Preliminary Assessment of Potential Air Quality Health Impacts from Industrial VOC Emissions in South Portland, Maine

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Introduction

- HEM-3 (single facility) and multi-HEM-3 were developed by the USEPA for estimating ambient concentrations, human exposure, and health risks from air pollution emissions from industrial facilities.
- Designed for ease of use by EPA, states, local agencies, industry, and other stakeholders.
- HEM-3 model performs three main operations:
    - Dispersion modeling;
    - Estimation of population exposure;
    - Estimation of human health risks.
- Multi HEM-3 (Human Exposure Model, version 1.55, for multiple facilities) was used to assess potential human health impacts from air emissions of hazardous air pollutants (HAPs) and volatile organic compounds (VOCs).

Objective: assess potential health impacts from permitted HAP and VOC emissions in South Portland:

- Questions and issues:
  - What are the potential health impacts of petroleum HAP and VOC emissions?
  - Are permit limits protective of human health?
  - What are the combined effects of emissions on ambient air quality?
  - What areas are most impacted by these emissions?
  - Can a model be used to establish permit limits protective of human health?

National Air Toxics Assessment (NATA) 2014:

- USEPA compiled air emissions from multiple sources across the US to model the potential health effects.
- Used the Community Multiscale Air Quality Model (CMAQ), a large-scale air model; CMAQ model less granular than HEM-3.
- For the five census tracts in South Portland, the NATA 2014 CMAQ model estimated 22.4 increased potential cancer occurrences per one million population due to air quality impacts from:
    - Formaldehyde (~11);
    - Carbon tetrachloride (~3.4);
    - Benzene (~3.3);
    - Other (~4.7).
- NATA results for South Portland are similar to Portland and Cumberland County; CMAQ model too large-scale for local effects.

Multi-HEM-3 uses:

- AERMOD for dispersion modeling, version 18081 (2018 release).
- Chemical health effects library;
    - Additional chemicals and risk factors can be added.
- Census data from 2010;
    - includes elevations to assess topography effects.
- Meteorological effects library data;
    - processed by AERMET for use in AERMOD.

Multi-HEM-3 assesses health risk:

- Uses emissions from multiple emissions sources to estimate total impacts.
- Assesses risk for each census block in model domain.
- Determines location of maximum individual risk.
- Estimates increased cancer risk and non-cancer health effects based on continuous, averaged, exposure over 70 years (lifetime).
- Uses health impact contributions from all compounds to be both cumulative and additive.

HEM-3 evaluates total combined risk from modeled air emissions:

For cancer risk:

$$CR_T = \sum_{i,j} CR_{i,j}$$

$$CR_{i,j} = DF_{i,j} \times CF \times \sum_k [E_{i,k} \times URE_k]$$

For noncancer hazard indices:

$$HI_T = \sum_{i,j} HI_{i,j}$$

$$HI_{i,j} = DF_{i,j} \times CF \times \sum_k [E_{i,k} / (RfC_k \times 1000\ \mu g/mg)]$$

where:

CR_T =	total cancer risk at a given receptor (probability for one person)
$\sum_{i,j}$ =	the sum over all sources i and pollutant types j (particulate or gas)
$CR_{i,j}$ =	cancer risk at the given receptor for source i and pollutant type j
$DF_{i,j}$ =	dilution factor [($\mu g/m^3$) / (g/sec)] at the given receptor for source i and pollutant type j
CF =	conversion factor, 0.02877 [(g/sec) / (tons/year)]
$\sum_k$ =	sum over all pollutants k within pollutant group j (particulate or gas)
$E_{i,k}$ =	emissions (tons/year) of pollutant k from source I
URE_k =	cancer unit risk estimate [1/($\mu g/m^3$)] for pollutant k (cancer risk for an individual exposed to 1 $\mu g/m^3$ over a lifetime)
HI_T =	TOSHI at a given receptor and for a given organ
$HI_{i,j}$ =	organ-specific hazard index at the given receptor for source i and pollutant type j
RfC_k =	noncancer health effect reference concentration (mg/m^3) for pollutant k (concentration at and below which no adverse health effect is expected)

Multi-HEM-3 air emissions model for South Portland:

- Model used total HAP and VOC permitted limits for industrial facilities in South Portland as the maximum potential discharges.
    - Model used facility-specific HAPs listed in the NATA database for listed facilities when available, and estimated HAP discharges based on facility-specific storage when appropriate.
- Model included emissions from bulk petroleum storage facilities and semiconductor manufacturers.
    - Completed model runs ***with and without*** emissions from Portland Pipe Line because of current limited operations there.
- Emissions modeled were mapped as discharged over the area of facility.
- Used standard/typical air model default parameter values when appropriate.

South Portland HEM-3 model HAP and VOC inputs:

Facility	Location	Total HAP (tons/year)	Total VOC (tons/year)	Total VOC (lbs/year)	HAP % of VOCs:
Global Companies, LLC	1 Clark Road	9.9	21.9	43,800	45%
Portland Pipe Line Corp.	30 Hill Street	24.9	220	440,000	11%
CITGO Petroleum Corp.	102 Mechanic St.	5	117.3	234,600	4%
South Portland Terminal LLC	170 Lincoln St.	14.1	135.4	270,800	10%
Gulf Oil	175 Front Street	24.9	49.9	99,800	50%
Sprague Operating Resources	59 Main Street	24.9	49.9	99,800	50%
	Petrol Terminal Totals:	104	594	1,188,800	17%
ON/Fairchild Semiconductor		24.9	40	80,000	62%
Texas Instruments		24.9	37	74,000	67%
	Other Industry Totals:	50	77	154,000	65%
	Combined Totals:	**154**	**671**	**1,342,800**	**23%**

Petroleum VOCs emission contain complex mixtures of hydrocarbons:

- Example results below using MADEP method for air phase hydrocarbons (APH) quantifies more VOC mass than TO-15 method used by MEDEP:

Parameter	Result	Qualifier	Units	RL
Petroleum Hydrocarbons in Air - Mansfield Lab				
1,3-Butadiene	ND		ug/m3	4.2
Methyl tert butyl ether	ND		ug/m3	5.8
Benzene	140		ug/m3	5.0
C5-C8 Aliphatics, Adjusted	31000		ug/m3	83
Toluene	1200		ug/m3	7.5
Ethylbenzene	1200		ug/m3	7.5
p/m-Xylene	2600		ug/m3	7.5
o-Xylene	1400		ug/m3	7.5
Naphthalene	600		ug/m3	9.1
C9-C12 Aliphatics, Adjusted	22000		ug/m3	83
C9-C10 Aromatics Total	9200		ug/m3	83

Multi-HEM-3 dose response values in model:

- Assigned inhalation cancer unit risk estimate (URE) and risk factor concentrations (RfC) values to total HAPs and total VOCs for permitted emissions in South Portland.
- UREs and RfCs for HAPs and VOCs were selected based on a surrogate approach to represent groups of compounds since UREs and RfCs are not available for these groups.
- Benzene and ethylbenzene UREs and RfCs were used as surrogates and averaged to represent unspecified HAPs potentially emitted in South Portland.
- Surrogates were used to develop UREs and RfCs for groups of aliphatic and aromatic hydrocarbons which were then averaged to obtain URE and RfC for unspecified VOCs potentially emitted in South Portland.

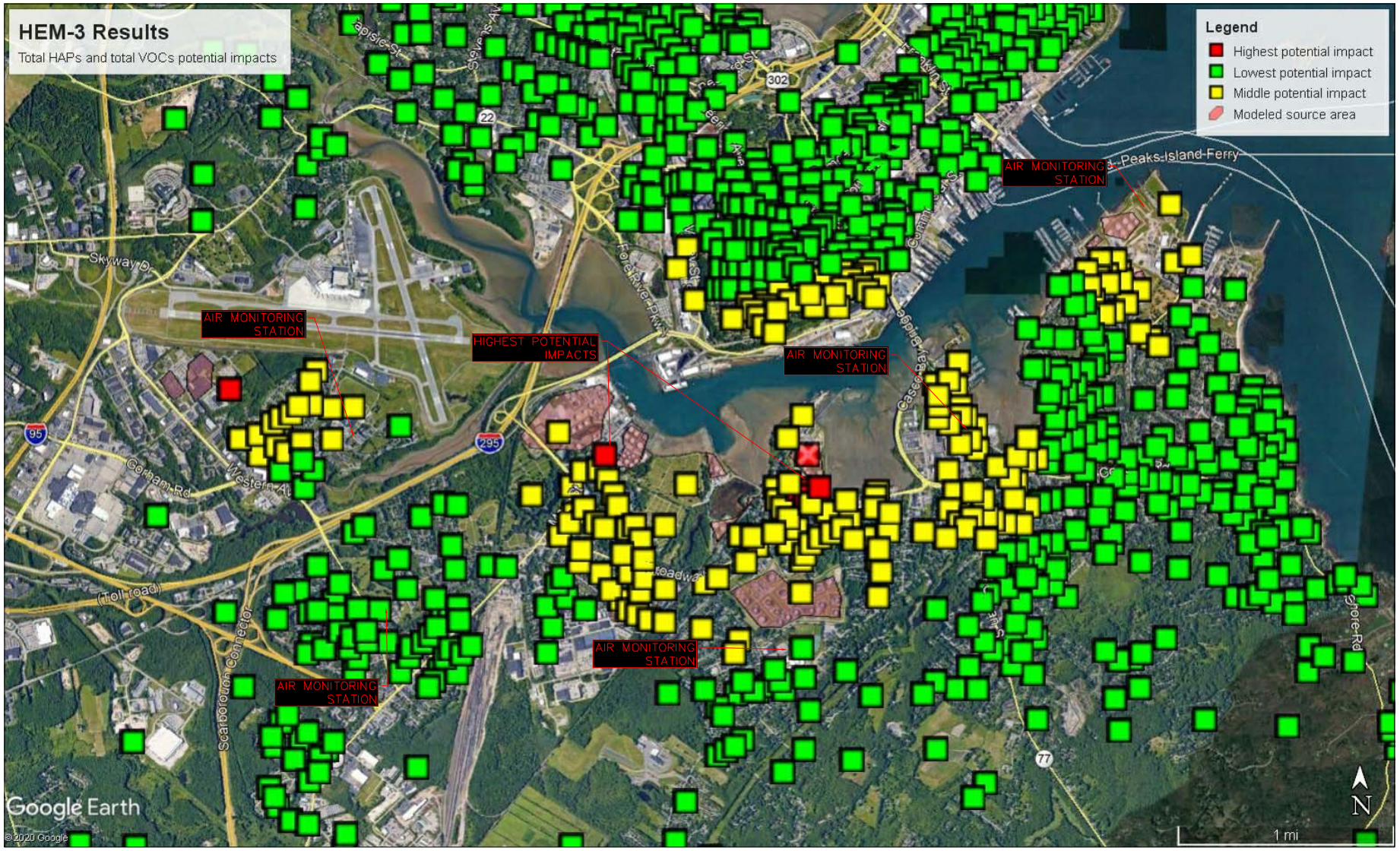
Summary of Inhalation Unit Risk Estimates (URE) and Hazard Risk Factor Concentrations (RfC):

Pollutant	URE 1/(ug/m3)	RFC (mg/m3)	Basis/Comments
Formaldehyde	0.000013	0.0098	HEM-3 Dose response library, USEPA 2018(1)
Benzene	7.80E-06	0.03	HEM-3 Dose response library, USEPA 2018(1)
Ethyl benzene	2.50E-06	1	HEM-3 Dose response library, USEPA 2018(1)
Naphthalene	3.40E-05	0.003	HEM-3 Dose response library, USEPA 2018(1)
Total HAPs	5.15E-06	5.15E-01	Average of benzene and ethylbenzene as surrogates to represent volatile HAPs for URE, RfC, values, based on guidance from PPRTVCMAAH(2)
Total VOCs	2.42E-06	7.78E-01	Average of C5 to C18 aliphatics and C6 to C8 aromatics as surrogates to represent VOCs for URE, RfC, values, based on guidance from PPRTVCMAAH(2)

1) "***Dose response library"*** associated with the HEM-3 air model contain the chemical health effects library adapted from the USEPA's Air Toxics Risk Assessment Library, Air Toxics Assessment Group, Health and Environmental Impacts Division, Office of Air Quality Planning and Standards, USEPA, Rsearch Triangle Park, NC 27711

2) ***Provisional Peer-Reviewed Toxicity Values for Complex Mixtures of Aliphatic and Aromatic Hydrocarbons***, 2009, Tables 8 and 9, Superfund Health Risk Technical Support Center, National Center for Environmental Assessment, Office of Research and Development, USEPA, Cincinnati, Ohio 045268

Preliminary Multi-HEM-3 output indicating relative potential impacts of total HAP and VOC emissions from modeled industrial sources in South Portland, *excludes PPL* :



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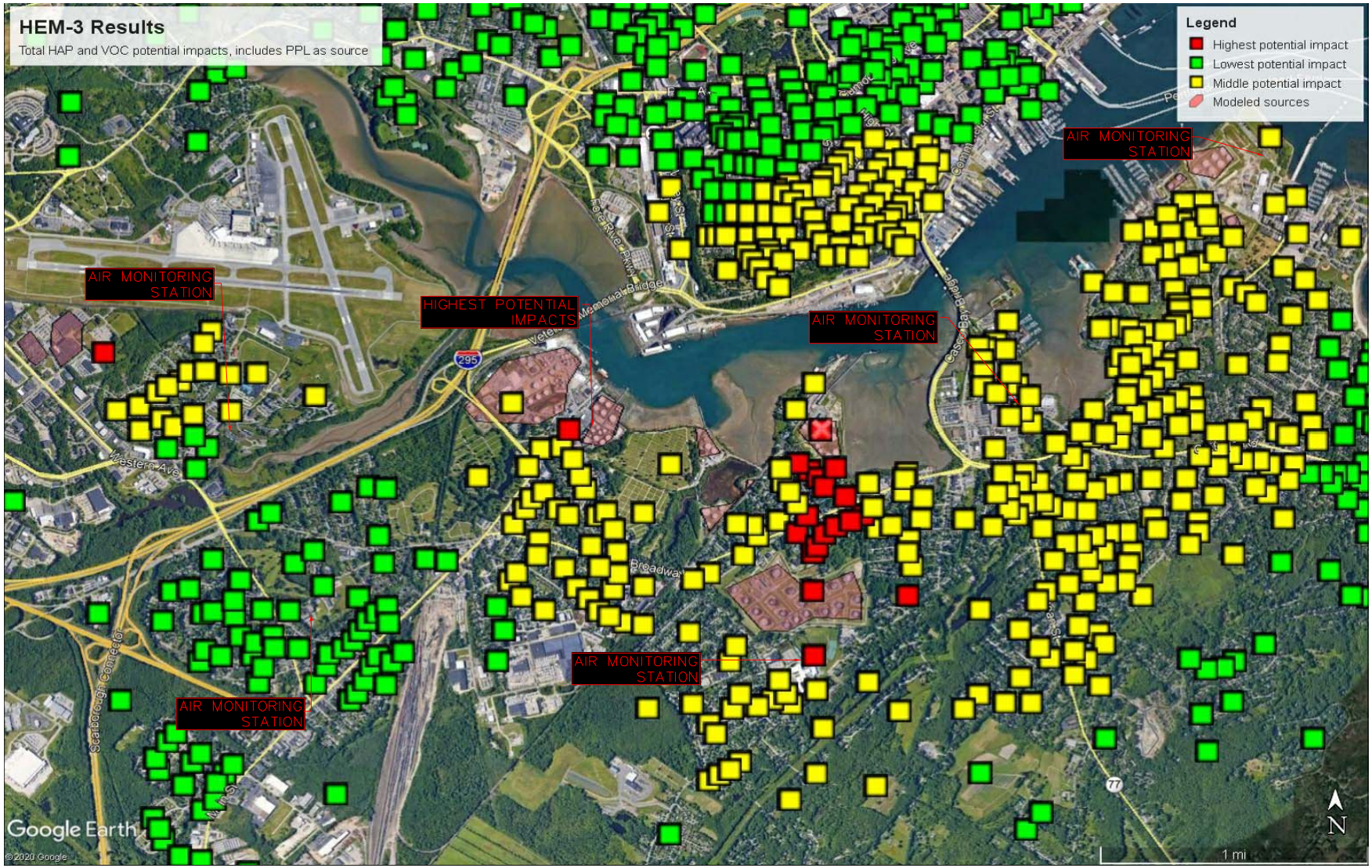
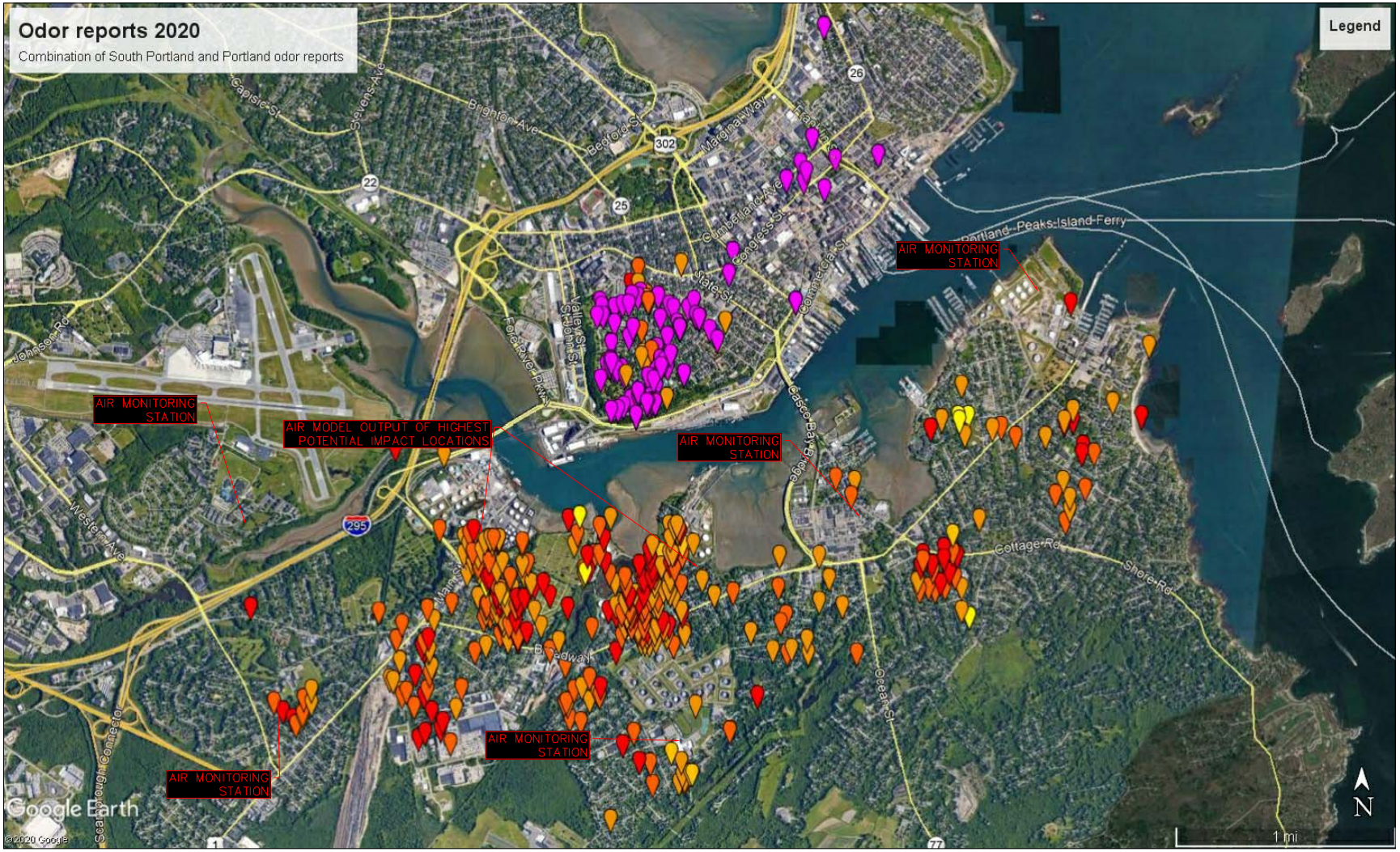


Preliminary Multi-HEM-3 South Portland model indicates:

- Potential highest human health impacts occur adjacent to largest emission sources.
- Location of highest impacts appears to be determined primarily by location of sources, receptors, and weather effects.
- Current air monitoring stations are located almost 1 mile away from potential highest human health impacts.

Odor complaints by location for South Portland and Portland, year to date 2020:



Odor complaint data for Portland and South Portland indicate:

- Complaint locations correlate with potential highest impact locations indicated by the Multi-HEM-3 model.
- Majority of complaint locations are clustered around the largest potential emission sources.
- Few complaints adjacent to monitoring stations; data from monitoring stations may not reveal severity of emissions in South Portland.

Conclusions

- Multi-HEM-3 model shows highest potential human health impacts for residents adjacent to the largest potential emitters.
- Odor complaints underscore the preliminary findings of the model.
- Both odor complaints and the model indicate emissions and potential impacts to those residents who live near, adjacent to, or downwind of the largest potential emitters.
- Full-scale operations at Portland Pipe Line could increase potential impacts across a larger area.
- Model could be used to determine appropriate industrial permit limits protective of human health for facilities adjacent to residential areas