Docket EF 131590
Tesoro Savage CBR
DEIS public comment HC #1576

F. E. "Skip" Kalb, Jr.
Director
Strategic Development

BNSF Railway Company
P.O. Box 961051
Fort Worth, TX 76161-0051
2650 Lou Menk Drive, 2nd. Fl.
Fort Worth, TX 76131-2830
817-867-6133 Office
817-352-0376 Fax
817-271-3057 Cell
Email:skip.kalb@bnsf.com

VIA Email and Overnight Mail

RECEIVED
JAN 22 2016
ENERGY FACILITY SITE
EVALUATION COUNCIL

January 21, 2016

State of Washington
Energy Facility Site Evaluation Council
P.O. Box 43172
1300 South Evergreen Park Drive, S.W.
Olympia, WA 98504

Re: Comments in Response to Publication of Draft Environmental Impact Statement; Tesoro Savage Vancouver Energy Distribution Terminal

To Whom It May Concern:

Through this letter, BNSF Railway Company ("BNSF") provides comments in response to the publication of a Draft Environmental Impact Statement ("DEIS") for the Tesoro Savage Vancouver Energy Distribution Terminal ("the Project") prepared by the Energy Facility Site Evaluation Council ("the Council").

In comments made to date regarding the Project, certain parties have suggested that the geographic scope of analysis under Washington State Environmental Policy Act ("SEPA") should extend well beyond the Project area in order to address the effects of train traffic and other purported impacts in localities throughout Washington State or even other states. For the reasons provided below, BNSF believes that extending the geographic scope of analysis beyond the area impacted by the Project would be inappropriate, and in conflict with applicable agency policies and regulations.

In particular, BNSF is concerned with the Council making a decision whether to approve the Project based on potential impacts resulting from interstate commerce moving into Washington. As you are aware, Article I, Section 8, Clause 3 of the United States Constitution grants to the United States Congress the power "To regulate commerce with foreign nations, and among the several states, and with the Indian Tribes." Further, the Interstate Commerce Commission Termination Act, *49 U.S.C.A. §10101 et seq.*, gives exclusive jurisdiction to the Surface Transportation Board ("STB") over "the construction, acquisition, operation, abandonment, or discontinuance of spur, industrial, team, switching, or side tracks, or facilities, even if the tracks are located, or intended to be located, entirely in one state. *49 U.S.C. § 10501(b)*. This federal scheme ensures that interstate rail operations occur in a safe, reliable

manner that protect interstate commerce. Consequently, BNSF believes the Council should defer to the STB and Federal Railroad Administration consideration of the interstate rail system.

Leaving aside these federal law issues, it appears from reading the DEIS that virtually the entire document focuses on the impacts to the State of Washington from a maximum of four loaded trains per day moving in interstate commerce to the Port of Vancouver, Washington. It is difficult to understand how this level of train traffic triggers a statewide study of the interstate rail system. This seems to be a significant over-reach by this Council. It is also worth noting that the DEIS fails to discuss the benefits to Washington's ports that come from being rail-served, including the environmental and economic benefits. The Council should take note that the Pacific Northwest Rail Corridor Environmental Assessment, written and approved by Washington Department of Transportation and the Federal Railroad Administration, two agencies with far more expertise on rail issues, found that adding eight trains to the BNSF system in the same geographic area resulted in no environmental impacts. (See additional reference below under "Terrestrial Wildlife".)

I. Scope of Environmental Review

SEPA and NEPA regulations require an analysis of the direct and indirect effects of the proposed action. *See* WAC 197-11-060(4)(d); 40 C.F.R. § 1508.8. However, both SEPA and NEPA regulations limit analysis of impacts to those which are "reasonably foreseeable" and not merely speculative. *See* WAC 197-11-060(4)(a); 40 C.F.R. § 1508.8(b). Moreover, SEPA expressly requires consideration of environmental impacts that are "likely, not merely speculative." *See* WAC 197-11-060(4)(a).

Courts applying these regulations have held that "remote" or "speculative" impacts do not require analysis. An impact is "reasonably foreseeable" if it is "sufficiently likely to occur that a person of ordinary prudence would take it into account in reaching a decision." *See Sierra Club v. Marsh,* 976 F.2d 763, 767 (1st Cir.1992). *See also City of Shoreacres v. Waterworth,* 420 F.3d 440, 453 (5th Cir. 2005). "Reasonable foreseeability" does not include "highly speculative harms" that "distort the decision making process" by emphasizing consequences beyond those of "greatest concern to the public and of greatest relevance to the agency's decision." *See City of Shoreacres*, 420 F.3d at 453. *See also Cheney v. Mountlake Terrace*, 87 Wash.2d 338, 344 (1976).

Contrary to assertions contained in the DEIS, it is speculative and not reasonably foreseeable that construction of the Project will cause train traffic to increase on any particular line in the State. As discussed in more detail below, the statewide increase in train traffic is not attributable to the Project or any other specific commodity movement.

II. Rail Capacity in Washington State

Although the Project has projected receiving up to four unit oil trains per day, should the terminal reach full capacity, depending upon market conditions, it is speculative and not reasonably foreseeable that construction of the Project will cause train traffic to increase on any particular rail line in the State. Current trends, as discussed further below, indicate that train

traffic will increase by approximately 13 percent statewide in the next thirty years. This projection already includes any increases associated with commodity shipment to the proposed terminal. Although it seems like an easy answer to say that a project adding four trains to the system will automatically result in an increase of four trains to overall traffic, this is an oversimplification and clear error. Traffic ebbs and flows, and four freight trains per day are insignificant relative to BNSF's overall traffic.

Due to the dynamic nature of train traffic, no statewide overall increase in train traffic is attributable to the Project or any other specific commodity movement. No credible evidence indicates that this proposed project would cause actual increased train traffic throughout Washington state. This dynamic nature is affected by many factors, including but not limited to the following:

- A diverse set of customers each with variable schedules
- Markets driven by global supply, commodity prices, and demand factors
- Competing modal choices, which themselves are influenced by factors such as highway congestion
- Population growth and the resultant demand for BNSF's transportation services
- Energy and environmental efficiencies of freight rail
- Scheduling factors for individual shipments, including seasonality and weather events

These supply and demand scenarios play out across the entire rail system in the United States, as further explained below.

BNSF operates a number of rail lines and retains the right to operate over some lines that are owned and/or controlled by other railroads. Possible routes thus include BNSF rail lines and other lines that may provide more convenient transportation options. Which route a train will take on a given day depends not only on convenience or distance, but also on the numerous variables listed above. While BNSF strives to provide reliable, exceptional rail transportation services, including individual project and rail lane reviews, these diverse and complex factors do not allow for complete certainty or predictability. Therefore, the route a particular train will take or how many trains any route will need to absorb is speculative, and not subject to precise prediction.

This letter addresses the following reasons why it is impermissibly speculative to assume that the proposed Project would increase rail traffic along any particular route:

1) BNSF rail traffic is complex and variable based on a host of factors beyond our control, which makes likely predictions impossible.
2) Several independent, government studies predict that rail traffic will increase over time due to various economic conditions, such as demand for commodities of the type proposed to be shipped at the proposed terminal.
3) BNSF already has adequate capacity on its mainline for the proposed Project.
4) Commodities will be shipped regardless of the proposed Project, either to existing or potential future terminals on the West Coast by any number of rail routes.

III. BNSF Range of Operations

BNSF Railway operates as a common carrier and is one of North America's leading freight transportation companies operating on 32,000 route miles of track in 28 states, as well as connections with Mexico via five border gateways and Canada via three border gateways, and direct service to and from British Columbia and Manitoba. BNSF Railway also employs more than 40,000 individuals and serves more than 40 ports.

BNSF is one of the top transporters of consumer goods, grain, industrial goods and low-sulfur coal that help feed, clothe, supply, and power American homes and businesses every day. BNSF and its employees have developed one of the most technologically advanced, and efficient railroads in the industry. BNSF is working continuously to improve the value of the safety, service, energy, and environmental benefits we provide to our customers and the communities we serve. This is a partnership that BNSF values tremendously, so we seek opportunities to advance our common interests of safety, opportunity, and success.

Transportation by rail provides significant economic benefits to the State of Washington. Freight rail contributes more than $28.5 billion to the state economy – accounting for more than 7.5 percent of Washington's Gross Domestic Product. More than 342,000 workers in this state depend on freight rail. In Washington alone, BNSF employs nearly 4,000 people, with a combined payroll of more than $260 million. Additional information regarding BNSF is available on our website at: www.bnsf.com.

Figure 1. BNSF Rail Network and Variability of Customer Demand

BNSF has a diverse customer base and has segmented its business into 4 main groupings: Industrial Products, Consumer Products, Coal and Agricultural Products. These business groups are further differentiated into 43 forecast groups and 178 sub-forecast groups. These customers' demands are subject to the same complex factors as those driving the economy; one segment may experience significant growth while another segment is in decline. This variability in customer demand creates considerable uncertainty with respect to the timing and volume of future transportation of specific commodities.

Other factors can also affect rail volumes over particular segments. Railroads operate in a competitive marketplace. We compete with other modes: trucks and barge as well as other rail carriers. Business shifts between modes and carriers based on price, service, capability, and reliability. These shifts can be meaningful and can have major impacts to our network volumes.

Freight rail traffic is very dynamic and unlike passenger service, it does not adhere to a fixed schedule or particular route. In general, freight trains can go any direction, at any time. Which route a freight train will take on a given day depends not only on convenience or distance, but also on other numerous factors, including weather events, customer needs, market demands, etc. BNSF's three existing east-west routes through Washington have available capacity and offer flexibility in ensuring network fluidity.

Market demand for any of the products we transport could cause an increase in rail traffic, and that demand fluctuates as the economy continuously demonstrates. Increases in train traffic associated with the proposed projects in Washington will depend on the market demand when the terminals open. It is simply too soon to know what the demands will be when the projects open, including the Vancouver Energy Project.

It is important to remember that even if none of these projects are built, and as stated above, we expect rail traffic to continue to grow. As such, we will continue to invest in capacity improvements, as we have done in Washington and the rest of our network for years, to accommodate all of the growth in our freight business. Further detail on our capacity improvements are provided below.

To accomplish this, BNSF has processes in place that review our operational capacity by specific rail lanes on a five-year planning cycle. Timely and predictable permitting processes are important to this established capacity review procedure as well.

IV. Nationwide Freight Rail Growth Projections

As noted above, a number of independent government agencies, national associations, and transportation professionals have predicted for years that this general growth trend will continue. Several national studies (FRA, AASHTO, GAO, Global Insights) have predicted that rail traffic in the United States will increase over the next 20-25 years based on a variety of factors. Some of the major factors contributing to this estimated growth in freight rail traffic include:

- Population Growth

- Highway Congestion
- Energy Efficiency of Rail
- Environmental Benefits of Rail vs. Truck
- Increased Demand
- Need for Maintaining Global Competitiveness
- Increased Passenger Use of the Rail Network

The AASHTO study titled, "Transportation Reboot: Restarting America's Most Essential Operating System, The Case for Capacity: To Unlock Gridlock, Generate Jobs, Deliver Freight, and Connect Communities" (July 2010) emphasizes the importance of the nation's transportation system: http://www.transportgooru.com/2010/07/transportation-reboot-%E2%80%93-aashto-study-growing-freight-demands-reaching-transportation-crisis/.

> ***We have prepared this report to describe how important an efficient freight system is to the economy, the congestion already taking place, the growth in anticipated demand, and the challenge of keeping America competitive in the world economy.***

AASHTO's study makes it clear that congestion on the nation's highways is emphasizing the need for the railroads to handle more freight, stating that:

> ***In 40 years, overall freight demand will double, from 15 billion tons today to 30 billion tons by 2050. Freight carried by trucks will increase 41 percent; by rail 38 percent from today's quantities. The number of trucks on the road compared to today will also double.***

Most recently, the USDOT released in October 2015 a draft National Freight Strategic Plan, which cites current Department of Transportation (DOT's) "Freight Analysis Framework" data including freight tonnage growth projections by mode.

Some excerpts are contained below and the full report can be found at: https://www.transportation.gov/freight/NFSP.

Expected Growth in Freight Tonnage (pg. 5):

> ***The U.S. economy is expected to double in size over the next 30 years. By 2045, the nation's population is projected to increase to 389 million people, compared to 321 million in 2015. Americans will increasingly live in congested urban and suburban areas, with fewer than 10 percent living in rural areas by 2040 (compared to 16 percent in 2010 and 23 percent in 1980). To support our projected population and economic growth, freight movements across all modes are expected to grow by roughly 42 percent by the year 2040. For example, container traffic at ports will increase steadily as the volume of imports and exports transported by our freight system more than doubles over this period. Air freight is expected to triple in response to demand for the rapid movement of***

high-value merchandise, while multimodal shipments are predicted to more than double.

Expected Growth in Freight Traffic (pg. 23):

Our freight system moves approximately 63 tons of goods per American each year. As our population grows and our economy expands, demand for freight will grow as well, placing additional strain on an already challenged transportation system. U.S. freight demand will be affected by several trends:

- ***Freight will grow across all transportation modes.***
- ***The changing nature of our economy and population will affect where and how freight moves.***
- ***All else being equal, growth in overall freight demand will place increased pressure on infrastructure throughout the country, with particularly significant impacts concentrated in certain areas.***
- ***Increasing domestic energy production will have profound implications for our transportation system.***

Freight will grow across all transportation modes. Even by conservative estimates, our economy is expected to double in size over the next 30 years. As the economy grows, freight movement is forecasted to increase as well, albeit at a slower rate as measured by tonnage. Freight movements are expected to increase at a rate of approximately 1.3 percent per year, or by roughly 42 percent by the year 2040. Air freight is expected to triple in response to demand for the rapid movement of high-value merchandise, while multimodal shipments are projected to more than double. Container traffic at ports is steadily increasing. Overall, the volume of imports and exports transported by our freight system is expected to more than double in the next 30 years. This growth in trade will have implications for ports, which handle 72 percent of America's international merchandise trade by tonnage; air cargo, which handles 25 percent of our international merchandise trade by value; and intermodal carriers that move imports and exports between ports of entry and inland locations.

Rail Volumes Will Increase by 49 percent (pgs.24-25):

The volume of goods moved by rail has increased steadily since 1980, and is projected to increase by 49 percent by 2040. With increases in passenger traffic and freight demand, track congestion may increase, especially in higher-traffic passenger corridors. Growing congestion may reduce the railway network's reliability for both freight and passenger movements unless appropriate investments are made.

As previously stated, growth in freight rail traffic of all commodities has significantly increased and is projected to continue to increase. This is good for

local economies and the environment, as railroads are the most environmentally efficient and cost effective way to move freight. Moving freight by rail uses less energy, reduces pollution, lowers greenhouse gas emissions and cuts highway congestion, when compared to all other transportation modes.

Figure 4 and Table 1-Tonnage of Freight Carried by Transportation Mode (millions of tons), U.S. Department of Transportation, Bureau of Transportation Statistics and Federal Highway Administration, Freight Analysis Framework, version 3.6, 2015) are attached as Appendices A and B, respectively.

V. The State of Washington Capacity Improvements

The Washington Department of Transportation (WSDOT) 2013-2035 State Rail Plan provides information regarding rail capacity in Washington. The plan is available at (http://www.wsdot.wa.gov/NR/rdonlyres/F67D73E5-2F2D-40F2-9795-736131D98106/0/StateRailPlanFinal201403.pdf) and provides as follows:

Summary of Future Demand for Rail Transportation

How will the system operate in the future?

The Federal Railroad Administration requires state rail plans include a rail system capacity analysis. This broad analysis is meant to show what a future rail system would look like with the anticipated freight and passenger rail growth, if no additional capacity or operational improvements were made.

In reality, it is anticipated the Class I railroads (BNSF and UP) and other infrastructure owners will likely address key capacity issues as they emerge. (Emphasis added.) Therefore, the 2035 capacity assessment is included here to illustrate the magnitude of growth anticipated for Washington's rail system. This underscores the need for continued planning and action to address capacity and mobility concerns throughout the system.

Washington's rail system is expected to handle more than 260 million tons of cargo by 2035— more than double the volume carried on the system in 2010. This represents a compound annual growth rate of 3.4 percent for all commodities carried on the rail system. As a result, and as shown in Figure 4.3, several rail segments are expected to require operational changes and/or capital improvements to manage anticipated freight rail volumes.

			Tons (000)							
Origin	**Destination**	**Mode**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2010-2040 CAGR**
Idaho	WA	Rail	53	76	82	88	90	93	95	8.6%
Montana	WA	Rail	8,991	9,543	9,791	10,785	12,546	13,893	15,355	7.9%
Oregon	WA	Rail	79	149	158	162	165	171	175	12.1%
Washington	WA	Rail	3,338	4,363	4,295	4,443	4,609	4,767	4,916	5.7%
Wyoming	WA	Rail	4,218	6,687	7,900	8,944	9,320	9,381	9,330	12.0%
Total all states	**WA**	**Rail**	**31,942**	**50,973**	**54,468**	**60,241**	**65,411**	**70,468**	**75,078**	**13.0%**
Idaho	WA	Truck	4,074	6,013	6,890	7,310	7,686	8,038	8,732	11.5%
Montana	WA	Truck	336	452	438	438	432	428	422	3.3%
Oregon	WA	Truck	15,910	21,306	23,673	26,181	28,620	31,558	35,402	12.1%
Washington	WA	Truck	226,472	302,616	309,309	326,220	344,303	360,189	379,597	7.7%
Wyoming	WA	Truck	44	112	128	152	179	195	213	25.2%
Total all states	**WA**	**Truck**	**259,350**	**351,581**	**363,111**	**385,582**	**409,375**	**431,322**	**458,663**	**8.5%**

Figure 2. Washington state traffic by rail is predicted to increase steadily, for an increase of 13% by the year 2040 (Source: Federal Highway Administration).

Washington state traffic by rail is predicted to increase steadily, for an increase of 13% by the year 2040 (Source: Federal Highway Administration).In the 30 years from 2010 to 2040, the State of Washington is expected to grow annual truck volumes by 6.4 million trucks to 15.8 million. This increase in truck traffic will result in additional highway congestion and drive additional freight to the more energy and environmentally efficient rail system.

By comparison, if and when the Project reaches full capacity, the associated train traffic would represent only a small fraction of one percent of the total transportation increase represented by the anticipated natural economic growth for Washington.

This growth in transportation enables the economies of both the state of Washington and the United States to meet the projected growth expectations of the shipping public. In 2010, freight-dependent businesses represented 44% of Washington state jobs. Likewise, the Washington Council on International Trade (WCIT) has stated that 40 percent of all jobs in Washington are tied to international trade.

VI. BNSF Capacity Commitments

BNSF has adequate capacity in the near and long term to accommodate current and anticipated future freight traffic growth in Washington. Despite assertions to the contrary, we do not have a looming regional capacity issue. Long-term forecast such as the 2011 Marine cargo Forecasts & Rail Capacity Study and the 2006 WSDOT Capacity Study made assumptions about growth, but are not actual predictions of when and where growth will occur. The economy and the marketplace are the key drivers of changes in freight volumes.

The 2006 WSDOT capacity study which was conducted during BNSF's all-time volume record, was quickly thrown out of date by the Great Recession and is inconsistent with what has

actually happened since then. In the 2011. Marine Cargo Forecasts & Rail Capacity Study, the conclusion is that capacity is sufficient for growth along most routes today. The two routes where potential capacity constraints are forecast under high-growth scenarios – Pasco to Vancouver and Everett to Blaine – would not experience constraint with existing capacity until after 2020, according to the study. The study indicated these potential issues are remediated with modest upgrades. Also, the Everett to Blaine high-growth scenario includes the expectation of additional export bulk commodities.

Rail improvements are made financially possible only by increased rail volume. The system ensures that the necessary private capital to refresh BNSF's physical infrastructure and capacity becomes available as necessary to provide adequate levels of service along rail lines. Therefore, BNSF invests in capacity improvements when actual traffic demand justifies the investment. Freight demand driven by the marketplace and the economy determine when that demand actually occurs. While BNSF plans on a multi-year basis, BNSF reviews and approves capital investments on an annual basis. We have invested for a long time on that basis, including in the state of Washington, and will continue to do so. It is the best way to ensure that capacity expansion investments are made in response to actual market needs.

All freight capacity expansion needed on BNSF's right of way is paid for by the railroad. We have invested more than $53 billion of our own private capital on our network since 2000. In 2015, we invested nearly $6 billion across our network, with $1 billion of that capital being invested in expansion and maintenance on the Northern Corridor alone, more than any other part of the network. BNSF has continued to make these improvements to its lines that have resulted in improved system-wide train velocity over the last few years.

BNSF's history of investment in the Pacific Northwest demonstrates BNSF's commitment to this important region. BNSF regularly invests more than $125 million annually in Washington state alone in order to maintain and improve freight rail capacity. In 2015, BNSF invested nearly $200 million in Washington, and BNSF expects to make a similar capital investment this year. Moreover during the last nine years, BNSF has invested approximately $1.5 billion in Washington, and since 2013, BNSF has invested approximately $3.5 billion to maintain and add capacity improvements in the Northern Corridor.

The three existing BNSF rail routes through Washington have available capacity and offer flexibility in ensuring network fluidity. In fact, to provide more capacity to move goods in and out of Washington, we invested more than $150 million in the mid-1990's to reopen the Stampede Pass Route. Shown below is an overview of the 2015 capital projects across our system, including in Washington:

- Started construction of double track from Ferndale to Custer totaling nearly seven miles.
- Reconfiguring the Bayside and Delta rail yards located in Everett to improve efficiency and provide more capacity.
- Continuing to work through permitting and right-of-way issues involving the replacement of the Washougal River Bridge in Camas. Construction should start this year and continue into 2016.

- BNSF's maintenance program in Washington included 1,011 miles of track surfacing and undercutting work, and the replacement of nearly 50 miles of rail and close to 203,000 ties, as well as signal upgrades for federally mandated positive train control (PTC).

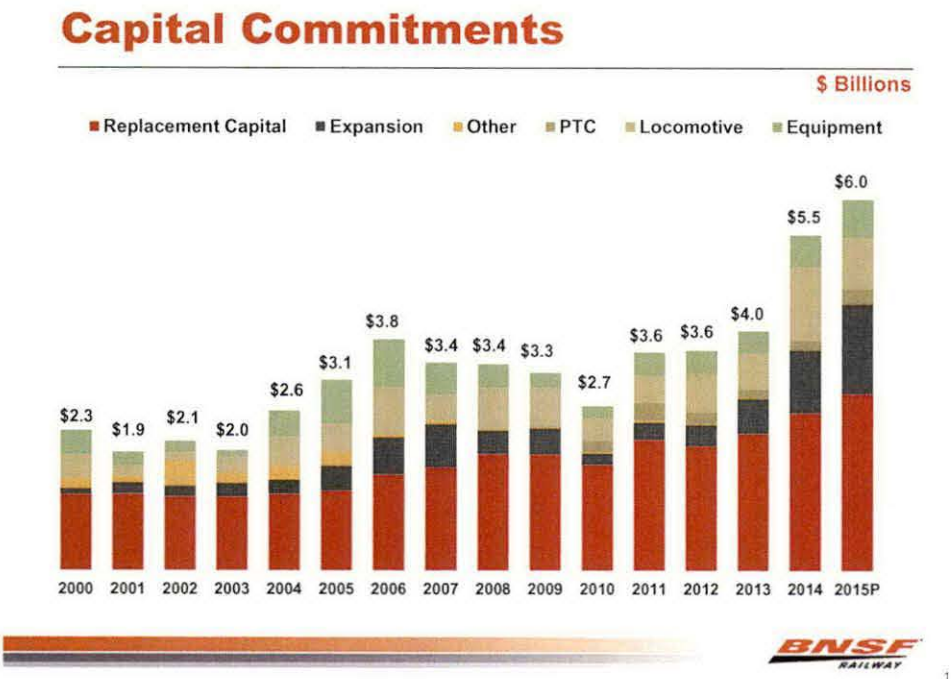


Figure 3.

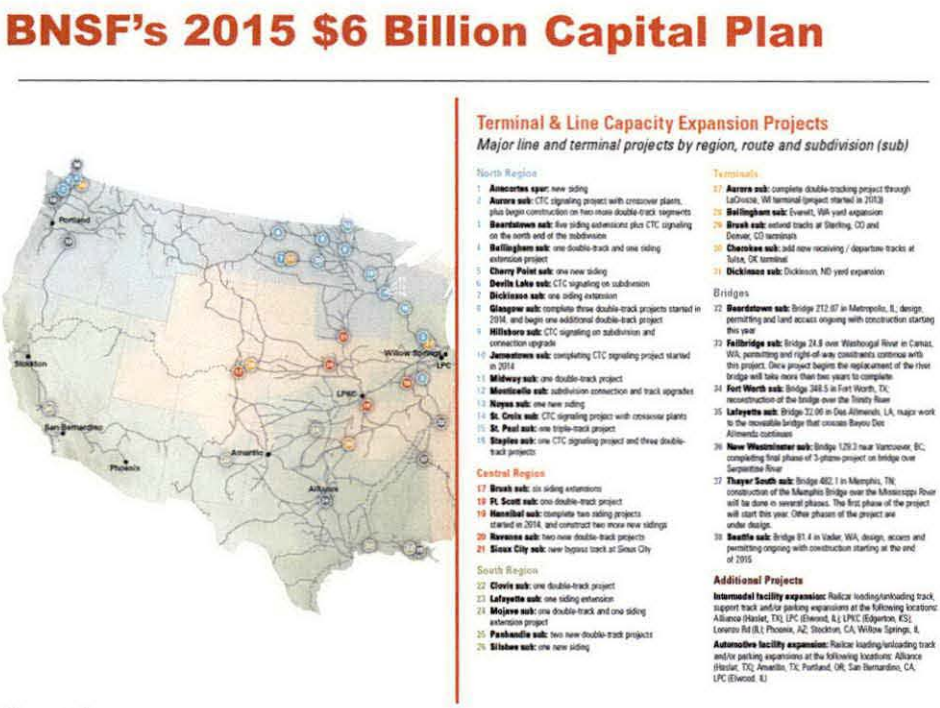


Figure 4.

Record Capital Investment Ensures Capability and Reliability
BNSF's 2015 Capital Commitment $6B
4%
23%
48%
25%
Core Network and Related Assets
Expansion and Efficiency
Locomotive, Freight Car, and Other Equip
PTC
$2.9 billion
Core Network & Related Assets
$1.4 billion
Loco, Freight Car, & Other Equip
$1.5 billion
Expansion & Efficiency
$200 million
PTC
BNSF RAILWAY

Figure 5.

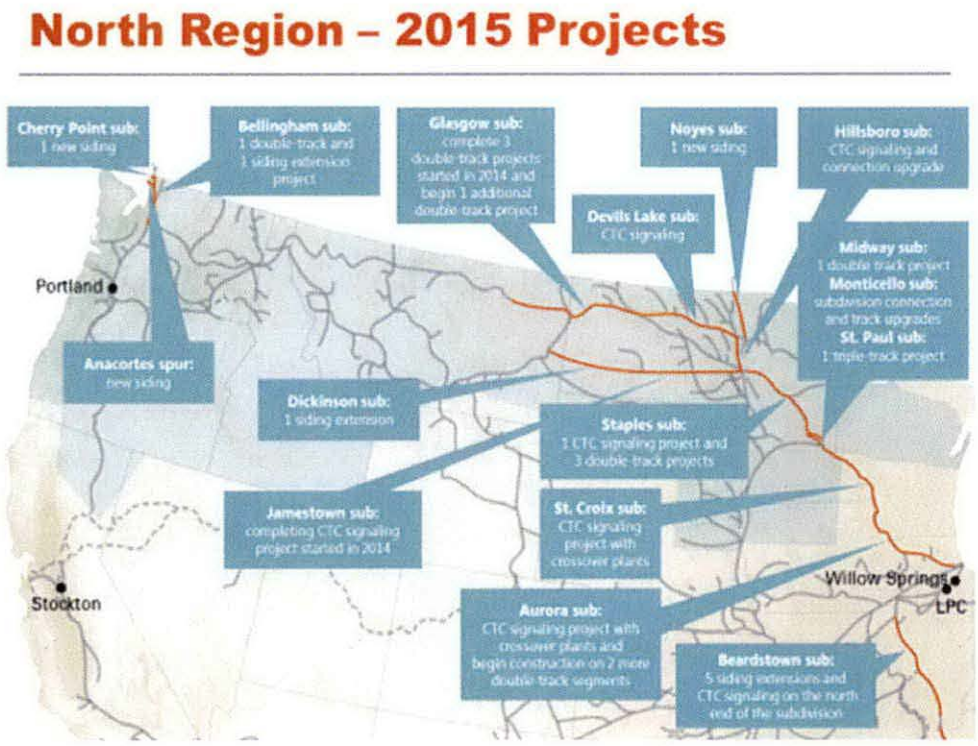

North Region – 2015 Projects
Cherry Point sub:
1 new siding
Bellingham sub:
1 double-track and
1 siding extension
project
Glasgow sub:
complete 3
double-track projects
started in 2014 and
begin 1 additional
double track project
Noyes sub:
1 new siding
Hillsboro sub:
CTC signaling and
connection upgrade
Devils Lake sub:
CTC signaling
Midway sub:
1 double track project
Monticello sub:
subdivision connection
and track upgrades
St. Paul sub:
1 triple-track project
Portland
Anacortes spur:
new siding
Dickinson sub:
1 siding extension
Staples sub:
1 CTC signaling project and
3 double-track projects
Jamestown sub:
completing CTC signaling
project started in 2014
St. Croix sub:
CTC signaling
project with
crossover plants
Willow Springs
LPC
Stockton
Aurora sub:
CTC signaling project with
crossover plants and
begin construction on 2 more
double track segments
Beardstown sub:
5 siding extensions and
CTC signaling on the north
end of the subdivision

Figure 6.

VII. Public-Private Partnerships

Public-private partnerships combine the business interests of private companies with the diverse goals of local, state and federal government entities who are working in the interest of the public. Cooperation between the private and public sectors may, in many cases, allow both sides to achieve their respective goals better, faster, and at lower cost. When more freight moves by rail, the public benefits through lower shipping costs, reduced highway gridlock, enhanced mobility, lower fuel consumption, lower greenhouse gas emissions and improved safety. And, since the railroads contribute funding commensurate with the benefits they receive -- It's a win-win for all involved.

BNSF engages in strategic public and private partnerships in the state of Washington. The recently opened West Vancouver Freight Access Project is a perfect example http://www.portvanusa.com/wvfa/wvfa-home/.

This project provides new and enhanced rail access to the Port of Vancouver USA. This project will have a big benefit for freight and passenger service which no longer will be slowed by trains entering or leaving the port. The companion project to this is the Vancouver By-Pass, which will provide a main line route that will allow trains to by-pass the lower tracks within our yard.

BNSF has a proven track record of coming together and working with the state of Washington on issues. The FAST Corridor is an excellent example of this. The FAST Corridor program was a first for the region and near-unique at the time in terms of corridor partnership commitment and cooperation: federal, state, local, private sector. This program had, for example, the Port of Tacoma contributing to a Port of Everett project – because the partners recognized each project benefited the viability of the whole corridor system.

VIII. Comments Concerning Environmental Impacts Associated with Rail Operations

BNSF offers the following detailed comments concerning the environmental impacts of rail operations discussed in the DEIS.

A. Air Quality

Rail is the most environmentally friendly method of moving the nation's freight. One train can carry as much freight as several hundred trucks. It would have taken approximately 5.6 million additional trucks to handle the 100.8 million tons of freight that originated in, terminated in, or moved through Washington by rail in 2012. (Source AAR: https://www.aar.org/Style%20Library/railroads_and_states/dist/data/pdf/Washington%202012.pdf).

According to the Association of American Railroads (AAR) (https://www.aar.org/), trains move the same ton of freight more than three times as far as trucks per gallon of fuel. This efficiency produces more than 50 percent fewer CO2 emissions per ton mile than trucks.

Diesel emissions have been extensively analyzed, and are federally regulated by the Environmental Protection Agency (EPA). In fact, the existing EPA standard for locomotives, called Tier 4, were tightened in 2015. Specifically, the Environmental Protection Agency (EPA) requires all newly manufactured and all remanufactured locomotives that were originally manufactured after 1972 to comply with increasingly stringent emission standards and to be equipped with idle reduction technology that automatically shuts down locomotives if they are left idling unnecessarily (EPA 2013b).

The idling control program is expected to eventually reduce NOx, volatile organic compounds (VOCs), and PM emissions from locomotive idling by approximately 90 percent as well as significantly reduce locomotive smoke emissions and exhaust odors (EPA 2013b). These measures will reduce future locomotive emissions compared with both past and some present locomotive emissions. (See pages 3.2-25)

More than ninety eight percent (98%) of BNSF's locomotives, including all high horse power (HHP) locomotives, that are used in our over the road and heavy haul fleets, are equipped with an Automatic Emission Shutdown System (AESS), which automatically shuts down a locomotive not in use to reduce idling emissions.

In addition to idle control technology, improvements in operation and maintenance practices also have an impact on the inherent fuel efficiency of rail. BNSF, which has the industry's newest and most fuel-efficient fleet of road locomotives, is able to move one ton of freight 500 miles on a single gallon of fuel.

A number of factors impact fuel efficiency, including age of the fleet, network fluidity, technological solutions, freight commodity mix, and operating and maintenance practices. Because fuel efficiency is influenced by various factors, BNSF also measures the energy used by determining fuel used per gross ton mile. (Gross ton miles are the weight of the train, excluding the locomotive, multiplied by the miles the train has traveled.)

In 2014, BNSF averaged 833 gross ton miles on a single gallon of diesel, which is a 10 percent improvement from a decade earlier when gross ton miles on a single gallon of diesel were 757.

With 92 ultra-low-emission locomotives in use, at the end of 2014, for switching operations inside its rail yards, BNSF reduces nitrogen dioxide and particulate matter emissions from locomotives by 80 to 90 percent at those facilities and improves fuel efficiency by 25 percent compared to older switch engines.

B. Bridges

As background, BNSF has approximately 13,000 bridges across our network. The visual appearance of these structures is not indicative of their structural integrity. Every bridge receives one comprehensive inspection per calendar year by a qualified bridge inspector and an inspection by a supervisor, with a more frequent inspection schedule occurring in some cases.

Additionally, on our busiest routes, track inspections occur every day, and while those inspectors are looking at the track, they are also observing track conditions that may indicate underlying issues with a bridge structure, providing additional review.

Further, if we receive an inquiry on a particular bridge, our Structures team will perform an inspection to determine whether repairs are needed. BNSF has a staff of trained bridge inspectors, as well as structural engineers, consultants, and specialized contractors. We maintain bridge inspection reports, which as the railroad's regulatory agency, the FRA can review, as well as inspect our structures.

As previously noted, railroads spend a higher percentage of revenue maintaining, replacing, and expanding infrastructure than any other industry. We spend private money to invest in our private rail network, unlike roads, highways, and bridges that are taxpayer funded. BNSF has an ongoing bridge replacement and maintenance program, which is part of the nearly $6 billion that we spent across our network in 2015 to replace and maintain our infrastructure. The Washougal River Bridge in Camas, Washington is a good example of this.

Inspections of all bridge structures are performed a minimum of once per year and are utilized to identify required maintenance and to ensure there are no structural exceptions. One of those inspections is also performed with the presence of a BNSF supervisor.

Bridges on BNSF's core routes are typically inspected three times per year, exceeding FRA standards. BNSF's bridge inspectors and engineering staff are also supported by consultants and contractors in our efforts to inspect and maintain BNSF bridges.

The key to the longevity of any structure is proper maintenance and repair. And railroads, such as BNSF, spend a higher percentage of revenue maintaining, replacing, and expanding its infrastructure than any other industry.

These bridge inspections are both comprehensive and as stated above, are supervised by a trained BNSF officer. Inspections are made on a periodic basis for underwater components, movable bridge machinery and other specific contract inspections. Additional inspections are performed when special conditions and events exist, such as high water, vehicle/boat strikes, fire, etc.

The following statistics apply to BNSF bridges:

- 99.9995% of bridge train miles occur without any type of service interruption.
- 0.02% of service interruptions across our entire network are caused by a bridge being removed from service.
- No derailments have been caused by the structural integrity of a bridge.
- BNSF's expert, certified Railroad Bridge Inspectors performed more than 35,000 Comprehensive Inspections in 2015.

C. Grade Crossings

Promoting grade-crossing safety is an essential part of our operation and culture. Our network includes just over 25,800 grade crossings, including approximately 17,200 public and 8,700 private and pedestrian at-grade crossings.

In addition, BNSF has more than 3,700 public grade separations and 650 private and pedestrian grade separations, including one of the lowest highway-railroad grade crossing collision rates in the rail industry. Since BNSF's merger in 1995, the rate of grade crossing collisions has declined about 68 percent – from 5.3 per million train miles in 1995 to a rate of 1.7 per million train miles in 2013.

Trains cannot stop quickly. A 100-car freight train traveling at 55 miles per hour will need more than a mile to stop once the train is set into emergency braking. When vehicle drivers or pedestrians violate traffic laws at grade crossings, or trespass onto railroad right of way, they are putting themselves and the train crews in danger.

In recent years, we've invested an average of $95 million annually on grade-crossing maintenance, improvements and safety programs. Our initiatives include community education and awareness, train crew education and testing, crossing closures, new safety technology, vegetation control, and track and signal inspection and maintenance. For more information see: BNSF Grade Crossing Safety brochure (Appendix C).

For the past several years, BNSF has invested an average of approximately $95 million annually on grade crossing maintenance, improvements, and safety programs. BNSF's expenditures include community education and awareness, train crew education and testing, crossing closures, new safety technology, vegetation control, and track and signal inspection and maintenance. To accomplish these educational and program activities, BNSF dedicates 17 grade crossing safety managers and 9 public projects manager. The amount spent on grade-crossing safety includes an annual average of approximately $20 million to maintain grade-crossing road surfaces.

Federal and State Roles

The 1973 Highway Rail Safety Act created a partnership to be built between the federal government, state government, local agencies and the railroads. Congress established guidelines for evaluating grade crossings, and the Federal Government would provide a funding mechanism for railroad-highway upgrades. In addition, the federal government created an inventory database of each crossing within the United States, available at http://safetydata.fra.dot.gov/OfficeofSafety/publicsite/crossing/crossing.aspx. There is also an app for mobile devices, https://www.fra.dot.gov/Page/P0703.

The Highway Rail Safety Act required each state Department of Transportation (DOT) to create a ranking system, review that ranking system of all public crossings within the state on an annual basis and provide information to maintain the national inventory that is maintained by the FRA. This Act also placed the responsibility for determining the adequacy of the crossing warning devices on each state DOT, based on the priority of ranking system they created.

The railroads participate in diagnostics requested by the Department of Transportation, provide railroad information and provide a workforce to install, and then maintain the crossing warning devices that the particular state DOT deems to be adequate for that crossing.
The Federal government provides the funding to the agencies that can be used for the installation and upgrading of traffic control devices and crossings. This information can be obtained through the FRA crossing database mentioned above. All crossing incidents and trespasser incidents on BNSF are sent to the FRA.

Grade Separated Crossings

The determination to grade separate a crossing is made by the appropriate road authority using their own calculations or other driving factors. BNSF participates in the process by conducting reviews of construction plans that would impact BNSF's ROW. Noise impacts are typically reviewed by the road authority through an environmental study.

Under federal law, there is a formula for cost-sharing between a community and the railroad for providing a grade-separated crossing when the grade separation results in the elimination of an at-grade crossing.

At-Grade Crossing Noise

There is no difference in train horn requirements by train type. The use of either train or an automated horn system, known as wayside horns, is determined through a diagnostic conducted by the Road Authority, FRA and BNSF. The installation and use is governed by the FRA Train Horn Rule https://www.fra.dot.gov/Page/P0105. Accordingly, BNSF does not determine where or when Wayside horns are installed. Section IV. Part 9 Subsection 9 of the FRA's Grade Crossing Safety Handbook (https://www.fra.dot.gov/Page/P0040 states that:

> ***A crossing bell is an audible warning device used to supplement other active traffic control devices. A bell is most effective as a warning to pedestrians and bicyclists. When used, the bell is usually mounted on top of one of the signal support masts. The bell is usually activated whenever the flashing light signals are operating. Bell circuitry may be designed so that the bell stops ringing when the lead end of the train reaches the crossing. When gates are used, the bell may be silenced when the gate arms descend to within 10 degrees of the horizontal position. Silencing the bell when the train reaches the crossing or when the gates are down may be desired to accommodate residents of suburban areas.***

Quiet Zones

Quiet Zones are established through the FRA Train Horn rule as outlined in the link below. https://www.fra.dot.gov/Page/P0104. BNSF participates in the diagnostics and review conducted by the road authority, the state DOT and the regional FRA representative. Crossing treatments and recommendations are determined through the diagnostic and calculations provided through the Train Horn Rule.

Grade-Crossing Consolidation

One of the best ways to address grade crossing safety is to reduce the number of at-grade crossings. BNSF's grade crossing safety program includes an aggressive initiative to close public and private at-grade crossings, working closely with communities and property owners. Good candidates for closure include those that are redundant (other crossings nearby allow access to the same roads or areas), are not designated emergency routes, have low traffic volumes, or are private crossings that are no longer needed or used. Since 2000, BNSF has closed more than 5,750 at-grade crossings.

Road crossing gate down times are minimal, especially for the number of trains anticipated by this project. BNSF has the ability to "split" a train in case a crossing is blocked and an emergency vehicle needs to pass. BNSF has a team that concentrates on eliminating at-grade crossings and working with communities who show an interest in grade-separating crossings.

D. Weather-Related Impacts

Weather and Earthquake Inspection Programs

Special inspections are required during extremely hot and cold weather conditions, storms, high water periods, and after earthquakes. When a significant earthquake is reported, BNSF inspects track based on the magnitude and epicenter location of the earthquake. BNSF's policy requires track to be inspected if the earthquake is measured at 5.5 magnitude or higher on the Richter scale. The required inspection radius is determined by the location of the epicenter.

Weather Alerts

BNSF subscribes to a private weather data service that monitors weather conditions on our network 24/7, and issues severe weather alerts to BNSF to enable our dispatchers to bring trains to a stop when severe local weather conditions such as tornadoes, very high winds or flash flooding could pose a threat to train movements anywhere on our network. When wind warnings are received that indicate possible wind speeds of 51 mph to 60 mph, BNSF instructs passenger trains to reduce speed to 40 mph. For wind warnings of possible wind speeds of 61mph or more, BNSF instructs passenger trains to stop. Depending on the type of freight trains in the area, some freight trains must come to a stop if.wind speeds exceed 51mph.

Weather alerts are issued for a specific time-frame and for a specific portion of the railroad. Our employees comply with the applicable restrictions until either the train exits the affected area or the alert expires. We have attached below portions of BNSF's Special Service Instruction, No. 5, July 1, 2014, that deals with Wind Speed & Flash Flood conditions.

Slide fence Detectors

BNSF has also invested in slide fences that have been strategically placed in potential slide areas to ensure that approaching rail traffic is warned in advance of possible dangerous track conditions stemming from rock or mud slides. When contact is made with the fences, a red block signal indication is displayed to provide advanced warning to approaching trains.

BNSF has also worked extensively with the Washington Department of Transportation (WSDOT) on a landslide mitigation plan (http://www.wsdot.wa.gov/NR/rdonlyres/8B3B653E-5C50-4E2B-977E-AE5AB36751B7/0/LandslideMitigationActionPlan.pdf) for slides in the Everett area, which is attached to this letter as Appendix D.

Excessive Wind Instructions
When wind warnings are received meeting the wind speed criteria, the train dispatcher will notify all affected trains and employees with movement authority in the area providing the time and limits of the expected high winds. The following table will govern train movement:

Wind Speed	Passenger Trains (includes Amtrak, commuter trains and freight trains consisting entirely of business cars)	Light engines, loaded ribbon rail trains and loaded bulk commodity unit trains as defined in the Air Brake and Train Handling Rules Glossary.	All other trains
51 to 60 MPH	40 MPH*	Not affected	Staging requirements*
61 MPH or greater	Staging requirements*	Not affected	Staging requirements*

Staging Requirements:
Affected trains and equipment may proceed not exceeding 20 MPH to a staging location (e.g. station, siding or location with double crossovers) as directed by the train dispatcher to allow trains not affected by the wind warning to pass.

* If a field employee (e.g. crew member on an affected train) observes that local weather conditions are not as severe as the wind warning indicated and these conditions would not impact safety, the employee will advise the train dispatcher of the local conditions. If the employee advises local wind conditions are 50 MPH or less, with chief dispatcher authority the train dispatcher may grant permission for passenger trains restricted to 40 MPH and other affected trains to operate at maximum authorized speed.

Tornado Watch and Warning Instructions
Tornadoes are the most violent of all storms. Paths of destruction range from a few hundred feet in width to more than a mile and extend the length of a city block to 300 miles.

E. Hazardous Materials

Railroad Transparency and Access to Information

BNSF has enjoyed a proud 160-year history of providing rail services to the customers and communities we serve and looks forward to continuing the excellent relationships we have enjoyed over the years. In this regard, an important conversation is happening in our nation around the safe movement of crude oil by freight railroads. As stated above, no matter what we carry, be it agriculture, crude oil or airplane fuselages, we are absolutely committed to moving products as safely and efficiently as possible.

We understand that local elected officials and emergency responders have an expectation to know what's moving through their communities. Accordingly, for more than 20 years, BNSF has provided, upon request, comprehensive hazmat rail traffic flow reports to first responders and emergency managers. The reports contain a list of all hazardous materials that are transported through a city or county over the preceding 12 months along with proper shipping name and ID number.

In 2014, BNSF began providing county specific reports with the number of trains per week which transport one million gallons or more of Bakken crude oil to the State Emergency Response Commissions (SERCs), which includes Washington, and sends updates if traffic changes up or down by 25 percent. This information is essential for local emergency responders, elected officials and emergency management officials for safety reasons.

Officials requesting the information are asked to agree to use the information solely for emergency response planning purposes. (U.S. Department of Transportation (USDOT) Emergency Order, Effective July 7, 2014.) In 2015, we handled the following volume of hazardous materials shipments in Washington state:

	Total	Crude Oil
Total Hazardous Material Shipments	151,932	80,454
Total Gross Tons	20,012,914	11,099,911
Total Gallons of Crude Oil		2,333,166,000
Average Gross Tons Per Car	131.7	138.0
Ave. Gallons of Crude Oil Per Car		29,000

A new improvement to allow swift access by emergency responders to the necessary information is a secure mobile device application called AskRail, website link: https://askrail.us/ created by BNSF and the other Class I railroads. It provides first responders immediate access to accurate real time data about individual rail cars on a train, which can help emergency responders make informed decisions about how to respond on a scene of a rail emergency.

AskRail is only available to emergency response planners and first responders and not for public use, nor does not replace current communication channels, but is intended as a real-time supplement to the existing process.

In addition, in 2015 BNSF developed our own secure mobile device app called "SECURETRAK" which was offered to state and local fusion centers that provides near real-time locations and consist information on hazardous material trains (including crude and ethanol trains) on the network with the use of a Geographical Information System (GIS) interface. The location of trains are indicated on a map and are color coded indicating the type of train. Users can obtain a train list that includes the sequencing of the train and hazmat commodity detail by clicking on the dot on the map.

Also, SECURETRAK can provide a "2 hour look ahead" that shows an estimated location of the train in the next two hours. The purpose is to provide a comprehensive consist list or make-up of a train with detailed hazardous materials information. Any agency who participates in SECURETRAK program signs an agreement to keep the information classified according to a license agreement.

During an incident response, we share information on the specific train and car consist through multiple channels to ensure there is no gap in communication. Train crews carry a list that provides the location of every car as well as hazmat emergency response information to share with first responders. The manifest is also faxed to the designated local first responder, and upon request, we provide the same information to CHEMTREC, National Response Center and other local, state and federal responders. BNSF's Rail Safety Presentation is attached to provide additional information as Appendix E.

F. Rail Safety

BNSF believes that every accident and injury is preventable. Operating free of accidents and injuries has long been part of BNSF's vision and our focus has been on preventing accidents in the first place. Rail is the safest mode of land transportation for freight in general and is one of the safest ways to transport crude oil and hazardous materials. According to the FRA, the rail industry as a whole has reduced employee injury rates, train accident rates, and grade crossing collision rates by 80 percent or more since 1980.

The Federal Railroad Administration named 2013 and 2014 as the safest in U.S. history for American freight railroads, including BNSF, and the rail industry has reduced hazardous material train accident rates by 91% since 1980. This record setting safety record continued in 2015. According to the USDOT's Draft National Freight Strategic Plan (October 2015, pg. 6) mentioned above:

> ***Recent trends show impressive improvements in freight rail safety. There was a 27 percent increase in freight ton-miles for all surface modes between 1990 and 2011, but freight-related fatalities across all modes declined by 33% over that same period.***

The USDOT also notes that total rail fatalities have decreased by over 37% from 1980 to 2013 (1,365 down to 509) (Appendix F). Yet, while certainly even one fatality is too many, this tremendous improvement in rail safety cannot be ignored, especially as rail shipments have been increasing over this same time period.

We have made this remarkable safety progress in partnership with our employees and by continually investing in new technologies that help make the railroad safer and more efficient. Our philosophy and practice for crude transportation is that we must prevent incidents from happening, mitigate their severity and mobilize effective, efficient response. We believe our progress in all three areas: prevention, mitigation and response, coupled with the recently released USDOT rules on crude transportation referenced above, enhance our commitment to continually improving safety on our network.

To make this point, 99.998% of all hazardous materials shipped by rail (including crude oil on BNSF) reach their destination without incident. (Source: American Association of Railroads; Federal Railroad Administration.)

In fact, hazardous materials shipped on BNSF receive special identification and handling that includes tracking of all sensitive shipments, in-train placement checks and emergency response information. These hazardous materials include other petroleum products, chemicals used to purify municipal drinking water, fertilizers used to produce abundant food crops, and chemicals needed to produce medicine.

As we summarized in our previous comments on this project, BNSF operates under a number of federal laws that govern our operations. These laws and regulations, as well as BNSF's own voluntary safety and prevention measures, make rail transportation the safest mode for transporting industrial goods in the United States.

Specifically, the USDOT (both the Pipeline and Hazardous Materials Safety Administration (PHMSA) and the FRA) have promulgated regulations (HM251) to help ensure the safe transportation of High Hazard Flammable Trains (HHFT). In addition, Congress has established additional safety measures under the 2015 FAST Act. Additional information on these important federal rules and BNSF's extraordinary efforts for the safe handling of crude by rail are described in more detail below.

A summary of USDOT's Crude by Rail Safety Rules and BNSF's voluntary efforts are attached as additional information. (See attached "Crude Oil Safety Measures Implemented by Railroads , (Appendix G) and "BNSF Hazardous Material Stats"(Appendix H), respectively).

BNSF prioritizes safety and the maintenance of its railroad network and makes significant investments in railroad safety and infrastructure. As noted above, in 2015 alone BNSF invested nearly $6 billion in support of its rail maintenance and expansion programs. Nearly 50% of our 2015 capital plan was spent on replacing and maintaining existing infrastructure. In Washington, we have invested more than $1 billion in our infrastructure over the past six years.

BNSF's Risk Reduction Program

BNSF has a broad-based, multi-level risk reduction program to reduce incident risk on our railroad. This multi-layered risk reduction program is designed to ensure that all commodities are handled in a safe and damage-free manner. The aspects of this program are highlighted below and discussed in additional detail later in this letter.

Employee Training and Compliance

As stated above, BNSF's employees share the vision of an injury and accident-free workplace and are trained on exposure and risk identification. They look out for one another—reinforcing positive safety behavior by acknowledging when people are working safely and expressing concern when someone puts themselves or others at risk.

There is nothing is more important than returning home safely in all of the communities in which we live and operate. BNSF's safety focus is built on a culture of compliance and commitment and uses a robust compliance oversight process, including both direct and remote operations testing, to monitor rules compliance. Employees are trained on a comprehensive set of safety rules and practices based on Federal requirements, industry recommendations and BNSF-specific safety initiatives. In addition, BNSF conducts operational tests and audits to verify employees are working safely and in compliance with all company rules, policies, instructions and procedures.

Record Capital Investments

Record capital investments are being made in the railroad to help create a safer and more reliable physical plant. Through the end of 2015, BNSF will have reinvested more than $50 billion into its equipment and its network and infrastructure work that helps to maintain train traffic fluidity and capacity expansion projects intended to meet customers' ever-growing freight shipment demands. BNSF spent a record of nearly $6 billion for the capital expenditure program in 2015, which is the third consecutive year of record investment in BNSF network and infrastructure.

In addition to these capital improvements, BNSF implements comprehensive inspection processes as discussed below, that ensures safety by identifying potential problems before they can lead to unsafe conditions on the rail network.

Track Inspections

BNSF inspects its tracks more frequently than required by the FRA to ensure they are safe. Most key routes on BNSF are inspected up to four times per week, more than twice the inspection frequency required by the FRA, and our busiest main lines can be inspected daily. These inspections include routine visual inspections by track inspectors and inspections with specially equipped rail cars that use ultrasonic and other advanced technology to look for flaws in the rail and to test track geometry, as discussed in further detail below.

Track inspections on BNSF main lines occur by a hy-rail vehicle, which rides on the rails. In addition to the normal hy-rail inspections, on-foot inspections of all turn-outs on the main lines and yard tracks are required at least monthly. Supervisors are also required to make regular train rides over their assigned territories.

BNSF employs track inspectors who are chartered by the FRA to comply with FRA regulations. These inspectors record track conditions and update data following each inspection, which is provided to the FRA.

For further details on FRA guidelines, visit the Track and Rail and Infrastructure Integrity Compliance Manual http://www.fra.dot.gov/Page/P0051. Please see "BNSF Railway Wayside Detection (July 16, 2015)" (Appendix I) for additional information on the technologies discussed below:

G. Track Inspections

Rail Detectors and Track Geometry Cars

BNSF's track inspection program also utilizes state-of-the-art technology to help identify defects or problem areas that cannot be detected by the human eye. BNSF has made significant investments in inspection and detection technology to enhance the regular manual inspection process.

Rail Detectors

BNSF's rail detectors use ultra-sonic rays to detect internal (and external) flaws in the rail. The frequency of inspections are determined by the tonnage moved over a given section of track, however, the main line routes across BNSF's system receive rail detector testing every 30 to 50 days on average.

Track Geometry Car

BNSF's track geometry car measures major main line routes annually and up to three times a year depending on rail volume. The track geometry car is a specially-equipped passenger car that measures the tracks' surface under load for, gauge, cross-level, alignment and vertical acceleration. A computerized print out of the trackage indicates where the measured flaws exist in the track. This information is immediately communicated to field personnel to ensure that the defects are addressed.

Freight Car Defect Technology

BNSF has an extensive network of special detection technology, which are described below, along key routes on its network to monitor each passing rail car for early signs of potential problems that could cause premature equipment wear or failure. Detecting such defects early has helped improve safety and extend the service life of equipment.

Wheel Impact Load Detector

Measures forces applied to the rail to evaluate wheel surface defects. Decreasing the number of high impact wheels can help prevent derailments and also extend the useful life of rail.

Warm Bearing Detection System

Monitors for excess heat coming from wheel bearings. Identifying internal bearing defects early prevents potential derailments and helps to extend wheel life.

Hot / Cold Wheel Detector & Technology Drive Train Inspection

Measures wheel tread temperature to identify sticking or inoperative brakes; and applied handbrakes. Acoustic Bearing Detectors use a microphone array to evaluate and identify internal journal bearing flaws.

Machine Vision System

Utilizes a camera system to evaluate and identify component wear or damage of wheels, brakes, draft gear and truck components. The early warning this technology provides enables BNSF to repair trucks before safety issues occur and can extend the life of wheels.

Truck Performance Detector

Measures forces applied to the rail to evaluate each truck's ride performance. Early warning of truck performance issues enable BNSF to perform repairs before safety issues occur and extends the life of the equipment.

Bridge Inspections

BNSF performs comprehensive bridge inspections that are supervised by a trained BNSF officer. These inspections are typically performed three times per year, exceeding FRA standards. Under BNSF's inspection program, we inspect bridges and tracks more frequently than required by the Federal Railroad Administration (FRA).

The key to the longevity of any structure is proper maintenance and repair. Railroads, such as BNSF, spend a higher percentage of revenue maintaining, replacing, and expanding its infrastructure than any other industry.

Planning and Response Plans

BNSF has developed and shared Geographic Response Plans (GRPs) with state and local emergency response organizations in many areas as adopted by the Northwest Area Committee ("NWAC") and as directed within the Northwest Area Contingency Plan ("NWACP"). In many cases, we have developed these GRPs in consultation with response agencies.

H. Crude Oil Safety Measures Implemented by Railroads (2014-2015)

BNSF has initiated specific actions that go over and above some of the USDOT's final rules on Crude Oil Shipments, as discussed above, however a few specific items are highlighted below. We want to emphasize that BNSF considers these measures minimum standards. BNSF will continue to look for opportunities for operational safeguards that go beyond these measures.

Lower Speeds

- Implemented nationwide speed restriction: 50 miles per hour (mph) for all Key Trains (a train containing 20 or more cars hazmat commodities; one car of Toxic Inhalation Hazard (TIH)/Poison Inhalation Hazard (PIH)). **Effective July 1, 2014.**
- Municipal speed restriction: 40 mph for crude oil trains with Department of Transportation (DOT-2111) tank cars moving through High Threat Urban Areas (HTIA). **Effective July 1, 2014.**
- BNSF Specific Action: 35 mph for all shale crude oil trains through municipalities of 100,000 population or larger. **Effective March 25, 2015.**

Key Train Operating Practices

As part of BNSF's commitment to safety, we have always handled some commodities with extra precautions to further reduce risk. For more than two decades BNSF and the rail industry have operated specially identified "Key Trains," which carry certain hazardous materials, with more restrictive operating procedures than required by federal regulation.

Key Train operating procedures and practices are ingrained into BNSF's day-to-day operations, and include lower speed limits (50 mph unless further restricted by lower speed limits on the track) and stricter rules for trackside warning device notifications and emergency brake applications.

On August 2, 2013 the FRA issued an Emergency Order and Safety Advisory regarding the movements of flammable liquids, which includes crude oil and ethanol. As a result, BNSF and the rail industry has implemented a number of additional measures to reduce risk and, in some cases, provide an additional layer of review to reinforce existing safety rules.

The FRA Emergency Order contained requirements for unattended trains carrying hazardous material such as chlorine that is classified as Toxic by Inhalation (TIH) or 20 or more loads of certain flammable liquids like crude oil and ethanol, as discussed in more detail below.

The FRA also issued a Safety Advisory that instructs the Rail Safety Advisory Committee, (membership includes railroads, shippers, labor, and car owners) to develop specific recommendations on a number of items including:

- Minimum train crew size

- Ensuring the appropriate oversight processes and requirements are in place to identify and reduce risk, such as testing for compliance with the rules.

The Safety Advisory also recommends a review of railroad and customer safety and security plans in addition to ensuring shipments of crude oil are properly classified for shipment.

- Key trains will not be left unattended on main line or siding tracks.
- The crew responsible for securing the train must tell the dispatcher how many hand brakes have been applied and provide any other relevant information such as train tonnage, weather, and grade. This information must be recorded, verified, and confirmed with the train crew.
- Narrow exemptions for specific locations and circumstances require a sufficient safety reason and a plan to be submitted that requires the lead locomotive doors to be locked or the operating control handle (reverser) removed once the train is secured.
- During a "train meet", a Key Train will hold the main track whenever practical.
- A Key Train experiencing an Emergency Brake application requires inspection of the entire train before proceeding.

Rail Risk-Based Traffic Routing Technology

The U.S. DOT requires railroads to use a Rail Corridor Risk Management System (RCRMS) to determine the safest and most secure routes for crude trains of 20 or more loaded cars, using PHMSA's mandated 27 factors, effective July 1, 2014. The FRA frequently audits our analysis and the routes we select.

Unattended Trains

- Crude oil trains left unattended require specific job safety briefing between the train crew and train dispatcher.
- Locomotive Cab Securement: Key Trains left unattended have reverser removed and cab doors locked.

Emergency Response

While we have made significant progress in reducing the likelihood of a hazmat incident in any community, we also want to ensure BNSF and the communities we serve can be prepared to respond if an incident were to occur. To this end, BNSF also invests in community hazmat training and provided free railroad hazmat response and training to over 8,500 local emergency responders in 2014 in communities across our network. In 2015, BNSF provided hazmat response training to over 10,250 first responders across the BNSF system, and we have provided training to more than 80,000 emergency responders since 1996.

In 2015, BNSF trained more than 900 first responders in Washington, many from the Columbia River Gorge. In the past five years, hazmat training has been conducted by BNSF to fire fighters across Washington, including in Anacortes, Auburn, Bellingham, Camas, Centralia,

Edmonds, Longview, North Bend, Olympia, Pasco, Seattle, Spokane, Tacoma, Vancouver and White Salmon.

This was in addition to the training we provided in 2014 to 937 first responders over 40 classes. We have also participated in tabletop exercises in Seattle, King County, Skagit County and Spokane, which are important opportunities for us to identify opportunities and any gaps in how we work with our community partners.

In 2014 and 2015, BNSF underwrote the travel and training expenses for nearly 1,200 local first responders, including 256 from Washington, for specialized training conducted at a national training and research center, the Security and Emergency Response Training Center (SERTC) in Pueblo, Colorado.

This year, BNSF is sponsoring 360 local first responders to attend this training at SERTC and Texas A&M. The three-day, hands-on field exercises at SERTC provide 24 hours of specialized training for a crude oil incident, which will help prepare them for managing incidents related to crude oil.

In addition, BNSF has provided the following to first responders:

PNW Fire Trailers (28 across the BNSF System – See Appendix J):
Type I - Whitefish, MT (550 G AR-AFFF, pumps/bladders etc.)
Type II - Spokane, WA (275 G AR-AFFF, pump/bladder etc.)
Type I - Pasco, WA (550 G AR-AFFF, pumps/bladders etc.)
Type II - Vancouver, WA (275 G AR-AFFF, pump/bladder et.)
Type I - Seattle, WA (550 G AR-AFFF, pumps/bladders etc.)
Type I - Redmond, OR (in place 1st Quarter 2016 – 550 G AR-AFFF, pumps/bladders etc.)
Type I - Klamath Falls, OR (550 G AR-AFFF, pumps/bladders etc.)

BNSF owned & contracted PNW Oil Spill Containment/Recovery Resources (See Appendix K):
BNSF - Spokane, WA (1000' boom/skimmer/storage tank, accessory items)
BNSF - Pasco, WA (1000' boom/skimmer/storage tank, accessory items)
BNSF - Wishram, WA (5 helicopter portable containers – 2,000' boom/skimmer/storage tank, accessory items)
BNSF – Sandpoint, ID (1000' boom/skimmer/storage tank, accessory items)
BNSF – Bonners Ferry, ID (2,800' boom/skimmer/storage tank, accessory items)

PNW Contracted Locations with equipment:
Spokane, Pasco, Portland, Prineville, Longview, Seattle, Everett, Anacortes, Bellingham

Here is a summary:

State/Province & Country	Total Spill Containment Boom (ft.)	Oil Spill Skimming Systems: Total EDRC (bbl.)	Total Recovered Oil Storage (BBL.)	Total Vessels (#)	Total ER Personnel [Includes Contractor Non-responders: I.E. Admin and Offsite Support] (#)
Oregon, USA					
BNSF Resources	3,600	343	144	0	2
BNSF Contractor Resources	28,375	6,520	2,679	27	194
Total	**31,975**	**6,863**	**2,823**	**27**	**196**
Washington, USA					
BNSF Resources	3,050	686	145	0	30
BNSF Contractor Resources	123,170	55,251	8,253	148	481
Total	**126,220**	**55,937**	**8,398**	**148**	**511**

BNSF has also entered into an agreement with the Clean Rivers Cooperative in Portland, OR (not yet included on above table) which is a non-profit spill response organization. Through this agreement, we have access to all of their resources in the Area of Responsibility (between the I-205 bridge and Astoria, OR). For areas outside of their AOR including the remainder of WA, OR, ID, CA, MT, ND and WY we have access to their specialized equipment including Wildlife Response Trailer, Communications trailer, Shoreline trailers, 20,000' of boom + 10% of their skimmer/recovery and boat inventory.

Finally, BNSF has a Mutual Aid Agreement with the Western State Petroleum Association (WSPA) for refinery assets including foam and oil spill resources from Tacoma Oil, Shell, Tesoro, BP and P66.

BNSF has launched a new website: www.BNSFHAZMAT.com that provides the following:

- Participate in on-line BNSF hazmat training
- Schedule BNSF hazmat training for first responders
- Download a summary of BNSF's System Emergency Response Plan
- Request a Hazmat Traffic Flow Report for your city or county
- Request access to AskRail (See additional information above.)

In 2015, BNSF entered into a mutual aid agreement with the five refineries in Washington, including BP Cherry Point, Phillips 66, Shell Oil Products US, Tesoro Companies, and U.S. Oil Refining Co. The following emphasize BNSF's commitment to hazmat safety:

- BNSF has earned the national TRANSCAER (Transportation Community Awareness and Emergency Response) award 14 times since 1998 for our national outreach efforts to

assist communities prepare for and respond to possible transportation hazardous material incidents.

- ➢ BNSF has specialized equipment and hazmat responders staged across its network to deal with hazmat and crude oil incidents, including for firefighting and spill cleanup.

- ✓ This includes fire-fighting rail assets, such as a specialized piece of rail capable equipment that is used for wild land fire-fighting that could also be used for any crude by rail incidents

- ➢ BNSF has more than 250 trained hazmat responders at 60 locations on our network who are supported by a network of contract emergency and environmental responders.

- ➢ BNSF has a Geographic Information System (GIS) for emergency incidents that enables BNSF to quickly identify and contact the local emergency responders closest to any incident on our network.

- ➢ BNSF was the first railroad in the industry to deploy a fleet (28) of industrial fire-fighting foam trailers on hazmat routes around its network. BNSF also makes the trailers available to other railroads and communities. These fire trailers are helicopter deployable and they also can be placed on a rail car for deployment to remote locations.

- ➢ BNSF has specialized equipment and hazmat responders staged across our network, which includes several locations in Washington such as Everett, Seattle, Longview, Wishram (Columbia River Gorge), Pasco and Spokane.

- ➢ The trailers produce alcohol-resistant foam to extinguish fires involving materials such as ethanol and crude oil by covering the spilled material and depriving it of oxygen. In the event of an incident that requires these trailers (you cannot, for example, extinguish a crude oil or ethanol fire by putting water on it), we mobilize the trailers to the incident location and deploy contract industrial fire fighters to operate the equipment.

- ➢ BNSF also mobilizes local, regional, and national contractors to fight fires, mitigate the incident, remediate the environmental damage, direct traffic, etc. This allows the local fire and police to return to their typical duties. Moreover, BNSF will compensate local fire and police for the cost incurred responding to the incident.

- ➢ BNSF has developed and shared geographic emergency response plans with state and local emergency response organizations, engages in ongoing planning, drills, and rapid response exercises with local, state, and federal agencies, and reports hazmat traffic and volumes to state emergency response agencies.

I. 2014 Washington State Marine and Rail Oil Transportation Study

The 2014 Washington State Marine and Rail Oil Transportation Study was performed with the intention of informing the state legislature regarding potential legislative discussions on the

transport of crude oil. This study was finalized in the Spring of 2015 during the waning session of the legislature, which was by that point finalizing draft legislation concerning CBR transport.

In addition and as discussed in more detail below, the USDOT has now passed federal legislation on crude by rail shipments. Similarly, the state legislature has passed and state agencies (Washington Department of Ecology and the Washington Utilities and Transportation Commission) are now drafting rules to implement state-specific versions of rail safety legislation.

Therefore, both Washington state and the federal government have extensively analyzed rail safety over a two-year period, and have developed comprehensive legislation and regulations applicable to the rail industry. These processes should be acknowledged and addressed in the FEIS.

J. Historic and Cultural Resources

The DEIS suggests that trains may block access to culturally-important areas, such as Usual and Accustomed (U&A) Places. BNSF knows of no instance in which access to U&A Places has been blocked, or where parties have not had access over public or private crossings. BNSF works regularly with tribes to identify and address concerns, and would certainly work with any tribe who could not access U&A Places by the use of a public or private crossing.

K. Insurance and Financial Responsibility

BNSF has a strong track record of corporate responsibility. We have never expected taxpayers to assume the expense of a clean up after a derailment, and we stand by the practices that have allowed us to keep that record to date. BNSF is financially sound with a long history, substantial assets and a track record of being a responsible corporate citizen. In the event of an incident, BNSF commences remediation efforts without regard to the availability of insurance, i.e., BNSF responds and then looks to recover from its insurers.

L. Noise-related Impacts

In 2005, in response to a Congressional mandate, the Federal Railroad Administration (FRA) issued a Final Rule on the Use of Locomotive Horns at Highway-/Rail Grade Crossings: https://www.fra.dot.gov/Page/P0105. Under the new rule, local governments may establish quiet zones or continue existing quiet zones, if they are willing to take remedial steps to address risk, based on a calculation of potential risk at the crossing. In many cases, the rule makes these designations subject to FRA review, approval and ongoing oversight.

These remedial steps can include crossing closure, grade separation, full-width crossing gates with an approved median divider, full-width gates and lights at crossings on a one-way street, temporary closure (for nighttime quiet zones only) or four quadrant gates. The rule also

allows for an automated horn system, commonly wayside horns, at the crossing as a substitute for the train horn, if this provision is approved by the Federal Highway Administration.

Certain Alternative Safety Measures (ASMs) are also described. BNSF works with communities who wish to establish quiet zones and regularly reviews their quiet zone applications to the FRA.

M. Positive Train Control

Congress mandated in 2008 that Positive Train Control (PTC) technology be installed on routes that carry passengers and/or toxic-by-inhalation (TIH) commodities. PTC deployment is an unprecedented technical and operational challenge that requires the entire U.S. railroad network to develop, test and implement this new safety system, and avoid impacts to network capacity and fluidity as we do.

The scope of BNSF's PTC installation is immense covering more than 11,100 miles of track, roughly half of the entire BNSF system and 80% of BNSF's freight density, as well as equipping 6,000 locomotives with PTC technology.

BNSF has been an early industry leader in and is committed to implementing PTC and has made great progress and devoted significant resources to that end. Specifically, BNSF has invested over $1.5 billion in the testing, development, purchase, and installation of PTC components out of an estimated total exceeding $2 billion. Thousands of BNSF employees have been trained on PTC, and thousands more will be.

BNSF expects to install and operate PTC on all legislatively mandated territories in the state of Washington within the federally mandated PTC timelines.

As of January 12, 2016, construction has been completed on more than 70% of the PTC-mandated subdivisions (See attached BNSF PTC Implementation Map. (Appendix J))

- Cutover Phases Completed: 868 of 1,012: 86%
- Base Stations Installed: 576 of 597: 96%
- Locomotives Equipped: 3,891 of 6,050: 64%

Additional information on PTC can be obtained from the Federal Railroad Administration (FRA) and American Association of Railroads (AAR) website links:
https://www.fra.dot.gov/Page/P0621 and https://www.aar.org/policy/positive-train-control.

N. Vegetation Management

BNSF dedicates resources and has established standards shown below for the proper treatment of terrestrial vegetation in order to maintain a safe and environmentally conscious rail operation in line with federal laws and regulations.

Herbicides

The use of herbicides on BNSF property allows for the following:

- Maintain a safe working environment for employees.
- Maintain drainage of ballast and waterways.
- Allow for structure and track inspections.
- Maintain visibility at grade crossings, signs, and signals.
- Allow for inspections of moving trains.
- Comply with federal regulations.
- Reduce the spread of noxious weeds.

Any herbicides that used are EPA approved and applied by licensed applicators, under strict BNSF Engineering Instructions, including, but not limited to those discussed below.

Applications of herbicides on BNSF property are only to be handled by licensed contractors and with the permission of BNSF's Manager Vegetation Control in Ft. Worth, Texas, who consults with our Technical Research & Development Department to ensure that such materials are within the guidelines of federal regulations.

This includes the October 31, 2011 NPDES nationwide restrictions for herbicide use on a landowners property as well as the responsibility for violations. The BNSF Manager Vegetation Control will select the chemicals to be used based both on their effectiveness for weed control and the safety considerations for workers, applicators, and bystanders.

The BNSF System areas of control for vegetation control contractors are identified in their specific contract. Any change to the designated areas of control must be communicated in writing by the exempt officer responsible for the territory to the vegetation control contractor and the BNSF Manager Vegetation Control. Labels on herbicide chemicals must be monitored with any application applied per the requirements of FIFRA. BNSF must approve of subcontractors and reserves the right to refuse specific applicators or applicators' employees access to its property. The contractor must submit a list of chemicals, including their labels and Material Safety Data Sheets (MSDS), to be used on BNSF property when requested by BNSF. This list will be pre-approved by the Manager Vegetation Control and the Manager Industrial Hygiene.

Lubricants

All the products that are utilized in BNSF Friction Management are approved through our Technical Research & Development Department to ensure they are well tested prior to uses on the railroad. All products are within the guidelines of federal regulations.

12 Vegetation Control

12.1 Program 12–3
12.1.1 Manager Vegetation Control 12–3
12.1.2 Reasons for Developing a Vegetation Control Program 12–3
12.1.3 Notification 12–3
12.1.4 Vegetation Control Accounting 12–4

12.2 Methods of Vegetation Control 12–4
12.2.1 Mechanical 12–5
12.2.2 Chemical 12–5
12.2.3 Spot Applications 12–5

12.3 Areas of Control 12–6
12.3.1 Chart of Patterns and Acreage 12–6
12.3.2 Main Line and Branch Lines 12–7
12.3.3 Sidings 12–7
12.3.4 Public Crossings 12–7
12.3.5 Private Crossings 12–9
12.3.6 Bridges 12–10
12.3.7 Yards 12–11
12.3.8 Off Track 12–12
12.3.9 Weed Abatement 12–12
12.3.10 Brush 12–12
12.3.11 Noxious Weeds 12–12

12.4 Vegetation Control Contractors 12–13
12.4.1 Compliance With BNSF and Other Regulations 12–13
A. Obtaining Permits and Licenses 12–13
B. Complying With BNSF Rules and Regulations 12–13
12.4.2 Equipment 12–13
A. Contractor Obligations 12–13
B. Equipment List 12–14
C. Contractor Responsibility 12–14
D. Pilot or Escorts 12–14
E. Equipment Transportation 12–15
F. Contractor Losses 12–15
12.4.3 Areas of Control 12–15
12.4.4 Schedule, Reports, and Work Performance 12–15
A. Schedule 12–15
B. Work Reports 12–16
C. Work Performance 12–16
12.4.5 Subcontractors and Access to Property 12–16
12.4.6 Chemical List 12–16
12.4.7 Labels and MSDS 12–16
12.4.8 Discontinue Application 12–16

O. Terrestrial Wildlife

BNSF follows the Endangered Species Act to ensure that all threatened and endangered species are protected under the law. When there is a threatened or endangered species that is likely to be affected by the movement of trains, BNSF works closely with federal and state regulators to take measures to protect these populations.

In particular, and as an example, BNSF is proud of the work it has done in Montana to protect grizzly bears. Although the grizzly bear population has increased substantially in recent years, and many other groups are seeing increases in grizzly bear incidents that result in the death of a grizzly bear, BNSF has actually seen a significant decrease in incidents along our tracks.

There is no evidence that any barrier effects or small quantities of contaminants exist and/or pose any reasonably foreseeable threat to terrestrial wildlife. In fact, the Washington Department of Fish & Wildlife's (WDFW) letter dated October 16, 2009 in connection with the "Pacific Northwest Rail Corridor Program Environmental Assessment; WSDOT-Federal Rail Administration Proponent, BNSF Railway north-south mainline from Vancouver, Washington to Blaine, Washington", https://www.fra.dot.gov/Page/P0413 "Finding of No Significant Impacts (FONSI), Appendix A: Comment Letters on the Tier I Environmental Assessment," stated the following:

> ***Fences, sound walls, railway buttresses, bulkheads, and other vertical surfaces can impede migration travel corridors for terrestrial wildlife and may result in fragmentation or isolation of certain wildlife species. Vertical surfaces may decrease terrestrial wildlife travel corridors to fewer locations which could concentrate crossings of nearby roads resulting in potential rail and road kill hotspots. WDFW encourages the proponent to avoid, minimize, or otherwise mitigate habitat fragmentation, population isolation, or the unintended funneling of animals where it may be undesirable for wildlife or dangerous to humans.***

Further, on October 22, 2009, the Washington Department of Transportation (WSDOT) responded to the WDFW in part as follows:

> ***The corridor currently hosts more than 60 trains per day in some rural segments, therefore the addition of eight trains per day is a relatively small increase in train frequency, Additionally, on average a train passes any given location on the corridor approximately once an hour. This frequency is far less than the vehicle frequency on I-5, which is in close proximity to the rail corridor over most of the route. Finally, nearly all the specific improvements in the corridor expansion are proposed to improve an existing corridor, so wildlife in the vicinity are already accustomed to the passing of trains.***

IX. Conclusion

In conclusion, and for all the reasons cited herein, BNSF believes the scope of review contained in the DEIS to be overly-broad, not supported by available information, and not

consistent with the requirements of SEPA or NEPA. BNSF recommends that the Council defer consideration of the interstate rail system and its regulatoin to federal agencies that possess authority and expertise in this area.

BNSF would like to thank the Council for this opportunity to provide comments and information concerning the Project and the DEIS.

Sincerely,

F. E. Kalb, Jr.
Director of Strategic Development

Enclosures

Appendices

Appendix A-Figure 4-"Expected Growth of U.S. Ton-Miles of Freight" (in millions)

Source: "Beyond Traffic", U.S. Department of Transportation, (October 2015)

Appendix B- Table 1-Tonnage of Freight Carried by Transportation Mode (millions of tons)

Source: U.S. Department of Transportation, Bureau of Transportation Statistics and Federal Highway Administration, Freight Analysis Framework, version 3.6, 2015)

Appendix C- "BNSF Grade Crossing Safety Brochure"

Appendix D- State Department of Transportation; Landslide Mitigation Action Plan, Final Report (2014)

Appendix E- "BNSF Rail Safety Overview", (January 2016)

Appendix F- "Figure 13. Fatalities by Freight Transportation Mode: 1980, 1990, & 2000-2013"
Source: BTS

Appendix G-"Crude Oil Safety Measures Implemented by Railroads"

Appendix H-"BNSF Hazardous Materials Stats"

Appendix I-"BNSF Railway Wayside Detection" (July 16, 2015)

Appendix J-"BNSF Fire Fighting Trailers 150 Mile Radius"

Appendix K-"PNW Oil Spill Response Equipment Locations" (January 2016)

Appendix L- "BNSF PTC Subdivision Implementation Map"

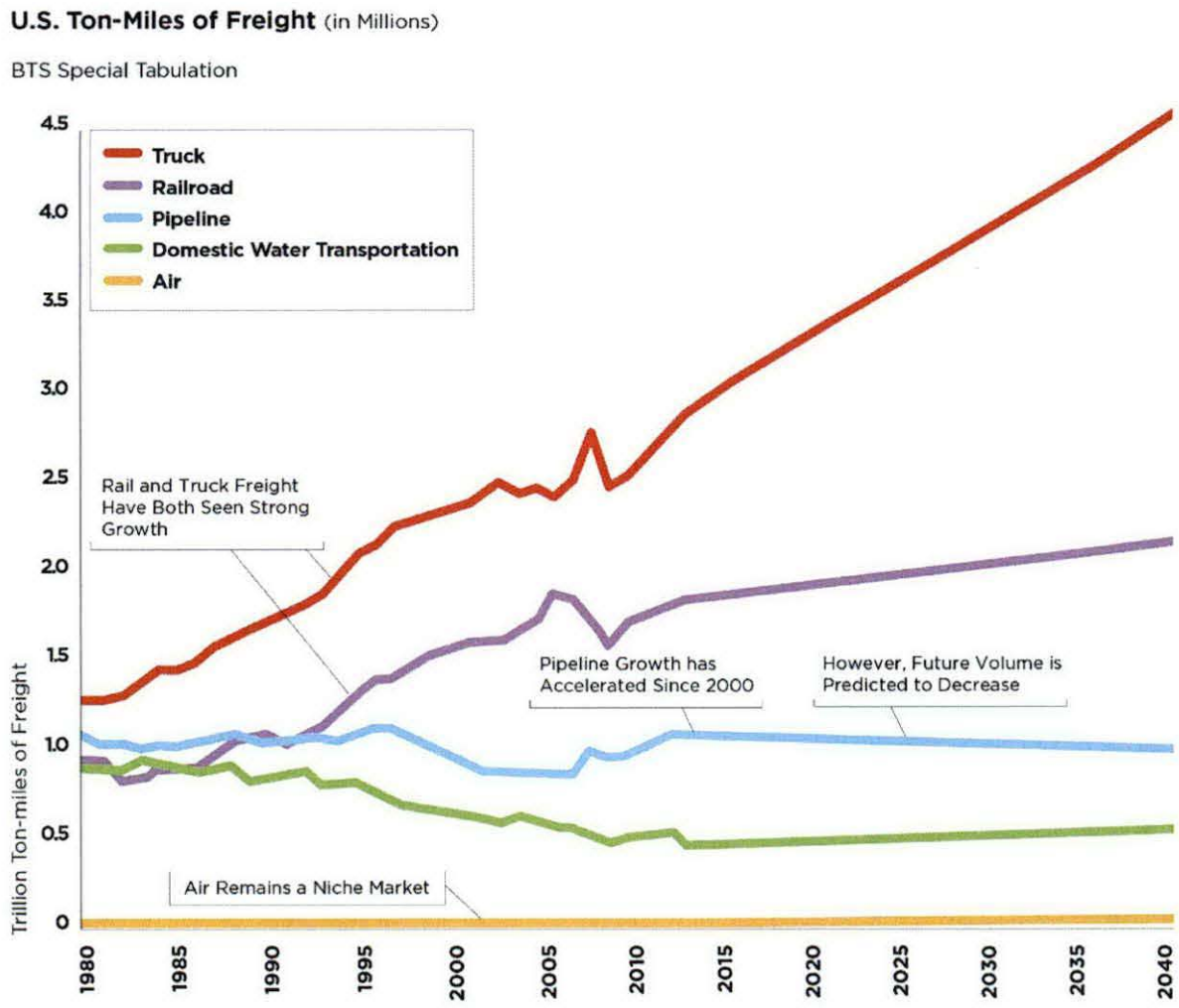


Figure 4. Expected Growth of U.S. Ton-Miles of Freight (in millions)

(Source: Beyond Traffic)

Table 1 shows a more detailed view of the expected growth of freight tonnage by transportation mode for 2007, 2013, and 2040 (forecasted), broken down into domestic movements, exports, and imports. Table 2 shows similar information, but for value of freight.

Table 1. Tonnage of Freight Carried by Transportation Mode (millions of tons) (Source: U.S. Department of Transportation, Bureau of Transportation Statistics and Federal Highway Administration, Freight Analysis Framework, version 3.6, 2015)

	2007				2013				2040			
	Total	Domestic	Exports[1]	Imports[1]	Total	Domestic	Exports[1]	Imports[1]	Total	Domestic	Exports[1]	Imports[1]
Total	**18,879**	**16,851**	**655**	**1,372**	**20,063**	**17,950**	**914**	**1,199**	**28,520**	**23,095**	**2,632**	**2,794**
Truck	12,778	12,587	95	97	13,955	13,732	120	103	18,786	18,083	368	335
Rail	1,900	1,745	61	93	1,858	1,681	82	94	2,770	2,182	388	201
Water	950	504	65	381	808	410	89	309	1,070	559	164	347
Air, air & truck	13	3	4	6	15	3	5	7	53	6	20	27
Multiple modes & mail	1,429	433	389	606	1,554	459	559	536	3,575	645	1,546	1,383
Pipeline	1,493	1,314	4	175	1,539	1,391	11	137	1,740	1,257	17	467
Other & unknown	316	266	36	14	333	274	47	13	526	362	130	34

[1]Data do not include imports and exports that pass through the United States from a foreign origin to a foreign destination by any mode.

Notes: Numbers may not add to totals due to rounding. The 2013 data are provisional estimates that are based on selected modal and economic trend data. All truck, rail, water, and pipeline movements that involve more than one mode, including exports and imports that change mode at international gateways, are included in multiple modes & mail to avoid double counting. As a consequence, rail and water totals in this table are less than other published sources.

Landslide Mitigation Action Plan

Final Report
2014

Washington State
Department of Transportation

Washington State Department of Transportation (WSDOT)
Rail Division

Contact information:

David Smelser
WSDOT Cascades High Speed Rail Program Manager
Olympia, WA 98504
360-705-6916
smelsed@wsdot.wa.gov

Acknowledgements

The Landslide Mitigation Action Plan was compiled by the Washington State Department of Transportation (WSDOT) with participation from the following entities:

BNSF Railway Company (BNSF)

Sound Transit

Amtrak

National Oceanic Atmospheric Administration (NOAA)

Governor's Office of Regulatory Innovation and Assistance (ORIA)

Washington State Department of Ecology (Ecology)

Washington State Department of Natural Resources (DNR)

Snohomish County

City of Everett

City of Mukilteo

City of Shoreline

City of Seattle

City of Edmonds

Town of Woodway

Port of Everett

Executive Summary

Each year, landslides along the Pacific Northwest Rail Corridor interrupt rail service for passenger and freight trains. High numbers of landslides between Seattle and Everett have been especially problematic for Sound Transit commuters and Amtrak Cascades passengers. Record numbers of service interruptions (sum of annulments and disruptions for all passenger trains) during the 2012-2013 winter season prompted collaboration among Washington State Department of Transportation (WSDOT), BNSF Railway Company, Sound Transit, Amtrak, and stakeholders to quantify the landslide-related impacts, identify the primary factors within the corridor that contribute to landslides, and develop mitigation strategies to reduce the occurrence and impact of landslides.

WSDOT created the Landslide Mitigation Work Group and convened bi-weekly meetings over a nine-month period. The mission of the Work Group was to develop short- and long-term strategies to reduce landslide impacts and improve transportation reliability throughout the corridor.

Documented landslide impacts for Sound Transit commuters and Amtrak passengers include direct costs, such as annulments (cancelation of trains), busing customers around the closure area, loss of ridership; and costs to BNSF for landslide debris cleanup. Indirect costs are also substantial but harder to quantify, and may include declining ridership due to perceived unreliability of winter service, devaluation of property values and subsequent loss of tax revenue, loss of commercial productivity, and increased congestion on roads when rail service is interrupted.

The majority of landslides that impact the rail line are shallow in depth and are sensitive to well-established factors and conditions. These factors include heavy or prolonged precipitation during the rainy season; the steep, high slopes that are prevalent along the corridor; underlying geology frequently associated with shallow landslides; and poor slope management practices carried out by adjacent landowners, such as discharging stormwater above or on steep slopes and disposing of yard, construction and earthen debris onto slopes. Commonly, it is a combination of factors that converge to start landslides.

Potential strategies to reduce landslide interruptions and impacts were explored by the Work Group. Strategies were outlined and evaluated for implementation time, complicating factors, and short, moderate-, and long-term effectiveness to reduce or prevent landslides.

The Work Group recognizes that measurable long-term reduction in landslide-related impacts to passenger service will require substantial investments in capital improvement projects. Depending on the financial resources available, as well as factors such as permitting, design, and construction scheduling, the time required to achieve significant reductions in landslide-related service interruptions will likely take one or more decades.

Key Findings

Short-term, low-cost strategies include:

- Develop education and public outreach to engage adjacent landowners to improve slope management practices.
- Continue low-cost mitigation options, such as maintenance of slide fences, ditches and other drainage facilities.
- Provide a drainage improvement incentive, such as reduced permit fees from BNSF to adjacent landowners (limited duration).
- Review landslide data through 2007 and develop landslide maps to be completed during the fall 2013. Inventory can be used to develop detailed landslide hazard maps to assist local agencies in the development of land use regulations on steep slopes.

Intermediate strategies include:

- Research and implement a landslide potential assessment model to inform decisions between agencies and provide additional time for contingency planning; model validation is targeted for the 2014-2015 rainy seasons.
- Design and construct up to six projects in high-priority landslide areas from 2013-2016 to mitigate landslide problems and improve service reliability.

Long-term strategies include:

- Continue community education and public outreach.
- Develop a permit process for improvements to private residential land adjacent to and/or above the track area, and identify a funding source or sources to implement improvements.
- Explore solutions for long-term slide debris removal and restoration process, such as beach nourishment.
- Optimize design of containment structures and evaluate effectiveness of stabilization measures for shallow slope failures.
- Develop a management system to prioritize and implement slope stabilization projects.
- Consider acquisition of additional right-of-way or long-term maintenance/construction easements on adjacent property in landslide-prone sections to improve opportunities to implement best-suited mitigation measures. (Note that this long-term strategy would require additional funding.)
- Explore justification for further public investment, recognizing that a significant increase in capital investment will be required to significantly reduce landslide-related closures.

Table of Contents

Executive Summary i
Key Findings ii
Introduction 1
Effect of the Plan 2
Work Group Coordination 2
Roles and Responsibilities 2
Study Schedule, February-September 2013, and Process 3
Landslide Impacts 4
Service and Cost Impacts of Landslides 5
Indirect Impacts/Costs 6
Currently Funded Capital Projects 10
Current Practice of Managing Landslide Impacts 10
Contributing Factors to Landslides 11
Climatic 11
Shape and Condition of Slope 12
Human Activity 14
Implications 15
Typical Mitigation Strategies 16
Stabilization (Capital Improvement Projects) 16
Protection 18
Avoidance 18
Maintenance and Monitoring 18
Proactive Versus Reactive Mitigation Strategies 19
Strategies to Reduce Landslide-Related Interruptions and Impacts 21
Complicating Factors for Landslide Reduction 22
Implementation Plan Status 25
Short-Term Improvement Strategies 25
Intermediate Strategies 26
Long-Term Strategies and Recommendations 26
References 28
Appendices 29

Introduction

Frequent landslides along the railroad corridor, especially between Seattle and Everett during the wet winter season pose periodic service interruptions for passengers on the Amtrak Cascades, Amtrak Long Distance, and Sounder. Landslides result in rail closures and emergency project activities every year, particularly during the rainy season from October to April. Disruption of rail service within the Seattle to Everett corridor has been especially problematic, with a record number of annulled and disrupted daily passenger trains (sum of both Sounder and Amtrak Cascades trips) due to landslides in 2013.

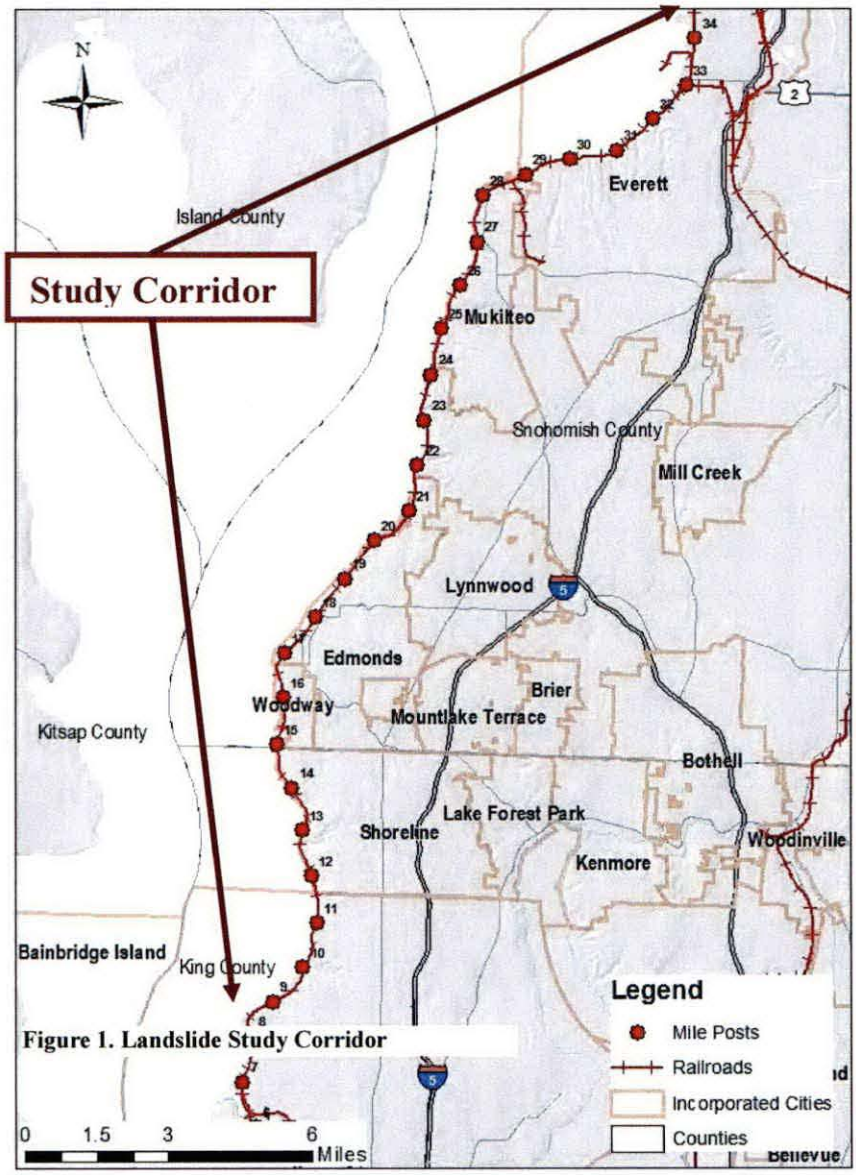


Figure 1. Landslide Study Corridor

At the request of the Washington State Secretary of Transportation, the Washington State Department of Transportation (WSDOT) initiated a joint work group effort with BNSF Railway Company (BNSF), Amtrak, Sound Transit, and local jurisdictions and stakeholders called the Landslide Mitigation Work Group. The mission was to investigate contributing factors to landslides within the corridor and determine a path to solutions.

The Work Group developed the Landslide Mitigation Action Plan to evaluate causes of landslides within this 26.6-mile-long railway corridor (Figure 1), and form reasonable mitigation strategies to reduce impacts to the traveling public. The extent of the study area was defined by the high frequency of events. Landslides within the study corridor are triggered by a combination of factors including climatic/hydrologic factors (e.g., heavy or prolonged precipitation during the rainy season), geomorphic factors (i.e., steep topography), geologic conditions and impacts from human activities.

Effect of the Plan

The purpose of this Plan:

- Document potential improvement strategies.
- Identify actions to minimize impacts to traveling public.
- Identify recommended actions for measureable improvements in interruptions due to landslides.

This Plan is *not* intended to:

- Guarantee landslides will not occur in the corridor.
- Prevent other government agencies or group members from advocating a particular improvement.
- Provide funding for proposed action strategies.

Work Group Coordination

Rail transportation is dependent on partnerships among government agencies, private industry and other stakeholders. The Work Group was a cooperative effort with WSDOT, BNSF, Sound Transit, Amtrak and local jurisdictions/stakeholders within the study corridor, such as the Washington Department of Natural Resources, Washington Department of Ecology, National Oceanic Atmospheric Administration, and Governor's Office of Regulatory Innovation and Assistance. Local jurisdictions include the cities of Everett, Mukilteo, Shoreline, Edmonds, and Seattle; the town of Woodway; and Snohomish County. The group implemented a reasonable strategy to identify contributing factors to landslides within the corridor, develop conclusions based on research, and create an implementation plan with recommendations for measurable improvements to the traveling public.

Roles and Responsibilities

- The WSDOT Rail Division sponsors the Amtrak Cascades and its intercity passenger rail service along the Pacific Northwest Rail Corridor, contracting with Amtrak as the service provider. Sound Transit and Amtrak contract with BNSF for track use.

  In WSDOT's Amtrak operating agreement, Amtrak is responsible for operating the Amtrak Cascades service.
- BNSF and Amtrak notify WSDOT of operational changes.

- BNSF owns and maintains the rail rights of way and track structures. BNSF is responsible for maintaining the railway infrastructure in compliance with Federal Railroad Administration safety standards. As the owner of the track, BNSF is responsible for addressing landslides within the BNSF right of way (ROW) only. However, landslide stabilization projects must often be constructed, at least in part, on property outside of BNSF-owned ROW to be effective, as a majority of landslide activity in this corridor originates from above and off BNSF property.

- Local agencies within the corridor are responsible for permitting development activities in geologically hazardous and/or sensitive areas (such as steep or unstable slopes) within their jurisdictions. This includes, but is not limited to, vegetation management and implementing development standards, such as building setbacks from steep slopes/bluffs, defining and communicating stormwater runoff requirements, erosion/sediment control during construction and communicating seasonal restrictions during the rainy season.

Study Schedule, February-September 2013, and Process

February	Develop framework for final product; initiate data collection.
March	Data collection and documentation.
April	Interim report: data collection; develop action strategies.
May	Continue development of action strategies; prioritize action strategies.
June	Interim report: immediate action strategies.
July-August	Implement immediate action strategies; draft final report.
September	Final report; executive summary; recommended solutions.

Landslide Impacts

Washington State supports a rail system that is integral to maintaining our economy, environment and quality of life. The rail system provides transportation for freight rail (BNSF), commuter rail (Sound Transit), intercity passenger rail (Amtrak Cascades), and long distance passenger rail (Amtrak).

Washington and Oregon jointly sponsor Amtrak Cascades, a 467-mile-long regional service that operates between Eugene, Ore., and Vancouver, British Columbia (Figure 2). Since 2000 Sound Transit has been operating a system of express buses, commuter rail and light rail to provide faster, more dependable ways to commute within the counties of Snohomish, King and Pierce. Sound Transit uses a portion of the BNSF line to provide daily commuter rail service between Everett and Seattle.

More than 60 areas along the 467-mile-long Amtrak Cascades route have been identified as at risk for landslides. However, the majority of landslides occur within a 26.6-mile-long corridor, from north Seattle to Everett along steep coastal bluffs. Since 1914, more than 900 blocking landslides have occurred along the Seattle-Everett rail corridor, with 5.5 miles of quarter-mile sections experiencing 10 or more blocking landslides (Appendix A).

Figure 2. Amtrak Cascades Route

Service and Cost Impacts of Landslides

Landslides not only present risks to passenger service operations, but also have social and economic effects. Landslides can destroy or damage residential and commercial developments and agricultural areas, and negatively affect water quality in rivers, lakes and the Puget Sound. Increased development in landslide prone areas, deforestation and precipitation can all contribute to higher landslide activity (Schuster 1996).

Direct costs of landslides, such as repair, replacement or maintenance, are more easily identified than indirect costs, such as loss of property values, loss of tax revenue, loss of commercial productivity and adverse effects to water quality (Schuster 1996). The Work Group evaluated direct and indirect costs of landslides within the study corridor.

Direct Costs

Direct costs include capital improvement projects and maintenance costs, such as debris cleanup and disposal. In most instances, BNSF must dispose of landslide debris offsite. Since 2008 direct costs for BNSF, as a result of landslide impacts, are estimated at more than $10 million (Table 1). This does not include losses associated with freight train delays.

Table 1. BNSF Railway Landslide Related Costs

Year	Expenditures
2013*	$4,041,000
2012	$2,442,000
2011	$796,000
2010	$2,628,000
2009	$374,000
2008	$110,000

** Data through May 2013.*

In addition to BNSF capital improvement projects, WSDOT has provided approximately $6.3 million of federal funding for landslide mitigation efforts, with an additional $92,000 directly from state funds. These expenditures represent progress on expected project costs budgeted at $16.1 million in federal dollars and $304,000 in state funds.

The Port of Everett identified direct impacts from landslides in the corridor that included property damage and interruption of seaport operations. For example, the Port spent significant money cleaning and repairing stormwater treatment facilities (bioswales) and cleaning a public access trail and Terminal Avenue due to slide damage (Figure 3). The Port cited difficulty maintaining compliance with stormwater permit conditions when treatment facilities fill with landslide debris. Landslide debris that spills across Terminal Avenue also impacts cargo staging areas, construction projects and access to land needed for operations.

Figure 3. Terminal Avenue train car derailed by landslide (photograph courtesy of Port of Everett).

Indirect Impacts/Costs

Indirect costs for Amtrak Cascades and Sounder Commuter Rail within the study corridor include disruptions to service and subsequent loss of ridership. Record numbers of service disruptions (total number of cancelled or disrupted passenger trips for Amtrak Cascades and Sounder) occurred during the 2012-2013 season. Costs to the local communities include direct loss of property, devaluation of property, higher insurance costs for homeowners along the bluff, and homeowner costs for repairs and/or prevention.

Local jurisdictions, such as the cities of Mukilteo and Everett, identified commuter disruption, impacting time lost to the individual, as well as increased roadway congestion. The impact to property owners can include direct loss of property, but also the expense of repair and/or construction, permitting costs and emotional impact. Some property owners lose access to their property, which requires time, money and effort to repair. For property owners without resources to fix the damages, funding is not available and they are profoundly affected.

In addition, the disruption of rail service from a catastrophic event can greatly impact the local and regional economy. These impacts affect the private sector and all governmental agencies, from smaller entities to the state level.

Amtrak Cascades

Amtrak Cascades trains have been impacted by landslides since daily intercity passenger rail service was re-established between Seattle and Vancouver, B.C. in May 1995. Since 2009, WSDOT maintained detailed data on service impacts resulting from landslides. These service impacts occur in two ways:

1. Trains are canceled and do not operate over any portion of their scheduled route. These service impacts are called annulments.
2. Trains operate over a portion of their route, with buses deployed to cover one or more segments of impacted areas between cities. These service impacts are called disruptions.

Seasonal service impacts from 2009 to 2013 ranged from 20 to 71 annulments, and 27 to 104 seasonal disruptions during the season (October-June) from 2009-2013 (Table 2).

Table 2. Amtrak Cascades Seasonal Annulments and Disruptions from 2009-2013

October – June	Annulments	Disruptions
2012 - 2013	50	81
2011 - 2012	23	31
2010 - 2011	71	104
2009 - 2010	20	27

Calculating the financial impacts during service annulments and disruptions is challenging because many factors influence a person's decision to ride Amtrak Cascades (ticket prices, automobile fuel prices and on-time performance of train service). The calculation of financial impacts is further complicated by the fact that travelers holding tickets when a landslide occurs will still be transported to their destination by either a bus or a combination of a bus and a train.

A comparison between ridership and revenue data for Amtrak Cascades trains between Seattle and Everett for the past four seasons showed a precipitous drop (20 to 35 percent for major city pairs) in ridership and revenue from 2012-2013 (Table 3). While this decline in ridership and revenues was observed in most of Amtrak's national network during April 2013, customers may have chosen not to ride the trains due to concerns for their safety after Amtrak's long-distance Empire Builder train was partially derailed by a landslide near Everett, specifically on April 7, 2013.

Table 3. Amtrak Cascades Trains 510, 513, 516 and 517-Ridership and Revenue 2009-2013

October-June	Ridership	Revenue
2012 - 2013	143,676	$5,860,420
2011 - 2012	163,207	$6,540,335
2010 - 2011	160,275	$6,052,903
2009 - 2010	162,995	$6,018,360

Sounder Commuter Rail

Sounder Commuter Rail, operated by Sound Transit, started its north line service between Everett and Seattle in December 2003 with a single daily round trip. Landslides began to significantly impact Sounder service in the 2005-2006 winter with 10 days of cancelled service and 40 annulments. All but one winter since 2008-2009 has experienced service disruptions from landslides with the number of impacts growing as service increased from one to four daily round trips. In the 2012-2013 winter, 28 days of Sounder rail service were disrupted, resulting in 206 annulments (Table 4).

Table 4. Sounder Commuter Rail Seasonal Annulments, Days Impacted, and Daily Trips Scheduled from 2003-2013

October – June	Annulments	Days Impacted	Daily Trips Scheduled
2012 – 2013	206	27.5	8
2011 – 2012	41	7	8
2010 – 2011	70	9	8
2009 – 2010	24	3	8
2008 – 2009	0	0	8
2007 – 2008	18	3	6
2006 – 2007	16	4	4
2005 – 2006	40	10	4
2004 – 2005	0	0	2
2003 – 2004	3	2	2

When Sounder service is cancelled, customers are directed to special bus transportation that Sound Transit arranges to transport riders to Sounder stations. These buses augment existing bus service, which are often overloaded from absorbing the additional commuters unable to commute by rail transit. There are also occasions when limited partial service is offered (i.e., morning or afternoon train, or a train to one or two stations not impacted by slide activity), rather than cancelling an entire train. For instance, if landslides occur north of Mukilteo, service may be possible between Seattle and Edmonds/Mukilteo, but not Everett. On these occasions, the replacement bus service is only required for customers that travel between Seattle and Everett.

The largest financial impact to Sounder north line service as a result of landslides is lost farebox revenue from declining ridership. However, quantifying these financial impacts is challenging

because it is unknown how many customers chose not to ride Sounder rail after a particular landslide event has impacted service. Other than the original $368 million provided to BNSF for the permanent easements and track improvements necessary to meet track-capacity requirements, as well as station construction, Sound Transit does not have additional capital investments in the corridor beyond what was approved in the 1996 Sound Move ballot measure. In 2008, voters approved a second platform and other station access improvements at the Mukilteo facility in the Sound Transit 2 ballot measure. Additional operating costs are incurred by Sound Transit when buses are required because of cancelled trains, which can cost several thousand dollars per day. These costs, however, are offset by the elimination of operating costs from cancelled train trips.

In the 2010 to 2011 season, when there were 70 cancelled trips in a season, average daily ridership decreased by approximately 10 percent, and it was more than a year before ridership returned to previous levels. The 2012-2013 season took a particularly heavy toll on Sounder north ridership, where 206 trips were cancelled, which nearly tripled the earlier high of 70 in the 2010-2011 season (Table 4). Although overall annual growth in Sounder ridership exceeded 10 percent during 2012, Sounder north line ridership was down 7 percent (1,215 average boardings) in July 2013 from the October 2012 high of 1,304 average daily boardings (Table 5).

Table 5. Sounder Commuter Rail North-line Service

Year	Annual Boardings	Average Daily Boardings	Percent Growth on Average Daily Boardings
2013	TBD	1,147*	6%*
2012	307,846	1,144	21%
2011	280,767	946	-9%
2010	303,060	1,024	-5%
2009	319,719	1,080	2%
2008	314,072	1,062	26%
2007	252,299	843	27%
2006	201,299	665	43%
2005	151,773	466	68%
2004	88,903	277	

*YTD through June 2013 Data

Amtrak Long-Distance Service

The Amtrak Empire Builder and Coast Starlight trains operate in Washington State with a terminal in Seattle at King Street Station. Because the landslide activity occurs primarily north of Seattle, the Empire Builder has experienced more impacts from the landslides than the Coast Starlight. The Amtrak long-distance train service has been impacted by landslides as long as service has been in existence.

Calculating the financial impacts that occur when there are service annulments and disruptions is challenging for the same reasons mentioned for Amtrak Cascades (i.e., other factors such as ticket prices, automobile fuel prices and on-time performance of train service). The table below compares ridership and revenue data for Amtrak long-distance trains that traveled within Washington state for the past four seasons. The 2010-2013 time periods were impacted by outages on the Empire Builder line.

Table 6. Amtrak Long Distance Trains 7, 8, 11, and 14 Ridership and Revenue Data from 2009-2013

October – June	Ridership	Revenue
2012 - 2013	247,259	$29,615,975
2011 - 2012	243,438	$29,007,289
2010 - 2011	218,625	$25,567,097
2009 - 2010	239,832	$25,296,150

Currently Funded Capital Projects

Recently, the Federal Railroad Administration (FRA) awarded $16.1 million to WSDOT to identify, design and construct slope stabilization improvements. WSDOT and BNSF are collaborating on environmental and engineering work. These long-term improvements will be in various stages of design and construction from 2013-2016.

Current Practice of Managing Landslide Impacts

As the owner of the rail corridor, BNSF is ultimately responsible for the operational and maintenance aspects of the track structure. BNSF routinely inspects and maintains the slopes, ditches, retaining structures and tracks to minimize impacts to railroad operations when landslides occur. BNSF also uses an extensive network of slide fences through much of the corridor. When the wires of a slide fence are severed by landslide debris, an indication is provided to the BNSF dispatcher and train crews are signaled accordingly. Inspection and monitoring of the rail corridor between Seattle and Everett is heightened during the rainy season. When a landslide occurs that blocks one or more tracks (referred to as a blocking event), BNSF imposes an automatic 48-hour moratorium on passenger rail service through the impacted segment of the corridor. Alternate bus service is then deployed for riders. Impacts to riders vary, ranging from longer commutes to missed appointments and work days.

Over the years, BNSF has invested millions of dollars in installing slide fences, building catchment walls and widening ditches to contain the landslide debris and stabilize the slopes.

Contributing Factors to Landslides

The occurrence of a landslide is dependent on a combination of site-specific conditions and influencing factors. Common factors that contribute to landslides fall into four broad categories:

1. Climatic/hydrologic (rainfall or precipitation)
2. Geomorphic (slope form and conditions - i.e., slope shape, height, steepness, vegetation and underlying geology)
3. Geologic/geotechnical/hydrogeological (groundwater)
4. Human activity.

Climatic

Climatic factors influencing landslides include the duration of rainfall events, intensity of rainfall, and type of precipitation (i.e., snow or rain), as well as rainfall conditions over a period of time (antecedent conditions). Typically, numerous landslide events are associated with intense and/or prolonged periods of rain (Baum et. al., 2000). Recorded landslides impacting the corridor largely occurred during the winter wet season between October and April. An example of an unusually large, deep-seated landslide occurred in January 1997 south of Edmonds in the town of Woodway (railroad milepost 14.80) following a two-week period of heavy precipitation (Figure 4). Some episodes of widespread landsliding corresponded with storms involving the rapid melting of previously accumulated snow by wind and warm rain, which is referred to as "rain-on-snow" storm event. The landslide cut 50 feet into the property above, passed over the railroad tracks and knocked a freight train into the Puget Sound.[1] Many of the shallow landslides prevalent along the corridor have occurred during a single storm event involving one or more days of intense rainfall (Baum et al, 2000).

Antecedent conditions

Refers to the amount of rainfall that has fallen in previous weeks, months or even years.

Figure 4: 1997 Woodway landslide.

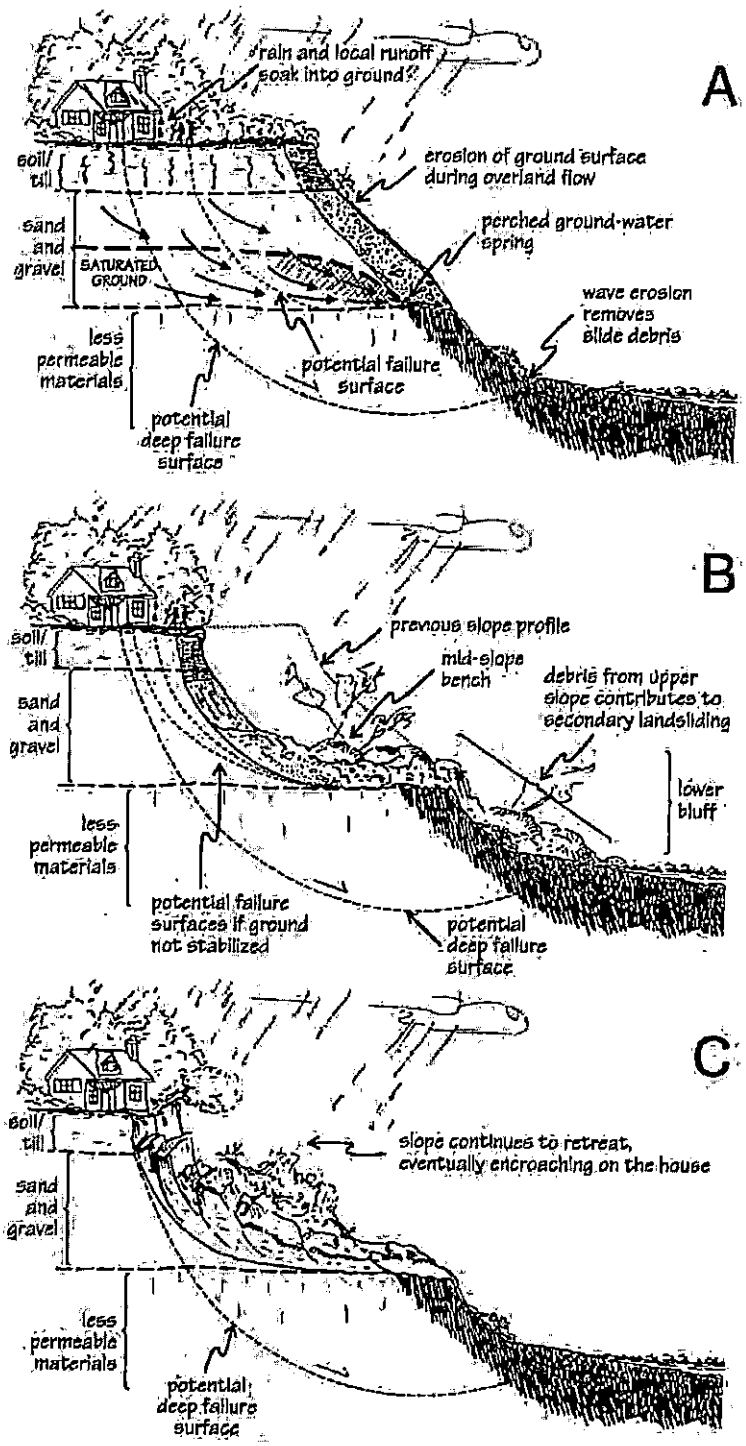
[1] www.ecy.wa.gov/programs/sea/landslides/show/woodway.html

Shape and Condition of Slope

Geomorphic (Slope Form)

The form and condition of a slope can affect its stability. Geomorphic factors affecting slope form include height and steepness, as well as vegetation and underlying geology. Increased steepness and slope height generally correlate with reduced stability. Many of the landslide-prone slopes along the corridors are more than ten stories (100 feet) in height and quite steep (35-45 degrees slope gradient). This steep orientation exceeds the long-term stability of the relatively weak sediments that comprise the slopes, and such slopes or segments of slopes are often referred to as being in an "oversteepened condition." Increased slope height and the lack of vegetative cover, especially conifers, increase the amount of rainfall that reaches the slope surface. Vegetation generally contributes to how well the near-surface soils hold together and thus helps resist surface erosion. Bare slopes tend to be more prone to erosion than well-vegetated slopes. Large trees, however, can also be a detriment to localized slope stability, where they root on steep slopes underlain by dense soils. For this reason, the presence and type of vegetation and its contribution or detraction from stability needs to be evaluated on a site-specific basis by qualified professionals.

Whether water infiltrates into the ground or runs off is influenced by the permeability (porousness) of the geologic substrate, its degree of saturation (affected by antecedent conditions) and precipitation intensity. The compact (solid) and fine-grained nature of some of the underlying geologic units within the corridor limits infiltration and increases the likelihood of saturating and weakening the near-surface, loosened soils. Within the corridor, this condition commonly results in the separation and rapid transport of relatively thin, slab-like portions of the slope, known as *debris avalanches*. Concentrated surface water runoff within drainages and swales can further lead to channel-confined slope failures, involving the rapid transport of highly fluidized debris, known as *debris flows*. More than 80 percent of the documented landslides between 1914 and 2001 were shallow landslide types (debris avalanches and debris flows) (Shannon & Wilson, 2001). Figure 5 illustrates how precipitation and groundwater can influence the occurrence of deep-seated landslides.



At the beginning of an idealized cycle, the bluff has a uniform slope. Water infiltrates the surface soils and perches above the relatively impermeable materials at the base of this sandy sequence. Saturation creates pore-water pressures that reduce the effective strength of these materials.

Runoff and precipitation introduced by the sources shown in A have infiltrated and weakened the sediments, causing failure of the unconsolidated upper sand unit. Once mobilized, the sand moves (sometimes episodically, sometimes continuously) along the contact with the underlying less permeable unit on the mid-slope bench, often cascading as a secondary landslide off the bluff formed by the lower unit. This migration of material across the bench decreases the buttressing of the upper bluff. Failure surfaces can be deep (those that project into the lower, less permeable materials) as well as shallow.

Benched bluff retreat continues. Movement of slide debris toward the lower bluff further destabilizes the upper bluff, causing continued sloughing onto the bench. Either failure of the upper bluff onto the bench or failure of the slide debris off the lower bluff can trigger a cycle of movement. Movement along a deep-seated surface can reset this sequence of events.

Figure 5: This sequence of sketches shows a conceptual process that forms bluffs in the northern Puget Sound area and causes them to retreat. More permeable soils/sediments sit on top of less permeable sediments. Water run off infiltrates this upper layer until it meets the lower layer, where water is "perched." This causes the soils at this interface to saturate to the point of failing. Lower soil layer failure removes the support for the upper layers and they also fail (Gerstel et al. 1997).

Geologic/Geotechnical/Hydrogeologic (Geology and Groundwater)

The geologic conditions, and engineering (geotechnical) and groundwater (hydrogeologic) characteristics of the geologic units that compose the slope greatly influence its stability. Generally, the upper portions of the slopes along the corridor are underlain by a sequence of glacial sediments deposited in advance, beneath and during the last continental glaciation (Vashon Stade). Fine-grained lake sediments that formed in front of and then compacted by the advancing ice sheet typically underlie the coarse-grained Vashon advance deposits, and have been referred to as transitional beds (Minard, 1982, 1983, 1985; Yount et al., 1993). These transitional beds are underlain by a variable sequence of very compact interglacial deposits (called the Olympia beds and Whidbey Formation) and older glacial deposits (known as Possession and Double Bluff Drifts), which typically outcrop in the middle to lower portions of the slope. Of all the geologic units within the corridor, several are recognized as "bad actors" — over 60 percent of the landslides reported between 1914 and 2001 originated within the transitional beds or the Whidbey Formation (Shannon & Wilson, 2001).

> **Glaciation**
>
> Alteration of any part of the earth's surface by passage of a glacier, such as erosion or deposition.

Landslides also commonly recur in the same areas. Remobilized landslide debris from previous landslides was another geologic unit significantly contributing (approximately 13 percent) to landsliding (Shannon & Wilson, 2001). Baum et al. (2000) noted that roughly two-thirds of the landslides generated during the winter storms of 1995-96 and 1996-97 initiated within the bounds of mapped landslide events.

Human Activity

Human activities have repeatedly been observed to be a substantial contributor to landslides within the corridor. These adverse and widespread activities primarily involve the discharge of stormwater onto or above slide-prone slopes; the cutting and re-grading of slopes; and the disposal of yard, construction, and earthen or other debris onto the upper portion of the slope (Shannon & Wilson, 2001). In addition to these adverse practices by adjacent landowners, the density of upslope development, even hundreds of feet behind the top of the slope, has the potential to significantly contribute to groundwater recharge through more concentrated discharge of storm water runoff. This in turn has the potential to adversely impact stability of the slopes along the rail corridor.

> **Transpiration**
>
> The evaporation of water from leaves.

More complex in its relationship to slope stability is the effect of removing vegetation. Rooting depth and the interception and transpiration potential offered by mature conifers during the winter wet season can be important contributors to stability. Conversely, the effect of wind on mature conifers, referred to as *windthrow*, can disturb the substrate in which they root, resulting in localized slope instability. For these reasons, the presence and type of vegetation and its

contribution or detraction from stability needs to be evaluated on a site-specific basis by qualified professionals.

Implications

While a landslide on an adjacent slope does not always impact the rail line, about 80 percent of the documented landslides between 1914 and 2001 generated debris that reached one or both railroad tracks. Despite the investigation bias of this data (landslides are generally only investigated when they might affect the tracks), the close proximity of the tracks to the base of the steep slopes and the very limited area available for debris containment is a primary reason for the apparent high likelihood of impact to the tracks when a landslide does occur. The volume of debris, material and transport characteristics [i.e., material composition, velocity, viscosity (thickness), path of travel, etc.], location of landslide initiation, and the potential to gather additional material during transport (bulking) further influence the potential for debris run-out onto the tracks and the extent of impacts.

Given the wide range of potential factors that influence landslide initiation characteristics, it is virtually impossible to predict the location and impacts of a single event within such a long landslide-prone corridor. However, of all the potential influencing factors, five factors were judged by Shannon & Wilson (2001) to be the most differentiating in quantifying risk of landslide-related impacts to the tracks:

1. Density of slides – Number of historic landslides per quarter mile of track.
2. Catchment area – Available area between the base of the slope and tracks to contain debris.
3. Slope height – Influences both debris volume and impact/run-out characteristics.
4. Geology – Tendency of specific geologic units to experience landslides.
5. Line closures – Percentage of total number of landslides per quarter mile of track that impacts tracks.

Such experience is invaluable for prioritizing where and what type of future mitigation should be considered when funding for capital improvements is available. There is ongoing research to develop better understanding of the precise climatic conditions that have a high potential of generating shallow landslides.

Typical Mitigation Strategies

There are four basic strategies to mitigate for a particular landslide:

- Stabilization
- Protection
- Avoidance
- Maintenance and monitoring

Only stabilization seeks to counter one or more key failure mechanisms and improve stability of the slope. The latter three strategies (protection, avoidance, and maintenance and monitoring) allow slope failure and seek to avoid, protect against or limit the associated impacts. The last mitigation strategy, maintenance and monitoring, is different than a "do-nothing" alternative; a "do-nothing" alternative is a management approach/decision, not a mitigation strategy.

Stabilization (Capital Improvement Projects)

Typical landslide stabilization measures include grading the unstable portion of the slope to a lower gradient, construction of rock buttresses and retaining walls, and drainage improvements. Examples shown below entail grading with slope armoring/buttressing (Figure 6) to address a large deep-seated landslide at railroad milepost (MP) MP 24.5; and patterned reinforcement of high-tensile-steel wire mesh that could potentially be used to address the abundant shallow-type landslides that originate upslope of BNSF's ROW (Figure 7). With the exception of drainage improvements, stabilization measures are typically moderate to high cost, but provide a long-term solution with low, long-term maintenance costs. Cessation of adverse human activities by diverting stormwater away from steep slopes, maintaining appropriate native vegetation, and properly disposing of debris off-site are also considered measures that would improve stability.

Figure 6. Recent slope reinforcement project at rail line MP 24.5 (Photographs courtesy of BNSF).

Figure 7. Slope reinforcement project in Germany involving a steep cut in highly weathered sandstone. Reinforcement consists of high-tensile-steel wire mesh secured with patterned ground anchors, showing installation and re-vegetation (photographs courtesy of Geobrugg).

Protection

Protection measures for landslides primarily focus on containment and/or diversion of the moving debris. Such measures include walls, berms, ditches and catchment basins, which can be low to moderate in cost. However, considerable long-term maintenance costs are often associated with these measures to clean out and dispose of accumulated debris. BNSF currently employs a number of timber and steel containment walls (Figure 8).

Figure 8. Debris containment wall along BNSF rail line consisting of steel "H" piles with precast concrete lagging to facilitate cleanout (photograph courtesy of BNSF).

Avoidance

Avoidance measures constitute a permanent solution to a landslide hazard. Measures include realignment away from the slope, relocation of the facility, tunnels and elevated structures that allow passage of debris beneath the facility. The typically high cost of these measures is offset by the elimination of further landslide-related maintenance costs and exposure to landslide risk.

Maintenance and Monitoring

Maintenance and monitoring measures may involve proactive cleanout of available catchment areas, routine observation and assessment of slope conditions, landslide-warning (slide) fences, monitoring slope and weather instrumentation and preemptive closures. Generally, these measures are relatively low cost and can be highly effective in reducing public exposure to slide risk. With the exception of cleaning existing catchment areas, these measures do not reduce the likelihood of a landslide event or the potential of landslide debris reaching the tracks. Slide fences are used extensively through the corridor to warn of the potential for debris on the tracks

(top of the wall in Figure 8). Another measure employed by BNSF is the passenger rail moratorium imposed for 48 hours following a blocking event due to a landslide.

Figure 9. Slide fence on top of a wall along the BNSF right of way (photograph courtesy of BNSF).

Selection of the most appropriate mitigation strategies is influenced by many factors that often have little relationship to the factors contributing to the landslide. Some of these include available funds, right-of-way/property ownership, required permits, access constraints, environmental effects and service interruption during construction.

Proactive Versus Reactive Mitigation Strategies

The mitigation strategies above can be implemented reactively or proactively. Reactive responses are instituted at the time of failure with little to no advanced planning. Expenditures are made when necessary, and are tailored to address actual conditions. No unnecessary expenditures are made on slopes that might not otherwise fail and impact the facility within a reasonable timeframe. However, reactive responses are often required at inconvenient times and locations, and are generally more costly to construct than when the same work is performed proactively at a more opportune time. Also, there are often more barriers to designing and constructing what is most effective and best suited for the site under emergent conditions. Further, direct and indirect costs/impacts — especially those indirect — are more difficult to manage by relying solely on reactive responses. Problems with a reactive management approach for unstable slope impacts to transportation facilities include high public expectations of the reliability, convenience and safety of the system (Lowell and Norrish, 2013).

Proactive responses, on the other hand, require considerable planning, especially when having to choose among hundreds of landslide-prone slopes. Some of the benefits of a proactive response generally include lower costs, better conditions to design and build under, and higher reliability. With the responsibility of managing many unstable slopes along transportation facilities, several public transportation departments (including WSDOT) instituted management systems for proactively identifying, prioritizing, programming, funding and ultimately mitigating these hazards. It is important to stress that implementation of a proactive management system to address large numbers of landslide-prone slopes does not relieve the need for reactive responses or eliminate the potential of further closures. When managing numerous unstable slopes, it is not possible to predict which slope will fail first or when it will fail. In addition, program implementation requires long-term commitments, since it can take many years to make necessary improvements to significantly reduce landslide-related closures on such a landslide-prone corridor. As an example, in 1974 a rock slope maintenance program was implemented along a rail corridor in British Columbia involving 750 rock fall sites. In the opinion of the geotechnical specialist involved since program inception, it took nearly three decades for the program benefits to become clearly recognizable (WSDOT, 2006).

Strategies to Reduce Landslide-Related Interruptions and Impacts

The work group evaluated potential strategies to reduce landslide interruptions and impacts. Strategies were outlined and evaluated for implementation time, complicating factors and effectiveness to reduce or prevent landslides over the short-, moderate- and long-term (Table 7). Strategies include:

1. Conduct community outreach and education:
   - Engage adjacent landowners to improve slope management practices.
   - Develop a public information campaign on best practices.
   - Construct demonstration projects in coordination with adjacent land owners.
   - Work with municipalities, Washington Department of Ecology and BNSF to streamline slope management permit process and provide clear direction on best practices (i.e., stormwater, vegetation management).

2. Implement vegetation management program:
   - Work with adjacent landowners to identify and implement vegetation management plans in specific areas based on recommendations from geotechnical and vegetation specialists.
   - Work with adjacent landowners to retain and replant native vegetation where it benefits slope stabilization.

3. Review feasibility of improving monitoring tools:
   - Research available systems and tools. Representatives from participating agencies have discussed whether monitoring tools can be developed.

4. Explore options for long-term debris disposal plan:
   - Evaluate beach nourishment as an option to remove slide debris. The strategy seeks to improve near-shore habitat and ecological function, as well as to reduce the amount of landslide debris to be removed offsite. Provides benefit for salmon restoration efforts through the restoration of forage fish spawning habitat.
   - Above strategy requires collaboration with U.S. Army Corps of Engineers (Corps), Ecology and BNSF for permitting revisions.

5. Continue maintenance and monitoring:
   - Proactively clean out available catchment areas and drainages.
   - Continue routine observation and assessment of slope conditions.
   - Maintain slide fences.

6. Consider acquisition of additional right-of-way or long-term maintenance/construction easements on adjacent property in landslide-prone sections:

- Recognizes difficulty of ensuring long-term implementation and maintenance of best slope management practices by adjacent landowners, and that adjacent landowners may lack resources to implement necessary improvements.
- Provides opportunity to implement best-suited mitigation measures, but assumes more responsibility.

7. Develop and maintain an inventory of landslide sites for possible implementation of a public-domain landslide management program:
   - Develop inventory and a systematic hazard/risk evaluation (rating), which would be subsequently used for project scoping and preliminary cost estimating, prioritization (benefit-cost analysis), programming, design and final construction estimating and plan development.
   - Use inventory as the basis for project selection, evaluating and justifying project merit, long-term management of the problem and measurement of program success.
   - Maintain a public-domain inventory of landslides, which provides a basis to relate landslide locations and frequency of occurrence to their associated impacts (e.g., annulments, volume of debris, closure duration and direct costs). Data would be invaluable for implementing a public-domain landslide management system, if deemed appropriate and justifiable.

8. Capital Improvement Projects:
   - Increase capital investment in landslide mitigation projects. Measurable long-term reduction in landslide-related impacts will require a significant increase in expenditure on capital improvement projects. The time required to significantly reduce landslide-related service interruptions is likely to require one or more decades, depending on the amount of financial resources available, permitting, design, and construction scheduling.

Complicating Factors for Landslide Reduction

Developing a plan that measurably reduces landslide-related interruptions to passenger rail service within the corridor is complicated by the following:

- *Large Problem Area* – More than 900 landslides have occurred at hundreds of locations within the 26.6-mile-long corridor since 1914. Many of the adjacent unstable slopes are greater than 100 feet high.
- *Land Ownership* – Most of the landslides on private property are outside BNSF's control or responsibility. Many of the landslides are partially due to poor slope management practices conducted by adjacent landowners.
- *Limited Right-of-Way (ROW)* – BNSF has a narrow ROW (about 50 feet upslope of the tracks) available to contain landslide debris or to construct protection structures. Construction of slope stabilization measures generally requires work outside of BNSF's ROW.
- *Differences in Organizational Priorities/Roles/Responsibilities* – Sound Transit, Amtrak, and WSDOT are charged with providing public service, and they do not own and are not directly responsible for track maintenance. BNSF, as a private corporation, is responsible for track maintenance and identifying, prioritizing and funding its own capital

improvement projects. Priorities for spending available funds may be different depending on the (public or private) source of the funds. Landslide origination point is often on private property outside BNSF right-of-way.

- *Low Risk Tolerance* – The risk tolerance for public safety is very low, so closure decisions will always err toward safety.
- *Assumption of Responsibility* – BNSF is responsible for determining safe operating conditions in their Seattle to Everett corridor. Implementation of some of the proposed mitigation strategies may involve more shared responsibilities or liabilities between stakeholders as several strategies are not constrained to State- or BNSF-owned right of way.
- *Funding* – Currently, there is no long-term source of public funds for capital improvements to proactively address landslide-prone slopes. Determining which, if any, slopes warrant expenditure for remediation, as well as the type and extent of remedial work, is the responsibility of BNSF.
- *Permitting* – Permitting process and timelines vary between agencies such as Ecology and the Corps, local jurisdictions, and BNSF.

Potential Strategies to Reduce Landslides

Implementation Time			Complicating Factors		Benefit	
Short-term	Intermediate	Long-term	Low	High	Low	Moderate
Ongoing – brochure developed and distributed; public workshops scheduled				Land ownership (difficult to ensure long-term implementation); permitting, funding		Potential to reduce landslide initiation best slope manager practices
	Specific site to be identified and recommendations developed			Land ownership, limited right of way, funding, permitting		May reduce damag structures/stabilize slopes over time
	Ongoing – validation planned within one to two years			Organizational priorities/responsibilities	Does not prevent or reduce landslides, but informs parties of potential landslide exposure	
		No current plan in place		Permit modifications needed; funding	Does not prevent or reduce landslides, but has benefit for salmon recovery efforts	
Currently implemented by BNSF			Lower cost than capital projects		Highly effective in reducing public risk exposure, but does not reduce landslides	
Ongoing – 6 proposed locations funded by WSDOT grants (current funding is $16.1 million)		Requires obtaining funding, planning (prioritization), designing, permitting, construction		Funding, prioritization of projects, organizational priorities/responsibilities, limited right-of-way		
		Funding, land ownership		Funding, prioritization of areas needed; organizational priorities/responsibility	Does not prevent or reduce landslides, but provides opportunity for best slope management practices	
	Information gathered for action plan could be used as starting point for program			Funding, land ownership, organizational priorities/responsibility	Does not prevent or reduce landslides, but guides capital projects; can be used to justify further public investment	

Implementation Plan Status

Short-Term Improvement Strategies

Community Outreach and Education

The Landslide Work Group identified the need for increased education and outreach to the community upslope of the rail corridor. Previous studies of landslides in Seattle, with similar geology, slope conditions, and urban development have shown that more than 80 percent of landslides are at least partially related to human influence, including poor slope management practices (Seattle, 2001). Landowner involvement is essential for prevention of landslides as these studies indicate that improper vegetation removal, inadequate and/or unmaintained drainage, cutting or grading slopes and dumping debris on slope edges can cause slope instability and contribute to landslides.

A brochure was developed and delivered to landowners along the top of the slope through the study corridor in early 2013. In addition, landslide workshops in the city of Mukilteo and the development of resources on city websites are in progress. To further investigate public perception of the landslides, a survey was created to gauge public response to education and outreach efforts and catalog frequently asked questions and/or concerns.

Drainage Improvement Incentive

Improper or poorly designed drainage systems can contribute to slope instability, such as drainage pipes which outlet mid-slope. To stabilize slopes, drainage should be brought down to the bottom of the slope. BNSF owns a drainage system at the bottom of the slope.

BNSF can issue permits to property owners for drainage on its ROW. BNSF is offering an incentive to upslope residents by waiving permit fees (up to $3,500 per permit) until April 2015 to place approved drainage structures onto BNSF property. Insurance requirements are still in place.

Maintenance and Monitoring

This lower-cost option is currently employed by BNSF in management of the Seattle to Everett corridor. BNSF will continue to maintain slide fences, ditches and drainage along their right of way to minimize impacts to railroad operations.

Corridor Landslide Inventory

A landslide inventory database and maps were compiled by the work group (Appendix A) using previous studies by Shannon & Wilson (2001 and 2007) with data provided by BNSF. Inventory maps can be used to identify priority areas for remedial work and to develop detailed landslide hazard maps to assist local agencies in the development of land use regulations for steep slopes.

Intermediate Strategies

Capital Improvement Projects

Capital improvement projects are intended to improve passenger service reliability by reducing the number and severity of track outages due to slope failures along the corridor. Projects are intended to prevent and minimize service-disrupting landslides by improving the overall slope stability and implementing measures, such as walls, to prevent landslide debris from impacting the tracks.

Six mitigation projects funded by WSDOT's American Recovery and Reinvestment Act (ARRA) grants are in design and a minimum of three (funding dependent) are planned for construction between 2013 and 2016 (construction is currently underway on two of the six projects). The six sites were prioritized based on slide history (high frequency of slides and service disruptions), geotechnical investigation and constructability as well as budgetary, schedule and property ownership constraints. Improvements primarily involve removing slide material, terracing slopes, installing trench drains, installing catchment walls, installing slide fences and appropriately capturing and directing drainage from adjacent properties.

Development of a Landslide Potential Assessment Model

Work is being done to determine whether the likelihood of a landslide event can be reliably determined by gathering improved rainfall and soil moisture data, and by improving models used to monitor slide activity. The accuracy of the model will be assessed using historical and 2013-2014 data. Work in 2013-2014 will focus on installing additional rain gauges at key locations in the corridor and working with the U.S. Geological Service (USGS) to update their model; validation of the model would take place in the 2014-2015 rainy season. This work will be complemented by efforts to improve slope stability at a number of locations in the corridor.

Long-Term Strategies and Recommendations

Continue community outreach and education efforts to the local communities along the corridor bluff. Recommendations include:

- Update education and outreach materials based on community feedback gained through brochure survey, workshops and local jurisdiction interaction.
- Provide support for community workshops.
- Develop a streamlined permit process and funding source to implement drainage improvements and best slope management practices by landowners along the corridor.

Explore solutions for long-term slide debris removal and restoration of near-shore processes, such as beach nourishment. Recommendations include:

- Cooperatively develop restoration plan and updated permit process with agencies (Ecology and the Corps), BNSF, and local stakeholders (e.g. Puget Sound Partnership and Snohomish County Marine Resources Committee). Such solutions may not impact BNSF's operations or limit BNSF's ability to return its tracks to service under current regulatory structure.

Explore justification for further public investment:

- Consider acceptable target level-of-service (how many landslide-related interruptions are tolerable), recognizing that interruption-free service from landslides is likely not achievable or affordable.
- Estimate order-of-magnitude, long-term improvement (capital) costs.
- Evaluate projected cost of impacts against long-term improvement (i.e., capital) costs for a reasonable lifecycle to justify further public investment.
- Distinguish public benefit from private benefit on privately owned infrastructure to ensure taxpayer dollars are used to benefit Washington State, its businesses and communities.

The science and structural response of a fluid-like mass impacting a rigid structure, like the debris containment walls commonly used along the corridor, are not well understood, and current design methodology is poorly constrained. Similarly, the use of patterned-reinforced wire mesh to address shallow slope instability has not yet achieved widespread use in North America but is gaining widespread use in Europe. Research efforts should be undertaken to optimize design of debris containment structures and evaluate effectiveness of slope stabilization methods for shallow failures. Recommendations include:

- Make design improvements to ensure reliability and optimize design of low-deflection, debris containment structures;
- Evaluate test sections of reinforced mesh to determine suitability for more widespread application.

If further public investment is deemed worthwhile, a landslide management system should be implemented and managed by a public agency that is closely coordinating with BNSF to proactively identify, prioritize, program and fund mitigation projects.

References

Baum, R.L., E.L. Harp, and W.A. Hultman, 2000, Map showing recent and historic landslide activity on coastal bluffs of Puget Sound between Shilshole Bay and Everett, Washington, USGS MF-2346, 1:24,000 scale.

Gerstel, Wendy J.; Brunengo, Matthew J.; Lingley, William S., Jr.; Logan, Robert L.; Shipman, Hugh; Walsh, Timothy J., 1997, Puget Sound bluffs--The where, why, and when of landslides following the holiday 1996/97 storms: Washington Geology, v. 25, no. 1, p. 17-31. [accessed Oct 21, 2013 at http://www.dnr.wa.gov/Publications/ger_washington_geology_1997_v25_no1.pdf.

Lowell, S.M. and N.I. Norrish, 2013, Chapter 18: Rockfall management programs, in *Rockfall: Characterization and Control*, eds. A.K. Turner and R.L. Schuster, Transportation Research Board, pp. 595-608.

Minard, J.P., 1982, Distribution and description of geologic units in the Mukilteo quadrangle, Washington, USGS MF-1438, 1:24,000 scale.

Minard, J.P., 1983, Geologic map of the Edmonds East and part of the Edmonds West quadrangles, Washington, USGS MF-1541, 1:24,000 scale.

Minard, J.P., 1985, Geologic map of the Everett 7.5-minute quadrangle, Snohomish County, Washington, USGS MF-1748, 1:24,000 scale.

Seattle, 2001, Seattle Landslide Study. City of Seattle Department of Planning and Development. Accessed on-line April 2013: www.seattle.gov/dpd/cms/groups/pan/@pan/documents/web_informational/dpdp025740.pdf.

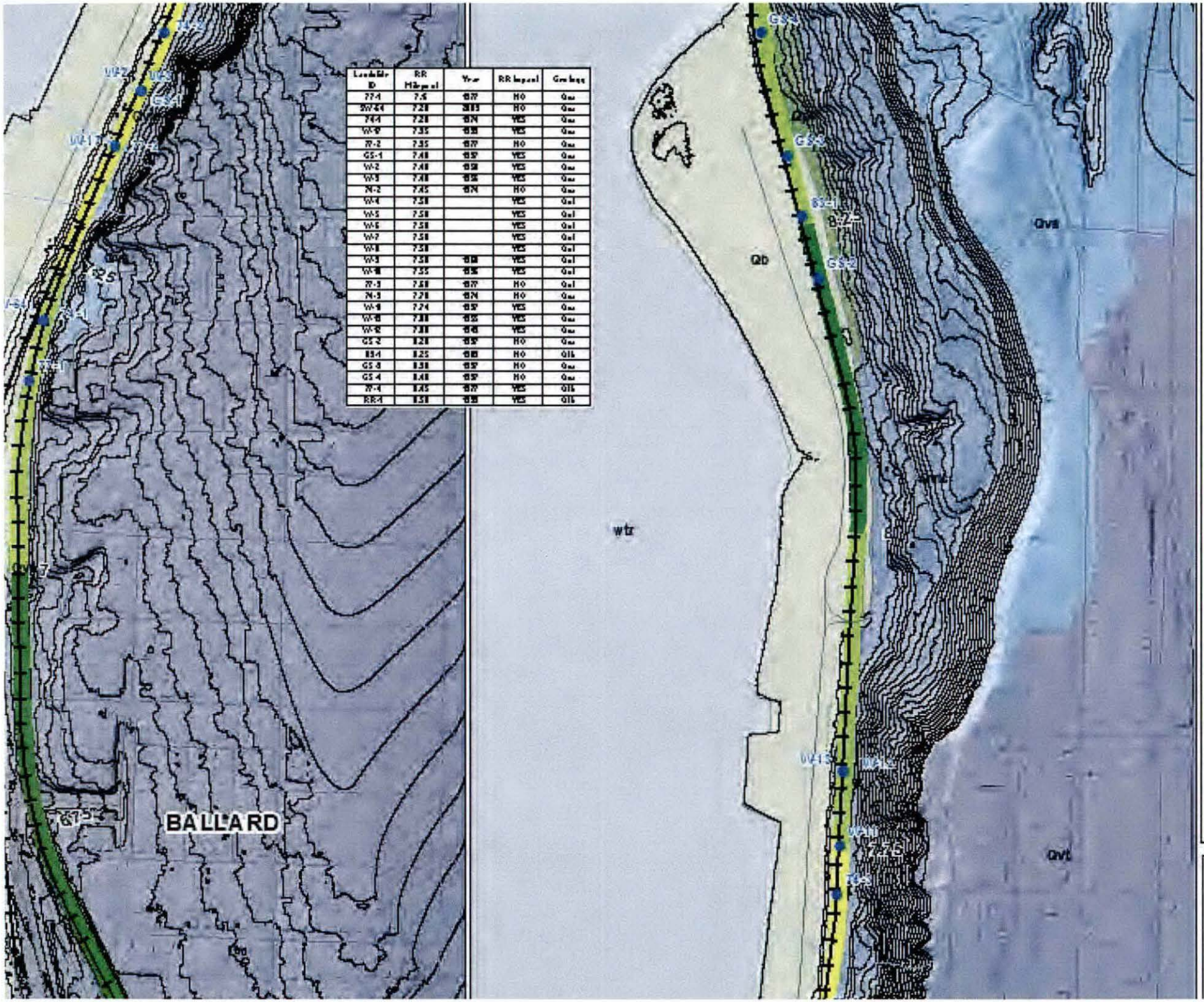
Shannon & Wilson, 2001, Final Stability Study Between Milepost 6.5, Line Segment 50, and Milepost 178.4, Line Segment 37, BNSF/Sound Transit Commuter Rail, Seattle to Everett, WA, 79 p.

Shannon & Wilson, 2007, BNSF/Sound Transit Commuter Rail Slope Stability Study Update Seattle to Everett, Washington, 61 p.

Shuster, R. 1996, Chapter 2: Socioeconomic significance of landslides, in *Landslides: Investigation and Mitigation*, Special Report 247, eds. A.K. Turner and R.L. Schuster, Transportation Research Board, pp. 12-31.

Washington State Department of Transportation, 2006, Unstable Slopes on I-90 Snoqualmie Pass: Reassessment and Recommendations, report to Governor Gregoire, 121 p.

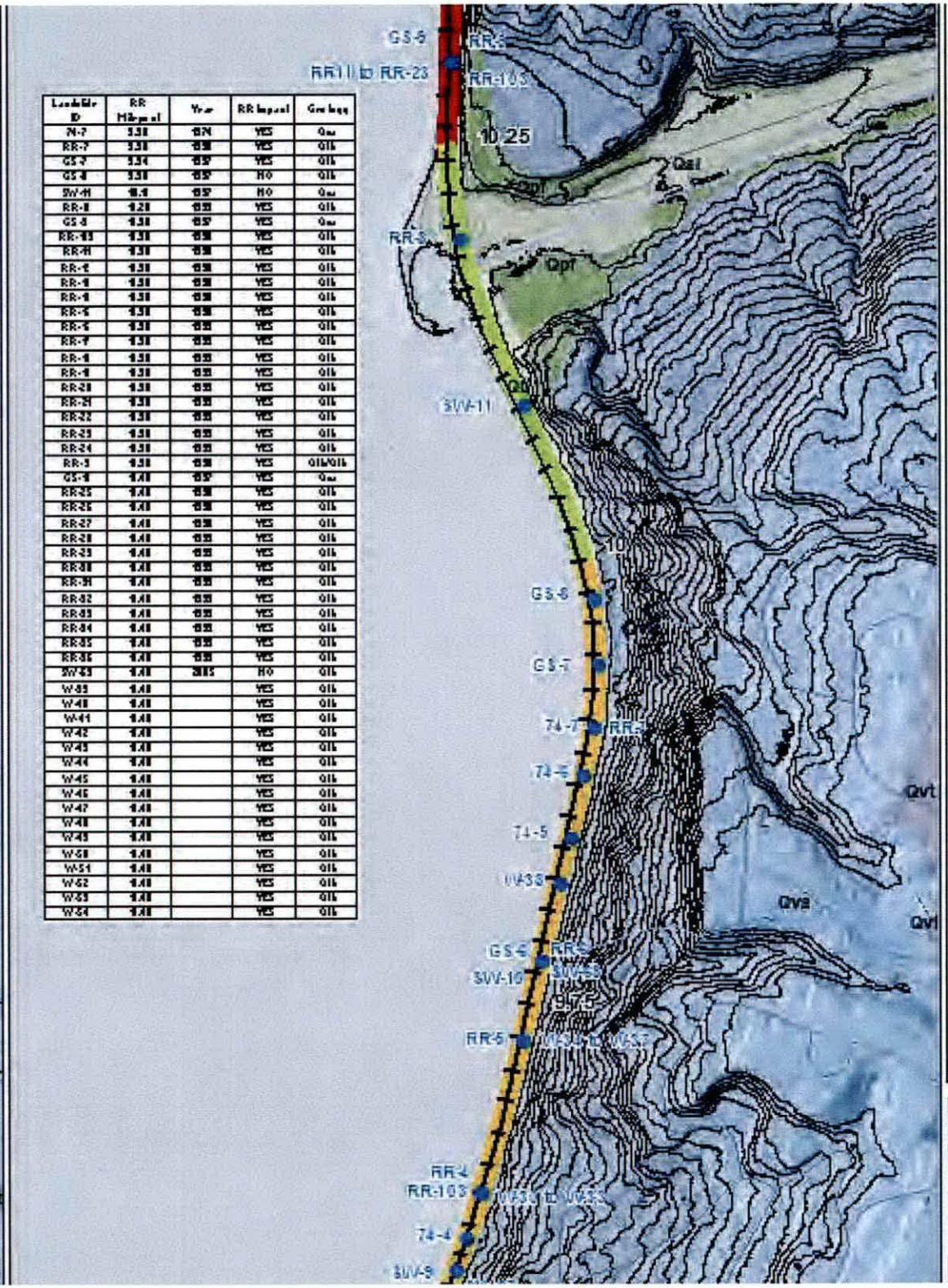
Yount, J.C., J.P. Minard, and G.R. Dembroff, 1993, Geologic map of the surficial deposits in the Seattle 30' by 60' quadrangle, Washington, USGS OF 93-233, 1:100,000 scale.

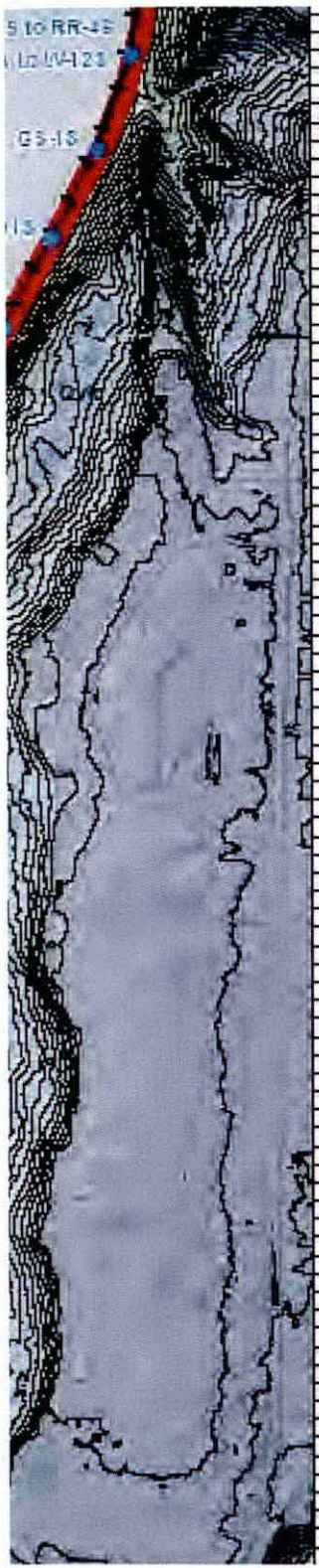


Landslide ID	RR Milepost	Year	RR Impact	Geology
77-1	7.5	1977	NO	Qas
SW-64	7.28	1985	NO	Qas
74-1	7.28	1974	YES	Qas
W-9	7.35	1995	YES	Qas
77-2	7.35	1977	NO	Qas
GS-1	7.48	1997	YES	Qas
W-2	7.48	1998	YES	Qas
W-3	7.48	1996	YES	Qas
74-2	7.45	1974	NO	Qas
W-4	7.58		YES	Qal
W-5	7.58		YES	Qal
W-6	7.58		YES	Qal
W-7	7.58		YES	Qal
W-8	7.58		YES	Qal
W-9	7.58	1998	YES	Qal
W-10	7.55	1996	YES	Qal
77-3	7.68	1977	NO	Qal
74-3	7.78	1974	NO	Qas
W-11	7.74	1997	YES	Qas
W-12	7.88	1995	YES	Qas
W-13	7.88	1996	YES	Qas
GS-2	8.28	1997	NO	Qas
85-1	8.25	1985	NO	Qls
GS-3	8.38	1997	NO	Qas
GS-4	8.48	1997	NO	Qas
77-4	8.45	1977	YES	Qls
RR-1	8.58	1998	YES	Qls

Landslide ID	RR Milepost	Year	RR Impact	Geology
W-4	8.45	1997	YES	Qlk
RR-4	8.51	1995	YES	Qlk
GS-3	8.51	1995	NO	Qvr
SW-4	8.51	1974	YES	Qlk
SW-45	8.71	2003	NO	Qlk
SW-2	8.51	1998	NO	Qlk
SW-46	8.51	2003	NO	Qlk
W-14	8.51	1998	YES	Qlk
W-15	8.51	1998	YES	Qlk
W-16	8.51	1998	YES	Qlk
SW-3	5.81	1996	YES	Qlk
SW-4	5.81	1995	NO	Qlk
SW-5	5.81	1995	YES	Qal
SW-6	5.81	1995	YES	Qal
W-9	5.81	1998	YES	Qlk
W-10	5.81	1998	YES	Qlk
W-11	5.81	1998	YES	Qlk
W-21	5.81	1998	YES	Qlk
RR-2	5.4	1995	YES	Qlk
RR-3	5.4	1995	YES	Qlk
W-21	5.4	1998	YES	Qal
W-22	5.4	1998	YES	Qal
W-23	5.4	1998	YES	Qal
SW-7	5.4	1978	NO	Qa
SW-8	5.4	1995	NO	
W-5	5.21	1997	YES	Qvr
W-24	5.21	1998	YES	Qal
W-25	5.21	1998	YES	Qal
W-26	5.21	1998	YES	Qal
W-27	5.45	1997	YES	Qlk
W-28	5.45	1995	YES	Qlk
W-29	5.45	1998	YES	Qlk
SW-47	5.55	2008	NO	Qlk
SW-3	5.55	1996	NO	Qlk
W-4	5.57	1974	YES	Qlk
RR-13	5.51	2006	YES	Qlk
RR-4	5.51	1995	YES	Qlk
W-30	5.51	1951	YES	Qlk
W-31	5.51	1951	YES	Qlk
W-32	5.51	1995	YES	Qlk
W-33	5.51	1998	YES	Qlk
RR-5	5.71	1995	YES	Qlk
W-34	5.71	1941	YES	Qlk
W-35	5.71	1941	YES	Qlk
W-36	5.71	1951	YES	Qlk
W-37	5.71	1951	YES	Qlk
GS-4	5.75	1995	YES	Qlk
RR-6	5.75	1998	YES	Qlk
SW-9	5.75	1995	NO	Qvr
SW-48	5.75	2002	NO	Qvr
W-38	5.81	1995	YES	Qvr
N-5	5.85	1974	NO	Qvr
N-6	5.87	1974	YES	Qvr

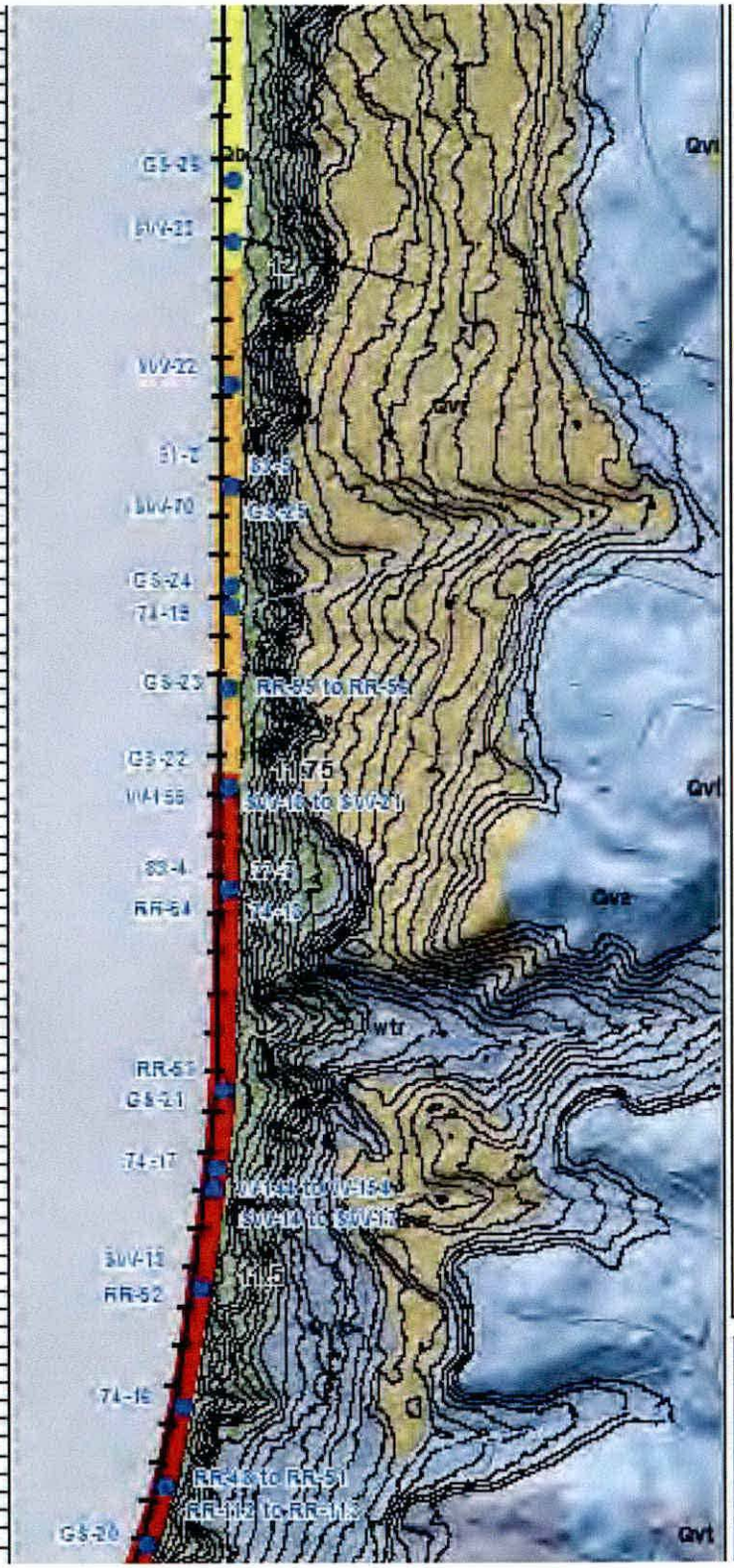
Landslide ID	RR Milepost	Year	RR Impact	Geology
N-7	5.91	1974	YES	Qvr
RR-7	5.91	1998	YES	Qlk
GS-7	5.94	1995	YES	Qlk
GS-8	5.91	1995	NO	Qlk
SW-11	6.4	1995	NO	Qvr
RR-8	6.21	1998	YES	Qlk
GS-9	6.31	1995	YES	Qvr
RR-13	6.31	1998	YES	Qlk
RR-11	6.31	1998	YES	Qlk
RR-12	6.31	1998	YES	Qlk
RR-13	6.31	1998	YES	Qlk
RR-14	6.31	1998	YES	Qlk
RR-15	6.31	1998	YES	Qlk
RR-16	6.31	1998	YES	Qlk
RR-17	6.31	1998	YES	Qlk
RR-18	6.31	1998	YES	Qlk
RR-19	6.31	1998	YES	Qlk
RR-20	6.31	1998	YES	Qlk
RR-21	6.31	1998	YES	Qlk
RR-22	6.31	1998	YES	Qlk
RR-23	6.31	1998	YES	Qlk
RR-24	6.31	1998	YES	Qlk
RR-5	6.31	1998	YES	Qlk/Qlk
GS-10	6.41	1995	YES	Qvr
RR-25	6.41	1998	YES	Qlk
RR-26	6.41	1998	YES	Qlk
RR-27	6.41	1998	YES	Qlk
RR-28	6.41	1998	YES	Qlk
RR-29	6.41	1998	YES	Qlk
RR-30	6.41	1998	YES	Qlk
RR-31	6.41	1998	YES	Qlk
RR-32	6.41	1998	YES	Qlk
RR-33	6.41	1998	YES	Qlk
RR-34	6.41	1998	YES	Qlk
RR-35	6.41	1998	YES	Qlk
RR-36	6.41	1998	YES	Qlk
SW-49	6.41	2005	NO	Qlk
W-39	6.41		YES	Qlk
W-40	6.41		YES	Qlk
W-41	6.41		YES	Qlk
W-42	6.41		YES	Qlk
W-43	6.41		YES	Qlk
W-44	6.41		YES	Qlk
W-45	6.41		YES	Qlk
W-46	6.41		YES	Qlk
W-47	6.41		YES	Qlk
W-48	6.41		YES	Qlk
W-49	6.41		YES	Qlk
W-50	6.41		YES	Qlk
W-51	6.41		YES	Qlk
W-52	6.41		YES	Qlk
W-53	6.41		YES	Qlk
W-54	6.41		YES	Qlk

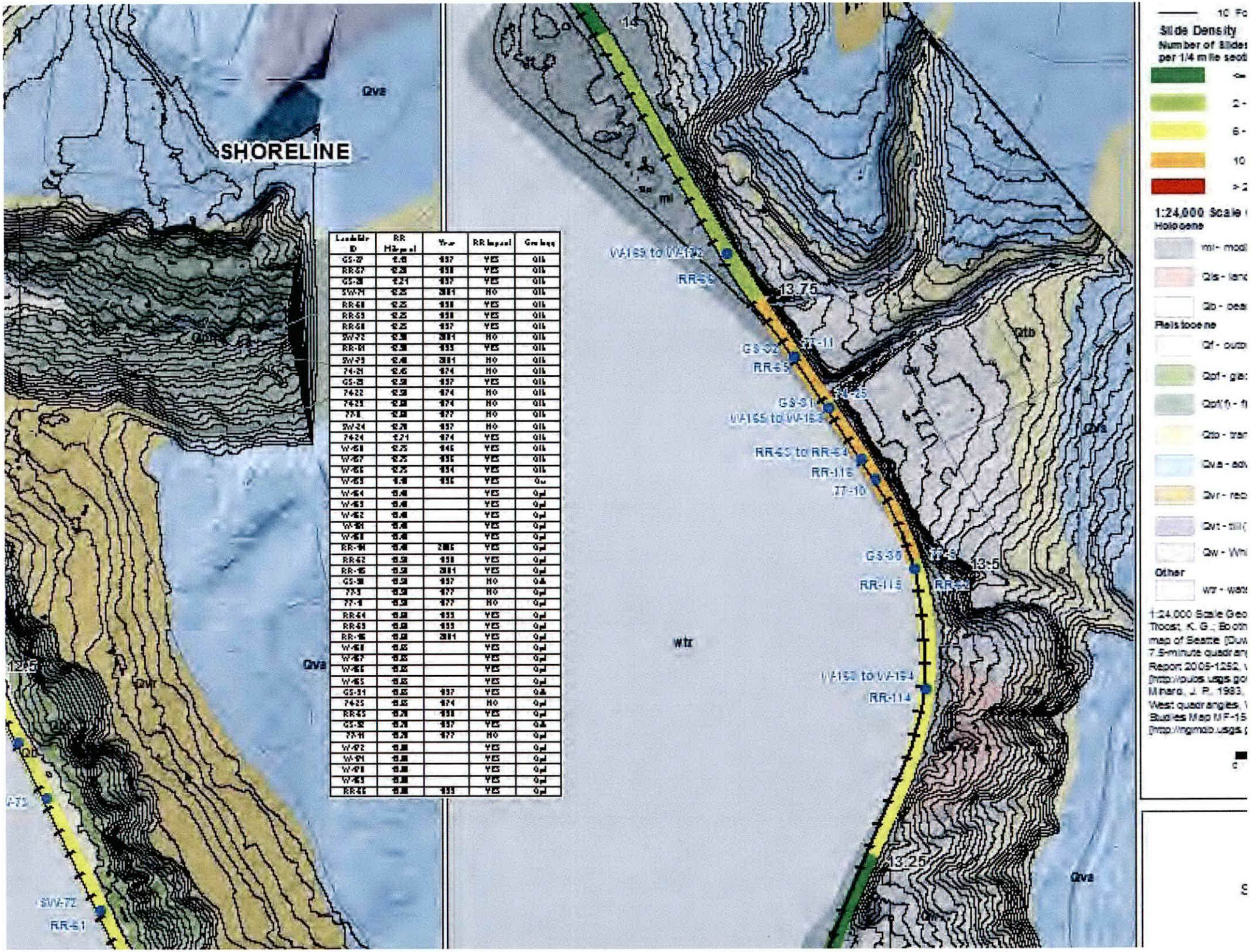




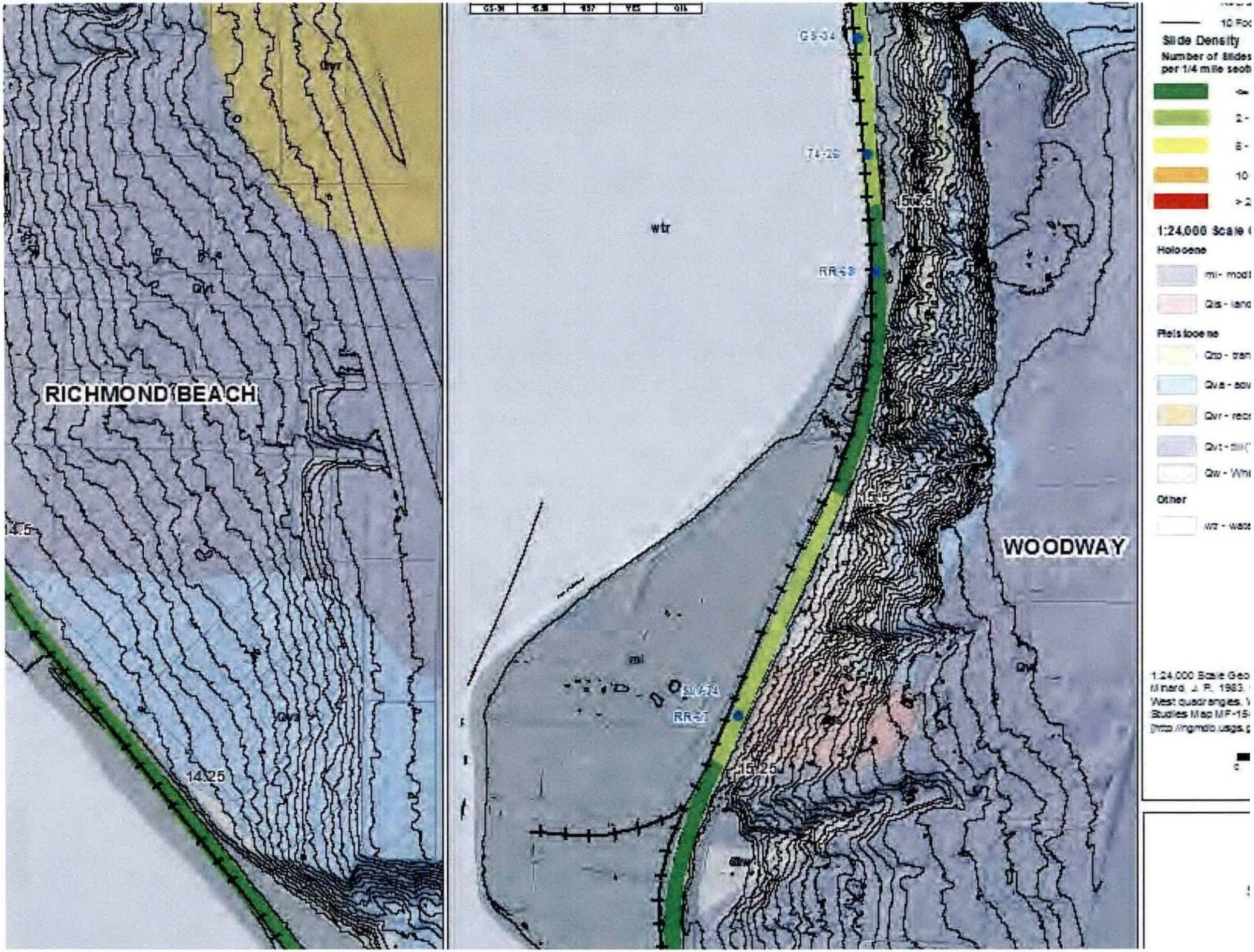
RR-25	[illegible]	[illegible]	YES	Qlk
RR-26	[illegible]	[illegible]	YES	Qlk
RR-27	[illegible]	[illegible]	YES	Qlk
RR-28	[illegible]	[illegible]	YES	Qlk
RR-29	[illegible]	[illegible]	YES	Qlk
RR-30	[illegible]	[illegible]	YES	Qlk
RR-31	[illegible]	[illegible]	YES	Qlk
RR-32	[illegible]	[illegible]	YES	Qlk
RR-33	[illegible]	[illegible]	YES	Qlk
RR-34	[illegible]	[illegible]	YES	Qlk
RR-35	[illegible]	[illegible]	YES	Qlk
RR-36	[illegible]	[illegible]	YES	Qlk
SW-43	[illegible]	[illegible]	NO	Qlk
W-39	[illegible]		YES	Qlk
W-40	[illegible]		YES	Qlk
W-41	[illegible]		YES	Qlk
W-42	[illegible]		YES	Qlk
W-43	[illegible]		YES	Qlk
W-44	[illegible]		YES	Qlk
W-45	[illegible]		YES	Qlk
W-46	[illegible]		YES	Qlk
W-47	[illegible]		YES	Qlk
W-48	[illegible]		YES	Qlk
W-49	[illegible]		YES	Qlk
W-50	[illegible]		YES	Qlk
W-51	[illegible]		YES	Qlk
W-52	[illegible]		YES	Qlk
W-53	[illegible]		YES	Qlk
W-54	[illegible]		YES	Qlk
74-8	[illegible]	474	YES	Qw
GS-9	[illegible]	457	NO	Qw
RR-86	[illegible]	286	YES	Qw
RR-87	[illegible]	455	YES	Qlk
W-55	[illegible]		YES	Qlk
W-56	[illegible]		YES	Qlk
W-57	[illegible]		YES	Qlk
W-58	[illegible]		YES	Qlk
W-59	[illegible]		YES	Qlk
W-60	[illegible]		YES	Qlk
W-61	[illegible]		YES	Qlk
W-62	[illegible]		YES	Qlk
W-63	[illegible]		YES	Qlk
W-64	[illegible]		YES	Qlk
W-65	[illegible]		YES	Qlk
W-66	[illegible]		YES	Qlk
W-67	[illegible]		YES	Qlk
W-68	[illegible]		YES	Qlk
W-69	[illegible]		YES	Qlk
W-70	[illegible]		YES	Qlk
W-71	[illegible]		YES	Qlk
74-3	[illegible]	474	YES	Qw
511	[illegible]	451	YES	Qal
852	[illegible]	483	NO	Qw
RR-85	[illegible]	286	YES	Qw
W-72	[illegible]		YES	Qlk
W-73	[illegible]		YES	Qlk
W-74	[illegible]		YES	Qlk
W-75	[illegible]		YES	Qlk
W-76	[illegible]		YES	Qlk
W-77	[illegible]		YES	Qlk
W-78	[illegible]		YES	Qlk
W-79	[illegible]		YES	Qlk
W-80	[illegible]		YES	Qlk
W-81	[illegible]		YES	Qlk
W-82	[illegible]		YES	Qlk
W-83	[illegible]		YES	Qlk
W-84	[illegible]		YES	Qlk
W-85	[illegible]		YES	Qlk
W-86	[illegible]		YES	Qlk
W-87	[illegible]		YES	Qlk
W-88	[illegible]		YES	Qlk
74-9	[illegible]	474	YES	Qw
776	[illegible]	477	NO	Qw
853	[illegible]	483	NO	Qw
GS-12	[illegible]	457	YES	Qw
74-11	[illegible]	474	YES	Qw
GS-8	[illegible]	457	YES	Qw
RR-88	[illegible]	455	YES	Qlk
RR-89	[illegible]	455	YES	Qlk
RR-90	[illegible]	455	YES	Qlk
RR-91	[illegible]	455	YES	Qlk
GS-14	[illegible]	457	YES	Qw
RR-96	[illegible]	286	YES	Qlk
RR-42	[illegible]	455	YES	Qlk
RR-43	[illegible]	455	YES	Qlk

W-84	[illegible]		YES	Qlk
W-85	[illegible]		YES	Qlk
W-86	[illegible]		YES	Qlk
W-87	[illegible]		YES	Qlk
W-88	[illegible]		YES	Qlk
W-89	[illegible]		YES	Qlk
W-90	[illegible]		YES	Qlk
W-91	[illegible]		YES	Qlk
W-92	[illegible]		YES	Qlk
GS-10	[illegible]	457	NO	Qlk
RR-45	[illegible]	455	YES	Qlk
RR-46	[illegible]	455	YES	Qlk
W-93	[illegible]		YES	Qlk
W-94	[illegible]		YES	Qlk
W-95	[illegible]		YES	Qlk
W-96	[illegible]		YES	Qlk
W-97	[illegible]		YES	Qlk
W-98	[illegible]		YES	Qlk
W-99	[illegible]		YES	Qlk
W-100	[illegible]		YES	Qlk
W-101	[illegible]		YES	Qlk
W-102	[illegible]		YES	Qlk
W-103	[illegible]		YES	Qlk
W-104	[illegible]		YES	Qlk
74-7	[illegible]	474	YES	Qw
GS-21	[illegible]	457	YES	Qlk
RR-83	[illegible]	455	YES	Qlk
74-6	[illegible]	474	YES	Qlk
777	[illegible]	477	YES	Qlk
854	[illegible]	483	NO	Qlk
RR-84	[illegible]	455	YES	Qlk
GS-22	[illegible]	457	YES	Qw

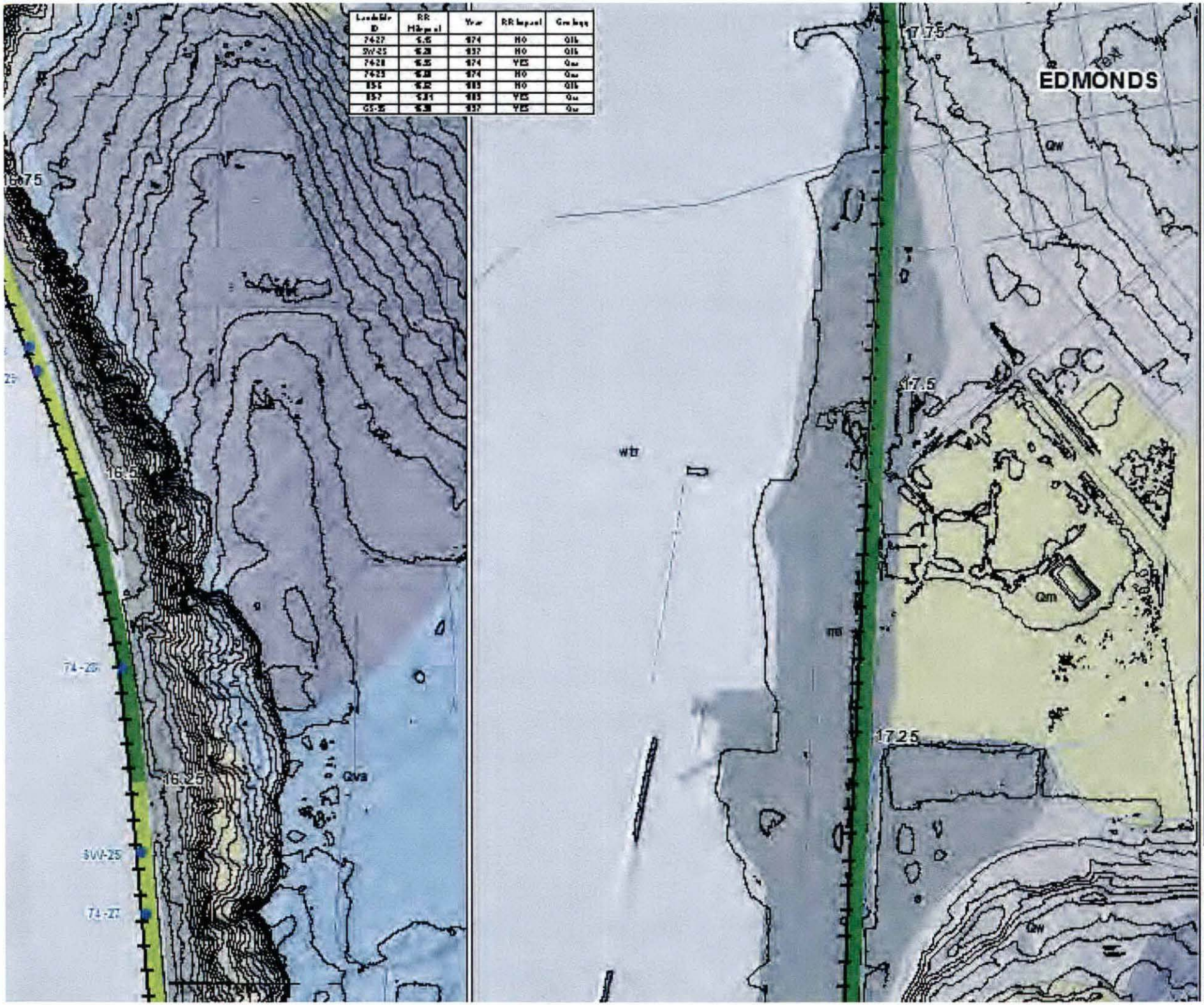


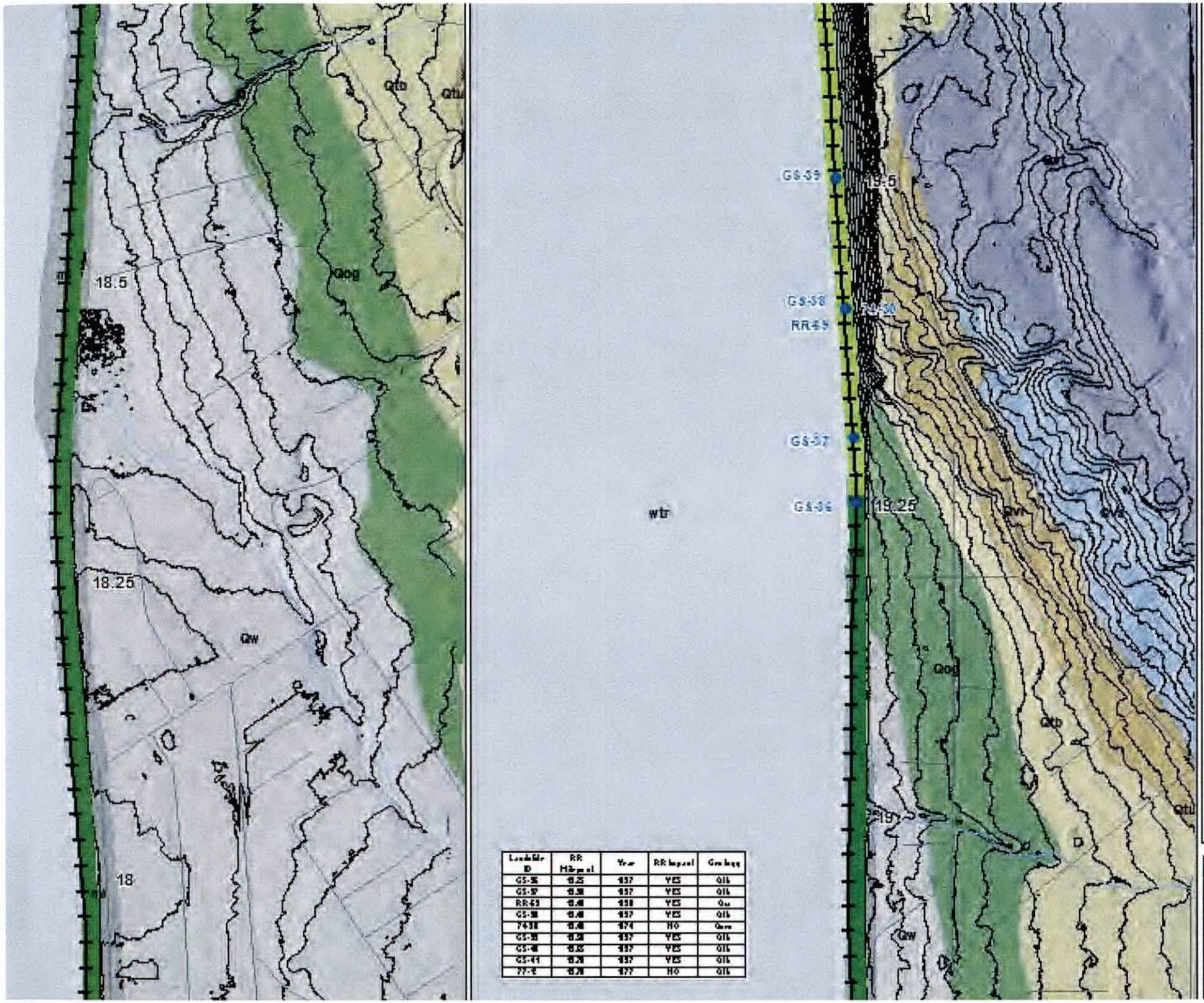


Landslide ID	RR Milepost	Year	RR Impact	Geology
GS-27	[illegible]	1937	YES	Qlk
RR-67	[illegible]	1931	YES	Qlk
GS-28	[illegible]	1937	YES	Qlk
SWA-74	[illegible]	2001	NO	Qlk
RR-68	[illegible]	1931	YES	Qlk
RR-69	[illegible]	1931	YES	Qlk
RR-68	[illegible]	1937	YES	Qlk
SWA-72	[illegible]	2001	NO	Qlk
RR-61	[illegible]	1933	YES	Qlk
SWA-73	[illegible]	2001	NO	Qlk
74-21	[illegible]	1974	NO	Qlk
GS-21	[illegible]	1937	YES	Qlk
74-22	[illegible]	1974	NO	Qlk
74-23	[illegible]	1974	NO	Qlk
77-8	[illegible]	1977	NO	Qlk
SWA-24	[illegible]	1937	NO	Qlk
74-24	[illegible]	1974	YES	Qlk
W-68	[illegible]	1946	YES	Qlk
W-67	[illegible]	1936	YES	Qlk
W-66	[illegible]	1934	YES	Qlk
W-65	[illegible]	1936	YES	Qu
W-64	[illegible]		YES	Qpl
W-63	[illegible]		YES	Qpl
W-62	[illegible]		YES	Qpl
W-61	[illegible]		YES	Qpl
W-60	[illegible]		YES	Qpl
RR-14	[illegible]	2001	YES	Qpl
RR-62	[illegible]	1931	YES	Qpl
RR-16	[illegible]	2001	YES	Qpl
GS-30	[illegible]	1937	NO	Qal
77-3	[illegible]	1977	NO	Qpl
77-4	[illegible]	1977	NO	Qpl
RR-64	[illegible]	1933	YES	Qpl
RR-63	[illegible]	1933	YES	Qpl
RR-15	[illegible]	2001	YES	Qpl
W-61	[illegible]		YES	Qpl
W-67	[illegible]		YES	Qpl
W-66	[illegible]		YES	Qpl
W-65	[illegible]		YES	Qpl
GS-31	[illegible]	1937	YES	Qal
74-25	[illegible]	1974	NO	Qpl
RR-65	[illegible]	1931	YES	Qpl
GS-32	[illegible]	1937	YES	Qal
77-11	[illegible]	1977	NO	Qpl
W-92	[illegible]		YES	Qpl
W-91	[illegible]		YES	Qpl
W-90	[illegible]		YES	Qpl
W-89	[illegible]		YES	Qpl
RR-66	[illegible]	1933	YES	Qpl

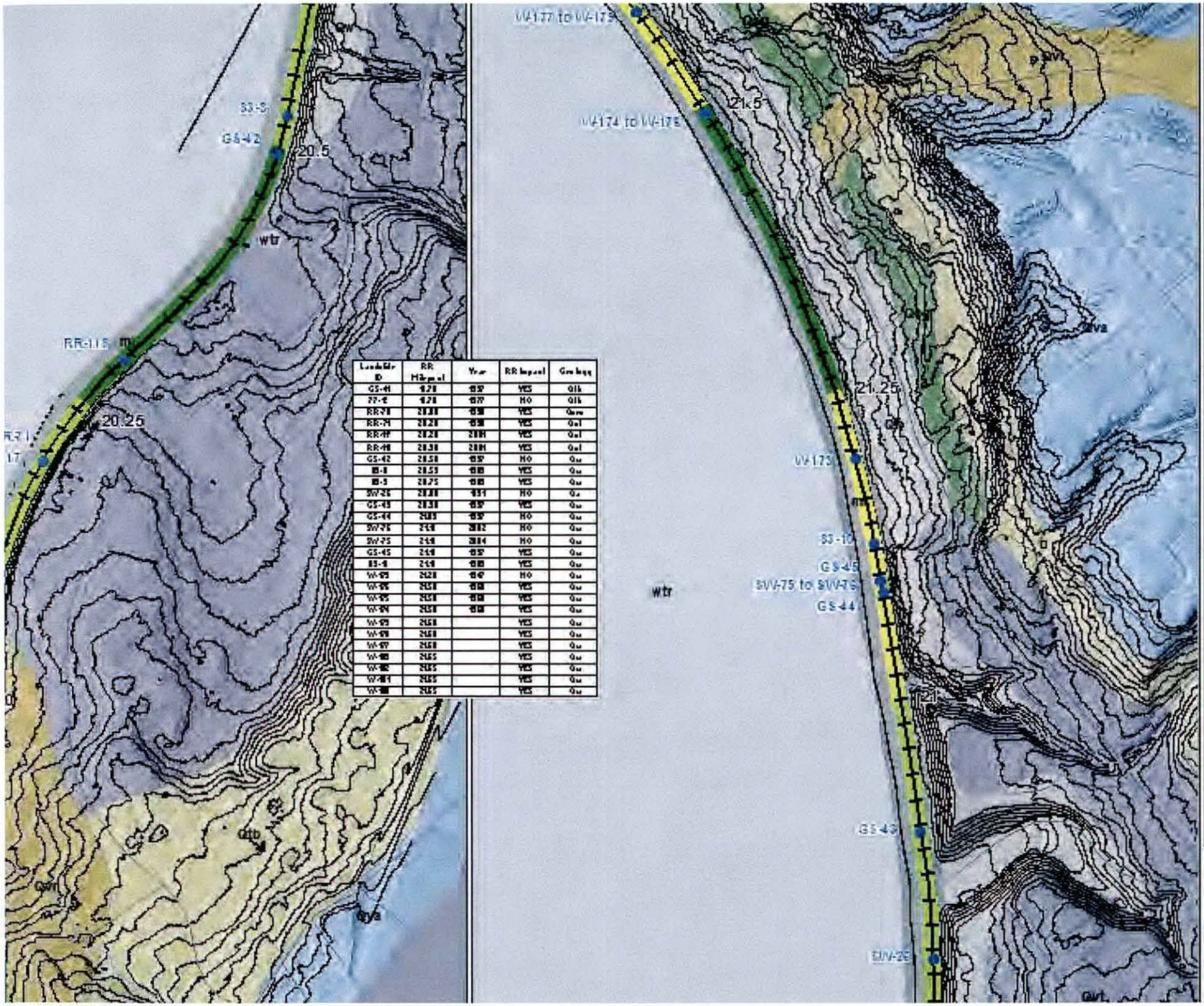

RICHMOND BEACH
WOODWAY
wtr
ml
Qvr
Qvt
Qvs
14.5
14.25
15.25
15.5
RR-58
RR-57
Slide Density
Holocene
Pleistocene
Other

Landslide ID	RR Milepost	Year	RR Impact	Geology
74-27	6.85	1974	NO	Qls
SW-25	6.28	1937	NO	Qls
74-28	6.35	1974	YES	Qw
74-25	6.38	1974	NO	Qw
85-6	6.32	1985	NO	Qls
85-7	6.34	1985	YES	Qw
65-35	6.38	1937	YES	Qw

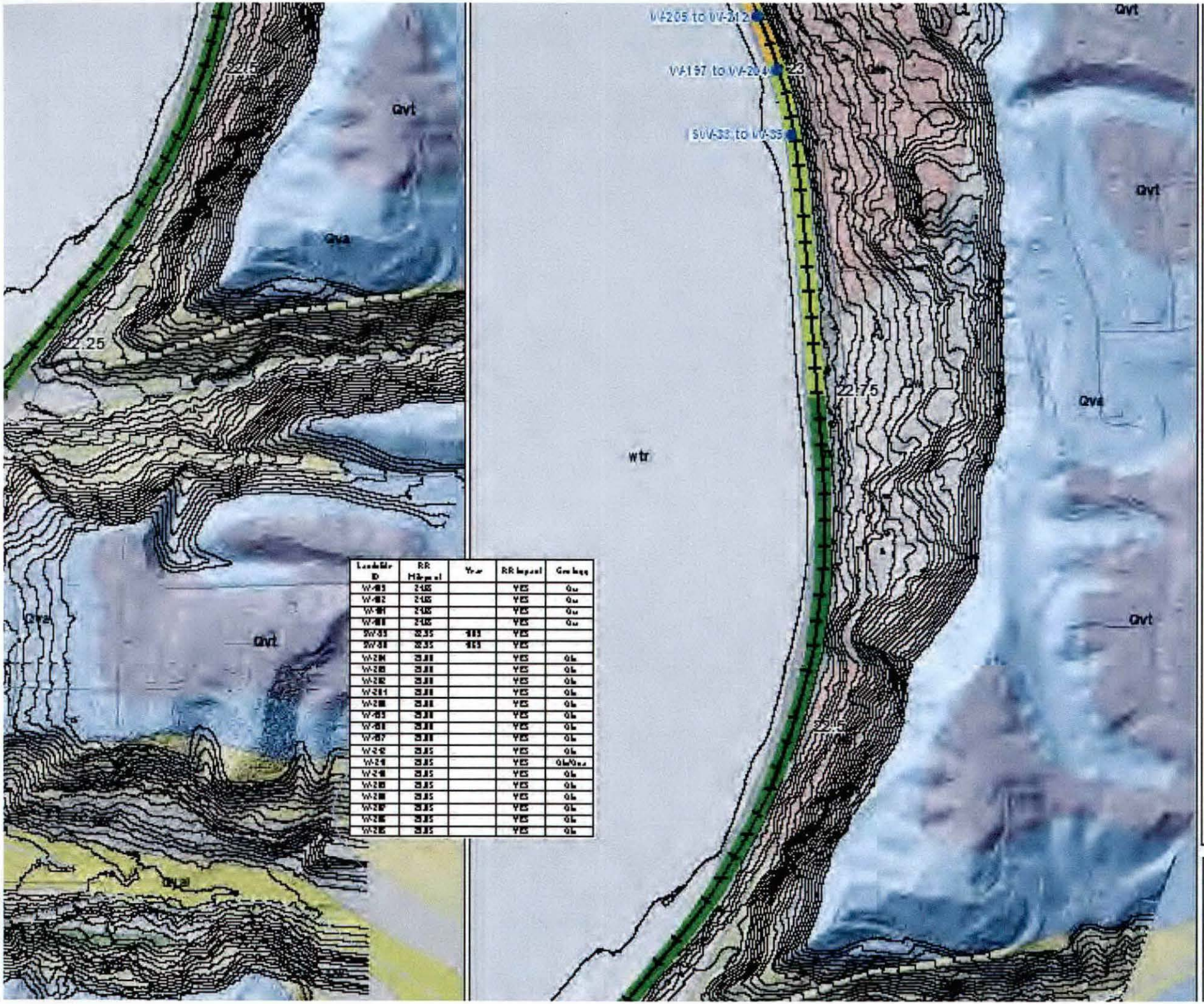




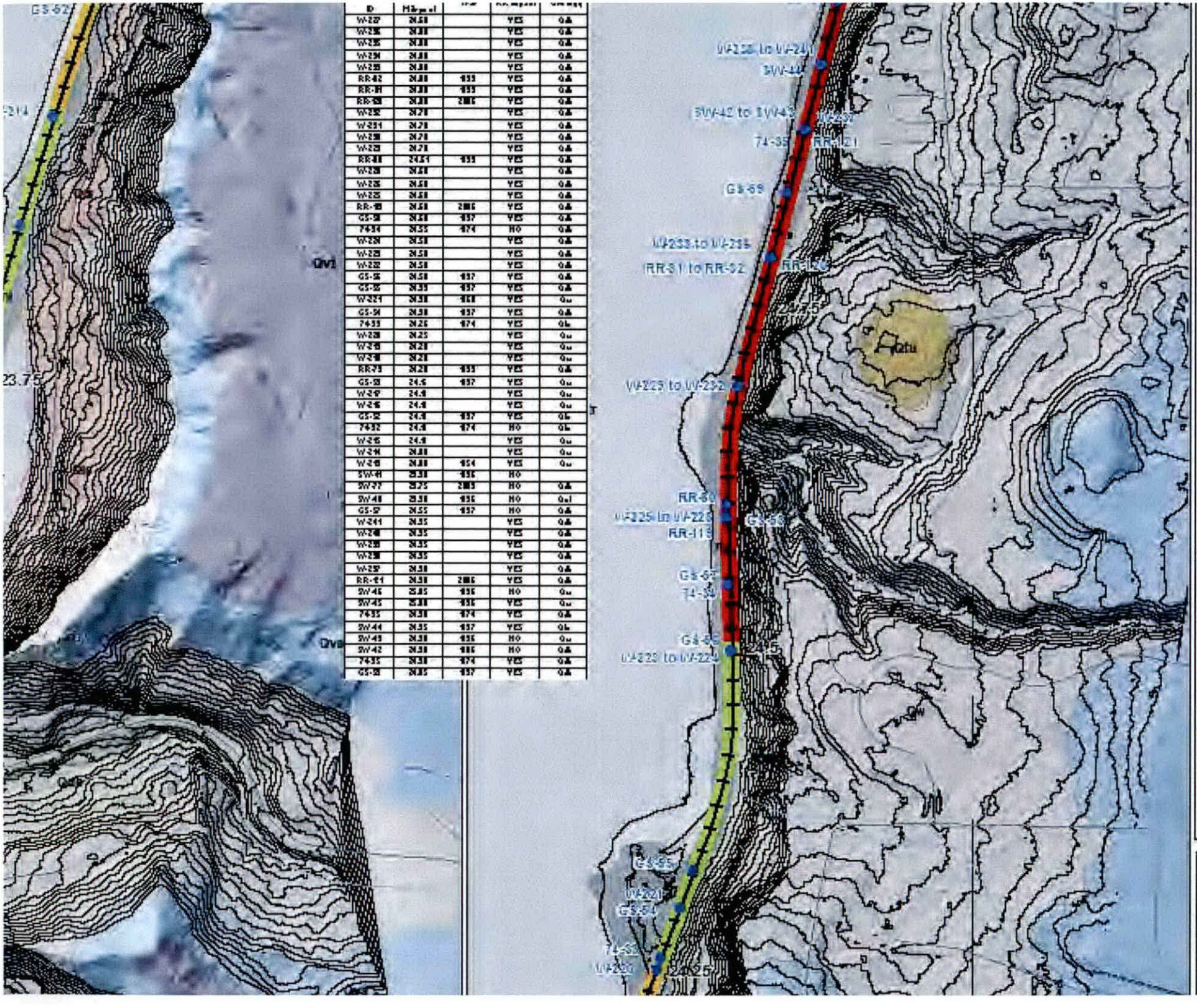
Landslide ID	RR Milepost	Year	RR Impact	Geology
GS-36	19.25	1997	YES	Qls
GS-37	19.38	1997	YES	Qls
RR45	19.40	1998	YES	Qw
GS-38	19.40	1997	YES	Qls
74-38	19.40	1974	NO	Qwm
GS-39	19.50	1997	YES	Qls
GS-40	19.55	1997	YES	Qls
GS-41	19.70	1997	YES	Qls
77-2	19.70	1977	NO	Qls



Landslide ID	RR Milepost	Year	RR Impact	Geology
GS-41	4.78	1957	YES	Qls
77-9	4.78	1957	NO	Qls
RR-78	20.38	1958	YES	Qva
RR-79	20.28	1958	YES	Qal
RR-80	20.28	2004	YES	Qal
RR-98	20.38	2004	YES	Qal
GS-42	20.50	1957	NO	Qw
SS-8	20.53	1958	YES	Qw
SS-9	20.75	1958	YES	Qw
SW-26	20.88	1951	NO	Qw
GS-43	20.88	1957	YES	Qw
GS-44	21.05	1957	NO	Qw
SW-75	21.0	2002	NO	Qw
SW-76	21.0	2004	NO	Qw
GS-45	21.0	1957	YES	Qw
SS-10	21.0	1958	YES	Qw
W-95	21.28	1957	NO	Qw
W-96	21.50	1958	YES	Qw
W-97	21.50	1958	YES	Qw
W-98	21.50	1958	YES	Qw
W-99	21.50		YES	Qw
W-100	21.50		YES	Qw
W-97	21.50		YES	Qw
W-98	21.55		YES	Qw
W-99	21.55		YES	Qw
W-101	21.55		YES	Qw
W-102	21.55		YES	Qw

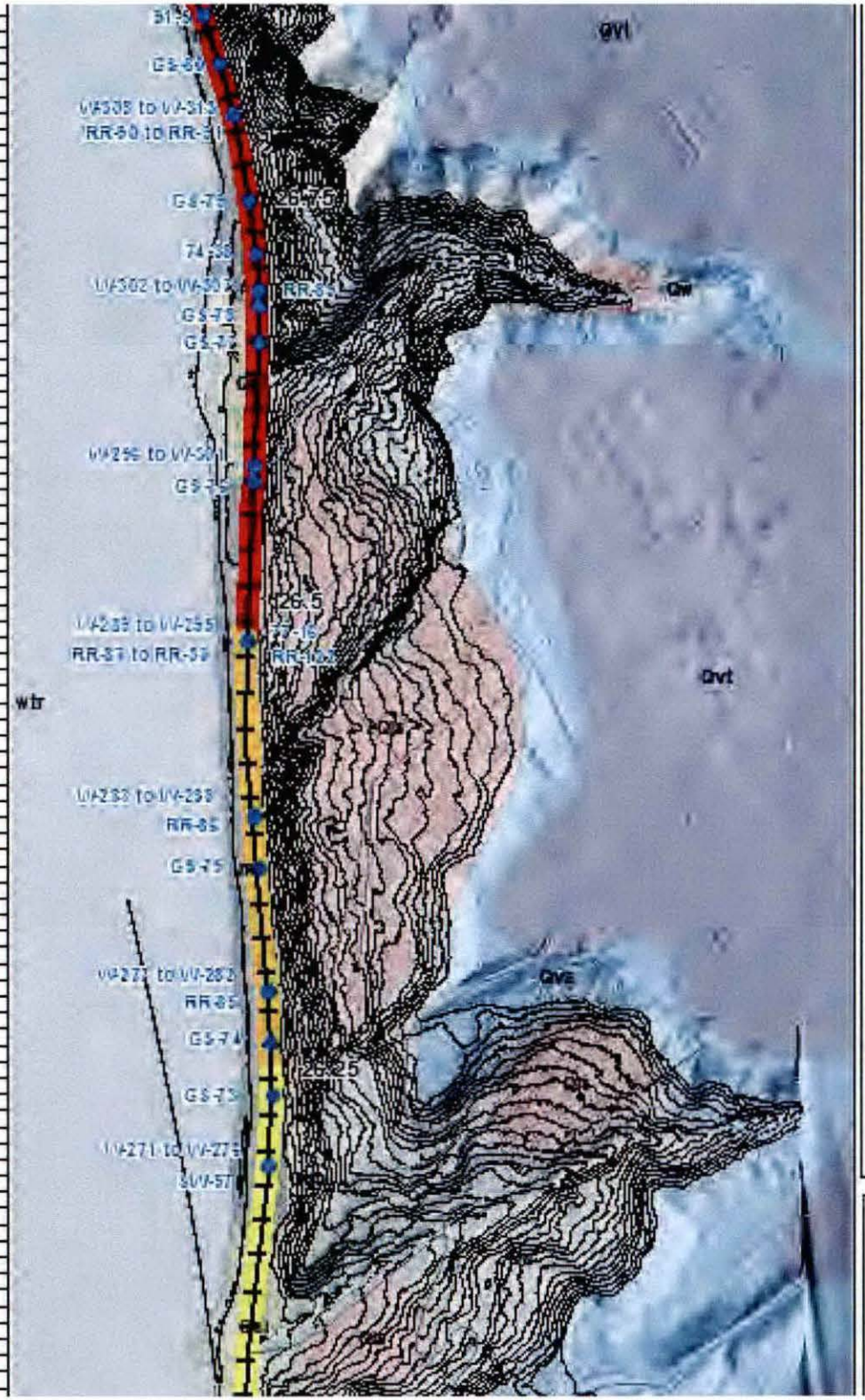


Landslide ID	RR Milepost	Year	RR Impact	Geology
W-83	24.05		YES	Qu
W-82	24.05		YES	Qu
W-81	24.05		YES	Qu
W-80	24.05		YES	Qu
SW-33	22.35	1983	YES	
SW-34	22.35	1955	YES	
W-204	23.80		YES	Qb
W-205	23.80		YES	Qb
W-202	23.80		YES	Qb
W-201	23.80		YES	Qb
W-200	23.80		YES	Qb
W-85	23.80		YES	Qb
W-86	23.80		YES	Qb
W-87	23.80		YES	Qb
W-212	23.85		YES	Qb
W-211	23.85		YES	Qb/Qu
W-210	23.85		YES	Qb
W-209	23.85		YES	Qb
W-208	23.85		YES	Qb
W-207	23.85		YES	Qb
W-206	23.85		YES	Qb
W-203	23.85		YES	Qb



ID	Height		Rockfall	Quality
W-237	34.50		YES	Qa
W-236	34.50		YES	Qa
W-235	34.50		YES	Qa
W-234	34.50		YES	Qa
W-233	34.50		YES	Qa
RR-82	34.50	1955	YES	Qa
RR-81	34.50	1955	YES	Qa
RR-80	34.50	2006	YES	Qa
W-232	34.25		YES	Qa
W-231	34.25		YES	Qa
W-230	34.25		YES	Qa
W-229	34.25		YES	Qa
RR-81	34.25	1955	YES	Qa
W-228	34.50		YES	Qa
W-227	34.50		YES	Qa
W-226	34.50		YES	Qa
RR-80	34.50	2006	YES	Qa
GS-58	34.50	1957	YES	Qa
74-34	34.55	1974	NO	Qa
W-224	34.50		YES	Qa
W-223	34.50		YES	Qa
W-222	34.50		YES	Qa
GS-56	34.50	1957	YES	Qa
GS-55	34.55	1957	YES	Qa
W-221	34.50	1958	YES	Qa
GS-54	34.50	1957	YES	Qa
74-33	34.25	1974	YES	Qa
W-220	34.25		YES	Qa
W-219	34.25		YES	Qa
W-218	34.25		YES	Qa
RR-79	34.25	1955	YES	Qa
GS-53	24.5	1957	YES	Qa
W-217	24.8		YES	Qa
W-216	24.8		YES	Qa
GS-52	24.8	1957	YES	Qa
74-32	24.8	1974	NO	Qa
W-215	24.8		YES	Qa
W-214	34.50		YES	Qa
W-213	34.50	1954	YES	Qa
SW-48	25.50	1956	NO	
SW-47	25.75	2005	NO	Qa
SW-46	25.50	1956	NO	Qal
GS-57	34.55	1957	NO	Qa
W-211	34.35		YES	Qa
W-210	34.35		YES	Qa
W-209	34.35		YES	Qa
W-208	34.35		YES	Qa
W-207	34.30		YES	Qa
RR-81	34.30	2006	YES	Qa
SW-45	25.85	1956	NO	Qa
SW-45	25.80	1956	YES	Qa
74-35	34.30	1974	YES	Qa
SW-44	34.35	1957	YES	Qa
SW-43	34.30	1956	NO	Qa
SW-42	34.30	1956	NO	Qa
74-35	34.30	1974	YES	Qa
GS-51	34.35	1957	YES	Qa

GS-61	25.21	937	YES	Qa
W-228	25.21		YES	Qa
W-252	25.21		YES	Qa
W-251	25.21		YES	Qa
W-250	25.21		YES	Qa
W-249	25.21		YES	Qa
W-248	25.21		YES	Qa
W-247	25.21		YES	Qa
W-246	25.21		YES	Qa
W-245	25.21		YES	Qa
W-244	25.21		YES	Qa
SW-48	25.21	937	HO	Qa
SW-47	25.21	936	HO	Qa
GS-60	25.26	937	YES	Qa
GS-62	25.30	937	YES	Qa
SW-50	25.30	936	YES	Qa
SW-49	25.30	938	HO	Qa
GS-63	25.37	937	YES	Qa
GS-64	25.35	937	YES	Qa
W-253	25.40		YES	Qa
W-258	25.40		YES	Qa
W-257	25.40		YES	Qa
W-256	25.40		YES	Qa
W-255	25.40		YES	Qa
W-254	25.40		YES	Qa
74-37	25.40	974	HO	Qa
GS-65	25.41	937	YES	Qa
GS-66	25.42	937	YES	Qa
SW-51	25.45	936	HO	Qa
GS-67	25.47	937	HO	Qa
W-263	25.50		YES	Qa
W-264	25.50		YES	Qa
W-265	25.50		YES	Qa
W-262	25.50		YES	Qa
W-261	25.50		YES	Qa
W-260	25.50		YES	Qa
RR-84	25.50	935	YES	Qa
RR-83	25.50	935	YES	Qa
GS-68	25.54	937	YES	Qa
SW-53	25.55	932	HO	Qa
SW-52	25.55	938	HO	Qa
SW-54	25.55	938	HO	Qa
W-266	25.60	938	YES	Qa
GS-70	25.60	937	YES	Qa
54	25.60	938	HO	Qa
SW-55	25.60	938	HO	Qa
W-269	25.60		YES	Qa
W-268	25.60		YES	Qa
W-267	25.60		YES	Qa
GS-71	25.60	937	YES	Qa
SW-56	25.65	935	HO	Qa
GS-72	25.65	937	YES	Qa
W-270	25.80	938	YES	Qa
W-276	25.21		YES	Qa
W-275	25.21		YES	Qa
W-274	25.21		YES	Qa
W-273	25.21		YES	Qa
W-272	25.21		YES	Qa
W-271	25.21		YES	Qa
SW-57	25.21	937	YES	Qa
GS-73	25.24	937	YES	Qa
GS-74	25.27	937	HO	Qa
W-282	25.30		YES	Qa
W-281	25.30		YES	Qa
W-280	25.30		YES	Qa
W-279	25.30		YES	Qa
W-278	25.30		YES	Qa
W-277	25.30		YES	Qa
RR-85	25.30	938	YES	Qa
GS-75	25.37	937	YES	Qa
W-288	25.40		YES	Qa
W-287	25.40		YES	Qa
W-286	25.40		YES	Qa
W-285	25.40		YES	Qa
W-284	25.40		YES	Qa
W-283	25.40		YES	Qa
RR-86	25.40	935	YES	Qa
W-295	25.50		YES	Qa
W-294	25.50		YES	Qa
W-293	25.50		YES	Qa
W-292	25.50		YES	Qa
W-291	25.50		YES	Qa
W-290	25.50		YES	Qa
W-289	25.50		YES	Qa
RR-88	25.50	935	YES	Qa
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]



10 Fo

Slide Density

Number of Slides per 1/4 mile sect

<=
2 -
6 -
10
> 2

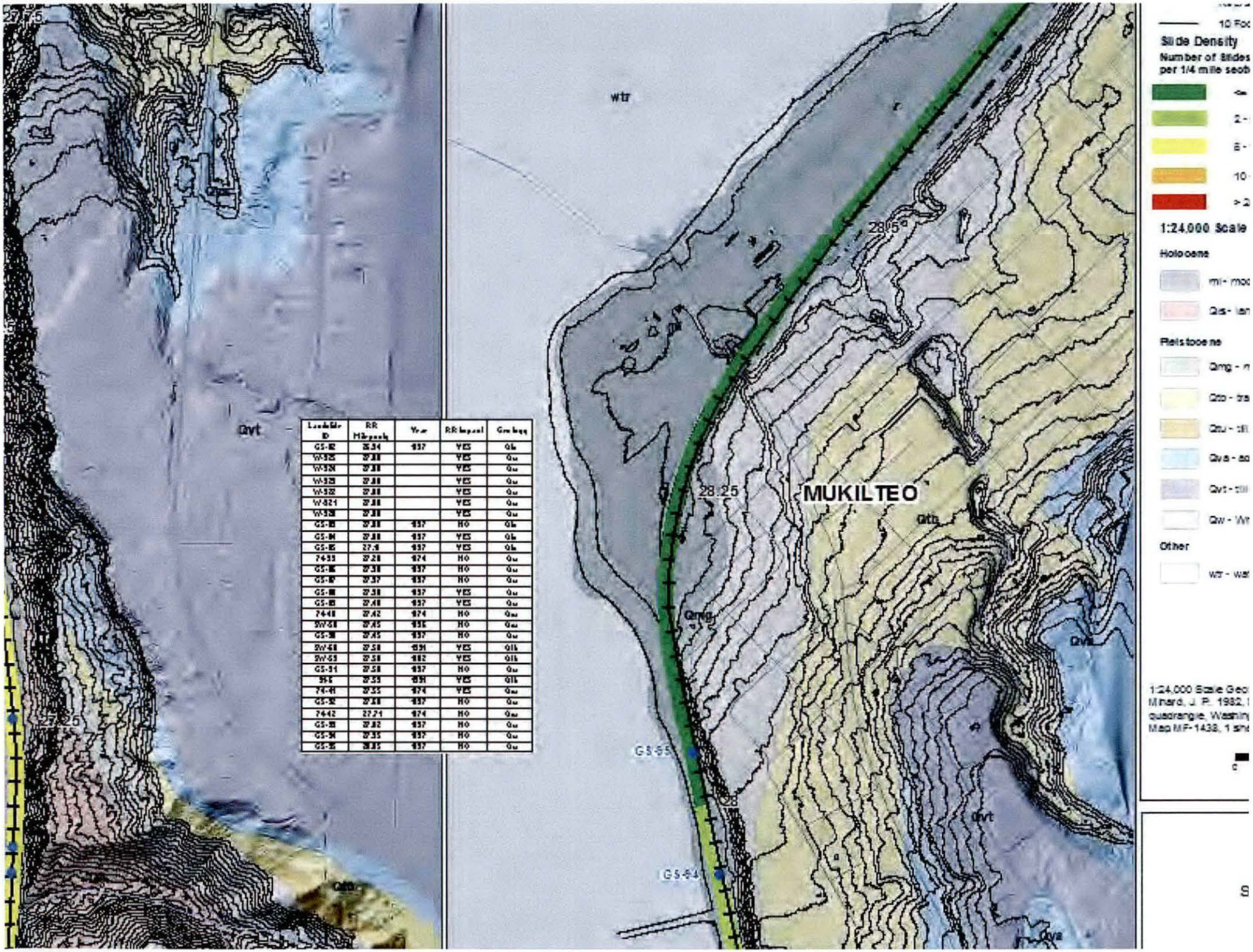
1:24,000 Scale

Holocene

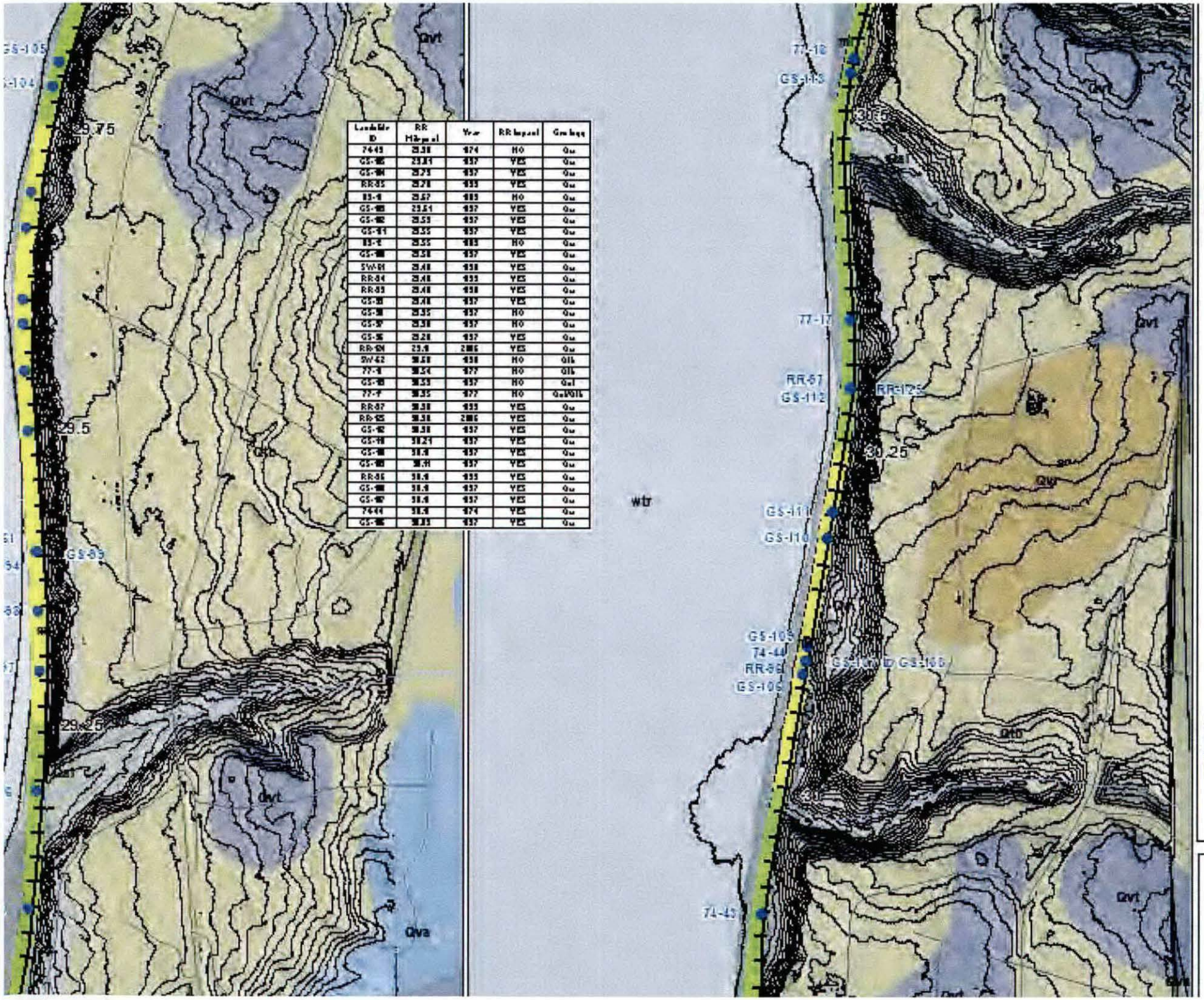
Pleistocene

Other

1:24,000 Scale Geo
Minard, J. P. 1982,
quadrangle, Washin
Map MF-1438, 1 sh

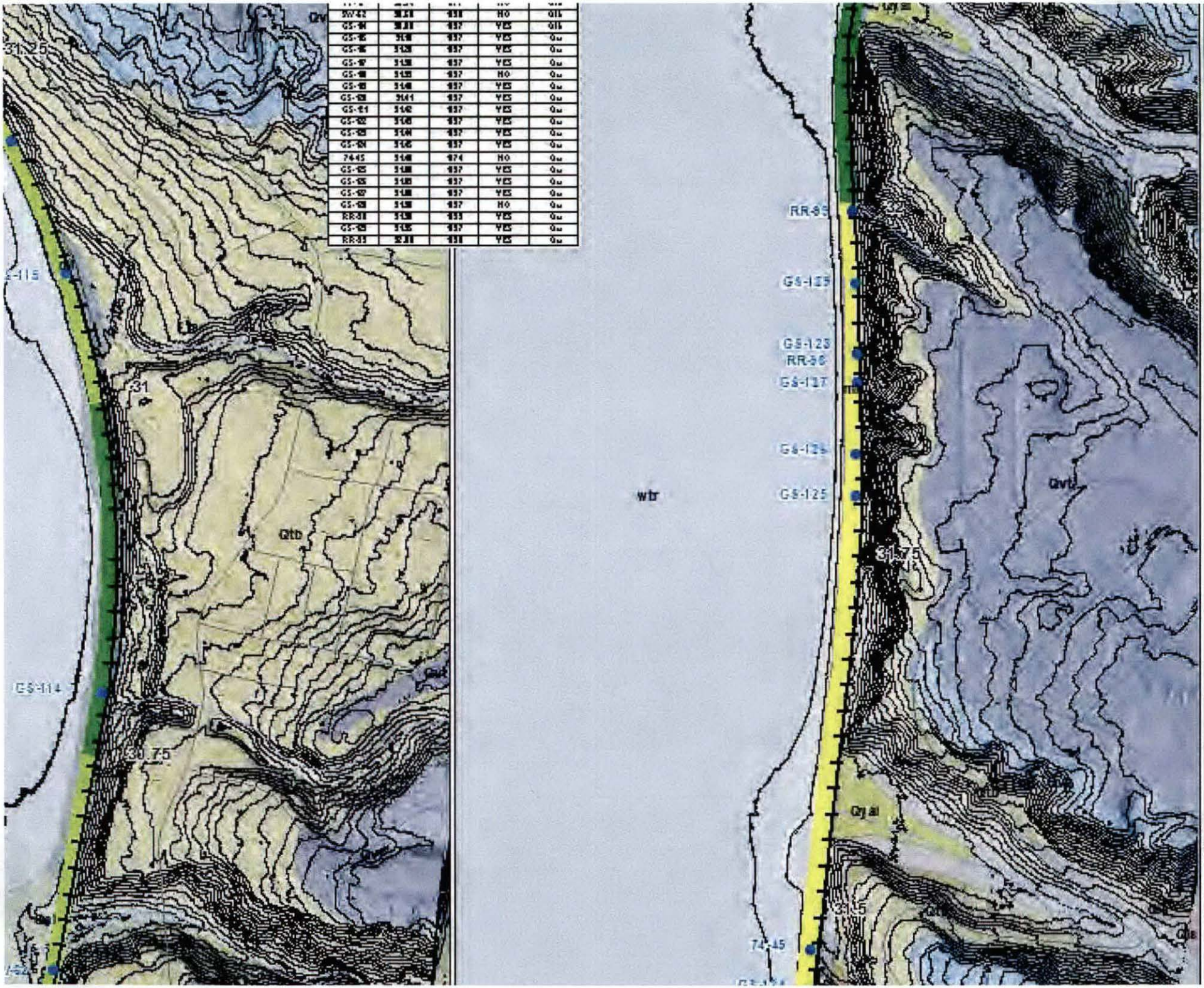


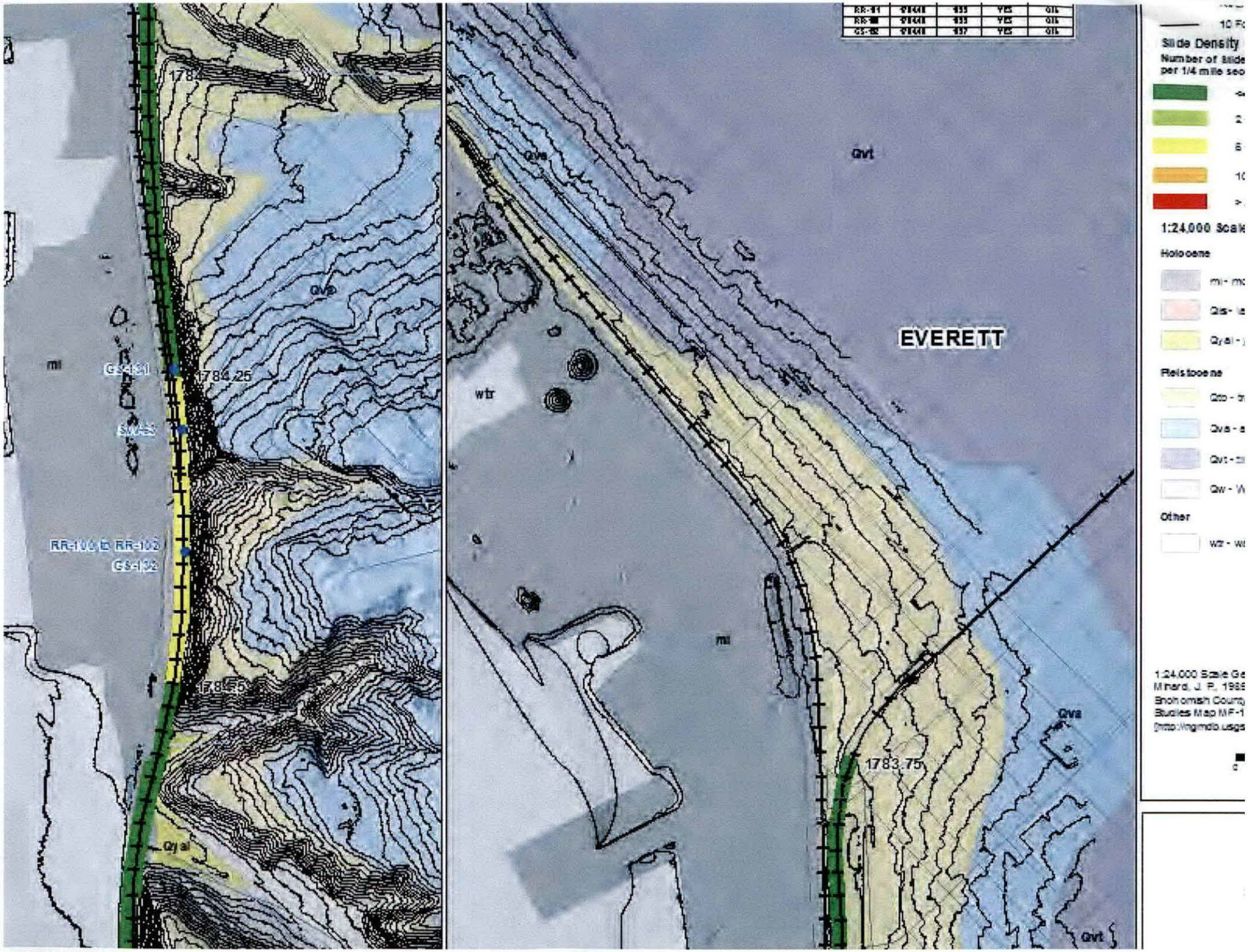
Location ID	RR Milepost	Year	RR Impact	Geology
GS-82	28.34	1937	YES	Qb
W-325	27.88		YES	Qu
W-326	27.88		YES	Qu
W-323	27.88		YES	Qu
W-322	27.88		YES	Qu
W-321	27.88		YES	Qu
W-320	27.88		YES	Qu
GS-83	27.88	1937	NO	Qb
GS-84	27.88	1937	YES	Qb
GS-85	27.8	1937	YES	Qb
74-55	27.28	1974	NO	Qu
GS-86	27.38	1937	NO	Qu
GS-87	27.37	1937	NO	Qu
GS-88	27.38	1937	YES	Qu
GS-89	27.48	1937	YES	Qu
74-48	27.42	1974	NO	Qu
SW-58	27.45	1936	NO	Qu
GS-90	27.45	1937	NO	Qu
SW-60	27.58	1936	YES	Qlk
SW-65	27.58	1932	YES	Qlk
GS-91	27.58	1937	NO	Qu
956	27.55	1936	YES	Qlk
74-41	27.55	1974	YES	Qu
GS-92	27.68	1937	NO	Qu
74-42	27.71	1974	NO	Qu
GS-93	27.82	1937	NO	Qu
GS-94	27.85	1937	NO	Qu
GS-95	28.85	1937	NO	Qu



Landslide ID	RR Milepost	Year	RR Impact	Geology
74-43	29.38	1974	NO	Qtu
GS-86	29.84	1957	YES	Qtu
GS-84	29.75	1957	YES	Qtu
RR-85	29.78	1955	YES	Qtu
85-4	29.67	1985	NO	Qtu
GS-88	29.61	1957	YES	Qtu
GS-82	29.59	1957	YES	Qtu
GS-81	29.55	1957	YES	Qtu
85-5	29.55	1985	NO	Qtu
GS-80	29.58	1957	YES	Qtu
SW-51	29.48	1958	YES	Qtu
RR-84	29.48	1955	YES	Qtu
RR-83	29.48	1958	YES	Qtu
GS-85	29.48	1957	YES	Qtu
GS-78	29.35	1957	NO	Qtu
GS-97	29.38	1957	NO	Qtu
GS-96	29.28	1957	YES	Qtu
RR-91	29.9	2006	YES	Qtu
SW-42	30.58	1958	NO	Qtb
77-9	30.54	1977	NO	Qtb
GS-98	30.53	1957	NO	Qal
77-7	30.35	1977	NO	Qal/Qtb
RR-87	30.38	1955	YES	Qtu
RR-95	30.38	2006	YES	Qtu
GS-92	30.38	1957	YES	Qtu
GS-99	30.24	1957	YES	Qtu
GS-100	30.9	1957	YES	Qtu
GS-90	30.9	1957	YES	Qtu
RR-86	30.9	1955	YES	Qtu
GS-101	30.9	1957	YES	Qtu
GS-102	30.9	1957	YES	Qtu
74-44	30.9	1974	YES	Qtu
GS-103	30.93	1957	YES	Qtu

SW-42	[illegible]	[illegible]	NO	Qtb
GS-[illegible]	[illegible]	[illegible]	YES	Qtb
GS-[illegible]	[illegible]	[illegible]	YES	Qw
GS-[illegible]	[illegible]	[illegible]	YES	Qw
GS-[illegible]	[illegible]	[illegible]	YES	Qw
GS-[illegible]	[illegible]	[illegible]	NO	Qw
GS-[illegible]	[illegible]	[illegible]	YES	Qw
GS-[illegible]	[illegible]	[illegible]	YES	Qw
GS-[illegible]	[illegible]	[illegible]	YES	Qw
GS-[illegible]	[illegible]	[illegible]	YES	Qw
GS-[illegible]	[illegible]	[illegible]	YES	Qw
7445	[illegible]	[illegible]	NO	Qw
GS-[illegible]	[illegible]	[illegible]	YES	Qw
GS-[illegible]	[illegible]	[illegible]	YES	Qw
GS-[illegible]	[illegible]	[illegible]	YES	Qw
GS-[illegible]	[illegible]	[illegible]	NO	Qw
RR-[illegible]	[illegible]	[illegible]	YES	Qw
GS-[illegible]	[illegible]	[illegible]	YES	Qw
RR-[illegible]	[illegible]	[illegible]	YES	Qw




EVERETT
Qvt
Qva
wtr
mi
1784.25
1783.75
Qyal
Slide Density
1:24,000 Scale
Holocene
Pleistocene
Other

BNSF Railway

Rail Safety Overview

January 2016

BNSF RAILWAY

Rail Transports Crude Safely

Since 1980, railroads reduced rates for employee injuries, train accidents and grade crossing collisions by 80 percent.

In 2015 BNSF moved hazardous materials 99.998 % of the time without an accidental release.

BNSF RAILWAY

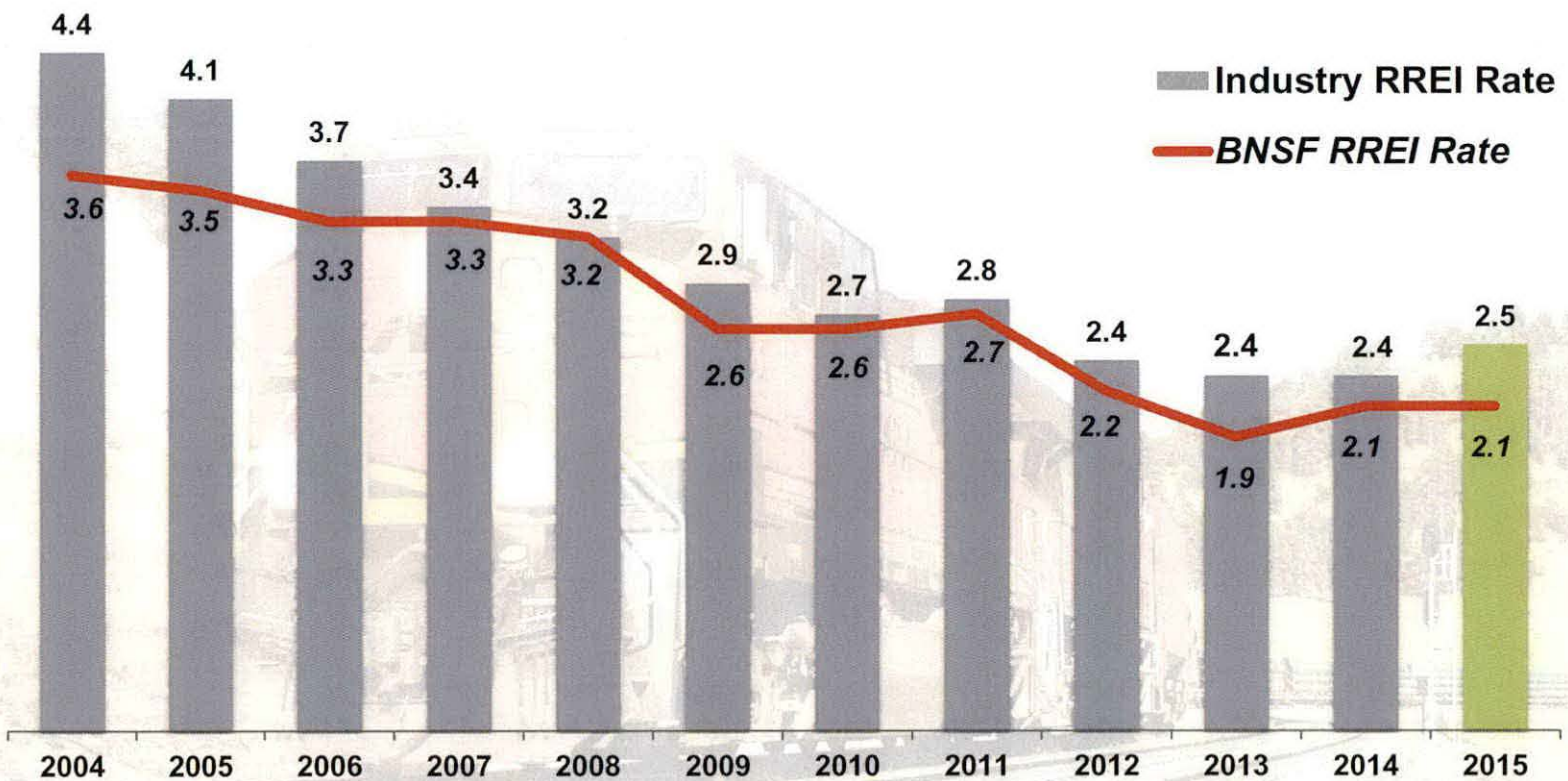
BNSF's Safety Overview

- Rail is safest mode of land transportation.
- BNSF's safety vision is to prevent accidents in the first place.
- BNSF has a broad-based risk reduction program.

BNSF RAILWAY

BNSF: Safety Leader for Continuous Risk Reduction

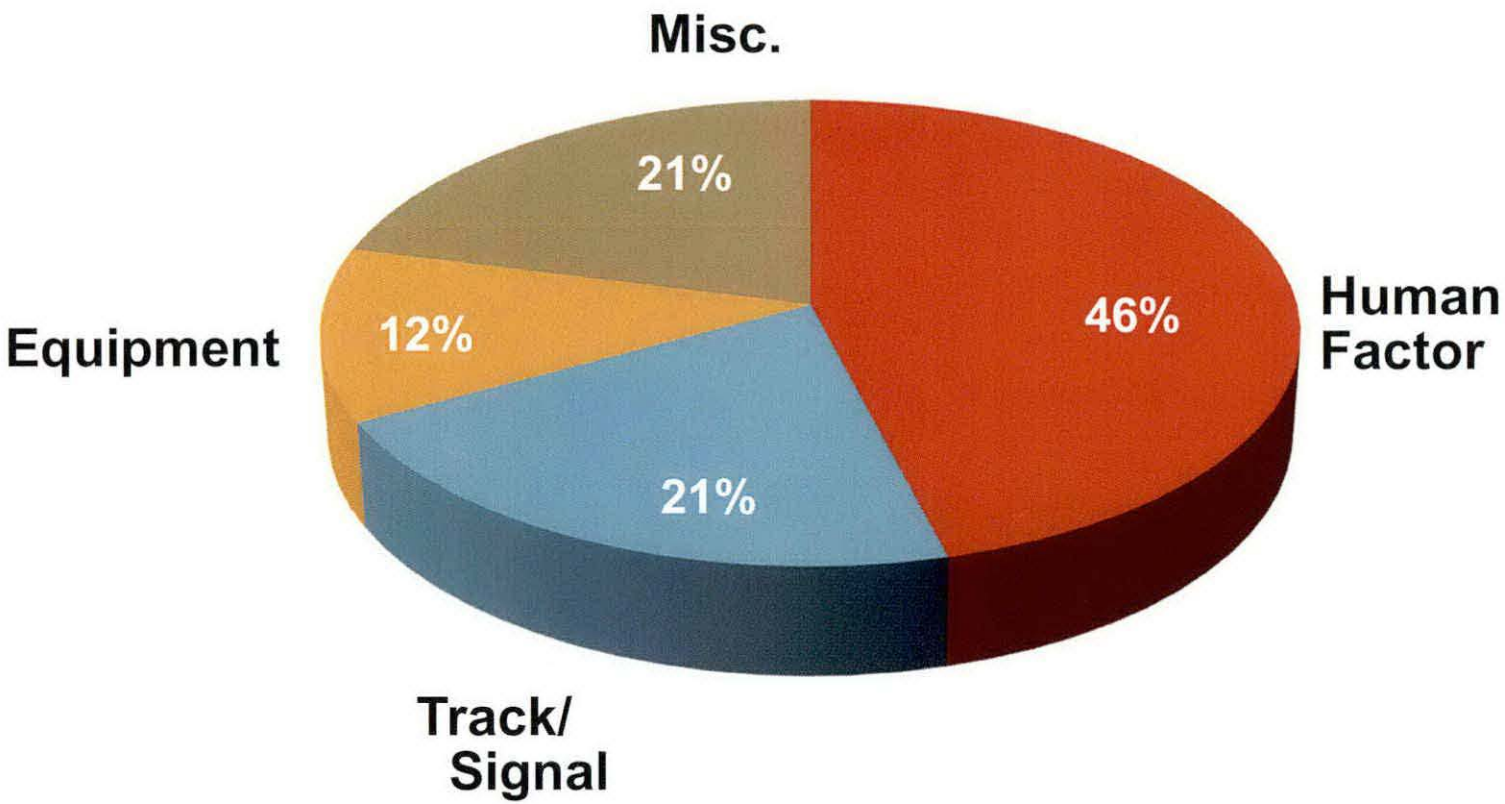
BNSF vs. Industry Reportable Rail Equipment Incident Rate *(Incidents per Million Train Miles)*



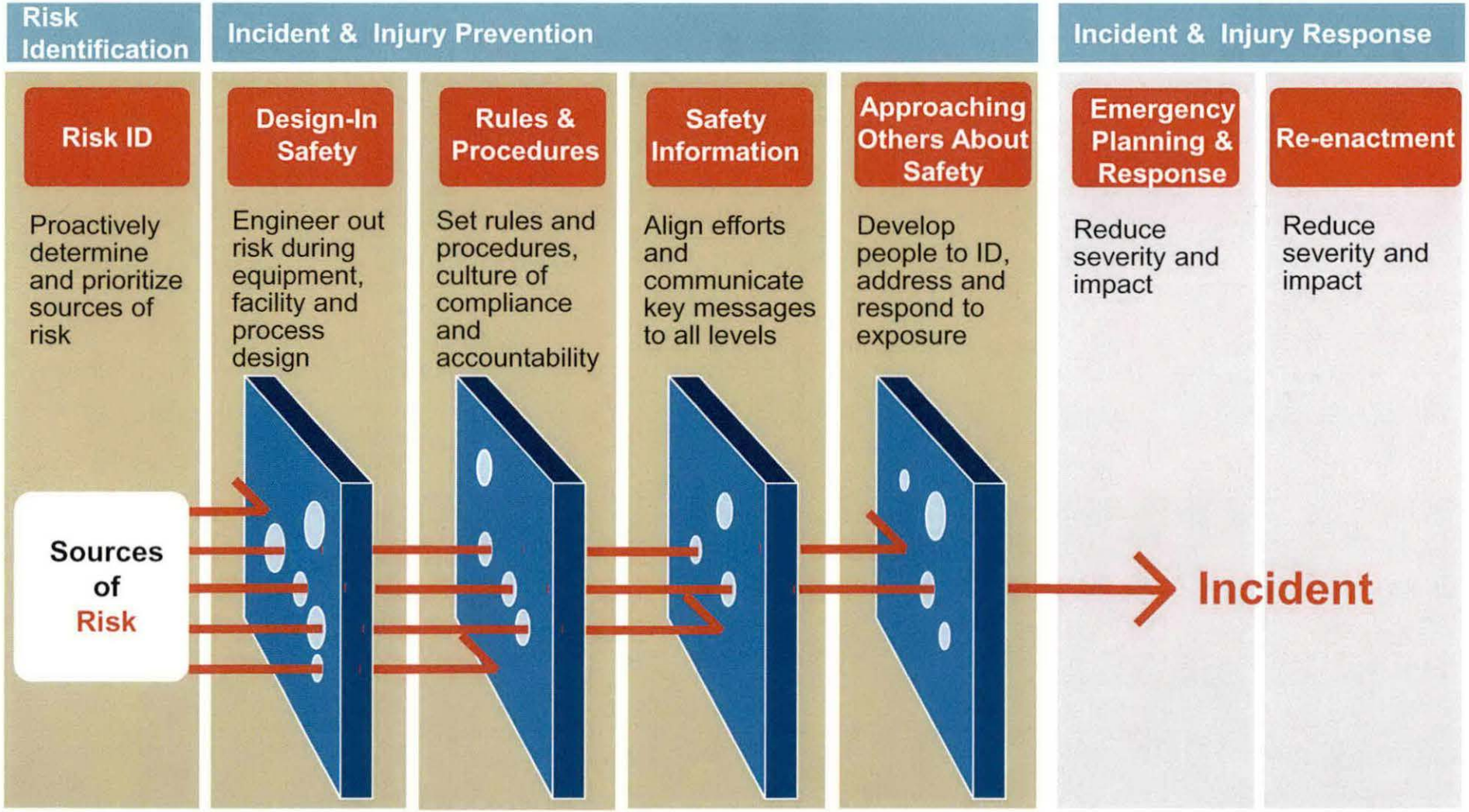
Source: FRA – Data for Calendar Year through Oct. 31, 2015

Prevention: Causes for Derailments

BNSF Reportable Train Accident Causes - 2015



Prevention: Risk-Reduction Efforts



BNSF RAILWAY

Prevention: Reducing Risk

Human Factor

- Training
- Remote monitoring
- Positive Train Control
- Self reporting protocol

Equipment/Mechanical

- Ultrasonic inspection
- Detector network - dragging equipment
- Technology
  - Thermal/infrared scanning for warm bearing detection

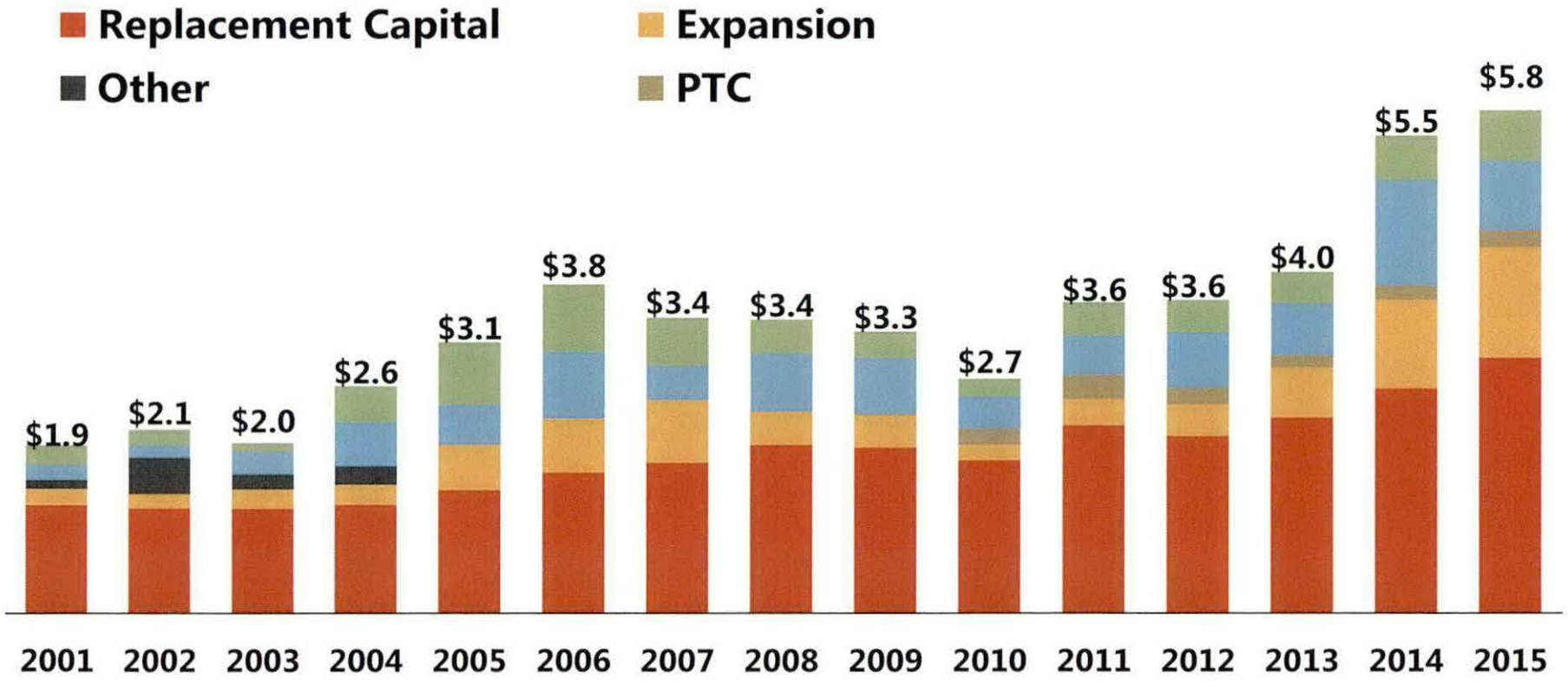
Track/Signal

- Enhanced track inspection training
- Continued elimination of jointed rail
- Strong capital program for tie renewal
- Technology - ground penetrating radar and enhanced geometry testing

- Machine Vision System
- Cracked Wheel Detector
- Truck Hunting Detector
- Hot Box Detector
- Hot Wheel Detector
- Optical Geometry Detector
- Acoustic Bearing Detector
- Cold Wheel Detector
- Wheel Impact Load Detector
- Truck Performance Detector

BNSF RAILWAY

Prevention: Record Capital Spending



BNSF RAILWAY

Prevention: Inspection/Condition Based on Safety Approach

Bridge and Track Inspections

BNSF inspects tracks and bridges more often than required by FRA

- Most BNSF key routes inspected **four times weekly** and **busiest daily**
- Geometry car inspections performed **at least two times** on crude oil routes annually
- Track inspections with state-of-the-art technology to detect internal and external flaws in the rail and track structure
- Weather and earthquake inspections

Proactive Rail Equipment Defect Detection Devices

- Wheel Impact Load Detector
- Warm Bearing Detection System
- Hot / Cold Wheel Detector
- Acoustic Bearing Detectors

Increased Rail Detection Testing Frequencies Along Critical Waterways

Increased rail detection testing along critical waterways from the FRA frequency of twice annually to **2.5 times in April 2015**

BNSF RAILWAY

Prevention: Key Train Operations

A Key Train has one or more loads of Toxic Inhalation Hazard/Poisonous Inhalation (TIH/PIH) materials or a train with 20 or more tank loads of any hazardous materials.

Special Handling for Key Trains

- Special identification and tracking.
- Speed restrictions for crude and ethanol trains
  - **BNSF requires a speed of 35 mph for all shale crude trains through municipalities of 100,000 or larger as of March 2015.**
  - 50 mph for all Key Trains as of July 2014.
  - Municipal speed restriction of 40 mph for crude oil trains consisting of one or more DOT111 tank cars, including CPC 1232 tank cars, moving through High Treat Urban Areas issued by the Department of Transportation on July 1, 2014.
- **Risk-based Routing:** Applied PHMSA's *Rail Corridor Risk Management System* and its 27 Risk Factors, defining the "most safe and secure" routes for trains carrying TIH/PIH, to crude unit trains starting July 2014.
- **Key Train Routes:** Wayside wheel bearing detector spacing, frequency of track inspections, minimum track maintenance standards for tracks used to meet or pass Key Trains.
- **Unattended Trains:** Crude oil trains left unattended require specific job safety briefing between train crew and train dispatcher.
- **Locomotive Cab Securement:** Key Trains left unattended have reverser removed and cab doors locked.

BNSF RAILWAY

Prevention: Risk Reductions for Crude Trains

Derailment Prevention – Increased Trackside Safety Technology

BNSF-SPECIFIC ACTION	INDUSTRY ACTION
Hot Bearing Detectors spacing of 10 miles on crude routes that parallel critical waterways, which is a higher standard than the industry maximum of 40 mile spacing. Key Trains stopped by Hot Bearing Detectors must set-out the indication car. Effective March 2015	Additional Hot Bearing Detectors on crude oil routes (maximum 40 mile spacing). Effective July 2014
Increase rail detection frequencies along critical waterways as BNSF went from the FRA frequency of twice a year to **2.5 times**. Effective April 1, 2015	
Key Trains with Level II Wheel Impact Load Detector (WILD) defect (120-140 Kilopound) will be handled as LEVEL I defect (immediate set-out). Effective March 2015	

BNSF RAILWAY

Prevention: Positive Train Control (PTC) Deployment Will Enhance Safety

Digital wireless communication technology

- Prevents train-to-train collisions
- Enforces speed limits
- Protects roadway workers and equipment
- Prevents movement of trains through a switch left in an improper position
- Interoperability allows operating on other railroads
- Predictive, advanced train control safety technology

BNSF RAILWAY

Mitigation: U.S. DOT Final Rule

Final Rule Issued May 2015 and Effective July 7, 2015

(various aspects of the new rule are currently being challenged in court and with the U.S. DOT)

New Braking Standards

- Requires End-of-Train (EOT) device or Distributive Power (DP) braking
- Electronically Controlled Pneumatic (ECP) braking system for High Hazard Flammable Unit Trains (70+ cars) by Jan. 1, 2021 or 30mph speed limit – Crude Oil
- ECP braking for High Hazard Flammable Trains by May 2023 or 30 mph speed limit – All Other HHFUT

Note: The FAST Act requires an independent evaluation of the electronic brakes standard, which may result in the repeal of the electronic brakes mandate.

New Operational Standards

- Reduced operating speeds - **BNSF-specific standards exceed**
- Routing requirements**
- Notification information for government agencies

New Classification Requirements

Document sampling and testing program

Ruling applies to HHFT (High-hazard flammable trains) = ≥20 loaded tank cars in a continuous block or ≥35 or more loaded tank cars dispersed through a train

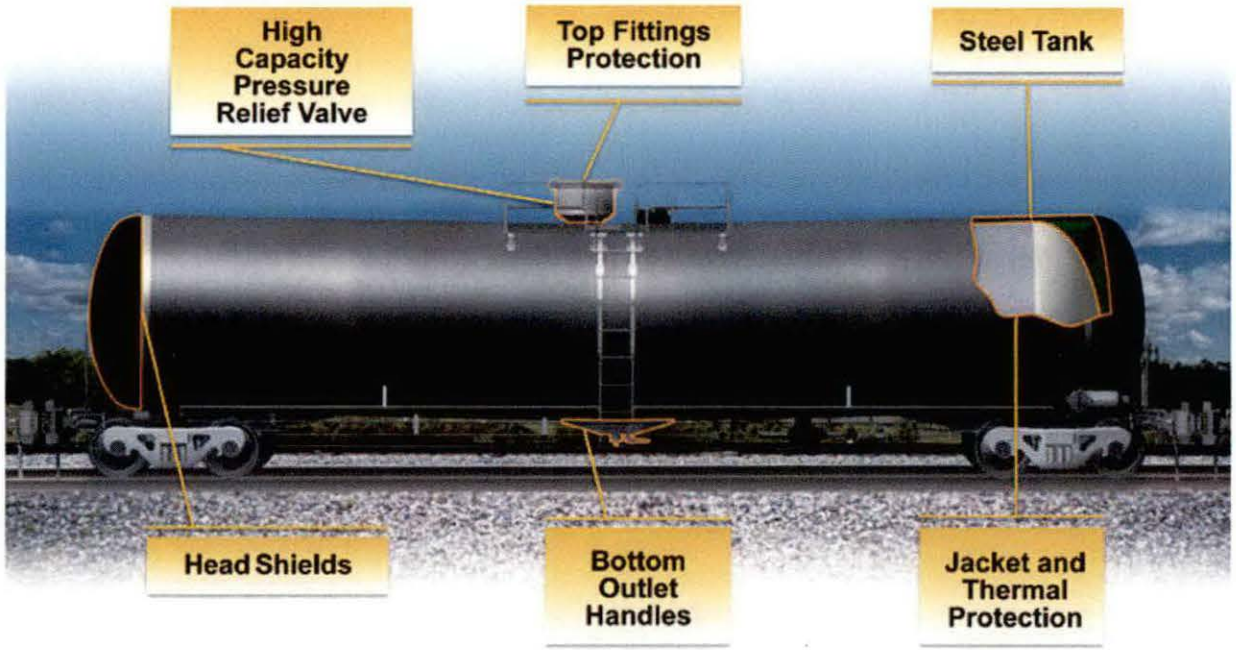
BNSF RAILWAY

Mitigation: New Tank Car Standards

Tank Cars for High-Hazard Flammable Trains (HHFT)

New tank cars built after Oct. 1, 2015, must meet enhanced DOT 117 design or performance criteria for HHFT:

- Increased thickness from 7/16 inch to 9/16 inch steel
- Thermal protection required
- Jacketing with minimum 11-gauge steel and weather-tight
- Full-height Head Shield - 1/2-inch thick



BNSF RAILWAY

Mitigation: New Tank Car Standards

Car specification /Service	U.S. Retrofit Timeline	Car specification /Service	Canadian Retrofit Timeline
DOT111 (NJ)/PGI	January 1, 2017* January 1, 2018	DOT111 (NJ)/Crude Oil	May 1, 2017
DOT111 (J)/PGI	March 1, 2018	DOT111 (J)/Crude Oil	March 1, 2018
CPC-1232 (NJ)/PGI	April 1, 2020	CPC-1232 (NJ)/Crude Oil	April 1, 2020
DOT111 (NJ)/PGII	May 1, 2023	DOT111 (NJ)/Ethanol	May 1, 2023
DOT111 (J)/PGII	May 1, 2023	DOT111 (J)/Ethanol	May 1, 2023
CPC-1232 (NJ)/PGII	July 1, 2023	CPC-1232 (NJ)/Ethanol	July 1, 2023
CPC-1232 (J)/PGI and II and all remaining cars in PGIII	May 1, 2025	CPC-1232 (J)/PGI and II all remaining cars in other flammable liquid service	May 1, 2025

Response: First Responder Coordination

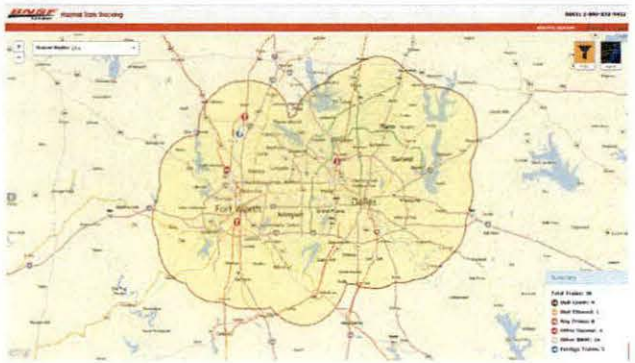
- Shipment **information access** by first responders
- **Training** first responders, employees and customer employees
- **Mobilizing** in the event of an incident

BNSF RAILWAY

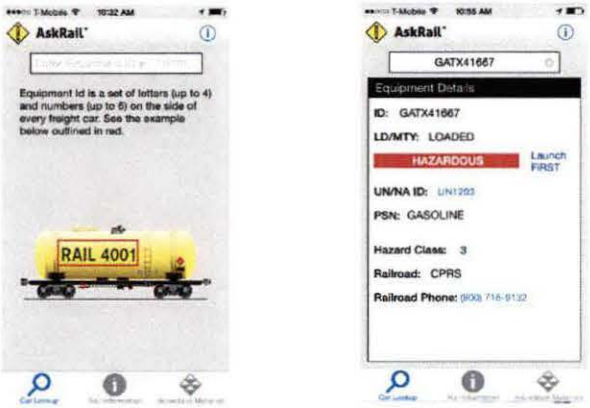
Response: First Responder Access to Information

Historically, BNSF has provided local first responders information about hazmat shipments upon request --- Today we go even further:

- Since July 2014, BNSF provides **State Emergency Response Commissions with Bakken crude traffic train counts** on transport of 1 million+ gallons.
- BNSF **offers SECURETRAK** website, a real-time Geographic Information System tracking program, to state and/or regional fusion centers.
- Industry **launched AskRail app** to provide first responders with car-specific data for hazmat contents and railroad contacts during incident.
- BNSF **developed national inventory of resources** for first responders, staging of emergency response equipment and community notification contacts.
- BNSF launched www.BNSFHAZMAT.com website to provide information such as training and emergency response plans to first responders.



SECURETRAK Website



AskRail App

Response: First Responder Training

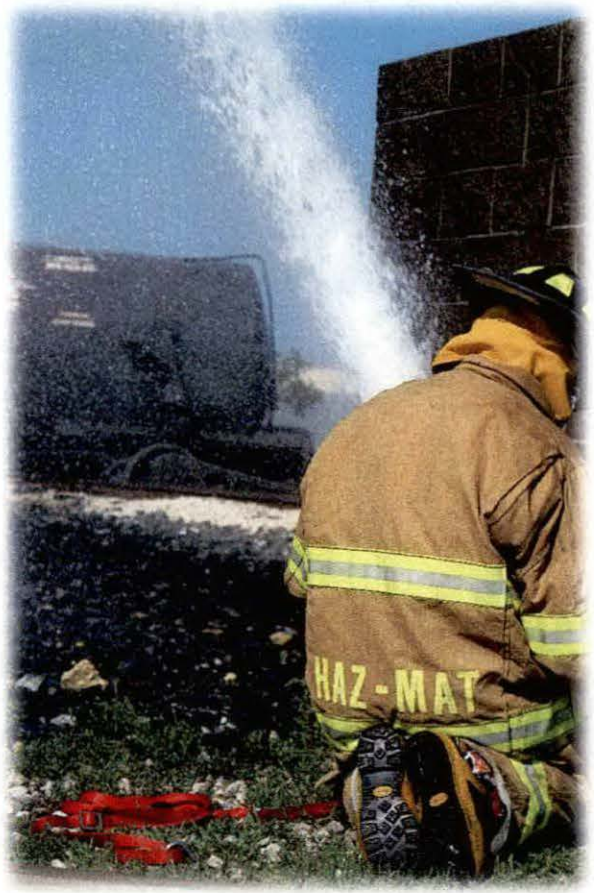
BNSF and rail industry train first responders in communities in TRANSCAER program
(Transportation Community Awareness and Emergency Response)

- Hands-on equipment in field – instructor lead
- Train list / shipping papers
- Placards
- Equipment
- Incident Assessment

- BNSF trained more than **10,000 local emergency responders** in 2015.
- More than **80,000 emergency responders** trained by BNSF since 1996.

BNSF RAILWAY

Response: Training First Responders at National Facilities



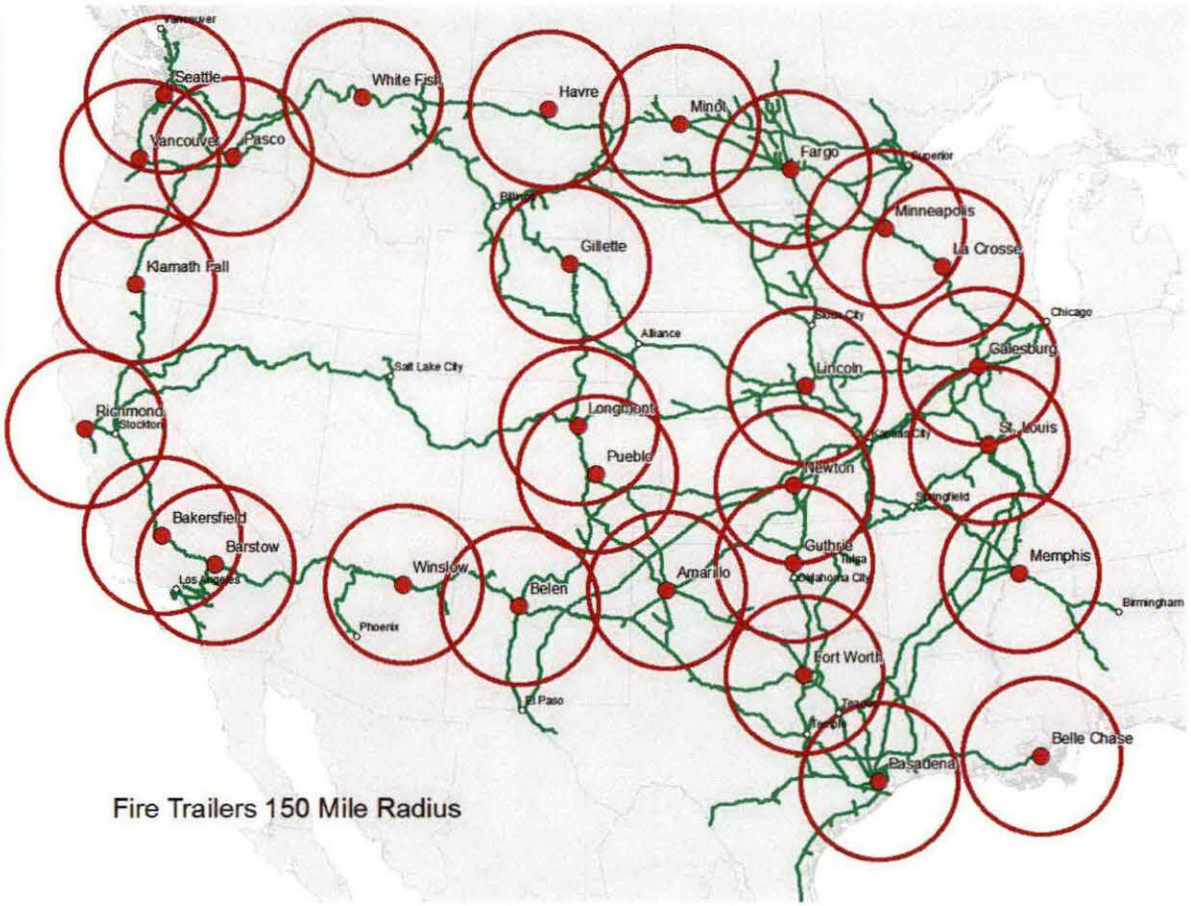
- **Security and Emergency Response Training Center (SERTC)** at national railroad research/training facility
- First responders **learn crude incident techniques** in three-day class with 24 hours of training
- In 2015, industry trained 1,700 first responders. **In 2014 and 2015 BNSF sponsored more than 1,200** local emergency responders; In 2016, BNSF sponsoring 360 responders to attend SERTC and Texas A&M
- BNSF believes first responders **must be properly trained** to respond safely

BNSF RAILWAY

Response: Incident Mobilization

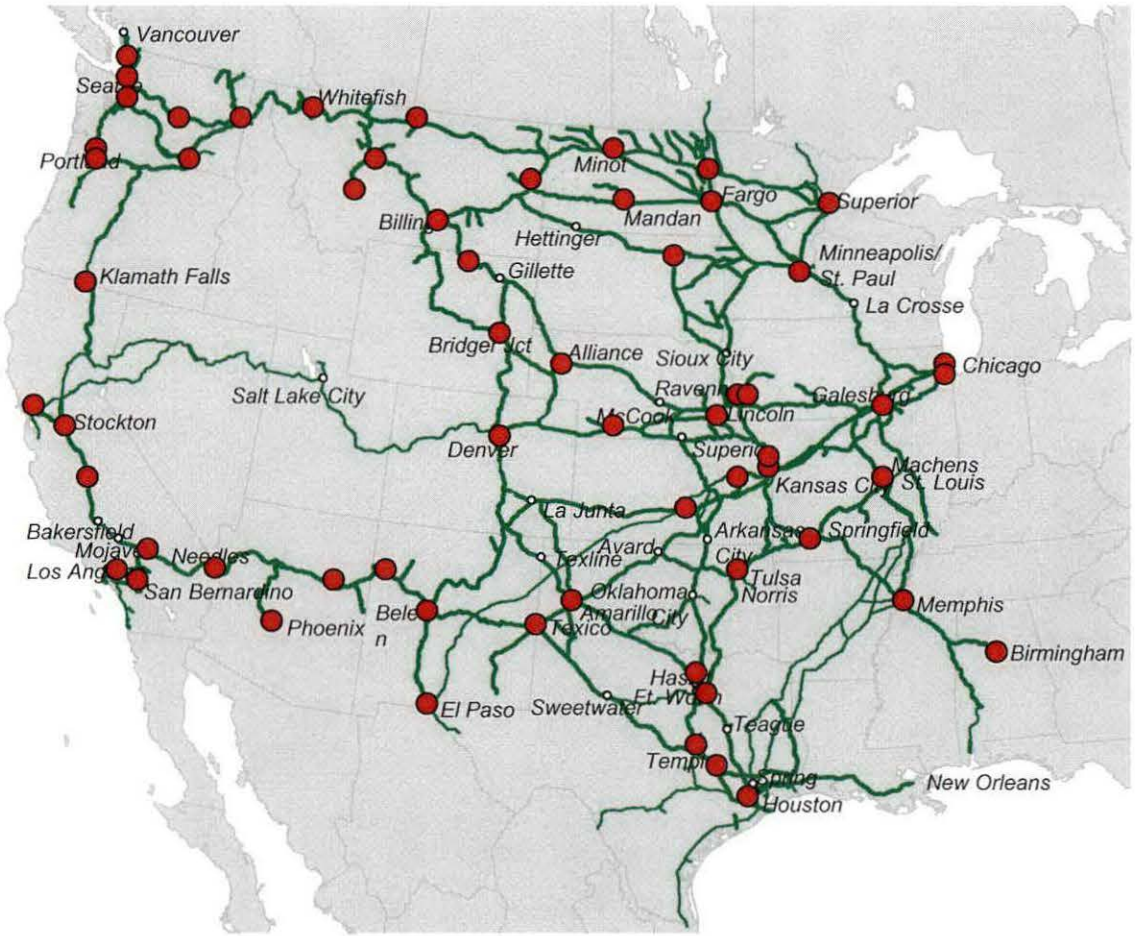
BNSF pre-positions equipment across its network

- Industrial fire-fighting foam trailers
- Emergency breathing air trailers
- Chlorine kits
- Midland kits
- Air monitoring assets



Response: Mobilization of Prepositioned BNSF Hazmat Responders

250 responders at 60 locations



Remediation

BNSF will restore the site

Cameron, Texas, post derailment

- BNSF is responsible for mitigation of the spill and any restoration tasks.
- BNSF contracts with pre-approved consultants and contractors to perform the remediation and restoration.
- State agencies oversee the work and BNSF must obtain their concurrence before a site is acceptably closed.

BNSF RAILWAY

BNSF RAILWAY

Figure 13. Fatalities by Freight Transportation Mode: 1980, 1990, and 2000–2013 (Source: BTS)

	1980	1990	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Total transportation fatalities	**NA**	**47,483**	**44,463**	**45,020**	**45,292**	**45,121**	**45,028**	**45,641**	**45,061**	**43,347**	**39,542**	**35,978**	**35,034**	**34,568**	**35,699**	**34,509**
Total freight transportation fatalities	**7,489**	**6,461**	**6,079**	**5,897**	**5,768**	**5,773**	**5,992**	**5,991**	**5,851**	**5,551**	**4,484**	**3,611**	**4,286**	**4,340**	**4,462**	**4,507**
Freight as a share of total fatalities	**NA**	**13.6%**	**13.7%**	**13.1%**	**12.7%**	**12.8%**	**13.3%**	**13.1%**	**13.0%**	**12.8%**	**11.3%**	**10.0%**	**12.2%**	**12.6%**	**12.5%**	**13.1%**
Highway[1]	**5,971**	**5,272**	**5,282**	**5,111**	**4,939**	**4,989**	**5,195**	**5,213**	**5,027**	**4,822**	**3,821**	**3,050**	**3,686**	**3,781**	**3,944**	**3,964**
Large truck occupants	1,262	705	754	708	689	726	766	804	805	805	682	499	530	640	697	691
Others killed in crashes involving large trucks	4,709	4,567	4,528	4,403	4,250	4,263	4,429	4,409	4,222	4,017	3,139	2,551	3,156	3,141	3,247	3,273
Railroad	**1,365**	**1,095**	**717**	**729**	**725**	**683**	**690**	**682**	**723**	**635**	**575**	**481**	**519**	**497**	**478**	**509**
Train accidents	28	10	8	5	8	3	11	19	6	7	2	3	4	6	9	6
Highway-rail grade crossing[2]	821	624	353	326	288	262	299	289	295	252	220	166	187	189	169	156
Trespassers	426	426	328	373	399	395	355	349	411	354	330	291	309	280	286	322
Other incidents	90	35	28	25	30	23	25	25	11	22	23	21	19	22	14	25
Waterborne[3]	**134**	**85**	**42**	**50**	**92**	**89**	**84**	**80**	**82**	**78**	**80**	**67**	**62**	**50**	**30**	**25**
Freight	NA	NA	NA	NA	48	39	37	33	37	42	34	30	22	18	14	8
Industrial/ Other	NA	NA	NA	NA	44	50	47	47	45	36	46	37	40	32	16	17
Pipeline	**19**	**9**	**38**	**7**	**12**	**12**	**23**	**16**	**19**	**16**	**8**	**13**	**19**	**12**	**10**	**9**
Hazardous liquid pipeline	4	3	1	0	1	0	5	2	0	4	2	4	1	1	3	1
Gas pipeline	15	6	37	7	11	12	18	14	19	12	6	9	18	11	7	8

KEY: NA = not available.

[1] Large trucks have a gross vehicle weight rating at or above 10,000 pounds and include single-unit and combination trucks.

[2] *Highway-rail grade crossing* fatalities include freight train collisions with vehicles and people at all public and private highway-rail grade crossings.

[3] *Freight* includes barges, bulk carriers, general dry cargo ships, refrigerated cargo ships, roll-on/roll-off ships, tank ships, and towing ships. *Industrial/Other* includes fishing vessels, miscellaneous vessels, and offshore. Waterborne fatalities include only closed cases where vessels were involved in a marine casualty as of April 6, 2015. Open cases by year not included above: 2003 = 5, 2004 = 5, 2005 = 8, 2006 = 4, 2007 = 7, 2008 = 19, 2009 = 38, 2010 = 36, 2011 = 120, 2012 = 644, and 2013 = 727. Data prior to 2002 were tabulated using a different reporting system and are not directly comparable with later years.

NOTES: There are differences in definitions and reporting periods across modes due to regulatory and legal requirements.

SOURCES: Highway: U.S. Department of Transportation, National Highway Transportation Safety Administration, National Center for Statistics and Analysis, *Traffic Safety Facts, Large Trucks* and *Highlights* (annual issues). **Railroad:** U.S. Department of Transportation, Federal Railroad Administration, Office of Safety Analysis, available at http://safetydata.fra.dot.gov/officeofsafety/default.asp as of July 10, 2015. **Waterborne:** U.S. Department of Homeland Security, U.S. Coast Guard, Data Administration Division, *Marine Casualty and Pollution Data for Researchers* (April 6, 2015), available at homeport.uscg.gov as of July 2015. **Pipeline:** U.S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration, Office of Pipeline Safety, Accident and Incident Summary Statistics by Year, available at http://phmsa.dot.gov/pipeline as of March 2015.

Crude Oil Safety Measures Implemented by Railroads

Rail's safety culture

Rail is the safest mode of land transportation for freight in general and is one of the safest ways to transport crude oil and hazardous materials. Below are the measures that have been implemented by the rail industry and BNSF to make the transport of crude oil and other hazardous materials even safer.

Increased Track Inspections

Effective March 25, 2014

- At least one additional internal rail inspection each year above Federal Railroad Administration (FRA) requirements on crude oil routes.
- At least two geometry car inspections each year on crude oil routes.

Effective April 1, 2015

- **Increase rail detection testing frequencies along critical waterways from twice a year per FRA standards to 2.5 times a year.**

Increased Trackside Safety Technology

Effective July 1, 2014

- Additional Hot Bearing Detectors (HBD) on crude oil routes (maximum 40 mile spacing).

Effective March 25, 2015

- **HBD spacing of 10 miles on crude routes that parallel critical waterways.**
- **Key Train stopped by HBD must set-out the indicated car.**
- **KEY Trains with Level II Wheel Impact Load Detector (WILD) defect (120–140 Kilopound, Kips,) will be handled as a LEVEL I defect for immediate set-out.**

Rail Risk-Based Traffic Routing Technology

Effective July 1, 2014

- Use of Rail Corridor Risk Management System to determine the safest and secure routes for crude trains of 20 or more loaded cars.

Denotes BNSF Specific Action

Published January 2016

BNSF RAILWAY

Continued on back

Lower Speeds

Effective July 1, 2014

- Implemented nationwide speed restriction of 50 mph for all Key Trains (20 or more cars hazmat, one car Toxic Inhalation Hazard/Poisonous Inhalation Hazard, TIH/PIH).
- Municipal speed restriction of 40 mph for crude oil trains consisting of one or more DOT111 tank cars, including CPC 1232 tank cars, moving through High Threat Urban Areas issued by the Department of Transportation.

Effective March 25, 2015

- **35 mph for all shale crude oil trains through municipalities of 100,000 or more.**

Key Train Operating Practice Restrictions

- When two trains meet a Key Train will hold the main track whenever practicable.
- A Key Train experiencing an emergency brake application requires inspection of the entire train before proceeding.

Unattended Trains

- Crude oil trains left unattended require a specific job safety briefing between the train crew and the train dispatcher.
- Key Trains left unattended must have the reverser removed and cab doors locked to secure the locomotive cab.

Emergency Response Training and Community Outreach

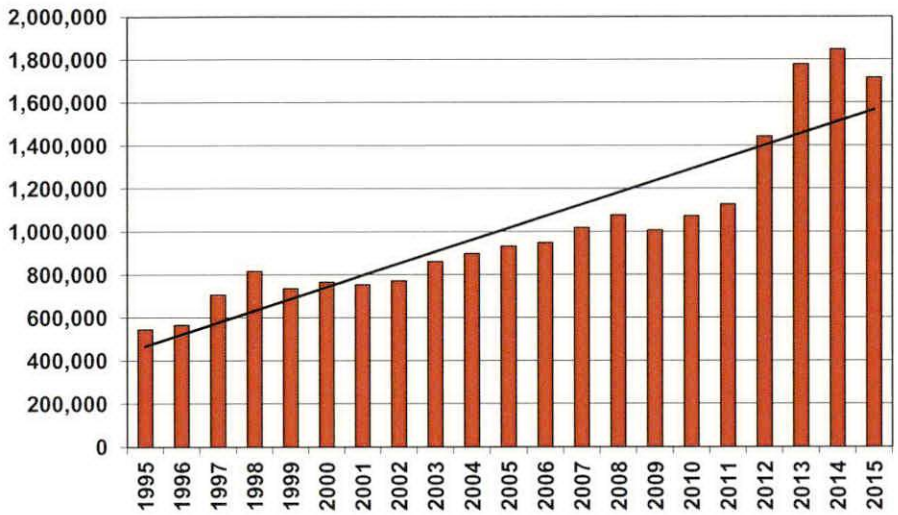
- Developed specialized Crude by Rail first responder training at the Transportation Technology Center Inc. in Pueblo, Colorado.
- Sharing hazmat unit volumes by major track segment.
- Rail industry launched *AskRail* app to provide first responders with car-specific data for hazmat contents and railroad contacts during an incident.
- **BNSF offers the *SECURETRAK* website, a real-time Geographic Information System tracking program, to state and/or regional fusion centers.**
- **In 2015, BNSF provided hazmat response training to more than 10,000 first responders. BNSF has trained more than 80,000 emergency responders across its network since 1996.**
- **In 2014 and 2015, BNSF sponsored more than 1,200 first responders from 25 states and one Canadian Province at the Security and Emergency Response Training Center (SERTC) at the national railroad research and training facility in Colorado. BNSF will sponsor 360 first responders for training at SERTC and at Texas A&M in 2016. The classes focus on specialized training for crude oil incidents with 24-hours of training over a three-day class.**

Denotes BNSF Specific Action

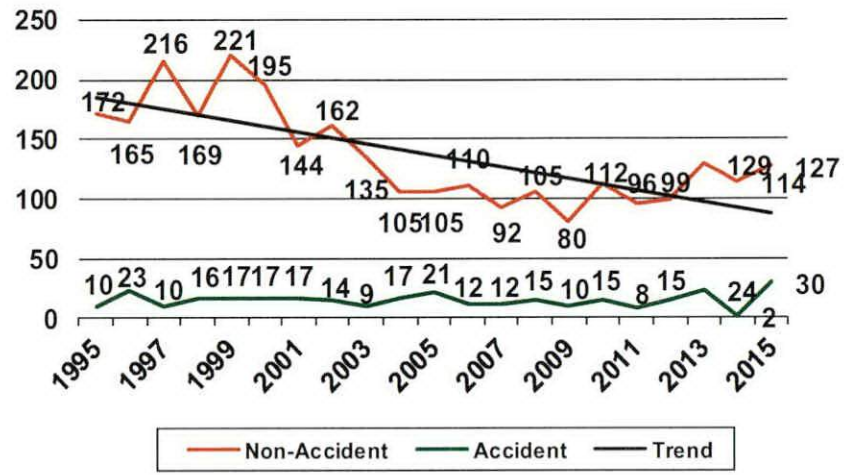
Published January 2016

BNSF RAILWAY

BNSF Hazardous Material Stats



BNSF Number of Hazmat Shipments



BNSF Total Hazmat Releases

99.997% of rail industry shipments of hazardous materials reach their destination without a release caused by a train incident.

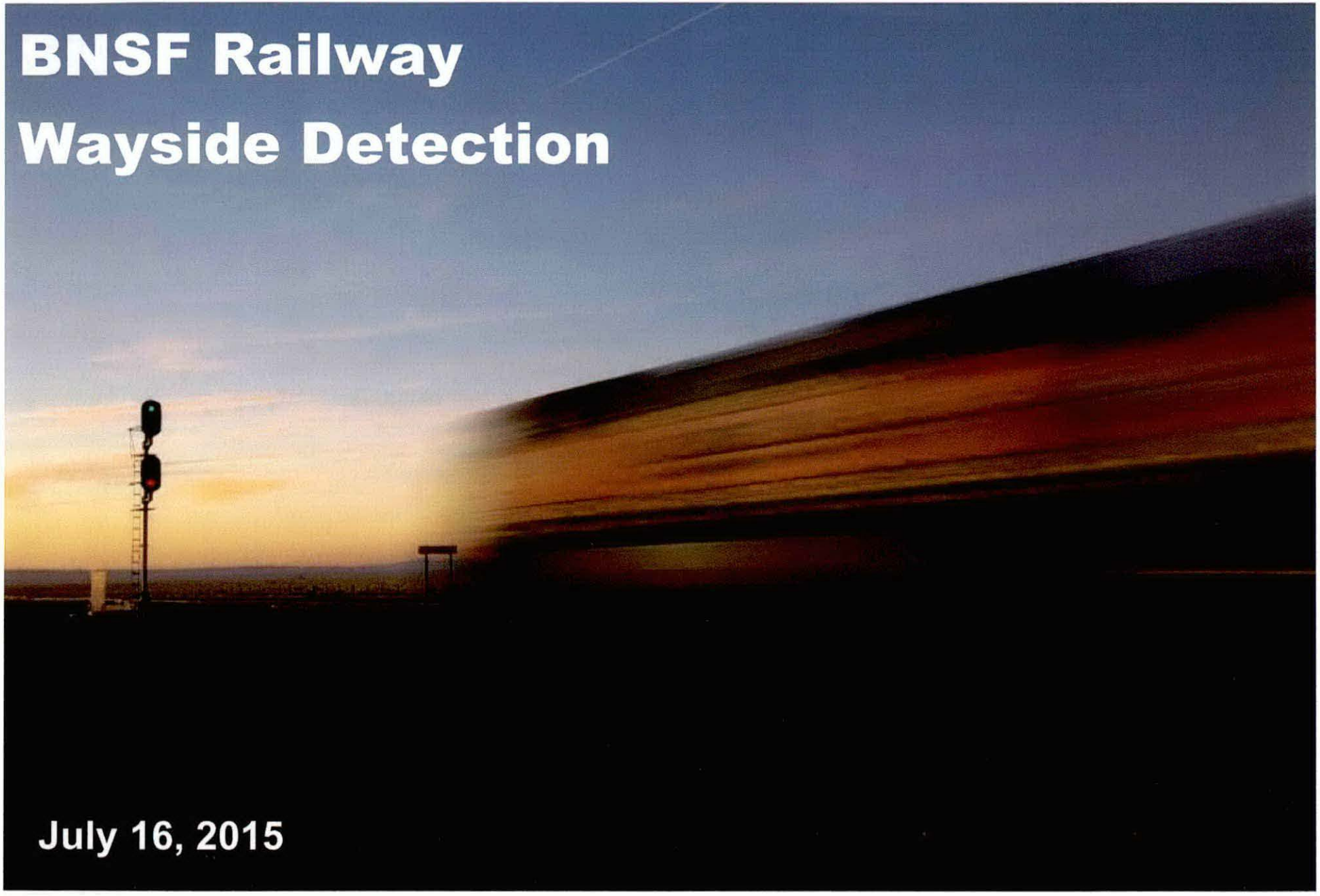
Hazmat Release Analysis

HAZMAT TRENDS	2009	2010	2011	2012	2013	2014	2015
Accident Release (AR) Yearly Totals	10	15	8	15	24	2	30
Number of Derailments with an AR	7	9	5	4	6	2	7
AR per 100 K Hazmat Shipments	0.99	1.40	0.71	1.04	1.35	0.11	1.75
Non Accident Release (NAR) Yearly Totals	80	112	96	99	129	114	127*
NAR per 100K Hazmat Shipments	7.9	10.4	8.5	6.9	7.3	6.2	7.4

** 13 NARs were from McKenzie valves*

BNSF

BNSF Railway
Wayside Detection

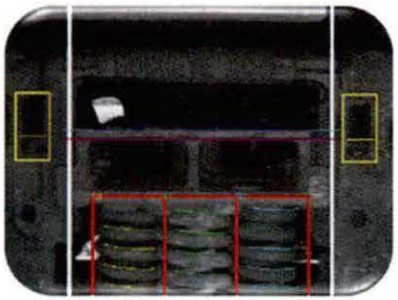


July 16, 2015

Vision - Why Wayside Detection

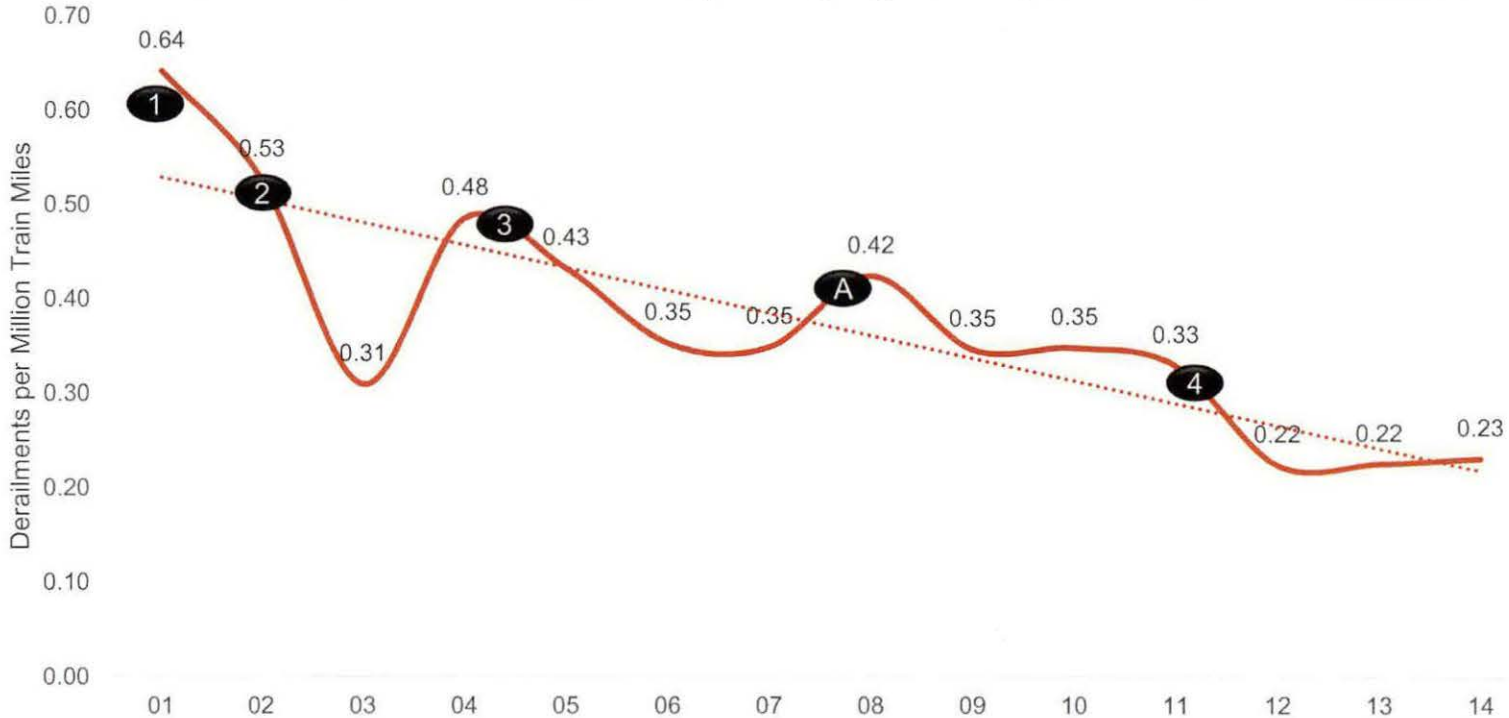
Vision

- Improve the safety, availability, reliability and velocity of rolling stock by minimizing derailments and service interruptions using new or re-purposed predictive technologies
- Augment manual inspections
- Identify defects in dynamic state while en route
- Inspections / repairs performed after unloading when possible
- Reduce train delays associated with setouts
- Proactively identify "Bad Actors"



2001 - 2014 Derailment

Mechanical Derailment Frequency by Year per Million Train Miles



Detector Implementation

1	Wheel Impact Load Detector (**WILD**) Truck Performance Detector (**TPD**)
2	Warm Bearing Detectors (**HBD**) Acoustic Bearing Detector (**ABD**)
3	Additional **WILD** to fill Gaps
4	MVS Coupler Carrier Plates system (**CCP & CCK**)

External Factor(s)

A	Detector data reviewed and cars inspected prior to being taken out of storage

Mechanical (2001-2014)

		Derailment CAGR*
		-7%
Bearing related	HWD, HBD, ABD	-6%
Wheel related	WILD	-4%
Truck related	TPD	-7%

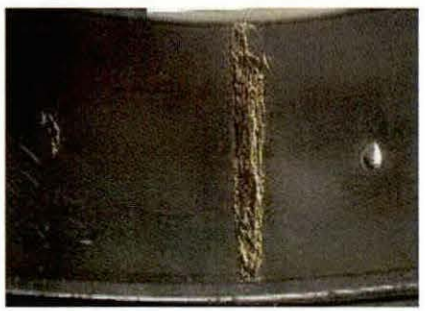
* CAGR: compounded annual growth rate

BNSF RAILWAY

Acoustic Bearing Detector (ABD)

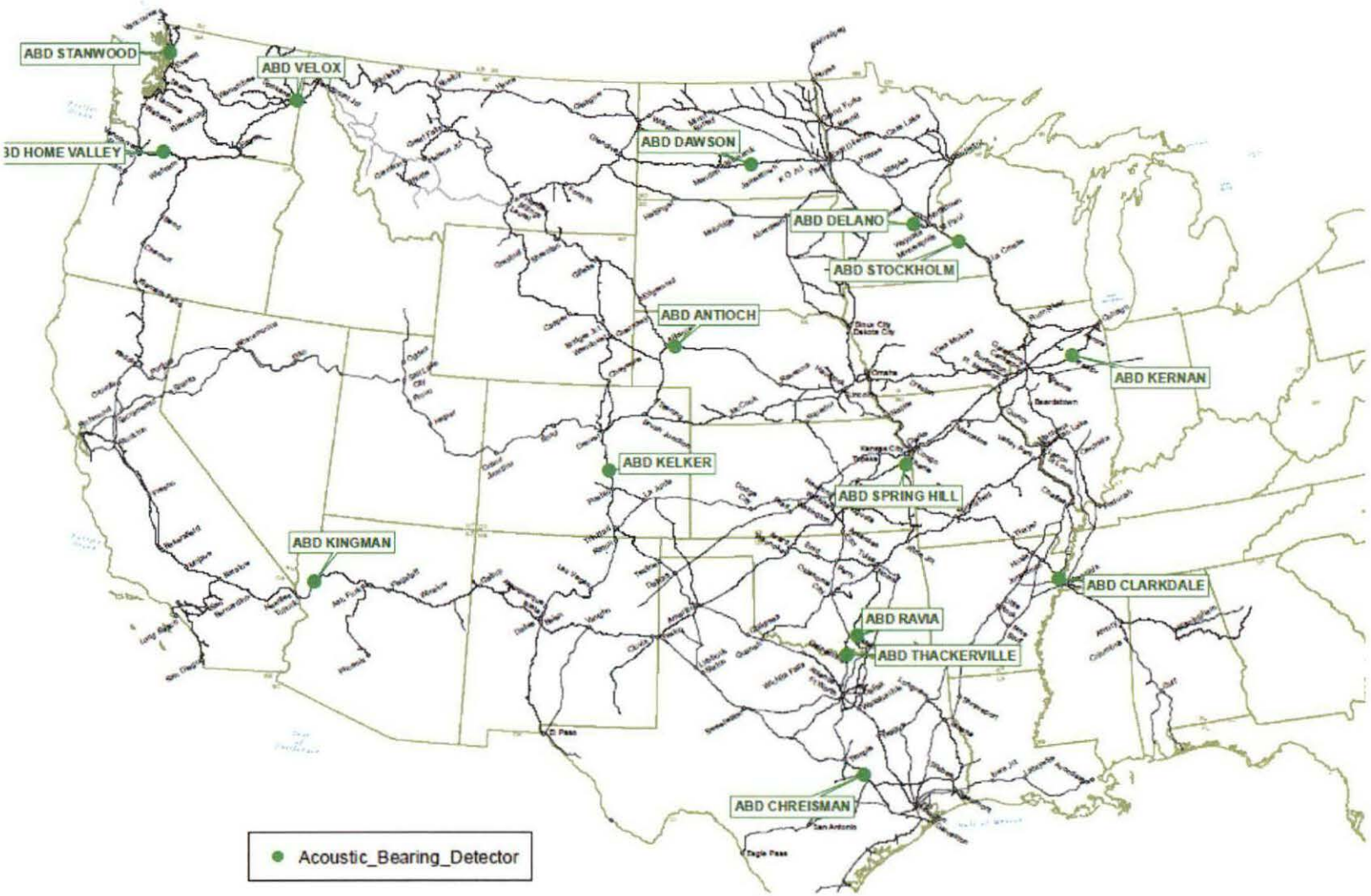
- Technology: Acoustic systems used to evaluate sounds generated by specific bearing component defects
- Targeted failure modes: Burned off journals
  - Spalling
  - Broken cages and cups
  - Water etch
  - Brinelling
  - Loose components
  - Growlers
- Current Sites: 15 (12 fixed / 3 Portable)

Acoustic Bearing Site



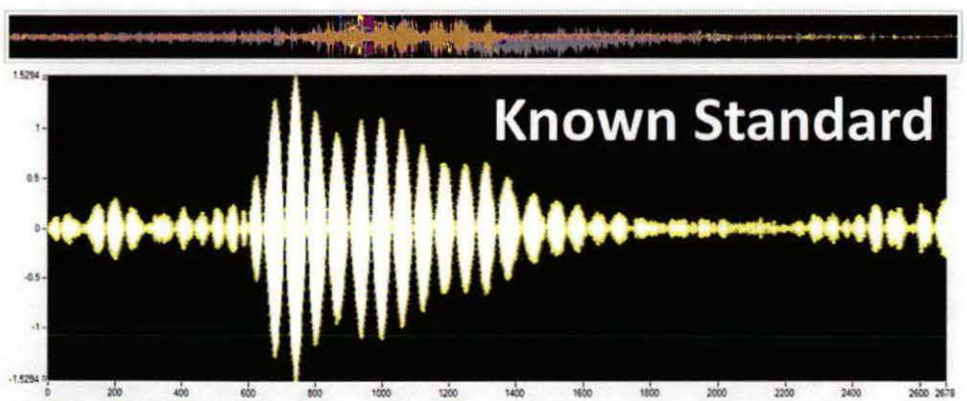
Spalled Bearing

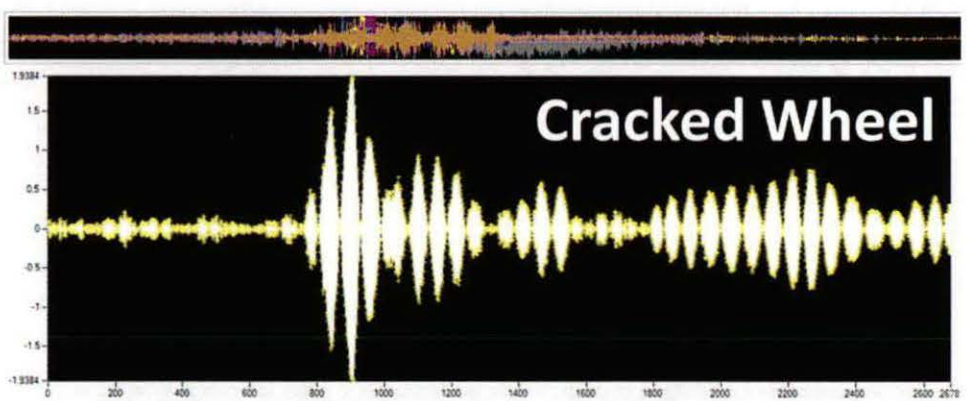
Acoustic Bearing Detector (ABD)



Cracked Wheel / Axle Detector (CWAD)

- <u>Technology</u>: Rail mounted sensors capable of detecting the difference between tones generated by normal vs. flawed wheels and axles
- <u>Concept</u>: The tone generated by solid wheels / axles *RING* longer than the tone of the same cracked component
- <u>Targeted failure modes</u>: Broken Wheels & Axles
- <u>Current Sites</u>: 4 (3 Jointed / 1 Jointless)

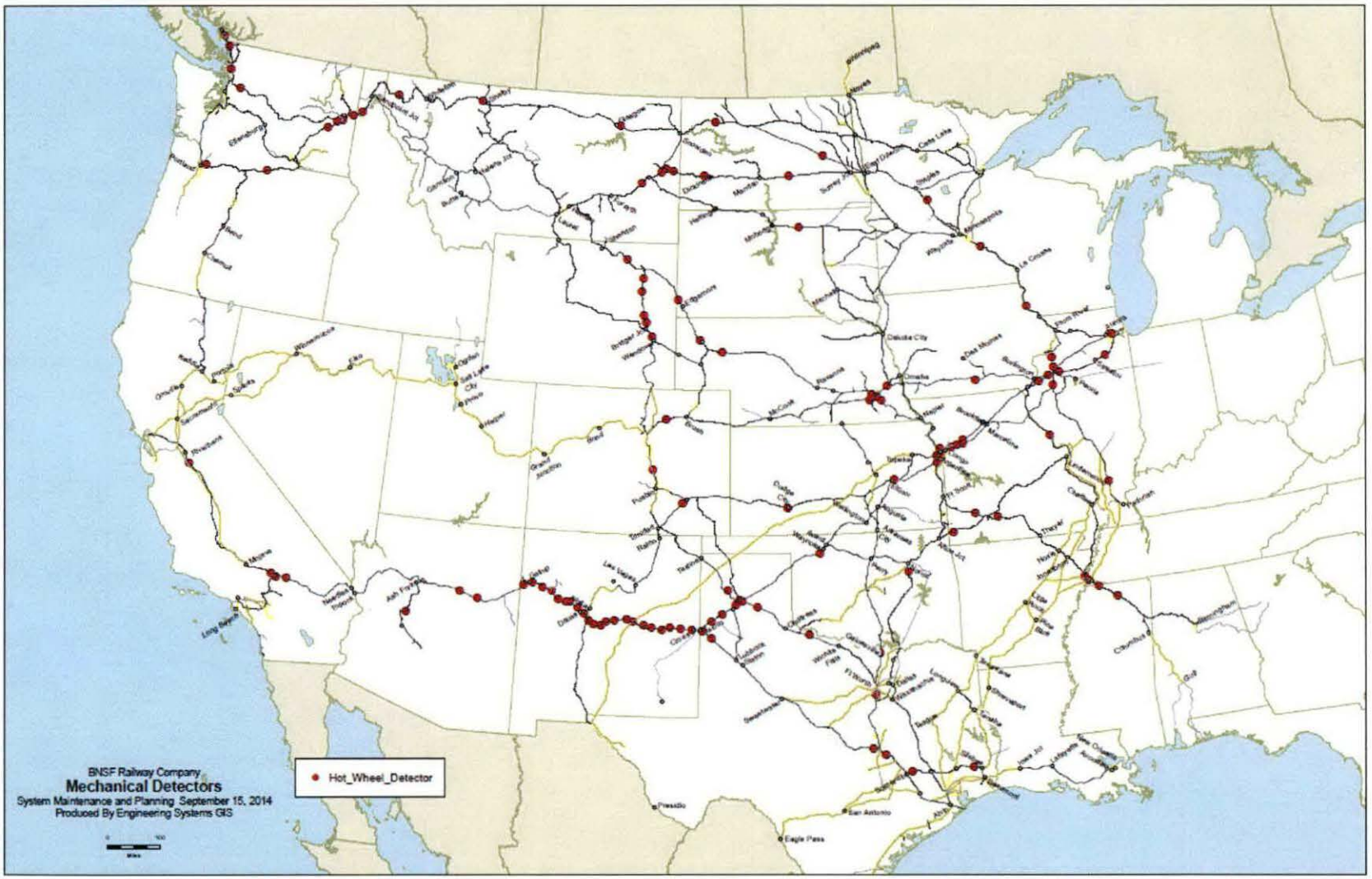




Hot Wheel Detectors (HWD)

- Technology: Thermal scanners used to detect overheated wheels caused by brake defects (HWD)
- Targeted failure modes: Brakes → Broken Wheels
  - Hand brake left on
  - Retainer valves in wrong position
  - Air valve and slack adjuster defects
  - Empty / load device defects
  - Inoperative brakes
- Current Sites: 179

Hot Wheel Detector (HWD)

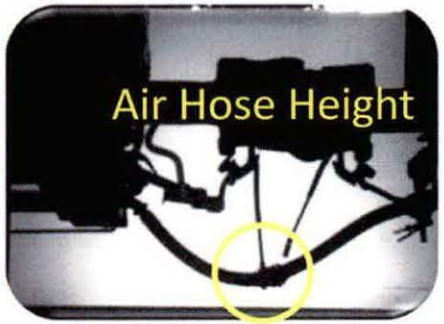


Machine Vision Systems

- Technology: Camera-based technology used to target specific defects / failure modes using custom algorithms, day or night; rain or shine
- Targeted failure modes:
  - Brake Shoe
  - Car body
  - Shifted Load
  - Undercarriage
  - Coupler Cross Key &Carrier Plate
  - Coal Car Hopper Door Lock
  - Truck Side
  - Wheel & Wheel Profile
- Current Sites: 12 (47 Modules)

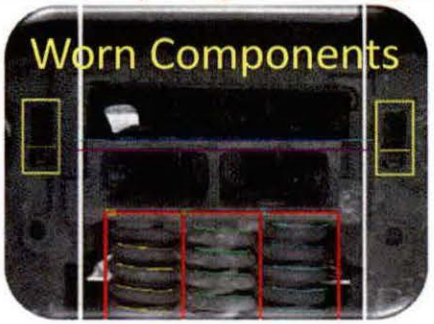
Machine Vision Systems (MVS)

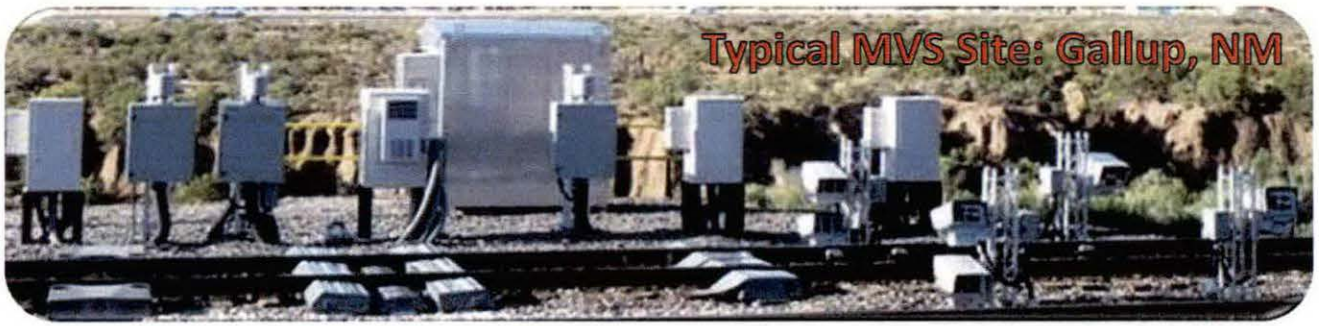
Low Air Hose

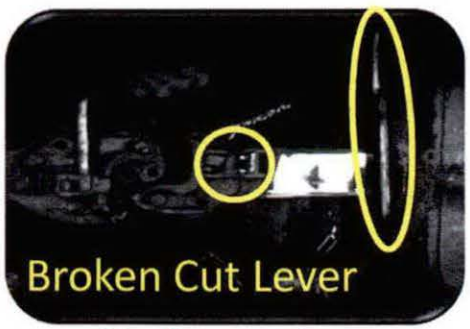


Coupler Cross Key

Truck Spring & Wedge







Undercarriage

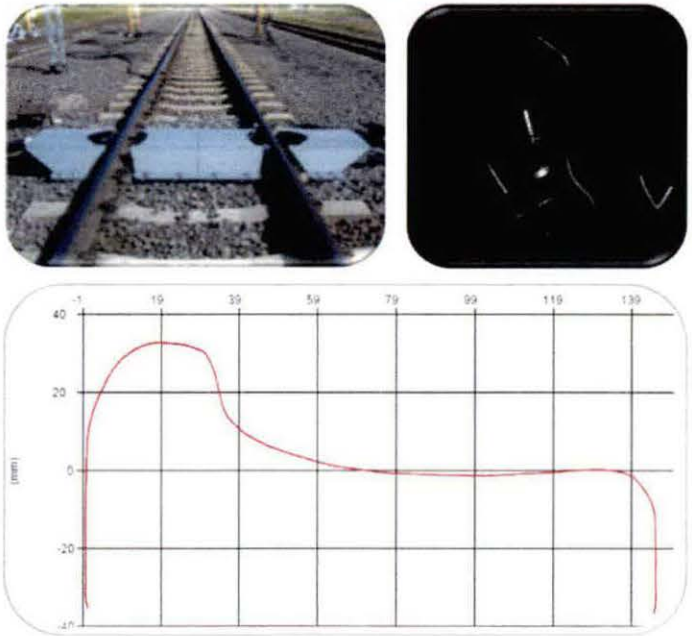
Coupler Carrier Plate

Brakes

- **MVS** - Defect identification in transit at over 70 mph… Day or night; rain or shine.
- **Coupler Carrier Plate & Cross Key** - Coupler securement. e.g. Missing fasteners
- **Spring and Wedge** - Truck side inspection. e.g. Worn truck components
- **Undercarriage** - Complete under frame inspection. e.g. Structural integrity
- **Brakes** - Brake system health. e.g. Worn brake shoes
- **Wheel Profile** - Wear limits. e.g. Flange thickness
- **Hopper Door Lock** - Door securement. e.g. Rapid discharge outlets

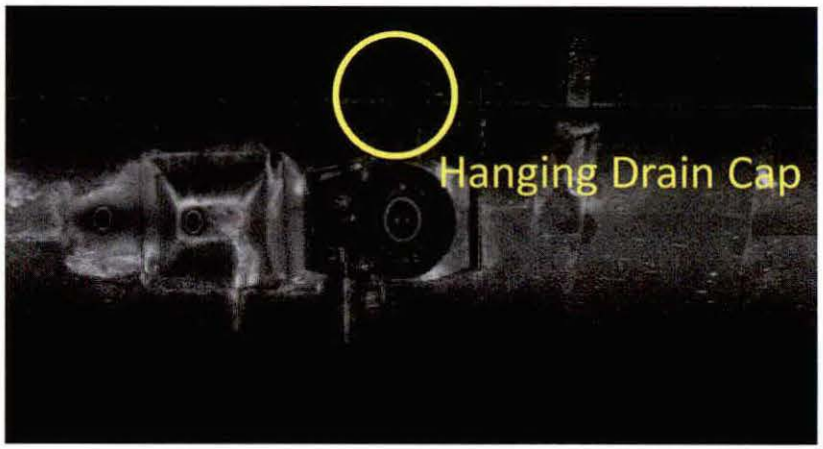
Machine Vision Systems - Continued

Wheel Profile



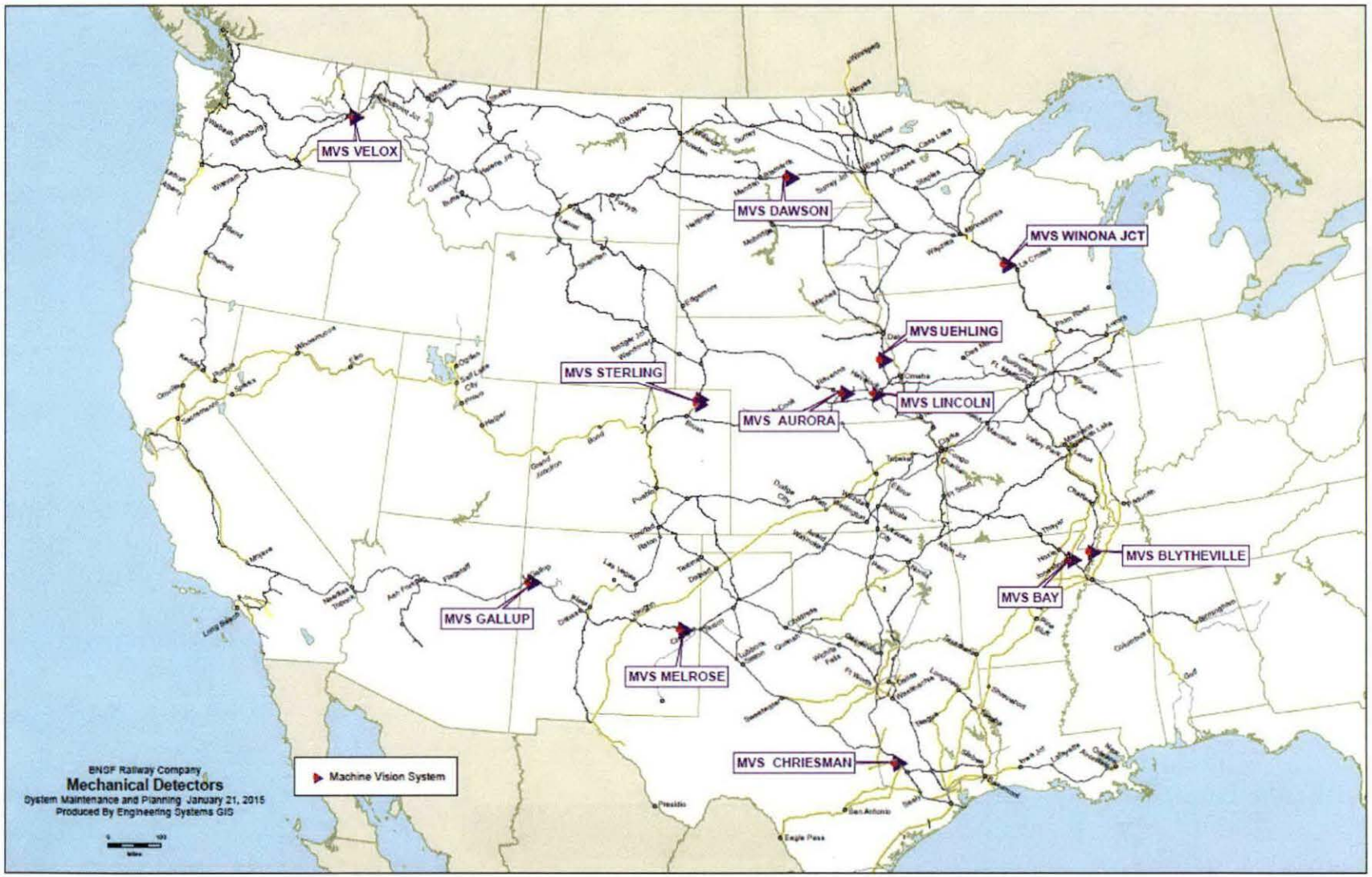
Undercarriage – Brake Rigging

Undercarriage – Drain Value Cap Security



Open Top Load

Machine Vision System Map



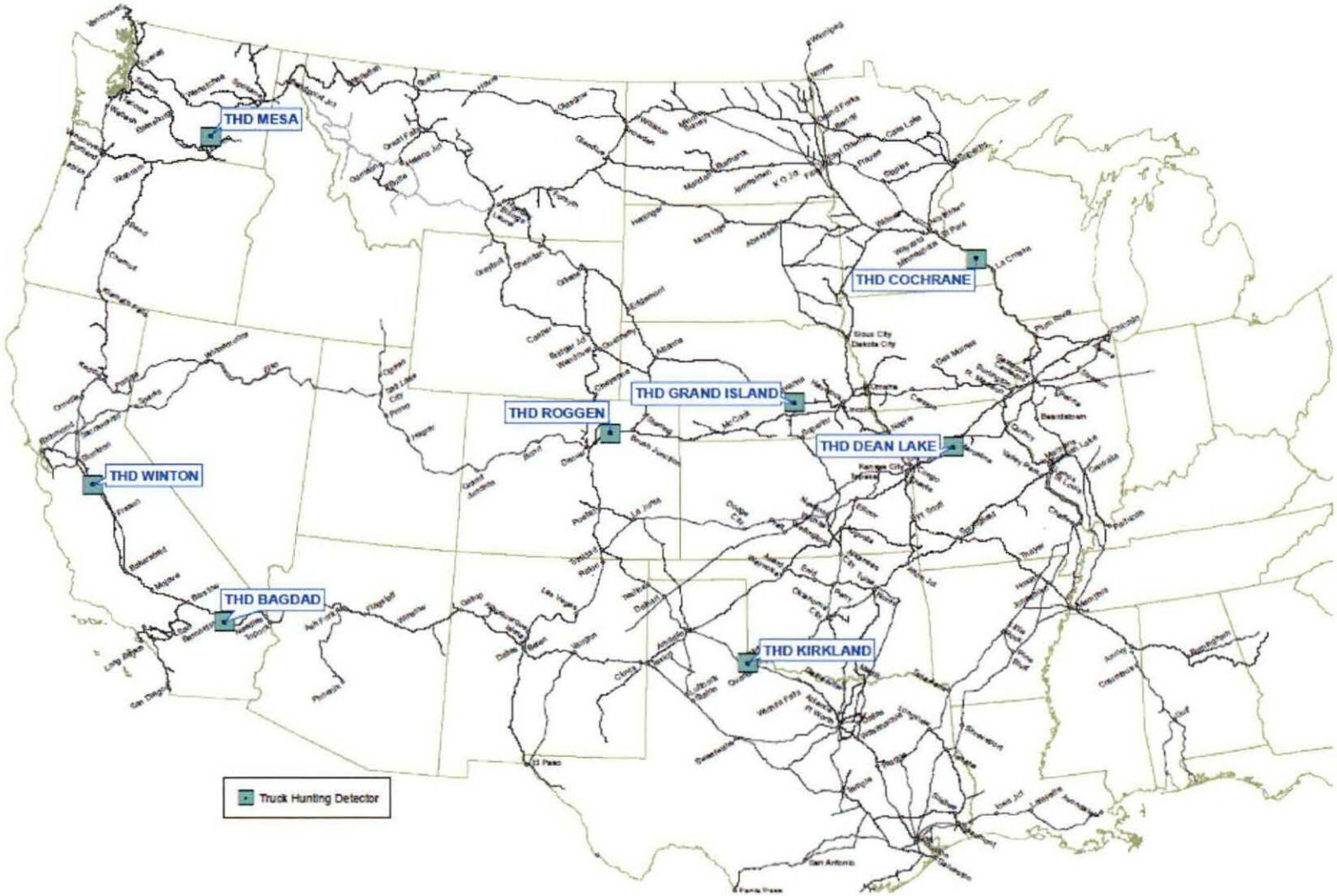
BNSF RAILWAY

Truck Hunting Detector (THD)

- Technology: Rail mounted strain gages used to detect trucks that continually search for the track centerline
- Targeted failure mode:
  - Poor truck steering
- Current Sites: 8 (co-located with WILD)

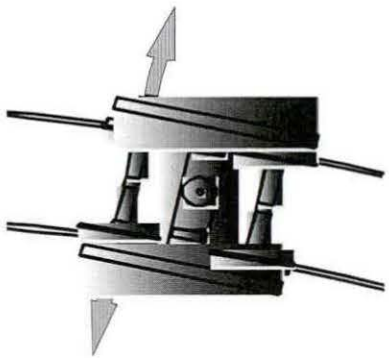
Symptom: Polishing on Cut Lever & Cut Lever Bracket

THD

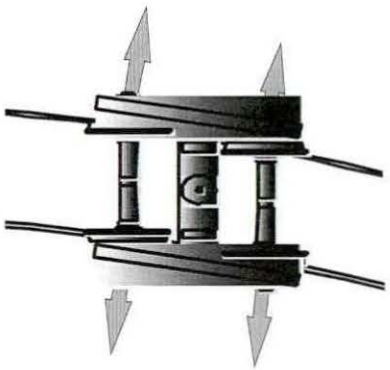

THD MESA
THD COCHRANE
THD GRAND ISLAND
THD ROGGEN
THD DEAN LAKE
THD WINTON
THD BAGDAD
THD KIRKLAND
Truck Hunting Detector

Truck Performance Detector (TPD)

- Technology: Rail mounted strain gauges installed in "S-Curves" to detect cars with reduced ability to steer around curves
- Targeted failure mode: Poor truck steering
- Current Sites: 10

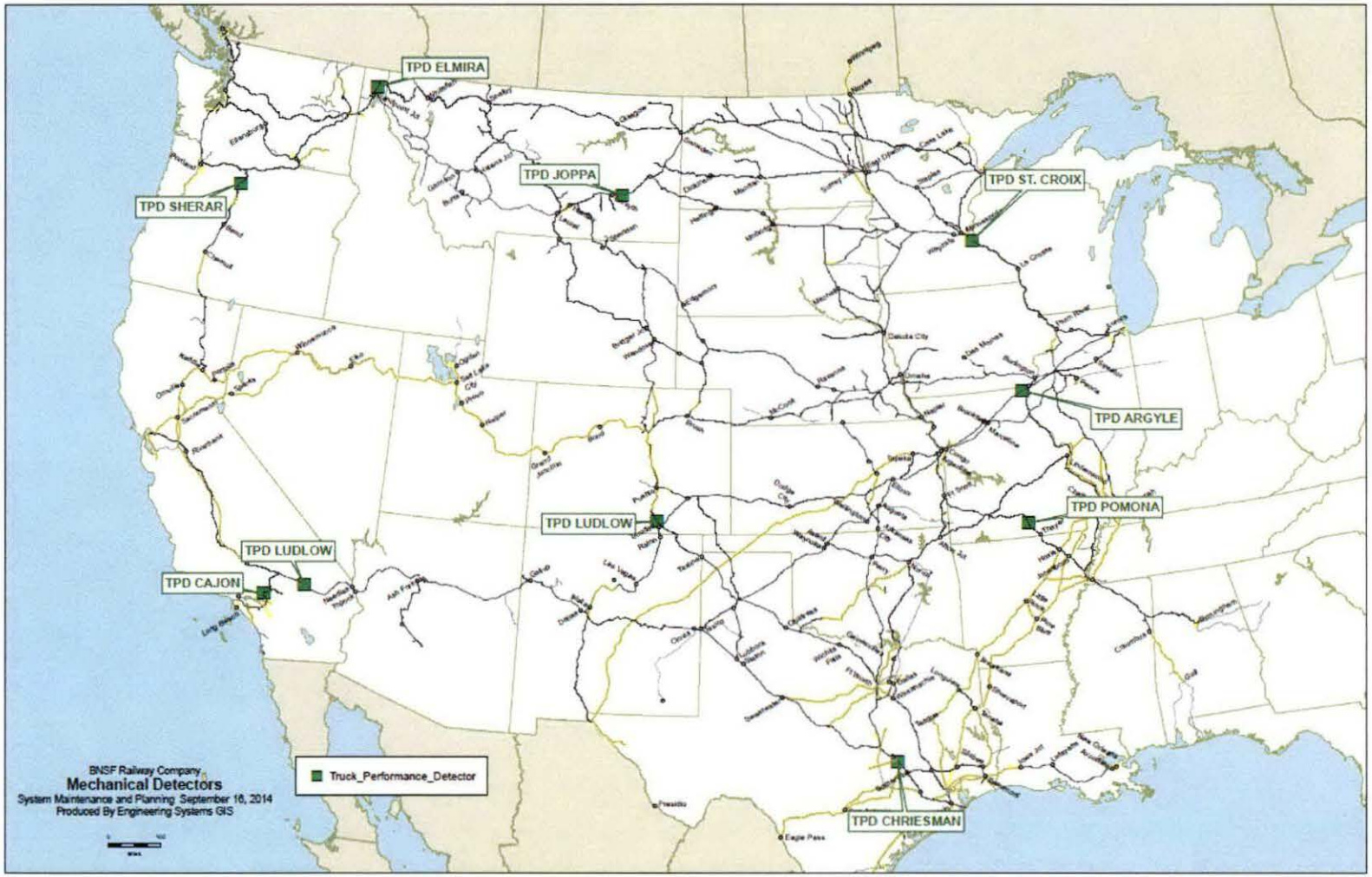


Normal Truck



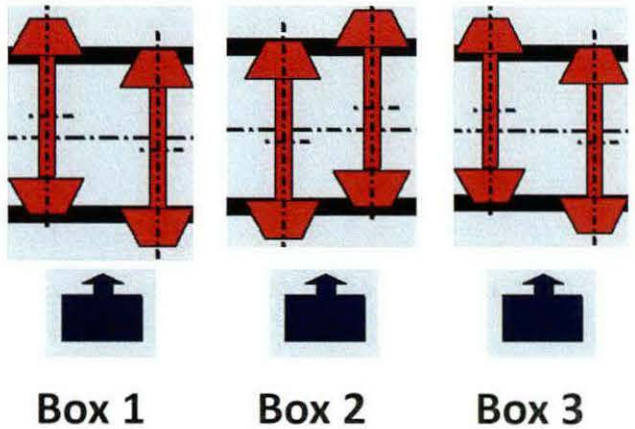
Warped Truck

Truck Performance Detector (TPD)



Optical Geometry Detector (OGD)

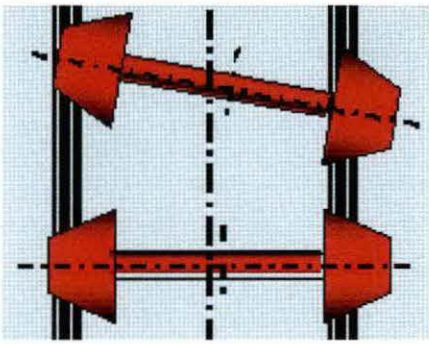
- <u>Technology</u>: Laser-based system used to determine the lateral position of wheel sets on tangent track
- <u>Targeted failure modes</u>:
  - Poor truck steering
  - Hunting
- <u>Current Sites</u>: 9



Truck Performance – Laser Based

Inter-Axle Misalignment (IAM)

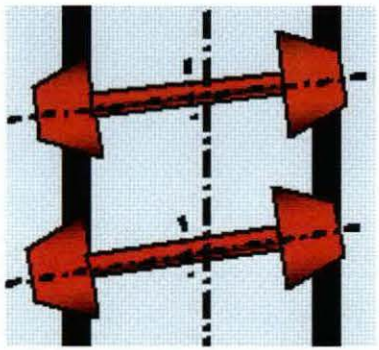
AOA measurement



Typical Findings
Mismatched side frames
Differential wheel wear
BO Adapter pad(s)

Rotation

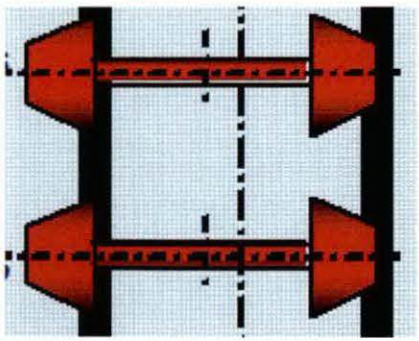
AOA measurement for both axles



Typical Findings
Dry / Rusty bowls
BO Side bearings
Insufficient bowl clearance

Shift

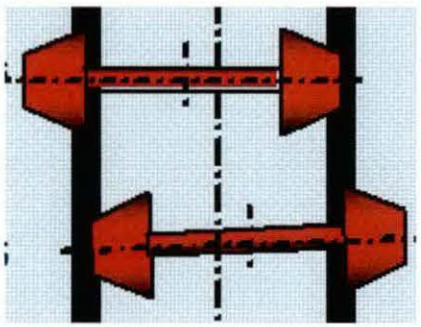
Distance from rail / known location



Typical Findings
Thin Flanges
BO Adapter pad(s)
BO Side bearings

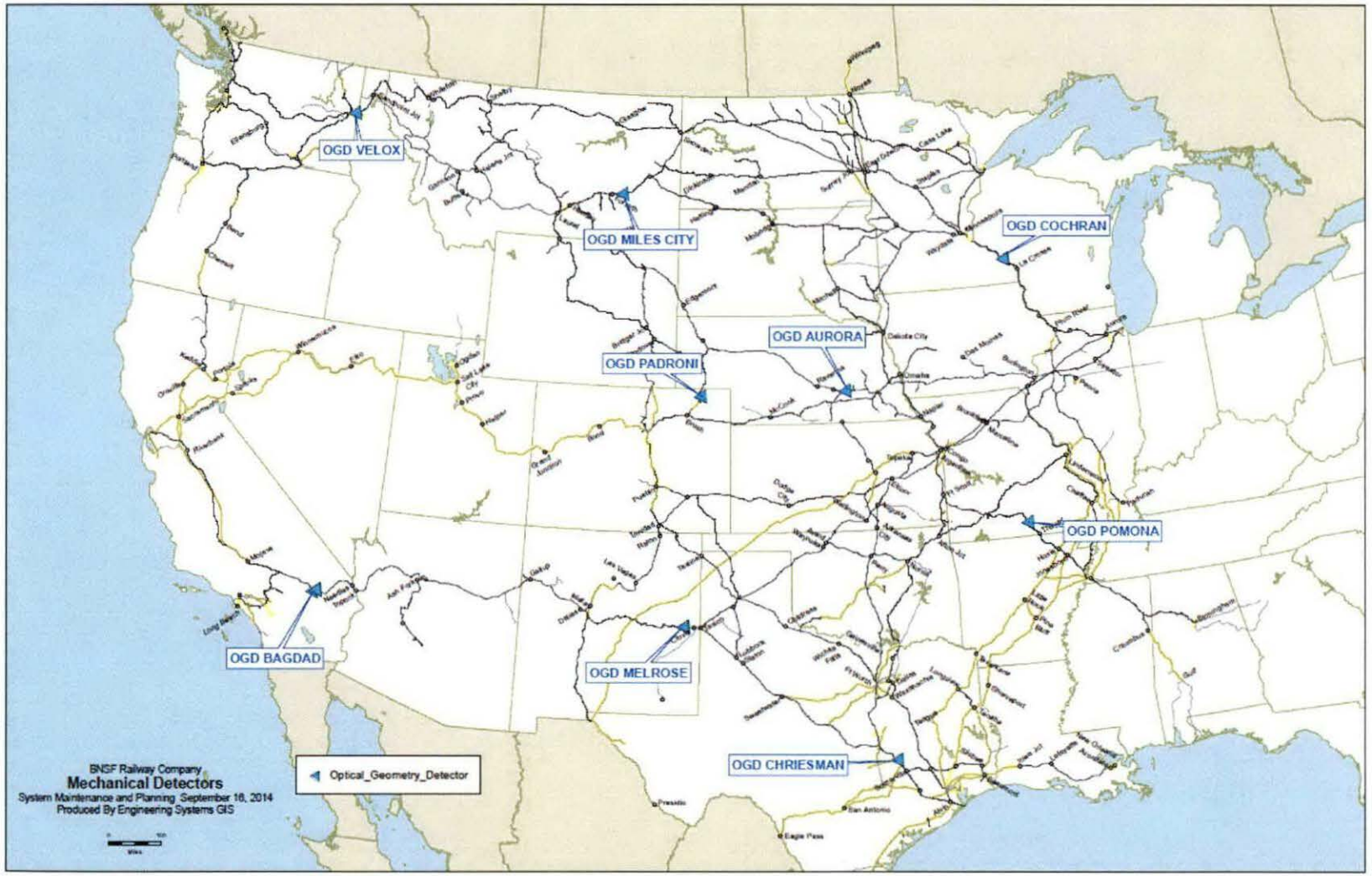
Tracking Error

AOA & distance measurement



Typical Findings
Differential flange wear
BO Adapter pad(s)
BO Friction wedges

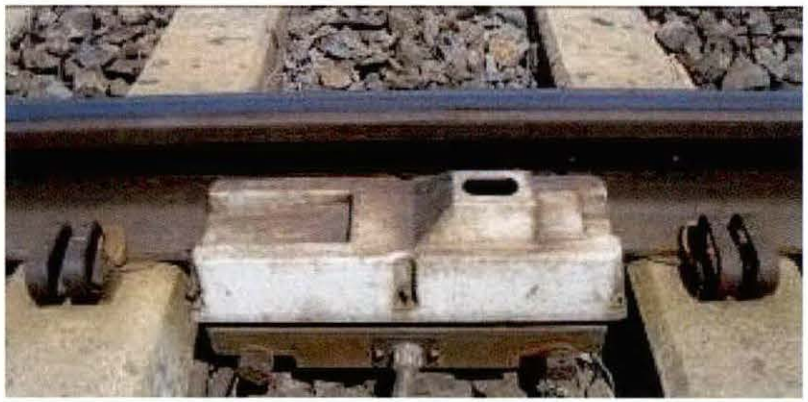
Optical Geometry Detector (OGD)



Warm Bearing (WBDS)

- Technology: Uses Hot Box Detector (HBD) Network to evaluate bearing temperature history for statistical outliers
- Targeted failure modes:
  - Burned off journals
  - Brake issues
- Current Sites: 886 HBDs on network

Hot Box Detector



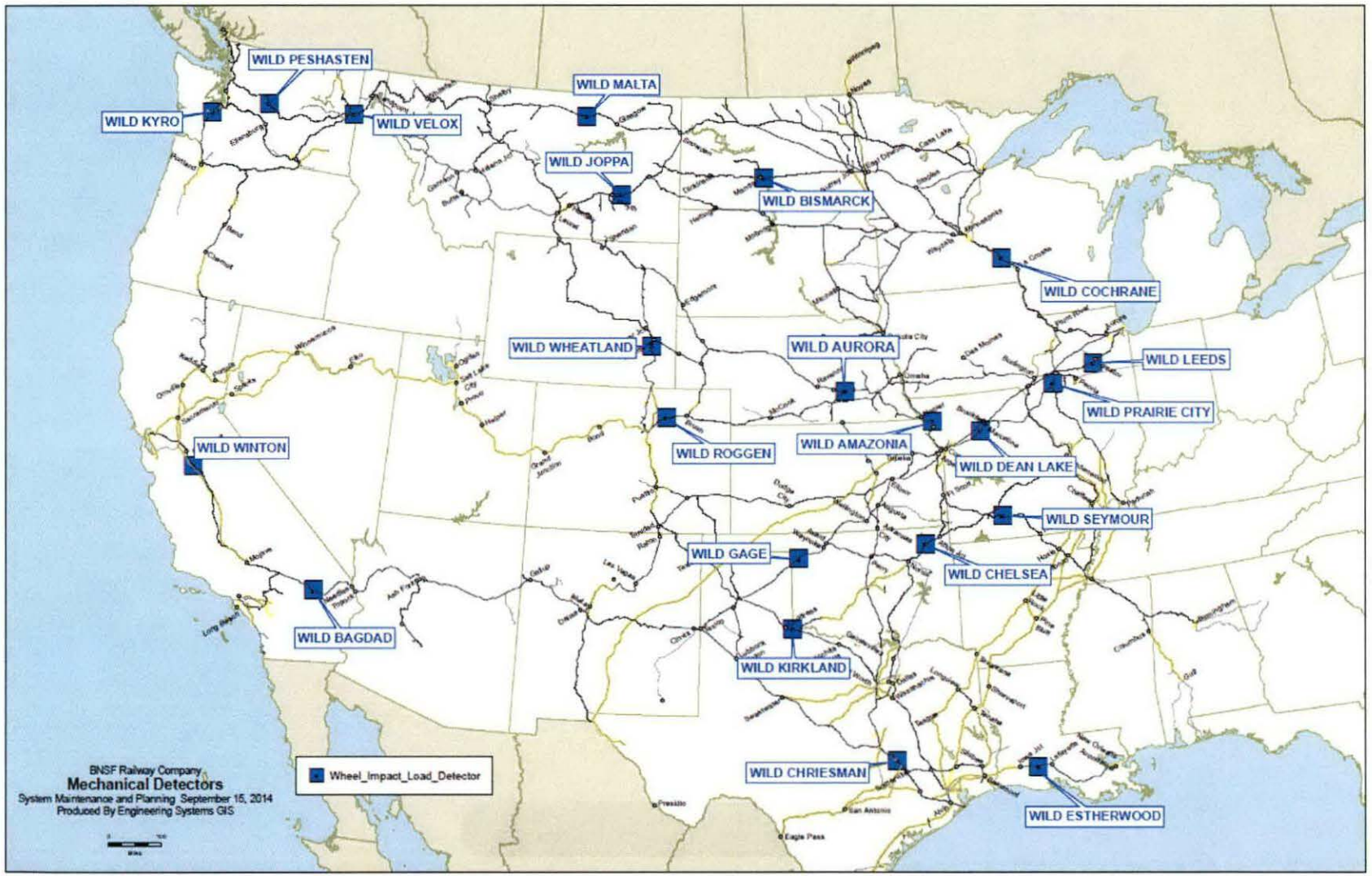
Warm Bearing Detectors (WBDS)

BNSF RAILWAY

Wheel Impact Load Detectors (WILD)

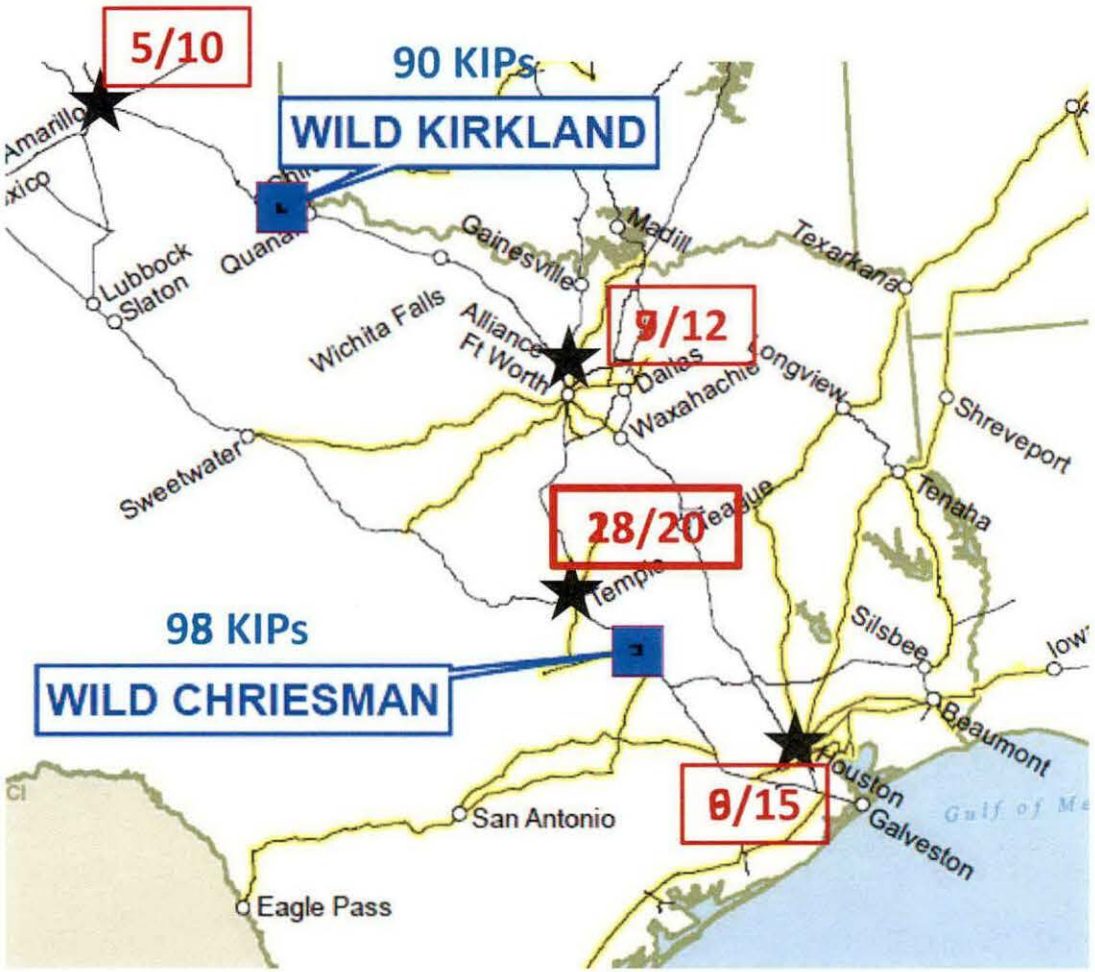
- Technology: Strain gauge based system used to evaluate vertical wheel forces on the rail
- Targeted failure modes:
  - Broken wheels and rails
  - Shelling and spalling
  - Flat spots and out of round
  - Broken bearing cages
- Current Sites: 22

WILD


WILD PESHASTEN
WILD KYRO
WILD VELOX
WILD MALTA
WILD JOPPA
WILD BISMARCK
WILD COCHRANE
WILD WHEATLAND
WILD AURORA
WILD LEEDS
WILD PRAIRIE CITY
WILD ROGGEN
WILD AMAZONIA
WILD DEAN LAKE
WILD WINTON
WILD SEYMOUR
WILD GAGE
WILD CHELSEA
WILD BAGDAD
WILD KIRKLAND
WILD CHRIESMAN
WILD ESTHERWOOD
BNSF Railway Company
Mechanical Detectors
System Maintenance and Planning September 15, 2014
Produced By Engineering Systems GIS
Wheel_Impact_Load_Detector

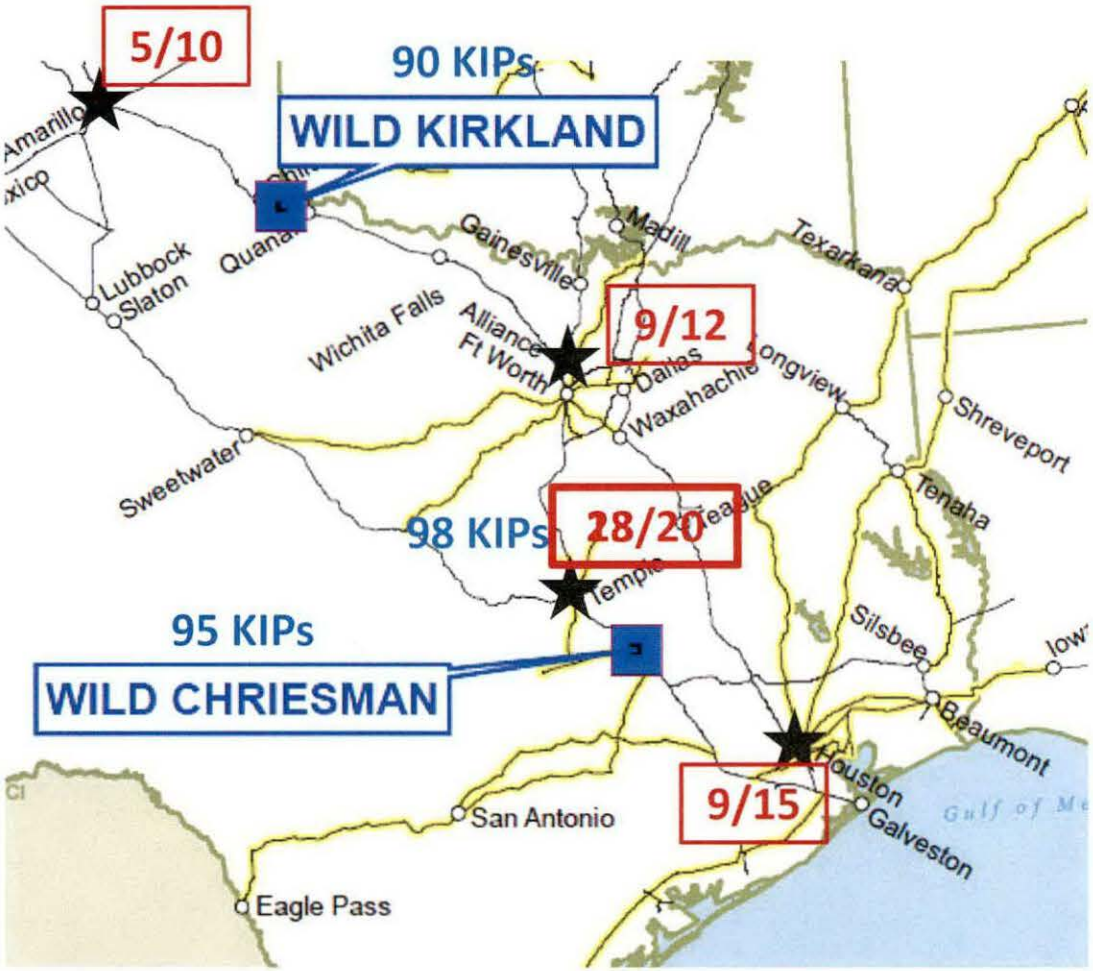
Traditional Model Limits / RIP Capacities

- Difficult to target one location
- Inequitable alarm levels



New Model Optimizes / RIP Capacities

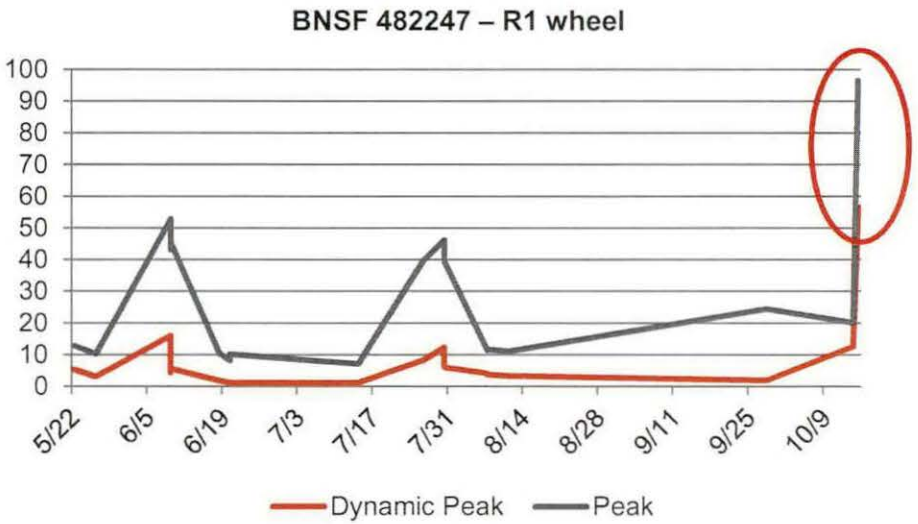
- RIP locations are assigned a KIP threshold
- Ability to affect single locations
- Maximizes system capacities



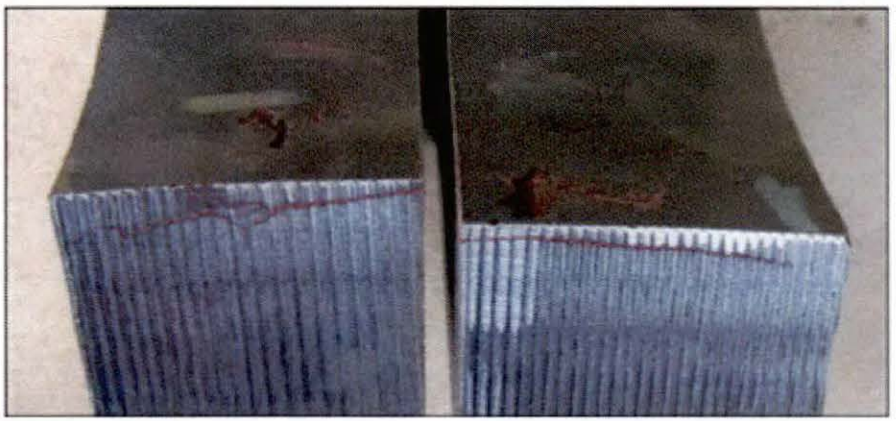
Prompt Jumps

Prompt Jump

- Manual algorithm run twice daily uses trending to identify wheels that have experienced a recent traumatic event
- Process currently being automated



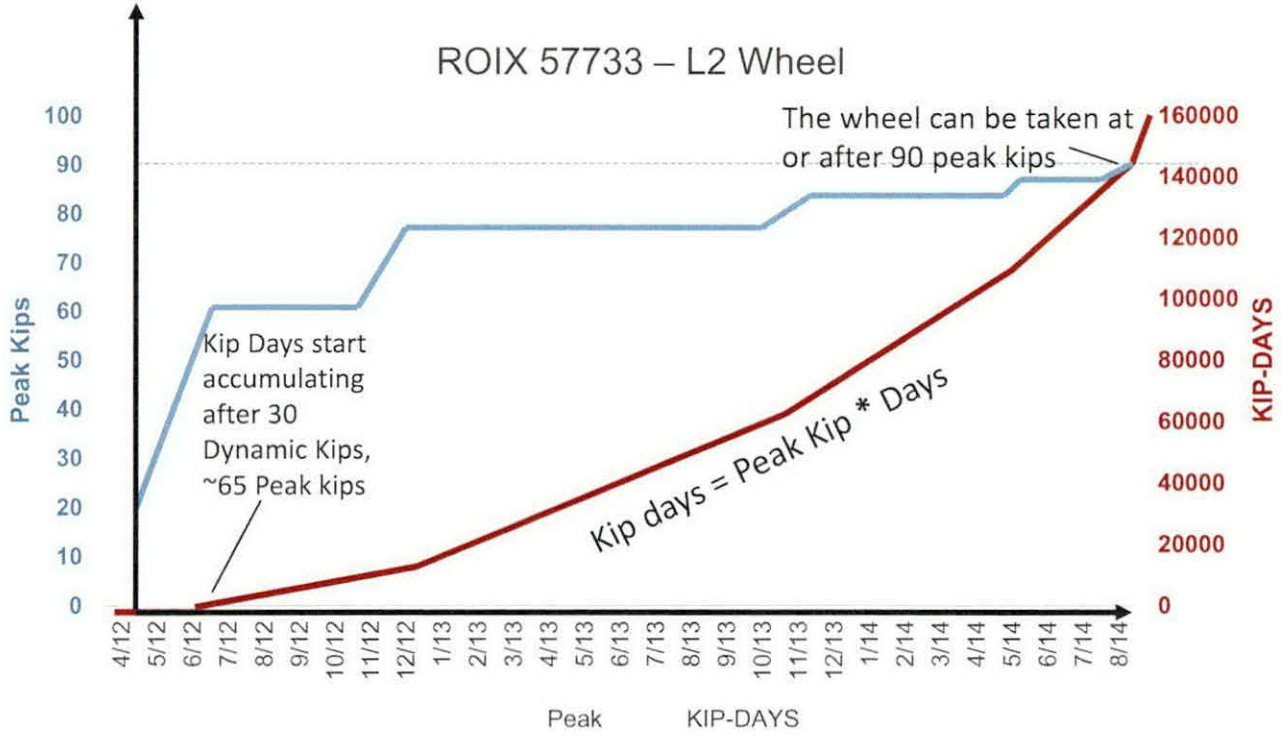
Subsurface fracturing and propagation



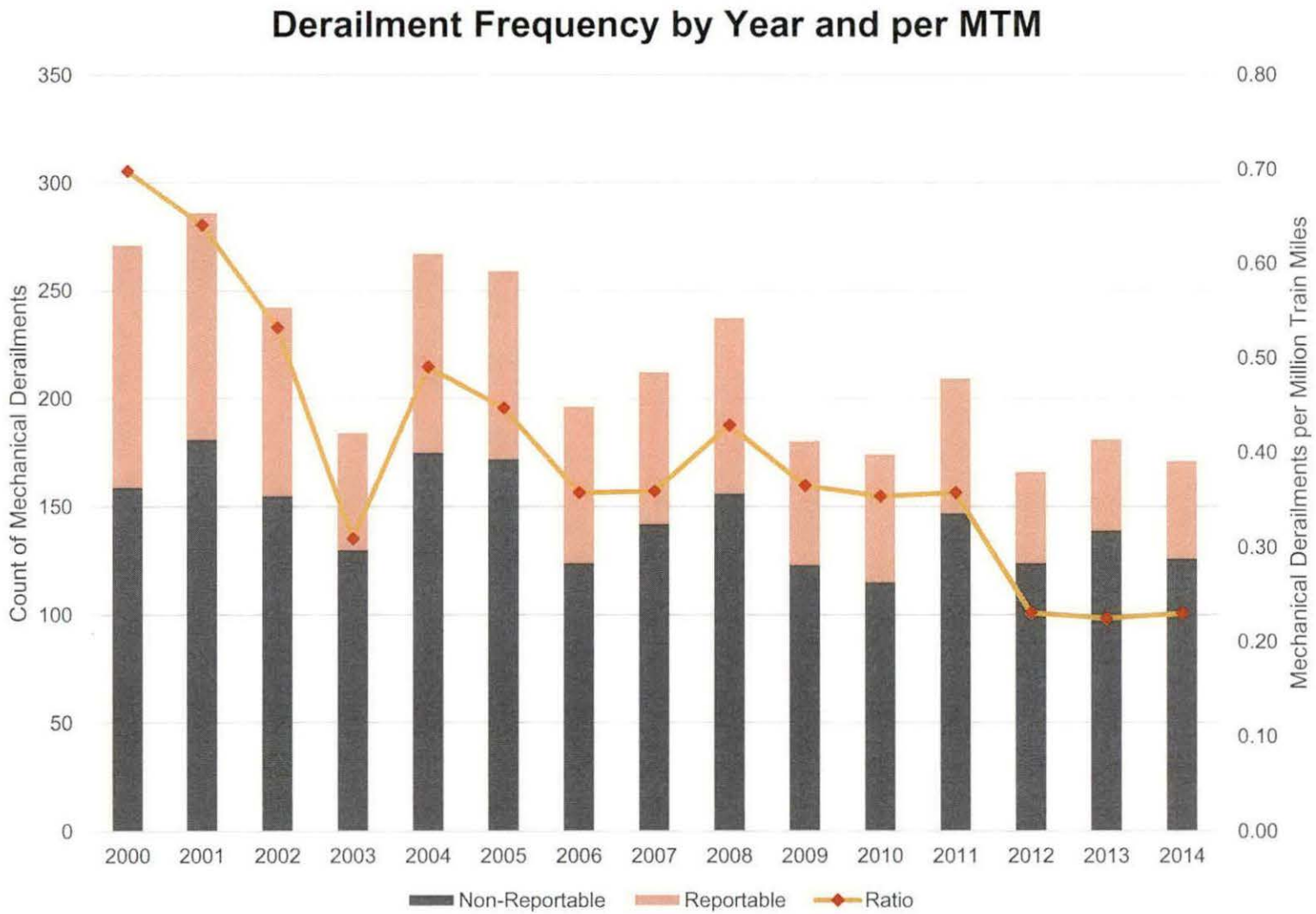
KIP-Day wheels

KIP-Days

Manual algorithm run twice daily identifies wheels with low level long term defects that negatively affect bearing life, wheel life and rail health



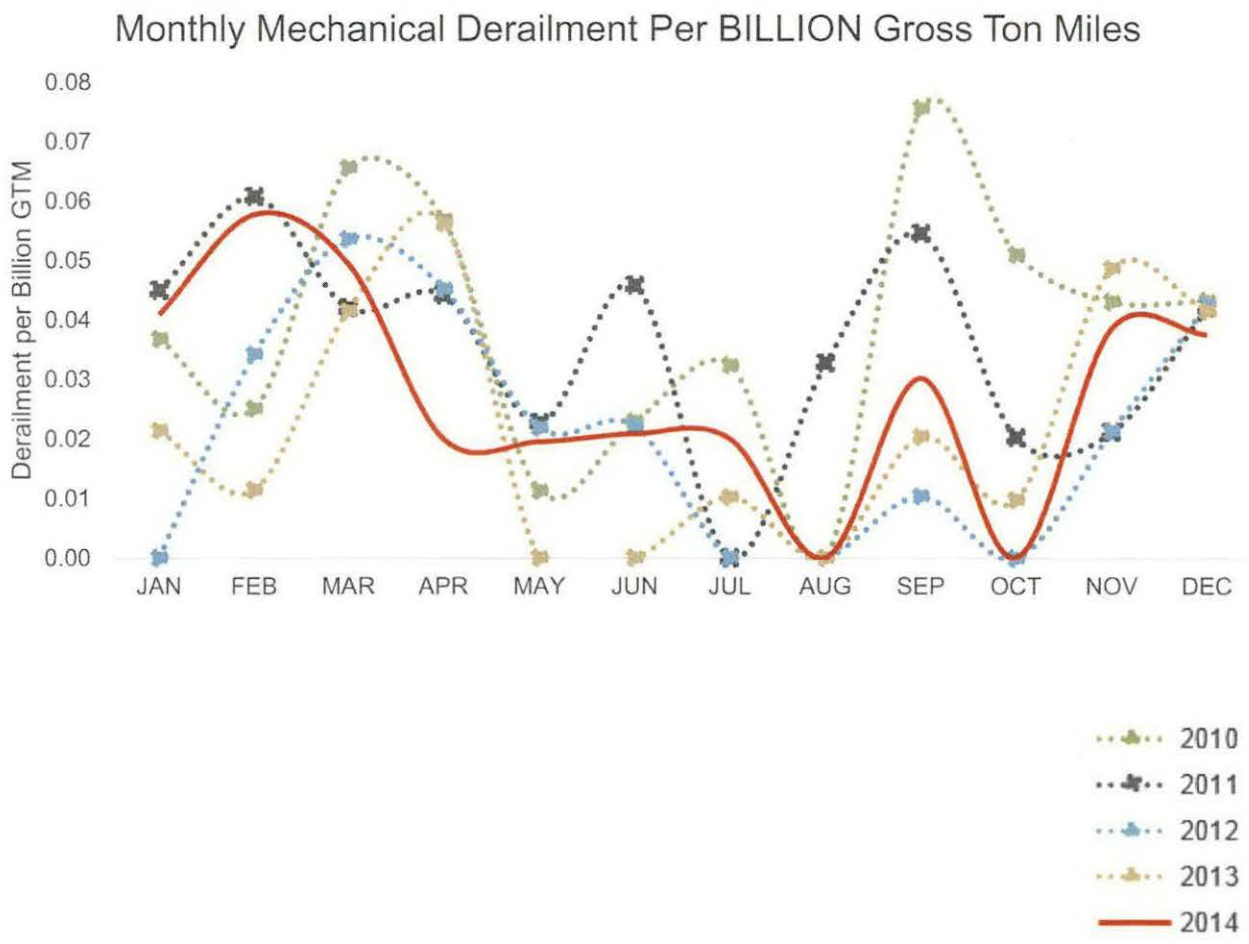
Mechanical Derailments 2000 - 2014



Source: Mechanical CBM

2010 - 2014 Derailment Comparison

Mechanical Mainline and Industry Derailments



There is a strong seasonal component to rail incidents. Every year there are more rail equipment incidents during winter.

Comparing 2010 through to 2014 the same trend is apparent.

BNSF RAILWAY

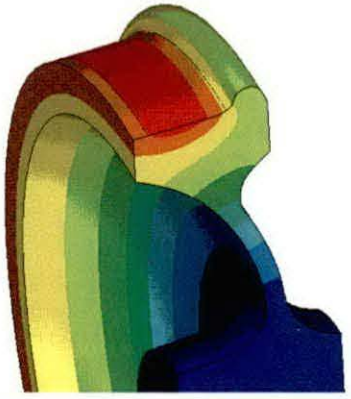
Wheel Defect Progression

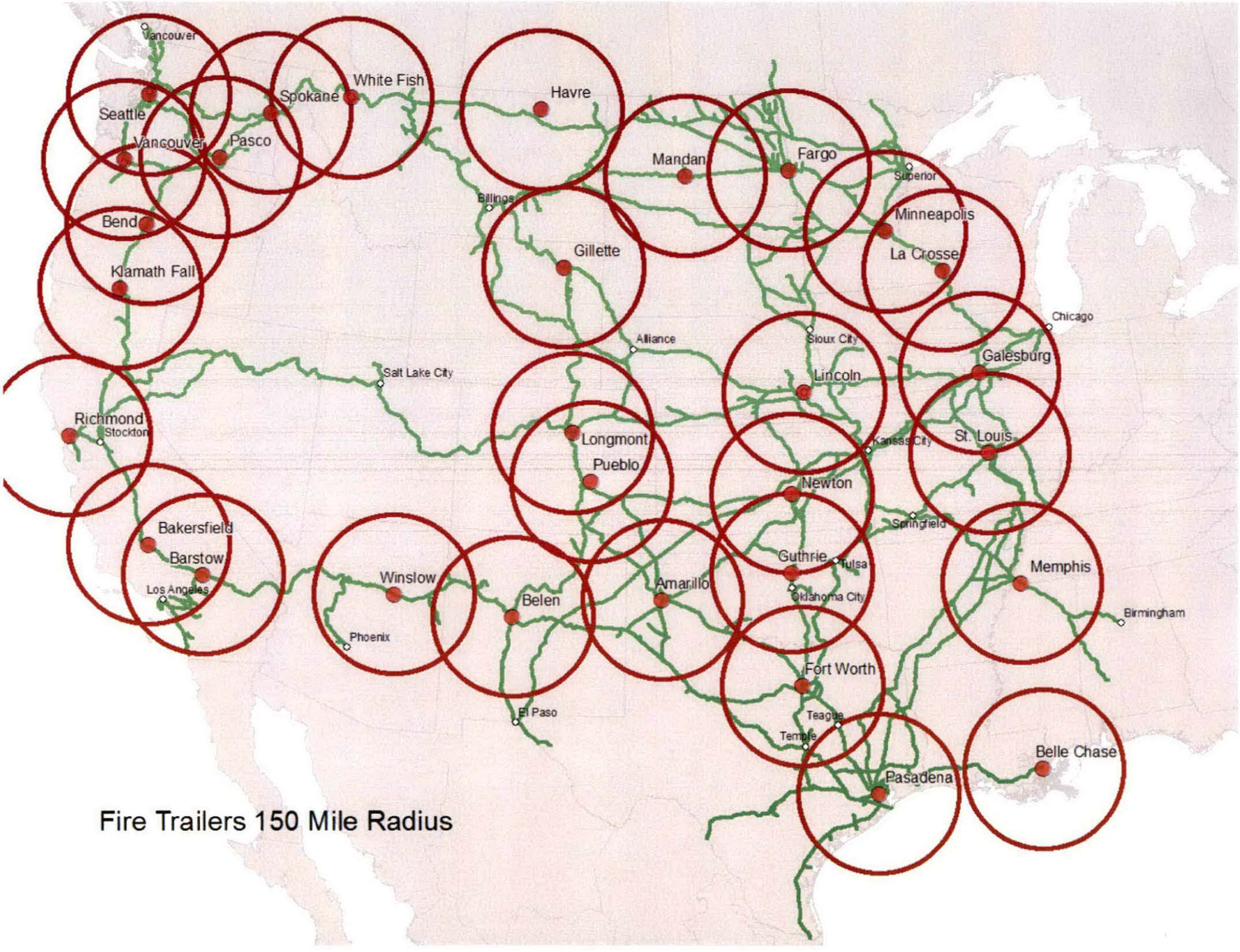
Hand brakes or air defects → **Hot Wheel alarms** → **WILD alarms**

- Proper air brake inspections
- Hand brakes left on
- Retainer valves in wrong position
- Wet and dirty yard and locomotive air
- Empty / load devices

- Algorithm identifies potential handbrakes left on
- NOC WB Desk contacts crew based on severity of alarm

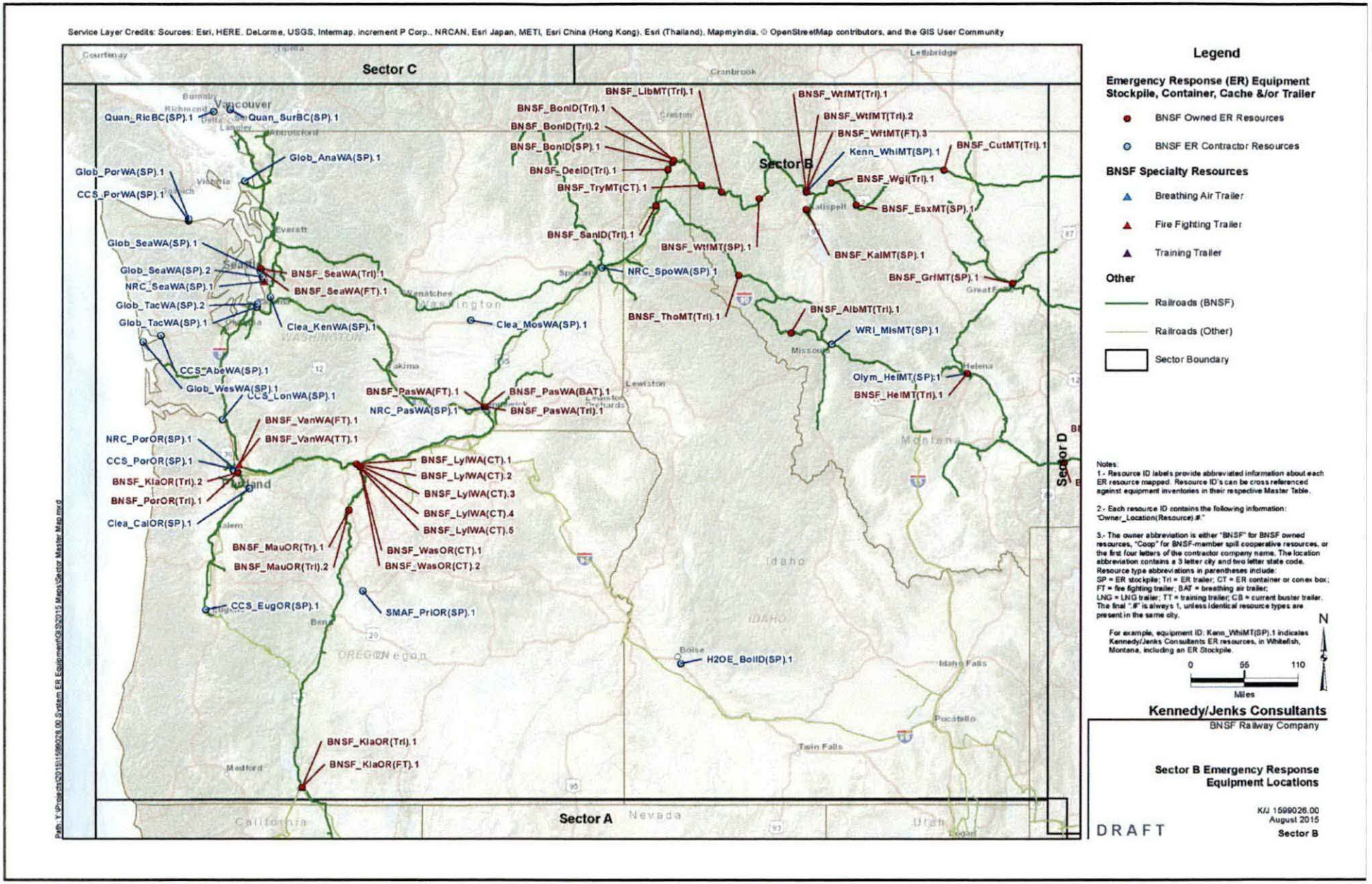
- **Level 1**
  - >140 KIPS
  - Identified for immediate setout
  - High risk for broken wheels or rail
- **Level 2**
  - >120 KIPS
  - Bad Ordered to nearest Mechanical Facility
- **Level 3**
  - > 90 KIPS
  - Bad ordered to destination
  - Detector thresholds optimized to not overrun locations yet minimize risk to infrastructure

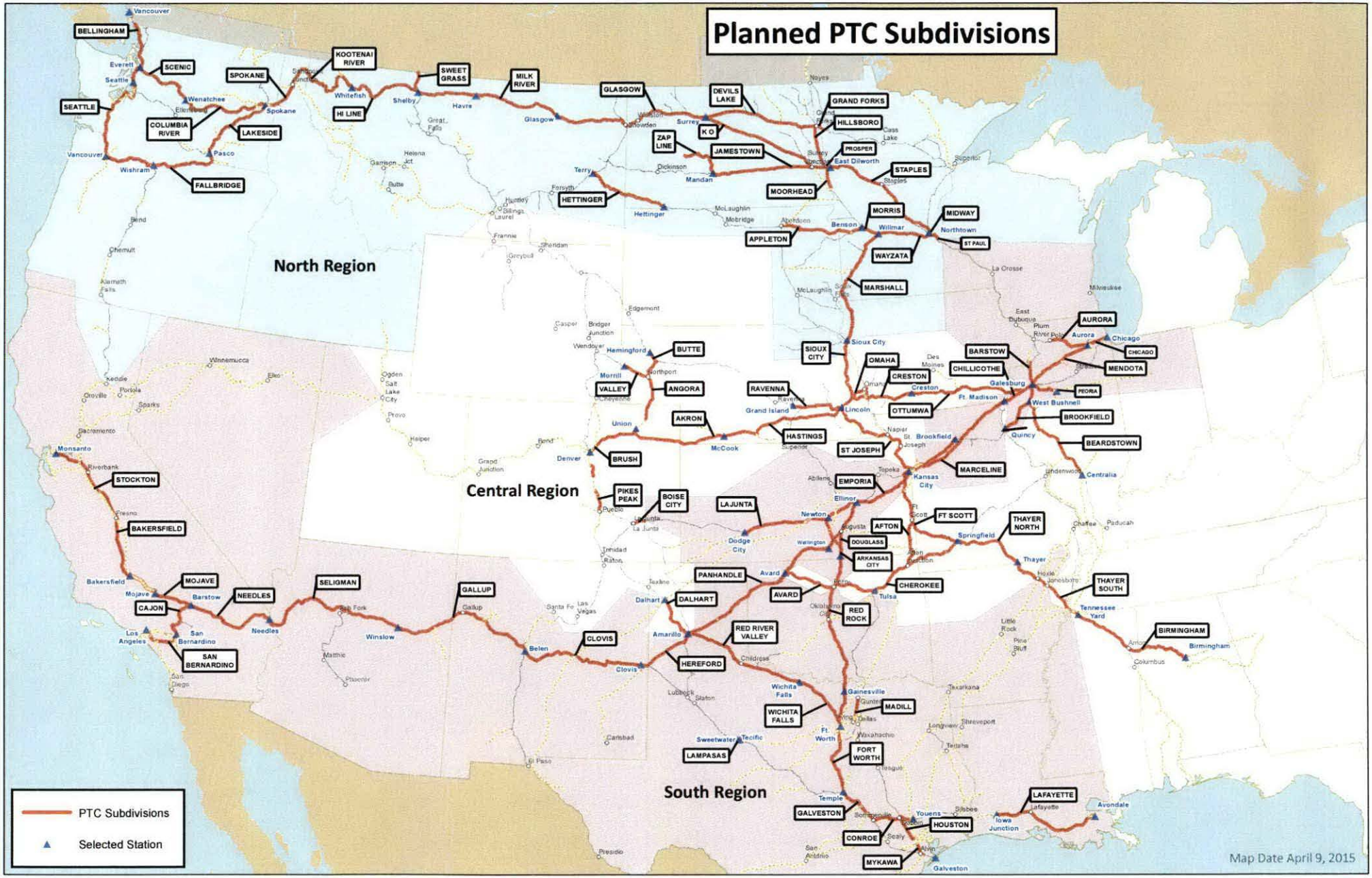




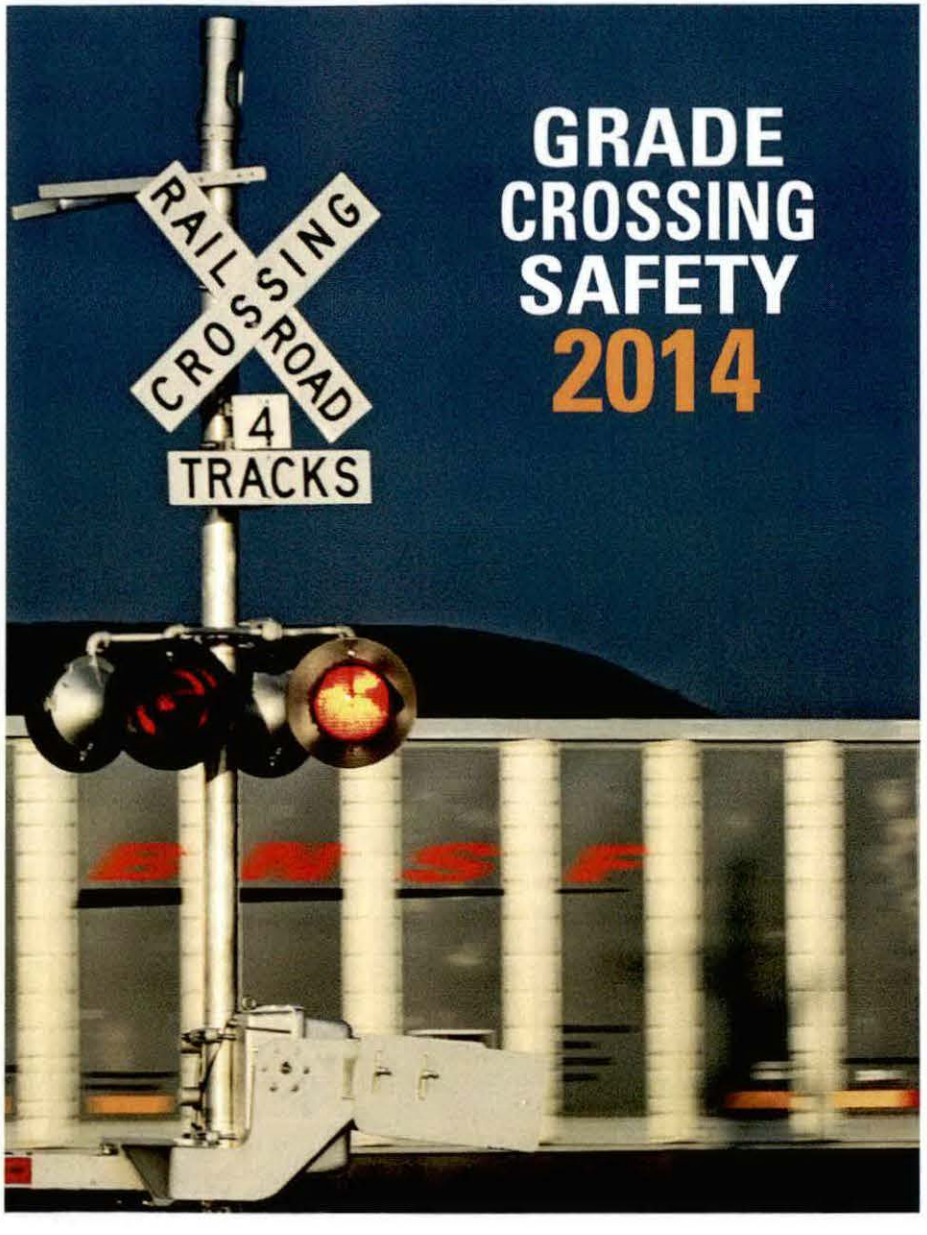
Fire Trailers 150 Mile Radius

PNW – Oil Spill Response Equipment Locations




Planned PTC Subdivisions
North Region
Central Region
South Region
BELLINGHAM
SCENIC
SEATTLE
COLUMBIA RIVER
SPOKANE
LAKESIDE
FALLBRIDGE
KOOTENAI RIVER
HI LINE
SWEET GRASS
MILK RIVER
GLASGOW
DEVILS LAKE
GRAND FORKS
HILLSBORO
K O
ZAP LINE
JAMESTOWN
PROSPER
STAPLES
MOORHEAD
HETTINGER
MORRIS
MIDWAY
APPLETON
WAYZATA
ST PAUL
MARSHALL
AURORA
CHICAGO
MENDOTA
BARSTOW
CHILLICOTHE
PEORIA
BROOKFIELD
BEARDSTOWN
BUTTE
SIOUX CITY
OMAHA
CRESTON
OTTUMWA
RAVENNA
ANGORA
VALLEY
AKRON
HASTINGS
ST JOSEPH
MARCELINE
BRUSH
PIKES PEAK
BOISE CITY
LAJUNTA
EMPORIA
FT SCOTT
THAYER NORTH
AFTON
DOUGLASS
ARKANSAS CITY
PANHANDLE
AVARD
CHEROKEE
THAYER SOUTH
DALHART
RED ROCK
BIRMINGHAM
RED RIVER VALLEY
HEREFORD
CLOVIS
GALLUP
SELIGMAN
NEEDLES
MOJAVE
CAJON
SAN BERNARDINO
STOCKTON
BAKERSFIELD
WICHITA FALLS
MADILL
LAMPASAS
FORT WORTH
GALVESTON
CONROE
MYKAWA
HOUSTON
LAFAYETTE
PTC Subdivisions
Selected Station
Map Date April 9, 2015

GRADE CROSSING SAFETY 2014



Overview of BNSF's Approach to Grade Crossing Safety

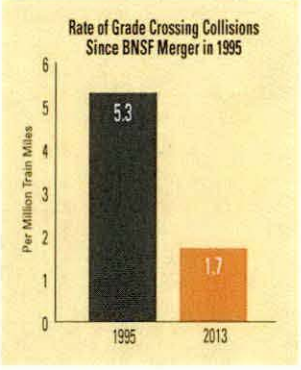
Highway-railroad grade crossing safety is an integral part of BNSF's operation and culture and involves the daily cooperative effort of many employees. Because oncoming trains cannot stop for vehicles whose drivers violate motor vehicle laws when approaching railroad tracks, each grade crossing presents possible danger to motorists and train crews. Recognizing this potential hazard, BNSF and BNSF employees are committed to grade crossing safety on many fronts, including the following:

- Community education and awareness
- Train crew education and field operations testing to monitor rules compliance
- Grade crossing closure
- Crossing safety technology
- Crossing resurfacing
- Vegetation control
- Installation of warning devices
- Track and signal inspection and maintenance

BNSF has one of the lowest highway-railroad grade crossing collision rates in the rail industry and, as an industry leader, will continue to work with the states and the communities we serve to further improve grade crossing safety.

General Information

- The United States has about 212,000 highway-railroad grade crossings, including just over 25,900 across BNSF's approximately 32,500 route-mile network.
- BNSF's highway-railroad grade crossings include approximately 17,200 public and 8,700 private and pedestrian at-grade crossings. In addition, BNSF has more than 3,700 public grade separations and 650 private and pedestrian grade separations.
- BNSF has one of the lowest highway-railroad grade crossing collision rates in the rail industry. Since BNSF's merger in 1995, the rate of grade crossing collisions has declined about 68 percent – from 5.3 per million train miles in 1995 to a rate of 1.7 in 2013.
- In 2012, 52 percent of the grade crossing collisions on BNSF occurred at crossings with active warning devices (automatic gates and/or flashing light signals).



- For the past several years, BNSF has averaged approximately $95 million annually on programs related to grade-crossing safety. BNSF expenditures include funding the educational and program activities of 17 grade crossing safety managers and 9 public projects managers, as well as crossing-signal maintenance and vegetation control. The amount spent on grade-crossing safety includes an annual average of approximately $20 million to maintain grade-crossing road surfaces.

Community Education/Law Enforcement/Awareness

Operation Lifesaver Program: In 2013, BNSF employees and operation Lifesaver volunteers presented more than 11,400 Operation Lifesaver (OL) classes on highway-railroad grade crossing safety in local communities. Many of the volunteers were trained by BNSF field safety managers, who are certified by OL to teach using the OL curriculum.

BNSF's program targets the highest risk populations: new drivers, adult drivers and professional drivers. Approximately 25 percent (2,899) of BNSF's OL courses were presented at drivers' education classes. More than 850 courses were conducted with truck and school bus drivers; more than 2,800 were offered to adult drivers; and 98 were conducted with emergency response personnel. The rest were held at elementary and junior high schools.

Officer on the Train: In 2013, BNSF conducted 55 Officer on the Train (OOT) exercises. This program gives local law enforcement the opportunity to observe motorist and pedestrian behavior from the cab of a locomotive or from the ground at a grade crossing in coordination with a BNSF train, to learn about grade crossing safety laws and get a sampling of compliance levels. Traffic citations or warnings are often issued as part of OOT exercises.

In addition, in 2013 BNSF participated in 210 positive enforcement efforts. This program places law enforcement officers near crossings to watch driver behavior. Motorists who obey grade crossing laws are stopped and thanked for their safe driving and rewarded with a small token of appreciation.

Roll Call: In BNSF's "Roll Call" program, 309 follow-up visits were conducted with patrol officers at law enforcement agencies to offer training or to reinforce prior training on the importance of enforcing grade crossing safety and trespassing laws.

Grade Crossing Collision Investigation: In 2013, BNSF participated in 119 Grade-Crossing Collision Investigation (GCCI) courses, which are four- to 16-hour courses offered as standard training at law enforcement academies. This program has been endorsed and certified by the National Sheriffs' Association and the International Association of Police Chiefs through OL and is now the standard for training nationwide.

Industrial Truck Driver Education Program: In 2013, BNSF offered over 860 truck driver education programs to trucking companies located along BNSF track. Primary targets included trucking companies that are BNSF customers, as well as trucking companies that haul commodities such as aggregate and gasoline over BNSF tracks.

Train Crew Education and Operations Testing: BNSF train crew employees receive extensive hands-on, performance-based training that covers safety and operating rules, air brake and train handling rules, and practice on locomotive simulators. This training, provided to newly hired employees as well as more seasoned employees as part of BNSF's recertification program, includes skills essential to grade crossing safety, such as a review of train whistle procedures and proper train speeds. This training is reinforced by frequent operations testing, as BNSF supervisors regularly monitor train operations to ensure all safety and operating rules are consistently followed.

Grade-Crossing Consolidation Programs

Grade-crossing Consolidation: One of the best ways to address grade crossing safety is to reduce the number of at-grade crossings. BNSF's grade crossing safety program includes an aggressive initiative to close public and private at-grade crossings, working closely with communities and property owners. Good candidates for closure include those that are redundant (other crossings nearby allow access to the same roads or areas), are not designated emergency routes, have low traffic volumes, or are private crossings that are no longer needed or used. Since 2000, BNSF has closed more than 5,750 at-grade crossings.

Private Crossing Permits Review: In 2013, about 13 percent of BNSF's grade crossing collisions occurred at private crossings. In response, BNSF is working to reduce the number of private grade crossings, especially those that are rarely used or redundant, and closely scrutinizes all requests for new private crossings. During 2012, there were 168 requests for private crossing permits. Only 25 new crossings were installed – and 22 of those were temporary for construction purposes.

Track and Signal Inspection and Maintenance

Track Inspection Programs: Key corridors on BNSF are inspected four times a week by BNSF track inspectors, and many heavily-traveled routes are inspected daily. These inspections include a review of condition of track and right-of-way as well as whistle posts, crossbucks and active warning devices. In addition, BNSF train crews are instructed to report any signal and crossing warning malfunctions immediately to BNSF's Network Operations Center (NOC) in Fort Worth. This program includes "power-on" lights at active warning devices that indicate a working power supply to the lights and gates.

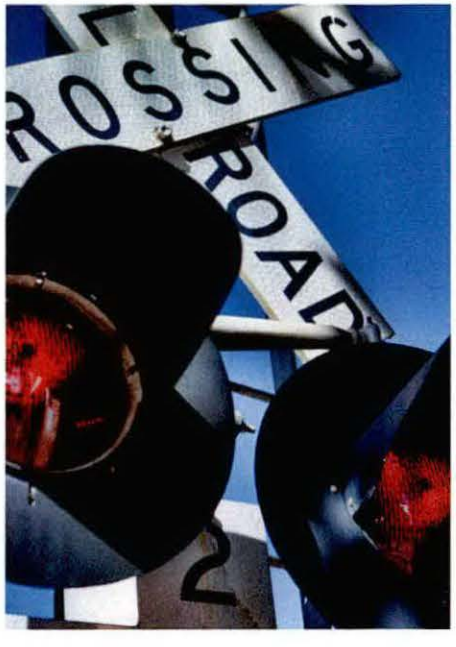
Grade Crossing Warning Inspection and Maintenance: BNSF is responsible for maintenance of active warning devices and spends an average of $45 million annually on grade crossing signal maintenance and repair. Each of the active warning devices is thoroughly inspected monthly by BNSF signal employees. This inspection includes a review of functionality of gates and lights and of battery back-up power sources

Vegetation Control

Vegetation Treatment and Brush Control: As much as practical, BNSF's goal is to reduce vegetation and other obstructions on its right-of-way that would materially interfere with motorists' ability to see approaching train traffic. In 2013, BNSF treated more than 38,000 acres along its right-of-way with herbicides to prevent growth of new vegetation at railroad crossings.

Crossing Safety Technology and Management Processes

Crossing Surveillance Systems: BNSF cooperated with various cities across the system to test surveillance systems that digitally record drivers who violate highway-rail grade crossing laws. Drivers receive correspondence advising them that they were observed behaving unsafely.



1-800 Number Signs: BNSF has posted an emergency contact number at all public grade crossings for the public's use in contacting BNSF's 24-hour Resource Operations Center with concerns regarding crossings or related questions (800-832-5452). These signs allow motorists who become stalled or in any way obstruct railroad tracks to call a number and simply provide the information on the sign. This information includes the Department of Transportation (DOT) identification number that pinpoints their location for BNSF's dispatching center and allows us to warn or stop trains in the affected area.

Other Technologies: BNSF continues to investigate new technologies that enter the marketplace related to highway-rail grade crossing safety. Examples are four quadrant gates, extended cantilever arms, median barriers, barrier gates, stationary horns and instantaneous reporting of active warning device failures via cellular technology.

Operations Monitoring Programs

Reports of Unsafe Motorists/Trespassers: As part of BNSF's unsafe motorist and trespasser program, train crews and other field employees submitted over 740 reports in 2013 of trespassers or drivers who violated grade crossing safety laws. The information is provided to state highway department personnel for consideration in preparing their grade crossing priority index to determine the possible need for traffic control devices, as part of the Federal Highway-Rail Grade Crossing and Trespasser Prevention Program. BNSF also uses this data to identify problem areas, respond with educational training and seek assistance from local law enforcement authorities.

Federal/Railroad Grade Crossing Safety Program

Federal and State Processes for Upgrading Crossing Signals: Each state determines the location and types of rail-highway grade-crossing signals to be installed, under a federal program. Crossing signals are defined by the Federal Highway Administration as highway control devices, not railroad signals.

Each state receives an allocation of federal safety funds and develops a priority list of crossings each year for grade-crossing improvements. The formula used to generate this list varies from state to state and typically includes elements such as train speed, train volume, average daily traffic and accident history.

Once a state determines which crossings are to be upgraded, it contacts the railroad to begin the "diagnostic" process. The railroad designs the circuitry for each crossing and estimates the cost. Once the state reviews and approves the estimate, the state issues an agreement to the railroad to install the specified signals. BNSF participated in more than 180 diagnostic projects in 2013.

Federal funds pay about 90 percent of the cost of a signal installation and the local government jurisdiction — city, county, etc. — pays the other 10 percent. The railroad maintains the signals from that time forward. These maintenance costs usually equal the cost of the initial installation in about 10 years. The railroad cannot, on its own, install crossing signals. It is required to get state permission.

FRA Locomotive Horn Rule: In 2005, in response to a Congressional mandate, the Federal Railroad Administration (FRA) issued a Final Rule on the Use of Locomotive Horns at Highway-/Rail Grade Crossings. Under the new rule, local governments may establish quiet zones or continue existing quiet zones, if they are willing to take remedial steps to address risk, based on a calculation of potential risk at the crossing. In many cases, the rule makes these designations subject to FRA review, approval and ongoing oversight.

These remedial steps can include crossing closure, grade separation, full-width crossing gates with an approved median divider, full-width gates and lights at crossings on a one-way street, temporary closure (for nighttime quiet zones only) or four quadrant gates. The rule also allows for an automated horn system at the crossing as a substitute for the train horn, if this provision is approved by the Federal Highway Administration. Certain Alternative Safety Measures (ASMs) are also described.

BNSF works with communities who wish to establish quiet zones and regularly reviews their quiet zone applications to the FRA. Community leaders who have questions about the proposed rule or about BNSF's role in implementing that rule should contact Mr. French Thompson, director Public Projects, who can be reached at french.thompson@bnsf.com.

ATTACHMENT A