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Draft Implementation Plan for Nine Total Maximum Daily Loads for Indicator Bacteria in the Chocolate Bay Watershed

Assessment Units: 1107_01, 1108_01, 2432A_01, 2432A_02, 2432A_03, 2432B_01, 2432C_01, 2432D_01, and 2432E_01

By Stakeholders of the Chocolate Bay Watershed
With Support from the Houston-Galveston Area Council

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Abbreviations

AA	authorized agent
AU	assessment unit
BMP	best management practice
cfu	colony forming units
CMP	conservation management plan
CRP	Clean Rivers Program
E. coli	*Escherichia coli*
EPA	Environmental Protection Agency (United States)
EQIP	Environmental Quality Incentives Program
FG	future growth
FM	farm-to-market
FOG	fats, oils, grease, and wipes
H-GAC	Houston-Galveston Area Council
I-Plan	implementation plan
mL	milliliter
MOS	margin of safety
NRCS	Natural Resources Conservation Service
OSSF	on-site sewage facility
RUS	Rural Utilities Service
SARE	Sustainable Agriculture Research and Education
SEP	Supplemental Environmental Project
SSO	sanitary sewer overflow
SWCD	Soil and Water Conservation District
SWMU	subwatershed management unit
TCEQ	Texas Commission on Environmental Quality
TEEX	Texas A&M Engineering Extension Service
TGLO	Texas General Land Office
TMDL	total maximum daily load
TPWD	Texas Parks and Wildlife Department
TSD	technical support document
TSSWCB	Texas State Soil and Water Conservation Board
TWDB	Texas Water Development Board
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
WEP	Water and Environmental Program
WLA	wasteload allocation
WQMP	water quality management plan
WWTF	wastewater treatment facility

Executive Summary

Between 2024 and 2025, the Texas Commission on Environmental Quality (TCEQ) adopted nine total maximum daily loads (TMDL) in the Chocolate Bay watershed:

- *Two Total Maximum Daily Loads for Indicator Bacteria in Chocolate Bayou* (TCEQ, 2024a) (assessment units [AUs] 1107_01, 1108_01),
- *Five Total Maximum Daily Loads for Indicator Bacteria in the Mustang, Persimmon, and New Bayous Watershed* (TCEQ, 2025a) (AUs 2432A_01, 2432A_02, 2432A_03, 2432D_01, and 2432E_01); and
- *Two Total Maximum Daily Loads for Indicator Bacteria in the Halls Bayou Tidal and Willow Bayou Watersheds* (TCEQ, 2024b), (AUs 2432B_01, 2432C_01).

This implementation plan, or I-Plan:

- describes the steps that watershed stakeholders and TCEQ will take toward achieving the pollutant reductions identified in the TMDL reports, and
- outlines the schedule for implementation activities.

The goal of this I-Plan is to restore the primary contact recreation 1 uses in the watershed AUs by reducing concentrations of fecal indicator bacteria to levels established in each TMDL. This I-Plan will benefit, not only the AUs listed, but all water bodies in the TMDL watersheds, including Chocolate Bay, Segment 2432, as a protective measure. Chocolate Bay is also considered impaired for indicator bacteria impacting recreational oyster producing waters. Chocolate Bay is currently a water body covered by the *Implementation Plan for Eleven Total Maximum Daily Loads for Bacteria of the Upper Gulf Coast* (TCEQ, 2015).

Escherichia coli (*E. coli*) and Enterococci are widely used indicator bacteria to assess attainment of the contact recreation use in water—*E. coli* in freshwater and Enterococci in saltwater. The criteria for assessing attainment of the contact recreation 1 use are expressed as the number of bacteria, typically given as colony forming units (cfu). The primary contact recreation 1 use is not attained when the geometric mean of indicator bacteria samples exceeds the geometric mean criterion of 126 cfu/100 mL (milliliter) for *E. coli* in freshwater or 35 cfu/100 mL for Enterococci in saltwater, including tidal water bodies.

This I-Plan includes five management measures that will be used to reduce bacteria within the Chocolate Bay watershed. Management measures are related to nonpoint sources (mostly unregulated), such as domesticated animals or wildlife fecal waste, or point sources (most often regulated), such as untreated or poorly treated human fecal waste.

Summary of Management Measures

For each of the management measures chosen, this plan names the responsible parties, technical and financial needs, monitoring and outreach efforts, and a schedule of activities. Implementation of management measures will be dependent upon the availability of funding. The management measures in this I-plan are:

1) Maintain and improve WWTF and collection system function
2) Promote safe on-site sewage facility (OSSF) use and maintenance
3) Reduce stormwater sources such as pet waste and illegal dumping
4) Support land management initiatives
5) Promote feral hog management

The stakeholders and TCEQ will review progress under TCEQ's adaptive management approach. Stakeholders may adjust the plan periodically based on progress reviews.

Introduction

To keep Texas' commitment to restore and maintain water quality in impaired rivers, lakes, and bays, TCEQ works with stakeholders to develop an I-Plan for each adopted TMDL. A TMDL is a technical analysis that:

- Determines the amount of a pollutant that a water body can receive and still meet applicable water quality standards.
- Sets limits on categories of sources that will result in achieving standards.

This I-Plan is designed to guide activities that will achieve the water quality goals for the Chocolate Bay watershed as defined in the TMDL reports. It is a flexible tool that governmental and nongovernmental organizations involved in implementation use to guide their activities to improve water quality. The participating partners may accomplish the activities described in the plan through rule, order, guidance, or other appropriate formal or informal action.

This I-Plan contains the following components:

- Description of management measures that will be implemented to achieve the water quality target.
- Schedule for implementing activities.
- Follow-up tracking and monitoring plan to determine the effectiveness of the management measures undertaken.
- Measurable outcomes and other considerations TCEQ and stakeholders will use to decide whether the I-Plan has been properly executed, water quality standards are being achieved, or the plan needs to be modified.
- Communication strategies TCEQ will use to share information with stakeholders.
- Review strategy that stakeholders will use to periodically review and revise the plan to ensure progress in improving water quality.

Watershed Overview

The Chocolate Bay watershed is approximately 312.75 square miles and consists of three main tributary watersheds: Chocolate Bayou, Mustang Bayou, and Halls Bayou (Figure 1). The water bodies generally flow south eastward from Fort Bend County. The bulk of the Chocolate Bay watershed is within eastern Brazoria County. The main cities, towns, or villages found partly or wholly within the watershed include: Algoa, Alvin, Arcola, Fresno, Hillcrest, Iowa Colony, Liverpool, Manvel, Missouri City, and Pearland.

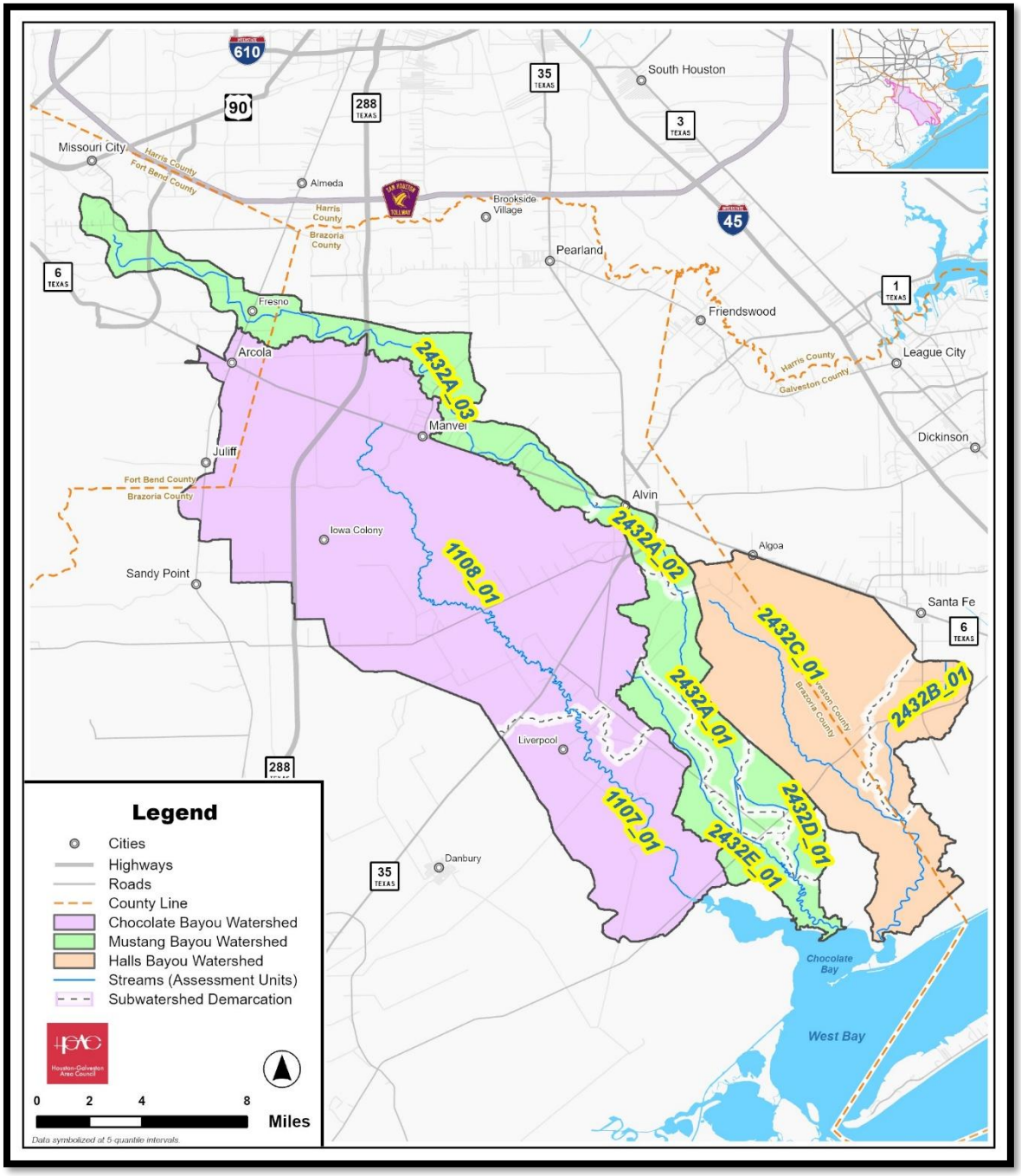

Figure 1. Chocolate Bay Watershed

The Chocolate Bay watershed has been heavily modified, with several important agriculture, industrial, and municipal water canals crossing the watershed. The predominant land use continues to be agriculture, though, areas in the north and west are transitioning to residential subdivisions along Hwy 6 and Hwy 288. Petroleum refining, oil production, rice farming, and cattle production have been the largest economic drivers.

Each of the subwatersheds are described in the paragraphs that follow. For greater detail, see the Technical Support Documents (TSD) (TCEQ, 2023; TCEQ, 2025b; and TCEQ, 2025c).

The Chocolate Bayou Tidal watershed is 35.52 square miles. This tidal AU (1107_01) begins at the terminus of the above tidal segment, about 1.5 miles northeast of the City of Liverpool in Brazoria County and traverses 16 miles southeastward to the mouth of Chocolate Bay. This AU is tidal as it includes a mix of freshwater and salt water due to the segment's downstream connection to the saline waters of Chocolate Bay and West Galveston Bay.

The Chocolate Bayou Above Tidal watershed is 137.65 square miles. This freshwater AU (1108_01) and begins approximately 1.4 miles west of the City of Manvel in Brazoria County. This AU is 22 miles in length prior to terminating at the upper boundary of Chocolate Bayou Tidal.

The Mustang Bayou watershed is 49.16 square miles. Mustang Bayou (AUs 2432A_01, 2432A_02, and 2432A_03) is approximately 42.7 miles long and flows southeast beginning in Fort Bend County and continuing through Brazoria County. The bayou terminates at the confluence with New Bayou, approximately 0.5 miles upstream of Farm-to-Market Road (FM) 2004.

The Willow Bayou watershed is 10.94 square miles. Willow Bayou (AU 2432B_01) is the major tributary to Halls Bayou. The intermittent headwaters for Willow Bayou begins three miles southwest of the City of Hitchcock in western Galveston County. The stream flows southwest for 8 miles to its confluence with Halls Bayou at the Brazoria County line.

The Halls Bayou Tidal watershed (AU 2432C_01) is 58.04 square miles. This tidal stream is 19.6 miles long and begins approximately 6 miles southeast of Alvin in Brazoria County with intermittent headwaters. The bayou flows southeasterly, briefly enters Galveston County, and then runs parallel to the Galveston County line. Halls Bayou then turns and flows southwesterly into Halls Lake, and then into Chocolate Bay.

The Persimmon Bayou Tidal watershed is 6.93 square miles. Persimmon Bayou (AU 2432D_01) branches off from Mustang Bayou near the intersection of FM 2004 and County Road 2917. This tidal bayou flows southeastward for approximately 5.5 miles until it joins New Bayou, near the confluence with Chocolate Bay.

The New Bayou Tidal watershed is 14.51 square miles. New Bayou (AU 2432E_01), a tidal water body, begins at Ditch C-1, a tributary to Chocolate Bayou, near County Road 169 and flows southeastward 15.8 miles to its confluence with Chocolate Bay.

Summary of TMDLs

Table 1 summarizes the allocations developed for nine TMDLs for indicator bacteria in the Chocolate Bay watershed. See the TMDL reports for additional background information for each subwatershed, including the problem definition, endpoint identification, source analysis, linkages between sources and receiving waters, and pollutant load allocations (TCEQ, 2024a; TCEQ, 2024b; and TCEQ, 2025a).

Table 1. TMDL Summaries

AU	Criterion (cfu/100 mL)	TMDL	WLA_{WWTF} [a]	WLA_{SW} [b]	LA [c]	FG [d]	MOS [e]
1107_01	35	907.154	21.700	159.286	591.276	89.534	45.358
1108_01	126	1,714.082	58.733	293.261	954.320	322.063	85.704
2432B_01	126	87.718	0.00	7.960	74.942	0.448	4.386
2432C_01	35	193.106	0.00	25.735	156.679	1.037	9.655
2432A_01	126	473.886	21.592	151.808	245.854	30.938	23.694
2432A_02	126	544.804	18.894	241.776	219.192	37.702	27.240
2432A_03	126	474.149	18.179	185.131	209.691	37.441	23.707
2432D_01	35	76.874	5.998	17.397	41.022	8.614	3.844
2432E_01	35	172.934	5.998	46.277	103.399	8.614	8.647

All loads are expressed in billion cfu/day.
[a] WLA_{WWTF}: wasteload allocation for WWTFs
[b] WLA_{SW}: wasteload allocation for stormwater
[c] LA: load allocation
[d] FG: future growth
[e] MOS: margin of safety

Implementation Strategy

This I-Plan documents five management measures to reduce bacteria loads. Stakeholders selected management measures based on feasibility, costs, support, and timing. Activities may be phased in based on the needs of the stakeholders, availability of funding, and the progress made in improving water quality.

Adaptive Implementation

All I-Plans use an adaptive management approach in which stakeholders periodically assess measures for efficiency and effectiveness. This adaptive

management approach is one of the crucial elements of the I-Plan. The iterative process of evaluation and adjustment ensures continuing progress toward achieving water quality goals and expresses stakeholder commitment to the process.

The stakeholders will periodically assess progress using the schedule of implementation, interim measurable milestones, water quality data, and the communication strategy included in this plan. If stakeholders find that there has been insufficient progress or that implementation activities have improved water quality, the implementation strategy can be adjusted.

Source Load Calculations

The Chocolate Bay watershed was divided into nine subwatershed management units (SWMU) to assist in estimating fecal bacteria source contributions. The units follow the AU reaches as the AUs were developed by considering common land use features and similar watershed characteristics (Table 2, Figure 2).

Table 2. AUs, SWMUs, and SWMU acreage

AU	SWMU	SWMU Area (acres)
1107_01	1	22,731.08
1108_01	2	88,098.57
2432A_01	3	9,288.85
2432A_02	4	4,255.91
2432A_03	5	17,916.10
2432B_01	6	7,001.05
2432C_01	7	37,143.23
2432D_01	8	4,435.11
2432E_01	9	9,289.54

The estimated nonpoint source pollutant loadings within each SWMU were determined to set management measure priorities. The Houston-Galveston Area Council (H-GAC) utilized landcover analysis for the Chocolate Bay watershed and source load calculations that have been developed in previous watershed-based plans where source modeling (e.g., SELECT) in the H-GAC region was used (H-GAC, 2018 and EPA, 2001). For the remainder of this report, each management measure may include some calculations that have been rounded and may not lead to the exact final amounts listed in the text, tables, or figures.

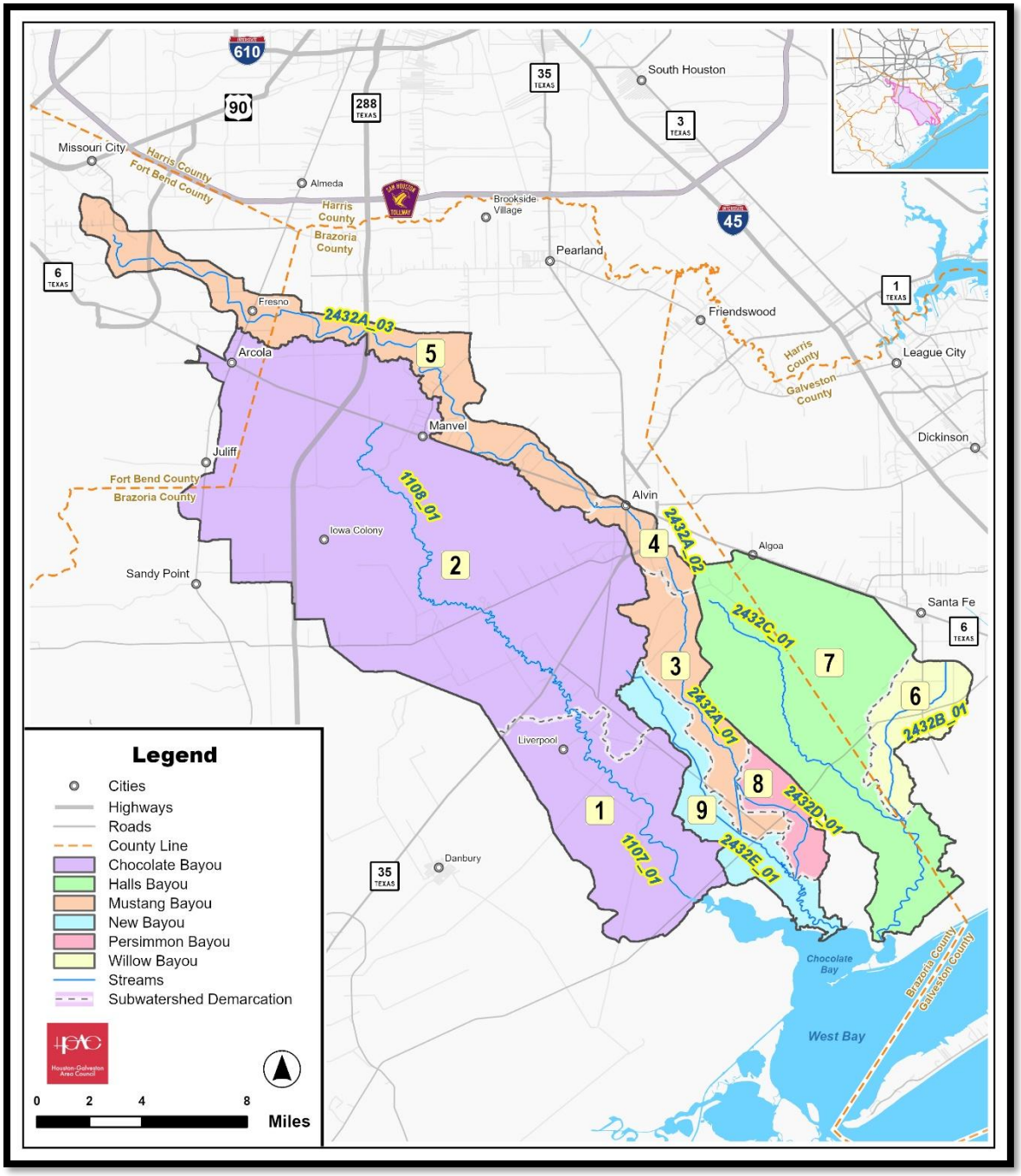

Figure 2. SWMUs for managing all sources

The loads and load reductions in Tables 3-7 are shown in *E. coli* (Teague, 2009; EPA, 2001; H-GAC, 2018). The representative units (Table 3) and their daily loads were applied uniformly across the subwatersheds regardless of which standard criterion was applicable, *E. coli* or Enterococci. Bacteria data collected in the Chocolate Bay watershed include both indicator bacteria because the watershed has both fresh and tidal waters. Enterococci were collected in the tidal water bodies (AUs 1107_01, 2432C_01, 2432D_01, and 2432E_01) and *E. coli* were collected in freshwater (all remaining water bodies). It was assumed

that *E. coli* and Enterococci are present in all sources and that management measures will result in proportional bacteria reductions to both indicators.

The source loads were calculated by multiplying the estimated total source population (e.g. the number of OSSFs in a SWMU), by the daily load per representative unit (e.g., daily load per one OSSF) (Teague, 2009; Table 3). This calculation is further described in the individual management measure sections.

Table 3. Representative unit source loads

Bacteria Source	Number in Watershed	Representative Unit	Representative Unit Daily Load (billion cfu/day)
Cattle	17,926	1 Cow	2.700
OSSF	15,440 (3,088 failing)	1 Failing OSSF	3.710
SSO [a]	103	1 SSO	4.930
Feral Hogs	4,052	1 Feral Hog	4.450
Dogs	18,981	1 Dog	2.500
Deer	7,920	1 Deer	0.175

[a] SSO: sanitary sewer overflow

Source loadings (Table 4) were determined using Table 3 and the estimated watershed source populations (e.g., number of dogs, OSSFs, and cattle). Estimating source populations within the Chocolate Bay watershed are described more fully within the three TSDs:

- *Technical Support Document for Two Total Maximum Daily Loads for Indicator Bacteria in the Chocolate Bayou Watershed* (TCEQ, 2023).
- *Technical Support Document for Five Total Maximum Daily Loads for Indicator Bacteria in the Mustang, Persimmon, and New Bayou Watersheds* (TCEQ, 2025b).
- *Technical Support Document for Two Total Maximum Daily Loads for Indicator Bacteria in the Halls Bayou Tidal and Willow Bayou Watersheds* (TCEQ, 2025c).

The estimated individual source loadings and total loading for all sources in each subwatershed can be found in Table 4. The source loadings were used to identify priorities based on individual source and total source loadings. Each management strategy presents individual source loading priorities across the Chocolate Bay watershed.

For this I-Plan, cattle were the only livestock used, as they account for around 90% of the loadings from all livestock. Using the information from Table 4, the

percentage each source contributes can be determined by dividing the individual source load by the total estimated source load for each watershed. Table 5 presents those percentages.

The reduction of indicator bacteria needed to attain the contact recreation standards for each AU was determined during TMDL development. This load reduction is the difference between the geometric mean load of observed data between 0 and 10% flows and the TMDL calculated at 5% flow on the load duration curve (TCEQ, 2023; TCEQ, 2025b; and TCEQ, 2025c). Table 6 provides the percentage reduction, and the load reduction needed to meet the contact recreation standard in each subwatershed.

Multiplying the load reduction values from Table 6 by the percentage source contribution (Table 5) yields the daily load reduction needed for each source and the total reduction by all sources for each watershed. The daily source load reduction values are presented in Table 7. To reach an annual source load reduction, each load is multiplied by 365. The load reduction values will be reviewed more closely within each management measure that follows.

The source reductions and source unit reductions are estimates. They present one solution to meeting the contact recreation standard. In practice, implementing the I-Plan will likely produce opportunities to act on certain measures while others prove more difficult. Due to the availability of funding or other technical assistance, some actions might be more practical. Therefore, completing the actions within one management measure and expanding beyond the estimated reductions expressed for that measure might be used to alleviate another measure that is discovered to be more difficult to implement.

Table 4. Estimated source loadings of fecal bacteria

Subwatershed	AU	SWMU	OSSF	SSO	Dogs	Cattle	Deer	Feral Hogs	Total Loading
Chocolate Bayou Tidal	1107_01	1	670.77	0.04	1,202.50	7,697.70	157.33	2,087.05	11,815.38
Chocolate Bayou Above Tidal	1108_01	2	6,134.11	0.06	17,922.50	26,338.50	610.05	7,894.30	58,899.52
Mustang Bayou	2432A_01	3	210.73	0.09	1,387.50	1,930.50	64.40	752.05	4,345.26
Mustang Bayou	2432A_02	4	341.32	0.03	5,780.00	494.10	29.40	360.45	7,005.30
Mustang Bayou	2432A_03	5	1,710.31	0.02	15,790.00	3,326.40	124.08	1,584.20	22,535.01
Willow Bayou	2432B_01	6	544.63	0.00	1,062.50	807.30	48.48	694.20	3,157.10
Halls Bayou Tidal	2432C_01	7	1,822.35	0.00	4,307.50	5,869.80	257.25	3,524.40	15,781.30
Persimmon Bayou Tidal	2432D_01	8	6.68	0.00	0.00	324.00	30.63	324.85	686.15
New Bayou Tidal	2432E_01	9	15.58	0.00	0.00	1,611.90	64.40	809.90	2,501.78
		Total	**11,456.48**	**0.23**	**47,452.50**	**48,400.20**	**1,386.00**	**18,031.40**	**126,726.81**

All loads are expressed in billion cfu/day.

Table 5. Percentage source contribution of fecal indicator bacteria

Subwatershed	AU	SWMU	OSSF	SSO	Dogs	Cattle	Deer	Feral Hogs	Total Percentage
Chocolate Bayou Tidal	1107_01	1	5.68%	0.0003%	10.18%	65.15%	1.33%	17.66%	100.00%
Chocolate Bayou Above Tidal	1108_01	2	10.41%	0.0001%	30.43%	44.72%	1.04%	13.40%	100.00%
Mustang Bayou	2432A_01	3	4.85%	0.0020%	31.93%	44.43%	1.48%	17.31%	100.00%
Mustang Bayou	2432A_02	4	4.87%	0.0004%	82.51%	7.05%	0.42%	5.15%	100.00%
Mustang Bayou	2432A_03	5	7.59%	0.0001%	70.07%	14.76%	0.55%	7.03%	100.00%
Willow Bayou	2432B_01	6	17.25%	0.0000%	33.65%	25.57%	1.54%	21.99%	100.00%
Halls Bayou Tidal	2432C_01	7	11.55%	0.0000%	27.29%	37.19%	1. 63%	22.33%	100.00%
Persimmon Bayou Tidal	2432D_01	8	0.97%	0.0000%	0.00%	47.22%	4.46%	47.34%	100.00%
New Bayou Tidal	2432E_01	9	0.62%	0.0000%	0.00%	64.43%	2.57%	32.37%	100.00%
		Total	**9.04%**	**0.0002%**	**37.44%**	**38.19%**	**1.09%**	**14.23%**	**100.00%**

All loads are expressed in billion cfu/day.

Table 6. Estimated reductions in fecal indicator bacteria by SWMU

Subwatershed	AU	SWMU	Estimated Loading of Bacteria at 5% Flow	Percent Reduction	Bacteria Reduction
Chocolate Bayou Tidal	1107_01	1	3,840.19	76.08%	2,921.62
Chocolate Bayou Above Tidal	1108_01	2	236,248.26	99.32%	234,641.77
Mustang Bayou	2432A_01	3	2,393.41	86.58%	2,072.21
Mustang Bayou	2432A_02	4	34,727.26	98.05%	34,050.08
Mustang Bayou	2432A_03	5	9,257.57	95.43%	8,834.50
Willow Bayou	2432B_01	6	400.76	85.30%	341.85
Halls Bayou Tidal	2432C_01	7	2,939.90	95.19%	2,798.49
Persimmon Bayou Tidal	2432D_01	8	2,127.09	97.25%	2,068.60
New Bayou Tidal	2432E_01	9	2,297.97	94.63%	2,174.57

All loads are expressed in billion cfu/day.

Table 7. Estimated load reductions in fecal indicator bacteria by source

Subwatershed	AU	SWMU	OSSF	SSO	Dogs	Cattle	Deer	Feral Hogs	Load Reduction
Chocolate Bayou Tidal	1107_01	1	165.86	0.0089	297.35	1,903.43	38.90	516.07	2,921.62
Chocolate Bayou Above Tidal	1108_01	2	24,436.86	0.2242	71,399.01	104,926.36	2,430.30	31,449.03	234,641.77
Mustang Bayou	2432A_01	3	100.49	0.0408	661.69	920.64	30.71	358.65	2,072.21
Mustang Bayou	2432A_02	4	1,659.03	0.1422	28,094.37	2,401.63	142.90	1,752.01	34,050.08
Mustang Bayou	2432A_03	5	670.50	0.0097	6,190.22	1,304.06	48.64	621.06	8,834.50
Willow Bayou	2432B_01	6	58.97	0.0000	115.05	87.41	5.25	75.17	341.85
Halls Bayou Tidal	2432C_01	7	323.16	0.0000	763.85	1,040.89	45.62	624.98	2,798.49
Persimmon Bayou Tidal	2432D_01	8	20.13	0.0000	0.00	976.79	92.33	979.35	2,068.60
New Bayou Tidal	2432E_01	9	13.54	0.0000	0.00	1,401.08	55.98	703.97	2,174.57
		Total	**27,448.55**	**0.4259**	**107,521.52**	**114,962.29**	**2,890.62**	**37,080.28**	**289,903.68**

All loads are expressed in billion cfu/day.

Large reductions, particularly in AUs 1108_01 and 2432A_01, result in potential management outcomes where the endpoint is larger than the source population. For example, in Management Measure 3, dog population is 18,981 but it was estimated that 43,010 units would need to be managed to address the bacteria load. Source reductions and management improvements will need to address other sources beyond the surrogates identified in this I-Plan. This could include investigating more thoroughly wastewater treatment facilities, wildlife contributions, or some other unknown stormwater source. Additional monitoring or modeling might be prudent and a first step by stakeholders to explore this further.

The amount of rural and natural land cover in the Chocolate Bay watershed would suggest a larger wildlife contribution, but, with exception of deer, no additional reliable data exists. Deer are used in this assessment as a surrogate for all wildlife. Efforts under the I-Plan to reduce indicator bacteria will need to account for the fact that no reduction measures will be implemented to address fecal sources from wildlife. Other actions will have to account for this loading. Riparian restoration efforts described in this document may help reduce loading from wildlife.

Activities and Milestones

H-GAC held a series of public meetings in the watershed from December 2017 through 2018 to facilitate the development of the TMDLs and I-Plan. H-GAC presented general water quality information to San Jacinto-Brazos Coastal Basin stakeholders during public meetings. These meetings provided information on water quality impairments, TMDL development, and typical water quality management strategies. Attendees were encouraged to participate in future meetings in the Chocolate Bayou, Mustang Bayou, and Halls Bayou watersheds as coordination committee team members.

The Chocolate Bay coordination committee formed in January 2018, first to address the Chocolate Bayou TMDL development. The group has continued to meet through 2025. The group reviewed water quality in the watershed and has discussed appropriate management measure activities. Four Chocolate Bay coordination committee meetings were held prior to the development of this plan. The implementation activities presented in this report represent the stakeholders' effort and are described in the following section.

The Chocolate Bay coordination committee met on Aug. 30, 2022, and members responded to a questionnaire which covered potential bacteria sources and management measures. The attendees were asked to determine if each fecal bacteria source was a concern and rank the concern on a high, medium, or low scale. A rank of five was considered high, three was considered medium, and one was considered low.

Table 8 presents a summary of the questionnaire results covering nine key fecal bacteria sources commonly found in watersheds.

Table 8. Results of the Chocolate Bay watershed stakeholder questionnaire

Bacteria Source	Priority Rank
WWTFs	4.50
Failing OSSFs	4.25
Sanitary Collection Systems	4.25
Urban Stormwater	4.25
Pet Wastes	4.00
Livestock	3.00
Rural Stormwater	3.00
Illicit Dumping	2.75
Feral Hogs	2.75

Management Measures

The Chocolate Bay stakeholders identified five key management measures to address water quality concerns.

1) Maintain and improve WWTF and collection system function.
2) Promote safe OSSF use and maintenance.
3) Reduce stormwater sources such as pet waste and illegal dumping.
4) Support land management initiatives.
5) Promote feral hog management.

Management Measure 1

Maintain and Improve Wastewater Treatment Facility and Collection System Function

The purpose of this management measure is to develop and implement strategies that reduce fecal waste from WWTFs and sanitary sewer collection systems in priority areas (Figure 3). Figure 3 presents the priority areas for this strategy across the Chocolate Bay watershed. The priority areas are represented by a five-color scheme based on source load concentration within the watershed. For example, SWMU 3 has the highest occurrence of SSOs and thus the largest potential for bacteria loads.

WWTFs collect and treat public wastewater, converting that wastewater into effluent before returning it to surface water or for other designated uses. Correctly functioning WWTFs contribute negligible amounts of bacteria to surface water, as defined by state-regulated permits.

Stakeholders indicated that failing WWTFs and collection systems were a high priority as a fecal bacteria source to the Chocolate Bay watershed. While WWTF self-reported discharge monitoring reports were found consistent with those in other watersheds within the H-GAC planning region, the elevated fecal indicator concentration found in Mustang Bayou 2432A_02 (TCEQ, 2025C), the number of SSOs reported in Chocolate Bayou and Mustang Bayou (TCEQ, 2023 and TCEQ, 2025C), and the continued growth in WWTFs and collections systems in the watershed led surveyed stakeholders to this priority determination (Table 8).

SSOs were considered a source surrogate for this management measure. As reported in the TSDs (TCEQ, 2023; TCEQ, 2025b; and TCEQ, 2025c), there were a total of 103 SSOs between 2016 and 2021 (Table 9), releasing an estimated volume of 3,339,334.5 gallons of untreated or partially treated effluent. SSOs were not reported for SWMUs 6, 7, 8 and 9 as there are no current wastewater collection systems in the subwatersheds. It should also be noted that the number of SSOs are often considered underreported and volumes underestimated.

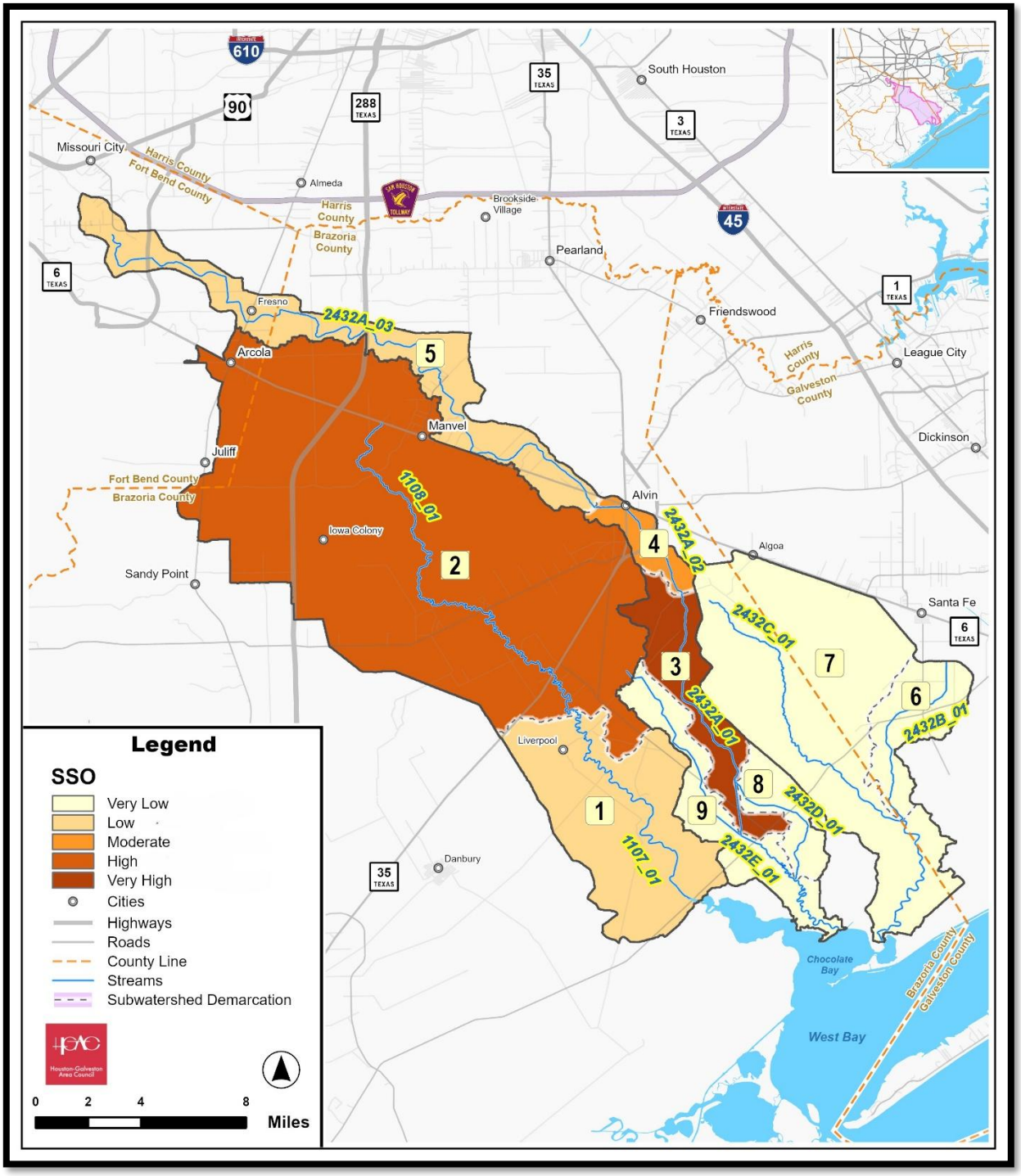

Figure 3. Priority areas to target for improving WWTF and collection system function

Table 9. Estimated daily bacteria load for SSOs

Watershed	AU	SWMU	Reported SSOs (2016-2021)	Reported SSO (Day)	Represented Unit Daily Load (SSO)	Estimated Daily Bacteria Load (SSOs)
Chocolate Bayou Tidal	1107_01	1	16	0.0073	4.93	0.04
Chocolate Bayou Above Tidal	1108_01	2	25	0.0114	4.93	0.06
Mustang Bayou	2432A_01	3	38	0.0174	4.93	0.09
Mustang Bayou	2432A_01	4	13	0.0059	4.93	0.03
Mustang Bayou	2432A_03	5	11	0.0050	4.93	0.02
Willow Bayou	2432B_01	6	0	0.0000	4.93	0.00
Halls Bayou Tidal	2432C_01	7	0	0.0000	4.93	0.00
Persimmon Bayou Tidal	2432D_01	8	0	0.0000	4.93	0.00
New Bayou Tidal	2432E_01	9	0	0.0000	4.93	0.00
		Total	**103**	**0.0470**	**4.93**	**0.24**

All loads are expressed in billion cfu/day.

To estimate a daily load contributed by SSOs, a daily SSO was calculated by dividing the number of SSOs by the number of days in the six-year reporting period. This number can then be multiplied by the SSO representative daily unit, 4.93 billion cfu/day, to arrive at a daily load. Table 9 presents the estimated daily bacteria load from SSOs. The estimated daily load is 0.24 billion cfu per day or 87.60 billion cfu per year.

This management measure outlines the strategy to target priority areas to reduce the instances of WWTF and collection system failures through asset management programs, which require life-cycle continuous repair and replacement, supporting compliance and enforcement efforts, regionalization of smaller facilities with chronic problems (when appropriate), and supporting operator workshops and training programs.

The success of this management measure relies on the efforts of the permit holders continuing to implement their operational best practices. As noted previously, when operated properly, WWTFs are not likely to contribute high levels of indicator bacteria. This plan encourages the continued use of best practices and recommends developing long-term replacement strategies to prevent future SSOs.

The goal of this management measure is to develop and conduct a fats, oils, grease, and wipes (FOG) prevention campaign, two technical assistance workshops, and one general outreach workshop.

Education Component

Operator education in the form of workshops and training programs is crucial to successfully implement this management measure. WWTF operators, utilities, and collection system owners should provide FOG outreach to utility customers to reduce the number of sewer blockages. There are several regional FOG educational programs that target homeowners and business owners, particularly multifamily homes. “Cease the Grease” and “Protect Our Pipes” are two of these that have ready-made informational flyers and brochures that can be adapted for the Chocolate Bay watershed.

Priority Areas

Priorities were assigned to subwatersheds based on land use, wastewater treatment service area boundaries, reported SSOs, and allocated loads from the TMDLs. Figure 3 shows how implementation in each SWMU will be prioritized.

Responsible Parties and Funding

Each organization listed below will be responsible only for expenses associated with its own efforts and as funds become available. The entities mentioned in this section provide resources of technical and financial assistance for Management Measure 1, but funding sources for this management measure are not necessarily limited to listed entities. This is not an exhaustive list, and

readers should consider whether they might have responsibility for implementing this management measure.

- **Local Governments** and political subdivisions of the state, including cities and municipal utility districts, hold wastewater permits that include indicator bacteria permit limits. Local governments also maintain collection systems. Routine maintenance of these complex systems requires the planning and dedication of resources to conduct inspections, life-cycle replacement costs, and continual training to prevent failures requiring repairs. Local governments holding stormwater permits are required to report annually on their efforts to inspect and continually maintain sanitary sewers within their jurisdictions to prevent SSOs.

- **TCEQ** oversees programs that address point sources of pollution impacting the waters of the state, including wastewater permits. This includes conducting inspections and enforcement of permit holders, setting rules and regulations, and requiring self-reporting by permit holders. TCEQ offers wastewater technical assistance and encourages the participation in its Sanitary Sewer Overflow Initiative Program. This is a voluntary program which began in 2004 to address an increase in SSOs due to aging collection systems throughout the state and to encourage corrective actions. Participating operators are not subjected to formal enforcement by TCEQ for most SSO violations so long as an SSO plan is in place. Participation allows the operator to direct resources to corrective actions rather than towards penalties and ongoing SSOs will not affect the system's compliance-history rating.

- **Texas A&M Engineering Extension Service (TEEX)** is the state extension agency that offers training programs and technical assistance to public safety workers, including those involved in water and wastewater.

- **United States Department of Agriculture (USDA) Rural Development** administers programs that provide infrastructure or infrastructure improvements to rural communities.

- **Water Professional Associations** like the Association of Water Board Directors, Texas Water Utilities Association, Water Environment Association of Texas, and Water Environment Federation are sources of information and provide a forum through conferences and meetings to educate municipalities, water districts, and others on the latest technology, laws, and rules that can affect their daily operation.

- The **watershed coordinator** would be charged to work with local stakeholders on issues related to wastewater collection systems to identify technical and funding opportunities, coordinate with federal, state, and local partners to assist with implementation, and to track

implementation success and consider actions or activities that need to be changed, including plan revisions.

Technical Assistance

Numerous trade and professional associations as listed above along with TCEQ, the Environmental Protection Agency (EPA), and TEEX provide educational and technical assistance to utility districts and municipalities.

Financial Assistance

Federal, state, and water professional associations provide support to wastewater operators, which can help them meet permit requirements. Management Measure 1 outreach activities are estimated to cost between $0 and $30,000 each year. A range is provided for workshop costs, as in some instances there may be no costs associated with the workshop, and in other instances there may be a cost for presenters, facility fees, certificates, or other charges that might be incurred. In some cases, a fee to attendees might offset these costs.

Permittee operation and maintenance costs covering infrastructure repair and replacement are highly variable and such costs are left to permittees to plan. The permittee might seek outside sources of funding. Estimates are that mid-sized cities spend approximately $1,000,000 to $5,000,000 per year on addressing aging systems. The list below is not an exhaustive funding list for Management Measure 1. Visit the funding resource pages for TCEQ (TCEQ, 2019) and EPA (EPA, 2019) for more extensive lists.

- The **Clean Water State Revolving Fund** is a loan program offered by the Texas Water Development Board (TWDB), authorized by the Clean Water Act, to serve low-cost financial assistance for planning, acquisition, design, and construction of wastewater, reuse, and stormwater infrastructure (TWDB, 2022).

- USDA Rural Utilities Service (RUS) **Water and Environmental Program** (WEP) provides technical assistance and financing to address water and wastewater infrastructure needs of rural communities with populations of 10,000 or fewer. WEP provides loans, grants, and loan guarantees for drinking water, sanitary sewer, solid waste, and storm drainage facilities in rural areas (USDA, 2019).

Measurable Milestones

Contingent upon the receipt of proposed project funding, the measurable milestones are:

- Development of a permittee list, with a focus on those with chronic problems, to invite to the technical assistance workshops.
- Reduction of the number of SSOs due to infrastructure repairs and replacements.

- Initiation of at least one FOG outreach campaign and general outreach workshop.
- Delivery of at least two operator trainings and technical assistance workshops.

Monitoring Component

Early programmatic monitoring of this management measure will consist of tracking the development of a campaign to prevent FOG blockages as well as a list of permittees for targeted outreach. As the implementation period progresses, number of operator technical assistance workshops held, number of home and business owner outreach events held, and number of FOG blockage prevention materials distributed will be tracked to assess progress. The watershed coordinator will provide a five-year report to TCEQ summarizing all activities related to this management measure. This report will also be posted for the public, by H-GAC, on the Chocolate Bay project page[1] (H-GAC, 2025).

Implementation Schedule

The implementation schedule is as follows. Contingent upon the receipt of proposed project funding, the responsible parties as identified above will:

Year 1:

- Develop a target permittee list.
- Devise a FOG blockage prevention campaign.

Year 2:

- Conduct a technical assistance workshop on technology, rules and regulation changes, operation and maintenance, reuse, and program assistance.
- Conduct a FOG blockage prevention campaign.

Year 3:

- Conduct one home and business owner general outreach/FOG campaign workshop.
- Conduct a FOG blockage prevention campaign.

Year 4:

- Conduct a technical assistance workshop on technology, rules and regulation changes, operation and maintenance, reuse, and program assistance.
- Conduct a FOG blockage prevention campaign.

Year 5:

- Provide one five-year Management Measure 1 progress report.
- Assess the FOG blockage prevention campaign.

[1] https://www.h-gac.com/watershed-based-plans

Estimated Load Reductions

The implementation measures listed in this I-Plan—including asset management, supporting compliance and enforcement efforts, and regionalization of smaller facilities (when and where appropriate)—may reduce fecal waste by humans through improved WWTF operation and the sanitary collection system maintenance.

Table 10 provides the estimated load reduction needed for SSOs and the number of SSOs that should be prevented. Table 10 shows the size of the load reduction needed for all subwatersheds presented in Table 7. Similar to the reported SSOs, the number of SSOs were converted from a daily number to a 1-year average of 33, in line with the I-Plan schedule. If all 33 SSOs were prevented, the daily load reduction is estimated to be 0.4259 billion cfu/day or 155.44 billion cfu/year.

The Chocolate Bayou Above Tidal (AU 1108_01) and Mustang Bayou (AU 2432A_02) estimated reductions were quite large compared to the other subwatersheds. SSOs estimated to be managed for these two subwatersheds is indicative of these large reduction values.

Ultimately, the goal is zero reportable SSOs, in line with the permit expectations. However, over five years, a target goal for this I-Plan is to prevent a minimum of one SSO of 10,000 gallons or more per subwatershed per year (or 45 in total). This number should be considered the minimum prevention, as SSOs were likely under-reported. This initial target is reasonable as future initiatives will target aging infrastructure that will close the gap and see fewer SSOs in the long run.

Additionally, this source does not include any WWTF effluent concerns. Therefore, any targeted improvements in WWTF and collection system operations and maintenance will contribute to the success of this I-Plan and help to offset possible shortfalls in implementing other management measures. Table 11 presents a summary of Management Measure 1.

Table 10. Total SSO load reduction and SSOs to be managed

Subwatershed	AU	SWMU	Total SSO Load Reduction	Representative Unit Daily Load (SSOs)	SSOs to be Managed (Day)	SSOs to be Managed (1-Yr)
Chocolate Bayou Tidal	1107_01	1	0.0089	4.93	0.0018	1
Chocolate Bayou Above Tidal	1108_01	2	0.2242	4.93	0.0455	17
Mustang Bayou	2432A_01	3	0.0408	4.93	0.0083	3
Mustang Bayou	2432A_02	4	0.1422	4.93	0.0289	11
Mustang Bayou	2432A_03	5	0.0097	4.93	0.0020	1
Willow Bayou	2432B_01	6	0.0000	4.93	0.0000	0
Halls Bayou Tidal	2432C_01	7	0.0000	4.93	0.0000	0
Persimmon Bayou Tidal	2432D_01	8	0.0000	4.93	0.0000	0
New Bayou Tidal	2432E_01	9	0.0000	4.93	0.0000	0
		Total	**0.4259**	**4.93**	**0.0864**	**33**

All loads are expressed in billion cfu/day.

Table 11. Management Measure 1: Maintain and improve WWTF and collection system function

Key Element	Summary
Causes and sources	Human fecal sources from SSOs and poorly maintained wastewater infrastructure
Potential load reduction	155.44 billion cfu/year
Technical and financial assistance	**Technical**: Trade and professional associations, along with TCEQ, EPA, and TEEX. **Financial**: • $0–30,000 for technical assistance workshops for WWTF and collection system operators. • $0–15,000 for one FOG campaign workshop. • $0–30,000 for FOG blockage prevention outreach campaign.
Educational component	Workshops, technical presentations, and one-on-one meetings. Distribution of informational flyers and brochures.
Schedule of implementation	• **Year 1**: Develop permittee list. Devise FOG blockage prevention campaign. • **Years 2 and 4**: Conduct technical assistance workshop for WWTF and collection system operators. • **Years 2–5**: Conduct and assess FOG blockage prevention campaign. • **Year 3**: Conduct one home and business owner general outreach/FOG campaign workshop. • **Year 5**: Provide five-year Management Measure 1 progress report, including assessment of the FOG blockage prevention campaign.
Interim, measurable milestones	• List of permittees to include in technical assistance workshops. • Number of technical assistance workshops held. • Completion of home and business owner general outreach workshop. • Successful implementation of FOG campaign. • Reduction of the number of SSOs due to infrastructure repairs and replacements.
Monitoring component	• **Environmental**: Clean Rivers Program (CRP) ambient monitoring data • **Programmatic**: Five-year report
Responsible parties	Local governments, TCEQ, TEEX, USDA Rural Development water professional associations, watershed coordinator

Management Measure 2

Promote Safe On-Site Sewage Facility Use and Maintenance

The purpose of this management measure is to develop and implement strategies that reduce fecal waste from failing OSSFs in priority areas. The priority areas in Figure 4 are represented by a five-color scheme based on the location of the sources in the watershed. For example, SWMU 2 has the highest occurrence of OSSFs, is estimated to have the largest number of failing systems, and the largest potential for bacteria loads.

Stakeholders indicated that failing OSSFs were a medium-high concern as a potential source of fecal bacteria. When functioning properly, OSSFs are a viable wastewater treatment option. However, limited awareness and lack of maintenance can lead to system failures. A failing system would be a direct source of untreated or partially treated human fecal waste.

The estimated number of OSSFs are provided in Table 12. The total number includes those systems with permits, plus an estimated number that might be found in the Chocolate Bay subwatersheds without a permit. The exact number of failing systems is unknown, but studies estimate the approximately 12% of systems are expected to be in failing condition (Reed, Stowe, and Yanke, 2001). However, considering the number of systems without a permit and the poorly draining coastal soils, a larger rate, 20%, is used in this I-Plan.

Table 12. Estimated number of OSSFs and daily bacteria load

Watershed	AU	SWMU	Total OSSF Systems	Failing Systems (20% Rate)	Representative Load (OSSF)	Estimated Daily Bacteria Load
Chocolate Bayou Tidal	1107_01	1	904	181	3.71	670.77
Chocolate Bayou Above Tidal	1108_01	2	8,267	1,653	3.71	6,134.11
Mustang Bayou	2432A_01	3	284	57	3.71	210.73
Mustang Bayou	2432A_02	4	460	92	3.71	341.32
Mustang Bayou	2432A_03	5	2,305	461	3.71	1,710.31
Willow Bayou	2432B_01	6	734	147	3.71	544.63
Halls Bayou Tidal	2432C_01	7	2,456	491	3.71	1,822.35
Persimmon Bayou Tidal	2432D_01	8	9	2	3.71	6.68
New Bayou Tidal	2432E_01	9	21	4	3.71	15.58
		Total	**15,440**	**3,088**	**3.71**	**11,456.48**

All loads are expressed in billion cfu/day.

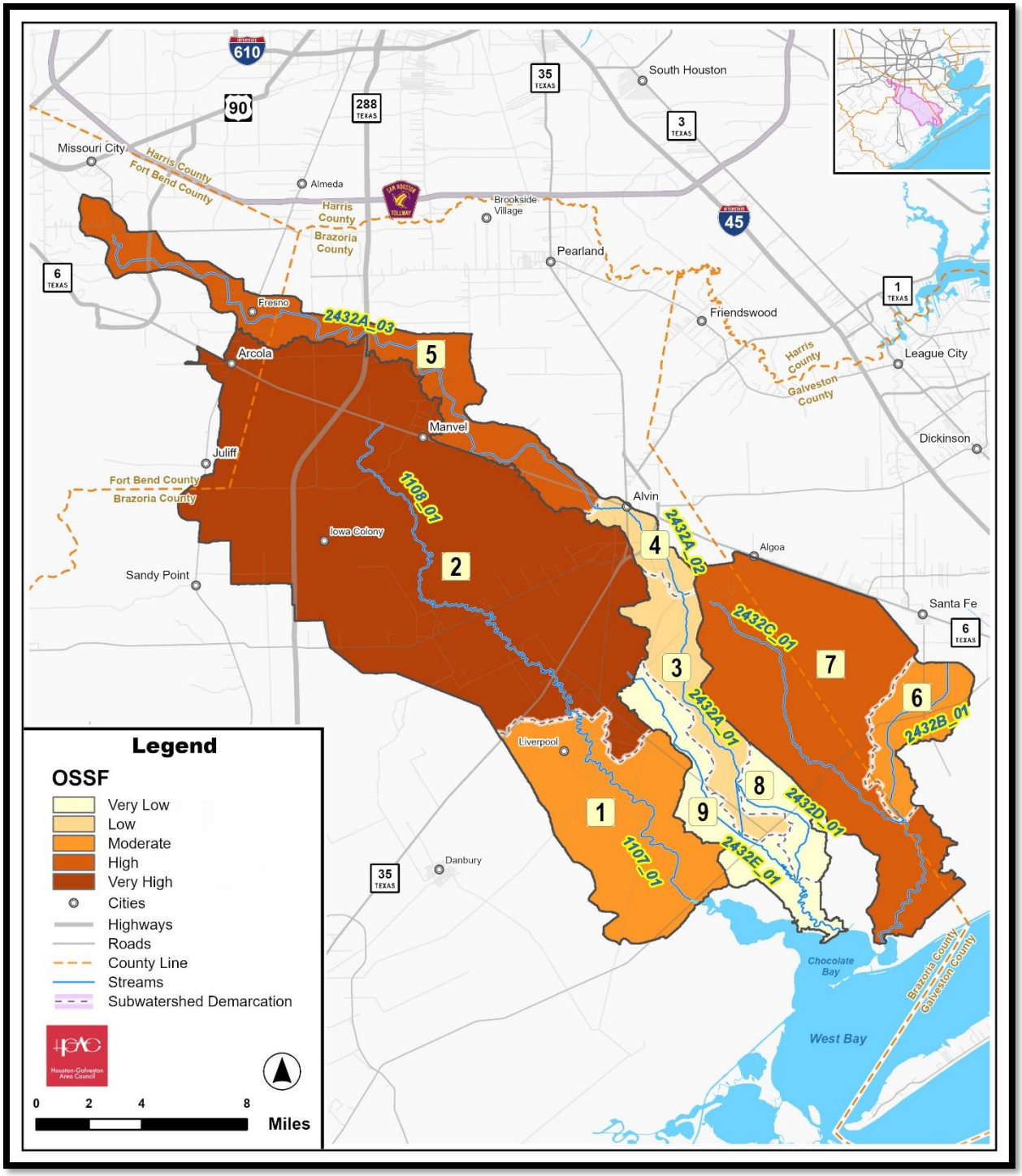

Figure 4. Priority areas for OSSFs in the Chocolate Bay watershed

This management measure outlines the strategy to target priority areas within the Chocolate Bay watershed for education and engagement on appropriate maintenance of OSSFs and identifies resources available to local governments and individuals to repair or replace failing OSSFs. In certain limited situations where conditions permit, the OSSF may be abandoned and left in place as wastewater is connected to a centralized wastewater system.

It is recommended that a watershed coordinator work with authorized agents (AAs) to engage with communities and notify them of available workshops and trainings for homeowner OSSF maintenance. The AAs in the Chocolate Bay watershed, including Brazoria, Galveston, and Fort Bend counties and TCEQ's Region 12 Office, regulate OSSF permitting and inspection. The watershed coordinator will also coordinate with H-GAC on potential sources of funding, including the Supplemental Environmental Project (SEP), and other potential funding sources, to provide financial support to remediate or replace failing OSSFs.

The goal of this management measure is to host three homeowner workshops or home inspector training courses, and support nine homeowners through the SEP or similar program.

Education Component

Given the finite funding available through the programs listed in the financial assistance section below, homeowner education is crucial to successfully implement this management measure. A variety of educational workshops, trainings, and informational materials are currently available through Texas A&M AgriLife Extension and H-GAC. These educational opportunities may address available financial resources for qualifying homeowners with failing OSSFs, training for home inspectors to conduct visual inspections, and other resource materials to encourage homeowners to maintain, repair, and replace their OSSFs, as necessary. However, awareness of available resources and materials, management practices, and their benefits should be assessed to allow for adjustments that encourage adoption.

Promotion methods include emails, targeted mailers advertising workshops and trainings, notices in newsletters and local newspapers, participation in local fairs and events, and coordination with AAs. Promotion efforts will be coordinated with The Texas State Soil and Water Conservation Board (TSSWCB), TCEQ, Texas A&M AgriLife Extension, real estate agents or inspectors, H-GAC, and other agencies, as appropriate, with a goal of increasing participation in the programs each year.

Priority Areas

Priorities were assigned to subwatersheds based on land use, location of permitted and non-permitted systems, and allocated loads from the TMDLs. Figure 4 shows how implementation in each SWMU will be prioritized.

Responsible Parties and Funding

Each organization listed below will be responsible only for expenses associated with its own efforts and as funds become available. The entities mentioned in this section provide resources of technical and financial assistance for Management Measure 2, but funding sources for this management measure are not necessarily limited to listed entities. This is not an exhaustive list, and readers should consider whether they might have responsibility for implementing this management measure.

- **AAs** are designated by TCEQ to regulate OSSFs within the Chocolate Bay watershed. Brazoria, Galveston, and Fort Bend counties are the AAs for their perspective portion of the watershed. TCEQ's Region 12 Office oversee OSSFs within city limits.

- **H-GAC** provides OSSF technical and outreach assistance to homeowners, real estate agents, and inspectors. Additionally, H-GAC manages an SEP for TCEQ addressing the maintenance, repair, and replacement of OSSFs.

- **Real Estate agents or inspectors** can educate prospective buyers on OSSF function and provide a point-of-sale inspection of the OSSF, through real estate transactions. Once inspected, repairs and replacements can be made as part of the transaction.

- **Texas A&M AgriLife Extension** and extension agents provide technical assistance and outreach to homeowners and water professionals that address maintenance, repairs, and replacement of OSSFs.

- The **Texas General Land Office (TGLO)** provides funding and technical assistance to local governments and nonprofits in the coastal zone to address parks and open space access and nonpoint sources of pollution, including failing OSSFs.

- The **USDA Rural Development** administers programs that provide infrastructure or infrastructure improvements to rural communities.

- The **watershed coordinator** will work with local stakeholders to identify technical and funding opportunities, coordinate with federal, state, and local partners to assist with implementation, and track implementation success and adapt the plan as necessary.

Technical Assistance

The repair and replacement of OSSFs requires licensed personnel and permits through respective county offices and TCEQ Region 12. The AAs can assist with the permitting process within their respective jurisdictions. H-GAC and Texas A&M AgriLife Extension offer education programs and training associated with OSSF maintenance, operations, and services. The design, construction, installation, and maintenance of new systems should be coordinated with local

licensed service providers that can provide technical assistance to homeowners as needed.

Financial Assistance

Federal, state, and local agencies provide support to address failing OSSF systems through technical assistance to improve maintenance, including holding tank pump out operations, funding for repairs or replacements, and in limited circumstances, providing connections to centralized wastewater treatment. Estimated costs for Management Measure 2 activities are estimated to range from $0 to $100,000 per year within the first five years of implementation. Below are several common financial programs that might be used to implement Management Measure 2.

- **Coastal Zone Management Program** is a program that is administered by the TGLO, with funding from the National Oceanic and Atmospheric Administration's Coastal Zone Management Program (TGLO, 2022). The program provides funding assistance to local governments and nonprofits in the Texas coastal zone to address parks, open space access, and nonpoint sources of pollution, including failing OSSFs, that affect the Texas coastal zone.

- The **SEP** program, administered by TCEQ, directs fines, fees, and penalties for environmental violations toward environmentally beneficial projects. H-GAC's SEP provides funding for the inspection, tank pump out, repair, and replacement of failing conventional septic systems or aerobic OSSFs using monies from businesses or individuals that fail to comply with environmental laws. Funding is available to homeowners who meet certain income restrictions. No matching funds are required. Geographic restrictions may apply. H-GAC also augments the program with additional grant funding from local governments and private organizations.

- The **Clean Water Act Section 319(h) Nonpoint Source Grant Program** is an EPA grant program (EPA, 2013), administered by TCEQ and TSSWCB, that provides funding to implement nonpoint source management measures. The funds require a 40% match and may be used to fund OSSF education, repairs, and replacements.

- The **Clean Water State Revolving Fund** is a loan program offered by TWDB, authorized by the Clean Water Act, to serve low-cost financial assistance for planning, acquisition, design, and construction of wastewater, reuse, and stormwater infrastructure.

- USDA RUS's **WEP** provides technical assistance and financing to address water and wastewater infrastructure needs of rural communities with populations of 10,000 or fewer. WEP provides loans, grants, and loan

guarantees for drinking water, sanitary sewer, solid waste, and storm drainage facilities in rural areas (USDA, 2019).

Measurable Milestones

Contingent upon the receipt of proposed project funding, the measurable milestones are:

- Number of homeowner workshops conducted.
- Number of home inspector trainings conducted.
- Number of homeowners with failing OSSFs supported through maintenance, repair, replacement, or centralization.

Monitoring Component

Programmatic monitoring of this management measure will consist of tracking the number of homeowner education workshops and real estate agent training courses held as well as the number of homeowners assisted with OSSF remediation through SEP or other funding sources. The watershed coordinator will provide a five-year report to TCEQ, summarizing all activities related to this management measure. This report will also be posted for the public, by H-GAC, on the Chocolate Bay project page (H-GAC, 2025).

Implementation Schedule

The implementation schedule is as follows. Contingent upon the receipt of proposed project funding, the responsible parties as identified above will:

Year 1:

- Host one homeowner workshop.
- Support, at minimum, one homeowner within the high or medium priority areas through the SEP or similar program.

Year 2:

- Host one home inspection training course for real estate agents and home inspectors.
- Support, at minimum, two homeowners within the high or medium priority areas through the SEP or similar program.

Year 3:

- Support, at minimum, two homeowners within the high or medium priority areas through the SEP or similar program.

Year 4:

- Host one homeowner workshop or host one home inspector training course.
- Support, at minimum, two homeowners within the high or medium priority areas through the SEP or similar program.

Year 5:

- Support, at minimum, two homeowners within the high or medium priority areas through the SEP or similar program.

- Provide one five-year Management Measure 2 progress report.

Estimated Load Reductions

By repairing or replacing failing OSSFs, promoting proactive homeowner maintenance, providing training opportunities and encouraging more inspections, the potential indicator bacteria loading reductions are estimated at 27,448.55 billion cfu/day or 10,018,720.75 billion cfu/year.

To express this reduction into more quantifiable terms, the OSSF load reductions were converted into unit reductions. The OSSF load reduction, 27,448.55 billion cfu/day, was divided by the representative unit daily load for OSSFs from Table 3, 3.71 billion cfu/day. (The representative unit daily load for failing OSSFs is not simply a measure of one unit but includes the concentration of indicator bacteria in one flush, the per capita daily discharge volume, and the number of persons per household. Each of these terms is multiplied together to get representative daily load for one failing OSSF.) This yields a total of 7,399 failing OSSFs that need to be repaired or replaced (Table 13).

Table 13. OSSF load reduction and number to be managed

Subwatershed	AU	SWMU	Total OSSF Load Reduction	Representative Unit Daily Load (OSSFs)	OSSFs to be Managed
Chocolate Bayou Tidal	1107_01	1	165.86	3.71	45
Chocolate Bayou Above Tidal	1108_01	2	24,436.86	3.71	6,587
Mustang Bayou	2432A_01	3	100.49	3.71	27
Mustang Bayou	2432A_02	4	1,659.03	3.71	447
Mustang Bayou	2432A_03	5	670.50	3.71	181
Willow Bayou	2432B_01	6	58.97	3.71	16
Halls Bayou Tidal	2432C_01	7	323.16	3.71	87
Persimmon Bayou Tidal	2432D_01	8	20.13	3.71	5
New Bayou Tidal	2432E_01	9	13.54	3.71	4
		Total	**27,448.55**	**3.71**	**7,399**

All loads are expressed in billion cfu/day.

Based on the estimated 3,088 failing OSSFs within the Chocolate Bay watershed (Table 12), 7,399 OSSFs from Table 13 is a larger target reduction estimate. This is likely due to the large reduction needed within two of the AUs, as noted previously.

Additionally, it is important to note that the number of failing systems should not increase for this measure to be effective. After repairing or replacing OSSFs, this management measure requires that the number of failing systems remain constant or decrease. The implementation of workshops and trainings will

educate homeowners and home inspectors on proper OSSF maintenance with the goal of keeping the number of failing OSSFs from increasing. Table 14 presents an overview of Management Measure 2.

Table 14. Management Measure 2: Promote safe OSSF use and maintenance

Key Element	Summary
Causes and Sources	Human fecal sources from untreated or insufficiently treated household sewage discharged from failing OSSFs
Potential load reduction	10,018,720.75 billion cfu/year
Technical and financial assistance	**Technical**: Brazoria, Galveston, and Fort Bend counties and TCEQ Region 12 for permitting; H-GAC and Texas A&M AgriLife Extension for education, programs, and training. **Financial**: • $0–10,000 for workshops and training events. • $0–100,000 to repair, replace, or abandon OSSFs.
Educational component	Workshops, technical presentations, and one-on-one meetings. Local promotional outreach such as emails; targeted mailers; notices in newsletters and newspapers; participation in fairs and events; and coordination with AAs.
Schedule of implementation	• **Year 1**: Host one homeowner workshop. • **Years 1–5**: Address a minimum of nine OSSFs in total. • **Year 2**: Host one home inspector training course. • **Year 4**: Host one homeowner workshop or one home inspector training course. • **Year 5**: Provide five-year Management Measure 2 progress report.
Interim, measurable milestones	• Number of homeowner workshops and home inspector trainings held. • Number of OSSFs addressed.
Monitoring component	• **Environmental**: CRP ambient monitoring data • **Programmatic**: Five-year report
Responsible parties	Watershed coordinator, AAs, H-GAC, Texas A&M AgriLife Extension, real estate agents/ inspectors, TGLO, USDA RUS.

Management Measure 3

Reduce Stormwater Sources Such as Pet Waste and Illegal Dumping

The purpose of this management measure is to develop and implement strategies to reduce stormwater sources of fecal wastes, including pet waste and illegal dumping in priority areas (Figure 5). The priority areas are represented by a five-color scheme based on waste load from the dog population in the watershed. For example, SWMU 2 has the highest dog population, yielding the largest potential for bacteria loads.

Stormwater, particularly in an urban setting, contains fecal indicator bacteria from permitted and unpermitted sources, e.g., pet wastes, collection systems, etc. The Chocolate Bay watershed is a mix of urban, suburban, and rural land covers. Developed land cover makes up the third largest land cover type in the watershed, with several small to medium sized developments along the waterway. As the size and density of these communities continue to grow, the stormwater contribution is also expected to expand.

Given the diffuse nature of nonpoint source pollution, it is difficult to determine potential stormwater sources of fecal waste. Watershed stakeholders rank developed and rural stormwater as a medium-high concern. Pet waste is a common fecal source ascribed to stormwater which stakeholders indicated was a medium priority.

Due to a lack of other stormwater fecal bacteria source data, pet numbers, through their waste, serve as a surrogate for other potential stormwater bacteria sources (Figure 5). The estimated dog population and estimated daily load is presented in Table 15. This estimate is potentially higher than what would be found if an accurate census could be performed. However, as this represents the total load from all potential stormwater sources, and can include contributions from wildlife, this estimate, 47,452.50 billion cfu/day, will be used.

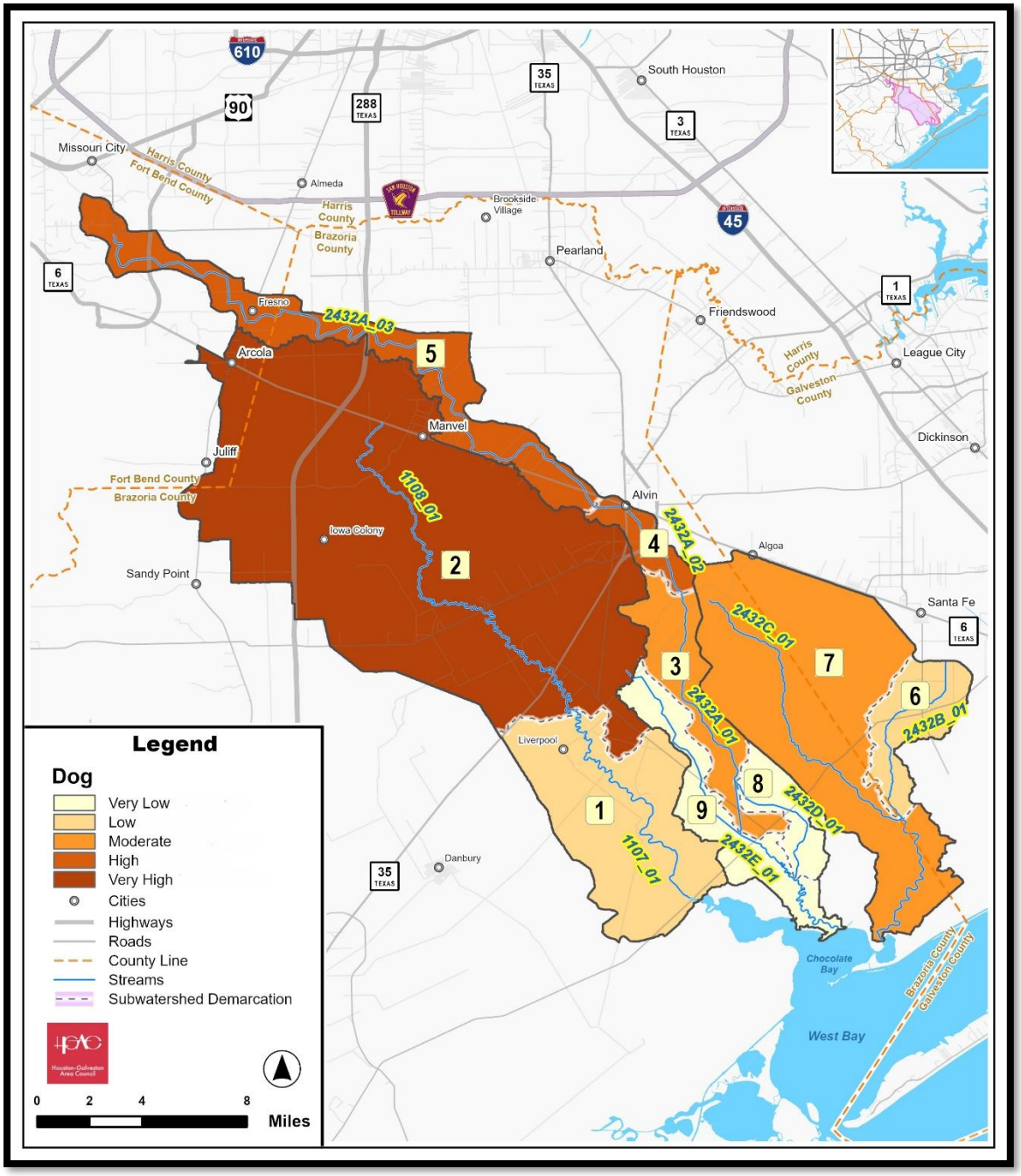

Figure 5. Priority areas to address pet waste in the Chocolate Bay watershed

Table 15. Estimated dog population and daily load

Watershed	AU	SWMU	Dog Population	Represented Unit Daily Load	Estimated Daily Bacteria Load (Dogs)
Chocolate Bayou Tidal	1107_01	1	481	2.50	1,202.50
Chocolate Bayou Above Tidal	1108_01	2	7,169	2.50	17,922.50
Mustang Bayou	2432A_01	3	555	2.50	1,387.50
Mustang Bayou	2432A_02	4	2,312	2.50	5,780.00
Mustang Bayou	2432A_03	5	6,316	2.50	15,790.00
Willow Bayou	2432B_01	6	425	2.50	1,062.50
Halls Bayou Tidal	2432C_01	7	1,723	2.50	4,307.50
Persimmon Bayou Tidal	2432D_01	8	0	2.50	0.00
New Bayou Tidal	2432E_01	9	0	2.50	0.00
		Total	**18,981**	**2.50**	**47,452.50**

All loads are expressed in billion cfu/day.

Pet waste management strategies become less effective in rural communities where dogs are often kept outside, and waste collection is less feasible and not required by a city or community ordinance. However, providing pet waste bag dispensers and collection stations in areas of higher pet density (e.g., parks, neighborhoods, and apartments) and addressing feral dog populations can assist with this measure.

Management Measure 3 also seeks to identify and reduce illegal dump sites and illicit discharges where fecal wastes and other pollutants might be illegally released to the Chocolate Bay watershed. Local governments and stakeholders should assist in identifying and eliminating these potential sites.

Preserving and enhancing the riparian areas in coordination with Management Measure 4, can build additional watershed capacity to improve water quality. Local governments and drainage districts can work together to enhance current and future drainage projects by incorporating riparian zone management. Landowners interested in conservation and habitat enhancement can use voluntary state and federal programs for assistance.

The goal of this management measure is to install and maintain a minimum of 12 pet waste stations, deliver education and outreach materials on pet waste, conduct a general stormwater education workshop, conduct illicit discharge and illegal dumping investigations, and complete one demonstration riparian corridor project in coordination with Management Measure 4.

Education Component

Education is crucial to successfully implementing this management measure. Campaigns and programs designed to educate on the potential impact pet waste and illegal dumping activities have on stormwater exist; however, more targeted distribution of those materials should be implemented. Methods for distributing materials include but are not limited to public service announcements, newspaper articles, utility bill inserts, direct mailers, and at community events.

Priority Areas

Priorities were assigned to subwatersheds based on human household distribution within the watershed and allocated loads from the TMDLs. Figure 5 shows how implementation in each SWMU will be prioritized.

Responsible Parties and Funding

Each organization listed below will be responsible only for expenses associated with its own efforts and as funds become available. The entities mentioned in this section provide resources of technical and financial assistance for Management Measure 3, but funding sources for this management measure are not necessarily limited to listed entities. This is not an exhaustive list, and readers should consider whether they might have responsibility for implementing this management measure.

- **Local Governments** can actively promote pet waste reduction measures by offering public education on the handling of pet wastes at apartments, parks, and other public spaces. The Brazoria County Stormwater Coalition serves as the lead entity for addressing stormwater education, addressing illicit discharges, and pollution prevention at construction sites. Additionally, local governments can actively work with drainage districts and the Texas Department of Transportation to enhance road and drainage projects to include the benefit of water quality features within the project.

- **Drainage Districts**, along with other county agencies, local governments, and landowners, present an opportunity to maintain and improve riparian zones. Drainage districts, with assistance from other stakeholders, identify drainage channels for restoration. There are five districts covering the Chocolate Bay watershed: Galveston County Drainage District 1, Fort Bend County Drainage District, Brazoria County Conservation & Reclamation District 3, Brazoria County Drainage District 4, and Brazoria County Drainage District 5.

- **H-GAC** manages pet waste outreach programs and coordinates pet waste reduction measures with other organizations. H-GAC has also been successful in applying for grant funding to acquire pet wastes stations for local communities. H-GAC can also provide planning assistance with

road construction and other areas where water quality enhancements can be encouraged.

- **Texas A&M AgriLife Extension** and extension agents provide outreach and assistance to a variety of topics including pet waste and riparian zone management.

- **United States Fish and Wildlife Service (USFWS)** holds conservation lands in the Chocolate Bay watershed and is a stakeholder. The Brazoria National Wildlife Refuge staff can provide conservation assistance to implement riparian restoration.

- The **watershed coordinator** would be charged to work with local stakeholders regarding pet waste and illegal dumping to identify technical and funding opportunities, coordinate with federal, state, and local partners to assist with implementation, and to track implementation success and consider actions or activities that need to be changed, including plan revisions.

Technical Assistance

H-GAC, EPA, and TCEQ have materials and resources for municipalities that manage and implement stormwater best management practices (BMPs). Texas Parks and Wildlife Department (TPWD) can provide conservation assistance to implement riparian restoration.

Financial Assistance

Federal, state, and local agencies provide support to entities and individuals as they seek to reduce the amount of pet waste entering water bodies. Contributions and participation from local governments in terms of technical and financial assistance will be key to reducing pet waste. Estimated costs for successfully carrying out Management Measure 3, ranging from $0 to $500,000 over five years. A range is provided for workshop costs as in some instances there might be no costs while in other instances there may be a cost for presenters, facility fees, certificates, or other charges that might be incurred.

- **Clean Water Act Section 319(h) Nonpoint Source Grant Program** is an EPA grant program, administered by TCEQ and TSSWCB, that provides funding for implementation of nonpoint source management measures. The funds require a 40% match and may be used to fund pet waste management programs, illegal dumping/illicit discharge investigations, stormwater education, and riparian restoration.

- Under **EPA Environmental Education Grants**, EPA seeks grant proposals from eligible applicants to support environmental education projects that promote environmental stewardship and help develop knowledgeable and responsible students, teachers, and citizens. This grant program provides financial support for projects that design, demonstrate, or

disseminate environmental education practices, methods, or techniques as described in the Environmental Education Grant Program solicitation notices.

- The objective of the **Urban Water Small Grants**, administered by EPA, is to fund projects that will foster a comprehensive understanding of local urban water issues, identify and address these issues at the local level, and educate and empower the community. The Urban Waters Small Grants Program seeks to help restore and protect urban water quality and revitalize adjacent neighborhoods by engaging communities in activities that increase their connection to, understanding of, and stewardship of local urban waterways.

- TWDB offers the **Clean Water State Revolving Fund**, authorized by the Clean Water Act, to serve low-cost financial assistance for planning, acquisition, design, and construction of wastewater, reuse, and stormwater infrastructure that include stormwater BMPs.

- USDA RUS's **WEP** provides technical assistance and financing to addressing water and wastewater infrastructure needs of rural communities with populations of 10,000 or less. WEP provides loans, grants, and loan guarantees for drinking water, sanitary sewer, solid waste, and storm drainage facilities in rural areas.

Measurable Milestones

Contingent upon the receipt of proposed project funding, the measurable milestones are:

- Number of pet waste stations installed.
- Number of educational materials developed and delivered.
- Number of workshops and trainings held.
- Number of illicit discharge and illegal dumping detection investigations completed.
- Area or stream miles of preserved, protected, or enhanced riparian corridor.

Monitoring Component

Early programmatic monitoring of this management measure will consist of tracking the number of local partners that collaborate to install pet waste stations and identify target locations for illicit discharge monitoring and illegal dumping. As the implementation period progresses, numbers of pet waste stations installed, educational material distribution events, and stormwater outreach events will be tracked to assess progress. Late phase implementation metrics will include continued tracking of previously listed metrics in addition to numbers of riparian projects completed and illicit discharge and illegal dumping investigations conducted. The watershed coordinator will provide a

five-year report to TCEQ summarizing all activities related to this management measure. This report will also be posted for the public, by H-GAC, on the Chocolate Bay project page (H-GAC, 2025).

Implementation Schedule

The implementation schedule is as follows. Contingent upon the receipt of proposed project funding, the responsible parties as identified above will:

Year 1:

- Identify willing local partners to develop and submit proposals for funding of pet waste stations and educational material delivery. Develop proposals for pet waste stations.
- Identify, with local community support, locations to conduct channel investigations for illicit discharges and illegal dumping.

Years 2 and 3:

- Install and maintain at least three pet waste collection stations per year.
- Deliver education and outreach materials on pet waste to pet owners and local community residents.
- Identify partners for one demonstration riparian corridor project in coordination with Management Measure 4. Develop a proposal for a minimum of one available funding grant.
- Initiate one demonstration riparian corridor project in coordination with Management Measure 4.
- Provide a stormwater outreach event as part of a general workshop with local communities covering fecal bacteria, source identification, nutrient enrichment, and riparian corridor protection in conjunction with Management Measure 4.

Year 4 and 5:

- Install and maintain at least three pet waste collection stations per year.
- Deliver education and outreach materials on pet waste to pet owners and local community residents.
- Conduct illicit discharge and illegal dumping detection investigations.
- Complete one demonstration riparian corridor project.
- Provide one five-year Management Measure 3 progress report.

Estimated Loading Reductions

Reducing pet waste, removing illicit discharges and illegal dump sites, and increasing community outreach should help to reduce indicator bacteria sources.

Pet numbers are used as a surrogate for the likely indicator bacteria reduction expected from Management Measure 3. By supporting the installation of pet waste disposal stations, increasing pet waste and illegal dumping education to local communities, and seeking opportunities to improve riparian corridors,

potential indicator bacteria loading reductions are calculated to be 107,521.52 billion cfu/day or 39,245,354.80 billion cfu/year.

To convert the load reduction into relatable terms, the load reduction, 107,521.52 billion cfu/day was divided by the representative unit daily load from Table 3, 2.5 billion cfu/day. The results of this calculation found that 43,010 total units would need to be managed from the Chocolate Bay watershed (Table 16).

Management Measure 3 does not recommend the removal of 43,010 dogs. Rather, Management Measure 3 is seeking to change pet owner actions with 43,010 representing the daily removal of pet waste from the equivalent number of dogs through active collection and the installation of pet waste stations. Again, it should be noted that this number is being driven by the large reductions needed in AUs 1108_01 and 2432A_02. With an average of 0.614 dogs per household (AVMA, 2018), even if all households, approximately 30,916, removed the waste from their dogs, it would only address 18,981 dogs, which is significantly less than the 43,010 needed. This is impractical, and points to the need to address other stormwater sources. Additional reductions will come from addressing other stormwater sources (e.g., illicit discharges), and increasing pollutant reduction capacity by restoring or enhancing riparian zones in coordination with Management Measure 4. Adaptive management during the implementation of this plan will help to focus efforts on bacteria reduction.

Table 16. Estimated dog load reduction and waste removal

Subwatershed	AU	SWMU	Total Dog Load Reduction	Representative Unit Daily Load (Dog)	# of Dogs From Which Waste Would be Managed
Chocolate Bayou Tidal	1107_01	1	297.35	2.5	119
Chocolate Bayou Above Tidal	1108_01	2	71,399.01	2.5	28,560
Mustang Bayou	2432A_01	3	661.69	2.5	265
Mustang Bayou	2432A_02	4	28,094.37	2.5	11,238
Mustang Bayou	2432A_03	5	6,190.22	2.5	2,476
Willow Bayou	2432B_01	6	115.05	2.5	46
Halls Bayou Tidal	2432C_01	7	763.85	2.5	306
Persimmon Bayou Tidal	2432D_01	8	0.00	2.5	0
New Bayou Tidal	2432E_01	9	0.00	2.5	0
		Total	**107,521.52**	**2.5**	**43,010**

All loads are expressed in billion cfu/day.

Table 17 presents a summary of Management Measure 3.

Table 17. Management Measure 3: Reduce stormwater sources such as pet waste and illegal dumping

Key Element	Summary
Causes and sources	Direct and indirect deposits of pet waste not properly disposed of by pet owners, illegal dumping, and other stormwater sources
Potential load reduction	39,245,354.80 billion cfu/year
Technical and financial assistance	**Technical**: Materials and resources to manage and implement stormwater BMPs can be provided by H-GAC, EPA, and TCEQ. Conservation assistance to implement riparian restoration can be provided by TPWD. **Financial**: • $0–10,000 for pet waste station installation. • $0–10,000 for stormwater outreach. • $0–500,000 to assist communities to identify opportunities to address stormwater and illegal dumping.
Educational component	Local promotional outreach such as emails; targeted mailers; notices in newsletters and newspapers; participation in fairs and events; and coordination with AAs.
Schedule of implementation	• **Year 1**: Identify local partners to develop and submit proposals for funding of pet waste stations and educational material delivery. Develop proposals for pet waste stations. Work with communities to identify locations to conduct channel investigations. • **Years 2–5**: Install and maintain at least three pet waste stations per year and distribute associated education and outreach materials. Plan and complete a stormwater/riparian demonstration project in coordination with Management Measure 4. • **Years 2–3**: Coordinate a stormwater outreach event as part of a watershed workshop. • **Years 4–5**: Conduct illicit discharge and illegal dumping detection investigations. • **Year 5**: Provide five-year Management Measure 3 progress report.
Interim, measurable milestones	• Number of pet waste stations installed • Number of educational materials developed and delivered • Number of workshops and trainings held • Number of illicit discharge and illegal dumping detection investigations completed • Area or stream miles of preserved, protected, or enhanced riparian corridor
Monitoring component	• **Environmental**: CRP ambient monitoring data • **Programmatic**: Five-year report
Responsible parties	Watershed coordinator, local governments, drainage districts, H-GAC, Texas A&M AgriLife Extension, USFWS

Management Measure 4

Support Land Management Initiatives

The purpose of this management measure is to develop and implement strategies to reduce bacteria loading from livestock into water bodies. Figure 6 shows priority areas based on the location of the highest cattle population and potential for bacteria loads.

Livestock are present throughout the Chocolate Bay watershed and stakeholders indicated them as a potentially significant source of indicator bacteria, having ranked this source as a medium priority (Table 8). Table 18 presents the estimated cattle population (USDA, 2024). TSSWCB staff reviewed the estimated cattle population numbers during the development of the TSDs. As stated earlier, while other types of livestock are mentioned in the TMDL (horses, domesticated pigs, sheep, and poultry), cattle were the only livestock used for calculations in this I-Plan, as they account for the bulk of loadings from livestock. Additionally, actions taken to address cattle under this measure will also cover other livestock.

While the fate and transport of fecal bacteria deposited on upland surfaces is not always certain, practices that manage livestock behavior and time spent grazing, particularly in riparian areas, can reduce potential bacteria loads reaching nearby water bodies. Livestock grazing behavior can be modified by the availability and location of food, shelter, and water.

Table 18. Cattle population and estimated daily bacteria load

Watershed	AU	SWMU	Cattle Population	Representative Unit Load	Estimated Daily Bacteria Load (Cattle)
Chocolate Bayou Tidal	1107_01	1	2,851	2.70	7,697.70
Chocolate Bayou Above Tidal	1108_01	2	9,755	2.70	26,338.50
Mustang Bayou	2432A_01	3	715	2.70	1,930.50
Mustang Bayou	2432A_02	4	183	2.70	494.10
Mustang Bayou	2432A_03	5	1,232	2.70	3,326.40
Willow Bayou	2432B_01	6	299	2.70	807.30
Halls Bayou Tidal	2432C_01	7	2,174	2.70	5,869.80
Persimmon Bayou Tidal	2432D_01	8	120	2.70	324.00
New Bayou Tidal	2432E_01	9	597	2.70	1,611.90
		Total	**17,926**	**2.70**	**48,400.20**

All loads are expressed in billion cfu/day.

Cattle grazing is highly dependent upon proximity to resources, especially water. Their fecal loading is also strongly tied to resource use as it is directly related to the amount of time an animal spends in an area. Therefore, reducing the amount of time livestock spend in riparian areas through rotational grazing, adding alternative watering facilities, or moving supplemental feeding locations can directly reduce potential bacteria loads reaching nearby water bodies.

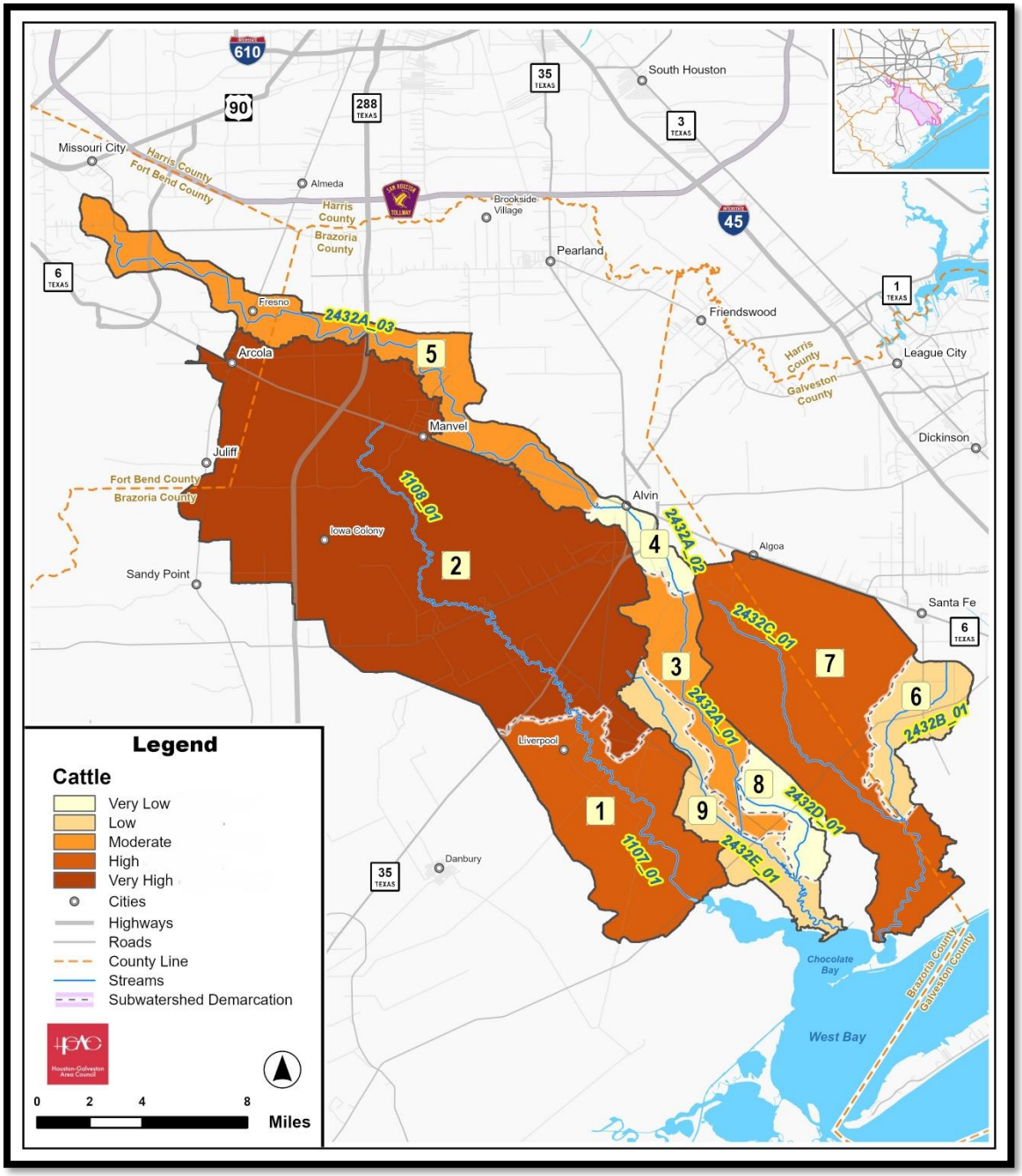

Figure 6. Priority areas to address livestock in the Chocolate Bay watershed

Recommended Management Measure 4 activities include promoting and implementing voluntary water quality management plans (WQMPs) and conservation management plans (CMPs), as well as restoring riparian buffers, and providing technical assistance and outreach. The USDA Natural Resources Conservation Service (NRCS) and TSSWCB give technical and financial assistance to producers for planning and implementing BMPs that protect and improve water quality. NRCS offers a variety of programs to implement operation-specific conservation plans that will meet producer goals and outline how BMPs will be implemented. TSSWCB, through local Soil and Water Conservation Districts (SWCDs), gives technical and financial assistance to develop and implement WQMPs through planning, implementation, and maintenance of each practice.

Additionally, managing riparian corridors and drainage areas can improve water quality and address livestock waste loading concerns. Restoring tree canopies, natural vegetation, and wetlands can benefit water bodies by improving aquatic and riparian habitats and serving as sinks for multiple water quality pollutants including bacteria. Implementation of Management Measure 4 can work in concert with the execution of Management Measure 3.

The goal of this management measure is to promote and establish at least six WQMPs and six CMPs, provide educational outreach, and complete one riparian corridor project.

Education Component

Education is crucial to successfully implement Management Measure 4. A variety of educational workshops, trainings, and informational materials are currently available to ranchers and landowners, providing information on how to combine agricultural production with environmental actions. These actions may address water quality, reduce soil erosion and sedimentation, provide livestock waste management, and result in soil enhancements that can increase yields.

However, awareness of available resources and materials, management practices, and their benefits should be assessed to allow for adjustments that encourage adoption. Promotion methods include emails, targeted mailers advertising workshops and trainings, notices in newsletters and local newspapers, participation in local fairs and events, and coordination with school agricultural programs. Promotion efforts will be coordinated with TSSWCB, local SWCDs, drainage districts, NRCS, Texas A&M AgriLife Extension, schools, H-GAC, and other agencies as appropriate with a goal of increasing participation in the programs each year.

Priority Areas

Priorities were assigned to subwatersheds based on land use and allocated loads taken from the TMDLs. Figure 6 shows how implementation in each SWMU will be prioritized.

Responsible Parties and Funding

Each organization listed below will be responsible only for expenses associated with its own efforts and as funds become available. The entities mentioned in this section provide resources of technical and financial assistance for Management Measure 4, but funding sources for this management measure are not necessarily limited to listed entities. This is not an exhaustive list, and readers should consider whether they might have responsibility for implementing this management measure.

- **Drainage Districts**, along with other county agencies, local governments, and landowners, present an opportunity to maintain and improve riparian zones. Drainage districts, with assistance from other stakeholders, identify drainage channels for restoration. There are five districts covering the Chocolate Bay watershed: Galveston County Drainage District 1, Fort Bend County Drainage District, Brazoria County Conservation & Reclamation District 3, Brazoria County Drainage District 4, and Brazoria County Drainage District 5.

- **SWCDs** work with federal and state agencies, particularly the TSSWCB, to provide technical assistance and funding for flood control, water quality enhancement, water supply, invasive species control, and other conservation initiatives. SWCDs will work with stakeholders to implement agriculture outreach, grazing management plans, and WQMPs. Waters Davis SWCD operates in Brazoria County, and Coastal Plains SWCD operates in Fort Bend County.

- **Texas A&M AgriLife Extension** and extension agents will provide technical assistance and outreach to agriculture producers and landowners on a variety of topics, including the latest research in animal, crop, and soil science, and protection of the environment.

- **TSSWCB** will work with stakeholders to provide outreach and technical assistance and expand the use of WQMPs.

- **NRCS** will work with stakeholders to provide outreach and technical assistance and expand the use of CMPs.

- **USFWS** holds conservation lands in the Chocolate Bay watershed and is a stakeholder. The Brazoria National Wildlife Refuge staff can provide conservation assistance to implement riparian restoration.

- A **watershed coordinator** should be retained to oversee the implementation of the Chocolate Bay I-Plan. The watershed coordinator would be charged to work with local stakeholders, identify technical and funding opportunities, coordinate with federal, state, and local partners to assist with implementation, and to track implementation success and

consider actions or activities that need to be changed, including I-Plan revisions.

- **Landowners and producers** may work with the NRCS, TSSWCB, and SWCDs as appropriate to develop WQMPs or CMPs and obtain funding to implement BMPs according to the site-specific plans.

Technical Assistance

Developing and implementing practices to reduce runoff from agricultural lands requires substantial technical expertise. Technical assistance can be obtained from local SWCDs, TSSWCB, local NRCS offices, and local Texas A&M AgriLife Extension offices. Producers requesting planning assistance may work with the local SWCD and local NRCS offices to define operation-specific management goals and objectives and develop management plans that prescribe effective practices that will achieve stated goals while also improving water quality. Additionally, TPWD can provide conservation assistance to implement riparian restoration.

Financial Assistance

Federal, state, and local agencies, many of which are identified above, provide support to landowners and producers as they seek to implement BMPs in the Chocolate Bay watershed. Estimated costs for the voluntary Management Measure 4 activities are estimated to range from $0 to $1,000,000 within the first five years of implementation. Below are several common financial programs that might be used to implement Management Measure 4.

- **WQMPs** are property-specific plans that outline the BMPs most appropriate to improve the quality of land and water on the property. TSSWCB may provide financial assistance to private property owners in implementing individual WQMPs, as funding allows.

- **Clean Water Act Section 319(h) Nonpoint Source Grant Program** is an EPA grant program, administered by TCEQ and TSSWCB, that provides funding for implementation of nonpoint source management measures. The funds require a 40% match and may be used to support education programs, watershed implementation, riparian restoration, and technicians.

- **Sustainable Agriculture Research and Education (SARE)** provides grants and educational programs to advance agricultural innovation which promotes profitability, stewardship of the land, air, and water, and quality of life for farmers, ranchers, and their communities. Southern SARE is the regional component that includes Texas and grants go towards land, crop, and livestock management.

- **NRCS Agricultural Management Assistance** program helps agricultural producers use conservation to manage risk and solve natural resource problems through natural resources conservation.

- **NRCS Conservation Stewardship Program** helps agricultural producers maintain and improve their existing conservation systems and adopt additional conservation activities to address priority resource concerns. Participants earn Conservation Stewardship Program payments for conservation performance; the higher the performance, the higher the payment.

- **Environmental Quality Incentives Program (EQIP)** is a voluntary program that provides financial and technical assistance to agricultural producers through contracts up to a maximum term of ten years. These contracts provide financial assistance to help plan and implement conservation practices that address natural resource concerns and for opportunities to improve soil, water, plant, animal, air, and related resources on agricultural land and non-industrial private forestland. An additional purpose of EQIP is to help producers meet federal, state, tribal, and local environmental regulations.

Measurable Milestones

Contingent upon the receipt of proposed project funding, the measurable milestones are:

- Number of grazing management plans developed.
- Number of WQMPs developed.
- Number of status reviews performed on existing WQMPs.
- Number of CMPs developed.
- Area or stream miles of preserved, protected, or enhanced riparian corridor.
- Number of education/outreach programs supported or implemented.
- Completion of demonstration riparian corridor project.

Monitoring Component

Early programmatic monitoring of this management measure will consist of tracking the number of local partners identified for collaborating on the development of a riparian corridor project as well as the execution of a riparian buffer workshop in the first year of implementation. As the implementation period progresses, number of grazing management plans/WQMPs, number of CMPs, and number of riparian buffer and BMP workshop events will be tracked to assess progress. Late phase implementation metrics will include continued tracking of previously listed metrics in addition to number of riparian projects completed. The watershed coordinator will provide a five-year report to TCEQ summarizing all activities related to this management measure. This report will

also be posted for the public, by H-GAC, on the Chocolate Bay project page (H-GAC, 2025).

Implementation Schedule

The implementation schedule is as follows. Contingent upon the receipt of proposed project funding, the responsible parties as identified above will:

Year 1:

- Provide, at minimum, one riparian buffer (or related) workshop for drainage districts, local governments, and agriculture producers/landowners.

Year 2:

- Provide, at minimum, one agriculture BMP (or related) workshop for agriculture producers/landowners.
- Identify partners, including drainage districts, for one demonstration riparian corridor project in coordination with Management Measure 3. Develop a proposal for a minimum of one available funding grant.

Year 3:

- Develop, at minimum, two grazing management plans or WQMPs and two CMPs.
- Initiate one demonstration riparian corridor project in coordination with Management Measure 3.

Year 4:

- Develop, at minimum, two grazing management plans or WQMPs and two CMPs.
- Continue development of one demonstration riparian corridor project.
- Provide, at minimum, one riparian buffer, agriculture BMP, or related workshop for drainage districts, local governments, and agriculture producers/landowners.

Year 5:

- Develop, at minimum, two grazing management plans or WQMP and two CMPs.
- Complete one demonstration riparian corridor project.
- Provide one five-year Management Measure 4 progress report.

Estimated Load Reductions

Implementing grazing, cross fencing, watering facilities, nutrient management, and other BMPs identified by local SWCDs provides the potential for indicator bacteria loading reductions. The load reduction surrogate for this measure is based on the number of cattle within the Chocolate Bay watershed because cattle make up the bulk of the livestock population. Estimated indicator bacteria reductions for cattle populations are presented in Table 19. Reducing fecal

loads from cattle results in an estimated daily load reduction of 114,962.29 billion cfu/day or 41,961,235.85 billion cfu/year.

A subsequent step was taken to determine how this reduction may be implemented. A representative unit daily load is used (2.7 billion cfu/day for cattle; see Table 3) to determine the number of cattle to be managed under a WQMP or a CMP. Table 19 presents the calculation where the total daily load reduction needed is divided by the daily load per representative unit. This yields a total of 42,579 units needed to reduce loadings in the Chocolate Bay watershed by 114,962.29 billion cfu/day. The 42,579 total units is larger than the estimated cattle population, 17,926. This number is again driven by the large reductions needed in AUs 1108_01 and 2432A_01.

This I-Plan is not recommending that this number of cattle be removed from the watershed. The units to be reduced are referring to the number of cattle to be managed under WQMPs or CMPs such that fecal loading from them would be prevented from entering the Chocolate Bay subwatersheds.

In prior publications, TSSWCB and USDA NRCS determined that a WQMP or CMP would reasonably address 50 livestock units (H-GAC, 2018). The cattle unit load reduction can then be divided by 50 to arrive at the estimated number of WQMPs or similar plans that would be needed to reduce the load by 114.962.29 billion cfu/day. This gives an estimated 854 management plans needed to address the required reduction throughout the Chocolate Bay watershed (Table 19). Understanding, however, reductions and plans assigned to AUs 1108_01 and 2432A_01 will be substantially lower than presented. Additional reductions will come from increasing pollutant reduction capacity by restoring or enhancing riparian zones in coordination with Management Measure 3. Table 20 presents an overview of Management Measure 4.

Table 19. Estimated cattle bacteria load reduction, number to be managed, and management plans

Subwatershed	AU	SWMU	Total Estimated Load Reduction (Cattle)	Representative Unit Daily Load (Cow)	Cattle to be Managed	Management Plans
Chocolate Bayou Tidal	1107_01	1	1,903.43	2.7	705	14
Chocolate Bayou Above Tidal	1108_01	2	104,926.36	2.7	38,862	777
Mustang Bayou	2432A_01	3	920.64	2.7	341	7
Mustang Bayou	2432A_02	4	2,401.63	2.7	889	18
Mustang Bayou	2432A_03	5	1,304.06	2.7	483	10
Willow Bayou	2432B_01	6	87.41	2.7	32	1
Halls Bayou Tidal	2432C_01	7	1,040.89	2.7	386	9
Persimmon Bayou Tidal	2432D_01	8	976.79	2.7	362	7
New Bayou Tidal	2432E_01	9	1,401.08	2.7	519	10
		Total	**114,962.29**	**2.7**	**42,579**	**853**

All loads are expressed in billion cfu/day.

Table 20. Management Measure 4: Support land management initiatives

Key Element	Summary
Causes and sources	Fecal deposition from cattle, horses, and sheep/goats in pastures, rangeland, and water bodies
Potential load reduction	41,961,234.15 billion cfu/year
Technical and financial assistance	**Technical**: Local SWCDs, TSSWCB, NRCS offices, and Texas A&M AgriLife Extension offices. Conservation assistance to implement riparian restoration can be provided by TPWD. **Financial**: • $0–30,000 for WQMPs. • $0–1,000,000 for CMPs. • $0–10,000 for technical assistance workshops.
Educational component	Workshops, technical presentations, and one-on-one meetings. Local promotional outreach such as emails, targeted mailers, notices in newsletters and newspapers, participation in fairs and events, and coordination with school agricultural programs.
Schedule of implementation	• **Year 1**: Host at least one riparian buffer workshop. • **Year 2**: Host at least one agricultural BMP workshop. Develop proposal for one demonstration riparian corridor project and identify partners. • **Years 3–5**: Develop a minimum of two WQMPs and two CMPs per year. Initiate and complete one demonstration riparian corridor project. • **Year 4**: Host at minimum either one riparian buffer workshop or one agricultural BMP workshop. • **Year 5**: Provide five-year Management Measure 4 progress report.
Interim, measurable milestones	• Number of education/outreach programs supported or implemented. • Number of grazing management plans developed. • Number of WQMPs developed. • Number of Status Reviews on existing WQMPs. • Number of CMPs developed. • Completion of demonstration riparian corridor project • Area or stream miles of preserved, protected, or enhanced riparian corridor.
Monitoring component	• **Environmental**: CRP ambient monitoring data • **Programmatic**: Five-year report
Responsible parties	TSSWCB, NRCS, SWCDs, watershed coordinator; drainage districts, Texas A&M AgriLife Extension, USFWS, landowners/ producers

Management Measure 5

Promote feral hog management.

The purpose of this management measure is to develop and implement strategies to reduce fecal deposition by feral animal populations, specifically feral hogs. Figure 7 shows priority areas based on the estimated bacteria load from feral hog populations across the AU watersheds.

Fecal bacteria are common inhabitants of the intestines of all warm-blooded animals. Feral hogs and most types of wildlife are attracted to water, increasing the likelihood of direct deposition of fecal bacteria into the water, and for fecal bacteria to be picked up off adjacent land during rainfall events.

While wildlife inhabits all parts of the Chocolate Bay watershed, areas that remain undeveloped are ideal habitat for wildlife. There are few data sources that consistently estimate wildlife populations except for TPWD deer population estimates. Source loadings included deer as a source to serve as a surrogate for wildlife. However, this management measure does not make any recommendation for reducing fecal bacteria sources from deer or other native wildlife.

Management Measure 5 recommends managing the feral hog population. TPWD considers feral hogs a nonnative invasive species. They can adapt to a variety of habitats and have high reproductive rates. Feral hogs have been identified as a large contributor of fecal bacteria impaired water bodies in Texas due to their tendency to wallow in mud and spend time in water. The feral hog population (TCEQ, 2023; TCEQ, 2025b; and TCEQ, 2025c) and estimated daily load for feral hogs is provided in Table 21.

Stakeholders indicated that feral hogs were a lower concern but still a potential fecal bacteria contributor to the watershed (Table 8).

There are numerous control efforts available to mitigate feral hog populations employed across the state. These measures, especially in priority areas, along with technical and financial assistance, are needed to reach the overall goal of this plan. Activities will be targeted towards priority areas where landowners should be contacted to discuss the economic savings of managing feral hogs, specific methods to do so, and available programs that can provide assistance.

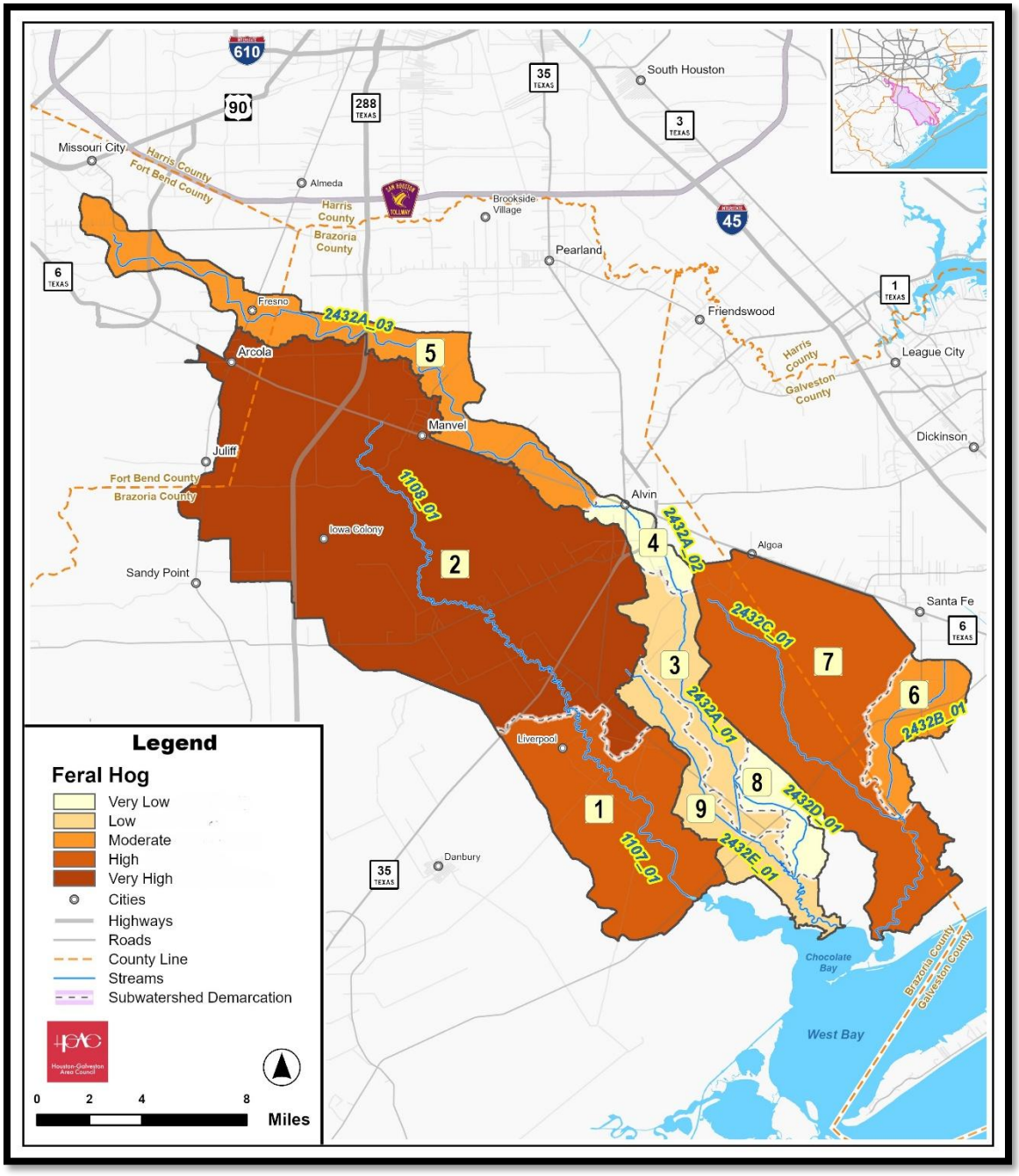

Figure 7. Priority areas to address feral hog populations in the Chocolate Bay watershed

Promoting and implementing BMPs focused on managing the feral hog populations within priority subwatersheds can lead to instream water quality improvements by minimizing fecal deposition.

The goal of this management measure is to coordinate feral hog outreach programs and conduct two feral hog workshops.

Table 21. Feral hog population and estimated daily bacteria load

Watershed	AU	SWMU	Feral Hog Population	Representative Unit Load (Feral Hog)	Estimated Daily Bacteria Load (Feral Hog)
Chocolate Bayou Tidal	1107_01	1	469	4.45	2,087.05
Chocolate Bayou Above Tidal	1108_01	2	1,774	4.45	7,894.30
Mustang Bayou	2432A_01	3	169	4.45	752.05
Mustang Bayou	2432A_02	4	81	4.45	360.45
Mustang Bayou	2432A_03	5	356	4.45	1,584.20
Willow Bayou	2432B_01	6	156	4.45	694.20
Halls Bayou Tidal	2432C_01	7	792	4.45	3,524.40
Persimmon Bayou Tidal	2432D_01	8	73	4.45	324.85
New Bayou Tidal	2432E_01	9	182	4.45	809.90
		Total	**4,052**	**4.45**	**18,031.40**

All loads are expressed in billion cfu/day.

Education Component

Education is crucial to successfully implement this management measure. A variety of educational workshops, trainings, and informational materials are available to residents, providing information about how feral hog populations degrade water quality. However, awareness of available resources and materials, management practices, and their benefits should be assessed to allow for adjustments that encourage adoption. Promotion methods include emails; targeted mailers advertising workshops and trainings; notices in newsletters and local newspapers; participation in local fairs and events; and coordination with school agricultural programs. Promotion efforts will be coordinated with TSSWCB, TCEQ, local Texas A&M AgriLife Extension offices, and other agencies as appropriate with a goal of increasing participation in the programs each year.

Priority Areas

Priorities were assigned to subwatersheds based on land use for suitable habitat for feral hogs and allocated loads from the TMDLs. Figure 7 shows how implementation in each SWMU will be prioritized.

Responsible Parties and Funding

Each organization listed below will be responsible only for expenses associated with its own efforts and as funds become available. The entities mentioned in this section provide resources of technical and financial assistance to landowners, city and county governments, and communities, for Management Measure 5, but funding sources for this management measure are not necessarily limited to listed entities. This is not an exhaustive list, and readers should consider whether they might have responsibility for implementing this management measure.

- **Landowners, Local Governments, and Communities** engage with resource agents to manage feral hogs on private and public lands.

- **Texas A&M AgriLife Extension** and extension agents provide outreach and assistance on a variety of topics including feral hogs.

- The **watershed coordinator** would be charged to work with local stakeholders in the management of the feral hog population to identify technical and funding opportunities, coordinate with federal, state, and local partners to assist with implementation, to track implementation success, and consider actions or activities that need to be changed, including plan revisions.

Technical Assistance

Numerous resources are available to assist landowners and managers in the management of feral hog populations. Texas A&M AgriLife Extension offers technical materials and workshops on feral hog impacts and control methods. TPWD also offers general information about identification and regulations regarding control measures for feral hogs.

Financial Assistance

Federal, state, and local agencies provide support to entities and individuals as they seek to manage feral hog populations in the Chocolate Bay watershed. Estimated costs for Management Measure 5 activities are estimated to range from $0 to $15,000/year. Below is one common financial program that might be used to implement Management Measure 5.

- The **Clean Water Act Section 319(h) Nonpoint Source Grant Program** is an EPA grant program, administered by TCEQ and TSSWCB, that provides funding for implementation of nonpoint source management measures. The funds require a 40% match and may be used to fund feral hog education workshops and outreach programs.

Measurable Milestones

Contingent upon the receipt of proposed project funding, the measurable milestones are:

- Number of educational programs delivered per year.
- Number of educational materials developed and disseminated.
- Number of individuals reached.
- Number of voluntary efforts implemented.
- Number of feral hogs removed per year.

Monitoring Component

Early programmatic monitoring of this management measure will consist of tracking the coordination efforts in scheduling feral hog outreach programs. As

the implementation period progresses, numbers of outreach material distribution efforts, landowners implementing voluntary control measures, feral hogs removed, and feral hog workshops held will be tracked to assess progress. Late phase implementation metrics will include continued tracking of previously listed metrics. The watershed coordinator will provide a five-year report to TCEQ summarizing all activities related to this management measure. This report will also be posted for the public, by H-GAC, on the Chocolate Bay project page (H-GAC, 2025).

Implementation Schedule

The implementation schedule is as follows. Contingent upon the receipt of proposed project funding, the responsible parties as identified above will:

Year 1:

- Coordinate and schedule feral hog outreach programs.

Years 2 and 3:

- Conduct a feral hog workshop each year.
- Track feral hog outreach efforts (materials created or disseminated or individuals reached), identify landowners and track implementation of voluntary control measures (fencing deer feeders, and others), including feral hog removal numbers.

Years 4 and 5:

- Track feral hog outreach efforts (materials created or disseminated or individuals reached), identify landowners and track implementation of voluntary control measures (fencing deer feeders, and others), including feral hog removal numbers.
- Provide one five-year Management Measure 5 progress report.

Estimated Load Reductions

By promoting the use of physical controls for feral hog management, such as fencing, educating residents on the effects of feral hog populations on water quality, and other controls, potential indicator bacteria loading reductions are estimated to be 37,080.28 billion cfu/day or 13,534,305.85 billion cfu/year.

The representative unit approach was applied to the feral hog load reduction by dividing the load reduction, 37,080.28 billion cfu/day, by the representative unit daily load for feral hogs, 4.45 billion cfu/day (Table 22). A total of 8,333 feral hogs were estimated for removal from the Chocolate Bay watershed to accomplish the potential load reduction. The 8,333 estimate is over twice the estimated feral hog population in the Chocolate Bay watershed. As has been previously stated, this number is driven by the larger reductions needed in AUs 1108_01 and 2432A_02. Additional fecal bacteria reductions will need to come from other sources.

As feral hog reproductive rates are quite high, the population after the removal of 8,333 feral hogs would need to be maintained. Studies by the Texas AgriLife Extension have suggested that the feral hog population needs to be culled each year by 50-70% to maintain a level feral hog population (Texas AgriLife Extension, 2012). Once the 8,333 feral hogs are removed, an additional number of feral hogs would require removal just to maintain the remaining population size.

Additional indicator bacteria removal capacity could be augmented by increasing the number of feral hogs removed each year, addressing other feral animal populations, and expanding the indicator bacteria reduction from other management measure sources. Table 23 presents a summary of Management Measure 5.

Table 22. Feral hog load reduction and estimated feral hogs to be removed

Subwatershed	AU	SWMU	Total Estimated Load Reduction (Feral Hogs)	Representative Unit Daily Load (Feral Hog)	Feral Hogs to be Removed
Chocolate Bayou Tidal	1107_01	1	516.07	4.45	116
Chocolate Bayou Above Tidal	1108_01	2	31,449.03	4.45	7,067
Mustang Bayou	2432A_01	3	358.65	4.45	81
Mustang Bayou	2432A_02	4	1,752.01	4.45	394
Mustang Bayou	2432A_03	5	621.06	4.45	140
Willow Bayou	2432B_01	6	75.17	4.45	17
Halls Bayou Tidal	2432C_01	7	624.98	4.45	140
Persimmon Bayou Tidal	2432D_01	8	979.35	4.45	220
New Bayou Tidal	2432E_01	9	703.97	4.45	158
		Total	**37,080.28**	**4.45**	**8,333**

All loads are expressed in billion cfu/day.

Table 23. Management Measure 5: Promote feral hog management

Key Element	Summary
Causes and sources	Direct and indirect deposits of feces form feral hogs.
Potential load reduction	13,534,305.85 billion cfu/year
Technical and financial assistance	**Technical**: Texas A&M AgriLife Extension and TPWD offer technical materials and workshops. **Financial**: • $0–10,000 for technical assistance workshops. • $0–10,000 for technical assistance such as workshops and other outreach programs.
Educational component	Workshops, technical presentations, and one-on-one meetings. Local promotional outreach such as emails; targeted mailers; notices in newsletters and newspapers; participation in fairs and events; and coordination with school agricultural programs.
Schedule of implementation	• **Years 1–5**: Track voluntary measures in coordination with landowners, including outreach efforts and feral hog control measures. • **Years 2–3**: Conduct one feral hog workshop each year. • **Year 5**: Provide five-year Management Measure 5 progress report.
Interim, measurable milestones	• Number of feral hogs removed each year. • Number of voluntary efforts implemented. • Complete a minimum of one feral hog program. • Successfully develop and disseminate outreach materials.
Monitoring component	• **Environmental**: CRP ambient monitoring data • **Programmatic**: Five-year report
Responsible parties	Watershed coordinator, Texas A&M AgriLife Extension

Sustainability

TCEQ, responsible parties, and other stakeholders in TMDL implementation projects periodically assess the results of the planned activities, along with other information, to evaluate the effectiveness of the I-Plan. Responsible parties and other stakeholders evaluate several factors, such as the pace of implementation, the effectiveness of BMPs, load reductions, and progress toward meeting water quality standards.

The responsible parties and other stakeholders will track progress using both implementation milestones and water quality indicators. These terms are defined as:

- **Water Quality Indicator** – A measure of water quality conditions for comparison to pre-existing conditions, constituent loadings, and water quality standards.
- **Measurable Milestone** – A measure undertaken to cause an improvement in water quality.

Water Quality Indicators

The goal for this I-Plan is attainment of the geometric mean criterion for the contact recreation use in each of the affected water bodies. The measure of success for each water body is a declining trend of the geometric mean concentration of the indicator bacteria.

As a partner with TCEQ CRP, H-GAC CRP will continue routine water quality monitoring during implementation as funding and resources allow. The indicators that will be used to measure improvement in water quality are *E. coli* in freshwater and Enterococci in saltwater. CRP data will be used to monitor surface water quality and measure bacteria loadings (especially in priority areas). The monitoring partners are the Environmental Institute of Houston, and the TCEQ Region 12 Office. Monitoring data collected by CRP will be evaluated by the watershed coordinator to assess impacts of this measure on surface water quality. The watershed coordinator will also work with the CRP partner to acquire funding to expand monitoring efforts, if needed.

Measurable Milestones

Implementation tracking helps stakeholders to determine if progress is being made toward meeting the goals of the TMDL and I-Plan. Tracking also allows stakeholders to identify whether specific actions are working or not and make any changes that may be necessary to get the I-Plan back on target. Measurable milestones track the completion of activities meant to reduce pollutant loadings. Schedules and milestones for this I-Plan are included in the descriptions of each management measure.

Communication Strategy

TCEQ will work with responsible parties and other stakeholders to hold meetings or obtain annual I-Plan updates for up to five years, so stakeholders may evaluate their progress. Responsible parties and stakeholders will continue to provide annual updates and/or take part in any meetings over the five-year period to evaluate implementation efforts. At the completion of the scheduled I-Plan activities, stakeholders will assemble and evaluate the actions, overall impacts, and results of their implementation efforts.

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