AN INLAND INTERMODAL TERMINAL IN THE PACIFIC NORTHWEST

King County
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EXECUTIVE SUMMARY

A transportation optimization model is developed to: (1) evaluate the feasibility of an inland container terminal in Washington State by estimating volume throughput, and (2) to evaluate the impacts of the proposed terminal on vehicle miles traveled, shippers' transportation costs, port truck traffic, and the collective public benefit realized from diverted truck traffic (reduced emissions, congestion, accidents, roadway wear, etc.).

Without an inland terminal, shippers exporting containerized products through the seaports in Seattle and Tacoma truck export containers long distances to the port. Under current conditions without an inland terminal, an estimated 87% of all containerized export volumes are trucked to the seaports, with an estimated 9,518 TEUs/month (4,759 trucks/month) transiting Snoqualmie Pass. The introduction of an inland terminal diverts export volumes from being trucked to the seaports, by drawing shippers' business within proximity of the inland terminal. Three proposed inland terminal locations are evaluated: Ellensburg, Quincy, and Wallula.

An inland terminal in Ellensburg is estimated to reduce truck miles traveled from the baseline (Not Operational) scenario by 42%, diverting an estimated 9,365 TEUs/month (2,341 carloads/month) to the inland terminal at Ellensburg, and yielding a 76% reduction in daily port truck traffic. With an inland terminal at Ellensburg an estimated 851 TEUs/month (426 trucks/month) transit Snoqualmie Pass.

An inland terminal in Quincy is estimated to reduce truck miles traveled from the baseline (Not Operational) scenario by 18%, diverting an estimated 3,176 TEUs/month (794 carloads/month) to the inland terminal at Quincy, and yielding a 24% reduction in daily port truck traffic. Production in the greater Tri-Cities area continues to be trucked to the seaports. With an inland terminal at Quincy an estimated 6,580 TEUs/month (3,290 trucks/month) transit Snoqualmie Pass.

An inland terminal in Wallula is estimated to reduce truck miles traveled from the baseline (Not Operational) scenario by 22%, diverting an estimated 2,541 TEUs/month (635 carloads/month) to the inland terminal at Wallula, and yielding a 21% reduction in daily port truck traffic. With an inland terminal at Wallula an estimated 6,979 TEUs/month (3,490 trucks/month) transit Snoqualmie Pass.

Compared to terminals in Quincy or Wallula, an inland terminal in Ellensburg yields relatively little cost savings to shippers, saving approximately $21,782/month across all shippers or approximately $3/container. Inland terminals in Quincy and Wallula on the other hand, yield $167,451/month ($23/container) and $313,181/month ($44/container) in cost savings respectively.

An inland terminal in Ellensburg, however, provides the largest public cost savings of $467,226/month ($5.6 million annually). Inland terminals in Quincy and Wallula provide public cost savings of $185,178/month ($2.2 million annually) and $230,206/month ($2.8 million annually).

INTRODUCTION

Inland container terminals are high-capacity intermodal inland freight depots with infrastructure to handle containers, and with direct Class 1 rail connections to one or more seaports (Crainic et al., 2014). Inland terminals provide shippers with a repositioning depot away from the often-congested seaport. In doing so, inland terminals potentially offer many benefits to shippers, port operators, railroads and the broader public if successfully positioned. These benefits include expanding port operations (volumes of throughput), offer inland shippers cost effective opportunities to meet secondary container demands (Kim and Van Wee, 2011), and reduce congestion, pollution, and roadway wear near densely populated seaports and along heavily trafficked highways (Bryan et al., 2007).

Inland container terminals, however, present significant investment costs associated with infrastructure, terminal handling, and coordination (Kim and Van Wee, 2011). Several studies investigate the feasibility of proposed inland terminals (Afandizadeh and Moayedfar, 2008; Dadvar et al., 2011; Idris et al., 2017; Lattila et al., 2013; Vergara et al., 2015; Zeng et al., 2015;), generally recognizing that feasibility depends on many factors including the terminals location, rail service, volume of shipments diverted, shipping costs, and characteristics of available seaports (Cullinane and Wilmsmeier, 2011).

Perhaps one of the most important determinants of the feasibility of an inland container terminal is total volume demand/throughput at the terminal. Class I railroads who serve inland terminals maximize efficiency over longer distances and typically prefer to minimize costly stops and transfers at smaller facilities. This is primarily related to scale efficiencies, but also related to the difference in marginal operating costs between truck and rail once moving. Thus, proposed inland container terminals (often within a few hundred miles from seaports) are cost prohibitive for rail lines to service, unless they offer sufficiently high-volume demand/throughput. When those high-volume demand attributes are met, Class I railroad can offer competitive service and rates (as compared to truck) and achieve profitable margins. But the volume is conditional on the service and rates.

The Northwest Seaport Alliance (Ports of Seattle and Tacoma, WA) has attempted to develop inland container terminals in the past. A current semi-operational inland container terminal is located at Richland, WA, approximately 200 miles east of Seattle, WA. Other attempts have been located at the Port of Quincy, WA and at the Port of Moses Lake, WA. Each attempted inland terminal has faced the challenge of uncertainty over rates/service from the Class 1 rail line, and volume of shipment from the regional shippers: without sufficient volume Class 1 rail lines will not commit to adequate rates/service, and without adequate rates/service regional shippers will not commit to enough volume.

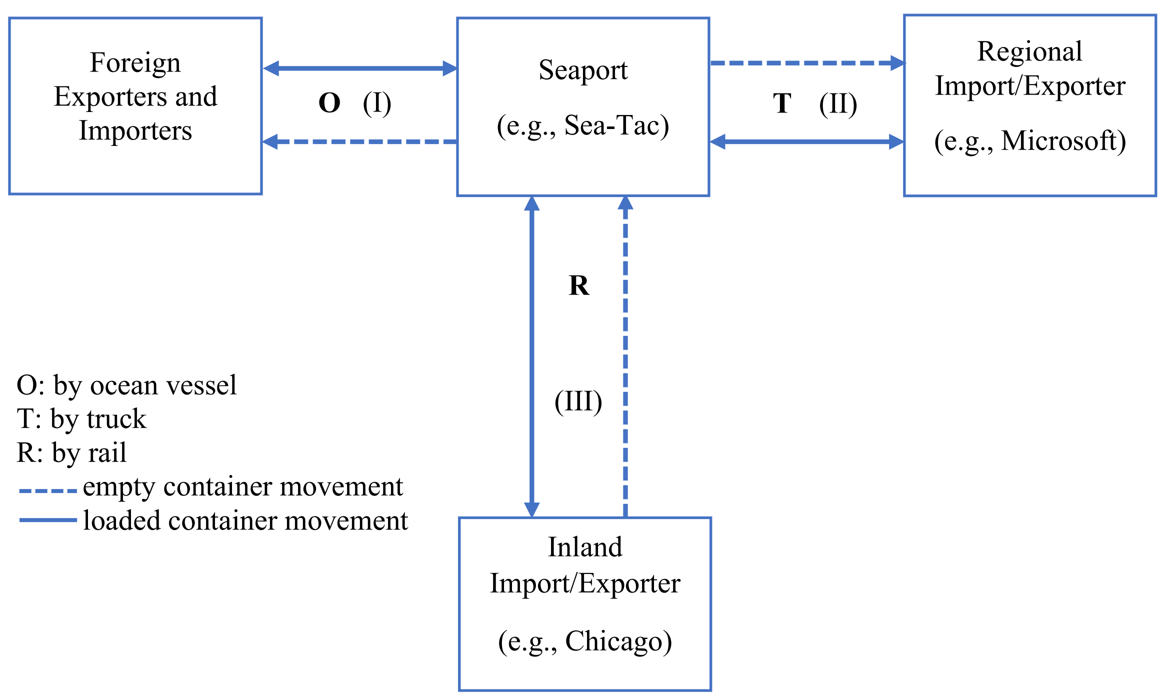
This uncertainty over volumes is caused in part by the diverse and varied nature of the many different agricultural commodities produced in the Pacific Northwest. Because production is spread across a wide array of commodities, any single commodity is not shipped with high enough volumes to secure competitive rates and service from the shipping lines and Class I railroads. Collectively, however, the many small to mid-size shippers across multiple commodities including hay, potatoes, onions, apples, cherries, peas, lentils, and garbanzo beans, represent a very sizeable market opportunity (likely warranting service from shipping lines and Class 1 railroads).

A transportation optimization model is developed to: (1) evaluate the feasibility of an inland container terminal in Washington State by estimating volume throughput, and (2) to evaluate the impacts of the proposed terminal on vehicle miles traveled, shippers' transportation costs, port truck traffic, and the collective public benefit realized from diverted truck traffic (reduced emissions, congestion, accidents, roadway wear, etc.).

INLAND CONTAINER TERMINAL

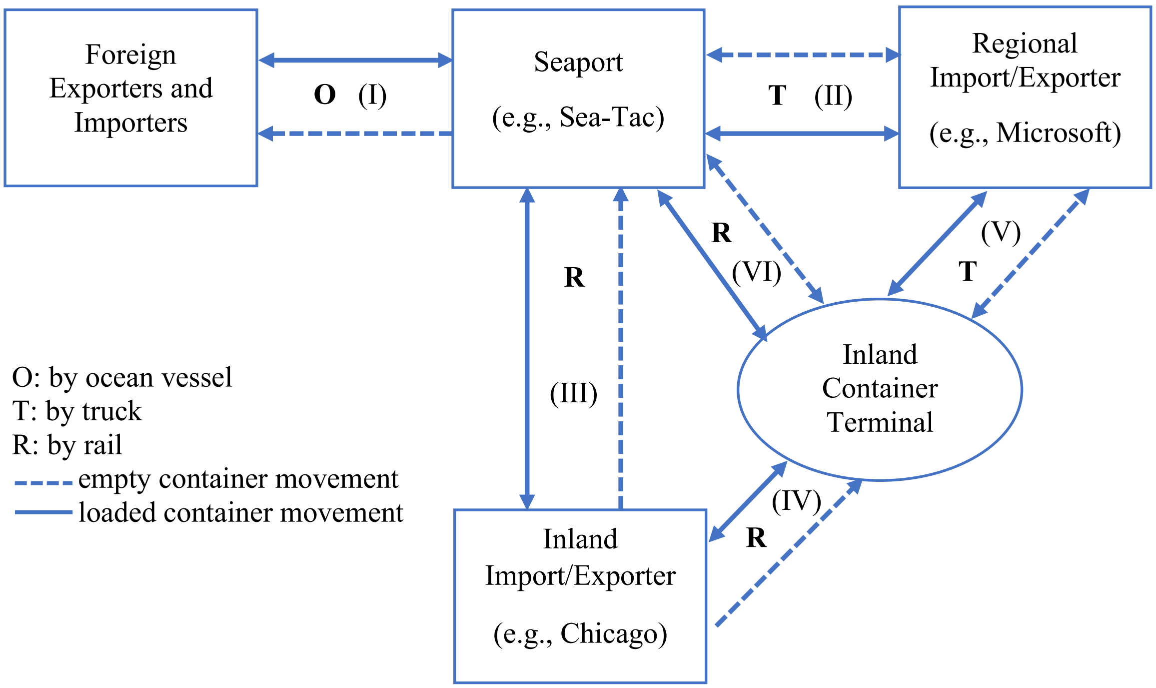
An inland container terminal plays an important role in the flow of containers from the import of foreign goods, all the way through to the export of domestic goods or the repositioning of empty containers. Figure 1 shows container movements in the typical ocean container port without an inland container terminal. Movement of loaded containers are indicated by solid lines, while movement of empty containers are indicated by dashed lines. Arrows indicate the direction of container flow. Initials denote the mode of transportation: O for ocean vessel, R for rail, and T for truck. Loaded inbound containers shipped from foreign markets arrive at the domestic seaport (e.g., the ports of Seattle-Tacoma). A portion of the loaded containers are trucked to local and regional distribution centers to be emptied and returned to the port, while the rest are shipped by truck or rail to their inland destination (e.g., Chicago). After being emptied at their inland destination, containers either filled and returned or returned empty back to the seaport and loaded onto the vessel for repositioning/export. Regional domestic exporters (e.g., Hay exporters) pick up empty containers from the port, fill them, and return them to the port for export. In this scenario, the seaport is the hub of local drayage for regional importer/exports and long-haul rail shipping/receiving.

Figure 1: Seaport Freight Terminal Schematic



With an inland container terminal, imports, exports, and empty containers can be moved efficiently by rail between the seaport and the inland terminal, reducing port congestion and drayage around the seaport (Figure 2). From the inland terminal, imports can be trucked to regional importers or aggregated onto trains to be shipped to their inland destination. After containers have been emptied at their inland destination, they can be shipped back to the inland terminal, providing regional exporters inland access to the empty containers they need for export. Inland and regional exporters can also deliver loaded containers for export to the inland terminal to be staged and moved to the seaport. An inland container terminal within this supply chain facilitates shipments of loaded containers away from seaport property (which is typically constrained), provides regional import/exporters an alternative (typically less congested) location to pick up/deliver their products for import/export, and provides additional access to empty containers on the secondary market to regional exporters.

Figure 2: Inland Container Terminal Schematic



Several entities operate within the supply chain of containerized imports/exports, to make this container flow possible. Ocean liners own the containers and offer international shipping for importers and exporters. Regional shippers transport containers between the seaport, inland container terminal, and regional import/exporters (distribution centers) by truck; they rely on empty containers from the ocean liners, trucking transportation services, and Class 1 rail lines. Long haul shippers transport containers between the seaport, inland container terminal, and inland import/exporters by rail. And Class 1 rail lines, who operate high volume trains for container transport between the seaport and inland intermodal facilities (including the inland terminal).

Each of these entities have their own objective functions. Ocean liners maximize profits by maximizing equipment utilization for both vessels and containers, generally achieved by maximizing their number of turns per year and using larger vessels to increase efficiencies. Class 1 rail lines (like ocean liners) seek to maximize equipment utilization but do so by setting service schedules to maximize network utilization and profit margins; profit margins are maximized by using longer trains, travelling longer distances, and making less frequent stops. Regional and long-haul shippers meet import/export demands and minimize costs, in part by selecting the most cost-effective mode and route of transit.

As Figure 2 shows, with an inland container terminal, regional and long-haul shippers can choose to ship directly between import/exporters and the seaport or use the inland container terminal. These shippers' route/mode choice decisions to either ship directly to/from the seaport, or indirectly via the inland container terminal determine the volume of freight moved through the inland container terminal, affecting terminal profitability. These decisions also determine the extent to which freight is re-routed or shipped using alternative modes when an inland terminal is available, affecting emissions, air pollution, congestion, accidents, noise pollution and roadway wear.

The focus of this paper is on the impact of inland terminals on regional exporters mode and route choice decisions (decisions II and V in Figure 2). Mode and route choice decisions are modeled for each regional exporter (shipper) to understand the private costs/benefits, and public costs/benefits of an inland container terminal.

FREIGHT DEMAND AND MODE CHOICE

To analyze shippers' mode and route choice to ship directly to the seaport or indirectly via an inland container terminal, we consider their cost minimization problem. The shippers' total cost function is decomposed into two components: 1) truck transportation costs from the production origin to the seaport or an inland terminal, and 2) rail transportation costs from an inland terminal to the seaport.

Each shipper solves their cost minimization problem:

$$\min_{Terminal} TruckRate * miles(Terminal) + RailCost(Terminal),$$

where shippers compare the cost of truck transport to the seaport, to the cost of truck transport at an inland terminal plus the rail cost from the inland terminal to the seaport and any transfer fee associated with going from truck to rail. Shippers can choose to utilize an inland terminal or truck directly to the seaports. Three proposed inland terminal locations within Washington state are considered: Ellensburg, Quincy, and Wallula.

Truck transportation costs are assumed to be $7.50/mile to transport 2 TEU (40 ft container) based on rate data from Bulkloads.com (Figure 5) and consultations with shippers. Rail transportation costs from each inland terminal to the Seattle and Tacoma seaports are identified based on shipper consultations and reported rates from the Surface Transportation Board Carload Waybill Data. The estimated rate per 2 TEU (40 ft container) for rail service to the seaport from each inland terminal is: Ellensburg: $800, Quincy: $1,000, Spokane: $1,475, Wallula: $1,200. These are estimated rates; sensitivity analysis is conducted to evaluate the impacts of alternative truck and rail rates.

By solving the shippers cost minimization problem, we can identify the optimal shipping route for each shipper. By aggregating over the chosen route for each shipper, we can identify volume flows for each commodity by origin, terminal, route and mode. These volume flows capture freight movements to the seaports within the modeled region.

We evaluate shippers' choices, and the resulting commodity flows, under eight operational scenarios. The baseline scenario assumes no rail service from Ellensburg, Quincy, or Wallula to the seaports. This baseline scenario is broadly consistent with current conditions as these inland terminals currently service very few, if any, export volumes to the seaports.[1] This baseline scenario requires most export traffic to Seattle and Tacoma to be transported by truck.

The baseline scenario is compared to seven alternative operating scenarios, under which one, two, or all of the proposed inland terminals in Ellensburg, Quincy, and Wallula become operational. The baseline and alternative operating scenarios include:

I. Not Operational (baseline):
   - Ellensburg, Quincy, and Wallula are not operational.

[1] We understand some volumes currently operate out of Wallula. This is not represented in the baseline scenario.

II. Ellensburg Operational:
   - Ellensburg is operational, but Quincy and Wallula are not.

III. Quincy Operational:
   - Quincy is operational, but Ellensburg and Wallula are not.

IV. Wallula Operational:
   - Wallula is operational, but Ellensburg and Qunicy are not.

V. Ellensburg and Quincy Operational:
   - Ellensburg and Quincy are operational, but Wallula is not.

VI. Ellensburg and Wallula Operational:
   - Ellensburg and Wallula are operational, but Quincy is not.

VII. Quincy and Wallula Operational:
   - Quincy and Wallula are operational, but Ellensburg is not.

VIII. All Operational:
   - Ellensburg, Quincy, and Wallula are all operational.

Rail from Spokane to the seaports is assumed to be operational in all scenarios. Under these operating scenarios we evaluate the impacts of inland terminal operations on commodity flows throughout the region. Commodity flows are used to calculate the impacts of inland terminal operations on public and private transportation costs under each scenario including: transport costs, greenhouse gas emissions, air pollution, highway accidents, noise pollution, congestion, and roadway wear.

PRIVATE AND PUBLIC COSTS

Private costs are equal to shippers' transport costs, and are straightforward to estimate as a function of route/mode choice and transport rates. Public costs, on the other hand, require intricate modeling and pricing to assign values to public goods (clean air, safe roads, etc.). Where available, these valuations are drawn from the USDOT Benefit Cost Analysis Guidance (2022). A discussion of all private and public transport costs are provided below. All costs are provided in 2024 USD.

TRANSPORT COSTS

Shippers' decision to ship directly via the seaport or indirectly via the inland terminal is determined by which option minimizes total transportation costs. For some shippers, the construction of an inland container terminal does not provide them with a cost-effective alternative to shipping directly to the seaport, given their proximity to the ocean port relative to the inland terminal. For others, the availability of an inland container terminal drives down total shipping costs. The aggregation of these savings on shipping costs for each shipper encompasses the private benefits of an inland container terminal. These transport costs are calculated based on assumed transport rates by mode and route ($7.50/truck-mile, rail service fees: Ellensburg: $800, Quincy: $1,000, Spokane: $1,475, Wallula: $1,200). Private transport costs are aggregated across shippers to estimate total transport costs under each operating scenario.

GREENHOUSE GAS EMISSIONS (CO_2, N_2O, CH_4)

Transportation is the leading contributor to greenhouse gas emission in the U.S., accounting for 28% of total emissions; freight transportation representing 23% of transportation greenhouse gas emissions (U.S. Environmental Protection Agency, 2024). The costs of climate change are complicated to calculate, but for our purposes, we rely on the numerous estimates of the public costs of carbon dioxide (CO_2, $55/ton), nitrous oxide ($N_2O$, $20,201/ton), and methane (CH_4, $1,259/ton) (USDOT Benefit Cost Analysis Guidance, 2022; U.S. Environmental Protection Agency, 2012). Each gallon of diesel is estimated to emit 10,180 grams of CO_2, 3 grams of N_2O, and 41 grams of CH_4. By estimating average fuel consumption/mile for freight trucks and trains, we can recover the amount of emissions under each operational scenario. We assume an average fuel efficiency 6.68 miles per gallon (mpg) for trucks (American Transportation Research Institute, 2023), and 439.7 miles per gallon for trains (Association of American Railroads, Carbon Calculator). Aggregating over the estimated emissions for each pollutant for each mode provides the total cost of greenhouse gas emissions under each scenario.

AIR POLLUTION (NO_X, SO_2, $PM_{2.5}$)

In addition to greenhouse gases, freight transport emits air pollution that causes health effects, crop losses, material and building damage, and biodiversity loss (Handbook on the External Costs of Transport, 2019). Damage cost estimation models identify the pathways through which pollutants cause such damages (Handbook Environmental Prices, 2018). For example, an increase of air particulate pollutants increases air concentration of particulates, which increases the prevalence of asthma, which is associated with economic costs. Air pollution from nitrogen oxide NO_x, sulfur dioxide SO_2, and particulates $PM_{2.5}$ are estimated to cost $16,200/ton, $44,000/ton, and $788,100/ton respectively (USDOT Benefit Cost Analysis Guide, 2022). Pollution rates are estimated to be 0.067 grams/highway mile for $PM_{2.5}$, 44.6 grams/gallon for NO_x, and 0.048 grams/gallon (15 ppm) of SO_2 (U.S. Environmental Protection Agency, 2024). Particulate pollution rates for rail are not known. Fuel efficiency is assumed to be 6.68 miles per gallon (mpg) for trucks (American Transportation Research Institute, 2023), and 439.7 miles per gallon for trains (Association of American Railroads, Carbon Calculator). Aggregating estimated emissions for each scenario provides the total cost of air pollution with and without an inland container terminal.

CONGESTION

Inland container terminals reroute the flow of traffic, as they divert previously port bound traffic to the inland terminal, taking some port bound traffic off the roads and onto rail. These shifts result in changes in congestion on each road segment. Congestion costs per additional freight mile traveled are estimated to be $0.38/mile in urban settings and $0.09/mile in rural settings (USDOT Benefit Cost Analysis Guide, 2022). Total congestion costs under each scenario are calculated by aggregating congestions costs across each road segment, where congestion on each segment priced by urban/rural classification of the roadway.

ACCIDENTS

Accidents involve both material and immaterial costs. Material costs include damage to vehicles, damage to persons, damages to roadway infrastructure, and response personnel costs (firefighters, police, and other non-medical emergency services). Material costs have prices associated with them, and in some cases are internalized through insurance premiums. Immaterial costs include the pain, suffering and sorrow caused by accidents, and are not priced. Accident costs depend on the severity of the accident. On average, accidents involving a heavy-duty truck are estimated to $15,652,441/accident for accidents involving a fatality, $368,955/accident for non-fatal accidents involving an injury, and $24,929/accident for property damage only accidents (USDOT Benefit Cost Analysis Guide, 2022; USDOT Unit Costs of Medium and Heavy Truck Crashes, 2007). Changes in traffic flows affect the likelihood of accidents. Increased truck traffic flows are estimated to increase accidents involving a fatality by 1.74 accidents/100 million truck miles driven, 35.7 non-fatal accidents involving an injury/100 million truck miles driven, and 122.4 property damage only accidents/100 million truck miles driven (USDOT Large Truck and Bus Crash Facts, 2021). Changes in highway vehicle miles travelled are multiplied by the cost and rate of accidents, to estimate the expected change in accident costs under each operational scenario.

NOISE POLLUTION

Shifts in traffic flows as a result of inland terminal operations result in changes in noise pollution. Noise pollution costs per additional road freight mile traveled are estimated to be $0.0479/mile in urban settings and $0.0040/mile in rural settings (USDOT Benefit Cost Analysis Guide, 2022). Noise pollution costs for rail freight are estimated to be $4.76/mile/train (Handbook on the External Costs of Transport, 2019).

ROADWAY WEAR

Inland container terminals reroute the flow of traffic, as they divert previously port bound traffic to the inland terminal and take some port bound traffic off the roads and onto rail. These shifts result in changes in vehicle miles traveled on each road segment. The damage to roadways from heavy duty trucks is estimated at $0.12/mile (Abdelazim et. al. 2020). Therefore, road wear costs can be calculated by multiplying the per/mile cost by truck miles driven under each scenario.

DATA

Monthly containerized export data provided by U.S. Customs aggregates export volumes by 2-digit HS code, state of origination, and mode (air, containerized vessel, or bulk vessel). Containerized vessel export volumes are measured by weight; for analysis, weights are converted into the number of twenty-foot equivalent units (TEUs) (Table 1). Containerized vessel exports from Washington total on average 179,687,133 kg/month, or approximately 14,244 TEUs/month. Oil Seeds and Misc Grain represent the largest share of containerized vessel export volumes, accounting for approximately 8,535 TEUs/month. Fruit and Vegetables account for approximately 2,215 TEUs/month and 1,602 TEUs/month respectively.

Table 1: Monthly Containerized Agricultural Vessel Exports Originating in WA

Commodity	Monthly Containerized Vessel Exports SWT (kg)	Monthly Containerized Vessel Exports (TEUs)
02 Meat And Edible Meat Offal	3,042,528	252
03 Fish, Crustaceans & Aquatic Invertebrates	10,546,810	917
06 Live Trees, Plants, Bulbs Etc.; Cut Flowers Etc.	285,746	55
07 Edible Vegetables & Certain Roots & Tubers	25,267,100	1,602
08 Edible Fruit & Nuts; Citrus Fruit Or Melon Peel	23,805,120	2,215
10 Cereals	9,740,629	668
12 Oil Seeds Etc.; Misc Grain, Seed, Fruit, Plant Etc.	106,999,200	8,535
Total	179,687,133	14,244

Agricultural export volumes within the state are mapped to production originations based on county-level production volumes (shares as a percentage of total state production) and township-level agricultural land use data. Figure 3 shows estimated monthly export volumes (TEUs) from each county in Washington. Figure 4 shows estimated monthly export volumes (TEUs) from each production origin in the state (Township/Region/Section). These production origins are used in the transportation optimization model to estimate commodity flows.

Figure 3: Containerized Agricultural Vessel Export Volumes by County (monthly)

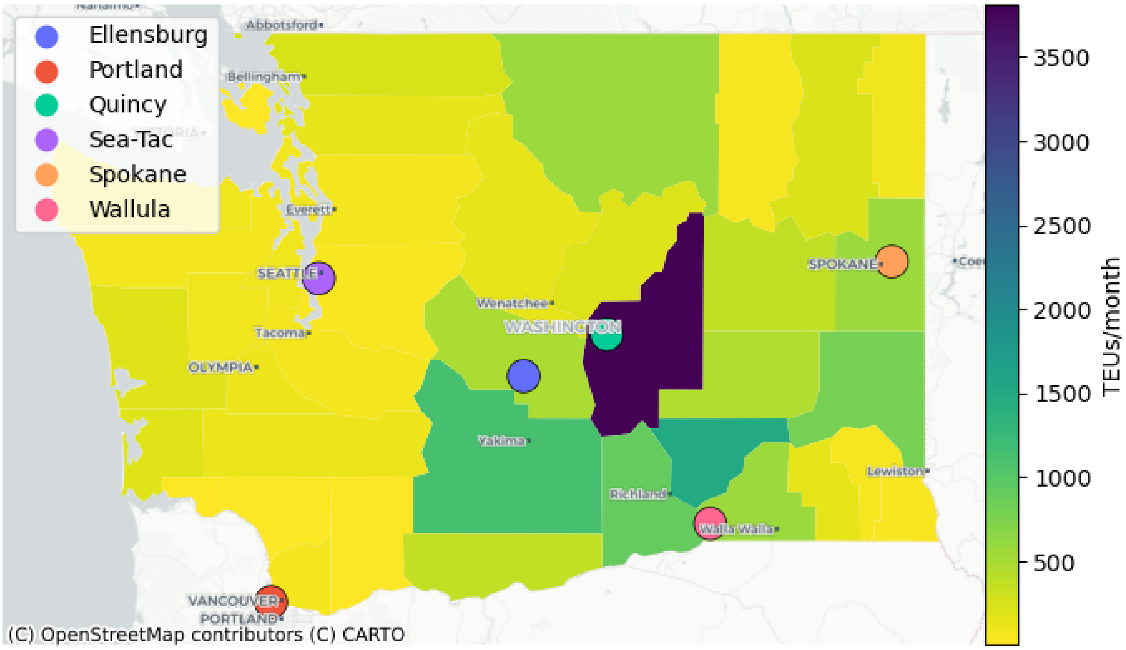
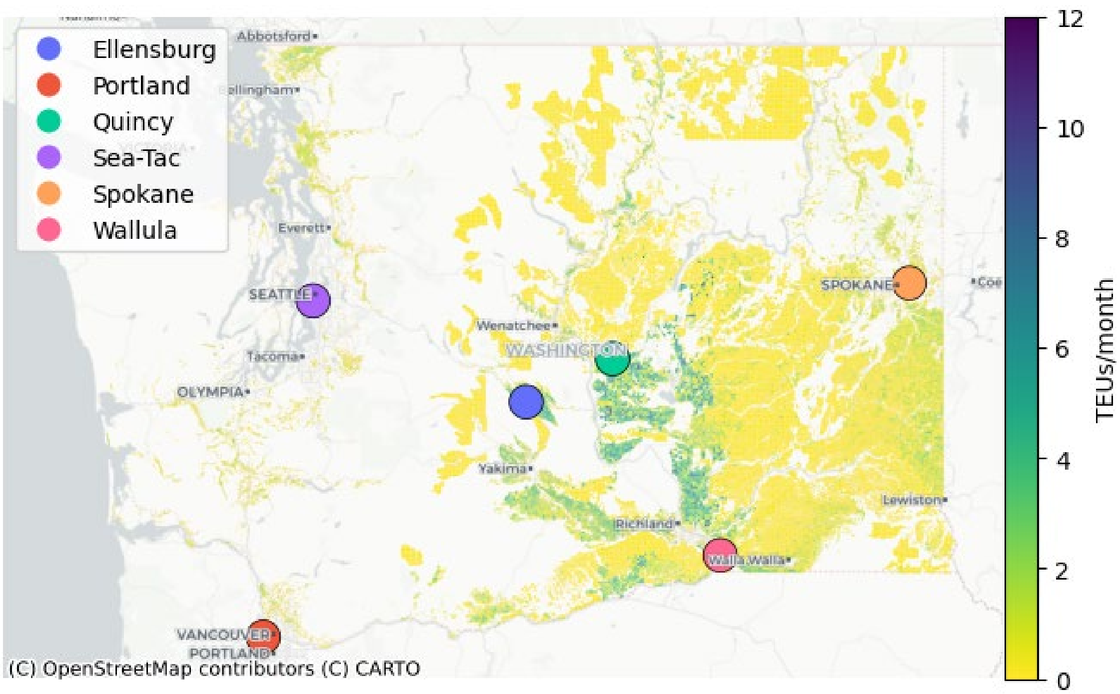
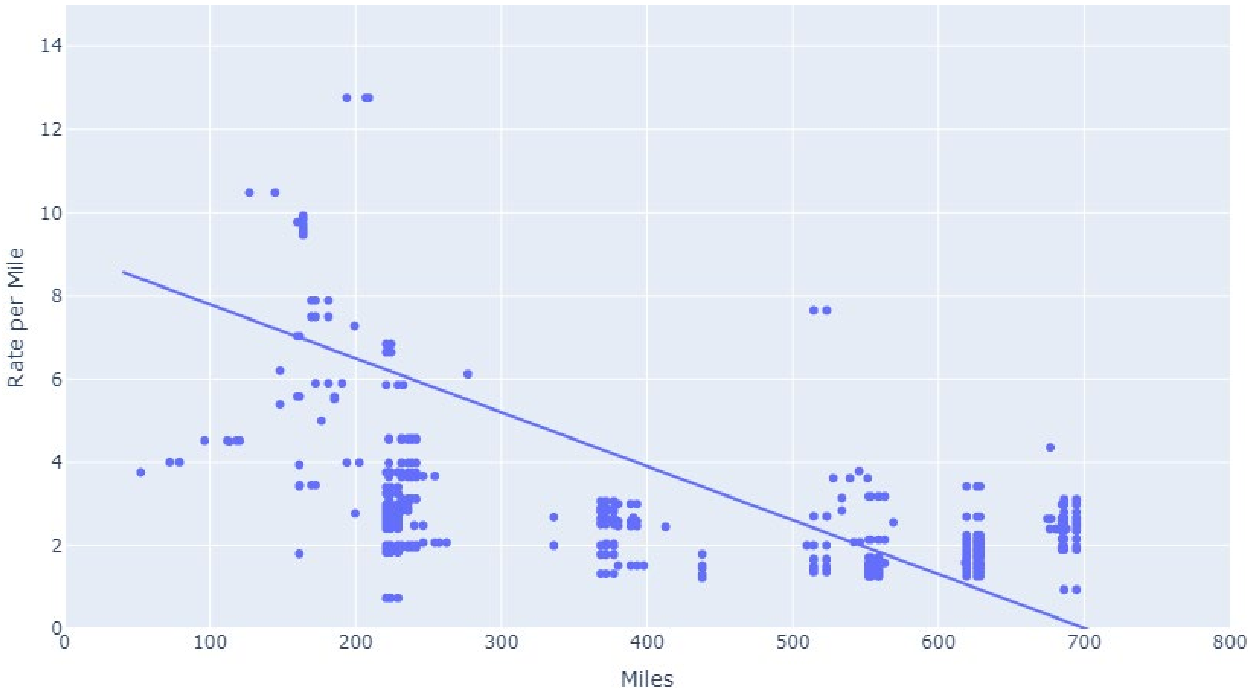


Figure 4: Containerized Agricultural Vessel Export Volumes by Township/Region/Section (monthly)



Information on truck transportation costs is derived from consultations with shippers and data from Bulkloads.com, a broker of agricultural truck transportation services. Average weekly rates per mile are shown in Figure 5, as a function of total transport distance. Most agricultural truck transportation within Washington is under 200 miles. For this analysis we assume an average truck rate of $7.5/mile.

Figure 5: Truck Rate Data - Bulkloads.com



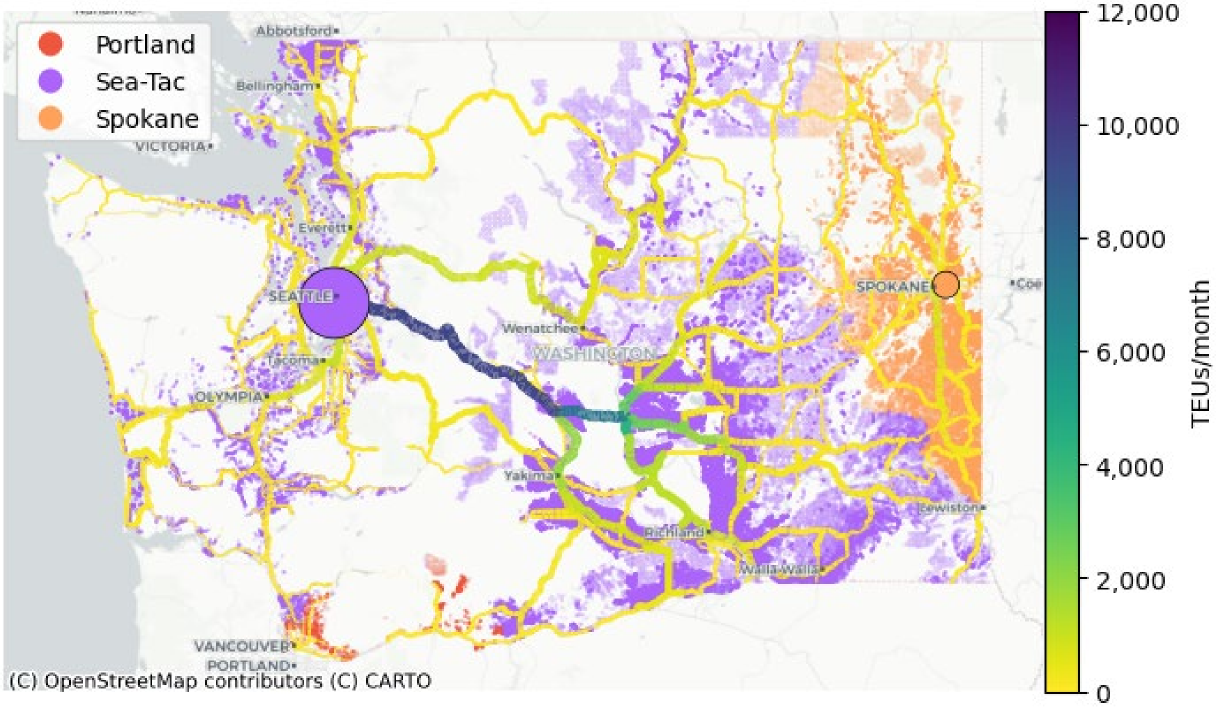
Information on rail transportation costs is derived from consultations with shippers and data from the Surface Transportation Board Confidential Waybill Sample, which provides reported rail rates for a sample of rail shipments within the U.S. The estimated rate per 2 TEU (40 ft container) for rail service to the seaports from each intermodal terminal is: Ellensburg: $800, Quincy: $1,000, Spokane: $1,475, Wallula: $1,200.

RESULTS

For each operational scenario, commodity flows from each production origin are identified based on the least cost mode/route. In total, 14,244 TEUs/month of containerized agricultural exports are modeled across 32,023 production origins, all destined for export from Sea-Tac.

Without an inland terminal, shippers exporting containerized products through the seaports truck export containers long distances to the seaport. Figure 6 shows shippers' terminal choices, terminal throughput volumes, and truck flows under the baseline scenario. Townships are shaded to reflect their terminal choice, where darker shaded regions indicate higher volume townships. Under this baseline scenario, an estimated 87% of all containerized export volumes are trucked to the seaports, with an estimated 9,518 TEUs/month (4,759 trucks/month) transiting Snoqualmie Pass. Shippers located near Spokane truck their export containers to Spokane where they are loaded onto trains for delivery to the seaports. A small number of shippers (120 TEUs/month) ship from Portland to Sea-Tac via rail.

Figure 6: Terminal Choices and Traffic Flows - Not Operational Scenario



The introduction of an inland terminal diverts export volumes from being trucked to the seaports, by drawing shippers' business within proximity of the inland terminal. Figure 7 shows shippers' terminal choice and volume flows after the introduction of an inland terminal in Ellensburg. An inland terminal in Ellensburg is estimated to reduce truck miles traveled from the baseline (Not Operational) scenario by 42%, diverting an estimated 9,365 TEUs/month (2,341 carloads/month) to the inland terminal at Ellensburg, and yielding a 76% reduction in daily port truck traffic. With an inland terminal at Ellensburg an estimated 851 TEUs/month (426 trucks/month) transit Snoqualmie Pass.

Figure 7: Terminal Choices and Traffic Flows - Ellensburg Operational Scenario

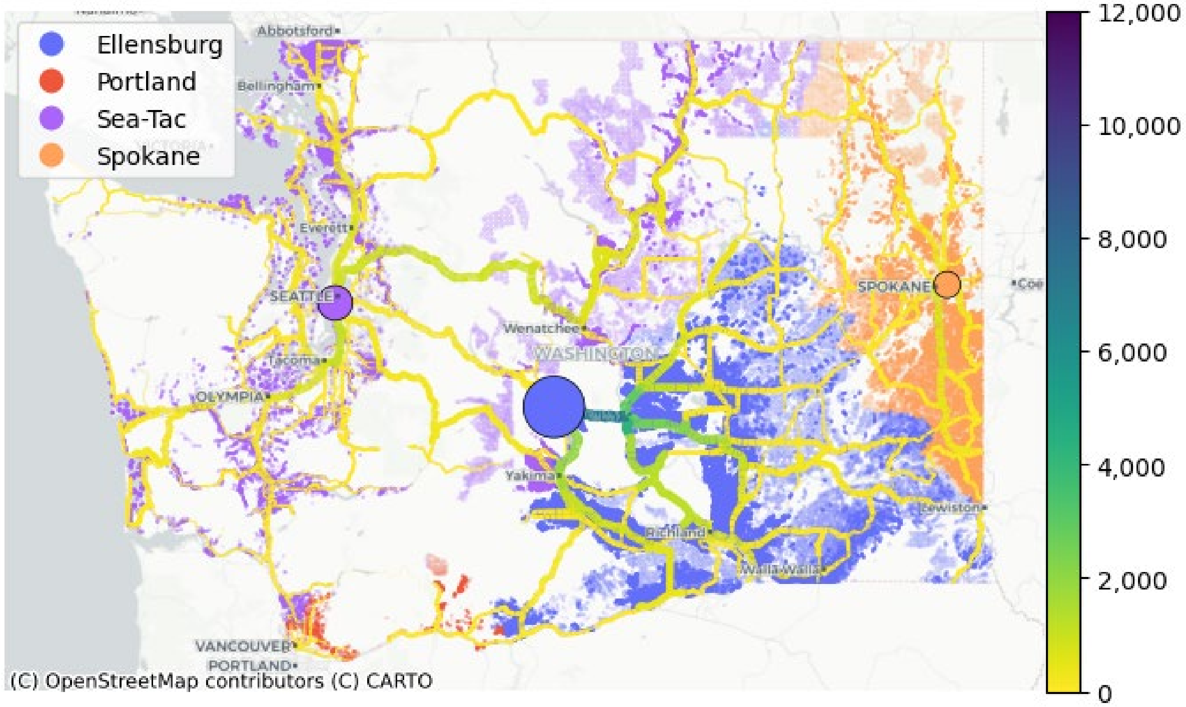


Figure 8 shows shippers' terminal choice and volume flows after the introduction of an inland terminal in Qunicy. An inland terminal at Quincy draws volumes from North of I-90 and West of Spokane. Production in the greater Tri-Cities area continues to be trucked to the seaports. An inland terminal in Quincy is estimated to reduce truck miles traveled from the baseline (Not Operational) scenario by 18%, diverting an estimated 3,176 TEUs/month (794 carloads/month) to the inland terminal at Quincy, and yielding a 24% reduction in daily port truck traffic. Production in the greater Tri-Cities area continues to be trucked to the seaports. With an inland terminal at Quincy an estimated 6,580 TEUs/month (3,290 trucks/month) transit Snoqualmie Pass.

Figure 9 shows shippers' terminal choice and volume flows after the introduction of an inland terminal in Wallula. An inland terminal in Wallula is estimated to reduce truck miles traveled from the baseline (Not Operational) scenario by 22%, diverting an estimated 2,541 TEUs/month (635 carloads/month) to the inland terminal at Wallula, and yielding a 21% reduction in daily port truck traffic. With an inland terminal at Wallula an estimated 6,979 TEUs/month (3,490 trucks/month) transit Snoqualmie Pass.

Figure 8: Terminal Choices and Traffic Flows - Quincy Operational Scenario

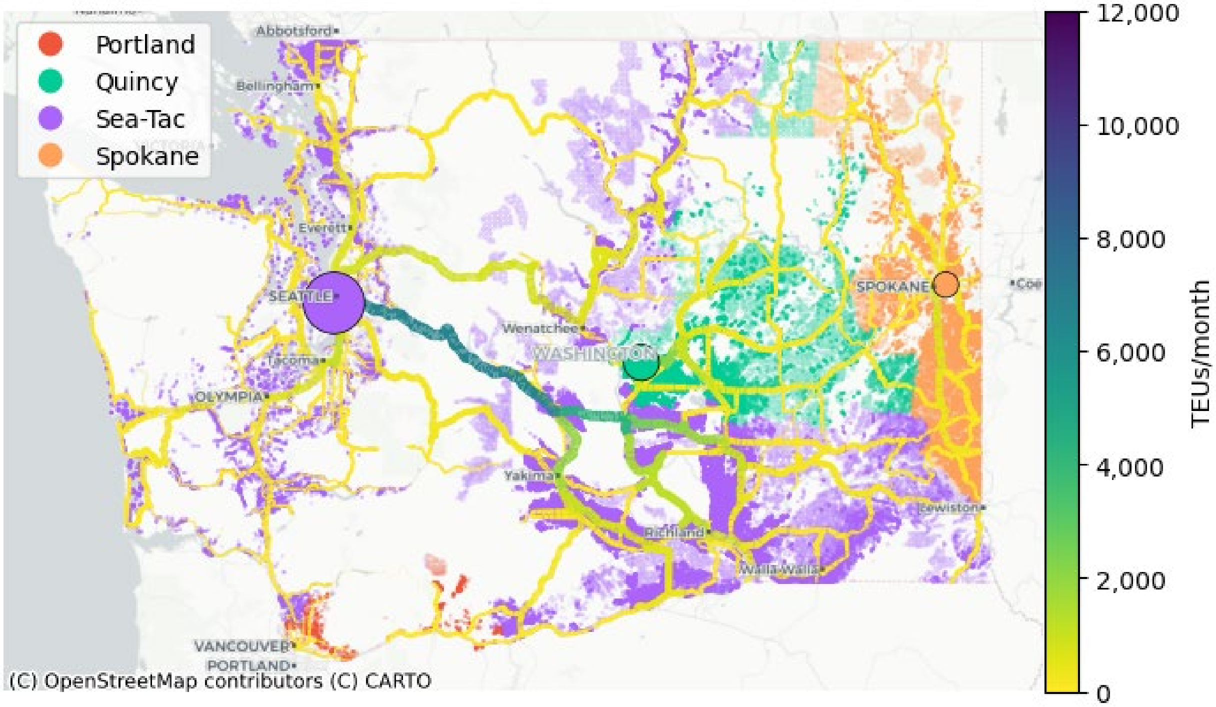
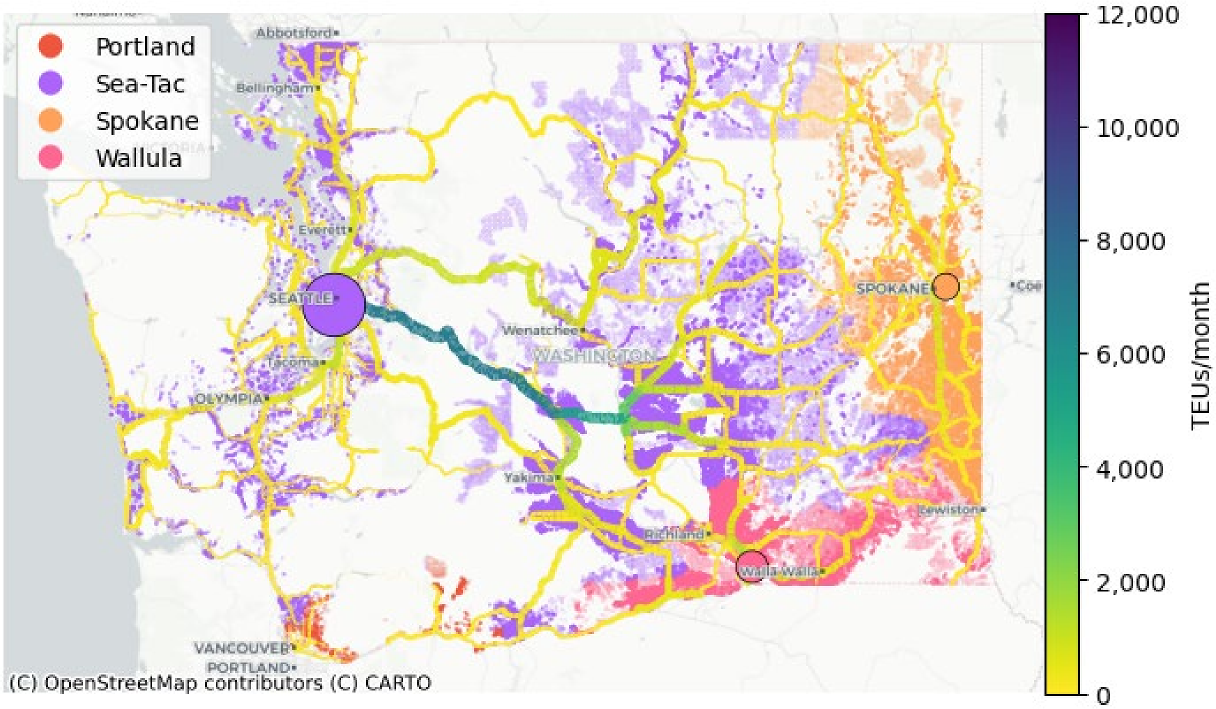


Figure 9: Terminal Choices and Traffic Flows - Wallula Operational Scenario



Throughput volumes for each terminal under each operational scenario are presented in Table 2. Throughput volumes represent each shippers' terminal choice multiplied by their volume of export production. In total, 14,244 TEUs are moved to export in each scenario. From commodity flows, we report truck miles traveled, rail carloads (assuming double stack 40 ft containers), daily port traffic at Seattle and Tacoma, and the average cost to ship a 40ft container to port (Table 3).

Table 2: Terminal Throughput Volumes (monthly)

TEUs/month	Seattle (direct)	Spokane	Portland	Ellensburg	Quincy	Wallula
Not Operational	12,368	1,758	120	-	-	-
Ellensburg	3,002	1,756	120	9,365		-
Quincy	9,342	1,604	120	-	3,176	-
Wallula	9,826	1,755	120	-	-	2,541
Ellensburg and Quincy	2,920	1,603	120	6,440	3,159	-
Ellensburg and Wallula	3,002	1,753	120	6,843	-	2,524
Quincy and Wallula	6,804	1,601	120	-	3,176	2,542
All Operational	2,920	1,600	120	3,919	3,159	2,524

Table 3: System Performance (monthly)

	Truck Miles Traveled	Rail Carloads (double stack 40 ft)	Port Truck Traffic (trucks/day)	Average cost of 40 ft container to port
Not Operational	1,306,462	470	203	$1,423
Ellensburg	757,968	2,810	49	$1,420
Quincy	1,076,615	1,225	153	$1,400
Wallula	1,021,169	1,104	161	$1,379
Ellensburg and Quincy	700,504	2,831	48	$1,398
Ellensburg and Wallula	621,964	2,810	49	$1,377
Quincy and Wallula	791,322	1,860	112	$1,356
All Operational	564,499	2,831	48	$1,354

Inland terminal operations affect private costs through transport costs, and public costs through greenhouse gas emissions, air pollution, noise pollution, congestion, accidents, and roadway wear (Table 4). Transport costs are affected by truck miles traveled and the proximity and service rate of inland terminals. Compared to terminals in Quincy or Wallula, an inland terminal in Ellensburg yields relatively little cost savings to shippers, saving approximately $21,782/month across all shippers or approximately $3/container. Inland terminals in Quincy and Wallula on the other hand, yield $167,451/month ($23/container) and $313,181/month ($44/container) in cost savings respectively.

Public costs are driven predominately by truck miles traveled, as truck traffic has higher emissions and pollution, causes congestion and accidents, and causes damage to public roadways; noise pollution caused by trains is higher cost and is thus increasing in rail miles traveled. An inland terminal in Ellensburg provides the largest public cost savings of $467,226/month ($5.6 million annually). Inland terminals in Quincy and Wallula provide public cost savings of $185,178/month ($2.2 million annually) and $230,206/month ($2.8 million annually) (Table 6).

Table 4: Private and Public Costs (monthly)

	Transport Cost	Emissions	Air Pollution	Noise Pollution	Congestion	Accidents	Roadway Wear
Not Operational	$10,135,992	$159,966	$248,504	$31,473	$195,448	$567,766	$156,775
Ellensburg	$10,114,210	$126,482	$180,481	$51,526	$111,133	$329,400	$90,956
Quincy	$9,968,541	$148,036	$222,265	$42,225	$162,664	$467,878	$129,194
Wallula	$9,822,811	$144,277	$214,985	$44,215	$157,538	$443,782	$122,540
Ellensburg and Quincy	$9,953,536	$124,947	$175,481	$55,952	$104,845	$304,427	$84,060
Ellensburg and Wallula	$9,634,987	$119,722	$165,276	$58,771	$96,121	$270,295	$74,636
Quincy and Wallula	$9,655,361	$132,348	$188,745	$54,972	$124,754	$343,895	$94,959
All Operational	$9,646,213	$118,186	$160,276	$63,201	$89,832	$245,321	$67,740

Private costs, public costs, and total costs for each scenario are reported in Table 5. The difference in private costs, public costs, and total costs relative to the baseline scenario are reported in Table 6. We focus our discussion on the cases where only one inland terminal is operational (Ellensburg, Quincy, or Wallula). An inland terminal at Ellensburg yields the largest public cost savings, while an inland terminal at Wallula yields the largest private and total cost savings.

Table 5: Total, Private and Public Costs (monthly)

	Private Costs	Public Costs	Total Costs
Not Operational	$10,135,992	$1,359,932	$11,495,924
Ellensburg	$10,114,210	$889,978	$11,004,188
Quincy	$9,968,541	$1,172,261	$11,140,802

Wallula	$9,822,811	$1,127,337	$10,950,148
Ellensburg and Quincy	$9,953,536	$849,712	$10,803,248
Ellensburg and Wallula	$9,634,987	$784,820	$10,419,807
Quincy and Wallula	$9,655,361	$939,672	$10,595,033
All Operational	$9,646,213	$744,557	$10,390,770

Table 6: Total, Private and Public Cost Savings (monthly)

	Private Cost Savings	Public Cost Savings	Total Cost Savings
Not Operational	-	-	-
Ellensburg	$21,782	$468,470	$490,252
Quincy	$167,451	$186,187	$353,638
Wallula	$313,181	$231,111	$544,292
Ellensburg and Quincy	$182,456	$508,736	$691,192
Ellensburg and Wallula	$501,005	$573,628	$1,074,633
Quincy and Wallula	$480,631	$418,776	$899,407
All Operational	$489,779	$613,891	$1,103,670

Costs, and cost savings are borne unequally among stakeholders. For localized public costs (e.g., congestion, noise pollution, accidents, roadway wear, air pollution), diverging truck traffic to an inland terminal benefits stakeholders who experience this reduction in truck traffic and thus the reduction in public costs. Placement of an inland terminal at Ellensburg, for example, accrues most public benefits to stakeholders on the I-90 corridor between Ellensburg and Seattle. The reduction of non-localized public costs (e.g., emissions) benefits stakeholders beyond the study region, and are priced to reflect these benefits accrued globally.

Private transport cost savings are accrued only by those for whom the introduction of an inland terminal yields a lower cost alternative. Cost savings generated by a terminal in Ellensburg are widespread, but small, yielding average savings of $4.65/TEU on the shipment of 9,635 TEUs/month (Figure 10). Cost savings generated by a terminal in Wallula are much larger, but concentrated among a smaller subset of shippers, yielding average savings of $260.48/TEU on the shipment of 2,541 TEUs/month (Figure 11).

Figure 10: Private Cost Savings - Ellensburg Operational Scenario

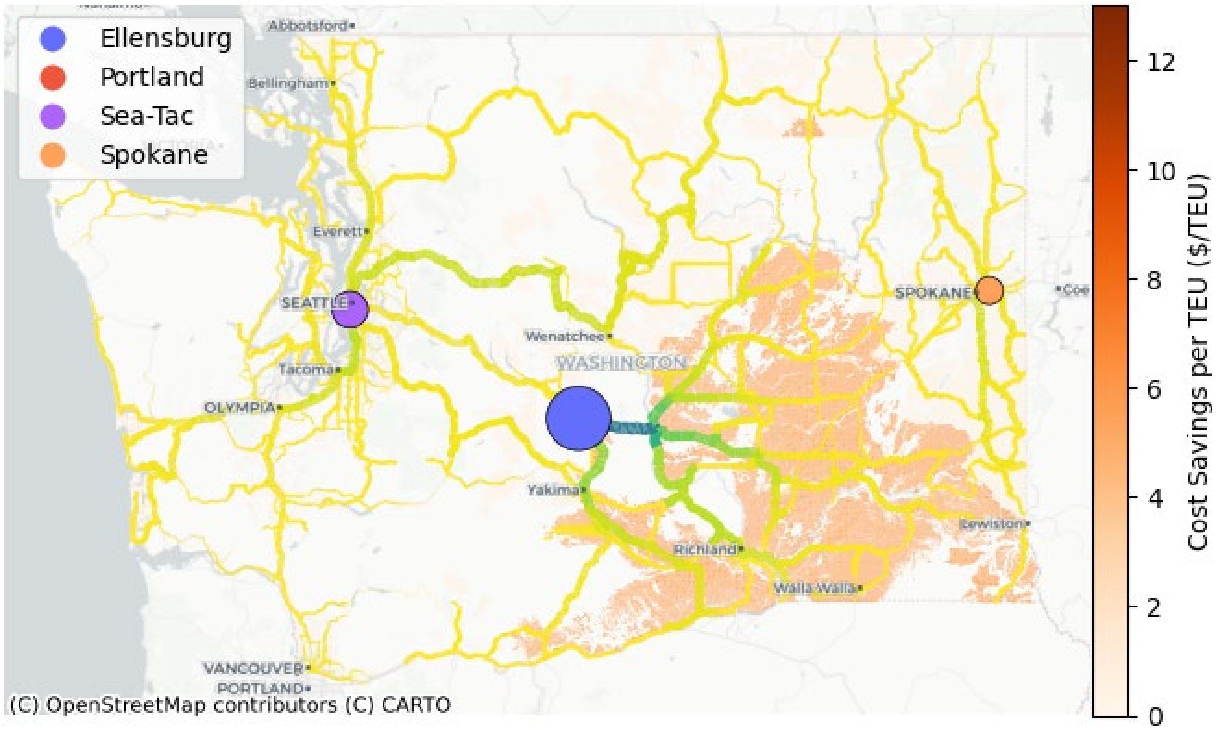
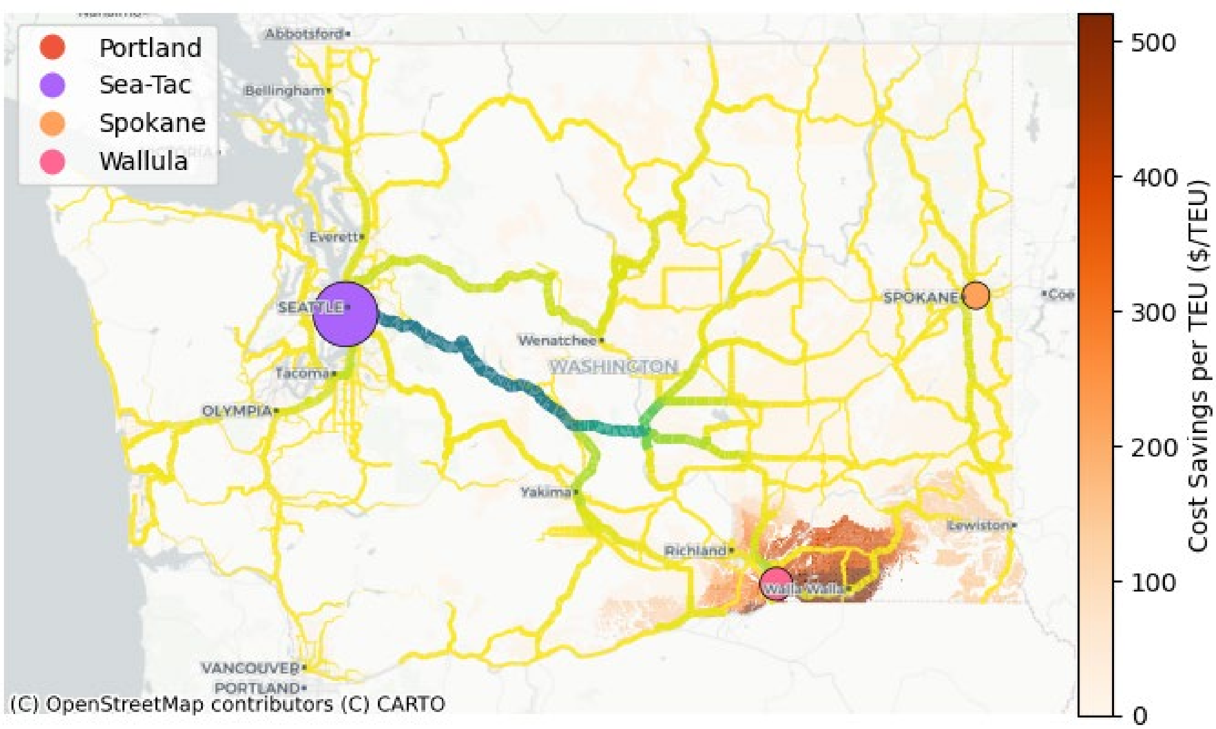


Figure 11: Private Cost Savings - Wallula Operational Scenario



SENSITIVITY ANALYSIS

Figures 12 and 13 show estimated throughput volumes at Ellensburg and Wallula under different rail rates. At rail rates above $800/TEU, rail service at Ellensburg is no longer competitive with cost of trucking, causing terminal throughput volumes to drop to zero as volumes are instead truck directly to Sea-Tac (Figure 12). Comparatively, a terminal at Wallula can sustain a much higher rail rate, however as the rail rate increase throughput volumes fall (Figure 13). At a rail rate of $1,500/TEU, rail service at Wallula is no longer competitive with the cost of trucking.

Figure 12: Rail Rate on Volumes - Ellensburg Operational Scenario

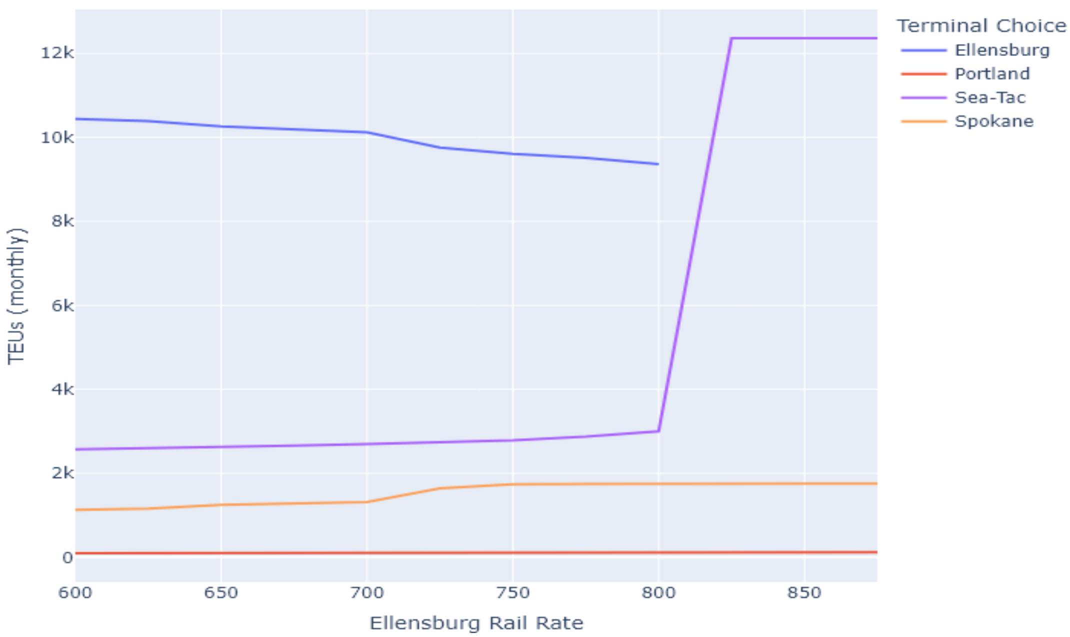
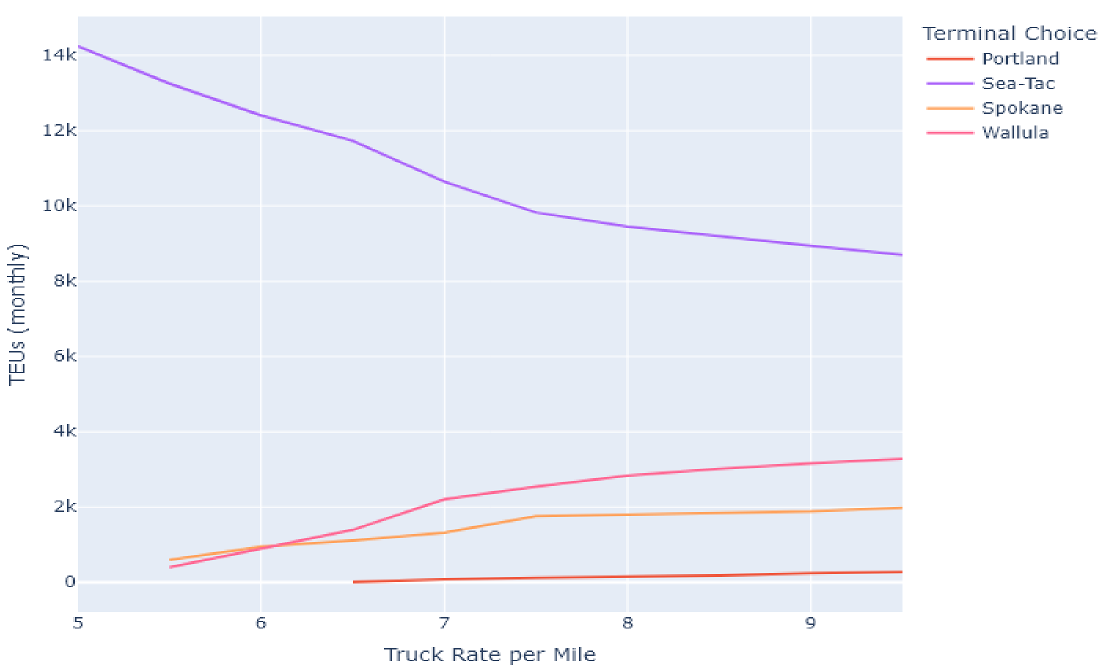


Figure 13: Rail Rate on Volumes - Wallula Operational Scenario

Inland terminals are more (or less) competitive with trucking as the cost to truck freight changes. Figures 14 and 15 show estimated throughput volumes at Ellensburg and Wallula under different truck rates. Truck rates below $7.5/mile (and a rail rate of $800/TEU), cause an inland terminal Ellensburg to no longer be competitive, driving throughput volumes to zero (Figure 14). At truck rates above $7.50/mile a terminal at Ellensburg is estimate to support 9,365 TEUs/month. Higher trucking costs also allow the terminal to remain competitive under higher rail rates. A terminal at Wallula is much less sensitive to truck rates, though even at high truck rates ($9/mile) estimated throughput volumes are 3,167 TEUs/month (Figure 15).

Figure 14: Truck Rate on Volumes - Ellensburg Operational Scenario

Figure 15: Truck Rate on Volumes - Wallula Operational Scenario



DISCUSSION

Positioning an inland terminal at either Ellensburg or Wallula is only viable if the Class 1 railroad is willing to provide adequate rail service. The Class 1 railroads willingness to provide service is dependent on throughput volumes and the rates they can charge. Throughput volumes at Ellensburg far exceed those projected for an inland terminal at Wallula. To be competitive with truck traffic, however, the rail rates offered at Ellensburg must be much lower than the rates offered at Wallula.

Public entities have a stake in the construction and location of an inland terminal, as an inland terminal within the region can generate significant public cost savings. Public entities can contribute to the construction of an inland terminal via cost share with the railroad(s). Public entities can also play a role in diverting traffic to an inland terminal through subsidies for terminal utilization, or discouraging port-bound truck traffic through port delivery fees (Figures 16-17). Ultimately investment decisions in an inland terminal are costly and are best served if coordinated between the public and private sectors.

There are several limitations of this work to be addressed. First, containerized export volumes are limited to agricultural exports and limited to only production volumes grown or processed (or positioned for storage) in Washington. Inland terminals in Washington may handle non-agricultural cargo, and may handle agricultural and non-agricultural cargo originating outside of Washington. Export volumes originating outside of Washington would affect throughput volumes at an inland terminal located at Wallula, and may affect throughput volumes at Ellensburg. Exclusion of these volumes causes the public and private cost savings of an inland terminal to be underestimated.

Second, for the purpose of computed truck miles traveled, truck traffic is assumed to be one-way, or with a non-empty backhaul. To the extent that a share of truck traffic volumes are roundtrip with an empty backhaul, then the truck traffic reported in each scenario are undercounted. In this case, the affect of inland terminals taking truck traffic off the road has been undervalued, yielding and underestimate of public cost savings.

Third, terminal infrastructure construction costs and terminal operating costs are omitted from this analysis. Terminal infrastructure costs and operating costs may be different at each proposed facility, which is relevant in site selection.

Fourth, the prices on external public costs are hotly debated and in many cases may be situationally and regionally specific. For example, congestion costs in Seattle near the port during rush hour are much higher than congestion on I-90 near Ellensburg in the middle of a week day. These differences are accounted for by pricing congestion differently on rural and urban road segments, but a more refined pricing mechanism may be required to more fully capture public cost savings.

Finally, some private and public costs/savings are omitted from analysis including: the rehabilitation of industrial property near the port; congestion relief and operating efficiencies at the port; changes in local and regional economies caused by an inland terminal and the new traffic flows; intermodal delays or service quality; import movements of containerized products; and many others.

Ultimately the construction of an inland terminal is a capital intensive, high risk investment. This work provides estimates of throughput volumes, private cost savings, and public cost savings for three proposed inland terminals in Eastern Washington. Decision makers are tasked with evaluating the validity of these estimates, and in the case of the railroad(s) identifying if projected throughput volumes are lucrative enough to build and operate a terminal, and in the case of public entities identifying what role they are willing to play in the construction of an inland terminal for the benefit of public cost savings.

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SUPPLEMENTARY FIGURES

Figure 16: Terminal Fee on Volumes - Ellensburg Operational Scenario

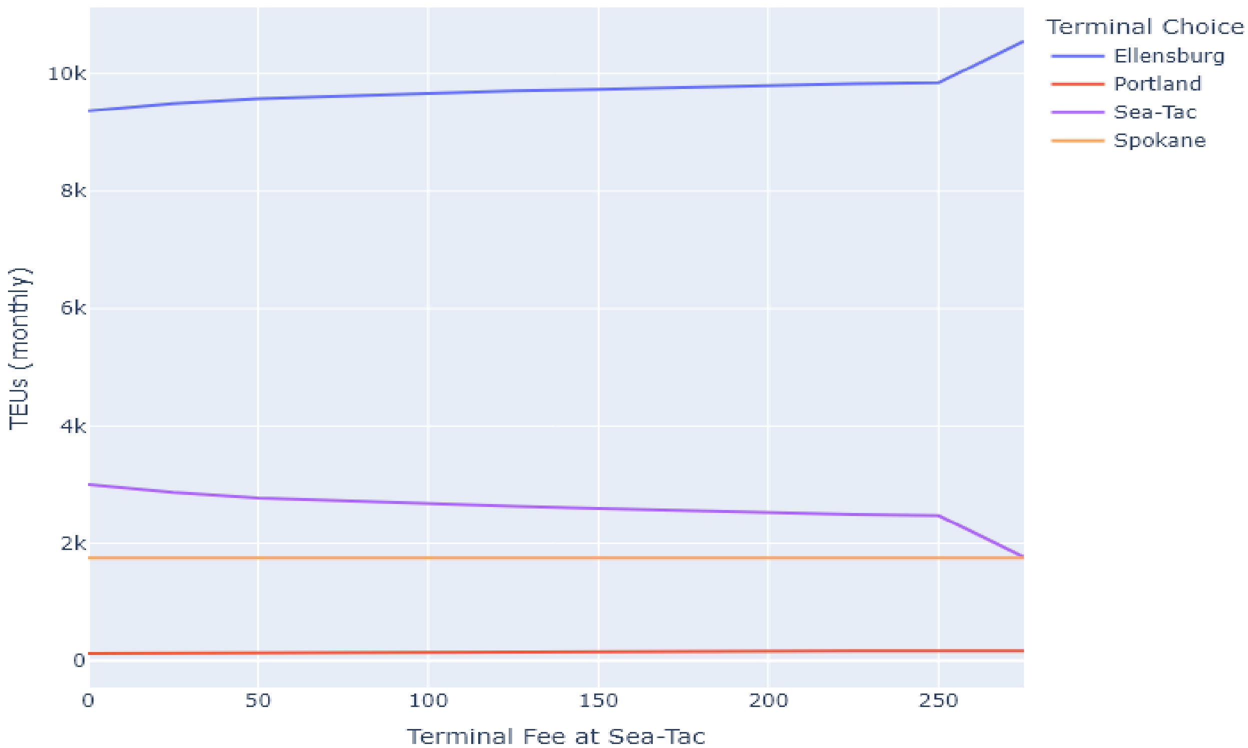

Figure 17: Terminal Fee on Volumes - Wallula Operational Scenario