Semiahmoo Renewable Natural Gas Facility
Air Quality Dispersion Modelling Rev.1

PRESENTED TO

Andion North America Ltd.

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EXECUTIVE SUMMARY

Andion North America Ltd. (Andion), in partnership with Semiahmoo First Nation, is proposing to develop, build, own and operate a commercial scale organic waste-to-renewable natural gas facility to be located on vacant and undeveloped lands on the Semiahmoo First Nation reserve in Surrey, British Columbia, approximately 1 km north of the Peace Arch border crossing. The proposed anaerobic digestion facility will accept and process discarded food waste and organic material for the purpose of diverting organic waste generated from landfill, producing biomethane (biogas) which will be upgraded to natural gas at the Project site and sold to FortisBC. The organic materials resource recovery process and upgrading of the biogas results in the discharge of various air contaminants including odorous compounds requiring an application for a Metro Vancouver Air Permit. This report describes the air dispersion modelling assessment which is a requirement of the air permit application process. Modelling of the emission rates described in the air permit application was conducted with CALPUFF.

Of the contaminants Andion has identified in its air permit application, predicted concentrations are above relevant assessment criteria at sensitive receptor locations for odour emitted from the biofilter. Exceedance of relevant odour criteria at identified sensitive receptors includes the Hills at Portal Golf Club (with peak impacts near Highway 99 adjacent to the proposed facility), and Peace Arch Duty Free (located 270 m south of the biofilter), and less frequently at Peace Arch Provincial Park (located 500 m south of the biofilter) and adjacent to portions of the Peace Arch border crossing on the Canadian side.

Nuisance odour is related to the type of odour and frequency and time of occurrence. While 1 Odour Unit (OU) represents an empirically derived value representative of odour detection for half the population in a laboratory setting, if existing background odour is present (i.e., background odour exceeding 1 OU), it is likely that odour originating from the biofilter at a concentration of 1 OU would not even be detectable outside the property lines. For this reason, the 5 OU and 10 OU thresholds were chosen since it would be more consistent with odour detection, and their frequency and timing of occurrence would be a more appropriate metric for assessing community impacts. Furthermore, odour nuisance is an olfactory perception which interferes with the enjoyment of outdoor activity or could ingress into a residence or business through an open window or door. Therefore, the seasonality and diurnal pattern of odour exceedance occurrence is another important consideration.

Of the identified receptors, an exceedance of 5 OU (more than once per year) is predicted to occur at the Hills at Portal Golf Club, Peace Arch Duty Free (and adjacent Highway 99) and Peace Arch Park (seven predicted occurrences per year), and an exceedance of 10 OU could occur only along the portion of the golf course nearest to Highway 99, adjacent to the proposed Project site. There are no predicted exceedances of 10 OU at any residence.

In addition to the predictions above, the majority of odour exceedances occur during fall and winter when people are much less likely to be outside golfing, frequenting Peace Arch Provincial Park, queuing at the border or have their residential windows open. In particular, less than 20% of the predicted exceedances at Peace Arch Park occur during the spring and summer. Similarly, the majority of predicted exceedances at the identified sensitive receptors also occurs during the nighttime.

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LIMITATIONS OF REPORT

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1.0 INTRODUCTION

Tetra Tech Canada Inc. (Tetra Tech) was retained by Andion North America Ltd. (Andion) to support the proposed development and operation of the Andion Organic Waste Processing Facility on a vacant and undeveloped parcel of land on the Semiahmoo First Nation reserve in Surrey, British Columbia (herein referred to as the "Project" or "Facility"). The proposed anaerobic digestion facility will accept and process discarded food waste and organic feedstocks to divert organic waste (generated from Metro Vancouver) from landfilling, and produce biomethane (biogas) which will be upgraded to compressed natural gas standards at the Project site and sold to FortisBC.

The anaerobic and biogas upgrading process results in the discharge of various air contaminants that requires a Metro Vancouver Air Permit. This report describes the emissions and air dispersion modelling assessment which will support the air permit application process.

Modelling of the emission rates for the air permit application was conducted using CALPUFF (v.7.2.1) and associated processors using Lakes Environmental CALPUFF View GUI (v.9.0.0).

2.0 FACILITY INFORMATION

Andion, in partnership with Semiahmoo First Nation, is proposing to develop, build, own and operate a commercial scale waste organics-to-renewable natural gas facility. The Project will process organic waste collected within Metro Vancouver and generate biogas which will be upgraded to renewable natural gas standards using Andion's proven proprietary anaerobic digestion solution.

The proposed Project is located on Lot 10-3 and Lot 11 of the Semiahmoo Indian Reserve. The Semiahmoo Indian Reserve is located in South Surrey, British Columbia. The site is less than 1 km northwest of the Peace Arch border crossing and is bound by Highway 99 to the east, 8 Avenue to the north, and Semiahmoo Bay to the southwest.

The operational components that may produce emissions consist of food waste reception and pre-treatment, anerobic digestion, and biogas upgrading line.

3.0 EMISSIONS

Andion has identified five emission sources (ES) in its air permit application:

1. Biofilter that releases treated exhaust gases from the food waste reception and pre-treatment buildings and vented gases from the biopulper and equalization tank headspace.
2. Biogas upgrading stack that releases gases from the biogas upgrading system.
3. Boiler stack that discharges combustion gases from a natural gas hot water boiler.
4. Flare stack from an emergency flaring system.
5. Stripping tower stack from an ammonia stripping tower.

ES-01 Biofilter

Air from within the food waste reception and pre-treatment buildings is exchanged at a rate of six air exchanges per hour, collected through a series of sealed ducts maintained at negative pressure and first sent to a set of recirculating water scrubbers to remove any particulate matter and water-soluble compounds. Air leaving the wet scrubbers is then directed at a flow rate of 1,167 m^3/min (during operational hours, lower during non-operational hours) to be processed by open top biofilters comprising an area of 495 m^2. The filter modules are packed with woodchips, lava rock, or other media with an expected contaminant reduction of approximately 75%. Contaminants remaining in the air that exits the biofilter forms the final air emission source.

Emissions from the biofilter include compounds such as ammonia (NH_3), hydrogen sulphide (H_2S), and volatile organic compounds (VOCs) that have an inherent odour.

The temperature of the biofilter exhaust air is typically at ambient room temperature, ranging between 10ºC and 20ºC. The flow to the biofilter is reduced during non-operational hours (1800 – 0600), estimated at three air exchanges per hour, or half the flow rate during non-operational hours.

ES-02 Biogas Upgrading Facility Stack

The biogas upgrading system removes impurities from the biogas to meet pipeline standards. This is undertaken by removing H_2S, water soluble VOCs, and carbon dioxide (CO_2). H_2S and VOCs are removed through water scrubbing and adsorption (e.g., activated carbon). CO_2 is removed by pressure swing adsorption. Since H_2S and VOCs are primarily removed through processes that do not result in air emissions, the biogas upgrading system exhaust is primarily CO_2, nitrogen (N_2), and oxygen (O_2) with small amounts of methane.

ES-03 Natural Gas-Fired Hot Water Boiler

The combustion of natural gas in the boiler produces various by-products, notably oxides of nitrogen (NOx). Combustion gases generated in the burners are exhausted directly through the stack without any interconnecting ductwork.

The boiler normally operates at approximately 80% capacity but at reduced capacity (under different operational and weather conditions) may run at approximately 42% capacity. Andion estimates operating the boiler at this reduced capacity approximately 40% of the time. The vendor states the NOx concentration in the flue gas is 86.01 mg/Sm^3 at 42% capacity compared to 114.8 mg/Sm^3 at 80%. The flow rate from the boiler at reduced capacity is 22.1 Sm^3/min compared to 52.5 Sm^3/min at peak capacity, resulting in 70% lower NOx emissions. The exit velocity at 42% capacity is approximately 2 m/s, compared to 5.7 m/s at 80%. A 70% reduction in NOx emissions is a much larger factor than reduced plume buoyancy due to lower discharge velocity and slightly lower exhaust temperature. Furthermore, the boiler is designed to have a rain cap, significantly affecting the exit velocity on dispersion. Modelling the boiler at 80% capacity with 70% higher emissions, therefore, represents the worst-case impacts from boiler emissions.

A boiler with a standard NOx emission burner was used in the modelling. A boiler can also be fitted with a low NOx or ultra-low NOx burner.

ES-04 Emergency Flare

Inline gas composition analyzers and automated process controls ensures that methane capture in the upgrader meets a minimum standard. If the system fails, the biogas is sent to the emergency flare, an enclosed vapour combustor, where the flame is at grade level (ground flare) and enclosed in an insulated combustion chamber. The system minimizes products of incomplete combustion (particulate matter and carbon monoxide), emitting most notably thermal NOx and sulphur dioxide (SO_2) formed from reduced sulphur compounds contained in the raw biogas.

The flare supplier listed 760ºC as the minimum exhaust temperature. Andion anticipates flaring exhaust temperatures will normally be around 980ºC; however, modelling at the minimum temperature provides for a lower buoyancy plume rise situation which would be more conservative approach for modelling purposes.

Flaring is not a 100% efficient process, meaning that a small portion (typically ~2% for enclosed flares) of uncombusted biogas is vented to the ambient air.

Flaring represents an upset condition – the biogas created from anaerobic digestion is cleaned/upgraded to be sold to FortisBC. Flaring is expected to occur 900 hours or less throughout the year – less than 10% of the time. Flaring may occur at any time and over durations shorter than an hour to longer than 24 hours.

ES-05 Ammonia Stripper Stack

Digestate leaving the anaerobic digester is high in ammoniacal nitrogen both in the form of dissolved ammonia gas (NH_3) and in solution as ammonium ion (NH_4+). The digestate is treated in air stripping reactors (tanks) that increases the pH and temperature shifting the equilibrium so that the majority of the ammoniacal nitrogen exists as gas phase ammonia. An air extraction system conveys the ammonia laden air from the air stripping reactors to the ammonia absorption column where it reacts with sulphuric acid forming ammonium sulphate $(NH_4)_2SO_4$. Treated air will be discharged from the absorption column into the atmosphere forming an air emission source.

3.1 Emissions Summary

For point sources ES-02 through ES-05, the outlet concentration limits described in Andion's air permit application along with the maximum exhaust flow rates define the rates of contaminant emission (Table 3-1). As such, the emission rates represent maximum levels.

For the biofilter (ES-01), outlet concentrations of odour (in OU/Nm^3) and specific contaminants (in mg/Nm^3) were assumed based on laboratory analysis of gas sampling conducted at the surface of the biofilter (following treatment) at Andion's biomethane facility in Mozzate, Italy. The Mozzate facility will have a similar design as the Semiahmoo facility. The odour concentration at the biofilter outlet was assumed as the highest of six samples (280 OU/Nm^3) obtained from flux measurements taken for the purpose of odour control sampling at the Mozzate facility on June 3, 2017 (as per European Standard ISO 13725:2004 - Determination of Odour Concentration by Dynamic Olfactometry). Contaminant mass concentrations were assumed based on chemical analysis of gas sampling obtained from flux measurements at the biofilter outlet conducted at the Mozzate facility on November 10, 2016.

Note that the concentration of H_2S was below the detection limit of the analysis method (0.23 mg/Nm^3). To provide a conservative estimate representative of the credible maximum H_2S concentration contained in the biofilter outlet effluent, 100% of the maximum odour concentration (280 OU/Nm^3) was assumed to be attributable to H_2S and converted to a mass concentration based on the odour threshold concentration for H_2S (0.00041 ppm) described in '*Measurement of Odor Threshold by Triangle Odor Bag Method*' (Nagata 2003). See sample calculation.

Table 3-1: Emission Sources and Emission Rates Summary

Source ID	Description	Type	Contaminant	Outlet Concentration	Flow Rate (Sm^3/min)	Emission Rate
ES-01	Biofilter emissions from reception/pre-treatment building exhaust, biopulper, and equalization tank headspace discharge	Area	NH_3	[1] 0.11 mg/Nm^3	1,167 (Nm^3/min)	[4] 4.32E-06 g/m^2/s
			H_2S	[1,2] 0.16 mg/Nm^3		[4] 6.28E-06 g/m^2/s
			VOC	[1] 1.27 mg/Nm^3		[4] 4.97E-05 g/m^2/s
			Odour	[3] 280 OU/Nm^3		[4] 11.0 ou/m^2/s
ES-02	Biogas Upgrading Facility Stack	Point	H_2S	1.7 mg/Sm^3	6.73	0.00019 g/s
ES-03	Gas Fired Hot Water Boiler Stack	Point	NOx	114.8 mg/Sm^3	52.56	0.101 g/s
ES-04	Emergency Enclosed Flare	Point	NH_3	0.01 mg/Sm^3	137.7	[5] 2.30E-05 g/s
			H_2S	0.47 mg/Sm^3		[5] 0.0011 g/s
			VOC	0.606 mg/Sm^3		[5] 1.39E-03 g/s
			NOx	182.75 mg/Sm^3		[5] 0.419 g/s
			SO_2	70.09 mg/Sm^3		[5] 0.161 g/s
ES-05	Ammonia Stripper Stack	Point	NH_3	[6] 4.0 mg/Nm^3	161	0.0107 g/s

1. Biofilter outlet contaminant concentrations from chemical analysis of gas sampling conducted at Mozzate biogas facility (11/10/2016).
2. H_2S concentration was below detection limit (D.L) of 0.23 mg/m^3 of analysis method (Footnote 1). Below D.L. concentration assumed equal to the odour concentration (Footnote 4) using odour threshold of 0.00041 ppm in Nagata 2003.
3. Emission rate divided by area of biofilter 495.2 m^2 (18.98 m x 26.09 m).
4. Based on 'outlet of biofilter' concentration from Mozzate biogas facility (Italy) odour control sampling (6/03/2017) as per European Standard ISO 13725:2004 - Determination of Odour Concentration by Dynamic Olfactometry.
5. Andion has indicated flaring of biogas may occur 900 hours per year as an upset condition. Flaring feasibly could occur at any time of day and over a duration ranging from 1 hour or less to longer than 24 hours. Assessment against all criteria related to contaminants emitted from flaring conservatively assumes continuous flaring operations. In this sense, while short-term predictions are representative of a credible worst-case emissions scenario, annual predictions are overstated but does not limit operation of the flare.
6. Metro Vancouver has acknowledged this value is not a combustion product and Andion has not converted effluent to Sm^3.

Example Emission Rate Calculation: Gas Fired Hot Water Boiler Stack (NOx)

- *Effluent concentration limit of 114.8 mg/m^3 at Standard Conditions (101.325 kPa, 20 ºC)*
- *Maximum exhaust gas flowrate 52.56 Sm^3/min*

$$\frac{114.8\ \text{mg}}{\text{Sm}^3}\cdot\frac{1\ \text{g}}{1000\ \text{mg}}\cdot\frac{52.56\ \text{Sm}^3}{\text{min}}\cdot\frac{1\ \text{min}}{60\ \text{s}}=0.101\ \text{g}\ \text{s}^{-1}$$

Example Emission Rate Calculation: Biofilter Odour

- *Odour control sampling conducted at the Mozzate (Italy) Biogas facility yielded a maximum biofilter outlet odour concentration (at surface of the biofilter, post-treatment) of 280 OU/m^3*
- *Biofilter has an outlet flow rate of 1,167 Nm^3/min*
- *The surface area of the biofilter is 495.2 m^2*

$$\frac{280\ ou}{m^3}\cdot\frac{1167\ Nm^3}{min}\cdot\frac{1\ min}{60\ s}=5{,}444\ ou\ s^{-1}=11.0\ ou\ m^{-2}\ s^{-1}$$

Example Effluent Calculation: Biofilter H_2S

- *H_2S in the biofilter outlet obtained from gas sampling conducted at the Mozzate (Italy) Biogas facility yielded a below detection level concentration (0.23 mg/m^3)*
- *For the purpose of obtaining a below detection level H_2S concentration, the maximum biofilter outlet odour concentration (280 OU/Nm^3) was assumed to be 100% attributable to H_2S*
- *Convert odour concentration to mass concentration of H_2S based on odour threshold (0.00041 ppm) described in Nagata 2003, molar mass of 34.1 g/mol and ideal gas law (v = RT/p) at Normal temperature and 1 atm*

$$280\ \frac{\mathrm{ou}}{\mathrm{m}^3}\cdot 0.00041\ \frac{\mathrm{ppm}}{\mathrm{ou\ m^{-3}}} = 0.115\ \mathrm{ppm}\cdot\frac{34.1\ \mathrm{g\ mol^{-1}}\cdot 1\ \mathrm{atm}}{0.0821\ \mathrm{L\ atm\ K^{-1}\ mol^{-1}}\cdot\ 298\ \mathrm{K}} = 0.16\ \frac{\mathrm{mg}}{\mathrm{m}^3}$$

3.2 Source Parameterization

Table 3-2 lists the various parameters for sources ES-01 through ES-05 used in CALPUFF modelling. For contaminant (non-odour) emissions, the biofilter (ES-01) was modelled using CALPUFF's external buoyant area source file format (BAEMARB.dat), originally implemented by the developers to model smoke plumes from forest fires and implicitly containing plume rise algorithms incorporating plume temperature and rise velocity. BAEMARB.dat allows for temporally varying parameters which accounted for the day/night distinction in the flow rate (19.4 m^3/s vs 9.7 m^3/s) due to reduced building air exchange during non-operational hours. BAEMARB.dat only handles emission rates in g/s and cannot be used to implicitly model odour units. For odour modelling, a standard area source was used in CALPUFF with an initial sigma-z (initial buoyancy) parameterized as 1 m, a highly conservative value but likely representative of a release at ambient temperature with low initial velocity.

Table 3-2: Source Parameters

Source ID	Source Height (m)	Diameter	Flow Rate (Am^3/s)	Exit Velocity (m/s)	Exhaust Temperature (C)	Rain Cap
ES-01	2.03	19.0 m x 26.1 m	19.4 (day) 9.7 (night)	0.04 (day) 0.02 (night)	10	n/a
ES-02	8.0	0.108	0.14	14.96	60	N
ES-03	6.1	0.48	1.04	5.70	63.9	Y
ES-04	9.75	1.7	24.4	10.75	760	Y
ES-05	9.75	0.60	4.1	14.7	65	N

The source locations and site plan, including significant buildings (see Section 4.4), are shown on Figure 3.1.

4.0 MODEL

The impact of anticipated facility emissions was modelled referencing Section D4: Air Quality Dispersion Modelling of Metro Vancouver's Guidance for Air Permit Applications and the Dispersion Modelling Plan approved by Metro Vancouver June 9, 2022. The modelling procedures adhere to protocols described in British Columbia Air Quality Dispersion Modelling Guideline (BC AQDMG, ENV 2021) and Guidance for NO_2 Dispersion Modelling in British Columbia (ENV 2022) unless otherwise described in the submitted modelling plan.

4.1 Meteorological Grid

The modelled area was 20 km x 20 km, centered over the northeastern portion of the proposed Andion facility site at 517646 m, 5428615 m UTM Z10 with a horizontal grid resolution of 100 m (200 x 200 grid cells). The vertical grid resolution was the CALMET default as described in Table 6.2 of the BC AQDMG (NZ = 10; ZFACE = 0 m, 20 m, 40 m, 80 m, 160 m, 320 m, 640 m, 1200 m, 2000 m, 3000 m, 4000 m).

4.2 Geophysical Grid

The proposed site is located less than 1 km from the United States-Canada border meaning that essentially half the model grid lies in either country. There is added complexity with a model domain straddling the international border due to the different sources of terrain and land cover data collected with distinct data methods, resolutions, and acquisition times. While spacecraft or satellite-derived data exists for the entirety of North America, such as Shuttle Radar Topography Mission (SRTM) terrain data or Global Land Cover Characterization (GLCC), the resolution of these global datasets have inherent inaccuracies such as terrain heights defined as treetop elevation rather than ground level elevation and lower resolution (e.g., GLCC has a 1 km resolution) or are outdated (e.g., SRTM was collected in 2000, GLCC is from 1992-1993). Each country has higher resolution digital terrain and land cover data (e.g., ~23 m resolution Canadian Digital Elevation Data); however, meshing the two datasets together results in discontinuities (e.g., elevation between two adjacent data points differing by several metres) and leaves a gap along the border that requires interpolation.

To provide a geophysical grid that adequately meshes with the inherent resolution of the meteorological grid, alternative datasets were sourced to those commonly used as described in Section 4.0 of the BC AQDMG.

Terrain

A high-resolution terrain data grid for the model domain was meshed using GIS software from high resolution datasets from Canada and the United States:

- BC DEM from LidarBC; 1:20,000 (~1 m resolution) Grid 92G.006 & 92G.007 (2016).
- WA DEM from USGS NED 1/9 arc-second (~3 m resolution) (2009).

The terrain grid (GEO.dat) at the CALPUFF grid resolution (100 m) is shown on Figure 4.1.

Land Cover

- North American Land Cover (30 m) from the North American Land Change Monitoring System (NALCMS 2015).

The NALCMS data on the Canadian side of the border appears to provide similar spatial resolution and detail as Canadian Land Cover, circa 2000 dataset and provides a large improvement over the GeoBC Baseline Thematic Mapping (BTM) dataset which does not provide nearly adequate enough spatial detail for air dispersion modelling in an urbanized area with complex land usage and high spatial variability such as Metro Vancouver.

The NALCMS dataset delineates the extent of the tidal flats on the U.S. side of Semiahmoo Bay as ‘wetland’ but ‘water’ on the Canadian side. Aerial imagery indicates the extent of the tidal flats in Semiahmoo Bay adjacent the Semiahmoo FN to Blaine Marine Park is approximately 1.15 km from shore, tapering to approximately 250 to 350 m offshore White Rock Beach Park. The delineation of the tidal flats in the NALCMS 2015 matches the aerial imagery. The delineation of the tidal flats on the Canadian side of Semiahmoo Bay in the Canadian Land Cover, circa 2000 dataset matches aerial imagery and meshes with the U.S. side in the NALCMS 2015 data and was used as the reference to modify the NALCMS 2015 dataset to provide a ‘tide out’ scenario.

Metro Vancouver expressed concern with the impact of tidal fluctuation on meteorology and contaminant dispersion. The tidal flats in Semiahmoo Bay can be exposed for several hours a day, sometimes twice daily at various times based on tides. To address Metro Vancouver's concern, two geophysical grids were created – one as described representing low tide with exposed tidal flats, parameterized as 'Non-Forested Wetlands (62)', and one with the tidal flats re-parameterized as 'Ocean/Seas (55)', representing a high tide scenario. It should be noted that there was minimal difference in the predicted concentrations between the two scenarios.

The land coverage grid (GEO.dat) at the CALPUFF grid resolution (100 m) is shown on Figure 4.2. The GEO.dat files used in modelling are submitted to Metro Vancouver as supplementary to the submission of this air dispersion modelling report.

Seasonal Parameterization

The geophysical properties of the terrain which drive the heat flux and stability algorithms in CALMET vary by season. To capture this seasonality, four seasonal gridded geophysical files (GEO.dat) were created assigning the characterizations for surface roughness, albedo, Bowen ratio, soil heat flux, anthropogenic heat flux and leaf area index as described in Tables 4.8, 4.9, 4.10 and 4.12 of the BC AQDMG following the monthly designations recommended in Metro Vancouver's Modelling Plan template for Metro Vancouver assessments as follows:

- Winter 1, no snow on the ground (November through March).
- Transitional Spring (April and May).
- Midsummer (June through August).
- Autumn (September and October).

4.3 Meteorological Modelling – CALMET

CALMET (v.6.5.0) was run in monthly segments with the appropriate seasonal geophysical data over a period of three years (2013 – 2015) in No-Obs mode using the BC Ministry Weather Research and Forecasting (WRF) model CALMET-ready output available for download at https://wrf.nrs.gov.bc.ca. As described in Section 6.2 of BC AQDMG, the WRF dataset provides a quality controlled, consistent source of Numerical Weather Prediction (NWP) model output suitable for use in CALMET. The WRF model results have been quality tested with comparisons to observations at selected surface and upper air stations in order to provide assurance that the output can be used for dispersion modelling purposes.

Although the output has been subject to these tests, users should still assess the validity of the output at their particular location using the criteria described in Section 6.1 of BC AQDMG. CALMET validations are described in Appendix B – CALMET Validations.

CALMET switch settings were set in accordance with the recommended settings listed in Table 6.2 of BC AQDMG, most of which are model defaults. TERRAD, defined as a 'Critical User-Defined, Site-Specific Parameter' in Table 6.1 of BC AQDMG was set to 5 km although the area is not geographically complex and terrain steering of winds through the region, which is more critical in valley settings, is not a significant phenomenon.

4.4 Building Downwash

Structures of significance with respect to plume downwash influences were obtained from georeferenced site plan drawings and included in the model. Downwash was modelled with BPIP-PRIME as the site buildings are not considered as squat structures (W:H aspect ratio > 5), the exception being the office which is located away from point sources. Buildings included in the model are shown in the site plan on Figure 3.1. Building dimensions are described in Table 4-1.

Table 4-1: Site Structures of Downwash Significance

ID	Structure	Length (m)	Width (m)	Height (m)	W:H Ratio
BLD_1	Processing Building	42.7	54.9	9.8 – 11.5 (E-W sloped)	4.8
BLD_2	Digester Tank	33.5		12.8	2.6
BLD_3	Cold Digester	13.5		18.4	0.7
BLD_4	Biopulper	14.0		14.0	1.0
BLD_5	Boiler Room	6.6	5.1	3.7	1.8
BLD_6	Storage Warehouse	18.8	9.8	4.1	4.6
BLD_7	Office	19.9	10.9	3.9	5.1

4.5 Receptors

Receptor Grid

The receptor grid adhered to spacing guidance in BC AQDMG:

- 20 m receptor spacing along the plant boundary.
- 50 m spacing within 500 m of source.
- 250 m spacing within 2 km of source.
- 500 m spacing within 5 km of source.

With the property boundary defined as the property lease boundary (See Figure 4.3 – Gridded Receptors).

In addition, gridded receptors were placed over residential neighbourhoods, parks or school grounds at a grid spacing equal to double the nested grid spacing in that part of the model (see Sensitive Receptors). All receptors were assigned a height of 1.5 m above ground, although accurate prediction of a difference in modelled concentration between ground level and 1.5 m is well below the capabilities of the CALPUFF model and is also largely irrelevant.

Sensitive Receptors

Receptors are the locations at which the air dispersion model calculates the contaminant concentration in the air. Residential areas, schools, hospitals, commercial day care, seniors' centres, parks and recreational areas represent locations at which more sensitive members of the population spend a significant amount of time at or where degradation of air quality may have significant consequences. Identification of sensitive receptors is standard protocol for air dispersion modelling assessments and is a requirement of Metro Vancouver for air assessments, however, the proposed application is for the conversion of food waste to biogas and the nature and rate of emission of contaminants is generally of low significance to most of the identified sensitive receptors beyond those located nearest the proposed facility.

Single discrete receptors were included in CALPUFF representing individual buildings such as schools or day cares. Where a sensitive receptor represents a larger area, such as a neighborhood or a park, a grid of receptors was placed within the perimeter of the area at double the resolution of the nested receptor grid within that area.

Identified sensitive receptors are listed in Table 4-2 and shown categorically on Figure 4.4. Note that potentially impacted businesses near the proposed facility were not specifically represented in the model as discrete receptors as they are not typically considered as sensitive locations, however, the potential for degradation of air quality at these locations may be detrimental to business and as such, they are specifically identified in Table 4-2 as locations of interest with modelled impacts directly predicted at or inferred through interpolation by the nested receptor grid.

Table 4-2: Identified Sensitive Receptors and Receptors of Interest

ID	Description	UTM Coordinates Z10	
		Easting	Northing
DC_1	Peace Arch Montessori School	518583.2	5426314.0
DC_2	Precious Smiles Academy	514479.6	5431964.1
DC_4	Creative Kids - Morgan Crossing	515812.2	5432510.6
DC_5	Creative Kids - Hazelmere	519273.9	5428507.7
DC_6	Robokids White Rock/ South Surrey	515195.6	5432668.3
DC_7	GoKidz Childcare Centre	515282.0	5432237.3
DC_8	Kids & Company	515607.9	5432900.7
DC_9	Pebble Lane Early Learning	516157.2	5429339.3
DC_10	Academics Pre-Kindergarten South Surrey - White Rock	514741.9	5434107.3
DC_12	Little Footprints Academy | White Rock Daycare	514415.7	5430770.1
DC_13	Treehouse Child Development Centre	513690.4	5430797.3
DC_14	Wind & Tide Preschools Ltd	514409.5	5430229.1
DC_15	Little Acorns Junior Kindergarten and Child Care	516049.0	5430827.8
DC_16	Evergreen Child Care Centre	514837.4	5430077.6
DC_17	Discovery Time Day Care Center	514625.5	5430055.7
CC_1	Meridian Centre	514159.9	5431786.8
CC_2	Kensington Prairie Community Centre	517852.6	5434147.9
CC_3	Elgin Community Hall	512605.5	5434903.9
CC_4	Sunnyside Community Hall	514844.2	5431406.7
HO_1	Peace Arch Hospital	515167.5	5430818.3
LIB_1	Ocean Park Library	509786.6	5431081.2
LIB_2	S. Surrey RCMP District Office & Semiahmoo Library	514497.4	5431376.1
LIB_3	Semiahmoo Library	514487.4	5431386.1
LIB_4	Blaine Public Library	518335.1	5426899.1
ED_1	Elgin Park Secondary School	511075.0	5432426.3
ED_2	Star of the Sea	514175.6	5432456.9

ID	Description	UTM Coordinates Z10	
		Easting	Northing
ED_3	Hall's Prairie Elementary School	520258.8	5429410.5
ED_4	H.T. Thrift Elementary School	513665.0	5431196.3
ED_5	Laronde (French Immersion) Elementary School	510432.9	5431423.9
ED_6	Bayridge Elementary School	512573.6	5431231.8
ED_7	Southridge Senior Secondary School	516370.8	5433083.6
ED_8	White Rock Elementary School	514655.8	5430280.2
ED_9	Peace Arch Elementary School	515855.9	5430383.3
ED_10	Ocean Cliff Elementary School	509113.7	5431683.0
ED_11	Rosemary Heights Elementary School	515149.3	5434898.4
ED_12	South Surrey / White Rock Learning Centre	515275.5	5432449.2
ED_13	Crescent Park Elementary School	509749.9	5432621.8
ED_14	Earl Marriott Secondary School	515678.6	5431011.7
ED_15	East Kensington Elementary School	520884.6	5433356.5
ED_16	Heritage Christian School	513260.8	5434669.8
ED_17	South Meridian Elementary School	516671.1	5430331.5
ED_18	Semiahmoo Secondary School	513620.3	5431351.5
ED_19	Southridge Junior School	516282.5	5433111.0
ED_20	Morgan Elementary School	515501.2	5434465.8
ED_21	Sunnyside Elementary School	516005.0	5433412.7
ED_22	Jessie Lee Elementary School	515021.2	5431870.1
ED_23	Chantrell Creek Elementary School	511467.4	5432861.3
ED_24	Semiahmoo Trail Elementary School	513242.3	5433921.0
ED_25	Ray Shepherd Elementary School	511349.2	5431019.0
ED_26	Pacific Heights Elementary School	518388.4	5432858.8
ED_27	White Rock Christian Academy	514447.8	5432298.0
ED_28	Grandview Heights Secondary School	518117.8	5432865.0
ED_29	Edgewood Elementary School	517444.3	5432282.0
ED_30	Douglas Elementary School	518776.6	5428184.9
ED_31	South Surrey/White Rock Continuing Education	513630.3	5431356.5
ED_32	Cranley Drive Senior Recreation Ctr	515979.8	5432007.4
ED_33	Blaine High School	519233.0	5426756.9
ED_34	Blaine Home Connections	518700.7	5427391.5
ED_35	Blaine Elementary School	518940.1	5426653.1
ED_36	Blaine Middle School	519114.0	5426767.9
ED_37	Blaine Primary School	519019.7	5426543.5
ED_38 - 49	Blaine Schools Complex Grounds	Receptor Grid	
SFN_1	Semiahmoo FN Church	516119.18	5429178.85

ID	Description	UTM Coordinates Z10	
		Easting	Northing
SFN_2	Semiahmoo FN Office	516249.77	5429098.27
Gridded	Peace Arch Golf Course (Business)	Receptor Grid	
Gridded	Peace Arch Duty Free (Business)	517662.4	5428196.5
RCPT_365	Pacific Palace Inn (Business)	517202.3	5430030.8
Gridded	La Baia Restaurant (Business)	515714.8	5429333.7
RCPT_382	Resident - Townhouse – 277 171 St. Douglas	518266.5	5428322.4
Gridded	Resident - House – 16847 Peace Park Drive	517846.3	5427959.0
Gridded	Resident - House – 16587 8th Ave	517319.5	5429363.3
RCPT_374 - 449	Residential Neighbourhood of Douglas	Receptor Grid	
RCPT_2 – 373 RCPT_450 – 464 RCPT_466 – 480 RCPT_466 – 496 RCPT_498 – 512 RCPT_514 – 528 RCPT_530 – 661	Residential Neighbourhood of White Rock	Receptor Grid	
RCPT_662 - 837	Residential Neighbourhood of Grandview Heights	Receptor Grid	
RES_1 – 104	Residential Neighbourhood of Blaine	Receptor Grid	
RCPT_366	Chartwell Crescent Gardens Retirement Community	517202.3	5430130.8
RCPT_465 -	Peace Arch Provincial Park	Receptor Grid	
RCPT_848 - 919	White Rock East Beach Park, White Rock Beach Promenade (East), White Rock Pier, White Rock Strip, Semiahmoo Park	Receptor Grid	
RCPT_465, 481, 497, 513, 529, 838 – 847, R_1 - 3	Peace Arch Historical State Park	Receptor Grid	
REC_BM1 - 40	Blaine Marine Park	Receptor Grid	
REC_SR1 - 7	Semiahmoo Marina	Receptor Grid	

5.0 RESULTS

5.1 Background Air Quality

The period from 2017 to 2019 was chosen to represent the baseline air quality for the assessment as Metro Vancouver emissions during this period would be more representative of normal activity. In 2020, and to a lesser degree 2021, overall activity was diminished due to the Covid-19 pandemic, particularly road traffic.

The majority of sensitive receptors within the modelling domain are located in White Rock and the neighbourhood of Douglas (east of the Project site), which can be considered as suburban with moderate population density (Douglas is more rural) and coastal influences (onshore/offshore circulation). The eastern part of the model domain becomes increasingly rural. Hourly air quality readings from three Metro Vancouver Lower Fraser Valley Air Quality Monitoring Network stations were assessed to provide a representative baseline for NO_2 and SO_2 for the modelled area.

Surrey East (T15), located in a semi-rural but rapidly growing residential area 15 km northeast of the Project site was chosen due to proximity and setting. Measurements at Surrey East can be considered as representative of an inland suburban area of Metro Vancouver, situated beyond denser urban areas to the west (300,000 people within 10 km as of 2012) and the more rural Fraser Valley. The dominant land coverage is residential within 2 km of the station, becoming evenly residential/agricultural at 5 km. The main influence on air quality is road traffic. The annual NO_2 concentration at Surrey East (as a metric of general NO_2 influences) ranked 14 and 13 out of 24 network stations in 2017 and 2018, respectively, per Metro Vancouver's Lower Fraser Valley Air Quality Monitoring Reports. SO_2 is not monitored at Surrey East.

Langley Central (T27), located in a predominately agricultural area with sparsely spaced detached residential homes 17 km northeast of the Project site was chosen due to proximity and setting. The dominant land coverage is residential/agricultural within 2 km of the station, becoming mostly agriculturally dominant beyond 2 km. Measurements at Langley Central would show influences similar to Surrey East but can be considered as more representative of more rural areas of the Lower Fraser Valley. The annual NO_2 concentration at Langley Central ranked 23 out of 24 network stations in both 2017 and 2018. The maximum 1-hour SO_2 was 16 out of 17 monitoring stations in both 2017 and 2018.

Tsawwassen (T39) is located in a residential neighbourhood 750 m inland from English Bluff and the Strait of Georgia and was established by Metro Vancouver to assess residential air quality near Deltaport and marine activities. The station was included in the assessment at the request of Metro Vancouver. Much more exposed to the general Strait of Georgia flows than the Project area, Tsawwassen is categorized by the BC Ministry of Environment and Climate Change Strategy as 'Coastal', whereas Surrey East and Langley are categorized as 'Urban'. The dominant land cover is residential within 1 km but is water-dominant within 5 km. The annual NO_2 concentration at Tsawwassen ranked 22 out of 24 network stations in both 2017 and 2018 but was 11 and 7 in terms of 1-hour NO_2 in 2017 and 2018 respectively, indicating high variance. The maximum 1-hour SO_2 concentration was 11 and 4 highest in 2017 and 2018 respectively out of 17 monitoring stations.

H_2S is not implicitly measured in Metro Vancouver. Total Reduced Sulphur (TRS) is currently measured at network stations located in Burnaby and Port Moody which observe air quality heavily influenced by petroleum facilities along Burrard Inlet and on Burnaby Mountain. TRS is also measured at Langdale Elementary (Gibsons) which can be considered as non-representative of the modelled area due to vast differences in geographical setting and population density. Rather than use a completely non-representative baseline for the TRS parameter (modelled as H_2S) considering the lack of significant industrial influences near the Project site, background was assumed to be negligible.

Ammonia has been measured exclusively in the Fraser Valley (Abbotsford and Chilliwack), rural settings where ammonia-emitting agricultural influences are significant and micro-meteorological conditions are vastly different than the modelled area. Ammonia emissions from the facility were therefore, assessed exclusive of background which, compared to the evaluation criteria, are insignificant. This actually represents a more conservative approach for assessing odour as agricultural ammonia, among other odorous compounds originating from agriculture such as manure, would be expected to provide a consistent background, masking odour impacts from a biogas facility.

The baseline 1-hour NO_2 concentration applied to the model results was simply taken as the highest three-year average of 98th percentile maximum (8 highest in a year) daily 1-hour maximum out of the three stations. '*Guidance on NO_2 Dispersion Modelling in British Columbia Baseline*' (ENV 2021) provides provision for refining the single value approach to an hour of day or seasonal/monthly hour-of-day, however, the single concentration value provides the most conservative and simplest approach and model predictions inclusive of background did not require additional refinement to achieve compliance. The baseline 1-hour SO_2 concentration applied to the model results was taken as the highest three-year average of 99th percentile maximum (4 highest in a year) daily 1-hour maximum out of the two stations that measure SO_2. The annual baseline was simply based on the station with the highest three-year average of hourly readings. Baseline concentrations are described in Table 5-1. The value assumed for the modelling assessment is highlighted as bold.

Table 5-1: Representative Baseline Air Quality (µg/m^3)

Station	NO_2		SO_2	
	1 Hr	Annual	1 Hr	Annual
Surrey East (T15)	**69.0**	**17.3**	-	-
Langley Central (T27)	50.1	11.2	9.2	0.41
Tsawwassen (T39)	63.4	12.8	**14.1**	**0.73**

5.2 Assessment of Modelled Contaminants

5.2.1 Criteria for Air Contaminants

As required by Metro Vancouver, predicted concentrations at receptor height of emitted air contaminants (NO_2, SO_2, NH_3, H_2S, VOCs, and Odour) were evaluated against both Metro Vancouver Ambient Air Quality Objectives (NO_2, SO_2, H_2S – as TRS) and relevant criteria from other jurisdictions (Canadian Ambient Air Quality Standards – CAAQS, Alberta, Ontario Point-of-Impingement (POI), Quebec, Texas Commission on Environmental Quality Effects Screening Levels (TCEQ ESL) and the United States Environmental Protection Agency – USEPA). The evaluation criteria for these air contaminants are listed in Table 5-2. Exposure criteria for various species of VOCs emitted from the biofilter and as the uncombusted portion of biogas from the flare are discussed in more detail in Section 5.2.6.

Table 5-2: Air Quality Assessment Criteria – Air Contaminants

Contaminant	Averaging Period	Metro Vancouver Objective	Other Jurisdiction Criteria	
NO_2	1-hour	113 $\mu g/m^3$ [a]	113 $\mu g/m^3$ [a] 79 $\mu g/m^3$ [a]	2020 CAAQS 2025 CAAQS
	Annual	32 $\mu g/m^3$ [b]	32 $\mu g/m^3$ [b] 22.5 $\mu g/m^3$ [b]	2020 CAAQS 2025 CAAQS
SO_2	1-hour	183 $\mu g/m^3$	183 $\mu g/m^3$ [c] 170 $\mu g/m^3$ [c]	2020 CAAQS 2025 CAAQS
	Annual	13 $\mu g/m^3$ [b]	13 $\mu g/m^3$ [b] 10.5 $\mu g/m^3$ [b]	2020 CAAQS 2025 CAAQS
NH_3	1-Hour	-	1,400 $\mu g/m^3$	Alberta (Odour Basis)
			180 $\mu g/m^3$	TCEQ [j] (Health Basis)
	24-hour	-	100 $\mu g/m^3$ [d,e]	Ontario POI [k]
	Annual	-	92 $\mu g/m^3$	TCEQ [j] (Health Basis)
H_2S	10-minute	-	13 $\mu g/m^3$ [d,e]	Ontario POI (Odour Basis) [k]
	1-hour (Acceptable)	14 $\mu g/m^3$ (as TRS)	14 $\mu g/m^3$	Alberta (Odour Perception) [l]
	1-hour (Desirable)	7 $\mu g/m^3$ (as TRS)	-	-
	24-hour	-	4 $\mu g/m^3$	Alberta (Health) [l]
VOCs	See Table 5-4 and Table 5-5			
Odour	4 minutes	-	1 OU [f] 5 OU [g]	Quebec (Guideline for Composting and biogas activities) [m]
	4 minutes	-	5 OU [f] 10 OU [h]	Boucherville, QC (bylaw, all facilities)
	10 minutes	-	1 OU [i]	Ontario
		3 OU	-	Regulatory Approach

Except where noted, Metro Vancouver objectives are "not to be exceeded".

a. Achievement based on annual 98th percentile of the daily 1-hour maximum, averaged over three consecutive years.
b. Achievement based on annual average of 1-hour concentrations over one year.
c. Achievement based on annual 99th percentile of daily 1-hour maximum, averaged over three consecutive years.
d. Ontario Point-of-Impingement (POI) Standards are an assessment of facility emissions at off-property locations exclusive of cumulative background.
e. For 24-hour averaging periods, Ontario allows for removal of the highest predicted concentration per modelled year. For shorter averaging periods, such as 1-hour (10-min) concentrations, Ontario allows for removal of 8 highest predictions per modelled year.
f. Based on 98th percentile maximum at nearest sensitive receptor.
g. Based on 99.5th percentile maximum at nearest sensitive receptor.
h. Based on 100th percentile maximum at nearest sensitive receptor.
i. Based on 99.5th percentile maximum at sensitive receptors.
j. Texas Commission on Environmental Quality Toxicity Factor Database (TCEQ 2023).
k. Ontario Regulation 419/05. Air Pollution – Local Air Quality (MECP 2022).
l. Alberta Ambient Air Quality Objectives (AEP 2019).
m. MELCC 2022.

5.2.2 Nitrogen Dioxide

NO_2 is one of a group of highly reactive gases referred to as NOx. Other NOx species includes nitric oxide (NO), nitrous acid (HNO_2) and nitric acid (HNO_3). NO_2 is used as the indicator for NOx and is regulated by ambient air quality criteria due to its acute and chronic respiratory effects.

Andion has identified two sources of NOx emissions in its application: the combustion of natural gas in the hot water boiler (ES-03) and the flaring of biogas in the enclosed flare (ES-04). NOx emissions from the combustion of fuels consists mainly of NO and NO_2, the ratio of which is dependent on the fuel type and the process. The initial NO_2 fraction of NOx in the exhaust effluent of combustion sources is referred to as the In-Stack Ratio (ISR). In the ambient air, NO further converts to NO_2. The atmospheric chemistry of NO to NO_2 conversion is complex, however, the main pathway is oxidation through interaction with ground level ozone (O_3), reaching an equilibrium ratio in the ambient air that is dependent on the concentration of NOx, where lower NOx yields a higher fraction of NO_2. This ambient equilibrium ratio is defined by a sixth order polynomial curve determined from NO and NO_2 monitoring data, constrained to a maximum NO_2 ratio of 0.9 and a minimum value of 0.2, deemed as representative for a specific location or setting. This conversion methodology is called the ARM2 method.

The BC Ministry of Environment and Climate Change Strategy's (ENV) '*Guidance for NO_2 Dispersion Modelling in British Columbia*' (ENV 2022) provides BC-specific sixth order polynomial ARM2 curve equations for categories of sites through the Province. As described in Section 5.1, the study area setting may be qualified as 'Urban' and/or 'Coastal'. As such, the ARM2 polynomial equations for both the 'Urban' and 'Coastal' category were applied. Tsawwassen, one of four sites described as 'Coastal' in the supplementary ENV guidance, is much more exposed to Strait of Georgia flows than the study area. Although influenced by circulation, the setting, population density and land cover of the study area is more similar to the rest of Metro Vancouver monitoring sites which are all categorized as 'Urban'. Of the two curves, the higher NO_2 yield was used.

In CALPUFF, ARM2 is implemented using POSTUTIL by defining a step function based on 14 NO_2/NOx ratios that vary with NOx concentration. Concentrations between the NOx concentrations specified by the 14 values are calculated using linear interpolation. The first value is used for all NOx concentrations at or below and the last value is used for all NOx concentrations at or above. The following ratios were used:

Table 5-3: Ambient NO_2/NOx Ratios Used for ARM2 Conversion

NOx Conc. (µg/m^3)	NO_2/NOx Ratio	NOx Conc. (µg/m^3)	NO_2/NOx Ratio
73	0.90	168	0.52
83	0.85	188	0.47
95	0.79	212	0.42
106	0.74	250	0.36
120	0.68	299	0.31
134	0.63	444	0.25
148	0.58	559	0.20

While the ARM2 approach provides a general indication of NO to NO_2 conversion based on several datasets of measured equilibrium ratios, and thus NO_2 concentrations for the purpose of a modelling assessment, the method has a limitation that should be noted in that it does not give consideration to travel time. The United States Environmental Protection Agency has noted this limitation in modelling NO_2 chemistry with regulatory models (USEPA 2021). The ambient NO/NO_2 ratios used to determine the best fit curve equations are based on monitoring data at fixed sites under the assumption that the NO/NO_2 ratio has had ample time to reach equilibrium. As the area of greatest impact was predicted by CALPUFF to be at the northeast corner of the property line immediately adjacent the boiler and flare stack sources, it is highly unlikely that the NOx has had sufficient time to reach equilibrium at the NO/NO_2 ratios deemed as typical of the site setting. In this sense, the initial ISR is likely a relatively important factor that is not considered with ARM2 and, at ISRs typical for combustion equipment (e.q., boilers operating on natural gas or process gas), NO_2 is most likely overpredicted with moderate to low NOx concentrations.

Figure 5.1 shows the 98th percentile maximum daily 1-hour maximum (D1HM) NO_2 concentration, based on ARM2, averaged over three modelled years, inclusive of the representative background concentration and evaluated against the MV/2020 CAAQS criterion of 113 µg/m^3 (blue line) and the 2025 CAAQS criterion of 79 µg/m^3 (purple line). The highest predicted 1-hour NO_2 concentration, inclusive of background, at the property line is 158 µg/m^3 and 110 µg/m^3 at the nearest sensitive receptor (Hole 2 of the Hills at Portal Golf Club).

Figure 5.2a and Figure 5.2b show the predicted number of annual exceedances on average, of the MV/2020 CAAQS and 2025 CAAQS 1-Hr NO_2 criteria respectively. Exceedance of the MV/2020 CAAQS NO_2 criteria (inclusive of the assumed background concentration) is predicted to occur adjacent the northeast corner of the property, nearest the boiler and flare stacks (the sources of NOx emissions) within Semiahmoo First Nation. There are zero predicted exceedances of the MV/2020 CAAQS NO_2 criteria at any sensitive receptor. As the assumed background concentration already comprises 87% of the 2025 CAAQS for NO_2, exceedance of the future standard is quite widespread, covering nearly the entirety of the Hills at Portal Golf Club and extending into Douglas (up to five annual exceedances) and residential areas north of 8th Ave (up to four annual exceedances).

Figure 5.3 shows the predicted annual NO_2 concentration, based on ARM2, averaged over three modelled years, inclusive of the representative background concentration and evaluated against the MV/2020 CAAQS criterion of 32 µg/m^3 and the 2025 CAAQS criterion of 22.5 µg/m^3. The highest predicted annual NO_2 concentration, inclusive of the assumed background, at the property line is 38 µg/m^3 and 20 µg/m^3 at the nearest sensitive receptor (Hole 2 and Hole 3 of the Hills at Portal Golf Club). There are no predicted exceedances of either the MV/2020 CAAQS or 2025 CAAQS criteria at sensitive receptors. Note that the assumed background makes up 54% of the MV/2020 CAAQS criterion and 77% of the 2025 CAAQS criterion. Note as well that the flare will only be operated on an emergency basis as an upset condition with an estimated maximum operation of 900 hours per year and the only consistent source of NOx emissions on the property is the boiler. The predictions of annual NO_2 conservatively assumes flaring as a continuous operation so not to limit operation of the flare and no prorating of hours has been assumed. As such, annual NO_2 is overpredicted.

Figures 5.4 through 5.6 show the same NO_2 assessments, but in reference to the most conservative 100% conversion method required by Metro Vancouver as an upper-bound estimate for NOx to NO_2 conversion.

5.2.3 Sulphur Dioxide

SO_2 is emitted during emergency flaring, a result of the combustion of sulphur constituents in the biogas. SO_2 emissions from the Andion facility are not considered as significant.

Figure 5.7a shows the 100th percentile D1HM SO_2 concentration, averaged over three modelled years, inclusive of the representative background concentration and evaluated against the Metro Vancouver criterion of 183 µg/m^3. There are no predicted exceedances of the Metro Vancouver criterion. The highest predicted 1-hour SO_2 concentration, inclusive of assumed background, at the property line is 65.7 µg/m^3 and 24.2 µg/m^3 at the nearest sensitive receptor (the Hills at Portal Golf Club).

Figure 5.7b shows the 99th percentile D1HM SO_2 concentration, averaged over three modelled years, inclusive of the representative background concentration and evaluated against the 2020 CAAQS criterion of 183 µg/m^3 and the 2025 CAAQS criterion of 170 µg/m^3. There are no predicted exceedances of either criterion. The highest predicted 1-hour SO_2 concentration at the 99th percentile metric, inclusive of assumed background, at the property line is 55.3 µg/m^3 and 20.9 µg/m^3 at the nearest sensitive receptor (the Hills at Portal Golf Club).

Figure 5.8 shows the predicted annual SO_2 concentration, averaged over three modelled years, inclusive of the representative background concentration and evaluated against the Metro Vancouver criterion of 13 µg/m^3 and the 2025 CAAQS criterion of 10.5 µg/m^3. There are no predicted exceedances of either the Metro Vancouver or 2025 CAAQS criteria. The highest predicted annual SO_2 concentration at the property line is 2.5 µg/m^3 and 1.0 µg/m^3 at the nearest sensitive receptor (the Hills at Portal Golf Club).

Note that the flare will only be operated on an emergency basis as an upset condition with an estimated maximum operation of 900 hours per year. Modelling conservatively assumes flaring as a continuous operation so not to limit operation of the flare and no prorating of hours has been assumed. As the flare is the only source of SO_2 emissions, annual SO_2 is overpredicted.

5.2.4 Ammonia

NH_3 is emitted from the ammonia stripper stack and from the biofilter as a constituent of off-gassing of received food wastes. Emissions of ammonia from the Andion facility are not considered as significant.

Figures 5.9, 5.10, and 5.11 show the maximum 1-hour, 24-hour and annual NH_3 concentration respectively, out of three modelled years, evaluated against the relevant criteria of 180 µg/m^3 (TCEQ short term ESL), 100 µg/m^3 (Ontario 24-hour POI) and 92 µg/m^3 (TCEQ long term ESL), respectively. Note, the Alberta criteria for 1-hour ammonia is 1,400 µg/m^3, based on odour perception, however the TCEQ short-term ESL is more stringent.

There are no predicted exceedances of the exposure criteria. The highest predicted 1-hour NH_3 concentration at the property line is 30.4 µg/m^3 and 8.4 µg/m^3 at the nearest sensitive receptor (Hole 2 of the Hills at Portal Golf Club). The maximum predicted 24-Hr NH_3 concentration at the property line is 4.3 µg/m^3 and 0.7 µg/m^3 at the nearest sensitive receptor (Hole 2 of the Hills at Portal Golf Club). The highest predicted annual NH_3 concentration at the property line is 1.2 µg/m^3 and 0.1 µg/m^3 at the nearest sensitive receptor (Hole 2 of the Hills at Portal Golf Club).

1-hour and annual ammonia concentrations are presented exclusive of background due to non-representative background data for the study area. The predicted concentrations at the nearest receptor locations are fractions of the assessment criteria (4.6% and 0.1%, respectively). If cumulative contributions (predicted plus background) were to exceed either of these criteria, the issue would be with the existing regional air quality condition. For reference, the peak 1-hour and annual measured NH_3 concentrations reported by Metro Vancouver in its most recent Lower Fraser Valley Air Quality Monitoring Report (2019) at Abbotsford Mill Lake, located in suburban Abbotsford, was 31 µg/m^3 (1-hour) and <5 µg/m^3 (annually). Note, Ontario's POI threshold concentrations (24-hour ammonia) are assessed exclusive of a background concentration.

5.2.5 Hydrogen Sulphide/Total Reduced Sulphur

Under normal operations, H_2S is removed from the biogas stream and emitted from the Biogas Upgrading Facility stack. H_2S is also emitted from the biofilter as a constituent of off-gassing of received food wastes. Under upset conditions, H_2S is emitted as a constituent of the uncombusted fraction of biogas (~2% due to inherent flaring inefficiency) during emergency flaring operations. Note that a flaring scenario would not occur concurrently with biogas upgrading. As such the modelled predictions are conservative.

Figure 5.12 shows the maximum 10-minute H_2S concentration out of three modelled years, evaluated against the Ontario POI criterion of 13 µg/m^3 which is based on odour perception. Ontario's short-period POI threshold concentrations (e.g., 10-minute H_2S) are assessed after removal of the eight highest predictions in each modelled year and are exclusive of background concentration. 10-minute concentrations were estimated from the hourly model predictions based on a standard time-scaling methodology as described in Methodology for Modeling Assessments of Contaminants with 10 Minute Average Standards and Guidelines under O. Reg. 419/05 (MECP 2016). The highest predicted 10-minute H_2S concentration at the property line is 44.9 µg/m^3, adjacent to the biofilter, and 11.9 µg/m^3 at the nearest sensitive receptor (Hole 2 of the Hills at Portal Golf Club).

Figure 5.13 shows the number of hours with predicted exceedance of the Ontario odour-based criteria, as an average of three modelled years. At the most impacted sensitive receptor (the Hills at Portal Golf Club), up to five exceedances are predicted to occur per year along Hole 2 of the Hills at Portal Golf Club nearest Highway 99, adjacent the biofilter. Note that five exceedances shows compliance with the Ontario POI assessment criteria. No other exceedances are predicted at identified sensitive receptors.

Figure 5.14 shows the maximum predicted 1-hour TRS concentration out of three modelled years, evaluated against the Metro Vancouver criterion of 7 µg/m^3 (desirable, blue contour line) and 14 µg/m^3 (acceptable). Note that for TRS, 2% of the predicted biofilter VOCs has been added to the H_2S predictions (see Table 5-3) to form TRS using CALPOST POSTUTIL to conservatively account for additional sulphur constituents of the biofilter emissions. The highest predicted 1-hour TRS concentration at the property line is 51.2 µg/m^3, adjacent to the biofilter, and 14.0 µg/m^3 at the nearest sensitive receptor (Hole 2 of the Hills at Portal Golf Club).

Figure 5.15 shows the number of hours with predicted exceedance of the Metro Vancouver acceptable criteria, as an average of three modelled years. Exceedance occurs within Semiahmoo First Nation in the vicinity of the biofilter and over Highway 99. There are no predicted exceedances at any sensitive receptor.

Figure 5.16 shows the maximum predicted 24-hour H_2S concentration, out of three modelled years, evaluated against the Alberta criterion of 4 µg/m^3. The highest predicted 24-hour H_2S concentration at the property line is 7.9 µg/m^3, adjacent to the biofilter, and 1.4 µg/m^3 at the nearest sensitive receptor (Hole 2 of the Hills at Portal Golf Club).

Figure 5.17 shows the number of hours with predicted exceedance of the Alberta 24-hour H2S criteria, as an average of three modelled years. Exceedance occurs within Semiahmoo First Nation in the immediate vicinity of the biofilter. There are zero predicted exceedances at any sensitive receptor.

5.2.6 Volatile Organic Compounds

There are several species of organics generated in the food waste-to-energy process. Andion has identified two discharge points of VOCs at the proposed Semiahmoo facility: the venting of food waste delivery and pre-treatment buildings/biopulper and final dewatering equalization tanks headspace through the biofilter, and the uncombusted portion of biogas when the emergency flare is operated due to inherent flare inefficiency (approximately 2% of the inlet flow).

The profile of VOCs emitted from the biofilter will be characteristic of that from food wastes in the initial stages of decomposition. Ciu et. al. 2022 identified a total of 110 species of volatile organics within seven general categories (alcohols, esters, aldehydes-ketones, alkanes, terpenes, esters, and sulphurs) emitted by food wastes representative of VOCs released at the waste reception area and tipping floor of collection facilities in Shanghai, China. Alcohols are released during the early stages of food waste decomposition. Esters can originate from the decomposition of fruit and food waste as well as reactions between alcohols and carboxylic acids. Alcohol oxidation can produce aldehydes and ketones. Terpenes are released during the volatilization of food waste. The degradation of sulphur-containing organics in food waste leads to the emission of sulphurous compounds.

While the general composition of food wastes would be expected to be somewhat similar across regions (e.g., meats, common fruits) there would be inherent differences. For applicability of the Cui et. al. speciation study to this assessment, it was assumed that the most prevalent species would be similar (e.g., ethanol) while variabilities likely exist in the secondary species.

Cui et. al. provided relative compositions for categories of organics at three temperatures: 10ºC, 20ºC, and 35ºC (Table 5-4). Considering the climate of Metro Vancouver, the VOC emissions profile at 35ºC is not considered as representative of what would be expected at the Semiahmoo facility but is listed in Table 5-4 to illustrate the observed temperature dependence. Andion provided a compositional analysis of inlet gas to the biofilter obtained as part of odour control sampling conducted in June 2017 at the Mozzate facility in Italy (Table 5-4). The facility was designed by Andion and will have similar operation as the Semiahmoo facility, but like the Shanghai study, there would be inherent regional differences in the food waste, although likely with slightly more similarities. The summer climate of Mozzate is also warmer than Vancouver with daily high temperatures during the summer typically above 25ºC.

In consideration of the variability between the two sets of data, a high and low range was considered as the proportion each organics grouping makes up of total VOC emissions based on the Mozzate speciation and the 10ºC and 20ºC values from the Shanghai study.

Table 5-4: Representative VOC Composition of Inlet Gas to Biofilter

Category of VOC	Andion (Mozzate)	Cui et. al (Shanghai, China)		
		10 ºC	20 ºC	35 ºC
Alcohols	48%	95%	90%	57%
Ketones [1]	26%	<1%	3%	<1%
Alkanes	-	1.5%	1%	<1%
Terpenes	14%	<1%	<1%	<1%
Esters	9%	2%	3%	40%
Sulphurs	2%	<1%	<1%	<1%
Aldehydes [1]	1%			
Ethers	0.4%			

[1] Ketones and aldehydes categorized together in Cui et. al.

Within each organics category, Cui et. al. identified the most prevalent, or primary species. These are ethanol (alcohol group), acetone and 2-butanone (aldehydes-ketone group), isobutane, isopentane, and pentane (alkanes group), camphene and limonene (terpene group), ethyl acetate (esters group) and carbon disulfide (sulphur group). It is assumed that the primary organic species would generally comprise VOC emissions from all types of food waste although the relative proportion of the primary species within each grouping will be variable. For the purpose of conservatism, primary species were assumed to comprise 100% of each category of VOC (e.g., 100% of the alcohol group assumed to be ethanol) which is an overestimation since secondary species will always comprise some portion of the speciation.

As the secondary species emitted by food waste would be expected to be highly variable – many will not even be present – they were grouped together as a pseudo-species and conservatively assumed to comprise 50% of an organics grouping. The actual proportion of an individual secondary species within a category of organics is likely less than 10% or 20%, otherwise it would have been specifically identified in the Cui et. al. study.

As such, the highest predicted VOC concentration attributed to emissions from the biofilter at or beyond the property line was first proportionated based on the highest of the three grouping compositions listed in Table 5-4 (Mozzate, Shanghai at 10ºC and Shanghai at 20ºC), then assumed to comprise 100% or 50% of this grouping's proportion for primary and secondary species respectively and assessed against the respective air quality criteria listed in Table 5-5. For example, secondary alcohols were assumed to comprise 47.5% (50% x 95%) of the total VOCs while secondary ketones were assumed to comprise 13% (50% x 26%) of the total VOCs.

For the secondary pseudo-species, the criteria for the entire sub-grouping were based on the most stringent exposure levels off all species identified within each category in Cui et. al. Although specific organics within a grouping tend to have similar properties (e.g., lower odour thresholds), this approach is conservative. Exposure-related evaluation criteria for the biofilter VOCs are described in Table 5-5.

Table 5-5: Health-Based Evaluation Criteria for VOCs Emitted from the Biofilter (µg/m³)

Species/Group	Evaluation Period	Criteria	Jurisdiction	Basis
Ethanol	Short Term ESL	18,800	TCEQ	Health
	Long Term ESL	1,880	TCEQ	Health
Secondary Alcohols [1]	24-hour	13 [a]	Ontario (B2 SL)	Health
	Short Term ESL	610 [b]	TCEQ	Health
	Long Term ESL	50 [c]	TCEQ	Health
Acetone (Primary Ketone)	1-hour	5,900	Alberta	Adopted
	24-hour	11,880	Ontario (Standard)	Health
	Annual	380	Quebec	Health
	Short Term ESL	7,800	TCEQ	Health
	Long Term ESL	4,800	TCEQ	Health
2-Butanone (Primary Ketone)	24-hour	1,000	Ontario (Standard)	Health
	Short Term ESL	18,000	TCEQ	Health
	Long Term ESL	2,600	TCEQ	Health
Secondary Ketones/Aldehydes [2]	1-hour	4.5 [a]	Alberta/Ontario	Health
	24-hour	0.4 [a]	Ontario (Standard)	Health
	Annual	0.084 [b]	Quebec	Health
	Short Term ESL	3.2 [a]	TCEQ	Health
	Long Term ESL	0.82 [a]	TCEQ	Health
Isobutane (Primary Alkane)	24-hour	618	Ontario (B2 SL)	Health
	Short Term ESL	23,000	TCEQ	Health
	Long Term ESL	7,100	TCEQ	Health
Isopentane (Primary Alkane)	24-hour	7,080	Ontario (B2 SL)	Health
	Short Term ESL	59,000	TCEQ	Health
	Long Term ESL	7,100	TCEQ	Health
n-Pentane (Primary Alkane)	24-hour	4,200	Ontario (B2 SL)	Health
	Short Term ESL	59,000	TCEQ	Health
	Long Term ESL	7,100	TCEQ	Health

Species/Group	Evaluation Period	Criteria	Jurisdiction	Basis
Secondary Alkanes [3]	24-hour	200 [a]	Ontario (B2 SL)	Health
	Short Term ESL	2,000 [b]	TCEQ	Health
	Long Term ESL	200 [b]	TCEQ	Health
Primary Terpenes [4]	24-hour	20 [a]	Ontario (B2 SL)	Health
	Short Term ESL	1,000 [a]	TCEQ	Health
	Long Term ESL	100 [a]	TCEQ	Health
Secondary Terpenes [5]	Short Term ESL	630 [a]	TCEQ	Health
	Long Term ESL	63 [a]	TCEQ	Health
Ethyl Acetate (Primary Ester)	Long Term ESL	1,440	TCEQ	Health
Secondary Esters [6]	24-hour	5.2 [a]	Ontario (B2 SL)	Health
	Annual	116 [b]	Quebec	Health
	Short Term ESL	130 [a]	TCEQ	Health
	Long Term ESL	13 [a]	TCEQ	Health
Carbon disulfide	Short Term ESL	7,500	TCEQ	Health
	Long Term ESL	32	TCEQ	Health
Secondary Organic Sulphides [7]	Short Term ESL	20 [a]	TCEQ	Health
	Long Term ESL	2 [a]	TCEQ	Health

Source: Cui et. al. 2022.

Notes: Criteria for organic groupings secondary determined as lowest published value among species identified in Cui 2022. Primary species assumed to comprise 100% of grouping. Secondary pseudo-species assumed to account for 50% of grouping.

1. a-2-methyl-1-butanol, b-1-butanol, c-eucalyptol.
2. a-acrolein, b-diacetyl.
3. a-p-mentha-1(7),2-diene, b-methylcyclopentane.
4. camphene.
5. a-alpha-pinene.
6. a-ethyl propionate, b-methyl butyrate.
7. a-dimethyl disulfide.

The VOC constituents of the digester gas, vented from the emergency flare as the uncombusted fraction (~2%) of waste biogas, are different than the speciation characteristic of received food waste in its initial stages of decomposition. Andion provided a VOC composition of digester gas based on measurement at the Mozzate facility. The vast majority (80%) of the digester gas consists of 2-butanone, or Methyl-ethyl-ketone (MEK), with acetone (6.0%), butanol (4.0%) and acrylonitrile (2.7%) as much lesser constituents and other trace (<1%) species. The composition and exposure-related evaluation criteria for the VOCs vented from the emergency flare are described in Table 5-6.

Table 5-6: Health-Based Evaluation Criteria for VOCs Characteristic of Uncombusted or Vented Biogas (μg/m³)

Species/Group	Composition	Evaluation Period	Criteria	Jurisdiction	Basis
Dichloromethane	3.3%	1-hour	14,000	Quebec	Health
		24-hour	220	Ontario	Health
		Annual	3.6	Quebec	Health
		Short Term ESL	3,600	TCEQ	Health
		Long Term ESL	350	TCEQ	Health
Methyl isobutyl ketone	0.7%	Short Term ESL	820	TCEQ	Health
		Long Term ESL	82	TCEQ	Health
Butanol	4.0%	24-hour	920	Ontario	Health
		Short Term ESL	610	TCEQ	Health
		Long Term ESL	61	TCEQ	Health
Acetonitrile	0.7%	24-hour	70	Ontario	Health
		Annual	3	Quebec	Health
		Short Term ESL	340	TCEQ	Health
		Long Term ESL	34	TCEQ	Health
Acrylonitrile	2.7%	24-hour	0.6	Ontario	Health
		Annual	12	Quebec	Health
		Short Term ESL	330	TCEQ	Health
		Long Term ESL	2.1	TCEQ	Health
2-Butanone (MEK)	80.8%	24-hour	1,000	Ontario	Health
		Short Term ESL	18,000	TCEQ	Health
		Long Term ESL	2,600	TCEQ	Health
Toluene	0.3%	1-hour	1,880	Alberta	Adopted
		24-hour	400	Alberta	Adopted
		Short Term ESL	4,500	TCEQ	Health
		Long Term ESL	1,200	TCEQ	Health
n-butyl acetate	0.7%	Short Term ESL	11,000	TCEQ	Health
		Long Term ESL	1,400	TCEQ	Health
Isopropanol	0.8%	1-hour	7,850	Alberta	Adopted
		24-hour	7,300	Ontario	Health
		Short Term ESL	4,920	TCEQ	Health
		Long Term ESL	492	TCEQ	Health
Acetone	6.0%	1-hour	5,900	Alberta	Adopted
		24-hour	11,880	Ontario	Health
		Annual	380	Quebec	Health
		Short Term ESL	7,800	TCEQ	Health
		Long Term ESL	4,800	TCEQ	Health

The maximum predicted 1-hour, 24-hour, and annual VOC concentrations out of three modelled years attributed to the biofilter and the flare at the property line, most impacted sensitive receptor (Hole 2 of the Hills at Portal Golf Course) and most impacted residence are listed in Table 5-7.

Table 5-7: Maximum Predicted VOC Concentrations (µg/m³)

Species/Group	1-Hr	24-Hr	Annual
Maximum Fenceline Biofilter VOC Concentration	350	63	8.1
Maximum Receptor Biofilter VOC Concentration	96	10.8	0.62
Maximum Residential Receptor Biofilter VOC Concentration	14.5	0.8	0.05
Maximum Fenceline Vented Biogas VOC Concentration	0.45	0.20	0.016
Maximum Receptor Vented Biogas VOC Concentration	0.10	0.026	0.002
Maximum Residential Vented Biogas VOC Concentration	0.037	0.003	<0.001

Assessment against the health-based criteria listed in Table 5-5 and Table 5-6 was therefore the predicted VOC concentration for the relevant averaging time multiplied by the assumed compositional volume fraction of an organics species or organics grouping. The health-based VOC assessment is listed in Table 5-8.

Table 5-8: Assessment of Specific Organics Against Health-Based Criteria

Species/Group	Evaluation Period	Criteria	Predicted Concentration (µg/m³)		
			Property Line	Receptor	Residence
Biofilter VOCs					
Ethanol	Short Term ESL	18,800	333	91	14
	Long Term ESL	1,880	8	0.6	0.05
Secondary Alcohols	24-hour	13 [a]	**30**	5	0.4
	Short Term ESL	610 [b]	166	46	7
	Long Term ESL	50 [c]	4	0.3	0.02
Acetone (Primary Ketone)	1-hour	5,900	91	25	4
	24-hour	11,880	16	3	0.01
	Annual	380	2	0.2	0.01
	Short Term ESL	7,800	91	25	4
	Long Term ESL	4,800	2	0.2	0.01
2-Butanone (Primary Ketone)	24-hour	1,000	16	3	0.01
	Short Term ESL	18,000	91	25	4
	Long Term ESL	2,600	2	0.2	0.01
Secondary Ketone/Aldehydes	1-hour	4.5	5.3	1.4	0.4
	24-hour	0.4	**0.9**	0.2	0.02
	Annual	0.084	**1.1**	0.08	0.01
	Short Term ESL	3.2	**5.3**	1.4	0.4
	Long Term ESL	0.82	0.12	0.01	0.002

Species/Group	Evaluation Period	Criteria	Predicted Concentration (µg/m^3)		
			Property Line	Receptor	Residence
Isobutane (Primary Alkane)	24-hour	618	1	0.2	0.01
	Short Term ESL	23,000	5	1	0.2
	Long Term ESL	7,100	0.1	0.01	0.001
Isopentane (Primary Alkane)	24-hour	7,080	1	0.2	0.01
	Short Term ESL	59,000	5	1	0.2
	Long Term ESL	7,100	0.1	0.01	0.001
n-Pentane (Primary Alkane)	24-hour	4,200	1	0.2	0.01
	Short Term ESL	59,000	5	1	0.2
	Long Term ESL	7,100	0.1	0.01	0.001
Secondary Alkanes	24-hour	200	0.5	0.08	0.006
	Short Term ESL	2,000	3	0.7	0.1
	Long Term ESL	200	0.06	0.005	0.0004
Primary Terpenes	24-hour	20	9	2	0.1
	Short Term ESL	1,000	49	13	2
	Long Term ESL	100	1	0.1	0.007
Secondary Terpenes	Short Term ESL	630	25	7	1
	Long Term ESL	63	0.6	0.04	0.06
Ethyl Acetate (Primary Ester)	Long Term ESL	1,440	0.7	0.06	0.004
Secondary Esters	24-hour	5.2	2.8	0.5	0.04
	Annual	116	0.4	0.03	0.002
	Short Term ESL	130	16	4	0.6
	Long Term ESL	13	0.4	0.03	0.002
Carbon disulfide	Short Term ESL	7,500	6	2	0.2
	Long Term ESL	32	0.1	0.01	0.0008
Secondary Organic Sulphides	Short Term ESL	20	3	0.8	0.1
	Long Term ESL	2	0.06	0.005	0.0004
Vented/Flared Biogas VOCs					
Dichloromethane	1-hour	14,000	1.5E-02	3.2E-03	1.2E-03
	24-hour	220	6.7E-03	7.9E-04	9.9E-05
	Annual	3.6	5.3E-04	6.6E-05	~0
	Short Term ESL	3,600	1.5E-02	3.2E-03	1.2E-03
	Long Term ESL	350	5.3E-04	6.6E-05	~0
Methyl isobutyl ketone	Short Term ESL	820	3.2E-03	6.8E-04	2.6E-04
	Long Term ESL	82	1.1E-04	1.4E-05	~0
Butanol	24-hour	920	8.2E-03	9.7E-04	1.2E-04
	Short Term ESL	610	1.8E-02	3.9E-03	1.5E-03
	Long Term ESL	61	6.5E-04	8.1E-05	~0

Species/Group	Evaluation Period	Criteria	Predicted Concentration (µg/m³)		
			Property Line	Receptor	Residence
Acetonitrile	24-hour	70	1.5E-03	1.8E-04	2.2E-05
	Annual	3	5.5E-03	1.5E-05	~0
	Short Term ESL	340	3.3E-03	7.1E-04	2.7E-04
	Long Term ESL	34	5.5E-03	1.5E-05	~0
Acrylonitrile	24-hour	0.6	5.5E-03	6.5E-04	8.1E-05
	Annual	12	4.3E-04	5.4E-05	~0
	Short Term ESL	330	1.2E-02	2.6E-03	1.0E-03
	Long Term ESL	2.1	4.3E-04	5.4E-05	~0
2-Butanone (MEK)	24-hour	1,000	1.6E-01	1.9E-02	2.4E-03
	Short Term ESL	18,000	3.6E-01	7.8E-02	3.0E-02
	Long Term ESL	2,600	1.3E-02	1.6E-03	~0
Toluene	1-hour	1,880	1.2E-03	2.7E-04	1.0E-04
	24-hour	400	5.6E-04	6.6E-05	8.3E-06
	Short Term ESL	4,500	1.2E-03	2.7E-04	1.0E-04
	Long Term ESL	1,200	4.4E-05	5.5E-06	~0
n-butyl acetate	Short Term ESL	11,000	3.0E-03	6.4E-04	2.4E-04
	Long Term ESL	1,400	1.1E-04	1.3E-05	~0
Isopropanol	1-hour	7,850	3.7E-03	8.0E-04	3.1E-04
	24-hour	7,300	1.7E-03	2.0E-04	2.5E-05
	Short Term ESL	4,920	3.7E-03	8.0E-04	3.1E-04
	Long Term ESL	492	1.3E-04	1.6E-05	~0
Acetone	1-hour	5,900	2.7E-02	5.8E-03	2.2E-03
	24-hour	11,880	1.2E-02	1.4E-03	1.8E-04
	Annual	380	9.6E-04	1.2E-04	~0
	Short Term ESL	7,800	2.7E-02	5.8E-03	2.2E-03
	Long Term ESL	4,800	9.6E-04	1.2E-04	~0

Of the VOCs emitted from the Andion facility, predicted concentrations are well below the exposure criteria with the potential exception of some species of secondary organic ketones and aldehydes emitted from the biofilter which show the highest potential for impingement on exposure criteria at the facility property line. The assessment however is extremely conservative in that these ketones and aldehydes with very low exposure criteria (e.g., acrolein and diacetyl) would need to comprise a significant fraction of the ketone/aldehyde group in the biofilter outlet gas or comprise a larger fraction of the biofilter outlet flow volume than measured in the Ciu et. al study or by Andion at its Mozzate facility.

5.2.7 Odour

Biofilter emissions associated with food waste in the initial stages of decomposition consists of various odorous compounds. Potential odour impacts from the biofilter are assessed in terms of OUs based on a bulk odour emission rate (OU/s) as described in Section 3.0.

There are no specific odour standards implicitly defined by MV or ENV although ambient air quality criteria for odorous air contaminants are currently being considered. Ontario and Quebec have established odour-based criteria relative to odour concentration (OU/m^3) or OUs as described in Table 5-2. The generally accepted definition of 1 OU is the concentration of an odorous substance in air that can be perceived by 50% of the population, generally empirically defined by an odour panel (a group of people screened to have a “normal” level of odour sensitivity and who are trained to assess odour). While the 1 OU threshold represents odour perception, it does not represent what is generally referred to as an odour complaint threshold which is related to odour recognition and occurs at a higher concentration such as 5 OU or 10 OU.

The evaluation period for odour assessment criteria is generally sub-hourly. Ontario uses a 10-minute average while Quebec uses a 4-minute average. Sub-hourly odour concentrations for the 10-minute averages were estimated from the hourly model predictions based on standard peak-over-mean scaling methodology as described in MECP 2016 using a factor of 1.65. Quebec inherently uses a peak-over-mean scalar of 1.9 for conversion from hourly to four-minute averages. The assessment of odour described herein does not consider existing background odour which will inherently mask some odorous compounds at lower concentrations (distinct odours are not cumulative), particularly near agricultural areas and over the golf course.

Figure 5.18 shows the 98th percentile maximum 4-minute odour concentration out of three modelled years (526 highest concentration out of 26,280 predictions), evaluated against the Quebec guideline for composting and biogas activities of 1 OU at sensitive receptors (purple contour line) and the Boucherville, Quebec bylaw of 5 OU at sensitive receptors (blue contour line). The 1 OU criterion at this metric is predicted to be exceeded at portions of the Hills at Portal Golf Club closest to the highway, Peace Arch Duty Free, portions of Peace Arch Provincial Park, and the Peace Arch Border Crossing on the Canadian side. 5 OU is predicted to be exceeded at the parking lot of the Peace Arch Duty Free but at no other off-property sensitive receptor.

Figure 5.19 shows the 99.5th percentile maximum 4-minute odour concentration out of three modelled years (132 highest concentration out of 26,280 predictions), evaluated against the Quebec guideline for composting and biogas activities of 5 OU at sensitive receptors (purple contour line). The 5 OU criterion at this metric is predicted to be exceeded at portions of the Hills at Portal Golf Club course nearest to the highway, Peace Arch Duty Free, and southbound border traffic queues when crossing times are long (Highway 99, adjacent to Peace Arch Duty Free).

Figure 5.20 shows the 100th percentile maximum 4-minute odour concentration out of three modelled years evaluated against the Boucherville, Quebec bylaw of 10 OU at sensitive receptors (blue contour line). The 10 OU criterion at this metric is predicted to be exceeded at portions of the Hills at Portal Golf Club course adjacent to the proposed Facility, Peace Arch Duty Free, and southbound border traffic queues when crossing times are long (Highway 99, adjacent to Peace Arch Duty Free).

Figure 5.21 shows the 99.5th percentile maximum 10-minute odour concentration out of three modelled years (132 highest 10-minute concentration out of 26,280 hourly predictions) evaluated against the Ontario criteria of 1 OU (purple contour line) at sensitive receptors. Also highlighted is 3 OU (blue contour line) to provide additional context in regard to Odorous Air Contaminant Emission Fees as described in Metro Vancouver Regional District Air Quality Management Fees Regulation Bylaw No. 1330, 2021. (http://www.metrovancouver.org/boards/Bylaws1/MVRD_Bylaw_1330.pdf).

Metro Vancouver Bylaw 1330 states:

- *Fees may be reduced by 75% if it can be demonstrated through approved dispersion modelling that 1 OU can be achieved at the nearest odorous air contaminant sensitive receptor location 99.5% of the time based on a ten-minute average of authorized maximum (permitted) emissions; and*

- *Fees may be reduced by 50% if it can be demonstrated through approved dispersion modelling that 3 OU can be achieved at the nearest odorous air contaminant sensitive receptor location 99.5% of the time based on a ten-minute average of authorized maximum (permitted) emissions.*

The 1 OU criterion at the 99.5th percentile metric is predicted to be exceeded most of the time at Hills at Portal Golf Club course and clubhouse, Peace Arch Duty Free, Peace Arch Provincial Park, and the Peace Arch Border crossing on the Canadian side. The maximum predicted odour concentration at any residence is slightly above 1 OU (1.1 OU) at residences in Douglas nearest to the Peace Arch Border Crossing at the 99.5th percentile metric.

Figures 5.22 through 5.24 show the number of hours in a year that the four-minute averaged odour concentration is predicted to exceed the 1 OU, 5 OU, and 10 OU thresholds respectively. Figure 5.25 and Figure 5.26 show the number of hours in a year that the ten-minute averaged odour concentration is predicted to exceed the 1 OU and 3 OU thresholds respectively. While 1 OU is a frequent occurrence, odour nuisance is generally associated with frequent exceedances that are in excess of 5 OU and 10 OU. Up to nine occurrences per month, on average, of 5 OU are predicted to occur at portions of the Hills at Portal Golf Club course (adjacent the proposed Facility) and 13 occurrences per month are predicted to occur at the parking lot of the Peace Arch Duty Free store. There are zero predicted exceedances of 5 OU or higher at any residence.

Up to six occurrences per month at 10 OU are predicted to occur at the westernmost portion of the Hills at Portal Golf Club course immediately adjacent Highway 99 and the proposed Facility. 10 OU is not predicted to be exceeded at any other receptor or residence.

The frequency of predicted odour threshold exceedances is described in Table 5-9.

Table 5-9: Summary of Odour Threshold Exceedances at Sensitive Receptors

Averaging Time	Odour Criteria	Predicted Hourly Exceedances per Year (Frequency of Occurrence)		
		The Hills at Portal Golf Club	Peace Arch Provincial Park	Highest Impacted Residences
4-Minute	**1 OU**	**750 (8.7%)**	**289 (3.3%)**	77 (0.9%)
	5 OU	**121 (1.4%)**	**7 (0.08%)**	1 (0.01%)
	10 OU	**68 (0.8%)**	0	0
10-Minute	**1 OU**	**608 (6.9%)**	**263 (3.0%)**	47 (0.5%)
	3 OU	*152 (1.7%)*	*59 (0.6%)*	*16 (0.2%)*

Seasonal and Diurnal Pattern to Odour Exceedance

Odour nuisance is an olfactory perception which interferes with the enjoyment of outdoor activity or due to odour that may ingress a residence or business through an open window or door. Therefore, the seasonality and diurnal pattern of odour exceedance occurrence is an important consideration. Generally, atmospheric conditions which lead to worst case air quality are associated with more stable conditions and low mixing heights, occurring most frequently on cloudy days, lower sun angles (late fall/winter) as well as the overnight period. Additionally, wind prevalence typically exhibits seasonality. Specific to the study area, onshore winds, which would tend to transport odour towards sensitive receptors are a much more frequent occurrence in the summer during the daytime when vertical mixing conditions are greatest (see Appendix B).

Figure 5.27 illustrates the percentage of the time that exceedances of 4-min averaged 1 OU occurs during spring/summer. The figure shows that the majority of odour exceedances do not occur during spring and summer when people are more frequently at Peace Arch Provincial Park or have their residential windows open. Specifically, less than 20% of the predicted exceedances at Peace Arch Park occur during the spring and summer season.

Figure 5.28 illustrates the percentage of the time exceedance of 4-min averaged 1 OU occurs during the day. Similarly, the majority of predicted exceedances at sensitive receptors does not occur during the daytime when people are typically outside as a result of better dispersion characteristics compared to nighttime.

Assessment of Specific Organics Against Odour-Based Criteria

Lending on the methodology described in Section 5.2.6, individual VOC constituents emitted from the biofilter and as uncombusted biogas from the flare were assessed against relative odour-based criteria as defined in Table 5-10 and Table 5-11.

Table 5-10: Odour-Based Evaluation Criteria for VOCs Emitted from the Biofilter (µg/m³)

Species/Group	Evaluation Period	Criteria	Jurisdiction	Basis
Ethanol	4-minute	340	Quebec	Odour
Secondary Alcohols [1]	4-minute	33 [a]	Quebec	Odour
	Short Term ESL	26 [b]	TCEQ	Odour
Acetone (Primary Ketone)	4-minute	8,600	Quebec	Odour
2-Butanone (Primary Ketone)	4-minute	740	Quebec	Odour
Secondary Ketones/Aldehydes [2]	4-minute	3.5 [a]	Quebec	Odour
Primary Terpenes [3]	4-minute	210 [a]	Quebec	Odour
Secondary Terpenes [4]	4-minute	100 [a]	Quebec	Odour
Ethyl Acetate (Primary Ester)	4-minute	20	Quebec	Odour
	1-hour	19,000	Ontario (B1 Guideline)	Odour
Secondary Esters [5]	4-minute	17 [a]	Quebec	Odour
Carbon disulfide	4-minute	25	Quebec	Odour
	1-hour	30	Alberta	Odour
Secondary Organic Sulphides [6]	10-minute	30 [a]	Ontario (B1 Guideline)	Odour
	Short Term ESL	2 [a]	TCEQ	Odour

Source: Cui et. al. 2022.

Notes: Criteria for organic groupings secondary determined as lowest published value among species identified in Cui 2022. Primary species assumed to comprise 100% of grouping. Secondary pseudo-species assumed to account for 50% of grouping.

1. a-isobutanol, b-eucalyptol.
2. a-diacetyl.
3. a-limonene.
4. a-alpha-pinene.
5. a-propanoic acid.
6. a-dimethyl disulfide.

Table 5-11: Odour-Based Evaluation Criteria for VOCs Characteristic of Uncombusted or Vented Biogas (µg/m³)

Species/Group	Composition	Evaluation Period	Criteria	Jurisdiction	Basis
Methyl isobutyl ketone	0.7%	4-minute	400	Quebec	Odour
		24-hour	1,200	Ontario (B1 Guideline)	Odour
Butanol	4.0%	4-minute	116	Quebec	Odour
		10-minute	2,100	Ontario	Odour
2-Butanone (MEK)	80.8%	4-minute	740	Quebec	Odour
Toluene	0.3%	4-minute	600	Quebec	Odour
		24-hour	2,000	Ontario (B1 Guideline)	Odour
n-butyl acetate	0.7%	4-minute	30	Quebec	Odour
		1-hour	15,000	Ontario (B1 Guideline)	Odour
Isopropanol	0.8%	4-minute	7,800	Quebec	Odour
Acetone	6.0%	4-minute	8,600	Quebec	Odour

As described in Section 5.2.6, assessment against the odour-based criteria was the maximum predicted VOC concentrations listed in Table 5-7, time scaled to a 4-minute or 10-minute averaging time where appropriate, multiplied by the compositional volume fraction of an organics species or organics grouping. The odour-based VOC assessment is listed in Table 5-12.

Table 5-12: Assessment of Specific Organics Against Odour-Based Criteria

Species/Group	Evaluation Period	Criteria	Predicted Concentration (µg/m³)		
			Property Line	Receptor	Residence
Biofilter VOCs					
Ethanol	4-minute	340	***556***	153	23
Secondary Alcohols	4-minute	33	**278**	**76**	12
	Short Term ESL	26	**166**	**46**	7
Acetone (Primary Ketone)	4-minute	8,600	152	42	6
2-Butanone (Primary Ketone)	4-minute	740	152	42	6
Secondary Ketones/Aldehydes	4-minute	3.5	**76**	**21**	3
Primary Terpenes	4-minute	210	82	22	3
Secondary Terpenes	4-minute	100	41	11	2
Ethyl Acetate (Primary Ester)	4-minute	20	**52**	14	2
	1-hour	19,000	31	9	1
Secondary Esters	4-minute	17	**26**	7	1
Carbon disulfide	4-minute	25	9	3	0.4
	1-hour	30	6	2	0.2
Secondary Organic Sulphides	10-minute	30	5	1	0.2
	Short Term ESL	2	**2.8**	0.8	0.1

Species/Group	Evaluation Period	Criteria	Predicted Concentration (µg/m^3)		
			Property Line	Receptor	Residence
Vented/Flared Biogas VOCs					
Methyl isobutyl ketone	4-minute	400	5.3E-03	1.1E-03	4.4E-04
	24-hour	1,200	1.4E-03	1.7E-04	2.1E-05
Butanol	4-minute	116	3.0E-02	6.5E-03	2.5E-03
	10-minute	2,100	3.0E-02	6.5E-03	2.5E-03
2-Butanone (MEK)	4-minute	740	6.1E-01	1.3E-01	5.0E-02
Toluene	4-minute	600	2.1E-03	4.5E-04	1.7E-04
	24-hour	2,000	5.6E-04	6.6E-05	8.3E-06
n-butyl acetate	4-minute	30	5.0E-03	1.1E-03	4.1E-04
	1-hour	15,000	3.0E-03	6.4E-04	2.4E-04
Isopropanol	4-minute	7,800	6.2E-03	1.3E-03	5.1E-04
Acetone	4-minute	8,600	4.5E-02	9.7E-03	3.7E-03

There are potential exceedances of odour-based criteria for some VOCs, notably primary alcohol ethanol and primary ester, ethyl acetate, but also secondary alcohols, ketones, and aldehydes. Predicted exceedance occurs at the property line and at portions of the Hills at Portal Golf Club. There are no predicted exceedances at residences. The assessment of VOCs is extremely conservative in that secondary species with very low exposure limit criteria (e.g., isobutanol, eucalyptol and diacetyl) would need to comprise a large fraction of the secondary group of species within the biofilter outlet flow volume.

6.0 SUMMARY

Table 6-1 lists the maximum predicted concentration for each contaminant over the averaging times relevant to the evaluation criteria. Table 6-3 lists the predicted odour concentration over the averaging times relevant to the odour evaluation criteria.

Of the contaminants Andion has identified in its air permit application, predicted concentrations are above relevant assessment criteria at sensitive receptor locations for odour emitted from the biofilter. Exceedance of relevant odour criteria at identified sensitive receptors includes the Hills at Portal Golf Club, with peak impacts nearest to Highway 99 adjacent to the proposed facility, Peace Arch Duty Free, located 270 m south of the biofilter and less frequently at Peace Arch Provincial Park, located 500 m south of the biofilter and adjacent portions of the Peace Arch border crossing on the Canadian side.

The biofilter outlet odour concentration used in modelling was obtained from an operating Andion facility in Italy and is assumed to be representative of biofilter emissions at the proposed Semiahmoo facility. Andion would conduct sampling on its biogas once operational. Odorous compounds emitted from the biofilter would consist of VOCs with low odour detection/recognition thresholds, such as those listed in Table 5-8; however, the speciation is highly variable, dependent on the waste stream composition, degree of decomposition and temperature among other factors.

Nuisance odour is related to the type of odour and frequency and time of occurrence. While 1 Odour Unit (OU) represents an empirically derived value representative of odour detection for half the population in a laboratory setting, if existing background odour is present (i.e., background odour exceeding 1 OU), it is likely that odour originating from the biofilter at a concentration of 1 OU would not even be detectable. For this reason, the 5 OU and 10 OU thresholds which are more consistent with odour detection, and their frequency of occurrence are a more appropriate metric for assessing community impacts. Furthermore, odour nuisance is an olfactory perception which interferes with the enjoyment of outdoor activity or due to odour that may ingress a residence or business through an open window or door. Therefore, the seasonality and diurnal pattern of odour exceedance occurrence is another important consideration.

Of the identified receptors, exceedance of 5 OU of more than once per year is predicted to occur at the Hills at Portal Golf Club, Peace Arch Duty Free store (and adjacent Highway 99) and Peace Arch Park (seven predicted occurrences per year) with exceedance of 10 OU occurring only along at the portion of the golf course nearest Highway 99, adjacent to the proposed Project. There are no predicted exceedances of 10 OU at any residence.

The majority of odour exceedances occur during fall and winter when people are less likely to be golfing, frequenting Peace Arch Provincial Park, queuing at the border or have their residential windows open. In particular, less than 20% of the predicted exceedances at Peace Arch Park occur during the spring and summer. Similarly, the majority of predicted exceedances at the identified sensitive receptors occurs during the nighttime.

Table 6-1: Summary of Predicted Contaminant Concentrations Against Air Quality Criteria

Contaminant	Averaging Period	Criteria	Jurisdiction	Prediction at Criteria Metric (µg/m^3)			
				Exclusive Background		Inclusive Background	
				Fenceline	Most Impacted Receptor	Fenceline	Most Impacted Receptor
NO_2	1-Hour	113 µg/m^3	Metro Vancouver	88.7	41.3	157.7	110.3
		79 µg/m^3	2025 CAAQS				
	Annual	32 µg/m^3	2020 CAAQS	20.5	2.3	37.8	19.6
		22.5 µg/m^3	2025 CAAQS				
SO_2	1-Hour	183 µg/m^3	Metro Vancouver	51.6	10.1	65.7	24.2
			2020 CAAQS	41.2	6.8	55.3	20.9
		170 µg/m^3	2025 CAAQS				
	Annual	13 µg/m^3	2020 CAAQS	1.8	0.3	2.5	1.0
		10.5 µg/m^3	2025 CAAQS				
NH_3	1-Hour	180 µg/m^3	Alberta	30.4	8.4	-	-
	24-Hour	100 µg/m^3	Ontario POI	4.3	0.7	-	-
	Annual	92 µg/m^3	TCEQ ESL	1.2	0.1	-	-
H_2S	10-Minute	13 µg/m^3	Ontario POI	44.9	11.9	-	-
	24-Hour	4 µg/m^3	Alberta	8.0	1.4	-	-
TRS	1-Hour	14 µg/m^3	Metro Vancouver (Acceptable)	51.2	14.0	-	-
		7 µg/m^3	Metro Vancouver (Desirable)				

Table 6-2: Summary of Maximum Short and Long Term Predicted Contaminant Concentrations

Contaminant	Averaging Period	Maximum Prediction at Averaging Period (μg/m³)			
		Exclusive Background		Inclusive Background	
		Fenceline	Most Impacted Receptor	Fenceline	Most Impacted Receptor
NO_2	1-Hour	89.1	73.7	158.1	142.7
	Annual	20.5	2.3	37.8	19.6
SO_2	1-Hour	51.6	10.1	65.7	24.2
	Annual	1.8	0.3	2.5	1.0
NH_3	1-Hour	30.4	8.4	-	-
	24-Hour	5.6	1.0	-	-
	Annual	1.2	0.1	-	-
H_2S	10-Minute	72.9	20.0	-	-
	24-Hour	8.0	1.4	-	-
TRS	1-Hour	51.2	14.0	-	-

Table 6-3: Summary of Predicted Odour Concentrations at Sensitive Receptors

Averaging Period	Criteria	Percentile	Prediction at Criteria Metric (OU)			Maximum Prediction (OU)		
			The Hills at Portal Golf Club	Peace Arch Provincial Park	Most Impacted Residence	The Hills at Portal Golf Club	Peace Arch Provincial Park	Most Impacted Residence
4-Minute	1 OU	98^{th}	2.9	2.0	0.3	48.3	6.2	5.0
	5 OU	99.5^{th}	16.0	3.8	1.5			
	10 OU	100^{th}	48.3	6.2	5.0			
10-Minute	1 OU	99.5^{th}	13.9	3.2	1.1	42.0	5.4	4.3

Table 6-4: Frequency of Occurrence of Odour Criteria Exceedance at Sensitive Receptors

Averaging Time	Criteria	Percentile	Predicted Hourly Exceedances per Year (Frequency of Occurrence)		
			The Hills at Portal Golf Club	Peace Arch Provincial Park	Highest Impacted Residence
4-Minute	1 OU	98th	750 (8.7%)	289 (3.3%)	77 (0.9%)
	5 OU	99.5th	121 (1.4%)	7 (0.08%)	1 (0.01%)
	10 OU	100th	68 (0.8%)	0	0
10-Minute	1 OU	99.5th	608 (6.9%)	263 (3.0%)	47 (0.5%)

7.0 CLOSURE

We trust this document meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
Tetra Tech Canada Inc.

FILE: 704-SWM.PLAN03183-03
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Reviewed by:
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FIGURES

G:\SOLID_WASTE\PLAN\PLAN03183-03\PLAN03183-03\Maps\AirQuality_20230529\PLAN03183-03_Fig03-1_EmissionSources.mxd modified 6/2/2023 by Stephanie.Leusink

LEGEND

- Emission Source
- Building
- Site Boundary
- Semiahmoo First Nation

Base Data

- Highway
- Local Road

NOTES
Base data source:
CanVec 1:50,000
Imagery from ESRI; Maxar (2022)

STATUS
ISSUED FOR USE

SEMIAHMOO RENEWABLE NATURAL GAS FACILITY AIR QUALITY DISPERSION MODELLING

Emission Sources

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	andion

Scale: 1:2,000
40 20 0 40
Metres

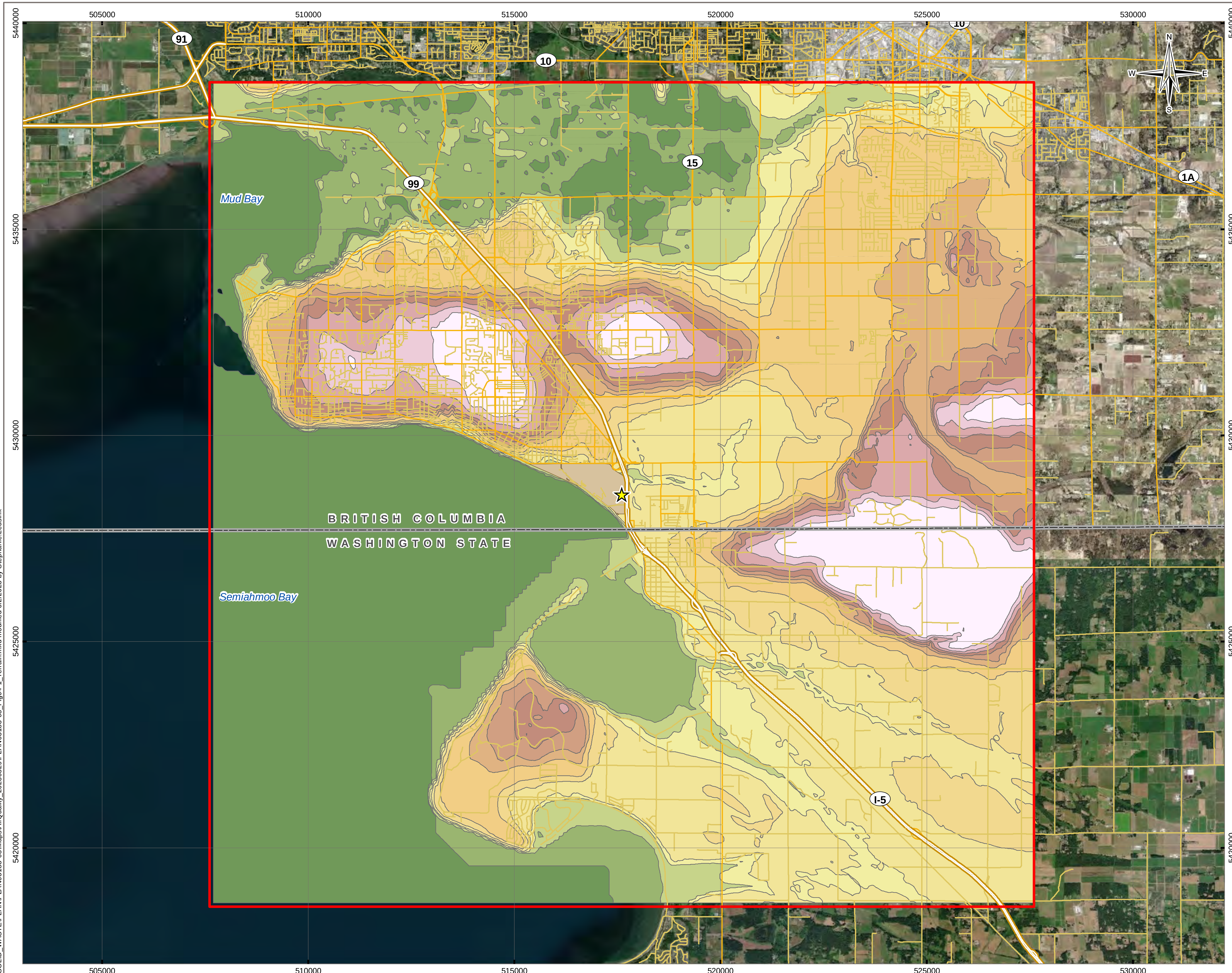
TETRA TECH

FILE NO.
PLAN03183-03_Fig03-1_EmissionSources.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	MRV	TM	0

DATE	PROJECT NO.
June 2, 2023	SWM.PLAN03183-03

Figure 3.1



LEGEND

- Facility Location
- Model Extent
- Semiahmoo First Nation

Elevation (m)

- < 0
- 0 - 1
- 1 - 5
- 5 - 10
- 10 - 20
- 20 - 30
- 30 - 50
- 50 - 60
- 60 - 70
- 70 - 80
- 80 - 90
- 90 - 100
- > 100

Base Data

- Highway
- Main Road
- Local Road
- International Boundary

NOTES
Base data source:
CanVec 1:50,000
Washington State Open Data
Imagery from ESRI; Maxar (2021)

STATUS
ISSUED FOR USE

SEMIAHMOO RENEWABLE NATURAL GAS FACILITY AIR QUALITY DISPERSION MODELLING

CALPUFF Terrain Grid

PROJECTION UTM Zone 10			**DATUM** NAD83	
Scale: 1:90,000 — 1 0.5 0 1 Kilometres				
FILE NO. PLAN03183-03_Fig04-1_Terrain.mxd				
OFFICE Tt-VANC	**DWN** SL	**CKD** MRV	**APVD** TM	**REV** 0
DATE June 2, 2023	**PROJECT NO.** SWM.PLAN03183-03			

CLIENT andion

TETRA TECH

Figure 4.1

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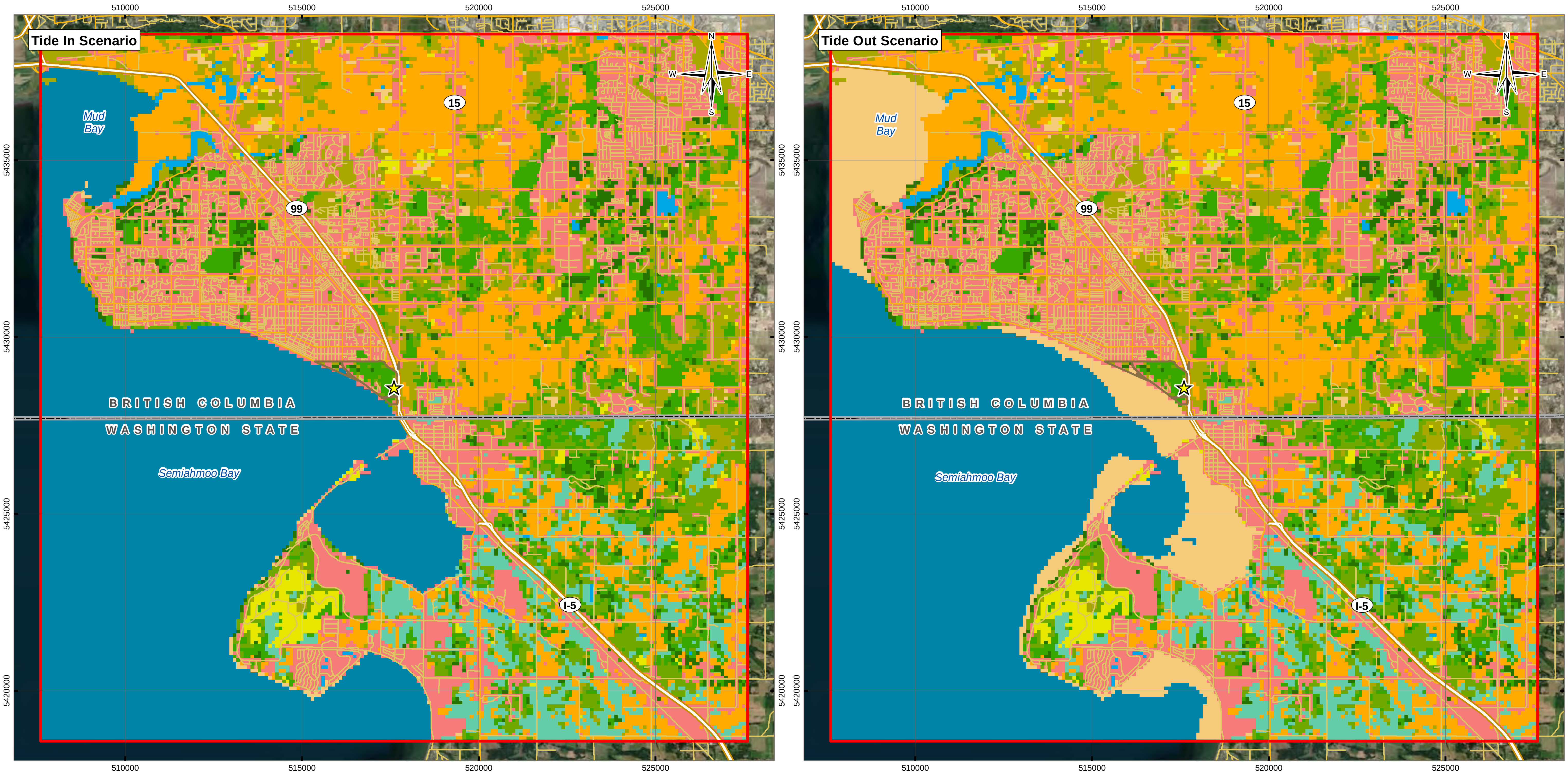

LEGEND

- ★ Facility Location
- Model Extent
- Semiahmoo First Nation

Base Data

- Highway
- Main Road
- Local Road
- International Boundary

Land Cover

- Urban (10)
- Agricultural Land (20)
- Grassland (30)
- Shrubland (32)
- Deciduous Forest (41)
- Evergreen Forest (42)
- Mixed Forest (43)
- Watercourse (51)
- Ocean (55)
- Wetland (62)
- Barren Land (70)

NOTES
Base data source:
CanVec 1:50,000
Washington State Open Data
Imagery from ESRI; Maxar (2021)

STATUS
ISSUED FOR USE

SEMIAHMOO RENEWABLE NATURAL GAS FACILITY AIR QUALITY DISPERSION MODELLING

CALPUFF Land Cover Grid (GEO.DAT)

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	andion

Scale: 1:110,000
2 1 0 2
Kilometres

FILE NO.
PLAN03183-03_Fig04-2_LandCover.mxd

TETRA TECH

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	MRV	TM	0

DATE	PROJECT NO.
June 2, 2023	SWM.PLAN03183-03

Figure 4.2

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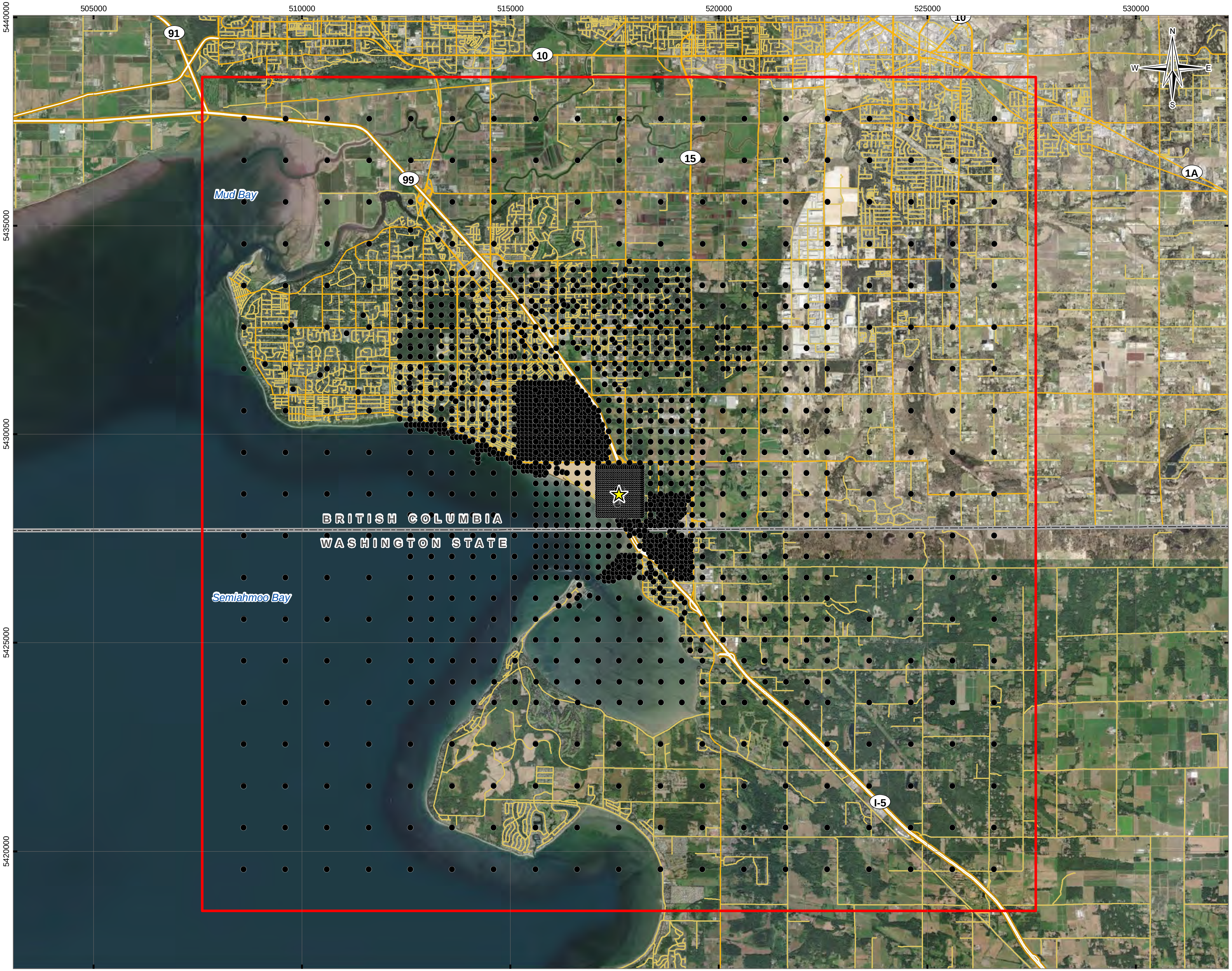

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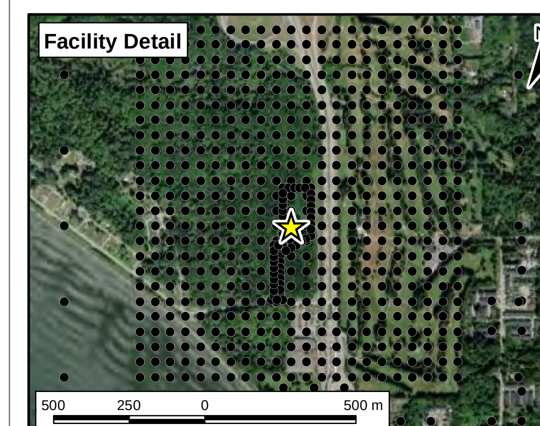
LEGEND

- Facility Location
- Receptor Point
- Model Extent
- Semiahmoo First Nation

Base Data

- Highway
- Main Road
- Local Road
- International Boundary



NOTES
Base data source:
CanVec 1:50,000
Washington State Open Data
Imagery from ESRI; Maxar (2021)

STATUS
ISSUED FOR USE

SEMIAHMOO RENEWABLE NATURAL GAS FACILITY AIR QUALITY DISPERSION MODELLING

Gridded Receptors

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	andion

Scale: 1:90,000
1 0.5 0 1
Kilometres

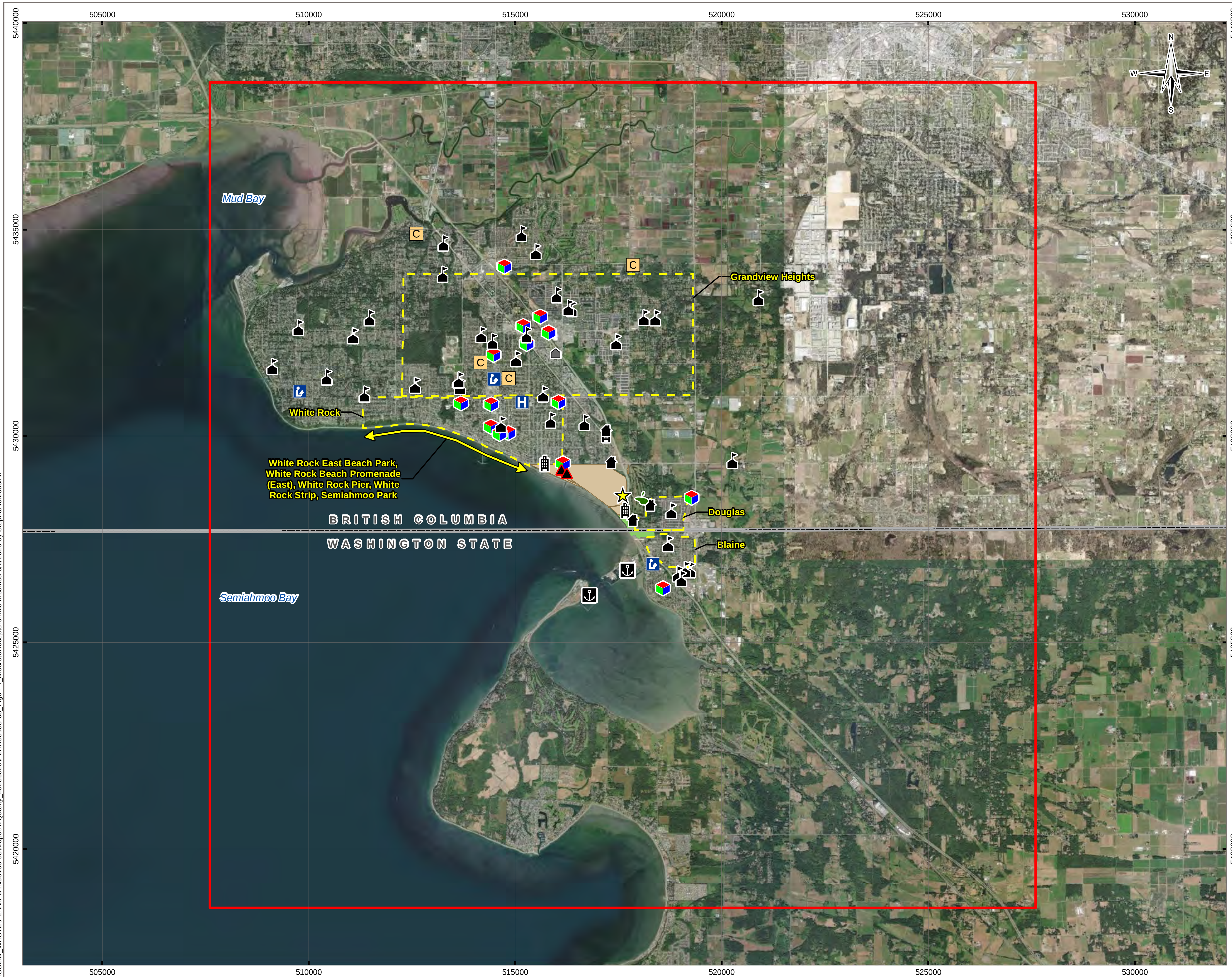
TETRA TECH

FILE NO.
PLAN03183-03_Fig04-3_GridReceptors.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	MRV	TM	0

DATE	PROJECT NO.
June 2, 2023	SWM.PLAN03183-03

Figure 4.3



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LEGEND

- Facility Location
- Model Extent

Receptor of Note

- Business
- Commercial Child Care
- Community Hall/Centre
- Golf Course
- Hospital
- Library
- Marina
- Resident
- School
- Semiahmoo First Nation
- Seniors Centre
- Residential Area
- Peace Arch Provincial Park/ Peach Arch Historical State Park
- Semiahmoo First Nation
- International Boundary

NOTES
Base data source:
City of Surrey Open Data
CanVec 1:50,000
Washington State Open Data

STATUS
ISSUED FOR USE

SEMIAHMOO RENEWABLE NATURAL GAS FACILITY AIR QUALITY DISPERSION MODELLING

Identified Discrete Receptors

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	andion

Scale: 1:90,000
1 0.5 0 1
Kilometres

TETRA TECH

FILE NO.
PLAN03183-03_Fig04-4_DiscreteReceptors.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	MRV	TM	0

DATE	PROJECT NO.
June 2, 2023	SWM.PLAN03183-03

Figure 4.4

LEGEND

- Building
- Site Boundary
- Semiahmoo First Nation

NO_2 Concentration (µg/m^3)

- 75 - 79
- 79 - 100
- 100 - 113
- 113 - 125
- 125 - 150
- > 150
- 79 µg/m^3 (CAAQS (2025) Criteria)
- 113 µg/m^3 (Metro Vancouver Objective)

Base Data

- Highway
- Main Road
- International Boundary

NOTES

1. Concentrations are inclusive of an assumed representative background NO_2 concentration of 69.0 µg/m^3 (Surrey East 2017-2019).
2. The Metro Vancouver Objective for 1-Hr NO_2 is 113 µg/m^3.
3. The CAAQS (2025) Criteria for 1-Hr NO_2 is 79 µg/m^3.
4. Achievement based on annual 98th percentile of the daily 1-hour maximum, averaged over three consecutive years.

Base data source:
CanVec 1:50,000
Washington State Open Data
Imagery from ESRI; Maxar (2022)

STATUS
ISSUED FOR USE

SEMIAHMOO RENEWABLE NATURAL GAS FACILITY AIR QUALITY DISPERSION MODELLING

98th Percentile Maximum 1-Hr NO_2 Concentration (ARM2)

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	andion

Scale: 1:10,000
200 100 0 200
Metres

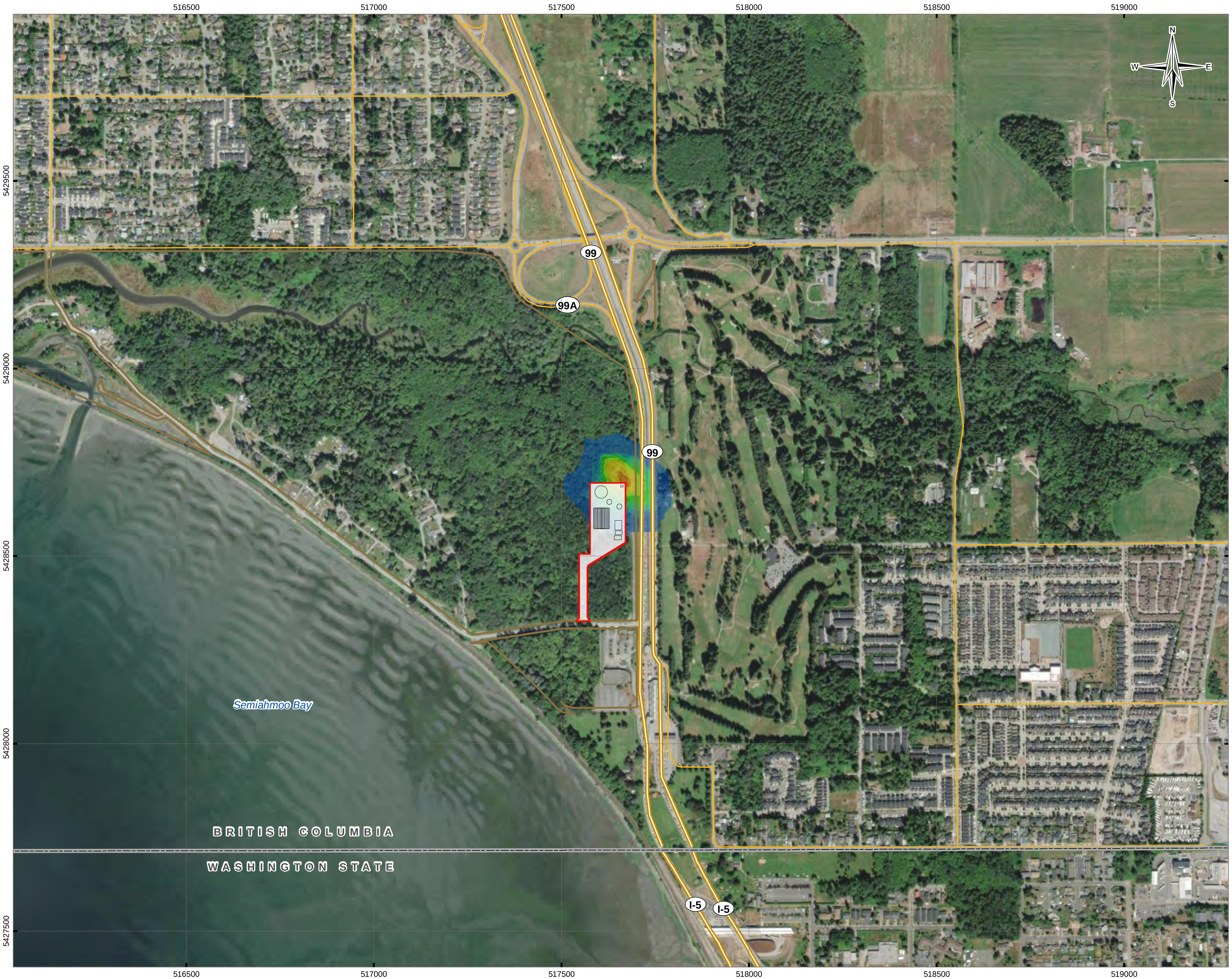
FILE NO.
PLAN03183-03_Fig05-01_NO2_98P_1HR.mxd

TETRA TECH

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	MRV	TM	0

DATE	PROJECT NO.
June 2, 2023	SWM.PLAN03183-03

Figure 5.1



LEGEND

- Building
- Site Boundary
- Semiahmoo First Nation

Annual Exceedances of NO_2 (# of occurrences/year)

- 1 - 24
- 24 - 48
- 48 - 120
- 120 - 240
- 240 - 480
- 480 - 1,200
- 1,200 - 2,400

Base Data

- Highway
- Main Road
- International Boundary

NOTES

1. Exceedances are inclusive of assumed background of 69 μg/m^3.

Base data source:
CanVec 1:50,000
Washington State Open Data
Imagery from ESRI; Maxar (2022)

STATUS
ISSUED FOR USE

SEMIAHMOO RENEWABLE NATURAL GAS FACILITY AIR QUALITY DISPERSION MODELLING

Annual Exceedances of 1-Hr Metro Vancouver NO_2 Objective (ARM2)

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	andion

Scale: 1:10,000

200 100 0 200

Metres

TETRA TECH

FILE NO.
PLAN03183-03_Fig05-02a_NO2_1HR_Ex2020.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	MRV	TM	0

DATE
June 2, 2023

PROJECT NO.
SWM.PLAN03183-03

Figure 5.2a

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LEGEND

- Building
- Site Boundary
- Semiahmoo First Nation

Annual Exceedances of NO_2 (# of occurrences/year)

- 1 - 24
- 24 - 48
- 48 - 120
- 120 - 240
- 240 - 480
- 480 - 1,200
- 1,200 - 2,400
- 2,400 - 4,800

Base Data

- Highway
- Main Road
- International Boundary

NOTES

1. Exceedances are inclusive of assumed background of 69 µg/m³.

Base data source:
CanVec 1:50,000
Washington State Open Data
Imagery from ESRI; Maxar (2022)

STATUS
ISSUED FOR USE

SEMIAHMOO RENEWABLE NATURAL GAS FACILITY AIR QUALITY DISPERSION MODELLING

Annual Exceedances of 1-Hr NO_2 2025 CAAQS (ARM2)

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	andion

Scale: 1:10,000
200 100 0 200
Metres

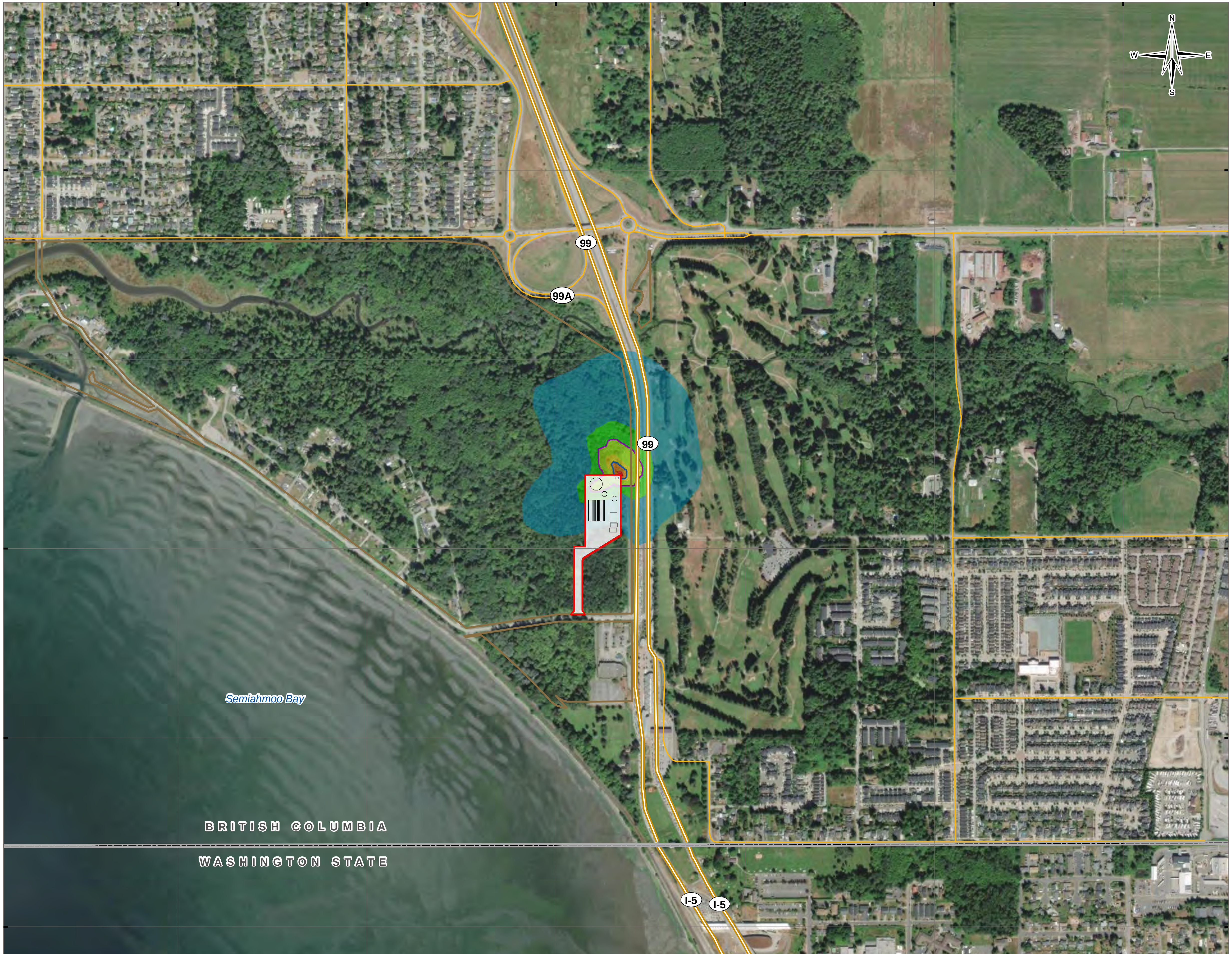
TETRA TECH

FILE NO.
PLAN03183-03_Fig05-02b_NO2_1HR_Ex2025.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	MRV	TM	0

DATE	PROJECT NO.
June 2, 2023	SWM.PLAN03183-03

Figure 5.2b



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LEGEND

- Building
- Site Boundary
- Semiahmoo First Nation

NO_2 Concentration ($\mu g/m^3$)

- 18 - 20
- 20 - 22.5
- 22.5 - 28
- 28 - 32
- 32 - 36
- 36 - 40
- 22.5 $\mu g/m^3$ (CAAQS (2025) Criteria)
- 32 $\mu g/m^3$ (Metro Vancouver Objective)

Base Data

- Highway
- Main Road
- International Boundary

NOTES

1. Concentrations are inclusive of an assumed representative background NO_2 concentration of 17.3 $\mu g/m^3$ (Surrey East 2017-2019).
2. The Metro Vancouver Objective for Annual NO_2 is 32 $\mu g/m^3$.
3. The CAAQS (2025) Criteria for Annual NO_2 is 22.5 $\mu g/m^3$.
4. Achievement based on annual average of 1-hour concentrations over one year.
5. Conservatively inclusive of continuous enclosed flaring operation. Andion has indicated approximately 900 hours of flaring per year which has not been prorated.

Base data source:
CanVec 1:50,000
Washington State Open Data
Imagery from ESRI; Maxar (2022)

STATUS
ISSUED FOR USE

SEMIAHMOO RENEWABLE NATURAL GAS FACILITY AIR QUALITY DISPERSION MODELLING

Annual NO_2 Concentration (ARM2)

PROJECTION UTM Zone 10
DATUM NAD83
CLIENT andion

Scale: 1:10,000
200 100 0 200
Metres

TETRA TECH

FILE NO. PLAN03183-03_Fig05-03_NO2_Annual.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	MRV	TM	0

DATE June 2, 2023
PROJECT NO. SWM.PLAN03183-03

Figure 5.3

G:\SOLID_WASTE\PLAN\PLAN03183-03\Maps\AirQuality_20230529\PLAN03183-03_Fig05-04_NOx_98P_1HR.mxd modified 6/2/2023 by Stephanie.Leusink

LEGEND

- Building
- Site Boundary
- Semiahmoo First Nation

NO_2 Concentration (µg/m^3)

- 75 - 79
- 79 - 100
- 100 - 113
- 113 - 125
- 125 - 150
- > 150
- 79 µg/m^3 (CAAQS (2025) Criteria)
- 113 µg/m^3 (Metro Vancouver Objective)

Base Data

- Highway
- Main Road
- International Boundary

NOTES

1. Concentrations are inclusive of an assumed representative background NO_2 concentration of 69.0 µg/m^3 (Surrey East 2017-2019).
2. The Metro Vancouver Objective for 1-Hr NO_2 is 113 µg/m^3.
3. The CAAQS (2025) Criteria for 1-Hr NO_2 is 79 µg/m^3.
4. Achievement based on annual 98th percentile of the daily 1-hour maximum, averaged over three consecutive years.

Base data source:
CanVec 1:50,000
Washington State Open Data
Imagery from ESRI; Maxar (2022)

STATUS
ISSUED FOR USE

SEMIAHMOO RENEWABLE NATURAL GAS FACILITY AIR QUALITY DISPERSION MODELLING

98th Percentile Maximum 1-Hr NO_2 Concentration (100% NO_x Conversion)

PROJECTION UTM Zone 10
DATUM NAD83
CLIENT andion

Scale: 1:10,000
200 100 0 200
Metres

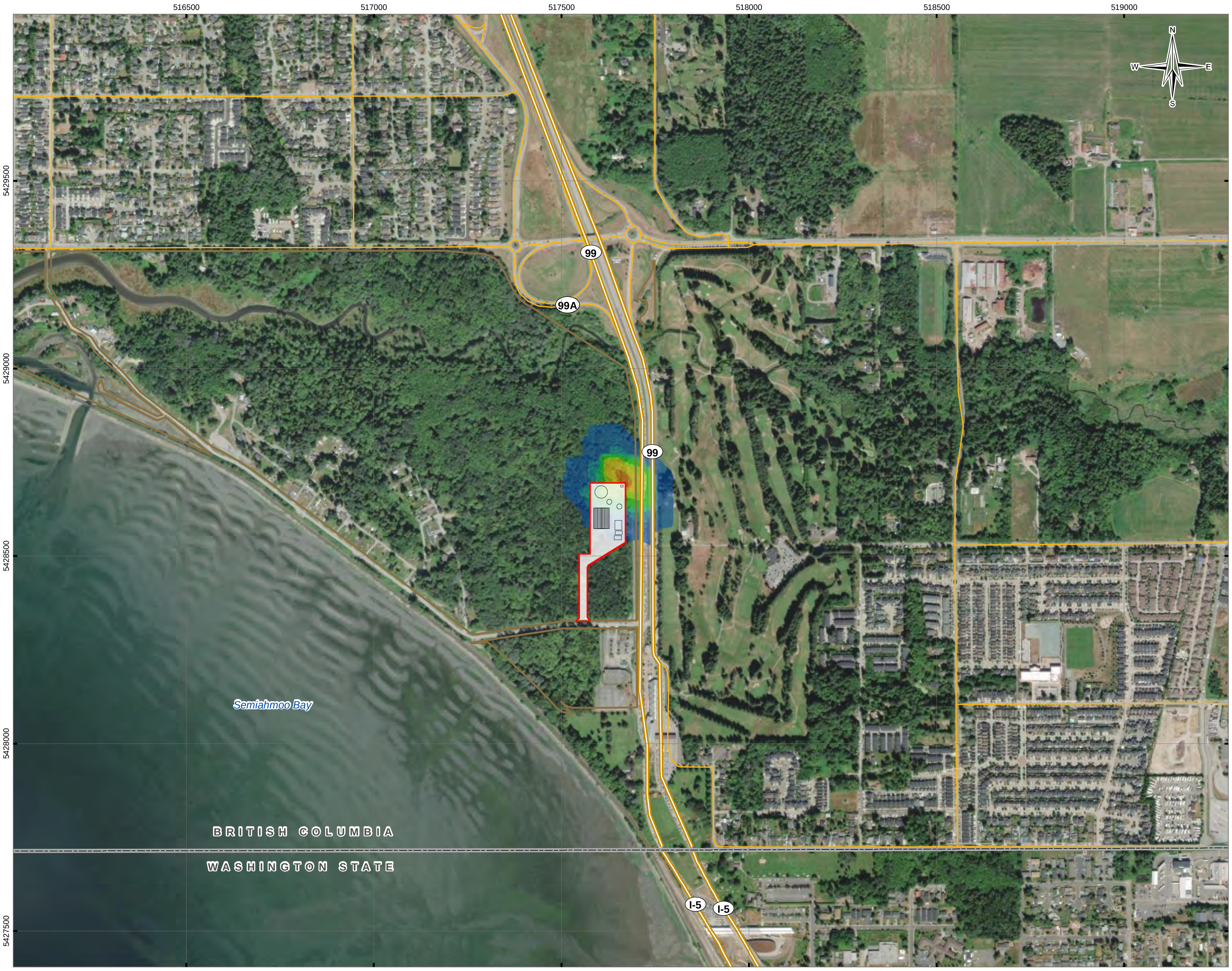
FILE NO. PLAN03183-03_Fig05-04_NOx_98P_1HR.mxd

TETRA TECH

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	MRV	TM	0

DATE June 2, 2023
PROJECT NO. SWM.PLAN03183-03

Figure 5.4



LEGEND

- Building
- Site Boundary
- Semiahmoo First Nation

Annual Exceedances of NO_2 (# of occurrences/year)

- 1 - 24
- 24 - 48
- 48 - 120
- 120 - 240
- 240 - 480
- 480 - 1,200
- 1,200 - 2,400

Base Data

- Highway
- Main Road
- International Boundary

NOTES

1. Exceedances are inclusive of assumed background of 69 µg/m³.

Base data source:
CanVec 1:50,000
Washington State Open Data
Imagery from ESRI; Maxar (2022)

STATUS
ISSUED FOR USE

SEMIAHMOO RENEWABLE NATURAL GAS FACILITY AIR QUALITY DISPERSION MODELLING

Annual Exceedances of 1-Hr Metro Vancouver NO_2 Objective ($100\%\ NO_x$ Conversion)

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	andion

Scale: 1:10,000

200 100 0 200

Metres

TETRA TECH

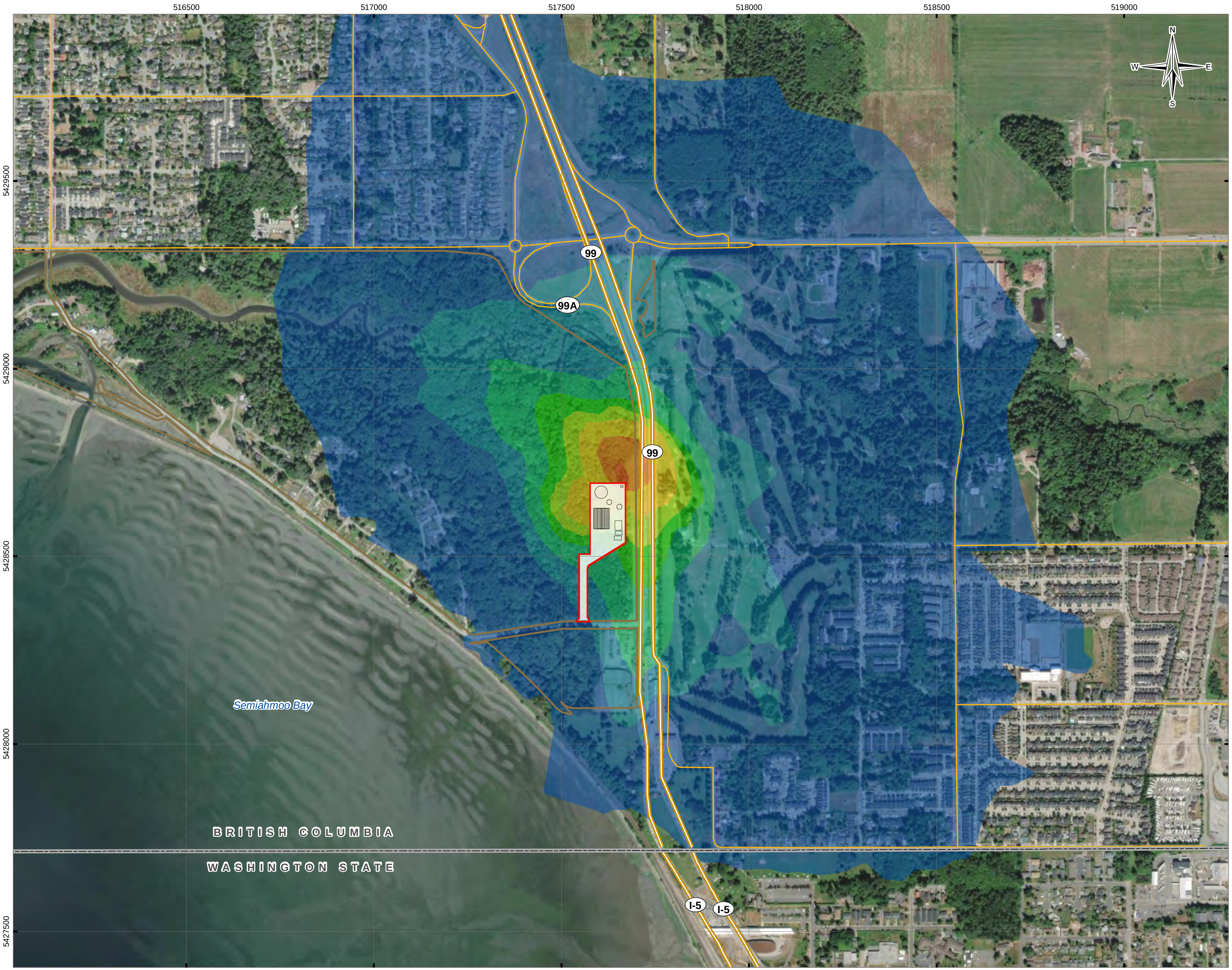
FILE NO.
PLAN03183-03_Fig05-05a_NOx_1HR_Ex2020.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	MRV	TM	0

DATE	PROJECT NO.
June 2, 2023	SWM.PLAN03183-03

Figure 5.5a

G:\SOLID_WASTE\PLAN\PLAN03183-03\Maps\AirQuality_20230529\PLAN03183-03_Fig05-05a_NOx_1HR_Ex2020.mxd modified 6/2/2023 by Stephanie.Leusink



LEGEND

- Building
- Site Boundary
- Semiahmoo First Nation

Annual Exceedances of NO_2 (# of occurrences/year)

- 1 - 24
- 24 - 48
- 48 - 120
- 120 - 240
- 240 - 480
- 480 - 1,200
- 1,200 - 2,400
- 2,400 - 4,800

Base Data

- Highway
- Main Road
- International Boundary

NOTES

1. Exceedances are inclusive of assumed background of 69 $\mu g/m^3$.

Base data source:
CanVec 1:50,000
Washington State Open Data
Imagery from ESRI; Maxar (2022)

STATUS
ISSUED FOR USE

SEMIAHMOO RENEWABLE NATURAL GAS FACILITY AIR QUALITY DISPERSION MODELLING

Annual Exceedances of 1-Hr NO_2 2025 CAAQS (100% NO_x Conversion)

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	andion

Scale: 1:10,000

200 100 0 200

Metres

TETRA TECH

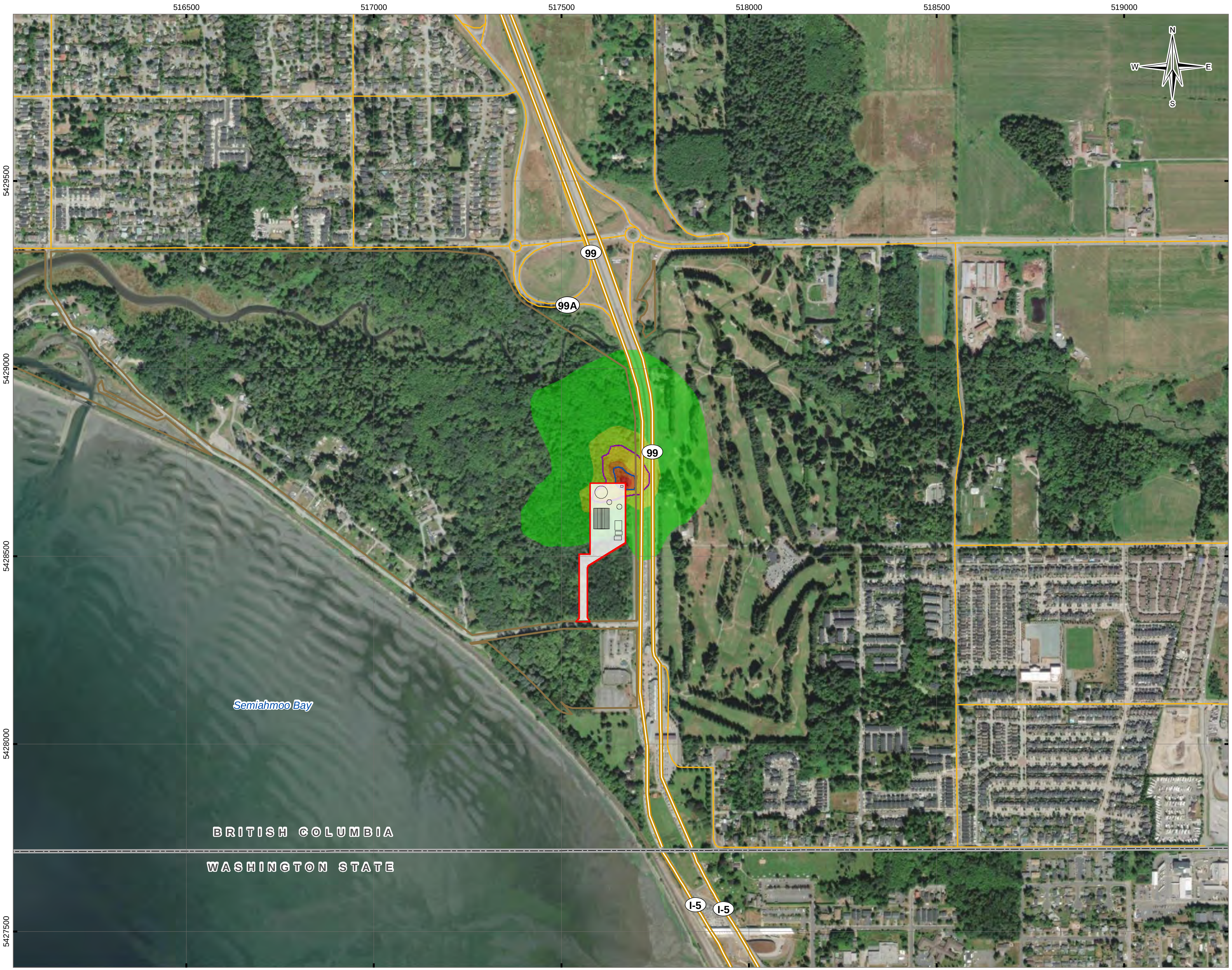
FILE NO.
PLAN03183-03_Fig05-05b_NOx_1HR_Ex2025.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	MRV	TM	0

DATE	PROJECT NO.
June 2, 2023	SWM.PLAN03183-03

Figure 5.5b

G:\SOLID_WASTE\PLAN\PLAN03183-03\Maps\AirQuality_20230529\PLAN03183-03_Fig05-05b_NOx_1HR_Ex2025.mxd modified 6/2/2023 by Stephanie.Leusink



G:\SOLID_WASTE\PLAN\PLAN03183-03\Maps\AirQuality_20230529\PLAN03183-03_Fig05-06_NOx_Annual.mxd modified 6/2/2023 by Stephanie.Leusink

LEGEND

- Building
- Site Boundary
- Semiahmoo First Nation

NO_2 Concentration (µg/m^3)

- 18 - 20
- 20 - 22.5
- 22.5 - 28
- 28 - 32
- 32 - 40
- 40 - 60
- 22.5 µg/m^3 (CAAQS Criteria)
- 32 µg/m^3 (Metro Vancouver Objective)

Base Data

- Highway
- Main Road
- International Boundary

NOTES

1. The Metro Vancouver Objective for Annual NO_2 is 32 µg/m^3
2. The CAAQS (2025) Criteria for Annual NO_2 is 22.5 µg/m^3.
3. Achievement based on annual average of 1-hour concentrations over one year.
4. Conservatively inclusive of continuous enclosed flaring operation. Andion has indicated approximately 900 hours of flaring per year which has not been prorated.

Base data source:
CanVec 1:50,000
Washington State Open Data
Imagery from ESRI; Maxar (2022)

STATUS
ISSUED FOR USE

SEMIAHMOO RENEWABLE NATURAL GAS FACILITY AIR QUALITY DISPERSION MODELLING

Annual NO_2 Concentration (100% NO_x Conversion)

PROJECTION UTM Zone 10
DATUM NAD83
CLIENT andion

Scale: 1:10,000
200 100 0 200
Metres

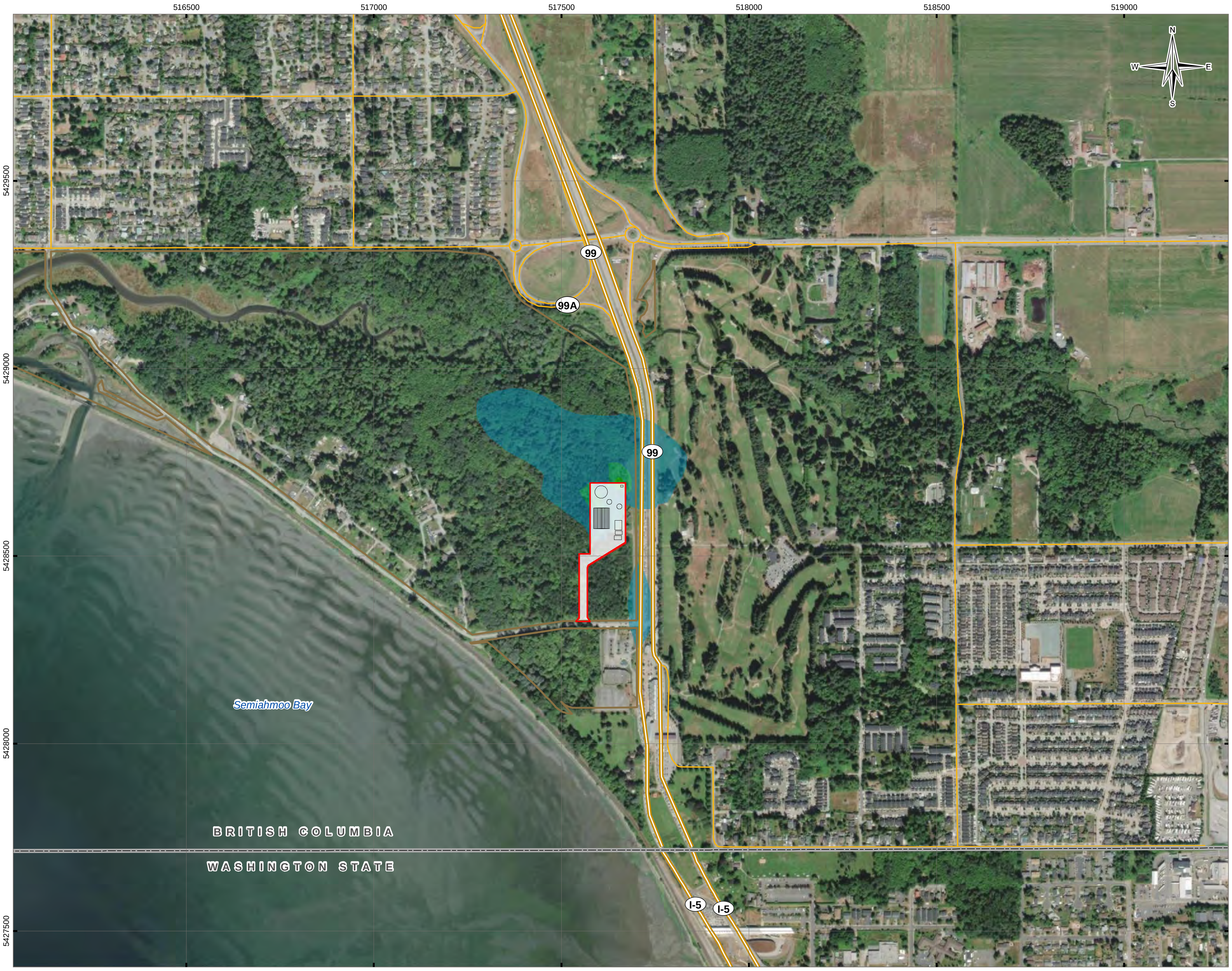
TETRA TECH

FILE NO. PLAN03183-03_Fig05-06_NOx_Annual.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	MRV	TM	0

DATE June 2, 2023
PROJECT NO. SWM.PLAN03183-03

Figure 5.6



LEGEND

- Building
- Site Boundary
- Semiahmoo First Nation

SO_2 Concentration ($\mu g/m^3$)

- 20 - 30
- 30 - 40
- 40 - 60

Base Data

- Highway
- Main Road
- International Boundary

NOTES

1. Concentrations are inclusive of an assumed representative background SO_2 concentration of 14.1 $\mu g/m^3$ (Tsawwassen 2017-2019).
2. The Metro Vancouver Objective for 1-Hr SO_2 is 183 $\mu g/m^3$.
3. Achievement based on annual 100th percentile of the daily 1-hour maximum, averaged over three consecutive years.

Base data source:
CanVec 1:50,000
Washington State Open Data
Imagery from ESRI; Maxar (2022)

STATUS
ISSUED FOR USE

SEMIAHMOO RENEWABLE NATURAL GAS FACILITY AIR QUALITY DISPERSION MODELLING

100th Percentile Maximum 1-Hr SO_2 Concentration

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	andion

Scale: 1:10,000
200 100 0 200
Metres

TETRA TECH

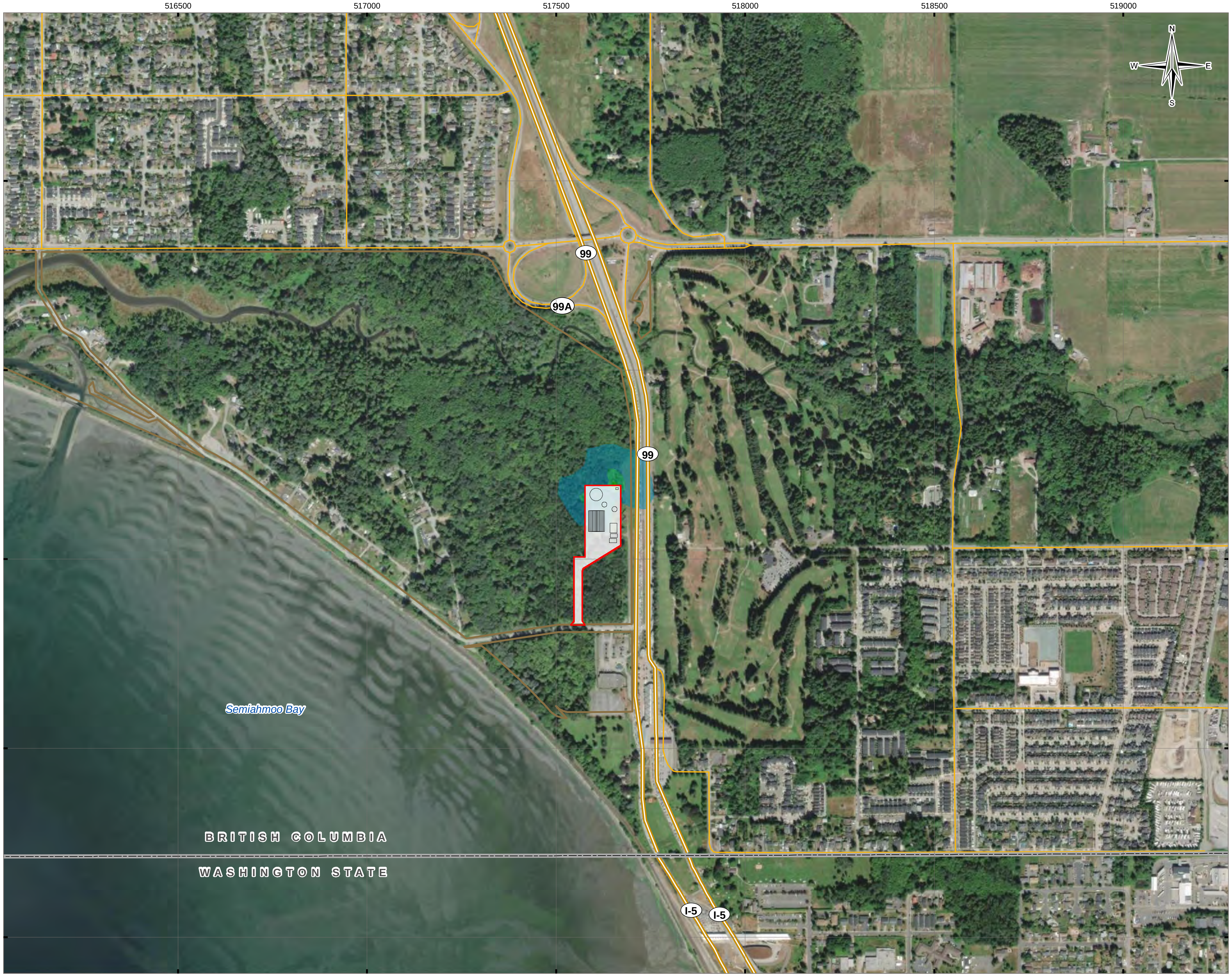
FILE NO.
PLAN03183-03_Fig05-07a_SO2_100P_1HR.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	MRV	TM	0

DATE: June 2, 2023
PROJECT NO.: SWM.PLAN03183-03

Figure 5.7a

G:\SOLID_WASTE\PLAN\PLAN03183-03\Maps\AirQuality_20230529\PLAN03183-03_Fig05-07a_SO2_100P_1HR.mxd modified 6/2/2023 by Stephanie.Leusink



G:\SOLID_WASTE\PLAN\PLAN03183-03\Maps\AirQuality_20230529\PLAN03183-03_Fig05-07b_SO2_99P_1HR.mxd modified 6/2/2023 by Stephanie.Leusink

LEGEND

- Building
- Site Boundary
- Semiahmoo First Nation

SO_2 Concentration ($\mu g/m^3$)

- 20 - 30
- 30 - 40
- 40 - 50

Base Data

- Highway
- Main Road
- International Boundary

NOTES

1. Concentrations are inclusive of an assumed representative background SO_2 concentration of 14.1 $\mu g/m^3$ (Tsawwassen 2017-2019).
2. The CAAQS (2020) Criteria for 1-Hr SO_2 is 183 $\mu g/m^3$.
3. The CAAQS (2025) Criteria for 1-Hr SO_2 is 170 $\mu g/m^3$.
4. Achievement based on annual 99th percentile of the daily 1-hour maximum, averaged over three consecutive years.

Base data source:
CanVec 1:50,000
Washington State Open Data
Imagery from ESRI; Maxar (2022)

STATUS
ISSUED FOR USE

SEMIAHMOO RENEWABLE NATURAL GAS FACILITY AIR QUALITY DISPERSION MODELLING

99th Percentile Maximum 1-Hr SO_2 Concentration

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	andion

Scale: 1:10,000
200 100 0 200
Metres

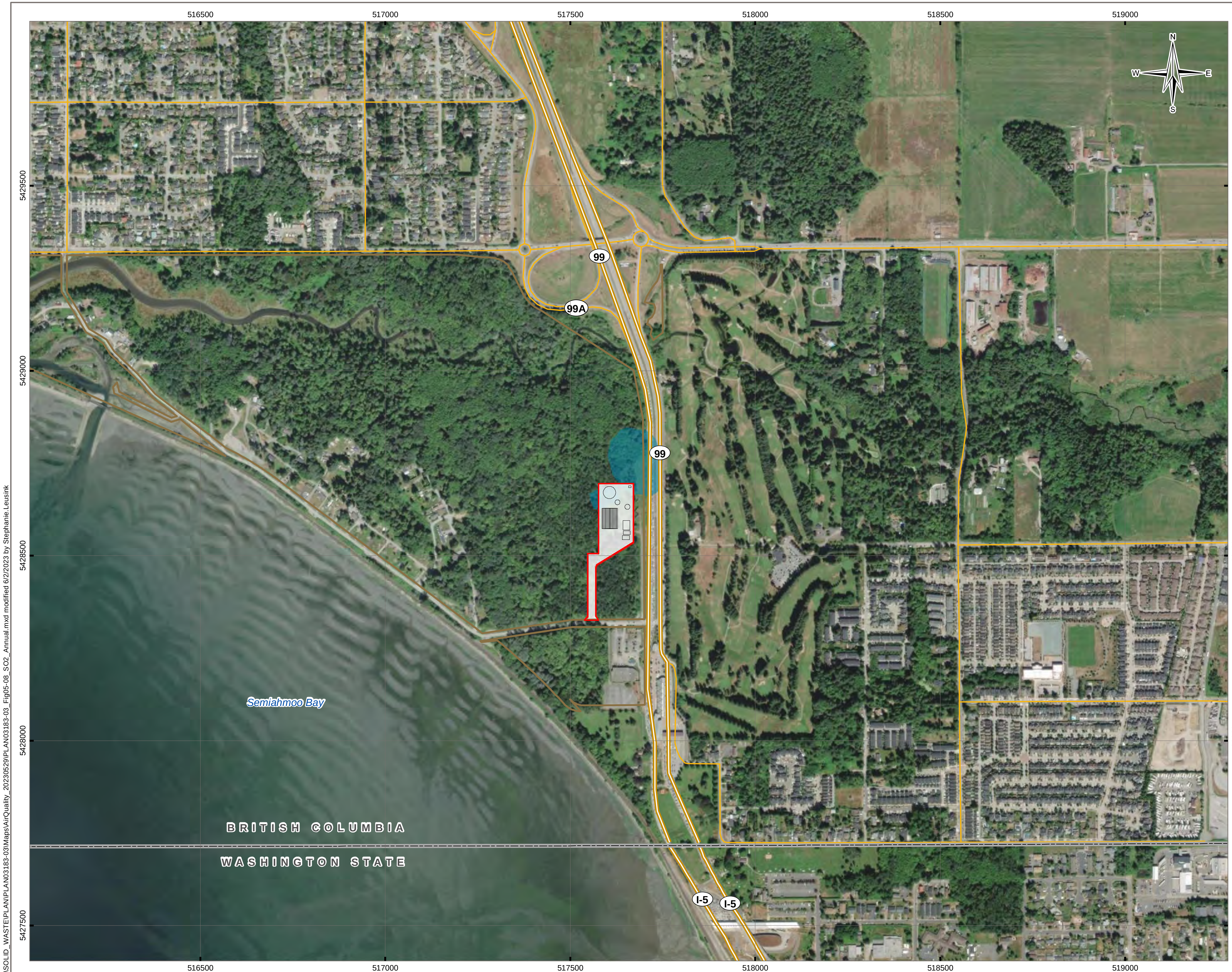
TETRA TECH

FILE NO.
PLAN03183-03_Fig05-07b_SO2_99P_1HR.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	MRV	TM	0

DATE	PROJECT NO.
June 2, 2023	SWM.PLAN03183-03

Figure 5.7b



LEGEND

Building

Site Boundary

Semiahmoo First Nation

SO_2 Concentration ($\mu g/m^3$)

1 - 2.5

Base Data

Highway

Main Road

International Boundary

NOTES

1. Concentrations are inclusive of an assumed representative background SO_2 concentration of 0.73 $\mu g/m^3$ (Tsawwassen 2017-2019).
2. The Metro Vancouver Objective for Annual SO_2 is 13 $\mu g/m^3$.
3. The CAAQS (2025) Criteria for Annual SO_2 is 10.5 $\mu g/m^3$.
4. Achievement based on annual average of 1-hour concentrations over one year.
5. Conservatively inclusive of continuous enclosed flaring operation. Andion has indicated approximately 900 hours of flaring per year which has not been prorated.

Base data source:
CanVec 1:50,000
Washington State Open Data
Imagery from ESRI; Maxar (2022)

STATUS
ISSUED FOR USE

SEMIAHMOO RENEWABLE NATURAL GAS FACILITY AIR QUALITY DISPERSION MODELLING

Annual SO_2 Concentration

PROJECTION UTM Zone 10

DATUM NAD83

CLIENT andion

Scale: 1:10,000

200 100 0 200

Metres

TETRA TECH

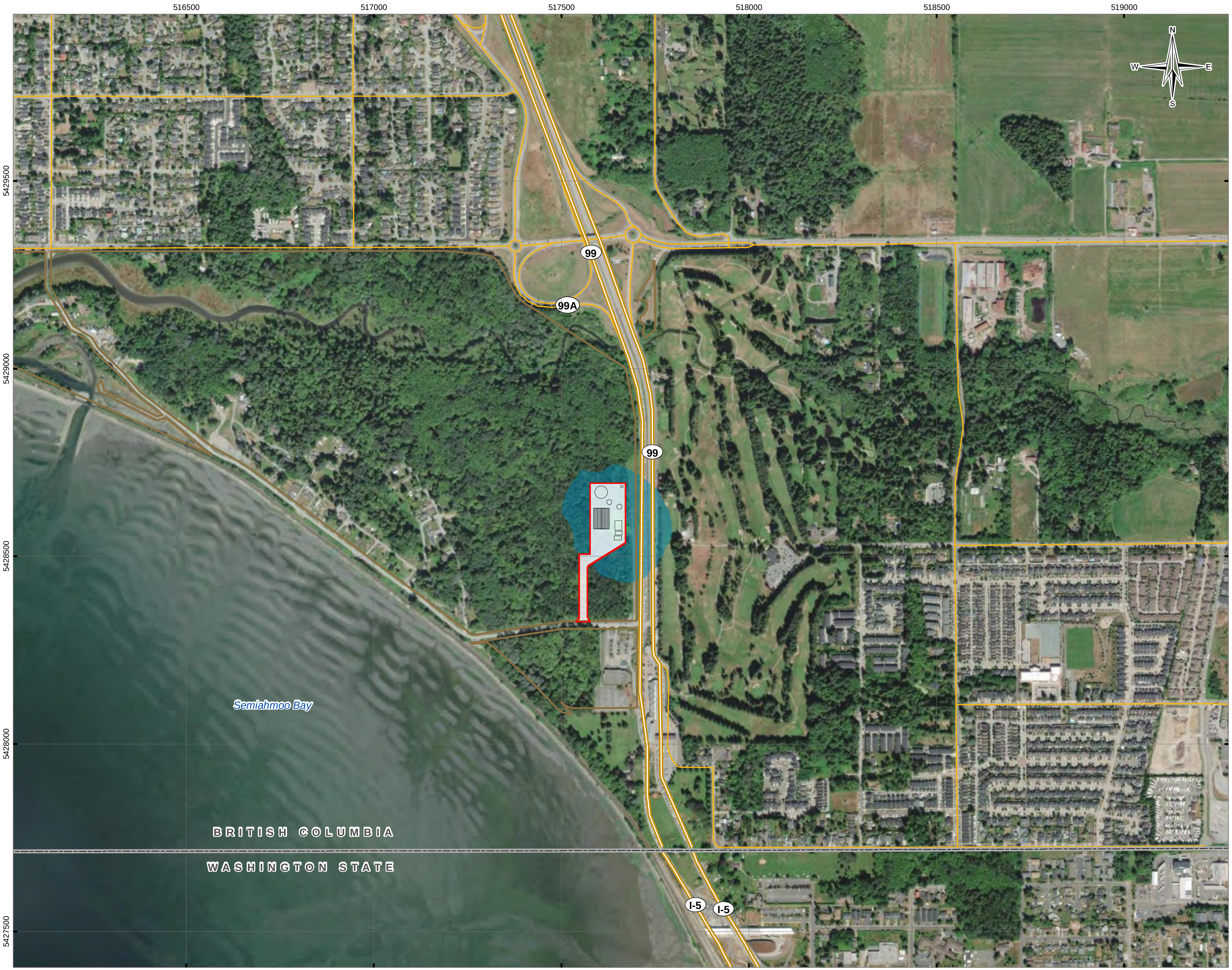
FILE NO. PLAN03183-03_Fig05-08_SO2_Annual.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	MRV	TM	0

DATE June 2, 2023

PROJECT NO. SWM.PLAN03183-03

Figure 5.8



LEGEND

- Building
- Site Boundary
- Semiahmoo First Nation

NH_3 Concentration (µg/m^3)

- 5 - 25
- 25 - 50

Base Data

- Highway
- Main Road
- International Boundary

NOTES

1. 100th percentile maximum 1-hr concentration out of three modelled years.
2. The TCEQ Short term ESL for NH_3 is 180 µg/m^3 (Health Basis).
3. The Alberta Criteria for 1-hour NH_3 is 1,400 µg/m^3 (Odour Basis).

Base data source:
CanVec 1:50,000
Washington State Open Data
Imagery from ESRI; Maxar (2022)

STATUS
ISSUED FOR USE

SEMIAHMOO RENEWABLE NATURAL GAS FACILITY AIR QUALITY DISPERSION MODELLING

Maximum 1-Hr NH_3 Concentration

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	andion

Scale: 1:10,000

200 100 0 200

Metres

FILE NO.
PLAN03183-03_Fig05-09_NH3_1HR.mxd

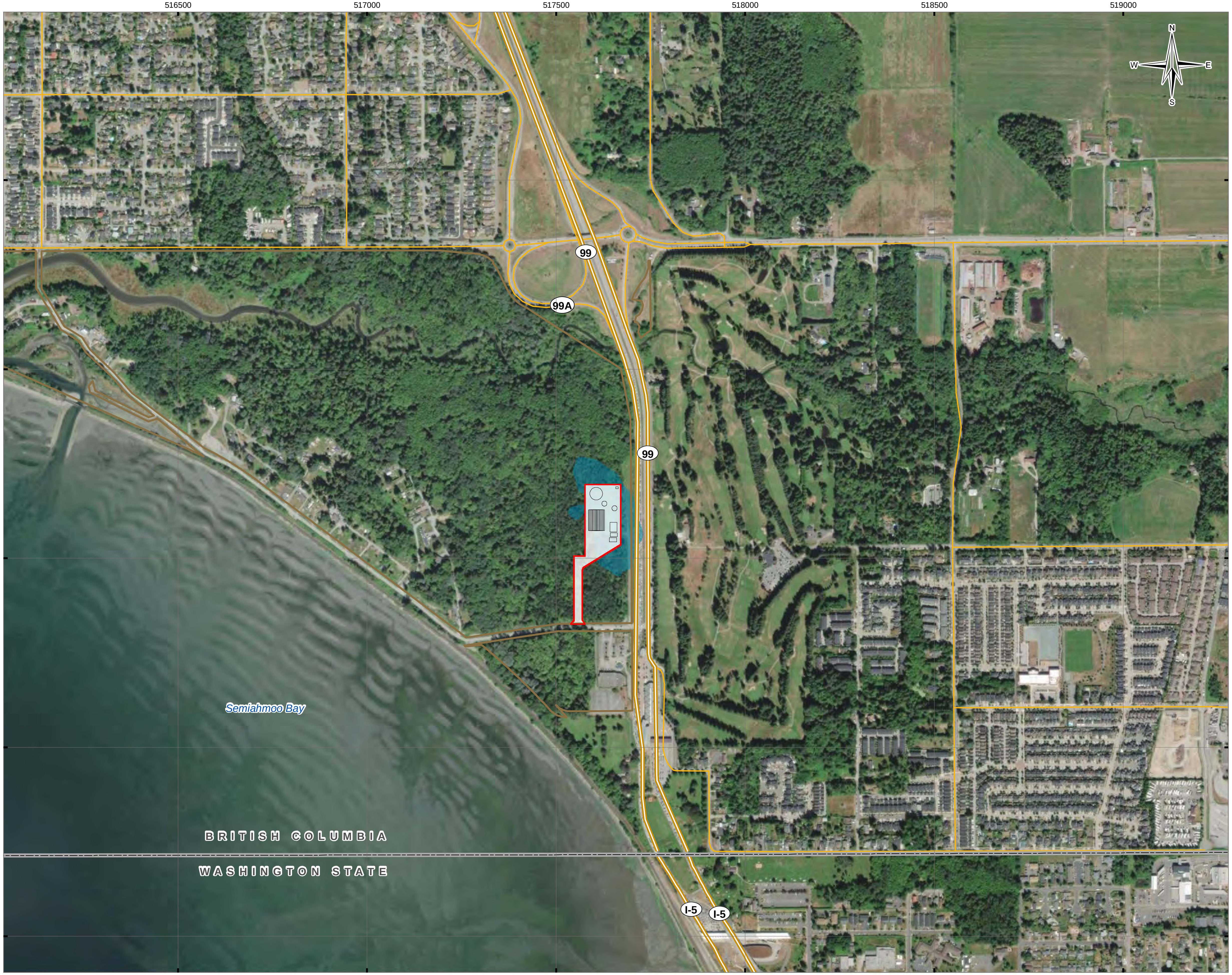
OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	MRV	TM	0

DATE	PROJECT NO.
June 2, 2023	SWM.PLAN03183-03

TETRA TECH

Figure 5.9

G:\SOLID_WASTE\PLAN\PLAN03183-03\Maps\AirQuality_20230529\PLAN03183-03_Fig05-09_NH3_1HR.mxd modified 6/2/2023 by Stephanie.Leusink



G:\SOLID_WASTE\PLAN\PLAN03183-03\Maps\AirQuality_20230529\PLAN03183-03_Fig05-10_NH3_24HR.mxd modified 6/2/2023 by Stephanie.Leusink

LEGEND

- Building
- Site Boundary
- Semiahmoo First Nation

NH_3 Concentration ($\mu g/m^3$)

- 1 - 10

Base Data

- Highway
- Main Road
- International Boundary

NOTES

1. The Ontario POI Criteria for 24-hour NH_3 is 100 $\mu g/m^3$.
2. Achievement based on highest 24-hour average of three modelled years after removal of highest 24-hour average in each year.
3. Ontario POI Standards are an assessment of facility emissions at off-property locations exclusive of cumulative background.

Base data source:
CanVec 1:50,000
Washington State Open Data
Imagery from ESRI; Maxar (2022)

STATUS
ISSUED FOR USE

SEMIAHMOO RENEWABLE NATURAL GAS FACILITY AIR QUALITY DISPERSION MODELLING

Maximum 24-Hr NH_3 Concentration

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	andion

Scale: 1:10,000
200 100 0 200
Metres

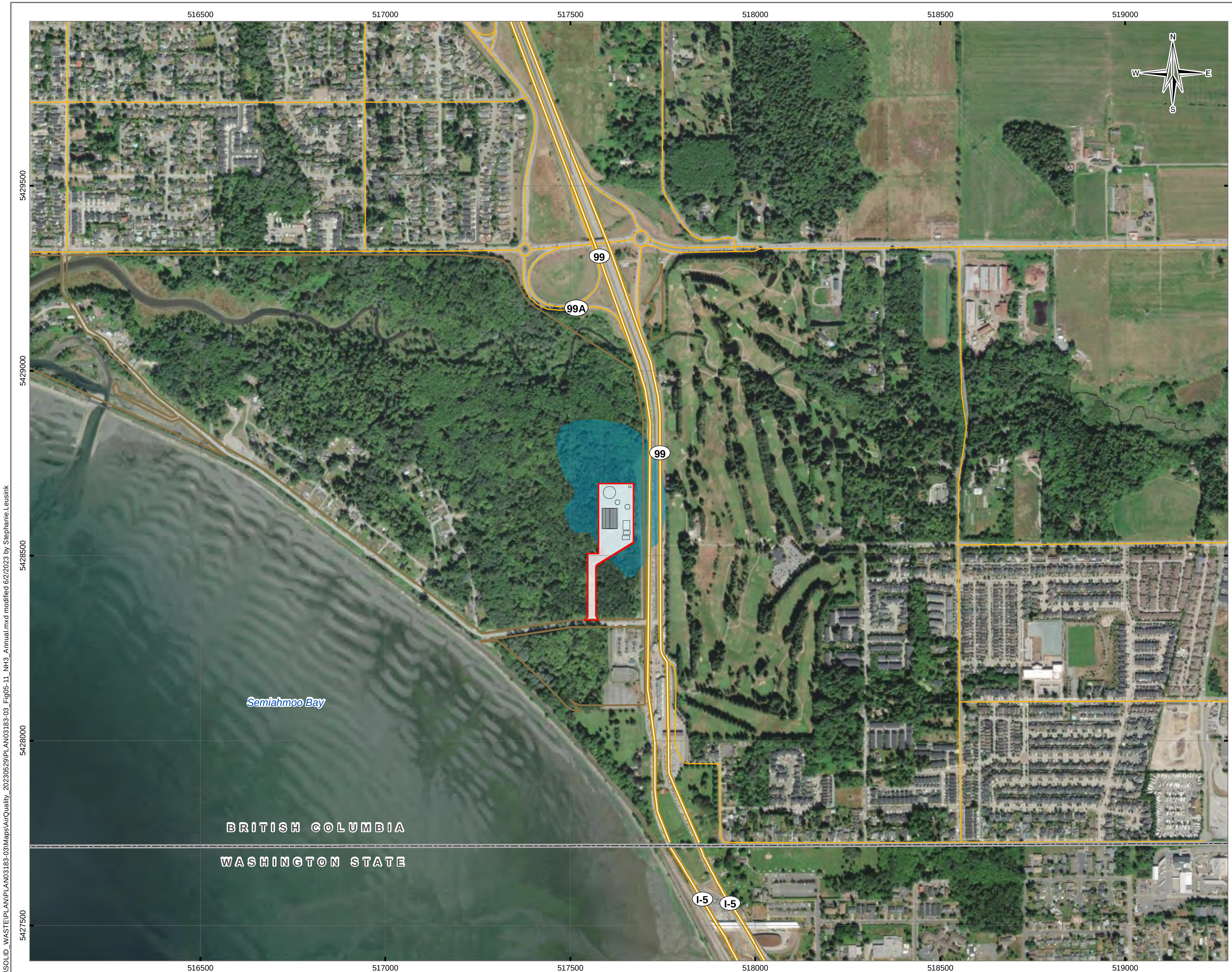
TETRA TECH

FILE NO.
PLAN03183-03_Fig05-10_NH3_24HR.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	MRV	TM	0

DATE	PROJECT NO.
June 2, 2023	SWM.PLAN03183-03

Figure 5.10



LEGEND

- Building
- Site Boundary
- Semiahmoo First Nation

NH_3 Concentration ($\mu g/m^3$)

- 0.1 - 2

Base Data

- Highway
- Main Road
- International Boundary

NOTES

1. The TCEQ Long Term (Annual) ESL for NH_3 is 92 $\mu g/m^3$.
2. Conservatively inclusive of continuous enclosed flaring operation. Andion has indicated approximately 900 hours of flaring per year which has not been prorated.

Base data source:
CanVec 1:50,000
Washington State Open Data
Imagery from ESRI; Maxar (2022)

STATUS
ISSUED FOR USE

SEMIAHMOO RENEWABLE NATURAL GAS FACILITY AIR QUALITY DISPERSION MODELLING

Maximum Annual NH_3 Concentration

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	andion

Scale: 1:10,000
200 100 0 200
Metres

TETRA TECH

FILE NO.				
PLAN03183-03_Fig05-11_NH3_Annual.mxd				
OFFICE	**DWN**	**CKD**	**APVD**	**REV**
Tt-VANC	SL	MRV	TM	0
DATE	**PROJECT NO.**			
June 2, 2023	SWM.PLAN03183-03			

Figure 5.11

LEGEND

- Building
- Site Boundary
- Semiahmoo First Nation

H_2S Concentration ($\mu g/m^3$)

- 2 - 5
- 5 - 7.5
- 7.5 - 10
- 10 - 13
- 13 - 25
- 25 - 50
- 50 - 100
- 13 $\mu g/m^3$ (Ontario Odour Basis Criteria)

Base Data

- Highway
- Main Road
- International Boundary

NOTES

1. The Ontario (Odour Basis) Criteria for 10-minute H_2S is 13 $\mu g/m^3$.
2. 10-minute average determined from hourly predictions multiplied by peak-over-mean scalar of 1.65.
3. Achievement based on highest 10-minute average of three modelled years after removal of the eight highest averages in each year.

Base data source:
CanVec 1:50,000
Washington State Open Data
Imagery from ESRI; Maxar (2022)

STATUS
ISSUED FOR USE

SEMIAHMOO RENEWABLE NATURAL GAS FACILITY AIR QUALITY DISPERSION MODELLING

Maximum 10-Minute H_2S Concentration

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	andion

Scale: 1:10,000

200 100 0 200

Metres

TETRA TECH

FILE NO.
PLAN03183-03_Fig05-12_H2S_10MIN.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	MRV	TM	0

DATE	PROJECT NO.
June 2, 2023	SWM.PLAN03183-03

Figure 5.12

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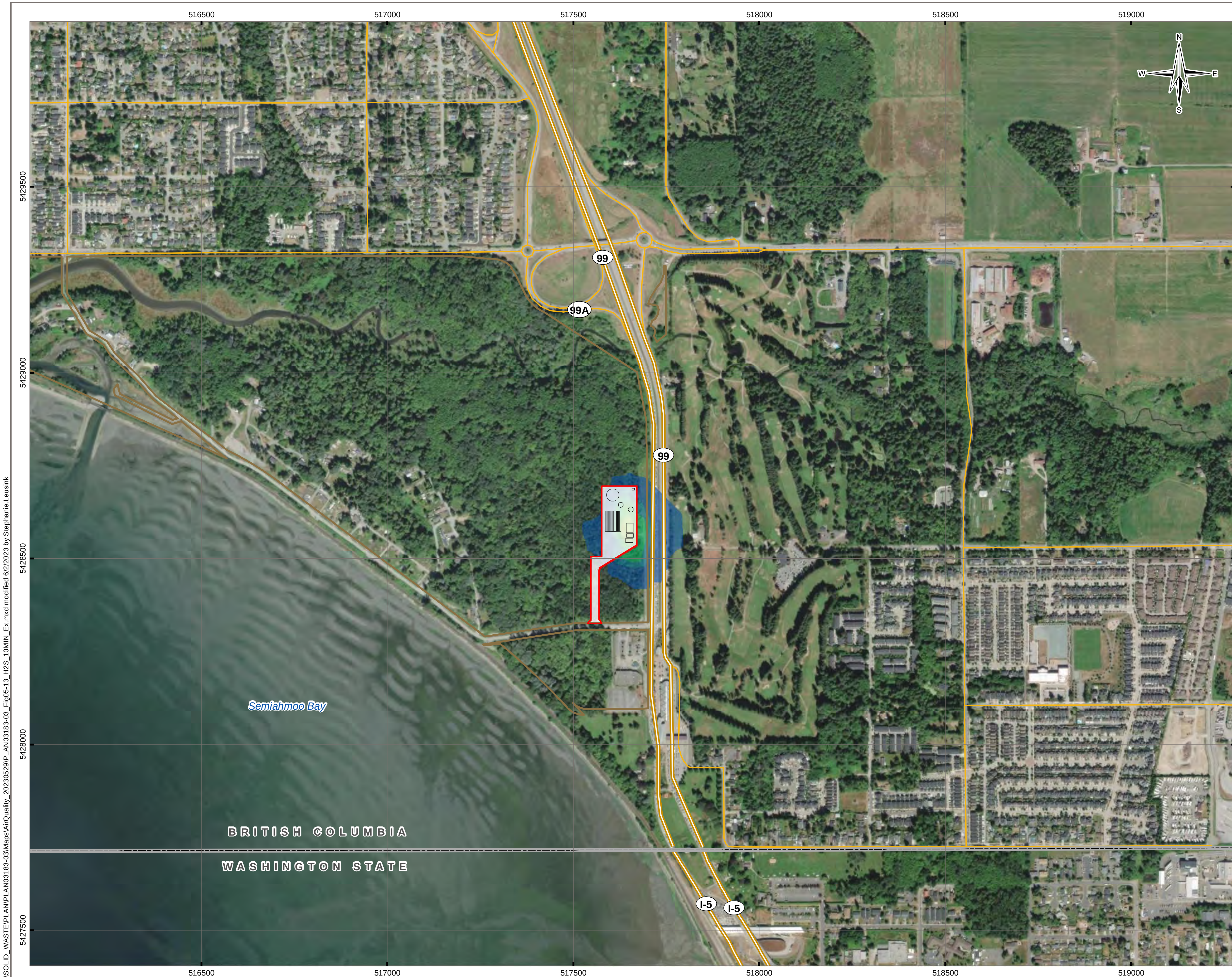


LEGEND

- Building
- Site Boundary
- Semiahmoo First Nation

Annual Exceedances of H_2S (# of occurrences/year)

- 1 - 24
- 24 - 48
- 48 - 120
- 120 - 240
- 240 - 480

Base Data

- Highway
- Main Road
- International Boundary

NOTES
Base data source:
CanVec 1:50,000
Washington State Open Data
Imagery from ESRI; Maxar (2022)

STATUS
ISSUED FOR USE

SEMIAHMOO RENEWABLE NATURAL GAS FACILITY AIR QUALITY DISPERSION MODELLING

Annual Exceedances of Ontario 10-Minute H_2S POI Criteria

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	andion

Scale: 1:10,000
200 100 0 200
Metres

TETRA TECH

FILE NO.
PLAN03183-03_Fig05-13_H2S_10MIN_Ex.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	MRV	TM	0

DATE
June 2, 2023

PROJECT NO.
SWM.PLAN03183-03

Figure 5.13

G:\SOLID_WASTE\PLAN\PLAN03183-03\Maps\AirQuality_20230529\PLAN03183-03_Fig05-14_TRS_1HR.mxd modified 6/2/2023 by Stephanie.Leusink

LEGEND

- Building
- Site Boundary
- Semiahmoo First Nation

TRS Concentration (µg/m³)

- 2 - 4
- 4 - 7
- 7 - 10
- 10 - 14
- 14 - 25
- 25 - 50
- 50 - 75
- 7 µg/m³ (Metro Vancouver Desirable Objective)
- 14 µg/m³ (Metro Vancouver Acceptable Objective)

Base Data

- Highway
- Main Road
- International Boundary

NOTES

1. The Metro Vancouver Objective for 1-hour TRS is 7 µg/m³ (Desirable) and 14 µg/m³ (Acceptable).
2. TRS is inclusive of representative sulphur fraction (2%) of biofilter VOCs.

Base data source:
CanVec 1:50,000
Washington State Open Data
Imagery from ESRI; Maxar (2022)

STATUS
ISSUED FOR USE

SEMIAHMOO RENEWABLE NATURAL GAS FACILITY AIR QUALITY DISPERSION MODELLING

Maximum 1-Hr TRS Concentration

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	andion

Scale: 1:10,000
200 100 0 200
Metres

TETRA TECH

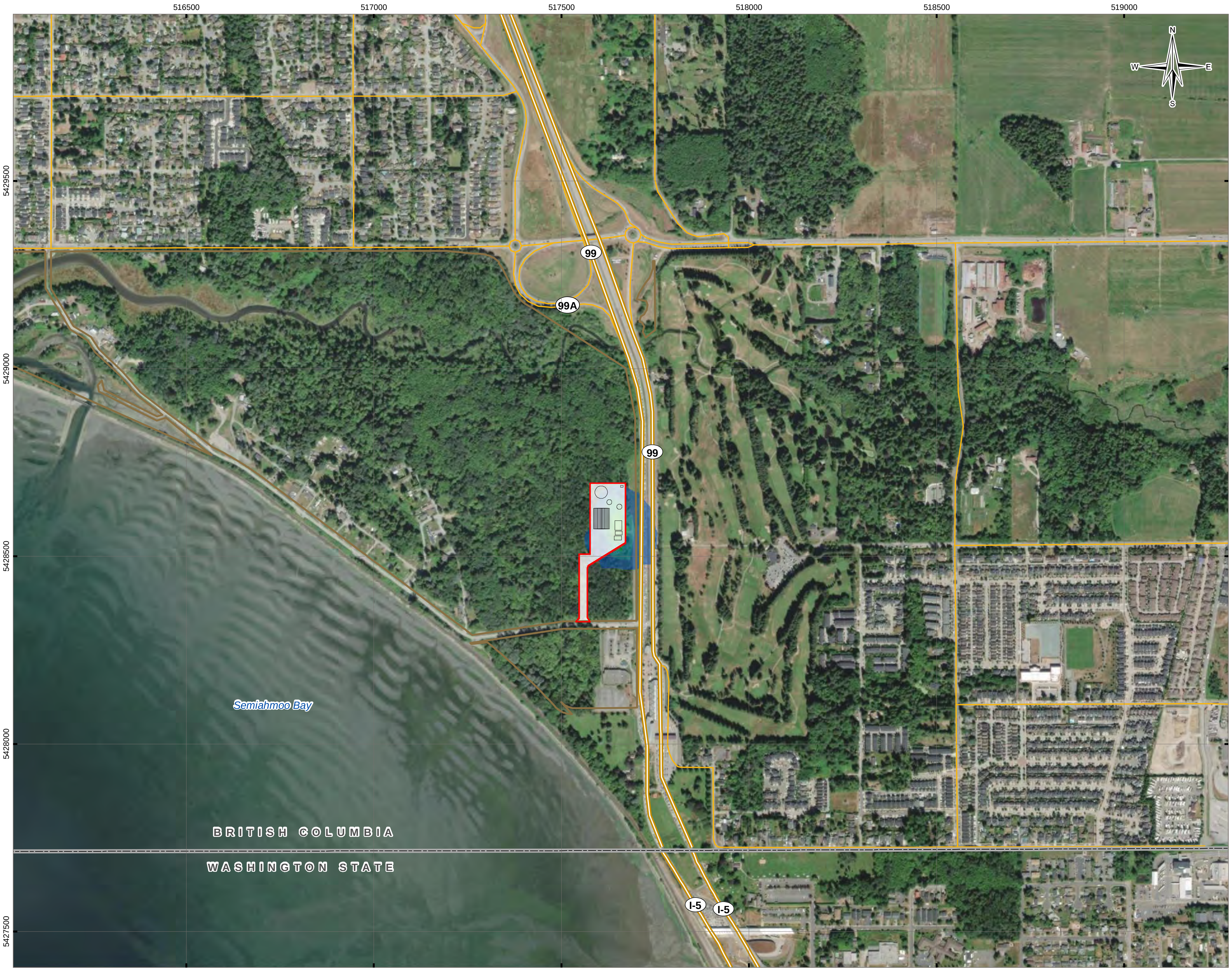
FILE NO.
PLAN03183-03_Fig05-14_TRS_1HR.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	MRV	TM	0

DATE
June 2, 2023

PROJECT NO.
SWM.PLAN03183-03

Figure 5.14



LEGEND

- Building
- Site Boundary
- Semiahmoo First Nation

Annual Exceedances of H_2S (# of occurrences/year)

- 1 - 24
- 24 - 48
- 48 - 120
- 120 - 240
- 240 - 480

Base Data

- Highway
- Main Road
- International Boundary

NOTES
Base data source:
CanVec 1:50,000
Washington State Open Data
Imagery from ESRI; Maxar (2022)

STATUS
ISSUED FOR USE

SEMIAHMOO RENEWABLE NATURAL GAS FACILITY AIR QUALITY DISPERSION MODELLING

Annual Exceedances of Metro Vancouver 1-Hr TRS Acceptable Objective

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	andion

Scale: 1:10,000
200 100 0 200
Metres

TETRA TECH

FILE NO.
PLAN03183-03_Fig05-15_TRS_1HR_Ex.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	MRV	TM	0

DATE	PROJECT NO.
June 2, 2023	SWM.PLAN03183-03

Figure 5.15

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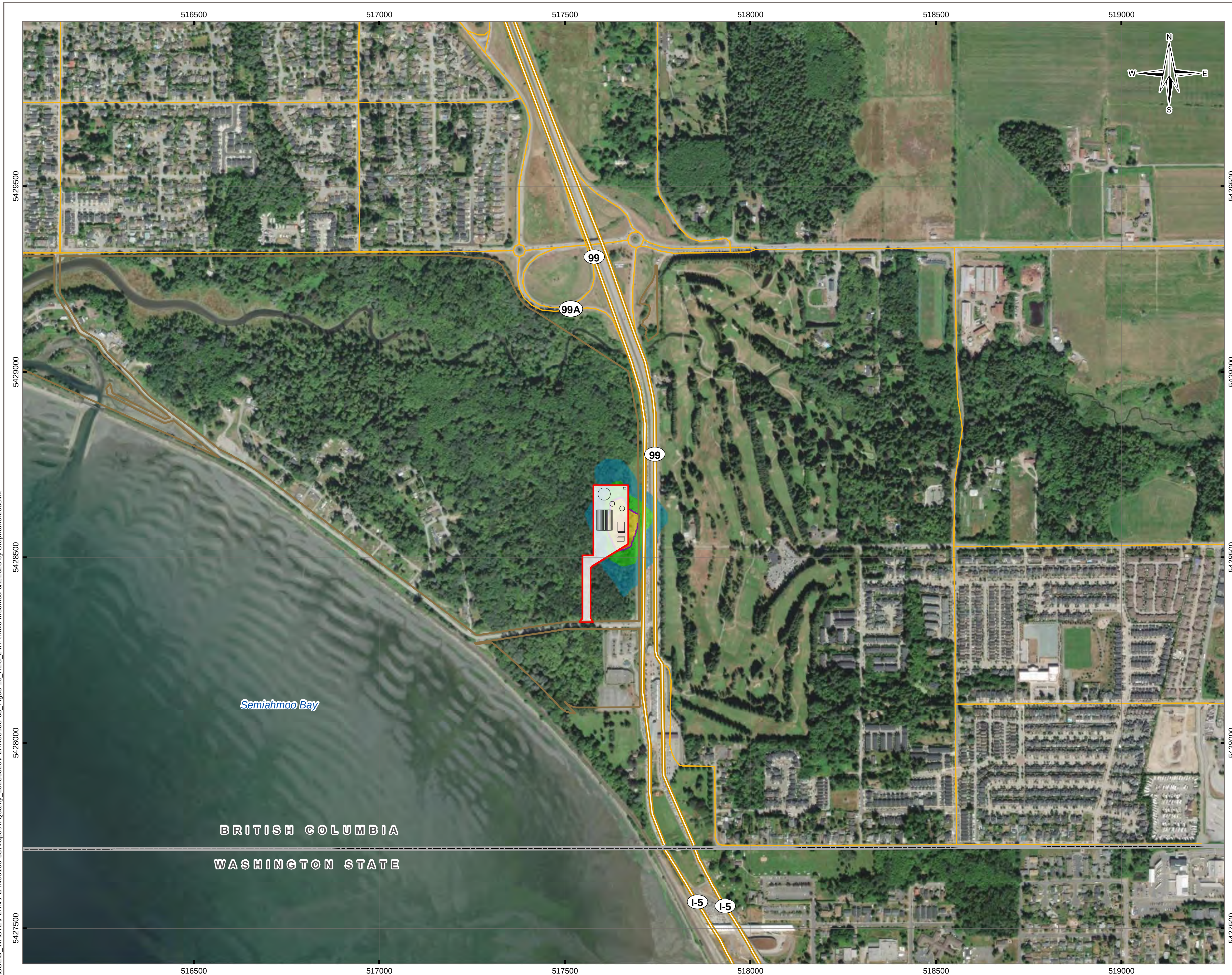


LEGEND

- Building
- Site Boundary
- Semiahmoo First Nation

H_2S Concentration ($\mu g/m^3$)

- 1 - 2
- 2 - 4
- 4 - 8
- 8 - 12
- 12 - 20
- 4 $\mu g/m^3$ (Alberta Criteria)

Base Data

- Highway
- Main Road
- International Boundary

NOTES

1. The Alberta Criteria for 24-hour H_2S is 4 $\mu g/m^3$.

Base data source:
CanVec 1:50,000
Washington State Open Data
Imagery from ESRI; Maxar (2022)

STATUS
ISSUED FOR USE

SEMIAHMOO RENEWABLE NATURAL GAS FACILITY AIR QUALITY DISPERSION MODELLING

Maximum 24-Hr H_2S Concentration

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	andion

Scale: 1:10,000

200 100 0 200

Metres

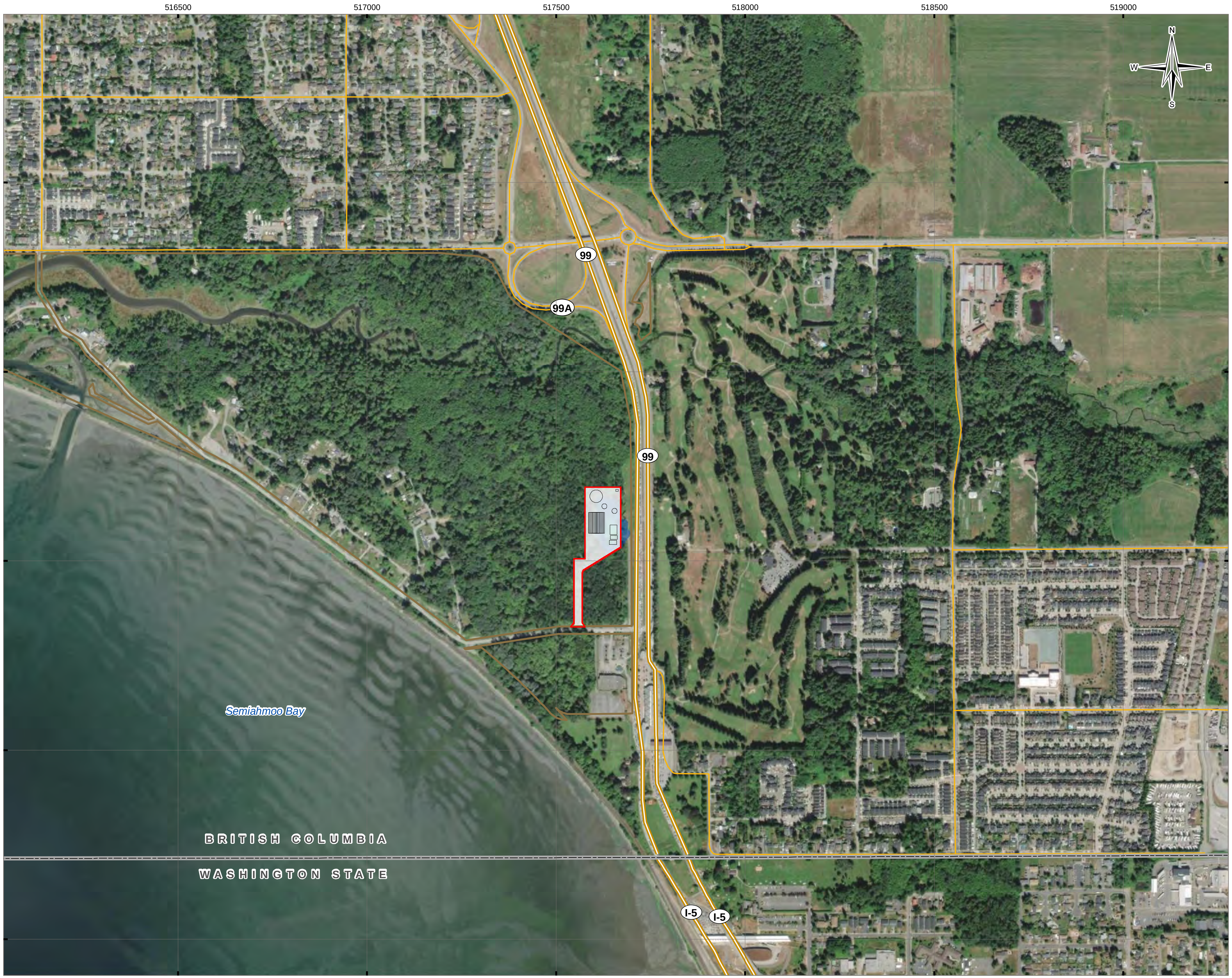
TETRA TECH

FILE NO.
PLAN03183-03_Fig05-16_H2S_24HR.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	MRV	TM	0

DATE	PROJECT NO.
June 2, 2023	SWM.PLAN03183-03

Figure 5.16



LEGEND

- Building
- Site Boundary
- Semiahmoo First Nation

Annual Exceedances of H_2S (# of occurrences/year)

- 1 - 24
- 24 - 48
- 48 - 120

Base Data

- Highway
- Main Road
- International Boundary

NOTES
Base data source:
CanVec 1:50,000
Washington State Open Data
Imagery from ESRI; Maxar (2022)

STATUS
ISSUED FOR USE

SEMIAHMOO RENEWABLE NATURAL GAS FACILITY AIR QUALITY DISPERSION MODELLING

Annual Exceedances of Alberta 24-Hr H_2S Objective

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	andion

Scale: 1:10,000
200 100 0 200
Metres

TETRA TECH

FILE NO.
PLAN03183-03_Fig05-17_H2S_24HR_Ex.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	MRV	TM	0

DATE	PROJECT NO.
June 2, 2023	SWM.PLAN03183-03

Figure 5.17

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LEGEND

- Building
- Site Boundary
- Semiahmoo First Nation

Odour Concentration (OU)

- 0.5 - 0.75
- 0.75 - 1
- 1 - 2
- 2 - 5
- 5 - 10
- > 10
- 1 OU (Quebec Guideline for Composting and Biogas Activities Criteria)
- 5 OU (Boucherville, QC By-law, all facilities)

Base Data

- Highway
- Main Road
- International Boundary

NOTES

1. The Quebec Guideline for Composting and Biogas Activities Criteria for 4-min odor is 1 OU.
2. The Boucherville, QC By-law, all facilities Criteria for 4-min odor is 5 OU.
3. Based on 98th percentile maximum at nearest sensitive receptor.

Base data source:
CanVec 1:50,000
Washington State Open Data
Imagery from ESRI; Maxar (2022)

STATUS
ISSUED FOR USE

SEMIAHMOO RENEWABLE NATURAL GAS FACILITY AIR QUALITY DISPERSION MODELLING

98th Percentile Maximum 4-Min Odour Concentration

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	andion

Scale: 1:10,000
200 100 0 200
Metres

TETRA TECH

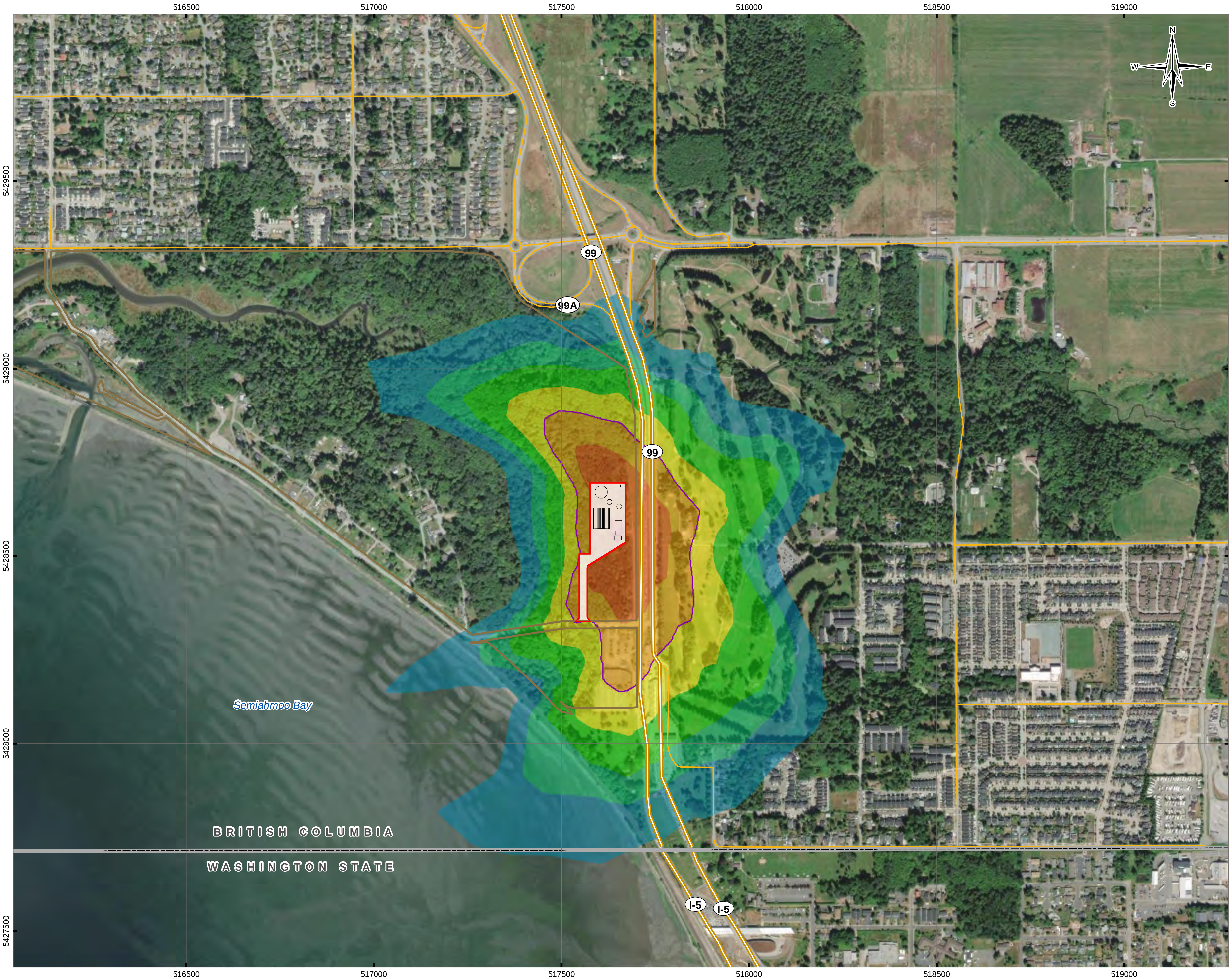
FILE NO.
PLAN03183-03_Fig05-18_Odour_98P_4MIN.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	MRV	TM	0

DATE
June 2, 2023

PROJECT NO.
SWM.PLAN03183-03

Figure 5.18



LEGEND

- Building
- Site Boundary
- Semiahmoo First Nation

Odour Concentration (OU)

- 1 - 1.5
- 1.5 - 2
- 2 - 3
- 3 - 5
- 5 - 10
- 10 - 100
- > 100
- 5 OU (Quebec Guideline for Composting and Biogas Activities Criteria)

Base Data

- Highway
- Main Road
- International Boundary

NOTES
1. The Quebec Guideline for Composting and Biogas Activities Criteria for 4-min odor is 5 OU.
2. Based on 99.5th percentile maximum at nearest sensitive receptor.

Base data source:
CanVec 1:50,000
Washington State Open Data
Imagery from ESRI; Maxar (2022)

STATUS
ISSUED FOR USE

SEMIAHMOO RENEWABLE NATURAL GAS FACILITY AIR QUALITY DISPERSION MODELLING

99.5th Percentile Maximum 4-Min Odour Concentration

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	andion

Scale: 1:10,000

200 100 0 200
Metres

TETRA TECH

FILE NO.
PLAN03183-03_Fig05-19_Odour_995P_4MIN.mxd

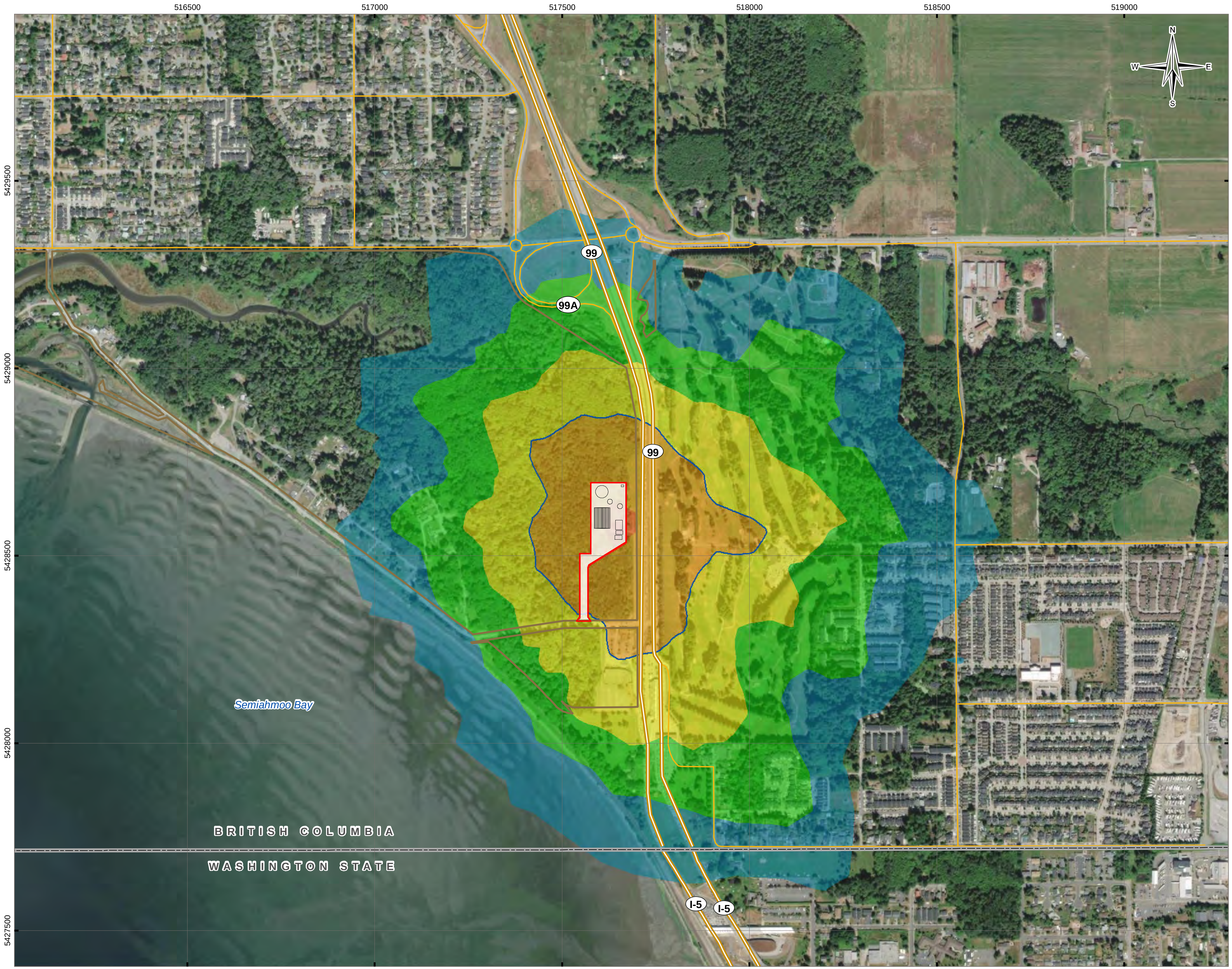
OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	MRV	TM	0

DATE
June 2, 2023

PROJECT NO.
SWM.PLAN03183-03

Figure 5.19

G:\SOLID_WASTE\PLAN\PLAN03183-03\Maps\AirQuality_20230529\PLAN03183-03_Fig05-19_Odour_995P_4MIN.mxd modified 6/2/2023 by Stephanie Leusink



LEGEND

- Building
- Site Boundary
- Semiahmoo First Nation

Odour Concentration (OU)

- 2 - 3
- 3 - 5
- 5 - 10
- 10 - 100
- 100 - 200
- > 200

Contour

- 10 OU (Boucherville, QC By-law, all facilities)

Base Data

- Highway
- Main Road
- International Boundary

NOTES

1. The Boucherville, QC By-law, all facilities Criteria for 4-min odor is 10 OU.
2. Based on 100th percentile maximum at nearest sensitive receptor and in residential areas.

Base data source:
CanVec 1:50,000
Washington State Open Data
Imagery from ESRI; Maxar (2022)

STATUS
ISSUED FOR USE

SEMIAHMOO RENEWABLE NATURAL GAS FACILITY AIR QUALITY DISPERSION MODELLING

100th Percentile Maximum 4-Min Odour Concentration

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	andion

Scale: 1:10,000

200 100 0 200

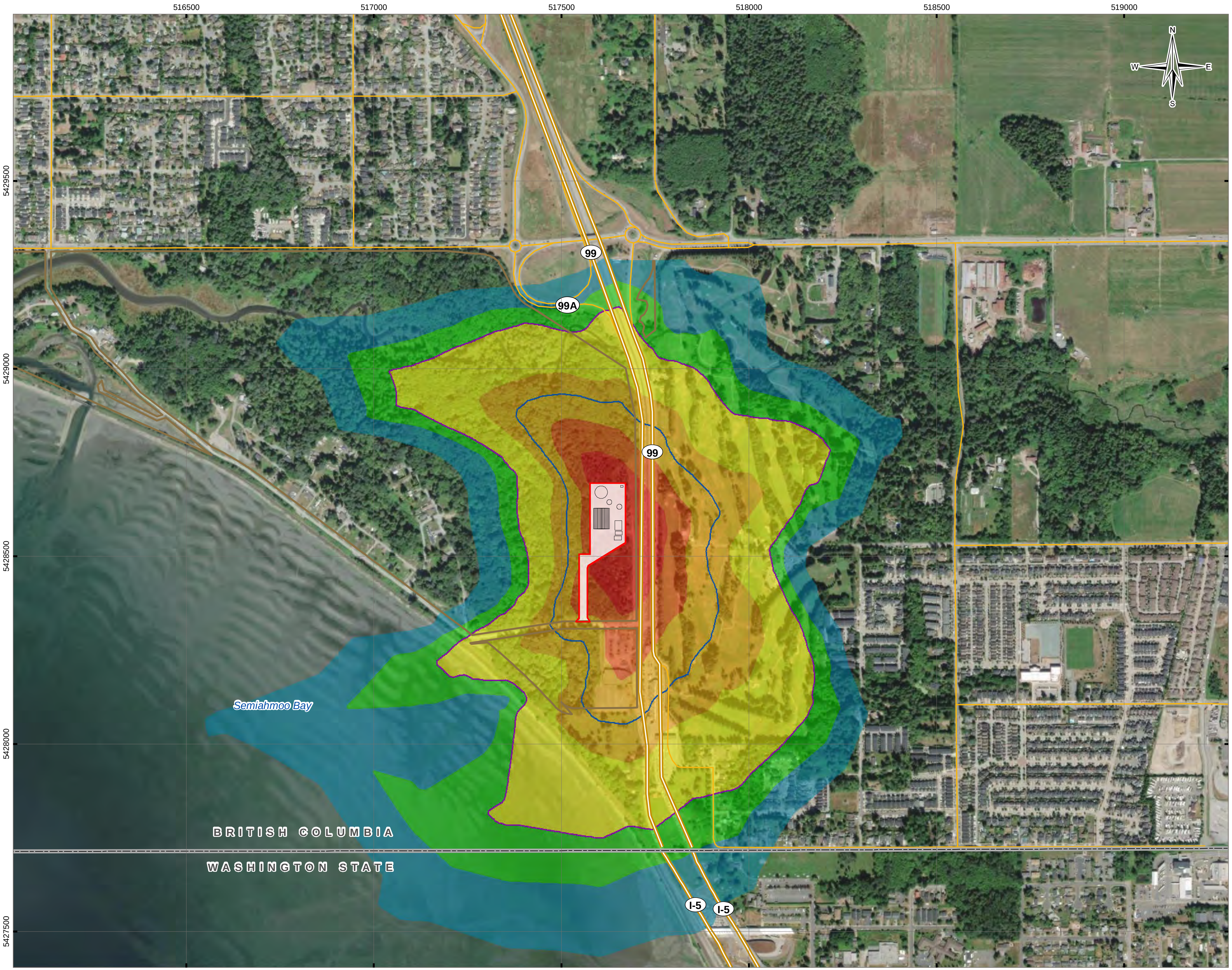
Metres

TETRA TECH

FILE NO.				
PLAN03183-03_Fig05-20_Odour_100P_4MIN.mxd				
OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	MRV	TM	0
DATE	PROJECT NO.			
June 2, 2023	SWM.PLAN03183-03			

Figure 5.20

G:\SOLID_WASTE\PLAN\PLAN03183-03\Maps\AirQuality_20230529\PLAN03183-03_Fig05-20_Odour_100P_4MIN.mxd modified 6/2/2023 by Stephanie.Leusink



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LEGEND

- Building
- Site Boundary
- Semiahmoo First Nation

Odour Concentration (OU)

- 0.5 - 0.75
- 0.75 - 1
- 1 - 2
- 2 - 5
- 5 - 10
- > 10
- 1 OU (Ontario Criteria)
- 3 OU

Base Data

- Highway
- Main Road
- International Boundary

NOTES

1. The Ontario Criteria for 10-min odor is 1 OU.
2. Based on 99.5th percentile maximum at sensitive receptors.

Base data source:
CanVec 1:50,000
Washington State Open Data
Imagery from ESRI; Maxar (2022)

STATUS
ISSUED FOR USE

SEMIAHMOO RENEWABLE NATURAL GAS FACILITY AIR QUALITY DISPERSION MODELLING

99.5th Percentile Maximum 10-Min Odour Concentration

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	andion

Scale: 1:10,000

200 100 0 200

Metres

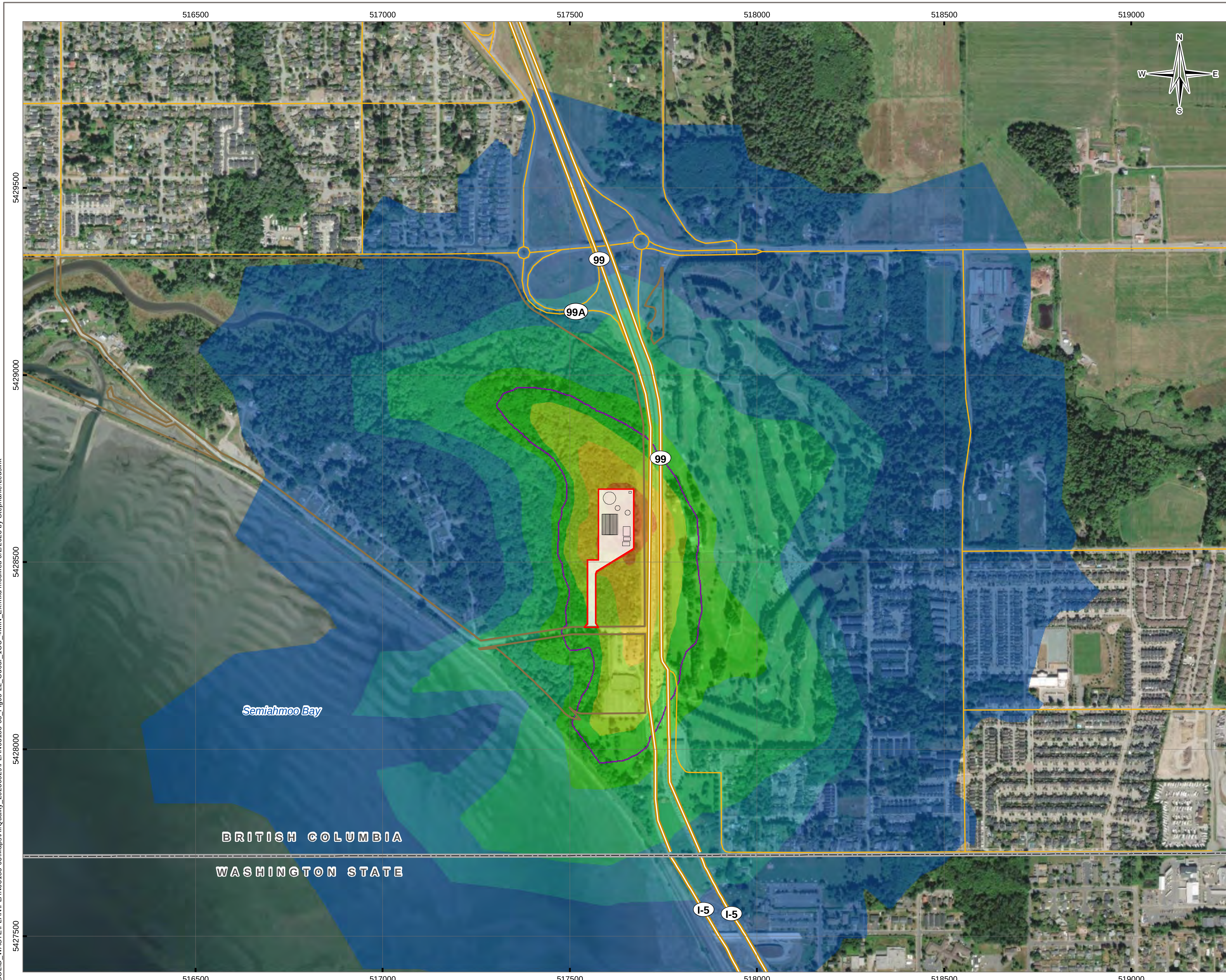
TETRA TECH

FILE NO.
PLAN03183-03_Fig05-21_Odour_995P_10MIN.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	MRV	TM	0

DATE	PROJECT NO.
June 2, 2023	SWM.PLAN03183-03

Figure 5.21



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LEGEND

- Building
- Site Boundary
- Semiahmoo First Nation

Annual Exceedances of 1 OU (# of occurrences/year)

- 1 - 24
- 24 - 48
- 48 - 120
- 120 - 240
- 240 - 480
- 480 - 1,200
- 1,200 - 2,400
- 2,400 - 4,800
- > 4,800
- 98th Percentile (173 occurrences/year)

Base Data

- Highway
- Main Road
- International Boundary

NOTES

1. 1OU is based off of Quebec (Guideline for Composting and biogas activities) 98th percentile maximum at nearest sensitive receptor.

Base data source:
CanVec 1:50,000
Washington State Open Data
Imagery from ESRI; Maxar (2022)

STATUS
ISSUED FOR USE

SEMIAHMOO RENEWABLE NATURAL GAS FACILITY AIR QUALITY DISPERSION MODELLING

Annual Exceedances of 1 OU 4-Min Odour Concentration

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	andion

Scale: 1:10,000
200 100 0 200
Metres

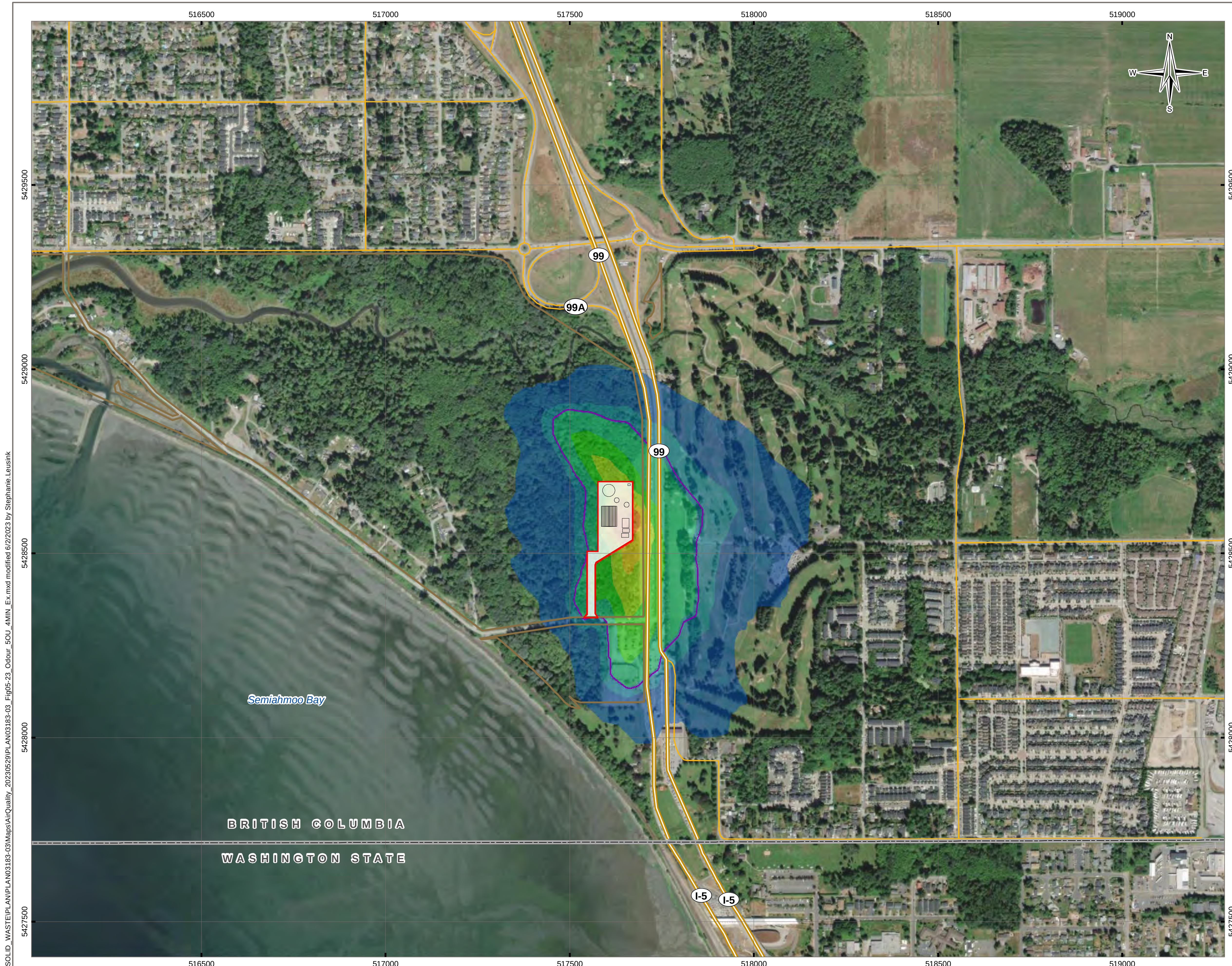
TETRA TECH

FILE NO.
PLAN03183-03_Fig05-22_Odour_1OU_4MIN_Ex.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	MRV	TM	0

DATE	PROJECT NO.
June 2, 2023	SWM.PLAN03183-03

Figure 5.22



LEGEND

- Building
- Site Boundary
- Semiahmoo First Nation

Annual Exceedances of 5 OU (# of occurrences/year)

- 1 - 24
- 24 - 48
- 48 - 120
- 120 - 240
- 240 - 480
- 480 - 1,200
- 1,200 - 2,400
- 2,400 - 4,800
- > 4,800
- 99.5th Percentile (44 occurrences/year)

Base Data

- Highway
- Main Road
- International Boundary

NOTES

1. 5OU is based off of Quebec (Guideline for Composting and biogas activities) 99.5th percentile maximum at nearest sensitive receptor.

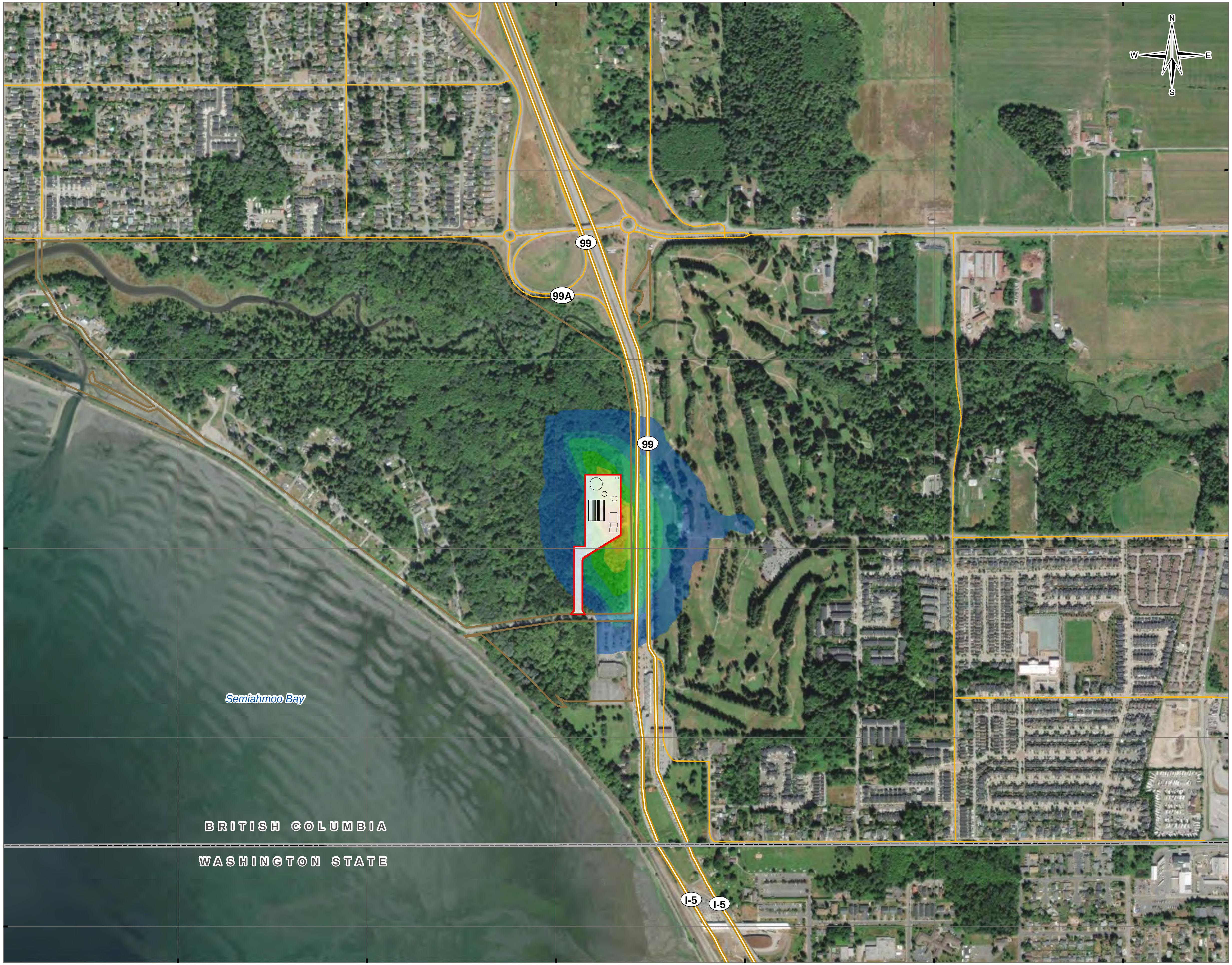
Base data source:
CanVec 1:50,000
Washington State Open Data
Imagery from ESRI; Maxar (2022)

STATUS
ISSUED FOR USE

SEMIAHMOO RENEWABLE NATURAL GAS FACILITY AIR QUALITY DISPERSION MODELLING

Annual Exceedances of 5 OU 4-Min Odour Concentration

PROJECTION		DATUM		CLIENT
UTM Zone 10		NAD83		andion
Scale: 1:10,000 (200 100 0 200 Metres)				TETRA TECH
FILE NO. PLAN03183-03_Fig05-23_Odour_5OU_4MIN_Ex.mxd				
OFFICE Tt-VANC	DWN SL	CKD MRV	APVD TM	REV 0
DATE June 2, 2023	PROJECT NO. SWM.PLAN03183-03			Figure 5.23



LEGEND

- Building
- Site Boundary
- Semiahmoo First Nation

Annual Exceedances of 10 OU (# of occurrences/year)

- 1 - 24
- 24 - 48
- 48 - 120
- 120 - 240
- 240 - 480
- 480 - 1,200
- 1,200 - 2,400
- 2,400 - 4,800

Base Data

- Highway
- Main Road
- International Boundary

NOTES

1. 10OU is based off of City of Boucherville (Quebec) Bylaw 100th percentile maximum at nearest sensitive receptor

Base data source:
CanVec 1:50,000
Washington State Open Data
Imagery from ESRI; Maxar (2022)

STATUS
ISSUED FOR USE

SEMIAHMOO RENEWABLE NATURAL GAS FACILITY AIR QUALITY DISPERSION MODELLING

Annual Exceedances of 10 OU 4-Min Odour Concentration

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	andion

Scale: 1:10,000
200 100 0 200
Metres

FILE NO.
PLAN03183-03_Fig05-24_Odour_10OU_4MIN_Ex.mxd

TETRA TECH

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	MRV	TM	0

DATE: June 2, 2023
PROJECT NO.: SWM.PLAN03183-03

Figure 5.24

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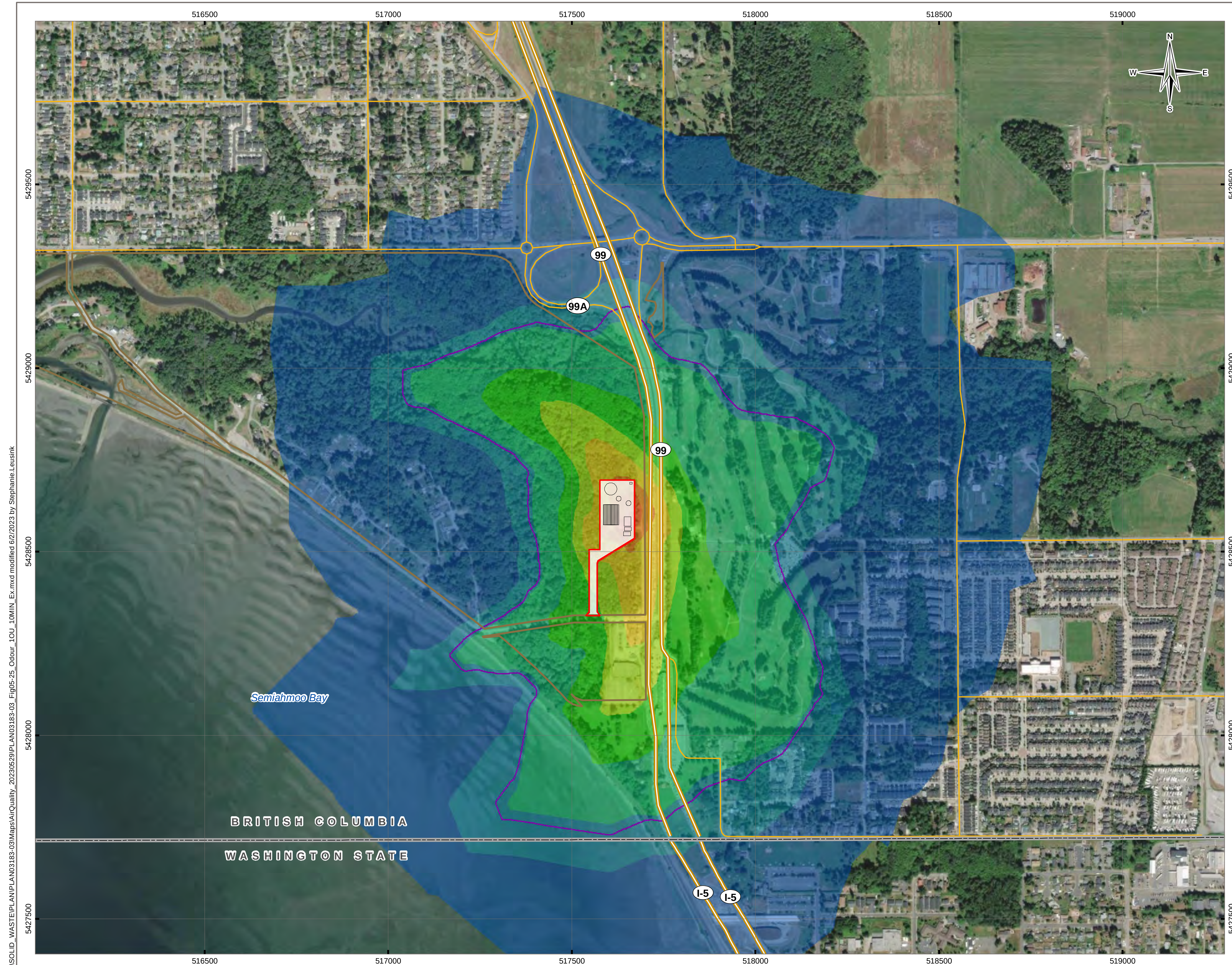


LEGEND

- Building
- Site Boundary
- Semiahmoo First Nation

Annual Exceedances of 1 OU (# of occurrences/year)

- 1 - 24
- 24 - 48
- 48 - 120
- 120 - 240
- 240 - 480
- 480 - 1,200
- 1,200 - 2,400
- 2,400 - 4,800
- > 4,800
- 99.5th Percentile (43 occurrences/year)

Base Data

- Highway
- Main Road
- International Boundary

NOTES

1. The Ontario Criteria for 10-Minute Odour is 99.5th percentile achievement of 1 OU at sensitive receptors.
2. As per Metro Vancouver Regional District Air Quality Management Fees Regulation Bylaw No. 1330, 2021, Odorous Air Contaminant Emission Fees may be reduced by 75% if it can be demonstrated through approved dispersion modelling that one odour unit can be achieved at the nearest odorous air contaminant sensitive receptor location 99.5% of the time based on a ten-minute average of authorized maximum (permitted) emissions.

Base data source:
CanVec 1:50,000
Washington State Open Data
Imagery from ESRI; Maxar (2022)

STATUS
ISSUED FOR USE

SEMIAHMOO RENEWABLE NATURAL GAS FACILITY AIR QUALITY DISPERSION MODELLING

Annual Exceedances of 1 OU 10-Min Odour Concentration

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	andion

Scale: 1:10,000

200 100 0 200

Metres

TETRA TECH

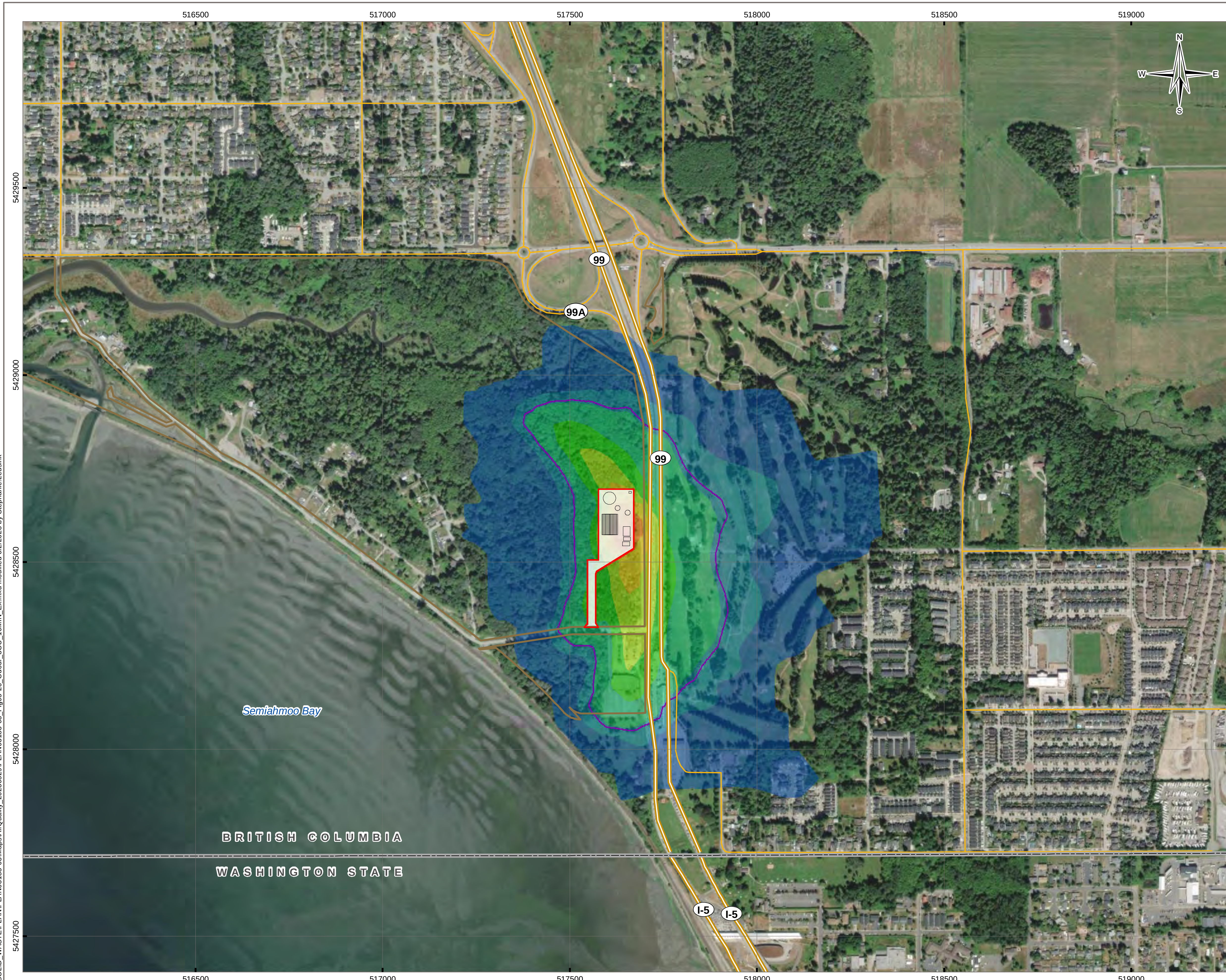
FILE NO.
PLAN03183-03_Fig05-25_Odour_1OU_10MIN_Ex.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	MRV	TM	0

DATE
June 2, 2023

PROJECT NO.
SWM.PLAN03183-03

Figure 5.25



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LEGEND

- Building
- Site Boundary
- Semiahmoo First Nation

Annual Exceedances of 3 OU (# of occurrences/year)

- 1 - 24
- 24 - 48
- 48 - 120
- 120 - 240
- 240 - 480
- 480 - 1,200
- 1,200 - 2,400
- 2,400 - 4,800
- > 4,800
- 99.5th Percentile (43 occurrences/year)

Base Data

- Highway
- Main Road
- International Boundary

NOTES

1. As per Metro Vancouver Regional District Air Quality Management Fees Regulation Bylaw No. 1330, 2021, Odorous Air Contaminant Emission Fees may be reduced by 50% if it can be demonstrated through approved dispersion modelling that three odour units can be achieved at the nearest odorous air contaminant sensitive receptor location 99.5% of the time based on a ten-minute average of authorized maximum (permitted) emissions.

Base data source:
CanVec 1:50,000
Washington State Open Data
Imagery from ESRI; Maxar (2022)

STATUS
ISSUED FOR USE

SEMIAHMOO RENEWABLE NATURAL GAS FACILITY AIR QUALITY DISPERSION MODELLING

Annual Exceedances of 3 OU
10-Min Odour Concentration

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	andion

Scale: 1:10,000
200 100 0 200
Metres

TETRA TECH

FILE NO.
PLAN03183-03_Fig05-26_Odour_3OU_10MIN_Ex.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	MRV	TM	0

DATE	PROJECT NO.
June 2, 2023	SWM.PLAN03183-03

Figure 5.26

LEGEND

- Building
- Site Boundary
- Semiahmoo First Nation

Percentage of Exceedances of 1 OU that Occurred in Spring/Summer

- 10% - 20%
- 20% - 30%
- 30% - 40%
- 40% - 50%
- 50% - 60%
- 60% - 80%

Base Data

- Highway
- Main Road
- International Boundary

NOTES

1. Locations with 10 exceedance occurances or less are not shown.

Base data source:
CanVec 1:50,000
Washington State Open Data
Imagery from ESRI; Maxar (2022)

STATUS
ISSUED FOR USE

SEMIAHMOO RENEWABLE NATURAL GAS FACILITY AIR QUALITY DISPERSION MODELLING

Percentage of Exceedances of 1 OU that Occurred in Spring/Summer 4-Min Odour Concentration

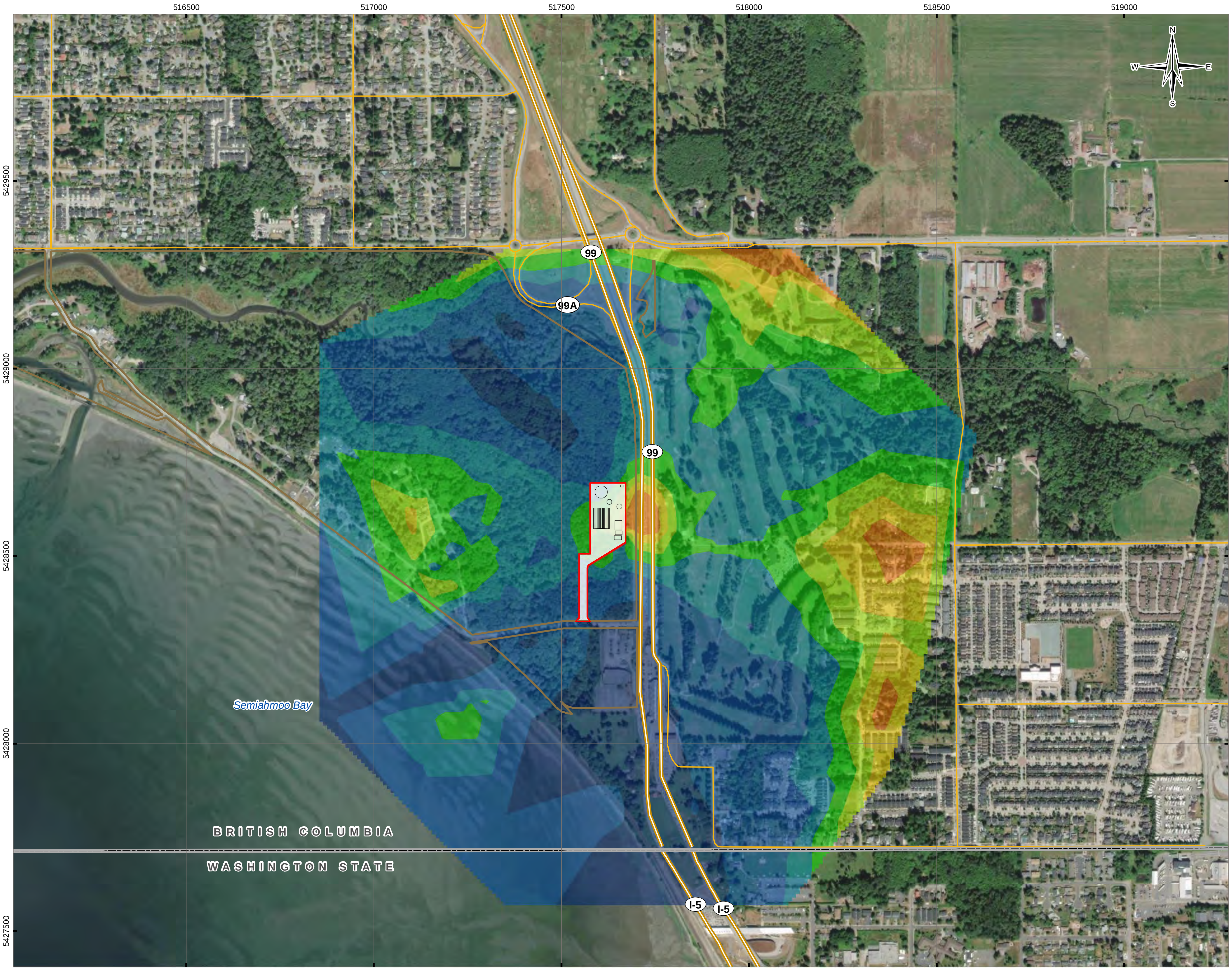
PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	andion

Scale: 1:10,000
200 100 0 200
Metres

TETRA TECH

FILE NO.				
PLAN03183-03_Fig05-27_1OU_4MIN_Ex_Summer.mxd				
OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	MRV	TM	0
DATE	PROJECT NO.			
June 2, 2023	SWM.PLAN03183-03			

Figure 5.27



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LEGEND

- Building
- Site Boundary
- Semiahmoo First Nation

Percentage of Exceedances of 1 OU that Occurred During the Day

- 1% - 10%
- 10% - 20%
- 20% - 30%
- 30% - 40%
- 40% - 50%
- 50% - 60%
- 60% - 80%

Base Data

- Highway
- Main Road
- International Boundary

NOTES

1. Locations with 10 exceedance occurances or less are not shown.

Base data source:
CanVec 1:50,000
Washington State Open Data
Imagery from ESRI; Maxar (2022)

STATUS
ISSUED FOR USE

SEMIAHMOO RENEWABLE NATURAL GAS FACILITY AIR QUALITY DISPERSION MODELLING

Percentage of Exceedances of 1 OU that Occurred During the Day 4-Min Odour Concentration

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	andion

Scale: 1:10,000
200 100 0 200
Metres

TETRA TECH

FILE NO.
PLAN03183-03_Fig05-28_1OU_4MIN_Ex_Day.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	MRV	TM	0

DATE	PROJECT NO.
June 6, 2023	SWM.PLAN03183-03

Figure 5.28

APPENDIX A

TETRA TECH'S LIMITATIONS ON THE USE OF THIS DOCUMENT

LIMITATIONS ON USE OF THIS DOCUMENT

GEOENVIRONMENTAL

1.1 USE OF DOCUMENT AND OWNERSHIP

This document pertains to a specific site, a specific development, and a specific scope of work. The document may include plans, drawings, profiles and other supporting documents that collectively constitute the document (the "Professional Document").

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1.2 ALTERNATIVE DOCUMENT FORMAT

Where TETRA TECH submits electronic file and/or hard copy versions of the Professional Document or any drawings or other project-related documents and deliverables (collectively termed TETRA TECH's "Instruments of Professional Service"), only the signed and/or sealed versions shall be considered final. The original signed and/or sealed electronic file and/or hard copy version archived by TETRA TECH shall be deemed to be the original. TETRA TECH will archive a protected digital copy of the original signed and/or sealed version for a period of 10 years.

Both electronic file and/or hard copy versions of TETRA TECH's Instruments of Professional Service shall not, under any circumstances, be altered by any party except TETRA TECH. TETRA TECH's Instruments of Professional Service will be used only and exactly as submitted by TETRA TECH.

Electronic files submitted by TETRA TECH have been prepared and submitted using specific software and hardware systems. TETRA TECH makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.

1.3 STANDARD OF CARE

Services performed by TETRA TECH for the Professional Document have been conducted in accordance with the Contract, in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided. Professional judgment has been applied in developing the conclusions and/or recommendations provided in this Professional Document. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of the Professional Document.

If any error or omission is detected by the Client or an Authorized Party, the error or omission must be immediately brought to the attention of TETRA TECH.

1.4 DISCLOSURE OF INFORMATION BY CLIENT

The Client acknowledges that it has fully cooperated with TETRA TECH with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site. The Client further acknowledges that in order for TETRA TECH to properly provide the services contracted for in the Contract, TETRA TECH has relied upon the Client with respect to both the full disclosure and accuracy of any such information.

1.5 INFORMATION PROVIDED TO TETRA TECH BY OTHERS

During the performance of the work and the preparation of this Professional Document, TETRA TECH may have relied on information provided by third parties other than the Client.

While TETRA TECH endeavours to verify the accuracy of such information, TETRA TECH accepts no responsibility for the accuracy or the reliability of such information even where inaccurate or unreliable information impacts any recommendations, design or other deliverables and causes the Client or an Authorized Party loss or damage.

1.6 GENERAL LIMITATIONS OF DOCUMENT

This Professional Document is based solely on the conditions presented and the data available to TETRA TECH at the time the data were collected in the field or gathered from available databases.

The Client, and any Authorized Party, acknowledges that the Professional Document is based on limited data and that the conclusions, opinions, and recommendations contained in the Professional Document are the result of the application of professional judgment to such limited data.

The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present, or variation in assumed conditions which might form the basis of design or recommendations as outlined in this report, at or on the development proposed as of the date of the Professional Document requires a supplementary exploration, investigation, and assessment.

TETRA TECH is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.

1.7 NOTIFICATION OF AUTHORITIES

In certain instances, the discovery of hazardous substances or conditions and materials may require that regulatory agencies and other persons be informed and the client agrees that notification to such bodies or persons as required may be done by TETRA TECH in its reasonably exercised discretion.

APPENDIX B

CALMET VALIDATIONS

Wind Speed and Direction Distribution

A series of wind roses are presented comparing wind observations at Environment and Climate Change Canada (ECCC) station White Rock Campbell Scientific (Climate ID 1108910; WMO ID 71785) to the CALMET derived surface layer at the same location (515715 m 5429484 m UTM Z10). ECCC White Rock CS is situated 2 kilometres northwest of the Project site on the grass covered roof of the storage facility at the White Rock Public Works yard. The elevation of the station is reported by ECCC as 13 m amsl.

ECCC White Rock CS is located 400 metres from shore within two-story residential housing and trees which likely influence the wind speed measurement. It also likely experiences blocking effects from the 4 or 5 metre high Public Works building which is located within 10 metres of the station on the east side. Overall, siting does not adhere to World Meteorological Organization (WMO) criteria and observed wind speeds at ECCC White Rock ECCC are likely lower than what would be expected at a near shore location (mean wind speed 1.26 m/s).

Figure B.1 shows the period of record (2013 – 2015) wind rose from (left), located at 515715 m 5429484 m UTM Z10, 2 km northwest of the Project site and from CALMET extracted at the same location.

The plot shows the frequency of occurrence of hourly wind speed and direction (from-direction) in the observed and modelled data. On an annual basis, observed winds can be characterized by three general directions: onshore winds (from the southwest), offshore winds (from the northeast) and synoptic/regional circulation winds (from the southeast). Southeast winds have the highest associated wind speeds.

Predicted winds also show a general southwest/northeast prevalence, however the onshore/synoptic wind direction is less discernable as onshore flow direction is more variable between the east to southeast. The SE synoptic winds do appear to be of slightly higher wind speed, but it is less distinguishable from the onshore flow wind speeds. The average wind speed predicted by CALMET at ECCC White Rock is 3.16 m/s.

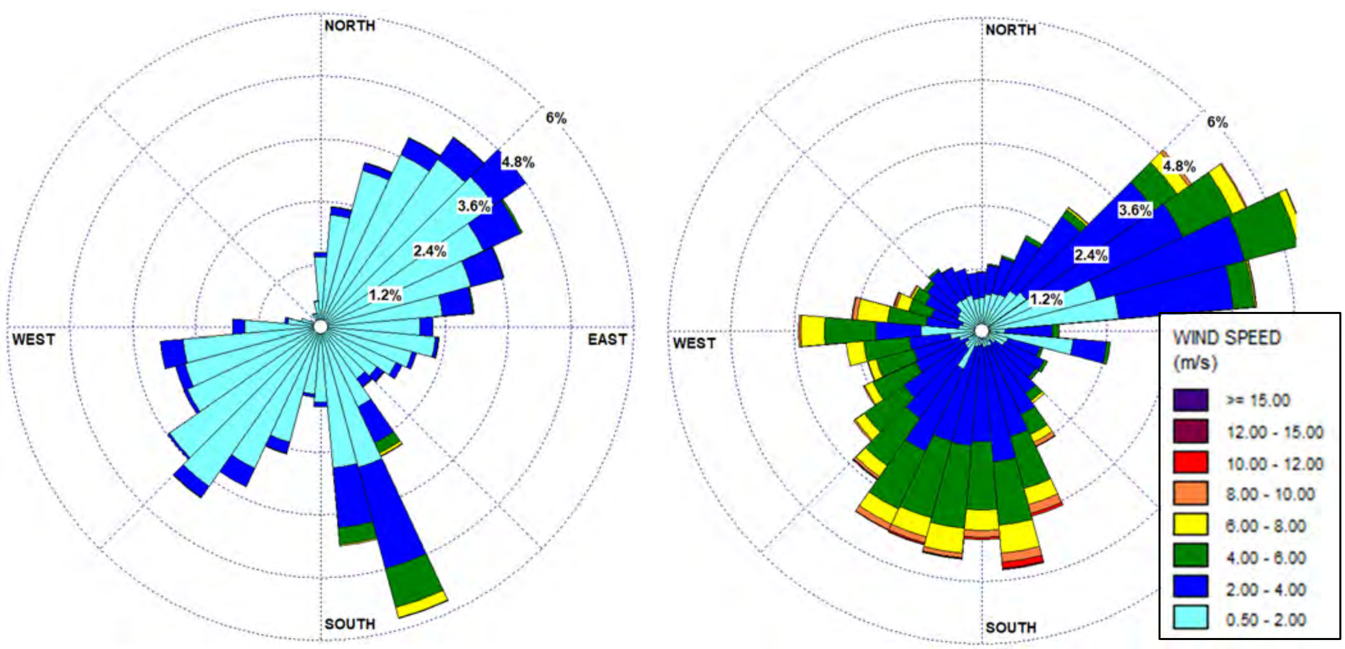


Figure B.1: 2013 - 2015 Wind Rose at ECCC White Rock CS and CALMET at 515715 m 5429484 m UTM Z10

Figure B.2 illustrates observed and CALMET-modelled winds during the summer period (June through August). Summer conditions would tend to result in a higher incidence of onshore flow (sea breeze) and less higher wind speed synoptic events (SE flows) which are more characteristic of autumn-winter-spring.

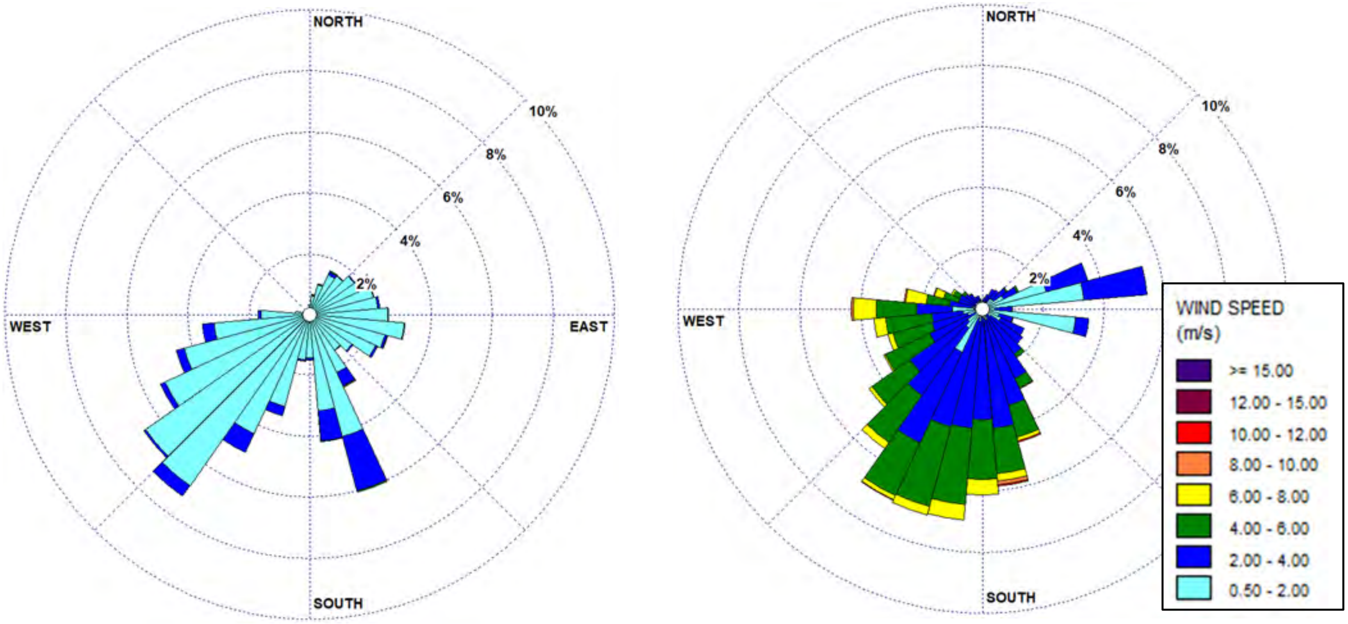


Figure B.2: Summer Wind Rose (ECCC White Rock CS, left; CALMET at ECCC White Rock CS, right)

The daytime summer wind roses shown in Figure B.3 illustrate the heavy predominance of onshore flow which would be expected to be prevalent in a nearshore area such as White Rock as a result of the diurnal sea-breeze/land breeze circulation .

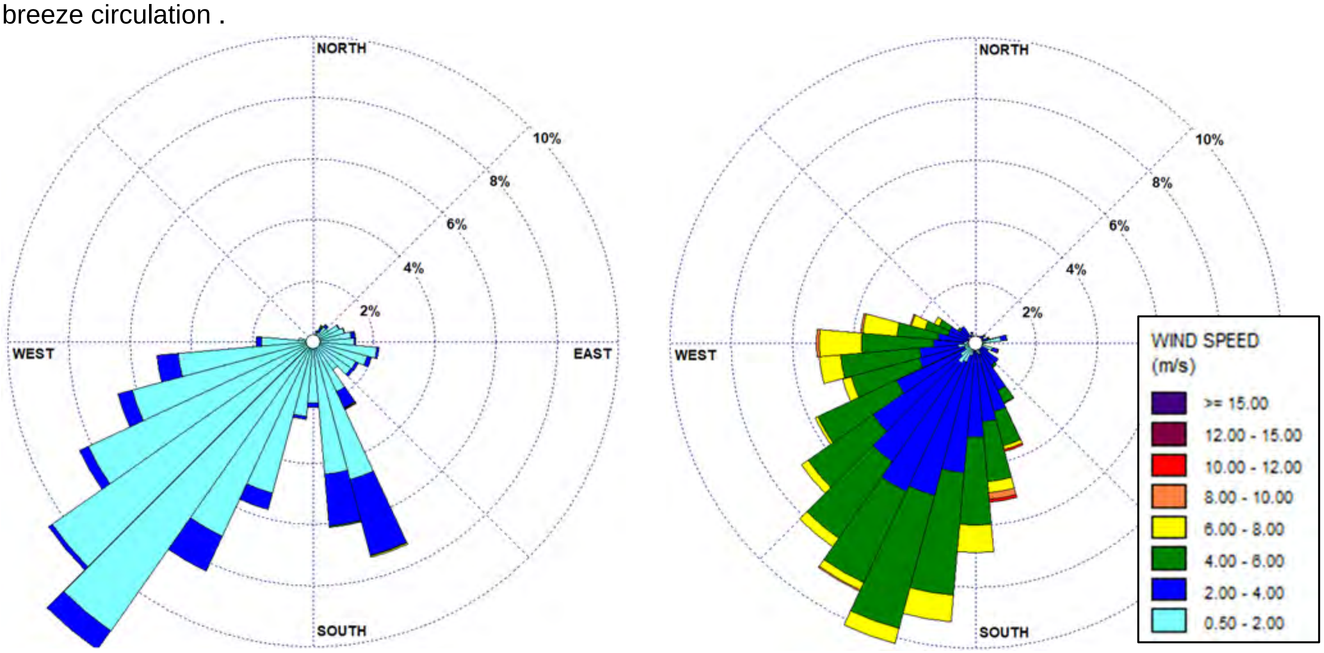


Figure B.3: Summer Daytime Wind Rose
(ECCC White Rock CS, left; CALMET at ECCC White Rock CS, right)

The nighttime summer wind roses shown in Figure B.4 illustrate the heavy predominance of offshore flow which would be expected to be prevalent in a nearshore area such as White Rock as a result of the diurnal sea-breeze/land breeze circulation.

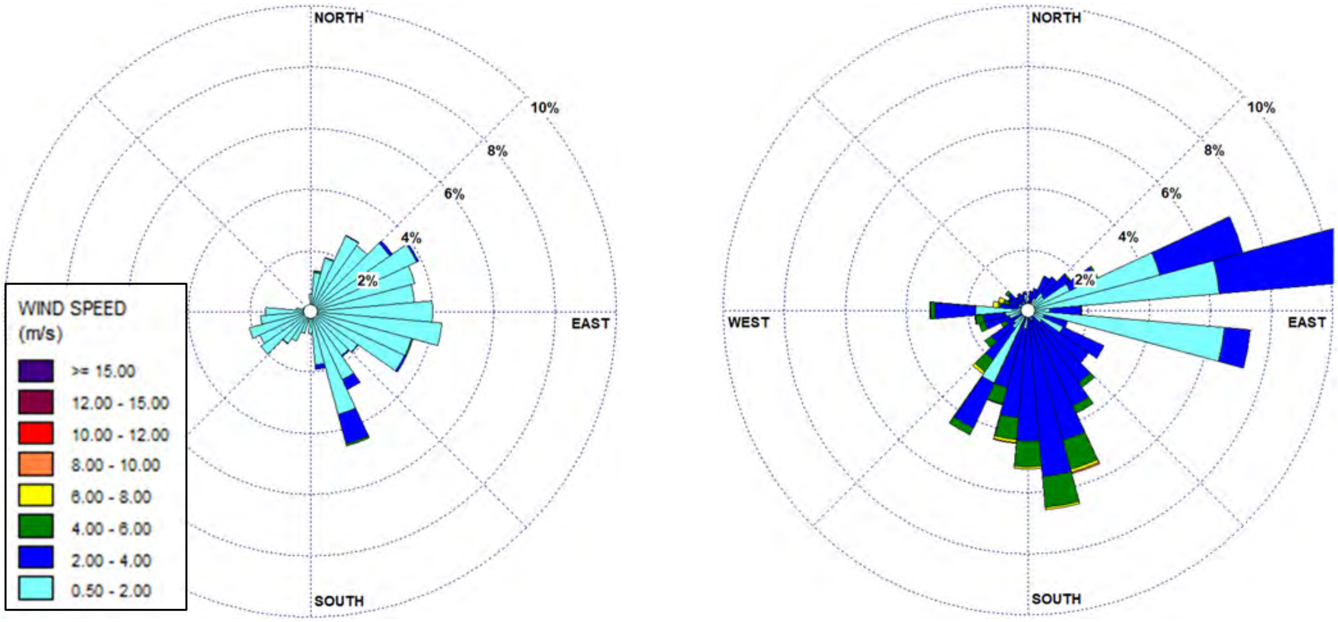
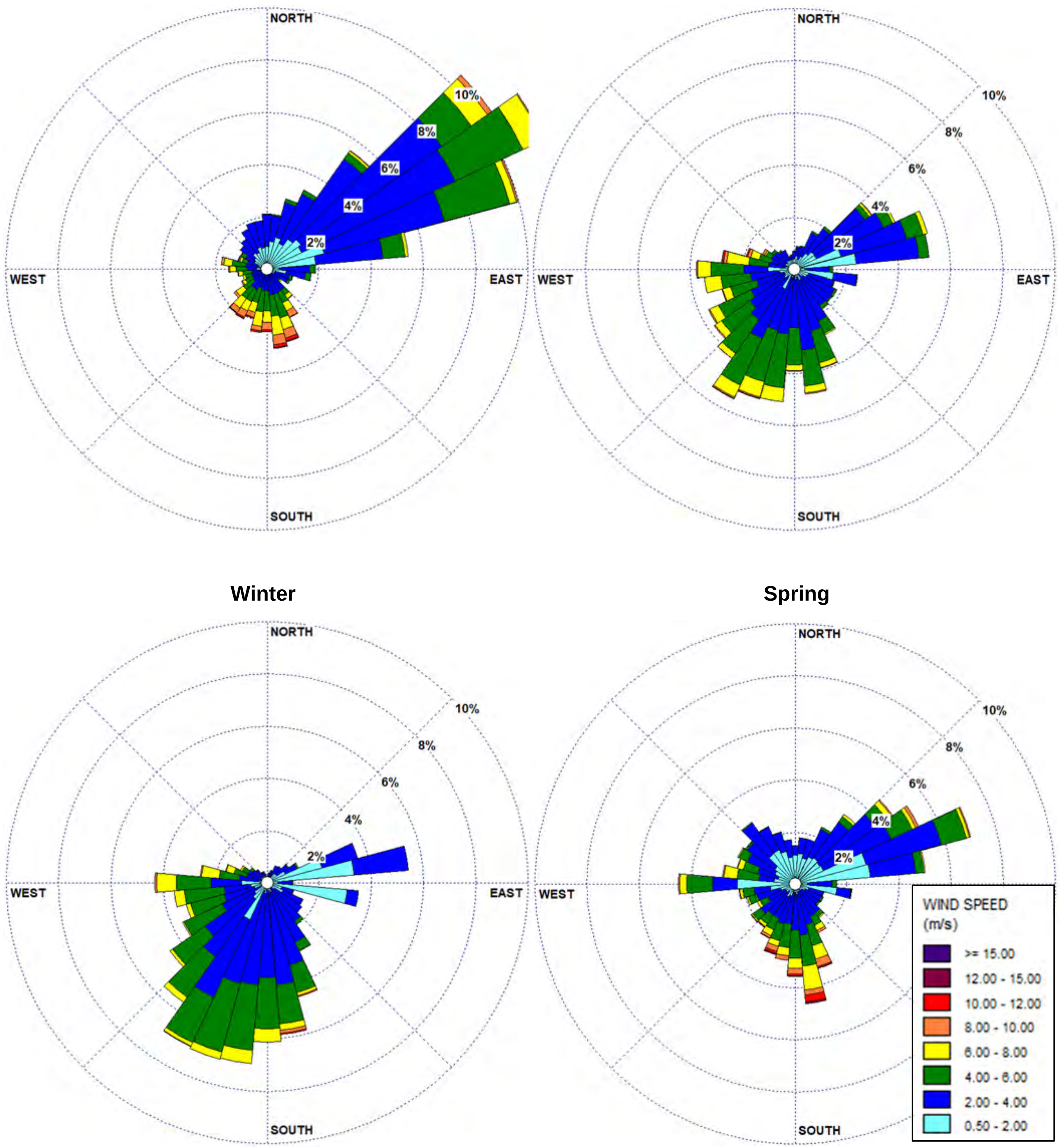


Figure B.4: Summer Nighttime Wind Rose
(ECCC White Rock CS, left; CALMET at ECCC White Rock CS, right)

Figure B.5 shows wind roses of the extracted CALMET data by season with winter (DJF) upper left, spring (MAM) upper right, summer (JJA) lower left and autumn (SON) lower right. Figure B.6 shows wind roses of observed winds at ECCC White Rock by season with winter (DJF) upper left, spring (MAM) upper right, summer (JJA) lower left and autumn (SON) lower right.



Winter Spring

Summer Autumn

Figure B.5: Seasonal Wind Roses CALMET at ECCC White Rock

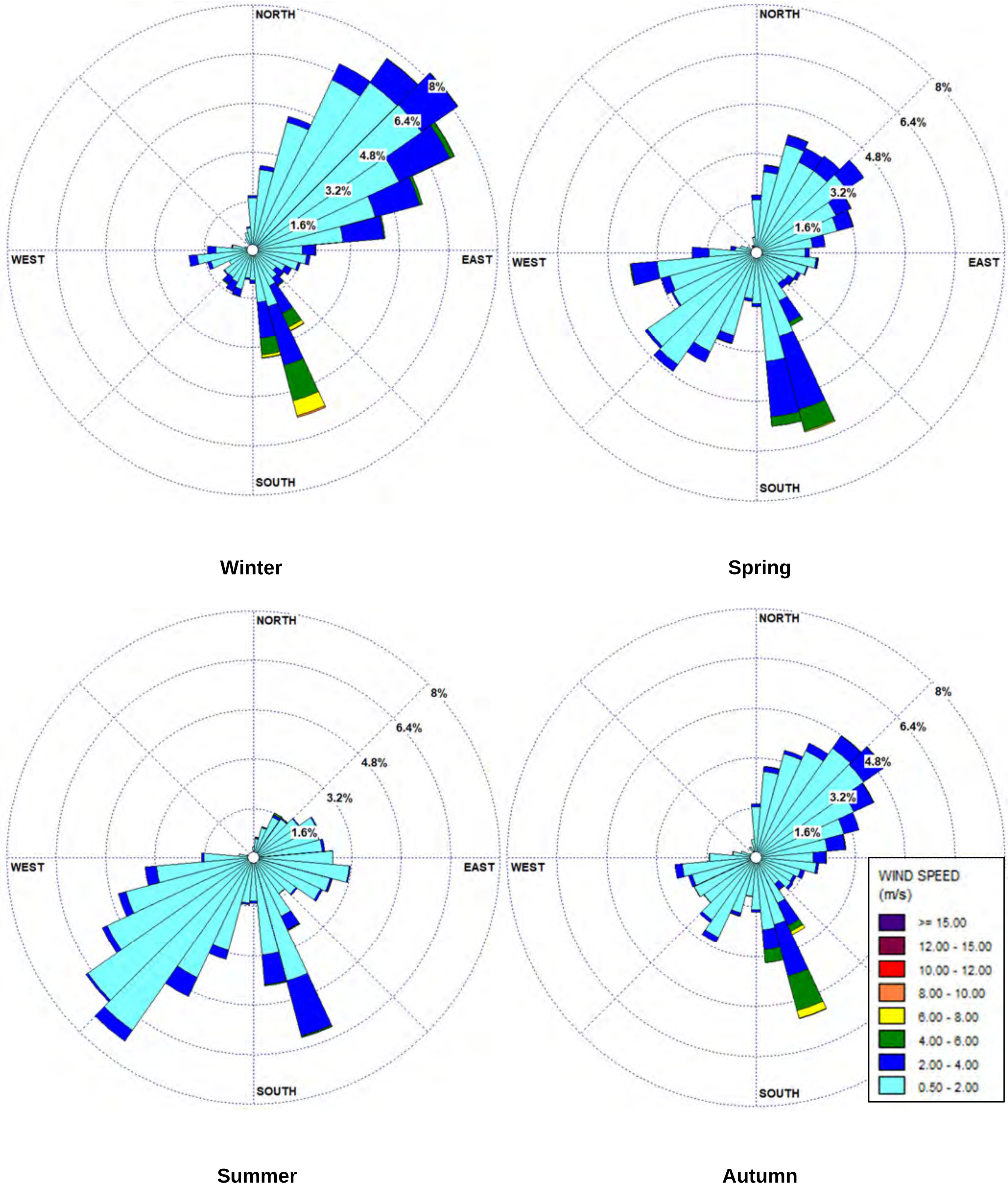


Figure B.6: Seasonal Wind Roses at White Rock CS

Thermally Generated Flows

Due to its proximity to Boundary Bay, the primary thermally-generated flow pattern influencing the study area is the diurnal land-sea breeze circulation. This mesoscale convection circulation is most prevalent during the late spring and summer with increased solar heating and stronger surface temperature differentials between land and water. During the day, surface air over land is heated, becomes less dense and rises setting up a sea-breeze circulation pattern as cooler, denser air over the water flows onshore. Aloft, there is a return offshore flow of air completing the circulation pattern. Generally, a temperature difference of 3ºC or 4ºC between land and water is needed for a sea breeze to develop, assuming synoptic-scale pressure influences are weak. The greater the temperature difference, the stronger the sea breeze. The typical depth of a sea breeze circulation is between 500 m and 1000 m above ground.

At night, air over land cools and contracts setting up a pressure differential between land and water, resulting in an offshore flow, or land breeze. Subsequently, aloft, the displaced air over water rises and flows onshore. Sea breeze wind speeds are typically stronger than wind speeds associated with the land breeze.

At a larger scale, the summer land breeze circulation offshore Metro Vancouver converges with the general summer Salish Sea flow pattern, as inflow winds through the Strait of Juan de Fuca are steered to the northwest between Vancouver Island and the Washington State mainland into the Strait of Georgia. This results in a typical southeasterly flow through Boundary Bay and through the study area. These southeasterly winds then steer/circulate to the west/converge with easterly offshore flow from the Fraser Valley, resulting in an easterly direction land breeze at Vancouver Int'l Airport (YVR).

Conversely, the sea breeze wind direction through Boundary Bay and White Rock is generally southwesterly, while at YVR the onshore flow is generally westerly.

Figures B.7(a) and (b) are snapshots from https://www.windy.com showing the land breeze and sea breeze circulations through Metro Vancouver and Boundary Bay. The figure shows the general wind flow through the area on May 31, 2023 during a period of generally fair weather conditions typical of late spring for the region.

The set of Figures B.8 show an extracted CALMET wind field during what was considered a typical summer day without synoptic influences based on wind and temperature observations at YVR, with emphasis on the immediate study area and Boundary Bay. Figures are shown over a 24-hour period (1 through 24) for (a) surface winds, (b) winds at 480 m, considered as representative of the top of the depth of the onshore-offshore circulation and (c) winds at 1600 m, considered to be above the depth of the onshore-offshore circulation.

Figure B.9 plots the observed wind direction and wind speed from YVR (blue), White Rock CS (orange) and extracted CALMET at Andion Semiahmoo. The directional timing of the land and see breeze circulation matches quite well between the modelled and the observed. The modelled wind speed also generally follows the observed at YVR. Note the diminished wind speeds observed at White Rock CS due to shielding effects. Quite likely YVR winds would have been included in the BC Ministry WRF dataset nudging. White Rock CS is not a major observational station and does not observe appropriate winds due to siting.

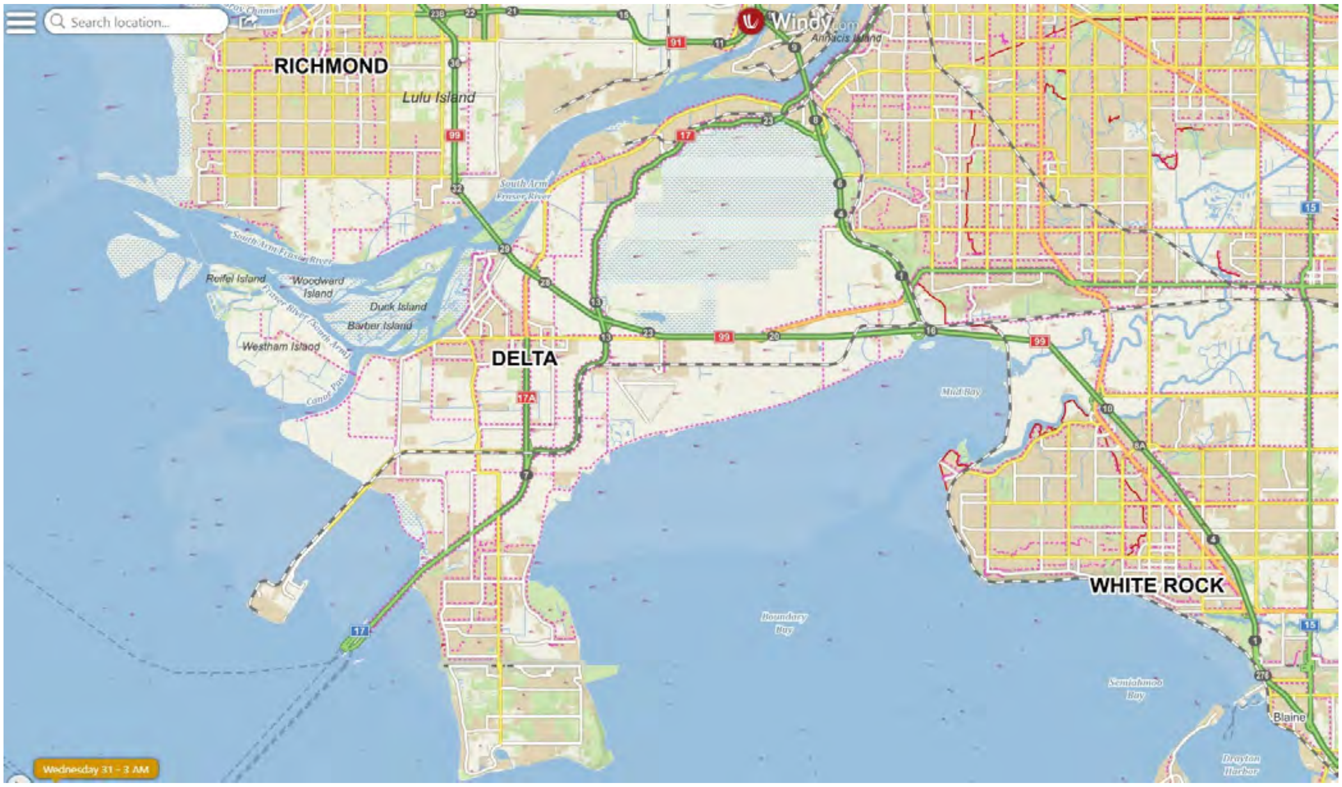


Figure B.7(a): Land Breeze Wind Field - Metro Vancouver & Boundary Bay, May 31, 2023 3 AM

Source: https://www.windy.com

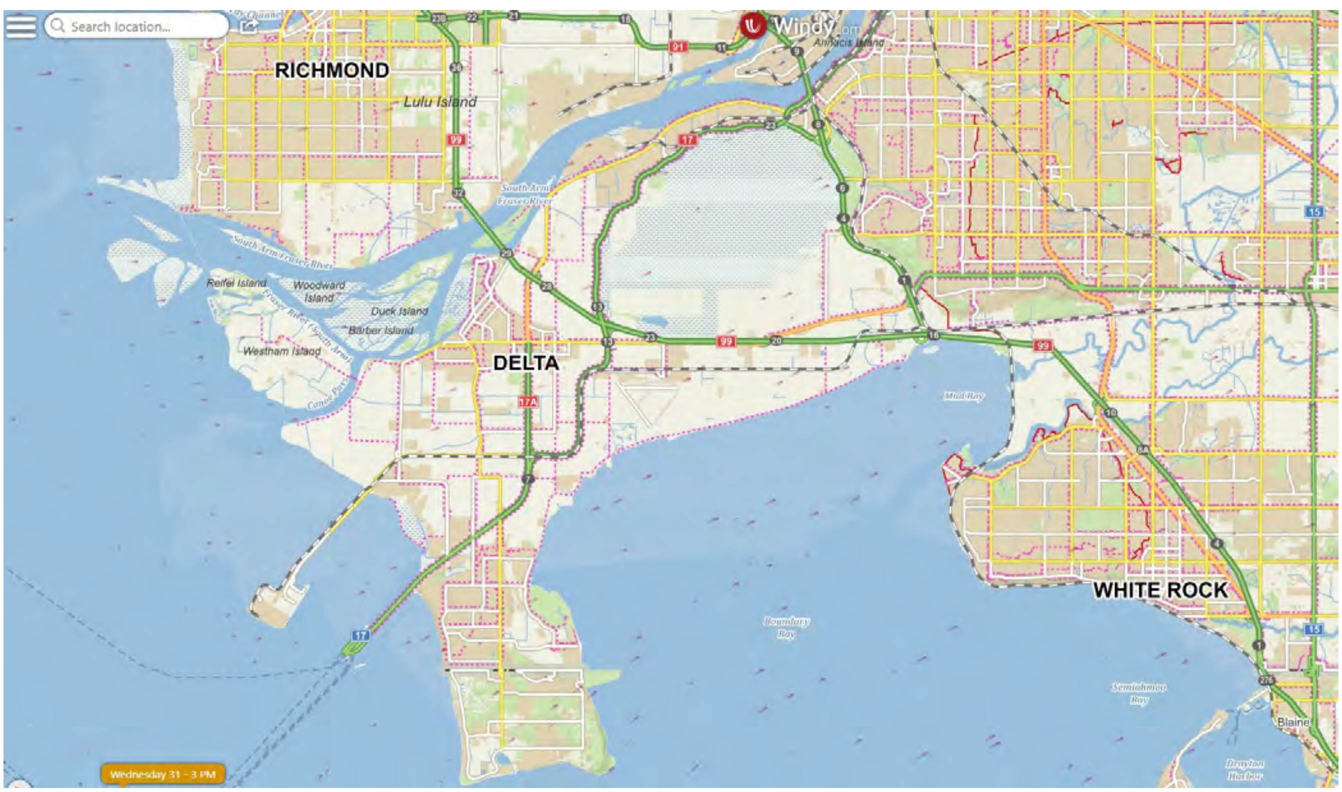


Figure B.7(b): Sea Breeze Wind Field - Metro Vancouver & Boundary Bay, May 31, 2023 3 PM

Source: https://www.windy.com

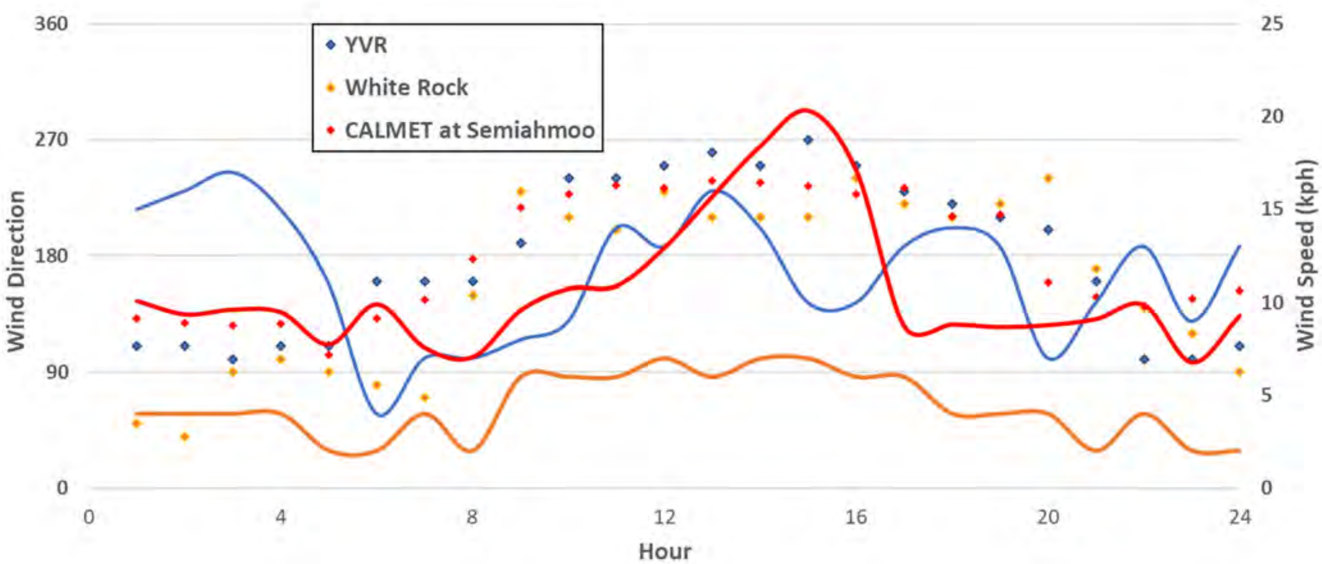


Figure B.9: Observed Wind Speed (solid) and Direction (line), July 18, 2013 – YVR (blue), White Rock CS (orange) and CALMET at Semiahmoo (red)

Mixing Height

With respect to air dispersion meteorology, mixing height refers to the height above ground, below which contaminants released near the surface are readily mixed and diluted. Mixing heights are generally higher during warm sunny days when the heating differential between the ground and the air above is high and as a result, air convection is strong. The mixing height can also increase due to mechanically-induced turbulence from stronger wind speeds. Subsequently, mixing heights drop much closer to the ground at night, in the absence of solar heating, or on overcast days under low wind conditions, especially during the winter.

Figure B.10 is a box plot showing the distribution of modelled mixing heights extracted from the CALMET data over each hour of the modelled period (2013-2015). Figure B.11 shows the same distributional data for winter, spring, summer and autumn.

Figures B.12 (1 through 24) show the predicted mixing height over the same 24-hour period as described in the Section on thermally-driven winds.

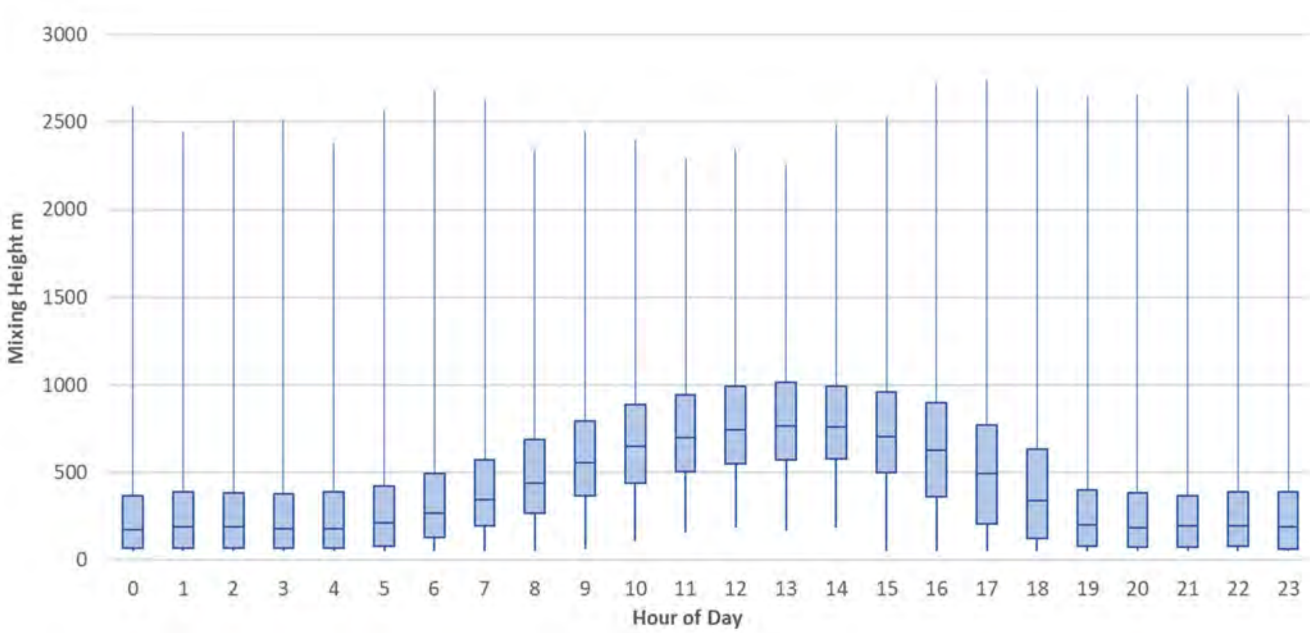
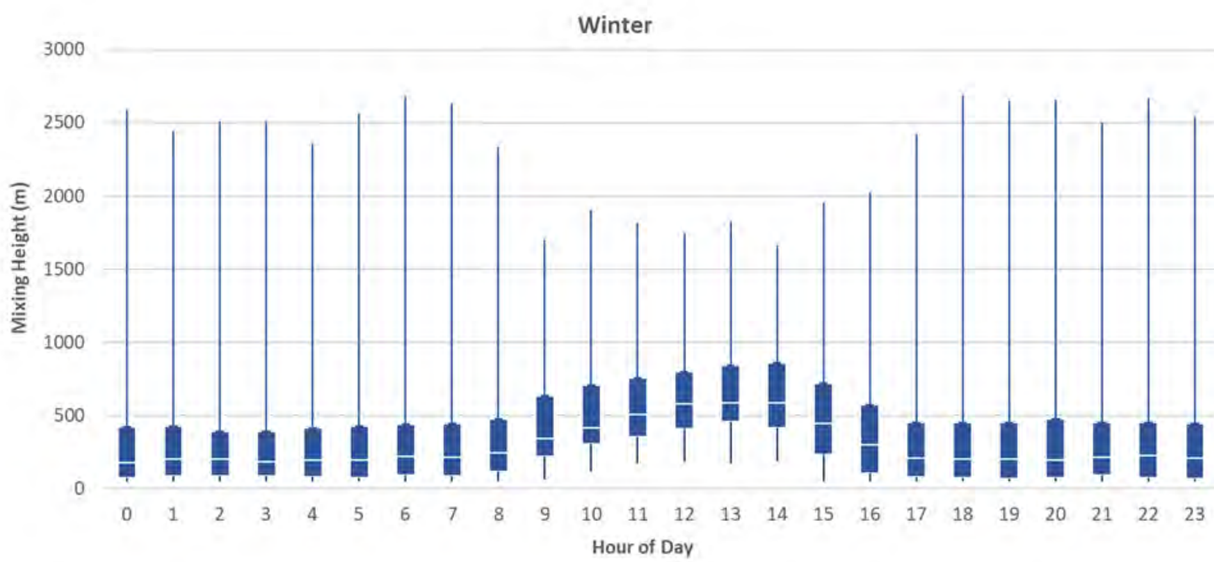


Figure B.10: Distribution of CALMET Modelled Mixing Heights by Hour of Day



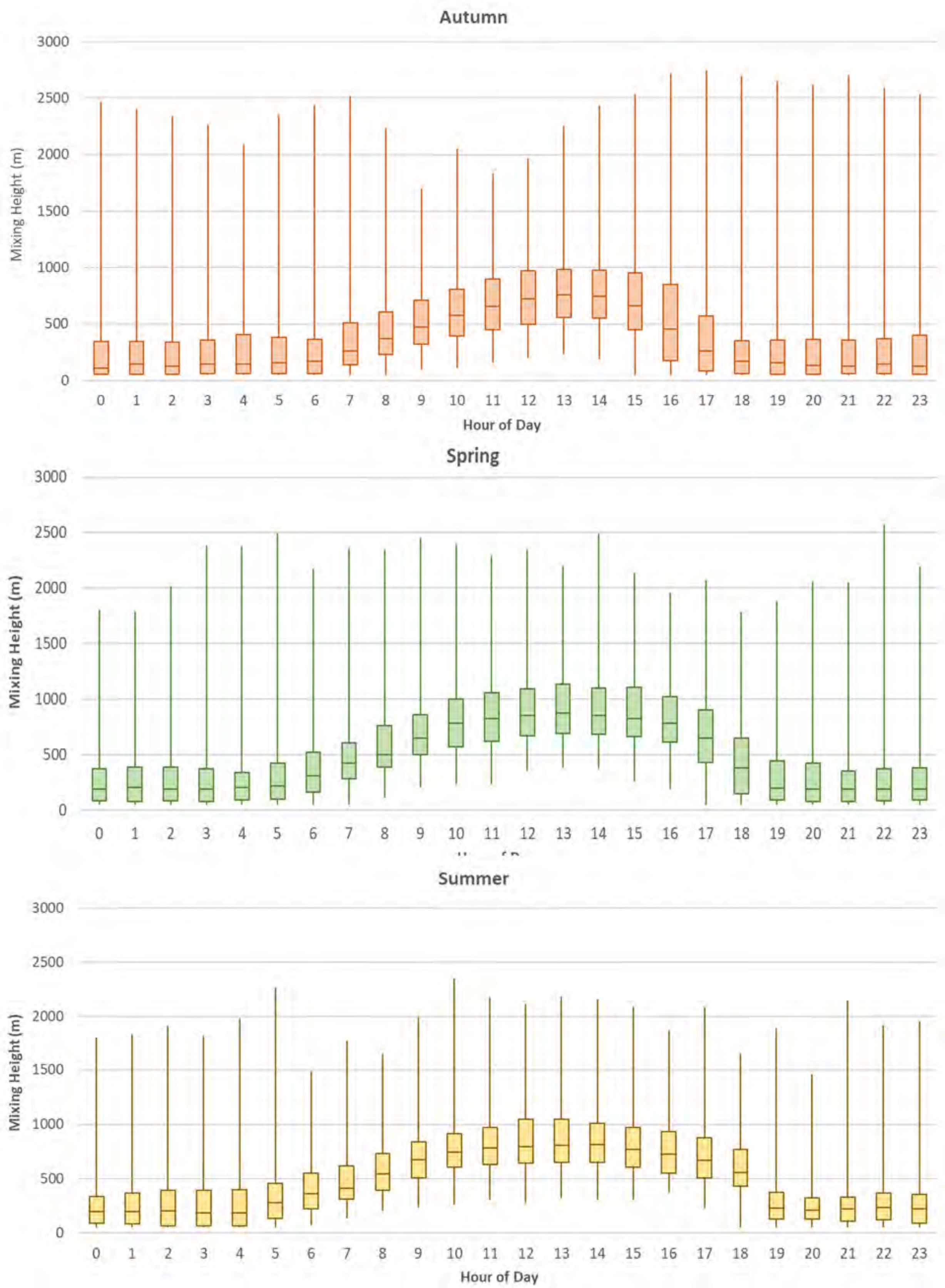


Figure B.11: Distribution of CALMET Modelled Mixing Heights by Hour of Day and Season

Atmospheric Stability

Related to mixing height, atmospheric stability is a measure of the tendency of a parcel of air to rise, and thus disperse contaminants released near the surface. Among other parameters, CALPUFF utilizes Pasquill-Giffford (PG) turbulence classifications which are applied to buoyancy algorithms to model plume rise and lateral spread. PG class categorizes the degree of turbulence in the atmosphere at a given time from A to F where A represents a high degree of turbulence, and thus instability and enhanced mixing, and F represents a low degree of turbulence and a very stable atmosphere which suppresses mixing. Slightly stable (PG class E) and stable (PG class F) atmospheres occur at night in the absence of solar-induced ground heating, and under lower wind speeds. PG class D represents a neutral atmosphere and occurs at night with stronger winds or during a cloudy day with stronger winds. Unstable atmospheres (PG classes A and B) only occur during the day and when winds are light and incident solar radiation is strong (i.e., non-overcast).

Figure B.13 plots the frequency of occurrence of PG classes in the CALMET-modelled meteorology. Figure B.14 shows the same data by season. As would be expected, PG class D is the most common condition. During summer with more daylight hours and higher sun angles, unstable atmospheres (P-G Classes A, B and C) occur more frequently than in other seasons. The plots would suggest more instances of poor dispersion conditions, and potentially worse air quality impacts, during the winter months, although in summer, stable conditions (P-G Classes D, E and F) were still predicted to occur the majority of the time.

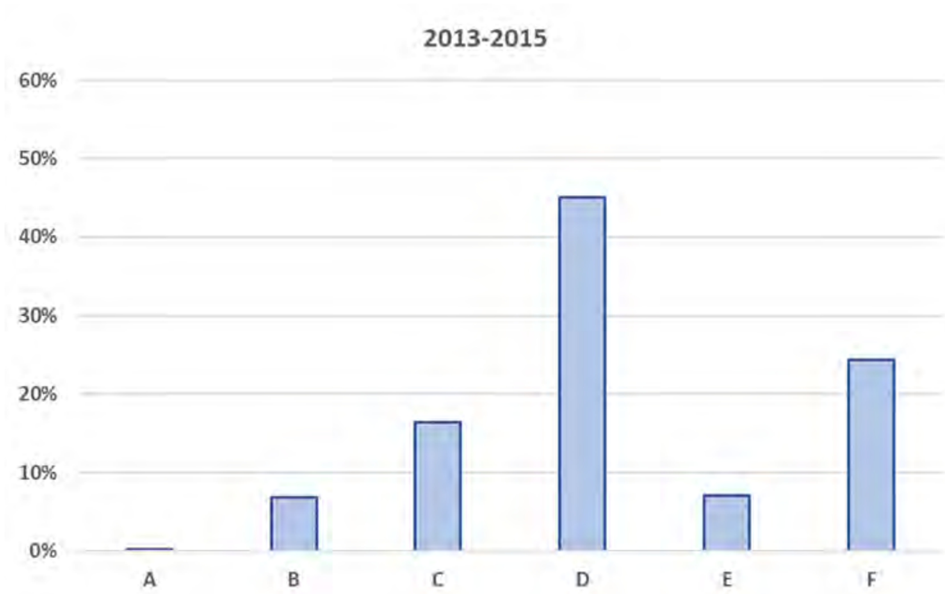


Figure B.13: CALMET-Modelled PG Stability Class Frequency of Occurrence

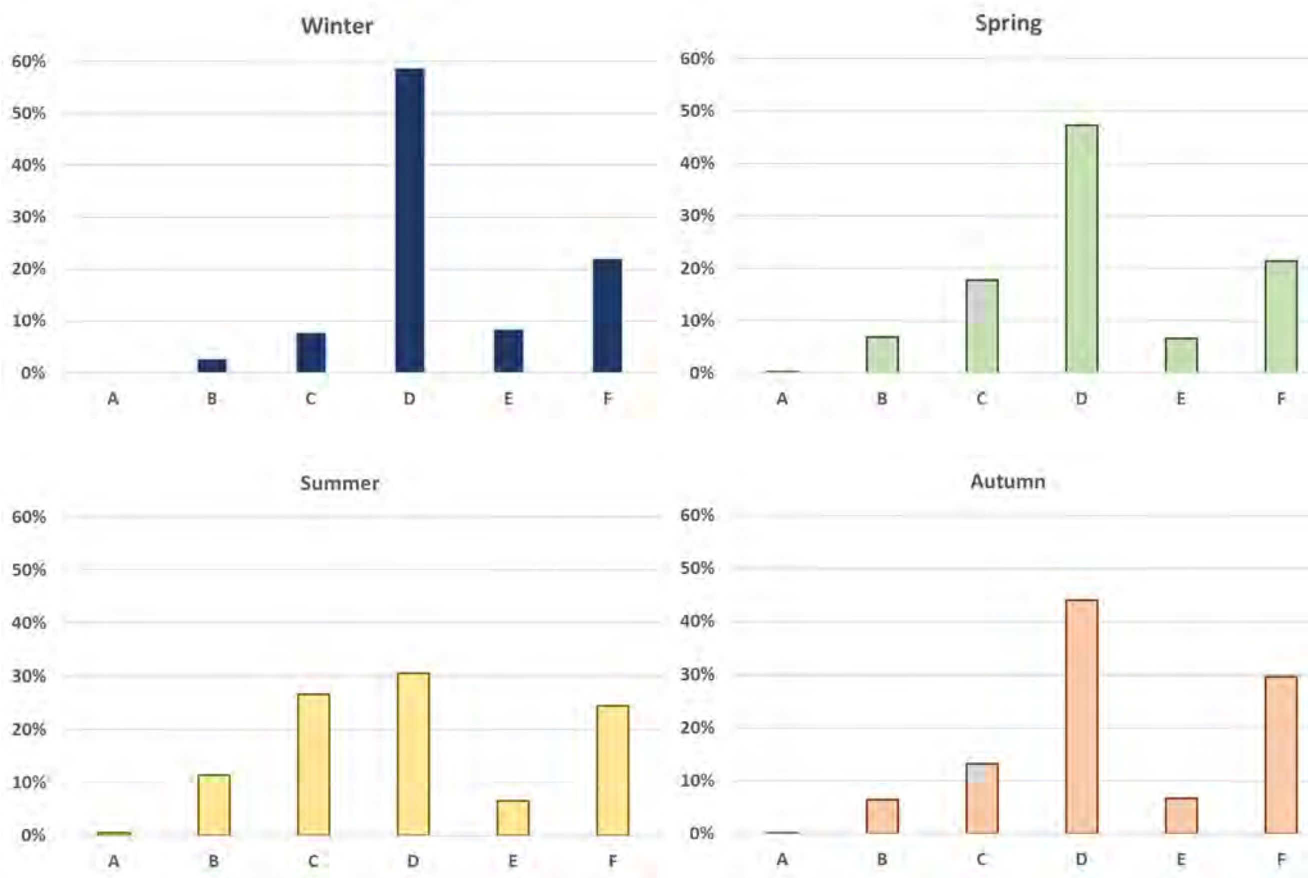


Figure B.14: CALMET-Modelled PG Stability Class Frequency of Occurrence by Season

Monin-Obukhov Length

The Monin-Obukhov length is an atmospheric stability parameter that expresses the relative roles of shear and buoyancy on turbulence, particularly near the surface in the atmospheric boundary layer. The Monin-Obukhov length represents the height at which turbulence is generated more by buoyancy than by wind shear. The inverse Monin-Obukhov length can be used as an indicator of the degree of instability in the atmosphere. Figure B.15 plots the distribution of inverse Monin-Obukhov lengths extracted from CALMET at the Drain All facility over each hour. A negative value indicates a more unstable atmosphere while a positive value indicates a more stable atmosphere. The larger the deviation from zero, the stronger the condition. Figure B.16 shows the same data by season.

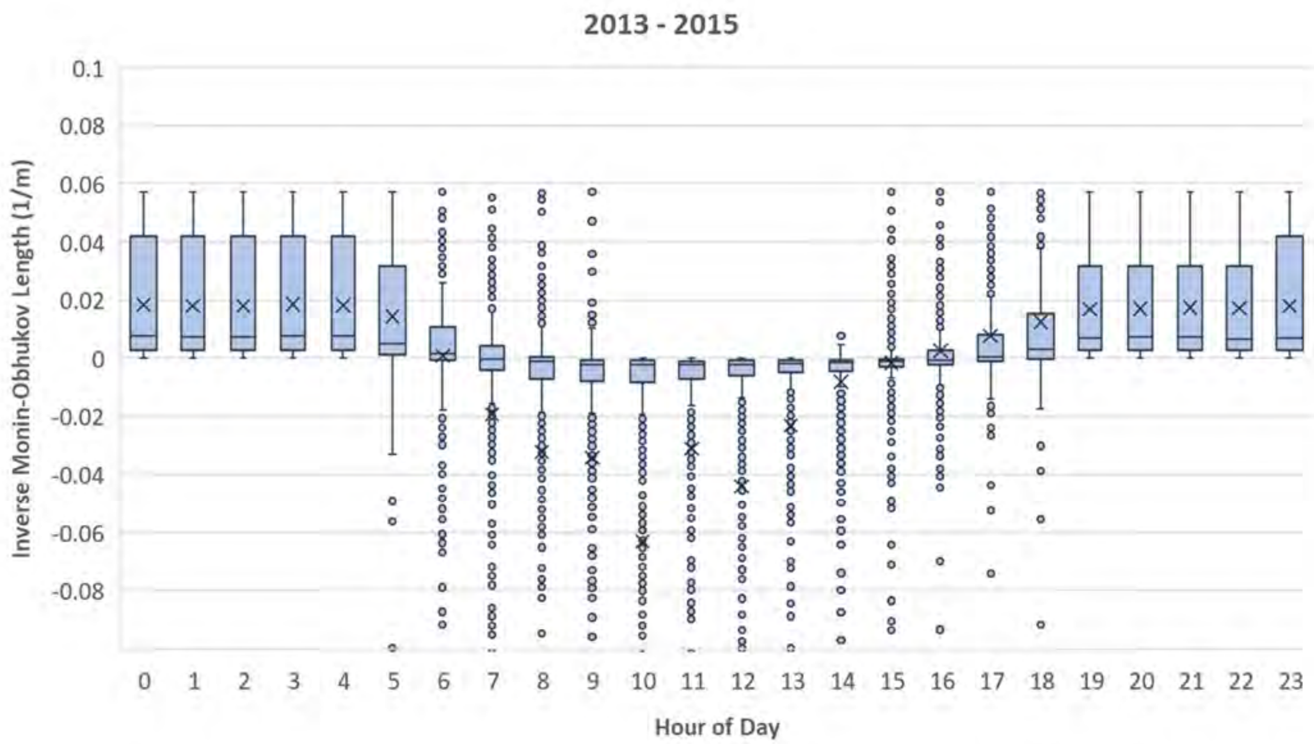


Figure B.15: Distribution of CALMET Modelled Inverse Monin-Obukhov Length by Hour

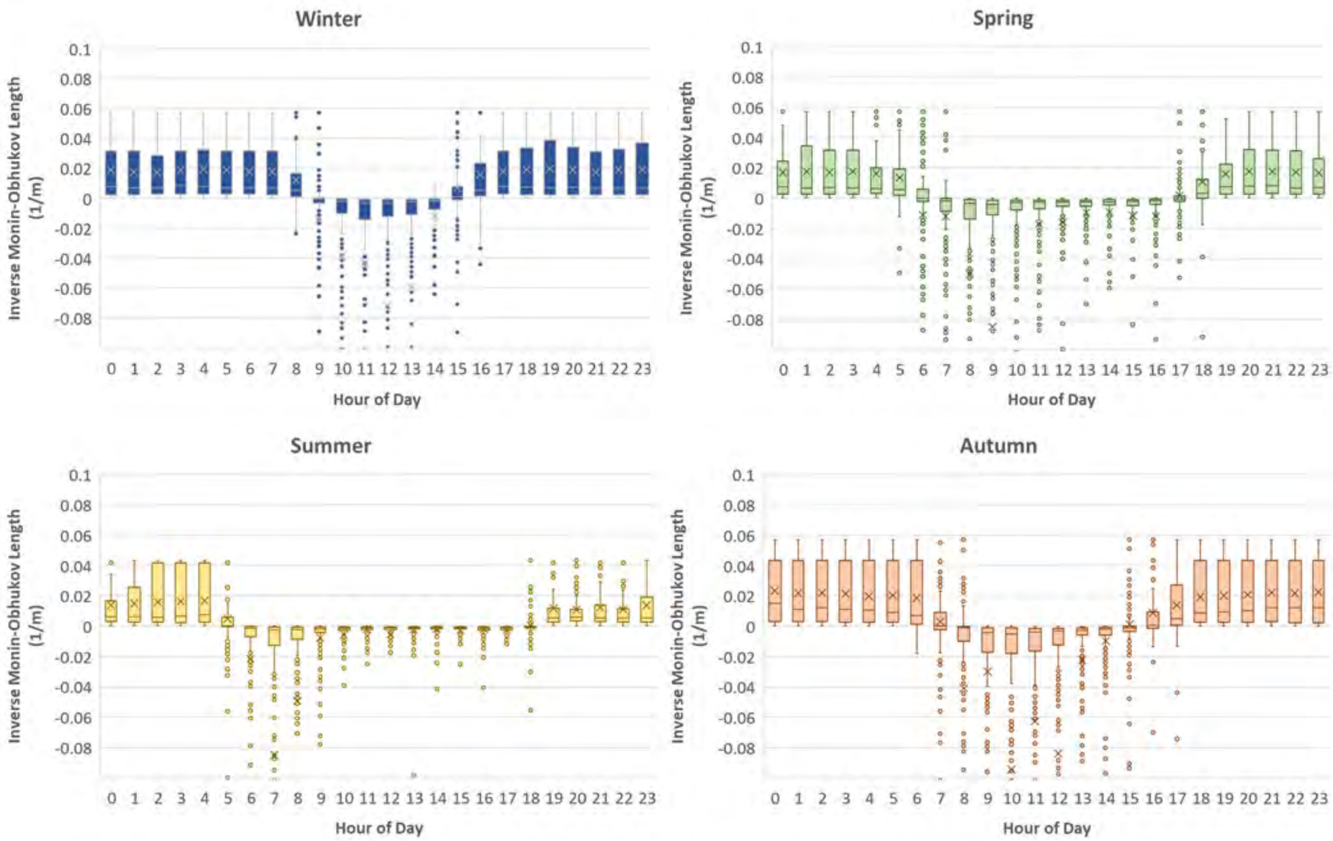


Figure B.16: Distribution of CALMET Modelled Inverse Monin-Obukhov Length by Hour and Season

Surface Air Temperature

Figure B.17 plots the mean monthly wind speed extracted over the three-year CALMET dataset at Andion Semiahmoo (red) compared to 1991-2010 Climate Normals for White Rock STP, the nearest station to Andion with Climate Normals. White Rock STP is located near the White Rock CS meteorological station. Figure B.18 plots the CALMET time series of hourly surface level air temperatures over the range of normal temperatures (mean – solid black line, mean daily max and min – dashed black line). The predicted temperatures follow the expected normal distribution. The dashed lines represent the average daily maximum and minimum temperature for the month, meaning there would obviously be fluctuations above and below this mean value. The overall range of extreme temperatures is consistent with the region (highs slightly above 30ºC and lows slightly below -5ºC). The CALMET predictions of -7ºC on December 8, 2013, and again on February 6, 2014, matches the regional observations – White Rock STP observed daily lows of -8.1 ºC and -6.2ºC respectively. Even the hour of occurrence of the low temperature coincides perfectly with the observational record (12 am on December 8, between 3 and 6 am on February 6).

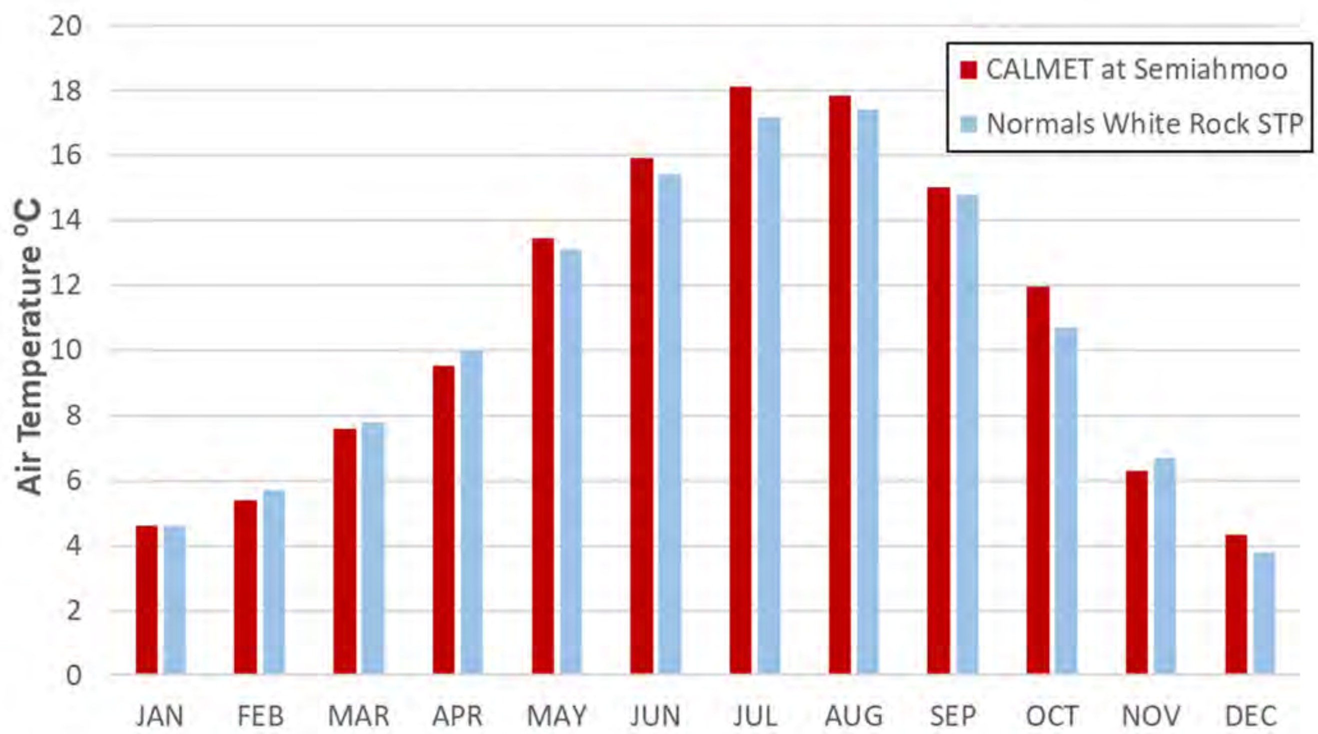


Figure B.17: Average Monthly Temperature (CALMET, red; White Rock STP 1990-2010 Climate Normals, blue)

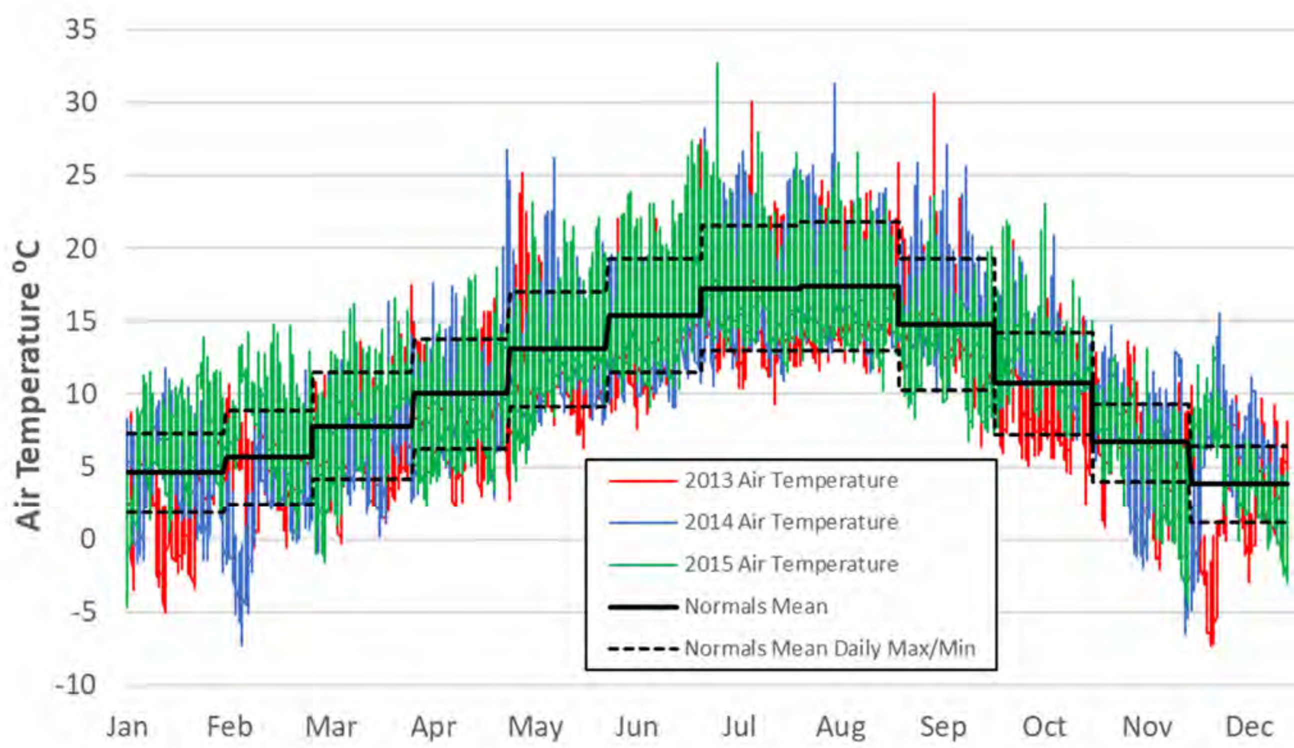
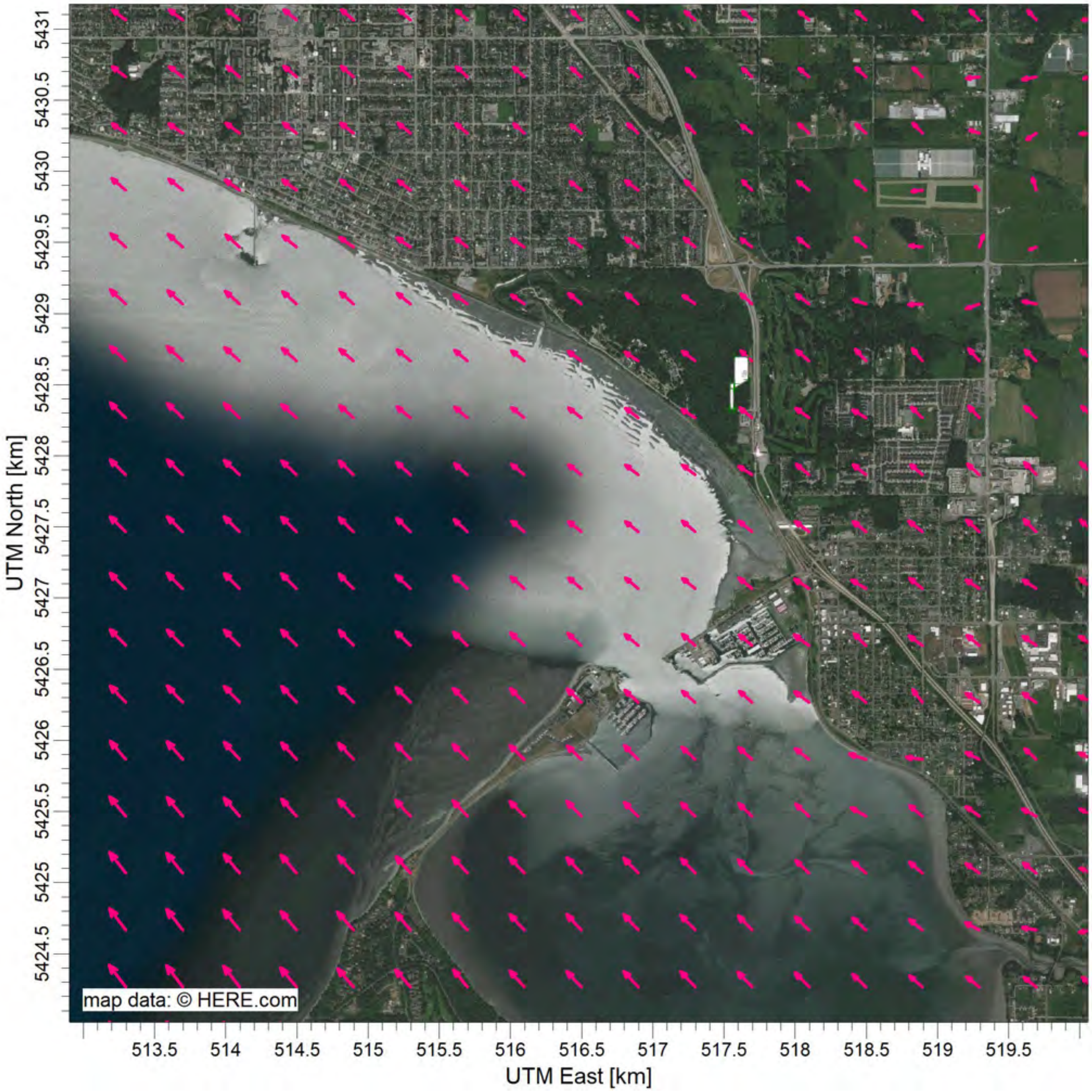


Figure B.18: Time Series of Air Temperature – CALMET at Andion Semiahmoo Facility

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 10m Wind Field - July 18, 2013 0100 PDT



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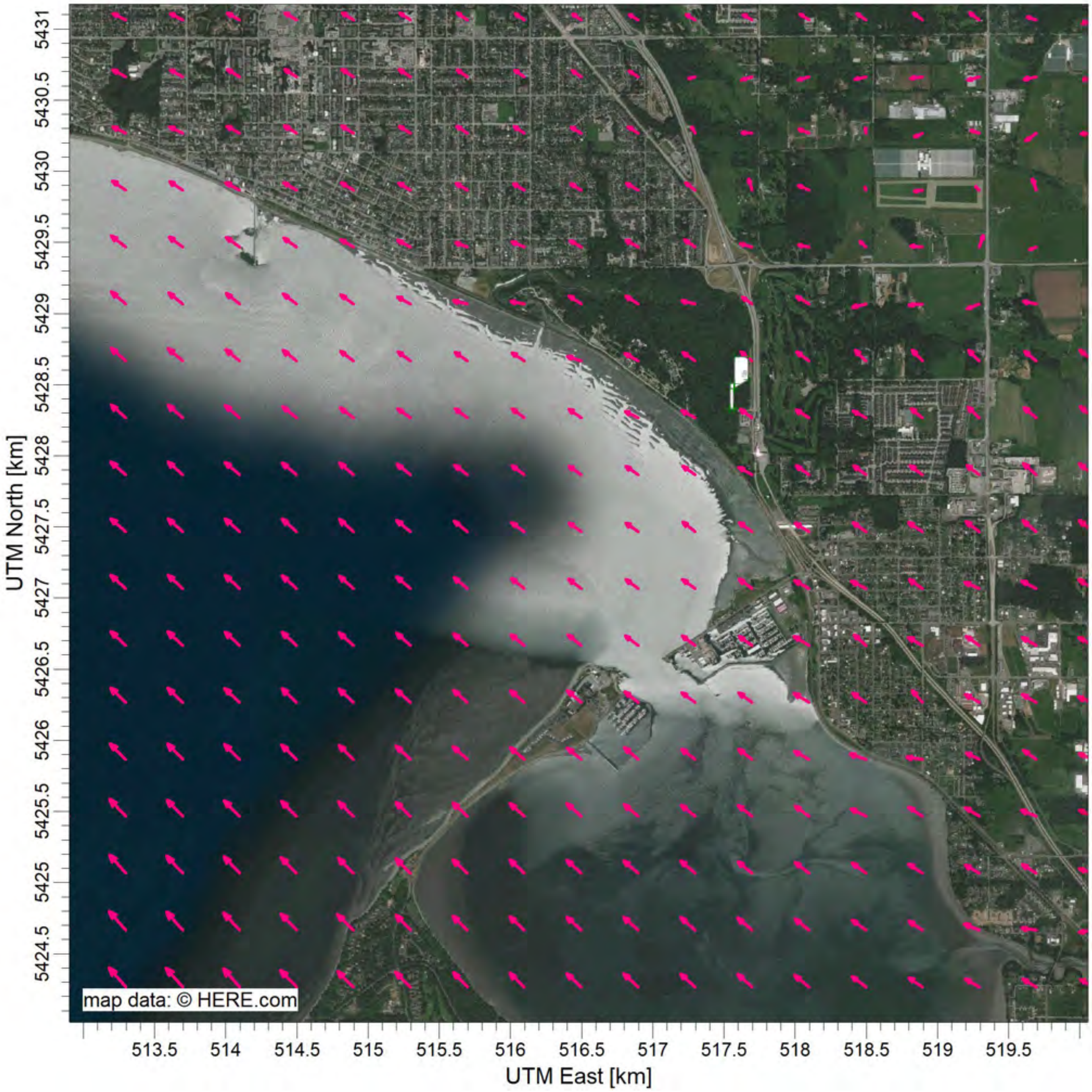
PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 10m Wind Field - July 18, 2013 0200 PDT



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COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:45,000

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andion

DATE:

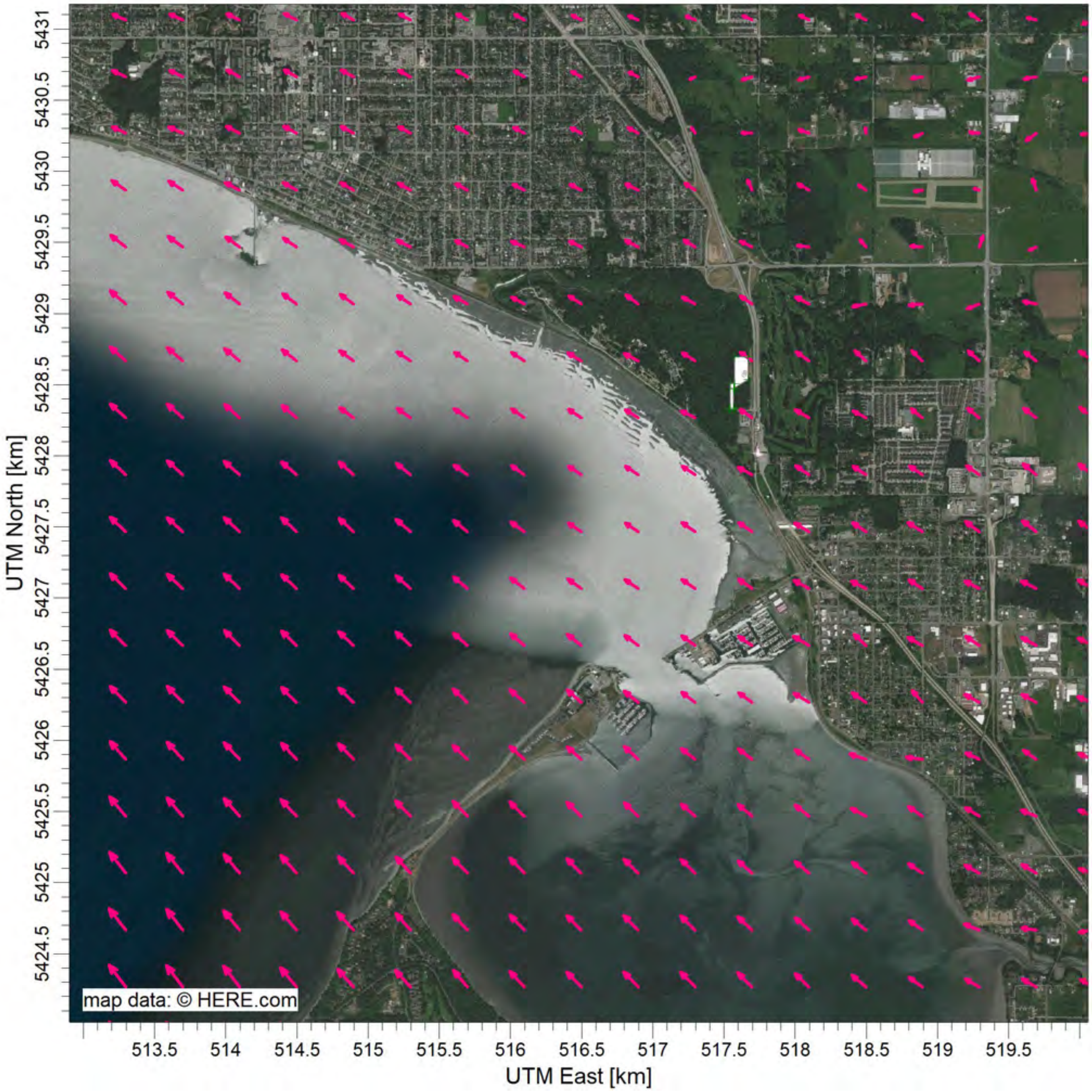
6/2/2023

Figure B.9(a).2

CALPUFF View - Lakes Environmental Software

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 10m Wind Field - July 18, 2013 0300 PDT



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MODELER:

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DATE:

6/2/2023

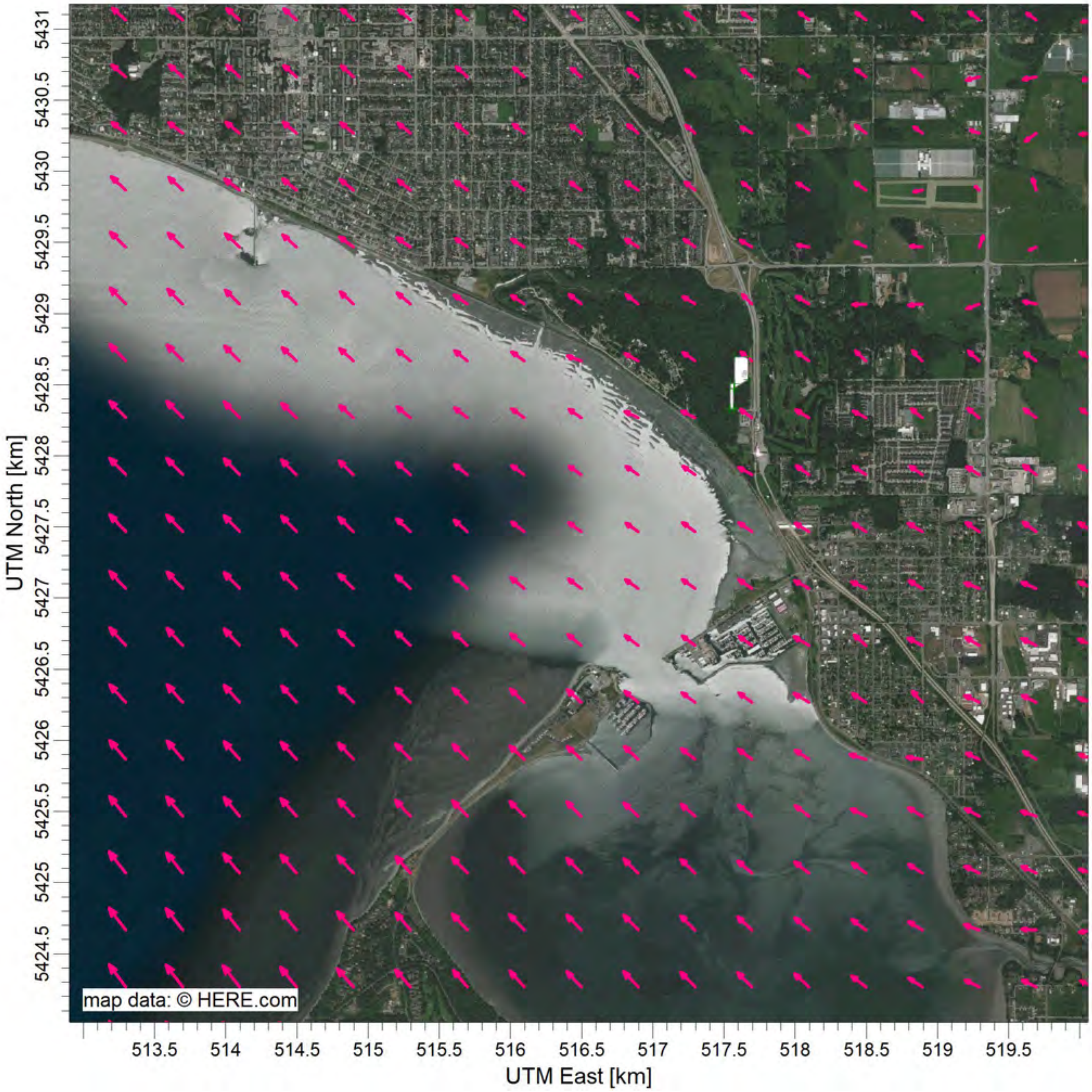
andion

Figure B.9(a).3

CALPUFF View - Lakes Environmental Software

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 10m Wind Field - July 18, 2013 0400 PDT



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MODELER:

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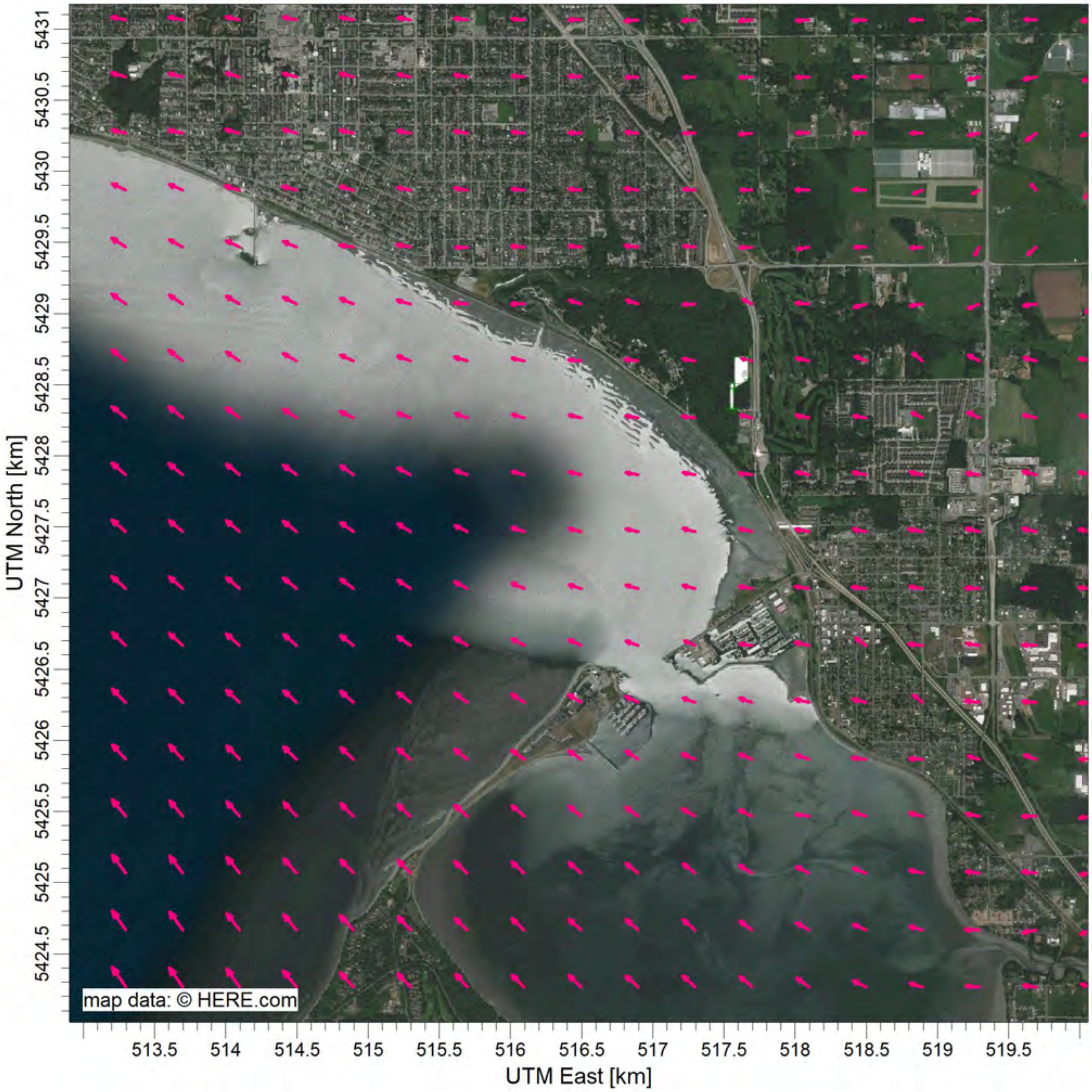
Figure B.9(a).4

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 10m Wind Field - July 18, 2013 0500 PDT



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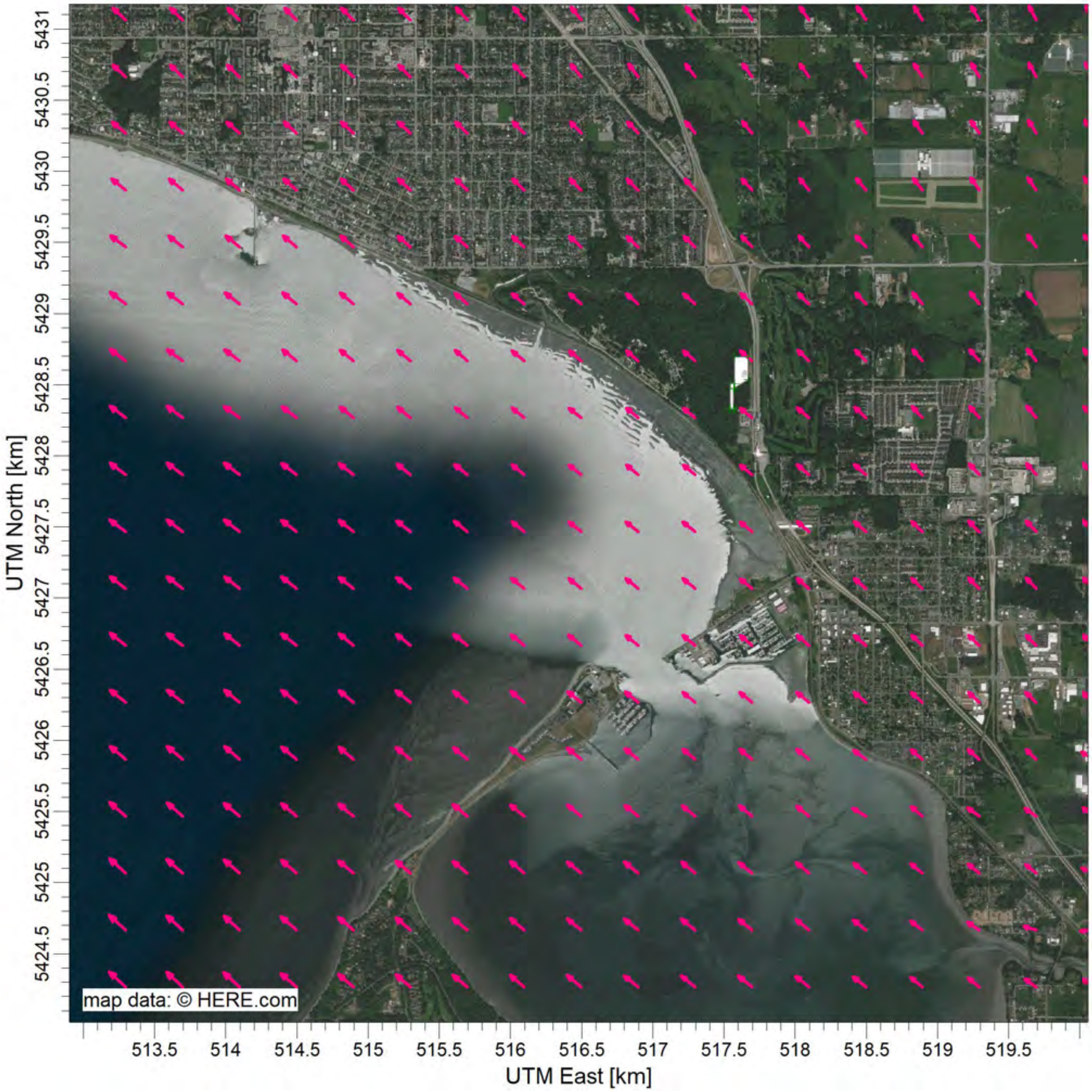
CALPUFF View - Lakes Environmental Software

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 10m Wind Field - July 18, 2013 0600 PDT



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MODELER:

T. Miguez

SCALE: 1:45,000

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DATE:

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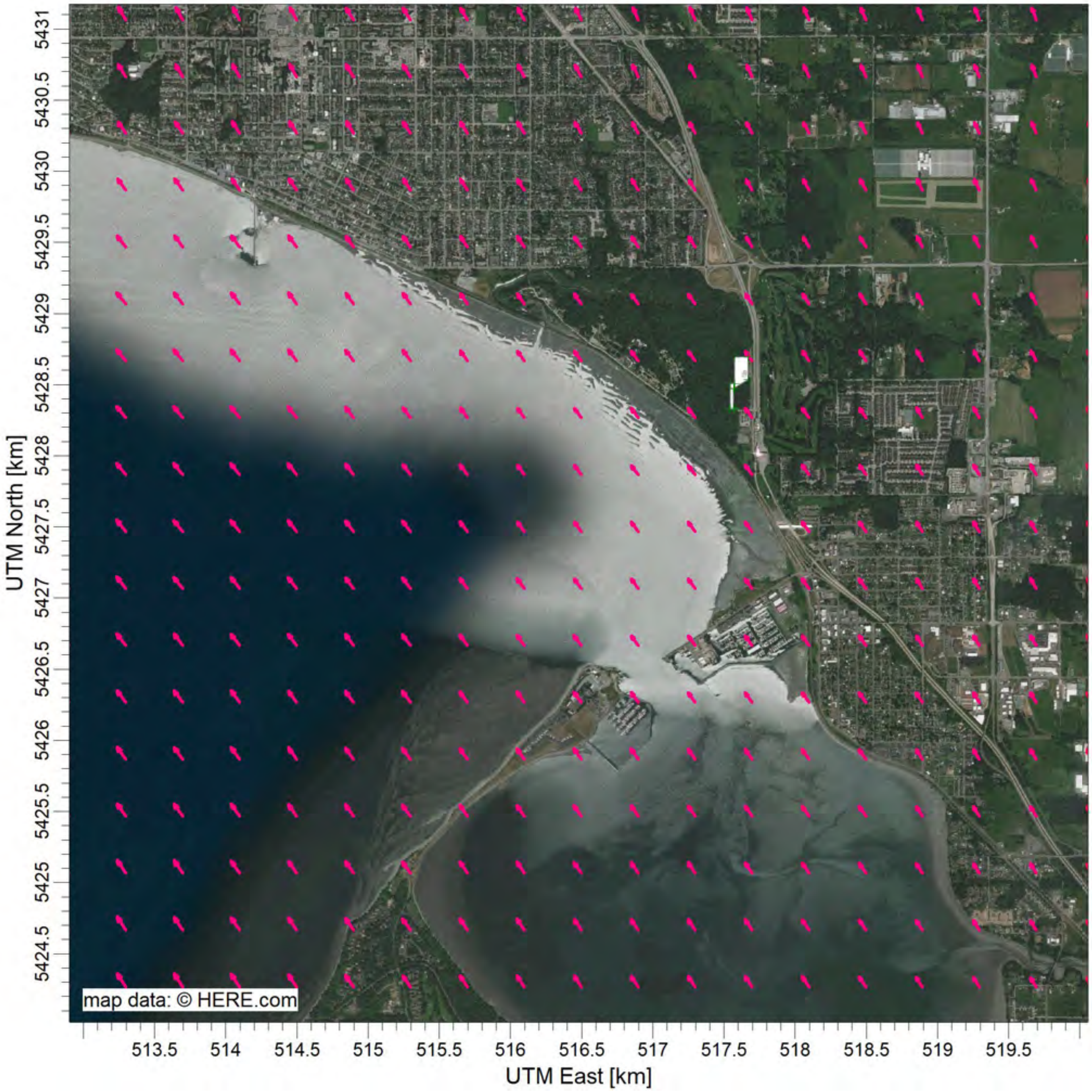
Figure B.9(a).6

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 10m Wind Field - July 18, 2013 0700 PDT



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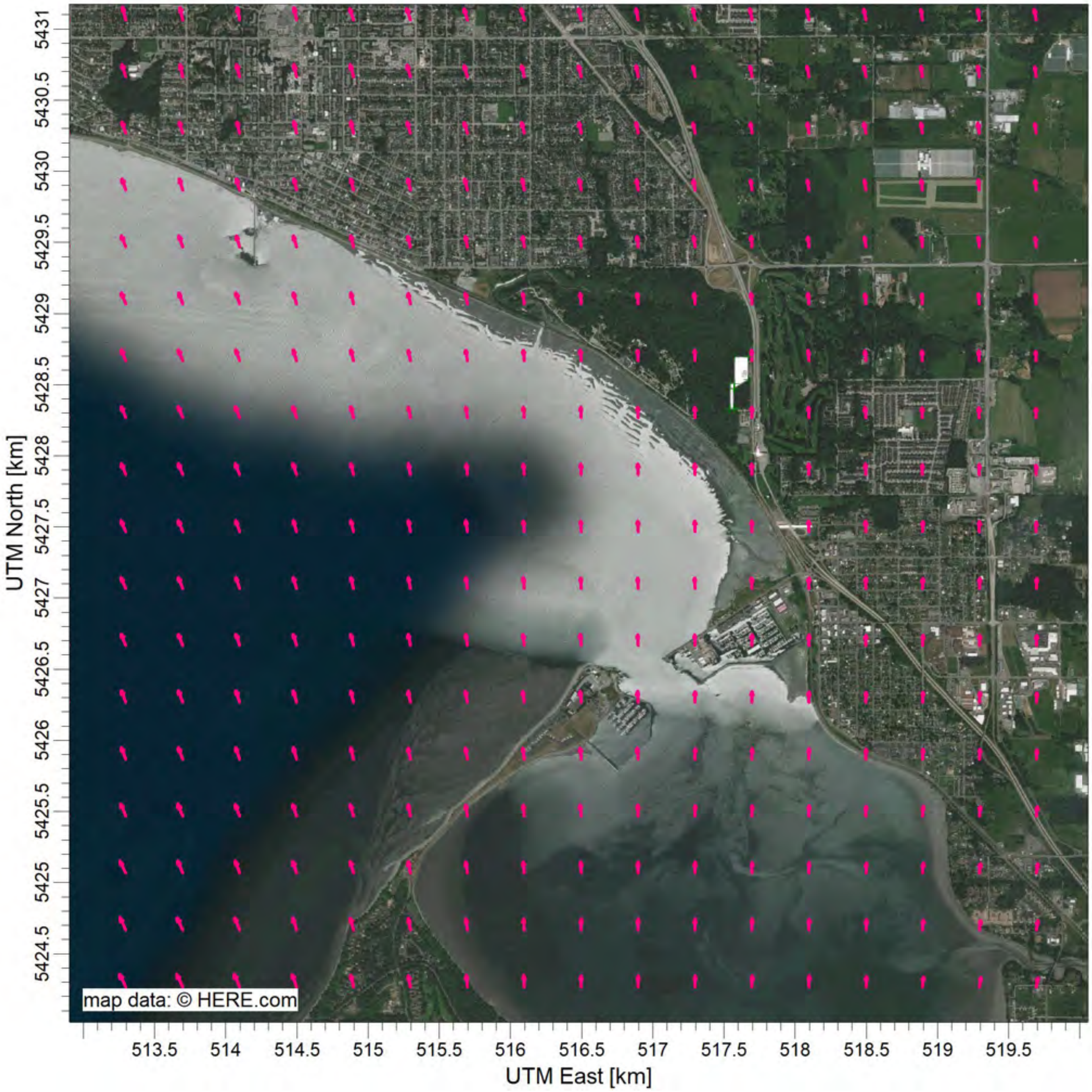
PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 10m Wind Field - July 18, 2013 0800 PDT



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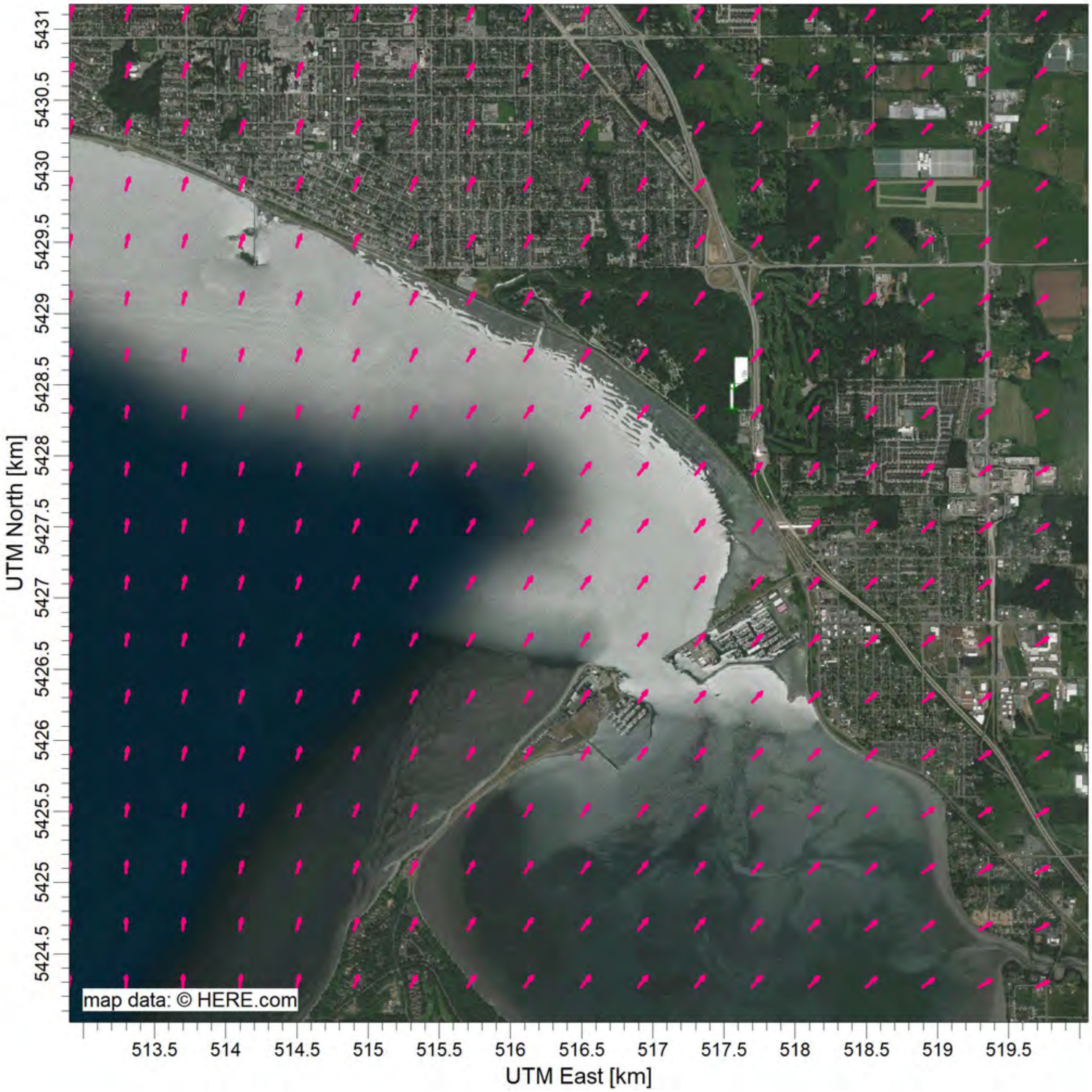
PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 10m Wind Field - July 18, 2013 0900 PDT



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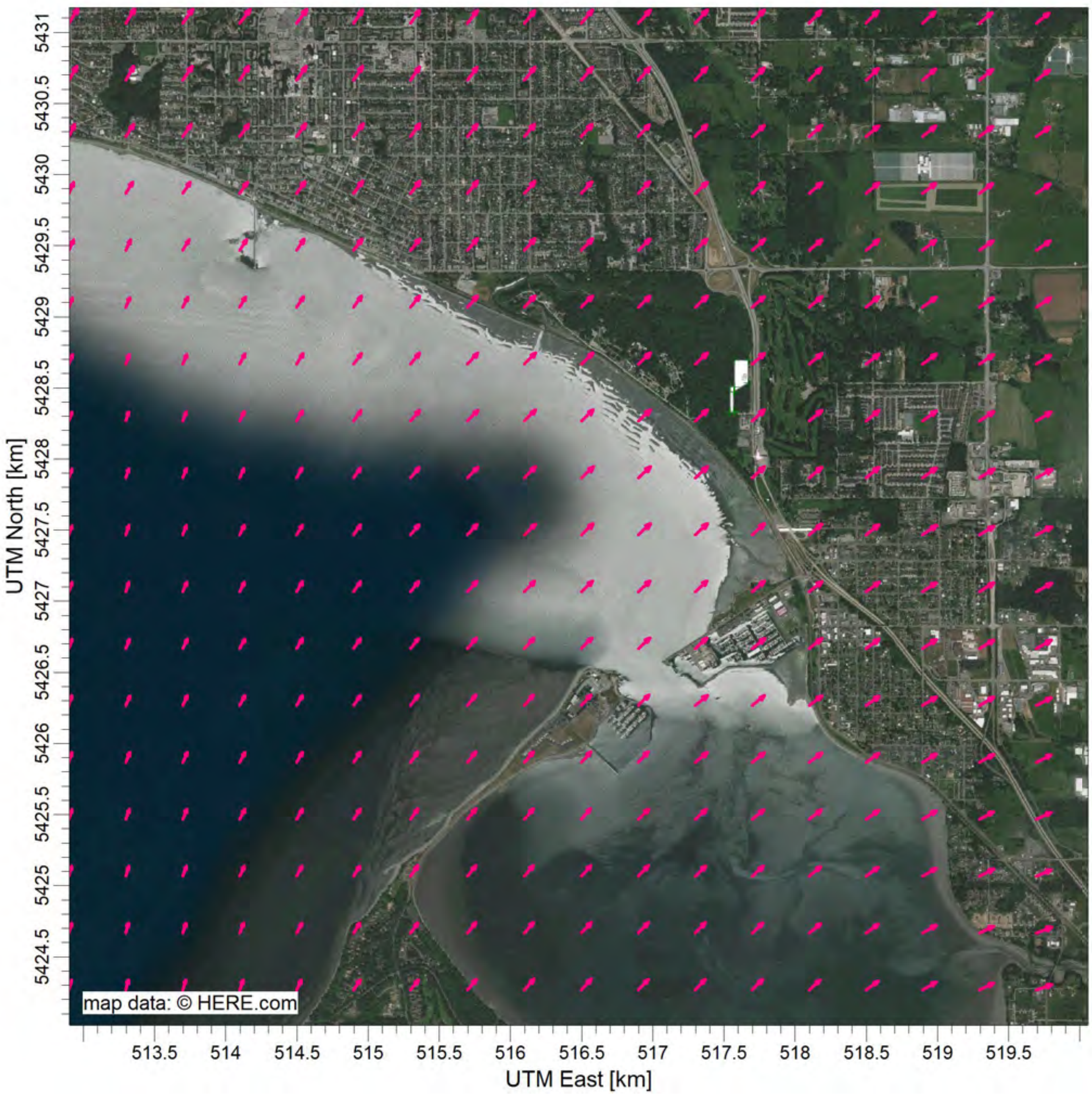
PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 10m Wind Field - July 18, 2013 1000 PDT



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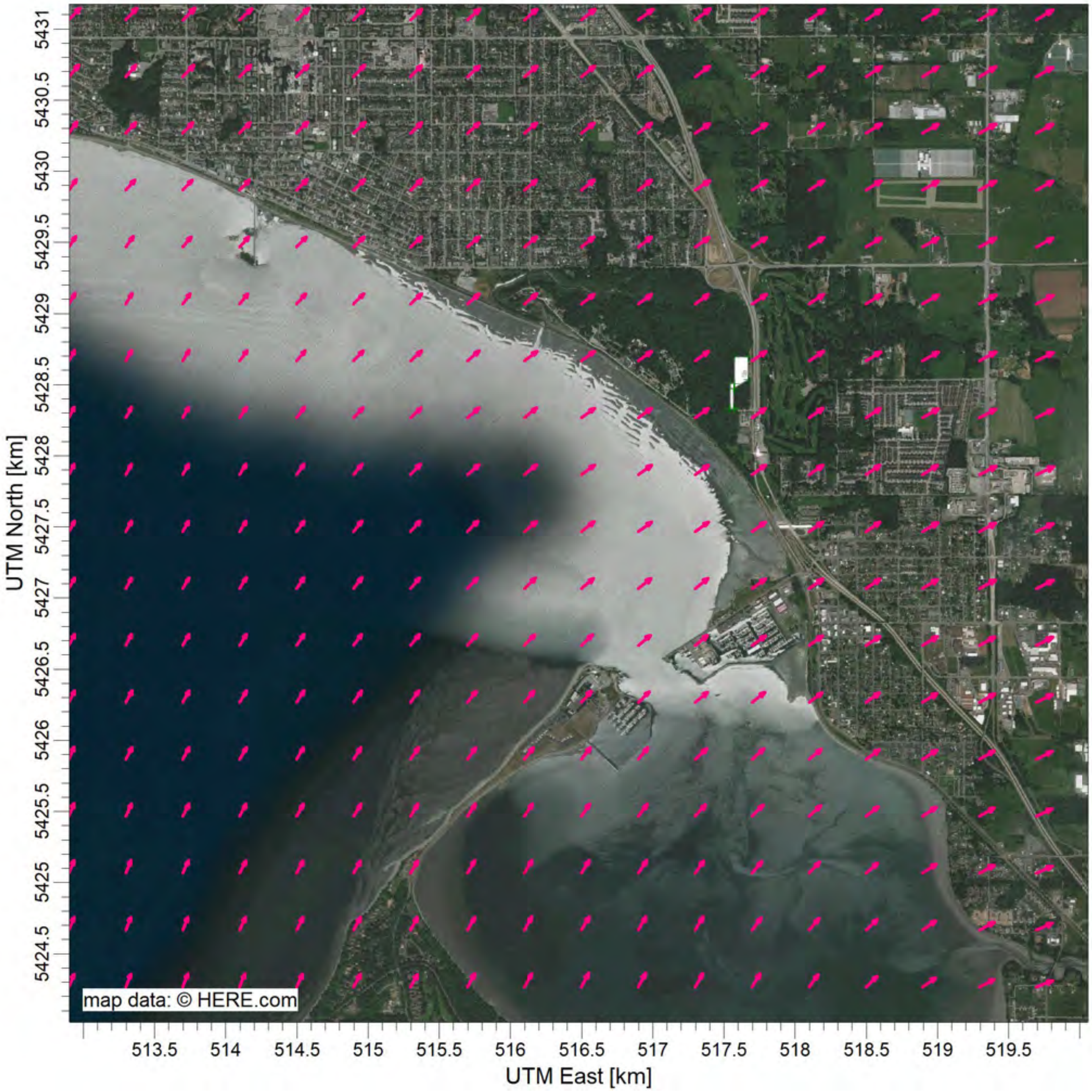
CALPUFF View - Lakes Environmental Software

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 10m Wind Field - July 18, 2013 1100 PDT



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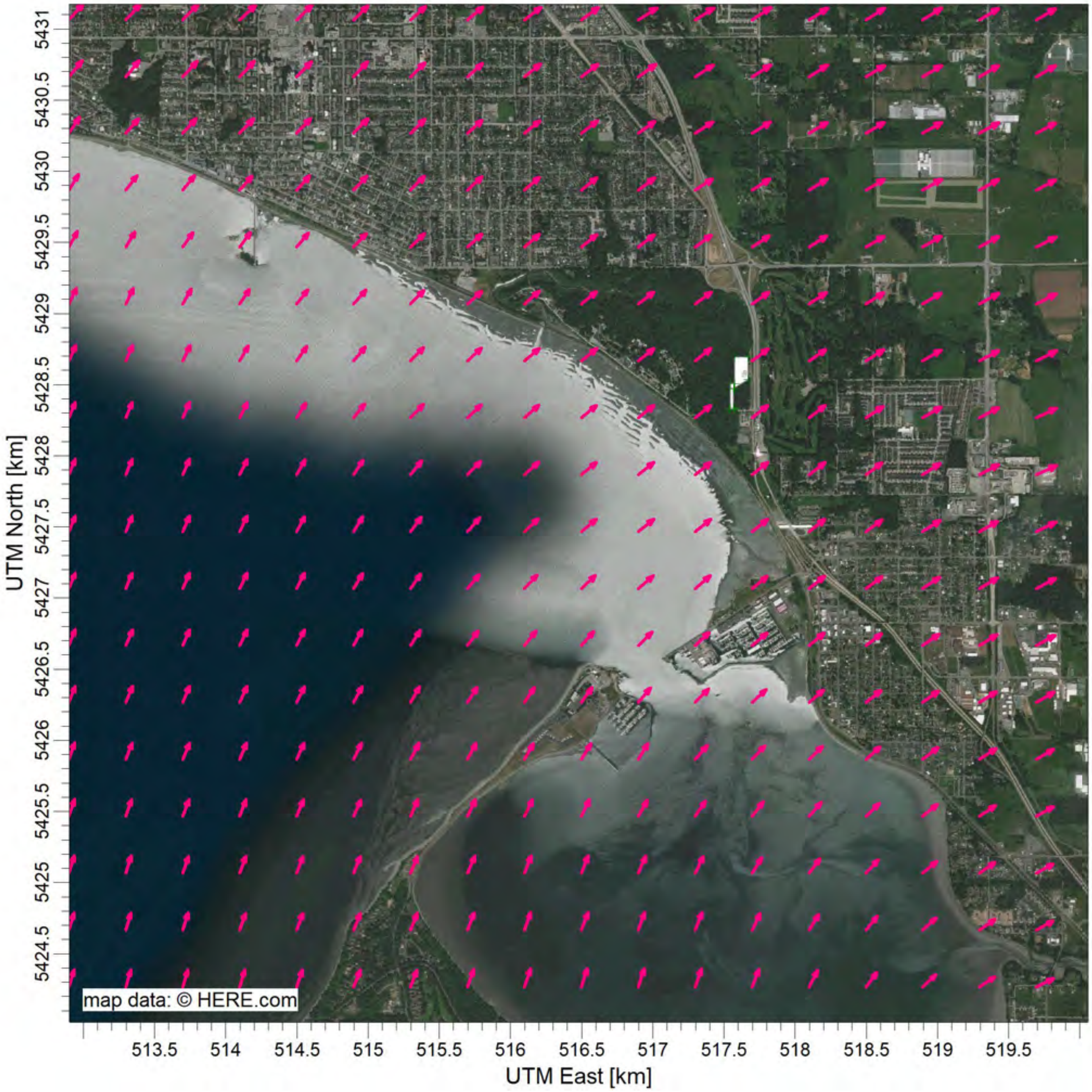
PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 10m Wind Field - July 18, 2013 1200 PDT



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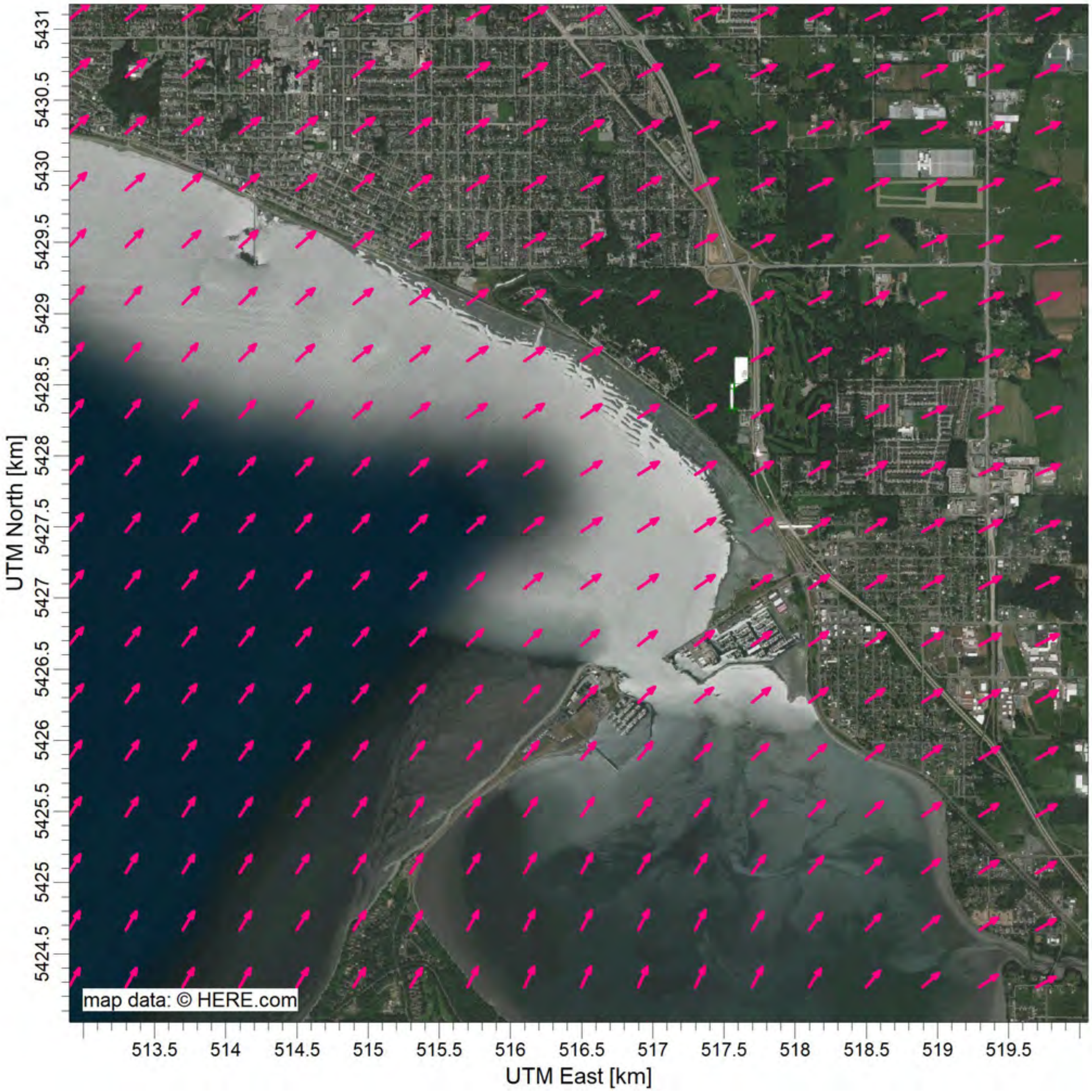
CALPUFF View - Lakes Environmental Software

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 10m Wind Field - July 18, 2013 1300 PDT



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PROJECT TITLE:

Land-Sea Breeze Circulation Validation
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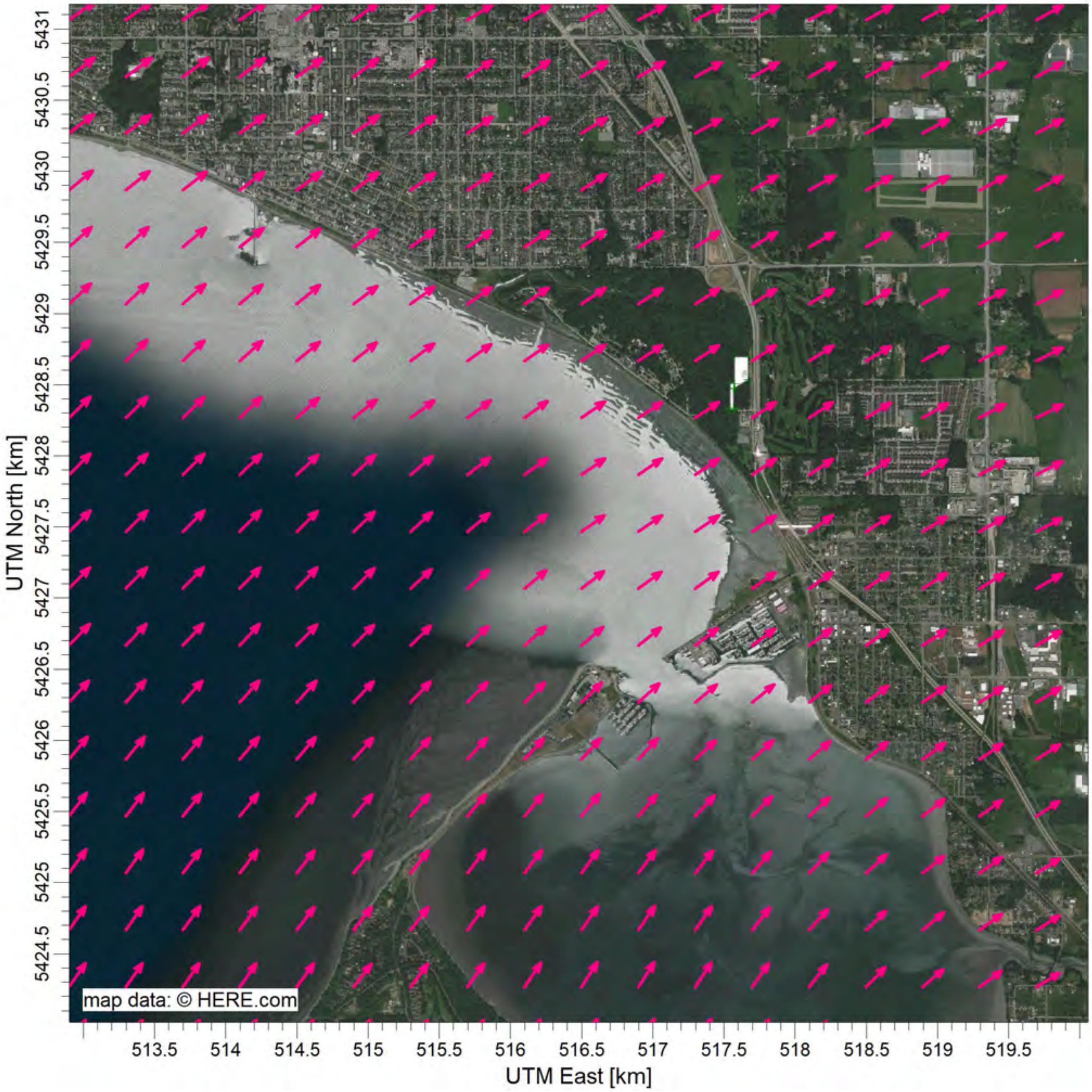

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PROJECT TITLE:

Land-Sea Breeze Circulation Validation
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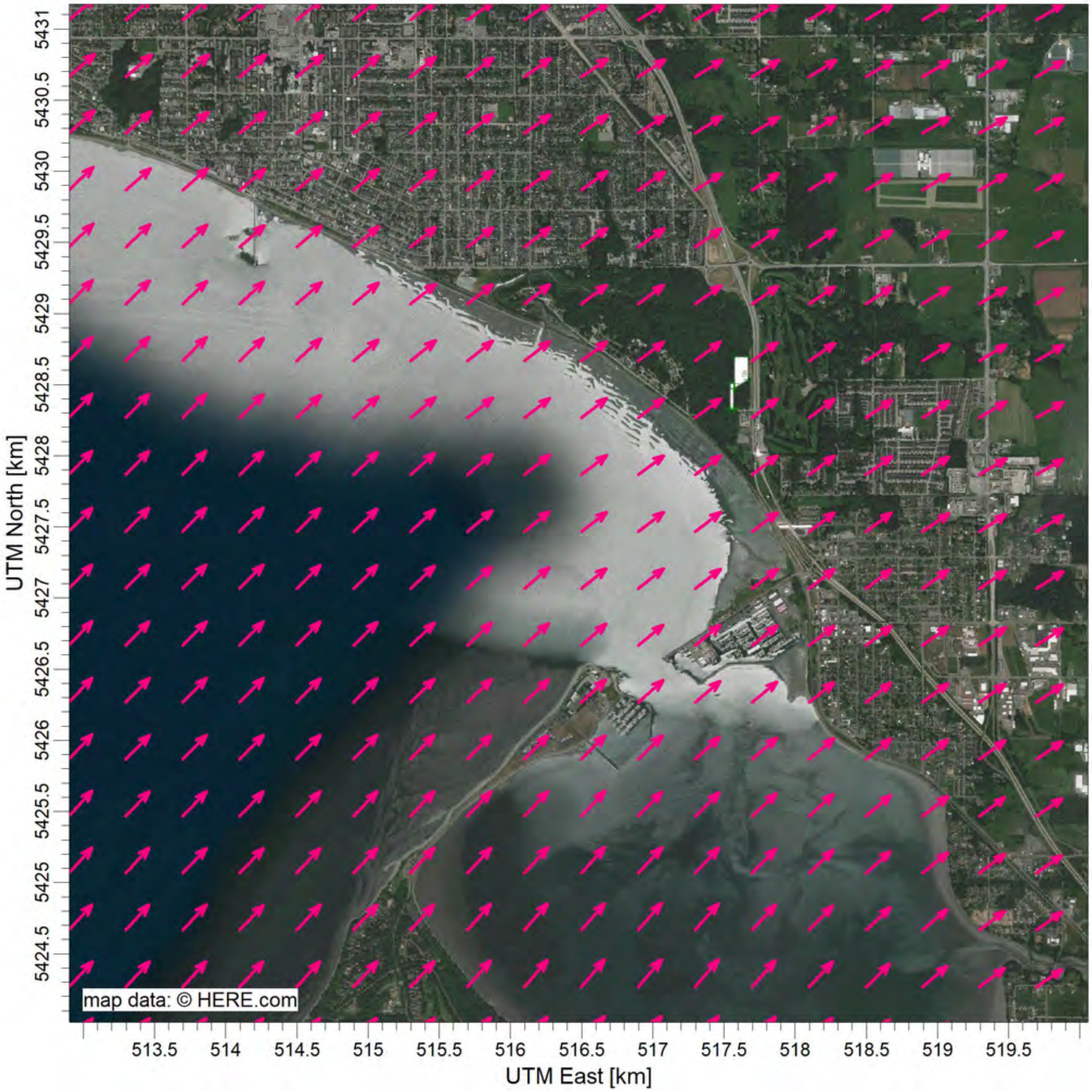

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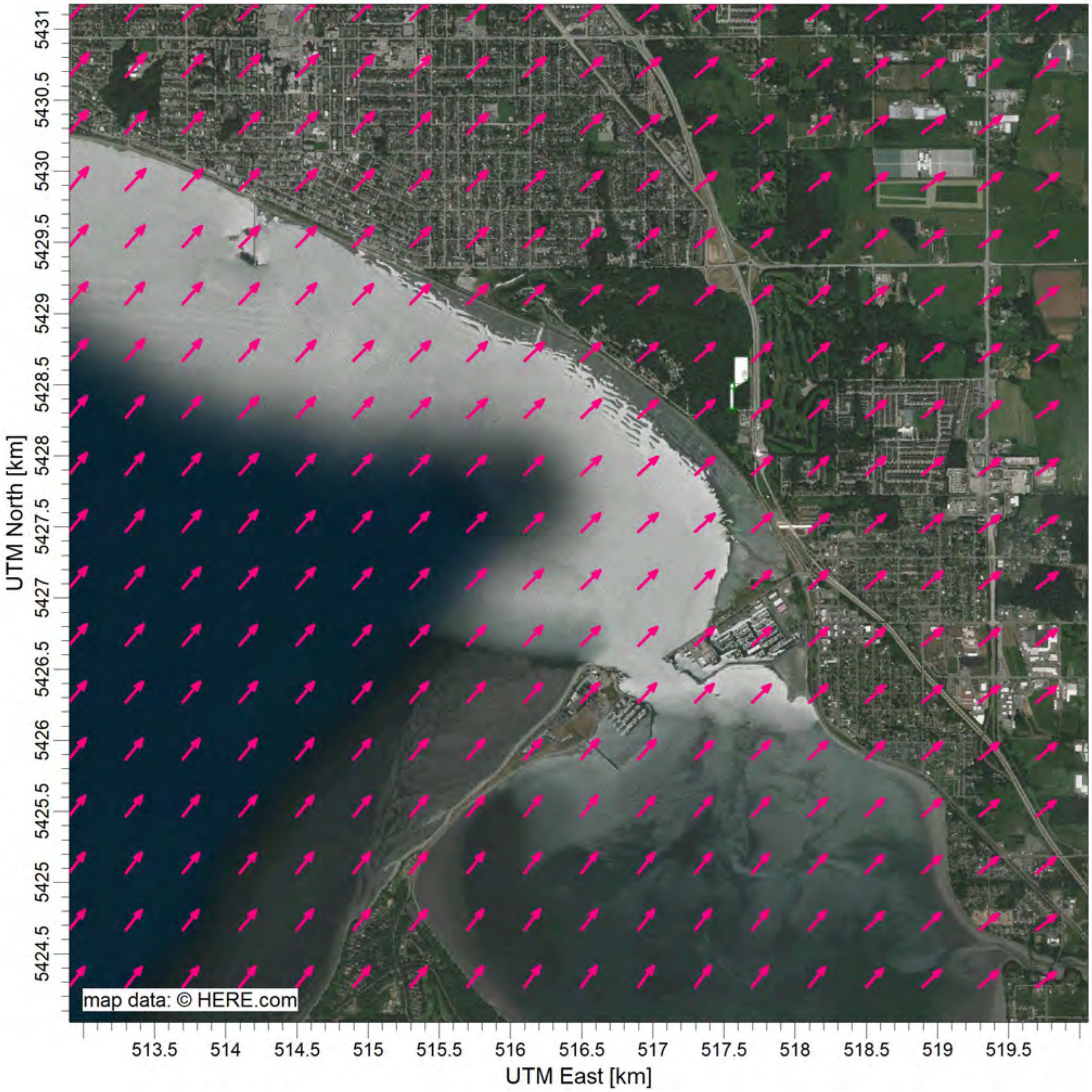
	DATE: **6/2/2023**	**Figure B.9(a).15**

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 10m Wind Field - July 18, 2013 1600 PDT



COMMENTS:

Surface (10 m) Layer

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:45,000

0 1 km

andion

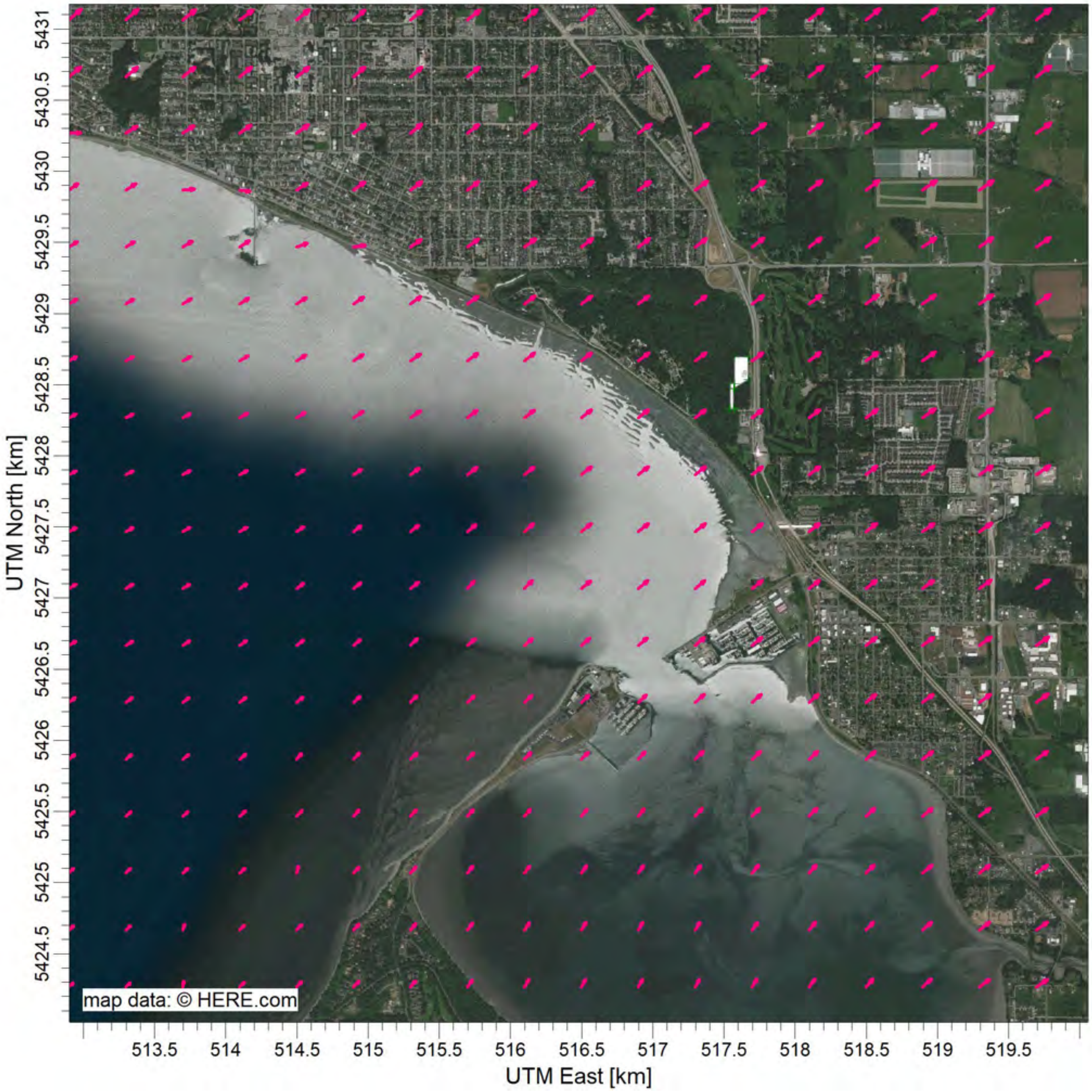
DATE:

6/2/2023

Figure B.9(a).16

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 10m Wind Field - July 18, 2013 1700 PDT



COMMENTS:

Surface (10 m) Layer

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:45,000

0 1 km

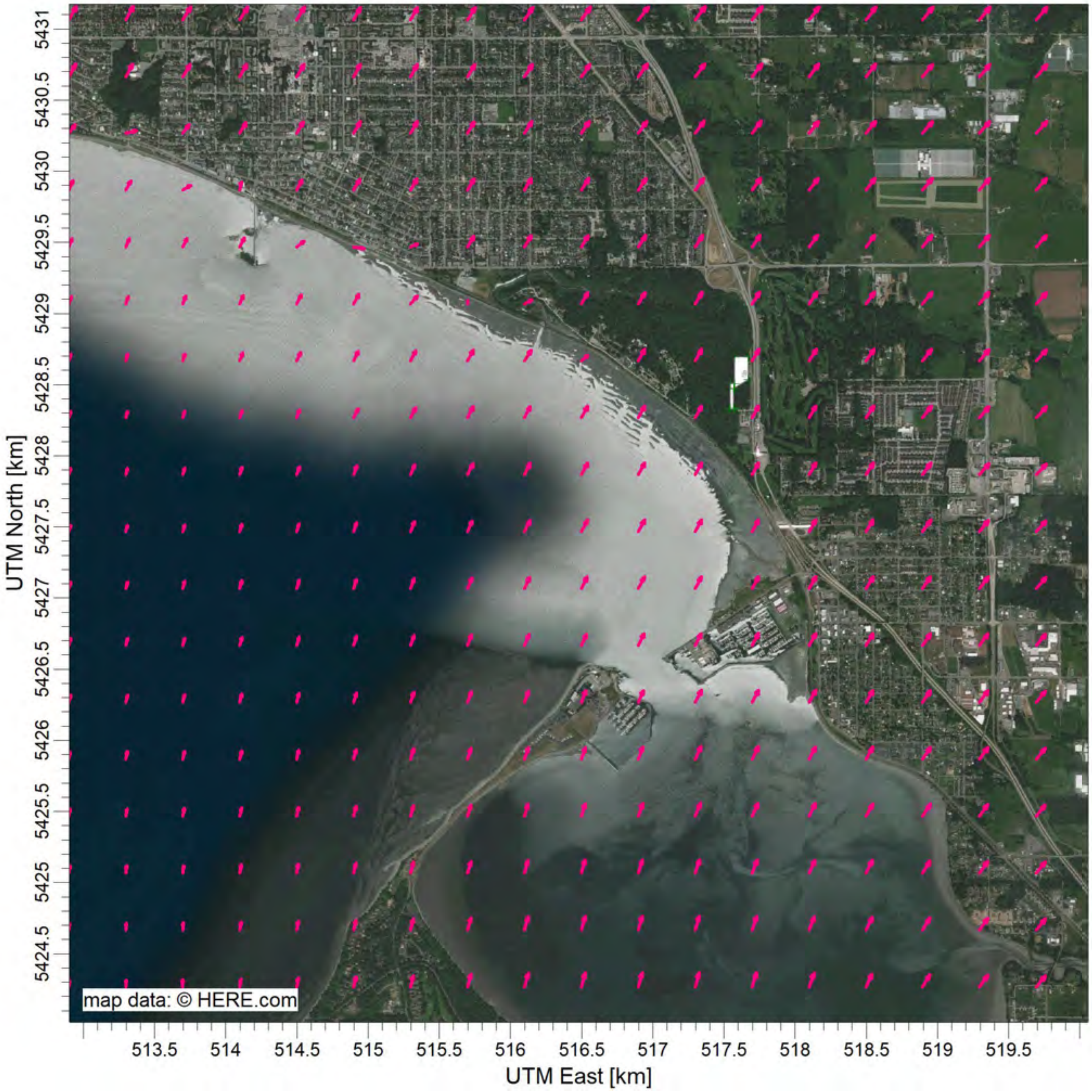
DATE:

6/2/2023

Figure B.9(a).17

PROJECT TITLE:

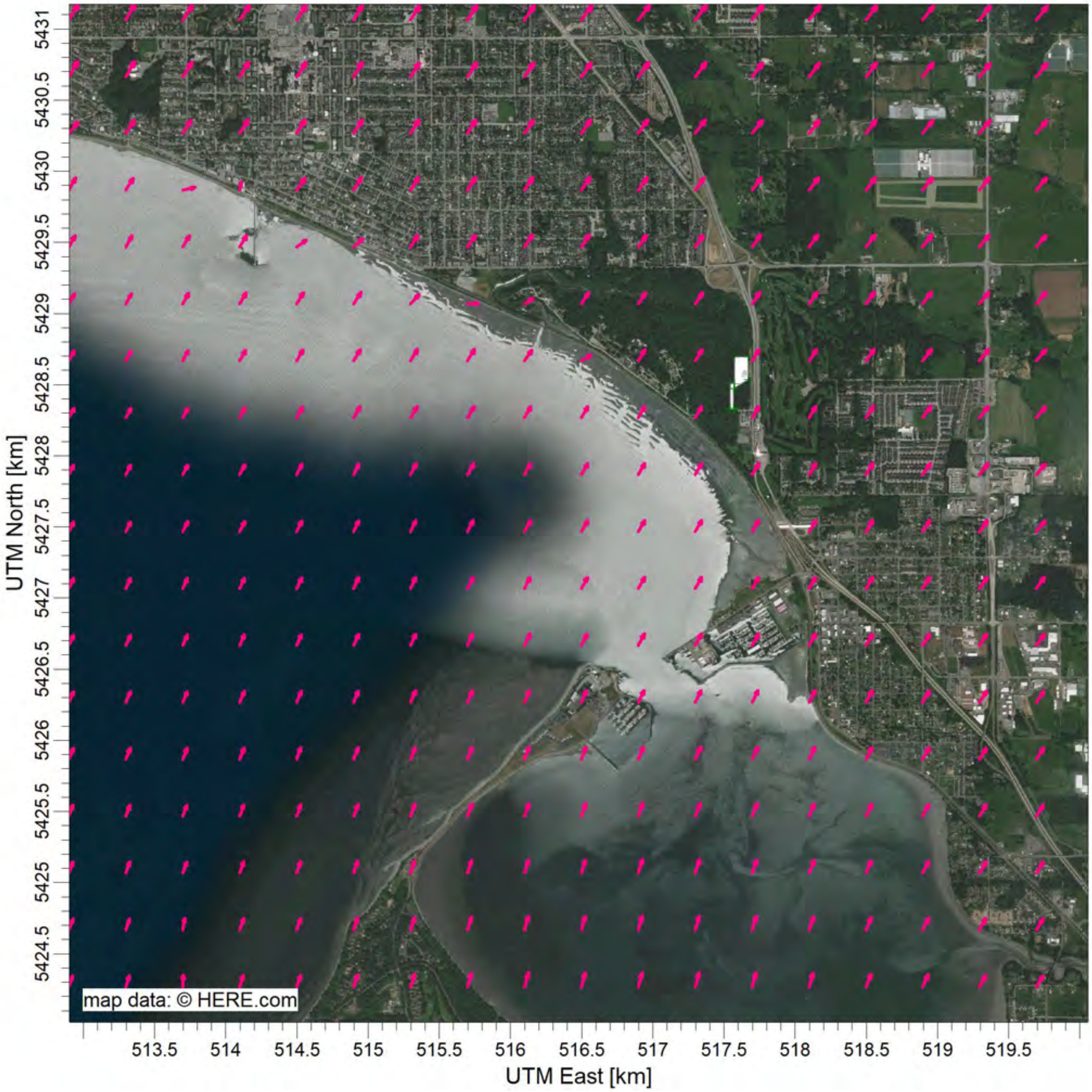
Land-Sea Breeze Circulation Validation
CALMET 10m Wind Field - July 18, 2013 1800 PDT



COMMENTS:	COMPANY NAME:	
Surface (10 m) Layer	**Tetra Tech**	
	MODELER: **T. Miguez**	andion
	SCALE: 1:45,000 (0 — 1 km)	
	DATE: **6/2/2023**	**Figure B.9(a).18**

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 10m Wind Field - July 18, 2013 1900 PDT



COMMENTS:

Surface (10 m) Layer

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:45,000

0 1 km

andion

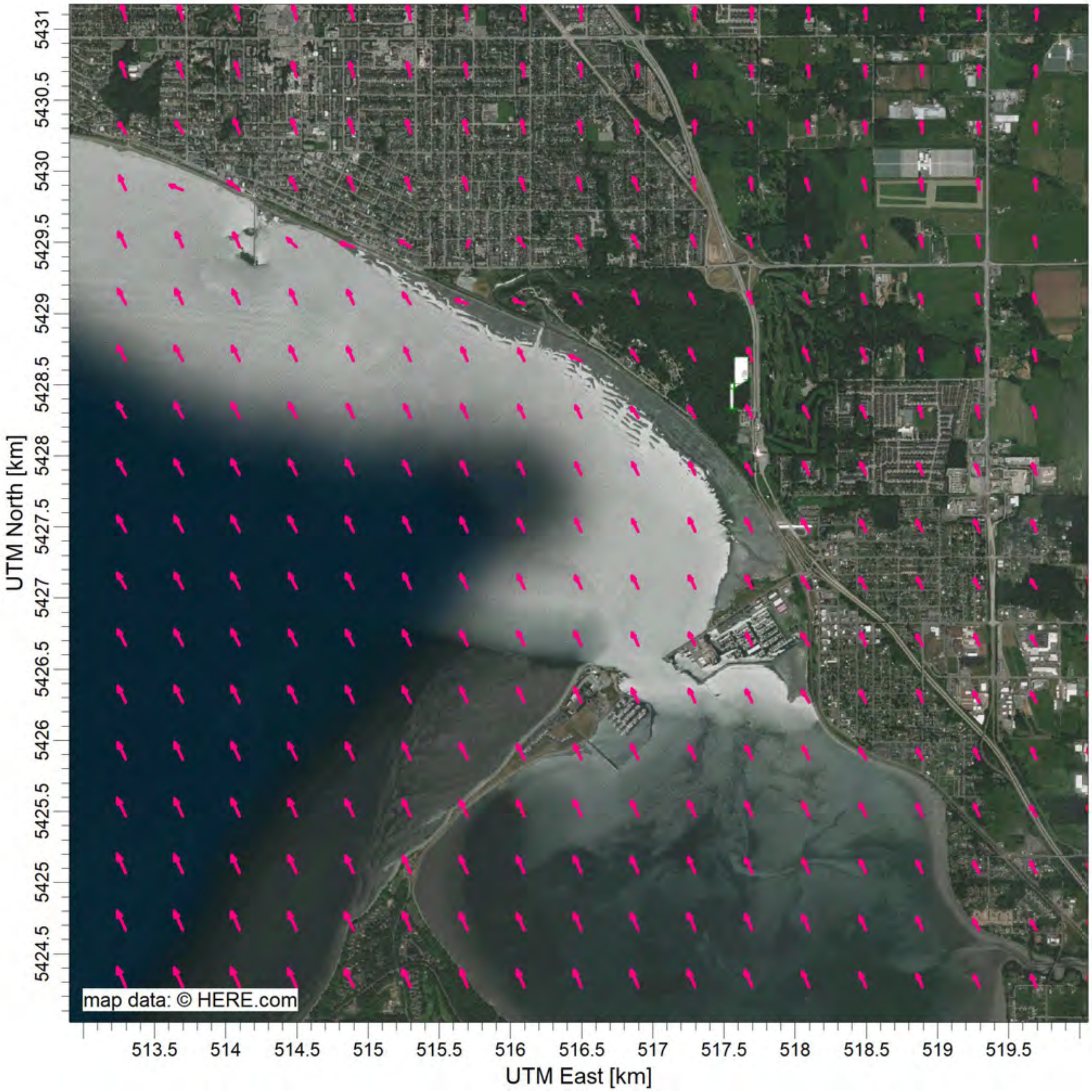
DATE:

6/2/2023

Figure B.9(a).19

PROJECT TITLE:

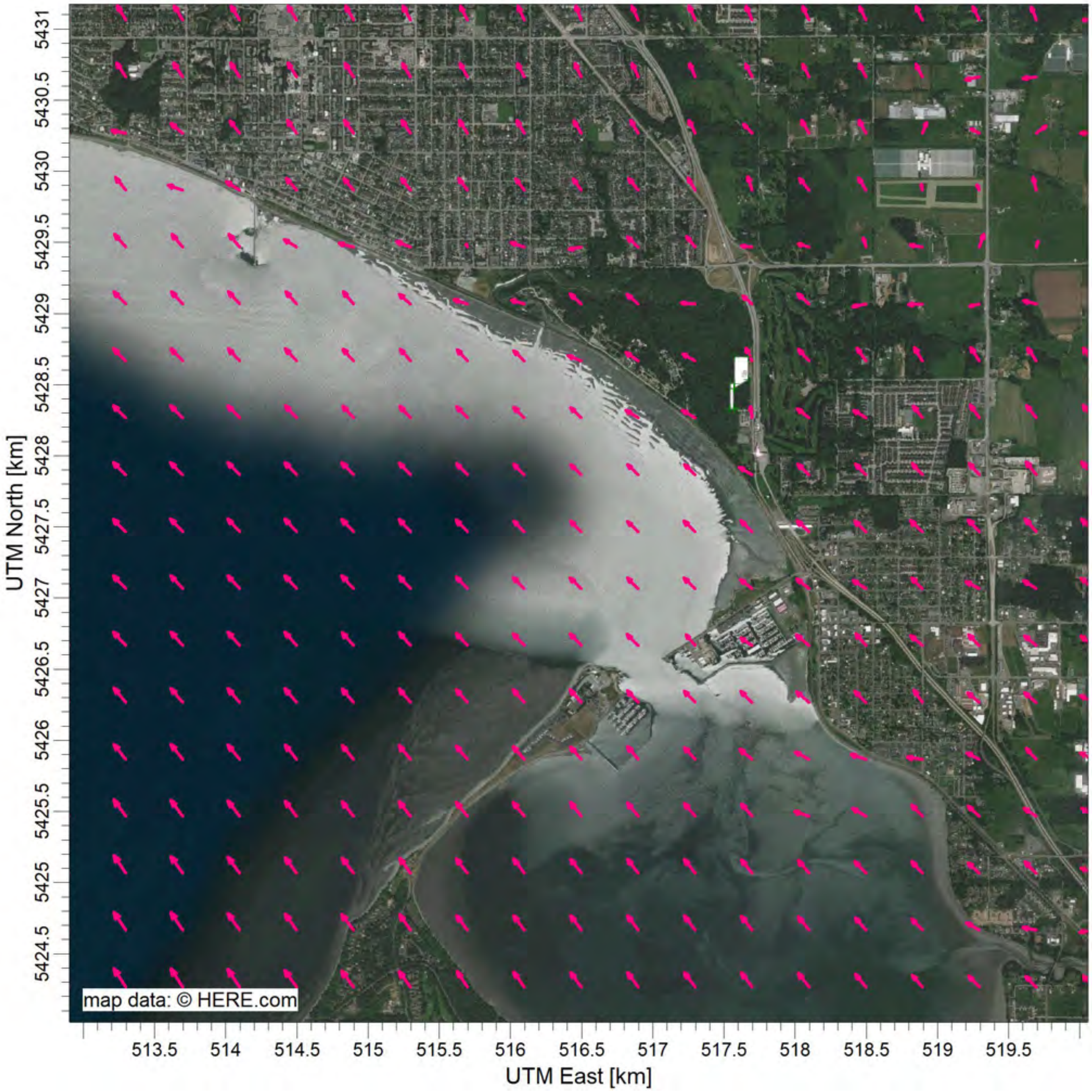
Land-Sea Breeze Circulation Validation
CALMET 10m Wind Field - July 18, 2013 2000 PDT



COMMENTS:	COMPANY NAME:	
Surface (10 m) Layer	**Tetra Tech**	
	MODELER: **T. Miguez**	andion
	SCALE: 1:45,000 (0 — 1 km)	
	DATE: **6/2/2023**	**Figure B.9(a).20**

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 10m Wind Field - July 18, 2013 2100 PDT



COMMENTS:

Surface (10 m) Layer

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:45,000

0 1 km

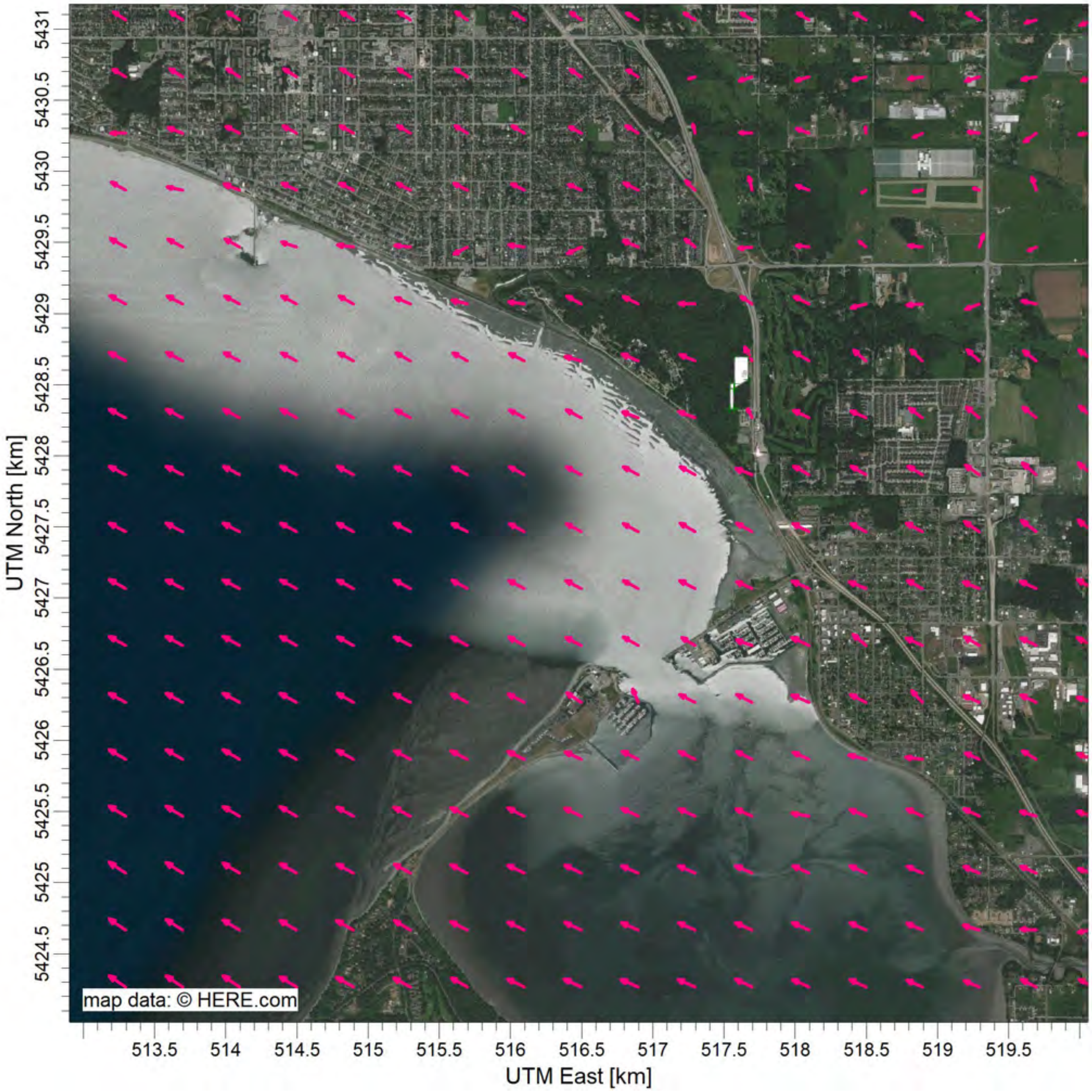
DATE:

6/2/2023

Figure B.9(a).21

PROJECT TITLE:

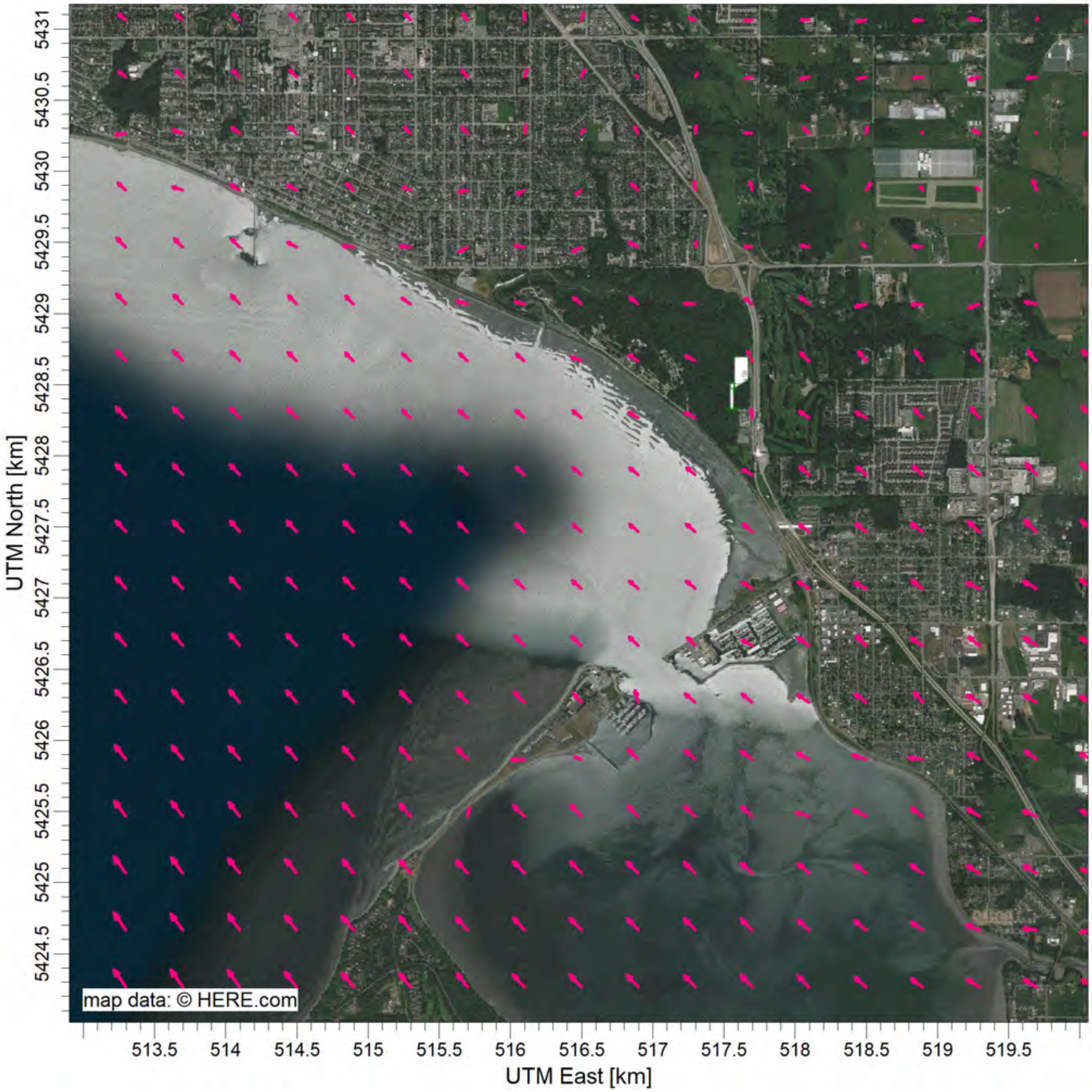
Land-Sea Breeze Circulation Validation
CALMET 10m Wind Field - July 18, 2013 2200 PDT



COMMENTS:	COMPANY NAME:	
Surface (10 m) Layer	**Tetra Tech**	
	MODELER: **T. Miguez**	andion
	SCALE: 1:45,000 (0 — 1 km)	
	DATE: **6/2/2023**	**Figure B.9(a).22**

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 10m Wind Field - July 18, 2013 2300 PDT



COMMENTS:

Surface (10 m) Layer

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:45,000

0 1 km

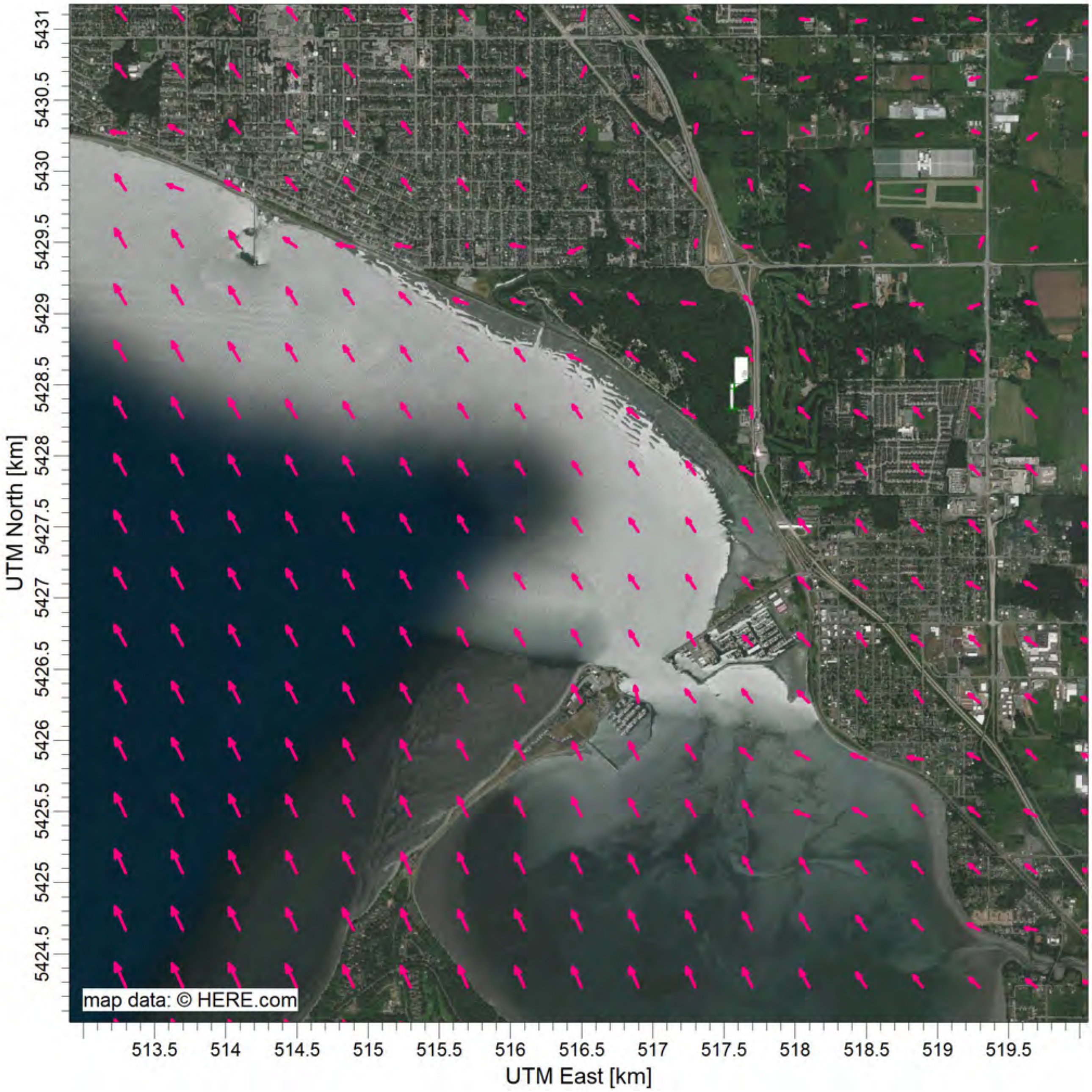
DATE:

6/2/2023

Figure B.9(a).23

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 10m Wind Field - July 18, 2013 2400 PDT



COMMENTS:

Surface (10 m) Layer

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:45,000

0 1 km

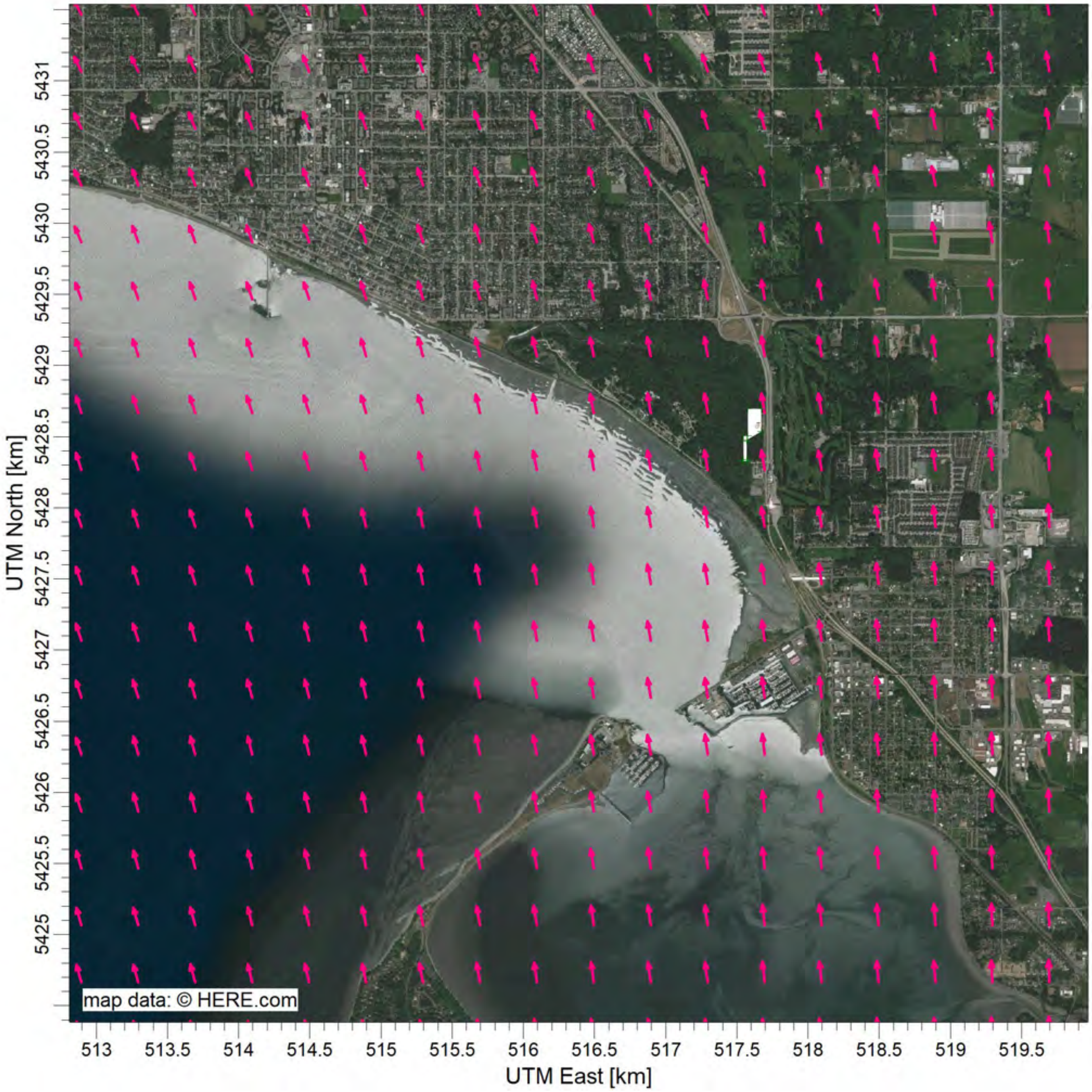
DATE:

6/2/2023

Figure B.9(a).24

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 480m Wind Field - July 18, 2013 0100 PDT



COMMENTS:

Mid (480 m) Layer

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:45,000

0 1 km

DATE:

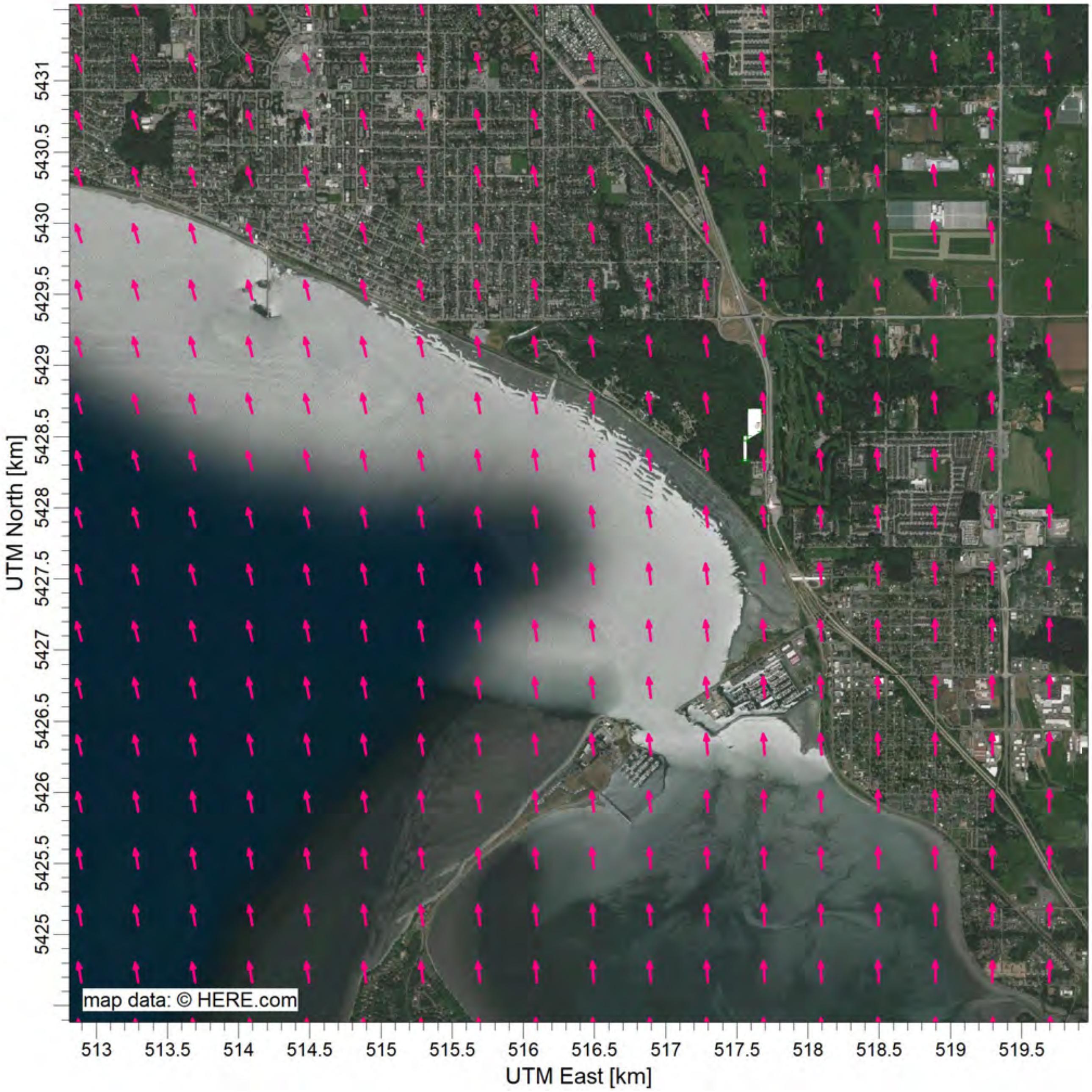
5/31/2023

andion

Figure B.9(b).1

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 480m Wind Field - July 18, 2013 0200 PDT



COMMENTS:

Mid (480 m) Layer

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:45,000

0 — 1 km

DATE:

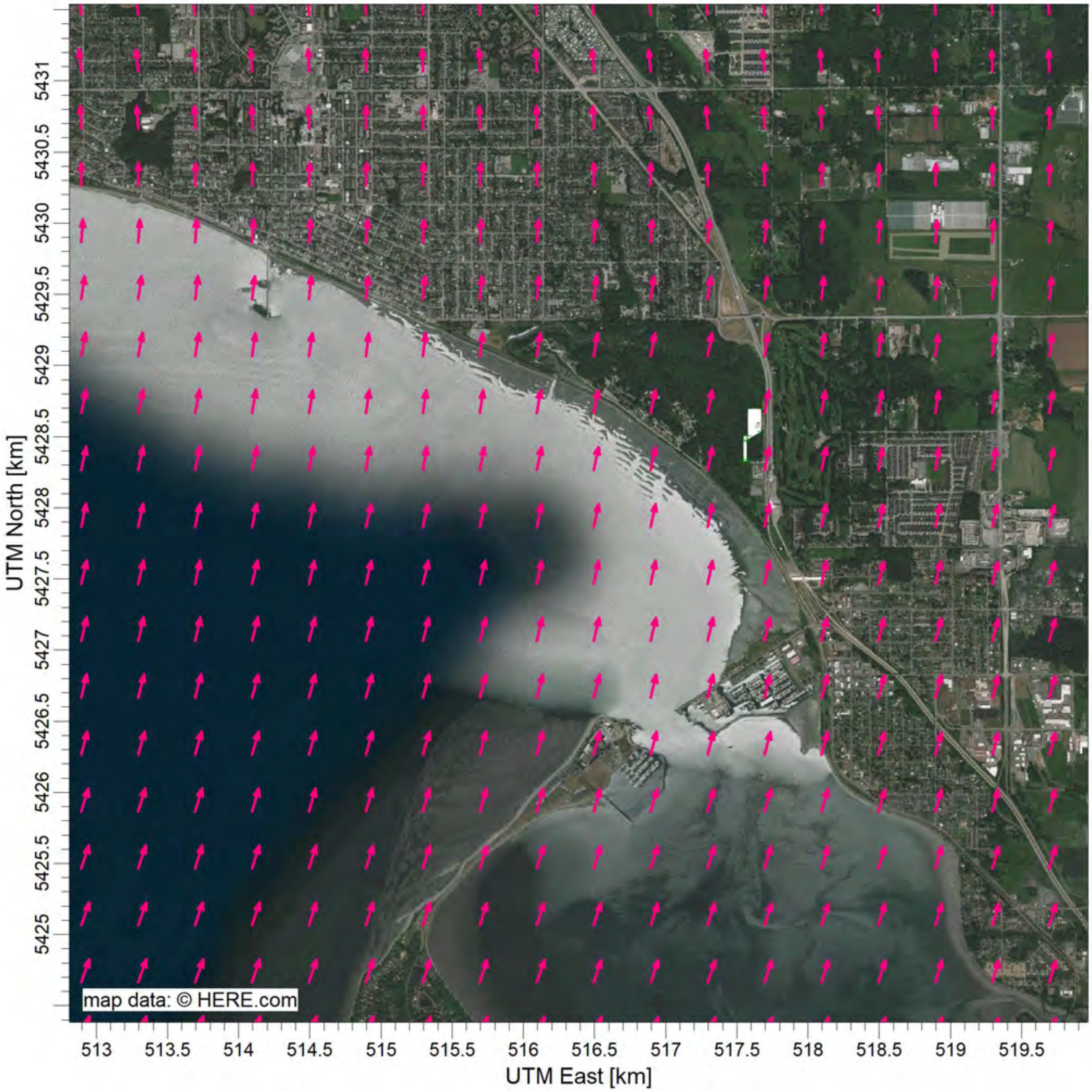
5/31/2023

andion

Figure B.9(b).2

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 480m Wind Field - July 18, 2013 0300 PDT

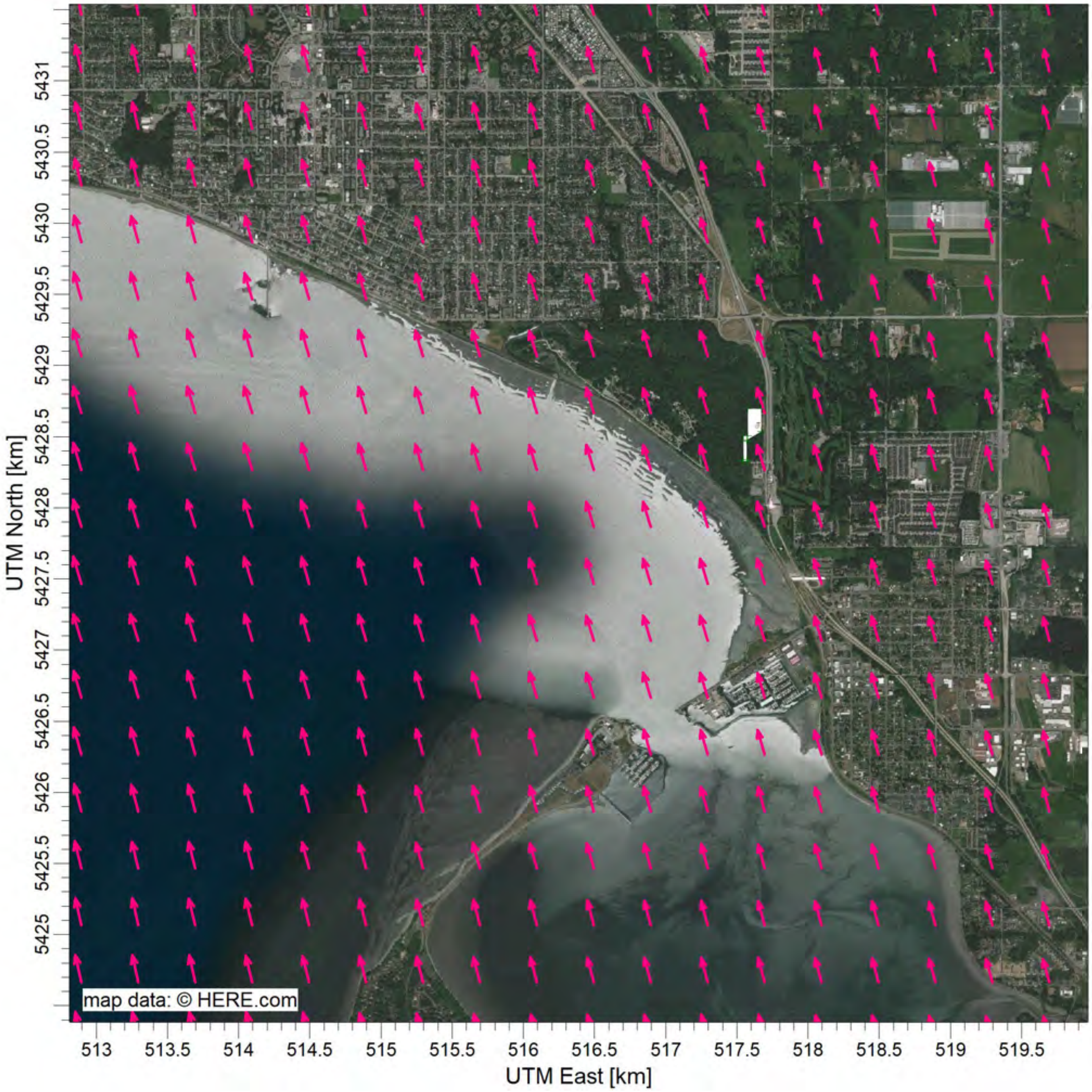


COMMENTS:	COMPANY NAME:	
Mid (480 m) Layer	**Tetra Tech**	
	MODELER: **T. Miguez**	
	SCALE: 1:45,000 (0 – 1 km)	
	DATE: **5/31/2023**	**Figure B.9(b).3**

CALPUFF View - Lakes Environmental Software

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 480m Wind Field - July 18, 2013 0400 PDT



COMMENTS:

Mid (480 m) Layer

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:45,000

0 1 km

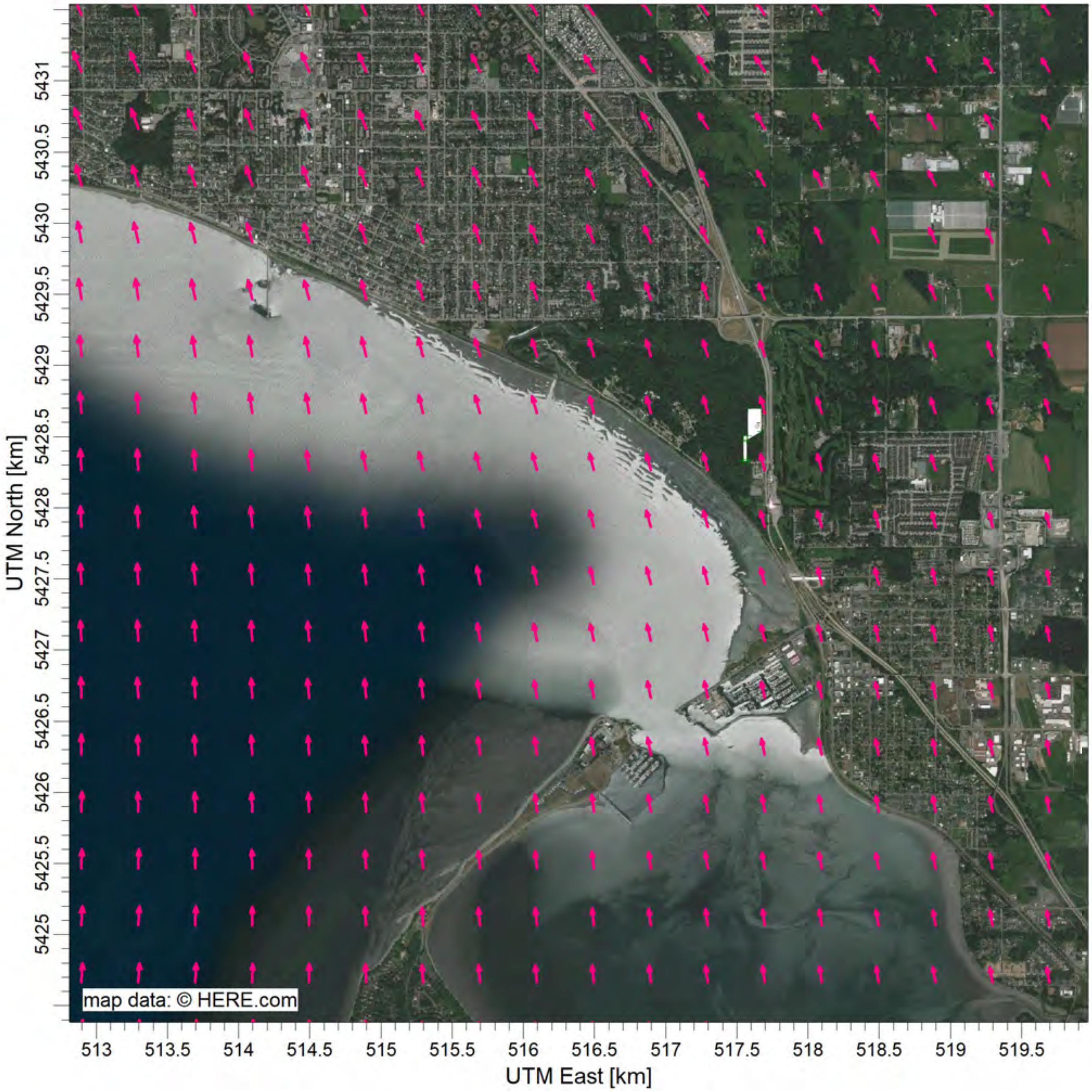
DATE:

5/31/2023

Figure B.9(b).4

PROJECT TITLE:

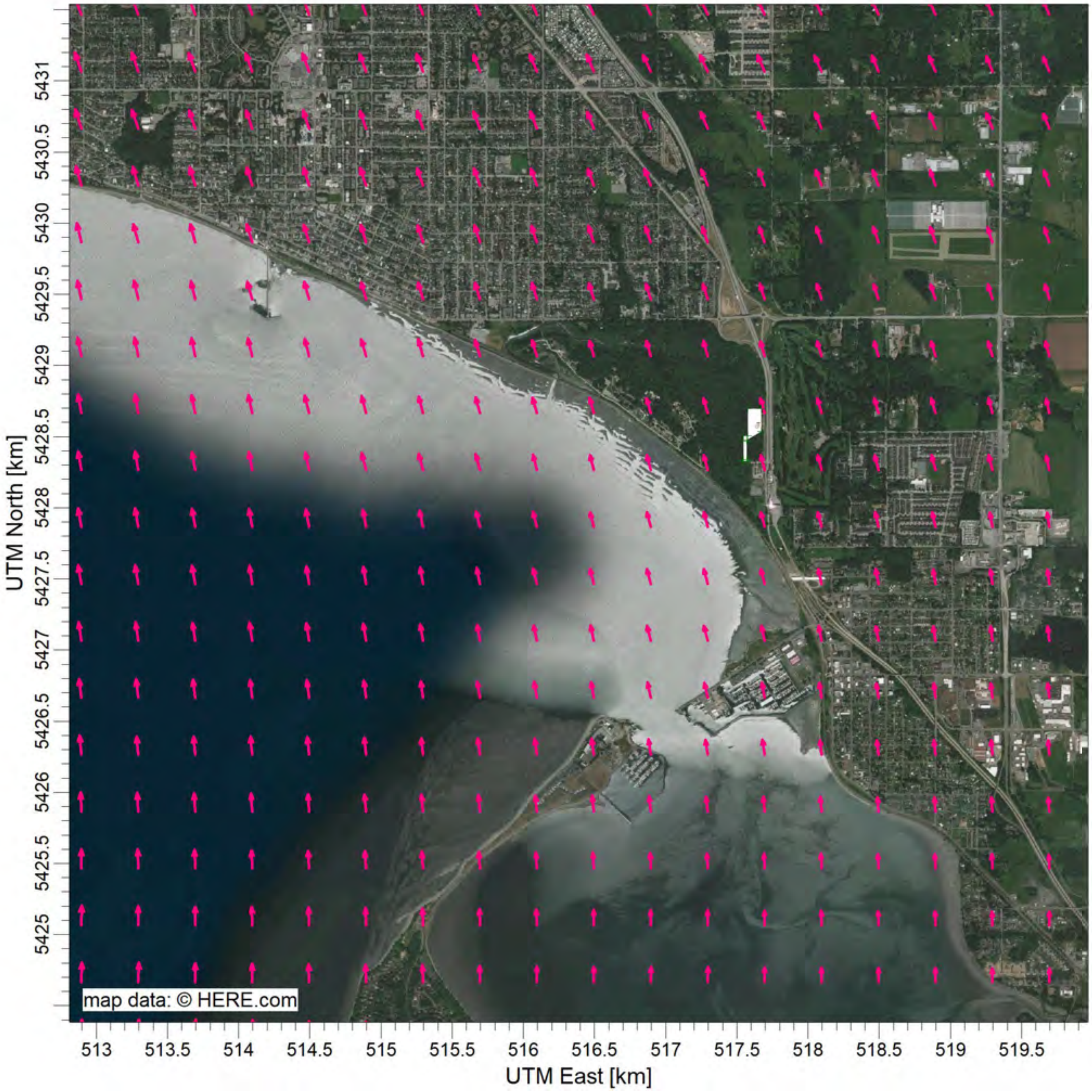
Land-Sea Breeze Circulation Validation
CALMET 480m Wind Field - July 18, 2013 0500 PDT



COMMENTS:	COMPANY NAME:	
Mid (480 m) Layer	**Tetra Tech**	
	MODELER: **T. Miguez**	andion
	SCALE: 1:45,000 (0 — 1 km)	
	DATE: **5/31/2023**	**Figure B.9(b).5**

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 480m Wind Field - July 18, 2013 0600 PDT



COMMENTS:

Mid (480 m) Layer

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:45,000

0 1 km

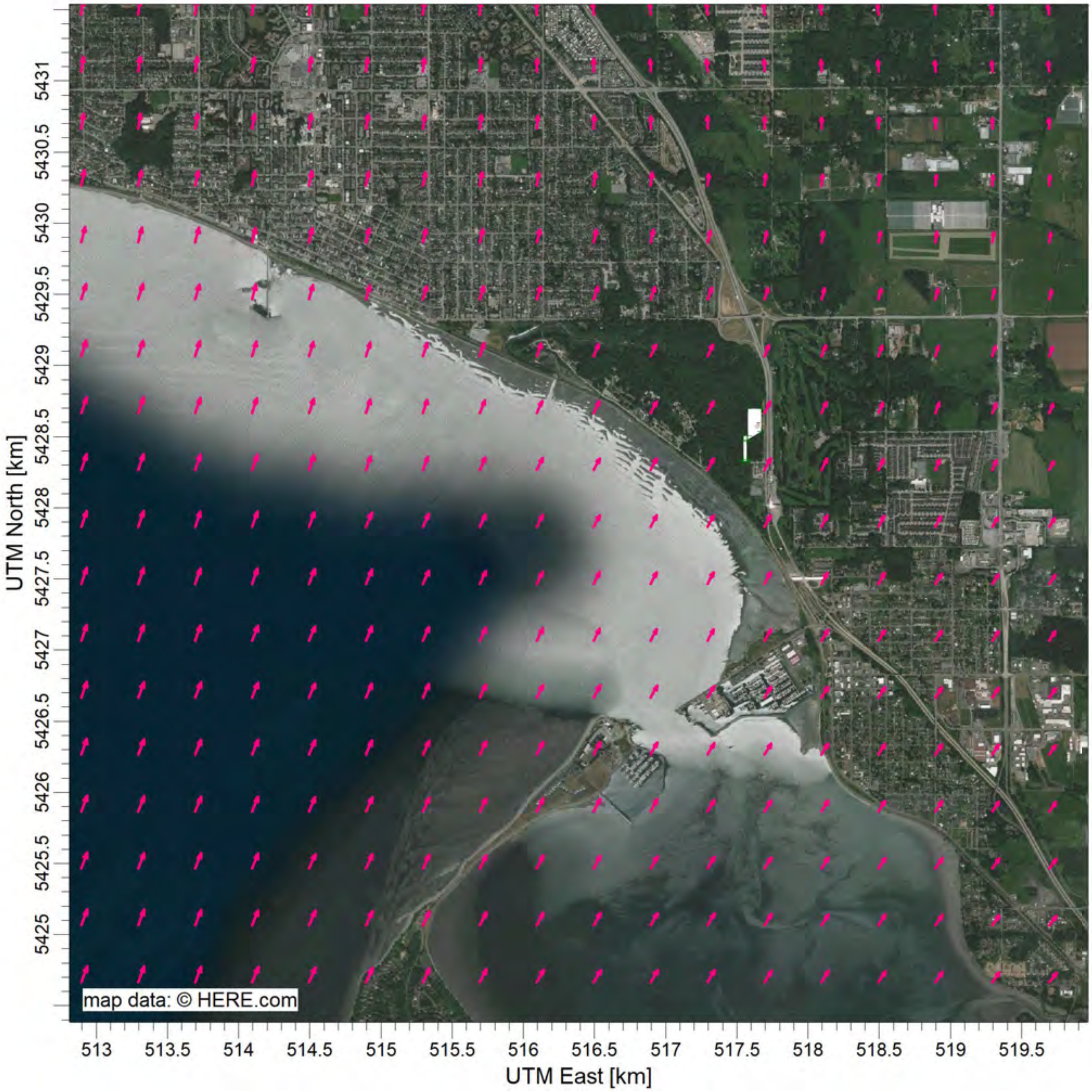
DATE:

5/31/2023

Figure B.9(b).6

PROJECT TITLE:

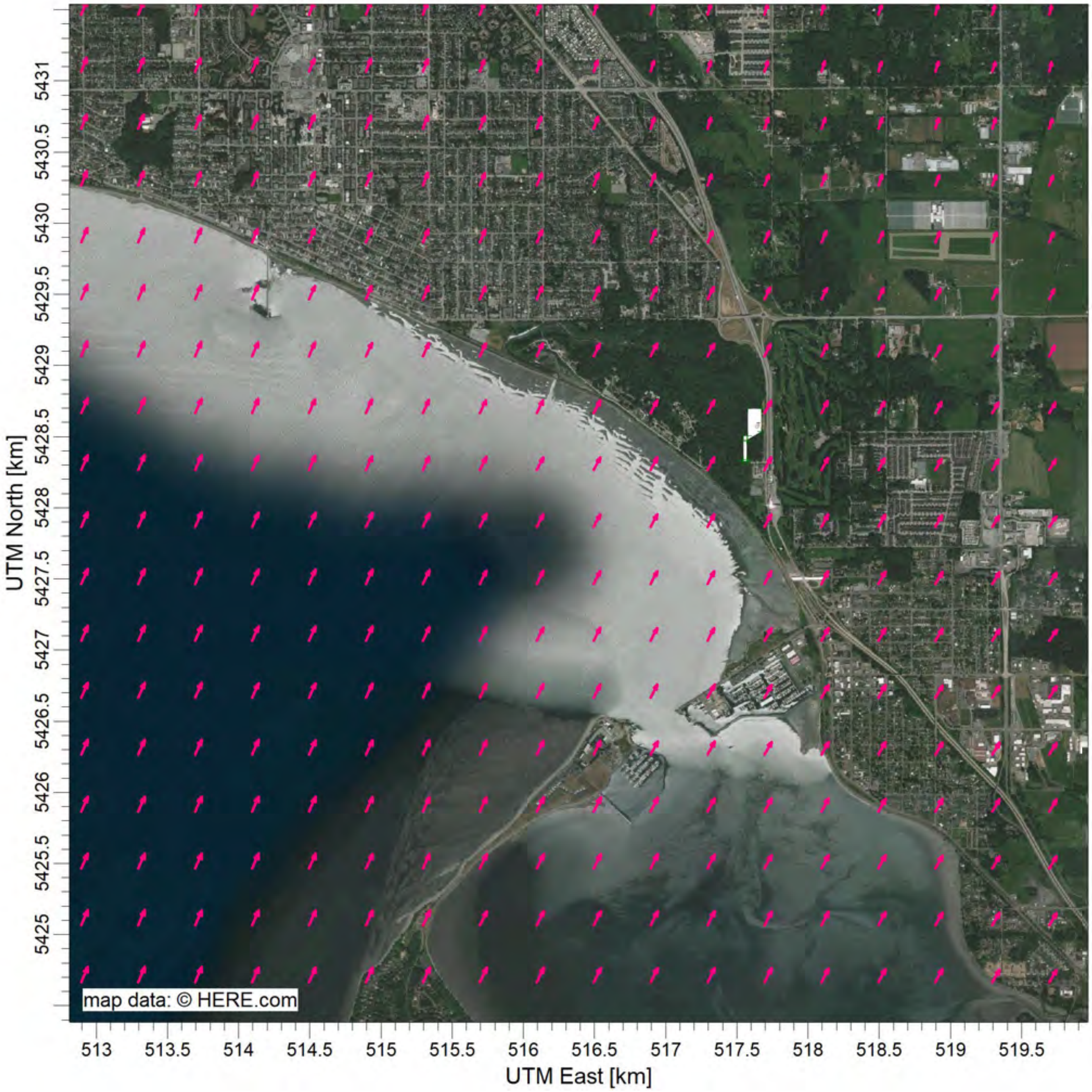
Land-Sea Breeze Circulation Validation
CALMET 480m Wind Field - July 18, 2013 0700 PDT



COMMENTS:	COMPANY NAME:	
Mid (480 m) Layer	**Tetra Tech**	
	MODELER: **T. Miguez**	andion
	SCALE: 1:45,000 (0 — 1 km)	
	DATE: **5/31/2023**	**Figure B.9(b).7**

PROJECT TITLE:

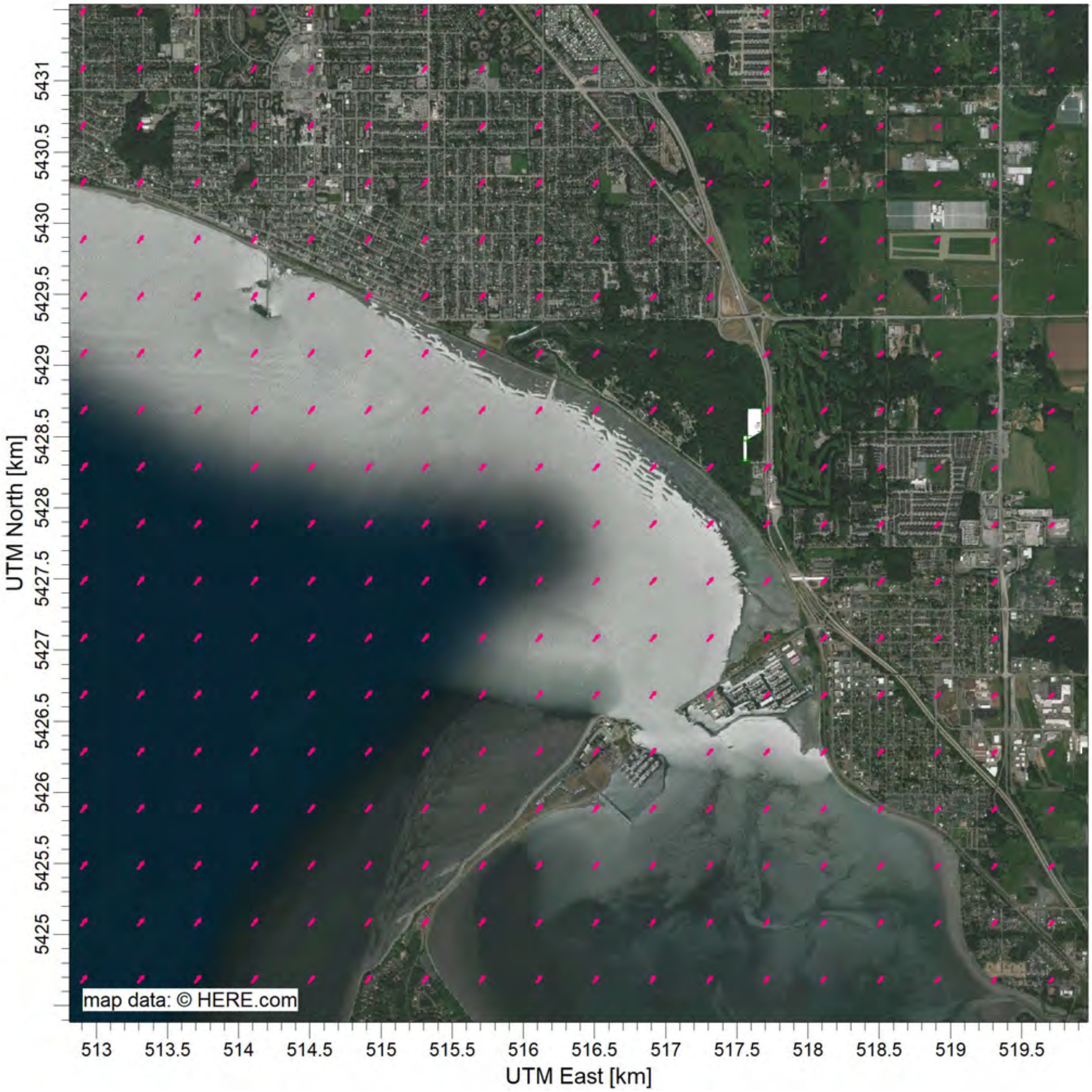
Land-Sea Breeze Circulation Validation
CALMET 480m Wind Field - July 18, 2013 0800 PDT



COMMENTS:	COMPANY NAME:	
Mid (480 m) Layer	**Tetra Tech**	
	MODELER: **T. Miguez**	andion
	SCALE: 1:45,000 (0 – 1 km)	
	DATE: **5/31/2023**	**Figure B.9(b).8**

PROJECT TITLE:

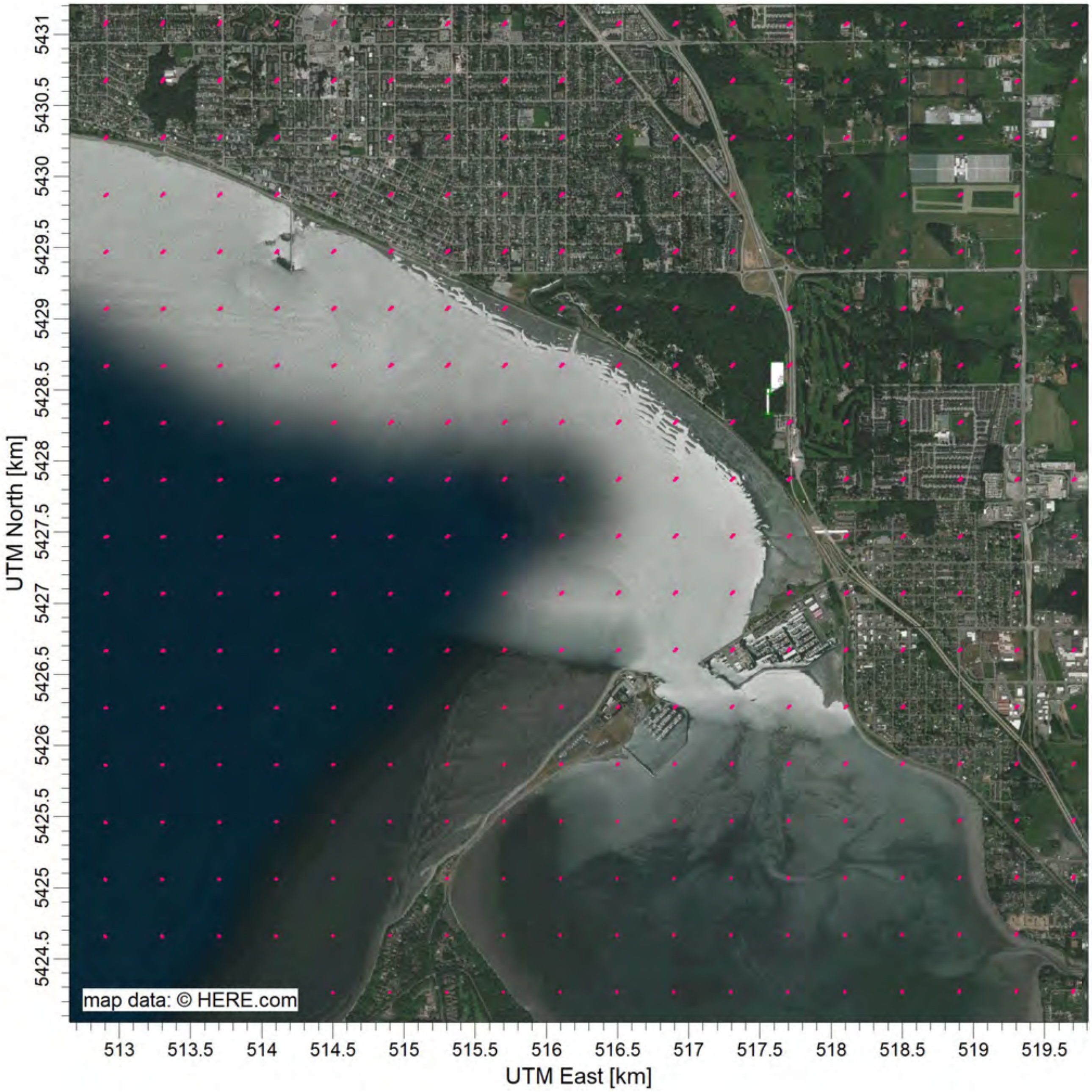
Land-Sea Breeze Circulation Validation
CALMET 480m Wind Field - July 18, 2013 0900 PDT



COMMENTS: Mid (480 m) Layer	COMPANY NAME: **Tetra Tech**
	MODELER: **T. Miguez**
	SCALE: 1:45,000 0 — 1 km
	DATE: **5/31/2023**
	Figure B.9(b).9

PROJECT TITLE:

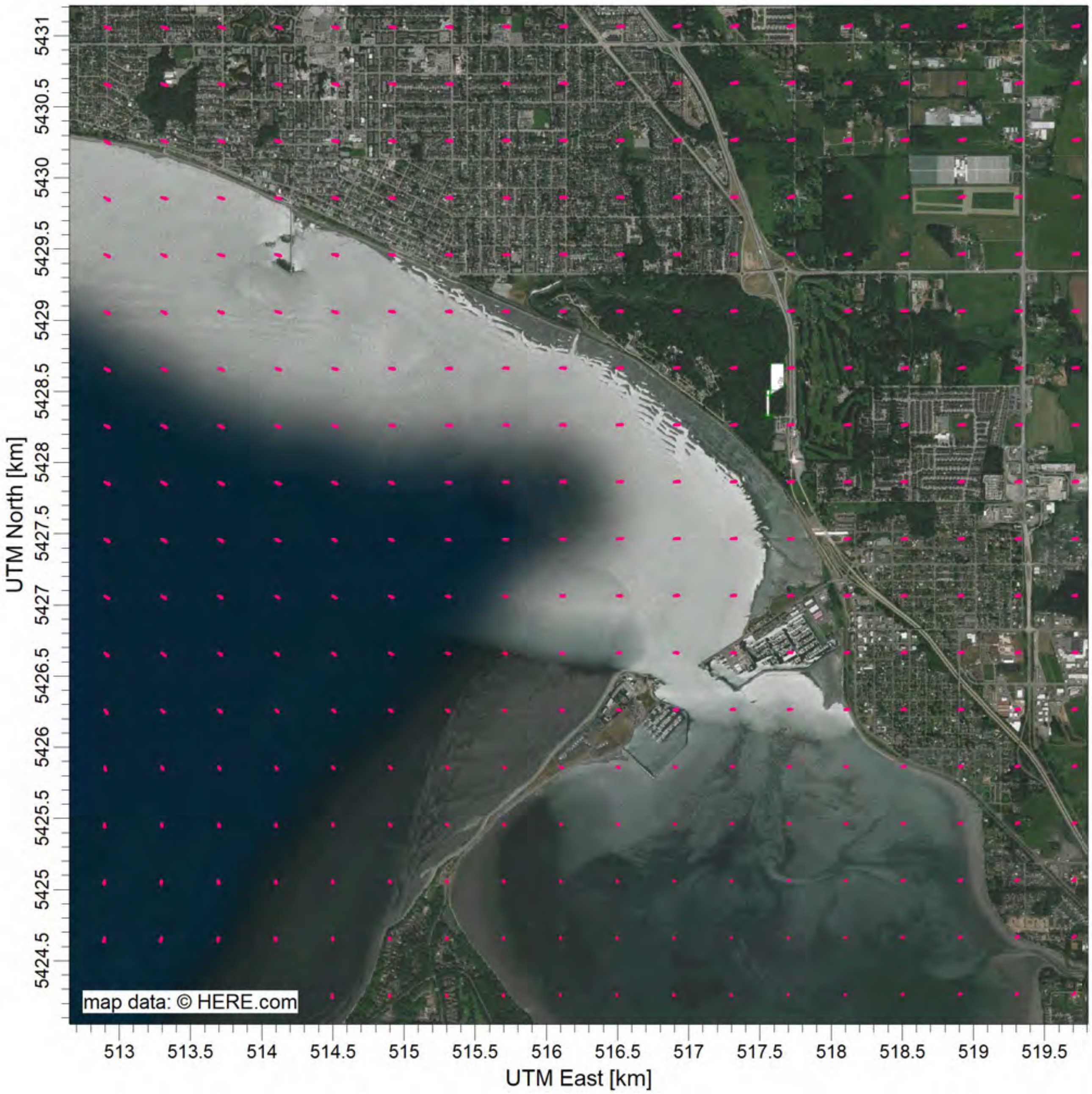
Land-Sea Breeze Circulation Validation
CALMET 480m Wind Field - July 18, 2013 1000 PDT



COMMENTS: Mid (480 m) Layer	COMPANY NAME: **Tetra Tech**	
	MODELER: **T. Miguez**	andion
	SCALE: 1:45,000 0 — 1 km	
	DATE: **5/31/2023**	**Figure B.9(b).10**

PROJECT TITLE:

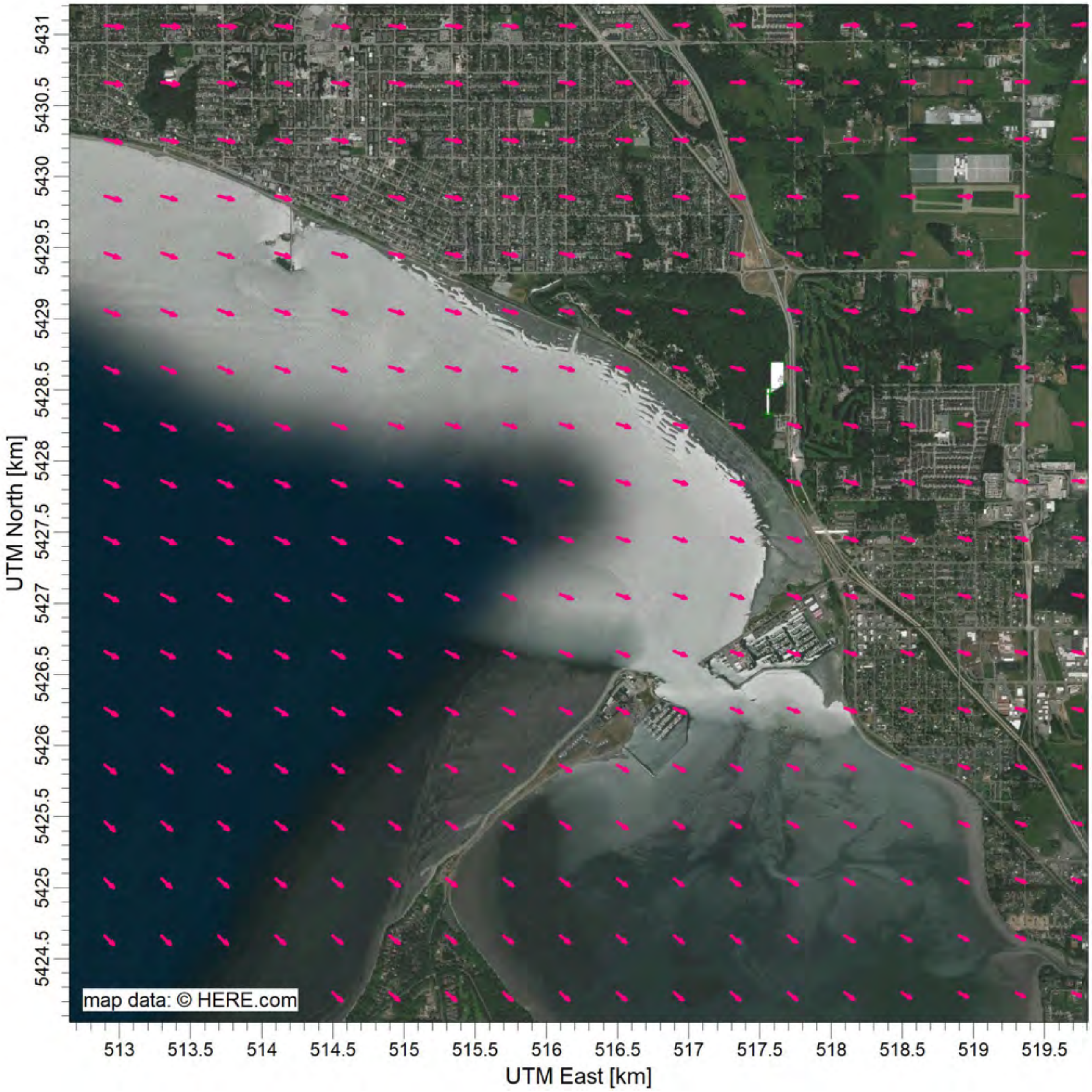
Land-Sea Breeze Circulation Validation
CALMET 480m Wind Field - July 18, 2013 1100 PDT



COMMENTS: Mid (480 m) Layer	COMPANY NAME: **Tetra Tech**
	MODELER: **T. Miguez**
	SCALE: 1:45,000 0 — 1 km
	DATE: **5/31/2023**
	Figure B.9(b).11

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 480m Wind Field - July 18, 2013 1200 PDT



COMMENTS:

Mid (480 m) Layer

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:45,000

0 — 1 km

DATE:

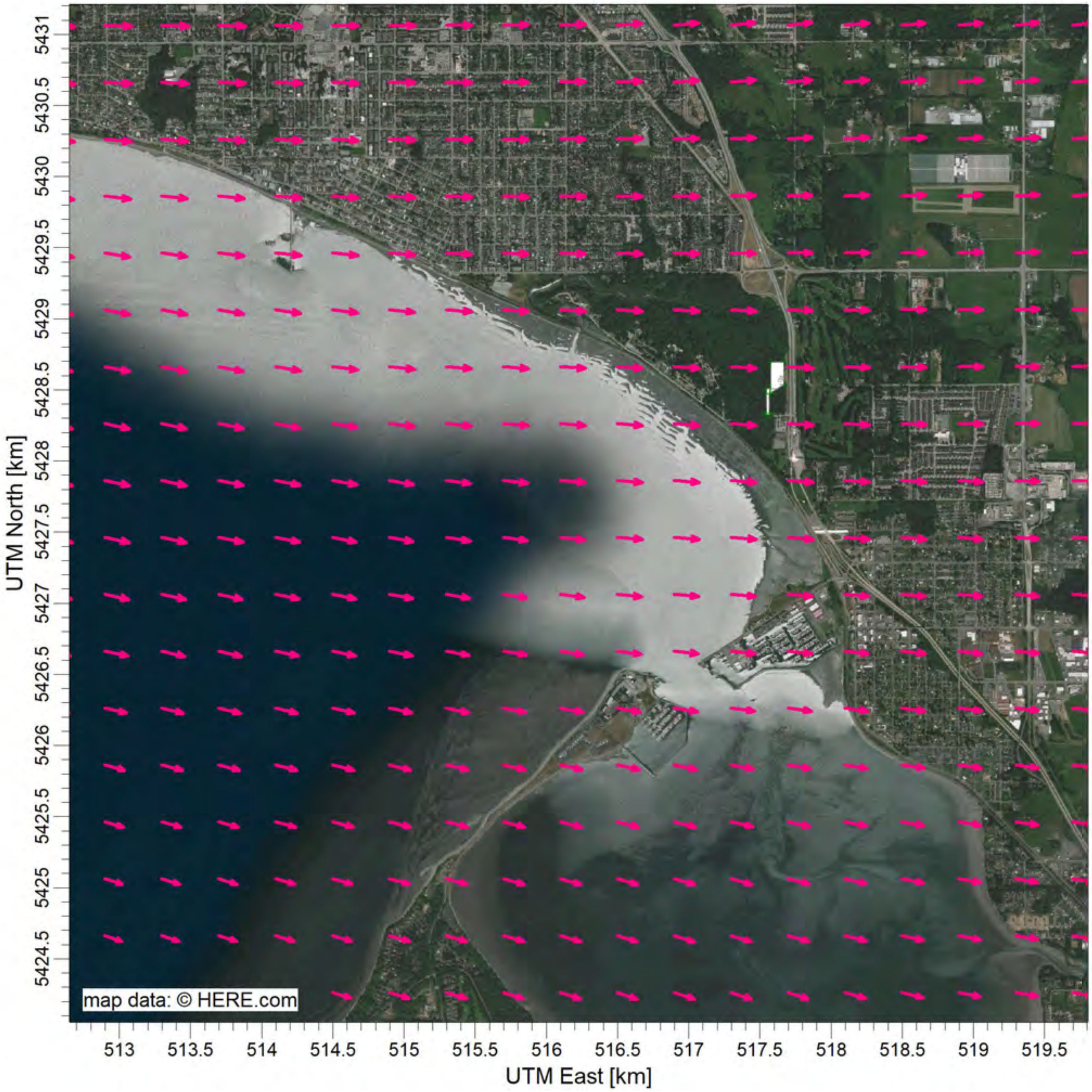
5/31/2023

andion

Figure B.9(b).12

PROJECT TITLE:

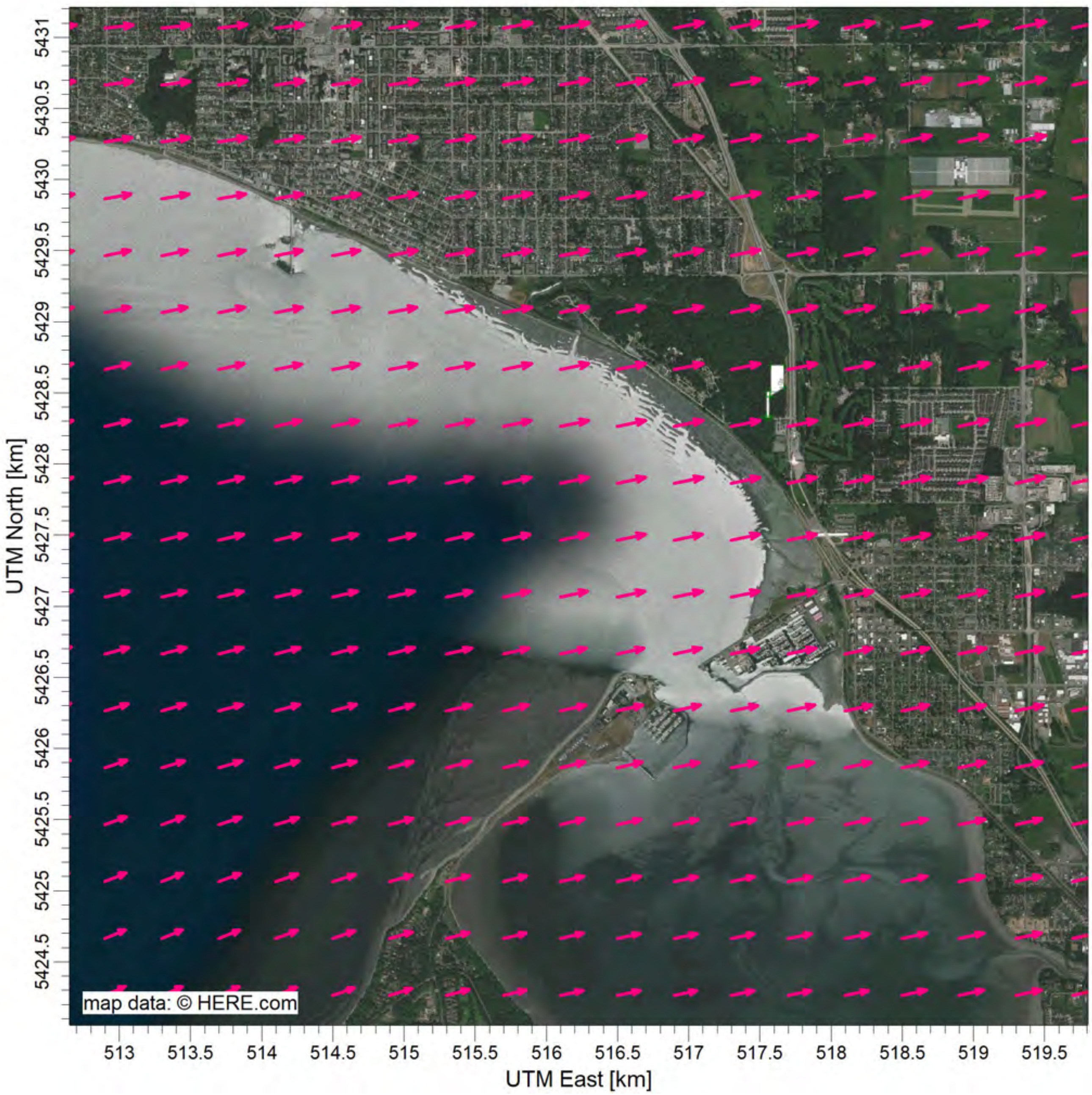
Land-Sea Breeze Circulation Validation
CALMET 480m Wind Field - July 18, 2013 1300 PDT



COMMENTS:	COMPANY NAME:	
Mid (480 m) Layer	**Tetra Tech**	
	MODELER: **T. Miguez**	andion
	SCALE: 1:45,000 (0 — 1 km)	
	DATE: **5/31/2023**	**Figure B.9(b).13**

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 480m Wind Field - July 18, 2013 1400 PDT



COMMENTS:

Mid (480 m) Layer

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:45,000

0 — 1 km

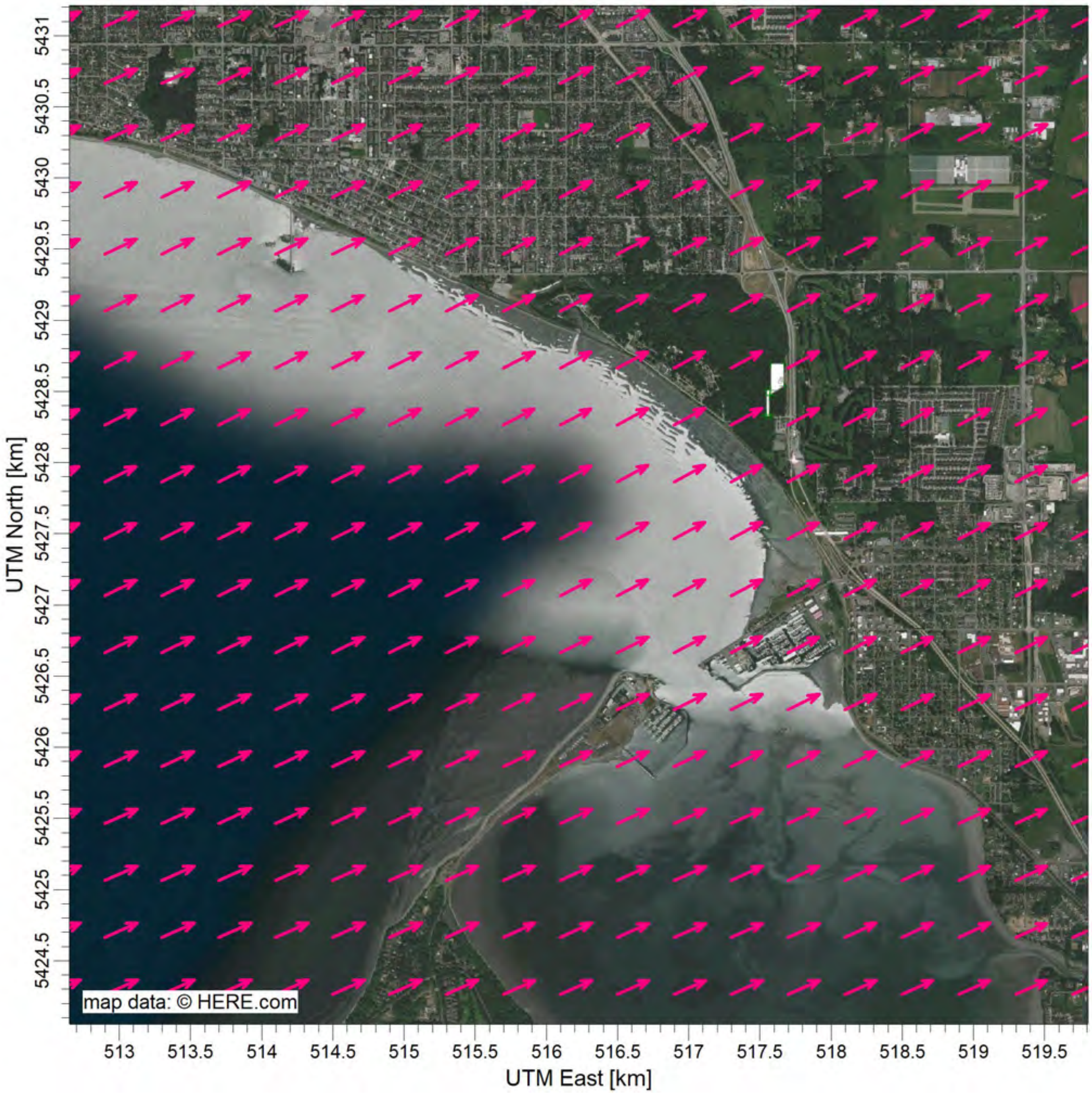
DATE:

5/31/2023

Figure B.9(b).14

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 480m Wind Field - July 18, 2013 1500 PDT



COMMENTS:

Mid (480 m) Layer

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:45,000

0 1 km

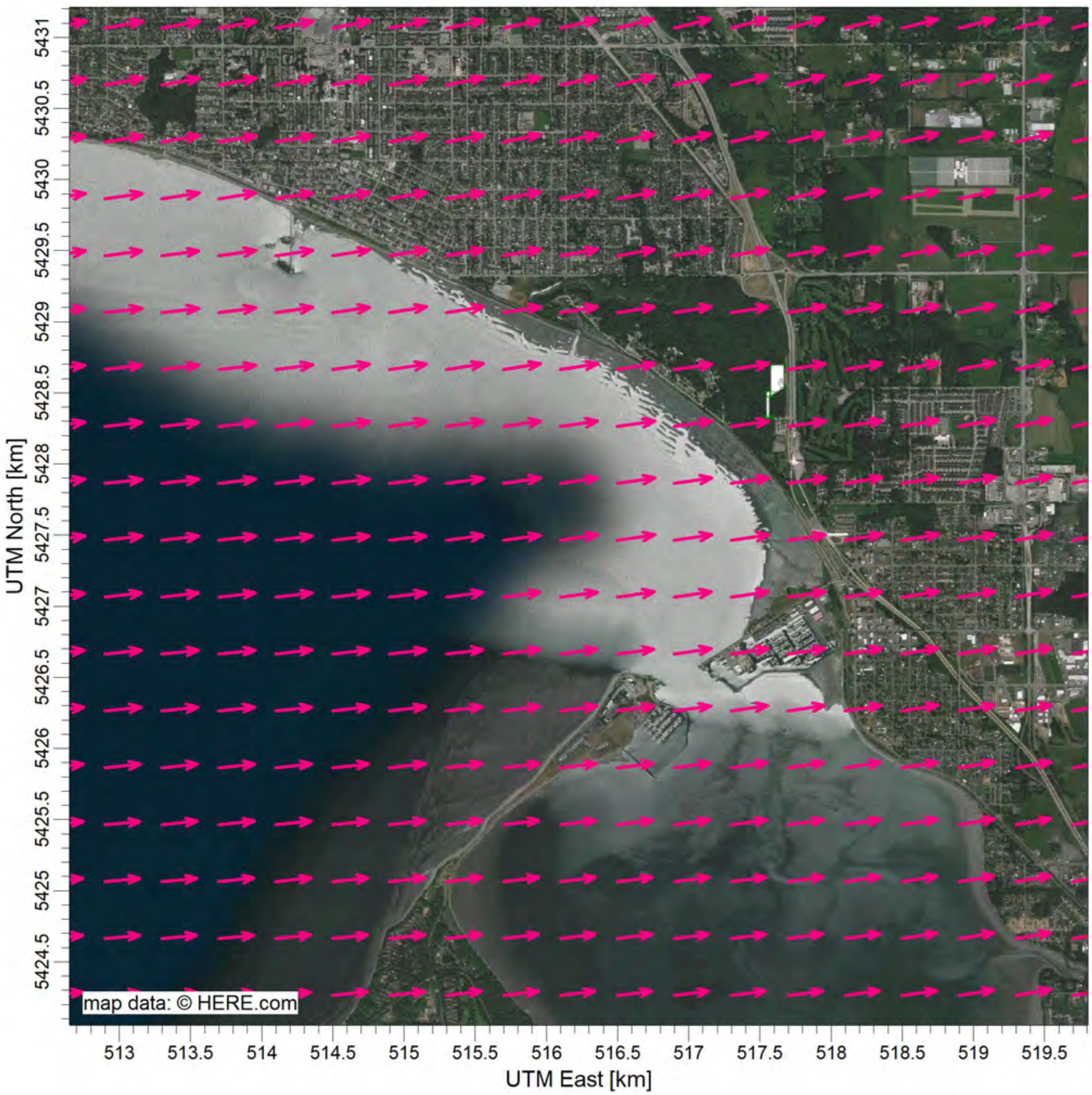
DATE:

5/31/2023

Figure B.9(b).15

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 480m Wind Field - July 18, 2013 1600 PDT

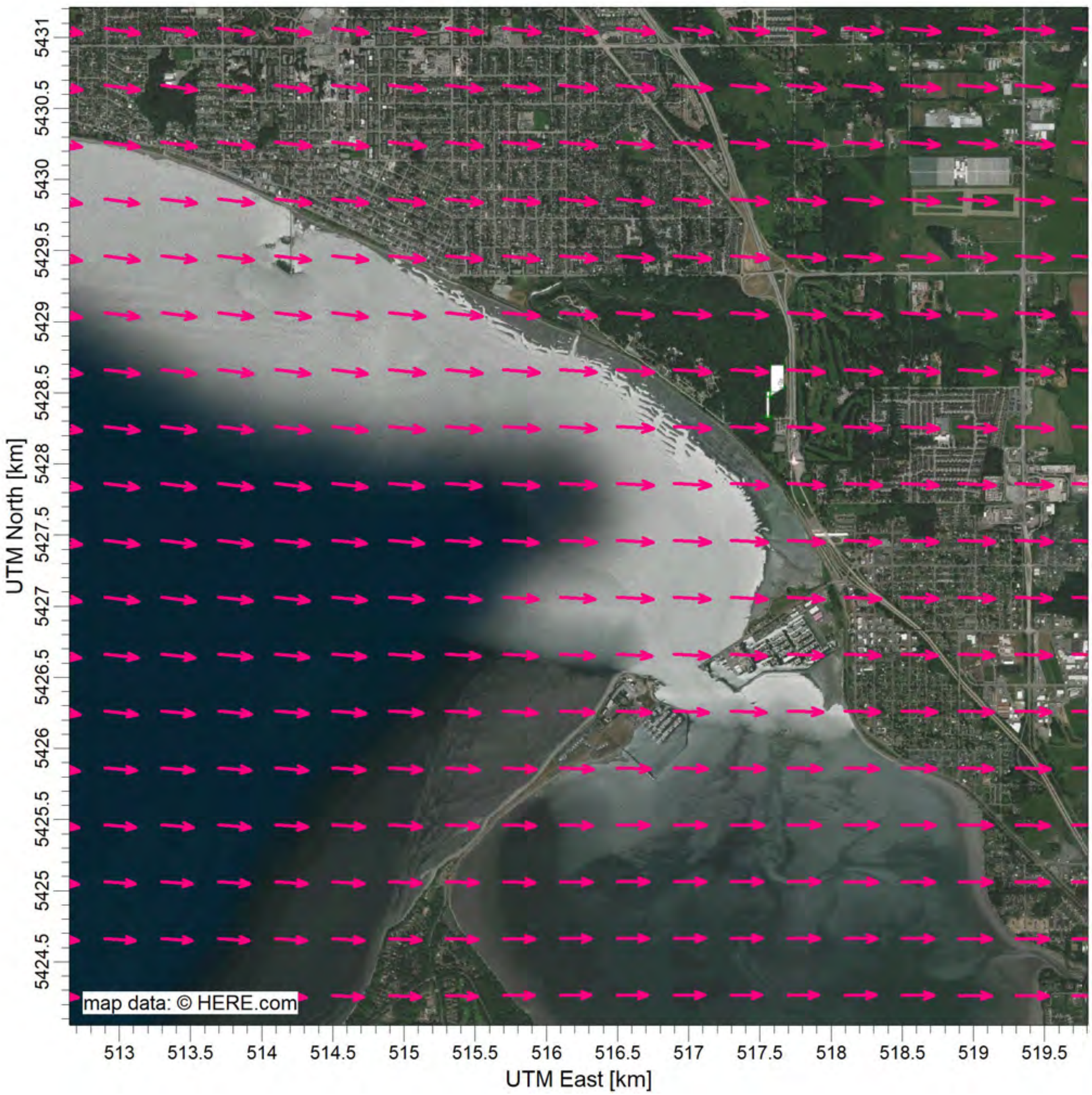


COMMENTS:	COMPANY NAME:	
Mid (480 m) Layer	**Tetra Tech**	
	MODELER: **T. Miguez**	andion
	SCALE: 1:45,000 (0 — 1 km)	
	DATE: **5/31/2023**	**Figure B.9(b).16**

CALPUFF View - Lakes Environmental Software

PROJECT TITLE:

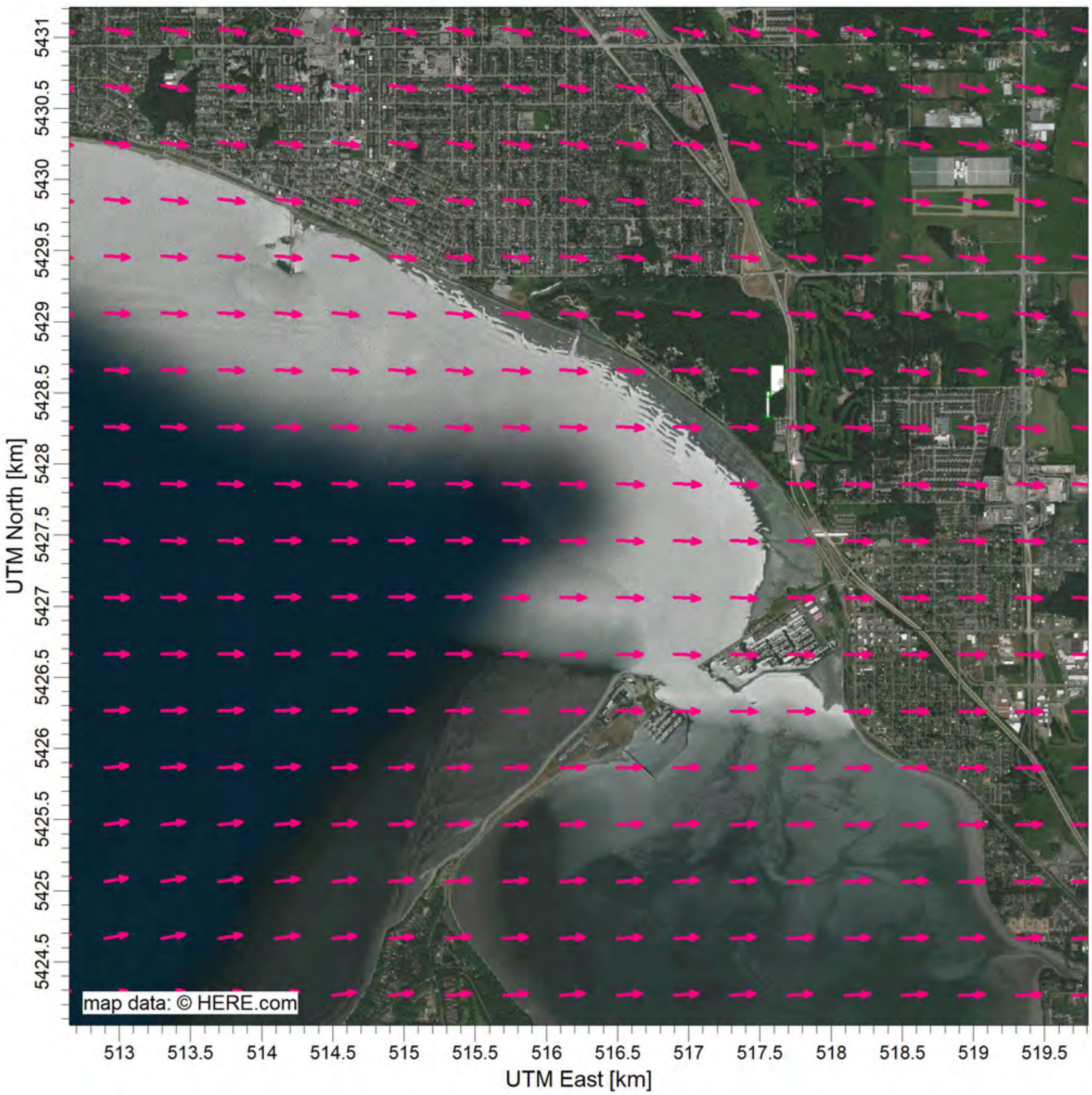
Land-Sea Breeze Circulation Validation
CALMET 480m Wind Field - July 18, 2013 1700 PDT



COMMENTS: Mid (480 m) Layer	COMPANY NAME: **Tetra Tech**
	MODELER: **T. Miguez**
	SCALE: 1:45,000 0 — 1 km
	DATE: **5/31/2023**
	Figure B.9(b).17

PROJECT TITLE:

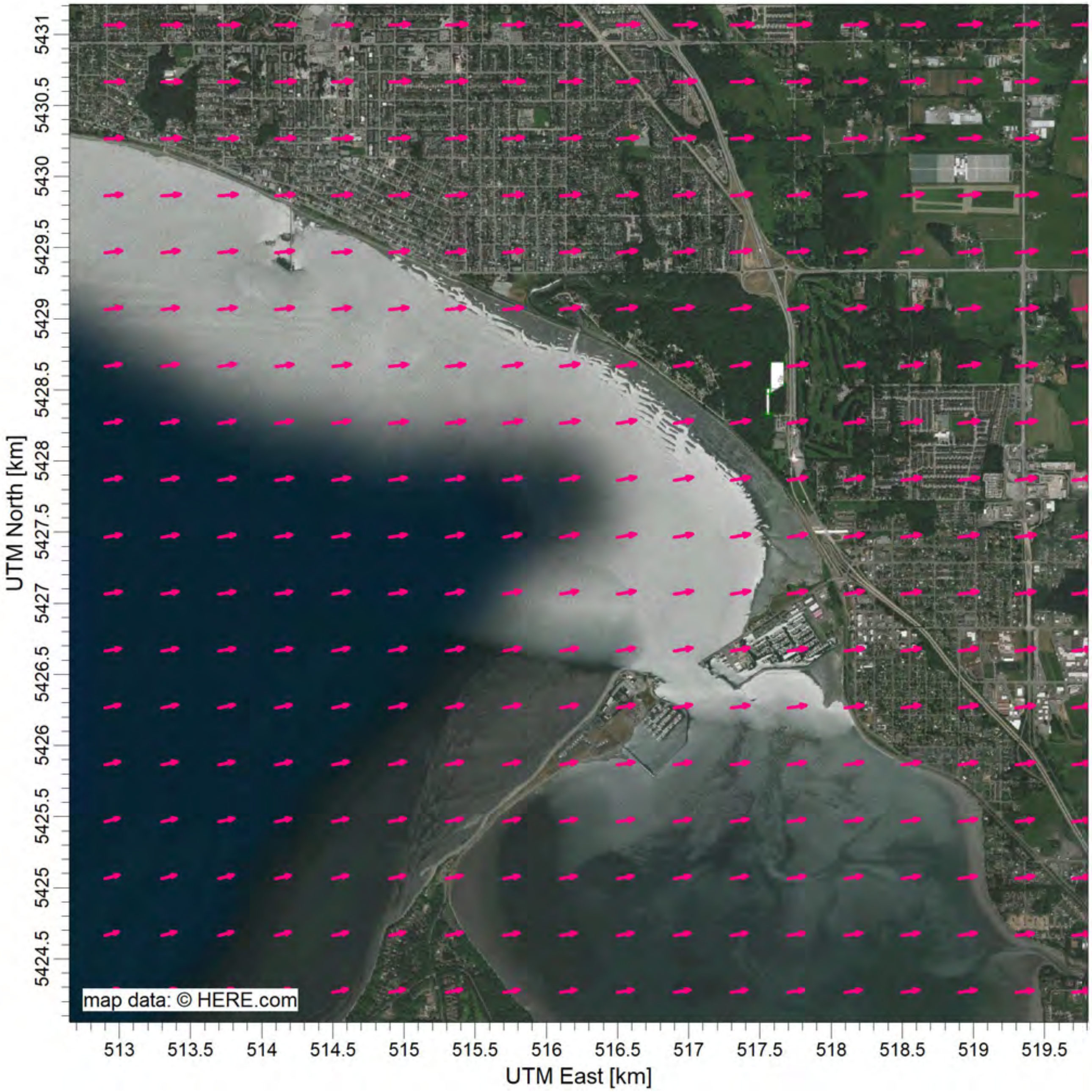
Land-Sea Breeze Circulation Validation
CALMET 480m Wind Field - July 18, 2013 1800 PDT



COMMENTS: Mid (480 m) Layer	COMPANY NAME: **Tetra Tech**
	MODELER: **T. Miguez**
	SCALE: 1:45,000 0 — 1 km
	DATE: **5/31/2023**
	Figure B.9(b).18

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 480m Wind Field - July 18, 2013 1900 PDT

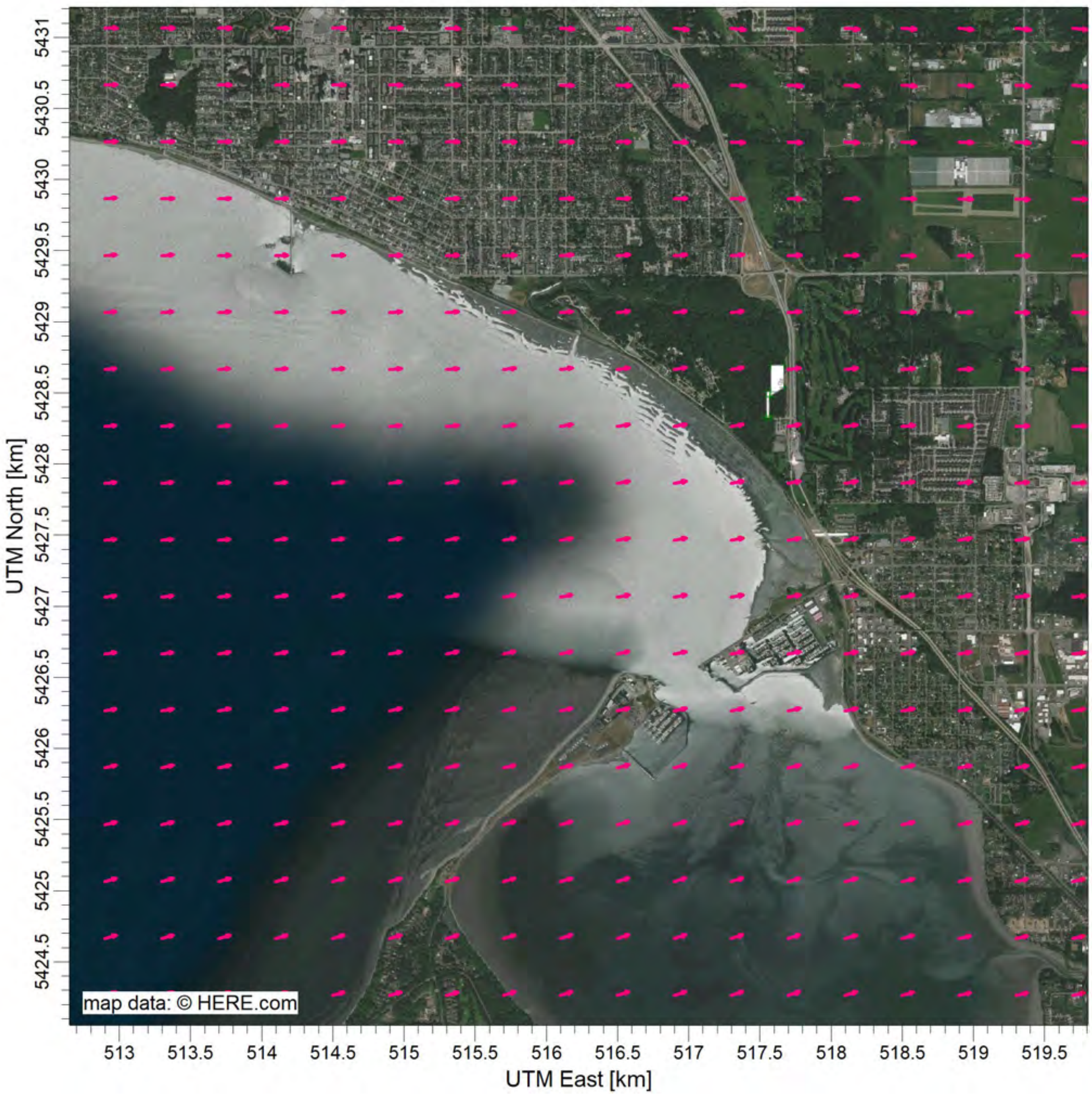


COMMENTS:	COMPANY NAME:	
Mid (480 m) Layer	**Tetra Tech**	
	MODELER: **T. Miguez**	andion
	SCALE: 1:45,000 (0 — 1 km)	
	DATE: **5/31/2023**	**Figure B.9(b).19**

CALPUFF View - Lakes Environmental Software

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 480m Wind Field - July 18, 2013 2000 PDT



COMMENTS:

Mid (480 m) Layer

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:45,000

0 1 km

andion

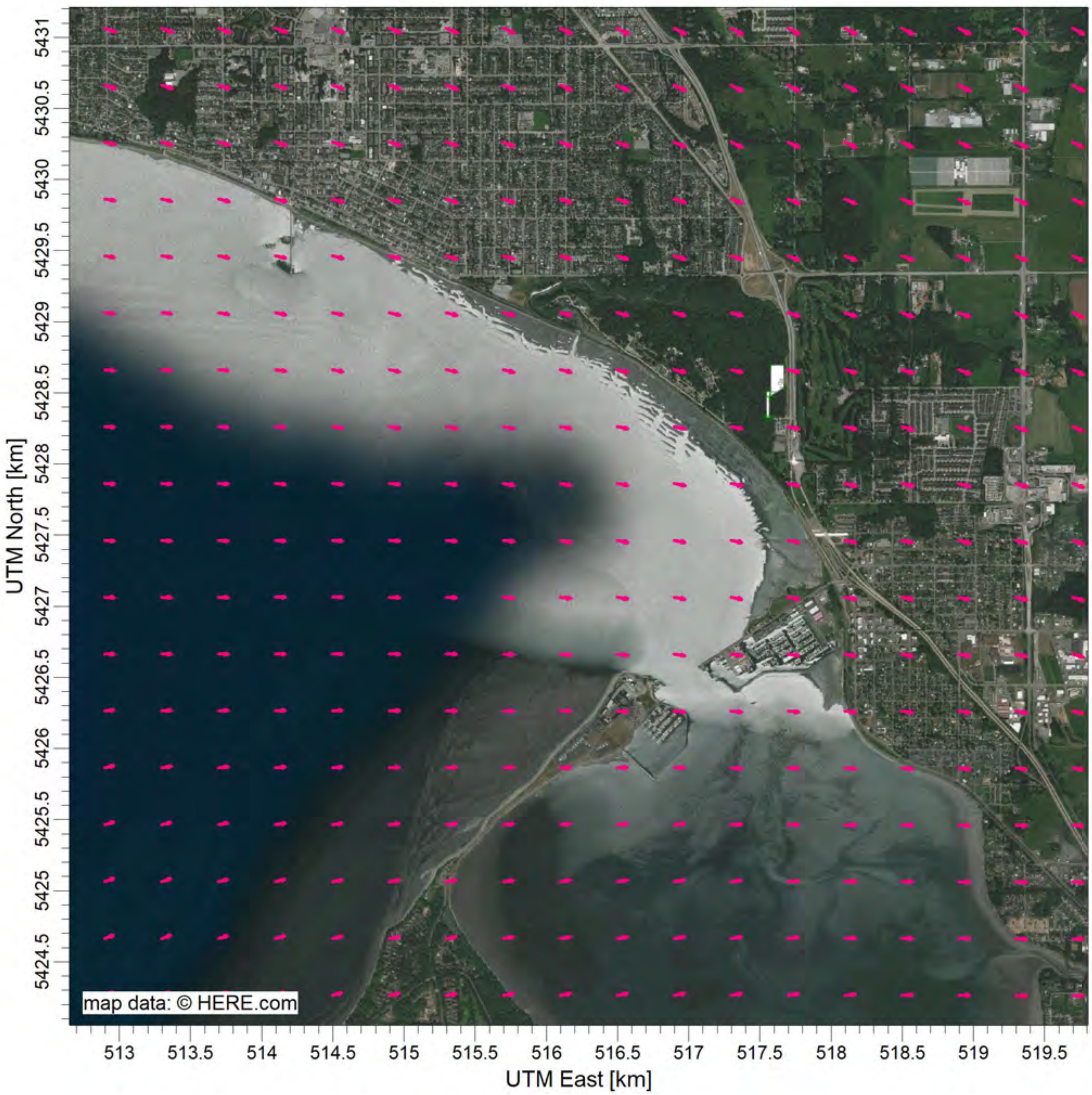
DATE:

5/31/2023

Figure B.9(b).20

PROJECT TITLE:

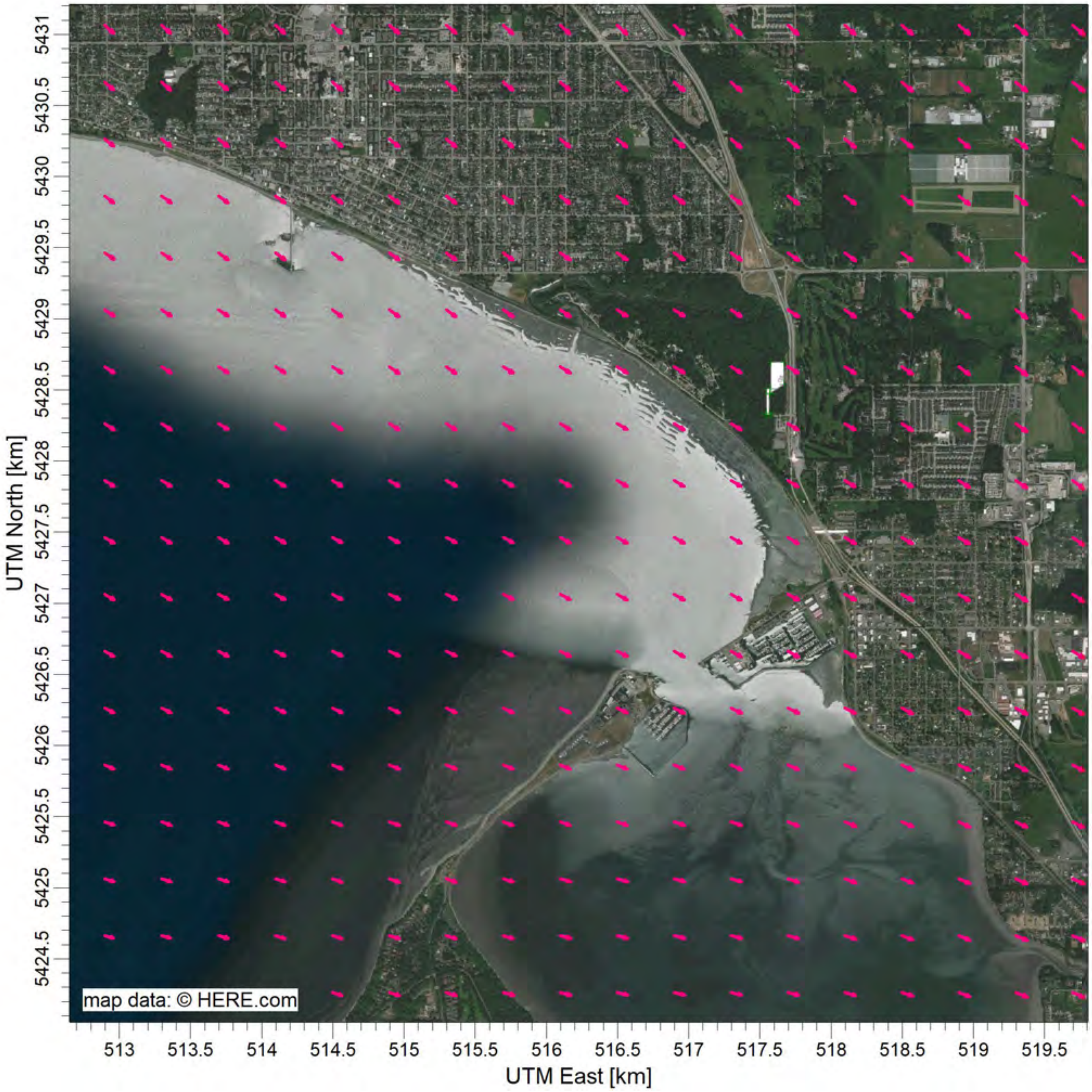
Land-Sea Breeze Circulation Validation
CALMET 480m Wind Field - July 18, 2013 2100 PDT



COMMENTS: Mid (480 m) Layer	COMPANY NAME: **Tetra Tech**
	MODELER: **T. Miguez**
	SCALE: 1:45,000 0 — 1 km
	DATE: **5/31/2023**
	Figure B.9(b).21

PROJECT TITLE:

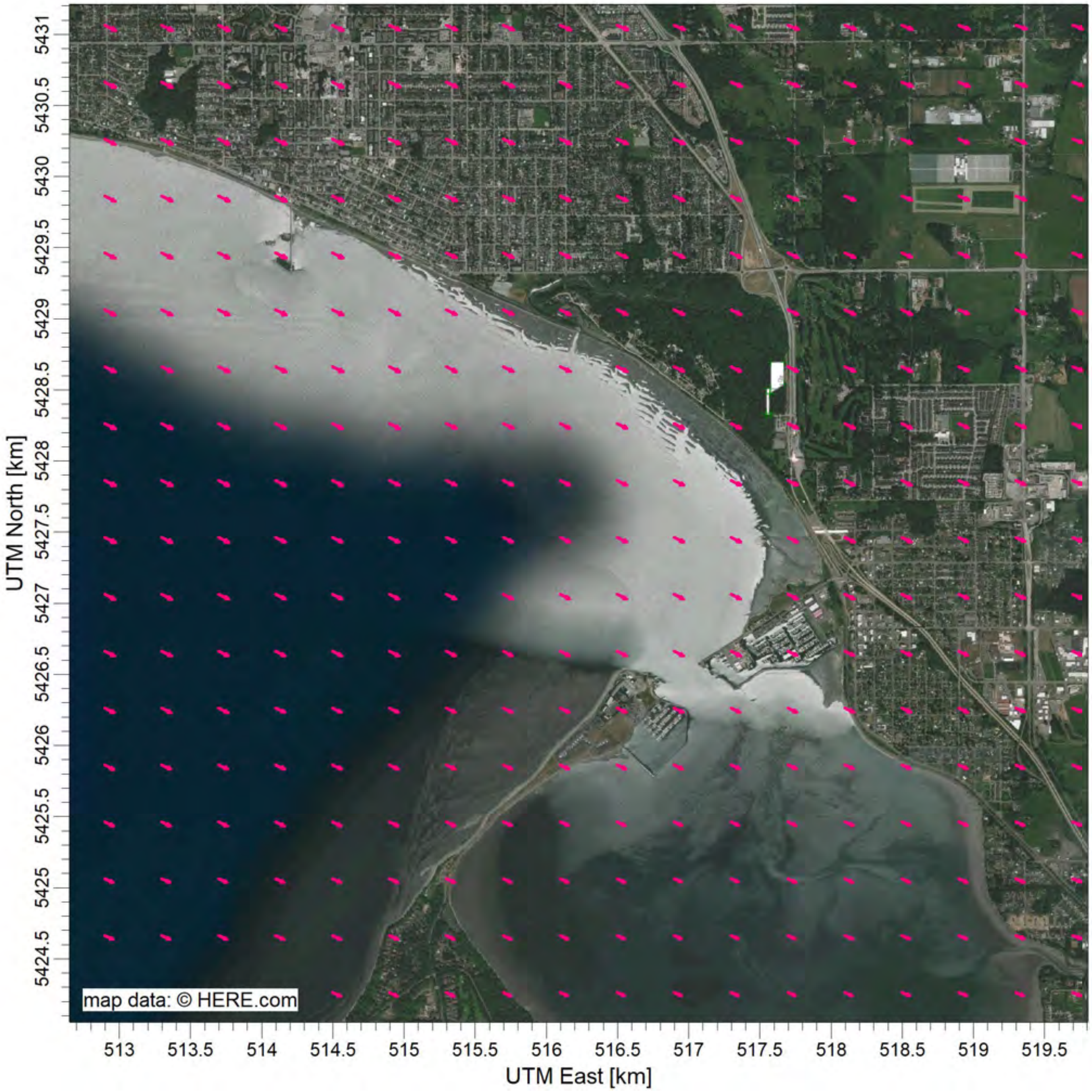
Land-Sea Breeze Circulation Validation
CALMET 480m Wind Field - July 18, 2013 2200 PDT



COMMENTS:	COMPANY NAME:	
Mid (480 m) Layer	**Tetra Tech**	
	MODELER: **T. Miguez**	
	SCALE: 1:45,000 (0 — 1 km)	
	DATE: **5/31/2023**	**Figure B.9(b).22**

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 480m Wind Field - July 18, 2013 2300 PDT



COMMENTS:

Mid (480 m) Layer

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:45,000

0 1 km

andion

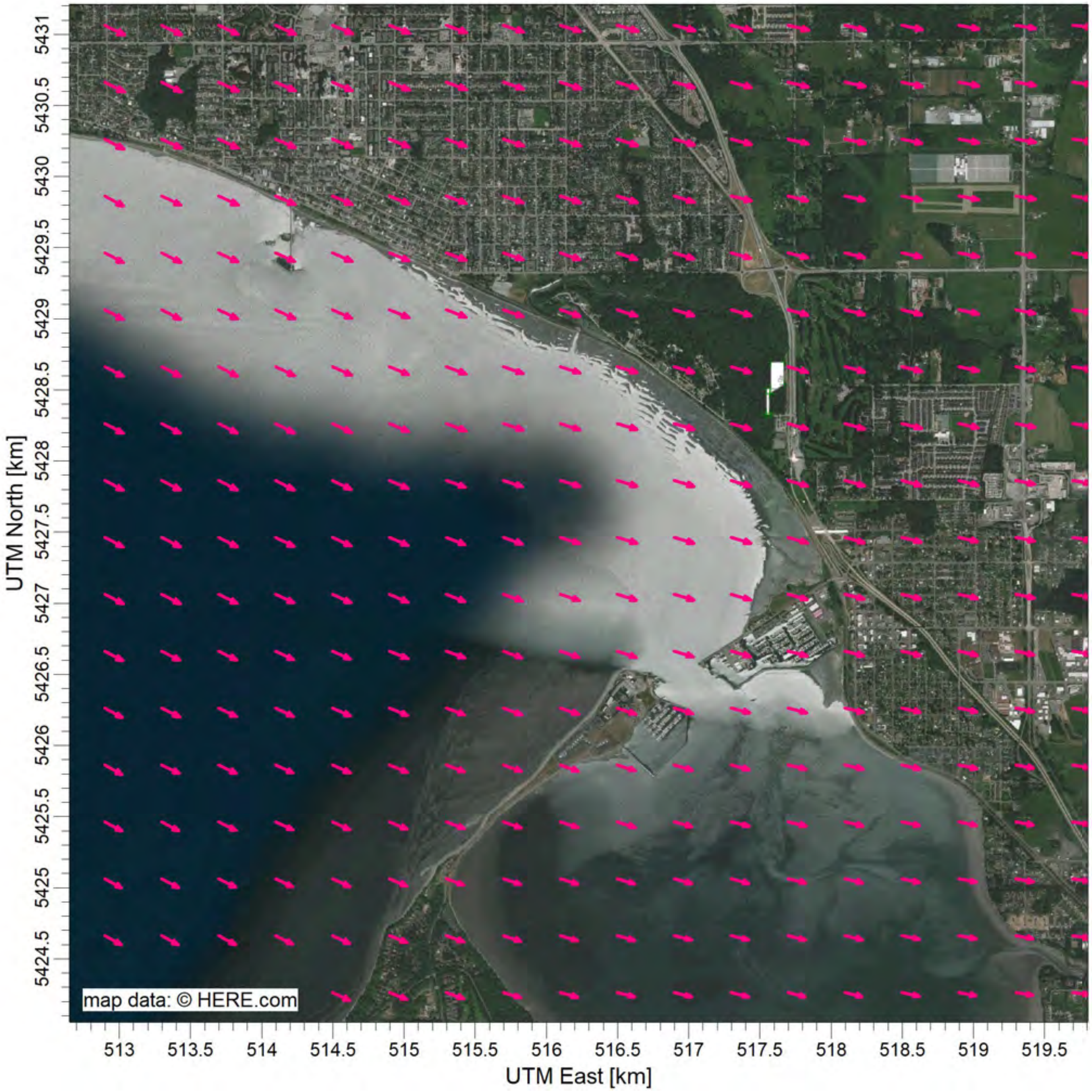
DATE:

5/31/2023

Figure B.9(b).23

PROJECT TITLE:

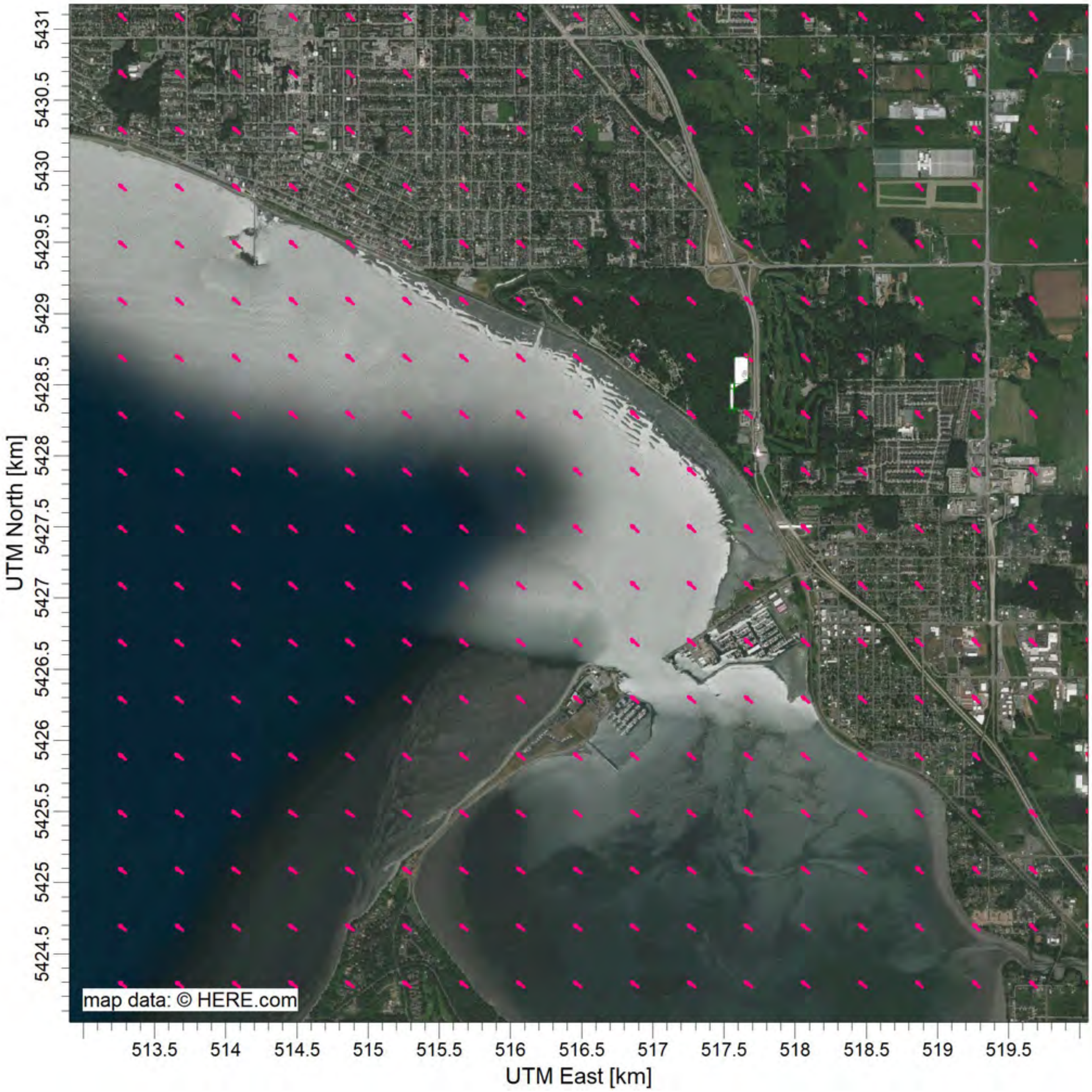
Land-Sea Breeze Circulation Validation
CALMET 480m Wind Field - July 18, 2013 2400 PDT



COMMENTS:	COMPANY NAME:	
Mid (480 m) Layer	**Tetra Tech**	
	MODELER: **T. Miguez**	andion
	SCALE: 1:45,000 (0 — 1 km)	
	DATE: **5/31/2023**	**Figure B.9(b).24**

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 1600m Wind Field - July 18, 2013 0100 PDT



COMMENTS:

Upper (1600 m) Layer

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:45,000

0 1 km

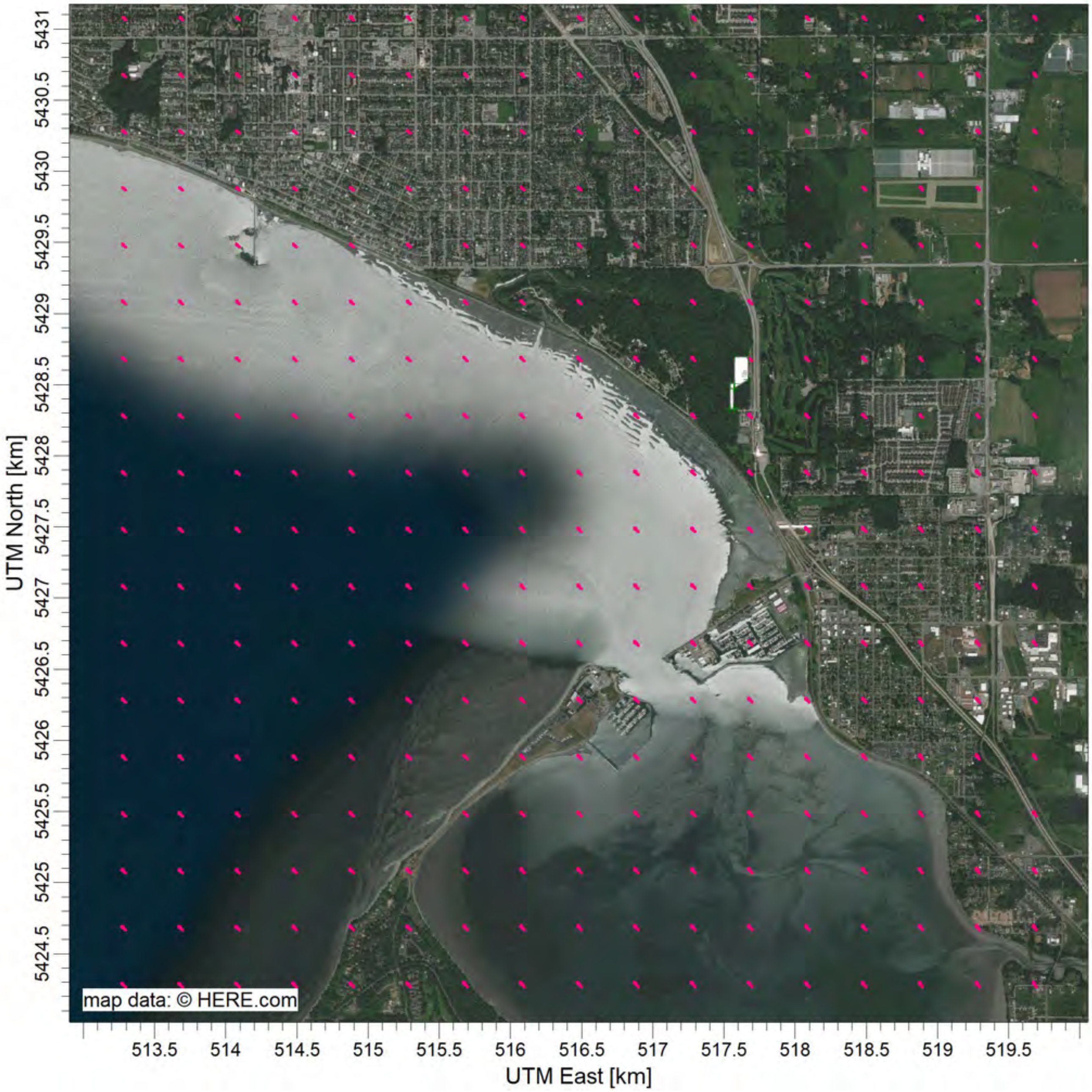
DATE:

6/2/2023

Figure B.9(c).1

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 1600m Wind Field - July 18, 2013 0200 PDT



COMMENTS:

Upper (1600 m) Layer

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:45,000

0 ▬ 1 km

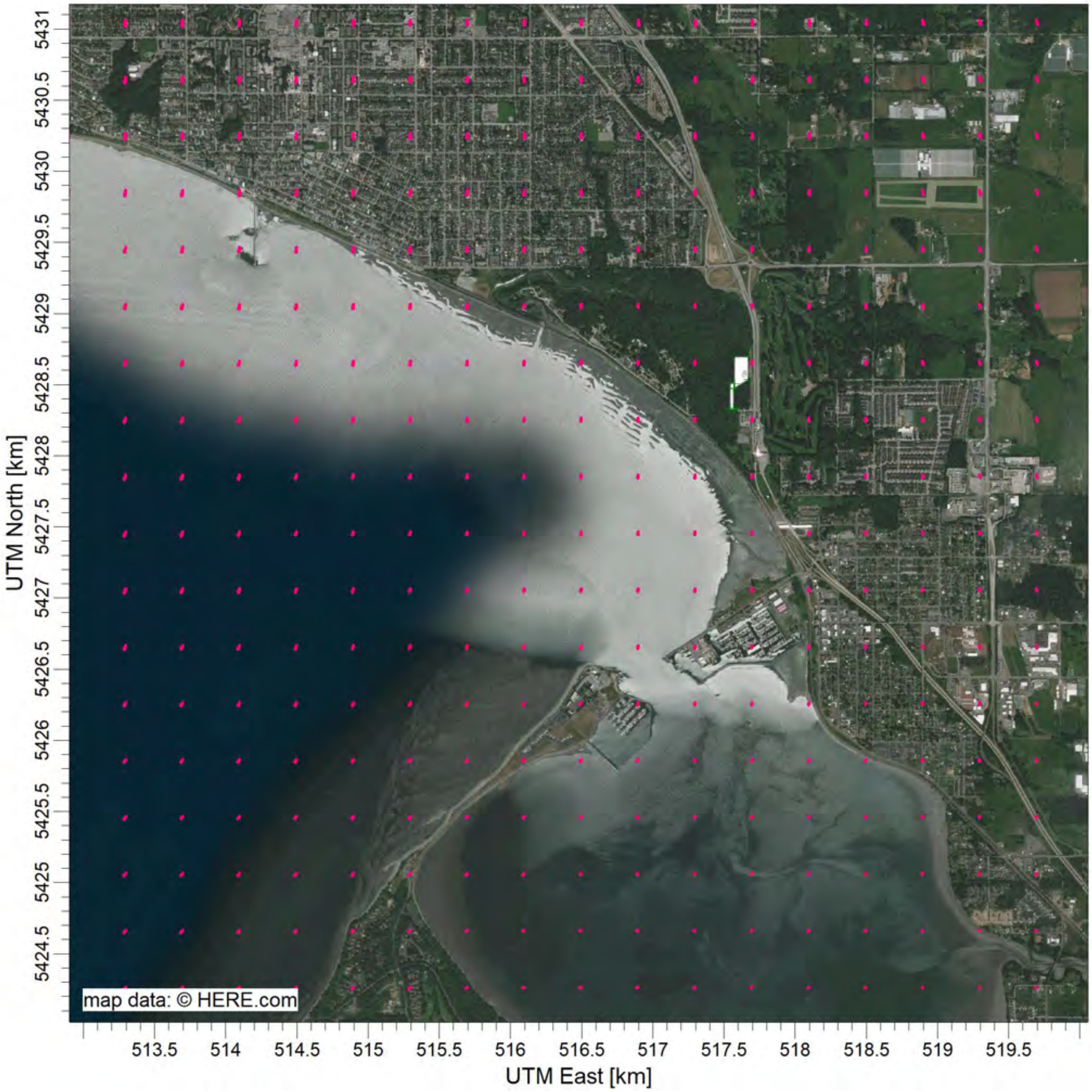
DATE:

6/2/2023

Figure B.9(c).2

PROJECT TITLE:

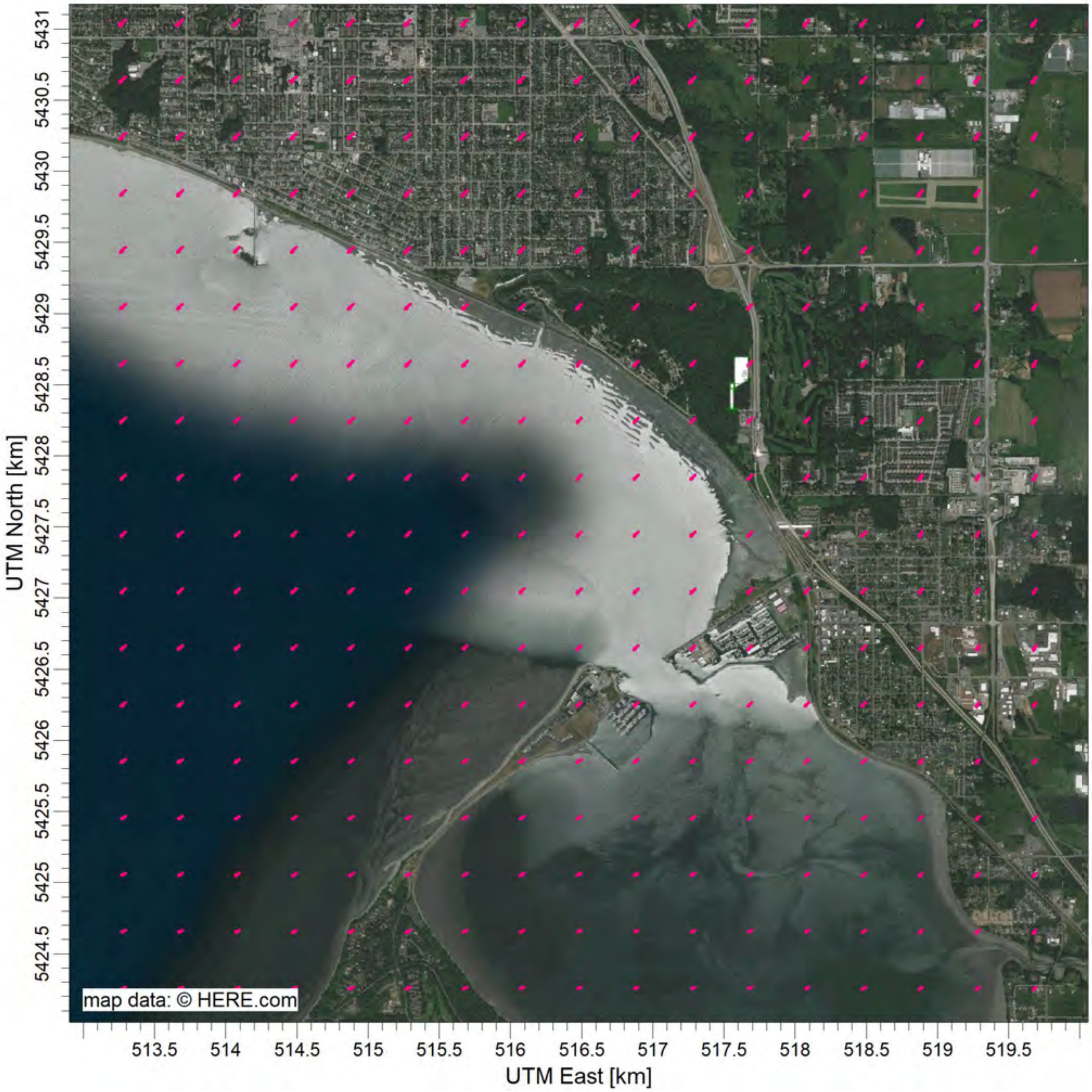
Land-Sea Breeze Circulation Validation
CALMET 1600m Wind Field - July 18, 2013 0300 PDT



COMMENTS:	COMPANY NAME:	
Upper (1600 m) Layer	**Tetra Tech**	
	MODELER: **T. Miguez**	andion
	SCALE: 1:45,000 (0 — 1 km)	
	DATE: **6/2/2023**	**Figure B.9(c).3**

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 1600m Wind Field - July 18, 2013 0400 PDT



COMMENTS:

Upper (1600 m) Layer

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:45,000

0 1 km

DATE:

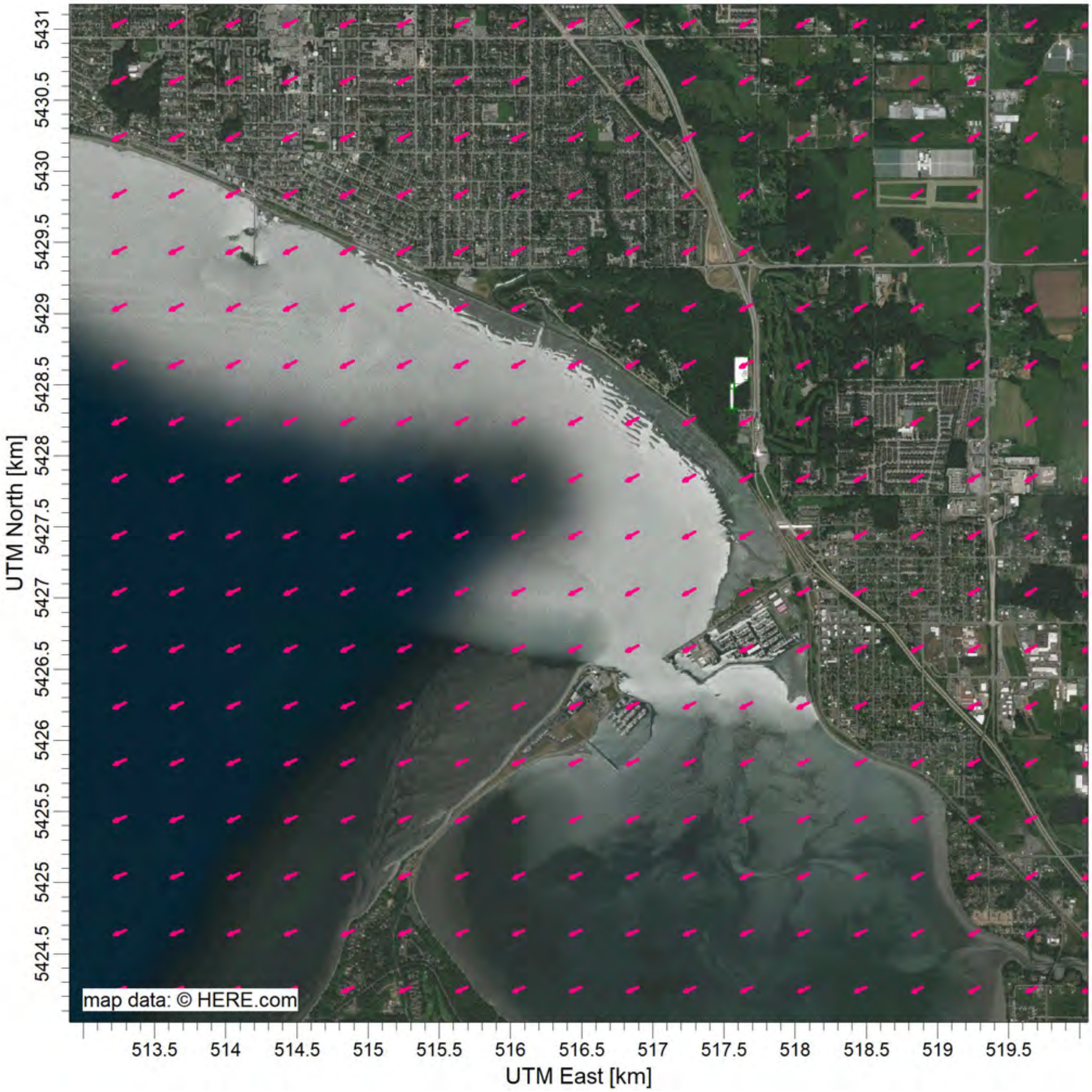
6/2/2023

Figure B.9(c).4

CALPUFF View - Lakes Environmental Software

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 1600m Wind Field - July 18, 2013 0500 PDT

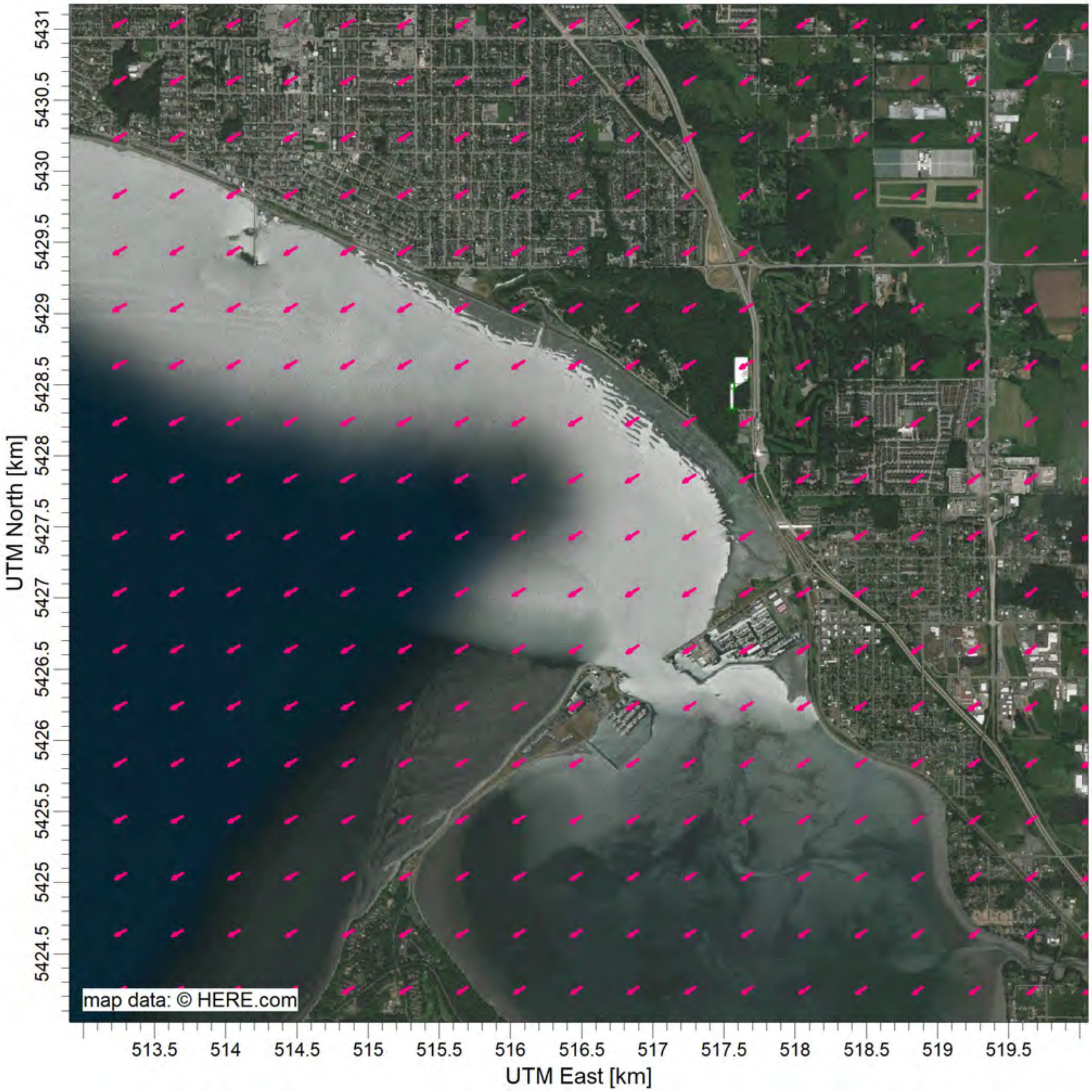


COMMENTS:	COMPANY NAME:	
Upper (1600 m) Layer	**Tetra Tech**	
	MODELER: **T. Miguez**	andion
	SCALE: 1:45,000 (0 — 1 km)	
	DATE: **6/2/2023**	**Figure B.9(c).5**

CALPUFF View - Lakes Environmental Software

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 1600m Wind Field - July 18, 2013 0600 PDT



COMMENTS:

Upper (1600 m) Layer

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:45,000

0 1 km

andion

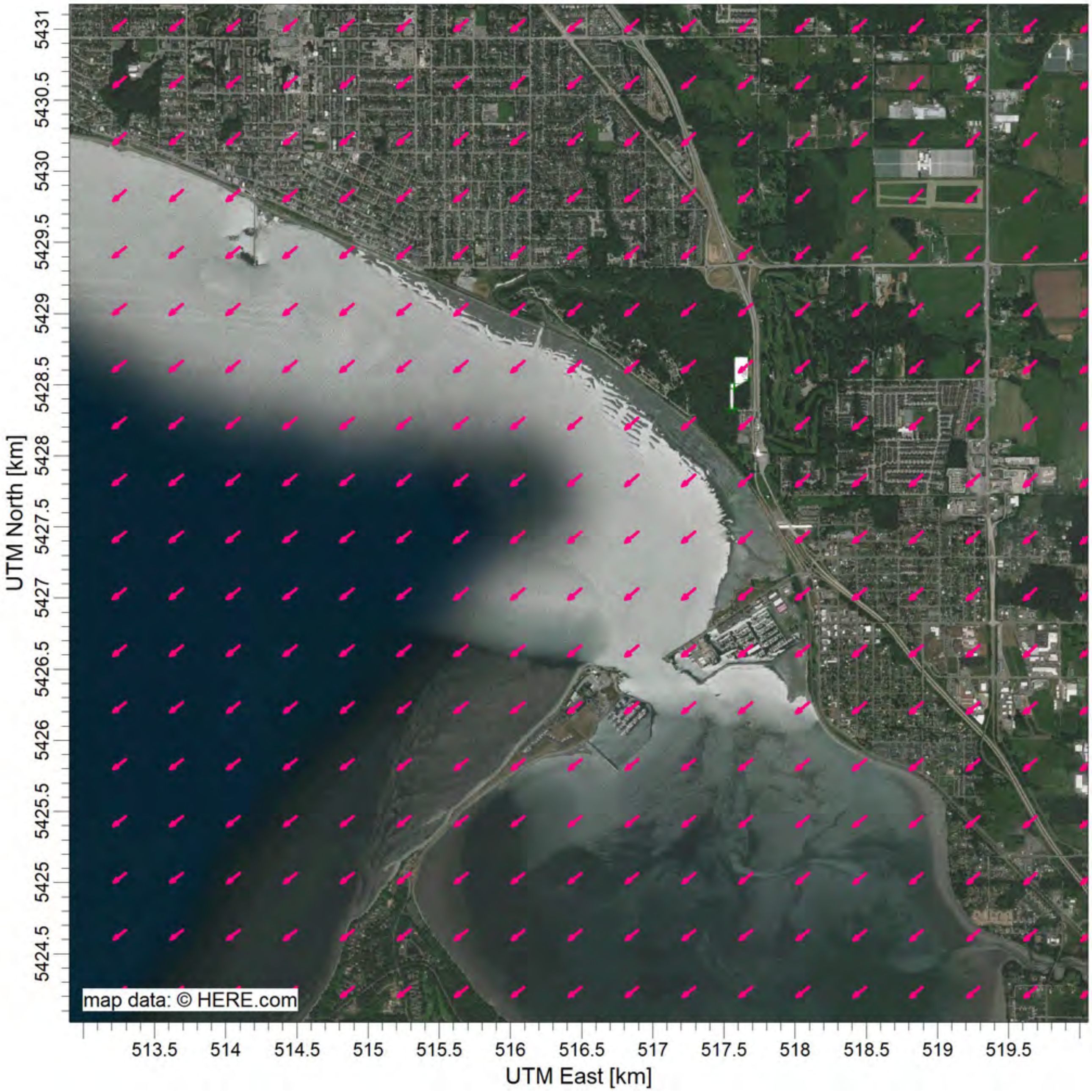
DATE:

6/2/2023

Figure B.9(c).6

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 1600m Wind Field - July 18, 2013 0700 PDT

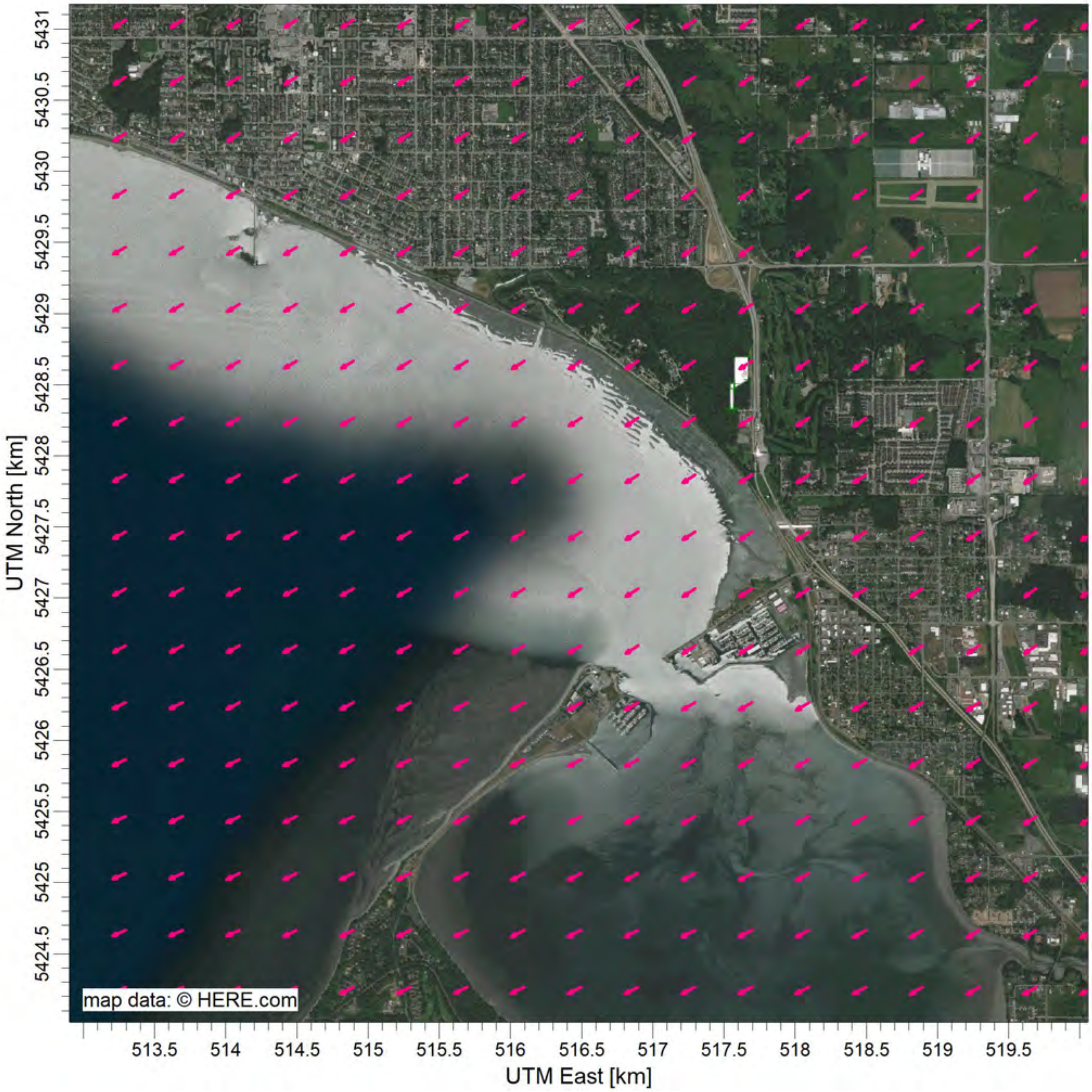


COMMENTS:	COMPANY NAME:	
Upper (1600 m) Layer	**Tetra Tech**	
	MODELER: **T. Miguez**	andion
	SCALE: 1:45,000 (0 — 1 km)	
	DATE: **6/2/2023**	**Figure B.9(c).7**

CALPUFF View - Lakes Environmental Software

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 1600m Wind Field - July 18, 2013 0800 PDT



COMMENTS:

Upper (1600 m) Layer

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:45,000

0 1 km

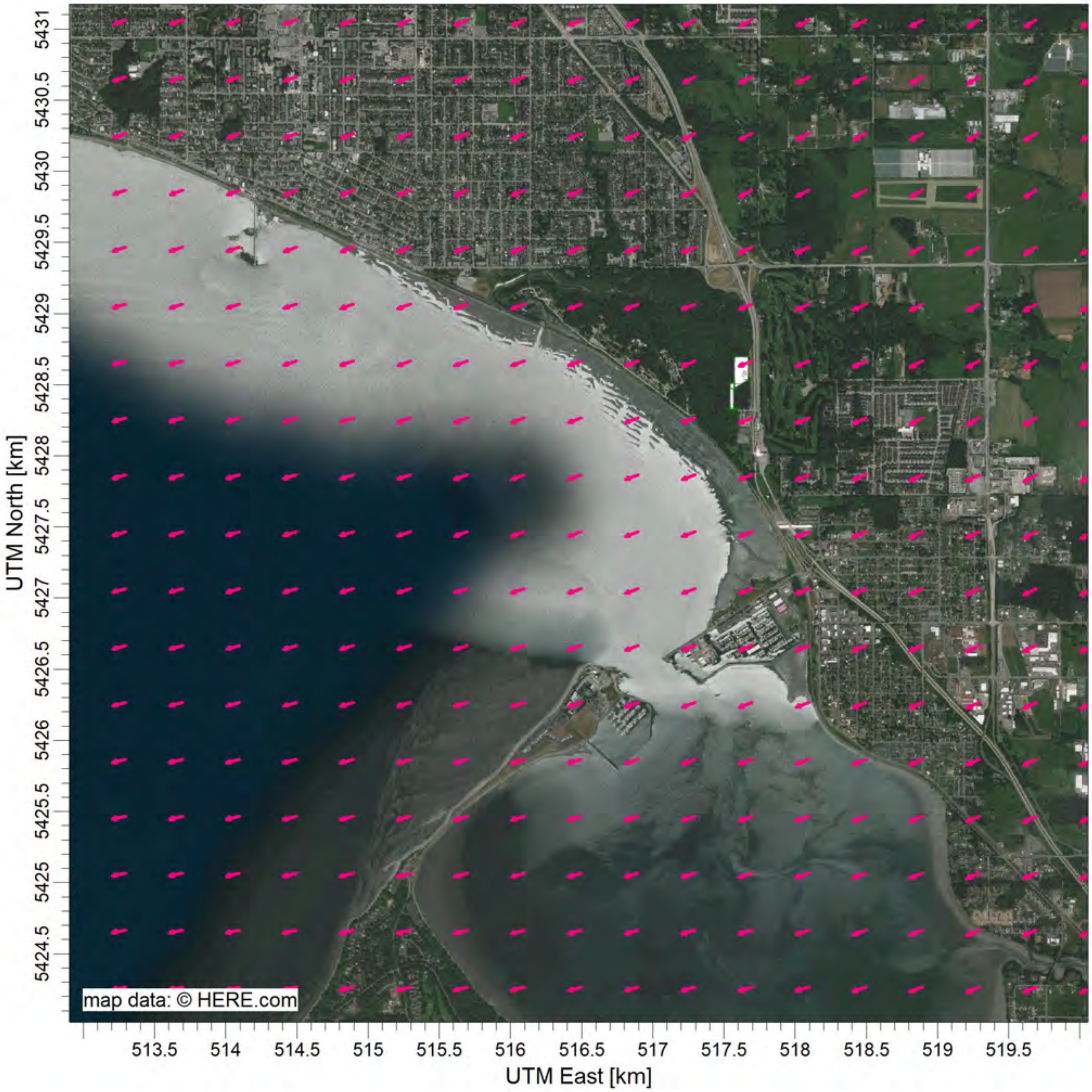
DATE:

6/2/2023

Figure B.9(c).8

PROJECT TITLE:

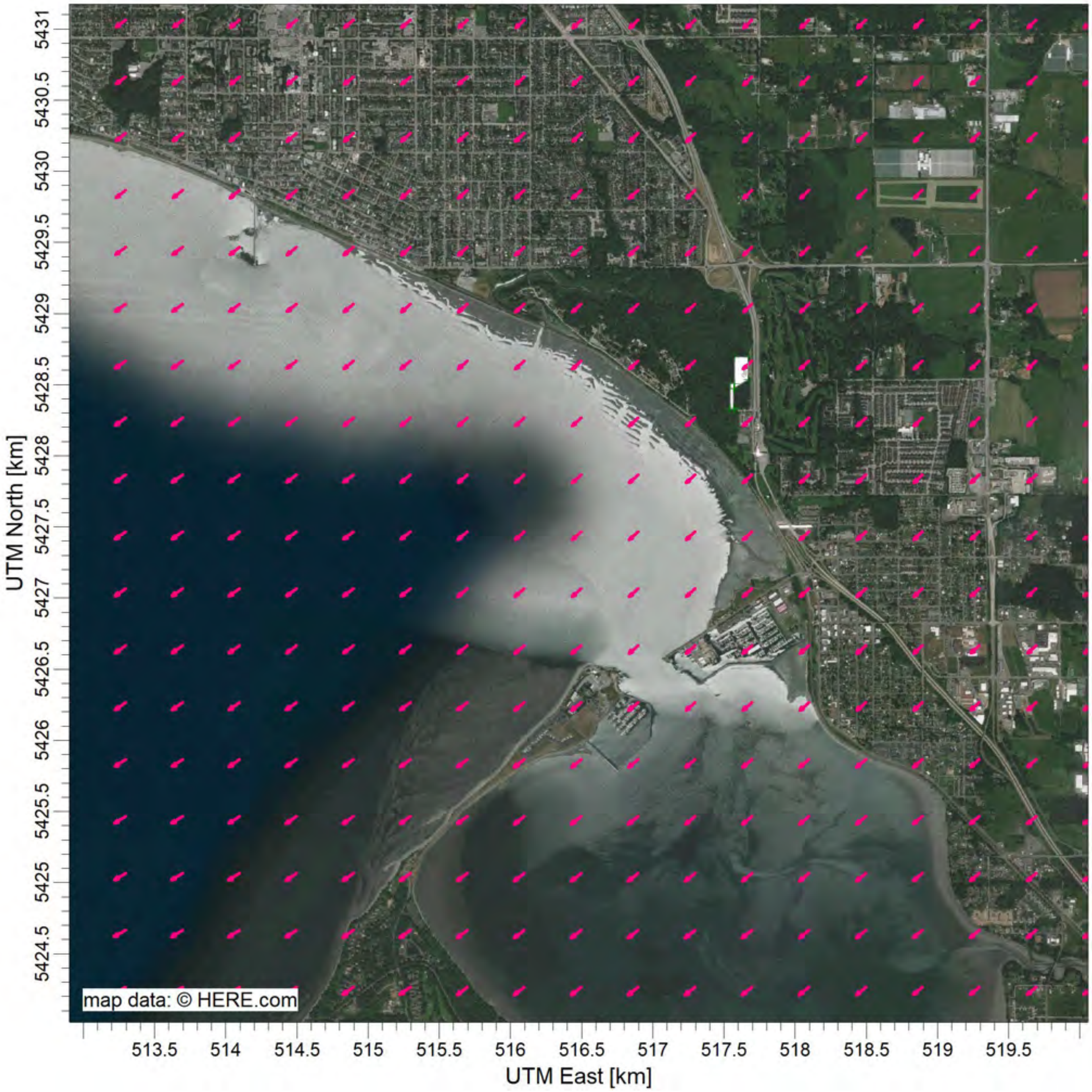
Land-Sea Breeze Circulation Validation
CALMET 1600m Wind Field - July 18, 2013 0900 PDT



COMMENTS: Upper (1600 m) Layer	COMPANY NAME: **Tetra Tech**	
	MODELER: **T. Miguez**	andion
	SCALE: 1:45,000 0 — 1 km	
	DATE: **6/2/2023**	**Figure B.9(c).9**

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 1600m Wind Field - July 18, 2013 1000 PDT



COMMENTS:

Upper (1600 m) Layer

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:45,000

0 1 km

andion

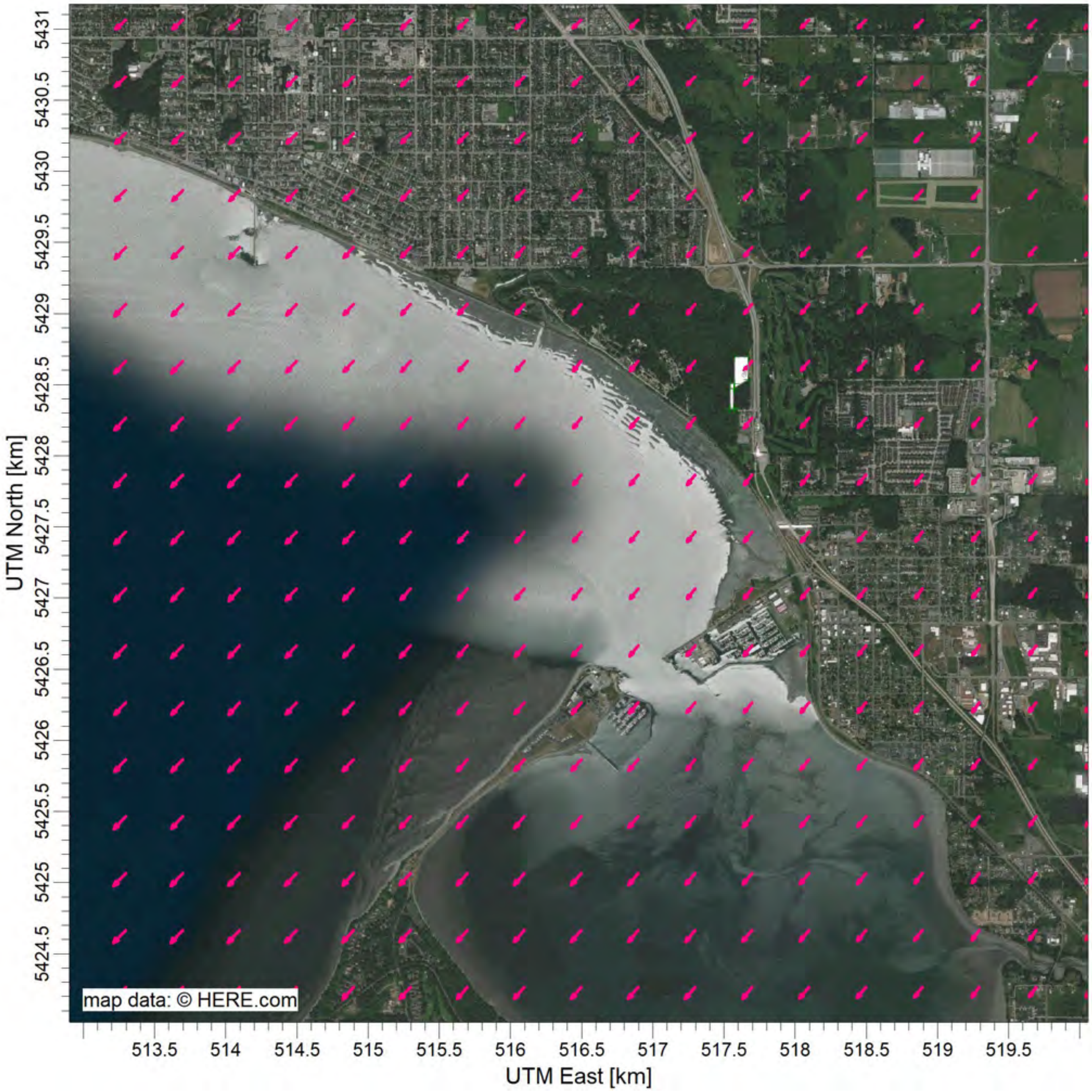
DATE:

6/2/2023

Figure B.9(c).10

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 1600m Wind Field - July 18, 2013 1100 PDT



COMMENTS:

Upper (1600 m) Layer

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:45,000

0 1 km

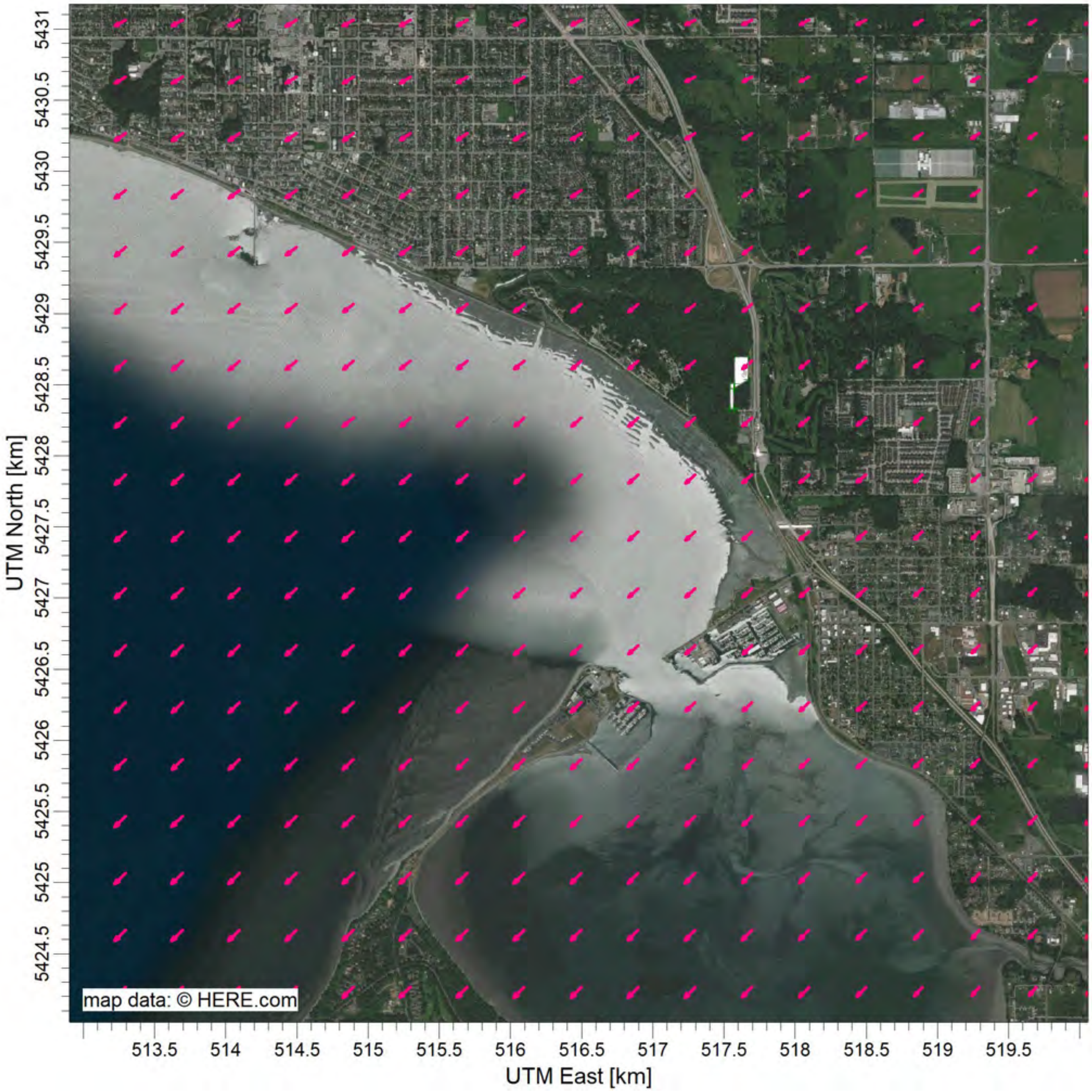
DATE:

6/2/2023

Figure B.9(c).11

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 1600m Wind Field - July 18, 2013 1200 PDT



COMMENTS:

Upper (1600 m) Layer

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:45,000

0 1 km

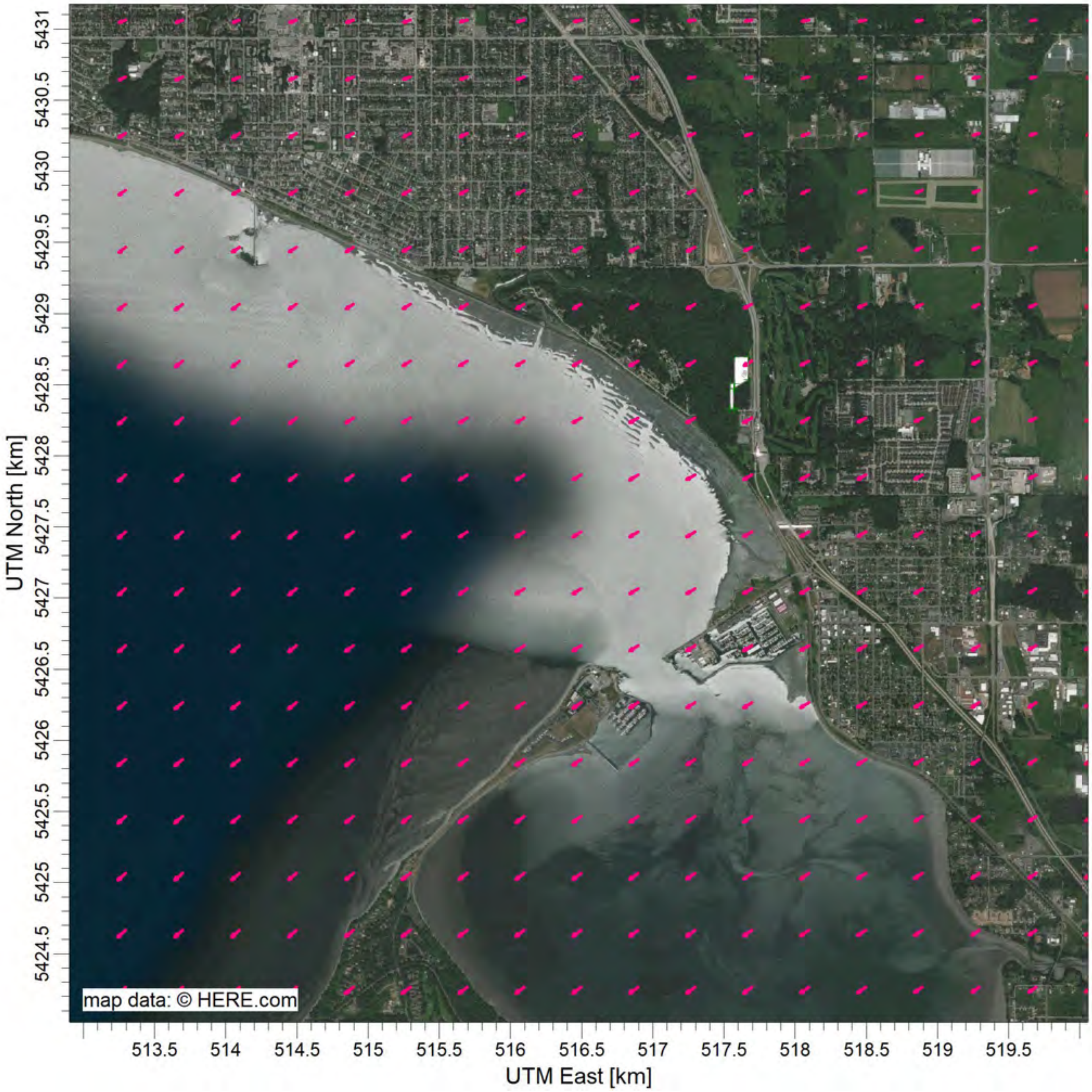
DATE:

6/2/2023

Figure B.9(c).12

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 1600m Wind Field - July 18, 2013 1300 PDT

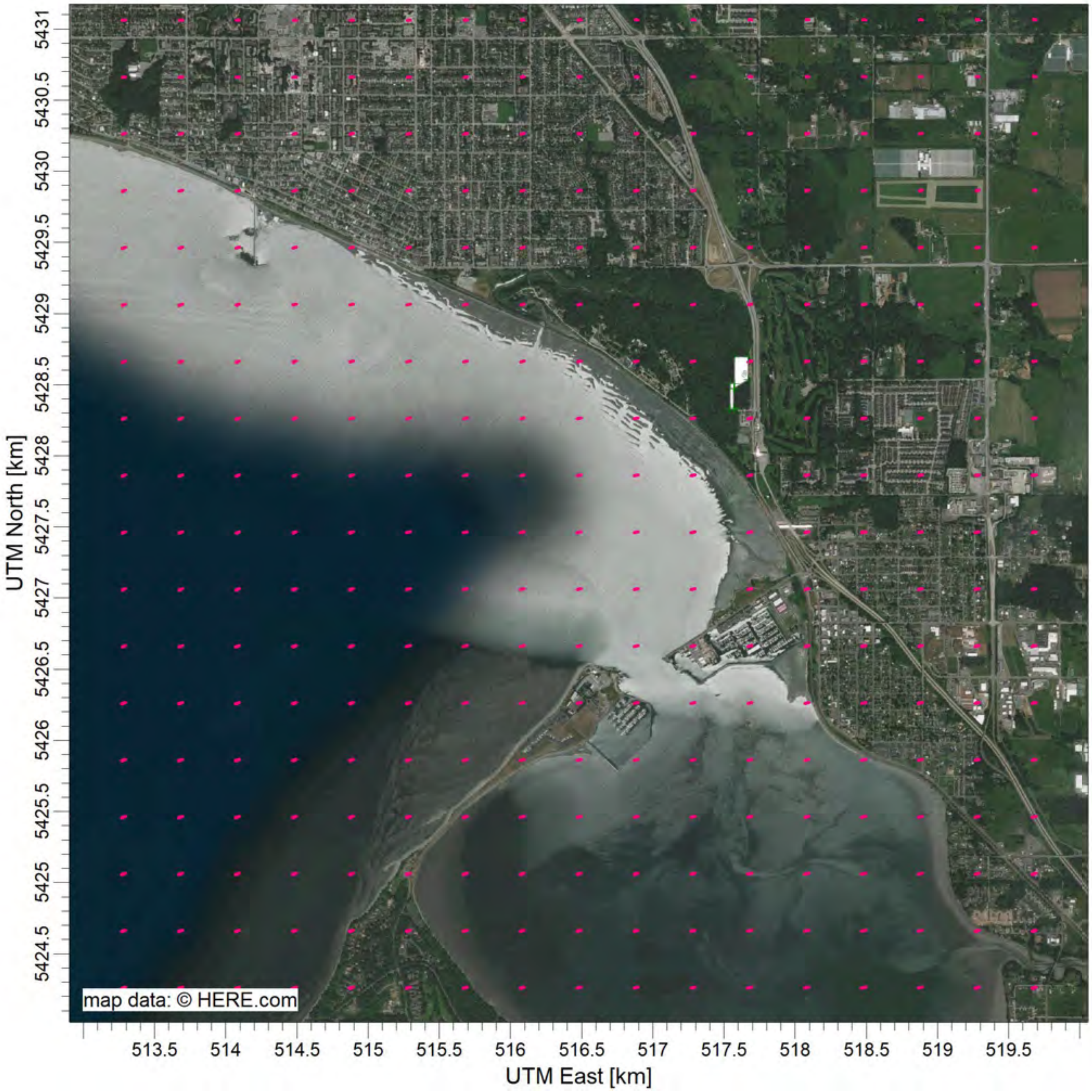


COMMENTS:	COMPANY NAME:	
Upper (1600 m) Layer	**Tetra Tech**	
	MODELER: **T. Miguez**	andion
	SCALE: 1:45,000 (0 — 1 km)	
	DATE: **6/2/2023**	**Figure B.9(c).13**

CALPUFF View - Lakes Environmental Software

PROJECT TITLE:

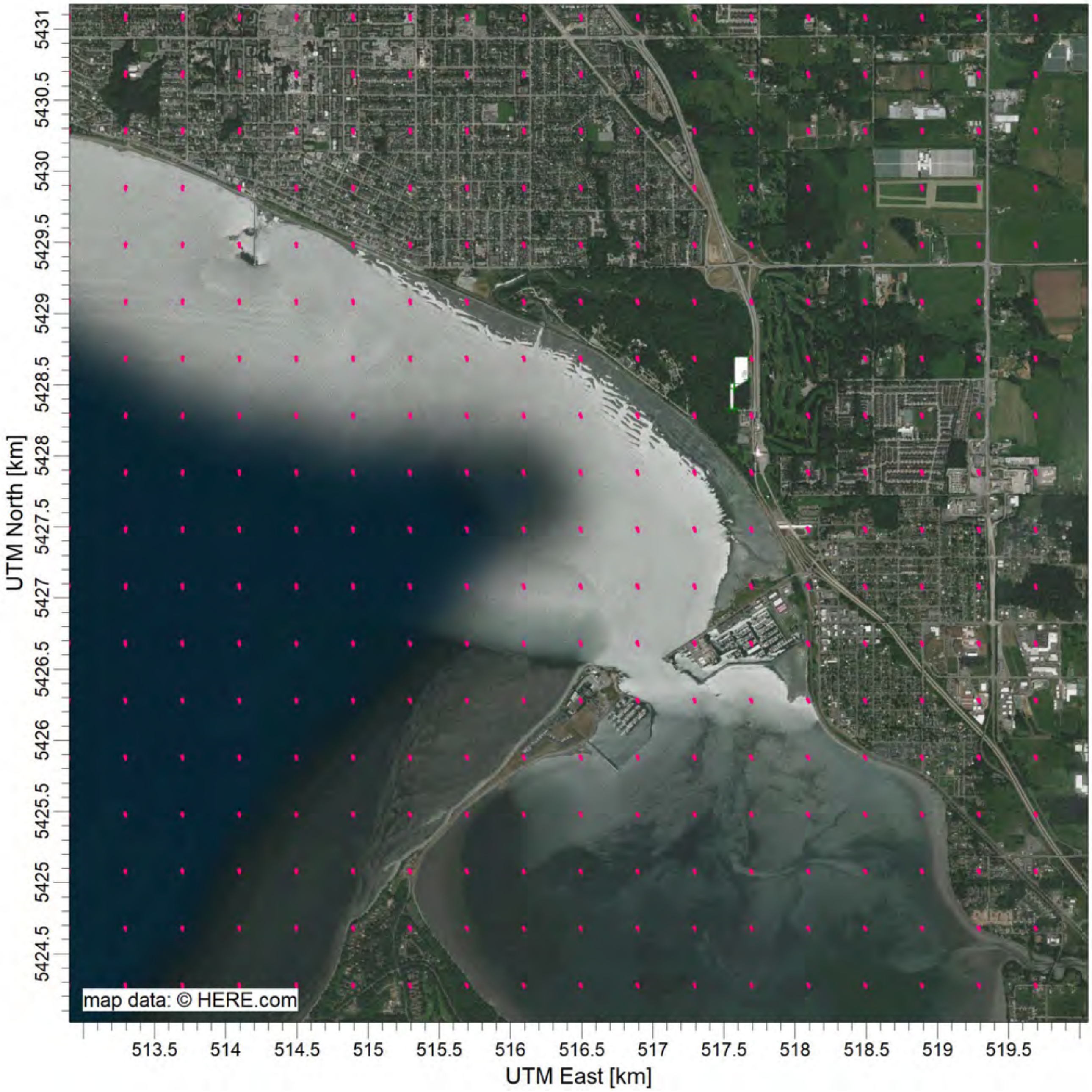
Land-Sea Breeze Circulation Validation
CALMET 1600m Wind Field - July 18, 2013 1400 PDT



COMMENTS: Upper (1600 m) Layer	COMPANY NAME: **Tetra Tech**
	MODELER: **T. Miguez**
	SCALE: 1:45,000 0 — 1 km
	DATE: **6/2/2023**
	Figure B.9(c).14

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 1600m Wind Field - July 18, 2013 1500 PDT



COMMENTS:

Upper (1600 m) Layer

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:45,000

0 1 km

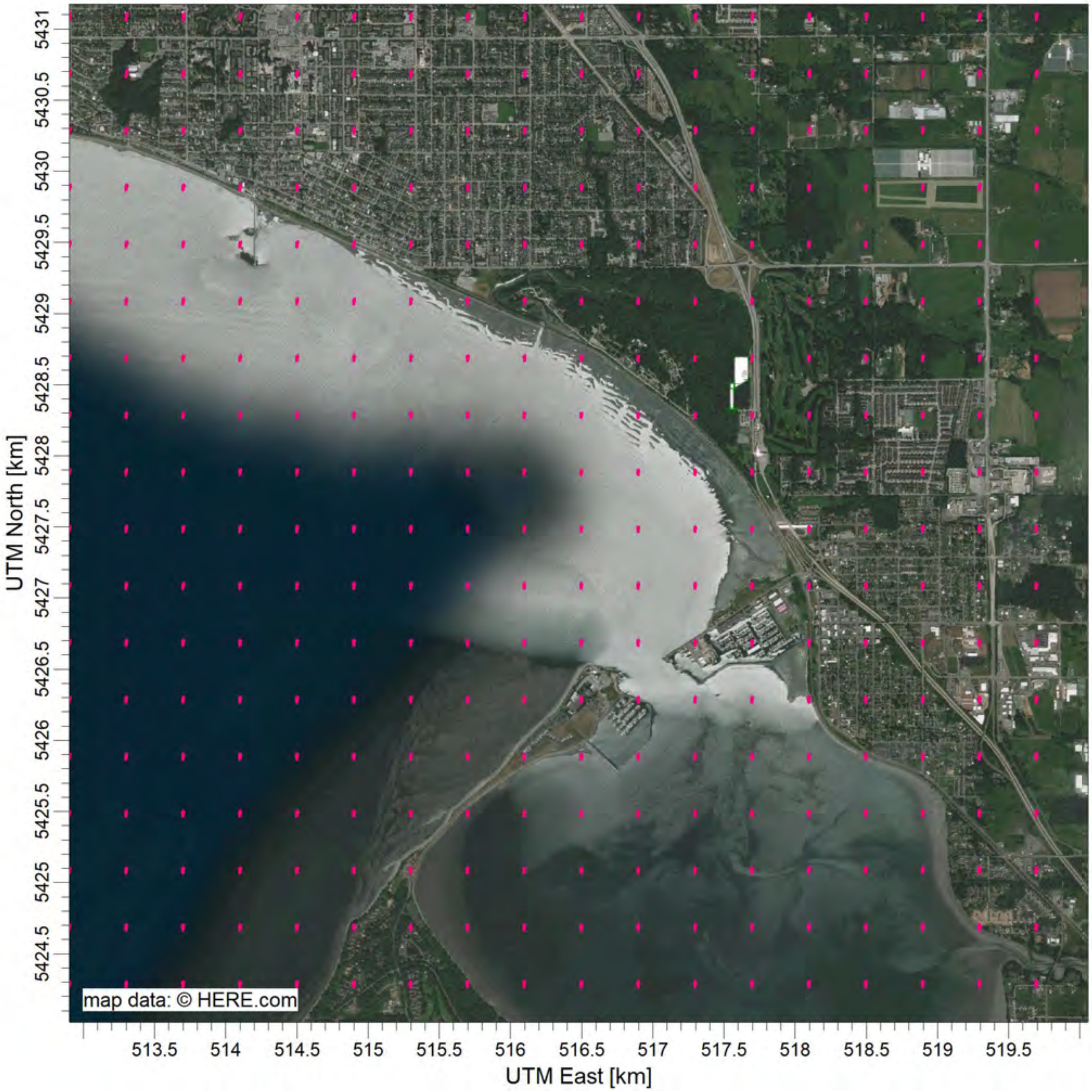
DATE:

6/2/2023

Figure B.9(c).15

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 1600m Wind Field - July 18, 2013 1600 PDT



COMMENTS:

Upper (1600 m) Layer

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:45,000

0 — 1 km

andion

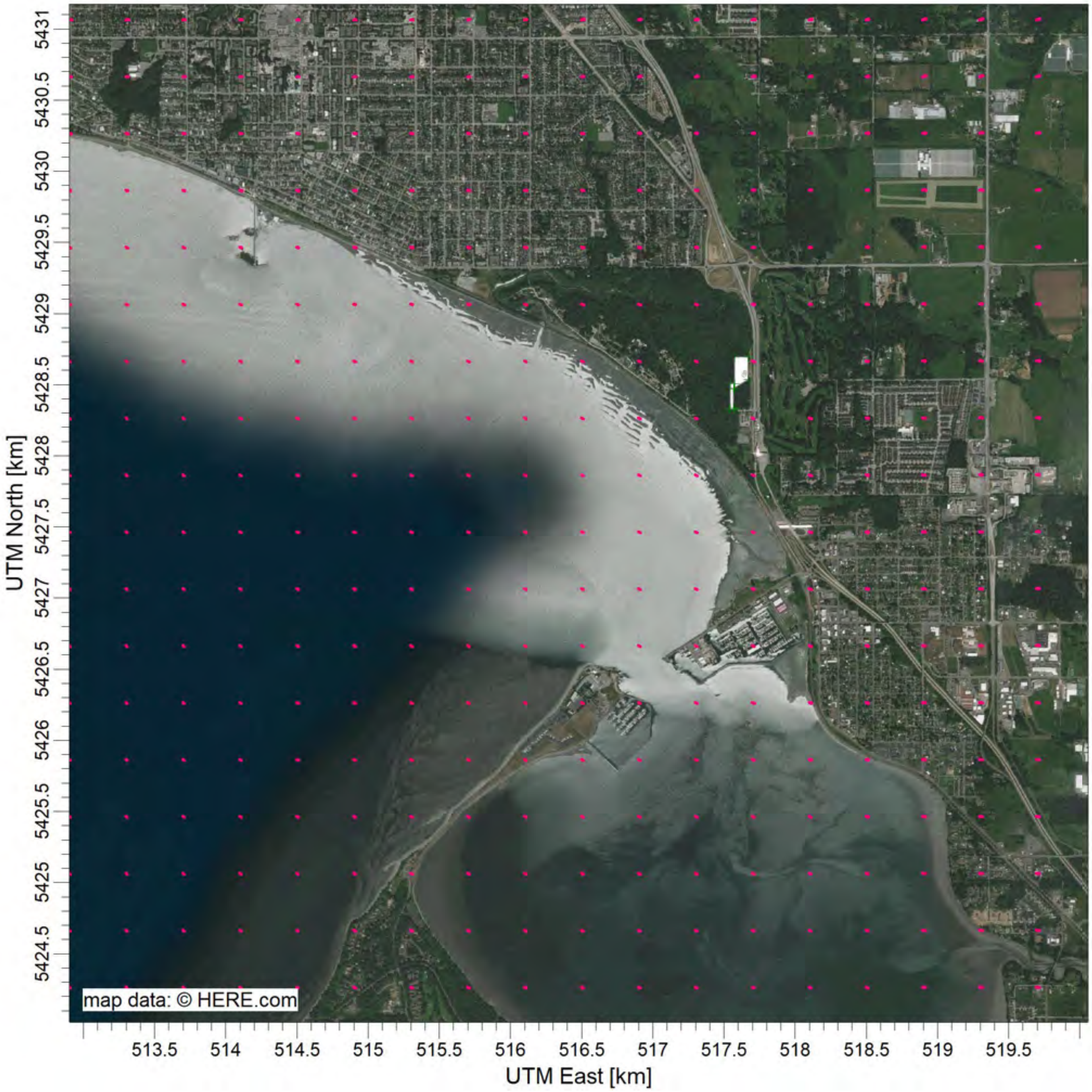
DATE:

6/2/2023

Figure B.9(c).16

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 1600m Wind Field - July 18, 2013 1700 PDT



COMMENTS:

Upper (1600 m) Layer

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:45,000

0 1 km

DATE:

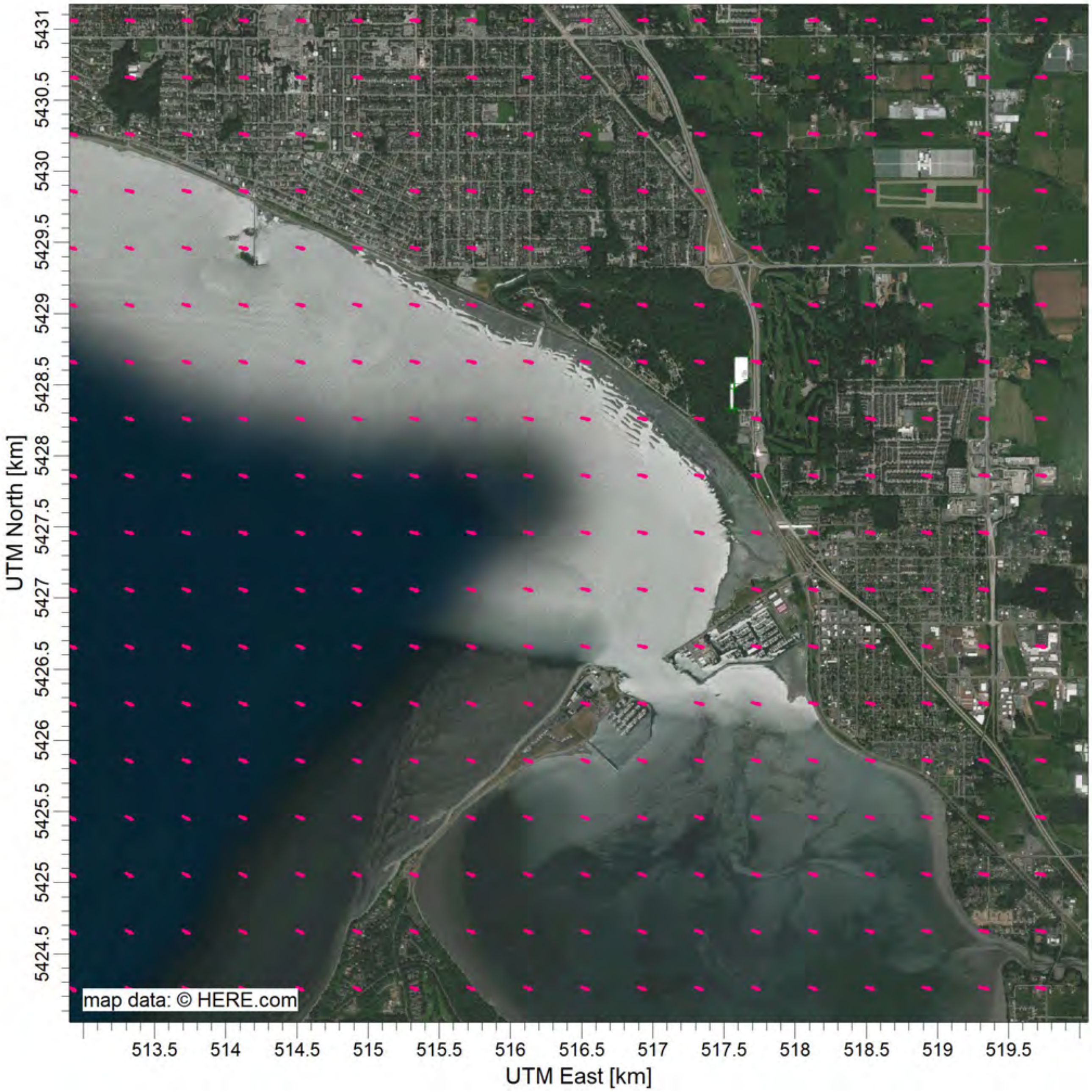
6/2/2023

andion

Figure B.9(c).17

PROJECT TITLE:

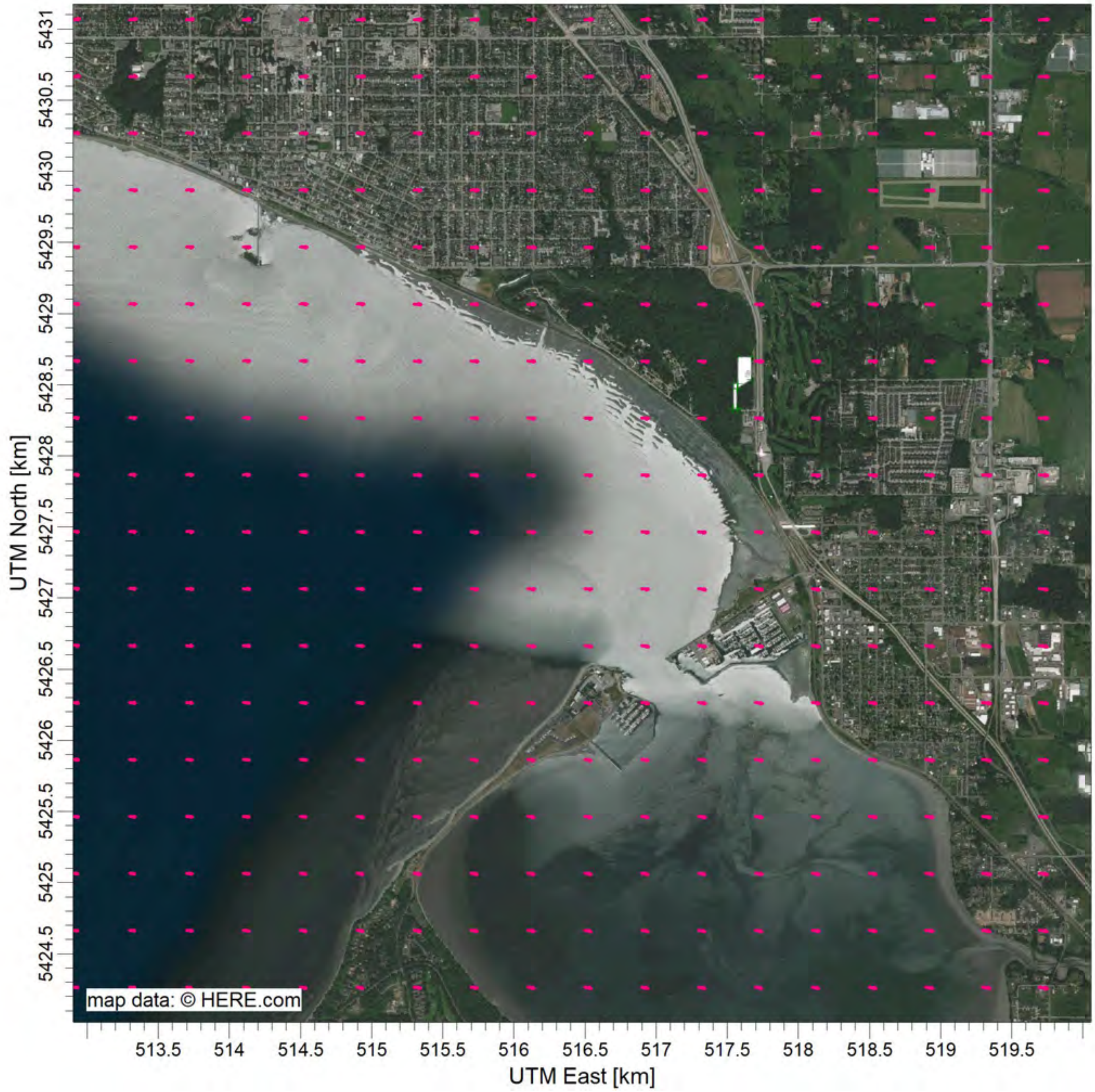
Land-Sea Breeze Circulation Validation
CALMET 1600m Wind Field - July 18, 2013 1800 PDT



COMMENTS: Upper (1600 m) Layer	COMPANY NAME: **Tetra Tech**	
	MODELER: **T. Miguez**	andion
	SCALE: 1:45,000 0 — 1 km	
	DATE: **6/2/2023**	**Figure B.9(c).18**

PROJECT TITLE:

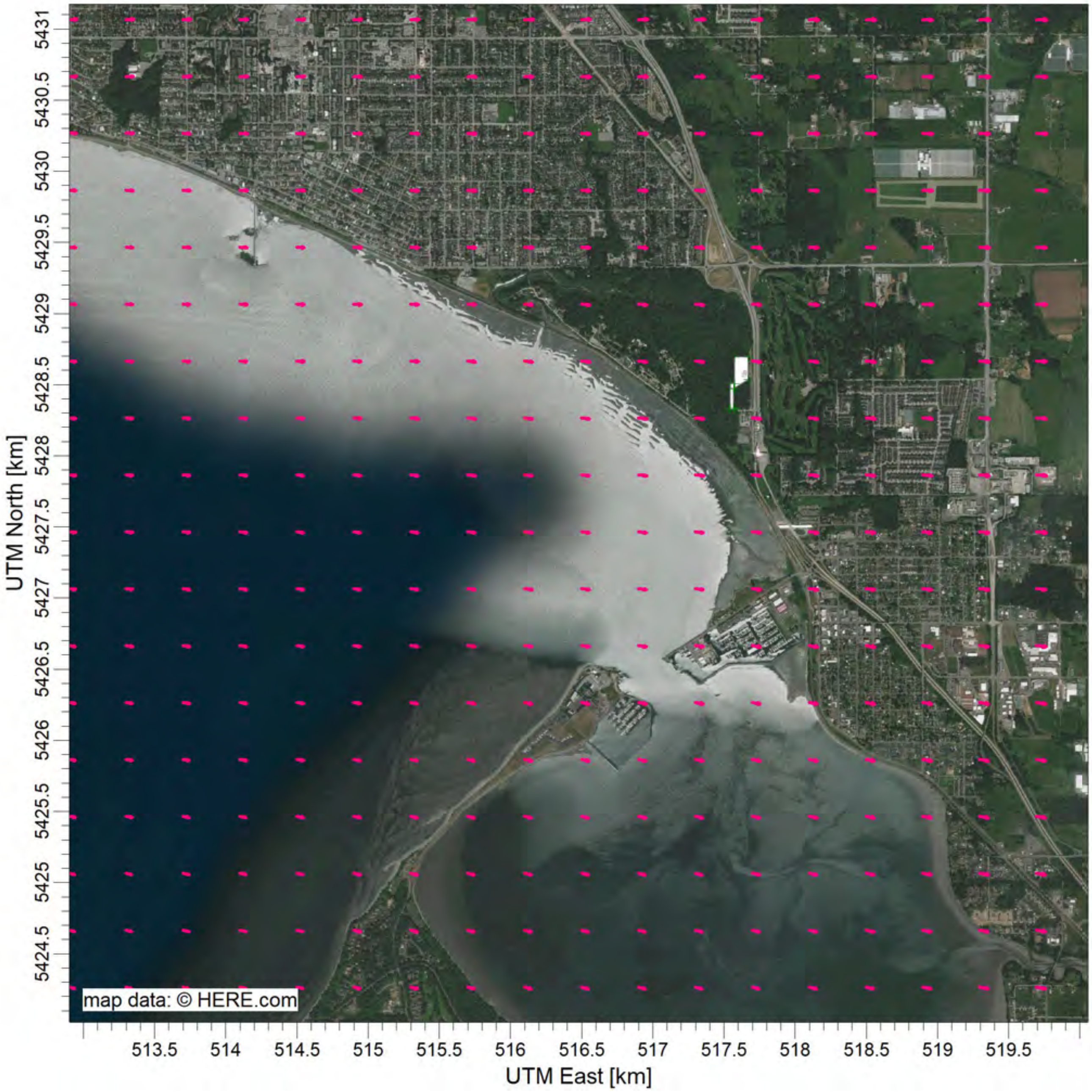
Land-Sea Breeze Circulation Validation
CALMET 1600m Wind Field - July 18, 2013 1900 PDT



COMMENTS: Upper (1600 m) Layer	COMPANY NAME: **Tetra Tech**
	MODELER: **T. Miguez**
	SCALE: 1:45,000 0 — 1 km
	DATE: **6/2/2023**
	Figure B.9(c).19

PROJECT TITLE:

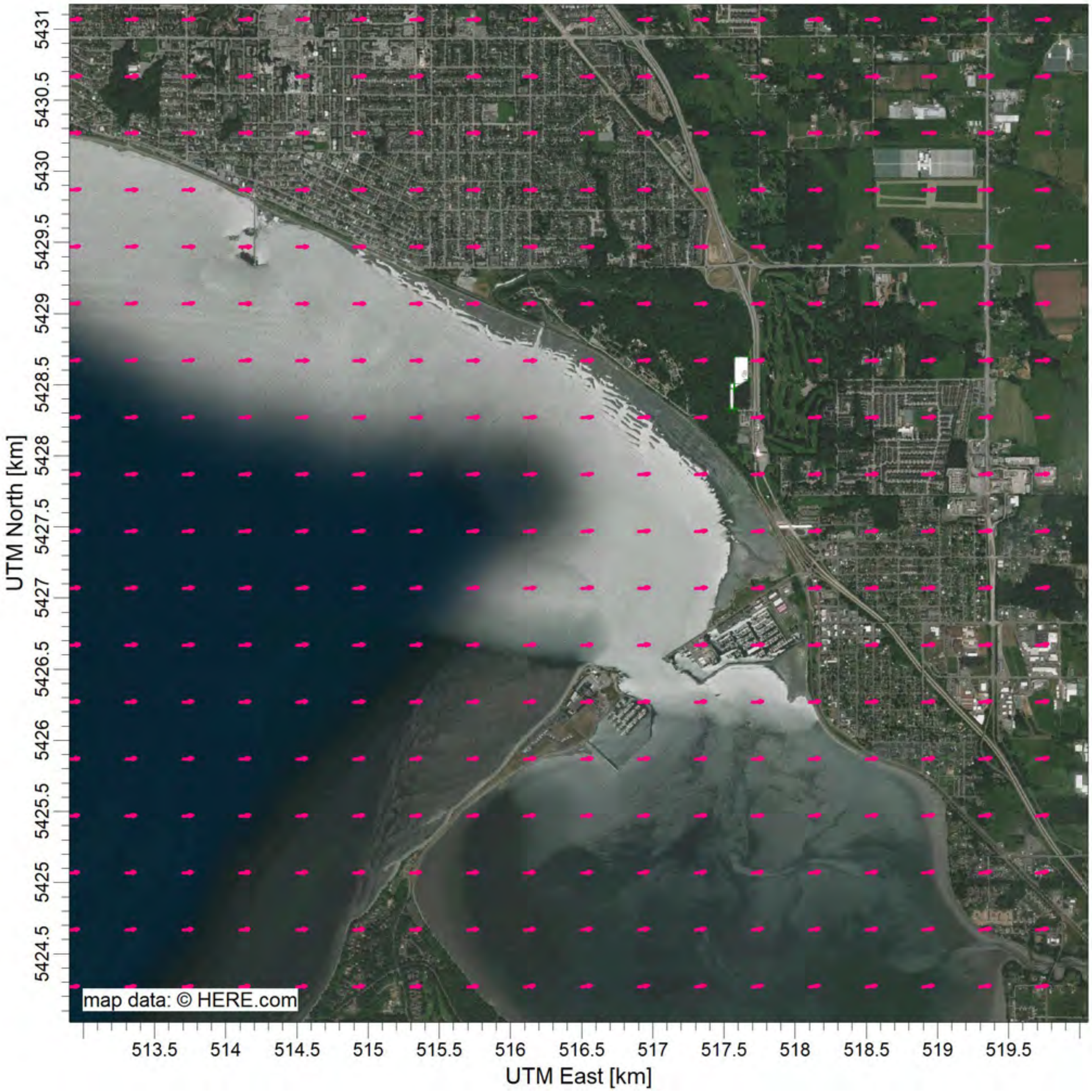
Land-Sea Breeze Circulation Validation
CALMET 1600m Wind Field - July 18, 2013 2000 PDT



COMMENTS: Upper (1600 m) Layer	COMPANY NAME: **Tetra Tech**
	MODELER: **T. Miguez**
	SCALE: 1:45,000 0 — 1 km
	DATE: **6/2/2023**
	Figure B.9(c).20

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 1600m Wind Field - July 18, 2013 2100 PDT



COMMENTS:

Upper (1600 m) Layer

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:45,000

0 1 km

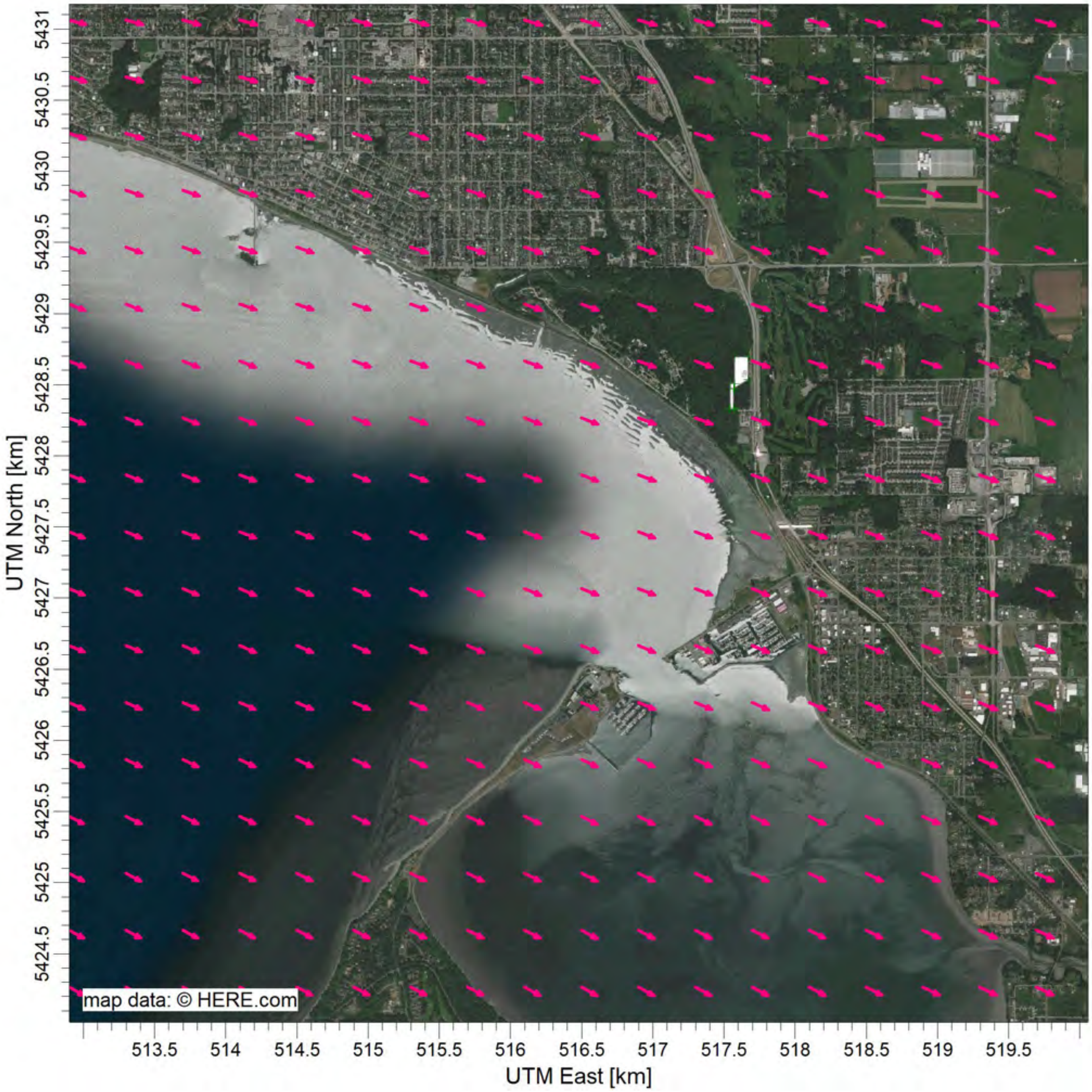
DATE:

6/2/2023

Figure B.9(c).21

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 1600m Wind Field - July 18, 2013 2200 PDT



COMMENTS:

Upper (1600 m) Layer

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:45,000

0 1 km

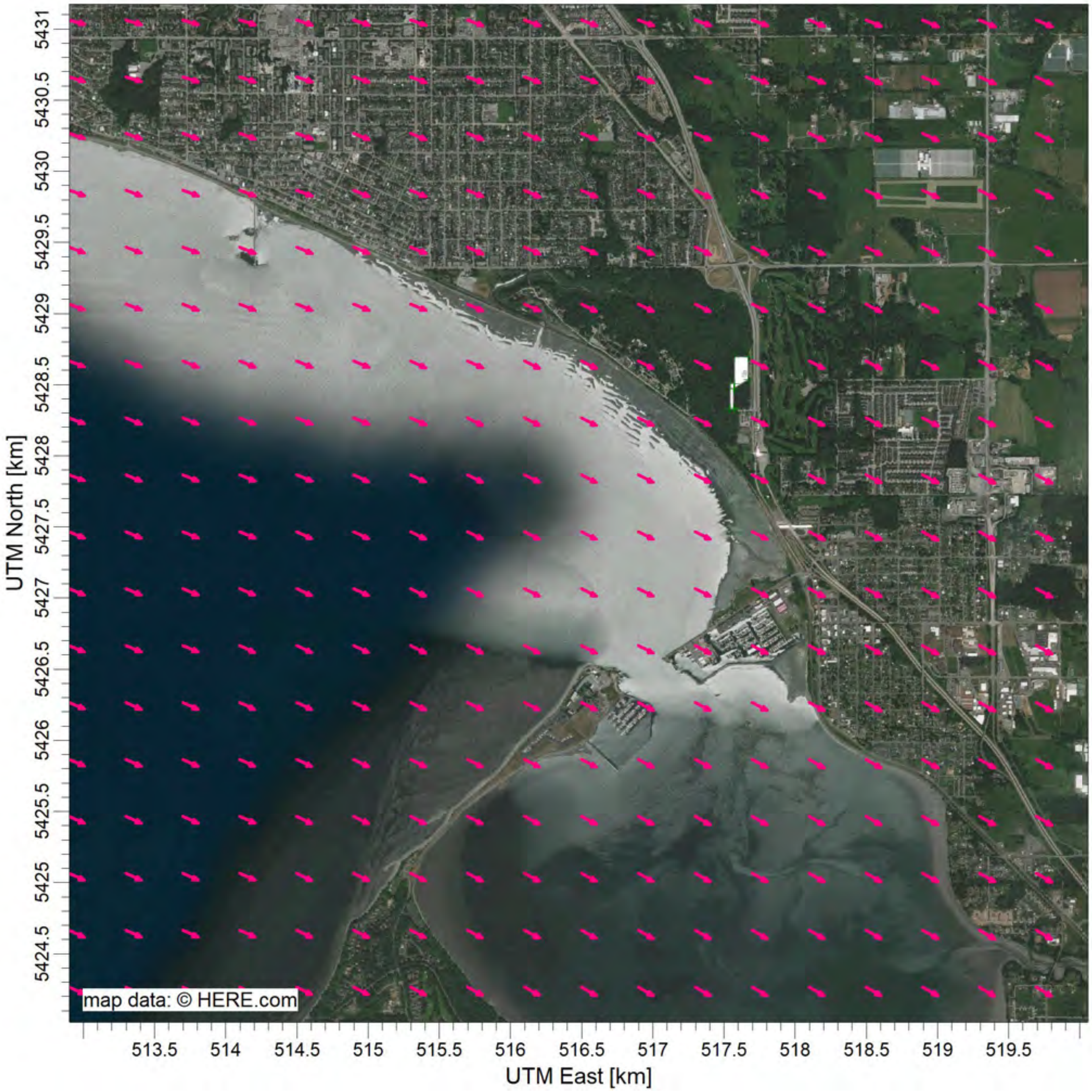
DATE:

6/2/2023

Figure B.9(c).22

PROJECT TITLE:

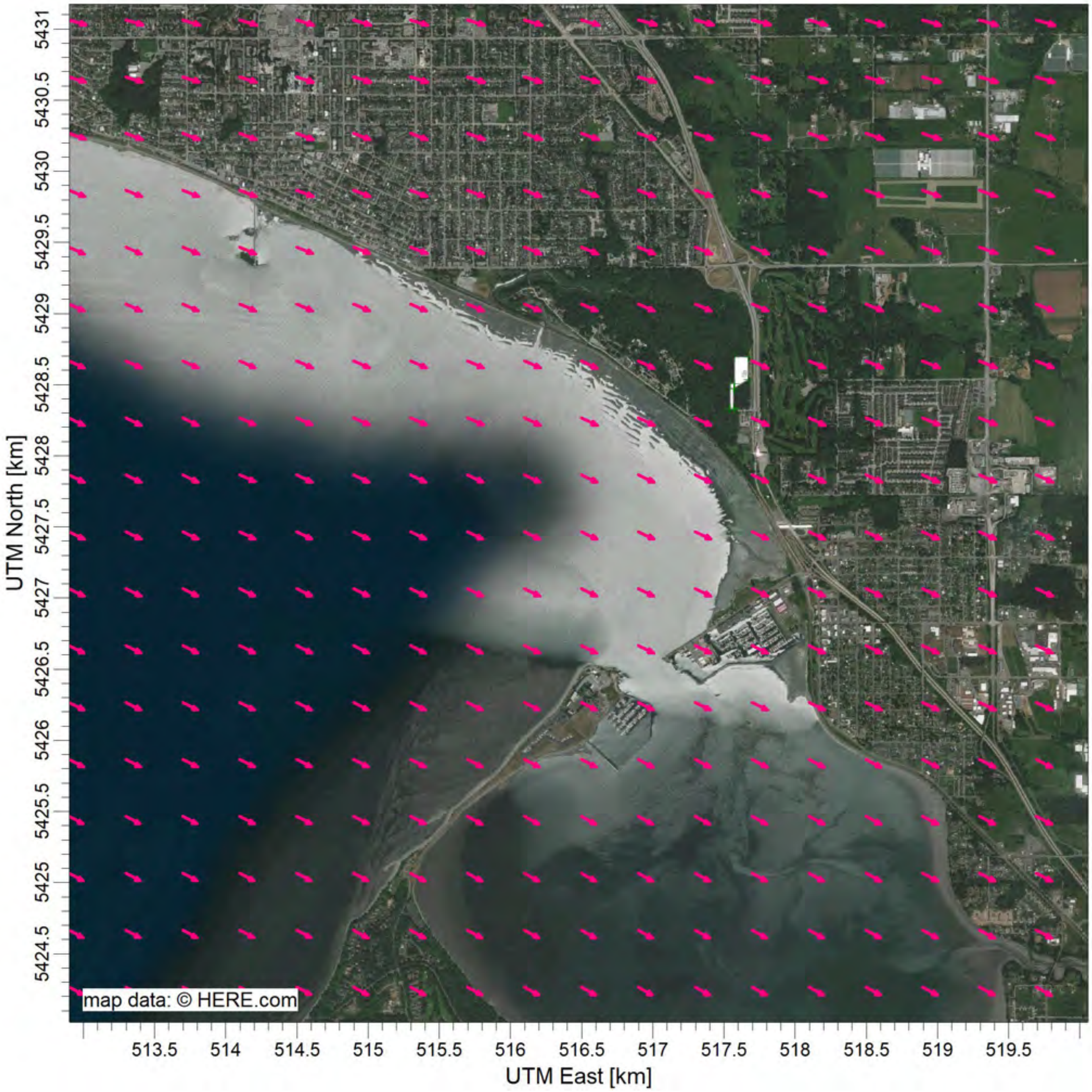
Land-Sea Breeze Circulation Validation
CALMET 1600m Wind Field - July 18, 2013 2300 PDT



COMMENTS: Upper (1600 m) Layer	COMPANY NAME: **Tetra Tech**
	MODELER: **T. Miguez**
	SCALE: 1:45,000 0 1 km
	DATE: **6/2/2023**
	Figure B.9(c).23

PROJECT TITLE:

Land-Sea Breeze Circulation Validation
CALMET 1600m Wind Field - July 18, 2013 2400 PDT



COMMENTS:

Upper (1600 m) Layer

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:45,000

0 1 km

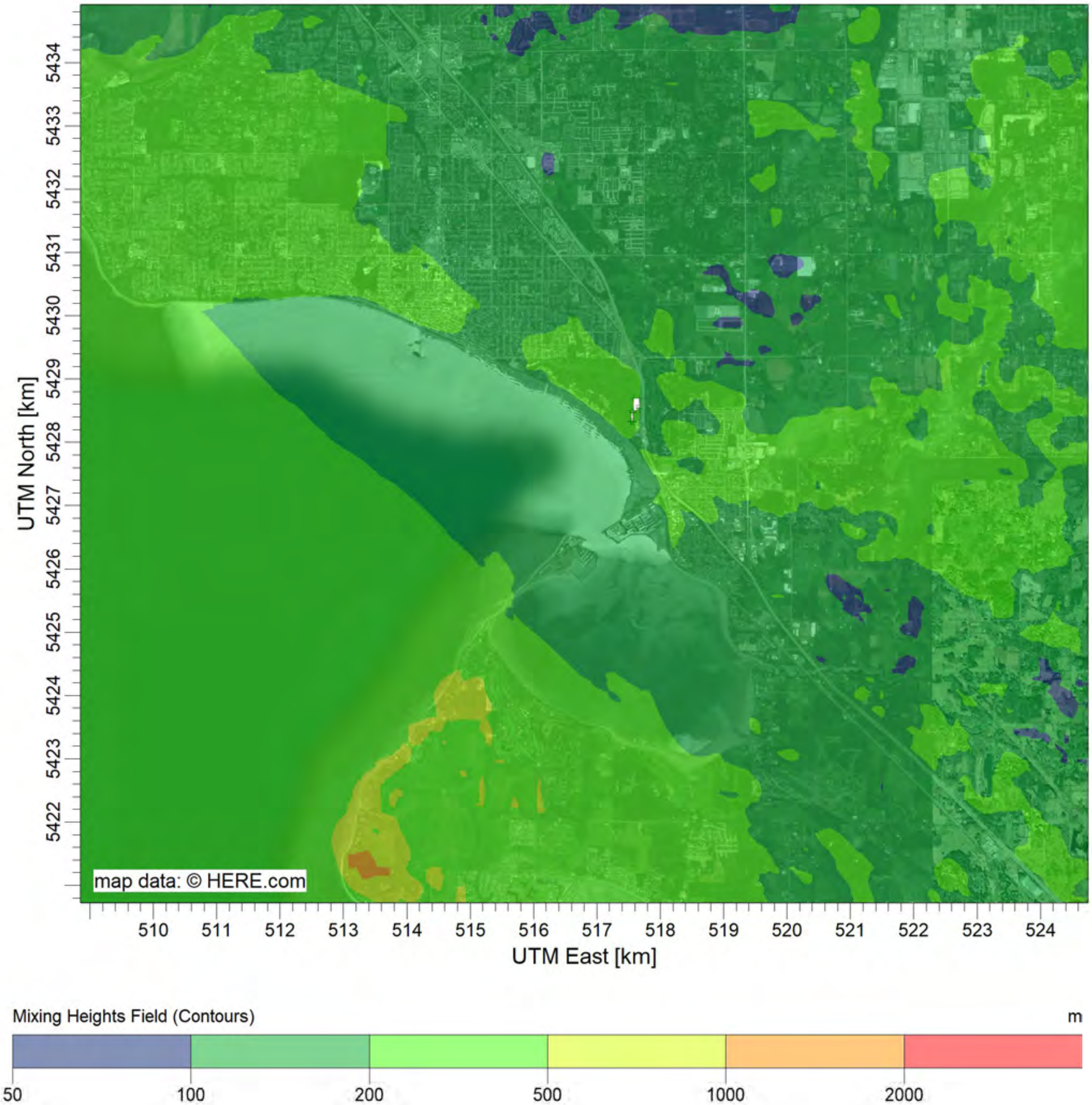
DATE:

6/2/2023

Figure B.9(c).24

PROJECT TITLE:

Diurnal Mixing Height Validation
CALMET Predicted Mixing Height - July 18, 2013 0100 PDT



COMMENTS:

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:100,000

0 3 km

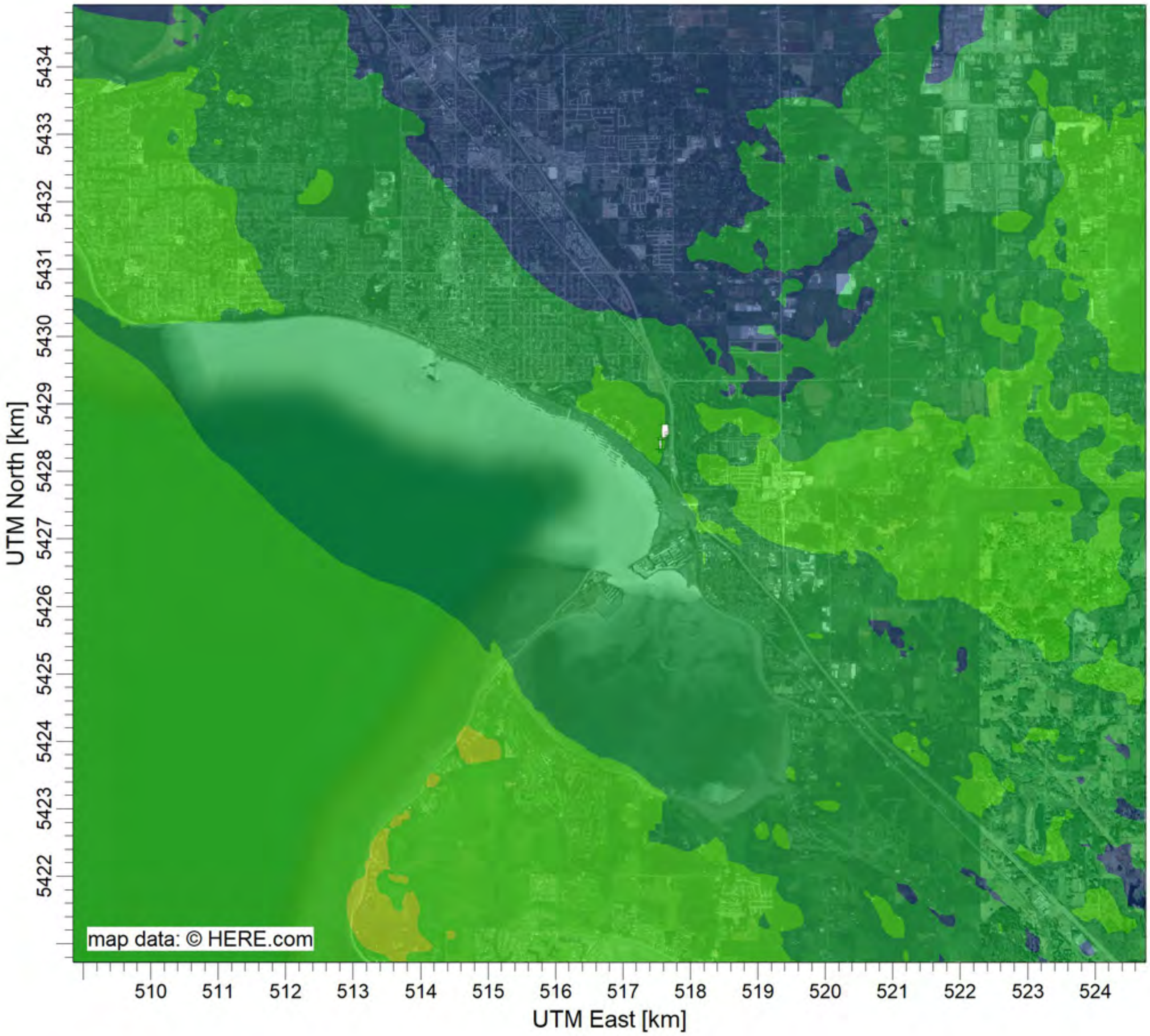
DATE:

6/2/2023

Figure B.12.1

PROJECT TITLE:

Diurnal Mixing Height Validation
CALMET Predicted Mixing Height - July 18, 2013 0200 PDT



COMMENTS:

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:100,000

0 3 km

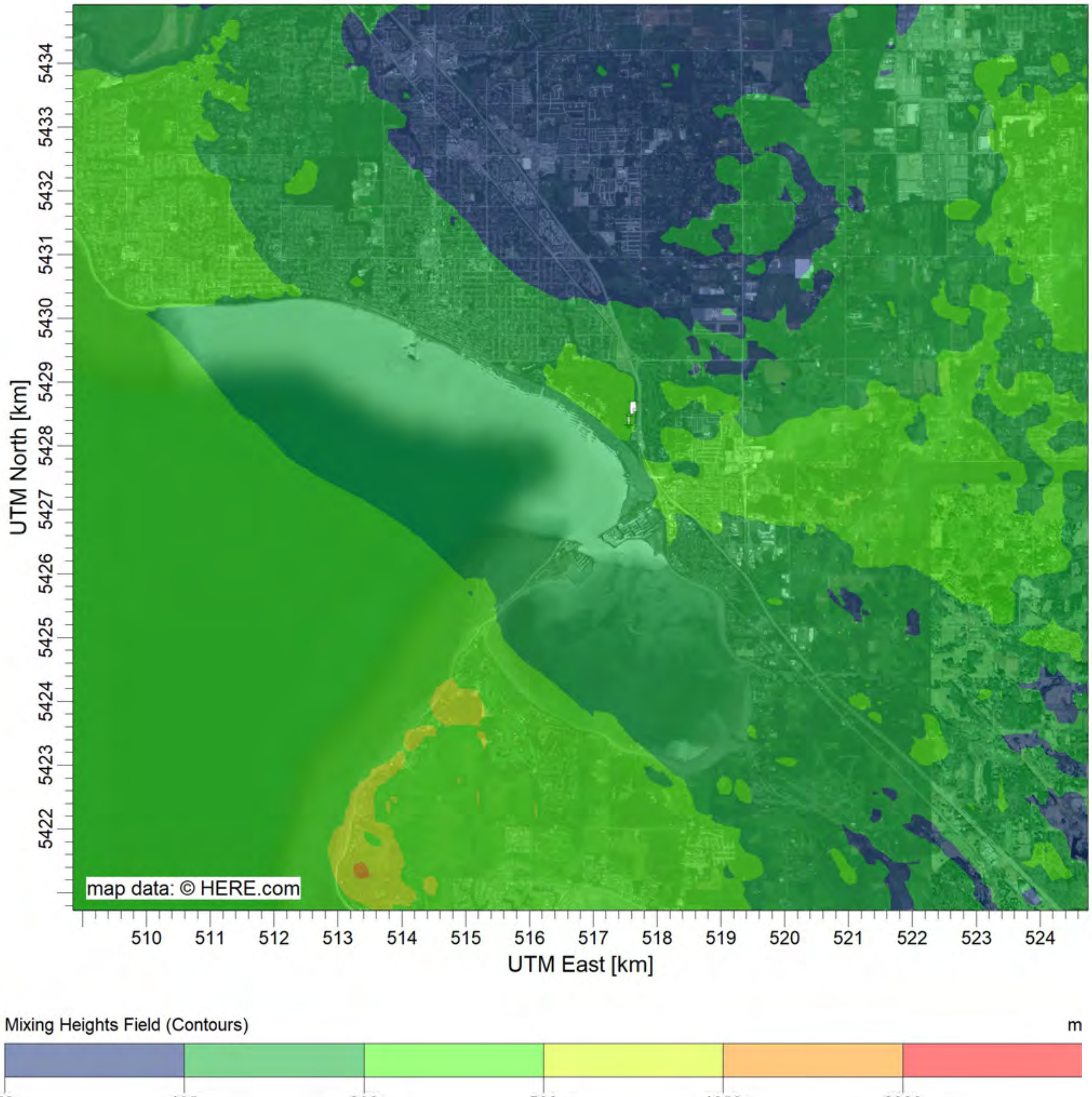
DATE:

6/2/2023

Figure B.12.2

PROJECT TITLE:

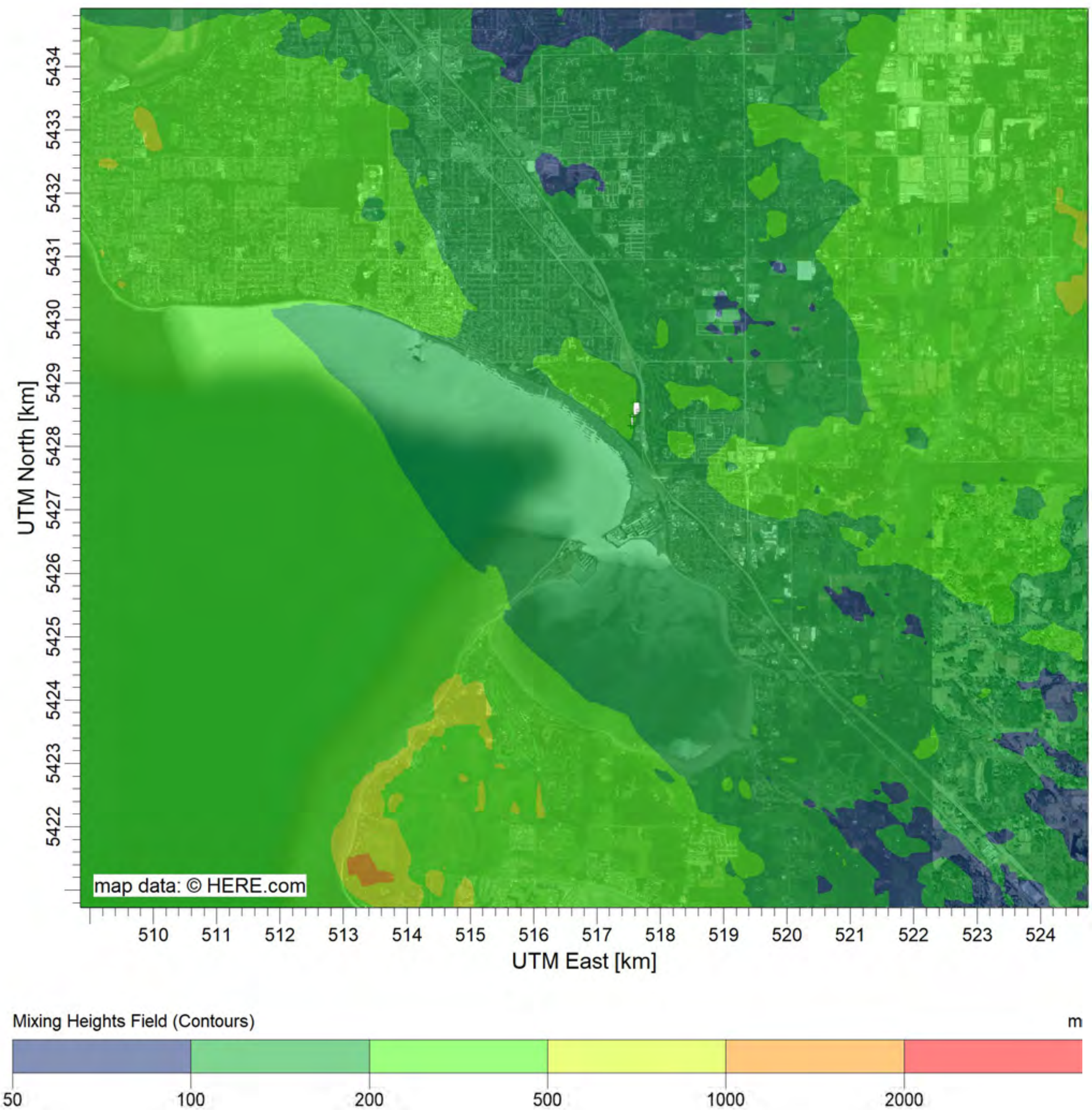
Diurnal Mixing Height Validation
CALMET Predicted Mixing Height - July 18, 2013 0300 PDT



COMMENTS:	COMPANY NAME: **Tetra Tech**	
	MODELER: **T. Miguez**	andion
	SCALE: 1:100,000 (0 — 3 km)	
	DATE: **6/2/2023**	**Figure B.12.3**

PROJECT TITLE:

Diurnal Mixing Height Validation
CALMET Predicted Mixing Height - July 18, 2013 0400 PDT



COMMENTS:

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:100,000

0 3 km

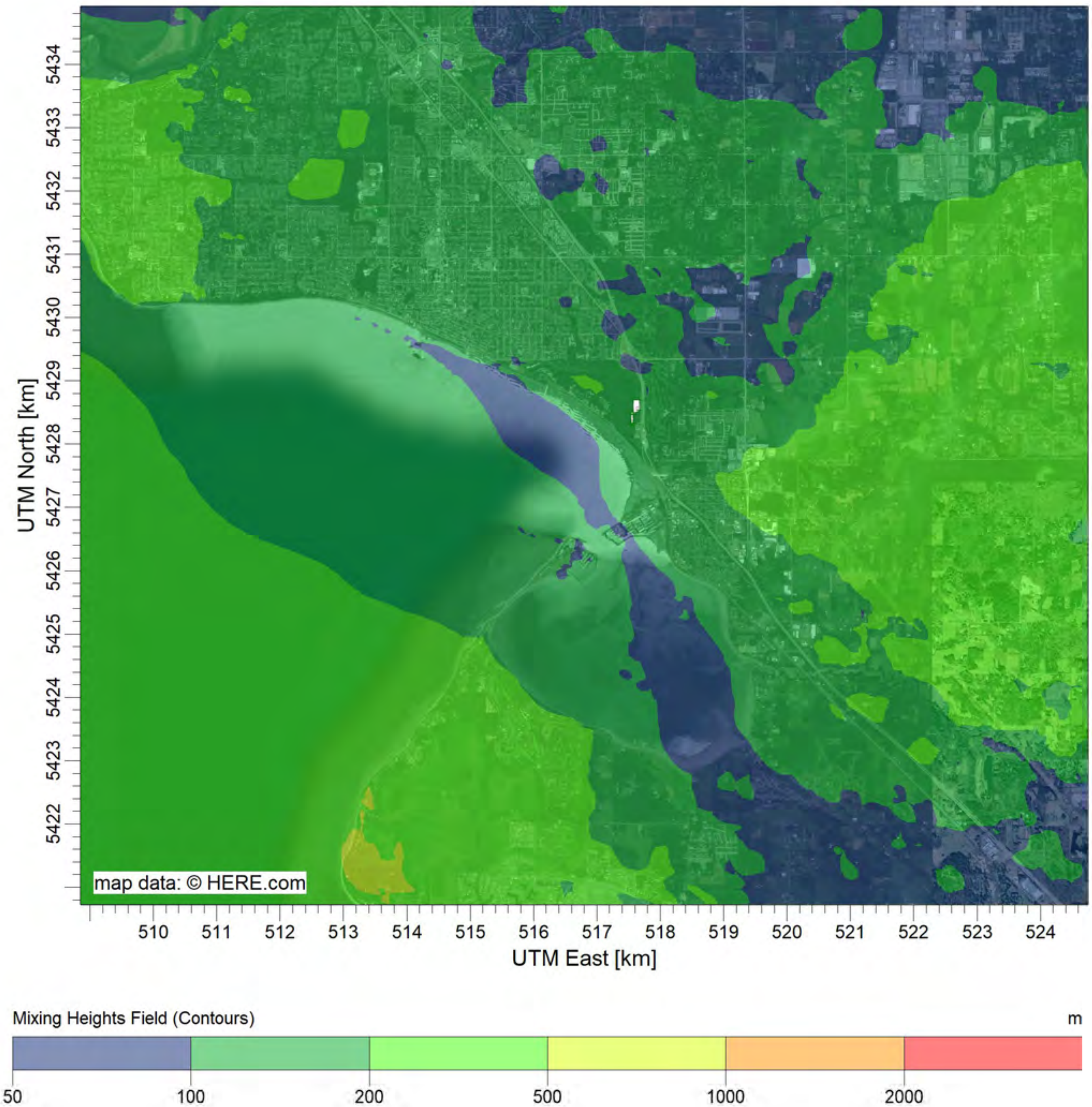
DATE:

6/2/2023

Figure B.12.4

PROJECT TITLE:

Diurnal Mixing Height Validation
CALMET Predicted Mixing Height - July 18, 2013 0500 PDT



COMMENTS:

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:100,000

0 3 km

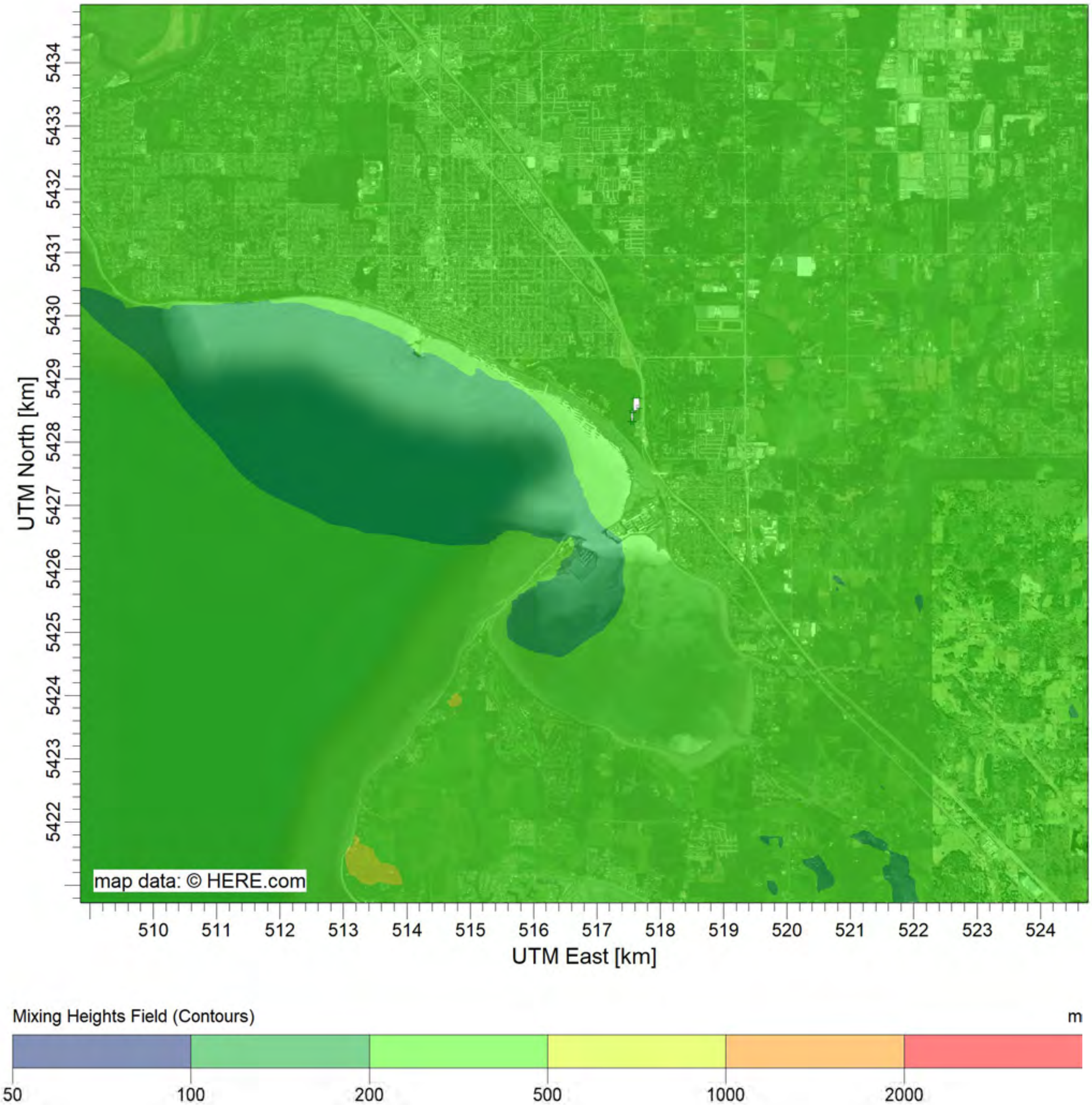
DATE:

6/2/2023

Figure B.12.5

PROJECT TITLE:

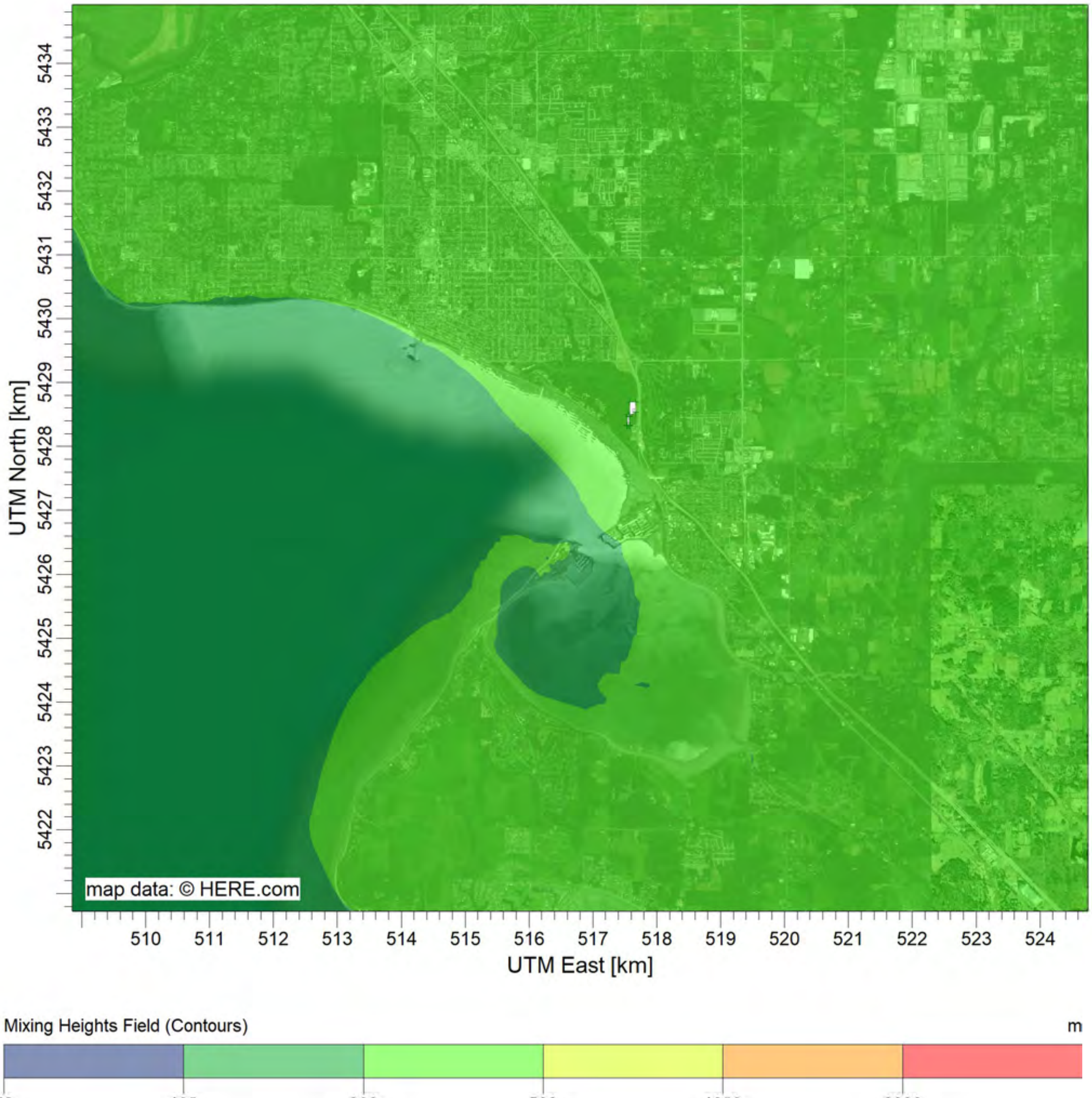
Diurnal Mixing Height Validation
CALMET Predicted Mixing Height - July 18, 2013 0600 PDT



COMMENTS:	COMPANY NAME: **Tetra Tech**	
	MODELER: **T. Miguez**	
	SCALE: 1:100,000 — 0 to 3 km	
	DATE: **6/2/2023**	**Figure B.12.6**

PROJECT TITLE:

Diurnal Mixing Height Validation
CALMET Predicted Mixing Height - July 18, 2013 0700 PDT



COMMENTS:

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:100,000

0 3 km

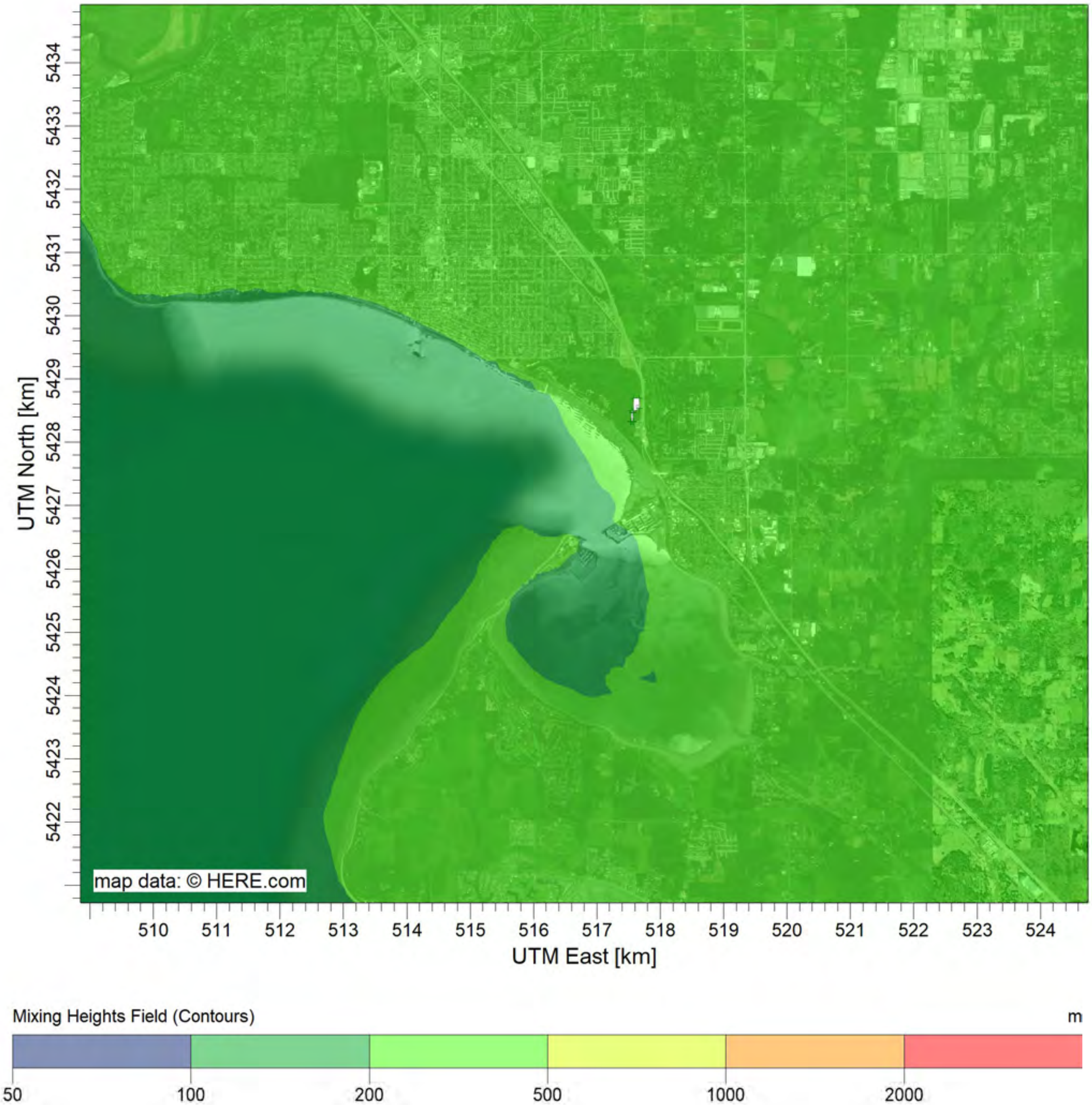
DATE:

6/2/2023

Figure B.12.7

PROJECT TITLE:

Diurnal Mixing Height Validation
CALMET Predicted Mixing Height - July 18, 2013 0800 PDT



COMMENTS:

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:100,000

0 3 km

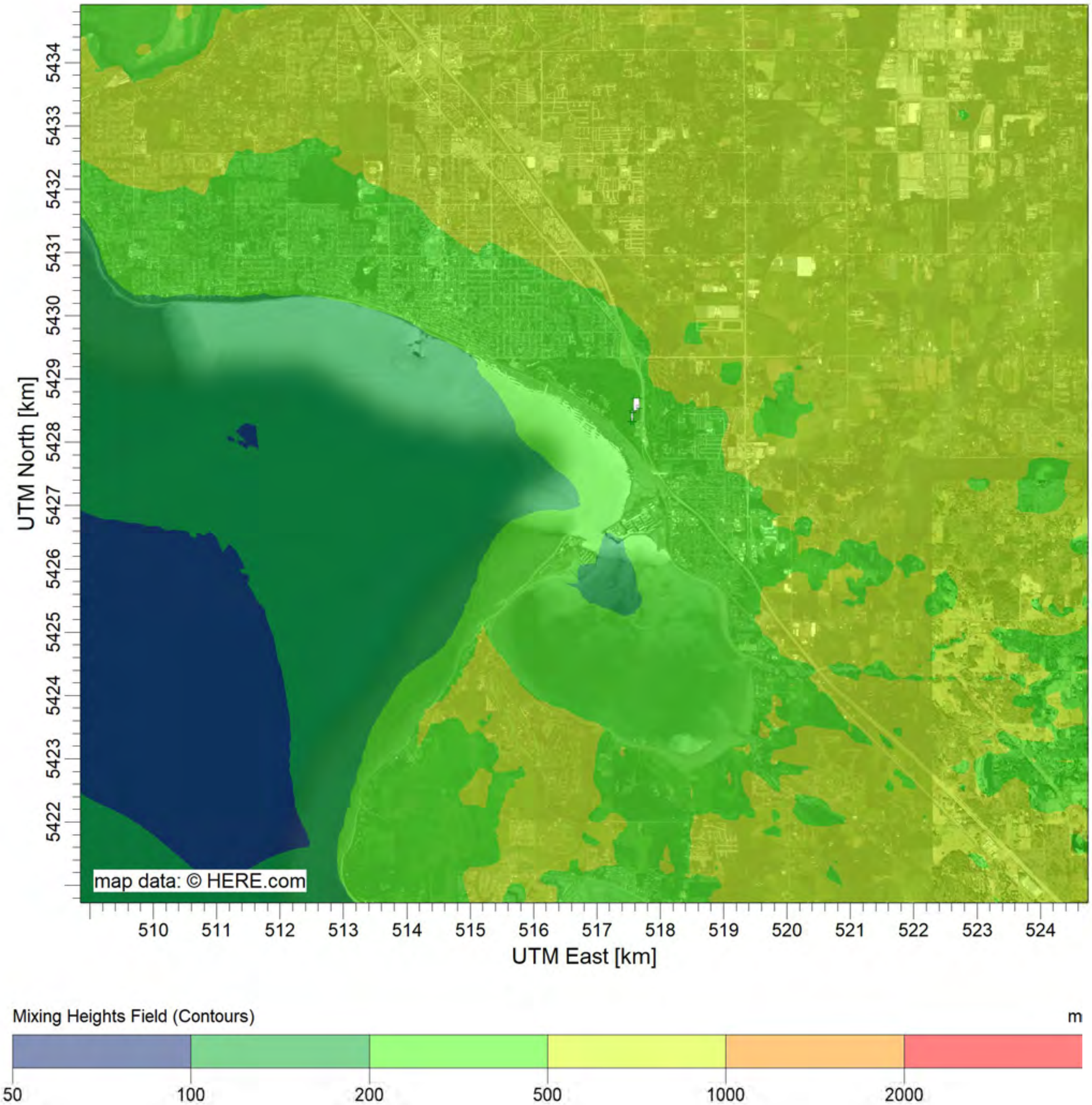
DATE:

6/2/2023

Figure B.12.8

PROJECT TITLE:

Diurnal Mixing Height Validation
CALMET Predicted Mixing Height - July 18, 2013 0900 PDT



COMMENTS:

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:100,000

0 3 km

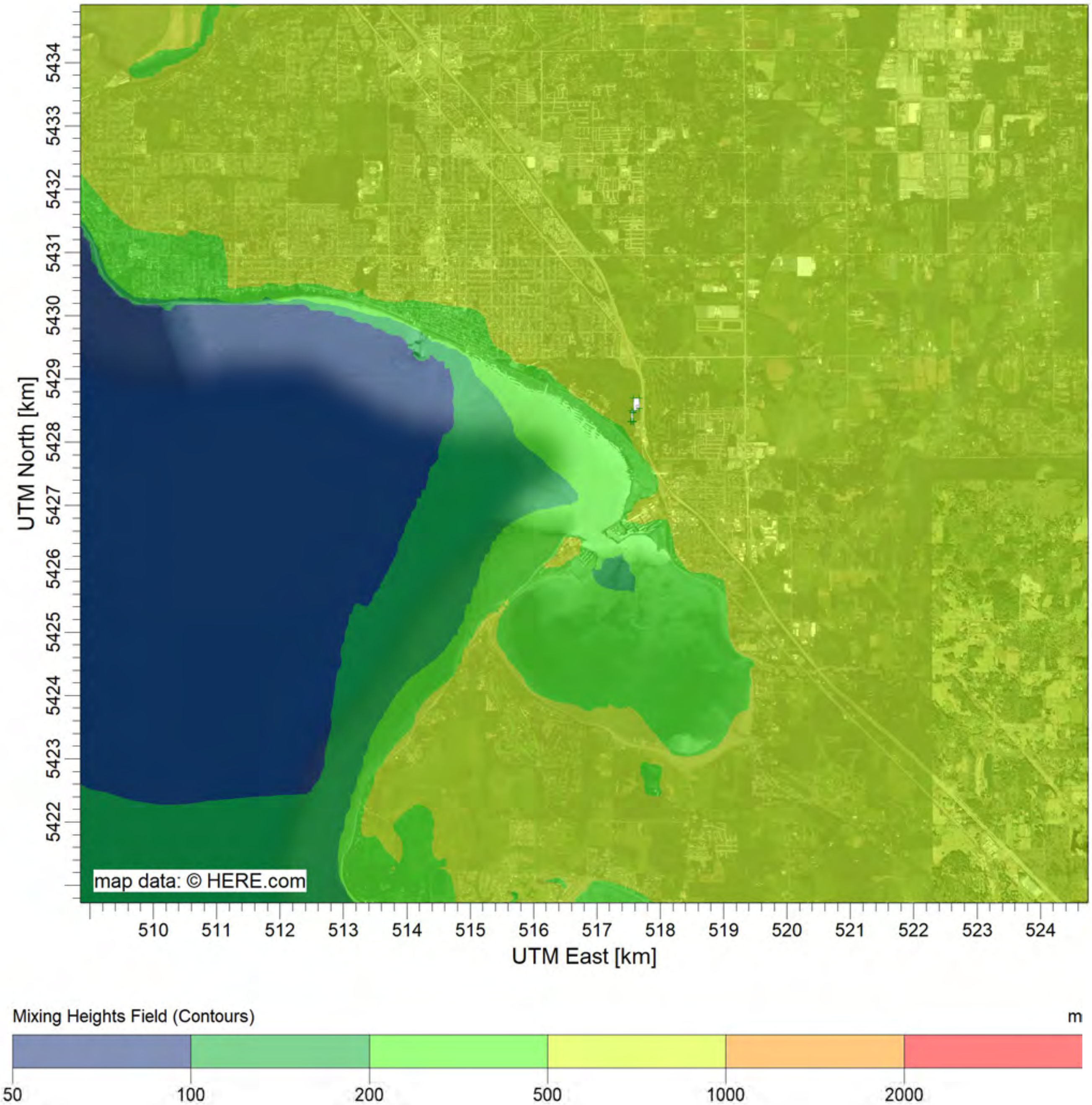
DATE:

6/2/2023

Figure B.12.9

PROJECT TITLE:

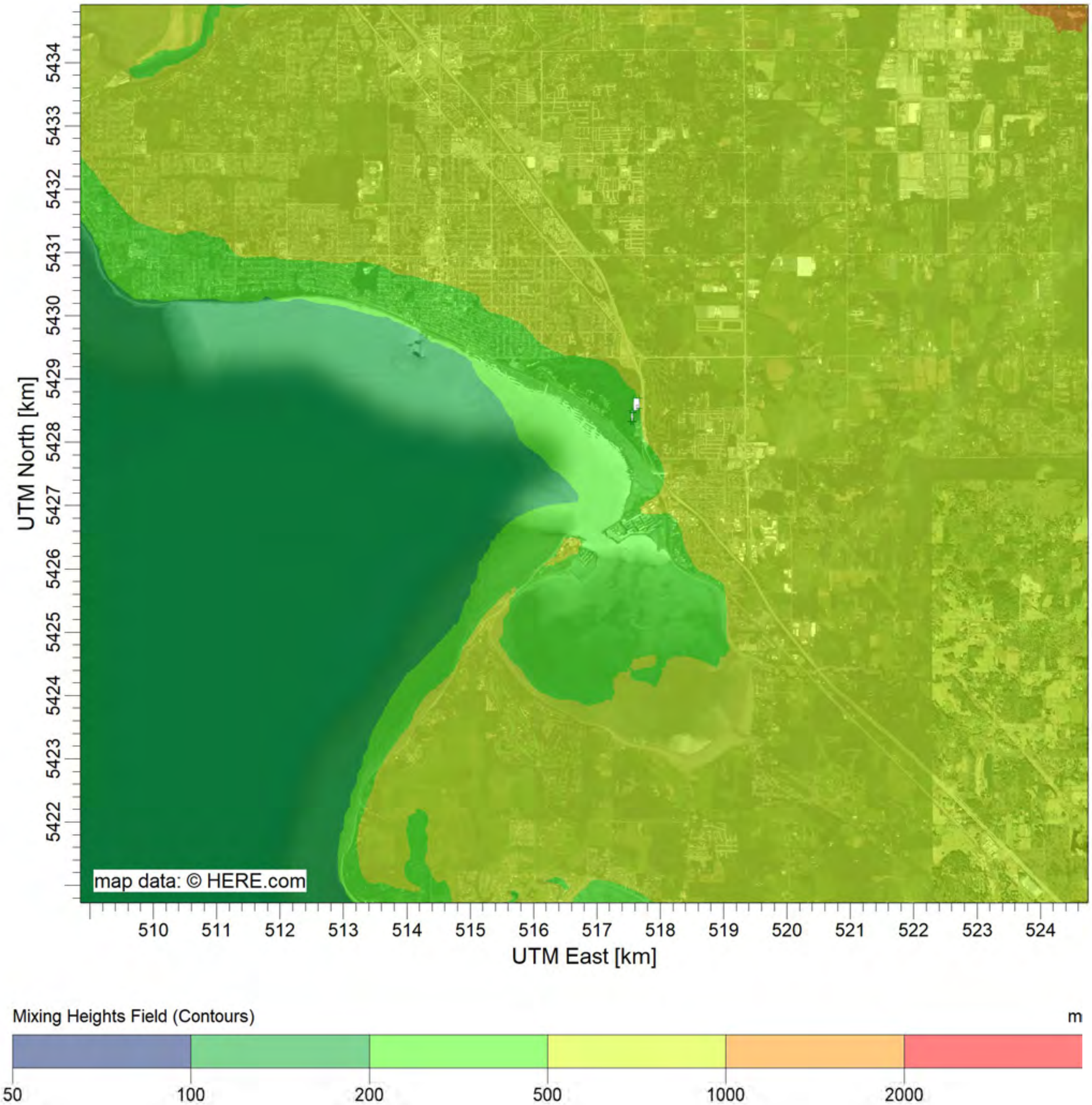
Diurnal Mixing Height Validation
CALMET Predicted Mixing Height - July 18, 2013 1000 PDT



COMMENTS:	COMPANY NAME: **Tetra Tech**	
	MODELER: **T. Miguez**	andion
	SCALE: 1:100,000 (0 – 3 km)	
	DATE: **6/2/2023**	**Figure B.12.10**

PROJECT TITLE:

Diurnal Mixing Height Validation
CALMET Predicted Mixing Height - July 18, 2013 1100 PDT



COMMENTS:

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:100,000

0 3 km

DATE:

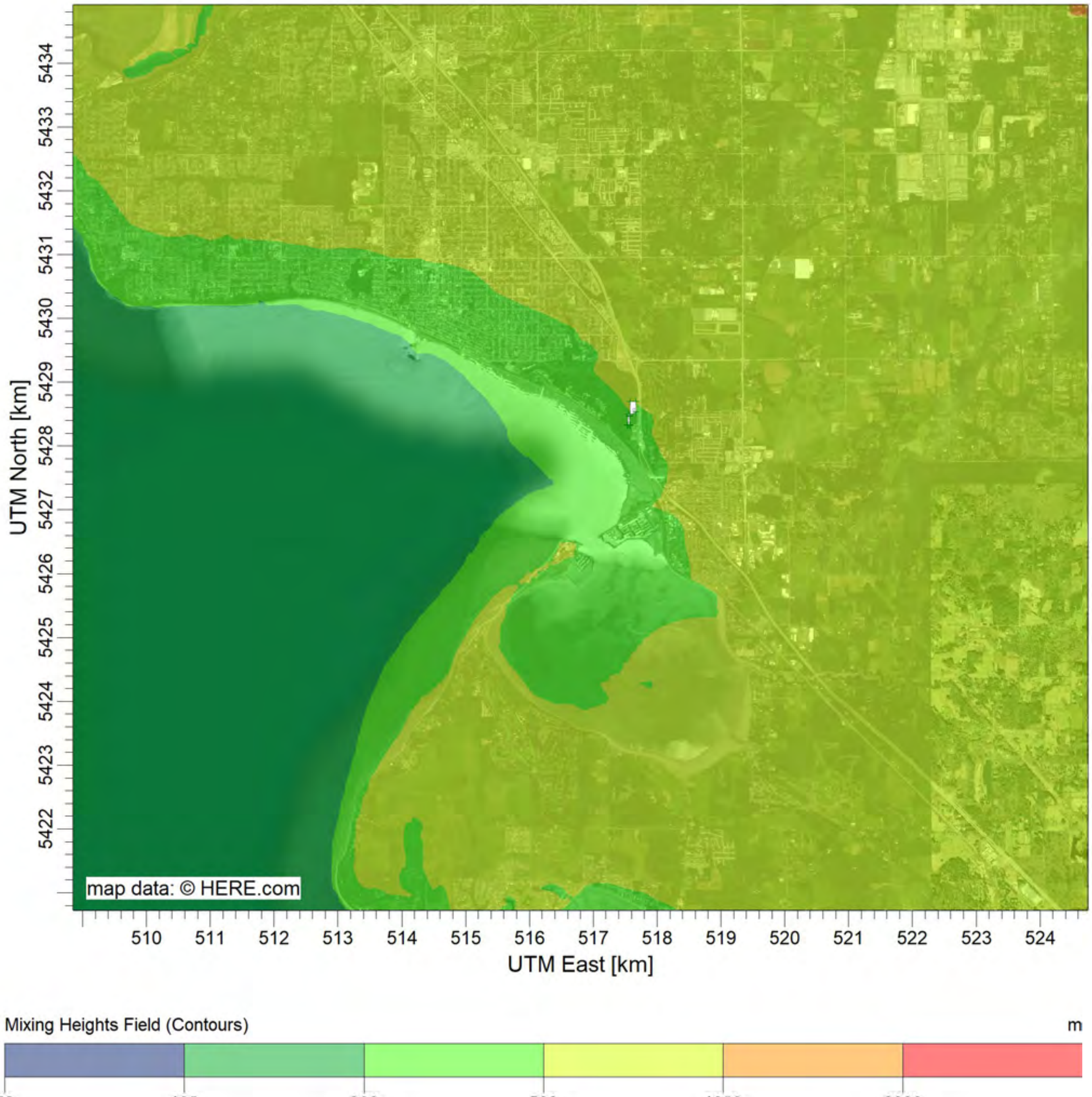
6/2/2023

andion

Figure B.12.11

PROJECT TITLE:

Diurnal Mixing Height Validation
CALMET Predicted Mixing Height - July 18, 2013 1200 PDT



COMMENTS:

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:100,000

0 3 km

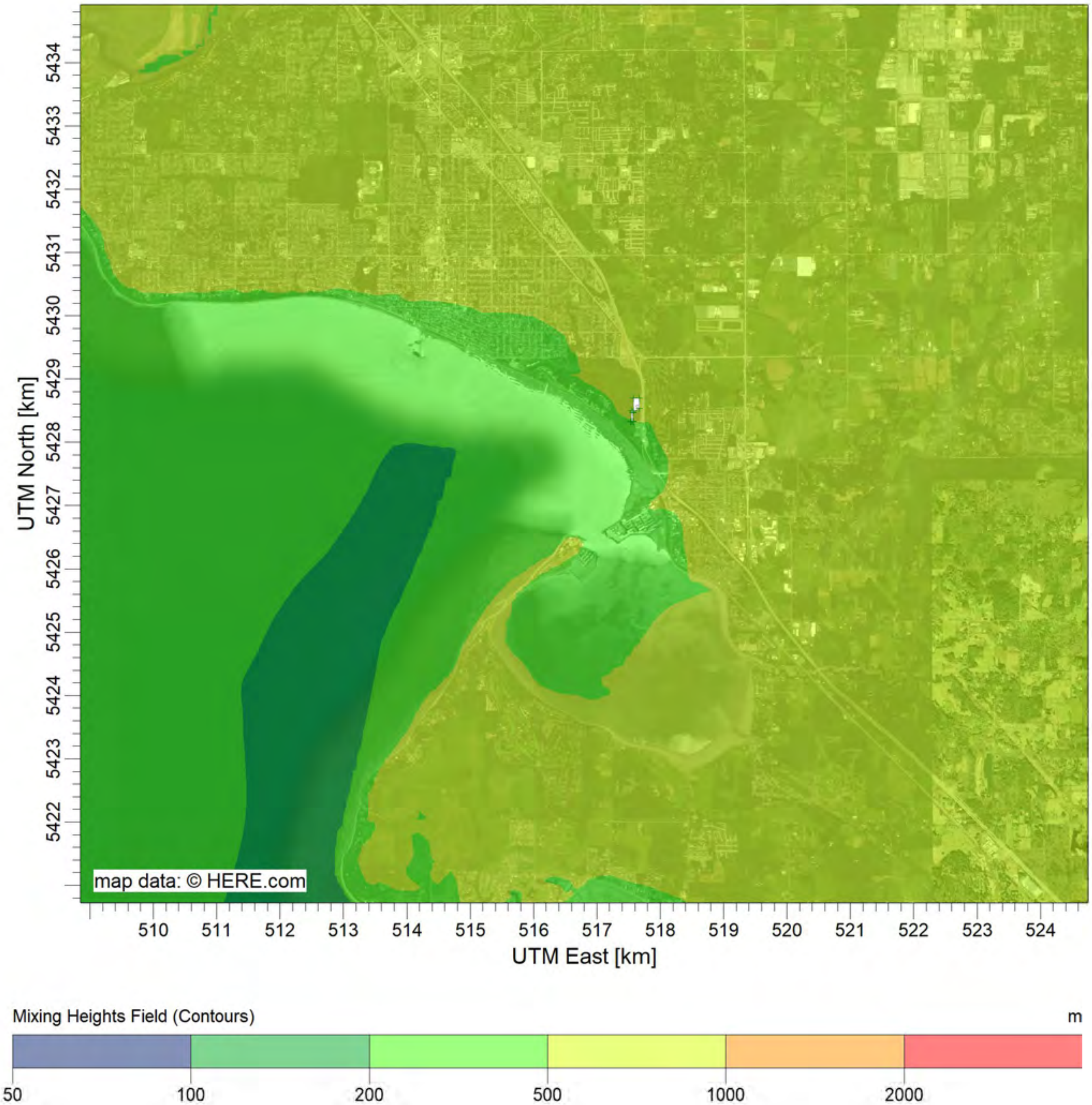
DATE:

6/2/2023

Figure B.12.12

PROJECT TITLE:

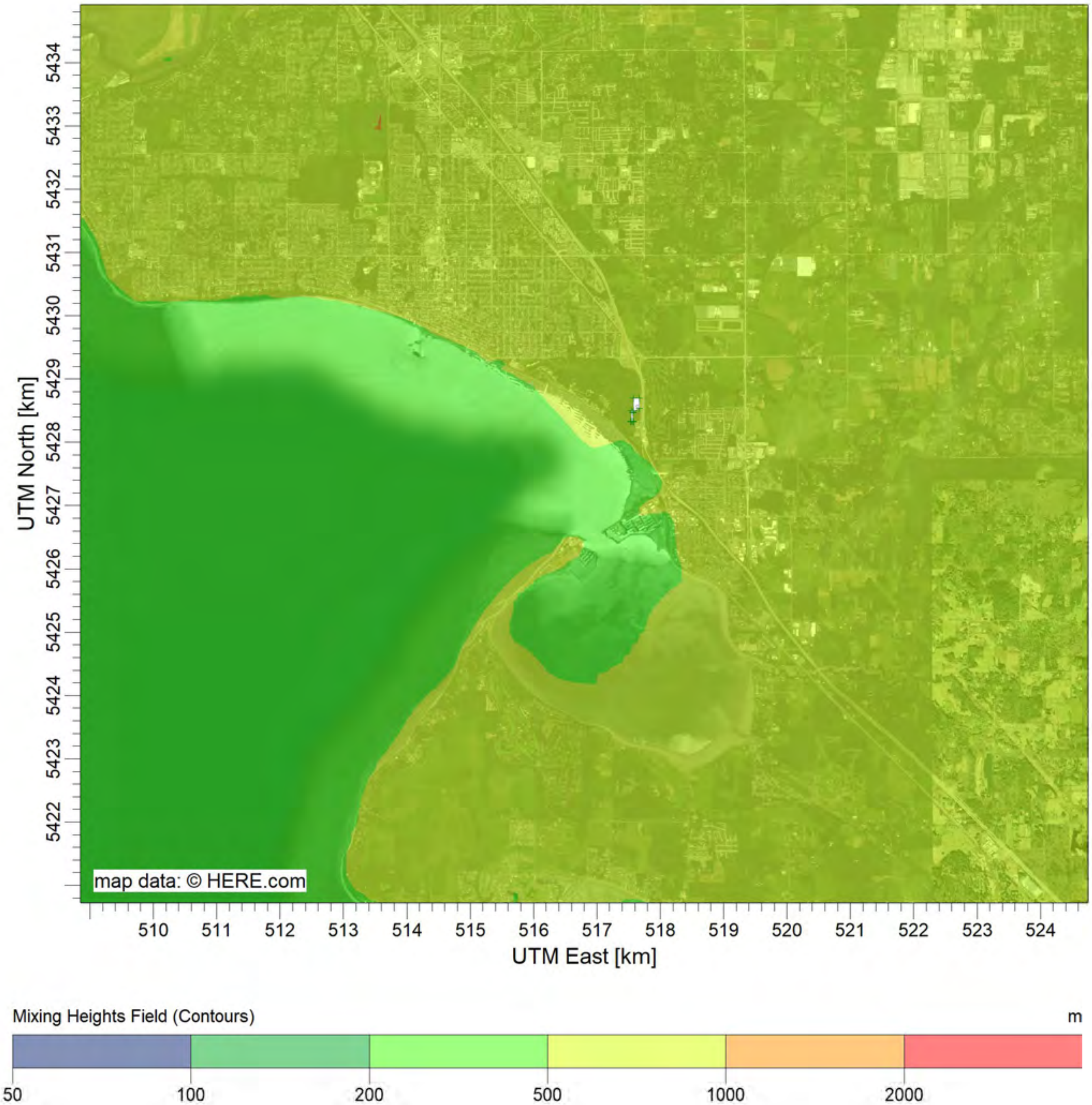
Diurnal Mixing Height Validation
CALMET Predicted Mixing Height - July 18, 2013 1300 PDT



COMMENTS:	COMPANY NAME: **Tetra Tech**
	MODELER: **T. Miguez**
	SCALE: 1:100,000 (0 – 3 km)
	DATE: **6/2/2023**
	Figure B.12.13

PROJECT TITLE:

Diurnal Mixing Height Validation
CALMET Predicted Mixing Height - July 18, 2013 1400 PDT



COMMENTS:

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:100,000

0 3 km

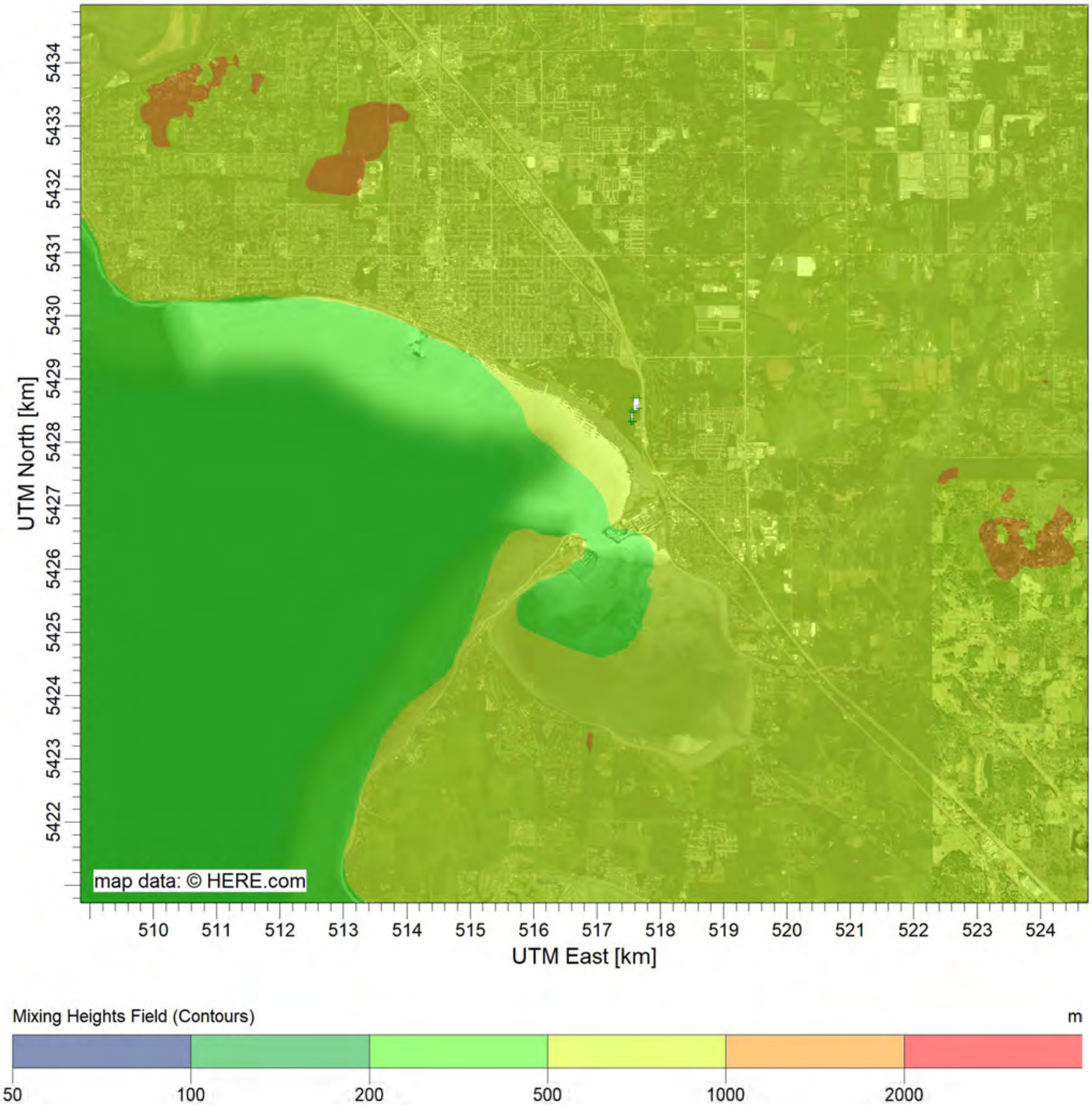
DATE:

6/2/2023

Figure B.12.14

PROJECT TITLE:

Diurnal Mixing Height Validation
CALMET Predicted Mixing Height - July 18, 2013 1500 PDT



COMMENTS:

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:100,000

0 3 km

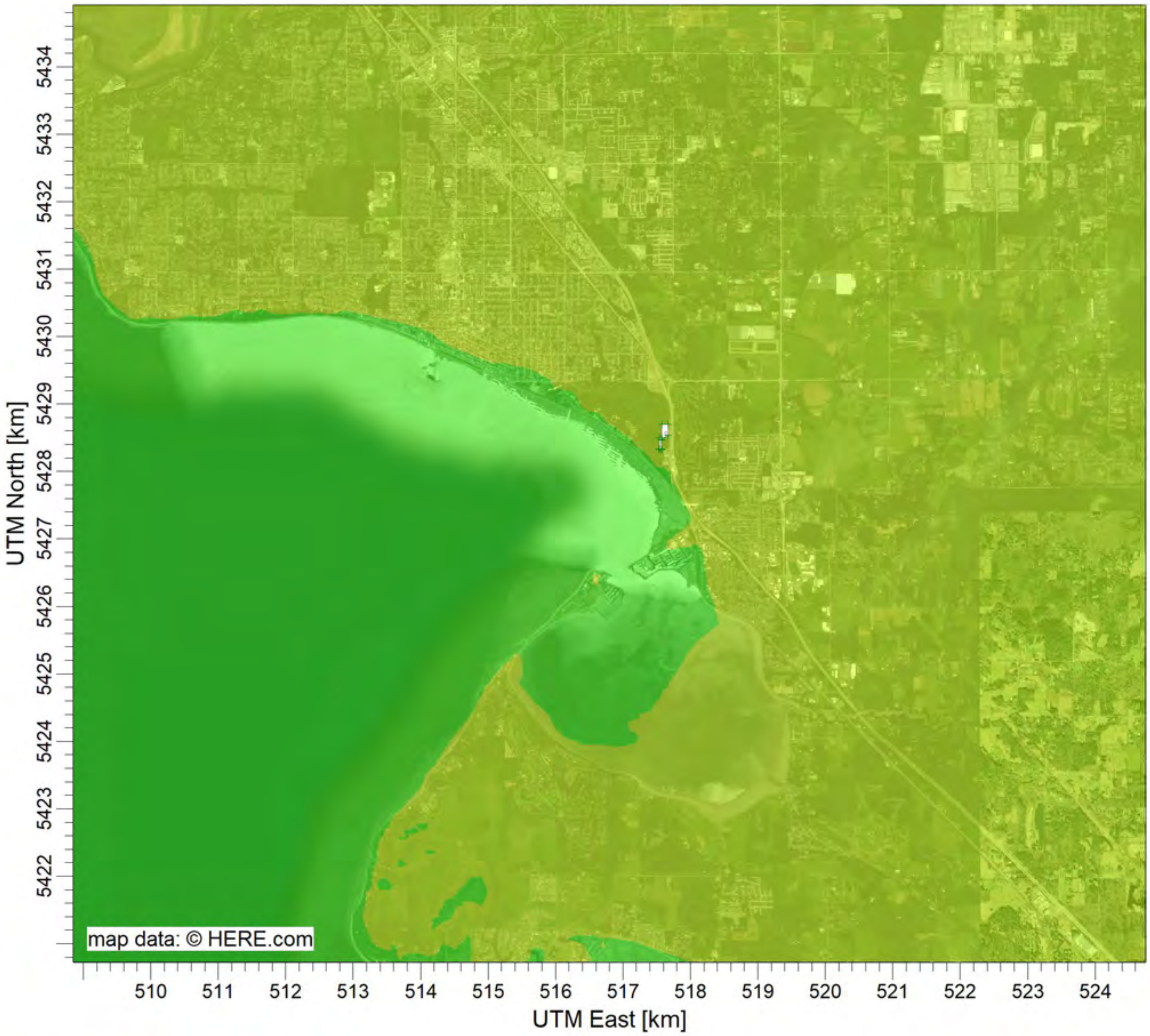
DATE:

6/2/2023

Figure B.12.15

PROJECT TITLE:

Diurnal Mixing Height Validation
CALMET Predicted Mixing Height - July 18, 2013 1600 PDT



COMMENTS:

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:100,000

0 3 km

andion

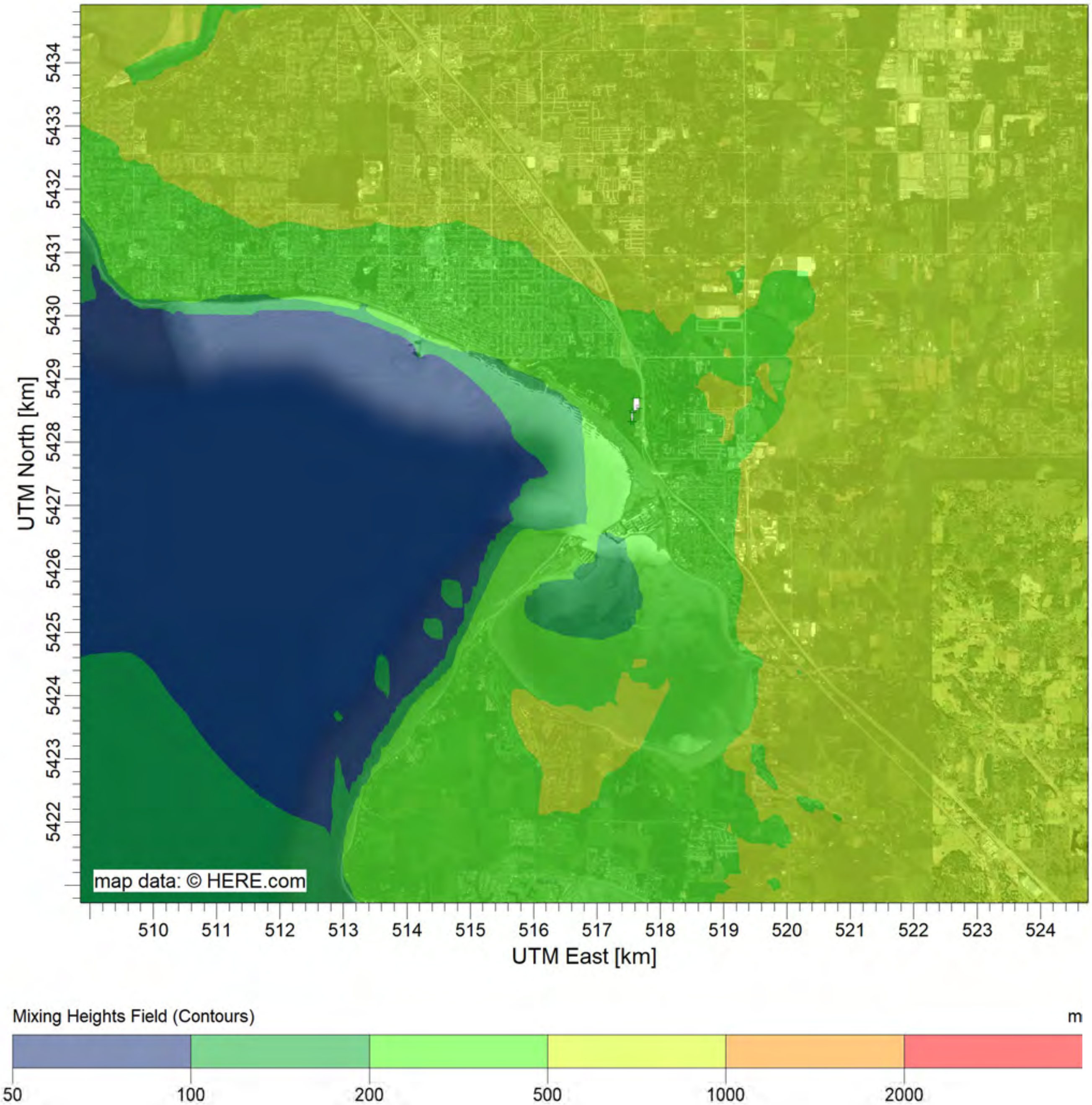
DATE:

6/2/2023

Figure B.12.16

PROJECT TITLE:

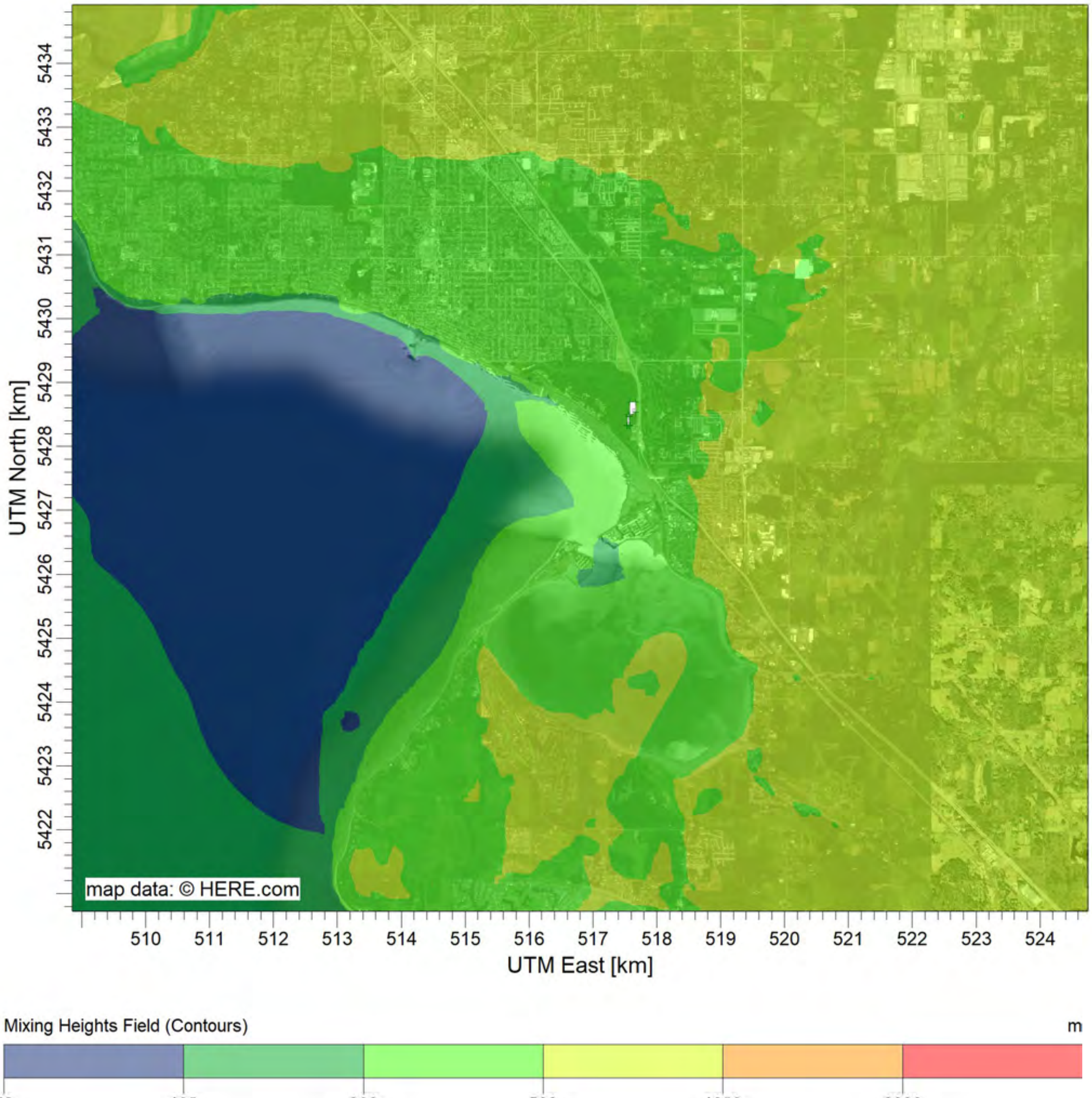
Diurnal Mixing Height Validation
CALMET Predicted Mixing Height - July 18, 2013 1700 PDT



COMMENTS:	COMPANY NAME: **Tetra Tech**
	MODELER: **T. Miguez**
	SCALE: 1:100,000 (0 — 3 km)
	DATE: **6/2/2023**
	Figure B.12.17

PROJECT TITLE:

Diurnal Mixing Height Validation
CALMET Predicted Mixing Height - July 18, 2013 1800 PDT



COMMENTS:

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:100,000

0 3 km

DATE:

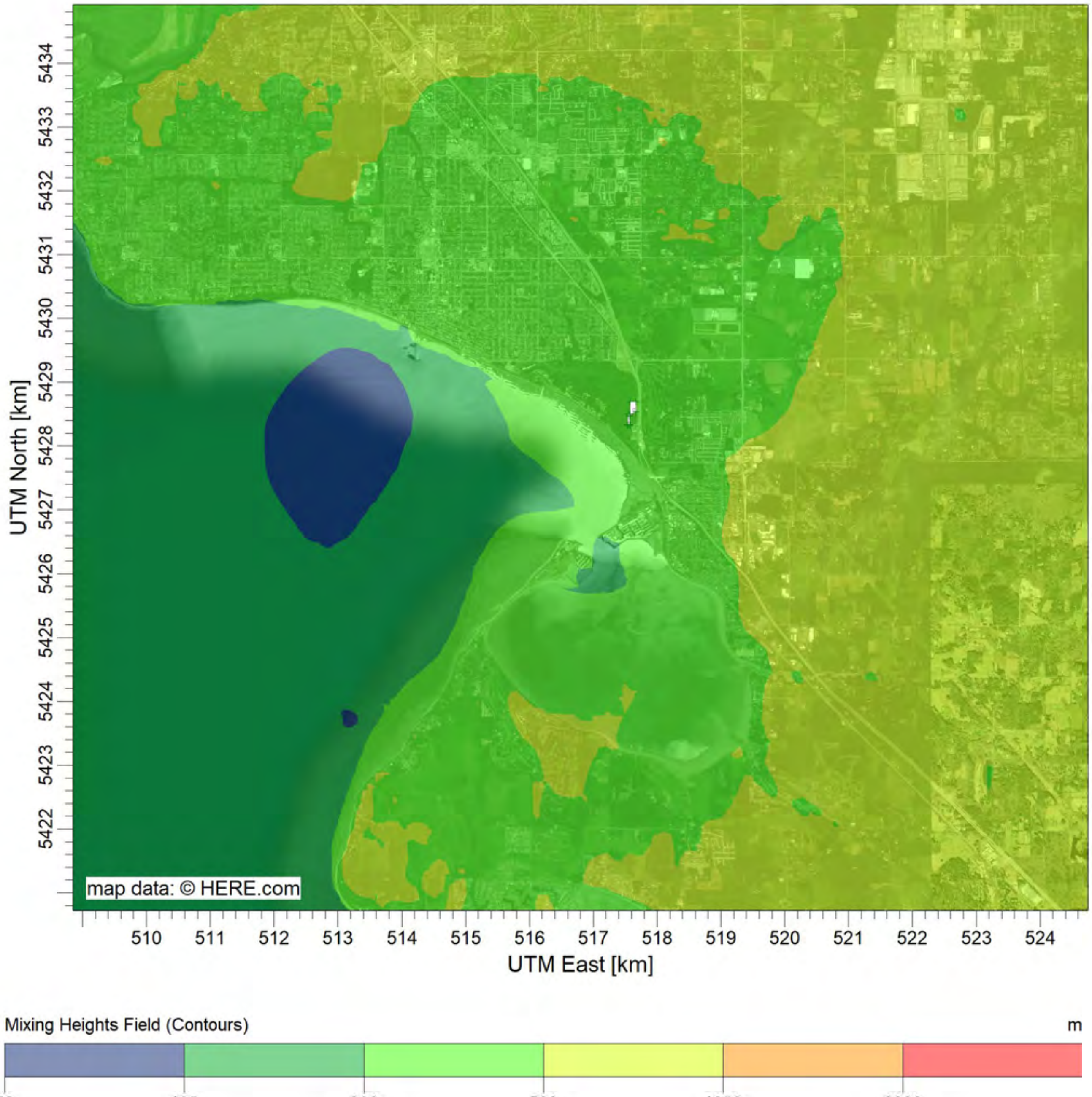
6/2/2023

Figure B.12.18

CALPUFF View - Lakes Environmental Software

PROJECT TITLE:

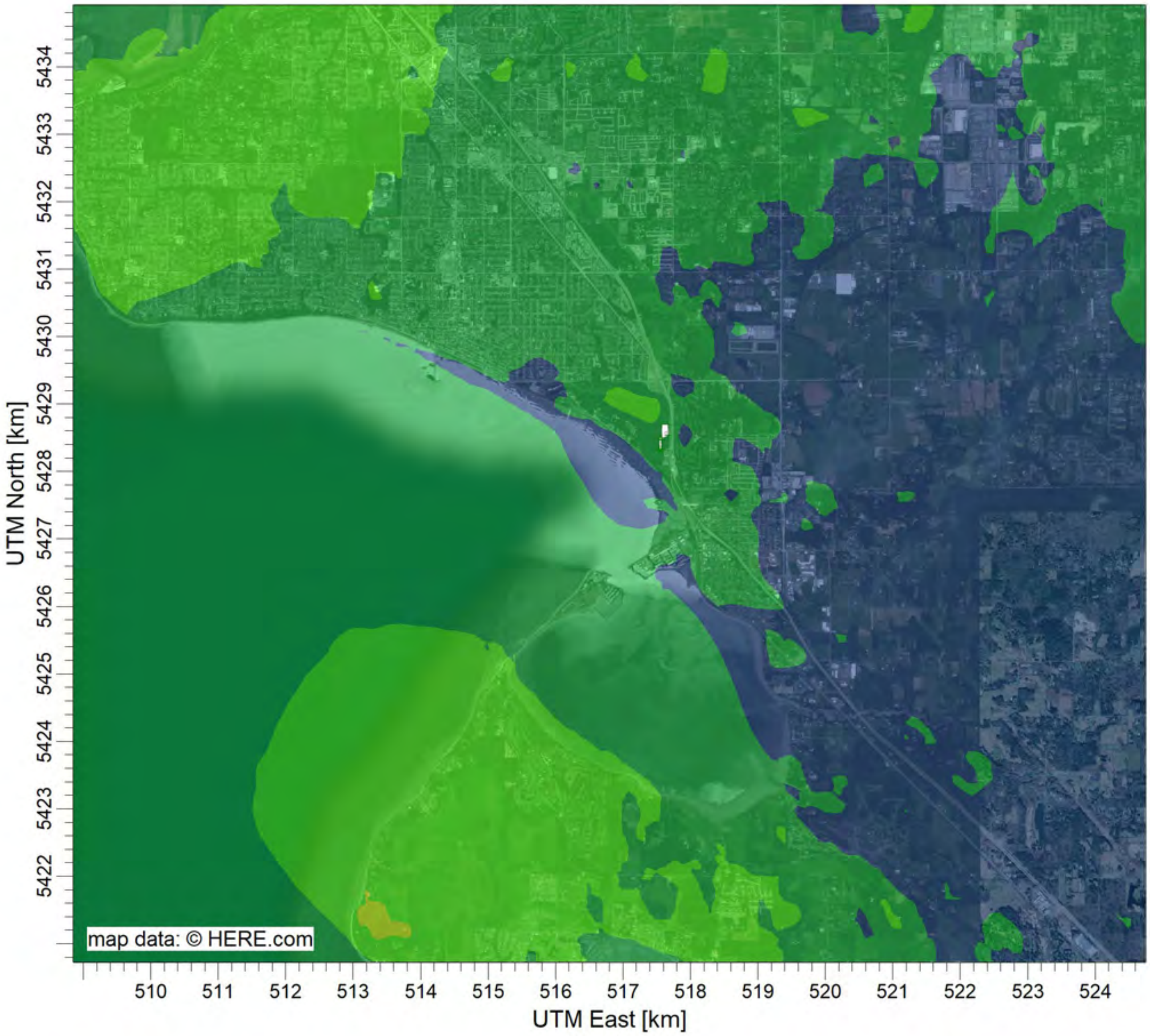
Diurnal Mixing Height Validation
CALMET Predicted Mixing Height - July 18, 2013 1900 PDT

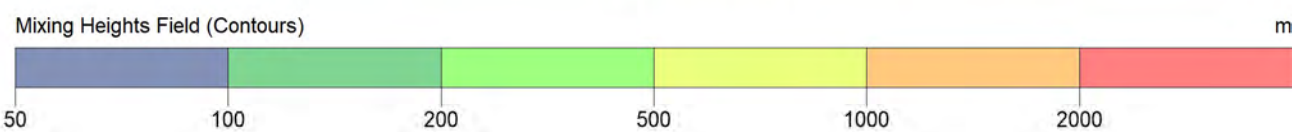


COMMENTS:	COMPANY NAME: **Tetra Tech**	
	MODELER: **T. Miguez**	
	SCALE: 1:100,000 (0 — 3 km)	
	DATE: **6/2/2023**	**Figure B.12.19**

PROJECT TITLE:

Diurnal Mixing Height Validation
CALMET Predicted Mixing Height - July 18, 2013 2000 PDT

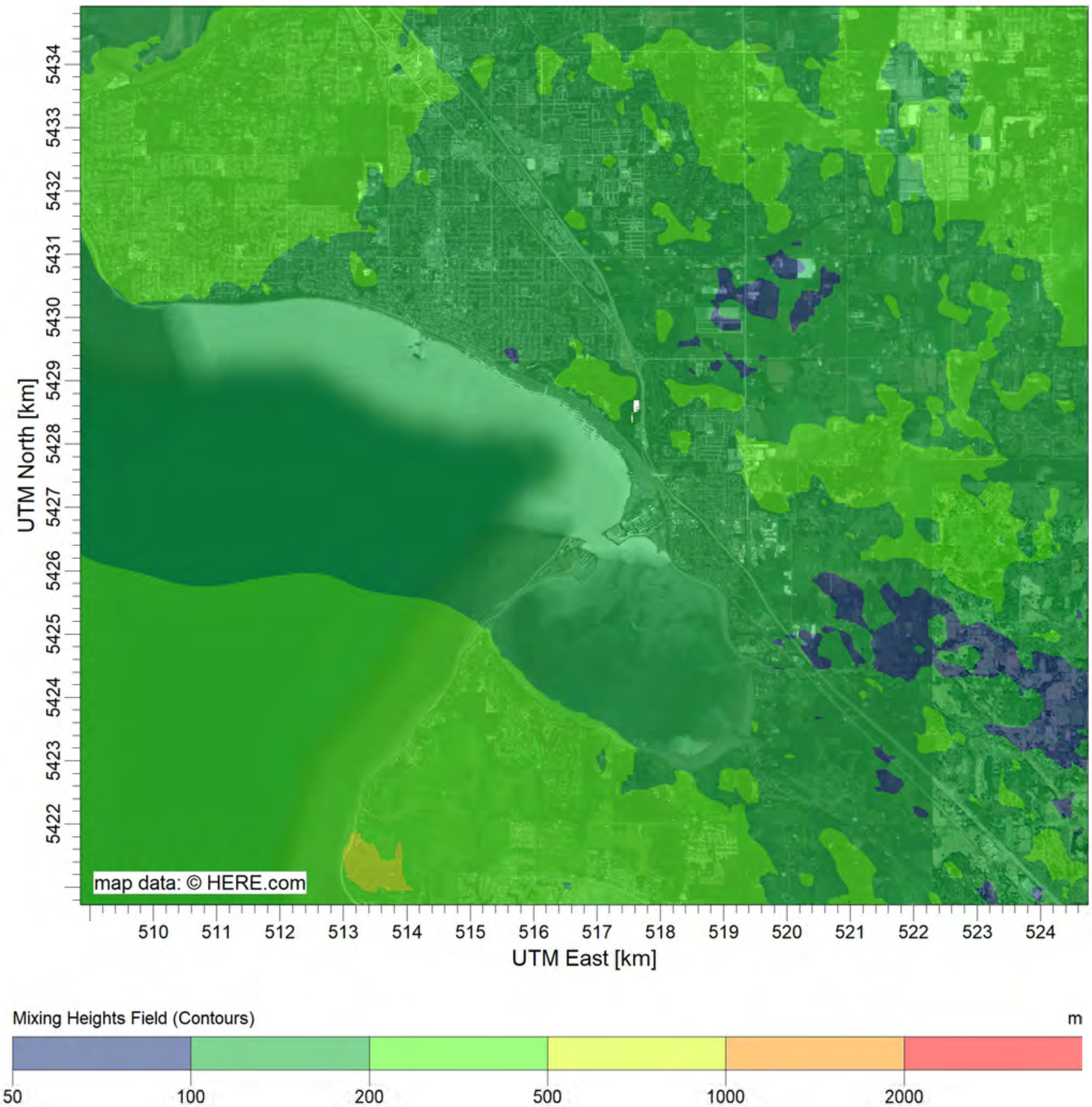




COMMENTS:	COMPANY NAME: **Tetra Tech**	
	MODELER: **T. Miguez**	andion
	SCALE: 1:100,000 0 — 3 km	
	DATE: **6/2/2023**	**Figure B.12.20**

PROJECT TITLE:

Diurnal Mixing Height Validation
CALMET Predicted Mixing Height - July 18, 2013 2100 PDT



COMMENTS:

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:100,000

0 — 3 km

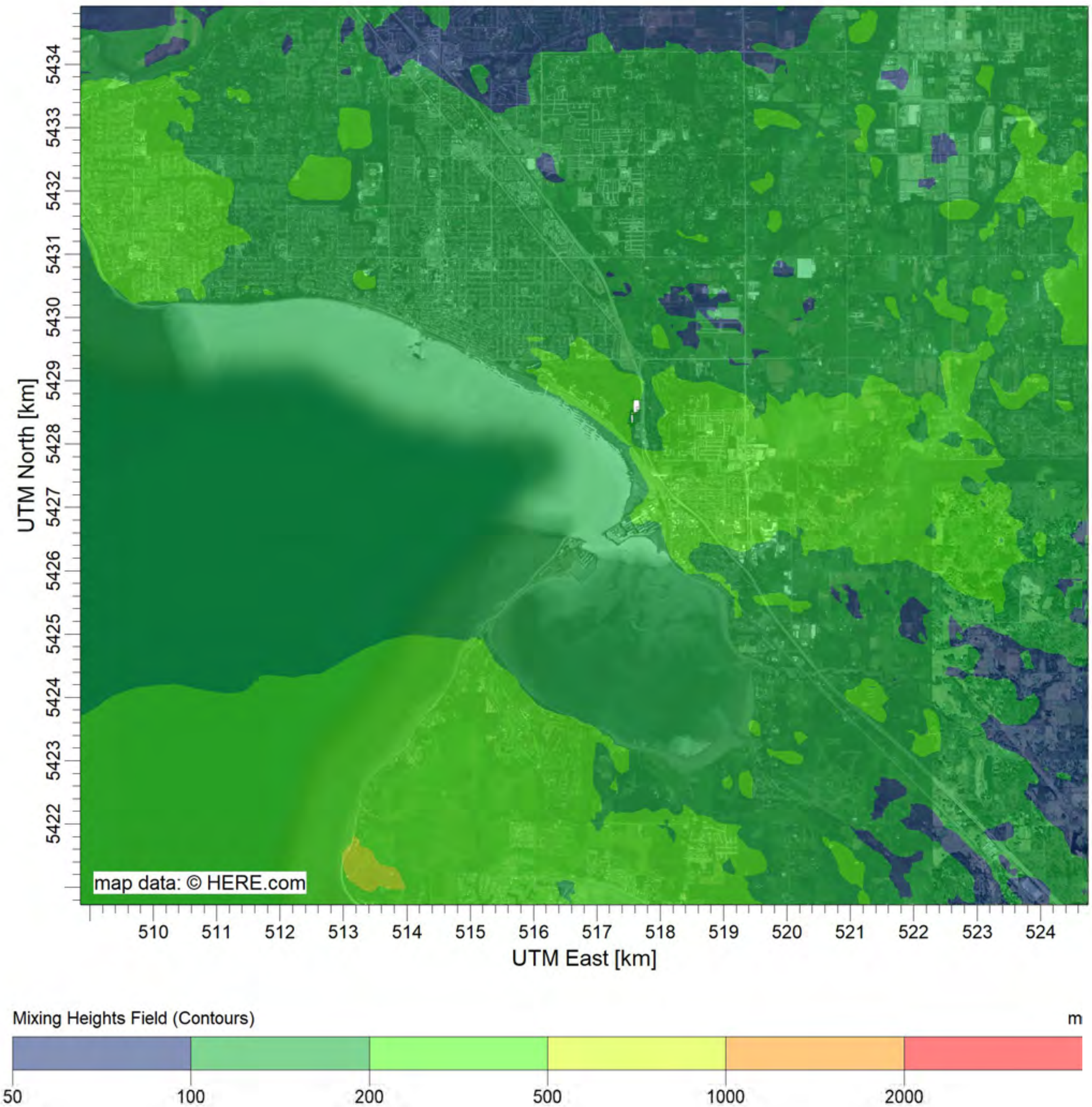
DATE:

6/2/2023

Figure B.12.21

PROJECT TITLE:

Diurnal Mixing Height Validation
CALMET Predicted Mixing Height - July 18, 2013 2200 PDT



COMMENTS:

COMPANY NAME:

Tetra Tech

MODELER:

T. Miguez

SCALE: 1:100,000

0 3 km

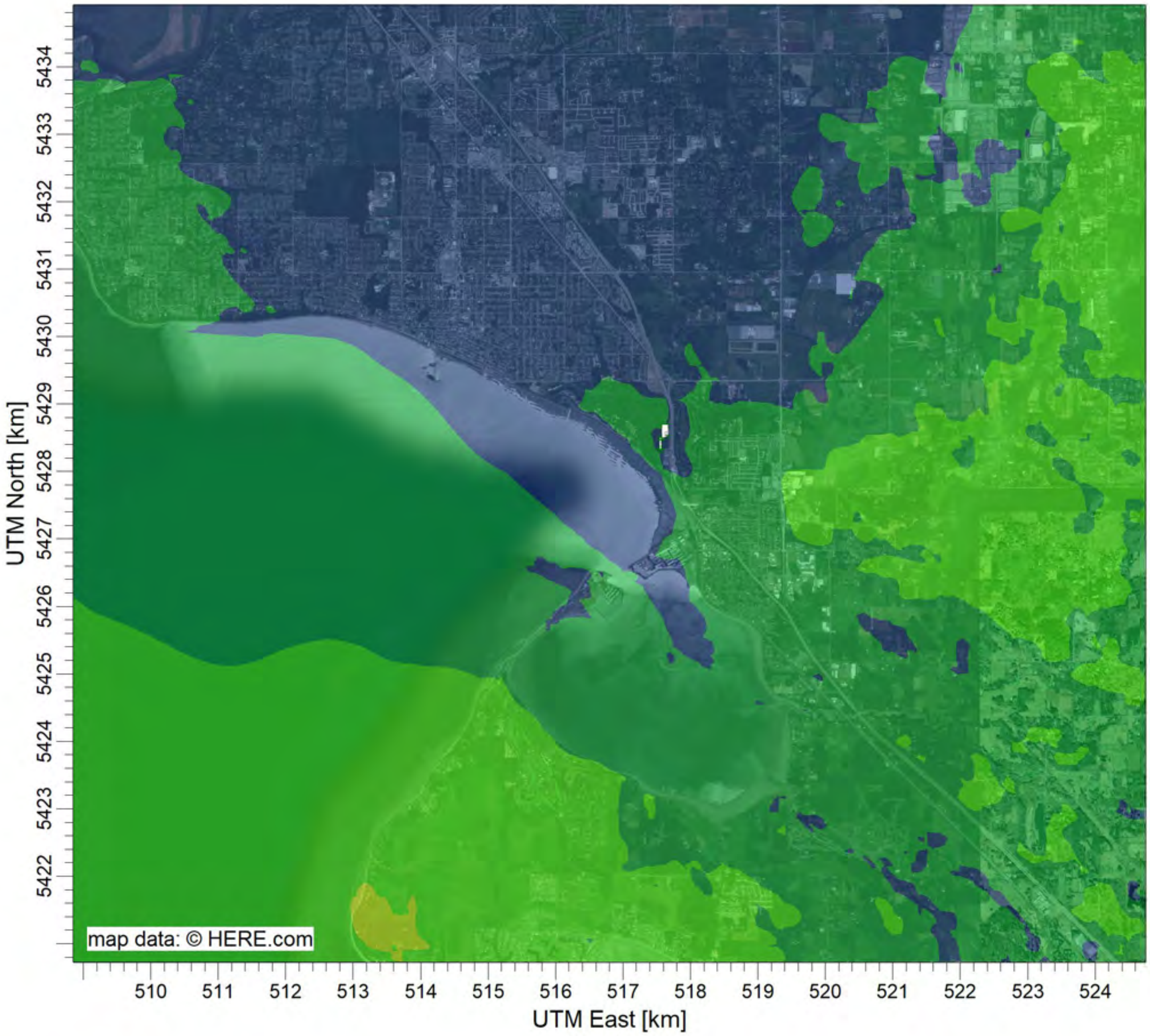
DATE:

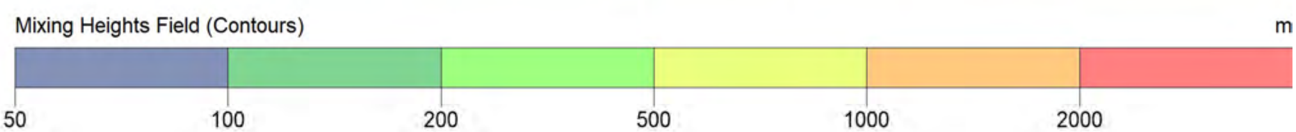
6/2/2023

Figure B.12.22

PROJECT TITLE:

Diurnal Mixing Height Validation
CALMET Predicted Mixing Height - July 18, 2013 2300 PDT

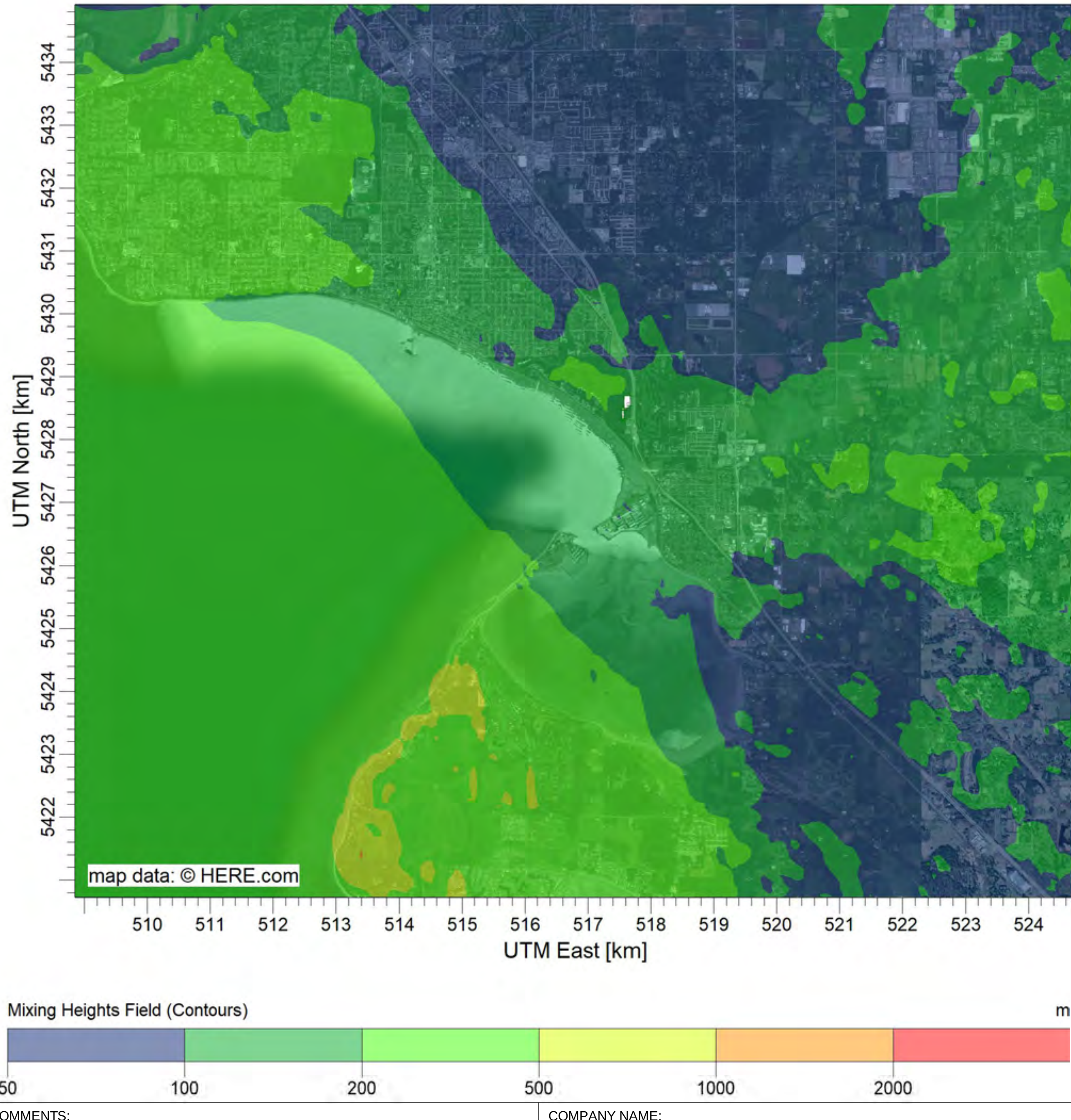




COMMENTS:	COMPANY NAME: **Tetra Tech**	
	MODELER: **T. Miguez**	andion
	SCALE: 1:100,000 0 — 3 km	
	DATE: **6/2/2023**	**Figure B.12.23**

PROJECT TITLE:

Diurnal Mixing Height Validation
CALMET Predicted Mixing Height - July 18, 2013 2400 PDT



COMMENTS:	COMPANY NAME: **Tetra Tech**
	MODELER: **T. Miguez**
	SCALE: 1:100,000 0 3 km
	DATE: **6/2/2023**
	Figure B.12.24