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References

1. Communication with PND, conceptual design of Cascade Point Ferry terminal drawing, *Concept_3.dwg*.
2. PND CASCADE POINT FERRY TERMINAL, Metocean Review, Document 23056.01-001, Rev B, 6 September 2023.
3. *Simulating WAves Nearshore (SWAN)* [software], Delft University of Technology, Version 41.31A, July 2021
4. NOAA - National Centers for Environmental Information, *Bathymetry Data Viewer*, https://www.ncei.noaa.gov/maps/bathymetry/, 1 March 2024.

Introduction

Glosten was tasked with performing a complete breakwater efficiency analysis at Cascade Point. This analysis was conducted to determine the reduction in wave heights caused by the proposed breakwater. This analysis was done to support the design of the proposed Alaska Department of Transportation and Public Facilities (AKDOT&PF) ferry terminal site located at Cascade Point, Alaska, provided by PND Engineers, Inc (PND). The proposed configuration of the terminal site and breakwater location is presented in Figure 1 (provided by PND Reference 1).

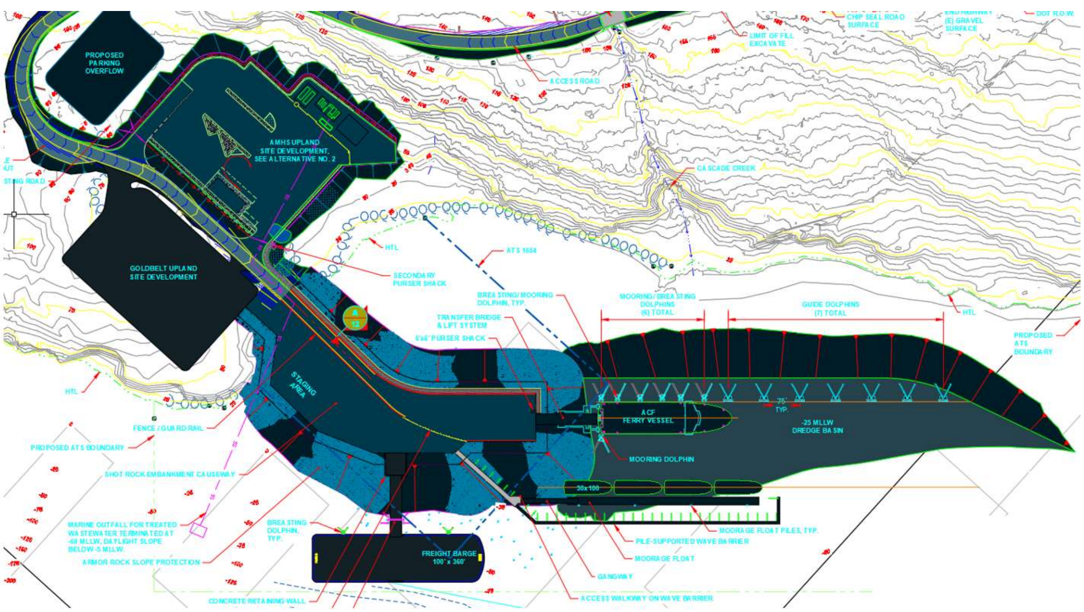

Figure 1 Proposed terminal and breakwater location (from PND)

Wind Conditions

The wind conditions used in this study are those computed by Glosten for the project site (Reference 2). These wind conditions are presented for reference here in Table 1.

Table 1 Wind conditions for the project site

Direction (from)	Return Period		
	25-years	50-years	100-years
S	54.6 kt	57.9 kt	61.2 kt
SW	61.6 kt	69.2 kt	77.0 kt
W	49.2 kt	56.8 kt	64.3 kt
NW	69.0 kt	76.4 kt	83.6 kt

Wave

The design wave heights were derived from the wind data by applying the design wind speeds to a model of the project site in SWAN (Reference 3). The bathymetry files were obtained from NOAA's National Centers for Environmental Information Bathymetry viewer (Reference 4). Three levels of computational mesh were defined for the model as coarse, medium, and fine regions with 0.001-, 0.00025-, and 0.00005-degree resolutions. The three regions are presented in Figure 2.

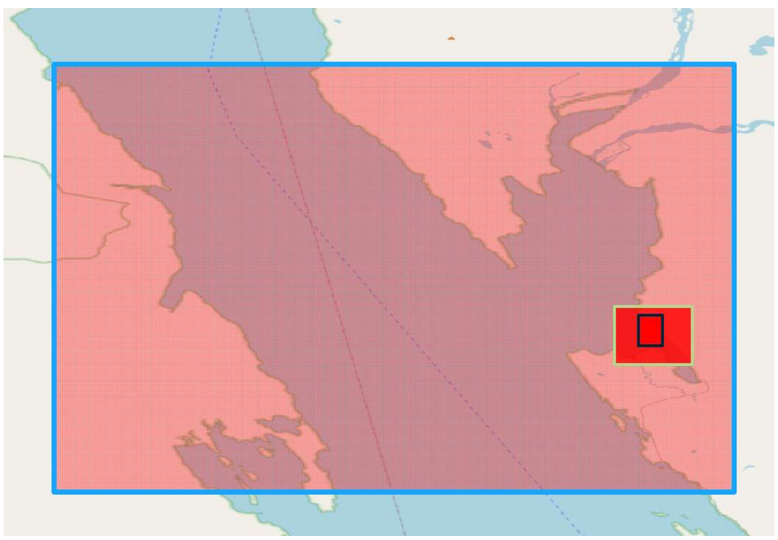

Figure 2 Three computational mesh regions, light blue: coarse, green: medium, and dark blue: fine.

Two models were developed, one based on the original project site, and a second with inclusion of a rock mound breakwater. The percent reduction was then defined as the reduction in significant wave height caused by the existence of the wave barrier. The wave barrier and rock mound were assumed to be completely impermeable in this analysis, without any height restrictions (no overtopping was allowed).

Significant wave heights were measured in 5 locations, defined by PND, the locations and coordinates of which are presented in Figure 3 and Table 2, respectively.

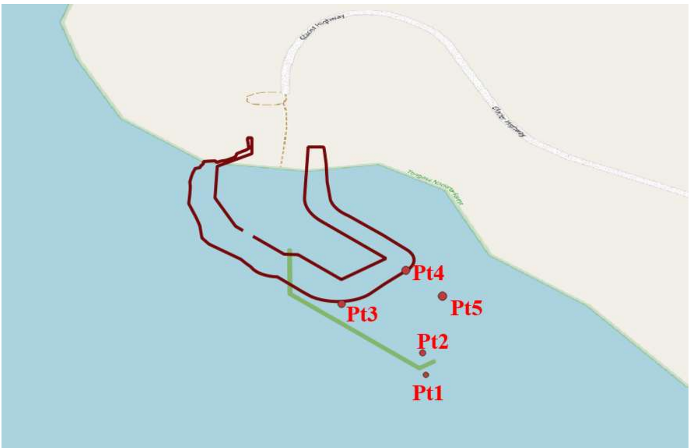

Figure 3 Locations of measuring points

Table 2 Measuring point coordinates

Measuring point	Latitude	Longitude	depth (m)
Pt1	58.6954263	-134.9379789	23.57
Pt2	58.6957467	-134.9380264	16.79
Pt3	58.6963875	-134.9391478	23.99
Pt4	58.6968503	-134.9382459	8.59
Pt5	58.6965061	-134.9377416	8.05

Results

The resulting significant wave heights were recorded at each of the 5 measuring points, with and without the presence of the wave barrier. An example of the significant wave heights resulting from the 50-year return period winds from the southwest is presented in Figure 4. Also, a detailed figure, showing the contours of significant wave heights inside the wave barrier, is presented in Figure 5. The resulting wave heights and percent reductions are presented in Table 3 to Table 6 for wind conditions from S, SW, W, and NW, respectively.

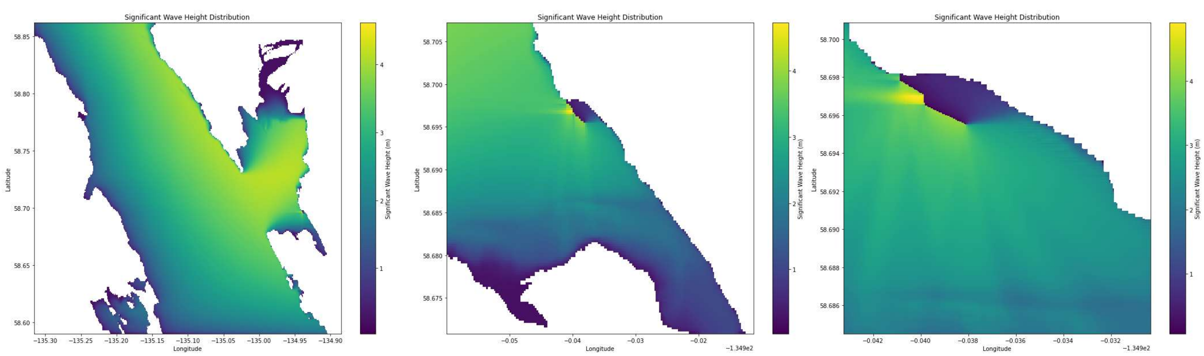

Figure 4 An example of three levels of SWAN results for 100 year return period SW wind condition with the breakwater.

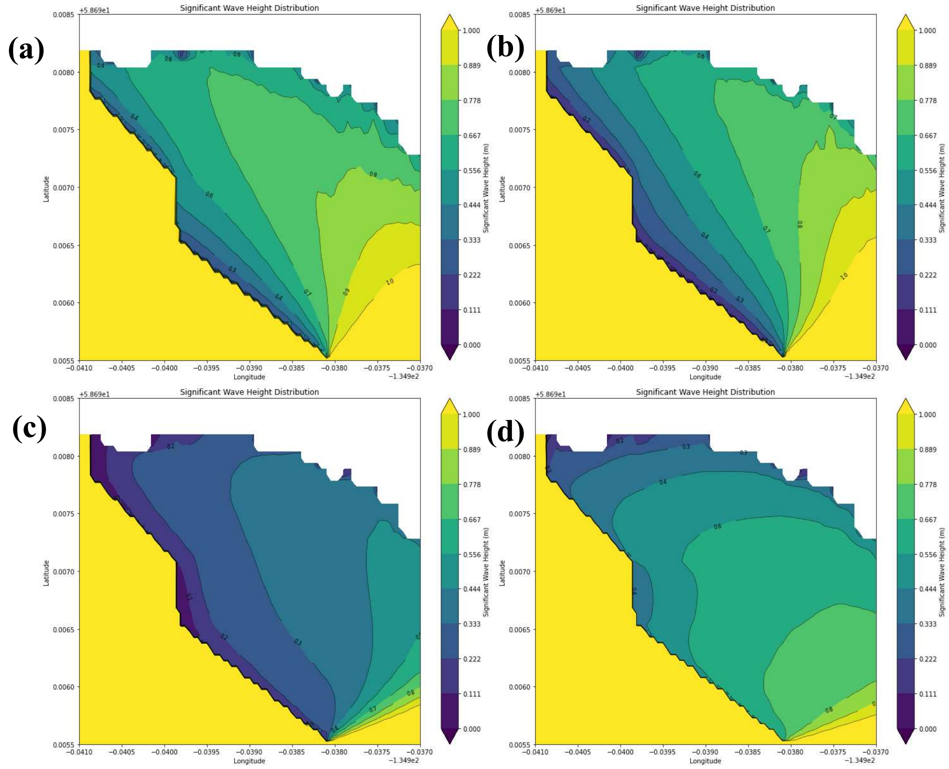

Figure 5 The significant wave height contours inside the wave barrier region for 100 year return period wind from (a) south, (b) southwest, (c) west, and (d) northwest.

Table 3 South wind condition

			No wave barrier		**With wave barrier**		**% Reduction**
Return Period (years)	Wind Speed (knots)	Measuring point	Hs (ft)	Tp (s)	Hs (ft)	Tp (s)	
25	54.6	Pt1	4.06	3.25	4.04	3.25	0.5%
		Pt2	4.08	3.30	2.50	3.10	38.7%
		Pt3	4.21	3.37	1.19	2.97	71.8%
		Pt4	4.10	3.39	2.21	3.16	46.1%
		Pt5	4.02	3.36	2.49	3.11	37.9%
50	57.9	Pt1	4.38	3.38	4.36	3.38	0.4%
		Pt2	4.40	3.40	2.68	3.20	39.0%
		Pt3	4.54	3.43	1.29	3.02	71.5%
		Pt4	4.40	3.43	2.37	3.30	46.1%
		Pt5	4.33	3.42	2.68	3.26	38.1%
100	61.2	Pt1	4.71	3.45	4.68	3.45	0.8%
		Pt2	4.73	3.47	2.89	3.33	39.0%
		Pt3	4.88	3.50	1.40	3.08	71.4%
		Pt4	4.71	3.51	2.53	3.35	46.2%
		Pt5	4.63	3.48	2.86	3.33	38.1%

Table 4 Southwest wind condition

			No wave barrier		With wave barrier		% Reduction
Return Period (years)	Wind Speed (knots)	Measuring point	Hs (ft)	Tp (s)	Hs (ft)	Tp (s)	
25	61.6	Pt1	7.61	5.44	7.75	5.44	-1.9%
		Pt2	7.53	5.43	1.77	2.92	76.5%
		Pt3	7.78	5.47	0.71	1.00	90.8%
		Pt4	7.21	5.48	1.71	2.79	76.4%
		Pt5	7.04	5.46	2.01	2.86	71.4%
50	69.2	Pt1	8.74	5.86	8.94	5.86	-2.3%
		Pt2	8.61	5.86	2.09	3.18	75.8%
		Pt3	8.92	5.89	0.88	1.10	90.1%
		Pt4	8.25	5.92	2.02	3.01	75.6%
		Pt5	8.04	5.91	2.36	3.09	70.6%
100	77	Pt1	9.89	6.12	10.11	6.11	-2.2%
		Pt2	9.73	6.12	2.40	3.30	75.3%
		Pt3	10.11	6.15	1.04	1.19	89.8%
		Pt4	9.36	6.25	2.33	3.09	75.1%
		Pt5	9.08	6.20	2.72	3.22	70.0%

Table 5 West wind condition

			No wave barrier		With wave barrier		% Reduction
Return Period (years)	Wind Speed (knots)	Measuring point	Hs (ft)	Tp (s)	Hs (ft)	Tp (s)	
25	49.2	Pt1	7.64	5.40	7.37	5.41	
		Pt2	7.42	5.38	0.74	1.23	90.1%
		Pt3	7.59	5.39	0.50	0.00	93.4%
		Pt4	6.47	5.34	0.86	1.33	86.7%
		Pt5	6.44	5.34	0.92	1.42	85.7%
50	56.8	Pt1	9.15	5.87	8.89	5.89	2.9%
		Pt2	8.81	5.85	0.91	1.34	89.7%
		Pt3	9.09	5.86	0.65	1.11	92.9%
		Pt4	7.62	5.79	1.05	1.46	86.2%
		Pt5	7.57	5.80	1.13	1.55	85.0%
100	64.3	Pt1	10.77	6.36	10.54	6.38	2.1%
		Pt2	10.29	6.33	1.10	1.45	89.3%
		Pt3	10.69	6.33	0.79	1.21	92.6%
		Pt4	8.85	6.18	1.27	1.58	85.7%
		Pt5	8.77	6.21	1.36	1.66	84.5%

Table 6 Northwest wind condition

Return Period (years)	Wind Speed (knots)	Measuring point	No wave barrier Hs (ft)	No wave barrier Tp (s)	With wave barrier Hs (ft)	With wave barrier Tp (s)	% Reduction
25	69	Pt1	9.71	6.57	9.01	6.61	7.2%
		Pt2	9.13	6.58	1.70	2.05	81.4%
		Pt3	9.40	6.55	1.37	1.77	85.4%
		Pt4	7.32	6.52	1.56	1.88	78.7%
		Pt5	7.58	6.60	1.66	1.97	78.0%
50	76.4	Pt1	10.85	6.96	10.26	7.00	5.4%
		Pt2	10.20	6.99	1.98	2.15	80.6%
		Pt3	10.48	6.92	1.60	1.90	84.8%
		Pt4	8.13	6.88	1.81	2.00	77.7%
		Pt5	8.42	7.00	1.94	2.09	77.0%
100	83.6	Pt1	11.93	7.36	11.61	7.41	2.7%
		Pt2	11.25	7.40	2.26	2.28	79.9%
		Pt3	11.53	7.32	1.85	2.06	84.0%
		Pt4	8.98	7.28	2.07	2.10	77.0%
		Pt5	9.28	7.40	2.22	2.25	76.1%

Concluding Remarks

A comprehensive analysis of the effectiveness of the proposed breakwater system at Cascade Point ferry terminal was performed and the reduction in significant wave height, at 5 different measuring points, was computed.

It was found that:

- Measuring point 1 is at the tip of the wave barrier, hence, there are minimal effects from the wave barrier at this point. One exception is for the winds from the southwest, which, due to reflections from the wave barrier, lead to larger significant wave heights with the wave barrier in place.
- The reduction percentages were found to be very consistent amongst different return periods.
- Table 7 presents the averaged reductions observed for each direction. The highest reduction was found to be for the winds from the west and the least was found to be for the conditions with wind from the south.

Table 7 Average percent reduction values for each direction

Direction (from)	Mean reduction percent
S	48.7%
SW	78.1%
W	88.5%
NW	80.0%