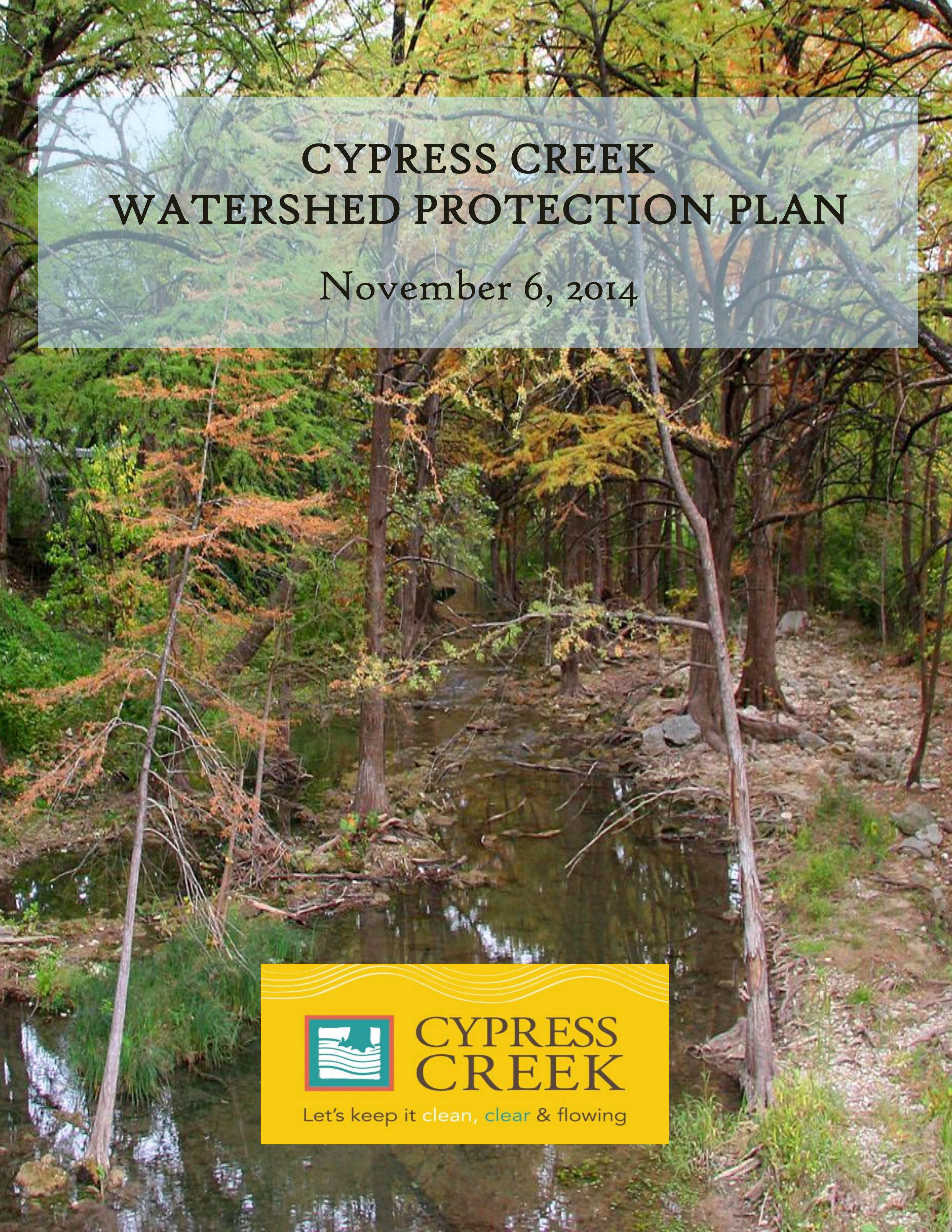
CYPRESS CREEK WATERSHED PROTECTION PLAN

November 6, 2014



CYPRESS CREEK

Let's keep it clean, clear & flowing

Cypress Creek Watershed Protection Plan

Prepared for the Cypress Creek Community
By
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IN COOPERATION WITH THE TEXAS COMMISSION ON ENVIRONMENTAL QUALITY AND U.S. ENVIRONMENTAL PROTECTION AGENCY. CWA §319H. CONTRACT NO. 582-11-12915.

Acknowledgements

The Cypress Creek Watershed Protection Plan is the result of a six-year collaboration between numerous groups and individuals. Each have played an important role in the Cypress Creek Project and its planning, activities, and garnering support from the community. While proper recognition of every person and organization that contributed to this Plan is not feasible, the Cypress Creek Stakeholder Committee gratefully acknowledges that it could not have happened without their dedication. We thank these individuals and organizations for their outstanding contributions of time, effort and commitment to the development of the Plan.

Special Thanks To:

The Cypress Creek Stakeholder Committee

The Cypress Creek Stakeholder Sub-Committees

Texas Commission on Environmental Quality

Environmental Protection Agency

Texas State Soil Water Conservation Board

AgriLife Extension Service

Guadalupe-Blanco River Authority

City of Woodcreek

City of Wimberley

Hays County

Wimberley Valley Watershed Association

Friends of Blue Hole

The Nature Conservancy of Texas

Purpose

The ultimate goal of the Cypress Creek Watershed Protection Plan is to ensure that the long-term integrity and sustainability of the Cypress Creek watershed is preserved and that water quality standards are maintained for present and future generations.

The Cypress Creek Watershed Protection Plan is a proactive plan that addresses likely future nonpoint source pollution impairments of nitrogen (N) and Total Suspended Solids (TSS). Although planning efforts focused primarily on surface water quality, the Stakeholders felt it was important to acknowledge the importance of properly managing the source groundwater in this Watershed Protection Plan. Accordingly, the plan incorporates groundwater and surface water components, spans agency jurisdictions, and is comprehensive in its approach for maintaining balance between natural resource management and economic development. This plan is significant because of its proactive nature, its engaged citizenry, inclusion of source groundwater for a complete hydrologic picture, and the implications for other potentially impaired watersheds in central Texas.

This Watershed Protection Plan is intended to be a living document, and may be adjusted to include new data and modified as conditions in the watershed change over time. It will evolve as needs and circumstances dictate and will be guided by the Stakeholder Committee as they undertake active stewardship of the watershed.

Vision

To preserve the natural beauty and excellent water quality of Cypress Creek for current and future generations.

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List of Acronyms and Abbreviations

AGWA	Automated Geospatial Watershed Assessment tool
BFZ	Balcones Fault Zone
BMP	Best management practices
BOD	Biochemical oxygen demand
CAPCOG	Capital Area Council of Governments
CCN	Certificate of Convenience and Necessity
CCP-DSS	Cypress Creek Project Decision Support System
Cm	Centimeter
Cfs	Cubic feet per second
Cfu	Colony forming units
CRP	Clean Rivers Program
CSA	Contributing source area
DO	Dissolved oxygen
DSS	Decision Support System
E. coli	*Escherichia coli*
EMC	Event mean concentration
Ft	Foot
GIS	Geographical Information Systems
HaysCAD	Hays County Appraisal District
HTGCD	Hays Trinity Groundwater Conservation District
ISC	Impervious surface cover
km^2	Kilometer(s) squared
L	Liter
LDC	Load duration curve
M	Meter
mg	Microgram
mm	Millimeter
mi^2	Mile(s) squared
N	Nitrogen
NELAP	National Environmental Laboratory Accreditation Program
NOAA	National Oceanic and Atmospheric Administration
NPS	Non-point source
OSSF	On-site sewage facility
P	Phosphorus
MCWE	Meadows Center for Water and the Environment
TCEQ	Texas Commission on Environmental Quality
TSS	Total suspended solids
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
WCR	Cypress Creek Watershed Characterization
WISD	Wimberley Independent School District
WPP	Watershed protection plan
WWTP	Waste water treatment plant

Technical Reference Document - Table of Contents

Find these in-depth or technical reports that support the Cypress Creek Watershed Protection Plan in the accompanying Technical Reference Document and on http://cypresscreekproject.squarespace.com/documents/cypress-creek-watershed-protection-plan/.

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Introduction

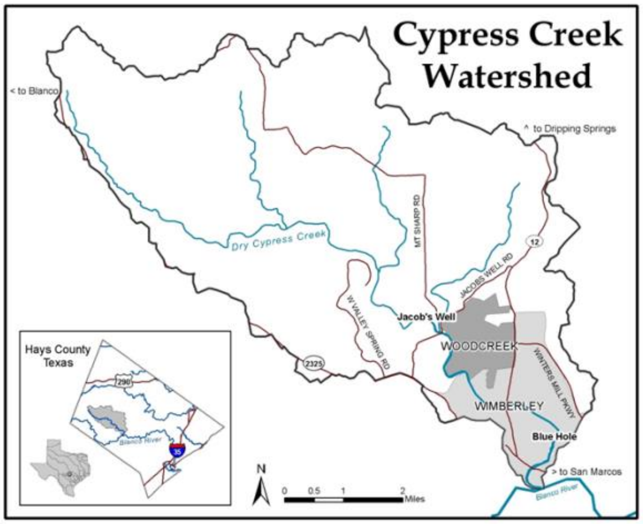


Figure 1. Cypress Creek Watershed

History of the Cypress Creek Project

The Cypress Creek Project was initiated when concerned landowners, non-governmental organizations (NGOs) and the Meadows Center for Water and the Environment (Meadows Center) applied for state and federal 319 funds to develop a preventative and community-driven watershed protection plan (WPP) for Cypress Creek (Figure 1). The goal was to keep Cypress Creek from being listed as impaired on the 303(d) list, as it had been in 2000 for inadequate dissolved oxygen (DO) (segment 1815). That year, the creek stopped flowing due to drought conditions, which negatively affected DO. When precipitation returned to average levels, the segment was delisted.

Beginning in 2008, the Meadows Center for Water and the Environment provided technical assistance and facilitation to a group of dedicated Cypress Creek stakeholders to create the WPP. The Stakeholder Committee and subject-specific subcommittees first identified significant information gaps needed to develop a comprehensive and effective WPP. This led to focused water quality monitoring, analysis, and collection of additional information and data to characterize the watershed. The resulting *2010 Cypress Creek Watershed Characterization Report* included water quality analyses, a comprehensive snapshot of the watershed, potential pollution sources, vulnerable areas, as well as target constituents.

The Stakeholder Committee then voted to adopt specific management measures that could be used to meet selected target water quality standards. The Stakeholder Committee also integrated an initial source water protection strategy with the goal to keep Cypress Creek flowing. Given that the quality of the water in the Creek is highly dependent on ensuring sufficient source groundwater flows, preservation of flows from Jacob's Well is a major component of this Watershed Protection Plan.

The resulting Cypress Creek Watershed Protection Plan presented here is meant to help guide decision makers and citizens to ***keep Cypress Creek clean, clear, and flowing*** for future generations. Additional resources, data and research are included in the Technical Reference Document that accompanies this plan. This plan satisfies the Environmental Protection Agency's nine elements required to be addressed in watershed plans. These elements, A-I, comprise the framework for the Watershed Protection Plan. More information about the Nine Elements can be found in the EPA's *Handbook for Developing Watershed Protection Plans to Restore and Protect Our Waters,* as well as in The EPA National and EPA Region 6 Watershed Based Plan

Guides (http://water.epa.gov/polwaste/nps/cwact.cfm, http://www.epa.gov/region6/water/ecopro/watershd/nonpoint/watershed-plan-review.pdf)

Significance of the Cypress Creek Watershed

Located in Hays County and the Hill Country of central Texas, the Cypress Creek watershed is a significant tributary to the Blanco River (Figure 1). It has rugged terrain, narrow canyons, and springs that dominate the landscape. The terrain also reflects the underlying karstic, faulted, and fractured limestone geology of central Texas that forms the basis of the regional aquifers. These aquifers are significant sources of surface water, providing much of the base flows to central Texas rivers. The groundwater is largely used for residential and commercial water supplies in the area. The regional climate is temperate, with hot dry summers and rainfall that ranges from infrequent and sparse to heavy downpours occasionally resulting in flash flooding. Cypress Creek is home to a diversity in species, including fishes, water fowl, reptiles and amphibians, mammals, and insects.

Hays County is projected to grow by approximately 300% in the coming years. This is an important consideration for all future natural resources management, particularly water. Cypress Creek's natural beauty is a major factor for the economy and population growth in the area. Weighing the needs of the community - to ensure sufficient quantity and quality for daily consumptive use and for the aesthetic, economic, and ecological value – is and will continue to be a challenge to community leaders in the future.

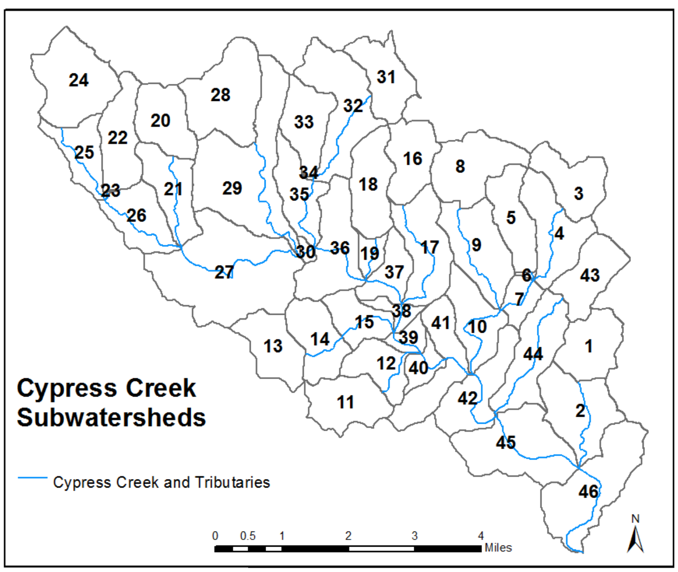


Figure 2. Cypress Creek Subwatersheds

Why the Community Wanted a Watershed Plan

Overall, water quality in Cypress Creek is meeting standards set by the Texas Commission on Environmental Quality. However, the Creek has shown signs of water quality degradation in the recent past and data have revealed that there is a potential for degradation in the future if nothing is done now. Data reveal both spatial and temporal trends that may be due to climate variability, nonpoint source pollution, and changes in land use and/or management at the sub watershed level (Figure 2).

Water quality in streams can directly affect water quality in the aquifer because of rapid recharge through karst features, such as fractures and sinkholes in streambeds. The reverse is also true where springs contribute to river flows. The health of the creek is highly dependent on maintaining adequate spring flows, making recharge and groundwater management in the larger region critical to maintaining a healthy system in Cypress Creek. Stakeholders and the Meadows Center used current conditions and information about groundwater recharge to determine potentially vulnerable tributaries (Figure 3).

Due to the karstic limestone and the interconnectivity between rainfall, surface waters (creeks) and groundwater, the watershed and the Upper and Middle Trinity Aquifers are vulnerable to nonpoint source pollutants (Figure 3). Such dispersed pollutants can be part of infiltration or surface water runoff from development, animal waste, septic systems, spills or dumping of chemical pollutants, and fertilizer applications. In addition, future development in the watershed will increase the opportunities for water quality impairments due to elevated pathogens, nutrients, sedimentation or siltation, organic enrichment, depressed oxygen levels, reduced aquifer recharge, habitat alterations, and biological impairments.

Priority subwatersheds were identified by modeled increases in nitrogen, *E. coli*, and TSS, as well as high densities of OSSFs and observed low flow conditions that could contribute to reduced DO Further, stakeholders used current conditions and information about groundwater recharge to determine potentially vulnerable tributaries. Each of these parameters or issues is described in detail in the document below. See Table 1 below, which identifies subwatersheds (either with instream concentrations or overland loadings) that have high observed/modeled levels for Nitrogen, TSS, *E. coli*, DO, high concentrations or clusters of OSSFs or are noted as vulnerable tributaries. The table also includes known baseline conditions for TSS and Nitrogen. (Please refer to Table 12 for information about parameter targets). These subwatersheds are designated as priority watersheds and most include current or potential future exceedances for multiple parameters. For example, Subwatershed 2 is expected to have instream levels of

TSS and nitrogen that exceed stakeholder targets, *E. coli* levels above stakeholder targets and is designated as a vulnerable tributary. Subwatershed 1 does not contain a reach of the creek or tributary but modeling results indicate that the land use activities within its boundaries yield high loadings for nitrogen and *E. coli* that are eventually carried to the creek by stormwater runoff.

Table 1. Stakeholder Identified Priority Subwatersheds by Parameter or Concern and Baseline Concentrations (in 2000)

	Reach within Priority Subwatershed	TSS* Base Line Concentrations (mg/L)	Nitrogen Base Line Concentrations (mg/L)	OSSF Density	*E. coli* (#/100 mL)	Vulnerable Tributary	DO Below 6.0 mg/L
Priority Subwatershed Reaches	2	137.08	1.66	-	X	X	-
	4	99.0	1.63	-	-	X	-
	6	-	-	-	-	X	-
	7	-	1.64	-	-	X	-
	9	95.38	1.27**	-	-	X	-
	10	-	-	X	-	X	-
	12	-	-	-	X	X	-
	14	72.79	-	-	-	X	-
	15	-	-	-	X	X	-
	21	-	-	-	-	X	-
	27	91.48	1.19**	-	X	-	-
	29	85.37	1.19**	-	-	X	-
	30	-	-	-	-	-	-
	32	100.10	1.86	-	-	-	-
	35	-	1.66	-	-	-	-
	36	102.42	1.39**	-	X	-	-
	41	91.52	-	-	X	-	X
	42	92.91	-	X	X	-	X
	44	84.91	1.1**	-	X	X	-
	45	93.21	1.36**	X	X	-	X
	46	102.76	1.42**	X	X	-	X
Subwatersheds with high potential load contributions	1	-	X	-	X	-	-
	8	X	-	-	-	-	-
	13	-	-	-	X	-	-
	24	X	X	-	-	-	-
	28	X	X	-	-	-	-

**At low flow conditions all reaches will exceed target loads for TSS.*

*** These subwatersheds do not show exceedances for Nitrogen but may in the future and have been identified as secondary priorities.*

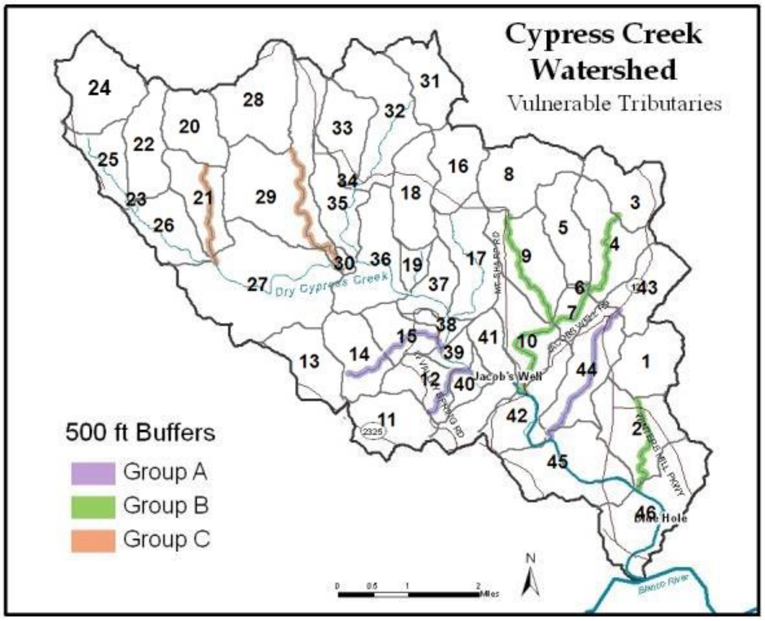


Figure 3. Vulnerable Tributaries Groups A, B, and C

Using Science to Find Answers - Causes and Sources of Pollution

To help understand the physical context and factors that may be influencing water quality in the creek, the Meadows Center created load duration curves for the primary pollutants of concern in the area, including: nitrogen, phosphorus, *E. coli*, suspended sediments and dissolved oxygen. These load duration curves were used to identify daily mean loading for the above parameters, which do not currently have set state or federal standards. Modeled water yields and event mean concentrations were used to calculate pollutant loads and identify potential sources of nonpoint source pollution for existing and future conditions at the watershed and subwatershed level (Figure 4).

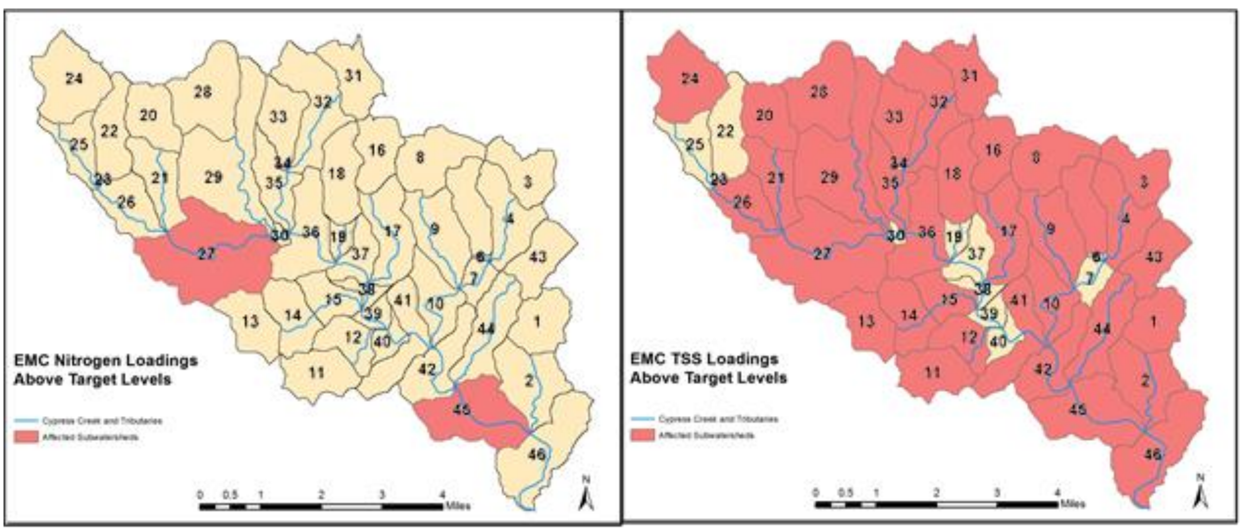


Figure 4. Example Model Output - Subwatersheds with Nitrogen and TSS Loadings Above Target Levels

The Stakeholder Committee and experts agreed that meeting State water quality standards would be insufficient to maintain the desired health and historical nature of the creek as a spring-fed stream. As a result, the stakeholders identified acceptable water quality and flow parameters based on historical information. A detailed description of water quality parameters, primary sources, and the potential causes are outlined in Table 2 below.

Table 2. Sources and Causes of Negative Impacts on Water Quality Parameters Identified by Stakeholder Committee

Parameter	Primary Sources (land use)	Causes
Nitrogen* 1.65 mg/L (Stakeholder target)	Residential and Undeveloped	Residential and Commercial application of Fertilizer. OSSFs, animal waste, overland flow, impervious cover, atmospheric deposition and low flows.
Total Suspended Solids* 4.0 – 5.0 mg/L	Residential and Undeveloped	Anthropogenic activities where land cover is disturbed, impervious cover and natural processes on undeveloped land. Soil across much of the watershed is shallow which limits ground cover. Low base flows in the wet portion of Cypress Creek.
E. coli	Residential and Commercial	Septic tanks (OSSFs), pets, and wildlife. Low flows in the creek lead to high concentrations.
Dissolved Oxygen	Residential and Commercial	Low base flows limit aeration of water downstream of ground/source waters.
Oil and Grease	Residential	Residential wastewater (kitchen and bathroom).
Impervious Cover increases	Residential, Commercial and Transportation	Increased urbanization.
Preferred Base Flows	Residential and Commercial	Groundwater pumping, uncoordinated drought management, insufficient knowledge of local aquifer supplying baseflow to Cypress Creek, insufficient protection for karst aquifer system, insufficient statutes and management of groundwater to maintain surface water flows, inefficient water use, increased impervious cover, decreased recharge, lack of stormwater management for recharge, climate variability (drought).

**** Red Rows Indicates Parameters Exceed Target Levels at low flows (2.5 cfs)***

Surface Water Strategies Chosen by the Community to Improve Water Quality

The Stakeholder Committee selected a suite of best management practices (BMP) to mitigate identified and potential water quality impairments in the watershed. The BMPs were prioritized for immediate implementation and as future options in an adaptive management suite. When possible, BMPs are targeted for priority subwatersheds. However, many of the selected BMPs will not be implemented until several years into future as pollutant loads increase with development.

The Cypress Creek Watershed Protection Plan is adaptive in nature and, as a result, it includes detailed practices and management approaches to address water quality the first three years, with the intention that the community will reevaluate specific watershed needs thereafter. The Stakeholder Committee agreed that the first three years implementing the plan should focus on stormwater assessment, employing demonstration BMPs, retrofitting and maintaining existing and recently built BMPs, and coordinating existing community efforts in order to address threats to water quality, including nitrogen and TSS from urbanization in the watershed. The Stakeholder Committee's goal is to keep the creek "clean, clear and flowing," but more specifically to prevent reductions in DO, and prevent TSS, Nitrogen and bacteria from exceeding set target levels and protect flow.

As a result of the six years it took to construct this plan, the City of Wimberley, City of Woodcreek and Hays County have each pledged to implement BMPs pending finalizing formal financial agreements during the Interim period.

Groundwater Strategies Chosen by the Community to Improve Water Quality

Efforts to maintain good water quality conditions are constrained by the reliance on adequate baseflows from Cypress Creek's artesian headwaters, Jacob's Well. Community expectations of maintaining a clean, clear, and flowing stream will succeed with this integrated management plan incorporating groundwater and surface water components, spanning agency jurisdictions, and with a comprehensive approach for maintaining balance between natural resource management and economic development. The Cypress Creek Stakeholder Committee identified several critical components for their ground/source water protection strategy. Preliminary goals listed below, have the primary purpose of preserving flows:

1. Maintain headwaters and flow regime at or above 6 cfs.
2. Launch a coordinated water conservation campaign between water suppliers and cities to effectively reduce demand for groundwater during drought stages 2 and 3.
3. Determine strategies for water suppliers to implement tiered pricing and market-based conservation efforts that will sufficiently incentivize demand reduction.
4. Establish science process, proposals, and estimated budget needed for determining recharge and artesian area affecting the springs of the Wimberley Valley.

The Importance of an Informed Community

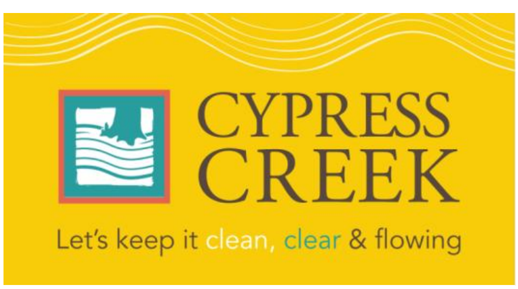


Figure 5. Cypress Creek Project Branding

Local residents and communities play a critical role in the success of natural resource conservation and watershed management initiatives through their meaningful participation and actions. Throughout the six year plan development, the Stakeholder Committee was dedicated to ensuring that the community at large was kept informed of the process and had the opportunity to participate. This was done through outreach campaigns such as Cypress Creek Project week, surveys, brand and slogans, permanent watershed signs, public informational meetings, notifications of Stakeholder Committee meetings, newsletters, and open public comment periods to review documents (Figure 5).

For future involvement and buy-in during the implementation of the Cypress Creek Watershed Protection Plan, the Stakeholder Committee created and *Education and Outreach Plan*. This plan defined the Cypress Creek community's education and outreach goals and objectives for the Watershed Protection Plan: to increase public awareness, increase community engagement and educate and support decision makers. Four target audiences were identified, including the community at large, homeowners/landowners, business owners and government/education.

Ensuring the Plan is Working

The Cypress Creek Watershed Protection Plan prescribes BMPs and other actions to attain, maintain and ultimately improve water quality in the creek and its tributaries. The implementation of management measures throughout the watershed over time will result in pollutant loading reductions, while established pollutant targets will serve as benchmarks of progress and indicators for future adaptive management activities. Tracking the effectiveness of these management measures will ensure that water quality goals are being achieved.

Components of the stakeholder approved monitoring plan include the coordination of all existing monitoring efforts, increased surface water quality monitoring, groundwater monitoring, the continuation of US Geological Survey gage collection of stream flow and water quality parameters, as well as the implementation of monitoring of:

- water quality related to stormflow, baseflow and rain events,
- biological and environmental components (including dissolved oxygen),
- demonstration best management practices,
- implemented and existing BMPS, and
- bacterial source tracking.

As the watershed continues to urbanize, water modeling results will be used as a guide for detecting early signs of potential pollution concerns. Routine water quality monitoring data will be disseminated to the Stakeholder Committee and will help to identify any new concerns. If target levels are exceeded regularly, the Stakeholder Committee will utilize adaptive management to address new concerns.

Indicators of Success

Measureable milestones adopted by the Stakeholder Committee include number of BMPs implemented and pollutant load reductions (e.g. 5% reduction of TSS) or areas of coverage (e.g. 5,000 feet of permeable sidewalk constructed). If the identified milestones are not achieved in year 3, 6, or 10 of implementation, the appropriate adaptive management activities will be initiated, tested and adjusted as needed. Table 3 summarizes the BMP milestones for the first three years of implementation. Table 21 provides additional information including subwatershed location for implementation. Milestones are presented in Table 25 in Chapter 11 of this document.

Table 3. Summary of Implementation Year 3 Milestones

Management Measure	Milestone Years 1-3 of Implementation	Milestones	Priority Watershed *
Comprehensive Stormwater Assessment	1 Assessment	Completion of Stormwater Assessment, including selection of BMPs and locations for implementation based on findings	12, 14, 15, 39, 40, 41, 44, (Basinwide)
Riparian Buffers	1 Managed buffer area Identified	Identify and prioritize locations for implementation, commitments for streamside natural buffer management	41, 45, 42
Rainwater Harvesting Strategies	1 Demonstration Area	Establishment demonstration area, and can include adoption of use in all new development	41, 46, 2, 44
Gabions (Rock Berms)	1 Berms Demonstration Areas	Establishment of demonstration areas throughout the basin and use in all new development in urban public spaces; added to existing codes where appropriate	41, and TBD
Biofiltration/rain garden	1 Demonstration Areas	Establishment of demonstration areas, and can include use in all new development in public spaces or added to existing codes as water quality protection measure	41, 46, 10, 44, 2, and TBD
Existing BMP Maintenance	6 Inspections and Maintenance When Needed	Establishment of program to maintain existing BMPs for proper function	41, 46, and TBD
"Entering Watershed" Signs on Roadway	3 Signs	Installation of 3 "Entering Watershed" Signs on Roadway to increase community awareness	TBD

Management Measure	Milestone Years 1-3 of Implementation	Milestones	Priority Watershed *
Watershed Coordinator	1 Coordinator	1 employee to implement BMPs for water quality reduction and community awareness	Watershed Wide
Enhanced Water Quality and Groundwater Modeling (CC-DSS)	1 Session	1 session in enhanced Water Quality and Groundwater Modeling (CC-DSS) to improve water quality decision making as the scenario changes	Watershed Wide

**Additional management measures may be implemented that are not mentioned in this table, or may be implemented in additional subwatersheds.*

Table 4 below shows the Stakeholder Committee's prioritization of accepted management measures (in addition to best management practices listed above in Table 3). These measures were ranked on importance and urgency as well cost, load reduction, and ease of implementation. Measures were also assigned to subwatersheds with highest modeled instream concentrations and land based loadings of pollutants and constituents of concern. It is important to note that there were several additional factors that guided the overall implementation strategy, including support committed by watershed partners for implementation activities, identification and approval of partner owned land for BMP and demonstration BMP implementation, availability of publicly accessible spaces for demonstration BMPs and engineering constraints. For example, rain and biofiltration gardens were selected for implementation in Subwatershed 41 because of the expected TSS exceedances (high TSS loadings), as well as the availability of a publically accessible space that would be suitable for a demonstration garden. The Stakeholder Committee will routinely review monitoring data to identify if milestones are being met and BMPs are working effectively.

If monitoring shows that the BMPs are not effective or unforeseen changes in the watershed occur, the Stakeholder Committee can potentially use one, several, or a combination of several approved BMPs from their BMP "Adaptive Management Toolbox" to address water quality (Table 4). Additional information including potential subwatershed locations, load reductions as well as associated milestones can be found in Table 26. The Stakeholder Committee will submit an adaptive management review after the first three years of implementation and in subsequent years as needed. During this time, efforts will be undertaken to increase the capacity of the existing model to determine pollution loading and mitigation efforts on a more localized scale. Additionally, each city will undergo an efficacy assessment of current and potential future ordinances that will improve our understanding of where and when to place appropriate BMPs.

Table 4. Adaptive Management Toolbox

Highest Prioritization	Second Highest Prioritization	Medium Prioritization	Low Prioritization
Water Conservation Pricing Strategies	Urban Wildlife Management – Deer	Rainwater Harvesting Strategies	Rock Weirs/Cross-vanes
Water Conservation Program for Water Providers or Municipalities	Riparian Buffers	Cypress Creek Land Trust	Vegetative Filter Strips
Groundwater Management strategies assessment and research	Water-intensive Turf Grass Ordinances and/or Ban	Nutrient & Fertilizer Management	Livestock Water Quality Management Plan
Groundwater Protection Strategy	Groundcover Establishment – Agricultural	Habitat Conservation Areas – Urban	Rain/soil moisture sensors
	Parking Lot Pervious Design Strategies	Rock Berms/Gabions	Wastewater Solutions
	Xeriscaping/Nativescaping	Biofiltration/Rain Garden	Septic replacement program
	Engineered Swales	Tree Protection	
	Conservation Easements	Groundcover Establishment – Urban	
	Karst Feature Protection Measures	Porous/Pervious Pedestrian Walkways	
	Comprehensive Stormwater Assessment	Alternative Brush Control -- Prescribed burns	
	Purchase of Development Rights	Grazing Management Strategies	
	Landscape Mulching	Landowner Incentive Program	
		Pet Waste Ordinance & Stations	

The Cypress Creek Stakeholder Committee will continue to meet on a regular basis to discuss progress on implementation, outreach efforts, identification of additional financial assistance, and adaptive management modifications to the plan as needed. The Stakeholder Committee is dedicated to vision initially set to preserve the natural beauty and excellent water quality of Cypress Creek for current and future generations.

Let's keep it clean, clear, and flowing!

1. Watershed Management

Watershed Definition

A watershed is an area of land that contributes water, nutrients, pollutants, and sediments to a common downstream point such as a stream, river or lake. Watersheds can be large or small. When it rains, water moves across the land surfaces or underground. Moving farther downhill by force or gravity, the water converges into a progressively larger system.

Watersheds and Water Quality

Water quality in Cypress Creek can directly affect water quality in the aquifers because of rapid recharge through fractures and sinkholes in streambeds. The reverse is also true where springs contribute to creek flows. The water levels in the creek are highly dependent on maintaining adequate spring flows, making recharge and groundwater management in the larger region critical to maintaining a healthy system in Cypress Creek.

Point source pollution is discharged from a defined location or a single point, such as a pipe, drain, or wastewater treatment plant. It includes any pollution that may be traced back to a single point of origin. Point source pollution is typically discharged directly into a waterway and often contributes flow across all conditions, including both droughts and floods. In Texas, dischargers holding a wastewater permit through the Texas Pollutant Discharge Elimination System (TPDES) are considered point sources, and their effluent is permitted with specific pollutant limits to reduce their impact on the receiving stream. There are no major permitted point sources within the Cypress Creek watershed. Currently, treated wastewater is used to irrigate golf course turf grass and no direct negative water quality effects from these discharges have been identified with limited water quality sampling. It is assumed that these discharges are operating in accordance with TCEQ permit requirements, but monitoring of these permitted sources is recommended. However, aging and improperly maintained septic systems pose an increasing threat throughout the watershed. This information was verified through the use of existing records, city efforts and volunteer collected water quality data.

Nonpoint source pollution (NPS), on the other hand, comes from a source that does not have a single point of origin. The pollutants are generally carried off the land by runoff from stormwater following rainfall events. As the runoff moves over the land, it can pick up both natural and human-related pollutants, depositing them into water bodies such as lakes, rivers, and bays. Ultimately, the types and amounts of pollutants entering a water body will determine the quality of water it contains and whether it is suitable for particular uses such as irrigation, fishing, swimming, or drinking.

Benefits of a Watershed Approach

Watershed protection stems from the knowledge of how natural and man-made processes affect watershed functions. Due to the karstic limestone and the interconnectivity between rainfall, surface waters (creeks) and groundwater, the watershed and the Upper and Middle Trinity Aquifers are vulnerable to nonpoint source pollutants. Such dispersed pollutants can be part of infiltration or surface water runoff from development, animal waste, septic systems, spray and subsurface effluent irrigation systems, spills or dumping of chemical pollutants, and fertilizer applications. In addition, future development in the watershed will increase the opportunities for water quality impairments due to elevated pathogens, nutrients, sedimentation/siltation, organic enrichment, depressed oxygen levels, reduced aquifer recharge, habitat alterations, and biological impairments.

Watershed Protection Planning

Because watersheds are determined by the landscape and not political borders, watersheds often cross municipal, county, and state boundaries. By using a watershed perspective, all potential sources of pollution entering a waterway can be better identified and evaluated. Just as important, all stakeholders in the watershed can be involved in the process. A watershed stakeholder is anyone who lives, works, or engages in recreation in the watershed. They have a direct interest in water quality issues and will be affected by planned efforts to address these. Individuals, groups, and organizations within a watershed can become involved as stakeholders in initiatives to protect and improve local water quality. Stakeholder involvement is critical to successful improvement of water quality through selection, design, and implementation of management measures (Berg et al., 2008).

The outcomes of this process are documented or referenced in a watershed protection plan (WPP), a strategy that provides assessment and management information for a geo-graphically defined watershed. The plan includes the analyses, actions, participants, and resources related to developing and implementing the plan. It is recommended that watershed protection plan follow the outline of the U.S. Environmental Protection Agency *Handbook for Developing Watershed Plans to Restore and Protect Our Waters* (USEPA, 2008). The development of watershed plans requires a certain level of technical expertise and the participation of a variety of people with diverse skills and knowledge. Using a watershed approach to restore impaired water bodies is beneficial because it addresses the problems in a holistic manner, and the stakeholders in the watershed are actively involved in selecting the management strategies that will be put into practice to solve the problems. NPS pollution poses the greatest threat to water quality and is the most significant source of water quality impairment in the nation. Therefore, USEPA is working with states, tribes, and watershed groups to realign its programs and strengthen support for watershed-based environmental protection programs.

Based on available information, the Cypress Creek watershed protection plan includes management, funding, and implementation strategies that will improve water quantity, quality and the health of watershed in the face of land use changes. The basis is voluntary stakeholder involvement, input, feedback, and stewardship, along with selected technical expertise and state water agency guidance throughout the process of WPP development and implementation. The development of the WPP is not the final answer to water challenges over time; rather, it is a starting point. New information will undoubtedly be discovered within and adjacent to Cypress Creek as the implementation process is carried out and will add to the collective knowledge of how to better manage the watershed. Additional information and data will be incorporated into the plan to improve management strategies, refine the areas where specific measures will be incorporated, and to better focus available resources so as to achieve maximum water quality benefits.

2. Cypress Creek Stakeholder Committee

Within a watershed protection planning process, it is important to understand the needs, priorities, perspectives, and culture of the community and its stakeholders. Watershed stakeholders include anyone who lives or works in the watershed, or shares an interest in protecting its resources. Stakeholder involvement is an essential component of successful watershed protection efforts because it enhances cooperation, collaboration, and community participation. Stakeholders provide local insight about history, public concerns and values that help bridge scientific research and community-driven efforts. This watershed protection plan exists, in great part, because of the efforts of Cypress Creek's dedicated stakeholders and their work over the last several years.

2008-2010: Characterization of the Watershed

Diverse stakeholder representation is fundamental to the continued success of the Cypress Creek Project and watershed protection planning. In order to represent these diverse interests, The Meadows Center for Water and the Environment worked with community members to reach out to key stakeholders who represented a broad range of perspectives. In the first phase of the project (2008-2010), 20 stakeholders were invited to participate in a stakeholder representation committee based on their background, expertise, and community involvement. These members were tasked with acting as liaisons to the community, and ensuring community engagement and participation. The first Cypress Creek Project Stakeholder Committee meeting convened on June 3, 2009 and was successful in developing and securing commitment from a Stakeholder Committee. This Committee identified topics of concern, selected chairs for various subcommittee groups, and nominated a Committee Chair. Ground rules and Subcommittee descriptions and work plans were developed (see Technical Reference Document for Ground Rules).

Subcommittee groups were created to target issues of concern within the watershed. Their topics were selected by the Stakeholder Committee at the initial meeting. Subcommittees included Water Quantity, Water Quality, Land Stewardship, Economic, Education and Outreach, and the project's Decision Support System. Subcommittee membership was comprised of Stakeholder Committee members, regional experts and concerned citizens within the watershed. Each Subcommittee designated a chair to present subcommittee activities, recommendations and suggested management measures at the Stakeholder Committee meetings. Subcommittee meetings were held monthly at various locations throughout the watershed and facilitated by The Meadows Center staff (See Technical Reference Document for Committee Representation List and subcommittee activities).

Efforts focused on identifying management strategies and areas for improvement to ensure the long-term integrity of Cypress Creek. Stakeholder Committee and Subcommittee membership was comprised of community members, local landowners, business owners, subject matter experts in areas such as real estate, law, education, water quality, water quantity, conservation, environmental resources, education, and representatives from Wimberley and Woodcreek City Council, Hays County Commissioners' offices, Hays Trinity Groundwater Conservation District Board, Texas Parks and Wildlife, Texas Commission on Environmental Quality, Texas Farm Bureau, The Nature Conservancy, Texas Agri-life Extension, Wimberley Valley Watershed Association, Wimberley Independent School District, GBRA, Texas State Soil and Water Conservation Board, Keep Wimberley Beautiful, Wimberley Water Supply Company, Wimberley Institute of Cultures, and more. Committee and Subcommittee representation included local realtors, lawyers, environmental consultants, developers, business owners, professors, various board members, retired teachers, master naturalists, rainwater collection experts, and local citizens. The results of initial Stakeholder Committee efforts included identification of potential future development strategies, approval of initial pollution potential results from the project DSS, the Cypress Creek Watershed Characterization Report, a draft Education and Outreach Plan, Public Participation Plan and management strategy suggestions from the Subcommittees for further development in 2011-2013. At the conclusion of the initial phase of the project, the Stakeholder Committee and subcommittees disbanded and revised their structure to include new community representation and committee members.

During this period, several documents with information about the hydrology, biology, known water quality and existing and potential water quality protection efforts were compiled and a Watershed Characterization Report was created. Initial modeling activities, including input data, methodology, calibration and results also were compiled into several documents. These resources were organized in a compendium (Technical Reference Document) and are referenced throughout this document. The Technical Resource Document can be found on the Cypress Creek Website, http://cypresscreekproject.net/documents/cypress-creek-watershed-protection-plan/technical-review-documents/.

2011-2014: Development of a Watershed Protection Plan

The Meadows Center and previous stakeholder committee members identified potential candidates and alternates representative of local businesses, local land owners (rural and urban), local watershed protection organizations, local real estate developers, the City of Wimberley, the City of Woodcreek, Hays County, the regional groundwater district (HTGCD) and river authority (GBRA), as well as an expert in local water quality regulation and protection. Those individuals met on April 4th, 2012 and formed an official 12 member committee, with each member having an alternate representative to ensure adequate representation and participation. The initial Committee Chair was nominated and approved by unanimous vote to continue as Chair. See the Technical Reference Document for Committee Representation List and Revised Ground rules.

The Stakeholder Committee was tasked with reviewing specific management measures and BMPs that addressed the management strategies identified by the Subcommittees. They also approved work plans for The Meadows Center, including technical aspects, research methodologies and assumptions related to WPP efforts. The Stakeholder Committee focused their efforts on developing and including a comprehensive ground/source water protection strategy in this watershed protection plan. Because the Cypress Creek WPP is a preventative plan and the future development scenario spans 40 years into the future, the Stakeholder Committee identified BMPs to be implemented in the first three years of this plan and approved a suite of BMPs to be included in a "toolbox" for long term and adaptive management to address water quality threats that arise as urbanization increases in the watershed. The Committee also formed a Technical Review Group, composed of Committee members and regional subject matter experts, to review and provide guidance regarding the WPP and supporting documentation. This form of the Stakeholder Committee continued until the WPP was submitted to TCEQ and EPA for review in December 2014 and throughout the addressing of comments in the fall of 2014.

2014-2015: Interim Committee

The Stakeholder Committee determined that an interim committee would be necessary to continue WPP related activities for the time elapsing time between submission of the final WPP and its implementation (a period between 3 and 12 months). The Stakeholder Committee is expected to continue as an Interim Committee, utilizing its 12 member format and meeting monthly. The committee will utilize virtual meeting software such as Skype, Go To Meeting or Face Time as needed to ensure participation. If altered, the Interim Committee will maintain no less than five active members, including city and county representation. If necessary, the Interim Committee can call for the formation of subcommittees to work on WPP related activities.

Additionally, the Stakeholder Committee appointed an Interim Watershed Coordinator. The Committee, with assistance from The Meadows Center for Water and the Environment was tasked with the revision of the WPP to address technical comments from the TCEQ and EPA. The Technical Review Group will continue to meet as needed during the interim process and will assist with WPP revisions and Implementation planning. The Interim Committee was also be tasked with the following activities:

- Determining the structure, function, protocols and tasks of the Implementation Committee (and possible subcommittees),
- Preparing for activities associated with Implementation, including a work plan and request for 319 funding (TCEQ program funds),
- Continuing to engage key stakeholders, including water providers, the groundwater district, and technical advisors,
- Seeking additional sources funding for WPP related activities in the interim period,
- Developing draft documentation and materials for the public, including an executive summary and simplified version of the WPP for the community, and
- Preparing a strategy and plan for the public roll out of the WPP.

The Stakeholder Committee determined that the final WPP, Updated Watershed Characterization Report, relevant data, EPA guides, and other documents and resources will be copied to USB flash drives with the Cypress Creek Project logo and distributed to city, county and regional leaders, as well as NGOs and citizen based groups involved in watershed protection, planning and development as part of the public roll out. Materials will also be available on The Meadows Center for Water and the Environment and the Cypress Creek Project websites. Additional activities will be determined by the Interim Committee.

2015 and Beyond: Implementation of the Watershed Protection Plan

After TCEQ and EPA acceptance of this submitted WPP, the Interim Stakeholder Committee will reform based on Committee determinations and will begin implementation of the Cypress Creek Project Watershed Protection Plan. Initially, the work plans and requests for funding developed in the interim period will be submitted to TCEQ and other potential funding sources. Once work plans have been approved and funding secured, The Implementation Committee and its partners will coordinate implementation activities, including application of BMPs, education and outreach activities, monitoring efforts, and additional modeling, as well as seeking continued funding for WPP activities and tracking expenditures.

The Implementation Stakeholder Committee will work with partners to undertake additional research needed to better understand, improve and protect ground/source water. These partners include The Meadows Center for Water and the Environment, GBRA, HTGCD, USGS, USFWS, TPWD and WVWA. The Implementation Committee also will review data from monitoring and modeling efforts and implementation progress to determine plan adherence to milestones and success in reaching targeted pollutant load reductions and desired flow conditions.

Based on plan progress and success, the Committee will select and implement adaptive management procedures at regularly scheduled intervals, as determined by the protocols developed and approved in the Interim period. Information regarding specific implementation and adaptive management activities, as well as responsible parties, is presented in Section 6 Management Measures and in Table 21.

3. State of the Watershed

A detailed discussion of the state of the watershed can be found in the 1.0 General Watershed Information section of the 2010 Cypress Creek Watershed Characterization Report (WCR) (see Technical Reference Document) and is summarized below.

History of the Cypress Creek Watershed

Central Texas has been continuously inhabited since the earliest humans lived in North America over 12,000 years ago, largely as a result of the abundant springs systems found in the region. The nomadic Tonkawa Native Americans inhabited the region between the 13th and 19th centuries. Native Americans and Europeans first made contact during early Spanish gold expeditions in the 17th century. During the 19th century, early Anglo settlers were former soldiers who had fought at the battle of San Jacinto and were given land grants in appreciation by the Republic of Texas. In 1856, William C. Winters bought 34 acres and built the first grist mill in the Cypress Creek watershed. In 1874, Pleasant Wimberley bought the mill and it was renamed Wimberley's Mill. An application for a post office was made in 1880 with the town name Wimberleyville. The post master dropped the "ville" and approved the application, thus creating the town of Wimberley. Soon after, churches and schools opened and the town flourished. An instant draw to the area was the water. The Blanco River, Cypress Creek, and Jacob's Well all flowed with clean, clear water and springs. Today, Wimberley is home to over 6,000 people, many shops and restaurants, and is a popular tourist destination.

In 1943, land was purchased in what is now known as Woodcreek for a resort community. More people bought land and built houses. A golf course, a swimming pool, a hotel and a restaurant were added. The City of Woodcreek was incorporated in 1984. As of 2007, the population of Woodcreek had grown to over 1,600 people.

Geography

Located in central Texas and part of the Edwards Plateau region of the Texas Hill Country, the Cypress Creek watershed has recognizable features of the region. Rugged terrain, narrow canyons, and springs dominate the landscape. Cypress Creek flows through unincorporated portions of Hays County and the cities of Wimberley and Woodcreek. It meets the Blanco River near the Wimberley town center (Figure 6).

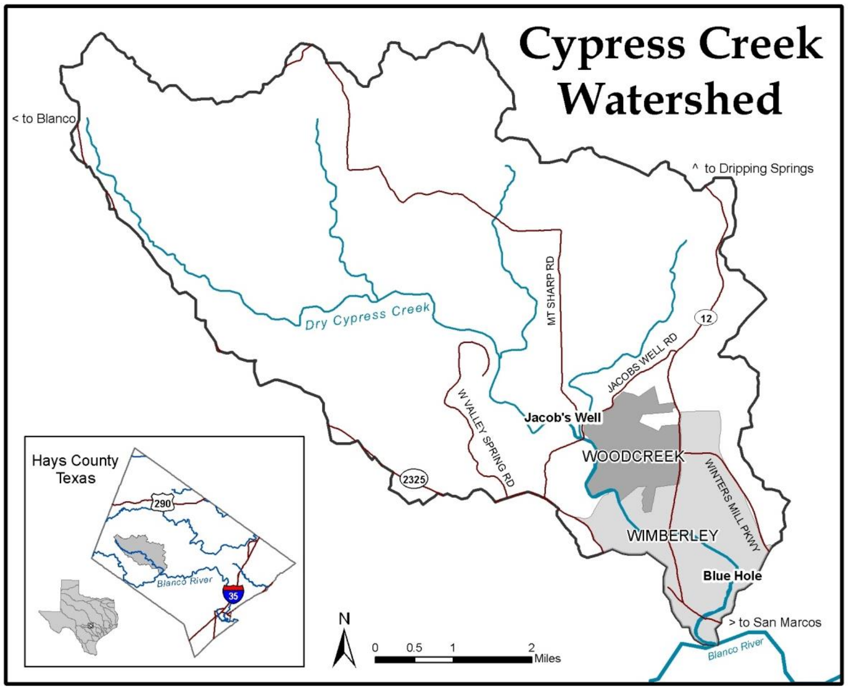


Figure 6. Cypress Creek Watershed, Central Texas

About five and a half miles upstream of the confluence, near the City of Woodcreek, is Jacob's Well, the headwaters of the historically perennial Cypress Creek. Jacob's Well is an artesian spring that is considered the lifeblood of the community as it feeds water to the lower third of the creek.

The Cypress Creek watershed is predominately a karstic limestone region. Karst areas contain soluble rocks, such as limestone, whose structures are dominated by occasionally, but not necessarily, interconnected conduits created by dissolution. Karst areas are highly susceptible to groundwater contamination for several reasons. The dissolved rocks form conduits and channels for underground flow and increase the ability of water to enter into these conduits from the surface. Secondly, the protective rock and soil deposits normally found in non-karst systems are minimal, making the system more vulnerable. Not only is pollution entry into the system a concern, high velocities of groundwater flow through the conduits can also be problematic.

Geologic rock formations in the Cypress Creek watershed are primarily limestone with some Quaternary sediment found along creek beds. The rock strata are identified as basal conglomerates and limestones of the Trinity Group, formed during cyclical development of shallow seas in the Cretaceous. The Trinity Group is comprised of seven formations with distinct characteristics. Hydrogeologically, the formations are recognized as the Lower, Middle, and Upper Trinity Aquifers due to variations in lithology and water production characteristics.

Vegetation on the hilltops is often sparse because of thin layers of topsoil. In the northern portion of the watershed, shallow or disturbed soils support evergreen shrubs and grasses. Woodlands of juniper, oak and mesquite are interspersed along the hillsides and, towards the bottom of the slopes, more native grasses can be found.

The creek and surrounding watershed offers habitat to a diversity of species, including fishes, water fowl, reptiles and amphibians, mammals, and insects. The climate is also typical of central Texas with hot dry summers and rainfall that ranges from infrequent and sparse to heavy downpours and flash flooding.

Urban development has been concentrated in the lower third of the watershed around Woodcreek and the City of Wimberley. Therefore the highest risk for excess sediment flow in the creek due to high slope comes from agriculture (primarily grazing) activities in the upper and northern portions of the watershed, and in bottomland areas the primary source for excess sediment flow results from development activities and land clearing.

Due to the population increases in the past two decades, land use in the Cypress Creek Watershed has shifted from predominantly rangeland and undeveloped land uses to residential land uses. This trend is expected to continue in the future as formerly large acreage holdings are subdivided for both high-density residential (<5 acres) and large lot "ranchettes" (>5 acres). In 2010 the Meadows Center worked with the Stakeholder Committee to develop a future development scenario that depicts a full build-out of existing and platted subdivisions in the watershed. Please see *Land Use Section* on page 34 for further information.

Despite rapid population growth, neither Wimberley nor Woodcreek are subject to Municipal Separate Storm Sewer Systems (MS4) requirements, which include a stormwater management program and "ditches, curbs, gutters, storm sewers, and similar means of collecting or conveying runoff that do not connect with a wastewater collection system or treatment plant." Such infrastructure is required by EPA and TCEQ to transport polluted stormwater runoff in larger communities. None of these surface and source water protection strategies currently exists in the Cypress Creek Watershed.

Water Resources

Jacob's Well, a Middle Trinity Aquifer artesian spring, provides the majority of flow in Cypress Creek and has been described as the "heart and soul" of the Hill Country. Blue Hole, located in Cypress Creek just upstream of Wimberley, is a swimming hole that has been enjoyed by generations of local residents and considered one of the top swimming holes in Texas.

Baseflow to Jacob's Well is artesian flow from the Cow Creek up through the confining Hensel and Lower Glen Rose. The major source of recharge to the Cow Creek occurs west of the Cypress Creek watershed from the downward leakage of water from the Upper and Lower Glen Rose and Hensel where these formations are exposed at the surface and exposed to precipitation.

Groundwater under artesian conditions in the Cow Creek provides the majority, if not all of the base flow at Jacob's Well.

Jacob's Well is an expression of underground water stored in the Trinity Aquifer that discharges at the land surface. During rain events, however, water flows downhill from the distant hilltops in the watershed and into the creek. Once the water is in the creek bed, part of it flows back underground into the aquifer. Cypress Creek's water flow pattern between the surface and subsurface creates a complex interaction between groundwater and surface water. Both urban and rural communities are heavily reliant on groundwater as the primary water supply, but are reliant on the unique surface water characteristics, such as Jacob's Well and Blue Hole, for recreational use and aesthetic value.

Water Quality Data and Monitoring

Routine water quality monitoring data through the Clean Rivers Program (CRP) through December 2009 and TCEQ were used. The TCEQ site data from 1973 to 1999 were compared to data from 2000 to 2009 to evaluate any long-term changes in water quality (see Figure 30).

Stormflow Monitoring: The Cypress Creek Project installed two automatic stormflow monitoring devices along the main creek channel to record stage, sediment, nutrient, and bacteria concentrations during runoff events. The samples were tested for sediment, analyzed in the lab for total suspended solids (TSS), nitrate-nitrogen, total phosphorus, and *E. coli*.

Water Quantity Data: Spring flow data collected by the USGS at Jacob's Well spring (08170990) and streamflow data at the Blanco River gauge (08171000) were used. Historical daily mean flows at the Blanco confluence were estimated based on a comparison between daily mean stage recorded at the confluence and daily mean stage at the USGS. Results from Dedden's stream gauging project in 2005 were also used.

Details on all data, monitoring and methodology are in the Technical Reference Document.

Figure 7. Water Quality and Data Monitoring

Water quality varies considerably between monitoring sites in the perennial portion of the creek (see more on monitoring in Figure 7). In general, the three upper most water quality monitoring sites (Jacob's Well, RR12 north, and Blue Hole) tend to be highly influenced by inflow of groundwater in terms of their water chemistry and concentrations related to flow, while the lower two sites (RR12 downtown and the Blanco confluence) tend to cluster closer together and show more of an influence of local stream conditions and runoff from contributing watersheds (additional information is available in Section 4.2.4 of the Watershed Characterization Report in the Technical Reference Document).

The Cypress Creek Stakeholder Committee' main goal was to preserve water quality in Cypress Creek by mitigating NPS pollution and maintaining adequate flows from Jacobs Well. Concerns included nitrogen, TSS, high bacteria concentrations, Dissolved Oxygen and increased impervious cover from urbanization. Residential land use contributes a large portion of nonpoint sources of pollution including pet and animal waste, excess fertilizer application and poorly performing septic systems.

Above the artesian headwaters flows in the Cypress Creek (Dry Cypress) are driven by rain events (Figure 8). Storm flow monitoring of the Dry Cypress watershed area indicates the upper watershed has a tendency toward high bacterial and sediment concentrations washing down through the channel after a storm, with occasionally high nitrogen levels as well.

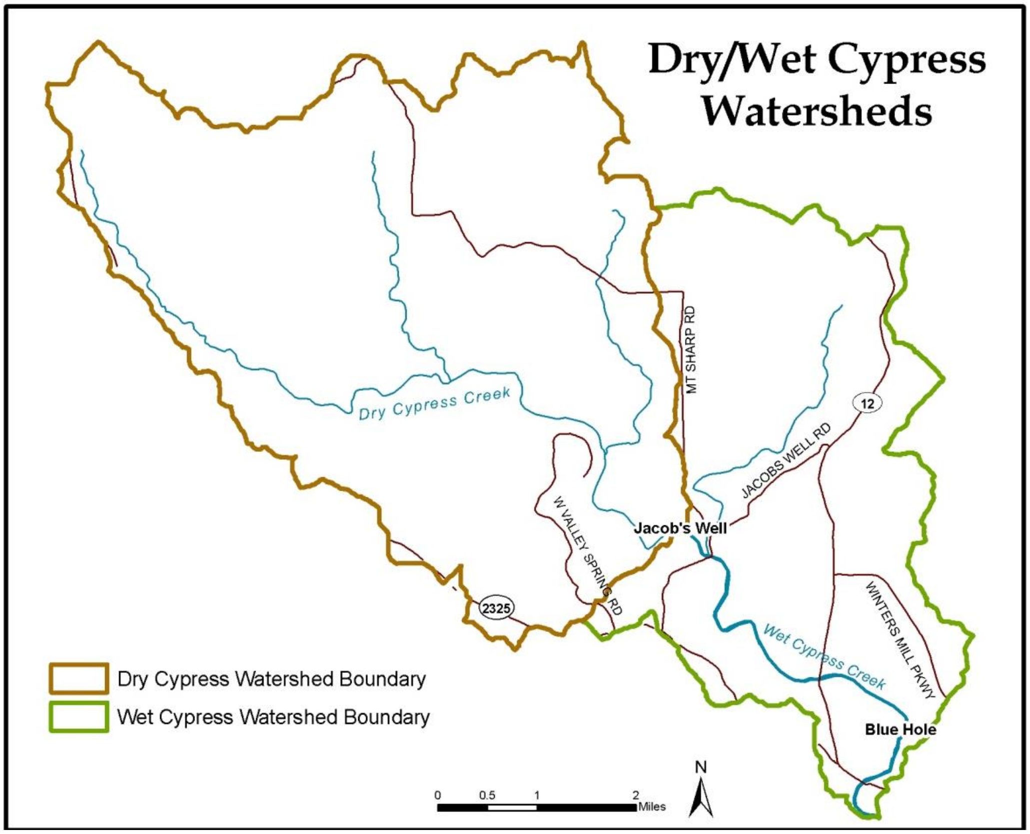


Figure 8. Dry and Flowing Segments Of Cypress Creek

Overall water quality in Cypress Creek is meeting water quality standards set by TCEQ, but shows signs of degradation. Data reveal both spatial and temporal water quality trends that may be due to climate variability, nonpoint source pollution, changes in land use and/or management in the watershed and stressed groundwater levels.

Annual Water Flow - Water Yield

Model results show an average water yield across the watershed of 260.61 mm (annual water flow), meaning that for an average annual rainfall of 879.37 mm (35 in), about 260 mm will flow out of the upland areas to the main stream channel (Figure 9). Model results indicate that a great deal of flow losses occur in the upper portions of the watershed through rapid infiltration and channel loss, or surface water flows converting to groundwater. Some of these flows travel through the shallow subsurface and reappear in downstream channels, while others are lost to deep percolation and/or utilized by vegetation. Areas that yield the largest amounts of water also have the greatest potential to carry high volumes of pollutants. Simulated yearly average water yield for each subwatershed was used with Event Mean Concentrations for six land uses to estimate pollutant loadings by source for NPS parameters and parameters of concern identified by the Stakeholder Committee. Results of these modeling activities are discussed below in the section titled *Water Quality*.

Management measures exist which may mitigate effects of these natural processes both to protect flows and to protect water quality of surface waters recharging source water supplies. Stakeholders have chosen to include such management measures in their implementation strategy and groundwater-surface water modeling is listed as a necessary tool to understand the relationships and implement future BMPs, if applicable.

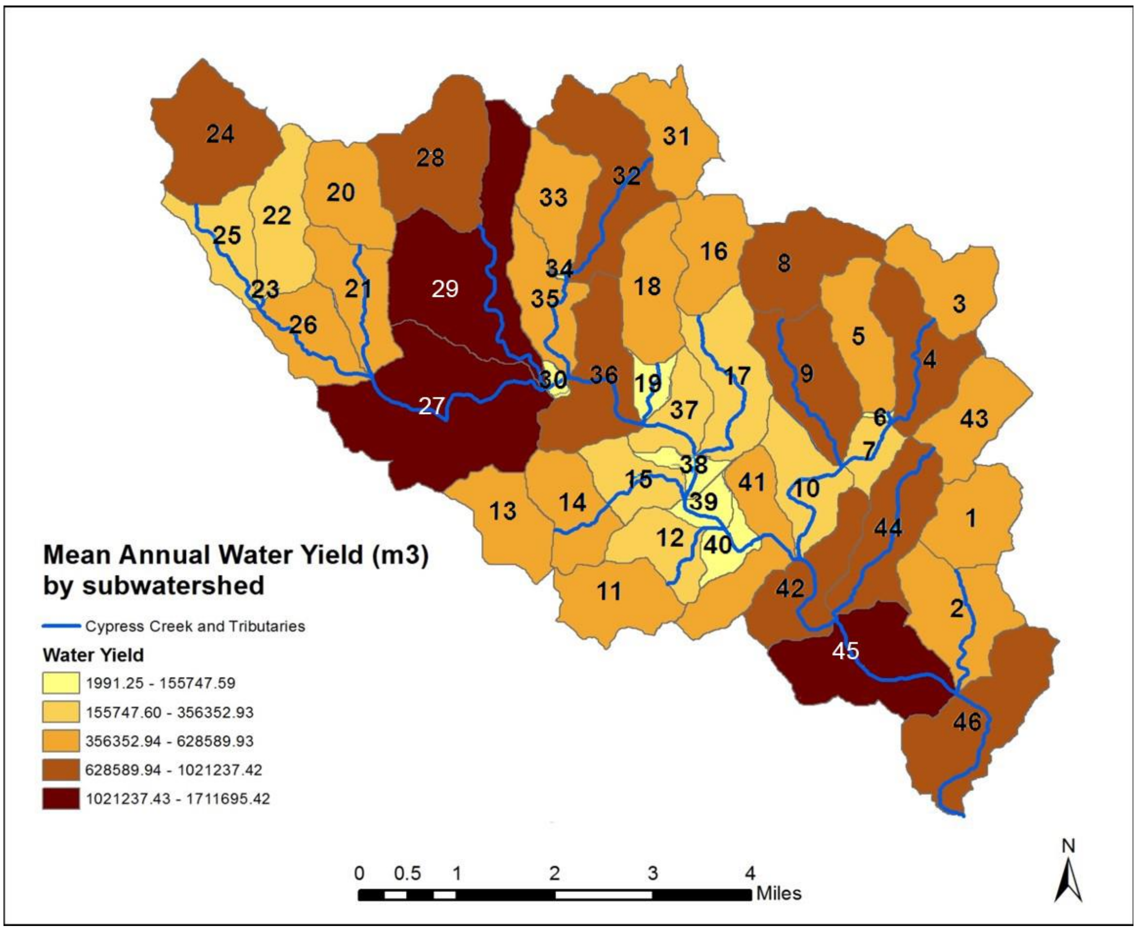


Figure 9. Simulated Average Water Yield by Subwatershed, 2000-2009 via SWAT

Land Use

As of 2009 the majority of land use is made up of open/undeveloped and rangeland, and urbanized land use makes up only 9.2%, most of which is residential (Table 5). Most developed land is concentrated around the wet portion of the cypress creek (Figure 10).

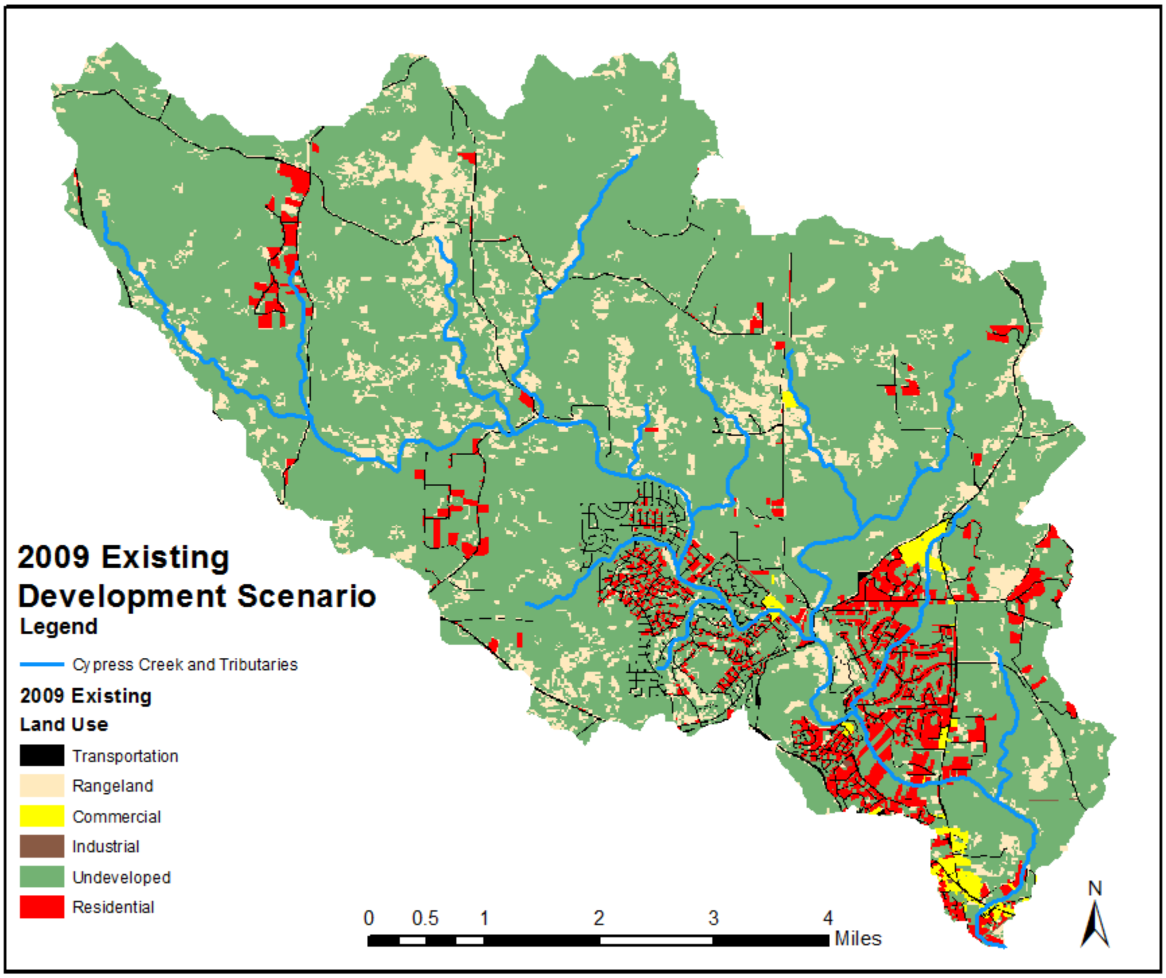


Figure 10. Land Use in Cypress Creek Watershed, 2009

Table 5. Land Use in Cypress Creek Watershed, 2009

2009 Existing Land Use	Area of Watershed
Residential	5%
Commercial	<1%
Industrial	<1%
Transportation	3%
Rangeland	11%
Open and Undeveloped	80%

Hays County is expected to grow by 300% by 2050. Based on data collected in 2009, land use change has been projected to be predominately residential (Table 6), with an increase of 440% (Table 7). In the Future Scenario, development extends into the dry portion of Cypress Creek and into the uplands (Figure 11).

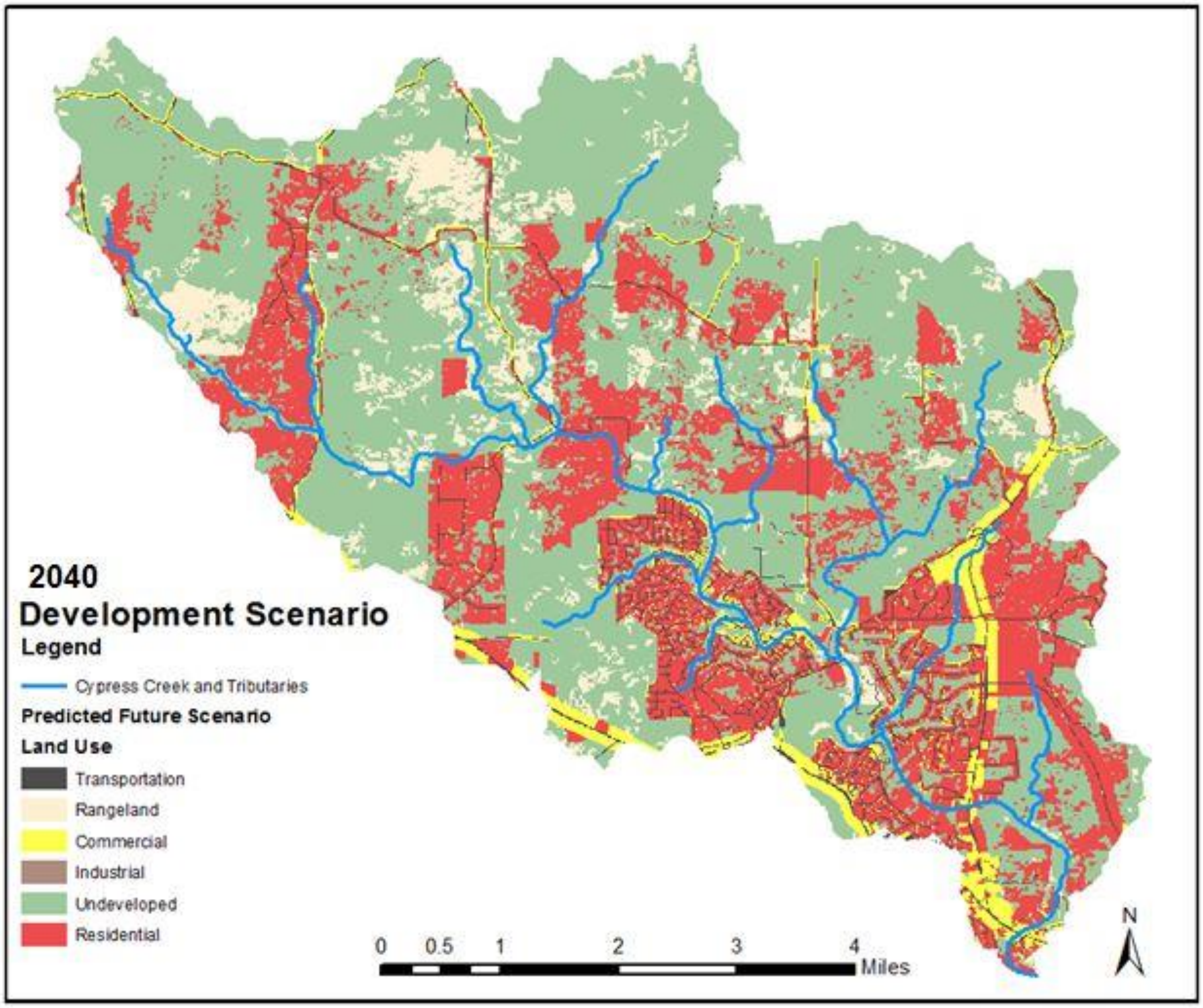


Figure 11. Land use in Cypress Creek watershed, Future Development Scenario (2040)

Table 6. Land Use In Cypress Creek Watershed, Future Development Scenario

Future Land Use	Area of Watershed
Residential	26%
Commercial	5%
Industrial	<1%
Transportation	3%
Rangeland	8%
Open and Undeveloped	57%

Over time the watershed will undergo significant conversions from undeveloped and rangeland to residential and commercial land uses (Figure 12). This is expected to lead to increased impervious cover resulting in increased stormflows and decreased aquifer recharge.

Table 7. Land Use Area Changes In The Watershed.

Existing Land Use Coverage in Cypress Creek Watershed	Existing Area	Future Area	Existing Percent	Future Percent	% Change
Residential	1231.57 Acres	6434.11 Acres	5%	27%	440%
Commercial	200.01 Acres	1235.57 Acres	<1%	5%	400%
Industrial	15 Acres	11.56 Acres	<1%	<1%	0%
Transportation	798.12 Acres	798.55 Acres	3%	3%	0%
Rangeland	2656.78 Acres	1932.66 Acres	11%	8%	[-27%]
Undeveloped	19426.1 Acres	13904.6 Acres	80%	57%	[-29%]
TOTAL	24327.6 Acres	24327.6 Acres	---	---	---

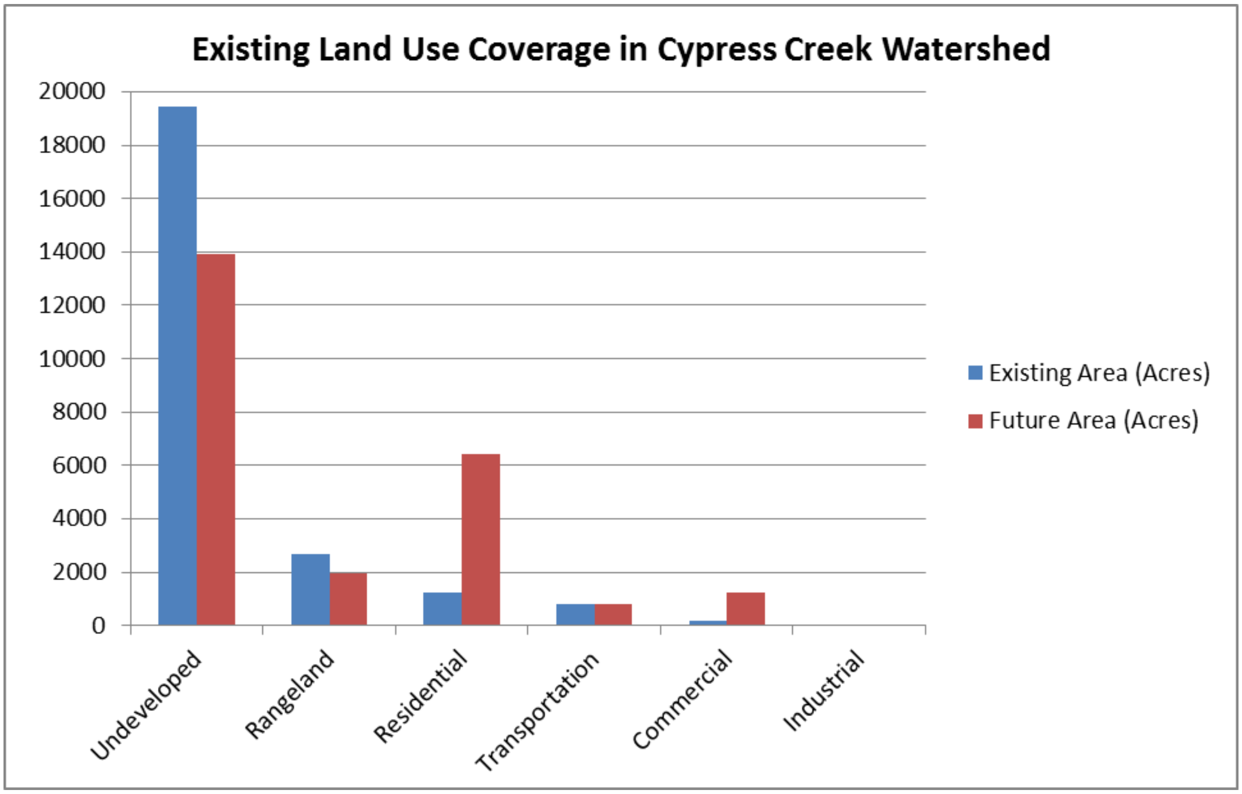


Figure 12. Existing Land Use in Cypress Creek Watershed in Acreage

4. General Causes and Sources of Pollution

There are no major permitted point sources within the Cypress Creek watershed. Currently, treated wastewater is used to irrigate golf course turf grass and no direct negative water quality effects from these discharges have been identified with limited water quality sampling. All modeling activities assume that these discharges are operating in accordance with TCEQ permit requirements, but monitoring of these permitted sources is recommended.

Due to the karstic limestone and the interconnectivity between rainfall, surface waters, and groundwater, the watershed and the Upper and Middle Trinity Aquifers are vulnerable to nonpoint source pollutants. Such dispersed pollutants can be part of infiltration or surface water runoff from development, septic systems/on-site sewage systems, spray and subsurface effluent irrigation systems, spills or dumping of chemical pollutants, fertilizer applications and other agricultural activities, including animal waste. During implementation, stakeholders will identify best management practices to mitigate effects of pollutants regarding surface and groundwater interactions.

The primary water quality factors addressed in the Cypress Creek Watershed Protection Plan are non-point sources of pollution. The stakeholder committee also identified issues of local concern with respect to water quality which include: bacteria levels in the water, oil and grease, dissolved oxygen levels, impervious cover, and adequate base flows.

The 2010 Cypress Creek Watershed Characterization Report (Technical Reference Document) and supporting information were used as the baseline information for determining the causes and sources of pollution for nitrogen, Phosphorus, Suspended Solids, Dissolved Oxygen, *E. coli,* Oil and Grease, and Ammonia. It included a comprehensive snapshot of the watershed such as its vulnerable areas, water quality monitoring results, watershed delineation, land use analysis, target constituents Figure 14). Common pollutants are briefly described below, while comprehensive descriptions of these and other pollutants can be found in the 5.0 Nonpoint Source Pollution Section of the WCR (located in the Technical Reference Document).

Wildlife and Pets

White-Tailed deer are abundant throughout the Texas Hill Country and excessive numbers of deer contribute significantly to bacteria and nutrient loadings. Feral hogs are a rapidly growing problem as well and tend to deposit their waste near or into water bodies. Further their rooting behavior can cause extensive erosion and siltation in water.

When not properly disposed, pet waste can enter waterways, lower the quality of the water, and increase pathogen levels. Pet waste contains *E. coli*, bacteria and other parasites that can be harmful to humans and aquatic life. In addition, future development in the watershed will increase the opportunities for water quality impairments due to elevated pathogens, nutrients, sedimentation/siltation, organic enrichment, depressed oxygen levels, reduced aquifer recharge, habitat alterations, and biological impairments.

Septic Tanks

Homeowners are responsible for the maintenance of their on-site sewage facilities (OSSFs). Septic systems work well when functioning correctly and sited in the correct soil. However, soil type, age, design and maintenance issues can contribute to OSSF failure. Septic system failure can impact the quality of ground and surface water and often contribute bacteria, nutrients and oil and grease pollutants within the watershed and Cypress Creek. High concentrations of OSSFs can be found in subwatersheds 10, 42, 45 and 46 of which 10, 42 and 45 are also vulnerable tributaries (Group B). These subwatersheds are listed as priority subwatersheds by the stakeholders due to their possible contribution to nonpoint source pollution. Medium concentrations of OSSFs can be found in subwatersheds 20, 21, 27, 39, and 40 of which 21 and 27 are considered vulnerable tributary (Group C).

According to a study conducted by the Texas On-Site Wastewater Treatment Council (Reed et al., 2001), septic systems built after 1987 have an estimated failure rate of 12%. Because of missing data and the uncertainty regarding failure rates for septic systems of any age, and considering the Steering Committee's input, OSSF calculations used in pollutant load modeling assume a failure rate of 12% for all systems regardless of year built. The estimated number of OSSF's in the watershed is 1452 Figure 13. below shows known OSSFs within the watershed. We anticipate doing a study of the OSSF potential failure rate (with improved data) during the first three years of implementation.

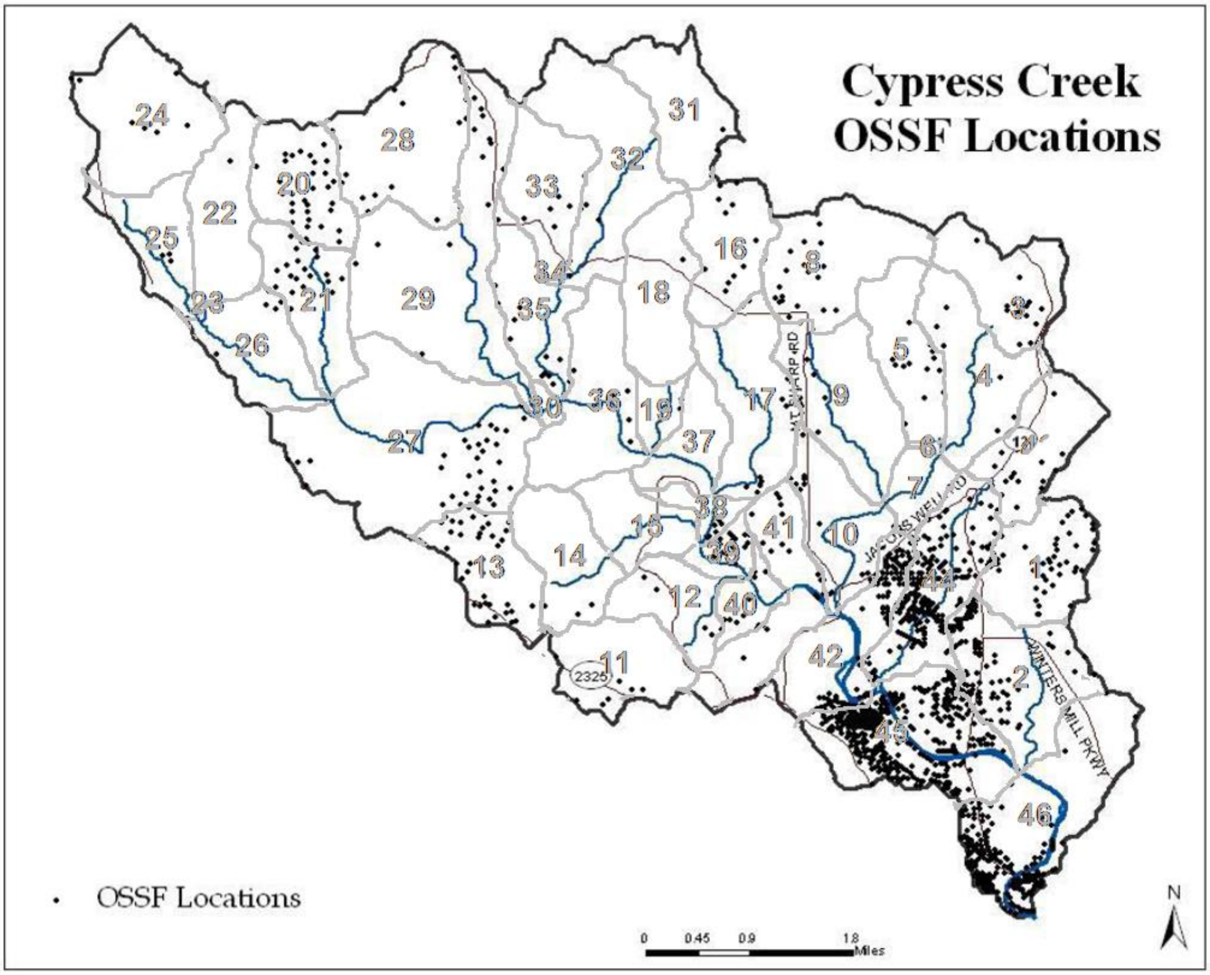


Figure 13. OSSF locations

Municipal Wastewater

Municipal wastewater management is a potentially significant source of pollution in the watershed. There are two wastewater treatment plants (WWTP) that serve the watershed. The Village of Wimberley and Guadalupe-Blanco River Authority have a permit for the Blue Hole Wastewater Treatment Facility in Wimberley. The plant is authorized to dispose of effluent at a maximum volume of 0.050 MGD by land application on 19 acres of land that is not available to the public. Application rates are not to exceed 2.96 acre-feet per year per irrigated acre.

The other WWTP is located in the City of Woodcreek. Aqua Wastewater Management, Inc. (AquaTexas) services a large number of households and businesses in the area. This WWTP is located outside of Cypress Creek watershed boundaries and the treated waste is pumped back into the watershed for dispersal. The plant is authorized to dispose of the treated wastewater at a maximum volume of 0.375 MGD by land applying on 175 acres of land. This acreage is the

Woodcreek Quick Sand golf course. Application rates cannot exceed 2.4 acre-feet per year per acre irrigated. No discharge of pollutants in to water is allowed by this permit.

Further testing of vulnerable areas near the golf course would be beneficial to definitively affirm that there is no negative impact from effluent runoff (Table 8).

Table 8. Reclaimed Water Quality Standards

For a 30 day average, per TCEQ (1997), Type I reclaimed water shall have a quality of:	
BOD5 or CBOD5	5 mg/l
Turbidity	3 NTU
Fecal coliform or *E. coli*	20 cfu/100 ml*
Fecal coliform or *E. coli*	75 cfu/100 ml**
Enterococci	4 cfu/100 ml*
Enterococci	9 cfu/100 ml**

**30 day geometric mean*
*** maximum single grab sample*

Agriculture

Agriculture is not a large source of pollution in the Cypress Creek Watershed. The thin, rocky soil makes it difficult to grow row, forage or other types of crops. In addition, there are no concentrated animal feeding operations in the watershed. Bacteria can enter waterways from waste excreted by livestock and was considered in pollutant loadings and best management practices.

Ground/Source Water

Water quality in streams can directly affect water quality in the aquifer because of rapid recharge through fractures and sinkholes in streambeds. The reverse is also true where springs contribute to river flows. In addition, the health of the creek is highly dependent on maintaining adequate spring flows, making recharge and groundwater management in the larger region critical to maintaining a healthy system in Cypress Creek.

Support for including the ground/source water strategy to protect Cypress Creek is found in research from State of Texas agencies. Texas Parks and Wildlife has designated Cypress Creek as an Ecologically Significant Stream Segment (ESSS) for its Hydrological function (Edwards Aquifer Recharge Zone) as well as high water quality, exceptional aquatic habitat and high aesthetic value (TPWD, 2013). The Bureau of Economic Geology at UT Austin identified in a 2005 study on ground and surface water interactions in Texas that increasing groundwater development can change streams from gaining to losing status and contaminated groundwater can impact surface water bodies (Tinker et al., 2005). Another Bureau of Economic Geology in 2009 highlights that polluted stormflows can minimize the amount of bacteria removed during the recharge process (Chaudhary et al., 2009).

Summary of Water Quality Sources and Potential Causes

In 2013, The Meadows Center conducted extensive modeling to identify the most likely causes and sources of pollution in the watershed. More detailed modeling results can be found in the *Water Quality* section below (Page 54).

Table 9 summarizes the parameters above water quality targets for N and TSS levels and parameters of concern, as well as their sources and causes. Targets were adopted and updated to account for the naturally occurring conditions in the creek. The tributary categories and subwatershed numbers in Figure 14 and Figure 15 correspond with those in Table 9 below.

The primary causes of increased nitrogen concentration levels in the watershed are due to residential and commercial application of fertilizers and from on-site septic facilities (OSSFs), septic maintenance, animal waste, and low flows in the creek, among other (see Table 9).

Total suspended solids levels spike when human activities have disturbed natural processes on otherwise undeveloped land and are exacerbated by storm events. Top soils in the watershed are relatively shallow which limit vegetative ground cover. Low flows in the creek also lead to higher TSS concentrations.

E. coli bacteria are present naturally, but are also attributed to septic tanks (OSSFs), pet waste, and other feces present naturally by wildlife. Low flows in the creek also lead to higher concentrations of *E. coli*.

Table 9. Water quality parameters, primary sources, and their potential causes

Parameters Exceeding Target Levels.			
	Number of Subwatersheds Affected	**Primary Sources (land use) Identified with EMCs**	**Primary Causes**
Nitrogen 1.65 mg/L (Stakeholder target)	5 (Subwatershed #2, 4, 7, 32, 35)	Residential and Undeveloped	Residential and Commercial application of Fertilizer. OSSFs, animal waste, overland flow, impervious cover, atmospheric deposition and low flows.
Parameters of Concern			
Total Suspended Solids 4.0 – 5.0 mg/L	34	Residential and Undeveloped	Anthropogenic activities where land cover is disturbed, impervious cover and natural processes on undeveloped land. Soil across much of the watershed is shallow which limits ground cover. Low base flows.
E. coli 126/100mL	Group A Group B Subwatersheds	Residential and Commercial	Septic tanks (OSSFs), pets, and wildlife. Low flows in the creek lead to high concentrations.
Dissolved Oxygen 24-hr mean values above 6.0 mg/L Grab sample values above 4.0 mg/L	Group A Group B Subwatersheds	Residential and Commercial	Low base flows limit aeration of water downstream of ground/source waters.
Oil and Grease	Group A Group B Subwatersheds	Residential	Residential wastewater (kitchen and bathroom),
Impervious Cover increases	Basinwide	Residential, Commercial and Transportation	Increased urbanization
Preferred Base Flows	Cypress Creek Headwaters to confluence with the Blanco River	Residential and Commercial	Most people living in the Cypress Creek rely on well water from the same aquifer that feeds the creek.

The stakeholders identified vulnerable tributaries within the watershed (see Figure 14). Because they are vulnerable, they are also included in Table 1 as stakeholder identified priority reaches. The tributaries are broken up into groups with similar characteristics including Group A (subwatersheds 12, 14, 15 and 44), Group B (subwatersheds 2, 4, 6, 7, 9 and 10), and Group C (subwatersheds 21 and 29).

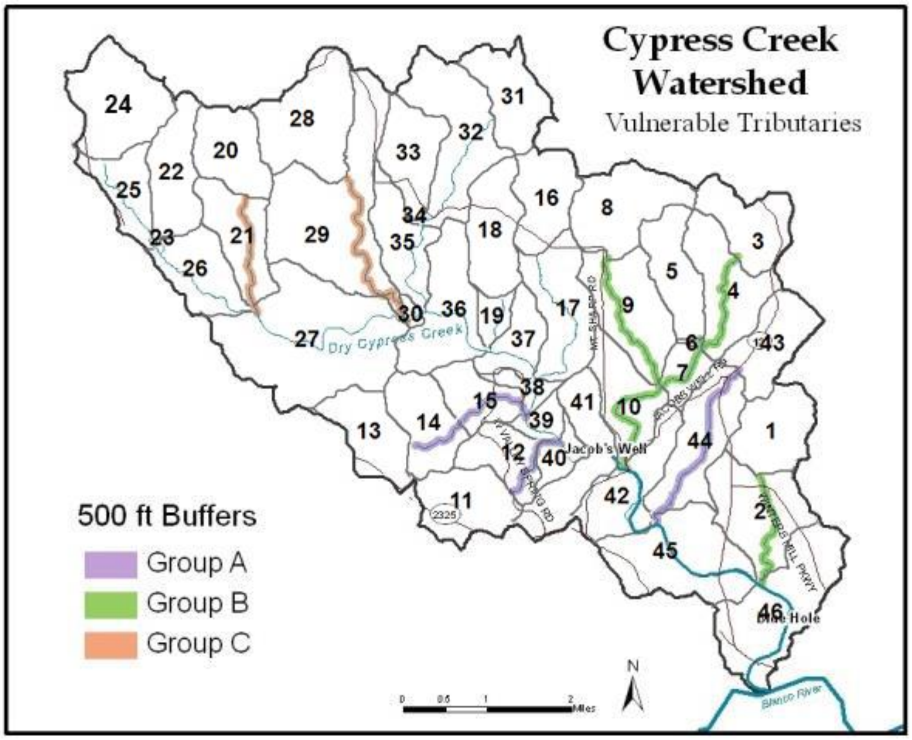


Figure 14. Vulnerable Tributaries Prioritized for BMPs.

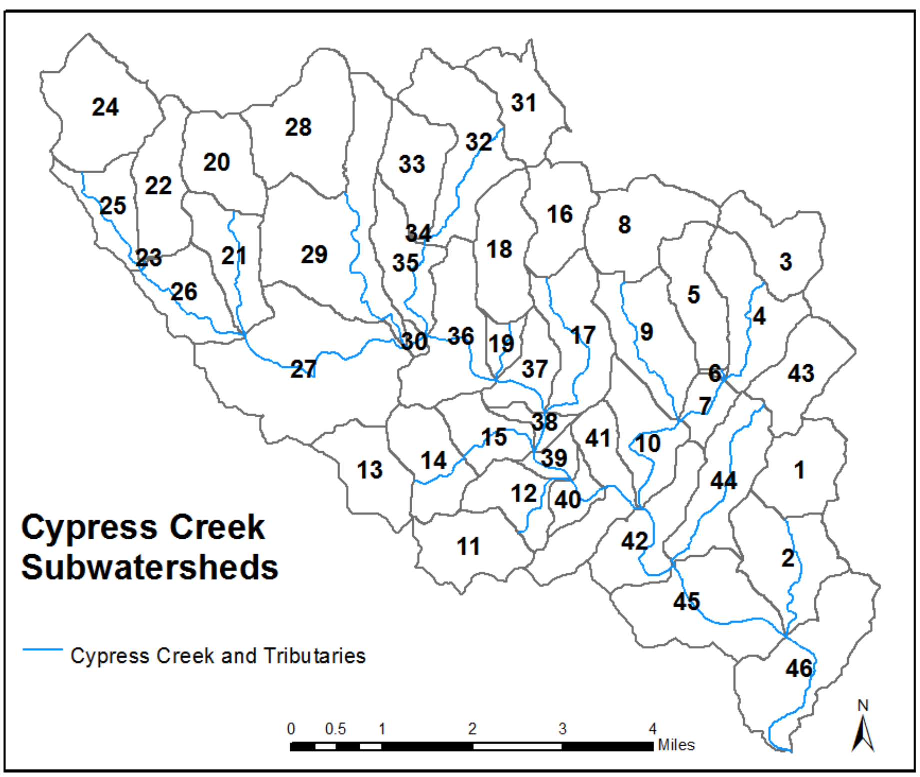


Figure 15. Subwatershed Delineation Map

5. Pollutant Loads: Observed and Modeled

Overall water quality in Cypress Creek is meeting water quality standards set by TCEQ, but the creek shows signs of degradation. Data reveal both spatial and temporal trends that may be due to climate variability, nonpoint source pollution, inflows from groundwater, or changes in land use and/or management in the watershed. To help understand the physical context and factors that may be influencing water quality in the creek, load duration curves were constructed using monitoring data for the primary pollutants of concern in the area: nitrogen, phosphorus, suspended sediments, *E. coli* and dissolved oxygen. These load duration curves were used to identify daily mean loading for the above parameters at monitoring sites.

Nitrogen exceedances above 0.5 mg/L tend to happen at higher flows, and these often occur in the fall and summer months. The highest exceedances are often seen when a period of very low flow is followed by a high flow event. In particular, the very dry period 2005-2006 was followed by exceedances in nitrogen targets at all sites from January through April 2007 (Figure 16). This evidence supports a nonpoint source of nitrogen in the contributing area, such as fertilizer or animal waste that builds up on the surface during dry periods and is washed in when rainfall produces surface runoff. This pattern is in contrast to the pattern of phosphorus loads, which points instead to a loading mechanism that acts at moderate flow levels.

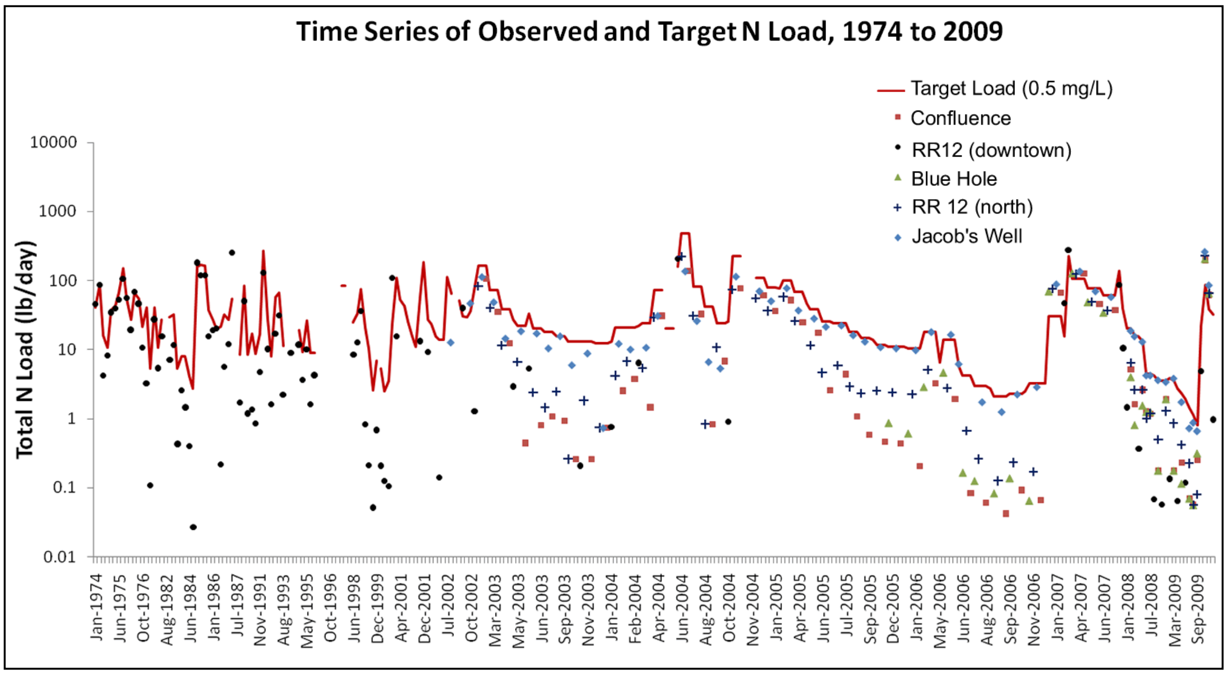


Figure 16. Time Series of Nitrogen Loads in Cypress Creek

Samples are taken monthly (CRP sites) or quarterly (TCEQ site). The red line indicates target loads calculated based on available flow estimates and 0.5 mg/L concentration. Points above this line represent exceedances of the target load.

A time series of target maximum (5.0 mg/L) and observed sediment concentrations reveals that there are a cluster of TSS exceedances that occurred from spring 2005 through fall 2006 (Figure 17). A major roadway, Winters Mill Parkway, was under construction from October 2005 to July 2007 in the southeastern portion of the watershed. Some of the highest relative exceedances in the spring of 2006 may be associated with the construction of this road, although RR12 downtown and the confluence both had exceedances in the spring of 2005 before work started. Instream dredging operations were documented in 2005. In addition exceedances occur at all sites during this period, including those above the influence of bypass construction. Other construction activities along RR12 and Jacob's Well Rd. could contribute excess sediment to the creek as well, if proper stormflow mitigation measures are not employed.

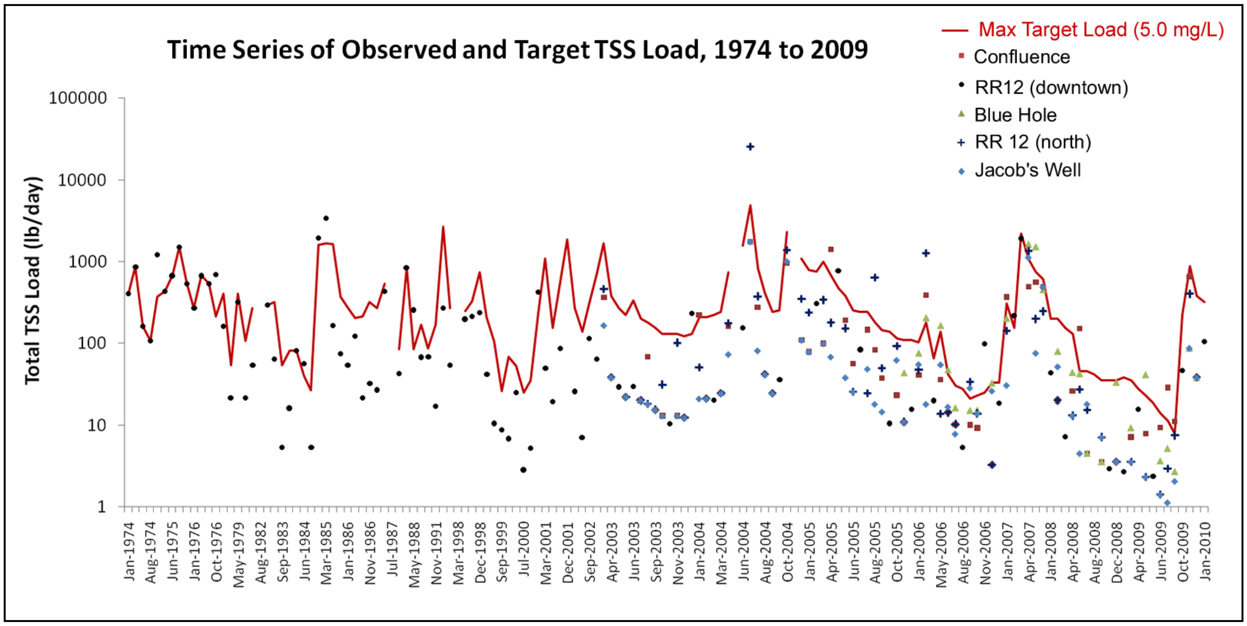


Figure 17. Time Series Of Observed And Target Maximum Sediment Loads In Cypress Creek

Samples are taken monthly (CRP sites) or quarterly (TCEQ site). The red line indicates target loads calculated based on available flow estimates and 5.0 mg/L concentration. Points above this line represent exceedances of the target load.

Figure 23 and Figure 24 below show *E. coli* measurements at five sites in Cypress Creek. Higher *E. coli* values are correlated with elevated TSS levels at all sites (except at Jacob's Well, which tends to generally have the lowest bacteria concentrations due to the influence of spring flow.

For DO, a parameter of concern due to the 303(d) listing in the year 2000, trends show that maintaining a minimum flow is critical. 10th, 20th, 30th, etc. percentiles were calculated for flows estimated at the confluence between 2000 to 2009, and DO observations plotted at each level (Figure 26, Figure 27). For all sites, a flow level between 1.31 and 4.1 cfs appears to be sufficient to sustain DO levels above 4.0 mg/L at least 75% of the time. Between 4.11 and 5.1 cfs, DO is above 6.0 mg/L at least 75% of the time, which is the target level.

To get watershed wide pollution concentrations the SWAT model was used to simulate instream pollution concentrations for all reaches of Cypress Creek. The sources of NPS pollution were determined by using Event Mean Concentrations or EMCs (Baird, Jennings, Ockerman, and Dybala 1996). To do this, the Soil and Water Assessment Tool (SWAT) was used to simulate an average annual water yield for each subwatershed. These modeled water yields were necessary for the EMC equations used to calculate pollutant loads and identify potential sources of NPS pollution for existing and future conditions. The Texas Administrative Code describes the designated uses and water quality criteria required to meet those designations (Table 10). Because there are no criteria for nitrogen, the Stakeholder Committee determined a target level (Table 12) for nitrogen that is more conservative than state screening levels. The modeled instream pollutant concentrations are used to identify reaches of Cypress Creek that need targeted attention to mitigate water quality.

Table 10. Cypress Creek Designated Uses and Criteria

Cypress Creek Site Specific Uses and Criteria (Classified Segment)				
Seg #	**Segment Name**	**Recreation**	**Aquatic Life**	**Domestic Water Supply & Aquifer Protection**
1815	Cypress Creek	PCR	E	PS/Aquifer regulated activities: any construction/post-construction activity occurring on the contributing zone of the Edwards Aquifer that has the potential for contributing pollution to surface streams that enter the Edwards Aquifer recharge zone (§213.21)

Criteria						
Cl^{-1} (mg/L)	**SO_4^{-2}** (mg/L)	**TDS** (mg/L)	**DO** (mg/L)	**pH Range** (SU)	***E. coli*** #/100ml	**Temperature** (°F)
50	50	400	6.0	6.3-9.0	126	86
* The aquifer protection use applies to the contributing, recharge and transition zones of the Edwards Aquifer.						

Methods of Analysis

The Meadows Center and Stakeholder Committee utilized the Soil and Water Assessment Tool (SWAT 2000) and Event Mean Concentration calculations to enhance their knowledge about pollution in the watershed, identify sources of pollution, and assist with determining strategies and best management practices.

Watershed delineation was performed using the Automated Geospatial Watershed Assessment (AGWA) tool, an interface for ESRI's ArcGIS jointly developed by the U.S. Environmental

Protection Agency, U.S. Department of Agriculture (USDA) Agricultural Research Service, and the University of Arizona to automate the parameterization and execution of two commonly-used hydrologic models (Miller et al., 2007). The AGWA delineation and discretization process utilizes the hydrology utilities provided by ArcGIS to define watersheds and stream networks. Watershed delineation segments a region into several hydrologically connected subwatersheds for use in characterization and modeling. AGWA's delineation tool requires an elevation raster, which was obtained from the USGS's National Map Seamless Server (USGS, 2010). This data set has a resolution of approximately 10 meters and is processed to filter artifacts and fill missing data at quadrangle seams. Automatic delineation uses a threshold method of contributing source areas (CSA) to delineate hydrologically distinct areas. The threshold parameter may be increased to decrease the number of sub-basins, or conversely, decreased to increase the number of sub-basins. CSA was varied from 1.0% (243 acres) to 2.5% (608 acres). In addition, stormflow gauge locations were used to create breaks between watersheds so that model output at those locations can be directly compared to measured values. The resulting delineations were compared to roads and other infrastructure to choose the best balance between the number and resolution of basins and potential watershed management units. The final delineation yielded 46 subwatersheds within the watershed of Cypress Creek (Figure 15) above. This subwatershed delineation was used to calculate statistics for soils, land uses, and pollutant loadings.

Watershed modeling of the Cypress Creek contributing area was performed using the Cypress Creek Decision Support System (CCP-DSS), a modeling and results visualization package based on the Automated Geospatial Watershed Assessment (AGWA2) tool. AGWA2 is an interface for ESRI's ArcGIS jointly developed by the U.S. Environmental Protection Agency, U.S. Department of Agriculture (USDA) Agricultural Research Service, and the University of Arizona to automate the parameterization and execution of two commonly-used hydrologic models, SWAT and KINEROS (Miller et al., 2007). The CCP-DSS is based on the AGWA2 system and in addition has been populated with all the relevant local data to perform scenario analyses on the Cypress Creek watershed.

The Soil and Water Assessment Tool (SWAT) was used to model flow, sediment, and nutrients across the watershed and stream channels. This model uses information on soils, topography, land cover, rainfall, and temperature to simulate hydrologic processes on the land surface that create surface flow, infiltration and subsurface flow, and routes these flows, sediment and nutrients through stream channels. It is a continuous simulation model, so outputs can be daily, monthly, or annual means for a period of several years to decades. Daily data from 2000 to 2009 were used to run the model and to compare the simulated outputs to observations. Daily flows and nutrient loadings simulated in each subwatershed from 2000-2009 were averaged and selected results are presented below. Existing BMPs were not surveyed for this study; therefore the model results presented represent initial estimates of average runoff and pollutant loadings based on known land uses and the physical properties of the area. Additional calibration of the model to incorporate existing BMPs and new monitoring data is recommended. Please refer to the Technical Reference Document for more details on model development, inputs, and calibration.

Water yield is defined as the average amount of water leaving a subwatershed or channel. Model results show an average water yield across the watershed of 8.5 in, meaning that for an average annual rainfall of 35 in, about 8.5 in of that will flow out of the upland areas to the main stream channel. Model results indicate that a great deal of flow losses occur in the upper portions of the watershed through rapid infiltration and channel loss. Some of these flows travel through the shallow subsurface and reappear in downstream channels, while others are lost to deep percolation and/or used by vegetation. Areas that yield the largest amounts of water also have the greatest potential to carry high volumes of pollutants in this water, so these areas should be targeted for BMP implementation to mitigate both nonpoint source pollution and flood risk (See Figure 9). Simulated average water yields for each subwatershed were also used along with data on land uses to calculate pollutant loadings for some additional parameters of interest as discussed in 5.0 Nonpoint Source Pollution Section of the WCR found in the Technical Reference Document.

Land Use Analysis

Methods

Land use characterization for the Cypress Creek watershed was determined using Hays Central Appraisal District (HaysCAD) 2009 cadastral data. At the time that the work on characterizing the watershed began, this data was received as an incomplete GIS parcel layer from HaysCAD, with parcel polygons outlined and a separate, partially completed annotation file containing tax reference numbers (R numbers). Thus, identification of parcel by R number was available for approximately 82% of the watershed. Spatial parcel data was joined (by R number) to a Wimberley Independent School District (WISD) 2009 tax roster, allowing each parcel to have data populated regarding relevant owner name, address, property values and existing land use/land type codes.

HaysCAD state code values were reclassified into a land use system of eight classes: Residential (A, B), Large Lot Residential (ALg), Undeveloped/Open-space (C), Agriculture (E), Commercial (F), Industrial (J), Parks (P) and Transportation (T). Since the protocol at HaysCAD is to identify properties by their zoned/potential land use type, many of the parcels that were coded as a residential type of land use were in fact still vacant lots, i.e. platted but undeveloped. The goals of the characterization involved evaluating current land use practices, so ground-truthing was conducted using 2008 aerial imagery from Capital Area Council of Governments (CAPCOG). Any parcel that was coded as residential but had no structure built on the property was re-coded as undeveloped. Also, any other necessary updates were made, such as coding all roads as transportation and creating and coding the parks classification. This 55 allows for an accurate assessment of where and what type of development has occurred in the watershed to date. There are a few known conservation easements and wildlife management areas within the watershed, but the exact nature and impacts on land management are not known. Therefore, in those areas the initial land use classification was used, which for these parcels was predominantly Rangeland.

Pollution Loading by Source

Estimating annual pollutant loadings can be very useful for identifying the types of nonpoint source pollution from different parts of the watershed and understanding the magnitude of loadings that need to be managed with the Watershed Protection Plan. Although the Cypress Creek watershed has a good record of ambient water quality in the watershed, these values have not been separated into the contributions from component land uses. In addition some parameters, such as oil/grease and biochemical oxygen demand (BOD), are not included in the current data set. EMCs for various agricultural and urban NPS pollution constituents are given in Baird et al., 1996. These values have been used in several studies in Texas when localized EMCs are not available. In order to augment the results from the SWAT model and to characterize the relative loading contribution from different land uses, annual loadings for various pollutants were estimated using a modeled mean annual water yield along with EMCs given in the Baird et al. (1996) land use study (see Table 11) using the formula outlined in the EMC Method section below.

Table 11. EMC Estimates for Selected NPS Constituents (From Baird Et Al., 1996)

Constituent	Land Use						
	Residential	Commercial	Industrial	Transportation	Cropland	Rangeland	Undev/Open
Total Nitrogen (mg/L)	1.82	1.34	1.26	1.86	4.40	0.70	1.50
Total Kjeldahl Nitrogen (mg/L)	1.50	1.10	0.99	1.50	1.7	0.20	0.96
Nitrate + Nitrite (mg/L as N)	0.23	0.26	0.30	0.56	1.6	0.40	0.54
Total Phosphorus(mg/L)	0.57	0.32	0.28	0.22	1.3	<0.01	0.12
Dissolved Phosphorus(mg/L)	0.48	0.11	0.22	0.10	--	--	0.03
Suspended Solids(mg/L)	41.0	55.5	60.5	73.5	107	1.0	70
Dissolved Solids(mg/L)	134	185	116	194	1225	245.0	--
Total Lead (µg/L)	9.0	13.0	15.0	11.0	1.5	5.0	1.52
Total Copper (µg/L)	15.0	14.5	15.0	11.0	1.5	<10	--
Total Zinc (µg/L)	80	180	245	60	16	6.0	--
Total Cadmium (µg/L)	0.75	0.96	2.0	< 1	1.0	<1.0	--
Total Chromium (µg/L)	2.1	10.0	7.0	3.0	<10.0	7.5	--
Total Nickel (µg/L)	< 10	11.8	8.3	4.0	--	--	--
BOD (mg/L)	25.5	23.0	14.0	6.4	4.0	0.5	--
COD (mg/L)	49.5	116	45.5	59	--	--	40
Oil and Grease (mg/L)	1.7	9.0	3.0	0.4	--	--	--
Fecal Coliform(colonies/100 ml)	20,000	6,900	9,700	53,000	--	37	--
Fecal Strep.(colonies/100 ml)	56,000	18,000	6,100	26,000	--	--	--

-- Data not available

Values shown as <0.01, <1, and <10 indicate that all or most of the values were below the reporting limit.

Time period for data is 1992-1993 except for cropland and rangeland, which was collected 1970-1995.

EMC Method

Mean annual water yields for each subwatershed were converted to runoff volume $(\frac{m^3}{yr})$ by converting to meters and multiplying by the total area of the subwatershed. EMCs for land use-constituent combinations for which no estimates are provided are not included in loading estimates. Also, EMC values below detection limits (i.e. <0.01) also were not included. NPS loadings for each constituent are calculated as the sum of EMCs for each land use multiplied by runoff volume and scaled by the relative area in each land use:

$$l_x = \sum(0.001EMC_{x1} * Q * a_1) + (0.001EMC_{x2} * Q * a_2) + \cdots + (0.001EMC_{ax} * Q * a_{n*})$$

Where l_x = annual loading of constituent *x* $(\frac{kg}{yr})$

EMC_{x1} = event mean concentration of constituent *x* from land use 1 $(\frac{mg}{L})$

Q = water yield (runoff volume) $(\frac{m^3}{yr})$

a_1 = percent of watershed area in land use 1

The results are then converted to unit loads (per unit area) given the formula:

$$L_x = \frac{10\,000 * l_x}{A}$$

Where L_x = annual unit loading of constituent *x* (kg/ha/yr)

A = total area of subwatershed (m^2)

Finally, loading estimates were converted to pounds per year (lb/year).

Water Quality Analysis

In order to preserve water quality and mitigate continued degradation, the Stakeholder Committee chose a water quality target for nitrogen that is stricter than state screening levels. Below is a summary of the water quality analysis (see Technical Reference Document).

It is important to note that because this project was carried out over 5 years, monitoring data is referred to as historical data (pre 2008), recent monitoring data (collected in 2008-2010) or new data (post 2010 stakeholder supplied data for BMPs).

Dissolved oxygen is of concern because the creek was briefly listed on the 303(d) list for inadequate DO levels in 2000. In addition, new data provided by GBRA in the 2013 CRP report (pg. 51) indicated a downward trend in DO in Cypress Creek. Stakeholder input was used to identify desired flow conditions required to maintain adequate DO levels. Mean bacteria concentrations in Cypress Creek are at attainment, but high concentrations have been identified at different points along the creek and are of concern as development in the watershed continues. Increased impervious cover is a concern because it contributes to higher pollutant concentrations during rain events and decreases localized groundwater recharge. Oil and grease was designated as a parameter of concern by the Stakeholder Committee. A 300-500% increase was determined to be acceptable when considering a full build-out scenario. Future modeling and increased monitoring will allow for a better understanding and improved targets during the implementation phase. Table 12 identifies the targets and standards for pollution parameters of primary concern. The Stakeholder Committee determined a goal of meeting state standards where applicable in the early years of implementation, and will strive for Stakeholder Committee established targets by the later years of the implementation process.

Table 12. Target Levels For Pollutant Constituents And Parameters Of Concern

Pollutant	State Standard or Screening Level if Applicable***	Target at a Minimum Cypress Creek Stakeholder Committee	Source of Information
Nitrogen (N)	---	Target- 1.65 mg/L	Cypress Creek Stakeholder Committee
	Nitrate screening level- 1.95 mg/L	---	TCEQ
Parameters of Concern		**Objectives**	**Source of Information**
Total Suspended Solids (TSS)	---	---	Cypress Creek Stakeholder Committee
	Screening level- 5.0 mg/L	---	TCEQ
Escherichia coli (E. coli)	Single sample- 394 cfu/100mL Geometric mean- 126 cfu/100mL	Single sample- 394 cfu/100mL Geometric mean- 126 cfu/100mL	TCEQ
Dissolved Oxygen (DO)	24-hr mean values above 6.0 mg/L Grab sample values above 4.0 mg/L	24-hr mean values above 6.0 mg/L Grab sample values above 4.0 mg/L	TCEQ
Flow	---	Jacob's Well- 3.8 to 6.4 cfs Blanco Confluence- 4.11 to 5.1 cfs Cypress Creek- 4 to 6 cfs	Cypress Creek Stakeholder Committee
Impervious Cover	---	15-20%	Cypress Creek Stakeholder Committee
Oil & Grease	---	No more than a 300-500% increase from current conditions	Cypress Creek Stakeholder Committee

* Unless otherwise noted, targets are for all CRP and TST monitoring sites, including confluence with the Blanco River.

** Targets are reported in annual averages, which allow for exceedances on individual sampling events, provided that the average of all events in a one year period do not exceed the specified target levels.

***State water quality standards have not been established for N, TSS, Flow, Impervious Cover, and Oil & Grease. N and TSS have a state screening level established.

Instream Pollution Concentration from SWAT Model

The SWAT model was used to simulate instream pollution concentrations in the creek for the Existing and Future scenarios. The results were used to identify reaches of the creek that currently and are expected to have pollution concentrations above stakeholder determined targets. The SWAT model uses observed precipitation and temperature data to simulate the amount of overland and instream flow based on elevation, slope, soil characteristics, the creek's physical characteristics and potential losses to karst features and or evaporation. To keep instream pollution concentrations in the same units and time step used in the EMC calculations, discussed in the following section, SWAT model results are shown as mean annual values with annual load reductions needed to meet stakeholder determined targets for nitrogen in the Existing and Future scenarios (Table 13 and Table 14).

Table 13. 2009/Existing Development Scenario

Mean Annual Instream Concentrations and Reductions Needed

Sub ID	Nitrogen Instream Load (Target = 1.5 mg/L)	Nitrogen Reduction Needed (mg/L)	% Nitrogen Reduction Needed*
2	1.66 mg/L	.16 mg/L	9%
4	1.63 mg/L	.13 mg/L	8%
7	1.64 mg/L	.14 mg/L	9%
32	1.86 mg/L	.36 mg/L	19%
35	1.66 mg/L	.16 mg/L	10%

* Estimated pollution load reductions needed to meet water quality goals in the watershed. This analysis is submitted to satisfy Element B of the EPA 9-element criteria for watershed-based plans.

Table 14. 2050/Future Full Development Scenario

Mean Annual Instream Concentrations and Reductions Needed.

Sub ID	Nitrogen Instream Load (Target = 1.5 mg/L)	Nitrogen Reduction Needed (mg/L)	% Nitrogen Reduction Needed
2	1.78 mg/L	0.28 mg/L	16%
4	1.68 mg/L	0.18 mg/L	11%
7	1.67 mg/L	0.17 mg/L	10%
32	1.90 mg/L	0.40 mg/L	21%
35	1.69 mg/L	0.19 mg/L	11%

* Estimated pollution load reductions needed to meet water quality goals in the watershed. This analysis is submitted to satisfy Element B of the EPA 9-element criteria for watershed-based plans.

Because there is a great deal of potential variability in runoff depths, both spatially between subwatersheds and temporally between wet and dry years, the Meadows Center used SWAT model outputs to identify instream concentrations that are above stakeholder determined target concentrations identified in Table 12. In reaches with concentrations above stakeholder determined targets EMCs were used to identify the potential sources of nitrogen for the subwatersheds that contribute flows to that reach (Figure 18, Figure 19, Figure 20, Figure 21).

Nitrogen and TSS Loads from EMC Calculations by Land Use

Likely sources of NPS pollution in the watershed include urban runoff, on-site septic treatment, residential landscaping, agricultural activities, fertilizer and pesticide application, land clearing for new construction, pet and livestock wastes, runoff from roads and parking lots, grazing activities, atmospheric deposition, and recreational use of the creek. Pollutant loadings were identified by subwatershed during the 2010 characterization of the watershed. Analysis of the EMC results for the Existing Scenario show that a majority of nitrogen comes from undeveloped land (Table 15). In the Future Scenario (Table 16), undeveloped land is still the largest contributor of nitrogen and TSS to the watershed, but increased residential land cover increases loads to approximately five times more nitrogen and TSS from this source. Existing residential land use is projected to increase by approximately 440% from 5% to 27% of the watershed (Table 7). With this change, nitrogen increases 371%, from 7% to 33%. TSS increases by 400% from 4% to 20%. Event mean concentration calculations show that the growth of residential land area is primarily responsible for total increased pollutant loadings by acre, as seen in Technical Reference Document F – Event Mean Concentration Calculation Results by Subwatershed.

The undeveloped land use is the largest source of potential loadings for nitrogen and TSS because it accounts for 80% (19,426 ac) of the total area (24,327 ac); whereas, the residential land use accounts for only 5% (1,231 ac) of the area. Although the residential nitrogen event mean concentration (EMC) is higher than the undeveloped EMC, the undeveloped contributes more due to its size. Both nitrogen and TSS potential loadings are calculated as a function of the percent of land use and EMC, therefore, the undeveloped area contributes approximately 82% of the nitrogen load and 91% of the TSS potential load mostly due to large amount of undeveloped land (19,426 ac). The event mean concentration (EMC) values are derived from EMC monitoring and research conducted in Texas by Baird et al.

Commercial land use is projected to increase by 400% in this Future Scenario, which causes a 400% increase in nitrogen and TSS. Industrial and Transportation land uses do not undergo a significant change and therefore, water quality modeling does not indicate a significant change in nitrogen and TSS loads. Rangeland decreases by 27% which results in a 40% reduction in nitrogen and 0% in TSS. Finally, undeveloped land decreases by 29% which causes a 34% reduction in nitrogen and a reduction of 24% TSS (See Table 17 and Table 18).

Table 15. Existing Scenario: Contribution from Source Land Uses

Existing Land Use Coverage in Cypress Creek Watershed	Area (acres)	Nitrogen EMC	Total Nitrogen Load	Percent of Nitrogen Load	TSS EMC	Total TSS Load	Percent of TSS Load
Residential	1231.57 acres	1.82 mg/l	2479.02 lb/yr	7%	41 mg/l	55846 lb/yr	4%
Commercial	200.01 acres	1.34 mg/l	282.55 lb/yr	1%	55.5 mg/l	11702.54 lb/yr	1%
Industrial	15 acres	1.26 mg/l	21.52 lb/yr	<1%	60.5 mg/l	1033.35 lb/yr	<1%
Transportation	798.12 acres	1.86 mg/l	1502.21 lb/yr	4%	73.5 mg/l	59361.54 lb/yr	4%
Rangeland	2656.78 acres	.70 mg/l	1809.45 lb/yr	5%	1 mg/l	2584.93 lb/yr	<1%
Undeveloped	19426.08 acres	1.50 mg/l	28241 lb/yr	82%	70 mg/l	1317912.15 lb/yr	91%
TOTAL	24327.56		34335.72			1448440.51 lb/yr	

* Estimated pollution load reductions needed to meet water quality goals in the watershed. This analysis is submitted to satisfy Element A of the EPA 9-element criteria for watershed-based plans.

Table 16. Future Scenario: Contribution from Source Land Uses

Future Land Use Coverage in Cypress Creek Watershed	Area (acres)	Nitrogen EMC	Total Nitrogen Load	Percent of Nitrogen Load	TSS EMC	Total TSS Load	Percent of TSS Load
Residential	6434.11 acres	1.82 mg/l	13053.63 lb/yr	33%	41 mg/l	294065.4 lb/yr	20%
Commercial	1235.57 acres	1.34 mg/l	1967.92 lb/yr	5%	55.5 mg/l	81507.24 lb/yr	6%
Industrial	11.56 acres	1.26 mg/l	19.42 lb/yr	<1%	60.5 mg/l	932.67 lb/yr	<1%
Transportation	798.55 acres	1.86 mg/l	1738.59 lb/yr	4%	73.5 mg/l	68702.46 lb/yr	5%
Rangeland	1932.66 acres	.70 mg/l	1335.62 lb/yr	3%	1 mg/l	1908.03 lb/yr	<1%
Undeveloped	13904.58 acres	1.50 mg/l	21383.92 lb/yr	54%	70 mg/l	997916.17 lb/yr	69%
TOTAL			39499.11 lb/yr			1445031.97 lb/yr	

* Estimated pollution load reductions needed to meet water quality goals in the watershed. This analysis is submitted to satisfy Element B of the EPA 9-element criteria for watershed-based plans.

Table 17. Land Use Contributions to Nitrogen and TSS Loads

Change of Land Use Coverage and Loads in Cypress Creek Watershed	Change in Land Use Cover	Existing Percent of Nitrogen Load	Future Percent of Nitrogen Load	Change in Nitrogen Load	Existing Percent of TSS Load	Future Percent of TSS Load	Change in TSS Load
Residential	440%	7%	33%	371%	4%	20%	400%
Commercial	400%	1%	5%	400%	1%	6%	500%
Industrial	0%	<1%	<1%	0%	<1%	<1%	0%
Transportation	0%	4%	4%	0%	4%	5%	25%
Rangeland	[-27%]	5%	3%	[-40%]	<1%	<1%	0%
Undeveloped	[-29%]	82%	54%	[-34%]	91%	69%	[-24%]

* Estimated pollution load reductions needed to meet water quality goals in the watershed. This analysis is submitted to satisfy Element B of the EPA 9-element criteria for watershed-based plans.

The Meadows Center modeled instream pollution concentrations and calculated mean annual loads by subwatershed for nitrogen and Total Suspended Solids in pounds per year (lb/yr) from modeling results and EMCs. The main sources for nitrogen are urban runoff, OSSFs and the open/undeveloped land use that includes Agricultural activities that require erosion/sediment control and pesticide management. Loadings by Subwatershed can be found in the Technical Reference Document - EMC Calculation Results by Subwatershed.

Stakeholders identified priority reaches 2, 4, 7, 32, and 35 because they have relatively high baseline nitrogen concentrations. Stakeholders identified additional priority subwatersheds 1, 24, and 28 because they have significant baseline overland nitrogen contributions. Secondary stakeholder priorities include subwatersheds 9, 27, 29, 36, 44, 45, and 46 because these have baseline nitrogen concentrations that are relatively high and may become above the target in the future.

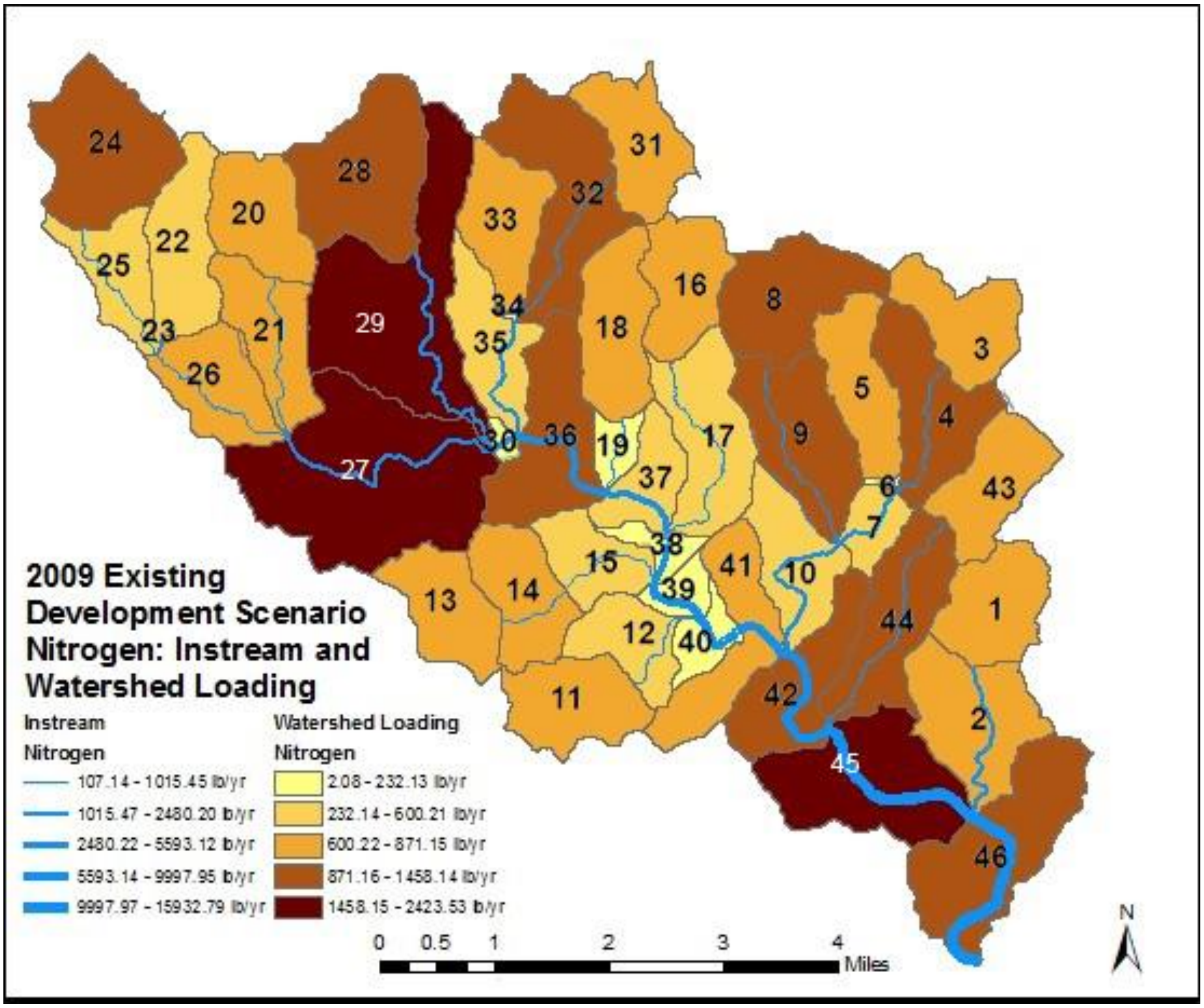


Figure 18. 2009 Existing Nitrogen Modeled Instream Loads

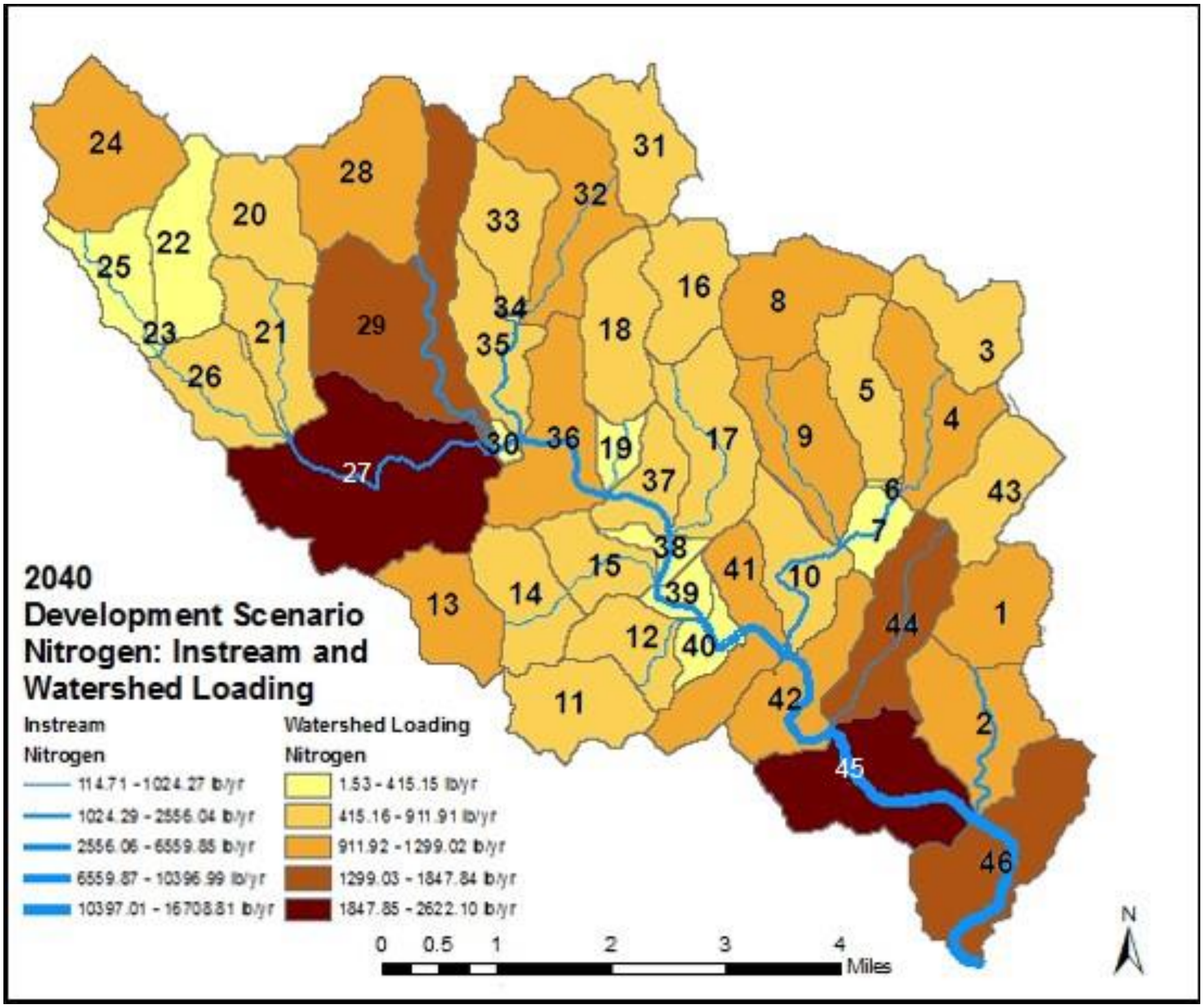


Figure 19. 2040 Future Nitrogen Modeled Instream Loads

Stakeholders identified priority reaches 2, 4, 9, 14, 27, 29, 32, 36, 41, 42, 44, 45, and 46 because they have high baseline TSS concentrations. Stakeholders identified additional priority subwatersheds 8, 24, and 28 because they have high baseline overland TSS contributions. All subwatersheds are expected to exceed targets when flows are low.

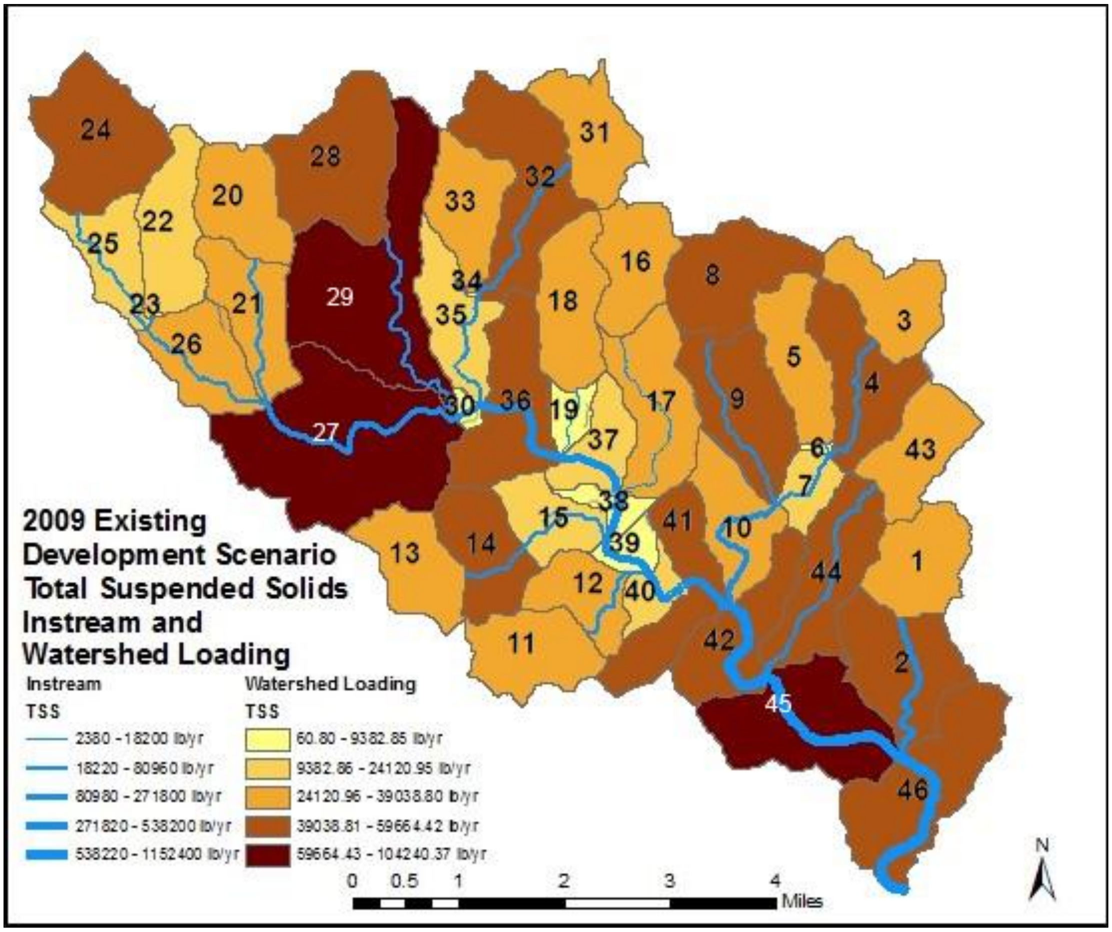


Figure 20. 2009 Existing Total Suspended Solids Modeled Instream Loads

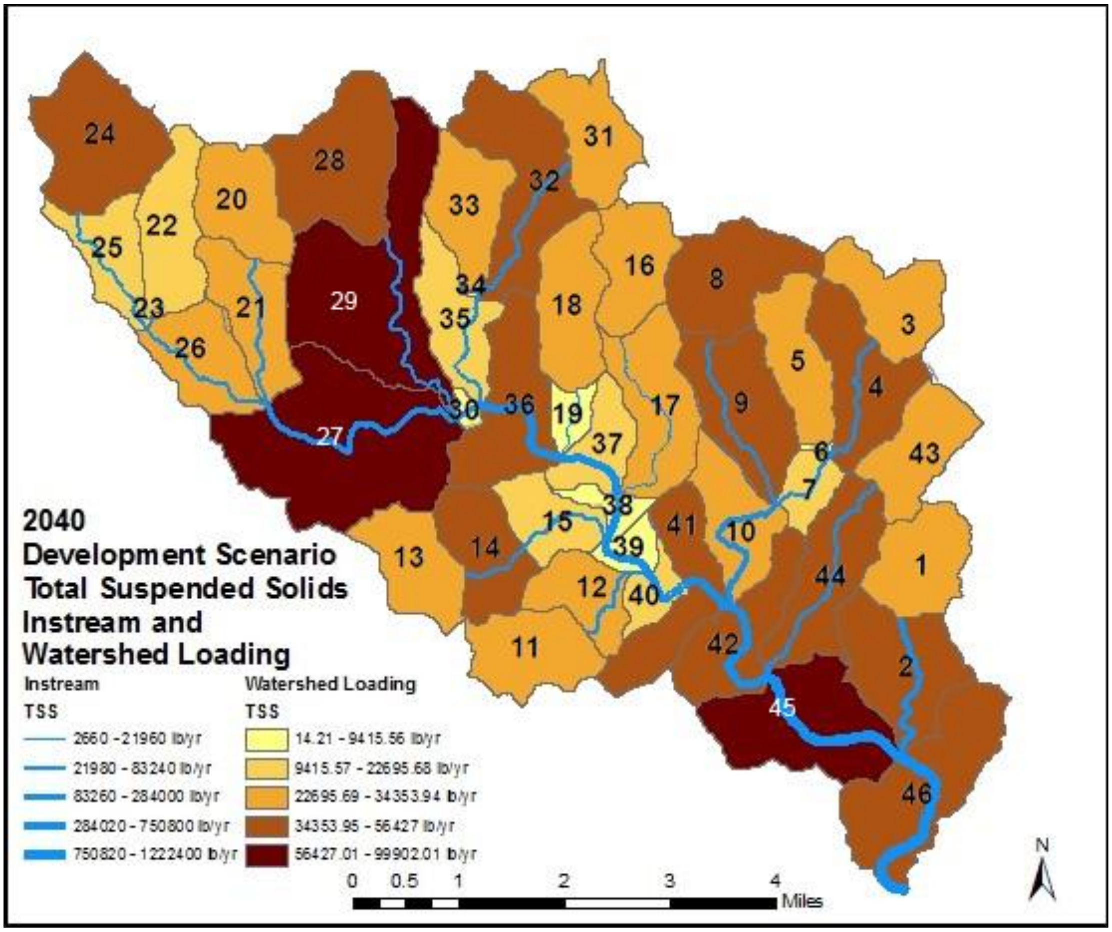


Figure 21. 2040 Future Total Suspended Solids Modeled Instream Loads

Bacterial Loads

E. coli is a form of bacteria that is used as an indicator of bacterial pollution which is often present when contamination exists from to untreated sewage, manure, wildlife or pet waste. Historical and recent monitoring data indicate that at flows below 2 cfs, *E. coli* exceedances occur at the RR12 bridge downtown. The bridge runs through downtown Wimberley and over Cypress Creek near the Square. A bat colony was discovered under the bridge and is a likely contributor of *E. coli* that may be exacerbated during low flow conditions. Another major source of *E. coli* is the high concentration of aging and overloaded OSSFs in the downtown area. Additional monitoring during the first 3 years of WPP implementation will determine whether this is a significant source of bacteria and if management measures are required.

Additional monitoring data indicates that high *E. coli* concentrations also were observed upstream of the bridge, closer to Blue Hole. The presence of residential land uses, coupled with this data suggests that *E. coli* is contributed by septic systems and potentially from pet/animal waste that flows into the creek. Higher *E. coli* values are correlated with elevated TSS levels at all sites except at Jacob's Well, indicating that overland flow is the likely mechanism for transporting bacteria to the creek (Figure 22, Figure 23). Jacob's Well generally has the lowest bacteria concentrations of location sampled, but also has the greatest variability of observed concentrations due to the influence of varying spring flows.

The Stakeholder Committee determined to set target *E. coli* levels below state standards to maintain the creek's contact recreation designated use. The Stakeholder Committee identified BMPs and a monitoring strategy that will comprehensively address this concern.

E. coli was modeled for the existing and future scenarios using EMCs to determine a percent increase and identify subwatersheds that are contributing the largest amounts of bacteria to the creek (Figure 24 and Figure 25). For more detailed information on *E. coli* loading refer to Section 6.3 of the WCR (Technical Resources Document).

Stakeholders identified priority reaches 2, 12, 15, 36, 41, 42, 44, 45, and 46 because they have relatively high bacteria loads. Stakeholders identified the priority subwatersheds to include 1 and 13 because they have baseline overland bacteria contributions above the target.

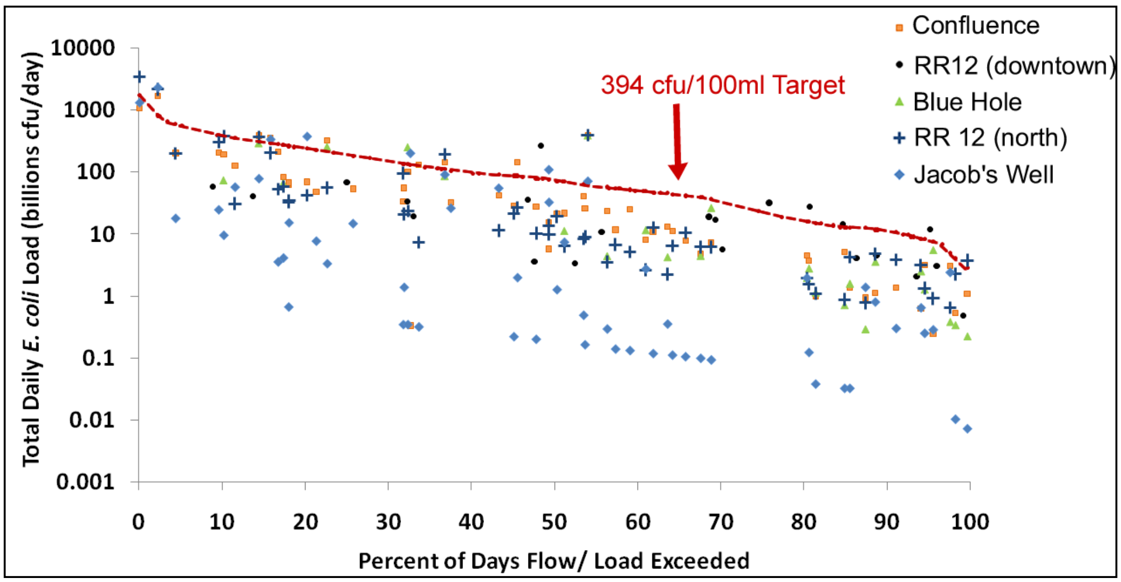


Figure 22. Load Duration Curve of *E. coli* At Five Sites Along Cypress Creek.

The red dashed line represents E. coli loads at a target concentration of 394 cfu/100ml, and dots represent loads calculated for observed conditions.

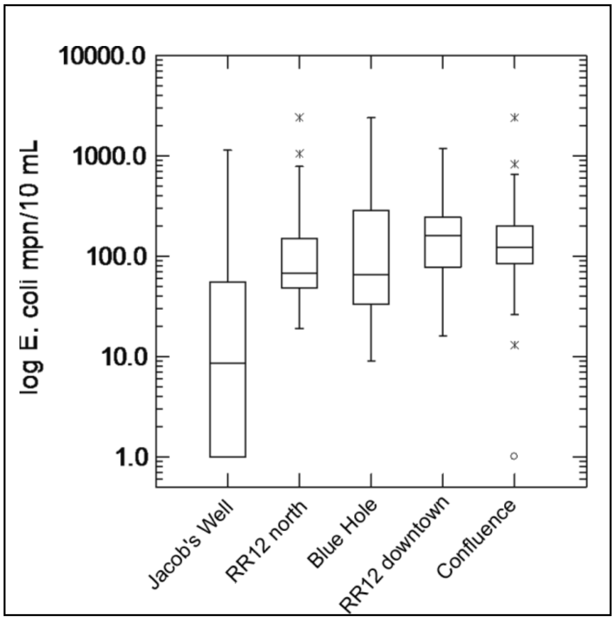


Figure 23. *E. coli* (cfu/100 ml) Measured At Five Sites.

The SELECT model was used to estimate *E. coli* loads from pets and wildlife. Because those numbers are based on real situations, future conditions cannot be estimated using the SELECT approach. EMCs for Fecal Coliform, an indicator for *E. coli*, were used to estimate loading under 2009 land uses and the future development scenario by subwatershed (Figure 11). The EMC calculation results show that total Fecal Coliform loads for the watershed may increase by nearly 300% (Table 18). While the modeling did not indicate *E. coli* annual exceedances in the Future Scenario, the Stakeholder Committee determined adhering to existing state standards for *E. coli* is best to maintain Cypress Creek's contact recreation designated use of Cypress Creek.

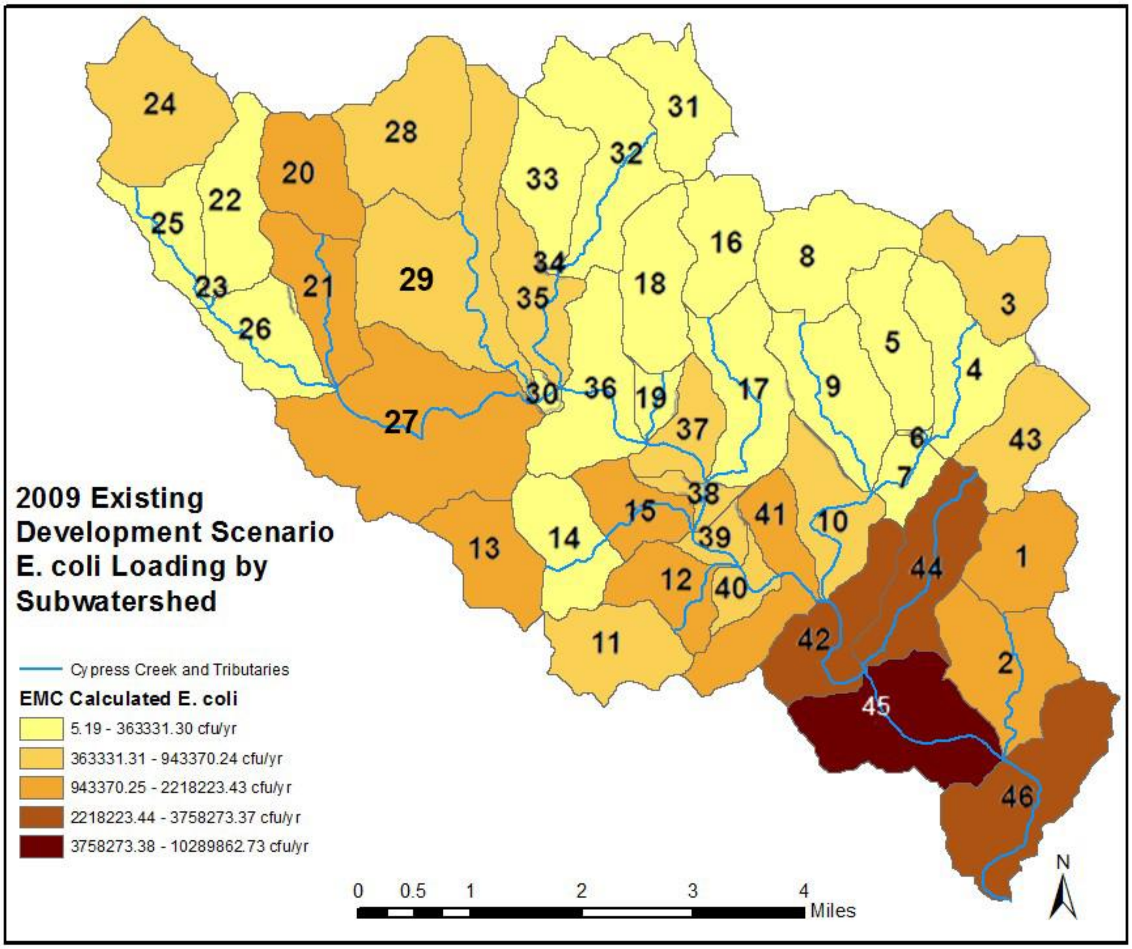


Figure 24. EMC Calculated 2009 *E. coli* Loadings By Subwatershed

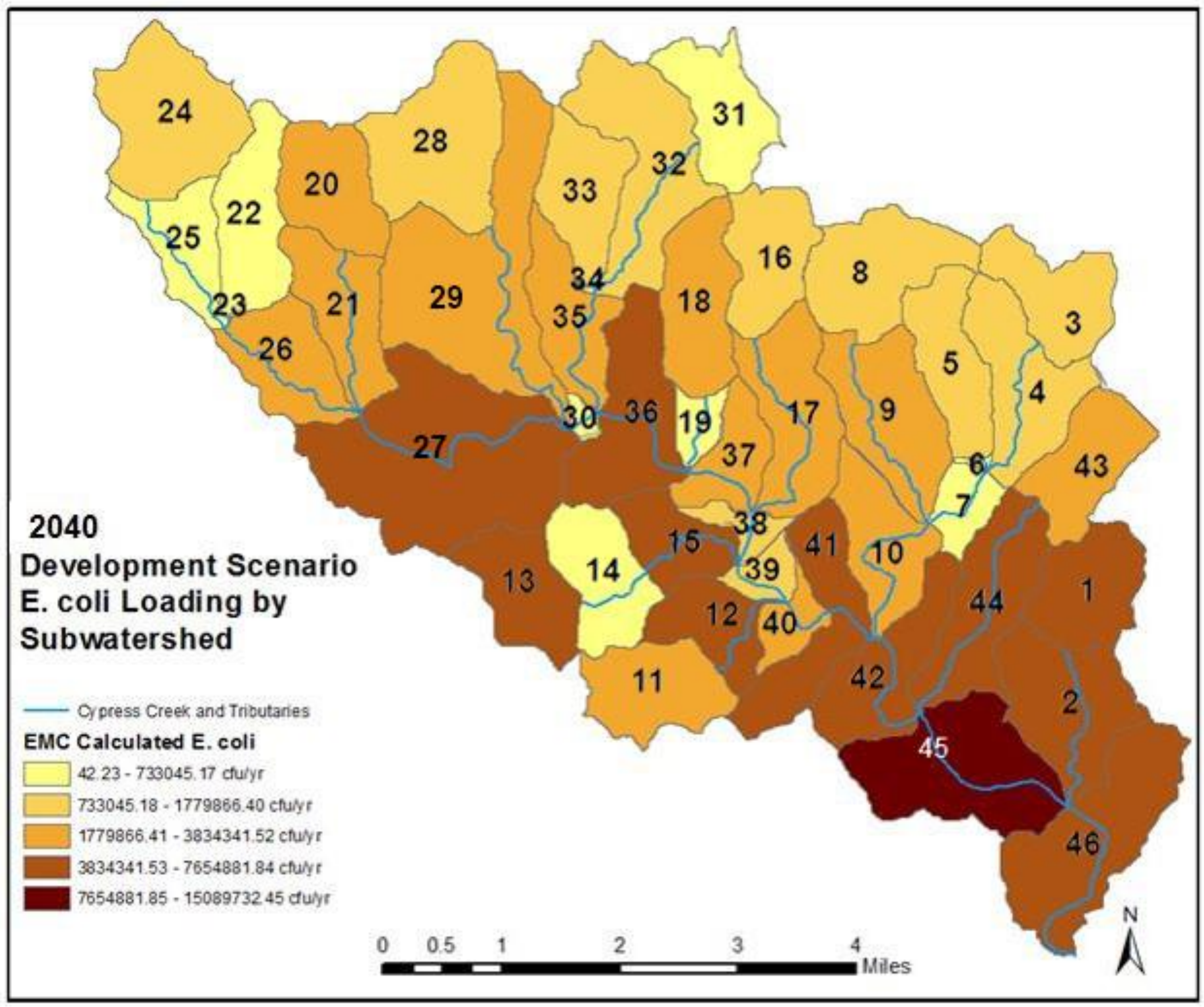


Figure 25. EMC Calculated Future *E. coli* Loadings By Subwatershed

Table 18. Total Current and Future Fecal Coliform Loadings

Total Existing calculated Fecal Coliform loading in cfu/year	Total Future calculated Fecal Coliform loading in cfu/year	Percent loading increase
45,210,755.66	128,104,549.17	283%

Parameters of Concern

The Stakeholder Committee chose to monitor indicators of threats to Cypress Creek's exceptional aquatic life and contact recreation designated uses. EMC calculations were used to identify potential Oil and Grease which is an indicator of failing septic tanks. The Stakeholder Committee also determined that maintaining adequate flows from Jacobs Well are essential to the preserving water quality in Cypress Creek. These parameters of concern can be viewed as indicators of water quality degradation as the Cypress Creek watershed experiences increased urbanization. These parameters (and indicators) are part of the Stakeholder Committee's comprehensive strategy to protect surface water quality and adequate groundwater levels in the aquifer that feeds Cypress Creek.

Oil and Grease

The majority of subwatersheds are estimated to have loading potentials for oil and grease. Subwatersheds with oil and grease loadings of concern in the Future Scenario are located in the southern region of the watershed and a section of the dry portion of the watershed. While no state water quality standards exist for oil and grease, the Stakeholder Committee identified this as a parameter of concern in their watershed. Under the future development scenario, modeling estimates over a 500% increase of oil and grease (Table 19). Primary sources for oil and grease are contributed by residential OSSFs and Commercial land use activities, and to a much lesser extent, Industrial and Transportation areas. The Stakeholder Committee determined that a 300% increase of oil and grease could be an indicator of failing septic systems or other water quality concerns. Additional information can be found in 7.2 Pollution Potential in the Watershed Section of the WCR, found in the Technical Resources Document.

Table 19. Total Current and Future Oil and Grease Loadings

Total existing calculated oil and grease loading in lb/yr	Total future calculated oil and grease loading in lb/yr	Percent loading increase
4587.57	25830.49	563%

Dissolved Oxygen

Cypress Creek was impaired for low Dissolved oxygen (DO) and listed on the 303(d) list in 2000. This impairment coincided with the first time in recorded history that flow at Jacob's Well Spring was reduced to zero cfs. The 5 water quality monitoring sites along the Cypress Creek provided the data used for statistical analyses of flow and DO.

Multivariate linear regression indicated strong correlations between low DO levels ($p < .05$), low flows and suspended solids ($p < .05$). DO levels above 6.0 mg/L are necessary to maintain the creeks exceptional aquatic life designation (Table 10). Though the creek was delisted, the Stakeholder Committee identified adequate DO levels a primary concern and maintaining preferred flows (

Table 20) in Cypress Creek a priority. Monitoring data shows that consistent preferred flows from Jacobs Well equate to higher base flows in Cypress Creek and adequate DO levels.

Stakeholders identified priority reaches 41, 42, 45, and 46 because they make up the main stem of Cypress Creek in the wet portion and can be subject to low DO during times of low flows.

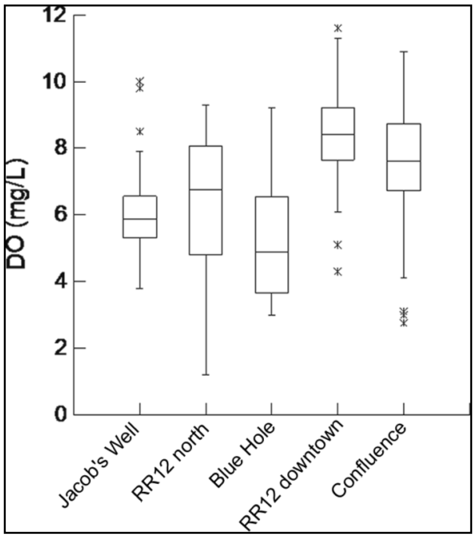


Figure 26. Box-and-Whisker Plot Of Dissolved Oxygen (Mg/L) Measured at Five Sites

Flow levels (given in cubic feet per second) correspond to the 10th, 20th, 30th, etc. percentile of flows estimated at the Cypress Creek confluence, 2000-2009. In this chart, a flow level of 0.9 reflects DO concentrations measured when flow is ≤ 0.9 cfs, 1.3 indicates flow from 0.91 to 1.3 cfs, etc.

Table 20. Comparison of Flows at High And Low Oxygen Levels

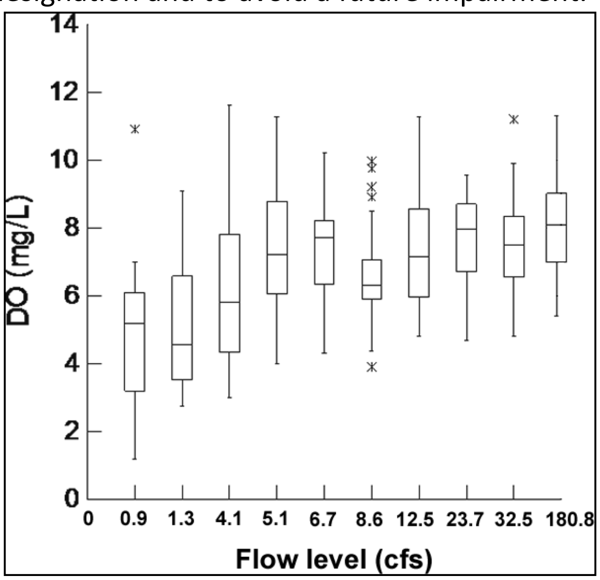
	RR12 north 12676		Blue Hole 12675		RR12 downtown 12674		Confluence 12673		Jacob's Well 12677	
	DO <6.0	DO ≥6.0	DO <6.0	DO ≥6.0	DO <6.0	DO <6.0	DO <6.0	DO ≥6.0	DO <6.0	DO ≥6.0
N of cases	21	36	17	10	24	24	10	50	24	9
Flow Min (cfs)	0.30	0.86	0.30	3.82	0.00	0.00	0.30	0.52	0.00	0.01
Flow Max (cfs)	9.50	180.7 6	28.33	39.45	26.00	26.00	6.71	180.76	26.00	9.90
Flow Mean (cfs)	3.17	23.35	4.28	12.89	5.28	5.28	1.65	19.05	5.28	3.28

Flows estimated at confluence (a) and measured at Jacob's Well (b) calculated for DO measurements above and below the target threshold of 6.0 mg/L. For all stream segments, mean flow is much lower when DO <6.0 mg/L. For Jacob's Well, the opposite is true, indicating that maintaining adequate flow throughout the length of the creek is critical for maintaining its historical condition as a spring-run creek.

Dissolved oxygen (DO) is a very important indicator of a stream's ability to support aquatic life. TCEQ standards for DO in the Cypress Creek require that 24-hour mean values do not go below 6.0 mg/L, and that individual grab samples do not fall below 4.0 mg/L. Factors influencing DO levels include flow, the physical conditions of a given reach, water temperature, sediment and dissolved solids. During higher flows, rushing water is aerated by bubbles as it churns over rocks and down waterfalls, causing DO to be relatively high. As water slows down behind small dams and becomes more stagnant, oxygen only enters the top layer of water, and deeper water is often low in DO concentration due to decomposition of organic matter by oxygen-depleting bacteria that live on or near the bottom. Colder water can hold more dissolved oxygen, so spring-fed streams such as Cypress naturally have very high levels. As flow decreases and channels widen and are exposed to more sun, temperature can increase and cause DO to drop. During rainy seasons, oxygen concentrations tend to be higher because the rain interacts with oxygen in the air as it falls. Higher levels of sediment and dissolved solids can also decrease DO in the stream. Higher nutrient levels can also affect DO by allowing for greater algae or plant growth, which generate oxygen during photosynthesis. This can cause the stream to become super-saturated with oxygen during the day (due to photosynthesis) and drop sharply at night (due to respiration). Algal blooms can also cause eutrophication as they decompose, severely reducing oxygen necessary to support aquatic life.

Although the water which emerges from Jacob's Well is low in Dissolved Oxygen from the aquifer environment, it soon becomes oxygenated (Figure 26) as it interacts with the surface air and photosynthesizing plants. When the well flow and velocity decreases it is detrimental to DO levels, indicating a strong reliance on groundwater supply for healthy DO in the creek (See the Ground/source Water Protection Strategy in the Technical Reference Document).

Further evidence that flow plays a critical role in dissolved oxygen concentrations is seen when examining plots of dissolved oxygen across a range of flow levels. 10th, 20th, 30th, etc. percentiles were calculated for flows estimated at the confluence from 2000 to 2009 and DO observations plotted at each level (Figure 27). For all sites, a flow level between 1.31 and 4.1 cfs appears to be sufficient to sustain DO levels above 4.0 mg/L at least 75% of the time. Between 4.11 and 5.1 cfs, DO is above 6.0 mg/L at least 75% of the time, which is the target level. Stakeholder consensus is that it is imperative that flows at Jacob's Well Spring be preserved at or above a minimum level of 4.1 cfs to maintain Cypress Creek's exceptional aquatic life designation and to avoid a future impairment.



Flow levels (given in cubic feet per second) correspond to the 10th, 20th, 30th, etc. percentile of flows estimated at the Cypress Creek confluence, 2000-2009. In this chart, a flow level of 0.9 reflects DO concentrations measured when flow is ≤ 0.9 cfs, 1.3 indicates flow from 0.91 to 1.3 cfs, etc.

Figure 27. Dissolved Oxygen (Mg/L) By Flow Level.

6. Management Measures

The following sections describe the BMPs approved by the Stakeholder Committee for immediate implementation, for future threats to water quality, their groundwater protection strategy, the education and outreach component necessary to inform the public and continue community support, and the monitoring plan that will inform the Stakeholder Committee about WPP effectiveness and new threats.

The estimated pollution reductions shown in Figure 30, Figure 28 and Figure 29 are the desired stakeholder target concentrations. The management measures will be implemented over several years in order to achieve the estimated load reductions needed to meet water quality goals in both Cypress Creek at the confluence with the Blanco and the identified priority reaches of the creek and its tributaries. This analysis is submitted to satisfy Element C of the EPA 9-element criteria for watershed-based plans. Modeling outputs show that the three reaches shown in the figures below are expected to have instream nitrogen concentrations above stakeholders' acceptable targets (the purple line in the figures below labeled Target 2 represents the stakeholders' allowable maximum limits for instream nitrogen loadings). Without BMPs put in place over time to mitigate increased loadings from changes in land use, instream nitrogen concentrations will far exceed allowable limits.

In Figure 28 and Figure 29, the implementation of stakeholder selected management measures and BMPs is estimated to prevent any significant increases in nitrogen loadings. Subwatersheds 4 and 7 are expected to drastically increase in residential density. In subwatershed 4, the percentage of land use classified as residential is less than 1% but grows to 18% in the future scenario. Residential land use area in subwatershed 7 is expected to grow from just over 1% to 15%. Modeling shows that these two subwatersheds contribute high loads of nitrogen now and in the future if no BMPs are implemented. Initial BMPs are shown in Table 21.

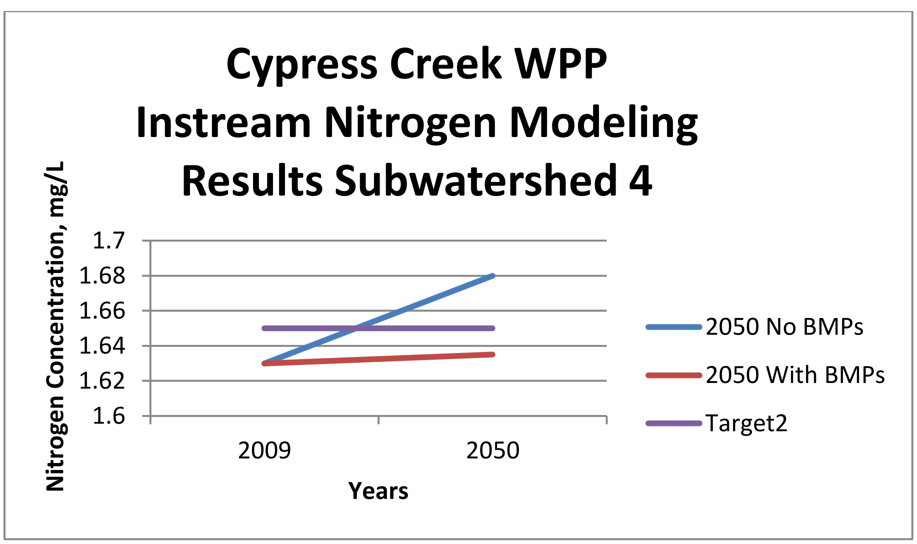


Figure 28. Instream Nitrogen Concentration in Subwatershed 4

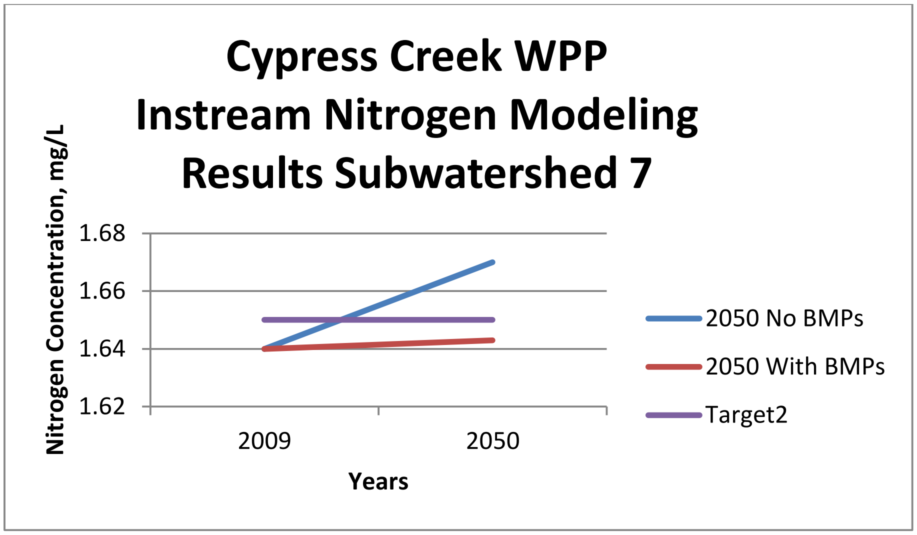


Figure 29. Instream Nitrogen Concentration in Subwatershed 7

Residential land use area in Subwatershed 2 is expected to grow from less than 10% to more than 42%. In addition, a 7% increase in commercial land use is also expected. Figure 30 shows that the initially selected BMPs will prevent significant increases in loadings, however modeled nitrogen loads are still slightly above stakeholder targets. Adaptive management activities performed in the first three years of implementation and biannually afterwards include updating model results and the review of additional best management practices. Despite heavy nitrogen concentrations from this this subwatershed, nitrogen loads at the confluence of Cypress Creek and the Blanco River are expected to be below stakeholder targets. Initial BMPs are shown in Table 21, and additional BMPs for future implementation are shown in Table 26.

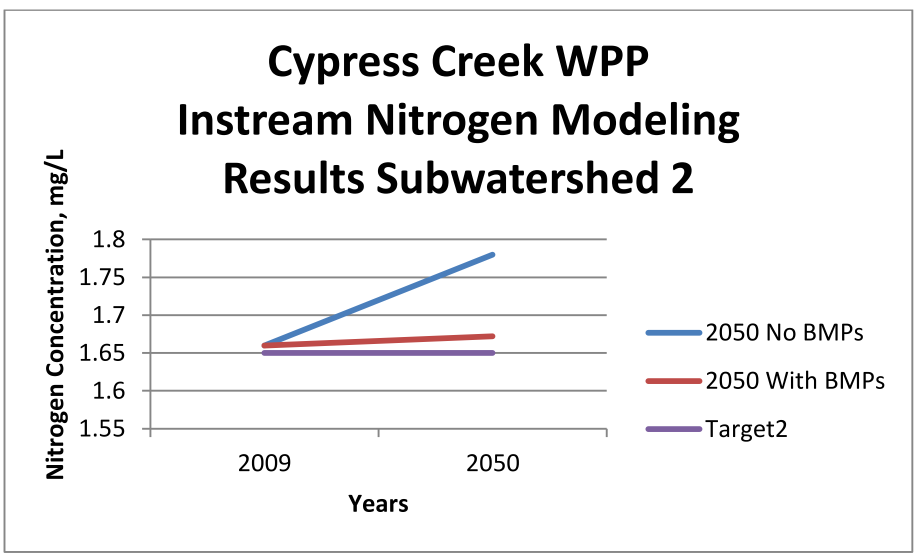


Figure 30. Instream Nitrogen Concentration in Subwatershed 2

BMPs for Immediate Implementation (Year 1-3)

The Cypress Creek community has been actively engaged in protecting their creek. Through the watershed protection planning efforts the Stakeholder Committee determined that initial implementation activities should focus on stormwater assessments, implementing demonstration BMPs, retrofitting and maintaining existing and recently built BMPs and coordinating existing community, city and county efforts in order to address current threats to water quality. These initial actions will demonstrate the WPP to the community. BMPs were chosen that will mitigate nitrogen and TSS levels affected by current urbanization in the watershed and target priority sub-watersheds. Additional existing city, county and private water quality protection programs are represented in **Description of Management Practices** below.

Strategies for funding vary, and include cash and in-kind contributions at the city and county level, as well as resources from NGO and private entities. Additional funding for implementation and maintenance are outlined below in Section 12, Financial and Technical Assistance. Wimberley, Woodcreek and Hays County have each pledged to implement the following BMPs pending finalizing formal financial agreements during the Interim period (Table 21). Correlating milestones are discussed below in Section 11, Milestones and Measures of Success.

Table 21. BMP Toolbox for Initial Implementation, years 1-3

Surface Water Quality BMPs	Responsible Party	Indicators of Success ***	Subwatershed	Average Estimated Cost@	Total Value
Rain Water Harvesting at County Buildings Installation and maintenance	Hays County	Decreased TSS, Improved Water Conservation	41	Installation $30,000 Maintenance $6,000/year	$72,000
Rain Water Harvesting at City Hall Installation and maintenance	Woodcreek	Decrease TSS, Improved Water Conservation	2	Installation $30,000 Maintenance $6,000/year	$36,000
Rain Water Harvesting at Nature Trail Park Installation and maintenance	Wimberley	Decrease TSS, Improved Water Conservation	46	Installation $30,000 Maintenance $6,000/year	$36,000
Rain Water Harvesting at Community Center Installation and maintenance	Wimberley	Decrease TSS, Improved Water Conservation	46	Installation $30,000 Maintenance $6,000/year	$36,000
Rain Water Harvesting at Jacobs Well Center Installation and maintenance	WVWA **$**	Decrease TSS, Improved Water Conservation	41	Installation $30,000 Maintenance $6,000/year	$36,000
Bio-swales at JWNA 500 lin ft	Hays County **$**	Decreased TSS	41	Installation $10,000/swale Maintenance $12,000 /year	$64,000
Riparian Buffers at JWNA 1/4 river mile	Hays County **$**	Decreased TSS, Decreased *E. coli*	41	$350,000/river mile	$87,500
Vegetative filter strips JWNA ¼ acre	Hays County **$**	Increased community awareness	41	$350/acre/year	$437.50
Pet Waste Stations	Wimberley, Woodcreek and Hays	Decreased *E. coli*	12, 14, 15, 39, 40, 41, 44	Installation $620/station Maintenance $85 /station/year	$1325
Low Impact Development at Jacobs Well Center in the form of Net Energy Zero Lodging	WVWA **$**	Limiting Impervious cover increases, Improved Water Conservation	41	$15,000/project	$15,000
Swales and Gabions at Jacobs Well Center 250 lin ft	WVWA **$**	Decreased N, Decreased TSS	41	Installation $5,000/swale Maintenance $6,000 /year Gabion Installation:	$20,200

Surface Water Quality BMPs	Responsible Party	Indicators of Success ***	Subwatershed	Average Estimated Cost@	Total Value
				$200/yard^3	
Blue Hole existing BMPs: maintenance performed by 1 contractor; 2-4 x/year	Wimberley **$**	N, TSS	46	$50,000/yr	$150,000
Rain Gardens at Brookeshire Brothers lot ½ acre ft pond	Wimberley	N, TSS	46	$25,000/pond	$25,000
Pervious Sidewalks at Old Kyle Road, Oak Drive 1500 ft^2	Wimberley	TSS	46	Installation $2460 Maintenance $240	$2700
Rain Gardens – Community Center ½ acre ft pond	Wimberley	N, TSS	46	$25,000/pond	$50,000
Rain Garden at Hog Creek near confluence (City land) ½ acre ft pond	Woodcreek	Decreased TSS, Increased Community Awareness	10	$25,000/pond	$25,000
Riparian Buffer at The Lodge ¼ mile	Private and Woodcreek Stakeholder Committee **$** *****	Decreased TSS, Decreased *E. coli*	45	$350,000/river mile	$87,500
Xeriscaping at Jacobs Well Center 200 ft^2/project	WVWA **$**	Decreased N, Improved Water Conservation	41	$40,000/project	$80,000
TPWD ESSS Recommended BMPs	TPWD **$**	--	Watershed Wide	--	--
Demo riparian buffer BMPs at Camp Young Judea ¼ mile	Private Woodcreek	Decreased TSS, Decreased *E. coli*	42	$350,000/river mile	$87,500
Demo Green Roof at Jacobs Well Center. Roof area 2500 ft2	WVWA **$**	Decreased TSS, Improved Water Conservation, Increased Community Awareness	41	$25/ ft2	$62,500
Demo BMPs at Water Tower, "Triangle Park", Old Kyle Road Rotary Club and Augusta Drive/Augusta Lane site (e.g. rainwater harvesting system, 200 ft^2 of xeriscaping, ½ acre	Wimberley, Woodcreek	Decreased TSS, Increased Community Awareness	2, 44	$26,000/project ****	$130,000

Surface Water Quality BMPs	Responsible Party	Indicators of Success ***	Subwatershed	Average Estimated Cost[@]	Total Value
ft rain gardens, and/or 1500 ft^2 of pervious sidewalks)					
Implementation of the Wimberley Master Plan	Wimberley **$**	Initial step toward improving WQ	City of Wimberley Wide	$100,000/ assessment/yr	$200,000
Stormwater Engineering assessment	Wimberley/ Woodcreek **$**	Initial step toward improving WQ	12, 14, 15, 39, 40, 41, 44	$100,000/ assessment	$100,000
Existing Stormwater Management - (Phase I) Engineering Assessment to retrofit existing stormwater management	Hays County	Initial step toward improving WQ	To Be Determined	$100,000/ assessment	$100,000
Existing Stormwater Management - (Phase II) Implement Retrofitting existing stormwater infrastructure	Hays County	Decreased N, Decreased TSS	To Be Determined	$600,000/project	$1,200,000
WQ Protection Ordinance Enforcement (1 FTE)	Woodcreek **$**	Decreased N, Decreased TSS, Limits increase in impervious cover	Watershed Wide	$50,000/yr	$150,000
Comprehensive assessment of potential WQ Ordinance enhancements (1 PTE)	Woodcreek **$**	Initial step toward improving WQ	Watershed Wide	$25,000/yr	$75,000
Wastewater Treatment Solutions: Collection and Treatment System to serve central Wimberley	Wimberley **$**		To Be Determined	Up to $9,000,000	$9,000,000
Small Scale Waste Water Treatment and Re-use at Jacobs Well Center	WVWA **$**	Mitigate effects of OSSF on WQ; Decreased *E. coli*, Decreased N	41	$125,000/project	$125,000
Comprehensive assessment of potential Karst Feature Protection Code enhancement (1 PTE)	Woodcreek **$**	Initial step toward improving surface and ground/source WQ	Watershed Wide	$25,000/yr	$50,000
Natural Trail Signage	Wimberley	Education	46	$700	$700

Surface Water Quality BMPs	Responsible Party	Indicators of Success ***	Subwatershed	Average Estimated Cost@	Total Value
Installation of 6 "Entering Watershed" Signs on Roadway*	Hays County **$**	Increased community awareness	To Be Determined	$200/sign	$1200
Watershed Coordinator 1 FTE	Wimberley, Woodcreek and Hays	Increased community awareness	Watershed Wide	$50,000/year ¥	$150,000
Enhanced Water Quality and Groundwater Modeling (CC-DSS) 1 PTE	Wimberley, Woodcreek and Hays **$**	Initial step toward improving WQ	Watershed Wide	$25,000/yr	$75,000

**These BMPs have been identified as candidates for implementation in the first few years of implementation. Once commitments are finalized, the table and descriptions will be updated to include site specifics, estimated cost and schedule for implementation.*

****The goal of the plan is to meet Stakeholder Targets. At a minimum, State water quality standards are to be met during implementation*

*****$50,000 is average cost of demonstration costs come from the following average project costs: rainwater harvesting system (Installation $30,000; Maintenance $6,000/year), Xeriscaping ($40,000/project) rain gardens ($25,000/pond) and/or pervious sidewalks (Installation $2460; Maintenance $240)*

****** Identified as a possible site for BMP implementation on private land. Stakeholder Committee will work with landowners during adaptive management.*

¥ Level of commitment and salary to be determined by Interim Committee

@Literature based values. To be updated with storm water assessment

$ Funding pledged by local entities

Description of Best Management Practices

Descriptions below are based on efforts by the Stakeholder Committee, Wimberley, Woodcreek and Hays County. Conversations were held during Stakeholder Committee Meetings and at meetings between TCEQ, City and County staff. The Meadows Center staff was present at all meetings and provided notes of the meetings/discussions to the Stakeholder Committee. Locations for many of the BMPs are mapped in Figure 31.

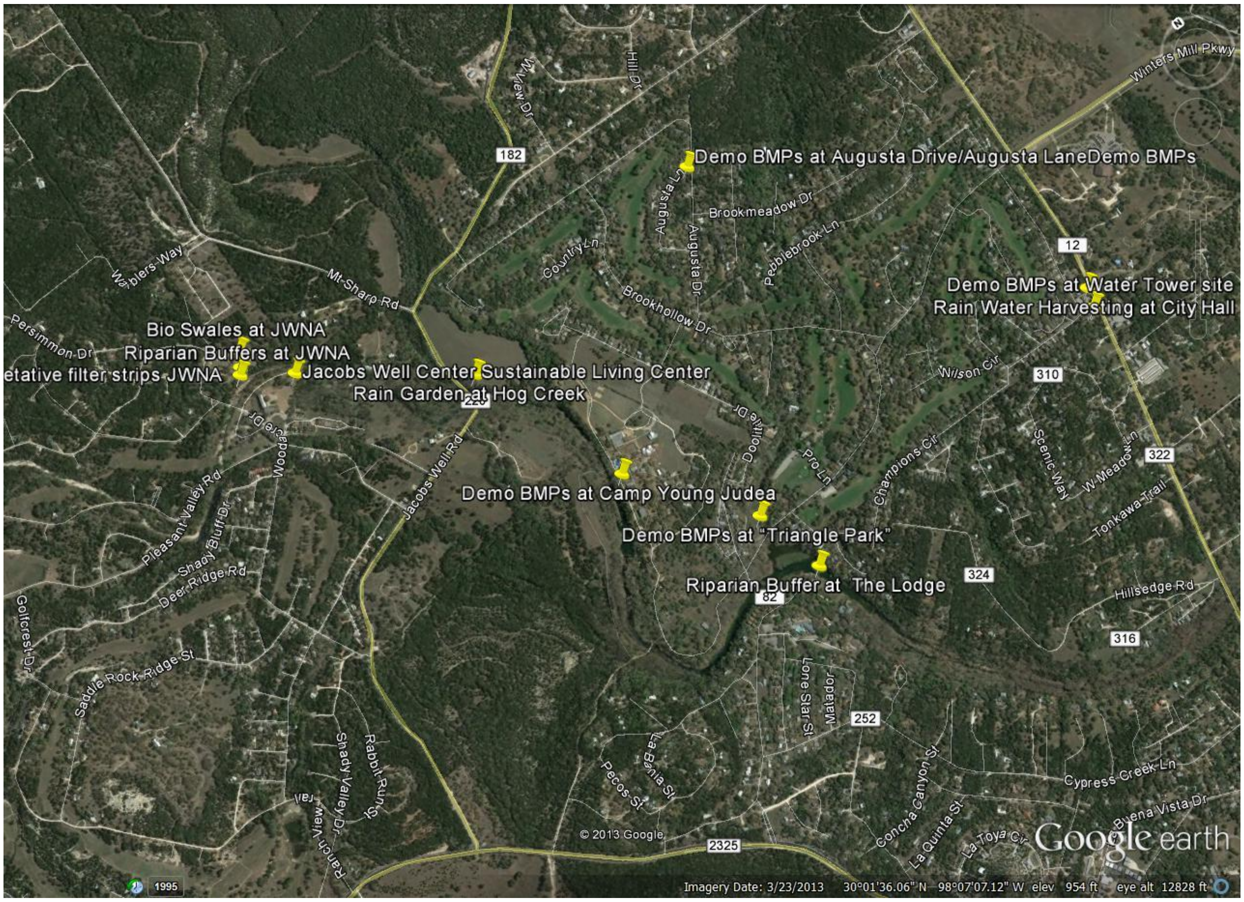


Figure 31. BMP Sites

Hays County

Bio-swales at Jacobs Well Natural Area (JWNA)

At least 3 bio-swales will be implemented by 2015 utilizing TPWD funding. Their locations are based on the community approved JWNA Master Plan.

Riparian Buffers at Jacobs Well Natural Area

These are being implemented by the County. Master Naturalists have already begun planting trees and working on the site. Maintenance is needed to ensure the buffers are able to establish themselves. These buffers are near Jacobs Well close to the low water crossing. Buffers cited according to JWNA Master Plan.

Vegetative Filter Strips

These are already being implemented by the County. Maintenance is needed to ensure filter strips are able to establish themselves. Vegetative filter strips are cited according to JWNA Master Plan.

Watershed Road Signs
The county is willing to install five watershed road signs purchased with project funds. Each sign says "Inside Cypress Creek Watershed Environmentally Sensitive Area". The signs will be placed at strategic locations on county roads within the watershed. The Stakeholder Committee will determine the best locations for the signs.

Rainwater Harvesting
The County has determined several sites for rainwater harvesting opportunities and demonstrations at county facilities located within the watershed.

Retrofit Existing Stormwater Management
The County has pledged to explore opportunities for an updated and enhanced stormwater assessment for areas of the watershed under the County's jurisdiction.

Retrofit Existing Stormwater Infrastructure
The County has pledged to explore retrofitting existing stormwater infrastructure to better mitigate stormflows, if feasible. This includes right of way limitations. An engineering assessment will be required.

Hays County Storm Water Management Program
The County has created a program to reduce storm water pollution by educating the public, monitoring for illicit discharges into storm sewers and monitoring construction and post-construction of new and redeveloped projects for storm water quality.

Hays County Ordinances:

- **Chapter 715:** Protection of Local Water Resources/ County Regulation of OSSF Facilities
  The County requires demonstrations of the ability of new subdivision plat developments to meet water and wastewater availability requirements before accessing local water supply, with an emphasis on groundwater protection. The County must approve all OSSF systems before installation or adding new users to a preexisting OSSF system by showing that County and TCEQ standards will be met.
- **Chapter 725:** Floodplain Easements
  The County has set aside all areas it has identified as a floodplain as public easements.
- **Chapter 735:** Floodplain Protection
  The County has created measures to protect the floodplain from improper development and alteration. By restricting alteration of the floodplain the county plans to reduce erosion, shifting flooding to unintended areas and reduce the financial loss caused by floods to the public and county.
- **Chapter 721:** Low Lot Density Incentive
  Developers are allowed to build country lane roads to service a development if the plots are larger than five acres, which incentivizes rural low density development.

- **Chapter 765:** Conservation Easements
  The County's minimum requirements for conservation easements increase amount of protected acres.
- **Chapter 761:** Water Conservation Incentives
  The County has created economic incentives for encouraging water conservation features, open space preservation, low intensity development, construction of storm water quality management features, rainwater harvesting facilities, construction of groundwater recharge enhancement structures, and cedar/ash juniper removal plan and wastewater reuse plumbing to individual lots.

Wimberley

Water Quality Protection Ordinance

The City of Wimberley's Water Quality Protection Ordinance already has protections in place, including impervious cover limits. The City is open to enhancing the ordinance to include metrics to quantify pollution mitigation. This will not include new ordinances or regulations; rather it will be a planning tool for decision makers to use when managing urbanization in the watershed.

Stormwater Assessment

Stormwater assessment for the City of Wimberley. The results of this assessment will be used to site BMPs in the interim period and to help site BMPs carried out under Adaptive Management. Stakeholder have expressed concerns about a bat colony under the Ranch Road 12 bridge in downtown Wimberley and 2 storm water drains that flow directly into Cypress Creek during storm conditions. The goal of the storm water assessment is to determine alternative flow routes and identify mitigation measures.

Wastewater Treatment Plant (Solutions)

The City of Wimberley is formally reviewing options for increasing wastewater processing, including a wastewater treatment plant and decentralized approaches. The city hosted a Wastewater Stakeholder Committee to review and assess three types of possible collections systems, including feasibility and cost projections. As the city moves forward with any required water quality sampling, engineering reviews or feasibility studies and other related activities, the WPP Interim Stakeholder Committee will track progress and incorporate the City Council's approved actions into WPP activities.

Rain Gardens – Community Center

Demonstration rain gardens at Wimberley Community Center. This site is ideal to highlight the benefits of rain gardens while demonstrating the effectiveness of mitigating stormflows and pollution (Resource Media, n.d.).

Rain Water Harvesting – Community Center

The Wimberley Community Center is an ideal location to demonstrate the benefits of a rain water harvesting system/strategy because of its close proximity to Cypress Creek. Rain water harvesting at this site will also mitigate nitrogen and TSS in runoff from the building and parking lot.

Rain Gardens – Brookshire Bros. parking lot

The Stakeholder Committee has identified the parking lot for the Brookshire Bros. Grocery Store as an ideal candidate for rain gardens to mitigate runoff from the parking lot because of the size of the parking lot and proximity to Cypress Creek. This site is adjacent to the Community Center site above. A strategy to have these sites work together could result from the stormwater assessment.

Blue Hole – Sustainable SITE, BMP maintenance

Blue Hole has received certification as a sustainable site from the Sustainable Sites Initiative (SITES). Water Quality BMPs on site will require maintenance and monitoring.

Wimberley Comprehensive Plan

This comprehensive plan is a long-range planning tool to guide City government in meeting the expectations of residents, business owners and visitors over the next 20 years. By and large the goals laid out in the plan are to maintain the small town atmosphere of Wimberley and maintain its natural scenic beauty while allowing for growth. To accomplish this, they are using zoning and new building requirements to prevent overly commercial or unsightly growth. Some methods include preventing construction on hills and ridgelines and the creation of zoning districts, making sure the entire city is zoned according to their desired outcome. In the past their zoning has been somewhat irregular leading to small scale commercial construction and residential areas in a somewhat mosaic fashion and may be further utilized by the city to further discourage large commercial development and to maintain the historical feel of the city.

Pervious Sidewalks

Pervious sidewalks can be implemented along Old Kyle road and Oak Drive.

BMP – Old Kyle road

Potential site for demonstration BMPS in "pocket park" includes, rain gardens, rainwater harvesting, nativescaping, xeriscaping, swales, mulching, pervious pathways and sidewalks.

Nature Trail Signage

Signage at Nature Trail Park. Refer to *Education and Outreach* section.

Rainwater Harvesting at Nature Trail Park

Structure at Nature Trail Park is ideal for rain water harvesting.

Demonstration BMP at commercial site in Wimberley

A commercial lot in Wimberley is a candidate for implementing a demonstration BMP. Ace Hardware and/or Brookshire Bros parking lots ideal due to their visibility in a high traffic area and require stormwater management to prevent run off into Cypress Creek. BMPs include rain gardens, vegetative filter strips, pervious cover and others.

Woodcreek

Stormwater Assessment

The results of this assessment will be used to site BMPs in the interim and implementation phases and to site BMPs carried out under Adaptive Management.

Water Quality Protection Ordinance

The City of Woodcreek's Water Quality Protection Ordinance already has protections in place, including impervious cover limits. The City is open to enhancing the ordinance to include metrics to quantify pollution mitigation. This will not be a new ordinances or regulation; rather it will be a planning tool for decision makers to use when managing urbanization in the watershed.

Code Enhancement – Impervious Cover Limits

Code can be enhanced to include metrics that quantify the water quality benefits of implementing rain water harvesting systems or decreased impervious cover. This will not be a new ordinance or regulation; rather it will be a planning tool for decision makers to use when managing urbanization in the watershed.

Code Enhancement – Karst Feature Protection

Known recharge features exist in Woodcreek. These features are protected under the existing ordinance, but the City sees the benefit to enhancing protections. This may be couple with above code enhancements. Land could be banked around specific karst recharge features.

Demonstrations BMPs – Water tower

Water Tower site next to City Hall is ideal for its high visibility and runoff mitigation potential. Area Master Naturalists are coordinating with the Stakeholder Committee and the City to develop and install BMPs and educational signage at this site. BMPs include rain gardens, rainwater harvesting, nativescaping, xeriscaping, swales, mulching, pervious pathways and sidewalks.

Demonstrations BMPs – City Owned Land

City owned land at Augusta Drive and Augusta Lane is an ideal site for demonstration BMPs. Could also be used for above mentioned code enhancement.

Demonstrations BMPs – City Owned Land "Triangle Park"
City owned land at Triangle Park will have demonstration BMPs installed. Potential BMPs include alternative grass and land cover, rain gardens, rainwater harvesting, nativescaping, xeriscaping, swales, mulching, pervious pathways and sidewalks.
Could also be used for above mentioned code enhancement.

Demonstrations BMPs – City Owned Land adjacent to Hog Creek
City owned land is will have demonstration BMPs installed. Potential BMPs include alternative grass and land cover, rain gardens, rainwater harvesting, nativescaping, xeriscaping, swales, mulching, pervious pathways and sidewalks. Could also be used for above mentioned code enhancement. More information needed.

Wimberley Valley Watershed Association

BMPs from Jacobs Well Center for Sustainable Living Master Plan
The Wimberley Valley Watershed Association hosts a sixteen acre site called *The Retreat,* which demonstrates the principles of sustainable living and inspires environmental stewardship by connecting people to the natural environment. In addition to providing a venue for environmental and sustainable living retreats and workshops, the retreat will be a demonstration site for rainwater harvesting, water treatment and reuse systems for on-site bathroom facilities, and additional low impact tent structures, as well as Net-Zero Lodging, swales and gabions for overland flow and karst feature protection, commercial scale xeriscaping, and a demonstration green roof. The site will be used for public tours, as a training facility for rainwater collection design and installation, and as an educational site for school and university programs.

The Meadows Center for Water and the Environment

Cypress Creek Decision Support System (CC-DSS). The Meadows Center developed a decision support that incorporates information from modeling efforts, stakeholder input and priorities, and watershed characteristics to allow the stakeholder group to assess best management practice (BMP) options to maximize their impacts on reducing NPS pollution. Through an iterative, collaborative process involving stakeholders, the DSS is being developed to incorporate a database management system, biophysical and socio-economic models, evaluation criteria developed in stakeholder workshops, and a graphical user interface to aid decision makers in understanding the results of the model outputs. Training will be provided for how to use the DSS and on how to modify the model(s) and evaluation criteria so that it may be adapted to changing future needs. The Stakeholder Committee will work to continue using the CC-DSS during implementation. As new data is collected and added to the CC-DSS decision makers will be able to use the results to see the effects of new development and urbanization and make decisions that protect water quality based on the science used to develop the watershed protection plan.

7. Ground/Source Water Protection Strategy – Preserving Flows

During the five year process to develop the Watershed Protection Plan, the Cypress Creek Stakeholder Committee was deeply concerned about Cypress Creek becoming an intermittent stream and the effects this would have on water quality. Recent monitoring data indicate the creek flows are below 1 cfs. Addressing flow from the headwaters of Cypress Creek will help mitigate and potentially prevent stormflow pollution sources in the karst terrain. Because surface water quality is directly affected by low spring flows, and after considering all the scientific information available, the Cypress Creek Stakeholder Committee determined that water quality in Cypress Creek will continue to be impaired and will worsen in the future without sufficient flows from Jacob's Well.

In the fall of 2013, a technical committee composed of stakeholders and regional scientists formed to determine what is needed to preserve base-flows, identify artesian and recharge zones for the local springs, develop localized groundwater/surface water interaction models, and to discuss how best to use the emerging science for decision-support. Gaps in available science, methods and approaches, and preliminary goals for ground/source water protection and flow regime preservation are presented below.

In order to pursue Clean Water Act 319 funds, to develop additional watershed protection plan elements pertaining to the flow target in the WPP, and to provide ground/source water protection management recommendations the following items were considered:

- What literature, data, and information exist?
- What data/research activities would benefit the Stakeholder Committee in developing a list of recommendation for management activities?
- What potential methodologies exist and what known components or criteria are required for a successful plan (especially ones with EPA involvement)?
- What activities are underway that can support management and management recommendations?
- What recommendations can be made for designing and implementing a special groundwater management area if it is determined to be an appropriate tool?
- What recommendations can be made for designing and implementing a source-water protection plan?
- Prioritized Goals and Potential Funding Sources

Prioritized Goals for Spring Flow and Ground Water Quality Protection

The Stakeholder Committee recognized that future development could negatively impact surface water quality from above and below the ground. The Committee voted to adopt a suite of management measures to address surface water quality issues while protecting ground/source water flows. Ground/source water protection strategies will enhance efforts of a collaborative management and governance scenario for local water resources.

The Stakeholder Committee identified several potential components that are critical and will be included in a ground/source water protection strategy for their watershed (see Technical Reference Document). Goals are listed below, with the primary purpose of preserving flows (See Dissolved Oxygen section above).

1. **Preserving Cypress Creek headwaters and flow regime at or above WPP target of 6 cfs**
   This strategy is an attempt at preserving (or recovering) the hydrologic regime for the health of the creek and its designated uses. The rationale for including a target spring-flow of 6 cfs as a goal is based on the Dissolved Oxygen criteria described in the DO section above. Additionally, for managing potential nutrient loading, maintaining flow conditions at or above a target flow level under a variety of conditions is a nutrient pollutant management strategy under the build-out development scenario. Thus, maintaining flow is a valued surface water target.

2. **Launch coordinated water conservation campaign between water suppliers and cities to effectively reduce demand for groundwater during drought stages 2 and 3 (Year 1)**

3. **Determine strategies for water suppliers to implement tiered pricing and market-based conservation efforts that will sufficiently incentivize demand reduction (Year 1)**

4. **Establish science process, proposals, and estimated budget needed for determining recharge and artesian area affecting the Springs of the Wimberley Valley (Year 1-3)**
   This scientific process would include consideration of:
   - Modeling – study inputs, revisions, uncertainty, land use change
   - Analysis - Artesian flow and artesian pressure flow regime analysis
   - Monitoring – Monitoring plan, Measuring flow in target reaches
   - Incorporating – EAA, USGS, MCWE and other hydrologic study efforts
   - Recommending - management recommendations for flow and protection of recharge features to prevent pollution entering into ground/source water

8. Education and Outreach Strategy

The purpose of the Education and Outreach Plan (See Technical Reference Document E) is to define the Cypress Creek community's education and outreach goals and objectives for the Watershed Protection Plan. The initial driving force for the plan's development was the desire by local citizens and Cypress Creek Stakeholder Committee to keep Cypress Creek *clean, clear, and flowing*. The information, education, and public participation initiatives to be implemented are submitted to satisfy Element E of the EPA 9-element criteria for watershed-based plans. Near term efforts are outlined below and longer term strategies are listed in the Education and Outreach Plan (Technical Reference Document E).

During 2009-2010, the Cypress Creek Education and Outreach Subcommittee brought forth ideas through public meetings, as well as the suggestions made by other Subcommittees regarding public awareness, social marketing, and community education. They were specifically tasked with:

- Consideration of other stakeholders and individuals that should be part of the subcommittee and to recruit members of the community;
- Identifying causes of water quality/quantity problems from an education and outreach perspective;
- Identifying existing outreach and education activities and how they can be improved;
- Providing information about the Watershed Committee activities to the local media; and
- Developing an Education and Outreach Plan to meet the goals of the Cypress Creek Project.

In 2012, the draft plan was reviewed by the Cypress Creek Stakeholder Committee and was further refined to specifically address identified challenges in engaging the community. In 2013, the Cypress Creek Stakeholder Committee adopted the Education and Outreach Plan.

The goals of the Education and Outreach Plan are:

1. Increase public awareness
2. Increase community engagement
3. Educate and support decision makers

The Education and Outreach Plan has four main target audiences:

1. Community at large
2. Homeowners/landowners
3. Business owners
4. Government/Education

Implementation of the Education and Outreach Plan includes new media (website, newsletters, signs, bumper-stickers, brochure, etc.) designed specifically to incorporate the themes described above. Educational activities and BMPs have been tailored and targeted toward areas identified as most in need (Table 22).

Table 22. Education and Outreach Implementation Plan

Education and Outreach Topic	Responsible Party	Estimated Cost	Number Implemented in Years 1-3	Total Value
Events				
Stakeholder Meetings	Stakeholder Committee	$500	3	$1500
Contests	Stakeholder Committee	$500	2	$1000
DSS Trainings	Stakeholder Committee	$500	3	$1500
Stewardship Workshop	Stakeholder Committee	$500	2	$1000
Industry Workshop	Stakeholder Committee	$500	5	$2500
WPP Workshop	Stakeholder Committee	$100	3	$300
World Water Day Celebration	Stakeholder Committee	$500	3	$1500
Booth & Outreach Dissemination	Stakeholder Committee	$500	3	$1500
Youth Events	Hays County	$0	6	$0
Texas Well Owner Network	Texas Water Resource Institute	$0	3	$0
Print Materials and Website				
Website	Stakeholder Committee	$125/yr	3	$250
Brochure	Stakeholder Committee	$500	3	$1500
Stickers and decals	Stakeholder Committee	$0	3	$0
Print Material Mass Mailing to Watershed Addresses	Stakeholder Committee	$1000	2	$2000
Newsletter	Stakeholder Committee	$500	6	$3000
PSAs	Stakeholder Committee	$500	3	$1500

Education and Outreach Topic	Responsible Party	Estimated Cost	Number Implemented in Years 1-3	Total Value
Physical Outreach Tools				
Road Signs	Hays County	$200/sign	6	$1200
Shower Timers (giveaway 100/yr @ $3 ea.)	Stakeholder Committee	$300/yr	2	$900
CFS Display	Stakeholder Committee	$500	1	$500
Watershed Model	Texas Stream Team	$225	3	$775
Kiosk	Stakeholder Committee	$0	1	$0
Bumper Stickers and Decals (150 to disseminate/yr)	Stakeholder Committee	$0	3	$0

Components

Events

Half day weekend workshops and events will be held at the Wimberley Community Center or other convenient location. Press Releases, newspaper notices and direct mailings will be used to attract interested individuals to the workshops. A database for additional direct mail and web-based invitations can be established and maintained by the WPP Partnership. Events will be funded through a variety of sources including Texas A&M University workshops, non-profit/NGO entities such as CARD and the Lion's Club and anticipated implementation funds from City and County resources as well as grants.

Stakeholder Meetings

The CCP Stakeholder Committee will continue to meet at least quarterly during implementation. Meetings will be announced via email and through the project website. Print announcements will be utilized and are dependent on funding. These meetings will be open to the public and will be an opportunity for collaboration with other NGOs (such as Citizens Alliance for Responsible Development and WVWA). Other meeting agenda items may include WPP progress, how to use the WPP, groundwater protection strategy monitoring results, DSS results and adaptive management. Meetings will be funded by non-profit/NGO entities and anticipated implementation funds from City and County resources as well as grants.

Contests

Develop a program similar to the "Yard of the Month" club, whereby qualifying urban land and home owners would receive recognition (and even ceremonial awards) for their efforts and commitment. This program shall be associated with BMP workshop content and additionally delivered through HOA/POA efforts. Contests will be funded by non-profit/NGO entities and anticipated implementation funds from City and County resources as well as grants.

Community photography contest featuring a call for images to be used in future publications (i.e. Wimberley Institute of Cultures, Wimberley Valley Art League, etc.) in order to generate support and maintain watershed awareness.

DSS Trainings

The DSS was developed based on input from a subcommittee of the Stakeholder Committee members recruited through the Cypress Creek Watershed Protection Planning process. The DSS needs updates to enhance the results from 2009 to incorporate current 2013-2014 land use patterns and the future. One comprehensive training session per year shall be held to give community members the opportunity to utilize this tool. Annual presentations to general audiences showing the future of Cypress Creek and impacts on water quality through the DSS shall illustrate results from the DSS as well as different impacts to the watershed through time and scenarios. Trainings will be funded by non-profit/NGO entities, Texas State University and University of Texas in-kind contributions, and anticipated implementation funds from City and County resources as well as grants.

Stewardship Workshops

Workshops will be funded through a variety of sources including Texas A&M University, non-profit/NGO entities, and anticipated implementation funds from City and County resources, as well as grants.

Groundwater Protection Strategy Workshop

Groundwater protection requires attention above and beyond surface water related activities. Strategic education and outreach shall be created to foster sustainable groundwater resources and awareness throughout the watershed. A series of presentations and workshops will be held to increase awareness about the relationship between surface water quality and groundwater. Audience includes agriculture irrigators, water supply providers, elected officials and community members. A factsheet will summarize the concepts for audiences including agriculture irrigators, water supply corporations, elected officials and community members.

Water Quality Protection for the Homeowner

Regional experts regularly present nonpoint source pollution information at HOA/POA, local gardening club, and Hays County Master Gardeners/ Master Naturalists meetings. Topics will include BMP design, and implementation strategies.

Industry Workshops
Workshops will be funded through a variety of sources including Texas A&M University, non-profit/NGO entities, water providers, and anticipated implementation funds from City and County resources, as well as grants.

Water Providers
A series of workshops will be held to educate water supply providers about the Watershed Protection Plan, highlighting their role in protecting water quality and water conservation efforts and demonstrate tools for high efficiency. These workshops will also establish industry partnerships with the Cypress Creek Project and will include discussions about funding and implementation activities.

Low Impact Development Workshops
The Stakeholder Committee identified educating developers and decision makers about the benefits of Low Impact Development (LID) as a good way to ensure the CCP-WPP LID strategies are implemented as urbanization increases in the watershed.

Rural Landowners, Agriculturalists, & Ranchers: Annual land owner workshops co-hosted by Master Naturalists, AgriLife Extension, Farm Bureau, Natural Resource Conservation Service, The Nature Conservancy and other WPP Partners shall incorporate topical WPP themes geared toward single-family as well as medium to large-sized land owners.

Business Community & Civic Organizations: Strategic partnerships in terms of education and outreach shall be created to foster an economically sustainable support system that generates business awareness throughout the watershed. Supporting participants shall be recognized publicly as a Supporting Partner of the WPP Partnership. Business interests should include locally owned businesses, real estate developers, home builders associations, banks and title companies.

Influential Decision Makers: Presentations designed for elected officials such as county judges and commissioners, city mayors and council members, state legislators and/or congressional representatives shall be held to keep influential decisions makers informed. They will be educated about groundwater issues, opportunities in low impact development, the results of the DSS, and water conservation.

WPP Workshops
Workshops will be funded through a variety of sources including non-profit/NGO entities, and anticipated implementation funds from City and County resources, as well as grants.

CCP Watershed Protection Plan Presentation
Because so many people in the watershed are already involved with some aspect of protecting Cypress Creek there are a number of existing events held. The Stakeholder

Committee will work with local meeting holders to have 20-30 minutes set aside on their agendas for an overview of the Cypress Creek Project. Having a prepared presentation to send the hosting organization will allow the Stakeholder Committee to reach a larger audience of concerned landowners. Presentations will be available to anyone seeking more information about the CCP-WPP via the project website.

World Water Day Celebration

Watershed entities will participate in Watershed Awareness Day and the Stakeholder Committee will approach the City Council regarding an official declaration.

Booth & Outreach Dissemination

The CCP maintained its presence in the watershed community by participating in events that reach target audiences. Previously, EcoFest, Jacob's Well Fall Festival, the Cypress Creek Blessing, Stakeholder meetings, and an awareness survey have been used as platforms for disseminating information, recruiting interest in the project, and generating community involvement. A booth at an event is an opportunity to pass out bumper stickers, decals, and brochures as well as talk with interested community members and potentially build partnerships.

Youth Events

The CCP worked with the Wimberley Valley Watershed Association (WVWA) to host elementary school students at Jacob's Well in order to teach them about the importance of this local resource. Popular weekly tours each Saturday at 10AM are currently lead by local docents and provide information about the spring, its caves, local flora and history. This education program for local schools is geared specifically toward youth groups.

Class projects on watershed issues in Cypress Creek can be explored through web- and media-based outreach assignments for middle and high school ages (i.e., blogs and video news). Wimberley Outdoor Educators, WIC, Texas Stream Team and GBRA have materials that can be applied to the curriculum.

Print Materials and Website

The Stakeholder Committee approved the brand for the Cypress Creek bumper sticker and window decal (see Technical Reference Document). The brand has been used on marketing materials, reports, and the project website. The take-away message is to keep Cypress Creek *Clean, Clear and Flowing*. On July 20, 2010, 1000 window decals and 2000 bumper stickers were printed. Many have already been disseminated, leaving approximately half for future CCP Education and Outreach activities. Print materials and website will be funded through a variety of sources including non-profit/NGO entities, and anticipated implementation funds from City and County resources, as well as grants.

Dissemination via:

Website

The project website, cypresscreekproject.org is funded through 2015 by the Meadows Center for Water and the Environment. The site will be linked from the TCEQ watershed webpage. The site currently serves as the clearinghouse for all projects related materials and news updates. The site will be reorganized to be a portal for the Stakeholder Committee to post meeting dates, agendas, education material, surveys, monitoring data and updates to the CCP-WPP. The site houses photos, maps, reports, project updates, meeting notifications and minutes, newsletters new and old, as well as a sign-up sheet for receiving newsletters. Information also includes charts showing patterns of dry and wet and the correlation between pumping and Jacob's Well discharge. The Watershed Characterization Report, housed on the CCP website was completed in late 2010 is an in-depth analysis of the Cypress Creek Watershed. The report describes the location of the watershed, the topography, geology, soils, vegetation, land uses, history, sources of pollution, and more. It is available online at the Cypress Creek website in the Data section as a downloadable PDF.

Brochure

The Cypress Creek Brochure (located in the Technical Reference Document) contains information on how individuals can help protect Cypress Creek and summarizes NPS pollution, urbanization and bacterial pollution in the watershed. The final page discusses the Cypress Creek Decision Support System and the development scenarios modeled to see how pollution in that watershed changes with increased urbanization. The brochure is an ideal document to share with community members, decision makers, developers, project partners to provide background information. An electronic version of the document is available for distribution. A youth version of the brochure is available for local schools. The project team developed the Cypress Creek brochure/pamphlet as a shorter version of the Watershed Characterization Report. This brochure will be available at events and will be directly mailed to the addresses in the watershed. Content of the brochure addresses home-based, rural, urban, and septic issues as well as education points illustrating NPS, Population and Land Use Change, Groundwater Pumping, and Bacterial issues. Information about the CCP-DSS is also included.

Water Conservation

Print Materials developed by Texas Water Development Board describing the benefits of water conservation will be available to the public at: Stakeholder Committee meetings, project website, public buildings, Jacobs Well Natural Area and public meetings and events where the CCP-WPP is represented. This material will also be offered to water supply companies in the watershed to be distributed via mail to their customers.

Newsletter

The *Cypress Flows* Newsletter: *Cypress Flows* was sent via email quarterly to regional stakeholders. These e-newsletters contained information about the project, biographies of local citizens and leaders, and scientific information about the watershed.

PSAs

Public Service Announcements to be implemented through different avenues. Examples include newspaper, web-based, and radio spots showing weekly water conservation tips.

Physical Outreach Tools

These are physical outreach tools identified as highest priority to be implemented in the first 3 years. Stakeholders feel that these measures are the easiest to implement and have the greatest potential to protect the watershed and indirectly reduce potential non-point source pollution impacts. Additional physical outreach tools can be found in Technical Reference Document E – Education and Outreach Plan Overview. Cost information for the tools listed is shown above in Table 22 and potential funding sources are included in the descriptions below.

Road Signs

Six road signs will be placed on county roads throughout the watershed. Each sign says "Inside Cypress Creek Watershed Environmentally Sensitive Area." The Stakeholder Committee worked with Hays County to identify high traffic roads and feasible places to put the signs. The signs were printed using project funds. Sites include Jacob's Well Road near the Veterans of Foreign Wars (VFW) Building, Winters Mill Parkway, and Mt. Sharp Road. The remainder will be posted on private or county roads. Existing road signs will be installed and paid for by the Hays County Road Crew/Transportation Division.

Shower Timers

Shower timers are a valuable water conservation tool, and shall be given away during events along with printed materials about the watershed and water conservation. Print materials are valuable for transmitting factual information, but community members can turn those facts into action using a shower timer. Tools like these familiarize laypeople with the application of water conservation and watershed stewardship while creating habits. The Cities of Wimberley and Woodcreek will partner with local and regional non-profit entities to cover the cost and distribution of shower timers.

CFS Display

Community displays to increase awareness shall be installed in high traffic areas. A Cypress Flow Message Display to be displayed in public showing present levels of discharge represents a daily reminder of current conditions, exposing citizens and visitors to the issues and encouraging public conversation. Project partners will collaborate with local and regional non-profit entities to cover the cost and installation of a CFS display. Additional messaging is expected to be installed using implementation funds if awarded.

Watershed Model

Texas Stream Team provides a traveling watershed model to teach about water quality and water pollution to youth groups. In this hands-on presentation, everybody gets to participate. The presentation demonstrates three things: (1) What is a watershed? (2) What is nonpoint source pollution? and (3) What are some things that you can do to prevent nonpoint source pollution? Students enjoy this hand on approach and leave with an understanding of watershed science and their role in non-point source pollution. This model will be demonstrated at community events and at schools throughout the year. The watershed model and related activities are provided by the Meadows Center for Water and the Environment and their network of trained volunteers.

Kiosk

The project team created an interactive informational kiosk which is available at the Wimberley Community Center. Information at the kiosk displays the issues in the watershed and shows real-time surface water monitoring data, the CCP website, and includes interactive and instructional videos with a touchscreen.

Evaluating Effectiveness of Education & Outreach Component

In order to evaluate the effectiveness of education practices' on water quality improvements, a system will be utilized and results will be documented throughout the implementation phase. The Social Indicator Planning & Evaluation System (SIPES) uses social indicators to help plan, implement and evaluate Nonpoint Source (NPS) management projects The seven steps (below) begin with a review of project plans and then guide projects through a process to collect, analyze and use social indicators data at the beginning and end of an NPS project (Grenskow and Prokopy, 2011).

1. Review project plan
2. Collect and enter pre-project survey data
3. Review data and refine social outcomes
4. Monitor social data throughout project
5. Collect and enter additional post project data
6. Collect and enter post-project survey data
7. Review data and use results

9. Monitoring for BMP Effectiveness and Adaptive Management

In order to determine if management measures are keeping Cypress Creek clean, clear and flowing, the Stakeholder Committee determined target levels for six pollution constituents, impervious cover levels and flows from the springs feeding Cypress Creek (Table 12).

The Cypress Creek Watershed Protection Plan implements best management practices and other actions to attain and maintain water quality in the creek and its tributaries. The implementation of management measures throughout the watershed over time will result in pollutant loading reductions and established pollutant targets will serve as benchmarks of progress and indicators for adaptive management activities. Tracking the effectiveness of these management measures will be required to ensure that water quality goals are being achieved.

Water quality monitoring will detect the longitudinal increases of pollution contributed by tributaries as water flows into the creek. This stormwater, baseflow and routine monitoring, along with biological and bmp effectiveness monitoring, will determine if desired pollutant load reductions are being met and will highlight management activities and measures that require adjustments.

As of 2012, according to the Texas Integrated Report, which describes water quality conditions for water bodies in the state, Cypress Creek meets water quality standards. However, with the watershed facing rapid growth, the water quality in Cypress Creek is expected to degrade in the coming years. The Stakeholder Committee held a series of meetings to determine practicality and feasibility of standards set at or above the state's levels for the constituents mentioned below, and chose target levels based on monitoring results. Based on detailed review of modeling results and water quality monitoring data, these targets were refined in the summer of 2013. Target levels were established for six pollution constituents (nitrogen, phosphorus, TSS, bacteria, oil & grease and dissolved oxygen), impervious cover levels and flows from the springs feeding Cypress Creek (Table 12).

Components of the stakeholder approved monitoring plan include the coordination of all existing monitoring efforts, increased surface water quality monitoring, groundwater monitoring, the continuation of USGS gage collection of stream flow and water quality parameters, as well as the implementation of monitoring of:

- water quality related to stormflow, baseflow and rain events,
- biological and environmental components (including dissolved oxygen),
- demonstration best management practices (BMPs),
- implemented and existing BMPS, and
- bacterial source tracking.

As the watershed continues to urbanize, water modeling results will be used as a guide for detecting early signs of potential pollution concerns. Routine water quality monitoring data will be disseminated to the Stakeholder Committee and will help to identify any new concerns. If target levels are exceeded regularly, the Stakeholder Committee will utilize adaptive management to address new concerns (25).

Selected Targets for Reduction in Pollution

Targets for reduction in pollutant concentrations were established with the understanding that some management measures are preventative and that as development increases in the watershed, pollution reductions must increase (via implementation of additional management measures). Staggered implementation of these management measures will accomplish total required pollutant load reductions by the end of the 10-year project period and many years into the future. Management measures that are relatively simple and cost efficient to implement early in the WPP, will address initial targeted load reductions. These measures were prioritized as “highest” by the Stakeholder Committee and include structural and non-structural measures and varied sources of funding (shown in Table 12.) These measures selected by the Stakeholder Committee will initially focus on demonstration BMPS implemented in the first 3 Years of the WPP to address critical concerns in the watershed (i.e. keeping water quality above target levels).

Implementation of some additional measures will require greater investments of time, planning, effort, and financial resources and will mitigate the increased pollution loads associated with continued development. The Stakeholder Committee will determine, based on monitoring results and updated modeling outcomes, which of these management measures require adoption, as well as when and where they should be implemented. Table 25 shows the management measures to be utilized as adaptive management strategies.

Reductions in concentrations (and associated pollutant loads) initially will be gradual, but will increase over time, as both sources of pollution and implementation of BMPs in the watershed increase. Activities and measures implemented will maintain water quality sufficient to meet selected target loads in years 1-10, but it is recommended that target loads be reassessed as additional BMPs are implemented and development in the watershed continues, including conversion of land uses. Further, results from ground/source water assessment and preservation of flows study results and additional monitoring data will contribute to knowledge regarding non-point source pollution. This will assist with updating load reductions during the adaptive management review process, as necessary.

However, in the case of TSS, targets will become more stringent over time and are tailored for certain levels of development and land uses in the watershed. Quantities of TSS are expected to increase during periods of increased development, but reduce over time as open land becomes developed and BMPs are implemented.

Load Reduction Modeling

While actual water quality conditions will not precisely follow the models and projections utilized to determine pollutant loadings, these estimates and targets facilitate stakeholder identified adaptive management strategies to keep Cypress Creek clean, clear and flowing (Table 23).

Table 23. Examples of Performance Indicators

A Quick Guide to Developing Watershed Plans to Restore and Protect Our Water (EPA April 2013, p.12).

Environmental	Programmatic	Social
• Number (or percentage) of river/stream miles that fully meet all water quality standards. • Reduction in pollutant loadings from nonpoint sources	• Number of public water systems with ground/source water protection plans • Number of management measures implemented in a watershed (e.g., number of acres under nutrient management, number of riparian buffers created)	• Increase the number of residents signing watershed stewardship pledge • Rates of participation in education programs specifically directed toward solving particular nonpoint source pollution problems

Plan to Measure Effectiveness of Management Measures in Load Reductions

The plan to measure effectiveness of management measures is based on a combination of the Implementation Schedule (Element F), modeled outcomes of measures (Element B), and identified management objectives (Element C). In order to evaluate effectiveness of the measures, a monitoring component outlined below will be engaged alongside the implementation schedule (Table 24).

Table 24. Monitoring Plan Components and Communication of Monitoring Results.

Component	Tasks	Notes
Texas Stream Team proposed monitoring plan/Citizen scientist monitoring group	TST - Develop plan and coordinate with monitoring group. Monitoring Group – conduct monitoring, submit data and email results to stakeholder/workgroup contact.	Data collected is quality assured through TCEQ
Texas Stream Team and US Fish and Wildlife's San Marcos Aquatic Resources Center long term	TST and USFWS will monitor and analyze macroinvertebrate assemblages at several sites along the creek as indicators of potential	

Component	Tasks	Notes
macroinvertebrate sampling program	water quality concerns. Results will be provided to stakeholder/workgroup contact.	
Clean Rivers Program Monitoring	Clean Rivers Program, TCEQ, USGS. Appoint 1 person from stakeholder committee/workgroup to compile results and email to stakeholder committee/workgroup.	Data is quality assured through various sources; TST, WVWA and GBRA are currently conducting monitoring
Stakeholder committee/workgroup assessment of monitoring results.	Coordinate with monitoring efforts and review results on a regular basis (at least quarterly).	
Wimberley Valley Advisory Group	Collect *E. coli* samples on a monthly basis, and report the results to the appointed representative on the stakeholder committee.	Samples are processed in a NELAP accredited lab
Hays County Citizens Alliance for Responsible Development	Results and recommendations will be reported to the stakeholder committee as they are completed. If necessary, ad hoc committees will be formed to plan for implementation activities and adaptive management.	

Coordinating Existing and Future Monitoring Efforts

The Stakeholder Committee determined it is best to coordinate all the concurrent monitoring activities (Figure 32 shows existing USGS, CRP, Cypress Creek Project/TST monitoring sites and LCRA rain gages.) occurring in the watershed throughout implementation. Many of the volunteer monitoring groups are represented on the Stakeholder Committee already work together to collect data and partner with an organization that can formally analyze monitoring results for them. The technical committee will also play a role in analyzing the data collected through monitoring efforts. See the Cypress Creek Stakeholder Committee section above for information about how the committee will coordinate monitoring efforts during implementation (Page 26).

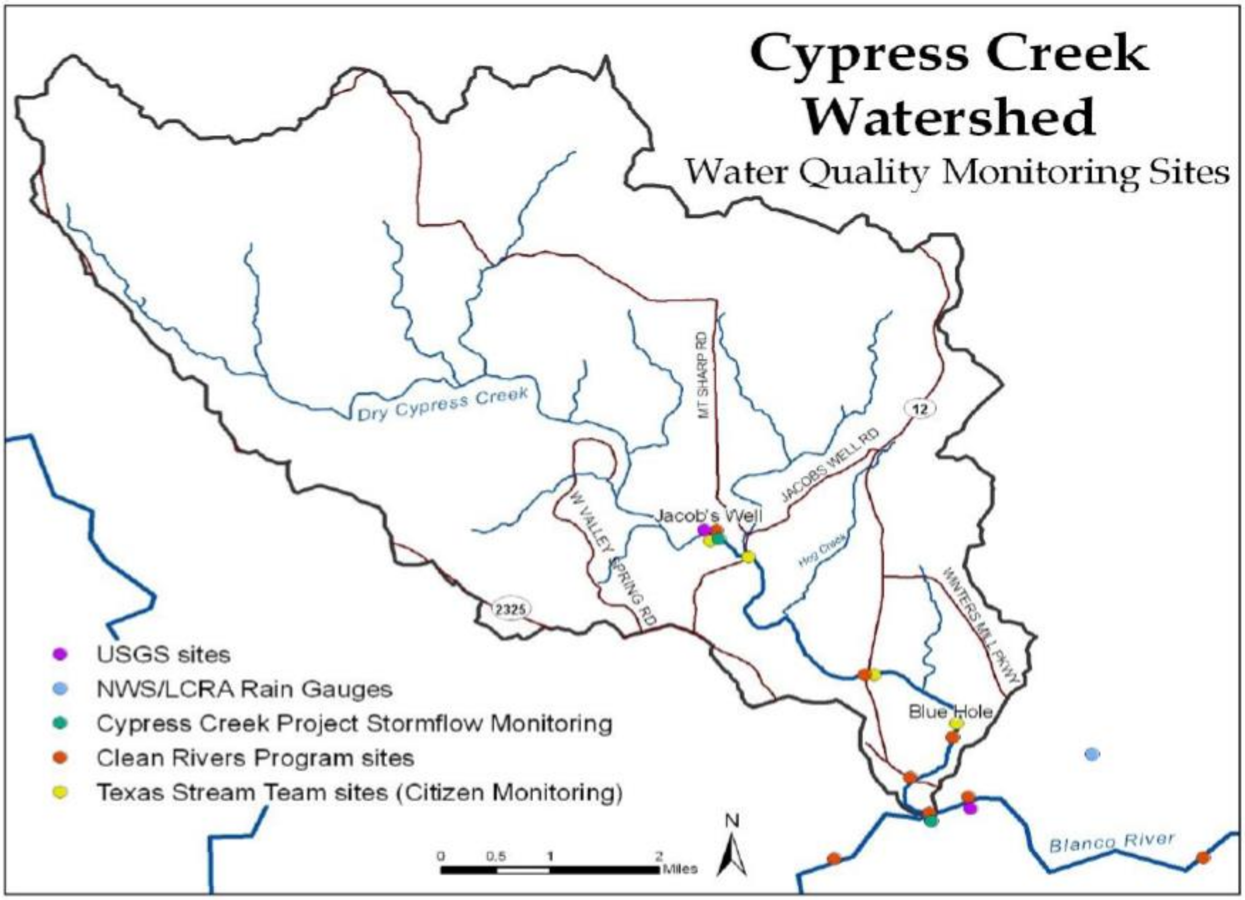


Figure 32. Existing Water Quality Monitoring Sites Rain Gages.

Baseflow Monitoring - The Texas Clean Rivers Program (GBRA and WVWA)

The Texas Clean Rivers Program is a partnership between the TCEQ and regional water authorities to coordinate and conduct water quality monitoring, assessment, and stakeholder participation to improve the quality of surface water within each river basin in Texas. The Guadalupe Blanco River Authority (GBRA) is the partner responsible for administrating The Clean Rivers Program in the Guadalupe River Basin, to which Cypress Creek belongs.

The Wimberley Valley Watershed Association (WVWA) is a non-profit organization dedicated to preserving the water quality of Cypress Creek, and contributes to the Clean Rivers Program by monitoring several sites on Cypress Creek in accordance with The Clean Rivers Program QAPP. Water quality data that is collected for Cypress Creek as part of the Clean Rivers Program includes: water temperature, specific conductivity, dissolved oxygen, and pH. Samples are collected and brought to GBRA's NELAP accredited lab where they are analyzed for total suspended solids, nitrates, ammonia, phosphorus, and *E. coli*.

There are five sites on Cypress Creek that are monitored for The Clean Rivers Program on a quarterly basis. GBRA monitors one location at the Ranch Road 12 crossing in downtown Wimberley. The WVWA monitors four sites on Cypress Creek that include: Jacobs Well, the upstream Ranch Road 12 crossing, the Blue Hole, and the confluence with the Blanco River. Data collected for the Clean Rivers Program can inform the Stakeholder Committee the quality of the water of Cypress Creek before and during the implementation phase of the Watershed Protection Plan.

Stormflow Monitoring

In general, ambient monitoring data are collected under baseflow conditions and occasionally following storm events when flows are elevated. Data are never collected when flows are elevated to a point that would compromise the safety of monitoring teams, nor are daily streamflow measurements routinely collected. However, proper characterization of the hydrology and water quality of the creek requires reliable data on streamflow, and this information is also necessary to calculate average pollutant loads using ambient data. In addition data on both streamflow and water quality should characterize the range and temporal variability of water quantity and quality under the full range of natural conditions. Because water quality parameters are highly influenced by flow rates, it is important to understand the hydrologic response of the watershed to identify causes and sources of NPS pollution, in addition to identifying and developing appropriate best management practices (BMPs) to address pollution issues of concern. Modeling efforts of the Cypress Creek Project are also dependent on accurate flow estimates to ensure the greatest possible accuracy when evaluating potential impacts of future development (Please refer to 4.2.3 Stormflow Monitoring Section of the WCR found in the Technical Reference Document.

The ISCO automatic sampler (20828) located several hundred feet above Jacobs Well in Cypress Creek will be used to monitor stormflows from the dry portion of the creek. Samples will be processed at the GBRA's NELAC certified lab used during the project. Monitoring stormflows at this site will differentiate pollutant loads from the dry portion of the creek and Jacobs Well during storm events.

Rain Event Monitoring

Precipitation accounts for a portion of the water in Cypress Creek and all of the water in the dry portion above Jacobs Well. In order to better understand how much rain falls over the Cypress Creek Watershed, the Cypress Creek Project installed a network of rain gauges within the watershed to collect precipitation data and compared it with surface flow data which to improve the accuracy of the SWAT model. Prior to the rain gauge network, only one long term rain gauge was measuring rainfall near Cypress Creek in Wimberley, TX (NCDC). Other gauges that lie in close proximity to the watershed (<10 km) include Fisher Store (NCDC) and Dripping Springs (LCRA), however rainfall recorded at these do not correlate with one another. One gauge may measure an inch and the other no rain at all. The three additional gauges at or near the points presented on the map will further characterize spatial climate variability in the watershed. The portion of the watershed represented by a rain gauge was determined by utilizing a theissen polygon analysis in ArcMap (Figure 33). Rainfall amounts measured from each gauge will be multiplied by the percentage of the watershed it covers and totaled with the others to give a more accurate measure of rainfall over the 38 square mile area. With Onset Computer Company's RG3 self-tipping rain gauges, data is electronically stored on a data logger within the gauge to be read at the first of every month for at least 12 months. The tipping mechanism is calibrated to tip when filled with 1/100th of an inch, and by multiplying the number of tips by 1/100, you get rainfall measured to the nearest 100th of an inch.

The Interim Stakeholder Committee will collect the data and determine who will analyze and incorporate it into the Cypress Creek DSS during the interim.

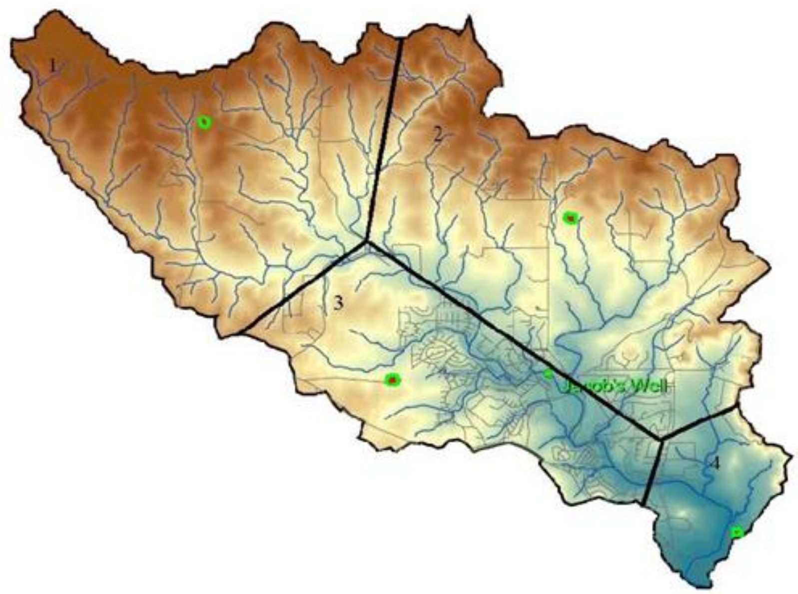


Figure 33. Rain Gauge sites in Cypress Creek Watershed

Supplemental Surface Water Monitoring

Texas Stream Team

Texas Stream Team is a program at The Meadows Center for Water and the Environment and is primarily funded by a Section 319(h) grant from The U.S. Environmental Protection Agency through the Texas Commission on Environmental Quality. The Texas Stream Team program supports a network of citizen scientists and partner organizations such as municipal government environmental divisions, river authorities, and non-profit organizations, who collaborate on projects related to improving or protecting water quality.

Citizen scientists who join Texas Stream Team are trained to collect water quality data in accordance with Texas Stream Team's TCEQ approved Quality Assurance Project Plan (QAPP). The parameters collected by Texas Stream Team Citizen Scientists include: water temperature, specific conductivity, pH, dissolved oxygen, water clarity, and field observations. Citizen Scientists collect nitrates, phosphates, *E. coli*, turbidity, and stream flow.

Once trained, these citizen scientists are assigned a site and expected to monitor on a monthly basis. The data is submitted to Texas Stream Team where it undergoes quality assurance according to Texas Stream Team's QAPP. The verified data is then uploaded to the Data Viewer, an interactive map/database that projects citizen scientists' data for public consumption.

Texas Stream Team can increase stakeholder involvement in the Cypress Creek Watershed Protection Plan by training local stakeholders to collect water quality data. The data can then be presented to stakeholder committees and the public to get a better understanding of current water quality conditions on Cypress Creek. This data can help supplement the other water quality data that is collected in the watershed, such as The Texas Clean Rivers Program monitoring, which is collected from five sites along the creek quarterly basis.

The Texas Stream Team (TST) is currently reaching out to the Cypress Creek community to reestablish citizen scientist water quality monitoring efforts. As part of the plan TST recommends a structured group to carry out monitoring activities. Groups ensure continuity of monitoring activities, increased numbers of monitoring sites and more effective communication among monitors and community members.

In addition to its traditional water quality monitoring programs, TST will partner with USFWS staff to routinely monitor aquatic macroinvertebrate assemblages in several sites along Cypress Creek. TST staff and citizen scientists will collect samples in conjunction with water quality sampling parameters and an identified and widely accepted protocol. USFWS experts will classify and categorize the samples, and analyze assemblage structures as indicators of water quality and environmental health. TST and USFWS will provide results to the Cypress Creek Community and Stakeholder Committee as part of the biological monitoring efforts outlined below.

The Wimberley Valley Advisory Group
The Wimberley Valley Advisory Group is a local Citizen Scientist Group that has been collecting *E. coli* samples from Cypress Creek for 20 years. These samples are sent to a NELAP accredited Lab and are very useful in analyzing and monitoring bacterial issues in the creek.

Hays County Citizens Alliance for Responsible Development
CARD supports and encourages sustainable development and practices that protect local natural resources, including Blue Hole, Jacob's Well, Cypress Creek, the Blanco River and local aquifers. CARD members also participate in a volunteer advisory group composed of regional scientists whose goal is to identify ground/source water that comprise flow in Jacob's Well. Their activities include groundwater monitoring. Better understanding ground/source water in Jacob's Well is critical to preserving flows in Cypress Creek.

Increased Surface Water Quality Monitoring

GBRA can process samples for oil and grease in their accredited lab. Presence is measured as mg/L and is typically only done when there is a sewage/septic spill. Total hydrocarbon tests also could be performed, which would test for oil and grease, as well as other pollutants such as gasoline. Currently, the oil and grease levels in the watershed are too low to justify testing and sampling expenditures, but as development in the watershed continues the Stakeholder Committee would like to implement oil and grease testing as an indicator for faulty or improperly functioning septic systems in the watershed.

Groundwater Monitoring

Most of the water quality data collected for Cypress Creek is focused on surface water quality. Groundwater monitoring is needed to better understand what pollution is contributed to Cypress Creek in flows from Jacobs Well. Jacobs Well can be seen as a point source of pollution to Cypress Creek. When it is determined what type of pollution, if any, flows from Jacobs Well work can begin to determine the source of that pollution. This will help the Stakeholder Committee determine the source of the pollution and water in Jacobs Well. The monitoring efforts coupled with the SWAT model results and EMC source identification calculations will help the committee determine the most appropriate BMPs from their toolbox for adaptive management and which karst features are priorities for protection measures. Monitoring will include continued operation of the USGS stream gage 08170990 in Jacobs Well and Clean River Program water quality monitoring site 12677 (Please refer to Table 4.1 in the WCR found in the Technical Reference Document). While the amount of water quality data for Jacobs Well and Cypress has increased there is still much analysis needed. Continued groundwater monitoring coupled with current data sets will allow for analysis into correlations that exist for pollutants as was done for dissolved oxygen. As pollutants are detected the Stakeholder Committee and project partners can work to identify the source of pollution flowing from Jacobs Well which will also help define the Cypress Creek recharge zone.

Preferred flows from Jacobs Well and in Cypress Creek are threatened by water demand from the aquifer feeding the creek. In order to determine the link between streamflow and wells the Stakeholder Committee will coordinate with project partners to follow approaches laid out in USGS Circular 1376 Streamflow Depletion by Wells-Understanding and Managing the Effects of Groundwater Pumping on Streamflow (Barlow and Leake, 2012).

Biological/Environmental Monitoring

Cypress Creek is classified in the Texas Administrative Code as being and Exceptional Aquatic Habitat. Biological monitoring will provide many indicators and a big picture view of water quality in Cypress Creek including flow regimes and water quantity. This monitoring can also provide early indicators of water quality issues and imbalances in the system. Looking holistically at the Cypress Creek the stakeholder committee will be able to see changes over time, overall ecosystem health and water quality water quantity conditions.

Current biological monitoring efforts from the USFWS, TPWD, GBRA and the Meadows Center should be a coordinated to ensure the data and conclusions reached from analysis are available to the stakeholder committee.

Monitoring of Demonstration BMPs

Demonstration BMPs implemented in the first 3 years of implementation will be monitored for effectiveness of mitigating pollution entering Cypress Creek. The Stakeholder Committee will work with the technical committee to determine if BMPs are operating effectively. If it is determined that a BMP may not be operating effectively the Stakeholder Committee will work with project partners to help determine what changes are needed. Demonstration BMPs that are working effectively will be presented to the community and encouraged for implementation where appropriate across the watershed.

Monitoring of Existing and Implemented BMPs

Existing BMPs installed by Wimberley, Woodcreek and Hays County need monitoring to determine their effectiveness at protecting water quality in Cypress Creek.

Bacterial Source Tracking

Monitoring for bacteria source only shows the amount of fecal bacteria in the creek. Bacterial Source Tracking identifies sources of fecal matter allowing targeted management strategies. Identification and assessment of sources is a key component for effective abatement programs (TWRI, 2012). Additionally, bacterial source tracking will provide valuable information about potential water quality impacts from the permitted discharges in the watershed.

Cypress Creek Decision Support System

The CC-DSS was developed to assist the Stakeholder Committee and decision makers with assessing the effects of increased urbanization in the watershed. As new data is collected and model accuracy increases, the CC-DSS will be used to model the effect of new development on water quality. Because this plan is preventative the Stakeholder Committee decided that water quality modeling results can be used as a proxy for monitoring instream concentrations in future development/urbanization scenarios and assist in determining the most appropriate location for BMPs. Improved monitoring data, and land use/land cover data is required to update the DSS and increase its functionality as a tool for City and County staff to utilize it as a planning tool.

10. Adaptive Management Plan

During characterization the Stakeholder Committee identified strategies to protect surface water quality in Cypress Creek. Those strategies were refined as the Stakeholder Committee reviewed, voted to adopt and prioritized BMPs to use throughout implementation of the Cypress Creek WPP. These BMPs are not all included in the first stage of implementation, but are expected to be implemented in the following years. They are regarded as the stakeholders' "toolbox" for future efforts and adaptive management (Table 25).

The Stakeholder Committee will review monitoring data and the plan to identify if milestones are being met and BMPs are working effectively. The Stakeholder Committee will submit an adaptive management review after the first 3 years of implementation. During this period, water quality monitoring will provide information about current pollution levels in Cypress Creek. Modeling efforts will illustrate potential changes or increases in nonpoint pollution from land use practices and more specific development activities at the subwatershed scale. Monitoring and modeling data will be compared with the water quality targets set forth by the stakeholders and where exceedances or increasing trends occur, best management practices will be selected for implementation.

Adaptive Management BMP Toolbox

In addition to the BMPs and ground/source water protection strategy the Stakeholder Committee approved a suite of BMPs (Table 25) necessary to address water quality threats as urbanization increases in the watershed. This was done to enable the Stakeholder Committee to act on monitoring data that indicates a new threat without having to go through the process of researching new management practices. The BMPs in the Adaptive Management Toolbox are already proven to be suitable options in the watershed. See the Cypress Creek Stakeholder Committee section above for information about how the committee will utilize adaptive management (Page 26).

Table 25. BMP Toolbox for Adaptive Management by Stakeholder Committee

Highest Prioritization	Second Highest Prioritization	Medium Prioritization	Low Prioritization
Water Conservation Pricing Strategies	Urban Wildlife Management – Deer	Rainwater Harvesting Strategies	Rock Weirs/Cross-vanes
Water Conservation Program for Water Providers or Municipalities	Riparian Buffers	Cypress Creek Land Trust	Vegetative Filter Strips
Groundwater Management strategies assessment and research	Water-intensive Turf Grass Ordinances and/or Ban	Nutrient & Fertilizer Management	Livestock Water Quality Management Plan
Groundwater Protection Strategy	Groundcover Establishment – Agricultural	Habitat Conservation Areas – Urban	Rain/soil moisture sensors
	Parking Lot Pervious Design Strategies	Rock Berms/Gabions	Wastewater solutions
	Xeriscaping/Nativescaping	Biofiltration/Rain Garden	Septic replacement program
	Engineered Swales	Tree Protection	
	Conservation Easements	Groundcover Establishment – Urban	
	Karst Feature Protection Measures	Porous/Pervious Pedestrian Walkways	
	Comprehensive Stormwater Assessment	Alternative Brush Control -- Prescribed burns	
	Purchase of Development Rights	Grazing Management Strategies	
	Landscape Mulching	Landowner Incentive Program	
		Pet Waste Ordinance & Stations	

11. Milestones and Measures of Success

Milestones

Milestones are check points in the plan to ensure that the plan is on schedule. This element identifies measureable milestones that show whether management measures are being implemented by a particular set date. Measureable milestones can be documented through load reductions (i.e. 5% reduction of in TSS) or area of coverage (i.e. 5,000 feet of permeable sidewalk constructed). If the milestones are not achieved, the appropriate adaptive management will be initiated, tested and adjusted as needed.

Continued monitoring for water quality, precipitation, groundwater, biology and flows are necessary for the Stakeholder Committee to know if the plan is successful at maintaining or improving water quality in Cypress Creek. The data collected for characterization of the watershed was analyzed to identify pollutants, possible sources and to enhance the SWAT model's (CC-DSS) effectiveness at simulating current and future conditions in the watershed. The Stakeholder Committee determined that coordinating monitoring efforts under the WPP and monitoring done by project partners is essential to the plan's success. The strategy developed by the committee involves compiling existing data and newly collected data into one dataset that can be analyzed to better identify water quality trends and threats. The monitoring data will also be used to enhance the outputs of the CC-DSS. The stakeholders wish to use the CC-DSS to aid decision makers as they plan the future urbanization in the watershed.

Milestones and other management measures scheduled for implementation in the first ten years are presented below in Table 26. The potential pollution prevention quantity is provided as a percentage per BMP or unit because the pollution loadings in the future are only estimated and are only as accurate as the current level of available data allows. Once accepted, this WPP will be updated annually with modeling outputs that show more current land use and land cover activities in the basin. These instream loadings and subwatershed contributions will be estimated and the management measures listed below will be implemented as necessary to mitigate increases in pollution. Minimum numbers of management measures or BMPs needed to maintain water quality (and quantity) in the creek has been identified by the stakeholders.

Routine monitoring will be required to determine if implemented BMPs are reducing pollutants. The results of monitoring activities will be compared with the water quality targets below. Although 2012 baseline data (from the Clean Rivers Program) is provided as background information, desired water quality conditions were determined by the stakeholders and are shown in Tables 28-30.

Table 26. Measureable Milestones for Implementation Phase – Surface Water Protection Strategy

Management Measure	Minimum # Needed Throughout 10 Year Period	Applicable Area/Sub Watershed	Measured Milestones	Year of Implementation			Potential Pollutant Prevention per Unit Implemented £
				1-3	4-6	7-10	
Comprehensive Stormwater Assessment	1 Assessment	12, 14, 15, 39, 40, 41, 44	Completion of assessment of potential WQ Ordinance enhancements (1 PTE), selection of BMPs and locations for implementation based on findings	1			*E. coli* – 30%
Riparian Buffers	3 Managed Buffer Areas	12, 14, 15, 39, 40, 41, 44	Identify and prioritize locations for implementation, commitments for buffer management	1	1	1	N – 50% TSS – 74% *E. coli* – 30%
Xeriscaping/ Nativescaping	2 Areas	Basinwide	Establishment of at least 2 demonstration areas throughout the basin and adoption of HOA rules allowing xeri- and nativescaping		1	1	N – 75%
Engineered Swales	2 Locations	12, 14, 15, 39, 40, 41, 44	Establishment of at least 2 demonstration areas throughout the basin and use in all new development		1	1	TSS – 99%
Karst Feature Protection Measures	5 Locations	Basinwide	At least 5 properties identified as beneficial to protecting water quality with measures implemented; adoption of protection measures in city and county codes		2	3	*E. coli* – 34%
Rainwater Harvesting Strategies	5 Areas	Basinwide	Establishment of at least 5 demonstration areas	1	2	2	Water quantity variable

Management Measure	Minimum # Needed Throughout 10 Year Period	Applicable Area/Sub Watershed	Measured Milestones	Year of Implementation			Potential Pollutant Prevention per Unit Implemented £
				1-3	4-6	7-10	
			throughout the basin and use in all new development				depending on precipitation
Rock Berms/Gabions	5 Berms	12, 14, 15, 39, 40, 41, 44	Establishment of at least 1 demonstration areas throughout the basin and use in all new development in urban public spaces; added to existing codes where appropriate	1	4		TSS – 55%
Biofiltration/Rain Garden	4 Areas	12, 14, 15, 39, 40, 41, 44	Establishment of at least 4 demonstration areas throughout the basin and use in all new development in public spaces; added to existing codes as water quality protection measure	1	1	2	N – 56% TSS – 93% *E. coli* – 75%
Pervious Sidewalks	10 Areas	12, 14, 15, 39, 40, 41, 44	Establishment of at least 10 demonstration areas throughout the basin and use in all appropriate new development in public spaces;		5	5	N – 80% TSS – 90%
Pet Waste Ordinance & Stations	3 Locations	12, 14, 15, 39, 40, 41, 44	Establishment of at least 3 pet waste stations in urban subwatersheds; added to existing codes as water quality protection measure		1	2	*E. coli* – 510 billion cfu/day

Management Measure	Minimum # Needed Throughout 10 Year Period	Applicable Area/Sub Watershed	Measured Milestones	Year of Implementation			Potential Pollutant Prevention per Unit Implemented £
				1-3	4-6	7-10	
Vegetative Filter Strips	1 location	12, 14, 15, 39, 40, 41, 44	Establishment of at least 1 demonstration area throughout the basin and use in all new development in public spaces; added to existing codes as water quality protection measure		1		N – 56% TSS – 93% *E. coli* – 75%
Low Impact Development	2 location	12, 14, 15, 39, 40, 41, 44	Establishment of at least 1 demonstration area throughout the basin to show Net Energy Zero Lodging and a green roof		1	1	Water quantity variable depending on precipitation
Existing BMP maintenance	20 inspections and maintenance when needed	12, 14, 15, 39, 40, 41, 44	Establishment of program to maintain existing BMPs for proper function	6	6	8	N – 50% TSS – 74% *E. coli* – 30%
Ordinance enforcements, enhancements and Master Plan development	3 ordinances/plans	12, 14, 15, 39, 40, 41, 44	Redevelopment and implementation of at least 3 key water quality ordinances or plans at the local government level		1	2	N – 50% TSS – 74% *E. coli* – 30%
Small Scale Waste Water Treatment	1 location	12, 14, 15, 39, 40, 41, 44	Establishment of at least 1 demonstration area throughout the basin to show small scale wastewater treatment		1		N – 50% *E. coli* – 30%

Management Measure	Minimum # Needed Throughout 10 Year Period	Applicable Area/Sub Watershed	Measured Milestones	Year of Implementation			Potential Pollutant Prevention per Unit Implemented £
				1-3	4-6	7-10	
Nature Trail Signs	3 signs	12, 14, 15, 39, 40, 41, 44	Erection of at least 3 signs for education		1	2	% prevention unknown
"Entering Watershed" Signs on Roadway	6 signs	Basinwide	Installation of 6 "Entering Watershed" Signs on Roadway to increase community awareness	3	3		% prevention unknown
Watershed Coordinator	10 years	Basinwide	1 employee to implement BMPs for water quality reduction and community awareness	3	3	4	% prevention unknown
Enhanced Water Quality and Groundwater Modeling (CC-DSS)	3 sessions	Basinwide	At least 3 sessions in enhanced Water Quality and Groundwater Modeling (CC-DSS) to improve water quality decision making as the scenario changes	1	1	1	% prevention unknown

This table satisfies Element I.
£ - Potential preventions as compared to no action taken in the face of projected development.

In the interim the Stakeholder Committee will begin work to compile historical data and data collected by project partners since characterization as well as implement components of the ground/source water protection strategy (Table 27).

Table 27. Potential Ground/source water Protection Strategy Benchmarks

Management Measure	Applicable Area	Benchmarks	Responsible Party/ Partners	Year of Implementation			
				1-2	3-4	5-6	7-8
Highest Prioritization							

Management Measure	Applicable Area	Benchmarks	Responsible Party/ Partners	Year of Implementation			
				1-2	3-4	5-6	7-8
Water Conservation Pricing Strategies	Basin-wide	Identification of successful pricing strategies	Stakeholder Committee	X			
	Basin-wide	Finalize pricing schedules and adoption by water providers	Stakeholder Committee	X			
	Basin-wide	Implementation of new pricing and monitoring of water use changes.	Stakeholder Committee	X	X	X	X
Water Conservation Program for Water Providers or Municipalities	Basin-wide	Identification of successful program components.	Stakeholder Committee	X			
		Development of program, schedule and adoption by water providers	Stakeholder Committee	X			
		Implementation of program and individual measures. Monitoring of water use changes.	Stakeholder Committee		X	X	X
Source Water Protection Strategy							
GW (Flowing) committee meets to ensure GW strategy implementation	Basin-wide	Meet quarterly	Stakeholder Committee	X	X	X	X
Begin meeting with responsible parties to determine what actions are possible	Basin-wide	As needed	Stakeholder Committee	X		X	
Identify what GMA9 process standards are used so CCP can effectively participate in the GMA process	Basin-wide	Identify protocols and report to Stakeholder Committee to determine next steps.	Stakeholder Committee	X			
Apply for funding and technical assistance – including JW USGS gage	Basin-wide	Begin applying for funds/assistance to implement Source Water Protection Strategy using accepted CC-WPP as justification.	Stakeholder Committee	X	X	X	X
Preliminary BMPs for Source Water Protection							
Data collection (historical and current)	Basin-wide	Begin collecting monitoring data for analysis	Stakeholder Committee	X			
Data analysis	Basin-wide	Perform analysis on collected monitoring data	Stakeholder Committee	X			

Management Measure	Applicable Area	Benchmarks	Responsible Party/ Partners	Year of Implementation			
				1-2	3-4	5-6	7-8
Present findings to Stakeholder Committee	Basin-wide	Present results of analysis to Stakeholder Committee and determine adaptive management strategy	Stakeholder Committee		X		
Identify Data gaps for next data collection and analysis	Basin-wide	Stakeholder Committee with technical assistance from project partners will identify what is needed to better understand flows from Jacobs Well and effects on surface water quality.	Stakeholder Committee		X		
Coordinate CCP conservation efforts and determine if they can work beyond the watershed to include the Cypress Creek Jacob's Well Springshed	Basin-wide	Stakeholder Committee to begin reaching out to conservation groups in the watershed to discuss pooling efforts and resources to protect the Cypress Creek recharge zone.	Stakeholder Committee			X	
Karst Feature Protection	Basin-wide	Identify and prioritize karst features for protection in the watershed that contribute water to Jacobs Well	Stakeholder Committee		X		

Water Quality Targets Measures of Success

The Cypress Creek WPP is a preventative plan that will first address immediate water quality threats from nitrogen while implementing the integrated ground/source water protection strategy. After the first 3 years of implementation the Stakeholder Committee will conduct an adaptive management review to see how well water quality and water quantity goals are being met (Table 28, Table 29, Table 30). Interim water quality milestones are designated in-stream concentrations between current conditions and future conditions. The Stakeholder Committee decided that between 2014 and 2050, nitrogen concentrations should remain constant, while *E. coli* levels could increase in 2020 and TSS would be reduced between 2020 and 2050. The Stakeholder Committee will also review monitoring data to determine when action is needed to mitigate parameters of concern.

Nitrogen Targets and BMP Effectiveness

The Stakeholder Committee identified priority reaches/subwatersheds affected by nitrogen concentrations in which to implement BMPs, as well as monitoring locations. Stakeholders selected initial BMPs to prevent increases in nitrogen and other pollutants as well as to promote education about nonpoint source pollution. These subwatersheds will be targeted in the first 3 years of implementation and routine monitoring will indicate if milestones are being met and if additional BMPS will be required in the future.

Table 28. Nitrogen Concentration Targets

Year	***Priority Reaches for Nitrogen Concentration (mg/L)***	
	Priority Reaches (including reaches 2, 4, 7, 32, 35)	Monitoring locations (including Jacobs Well, Downtown and Confluence)
2014 - 2050	1.65 mg/L	1.65 mg/L

Parameters of Concern

The Stakeholder Committee identified priority reaches/subwatersheds affected by other parameters. BMPs will be implemented during the first 3 years in these subwatersheds as well. Monitoring will be performed at Jacobs Well, in the creek downtown, and at the confluence, as well as in any priority tributaries required to complete existing data gaps.

Table 29. *E. coli* Concentration Targets

Year	***E. coli*** **Concentration (cfu/100mL)**	
	Priority Reaches (including reaches 2, 12, 15, 27, 36, 41, 42, 44, 45, 46)	Monitoring locations (including Jacobs Well, Downtown and Confluence)
2014-2018	126 cfu/100ml	126 cfu/100ml
2020-2050	<394 cfu/100ml	<394 cfu/100ml

Table 30. TSS Concentration Targets

Year	*TSS Concentration (mg/L)*	
	Priority Reaches (including reaches 2, 4, 9, 14, 27, 29, 32, 36, 41, 42, 44, 45, 46)	Monitoring locations (including Jacobs Well, Downtown and Confluence)
2014-2018	5.0 mg/L	5.0 mg/L
2020-2050	Groups A, B, C - 4.5 mg/L	Groups A, B, C - 4.5 mg/L

12. Technical and Financial Assistance

During the fall of 2013, the Cypress Creek Stakeholder Committee worked together with governmental and nongovernmental organizations to gain commitment for technical and financial assistance in implementing the Watershed Protection Plan. Both cities, the County and local NGOs discussed commitments for implementing WPP activities. Formal financial agreements will be finalized during the Interim period (between acceptance of the WPP and implementation:

- **Woodcreek, Wimberley, Hays County and WVWA have pledged to implement the BMPs in Table 21 with TCEQ guidance with an estimated value of $2,832,060.**
- **Since appropriation funding cycles for local governments cannot anticipate future projects beyond the current budget cycles, the formal appropriations at the city and county-level have not yet been approved nor allocated. The city of Woodcreek, city of Wimberley, and Hays county representatives have pledged to support and present the WPP implementation needs to their respective appropriations bodies for approval and allocation.**
- **The local governments have pledged to seek proclamations adopting the WPP during the interim.**
- **The local governments have pledged to conduct an education and outreach campaign for elected officials to ensure approval, appropriation, and allocation of funds for implementation of the WPP.**

Table 21 above shows dollar amounts pledged for initial implementation of BMPs throughout the watershed. Stakeholders decided that initial implementation efforts should span a three year period, during which time additional modeling, monitoring and assessments of pollution reductions from existing and proposed ordinances will take place, in addition to the installation of demonstration and pollution reduction BMPs. Modeling, monitoring and ordinance review outcomes will likely lead to adaptive management and revisions to this plan, including strategic placement of structural BMPs in vulnerable subwatersheds, additional land management activities and revised ordinances to prevent and mitigate nonpoint source pollution.

Technical committee composed of Stakeholder Committee members and regional scientists

Throughout the Cypress Creek Project local and regional scientists have contributed their time, expertise, efforts and results of studies to the process of characterizing the watershed and determining how to keep Cypress Creek clean, clear and flowing. The Interim Stakeholder Committee will continue to work with these individuals to analyze the results of monitoring, modeling and other activities.

Table 31 below shows pledged matching funds for technical assistance, outreach and education and implementation activites, but does not include anticipated additional cash contributions from city, county or NGO participants. Additional inkind contributions are also expected from these entities and The Meadows Center for Water and the Environment.

Table 31. Partial List of Pledged In-kind Implementation Funds

WVWA donated office space [$350 mo rent + $100 mo supplies/utilities for 36 mo]	$ 16,200
Stakeholder Committee member participation in meetings and implementation activities [$40/hr (4 technical members) + $23.40/hr (4 community members)x 3hr x 36 meetings x 8 members]	$ 27,389
Stakeholder Committee Chair commitment to raise additional funds and assist with implementation activities. [$40/hr for 5 hr per week for 20 weeks out of the year for 3 years]	$ 12,000
WVWA Executive Director commitment to raise additional funds and assist with implementation activities [funds from external source to support grant activities if this grant is approved]	$ 20,000
GBRA Staff time contributions [.01 FTE/20 hr per year x 3 yr: $50/hr Director of WQ Serv, $22/hr WQ Technician and $32/hr for E&O staff]	$ 6,240
Use of meeting rooms donated monthly [$150 x 36 meetings]	$ 5,420
GBRA assistance with Monitoring QAPP [48 hours @ $50/hr x 40.5% Fringe x 25.22% indirect]	$ 4,222
GBRA assistance with annual QAPP updates YR2&3 [12 hours @ $50/hr x 40.5% Fringe x 25.22% indirect]	$ 1,056
GBRA monitoring and analyses of CRP site [$370 per quarter x 3 yr]	$ 4,400
SwRI in-kind contribution of time to modeling develop QAPP [$50/ hr staff time x 36 hr]	$ 1,800
Halff/TRC in-kind contribution to develop modeling and mapping QAPP [$50/hr staff time x 70 hr]	$ 3,500
Hays County Development Services/Road Crew assistance with RWH system installation	$ 40,000

Lions Club Water Speaker Series [9 events x $200 room rental + $300 recording fee x 40 hr volunteer time @ $23.40/hr]	$ 12,924
Wimberley Volunteer Advisory Group technical assistance with data compiling, analyses and modeling activities [monthly meetings at $362.55/hour (total for 5 engineers) for 3 hour meetings +$150 meeting space for 36 mo]	$ 57,607
Pledged matching funds	$ 212,758

Financial Assistance by Program (Potential Funding Sources for Implementation)

During the first three years of implementation, a watershed coordinator will be hired to assist the Stakeholder Committee secure additional funding for the implementation of demonstration BMPs, structural BMPs and outreach and education efforts. Potential sources of funding (detailed below) will be identified for specific management measures during this period. Because this is a preventative plan and future development is the predicted major cause of increased pollution loads, many BMPs will not require implementation for several years. Therefore, seeking financial and technical assistance will be an on-going and iterative process.

City of Wimberley

Wastewater solutions were reviewed by a seven person City appointed panel. Results of the panel, including recommendations and actions for the WPP may be finalized in 2014 and will be added to this section in subsequent versions of the WPP. Any additional funding sources will be identified during this effort.

Clean Water State Revolving Fund

The State Revolving Fund (SRF) administered by the TWDB provides loans at interest rates below the market to entities with the authority to own and operate wastewater treatment facilities. Funds are used in the planning, design, and construction of facilities, collection systems, stormwater pollution control projects, and nonpoint source pollution control projects. If a wastewater treatment plant is deemed feasible in the Cypress Creek Watershed, involved parties will pursue funds to build one.

Grassland Reserve Program Farm & Ranch Lands Protection Program

NRCS Texas Conservation Easements Under the authority of the Wetlands Reserve Program (WRP), Grassland Reserve Program (GRP), and the Farm and Ranch Lands Protection Program (FRPP), NRCS acquires or provides funds for the acquisition of conservation easements to protect significant natural resources. The easements are filed in the county records and are considered public information. NRCS freely releases the location of these easements so that planned routes for pipelines, transmission lines are roads may avoid impact. NRCS easements lands are not subject to condemnation through eminent domain.

Lonestar Healthy Streams Program

Administered via TWRI/AgriLife/TSSWCB, the goal of the Lone Star Healthy Streams (LSHS) program is the protection of Texas waterways from bacterial contamination originating from livestock operations and feral hogs that may pose a serious health risk to Texas citizens. To achieve this important goal, the program's objective is the education of Texas farmers, ranchers, and landowners about proper grazing, feral hog management, and riparian area protection to reduce the levels of bacterial contamination in streams and rivers.

NRCS Water Resources Programs

Through the National Water Quality Initiative, NRCS is offering financial and technical assistance to farmers, ranchers and forest landowners interested in improving water quality and aquatic habitats in priority watersheds with impaired streams. NRCS will help producers implement conservation and management practices through a systems approach to control and trap nutrient and manure runoff. Qualified producers will receive assistance for installing conservation practices such as cover crops, filter strips and terraces. For over 75 years, NRCS has provided agricultural producers with assistance to implement voluntary conservation practices that protect natural resources while maintaining production and profits.

Nonpoint Source 319 Grant Program

The USEPA provides funding to states to support projects and activities that meet federal requirements of reducing and eliminating nonpoint source pollution. In Texas, both the TSSWCB and the TCEQ receive 319(h) funds to support nonpoint source projects, with TSSWCB funds going to agricultural and silvicultural issues and TCEQ funds going to urban and other non-agricultural issues. 319(h) funds from the TCEQ supported the development of the Cypress Creek Project and can be used during best management practice implementation.

Texas Environmental Quality Incentives Program

The Environmental Quality Incentives Program is administered by the NRCS. This voluntary conservation program promotes agricultural production and environmental quality as compatible national goals. Through cost-sharing, EQIP offers financial and technical assistance to eligible participants for the installation or implementation of structural controls and management practices on eligible agricultural land. This program will be engaged to assist in the implementation of agricultural management measures in the watershed.

Traditional Statewide LIP Funding Series

Administered through TPWD, these USFWS funds create the Landowner Incentive Program (LIP) which provides federal grant funds to grant funds to the states to protect and restore habitats on private lands, to benefit Federally listed, proposed or candidate species or other species determined to be at-risk. Grant funds must be used to establish or supplement State landowner incentive programs to benefit species identified in the State's Comprehensive Wildlife

Conservation Strategy (State Wildlife Action Plan) or classified as Special Concern by the State, or Federally listed, proposed, or candidate species or other species determined to be at-risk. These grant funds may also be used to provide technical and financial assistance to private landowners for habitat protection and restoration.

Water Conservation Field Services Program- Demonstration
Funded via US BOR/US DOI, the WCFSP demonstrates innovative conservation technologies. The program specifically emphasizes ways to improve water measurement techniques in effective and affordable ways for agricultural districts. This includes demonstrations in water measurement, canal automation, diversion structures, seepage control, xeriscaping, and urban retrofitting.

Water and Environmental Program
Funded via Rural Utilities Service (RUS)/USDA, the Water and Environmental Programs (WEP) provide loans, grants and loan guarantees for drinking water, sanitary sewer, solid waste and storm drainage facilities in rural areas and cities and towns of 10,000 or less. Public bodies, non-profit organizations and recognized Indian tribes may qualify for assistance. WEP also makes grants to nonprofit organizations to provide technical assistance and training to assist rural communities with their water, wastewater, and solid waste problems.

Water Quality Management Plan
The WQMP program is administered by the TSSWCB. Also known as the 503 program, the WQMP program is a voluntary mechanism by which site-specific plans are developed and implemented on agricultural and silvicultural lands to prevent or reduce nonpoint source pollution from these operations. Plans include appropriate treatment practices, production practices, management measures, technologies, or combinations thereof. Plans are developed in cooperation with local SWCDs, cover an entire operating unit, and allow financial incentives to augment participation. Funding from the 503 program will be sought to support implementation of agricultural management measures in the watershed.

Wetlands Reserve Program
Funded via USDA/NRCS, the Wetlands Reserve Program (WRP) is a voluntary program offering landowners the opportunity to protect, restore, and enhance wetlands on their property. The USDA Natural Resources Conservation Service (NRCS) provides technical and financial support to help landowners with their wetland restoration efforts. This program offers landowners an opportunity to establish long-term conservation and wildlife practices and protection. The goal of NRCS is to achieve the greatest wetland functions and values, along with optimum wildlife habitat, on every acre enrolled in the program.

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