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Dear Dimitrios,

MHL2761 – Tweed Sand Bypass Tidal Analysis 2020/21

MHL is pleased to provide this report for a tidal analysis of the Tweed River entrance for the period March 2020 – February 2021. 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 analysed 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. Mean levels behave consistently between all three sites with Mooloolaba and Letitia behaving nearly identically over the period. Mean water levels at Mooloolaba were lower than the other two sites over the analysis period. There were no significant meteorological events which affected all three sites.

Figure 3 compares the spring tidal range of the three sites. The spring tidal range is steady across the 12-month period and consistent with the previous year's analysis. Figure 4 shows the comparison of spring tidal range ratio between Letitia 2A, Coffs Harbour and Mooloolaba. The ratio of spring tide range between sites also remains consistent with last year's analysis.

Figure 5 and Figure 6 compare Mean High Water Springs (MHWS) and Mean Low Water Springs (MLWS) respectively among the three sites. Figures 5 to 6 show similar trends to previous years and remain consistent over this 12-month period of analysis.

The monthly residuals over this period range from a high of 0.14m at Letitia 2A, to a low of 0.045m at Mooloolaba, with a median of 0.09m for Coffs Harbour, 0.07m for Mooloolaba, and 0.08m for Letitia 2A.

Monthly rainfall at Murwillumbah is presented in Table 1. Contrasting to last year, this 12-month period was characterised by more rain, with three months exceeding long term values. Around 103% of the long-term rainfall was recorded over this period, with over 40% of that occurring in December 2020. Significant floods are observable at Letitia 2A in May, July, and December 2020. Each of these is also visible at at least one of the other two sites. Therefore, most large tidal anomalies recorded at Letitia were due to flooding and unrelated to changes in entrance dynamics.

2 Tidal Comparison

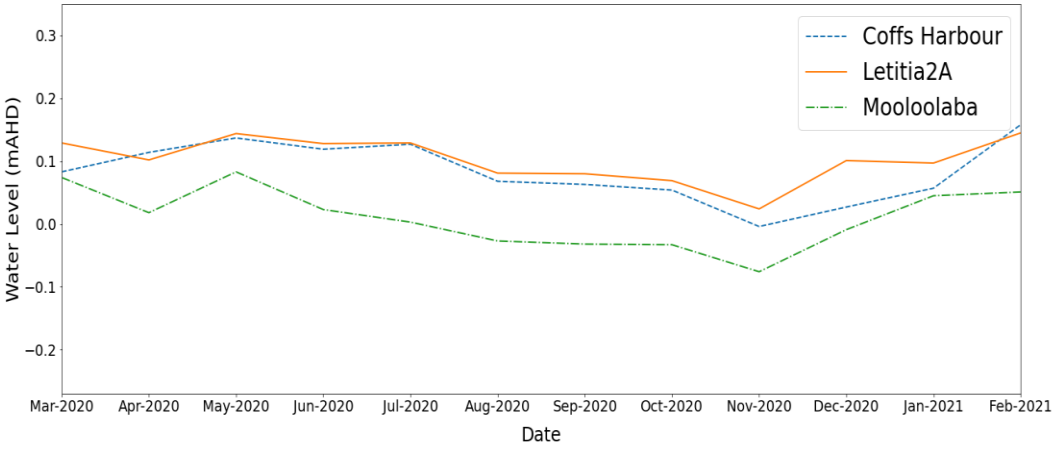

Figure 2 – Mean Water Level Comparison

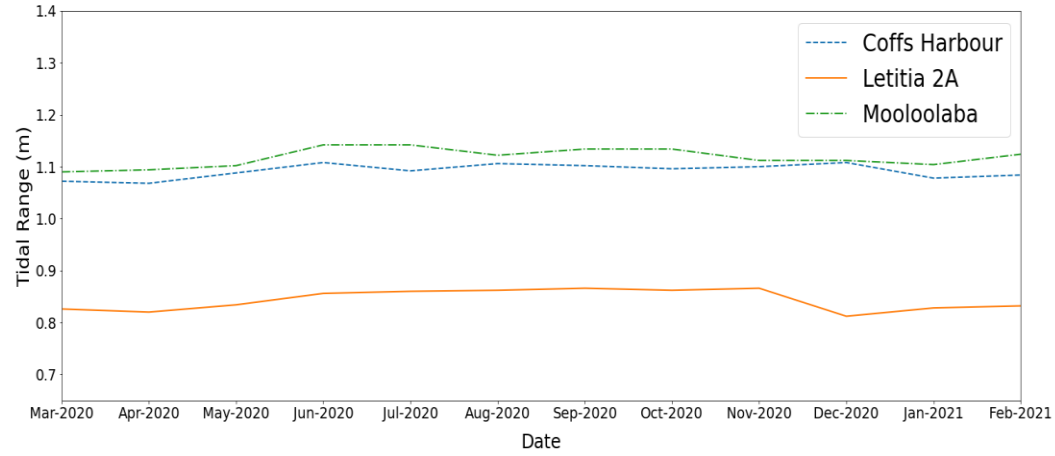

Figure 3 – Spring Tidal Range Comparison

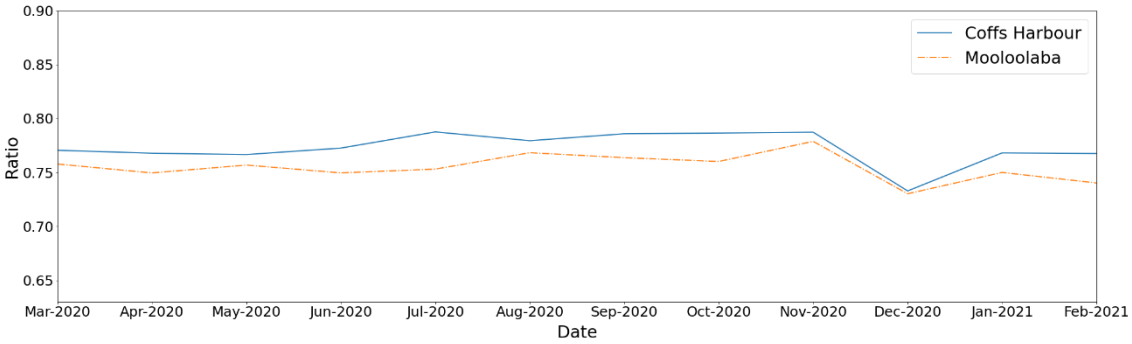

Figure 4 – Spring Tidal Range Ratio Comparison (Letitia 2A to Other Sites)

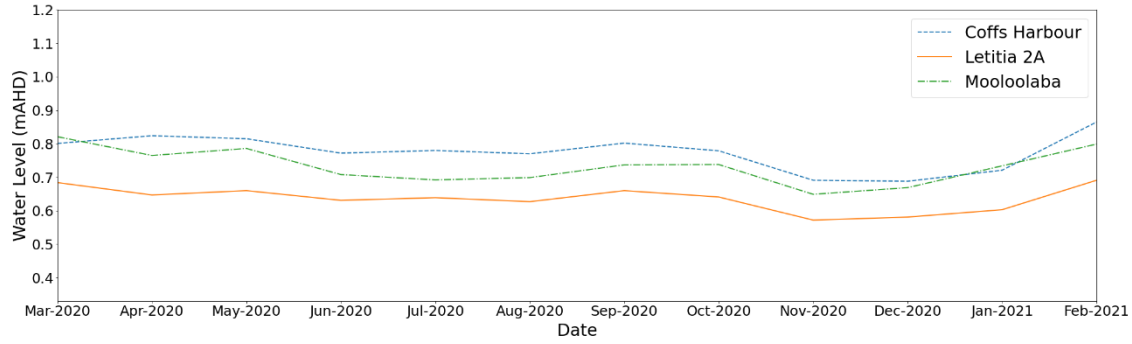

Figure 5 – Spring Tidal Planes Comparison (MHWS)

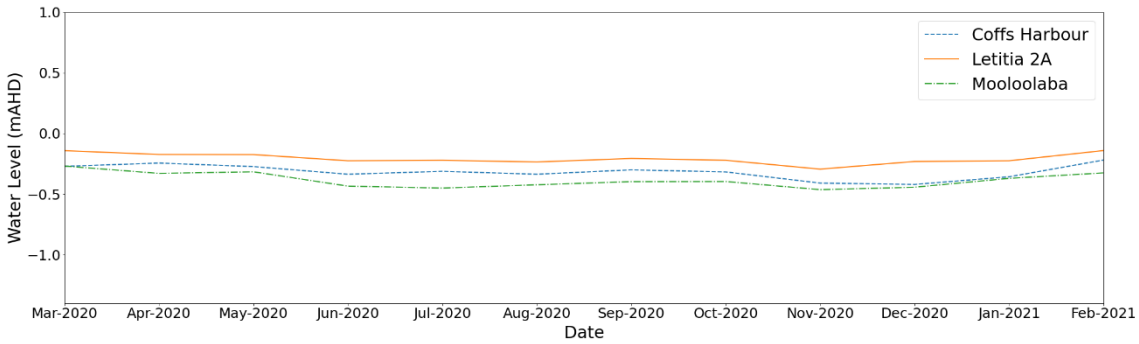

Figure 6 – Spring Tidal Planes Comparison (MLWS)

Table 1 – Murwillumbah recorded rainfall for the period March-2020 to February 2021 (all values in mm)

	Long Term Average	Monthly Totals	Highest Daily Recording	% Monthly Avg
Mar-20	217.4	119.1	44	54.78%
Apr-20	150.6	16.5	6.1	10.96%
May-20	127	48.8	11	38.43%
Jun-20	106.5	102.8	62	96.53%
Jul-20	62	155.8	67	251.29%
Aug-20	52.5	26	13	49.52%
Sep-20	39.7	27.2	9	68.51%
Oct-20	107.6	88.1	37	81.88%
Nov-20	118.4	8.7	6.1	7.35%
Dec-20	175.8	638.7	160	363.31%
Jan-21	204.7	173.7	60	84.86%
Feb-21	232	299.4	45.8	129.05%
Mean:			44	103.04%
Sum:	1594.2	1704.8		

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 2020

	Coffs Harbour	Letitia 2A	Mooloolaba	Kerosene Inlet	Tony's Island
HHWS	1.002	0.871	1.039	0.893	0.827
MHWS	0.801	0.684	0.821	0.707	0.642
MHWN	0.437	0.400	0.417	0.397	0.409
MWL	0.083	0.129	0.074	0.116	0.162
MLWN	-0.635	-0.426	-0.673	-0.474	-0.319
MLWS	-0.271	-0.142	-0.269	-0.164	-0.086
LLWS	-0.836	-0.613	-0.891	-0.660	-0.504
MSTR	1.436	1.110	1.494	1.181	0.961
MNTR	0.708	0.542	0.686	0.561	0.495
Residual	0.066	0.062	0.089	NA	NA

Table 3 – Tidal planes and ranges for April 2020

	Coffs Harbour	Letitia 2A	Mooloolaba	Kerosene Inlet	Tony's Island
HHWS	1.038	0.848	0.993	0.874	0.793
MHWS	0.824	0.647	0.765	0.673	0.600
MHWN	0.472	0.377	0.365	0.375	0.379
MWL	0.114	0.102	0.018	0.086	0.129
MLWN	-0.596	-0.443	-0.729	-0.501	-0.342
MLWS	-0.244	-0.173	-0.329	-0.203	-0.121
LLWS	-0.810	-0.644	-0.957	-0.702	-0.535
MSTR	1.420	1.090	1.494	1.173	0.941
MNTR	0.716	0.550	0.694	0.578	0.500
Residual	0.088	0.079	0.106	NA	NA

Table 4 – Tidal planes and ranges for May 2020

	Coffs Harbour	Letitia 2A	Mooloolaba	Kerosene Inlet	Tony's Island
HHWS	1.067	0.896	1.062	0.923	0.855
MHWS	0.815	0.660	0.786	0.686	0.626
MHWN	0.547	0.462	0.482	0.468	0.463
MWL	0.137	0.144	0.083	0.131	0.179
MLWN	-0.541	-0.372	-0.620	-0.425	-0.268
MLWS	-0.273	-0.174	-0.316	-0.207	-0.105
LLWS	-0.793	-0.608	-0.896	-0.662	-0.497
MSTR	1.356	1.032	1.406	1.111	0.893
MNTR	0.820	0.636	0.798	0.675	0.567
Residual	0.130	0.112	0.075	NA	NA

Table 5 – Tidal planes and ranges for June 2020

	Coffs Harbour	Letitia 2A	Mooloolaba	Kerosene Inlet	Tony's Island
HHWS	1.050	0.899	1.028	0.917	0.847
MHWS	0.772	0.631	0.708	0.650	0.591
MHWN	0.574	0.481	0.480	0.486	0.470
MWL	0.119	0.128	0.023	0.112	0.161
MLWN	-0.534	-0.375	-0.662	-0.427	-0.269
MLWS	-0.336	-0.225	-0.434	-0.262	-0.148
LLWS	-0.812	-0.643	-0.982	-0.694	-0.525
MSTR	1.306	1.006	1.370	1.077	0.860
MNTR	0.910	0.706	0.914	0.748	0.618
Residual	0.085	0.058	0.063	NA	NA

Table 6 – Tidal planes and ranges for July 2020

	Coffs Harbour	Letitia 2A	Mooloolaba	Kerosene Inlet	Tony's Island
HHWS	1.060	0.901	1.006	0.917	0.845
MHWS	0.780	0.639	0.692	0.655	0.594
MHWN	0.566	0.479	0.456	0.476	0.466
MWL	0.127	0.129	0.003	0.111	0.160
MLWN	-0.526	-0.381	-0.686	-0.434	-0.273
MLWS	-0.312	-0.221	-0.450	-0.255	-0.145
LLWS	-0.806	-0.643	-1.000	-0.696	-0.524
MSTR	1.306	1.020	1.378	1.090	0.867
MNTR	0.878	0.700	0.906	0.731	0.611
Residual	0.087	0.083	0.076	NA	NA

Table 7 – Tidal planes and ranges for August 2020

	Coffs Harbour	Letitia 2A	Mooloolaba	Kerosene Inlet	Tony's Island
HHWS	1.026	0.868	0.974	0.882	0.799
MHWS	0.770	0.627	0.699	0.643	0.569
MHWN	0.472	0.397	0.369	0.392	0.386
MWL	0.068	0.081	-0.027	0.062	0.109
MLWN	-0.634	-0.465	-0.753	-0.519	-0.352
MLWS	-0.336	-0.235	-0.423	-0.269	-0.169
LLWS	-0.890	-0.706	-1.028	-0.759	-0.582
MSTR	1.404	1.092	1.452	1.162	0.921
MNTR	0.808	0.632	0.792	0.661	0.555
Residual	0.092	0.067	0.049	NA	NA

Table 8 – Tidal planes and ranges for September 2020

	Coffs Harbour	Letitia 2A	Mooloolaba	Kerosene Inlet	Tony's Island
HHWS	1.017	0.859	0.969	0.873	0.777
MHWS	0.802	0.660	0.737	0.675	0.584
MHWN	0.426	0.366	0.333	0.355	0.354
MWL	0.063	0.080	-0.032	0.054	0.101
MLWN	-0.671	-0.503	-0.804	-0.572	-0.381
MLWS	-0.300	-0.206	-0.397	-0.248	-0.152
LLWS	-0.891	-0.699	-1.033	-0.766	-0.575
MSTR	1.478	1.160	1.538	1.242	0.966
MNTR	0.726	0.572	0.730	0.602	0.506
Residual	0.061	0.052	0.049	NA	NA

Table 9 – Tidal planes and ranges for October 2020

	Coffs Harbour	Letitia 2A	Mooloolaba	Kerosene Inlet	Tony's Island
HHWS	0.996	0.840	0.972	0.856	0.762
MHWS	0.779	0.641	0.738	0.657	0.569
MHWN	0.425	0.359	0.330	0.350	0.351
MWL	0.054	0.069	-0.033	0.043	0.094
MLWN	-0.676	-0.500	-0.801	-0.568	-0.382
MLWS	-0.317	-0.221	-0.396	-0.265	-0.163
LLWS	-0.888	-0.702	-1.038	-0.771	-0.574
MSTR	1.450	1.144	1.542	1.229	0.950
MNTR	0.742	0.580	0.726	0.614	0.514
Residual	0.078	0.072	0.076	NA	NA

Table 10 – Tidal planes and ranges for November 2020

	Coffs Harbour	Letitia 2A	Mooloolaba	Kerosene Inlet	Tony's Island
HHWS	0.951	0.808	0.923	0.821	0.728
MHWS	0.691	0.572	0.649	0.583	0.501
MHWN	0.401	0.342	0.311	0.333	0.321
MWL	-0.004	0.024	-0.076	-0.003	0.046
MLWN	-0.699	-0.524	-0.801	-0.590	-0.409
MLWS	-0.409	-0.294	-0.463	-0.340	-0.229
LLWS	-0.959	-0.760	-1.075	-0.828	-0.636
MSTR	1.390	1.096	1.450	1.173	0.911
MNTR	0.810	0.636	0.774	0.673	0.550
Residual	0.096	0.103	0.069	NA	NA

Table 11 – Tidal planes and ranges for December 2020

	Coffs Harbour	Letitia 2A	Mooloolaba	Kerosene Inlet	Tony's Island
HHWS	0.985	0.849	0.978	0.862	0.802
MHWS	0.688	0.581	0.669	0.596	0.558
MHWN	0.474	0.433	0.425	0.422	0.461
MWL	0.027	0.101	-0.009	0.072	0.170
MLWN	-0.634	-0.379	-0.687	-0.451	-0.217
MLWS	-0.420	-0.231	-0.443	-0.277	-0.120
LLWS	-0.931	-0.647	-0.996	-0.717	-0.462
MSTR	1.322	0.960	1.356	1.047	0.775
MNTR	0.894	0.664	0.868	0.698	0.581
Residual	0.076	0.138	0.097	NA	NA

Table 12 – Tidal planes and ranges for January 2021

	Coffs Harbour	Letitia 2A	Mooloolaba	Kerosene Inlet	Tony's Island
HHWS	1.010	0.863	1.043	0.877	0.829
MHWS	0.721	0.603	0.734	0.617	0.578
MHWN	0.471	0.419	0.460	0.407	0.423
MWL	0.057	0.097	0.045	0.073	0.131
MLWN	-0.607	-0.409	-0.644	-0.470	-0.316
MLWS	-0.357	-0.225	-0.370	-0.260	-0.161
LLWS	-0.896	-0.669	-0.953	-0.730	-0.567
MSTR	1.328	1.012	1.378	1.088	0.894
MNTR	0.828	0.644	0.830	0.668	0.584
Residual	0.079	0.051	0.062	NA	NA

Table 13 – Tidal planes and ranges for February 2021

	Coffs Harbour	Letitia 2A	Mooloolaba	Kerosene Inlet	Tony's Island
HHWS	1.112	0.917	1.056	0.937	0.882
MHWS	0.865	0.691	0.799	0.713	0.667
MHWN	0.535	0.431	0.427	0.428	0.451
MWL	0.158	0.145	0.051	0.131	0.193
MLWN	-0.549	-0.401	-0.697	-0.451	-0.281
MLWS	-0.219	-0.141	-0.325	-0.166	-0.064
LLWS	-0.796	-0.627	-0.954	-0.675	-0.496
MSTR	1.414	1.092	1.496	1.164	0.947
MNTR	0.754	0.572	0.752	0.594	0.515
Residual	0.105	0.081	0.045	NA	NA

4 Residual Plots

Figure 7 – March 2020 to May 2020 Water Levels

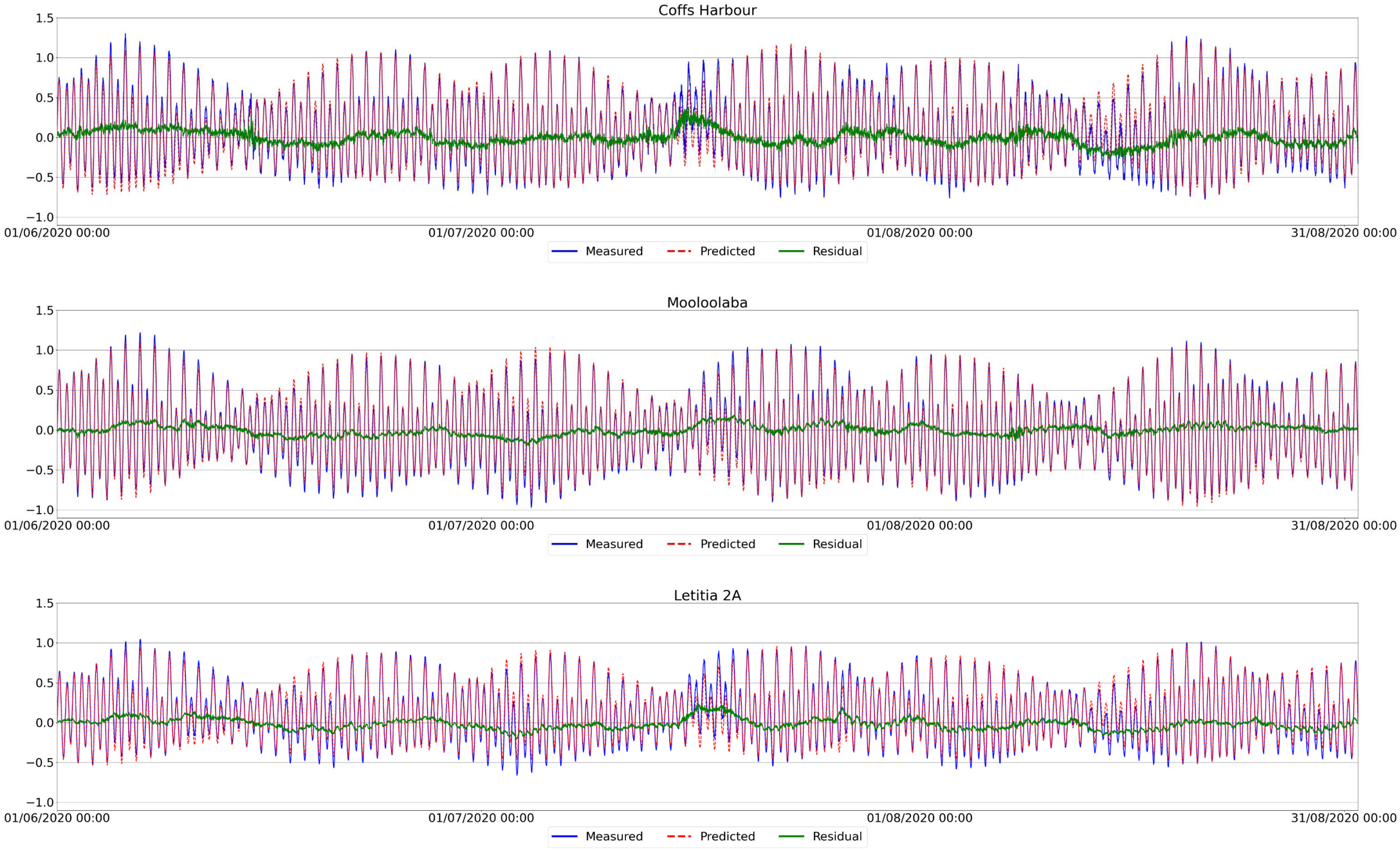

Figure 8 – June 2020 to August 2020 Water Levels

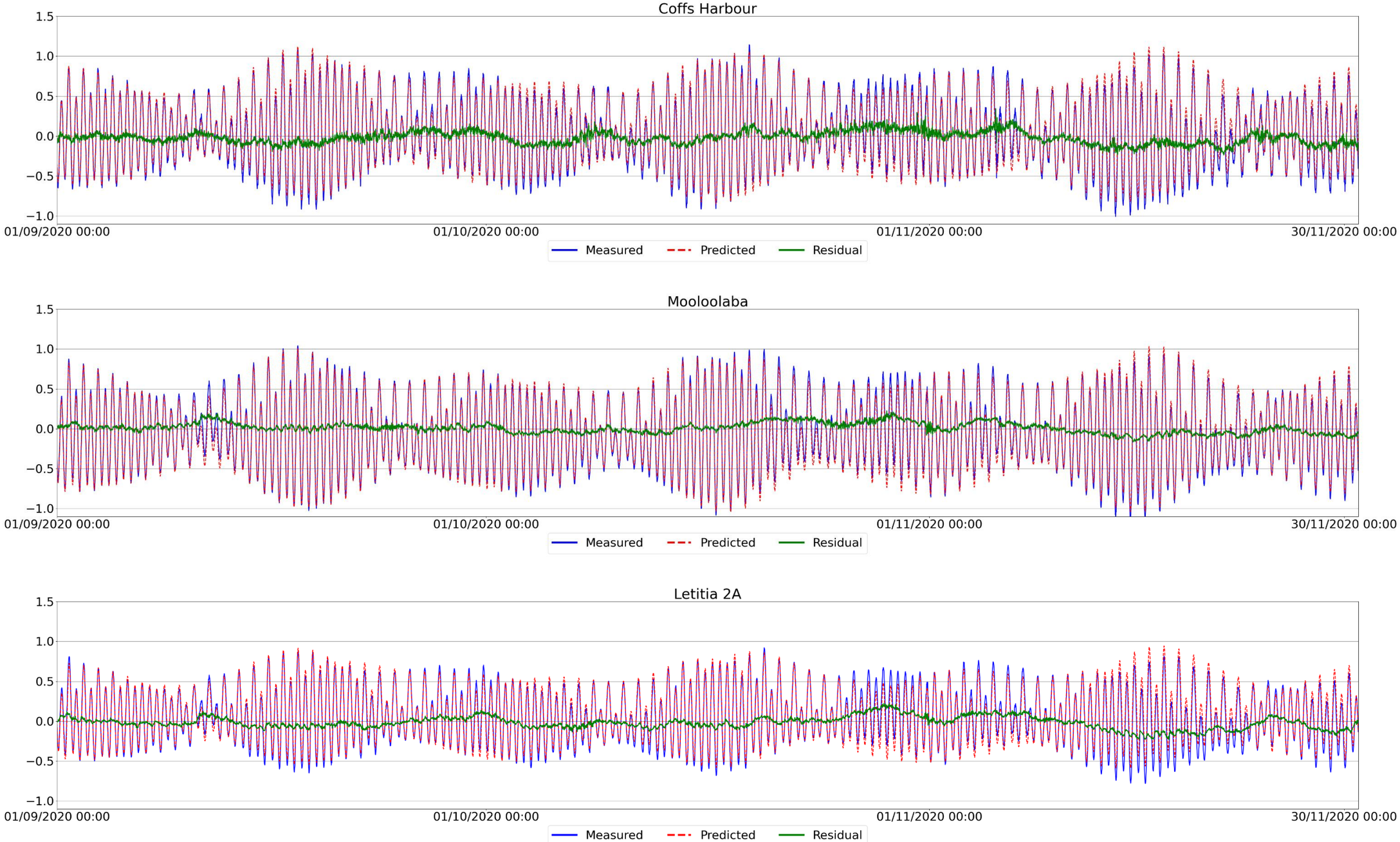

Figure 9 – September 2020 to November 2020 Water Levels

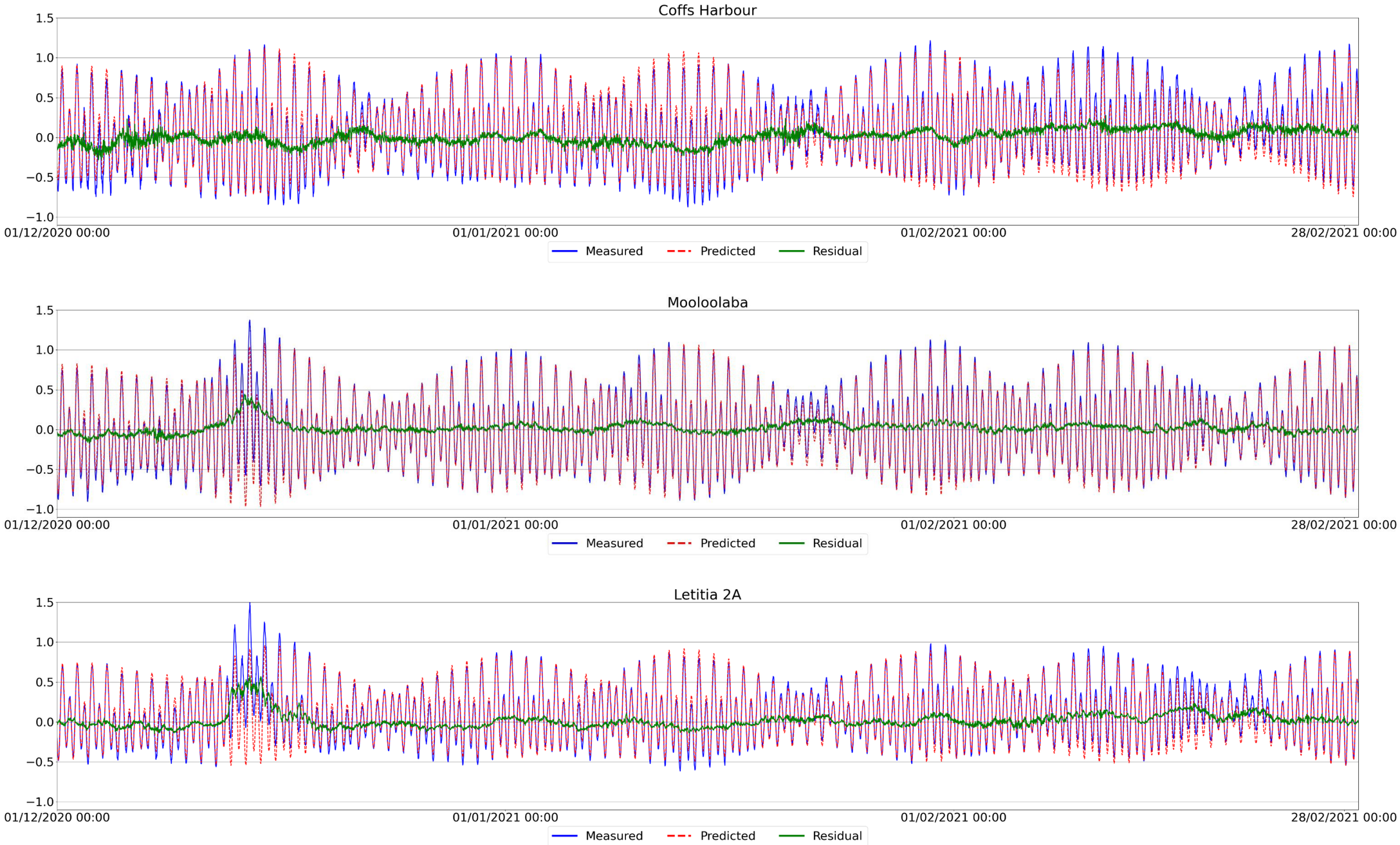

Figure 10 – December 2020 to February 2021 Water Levels

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

BMc

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Document Control

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