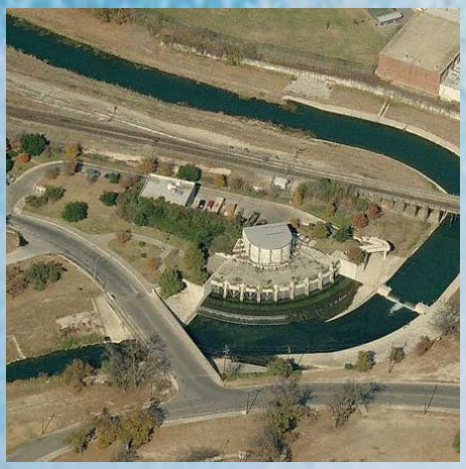
Upper San Antonio River Revised Watershed Protection Plan Summary

San Antonio River Authority
Bexar Regional Watershed Management Partnership
Texas Commission on Environmental Quality



James Miertschin & Associates, Inc.

JAMES MIERTSCHIN & ASSOCIATES, INC.
ENVIRONMENTAL ENGINEERING (F-2458)
P.O. BOX 162305 • AUSTIN, TEXAS 78716-2305 • (512) 327-2708

DRAFT

UPPER SAN ANTONIO RIVER
REVISED WATERSHED PROTECTION PLAN SUMMARY

Prepared For:

San Antonio River Authority
100 East Guenther Street
San Antonio, Texas 78204

and

Bexar Regional Watershed Management Partnership

Prepared in Cooperation With:

Texas Commission on Environmental Quality

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Prepared By:

James Miertschin & Associates, Inc.

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LIST OF ABREVIATIONS

BMP	best management practice
BRWM	Bexar Regional Watershed Management Partnership
BST	bacterial source tracking
CFR	Code of Federal Regulations
cfs	cubic feet per second
CFU	Colony Forming Units
COSA	City of San Antonio
E. coli	*Escherichia coli*
EARZ	Edwards Aquifer Recharge Zone
EPA	United States Environmental Protection Agency
gpm	gallons per minute
JMA	James Miertschin & Associates, Inc.
LID	Low Impact Development
MEP	Maximum Extent Practicable
MGD	million gallons per day
MS4	municipal separate storm sewer system
NPDES	National Pollutant Discharge Elimination System
org/100mL	bacteria count per 100 milliliters of water
SARA	San Antonio River Authority
SAWS	San Antonio Water System
SWMP	Stormwater Management Plan

TCEQ	Texas Commission on Environmental Quality
TMDL	total maximum daily load
TPDES	Texas Pollutant Discharge Elimination System
TxDOT	Texas Department of Transportation
USAR	Upper San Antonio River
UV	ultraviolet
WPP	Watershed Protection Plan

1.0 INTRODUCTION

1.1 WATERSHED PROTECTION PLAN CONCEPT

A Watershed Protection Plan (WPP) is a study of pollutant sources and a plan of action consisting of control measures to control those sources. A WPP is voluntary in that it is not required by any applicable rules or regulations, in contrast to Total Maximum Daily Load (TMDL) studies which are mandated by the US Environmental Protection Agency (EPA). The WPP is meant to follow the TMDL and serve as a template for control measures that may be incorporated in the subsequent TMDL Implementation Plan. A benefit of the WPP is that it is a stakeholder-driven process. Stakeholders are local entities and individuals who provide input during development of the WPP. Therefore, the WPP is an opportunity for local control and direction to guide the Implementation Plan that will ultimately be approved by the Texas Commission on Environmental Quality (TCEQ).

This document is a revised version of the original WPP document that was issued in December 2006 (JMA, 2006a). The original WPP was a complete report that was finalized and accepted by the TCEQ, but there were lingering technical and administrative issues presented in post-final review comments from the EPA that needed to be addressed in order to secure EPA approval. This revised version provides additional clarification on the issue of point source versus nonpoint source controls, requirements of the MS4 permit, quantification of the anticipated bacteria load reductions, and a brief update of recent water quality monitoring activities. The format of the revised WPP document incorporates the information contained in "Part I - WPP Summary" of the original WPP report. The remainder of the original WPP report, namely "Part II - Supplemental Sections and Appendices", containing lengthy generic descriptions of BMPs, will not be modified in this revised document. Where necessary, reference will be made to any applicable information presented in the original WPP report. The revised WPP document will therefore be a more concise summary version of the original WPP report, and the content of the original report will be incorporated by reference.

This WPP presents a voluntary strategy for reducing bacteria levels in the Upper San Antonio River above Loop 410 South. A TMDL for the Upper San Antonio River, has set "allocations" for the allowable discharges of bacteria to the river. Adoption of the TMDL by the TCEQ represents an update to the state's Water Quality Management Plan and will thus serve as the basis for permitting decisions in the watershed. In this way, the TMDL may lead to modifications to wastewater and storm water permits issued by the TCEQ, which may or may not be addressed in the WPP. The TMDL Implementation Plan may incorporate some or all of the action items of the WPP; but it will not be limited or postponed by the WPP.

1.2 PROJECT DEVELOPMENT

The WPP was prepared in response to a bacteria TMDL study for the Upper San Antonio River, Segment 1911, that was adopted by the TCEQ in 2007 (TCEQ, 2007). In work completed in conjunction with the TMDL, it was confirmed that bacteria levels in the Upper San Antonio River regularly exceed state standards, and that significant load reductions are required in order

for bacteria levels in the river to be reduced to levels considered acceptable for primary contact recreation.

The urban environment surrounding the Upper San Antonio River has many potential sources of bacteria. The ultimate source of these bacteria is fecal matter originating from warm blooded animals (wildlife, pets, livestock, and humans). Bacteria from these sources can reach the San Antonio River through numerous potential pathways, including:

1. Direct deposition into a waterbody (i.e. ducks)
2. Deposition onto the land surface which is available for subsequent washoff (i.e. dogs)
3. Leaking wastewater infrastructure (human)
4. Improperly treated municipal discharges (human)

The WPP addresses potential sources of bacteria in terms of their magnitude and in terms of available management measures - often referred to as best management practices (BMPs).

This report is conceptual with respect to the exact locations and sizes of structural stormwater BMPs. The report presents the level of treatment that will be required within the study area for various source types. Additional planning and stakeholder input from local communities will be required (and is ongoing) before exact BMP locations can be selected and implemented.

Watershed management is an iterative process, and pollutant removal goals may not always be attained in the first or second round of BMP deployment (EPA, 2005). Therefore, monitoring will continue to be required to assess the health of the watershed and to determine the effectiveness of the various BMPs.

1.3 PROJECT BACKGROUND

1.3.1 Upper San Antonio River Basin

The study area for the WPP consists of the watershed of the Upper San Antonio River (TCEQ Segment #1911) upstream of Loop 410 South. The river basin encompasses all of San Antonio's downtown area and much of the central and eastern portions of the City. The total drainage area of the study is about 125 square miles (80,000 acres). The river's watershed and major tributaries are shown in Figure 1-1.

The San Antonio River begins just north of East Hildebrand Avenue at the San Antonio Springs, which discharge at rates of 0 to 100 cfs, depending upon the level of the Edwards Aquifer. The tributary Olmos Creek, with headwaters north of Loop 1604, joins the river near the origin. From here, the river flows through downtown San Antonio and the River Walk. South of downtown, the river is joined by San Pedro Creek and its tributaries. These tributaries have a drainage area of 45 square miles (29,000 acres), and represent a significant portion of the overall watershed. San Pedro Creek is fed by the San Pedro Springs which discharge at rates from 0 to 17 cfs, depending upon the level of the Edwards Aquifer.

Below the confluence with San Pedro Creek, the topography becomes relatively flat. Drainage in the southeast portion of the study area is defined primarily by a series of storm sewers and

channels. Six-Mile Creek (also known as Piedras Creek) is the only major tributary, and it is highly channelized. Above the confluence with 6-Mile Creek, the 330 foot long New Espada Dam impounds Davis Lake. From Olmos Dam to Loop 410, the San Antonio River travels about 14.4 miles.

The San Antonio River has been modified to suit the needs of the urban environment. Several sections of the river have been straightened and lined with concrete or rock. Numerous small dams and gates control the flow of the river at various locations. Perhaps the most significant enhancement is the San Antonio River tunnel, which is a three mile long, 24-foot diameter conveyance structure that allows storm flows to bypass downtown. There is also a smaller tunnel that provides stormwater relief for San Pedro Creek. Many of these features are shown in Figure 1-2, which highlights the highly urbanized downtown portion of the river.

Springs and rainfall runoff are not the only major sources of flow in the San Antonio River. The San Antonio Water System (SAWS) has the ability to discharge reclaimed water (treated wastewater) into the river at various locations, as shown on Figure 1-2. These discharges are useful for keeping a minimum base flow moving through the river at all times. Therefore, these discharges are typically only active when natural stream flows are minimal (i.e. when San Antonio Springs are not discharging due to low aquifer level).

The river also receives regular flow from the San Antonio Zoo. This flow is pumped from the Edwards Aquifer at a relatively constant rate (averaging 3.8 cfs, 1700 gpm), and flows through a number of Zoo exhibits before discharging through an open channel to the San Antonio River. This flow will be discussed in further detail in Section 5.0.

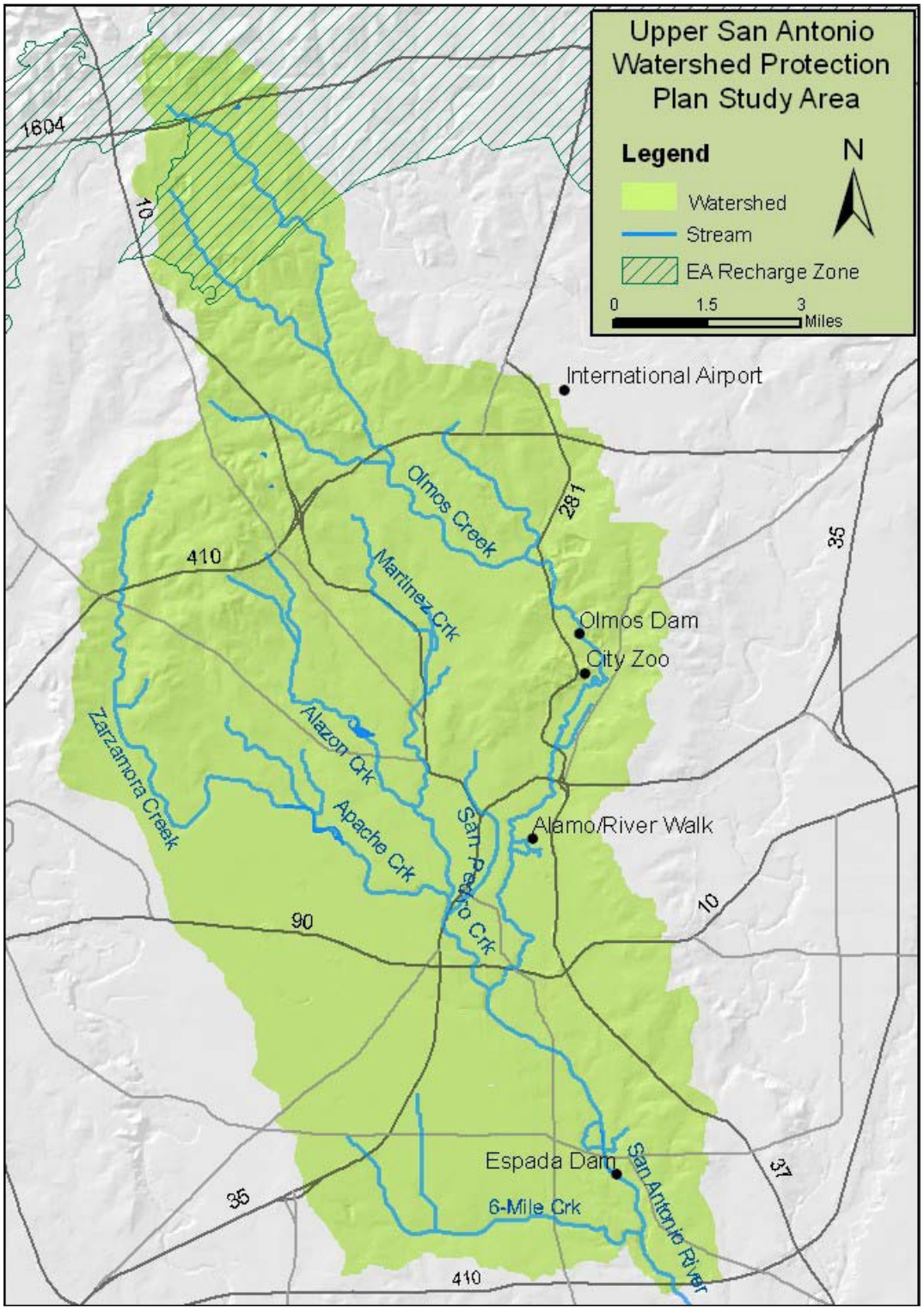

Figure 1-1: Upper San Antonio River Watershed and Tributaries

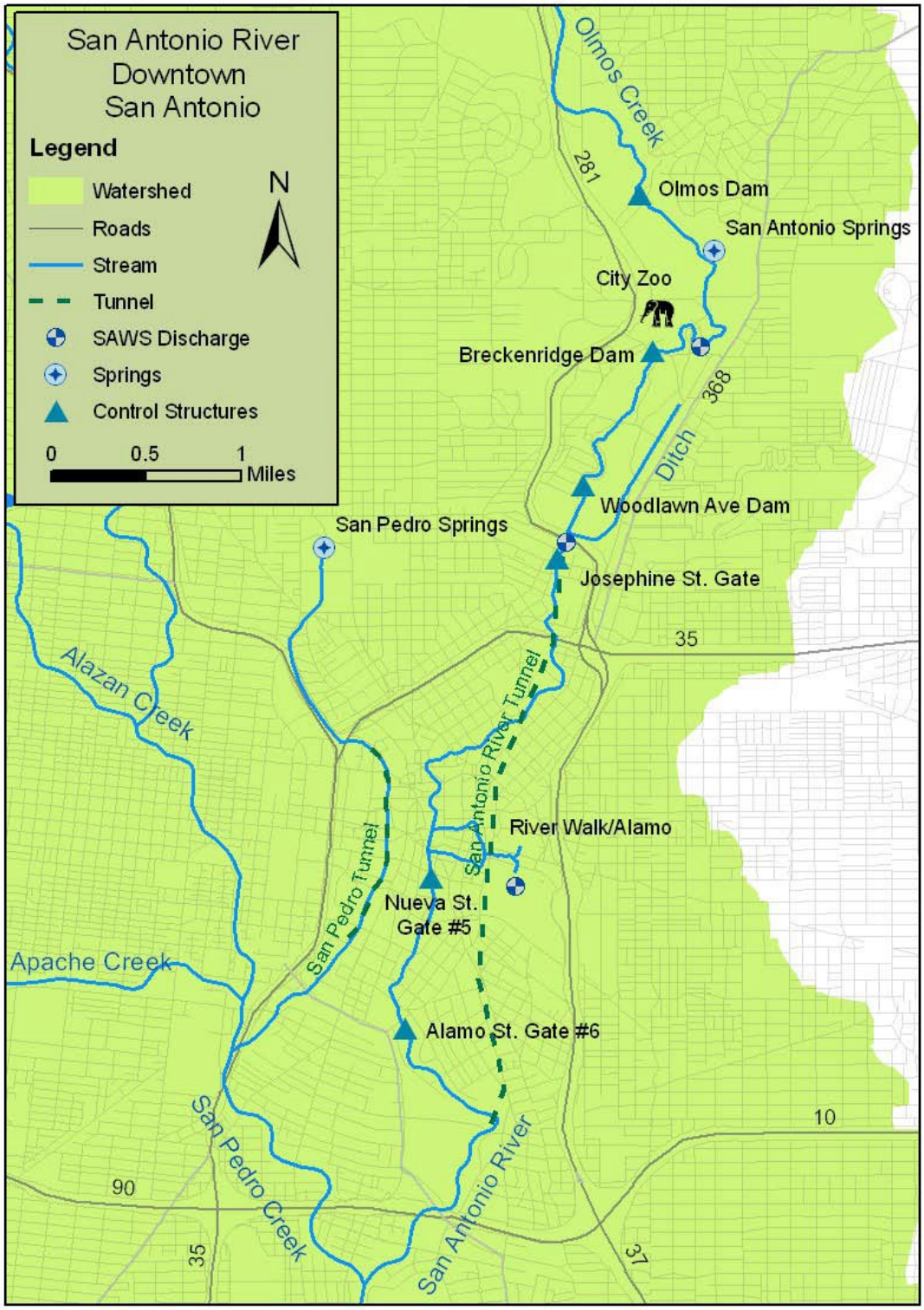

Figure 1-2: Upper San Antonio River in Downtown San Antonio

1.3.2 Water Quality Criteria for Bacteria

According to Texas water quality standards for primary contact recreation waters developed by the TCEQ, the geometric mean of samples should not exceed 126 org/100ml *E. coli*, or 200 org/100ml fecal coliform. In addition, grab samples should not exceed 399 org/100ml *E. coli* or 400 org/100ml fecal coliform. However, according to TCEQ guidance documents, if less than 25% of samples exceed the grab sample criterion, then the water body is not typically classified as impaired (unless the geometric mean criterion is exceeded).

It is standard convention to report bacteria levels in terms of a bacterial count per 100 milliliters. The bacterial count is often referred to in a number of different ways, including the number of organisms (org/100mL), or the number of colonies (col/100mL), or the number of colony forming units (CFU/100mL). In reality, these different nomenclatures all represent the same thing, which is the number of colony-forming bacteria identified during a laboratory test. This report will use "org/100mL" as the standard nomenclature.

1.3.3 Assessment of Bacteria Impairment

Section 303(d) of the Federal Clean Water Act and the U.S. Environmental Protection Agency (EPA) Regulation 40 CFR 130.7 require states to identify waterbodies that do not meet, or are not expected to meet applicable water quality standards. This compilation of subject waterbodies is known as the 303(d) List. Each state must assign priorities to waterbodies on the list in order to schedule development of TMDLs. The TMDL is an allocation of point and nonpoint source pollutant loadings that will enable the waterbody to meet water quality standards.

As a result, in 2000, the Upper San Antonio River (Segment 1911) was added to the state's 303(d) List due to nonsupport of contact recreation resulting from elevated levels of bacterial indicators for pathogens. Freshwater bacterial indicators for pathogens include fecal coliform and *Escherichia coli* (*E. coli*). *E. coli* has recently become the preferred indicator for estimating the level of pathogens, but fecal coliform can be used as an alternate indicator while additional data on *E. coli* are being collected. (Fecal coliform was selected as the key modeling parameter in work associated with the TMDL and WPP, but final TMDL allocations are assessed with respect to *E. coli*. Fecal coliform measurements were converted to *E. coli* using a ratio of 0.63 *E. coli* per fecal coliform.) These coliform bacteria are associated with the fecal matter of all warm-blooded animals.

1.4 REVIEW OF TMDL RESULTS

The TCEQ completed the bacteria TMDL development for the Upper San Antonio River (TCEQ, 2007). This work included data collection, analysis, supplemental sampling, mathematical modeling of water quality, load allocations, and report preparation (JMA, 2006b). The TMDL addressed bacteria impairment in Segments 1910 - Salado Creek, Segment 1910A - Walzem Creek, and Segment 1911 - Upper San Antonio River.

1.4.1 Source Identification

As part of this project, a number of bacterial sources were identified. These sources fall into two primary categories – point and nonpoint. Point sources are inputs of bacteria that can be attributed to a specific facility or a specific geographic location. Nonpoint sources include diffuse bacteria inputs that have the potential to occur over a large geographic area. These are traditional definitions of the general categories, and not necessarily regulatory definitions.

The TMDL identified several existing point and nonpoint sources for indicator bacteria. Point sources are typically regulated by a discharge permit, but this is not always the case. There are three permitted municipal effluent (SAWS reclaimed water) outfalls located in the WPP study area. However, these point sources utilize disinfection to ensure that bacteria concentrations consistently meet state criteria. Other permitted discharges, such as industrial outfalls, may also exist in the study area, but are not considered potential sources because of the low likelihood of containing pathogens. One significant non-permitted point source was identified in the original WPP report as the San Antonio Zoo, later brought under permit coverage as described below.

Stormwater runoff, which conveys bacteria from the land surface to the receiving stream, is the single largest source of bacterial loading in the San Antonio River. Traditionally, stormwater runoff has been considered a nonpoint source. However, as a result of EPA guidelines, when stormwater is regulated by a municipal separate storm sewer system (MS4) permit, the stormwater is considered a point source. As a major municipality, San Antonio is required to have an MS4 permit, and thus all runoff-related bacteria loads in the study area are considered to be point sources. After development of the original WPP report, the Zoo discharge was assigned to the MS4 permit for coverage.

There are nonpoint sources in the San Antonio River watershed that are not associated with rainfall runoff, and these have been labeled as direct nonpoint sources in the terminology of the TMDL. Direct nonpoint sources are those sources that have the potential to enter the river system at all times, regardless of climatic conditions. Potential direct sources for indicator bacteria include sources such as wastewater infrastructure, direct animal defecation, and septic systems.

1.4.2 Linkage Between Sources and Receiving Waters

Establishing a link between in-stream water quality and the pollutant sources is a critical component of the TMDL process. This relationship allows for the evaluation of management options that will achieve the desired water quality goals. A variety of techniques are available for creating this link, ranging from qualitative assumptions based on scientific principles to sophisticated mathematical modeling. In the development of the TMDL for the Upper San Antonio River, the relationships were defined through a computer simulation model. Monitored flow and water quality data were used to calibrate the relationships used in this model. Water quality data and model development were discussed in further detail in Sections 3.0 and 4.0, respectively, of the original WPP (JMA, 2006a).

The bacterial loads associated with the model calibration can be readily examined in terms of load originating from the land use categories and point sources embodied in the analysis. The

simulated loads for the WPP study area are compared graphically in Figure 1-3. The loads presented are the total annual average loads of *E. coli* that enter the impaired stream under existing conditions. The loads do not account for decay that occurs as the bacteria travel downstream.

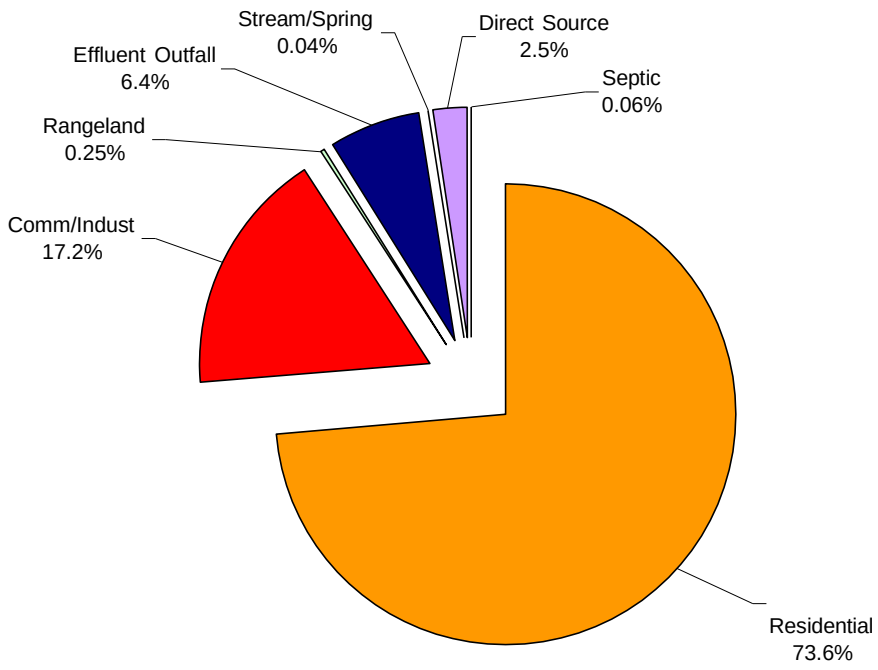

Figure 1-3: Bacteria Sources (Annual Loadings) in the WPP Study Area

Loads from residential, commercial/industrial, and rangeland sources are the result of washoff during rainfall events. The remaining four source categories discharge continuously, independent of climatic conditions. Although the loads from these latter four categories appear relatively small on an annual basis, they have a large effect on water quality in the river under baseflow conditions, which occur most of the time.

For the study reach, it is apparent that the largest presumed source of fecal coliform bacteria is washoff from residential areas. This is attributable to the fact that residential is the largest land use category in terms of acreage, and it is the recipient of bacterial deposition from pets and wildlife. The next largest contribution is estimated to be commercial/industrial, which also receives deposition from pets and wildlife, but at a presumably lower rate. The third largest source is shown to be effluent outfalls, and this source category is dominated by loads from the San Antonio Zoo (the loading from reclaimed effluent outfalls is essentially negligible). The Zoo loadings are discharged under both baseflow and runoff conditions: under baseflow

conditions, the Zoo represents the largest bacterial load present; under wet weather conditions, stormwater runoff loadings dominate.

The TMDL modeling work (JMA, 2006b) developed bacterial loading estimates for a network of subwatersheds that contribute flow to the impaired segment of the Upper San Antonio River. Each subwatershed corresponds to a defined reach of the receiving stream, whether mainstem or tributary. Contributions for each of these subwatershed/reach combinations derived from the modeling analysis are presented in Table 1-1, with loadings in terms of annual bacterial loadings of *E. coli* that emanate from the land surface and other sources.

Table 1-1: Current Subwatershed Bacterial Loadings (10^9 org/year *E. coli*)

Reach	Residential	Comm/Indust	Rangeland	Reclaim Outfall	Zoo Outfall	Stream/Spring	Direct Source	Septic	Grand Total
36	279,949	58,394	4,489	0	0	0	16,243	3,313	362,388
59	594,777	191,073	1,836	0	0	0	37,389	12	825,086
60	117,242	15,132	611	0	0	2,092	3,561	1	138,639
61	48,431	7,864	279	40	391,860	0	4,548	0	453,023
62	97,436	24,608	515	4	0	0	3,012	0	125,575
65	46,253	55,024	44	0	0	0	5,297	0	106,619
64	34,888	53,442	7	0	0	0	3,358	0	91,695
66	24,013	11,481	2	0	0	0	2,278	0	37,775
67	163,510	33,703	58	0	0	0	3,340	1	200,613
17	95,047	51,987	0	0	0	361	1,433	1	148,829
18	939,128	116,025	2,152	0	0	0	11,722	22	1,069,049
19	771,712	95,556	247	0	0	0	4,113	6	871,634
63	93,951	29,486	0	0	0	0	1,172	2	124,611
68	516,865	79,451	532	0	0	0	2,719	3	599,570
69	158,932	17,732	683	0	0	0	845	2	178,194
70	44,544	40,970	1,226	0	0	0	1,480	8	88,227
77	455,345	149,670	1,404	0	0	0	47,438	6	653,863
71	3,208	16,927	1,303	0	0	0	1,132	5	22,575
Total	4,485,231	1,048,527	15,389	44	391,860	2,453	151,080	3,381	6,097,965
Source Total	5,549,146			44	391,860	2,453	151,080	3,381	6,097,965

Note: units are presented as billions of organisms per year to facilitate comparisons

The subwatersheds were delineated based upon hydrologic flow patterns, rather than neighborhoods, land use, or socioeconomic considerations. Loading factors for washoff of bacteria in the model were a function of land use. As a result, the magnitude of loading from a specific watershed is based upon land use characteristics and surface area of the land use. Therefore, a subwatershed with higher loads would typically be due to a larger area and specific land use traits. In this sense, the subwatershed relative rankings are not indicative of local priority "hot spots" of bacteria sources, and the magnitude of loadings is not sufficient to target specific watersheds for priority action with respect to BMP deployment.

1.4.3 Required Load Reductions

The TMDL modeling exercise led to the development of bacterial load allocations for the Upper San Antonio River. Allocations were determined based on the reductions in existing loads (Figure 1-3) required to bring the river into compliance with state criteria for bacteria. Table 1-2 summarizes the existing loads, required reductions, and loading allocations for bacteria sources

within the WPP study area. These loadings are summations of the subwatershed loadings shown in Table 1-1, representing loadings emanating from the various sources. (Later, Table 3-1 summarizes anticipated load reductions.),

Table 1-2: Required Loading Reductions from TMDL (10^9 org/year *E. coli*)

Source Type	Existing Load	Reduction	TMDL Allocation
Point Sources:			
Storm water (MS4 Permit)	5,549,146	30%	3,884,402
SAWS Reclaimed Effluent Outfalls	44	0%	44
San Antonio Zoo	391,860	99.9%	392
Point Source Subtotal	5,941,050		3,884,838
Nonpoint Sources			
Springs	2,453	0%	2,453
Septic Systems	3,381	0%	3,381
Other Direct Sources	151,080	50%	75,540
Nonpoint Source Subtotal	156,914		81,374
Total	6,097,965		3,966,212

Note: units are presented as billions or organisms per year to facilitate comparisons

It should be noted that the reductions shown in Table 1-2 are not the only combination of reductions that could be used to achieve compliance with state criteria. A similar scenario, but with 70% direct source reduction and 0% storm water reduction, was also shown to achieve compliance within the WPP study area (JMA, 2006b). The combination of reductions included in Table 1-1 was determined based on best professional judgment, considering what reductions are most likely to be feasible and effective. Based on this fact, and the uncertainties inherent in the modeling process, it is possible that some other similar combination of loading reductions might also lead to compliance with water quality criteria. Ultimately, future in-stream bacteria monitoring will be the test of success for the WPP.

The bacterial loadings and reductions shown in Table 1-2 were prescribed in the TMDL to achieve compliance with the water quality criterion. The required load reductions can also be shown graphically, which is particularly useful to illustrate reductions over time. For purposes of the WPP, an overall 40-year time frame is projected. Initially, a proportionally larger reduction is anticipated for the first time interval, as the zoo disinfection system becomes operational. Subsequent time intervals reflect the systematic reduction in primarily stormwater runoff loads, a process that will require a substantial period of time in the fully developed urban environment. A large component of the stormwater reduction will be associated with application of LID principles to urban redevelopment (see Sec. 3.1.2.3). The Center for Watershed Protection (Schueler, et al, 2007) has prepared a series of manuals (funded by EPA) to provide guidance for urban subwatershed restoration. In Urban Stormwater Retrofit Practices (Schueler, et al, 2007), it is estimated that a sizeable fraction of every subwatershed will undergo redevelopment, infill, or infrastructure rehabilitation over a period spanning several decades, with typical design or service life of 50-60 years for buildings, 20-30 years for parking lots, 40- 50 years for bridge decks, and 30-50 years for drainage infrastructure. The anticipated 40-year WPP time frame is for planning purposes, and actual successful reductions may occur earlier or later.

Figure 1-4 displays the bacterial load reductions moving forward with time. At year 2006, the *E. coli* annual loads are shown at their magnitudes defined in the TMDL. (Note that the graph does not begin at an ordinate value of 0.0 in order to provide a reasonable figure size. As a consequence, the loadings for septic systems and springs are too small to be readable.) As shown in Figure 1-4, stepwise reduction in the zoo load, the stormwater load, and the direct source load over a projected 40-year timeline results in compliance with the applicable water quality criterion. In the figure, this compliance level is represented by the annual *E. coli* loading of 3.966 x 10^{15} org/year.

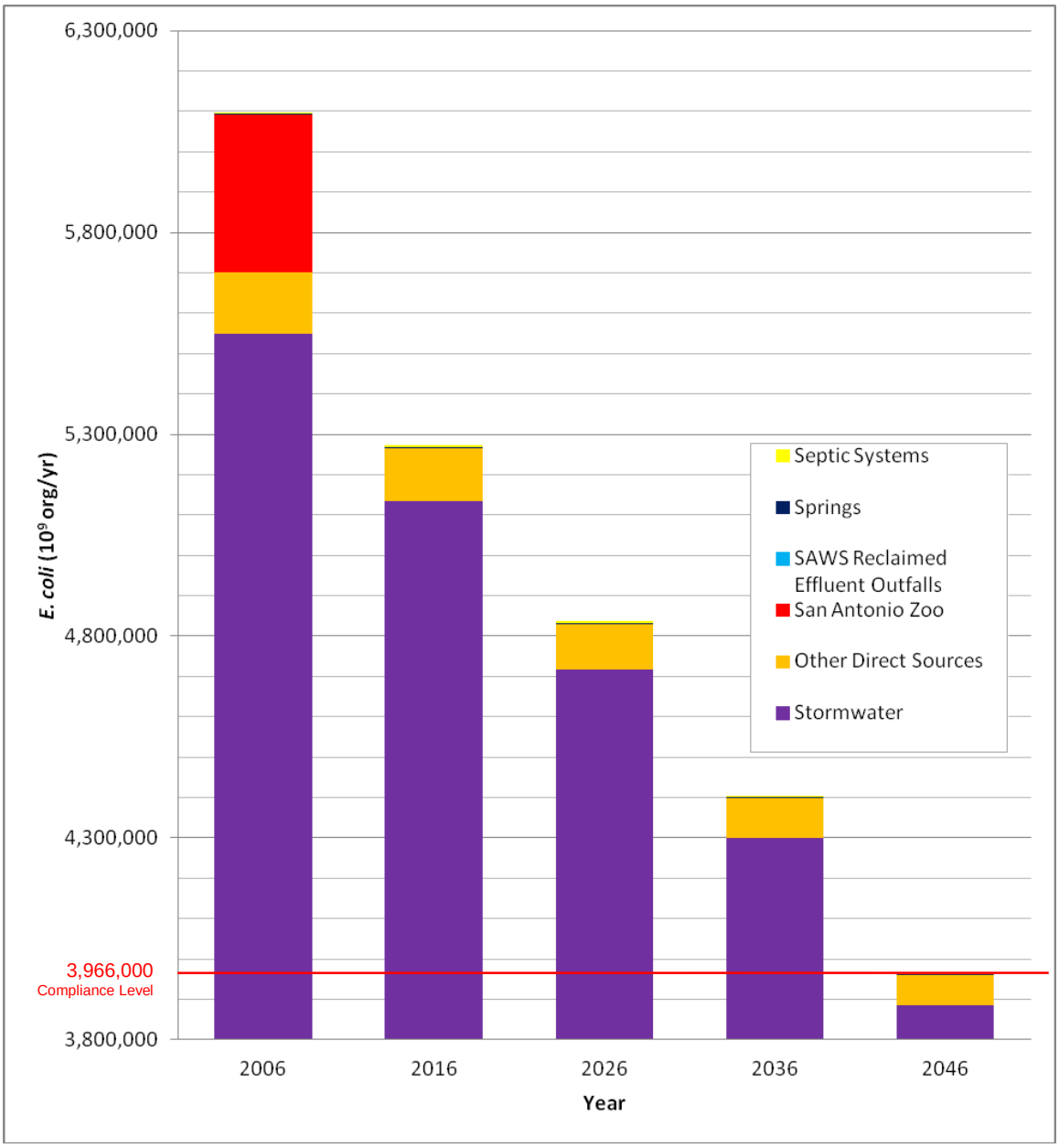

Figure 1-4: Bacteria Loading Reductions over Time in the Study Area

An alternate graphical presentation of the same information can be prepared using a logarithmic scale for the ordinate axis. As shown in Figure 1-5, each of the component *E. coli* loadings is represented by a discrete line, and the reductions for each component are accounted for. This format does not mask viewing of the septic loadings and spring loadings. Similar to Figure 1-4, this format also displays a 40-year timeline for compliance.

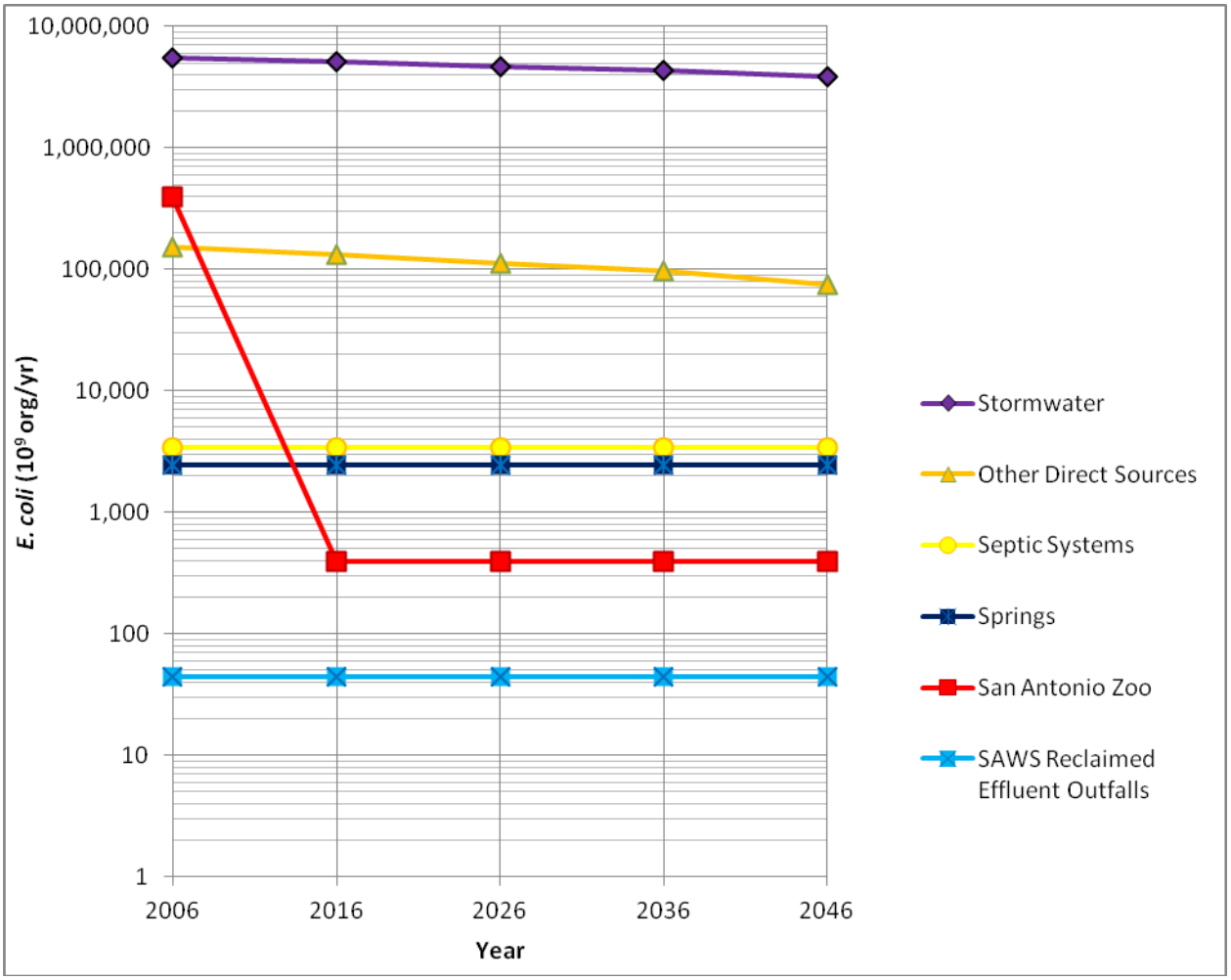

Figure 1-5: .Log-Scale Bacterial Load Reductions Over Time in the WPP Study Area

It is apparent from Table 1-2, Figure 1-4, and Figure 1-5 that stormwater runoff is the predominant *E. coli* bacteria loading source in the study area on an annual basis. The magnitude of the stormwater loading and the required reduction are an order of magnitude greater than other components. This stormwater load is covered under the MS4 permit for the study area, which is described in detail in the next section. The MS4 permit requires an array of activities and BMPs with the potential to effect water quality. However, the MS4 permit lacks specificity regarding

implementation of structural BMPs for stormwater treatment and for most other BMPs, particularly with respect to amelioration of bacteria loadings.

1.5 MS4 PERMIT COVERAGE

The current City of San Antonio Municipal Separate Storm Sewer System (MS4) permit was issued by the TCEQ on April 11, 2011. The named co-permittees are the City of San Antonio, Texas Department of Transportation (TxDOT), and San Antonio Water System (SAWS). The permit authorizes stormwater discharges from the coverage area that includes the developed urban areas of the City. Discharges occur to ditches, storm drains, and tributaries that ultimately reach the Upper San Antonio River segments. The permit coverage area includes the WPP study area.

The current MS4 permit does not specifically address the bacteria impairment in the permit area. Further, it provides no quantifiable goals or limitations regarding discharge of bacterial loadings from the MS4 area. There are no actions or BMPs prescribed for either the City, TxDOT, or SAWS for specific management of bacterial loadings. Instead, the MS4 establishes general runoff control practices and requirements for each entity, some of which may also contribute to reduction of bacteria loadings.

The co-permittees are instructed by the MS4 permit to develop and implement a Storm Water Management Program (SWMP) to control storm water quality. The program must include controls necessary to prohibit non-storm water discharges, and must reduce the discharge of pollutants to the Maximum Extent Practicable (MEP). (Note, the definition of practicable, taken from the 40 CFR Sec. 404 (b)1 guidelines, shall mean "available and capable of being done after taking into consideration cost, existing technology, and logistics in light of overall project purposes.") Each co-permittee prepares a separate SWMP for their areas of responsibility, which together comprise the overall permit-mandated SWMP.

The MS4 permit requires that the SWMP contain the following elements:

1. Structural controls - operate to reduce pollutant discharge to MEP
2. Areas of new development/significant redevelopment - limit/reduce discharge of pollutants
3. Roadways - minimize discharge of pollutants
4. Flood control projects - assess influence on receiving water quality, provide retrofits where practical
5. Pesticide, herbicide, and fertilizer application - develop/implement controls to reduce discharge
6. Illicit discharges and improper disposal
    a. Illicit non-storm water discharges to MS4 prohibited
    b. Overflows and infiltration - prevent dry weather and wet overflows from sanitary sewers, limit infiltration/seepage from sewers
    c. Floatables - reduce discharge of litter/refuse, include source controls, structural controls or others where necessary

    d. Household hazardous waste and used motor vehicle fluids - prohibit discharge of hazardous waste, motor vehicle fluids, disposal of grass clippings, leaf litter, animal wastes
    e. MS4 screening and illicit inspections - include Dry Weather Screening Program to locate suspected illicit discharges
    f. Elimination of illicit discharges and improper disposal - minimize discharge of pollutants
    g. Maintain list of NPDES/TPDES permitted discharges
7. Spill prevention and response - continue/improve programs
8. Industrial & high risk runoff - continue/improve programs to identify and control
9. Construction site runoff - reduce discharge of pollutants
10. Public education - implement program for illicit discharges, improper disposal
11. Monitoring and screening programs -
    a. Dry weather screening program - continue efforts to detect illicit/improper discharges
    b. Wet weather screening program - sampling and non-sampling techniques for screening and follow-up
    c. Industrial and high risk runoff monitoring program - monitoring or no exposure certification

While the preceding list of requirements is extensive, it is apparent that it does not specifically list a specific number of, say, structural BMPs, BMP sizing, or BMP placement in the permit coverage area. Instead, the requirements are guidelines designed to provide flexibility for the co-permittees to achieve the objectives.

2.0 WATER QUALITY MONITORING

2.1 UPDATE TO MONITORING DATA

2.1.1 Implementation Plan Support Monitoring

There has been extensive *E.coli* monitoring conducted in the study area since the time of the original WPP report (JMA, 2006a). Much of the sampling has targeted identification of potential sources of bacteria loadings.

A comprehensive, focused monitoring program was executed over 2008 - 2009 by SARA in support of development of an implementation plan for bacteria impairment. The monitoring program included routine (roughly monthly) synoptic sampling surveys designed to explore the spatial and temporal variation in bacteria levels in streams throughout the study area. In addition, spatially intensive surveys were designed to be performed (twice) under non-storm water hydrologic conditions along the entire length of the Upper San Antonio River and its major tributaries. These intensive surveys featured sampling more spatially dense than the synoptic sampling surveys, and were intended to ensure that all potential sources of loadings were accounted for. Voluminous amounts of *E. coli* data were obtained, and a full description of the results and analyses is available in the final report, entitled "BMP Assessment Report Update" (JMA, 2010).

As an example of the monitoring results and presentation, a mapping of the synoptic *E. coli* data for the February 2009 survey is shown in Figure 2-1. Monitoring stations are represented by colored circles. This plot is typical of the numerous monthly plots available in the report, showing several stations, mainstem and tributary, with *E. coli* concentrations in excess of the average criterion of 126 org/100 mL. Station results varied over a wide range from month to month.

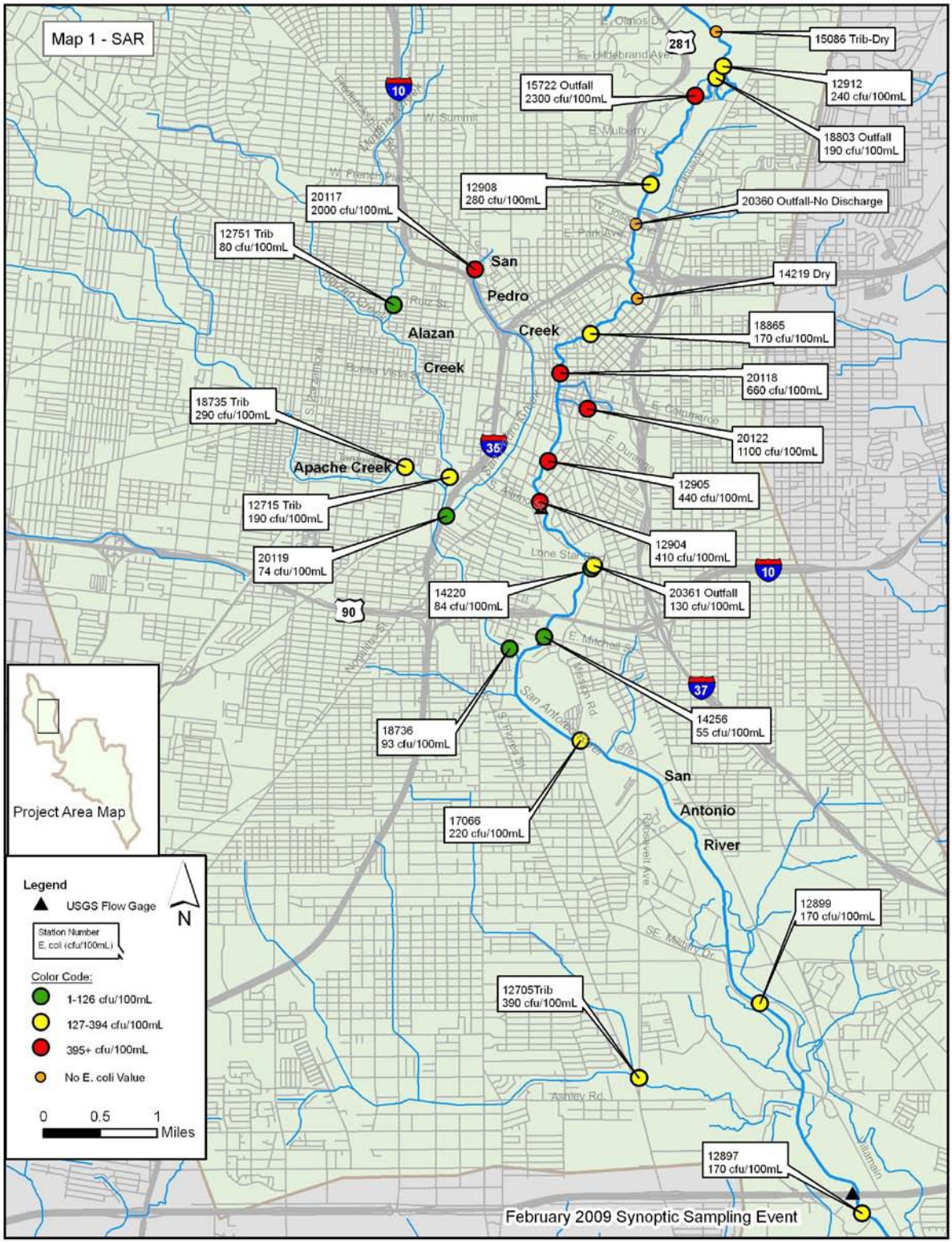

Figure 2-1: February 2009 Synoptic Survey of USAR above Loop 410

Other data analyses were performed. The *E. coli* concentration data for the synoptic sampling surveys were analyzed for loadings using the streamflow data, and a loading schematic was prepared for each stream and sampling date. The loading schematic that accompanied the data from February 2009 referenced above is shown for illustration in Figure 2-2. Monitoring stations are represented by the numbers alongside hash marks (12912, for example). The bold numbers represent calculated *E. coli* loadings (10^9 org/day) at each station. Red highlighting is applied to denote reaches with substantial increases in loading. From these schematics, observations could be made regarding specific stream reaches showing higher than typical bacteria loadings, which would ostensibly be indicative of some bacteria source. As expected, there was a high variability between surveys regarding the magnitude of loadings and their locations. A full description of various reaches with observed substantial bacteria load increases is available in the project report (JMA, 2010).

The monitoring data were closely examined for inferences regarding potential sources of bacteria. The synoptic surveys were conducted under baseflow conditions, therefore, bacteria sources that are associated with delivery via stormwater runoff could not be expected to be contributing to the observed concentrations and loadings at the time of the sampling events. In the absence of runoff, the likely principal potential sources of observed bacteria loadings were hypothesized to be animals, transients, and wastewater infrastructure. It should be noted though, that SAWS conducted extensive investigations of local wastewater infrastructure at many of the sites and reaches in question. As the sampling progressed, specific locations with relatively high bacteria concentrations were identified. In some cases, observed concentrations that were inordinately high prompted immediate site-specific source investigations by SAWS. Some of these site-specific investigations revealed leakage or releases from wastewater infrastructure, while others (most of them) revealed no ready explanation for observed bacteria concentrations.

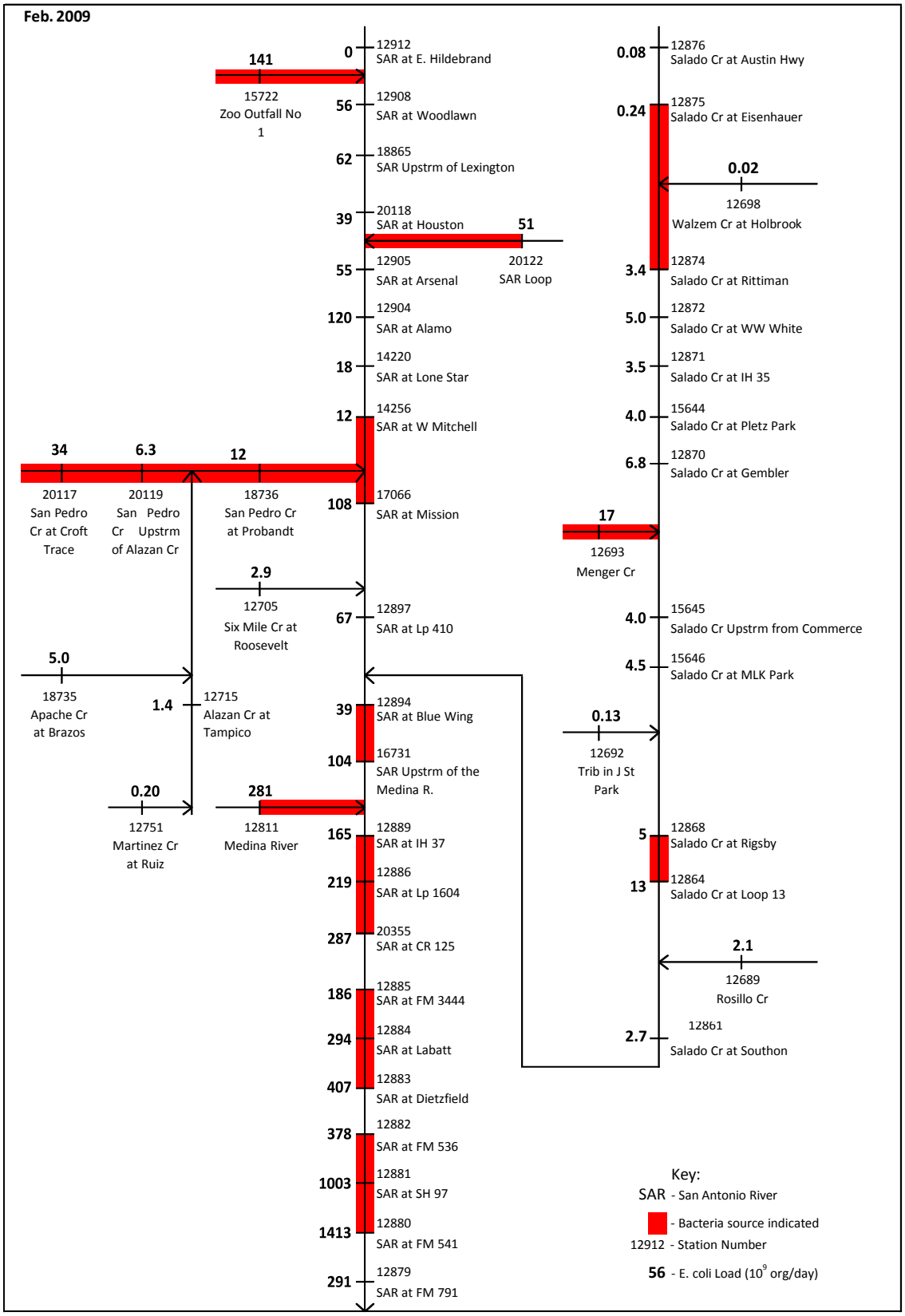

Figure 2-2: *E. coli* Loading Analysis Schematic, February 2009 Survey

2.1.2 WPP Monitoring

As a component of this WPP revision project, SARA has conducted monitoring for *E. coli* in stormwater runoff. The objective was to provide baseline data for selected urban sites. Data have been collected from 2012 through 2013 at four stream sites: San Antonio River at W. Mitchell Street (st. 14256), Alazan Creek at Tampico Street (st. 12715), Apache Creek at Brazos Street (st. 18735), and San Pedro Creek at W. Mitchell Street (st. 21105). SARA selected these four stations because of public interest in the "Westside Creeks." These sites are representative of stations throughout the study area that are highly urbanized and have continuous flow. Results obtained to date show frequently high concentrations of *E. coli* in stormwater runoff at the sampling sites. A summary of statistics for the sampling sites is shown in Table 2-1.

Table 2-1: 2012-2013 *E. coli* Monitoring Summary Statistics

Station	Station Location	Storm Events (> 0.1 in)	*E. coli* (org/100 mL)		
			Range	GeoMean	Median
14256	San Antonio River at W. Mitchell St.	5	96-34,000	2,068	1,700
12715	Alazan Creek at Tampico St.	6	50-110,000	3,685	3,400
18735	Apache Creek at Brazos St.	6	64-100,000	2,163	2,000
21105	San Pedro Creek at W. Mitchell St.	5	5-29,000	1,746	2,000

Complete data sets for the sampling events, including additional parameter coverage, are available from SARA.

2.2 CONTINUING MONITORING STRATEGY

As the TMDL implementation plan is developed and enacted, comprehensive monitoring for *E. coli* will continue in the WPP study area. Routine data collection will be conducted by SARA at numerous sampling stations. This data is needed to document concentration trends in the impaired reach as implementation of the TMDL moves forward. SARA is scheduled to conduct comprehensive monitoring for bacteria in the study segment immediately before and after the zoo disinfection system is fully operational. This will be a key component of the adaptive management strategy, and provide an indication of the need for additional BMPs. SAWS will continue to monitor numerous field points to check for evidence of sanitary wastewater leaks or problems. SAWS will also be responsible for outfall monitoring for the new Zoo disinfection facility. SARA and other stakeholders will continue to look for opportunities to monitor BMPs as they are planned and deployed in the future.

3.0 WPP KEY ELEMENTS

According to guidance provided by the US EPA, a watershed protection plan should include nine specific elements considered "critical for achieving improvements in water quality" (EPA, 2005). These elements are summarized below:

a) Identification of causes and sources of impairment, and their estimated loads
b) An estimate of the load reductions expected from management measures
c) A description of the management measures, and the areas where they will be implemented
d) Costs associated with the management measures, and potential funding sources
e) Education component for each management measure
f) Schedule of implementation for management measure
g) Measurable milestones of management measure implementation, other than water quality indicators (element h)
h) Water quality indicators to quantify effectiveness of management measure
i) Water quality monitoring component to evaluate criteria from element h

Sections 3.1 through 3.2 discuss the management measures (aka BMPs) recommended by the WPP. Section 3.3 summarizes all of the recommended BMPs in a tabular format, emphasizing the nine key elements presented above.

A WPP is intended to address loadings that contribute to a water quality impairment. In this WPP, a review of point source loads and nonpoint source loads and their BMPs are presented to provide a complete accounting of all known loadings.

3.1 MANAGEMENT MEASURES FOR BACTERIAL SOURCES

Management measures for bacterial sources are described in this section, both point source and nonpoint source. In the WPP study area, there were several key source loads identified in the TMDL for bacteria impairment. First, the San Antonio Zoo is a unique point source that discharges substantial bacterial loadings to the upper San Antonio River. Second, stormwater runoff is the largest source of bacterial loading in the study area. Third, direct nonpoint source loadings must also be addressed. Each of these sources will be described below. Categorically, BMPs for point source loadings are not eligible for Sec. 319 nonpoint source-related funding.

3.1.1 San Antonio Zoo Point Source

The San Antonio Zoo, located in Brackenridge Park, has been identified in the TMDL modeling work (JMA, 2006b) and the original WPP (JMA, 2006a) as a major point source contributor of bacteria in the Upper San Antonio River. The bacteria originate from resident and nonresident animals, principally waterfowl and other birds, that are located along the internal waterway that traverses the Zoo. The internal waterway is fed by a well, withdrawing water from the Edwards Aquifer at a rate of approximately 1700 gpm. There exists one primary and one secondary

outfall from the internal waterway to the Upper San Antonio River. Flows from the secondary outfall are generally negligible, except under rainfall runoff conditions.

According to the TMDL water quality model, disinfection (99.9% bacteria removal) of the Zoo's discharge will bring most of the Upper San Antonio River into compliance with the state criteria, except under periods of wet weather. Under periods of wet weather, bacteria concentrations are heavily influenced by loads from urban runoff, and Zoo controls alone are not sufficient to achieve compliance with water quality criteria.

The most cost effective BMP for reducing bacteria loads to the Upper San Antonio River was determined to be disinfection of the dry weather flow leaving the San Antonio Zoo. The discharge from the Zoo is the primary cause of impairment from Brackenridge Park through downtown San Antonio. Removal of the bacteria load from the Zoo could be most efficiently achieved through the utilization of disinfection treatment facilities. The original WPP report recommended an ultraviolet (UV) disinfection process be installed at the Zoo's primary outfall, although other, more expensive disinfection options are also available. The originally estimated cost to construct the UV facility was about $700,000. This and other treatment options were discussed in more detail in Section 5.0 of the original WPP.

Since the original WPP report was issued, a UV disinfection system has been designed and constructed by the City of San Antonio (at a cost substantially higher than originally estimated, approximately $2,200,000). The UV disinfection system is expected to be placed in service in 2014. This treatment facility is not specifically required in the MS4 permit; however, the permit does include a monitoring requirement for the discharge from the facility in anticipation of its construction.

Once the base flow from the Zoo has been controlled, there should be an immediate observable improvement in water quality in the upper reach of the river. On an annual basis, the uncontrolled bacterial discharge from the Zoo was estimated in the TMDL to be 3.91×10^{14} org/year of *E. coli*. Successful disinfection was estimated to reduce the annual base flow loading to 3.92×10^{11} org/year of *E. coli* (a 99.9% reduction). With disinfection, concentrations at the Zoo outfall should be reduced to less than 50 org/100mL. Concentrations downstream of the outfall should also decrease substantially. According to the water quality model, concentrations as far downstream as Loop 410 should drop substantially (geometric means drop by about half).
However, due to all of the variability associated with bacteria sampling, this can only be validated through long-term sampling.

Treatment of runoff-related flows from the Zoo was not recommended in the original WPP. If treatment were required, at a later stage of TMDL implementation, storm flows from the Zoo's primary waterway would need to be diverted to a large structural BMP or mechanical treatment facilities. However, due to the scarcity of undeveloped land near the Zoo grounds, this could be problematic.

3.1.2 Stormwater Runoff Point and Nonpoint Sources

There are two basic types of BMPs for stormwater sources: structural and nonstructural. Section 6.0 of the original WPP report provides detailed information for both of these BMP types. In

general, nonstructural BMPs are relatively inexpensive, but their effectiveness is difficult to quantify. The objective of most nonstructural BMPs is to prevent the accumulation of fecal material at the land's surface so that it is not available for washoff during runoff events. Structural BMPs, such as wet ponds and sand filters, are typically much more expensive to implement, but provide relatively reliable reductions in stormwater sources. The objective of structural BMPs is to remove pollutants that accumulate in runoff before that runoff reaches the receiving streams.

Stormwater runoff is the largest source of bacterial loading in the study area. An estimated 30% reduction in stormwater runoff bacteria loads is required to bring the river into compliance with the applicable water quality criterion, according to the TMDL modeling work (JMA, 2006b). The estimated annual loading of *E. coli* from stormwater runoff was 5.549 x 10^{15} org/year in the TMDL modeling. With a 30% reduction, the allocated load would be 3.884 x 10^{15} org/year. Although the TMDL modeling work encapsulated all of the stormwater runoff bacteria loading into the point source category, it is possible that nonpoint source controls can be implemented to reduce certain loadings at the source. Therefore, the overall 30% reduction in stormwater-related loading can be achieved, but it can be achieved with a combination of point source BMPs and nonpoint source BMPs, as explained in subsequent sections.

The San Antonio MS4 permit does not currently require specific structural and nonstructural BMPs to address bacterial loading reduction. Instead, there are general requirements designed to "reduce the discharge of pollutants to the MEP". The SWMP for the MS4 is supposed to contain BMP requirements described previously in Sec. 1.5, but site-specific requirements are not included. For example, structural controls are to be operated to reduce pollutant discharges, but there is no specificity regarding the number of controls or their locations.

The effectiveness of stormwater BMPs will be determined by future water quality monitoring. Immediate results can be determined for structural BMPs by monitoring bacteria levels in the BMP outfall. However, for the river as a whole, most stormwater source control efforts will not produce immediate results. Incremental load reductions may not be immediately noticeable in the river sampling, since the inherent variability in bacteria sampling may be greater than the effect of individual BMPs. However, as progress continues, long-term monitoring should indicate a gradual decrease in bacteria concentrations.

3.1.2.1 Nonstructural Stormwater BMPs

With their lower costs, nonstructural BMPs should first be implemented in the study area, and their effectiveness should be determined based on long term water quality monitoring. If success is indicated, implementation of additional items may cease.

An estimated 5% reduction in stormwater runoff loads may be achievable through the implementation of nonstructural BMPs. A 5% reduction would amount to removal of 2.775 x 10^{14} org/year of *E. coli*. Any load reduction achieved through nonstructural stormwater BMPs would reduce the reduction needed through structural controls on stormwater runoff.

Much of this nonstructural load reduction may be achieved through the management of pet waste. The City of San Antonio already maintains a "Pooper Scooper" program to encourage the removal of pet waste from the land surface. The expansion of this program, and the enforcement of pet control ordinances, may significantly reduce nonpoint source loading. In addition, public education can be used to educate pet owners on the need for proper pet waste management, both at home and in public parks.

Other nonstructural stormwater BMPs will address wild birds, which are believed to be a large source of the stormwater runoff load. However, the complete exclusion of wild birds is unrealistic and undesirable. Instead, limited actions can be taken at key locations to reduce the number of birds present. The City of San Antonio could institute a bird feeding ban at the River Walk and at public parks in riparian areas. This action would be well served by a public awareness program explaining the purpose of the ban. Other bird deterrent practices, such as a falconer program and the removal of bird nesting locations, may also be considered to achieve the desired load reductions. These BMPs will also reduce direct nonpoint source loads, because birds often deposit fecal material directly into the stream.

These nonstructural stormwater BMPs for pet waste and bird waste are methods to reduce the magnitude of waste deposited on the land surface, so that it is not subsequently available for washoff in a runoff event.

3.1.2.2 Structural Stormwater BMPs

Retrofitting a major portion of the City's stormwater drainage system with structural BMPs could result in tens or hundreds of millions of dollars in capital improvement costs. Therefore, this report recommends that stormwater BMPs be implemented using a phased approach. This phased approach is also known as adaptive implementation.

If nonstructural BMPs can achieve a 5% reduction in the stormwater runoff loading as described in the preceding discussion, this would leave a 25% reduction to be achieved by structural or other control measures. A 25% reduction would amount to removal of 1.388×10^{15} org/year of *E. coli* loading. In this case, the 5% nonstructural plus 25% structural BMP removals would sum to the required 30% removal. A portion of the targeted stormwater load reduction will be accomplished by methods to reduce the loading at the source. The MS4 permit does not provide a list of structural BMPs that must be constructed at specific locations or within specific timeframes to address the bacteria impairment.

It is recommended that one or two representative watershed sites be selected and scheduled for structural BMP pilot projects. This report recommends as candidates the San Pedro Creek, Alazan Creek, and/or Apache Creek watersheds. This limited first-phase implementation would incorporate site selection, design, construction, and post-construction monitoring of different types of structural BMPs. After this stage, a more thorough cost/benefit analysis could be developed.

Finally, in the second phase, additional structural stormwater BMPs can be implemented basin-wide, as required, to achieve compliance with water quality criteria. While it is expected that the

City of San Antonio will be the primary initiator of stormwater BMPs, surrounding entities in the study area such as SARA, Bexar County, Alamo Heights, Balcones Heights, Castle Hills, Ft. Sam Houston, Leon Valley, Olmos Park, and Terrel Hills should also review their stormwater and drainage programs.

The City of San Antonio already maintains a number of structural stormwater BMPs that have been installed for purposes other than control of bacteria loadings. Elmendorf Lake, for example, eliminates bacteria through natural decay and settling. The City is currently planning to install BMP features around the lake and provide aeration in the lake, which could have some ancillary benefits regarding bacteria removal. In addition the City maintains over 70 miles of vegetated swales and strips along the San Antonio River and its tributaries. Although the strips and swales do not have a high potential for bacteria removal, the City is taking actions to prevent the future dumping of debris (including fecal material) into these vegetated areas.

Additional structural stormwater BMPs will likely be required to achieve the load reductions required by the TMDL. These BMPs may range from large regional wet basins to small drain inserts for storm sewers. It is expected that large basin type BMPs will be most reliable and effective. (One stakeholder-recommended measure involves retrofit of existing detention basins with remote controlled outlets for extended retention time, currently being tested in a 319-funded project in Austin, TX.) For the purposes of the revised WPP, it is assumed that structural controls will be implemented systematically over a 40-year timeframe in a phased approach. The long-term objective will be to contribute to achievement of the 30% reduction in bacterial loading from stormwater required by the TMDL.

3.1.2.3 Stormwater Source BMPs

The TMDL did not have a separate category for nonpoint source stormwater runoff, since virtually the entire study area is covered by the MS4 permit. There is potential to reduce certain loadings at their source, prior to entrance into the conveyance system.

One pertinent example of application of stormwater BMPs that treat pollutants at the source are the requirements for site development in the Edwards Aquifer Recharge Zone, which makes up a portion of the upper WPP study area. Rules for protection of the Edwards Aquifer are implemented by the TCEQ. They require permanent BMPs for activities that have the potential for polluting the aquifer or connected surface streams. The requirements generally apply to any development with more than 20% impervious cover, including public infrastructure projects such as roads and utilities. These rules require mitigation of 80% of the increase in total suspended solids, based on existing conditions (TCEQ, 2005). The types of BMPs utilized would also likely contribute to reduction in bacteria loadings under stormwater conditions. For planning purposes, it can be assumed that application of the Recharge Zone requirements to future development and redevelopment will achieve a reduction in bacterial source loadings.

Along these same lines of localized source control, SARA and City of San Antonio have been focusing on long-term implementation of low-impact development (LID) principles in the study area. LID to a large extent embraces maintenance of natural drainage patterns and treatment of runoff at the source. LID methods strive to reduce the volume of runoff generated on a site, which thereby reduces the magnitude of pollutant loading. Further, LID methods seek to apply

structural BMPs in a localized deployment to treat runoff at the source. EPA has endorsed the application of LID principles and the treatment of stormwater at a site-specific basis, which minimizes the stormwater volume that is washed into traditional conveyance systems (EPA, 2009). Many of the structural BMPs detailed in the original WPP report (JMA, 2006a) and the subsequent BMP Assessment Report in support of implementation plan development (JMA, 2010) can be utilized in an LID context. For example, implementation of infiltration basins, bioretention facilities, and rainwater harvesting are typical components on a site-specific basis. The City's Unified Development Code has been closely examined and it can readily accommodate LID development. The City's Complete Streets Initiative encourages LID application with the statement: "…will encourage green infrastructure and LID principles on Complete Streets to help manage stormwater runoff and provide landscaping amenities" (City of San Antonio, 2011). The San Antonio River Basin Low Impact Development Technical Guidance Manual has recently been completed, and it provides instruction and guidance to help plan, select, design, and maintain LID BMPs (SARA, 2013).

Since the original WPP (JMA, 2006a) was prepared, the City has initiated at least one notable LID development project: the Mission Drive In site located within the upper San Antonio River watershed. This tract redevelopment was designed with several LID principles, and water quality monitoring of the BMPs was prescribed. Valuable data will be produced as the development is completed and monitoring continues.

This local initiative to embrace LID-type development can potentially provide significant reduction of bacterial loadings in the study area. Reductions achieved by LID implementation would be considered as nonpoint source loading reductions, since they are not specified actions in the MS4 permit or the SWMP. Bacteria loads reduced in this manner would alleviate some of the reduction previously prescribed for MS4 point source runoff. The potential mix between the two categories of point and nonpoint source runoff is speculative, but it is conceivable that the LID approach could satisfy the required runoff-based load reduction.

The proposed implementation of LID in the study area is a long-term scenario. The greatest opportunities within the highly urbanized study area will be associated with redevelopment of previously-developed tracts. The Center for Watershed Protection (Schueler, et al, 2007) notes that the urban landscape is in constant flux, with the design or service life of most structures and infrastructure measured in decades, for example buildings (50-60 years), parking lots (20-30 years), bridge decks (40-50 years), and drainage infrastructure (30-50 years). Thus, to provide a realistic plan, it would be expected that the pace of LID deployment and realization of bacterial loading reductions from this approach would entail at least a 40-year timeframe.

Implementation of LID practices for nonpoint source control is projected to potentially reduce *E. coli* loadings from stormwater in the WPP study area by 15% over a 40-year timeframe. This expectation is based on the combination of reduced runoff flow volumes and structural control measures. This 15% reduction would amount to a loading of 8.324×10^{14} org/year, which would be deducted from the previously discussed stormwater runoff source category. If achieved, this 15% reduction would account for half of the 30% reduction prescribed for stormwater loadings. Therefore, the application of LID will be considered as a quantifiable nonpoint source loading reduction for the purpose of this revised WPP document.

There have been two recent planning studies completed (2013) to evaluate the feasibility of BMP implementation in select subwatersheds. These studies and their BMPs could address a combination of MS4 stormwater treatment and nonpoint source stormwater treatment, depending upontheir relationship to the requirements of the MS4 permit and SWMP. Much of the BMP treatment would incorporate LID principles where possible. The "Site-Specific BMP Assessment" report (JMA, 2013a) was prepared to take a practical look at the potential widespread implementation of BMPs within specific watersheds with respect to availability of publicly-owned sites. The study revealed that about 19% of the overall WPP watershed area is owned by public entities (with the definition of "public" expanded to include nonprofit organizations such as private schools and churches). Next, nine example sites were selected for conceptual level application of BMPs. Bioretention facilities and sand filters were the BMPs used in the conceptual application. For the nine example sites, it was projected that an overall bacteria loading reduction of 63% could be achieved with the application of the BMPs. For the total 30.59 acres of watershed area so treated, the bacteria loading removal was estimated to be 4.542×10^{11} org/year fecal coliform (so, estimated 2.861×10^{11} org/year *E. coli*).

The "Subwatershed-Specific BMP Assessment" report (JMA, 2013b) was prepared to examine the potential for retrofit of BMPs with a typical urbanized subwatershed. The example subwatershed selected for study was the 840 acre urbanized portion of upper San Pedro Creek, which includes a diverse mix of industrial, residential, park, and commercial land uses. Flowpaths for runoff were determined and the study area was broken down into multiple subdrainage areas. Bioretention was selected as the predominant BMP, along with grassy infiltrating swales and limited application of sand filter basins. The conceptual application of BMPs across the upper San Pedro Creek subwatershed demonstrated the potential opportunities and feasibility of a large-scale retrofit. For that study area, a total of 50 bioretention ponds, 22,000 feet of grassy infiltrating swales, and two sand filters were conceptually proposed. The projected bacteria removal for the test area was estimated at 2.14×10^{13} org/year of fecal coliform (so, estimated 1.35×10^{13} org/year as *E. coli*).

As the preceding two studies illustrate, opportunities exist for retrofit of BMPs, and reduction of bacterial loadings, throughout all of the subwatersheds of the study area. This could conceivably occur on publicly-owned sites or privately-owned sites. Although there is no immediate plan by any of the major stakeholders to move forward with a large-scale BMP retrofit program, this approach does represent a potential mechanism that could be applied to reduce the overall time frame for achievement of the required watershed loading reduction. As more BMPs are installed, pre- and post-monitoring can be conducted to determine loading reductions.

3.1.3 Direct Nonpoint Sources

Direct nonpoint sources discharge without dependency on stormwater runoff, so they have the greatest impact under dry weather (baseflow) conditions. These sources have not been heavily monitored, and the magnitude and location of these sources are still largely unknown. The existing loads and proposed loading reductions for these sources are based on TMDL modeling results, the bacterial output of various animal species (as documented in literature), bacterial source tracking (BST) results, and best professional judgment. Based on information currently available, it is presumed that wildlife and humans are the two primary contributors to the total direct source loading.

According to the TMDL modeling results, only 2.48% of the annual average load (1.511 x 10^{14} org/year *E. coli*) is attributable to direct sources (2.53% if septic systems are included in this category, see Table 1-1). Nonetheless, because of their importance under baseflow conditions, a 50% reduction in direct nonpoint sources is required to bring the stream into compliance with water quality standards. The 50% reduction will remove 7.555 x 10^{13} org/year of *E. coli*.

Direct nonpoint source BMPs can be targeted to areas that exhibit high bacteria concentrations under base flow conditions, based on water quality monitoring data. For example, the verification sampling, performed as part of the WPP process, indicated high levels of bacteria in San Pedro Creek at Alamo Street. Therefore, it is likely that a significant bacteria source exists in the vicinity. During the implementation phase of the WPP, it is recommended that additional sampling be performed to better locate this and other potential direct nonpoint source contributions.

As with point source BMPs, the effectiveness of direct source BMPs will be determined by future water quality monitoring. For some potential sources, such as a septic system found discharging directly to the river, the effect of control measures could be very noticeable, particularly in the vicinity of the discharge. However, most direct source control efforts will not produce immediate results. Small direct source load reductions may not be immediately noticeable in the sampling, since the inherent variability in bacteria sampling may be greater than the effect of the source control. However, as progress continues, long-term monitoring should indicate a gradual decrease in bacteria concentrations, particularly under low flow conditions.

3.1.3.1 Direct Nonpoint Sources – Wildlife

Wildlife are presumed to be the greatest contributors to direct source loading. Avian wildlife and bats (which are technically not "avian") are expected to be the primary sources, because they frequently make streams and riparian areas their primary habitat. It is hoped that a 35% reduction in direct source loading can be realized by controlling wildlife sources.

One of the candidate source components identified in the original WPP report was the Houston Street bat colony. This bridge probably contained the largest population of source animals living directly above the river, although the bat colony's population was unknown. The City of San Antonio installed bat deterrent/exclusion features on the bridge in 2007, preventing the bats from returning after their winter migration. Water quality monitoring was performed by SARA immediately downstream of the bridge, before and after exclusion, and the results did not indicate any significant change in bacteria concentrations in the water column. Nonetheless, this action certainly did remove some magnitude of bacteria loading to the river. With an estimated population of 5000 bats at the Houston Street bridge (half contributing direct deposition), producing bacteria at a rate of 10^7 org/day and residing at the bridge nine months out of the year, this would equal an annual load of 6.0×10^{12} org/yr. In this case, removal of the bat colony would be expected to have achieved approximately a 4% reduction in direct nonpoint sources.

Wild birds, such as ducks, geese, egrets, and pigeons are also presumed to be a large source of direct nonpoint source loads. However, the complete exclusion of these animals is probably unrealistic and undesirable. Instead, limited actions can be taken at key locations to reduce the

number of birds present. For example, the City of San Antonio has recently placed signage along the River Walk to discourage feeding of wildlife. The City of San Antonio could carry this further and institute a bird feeding ban at the River Walk and at public parks in riparian areas. This action would be well served by a public awareness program explaining the purpose of the ban. Other bird deterrent practices, such as a falconer program and the removal of bird nesting locations, may also be considered to achieve the desired load reductions. The falconer is still in use, and the City has recently applied a motorized faux falcon bird deterrent. Because birds may deposit fecal material on the land's surface as well as in the river, these BMPs are also expected to reduce stormwater runoff loads, as described in Section 3.1.2.1.

The City of San Antonio has proposed to reduce bacteria concentrations by improving management practices downtown and along the River Walk. This effort could include several components including owner/tourist education, improved trash collection and maintenance operations, and improvements in flow circulation and general water quality. The City and SARA did complete a program in 2010 to educate property owners along the River Walk. Although this effort is not expected to result in large bacteria load reductions for the overall river, it has significantly reduced bacteria concentrations in the River Walk area.

3.1.3.2 Direct Nonpoint Sources – Human Origin

It is hoped that a 15% (or greater) reduction in direct sources can be realized from targeting human waste sources. These sources potentially include wastewater infrastructure, septic systems, and the homeless population. Regarding wastewater infrastructure, SAWS, the primary wastewater service provider in the region, has an aggressive program in place to reduce the potential for wastewater leakage. SAWS BMPs include sewer inspection, maintenance, emergency response, and rehabilitation. These BMPs were discussed in detail in Section 6.0 and Appendix D of the original WPP. Surrounding wastewater entities in the study area (Alamo Heights, Balcones Heights, Castle Hills, Ft. Sam Houston, Leon Valley, Olmos Park, and Terrel Hills) should institute similar programs if they do not already exist, perhaps with SAWS guidance. It is anticipated that all of the wastewater entities will work jointly with SARA and other agencies, if future water quality monitoring identifies specific locations where wastewater infrastructure may be contributing to the bacteria load. The City of San Antonio and SAWS annually drain the River Walk for cleaning and attempt to identify and repair any illicit connections (discharges) to the River Walk. Depending upon the number and types of connections identified, this could result in a significant bacteria load reduction in the immediate vicinity.

Septic systems are becoming increasingly rare in the WPP study area, as most homes are now served by wastewater collection systems. Nonetheless, there are still isolated communities relying on relatively old septic facilities inside the city. In addition, septic systems are common among newer developments in the northernmost parts of the study area. Bexar County is generally responsible for the management of these systems, except in some of the smaller incorporated areas, and will continue inspections with an emphasis on locating potential discharges to surface waters. Bexar County maintains records of failing systems and their repair, and there is no indication that failing systems are substantial. SAWS and COSA are also involved in reducing the potential for septic discharges. For example, they worked jointly to provide service to the previously unsewered Espada community in San Antonio, where 117

connections were added in 2008. This project and other BMPs for septic systems were discussed further in Section 6.0 of the original WPP.

Another potential source of bacteria loads is the homeless/vagrant population. To help reduce this potential load, the City of San Antonio can provide restroom facilities and adequate maintenance in areas with concentrated homeless populations. One notable such facility was established in 2010: the 37-acre Haven for Hope campus, which is sized to house thousands of homeless people, and is located just northeast of the downtown area.

3.1.3.3 Direct Nonpoint Sources – Flow Augmentation

SAWS activated a third reclaimed water outfall in 2007, located at the Henry B. Gonzales Convention Center on the River Loop. The additional flow will increase the assimilative capacity of the river, resulting in an effective direct nonpoint source load reduction. The effect of this discharge should be detectable through long-term monitoring, particularly under base flow conditions, and near the River Walk.

3.2 SUMMARY OF ANTICIPATED LOADING REDUCTIONS

Previous sections have discussed the TMDL generated bacterial loadings, the loading reductions and allocations prescribed in the TMDL, and the application of point source and nonpoint source control measures. This section will provide a summary accounting of the anticipated bacterial loading reductions that will be targeted within the WPP study area.

Table 3-1: Control Measure Loading Reductions

SOURCES	*E. coli* Existing Load (10^9 org/yr)	TMDL Prescribed *E. coli* Reduction		Source Type	Projected BMPs	Treatment Reduction by Source (%)	Proposed *E. coli* Reductions (10^9 org/yr)	Reduction of Total Load (%)
		(%)	(10^9 org/yr)					
Zoo	391,860	99.9%	391,468	Point	UV Facilty	99.9%	391,468	6.42%
Stormwater	5,549,146	30%	1,664,744	MS4 Point and Nonpoint	Nonstructural BMPs	5%	277,457	4.55%
					Structural BMPs	10%	554,915	9.10%
					Source BMPs	15%	832,372	13.65%
Direct Sources	151,080	50%	75,540	Nonpoint	Human	15%	22,662	0.37%
					Wildlife BMPs	35%	52,878	0.87%
Reclaimed Effluent	44	0%	0	Point	--	--	--	--
Springs	2,453	0%	0	Nonpoint	--	--	--	--
Septic Systems	3,381	0%	0	Nonpoint	--	--	--	--
TOTALS:	6,097,965	35%	2,131,752	--	--	--	2,131,752	35%

Note: units are presented as billions or organisms per year to facilitate comparisons

3.3 NINE ELEMENT SUMMARY TABLE

The following "Nine Key Elements Table" was developed by TCEQ staff to provide an effective template for documenting the nine critical elements of a WPP, as required by the US EPA. In the table, the order of items (b) and (c) have been reversed for a more effective presentation. Hopefully, this table will serve as a valuable tool in the development of the Implementation Plan. In addition, it will be the basis for requesting additional grants to assist in BMP deployment. At this stage, there is quite a lot of uncertainty in estimation of potential load reductions for control measures. This is understandable with the magnitude of the bacterial loadings, and it will allow for adaptive management during implementation

Table 3-2: Nine Key Elements of Proposed Management Measures

(a)	(c)	(b)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
Causes and Sources of Bacterial Impairment	**Management Measures and Targeted Critical Areas**	**Estimated Potential Load Reduction (10^9 org/yr)**	**Technical and Financial Assistance Needed for Each Measure**	**Education Component for Each Measure (and Other Education)**	**Schedule of Implementation for Each Measure**	**Interim, Measurable Milestones for Each Measure**	**Indicators to Measure Progress**	**Monitoring Component**	**Responsible Entity**
SAN ANTONIO ZOO POINT SOURCE, Existing Load = 391,860 (10^9 org/yr), Required Load Reduction = 391,468 (10^9 org/yr) (99.9%)									
San Antonio Zoo internal waterway	disinfection of Zoo base flow	391,468 (99.9%)	$2,200,000	none/optional exhibits in Brackenridge Park	2014	n/a	reduction in baseflow-related bacteria conc.	monitor zoo outfall to verify disinfection	CoSA construction, SAWS operation
San Antonio Zoo sewer	sump and interceptor maintenance plan and implementation		n/a	develop maintenance plan for all interceptors and sumps	2009 (completed)	regular inspections to document functionality of sumps and interceptors	n/a	n/a	Zoo

Table 3-2: Nine Key Elements of Proposed Control Measures (continued… 2/5)

STORM WATER RUNOFF POINT AND NONPOINT SOURCES, Existing Load = 5,549,146 (10^9 org/yr), Required Load Reduction = 1,664,744 (10^9 org/yr) (30%)									
Nonstructural Controls									
Avian land deposition (urban runoff)	bird feeding ban at River Walk and City Parks in riparian areas	277,457 (5%)	$100,000	signs and exhibits, public awareness programs	2010 + (ongoing)	Fewer birds observed along riparian areas	reduction in runoff-related bacteria conc. basin-wide	routine basin monitoring	CoSA
	bird exclusion/deterrent practices and devices at River Walk and selected riparian areas		$100,000	education of CoSA Parks staff by Texas Parks and Wildlife	2010 + (ongoing)	Fewer birds roosting along riparian areas	reduction in runoff-related bacteria conc. basin-wide	routine basin monitoring	CoSA
Pet land deposition (urban runoff)	increase awareness and enforcement of pet control ordinance		already funded, additional funds could be used to expand public awareness campaign and enforcement	public awareness program at Community Link Centers: (Valley View, South Park, McCreless, and Las Palmas)	2010 + (ongoing)	pet owner participation, number of citations and complaints	reduction in runoff-related bacteria conc. basin-wide	routine basin monitoring	CoSA
	expand Pooper Scooper programs (75 of 230 parks at present)		expand existing program to all City Parks: $100,000	signs and exhibits, community education, mitt dispensers and disposal	2010 + (ongoing)	pet owner participation, number of citations and complaints; increase in number of mitts used per year	reduction in runoff-related bacteria conc. basin-wide	routine basin monitoring	CoSA

Table 3-2: Nine Key Elements of Proposed Control Measures (continued… 3/5)

continued… STORM WATER RUNOFF POINT AND NONPOINT SOURCES, Existing Load = 5,549,146 (10^9 org/yr), Required Load Reduction = 1,664,744 (10^9 org/yr) (30%)									
Structural Controls									
General urban runoff sources	New structural stormwater BMPs (should cover ~20% of basin area based on BMPs with 50% overall effectiveness) to operate under MS4 permit	554,915 (10%)	$30,000,000 (based on $2.00/cf BMP treatment volume, and $20,000/ac)	education for engineers/ contractors on BMP construction and maintenance	As required, by adaptive management 2012 + redevelopment opportunities	continue application of MS4 SWMP, add BMPs as needed	reduction in runoff-related bacteria conc. basin-wide	monitor BMP inlets and outfalls as available; routine basin monitoring for basin-wide deployment	CoSA TxDOT
	Provide illegal dumping signs for existing vegetated swales/filter strips along waterways		$10,000	signs	2012 (completed)	regular site inspections to verify that refuse (including fecal material) is no longer being dumped in buffer areas	n/a	routine basin monitoring	CoSA
Stormwater Source Controls									
General urban runoff at source	Applications of LID to new development and redevelopment projects	832,372 (15%)	Technical Guidance Manual (completed 2013)	BRWM LID Manual Technical subcommittee	2014 + (ongoing)	add BMPs as opportunities arise	reduction in runoff-related bacteria conc. locally and basin-wide	monitiring for BMP inlets, outfalls as available, routine basin monitoring	CoSA SAWS SARA BEXAR
	Applications of Recharge Zone BMPs to new development and redevelopment		n/a - Primarily funded privately	TCEQ guidance manual for Recharge Zone	2014 + (ongoing)	add BMPs as opportunities arise	reduction in runoff-related bacteria conc. locally and basin-wide	monitiring for BMP inlets, outfalls as available, routine basin monitoring	SAWS

Table 3-2: Nine Key Elements of Proposed Control Measures (continued… 4/5)

DIRECT NONPOINT SOURCES, Existing Load = 151,080 (10^9 org/yr), Required Load Reduction = 75,540 (10^9 org/yr) (50%)									
Human Origin									
Wastewater collection system	institute ordinance/ subsidize private lateral rehab (offered for consideration)	22,662 (15%)	investigate private sewer laterals contribution to bacteria loadings	homeowner education	research issue beginning 2012 +; scope development	number of defective connections, number repaired	reduction in baseflow-related bacteria conc.	routine basin monitoring	CoSA and other municipalities with SAWS assistance
	odor/corrosion control program: optimize existing ferrous sulfate injection program		in-house study supplemented by financial aid, consulting assistance	none	2014 + (ongoing)	pending completion of odor/corrosion control master plan	reduction in baseflow-related bacteria conc.	routine basin monitoring	SAWS
	wastewater main cleaning program: improve flow capacity		unknown	eliminate illegal dumping of debris in manholes, i.e. vandalism	2010 + (ongoing)	miles of mains cleaned annually	reduction in baseflow-related bacteria conc.	routine basin monitoring	SAWS
	wastewater system capital improvement program: Comprehensive risk management approach to optimize infrstr. renewal decisions		unknown	none	2009 + (ongoing)	miles of mains renewed annually	reduction in baseflow-related bacteria conc.	routine basin monitoring	SAWS
	identify and repair illicit connections to River Walk		already funded, $1,300,000	education and training with TPDES permit	2010 (completed)	number of illicit connections documented, repaired	reduction in baseflow-related bacteria conc.	routine basin monitoring	CoSA, SAWS
Homeless/ vagrant population	provide restroom facilities and maintenance in areas with significant vagrant populations		unknown	none	2011 (restrooms available at 6 locations)	inspections to verify utilization of facilities provided	reduction in baseflow-related bacteria conc.	routine basin monitoring	CoSA
Septic systems	Inspection and repair (if necessary) of near-stream septic systems		unknown	none	2014 + (ongoing)	number of failures located, number repaired	reduction in baseflow-related bacteria conc.	routine basin monitoring	Bexar County
	Connection of 117 homes in Espada Community.		currently funded	none	2008 (completed)	number of homes connected to sewer	reduction in baseflow-related bacteria conc.	routine basin monitoring	SAWS, CoSA

Table 3-2: Nine Key Elements of Proposed Control Measures (continued… 5/5)

continued… DIRECT NONPOINT SOURCES, Existing Load = 151,080 (10^9 org/yr), Required Load Reduction = 75,540 (10^9 org/yr) (50%)									
Wildlife									
Bat colony in Houston Street bridge	bat exclusion/ deterrent practices and devices	52,878 (35%)	assistance from Texas Parks and Wildlife	none	2009 (completed)	annual inspections to verify exclusion of bats from city bridges	reduction in baseflow-related bacteria conc.	monitoring at bridge, routine basin monitoring	CoSA
Low flows	introduce new 0.65 MGD outfall at HB Gonzalez Convention Center		already completed	none	2007 (completed)	flow records	reduction in baseflow-related bacteria conc.	basin monitoring inside and downstream of River Loop	SAWS
Avian direct deposition	bird feeding ban at River Walk and City Parks in riparian areas		$100,000	signs and exhibits, public awareness programs	2012 + (ongoing)	Fewer birds observed along riparian areas	reduction in baseflow-related bacteria conc.	routine basin monitoring	CoSA
	bird exclusion/deterrent practices and devices at River Walk and selected riparian areas		$100,000	education of CoSA Parks staff by Texas Parks and Wildlife	2012 + (ongoing)	Fewer birds roosting along riparian areas	reduction in baseflow-related bacteria conc.	routine basin monitoring	CoSA
Misc. animal deposition	additional studies to assess potential sources and identify BMPs		$100,000	none	2014-2016	n/a	reduction in baseflow-related bacteria conc.	routine basin monitoring	SARA
River Walk/ downtown sources from improper waste disposal and debris accumulation	owner/tourist awareness and education campaign		City plan to improve water quality in River Walk, $320,000	provide training for stakeholders	2010 (completed)	stakeholder participation; visual improvements in appearance of water	reduction in baseflow-related bacteria conc.	basin monitoring inside and downstream of River Loop	CoSA
	investigate and implement measures to improve flow circulation/water quality		not currently funded; $12,000-$100,000 required	technical assistance required	2008 + (ongoing)	visual improvements in appearance of water and flow	reduction in baseflow-related bacteria conc.	basin monitoring inside and downstream of River Loop	CoSA
	specially designed boat (Lady Eco) for removing all floating debris on a daily basis.		$100,000 received from Parks Foundation	instruction provided by Aquasweep	2008 + (ongoing)	annual load of debris removed	reduction in baseflow-related bacteria conc.	basin monitoring inside and downstream of River Loop	CoSA
	investigate and implement measures to improve cleaning and maintenance operations, in order to prevent load from entering River Loop		Current costs: City-$46,000; SAWS-$15,000. More funding needed to purchase additional power washing equipment	education and training for maintenance personnel	2008 (completed)	monitor and inspect River Loop clean-up practices	reduction in baseflow-related bacteria conc.	basin monitoring inside and downstream of River Loop	CoSA

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