# Wake Monitoring Program – Period 1 - 2, Baseline Conditions

File: 12322164EN-RPT0051

April 1, 2025

Prepared for:
Woodfibre LNG General Partner Inc.
900 – 1185 West Georgia St
Vancouver, BC  V6E 4E6

Prepared by:
Stantec Consulting Ltd.
6080 Tennyson Parkway Suite 200
Plano TX  75024-6003

Project/File:
123222160

Stantec

# Limitations and Sign-off

The conclusions in the Report titled Woodfibre LNG Wake Monitoring Program are Stantec's professional opinion, as of the time of the Report, and concerning the scope described in the Report. The opinions in the document are based on conditions and information existing at the time the scope of work was conducted and do not take into account any subsequent changes. The Report relates solely to the specific project for which Stantec was retained and the stated purpose for which the Report was prepared. The Report is not to be used or relied on for any variation or extension of the project, or for any other project or purpose, and any unauthorized use or reliance is at the recipient's own risk.

Stantec has assumed all information received from Woodfibre LNG General Partner Inc. (the "Client") and third parties in the preparation of the Report to be correct. While Stantec has exercised a customary level of judgment or due diligence in the use of such information, Stantec assumes no responsibility for the consequences of any error or omission contained therein.

This Report is intended solely for use by the Client in accordance with Stantec's contract with the Client. While the Report may be provided by the Client to applicable authorities having jurisdiction and to other third parties in connection with the project, Stantec disclaims any legal duty based upon warranty, reliance or any other theory to any third party, and will not be liable to such third party for any damages or losses of any kind that may result.

Prepared by: Jimenez Martinez, Arturo — Digitally signed by Jimenez Martinez, Arturo Date: 2025.04.02 11:45:09 -05'00'

Signature

**Arturo Jimenez Martinez**, P.E.
Printed Name

Reviewed by: Nathan L Dill 2025.04.02 13:37:54 -04'00'

Signature

**Nathan Dill**, P.E.
Printed Name

Approved by: Adriana MacLeod — Digitally signed by Adriana MacLeod Date: 2025.04.01 17:27:12 -07'00'

Signature

**Adriana MacLeod**, B.Sc.
Printed Name

# Executive Summary

Woodfibre LNG General Partner Inc. (Woodfibre LNG) will construct and operate the Woodfibre Liquefied Natural Gas Project (the Project), located on the former Woodfibre Pulp Mille site in Átlḵ'a7tsem (Howe Sound), approximately seven kilometers (km) southwest of Skwxwú7mesh (Squamish), British Columbia (BC).

In 2015, during the environmental assessment process for the Project, Moffatt & Nichol conducted a desktop vessel wake assessment to estimate wake heights generated by Project vessels (including liquefied natural gas (LNG) carriers and escort tugs) in Átlḵ'a7tsem (Howe Sound). The assessment concluded that wakes from Project vessels are comparable to naturally occurring waves within Átlḵ'a7tsem (Howe Sound). However, safety concerns voiced by stakeholders resulted in Environmental Assessment Certificate (EAC) Condition 18 and Decision Statement (DS) Condition 7.2 which require the verification of the results of the vessel wake assessment by Moffatt & Nichol through the collection of wave data during Project pre-construction, construction, and the first two years of operations.

MarineLabs Data Systems Inc. (MarineLabs) has deployed two CoastScout wave buoys in the nearshore of the western shoreline of Átlḵ'a7tsem (Howe Sound) along the Project's primary shipping route (which includes but is not limited to the Certified Marine Route). The buoys are located near Kw'emkw'em (Defence Island) and Sts'its'a7kin (Foulger Creek). Table ES.1 presents the periods of wave and wind data available. The periods are defined by the time spanned between the retrieval of data from the wave buoys. MarineLabs uses a proprietary algorithm to identify wake events and determine wake heights from the wave buoy measurements.

*Table ES.1 Periods of wave and wind data available from wave buoys in Howe Sound*

| | **Kw'emkw'em (Defence Island)** | **Sts'its'a7kin (Foulger Creek)** |
|---|---|---|
| Period 1 | Nov. 25, 2022 – Jan. 1, 2024 | Jan. 28, 2023 – Jan. 1, 2024 |
| Period 2 | Nov. 23, 2023 – Nov. 23, 2024 | Nov. 23, 2023 – Nov. 23, 2024 |
| Total Record Length (Period 1 – 2) | Nov. 25, 2022 – Nov. 23, 2024 | Jan. 28, 2023 – Nov. 23, 2024 |

Stantec has analyzed the data collected by the wave buoys and the wake events identified by MarineLabs from Nov. 25, 2022, to Nov. 23, 2024. This period is herein referred to as Period 1 – 2. Period 1 – 2 captures the wake baseline conditions, as it covers pre-construction and construction periods. Wakes generated by Project operations vessels going to and from the Project Site (e.g., LNG carriers and escort tugs) are nonexistent in Period 1 – 2.

Table ES.2 summarizes the results of the wave and wake analysis. Differences between percentiles of significant wave height and maximum wake height are < 0.5 m. Percentiles of maximum wave height are similar to the corresponding percentiles of the maximum wake height with minimal differences of about 0.15 m or less between the two values. Therefore, the results indicate that baseline maximum wake heights are comparable to naturally occurring waves.

*Table ES.2 Summary of wave heights and wake heights by percentile (Period 1 – 2, Baseline Conditions)*

| Location | Parameter | Percentile | | | | | | Max. |
|---|---|---|---|---|---|---|---|---|
| | | **25th** | **50th** | **75th** | **90th** | **95th** | **99th** | |
| Kw'emkw'em (Defence Island) | Hs (m) | 0.06 | 0.12 | 0.23 | 0.32 | 0.38 | 0.61 | 0.99 |
| | $H_{max}$ (m) | 0.10 | 0.21 | 0.37 | 0.51 | 0.63 | 1.00 | 1.71 |
| | $H_{max\text{-}wake}$ (m) | 0.14 | 0.22 | 0.38 | 0.62 | 0.78 | 1.00 | 1.24 |
| Sts'its'a7kin (Foulger Creek) | Hs (m) | 0.03 | 0.06 | 0.11 | 0.16 | 0.20 | 0.38 | 1.06 |
| | $H_{max}$ (m) | 0.05 | 0.11 | 0.19 | 0.28 | 0.35 | 0.66 | 1.78 |
| | $H_{max\text{-}wake}$ (m) | 0.08 | 0.14 | 0.22 | 0.33 | 0.42 | 0.63 | 0.99 |

Notes:

Hs: significant wave height

$H_{max}$: Maximum wave height

$H_{max\text{-}wake}$: Maximum wake height

This analysis of wave and wake data for Period 1 – 2 is inconclusive regarding the verification of wakes analytically estimated during the environmental assessment process because the period of available measurements from the wave buoys is limited to baseline conditions (pre-construction and initial stages of construction) and does not include wakes generated by Project vessels. Continuation of wave data collection is essential to verifying the baseline conditions and formally completing the wake verification based on wave and wake data collected in the first two years of operations (e.g., when Project vessels are operational).

# Table of Contents



## List of Tables



## List of Figures



## List of Appendices

# Acronyms / Abbreviations

| | |
|---|---|
| AIS | Automatic Identification System |
| BC | British Columbia |
| BC EAO | British Columbia Environmental Assessment Office |
| CEAA | *Canadian Environmental Assessment Act* |
| CPA | Certified Project Area |
| EAC | Environmental Assessment Certificate |
| DS | Decision Statement |
| km | kilometer |
| LNG | liquefied natural gas |
| m | metre |
| MarineLabs | MarineLabs Data Systems Inc. |
| M&N | Moffatt & Nichol |
| The Plan | Construction Wake Verification Plan |
| The Project | Woodfibre Liquefied Natural Gas Project |
| Woodfibre LNG | Woodfibre LNG General Partner Inc. |

# 1 Introduction

Woodfibre LNG General Partner Inc. (Woodfibre LNG) will construct and operate the Woodfibre Liquefied Natural Gas Project (the Project), located on the former Woodfibre Pulp Mille site in Átlḵ'a7tsem (Howe Sound), approximately seven kilometers (km) southwest of Sḵwx̱wú7mesh (Squamish), British Columbia (BC). The Project will export liquefied natural gas (LNG) via tankers.

The Project underwent a comprehensive environmental assessment process from 2013 to 2015 and Woodfibre LNG received an Environmental Assessment Certificate (EAC; #E15 02) for the Certified Project Area (CPA) under the BC *Environmental Assessment Act* (; EAC #E15 02) in 2015; an environmental assessment approval from Sḵwx̱wú7mesh Úxwumixw (Squamish Nation) through the Squamish Nation Environmental Assessment Agreement in 2015; and a positive Decision Statement under *the Canadian Environmental Assessment Act*, 2012 in 2016. The Designated Project underwent changes after the EAC and Decision Statement were granted, resulting in three EAC amendments (issued by the BC Environmental Assessment Office (EAO) in 2017,2019 and 2023) and reissuance of the Decision Statement in 2018, 2023 and 2024. Additionally, the BC EAO granted an extension of the EAC #E15-02 to Woodfibre LNG in 2020.

During the environmental assessment process, potential safety considerations and effects from Project vessel wake generated by LNG carriers along the primary shipping route were discussed with Indigenous communities. Woodfibre LNG contracted Moffatt & Nichol (M&N) to undertake a desktop vessel wake assessment to assess wake heights generated from three scenarios of vessels passing through Átl'ḵa7tsem (Howe Sound) (M&N, 2015). Empirical data were requested by stakeholders to verify model results and to further address concerns of large wake interactions, resulting in EAC Condition 18 and Decision Statement Condition 7.2.

Condition 18 of the EAC states that:

> *The Holder must develop, in consultation with Pacific Pilotage Authority and Aboriginal Groups, a wake verification plan for Operations along the Certified Marine Route. The plan must at a minimum:*
>
> - *Identify monitoring areas within Howe Sound, at shorelines and in the waters of Howe Sound, and periods for monitoring wake;*
> - *Describe the methodology for the selection of the focus areas and periods, including how information from marine users and Aboriginal Groups informed their identification and selection;*
> - *Specify a methodology for monitoring the wake of the Holder's LNG carriers within the marine environment and at shorelines along the Certified Marine Route, particularly in relation to potential safety hazards to marine and shoreline users;*
> - *Specify a process for reporting the results of the wake verification plan;*

- *Include options for complaint reporting, recording, and responding to wake interactions between the Holder's LNG carriers and marine and shoreline users; and*
- *Specify an adaptive management plan to address the effects of Project wake on marine and shoreline users in the event (i) those effects on marine and shoreline users are not mitigated to the extent identified in the Application, or (ii) effects on marine and shoreline users occur that were not predicted in the Application.*

Condition 7.2 of the Decision Statement states that:

> *The Proponent shall, in consultation with Aboriginal groups, develop, prior to construction, and implement, during the construction and operation phases of the Designated Project, a follow-up program to verify the accuracy of the predictions made during the environmental assessment in relation to the effects of the wake generated by Designated Project-related vessels on the current use of lands and resources for traditional purposes and on physical and cultural heritage and structures, sites or things of historical, archaeological, paleontological or architectural significance. The follow-up program shall include:*
>
> - *7.2.1 monitoring during the construction period and the first two years of operation of the degree of wake generated by Designated Project-related vessels and of adverse environmental effects on harvesters caused by vessel wake attributable to Designated Project-related vessels at key harvest sites and during key harvest periods for Aboriginal groups and on physical and cultural heritage and structures, sites or things of historical, archaeological, paleontological or architectural significance located on or near the shoreline and identified in consultation with Aboriginal groups; and*
> - *7.2.2 providing the results of the follow-up program and details of any additional mitigation measures implemented as a result of the follow-up program to Aboriginal groups.*

Stantec Consulting Ltd. (Stantec) assisted Woodfibre LNG in addressing these conditions by preparing a Construction Wake Verification Plan (Stantec, 2023) describing the monitoring methods, monitoring locations, data analysis, and verification reporting for the assessment of wakes generated by Project vessels transiting the primary shipping route during the pre-construction and construction periods. Project vessels include construction vessels and operations vessels (LNG carriers and escort tugs). The primary shipping route includes, but is not limited to, the Certified Marine Route referenced in EAC Condition 18. An Operations Wake Verification Plan will be developed by Woodfibre LNG prior to commencement of operations for the same purpose.

Based on the information presented in the Construction Wake Verification Plan (Stantec 2023), Woodfibre LNG proceeded with the collection of wave data using wave buoys to quantify vessel wake heights at two nearshore locations in Átl̲k̲'a7tsem (Howe Sound): Kw'emkw'em (Defence Island) and Sts'its'a7kin (Foulger Creek). Additional information about the wave buoys is provided in Section 2.

This Wake Monitoring Program – Period 1 – 2, Baseline Conditions report (the report) presents the analysis of the data collected by the wave buoys from initial deployment on November 25, 2022 at Kw'emkw'em (Defence Island) and January 28, 2023 at Sts'its'a7kin (Foulger Creek) to November 23, 2024 (herein referred to as Period 1 – 2) and of the wakes identified by MarineLabs Data Systems Inc. (MarineLabs) during this period. Period 1 – 2 captures baseline conditions in terms of wakes, as it covers the Project pre-construction period and initial stages of the construction period. Wakes generated by Project operations vessels (e.g., LNG carriers and escort tugs) going to the Project are nonexistent in Period 1 – 2. The verification of Project vessel wakes estimated during the environmental assessment process by M&N will be formally conducted once data from the buoys covers the period of operations (anticipated to start in 2027).

# 2 Vessel Wakes

Variations in water pressure and velocity caused by a moving vessel result in primary and secondary wave systems radiating from the vessel.

Primary waves were not examined in the assessment completed by M&N and, therefore, are not included in this wake verification. At a nearshore observation point, primary waves are more pronounced in confined, narrow waterways used by deep draft vessels where the lateral constraint (the shoreline) and limited depth (dredged channel and vessel displacement) can result in large drawdown (Dempwolff et al., 2022). As these are not characteristics of the waterway of the primary shipping route for Project vessels in Átlḵ’a7tsem (Howe Sound), it is reasonable to qualify primary waves from Project vessels as negligible.

The secondary wave system is composed of the clearly visible, short period waves emitted by the vessel as it travels through water. The secondary waves system consists of transverse and diverging waves that interfere at a cusp line (Figure 1). These cusps are popularly referred to as wakes and are also the definition of wakes for the purposes of this report.

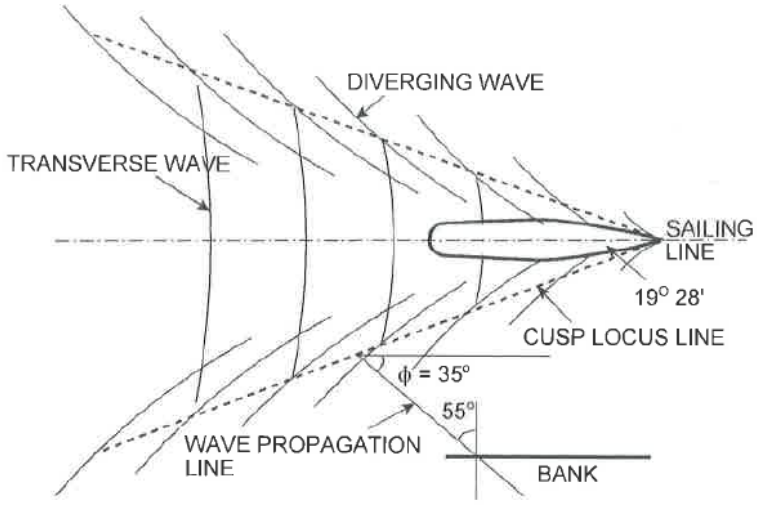


*Figure 1 Secondary wave system from a moving vessel (Schiereck, 2004)*

The main parameter governing the height of the wakes at the source is the speed of the vessel. As wake height decays with distance from the vessel, the wake height at a nearshore observation point depends on the sailing route of the vessel. For this reason, small vessels may generate greater wakes in the nearshore, compared to larger vessels, because they can travel at faster speeds and navigate in shallower water closer to the shore. This is an important consideration in the context of the wake verification, as Project vessels will be required to use the primary shipping route (see Figure 2) while non-Project vessels may not be limited in vessel speed and sailing route.

# 3 M&N Vessel Wake Assessment

In 2015, Woodfibre LNG contracted M&N to perform a desktop vessel wake assessment to evaluate wakes generated from passing Project vessels through Átl'ka7tsem (Howe Sound). The assessment evaluated the following three scenarios:

- LNG carrier accompanied by three escort tugs;
- LNG carrier with three escort tugs and a BC Ferry; and
- Largest worker ferry.

The findings of the assessment are as follows (verbatim from M&N, 2015):

1. Wakes from project vessels are found to be comparable to naturally occurring waves within Howe Sound.
2. Project related vessel traffic volumes will be small relative to existing traffic levels and project wakes will not appreciably increase the existing vessel wake environment.
3. Wakes from project vessels transiting to the Woodfibre site are projected to be smaller than the wakes generated by the existing BC Ferries because project vessels will transit at lower speeds and will travel as far removed from shore as practicable.
4. Wakes from vessels transiting to the Woodfibre site will be less than wakes generated by existing vessels transiting to Squamish Terminals, because project vessels will transit at substantially lower speed.
5. To the extent that the present study is accurate, it is not envisaged that wake waves would heighten exposure of the public, contribute to shoreline erosion, or have any appreciable effect on existing infrastructure within Howe Sound.
6. It is concluded that no additional wake mitigation measures are necessary for project related vessel traffic beyond those considered within this study.

This report primarily focuses on verifying Conclusion (1) of the M&N study, as this conclusion relates naturally occurring waves to Project vessel wakes, both of which can be quantified with the measurements from the deployed wave buoys.

# 4 Monitoring Methods

MarineLabs was contracted by Woodfibre LNG to provide, maintain, and deploy two wave buoys to record wave and wind data at Kw'emkw'em (Defence Island) and Sts'its'a7kin (Foulger Creek) in Átl'ka7tsem (Howe Sound). Figure 2 shows the wave buoy locations. Table 1 provides the properties of the wave buoys.

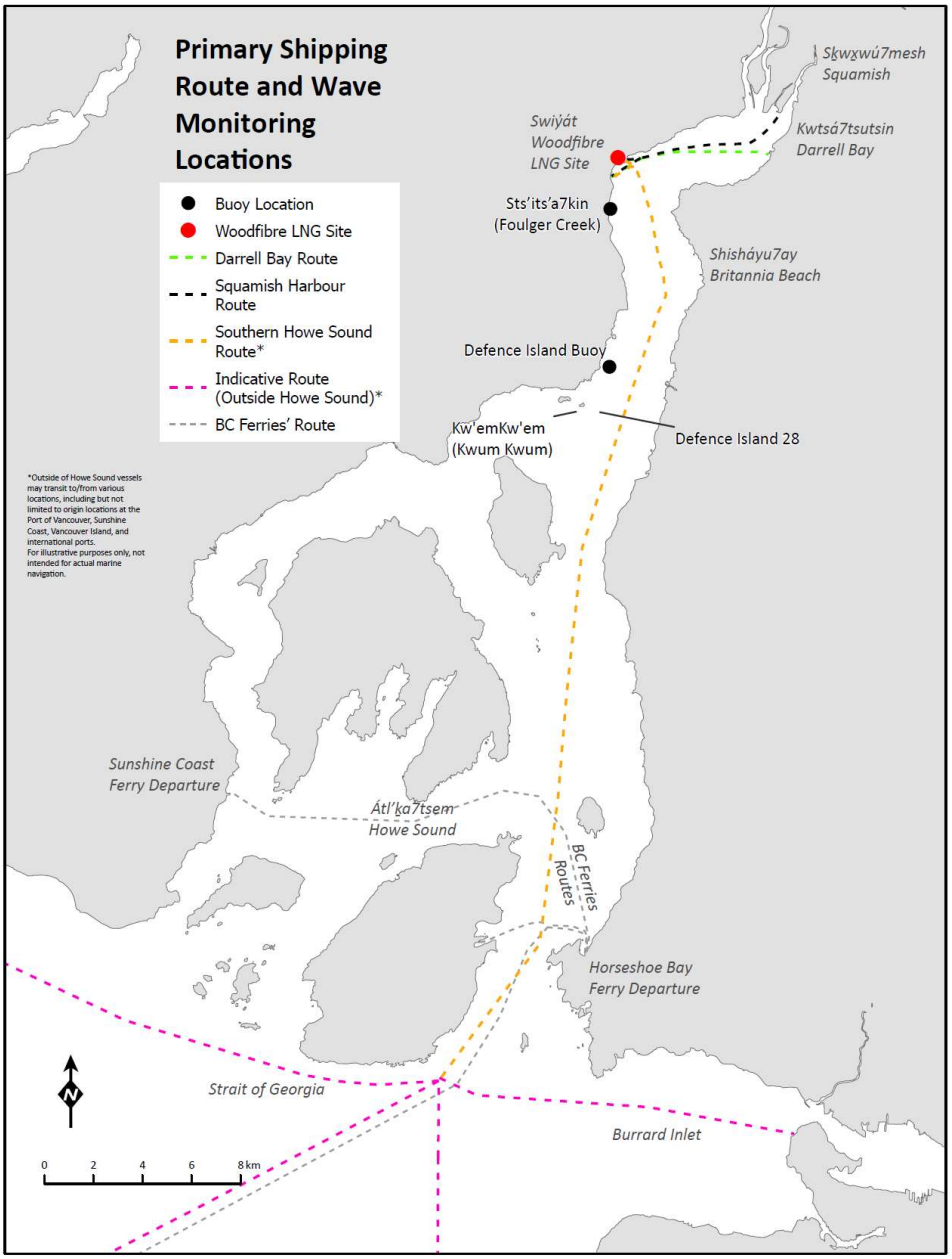


*Figure 2 Wave monitoring locations*

*Table 1 Wave buoy properties*

| Property | Kw'emkw'em (Defence Island) | Sts'its'a7kin (Foulger Creek) |
|---|---|---|
| Type | MarineLabs CoastScout | MarineLabs CoastScout |
| Location | 49.591˚N, 123.259˚W | 49.647˚N, 123.261˚W |
| Water Depth | 34 m | 31 m |
| Measurements | Waves<br>Winds<br>Air Temperature | Waves<br>Winds<br>Air Temperature |
| Sample Interval | 15 min | 15 min |
| Period 1 | Nov. 25, 2022 – Jan. 1, 2024 | Jan. 28, 2023 – Jan. 1, 2024 |
| Period 2 | Nov. 23, 2023 – Nov. 23, 2024 | Nov. 23, 2023 – Nov. 23, 2024 |
| Total Record Length (Period 1 – 2) | Nov. 25, 2022 – Nov. 23, 2024 | Jan. 28, 2023 – Nov. 23, 2024 |

The data collected by the wave buoys are processed by MarineLabs to generate two files: one with standard parameters describing the wave conditions measured by the buoy (which includes both naturally occurring waves and vessel wakes) and one with parameters describing the detected wake events (including vessel type and vessel speed). The method used by MarineLabs to identify wake events and determine wake heights is described in MarineLabs (2024a, 2024b).

# 5 Data Analysis

The basis of the wake verification is in the comparison of naturally occurring wave heights and Project vessel wake heights. Wave height is the height between the trough and crest of a wave, as illustrated in Figure 3. The same definition applies to the wake height.

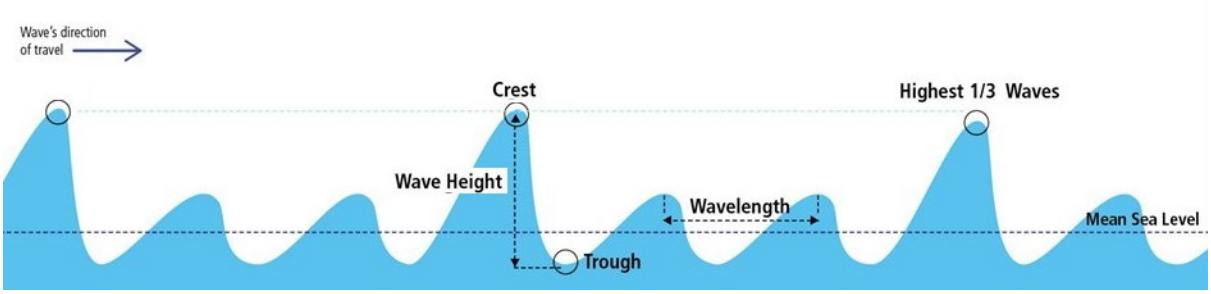


*Figure 3 Graphical wave height definition*

MarineLabs provides the following three height parameters:

- Significant wave height (Hs): the average of the highest one-third of wave heights in a record of random waves. In practice, the significant wave height correlates well with the wave height that a skilled observer, such as a mariner, would visually estimate at sea. This parameter is commonly used in marine weather forecasts and in marine/coastal engineering. As this parameter is computed from the total wave spectrum measured by the wave buoy, the significant wave height reported by MarineLabs includes both waves and wakes.
- Maximum wave height (Hmax): the maximum individual wave height in a record, computed from zero up-crossing and down-crossing analyses of the time series of the water surface elevation derived from the wave buoy measurements.
- Maximum wake height (Hmax-wake): The maximum wake height measured during a wake event, computed from zero up-crossing and down-crossing analyses of the time series of the water surface elevation from the wave buoy measurements.

The wake verification is based on two comparisons. The maximum wake height is compared to the significant wave height to provide an assessment that is relatable to an observer at sea. A wake height that is smaller than the significant wave height is essentially expected to be undistinguishable to the observer. The maximum wake height is compared to the maximum wave height to provide a direct, numerical comparison of maximum values.

## 5.1 Analysis of Wakes

A summary of the wake events and wake heights by vessel type identified at Kw'emkw'em (Defence Island) and Sts'its'a7kin (Foulger Creek) is presented in Table 2 and Table 3, respectively. The 'No AIS' vessel type is a vessel that could not be linked to a vessel in the Automatic Identification System (AIS). The vessel speed in these tables is the vessel speed associated with the maximum wake height. The maximum wake height during Period 1 – 2 is 1.24 m at Kw'emkw'em (Defence Island) and 0.99 m at Sts'its'a7kin (Foulger Creek).

*Table 2 Summary of wakes at Kw'emkw'em (Defence Island) (Period 1 – 2, Baseline Conditions)*

| Vessel Type | Number of Wake Events | % Total | Max. Wake Height (m) | Vessel Speed (knots) |
|---|---|---|---|---|
| Passenger | 967 | 22.39 | 1.24 | 15.3 |
| No AIS | 2979 | 68.97 | 1.23 | NA |
| Tug | 112 | 2.59 | 0.86 | 24.8 |
| Other | 96 | 2.22 | 0.79 | 16.6 |
| Special Craft | 11 | 0.25 | 0.72 | 18.1 |
| Unknown | 35 | 0.81 | 0.69 | 14.9 |
| General Cargo | 14 | 0.32 | 0.67 | 12.9 |
| Pleasure Craft | 25 | 0.58 | 0.62 | 28 |
| Cargo | 15 | 0.35 | 0.59 | 14.1 |
| Sailing | 6 | 0.14 | 0.47 | 9.6 |
| Anti Pollution | 4 | 0.09 | 0.47 | 19.1 |
| Military Ops | 2 | 0.05 | 0.46 | 11.7 |
| Dry Bulk | 10 | 0.23 | 0.44 | 13.9 |
| Search And Rescue | 8 | 0.19 | 0.41 | 20.8 |
| Unspecified | 14 | 0.32 | 0.37 | 26.7 |
| Search and Rescue | 19 | 0.44 | 0.28 | 40.4 |
| Reefer | 1 | 0.02 | 0.27 | 12.2 |
| Sailing Vessel | 1 | 0.02 | 0.07 | 5.9 |
| Project Vessels | 0 | 0 | N/A | N/A |
| Total | 4319 | 100 | - | - |

*Table 3 Summary of wakes at Sts'its'a7kin (Foulger Creek) (Period 1 – 2, Baseline Conditions)*

| Vessel Type | Number of Wake Events | % Total | Max. Wake Height (m) | Vessel Speed (knots) |
|---|---|---|---|---|
| No AIS | 3002 | 72.78 | 0.99 | NA |
| Passenger | 863 | 20.92 | 0.87 | 19.4 |
| Unknown | 57 | 1.38 | 0.59 | 12.2 |
| Other | 43 | 1.04 | 0.56 | 11.9 |
| Dry Bulk | 2 | 0.05 | 0.51 | 9.8 |
| Anti Pollution | 1 | 0.02 | 0.51 | 12.2 |
| Tug | 113 | 2.74 | 0.43 | 10.2 |
| Pleasure Craft | 12 | 0.29 | 0.35 | 13.3 |
| Unspecified | 12 | 0.29 | 0.34 | 17.7 |
| Dive Vessel | 1 | 0.02 | 0.31 | 27.6 |
| Special Craft | 2 | 0.05 | 0.28 | 19 |
| General Cargo | 5 | 0.12 | 0.19 | 11.7 |
| Search And Rescue | 12 | 0.20 | 0.16 | 18.1 |
| Project Vessels | 0 | 0 | N/A | N/A |
| Total | 4125 | 100 | - | - |

Table 4 presents percentiles of the maximum wake height at the two locations calculated from the total record of maximum wake heights. The percentiles provide insight into the frequency of maximum wake heights during the period of measurements. For example, the 90$^{th}$ percentile is the maximum wake height that was exceeded 10% of the time. Table 5 presents the percentile corresponding to maximum wake heights of 0.25 m, 0.5 m, 0.75 m, and 1.0 m, as applicable at each location.

*Table 4 Maximum wake height percentiles (Period 1 – 2, Baseline Conditions)*

| Location | Maximum wake height (m) | | | | | | Max |
|---|---|---|---|---|---|---|---|
| | 25$^{th}$ | 50$^{th}$ | 75$^{th}$ | 90$^{th}$ | 95$^{th}$ | 99$^{th}$ | |
| Kw'emkw'em (Defence Island) | 0.14 | 0.21 | 0.37 | 0.61 | 0.75 | 1.00 | 1.24 |
| Sts'its'a7kin (Foulger Creek) | 0.08 | 0.14 | 0.22 | 0.33 | 0.43 | 0.63 | 0.99 |

*Table 5 Percentile of selected maximum wake heights (Period 1 – 2, Baseline Conditions)*

| Location | Percentile | | | |
|---|---|---|---|---|
| | **0.25 m** | **0.5 m** | **0.75 m** | **1.0 m** |
| Kw'emkw'em (Defence Island) | 57.8$^{th}$ | 84.5$^{th}$ | 94.9$^{th}$ | 99$^{th}$ |
| Sts'its'a7kin (Foulger Creek) | 80.3$^{th}$ | 96.8$^{th}$ | 99.3$^{th}$ | out of range |

## 5.2 Analysis of Waves

Products of the analysis are provided in Appendix A for Kw'emkw'em (Defence Island) and Appendix B for Sts'its'a7kin (Foulger Creek). These include time series, wind and wave roses, and scatter plots. The following is a summary of the wave conditions at each location.

**Defence Island.** Wave conditions are characterized by significant wave heights generally less than 0.5 m (97.7$^{th}$ percentile) with peak wave periods generally below 6 seconds, approaching primarily from the NNE – NE sector in the fall and winter and from the S – SSW sector in the spring and summer. Wave conditions at Defence Island are highly influenced by local wind conditions, based on the following observations:

- The prevailing wave directions are consistent with the prevailing wind directions. Prevailing winds are from the NNE – NE in the fall and winter and from the S – SSW in the spring and summer.
- There is a clear correlation between wind speed and wave height in which wave heights increase with increasing wind speed when the fetch is towards the location of the buoy. The highest wave heights occur from the NNE – N during the winter and can be correlated to periods of high wind speeds from the same sector.

Statistics of the significant and maximum wave height are presented in Table 6 and Table 7.
The maximum significant wave height of 0.99 m occurred on December 26, 2022. The maximum value of the maximum wave height is 1.71 m and occurred on December 23, 2022. Wakes were not identified during these dates, indicating that the wave heights were generated by natural (wind-driven) processes.

**Foulger Creek.** Wave conditions are characterized by significant wave heights generally less than 0.25 m (97.3$^{th}$ percentile) with peak wave periods below 5 seconds, approaching primarily from the NE – SE sector. Wave conditions at Sts'its'a7kin (Foulger Creek) are weakly correlated to local wind conditions. Prevailing winds are from the WSW – SW sector year-round, which support wave growth and propagation towards the opposite, eastern shoreline of Átlḵ'a7tsem (Howe Sound). Sts'its'a7kin (Foulger Creek) is less vulnerable than Kw'emkw'em (Defence Island) from wind-generated waves due to the prevailing wind directionality and lower wind speeds overall.

Statistics of the significant and maximum wave height are presented in Table 6 and Table 7. The maximum values of significant wave height and maximum wave height of 1.06 m and 1.78 m, respectively, occurred on Feb 23, 2023. Wakes were not identified on that day, indicating that the wave heights were generated by natural (wind-driven) processes.

*Table 6 Wave heights by percentile (Period 1 – 2, Baseline Conditions)*

| Location | Parameter | Percentile | | | | | | Max. |
|---|---|---|---|---|---|---|---|---|
| | | **25th** | **50th** | **75th** | **90th** | **95th** | **99th** | |
| Kw'emkw'em (Defence Island) | Hs (m) | 0.06 | 0.12 | 0.23 | 0.32 | 0.38 | 0.61 | 0.99 |
| | $H_{max}$ (m) | 0.10 | 0.21 | 0.37 | 0.51 | 0.63 | 1.00 | 1.71 |
| Sts'its'a7kin (Foulger Creek) | Hs (m) | 0.03 | 0.06 | 0.11 | 0.16 | 0.20 | 0.38 | 1.06 |
| | $H_{max}$ (m) | 0.05 | 0.11 | 0.19 | 0.28 | 0.35 | 0.66 | 1.78 |

*Table 7 Percentile of selected wave heights (Period 1 – 2, Baseline Conditions)*

| Location | Parameter | Wave Height | | | |
|---|---|---|---|---|---|
| | | **0.25 m** | **0.5 m** | **0.75 m** | **1.0 m** |
| Kw'emkw'em (Defence Island) | Hs | 79.6th | 97.7th | 99.4th | out of range |
| | $H_{max}$ | 57.5th | 88.9th | 97th | 99th |
| Sts'its'a7kin (Foulger Creek) | Hs | 97.3th | 99.2th | 99.5th | 99.9th |
| | $H_{max}$ | 86.2th | 98.1th | 99.1th | 99.3th |

## 5.3 Discussion

A summary of the wave heights and wake heights at each location is presented in Table 8 in terms of percentiles and maximum value. Differences between percentiles of significant wave height and maximum wake height are < 0.5 m. Percentiles of maximum wave height are similar to the corresponding percentiles of the maximum wake height with minimal differences of about 0.1 m or less between the two values. Therefore, the results indicate that baseline maximum wake heights are comparable to naturally occurring (wind-driven) waves. This conclusion is true for the vessels that generated wakes that were detectable by MarineLabs algorithm. Project vessels were not identified in Period 1 – 2.

*Table 8 Summary of wave heights and wake heights by percentile (Period 1 – 2, Baseline Conditions)*

| Location | Parameter | Percentile | | | | | | Max. |
|---|---|---|---|---|---|---|---|---|
| | | **25th** | **50th** | **75th** | **90th** | **95th** | **99th** | |
| Kw'emkw'em (Defence Island) | Hs (m) | 0.06 | 0.12 | 0.23 | 0.32 | 0.38 | 0.61 | 0.99 |
| | $H_{max}$ (m) | 0.10 | 0.21 | 0.37 | 0.51 | 0.63 | 1.00 | 1.71 |
| | $H_{max\text{-}wake}$ (m) | 0.14 | 0.21 | 0.37 | 0.61 | 0.75 | 1.00 | 1.24 |
| Sts'its'a7kin (Foulger Creek) | Hs (m) | 0.03 | 0.06 | 0.11 | 0.16 | 0.20 | 0.38 | 1.06 |
| | $H_{max}$ (m) | 0.05 | 0.11 | 0.19 | 0.28 | 0.35 | 0.66 | 1.78 |
| | $H_{max\text{-}wake}$ (m) | 0.08 | 0.14 | 0.22 | 0.33 | 0.43 | 0.63 | 0.99 |

# 6 Conclusions

This analysis of wave and wake data for Period 1 – 2 indicates that baseline maximum wake heights are comparable to naturally occurring (wind-driven) waves. This conclusion does not satisfy the verification of wakes analytically estimated by M&N (2015) because the period of available measurements from the wave buoys is limited to baseline conditions (pre-construction and initial stages of construction) and does not include wakes generated by Project operations vessels (e.g., LNG carriers, escort tugs). Continuation of wave data collection is essential to verifying the baseline conditions and formally conduct the wake verification based on wave and wake data collected in the first two years of operations (e.g., when Project vessels are operational).

# 7 References

Dempwolff, L.C., Melling, G., Windt, C., Lojek, O., Martin, T., Holzwarth, I., Bihs, H., and Goseberg, N. (2022). “Loads and effects of ship-generated, drawdown waves in confined waterways - A review of current knowledge and methods.”

MarineLabs (2023a). “Vessel Wake Insights Report from CoastScout Buoy Defence Island.”

MarineLabs (2023b). “Vessel Wake Insights Report from CoastScout Buoy Foulger Creek.”

MarineLabs (2024a). “Vessel Wake Insights Report from CoastScout Buoy Defence Island.”

MarineLabs (2024b). “Vessel Wake Insights Report from CoastScout Buoy Foulger Creek.”

Moffatt & Nichol (2015). “Vessel Wake Assessment.” Prepared for Woodfibre LNG.

Schiereck, G.J. (2004). “Introduction to Bed, Bank, and Shore Protection.”

Stantec (2023). “Construction Wake Verification Plan.” WLNG-W0001-CM-PLN-0018 Rev 1. Prepared for Woodfibre LNG.

Stantec (2024). “Wake Monitoring Program – Period 1, Baseline Conditions.” 12322164EN-RPT0051. Prepared for Woodfibre LNG.

# Appendices

# Appendix A Kw’emkw’em (Defence Island) Figures Baseline Conditions Period 1 – 2: Nov 25, 2022 – Nov 23, 2024

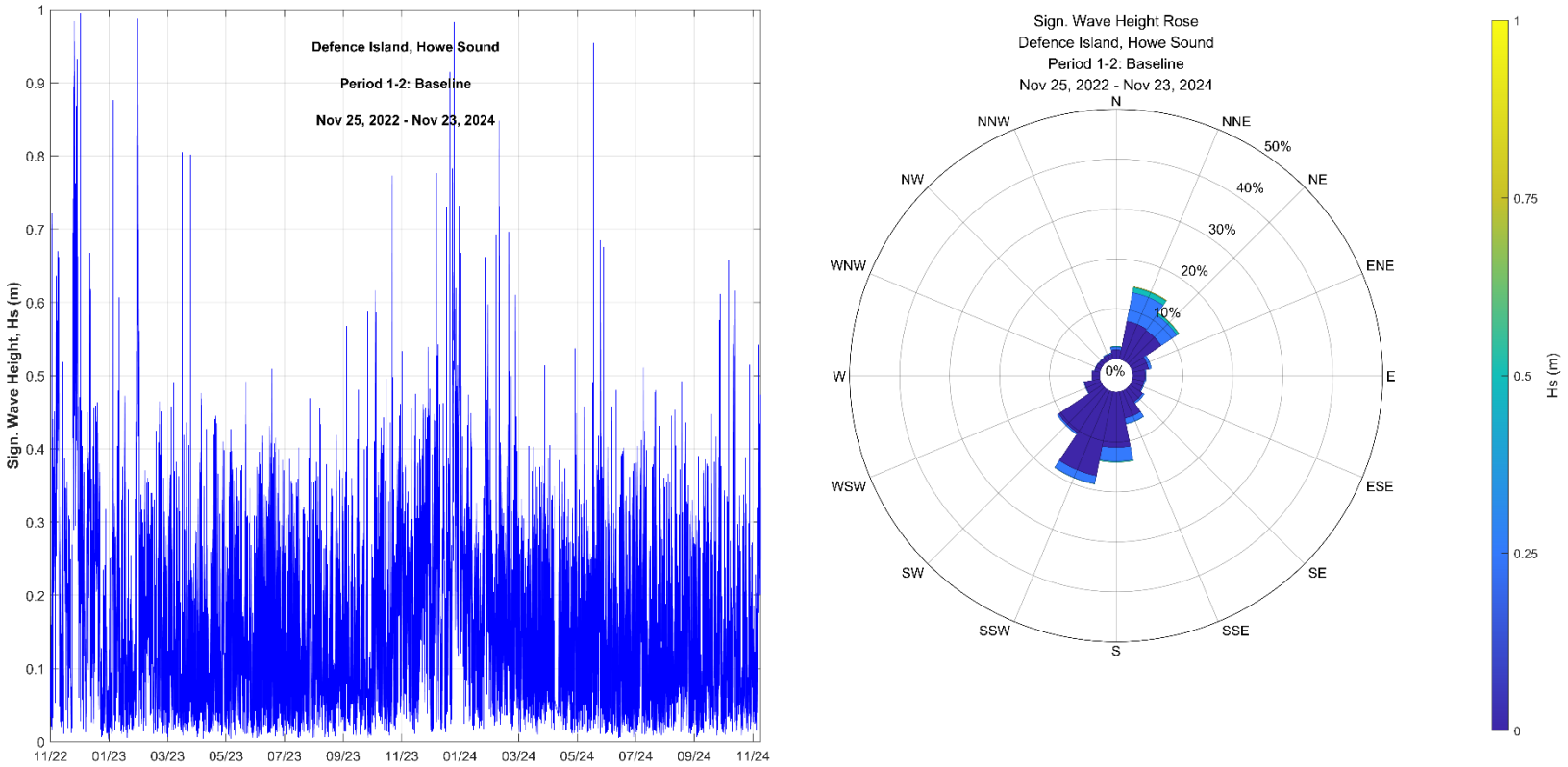


*Figure A.1* *Time series of significant wave height (left) and significant wave height rose (right), Kw'emkw'em (Defence Island), Period 1 – 2, Baseline Conditions*

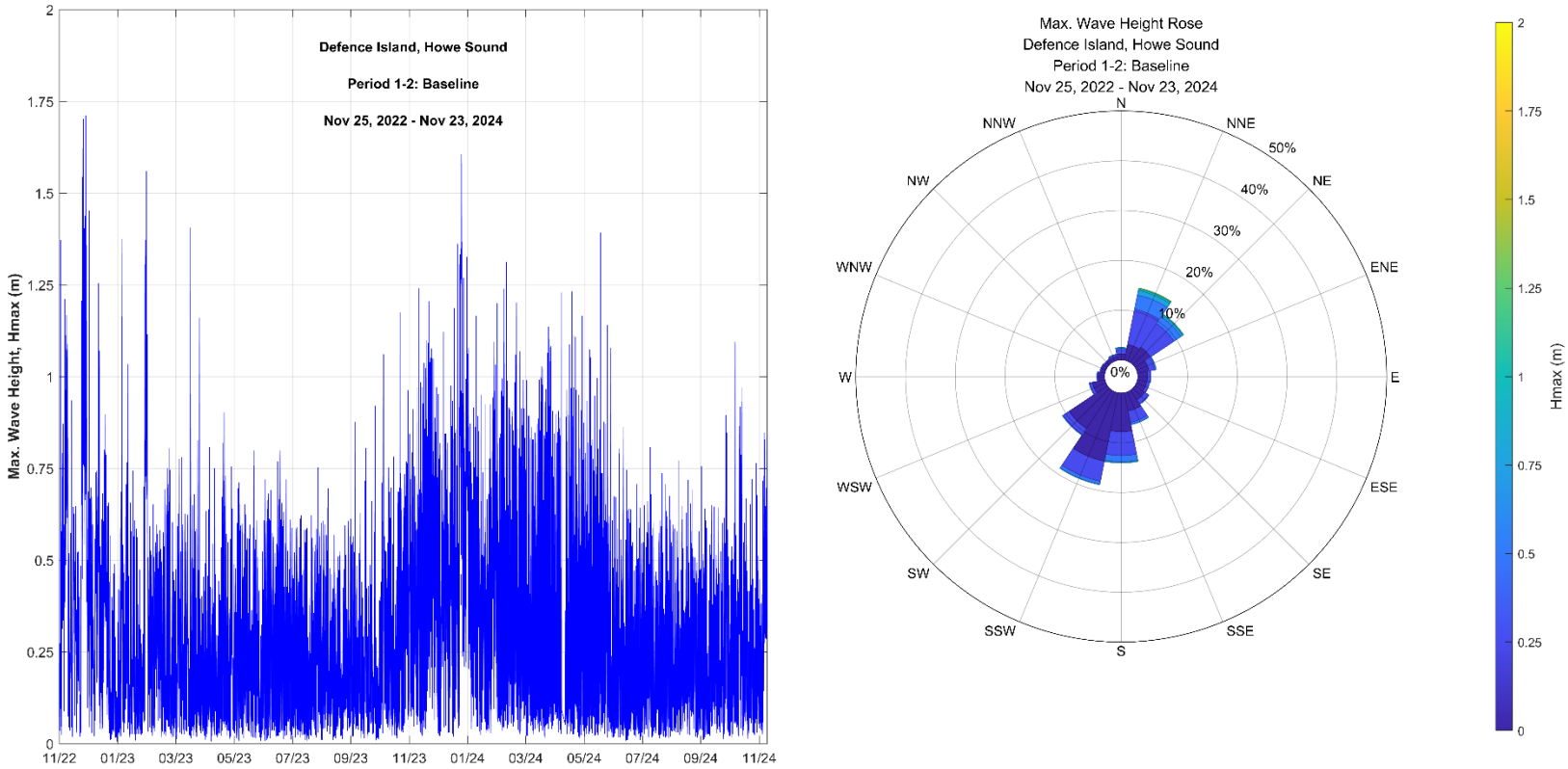


*Figure A.2 Time series of maximum wave height (left) and maximum wave height rose (right), Kw'emkw'em (Defence Island), Period 1 – 2, Baseline Conditions*

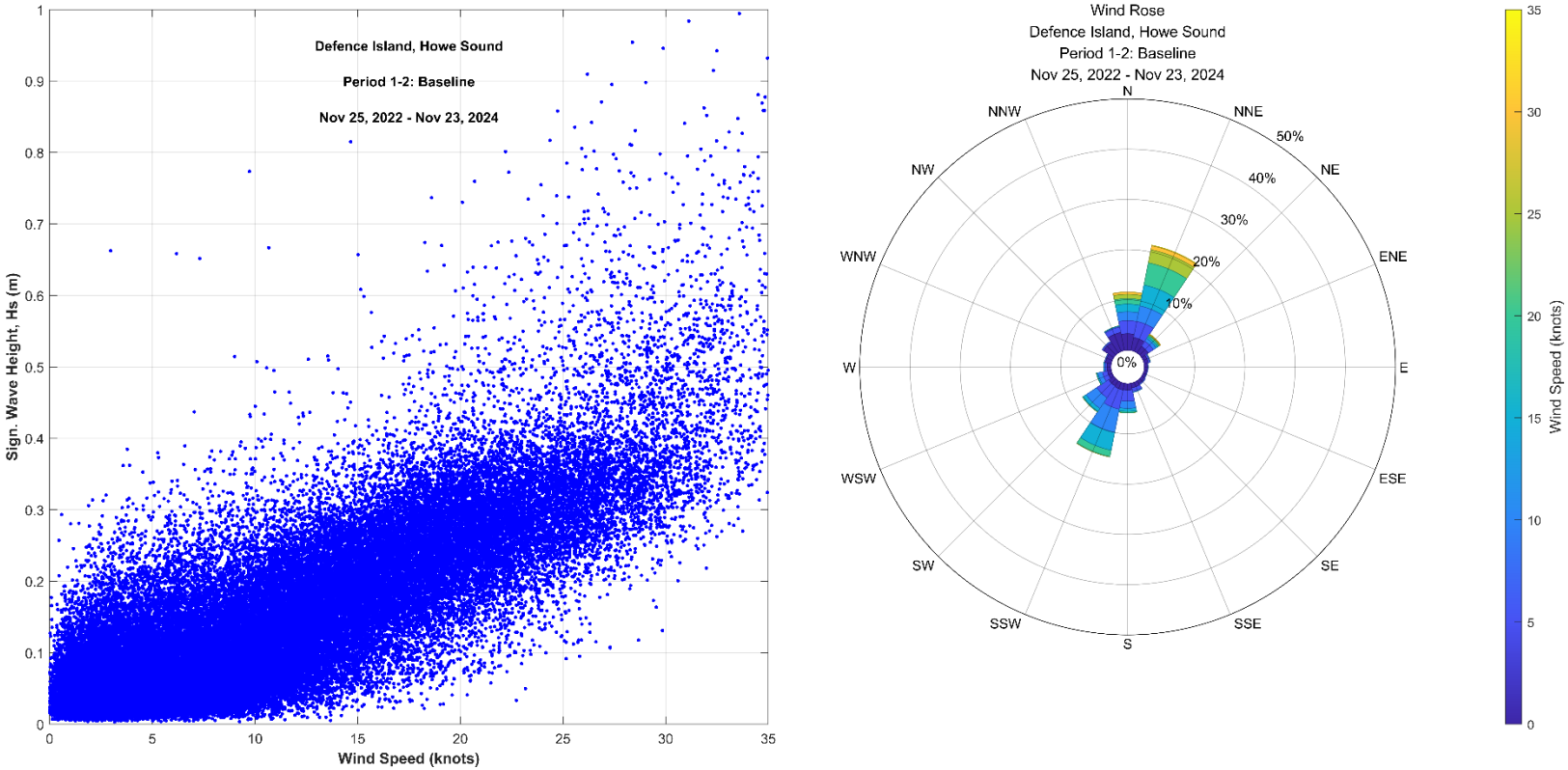


*Figure A.3* *Scatter of wind speed and significant wave height (left) and wind rose (right), Kw'emkw'em (Defence Island), Period 1 – 2, Baseline Conditions*

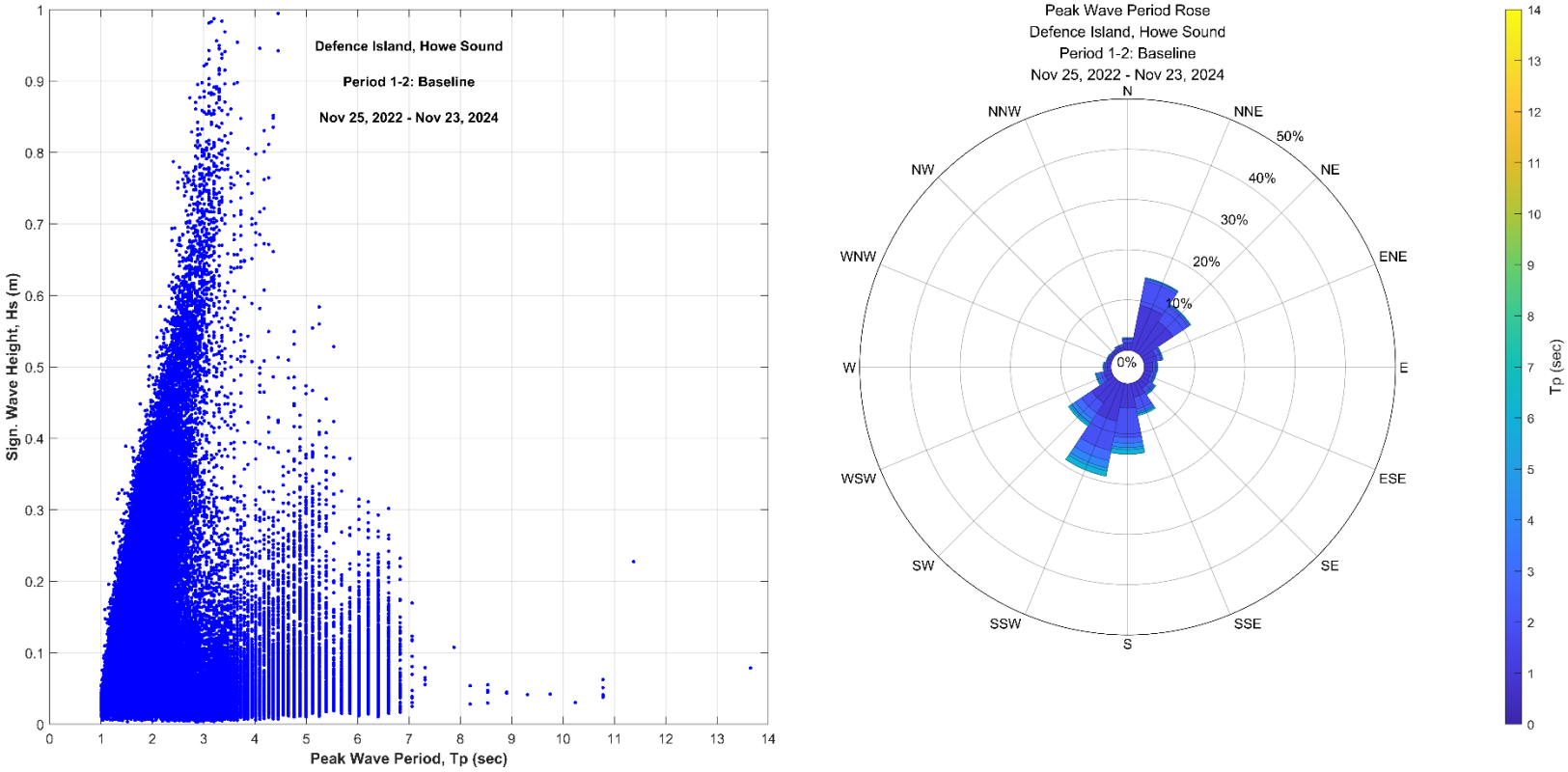


*Figure A.4* *Scatter of peak period and significant wave height (left) and peak period rose (right), Kw'emkw'em (Defence Island), Period 1 – 2, Baseline Conditions*

# Appendix B Sts'its'a7kin (Foulger Creek) Figures Baseline Conditions Period 1 – 2: Jan 28, 2023 – Nov 23, 2024

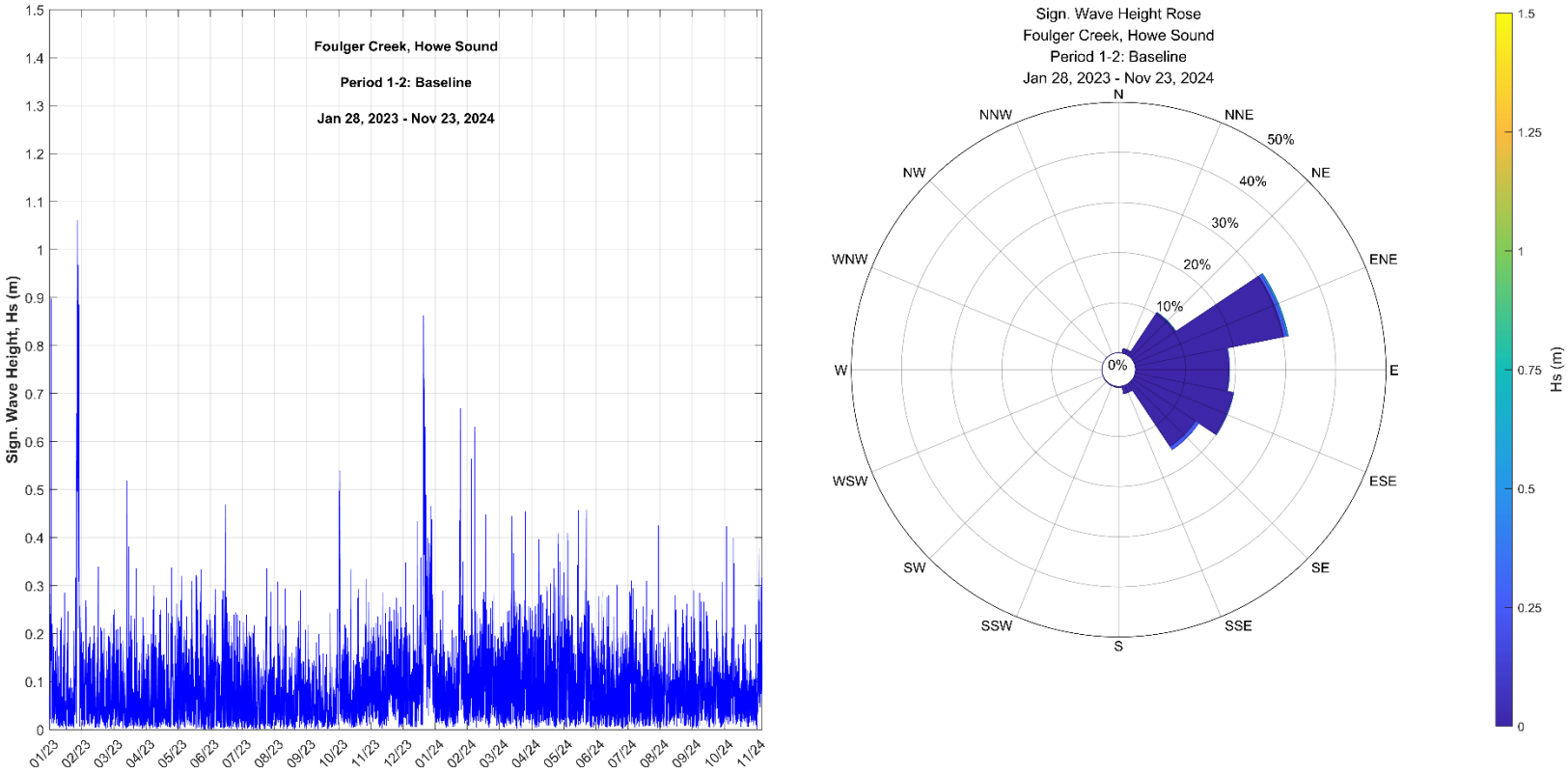


*Figure B.1* *Time series of significant wave height (left) and significant wave height rose (right), Sts'its'a7kin (Foulger Creek), Period 1 – 2, Baseline Conditions*

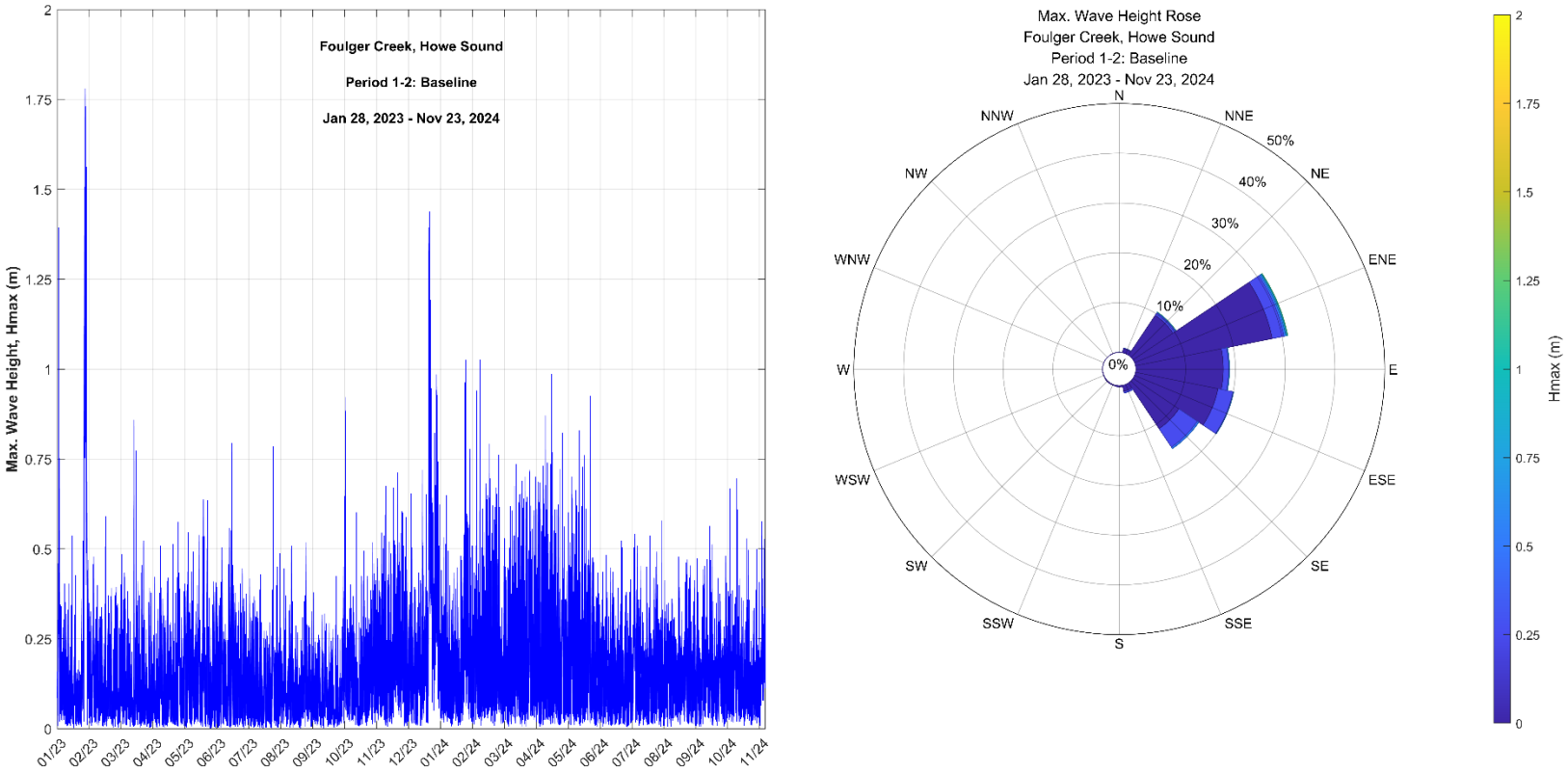


*Figure B.2 Time series of maximum wave height (left) and maximum wave height rose (right), Sts'its'a7kin (Foulger Creek), Period 1 – 2, Baseline Conditions*

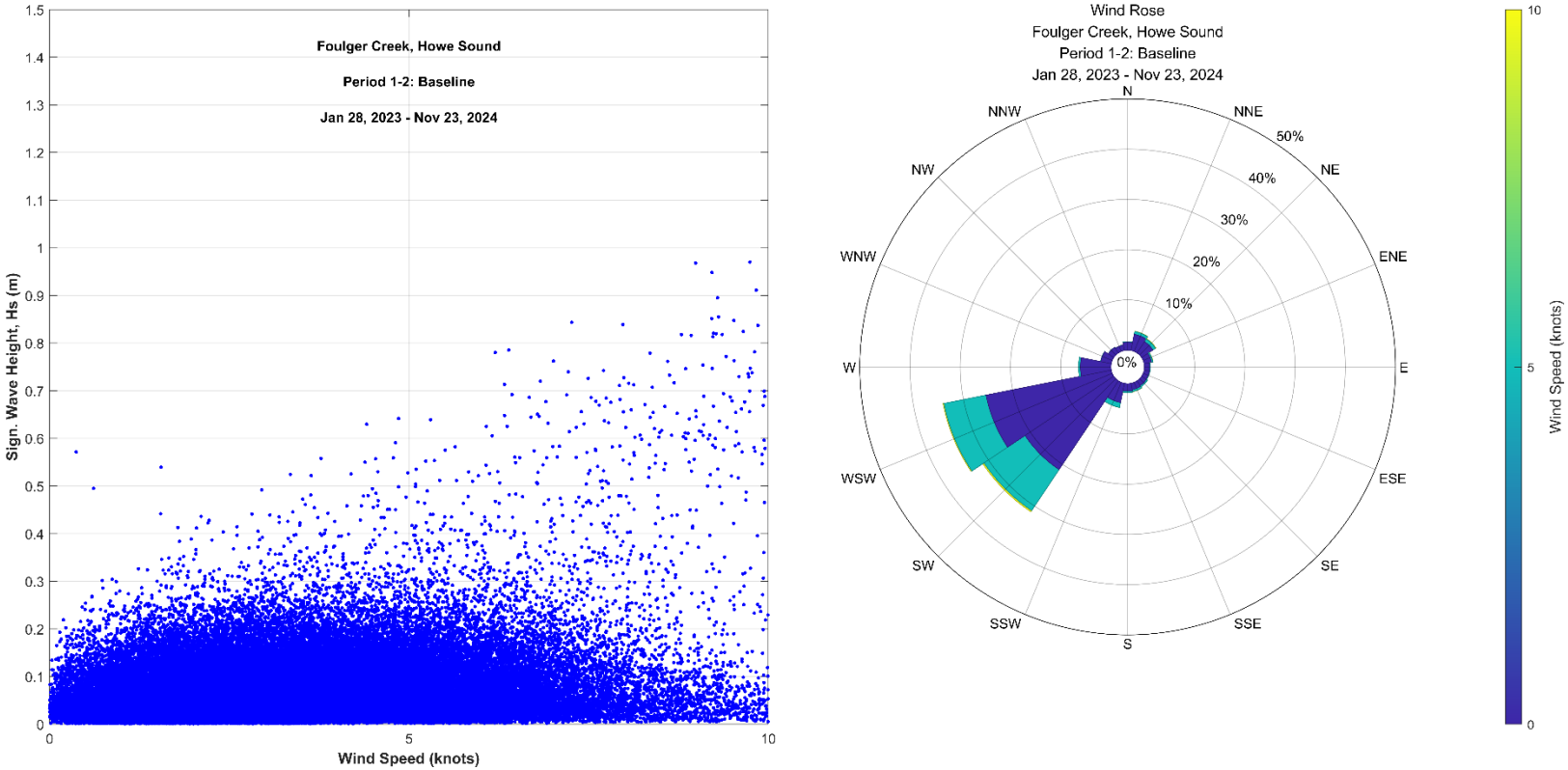


*Figure B.3* *Scatter of wind speed and significant wave height (left) and wind rose (right), Sts'its'a7kin (Foulger Creek), Period 1 – 2, Baseline Conditions*

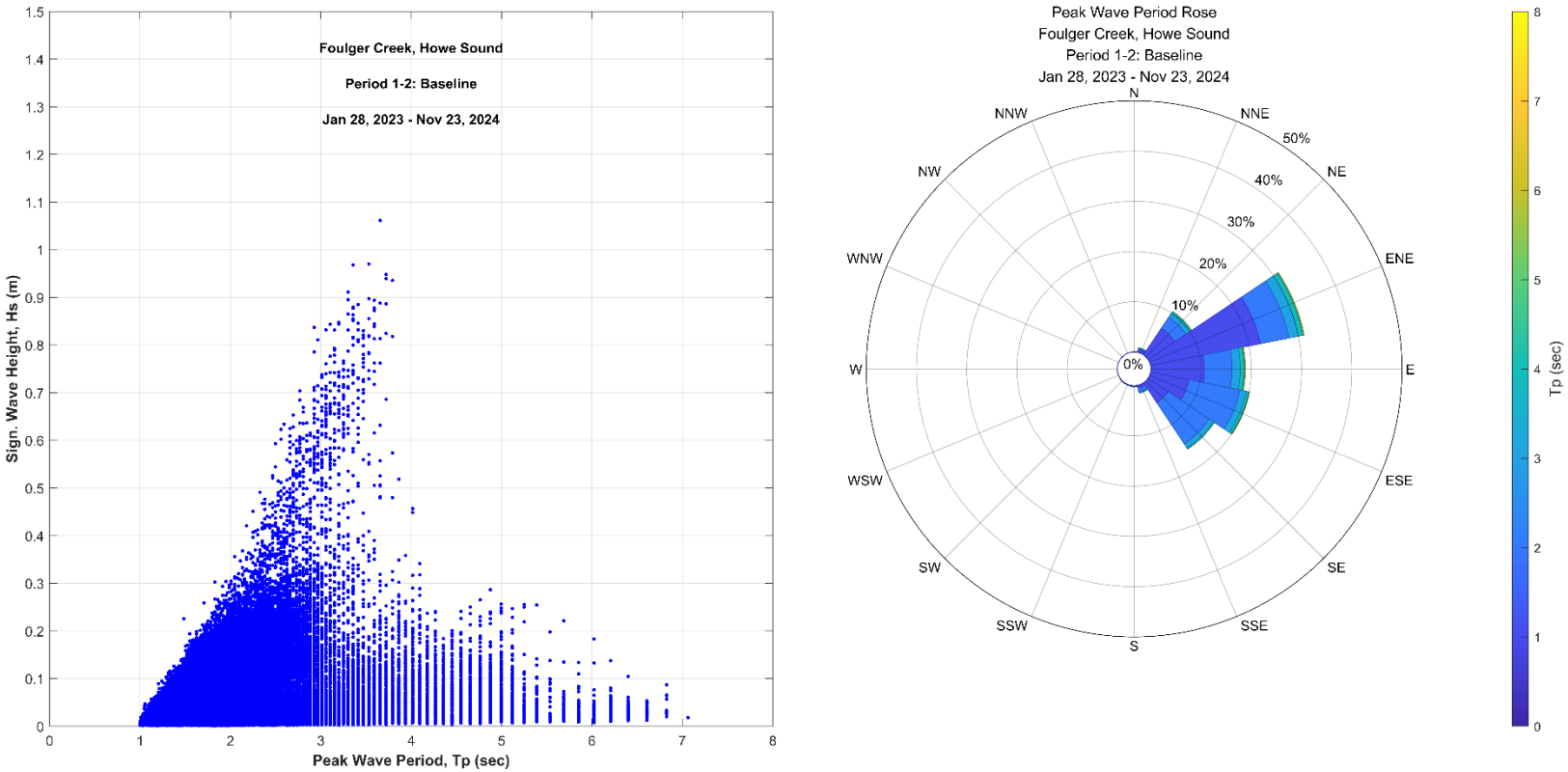


*Figure B.4* *Scatter of peak period and significant wave height (left) and peak period rose (right), Sts'its'a7kin (Foulger Creek), Period 1 – 2, Baseline Conditions*