Gladstone Ports Corporation
Growth, Prosperity, Community.

Appendix D

Appendix D – TSS and Light Impacts Report

GHD

CLIENTS | PEOPLE | PERFORMANCE

Report for Western Basin EIS

TSS and Light Impacts

April 2010

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

Contents

Table Index

1. Turbidity Impacts

This report provides an update with respect to the turbidity and light attenuation calculations previously undertaken for four locations within the Western Basin/Port Curtis region. The work has been updated to account for findings at all 28 locations where model results have been produced.

Error! Reference source not found. summarises specific turbidity objectives (i.e. the 80th and 95th percentile values which were previously derived using measured data), background levels (i.e. median of measured data), and the conversion of turbidity to TSS using the adopted relation from turbidity. The expression of TSS in units of mg/L allows a comparison with the results of plume simulations at each of the 28 nominated locations.

It is important to note that all plume simulations relate to dredge plume material, and not the ambient TSS climate. Water quality objectives (thresholds) have been defined below as the 80th or 95th percentile TSS concentration less the 50th percentile value. The 80th percentile threshold represents the difference between the 80th percentile and median of measurements at a given location, and is used to define the primary water quality objective. For the purpose of assessing likely compliance to this target, the threshold is then used as a basis for comparison to modelled plume concentrations. Where the modelled plume is less than the threshold, it can then be seen that the model predicts compliance with the 80th percentile TSS objective.

Table 1-1 Summary of 50th (median), 80th and 95th percentile turbidity and derived TSS thresholds (water quality objectives)

	Turbidity (NTU)			TSS (mg/L)			WQOs TSS (mg/L)	
Measurement Location	Median	80 th Percentile	95 th Percentile	Median	80 th Percentile	95 th Percentile	80th Percentile Threshold	95 th Percentile Threshold
Western Basin seagrass beds	9	24	55	15	70	184	55	169
Wiggins, South FL seagrass beds	9	25	91	15	74	317	59	302
Fisherman's Landing shallow areas	9	17	30	15	44	92	29	77

Notes: Turbidity based on measurements. TSS values converted from turbidity using previously derived equation. Simulated dredge plume TSS water quality objectives (threshold) defined as the 80th or 95th percentile TSS values less the 50th percentile concentration.

Results are presented for the same scenarios as presented in the Western basin EIS (i.e. inclusive of rehandling) and also for scenarios without rehandling (i.e. the removal of TSHD dumping and subsequent re-dredging by CSD). In under-taking the "no rehandling runs", the 3 hour cycle time for TSHD dredging and pump out was preserved.

A tabular comparison of the 50th (i.e. median), 20th, 10th and 5th probability exceedance dredge plume

TSS concentrations at twenty-eight locations along with comparisons to the relevant TSS objectives is provided in Table 1-2 with and without rehandling activities. The purpose of this table is twofold:

- To allow presentation of the benefits (reduced TSS) of removing rehandling; and
- To provide an interim indication as to which areas are most likely to meet water quality objectives based on an 80%ile criteria, and which areas are most likely to exceed this, providing confirmation of the areas requiring environmental offsets.

TSS water quality objectives were prepared for three locations only (as limited by the availability of collected data), and will need to be updated using additional data to be obtained during the pre-dredging period. In addition, it is noted that the bulk of data measurements have been in channel areas, which tend not to have seagrass meadows. It is recommended that the pre-dredge monitoring program targets shallower areas, in which seagrass can or does grow, as these will provide the most relevant data for the setting of water quality objectives.

Site specific objectives have been applied to the Narrows, the Western Basin and Wiggins Island, as noted in Table 1-1. Channel areas, and those areas towards eastern Port Curtis which do not have relevant data sets, have had the Narrows (shallow Fisherman's Landing) data set applied, as this is more conservative than the Western Basin or Wiggins seagrass bed datasets.

Table 1-2 Comparison of 50th, 20th, 10th and 5th probability exceedance of TSS at each of the time series points for each scenario with and without rehandling

			With Rehandling				Without Rehandling			
Site and Scenario	Turbidity Objective 95th %ile	Turbidity Objective 80th %ile	Median	20th % Exceedance	10th % Exceedance	5th % Exceedance	Median	20th % Exceedance	10th % Exceedance	5th % Exceedance
The Narrows										
WBM01 (Upper Narrows)										
Scenario 1a	77	29	5	12	15	17	1.5	3	4	5
Scenario 1b	77	29	7	18	30	35	3	9	19	23
Scenario 2	77	29	5.5	15	19	23	2	7	8	11
Scenario 3	77	29	1	3	4	4.5	1	3	4	4.5
WBM02 (Upper Narrows)										
Scenario 1a	77	29	3	8	12	14	1	2	3	3.5
Scenario 1b	77	29	4	12	20	27	2	6	10	16
Scenario 2	77	29	3.5	10	15	18	1.5	4	6	7
Scenario 3	77	29	1	2	3	4	1	2	3	4

Site and Scenario	Turbidity Objective 95th %ile	Turbidity Objective 80th %ile	With Rehandling				Without Rehandling			
			Median	20th % Exceedance	10th % Exceedance	5th % Exceedance	Median	20th % Exceedance	10th % Exceedance	5th % Exceedance
WBM03 (Lower Narrows)										
Scenario 1a	77	29	15.5	21	25	28	3	5	7.5	10
Scenario 1b	77	29	22	39	47	53	10	23	29	34
Scenario 2	77	29	19	29	35	39	6	13	18	22
Scenario 3	77	29	4	5.5	7.5	8.5	4	5.5	7.5	8.5
WBM14 (Middle Narrows)										
Scenario 1a	77	29	7	12.3	17.5	19.5	2	4	6	7
Scenario 1b	77	29	10.2	29	35	39.5	6	18	24	27
Scenario 2	77	29	10	20	26	29.5	5	9	15	18
Scenario 3	77	29	1.5	2	2.1	2.2	1.5	2	2.1	2.2
WBM15 (Lower Graham Creek)										
Scenario 1a	77	29	6.5	14.8	17.5	18	3	8	10	11
Scenario 1b	77	29	10	21.5	23	24.5	7	15	18	19
Scenario 2	77	29	7.5	14	17	18.5	4	7	10	12
Scenario 3	77	29	1.5	2.3	3	3.5	1.5	2.3	3	3.5
Western Basin										
WBM17 (North Western Basin)										
Scenario 1a	184	55	17	30	36	41	2.5	4	4.5	5
Scenario 1b	184	55	22	37	44	49	7	12	14	15
Scenario 2	184	55	19	34	40	45	4	7	10	12
Scenario 3	184	55	3	4	5	6	3	4	5	6
WBM04 (Middle Western Basin)										
Scenario 1a	184	55	28	55	73	85	3.5	4.5	5	6
Scenario 1b	184	55	33	63	80	93	9	11	12	13
Scenario 2	184	55	30	58	76	89	5	7	8.5	9.5

Site and Scenario	Turbidity Objective 95th %ile	Turbidity Objective 80th %ile	With Rehandling				Without Rehandling			
			Median	20th % Exceedance	10th % Exceedance	5th % Exceedance	Median	20th % Exceedance	10th % Exceedance	5th % Exceedance
Scenario 3	184	55	4	4.5	5	6	4	4.5	5	6
WBM18 (Middle Western Basin)										
Scenario 1a	184	55	38	51	66	76	9	22	28	32
Scenario 1b	184	55	42	57	69	81	14	23	29	33
Scenario 2	184	55	32	50	65	80	7	10	13	15
Scenario 3	184	55	9	21	28	31	9	21	28	31
WBM19 (Middle Western Basin)										
Scenario 1a	184	55	18	38.5	47.5	54	7.5	15	18	21
Scenario 1b	184	55	19.5	40.5	51	60	10	17	21	22
Scenario 2	184	55	15.5	34	45	52.5	6	11	12	13
Scenario 3	184	55	7	15	18.5	21	7	15	18.5	21
WBM05 (Southern Western Basin)										
Scenario 1a	184	55	3.5	16	24	30	1.5	7	9.5	11
Scenario 1b	184	55	4	17.5	26.5	32	2	8.5	11.5	13
Scenario 2	184	55	3	13.5	21	28	1	5	7	8
Scenario 3	184	55	2	7	9	10.5	2	7	9	10.5
WBM20 (Southern Western Basin)										
Scenario 1a	184	55	4	5.8	8.5	12	1	2.5	3.5	4.5
Scenario 1b	184	55	4.1	6	9	12.5	1	3	4	5.5
Scenario 2	184	55	2.8	5	7.5	10	0.5	1.5	2.5	3.5
Scenario 3	184	55	1.2	2.3	3.1	4	1.2	2.3	3.1	4
Main Channel										
WBM16 (Upper North-western Main Channel)										
Scenario 1a	77	29	22	40	49.5	54	3	5	7	8
Scenario 1b	77	29	30.5	50	58.5	65	11	16	18	21
Scenario 2	77	29	28	45	34	60	7	12	15	17

Site and Scenario	Turbidity Objective 95th %ile	Turbidity Objective 80th %ile	With Rehandling				Without Rehandling			
			Median	20th % Exceedance	10th % Exceedance	5th % Exceedance	Median	20th % Exceedance	10th % Exceedance	5th % Exceedance
Scenario 3	77	29	4	5	6	8	4	5	6	8
WBM06 (Upper North-eastern Main Channel)										
Scenario 1a	77	29	16	22.5	24	26.5	12	16	17	18
Scenario 1b	77	29	22.5	20	33.5	37	17	23	26	28
Scenario 2	77	29	14.5	17.5	19.5	20.5	8	12	13	13.5
Scenario 3	77	29	2.5	4	5	5.5	2.5	4	5	5.5
WBM21 (Middle North-western Main Channel)										
Scenario 1a	77	29	45	123	174	222	4.5	6	7	8.5
Scenario 1b	77	29	50	127	178	224	11	12.5	13	14
Scenario 2	77	29	48	125	176	223	8.5	10	12	13
Scenario 3	77	29	5	5	5	6	5	5	5	6
WBM23 (Middle North-eastern Main Channel)										
Scenario 1a	77	29	16	19	21.5	27.7	9	13	14	16
Scenario 1b	77	29	23.5	27.5	31.5	27.7	15	20	23	26
Scenario 2	77	29	16.2	19.4	21.7	34	10	12	13	14.5
Scenario 3	77	29	3	3.5	4	4.4	3	3.5	4	4.4
WBM22 (Lower North-western Main Channel)										
Scenario 1a	77	29	29	65	85	98	5	7.5	9	9.5
Scenario 1b	77	29	32	70	90	100	10	12.5	13.5	14.5
Scenario 2	77	29	31	69	88	100	9	11.5	12.5	13.5
Scenario 3	77	29	2	2.5	3	3.5	2	2.5	3	3.5
WBM07 (Lower North-western Main Channel)										
Scenario 1a	77	29	20	22	25	28	7	10	12	15
Scenario 1b	77	29	30	65	82	107	22	47	72	91
Scenario 2	77	29	25	33	46	53	10	24	34	43
Scenario 3	77	29	5	7	9	11	5	7	9	11

Site and Scenario	Turbidity Objective 95th %ile	Turbidity Objective 80th %ile	With Rehandling				Without Rehandling			
			Median	20th % Exceedance	10th % Exceedance	5th % Exceedance	Median	20th % Exceedance	10th % Exceedance	5th % Exceedance
WBM24 (Lower North-eastern Main Channel)										
Scenario 1a	77	29	19.8	22.4	24	25.5	13	17	18	19
Scenario 1b	77	29	24	30.5	34	36.5	17.5	23	26	28
Scenario 2	77	29	16.1	20	22.2	22.5	10	13	14	14.5
Scenario 3	77	29	3	5	6	6.5	3	5	6	6.5
WBM08 (Upper Middle Main Channel)										
Scenario 1a	77	29	20	22	24	25	10	13	15	17
Scenario 1b	77	29	24	38	50	56	17	25	33	40
Scenario 2	77	29	27	53	76	103	17	40	70	95
Scenario 3	77	29	5	6	7	9	5	6	7	9
WBM26 (Lower Middle Main Channel)										
Scenario 1a	77	29	18	21.5	25	28	12	17	21	24
Scenario 1b	77	29	13.5	27.5	32	35.5	12	19	22	25
Scenario 2	77	29	17	28	34	37.5	13	20	25	28
Scenario 3	77	29	2.6	3.8	4	4.4	2.6	3.8	4	4.4
WBM10 (Upper Lower Main Channel)										
Scenario 1a	77	29	15.5	20.5	23.5	31.5	12	16	22	26
Scenario 1b	77	29	7.5	17.5	23.5	27	7	13	15	17
Scenario 2	77	29	9.5	17.5	22	24.5	5	13	16	18
Scenario 3	77	29	2	2.5	3	3.5	2	2.5	3	3.5
WBM28 (Lower Main Channel)										
Scenario 1a	77	29	13.5	16	17	17.5	9	12	13.5	15
Scenario 1b	77	29	5.5	12	17.5	20	4	8.5	12	13
Scenario 2	77	29	7	14.5	18	18	5.5	10.5	12	13
Scenario 3	77	29	1	2	2.2	2.3	1	2	2.2	2.3

Site and Scenario	Turbidity Objective 95th %ile	Turbidity Objective 80th %ile	With Rehandling				Without Rehandling			
			Median	20th % Exceedance	10th % Exceedance	5th % Exceedance	Median	20th % Exceedance	10th % Exceedance	5th % Exceedance
Wiggins Island Region										
WBM09 (Wiggins Island)										
Scenario 1a	302	59	5	12	14	16	2.5	6	7.5	9
Scenario 1b	302	59	6.5	15	17.5	18.5	4	9	11	12
Scenario 2	302	59	6	14	16.5	17.5	3.5	8.5	10	11
Scenario 3	302	59	1	2	2.5	2.5	1	2	2.5	2.5
WBM25 (North of Wiggins Island)										
Scenario 1a	302	59	9	13.8	15.5	16.2	4.5	7	8.5	9
Scenario 1b	302	59	11.8	17	19	21	7	10	12	13
Scenario 2	302	59	11.8	16.8	18.4	19.9	7	10	12	13
Scenario 3	302	59	1.5	2	2.2	2.4	1.5	2	2.2	2.4
Eastern Port Curtis Region										
WBM13 (Western Eastern Port Curtis)										
Scenario 1a	77	29	10.5	17	18	18.5	8.5	12	13.5	14.5
Scenario 1b	77	29	7.7	17	19	21	6	12.5	14	15.5
Scenario 2	77	29	7.2	12.7	15	16.8	5.5	9	10	11
Scenario 3	77	29	3.5	4.8	6	7	3.5	4.8	6	7
WBM27 (Western Middle Eastern Port Curtis)										
Scenario 1a	77	29	4.7	6.2	7.1	7.6	3.5	5.5	6	6.5
Scenario 1b	77	29	2.5	3.5	4	4.4	1.5	2.5	2.8	3.1
Scenario 2	77	29	2.8	3.9	4.2	4.6	2	2.8	3.1	3.3
Scenario 3	77	29	0.75	1	1.5	1.9	0.75	1	1.5	1.9
WBM11 (Eastern Middle Eastern Port Curtis)										
Scenario 1a	77	29	1.15	1.8	2.35	2.7	1	1.5	1.8	2.3
Scenario 1b	77	29	0.6	1.05	1.4	1.55	0.4	0.7	0.9	1.1

Site and Scenario	Turbidity Objective 95th %ile	Turbidity Objective 80th %ile	With Rehandling				Without Rehandling			
			Median	20th % Exceedance	10th % Exceedance	5th % Exceedance	Median	20th % Exceedance	10th % Exceedance	5th % Exceedance
Scenario 2	77	29	0.7	1.15	1.5	1.7	0.5	0.8	1.1	1.2
Scenario 3	77	29	0.15	0.25	0.3	0.35	0.15	0.25	0.3	0.35
WBM12 (Eastern Eastern Port Curtis)										
Scenario 1a	77	29	0.22	0.48	0.66	0.88	0.2	0.4	0.55	0.7
Scenario 1b	77	29	0.12	0.26	0.37	0.48	0.1	0.2	0.25	0.3
Scenario 2	77	29	0.13	0.29	0.41	0.52	0.1	0.2	0.3	0.35
Scenario 3	77	29	0.02	0.06	0.08	0.11	0.02	0.06	0.08	0.11

Note: Grey and pink shading denotes exceedance of the 80th and 95th percentile dredge plume TSS objectives, respectively.

From Table 1-2, it is clear that generally Scenarios 1a, 1b and 2 (inclusive of TSHD dredging operations) result in elevated levels of TSS relative to Scenario 3. Further, it is quite clear that for dredging without rehandling, there is a significant decrease in TSS levels at many locations.

In Table 1-3 the average dredge plume TSS concentrations of Scenarios 1A, 1B and 1C with and without rehandling from Table 1-2 are reported, allowing greater ease of comparison. Typically, the median value during dredging should be compared to the 80th percentile prior to dredging, in order to determine if WQOs are likely to be met.

Several clear patterns emerge from this comparison, which include:

- For the rehandling scenarios, the median dredge plume TSS does not increase over the 80th percentile TSS objective at any location other than stations 07, 16, 21 and 22.
- For the non-rehandling scenarios:
  - There is a marked decrease in TSS levels relative to the rehandling scenario, particularly the Narrows, Western Basin and much of the Main Channel.
  - The average of the median TSS of dredge plume material from Scenarios 1A, 1B and 2 without rehandling does not exceed the 95th percentile TSS objective at any locations.
  - The average of the median TSS of dredge plume material from Scenarios 1A, 1B and 2 without rehandling just exceeds the 80th percentile TSS objective at only 1 location in the Main Channel (WBM07).

Table 1-3 Comparison of 50th, 20th, 10th and 5th probability exceedance of TSS at each of the time series points for the average of scenarios 1A, 1B and 2

Site	Turbidity Objectives 95th%ile	Turbidity Objectives 80th %ile	With Rehandling				Without Rehandling			
			Median	20th % Exceedance	10th % Exceedance	5th % Exceedance	Median	20th % Exceedance	10th % Exceedance	5th % Exceedance
The Narrows										
WBM01 (Upper Narrows)	77	29	6	15	21	25	2	6	10	13
WBM02 (Upper Narrows)	77	29	4	10	16	20	2	4	6	9
WBM03 (Lower Narrows)	77	29	19	30	36	40	6	14	18	22
WBM14 (Middle Narrows)	77	29	9	20	26	30	4	10	15	17
WBM15 (Lower Graham Creek)	77	29	8	17	19	20	5	10	13	14
Western Basin										
WBM17 (North Western Basin)	184	55	19	34	40	45	5	8	10	11
WBM04 (Middle Western Basin)	184	55	30	59	76	89	6	8	9	10
WBM18 (Middle Western Basin)	184	55	37	53	67	79	10	18	23	27
WBM19 (Middle Western Basin)	184	55	18	38	48	56	8	14	17	19
WBM05 (Southern Western Basin)	184	55	4	16	24	30	2	7	9	11
WBM20 (Southern Western Basin)	184	55	4	6	8	12	1	2	3	5
Channel Areas										
WBM16 (Upper North-western Main Channel)	77	29	27	45	47	60	7	11	13	15
WBM06 (Upper North-eastern Main Channel)	77	29	18	20	26	28	12	17	19	20
WBM21 (Middle North-western Main Channel)	77	29	48	125	176	223	8	10	11	12
WBM23 (Middle North-eastern Main Channel)	77	29	19	22	25	30	11	15	17	19

Site	Turbidity Objectives 95th%ile	Turbidity Objectives 80th %ile	With Rehandling				Without Rehandling			
			Median	20th % Exceedance	10th % Exceedance	5th % Exceedance	Median	20th % Exceedance	10th % Exceedance	5th % Exceedance
WBM22 (Lower North-western Main Channel)	77	29	31	68	88	99	8	11	12	13
WBM07 (Lower North-western Main Channel)	77	29	25	40	51	63	13	27	39	50
WBM24 (Lower North-eastern Main Channel)	77	29	20	24	27	28	14	18	19	21
WBM08 (Upper Middle Main Channel)	77	29	24	38	50	61	15	26	39	51
WBM26 (Lower Middle Main Channel)	77	29	16	26	30	34	12	19	23	26
WBM10 (Upper Lower Main Channel)	77	29	11	19	23	28	8	14	18	20
WBM28 (Lower Main Channel)	77	29	9	14	18	19	6	10	13	14
Wiggins Island										
WBM09 (Wiggins Island)	302	59	6	14	16	17	3	8	10	11
WBM25 (North of Wiggins Island)	302	59	11	16	18	19	6	9	11	12
Eastern Port Curtis										
WBM13 (Western Eastern Port Curtis)	77	29	8	16	17	19	7	11	13	14
WBM27 (Western Middle Eastern Port Curtis)	77	29	3	5	5	6	2	4	4	4
WBM11 (Eastern Middle Eastern Port Curtis)	77	29	1	1	2	2	1	1	1	2
WBM12 (Eastern Eastern Port Curtis)	77	29	0	0	0	1	0	0	0	0

Note: Grey and pink shading denotes exceedance of the 80th and 95th percentile dredge plume TSS objectives, respectively.

It is important to note that as additional data is collected, with site specific targeting of seagrass areas in particular, the value of some of the water quality objectives may also change.

2. Light Impacts

Updates to potential impacts of dredging works on the light climate are provided next. The specific attenuation coefficient of TSS was estimated through comparisons with measured PAR near the seabed by the loggers at locations 1, 2 and 4 with a background turbidity of 5 NTU (5.6 mg TSS L^{-1}). These values yield a specific attenuation coefficient of roughly 0.15 m^{-1} (mg TSS L^{-1})$^{-1}$. Estimates here also assumed a median chlorophyll a level of 1 ug chla L^{-1} with a specific attenuation coefficient of 0.02 m^{-1} (mg chla L^{-1}).

The relative percent of incident PAR at the seabed was estimated with the following assumptions:

- Characteristic or 'representative' tidal cycles for the Project Area can be estimated as the 5th, 25th, 50th, 75th and 95th percentile tide predictions over a 12 hour cycle;
- Specific attenuation coefficients of 0.15 m^{-1} (mg TSS L^{-1})$^{-1}$ and 0.02 m^{-1} (mg chla L^{-1}) for TSS and chla, respectively;
- Seagrass beds at elevations of -1, -1.5 and -2 m relative to mean sea level; and
- A background turbidity of 9 NTU (15.6 mg TSS L^{-1}) was assumed that is typical for shallow waters as this assessment primarily focuses on the impact to benthic primary producer habitat (BPPH) that is typified by shallow waters. However, the dredge plume TSS applied is that at each time series point where it is assumed that concentration is representative of nearby shallow BPPH.

TSS at each site was assumed to be the average of the median simulated dredge plume TSS for each of Scenarios 1a, 1b and 2. This was added to the background TSS to assess light climate impacts at each of the time series locations with (Table 2-1) and without (Table 2-2) rehandling.

With the dredging program expected to occur over several years, the following assumptions were made to provide an integrated light climate impact assessment over this time scale:

- The range of tidal cycles and water depths are evenly distributed across dredging years in terms of high insolation periods (e.g. several hours either side on solar noon);
- No differences in background TSS between spring and neap tides; and
- The median dredge plume TSS is a reasonable approximation of the long-term particle climate that is added to the background levels for impact assessment over annual time scales.

An annual light climate impact assessment on the basis of representative astronomical tides, high incident PAR of 1800 uE/m^2/s and a mean water depths of 1, 1.5 and 2 m with (Table 2-1) and without (Table 2-2) rehandling can be summarised as:

- For rehandling scenarios:
  - For a 1 m water depth relative percentage of incident PAR is generally in the range of 10-30% decrease over current conditions;
  - For a 1.5 m water depth relative percentage of incident PAR is generally in the range of 30-50% decrease over current conditions; and

- For a 2 m water depth relative percentage of incident PAR is generally in the range of 60-90% decrease over current conditions.

- For no rehandling scenarios there is considerably lower effects on the light climate relative to rehandling, namely:
  - For a 1 m water depth relative percentage of incident PAR is generally in the range of 5-20% decrease over current conditions;
  - For a 1.5 m water depth relative percentage of incident PAR is generally in the range of 20-40% decrease over current conditions; and
  - For a 2 m water depth relative percentage of incident PAR is generally in the range of 50-70% decrease over current conditions.

Table 2-1 Overall light climate impact assessment with rehandling

	% of Incident PAR at Seabed			% Change of Incident PAR relative to Background		
Depth (m)	**1 m**	**1.5 m**	**2 m**	**1 m**	**1.5 m**	**2 m**
Background	**30.0%**	**15.2%**	**5.3%**			
WBM01 (Upper Narrows)	26.2%	11.7%	2.9%	13%	23%	45%
WBM02 (Upper Narrows)	27.5%	12.8%	3.7%	9%	16%	31%
WBM03 (Lower Narrows)	22.1%	8.3%	1.2%	26%	45%	78%
WBM14 (Middle Narrows)	24.8%	10.5%	2.2%	17%	31%	58%
WBM15 (Lower Graham Creek)	25.2%	10.8%	2.4%	16%	29%	54%
WBM17 (North Western Basin)	22.1%	8.3%	1.1%	27%	46%	79%
WBM04 (Middle Western Basin)	20.4%	7.1%	0.7%	32%	53%	88%
WBM18 (Middle Western Basin)	19.7%	6.7%	0.5%	34%	56%	90%
WBM19 (Middle Western Basin)	22.4%	8.5%	1.2%	25%	44%	77%
WBM05 (Southern Western Basin)	27.5%	12.8%	3.7%	9%	16%	31%
WBM20 (Southern Western Basin)	27.4%	12.7%	3.6%	9%	16%	32%
WBM16 (Upper Northwestern Main Channel)	20.8%	7.4%	0.8%	31%	51%	86%
WBM06 (Upper Northeastern Main Channel)	22.4%	8.5%	1.2%	25%	44%	77%
WBM21 (Middle Northwestern Main Channel)	18.9%	6.3%	0.4%	37%	59%	93%
WBM23 (Middle Northeastern Main Channel)	22.2%	8.4%	1.2%	26%	45%	78%
WBM22 (Lower Northwestern Main Channel)	20.3%	7.1%	0.7%	32%	53%	88%

	% of Incident PAR at Seabed			% Change of Incident PAR relative to Background		
Depth (m)	**1 m**	**1.5 m**	**2 m**	**1 m**	**1.5 m**	**2 m**
WBM07 (Lower Northwestern Main Channel)	21.1%	7.6%	0.8%	30%	50%	84%
WBM24 (Lower Northeastern Main Channel)	21.9%	8.2%	1.1%	27%	46%	80%
WBM08 (Upper Middle Main Channel)	21.3%	7.7%	0.9%	29%	49%	83%
WBM26 (Lower Middle Main Channel)	22.8%	8.8%	1.4%	24%	42%	74%
WBM10 (Upper Lower Main Channel)	24.2%	9.9%	2.0%	19%	34%	63%
WBM28 (Lower Main Channel)	25.0%	10.6%	2.3%	17%	30%	57%
WBM09 (Wiggins Island)	26.2%	11.7%	2.9%	13%	23%	45%
WBM25 (North of Wiggins Island)	24.2%	9.9%	1.9%	19%	35%	64%
WBM13 (Western Eastern Port Curtis)	25.0%	10.7%	2.3%	17%	30%	56%
WBM27 (Western Middle Eastern Port Curtis)	27.6%	12.9%	3.7%	8%	15%	30%
WBM11 (Eastern Middle Eastern Port Curtis)	29.3%	14.5%	4.9%	2%	4%	9%
WBM12 (Eastern Eastern Port Curtis)	29.9%	15.1%	5.2%	0%	1%	2%

Table 2-2 Overall light climate impact assessment without rehandling

	% of Incident PAR at Seabed			% Change of Incident PAR relative to Background		
Depth (m)	**1 m**	**1.5 m**	**2 m**	**1 m**	**1.5 m**	**2 m**
Background	**30.0%**	**15.2%**	**5.3%**			
WBM01 (Upper Narrows)	28.3%	13.6%	4.2%	6%	11%	21%
WBM02 (Upper Narrows)	28.8%	14.0%	4.5%	4%	8%	15%
WBM03 (Lower Narrows)	26.0%	11.5%	2.8%	14%	25%	47%
WBM14 (Middle Narrows)	27.0%	12.4%	3.4%	10%	19%	37%
WBM15 (Lower Graham Creek)	26.8%	12.2%	3.3%	11%	20%	39%
WBM17 (North Western Basin)	26.9%	12.3%	3.3%	10%	19%	38%
WBM04 (Middle Western Basin)	26.2%	11.7%	2.9%	13%	23%	45%
WBM18 (Middle Western Basin)	24.5%	10.2%	2.1%	18%	33%	61%
WBM19 (Middle Western Basin)	25.3%	10.9%	2.5%	16%	28%	54%

	% of Incident PAR at Seabed			% Change of Incident PAR relative to Background		
Depth (m)	1 m	1.5 m	2 m	1 m	1.5 m	2 m
WBM05 (Southern Western Basin)	28.8%	14.0%	4.5%	4%	8%	15%
WBM20 (Southern Western Basin)	29.3%	14.5%	4.9%	2%	4%	9%
WBM16 (Upper North-western Main Channel)	25.7%	11.2%	2.7%	15%	26%	50%
WBM06 (Upper North-eastern Main Channel)	23.7%	9.6%	1.7%	21%	37%	67%
WBM21 (Middle North-western Main Channel)	25.2%	10.8%	2.4%	16%	29%	54%
WBM23 (Middle North-eastern Main Channel)	24.0%	9.8%	1.9%	20%	35%	65%
WBM22 (Lower North-western Main Channel)	25.2%	10.8%	2.4%	16%	29%	54%
WBM07 (Lower North-western Main Channel)	23.5%	9.4%	1.7%	22%	38%	69%
WBM24 (Lower North-eastern Main Channel)	23.4%	9.3%	1.6%	22%	39%	70%
WBM08 (Upper Middle Main Channel)	23.1%	9.1%	1.5%	23%	40%	72%
WBM26 (Lower Middle Main Channel)	23.7%	9.6%	1.7%	21%	37%	67%
WBM10 (Upper Lower Main Channel)	25.2%	10.8%	2.4%	16%	29%	54%
WBM28 (Lower Main Channel)	26.0%	11.5%	2.9%	13%	24%	47%
WBM09 (Wiggins Island)	27.6%	12.9%	3.7%	8%	15%	30%
WBM25 (North of Wiggins Island)	26.0%	11.5%	2.9%	13%	24%	47%
WBM13 (Western Eastern Port Curtis)	25.8%	11.3%	2.7%	14%	25%	49%
WBM27 (Western Middle Eastern Port Curtis)	28.2%	13.5%	4.1%	6%	11%	23%
WBM11 (Eastern Middle Eastern Port Curtis)	29.5%	14.7%	5.0%	2%	3%	7%
WBM12 (Eastern Eastern Port Curtis)	29.9%	15.1%	5.3%	0%	1%	2%