Impacts of a Cascadia Subduction Zone Earthquake Event on the CEI Hub

August 4, 2021

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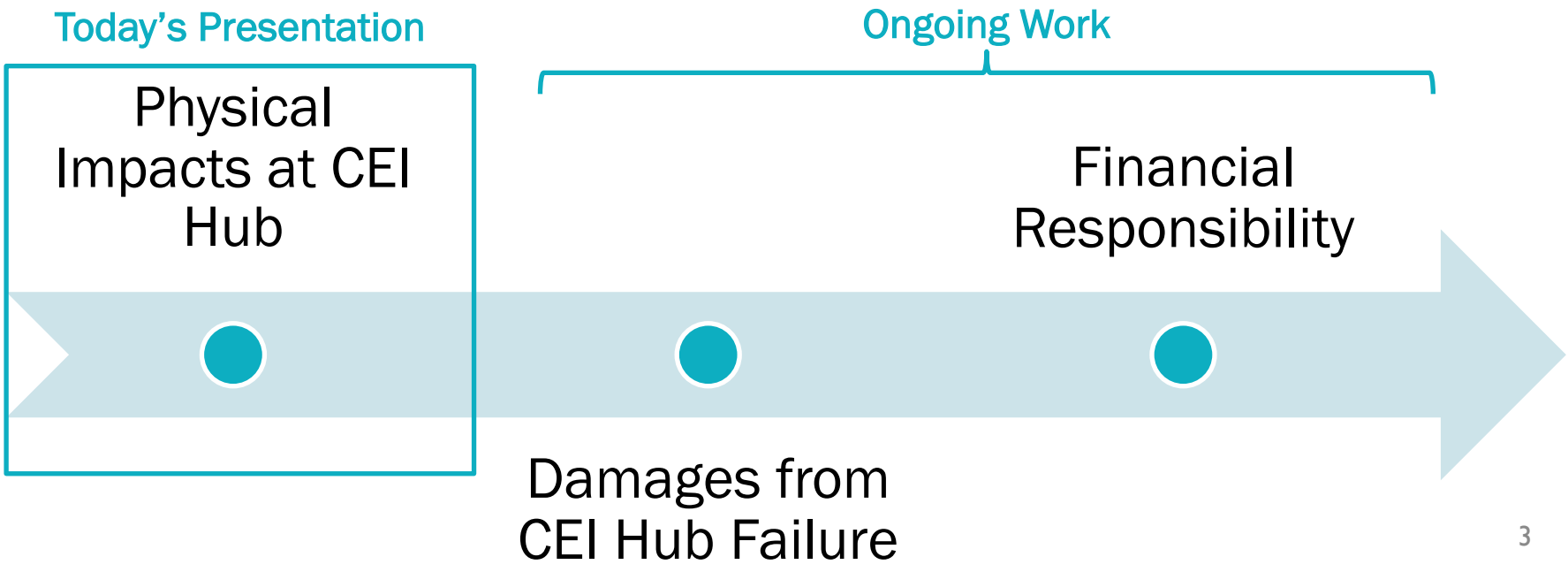
HARTCROWSER
A division of Haley & Aldrich

The Critical Energy Infrastructure (CEI) Hub

- A group of fuel storage and transfer facilities along the Willamette River in Portland.
- Over 90 percent of Oregon's liquid fuel supply is transported through CEI Hub facilities.
- A magnitude 8 or 9 Cascadia Subduction Zone (CSZ) earthquake could result in releases of the materials stored at the CEI Hub into land, water, and air.

Study Purpose

- Estimate the magnitude and extent of physical impacts of potential releases,
- Evaluate the resulting damages, and
- Identify financial responsibility.



Project Team

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Research Questions and Scenario

- What are the expected failures at the CEI Hub following a CSZ earthquake?
  - How much and what type of material will be released?
  - Where will the materials go?
- What are the expected impacts of the releases?

- Scenario: 9.0M Cascadia earthquake

Scenario Variables

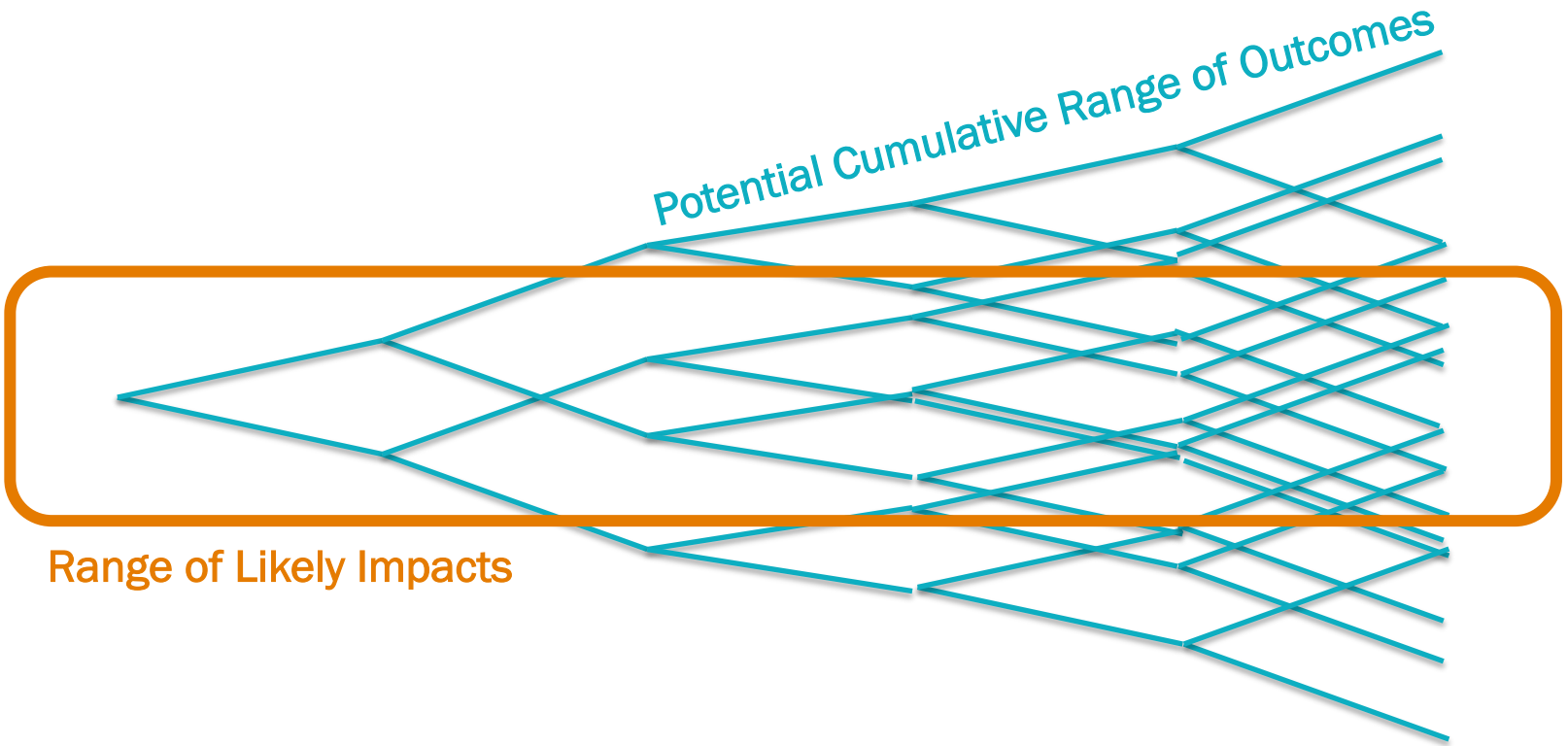
Inherent Uncertainty In Analysis …

- Physical damage to tanks and containment structures
- Volume of fuels in tanks at time of incident
- Fate and transport of fuels (ignition source?)
- Seasonal variation in winds and river current
- Seasonal population of migratory and anadromous species downstream
- Cumulative impacts of a 9.0M earthquake

Scenario Variables

Inherent Uncertainty In Analysis …

… Can Produce A Wide Range of Outcomes



Study Goal: Identify Range of Likely Impacts

Expected Failures at the CEI Hub

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CEI Hub Tank Failure Variables

Geologic Risk

- Land characteristics that impact tank failure

Tank Location

- Where materials will go if they are released

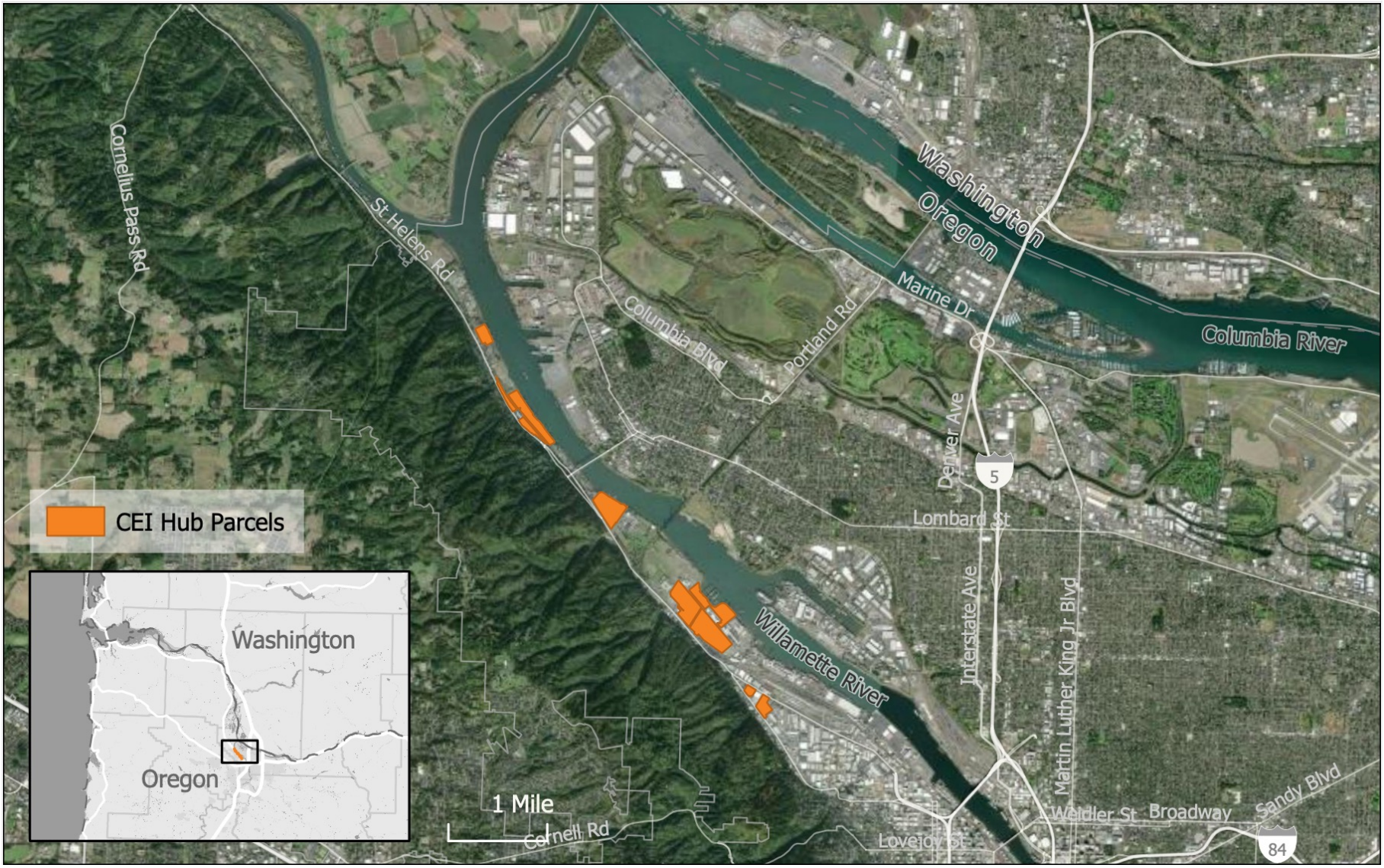
Tank Integrity

- Extent of tank failure based on age of tank

Tank Contents

- Amount of hazardous, flammable, or volatile material

Location of CEI Hub



Pipelines

- Olympic pipeline from northern WA
- Kinder Morgan PDX Pipeline
- Others

Rupture could occur anywhere, contents and magnitude vary.

Tank Data

- **630 total tanks**
  - 558 tanks have available location data from either Oregon State Fire Marshal data, City of Portland data and permitting information
    - 143 out of service
    - 415 active tanks
  - 72 tanks identified via aerial photos alone, all smaller tanks at Zenith Energy

Tank Capacities

- 67% Average Tank Fill (PSU Data)

Material Type	Maximum Tank Capacity (gallons)	Expected Fill (gallons)
Light Oil	215,337,397	144,738,841
Medium Oil	43,829,634	39,585,777
Heavy Oil	34,928,796	23,402,293
Other	24,587,064	16,473,333
Natural Gas	7,100,000	4,757,000
Biodiesel	4,082,877	2,808,788
Slop Oil	1,826,017	1,223,431
Additive	702,924	470,959
Empty	344,469	0
Unknown	? (treated as 0)	? (treated as 0)
Total	**332,739,178**	**233,460,422**

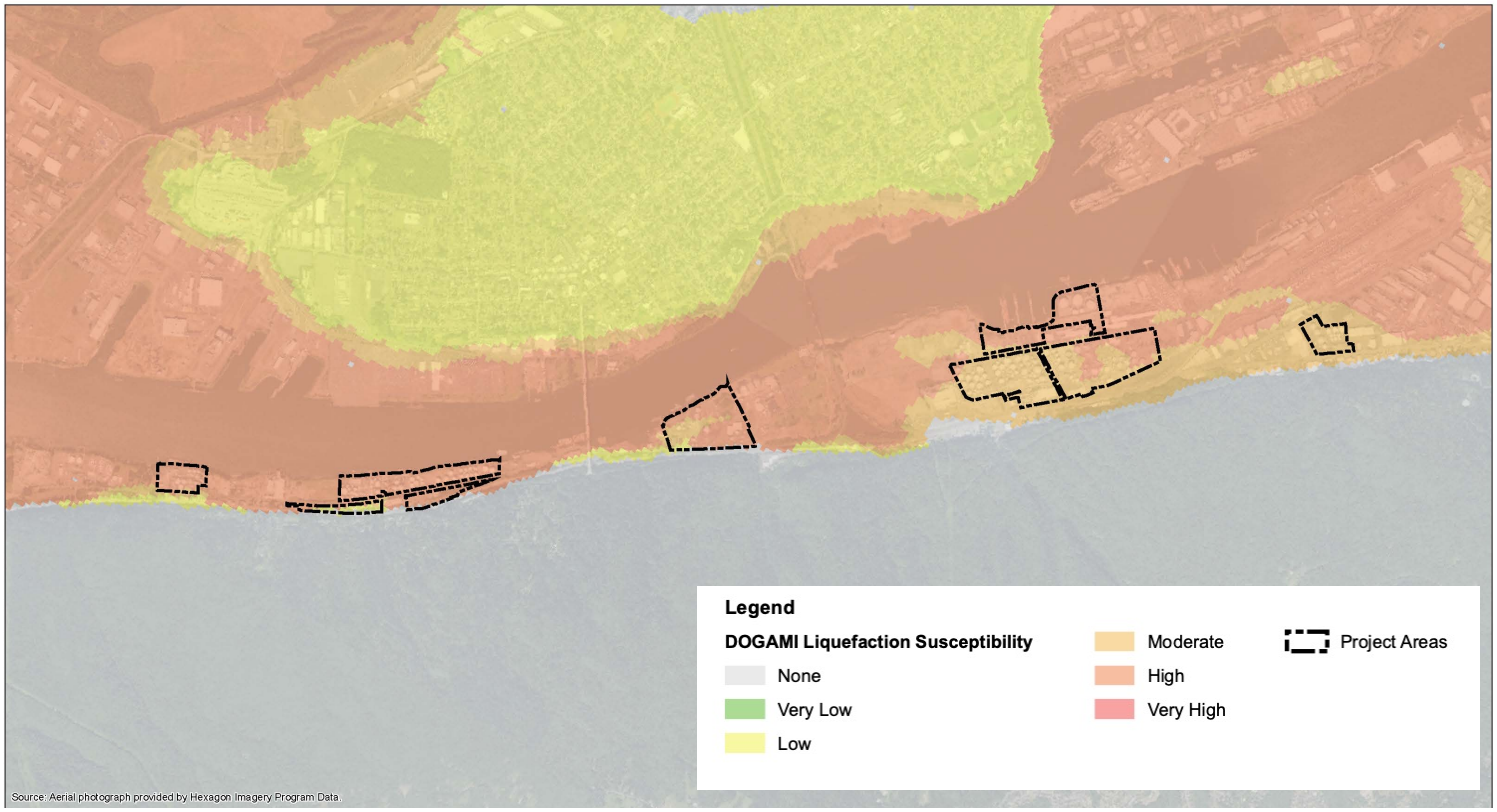
- 106 out of 630 tanks with unknown capacity

Geologic Risk

- Geologic Risk Evaluation – CSZ 9.0
  1. Developed soil conditions cross section from PortlandMaps geotechnical reports
  2. Evaluated shaking at site based on scenario earthquake and soil conditions
  3. Evaluated liquefaction/seismic strength loss potential at each cross-section
  4. Developed settlement and strength loss estimates at each location

Geologic Risk

- Evaluated each section for settlement and lateral movement based on soil conditions, seismic soil effects, and topography.



Damage Zones

Damage Zones

	Damage Zone (distance from water in feet)		
Property Location	Contents In Water	Contents Potentially in Water	Contents On Land
Area 1 - Kinder Morgan N	0-500	500-750	750+
Area 2 - Linnton N	0-500	500-750	750+
Area 2 - Linnton S	0-500	500-750	750+
Area 3 - NW Natural	0-250	250-500	500+
Area 4 - Willbridge	0-250	250-500	500+
Area 5 - Equilon	N/A	N/A	All

Tank Age Failure Assumptions

- **<1993: Fail, 50% to 100% released**
  - Tanks with no tank age data that are assumed to have been constructed prior to 1993 (266 tanks).
- **1993-2004: Could fail, up to 10% released**
  - Tanks are designed for shaking but not liquefaction settlement and lateral spread.
- **>2004: Unlikely to fail, up to 10% released**
  - Releases due to connection failures and other incidental damage may result in up to 10% release.

Tank Age

Material Type or Status	Built before 1993 or Unknown	Built between 1993-2004	Built after 2004	Total
Medium Oil	142	2		**144**
Light Oil	110	14	6	**130**
Other	47		3	**50**
Heavy Oil	25	4		**29**
Empty	16	2		**18**
Slop Oil	15	1		**16**
Additive	11		2	**13**
Biodiesel	10			**10**
Unknown	4			**4**
Natural Gas			1	**1**
Total	**380**	**23**	**12**	**415**

- Does not include 143 out of service tanks and 74 tanks at Zenith Energy identified from aerial photos alone - 106 tanks with unknown year built, assumed to be before 1993.

Tank Releases

- Expected Release: Total of 94 to 194 million gallons
  - *Deepwater Horizon was 134 to 206 million gallons*
- 93% of released substances are flammable (Category 1-3)
- 81% of released substances are light or medium oils
- 12% of released substances are heavy oils

Spill Location	Tanks with 50–100 percent failure	Tanks with up to 10 percent failure	Volume Released Min (gal)	Volume Released Max (gal)
Ground	269	21	53,882,252	111,183,900
Water	96	11	40,751,753	82,503,352
Total	**365**	**32**	**94,634,005**	**193,687,251**

Potential Physical Impacts

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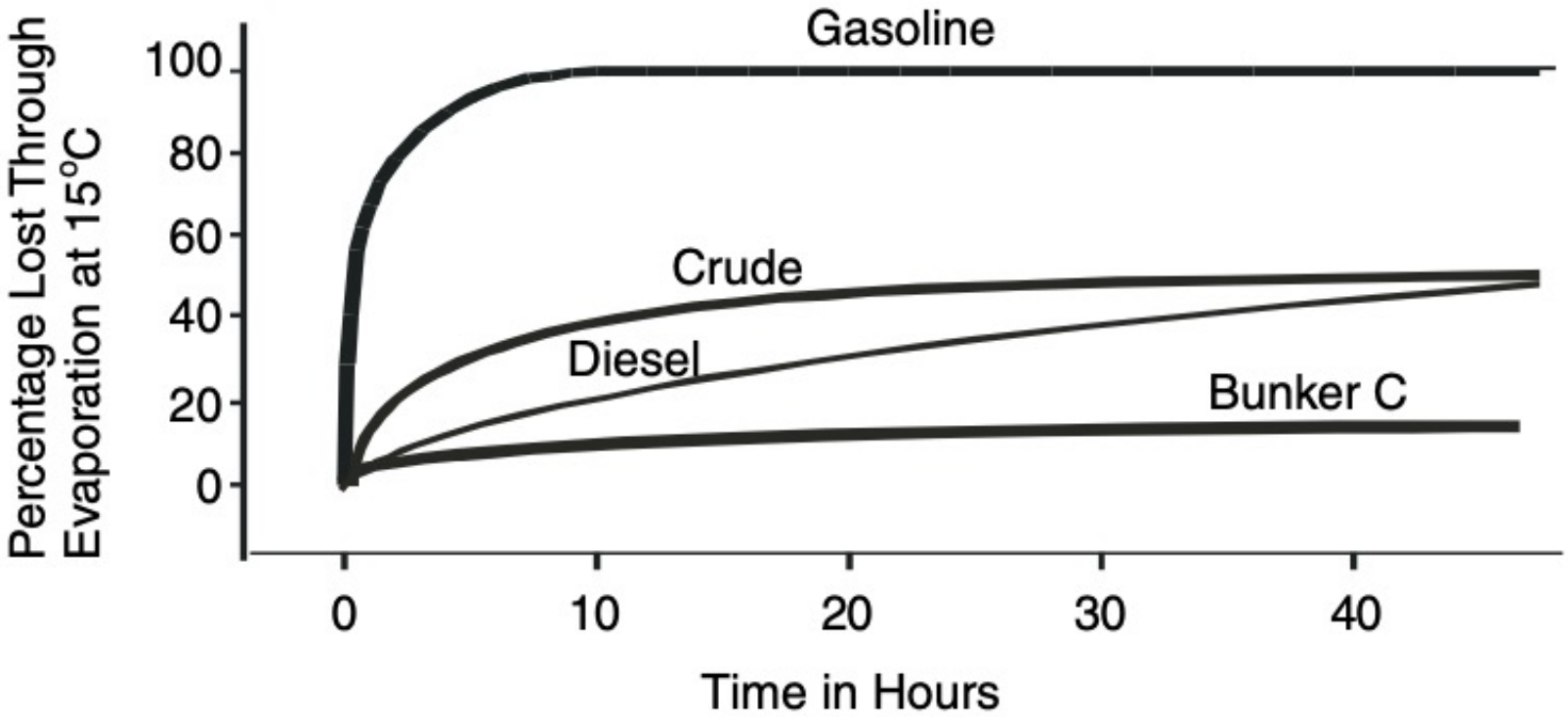
Oil Impacts by Type

Group 1: Non-Persistent Light Oils (Gasoline, Condensate)	Highly volatile (should evaporate within 1-2 days). Cleanup can be dangerous due to high flammability and toxic air hazard.
Group 2: Persistent Light Oils (Diesel, No. 2 Fuel Oil, Light Crudes)	Moderately volatile; will leave residue (up to one-third of spill amount) after a few days. Will "oil" intertidal resources with long-term contamination potential. Cleanup can be very effective.
Group 3: Medium Oils (Most Crude Oils, IFO 180)	About one-third will evaporate within 24 hours. Oil contamination of intertidal areas can be severe and long-term. Oil impacts to waterfowl and fur-bearing mammals can be severe. Cleanup most effective if conducted quickly.
Group 4: Heavy Oils (Heavy Crude Oils, No. 6 Fuel Oil, Bunker C)	Little or no evaporation or dissolution. Heavy contamination of intertidal areas likely. Severe impacts to waterfowl and fur-bearing mammals (coating and ingestion). Long-term contamination of sediments possible. Shoreline cleanup difficult under all conditions.
Group 5: Sinking Oils (Slurry Oils, Residual Oils)	Will sink in water. Severe impacts to animals living in bottom sediments, such as mussels. Long-term contamination of sediments possible. Can be removed from the bottom of a water body by dredging.

Evaporation Rates

Light oils will volatilize, heavy oils will remain over time.

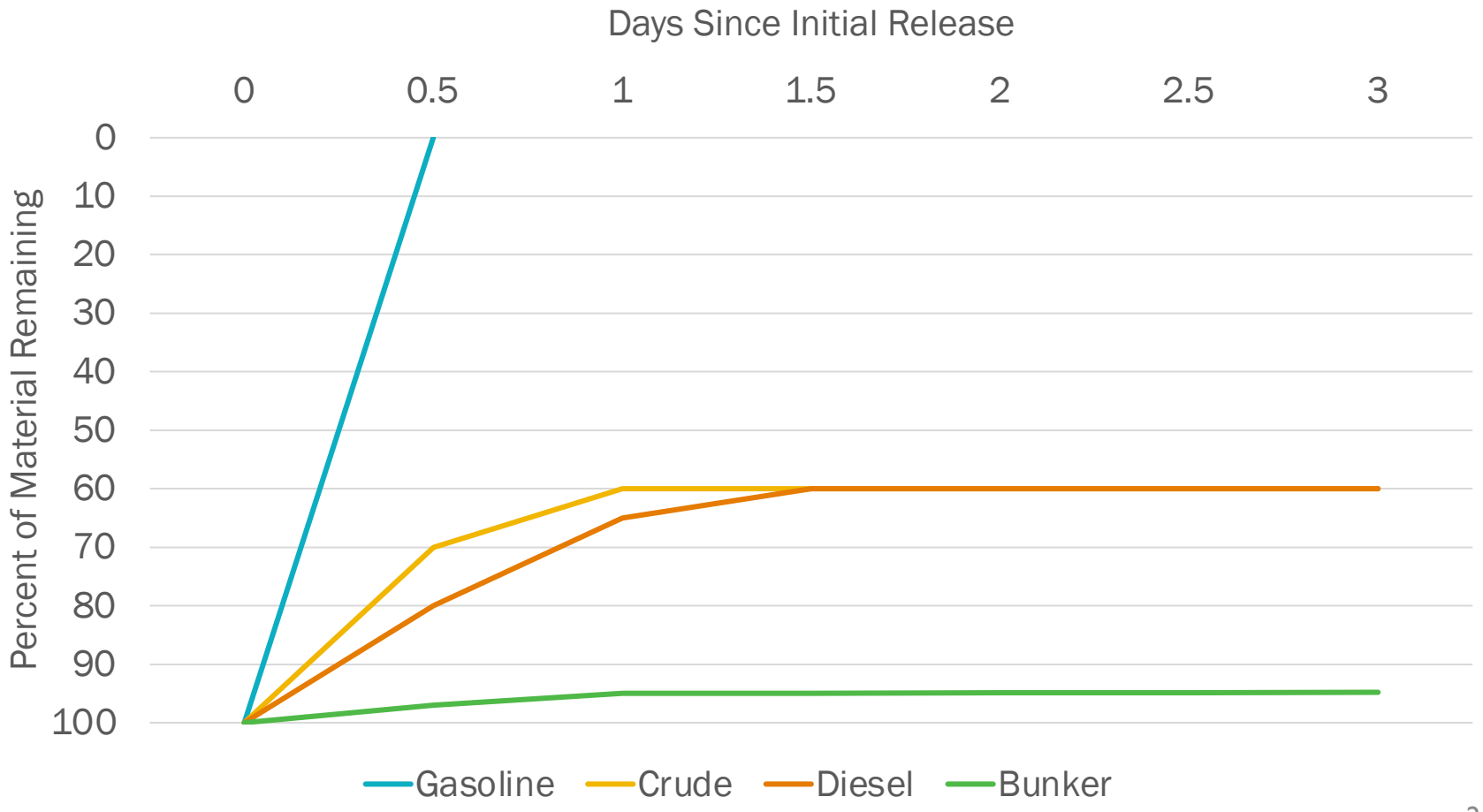


Fire Risk

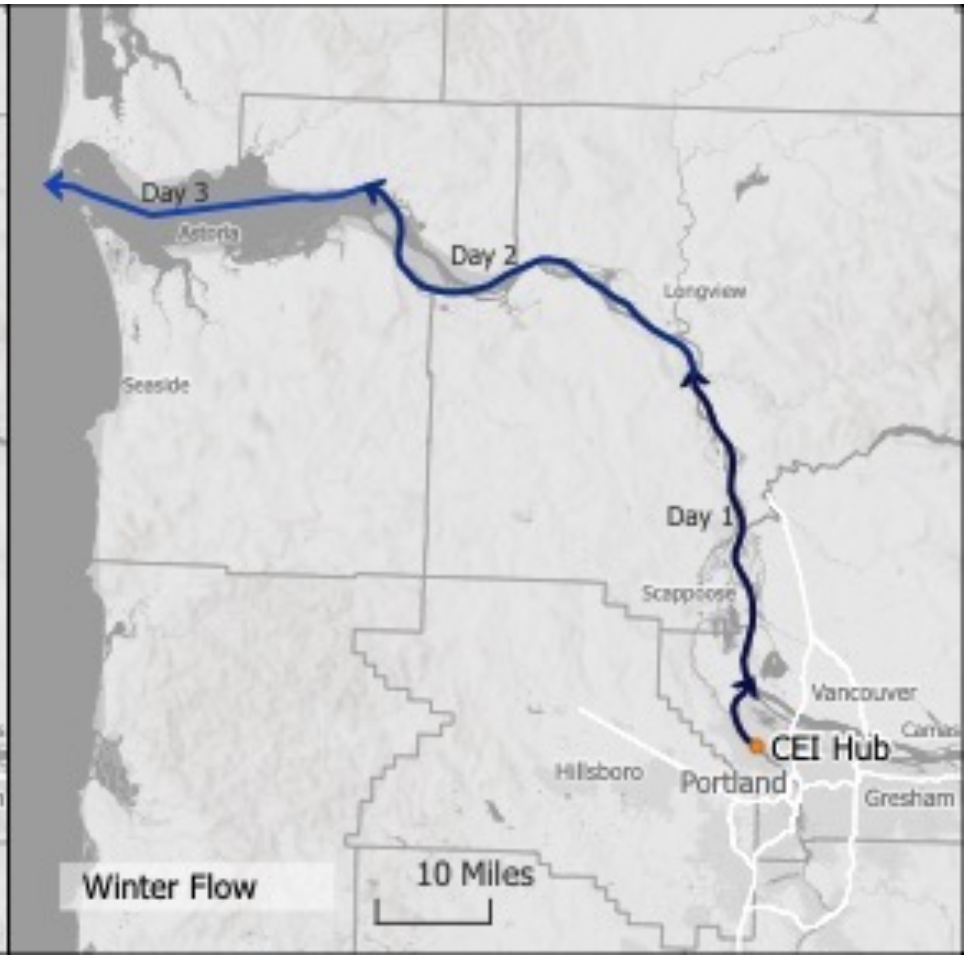
- Ignition sources from power lines, tank friction, others.
- Delayed response due to earthquake.
- Hazardous materials burning - air quality and health impacts.
- Burning as clean up method.

Material in Water

After 3 days between 18.6 million and 37.4 million gallons of oils could remain in the water (out of an initial in-water release of 40.8 – 82.5 million gallons)



Timeframe of Water Spread



Impact Types

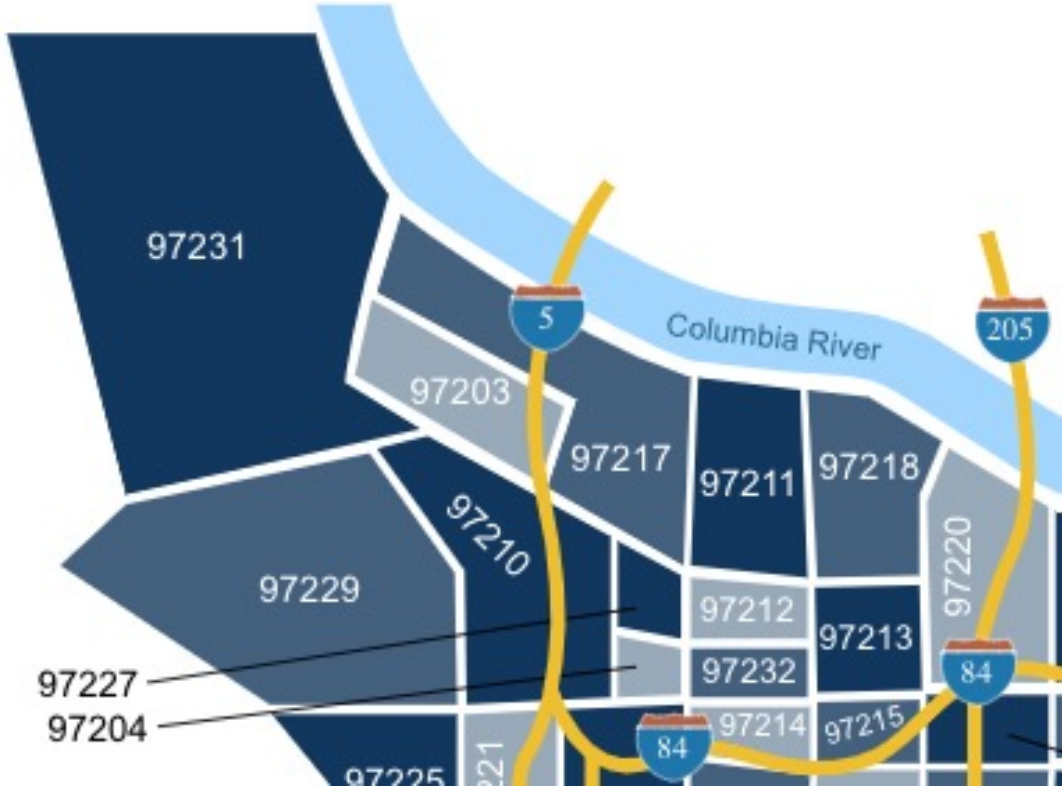
1. Loss of life and injuries directly related to releases at the CEI Hub;
2. Impacts to navigation and river-related commercial activity;
3. Impacts to recreation activities and recreation areas;
4. Short-term and long-term impacts on the environment;
5. Short-term and long-term impacts from air quality impacts;
6. Impacts to cultural resources.

People and Property

- Approximately 200 people work at CEI Hub facilities that could be directly harmed (injured or killed) by releases.
- Other nearby workers, residents, and people traveling through the area are also at risk of direct physical harm.

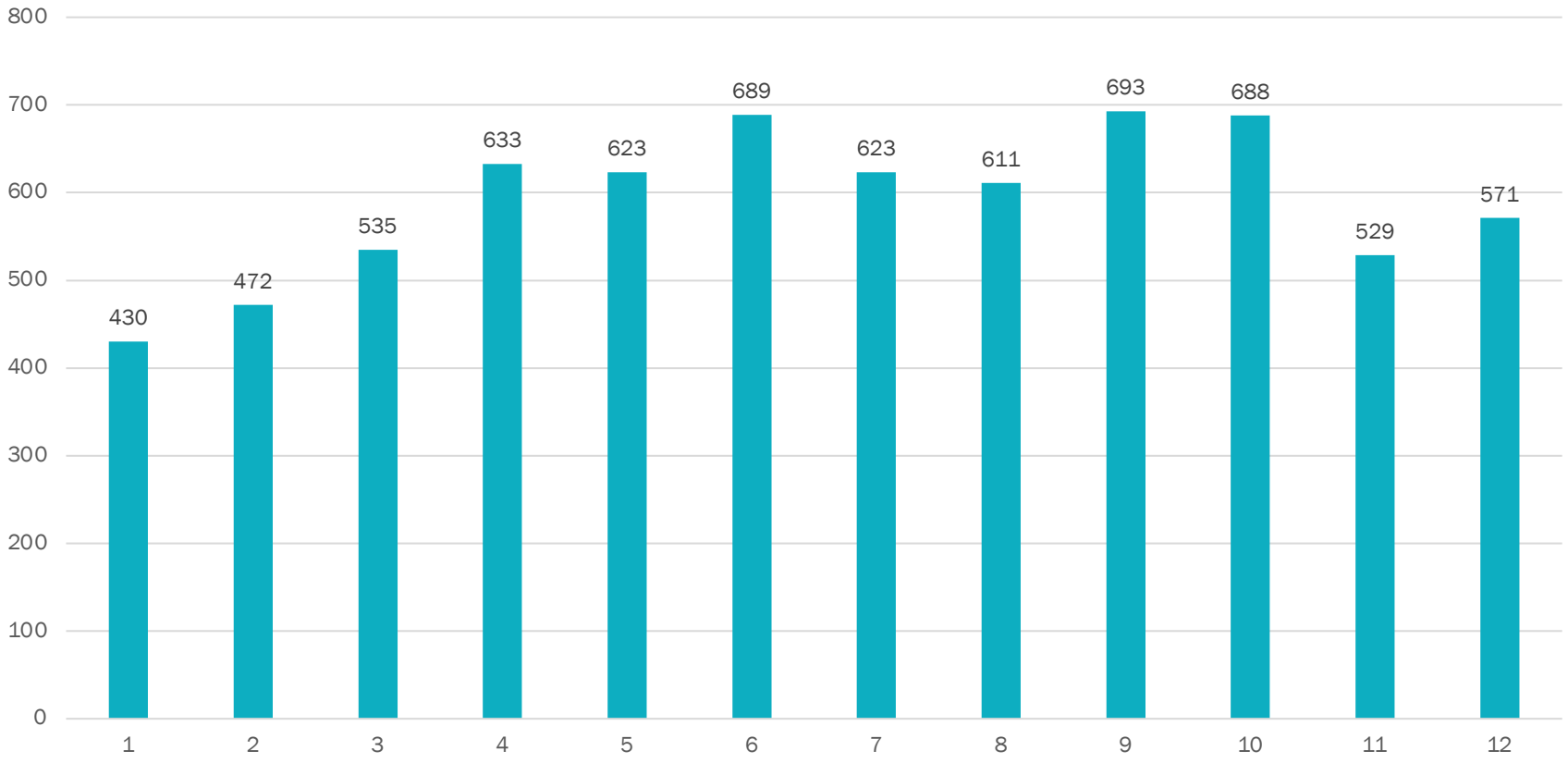
People and Property

- CEI Hub zip codes (97231 and 97210) have a total combined population of 16,508 and total employment of 31,517.



Navigation and Commercial Activity

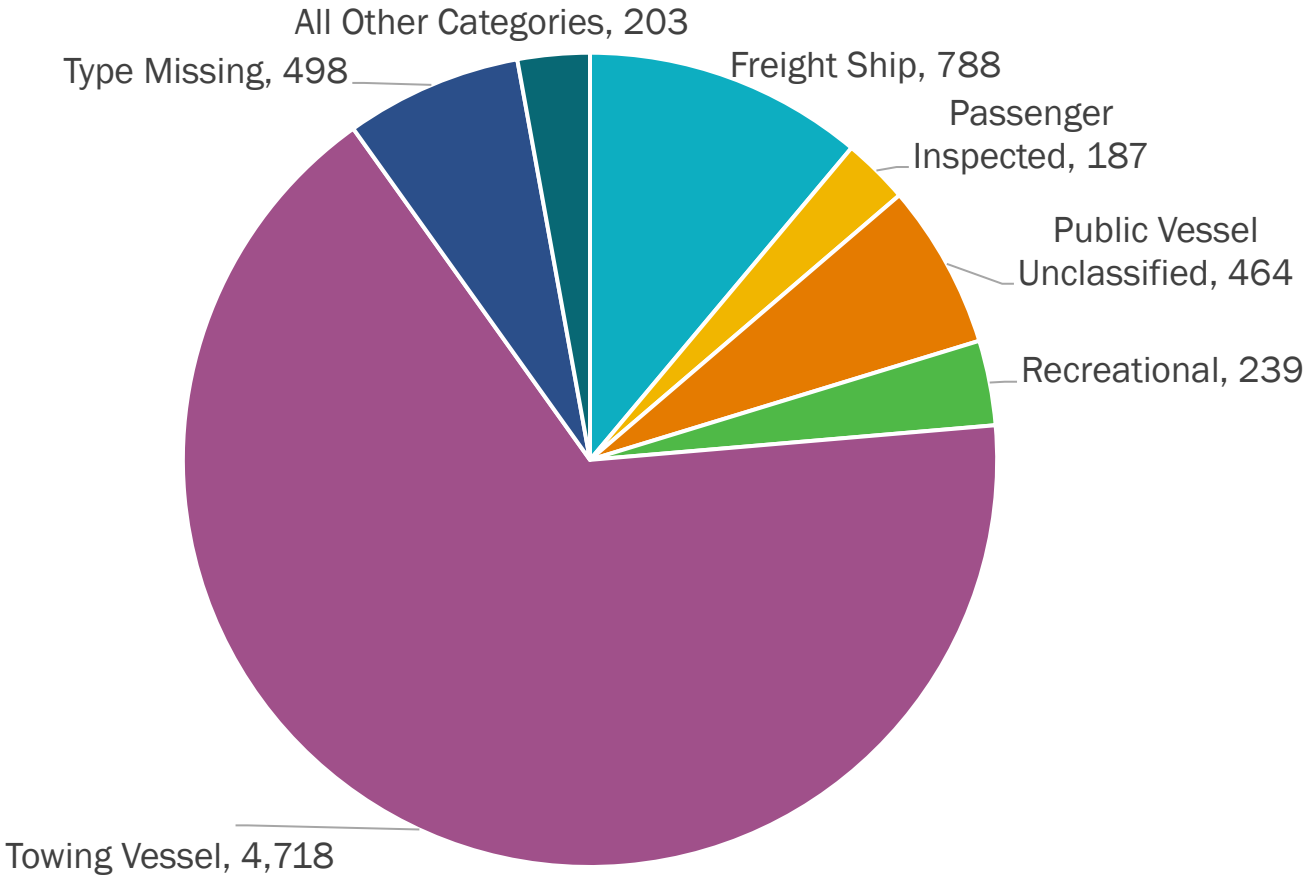
Substance releases could result in river closure



Willamette River number of vessels with AIS transponders by month (Confluence with Columbia River to I-405 bridge). Data does not include the majority of recreational vessels.

Navigation and Commercial Activity

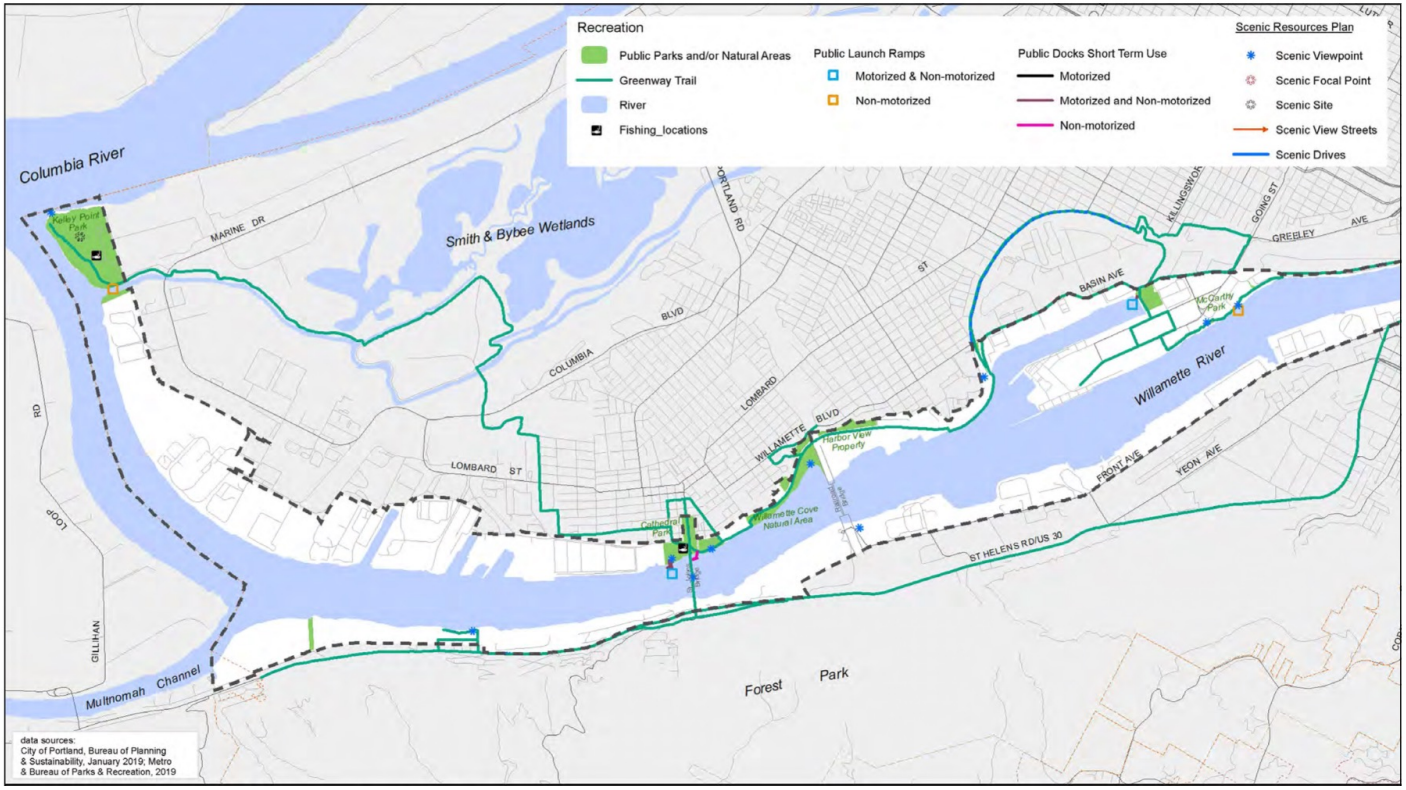
Annual total vessels by type (2017)



Source: Automatic Identification System (AIS) data provided by the Bureau of Ocean Energy Management (BOEM). (2017). Retrieved from https://marinecadastre.gov/data/. Data does not include the majority of recreational vessels.

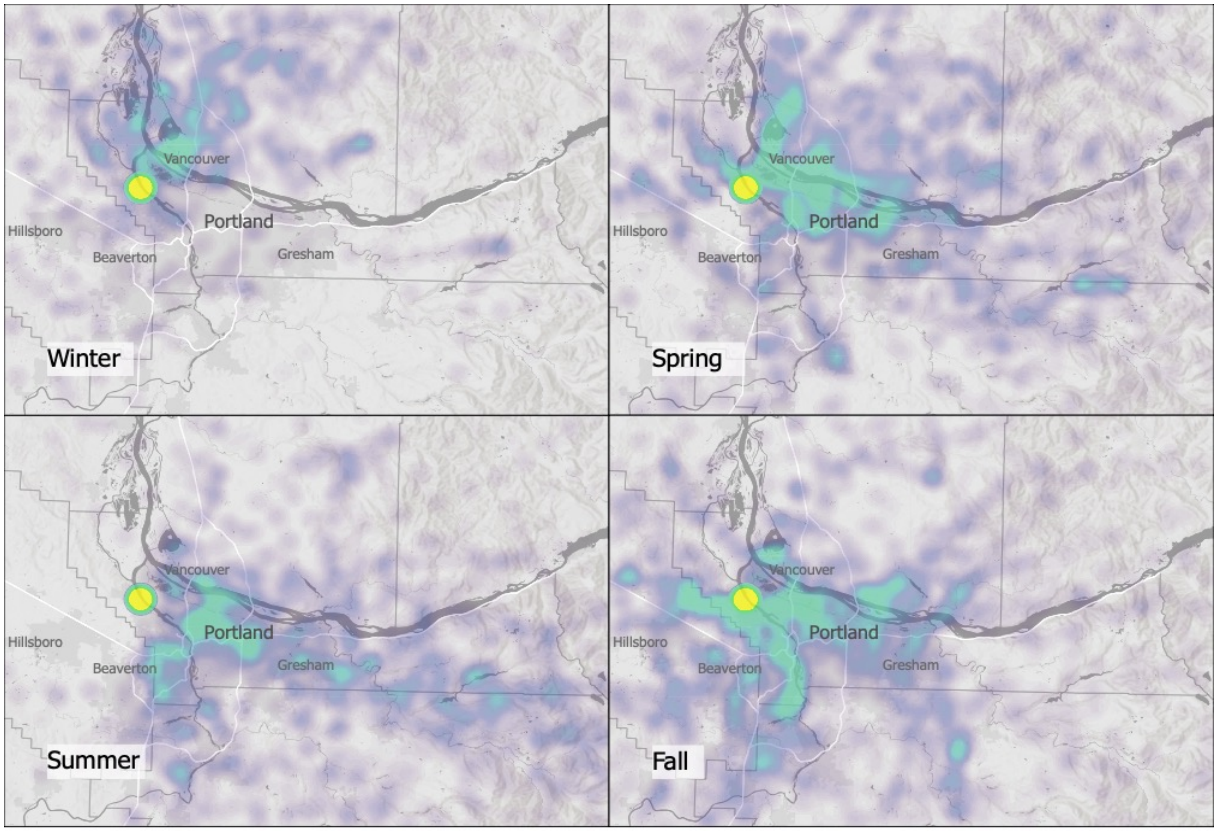
Recreation Impacts

- Possible recreation closures of multiple months for water-based recreation and at parks.
- Sauvie Island and Forest Park impacts.
- Citywide impacts from air quality impairment possible.



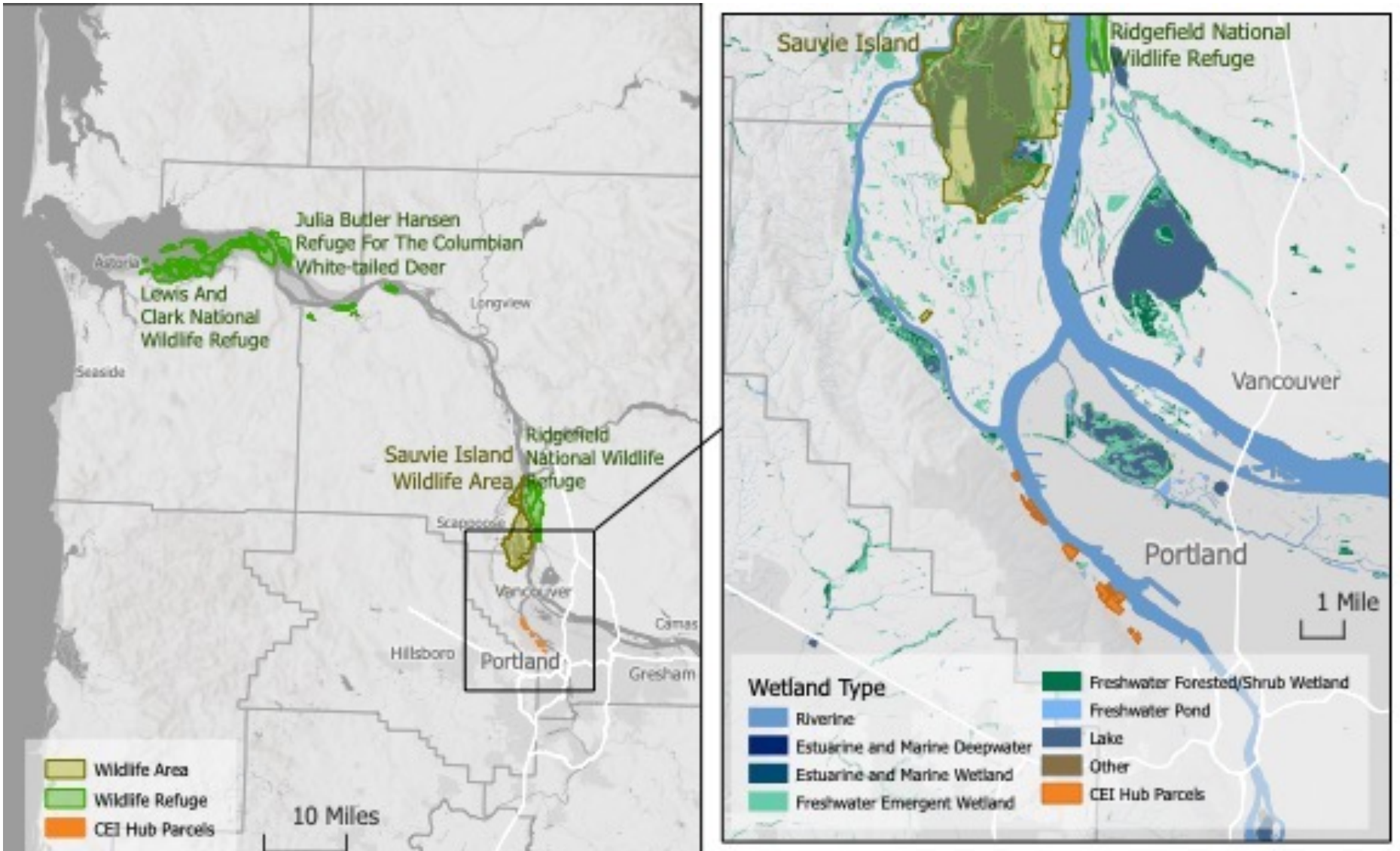
Air Quality and Health

Burning petrochemicals produce several types of air pollutants including: VOCs, NOx, sulfur dioxide (SO_2), and particulate matter ($PM_{2.5}$).



Source: NOAA HYSPLIT analysis performed by ECONorthwest

Sensitive Wildlife and Habitat Areas



Ecological Impacts

- **Birds:** Bald eagle, osprey, and other waterfowl.
- **Fish:** Chinook salmon, Coho salmon, sockeye, steelhead, white sturgeon, and others.
- **Reptiles:** Western pond turtle and western painted turtle.

Direct mortality to animals from oiling and toxicity

- Indirect mortality through:
  - Loss of food supply
  - Reproductive harm (nesting, spawning, etc.)
  - Oiling leading to hypothermia, drowning, loss of flight ability, inability to forage
  - Lung, liver, kidney damage

Cultural Resources

- Impacts to tribal treaty rights
  - Salmon, lamprey, wapato, other native vegetation
- Impacts to tribal subsistence, transportation, commerce, and ceremonial values.
- Impacts in the same area as the Portland Harbor Superfund Site – potential cumulative impacts of historic loss of cultural and environmental value in this area.

Questions and Feedback?

Thank you.

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