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30 November 2018

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Dear Matthew,

MHL2650 – Tweed Sand Bypass Tidal Analysis 2017/18

MHL is pleased to provide this report for a tidal analysis of the Tweed River entrance for the period March 2017 – February 2018. The study consists of a tidal harmonics analysis for three locations on the Eastern Australia coastline: two in northern NSW and one on the Sunshine Coast in QLD (Figure 1). By observing long term trends in tidal response characteristics against two control sites, it can be determined if the entrance dynamics of an estuary are changing over time.

Figure 1 – Location of study area

1 Tweed Entrance Behaviour

A tidal harmonic analysis was performed on three tidal measurement datasets: Letitia 2A at the Tweed River entrance, Coffs Harbour Jetty, and Mooloolaba on the Sunshine Coast. This harmonic analysis can be used to, among other things, remove meteorological and flood events from a measured tidal signal, extracting from the noisy measurements only those components which can be described by periodic astronomical forcings. From these components, descriptive characteristics of the tidal signal at the given location can be generated and it is these characteristics which are observed and compared over time to gain insight into whether the morphology of the entrance is changing.

Figure 2 shows the Mean Water Level behaviour over the preceding 12 months. Sites show a generally consistent trend with Mooloolaba trending lower than other sites over the analysis period compared. The impact of a large meteorological event in August is evident at all sites with mean ocean levels rising at this time. Despite this, all sites remain relatively constant over the 12-month period.

The Spring Tidal Range at all sites is around 20cm smaller than the previous analysis period and remains steady for all sites across the current 12-month period. Comparing the ranges between sites (Figure 4 & 5) demonstrates that all sites have behaved similarly with the ratio between Letitia and Coffs Harbour and Mooloolaba remaining in the 0.7-0.8 range. This indicates that atmospheric forcings are a more likely explaination for the reduced tidal range than physical changes in the Tweed estuary.

For this period of analysis, the residuals range from high of 0.18m at Letitia 2A, down to values around 0.048m with the median values around 0.07m for Letitia and Coffs Harbour and 0.08m for Mooloolaba. The large residual for Letitia in March 2017 was due to two extended catchment events: one from the 7th to the 11th of the month, and the other beginning on the 30th and extending well into April. This latter event also explains the relatively high residual for April 2017 at that location. Otherwise anomalies for all sites remain fairly consistent and low across the analysed period.

Monthly rainfall at Murwillumbah is presented in Table 1. The March 2017 event was by far the largest with monthly totals more than tripling above the long-term average. Once again the analysis period displayed generally greater amounts of rain compared to the average, however, other than the March event, these events were spread over longer periods and were not accompanied by large coastal anomalies which would appear on the tidal response. As such the tidal behaviour of the Tweed River is consistent with the behaviour of previous years and with the oceanic sites.

2 Tidal Comparison

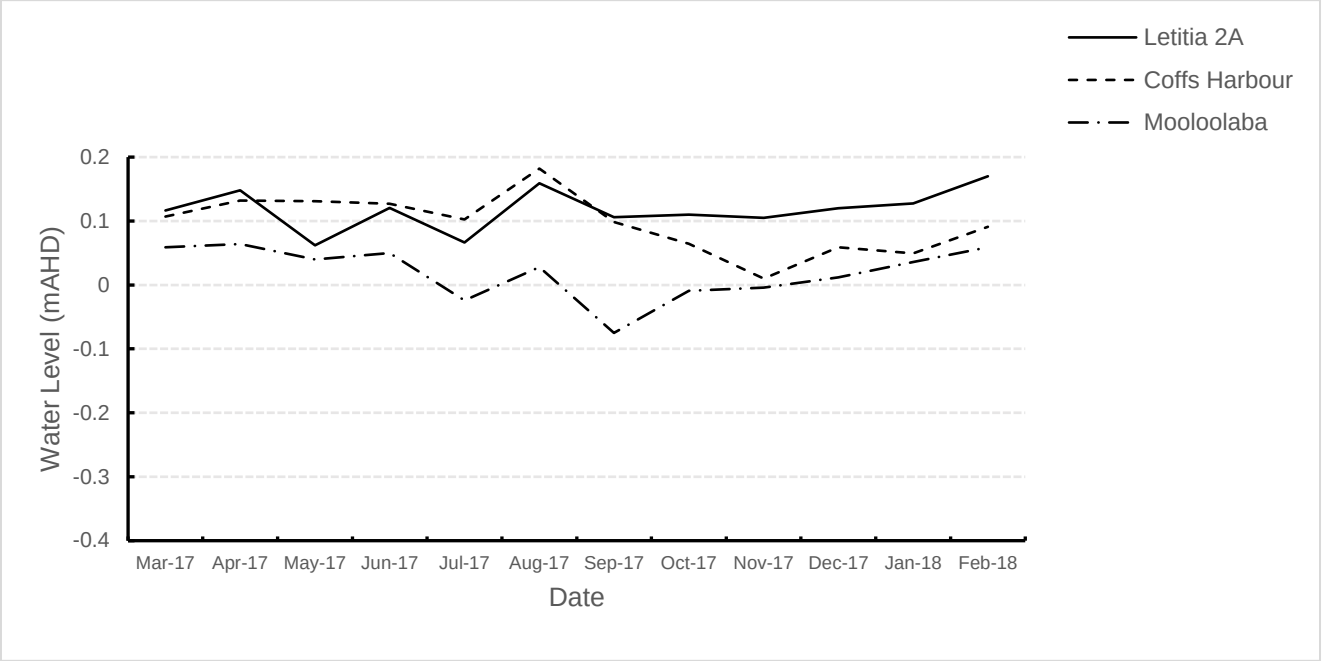


Figure 2 – Mean Water Level Comparison

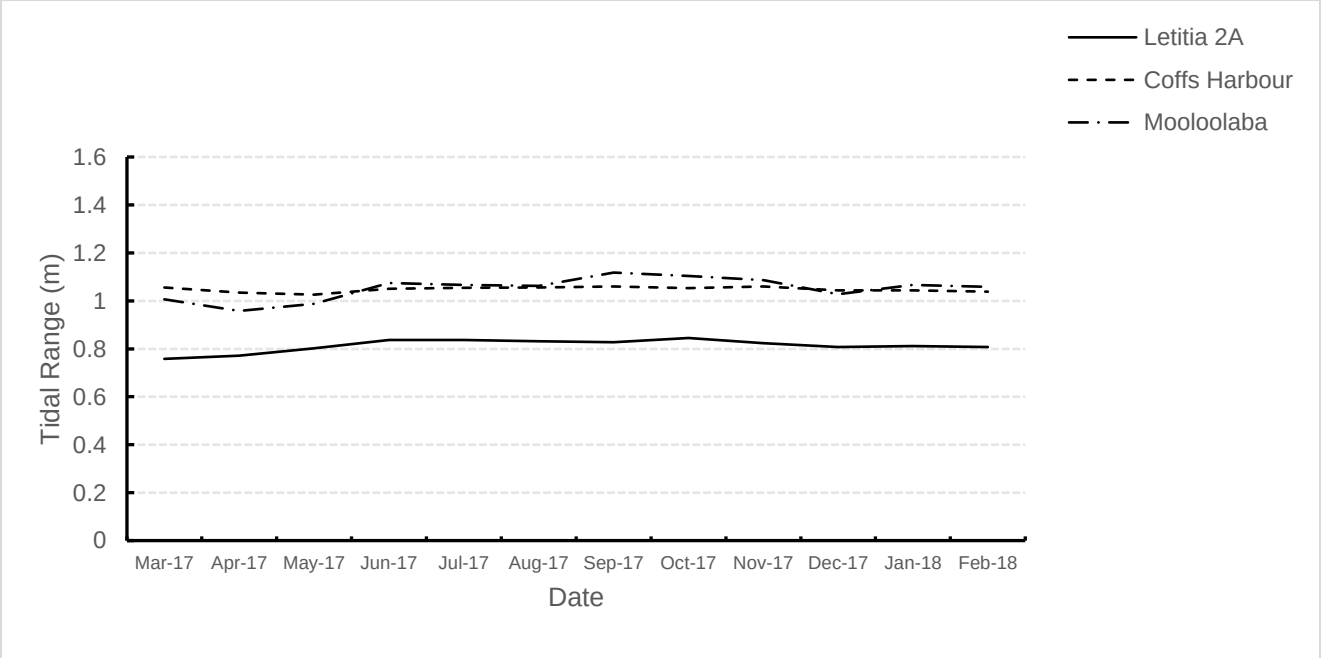


Figure 3 – Spring Tidal Range Comparison

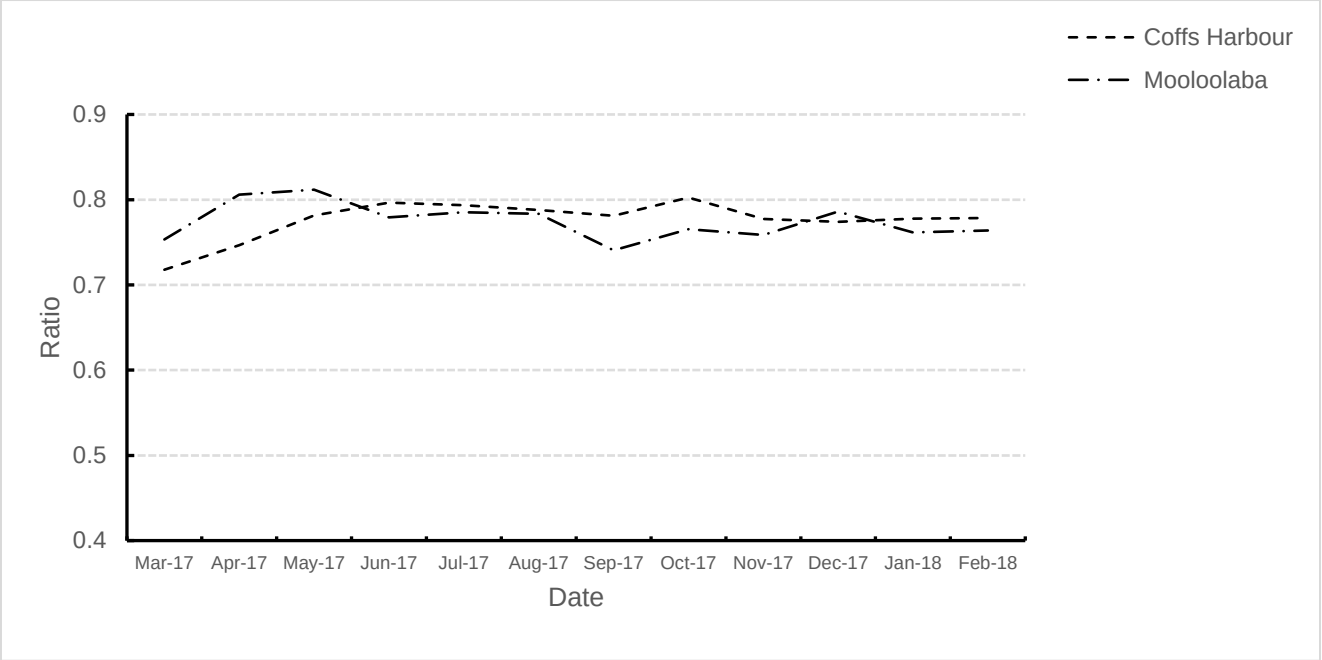


Figure 4 – Spring Tidal Range Ratio Comparison (Letitia 2A to Other Sites)

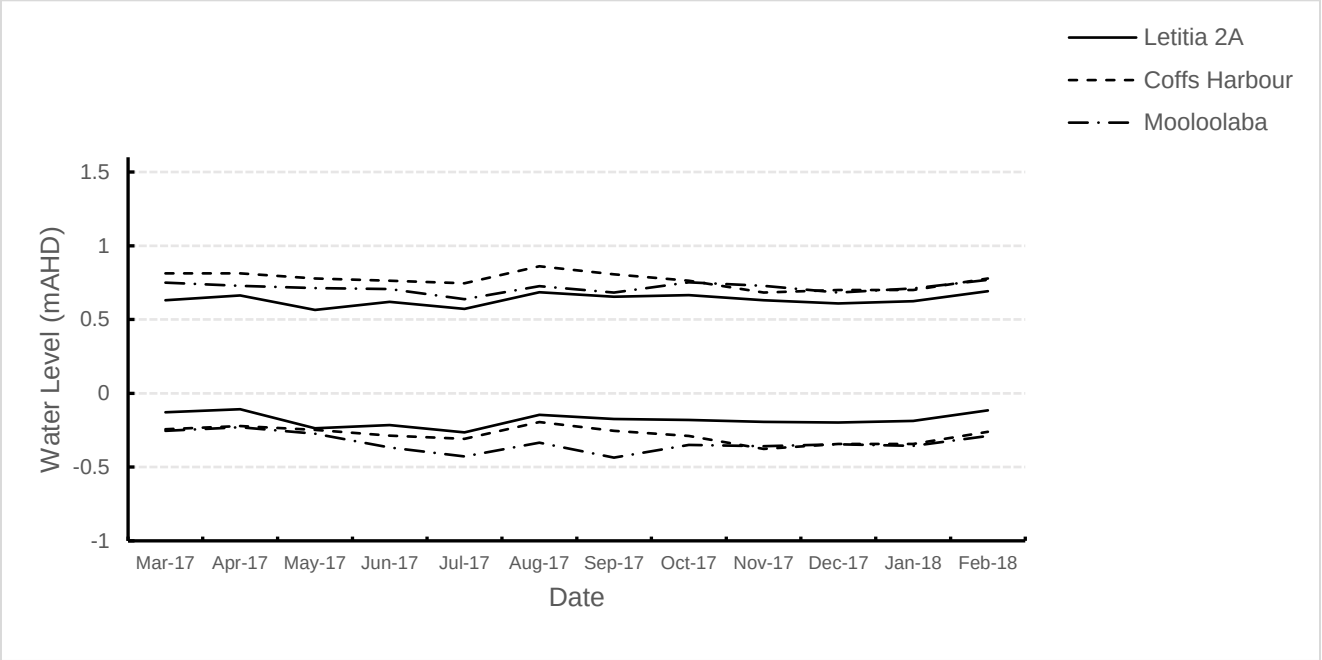


Figure 5 – Spring Tidal Planes Comparison

Table 1 – Murwillumbah recorded rainfall for the period March-2018 to February 2018 (all values in mm)

	Long Term Average	Monthly Totals	Highest Daily Recording	% Monthly Avg
Mar-17	217.3	825.6	275.4	379.94%
Apr-17	153.8	29.2	8.2	18.99%
May-17	130.1	145.2	44.2	111.61%

	Long Term Average	Monthly Totals	Highest Daily Recording	% Monthly Avg
Jun-17	106.6	243.6	84.2	228.52%
Jul-17	60	16.2	10.4	27.00%
Aug-17	53.9	7.2	7.2	13.36%
Sep-17	40.7	3.6	3.6	8.85%
Oct-17	109.7	266.3	96.8	242.75%
Nov-17	125	147.2	32	117.76%
Dec-17	168.5	245	65	145.40%
Jan-18	208.4	104.6	58.6	50.19%
Feb-18	224.1	266.6	58.8	118.96%
Mean:			62	121.94%
Sum:	1598.1	2300.3		

3 Tidal Planes

Presented below are a series of monthly tidal plane tables for the five selected sites.

Key:

- **HHWS** - Highest High Water Springs
- **MHWS** - Mean High Water Springs
- **MHWN** - Mean High Water Neaps
- **MWL** - Mean Water Level
- **MLWN** - Mean Low Water Neap
- **MLWS** - Mean Low Water Springs
- **LLWS** - Lowest Low Water Springs
- **MSTR -** Mean Spring Tidal Range
- **MNTR** - Mean Neap Tidal Range
- **Residual** - Root Mean Square Residual

Table 2 – Tidal planes and ranges for March 2017

	Coffs Harbour	Letitia 2A	Mooloolaba	Kerosene Inlet	Tony's Island
HHWS	1.0385	0.8405	0.984	0.891	0.826
MHWS	0.812	0.630	0.751	0.681	0.622
MHWN	0.458	0.361	0.373	0.385	0.407
MWL	0.107	0.117	0.059	0.124	0.188
MLWN	-0.598	-0.397	-0.633	-0.434	-0.245
MLWS	-0.244	-0.128	-0.255	-0.137	-0.030
LLWS	-0.825	-0.608	-0.866	-0.644	-0.449
MSTR	1.410	1.027	1.384	1.116	0.866
MNTR	0.702	0.489	0.628	0.522	0.436
Residual	0.102	0.183	0.095	*NA*	*NA*

Table 3 – Tidal planes and ranges for April 2017

	Coffs Harbour	Letitia 2A	Mooloolaba	Kerosene Inlet	Tony's Island
HHWS	1.048	0.891	0.971	0.930	*No Data*
MHWS	0.812	0.664	0.728	0.704	*No Data*
MHWN	0.486	0.404	0.358	0.424	*No Data*
MWL	0.132	0.148	0.064	0.155	*No Data*
MLWN	-0.548	-0.368	-0.600	-0.394	*No Data*
MLWS	-0.222	-0.108	-0.230	-0.114	*No Data*
LLWS	-0.784	-0.595	-0.843	-0.620	*No Data*
MSTR	1.360	1.032	1.328	1.098	*No Data*
MNTR	0.708	0.512	0.588	0.538	*No Data*
Residual	0.064	0.126	0.082	*NA*	*NA*

Table 4 – Tidal planes and ranges for May 2017

	Coffs Harbour	Letitia 2A	Mooloolaba	Kerosene Inlet	Tony's Island
HHWS	1.058	0.825	1.004	0.875	0.799
MHWS	0.779	0.565	0.713	0.614	0.547
MHWN	0.509	0.361	0.355	0.392	0.380
MWL	0.131	0.062	0.040	0.080	0.116
MLWN	-0.517	-0.441	-0.633	-0.454	-0.315
MLWS	-0.247	-0.237	-0.275	-0.233	-0.148
LLWS	-0.796	-0.701	-0.924	-0.715	-0.567
MSTR	1.296	1.006	1.346	1.068	0.863
MNTR	0.756	0.598	0.630	0.625	0.528
Residual	0.069	0.075	0.104	*NA*	*NA*

Table 5 – Tidal planes and ranges for June 2017

	Coffs Harbour	Letitia 2A	Mooloolaba	Kerosene Inlet	Tony's Island
HHWS	1.084	0.924	1.048	0.962	0.894
MHWS	0.764	0.621	0.706	0.663	0.609
MHWN	0.542	0.458	0.468	0.484	0.477
MWL	0.127	0.121	0.050	0.137	0.188
MLWN	-0.510	-0.380	-0.606	-0.389	-0.232
MLWS	-0.288	-0.217	-0.368	-0.209	-0.100
LLWS	-0.830	-0.683	-0.948	-0.688	-0.517
MSTR	1.273	1.000	1.312	1.053	0.842
MNTR	0.829	0.674	0.836	0.693	0.577
Residual	0.086	0.072	0.071	*NA*	*NA*

Table 6 – Tidal planes and ranges for July 2017

	Coffs Harbour	Letitia 2A	Mooloolaba	Kerosene Inlet	Tony's Island
HHWS	1.070	0.871	0.995	0.901	0.848
MHWS	0.746	0.572	0.638	0.604	0.563
MHWN	0.515	0.398	0.380	0.414	0.428
MWL	0.103	0.067	-0.024	0.068	0.138
MLWN	-0.541	-0.439	-0.686	-0.467	-0.287
MLWS	-0.310	-0.265	-0.428	-0.277	-0.151
LLWS	-0.865	-0.738	-1.043	-0.764	-0.572
MSTR	1.286	1.011	1.324	1.071	0.850
MNTR	0.824	0.663	0.808	0.691	0.579
Residual	0.064	0.071	0.075	*NA*	*NA*

Table 7 – Tidal planes and ranges for August 2017

	Coffs Harbour	Letitia 2A	Mooloolaba	Kerosene Inlet	Tony's Island
HHWS	1.150	0.955	1.047	0.970	*No Data*
MHWS	0.861	0.686	0.727	0.702	*No Data*
MHWN	0.559	0.464	0.391	0.458	*No Data*
MWL	0.182	0.159	0.028	0.140	*No Data*
MLWN	-0.497	-0.368	-0.671	-0.423	*No Data*
MLWS	-0.195	-0.146	-0.335	-0.178	*No Data*
LLWS	-0.786	-0.637	-0.991	-0.691	*No Data*
MSTR	1.358	1.054	1.398	1.125	*No Data*
MNTR	0.754	0.610	0.726	0.636	*No Data*
Residual	0.107	0.100	0.105	*NA*	*NA*

Table 8 – Tidal planes and ranges for September 2017

	Coffs Harbour	Letitia 2A	Mooloolaba	Kerosene Inlet	Tony's Island
HHWS	1.041	0.881	0.962	0.896	0.793
MHWS	0.806	0.654	0.682	0.670	0.576
MHWN	0.451	0.386	0.286	0.378	0.363
MWL	0.099	0.106	-0.075	0.082	0.116
MLWN	-0.609	-0.442	-0.832	-0.505	-0.344
MLWS	-0.254	-0.174	-0.436	-0.213	-0.131
LLWS	-0.844	-0.669	-1.112	-0.731	-0.561
MSTR	1.415	1.096	1.514	1.176	0.920
MNTR	0.705	0.560	0.722	0.591	0.494
Residual	0.050	0.071	0.085	*NA*	*NA*

Table 9 – Tidal planes and ranges for October 2017

	Coffs Harbour	Letitia 2A	Mooloolaba	Kerosene Inlet	Tony's Island
HHWS	1.001	0.883	1.011	0.893	0.795
MHWS	0.764	0.665	0.753	0.675	0.586
MHWN	0.418	0.401	0.333	0.389	0.376
MWL	0.065	0.110	-0.009	0.085	0.123
MLWN	-0.635	-0.445	-0.771	-0.504	-0.340
MLWS	-0.289	-0.181	-0.351	-0.219	-0.130
LLWS	-0.872	-0.663	-1.029	-0.723	-0.550
MSTR	1.399	1.109	1.524	1.179	0.926
MNTR	0.707	0.581	0.684	0.607	0.506
Residual	0.064	0.063	0.087	*NA*	*NA*

Table 10 – Tidal planes and ranges for November 2017

	Coffs Harbour	Letitia 2A	Mooloolaba	Kerosene Inlet	Tony's Island
HHWS	0.977	0.897	1.042	0.903	0.797
MHWS	0.683	0.630	0.728	0.636	0.542
MHWN	0.397	0.404	0.350	0.391	0.370
MWL	0.010	0.105	-0.004	0.075	0.105
MLWN	-0.663	-0.420	-0.736	-0.486	-0.332
MLWS	-0.377	-0.194	-0.358	-0.241	-0.160
LLWS	-0.957	-0.687	-1.050	-0.754	-0.587
MSTR	1.346	1.050	1.464	1.122	0.873
MNTR	0.774	0.598	0.708	0.632	0.529
Residual	0.080	0.048	0.072	*NA*	*NA*

Table 11 – Tidal planes and ranges for December 2017

	Coffs Harbour	Letitia 2A	Mooloolaba	Kerosene Inlet	Tony's Island
HHWS	1.023	0.902	1.023	0.907	0.812
MHWS	0.700	0.610	0.682	0.615	0.533
MHWN	0.462	0.438	0.370	0.426	0.401
MWL	0.059	0.120	0.012	0.089	0.117
MLWN	-0.582	-0.370	-0.658	-0.437	-0.299
MLWS	-0.344	-0.198	-0.346	-0.248	-0.167
LLWS	-0.905	-0.662	-0.999	-0.730	-0.578
MSTR	1.282	0.980	1.340	1.051	0.833
MNTR	0.806	0.636	0.716	0.674	0.567
Residual	0.071	0.050	0.055	*NA*	*NA*

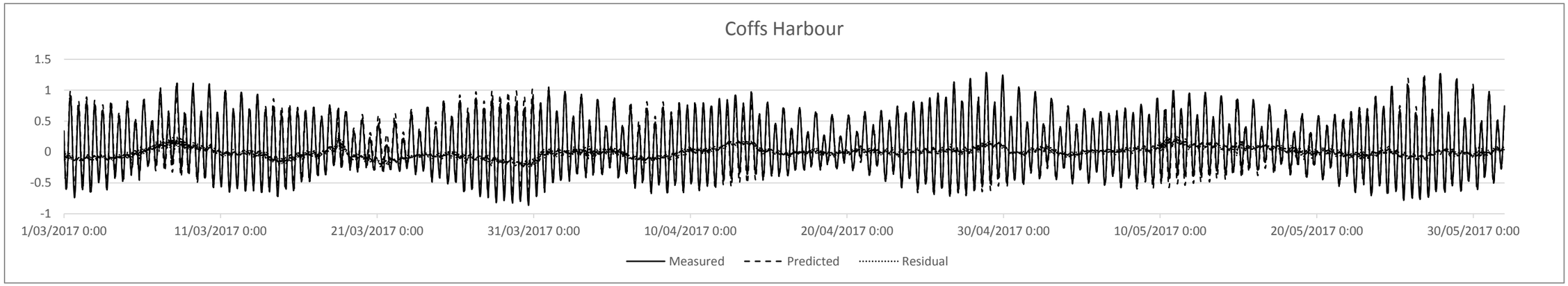
Table 12 – Tidal planes and ranges for January 2018

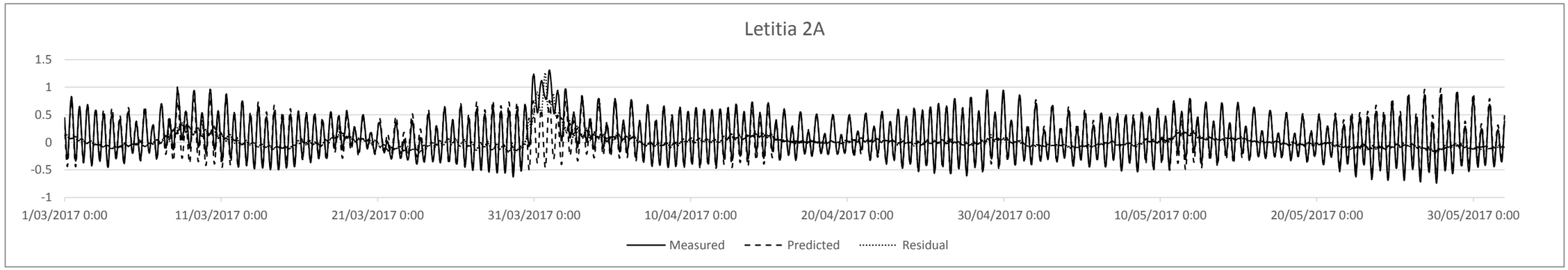
	Coffs Harbour	Letitia 2A	Mooloolaba	Kerosene Inlet	Tony's Island
HHWS	1.017	0.917	1.056	0.927	0.833
MHWS	0.701	0.625	0.710	0.633	0.553
MHWN	0.443	0.442	0.428	0.430	0.403
MWL	0.050	0.128	0.036	0.100	0.127
MLWN	-0.602	-0.370	-0.638	-0.433	-0.299
MLWS	-0.344	-0.187	-0.356	-0.230	-0.149
LLWS	-0.918	-0.662	-0.984	-0.727	-0.580
MSTR	1.302	0.995	1.348	1.067	0.852
MNTR	0.786	0.629	0.784	0.660	0.552
Residual	0.096	0.097	0.088	*NA*	*NA*

Table 13 – Tidal planes and ranges for February 2018

	Coffs Harbour	Letitia 2A	Mooloolaba	Kerosene Inlet	Tony's Island
HHWS	1.043	0.945	1.053	0.953	0.850
MHWS	0.778	0.692	0.769	0.701	0.612
MHWN	0.442	0.456	0.407	0.438	0.421
MWL	0.091	0.170	0.059	0.143	0.172
MLWN	-0.596	-0.352	-0.651	-0.415	-0.267
MLWS	-0.260	-0.116	-0.289	-0.152	-0.077
LLWS	-0.861	-0.605	-0.935	-0.667	-0.506
MSTR	1.374	1.044	1.420	1.116	0.879
MNTR	0.702	0.572	0.696	0.590	0.498
Residual	0.074	0.054	0.078	*NA*	*NA*

4 Residual Plots





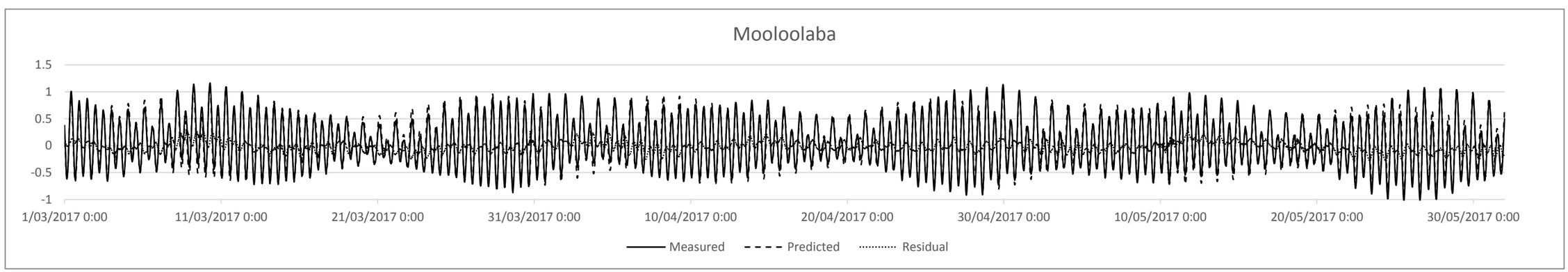
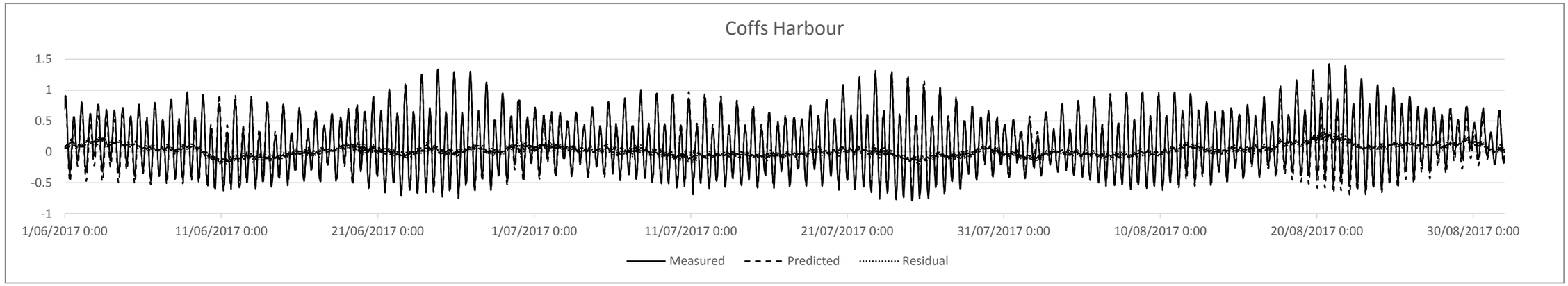
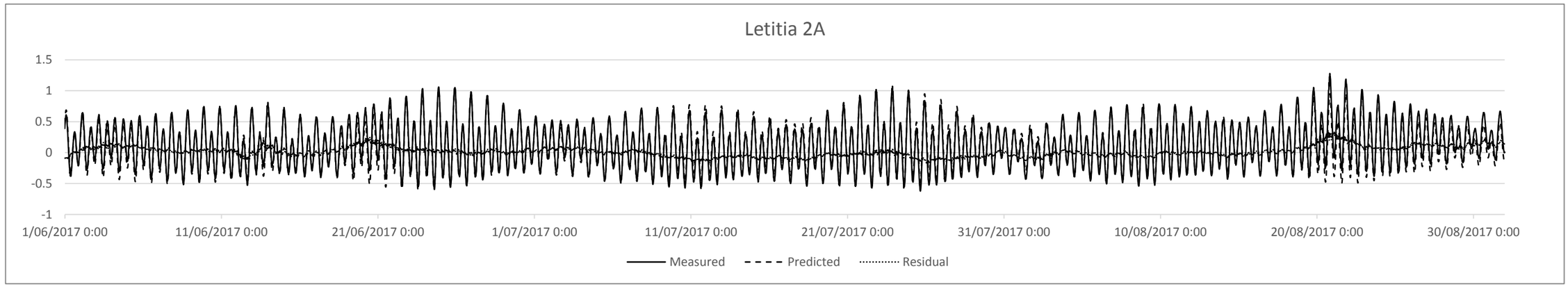


Figure 6 – March 2017 to May 2017 Water Levels





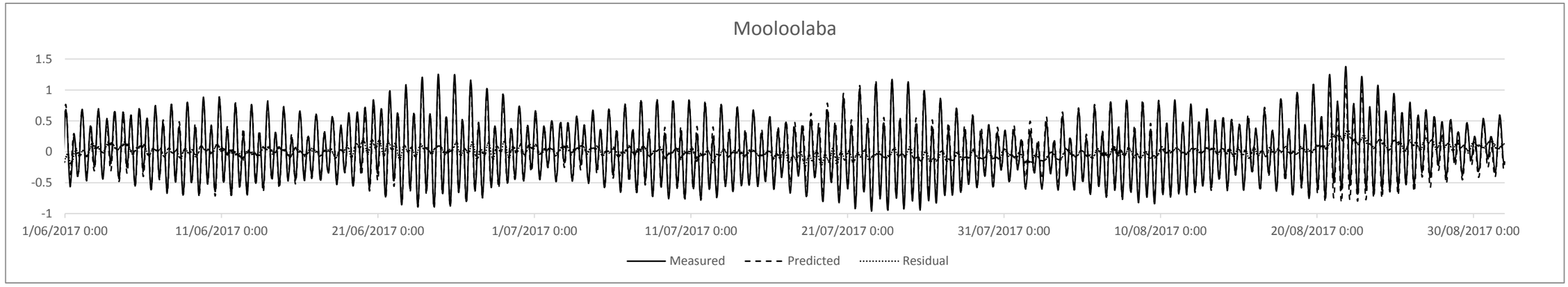
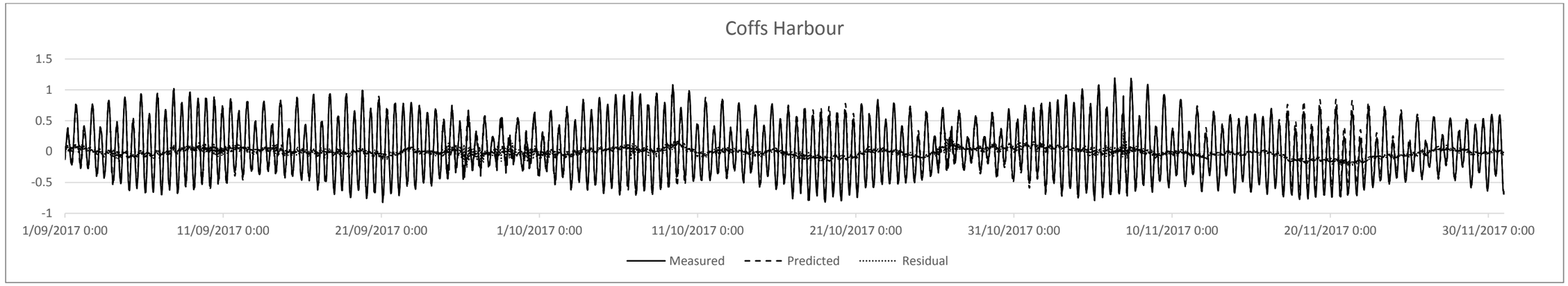
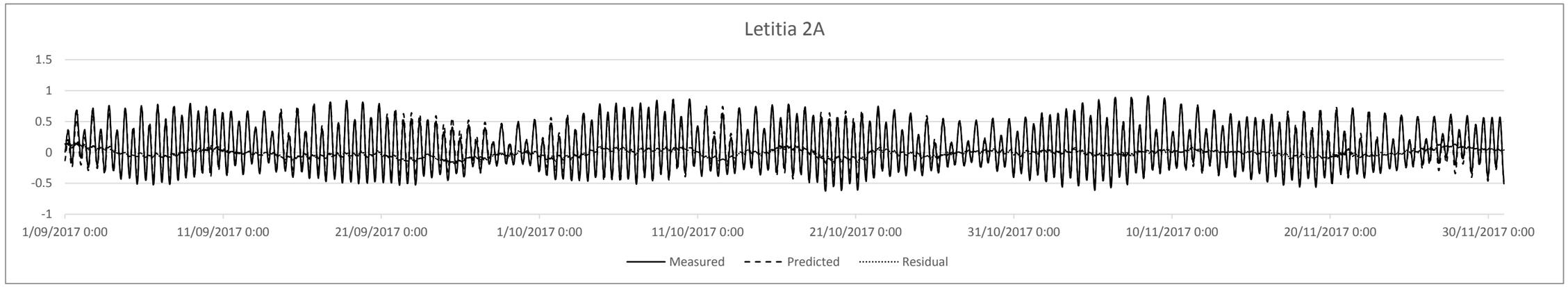


Figure 7 – June 2017 to August 2017 Water Levels





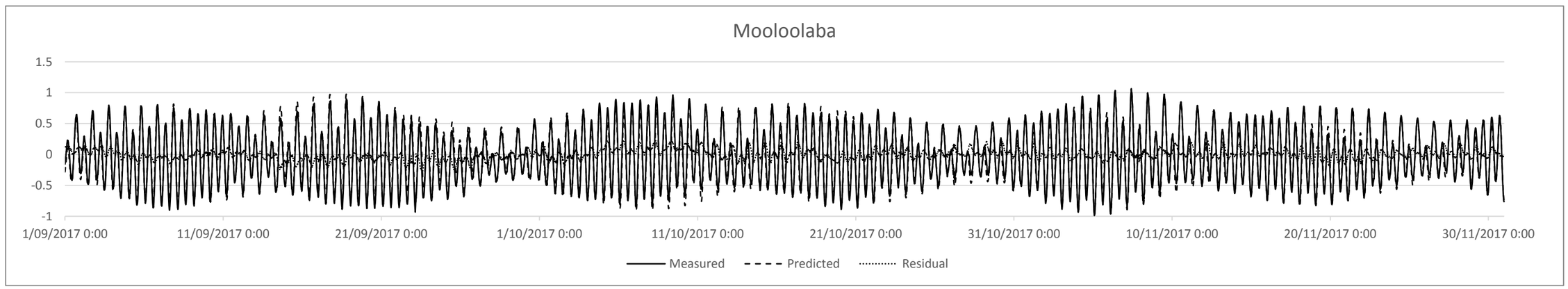
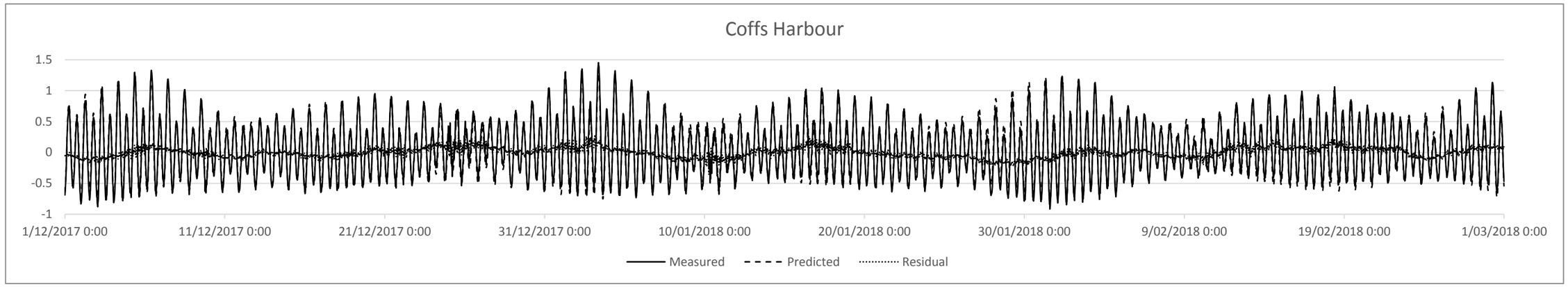
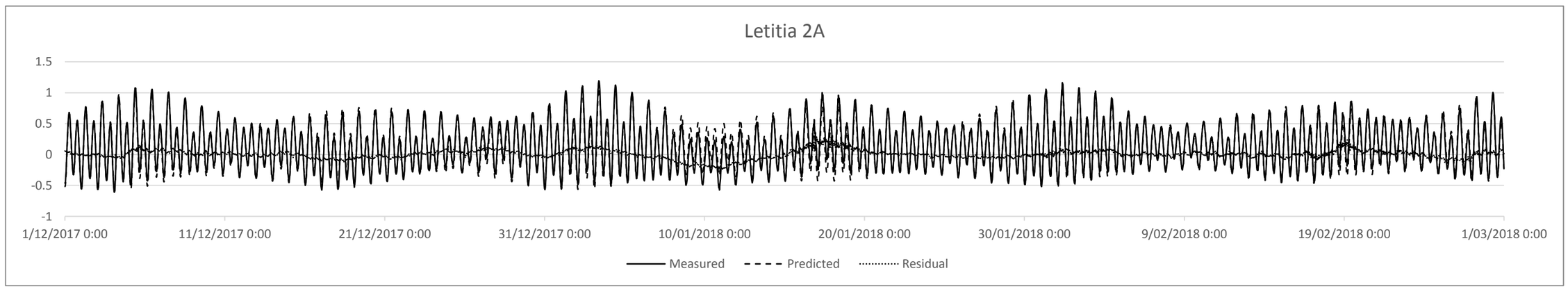


Figure 8 – September 2017 to November 2017 Water Levels





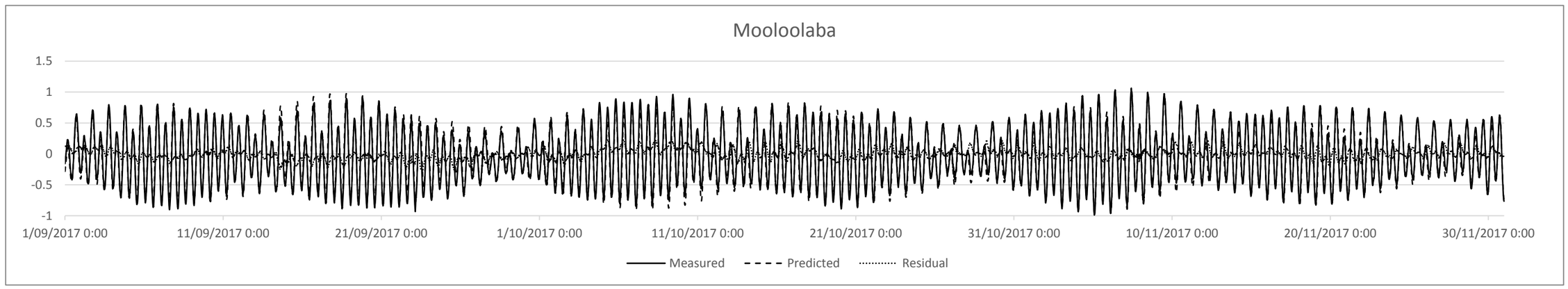


Figure 9 – December 2017 to February 2018 Water Levels

5 Conclusions

Based on the analysis presented above it is unlikely that the Tweed entrance has experienced any significant morphological changes in the preceeding 12-months which would manifest in changes to the astronomical tidal response.

Should you require further information please contact **Bronson McPherson** on (02) 9949 0244 or by email at Bronson.Mcpherson@mhl.nsw.gov.au

Yours sincerely

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Document Control

Issue/ Revision	Author	Reviewer	Approved for Issue	
			Name	Date
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Manly Hydraulics Laboratory is Quality System Certified to AS/NZS ISO 9001:2008.