

APPENDIX G
SUPPLEMENTAL WATER QUALITY INFORMATION

APPENDIX G – Supplemental Water Quality Information

Constituents of Highway Storm Water Runoff

Studies and data collection efforts to characterize the quality of storm water runoff from high traffic volume roadways, often referred to as highway runoff, have been conducted at the national scale as well as in Texas (for example, see data compilations and storm water runoff studies in Pitt et al. 2004; U.S. EPA 1993; U.S. EPA 1999; Driscoll et al. 1990; Horner et al. 1994; Barrett et al. 1995a; Malina et al. 2005; and Hallock 2007). A number of constituents that are potentially detrimental to receiving waters have been documented in studies evaluating highway runoff characteristics, with values reported as concentrations (e.g., mg per liter) and/or as pollutant loads (e.g., kg per ha per year) that may potentially enter receiving waters. These constituents include: total suspended solids; volatile suspended solids; chemical oxygen demand; biological oxygen demand; pathogen indicator bacteria, including fecal coliform and E coli; oil and grease; nitrite + nitrate (inorganic) nitrogen; ammonia nitrogen; total nitrogen; total phosphorus; orthophosphate phosphorus; and dissolved and total metals, including copper, lead, and zinc. A summary of available information on selected highway runoff constituents is presented in **Table G-1**.

Motor vehicles generate pollutants that can be entrained in runoff as a result of emission and deposition of components of automobile exhaust and through the release of both fluids and solid particles while traveling and braking (U.S. EPA 2005). Roadway pavement wear is an important source of solid particles in highway runoff. Other, non-vehicle sources of pollutants that end up in highway runoff or discharges from highway drainage systems are atmospheric deposition onto the pavements and rights of way and vegetation management, exposed soils, or other sources associated with adjacent land uses within the drainage area of the roadway. The sources of specific highway runoff constituents have been reported by various studies. As summarized by Dupuis et al. (2002), the primary sources include: pavement wear, motor vehicle emissions, and atmospheric deposition for particulate matter; atmospheric deposition and roadside fertilizer application for nitrogen and phosphorus; tire wear, motor oil, and grease for zinc; bearing and bushing wear, moving engine parts, and brake lining wear for copper; and spills, leaks or blow-by of motor lubricants, antifreeze and hydraulic fluids for petroleum hydrocarbons. The presence of many storm water constituents of concern is associated with the particulate matter in the runoff. The constituents and amounts of atmospheric deposition are influenced by surrounding land uses, with urbanized and industrial land uses such as occur in the vicinity of the Harbor Bridge project having higher levels of deposition. A study cited in Irish et al. (1995) reported that typical dustfall in U.S. cities ranges from 2,600 to 26,000 kg/km² per month, and noted that atmospheric fallout can contribute solids, metals, nutrients and organic pollutants. Dupuis et al. (2002) identified soil, litter, bird droppings, and trucks hauling livestock or stockyard waste as the primary sources of pathogen indicator bacteria in highway runoff.

Table G-1 Concentration and Estimated Annual Load of Selected Constituents in Highway Storm Water Runoff; Reference Data From National and Texas Studies								
Constituent (Concentration Units)	National Stormwater Quality Database, (Pitt et al. 2004)	FHWA Study 31 Sites in 11 States (U.S.EPA 1993, citing Driscoll et al., 1990)	FHWA Database (Horner et al., 1994)	Loop 1 @ 35 th St, Austin, TX (Barrett et al. 1995a)		Loop 360 Bridge Austin, TX (Malina et al. 2005)		Typical Pollutant Loadings for Freeways (U.S.EPA, 1999, citing Horner et al., 1994)
	Median Conc.	Event Mean Conc. for > 30,000 ADT	Median Conc. (Range)	Median Conc.	Annual Loading kg/ha/yr	Median Conc.	Annual Loading kg/ha/yr	Annual Loading kg/ha/yr
Total Suspended Solids (TSS – mg/L)	99	142	220 (14 – 522)	131	229	91	924	987
Oil & Grease (mg/L)	8.0	--	--	4.1	7.36	4.76	35	--
Ammonia (NH ₃ – mg/L)	1.07	--	--	--	--	--	--	1.68
Nitrite + Nitrate Nitrogen (NO ₂ + NO ₃ – mg/L)	0.28	0.76	--	1.03	1.42	0.29	2.85	4.71
Total Nitrogen (mg/L)	2.28	2.59	2.72 (up to 3.4)	--	--	1.35	10.9	--
Total Phosphorus (mg/L)	0.25	--	0.59 (up to 0.7)	0.33	0.48	0.09	0.927	1.01
Total Zinc (mg/L)	0.2	0.329	0.380 (0.040 – 25.5)	0.208	0.269	0.168	1.38	2.35
E coli bacteria (MPN/100 ml)	1900	--	--	--	--	--	--	--

Source: see heading

The constituents listed in **Table G-1** are not unique to highway runoff; they are found in storm water runoff generated from most urban and developed land uses. In an evaluation of performance measures for urban storm water BMPs, the *Nationwide Urban Runoff Study* reported that there is not a significant difference in pollutant concentrations in runoff from different urban land use categories, but that there is a significant difference in runoff pollutant concentrations between urban and non-urban areas (U.S. EPA 1999). Horner et al. (1994) evaluated available information on runoff concentrations and loading rates from several sources, and concluded that highway runoff is similar to urban drainage, but with higher mean and maximum concentrations. In terms of pollutant loading rates, Horner et al. (1994) reported that the general order of pollutant loading among land uses is: industrial and commercial > freeway > higher density residential > lower density residential > open land.

Other, more recent national compilations of storm water runoff data (Pitt et al. 2004), show that concentrations of TSS, oil and grease, total phosphorus and total zinc in storm water from commercial

and industrial land uses are similar to levels found in freeway runoff. These data also show that median nitrite + nitrate levels are lower in freeway runoff than in commercial and industrial land uses, while median ammonia levels are higher in freeway runoff than in commercial and industrial land uses. There is less information available on bacteria levels in highway runoff, which are generally not directly associated with highway operations, as some of the studies reviewed did not include the highly variable bacteria parameters. Data summarized in Pitt et al. (2004) shows that median fecal coliform bacteria levels in freeway runoff samples are lower than median levels found in residential, commercial and industrial land uses, whereas median levels of E. Coli bacteria are slightly higher than residential land uses (no E.Coli levels were available for commercial and industrial land uses).

Effectiveness of Water Quality Best Management Practices

Roadway runoff may be treated by permanent Best Management Practices (BMPs) such as vegetated swales and vegetated filter strips. Implementation of such treatment measures, where practicable in consideration of the design constraints presented by the right of way and by hydraulic design and safety considerations, would be expected to reduce the concentration and loading of runoff constituents. For example, Shoemaker et al. (2002) describe the practicability and effectiveness of vegetated swales, and reported that dry swales typically remove 65 percent of total phosphorus, 50 percent of total nitrogen, and between 80 and 90 percent of metals and total suspended solids from runoff. In an evaluation of the effectiveness of a vegetated swale in the center median of a highway in Austin, Texas, Barrett et al. (1995b) concluded that the grassy swale proved effective for reducing the concentrations of most constituents in highway runoff, reporting removal efficiencies of 74 percent for total suspended solids, 88 percent for oil and grease, 59 percent for nitrate, 31 percent for total phosphorus, and 74 percent for total zinc. Furthermore, the researchers noted that the low runoff coefficient associated with infiltration within the swale effectively produced a large reduction (90 percent) in the overall pollutant load discharged (Barrett et al. 1995a).

For bridge deck runoff, direct discharge of storm water is generally avoided to the extent practicable, by conveyance to at-grade storm water drainage systems where BMPs such as vegetated swales may be used to treat runoff. Where avoidance of direct storm water discharge from bridges is impracticable, the feasibility of non-structural BMPs may be considered. Non-structural BMPs that may be applicable to bridge deck runoff include inlet cleaning and street sweeping. Dupuis et al. (2002) note that high efficiency street sweeping systems are available that can remove a significant fraction of pollutants associated with small and large particles. Shoemaker et al. (2002) discuss operational considerations for street sweeping effectiveness, and reported pollutant removal efficiencies for vacuum-assisted sweepers of 93 percent for total solids, 74 percent for total phosphorus, 77 percent for total nitrogen, and 85 percent for zinc.

City of Corpus Christi Municipal Separate Storm Sewer System (MS4)

All of the storm water discharges that would occur during the construction and operation of the proposed US 181 Harbor Bridge project are authorized by a municipal separate storm sewer system (MS4) permit issued to the City of Corpus Christi, with co-permittees that include TxDOT and the Port of Corpus Christi Authority (TPDES Permit No. WQ0004200000). This MS4 permit provides coverage for non-industrial storm water discharges, including discharges from roadway facilities, which are subject to the pollution prevention management measures of that permit, as described in the permittee's Storm Water Management Program Annual Report (City of Corpus Christi 2013a). These measures would address storm water discharges that enter the system's storm water conveyances from both construction phase and post-construction operation of the proposed roadway.

Storm water monitoring data reported by the City of Corpus Christi Storm Water Department (2013a) (see **Table G-2**) for the MS4 Storm Water Management Program indicate that levels of total suspended solids, nitrate, total nitrogen, total phosphorus and total zinc in the urban storm water of Corpus Christi are within the range of values reported in national studies of urban runoff, and are similar in terms of median and mean constituent concentrations. Median and mean concentrations of oil and grease and ammonia reported for Corpus Christi storm water sampling are somewhat lower than the levels reported in other national data sets that were reviewed (Pitt et al. 2004; Horner et al. 1994; and Hallock 2007), and the range reported for ammonia was notably lower in the Corpus Christi data. The median concentration of E coli bacteria reported for Corpus Christi storm water sampling is considerably higher than levels reported from a national data set (Pitt et al. 2004). The city storm water data also showed high levels of Enterococci, the pathogen indicator bacteria for marine waters; however, no data on Enterococci levels were available for comparison from national urban runoff or highway runoff sampling. **Table G-2** includes results of storm water sampling for these priority constituents from the most recent Corpus Christi Storm Water Management Program annual report (City of Corpus Christi 2013a).

Table G-2: City of Corpus Christi MS4 Storm Water Runoff Sampling Results^{1,2}

Constituent (Concentration Units)	Outfall 1: Carmel Pkwy	Outfall 2: Rodd Field	Outfall 3: Schanen	RANGE, Total Number of samples with Values	MEDIAN Conc.
Total Suspended Solids (TSS – mg/L)	IRF, CPM, 219, 75, IRF, 263, 99	25, CPM, 59, PC, EF, 10, 121	EF, 58, 46, 55, CPM, 270, 32	10 – 270 13	59
Oil & Grease (mg/L)	4, 3.0, PC, PC, 9, 3.0, PC	MFF, 3.0, PC, <3, <3, <3, PC	<3, 9.6, PC, PC, <3.0, PC, 4.0	<3 – 9.6 12	3.0
Ammonia (NH₃ – mg/L)	IRF, CPM, <0.2, <0.2, IRF, 0.2, <0.2	<0.2, CPM, <0.2, PC, EF, <0.2, <0.2	EF, <0.2, <0.2, 0.2, CPM, <0.2, <0.2	<0.2 – 0.2 13	<0.2
Nitrate Nitrogen (NO₃ – mg/L)	IRF, CPM, 0.6, 0.47, IRF, 1.30, 0.7	<0.2, CPM, 0.2, PC, EF, <0.2, <0.2	EF, <0.2, 0.7, <0.2, CPM, 0.3, <0.2	<0.2 – 1.3 13	0.2
Total Nitrogen (mg/L)	IRF, CPM, 2.9, 1.47, IRF, 5.1, 2.4	1.1, CPM, 1.7, PC, EF, <1.2, <1.6	EF, 1.4, 2.5, <1.4, CPM, 2.9, <2.20	1.1 – 5.1 13	1.5
Total Phosphorus (mg/L)	IRF, CPM, 0.4, 0.22, IRF, 0.6, 0.5	<0.2, CPM, <0.2, PC, EF, <0.2, 0.27	EF, <0.2, <0.2, 0.2, CPM, 0.4, <0.2	<0.2 – 0.6 13	0.2
Total Zinc (mg/L)	IRF, CPM, 0.143, 0.621, IRF, 0.162, 0.109	0.469, CPM, 0.023, PC, EF, 0.055, 0.864	EF, 0.067, 0.028, 0.037, CPM, 0.109, <0.005	<0.005 – 0.86 13	0.109
E coli bacteria (MPN/100 ml)	12053, 70790, PC, PC, 30368, 26695, PC	MFF, 1767, PC, 71, 4246, 274, PC	8061, 5607, PC, PC, 6967, PC, 59401,	71 – 70790 12	7514

¹ Seasonal monitoring periods for the November 2011 through October 2012 Annual Report are: Dry – Nov 1 to Apr 30; Wet – May 1 to Oct 31. Seven sampled storms in order of data entered: 11/3 or 15/2011; 12/2/11; 12/3/2011 or 1/25/2012; 12/10 - 11/2011 or 3/20/2012; 5/8, 10, or 15/2012; 6/19-21/2012 or 5/12/2012; and 6/21 or 29/2012 or 9/14/2012.

² Sampling explanation codes where values not reported: IRF = insufficient rainfall; CPM = collected past midnight; PC = previously collected; MFF = missed first flush; EF = equipment failure.

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