Acoustic Monitoring Plan

Turnagain Marine Construction
Whittier Head of the Bay Cruise Ship Terminal
Passage Canal, Whittier, Alaska
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INTRODUCTION

This document presents an Acoustic Monitoring Plan for the proposed Whittier Head of the Bay Cruise Ship Dock in Whittier, Alaska (Figure 1).   Turnagain Marine Construction will install foundation piles for the new dock and will use a Down-The-Hole hammer during installation of some foundation piles.

The draft IHA (WhittierTMCConstruction_2023IHA_Issued_OPR1.pdf) calls for monitoring and reporting underwater sound levels during use of a Down-The-Hole hammer to drill rock sockets for one 36"OD pile and one 48"OD pile selected from different locations. We understand that subsequent discussions indicate such monitoring should occur for piles installed where the water depth exceeds 60 ft. A required report is to include post-processing results which quantify sound levels and aspects of the sound's character together with certain relevant field and measurement details. In response to these requirement details of the planned acoustic monitoring are presented herein.

PROJECT DESCRIPTION

Turnagain Marine Construction (TMC), under contract with Huna Totem Corporation, will construct a cruise ship berth on the western shore of Passage Canal, approximately 1.2 kilometers (km) northwest of downtown Whittier, Alaska. The cruise ship berth would include a trestle, a floating dock, and mooring dolphins, all of which will be supported by piles. Figure 2 depicts the general layout of the structures, the piles and the water depth. Open end piles of 36" diameter will support the outboard end of the trestle and 48" diameter piles will restrain the floating dock and the mooring dolphins. Piles will be installed to various depths above rock using vibratory or impact hammers, and also advanced into rock by means of a Down-The-Hole (DTH) hammer.

SCOPE, AND OBJECTIVES

The draft IHA calls for underwater acoustic monitoring during DTH drilling for one 36" OD pile and one 48" OD pile, each from different locations. Such monitoring will involve field measurements for all DTH operation on each pile, post-processing of measurements, and reporting. Sound metrics to be reported include those commonly applied to vibratory hammers and also those applied to impact hammers. Additional customary report elements are required to further characterize the sounds and the measurement conditions.

The objective of the monitoring is taken to be characterization of the sound levels from the monitored combinations of hammers and piles and evaluation of an effective Transmission Loss Coefficient for prevailing circumstances.

Figure 1. General location of the proposed Whittier Head of the Bay Cruise Ship Terminal Passage Canal, Whittier, Alaska.

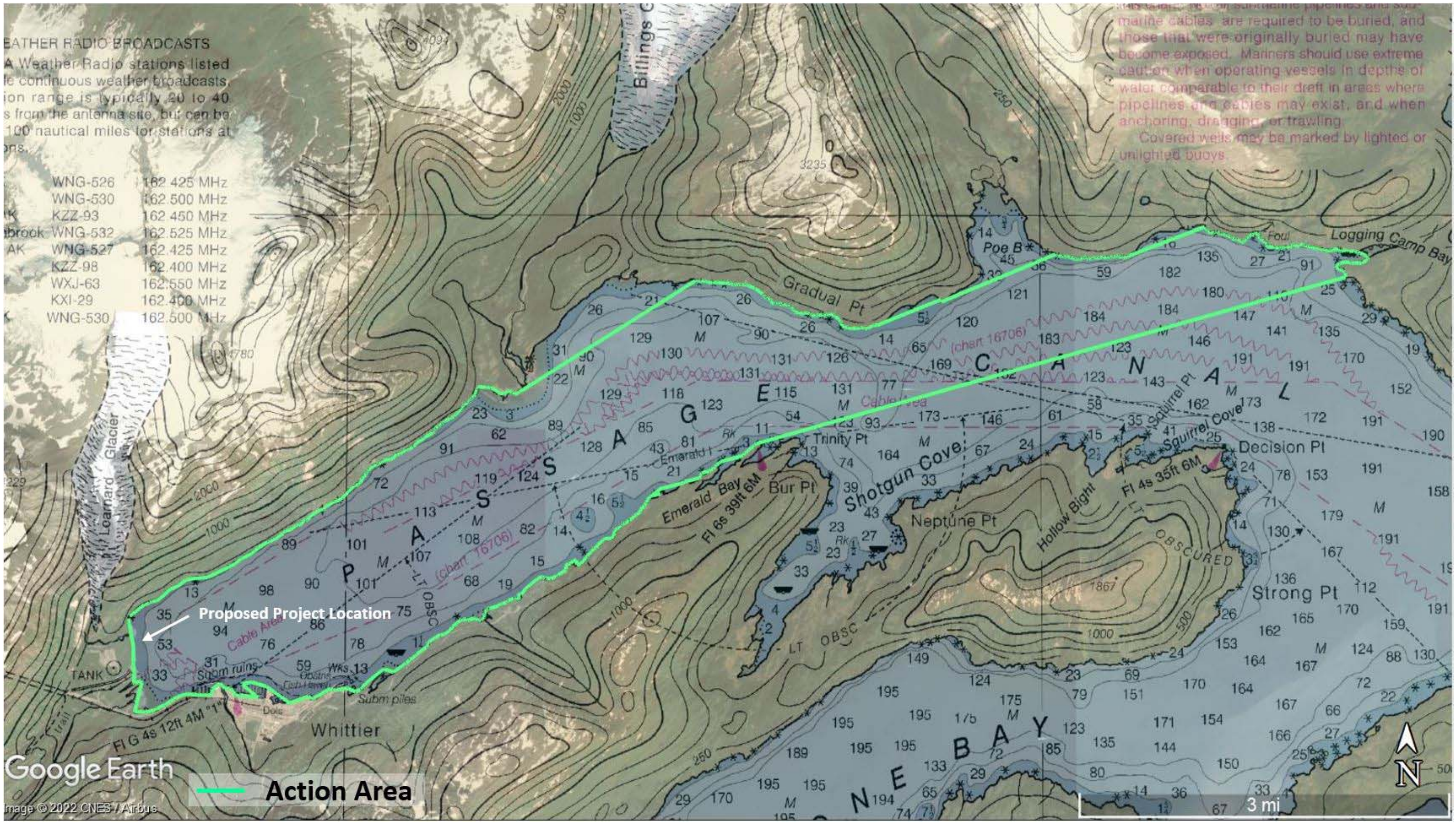
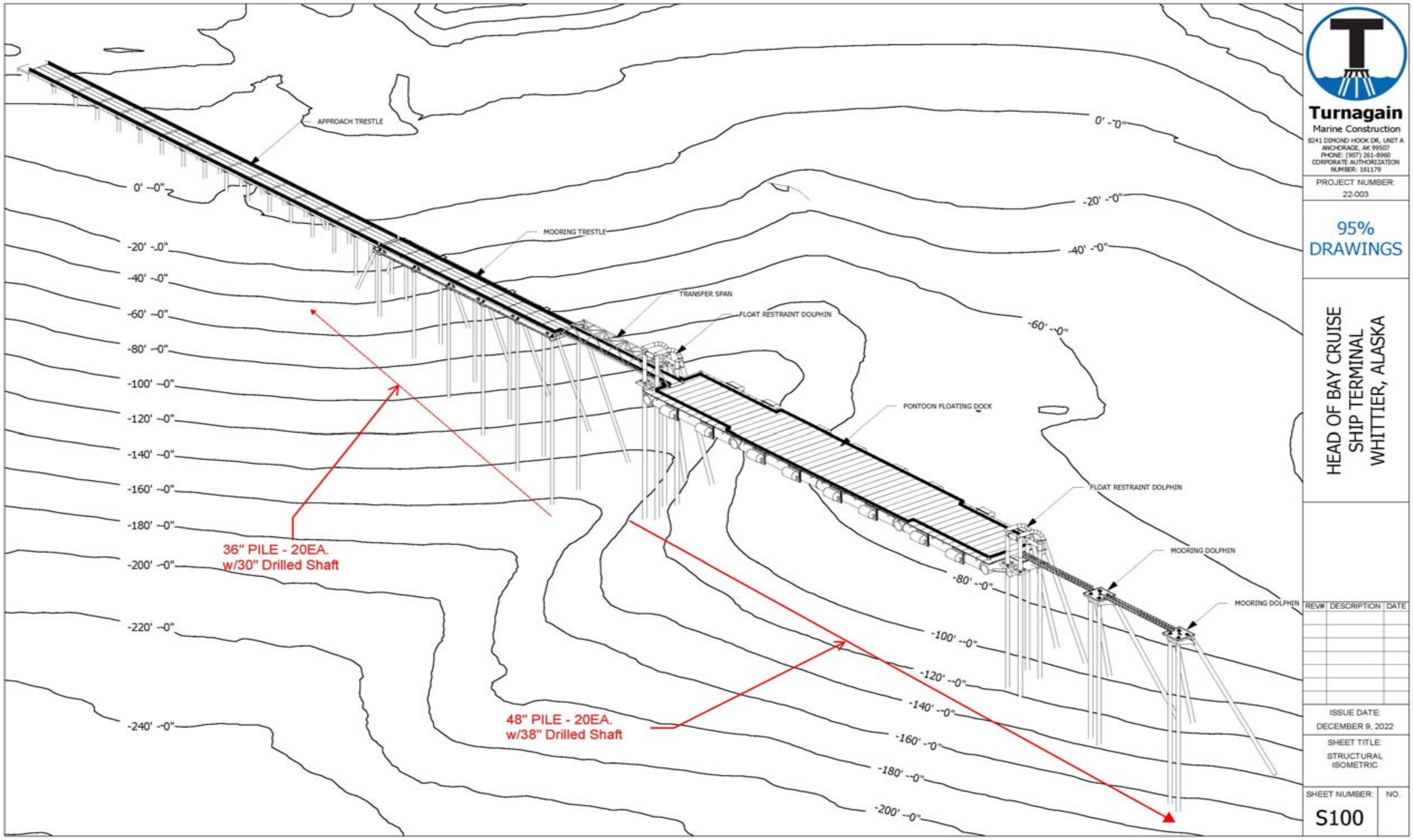


Figure 2. Generalized Foundation Pile Layout, Whittier Head of Bay Cruise Ship Terminal.



FIELD METHODS AND EQUIPMENT

Underwater sound associated with operation of the Down-the-Hole hammer will be measured using equipment and field methods which comply with NMFS guidance issued in 2012 regarding best practices for field data collection.

Measurement Locations

Measurements will be made at distances of 10 m, approximately 3H, and approximately 1000 m, as measured laterally from the subject pile, where 3H is approximately three times the water depth at the pile location. At 10, and 3H the hydrophones will be deployed at depths that are approximately 0.50 to 0.7 times the water depth. At 1000 m the hydrophone will be deployed approximately 3m above the mudline, or approximately 0.9 times the water depth, whichever is further from the mudline. The hydrophones at the 10 m and 3H locations will be positioned with an unobstructed "line-of-sight" to the pile. Field circumstances such as water depth and sea state may constrain the location of the far field (1000 m hydrophone) and field discretion may be used to modify this distance, as necessary. Distances between the pile and the hydrophone will be measured using a laser range finder manufactured by Leica.

Hydrophones

Hydrophones having suitable receiving sensitivity and suitable frequency response will be deployed at each location for simultaneous measurements. A Reson TC4040 or TC4033 hydrophone or an HTI 96min hydrophone will be deployed at the 10 m location, with selection from these options made on-site based on practical field considerations. The TC 4040 and TC4033 units have receiving sensitivities of -206 and -203 dB re: 1 V/µPa, respectively. An HTI 96min hydrophone would have a receiving sensitivity of -210 dB re: 1 V/µPa if used at 10m.

At the 3H location an internally amplified RESON TC 4032 (-167 dB re: 1 V/µPa) or an HTI-96min unit (-180 dB re: 1 V/µPa will be deployed. At the 1000 m distance a more sensitive HTI 96min unit (-170 dB re: 1 V/µPa) will be deployed.

Recording Equipment

Signals from the Reson TC 4040 and 4033 hydrophones will be conditioned by Bruel and Kjar Type 2635 charge amplifiers. The Reson TC 4032 signal has an internal amplifier and does not require a charge amplifier for signal conditioning. Bruel and Kjar 2270 sound level meters having digital storage on SD cards will digitize and store signals from the Reson hydrophones. The HTI hydrophones will be used with submersible recording units, Model Snap, manufactured by Loggerhead Instruments of Sarasota FL. All measurements will be recorded with a 48 kHz sample frequency and stored in uncompressed wave files with a recurring length of 600 seconds. Low-pass and high-pass filters will be applied at 20 kHz and approximately 7 Hz, respectively.

Class 1 sound level calibrators manufactured by GRAS will be used for daily (AM and PM) recordings of reference calibrations signals and for functional checks of the systems. Two Gras 42 AC piston-phones with couplers for all hydrophones will be on site, and one Gras dual frequency calibrator will be on site for use with only the HTI hydrophones.

Data Management

Field notes will be maintained to document various aspects of the DTH drilling and sound measurement details. Following the recording of daily (PM) calibration signals, the SD cards with digitized measurements will be retrieved, copied to a field hard drive, and stored. New SD cards will be used for each deployment. The recording will be in default time lengths of 600 seconds, with internal metadata indicating the associated system, date and time. Post-processing will use the raw field data which is in the form of uncompressed ".wav" files native to the Bruel and Kjar and Loggerhead devices.

ANALYSIS OF MEASUREMENTS and REPORTING

The draft IHA calls for post processing to compute results consistent with common practice for non-impulsive and impulsive signals in the context of vibratory and impact pile driving. The following results derived from post-processing field measurement will be reported as defined here.

For Impulsive (Impact) Pile Driving

Three sound metrics impact driving are computed for the pulse of sound energy associated with individual strikes of the DTH hammer on the substrate and pile shoe:

The *peakSPL* metric is the largest zero-to-peak instantaneous over-pressure (positive or negative) in a single strike, expressed in dB re: 1μPa as follows:

$$peakSPL = 10\log_{10}\left(\frac{\max\left|p^2(t)\right|}{p_o^{\ 2}}\right)$$

For impact driving the root mean square (rms) SPL is computed for a time which encompasses 90% of the sound energy in a single strike. This sound metric may be referred to as 90% RMS SPL, SPL_{rms}, etc. In this report we refer to it as RMS_{90}; it is computed as follows:

$$RMS_{90} = 10\log_{10}\left(\frac{1}{T_{90}}\int_{t_{05}}^{t_{95}} \frac{p^2(t)dt}{p_o^{\ 2}}\right)$$

where the integration limits t_{05} and t_{95} are the times at which the energy in the pulse reaches 5 and 95 percent of the full pulse energy, respectively, and T_{90} is the length of time between t_{05} and t_{95} which therefore encompasses 90 percent of the pulse energy. Impact pulses typically have a concentration of energy in a short portion of the pulse such that T_{90} is much less than 0.9 times the effective pulse length T_{100}. Hence, RMS_{90} may be significantly larger than "RMS_{100}" which would be the root mean square result for the full pulse width. RMS_{90} is given in dB re 1μPa.

The single strike sound exposure level, $SEL_{ss,}$, is a measure of the sound energy in a pulse associated with a singe strike of the hammer on a pile. This sound descriptor is expressed in dB re 1μPa^2-sec and computed as follows:

$$SELss = 10\log_{10}\left(\int_T \frac{p^2(t)dt}{p_0^{\ 2}T_o}\right)$$

where T is the full strike duration, and T_o is 1 second.

The cumulative single strike SEL, cSELss expressed in dB re 1μPa ^{2}-sec is computed using the all the individual single strike $SELss_i$ values for a series of N strikes as follows:

$$cSEL_{ss} = 10\log_{10}\left(\sum_{i=1}^{N} 10^{\frac{SELss_i}{10}}\right)$$

For impulsive analysis additional results will include the number of strikes per pile, the strike rate in strikes per second or minute, and the driving time.

Analyses for Non-Impulsive Pile Driving

For non-impulsive driving the standard metrics are the rmsSPL and cSEL as defined below.

$$rmsSPL = 10\log_{10}\left(\frac{1}{T}\int_T \frac{p^2(t)dt}{p_0^{\ 2}}\right)$$

where the time duration, T, is the rms integration ("averaging") period and p(t) is pressure at time, t. For this project we propose to apply a 1 second RMS averaging period, that is,

T =1 second.

The metric referred to as the Cumulative Sound Exposure Level, cSEL, is the accumulated sound energy for the period, T_{100}, expressed as an equivalent energy occurring for a period of 1 second, as indicated below wherein T_0 is 1 second.

The cSEL metric is expressed in dB re 1μPa^2-sec. As indicated in specific contexts the period, T_{100}, may address the accumulated sound energy resulting from hammer operation for one pile, or one day, or some other stated period or event.

$$cSEL = 10\log_{10}\left(\int_{T_{100}} \frac{p^2(t)dt}{p_0{}^2 T_o}\right)$$

Results for Various Functional Hearing Groups

NOAA Technical Memorandum NMFS-OPR-59, April 2018 identifies non-linear auditory weighting functions (M-weightings) for five functional hearing groups of marine mammals. Post-processing will provide the results discussed above (*peak*SPL, RMS_{90}, SELss, cSELss *rms*SPL and cSEL) for the M-weightings applicable to Low, Mid and High frequency cetaceans (LF, MF and HF) and Phocid and Otariid pinnipeds in water (PW and OW) at the 10m, 3H and 1000 m measurement locations.

Characterization of the Waveform and Sound Spectrum

Representative wave forms for time histories of 1 second duration and for single strikes will be presented together with spectral information. This will include plots of the sound spectrum in the form of one-third octave plots and SEL spectral density plots.

Transmission Loss

A representative Transmission Loss Coefficient, *B*, will be computed using results for distances of 10m, 3H and approximately1000m with regression analysis. The customary practical spreading loss calculation computes a transmission loss value in dB as follows:

$$TL = B\log_{10}\left(\frac{R_1}{R_2}\right)$$

where *B* is a Transmission Loss coefficient, R1 and R2 are, respectively, the far and near distance from the pile over which TL is to be estimated.

Written Report

The acoustic monitoring contractor will submit a draft final report no later than 60 days following the end of field monitoring. The report will present the following information:

1) Pertinent general field details including those related to the piles, the DTH hammer, the subsurface material, bathymetry, test sequence, the distance the pile was advanced with the DTH drill and the weather during monitoring.

2) Details of the acoustic measurement equipment and measurement locations, including and model and receiving sensitivity of each hydrophone, the distance between the pile and each hydrophone, the water depth and hydrophone depth at each measurement location,.

3) Results of the acoustic monitoring as follows:

- at least six plots of the directly measured pressure-time history at each measurement location for purposes of characterizing the signal. Such plots will present periods of 1 second duration with SEL Spectral Density and one-third octave band plots.
- at least six plots of measured time histories for individual DTH strikes with computed single strike metrics and spectral data.
- the apparent duration of DTH operation, the total number of DTH strikes, and the characteristic strike rate (strikes/minute) for each pile as determined from the sound measurements.
- Session Logs (plots of results vs time) for impulsive and non-impulsive broadband metrics *peak*SPL, RMS_{90}, SELss, and cSELss, rmsSPL and cSEL at each measurement location.
- tabular (numeric) summaries of impulsive and non-impulsive broadband metrics *peak*SPL, RMS_{90}, SELss, and cSELss, rmsSPL and cSEL at each measurement location, together with mean, median, minimum, maximum and standard deviation for all metrics except cSELss and cSEL.
- tabular (numeric) summaries of impulsive and non-impulsive M-weighted metrics *peak*SPL, RMS_{90}, SELss, and cSELss, rmsSPL and cSEL at each measurement location, together with mean, median, minimum, maximum and standard deviation for all metrics except cSELss and cSEL.
- regression analysis and semi-log plots of computed metrics versus distance from the pile for the purpose of computing the apparent Transmission Loss Coefficient, *B*.
- discussion addressing general findings, any unexpected results, measurement quality, and limitations of results associated with data quality, if any.

4) If there is an opportunity to collect overnight background measurements in the absence of construction activity, a Cumulative Distribution Function plot will be provided for such background sound levels. This would be done with rmsSPL for a 10 second integration time.

The contractor will provide a final report within 30 days following resolution of NMFS comments on the draft report. If no comments are received from the agencies within 30 days, the draft final report will be considered the final report.