Appendix D Preliminary Source Water Protection: Enhancing the WPP with Integrated Water Planning

During the 5-year process to develop the Watershed Protection Plan, the Cypress Creek stakeholders were vocally concerned about Cypress Creek becoming an intermittent stream and the effects this will have on water quality. Recent monitoring data indicates the creek flows are below 1 cfs. 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 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 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 source water protection management recommendations the following items were considered:

- What literature, data, and information exist? (This section contains some info, but is in no way the comprehensive literature review needed)
- What data/research activities would benefit Stakeholders 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?
- What recommendations can be made for designing and implementing a source-water protection plan?
- Prioritized Goals & Potential Funding Sources

Study Area and Context

Surface and groundwater interaction in Central Texas' rivers, streams, creeks and aquifers is frequent, due to the common karst geological features that define the area. This watershed is a part of the Edwards Plateau region of the Texas Hill Country. The topography of the Hill Country varies from hills of predominantly karstic limestone terrain to plateaus that serve as major recharge zones to the underlying Edwards, Edwards-Trinity, and Trinity Aquifers (Longley, 1986). The hills are characterized by unstable inter-bedded limestone, shale and clays (Riskind and Diamond 1986). The limestone plateaus are karstic, thus the dissolved bedrock can provide many conduits for recharge from rain events. These karstic limestone features facilitate the movement and interconnectedness of rainfall, surface water and groundwater.

Trinity Aquifer System

Characteristics of the Trinity Aquifer include rapid flow and transit patterns, as well as significant impacts of hydrologic conditions on water chemistry (USGS 2013). Groundwater stored in the Upper and Middle Trinity Aquifers provide the primary source for municipal and all other water supplies in the Cypress Creek watershed, and are not only vulnerable to nonpoint source pollutants, but provide the majority of flows to Cypress Creek.

With the continued rapid growth and development of the Wimberley Valley, and several hot, dry Texas summers, a great deal of pressure has been placed on the groundwater resources of the community. Researchers with the Groundwater District have estimated that at current pumping rates water levels in the Trinity Aquifer are being depleted by 1 foot per year in the area.

Groundwater Recharge

Faults and caves in the upper parts of the watershed are likely places of localized aquifer recharge. There is anecdotal evidence that these features can act as major sinks during rainfall events. In 2011, a review of existing studies was undertaken to delineate a "probable contributing area for Jacob's Well and Cypress Creek" (Vogl 2011). Estimated recharge rates for the Trinity Aquifer in the Hill Country region range from 1.5% to 11% of total annual rainfall and local groundwater availability models used by TWDB utilize a recharge rate of 4.7% (Mace, 2000; Jones, 2004). At a rate of 4.7%, approximately 1.34 inches per year of recharge would result from an average annual precipitation of 33.5 in. per year (Wierman et al 2008).

Figure X1 below shows known areas or parcels of land containing karst features or located along Lower Glen Rose outcrops in the author's study area in Central Texas, while Figure X2 shows known features such as caves, sinks and springs in southern Hays County in proximity to Cypress Creek's headwaters, Jacob's Well. Figure X3 shows

modeling results for estimated recharge using Soil and Water Assessment Tool (SWAT) and Automated Geospatial Watershed Assessment (AGWA2). Although, much of the mapped area is outside the Cypress Creek watershed boundaries, this model output provides valuable information about potential recharge rates and locations that impact Cypress Creek.

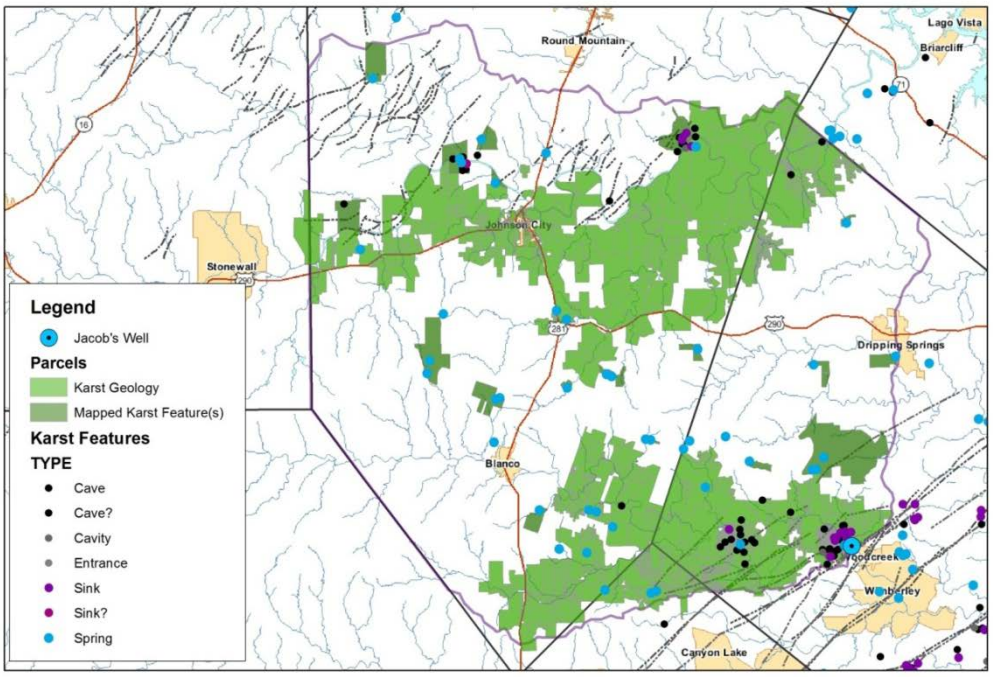

Figure X1. Areas with known karst features and/or having karst geology (Vogl 2011).

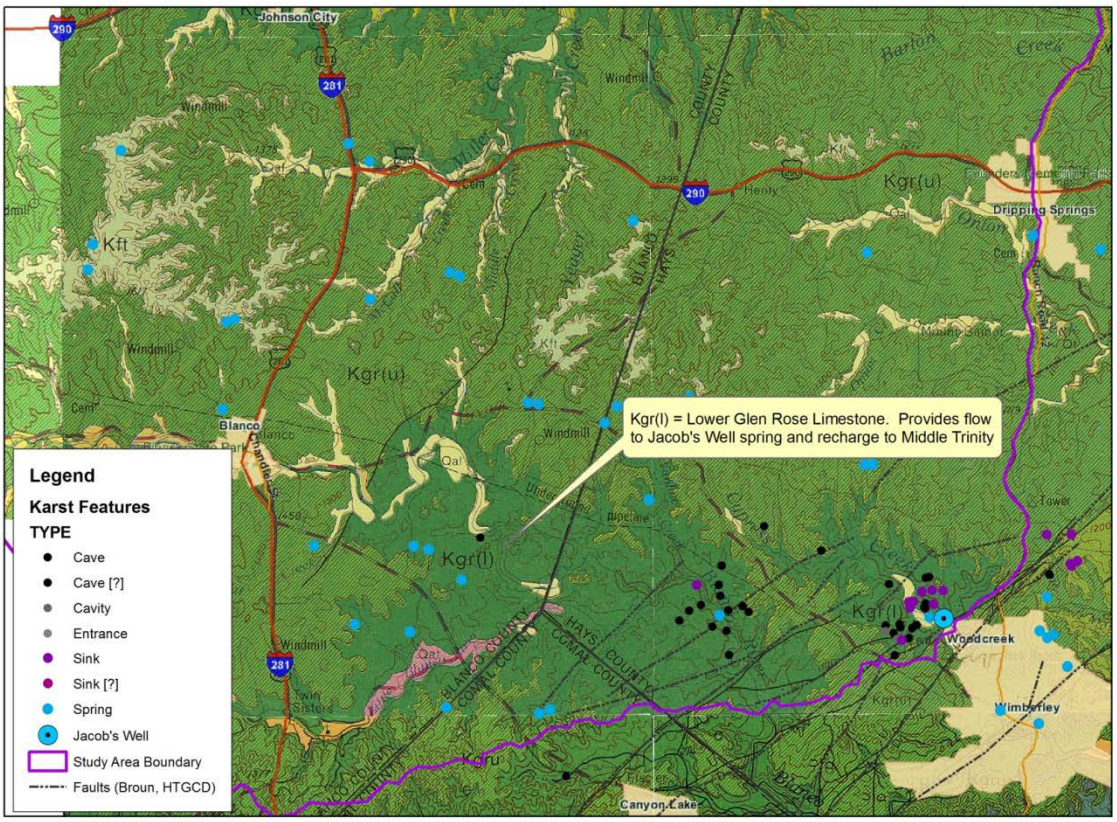

Figure X2. Location of Lower Glen Rose outcrops and karst features within the study area (Vogl 2011).

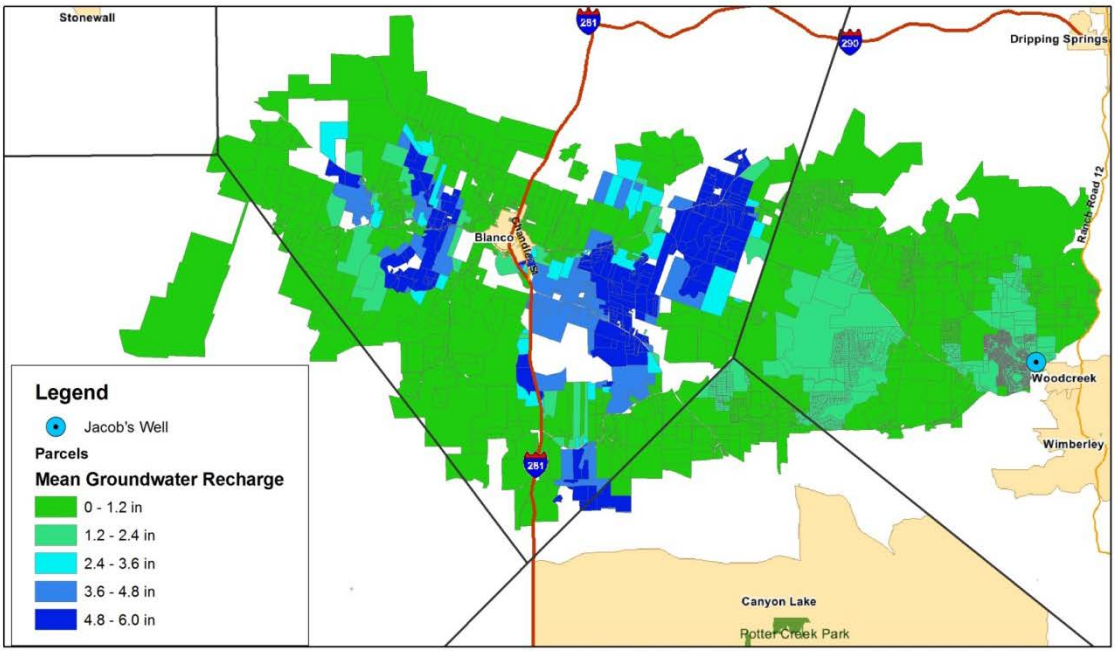

Figure X3. Average annual groundwater recharge by parcel, based on results from the Upper Blanco watershed model and historical climate (Vogl 2011).

The Hays-Trinity Groundwater Conservation District (Wierman et al 2008) estimated that sources of storm water related flow in Jacob's Well is approximately equivalent to the Cypress Creek watershed. The watershed boundaries include an outcrop of the unconfined Lower Glen Rose formation. The rapid recharge and through-flow facilitated by the karst features of the Lower Glen Rose likely contribute to the rapid flows related to storm events at Jacob's Well (Vogl 2011). The recharge areas contributing most of the base flow to Cypress Creek, however are not likely to be sourced within the Cypress Creek watershed.

Jacob's Well

Jacob's Well is one of the natural treasures of the Hill Country. Located near Wimberley in Hays County, the spring typically flows around 3.5 cubic feet per second from the Trinity Aquifer, supporting downstream flows in Cypress Creek. Jacob's Well is the largest perennial spring in the Trinity Aquifer and one the longest underwater caves in Texas. The cave and spring are inhabited by uniquely adapted spring and aquifer fauna. The spring also helps support a thriving ecological community in the Cypress Creek by providing a consistent source of fresh, clear water to the surface, even during prolonged droughts. Jacob's Well and Cypress Creek are threatened by NPS pollution and increased groundwater pumping caused by rapid and water-intensive development in the area. Continuing and accelerated urbanization and persistent drought add further stress to Jacob's Well and Cypress Creek.

Baseflow to Jacob's Well is likely artesian flow from the Cow Creek up through the confining Hensel and Lower Glen Rose formations. The following excerpt from Wierman et al's 2008 report describes this baseflow and recharge:

Groundwater under artesian conditions in the Cow Creek section of the Middle Trinity Aquifer provides the majority, if not all of the base flow at Jacob's Well (Wierman et al 2008) Recharge from storm events may enter the subsurface and provide direct recharge to the Well through surficial karst features in the area. Dye tracing studies during storm events would be necessary to confirm this recharge pathway (Wierman et al 2008).

Because flow at Jacob's Well is very sensitive to groundwater levels in the Middle Trinity Aquifer, the spring is the proverbial canary in the coal mine for the health of the underlying aquifer. The spring flowed through the 1950's drought of record; yet in last decade Jacob's Well has stopped flowing several times in response to much less severe droughts than were experienced in the 1950s.

During dry conditions accompanying the drought in the summer of 2000, Jacob's Well ceased to flow for the first time in recorded history, degrading fish, wildlife, and water quality. During the drought of 2008-2009, the well stopped flowing again, for 167 days. The spring ceased flowing again in 2011. This cessation of flow is partly attributed to a

two to three foot drawdown of the aquifer, as well as the effects of persistent drought conditions.

A 30 foot drawdown of the Trinity Aquifer has been set by the regional groundwater authorities, Groundwater Management Area 9 and Hays Trinity Groundwater Conservation District. Regional experts and critics of the drawdown highlight the negative impacts to well owners, landowners, aquatic habitats and businesses dependent on the spring flow, which feeds the Cypress Creek and other creeks, rivers and streams in the Hill Country.

Gaps in available "Source Water" information:

The health of Cypress Creek is highly dependent on maintaining adequate spring flows, making recharge and groundwater or source water management in the larger region critical to maintaining a healthy system. Dr. Vogl's 2011 report indicated that future research required includes the use of compiled data and information from regional conservation partners to "develop a conservation plan and implementation strategy that will address long-term land conservation needs." Effective management and protection of source water is dependent on adequate information and available data.

Wierman et al (2008) recommended activities to improve understanding of flow and recharge to Jacob's Well and Cypress Creek:

- Continue existing water level monitoring, including maintaining and expanding the network of pressure transducers,
- Collect available information and water levels from wells completed in the Lower Trinity Aquifer to determine groundwater flow directions and establish a baseline of water levels,
- Install series of dedicated monitoring wells to be permanent water level monitoring points,
- Perform geologic field reconnaissance and map the Cow Creek/Hensel outcrop along the Blanco River near Valley View Road,
- Perform periodic loss/gain studies along Cypress Creek/Blue Hole and the Blanco River Establish and maintain a series of precipitation monitoring stations throughout the Cypress Creek watershed and further west towards the outcrop areas of the Cow Creek, Hensel and Lower Glen Rose in Blanco County,
- Develop predictive groundwater model for the watershed that accounts for changes in groundwater withdrawal, and
- Conduct dye trace studies in surficial karst features near Jacob's Well.

In 2013, USGS identified the following data needs relating to source water management for Jacob's Well:

- Enhancement of existing continuous monitoring of discharge and selected physicochemical constituents at Jacob's Well,
- Compilation and analysis of historical hydrologic, geologic, and water-quality data,
- Groundwater monitoring, and
- Identification and mapping of geologic and potential recharge features.

The following paragraphs are reproduced from a USGS proposal written in August 2013 by Patty Ging and MaryLynn Musgrove, *Surface Water and Groundwater Conditions near Jacob's Well, Hays County, Texas.*

> New and planned developments in the Wimberley Valley area are anticipated to increase withdrawals from the Trinity aquifer, which supplies discharge at Jacob's Well. There is concern that increased groundwater withdrawals might reduce discharge from the spring. Little streamflow or groundwater level, and water-quality data exist for the area around Jacob's Well, in the Cypress Creek watershed or for nearby areas of the Blanco River watershed that might contribute recharge to Jacob's Well. Such data, however, are critical for understanding the regional and local hydrogeology, for the preservation of spring flow, for regional water-use management, and for understanding the effects of urbanization on spring flow and water quality.
>
> Continuous discharge has been collected at Jacob's Well since 2005, and temperature, specific conductance, and turbidity data have been collected since 2009, but with little data analysis. Baseflow discharge from Jacob's Well is likely maintained by artesian flow from the Cow Creek formation of the Middle Trinity aquifer (Wierman and Hunt, 2011). During major rainfall events, observed increases in discharge at Jacob's Well might result from a variety of recharge sources, including surface water and recharge features in the Cypress Creek and Blanco River watersheds.
>
> Knowledge of the hydrologic interconnection of Jacob's Well and Cypress Creek with the local and regional aquifer flow system, surface water and groundwater interaction, and recharge sources is lacking, and recharge sources that supply discharge at Jacob's Well are not defined.

Addressing Data/Information Gaps

Guidelines have been developed in other states for developing source water protection strategies. One strategy developed in Illinois, utilizing local subject matter experts, community members, regional and state environmental agencies and the USEPA is particularly well suited to the Cypress Creek Watershed: Groundwater Protection Needs Assessment, referred to as GPNA. The purpose of a GPNA is to comprehensively determine and evaluate groundwater protection measures necessary "to assure a long-term supply of potable water that is not highly vulnerable…" Although initially developed to evaluate groundwater quality, this strategy can be

a valuable mechanism for protecting source waters at a regional scale. Community impacts considered include devalued real estate values and sales, losses to tax bases, increased operation costs of supplying water and long term remediation costs – in short, issues addressed in the overall WPP. Methodologies relating to addressing data needs are detailed below as well as recommended approaches for designing and implementing a groundwater protection plan are reported.

A guidance document prepared by the Illinois Environmental Protection Agency, Geological Survey and Water Survey lays out the following recommendations for a groundwater protection needs assessment development process[1] (IEPA 1995):

> **Scoping Process – collecting data and information about the hydrogeology of the regional aquifer systems; collect land use data and zoning information.** Both of these activities have been completed in Phases I and II of the Cypress Creek Project, in both the Watershed Characterization and the Watershed Protection Plan. Additionally, much of the data and information lacking have been determined in part by recent proposals (some listed above) and are intended to be reviewed and prioritized by the Cypress Creek Technical Review Committee during the Interim Period.
>
> **Detailed Technical Analysis and Options Development – analysis of recharge and flow characteristics and conditions, as well as regulatory frameworks.** Several initial efforts by researchers from HTGCD, WVWA and other institutions have helped to determine information about regional groundwater flow systems; characteristics and locations of recharge areas; anticipated changes to land use effects within the recharge area; groundwater district, groundwater management areas and county and municipal jurisdiction boundaries relative to the recharge areas; and, regulatory enforcement mechanisms for pumping, desired future conditions and potential desired spring flow regimes. Existing direct and indirect protection afforded to recharge areas must be evaluated to determine scope and extent of special groundwater management area.

Modeling Groundwater, Source Water and Flow

Groundwater flow modeling can improve conceptualization of the relationships between recharge and groundwater and surface water flow regimes. An outcome of this improved understanding is the ability to determine and prioritize additional data collection efforts. While delineating recharge areas, modeling can also estimate the head distribution across the watershed and recharge zones, allowing flow path and travel-time analyses. Most importantly, groundwater flow modeling can report the effects of increased groundwater withdrawal patterns on the groundwater levels, flow patterns and ultimately surface water quantities at Jacob's Well and in Cypress Creek.

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[1] http://www.epa.state.il.us/water/groundwater/publications/needs-assessment.pdf

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.

The Edwards Aquifer Authority is evaluating inter-formational flows and other hydrogeological relationships in this study area[2]. A model has been proposed by Ron Green at the Southwest Research Institute (SwRI) which would examine groundwater at a very local scale and could be potentially interfaced with the Cypress Creek DSS. Additionally, research staff at The Edwards Aquifer Authority is undertaking a five year study regarding the interface and relationship between the Edwards and Trinity Aquifers. This data can be used to further refine the nested modeling tool. Finalization and tailoring of these models for coupling with the existing Cypress Creek modeling tools is included in the WPP implementation schedule and has been recommended as a necessary management measure for protecting water quality in Cypress Creek.

The lists below provide a framework for data, inputs and structure required by groundwater and source water flow modeling.

Data Requirements for a Predictive Model (IEPA 1995)

Physical framework

- Hydrogeologic map showing aerial extent, boundaries, and boundary conditions of all aquifers under investigation,
- Topographic map showing surface water bodies,
- Water table, bedrock configuration, and saturated thickness maps,
- Hydraulic conductivity map showing aquifer and boundaries,

[2] EAA Board Tech Briefing – 20130910 – Marcus Gary

- Hydraulic conductivity and specific storage maps of any confining beds,
- Map showing variation in storage coefficient of aquifer,
- Relationship of saturated thickness to hydraulic conductivity,
- Relationship(s) of any stream(s) and aquifer (hydraulic connection).

Stresses on groundwater system

- Type and extent of recharge areas (irrigated areas, recharge basins, recharge wells, etc.),
- Surface water diversions,
- Time-varying groundwater pumpage,
- Streamflow (if applicable),
- Precipitation,
- Evapotranspiration.

Other factors

- Information on the local water supply,
- Legal and administrative rules,
- Planned changes in regional water and/or land use.

Approaches for Developing a Source Water Protection Strategy

Current and potential future water quality concerns affecting recharge areas are defined in Elements A and B of the WPP and can be used to determine comprehensive groundwater protection options. Potential in situ management solutions are presented in Element C as well as in the Adaptive Management section's management considerations.

Specific activities needed may include:

- Updating and assessing existing information compiled regarding recharge areas and flow regimes,
- Updating/Developing a hydrogeologic data base,
- Describing the groundwater flow system,
    - Selecting representative wells for collection of groundwater level data,
    - Measuring groundwater levels in selected wells & determine groundwater surface elevations,
    - Preparing potentiometric surface maps and determine direction of groundwater movement,
- Finalizing delineation of groundwater recharge areas or capture zones,
    - Assembling data set for flow modeling,
    - Calibrating flow model (compare modeled heads with actual head measurements),
    - Performing flow path analysis to delineate groundwater capture zones (IEPA 1995).
- Identify Cypress Creek ~Jacob's Well Springshed, effects of land cover alteration, base flows, flow patterns (some or all may be addressed by USGS suggested study),

- USGS studies: continue monitoring at JW, analyze historical discharge and WQ data, synoptic and event based WQ studies, expansion of groundwater monitoring program and compilation of local pumping records, mapping recharge features, synoptic water-level measurements, flow-modeling approaches
- Integration of SELECT (or other modeling) with both long-term water quality monitoring and the targeted sampling efforts will allow assessment of management measures
- Identify critical karst recharge features
- Dye trace studies[3]

The Illinois guidance document includes the following steps for designing a protection strategy:

> Three potential options for protection of groundwater resources (specifically source waters) are regulatory (state and/or local), non-regulatory (voluntary) and legislative, or some combination of the three. Voluntary or regulatory local, regional or state management controls that should be applied to protect well and groundwater recharge areas. Implementation of these controls may be phased over time to mirror local conditions and readiness to proceed.
>
> Local, Watershed Management/Protection Options
> Zoning ordinances can be useful tools for land use and development strategies to conserve water locally. Zoning restrictions on development between cities and counties within the watershed should align types of land use allowed, density of development, placement of structures on lots (setbacks), street frontage, parking, signage and potential development, storm water mitigation credits (like those in the Wimberley Water Quality Ordinances) for best management practices, including rainwater harvesting, rain gardens, swales and other physical features. Aligning such city and county ordinances will result in easier tracking, measurement and management of withdrawal quantities and non-point source pollutant mitigation.
>
> The following information on overlay districts is reproduced from the Illinois guidance document: *One form of zoning that could be applied to protect recharge areas is referred to as an overlay zoning district. Overlay districts are adopted by communities to protect a range of resources including recharge areas, surface watersheds, and wetlands or to protect from threats such as floods. To establish an overlay district, the community must have a map of the recharge area necessary for protection of a resource (i.e. recharge area). Once a community knows which areas impact its public groundwater supplies, an overlay district is adopted within which additional land use controls apply. Examples of controls applied in overlay districts include prohibiting or restricting certain uses, or imposing performance standards and site design requirements. Overlay zoning invokes taking an already zoned area and overlying an additional zoning district and regulations on that land area. An advantage of an overlay district is that regulatory changes only apply to areas affecting a particular resource.*

[3] http://www.karstwaters.org/files/dyetracer.pdf

Local Non-regulatory Approaches

Voluntary approaches for protecting recharge areas typically take the form of public education and can be tied to the ongoing pollution prevention and water conservation efforts presented in this community's Outreach and Education Plan beginning on page X and selected BMPs for implementation, Tables X-X, pages X-X. Coordination of education and outreach efforts with groundwater protection and management organizations (GCDs, GMAs) and the establishment of local groundwater protection programs are important. Public education and outreach activities are paramount in building public support for regulatory changes and local funding, as well as for water conservation efforts.

Other voluntary approaches include voluntary conservation programs for local businesses and well owners and coordinated conservation efforts with local water providers. The Stakeholder Committee has identified meeting with water providers to discuss rate strategies, other water conservation efforts and potential changes to pumping regimes as an Interim Committee task to be performed in the Winter/Spring of 2013-14.

Protecting recharge and minimizing future withdrawals can be achieved through strategic land acquisition, easements and purchase of development rights. Although expensive, acquisition of lands with known recharge features and future development potential (both inside the watershed and the contributing zone) can protect local recharge. The formation of a Cypress Creek land trust and increased efforts for conservation easements and purchase of development rights are management practices selected by Cypress Creek stakeholders. These activities could include a focus on recharge protection. Please see pages X and X for additional information on these BMPs.

State Regulatory Management/Protection Options

A portion of Hays County is encompassed by a Priority Groundwater Management Area (PGMA) designated to ensure the management of groundwater in areas with "critical groundwater problems." A PGMA evaluation considers options and needs for the creation of groundwater conservation districts, which are authorized to "adopt policies, plans, and rules that can address critical groundwater problems"[4]. Locally developed and enforced Groundwater Conservation Districts (GCD) are created through PGMA activities. The Hays Trinity Groundwater Conservation District is the established GCD overlaying the Cypress Creek Watershed and a large portion of the likely recharge areas for the source waters of Jacob's Well and Cypress Creek. The District defines it goals and activities as follows: *to conserve, preserve, recharge and prevent waste of groundwater within western Hays County. To help accomplish these goals the District is charged to gather information needed for sound decisions, to provide information to citizens and*

[4] http://www.tceq.texas.gov/groundwater/pgma.html

local agencies, and to insure that groundwater is used efficiently and at sustainable rates.

Groundwater Management Areas (GMAs) "provide for the conservation, preservation, protection, recharging, and prevention of waste of the groundwater, and of groundwater reservoirs or their subdivisions, and to control subsidence caused by withdrawal of water from those groundwater reservoirs or their subdivisions." GMA 9 encompasses 9 GCDs, including the HTGCD[5].

In July of 2010, a TWDB approved a Desired Future Conditions (DFC) allowing an average drawdown of approximately 30 feet by 2060 of the Trinity Aquifer located in GMA 9. A DFC is a management goal set by regional GCDs. The DFC was challenged and appealed locally by several entities and agencies, based on scientific evidence that such a large drawdown of the aquifer could result in local spring flow and base flow rates permanently declining to below long-term-average historical conditions. The DFC was formally approved in March of 2012.

More comprehensive regional groundwater protection for Jacob's Well and Cypress Creek can be achieved through the creation of a Special/Specific Groundwater Management Area (SGMA). A resolution describing the need for a SGMA was presented to the Wimberley City Council and passed in February, 2012.[6]

In March, 2012 local stakeholder requested that the Texas Water Development Board recommend a SGMA or groundwater management zone for Jacob's Well. TWDB responded that creating a SGMA was not on the current agenda and stated that the local groundwater districts currently have the authority to create SGMAs, with such responsibility falling to (HTGCD). GMA-9 Coordinator Ron Feisler indicated that "GMA-9 is willing to have discussions to consider a SGMA in Wimberley." HTGCD board member Ed Pope, President Jimmy Skipton and treasurer Mark Key also voiced support for a SGMA to manage Jacob's Well. The Cypress Creek Stakeholder Committee has identified the creation of a SGMA as a necessary management measure to protect water quality and related source flows.

Source Water Protection for Cypress Creek

Currently, low spring flows coupled with high E. coli levels are threatening Cypress Creek. 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, Stakeholder Creek Stakeholders assert that water quality

[5] http://www.twdb.texas.gov/groundwater/management_areas/

[6] http://hayscard.org/downloads/WIMBERLEY%20RESOLUTION%20DFC%20R-02-2012%20(Encourage%20Specific%20GMA%20for%20Jacobs%20Well).pdf

in Cypress Creek will continue to be impaired and will worsen in the future without flows from Jacob's Well.

Additionally, local public water supply provider – Aqua Texas – has repeated human health based, monitoring, and reporting violations in their system for Woodcreek (Woodcreek Utility Co. 2) and that system is designated - Groundwater Under the Influence of Surface Water by TCEQ. [7] Other boil water notices[8] have been issued to residences, but these data sources and information have yet to be researched and analyzed for opportunities to incorporate into the WPP.

In Phase 1 of the Cypress Creek Project, the Stakeholder Committee identified that future development threatens surface water quality from above and below the ground. In Phase 2, the Committee voted to adopt a suite of management measures to address surface water quality issues while protecting source water flows. Source water protection strategies will enhance efforts of a collaborative management and governance scenario for local water resources.

EPA Source Water Protection documents offer the following guidance regarding source water protection at the watershed level: *Communities can implement ground water protection through wellhead protection programs and surface water protection programs that use watershed management strategies. These programs involve assessing the problems in the protection area, identifying and prioritizing management measures for those problems, and then implementing the management measures*[9]*.*

The Cypress Creek Stakeholder Committee identified several potential components that are critical and must be included in a source water protection strategy for their watershed. It is anticipated that additional research and modeling will allow stakeholders to further develop this strategy and refine the current goals, management activities and monitoring set forth below. The need for water demand reduction was ranked as the most important and demand reduction measures can be implemented while required technical studies are being conducted.

Vogl (2011) recommended that for short-term planning, conservation efforts should be targeted toward "areas with a higher probability of direct connection to the Trinity Aquifer and Jacob's Well, particularly areas in close proximity (such as within the Cypress Creek watershed)."

The development of a SGMA and similar protection activities also were highly ranked by the Stakeholder Committee. Reviewing local and regional regulations based on effects of research

[7] http://oaspub.epa.gov/enviro/sdw_report_v2.first_table?pws_id=TX1050039&state=TX&source=Groundwater_under_infl_of_surface_water&population=1857&sys_num=0

[8] http://hayscountyroundup.blogspot.com/2010/02/tceq-finds-e-coli-in-raw-water-sample.html

[9] http://water.epa.gov/infrastructure/drinkingwater/sourcewater/protection/localprotection.cfm

and modeling for potential improvements to surface water protection is included among additional components that could be implemented based on the outcome of the planned studies and modeling.

Evaluation and Refinement

Groundwater and source water protection efforts should include mechanisms for evaluation and refinement. Because a recommendation for a Special Groundwater Management Area and a source water protection strategy will be finalized by stakeholders in the watershed in conjunction with WPP as an adaptive management strategy, these mechanisms will be well developed and married with the WPP's water quality milestones and criteria for success, as well as triggers and protocols for adaptive management.

Local Prioritized Goals for Spring Flow and Ground Water Quality

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. Preliminary goals are listed below, with the primary purpose of preserving flows.

Preserving Cypress Creek headwaters and flow regime at or above WPP target of 6 cfs

The stakeholders are concerned about Cypress Creek becoming an intermittent stream and the effects this will have on water quality. Recent monitoring data indicates the creek flows are below 1 cfs. Including strategy sets for preserving (or recovering) the hydrologic regime is 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 and was 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.

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

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

Establish science process, proposals, and estimated budget needed for determining

recharge and artesian area (aka "defining the SGWMA") 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 source water

1.8 Potential Funding Sources

- EPA Source water protection funds: water.epa.gov/infrastructure/drinkingwater/sourcewater/protection/funding.cfm
- Clean Water State Revolving Funds (http://go.usa.gov/2K9z www.cfda.gov/)
- Clean Water Act funds
- Water Pollution Control Program Grants (section 106)
- Safe Drinking Water Act
- Drinking Water State Revolving Fund (DWSRF)
- Water Quality Cooperative Agreements
- Environmental Quality Incentives Program (EQIP) – USDA
- USDA Conservation Reserve Program (CRP)
- USDA Conservation Stewardship Program (CSP)
- Environmental Education Grants
- Targeted Watershed Grants Program
- Water Resources Research National Competitive Grants Program – USGS
- TSSWCB {Previously funded studies include: GW nitrogen source identification, Preventing WQ contamination through TX Well Owner Network, BMPs to reduce Nitrogen impacts in GW, Identify and characterize NPS bacteria (funded water quality monitoring of groundwater to examine potential role of subsurface flows), Seymore Aquifer water quality improvement project?}
- Private
- City, county funding (strategies may fall under existing initiatives)
- Wimberley Water Supply Corporation / Aqua Texas

PRELIMINARY BMPs FOR SOURCEWATER PROTECTION TO BE CONSIDERED

PRELIMINARY BMPs FOR SOURCEWATER PROTECTION

Management Measure	Applicable Area	Milestones	Year of Implementation			
			1-2	3-4	5-6	7-8
Highest Prioritization						
Water Conservation Pricing Strategies	Basin-wide	Identification of successful pricing strategies				
	Basin-wide	Finalize pricing schedules and adoption by water providers				
	Basin-wide	Implementation of new pricing and monitoring of water use changes.				
Water Conservation Program for Water Providers or Municipalities	Basin-wide	Identification of successful program components.				
		Development of program, schedule and adoption by water providers				
		Implementation of program and individual measures. Monitoring of water use changes.				
Ground Water Protection Strategy						
GW (Flowing) committee meets to ensure GW strategy implementation						
Begin meeting with responsible parties to determine what actions are possible						
Identify what GMA9 process standards are used so CCP can speak their language						
Apply for funding and technical assistance – including JW USGS						

PRELIMINARY BMPs FOR SOURCEWATER PROTECTION						
Management Measure	**Applicable Area**	**Milestones**	**Year of Implementation**			
			1-2	**3-4**	**5-6**	**7-8**
gage						
Identify avenues to create a SGMA-Watershed Management Boundaries						
Begin SGMA process						
USGS study						
Determine what CCP needs to know to protect GW – (beyond current knowledge base)						
Coordinate CCP conservation efforts and determine if they can work beyond the watershed to include the Cypress Creek Jacob's Well Springshed.						
Conservation Easements	Basin-wide with priority in Group C	Coordinate with existing easement efforts to identify potential parcels and funding.	Move Here			

PRELIMINARY BMPs FOR SOURCEWATER PROTECTION						
Management Measure	**Applicable Area**	**Milestones**	**Year of Implementation**			
			1-2	**3-4**	**5-6**	**7-8**
		Coordinate with groundwater management activities				
Karst Feature Protection Measures	Basin-wide	Identify features and prioritize.				
		Implement protection measures for top 5 features.				
Purchase of Development Rights	Basin-wide with priority in Group C	Coordinate with existing easement efforts to identify potential parcels and funding.				
		Coordinate with groundwater management activities				
Medium Prioritization						
Rainwater Harvesting Strategies SHOULD BE HIGHER UP	Basin-wide with emphasis on existing development.	Education and Outreach material compiled and distributed. (Can be done in conjunction with water conservation program and other landscaping programs).				
		Demonstration areas in city and county areas.				
		Finalize and implement incentive or assistance program.				
	Basin-wide with emphasis on new development.	Coordinate with city, state and county efforts to guide implementation of individual and system wide rainwater harvesting systems.				
Cypress Creek Land Trust	Basin-wide with priority in Group C	Identify partners Coordinate with established land trust and develop the land trust.	Move Here			
		Coordinate with existing easement efforts to identify potential parcels and funding.	Move Here			
		Coordinate with groundwater management activities				
Biofiltration/Rain	Basin-wide	Education and Outreach material				

PRELIMINARY BMPs FOR SOURCEWATER PROTECTION						
Management Measure	**Applicable Area**	**Milestones**	**Year of Implementation**			
			1-2	**3-4**	**5-6**	**7-8**
Garden		compiled and distributed. (Can be done in conjunction with water conservation and LID practices.)				
	Basin-wide	Demonstration gardens in city and county areas.				
	Basin-wide with emphasis on new development	Coordinate with at least 4 developers to implement rain gardens in new development/construction.				
Landowner Incentive Program	Basin-wide with priority in Group C	Coordinate with existing easement efforts to identify potential parcels and funding. (Can be done in conjunction with conservation easements with current and Cypress Creek Land Trust)				
		Coordinate with groundwater management activities	Move Here			
Watershed Coordinator pending stakeholder committee approval HIGH**	Basin-wide	Cooperative agreement and finding from basin partners. (Cities, county, river authority, Meadows Center and NGOs).	High			
		Stakeholder committee interview and hire watershed coordinator.				
		Stakeholder committee and partners review watershed coordinator progress.				
SGMA HIGH	TBD	Formation of workgroup to determine criteria and delineate SGMA boundaries.	High			