ENVIRON

MEMORANDUM

To: James Nadalini, BNSF

From: Chris Lindhjem and Tim Sturtz, ENVIRON

Date: August 19, 2010

Subject: Emission Reductions from Reduced Rail Congestion at Tower 55

This document outlines the approach used to estimate the emission reductions from vehicle and locomotives delayed at grade crossings due to rail congestion and locomotive diverted to other routes in the area if the congestion continues. The congestion in this situation is due to the at-grade crossing of the UP and BNSF main lines at Tower 55 in Ft. Worth.

The summary benefits are shown in the table below. The calculations of the benefits shown are described in more detail in the remainder of this report.

Summary Table of Project Benefits Over Project Life

Source Reduction	HC (tons)	CO (tons)	NOx (tons)	PM (tons)	SOx (tons)	CO2 (tons)
Locomotive Congestion Relief (BNSF)	83	516	2,075	51	2	199,166
Locomotive Diversions (BNSF)	15	257	423	8	1	99,189
Locomotive Diversions (Other)	592	9,089	16,261	317	33	3,506,184
Total	**690**	**9,862**	**18,759**	**377**	**36**	**3,804,539**

Approach to Reduced Locomotive Fuel Consumption Due to Congestion

BNSF provided an analysis of the current fuel consumption around the Tower 55 intersection, and predicted fuel consumption with and without the project through RTC modeling efforts.

EPA (1997, 2009) provided base emission rates in Table 1 and forecasts of the Large Line-Haul average emission rates in EPA (2009) in Table 2. The emission reductions were due to two rulemakings described in EPA (1998 and 2008) with accompanying fleet turnover with newer engines meeting lower emission standards. The EPA (2009) document only provides emission factors through 2040, but communication with EPA staff indicated that by 2040 Tier 4 locomotives would comprise 92% of the fleet activity and accruing at a rate of 1.5 to 2% per year in the years leading up to 2040. ENVIRON

then expected and forecasted 5 additional years of emission factor benefits before the fleet would be comprise entirely of Tier 4 engines. The forecasted reduction in locomotive emission factors resulted in lower emission benefit estimated from reduced locomotive activity during that period.

Table 5. Base Line Haul Emission Factors for Locomotives (EPA, 1997)

HC (g/gal)	CO (g/gal)	NOx (g/gal)	PM (g/gal)	SOx (g/gal) (15 ppm)	CO2 (g/gal)
10	26.6	270	6.7	0.1	10,268

Table 2. Forecasted locomotive emission factors (EPA, 2009)

Year	HC (g/gal)	CO (g/gal)	NOx (g/gal)	PM (g/gal)
2014	6.1	26.6	135	3.6
2015	5.7	26.6	129	3.4
2016	5.1	26.6	121	3.1
2017	4.6	26.6	114	2.9
2018	4.2	26.6	108	2.7
2019	3.9	26.6	103	2.5
2020	3.6	26.6	99	2.3
2021	3.4	26.6	94	2.2
2022	3.2	26.6	89	2.0
2023	3.0	26.6	84	1.9
2024	2.8	26.6	79	1.7
2025	2.6	26.6	74	1.6
2026	2.5	26.6	69	1.5
2027	2.3	26.6	65	1.4
2028	2.1	26.6	61	1.3
2029	2.0	26.6	57	1.1
2030	1.9	26.6	53	1.0
2031	1.7	26.6	49	1.0
2032	1.6	26.6	46	0.9
2033	1.5	26.6	43	0.8
2034	1.4	26.6	40	0.7
2035	1.3	26.6	37	0.7
2036	1.2	26.6	35	0.6
2037	1.2	26.6	33	0.6
2038	1.1	26.6	31	0.5
2039	1.1	26.6	29	0.5
2040	1.0	26.6	28	0.4
2041*	0.95	26.6	25.0	0.35
2042*	0.93	26.6	24.1	0.30
2043*	0.92	26.6	23.5	0.25
2044*	0.92	26.6	23.0	0.20
2045*	0.92	26.6	22.8	0.15

* ENVIRON estimate

The SOx and CO2 emission rates were calculated directly from the fuel consumption. Fuel sulfur for locomotives is set at less 15 ppm because the low sulfur fuel is mandated for 2012. The sulfur was assumed to convert to SO2. The CO2 emission rate is

calculated from the fuel consumption using an average fuel density of 7.1 lb/gallon and multiplying by 44 (molecular weight of CO2) and dividing by 13.8 (Code of Federal Regulations estimate of molecular weight of the fuel per carbon atom) to account for the molecular weight of CO2 and average fuel carbon and hydrogen content.

Locomotive Activity Rates

BNSF provided calculations of the fuel consumption with and without the project at the initial year 2014 based on their model of the rail network and expected operations. BNSF used the Rail Traffic Controller (RTC) model to provide the fuel consumption benefit of the project for the congestion relief and fuel consumption for diverted traffic. The RTC model accounts for rail congestion relief (reduced braking, idling, and restarting due to better traffic flow) and avoiding the expected diversions from the congested intersection.

Locomotive Congestion Relief Reductions Benefits

The emissions benefits shown in Table 3 were calculated by applying the average line-haul emission rates in Table 2 multiplied by the fuel consumption benefits calculated for this project. For the years 2028 and later no benefits accounted due to saturation capacity at the rail intersection reached within 15 years after the project start date. At saturation capacity, additional growth will limit congestion relief of the at-grade improvements for train movements through this intersection. Between the initial year and 2028, the congestion benefit was scaled proportionally to the remaining capacity for each year relative to the initial year 2014.

Table 3. Annual benefit from the project in reduced locomotive fuel consumption.

Year	Fuel Reduced (gal)	HC (tons)	CO (tons)	NOx (tons)	PM (tons)	SO2 (tons)	CO2 (tons)
2014	2,032,888	13.67	59.66	302.52	8.07	0.22	23,010
2015	2,032,888	12.77	59.66	289.07	7.62	0.22	23,010
2016	1,920,375	10.80	56.36	256.14	6.56	0.20	21,737
2017	1,787,931	9.07	52.47	224.68	5.72	0.19	20,238
2018	1,652,539	7.65	48.50	196.73	4.92	0.18	18,705
2019	1,514,123	6.51	44.44	171.91	4.17	0.16	17,138
2020	1,371,191	5.44	40.24	149.64	3.48	0.15	15,521
2021	1,224,953	4.59	35.95	126.93	2.97	0.13	13,865
2022	1,073,830	3.79	31.51	105.35	2.37	0.11	12,155
2023	916,346	3.03	26.89	84.85	1.92	0.10	10,372
2024	753,870	2.33	22.12	65.65	1.41	0.08	8,533
2025	587,673	1.68	17.25	47.94	1.04	0.06	6,652
2026	417,653	1.15	12.26	31.77	0.69	0.04	4,727
2027	243,709	0.62	7.15	17.46	0.38	0.03	2,759
2028	65,735	0.15	1.93	4.42	0.09	0.01	744
Total		**83**	**516**	**2,075**	**51**	**2**	**199,166**

Diversion of BNSF Rail Traffic

Without the project, the growth in traffic along this route would otherwise be diverted to other routes often within the Dallas – Ft. Worth nonattainment area. BNSF performed an analysis and apportioned the additional traffic to the alternative routes to determine activity that would be diverted starting before 2014 when the current rail network reaches capacity. The BNSF analysis estimated the fuel consumption difference between the proposed route and the alternative routes. The project decreases the number of trains diverted and thus reduces total gallons used. Table 4 provides the number of trains diverted daily under the build and no build scenario for BNSF.

Table 4. Number of BNSF trains diverted daily
(Network capacity; no build 28 and build 35 trains per day starting in 2014)

Year	Forecast Trains per Day	No Build		Build	
		Planned WB Slaton Divert	Planned EB Slaton Diverts	Planned WB Slaton Divert	Planned EB Slaton Diverts
2014	28.9	0.9			
2015	28.9	0.9			
2016	29.2	1.2			
2017	29.6	1.6			
2018	30.0	2.0			
2019	30.5	2.5			
2020	30.9	2.9			
2021	31.3	3.3			
2022	31.8	3.8			
2023	32.3	4.3			
2024	32.7	4.7	0.1		
2025	33.2	4.7	0.5		
2026	33.7	4.8	1.0		
2027	34.3	4.8	1.5		
2028	34.8	4.9	1.9		
2029	35.4	4.9	2.4	0.4	
2030	36.0	5.0	3.0	1.0	
2031	36.6	5.0	3.5	1.6	
2032	37.2	5.1	4.1	2.2	
2033	37.8	5.2	4.4	2.8	
2034	38.5	5.2	4.5	3.5	
2035	39.2	5.3	4.6	4.2	
2036	39.9	5.3	4.6	4.9	
2037	40.6	5.4	4.7	5.4	
2038	41.3	5.5	4.7	5.5	0.8
2039	42.1	5.5	4.8	5.5	1.5
2040	42.8	5.6	4.9	5.6	2.2
2041	43.5	5.7	4.9	5.7	2.9
2042	44.2	5.7	5.0	5.7	3.5
2043	44.9	5.8	5.1	5.8	4.1
2044	45.6	5.9	5.1	5.9	4.8
2045	46.3	5.9	5.2	5.9	5.2

The number of trains diverted correlates to the extra number of miles (19 per train) and fuel consumption in gallons (35 gallons per west bound and 390 gallons per east bound

train) increased due to the diversion. Eastbound and Westbound emissions differ by the load carried by the locomotive (westbound locomotives are considered unloaded while eastbound is loaded) and the diversion track configuration such as grade are included in the estimates as well. The number of gallons of fuel increased was used by ENVIRON as the activity for diversion and was provided by BNSF. The emissions calculated using the emission factors from Table 2 and the gallons saved (no build case subtracting the build case) are provided below. The annual benefit of the project is provided in Table 5 below.

Table 5. BNSF Rail Diversion Benefits

Year	Fuel Consumption Reduced (gallons)	HC (tons)	CO (tons)	NOx (tons)	PM (tons)	SOx (tons)	CO2 (tons)
2014	11,847	0.08	0.35	1.76	0.05	0.00	134
2015	11,192	0.07	0.33	1.59	0.04	0.00	127
2016	15,811	0.09	0.46	2.11	0.05	0.00	179
2017	20,888	0.11	0.61	2.62	0.07	0.00	236
2018	26,078	0.12	0.77	3.10	0.08	0.00	295
2019	31,384	0.13	0.92	3.56	0.09	0.00	355
2020	36,863	0.15	1.08	4.02	0.09	0.00	417
2021	42,468	0.16	1.25	4.40	0.10	0.00	481
2022	48,261	0.17	1.42	4.73	0.11	0.01	546
2023	54,298	0.18	1.59	5.03	0.11	0.01	615
2024	70,898	0.22	2.08	6.17	0.13	0.01	802
2025	135,115	0.39	3.97	11.02	0.24	0.01	1,529
2026	200,872	0.55	5.90	15.28	0.33	0.02	2,274
2027	268,210	0.68	7.87	19.22	0.41	0.03	3,036
2028	337,173	0.78	9.90	22.67	0.48	0.04	3,816
2029	405,505	0.89	11.90	25.48	0.49	0.04	4,590
2030	475,136	1.00	13.94	27.76	0.52	0.05	5,378
2031	547,464	1.03	16.07	29.57	0.60	0.06	6,197
2032	621,569	1.10	18.24	31.52	0.62	0.07	7,036
2033	662,281	1.10	19.44	31.39	0.58	0.07	7,496
2034	662,690	1.02	19.45	29.22	0.51	0.07	7,501
2035	663,046	0.95	19.46	27.04	0.51	0.07	7,505
2036	663,347	0.88	19.47	25.59	0.44	0.07	7,508
2037	665,966	0.88	19.54	24.23	0.44	0.07	7,538
2038	553,845	0.67	16.25	18.93	0.31	0.06	6,269
2039	465,709	0.56	13.67	14.89	0.26	0.05	5,271
2040	374,806	0.41	11.00	11.57	0.17	0.04	4,242
2041	293,610	0.31	8.61	8.11	0.11	0.03	3,323
2042	212,716	0.22	6.24	5.66	0.07	0.02	2,408
2043	132,130	0.13	3.87	3.42	0.04	0.01	1,496
2044	51,858	0.05	1.52	1.32	0.01	0.01	587
2045	0	0.00	0.00	0.00	0.00	0.00	0
Total		**15**	**257**	**423**	**8**	**1**	**99,189**

Diversion of Other Rail Traffic Through Nonattainment Area

To further accommodate rail volume growth in the region based on IHS Global Insight growth projections, other rail diversions are required to handle rail volume not capable of being handled through Tower 55. BNSF railroad provided the number of additional rail miles diverted due to congestion at Tower 55 under the no build and build scenarios through 2032 and estimated to be a constant benefit after that period as the build and no build diversion increase at the same rate. The average fuel rate in gallons per train-mile (11.18 gallons per train-mile estimated for the BNSF diversions) was used to determine the gallons used for other train diversions. Table 6 provides the activity between no build and build scenarios as well as the total benefits provided by the project on an annual basis.

Table 6. Other rail diversion annual activity and benefits

Year	Train-Miles Reduced (per day)	Fuel Consumption Reduced (gallons per year))	HC (tons)	CO (tons)	NOx (tons)	PM (tons)	SOx (tons)	CO2 (tons)
2014	173	706,227	5	21	105	3	0	7,994
2015	173	706,227	4	21	100	3	0	7,994
2016	346	1,412,454	8	41	188	5	0	15,988
2017	692	2,824,908	14	83	355	9	0	31,975
2018	865	3,531,135	16	104	420	11	0	39,969
2019	1,038	4,237,362	18	124	481	12	0	47,963
2020	1,211	4,943,589	20	145	539	13	1	55,957
2021	1,384	5,649,816	21	166	585	14	1	63,950
2022	1,730	7,062,270	25	207	693	16	1	79,938
2023	1,903	7,768,497	26	228	719	16	1	87,932
2024	2,076	8,474,724	26	249	738	16	1	95,926
2025	2,249	9,180,951	26	269	749	16	1	103,919
2026	2,595	10,593,405	29	311	806	18	1	119,907
2027	2,595	10,593,405	27	311	759	16	1	119,907
2028	2,595	10,593,405	25	311	712	15	1	119,907
2029	2,595	10,593,405	23	311	666	13	1	119,907
2030	2,595	10,593,405	22	311	619	12	1	119,907
2031	2,660	10,858,750	20	319	587	12	1	122,910
2032	2,790	11,389,441	20	334	578	11	1	128,917
2033	2,855	11,654,786	19	342	552	10	1	131,921
2034	2,985	12,185,477	19	358	537	9	1	137,928
2035	3,050	12,450,822	18	365	508	10	1	140,931
2036	3,180	12,981,513	17	381	501	9	1	146,938
2037	3,245	13,246,859	18	389	482	9	1	149,942
2038	3,375	13,777,549	17	404	471	8	1	155,948
2039	3,505	14,308,240	17	420	457	8	2	161,955
2040	3,570	14,573,586	16	428	450	6	2	164,959
2041	3,570	14,573,586	15	427	402	6	2	164,959
2042	3,570	14,573,586	15	427	388	5	2	164,959
2043	3,570	14,573,586	15	427	377	4	2	164,959
2044	3,570	14,573,586	15	427	370	3	2	164,959
2045	3,570	14,573,586	15	427	366	2	2	164,959
Total			**592**	**9,089**	**16,261**	**317**	**33**	**3,506,184**

References

EPA (2009), “Emission Factors for Locomotives,” Office of Transportation and Air Quality EPA-420-F-09-025 April 2009.

EPA (2008), “Regulatory Impact Analysis: Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression Ignition Engines Less than 30 Liters Per Cylinder,” Assessment and Standards Division Office of Transportation and Air Quality U.S. Environmental Protection Agency, EPA420-R-08-001, March 2008. http://www.epa.gov/otaq/regs/nonroad/420r08001.pdf

EPA (1998), “Locomotive Emission Standards,” Regulatory Support Document (RSD), United States Environmental Protection Agency, Office of Mobile Sources, April 1998.

EPA (1997), “Emission Factors (EF) for Locomotives,” EPA420-F-97-051, December 1997.