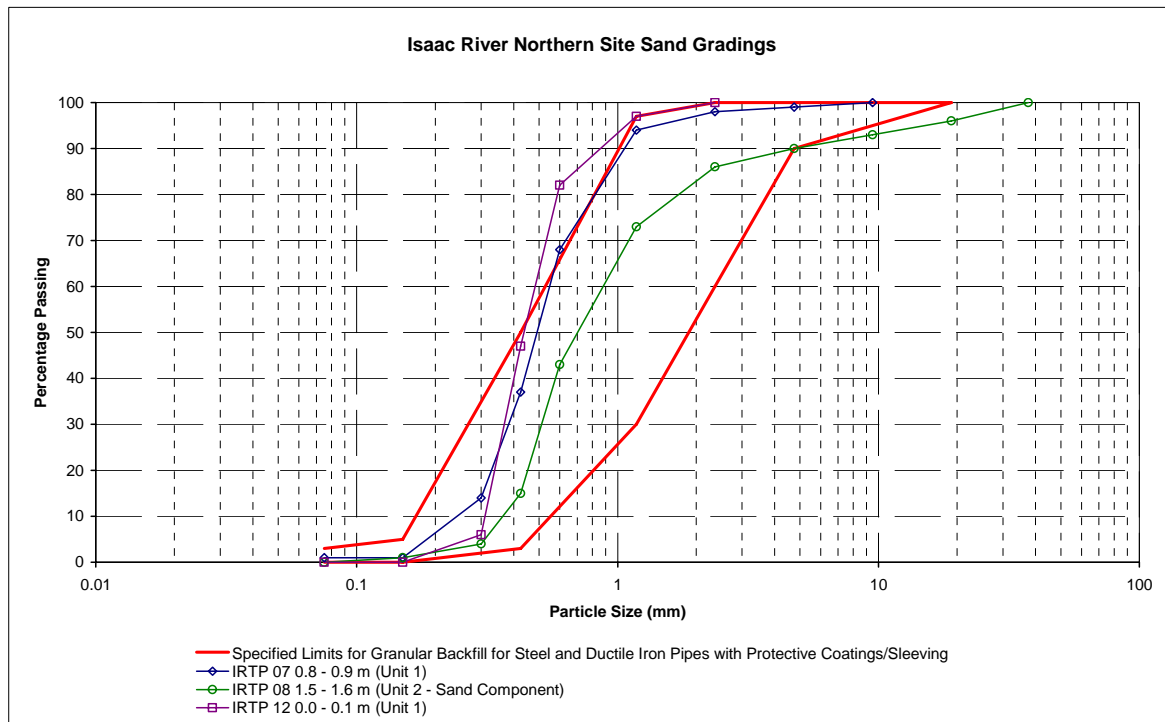
Three test pits, designated IRTP07 to IRTP09, were excavated on 9 July 2009. A further four test pits, designated IRTP10 to IRTP13, were completed on 10 July 2009. The test locations are shown in Figure 3. Groundwater was encountered during intrusive investigation between 0.8 m to 1.3 m below ground level.

Three PSD tests were performed on selected samples from the Isaac River Northern Site. The test results are plotted against the requirement curves in Plot 2. It is noted that the PSD test of the sample collected from IRTP 08 (1.5 m to 1.6 m) was performed on the 'SAND' component after coarser material had been removed.





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*Plot 2: Isaac River Northern Site Sand Gradings*

Based on the laboratory results and the investigation carried out over the site, the ground strata was interpreted to be represented by three units. These units, along with the depth of the units encountered in each intrusive investigation are summarised in Table 8.

**Table 8: Isaac River Northern Site Units Description and Strata**

Unit Description	Strata Interval (m)						
	IRTP07	IRTP08	IRTP09	IRTP10	IRTP11	IRTP12	IRTP13
Unit 1 – SAND, medium to coarse, trace fine angular gravel	0.0 – 2.0	0.0 – 1.3	0.0 – 2.1*	0.0 – 0.9	0.0 – 1.6	0.0 – 0.6	0.0 – 0.9
Unit 2 – Gravelly SAND, medium coarse (95%) and COBBLES (5%)	-	1.3 – 3.4	-	0.9 – 2.5*	-	0.6 – 3.3	0.9 – 2.3
Unit 3 – Clayey SAND, medium to coarse	-	-	-	-	1.6 – 2.0*	-	-
Undefined strata due to limited data from intrusive investigation and laboratory testing	2.0 – 3.2*	3.4 – 3.7*	-	-	-	3.3 – 4.1*	2.3 – 2.7*

Note: \* denotes end of intrusive investigation



Unit 1 and the Gravelly SAND component of Unit 2 fall just outside the grading envelope for pipeline bedding material provided by SunWater. However, a mixture of these is likely to meet the requirements, or very close to it. Based on the interpreted strata, an average riverbed width of 45 m and the investigated river section length of approximately 2.3 km, it is estimated that the Isaac River Northern site stores 287,500 m<sup>3</sup> of material that may be suitable for the pipeline construction.

## 5.2 North Creek

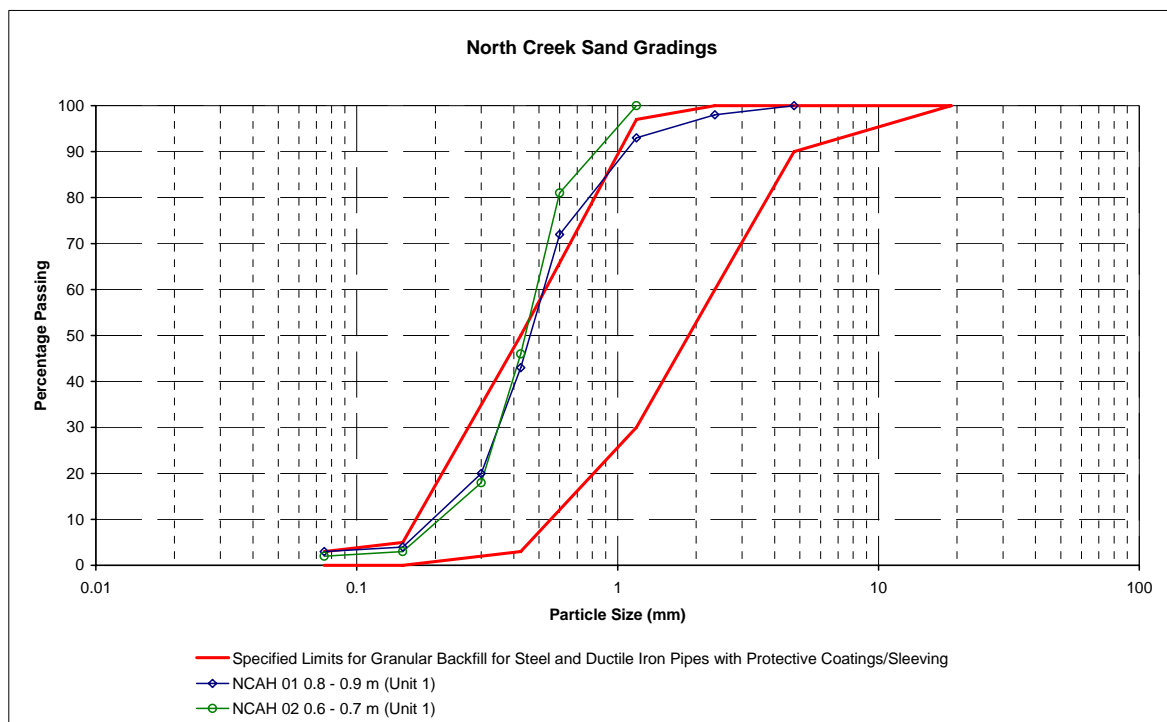
The area of the North Creek investigation is located 25 km east of Moranbah. The length of the investigation area is approximately 4.9 km and the creek bed width varied between 7 and 17 m.

Three hand auger holes, designated NCAH01 to NCAH03, were performed at North Creek on 13 July 2009. The test locations are presented on Figure 4.

Access to NCAH01 and NCAH02 was obtained predominately via existing vehicle tracks followed by short walks down the creek banks. Access to NCAH03 was obtained using existing vehicle track followed by walking approximately 600 m through densely vegetated areas. The creek banks have an angle of between 30 to 45° and average height of 5 m. There were no existing vehicle tracks leading into the creek bed.

The location of NCAH 03 is outside the preliminary area due to the presence of ponded water along the northern end of the previously identified site. The creek bed was free of vegetation and relatively flat.

During the intrusive investigation, groundwater was encountered at 0.7 m and 0.6 m below ground level at NCAH01 and NCAH02, respectively. No groundwater was encountered at NCAH03. Two PSD tests were performed on selected samples from North Creek. The test results are plotted against the specified bedding material limits in Plot 3.



Plot 3: North Creek Sand Gradings



Based on the laboratory test results and the intrusive investigation carried out over the site, the ground strata were interpreted to be represented by three units. These units, along with the depth of the units encountered in each intrusive investigation are summarised in Table 9.

**Table 9: North Creek Units Description and Strata**

Unit Description	Strata Interval (m)		
	NCAH01	NCAH02	NCAH03
Unit 1 – SAND, medium to coarse, trace fine angular gravel	0.0 – 1.8	0.0 – 0.8	0.0 – 0.3
Unit 2 – Clayey SILT, high plasticity	-	0.8 – 2.1*	-
Unit 3 – Sandy CLAY / Clayey SAND, high plasticity clay, fine to coarse sand	-	-	0.3 – 2.1*
Undefined strata due to limited data from intrusive investigation and laboratory testing	1.8 – 2.0*	-	-

Note: \* denotes end of intrusive investigation

Unit 1 lacks the fine gravel component of the grading but may be considered by SunWater as a suitable material. Based on the interpreted strata, an average creek bed width of 10.5 m and the investigated river section length of approximately 4.9 km, it was estimated that the North Creek site stores 57,000 m<sup>3</sup> of material that may be deemed suitable for the pipeline construction.

### 5.3 Harrybrandt Creek

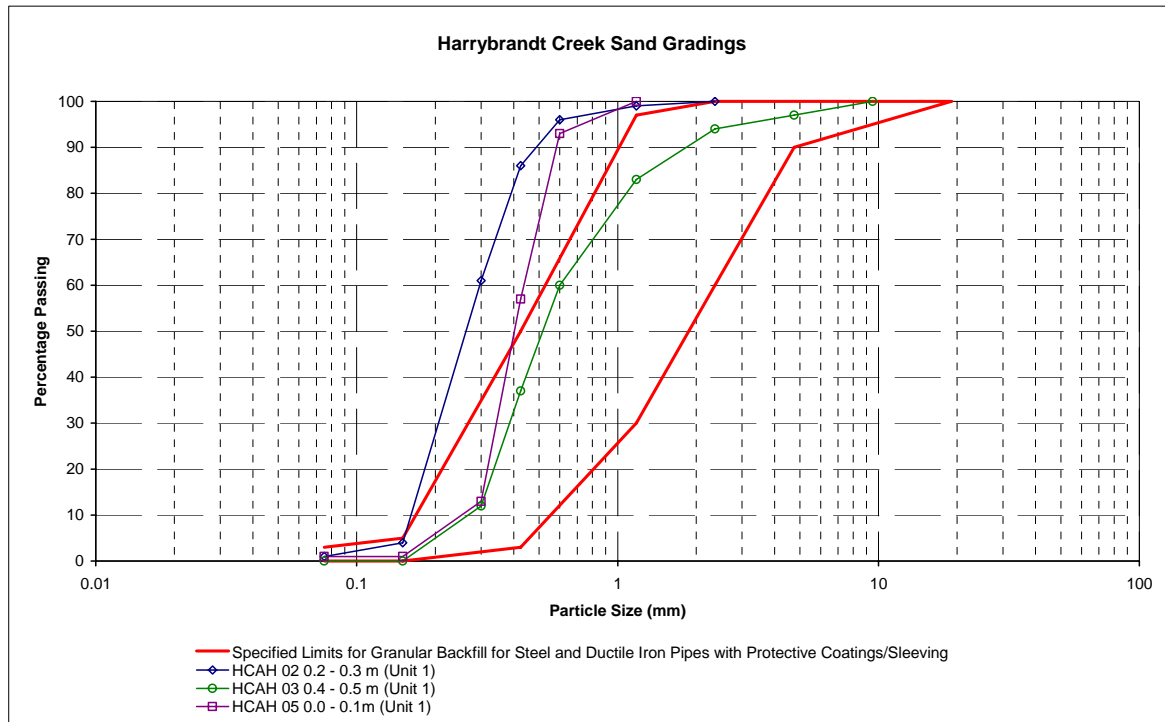
The Harrybrandt Creek investigation area is located 45 km east of Moranbah. The investigated area is between AMTD 12.6 to AMTD 23.2, running parallel to the Peak Downs Highway. The eastern limit of the investigated area is close to the allocated QMAN 100671 and 101029.

Five hand auger holes, designated HCAH01 to HCAH05, were performed at Harrybrandt Creek on 12 July 2009. The test locations are shown in Figure 5. Access to HCAH01, HCAH02 and HCAH04 was obtained via existing farm tracks and creek crossings leading into the creek bed. Vehicle access to HCAH03 was possible to within 300 m of the test location, followed by trekking through a heavily vegetated area. Access to HCAH05 was possible through a heavily vegetated, low bank area. The creek bed was free of vegetation and relatively flat. Most of the creek bank has an angle of 30° to a height of 5 m, with some areas having higher angles.

Groundwater was encountered at around 0.3 m below ground level at HCAH01 to HCAH04, and at 2.3 m below ground level for HCAH05. Three PSD tests were performed on selected samples from Harrybrandt Creek. The test results are plotted against the specified limits in Plot 4.



## CRD TO MORANBAH PIPELINE



*Plot 4: Harrybrandt Creek Sand Gradings*

Based on the laboratory test results and the intrusive investigation carried out over the site, the ground strata was divided into three representative units. The description of each units, along with along with the depth of the units encountered at each investigation location are summarised in Table 10.

**Table 10: Harrybrandt Creek Units Description and Strata**

Unit Description	Strata Interval (m)				
	HCAH01	HCAH02	HCAH03	HCAH05	HCAH04
Unit 1 – SAND, fine to medium, trace fine gravel	0.0 – 0.6	0.0 – 2.3	0.0 – 2.1	0.0 – 1.4	0.0 – 2.1
Unit 2 – Silty SAND, fine to medium, trace fine gravel	0.6 – 3.6*	-	-	-	-
Unit 3 – Sandy GRAVEL, fine (80%) and COBBLES (20%)	-	-	-	1.4 – 2.5*	-
Undefined strata due to limited data from intrusive investigation and laboratory testing		2.3 – 3.1*	2.1 – 2.3*	-	2.1 – 2.3*

Note: \* denotes end of intrusive investigation

One sample from Unit 1 collected from HCAH03 falls within the limits of acceptable pipeline bedding material. However, other samples from Unit 1 collected from HCAH02 and HCAH05 contains too many fine particles. Based on the interpreted strata, an average creek width near HCAH03 of approximately 22 m and an investigated creek section length of approximately 2.5 km, it was estimated that the Harrybrandt Creek site stores 77,000 m<sup>3</sup> of suitable material to be used for the pipeline construction. This estimation only takes into account the Unit 1 material in the vicinity of HCAH03.

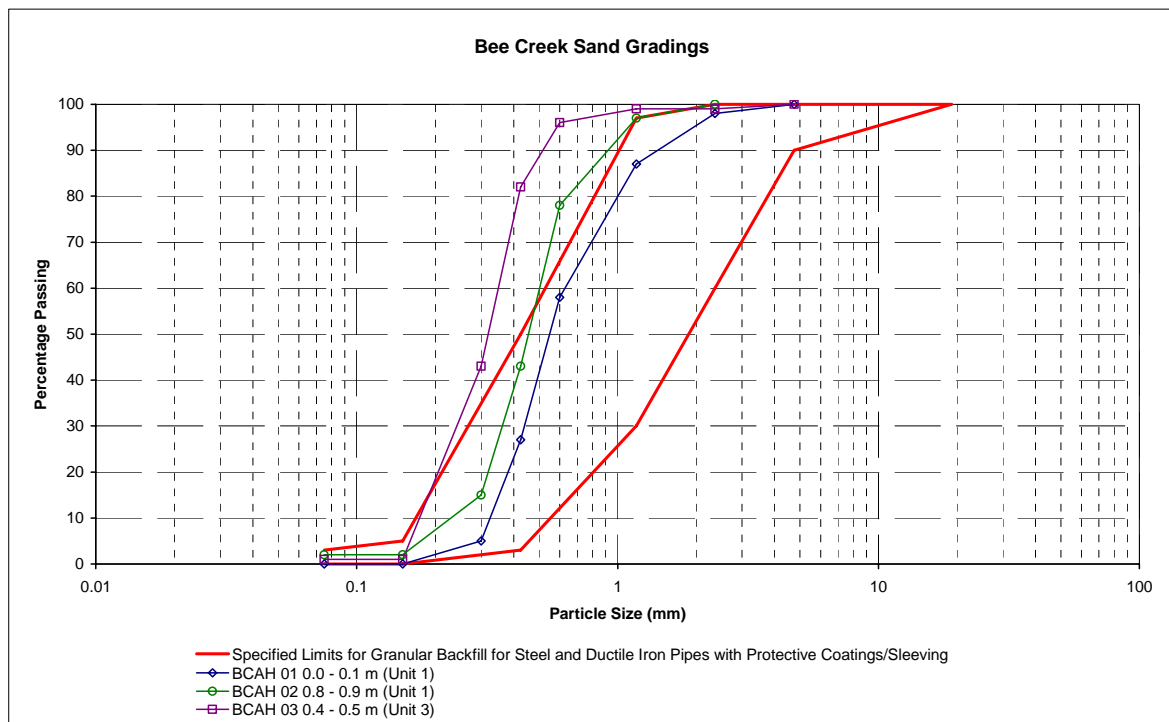


## 5.4 Bee Creek

The Bee Creek investigation area is located 25 km south-west of the Nebo township, near the junction of the Peak Downs Highway and Fitzroy Development Road. Four hand augers, designated BCAH01 to BCAH04, were performed around the Bee Creek area on 11 July 2009. The test locations are shown in Figure 6. The Bee Creek investigation area can be separated into the Northern site, which contains BCAH01 and BCAH02, and the Southern site, which contains BCAH03 and BCAH04. Although the Southern site was given the 'Bee Creek' designation, it was actually performed in the Harrybrandt Creek subsystem.

Access to the investigation locations was along existing vehicle tracks to within 30 m of the creek followed by walking through moderately vegetated areas. There were no existing vehicle tracks leading into the creek bed. The creek banks at the Northern site have an average angle of 40° and a height between 10 to 15 m, while the banks at the Southern site have an average angle of 30° and a height between 7 and 12 m. The Northern site has a creek bed free of vegetation, dry, relatively flat and a width ranging from 12 to 25 m. The Southern site has a relatively flat creek bed with ponded water present at the northern end of the creek, dense vegetation at the southern end, and a width range between 13 to 27 m.

During the intrusive investigation, groundwater was encountered at 1.6 m below ground at BCAH01 and at 0.3 m below ground at BCAH03 and BCAH 04. No groundwater was encountered at BCAH02. Three PSD tests were performed on selected samples from Bee Creek. The test results are plotted against the specified limits in Plot 5.



Plot 5: Bee Creek Sand Gradings

The ground strata was best represented by three units based on the laboratory test results and the intrusive investigation carried out over the site. The definitions of each unit, along with the depth of the units encountered in each intrusive investigation are summarized in Table 11 for the Northern site and Table 12 for the Southern Site.



**Table 11: Bee Creek Northern Site Units Description and Strata**

Unit Description	Strata Interval (m)	
	BCAH01	BCAH02
Unit 1 – SAND, medium to coarse, trace fine angular gravel	0.0 – 4.7	0.0 – 1.4
Unit 2 – Gravelly SAND, medium to coarse, fine gravel, some sub angular and rounded cobbles to 0.08 m	-	1.4 – 2.0*
Undefined strata due to limited data from intrusive investigation and laboratory testing	4.7 – 5.0*	-

Note: \* denotes end of intrusive investigation

**Table 12: Bee Creek Southern Site Units Description and Strata**

Unit Description	Strata Interval (m)	
	BCAH03	BCAH04
Unit 3 – SAND, medium, trace fine gravel	0.0 – 3.3	0.0 – 1.9
Undefined strata due to limited data from intrusive investigation and laboratory testing	3.3 – 3.5*	1.9 – 2.1*

Note: \* denotes end of intrusive investigation

Units 1 and 2 are both likely to be considered acceptable pipeline bedding material. At the location of BCAH01, the average creek bed width was 18 m and the investigated section length was 940 m. At the location of BCAH02, the average creek bed was 25 m with an investigated section length of 230 m. Based on the interpreted strata and the creek dimensions presented above, it is estimated that the Bee Creek Northern site stores 87,500 m<sup>3</sup> of suitable material to be used for the pipeline construction. The sand in the Southern area is too fine and poorly graded for use as bedding.

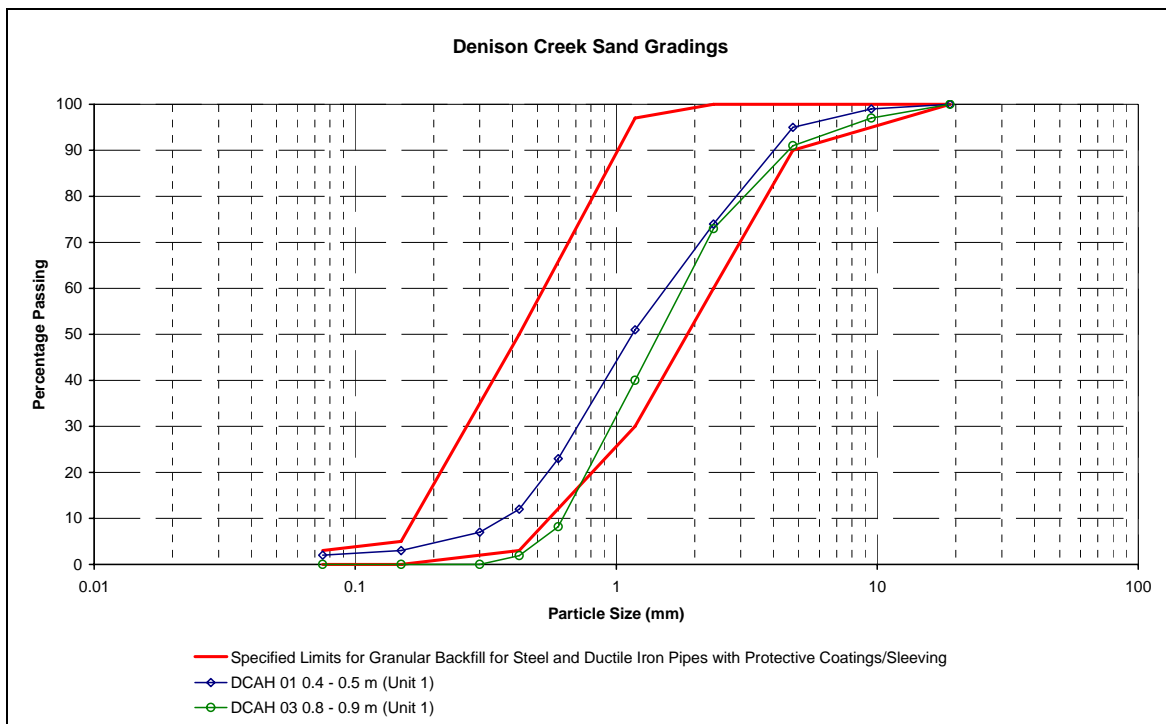


### 5.5 Denison Creek

The Denison Creek investigation area is located 18 km south of the Nebo township and was accessed using a farm track off Cockezie Road. The investigation area spreads between approximately AMTD 17.0 and AMTD 20.0. The length of this area is 3.5 km and the creek varies from 24 to 35 m wide. Upstream of the investigated area, starting at AMTD 30.2, is the area with allocated QMAN 100713.

Three hand augers, designated DCAH01 to DCAH03, were performed along Denison Creek on 14 July 2009. The test locations are shown in Figure 7. Access to all sites was via existing vehicle tracks to within 100 m of the creek, followed by trekking up to 100 m through densely vegetated area and creek banks angled at 30 to 50° and up to 7 m high. The creek bed was dry, mainly free of vegetation and relatively flat. A section of the creek bed near DCAH02 is densely vegetated as illustrated in Figure B13.

Groundwater was encountered at 0.4 m below ground level at DCAH01 and 0.8 m below ground level at DCAH02. No groundwater was encountered at DCAH 03. Two PSD tests were performed on selected samples from Denison Creek and the test results are plotted against the specified limits in Plot 6.



Plot 6: Denison Creek Sand Gradings

A single unit can be used to represent the ground strata at Denison Creek. The description of this unit along with the depth of the unit encountered at each intrusive investigation is summarized in Table 13.



**Table 13: Denison Creek Units Description and Strata**

Unit Description	Strata Interval (m)		
	DCAH01	DCAH02	DCAH03
Unit 1 – Gravelly SAND, medium to coarse, fine to medium gravel	0.0 – 5.0*	0.0 – 3.2	0.0 – 4.9*
Undefined strata due to limited data from intrusive investigation and laboratory testing	-	3.2 – 3.6*	-

Note: \* denotes end of intrusive investigation

Based on its grading, Unit 1 is an acceptable pipeline bedding material. Using the interpreted strata, an average creek bed width of approximately 26 m and an investigated creek section length of approximately 3.5 km, it is estimated that the Denison Creek site stores 365,000 m<sup>3</sup> of suitable material for the pipeline construction.

## 5.6 Funnel Creek

The Funnel Creek investigation area is located approximately 30 km south-east from the Nebo township and was accessed using a farm track leading from the Marlborough Sarina Road. Figure 8 focuses on the Funnel Creek investigation area. The southern end of the investigation area was located at the crossing of a high voltage powerlines corridor. The presence of the powerline access road allowed vehicle access to within 100 m of the creek.

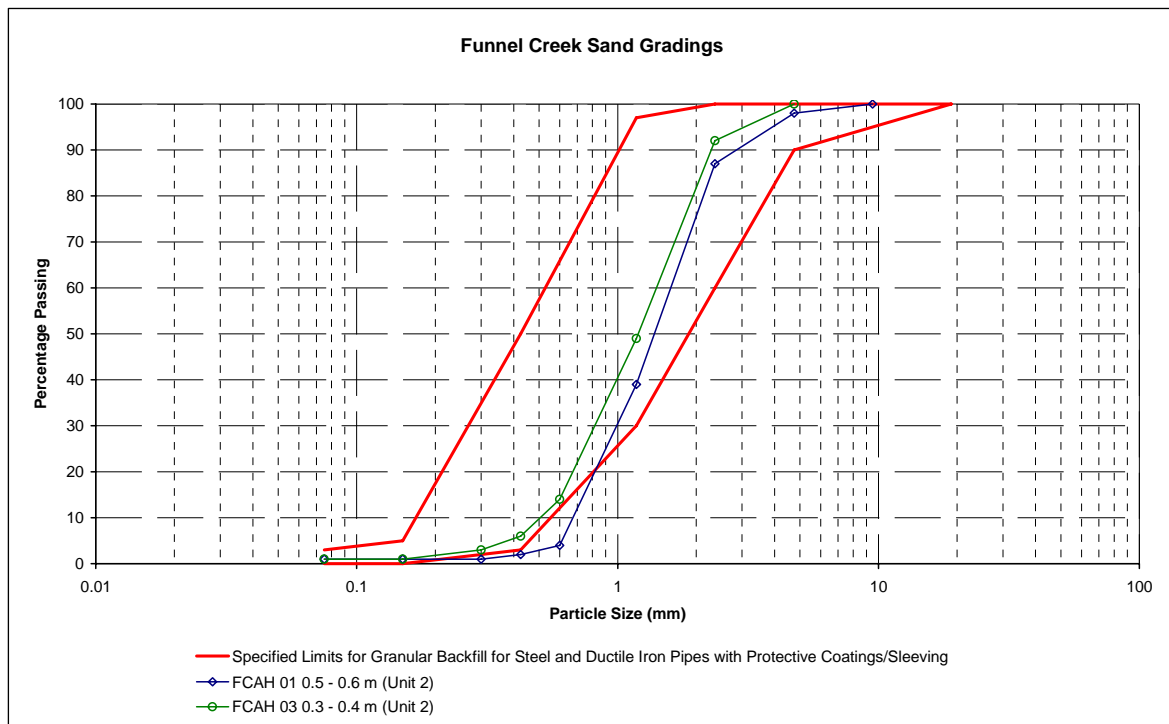
At the time of the investigation the creek had flowing water approximately 20 m wide, close to the left bank of the creek. An elevated dry creek area, approximately 2 m high was present at the right hand side of the flowing creek. The elevated dry creek area was approximately 40 m wide at the southern end, opening up to about 130 m upstream at the northern limit of the area.

Access to the dry creek area was obtained by crossing the creek at the southern end where the water was only approximately 9 m wide and 700 mm deep as shown in Figure B16. An unnamed dry creek flows from the west and intersects Funnel Creek close to the crossing described previously.

Three hand augers, designated FCAH01 to FCAH03, were performed at Funnel Creek on 15 July 2009. The investigation locations are also shown in Figure 8. The dry creek area was vegetated by mature trees widely spread apart. Vehicle access was possible to the southern end of the area with a cattle track leading down from the approximately 15 m high left bank into the creek bed. The right bank rises steadily from the dry creek area up to an undefined height due to heavy vegetation.

No groundwater was encountered at the investigated locations. Two PSD tests were performed on selected samples from Funnel Creek and the results are plotted against the requirement curves in Plot 7.





Plot 7: Funnel Creek Sand Gradings

Based on the laboratory test results and the investigation carried out over the site, the ground strata was interpreted to be represented by two units. These units, along with the depth of the units encountered in each intrusive investigation are summarised in Table 14.

Table 14: Funnel Creek Units Description and Strata

Unit Description	Strata Interval (m)		
	FCAH03	FCAH01	FCAH02
Unit 1 – SAND, medium to coarse, some fine to medium gravel	0.0 – 0.1	-	-
Unit 2 – Gravelly SAND, coarse, fine gravel	0.1 – 3.2	0.0 – 1.1	0.0 – 1.2
Undefined strata due to limited data from intrusive investigation and laboratory testing	3.2 – 3.5*	1.1 – 1.7*	1.2 – 1.7*

Note: \* denotes end of intrusive investigation

The grading of Unit 2 samples generally falls within the limits and may be considered an acceptable pipeline bedding material. The average creek bed width between FCAH01 and FCAH02 was approximately 100 m. The average creek bed width between FCAH01 and FCAH03 was approximately 60 m. The investigated creek section length was approximately 880 m. Based on the interpreted strata and the dimensions presented above, it is estimated that the Funnel Creek site stores 108,000 m<sup>3</sup> of suitable material to be used for the pipeline construction.

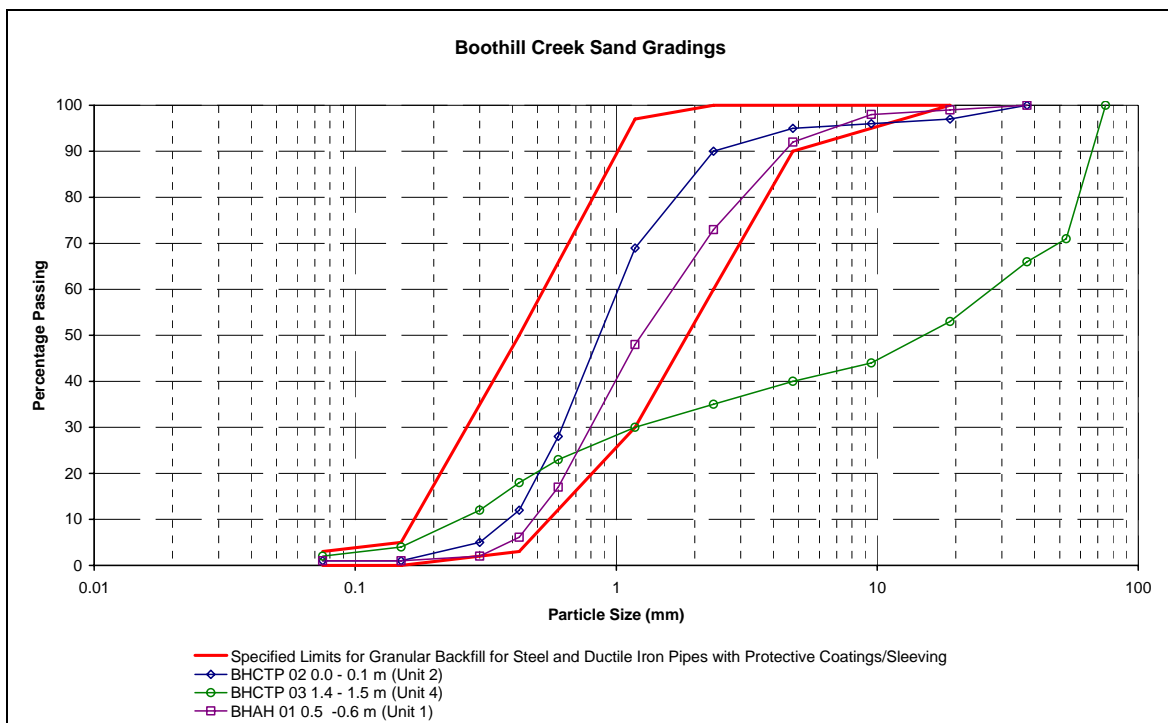


## 5.7 Boothill Creek

The investigation area for Boothill Creek is located approximately 2 km west of the Marlborough Sarina Road and is 4.5 km north-east of the Funnel Creek investigation area. The area is approximately 400 m long and the creek bed was approximately 100 m wide upstream narrowing down to 14 m downstream.

Two test pits, designated BHCTP02 and BHCTP03, were performed at the Boothill Creek on 6 July 2009. The site was revisited on 15 July and two additional hand augers, designated BHAH01 and BHAH02, were performed. The test locations are shown in Figure 9. Access into Boothill Creek was via an existing vehicle track leading into the creek. The creek bed was dry, vegetated with mature trees spaced widely apart and relatively flat. The creek banks have an average angle of 40° and were between 5 and 9 m high.

No groundwater was encountered during the intrusive investigations. Three PSD tests were performed on selected samples from Boothill Creek. The test results are plotted against the requirement curves in Plot 8.



Plot 8: Boothill Creek Sand Gradings

The ground strata was best represented by four units based on the laboratory test results and the intrusive investigation carried out over the site. The definitions of each unit, along with the depth of the units encountered in each intrusive investigation are summarized in Table 15.



**Table 15: Boothill Creek Units Description and Strata**

Unit Description	Strata Interval (m)			
	BHAH01	BHCTP02	BHCTP03	BHAH02
Unit 1 – Gravelly SAND / Sandy GRAVEL, medium to coarse sand, fine to coarse gravel	0.0 – 3.9*	-	-	0.0 – 4.2*
Unit 2 – SAND, medium to coarse, some fine to medium angular gravel	-	0.0 – 0.4	0.0 – 0.2	-
Unit 3 – COBBLES (70%) and SAND, medium to coarse (30%)	-	0.4 – 3.7*	-	-
Unit 4 – Sandy GRAVEL, fine to coarse (70%) and COBBLES (30%)	-	-	0.2 – 2.5*	-

Note: \* denotes end of intrusive investigation

The results of the investigation suggest that Unit 1 and Unit 2 would both be acceptable for pipeline bedding material. Unit 1 was present in BHAH01 and BHAH02, while Unit 2 was present as surface material at BHCTP02 and BHCTP03. Based on the interpreted strata and the dimensions presented above, it is estimated that the Boothill Creek site stores 43,000 m<sup>3</sup> of suitable material to be used for the pipeline construction.

Unit 4 might also be considered suitable once the oversize material was removed. However, it was only identified in one location and is therefore not likely to be available in sufficient quantities.

### 5.8 Boothill and Funnel Creek Junction

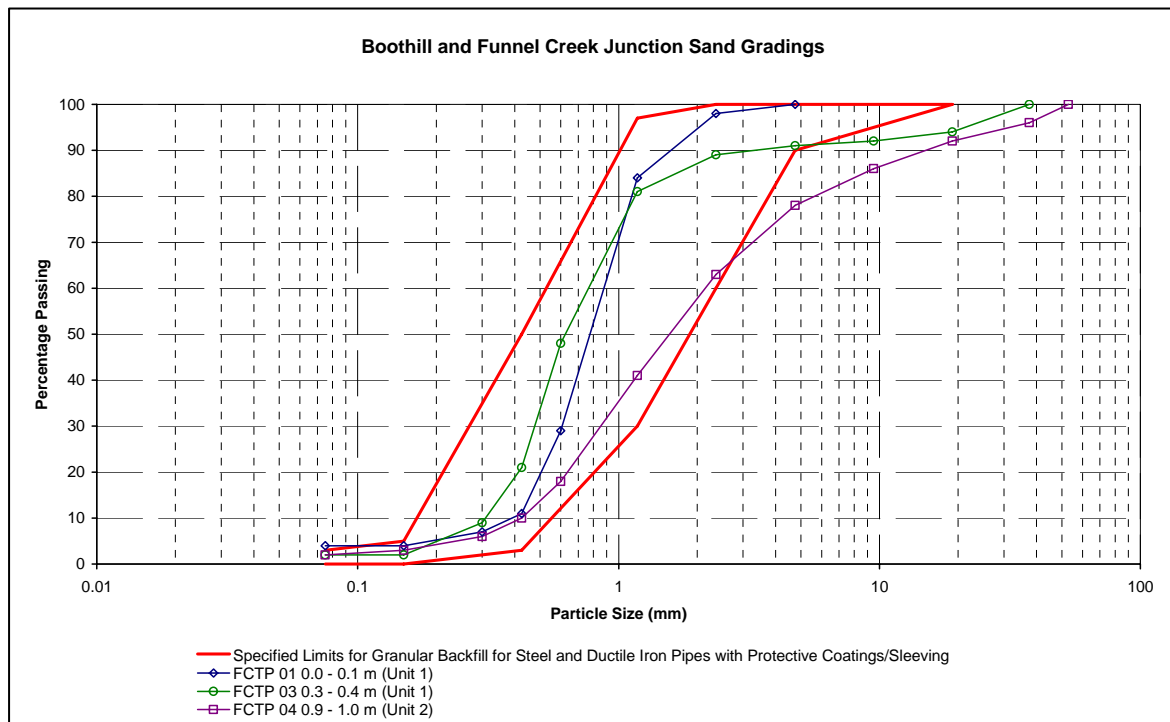
The Boothill and Funnel Creek Junction is located 3.5 km west of the Boothill Creek investigation area. The Junction area is approximately 130 m wide and 150 m long.

Four test pits were performed at the Boothill and Funnel Creek Junction with designation FCTP01 to FCTP04 on 7 July 2009. The test locations are shown in Figure 10. Access into the Boothill and Funnel Creek Junction was made using an existing track leading from Boothill into the creek. Test pits FCTP01 and FCTP04 were performed at the Junction, while test pits FCTP02 and FCTP03 was performed along an unnamed creek leading from the Junction in an easterly direction. The creek banks rises 5 m from the creek bed. The creek bed is vegetated by mature trees that are spaced widely apart.

No groundwater was encountered during the intrusive investigations. Three PSD tests were performed on selected samples from Boot Hill and Funnel Creek Junction. The test results are plotted against the requirement curves in Plot 9.



## CRD TO MORANBAH PIPELINE



Plot 9: Boothill and Funnel Creek Junction Sand Gradings

Table 16 summarizes the four representative units identified at the Junction, based on the laboratory test results and the investigations carried out over the site. Along with the unit descriptions, Table 16 also includes the depth of the units encountered in the intrusive investigation.

**Table 16: Boothill and Funnel Creek Junction Units Description and Strata**

Unit Description	Strata Interval (m)			
	FCTP01	FCTP04	FCTP02	FCTP03
Unit 1 – SAND, medium to coarse, some fine angular gravel	0.0 – 4.6*	0.0 – 0.2	-	0.0 – 0.8
Unit 2 – Gravelly SAND, medium to coarse, fine to coarse gravel	-	0.2 – 2.6*	-	-
Unit 3 – Gravelly SAND, medium to coarse (50%) and COBBLES (50%)	-	-	0.0 – 2.5*	0.8 – 1.5
Unit 4 – Silty SAND, medium to coarse (60%) and COBBLES (40%)	-	-	-	1.5 – 2.6*

Note: \* denotes end of intrusive investigation

Based on its grading, Unit 1 generally falls within the bedding sand requirement lines. One of the samples of Unit 1 that was tested has a low percentage of coarse particles that would have to be removed prior to it being used as bedding sand. Unit 1 was present in the section between FCTP01 and FCTP04. This section of the Junction has a dimension of approximately 140 m long and 60 m wide. Unit 1 was also present at the top layer of FCTP03 which was located along the unnamed creek. The area around FCTP03 was approximately 90 m long and 15 m wide. Based on the field material description, it is possible the Unit 2 could also be an acceptable bedding material once the coarser material is screened out. The section between FCTP03 and FCTP02 is approximately 100 m long and 25 m wide.



Based on the interpreted strata and the dimensions presented above, it is calculated that the Boothill and Funnel Creek Junction site stores 37,000 m<sup>3</sup> of suitable material to be used for the pipeline construction.

### 5.9 Connors River

The Connors River investigation area is located 4 km south west of the proposed Connors River Dam centreline axis. Four test pits, designated CRTP05 to CRTP08, were performed on 8 July 2009. The test locations are presented in Figure 11. Vehicle access to Connors River was off-road through a heavily grassed area to about 100 m from the riverbed. From that point, a temporary track was pushed using the excavator to access the investigation area.

Prior to performing the test pits, a visual inspection was undertaken of the area identified in the desktop study. The visual inspection revealed the area to be heavily vegetated as shown in Photograph 1. The surface material of the area was predominantly fine grained.



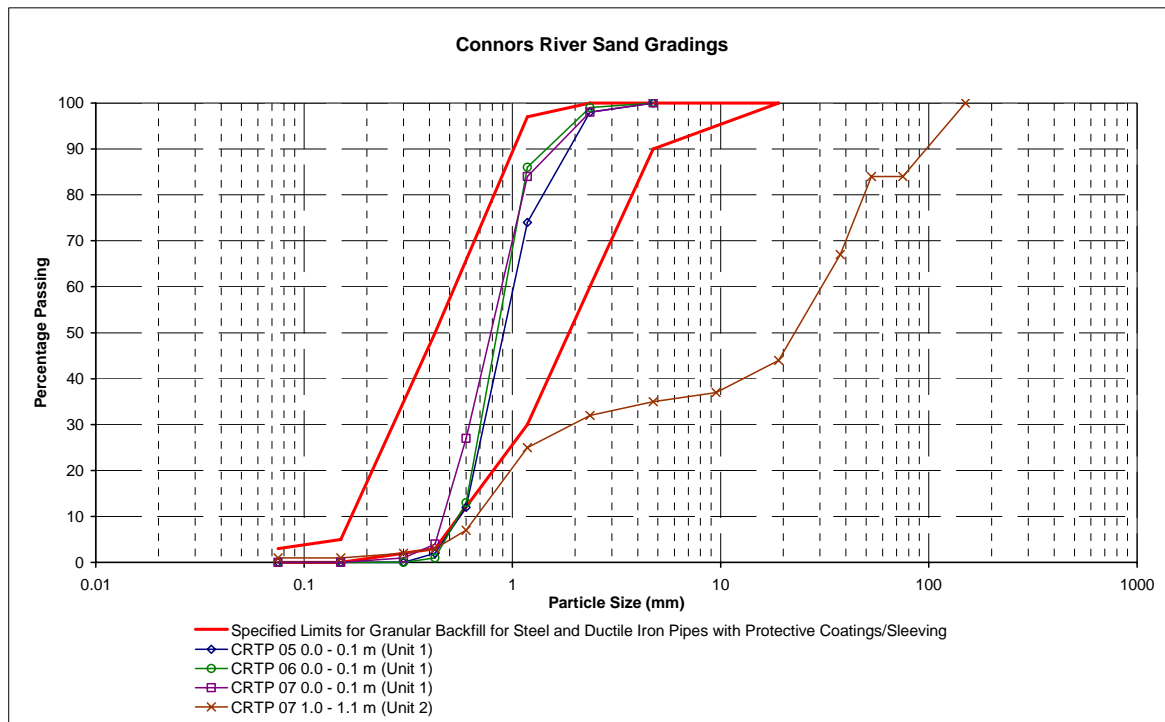
*Photograph 1: Surface condition of desktop study area*

A new investigation area was identified south of the area defined by the desktop study. The new area is along a dry riverbed which comprised predominantly medium to coarse gravel. The test pits were performed mainly along a 140 m stretch along the riverbed where sand was present at the surface.

Groundwater was encountered between 2.0 m and 2.4 m depth during intrusive investigations. Four PSD tests were performed on selected samples from the Connors River. The test results are plotted against the preferred grading envelope in Plot 10.



## CRD TO MORANBAH PIPELINE



Plot 10: Connors River Sand Gradings

Based on the laboratory results and the investigation carried out over the site, the ground strata was interpreted to be represented by two units. These units, along with the depth of the units encountered in each intrusive investigation are summarised in Table 17.

**Table 17: Connors River Units Description and Strata**

Unit Description	Strata Interval (m)			
	CRTP06	CRTP05	CRTP07	CRTP08
Unit 1 – SAND, coarse, trace angular gravel	0.0 – 0.6	0.0 – 0.6	0.0 – 0.3	-
Unit 2 – COBBLES (80%) and Sandy GRAVEL / Gravelly SAND, fine to coarse gravel, medium to coarse sand (20)	0.6 – 2.6*	0.6 – 2.6*	0.3 – 2.6*	0.0 – 2.5*

Note: \* denotes end of intrusive investigation

The laboratory testing of samples of Unit 1 material indicate its grading is within the required limits for use as pipeline bedding material. Unit 1 is present as surface material at CRTP05 to CRTP07. Based on the thickness of Unit 1 in the test pits, an average riverbed width of approximately 20 m and the investigated river section of 140 m, it is estimated that the site stores 1,500 m<sup>3</sup> of suitable material for the pipeline construction.

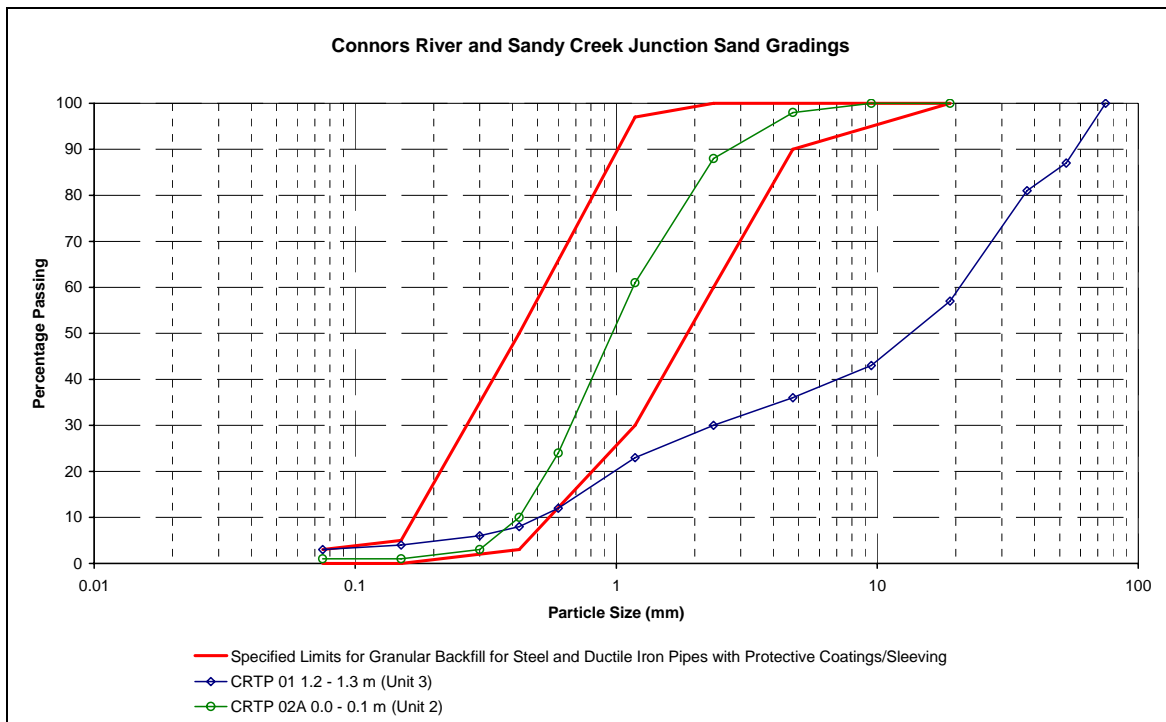


### 5.10 Connors River and Sandy Creek Junction

The Connors River and Sandy Creek Junction is located 1 km south of the Connors River sand investigation area. The Junction area was accessed using an existing vehicle track heading west from the Connors River Collaroy Road.

Four test pits, designated CRTP01, CRTP02, CRTP02A and CRTP03, were performed at the Connors River and Sandy Creek Junction on 7 July 2009. The test locations are presented in Figure 11. CRTP01 was performed in Connors River where the surface material comprises mainly cobbles. The remaining test pits were performed along Sandy Creek where the surface material comprises mainly of medium to coarse sand. Representative photographs of the surface materials at Connors River and Sandy Creek are presented in Figure B21.

Groundwater was encountered at 0.7 m depth at CRTP01, at 1.4 m depth at CRTP02 and at 2.3 m depth at CRTP03. No groundwater was encountered at CRTP02A due to shallow test pit depth. Two PSD tests were performed on selected samples from Connors River and Sandy Creek Junction. The test results are plotted against the preferred grading envelope in Plot 11.



Plot 11: Connors River and Sandy Creek Junction Sand Gradings

The ground strata was best represented by three units based on the laboratory test results and the intrusive investigation carried out over the site. The definitions of each unit, along with the depth of the units encountered in each intrusive investigation are summarized in Table 18.



**Table 18: Connors River and Sandy Creek Junction Units Description and Strata**

Unit Description	Strata Interval (m)			
	CRTP01	CRTP02	CRTP02A	CRTP03
Unit 1 – Silty SAND, fine to coarse, some fine to coarse gravel	-	0.0 – 0.1	-	-
Unit 2 – Gravelly SAND, medium to coarse, fine gravel	-	-	0.0 – 0.6	-
Unit 3 – COBBLES & BOULDERS (80%) and Sandy GRAVEL, fine to coarse (20%)	0.0 – 2.4*	0.1 – 1.8*	0.6 – 0.9*	0.0 – 2.6*

Note: \* denotes end of intrusive investigation

The investigation indicates that only Unit 2 meets the required grading envelope for bedding material, with Unit 1 too fine and Unit 3 too coarse. However, Unit 2 was only identified at one location and has a limited thickness. It might be expected that up to 1,500 m<sup>3</sup> of Unit 2 is present.

## 6.0 ASSUMPTIONS

The following assumptions were made to assess the volume of sand available for use as pipeline bedding material:

- The ground level as each site is relatively flat and even;
- The Unit thicknesses between investigation locations changes gradually;
- The river width between investigation location changes gradually; and
- The quantity of laboratory tests performed for each unit was sufficient to represent the unit.

## 7.0 DISCUSSION

The investigations undertaken to date indicate that ample sand is present in the creeks and rivers along the CRD to Moranbah pipeline route that meets the grading requirements provided by SunWater. The largest resources are in the following locations:

- Isaac River;
- Denison Creek; and
- Funnel Creek.

DERM has already indicated that the upper limit of an allocation from the Isaac River may be 45,000 m<sup>3</sup> of sand. Assuming extraction is limited to above the water table, which is at an average depth of approximately 1 m, the allowed volume could be extracted from a 1 km stretch of the river.

Restrictions on extraction volumes for the Denison and Funnel Creeks should be investigated as they have the potential to supply the remaining bedding sand for the pipeline if restrictions allow.





The investigations performed have focused on an assessment of the grading of the materials and an estimate of the volumes based on surface appearance and apparent depth of materials from the intrusive investigation. To further assess the suitability and volume of the sand identified additional investigations would be required. Borehole drilling is recommended to assess the total thickness of prospective materials and to further define the available volumes and additional laboratory testing would be required to assess the plasticity of the fines present.

### 8.0 LIMITATIONS

Your attention is drawn to the document - "Limitations", which is included in Appendix D of this report. The statements presented in this document are intended to advise you of what your realistic expectations of this report should be, and to present you with recommendations on how to minimise the risks associated with the groundworks for this project. The document is not intended to reduce the level of responsibility accepted by Golder Associates, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

We would be pleased to answer any questions about these limitations from the reader of this report.

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