Weston Mill Lake
Marine Inter-tidal Baseline Survey

September 2011

Prepared for

MVV Environment
Devonport Ltd

Revision Schedule

Marine Inter-tidal Baseline Survey

Rev	Date	Details	Prepared by	Reviewed by	Approved by
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1 Introduction

1.1.1 MVV proposes to construct and operate an Energy from Waste Combined Heat and Power (EfW CHP) facility at North Yard, Devonport. Two existing access bridges are to be removed and replaced with one clear-span bridge as part of the development.

1.1.2 A marine phase I intertidal habitat (biotope) survey was undertaken to obtain baseline data on intertidal habitats present within Weston Mill Lake. Weston Mill Lake includes the Creek and Barne Brake tributaries.

1.1.3 Phase II marine surveys were also undertaken, which included core samples being taken for intertidal soft sediment macroinvertebrate infauna. Bait traps were deployed to identify errant macroinvertebrate fauna. Netting was also deployed to identify fish species present within the estuary.

1.1.4 All netting and trapping within the estuary was undertaken by trained Ecologists under license from the Environment Agency and consent by Devon Sea Fisheries Committee.

1.1.5 The purpose of the survey is to provide an ecological baseline evaluation of the site prior to bridge demolition and construction works and provide recommendations for mitigation. Monitoring of Weston Mill Lake will be undertaken for the next five years to identify any impacts associated with the bridge demolition and construction works.

2 Methodology

2.1.1 The Phase I biotope survey and first core sampling surveys were undertaken on 13 and 14 July 2011. The first fish survey took place on 19 July 2011. The second core sampling survey took place on 30 and 31 August 2011 and the second fish survey took place on 1 September 2011. Two 'visits' were therefore undertaken during the period May – September, which is optimum time for survey following appropriate guidance[1]. Methodologies and data collection followed standard protocol developed by the *Marine Nature Conservation Review (MNCR) 1996: review and methods*.

2.1.2 The surveyed area includes the area within the boundary of the site (see Appendix 1). Survey results were recorded on field maps with a hand-held GPS unit used to record grid references for specific locations of interest. A Phase I intertidal habitat biotope map was produced for the site and associated intertidal areas with the aid of nautical charts and GIS.

2.1.3 Phase II marine surveys were also undertaken for intertidal soft sediment macroinvertebrate infauna. Core samples (70mm x 110mm) were taken at various locations within the estuary (see Appendix 1). Ten stations were identified within the estuary in consultation with the Environment Agency. Sampling stations were chosen to take into account any variation in macroinvertebrate community composition due to environmental gradients, such as the tidal cycle and freshwater influence. At each station one core sample was taken along with two replicates. Core samples were processed in-situ and the contents sieved (1mm mesh size) at the nearby water's edge. A total of thirty samples were taken during the July visit. A further thirty samples were taken during the September visit. All macroinvertebrate infauna were identified to species level and counted in-situ and re-released. Numbers were used to obtain species density and diversity indices were applied to the data for evaluation.

2.1.4 Interstitial or overlying water was analysed for salinity, temperature and pH in-situ whilst on site.

2.1.5 Fish species present were initially obtained with the aid of a stop net, which was positioned across a narrow part of the estuary within Weston Mill Creek. The stop net was deployed at high water. However, due to the strong tidal conditions with the estuary the stop net failed due to the net being lifted off the bottom of the river bed.

2.1.6 The net was consequently then deployed as a seine net at low water. This was undertaken by towing the net by two ecologists walking either side of the estuary tributary. The net was then hauled up on one side of the bank.

2.1.7 Any fish caught were put into aerated tanks to then be re-released in a suitable area. Several bait traps were positioned at points of relevance within the tributary. Traps were secured and designed with a 95mm diameter entrance to prevent otters from accessing the traps.

2.1.8 None of the traps were left unattended throughout the day and all species were returned alive from where they were caught.

[1] 5.1.8 Wyn, G., et al. 2006. Marine Intertidal Phase 1 Biotope Mapping Survey. Countryside Council for Wales (CCW), Bangor, Gwynedd, Wales.

2.1.9 All netting and trapping within the estuary was undertaken under license from the Environment Agency and consent by Devon Sea Fisheries Committee.

3 Results

3.1 Habitats and Species

3.1.1 Habitats on the site consist of saltmarsh and soft sediment estuary mud. Saltmarsh species included sea couch-grass (*Agropyron junceiforme*), saltmarsh-grass (*Puccinella maritima*), red fescue (*Festuca rubra*), curled dock (*Rumex crispus*) and buck's-horn plantain (*Plantago coronopus*) above the mean high water mark. Upper saltmarsh species included sea purslane (*Halimione portulacoides*) which dominated the foreshore with components of sea beet (*Beta vulgaris* ssp. *Maritima*), spear-leaved orache (*Atriplex prostrata*), annual sea-blite (*Suaeda maritima*) and lesser sea-spurrey (*Spergularia media*). Lower shore species included sea aster (*Aster tripolium*), sea arrowgrass (*Triglochin maritimum*), and common cord-grass (*Spartina anglica*) with components of common glasswort (*Salicornia europaea*) located towards the lower reaches of the saltmarsh within the pioneer zone.

3.1.2 Bladder wrack (*Fucus vesiculosus*) was the dominant alga within the intertidal mudflats and included gutweed (*Enteromorpha intestinalis*), sea lettice (*Ulva lactuca*) and green filamentous algae *Enteromorpha sp.*

3.1.3 Fauna included macroinvertebrates, such as common ragworm (*Hediste diversicolor*), shore crab (*Carcinus maenas*), brown shrimp (*Crangon crangon*), peppery furrow shell (*Scrobicularia plana*), amphipods (*Chaetogammerus marinus*) and (*Melita palmata*), non-native barnacle (*Elminius modestus*) edible mussel (*Mytilus edulis*), a brittlestar (*Ophiura Sp.)* edible cockle (*Cerastoderma edule*) a terebellid worm, the isopod (*Cyathura carinata*) and the non-native leathery sea squirt (*Styela clava*).

3.1.4 Fish species recorded included flounder (*Pleuronectes Flesus*), thick-lipped grey mullet (*Chelon labrosus*), common goby (*Pomatoschistus microps*), eel (*Anguilla anguilla*) and three-spined stickleback (*Gasterosteus aculeatus*).

3.1.5 Within Barne Brake tributary (Appendix 1 Station D) there is a sewage discharge pipe located on the Weston bank. There is a considerable amount of raw 'unscreened' sewage discharging from the pipe. The presence of *Beggiatoa* (filamentous bacterial mats) was recorded within the Creek. This has been reported to South West Water.

3.2 Survey Results

3.2.1 The biological and chemical analytical results are presented in the tables for July and September below:

Table 1. Sample sites showing salinity, pH and temperature of interstitial or overlying water at each station for July.

Station	Sal (%)	pH	Temp (°C)	NGR
A	2.3	7.16	15.6	SX 44942 57413
B	2.1	7.42	16.3	SX 44834 57434
C	2.0	7.3	16.6	SX 44796 57402
D	2.0	7.9	16.6	SX 44829 57493
E	3.0	7.7	16	SX 44846 57541
F	1.5	7.37	17.6	SX 44793 57351
G	1.5	7.37	17.6	SX 44782 57354
H	2.1	7.65	20	SX 44599 57209
I	1.7	7.2	19	SX 44639 57159
J	2.3	7.25	25	SX 44703 57231

Table 2. Sample sites showing salinity, pH and temperature of interstitial or overlying water at each station for September.

Station	Sal (%)	pH	Temp (°C)	NGR
A	1.6	7.45	17.4	SX 44942 57413
B	1.6	7.12	17.1	SX 44834 57434
C	1.4	7.24	17.6	SX 44796 57402
D	1.5	7.45	18.1	SX 44829 57493
E	0.3	7.97	17.1	SX 44846 57541
F	2.0	-	17.5	SX 44793 57351
G	2.0	-	17.5	SX 44782 57354
H	2.1	7.3	18.2	SX 44599 57209
I	2.3	7.15	17.1	SX 44639 57159
J	2.6	-	22.5	SX 44703 57231

- No data available due to temporary equipment malfunction

Table 3. Alkalinity, dissolved oxygen, and carbon dioxide of estuarine water sample in mg/L for July.

Alkalinity $CaCO_3$ (mg/L)	O_2 (mg/L)	CO_2 (mg/L)
192	6.8	45

Table 4. Alkalinity, dissolved oxygen, and carbon dioxide of estuarine water sample in mg/L for September.

Alkalinity $CaCO_3$ (mg/L)	O_2 (mg/L)	CO_2 (mg/L)
141	4.7	46

Table 5. Number of species from each sample and total number present at each station for July.

Stations	A			B			C			D			E			F			G			H			I			J		
Replicates	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Species																														
Hediste diversicolor		5	4	7	8	7	1	7	2	11	8	15	8	18	14									6		3	3			2
Tubifex Sp.							1			1	2						28	20	10	3	3		2							
Melita palmata					2	1	1	4			1																			
Carcinus maenas										1					1	1				1										
Cyathura carinata																				1										
Scrobicularia plana																														1
Copepod sp.																							2							
Oligochaete sp.																							2							
Crangon crangon																													6	
Total	9			25			16			39			41			49			18			12			6			9		

Table 6. Number of species from each sample and total number present at each station for September.

Stations	A			B			C			D			E			F			G			H			I			J		
Replicates	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Species																														
Hediste diversicolor	5	4	11			1				18	21	5	18	31	12	4	19	1	4	12	4		3	22	5	8	7	3	9	9
Tubifex Sp.			1	3	4	12	1	58	4										1			3		1						
Carcinus maenas																	1													
Scrobicularia plana															1															
Oligochaete sp.						1																								
Cerastoderma edule		1																												
Ophiura Sp.																							1							
Crangon crangon																											3			
Ophiura Sp.																							1							
Total	22			21			83			44			62			25			21			31			23			21		

Table 7. Total number of individuals and proportion of pooled samples for July.

Species	no. of individuals	Proportion of pooled samples
(1) *Hediste diversicolor*	129	0.5759
(2) *Tubifex sp.*	70	0.3125
(3) *Melita palmata*	9	0.0402
(4) *Scrobicularia plana*	1	0.0045
(5) *Copepod sp.*	2	0.0089
(6) *Cyathura carinata*	1	0.0045
(7) *Carcinus maenas*	4	0.0179
(8) Oligochaete sp.	2	0.0089
(9) *Crangon crangon*	6	0.0268
Total no. of individuals	224	

Table 8. Total number of individuals and proportion of pooled samples for September.

Species	no. of individuals	Proportion of pooled samples
(1) *Hediste diversicolor*	236	0.7108
(2) *Tubifex Sp.*	88	0.2651
(3) *Carcinus maenas*	1	0.0030
(4) *Scrobicularia plana*	1	0.0030
(5) Oligochaete sp.	1	0.0030
(6) *Cerastoderma edule*	1	0.0030
(7) *Ophiura Sp.*	1	0.0030
(8) *Crangon crangon*	3	0.0090
Total no. of individuals	332	

Table 9. Heterogeneity and evenness measures of species diversity for macroinvertebrates for July.

Heterogeneity (Diversity) Indices	
Simpson's Diversity (1-D) (for finite population)	0.570
Shannon-Wiener Diversity (H') (bits per individual)	1.604
Evenness Measures Indices	
Simpson (1/D) Measure	0.257
Smith and Wilson Evar Measure	0.223

Table 10. Heterogeneity and evenness measures of species diversity for macroinvertebrates for September.

Heterogeneity (Diversity) Indices	
Simpson's Diversity (1-D) (for finite population)	0.426
Shannon-Wiener Diversity (H') (bits per individual)	1.045
Evenness Measures Indices	
Simpson (1/D) Measure	0.215
Smith and Wilson Evar Measure	0.140

Table 11. Seine netting and bait trap results for July.

Species and species no.	Seine netting	Bait trap
Flounder (*P. Flesus*)	5	
Shore crab (*C. maenas*)	20 +	62
Brown shrimp (*C. crangon*)	1	

Table 12. Seine netting and bait trap results for September.

Species and species no.	Seine netting	Bait trap
Shore crab (*C. maenas*)	10+	85
Brown shrimp (*C. crangon*)	1	1

3.2.2 In July the salinity varied between 1.5% and 3.0%; pH varied from 7.16 and 7.9, whilst temperatures recorded ranged from 15.6°C to 25°C at all stations (Table 1). Alkalinity ($CaCO_3$) was 192 mg/L, dissolved oxygen was 6.8 mg/L and carbon dioxide was 45 mg/L for the estuarine water sample (Table 3).

3.2.3 In September the salinity varied between 0.3% and 2.6%; pH varied from 7.12 and 7.97, whilst temperatures recorded ranged from 17.1°C to 22.5°C at all stations (Table 2). Alkalinity ($CaCO_3$) was 141 mg/L, dissolved oxygen was 4.7mg/L and carbon dioxide was 46 mg/L for the estuarine water sample (Table 4).

3.2.4 There was little variation in macroinvertebrate species present and species number between the stations. Dominant species comprised *Hediste diversicolor* (ragworm), *Scrobicularia plana* (peppery furrow shell) shore crab (*Carcinus maenas*), brown shrimp (*Crangon crangon*) and *Tubifex sp.* (oligochaete worms).

3.2.5 Station F and G (see Appendix 1) incurred the highest count of *Tubifex sp.* In July and no *H. diversicolor*, *C. maenas* were present during the July survey. *H. diversicolor* and *M. palmata* were mainly recorded from the upper tributaries of Weston Mill Creek and Barne Brake with salinities ranging from 2.1% to 3.0% and a more constant temperature range of 15.6°C to 16.6°C. Species were less abundant within the southern part of Weston Mill Lake (Table 5). A total of 9 species was recorded for all the stations consisting of 224 individuals (Table 7).

3.2.6 There was little variation in macroinvertebrate species present and species number between the stations during September. Dominant species was similar to July but included *C. edule* and the brittlestar *Ophiura sp.*

3.2.7 Heterogeneity indices range from 0 (homogenous – low diversity) to 1 (heterogeneous – high diversity). Type I indices are most sensitive to changes in the rare species in the community samples. This was best represented by Shannon-Wiener Diversity Index. Type II indices are most sensitive to changes in the more abundant species in the community sample. This was best represented by Simpson's Diversity Index. Therefore the Simpson's Diversity Index is the best index fit as the community is dominated by *H. diversicolor* with an index of 0.570 – low diversity in July (Table 7 and 9) and 0.426 – low diversity in September (Table 8 and 10).

3.2.8 Measures of evenness, *i.e.* how even the community is distributed, range from 0 (uneven) to 1 (even). The Smith and Wilson index is independent of species richness and is sensitive to both rare and common species in the community. Therefore the Smith and Wilson index is the best index fit as the community is dominated by one species *H. diversicolor* with an index of 0.223 – uneven (Table 7 and 9) in July (Table 7 and 9) and 0.140 – uneven in September (Table 8 and 10).

3.2.9 Seine netting revealed 5 flounder (*P. Flesus*), 1 brown shrimp (*C. crangon*) and 20+ shore crabs (*C. maenas*) whilst the bait traps revealed 62 shore crabs (*C. maenas*) in July. In September seine netting revealed 1 brown shrimp (*C. crangon*) and 10+ shore crabs (*C. maenas*) whilst the bait traps revealed 1 brown shrimp (*C. crangon*) and 85 shore crabs (*C. maenas*) (Table 11 and 12).

3.2.10 Thick-lipped grey mullet (*C. labrosus*), common goby (*P. microps*) and eel (*A. anguilla*) were recorded during general visual observations. Thick-lipped grey mullet (*C. labrosus*) were recorded in large shoals during July and consisted of various cohorts. The number recorded in September was significantly less.

4 Discussion and Conclusions

4.1.1 Habitats on the site consist of saltmarsh and soft sediment estuary mud. Saltmarsh and mudflats are National Priority Biodiversity Action Plan (BAP) habitats. Through Section 40 of the Natural Environmental and Rural Communities Act, 2006, local planning authorities have a duty to consider habitats and species listed within the national BAP (priority species and priority habitats) and local BAPs when considering a planning application. BAP habitats and species are also a material consideration in the planning process under Planning Policy Statement 9 (PPS9).

4.1.2 The variation in salinity of the interstitial/overlying water was between 1.5% and 3.0% in July and 0.3% and 2.6% in September which is as expected in estuarine water. Euryhaline and brackish water species, such as those found within the sediments at the site, can tolerate a range of salinities of around 3.0 % down to 0.3%. However, within the sediments the salinity remains relatively constant. The pH of the interstitial/overlying water was relatively constant between 7.16 and 7.9 in July and 7.12 and 7.97 in September this would be expected due to the input of freshwater within the estuary. Pure seawater (3.5%) has a limited range of pH 7.5 – 8.4.

4.1.3 There was little variation in species present and species number between the stations except at the Station F and G during the July survey. Both these stations were located either side the water channel south of the access bridge (Appendix 1).

4.1.4 Stations F and G incurred large amounts of terrestrial organic matter (leaves and vegetation) within the anoxic layer. This also coincided with the highest number of *Tubifex sp.* associated with reduced conditions, *i.e.* no oxygen and anaerobic respiration. There were 2 juvenile shore crabs (*C. maenas*) within the sample, probably 1st instars. Alluvial organic material would be retained within the estuary and deposited within the area due to the canalisation of the bridge structure, which would result in organic enrichment of the sediment, low number of species and presence of *Tubifex sp.*

4.1.5 There was little variation in species present and species number between all the stations in September. During the months following the July survey the area experienced several storm events with excessive freshwater input coinciding with equinoxial spring tides. This may have removed a lot of organic material from stations F and G allowing the recolonisation of more errant species such as *H. diversicolor*.

4.1.6 In the vicinity of the sampling stations the general observations were that of a typical healthy estuarine system. *Scrobicularia plana* siphon marks were identified on the mud with the occasional *M. palmata* burrows within the sediment surface.

4.1.7 Typically within most estuarine systems they have a low diversity but are high in biomass *i.e.* low species numbers but abundant. Weston Mill Lake is typical of a variable-reduced/low salinity sheltered site that consists of a substrate of mud to sandy mud with an anoxic layer of sediment below the surface.

4.1.8 The diversity indices indicate that the infanual community composition is typical of a mid estuary habitat, in which diversity is low and uneven in species richness, *i.e.* low diversity with a few individual species dominating the community.

4.1.9 The ecological communities according to the UK Marine SACs Project website[2] indicate that the biotope is typical of intertidal mud and sandflats. The Biotope definition and code is classed as *Hediste diversicolor* and *Scrobicularia plana* in reduced salinity mud shores: (LMU.HedScr). Environmental characteristics consist of variable-reduced/low salinity, sheltered-very sheltered; mud-sandy mud with an anoxic layer present. Characterising species include, *Hediste* (*nereis*) *diversicolor* and the bivalve *Scrobicularia plana* are abundant. Other polychaetes include *Eteone longa*, Oligochaete - *Tubificoides benedeni*; Isopod, *Cyathura carinata* and other bivalves include *Macoma balthica* and *Cerastoderma edule*.

4.1.10 Seine netting, bait traps along with general observations revealed that Weston Mill Lake and tributaries are an important feeding and nursery site for thick-lipped grey mullet (*C. labrosus*). Shoals of various age classes were recorded migrating up into the upper reaches of Weston Mill Lake at high water, via the channel under the bridge, and then returning to the deeper water of the estuary on the ebbing tide. Weston Mill Lake and tributaries are also important nursery areas for Shore crab (*C. maenas*) and flounder (*P. Flesus*), with all age classes being represented.

4.1.11 The European eel (*A. anguilla*) was recorded within Weston Mill Lake and Creek during general visual observations. This species is a BAP Priority Species and is a species of principal importance under the Natural Environment and Rural Communities Act 2006.

4.1.12 The European Eel Regulation (EC) No 1100/2007 have been implemented to conserve European depleted eel stocks. The European Commission has initiated an Eel Recovery Plan to try to return the European eel stock to more sustainable levels of adult abundance and glass eel recruitment. Each Member State is required to establish national Eel Management Plans (EMPs). These plans aim to achieve an escapement of silver eel to the spawning population that equals or exceeds a target set at 40% of the potential biomass that would be produced under conditions with no anthropogenic disturbance due to fishing, water quality or barriers to migration.

4.1.13 Raw sewage and the presence of *Beggiatoa* bacterial mats within Weston Mill Creek should be investigated further by South West Water. The bacterial mats are found in polluted marine environments. *Beggiatoa* are evident in the marine environment as white filamentous mats on top of sulphide-rich sediments. *Beggiatoa* tend to prefer areas that are rich in hydrogen sulphate, including water that has been contaminated with sewage.

4.1.14 In conclusion the demolition and construction of the new bridge will have an impact on the macroinvertebrate infaunal communities within the direct vicinity of the bridge structure. Impacts will be by displacement caused by removal of sediments and bed scour. Resettlement of suspended sediment caused by the demolition and construction process may impact on macroinvertebrate infaunal communities further up and downstream of the bridge structure by causing smothering effects.

4.1.15 However, impacts will only be temporary. Once construction of the bridge is complete recolonisation by macroinvertebrate infaunal communities would take between one and two years to reach existing community composition. The demolition and construction of the new bridge is expected to last approximately one and a half years to completion.

[2] The UK Marine SACs Project: http://www.ukmarinesac.org.uk/index.htm

4.1.16 There will be no loss of saltmarsh or mudflat habitats as part of the development. In fact, by replacing two culverted bridges with one clear-span bridge there will be an increase in such habitat, and a more open pathway for transit of water up/downstream.

4.1.17 Access to the estuary during bridge demolition and construction will need to be kept open at all times to facilitate the migration of fish species, such as eel and thick-lipped grey mullet.

4.1.18 The installation of a temporary pollution prevention control/s, such as silt fencing, filter fabrics and/or straw bale barriers will reduce the probability of sediment pollution resetting further downstream and upstream and potentially smothering the macroinvertebrate infaunal community habitats.

4.1.19 Straw bale barriers should be bound, entrenched, and securely anchored to prevent deterioration. A row of straw bales slows runoff flow and creates a pond behind the barrier where sediment can settle out. Straw bale barriers are most effective for filtering low to moderate storm flows, where structural strength is not required.

4.1.20 Filter fabrics are engineering fabrics designed to retain sediment particles larger than a certain size and allow water to pass through. Filter fabrics can be used in silt fences. Silt fences are vertical fences of filter fabric that are stretched across and attached to support poles. The fabric retains sediment on the construction site and allows relatively sediment-free water to pass through. Silt fences may be placed in areas of the stream that experience lower flow rates.

4.1.21 Monitoring in Weston Mill Lake will be undertaken for the next five years once the construction is complete and the bridge is operational.

5 References

5.1.1 Devon Local Biodiversity Action Plan (2009 - 2010 update).

5.1.2 Grimwood, M.J. & Dixon, E. 1997. Assessment of risks posed by List II metals to Sensitive Marine Areas (SMAs) and adequacy of existing environmental quality standards (EQSs) for SMA protection. Report to English Nature.

5.1.3 Hayward, P., J. and Ryland, J., S., *ed*. 1996. *Handbook of the Marine Fauna of North-West Europe*. Oxford University Press.

5.1.4 Hayward, P., J., *ed*. 1994. *Animals of sandy shores*. The Richmond Publishing Co. Ltd.

5.1.5 Hiscock, K., *ed*. 1966. *Marine Nature Conservation Review: rationale and methods*. Peterborough, Joint Nature Conservation Committee. (Coasts and seas of the United Kingdom. MNCR series).

5.1.6 Krebs, C., J., 1999. Ecological Methodology, 2nd Ed. Benjamin/Cummings. ISBN 0-321-02173-8.

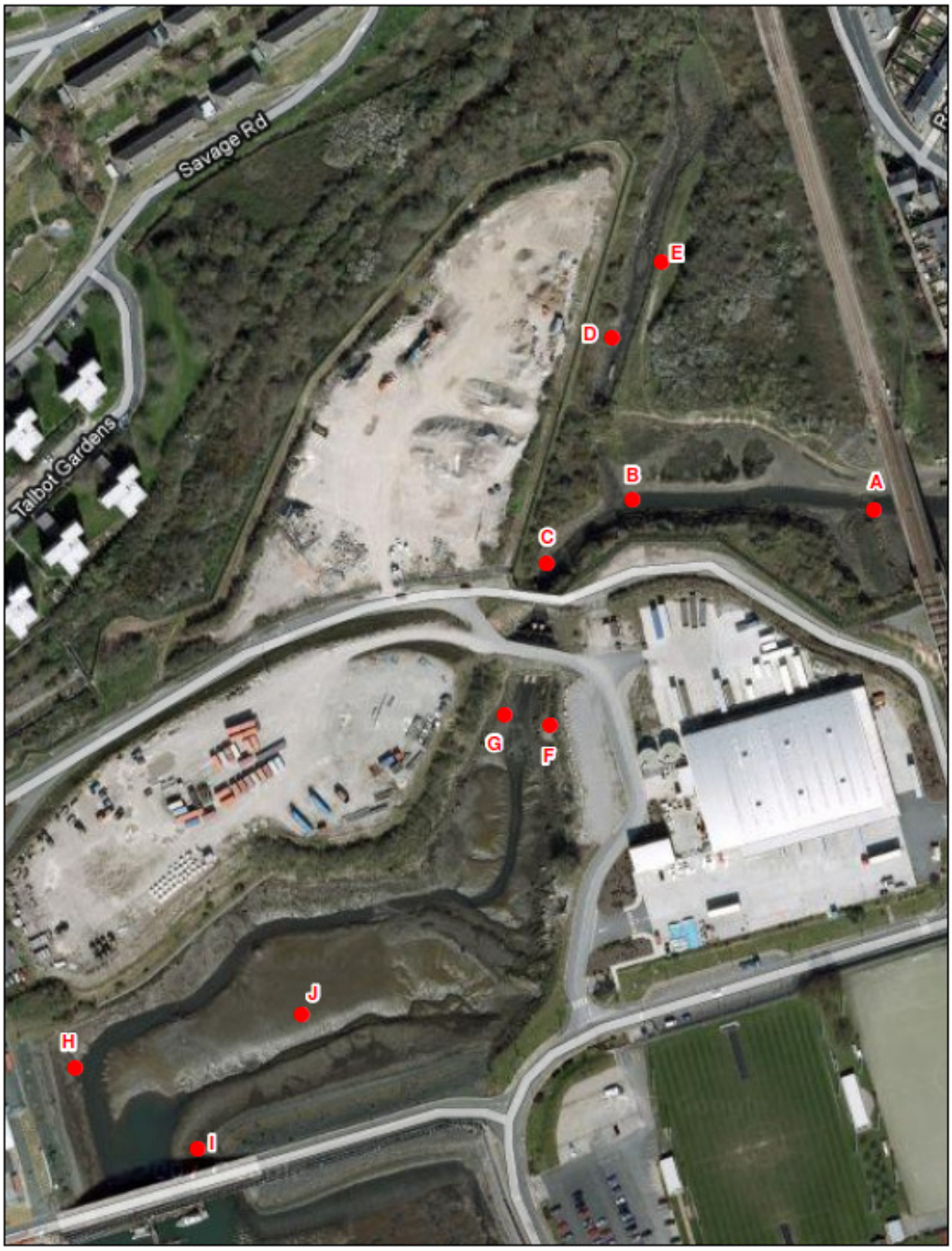
5.1.7 Nybakken, J., W. 1993. *Marine Biology: An ecological Approach*, 3rd Ed. Harper Collins College publishers.

5.1.8 UK Biodiversity Action Plan (UK BAP) (2007). UK Biodiversity Action Plan website: http://www.ukbap.org.uk . Accessed on 31st August 2011.

5.1.9 WRC Swindon 1999. Guidelines for managing water quality impacts within UK European marine sites. English Nature, UK Marine SACs Project. pp 440.

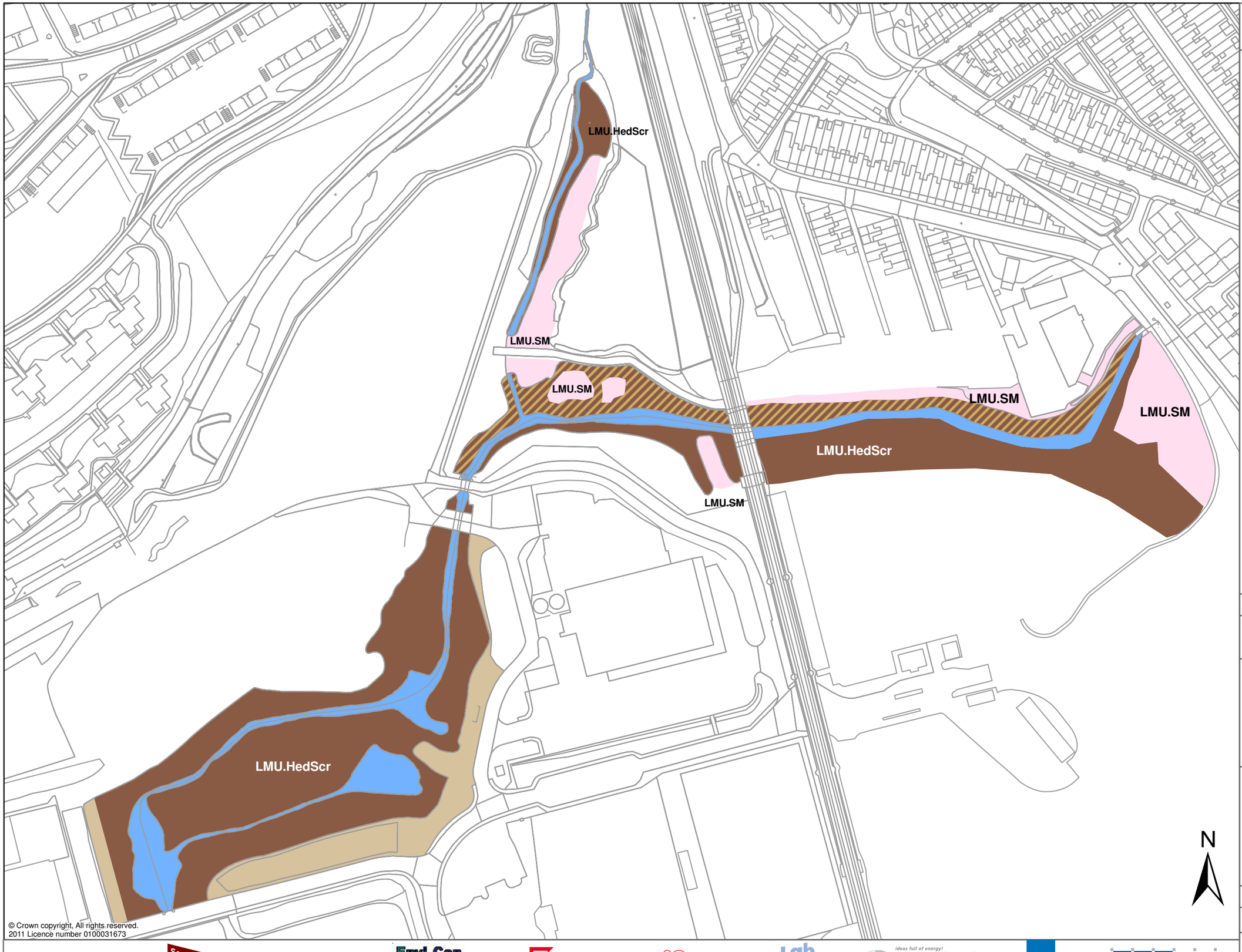
5.1.10 Wyn, G., *et al*. 2006. *Marine Intertidal Phase 1 Biotope Mapping Survey*. Countryside Council for Wales (CCW), Bangor, Gwynedd, Wales.

Appendix 1 Map Showing Sampling Stations



● Approximate phase II marine survey stations

Appendix 2 Intertidal Phase I Habitat (Biotope) Map



THIS DRAWING MAY BE USED FOR THE PURPOSE INTENDED AND ONLY WRITTEN DIMENSIONS SHALL BE USED

NOTES

- Mud
- Mud and stone
- Saltmarsh
- Man-made rock work revetment
- Water

Revision Details	By / Check	Date	Suffix

Drawing Status
PLANNING

Job Title
EfW CHP FACILITY,
NORTH YARD,
DEVONPORT

Drawing Title
MARINE INTERTIDAL
PHASE I BIOTOPE MAP

Scale at A3 1:2,000

Drawn	Approved
MP	PG

Stage 1 Check	Stage 2 Check	Originated	Date

Drawing Number
D123356/A003
Rev

Contractor to SWDWP	Environmental & Planning Consultant	EPC Contractor	General Designer	Civil Works	Architect	Air Pollution Control	Boiler & Grate	Electrical & Control	Water Steam System
MVV Environment Devonport Ltd	Scott Wilson	MVV O&M	Envi Con Envi Con & Plant Engineering GmbH	KIER	SC	Lab	ideas full of energy! Standardkessel Baumgarte	SAR www.sar.biz	Imtech

Filepath:

Appendix 3 Diversity Indices

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 MEASURES OF SPECIES DIVERSITY
    (Program DIVERS, Version 7.2)

* Western Mill Lake Macroinvertebrate infauna
    RAW DATA
 SPECIES NO.    NO. OF INDIVIDUALS    PROPORTION OF SAMPLE
        1            129.0               0.5759
        2             70.0               0.3125
        3              9.0               0.0402
        4              1.0               0.0045
        5              2.0               0.0089
        6              1.0               0.0045
        7              4.0               0.0179
        8              2.0               0.0089
        9              6.0               0.0268

      Total No. of Individuals =     224.

======================================================================

 * SIMPSON'S DIVERSITY (1-D) =    0.570 (for finite population)  (Eq. 12.29)
   RECIPROCAL OF SIMPSON'S DIVERSITY (1/D) =     2.314  (N(2)  (Eq. 12.30)

 ** SHANNON-WIENER DIVERSITY (H') =    1.604 bits per individual    (Eq. 12.31)
    NO. OF EQUALLY COMMON SPECIES (N(1) =       3.04    (Eq. 12.32)

 *** BRILLOUIN'S DIVERSITY (H) =    1.521 bits per indiv.    (Eq. 12.33)

 EVENNESS MEASURES -
        SIMPSON (1/D) MEASURE =    0.257    (Eq. 12.35)
        CAMARGO E-prime MEASURE =    0.269    (Eq. 12.36)
        SMITH AND WILSON Evar MEASURE =    0.223    (Eq. 12.37)
        MODIFIED NEE et al. E(Q) MEASURE =    0.103    (Eq. 12.38)


** Western Mill Lake Macroinvertebrate infauna                          **

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 MEASURES OF SPECIES DIVERSITY
    (Program DIVERS, Version 7.2)

* Septemeber Survey
    RAW DATA
 SPECIES NO.    NO. OF INDIVIDUALS    PROPORTION OF SAMPLE
        1            236.0              0.7108
        2             88.0              0.2651
        3              1.0              0.0030
        4              1.0              0.0030
        5              1.0              0.0030
        6              1.0              0.0030
        7              1.0              0.0030
        8              3.0              0.0090

      Total No. of Individuals =     332.

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 * SIMPSON'S DIVERSITY (1-D) =    0.426 (for finite population)  (Eq. 12.29)
   RECIPROCAL OF SIMPSON'S DIVERSITY (1/D) =     1.737  (N(2)  (Eq. 12.30)

 ** SHANNON-WIENER DIVERSITY (H') =    1.045 bits per individual    (Eq. 12.31)
    NO. OF EQUALLY COMMON SPECIES (N(1) =       2.06    (Eq. 12.32)

 *** BRILLOUIN'S DIVERSITY (H) =    1.004 bits per indiv.    (Eq. 12.33)

 EVENNESS MEASURES -
        SIMPSON (1/D) MEASURE =    0.217    (Eq. 12.35)
        CAMARGO E-prime MEASURE =    0.215    (Eq. 12.36)
        SMITH AND WILSON Evar MEASURE =    0.140    (Eq. 12.37)
        MODIFIED NEE et al. E(Q) MEASURE =    0.071    (Eq. 12.38)


** Septemeber Survey                                                    **

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Appendix 4 Photographic Images

1. Brown shrimp (*Crangon crangon*).

2. Shore crab (*Carcinus maenas*).

3. Common glasswort (*Salicornia europaea*).

4. Sewage outfall in Barn Break.

5. Peppery furrow shell (*Scrobicularia plana*) and edible cockle (*Cerastoderma edule*).

6. Common ragworm (*Hediste diversicolor*)