Gladstone Conservation Council Inc.

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14th October 2014

Input into TACC

To: Gordon Dwane
Gladstone Ports Corporation

Gordon,

Can I firstly apologise for the delay, I fully intended providing a fuller submission but have not been able to find the time.

Metals in sediment

At the first TACC meeting I attended, I made comment about the risk of oversimplification of the character of sediments being moved around in the harbour particularly as it seems we have committed to ongoing disturbance of increasingly larger quantities of harbour sediments under the heading of “maintenance” dredging.

It stems from the fact that all sediment in the harbour contains appreciable levels of sulphides and the negligent attitude that this represents no risk when the concentrations are below an assumed threshold where the natural buffering capacity of the seawater prevents this from becoming “acidic”.

Where I intended to provide a more detailed expose of sediment metals contents, I now just provide a couple of tables from the WBDDP EIS. Almost every sample taken had detectable to serious levels of Arsenic, Chromium, Cobalt, Copper, Lead, Nickel and Vanadium. Its pervasiveness evidenced by the high proportion of “Number of Detects”.

Table 10 Statistical Summary and Compliance of 95% UCL to NAGD (2009) Screening Levels for Metals and Metalloids in Stage 1A

Compound	Aluminium	Antimony	Arsenic	Cadmium	Chromium (III+VI)	Cobalt	Copper	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Silver	Vanadium	Zinc
Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
LOR	50	0.5	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.01	0.1	0.1	0.1	0.16	0.1
Draft - Contam Land Qld - EIL		20	20	3			60		300	500	1	60				200
NAGD - Screening Levels		2	20	1.5	80		65		50		0.15	21		1		200
NAGD - Sediment quality high values		25	70	10	370		270		220		1	52		3.7		410
Statistical Summary (all depths)																
Number of Results	396	396	396	396	396	396	396	396	396	396	396	396	396	396	396	396
Number of Detects	396	0	366	5	396	395	396	396	387	394	124	388	350	5	394	395
Minimum Concentration	910	<0.5	<1	<0.1	1.1	<0.5	1.2	560	<1	<10	<0.01	<1	<0.1	<0.1	<2	<1
Minimum Detect	910	ND	1.08	0.1	1.1	0.6	1.2	560	1	11	0.01	1.3	0.1	0.1	6.2	2
Maximum Concentration	16900	<0.5	28.3	0.3	33.1	46.6	53.6	75500	43	5780	0.08	30.5	2	0.6	224	80.2
Maximum Detect	16900	ND	28.3	0.3	33.1	46.6	53.6	75500	43	5780	0.08	30.5	2	0.6	224	80.2
Average Concentration	6504	0.25	8.8	0.052	13	9.8	14	17111	4.9	447	0.0096	7.7	0.38	0.053	44	21
Geometric Average	26	0.25	6.1	0.051	12	8.3	11	12	4	7.2	0.047	6.7	0.29	0.051	6.5	19
Median Concentration	5805	0.25	7.865	0.05	12.5	9.55	10	16000	4.4	309.5	0.005	7.3	0.3	0.05	39.95	19
Standard Deviation	3715	0	6.1	0.017	5.5	5.6	9.8	8830	3.2	502	0.01	3.9	0.28	0.031	24	12
Geometric Standard Deviation	1.9		2.8	1.2	1.6	1.9	1.9	1.8	1.9	3.2	1.9	1.8	2.4	1.2	1.7	1.8
Number of Guideline Exceedances	0	0	20	0	0	0	0	0	0	127	0	3	0	0	0	0
95% Upper Confidence Limit	7318		10.83		13.43	11.04	15.88	19045	5.217	487.6		8.174	0.491		46.39	22.51
Distribution[8]	NP		NP		Gamma	NP	NP	NP	Gamma	Gamma		Gamma	NP		Normal	Normal

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It is not a one of for example limited to Stage 1A dredging but is also seen in the sediment characterisation of Stage 1B sediment.

Table 14 Statistical Summary and Compliance of 95% UCL to NAGD (2009) Screening Levels for Metals and Metalloids in Stage 1B

Compound	Aluminium	Antimony	Arsenic	Cadmium	Chromium (III+VI)	Cobalt	Copper	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Silver	Vanadium	Zinc
Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
LOR	50	0.5	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.01	0.1	0.1	0.1	0.16	0.1
Draft - Contam Land Qld - EIL		20	20	3			60		300	500	1	60				200
NAGD - Screening Levels		2	20	1.5	80		65		50		0.15	21		1		200
NAGD - Sediment quality high values		25	70	10	370		270		220		1	52		3.7		410
Statistical Summary (all depths)																
Number of Results	196	208	208	208	208	196	208	196	208	208	208	208	196	196	196	208
Number of Detects	196	0	200	4	208	196	206	196	193	208	115	207	180	3	196	208
Minimum Concentration	1270	<0.5	<1	<0.1	3.5	0.8	2	1960	<1	14	<0.01	1.3	<0.1	<0.1	7.1	4.9
Minimum Detect	1270	ND	1.18	0.2	3.5	0.8	2	1960	1.2	14	0.01	1.3	0.1	0.1	7.1	4.9
Maximum Concentration	20600	<2	32.4	2.4	31	77.4	54.4	58300	20.1	7680	<0.1	40	5.4	0.4	126	87.5
Maximum Detect	20600	ND	32.4	2.4	31	77.4	54.4	58300	20.1	7680	0.08	40	5.4	0.4	126	87.5
Average Concentration	10012	0.29	9.4	0.095	17	13	18	24484	6.9	408	0.017	11	0.59	0.052	48	32
Geometric Average	218	0.27	7.1	0.06	15	11	15	573	5.7	248	0.012	9.1	0.41	0.051	43	27
Median Concentration	9755	0.25	9	0.05	18.4	13	18.05	26050	6.8	302.5	0.01	10.6	0.5	0.05	46.3	35.05
Standard Deviation	5448	0.18	6	0.2	7.2	8.8	10	10288	3.7	685	0.015	6.5	0.65	0.025	22	15
Geometric Standard Deviation	2.1	1.4	2.4	1.9	1.7	2	2	1.8	2	2.7	2.3	1.9	2.5	1.2	1.7	1.9
Number of Guideline Exceedances	0	0	12	1	0	0	0	0	0	39	0	15	0	0	0	0
95% Upper Confidence Limit	11709		11.52		19.65	16.61	21.34	27687	8.406	614.7	0.024	12.87	0.855		54.76	36.41
Distribution[10]	NP		NP		NP	NP	NP	NP	NP	NP	NP	NP	NP		NP	NP

…and throughout the harbour's sediment of the various monitoring stations, as shown in the table below:

Table 2. Concentrations of metals and metalloids in sediments from Port Curtis during February and March 2012. The certificates of analysis that correspond to these results are presented in Appendix 1.

Analyte	Units	LOR	BW1	BW2	SGW4	E1a	E3a	FL	QE3	QE4	ST1	RB1	RB3	STINM	STISM	STI4.8	STI10.9
Aluminium	$mg\ kg^{-1}$	50	16200	19600	3690	4520	15800	16600	9290	6470	2880	4390	3750	6670	2040	16400	10900
Antimony	$mg\ kg^{-1}$	0.5	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Arsenic	$mg\ kg^{-1}$	1	10.9	11.8	24	11.6	13.7	16.4	20.5	12.1	10.3	25.7	13.5	11	12.8	16.8	14.9
Cadmium	$mg\ kg^{-1}$	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	$mg\ kg^{-1}$	1	26.4	29.8	9.9	13.5	24.5	25.7	21.5	10.7	6.9	8.5	7.3	13	5	27.6	17.9
Cobalt	$mg\ kg^{-1}$	0.5	15.2	13.7	6.2	2.6	10.7	12.2	10.1	6.9	9.6	3.9	3.7	6.6	2.9	12.6	9.2
Copper	$mg\ kg^{-1}$	1	21.5	23.3	3	17.2	28.1	23.7	11.7	9.3	5.1	1.8	1.5	7.3	1.9	21.7	13.4
Iron	$mg\ kg^{-1}$	50	30200	33200	13600	16600	27900	29200	32400	15700	13100	18600	11100	15500	8490	30000	23200
Lead	$mg\ kg^{-1}$	1	9.4	10.2	3.1	3.5	9.4	9	6	4.4	2.7	4.1	4.1	4.9	1.6	10.9	7.3
Manganese	$mg\ kg^{-1}$	10	259	225	672	82	492	445	140	373	576	260	88	323	210	233	167
Mercury	$mg\ kg^{-1}$	0.01	0.01	0.02	<0.01	0.01	0.02	0.02	0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01
Nickel	$mg\ kg^{-1}$	1	14.4	16.9	4.1	2.1	12.8	13.4	9.3	5.1	4	2.5	2.5	5.4	2.2	13.8	10
Selenium	$mg\ kg^{-1}$	0.1	0.7	0.7	0.3	0.4	0.9	0.6	0.6	0.6	0.3	0.6	0.3	0.4	0.2	0.9	0.7
Silver	$mg\ kg^{-1}$	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Vanadium	$mg\ kg^{-1}$	2	62.9	70.7	25.5	53.8	56.4	57.6	64.4	28.6	30.6	31.8	20.2	30.3	16.1	67.1	56.6
Zinc	$mg\ kg^{-1}$	1	52.2	45.8	11.8	12.1	42.1	48.8	32	20.2	20.4	9.2	9.6	21.7	9.2	49.3	32.4

Analyte	Units	LOR	STI20.0	B0.0	B5.1	BG10	NGPCDP2	NGPCSW3	SCI	BC	C1.6	C6.4	MM2	AUK0.0	SFI	COI	HHI	FRE0.0
Aluminium	$mg\ kg^{-1}$	50	5010	2270	8560	4350	11600	5140	9020	19300	16100	3640	20200	16800	1920	4150	5010	2880
Antimony	$mg\ kg^{-1}$	0.5	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Arsenic	$mg\ kg^{-1}$	1	9.91	15	10.3	13.4	7.98	10.2	9.88	15.6	9.03	3.45	11.9	13.9	20.2	19.6	10.7	4.04
Cadmium	$mg\ kg^{-1}$	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	$mg\ kg^{-1}$	1	8.7	4.3	16.8	8.9	19.9	11.3	17.1	28.9	24.8	8.5	32	27.4	5.1	9.6	10.8	10.5
Cobalt	$mg\ kg^{-1}$	0.5	4.5	2.8	7	9.1	9.6	6.9	8.1	14	12	5.6	12.6	11.8	4.6	5	3.8	6.6
Copper	$mg\ kg^{-1}$	1	6.3	2.1	7.1	6.3	21.4	9.4	9.2	27.1	25.5	6.3	44.4	20.7	2.2	2.1	2.6	2.2
Iron	$mg\ kg^{-1}$	50	16800	8840	16100	15400	23400	16000	17800	34300	28800	11100	34100	28300	8850	11300	10700	8740
Lead	$mg\ kg^{-1}$	1	3.4	1.9	6.3	3.2	6.6	5.1	6	10.8	9.1	2.1	11.4	9.6	1.6	3.1	4	2.6
Manganese	$mg\ kg^{-1}$	10	375	248	403	589	240	372	280	398	247	309	307	531	630	282	182	766
Mercury	$mg\ kg^{-1}$	0.01	<0.01	1.37	<0.01	<0.01	0.01	<0.01	0.01	0.02	0.02	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01
Nickel	$mg\ kg^{-1}$	1	5.3	2.5	7.2	5	10.3	5.3	7.8	15.4	13.2	3.9	16.6	13.6	2.7	3.5	3.7	10.3
Selenium	$mg\ kg^{-1}$	0.1	0.3	0.2	0.5	0.4	0.5	0.4	0.5	0.8	0.7	0.1	0.8	0.7	0.2	0.3	0.4	0.2
Silver	$mg\ kg^{-1}$	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	<0.1	<0.1	<0.1	<0.1	<0.1
Vanadium	$mg\ kg^{-1}$	2	34.1	15.5	33.5	32.8	52	39.5	31	71	61.9	26.5	63.6	54.3	18.3	25	17.3	14.7
Zinc	$mg\ kg^{-1}$	1	20.6	9.2	24.2	17.2	37.8	30.4	27.8	55.8	53.5	15	78.2	48.4	7.5	8.9	10.7	10.6

The significance of these environmentally dangerous metals has been dismissed as negligible, interpreting the levels as generally low concentrations, typically only a few tens of mg per kg of sediment and a fallacious assumption of non-mobility of the metals in "buffered" seawater conditions.

Sulphides in the environment

The metals correlate with sulphur analyses suggesting they are present as metal sulphide, consistent with the anaerobic bacterial activity in the sediment particularly in mangroves and the sub-surface of the marine flood plains. While it is

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accurate to point out that the presence of the metal sulphides are "natural" and reflect local geology, it is profoundly unnatural for these sulphides to be stirred up and suspended in the water column.
The sulphides are generally sequestered in stable sediment layers whereas mobile/saltating sediment is generally relatively free of sulphides. These biogenic sulphides are amorphous, cryptocrystalline in form and have very high surface area, making for very rapid reaction kinetics when exposed to chemically available oxygen. Even the dissolved oxygen in seawater will react with the metal sulphides, viz:

$$2\ FeS_2 + 9\ O_2 + 4\ H_2O \rightarrow 8\ H^+ + 4\ SO_4^{2-} + 2\ Fe(OH)_3$$

Note the formation of iron hydroxide, but of course all the other metal sulphide variants as clearly demonstrated to present in the harbour's sediment can be substituted. Sea water typically contains 2 moles of dissolved oxygen; all that is required is 0.0064% sulphur as metal sulphide in the sediment to deliver 2 moles of metal into every cubic meter of slurried water. Even at levels well below the buffering capacity of seawater, these metal hydroxides are being generated and will report to the water column as stable colloids. These colloids remain suspended and will not gravity settle they are instead dealt with through biological activity from algae and bacteria such as schewanella implicated in the human health impacts of the dredging observed from Gladstone harbour.

Not all sediment is alike

The relatively stable hydrodynamic conditions in the mangroves and marine flood plains, results in labile metals being sequestered into the sediments. It is this process after all that made it possible for our wonderful reef to exist. In contrast, in the active channels of the estuary, sediments are turned over frequently and are likely to be relatively low in sulphide content. Disturbing clean sediment would be relatively low impact as far as ASS is concerned. The artificial deep shipping channels on the other hand have been carved through historically stable sediment, high in sulphides. Certainly initially, the channels will be lined with high sulphide sediment. Every vessel movement through the channel will resuspend sulphides into the water column. Ultimately the sulphide content is likely to diminish as it is washed out and reacted with chemically available oxygen, but not before the walls of the channel stop slumping fresh sulphide sediment into the channel. This ongoing source of metal hydroxides into the water column will be spiked annually by maintenance dredging.

Skilfulness of experimental design

How these dynamics I describe impact the harbour's ecology are hard to quantify. We have learned that despite investing substantial resources, the authorities failed to make a definitive quantifiable link between ecological effects and dredging activities. Even though spatial and temporal evidence of turbidity plumes and dredging was abundantly clear and the strong correlation between metal levels and observed turbidity. The authorities failed to ascribe a cause to the human health impacts such as Schewanella infections, failed to explain unseasonal toxic algal blooms, failed to explain the pervasive red rashes on the bellies of almost ever fish species during the dredging, failed to identify the cause of turtle morbidity and associated metal toxication present in blood and organ samples of sick turtles. It flags a profound failure of the experimental design.

The skilfulness of an experiment is its ability to tell us more about our subject than we otherwise would have known. We waste out time and money if skilfulness is lacking.

I was asked the question, what I recommend is done to "monitor" the harbour?

My answer is that I am not the right person to give such advice as I am not specialised in this field. Even though I recognise failure of the WBDDP environmental management and monitoring processes to deliver a satisfactory outcome, I was not party to its design or implementation.

There are however some things to avoid and some guiding principles I feel should help.

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1) Leadership – At the height of the ecological distress and the dredging campaign, the GPC leadership were publically and prominently denying the possibility of a causal link. It clearly was pre-emptive. Leadership failed to provide a culture of genuine learning.
2) Independence – The monitoring was carried out by an organisation with clear economic dependence on the proponent. Not to suggest any specific wrongdoing, it stands to reason that they would not want to bite the hand that feeds. The tone of supervisory comment of many of the reports deflect interpretation of causal links of water quality impact with dredging activities while frivolously linking observed variations to rainfall events.
3) Openness – Even though it was a condition of approval, data was denied the public. Reports were delayed and no operational data as to the exact timing of dredging was made available at all. What limited material could be accessed was showing substantial discrepancies. RTI requests for the data were refused, it took more than two years to get incomplete data and what data was provided was clearly incapable of resolving the water quality variation issues. Had the system been more open, the management system may have responded to feedback from the community and avoided such catastrophic failure of its monitoring program. It would be sooo nice if I could walk into a GPC office and converse with technical staff and look at data and share ideas and thoughts about all the material at hand rather than being sent from pillar to post and treated like a mushroom.
4) Inclusiveness – There was a stifling bureaucratic arrogance evident all the way from Mr Beattie's announcement of LNG on world heritage property to the Coordinator General's office gazumping of Curtis Island and its subsequent industrialisation. The profound marginalisation and misrepresentation of community input at all stages of the LNG rape of Curtis Island including the WBDDP was telling. For this I refer you to Risk = Hazard + Outrage http://en.wikipedia.org/wiki/Outrage_factor. I strongly suggest GPC adopt some of Peter Sandman's advice in future programs.

Sincerely,
Jan Arens
President – Gladstone Conservation Council