Remediation Gumbo: Blending Science, Engineering and Construction for Successful Project Delivery

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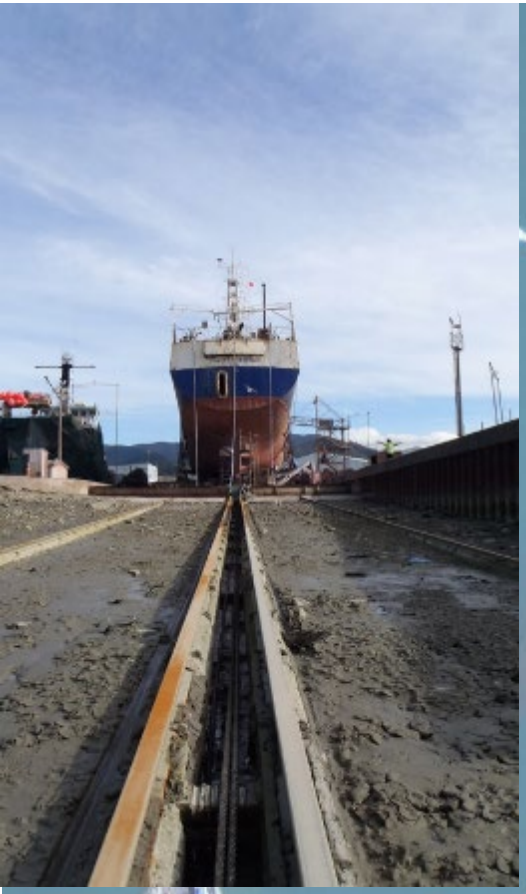
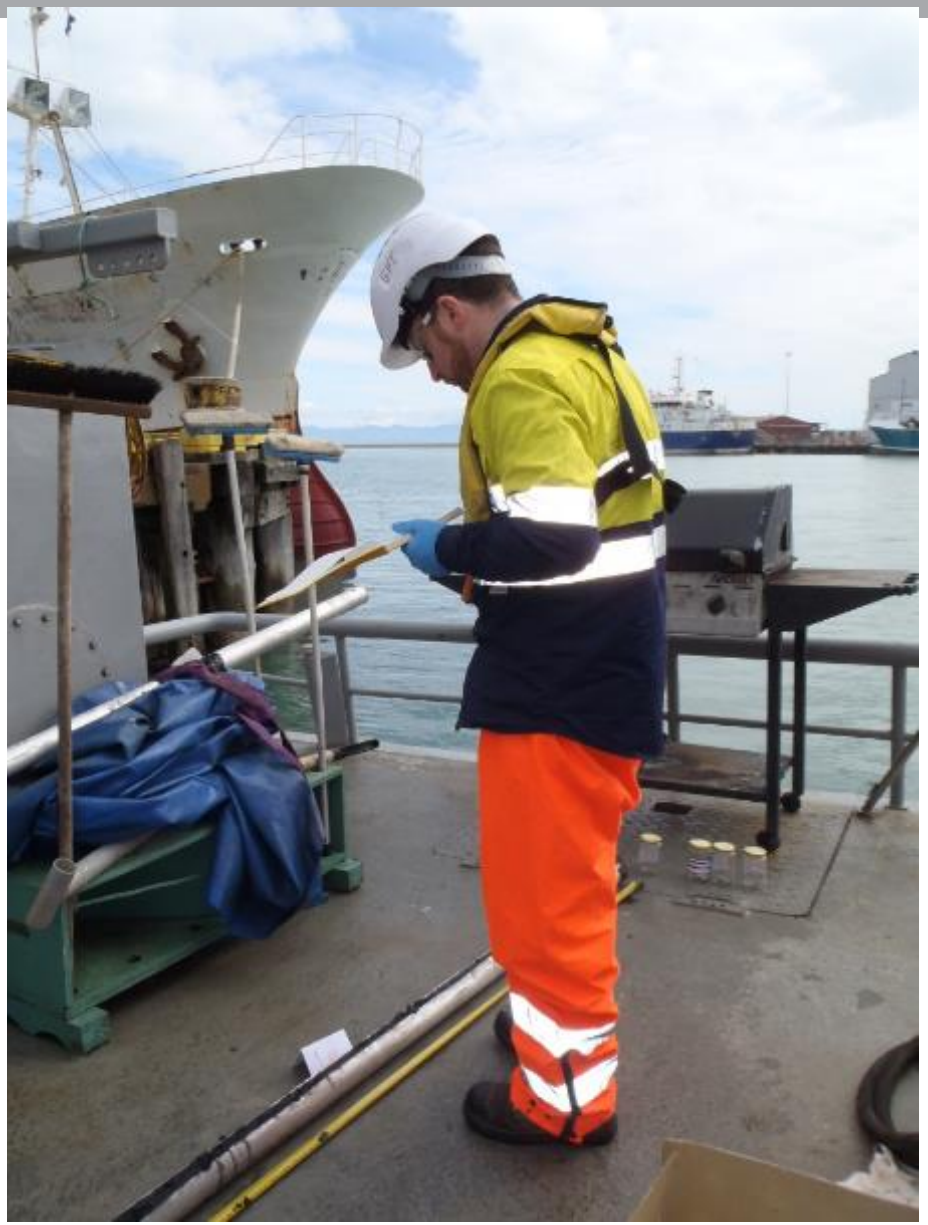
SCIENCE
ENGINEERING

Project Overview: Site Layout / Location



Science: Investigation



Cores

Science: Remedial Option / Approach

- Needed to consider treatment and disposal options separately
- Remedial options study with MCA
- Early and proactive engagement with stakeholders and iwi (Maori)
- Preferred option:
  - Stabilisation with:
    - Cement (≈5% by wet weight)
    - PAC (≈0.3% by wet weight)
  - Reclamation in coastal marine area

….BUT:

Permitting: Achieving the impossible

- **RMA (Sect. 12) states**:
  - *No person may, in the coastal marine area:*
    (a) reclaim …… any foreshore or seabed;

- **New Zealand Coastal Policy Statement (Policy 10) states**:
  - *avoid reclamation unless there are no practicable alternatives*

- **Nelson Resource Management Plan states***:*
  Prohibited activity:
  - *Disposal of toxic materials in the coastal marine area is prohibited*

Tough policy tests!

So, no can do?

Science: Treatability Trials

- Blend performance objectives:
  - Low permeability (reduce leaching potential)
  - Low contaminant leachability
  - Geotechnical engineering performance

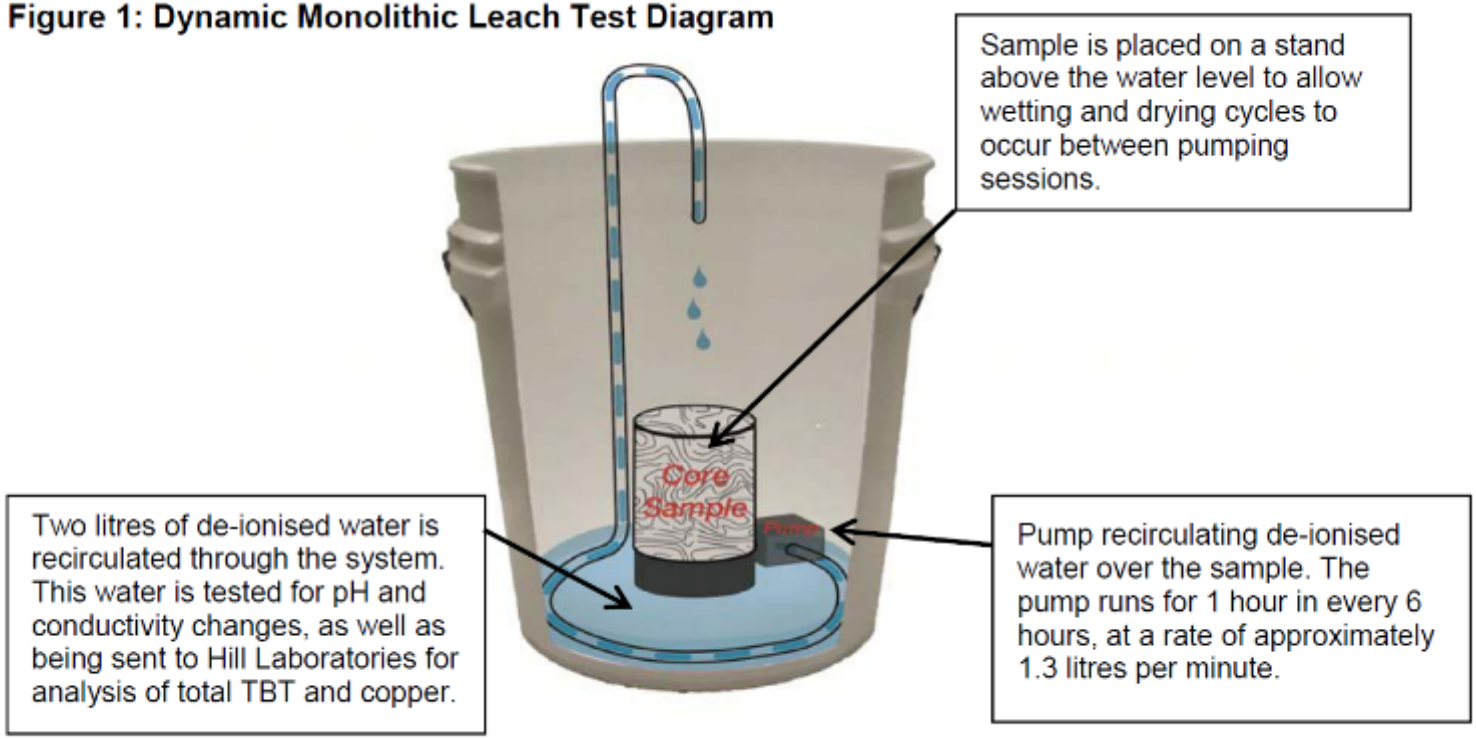
- Bench trials to work out preferred blend (varying blends and mix ratios)
- Cement / PAC blend then optimized to reduce material costs

- Remedial goals for residual sediment contamination:

Contaminant	Target Concentration (mg/kg dry weight)
Copper	270
Tributyltin (TBT)	0.07

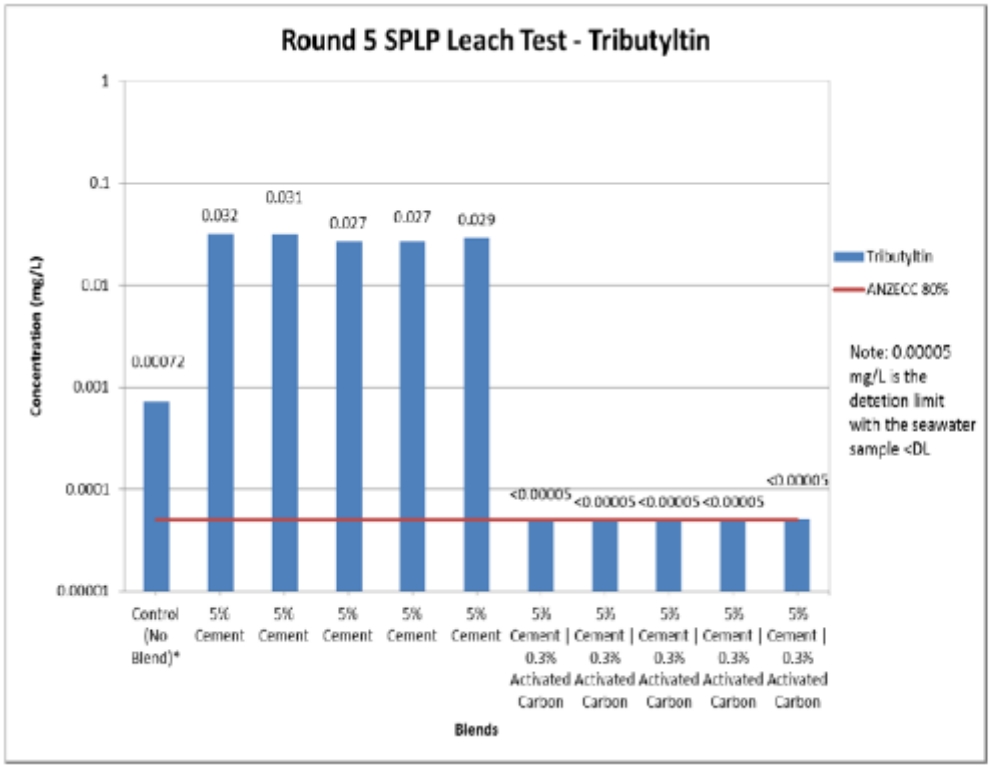
Science: Dynamic Leach tests

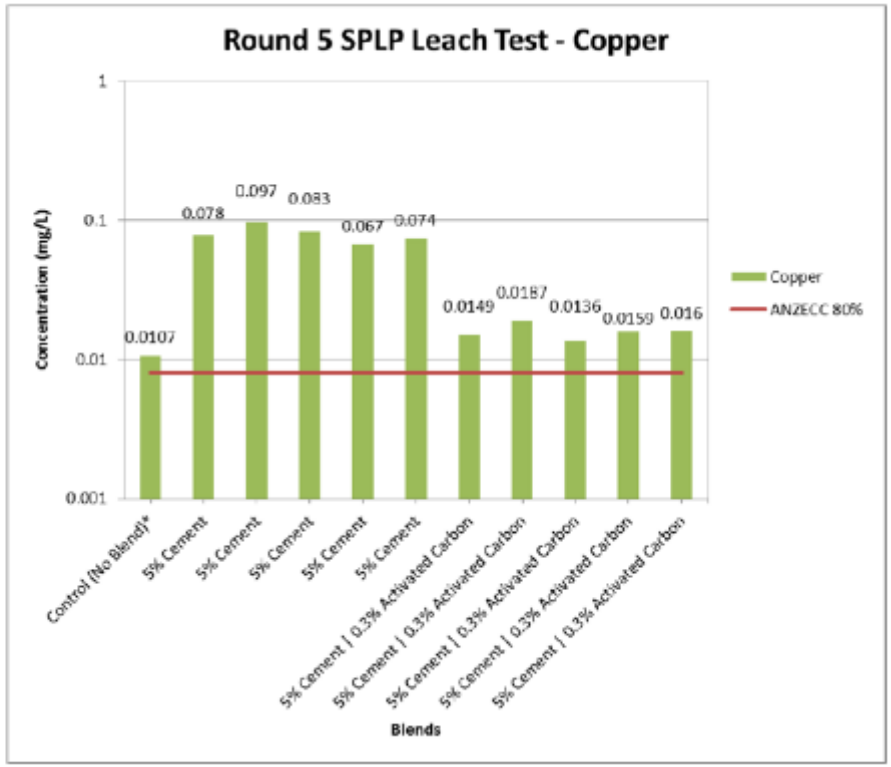
Figure 1: Dynamic Monolithic Leach Test Diagram



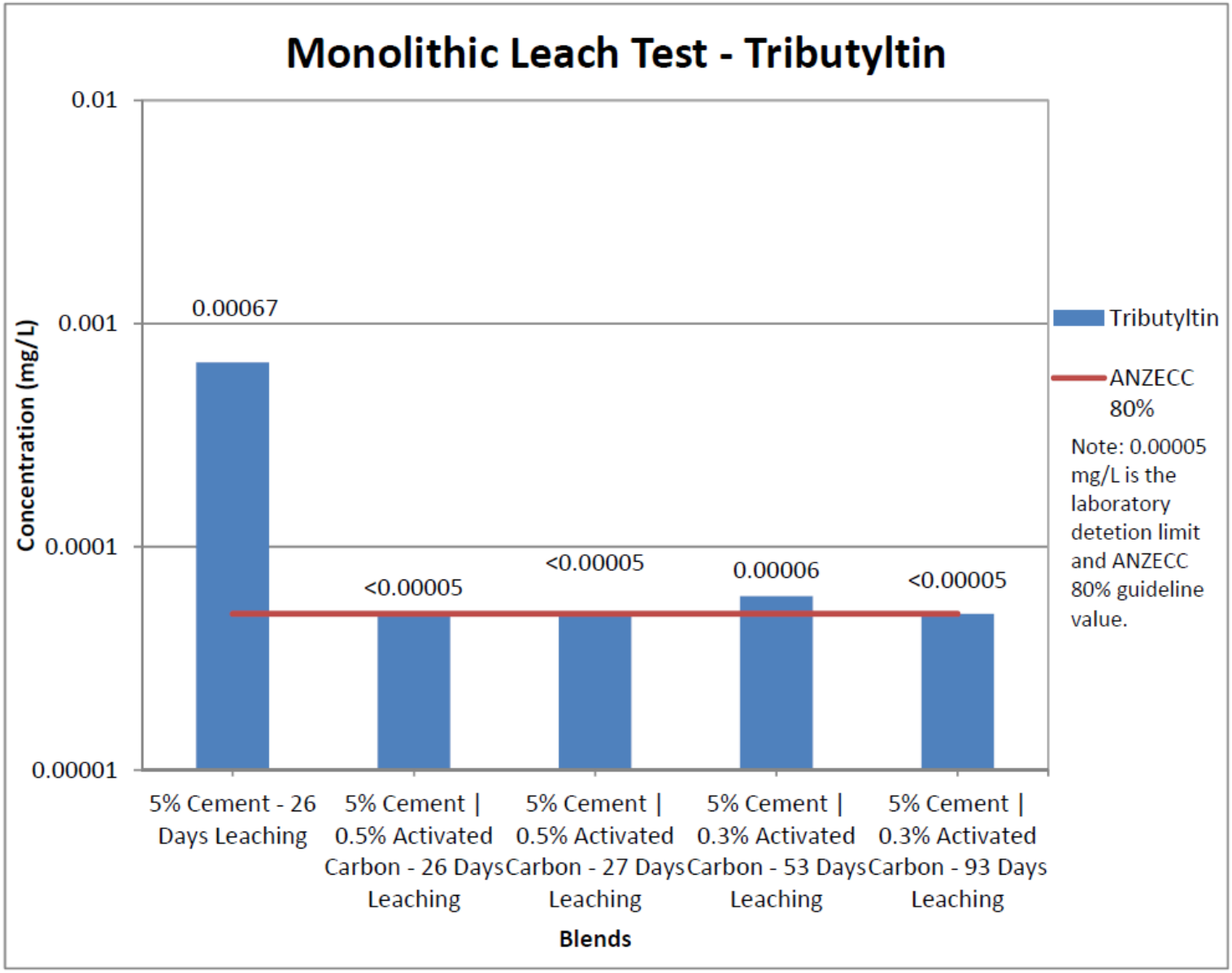
- EPA method 1315: *Mass transfer rates of constituents in monolithic or compacted materials using a semi-dynamic tank leaching procedure, 2013*.

Science: SPLP Tests



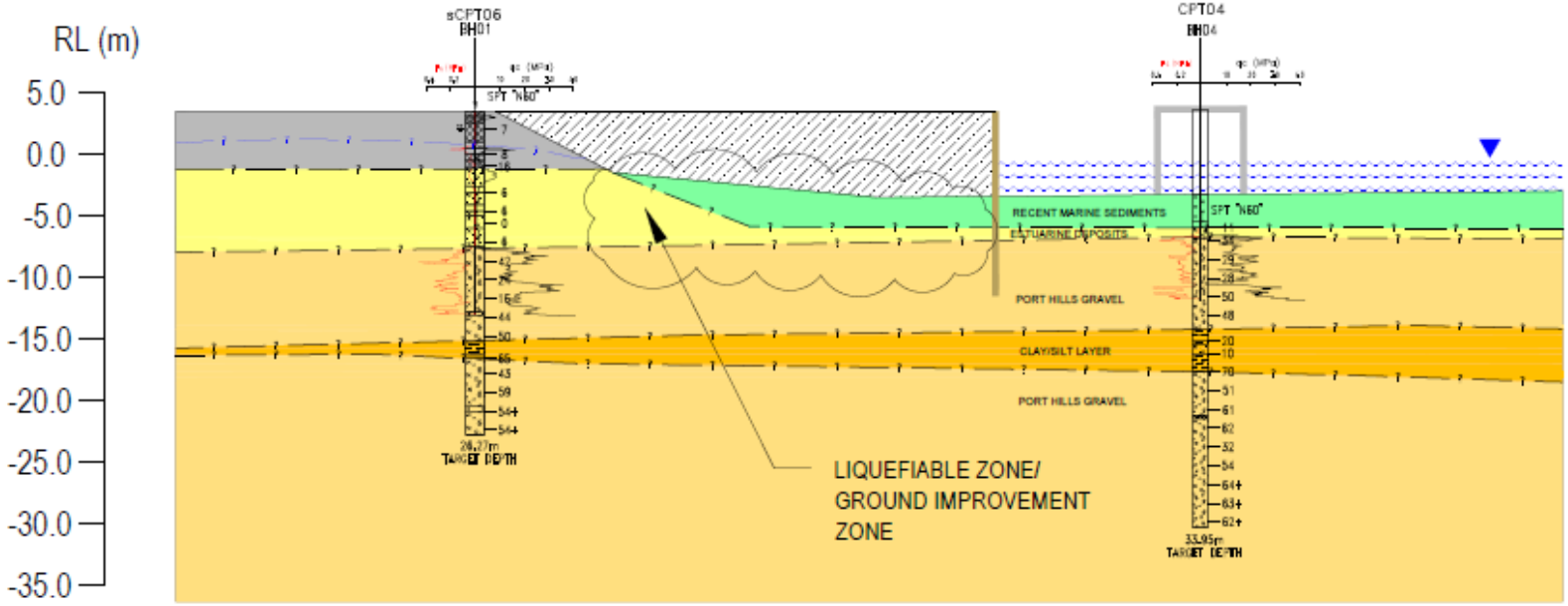


Science: DML Tests



Engineering: Proving blend performance

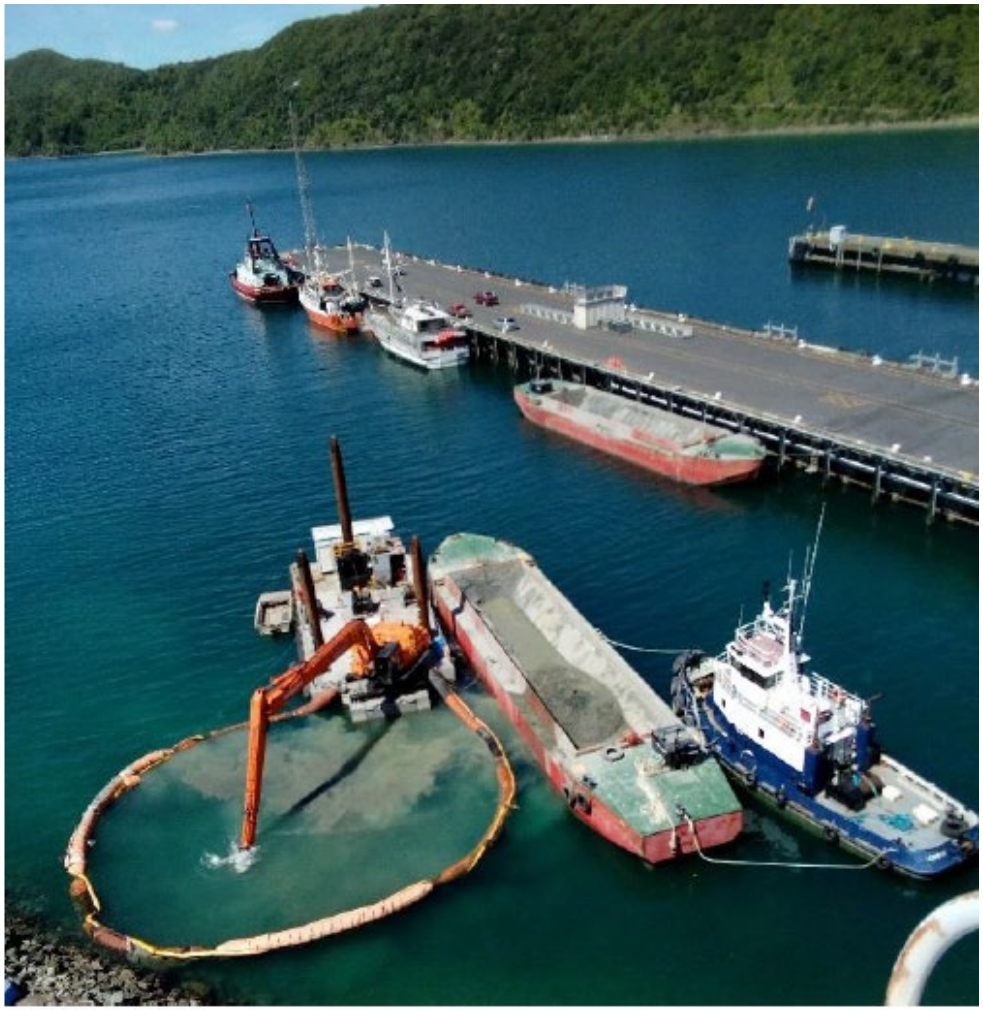
- Hydraulic permeability (triaxial) of the mudcrete 10^{-8} to 10^{-9}
- UCS of upto 350Kpa (28 day)
- Blend tweaked during pilot trial – on mobilisation



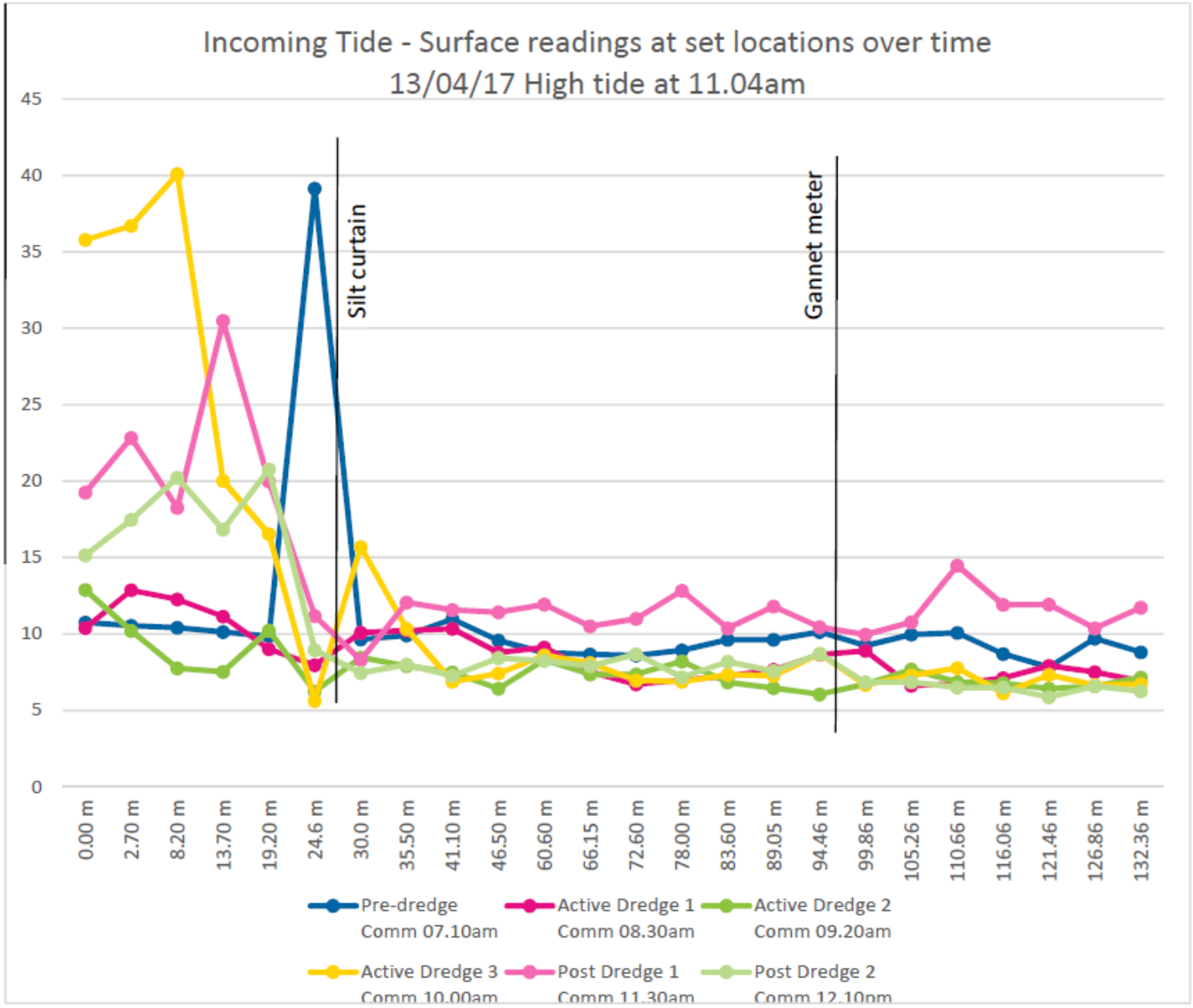
Science: Eluate Eco toxicity

- Algae
- Amphipod
- Bivalves (larvae)
- Freshwater SPLP with brine added
- Mutations still observed >0.0005 mg/L for cement only blends
- Preferred blend showed no deleterious eco tox effects

Science: Supporting permitting process, engineering approach and construction methodology



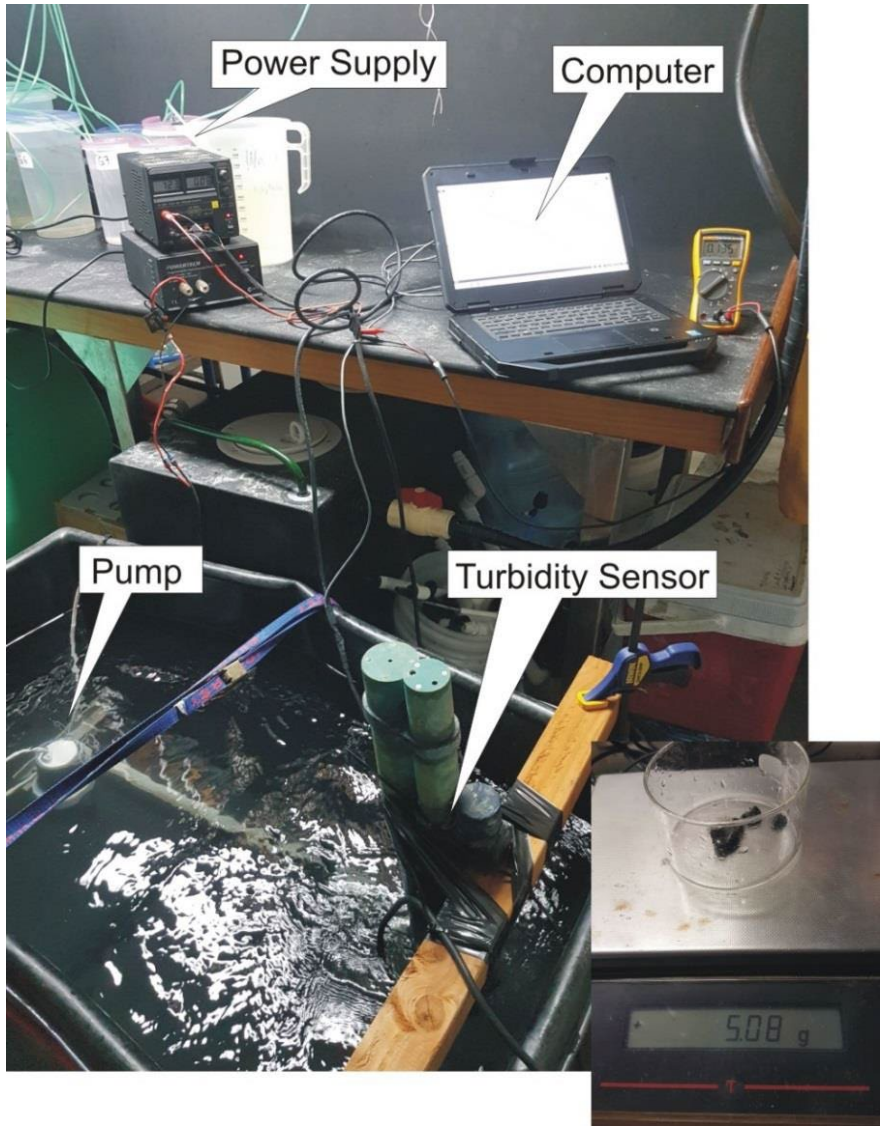
Remediation Gumbo

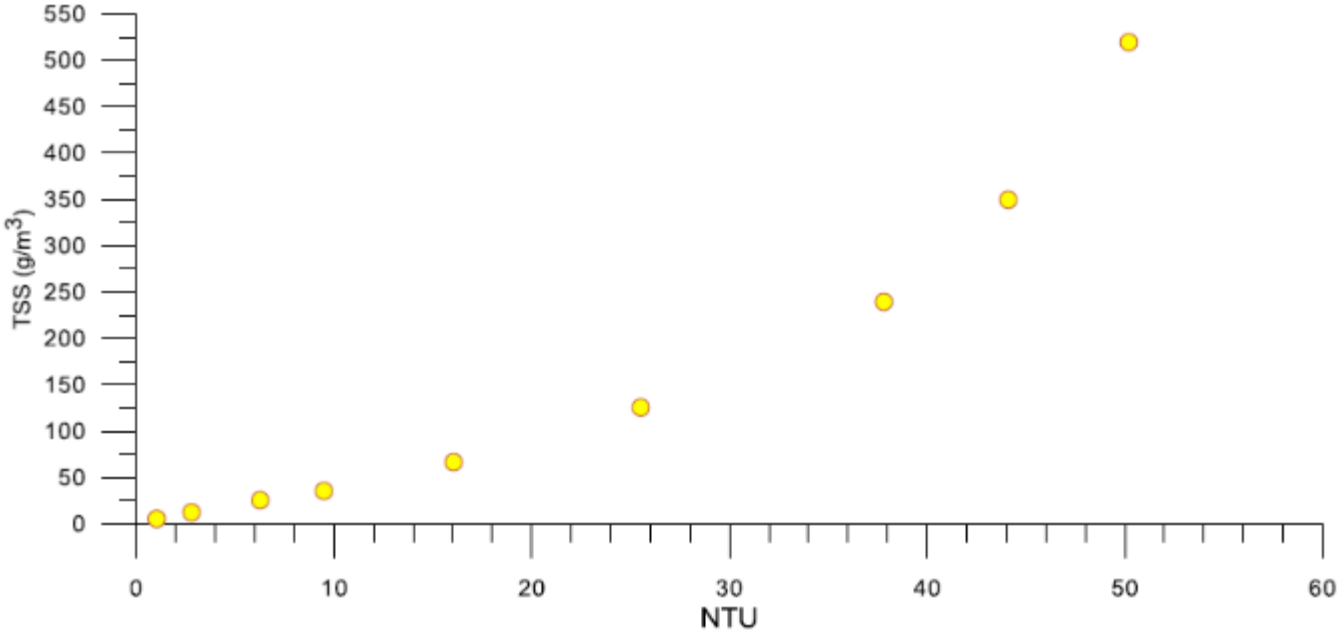

Incoming Tide - Surface readings at set locations over time
13/04/17 High tide at 11.04am
45
40
35
30
25
20
15
10
5
0
Silt curtain
Gannet meter
0.00 m
2.70 m
8.20 m
13.70 m
19.20 m
24.6 m
30.0 m
35.50 m
41.10 m
46.50 m
60.60 m
66.15 m
72.60 m
78.00 m
83.60 m
89.05 m
94.46 m
99.86 m
105.26 m
110.66 m
116.06 m
121.46 m
126.86 m
132.36 m
Pre-dredge
Comm 07.10am
Active Dredge 1
Comm 08.30am
Active Dredge 2
Comm 09.20am
Active Dredge 3
Comm 10.00am
Post Dredge 1
Comm 11.30am
Post Dredge 2
Comm 12.10pm

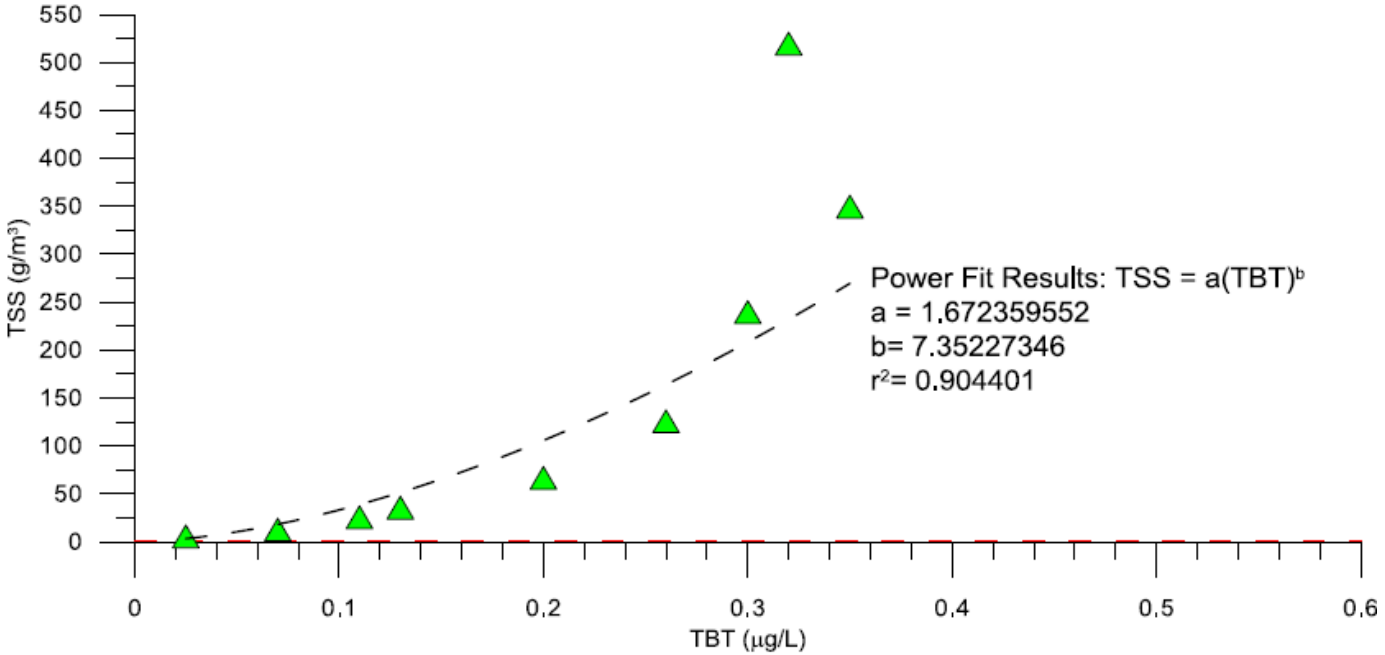
Science: Supporting permitting process, engineering approach and construction methodology

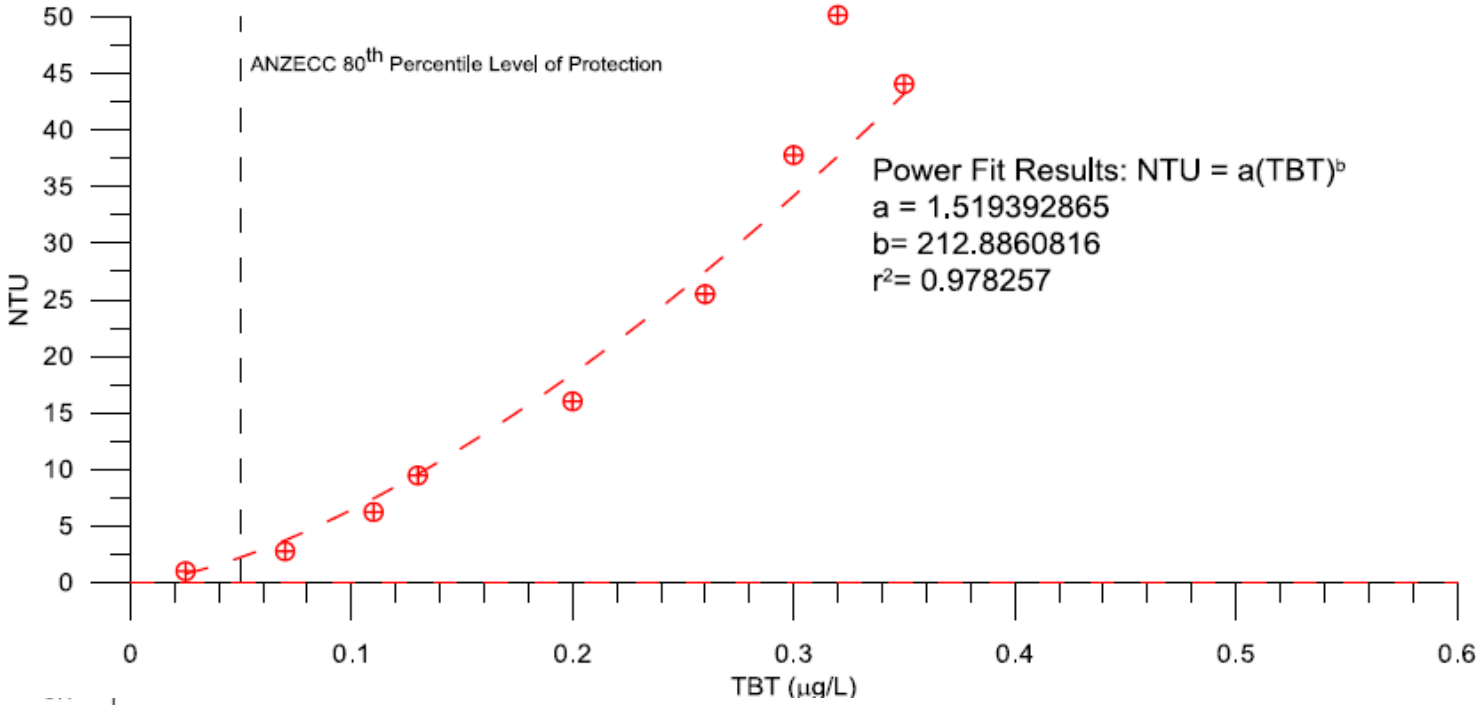
- Elutriation tests
- Tank tests to develop TBT proxy using turbidity

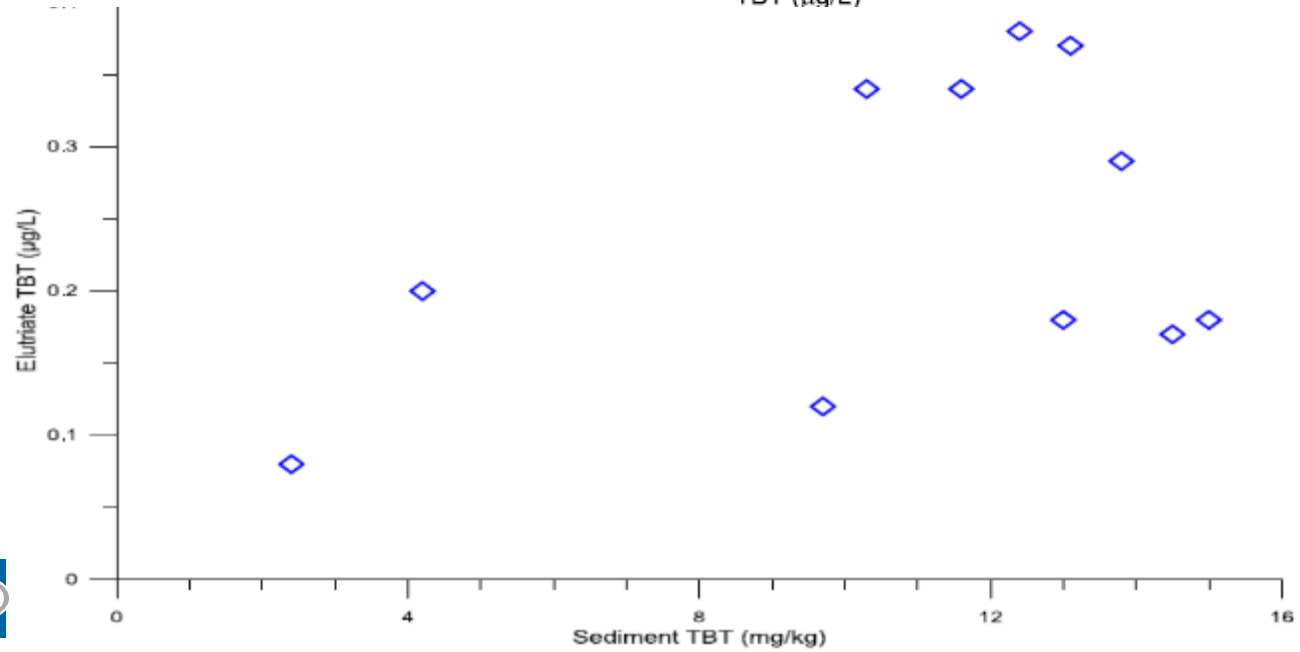
Sediment addition (g wet wt.)	Total sediment added (g wet wt.)	Turbidity reading (NTU)	Water samples	
			TSS (g/m^3)	TBT (µg/L)
None	None	0.193		
2.51	2.51	0.651		
2.47	4.98	1.036	6	<0.05
2.51	7.49	1.518		
2.50	9.99	1.976		
5.05	15.04	2.796	13	0.07
5.05	20.09	3.711		
5.06	25.15	4.675		
10.01	35.16	6.266	26	0.11
10.02	45.18	8.025		
10.02	55.20	9.495	36	0.13
9.96	65.16	10.869		
10.08	75.24	12.604		
25.01	100.25	16.051	67	0.20
24.97	125.22	18.726		
24.94	150.16	20.630		
50.06	200.22	25.522	126	0.26
50.05	250.27	29.426		
49.99	300.26	32.728		
100.05	400.31	37.813	240	0.30
100.00	500.31	41.428		
100.00	600.31	44.103	350	0.35
200.03	800.34	47.284		
199.97	1000.31	50.200	520	0.32




TSS (g/m3)
550
500
450
400
350
300
250
200
150
100
50
0
0
10
20
30
40
50
60
NTU


TSS (g/m3)
550
500
450
400
350
300
250
200
150
100
50
0
0
0,1
0,2
0,3
0,4
0,5
0,6
TBT (µg/L)
Power Fit Results: TSS = a(TBT)b
a = 1,672359552
b= 7.35227346
r2= 0.904401


ANZECC 80th Percentile Level of Protection
Power Fit Results: NTU = a(TBT)^b
a = 1.519392865
b= 212.8860816
r²= 0.978257
NTU
TBT (µg/L)
0
5
10
15
20
25
30
35
40
45
50
0
0.1
0.2
0.3
0.4
0.5
0.6


Elutriate TBT (µg/L)
Sediment TBT (mg/kg)
0
0.1
0.2
0.3
0
4
8
12
16

Application of turbidity proxy

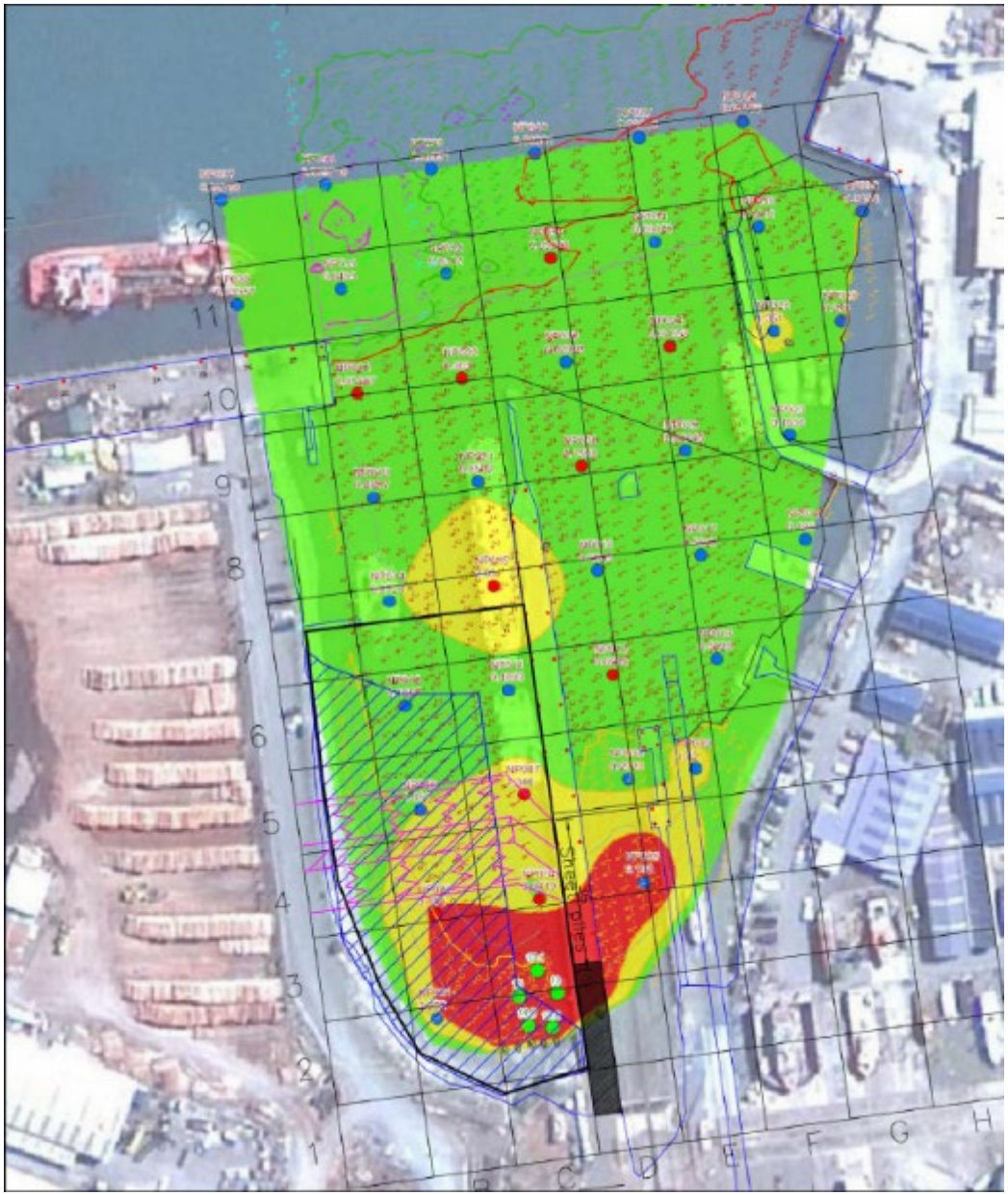


Table 5 NTU Proxy trigger values

Sediment TBT Concentration (mg/kg)	Dredge Zone	NTU Proxy
<1	Green	20
1-3	Amber	10
>3	Red	<5

Constructor / Contractor


SEAFLIES

Success

- 1/2 Ha (2 acres) of new port land created
- Capital value of land >NZD $1.8m
- Remediated 10% more volume due to liquefiable sediments
- Project on time (30 weeks from mob to demob)
- NZD $320,000 under budget
- No measured environmental effect during construction beyond project site boundary

Contaminant	Mean Concentration (mg/kg)	Chebyshev 95% UCL (mg/kg)	Remedial Target (mg/kg)
Copper	30.51	42.22	270
Tributyltin	0.0197	0.039	0.07

Conclusions

- Empirical data used and quantify actual risks and allow engineering and construction practices to be more workable with less restrictions
- Enabled permitting to occur – achieving the impossible
- Helped to inform regulators to understand risks

Key Lessons

- Early engagement between disciplines to share ideas
- Strong and proactive project management and communication
- Early and meaningful engagement with stakeholders
- Engage with contractors during engineering design