



TO: David Danner, Chairman
Philip B. Jones, Commissioner
Ann Rendahl, Commissioner
Steve King, Executive Director

FROM: Rail Safety Rulemaking Team

DATE: January 7, 2015

SUBJECT: Rail safety rulemaking related to ESHB 1449, Docket TR-151079
Oil Train Safety Rulemaking

Synopsis

The Oil Train Safety rulemaking before the Commission is one part of a larger effort to enhance safety around crude oil trains and mitigate, to the extent possible, risks posed by the transportation of oil by rail in the state of Washington. The Commission participated in the Oil Transportation Study (Study)¹, led by the Department of Ecology (ECY) at the direction of the 2014 legislature. The Study was further tasked by the Governor² with analyzing oil transportation in regards to marine and rail along with developing recommendations to enhance safety and environmental stewardship. As a result of the study, the Governor requested legislation on oil movements by marine and rail. The recommendations that the Commission and ECY submitted during the Study were drafted into the Governor's legislation (HB 1449). The passage of HB 1449 gave the Commission regulatory authority over a few key areas (private shipper property, private crossings, first class city opt-in and financial responsibility reporting) along with increasing the regulatory fee paid by the railroad industry to provide more Commission railroad inspectors.

This rulemaking is necessary to implement ESHB 1449, as signed into law on May 14, 2015.

¹ <https://fortress.wa.gov/ecy/publications/SummaryPages/1508010.html>

² http://www.governor.wa.gov/sites/default/files/directive/dir_14-06.pdf

Commission Provisions in ESHB 1449

Private Shipper Property (Not part of the rulemaking)

Before the passage of ESHB 1449, Commission employees needed an escort from the Federal Railroad Administration (FRA) to enter private shipper property to conduct hazardous materials inspections. This requirement created delays in inspections and inefficient scheduling. After the passage of ESHB 1449, Commission employees that are FRA-certified inspectors are able to go onto shippers property, with prior notice, to inspect any rail cars, review documents (generally located near the rail cars) and observe any loading or unloading of hazardous materials. The inspector then forwards notice of any defects to the Federal Railroad Administration for enforcement. Since 2010 there have been approximately 134 safety defects discovered during these inspections.

Private Crossings along Oil Routes

Before the passage of EHB 1449, neither the state nor federal government had authority over private crossings. This provision allows the Commission to adopt minimum safety language at private crossings along oil routes and gives the Commission authority to inspect the crossings. There are approximately 3,000 private crossings in the state of Washington, with 350 along the oil routes.

Increase in Regulatory Fee

The Commission rail program is funded by fees paid for by the railroad industry. The current fee on railroads is 1.5 percent of the gross annual intrastate operating revenues. Existing fees do not apply to oil, since oil is considered an interstate activity. ESHB 1449 allows for an increase in the regulatory fee, up to 2.5 percent, for railroads that haul crude oil. The increase in regulatory fees allows the Commission to hire additional inspectors in the areas of track, hazardous materials, motive power and equipment, signal and train control and operating practices.

First Class City Opt-In

First-class cities are exempt from the Commission's railroad safety jurisdiction. However, the influx of hazardous materials and train traffic has overwhelmed the resources of some first-class cities. This provision allows first-class cities to opt in to the Commission's grade crossing inspection program. There is also a requirement that first-class cities inform the Commission when crossings are opened or closed.

Financial Responsibility Reporting

ESHB 1449 requires each railroad company to provide information on the company's ability to pay for a reasonable worst case spill in its annual report to the Commission. The Commission is prohibited from using the information in the reports as a basis for developing economic regulations or issuing penalties against railroad companies.³

Background

There have been significant changes in the transportation of crude oil in the state. Historically, 90 percent of crude oil used by Washington refineries was delivered by tank ship. However, in 2014, pipeline and rail delivery accounted for approximately 30 percent of the oil imported. In addition to the increase in oil being imported via rail, there is a concern surrounding the volatility of some of the types of oil, like Bakken crude.⁴

Concerns regarding oil transportation led the Legislature to authorize the Oil Transportation Study in April of 2014. The objective of the Study was to analyze the risks to public health and safety associated with the transport of oil in Washington. Final recommendations were delivered to the Legislature and Governor in March of 2015. Prior to completion of the study, in October of 2014, Governor Inslee requested a preliminary set of recommendations regarding oil transportation. The Commission provided a list of recommendations that were incorporated into Governor-request legislation (ESHB 1449) and ultimately signed into law.

Notice of Opportunity to File Written Comments

On May 22, 2015, the Commission published a "Notice of Opportunity to File Written Comments" and distributed it to the list of rail stakeholders on file at the Commission, those individuals that signed up and/or testified at one of the legislative hearings on oil by rail, the railroads in the state and legislative staff. The Commission also posted it on its website. The notice served the purpose of informing interested persons of a scheduled workshop to discuss the rulemaking and to ask three questions related to the rulemaking. The Commission asked the following questions:

1. What is your definition of a reasonably likely worst-case spill of oil?
2. What is a reasonable per-barrel cleanup and damage cost of spilled oil?
3. What risk factors should the Commission consider in establishing safety standards on private crossings?

³ Financial responsibility is explained in greater detail in the justification section of the memo

⁴ <https://fortress.wa.gov/ecy/publications/SummaryPages/1508010.html>

The Commission accepted comments until June 22, 2015, and received more than 240 responses. A summary of the comments are below.

Many of the comments focused on the need for the Commission to stop oil trains and oil facilities, as well as the need to guarantee safety before allowing trains to transit Washington state. Federal preemption precludes the Commission from stopping trains, setting train speeds or interfering with interstate commerce.

In general, comments can be summarized as follows:

1. In looking at a “reasonable worst case spill” consider:

- A spill could include 1 to 3.5 million gallons of fuel.
- An explosion could result, causing further damage and clean-up costs.
- Environmental impacts can drive up costs.
- A worst case spill should be calculated at the largest foreseeable discharge of oil.
- A worst case spill should be considered one tank car.

2. Reasonable clean-up costs should be calculated at:

- \$78,750 per barrel.
- The clean-up amounts estimated in Ecology studies.
- The cost of all impacts, including environmental, human, economic, etc.
- \$175 per barrel.

3. Rules for private crossing safety should include risk factors such as traffic, type of cargo and location of the crossing. Railroads suggest maintaining existing contractual relationships between the railroads and private crossing owners.

4. The Commission should stop oil projects and trains completely.

5. The Commission needs to keep federal preemption in mind in thinking about any new rules.

Workshop

A workshop was held at the Commission on July 8, 2015. The comments received at the workshop were from the railroad industry and concerns from the Confederated Tribes of the Warm Springs Reservation of Oregon.

CR-101 Draft Language

On August 21, 2015, the Commission issued draft language on opt-in for first class cities, private crossing signage standards, an increase in the regulatory fee paid by railroads hauling crude oil and financial responsibility standards for railroads that haul crude oil. The Commission received comments from eight respondents.

Stakeholder Response

The comments received from respondents to the draft language can be summarized as follows:

1. First Class Cities Opt-In
 - a. Karen Hengerer
 - i. UTC should require participation
2. Private Crossings
 - a. Tacoma Rail
 - i. Recently made significant investment to comply with federal Emergency Notification System (ENS) regulation 49 CFR 234
 - ii. Requests language that would honor investments already made on existing signage
 - b. Kennewick Terminal Railroad & Western Washington Railroad
 - i. Language is duplicative and conflicts with federal standards
 - ii. Ninety days is not enough time to respond to a Commission finding
 - c. Dow Constantine
 - i. Supports language
 - d. Confederated Tribes of the Warm Springs Reservation of Oregon
 - i. Recommends installation of stop signs where no automatic grade crossing protective device is installed
 - e. Johan Hellman (BNSF)
 - i. Supports language in the private crossing section
3. Regulatory Fees
 - a. No comments received
4. Financial Responsibility
 - a. Tacoma Rail
 - i. Kinetic energy scale-down is flawed
 - ii. Consideration should be given to railroads that operate at speeds less than 45 miles per hour
 - iii. Tacoma Rail does not exceed 10 miles per hour
 - b. Kennewick Terminal Railroad & Western Washington Railroad
 - i. Item 2(d), relating to information sufficient to demonstrate a railroad's ability to pay the cost of a reasonable worst case spill, is burdensome and potentially in conflict with federal requirements.
 - c. Karen Hengerer
 - i. \$400 gallon is not high enough
 - d. Dow Constantine
 - i. Supports definition of reasonable worst case
 - ii. Recommends a per-gallon clean up of \$1,880 (Lac-Megantic costs)
 - iii. \$400 per gallon only captures clean up and not loss of life, property damage, loss of tribal access, etc.
 - e. Confederated Tribes of the Warm Springs Reservation of Oregon
 - i. Reasonable worst case should be the largest foreseeable discharge

- ii. There should be no cap on liability
- iii. There should be a format for reimbursement to federal, state, tribal and local governments
- iv. Natural resource damage assessment should be included
- f. Johan Hellman (BNSF)
 - i. Concerns with the definition of reasonable worst case and clean-up costs of \$400 gallon
 - ii. PHMSA never defined reasonable worst case in scale-down approach
 - iii. Lac-Megantic is not representative of a worst case
 - iv. Numerous safety enhancements have been adopted and reduce PHMSA scale-down calculation
 - v. PHMSA's scale-down costs were in the event that federal rules were not adopted
 - vi. Supports using historical data to determine reasonable worst case instead of Lac-Megantic

5. Other

- a. Jeanne Poirier
 - i. Concerns regarding oil and coal transportation
 - ii. Draft language does not go far enough
- b. Karen Hengerer
 - i. Rules should not be on an opt-in basis
- c. Confederated Tribes of the Warm Springs Reservation of Oregon
 - i. Opposed to the transportation of oil in general due to the impact to the tribe

CR-102 Draft Language

Technical changes were made in the CR-101 draft language stage to address stakeholder comments. Some of the changes that were addressed dealt with:

- Private crossings – Allowing 120 days to correct deficiency from the time of notification.
- Financial Responsibility Reporting – Converting the cleanup costs to a per barrel basis instead of per gallon and allowing the reporting requirement to be based on operating speed.

Federal Action

The federal government has taken several actions that may impact the movement of oil by railroad within our state. These include:

- A study that may remove electronically controlled pneumatic brakes from the federal enhanced tank car rule (Docket No. PHMSA-2012-0082 (HM-251)). This would eliminate the only derailment mitigation measure addressed in the rulemaking. A separate

action, in HR-22, Fixing America's Surface Transportation Act, Section 7311, directs the Comptroller General to conduct an independent evaluation of electronically controlled pneumatic brakes and determine whether or not the benefits outweigh the costs.

- HR 22, Section 7310, requires the USDOT Secretary to initiate a study on the levels and structure of insurance for railroads transporting hazardous materials.
- On December 18, 2015, President Obama signed the law removing the ban on crude oil exports. Crude oil export restrictions were introduced in the US in 1975 in the middle of the energy crisis. It is unknown how many more unit trains will traverse Washington due to lifting the export ban.

Financial Responsibility Methodology

In its determination of financial responsibility reporting, the definition of a “reasonable worst case” spill and the scope and costs associated with cleanup, the Commission staff relied heavily on the federal agencies charged with regulating the railroads and the tank cars that are used by railroads, the Pipeline Hazardous Materials Safety Administration (PHMSA) and the Federal Railroad Administration (FRA). PHMSA is an agency within the USDOT and is responsible for establishing and enforcing requirements for the safe transport of hazardous materials by all modes of transportation. This includes the design of railroad tank cars carrying crude oil. PHMSA was created in 2004 to provide USDOT with a more focused research organization and establish an operating administration for the inspection and enforcement of requirements for pipeline safety and hazardous materials transportation. The FRA is also an agency within the USDOT and has jurisdiction over railroad safety at the federal level. FRA was created by Department of Transportation Act of 1966 and was charged with the uniform administration of the Federal Railroad Safety Act. Under the FRA region designation, Washington is located in FRA Region 8, along with Alaska, Idaho, Montana, North Dakota, Oregon, South Dakota, and Wyoming.⁵

The Commission was charged with defining a “reasonable worst case” spill and calculating costs for the purposes of reporting by the railroads that haul crude oil. Staff looked at the implementing legislation in determining the scope of the definition and intent. As originally drafted, the financial responsibility reporting was intended to be a certificate of financial responsibility that would be reported to ECY. The legislature amended the language to create a simple reporting function on the railroads annual report submitted to the Commission. The legislature specifically prohibited any punitive actions based on the information provided and expressly stated that the report was not a means of economic

⁵ Oil Transportation Study, page 86.

regulation. Instead of defining the reporting for a “worst case” spill, the legislature used the term “reasonable worst case” for the purposes of reporting. Commission staff looked to the federal agencies charged with regulating railroads and at the conditions and requirements for a certificate of financial responsibility in determining the necessary scope for the reporting requirement. According to the Pacific States/B.C. Oil Spill Task Force, the certificate of financial responsibility requirements for the west coast states are as follows:⁶

⁶ http://www.oilspilltaskforce.org/docs/project_reports/CofrMatrix2.pdf

RESPONSIBLE PARTY OR DAMAGE TYPE	ALASKA (SEE CITATIONS BELOW)	BRITISH COLUMBIA (CANADA) ²	WASHINGTON (SEE RCS 88.40)	OREGON (SEE ORS 468B.390)	CALIFORNIA (CCR TITLE 14, SECTIONS 791-797 S.8670.32 AND S.8670.56.5)
Small Tank Barges	Same as for large tank barges (see below)	See below	Tank barges < 300 GT: Greater of \$2 million or \$3,000/bbl for persistent oil	None	Tank barges <150,000 bbls: \$12,500 x 30% maximum cargo capacity
Tank Vessels and Large Barges	Greater of \$469.80/bbl of crude capacity or \$156.6 million, per Greater of \$156.60/bbl of non-crude capacity or \$1.566 million per incident, up to a maximum of \$54,810,000. See AS 46.04.040 and 18 AAC 75.235	The Canada Shipping Act between convention ships and Non-convention to the CLC/Fund scheme of recently amended in 1992. convention means seagoing wherever registered carrying in cargo, crude oil, fuel oil, lubricating oil or any other hydrocarbon mineral oil or on a following any such carriage unless it is proved that there residue of the oil on board. maximum liability under Convention ship in respect of occurrence is if the ship has a of not more than 5,000 tons, units of account (SDRs) and if has a tonnage of more than 4,510,000 units of account for 5,000 tons and 631 units of each additional ton, not 89,770,000 units of account aggregate.	For all tank ships and tank barges =>300 GT (\$1 billion after 1/1/04)	>300 GT & < 3000 Greater of \$2 million or >3000 GT: Greater of million or \$1200/gross ton ³	

In addition to reviewing the certificate of financial responsibility requirements, Commission staff looked to the state of California in its recently adopted regulation on certificate of financial responsibility and contingency plan standards on railroads that haul crude oil.⁷ The state of California defined a “reasonable” worst case spill as “(C) Railroads: Twenty percent (20%) of the maximum volume of oil cargo that a railroad may transport by a single train within the state (e.g. a manifest train or a “unit train”), based on 714 barrels per tank car.”⁸ Because the Commission started its rulemaking before California’s certificate of financial responsibility rule was finalized and because Commission staff could not determine the methodology that California used in its regulation, staff relied on the federal enhanced tank car rule, Docket No. PHMSA-2012-0082 to determine “reasonable worst case” spill of oil and the associated cleanup costs. The data that PHMSA and the FRA presented in its rulemaking was the most complete and exhaustive analysis available on the subject.

In determining a “reasonable” worst case for the purposes of the regulation, staff needed to look at a scenario that would be less than the worst case scenario described in the certificate of financial responsibility and less than the worst recorded tragedy in North America. However, staff did not believe that a “reasonable” worst case spill was synonymous with a most probable or an average derailment. In the United States, historical evidence of derailments show an average derailment of 9 cars.⁹ The largest derailment of crude and ethanol in the U.S. is 31 cars.¹⁰ In looking for a comparison of “reasonable worst case,” the Commission noted that it is similar but not necessarily interchangeable with the PHMSA analysis of High Consequence Event used in the previously referenced enhanced tank car rule.

PHMSA determined that High Consequence Events are “events that exceed the “typical” derailment event because they would result either in multiple fatalities or injuries, or would cause greater environmental damages than a typical derailment.”¹¹ In its evaluation of criteria for calculating costs of a reasonable worst case spill, Commission staff elected to use the PHMSA scale down methodology that was used in the federal Enhanced Tank Car Rule. The PHMSA approach was applied, in determining reasonable worst case, primarily for two reasons. First, the tragedy in Lac Mégantic, Quebec is to-date the worst case example of a catastrophic derailment in North America involving crude oil. Using the tragedy in Lac Mégantic, Quebec as a worst case scenario seems appropriate. While it is true that a catastrophic event like what was seen in Lac Mégantic, Quebec could be exponentially worse, staff considered that the catastrophe in Quebec was the result of a number of failures, and that the USDOT has adopted regulations to ensure such an event would not happen

⁷ <https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=107198>

⁸ 14 CCR § 817.04 § 817.04. Inland Facilities.

⁹ Journal of Hazardous Materials 276 (2014) 442-451,

<http://railtec.illinois.edu/articles/Files/Journal%20Articles/2014/Liu%20et%20al%202014%20JHM%20Multiple%20Car%20Release.pdf>.

¹⁰ Final Regulatory Impact Analysis, Docket No. PHMSA-2012-0082, at 98.

¹¹ Final Regulatory Impact Analysis, Docket No. PHMSA-2012-0082, at 52

again. Staff considered new federal regulations adopting enhanced tank car requirements to mitigate the risks associated with moving crude oil by rail. Ultimately, staff chose to move forward with the scale down approach used by PHMSA because, while there were safety measures adopted through the enhanced tank car rule, those safety measures would not be fully implemented for ten years. However, since it appears the electronically controlled pneumatic brakes may be removed from the enhanced tank car regulations, staff believes it is prudent to define a “reasonable worst case” as though there were no additional safety measures adopted at the federal level.

In applying the scale down calculation, staff accepts the PHMSA assertion that kinetic energy varies directly with the square of speed. In Lac Mégantic, the train in question was travelling at a rate of 65mph¹² and resulted in the loss of approximately 78% of its crude oil cargo or 1.59 million gallons. PHMSA calculations on average train derailments in the U.S. use an average speed of 41 mph in determining a “scale down” calculation of Lac Mégantic. While this is used to illustrate monetary assumptions, an assumption on damage should be calculated using the operating speeds in the state. Kinetic energy = $\frac{1}{2}$ Mass x (Velocity)². Staff agreed with the PHMSA assumption that loaded high hazard flammable trains are of equal mass. While the purpose of the kinetic force scale down calculation in the federal Enhanced Tank Car Rule was to show the projected number of high consequence events over the next 20 years in the absence of the federal Enhanced Tank Car Rule, staff believes that because it will take ten years to phase out older tank cars, and because the only mitigating factor in derailments will likely be removed, the calculation can be used to determine a “reasonable worst case.”

As an example, a railroad that operates crude oil trains at a maximum speed of 45 mph would have a reasonable worst case spill of approximately 48%.

There were a number of factors the Commission staff weighed in the evaluation of the definition of “reasonable.” These include comments received (Dow Constantine, Confederated Tribes of the Warm Springs Reservation, Tacoma Rail and BNSF), history of derailments, safety measures in place to prevent or reduce derailment impacts, damages of largest crude oil train, tribal impacts, implementation of the federal Enhanced Tank Car Rule, environmental impacts of a spill, consistency with federal and state standards, and regulatory authority of the Commission. Staff also considered the federal agencies that regulate railroads, the data used in determining safety considerations for enhanced tank cars, existing regulations pertaining to certificates of financial responsibility and states that have adopted regulations on “reasonable” worst case spills and the cost calculation used to determine the necessary financial resources needed by a railroad.

The cost for a cleanup of a “reasonable worst case” spill was weighed using the same data. It would not seem reasonable to have a cleanup cost disproportionately greater than existing

¹² Railway Investigation Report R13D0054, <http://www.tsb.gc.ca/eng/rapports-reports/rail/2013/R13D0054/R13D0054.pdf>.

financial responsibility reporting requirements. Staff needed to determine the scope of the cleanup costs and damages as used in the legislation. Given that the financial reporting requirement started as a certificate of financial responsibility and that the term damages were not defined, staff used the certificate of financial responsibility and the final bill report as a guide. As stated in the ESHB 1449 bill report, “Railroads that transport oil as bulk cargo must provide information to the UTC regarding their ability to pay for a reasonable worst-case spill of oil, an amount which is to be calculated by multiplying the reasonable anticipated per-barrel cleanup costs by the reasonable worst case spill volume. This information is to be provided to the UTC as part of railroad's annual report, and the UTC may not use this information to economically regulate or penalize a railroad.”¹³

In evaluating how the per barrel costs should be calculated, Commission staff received comments requesting that it look towards ECY past rulemakings in its calculations. ECY is in the process of adopting contingency plan standards for railroads, which Commission staff supports, but available data on cleanup and damage costs by ECY do not seem to be appropriate for this reporting function. ECY costs are more applicable to maritime. The Commission will be interested in the calculations that ECY uses in its ongoing rulemaking.

Costs by Quantity and Oil Type ¹⁴				
			Environmental Damage	Socioeconomic Cost
Oil Type	Volume (Gallons)		2005\$ / Gallon	2005\$ / Gallon
Volatile Distillates	<500		\$51	\$69
	500-1,000		\$48	\$281
	1,000-10,000		\$37	\$425
	10,000-100,000		\$32	\$191
Light Fuels	<500		\$90	\$85
	500-1,000		\$85	\$350
	1,000-10,000		\$74	\$531
	10,000-100,000		\$69	\$212
Heavy Oils	<500		\$101	\$159
	500-1,000		\$96	\$637
	1,000-10,000		\$90	\$955
	10,000-100,000		\$80	\$531
Crude Oil	<500		\$96	\$53
	500-1,000		\$92	\$212
	1,000-10,000		\$85	\$318
	10,000-100,000		\$77	\$149

Table 7.1:

Environmental and Socioeconomic Damage Estimates

The weighted average of these costs provides an estimate of the value that may accrue for removal on an overall per gallon basis for a large number of spills. The costs were weighted based on the share of spills in each of the sized classes. Further weighting by the shares of light and heavy oils give an average value of \$124 per gallon for socioeconomic damages and \$86 for environmental losses.

¹³ <http://lawfilesexternal.wa.gov/biennium/2015-16/Pdf/Bill%20Reports/House/1449-S.E%20HBR%20FBR%2015.pdf>

¹⁴ Final Cost Benefit Analysis for Oil Spill Contingency Planning

The Commission determined that a clean-up cost of \$400 per gallon should be used in determining the financial reporting, based primarily on the federal enhanced tank car rule. In determining the cleanup costs associated with a “reasonable worst case” spill, the Commission looked at costs associated with the spill and did not take into account those costs outside of the spill or spill cleanup. In addition, the Commission looked at the PHMSA enhanced tank car regulation, where the federal government determined that an event like Lac Mégantic “would not be representative of damages from a typical accident or even a high consequence accident.”¹⁵ One recent higher consequence event was the Lynchburg, Virginia incident which resulted in 30,000 gallons spilled. The emergency response and cleanup costs for that incident were reported to the FRA by CSX as \$8.99 million. Of this \$8.99 million cost, an estimated \$5 million was due to environmental damage. The CSX estimate of the costs of Lynchburg results in a cost per gallon of crude of about \$300.¹⁶

The weighted average of the per gallon estimates from all the federal Enhanced Tank Car Rule listed literature, including marine, pipeline and rail, is between \$ 407 to \$415 per gallon spilled of crude oil or ethanol. It is unlikely that any of these estimates capture the full comprehensive societal damages that result from these incidents.¹⁷ The PHMSA Final Regulatory Impact Analysis for the Federal Enhanced Tank Car rule stated that costs for crude oil for rail carriers was estimated at \$200 per gallon but “the review found that damages could be as high as twice that amount for crude oil spills.”¹⁸ Further, the 1999 Etkin¹⁹ crude oil study had a cost of \$326 per gallon for cleanup and the 2012 Marruffo²⁰ study showed a cleanup cost of \$378.34 for crude oil by rail.²¹

Based on the available information, the Commission has elected to propose a reasonable worst case definition that would use the kinetic force scale down formula, using the railroad’s maximum operating speed for a train moving oil. The cleanup cost to be used in the reporting regulation is \$16,800 per barrel, or \$400 per gallon.

¹⁵ Final Regulatory Impact Analysis, Docket No. PHMSA-2012-0082, at 87

¹⁶ Final Regulatory Impact Analysis, Docket No. PHMSA-2012-0082, at 87

¹⁷ Final Regulatory Impact Analysis, Docket No. PHMSA-2012-0082, at 115

¹⁸ Final Regulatory Impact Analysis, Docket No. PHMSA-2012-0082, at 86

¹⁹ Etkin, D.S. “Estimating Clean-up Costs for Oil Spills.” Proceedings, International Oil Spill Conference, 1999

²⁰ Marruffo, Amanda, Hongkyu Yoon, David J. Schaeffer, Christopher P. L. Barkan, Mohd Rapik Saat, and Charles J. Werth. “NAPL Source Zone Depletion Model and Its Application to Railroad-Tank-Car Spills.” *Groundwater* 50, no. 4 (2012): 627–632

²¹ The model described in Marruffo (2012) model is used to predict the relative impact of crude oil or ethanol released from railroad-tank car accidents on soil and groundwater contamination and cleanup times, but no monetized costs are presented. (page 115)