BEFORE THE STATE OF WASHINGTON
ENERGY FACILITY SITE EVALUATION COUNCIL

In the Matter of: Application No. 2013-01 TESORO SAVAGE, LLC TESORO SAVAGE DISTRIBUTION TERMINAL	CASE NO. 15-001 SWORN PRE-FILED TESTIMONY OF CHRISTOPHER P. L. BARKAN

I, Christopher P. L. Barkan, state as follows:

1. I swear under the penalty of perjury of the laws of Washington and the United States that the following testimony is true and correct.

2. I am over eighteen years of age and am otherwise competent to testify in this case. My testimony is based upon my education, training, experience, professional qualifications, and understanding of the matters herein.

3. I am a Professor in the Department of Civil & Environmental Engineering, as well as the Executive Director of the Rail Transportation and Engineering Center at the University of Illinois at Urbana-Champaign. My Curriculum Vitae ("CV") has been attached hereto as Attachment A.

4. Based on my professional experiences and background, I have developed an expertise in railroad hazardous materials transportation safety and risk. That has been a major focus of my research over the past 27 years. This includes quantitative analysis of factors affecting railroad accident likelihood, tank car safety design and its effects on their performance in accidents and consequence analysis of spills of hazardous materials. My work in this field, a partial list of which is included in my CV, has been peer-reviewed and published in academic and scientific journals.

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5. My testimony responds to the concerns over the impact of the petroleum crude oil traffic associated with the Tesoro-Savage Vancouver Energy Terminal (the "Project"), that would be transported in unit trains via the BNSF railway mainline from where it enters the state of Washington near Newman Lake, Washington to the proposed Project site in Vancouver, Washington. Specifically, I was asked to conduct a risk analysis of that train traffic. Additionally, I was asked to evaluate and compare the results of our analysis with the analysis of rail-related risk conducted for the Energy Facility Site Evaluation Counsel and presented in the Draft Environmental Impact Statement ("DEIS") for this project.

I. SUMMARY OF RISK ANALYSIS METHODOLOGY

6. Estimating the risk of a release accident involving a unit train transporting petroleum crude oil can be calculated by systematically quantifying the probability of the series of events that ultimately result in a spill. This involves the following sequence of events and corresponding probabilities or probability distributions:

- the probability of a derailment occurring,
- the probability distribution of the number of cars involved in the derailment,
- the probability distribution for the number of derailed tank cars that release, and
- the probability distribution of the quantity released from each car that releases.

The corresponding steps in this calculation involve analysis of the following:

(a) The estimated derailment rate for trains on each segment of track along the route. (Previous research has shown that three principal factors are correlated with this rate: Federal Railroad Administration ["FRA"] track class, railroad method of operation [e.g., whether the track has wayside traffic control signals or not] and the traffic density of the section of track. This information, combined with train

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configuration [number of locomotives and cars in the train] is compiled for each specific segment of the route studied to develop an estimated derailment rate specific to these trains traveling on this route.)

(b) The distribution of the number of cars derailed is affected by the configuration of the train (i.e. number of locomotives and cars) and speed of the train at the time of the derailment;

(c) The probability that one or more tank cars will release some or all of their contents if they are involved in a derailment. This is affected by various features of the tank car design that affect its resistance to damage in accidents and the speed of train at the time of the derailment; and

(d) The distribution of quantity released given an accident with a release. This is affected by which part of the car is damaged in an accident and various features of its design.

7. The approach to estimation of railroad hazardous materials transportation risk used in our analysis is widely accepted. This field has been developing for more than three decades and there is extensive published literature describing the general form of the models as well as more detailed analysis of particular elements and statistics used. In a previous position I held in the Research and Test Department of the Association of American Railroads ("AAR") in the early 1990s, I had principal technical responsibility for development of a comprehensive railroad hazardous materials transportation risk analysis model. In addition, at least two textbooks have been published describing approaches to hazardous materials transportation risk analysis such as we used (Rhyne, W.R., 1994. *Hazardous materials transportation risk analysis: Quantitative approaches for truck and train*. Van Nostrand Reinhold, New York, and Center for Chemical Process Safety, 1995. *Guidelines for chemical transportation risk analysis*. Center for Chemical

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Process Safety of the American Institute of Chemical Engineers, New York), as well as numerous papers and reports by me, my colleagues, students and other researchers and transportation safety analysts.

II. SUMMARY OF RISK ANALYSIS METHODOLOGY

8. I prepared a risk analysis report consistent with the methodology discussed above. My opinions and conclusions related to the risk of a rail incident are contained in the report attached hereto as Attachment B (hereinafter my "Report"), which is incorporated herein by reference. I have summarized the key findings in my Report below.

9. My Report describes an analysis of the estimated petroleum crude oil train derailment rate, the estimated conditional probability of release given a derailment event and the estimated conditional probability of quantity released given a release event. The route studied was the BNSF rail line from the Idaho/Washington state line at Newman Lake, Washington, to the Vancouver Energy Project site in Vancouver, Washington. Several major risk factors were taken into account, including FRA track class, railroad method of operation, tank car safety design, traffic volume, and train configuration. The train operation is summarized below and the risk estimates are summarized in the table on the following page.

A. <u>Summary of Operation Analyzed</u>

10. Four trains per day over the route, configured as follows: 3 locomotives (2 head-end, 1 rear-end), 2 buffer cars (1 head-end, 1 rear-end), and 118 loaded tank cars.

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B. Summary of Probability Estimates

	FRA Reportable Mainline Derailment Rates
Derailment Rate for All Trains on the Route (per million train miles)	0.75
Estimated Derailment Frequency (per year)	0.424
Derailment Return† (years)	2.4

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Tank Car Types	Legacy DOT 111		CPC-1232		DOT-117
	Non-Jacketed (7/16") 111A100W1	Jacketed (7/16") 111A100W1	Non-Jacketed CPC 1232 (1/2")	Jacketed CPC 1232 (7/16")	Jacketed (9/16")
Route Estimates					
Car-Conditional Probability of Release (Car - CPR)	30.3%	14.5%	16.2%	7.9%	5.1%
Train-Conditional Probability of Release (Train - CPR)	78.6%	62.2%	62.3%	45.4%	36.7%
Any Spill Return (years)	3.0	3.8	3.8	5.2	6.4
Median spill: 700 bbl / 30,000 gal Spill Return (years)	5	9	8	15	23
Large Spill: 2,200 bbl / 92,000 gal Spill Return (years)	13	33	25	57	110
EWCD**: 20,000 bbl / 840,000 gal Spill Return (years)	1,297	5,182	2,072	5,847	20,176
Average Route Location Estimates					
Median spill: 700 bbl / 30,000 gal Spill Return (years)	2,000	3,400	3,200	5,800	9,000
Large Spill: 2,200 bbl / 92,000 gal Spill Return (years)	4,900	12,600	9,500	21,900	42,500
EWCD**: 20,000 bbl / 840,000 gal Spill Return (years)	500,000	1,996,000	798,000	2,253,000	7,773,000

† In this table and throughout my Report, "Return" refers to the expected interval between events in years. It is the inverse of the annual probability of an event.

**EWCD: Effective Worst Case Discharge: as defined by DEIS Appendix E

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11. The risk estimates presented in my analysis may be conservative in terms of future projections of risk, i.e., they may tend to overestimate the risk for several reasons. These reasons include BNSF's lower than average derailment rate compared to national statistics (our statistics are based on national figures for Class 1 railroads); the general decline in the U.S. Class 1 railroad train accident rate (down 39% since 2005 and 29% since 2009), which can be expected to continue due to improvements in infrastructure, rolling stock and implementation of new and improved defect detection technologies that detect potential problems before they cause an accident; additional safety practices implemented by BNSF for rail transport of petroleum crude oil; and the installation of PTC on this and other routes. The derailment rate, and consequent risk analysis, did not account for the safety benefits of these factors.

12. Our research has found that at a national level, the most important factors correlated with U.S. Class 1 railroad derailment rate are FRA track class, annual traffic density, and railroad "method of operation" (presence or absence of wayside traffic control signals). The most comprehensive, quantitative analysis of the effect of these factors to date was conducted as part of the doctoral dissertation research of my former student, Xiang Liu, Ph.D. (now an Assistant Professor of Civil & Environmental Engineering at Rutgers University). Such an analysis requires data on derailment occurrences and railroad traffic density organized according to the three characteristics referenced above. Development of the requisite database is a time-consuming exercise that took the railroads and the University of Illinois approximately one year to develop in the 2010-2011 time frame and used data from 2005 through 2009. Since that time frame, the U.S. Class 1 railroad mainline accident rate has declined approximately 29%, so our method probably over-estimates the current accident rate.

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13. The new DOT-117J tank car specification (and the similar DOT-120 tank car) uses several design features that have been shown to improve resistance to damage in accidents. These include:

- A thicker, more puncture-resistant tank constructed of stronger steel;
- Full-height head shields (extra layer of steel to protect the ends of the car);
- Consolidation of top fittings within a robust protective structural steel housing; and
- A thermal protection system encased in a steel jacket.

14. These design features of the DOT-117J (and the similar DOT-120) are expected to reduce the average probability of a release caused by the impacts in an accident by 85 percent compared with the probability of a release from a non-jacketed DOT-111 tank car.

15. In addition to the safety benefit of the structural features described above, the DOT-117J and DOT-120 cars will be much less likely to experience secondary failures due to thermal tears caused by exposure to fire in an accident. These cars are required to have a thermal protection system that includes a layer of thermal insulation and an appropriately sized pressure relief valve.

16. The Fixing Americas Surface Transportation ("FAST") Act, H.R. 22, 114th Cong., Pub. L. No. 114-94, passed by Congress in December 2015 requires use of a layer of thermal insulation surrounding the tank to reduce the rate of heat flux into the tank if it is engulfed in fire. Additionally a steel jacket protects and holds the thermal insulation in place, and also improves resistance to impact damage in derailments. The layer of thermal protection substantially reduces the likelihood of secondary thermal failures of these cars.

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17. In addition, the new cars are equipped with an appropriately sized pressure-relief valve that effectively reduces internal pressure in a controlled manner, thereby further reducing the likelihood of secondary thermal failure of the tank.

III. EVALUATION OF THE DEIS RISK ANALYSIS

18. While some of the conclusions in the Energy Facility Site Evaluation Council ("EFSEC") DEIS are similar to our conclusions, there are differences in the details of how the two studies were conducted, the assumptions made, the level of detail of the analysis, and the data and statistics used. The general nature of these differences is that EFSEC used a variety of national historical averages derived from FRA statistics, whereas we used more detailed, current statistics and analytical models of train and tank car accidents specific to the train and route using a combination of FRA and industry data. Some of the calculations in the DEIS yield higher values than ours and others lower, but overall, the final, quantitative estimates of risk do not differ much between the two studies. Following is a summary of these differences.

A. <u>Derailment Rate</u>

19. The DEIS used a simpler, more coarse-grained historical approach to estimate average derailment rate compared to our method that accounts for specific features of the route and the train configuration that affect derailment rate. In the end, the estimated derailment rate estimates for the two studies do not differ much.

- Estimated annual derailment frequency: DEIS 0.495 vs. our range, 0.424 – 0.672.

20. Derailment Severity (number of cars derailed). The DEIS used a simpler, national average approach, which implicitly assumes an average train length. Our study specifically accounted for train length and speed of operation along the route, both of

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which affect derailment severity. Our estimate of derailment severity is higher than the DEIS's.

- Average cars derailed per accident: EFSEC 7.7 vs. our 12.7.

B. <u>Tank Car Release Probability</u>

21. The DEIS used a simpler, average rate of release for the train as a whole based on all hazardous materials cars involved in accidents over the period 1975-2014. This approach does not account for the wide range of differences in hazardous materials railcar design and their corresponding range of resistance to damage in accidents. It also does not properly account for the variability in number of cars releasing within a derailed train, which may range from none, or very few, to a large percentage of the cars derailed. We specifically accounted for the safety design features of the DOT-117J tank car (very similar to DOT-120 to be used in this service), and used a state-of-the-art statistical analysis to calculate these cars' probability of release in accidents. We included this model, combined with the analysis of the number of cars derailed described above, to estimate the distribution of the number of cars that would release. Our estimate of the probability that a DOT-117J releases is less than the generic estimate of a hazardous materials car releasing in the DEIS, but our estimate of the probability that at least one car in a train releases is higher than the estimate in the DEIS.

- Estimated probability of release for a car involved in a derailment: DEIS 9.2% or 16.7% vs. our estimate for the DOT-117J, which is 5.1%.
- Average percentage of cars releasing per accident:
  DEIS 9.2% or 16.7% vs. our estimate given the specific conditions of the route, train and tank car, which is 36.7%.

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C. Tank Car Release Quantity

22. EFSEC assumed that every car that releases in an accident will lose its entire contents. This is inconsistent with extensive empirical data on tank cars involved in railroad accidents that show a wide range of release quantities. For example, approximately one third of release incidents result in less than 5% of the tank's contents being spilled. We formally incorporated statistics on the range of quantity lost into the risk assessment. Depending on which measure of spill quantity is used, our estimates of the probability are either higher than EFSEC's (median or large spill) or about the same, in the case of the Effective Worst Case Discharge as defined by DEIS.

IV. INTERPRETING CONCLUSIONS

23. While there have been concerns expressed about the probability of derailment of tank cars as compared to other types of freight cars, there is no evidence indicating that tank cars have a derailment rate that is substantially different than other railcar types. An important function of AAR Interchange rules, as well as applicable FRA regulations, is to specify a comprehensive set of mechanical standards that all railcars, tank cars or otherwise, must adhere to ensure their safe operation. Tank cars, like all other railcars in unrestricted interchange service on North American railroads, must comply with this comprehensive set of mechanical design standards. Furthermore, FRA mandates frequent inspections of the running gear on railcars and trains are required with the objective of assuring that they remain in proper working order.

24. In addition to these designs and frequent inspections, railroads continue to develop and install increasingly sophisticated new technologies that automatically inspect railcars for a range of defects. These systems further reduce the likelihood that a component will fail and cause an accident. FRA data show that accident rates due to

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rolling stock failures have been steadily trending downward over the past decade (39% since 2005 and 29% since 2009).

25. The spate of crude-oil-unit-train derailments in the 2013-2015 time frame led to considerable interest in understanding unit-train derailment rate. Several industry studies were done as well as a preliminary analysis conducted by Rutgers University. None of these suggested that the derailment rate for unit trains differed significantly from that of other types of freight trains. Research on this topic is continuing, but the increased incidence of crude oil unit train derailments in recent years was more likely the result of the enormous (more than 40-fold) increase in petroleum crude oil traffic since 2009. The substantial growth in this traffic meant that these trains were exposed to greater potential involvement in accidents. There is no evidence that these trains were themselves inherently less safe than other types of trains, just that there were many more of them operating. Thus the more recent and highly publicized derailments from 2013-2015 are not inconsistent with the overall conclusions in the Report.

26. Railroads have continued to invest in improved infrastructure, rolling stock, operating practices, training and new defect detection technologies intended to detect problems in both track and rolling stock before they cause an accident. Since 2009 the Class 1 railroads' mainline track-caused derailment rate has declined 35%, their rolling-stock-caused derailment rate has declined 29%, and their human-factors-caused rate has declined 12%, for an overall decline in accident rate of 22%. Accordingly, it is reasonable to assume a general downward trend in the accident rate.

27. One commenter cited a much higher incident frequency and percentage of cars releasing as evidence that the DEIS study understated the risk; however, it is unclear where the supporting data came from. Furthermore, the data do not seem to have been properly normalized to determine an accurate rate of incidence. Many derailments occur

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with few tank cars derailed or releases. These do not receive the same media attention as have the smaller number of high profile accidents over the past five years, but these lower profile incidents must be included in order to develop accurate risk estimates. Furthermore, several high profile incidents occurred under different circumstances, where accidents were more likely to occur, than those that exist along the BNSF route to the Project site. It is incorrect to apply those circumstances to rate estimates for routes that have higher quality infrastructure and other attributes that make accidents less likely.

28. In our report, as well as the EFSEC analysis, estimates of risk were developed for an incident occurring anywhere on the entire BNSF route from the Washington state line to the Project site, a distance of approximately 385 miles. This is a cumulative estimate of risk. Understandably however, communities along the route are also interested in the risk at their own locale. As indicated in the Report, the probability of an incident at any particular location is much lower than the risk over the entire route (is at least 100 times lower, and on average, more than 350 times lower). It is important that communities understand the distinction between the overall route risk estimates, and the risk at their particular location, which is much lower.

29. The following documents are attached to my testimony for reference:

Attachment A: Curriculum Vitae of Dr. Christopher P. L. Barkan

Attachment B: Christopher P. L. Barkan, M. Rapik Saat, and Manuel Martin Ramos, "Petroleum Crude Oil Unit Train Transportation Risk Analysis: Vancouver Energy Project" (January 21, 2016).

[Signature on the Following Page]

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DATED this 12th day of May, 2016.

Christopher P. L. Barkan, Declarant

STATE OF Illinois)
)
COUNTY OF Champaign)

Christopher P. L. Barkan, being duly sworn upon oath, deposes and says: The foregoing testimony is true, correct and complete to the best of my knowledge, information and belief and is given subject to the laws of perjury in the State of Washington.

GIVEN under my hand and official seal this 12th day of May, 2016.

NOTARY PUBLIC in and for the State of:
Illinois

OFFICIAL SEAL
DIANNA M. LIENARD
NOTARY PUBLIC - STATE OF ILLINOIS
MY COMMISSION EXPIRES MAR 02 2017

Residing at: 1717 W. Kirby Ave., Champaign IL

My Commission Expires: March 2nd, 2017

Dianna M. Lienard
Printed Name of Notary:

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