RPS

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Results Summary - PSA Size Class & Statistics

Report No.: **18-69863**
Customer Reference: 17-0769
Customer Order No: 1711-360

Customer Sample No				**BH37 4.0**	**BH38 0.50**	**BH38 1.0**	**BH38 1.5**	**BH38 2.0**	**BH38 2.5**	**BH38 3.0**	**BH38 3.5**	**BH39 2.0**	**BH39 2.5**	**BH39 3.0**	**BH39 3.50**	**BH39 .50**	**BH39 1.0**	**BH39 1.5**
Customer Sample ID																		
RPS Sample No				357047	357048	357049	357050	357051	357052	357053	357054	357055	357056	357057	357058	357059	357060	357061
Sample Type				**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**
Sample Location																		
Sample Depth (m)				4.0m	.50m	1.0m	1.5m	2.0m	2.5m	3.0m	3.5m	2.0m	2.5m	3.0m	3.5m	.50m	1.0m	1.50m
Sampling Date				23/02/2018	15/02/2018	15/02/2018	15/02/2018	15/02/2018	15/02/2018	15/02/2018	15/02/2018	20/02/2018	20/02/2018	20/02/2018	20/02/2018	20/02/2018	20/02/2018	20/02/2018
Sampl ng Time																		
Sediment	**mm**	**phi ϕ**	**Units**															
Very coarse gravel	>32<64	<-5>-6	%	0.00	38.60	0.00	12.30	42.20	1.72	30.60	0.00	13.70	13.60	0.00	0.00	13.40	16.80	44.30
Coarse gravel	>16<32	<-4>-5	%	33.10	12.90	57.50	4.59	14.20	20.70	38.90	0.00	11.10	1.31	9.48	0.00	72.30	18.80	42.60
Medium gravel	>8<16	<-3>-4	%	50.70	16.50	19.70	15.20	11.30	28.90	8.16	0.23	25.50	14.60	0.65	4.05	10.80	22.30	10.80
Fine gravel	>4<8	<-2>-3	%	2.73	10.50	6.24	20.60	8.67	21.60	5.92	0.13	17.50	17.40	1.49	4.53	0.59	15.30	0.03
Very fine gravel	>2<4	<-1>-2	%	3.55	11.40	8.61	24.50	10.20	14.60	6.58	1.20	17.80	14.20	2.50	4.85	1.21	15.60	0.61
Very coarse sand	>1<2	<0>-1	%	2.98	6.72	5.00	14.90	9.41	7.50	4.73	1.59	8.40	9.52	3.12	3.92	0.76	7.28	0.87
Coarse sand	>0.5<1	<1>0	%	2.43	1.79	1.54	4.21	2.62	2.92	2.82	1.69	3.65	2.76	9.63	5.28	0.16	2.01	0.30
Medium sand	>0.25<0.5	<2>1	%	1.85	1.10	0.95	2.65	1.07	1.47	1.70	2.80	1.81	3.04	2.73	7.12	0.35	1.36	0.25
Fine sand	>0.125<0.25	<3>2	%	1.45	0.34	0.32	0.80	0.34	0.43	0.38	9.08	0.43	4.30	5.70	9.73	0.30	0.47	0.16
Very fine sand	>0.0625<0.125	<4>3	%	0.80	0.09	0.07	0.16	0.08	0.12	0.10	12.90	0.11	4.06	8.93	10.40	0.08	0.09	0.04
Very coarse s lt	>0.03125<0.0625	<5>4	%	0.43	0.01	0.01	0.03	0.01	0.04	0.02	15.60	0.02	3.25	11.90	10.60	0.01	0.01	0.01
Coarse s lt	>0.015625<0.03125	<6>5	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.70	0.00	3.03	12.30	10.80	0.00	0.00	0.00
Medium silt	>0.007813<0.015625	<7>6	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.00	0.00	3.14	12.10	10.90	0.00	0.00	0.00
Fine silt	>0.003906<0.007813	<8>7	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.00	0.00	2.58	9.05	8.29	0.00	0.00	0.00
Very fine silt	>0.001953<0.003906	<9>8	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.10	0.00	1.52	4.98	4.58	0.00	0.00	0.00
Clay	<0.001953	>9	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.93	0.00	1.77	5.42	5.05	0.00	0.00	0.00
Statistics*	Mean (phi)			-3.65	-3.65	-3.74	-2.46	-3.72	-2.94	-3.92	5.31	-2.85	-0.632	3.81	3.62	-4.56	-3.27	-4.79
	Sorting			1.13	1.71	1.38	1.89	2.00	1.54	1.64	2.48	1.67	3.92	3.96	3.68	0.492	1.70	0.575
	Skewness			0.538	0.437	0.760	-0.160	0.381	0.176	0.640	0.001	0.172	0.417	-0.285	-0.155	0.297	0.198	0.383
	Kurtosis			3.29	0.731	1.45	1.01	0.691	0.976	1.47	1.06	0.973	1.11	0.952	0.958	1.28	0.835	1.07
	% Silt/Clay		%	0.43	0.01	0.01	0.03	0.01	0.04	0.02	70.33	0.02	15.29	55.75	50.22	0.01	0.01	0.01
	Textural Group**			Gravel	Gravel	Gravel	Sandy Grave	Gravel	Gravel	Gra l	Gravelly San	Gravel	ddy Sandy Gr	Gravelly Mud	Gravelly Mud	Gravel	Gravel	Gravel

* Folk & Ward
** GRADISTAT class f cation system (Blott, S. J. & Pye, K., 2001)

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Results Summary - PSA Wentworth Scale

Report No.: 18-69863
Customer Reference: 17-0769
Customer Order No: 1711-360

Parameter	Customer Sample No	BH33 0.40	BH34 0.50	BH34 1.0	BH34 1.5	BH34 2.0	BH34 2.5	BH34 3.0	BH35 0.50	BH35 1.0	BH35 1.5	BH35 2.0	BH35 2.5	BH35 3.0	BH35 3.5	BH35 4.0
	Customer Sample ID															
	RPS Sample No	357017	357018	357019	357020	357021	357022	357023	357024	357025	357026	357027	357028	357029	357030	357031
	Sample Type	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT
	Sample Location															
	Sample Depth (m)	0.40m	0.50m	1.0m	1.5m	2.0m	2.5m	3.0m	.50m	1.0m	1.5m	2.0m	2.5m	3.0m	3.5m	4.0m
	Sampling Date	01/03/2018	28/02/2018	28/02/2018	28/02/2018	28/02/2018	28/02/2018	28/02/2018	27/02/2018	27/02/2018	27/02/2018	27/02/2018	27/02/2018	27/02/2018	27/02/2018	27/02/2018
	Sampling Time															
Parameter	**Units**															
Pebble	%	83.10	76.40	33.30	50.90	67.30	85.47	87.35	98.65	95.08	74.35	62.90	42.50	19.74	43.95	79.51
Granule	%	6.86	6.19	18.00	13.60	12.70	3.21	5.11	0.64	2.51	7.59	16.90	12.50	7.80	12.80	7.27
Very coarse sand	%	3.88	5.48	15.40	13.00	7.82	3.32	3.17	0.26	0.88	5.80	12.30	18.20	7.99	11.90	5.72
Coarse sand	%	2.13	4.41	12.60	9.34	4.66	2.90	1.86	0.17	0.75	6.33	4.40	14.40	12.70	10.90	3.21
Medium sand	%	1.73	3.86	11.70	7.57	3.70	2.68	1.27	0.14	0.53	4.78	1.77	7.36	11.20	8.45	1.93
Fine sand	%	1.77	2.85	7.17	4.47	2.86	1.84	0.76	0.07	0.22	0.97	1.36	3.66	6.47	4.67	1.36
Very fine sand	%	0.47	0.68	1.54	0.91	0.86	0.51	0.36	0.03	0.05	0.19	0.42	1.29	4.37	2.01	0.73
Silt Clay	%	0.09	0.20	0.38	0.26	0.23	0.05	0.11	0.00	0.01	0.02	0.01	0.14	29.72	5.36	0.31
Total	%	100.0	100.1	100.1	100.1	100.1	100.0	100.0	100.0	100.0	100.0	100.1	100.1	100.0	100.0	100.0

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Results Summary - PSA Wentworth Scale

Report No.: 18-69863
Customer Reference: 17-0769
Customer Order No: 1711-360

	Customer Sample No	**BH36 .50**	**BH36 1.0**	**BH36 1.5**	**BH36 2.0**	**BH36 2.5**	**BH36 3.0**	**BH36 3.5**	**BH36 4.0**	**BH37 .50**	**BH37 1.0**	**BH37 1.5**	**BH37 2.0**	**BH37 2.5**	**BH37 3.0**	**BH37 3.5**
	Customer Sample ID															
	RPS Sample No	357032	357033	357034	357035	357036	357037	357038	357039	357040	357041	357042	357043	357044	357045	357046
	Sample Type	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**	**SEDIMENT**
	Sample Location															
	Sample Depth (m)	.50m	1.0m	1.5m	2.0m	2.5m	3.0m	3.5m	4.0m	.50m	1.0m	1.5m	2.0m	2.5m	3.0m	3.5m
	Sampling Date	24/02/2018	24/02/2018	24/02/2018	24/02/2018	24/02/2018	24/02/2018	24/02/2018	24/02/2018	23/02/2018	23/02/2018	23/02/2018	23/02/2018	23/02/2018	23/02/2018	23/02/2018
	Sampling Time															
Parameter	**Units**															
Pebble	%	92.01	90.90	93.49	74.95	71.30	75.60	67.50	31.92	83.54	70.30	75.70	75.76	73.20	46.49	92.15
Granule	%	1.92	1.46	1.28	6.07	8.98	7.86	14.00	12.30	8.55	11.70	9.26	11.40	12.10	8.69	1.34
Very coarse sand	%	2.19	2.59	1.68	7.14	9.17	7.67	9.38	6.74	4.24	8.22	5.82	5.50	6.68	6.40	1.40
Coarse sand	%	2.13	2.74	1.66	6.43	6.84	5.73	5.78	1.14	1.79	4.07	3.52	2.65	3.05	2.18	1.40
Medium sand	%	1.23	1.69	1.25	4.15	2.80	2.47	2.65	2.51	1.30	3.72	3.59	2.74	2.95	2.36	1.60
Fine sand	%	0.43	0.41	0.47	1.02	0.69	0.50	0.57	6.37	0.56	1.71	1.78	1.50	1.58	5.69	1.17
Very fine sand	%	0.16	0.15	0.10	0.18	0.14	0.10	0.11	8.05	0.10	0.28	0.29	0.30	0.32	8.61	0.61
Silt Clay	%	0.01	0.00	0.01	0.03	0.03	0.02	0.02	30.88	0.01	0.07	0.07	0.07	0.05	19.58	0.27
Total	%	100.1	99.9	99.9	100.0	100.0	100.0	100.0	99.9	100.1	100.1	100.0	99.9	99.9	100.0	99.9

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Customer Order No: 1711-360

Parameter	Units	BH37 4.0	BH38 0.50	BH38 1.0	BH38 1.5	BH38 2.0	BH38 2.5	BH38 3.0	BH38 3.5	BH39 2.0	BH39 2.5	BH39 3.0	BH39 3.50	BH39 .50	BH39 1.0	BH39 1.5
Customer Sample ID																
RPS Sample No		357047	357048	357049	357050	357051	357052	357053	357054	357055	357056	357057	357058	357059	357060	357061
Sample Type		SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT
Sample Location																
Sample Depth (m)		4.0m	.50m	1.0m	1.5m	2.0m	2.5m	3.0m	3.5m	2.0m	2.5m	3.0m	3.5m	.50m	1.0m	1.50m
Sampling Date		23/02/2018	15/02/2018	15/02/2018	15/02/2018	15/02/2018	15/02/2018	15/02/2018	15/02/2018	20/02/2018	20/02/2018	20/02/2018	20/02/2018	20/02/2018	20/02/2018	20/02/2018
Sampling Time																
Pebble	%	86.53	78.50	83.44	52.69	76.37	72.92	83.58	0.36	67.80	46.91	11.62	8.58	97.09	73.20	97.73
Granule	%	3.55	11.40	8.61	24.50	10.20	14.60	6.58	1.20	17.80	14.20	2.50	4.85	1.21	15.60	0.61
Very coarse sand	%	2.98	6.72	5.00	14.90	9.41	7.50	4.73	1.59	8.40	9.52	3.12	3.92	0.76	7.28	0.87
Coarse sand	%	2.43	1.79	1.54	4.21	2.62	2.92	2.82	1.69	3.65	2.76	9.63	5.28	0.16	2.01	0.30
Medium sand	%	1.85	1.10	0.95	2.65	1.07	1.47	1.70	2.80	1.81	3.04	2.73	7.12	0.35	1.36	0.25
Fine sand	%	1.45	0.34	0.32	0.80	0.34	0.43	0.38	9.08	0.43	4.30	5.70	9.73	0.30	0.47	0.16
Very fine sand	%	0.80	0.09	0.07	0.16	0.08	0.12	0.10	12.90	0.11	4.06	8.93	10.40	0.08	0.09	0.04
Silt Clay	%	0.43	0.01	0.01	0.03	0.01	0.04	0.02	70.33	0.02	15.29	55.75	50.22	0.01	0.01	0.01
Total	%	100.0	100.0	99.9	99.9	100.1	100.0	99.9	100.0	100.0	100.1	100.0	100.1	100.0	100.0	100.0

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Report No.: 18-69863-1
Customer Reference: 17-0769
Customer Order No: 1711-360

Comments

RPS Sample Number	Customer Number	Sample Comments
357017	BH33 0.40	Visual Inspection: Colour - Brown Texture - Stones/Shells Odour - None Biota - None Anthropogenic Inputs - None
357018	BH34 0.50	Visual Inspection: Colour - Brown Texture - Stones/Shells Odour - None Biota - None Anthropogenic Inputs - None
357019	BH34 1.0	Visual Inspection: Colour - Red/Brown Texture - Stones/Shells Odour - None Biota - None Anthropogenic Inputs - None
357020	BH34 1.5	Visual Inspection: Colour - Brown Texture - Gravel Odour - None Biota - None Anthropogenic Inputs - None
357021	BH34 2.0	Visual Inspection: Colour - Brown Texture - Gravel Odour - None Biota - None Anthropogenic Inputs - None
357022	BH34 2.5	Visual Inspection: Colour - Brown Texture - Rocks/Gravel Odour - None Biota - None Anthropogenic Inputs - None
357023	BH34 3.0	Visual Inspection: Colour - Brown Texture - Rocks/Gravel Odour - None Biota - None Anthropogenic Inputs - None
357024	BH35 0.50	Visual Inspection: Colour - Red/Brown Texture - Rocks Odour - None Biota - None Anthropogenic Inputs - None Sample 357024 unsuitable for dry weights (rocks)

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Comments

RPS Sample Number	Customer Number	Sample Comments
357025	BH35 1.0	Visual Inspection: Colour - Red/Brown Texture - Rocks Odour - None Biota - None Anthropogenic Inputs - None Sample 357025 unsuitable for dryweight (rocks)
357026	BH35 1.5	Visual Inspection: Colour - Red/Brown Texture - Gravel/Rocks Odour - None Biota - None Anthropogenic Inputs - None
357027	BH35 2.0	Visual Inspection: Colour - Red/Brown Texture - Gravel/Rocks Odour - None Biota - None Anthropogenic Inputs - None
357028	BH35 2.5	Visual Inspection: Colour - Red/Brown Texture - Gravel Odour - None Biota - None Anthropogenic Inputs - None
357029	BH35 3.0	Visual Inspection: Colour - Brown Texture - Clay/Rocks Odour - None Biota - None Anthropogenic Inputs - None
357030	BH35 3.5	Visual Inspection: Colour - Brown Texture - Clay/Gravel Odour - None Biota - None Anthropogenic Inputs - None
357031	BH35 4.0	Visual Inspection: Colour - Red/Brown Texture - Rocks/Gravel Odour - None Biota - None Anthropogenic Inputs - None
357032	BH36 .50	Visual Inspection: Colour - Red/Black/Brown Texture - Rocks Odour - None Biota - None Anthropogenic Inputs - None

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Comments

RPS Sample Number	Customer Number	Sample Comments
357033	BH36 1.0	Visual Inspection: Colour - Red/Black/Brown Texture - Rocks Odour - None Biota - None Anthropogenic Inputs - None
357034	BH36 1.5	Visual Inspection: Colour - Red/Brown Texture - Rocks/Gravel Odour - None Biota - None Anthropogenic Inputs - None
357035	BH36 2.0	Visual Inspection: Colour - Red/Black/Brown Texture - Gravel Odour - None Biota - None Anthropogenic Inputs - None
357036	BH36 2.5	Visual Inspection: Colour - Red/Black/Brown Texture - Gravel Odour - None Biota - None Anthropogenic Inputs - None
357037	BH36 3.0	Visual Inspection: Colour - Brown/Black Texture - Gravel Odour - None Biota - None Anthropogenic Inputs - None
357038	BH36 3.5	Visual Inspection: Colour - Brown/Black/Red Texture - Gravel Odour - None Biota - None Anthropogenic Inputs - None
357039	BH36 4.0	Visual Inspection: Colour - Black Texture - Mud/Stones/Sludge Odour - None Biota - None Anthropogenic Inputs - None
357040	BH37 .50	Visual Inspection: Colour - Red/Black/Brown Texture - Gravel Odour - None Biota - None Anthropogenic Inputs - None

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Comments

RPS Sample Number	Customer Number	Sample Comments
357041	BH37 1.0	Visual Inspection: Colour - Red/Black/Brown Texture - Gravel Odour - None Biota - None Anthropogenic Inputs - None
357042	BH37 1.5	Visual Inspection: Colour - Brown/Black Texture - Gravel Odour - None Biota - None Anthropogenic Inputs - None
357043	BH37 2.0	Visual Inspection: Colour - Red/Brown Texture - Gravel Odour - None Biota - None Anthropogenic Inputs - None
357044	BH37 2.5	Visual Inspection: Colour - Red/Brown Texture - Gravel Odour - None Biota - None Anthropogenic Inputs - None
357045	BH37 3.0	Visual Inspection: Colour - Grey Texture - Clay Odour - None Biota - None Anthropogenic Inputs - None
357046	BH37 3.5	Visual Inspection: Colour - Brown Texture - Gravel Odour - None Biota - None Anthropogenic Inputs - None
357047	BH37 4.0	Visual Inspection: Colour - Brown Texture - Rocks/Mud Odour - None Biota - None Anthropogenic Inputs - None
357048	BH38 0.50	Visual Inspection: Colour - Brown/Black Texture - Gravel Odour - None Biota - None Anthropogenic Inputs - None

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Customer Reference: 17-0769
Customer Order No: 1711-360

Comments

RPS Sample Number	Customer Number	Sample Comments
357049	BH38 1.0	Visual Inspection: Colour - Brown/Red Texture - Gravel Odour - None Biota - None Anthropogenic Inputs - None
357050	BH38 1.5	Visual Inspection: Colour - Brown/Grey Texture - Gravel Odour - None Biota - None Anthropogenic Inputs - None
357051	BH38 2.0	Visual Inspection: Colour - Red/Brown Texture - Gravel Odour - None Biota - None Anthropogenic Inputs - None
357052	BH38 2.5	Visual Inspection: Colour - Red/Brown/Grey Texture - Gravel Odour - None Biota - None Anthropogenic Inputs - None
357053	BH38 3.0	Visual Inspection: Colour - Red/Black Texture - Gravel Odour - None Biota - None Anthropogenic Inputs - None
357054	BH38 3.5	Visual Inspection: Colour - Black Texture - Sludge Odour - Sulphur Biota - None Anthropogenic Inputs - None
357055	BH39 2.0	Visual Inspection: Colour - Red/Brown Texture - Gravel Odour - None Biota - None Anthropogenic Inputs - None
357056	BH39 2.5	Visual Inspection: Colour - Grey Texture - Clay/Seashells/Rocks Odour - None Biota - None Anthropogenic Inputs - None

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Report No.: 18-69863-1
Customer Reference: 17-0769
Customer Order No: 1711-360

Comments

RPS Sample Number	Customer Number	Sample Comments
357057	BH39 3.0	Visual Inspection: Colour - Grey Texture - Clay Odour - None Biota - None Anthropogenic Inputs - None
357058	BH39 3.50	Visual Inspection: Colour - Grey Texture - Clay Odour - None Biota - None Anthropogenic Inputs - None
357059	BH39 .50	Visual Inspection: Colour - Red/Brown Texture - Gravel Odour - None Biota - None Anthropogenic Inputs - None
357060	BH39 1.0	Visual Inspection: Colour - Red/Grey Texture - Gravel Odour - None Biota - None Anthropogenic Inputs - None
357061	BH39 1.5	Visual Inspection: Colour - Red/Grey Texture - Gravel Odour - None Biota - None Anthropogenic Inputs - None

2 Shaftesbury Industrial Centre, Icknield Way, Letchworth Garden City, Hertfordshire, SG6 1HE
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Report Information

Key to Report Codes

U	UKAS Accredited
M	MCERTS Accredited
N	Not Accredited
S	Subcontracted to approved laboratory
US	Subcontracted to approved laboratory UKAS Accredited for the test
MS	Subcontracted to approved laboratory MCERTS/UKAS Accredited for the test
SI	Subcontracted to internal RPS Group Laboratory
USI	Subcontracted to internal RPS Group Laboratory UKAS Accredited for the test
MSI	Subcontracted to internal RPS Group Laboratory MCERTS/UKAS Accredited for the test
I/S (in results)	Insufficient Sample
U/S (in results)	Unsuitable Sample
S/C (in results)	See Comments
ND (in results)	Not Detected
DW (in units)	Results are expressed on a dry weight basis

Sample Retention and Disposal

Samples will generally* be retained for the following times prior to disposal:

Perishables, e.g. foodstuffs	1 month (if frozen) from the issue date of this report
Waters	2 weeks from the issue date of this report
Other Liquids	1 months from the issue date of this report
Solids (including Soils)	1 months from the issue date of this report

*Sample retention may be subject to agreement with the customer for particular projects

Analytical Methods

PAH's and PCB's	GCMS analysis following extraction of the wet sediment with DCM:acetone by ASE 350 extraction. Extract cleaned-up with silica and activated copper.
Metals	ICP-MS analysis following microwave assisted digestion in hydrofluoric acid of the dried (<30°C) and ground sediment.
TOC	Combustion and infrared analysis following carbonate removal with hydrochloric acid.
PSA	Wet and dry sieving followed by laser diffraction analysis.
Density	Determination of density from the dry sediment by gravimetric analysis of a known volume of sediment.
Dry solids at 105°C	A portion of the wet sediment is dried at 105°C to constant weight.
TBT and DBT	GCMS analysis following the extraction of the wet sediment and subsequent derivatisation.
Please note:	All testing carried out using the <2mm fraction

Laboratories

RPS Letchworth	UKAS Accreditation Laboratory No. 1663
RPS Manchester (Metals only)	UKAS Accreditation Laboratory No. 0605
Ocean Ecology PSA only	NMBAQC

RPS Letchworth and Manchester Laboratories participate in the QUASIMEME Proficiency Testing Scheme

APPENDIX F

Environmental laboratory test results

Chemtest
The right chemistry to deliver results
Chemtest Ltd.
Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070
Email: info@chemtest.co.uk

Final Report

Report No.:	18-06789-1
Initial Date of Issue:	15-Mar-2018
Client	Causeway Geotech Ltd
Client Address:	8 Drumahiskey Road Balnamore Ballymoney County Antrim BT53 7QL
Contact(s):	[Redacted]

Project	17-0769 Causeway Geotech Ltd Site Compound No. 1 Pier		
Quotation No.:	Q18-11997	**Date Received:**	12-Mar-2018
Order No.:		**Date Instructed:**	12-Mar-2018
No. of Samples:	48		
Turnaround (Wkdays):	4	**Results Due:**	15-Mar-2018
Date Approved:	15-Mar-2018		

Approved By:
[Redacted]

Results - Leachate

Project: 17-0769 Causeway Geotech Ltd Site Compound No. 1 Pier

Client: Causeway Geotech Ltd				**Chemtest Job No.:**	18-06789	18-06789	18-06789	18-06789	18-06789	18-06789	18-06789	18-06789	18-06789
Quotation No.: Q18-11997				**Chemtest Sample ID.:**	590203	590204	590205	590206	590207	590208	590209	590210	590211
Order No.:				Client Location ID.:	BH33	BH34	BH34	BH34	BH34	BH34	BH34	BH35	BH35
				Client Sample Ref.:	ES2	ES1	ES4	ES6	ES8	ES10	ES12	ES2	ES4
				Sample Type:	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
				Top Depth (m):	0.50	0.50	1.00	1.50	2.00	2.50	3.00	0.50	1.00
				Date Sampled:	01-Mar-2018	28-Feb-2018	28-Feb-2018	28-Feb-2018	28-Feb-2018	28-Feb-2018	28-Feb-2018	27-Feb-2018	27-Feb-2018
Determinand	**Accred.**	**SOP**	**Units**	**LOD**									
Arsenic (Dissolved)	U	1450	µg/l	1.0	3.0	2.7	2.5	2.1	1.8	1.4	< 1.0	< 1.0	1.0
Cadmium (Dissolved)	U	1450	µg/l	0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080
Chromium (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	400	2.4	1.2	47	8.8	< 1.0	240
Copper (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	2.4	1.5	1.3	1.1	< 1.0	< 1.0	1.1
Mercury (Dissolved)	U	1450	µg/l	0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Nickel (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	67	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	40
Lead (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Zinc (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	1.1	2.8	< 1.0	< 1.0	< 1.0	1.8
Total TPH >C6-C40	U	1670	µg/l	10	20	< 10	< 10	< 10	280	< 10	< 10	< 10	< 10
Naphthalene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Acenaphthylene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Acenaphthene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Fluorene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Phenanthrene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Anthracene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Fluoranthene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	9.3	< 0.10	< 0.10	< 0.10	< 0.10
Pyrene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	8.2	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[a]anthracene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Chrysene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[b]fluoranthene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[k]fluoranthene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[a]pyrene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Indeno(1,2,3-c,d)Pyrene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Dibenz(a,h)Anthracene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[g,h,i]perylene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Of 16 PAH's	U	1700	µg/l	2.0	< 2.0	< 2.0	< 2.0	< 2.0	18	< 2.0	< 2.0	< 2.0	< 2.0
Tributyl Tin	N	1730	µg/l	0.0500	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
PCB 28	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PCB 52	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PCB 90+101	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PCB 118	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PCB 153	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PCB 138	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PCB 180	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Total PCBs (7 congeners)	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010

Chemtest
The right chemistry to deliver results

Results - Leachate

Project: 17-0769 Causeway Geotech Ltd Site Compound No. 1 Pier

Client: Causeway Geotech Ltd				**Chemtest Job No.:**	18-06789	18-06789	18-06789	18-06789	18-06789	18-06789	18-06789	18-06789	18-06789
Quotation No.: Q18-11997				**Chemtest Sample ID.:**	590212	590213	590214	590215	590216	590217	590218	590219	590220
Order No.:				Client Location ID.:	BH35	BH35	BH35	BH35	BH35	BH35	BH38	BH38	BH38
				Client Sample Ref.:	ES6	ES8	ES10	ES12	ES14	ES25	ES21	ES2	ES23
				Sample Type:	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
				Top Depth (m):	1.50	2.00	2.50	3.00	3.50	4.00	0.50	1.00	1.50
				Date Sampled:	27-Feb-2018	27-Feb-2018	27-Feb-2018	27-Feb-2018	27-Feb-2018	27-Feb-2018	15-Feb-2018	15-Feb-2018	15-Feb-2018
Determinand	**Accred.**	**SOP**	**Units**	**LOD**									
Arsenic (Dissolved)	U	1450	µg/l	1.0	< 1.0	4.0	2.6	1.2	1.3	< 1.0	< 1.0	< 1.0	< 1.0
Cadmium (Dissolved)	U	1450	µg/l	0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080
Chromium (Dissolved)	U	1450	µg/l	1.0	< 1.0	1.4	< 1.0	< 1.0	1.1	< 1.0	< 1.0	< 1.0	< 1.0
Copper (Dissolved)	U	1450	µg/l	1.0	< 1.0	1.1	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	1.1
Mercury (Dissolved)	U	1450	µg/l	0.50	0.52	0.66	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Nickel (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Lead (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Zinc (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Total TPH >C6-C40	U	1670	µg/l	10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Naphthalene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Acenaphthylene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Acenaphthene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Fluorene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Phenanthrene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Anthracene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Fluoranthene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Pyrene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[a]anthracene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Chrysene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[b]fluoranthene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[k]fluoranthene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[a]pyrene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Indeno(1,2,3-c,d)Pyrene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Dibenz(a,h)Anthracene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[g,h,i]perylene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Of 16 PAH's	U	1700	µg/l	2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Tributyl Tin	N	1730	µg/l	0.0500	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
PCB 28	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PCB 52	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PCB 90+101	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PCB 118	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PCB 153	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PCB 138	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PCB 180	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Total PCBs (7 congeners)	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010

Chemtest
The right chemistry to deliver results

Results - Leachate

Project: 17-0769 Causeway Geotech Ltd Site Compound No. 1 Pier

Client: Causeway Geotech Ltd	**Chemtest Job No.:**				18-06789	18-06789	18-06789	18-06789	18-06789	18-06789	18-06789	18-06789	18-06789
Quotation No.: Q18-11997	**Chemtest Sample ID.:**				590221	590222	590223	590224	590225	590226	590227	590228	590229
Order No.:	Client Location ID.:				BH38	BH38	BH38	BH38	BH39	BH39	BH39	BH39	BH39
	Client Sample Ref.:				ES4	ES25	ES6	ES27	ES17	ES19	ES21	ES23	ES25
	Sample Type:				SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
	Top Depth (m):				2.00	2.50	3.00	3.50	0.50	1.00	1.50	2.00	2.50
	Date Sampled:				15-Feb-2018	15-Feb-2018	15-Feb-2018	15-Feb-2018	20-Feb-2018	20-Feb-2018	20-Feb-2018	20-Feb-2018	20-Feb-2018
Determinand	**Accred.**	**SOP**	**Units**	**LOD**									
Arsenic (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	1.1	< 1.0	< 1.0	< 1.0	< 1.0	1.9
Cadmium (Dissolved)	U	1450	µg/l	0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080
Chromium (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	1.5	< 1.0	< 1.0	< 1.0	< 1.0	4.5
Copper (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	1.2	< 1.0	< 1.0	< 1.0	< 1.0	1.9
Mercury (Dissolved)	U	1450	µg/l	0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Nickel (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Lead (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Zinc (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Total TPH >C6-C40	U	1670	µg/l	10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Naphthalene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Acenaphthylene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Acenaphthene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Fluorene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Phenanthrene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Anthracene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Fluoranthene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Pyrene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[a]anthracene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Chrysene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[b]fluoranthene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[k]fluoranthene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[a]pyrene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Indeno(1,2,3-c,d)Pyrene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Dibenz(a,h)Anthracene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[g,h,i]perylene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Of 16 PAH's	U	1700	µg/l	2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Tributyl Tin	N	1730	µg/l	0.0500	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
PCB 28	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PCB 52	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PCB 90+101	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PCB 118	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PCB 153	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PCB 138	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PCB 180	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Total PCBs (7 congeners)	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010

Results - Leachate

Project: 17-0769 Causeway Geotech Ltd Site Compound No. 1 Pier

Client: Causeway Geotech Ltd				**Chemtest Job No.:**	18-06789	18-06789	18-06789	18-06789	18-06789	18-06789	18-06789	18-06789	18-06789
Quotation No.: Q18-11997				**Chemtest Sample ID.:**	590230	590231	590232	590233	590234	590235	590236	590237	590238
Order No.:				Client Location ID.:	BH39	BH39	BH40	BH40	BH40	BH36	BH36	BH36	BH36
				Client Sample Ref.:	ES27	ES29	ES1	ES2	ES3	ES2	ES4	ES6	ES8
				Sample Type:	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
				Top Depth (m):	3.00	3.50	0.50	1.00	1.50	0.50	1.00	1.50	2.00
				Date Sampled:	20-Feb-2018	20-Feb-2018	02-Mar-2018	02-Mar-2018	02-Mar-2018	24-Feb-2018	24-Feb-2018	24-Feb-2018	24-Feb-2018
Determinand	**Accred.**	**SOP**	**Units**	**LOD**									
Arsenic (Dissolved)	U	1450	µg/l	1.0	4.6	1.9	3.6	4.7	4.5	< 1.0	1.4	< 1.0	< 1.0
Cadmium (Dissolved)	U	1450	µg/l	0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080
Chromium (Dissolved)	U	1450	µg/l	1.0	8.2	1.9	2.4	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Copper (Dissolved)	U	1450	µg/l	1.0	2.7	2.7	4.2	5.4	1.8	< 1.0	< 1.0	< 1.0	< 1.0
Mercury (Dissolved)	U	1450	µg/l	0.50	< 0.50	< 0.50	< 0.50	1.2	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Nickel (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Lead (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Zinc (Dissolved)	U	1450	µg/l	1.0	1.3	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Total TPH >C6-C40	U	1670	µg/l	10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	140
Naphthalene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Acenaphthylene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Acenaphthene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Fluorene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Phenanthrene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Anthracene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Fluoranthene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Pyrene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[a]anthracene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Chrysene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[b]fluoranthene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[k]fluoranthene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[a]pyrene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Indeno(1,2,3-c,d)Pyrene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Dibenz(a,h)Anthracene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[g,h,i]perylene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Of 16 PAH's	U	1700	µg/l	2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Tributyl Tin	N	1730	µg/l	0.0500	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
PCB 28	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PCB 52	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PCB 90+101	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PCB 118	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PCB 153	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PCB 138	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PCB 180	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Total PCBs (7 congeners)	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010

Chemtest
The right chemistry to deliver results

Results - Leachate

Project: 17-0769 Causeway Geotech Ltd Site Compound No. 1 Pier

Client: Causeway Geotech Ltd				**Chemtest Job No.:**	18-06789	18-06789	18-06789	18-06789	18-06789	18-06789	18-06789	18-06789	18-06789
Quotation No.: Q18-11997				**Chemtest Sample ID.:**	590239	590240	590241	590242	590243	590244	590245	590246	590247
Order No.:				Client Location ID.:	BH36	BH36	BH36	BH36	BH37	BH37	BH37	BH37	BH37
				Client Sample Ref.:	ES10	ES12	ES14	ES16	ES2	ES4	ES6	ES8	ES10
				Sample Type:	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
				Top Depth (m):	2.50	3.00	3.50	4.00	0.50	1.00	1.50	2.00	2.50
				Date Sampled:	24-Feb-2018	24-Feb-2018	24-Feb-2018	24-Feb-2018	23-Feb-2018	23-Feb-2018	23-Feb-2018	23-Feb-2018	23-Feb-2018
Determinand	**Accred.**	**SOP**	**Units**	**LOD**									
Arsenic (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	6.2	< 1.0	< 1.0	< 1.0	< 1.0	1.3
Cadmium (Dissolved)	U	1450	µg/l	0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080
Chromium (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	7.3	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Copper (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	2.1	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Mercury (Dissolved)	U	1450	µg/l	0.50	< 0.50	< 0.50	< 0.50	1.2	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Nickel (Dissolved)	U	1450	µg/l	1.0	< 1.0	2.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Lead (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Zinc (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Total TPH >C6-C40	U	1670	µg/l	10	< 10	84	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Naphthalene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Acenaphthylene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Acenaphthene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Fluorene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Phenanthrene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Anthracene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Fluoranthene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Pyrene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[a]anthracene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Chrysene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[b]fluoranthene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[k]fluoranthene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[a]pyrene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Indeno(1,2,3-c,d)Pyrene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Dibenz(a,h)Anthracene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[g,h,i]perylene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Of 16 PAH's	U	1700	µg/l	2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Tributyl Tin	N	1730	µg/l	0.0500	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
PCB 28	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PCB 52	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PCB 90+101	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PCB 118	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PCB 153	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PCB 138	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PCB 180	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Total PCBs (7 congeners)	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010

Results - Leachate

Project: 17-0769 Causeway Geotech Ltd Site Compound No. 1 Pier

Client: Causeway Geotech Ltd				**Chemtest Job No.:**	18-06789	18-06789	18-06789
Quotation No.: Q18-11997				**Chemtest Sample ID.:**	590248	590249	590250
Order No.:				Client Location ID.:	BH37	BH37	BH37
				Client Sample Ref.:	ES12	ES27	ES29
				Sample Type:	SOIL	SOIL	SOIL
				Top Depth (m):	3.00	3.50	4.00
				Date Sampled:	23-Feb-2018	23-Feb-2018	23-Feb-2018
Determinand	**Accred.**	**SOP**	**Units**	**LOD**			
Arsenic (Dissolved)	U	1450	µg/l	1.0	3.1	< 1.0	< 1.0
Cadmium (Dissolved)	U	1450	µg/l	0.080	< 0.080	< 0.080	< 0.080
Chromium (Dissolved)	U	1450	µg/l	1.0	4.3	< 1.0	1.2
Copper (Dissolved)	U	1450	µg/l	1.0	1.5	< 1.0	< 1.0
Mercury (Dissolved)	U	1450	µg/l	0.50	< 0.50	< 0.50	< 0.50
Nickel (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0
Lead (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0
Zinc (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0
Total TPH >C6-C40	U	1670	µg/l	10	< 10	< 10	< 10
Naphthalene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10
Acenaphthylene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10
Acenaphthene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10
Fluorene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10
Phenanthrene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10
Anthracene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10
Fluoranthene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10
Pyrene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10
Benzo[a]anthracene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10
Chrysene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10
Benzo[b]fluoranthene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10
Benzo[k]fluoranthene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10
Benzo[a]pyrene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10
Indeno(1,2,3-c,d)Pyrene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10
Dibenz(a,h)Anthracene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10
Benzo[g,h,i]perylene	U	1700	µg/l	0.10	< 0.10	< 0.10	< 0.10
Total Of 16 PAH's	U	1700	µg/l	2.0	< 2.0	< 2.0	< 2.0
Tributyl Tin	N	1730	µg/l	0.0500	< 0.050	< 0.050	< 0.050
PCB 28	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010
PCB 52	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010
PCB 90+101	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010
PCB 118	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010
PCB 153	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010
PCB 138	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010
PCB 180	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010
Total PCBs (7 congeners)	N	1815	µg/l	0.010	< 0.010	< 0.010	< 0.010

Report Information

Key

U	UKAS accredited
M	MCERTS and UKAS accredited
N	Unaccredited
S	This analysis has been subcontracted to a UKAS accredited laboratory that is accredited for this analysis
SN	This analysis has been subcontracted to a UKAS accredited laboratory that is not accredited for this analysis
T	This analysis has been subcontracted to an unaccredited laboratory
I/S	Insufficient Sample
U/S	Unsuitable Sample
N/E	not evaluated
<	"less than"
>	"greater than"

Comments or interpretations are beyond the scope of UKAS accreditation
The results relate only to the items tested
Uncertainty of measurement for the determinands tested are available upon request
None of the results in this report have been recovery corrected
All results are expressed on a dry weight basis
The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols
For all other tests the samples were dried at < 37°C prior to analysis
All Asbestos testing is performed at the indicated laboratory
Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

A - Date of sampling not supplied
B - Sample age exceeds stability time (sampling to extraction)
C - Sample not received in appropriate containers
D - Broken Container
E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

Sample Retention and Disposal

All soil samples will be retained for a period of 45 days from the date of receipt
All water samples will be retained for 14 days from the date of receipt
Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:
customerservices@chemtest.co.uk

Chemtest
The right chemistry to deliver results
Chemtest Ltd.
Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070
Email: info@chemtest.co.uk

UKAS TESTING 2183

Final Report

Report No.:	18-06794-1
Initial Date of Issue:	21-Mar-2018
Client	Causeway Geotech Ltd
Client Address:	8 Drumahiskey Road Balnamore Ballymoney County Antrim BT53 7QL
Contact(s):	[Redacted]

Project	17-0769 Causeway Geotech Ltd Site Compound No. 1 Pier		
Quotation No.:	Q18-11997	**Date Received:**	12-Mar-2018
Order No.:		**Date Instructed:**	12-Mar-2018
No. of Samples:	4		
Turnaround (Wkdays):	7	**Results Due:**	20-Mar-2018
Date Approved:	20-Mar-2018		

Approved By:

[Redacted]

Results - 2 Stage WAC

Project: 17-0769 Causeway Geotech Ltd Site Compound No. 1 Pier

							Landfill Waste Acceptance Criteria Limits		
Chemtest Job No:	18-06794						**Inert Waste Landfill**	**Stable, Non-reactive hazardous waste in non-hazardous Landfill**	**Hazardous Waste Landfill**
Chemtest Sample ID:	590284								
Sample Location ID:	BH35								
Sample Ref:	ES2								
Top Depth(m):	0.50								
Bottom Depth(m):									
Sampling Date:	27-Feb-2018								
Determinand	**SOP**	**Accred.**	**Units**						
Total Organic Carbon	2625	U	%			< 0.20	3	5	6
Loss On Ignition	2610	U	%			0.73	--	--	10
Total BTEX	2760	U	mg/kg			< 0.010	6	--	--
Total PCBs (7 Congeners)	2815	U	mg/kg			< 0.10	1	--	--
TPH Total WAC (Mineral Oil)	2670	U	mg/kg			< 10	500	--	--
Total (Of 17) PAH's	2700	N	mg/kg			< 2.0	100	--	--
pH	2010	U				9.4	--	>6	--
Acid Neutralisation Capacity	2015	N	mol/kg			0.0060	--	To evaluate	To evaluate
Eluate Analysis			**2:1 mg/l**	**8:1 mg/l**	**2:1 mg/kg**	**Cumulative mg/kg 10:1**	**Limit values for compliance leaching test using BS EN 12457 at L/S 10 l/kg**		
Arsenic	1450	U	0.013	0.0060	< 0.050	0.069	0.5	2	25
Barium	1450	U	0.016	0.066	< 0.50	0.60	20	100	300
Cadmium	1450	U	< 0.00010	< 0.00010	< 0.010	< 0.010	0.04	1	5
Chromium	1450	U	0.0026	0.0032	< 0.050	< 0.050	0.5	10	70
Copper	1450	U	0.0023	0.0035	< 0.050	< 0.050	2	50	100
Mercury	1450	U	< 0.00050	< 0.00050	< 0.0010	< 0.0050	0.01	0.2	2
Molybdenum	1450	U	0.0029	< 0.0010	< 0.050	< 0.050	0.5	10	30
Nickel	1450	U	< 0.0010	< 0.0010	< 0.050	< 0.050	0.4	10	40
Lead	1450	U	< 0.0010	0.0024	< 0.010	0.021	0.5	10	50
Antimony	1450	U	< 0.0010	< 0.0010	< 0.010	< 0.010	0.06	0.7	5
Selenium	1450	U	0.0017	< 0.0010	< 0.010	< 0.010	0.1	0.5	7
Zinc	1450	U	< 0.0010	0.0035	< 0.50	< 0.50	4	50	200
Chloride	1220	U	67	16	130	230	800	15000	25000
Fluoride	1220	U	0.24	0.18	< 1.0	1.9	10	150	500
Sulphate	1220	U	19	6.9	38	85	1000	20000	50000
Total Dissolved Solids	1020	N	200	46	400	660	4000	60000	100000
Phenol Index	1920	U	< 0.030	< 0.030	< 0.30	< 0.50	1	-	-
Dissolved Organic Carbon	1610	U	10	9.4	< 50	95	500	800	1000

Solid Information	
Dry mass of test portion/kg	0.175
Moisture (%)	0.93

Leachate Test Information	
Leachant volume 1st extract/l	0.348
Leachant volume 2nd extract/l	1.400
Eluant recovered from 1st extract/l	0.226

Waste Acceptance Criteria

Landfill WAC analysis (specifically leaching test results) must not be used for hazardous waste classification purposes. This analysis is only applicable for hazardous waste landfill acceptance and does not give any indication as to whether a waste may be hazardous or non-hazardous.

Chemtest
The right chemistry to deliver results

Results - 2 Stage WAC

Project: 17-0769 Causeway Geotech Ltd Site Compound No. 1 Pier

							Landfill Waste Acceptance Criteria Limits		
Chemtest Job No:	18-06794						**Inert Waste Landfill**	**Stable, Non-reactive hazardous waste in non-hazardous Landfill**	**Hazardous Waste Landfill**
Chemtest Sample ID:	590285								
Sample Location ID:	BH39								
Sample Ref:	ES21								
Top Depth(m):	1.50								
Bottom Depth(m):									
Sampling Date:	20-Feb-2018								
Determinand	**SOP**	**Accred.**	**Units**						
Total Organic Carbon	2625	U	%			< 0.20	3	5	6
Loss On Ignition	2610	U	%			0.45	--	--	10
Total BTEX	2760	U	mg/kg			< 0.010	6	--	--
Total PCBs (7 Congeners)	2815	U	mg/kg			< 0.10	1	--	--
TPH Total WAC (Mineral Oil)	2670	U	mg/kg			< 10	500	--	--
Total (Of 17) PAH's	2700	N	mg/kg			< 2.0	100	--	--
pH	2010	U				9.2	--	>6	--
Acid Neutralisation Capacity	2015	N	mol/kg			0.0040	--	To evaluate	To evaluate
Eluate Analysis			**2:1 mg/l**	**8:1 mg/l**	**2:1 mg/kg**	**Cumulative mg/kg 10:1**	**Limit values for compliance leaching test using BS EN 12457 at L/S 10 l/kg**		
Arsenic	1450	U	0.0056	0.0042	< 0.050	< 0.050	0.5	2	25
Barium	1450	U	0.0088	0.018	< 0.50	< 0.50	20	100	300
Cadmium	1450	U	< 0.00010	< 0.00010	< 0.010	< 0.010	0.04	1	5
Chromium	1450	U	0.0037	0.0025	< 0.050	< 0.050	0.5	10	70
Copper	1450	U	0.0015	0.0021	< 0.050	< 0.050	2	50	100
Mercury	1450	U	< 0.00050	< 0.00050	< 0.0010	< 0.0050	0.01	0.2	2
Molybdenum	1450	U	0.0024	< 0.0010	< 0.050	< 0.050	0.5	10	30
Nickel	1450	U	< 0.0010	< 0.0010	< 0.050	< 0.050	0.4	10	40
Lead	1450	U	< 0.0010	0.0013	< 0.010	0.010	0.5	10	50
Antimony	1450	U	< 0.0010	< 0.0010	< 0.010	< 0.010	0.06	0.7	5
Selenium	1450	U	0.0027	< 0.0010	< 0.010	< 0.010	0.1	0.5	7
Zinc	1450	U	0.0016	0.0048	< 0.50	< 0.50	4	50	200
Chloride	1220	U	240	12	480	570	800	15000	25000
Fluoride	1220	U	0.41	0.15	< 1.0	2.0	10	150	500
Sulphate	1220	U	39	4.0	78	110	1000	20000	50000
Total Dissolved Solids	1020	N	500	61	1000	1500	4000	60000	100000
Phenol Index	1920	U	< 0.030	< 0.030	< 0.30	< 0.50	1	-	-
Dissolved Organic Carbon	1610	U	8.3	7.0	< 50	73	500	800	1000

Solid Information	
Dry mass of test portion/kg	0.175
Moisture (%)	0.79

Leachate Test Information	
Leachant volume 1st extract/l	0.349
Leachant volume 2nd extract/l	1.400
Eluant recovered from 1st extract/l	0.345

Waste Acceptance Criteria

Landfill WAC analysis (specifically leaching test results) must not be used for hazardous waste classification purposes. This analysis is only applicable for hazardous waste landfill acceptance and does not give any indication as to whether a waste may be hazardous or non-hazardous.

Chemtest
The right chemistry to deliver results

Results - 2 Stage WAC

Project: 17-0769 Causeway Geotech Ltd Site Compound No. 1 Pier

Chemtest Job No:	18-06794						Landfill Waste Acceptance Criteria Limits		
Chemtest Sample ID:	590286								
Sample Location ID:	BH40						Inert Waste Landfill	Stable, Non-reactive hazardous waste in non-hazardous Landfill	Hazardous Waste Landfill
Sample Ref:	ES1								
Top Depth(m):	0.50								
Bottom Depth(m):									
Sampling Date:	02-Mar-2018								
Determinand	**SOP**	**Accred.**	**Units**						
Total Organic Carbon	2625	U	%			< 0.20	3	5	6
Loss On Ignition	2610	U	%			1.1	--	--	10
Total BTEX	2760	U	mg/kg			< 0.010	6	--	--
Total PCBs (7 Congeners)	2815	U	mg/kg			< 0.10	1	--	--
TPH Total WAC (Mineral Oil)	2670	U	mg/kg			< 10	500	--	--
Total (Of 17) PAH's	2700	N	mg/kg			< 2.0	100	--	--
pH	2010	U				9.2	--	>6	--
Acid Neutralisation Capacity	2015	N	mol/kg			0.026	--	To evaluate	To evaluate
Eluate Analysis			**2:1 mg/l**	**8:1 mg/l**	**2:1 mg/kg**	**Cumulative mg/kg 10:1**	**Limit values for compliance leaching test using BS EN 12457 at L/S 10 l/kg**		
Arsenic	1450	U	0.014	0.017	< 0.050	0.17	0.5	2	25
Barium	1450	U	0.011	0.0024	< 0.50	< 0.50	20	100	300
Cadmium	1450	U	< 0.00010	< 0.00010	< 0.010	< 0.010	0.04	1	5
Chromium	1450	U	0.017	0.0081	< 0.050	0.096	0.5	10	70
Copper	1450	U	0.0054	0.0044	< 0.050	< 0.050	2	50	100
Mercury	1450	U	< 0.00050	< 0.00050	< 0.0010	< 0.0050	0.01	0.2	2
Molybdenum	1450	U	0.053	0.0078	0.11	0.16	0.5	10	30
Nickel	1450	U	< 0.0010	< 0.0010	< 0.050	< 0.050	0.4	10	40
Lead	1450	U	< 0.0010	< 0.0010	< 0.010	< 0.010	0.5	10	50
Antimony	1450	U	0.0026	0.0012	< 0.010	0.014	0.06	0.7	5
Selenium	1450	U	0.011	0.0022	0.022	0.037	0.1	0.5	7
Zinc	1450	U	0.0047	0.0038	< 0.50	< 0.50	4	50	200
Chloride	1220	U	1000	87	2100	2500	800	15000	25000
Fluoride	1220	U	3.1	0.68	6.2	11	10	150	500
Sulphate	1220	U	180	23	350	500	1000	20000	50000
Total Dissolved Solids	1020	N	2000	180	4000	5000	4000	60000	100000
Phenol Index	1920	U	< 0.030	< 0.030	< 0.30	< 0.50	1	-	-
Dissolved Organic Carbon	1610	U	8.1	8.0	< 50	80	500	800	1000

Solid Information	
Dry mass of test portion/kg	0.175
Moisture (%)	6.7

Leachate Test Information	
Leachant volume 1st extract/l	0.337
Leachant volume 2nd extract/l	1.400
Eluant recovered from 1st extract/l	0.304

Waste Acceptance Criteria

Landfill WAC analysis (specifically leaching test results) must not be used for hazardous waste classification purposes. This analysis is only applicable for hazardous waste landfill acceptance and does not give any indication as to whether a waste may be hazardous or non-hazardous.

Chemtest
The right chemistry to deliver results

Results - 2 Stage WAC

Project: 17-0769 Causeway Geotech Ltd Site Compound No. 1 Pier

Chemtest Job No:	18-06794						Landfill Waste Acceptance Criteria Limits		
Chemtest Sample ID:	590287								
Sample Location ID:	BH37						Inert Waste Landfill	Stable, Non-reactive hazardous waste in non-hazardous Landfill	Hazardous Waste Landfill
Sample Ref:	ES4								
Top Depth(m):	1.00								
Bottom Depth(m):									
Sampling Date:	23-Feb-2018								
Determinand	SOP	Accred.	Units						
Total Organic Carbon	2625	U	%			< 0.20	3	5	6
Loss On Ignition	2610	U	%			0.69	--	--	10
Total BTEX	2760	U	mg/kg			< 0.010	6	--	--
Total PCBs (7 Congeners)	2815	U	mg/kg			< 0.10	1	--	--
TPH Total WAC (Mineral Oil)	2670	U	mg/kg			< 10	500	--	--
Total (Of 17) PAH's	2700	N	mg/kg			< 2.0	100	--	--
pH	2010	U				8.8	--	>6	--
Acid Neutralisation Capacity	2015	N	mol/kg			0.034	--	To evaluate	To evaluate
Eluate Analysis			2:1 mg/l	8:1 mg/l	2:1 mg/kg	Cumulative mg/kg 10:1	Limit values for compliance leaching test using BS EN 12457 at L/S 10 l/kg		
Arsenic	1450	U	0.0093	0.0035	< 0.050	< 0.050	0.5	2	25
Barium	1450	U	0.052	0.0062	< 0.50	< 0.50	20	100	300
Cadmium	1450	U	< 0.00010	< 0.00010	< 0.010	< 0.010	0.04	1	5
Chromium	1450	U	0.020	0.0053	< 0.050	0.080	0.5	10	70
Copper	1450	U	0.0047	< 0.0010	< 0.050	< 0.050	2	50	100
Mercury	1450	U	< 0.00050	< 0.00050	< 0.0010	< 0.0050	0.01	0.2	2
Molybdenum	1450	U	0.0063	< 0.0010	< 0.050	< 0.050	0.5	10	30
Nickel	1450	U	< 0.0010	< 0.0010	< 0.050	< 0.050	0.4	10	40
Lead	1450	U	< 0.0010	< 0.0010	< 0.010	< 0.010	0.5	10	50
Antimony	1450	U	0.0013	< 0.0010	< 0.010	< 0.010	0.06	0.7	5
Selenium	1450	U	0.011	< 0.0010	0.022	0.020	0.1	0.5	7
Zinc	1450	U	0.0061	< 0.0010	< 0.50	< 0.50	4	50	200
Chloride	1220	U	890	45	1800	2000	800	15000	25000
Fluoride	1220	U	0.38	0.12	< 1.0	1.7	10	150	500
Sulphate	1220	U	130	9.5	260	320	1000	20000	50000
Total Dissolved Solids	1020	N	1700	110	3400	4100	4000	60000	100000
Phenol Index	1920	U	< 0.030	< 0.030	< 0.30	< 0.50	1	-	-
Dissolved Organic Carbon	1610	U	7.1	7.0	< 50	70	500	800	1000

Solid Information	
Dry mass of test portion/kg	0.175
Moisture (%)	6.8

Leachate Test Information	
Leachant volume 1st extract/l	0.337
Leachant volume 2nd extract/l	1.400
Eluant recovered from 1st extract/l	0.326

Waste Acceptance Criteria

Landfill WAC analysis (specifically leaching test results) must not be used for hazardous waste classification purposes. This analysis is only applicable for hazardous waste landfill acceptance and does not give any indication as to whether a waste may be hazardous or non-hazardous.

Report Information

Key

U	UKAS accredited
M	MCERTS and UKAS accredited
N	Unaccredited
S	This analysis has been subcontracted to a UKAS accredited laboratory that is accredited for this analysis
SN	This analysis has been subcontracted to a UKAS accredited laboratory that is not accredited for this analysis
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U/S	Unsuitable Sample
N/E	not evaluated
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>	"greater than"

Comments or interpretations are beyond the scope of UKAS accreditation
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All results are expressed on a dry weight basis
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For all other tests the samples were dried at < 37°C prior to analysis
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Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

A - Date of sampling not supplied
B - Sample age exceeds stability time (sampling to extraction)
C - Sample not received in appropriate containers
D - Broken Container
E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

Sample Retention and Disposal

All soil samples will be retained for a period of 45 days from the date of receipt
All water samples will be retained for 14 days from the date of receipt
Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:
customerservices@chemtest.co.uk

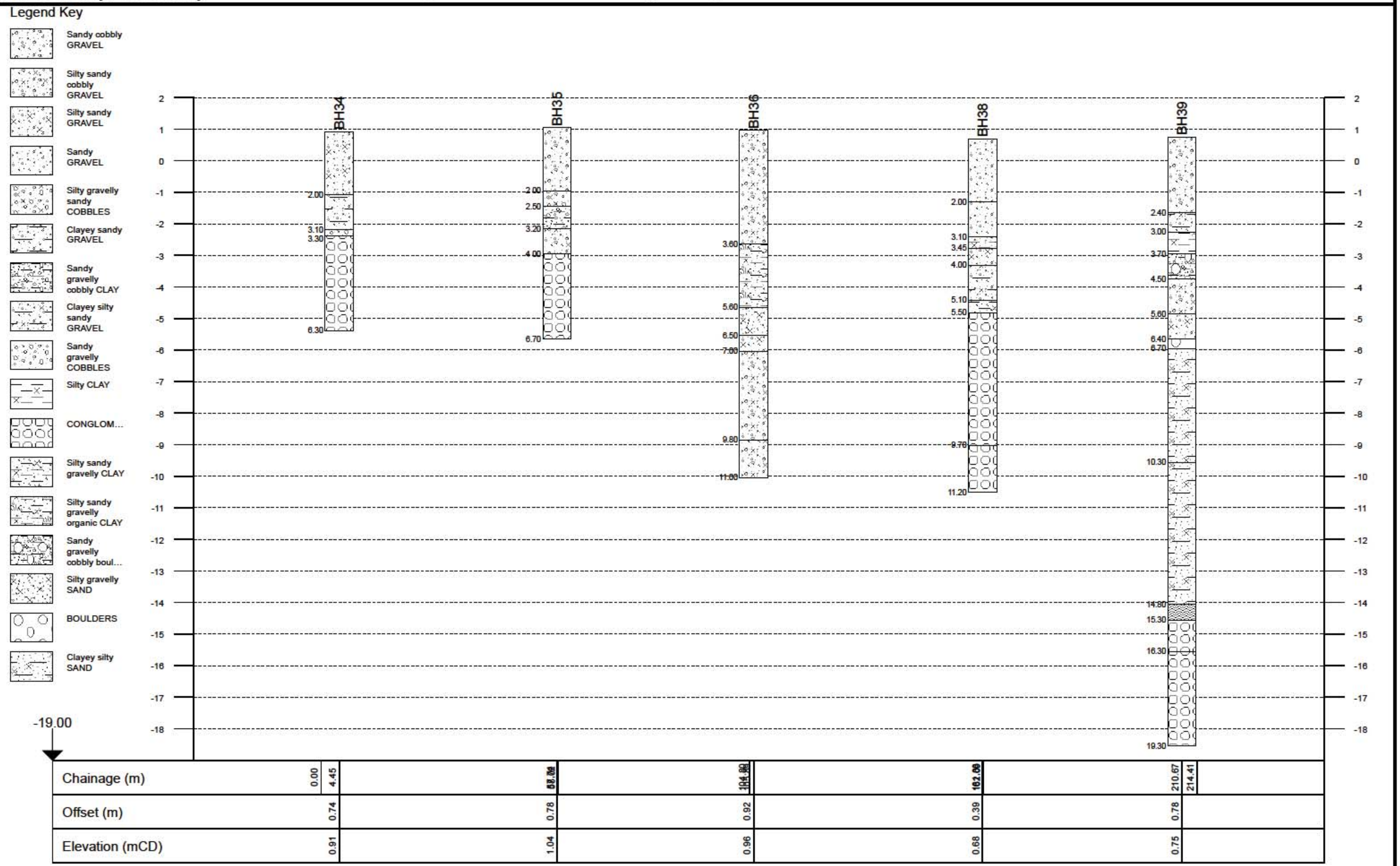
CAUSEWAY GEOTECH

APPENDIX G

Geological long sections

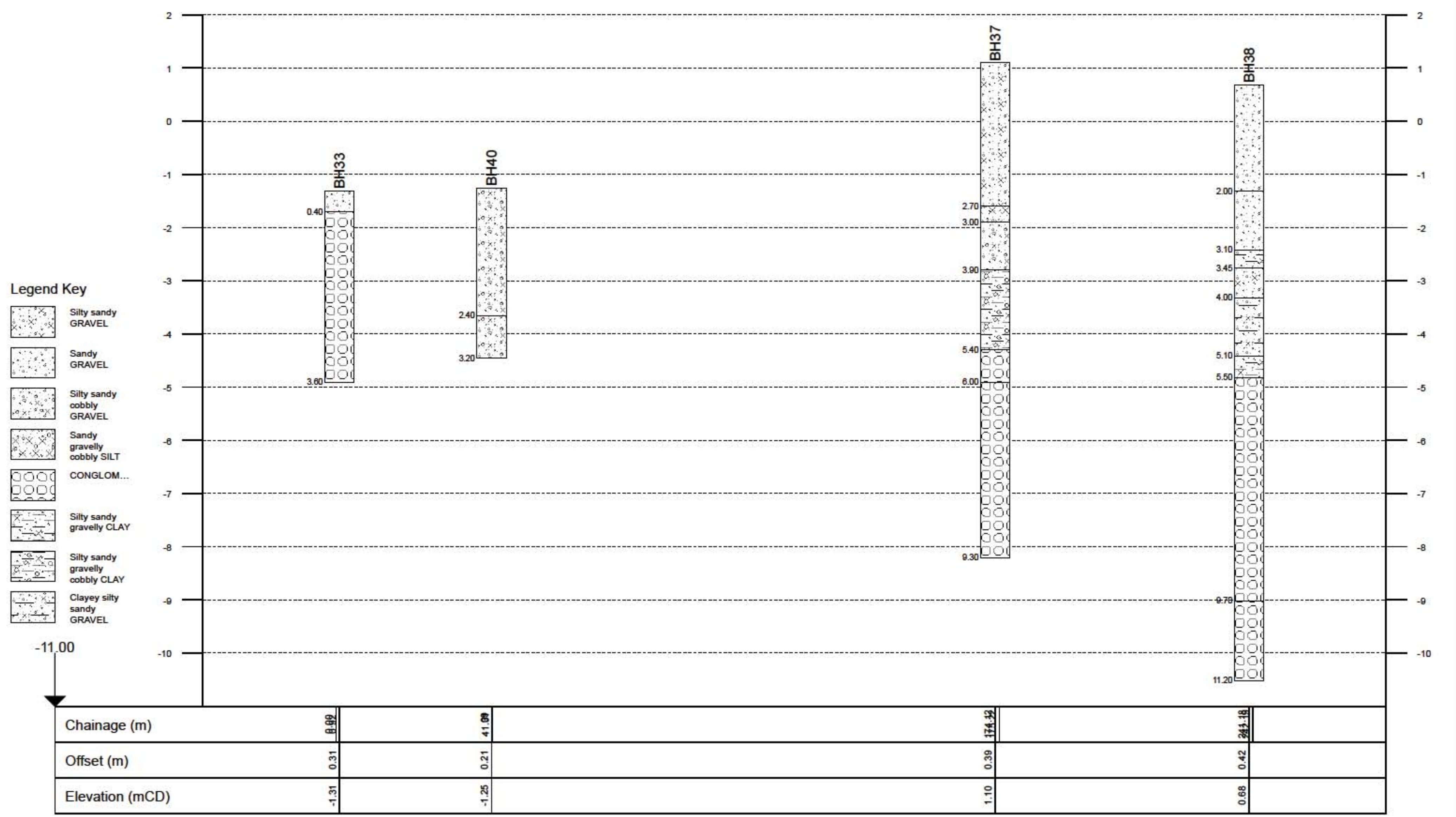
Project Id: 17-0769b
Project Title: Stornoway Deep Water Berth G.I.
Location: Newton Basin
Client: Stornoway Port Authority

Title: Section 1 - North to South Transect
Vertical Scale: 1:161
Horizontal Scale: 1:1242
Engineer: Wallace Stone Consulting Civil Engineers



Project Id: 17-0769b
Project Title: Stornoway Deep Water Berth G.I.
Location: Newton Basin
Client: Stornoway Port Authority

Title: Section 2 - West to East Transect
Vertical Scale: 1:100
Horizontal Scale: 1:1403
Engineer: Wallace Stone Consulting Civil Engineers



APPENDIX H

SPT hammer energy measurement report

SPT Calibration Report

www.equipegroup.com

Hammer Energy Measurement Report

Type of Hammer	SPT HAMMER
Client	CAUSEWAY GEOTECH
Test No	EQU1763
Test Depth (m)	7.50
Date of Test	18 February 2017
Valid until	18 February 2018
Hammer ID	EQU1763

Mass of the hammer	m = 63.5kg
Falling height	h = 0.76m
E_{theor} =	$m \times g \times h$ = 473J

Characteristics of the instrumented rod

Diameter	d_r = 0.052 m
Length of the instrumented rod	0.558 m
Area	A = 11.61 cm^2
Modulus	E_a = 206843 MPa

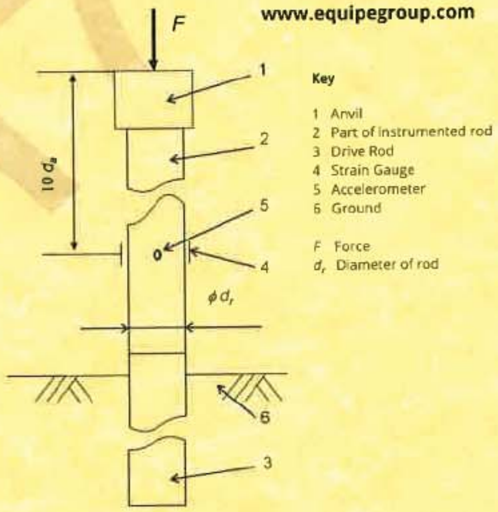
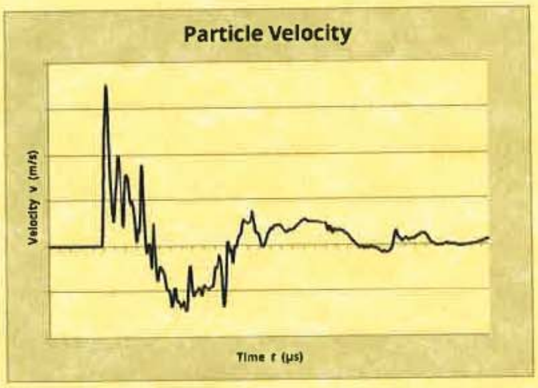
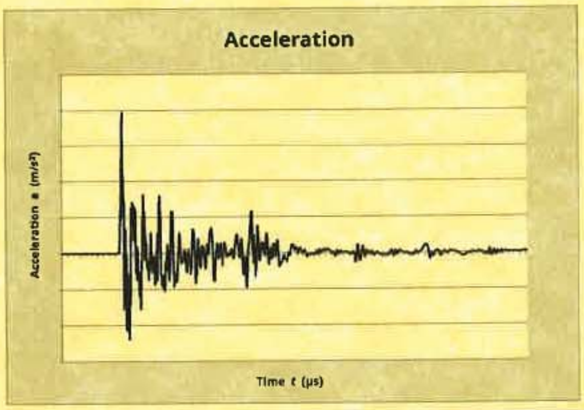
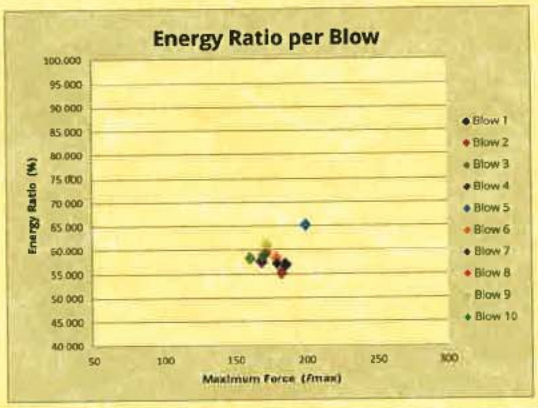


Fig. B.1 and B.2 BS EN ISO 22476-3 : 2005 + A1 : 2011







Observations:

1.

E_{meas} = **0.277** kN-m

E_{theor} = **0.473** kN-m

Energy Ratio (E_r) = $\frac{E_{meas}}{E_{theor}}$ 58.61%

Equipe SPT Analyzer Operators: AF

Prepared by:	[Redacted]	**Checked by:**	[Redacted]	**Date**	**02/03/2017**

 Equipe Group, The Paddocks, Home Farm Offices, The Upton Estate, Banbury, Oxfordshire, OX15 6HU
Tel: +44 (0)1295 670990 Fax: +44 (0)1295 678232 Email: info@equipegroup.com

Technical Appendix 8.2

Newton Basin Stornoway Marina Development Hydraulic Modelling Report

DOCUMENT CONTROL SHEET

Client	Stornoway Port Authority					
Project Title	Newton Basin Marina Development – Hydraulic Modelling					
Document Title	Report					
Document No.	IBE1434 - NB					
This Document Comprises	DCS	TOC	Text	List of Tables	List of Figures	No. of Appendices
	1	1	76	1	1	1

Rev.	Status	Author(s)	Reviewed By	Approved By	Office of Origin	Issue Date
0	Draft	[Re	[R	[Re	Belfast	15/02/18
2a	Final	[Re	[R	[Re	Belfast	28/06/18

Consulting Engineers

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1 INTRODUCTION

Stornoway Port Authority through their Consulting Engineers, Wallace Stone LLP, have appointed RPS to undertake computational modelling of the hydraulic regime for a proposed marina scheme to be developed in the Newton Basin area of Stornoway Port.

Newton Basin lies within the shelter of Goat Island, Figure 1.1, but is exposed to winds from the West to North West. It is proposed to build a sheltering breakwater and land reclamation using material excavated in forming the entrance channel and the marina basin. Some of the excavated material will also be used in the construction of the public slipway which will allow launching and recovering of boats from trailers.

Figure 1.1: Location of the Newton Basin in Stornoway Harbour.

The objectives of this study are to:

1. Briefly describe the existing site conditions and the development scheme proposed for the Newton Basin
2. Present the bathymetry field data collected in support of this study.
3. Develop computational numerical models of the Stornoway Harbour area.
4. Identify and summarise baseline conditions in the study area.
5. To understand and quantify the potential effects of the proposed scheme on the existing coastal processes.
6. To provide engineering design data in terms of the design wave climate, extreme tidal levels and the joint probability of waves and water levels.
7. Provide information on the wave patterns and heights around the marina basin.

The computational modelling used to provide the engineering data, determine baseline conditions and assess the impact of the proposed scheme was undertaken using RPS' in house suite of MIKE coastal process modelling software developed by the Danish Hydraulic Institute. This software has been described in more detail in Appendix 1.

2 NEWTON BASIN MARINA

2.1 PROPOSED SCHEME

The Newton Basin Marina is proposed in response to the success of the Stornoway Inner Harbour Marina, which has been full, with the 83 berths occupied virtually all year, since it opened 3 years ago. The Newton Basin development will provide berthing for an additional 75 vessels and relieve the pressure over the summer months for visiting yachts. The proposed scheme is shown in Figure 2.1 below.

It is proposed to build a sheltering breakwater and land reclamation using material excavated in forming the entrance channel and the marina basin. Some of the excavated material will also be used in the construction of the public slipway which will allow launching and recovering of boats from trailers.

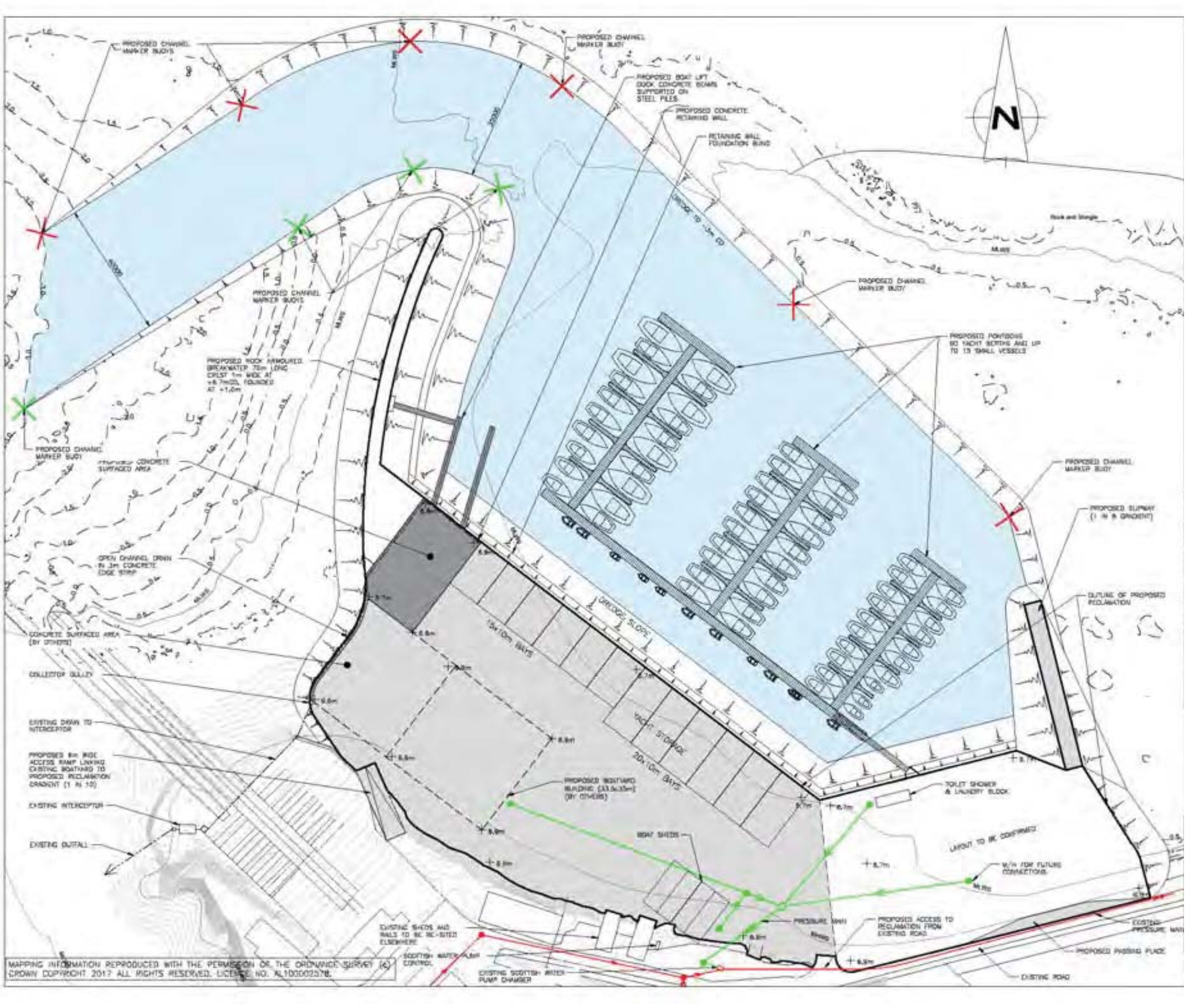


Figure 2.1: Plan of proposed marina development in Newton Basin.

The total dredged volume in the entrance channel and marina basin is not expected to exceed 92,220m³. It is anticipated that all material dredged by the cutter suction dredger (up to 83,770m³), excavated by land-based plant (up to 80,000m³), and imported for the access bund (up to 20,000m³), will be re-used in the construction of the new works. There is some unsuitable material (estimated at 8,430m³), which may have to be deposited at sea in the licenced disposal site to the east of Arnish peninsula.

Good quality dredged material will be placed and compacted to form the reclamation, the core of the sheltering breakwater, and the core of the slipway. Once the slopes were dressed to a suitable gradient, imported armour stone would be placed to protect the core material from erosion.

The marina will be formed from a 100 metre long floating access walkway and three walkway legs, each around 60m long and with finger pier berths on either side. With water depth of between 2 and 3 metres at lowest tide, the berths will be able to accommodate vessels up to 15 metres in length. Smaller boats will berth on the shore side of the access walkway which will be linked to the shore by a 24m long bridge. All walkways will be secured in place by vertical cantilevered steel tubes, grouted into sockets drilled into the rock of the basin bed.

2.2 ADJOINING HARBOUR STRUCTURES

As can be seen from Figure 2.2 there is a solid vertical walled breakwater running North West from the North West end of Goat Island. This structure protects the Newton Basin from wave attack for the South to South West directions. There are also three piers lying to the North West of the Newton Basin. The southerly half of the Pier No 1 at the end of South Street and Pier No 2 at the south beach, Figure 2.3 and Figure 2.4, are open piled structures using concrete piles. The new ferry pier for the service to Ullapool is supported by tubular steel piles as illustrated in Figure 2.5. There is a semi-circular fender wall at the end of this pier, Figure 2.6. The open piled structures will allow the low speed tidal flows to pass through the piers and with the exception of the semi-circular fender wall, the wave energy will be able to penetrate through the structures. The semi-circular fender wall will reflect wave energy and this has been included in the models. The density of concrete piles in the southern half of Pier No 1 will reduce the wave energy passing through the pier to a degree but, to be conservative no reduction in the wave energy has been assumed for this study.

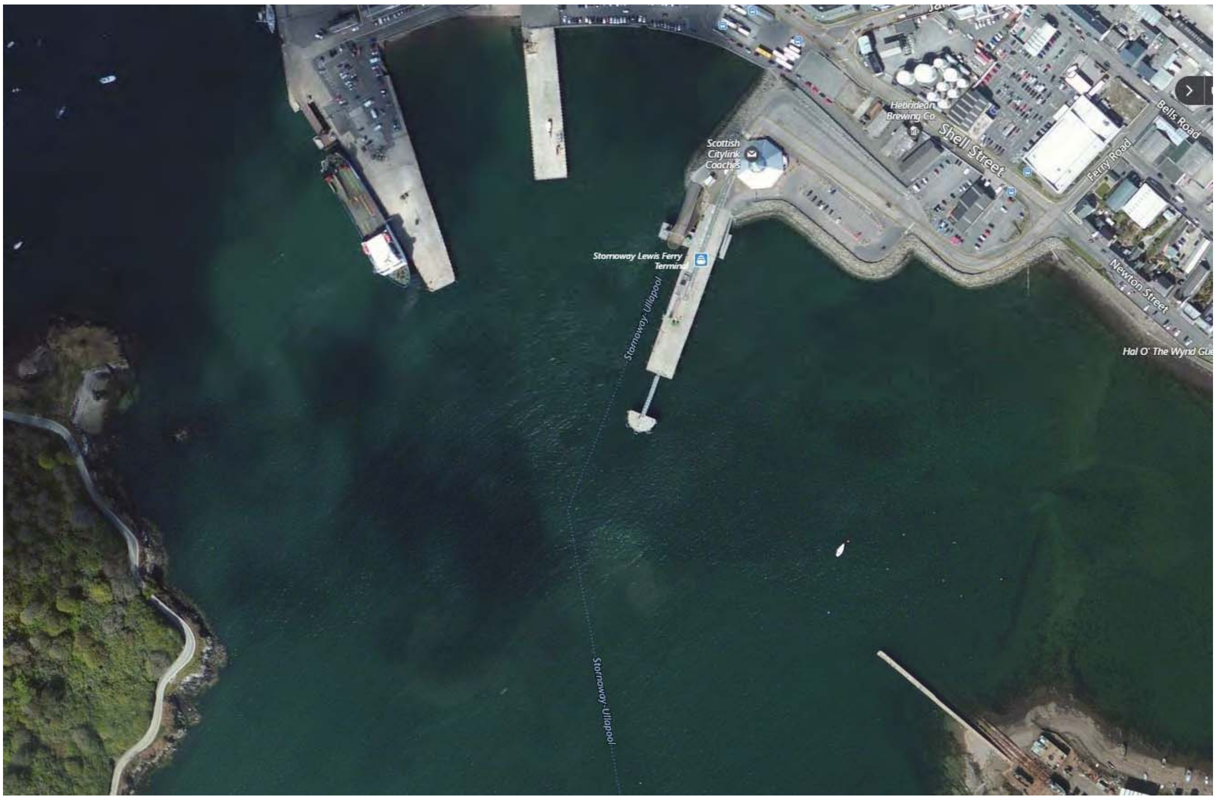


Figure 2.2: Harbour structures adjoining the Newton Basin.

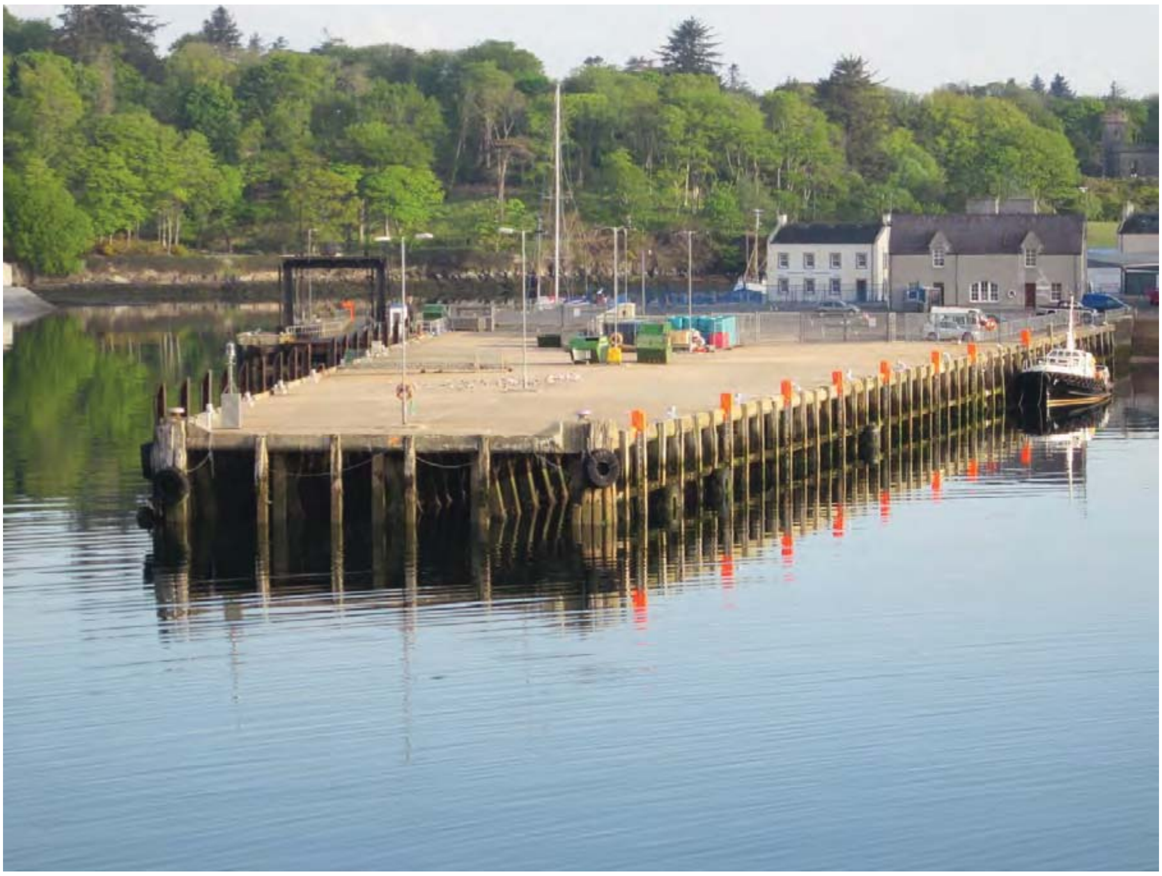


Figure 2.3: Open plied section of .the outer pert of No 1 pier

Figure 2.4: Open piled structure of the pier at South Beach (No 2 pier)

Figure 2.5: Tubular steel piled structure supporting the Stornoway Ferry terminal pier

Figure 2.6: Semi-circular fender wall at the end of the ferry terminal pier

3 SURVEYS AND INVESTIGATIONS

In April 2017 Aspect Land & Hydrographic Surveys Ltd were contracted by Wallace Stone LLP on behalf of Stornoway Port Authority to carry out multi beam bathymetric and geophysical surveys for the Newton Basin and the Deep Water Port projects. Aspect Surveys had previously undertaken hydrographic surveys of Stornoway Harbour and its approaches in 2013. The data collected during these surveys and investigations are summarised in the following sections of this chapter.

3.1 APRIL 2017 MULTI BEAM SURVEYS

An overview of the extent of the high resolution multi beam survey that was undertaken by Aspect Surveys for the Newton Basin is presented in Figure 3.1 below. The data collected during this survey was converted into 0.5m grid dataset which was then used with other survey data to develop the range of numerical models used for this study

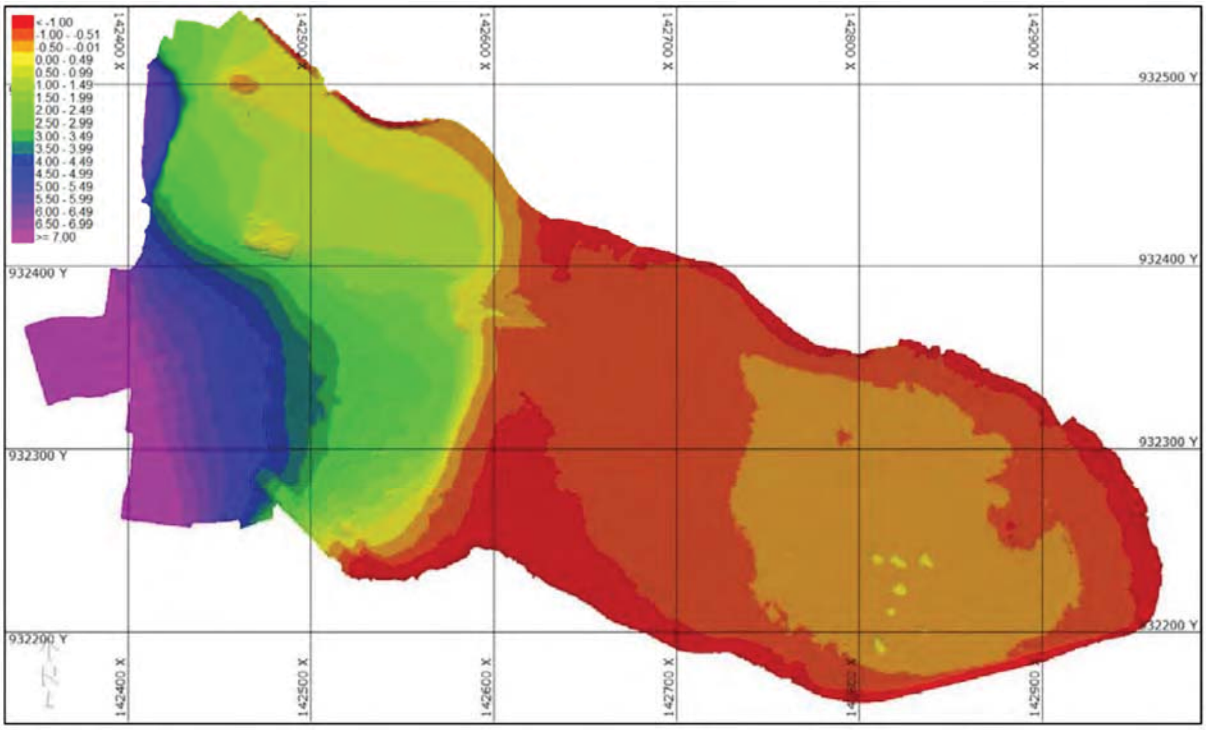


Figure 3.1: Extent of the 2017 multi beam bathymetric survey undertaken for Newton Basin.

3.2 BATHYMETRIC SURVEY DATA FOR STORNOWAY HARBOUR MODEL

The 2013 bathymetric surveys carried out by Aspect Land & Hydrographic Surveys Ltd. was used as a source of bathymetric data for areas of Stornoway harbour and its approaches not covered in the April 2017 multi beam surveys.

The extent of the multi beam surveys undertaken in 2013 is shown Figure 3.2 below.

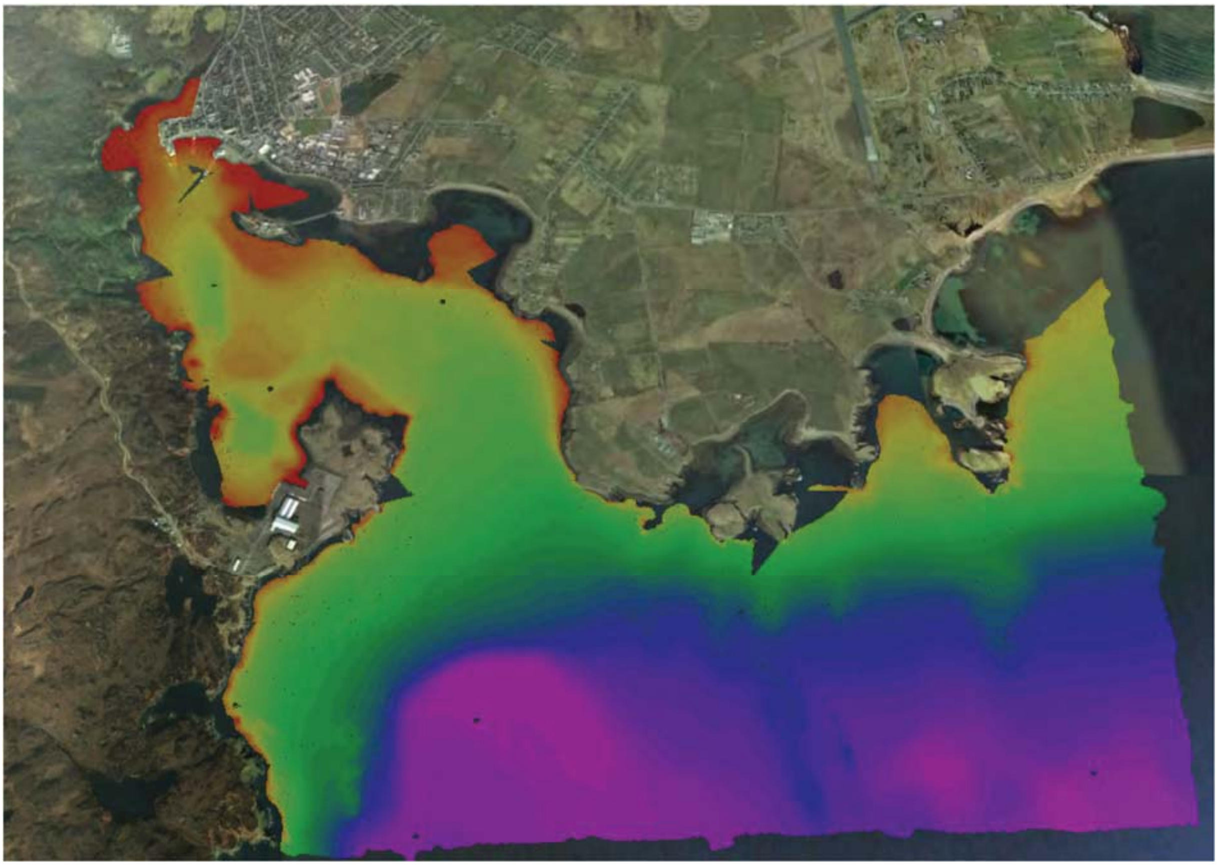


Figure 3.2: Extent of the 2013 multi beam hydrographic surveys of Stornoway Harbour.

The 2013 survey data was split into 5 sub areas and the hydrographic data supplied as a 1m resolution grid. After combining the various surveys the overall data set which was used for the numerical model was compiled and is shown in Figure 3.3 below. Data for some small areas not covered by the 2013 and 2017 surveys (mainly drying intertidal areas) was taken from digital chart data supplied by C-Map.

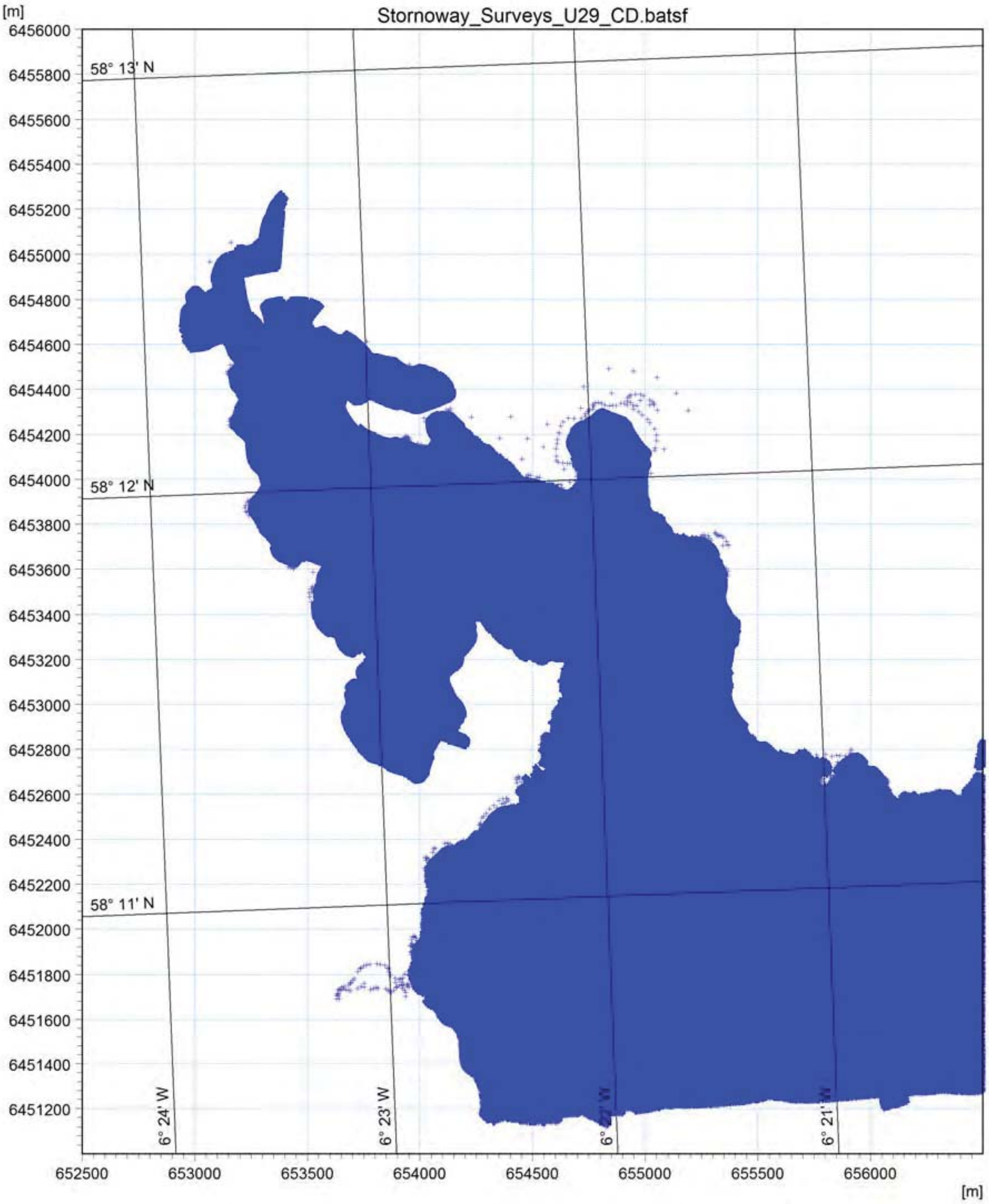


Figure 3.3: Combined survey data points for the Stornoway Harbour and approaches model

4 METHODOLOGY FOR MODELLING COASTAL PROCESSES

4.1 OVERVIEW

The RPS Coastal Processes Team has undertaken various modelling tasks in order to provide data for the engineering design of the scheme and to ascertain the potential impacts of the proposed scheme on the coastal processes in Stornoway Harbour. The modelling tasks were divided into five main areas as follows:

- Flow regime modelling
- Wave climate modelling
- Harbour disturbance modelling
- Extreme wave and water level modelling
- Impact of Dredging on Water Quality

The computational modelling was undertaken using RPS' in house suite of MIKE coastal process modelling software which was developed by the Danish Hydraulic Institute. Details of the modelling software used in this study are described in Appendix 1.

4.2 COASTAL PROCESS MODELS

As this study was interested in quantifying a range of coastal processes that occur at the site and adjoining areas of Stornoway Harbour, it was necessary to develop and utilise models of the North Minch and Stornoway Harbour and its approaches. RPS has already developed models for the whole of the west coast of Scotland and the western waters of the UK and Ireland. These existing models were adapted for use in this study. A description of the models and the data used to develop each model variation is described in the following sections.

4.2.1 North Minch Spectral Wave Model

In order to maximise computational efficiency RPS reduced the extent of an existing model of Scottish waters so that only the northern section of the west coast of Scotland model was included. For the purposes of this study, this reduced model domain is referred to as the North Minch wave model.

The extent and mesh structure of this model is illustrated in Figure 4.1. The model was developed using flexible mesh technology and had cell sizes ranging from $50x10^6m^2$ to $10,000m^2$. The bathymetry for this model was obtained from a range of sources including bathymetric data supplied by the UK Hydrographic Office (UKHO) under the IMAGINE project and from detailed hydrographic surveys undertaken for previous projects.

This particular model was used to generate and transform waves from the North Minch into the approaches to Stornoway Harbour whereby boundary conditions could be derived for the Stornoway Harbour model.

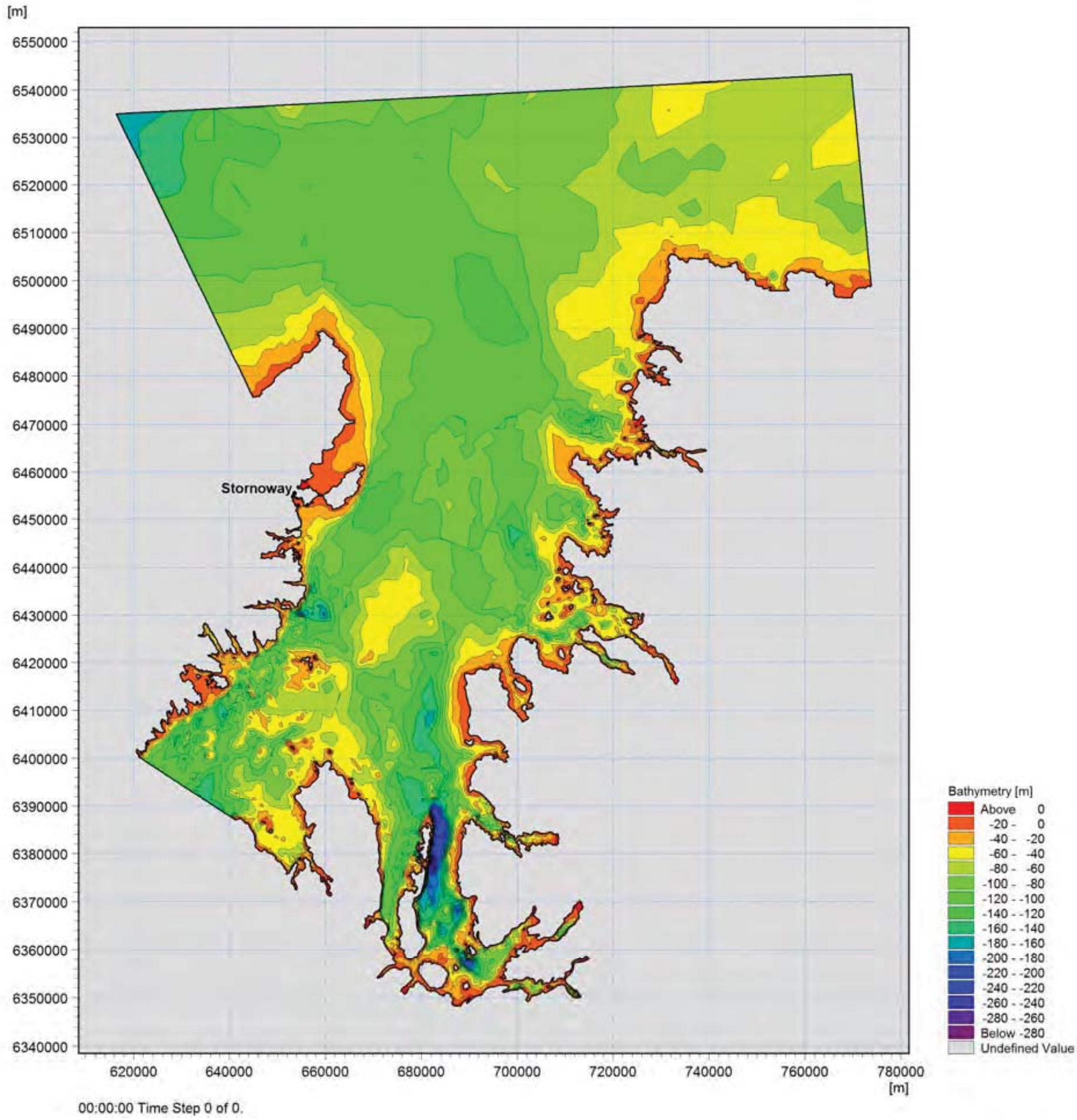


Figure 4.1: Extent and bathymetry of the North Minch wave model (to CD).

4.2.2 North Minch Flow Model

The North Minch flow model covers an area of the North Minch as shown in Figure 4.2. The bathymetry for this model was defined relative to MSL and used a collection of bathymetric survey data including recent surveys of the Stornoway Harbour area which were undertaken in 2013 and 2017 as well as high resolution data collected by the UKHO as part of the government funded INSPIRE initiative. The model resolution varied across the domain with coarser cells at the model boundaries and finer cells in the order of 15m grid size in the vicinity of Stornoway.

The boundaries of the North Minch flow model were specifically chosen so that tidal flows were accurately simulated throughout the domain. This model was primarily used to simulate tidal conditions at approaches to Stornoway Harbour with the aim of deriving tidal boundary conditions for the Stornoway Harbour model.

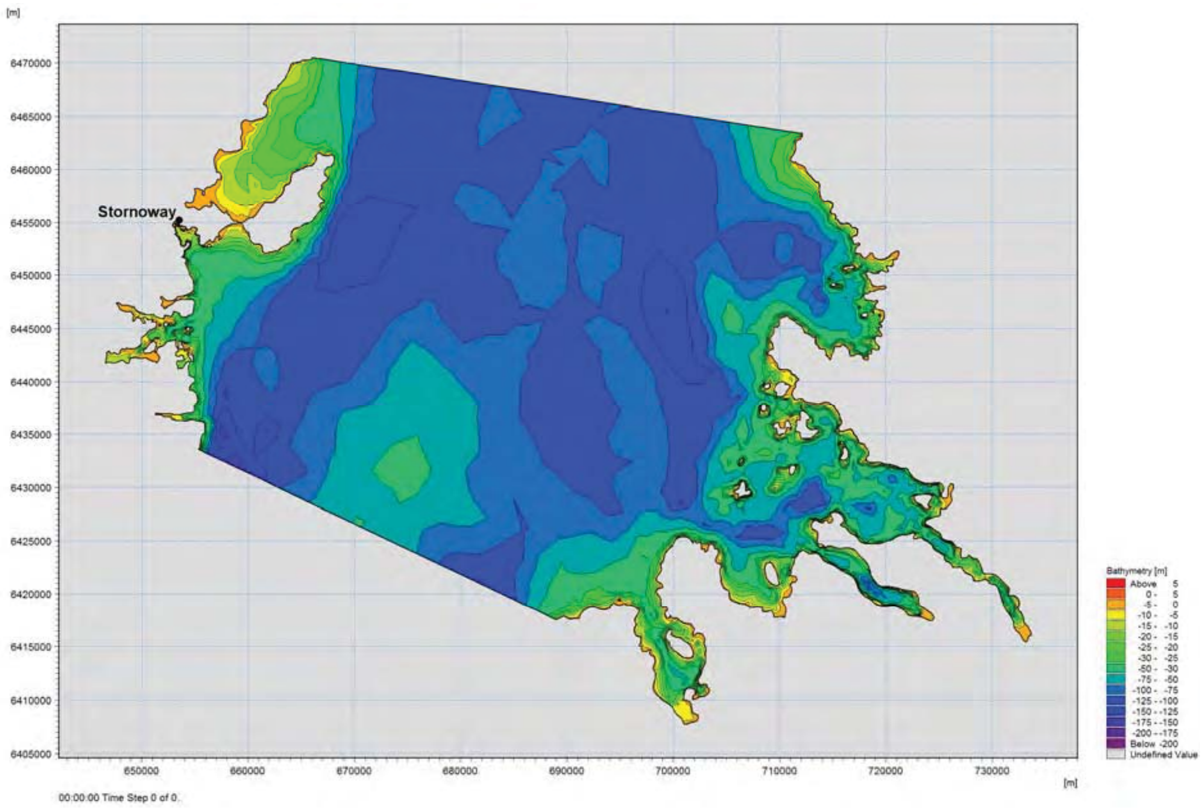


Figure 4.2: Extent and bathymetry of the North Minch Flow model (to MSL).

4.2.3 Stornoway Harbour Flow and Spectral Wave Model

A detailed model of Stornoway Harbour was developed to improve computational efficiency and allow the inclusion of finer resolution data around the proposed schemes. This model was designed with a flexible mesh grid system that would allow for the inclusion of the proposed Newton Basin and Deep Water Port developments without having to alter the model grid system. The model bathymetry was taken from the Aspect Survey's data of 2013 and 2017 as described in Section 3.2 and the extent and model mesh is shown in Figure 4.3. The model also included the tidal section of the River Creed.

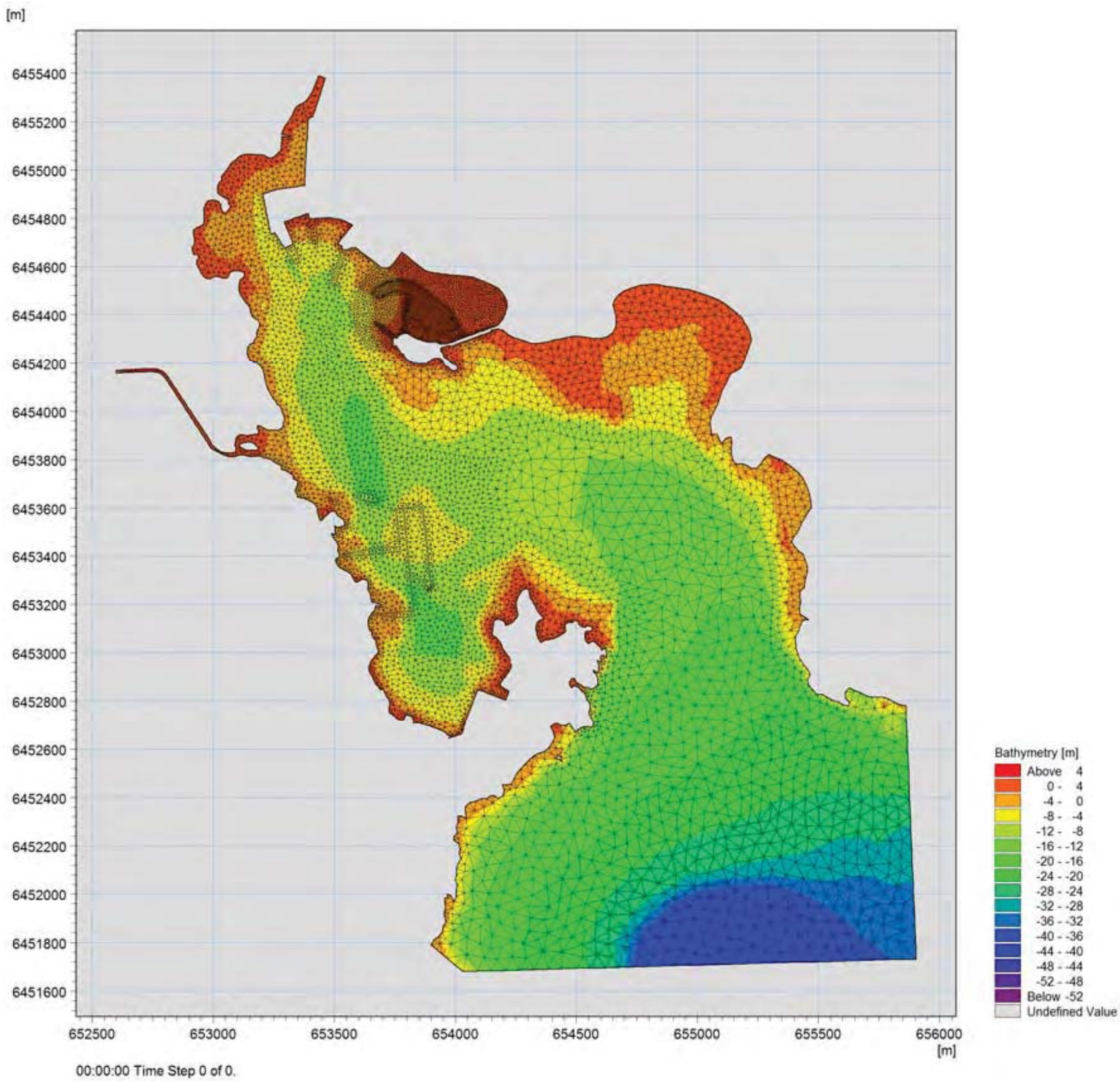


Figure 4.3: Extent and bathymetry of the Stornoway Harbour flow and wave model [toCD]

This model utilised tidal and wave boundary conditions derived from the models detailed in Sections 4.2.2 and 4.2.2 and was ultimately used to run coupled hydrodynamic and spectral wave simulations for the Newton Basin proposals. Two different versions of this particular model were developed to represent the existing and proposed marina at Newton Basin.

Figure 4.4 below illustrates the bathymetry and mesh of the existing Newton Basin configuration. By comparing this to Figure 4.5, which illustrates the bathymetry and mesh of the proposed development and the associated dredging works, it can be seen that both configurations have been represented by the numerical models to a high degree of accuracy.

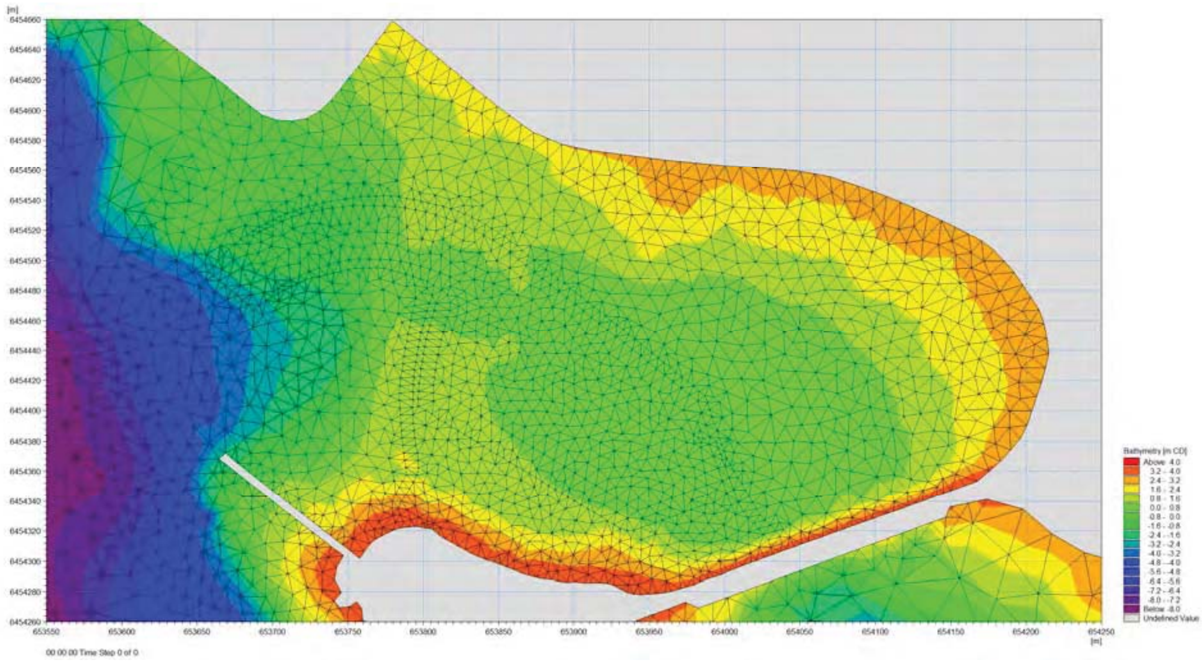


Figure 4.4: Bathymetry and mesh of the Newton Basin existing model [toCD].

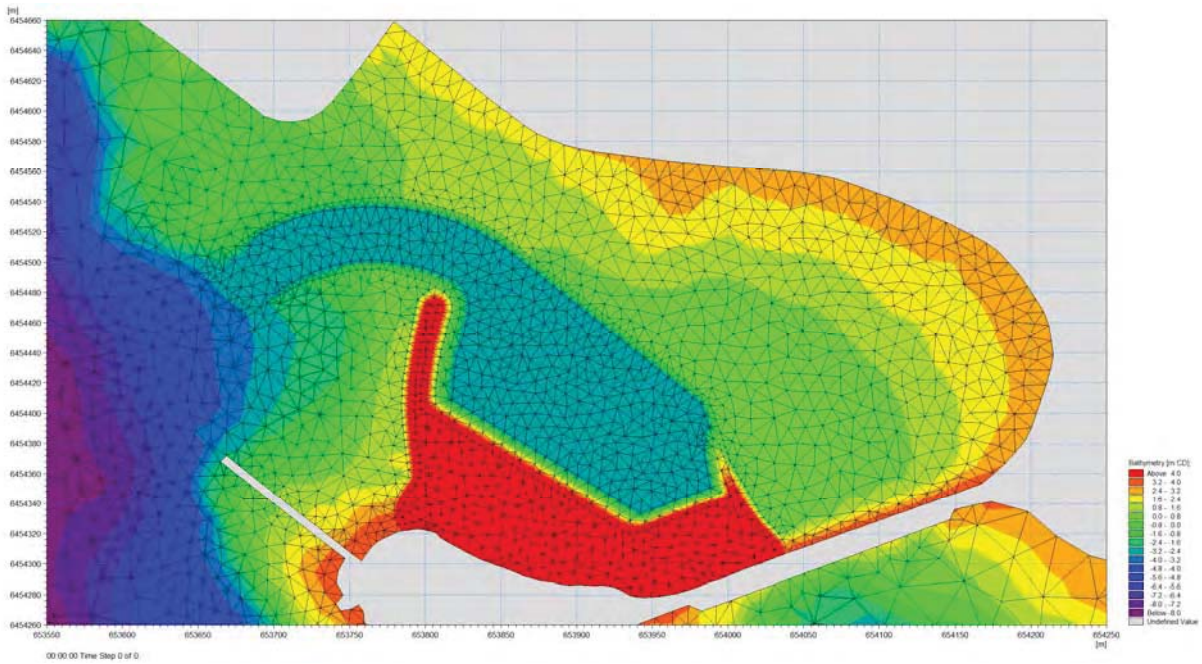


Figure 4.5: Bathymetry and mesh of the Newton Basin proposed model [toCD]

4.3 FLOW REGIME MODELLING

The North Minch flow model described in Section 4.2.2, was used to simulate tidal flows within the model domain for 3 months of tides so that the base hydrodynamics would be available to provide input tidal conditions for the Stornoway Harbour model.

The tidal boundary data used for the North Minch flow model was generated by RPS' Western UK and Irish Waters Storm Surge model. This model stretches from the north western end of France into the Atlantic to 16° west, including the Porcupine Bank and Rockall. In the other direction it stretches from the northern part of the Bay of Biscay to just south of the Faeroes Bank. Overall, the model covers the Northern Atlantic Ocean and UK continental shelf up to a distance of 600km from the Irish Coast as illustrated in Figure 4.6. This model is driven by astronomic tides generated using the global tidal model developed by DTU Space (DTU10). The model is currently run 24/7 to provide storm surge warnings for the whole of the Irish Coast.

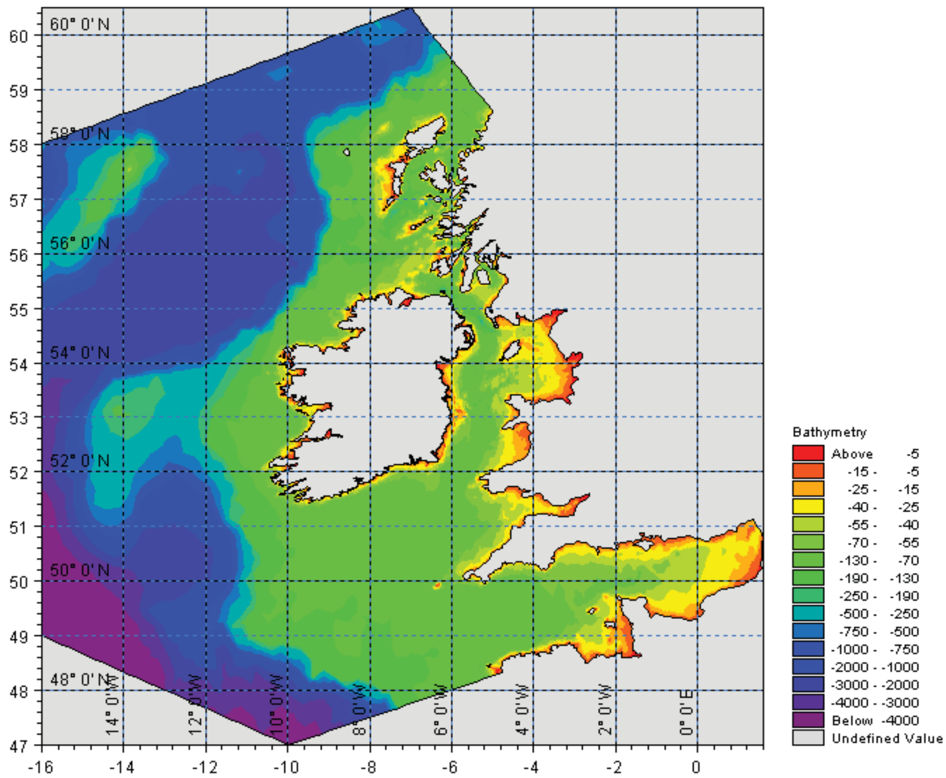


Figure 4.6: Extent of the RPS Western UK and Irish Waters Storm Surge model

The results of the North Minch flow model simulations were used to provide the tidal velocities and tidal elevations along the seaward boundaries of the Stornoway Harbour model. The Stornoway harbour model was run for a full 29 day lunar cycle, including mean river flow conditions in the River Creed, for both the existing harbour configuration and for the harbour with the proposed Newton Basin marina in place. This enabled a comparison to be made of the flow conditions both before and after the installation of the proposed development and provided data for the modelling of extreme waves and water levels.

4.4 WAVE CLIMATE MODELLING

The modelling was undertaken using a two stage computational model simulation procedure for storm directions with long fetches to the approaches to Stornoway Harbour (directions 060^o to 195^o). This involved firstly the generation and transformation of waves from the North Minch to the approaches to Stornoway Harbour and then using the Stornoway Harbour model these waves were run into the study area.

For storm directions with shorter fetches within the harbour area, (directions 210^o to 315^o) the modelling was undertaken using the Stornoway Harbour model alone.

The model simulations were run for each relevant 15^o sector at high tide levels for 1 in 1, 1 in 50, 1 in 100 and 1 in 200 year return period storms. Simulations were also undertaken over the full tidal spring cycle for the most exposed wave direction so that the impact of any wave set up could be included in the assessment of extreme waves and water levels.

As with the flow modelling, all wave modelling was undertaken using the bathymetry for both the existing harbour and with the proposed Newton Basin Marina scheme in place. This allowed the impact of the proposed scheme on the wave climate at other parts of the harbour to be assessed.

4.5 HARBOUR DISTURBANCE MODELLING

Harbour disturbance simulations were undertaken to assess the effectiveness of the proposed breakwater in providing shelter to the pontoon berths in the marina. The marina basin is most exposed to waves approaching from the West North West direction when the wave climate approaching the marina will consist of short steep breaking waves. Thus the harbour disturbance modelling was undertaken using a combination of the spectral wave model with diffraction and the Boussinesq wave model. The Boussinesq wave model is required to assess the impact of reflected waves around the marina basin, although as it does not include wind wave generation within the model area, the short steep wind driven waves decline too quickly in the further areas of the model. Thus the combination of the detailed spectral diffraction model and the Boussinesq wave model was used to accurately assess the wave climate around the pontoon berth area.

4.6 EXTREME WAVE AND WATER LEVEL MODELLING

A joint probability analysis was undertaken for extreme water levels and wave heights using the techniques and data contained in the DEFRA/EA "Joint Probability: Dependence Mapping and Best Practice:" report FD2308/TR1. This report indicates that the correlation coefficient for waves from directions from 210^o to 290^o is 0.4 in the Stornoway area. The extreme water levels were taken from EA/SEPA's Coastal flood boundary conditions for the UK mainland and islands: design sea levels data base. SEPA currently indicate that the projected sea level rise to 2080 at Stornoway would be 0.53 metres. However updated IPCC sea level projections are due in November 2018 and the indications are that the projected sea level rise figures will be increased.

The proposed development at Newton Basin is most exposed to waves from the West North West. The extreme wave conditions at the site are dependent on the extreme wind speeds across the harbour. Thus the joint probability analysis was undertaken between extreme water levels and wind speeds and the equivalent waves at the site were then determined by computational modelling using the appropriate wind speed for wave generation.

4.7 MODELLING SOFTWARE

The coastal processes at Stornoway were simulated using the coupled MIKE 21 Flow Model FM. The MIKE 21 Flow Model FM is a state of the art modelling system based on a flexible mesh approach. The modelling system was developed by the Danish Hydraulics Institute (DHI) for applications within oceanographic, coastal and estuarine environments and the software has been approved by numerous leading institutions and authorities around the world.

The Hydrodynamic Module is the basic computational component of the entire MIKE 21 Flow Model FM modelling system providing the hydrodynamic basis for the advection/dispersion Module, ECO Lab Module, Mud Transport Module and Sand Transport Module all of which may be coupled with the Spectral Wave module. For this study RPS utilised the following modules within the MIKE software package:

- Hydrodynamic module;
- Spectral Wave module;
- Boussinesq Wave module; and
- Extreme Value Analysis module;

A full description of these modules can be found in Appendix 1.

5 TIDAL REGIME IN STORNOWAY HARBOUR

5.1 TIDAL REGIME UNDER EXISTING CONDITIONS

The hydrodynamic model of Stornoway harbour, illustrated in Figure 4.4, was used to simulate over a month of tidal conditions across the entire model domain. The tidal curve for the simulation period is shown in Figure 5.1.

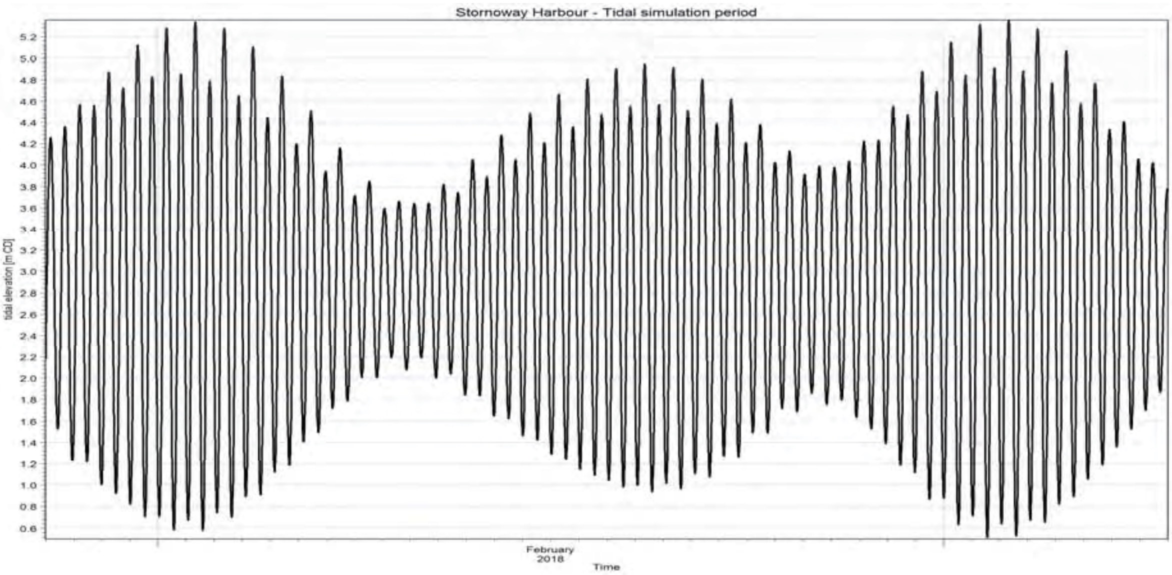


Figure 5.1: Tidal elevation in Stornoway Harbour during model simulation period.

Results of the numerical simulations indicated that at Stornoway the change in tidal currents are largely in phase with the tidal elevations as illustrated in Figure 5.2.

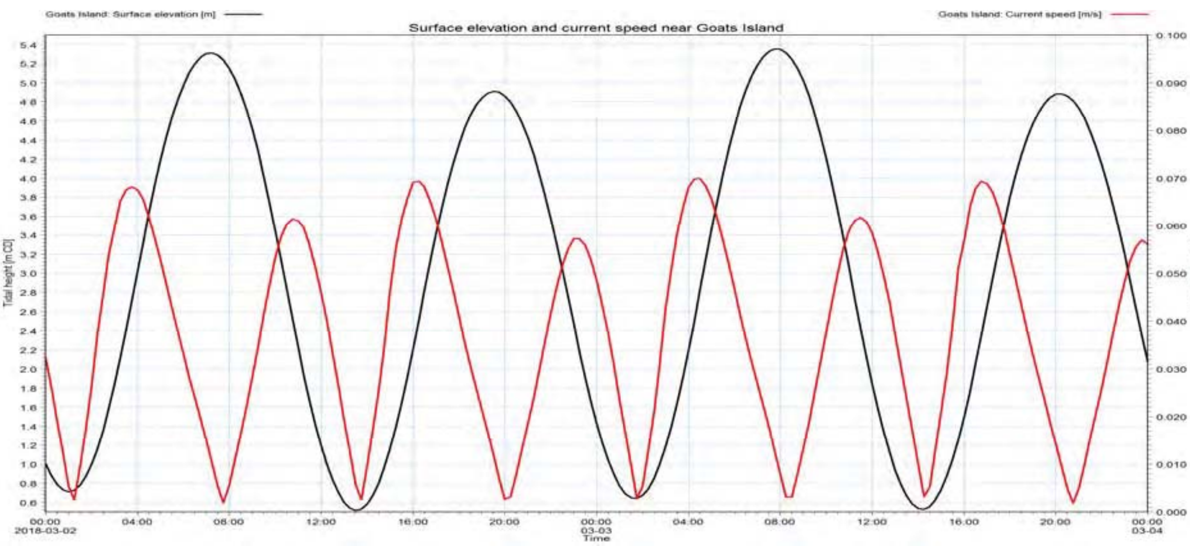


Figure 5.2: Spring tidal elevation and currents at a point to the west of Goats Island.

The tidal currents within Stornoway Harbour are weak and generally do not exceed about 0.1m/s. The current field at mid flood and mid ebb of the spring tidal cycle are illustrated in Figure 5.3 and Figure 5.4. From these figures it will be seen that the highest current velocities are observed off the Reef Rock at Arnish Point during the flood and off the Reef and Seid rocks on the ebb. The effect of Goat Island and its causeway is to slightly increase the tidal velocities to the west of Goat Island and increase the tidal flow velocities over the bar between the north end of Goat Island and the shore.

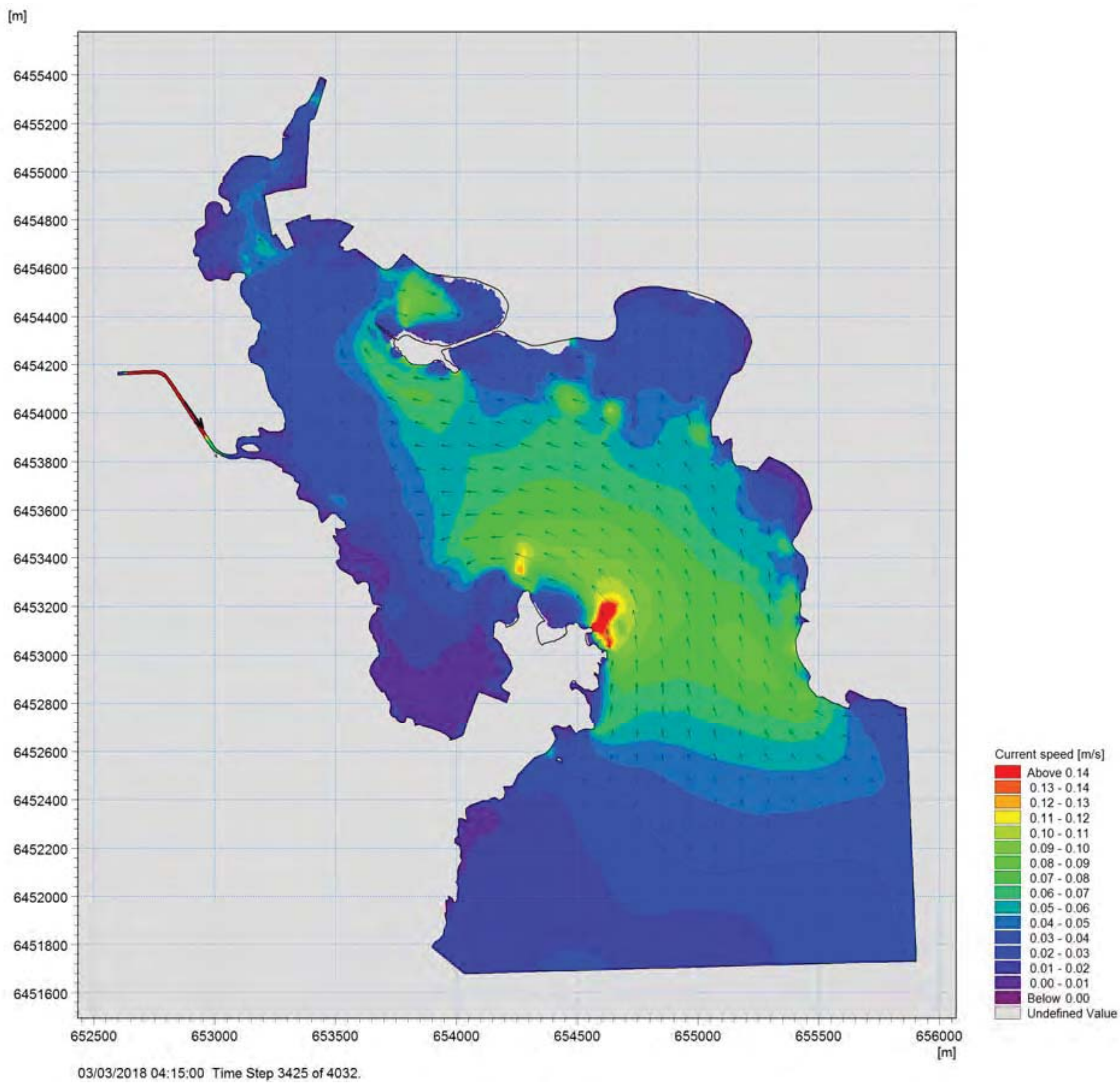


Figure 5.3: Typical spring tide peak flood current velocities in the existing Stornoway Harbour

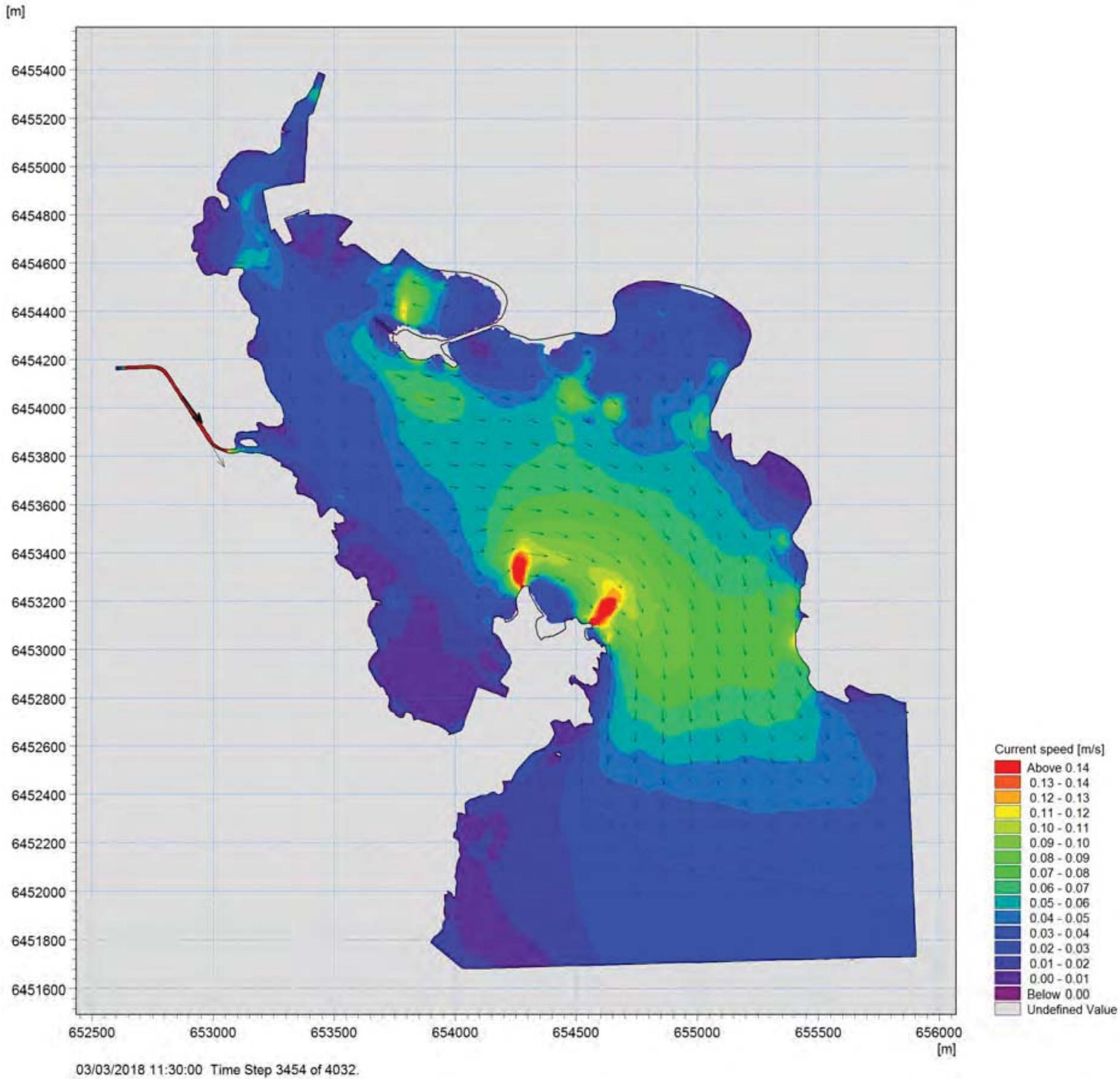


Figure 5.4: Typical spring tide peak ebb current velocities in the existing Stornoway Harbour.

5.2 TIDAL REGIME WITH THE PROPOSED DEVELOPMENT

The hydrodynamic model was then re-run for the same time period as the existing scenario modelled in Section 5.1 of this report using an updated model to reflect the implementation of the proposed scheme; this updated model was previously illustrated in Figure 4.5. The current field at mid flood and mid ebb of the spring tidal cycle are illustrated in Figure 5.5 and Figure 5.6. As can be seen from these figures there is little apparent change in the flood or ebb current patterns in the majority of the harbour area.

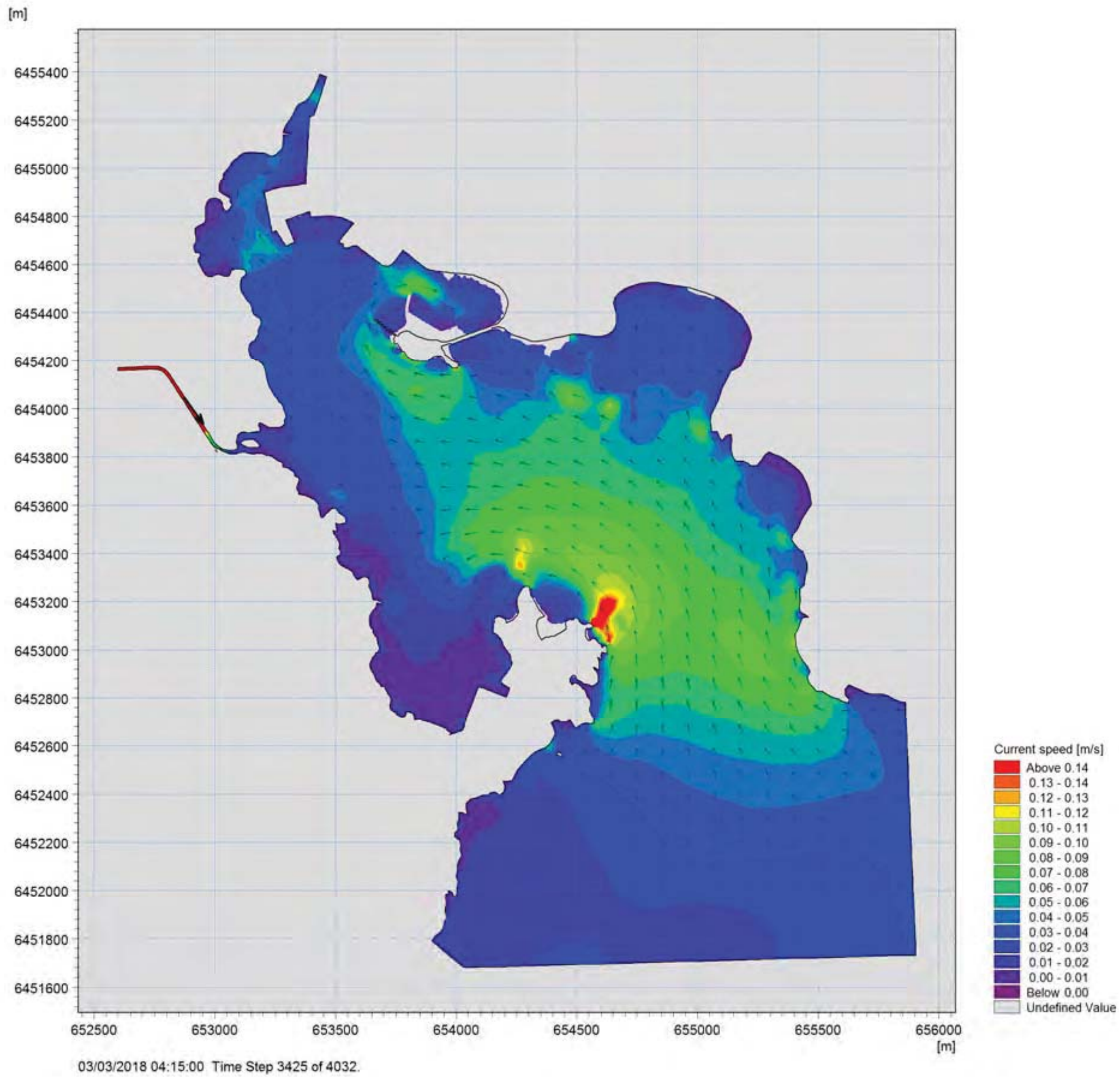


Figure 5.5: Spring tide peak flood current velocities in Stornoway Harbour with the Newton Basin development in place

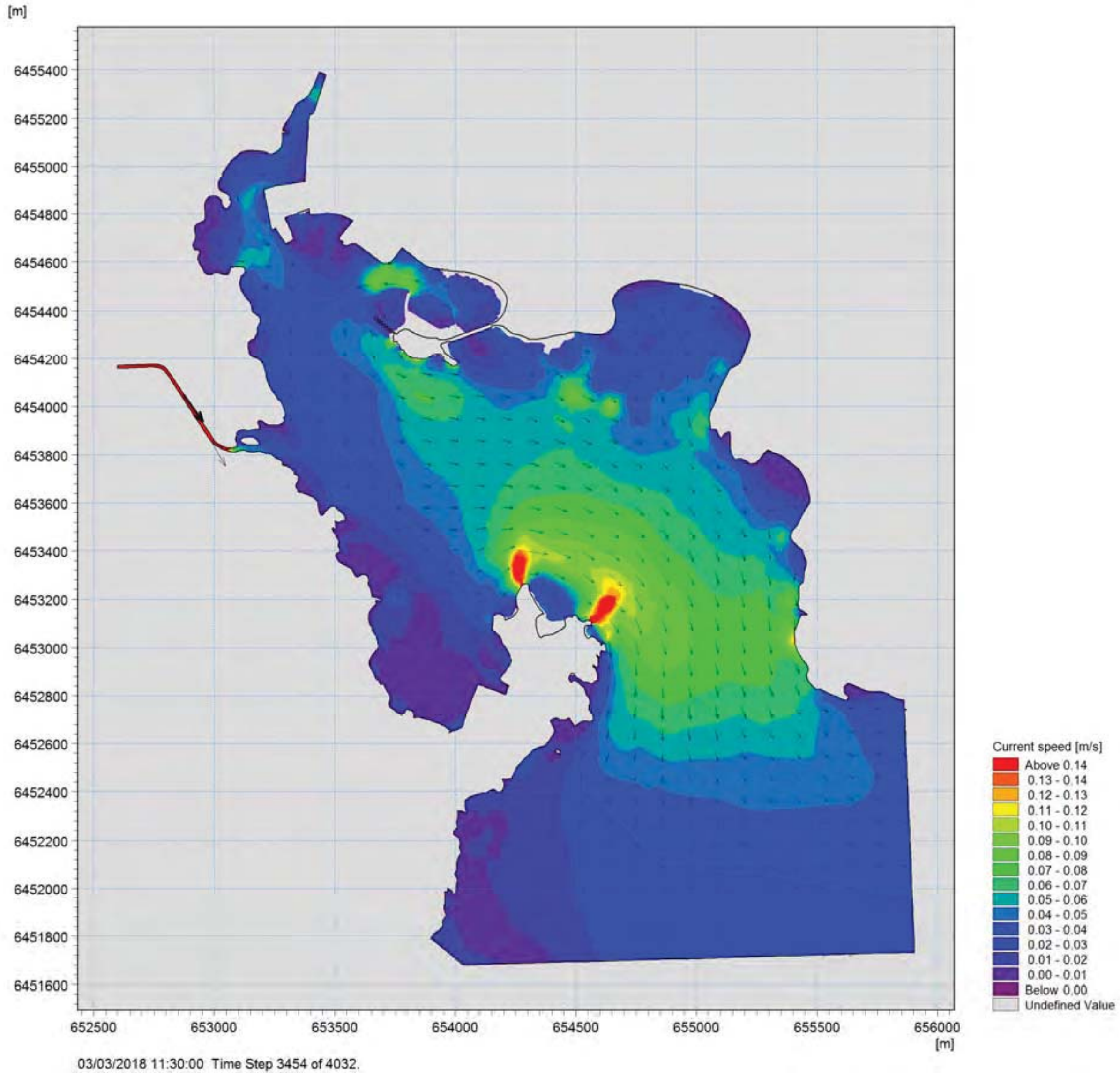


Figure 5.6: Spring tide peak ebb current velocities in Stornoway Harbour with the Newton Basin development in place

5.3 IMPACT OF THE PROPOSED SCHEME ON THE TIDAL REGIME

The results of the tidal modelling have been used to assess the impact of the proposed Newton Basin marina of the tidal regime in Stornoway Harbour. A series of difference plots (harbour with marina minus existing harbour) have been used to illustrate the extent and magnitude of the impacts.

Impact on Tidal Elevations

Figure 5.7 and Figure 5.8 illustrate the differences in the tidal elevations between the harbour with the proposed scheme and the existing scheme at high and low water during a spring tidal cycle.

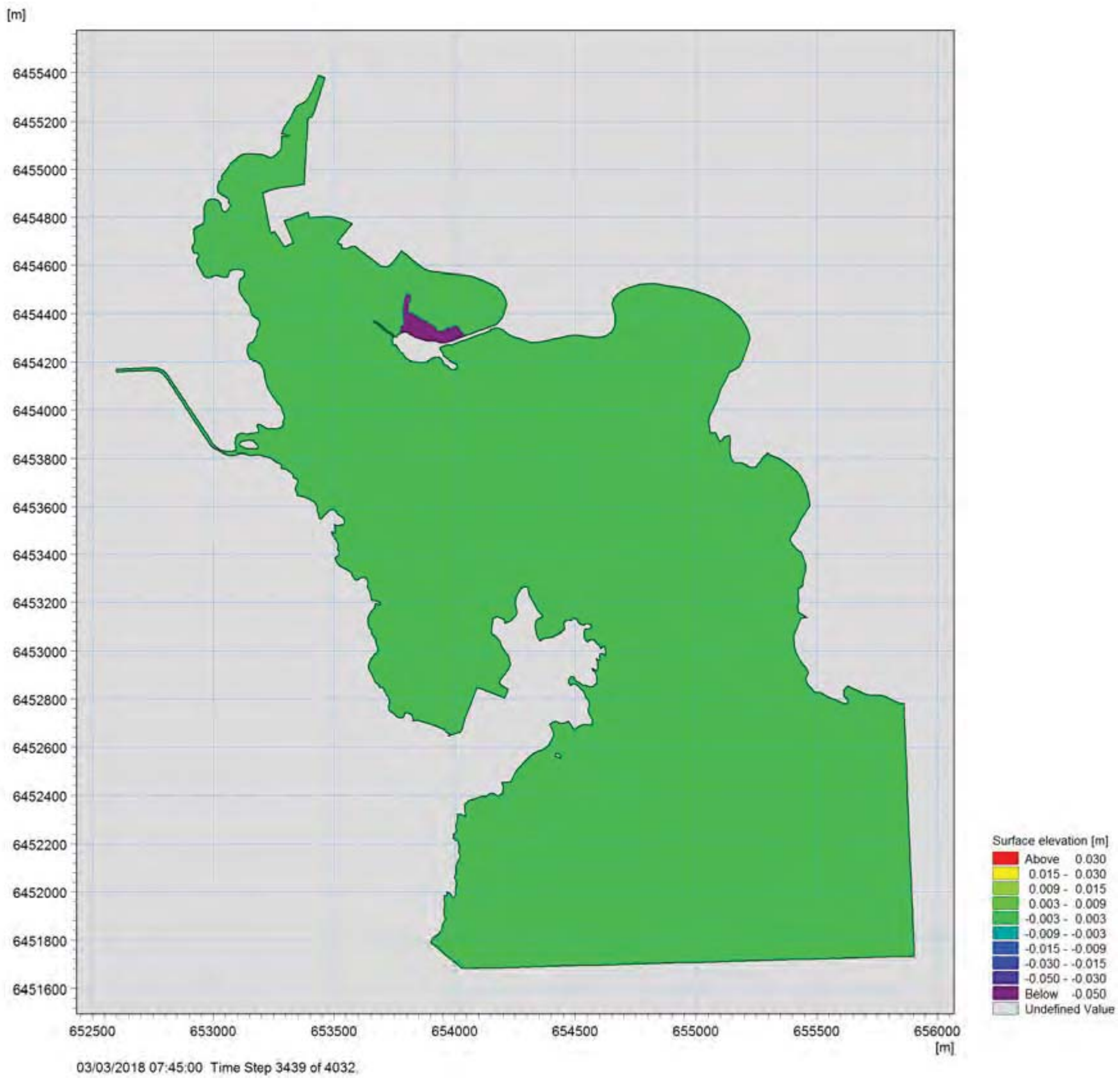


Figure 5.7: Tidal level difference (with scheme minus existing) at MHWS

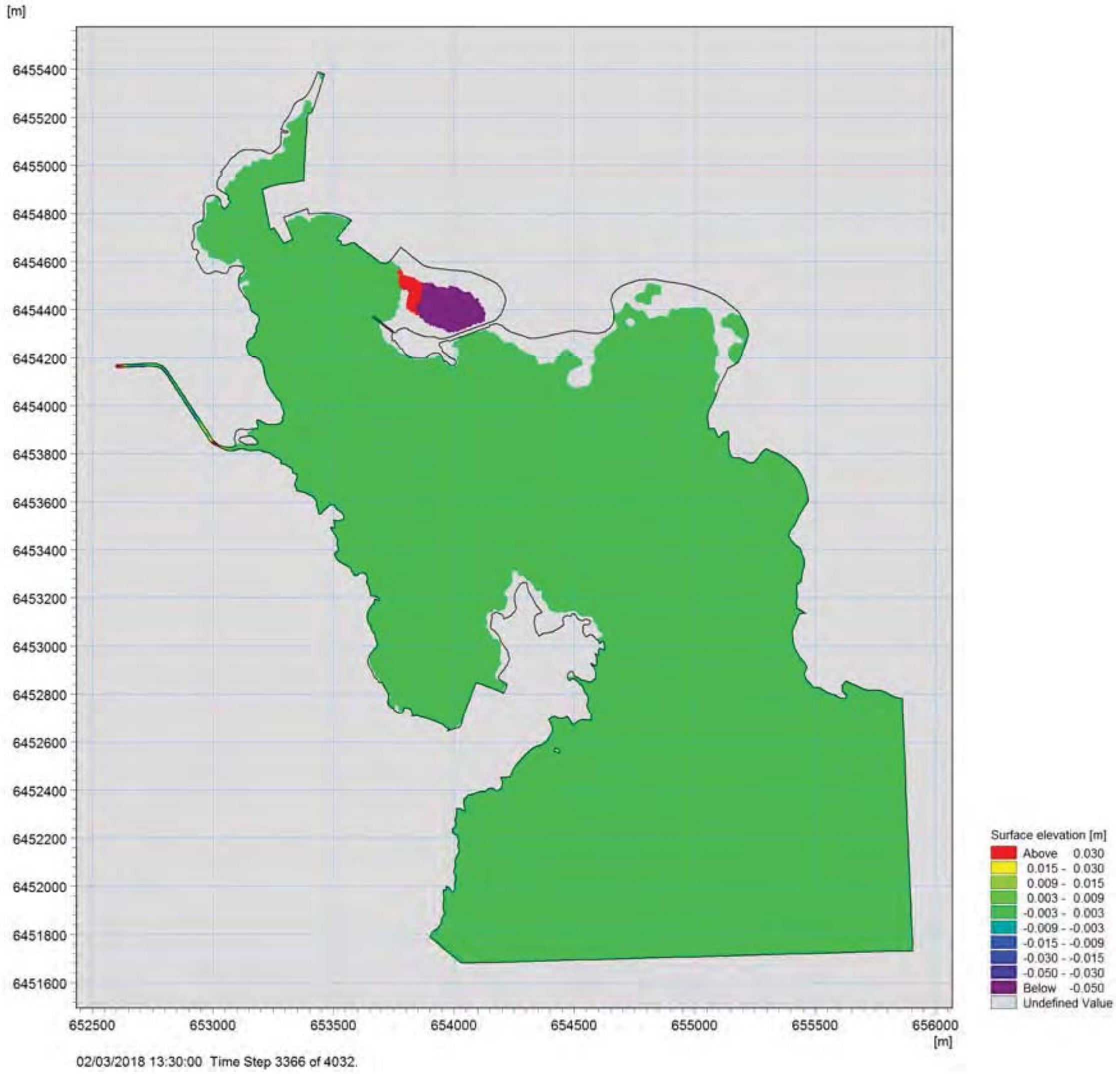


Figure 5.8: Tidal level difference (with scheme minus existing) at MLWS

It will be seen from Figures 5.7 and 5.8 that the proposed Newton Basin marina project will neither significantly increase the high tide levels or significantly reduce the low tide levels so the proposed scheme will not affect either flooding or navigation water levels in the harbour away from the immediate area around the proposed marina.

Impact on Tidal Flows

Difference plots have also been produced to show any changes in the tidal flood or ebb flow regime around the harbour which may result from the construction of the proposed marina scheme. Figure 5.9 and Figure 5.10 show the changes in the mid flood and mid ebb tidal currents speed during a spring tide.

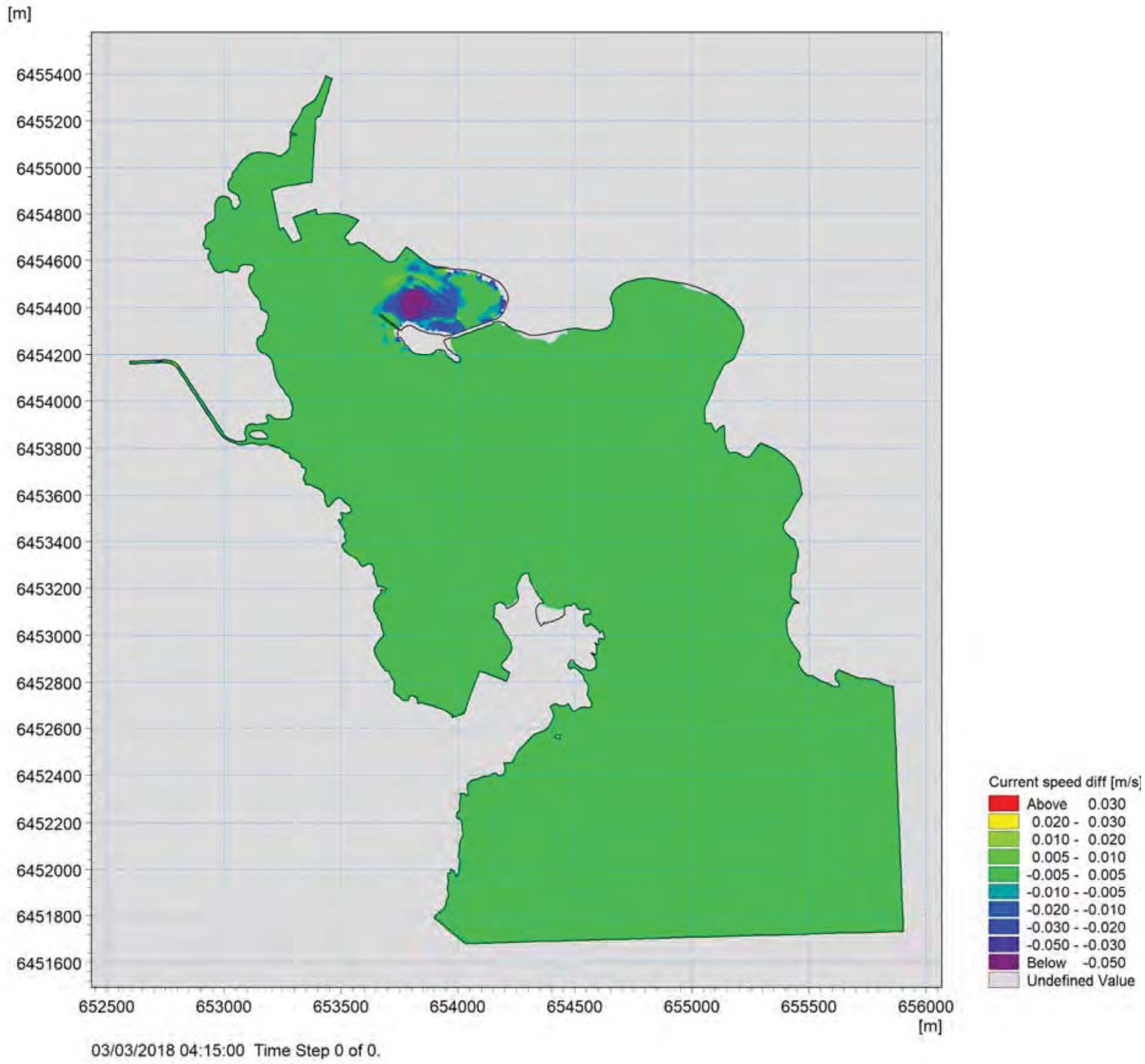


Figure 5.9: Tidal current speed difference (with scheme minus existing) at mid flood springs

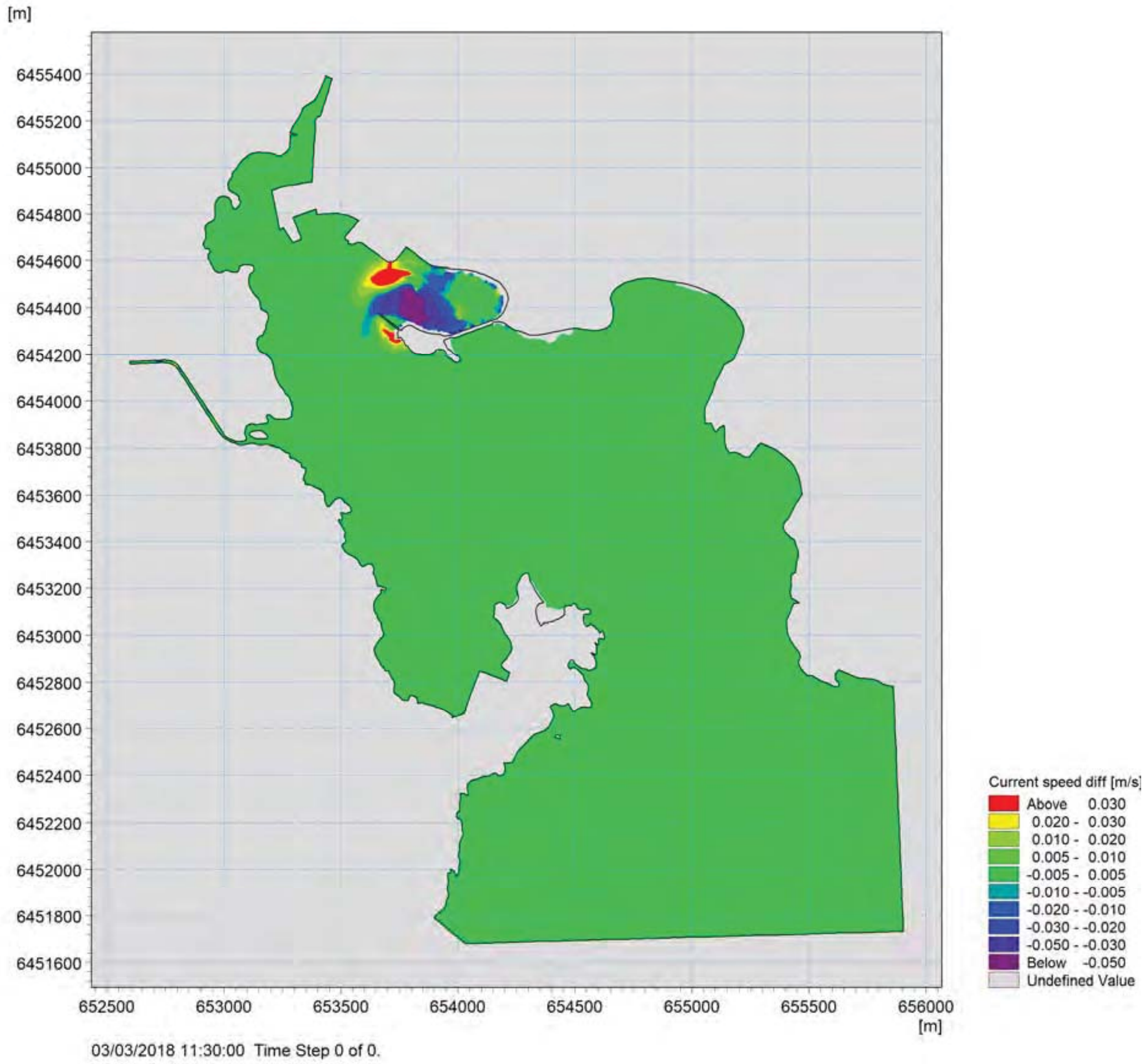


Figure 5.10: Tidal current speed difference (with scheme minus existing) at mid ebb springs

It will be seen from the difference plots that under typical tidal conditions the changes in current speeds as a result of the proposed development do not generally exceed ±0.005 m/s within the harbour area away from the immediate area around the proposed marina development. This velocity difference is very small and is not really measurable.

The presence of the dredged channel out from the marina basin results in a small increase in the tidal velocity during the peak-ebb phase of the tidal cycle. However the tidal velocities in this area are still very low so this increase in the flow in the channel is not significant.

6 WAVE CLIMATE IN STORNOWAY HARBOUR

6.1 GENERAL

The proposed development at Newton Basin is potentially exposed to waves which penetrate into Stornoway Harbour past Arnish Point as well as to waves generated over the local fetches within Stornoway Harbour itself. The waves which enter Stornoway Harbour past Arnish Point are generated during storms from the 90^o to 195^o directions over the fetches across the Minch while the locally generated storm waves which may reach the Newton Basin site occur during storms from the sector 210^o to 315^o.

6.2 WIND DATA

Wind data prepared by the Met Office for BS EN 1991-1-4:2005+A1:2010 for extreme wind speeds throughout the British Isles has been compared with the results from wind recording stations on the West Coast of Scotland. The results of the analysis showed that the data produced for BS EN 1991-1-4:2005+A1:2010 gave similar results for overland storm wind speeds to the data from analysis of the wind recording stations. Therefore the wind data from the Met Office given in BS EN 1991-1-4:2005+A!:2010 was used for the storm wave generation over the fetches across the Minch in this study with the wind speeds adjusted for overwater values and for the length of time required to fully develop the waves over the fetches across the Minch. The values used in the storm simulations for the fetches across the Minch are given in Table 6.1.

Table 6.1: Wind speeds for storm simulations over the fetches across the Minch.

Storm direction [deg N]	1 in 1 yr return period [m/s]	1 in 50 yr return period [m/s]	1 in 100 yr return period [m/s]	1 in 200 yr return period [m/s]
90	18.96	26.95	28.33	29.99
105	19.05	27.08	28.47	30.14
120	19.03	27.04	28.43	30.10
135	20.17	28.66	30.13	31.90
150	20.89	29.68	31.21	33.04
165	21.53	30.61	32.18	34.07
180	22.29	31.67	33.30	35.25
195	23.64	33.60	35.32	37.39

The waves generated over the very short fetches within Stornoway Harbour were modelled using the parametric formulation within the Mike21 SW model as this option uses empirical wind wave growth curves based on overwater wind speeds. This formulation is the most suitable for very short fetches and the overwater wind speeds were derived from gust wind speeds amended for the length of time required to develop the waves over the short fetches. The wind speeds used in the storm simulations for the fetches across Stornoway Harbour are given in Table 6.2.

Table 6.2: Wind speeds for storm simulations over the fetches across Stornoway Harbour.

Storm direction [deg N]	1 in 1 yr return period [m/s]	1 in 50 yr return period [m/s]	1 in 100 yr return period [m/s]	1 in 200 yr return period [m/s]
210	28.30	40.05	42.08	44.52
225	28.30	40.05	42.08	44.52
240	28.36	40.14	42.18	44.63
255	28.33	40.09	42.13	44.57
270	28.38	40.18	42.22	44.67
285	28.16	39.84	41.86	44.28
300	28.14	39.81	41.82	44.25
315	26.75	37.87	39.80	42.11

The 1 in 50 year storm 3 second gust wind speed at the Newton Basin development is predicted to be 54 m/s while the equivalent 30 second gust speed is 48 m/s.

6.3 WAVE CLIMATE APPROACHING STORNOWAY HARBOUR

The wave climate approaching Stornoway Harbour was simulated using the Mike21 Spectral Wave model of the North Minch as shown in Figure 4.1. The simulations were run for storms from each 15^{o} direction from 090^{o} to 195^{o} for return periods of 1 in 1, 1 in 50, 1 in 100 and 1 in 200 years at high tide water levels plus an allowance for storm surge where appropriate. An example of the output from one of these simulations is shown in Figure 6.1 which shows the significant wave heights and mean wave direction for a 1 in 50 year return period storm from 165^{o} N.

The results of these simulations indicated that waves of up to 2.77 metres significant wave height with mean wave periods of 5.5 seconds would approach the entrance to Stornoway harbour during a 1 in 1 year return period storm. The equivalent figures for a 1 in 50 year and 1 in 200 year return period storm were significant wave heights of up to 4.5 metres with mean wave periods of 6.6 seconds and significant wave heights of up to 5.0 metres with mean wave periods of 6.9 seconds respectively.

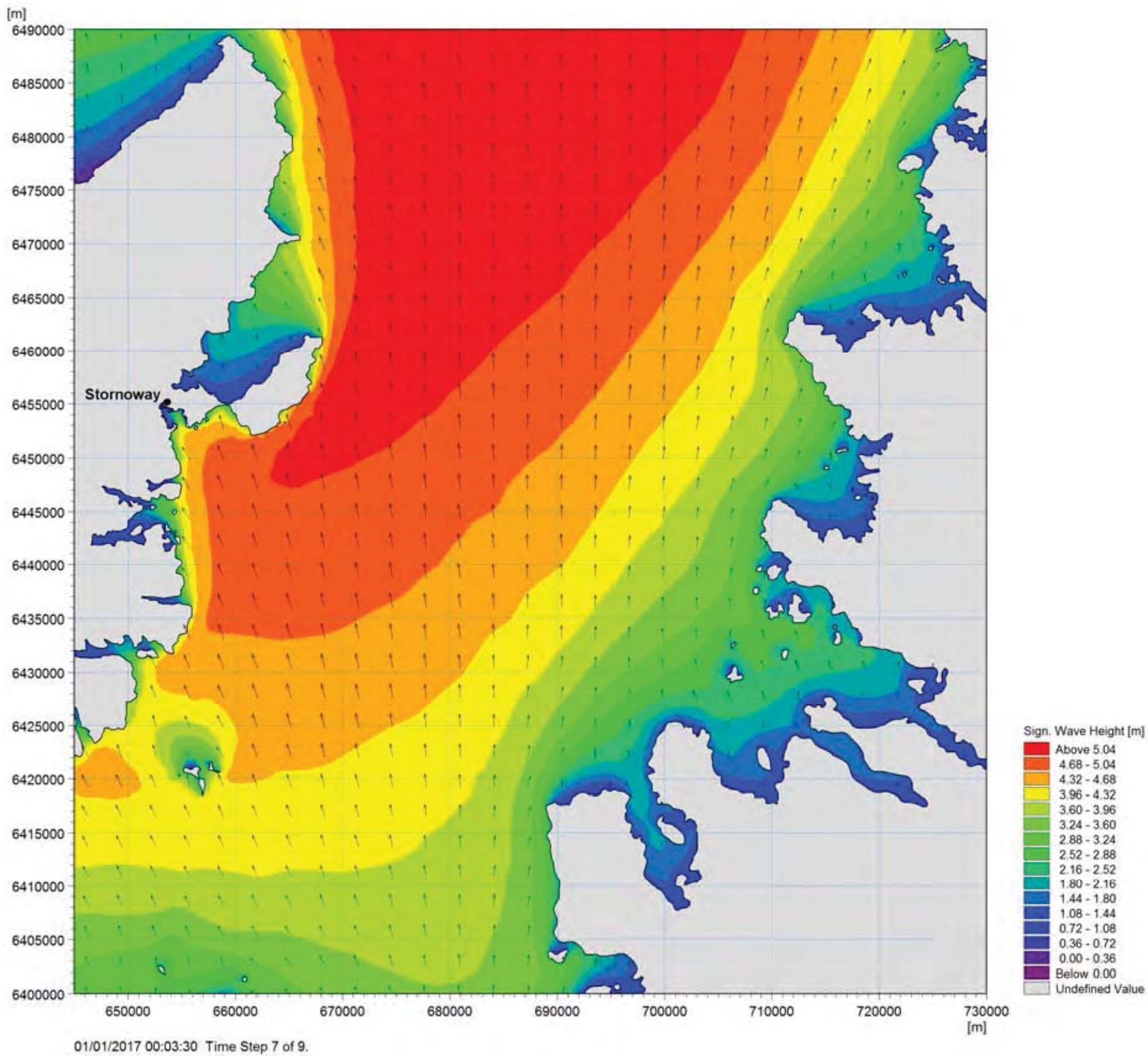


Figure 6.1 Significant wave height and mean wave direction in the North Minch - 1 in 50 year return period storm from 165^{o}N

6.4 WAVE CLIMATE APPROACHING NEWTON BASIN

The wave modelling showed that waves which may approach the site of the proposed development in Newton Basin consists of those waves which penetrate into the harbour past Arnish Point as well as waves generated within Stornoway Harbour itself.

During storms from 090^o to 195^o storm waves which enter Stornoway Harbour can approach Goat Island and be diffracted around towards the site. However the existing concrete breakwater running North West from the north western end of Goat Island protects the site from this longer period disturbance. The largest waves which penetrate into Stornoway Harbour and approach Goat Island occur during storms from the 165° to 180° directions. Figure 6.2 shows the significant wave heights and mean wave directions of the waves in the existing Stornoway Harbour during a 1 in 50 year return period storm from 180° at high water spring tides. Figure 6.3 shows the same storm conditions for Stornoway Harbour with the Newton Basin development in place.

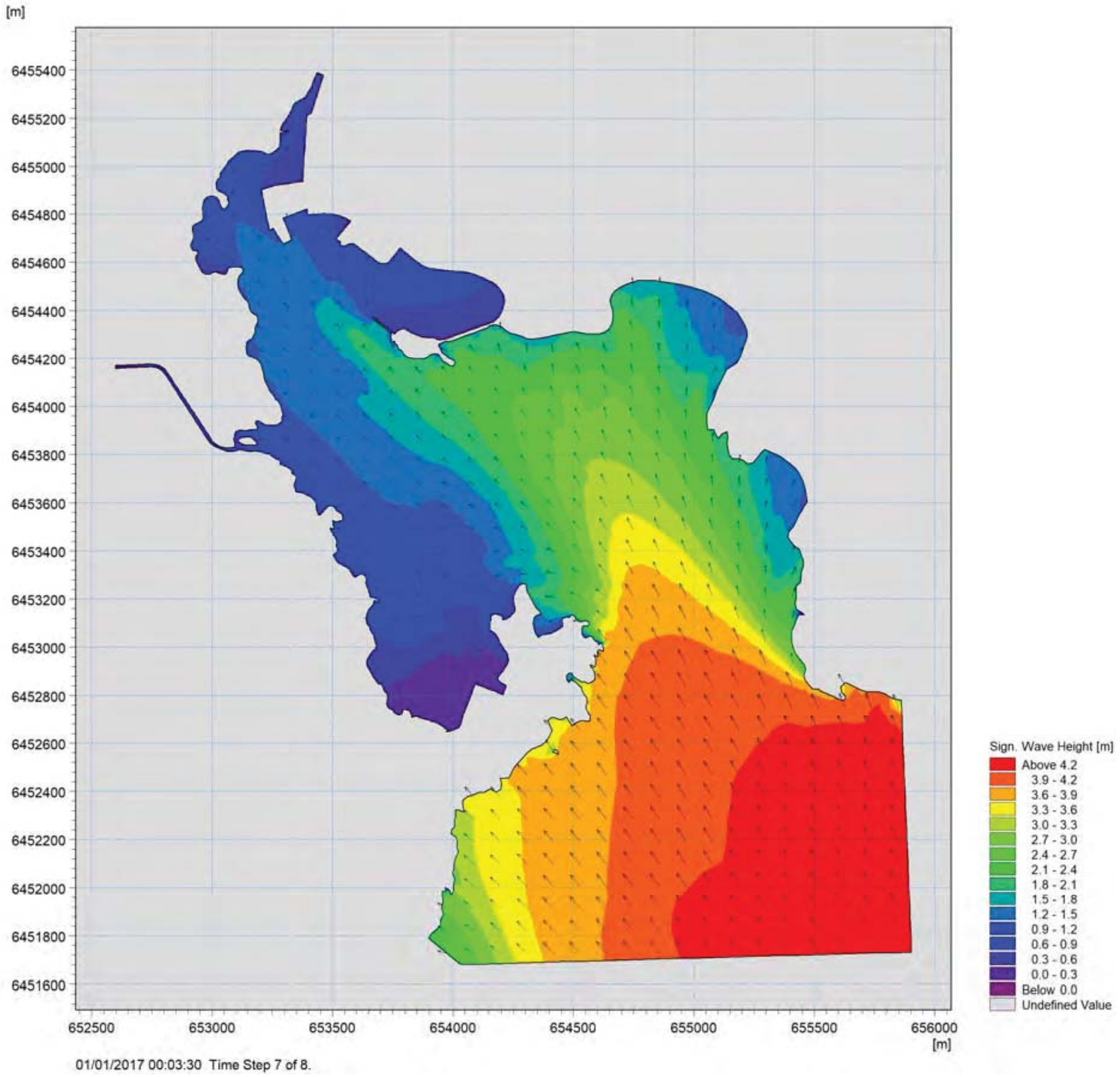


Figure 6.2: Significant wave height and mean wave direction in Stornoway Harbour - 1 in 50 year return period storm from 180°N

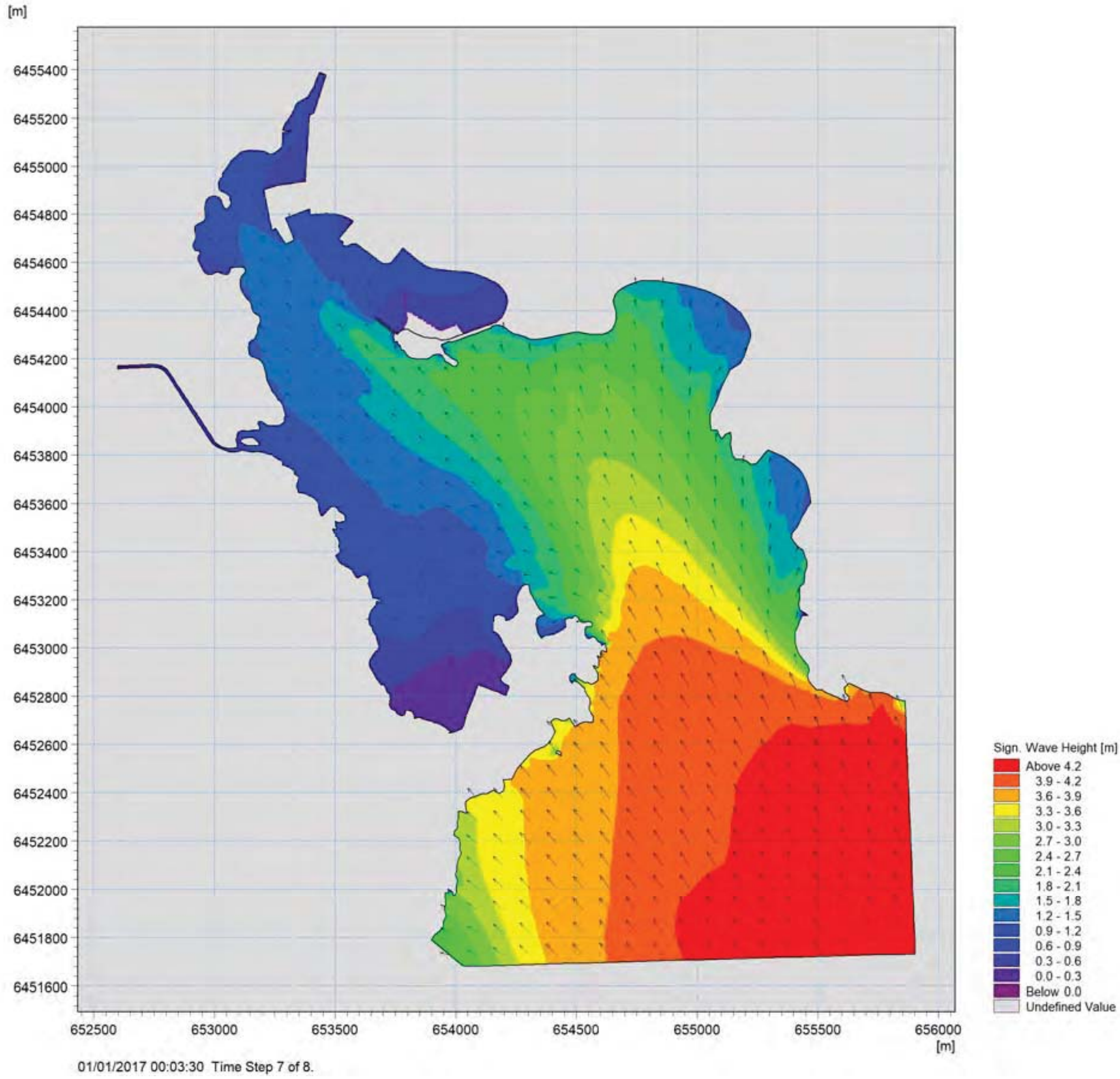


Figure 6.3 Significant wave height and mean wave direction in Stornoway with Newton Basin development in place - 1 in 50 year return period storm from 180°N

A comparison of Figures 6.2 and 6.3 shows that the wave climate at the existing piers and berths during storms from the South East to South directions is not significantly changed by the construction of the Newton Basin marina development.

During storms from 210° to 315° the waves in Stornoway Harbour are generated over the local fetches within the harbour. Figure 6.4 and Figure 6.5 show the significant wave heights and mean wave directions around the harbour during a 1 in 50 year storm from 225° at high water spring tides for the existing harbour and for the harbour with the Newton Basin marina development in place respectively.

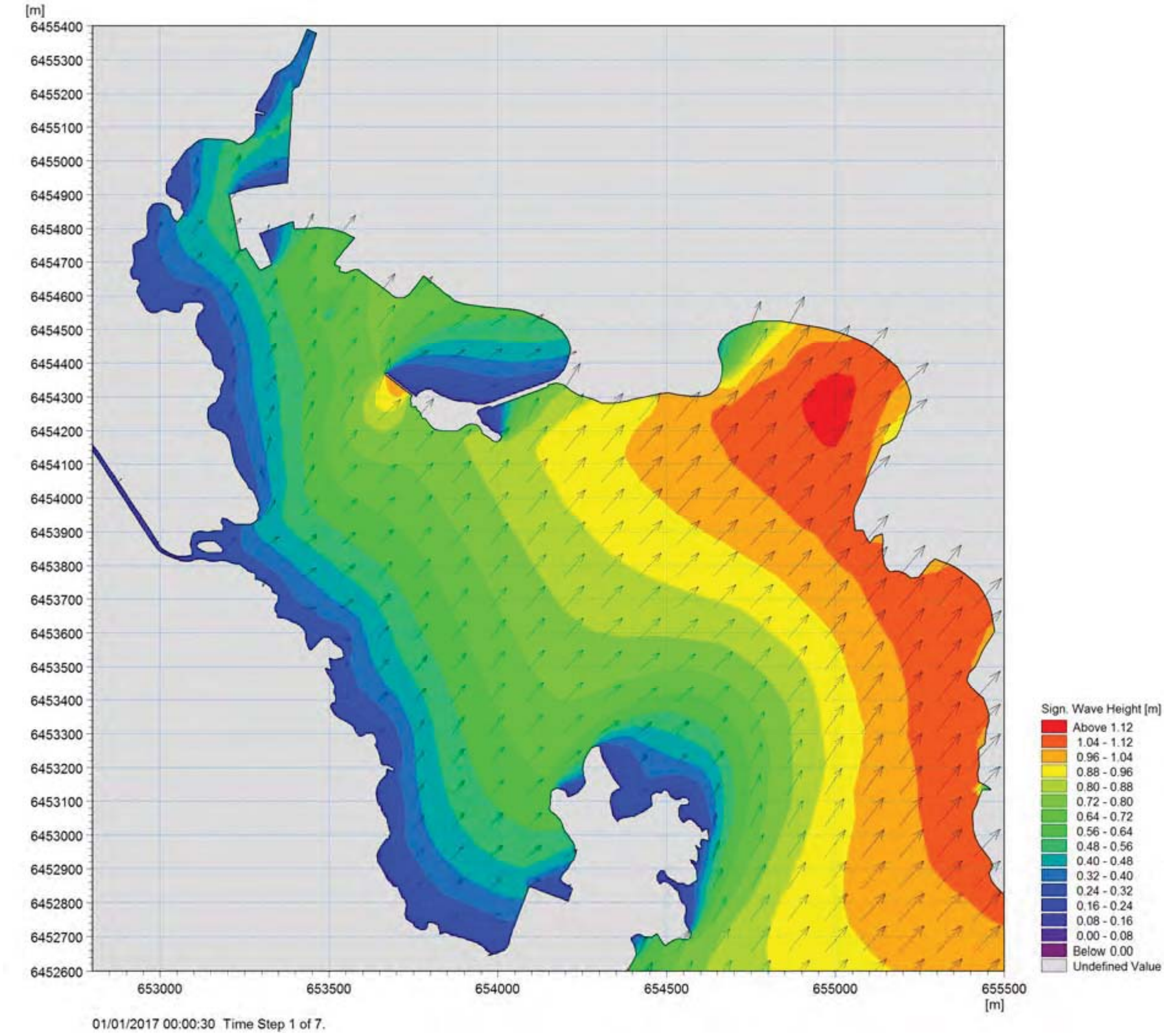


Figure 6.4 Significant wave height and mean wave direction in Stornoway Harbour - 1 in 50 year return period storm from 225°N

During south westerly storms the waves are diffracted around the end of the existing concrete breakwater at the north western end of Goat Island and penetrate into the Newton Basin area. As can be seen in Figure 6.5 the proposed breakwater at the western end of the marina basin provides good shelter to the berths in the proposed pontoon area during storms from this direction.

A comparison of Figures 6.4 and 6.5 shows that the wave climate at the existing piers and berths during storms from the South West direction is not significantly changed by the construction of the Newton Basin marina development.

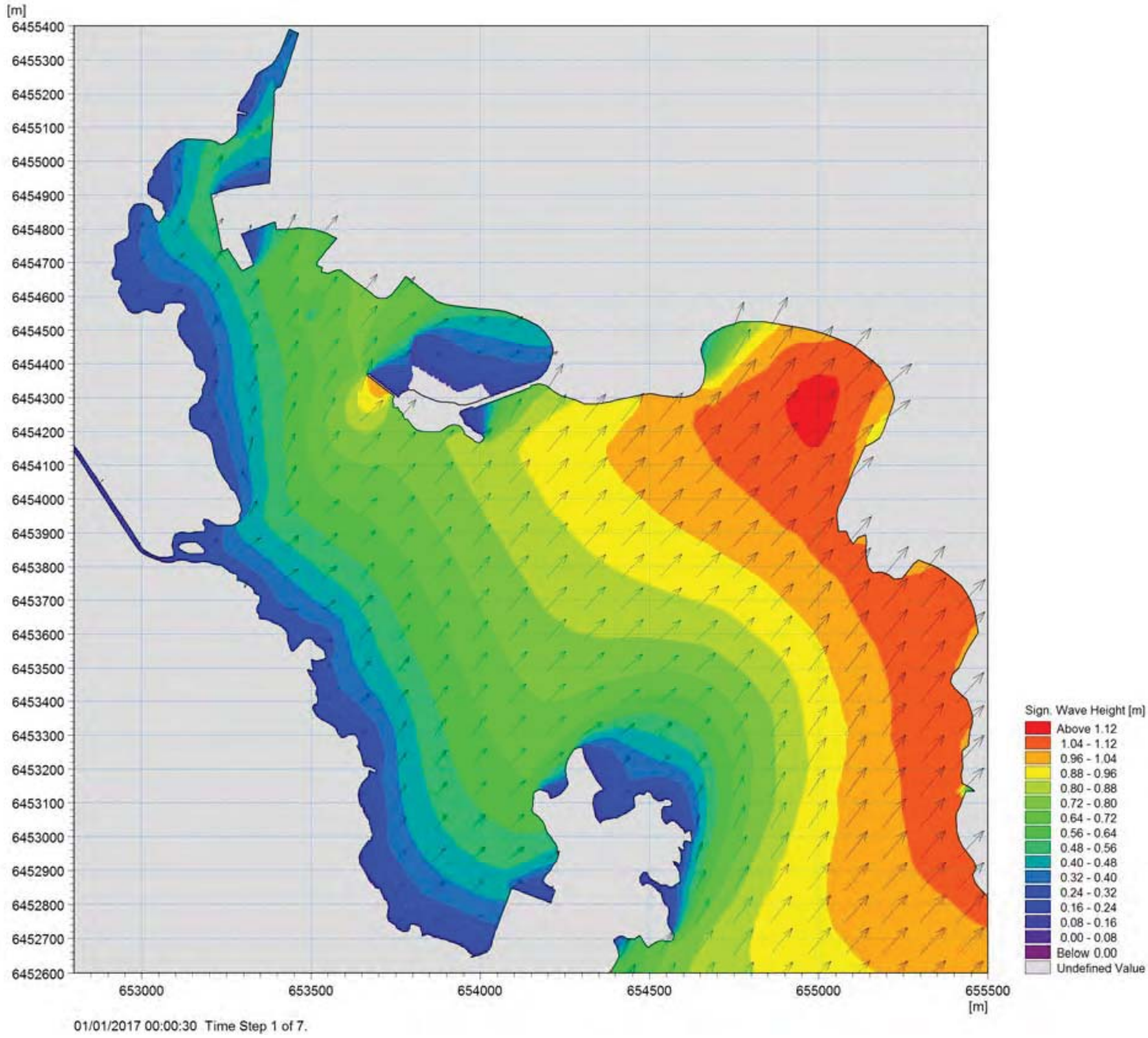


Figure 6.5: Significant wave height and mean wave direction in Stornoway with Newton Basin development in place - 1 in 50 year return period storm from 225°N

The largest wave heights at the site of the proposed marina development in Newton Basin occur during storms from 285° N. Figure 6.6 and 6.7 show the significant wave heights and mean wave directions around the harbour during a 1 in 50 year storm from 285° at high water spring tides for the existing harbour and for the harbour with the Newton Basin marina development in place respectively.

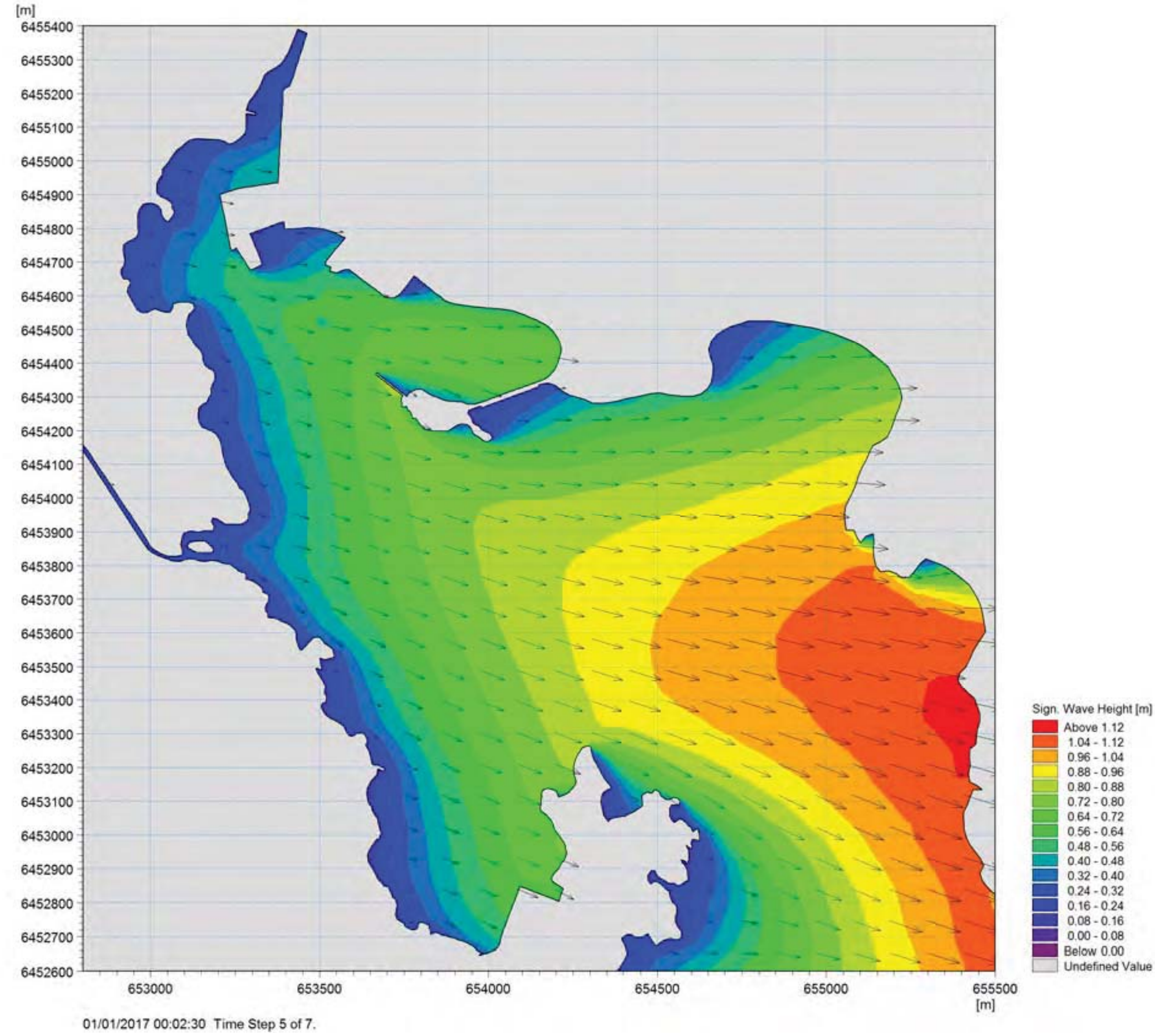


Figure 6.6: Significant wave height and mean wave direction in Stornoway Harbour - 1 in 50 year return period storm from 285ºN

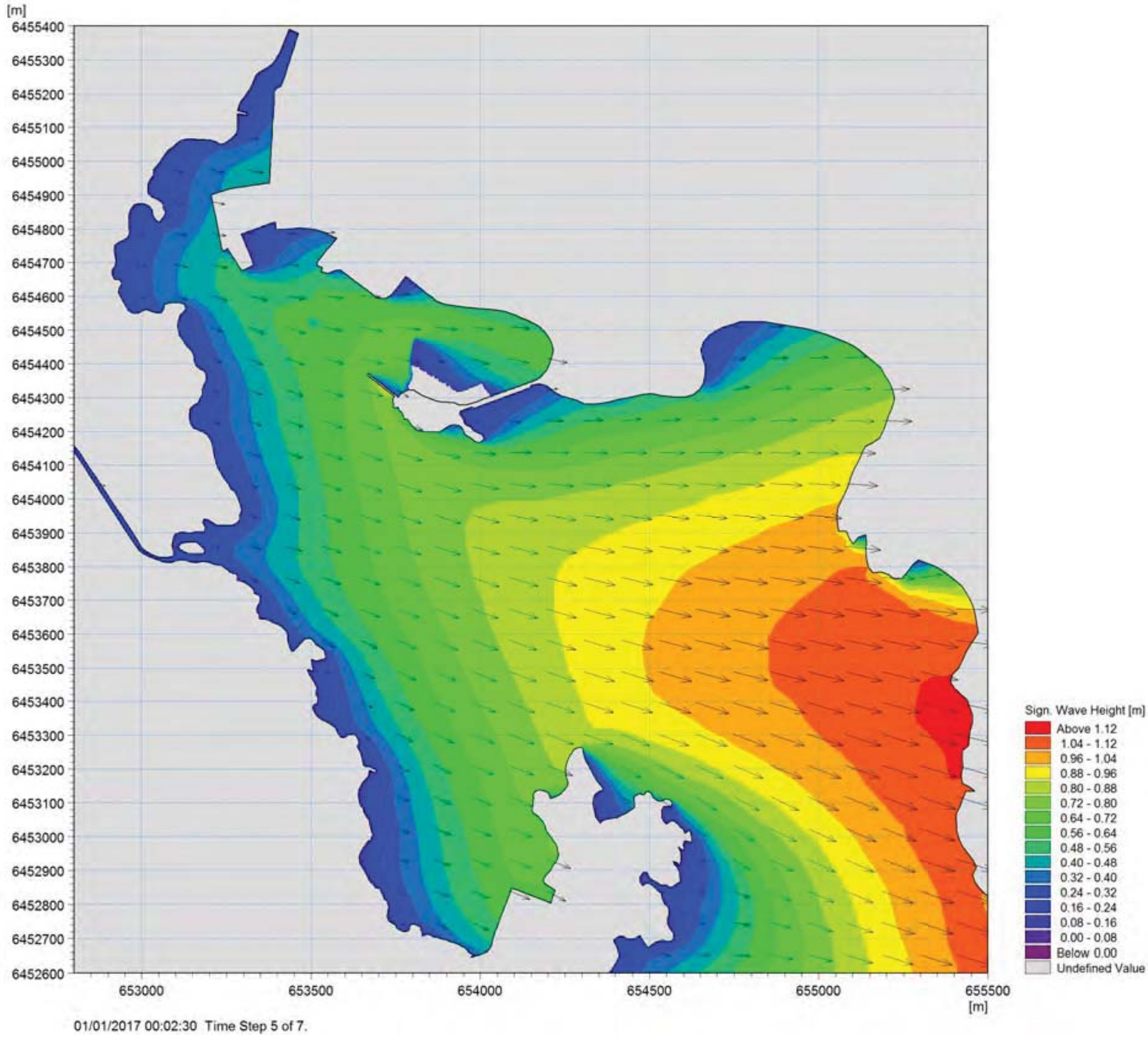


Figure 6.7: Significant wave height and mean wave direction in Stornoway with Newton Basin development in place - 1 in 50 year return period storm from 285°N

6.5 IMPACT OF THE PROPOSED SCHEME ON THE WAVE CLIMATE

As shown in Section 6.4 computational modelling of the wave climate approaching and within Stornoway Harbour has shown that for the longer period waves penetrating into the harbour from the Minch (6 to 8 second wave period), the Newton Basin site is sheltered by the existing concrete breakwater at the north western end of Goat Island. Thus the proposed development does not affect the wave climate at the existing piers and berths for storms in the Minch from East to South South West sector.

For storms from the South West to West sector the waves are generated within Stornoway Harbour and have a relatively short wave period (1.8 to 2.2 seconds) and the existing concrete breakwater at the north western end of Goat Island still provides a significant influence on the wave climate in the Newton Basin area. The wave modelling has shown that the proposed development does not affect the wave climate at the existing piers and berths to any significant degree. The proposed marina development will slightly reduce the wave activity at the existing piers and berths during local storms from the South East but the reduction will be relatively small.

The proposed marina site is most exposed to waves from the West North West. For storms from this direction the marina lies down wind of the existing piers and berths and therefore the marina has no direct effect on the wave climate at the piers during these storm events. However there will be wave reflections coming off the north western side of the marina rubble mound breakwater. Although these reflected waves will propagate towards the existing piers the reflected waves will be of low magnitude, typically less than 0.3 metres in height, and will be effectively attenuated by interaction with the incoming waves before they reach any of the berths at the existing piers.

Overall the modelling and analysis shows that the proposed Newton Basin marina development will not significantly affect the wave climate in other areas of Stornoway Harbour.

6.6 WAVE CLIMATE AROUND THE NEWTON BASIN MARINA

6.6.1 Storm wave climate for engineering design

The storm wave climate has been extracted from the various model simulations for three locations around the proposed marina for stability analysis. The locations are breakwater outer, breakwater inner and slipway as shown in Figure 6.8

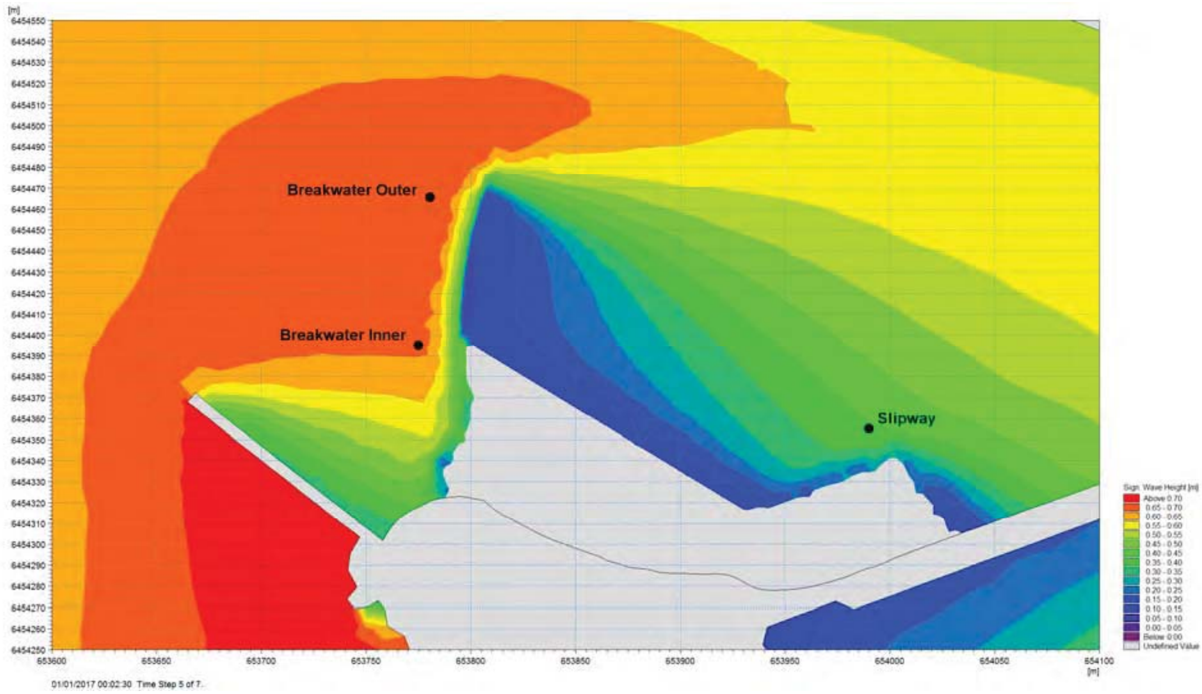


Figure 6.8: Location of wave climate extraction points from model simulations for Newton Basin

For the simulations of the storm waves generated in the Minch (directions 090° to 195°) the longer period disturbance only has been tabulated, i.e. the local wind seas generated across the Newton Basin itself have been ignored.

The following tables give the wave climate at each of the three points for every 15° storm direction for storm return periods of 1 in 1, 50, 100 and 200 years.

Table 6.3: Wave point – Breakwater Outer – 1 in 1 year return period storms

Storm direction deg N	Significant wave height Hm0 [m]	Maximum wave height Hmax [m]	Spectral peak wave period Tp [s]	Mean wave period Tm [m]	Mean wave direction deg N
90	0.026	0.052	5.79	4.81	240
105	0.040	0.079	6.07	5.04	241
120	0.052	0.102	6.25	5.19	242
135	0.066	0.128	6.48	5.38	243
150	0.074	0.143	6.69	5.55	244
165	0.080	0.155	6.97	5.78	245
180	0.079	0.153	7.07	5.86	245
195	0.074	0.143	7.11	5.90	245
210	0.282	0.437	1.41	1.17	226
225	0.342	0.545	1.57	1.31	239
240	0.405	0.631	1.69	1.40	248
255	0.448	0.669	1.74	1.44	259
270	0.468	0.687	1.76	1.46	271
285	0.457	0.679	1.75	1.45	283
300	0.423	0.628	1.69	1.40	294
315	0.342	0.512	1.52	1.26	303

Table 6.4: Wave point – Breakwater Outer – 1 in 50 year return period storms

Storm direction deg N	Significant wave height Hm0 [m]	Maximum wave height Hmax [m]	Spectral peak wave period Tp [s]	Mean wave period Tm [m]	Mean wave direction deg N
90	0.076	0.148	7.03	5.83	244
105	0.098	0.189	7.20	5.97	245
120	0.115	0.223	7.31	6.07	245
135	0.145	0.280	7.80	6.48	247
150	0.153	0.295	7.94	6.59	247
165	0.157	0.301	8.08	6.71	247
180	0.157	0.301	8.31	6.89	247
195	0.153	0.293	8.54	7.09	248
210	0.432	0.586	1.63	1.35	226
225	0.525	0.725	1.81	1.50	239
240	0.620	0.840	1.95	1.62	248
255	0.687	0.890	2.01	1.67	259
270	0.717	0.915	2.03	1.69	271
285	0.701	0.901	2.02	1.68	283
300	0.648	0.835	1.94	1.61	294
315	0.526	0.682	1.76	1.46	303

Table 6.5: Wave point – Breakwater Outer – 1 in 100 year return period storms

Storm direction deg N	Significant wave height Hm0 [m]	Maximum wave height Hmax [m]	Spectral peak wave period Tp [s]	Mean wave period Tm [m]	Mean wave direction deg N
90	0.084	0.164	7.15	5.94	245
105	0.109	0.211	7.35	6.10	245
120	0.131	0.254	7.59	6.30	246
135	0.159	0.305	7.94	6.59	247
150	0.168	0.322	8.08	6.71	247
165	0.176	0.337	8.40	6.97	248
180	0.176	0.337	8.64	7.17	248
195	0.169	0.323	8.76	7.27	248
210	0.460	0.605	1.66	1.37	225
225	0.558	0.755	1.85	1.53	239
240	0.659	0.875	1.99	1.65	248
255	0.730	0.927	2.05	1.70	259
270	0.762	0.953	2.08	1.72	271
285	0.745	0.939	2.06	1.71	283
300	0.689	0.870	1.98	1.65	294
315	0.559	0.711	1.79	1.49	303

Table 6.6: Wave point – Breakwater Outer – 1 in 200 year return period storms

Storm direction deg N	Significant wave height Hm0 [m]	Maximum wave height Hmax [m]	Spectral peak wave period Tp [s]	Mean wave period Tm [m]	Mean wave direction deg N
90	0.098	0.189	7.38	6.13	245
105	0.128	0.247	7.71	6.40	246
120	0.150	0.288	7.88	6.54	247
135	0.175	0.336	8.09	6.71	247
150	0.191	0.366	8.42	6.99	248
165	0.197	0.377	8.68	7.20	248
180	0.194	0.371	8.82	7.32	248
195	0.186	0.355	8.93	7.41	248
210	0.492	0.634	1.69	1.41	226
225	0.598	0.792	1.89	1.57	239
240	0.707	0.917	2.04	1.69	248
255	0.782	0.971	2.10	1.74	259
270	0.817	0.998	2.12	1.76	271
285	0.799	0.983	2.11	1.75	283
300	0.738	0.911	2.03	1.68	294
315	0.599	0.744	1.84	1.52	303

Table 6.7: Wave point – Breakwater Inner – 1 in 1 year return period storms

Storm direction deg N	Significant wave height Hm0 [m]	Maximum wave height Hmax [m]	Spectral peak wave period Tp [s]	Mean wave period Tm [m]	Mean wave direction deg N
90	0.009	0.018	6.00	5.00	269
105	0.016	0.031	6.06	5.03	270
120	0.022	0.043	6.25	5.19	270
135	0.029	0.057	6.48	5.38	271
150	0.034	0.067	6.69	5.55	271
165	0.039	0.076	6.97	5.79	272
180	0.039	0.076	7.07	5.87	272
195	0.037	0.071	7.12	5.91	272
210	0.180	0.221	1.00	0.83	219
225	0.211	0.306	1.18	0.98	241
240	0.267	0.441	1.41	1.17	259
255	0.333	0.566	1.60	1.33	271
270	0.395	0.646	1.71	1.42	281
285	0.429	0.667	1.74	1.44	289
300	0.433	0.651	1.72	1.42	297
315	0.387	0.577	1.62	1.34	309

Table 6.8: Wave point – Breakwater Inner – 1 in 50 year return period storms

Storm direction deg N	Significant wave height Hm0 [m]	Maximum wave height Hmax [m]	Spectral peak wave period Tp [s]	Mean wave period Tm [m]	Mean wave direction deg N
90	0.038	0.074	7.03	5.84	272
105	0.050	0.096	7.20	5.98	272
120	0.060	0.116	7.31	6.07	272
135	0.080	0.155	7.81	6.48	273
150	0.086	0.166	7.95	6.59	273
165	0.090	0.172	8.09	6.71	273
180	0.092	0.176	8.31	6.90	274
195	0.092	0.176	8.54	7.09	274
210	0.273	0.296	1.16	0.96	219
225	0.324	0.404	1.35	1.12	240
240	0.408	0.587	1.63	1.35	259
255	0.509	0.754	1.85	1.53	271
270	0.616	0.872	1.99	1.65	278
285	0.682	0.913	2.03	1.69	288
300	0.686	0.891	2.01	1.67	298
315	0.592	0.768	1.86	1.55	309

Table 6.9: Wave point – Breakwater Inner – 1 in 100 year return period storms

Storm direction deg N	Significant wave height Hm0 [m]	Maximum wave height Hmax [m]	Spectral peak wave period Tp [s]	Mean wave period Tm [m]	Mean wave direction deg N
90	0.043	0.083	7.15	5.94	272
105	0.057	0.110	7.35	6.10	272
120	0.071	0.137	7.59	6.30	273
135	0.089	0.172	7.95	6.60	273
150	0.096	0.184	8.09	6.71	273
165	0.104	0.199	8.40	6.98	274
180	0.106	0.204	8.64	7.17	274
195	0.103	0.197	8.77	7.28	274
210	0.294	0.300	1.17	0.97	218
225	0.344	0.421	1.38	1.15	240
240	0.434	0.611	1.66	1.38	259
255	0.541	0.785	1.88	1.56	271
270	0.655	0.908	2.03	1.68	278
285	0.724	0.950	2.07	1.72	288
300	0.728	0.928	2.05	1.70	298
315	0.630	0.800	1.90	1.58	309

Table 6.10: Wave point – Breakwater Inner – 1 in 200 year return period storms

Storm direction deg N	Significant wave height Hm0 [m]	Maximum wave height Hmax [m]	Spectral peak wave period Tp [s]	Mean wave period Tm [m]	Mean wave direction deg N
90	0.051	0.099	7.39	6.13	272
105	0.070	0.136	7.72	6.41	273
120	0.084	0.161	7.88	6.54	273
135	0.100	0.193	8.09	6.72	273
150	0.113	0.217	8.43	7.00	274
165	0.120	0.229	8.68	7.21	274
180	0.119	0.228	8.82	7.32	274
195	0.115	0.220	8.93	7.42	274
210	0.315	0.314	1.19	0.99	218
225	0.369	0.441	1.41	1.17	240
240	0.465	0.640	1.70	1.41	259
255	0.580	0.822	1.93	1.60	271
270	0.701	0.950	2.07	1.72	278
285	0.775	0.994	2.12	1.76	288
300	0.780	0.971	2.10	1.74	298
315	0.675	0.838	1.95	1.62	309

Table 6.11: Wave point – Slipway – 1 in 1 year return period storms

Storm direction deg N	Significant wave height Hm0 [m]	Maximum wave height Hmax [m]	Spectral peak wave period Tp [s]	Mean wave period Tm [m]	Mean wave direction deg N
90	0.003	0.007	6.50	5.40	310
105	0.006	0.012	6.53	5.42	310
120	0.008	0.016	6.57	5.45	310
135	0.010	0.021	6.60	5.48	310
150	0.012	0.024	6.64	5.51	311
165	0.013	0.026	6.93	5.75	311
180	0.013	0.026	7.03	5.84	311
195	0.013	0.025	7.09	5.88	311
210	0.110	0.108	0.70	0.58	220
225	0.127	0.131	0.77	0.64	237
240	0.150	0.165	0.87	0.72	253
255	0.173	0.216	0.99	0.82	271
270	0.218	0.282	1.13	0.94	284
285	0.255	0.350	1.26	1.05	297
300	0.295	0.413	1.37	1.14	306
315	0.298	0.418	1.38	1.14	316

Table 6.12: Wave point – Slipway – 1 in 50 year return period storms

Storm direction deg N	Significant wave height Hm0 [m]	Maximum wave height Hmax [m]	Spectral peak wave period Tp [s]	Mean wave period Tm [m]	Mean wave direction deg N
90	0.012	0.024	6.97	5.79	310
105	0.016	0.032	7.17	5.95	311
120	0.019	0.038	7.28	6.04	311
135	0.026	0.049	7.76	6.44	311
150	0.027	0.052	7.90	6.56	311
165	0.028	0.053	8.04	6.67	311
180	0.028	0.054	8.26	6.86	312
195	0.028	0.053	8.50	7.05	312
210	0.168	0.142	0.80	0.67	219
225	0.186	0.172	0.88	0.73	238
240	0.225	0.218	1.00	0.83	254
255	0.274	0.289	1.15	0.95	270
270	0.333	0.383	1.32	1.09	285
285	0.391	0.471	1.47	1.22	297
300	0.452	0.552	1.59	1.32	306
315	0.456	0.555	1.59	1.32	316

Table 6.13: Wave point – Slipway – 1 in 100 year return period storms

Storm direction deg N	Significant wave height Hm0 [m]	Maximum wave height Hmax [m]	Spectral peak wave period Tp [s]	Mean wave period Tm [m]	Mean wave direction deg N
90	0.014	0.027	7.11	5.90	311
105	0.018	0.036	7.32	6.07	311
120	0.023	0.044	7.55	6.27	311
135	0.028	0.054	7.90	6.56	311
150	0.030	0.057	8.04	6.67	311
165	0.031	0.060	8.36	6.94	312
180	0.032	0.061	8.59	7.13	312
195	0.030	0.058	8.72	7.24	312
210	0.175	0.144	0.81	0.67	220
225	0.204	0.179	0.90	0.75	237
240	0.241	0.227	1.01	0.84	253
255	0.290	0.302	1.17	0.97	270
270	0.353	0.399	1.35	1.12	285
285	0.416	0.491	1.50	1.24	297
300	0.480	0.575	1.62	1.35	306
315	0.485	0.577	1.63	1.35	316

Table 6.14: Wave point – Slipway – 1 in 200 year return period storms

Storm direction deg N	Significant wave height Hm0 [m]	Maximum wave height Hmax [m]	Spectral peak wave period Tp [s]	Mean wave period Tm [m]	Mean wave direction deg N
90	0.016	0.032	7.34	6.09	311
105	0.022	0.043	7.67	6.37	311
120	0.026	0.050	7.84	6.51	311
135	0.031	0.059	8.05	6.68	311
150	0.034	0.065	8.38	6.96	312
165	0.035	0.068	8.63	7.17	312
180	0.035	0.067	8.77	7.28	312
195	0.034	0.064	8.89	7.38	312
210	0.190	0.154	0.83	0.69	219
225	0.166	0.209	0.97	0.81	241
240	0.258	0.239	1.04	0.87	253
255	0.311	0.317	1.20	1.00	270
270	0.379	0.419	1.38	1.15	285
285	0.445	0.515	1.53	1.27	297
300	0.514	0.602	1.66	1.38	306
315	0.519	0.604	1.66	1.38	316

6.6.2 Wave disturbance within marina basin

As noted in Section 4.5, the harbour disturbance modelling was undertaken using a combination of the spectral wave model with diffraction and the Boussinesq wave model. The Boussinesq wave model is required to assess the impact of reflected waves around the marina basin but as it does not include wind wave generation within the model area, the short steep wind driven waves decline too quickly in the further areas of the model. Thus the combination of the detailed spectral diffraction model and the Boussinesq wave model was used to accurately assess the wave climate around the pontoon berth area.

The wave climate within the pontoon berth area was assessed on the basis of 1 in 1 and 1 in 50 year return period storms for the most exposed storm directions of 285° to 300° N. Figure 6.9 and Figure 6.10 show the predicted wave heights around the marina basin ignoring wave reflections within the harbour basin for 1 in 1 and 1 in 50 year return period storms respectively.

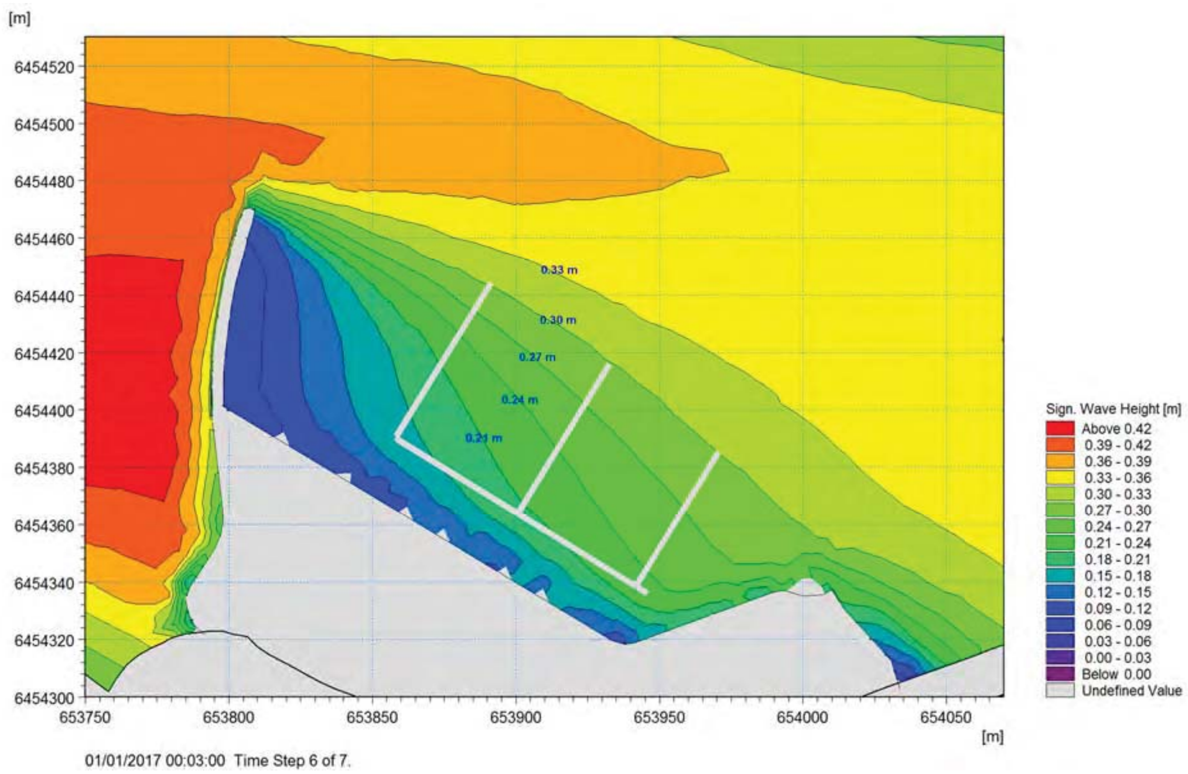


Figure 6.9: Predicted significant wave heights in marina basin without wave reflections 1 in 1 year return period storm at high water spring tides

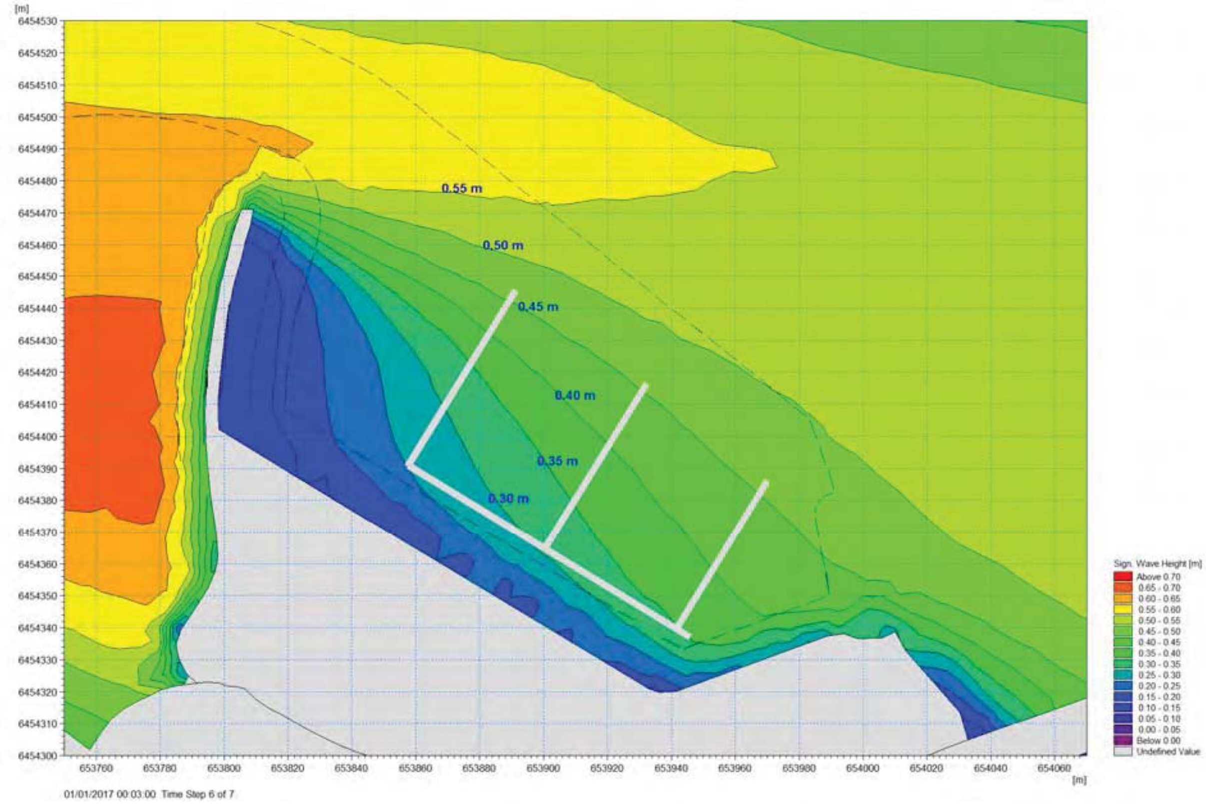


Figure 6.10: Predicted significant wave heights in marina basin without wave reflections 1 in 50 year return period storm at high water spring tides

Figure 6.11 shows the wave patterns around the marina with wave reflections from the basin revetments as simulated using a Boussinesq wave model.

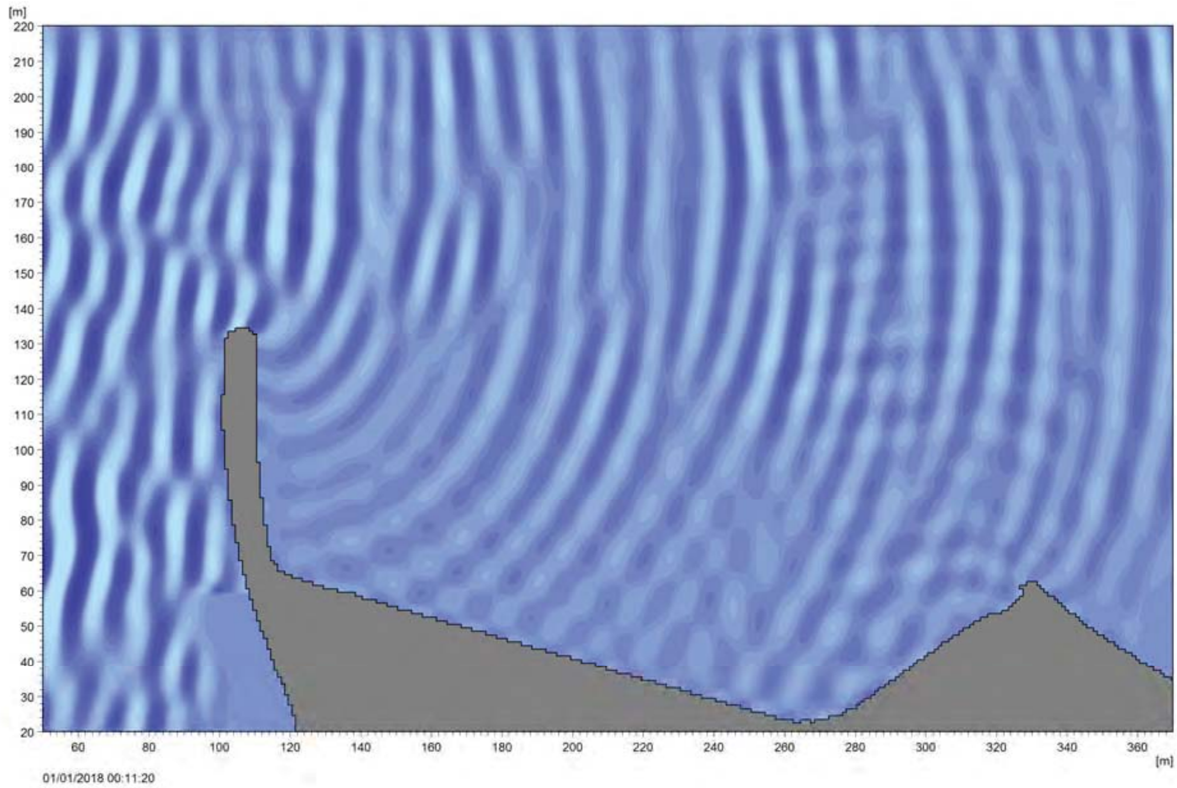


Figure 6.11: Wave disturbance patterns in marina basin including wave reflections

The Boussinesq wave modelling has been used to evaluate the effect of the reflections from the internal walls around the marina basin. The reflected wave from the main wall on the south western side of the basin will have wave height of about 70mm and 100 mm for the 1 in 1 and 1 in 50 year return period storms respectively. These reflected waves mainly affect the inner part of the pontoon berthing area where the incoming wave heights are lower than those at the outer ends of the pontoon walkways. There will also be a small standing wave pattern at the inner end of the basin due to wave reflection from the North West facing wall. However most of the standing wave patterns will occur in an area between the slipway and the most south easterly pontoon and the resulting wave heights are expected to be less that those that occur in the outer regions of the berthing area.

The modelling showed that the wave heights in the outer parts of the berthing area during severe storms are above the ideal heights recommended for all the year round berthing. However the berths are arranged such that the vessels will be head on to the wave direction in the most exposed parts of the marina and thus the moored boats will be much less susceptible to damage compared to a situation where the vessels are beam on to the waves.

7 EXTREME WAVES AND WATER LEVELS AND OVERTOPPING

7.1 JOINT PROBABILITY ANALYSIS

As set out in Section 4.6, a joint probability analysis was undertaken for extreme water levels and wave heights using the techniques and data contained in the DEFRA/EA "Joint Probability: Dependence Mapping and Best Practice:" report FD2308/TR1.

The proposed development at Newton Basin is most exposed to waves from the West to North West sector. The extreme wave conditions at the site are dependent on the extreme wind speeds across the harbour. Thus the joint probability analysis was undertaken between extreme water levels and wind speeds and the equivalent waves at the site were then determined by computational modelling using the appropriate wind speed for wave generation.

The extreme water levels were taken from EA/SEPA's "Coastal flood boundary conditions for the UK mainland and islands: design sea levels" database. The extreme water levels in metres to OD and CD are shown in Table 7.1 SEPA currently indicate that the projected sea level rise to 2080 at Stornoway would be 0.53 metres which, using UKCP09, equates to a sea level rise of 0.715m by 2100.

Table 7.1: SEPA - Extreme water levels for Stornoway Harbour – current sea level conditions

Return period years	Sea level metres OD	Sea Level metres CD
1	2.91	5.62
2	2.98	5.69
5	3.07	5.78
10	3.14	5.85
20	3.20	5.91
25	3.22	5.93
50	3.28	5.99
75	3.32	6.03
100	3.34	6.05
150	3.37	6.08
200	3.40	6.11
250	3.42	6.13
300	3.42	6.13
500	3.46	6.17
1000	3.51	6.22
10000	3.67	6.38

An EVA analysis was undertaken of the overwater wind speeds for the fetch from the West North West sector for wind wave generation at Newton Basin in Stornoway Harbour. The results of the analysis are shown graphically in Figure 7.1.

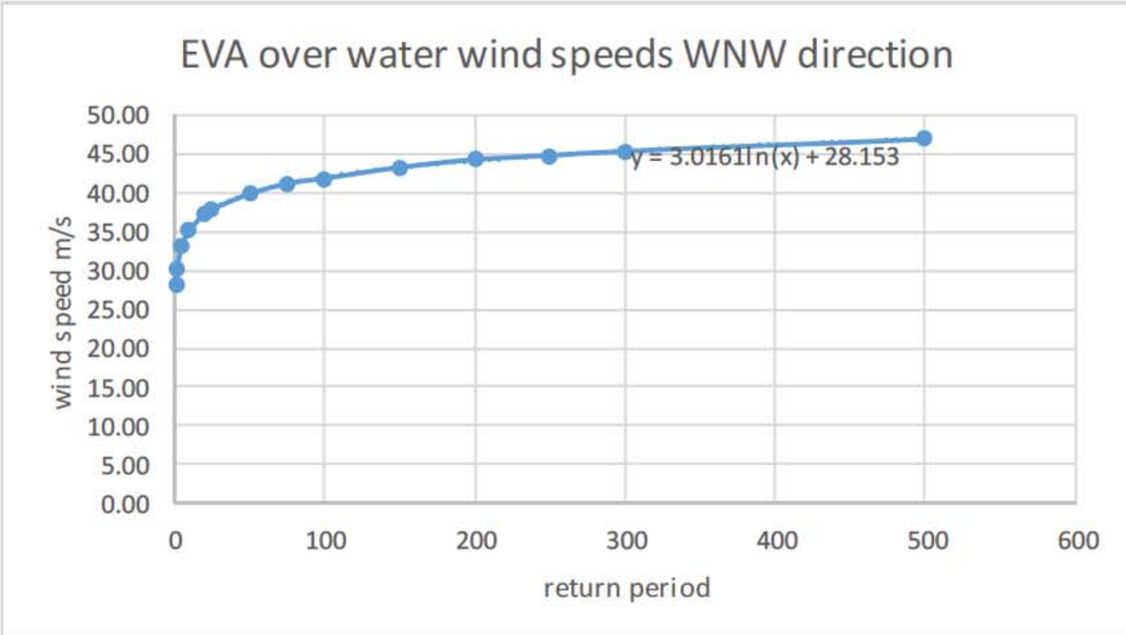


Figure 7.1: Extreme value Analysis of overwater wind speed for WNW fetch in Stornoway Harbour.

The results of the joint probability analysis are shown graphically in the form of joint exceedance curves for water levels and wind speeds in Figure 7.2 and in tabular form in Table 7.2.

As the standard for coastal flooding is 1 in 200 years return period, wave simulations were undertaken for a series of six combinations of wind speeds and water levels all with a joint return period of 1 in 200 years. Simulations were initially run using the coupled wave and tidal model to check if the larger of the 1 in 200 year return period waves resulted in any significant wave set up at the Newton Basin marina breakwater and reclamation. However the modelling showed that the wave periods were too short for wave set up to be of any significance in the extreme water levels at the proposed development. Consequently all the wave/water level simulations were undertaken at the appropriate extreme water levels.

Following the completion of the simulations under current sea level conditions the levels were raised to take account of predicted sea level rise and the simulation re run for the increased sea level scenarios applicable to 2080 and 2100.

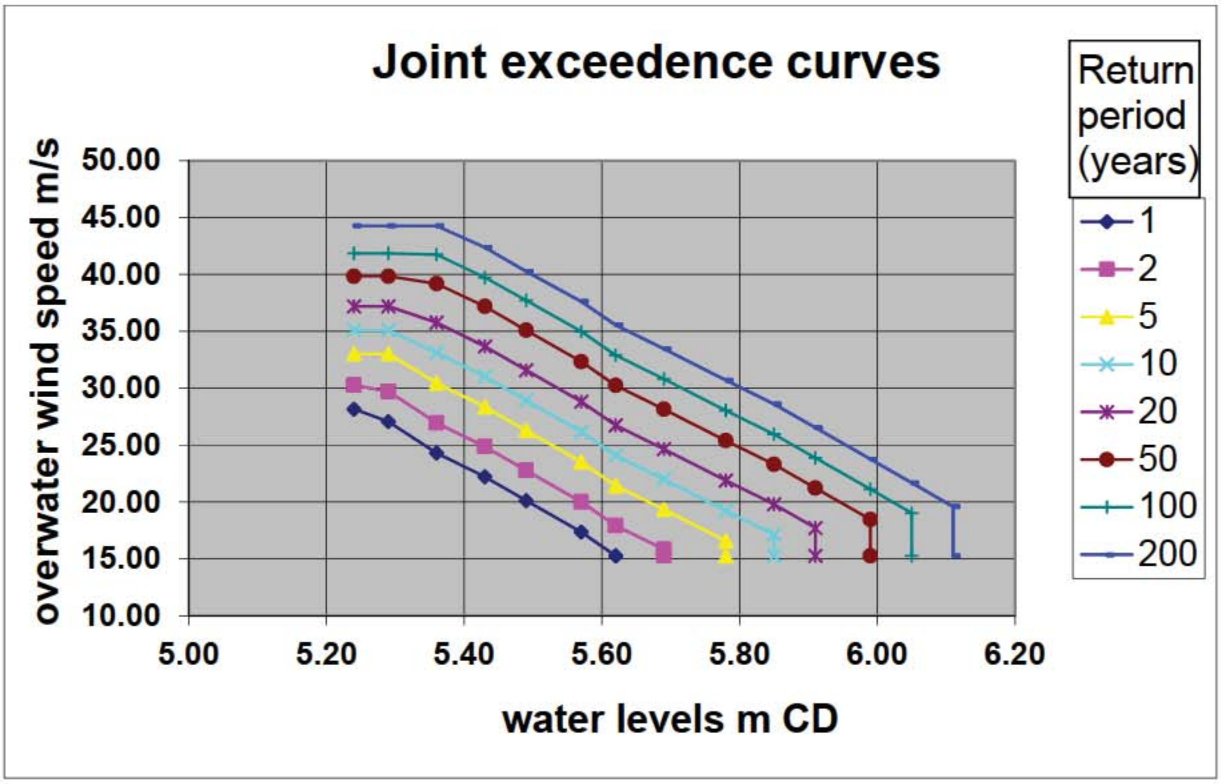


Figure 7.2: Joint exceedance curves for extreme wind speeds and water levels for WNW sector

Table 7.2: Joint probability combinations of water levels and wind speeds for extreme events from the West North West sector at Newton Basin

Value of first variable:	Joint exceedence return period (years)							
	1	2	5	10	20	50	100	200
Present-day sea level Stornoway(mOD)	Value of second variable:			Overwater wind speeds 285				
5.24	28.16	30.26	33.02	35.11	37.20	39.84	41.86	44.28
5.29	27.05	29.71	33.02	35.11	37.20	39.84	41.86	44.28
5.36	24.30	26.95	30.46	33.11	35.77	39.19	41.75	44.28
5.43	22.21	24.86	28.36	31.03	33.68	37.19	39.73	42.38
5.49	20.12	22.77	26.28	28.93	31.59	35.10	37.73	40.27
5.57	17.36	20.01	23.52	26.17	28.82	32.34	34.99	37.63
5.62	15.27	17.92	21.43	24.09	26.74	30.25	32.90	35.56
5.69	#N/A	15.83	19.34	22.00	24.65	28.15	30.81	33.47
5.78	#N/A	#N/A	16.58	19.23	21.89	25.40	28.04	30.71
5.85	#N/A	#N/A	#N/A	17.14	19.80	23.31	25.96	28.61
5.91	#N/A	#N/A	#N/A	#N/A	17.71	21.22	23.87	26.53
5.99	#N/A	#N/A	#N/A	#N/A	#N/A	18.46	21.11	23.77
6.05	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	19.02	21.68
6.11	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	19.59

7.2 EXTREME WAVE/WATER LEVEL AND OVERTOPPING AT NEWTON BASIN

The results of the of the extreme wave and water level combinations for the 1 in 200 year joint probability simulations are shown in Tables 7.3, 7.4 and 7.5 for the current sea levels and for sea level rise to 2080 and 2100 respectively. The results are shown for three locations; one halfway along the breakwater, one at the western end of the land reclamation and the third at the revetment to the west of the slipway. The tables also include the mean overtopping values derived from equation 6.6 in the EurOtop 2016 manual with the level of the reclamation area set at +6.7m CD in accordance with Wallace Stone LLP drawing 1874-101B.

It will be seen from the results of the extreme wave - water level analysis and the overtopping that the current proposed reclamation level of 6.7m CD should be adequate for the current sea level projections up to about 2080. However the analysis suggests that the 6.7m CD level will flood during a 1 in 200 year return period event by 2100.

It should be noted that the revised IPCC projections for sea level rise are due to be issued by November 2018. Although the actual figures will not be known until November 2018, it is thought that the revised projections are likely to indicate an increase in the rate of sea level rise above those currently recommended by SEPA.

Table 7.3: Extreme waves/water levels and overtopping for 1 in 200 year return period joint probability events from the West North West sector with current sea level conditions

Breakwater - current sea levels

Water level CD [m]	Significant wave height Hm0 [m]	Maximum wave height Hmax [m]	Peak wave period Tp [s]	Mean wave period Tm [m]	Freeboard at 6.7m CD [m]	Mean Overtopping [l/s/m]
5.36	0.781	0.960	2.08	1.73	1.34	0.050
5.49	0.693	0.889	2.01	1.66	1.21	0.034
5.62	0.594	0.802	1.91	1.58	1.08	0.017
5.78	0.498	0.710	1.79	1.49	0.92	0.011
5.91	0.416	0.629	1.69	1.40	0.79	0.006
6.11	0.283	0.492	1.49	1.24	0.59	0.001

Reclamation - current sea levels

Water level CD [m]	Significant wave height Hm0 [m]	Maximum wave height Hmax [m]	Peak wave period Tp [s]	Mean wave period Tm [m]	Freeboard at 6.7m CD [m]	Mean Overtopping [l/s/m]
5.36	0.754	0.946	2.07	1.72	1.34	0.032
5.49	0.671	0.876	1.99	1.65	1.21	0.023
5.62	0.576	0.791	1.89	1.57	1.08	0.011
5.78	0.482	0.702	1.78	1.48	0.92	0.007
5.91	0.402	0.622	1.68	1.39	0.79	0.004
6.11	0.276	0.483	1.48	1.23	0.59	0.001

Revetment at slipway - current sea levels

Water level CD [m]	Significant wave height Hm0 [m]	Maximum wave height Hmax [m]	Peak wave period Tp [s]	Mean wave period Tm [m]	Freeboard at 6.7m CD [m]	Mean Overtopping [l/s/m]
5.36	0.380	0.416	1.61	1.34	1.34	0.000
5.49	0.358	0.414	1.54	1.28	1.21	0.000
5.62	0.325	0.397	1.44	1.19	1.08	0.000
5.78	0.284	0.370	1.33	1.11	0.92	0.000
5.91	0.241	0.350	1.28	1.06	0.79	0.000
6.11	0.171	0.274	1.12	0.93	0.59	0.000

Table 7.4: Extreme waves/water levels and overtopping for 1 in 200 year return period joint probability events from the West North West sector with sea level rise to 2080

Breakwater - SLR_2080

Water lev el CD [m]	Significant wave height Hm0 [m]	Maximum wave height Hmax [m]	Peak wave period Tp [s]	Mean wave period Tm [m]	Freeboard at 6.7m CD [m]	Mean Overtopping [l/s/m]
5.89	0.781	0.960	2.08	1.73	0.81	2.821
6.02	0.693	0.888	2.01	1.66	0.68	3.205
6.15	0.594	0.802	1.91	1.58	0.55	3.421
6.31	0.495	0.712	1.80	1.49	0.39	5.478
6.44	0.414	0.634	1.70	1.41	0.26	9.042
6.64	0.283	0.492	1.49	1.24	0.06	28.081

Reclamation - SLR_2080

Water lev el CD [m]	Significant wave height Hm0 [m]	Maximum wave height Hmax [m]	Peak wave period Tp [s]	Mean wave period Tm [m]	Freeboard at 6.7m CD [m]	Mean Overtopping [l/s/m]
5.89	0.755	0.947	2.07	1.72	0.81	2.195
6.02	0.672	0.877	1.99	1.65	0.68	2.580
6.15	0.576	0.791	1.89	1.57	0.55	2.804
6.31	0.481	0.700	1.78	1.48	0.39	4.502
6.44	0.401	0.621	1.68	1.39	0.26	7.675
6.64	0.276	0.482	1.48	1.23	0.06	26.380

Revetment at slipway - SLR_2080

Water lev el CD [m]	Significant wave height Hm0 [m]	Maximum wave height Hmax [m]	Peak wave period Tp [s]	Mean wave period Tm [m]	Freeboard at 6.7m CD [m]	Mean Overtopping [l/s/m]
5.89	0.437	0.496	1.57	1.30	0.81	0.008
6.02	0.402	0.473	1.50	1.24	0.68	0.021
6.15	0.352	0.437	1.42	1.18	0.55	0.040
6.31	0.298	0.396	1.34	1.12	0.39	0.143
6.44	0.251	0.356	1.27	1.06	0.26	0.517
6.64	0.173	0.278	1.12	0.93	0.06	8.102

Table 7.5: Extreme waves/water levels and overtopping for 1 in 200 year return period joint probability events from the West North West sector with sea level rise to 2100

Breakwater - SLR_2100

Water lev el CD [m]	Significant wave height Hm0 [m]	Maximum wave height Hmax [m]	Peak wave period Tp [s]	Mean wave period Tm [m]	Freeboard at 6.7m CD [m]	Mean Overtopping [l/s/m]
6.08	0.781	0.960	2.08	1.73	0.62	10.186
6.21	0.693	0.888	2.00	1.66	0.49	13.138
6.34	0.594	0.802	1.91	1.58	0.36	16.900
6.5	0.495	0.712	1.80	1.49	0.20	31.878
6.63	0.414	0.634	1.70	1.41	0.07	57.664
6.83	0.283	0.492	1.49	1.24	-0.13	flooded

Reclamation - SLR_2100

Water lev el CD [m]	Significant wave height Hm0 [m]	Maximum wave height Hmax [m]	Peak wave period Tp [s]	Mean wave period Tm [m]	Freeboard at 6.7m CD [m]	Mean Overtopping [l/s/m]
6.08	0.755	0.947	2.07	1.72	0.62	8.402
6.21	0.671	0.876	1.99	1.65	0.49	11.178
6.34	0.576	0.790	1.89	1.57	0.36	14.729
6.5	0.481	0.700	1.78	1.48	0.20	28.457
6.63	0.401	0.621	1.68	1.39	0.07	53.527
6.83	0.276	0.482	1.48	1.23	-0.13	flooded

Revetment at slipway - SLR_2100

Water lev el CD [m]	Significant wave height Hm0 [m]	Maximum wave height Hmax [m]	Peak wave period Tp [s]	Mean wave period Tm [m]	Freeboard at 6.7m CD [m]	Mean Overtopping [l/s/m]
6.08	0.451	0.512	1.56	1.30	0.62	0.180
6.21	0.409	0.483	1.50	1.25	0.49	0.438
6.34	0.356	0.444	1.43	1.19	0.36	1.003
6.5	0.300	0.400	1.35	1.12	0.20	4.559
6.63	0.252	0.357	1.27	1.06	0.07	18.589
6.83	0.160	0.324	1.27	1.06	-0.13	flooded

8 IMPACT OF CAPITAL DREDGING ON WATER QUALITY

8.1 BACKGROUND

8.1.1 Description of Capital Dredging Requirements

In order to facilitate the development of the proposed Newton Basin Marina at Stornoway, dredging and reclamation activities have been planned to increase the depth of the seabed within the marina and approach channel to -3m CD as illustrated in blue in Wallace Stone LLP drawing 1874-101G, shown in Figure 8.8.1**.**

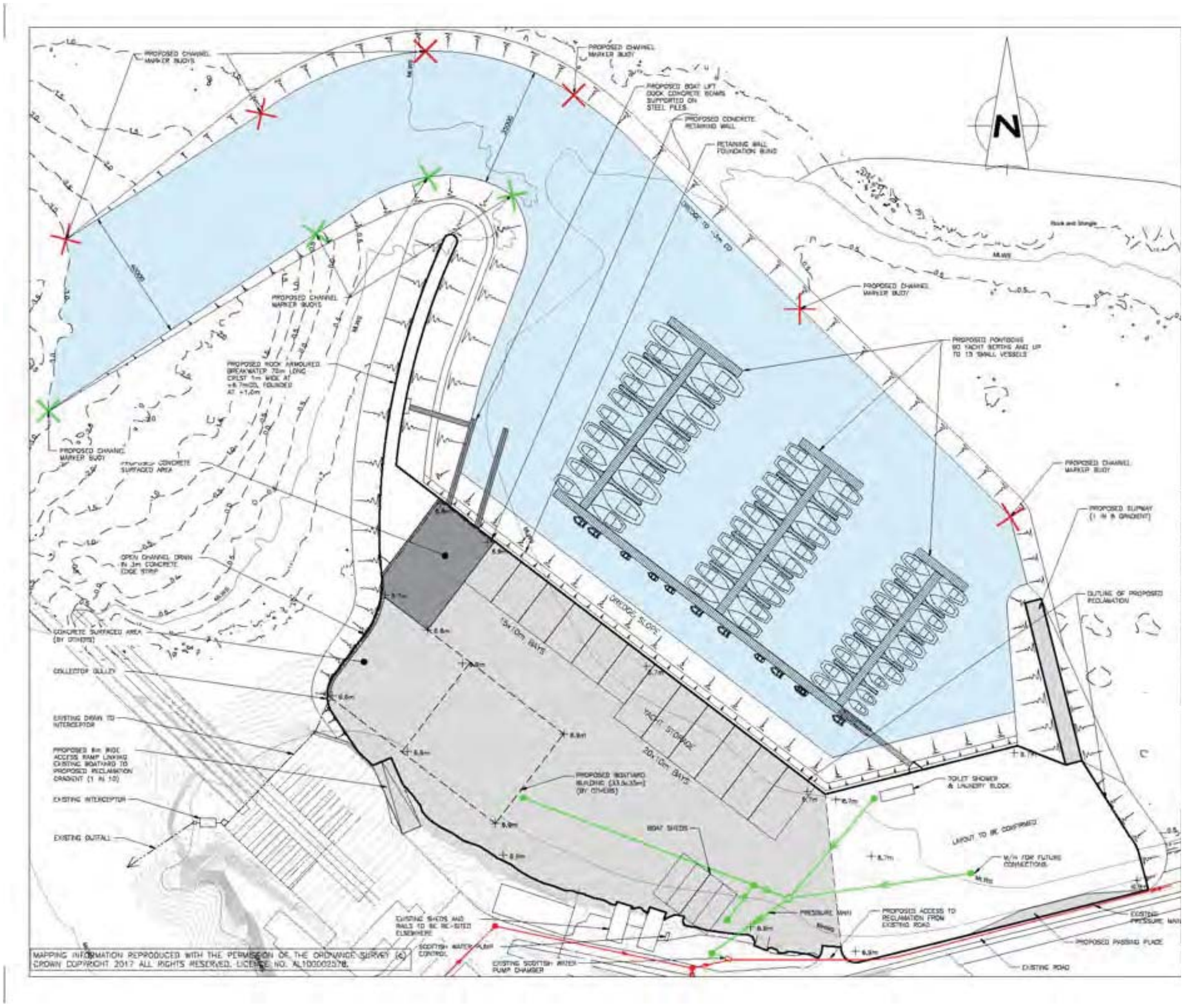


Figure 8.8.1: The extent of the capital dredging works required as part of the proposed Newton Basin Marina development.

Comparison of the existing and the proposed dredged seabed levels indicates that some 92,220m^3 of material will have to be removed to achieve the required water depths, including an allowance of 0.15m for over dredge, around the proposed marina. Some 83,770m^3 of the material to be dredged is a sandy Gravel which is suitable for land reclamation. However there is a layer of silty material at a level between circa -2.5 to -3.0m CD in the south eastern half of the proposed marina basin. Some 8,430m^3 of this silty material will have to be dredged from the proposed basin and disposed of at the licensed dump site at sea.

Due to the proximity of the proposed marina to the town it is possible that the dredging will only be undertaken during the day and therefore the dredging has been assumed to be undertaken from 8am to 8pm each day. Taking a 60 day overall dredging period, the dredging of the gravely material which will be pumped ashore to the reclamation area will take about 50 days to complete at a rate of 1671m^3 per 12 hour day. The dredging of the silt which will be retained in the dredger hopper or in a dump barge will take about 10 days at a rate of 865m^3 per 12 hour day.

8.1.2 Characterisation of seabed

Particle Size Analyses (PSA) of the sediment samples collected during the geotechnical survey indicated that the material in the dredge area is dominated by gravel and sands but there is a layer of silt at depths below circa -2.5m CD in the south eastern half of the proposed marina basin.

To accurately reflect the nature of the proposed dredge material RPS has examined the sediment characteristics from 12 sediment samples collected from 7 boreholes for submission to Marine Scotland. The location of these boreholes is shown in Figure 8.2, whilst a description of the PSA is presented in Table 8.1 overleaf. It will be seen from this table that there are two quite distinct types of material to be dredged. The majority of the material is a slightly silty sandy GRAVEL, while the material below -2.5m CD in the south eastern end of the proposed marina basin is a sandy gravely SILT with about 38% of the material in the silt clay range. The average PSA of the two types of material to be dredged are shown in Table 8.2.

Table 8.1: PSA of Seabed sediments around the dredged area

Borehole No.	34	35 (>-2)	35(<-2)	36(>-2.5)	36(<-2.5)	37(>-2.5)	37(<-2.5)	38(>-2.5)	38(<-2.5)	39(>-2.5)	39(<-2.5)	40
Gravel %	76.6	82.7	42.2	86.8	44.2	86.3	55.2	87.2	1.6	86.4	13.8	71.0
Sand %	23.3	17.3	40.3	13.2	24.8	13.7	25.2	12.7	28.0	10.5	33.3	18.5
Silt %	0.2	0.0	17.6	0.0	30.9	0.1	19.6	0.0	70.4	3.1	53.0	10.5
very coarse gravel	8.94	7.11	0.00	17.13	0.00	17.35	7.94	20.89	0.00	20.36	0.00	21.00
coarse gravel	23.60	40.44	12.50	29.66	11.10	25.39	15.60	24.80	0.00	29.22	4.74	20.00
medium gravel	22.36	17.87	10.47	25.83	8.32	18.12	13.40	16.63	0.23	16.80	2.35	18.00
fine gravel	11.88	9.27	8.93	8.21	12.50	14.84	9.55	12.26	0.13	10.16	3.01	7.00
very fine gravel	9.80	8.03	10.30	5.94	12.30	10.62	8.69	12.65	1.20	9.88	3.68	5.00
very coarse sand	8.03	7.49	9.95	5.69	6.74	6.09	6.40	8.04	1.59	5.37	3.52	4.00
coarse sand	5.96	5.21	11.80	4.47	1.14	3.02	2.18	2.65	1.69	1.78	7.46	4.00
medium sand	5.13	2.92	9.83	2.32	2.51	2.86	2.36	1.49	2.80	1.36	4.93	4.00
fine sand	3.33	1.26	5.57	0.58	6.37	1.43	5.69	0.44	9.02	1.13	7.72	3.45
very fine sand	0.81	0.40	3.19	0.13	8.05	0.26	8.61	0.10	12.90	0.88	9.67	3.00
very coarse silt	0.21	0.04	3.08	0.02	6.66	0.05	5.76	0.02	15.60	0.66	11.25	2.00
coarse silt	0.00	0.00	3.00	0.00	7.06	0.00	3.67	0.00	15.70	0.61	11.55	2.00
medium silt	0.00	0.00	2.97	0.00	6.98	0.00	3.62	0.00	15.03	0.63	11.55	2.00
fine silt	0.00	0.00	2.65	0.00	4.98	0.00	2.89	0.00	11.00	0.52	8.67	1.50
very fine silt	0.00	0.00	2.06	0.00	2.53	0.00	1.67	0.00	6.10	0.30	4.78	1.50
clay	0.00	0.00	3.81	0.00	2.67	0.00	1.98	0.00	6.93	0.35	5.24	1.50

Figure 8.8.2: Location of Boreholes at site of proposed Newton Basin Marina

Table 8.2: Average PSA of Seabed sediments samples

Type of material	mm	sandy GRAVEL Average PSA %	gravely sandy SILT Average PSA %
very coarse gravel	>32<64	16.11	1.59
coarse gravel	>16<32	27.59	8.79
medium gravel	>8<16	19.37	6.95
fine gravel	>4<8	10.52	6.82
very fine gravel	>2<4	8.85	7.23
very coarse sand	>1<2	6.39	5.64
coarse sand	>0.5<1	3.87	4.85
medium sand	>0.25<0.5	2.87	4.48
fine sand	>0.125<0.25	1.66	6.87
very fine sand	>0.0625<0.125	0.80	8.48
very coarse silt	>0.03125<0.0625	0.43	8.47
coarse silt	>0.015625<0.03125	0.37	8.20
medium silt	>0.007813<0.015625	0.38	8.03
fine silt	>0.003906<0.007813	0.29	6.04
very fine silt	>001953<0.003906	0.26	3.43
clay	<0.001953	0.26	4.12

8.2 MODELLING OF DREDGED PLUME

8.2.1 Modelled dredging techniques

A common method of assessing the potential environmental impact of dredging plumes involves the use of coupled hydrodynamic and sediment transport modelling techniques. An important step in this approach is stipulating appropriate source terms to define the input of dredge material into the model. One of the primary factors in determining the dredging source term is based on the total amount of available fines within the dredge material.

Other studies (Becker *et al*. 2015; Koningsveld 2015) that investigated the large scale spatial and temporal fate of dredge plumes have only accounted for the fraction of fine material (<63μm), as coarser particles are known to settle to the seabed within the near zone (Land *et al*. 2004).

However as this study is interested in assessing the fate of dredge plumes in relation to the adjacent environment within Stornoway Harbour, RPS has also accounted for material as large as very coarse sand (2mm) in the sediment transport simulations detailed in the following Sections. Preliminary investigations found that material coarser than 2mm (Gravels) quickly fell back to the seabed and did not re-enter suspension. The dispersion of the silt and sand fractions lost to the water column from the dredging operations were represented in the numerical simulations based on the physical characteristics of the five sediment classes from the PSA results. A summary of these physical characteristics is presented in Table 8.38.3 and 8.2 overleaf.

Table 8.3: Modelled sediment characteristics for sandy GRAVEL.

Average PSA values	%	Classes	%
Gravels	16.11		
	27.59		
	19.37	not included	82.43
	10.52		
	8.85		
Coarse Sand	6.39		
	3.87	1 mm	10.26
Fine Sands	2.87		
	1.66	0.25 mm	4.53
Sandy Silt	0.80		
	0.43	0.0625 mm	1.22
Medium Silt	0.37		
	0.38	0.015625 mm	0.75
Very Fine Silt	0.29		
	0.26	0.003 mm	0.81
	0.26		

Table 8.4: Modelled sediment characteristics for sandy gravely SILT.

Average PSA values	%	Classes	%
Gravels	1.59		
	8.79		
	6.95	not included	31.39
	6.82		
	7.23		
Coarse Sand	5.64		
	4.85	1 mm	10.49
Fine Sands	4.48		
	6.87	0.25 mm	11.36
Sandy Silt	8.48		
	8.47	0.0625 mm	16.95
Medium Silt	8.20		
	8.03	0.015625 mm	16.23
Very Fine Silt	6.04		
	3.43	0.003 mm	13.59
	4.12		

8.2.2 Dredging equipment

It is assumed that a Cutter Suction Dredger (CSD) will be used to remove sandy gravel material from the dredge areas. The CSD will dislodge material using a rotating cutter head and then pump the mixture of dredge material and water to the reclamation area by means of a discharge pipeline. The overflow from the stilling pond is assumed to discharge into the basin area at the most southerly point of the new wall along the southern boundary of the marina basin. In this analysis, to be conservative, the CSD is assumed to operate at full capacity on a 12 hours/day basis from 8.00am to 8.00pm. working its way in from deep water to the south eastern end of the basin. This part of the dredging is expected to take just over 50 days to dredge all the gravel material from the area. Following completion of the dredging of the gravel, the dredger will move on to dredge the silt area. This material is not suitable for reclamation so it is proposed that the silt be dumped at sea at the licensed dump site outside Stornoway Harbour. The cutter suction dredger will dredge the material and place the material in its own hopper (if it has one) or alternatively fill a separate dumping barge. The rate of production will be about half of the rate for the dredging of the gravel in order to limit the amount of silt lost through over spilling of the hopper. It is expected that it will take just over 10 days to dredge the silt with the dredger working on a 12 hours per day basis.

8.2.3 Source term analysis

The material introduced into the marine environment as a result of CSD dredging operations can be represented by two source terms: The loss of material from the cutter head near the sea bed and the overspill of material from the stilling pond or barge hopper into the sea surface.

The losses at the CSD cutter head were taken as 5% of the sand and silt material in dredged areas whilst the overspill from the placement area was taken as up to 4.5% of the silt material. Details of these source terms are shown in Table 8.5 and Table 8.6 for the sandy Gravel material and in Table 8.7 and Table 8.8 for the silt layer.

Table 8.5: Composition of the losses from the cutter head dredging source term for the sandy gravel material for reclamation

Source Term	Fraction	Grain size (mm)	Source Distribution (%)	Mass (kg/s)	5% of mass (kg/s)
Cutter Head	1	1	58.39	6.3509	0.3175
	2	0.25	25.78	2.8041	0.1402
	3	0.063	6.94	0.7552	0.0378
	4	0.01563	4.27	0.4643	0.0232
	5	0.003	4.61	0.5014	0.0251

Table 8.6: Composition of the losses from the overspill source term for the reclamation

Source Term	Fraction	Grain size (mm)	Source Distribution (%)	Mass (kg/s)
Overspill	3	0.063	23.689	0.0113
	4	0.01563	29.126	0.0139
	5	0.003	47.184	0.0226

Table 8.7: Composition of the losses from the cutter head dredging source term for the sandy silt material for disposal

Source Term	Fraction	Grain size (mm)	Source Distribution (%)	Mass (kg/s)	5% of mass (kg/s)
Cutter Head	1	1	15.287	6.4933	0.3247
	2	0.25	16.555	7.0318	0.3516
	3	0.063	24.701	10.4921	0.5246
	4	0.01563	23.652	10.0464	0.5023
	5	0.003	19.805	8.4122	0.4206

Table 8.8: Composition of the losses from the overspill source term for the hopper

Source Term	Fraction	Grain size (mm)	Source Distribution (%)	Mass (kg/s)
Overspill	3	0.063	18.80	0.1049
	4	0.01563	35.99	0.2009
	5	0.003	45.21	0.2524

8.2.4 Numerical representation

Using the source terms summarised in Tables 8.5 to 8.8 to represent the input of sand and silt material into the marine environment, the sediment plume simulations were run over the course of a 60 day period which included a full range of spring and neap tidal conditions. This 60 day period relative to the tidal cycle is shown in green and orange in Figure 8.3. The green line represents the period for the dredging of the gravel material for reclamation while the orange line shows the period for the dredging of the silt. The coupled tidal and sediment transport model simulations were continued for a week after the completion of the dredging operations to allow for the transport and deposition of any material in suspension at the end of the dredging period.

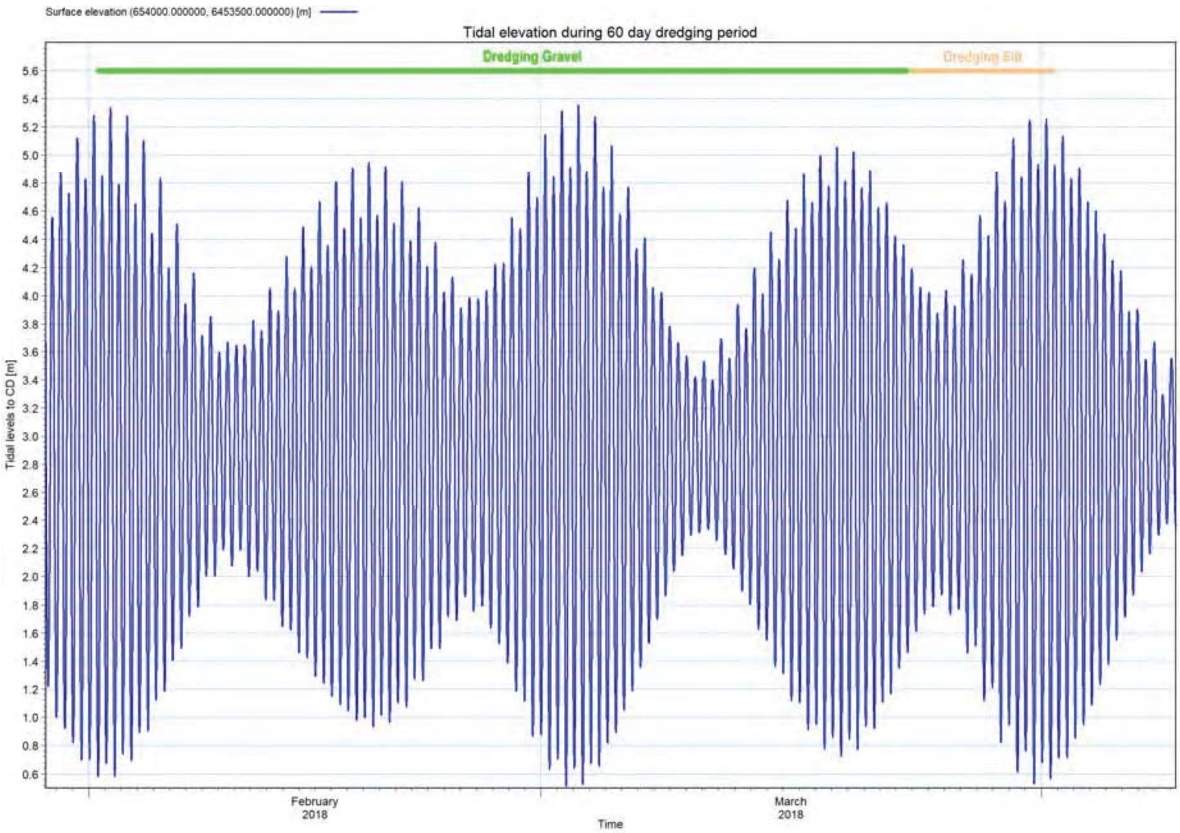


Figure 8.3: The simulated 60 day CSD dredger programme in relation to the tidal cycle at Stornoway

Given that the capital dredging programme will be undertaken after the installation of the retaining walls and bunds for the reclamation, the coupled hydrodynamic and sediment transport simulations were run using the Stornoway Harbour model domain with the walls and rock bunds in place. The tidal model set up and boundary conditions have been described in more detail in Section 5.

The track for the dredger over the 60 day period is illustrated by the black lines in Figure 8.4. In the simulations the dredger works its way into the basin commencing at point S1 in Figure 8.4 and dredges the sand and gravel material for reclamation up to point F. The dredger then dredges the silt for disposal commencing at Point S2 and working its way to point F. The speed at which the dredger moves along the track is dependant on the amount of material that has to be removed at any point, with the speed adjusted to maintain the designed dredging rate of 1,671 m^3 and 865 m^3 per 12 hour day for the dredging of the gravel and silt material respectively.

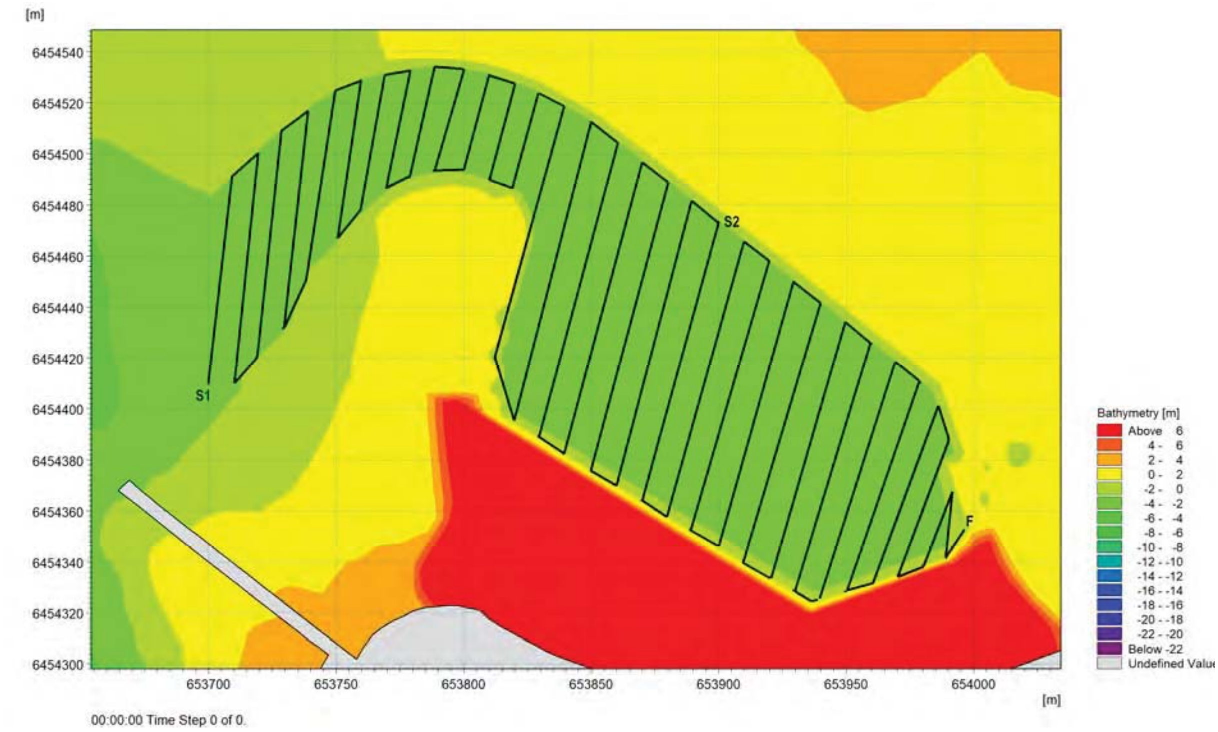


Figure 8.4: Assumed track of Cutter Suction Dredger during the 60 day dredging period

8.3 RESULTS OF DREDGING SIMULATIONS

A sediment plume is created during the course of the dredging operations due to sediment entering the water column from losses around the cutter head and the overspill of the water used to pump the dredged sediment ashore to the reclamation area or into the hopper of a barge. The sediment plume will move in response to the tidal currents and the location of the dredger. Figure 8.5 shows a typical suspended sediment concentration (SSC) plume at a point in time when the dredger is excavating silt and the tidal currents in the area are ebbing.

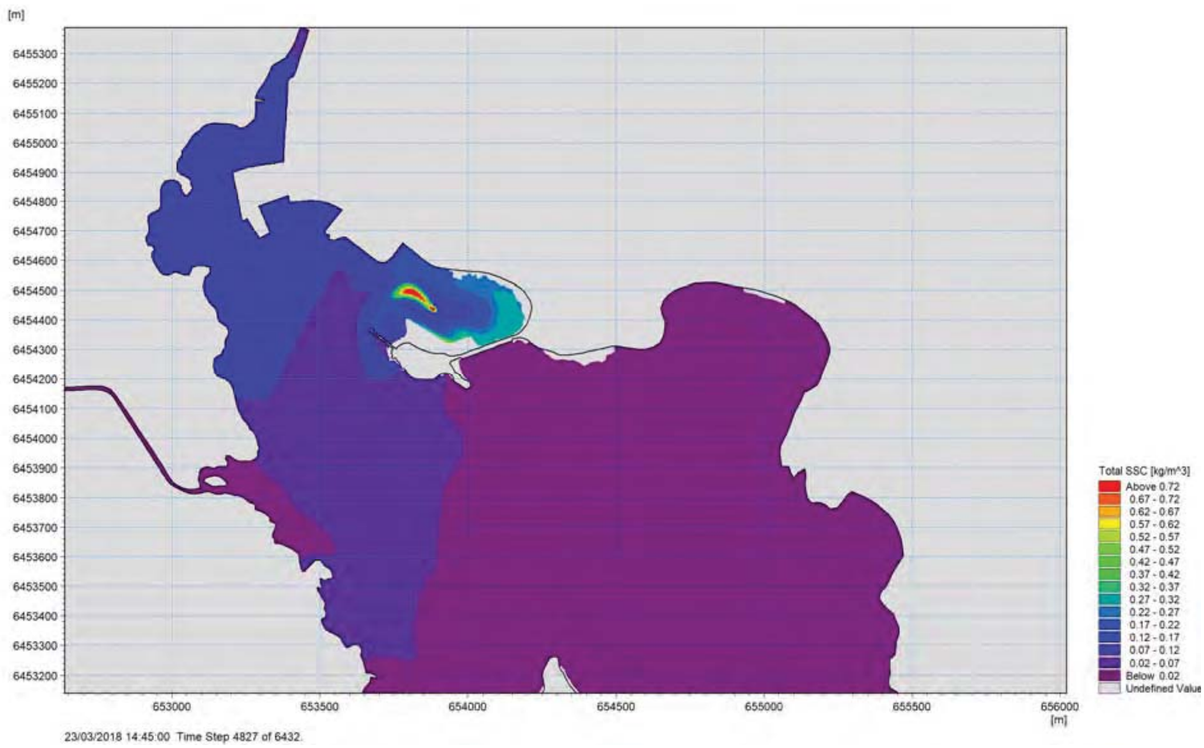


Figure 8.5: Typical SSC plume at a point in time when dredger is dredging silt and the tidal currents are ebbing

The results of the dredging simulations are given in terms of the total increase in suspended sediment concentrations (SSCs) and deposition of the sediment on the sea bed as a result of the cutter suction dredging operations. The total increase in SSC is presented in terms of the maximum and mean plume envelopes given in Figures 8.6 and 8.7 respectively.

These diagrams represent the envelope that encompasses all the suspended sediment plumes that are generated during the entire dredging operation. Thus the maximum plume envelope presented in Figure 8.6 represents the peak value of the total SSC at each point in the model area as the dredging plume responds to the local tidal currents and the movement of the dredger.

It will be seen from Figure 8.6 that the peak value of the increase in SSC in the north harbour area is predicted to reach circa 280 mg/l during the dredging operation. In other parts of Stornoway Harbour remote from the Newtown Basin area, the maximum increase in the SSC is predicted to be less than 100 mg/l at any time during the dredging operation.

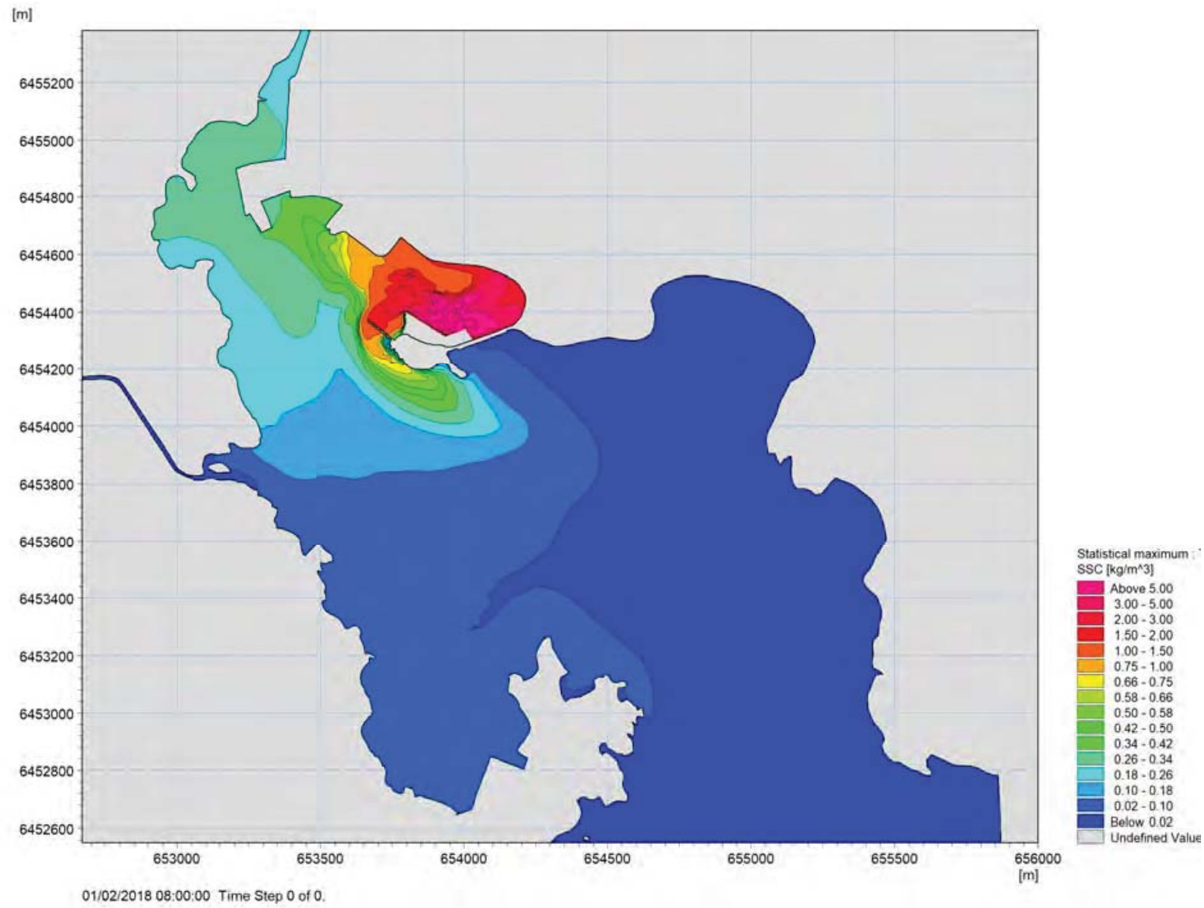


Figure 8.6: Maximum value envelope of the Total Suspended Sediment Concentration that occurs during the 60 day dredging simulation

The peak values may only occur for a very short time during the whole of the dredging operation so the results are also given for the mean value envelope. This envelope, Figure 8.7, represents the mean value to the SSC at each point in the model area over the entire dredging period. The use of the two envelopes gives a measure of the short term and medium term impact of the dredging operation on the increase in SSC around Stornoway Harbour.

Figure 8.7 shows that the mean increase in the total SSC in the north harbour area is circa 80 mg/l during the dredging period. In Stornoway Harbour away from the immediate area around the proposed Newtown Basin Marina project the increase in the total SSC over the dredging period will be less than 50 mg/l. The area most affected by an increase in SSC due to the dredging operations will be the Newton Basin area itself, where there will be mean values of the total SSC of up to 300mg/l.

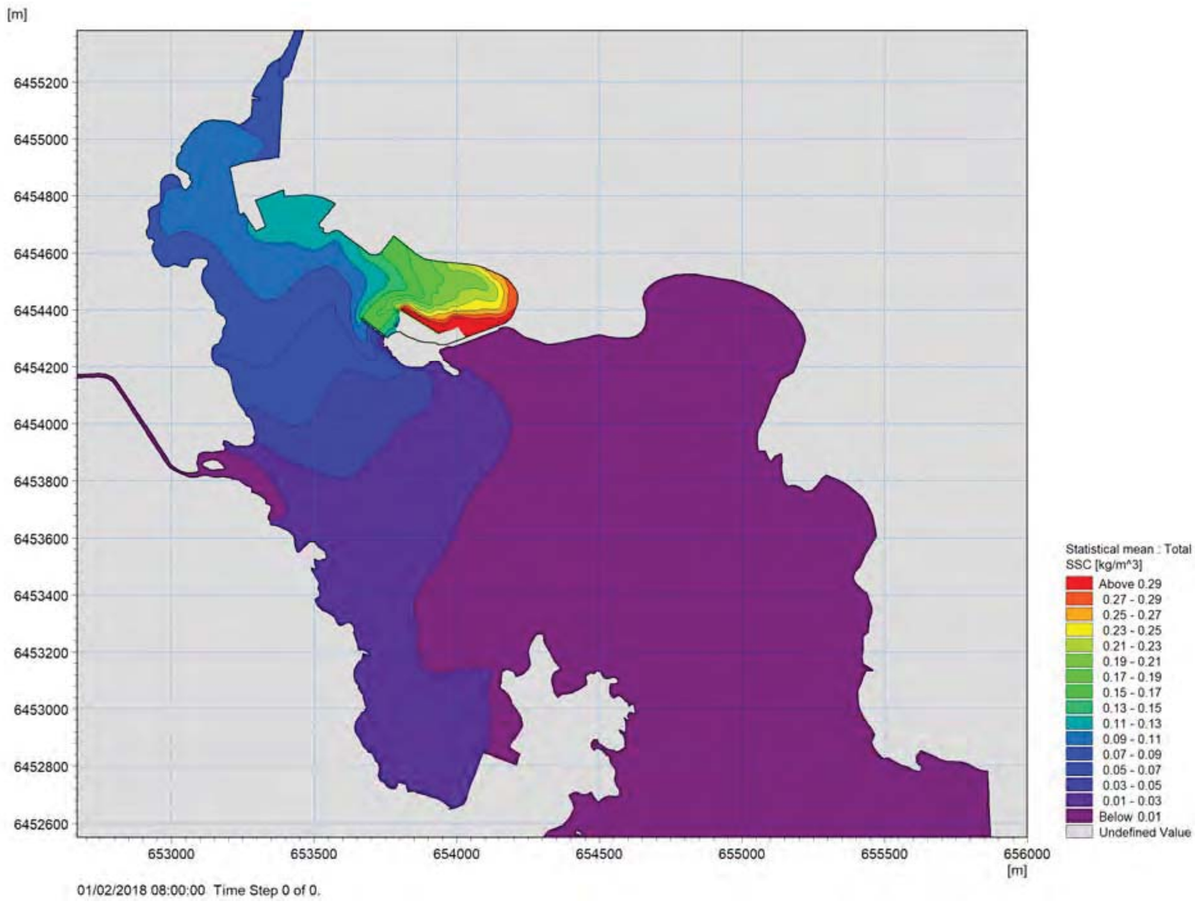


Figure 8.7: Mean value envelope of the Total Suspended Sediment Concentration for the whole of the 60 day dredging period simulation

The deposition of the sand and silt material at the end of the 60 day CSD dredging campaign is illustrated in Figure 8.8. It will be seen that the vast majority of the sand and silts lost to the water column during the dredging operation will be retained within the dredged area. This material will either be picked up during the tidying up operation at the end of the dredging contract or will remain within the over dredged tolerance permitted within the dredging contract.

The results of the simulations show that the deposition depths of material lost to the water column during the dredging operations will be generally less than 0.5 mm in Stornoway Harbour away from the Newton Basin and existing pier area and even in the existing pier area the deposition depths are expected to be less then 1mm.

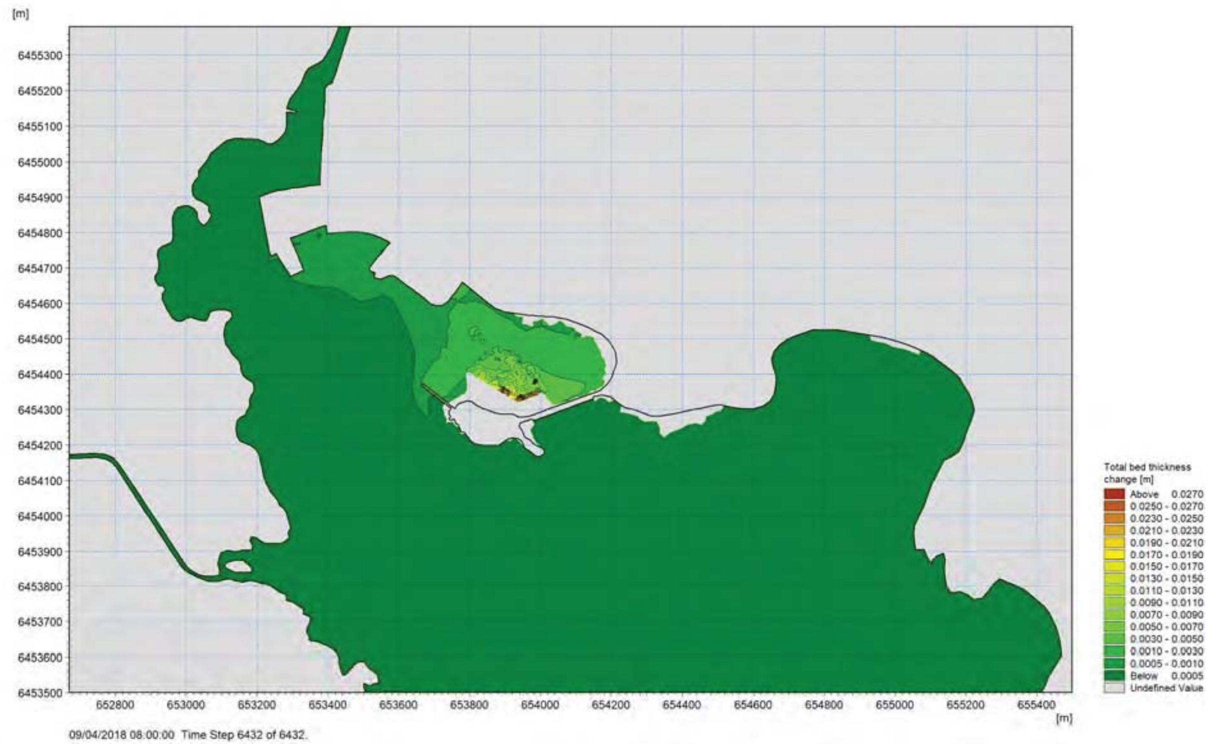


Figure 8.8: Deposition depths of sands and silts lost from the CSD dredging operations at the end of the whole of the 60 day dredging period simulation

Most of the significant levels of Total SSC occur as a result of the dredging of the silt lens in the southern half of the marina basin. Figure 8.9 shows the total SSC value in the water at the approaches to the north harbour. It will be seen from this diagram that the levels of the SSC remain below 100mg/l during the dredging of the sandy gravel material but rise steeply to about 280 mg/l during the dredging of the fine silt.

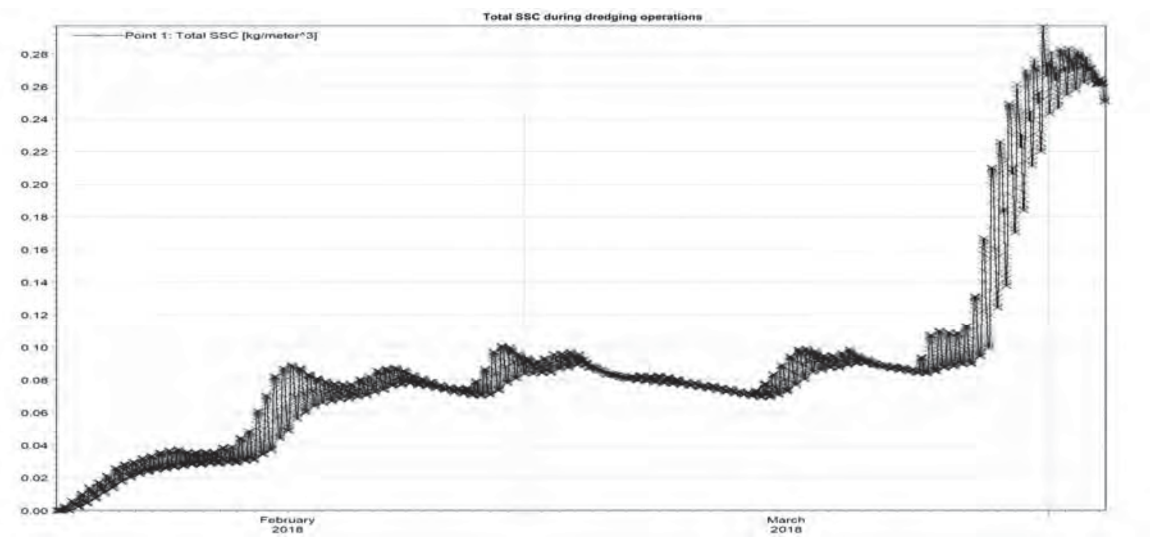


Figure 8.9: Total SSC at entrance to north harbour basin during dredging operations

If the level of the suspended sediment concentration during the dredging of the silt using the cutter suction dredger discharging to a hopper/barge is unacceptable, then the dredging of the silt layer could be undertaken using a backhoe dredger which could load into a barge with no overspill. This would significantly reduce the losses of silt to the water column during this part of the dredging operation. Figure 8.10 shows the maximum plume envelope of the total suspended sediment concentration in the water column during the 60 day dredging operation using the combination of cutter suction dredger for the sandy gravel and backhoe for the silt. It will be seen from a comparison of Figures 8.6 and 8.10 that the use of the backhoe dredger for the excavation of the silt significantly reduces the SSC in the northern part of the harbour.

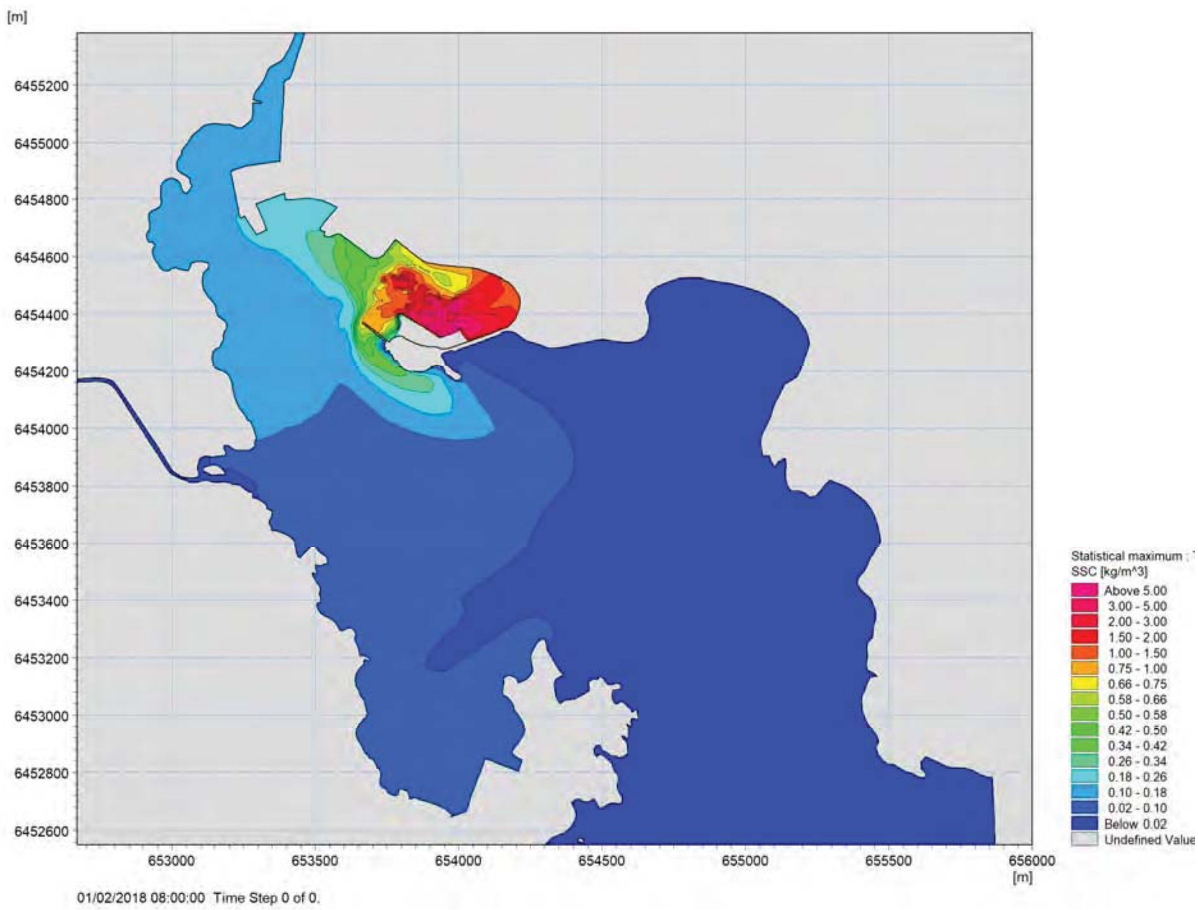


Figure 8.10: Maximum value envelope of the Total Suspended Sediment Concentration that occurs during the 60 day dredging simulation using combination of Cutter Suction and Backhoe dredgers

The mean concentration envelope of the SSC resulting from the use of the combination of the cutter suction and backhoe dredgers during the dredging operation is shown in Figure 8.11. As with the maximum envelope, the mean envelope diagram shows that the use of the backhoe dredger for the excavation of the silt would reduce the level of the suspended sediment concentration in the northern part of the harbour during the dredging operations.

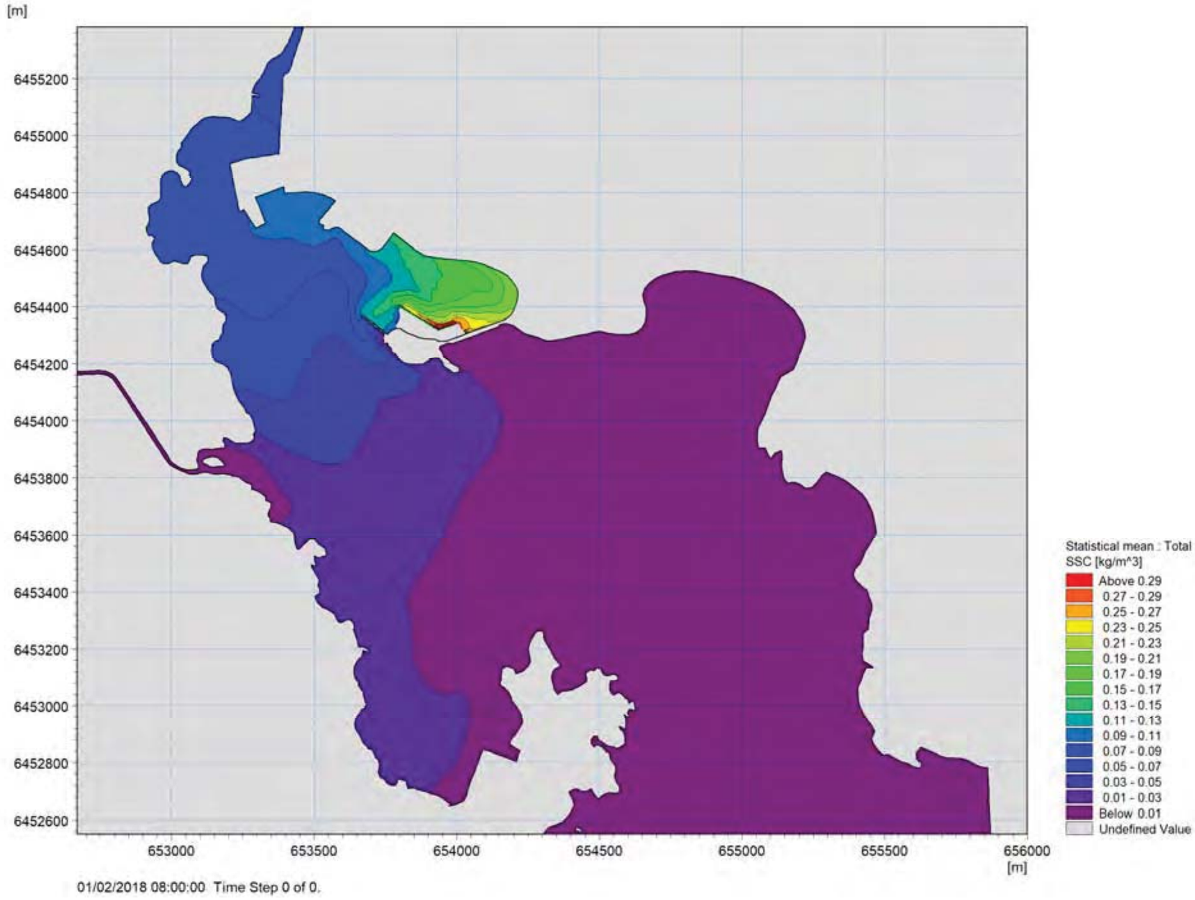


Figure 8.11: Mean value envelope of the Total Suspended Sediment Concentration that occurs during the 60 day dredging simulation using combination of Cutter Suction and Backhoe dredgers

8.4 SUMMARY OF THE IMPACT OF THE DREDGING ON WATER QUALITY

Based on the modelling results presented in Section 8.3 it was found that the peak value of the increase in suspended sediment concentration (SSC) in the northern part of the harbour would be about 280 mg/l during the dredging of the silt layer. In other parts of Stornoway Harbour remote from the Newton Basin area the maximum increase in the SSC is predicted to be less than 100 mg/l at any time during the dredging operation.

The modelling also showed that the mean increase in the total SSC in the north harbour area is about 80 mg/l during the dredging period. In Stornoway Harbour away from the immediate area around the proposed Newton Basin Marina project the increase in the total SSC over the dredging period will be less than 50 mg/l. The area most affected by an increase in SSC due to the dredging operations will be the Newton Basin area itself where there will be mean values of the total SSC of up to 300mg/l.

The results of the simulations demonstrate that the vast majority of the sand and silts lost to the water column during the dredging operation will be retained within the dredged area. This material will either be picked up during the tidying up operation at the end of the dredging contract or will remain within the over dredged tolerance permitted within the dredging contract.

The results of the simulations show that the deposition depths of material lost to the water column during the dredging operations will be generally less than 0.5 mm in Stornoway Harbour away from the Newton Basin and existing pier area and even in the existing pier area the deposition depths are expected to be less then 1mm.

If the levels of the SSC in the northern part of the harbour during the 10 day dredging of the silt layer in the Newton Basin are unacceptable, these may be significantly reduced by the use of a backhoe dredger loading barges without overspill in place of the cutter suction dredger which would still be used to dredged and pump ashore the sandy gravel material.

The modelling of the Newton Basin dredging has been simulated assuming the dredging would be undertaken on a 12 hour day basis as this is conservative. If the dredging is undertaken on a 24 hour basis over the same dredging period the rate of the dredging losses per hour will be less and initially the total SSC will be smaller. However over time the concentrations will build up and in the end it will not make a significant difference as there will still be same amount of material lost to the water column over the same 3 month period. Thus while there will be a small reduction in the SSC concentrations within the basis itself, there will be no significant difference in the far field concentration levels between the continuous 24 hour discharge and the 12 hours on and 12 hours off discharge as there will still be the same losses on a 24 hour basis.

9 SUMMARY AND CONCLUSIONS

The coastal process around the Newton Basin and Stornoway Harbour have been investigated using computational modelling techniques based on the DHI MIKE coastal process software.

Tidal regime

The tidal regime in Stornoway Harbour has been simulated for a complete lunar month of tides both for the existing harbour configuration and for the harbour with the proposed Newton Basin marina development in place. The tidal currents within Stornoway harbour are weak and generally do not exceed about 0.1m/s. The maximum flood and ebb velocities off Arnish Point are about 0.15 m/s.

It was found that the construction of the proposed Newton Basin marina project would have no significant effect on either the tidal levels or the tidal flows in Stornoway Harbour away from the immediate area around the proposed development.

Wave climate

Computational modelling of the wave climate approaching and within Stornoway Harbour has shown that for the longer period waves penetrating into the harbour from the Minch (6 to 8 second wave period), the Newton Basin site is sheltered by the existing concrete breakwater at the north western end of Goat Island. Thus the proposed development does not affect the wave climate at the existing piers and berths for storms in the Minch from East to South South West sector.

For storms from the South West to West sector the waves are generated within Stornoway Harbour and have a relatively short wave period (1.8 to 2.2 seconds) and the existing concrete breakwater at the north western end of Goat Island still provides a significant influence on the wave climate in the Newton Basin area. The wave modelling has shown that the proposed development does not affect the wave climate at the existing piers and berths to any significant degree.

The proposed marina site is most exposed to waves from the West North West. For storms from this direction the marina site is down wind of the existing piers and berths and therefore the marina has no direct effect on the wave climate at the piers during these storm events. However there will be wave reflections coming off the north western side of the marina rubble mound breakwater. Although these reflected waves will propagate towards the existing piers the reflected waves will be of low magnitude, typically less than 0.3 metres in height, and will be effectively attenuated by interaction with the incoming waves before they reach any of the berths at the existing piers.

The largest longer period waves which can reach the proposed breakwater in the Newton Basin marina project will have significant wave heights ranging from 0.080 to 0.197 metres with periods of 7.0 to 8.86 seconds for 1 in 1 and 1 in 200 year return period events respectively. These conditions are predicted to occur during storms in the Minch from the South South East direction. The largest waves at the site of the proposed breakwater occur during storms from the West to North West sector. The significant wave heights will range between 0.468 to 0.817 metres with wave period in the range 1.76 to 2.12 seconds for 1 in 1 to 1 in 200 year return period events.

Harbour disturbance

Harbour disturbance simulations have been undertaken to examine the wave conditions with the proposed marina basin. The wave climate within the pontoon berth area was assessed on the basis of 1 in 1 and 1 in 50 year return period storms for the most exposed storm directions of 285^o to 300^o N.

The significant wave heights at the outer sections of the proposed pontoon berths were 0.30 metres and 0.45 metres for the 1 in 1 and 1 in 50 year return period storms respectively. While these values are above the ideal heights recommended for all the year round berthing, the berths are arranged such that the vessels will be head on to the wave direction in the most exposed parts of the marina and thus the moored boats will be much less susceptible to damage compared to a situation where the vessels are beam on to the waves.

Coastal flooding

A joint probability analysis of extreme waves and water levels, including overtopping computations, has been completed at the Newton Basin site for 1 in 200 year return period joint probability events. The analysis showed that using the current sea level rise predictions recommended by SEPA up to 2080, the site level of +6.7m CD would result in no direct tidal flooding and overtopping rates would be within safe limits for pedestrians during these events. However the predicted sea level rise to 2100 would result in the possibility of the site being flooded during an extreme 1 in 200 year event. It was also noted that the updated IPCC forecast for sea level rise is due in November 2018 when increases in the predicted rate of sea level rise are expected to be given.

Impact of dredging on water quality

The computational modelling predicted that the peak value of the increase in suspended sediment concentration (SSC) in the northern part of the harbour would be about 280 mg/l during the dredging of the silt layer. In other parts of Stornoway Harbour remote from the Newton Basin area the maximum increase in the SSC is predicted to be less than 100 mg/l at any time during the dredging operation.

The vast majority of the sand and silts lost to the water column during the dredging operation will be retained within the dredged area. This material will either be picked up during the tidying up operation at the end of the dredging contract or will remain within the over dredged tolerance permitted within the dredging contract. The simulations show that the deposition depths of material lost to the water column during the dredging operations will be generally less than 0.5 mm in Stornoway Harbour away from the Newton Basin and existing pier area and even in the existing pier area the deposition depths are expected to be less then 1mm.

If the levels of the SSC in the northern part of the harbour during the 10 day dredging of the silt layer in the Newton Basin are unacceptable, these may be significantly reduced by the use of a backhoe dredger loading barges without overspill in place of the cutter suction dredger which would still be used to dredged and pump ashore the sandy gravel material.

Overall conclusions

The overall conclusion of the coastal process studies for the Newton Basin marina development is that the project will have no significant detrimental impact on any of the coastal process within Stornoway Harbour and will not affect the hydrodynamic conditions at any of the adjoining piers or berths.

APPENDIX 1

MIKE Modelling Modules

1 MIKE MODELLING MODULES

1.1 MIKE 21/3 COUPLED FM

The MIKE 21/3 Coupled Modelling module which is a 2D numerical modelling systems respectively was used to simulate the coastal processes within Stornoway Harbour and its approaches. The MIKE 21/ are truly dynamic modelling systems for application within coastal and estuarine environments and can be used for investigating the morphological evolution of the nearshore bathymetry due to the impact of engineering works (coastal structures, dredging works etc.). The engineering works may include breakwaters (surface-Piercing and submerged), groynes, shoreface nourishment, harbours etc. MIKE 21/3 Coupled Model FM can also be used to study the morphological evolution of tidal inlets.

MIKE 21 Coupled Model FM is composed of the following modules:

- Hydrodynamic Module
- Transport Module
- ECO Lab Module
- Mud Transport Module
- Sand Transport Module
- Particle Tracking Module
- Spectral Wave Module

The Hydrodynamic Module and the Spectral Wave Module are the basic computational components of the modelling system. Using MIKE 21/3 Coupled Model FM it is possible to simulate the mutual interaction between waves and currents using a dynamic coupling between the Hydrodynamic Module and the Spectral Wave Module. The MIKE 21/3 Coupled Model FM also includes a dynamic coupling between the Mud Transport, Particle Tracking and the Sand Transport models and the Hydrodynamic Module and the Spectral Wave Module. Hence, a full feedback of the bed level changes on the waves and flow calculations can be included.

The main features of the MIKE 21 Coupled Model FM are as follows:

- Dynamic coupling of flow and wave calculations
- Full feedback of bed level changes on flow and wave calculations
- Easy switch between 2D and 3D calculations (hydrodynamic module and process modules)

- Optimal degree of flexibility in describing bathymetry and ambient flow and wave conditions using depth-adaptive and boundary-fitted unstructured mesh

1.2 HYDRODYNAMIC MODULE

The Hydrodynamic Module simulates water level variations and flows in response to a variety of forcing functions in lakes, estuaries and coastal regions. The effects and facilities include:

- Flooding and drying
- Momentum dispersion
- Bottom shear stress
- Coriolis force
- Wind shear stress
- Barometric pressure gradients
- Ice coverage
- Tidal potential
- Precipitation/evaporation
- Wave radiation stresses
- Sources and sinks

The Hydrodynamic Module can be used to solve both three-dimensional (3D) and two-dimensional (2D) problems. In 2D the model is based on the shallow water equations - the depth-integrated incompressible Reynolds averaged Navier-Stokes equations.

1.3 MUD TRANSPORT (MT) MODULE MODELLING SYSTEM

The Mud Transport (MT) module of the MIKE 21/3 Flow Model FM describes erosion, transport and deposition of mud or sand/mud mixtures under the action of currents and (if appropriate) waves. The hydrodynamic basis for the MT Module is calculated using the Hydrodynamic Module of the MIKE 21/3 Flow Model FM modelling system and the MT is implemented as a couple model with the two running concurrently. The MT module is applicable for mud fractions and also sand/mud mixtures.

The following processes may be included in the simulation.

- Forcing by waves
- Salt-flocculation
- Detailed description of the settling process
- Layered description of the bed, and
- Morphological update of the bed

In the MT-module, the settling velocity varies, according to the salinity, if included, and the concentration taking into account flocculation in the water column. Bed erosion can be either non-uniform, i.e. the erosion of soft and partly consolidated bed, or uniform, i.e. the erosion of a dense and consolidated bed. The bed is described as layered and is characterised by the density and shear strength.

1.4 SAND TRANSPORT (ST) MODULE MODELLING SYSTEM

The hydrodynamic basis for the Transport Module is calculated using the Hydrodynamic Module of the MIKE 21/3 Flow Model FM modelling system. The transport module calculates the resulting transport of material based on these flow conditions coupled with the other appropriate aforementioned modules. A number of components may be specified with each component defining a separate transport equation. The time integration of the transport (advection-dispersion) equations is then performed using an explicit scheme to calculate the resulting sediment transport.

1.5 MIKE21 FM FLEXIBLE MESH SPECTRAL WAVE MODELLING SYSTEM

Modelling the wave generation and transformation within the Minch and Stornoway Harbour was undertaken using the MIKE 21 Spectral Wave (SW) model which is a third generation spectral wind-wave model based on unstructured meshes. The model simulates the growth, decay and transformation of wind-generated waves and swell in offshore and coastal areas.

MIKE 21 SW accounts for the following physical phenomena:

- Wave growth by wind action
- Non-linear wave-wave interaction
- Dissipation due to white-capping
- Dissipation due to bottom friction
- Dissipation due to depth-induced wave breaking
- Refraction and shoaling due to depth variations
- Diffraction
- Wave-current interaction
- Effect of time-varying depth and flooding and drying

The discretisation of the governing equation in geographical and spectral is performed using a cell-centred finite volume method. In the geographical domain, an unstructured mesh technique is used. The time integration is performed using a fractional step approach where a multi-sequence explicit method is applied for the propagation of wave action.

The MIKE 21 SW includes two different formulations:

- Directional decoupled parametric formulation
- Fully spectral formulation

The directional decoupled parametric formulation is based on a parameterization of the wave action conservation equation. The parameterization is made in the frequency domain by introducing the zeroth and first moment of the wave action spectrum as dependent variables following Holthuijsen (1989).

The fully spectral formulation is based on the wave action conservation equation, as described in e.g. Komen et al. (1994) and Young (1999), where the directional-frequency wave action spectrum is the dependent variable.

The fully spectral formulation was used for the wave modelling in this study with the exception of the wave generation across the very short fetches with in Stornoway Harbour itself which were undertaken using the parametric formulation as this is more accurate for wind wave generation and transformation over very short fetches.

1.6 MIKE21 BOUSSINESQ WAVE MODEL

The Boussinesq Wave model, MIKE 21 BW, is the state-of-the-art numerical model for calculation and analysis of short- and long-period waves in ports, harbours and coastal areas. MIKE 21 BW is capable of reproducing the combined effects of all important wave phenomena of interest in port, harbour and coastal engineering. These include:

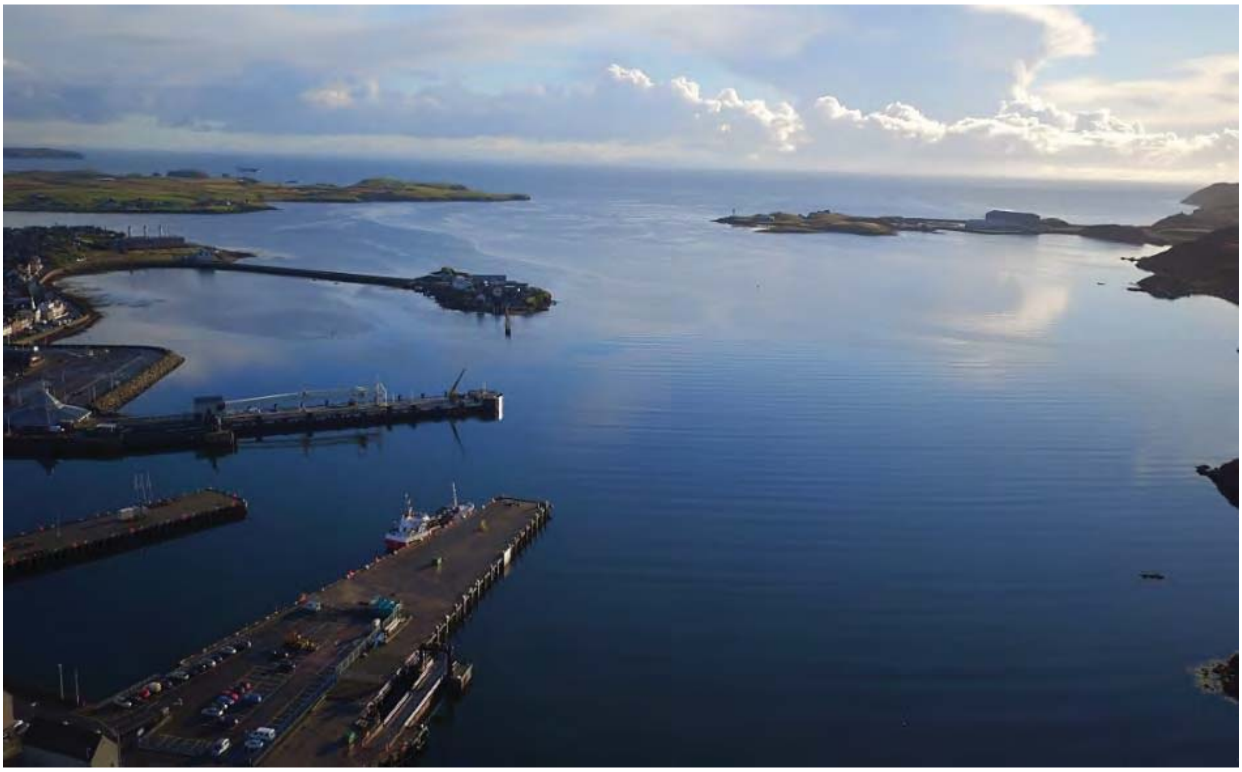
- Shoaling
- Refraction
- Diffraction
- Wave breaking
- Bottom friction
- Moving shoreline
- Partial reflection and transmission
- Non-linear wave-wave interaction
- Frequency spreading
- Directional spreading

Phenomena, such as wave grouping, surf beats, generation of bound sub-harmonics and super-harmonics and near-resonant triad interactions, can also be modelled using MIKE 21 BW. The 2DH module (two horizontal space co-ordinates) solves the enhanced Boussinesq equations by an implicit finite difference technique with variables defined on a space-staggered rectangular grid.

The Boussinesq wave model includes the provision of wave reflection and transmission properties for various structures within the harbour. This is achieved by placing porosity layers in the model either along the face in front of fixed structures or, in the case of floating breakwaters, along the line of the breakwater location.

Newton Marina

Technical Appendix 9.1



September 2018

Newton Marina Development, Stornoway

Reference number GB01T17O43/10708512

13/08/2018

TRANSPORT ASSESSMENT

NEWTON MARINA DEVELOPMENT, STORNOWAY

TRANSPORT ASSESSMENT

IDENTIFICATION TABLE	
Client/Project owner	EnviroCentre / Stornoway Port Authority
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Study	Transport Assessment
Type of document	Final Report
Date	13/08/2018
Reference number	GB01T17O43/10708512
Number of pages	39

APPROVAL

Version	Name		Position	Date	Modifications
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3	Author	[Redacte	Consultant	13/08/2018	Final Report
	Checked by	[Redacted]	Associate	13/08/2018	
	Approved by	[Redacted]	Associate	13/08/2018	

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1. INTRODUCTION

1.1 General

1.1.1 SYSTRA Ltd (SYSTRA) has been appointed by EnviroCentre Ltd on behalf of Stornoway Port Authority (SPA) to prepare a Transport Assessment (TA) in support of a planning application for the proposed development of a marina and associated facilities on Goat Island in Stornoway, Isle of Lewis. The general location of the proposed development is indicated by Figure 1 below.

Figure 1. General Site Location

1.2 Development Proposal

1.2.1 The existing marina (Stornoway Inner Harbour Marina, situated approximately 1km north-west of the proposed development, as the crow flies) has operated exceptionally well and been virtually at capacity since it opened 3 years ago with 83 berths being occupied all year. The proposed development of the new marina is aimed to support growth in the marine leisure sector.

1.3 Purpose of the Report

1.3.1 The TA examines the current and future transport matters associated with the proposed development site. The report considers all travel modes including pedestrians, cyclists and public transport users as well as vehicular access requirements and parking.

1.3.2 The TA also provides an analysis of any anticipated off-site transport impacts for staff and operational movements associated with the proposed development. This analysis determines whether the existing transportation network is suitable to accommodate the proposed development without detriment to existing users, as well as considering the requirements of sustainable travel policy.

1.3.3 SYSTRA has also prepared the associated Environmental Impact Assessment (EIA) Report Traffic and Transport Chapter for the proposed development which should be considered alongside the TA.

1.4 Pre-Application Consultation

1.4.1 A Scoping Letter (contained within Appendix A) was prepared which set out the methodology and parameters that would be adopted by the TA. The Scoping Letter was submitted to the Local Authority – Comhairle nan Eilean Siar (CnES) – in March 2018 and the scope of the TA was subsequently agreed with CnES. A copy of the Scoping Letter is contained within Appendix A.

1.4.2 The TA has also been informed by a site visit undertaken by SYSTRA on 16th January 2018.

1.5 Transport Assessment Structure

1.5.1 The TA has been completed in accordance with appropriate Local, Regional and National policy and guidance. Specifically, reference is made to the following:

- Transport Scotland – "Transport Assessment Guidance" (TAG) (2012);
- Planning Advice Note (PAN) 75 – "Planning for Transport";
- Scottish Planning Policy (2014);
- Cycle Action Plan for Scotland (2010)
- Outer Hebrides Local Development Plan 2 (LDP2) – "Adopted Plan" (August, 2018) and "Supplementary Guidance: Standards for Car Parking & Roads Layout" (2018); and
- SCOTS "National Roads Development Guide" (NRDG) (2017).

1.5.2 The TA is structured as follows:

- Planning Policy Context;
- Existing Conditions;
- Proposed Development Travel Characteristics;
- Measures to Support the Proposed Development;
- Traffic Impact Assessment; and
- Summary and Conclusion.

2. PLANNING POLICY CONTEXT

2.1 Introduction

2.1.1 The purpose of this Chapter is to set out national and local Planning Policy which is applicable to the proposed development site.

2.2 National Planning Policy

Scottish Planning Policy (SPP)

2.2.1 The purpose of the SPP is to provide policy on land use planning and the planning process. This document sets out a range of transport considerations, with an emphasis on promoting the importance of providing sustainable developments. There are number of key elements of SPP that a development should seek to satisfy. These are summarised as follows:

- ***"Paragraph 15*** *– Locating the development in the right place can provide opportunities for people to make sustainable choices, improve quality of life and delivering high quality infrastructure and a choice of how to access amenities and services;*
- ***Paragraph 23*** *– Align development more closely with transport to improve sustainability and connectivity. This is in relation to 'Planning Outcome 4' of SPP to provide a more connected place supporting better transport (and digital) connectivity;*
- ***Paragraph 29*** *– Planning policies and decisions should be guided by a number of principles including supporting delivery of accessible housing, business, retailing and leisure development and, support delivery of infrastructure for example transport;*
- ***Paragraph 40*** *– Planning should direct the right development to the right place by optimising the existing resource capacities, principally by co-ordinating housing and business development with infrastructure investment including transport;*
- ***Paragraph 46*** *– Developments should be easy to move around and beyond by considering the needs of people before the movement of motor vehicles. This could include higher densities and mix of uses that enhances accessibility by reducing reliance on private cars, prioritising sustainable and active travel choices such as walking, cycling and public transport. This would include paths and routes with direct connections and would be well connected to the wider area beyond the site boundary.*
- ***Paragraph 270*** *– The planning system should support patterns of development that optimises the use of existing infrastructure, reduces the need to travel, provides safe and convenient opportunities for walking and cycling and facilitates travel by public transport and, enables the integration of transport modes;*
- ***Paragraph 273*** *– Promote development which maximises the extent to which travel demands are met first from walking, cycling, public transport and finally car. Plans should facilitate integration between transport modes;*
- ***Paragraph 279*** *– Significant travel generation developments should be sited at locations which are well served by public transport and supported by measures to*

promote the availability of high quality public transport services, that provide access to a range of destinations;

- ***Paragraph 281*** *– When an area is well served by sustainable transport modes, planning authorities may set more restrictive parking standards; and*
- ***Paragraph 287*** *– Planning permission should not be granted for significant travel generating developments where direct links to local facilities on foot and bicycle is not available, public transport networks would involve walking more than 400m and the Transport Assessment does not identify satisfactory measures to meet sustainable transport requirements.''*

Planning Advice Note (PAN) 75: Planning for Transport

2.2.2 PAN 75 provides a good practice guide for planning authorities and developers in relation to carrying out policy development, proposal assessment, and project delivery. Paragraphs 7 and 24 of PAN 75 respectively highlight the following:

> *"The intention is for new developments to be user focused and for the transport element to promote genuine choice, so that each mode contributes its full potential and people can move easily between different modes. Consideration should be given to freight logistics as well as person travel."*
>
> *"Development plan policy should encourage development of significant travel generating proposals at locations which are key nodes on the public transport network that have a potential for higher density development and a potential for mixed use development with an emphasis on high quality design and innovation. These locations should encourage modal shift of people and freight by providing good linkages to rail, walking and cycling networks and with vehicular considerations, including parking, having a less significant role."*

Cycling Action Plan for Scotland

2.2.3 The Cycling Action Plan for Scotland sets out a vision for achieving 10% of all commuter journeys by bike by 2020. It provides a framework to help create an environment which is attractive, accessible and safe for cycling. Currently only 1% of journeys in Scotland are made by bike, while around half of short journeys made (less than two miles) are made by car.

2.3 Local Planning Policy

Outer Hebrides: Local Development Plan 2 (Adopted Plan, 2018)

2.3.1 The Outer Hebrides LDP 2 sets out a vision and spatial strategy for the development of land in the Outer Hebrides over the next 10-20 years. The Adopted LDP 2 (which supersedes the 2012 LDP) contains the land use planning policies which the CnES will use for determining planning applications. LDP2 sets out 34 policies.

2.3.2 In relation to traffic and transport, **Policy EI 9:** Transport Infrastructure states:

- *"The priority areas for the upgrading and development of the transport infrastructure within, and serving the Outer Hebrides, are:*
  - **a)** *the spinal and inter island routes;*
  - **b)** *the airports at Barra, Balivanich and Stornoway;*
  - **c)** *ports and harbours, including ferry facilities for mainland and intra island connections.*
- *Development proposals associated with new or improved transport infrastructure and traffic management measures will be required to meet all the following:*
  - **d)** *fit with the character of the area in relation to the Development Strategy and the immediate surrounding area;*
  - **e)** *utilise a sustainable drainage system (SuDS) to deal with surface water;*
- *where possible accommodate cyclists and pedestrians and secure improved road safety related to the proposal, in particular around schools, community or leisure facilities."*

Car Parking

2.3.3 Guidance on car parking standards is provided through Supplementary Guidance of the Outer Hebrides LDP 2. These guidelines state that for marina developments, 1 space per berth plus 1 space per 3 staff should be provided. Disabled parking spaces should be provided on a basis of 6% of total (car park size of up to 200 spaces) or 4 spaces plus 4% of total number (car park size of over 200 spaces), with a minimum of 3 disabled spaces provided.

3. EXISTING CONDITIONS

3.1 Introduction

3.1.1 This section considers the existing accessibility of the site and local area. This is based on the hierarchy set out in the TAG document which details the transport user hierarchy where more sustainable modes of travel are prioritised ahead of the private car.

3.2 Site Location

3.2.1 Goat Island is bound to the north, west and south by Stornoway Harbour, whilst being joined to the rest of Stornoway by the 240m long and 4.5m wide causeway. Beyond the causeway to the east, the Coastguard and SSE's Battery Point power station are situated approximately 395m from the closest point of Goat Island. The nearest residential dwellings are located on Newton Street (approx. 160m to the north), with other dwellings on Seaview Terrace (approx. 320m to the north-east), Island Road (approx. 250m to the north) and Inaclete Road (approx. 265m to the north).

3.2.2 Figure 2 indicates the application site boundary and the 'primary' local road network.

Figure 2. Planning Application Boundary and Transport Network

3.2.3 The general area of Stornoway is a popular tourist destination as well as a regional employment centre, offering local services and amenities to a large local residential catchment.

3.3 Pedestrian and Cyclist Facilities

Walking

3.3.1 There is a good network of footways in the vicinity of the site. There is a footway along the length of the causeway on the eastern side of the carriageway which is approximately 1.5m wide and has street lighting throughout. The general characteristics are indicated by Figure 3 below.

Figure 3. Footway Along Causeway

3.3.2 The footway along the causeway connects to Newton Street and footway provision is continued along Newton Street on both sides of the road linking to the wider pedestrian network.

3.3.3 Whilst there are no formal controlled pedestrian crossing opportunities along Newton Street, traffic speeds are low due to traffic calming measures in place.

3.3.4 Walking from the site to the town centre is achievable along a route of approximately 1.3km (17 minutes walking distance) via the causeway, Newton Street, Shell Street and Kenneth Street. This route is indicated by Figure 4.

Figure 4. Walking Route to Town Centre

Cycling

3.3.5 There is no formal cycling infrastructure provided in the vicinity of the site, therefore, cyclists are expected to utilise the public road network. As the roads surrounding the site are predominantly residential in nature with flat terrain and low vehicle speeds, SYSTRA would considered them to be conducive to cycling.

3.4 Public Transport

3.4.1 There is public transport provision accessible within a short walking distance from the site in the form of bus services. The nearest bus stop is located on Newton Street approximately 600m (7 minute walking distance) from Goat Island. Two bus services are provided from this stop on Newton Street. It is noted that the distance between the site and the nearest bus stop exceeds the PAN 75 guidelines of 400m.

3.4.2 A further distance from the site (approximately 1.2km) but still within reasonable walking distance (approximately 14 minutes) is the bus station where a number of additional services can be accessed.

3.4.3 Figure 5 indicates the location of the bus stops and bus station in the vicinity of the site whilst Table 1 indicates the services that operate at the bus stop on Newton Street and/or the bus station.

Figure 5. Public Transport Network

Table 1. Bus Services, Routes and Frequencies

OPERATOR	BUS STOP	SERVICE NO.	ROUTE	FREQUENCY		
				Mon – Fri	Sat	Sun
GAL	Bus station	W1	Stornoway - Ness	90 – 150 min	180 min	No service
AIM/GAL/MMI	Bus station	W2	Stornoway – West Side circular	120 – 180 min	4 services	No service
AIM/PML/TFS	Bus station	W4	Stornoway - Uig	3 services	1 service	No service
BNC	Newton Street – Bus station	W5	Stornoway - Point	60 – 90 min (bus station) 90 – 120 min (Newton St.)	30 – 120min (bus station) 120 min (Newton St.)	No service
BNC	Newton Street – Bus station	W7	Stornoway – Town Services	40 min until 15 :15(Bus station) 4 services (Newton Street)	90 – 120 min (bus station) 3 services (Newton Street)	No service
LMT/VAT	Bus station	W8	Stornoway – North Lochs	90 – 120 min	90 – 150 min	No service

OPERATOR	BUS STOP	SERVICE NO.	ROUTE	FREQUENCY		
				Mon – Fri	Sat	Sun
AMD/PML	Bus station	W9	Stornoway – South Lochs	2 services	3 services	No service
HET	Bus station	W10	Stornoway - Leverburgh	4 services	4 services	No service

Source: Traveline Scotland (timetabling information accurate as of June 2018)
MacLennan Coaches – AIM; Peter MacLennan – PML; Uig Bus Services – TFS; Bus Na Comhairle – BNC; Galson Motors – GAL; Lochs Motor Transport – LMT; Staran Community Interest Company – VAT; Alasdair MacDonald – AMD; Hebridean Transport – HET; Murdo MacIver - MMI

3.4.4 The W5 service which operates at the stops along Newton Street provides a connection between Stornoway Town Centre and more rural residential areas to the east of the site such as Melbost, Knock, Suardail, Upper Bayble and Garrabost on weekdays and Saturdays.

3.4.5 The W7 service which operates at the stops along Newton Street provides a connection into the town centre, to residential areas in and around Stornoway such as Laxdale, Steinis, Plasterfield and Sandwick on weekdays and Saturdays.

3.4.6 It is noted that no bus services operate on a Sunday. This is generally when traffic volumes are lower than during the rest of the week, therefore, travelling by car (of walking and cycling if possible) on Sundays is the best option.

3.5 Vehicular Access, Local and Wider Road Network

Goat Island Causeway

3.5.1 The causeway provides the sole vehicular access to Goat Island and links to Newton Street via an approximately 3.5m wide road which has one passing place located next to the Coastguard Station, just under half way along the causeway, as indicated by Figure 6 below.

Figure 6. Passing Place on Causeway

3.5.2 The causeway permits two-way traffic and visibility is excellent and unobstructed between the junction with Newton Street and the mid-point passing place, and between the passing place and Goat Island, as indicated by Figure 7 and Figure 8 respectively. The causeway is subject to a speed limit of 15mph.

3.5.3 All traffic accessing the proposed development during the construction and operational phases will be required to travel along the causeway.

Figure 7. Visibility to Newton Street Junction from Passing Place

Figure 8. Visibility to Causeway Passing Place from Goat Island

Newton Street

3.5.4 The causeway meets Newton Street at a wide bellmouth priority controlled junction which has space for a vehicle to be waiting at the junction if there is an oncoming vehicle on the causeway and not obstruct the flow of two-way traffic along Newton Street. This is indicated by Figure 9 below.

Figure 9. Newton Street / Causeway Priority Junction

3.5.5 The site visit determined that Newton Street and the surrounding roads are good standard single carriageways of approximately 6.5m wide.

3.5.6 Traffic calming measures are in place along many of the roads which would be used by the proposed development traffic. Along Newton Street there are speed tables and a build-out, as indicated by Figure 10 and Figure 11 respectively.

3.5.7 All traffic accessing the site will be required to travel along a section of Newton Street to reach the causeway.

Figure 10. Speed Table Along Newton Street

Figure 11. Build-Out Along Newton Street

Wider Road Network

Island Road

3.5.8 Island Road is a single carriageway road which runs between Newton Street and the A866 through an industrial area. There are footways of approximately 1.5m wide on both sides of the road and street lighting provided throughout. Island Road is subject to a 30mph speed limit. A proportion of staff / visitors during the operational phases are likely to travel down Island Road to route to and from the site.

Matheson Road

3.5.9 Matheson Road is an "urban" road that routes between a roundabout with the A866 and a roundabout with the A857 Macauley Road. Matheson Road is single carriageway and has a varying speed limit which is predominantly 30mph, apart from a 20mph zone "when lights flash" during school peak periods at the A866 end of the road adjacent to The Nicholson Institution secondary school.

3.5.10 Matheson Road has footways on both sides of the road and street lighting throughout. There are residential properties and various intersections with residential roads along the length of Matheson Road. Signalised crossroads junctions and signalised pedestrian crossing are located along various points of the road. A proportion of staff / visitors during the operational phases are likely to travel down Matheson Road to route to and from the site.

A857

3.5.11 The A857 routes north from Stornoway Town Centre to Port Ness at the most northern tip of the Isle of Lewis. Within Stornoway the A857 has street lighting and good standard footways on both sides of the carriageway. Various pedestrian crossing opportunities are provided in the form of signalised crossings and paved speed tables which also act as traffic calming measures.

3.5.12 It anticipated that a proportion of the staff / visitor trips will utilise the sections of the A857 to route to and from the town centre and the neighbouring residential areas.

A859

3.5.13 The A859 is a good standard single carriageway road, generally subject to the National Speed Limit (60mph). In the vicinity of Stornoway, there is street lighting and footways along the northern side of the A859 where the road is referred to as "Willowglen Road" and the speed limit reduces to 40mph. However, beyond Willowglen Road the A859 generally does not experience pedestrian activity.

3.5.14 It anticipated that a proportion of the staff / visitor trips will utilise the sections of the A859 to route to and from the town centre and the neighbouring residential areas.

3.6 Accessibility Summary

- A pedestrian link is provided between Goat Island and Newton Street via a footway along the causeway and there are footways along Newton Street connecting to the wider pedestrian network. Street lighting is provided throughout;
- There is no formal cycling infrastructure in place, however, the local road network is considered to be conducive to cyclists;
- There are bus stops located on Newton Street offering two bus services and a bus station within reasonable walking distance of the site offering additional bus services;
- The site is accessed via the causeway road which is single lane with a mid-point passing place and there is space at the junction with Newton Street for a vehicle to wait without obstructing two-way traffic flow along Newton Street; and
- The surrounding local and wider road network is of a good standard overall.

4. PROPOSED DEVELOPMENT TRAVEL CHARACTERISTCS

4.1 Overview

4.1.1 This chapter considers the people trip generation for the proposed development and the resultant vehicle trip generation. In line with best practice, the TRICS[1] database has been utilised to obtain people trip rates for the proposed development where applicable, as was agreed through Scoping discussions with the CnES. Where it was not possible to utilise TRICS information (i.e. for the boat workshop element of the proposed development), a first principles approach to trip generation was applied.

4.1.2 The people trip generation has been assessed on a vehicle trip basis only as this will have the most crucial impact on the surrounding transport network.

4.1.3 While a choice of travel modes are available in the vicinity of the site (i.e. walking, cycling and bus) if travelling from in and around Stornoway, this assessment considers that 100% of staff and visitors to the proposed development travel by private car to ensure a robust assessment.

4.2 Proposed Development

4.2.1 The main land uses which make up the development proposals is a marina with approximately 75 berths, and marina services including a slipway and boat storage area,. It is understood that SPA also intend to seek consent to construct a replacement of the existing marine engineering workshop with a new workshop (referred to as "boat workshop").on the site of the proposed development. The boat workshop will be subject to a separate application at a later stage, however, to provide a robust and worst-case assessment of the end-use scenario for the development site as a whole, the TA has included consideration of the trip generation associated with the boat workshop element.

4.2.2 Operational traffic associated with the proposed development will comprise local residents, predominantly by private car, visiting their yacht berthed at the marina and using the marina services / slipway as required. Also travelling to and from the site will be staff and visitors to the boat workshop element of the site, also predominantly by private car.

4.2.3 A small number of heavy goods vehicle (HGV) trips would occur per week associated with deliveries and servicing activities, however, these trips would be minimal and would occur outwith the network peak periods.

[1] TRICS (Trip Rate Information Computer System) is a database of trip rates for developments used in the United Kingdom and Ireland for transport planning purposes, specifically to quantify the trip generation of new developments

4.3 Vehicle Trip Generation

Marina Element (Inc. Associated Facilities)

4.3.1 Of the 75 berths proposed at the Newton Marina development, SPA estimates that 40 berths will be used by locals who currently utilise a berth at the existing town centre marina, as a key aspect of the proposed development is to "free up" berths at the existing marina for visitors' use. As visitors using berths at the Newton Marina development are expected to sail and berth this will not manifest as a vehicle trip to / from the proposed development, it is considered that the use of 35 berths at the proposed development can effectively be "discounted" from the trip generation assessment. Therefore, the trip generation assessment has been based vehicle movements associated with the 40 berths used by locals. However, to provide a robust and worst-case scenario, the TRICS vehicle trip generation assessment has been based on 50 berths.

4.3.2 The TRICS database provides weekend vehicle trip rates only for marina developments (incorporating marina service facilities and boat storage yard). The daily profile (07:00 – 22:00) of vehicle trip rates and resultant trip generation for 50 berths is indicated by Table 2 below. A full breakdown of the TRICS output files is provided in Appendix FB.

Table 2. TRICS Weekend Daily Vehicle Trip Rate and Trip Generation

PERIOD	TRIP RATE (PER BERTH)			TRIP GENERATION (FOR 50 BERTHS)		
	Arrive	Depart	Total	Arrive	Depart	Total
07:00-08:00	0.017	0.015	0.032	1	1	2
08:00-09:00	0.04	0.022	0.062	2	1	3
09:00-10:00	0.084	0.042	0.126	4	2	6
10:00-11:00	0.074	0.039	0.113	4	2	6
11:00-12:00	0.11	0.063	0.173	5	3	9
12:00-13:00	0.121	0.086	0.207	6	4	10
13:00-14:00	0.108	0.085	0.193	5	4	10
14:00-15:00	0.095	0.12	0.215	5	6	11
15:00-16:00	0.096	0.117	0.213	5	6	11
16:00-17:00	0.076	0.146	0.222	4	7	11
17:00-18:00	0.059	0.103	0.162	3	5	8
18:00-19:00	0.04	0.074	0.114	2	4	6
19:00-20:00	0.028	0.039	0.067	1	2	3

PERIOD	TRIP RATE (PER BERTH)			TRIP GENERATION (FOR 50 BERTHS)		
	Arrive	Depart	Total	Arrive	Depart	Total
20:00-21:00	0.021	0.029	0.05	1	1	3
21:00-22:00	0.011	0	0.011	1	0	1
Total	**0.98**	**0.98**	**1.96**	**49**	**48**	**98**

Note: Variances due to rounding

4.3.3 Table 2 indicates that peak period for vehicle trips associated with marina developments is between 14:00-17:00 with 11 two-way vehicle trips per hour respectively. Over the course of the day (07:00-22:00) the TRICS assessment and Table 2 indicate that 50 berths would result in 49 arrivals and 48 departures associated with vehicle trips, equating to 98 two-way movements. This is considered to be a minimal volume of vehicle movements over the course of the day and when distributed across the local road network.

Boat Workshop Element

4.3.4 Regarding the boat workshop element of the development site, the potential trip generation has been considered as if this is a new land use rather than replacement of the existing boat workshop to represent a robust approach, i.e. all trips associated with this element are considered as "new" to the network.

4.3.5 TRICS does not provide a trip rate for this type of development. However, it is estimated that the new boat workshop will create 11 new staff positions, that staff and visitors will arrive outwith the peak periods, and that a proportion of visitor trips will be "linked" trips with the marina element of the proposed development whereby users of the boat repair workshop also store their boat at the marina on Goat Island. 11 new staff members would equate to 22 two-way vehicle movements if each staff member were to travel by single occupancy car. It is estimated that staff trips to and from the proposed development would occur during the AM and PM peak hour periods respectively.

4.3.6 It has been estimated that the boat workshop would have 16 visitors per day (two per hour over an 8 hour day) which equates to 32 two-way vehicle trips. This represents a robust assessment as it assumes that all staff work each day, whereas it is likely that staff will work in shift patterns and therefore all 11 staff would not be on-site at one time.

4.4 Vehicle Trip Generation Summary

4.4.1 As discussed, this assessment considers that 100% of staff and visitors to the proposed development / boat workshop will travel by private car to ensure a robust assessment, but it should be noted that there are other more sustainable travel mode options available if travelling in and around Stornoway.

Daily

4.4.2 The estimated daily vehicle trip generation associated with the proposed development / boat workshop is as follows:

- 75 berths (assuming only 50 are occupied by locals and therefore translate into a potential vehicle movement – agreed with Roads Officer) equating to 98 two-way vehicle movements per day;
- 11 new members of staff equating to 22 two-way vehicle movements; and
- 16 visitors to the boatshed per day (2 per hour) equating to 32 two-way vehicle movements.

Peak Periods

4.4.3 Turning count surveys of the key junctions which would be affected by the proposed development were undertaken and demonstrate that the network peak hour periods are 08:00 – 09:00 in the AM and 16:30 – 17:30 in the PM. During the network AM and PM peak periods, the proposed development's estimated traffic generation (marina element plus boat workshop element) is as follows:

- AM: 14 two-way vehicle trips (13 arrivals and 1 departure); and
- PM: 22 two-way vehicle trips (4 arrivals and 18 departures).

4.5 Trip Distribution & Assignment

4.5.1 In relation to staff and visitors, the distribution of vehicle trips has been calculated using a gravity model and based on 2011 Scottish Census data for the Isle of Lewis. Data on the number of working adults in each zone within reasonable commuting distance from the site was gathered and a percentage applied to each zone appropriately representing the proportion of potential staff residing in that area. The zones selected are indicated by Figure 12 below.

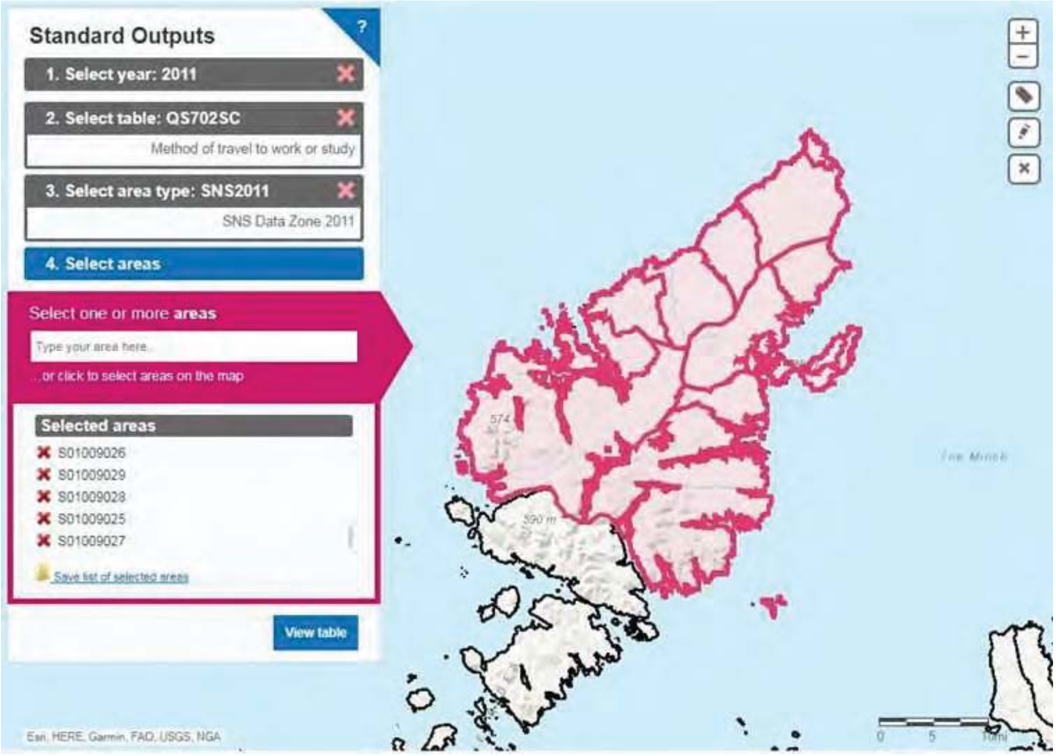

Figure 12. Census Zones Selected Within Community Distance of the Proposed Development

4.5.2 The route(s) staff / visitors would take to travel to and from the site was estimated considering the options available (distance of route and time of journey) and the corresponding vehicle trips have then been applied to the relevant traffic counter which represents the road link.

4.5.3 The census data suggests that 23% of staff / visitors would approach the site from the east along Seaview Terrace whilst the remaining 77% would approach the site from the west along Newton Street. At the Island Road / Newton Street junction, the census data suggests that 40% of staff / visitors would come from Island Road and turn left whilst 36% will be travelling straight along Newton Street. It is estimated that 34% of staff / visitors would route along Matheson Road, 31% along the A857 Macauley Road and 31% along the A859 Willowglen Road travelling to and from the site.

4.5.4 The distribution and assignment of development related trips is provided in Appendix C.

5. MEASURES TO SUPPORT THE DEVELOPMENT

5.1 General

5.1.1 The following section considers the integration of the proposed development into the surrounding transport network by all modes. The proposed development will comprise:

- Land reclamation along the north side of Goat Island and the causeway;
- Breakwater and marina with approximately 75 berths;
- Slipway and yacht lift;
- Boat storage (on land);
- Marina services (club house, toilets, showers, etc.); and
- Parking.

5.1.2 Figure 13 below indicates an indicative layout of the proposed development. A copy is also provided in Appendix B of this report.

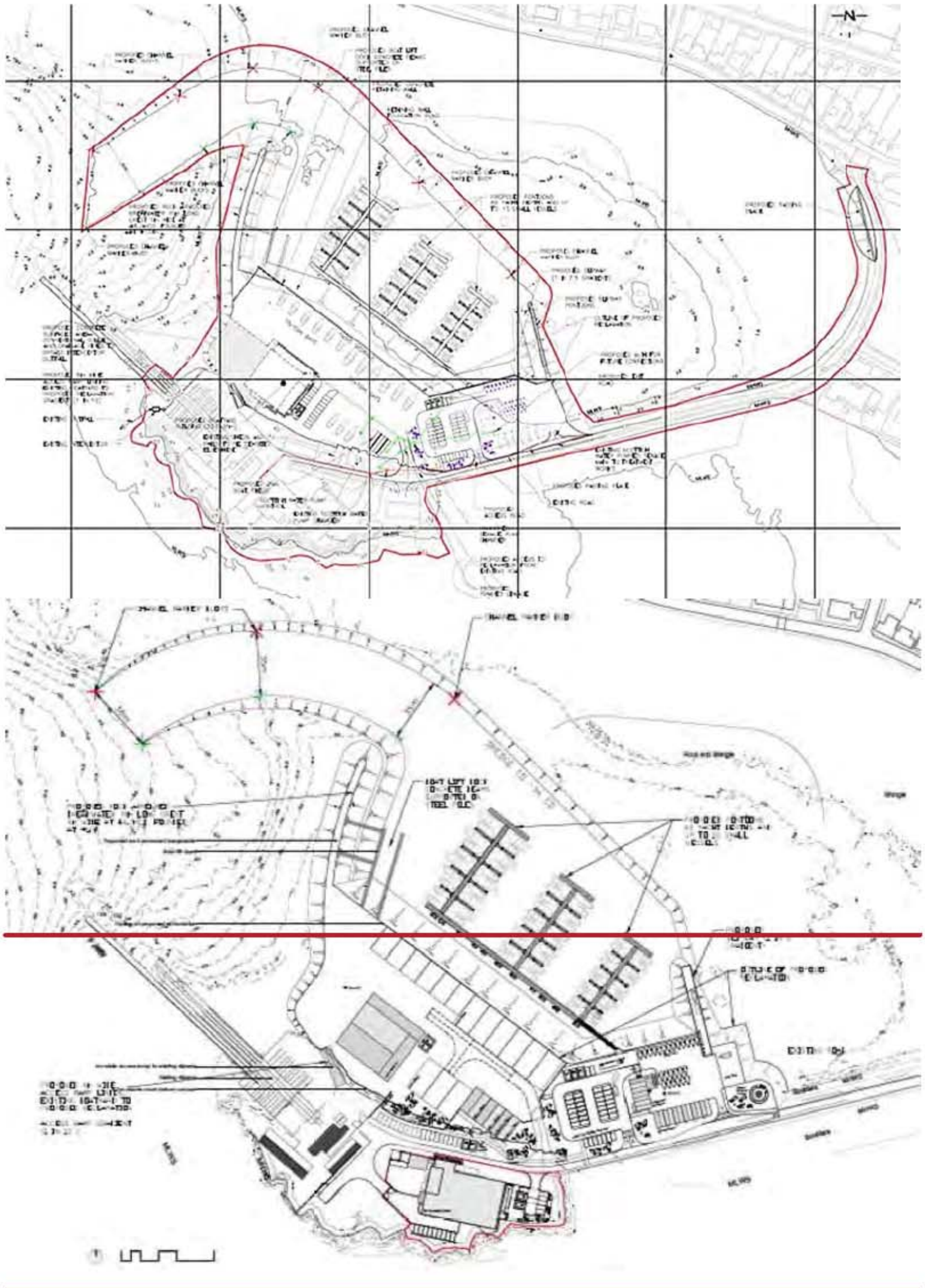

Figure 13. Indicative Development Layout

5.2 Pedestrian & Cyclist Infrastructure

5.2.1 Government guidelines indicate a hierarchy of travel modes with walking being the highest and most sustainable form of travel. It is clear that walking will not reduce long distance trips but encouraging walking will reduce short distance vehicle trips, provide linkage to public transport and as an added benefit, improve health and fitness.

5.2.2 As Chapter 3 demonstrated, there is a footway alongside the causeway linking Goat Island to Newton Street and the wider pedestrian network. This pedestrian connection will be maintained and serve as the sole pedestrian access route into to the proposed development.

5.2.3 Whilst it is anticipated that the majority of trips to and from the proposed development will be vehicle-based, there is the opportunity for locals living in the immediate vicinity to walk to the development. Furthermore, visitors utilising the berths at the proposed development that have arrived by yacht are unlikely to have access to a vehicle, therefore, may choose to walk as a mode of transport (certainly for the initial part of their trip).

5.2.4 Isochrones for 400m, 800m and 1,600m walking distance from the proposed development which approximate to a 5, 10 and 20 minute walking journey time (assuming a 1.4m/s walking speed) are indicated by Figure 14 below.

Figure 14. Walking Isochrones