ASTM C29 test procedure was used for finding porosity or air voids with the known values of the specific gravity and box volume and the weight of ballast compacted.

For the coal dust fouling case, 25% coal dust by weight of aggregate was found to completely fill in the voids of the clean granite thus referred to here as "fully coal dust fouled" condition after sample preparation. Similarly, 32% clay by weight of aggregate and 40% mineral filler by weight of aggregate were observed to completely fill in the same void space of the clean granite for the clay and mineral filler fully fouled conditions, respectively.

Direct Shear Test Results

The ballast samples were sheared horizontally in the shear box under target normal pressures of 172, 241, 310 kPa (25, 35, 45 psi), typical ballast layer confining pressures, so that the relationships between the normal stress and shear stress could be established. The maximum shear stress at failure under each applied normal pressure was recorded from each test. This maximum shear stress typically occurred when approximately 10% shear strain was reached during testing. The shear strength $\tau_{max} = C + \sigma_n * \tan\Phi$ (where C is the cohesion intercept, σ_n is the applied normal stress, and Φ is the internal friction angle) expression was then developed for each ballast sample tested at a corresponding fouling fines content and moisture state.

Figure 7 shows the maximum shear stresses predicted under the applied normal stresses during shear box testing for coal dust fouling cases in comparison to the clean granite test results. As the applied normal stresses increased, the maximum shear stresses at failure or simply shear strength τ_{max} also increased primarily influenced by the ballast fouling percentage and the moisture condition of the coal dust, i.e., dry or wet at OMC = 35%. As expected, the highest shear strength values were obtained from the clean ballast at all applied normal stress levels. When ballast samples were fouled, the shear strengths typically decreased. For all the samples tested, wet coal dust fouling resulted in lower shear strengths when compared to those obtained from dry coal dust fouling. The lowest shear strength values were recorded for the fouling level of 25% by weight (fully fouled) of ballast when wet coal dust was at 35% moisture content.

Figure 8 shows the maximum shear stresses predicted under the applied normal stresses during shear box testing for clay fouling cases in comparison to the clean granite test results. Limited data were obtained due to the difficulties encountered during sample preparation especially for wet clay fouled cases. According to the test results the clean ballast sample still gave the highest strength. With clay being the fouling agent, the trend of decreasing strength with increasing fouling percentage could not be observed as clearly as in the case of coal dust fouling. In the clay fouling cases, the cohesion intercept (C) in the strength equation increased and the friction angle (Φ) typically decreased with the increasing fouling percentage, which made shear strength of samples less sensitive to varying normal stresses and confining pressures as expected. This effect was even more significant in the wet clay fouling cases, since wet clay served as a lubricant with overall much lower friction angles (Φ) obtained compared to that of the clean granite sample. It however still makes sense since the cohesion increased because of the clay paste in the voids supplies some bonding strength whereas the friction angle decreased because of the lubricating effect of clay paste within the aggregate-aggregate contact.

Figure 9 shows the maximum shear stresses predicted under the applied normal stresses during shear box testing for mineral filler fouling cases in comparison to the clean granite test results. In the dry case, results showed very similar trend to clay fouled case. Once again, the clean ballast sample gave the highest shear strength. In the dry fouling cases, the cohesion intercept C in the strength equation increased and the friction angle Φ typically decreased with the increasing fouling percentage, similar to the general trend observed for clay fouled samples. However, for the wet mineral filler tests at only 11% OMC, samples at all fouling levels behaved very close to dry conditions with the data points almost falling in the same line thus indicating that mineral filler as a fouling agent is not as sensitive to moisture as the cohesive clay.

Figure 10 compares under wet conditions the maximum shear stresses obtained from the clean granite with those of the coal dust, clay, and mineral filler fouled samples at 5%, 15%, and 25% by weight of ballast. Note that for the 25% clay fouled samples, clay moisture content was at the Liquid Limit (LL) of 37% instead of OMC, which is very close to 35% OMC of the coal dust fouled samples. Yet, the wet coal dust sample fouled at 25% gave the worst case scenario with the lowest shear stress values (biggest drop in Figure 11) among all the samples tested. Then came the wet mineral filler fouled at 25% by weight of ballast and the wet clay fouled at 15% by weight of ballast, as indicated with the dashed lines in Figure 10. This implies that railroad ballast layers fouled with coal dust contamination are at much higher risk of causing track instability and failures especially after heavy precipitation when compared to ballasts fouled due to mineral filler accumulation from aggregate breakdown or even cohesive subgrade soil intrusion.

Since the coal dust fouling was found to be the most detrimental case, a statistical analysis was performed for the significance of the different coal dust levels affecting the critical stages of ballast fouling. As described early in this paper, it is important to determine at what fouling level a significant drop in strength would be realized. In another word, there is a need to determine the reasonable dividing line between Phase I and II. For this purpose, an "F test" type statistical approach was used to evaluate the differences between the strength lines graphed in Figure 7. With a value of significance (p-value) of 0.0014 (much less than 0.05), 15% coal dust fouling was found to significantly decrease the strength of ballast. As all other strength lines in Figure 7 are below the 15% dry coal dust fouling line, 15% coal dust by weight is considered to be the critical stage of coal dust fouling in terms of ballast shear strength.

Table 2 lists cohesion intercepts (C) and friction angles (Φ) obtained from the ballast testing program. High correlation coefficients, R^2 values, were typically obtained for the established shear strength equations except for two mineral filler samples. The clean granite typically had the highest friction angle Φ of 46.6 degrees except for 47.7 degrees obtained for the low 5% dry mineral filler sample. For the case of 25% wet coal dust fouling, the friction angle computed is as low as 34.5 degrees. This value is very close to the friction angle of 33.5 degrees, obtained from a parallel research study (*11*), for the pure coal dust direct shear samples tested at OMC. Similarly, a low cohesion intercept of 35 kPa (5.1 psi) is close to the very low unconfined compressive strength of 24 kPa (3.5 psi) also obtained for the coal dust shear strength properties (*11*). This implies that the shearing action for the 25% coal dust fouled sample was mainly resisted in the direct shear apparatus by the wet coal dust governing the behavior. Again, one should note that 35% OMC condition does not represent fully saturated coal dust state. After soaking or 100% saturation, soil suction would be destroyed thus resulting in even lower strengths and unstable ballast conditions.

Table 2 also lists for direct comparison purposes the shear strength values computed under normal stress levels of 200 and 300 kPa (29.0 and 43.5 psi), typical field railroad ballast stress conditions experienced. Most of the trends already mentioned and their effects can be clearly seen by comparing the computed shear strength values. In the case of mineral filler fouled ballast, strength values from both dry and wet tests were very close which may suggest that the 11% optimum moisture had a minor effect on mineral filler fouling. On the other hand, the clay fouled ballast samples at OMC give higher strength values than the dry clay fouled samples, which implies that clayey soils at OMC have higher shear strength properties. Since most geomaterials compacted at OMC usually give the best mechanical properties, future research will need to also investigate fouled ballast behavior when moisture content increases beyond optimum conditions.

SUMMARY AND CONCLUSIONS

Large-sized shear box direct shear laboratory tests were conducted at the University of Illinois on granite ballast samples obtained from the Powder River Basin (PRB) joint line in Wyoming to measure strength and deformation characteristics of both clean (new) and fouled ballast aggregates with three different fouling agents, i.e., coal dust also obtained from the PRB joint line, plastic clay, and nonplastic mineral filler from crushing of the same granite aggregate, at various stages of fouling. The grain size distribution of the aggregate conformed to the typical AREMA No. 24 ballast gradation with a maximum size (D_{max}) of 63.5 mm (2.5 in.) and a minimum size (D_{min}) of 25.4 mm (1 in.). Each fouling material was mixed with clean aggregates for achieving fouling levels of 5%, 15%, 25%, and sometimes up to 40% by weight of ballast under dry and wet, mostly optimum moisture content (OMC), conditions. The coal dust material was spread on the clean aggregate specimen and vibrated on top to achieve its percolation into the voids in an effort to realistically simulate coal dust falling off the trains into the ballast layer in the field. The plastic refractory clay and the mineral filler were mixed with granite aggregates by means of different sample preparation techniques again to simulate realistic field fouling scenarios of subgrade intrusion and aggregate breakdown, respectively.

From the direct shear tests, the highest shear strength values were obtained from the clean ballast samples at all applied normal stress levels, which were representative of typical stress states experienced in the ballast layer under train loading. When ballast samples were fouled, the shear strengths always decreased. This was mostly apparent with lower friction angles and cohesion intercepts. Wet fouling generally resulted in lower ballast shear strengths when compared to those obtained from dry coal dust fouling. Primarily due to increasing cohesive nature, i.e., cohesion intercepts, with increasing fouling percentages, plastic refractory clay fouled samples exhibited slight shear strength increases under both dry and wet conditions. However, samples fouled with mineral filler at 5%, 15%, and 25% were somewhat insensitive to the low 11% moisture content increase from the dry condition and resulted in similar shear strength values.

Coal dust was by far the worst fouling agent for its impact on track substructure and roadbed and caused the most drastic shear strength decreases especially at high fouling levels. Through statistical evaluation, 15% dry coal dust fouling by weight of ballast was shown to be significant to cause critical fouling and decrease considerably the ballast strength. For the case of 25% wet coal dust fouling by weight of ballast, the lowest shear strength properties, internal friction angle and cohesion, obtained were equivalent to those properties of the coal dust itself at 35% OMC. Note that even more drastic strength reductions can be realized when dry coal dust, never been saturated or soaked in the field and therefore having a high suction potential, is subjected to inundation and 100% saturation.

It is still difficult to make unique conclusions on ballast fouling due to the differences between laboratory and field conditions and difficulties in sample preparation process. This study is a first step of trying to better understand fouling mechanism and its effect to the ballast strength and stability. Further studies as well as different methods of investigations are needed to fully understand ballast fouling.

ACKNOWLEDGEMENTS

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LIST OF TABLES

LIST OF FIGURES

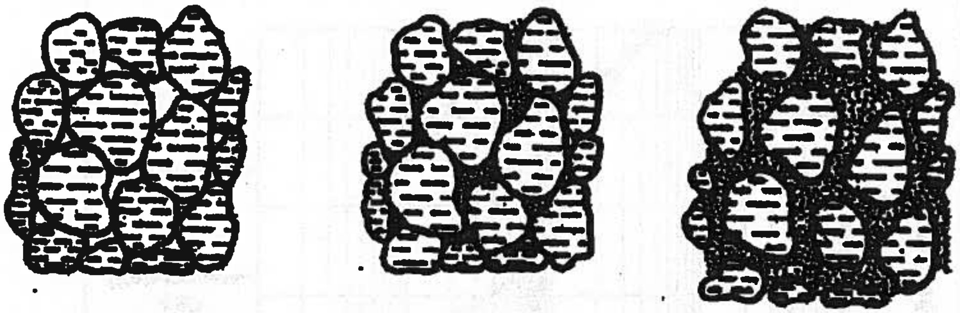
TABLE 1 Engineering Properties of the Selected Fouling Materials

	Specific Gravity	Liquid Limit (%)	Plastic Limit (%)	Optimum Moisture Content or OMC[2] (%)	Maximum Dry Density[2] (kg/m^3)	Passing 0.075 mm or No. 200 sieve (%)
Coal Dust	1.28	91	50	35	874	24
Refractory Clay	2.60	37	19	16	1,806	64
Mineral Filler	2.62	NP[1]	NP[1]	11	2,193	8

[1]: Nonplastic; [2]: Obtained from standard Proctor ASTM D 698 test procedure.

TABLE 2 Shear Box Direct Shear Strength Test Results

Fouling Agent	Percentage by Weight of Clean Ballast (%)	Moisture Condition (see Table 1)	$\tau_{max} = C + \sigma_n * \tan\Phi$		Correlation Coefficient, R^2	Shear Strength τ_{max} (kPa)	
			Cohesion "C" (kPa)	Friction Angle (Φ)		200 kPa Normal Stress	300 kPa Normal Stress
Clean	0	Dry	72	46.6	0.96	283	389
Coal Dust	5	Dry	80	44.4	0.99	276	374
	15	Dry	93	36.2	0.99	239	312
	25	Dry	75	36.6	0.98	224	298
	5	OMC	61	44.7	0.99	259	359
	15	OMC	77	37.7	0.99	231	309
	25	OMC	35	34.5	0.97	173	242
Clay	5	Dry	44	40.5	0.99	215	300
	15	Dry	131	31.2	0.99	252	313
	25	Dry	59	39.5	0.99	224	307
	32	Dry	114	33.7	0.97	247	314
	5	OMC	61	44.1	0.95	255	352
	15	OMC	85	38.0	0.99	241	319
	25	LL	144	36.1	0.98	290	363
Mineral Filler	5	Dry	0	47.7	0.99	195	305
	15	Dry	41	41.6	0.93	219	308
	25	Dry	94	34.6	0.85	232	301
	40	Dry	116	35.7	0.71	260	332
	5	OMC	40	42.6	0.98	224	316
	15	OMC	26	43.4	0.97	215	309
	25	OMC	66	38.0	0.98	222	300



(a) Clean ballast (Phase I) (b) Partially fouled ballast (Phase II) (c) heavily fouled ballast (phase III)

FIGURE 1 Critical ballast fouling phases

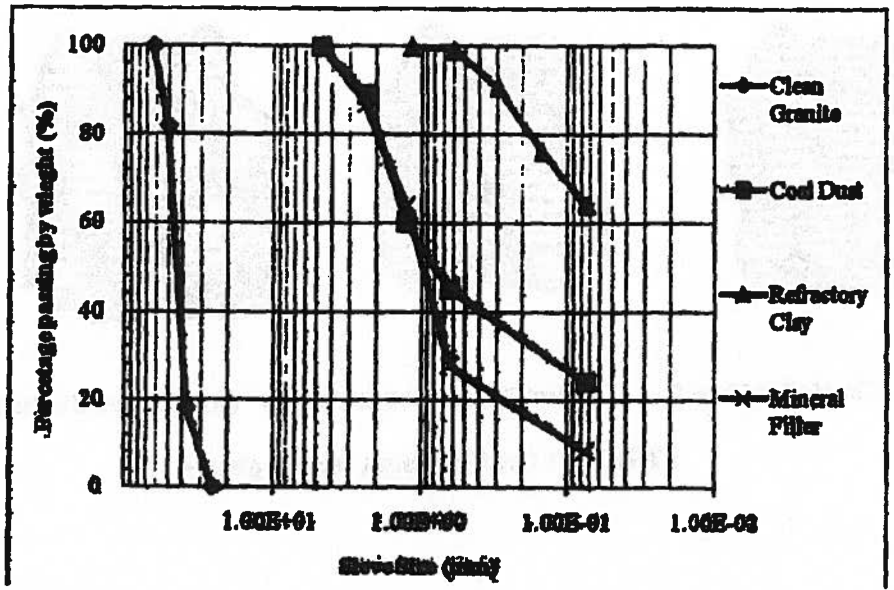


FIGURE 2 Grain size distributions of the clean ballast and fouling materials

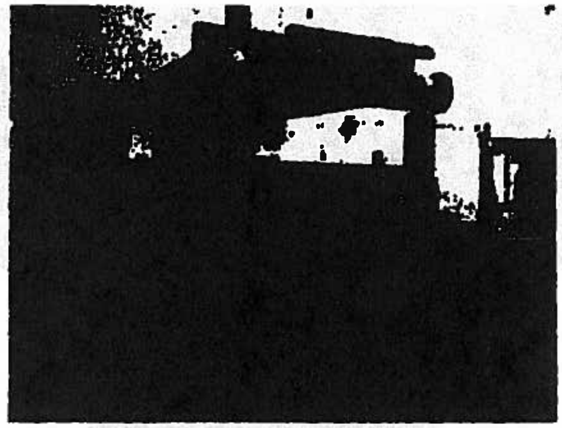


FIGURE 3 The direct shear strength test equipment at the University of Illinois

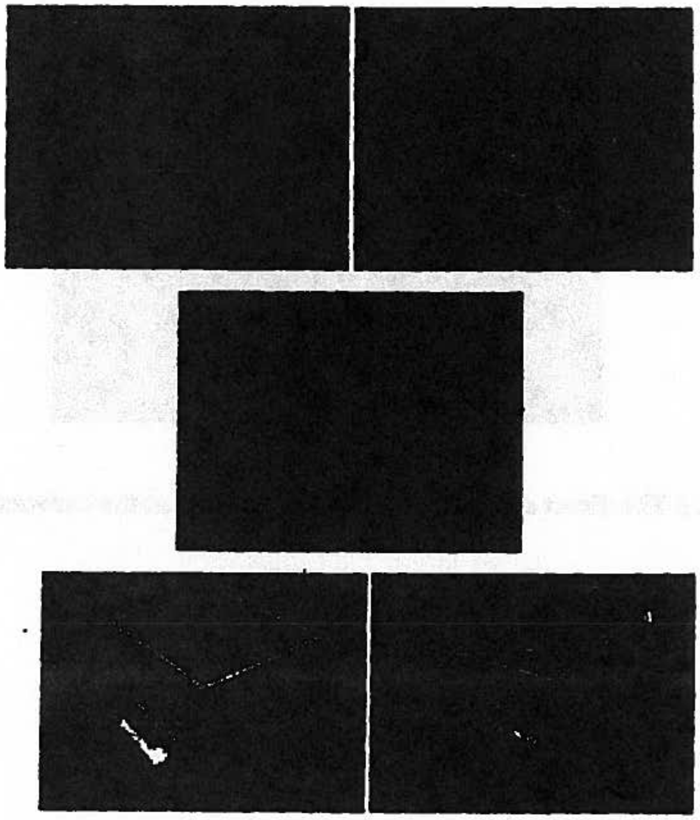


FIGURE 4 Stages of ballast compaction and loading upper ring

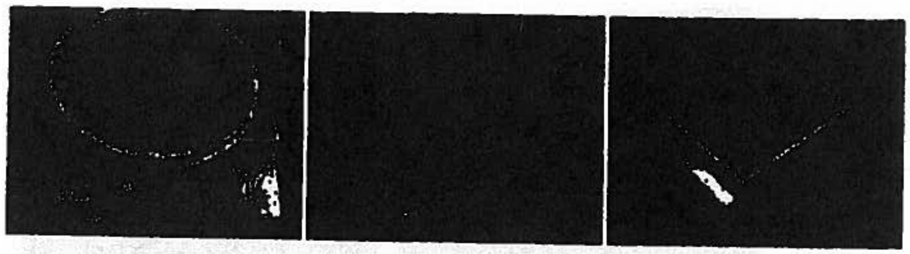


FIGURE 5 Mixing coal dust as the fouling material

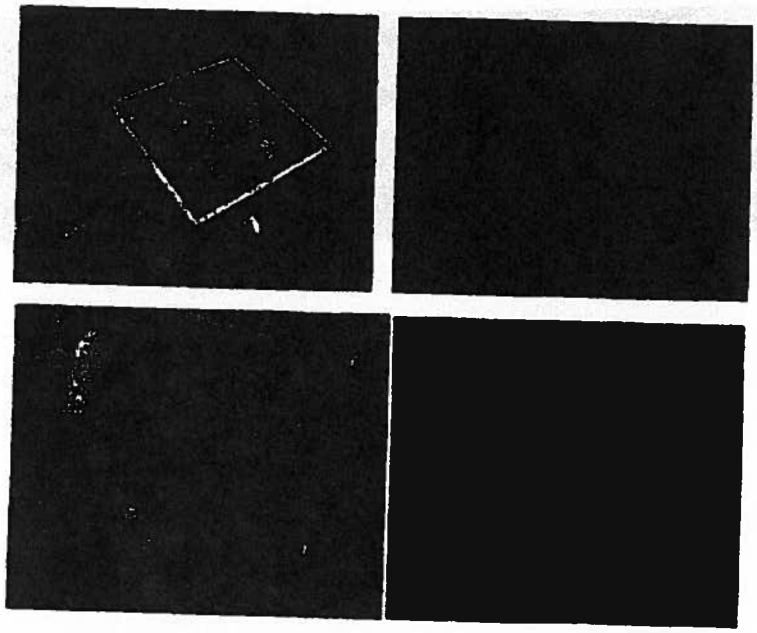


FIGURE 6 Setting-up the direct shear box apparatus

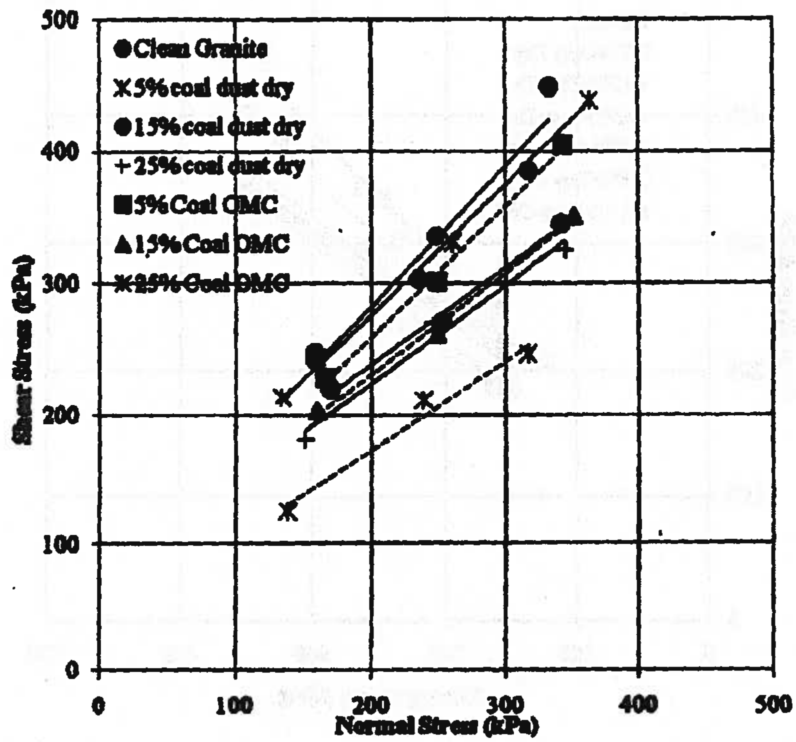


FIGURE 7 Direct shear box test results of coal dust fouled ballast samples

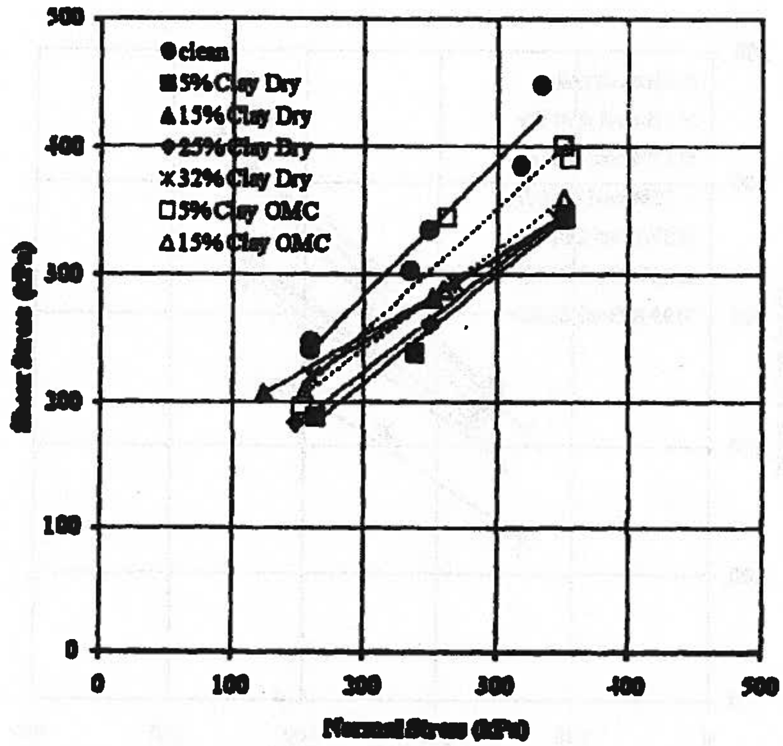


FIGURE 8 Direct shear box test results of clay fouled ballast samples

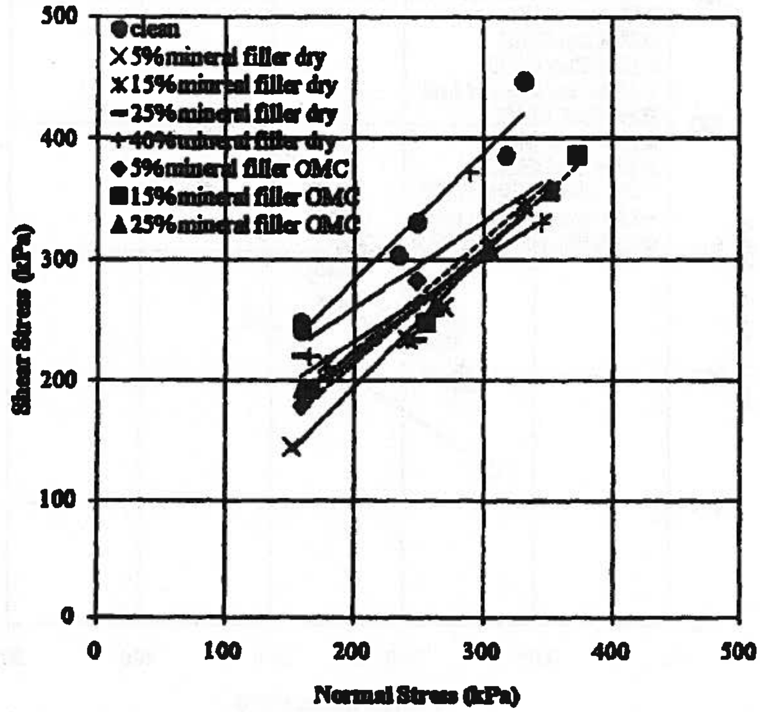


FIGURE 9 Direct shear box test results of mineral filler fouled ballast samples

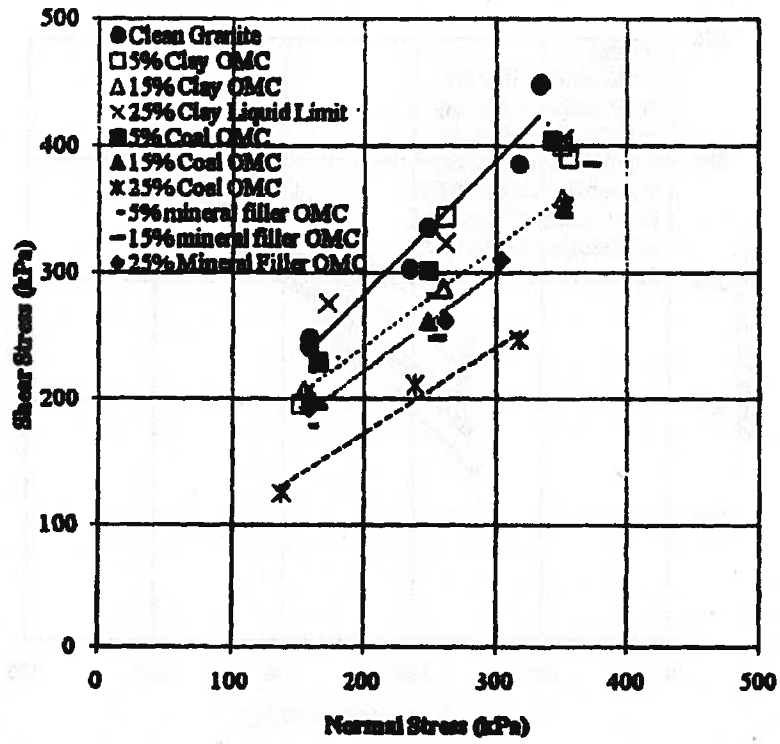


FIGURE 10 Comparisons between three fouling scenarios under wet conditions

Exhibit DC-2

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Exhibit DC-3

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Exhibit DC-4

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Exhibit DC-5

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Exhibit DC-6

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Exhibit DC-7

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Exhibit DC-8

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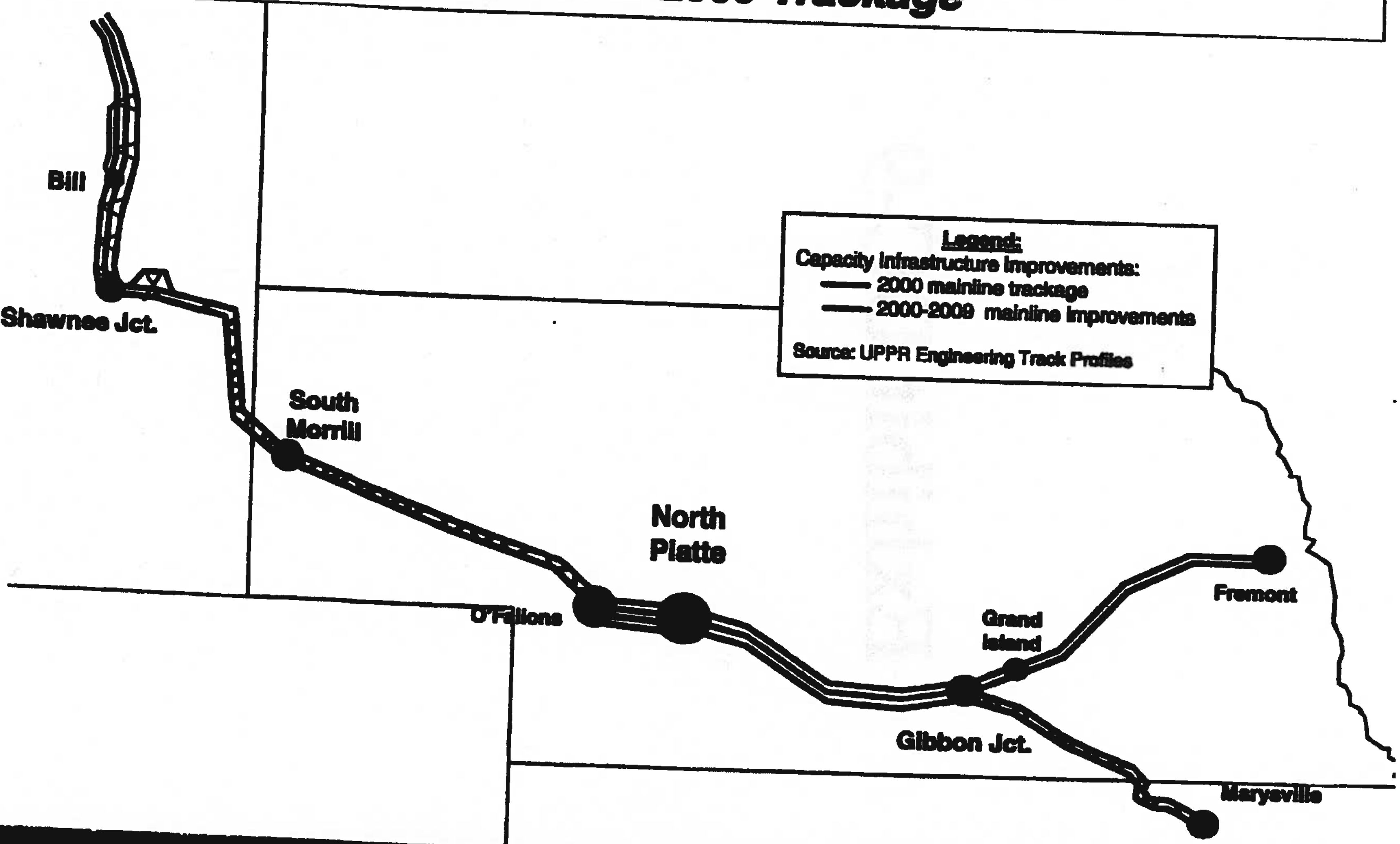
Exhibit DC-9

UPRR's SPRB Coal Route

Capacity Improvements 2000 to 2009 Trackage



OPERATIONS – NETWORK PLANNING
March 9, 2009

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Exhibit DC-10

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DC – App. 1

Track miles on UP's SPRB Coal Corridor

From	To	Route Miles	Track Miles
Shawnee Jct	Gibbon	396.86	948.24
Gibbon	Fremont	136.35	272.70
Gibbon	Menoken Jct	214.84	369.80
		748.05	1,590.74

This includes the miles through North Platte Terminal. It terminates at Fremont on the east end of the Columbus Sub, and at Menoken Jct, which is at MP73 on the Kansas Sub on the west edge of Topeka.: This includes all or portions of Powder River, South Morrill, Sidney, North Platte, Kearney, Columbus, Marysville and Kansas subdivisions.

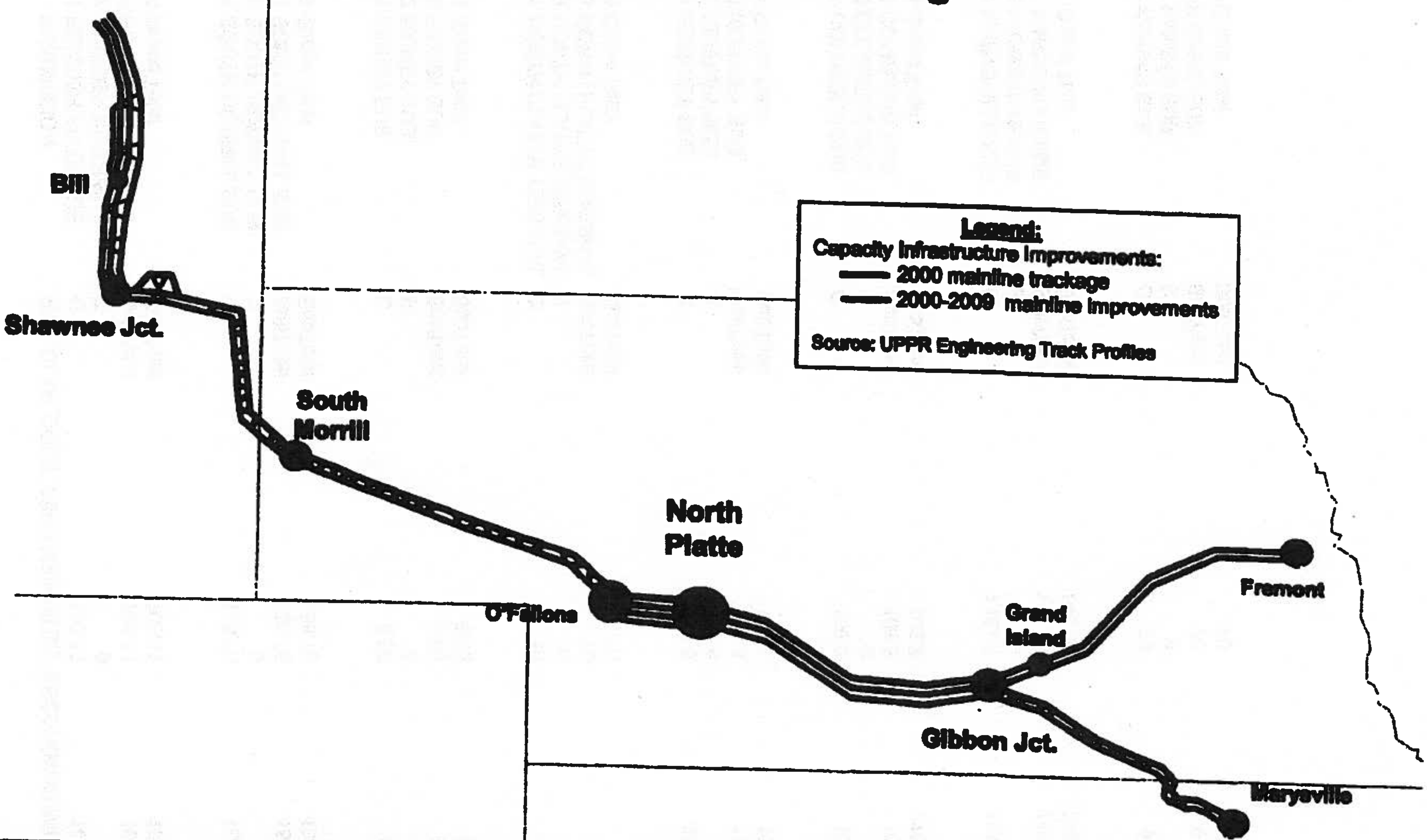
Per the Shannon & Wilson study, the recommendation is a 6 year undercutting cycle on average within the study limits, which are the same limits as above. It is an average, so one would expect that undercutting might be required more on the west end than on the east end. By this logic, we would need to undercut an average of 1590/6=265 miles per year in this corridor.

Undercutters will average 1.5 miles per day if allowed to stay cut in to the track overnight, or 0.75 miles per day if track is returned to service each night. So depending on track availability, it would take between 177 and 353 working days to undercut 265 miles. (265/.75 = 353.33 and 265/1.5 =176.66)

The working season in this zone is approximately April 15 to November 15, or about 214 days. In order to undercut 265 miles in 214 days, it would require an average rate of 1.24 miles per day every day of the working season. Two large undercutters would most likely need to be used in order to obtain the required production, especially as traffic levels continue to rebound.

UPRR's SPRB Coal Route

Capacity Improvements 2000 to 2009 Trackage



	SUBDIVISION	RTE_CLAS_CODE	FIRSTMAINMILES	SECONDMAINMILES
1	POWDER RIVER SUB	C	106.11	106.11
2	POWDER RIVER SUB	S	0	0
3	POWDER RIVER SUB	SubTotal	106.11	106.11
4	Grand Total	SubTotal	106.11	106.11
1	SOUTH MORRILL SUB	C	165.75	165.75
2	SOUTH MORRILL SUB	S	0	0
3	SOUTH MORRILL SUB	SubTotal	165.75	165.75
4	Grand Total	SubTotal	165.75	165.75
1	SIDNEY SUB	C	8.55	8.55
2	SIDNEY SUB	S	0	0
3	SIDNEY SUB	SubTotal	8.55	8.55
4	Grand Total	SubTotal	8.55	8.55
1	NORTH PLATTE TERMINAL	C	10	10
2	NORTH PLATTE TERMINAL	S	0	0
3	NORTH PLATTE TERMINAL	SubTotal	10	10
4	Grand Total	SubTotal	10	10
1	KEARNEY SUB	C	137.5	137.5
2	KEARNEY SUB	S	0	0
3	KEARNEY SUB	SubTotal	137.5	137.5
4	Grand Total	SubTotal	137.5	137.5
1	COLUMBUS SUB	C	105.3	105.3
2	COLUMBUS SUB	S	0	0
3	COLUMBUS SUB	SubTotal	105.3	105.3
4	Grand Total	SubTotal	105.3	105.3
1	MARYSVILLE SUB	C	144.84	145.42
2	MARYSVILLE SUB	S	0	0
3	MARYSVILLE SUB	SubTotal	144.84	145.42
4	Grand Total	SubTotal	144.84	145.42
1	KANSAS SUB	C	70	9.54
2	KANSAS SUB	S	0	0
3	KANSAS SUB	SubTotal	70	9.54
4	Grand Total	SubTotal	70	9.54

THIRDMAINMILES	OTHERMAINMILES	BRANCHMAINMILES	TOTLMAINMILES	RUNNINGTRACKMILES
0	14.69	0	226.91	0
0	0	0	0	2.94
0	14.69	0	226.91	2.94
0	14.69	0	226.91	2.94
0	2	0	333.5	0
2.31	4.25	0	6.56	6.62
2.31	6.25	0	340.06	6.62
2.31	6.25	0	340.06	6.62
0	16.75	0	33.85	0
0	0	0	0	0.58
0	16.75	0	33.85	0.58
0	16.75	0	33.85	0.58
6.58	1.49	0	28.07	0
0	0	0	0	8.442
6.58	1.49	0	28.07	8.442
6.58	1.49	0	28.07	8.442
106.45	0	0	381.45	0
0	0	0	0	11.45
106.45	0	0	381.45	11.45
106.45	0	0	381.45	11.45
0	0	0	210.6	0
0	0	0	0	15.68
0	0	0	210.6	15.68
0	0	0	210.6	15.68
0	0	0	290.26	0
0	0	0	0	8.54
0	0	0	290.26	8.54
0	0	0	290.26	8.54
0	0	0	79.54	0
0	0	0	0	18.72
0	0	0	79.54	18.72
0	0	0	79.54	18.72

	WAYSWITCHMILES	YARDSWITCHMILES	TOTLSPRTMILES
	0	0	0
	2.232	2.769	7.941
	2.232	2.769	7.941
	2.232	2.769	7.941
	0	0	0
	4.4	37.615	48.635
	4.4	37.615	48.635
	4.4	37.615	48.635
	0	0	0
	0.29	0.597	1.467
	0.29	0.597	1.467
	0.29	0.597	1.467
	0	4.75	4.75
	4.07	299.184	311.696
	4.07	303.934	316.446
	4.07	303.934	316.446
	0	0	0
	13.89	45.5	70.84
	13.89	45.5	70.84
	13.89	45.5	70.84
	0	0	0
	6.8	21.97	44.45
	6.8	21.97	44.45
	6.8	21.97	44.45
	0	0	0
	2.79	27.75	39.08
	2.79	27.75	39.08
	2.79	27.75	39.08
	0	0	0
	0.75	3.12	22.59
	0.75	3.12	22.59
	0.75	3.12	22.59

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VERIFIED STATEMENT OF
DOUGLAS GLASS

Introduction

My name is Douglas Glass. I am Vice President and General Manager-Energy of Union Pacific Railroad Company ("Union Pacific"). I was promoted to this position in April 2005. I am responsible for the marketing and sale of transportation of coal to utility and industrial customers.

I began my career with Union Pacific in 1976 and have held a variety of positions during the past 33 years, all in Union Pacific's Marketing and Sales Department. In June 2003, I became Senior Assistant Vice President, Business Development and held this position until promoted to my current position. I have two bachelor's degrees (marketing and economics) from the University of Colorado, a master's degree in business administration, finance, from the University of Nebraska-Omaha, and attended Harvard University's Program for Management Development.

The Energy business unit manages all commercial aspects of Union Pacific's coal business, including coordinating the operation of the rail network to provide coal deliveries to our customers. My introduction to, and subsequent experience in the Energy business unit, provide me an appreciation on the impact coal dust has on our coal rail network and service to our coal customers.

I begin with an overview of Union Pacific's coal transportation system on the Joint Line and then describe Union Pacific's relationship with Arkansas Electric Cooperative Corporation ("AECC"). Next, I summarize Union Pacific's coal dust concerns. I then explain the importance of adopting reasonable rules that insure customers assume appropriate responsibility for keeping their lading in the railcars. I

next explain why AECC's concern that its trains would be stopped is misplaced. Finally, I describe the "chilling" impact that a Board decision finding the BNSF tariff rules unreasonable would have on Union Pacific's collaborative efforts with its customers to develop coal dust prevention methods.

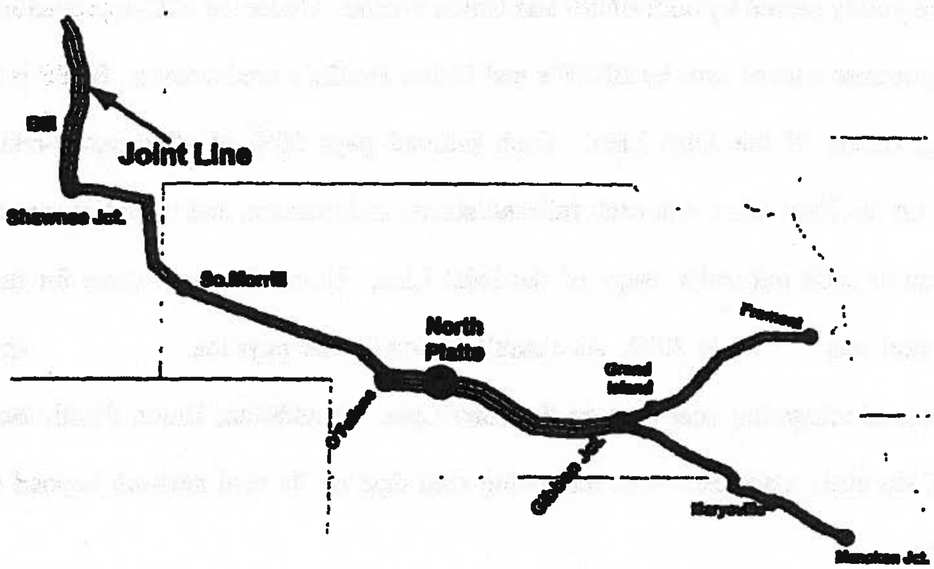
Overview of Union Pacific's Transportation of Coal from Wyoming's Powder River Basin

Union Pacific and BNSF each own 50% of the Joint Line, a 102-mile stretch of railroad used to serve ten sub-bituminous coal mines and transport over 350 million tons of coal from Wyoming's Southern Powder River Basin (SPRB) throughout the U.S. Both railroads have the right to operate trains over the line. These ten coal mines are jointly served by both BNSF and Union Pacific. Under the ICC-approved Joint Line Agreement entered into by BNSF's and Union Pacific's predecessors, BNSF is the operating carrier of the Joint Line. Each railroad pays 50% of all capacity-related projects on the Joint Line, and each railroad shares maintenance and operating costs in proportion to each railroad's usage of the Joint Line. Union Pacific's share for these expenditures was in 2009. As a result, Union Pacific pays the share of the cost of mitigating coal dust on the Joint Line. In addition, Union Pacific bears 100% of the costs associated with mitigating coal dust on its coal network beyond the Joint Line.

The transportation of coal to Union Pacific's energy customers is a significant component of our business. Union Pacific transports coal from the SPRB for customers over the Joint Line and its own lines to destinations in 23 states across the western two-thirds of the United States. In 2009, approximately 75% of the coal shipped by Union Pacific originated in the SPRB. Union Pacific transported in excess of 175

million tons of SPRB coal in 2009 over the Joint Line, and we currently average approximately 33 SPRB train loads daily. Union Pacific's average length of haul for a typical coal train is over 950 miles. Our Joint Line-originating coal network spans approximately 533 route miles running from Shawnee Junction in eastern Wyoming to Fremont, Nebraska or 612 route miles south on our Kansas Subdivision to Menoken Junction, just west of Topeka, Kansas. The track miles between Shawnee Junction and Fremont and Gibbon Junction to Menoken Junction total nearly 1600.

The Core of Union Pacific's Coal Network



Union Pacific's Relationship with AECC

Arkansas Electric Cooperative Corporation ("AECC"), the shipper who asked the Board to initiate this proceeding, is a customer of Union Pacific. AECC owns an interest in three coal-fired power plants, all of which are subject to long-term

49 U.S.C. § 10709 contracts with Union Pacific. Those power plants include the White Bluff plant at Redfield, Arkansas, the Independence plant at Newark, Arkansas, and the Flint Creek plant at Gentry, Arkansas. Union Pacific moves all of the coal for these power plants under contract. As described in more detail below, the coal transported by Union Pacific for these plants—AECC's coal—is not subject to BNSF tariff rules.

Union Pacific's Concern about Track Problems Arising from Coal Dust

Coal dust has created service difficulties on the Joint Line and left unchecked, threatens service difficulties in the future. David Connell, Union Pacific's chief engineer, describes how coal dust is unusually dangerous as a fouling agent because of how quickly it compromises the track bed when mixed with water. (Connell VS at 13-14.) Coal dust, in sufficient quantities, is known to compromise the track structure and roadbed, which can result in decreased stability, and ultimately loss of track gauge and proper geometry. (Connell VS at 13.) Location-specific coal dust mitigation efforts cannot practically remove all the coal dust in the roadbed (Connell VS at 14) and because track capacity is affected while those mitigation efforts are underway, the prudent solution to the coal dust problem is to keep the coal dust in the railcars during transportation. This does not just apply to coal, but is true for every commodity transported by rail—the product must be confined to the railcar or container.

Coal dust emissions foul ballast in the track bed and cause other track-related problems. (Connell VS at 12-13.) Absent rules for keeping coal dust confined to the railcars, Union Pacific has been compelled to adopt more aggressive mitigation efforts to remove coal dust from the ballast on its lines. These efforts include activities such as more frequent and extensive undercutting, shoulder cleaning and switch repair and replacement. As a result, the cycle for undercutting and switch cleaning schedules is being significantly shortened. (Connell VS at 17.) In addition to the potential for track-related problems, coal dust removal efforts disrupt Union Pacific's coal transportation by delaying trains and reducing track capacity because maintenance crews must be on the rail lines more often operating under maintenance curfews. With a six-year cycle and approximately 1,600 track miles, Union Pacific would have to average 265 miles of undercutting a year. Based on the average production pace and the fact that undercutting can only be done when the ground and track is not frozen, our Engineering Department has concluded that it is unlikely that we could sustain this amount of undercutting every year perpetually. (Connell VS at 18.) I also understand that coal dust cannot be completely removed from the ballast by simply undercutting, which increases the likelihood of further track-related problems in the future.

Increased maintenance and undercutting efforts to remove coal dust will ultimately result in increased cycle times and reduce the velocity of rail and customer car assets, impeding Union Pacific's customer service. Additionally, undercutting efforts over hundreds of miles of coal corridor each year are unsustainable and would not remove all coal dust. Because the coal dust can be so pernicious, particularly when combined with water (Connell VS at 13-14), the best and most logical solution is for shippers to take steps that keep their lading (in this case, coal) in their railcars and off of the railroad's right-of-way.

Rules That Require a Customer to Load Freight so That it Remains in the Car Are Reasonable

Railroads are responsible for transporting all types of freight over their lines. Shippers are responsible for loading their freight into cars in a manner so that it remains in the car, instead of falling or blowing out of the car and onto the track and creating safety hazards to other trains or damaging the integrity of the rail carrier's track or right-of-way. Coal shippers are no different than other rail customers in this respect. Accordingly, it is logical and should be a common sense practice for railroads to adopt reasonable rules that require their customers to keep coal and coal dust off the railroad's right-of-way – especially given the pernicious nature of coal dust. Similar to all other products hauled by the railroad industry, the coal shippers bear responsibility to insure that the coal remains in the railcar once it leaves the mine.

Coal dust is an unusually harmful foulant to the railroad track structure and supporting ballast, due to its unique characteristics, its fine granular shape and its reaction when exposed to water. (Connell VS at 13-14.) Even though we are engaged in undercutting efforts to remove coal dust, the fact remains that coal dust is still accumulating on the Joint Line and on UP's coal routes at disturbing rates. (Connell VS at 17.) Of even greater concern, coal dust that permeates the ballast is often not visible to the naked eye, requiring a complex and periodic sampling process to confirm the amount of and rate of dust accumulation over-time. (Connell VS at 14.)

Union Pacific has various loading rules that we have adopted for other traffic so that our customers' freight stays in the railcars. For example, woodchip customers are required to use netting to keep woodchips from flying out of railcars. Similarly, customers moving steel or iron scrap in open gondolas are required to secure their loads with tarp. We have rules for soda ash moving in covered hoppers where failure to adequately secure the bottom gates allows a granular caustic substance to be deposited in the track bed that can cause signal failures and prematurely age ties, ballast, and roadbeds. These examples are common sense railroad rules requiring shippers to take necessary steps and precautions that ensure their freight stays in the car. Like they have with other types of freight, railroads should be permitted to adopt reasonable rules as to their coal customers to prevent coal (including coal dust) from leaving the railcar and accumulating on the right-of-way.

AECC's Concern That its Trains Will be Stopped Is Misplaced

In its petition, AECC expressed concern that BNSF, under authority of its tariff rules (Items 100 and 101 of BNSF's Tariff 6041-B), would refuse to let AECC's trains operate over the Joint Line if the coal dust emissions from any train exceeded BNSF's tariff rules. (AECC Pet. for Decl. Order at 1-2.) AECC's concern is misplaced. BNSF tariff rules cannot apply to Union Pacific customers any more than a Union Pacific tariff rule could be applied against another railroad's customer.

Further, BNSF has not advised anyone at Union Pacific that it would stop Union Pacific trains under the tariff at issue if such trains emit too much coal dust, nor has BNSF told Union Pacific that it would enforce the tariff's provisions against Union Pacific. In fact, the tariff rules that AECC questions make no mention of refusing to allow trains that do not comply to move. Accordingly, BNSF's tariff rules (Tariff 6041-B Items 100 and 101) are not expected to disrupt or impact Union Pacific's transportation of AECC's SPRB coal to its coal-fired power plants (or those of other Union Pacific customers).

Although AECC did not mention BNSF's coal dust operating rule, General Order No. 19 (Orin Subdivision Timetable Amendments, adopted in January 2009), in its Petition, Union Pacific is subject to BNSF operating rules while on the Joint Line and under the authority of the Joint Line Agreement. While we do not share AECC's belief that BNSF would or could stop Union Pacific trains from operating over the Joint Line under that rule, we would be even more concerned than AECC if BNSF ever tried. Such an attempt would threaten Union Pacific service to other customers besides AECC, deprive us of revenue, and disrupt our operations. But BNSF has not stated that it plans to enforce this rule by stopping Union Pacific trains. Indeed, similar to BNSF's tariff rules, nowhere in its coal dust operating rule does BNSF state that it will stop trains on the Joint Line if the trains exceed their dust emission standard.

Moreover, stopping trains on the Joint Line would be extremely disruptive on such a busy corridor. Since the train must already be running on the Joint Line in order to pass the Track Station Monitor ("TSM") at mile post ("MP") 90.7 in order to be "caught", the only way BNSF could stop the train would be to hold it on the Joint Line. This would be counterproductive, especially since by the time the BNSF dispatcher could learn of the violation, contact the train crew, and the engineer could stop a 15,000-ton train moving at 40 m.p.h. or more the train would be approaching or past the end of the Joint Line at Shawnee Junction MP 117.1.[1] But in the hypothetical situation that this operating rule would be enforced by restricting Union Pacific trains, we would vigorously object and pursue any remedies before the Board.

Ruling That Prohibits or Restricts Coal Dust Emission Rules Would Chill Development of Prevention Techniques

Preventing the deposit of coal dust on the railroad right-of-way is better than perpetually removing it afterwards. Prevention, however, requires action by coal shippers since railroads cannot implement prevention measures unilaterally. Union

1 In fact, all of the Joint Line mines are located on the northern half of the Joint Line, but the monitoring station is located near the southern end where Union Pacific's trains exit the Joint Line. Thus, BNSF would not seem to have any reason to stop the train before it reached Union Pacific's lines. (*See also* VS Connell at 3, illustration.)

Pacific is committed to working with its customers to explore and to implement effective prevention measures. However, our ability to do so will be compromised if the Board determines that BNSF cannot adopt rules to inhibit coal dust dispersion or imposes unduly restrictive conditions on such rules. In this section, I will discuss why shipper participation is essential to prevent the dispersion of coal dust, how Union Pacific is pursuing collaborative efforts to develop effective measurement and prevention measures, and how prior collaboration has delivered mutual benefits.

Prevention requires active customer involvement because the shippers own the coal, the shippers own virtually all of the railcars used on the Joint Line, and the trains are loaded by the shippers' coal suppliers before they are released to Union Pacific for transport. These ownership interests effectively eliminate any steps that Union Pacific can take unilaterally to keep coal in the car while moving over its lines.

Ultimately, we aim to incent our customers to take reasonable steps to prevent coal dust from being left behind on our track. Currently, we are pursuing that objective by exploring alternative techniques for reducing coal dust emissions and developing venues for providing timely information to customers and the coal mines about the profile and performance of individual trains relative to all trains handled.

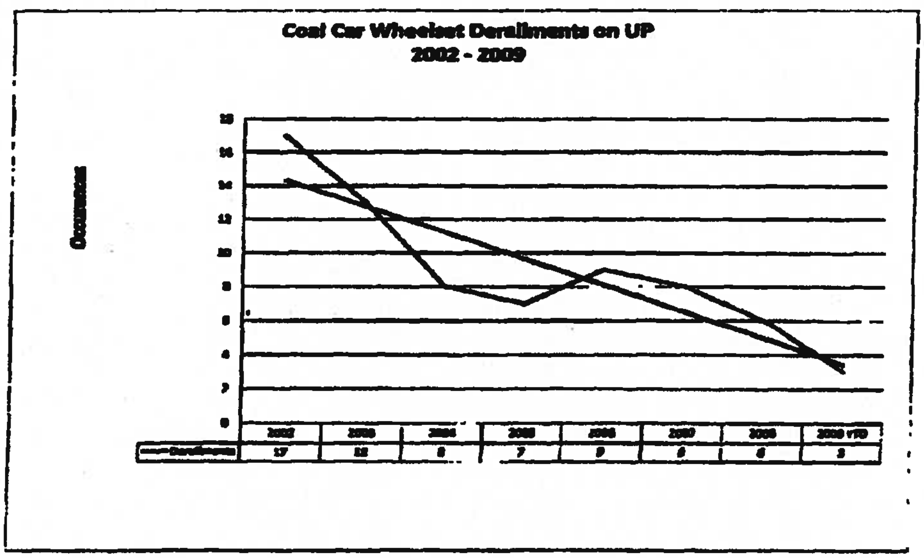
In addition to other options, such as application of chemical surfactants, grooming and shaping of railcar load profiles that were studied earlier, we are currently evaluating both load compression and car covers as alternative methods for coal dust prevention. One manufacturer is planning to introduce a mechanical system that can compact the coal in each railcar, lowering the coal profile and compressing the small grains of coal dust tighter within the car, thereby preventing the fines from blowing off the top of the car. We are interested in field testing this system in cooperation with one or more of our customers and are communicating with the manufacturer on its readiness to engage in a broad-based field test. We are also working with two other vendors on the development of car covers, and have discussed testing the covers in unit train service later this year.

Union Pacific also has several projects underway for sharing information with our customers and their coal producers on issues concerning coal dust. First, coal dust event data (Integrated Dust Values or IDV.2 data) collected at TSMs on the Joint Line at MP 90.7, as well as Union Pacific's own line near South Morrill, NE to be installed at MP 154.75-155, will be made available to our customers and mines on virtually a real-time basis via a secured customer website. The data will allow our customers and Union Pacific to observe the amount of coal dust deposited by their trains, relative to all coal trains, and to identify conditions that may cause a higher frequency of coal dusting events as well as the existence.

Later this year, we will begin sharing visual information on how well railcars are loaded and profiled to resist particles blowing off the top of the railcars. This will provide producers and customers with feedback to improve consistency and uniformity of load profiling techniques. By the second quarter of this year, Union Pacific, in conjunction with BNSF, intends to install a laser system (Coal Car Load Profiling System-CCLPS) on the Joint Line at MP 90.7. This system, along with the camera-monitoring device that Union Pacific and BNSF installed at the same location, will provide real-time feedback on the load profiles of each carload in the train for every train handled on the Joint Line by Union Pacific. Customers and their mines will be able to access data on their loaded cars via a secured customer website. We are completing the pilot program portion of this project and expect that the data will be available to all customers later this year.

Union Pacific's past collaborative efforts with customers have delivered improved safety and reliability. We anticipate the same for our coal dust prevention efforts. Union Pacific has succeeded in working with its customers in the past to improve rail service reliability, productivity, velocity and safety initiatives because we recognize that most opportunities cannot be achieved unilaterally. Union Pacific's processes involve research and development, education and exchange of information, followed by ongoing discussion in a collaborative environment. (Due to antitrust and competitive concerns, many of these discussions must take place on an individual customer basis.) Some examples of our past improvements that involved rail and customer cooperation include the deployment of distributed power, higher capacity coal cars, longer trains, expanded unloading infrastructure at customers' plants, and improved mechanical inspections and repairs.

Union Pacific's enhanced car inspection and maintenance guidelines and rules are a good example of how, through a combination of tariff rule changes, cooperation and negotiations, Union Pacific, along with its customers, has been able to improve rail safety and reliability by implementing rules that resulted in the reduction of equipment-related derailments. In 2002, Union Pacific conducted a comprehensive mechanical evaluation of heavy-haul cars in response to a significant number of broken wheel and axle derailments. As a result of its research, Union Pacific adopted several improvements on its system coal cars that operate in heavy-haul traffic. With the goal of further reducing equipment-caused incidents, in April 2005, we also reached out to our customers and asked that they voluntarily adopt certain inspection and repair standards on their cars (related to broken wheels, axles, and hot bearings). The following year, Union Pacific incorporated the new railcar inspection standards as recommendations for its then current contracts and adopted its new rail inspection standards to apply to all new commercial agreements with Union Pacific, effective November 1, 2006. Finally, we published the standards as requirements effective January 1, 2008. As a result of these initiatives and the collaborative efforts of our customers, derailments attributable to coal car wheel set issues moving along Union Pacific lines decreased significantly—from seventeen in 2002 to only six in 2008. Our approach to coal dust is no different.



Ongoing customer communications and collaborative relationships are vital to our efforts to find solutions to coal dust emissions and provide long term, superior service to our coal customers. A Board decision that finds BNSF's tariff rules are unreasonable or one that sets forth a narrow standard of what constitutes a reasonable

practice will discourage customer participation in coal dust discussions and "chill" our efforts to reach agreement with customers on how they can effectively and efficiently reduce their coal dust emissions. Even those customers who would ordinarily be progressive and cooperative, will be discouraged from supporting the reduction of coal dust emissions out of fear that such cooperation will put them at a competitive disadvantage against those who refuse to do anything.

VERIFICATION

I, Douglas Glass, Vice President and General Manager-Energy of Union Pacific Railroad Company, declare under penalty of perjury that the foregoing is true and correct to the best of my knowledge.

Executed on 12 day of March, 2010.

Douglas Glass

Signed before me this 12th day of March 2010.

GENERAL NOTARY - State of Nebraska
MAUREEN FONG HINNERS
My Comm. Exp. Dec. 6, 2011

Maureen Fong Hinners

Technical Memorandum

MIDWEST RESEARCH INSTITUTE

March 12, 2010

To: Mr. Joseph Rebein, Shook, Hardy & Bacon LLC

From: Gregory E. Muleski

Subject: Project No. 311023.1.001, "Review of Coal Emissions from Rail Cars"

This memorandum summarizes findings from a review of information that Shook, Hardy & Bacon (SHB) provided about coal dust monitoring along the Joint Line rail corridor in Wyoming. The line is used to transport coal from mines in the Southern Powder River Basin (SPRB) and it is jointly owned by BNSF and Union Pacific.

Introduction

My name is Gregory E. Muleski. I have been employed as a Principal Environmental Engineer at Midwest Research Institute (MRI) in Kansas City, Missouri since 1981. As an independent, not-for-profit institute, MRI delivers innovative thinking and unbiased results to its customers, both large and small. Since its founding in 1944, MRI has completed over 16,000 projects for over 5,000 clients. Environmental engineering services have been a core competency of MRI for over 50 years. MRI is internationally recognized as expert in the field of open dust source emission characterization and control.

In addition to a bachelor's degree in mathematics, I hold a bachelor's, a master's and a Ph.D. in engineering science. Since joining MRI, I have specialized in the measurement and modeling of open dust sources. I have over 25 years of direct experience characterizing fugitive dust for coal and other materials in field and laboratory studies. I have personally conducted over 900 fugitive dust field tests on two continents. I have served as Program Manager for a multiple year field evaluation of Powder River Basin coal mine emission factors and dispersion modeling as required by Section 234 of the Clean Air Act Amendments (CAAA) of 1990. In this capacity, I designed a follow-on field evaluation study for mines combining extensive long-term air quality and meteorological monitoring with intensive short-term, source-directed testing. I also directed the collection and reporting of ambient monitoring results for use in evaluating available dispersion models.

In addition to my work in the Powder River Basin, I have also conducted studies in South America where I developed and performed three large-scale field testing programs (1997, 2003, and 2010) of wind erosion and material handling operations at two major industrial facilities in Brazil. Other work included a thorough air quality review for coal mining company Carbones del Cerrejón LLC. The objectives were to (a) perform an independent assessment of the air quality management program at Cerrejón's mine in La Guarjira, Colombia and (b) advise on methods to improve the process.

I also have experience testing fugitive dust mitigation techniques. I conducted tests to characterize the effectiveness of control measures applied to wind erosion of steam coals, metallurgical coals, petroleum coke, and other materials in open storage and/or rail cars, as well as conducted multiple feasibility studies of wind fences to prevent large particles from depositing onto resort and residential property downwind of coal and other material storage piles in Brazil.

Due to my extensive field work experience in modeling, measurement and control of fugitive coal dust emissions, I was asked by Shook, Hardy and Bacon (SHB) to provide expert analysis on the issue of fugitive coal dust measurement and mitigation on the Joint Line rail corridor. SHB asked that, after reviewing several research studies and presentations, I report on the validity and effectiveness of (a) track side monitoring (TSM) techniques developed by Simpson Weather Associates and (b) the "integrated dust value" (version 2, or "IDV.2") obtained from TSM. I was also asked to comment on fugitive coal dust mitigation techniques that might be employed.

Executive Summary

The Joint Line rail corridor, co-owned by BNSF Railway and Union Pacific Railroad, is used to transport coal from mines in the Southern Powder River Basin. Coal dust is accumulating in and along the Joint Line's road bed. Coal dust works its way into the ballast and interferes with normal drainage and diminishes the vertical shear strength of the track under normal load conditions by passing trains.

A number of studies have been undertaken to not only characterize the loss of coal dust from rail cars but also to evaluate the effectiveness of control measures aimed to reduce the loss. After review of these studies and documents about coal dust monitoring along the Joint Line rail corridor in Wyoming, several conclusions can be drawn.

1. A rail car filled with coal is susceptible to wind erosion resulting in coal dust becoming incorporated into the airflow above the car. Larger coal dust particles will be deposited on and around the track road bed. Smaller particles will become suspended in the air and will disperse as they travel downwind before they can be detected by the track side monitor. The dusting problem is accentuated if the coal surface is higher than the car sidewalls. Furthermore, as additional track is added within the Joint Line (both triple and quad track) more dust that once would have deposited off to the side downwind is now being deposited near tracks.

2. There is a relationship between airborne dust measured by Simpson Weather at the track side monitors (TSM) and the particles that deposit on the right-of-way. Large particles are necessary to suspend coal particles detected at the trackside monitor. However, those larger particles cannot remain suspended in the air and will deposit on the right-of-way. Assuming comparable wind conditions between two events on the same track, one would conclude that the event with the higher IDV.2 value corresponds to more mass being deposited on

the right-of-way. Furthermore, as more tracks are added to the Joint Line, there is greater opportunity for coal dust to fall onto the track structures.

3. There exist several viable and proven methods to characterize the effectiveness of measures used to mitigate fugitive coal dust from wind erosion. Control measures include: covering the railcar; compaction of the coal surface; the application of suppressant/surfactant sprays; and profile modification of the coal load's profile (shape).

Ballast Fouling by Coal Dust on the Joint Line and on UP Main Line

Ballast fouling by coal dust occurs along the Joint Line. The work of Dr. Erol Tutumluer of the University of Illinois describes his analysis of ballast taken from the Joint Line. Dr. Tutumluer's report concludes that coal dust contributes significantly to ballast fouling.

Additionally, the engineering firm of Shannon & Wilson, Inc. has been engaged by Union Pacific to measure the coal dust levels on its main coal lines. Two Shannon & Wilson reports (dated July 30, 2008 and January 2010) have found that the level of coal dusting tends to decrease with increasing distance from the coal mines. Shannon & Wilson, though, did find measureable quantities of coal dust throughout the Union Pacific track that it measured.

These studies are consistent with my views about coal and wind erosion during transportation. The most significant erosion from railcars occurs immediately after an untreated load first reaches a travel speed above the surface's "threshold velocity." As the erodible material is depleted, the rate of emission decreases. However, the erosion potential can be restored when the surface is disturbed (for example, by starts and stops or rough spots causing material to tumble down in the railcar). For that reason, one could expect coal dust to be lost throughout the trip. This conclusion is supported by Shannon & Wilson's findings.

Ballast Fouling by Coal Dust Appears to be a Recent Problem

Coal dust fouling of ballast along the Joint Line appears to be a recent and increasing problem. This is due in part to a continual rise in the volume of rail traffic on the Joint Line over the past two decades.[1] Increased rail traffic equates to increased deposition of coal dust along the right of way. Furthermore, BNSF and UP have added dual, triple and quad rail lines to the corridor (Figure 1). This increase in track structure means dust that would have fallen off to the side can now deposit onto adjacent track structures where it may contribute to ballast fouling.

[1] Slide "UP-AECCBN-0008024" illustrates the growth in coal shipments along the Joint Line.

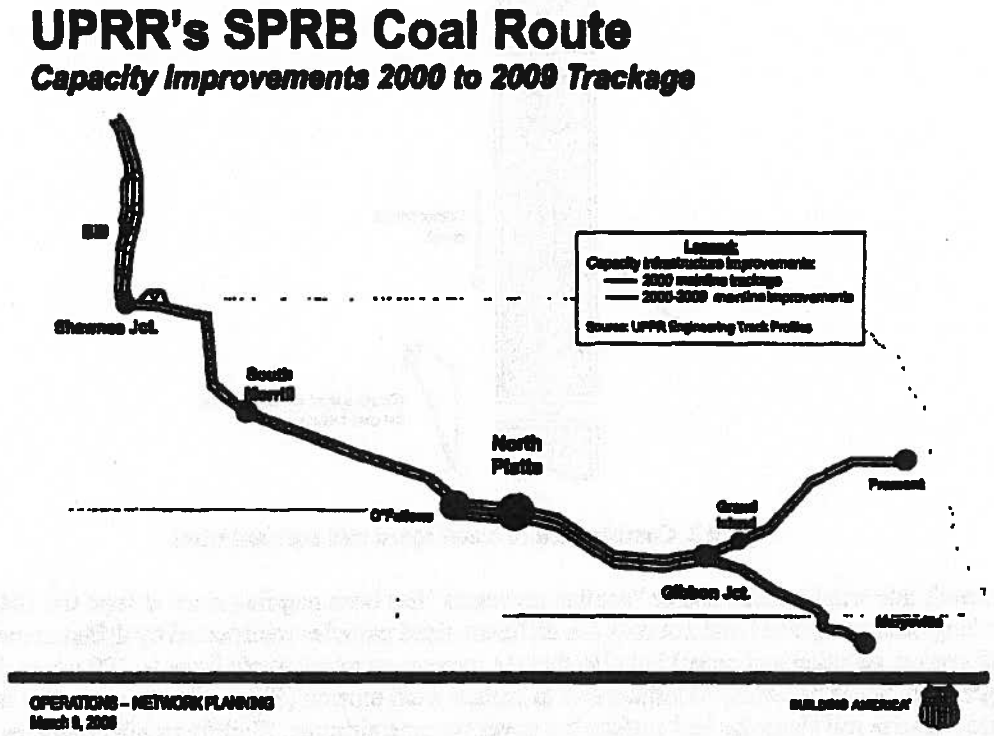


Figure 1. UPRR's capacity improvements to the SPRB

Fugitive Coal Dust from Open Rail Cars

A primary source of coal loss is falling or blowing from the top of open rail cars. Although improperly sealed or defective bottom dump doors on a coal car can result in coal loss during transit, coal blowing from the open rail cars is fundamentally a wind erosion source in which particles are drawn into the airflow above the car.[2] Figure 2 illustrates how the train travel speed and the ambient wind combine to produce the effective air speed "seen" or experienced by the coal surface. In the absence of high ambient winds, one would reasonably approximate the effective speed to be the same as the train travel speed.

[2] "Entrainment" is a general term that describes loose surface material becoming incorporated into a fluid (air or water) flowing over the surface.

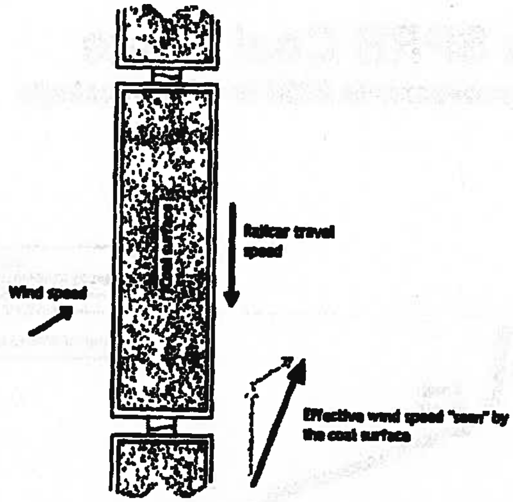


Figure 2. Combination of travel speed and ambient wind

Research into wind erosion and/or "aeolian processes" has been ongoing since at least the 1940s. It has long been recognized that not only are different-sized particles transported by different means (suspension, saltation and creep) but also that the movement of relatively large (~ 100 μm and larger) particles is necessary to initiate and to sustain wind erosion (Figure 3). Creep occurs when loose particles roll along the bed surface but never become airborne. Slightly smaller particles undergo saltation, a word whose Latin root means leaping or dancing. Saltation occurs when particles become airborne (up to a height of roughly 1 meter) and are carried a short distance before falling back on the bed surface. When the particles fall back, they dislodge smaller particles which can remain suspended in the air. Particles that are sufficiently small are transported by suspension and can travel a considerable distance away from their source.

In the context of coal blowing from rail cars, the movement of the car at 20 to 25 mph[3] is sufficient to initiate creep and saltation of large coal particles as well as suspension of smaller coal particles in the airstream. Saltating particles can travel from the forward cars down the length of the train, creating an "avalanche" of more and more suspended particles.

Once the train has left the vicinity of the monitoring location, the ambient winds control the dispersal of dust at the location. Large particles fall to the ground ("dustfall") while smaller particles remain suspended and are transported downwind. The large particles that settle to the ground are among those that may contribute to ballast fouling. Certain variables can increase the amount of material that is deposited. If coal is loaded above the top rails of the coal car, there is a greater surface area susceptible to wind erosion. Additionally, the surface profile of the coal load

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[3] Threshold velocity information for western coal may be found in (a) Table 10-3 of the report entitled *Improved Emission Factors for Fugitive Dust From Surface Coal Mining Sources* (EPA-600/7-84-048) and (b) Table 13.2.5-2 in AP-42 Section 13.2.5 ("Industrial Wind Erosion") of EPA's *Compilation of Air Pollutant Emission Factors* (http://www.epa.gov/ttn/chief/ap42/ch13/index.html). Note also that, in more recent tests, I have used a real-time aerosol monitor to supplement my visual determination of the onset of erosion. Using this technique, I have determined coal threshold velocities as low as 17 mph.

can affect the amount of coal lost. Both loose coal on the sills or a higher coal surface will increase the chance that a saltating or creeping particle leaves the railcar and deposits onto the ground.

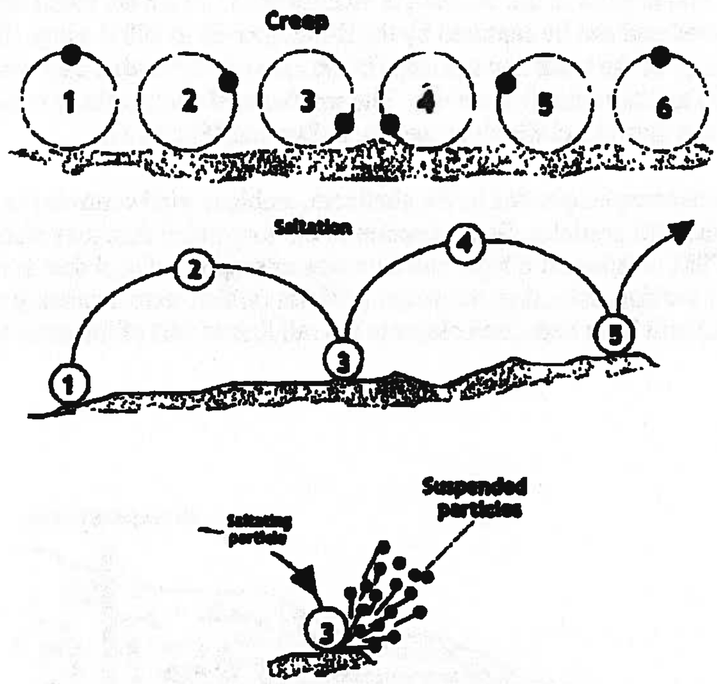

Figure 3. Means of coal dust particle transport

Track Side Monitoring by Met One E-Sampler

The Simpson Weather materials that I have reviewed describe various sampling programs instituted to detect and monitor fugitive coal dust from passing trains on the Joint Line rail corridor. I discussed general features of Track Side Monitoring (TSM) with SWA personnel during February 24, 2010 and March 9, 2010 telephone conversations. TSM equipment is mounted on a tower about 60 to100 ft east and west of the Joint Line tracks. This equipment includes Met One E-Sampler monitors. The E-Sampler is a real-time instrument for detecting suspended particles which enter the detector. The tower also contains a R. M. Young propeller anemometer to monitor wind speed and direction, temperature and relative humidity sensors, and a data logger. There is a precipitation gauge as well as several dustfall collectors nearby.

Towers are placed on both the East and West side of the Joint Line at mile marker 90.7. The location of the TSM at mile 90.7 was dictated by many factors including access to utility services, security, ease of maintenance as well as ambient conditions along the line. Furthermore, the towers could not interfere with access for necessary railway maintenance; for that reason, the towers needed to be located away from the tracks. MRI recognizes the need to balance competing requirements and has concluded that the location is reasonable for the testing performed. These factors are similar to the ones that MRI has considered in its location of field testing equipment.

Coal particles that deposit in the immediate vicinity of the tracks are much larger than those that remain suspended and can be captured by the E-Sampler 60 to 100 ft away. The larger particles fall in the vicinity of the track due to creep (in the case of overloaded cars where particles can simply roll out) and saltation (Figure 4)[4]. The smaller coal dust particles remain suspended in the airstream as a dust cloud which passes the E-Sampler (Figure 3).

Once particles become suspended in the airstream, ambient wind controls the direction and dispersion of the dust particles. Some fraction of the suspended dust may also deposit before reaching the TSM location. If a high concentration of suspended coal dust is detected at the TSM at the time of a passing train, then the larger particles (which were necessary to initiate and sustain erosion) will have deposited closer to the rail line as part of the same train passage event.

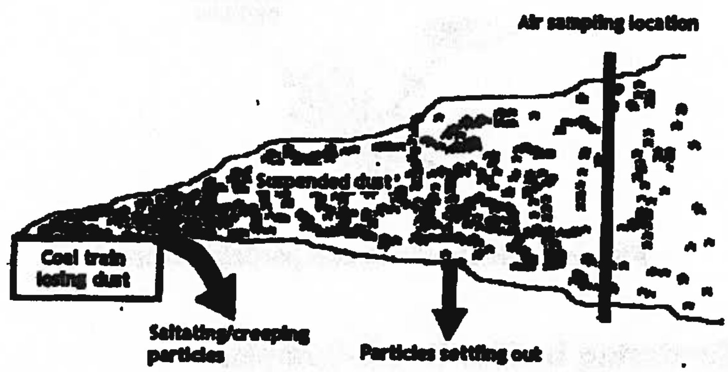

Figure 4. Coal dust dispersion by creep, saltation and suspension from moving coal cars.

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[4] Gravitational settling velocity is described in Baron and Willeke, *Aerosol Measurement: Principles, Techniques and Applications*. For illustration in the context of trackside monitoring, the following terminal settling velocities are found for (assumed spherical) coal particles (with a density $\rho = 1.5\ g/cm^3$) :

Diameter (μm)	Terminal Velocity (cm/s)	Time (s) to Fall 14 ft *	Distance (ft) Traveled While Falling 14 ft *
50	11	40	600
100	45	9.5	140
150	100	4.3	63
200	180	2.4	35
250	280	1.5	22
300	410	1.0	,2

*Fall distance of 14 ft chosen to approximate height of railcar. Distance traveled estimate assumes a 10 mph horizontal wind.

The Integrated Dust Value

The Integrated Dust Value is a measurement developed by SWA to indicate the dust "signature" for a passing train as detected by the TSM. Of particular interest in my review was an evaluation of the scientific merits of the integrated dust value (IDV.2) developed from data collected by the TSM. SWA personnel have described the general approach used to calculate the IDV.2 to MRI. Essentially, the concentration of dust detected by the E-Sampler is integrated over time (after making allowances for the locomotives) to provide a single dust characterization for a passing train. The concept of integrating time data is common. Increases in IDV.2 should be correlated with increases in the amount of dust detected by the E-Sampler. Because (a) airborne dust at the sampling location is due to erosion of the coal surface and (b) large (saltating) particles are necessary for erosion, it is reasonable to assume that, with comparable wind conditions between any two events on the same track, the event with the higher IDV.2 value corresponds to more mass being deposited on the right-of-way.

Mitigation Techniques

There exist several viable methods to mitigate fugitive coal dust formation due to wind erosion. I draw upon my years of experience testing fugitive dust mitigation techniques applied to wind erosion of steam coals, metallurgical coals, petroleum coke, and other materials in open storage and/or rail cars.

Coal compaction is a valid means to control erosion. The Coleman report focuses on a specific version of this technique involving a vibratory roller. In my experience, less intensive compaction using a simple frame-mounted roller of the type shown in Figure 5a, may be just as effective in preventing coal losses.[5] Compaction reduces the surface area available for erosion and smoothes the surface to reduce shearing from the air. Another viable technique involves spraying the surface of the coal with a material that assists in crusting or binding loose material together. The effectiveness of spraying is likely to decrease because of weathering over a period of two to four days. Control due to compaction of the surface may also decrease over time. Covering the coal very effectively prevents wind erosion by isolating the coal surface from the wind.

Other methods of remediation have already been implemented to some degree. Recently, the method with which some coal is loaded into the cars was altered slightly to change the top profile of the bed from an angular load to a more bread loaf shape. The resulting load profile may lower dust generation. The inclusion of "non-erodible" elements has been shown to reduce erosion in storage piles and open areas

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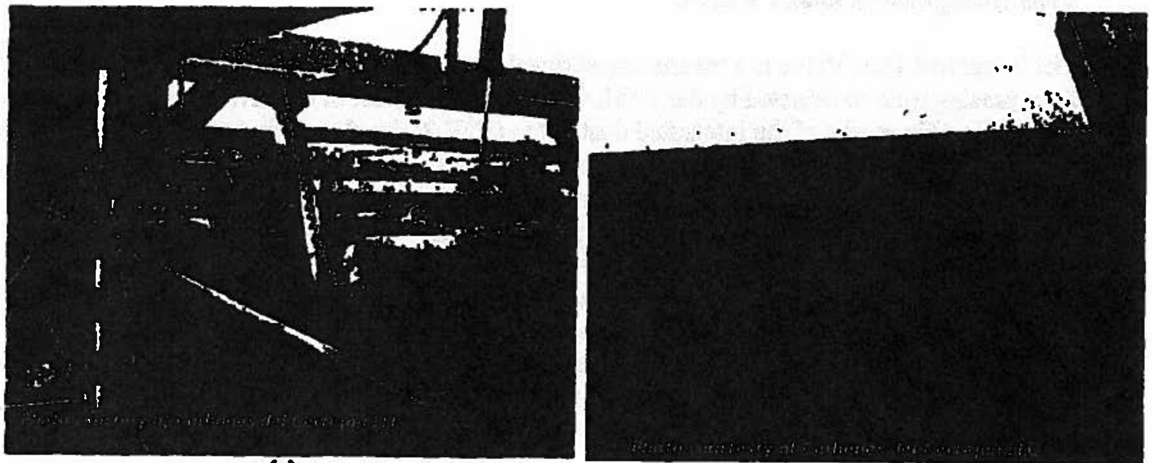
[5] The compaction roller shown in Figure 5a is the third station in a three-part process after load-out. The coal surface is first struck level with V-shaped implement. The surface is then sprayed with water (as seen in the background of Figure 5a) and finally compacted.



(a) (b)

Figure 5. Coal surface compacted by a frame-mounted roller.

Summary and Conclusions

Based on the materials reviewed and my own experience with coal dust experimentation and control, several conclusions can be drawn. A rail car filled with coal, traveling at or above 20-25 mph is susceptible to wind erosion resulting in coal dust being entrained into the airflow above the car. At a fixed TSM location, the larger coal dust particles will deposit on and around the track road bed while the smaller particles will remain suspended in the air and can travel toward the track side monitor. The general description of how the IDV.2 value is calculated appears to be a reasonable method to characterize airborne dust from a single train passage. Assuming comparable wind conditions for two events on the same track, one would reasonably expect that the event with the higher IDV.2 will result in more dust deposited. Finally, several viable and proven methods exist to mitigate fugitive coal dust from wind erosion, including covering, compaction, the application of suppressant/surfactant sprays, and profile modification.

Verification

I, Gregory E. Muleski, Ph.D., Principal Engineer with Midwest Research Institute, declare under penalty of perjury that the foregoing is true and correct to the best of my knowledge.

Executed on the 12th of March, 2010.

Gregory E. Muleski, Ph.D.

Document Reviewed by Dr. Muleski

Document Name	Bates Prefix	bates # from	bates # to
Summary of Data Analyses: BNSF and UP Study	BNSF_COALDUST_	20817	20851
Argus Coal Weekly (Volume 4, 28, 13 July 2007)	BNSF_COALDUST_	20596	20601
MP 90.7 TrackSide Monitor (TSM) (Orin Subdivision) Exceedance Trains Dust Report Summary	BNSF_COALDUST_	18326	18342
Monthly Rept on Activities Related to the Monitoring and Control of Fugitive Dust Emissions in the Powder River Basin for Burlington Northern Santa Fe Railway and Union Pacific Railroad (Covering period October - November 2006)	BNSF_COALDUST_	19741	19744
Monthly Rept on Activities Related to the Monitoring and Control of Fugitive Dust Emissions in the Powder River Basin for Burlington Northern Santa Fe Railway and Union Pacific Railroad (Covering period March 2007)	BNSF_COALDUST_	21611	21617
Monthly Rept on Activities Related to the Monitoring and Control of Fugitive Dust Emissions in the Powder River Basin for Burlington Northern Santa Fe Railway and Union Pacific Railroad (Covering period April 2007)	BNSF_COALDUST_	21710	21716
Monthly Rept on Activities Related to the Monitoring and Control of Fugitive Dust Emissions in the Powder River Basin for Burlington Northern Santa Fe Railway and Union Pacific Railroad (Covering period May 2007)	BNSF_COALDUST_	37225	37233
Monthly Rept on Activities Related to the Monitoring and Control of Fugitive Dust Emissions in the Powder River Basin for Burlington Northern Santa Fe Railway and Union Pacific Railroad (Coving period November 2007)	BNSF_COALDUST_	40149	40150
Monthly Rept on Activities Related to the Monitoring and Control of Fugitive Dust Emissions in the Powder River Basin for Burlington Northern Santa Fe Railway and Union Pacific Railroad (Covering period December 2007)	BNSF_COALDUST_	40203	40204
Monthly Rept on Activities Related to the Monitoring and Control of Fugitive Dust Emissions in the Powder River Basin for Burlington Northern Santa Fe Railway and Union Pacific Railroad (Covering period January 2008)	BNSF_COALDUST_	40710	40711
Monthly Rept on Activities Related to the Monitoring and Control of Fugitive Dust Emissions in the Powder River Basin for Burlington Northern Santa Fe Railway and Union Pacific Railroad (Covering period February 2008)	BNSF_COALDUST_	40721	40722
Monthly Rept on Activities Related to the Monitoring and Control of Fugitive Dust Emissions in the Powder River Basin for Burlington Northern Santa Fe Railway and Union Pacific Railroad (Covering period May 2008)	BNSF_COALDUST_	40400	40401
Monthly Rept on Activities Related to the Monitoring and Control of Fugitive Dust Emissions in the Powder River Basin for Burlington Northern Santa Fe Railway and Union Pacific Railroad (Covering period June 2008)	BNSF_COALDUST_	40425	40426

Document Name	Bates Prefix	bates # from	bates # to
Monthly Rept on Activities Related to the Monitoring and Control of Fugitive Dust Emissions in the Powder River Basin for Burlington Northern Santa Fe Railway and Union Pacific Railroad (Covering period July 2008)	BNSF_COALDUST_	40531	40532
Monthly Rept on Activities Related to the Monitoring and Control of Fugitive Dust Emissions in the Powder River Basin for Burlington Northern Santa Fe Railway and Union Pacific Railroad (Covering period August 2008)	BNSF_COALDUST_	57313	57314
Monthly Rept on Activities Related to the Monitoring and Control of Fugitive Dust Emissions in the Powder River Basin for Burlington Northern Santa Fe Railway and Union Pacific Railroad (Covering period September 2008)	BNSF_COALDUST_	57782	57783
Monthly Rept on Activities Related to the Monitoring and Control of Fugitive Dust Emissions in the Powder River Basin for Burlington Northern Santa Fe Railway and Union Pacific Railroad (Covering period October 2008)	BNSF_COALDUST_	57970	57971
Monthly Rept on Activities Related to the Monitoring and Control of Fugitive Dust Emissions in the Powder River Basin for Burlington Northern Santa Fe Railway and Union Pacific Railroad (Covering period November 2008)	BNSF_COALDUST_	57976	57977
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Joint Line Map	BNSF_COALDUST_	3161	
Coal Compaction Report Coleman Aerospace	UP-AECCBN-	9825	9837
Shannon & Wilson 7-3-2008 (Native File)	UP-AECCBN-	10275	
Overview of UP Dustfall Collector Network along North Platte Division	UP-AECCBN-	6799	6807
Coal Dust Mitigation Test Nov. 15, 2007	BNSF_COALDUST_	43452	43509
Coal Dust Threshold Performance Stanadard Oct. 9, 2007	BNSF_COALDUST_	39332	39348
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BNSF 9532 11-2-05 (Native File)	BNSF_COALDUST_	22995	
BNSF 5729-2 (Native File)	BNSF_COALDUST_	22996	
BNSF 9902 (Native File)	BNSF_COALDUST_	22997	
UP 6053 11-3-05 (Native File)	BNSF_COALDUST_	23002	
UP 6498_2 11-3-05 (Native File)	BNSF_COALDUST_	23003	
UP 6530 11-2-05 (Native File)	BNSF_COALDUST_	23004	

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UP 6695 11-2-05 (Native File)	BNSF_COALDUST_	23005	
UP 6732 11-2-05 (Native File)	BNSF_COALDUST_	23006	
BNSF - UP Chemical Dust Suppression Agents Field Testing September 2005	BNSF_COALDUST_	64500	64505
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BNSF - UP Field Testing Passive Collec. & RTEPS Dusting Events Sum. May 7 2007	BNSF_COALDUST_	65206	65220
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BNSF Coal Dust Detec. Equip. in Powder River Basin July 2009	BNSF_COALDUST_	59322	59339
BNSF Coal Dust Detection Equip. in Powder River Basin October 2009	BNSF_COALDUST_	60192	60209
BNSF TrackSide Monitor Troubleshooting August 9 2009	BNSF_COALDUST_	59882	59902
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Coal Dust Mitigation Testing Results & Performance Standard Nov. 15 2007	BNSF_COALDUST_	63755	63810
Descrip. of Impro. to BNSF-UP Trackside Mon Integ. Dust Val cal. log. Oct.9 2007	BNSF_COALDUST_	39361	39372
Dustfall Monitoring Network for the Orin Sub January 19 2007	BNSF_COALDUST_	21358	21367
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Test Equip. to Use during Jacobs Ranch Body Treat. In-tran. Dust Red.Fld.Test Ju	BNSF_COALDUST_	59267	59271
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Proposed Improvements to BNSF/UP TrackSide Monitor Integrated Dust Value Calculation	BNSF_COALDUST_	20580	20591
Train 1_0002 (Native File)	BNSF_COALDUST_	22999	
Train 2_2 (Native File)	BNSF_COALDUST_	23000	
Train 3 with comparison graph_0006 (Native File)	BNSF_COALDUST_	23001	
Shannon & Wilson Jan. 2010	UP-AECCBN-	13428	13538
3.25.08email	BNSF_COALDUST_	62600	
3.27.08Qualtec	BNSF_COALDUST_	62612	62614
3.28.08 response	BNSF_COALDUST_	62615	
52808email	BNSF_COALDUST_	44408	
june1108email	BNSF_COALDUST_	62712	62713
6/2/2008	BNSF_COALDUST_	44417	44420
Qualtec3.25.08email	BNSF_COALDUST_	44109	44110
Qualtec 3.27.08	BNSF_COALDUST_	75990	75993
Smarter Solutions	BNSF_COALDUST_	75992	75925
SSinitial analysis	BNSF_COALDUST_	44409	44411
UP-AECCBN-0008024 (Native File)	UP-AECCBN-	8024	

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Public documents			
Improved Emission Factors for Fugitive Dust From Western Coal Mining Sources PB84170802			
TRB-09-2065 Huang et al - Publication Copy			
AREMA 2008 Conf Paper by Tutumluer et al			
EPA Coal PB284-297			
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Subcommittee Coal study Virginia			
Environmental Progress			
Aerosol Measurement: Principles, Techniques and Applications, Baron and Willeke			
Pleadings			
10-22-09 Ltr to Anne K. Quinlin from John H. LeSeur			
BNSF Reply to AECC's Pet for Declaratory Order			
Pet of UP Railroad Co to Intervene			
Petition of AECC for a Declaratory Order			
Reply of UP Railroad Co to Western Coal Req for Leave to Intervene			

CERTIFICATE OF SERVICE

I hereby certify that on this 16th day of March, 2010, I have served a copy of the above Opening Evidence and Argument of Union Pacific Railroad Company and accompanying Verified Statements via Federal Express on the following parties of record:

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