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KARST SENSITIVITY MAP FOR HAYS COUNTY

Edwards Aquifer as seen from inside Ezell's Cave, Hays County, Texas

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Abstract

We used biological and geological data to create a map detailing areas of sensitivity with respect to geology, cave and karst feature distribution, and karst and aquatic species distribution in Hays County, Texas. The map delineates all geologic outcrops that may contain caves and karst features (karst terranes), and within those outcrops there are Generalized Cave Locations showing where known caves and karst features occur. The Generalized Cave Locations, delineated using detailed geologic maps and probable hydrologic catchment, are further divided into two categories: those that are known to contain rare species and those that are not. The Biological Advisory Team to the Hays County Regional Habitat Conservation Plan (RHCP) used various filters to create the list of rare species, including distribution within the county, state distribution (S-ranks), global distribution (G-ranks) and state and federal protection. For purposes of the RHCP these rare species are identified Evaluation Species of Concern, which include the first 40 taxa in Table 1, and Additional Species of Concern which are the final five federally listed species in Table 1.

Land planners should generally consider all geologic outcrops that may contain caves and karst features more sensitive than non-karst terranes. Their characteristics include rapid recharge of unfiltered surface water into the subsurface and high flow velocities within the system - features that increase the likelihood and severity of contamination events. Within the sensitive karst terranes, Generalized Cave Locations with known karst features are more sensitive than those areas outside of the Generalized Cave Locations, with the caveat noted below. Among the Generalized Cave Locations, those known to have rare species in them are more sensitive than those without, also noting the caveat below.

The caveat is that this report is an accumulation of the data available to us at this point. There have been very few systematic efforts to map caves, karst features, or terrestrial cave invertebrate distribution in Hays County. The cave and karst invertebrate results summarized herein are primarily the product of sporadic cave surveys done by recreational speleologists using inconsistent methods over several decades. Due to these shortcomings, the distribution of caves and species is not representative of what actually exists, but rather of our current state of knowledge. For this reason it is quite likely that a cave fauna inventory would not only find cave and karst features previously unmapped, but possibly new localities for rare karst species.

Methods

Biology

We consulted a variety of sources to accumulate rare troglobite species distribution data for the county (Table 1). We used the database of karst invertebrates in the Texas Memorial Museum (maintained by James Reddell) as a foundation for species range data. Other recent publications cited in the results provided information relevant to Hays County. Additionally, we conducted interviews of active taxonomists, cave biologists and land managers (James Reddell, William Russell, Randy Gibson, Dave Hillis, Dee Ann Chamberlain, Nico Hauwert Nate Bendick, Andy Gluesenkamp, Chris Thibodaux, Andy Grubbs, Peter Sprouse, Pierre Paquin and Pat Connor). James Reddell provided a list of taxa from an unpublished report on the fauna of caves along a proposed extension to Wonder World Drive in San Marcos, Texas.

There have been no systematic efforts to survey the karst fauna of Hays County. Of the known caves and karst features, biologists made collections in less than 25% of them, and of those, very few have been intensely surveyed with the goal of identifying every species in the cave. The bulk of the species records summarized herein are the result of sporadic collections made by recreational speleologists using inconsistent methods over several decades. During a single study performed on the proposed extension to Wonder World Drive in San Marcos, surveyors made an effort to systematically bioinventory 11 caves, karst features, and wells, but even this study only consisted of one or two visits to those sites (though the report also summarized historic visits). Given the low numbers of individuals, small physical sizes, and sheltering habits of troglobites, they have low detectabilities and require greater than ten visits to find the majority of taxa that occur in a cave (Krejca and Weckerly 2007). Ezell's Cave is the only cave in Hays County visited orders of magnitude more times by biologists than any other cave in the county, and most in the state. It is famous for access to the Edwards Aquifer and a population of Texas Blind Salamanders, *Eurycea rathbuni*. However even this cave, visited at least 50 times by invertebrate biologists, yielded a new record for *Rhadine* n. sp. 2 (*subterranea* group) in 2007, demonstrating that multiple visits are required in order to find taxa with low detection probabilities.

There is a single locality with remarkable diversity worthwhile of mention because of the many synonyms. In this report, we call it the Artesian Well, but it also is referred to as: Old Federal Fish Hatchery well, U.S. Fish Commission well, Artesian Well at/in San Marcos, San Marcos Artesian Well, Artesian well on [TSU/SWT] campus.

Given the scope of this project, we made only a minimal attempt to describe the biogeography of the taxa in Table 1. Reviewing the geologic unit(s) these 45 species are known from and the geographic spread of the localities yielded no obvious correlations. We recommend performing additional work, including species surveys, phylogenetics, and analyses of endemicity in order to make and test biogeographical hypotheses. Some of these are discussed in the recommendations section.

Geology

We consulted several geologic maps to take advantage of the best-resolution mapping available and to create the composite geologic basemap for this project. Hanson and Small (1995) provided the mapping of Edwards Limestone at the member level. The Geologic Atlas of Texas (University of Texas 1979; 1981a; 1981b; 1983) was used to compare the overall extent of the Edwards Limestone to the Hanson and Small (1995) maps. The GAT maps also served as the basis for delineating Glen Rose outcrops. While the upper member of the Glen Rose formation has been formally subdivided and mapped in northern Bexar County (Clark, 2003), that scale of mapping has not yet been published for Hays County. These publications include maps created at a regional scale, and the boundaries of the karst terranes of Hays County presented here have a similar resolution; local studies will lead to a refinement of our understanding of the limits and distribution of karst resources in Hays County. The scope of this project did not include ground-truthing the geological mapping.

Based on the distribution of known karst features relative to bedrock geology, we designated five types of bedrock outcrop where karst features are likely to form, and refer to them as karst terranes. These outcrops are, from youngest to oldest, the Buda Limestone, the main outcrop of the Edwards Aquifer (Georgetown, Person, and Kainer Formations), outliers of the Kainer Formation that are geographically isolated from other outcrops of Edwards Limestone, the lower member of the Glen Rose Formation, and the Cow Creek Limestone. We acknowledge, as discussed below, that the distribution of known karst features is strongly biased by the places where people have been able to look for them. Future surveys in the karst terranes are likely to discover additional caves and karst features, but karst features are not likely to be found outside of these karst terranes (white or ‘non-karstic’ areas in Figure 1). However, it must be noted that while it is unlikely to find caves outside of the karst terranes, it is not impossible. In five specific cases there are occupied springs and wells that are outside of mapped karst terranes, and they are explained here. We derived four spring locations occupied by *Eurycea pterophila* from Heitmuller and Reece (2007). In Figure 1 they appear as a single red polygon spanning the western border of the county and just north of the Lower Glen Rose areas, two red polygons in the south central part of the county between the Lower Glen Rose and Georgetown/Edwards outcrops, and a single red polygon on the northern border of the county just north of the northernmost extent of the Georgetown/Edwards outcrops. These are springs that may be discharging from buried cavernous limestone, or they may be innacurately located. A final occupied location outside of mapped karst terranes is in the southeast part of the county east of the majority of mapped Georgetown/Edwards outcrops. This is the single known locality for *Eurycea robusta*, which was collected from a narrow vertical fissure located in the Austin Chalk (a non-cavernous unit), but probably originated from the underlying Edwards Limestone (Russell 1976).

There has been no formal or professional survey of all of the karst of Hays County. There have been few formal karst surveys in any areas of the county. The known caves are known because of the efforts of individuals, almost exclusively volunteers, who have tried to catalogue what caves they found or heard of. There are many reasons that caves have gone undocumented, but the primary reason is limited access to private property. The variable level of urbanization also plays a role. While access to land might be better while property is being developed, caves are also destroyed or obscured during development. The Texas Speleological Survey (TSS) generously allowed access to their database, which contained references to 361 karst features. Of these, 268 had recorded locations and 93 did not. After careful inspection of the data and consultation with several speleologists familiar with the area, we added several new caves to the list, and determined that some features consisted of duplicate names to previously known caves. Interpretation of the karst terranes was based on a final list of 301 caves and karst features (Table 2). The locations of these features came from trusted sources, but most have not been field verified by the authors. Therefore if this map is used to determine exact boundaries for sensitive parcels, field verification should be performed. There are still over 70 records of caves and karst features for which locations and descriptions could not be obtained. These features may have been destroyed since they were discovered or may be on property which is now inaccessible. Old descriptions may be inadequate, or the modern landscape may have changed too much in recent years to use old descriptions to estimate locations.

We constructed the maps presented here as shapefiles in ArcMap 9.2 (Figures 1 and 2). The reference is to UTM Zone 14 North coordinates and North American Datum 1983. The TCEQ Edwards Aquifer Recharge Zone shapefile is in UTM Zone 14 North coordinates and North American Datum 1927. No specific locations of caves or karst features are given. Instead, we created Generalized Cave Locations, polygons around precise locations of caves, springs, and other karst features. To make the Generalized Cave Locations we plotted precise feature locations over a topographic map and a composite geology map (based on all of the geologic maps cited above). Then we drew polygons around those precise locations based on geologic interpretation and a buffer around the location. This method, per agreement with the TSS, avoids publishing exact cave locations in a form that could enable trespassing and vandalism on private or public property. The geologic and geomorphologic interpretation used to create the polygons included the member-scale mapping of Hanson and Small (1995) in the Edwards Limestone, and the probable hydrologic catchment of specific caves. Catchment areas were based on topography and an interpretation of the

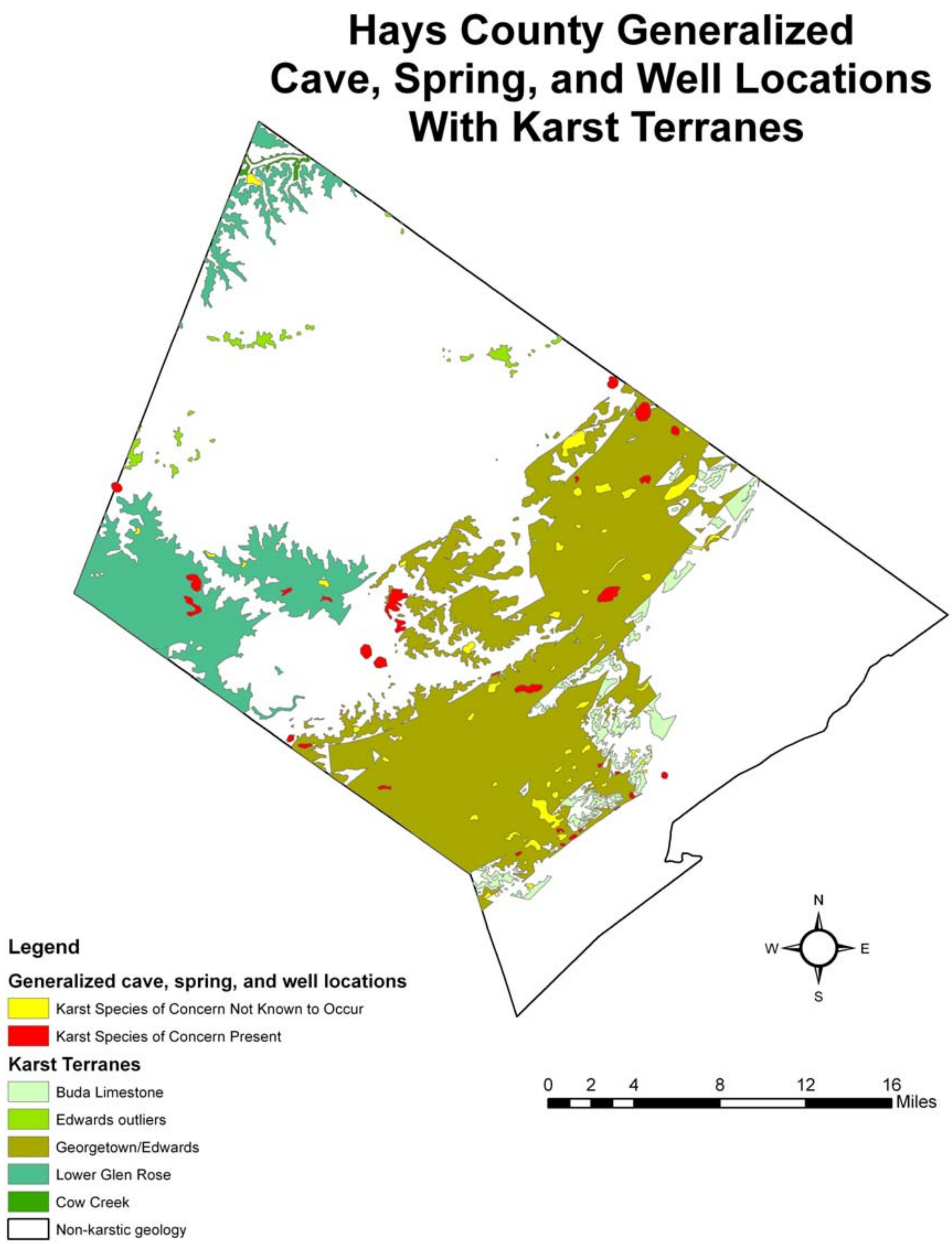

Figure 1. Hays County karst terranes and Generalized Cave Locations, showing distribution of rare species.

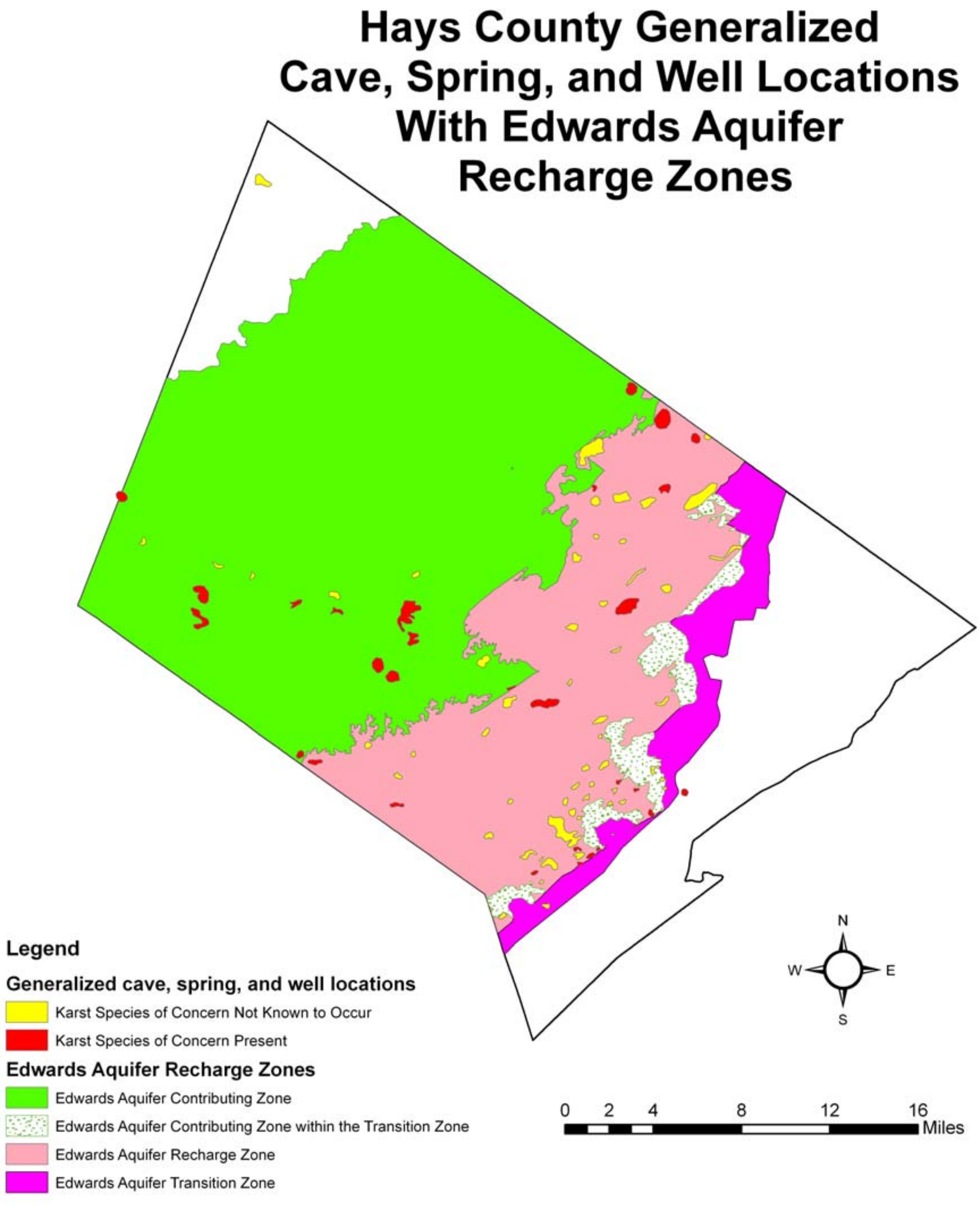

Figure 2. TCEQ Edwards Aquifer Recharge Zones in Hays County showing locations of rare species.

speleogenesis of individual caves, when possible. We interpreted the speleogenesis based on the physiographic settings of caves, as well as cave maps, personal knowledge of the authors, verbal descriptions, or photos from other speleologists. Extensive examples of how geologists interpret speleogenesis can be found in Klimchouk et al. (2000).

In several cases reliable cave locations indicated that the regional-scale bedrock mapping was incorrect. In these cases we adjusted karst terrane boundaries to include the following caves: Academy Cave, Bethke Ranch Cave, Fern Bank Spring, Finger Cave, Kira's Karst Park, Quarry Cave, Quarry Sink, Radiance Sink, part of the San Marcos Spring complex, Sites' Cave, Spring 015, WWD-24, WWD-59, and WWD-60. Similarly we included a set of springs in the top of the upper member of the Glen Rose Limestone, which are almost certainly discharging water that recharged through the adjacent Edwards uplands.

Results

Each taxon listed in Table 1 is discussed in detail in another appendix of the Hays County Regional Habitat Conservation Plan. In many cases the known distribution of these taxa includes only a handful of localities, and many already fit the criteria of globally endangered by the World Conservation Union (Baillie et al. 2004). With more collecting effort in the county, some species records will undoubtedly increase in number accompanied with an increase of the overall size of their range. In cases where undescribed species are considered (e.g. *Neoleptoneta* n. sp. eyeless), it is possible that the range in the species description will be different than the estimation made herein. The species description in the scientific literature should be the ultimate source for information on these as-yet unrecognized species.

The lack of systematic karst surveys of the karst terranes of the county and a lack of detailed information about many of the caves that have been reported limit the analysis we can perform of the karst of Hays County. Ideally, we would base analyses on detailed cave maps and geologic observations for each cave. That information is not readily available, and that level of analysis is beyond the scope of this project.

We present a basic discussion below, addressing the cavernous nature of bedrock in Hays County from youngest to oldest. Before describing the karst terranes, we note several features excluded by the karst terranes. East of the Balcones fault zone, bedrock mapping is difficult due to the lack of outcrops. East of the Balcones fault zone, there are two karst features which might be located in the Austin Chalk (Cave on old Haupt place, small holes on Plum Creek). Veni (1998) noted that the Austin Chalk is cavernous in some parts of central Texas. These features cannot be assigned confidently to the Austin Chalk due to disagreement between the maps consulted, so we do not include the extent of the Austin Chalk in the set of karst terranes. These features may also be located stratigraphically lower, in a non-karstic rock overlying the Buda Limestone. If so, they could result from collapse or piping into karst features in the underlying Buda Limestone. Little is known about these features, and due to the uncertainty of their nature and geology, we did not represent these features with Generalized Cave Locations.

The Buda Limestone outcrops primarily in the central and southeast part of the county, along the eastern boundary of the Balcones fault zone. It forms occasional caves in Hays County, and is underlain by the Del Rio Clay, which is relatively impermeable. Of the 301 karst features analyzed in this project, six are located in the Buda Limestone (Academy Cave, Bethke Ranch Cave, Ken Barnes' Cave, Quarry Sink, Sink (Ogden 10) and Sink (Ogden 11)). Caves in the Buda Limestone are likely to be relatively shallow and discharge along the Buda/Del Rio contact. However, in low lying areas where this contact is not exposed, the possibility exists that water entering karst features in the Buda Limestone (within the Edwards Aquifer Contributing Zone within the Transition Zone) continues downward into the Georgetown Formation and ultimately reaches the Edwards Aquifer.

The Georgetown Formation and Edwards Limestone are cavernous in Hays County. They form many caves; solutional development in these rocks is also evident in the density of sinkholes and other non-enterable karst features found whenever a formal karst survey is conducted. The cavernous nature of the Edwards Limestone is further displayed in its springs. There are major fault-controlled springs along the southeastern boundary of the Edwards Plateau in San Marcos. The San Marcos Springs are karst springs issuing from a network of conduits and solutionally enlarged fractures, discharging water from the Edwards Aquifer. These springs are the most productive in the county, and are among the largest of the major Edwards Aquifer springs of central Texas.

Smaller springs discharge near the base of the Edwards Limestone and its contact with the underlying upper member of the Glen Rose Limestone. These springs likely form when water enters the Edwards Limestone and travels downward through the Edwards Limestone along solutional passages, then travels horizontally along bedding planes when it encounters the less soluble upper member of the Glen Rose limestone. Such springs have been noted east of Wimberley along Lone Man Creek and Smith Creek. These springs are known to the TSS as Springs 001, 002, 003, 004 and 005. The low number of known springs elsewhere along the Edwards/Glen Rose contact is likely due to the lack of spring mapping. Researchers do not yet know whether these smaller perched springs have a different set of fauna.

Geologists treat the lithology of the Georgetown Formation and Edwards in two parts: the main body of the Georgetown Formation and Edwards Limestone, and erosional outliers of Edwards Limestone. The main portions of Georgetown Formation and Edwards Limestone outcrops occur in the central part of the county, in the densely faulted Balcones fault zone. Of the 301 karst features analyzed, 247 occur in this extensive area. There are also remnants of the oldest members of the Edwards Limestone on isolated hilltops in the northern part of the county. These outcrops range up to 25 m in thickness. Currently, no caves or karst features are known from this set of outcrops. The lack of karst features is probably a sampling artifact, as solutional features are likely to be found in this limestone regardless of current thickness. The physical isolation of these outcrops could have implications for distribution of cave organisms, if inhabited karst features exist in these places.

The upper member of the Glen Rose Limestone forms springs near its contact with the overlying Edwards Limestone, as discussed above. These springs are likely formed by water recharging through the Edwards Limestone and discharging along the top of the less soluble upper Glen Rose limestone. The records we consulted show 17 springs recorded in the upper member of the Glen Rose Limestone. Of these, five springs listed above are close to the top Glen Rose Limestone and are likely discharging water from karst flow systems in the overlying Edwards Limestone. Twelve more springs are located lower in the upper member of the Glen Rose Limestone and are not associated with any known karst features. These springs may correlate to lithology within the member, and may indicate a thin but relatively extensive unit of karstic rock, similar to the biostromes of Interval D of the upper member of the Glen Rose Limestone in northern Bexar County (Clark 2003 and 2004). At Camp Bullis Training Area in northern Bexar County, the Interval D biostrome mapped by Clark has developed a set of caves over a large area that is both hydrologically and biologically significant (George Veni and Associates 2006). The five springs near the top of the Glen Rose Limestone are included in the Edwards Limestone karst terrane, while the 12 springs located lower in the upper member of the Glen Rose Limestone are not assigned to a karst terrane due to a lack of resolution in the stratigraphy.

The lower member of the Glen Rose Limestone is cavernous, forming a number of significant caves and springs, such as Jacob's Well. These outcrops occur in two groups: one in the western corner of the county, and one in the northern corner of the county. The outcrops are centered on the Blanco River and Cypress Creek in the western corner of the county. In the northern corner of the county, the outcrops are exposed along the steep slopes leading down to the Pedernales River. Of the 301 karst features analyzed in this project, 16 occur in the lower member of the Glen Rose Limestone. All are from the western outcrop area. The northern outcrop area is located in steep terrain, which makes searching for karst features more difficult. The steep terrain also makes it likely that karst features found in this area would be springs, seeps and paleosprings. Most karst feature locations come from recreational cavers searching for new caves, and since small springs and paleosprings rarely yield substantial amounts of cave passage, many cavers aren't likely to report such features. Therefore, the absence of karst features in the northern outcrop of the lower member of the Glen Rose Limestone is probably a sampling bias introduced by a lack of systematic searching.

Outcrop of the Cow Creek Limestone is limited to the far northern corner of the county. The Cow Creek Limestone lies below the Glen Rose Limestone and Hensell Sand, along the steep slopes leading down to the Pedernales River. We know of a single karst feature – Dead Man's Hole –in this area. Researchers have not recently visited this location due to access restrictions. While it is likely to be karstic, its origins are not well understood. It may be an old phreatic passage that has since been abandoned and breached, or it may be an old collapse feature into an older underlying void. Formed at the head of a steep drainage, it is likely that the feature periodically acts as a spring and discharges groundwater from the surrounding area. If so, it may host an interesting aquatic fauna. Caves are known elsewhere in the Cow Creek Limestone (Veni 1997), and further searching for karst features in the Hays County outcrop is warranted.

Discussion

Karst terranes are extremely sensitive to degradation from human activities. This is because karst systems are highly interconnected and heterogeneous, characterized by rapid recharge of unfiltered surface water into the subsurface, and high flow velocities within the system. This behavior makes these systems vulnerable from both biological and hydrological perspectives (Ford and Williams 1989, White 1988).

While we performed this analysis on the known caves and karst features of Hays County, the list is incomplete. In karst terranes, enterable caves are always outnumbered by karst features (Curl 1966). More caves and many more karst features and small springs that have not yet been documented exist in Hays County in areas that are undergoing rapid development. Many karst features go unrecognized during development, contributing to biological and hydrological degradation to the karst resources. Researchers have conducted few karst surveys in Hays County, but the number of known caves indicates that a great number of karst features exist. The need for professional karst surveys is illustrated by comparing the results of one such survey with what is known in the rest of the county. Veni (2002) surveyed a tract of land in the San Marcos area. In that 4.2 km^2 area, eight caves and 112 karst features were found. There is no evidence to show that this is an atypical cave density for the area, and when extrapolated for the entire Georgetown Formation and Edwards Limestone outcrop of Hays County, we could expect to find 752 caves and 10,533 karst features in the additional 395 km^2 of that outcrop. We currently only know of 90 caves and 14 karst features outside of that survey area.

The karst features of the Georgetown Formation and Edwards Limestone recharge the Edwards Aquifer. Development over these outcrops poses groundwater contamination risks, as well as decreasing the amount of recharge entering the Aquifer (Hansen and Small 1995). This well-developed karst network provides habitat for a rich invertebrate fauna. Karst invertebrates are able to occupy non-enterable karst features as well as caves, so all karst features, not just caves, should be treated as biologically and hydrologically vulnerable.

Species distribution

The World Conservation Union and NatureServe databases consider species with restricted ranges (e.g. five or fewer localities) in urbanizing areas critically imperiled (Baillie et al. 2004). It is possible that the documented localities of these species represent the real ranges of these species, or future collecting efforts may find they are more widespread. Researchers have done little collecting in comparison to other areas in central Texas, such as Travis and Williamson Counties.

The distribution of these species in relation to the geology is not clear from the cursory examination we have performed. Some taxa are known from all areas, including the Georgetown Formation, Edwards Limestone, and lower member of the Glen Rose Limestone, others from only one of those members, and still others from only single caves. To create a more detailed map, we recommend performing an endemicity analysis, a detailed review of geologic controls between sites where we have biological data, and an algorithm to subdivide the karst terrane. It may be possible to identify vicariant events responsible for range boundaries such as surface rivers that bisect cavernous rock, subsurface drainage basins, and faults that juxtapose cavernous and non-cavernous rock. Different members of the Edwards Limestone or subdivisions of the lower member of the Glen Rose Formation may correlate with species ranges.

In other areas of Texas where federally listed terrestrial karst species occur (Travis, Williamson and Bexar counties), more in-depth studies revealed limits to the biogeography of those species. These studies created Karst Fauna Regions (KFRs), or geographic areas delineated based on discontinuity of cave habitat that may obstruct communication between troglobite populations (Reddell 1993, Veni 1992, Veni 1994, USFWS 1994, USFWS 2000). Karst Fauna Regions were further subdivided into karst zones based on probability of containing habitat suitable for listed karst invertebrate species. The KFRs and karst zones are an integral part of the regulation, management and recovery for the listed species in those three counties. The map of karst terrane created herein has not been subdivided to this level, it simply shows all possible karst in the county overlain with all rare karst invertebrate localities. It was not in the scope of this project to perform an endemicity analysis for the species or hydrogeologic investigation at the level of those performed in these other areas.

Biology in the Trinity Aquifer

Regulatory entities focus on activities in and over the Edwards Aquifer because of the federally listed aquatic organisms in Hays County (*Eurycea nana, Eurycea rathbuni, Heterelmis comalensis, and Stygoparnus comalensis*), the Texas Commission on Environmental Quality Edwards Aquifer Rules, and the Edwards Aquifer Authority jurisdiction. However much of Hays County is underlain by the Trinity Aquifer, and at least one and probably two aquifer-restricted organisms occur in both aquifers in Hays County. In a genetic analysis of aquifer isopods, closely related *Lirceolus hardeni* populations occurred in both Edwards (Rattlesnake Cave) and Trinity (Jacob's Well) localities, indicating that species boundaries do not follow aquifer boundaries (Krejca 2005). Reliable reports from SCUBA divers at one Trinity locality, Jacob's Well, indicate that the blind shrimp *Palaemonetes antrorum* occurs there (though no samples were collected), and this species is also known from Edwards Aquifer localities for the endangered salamander, *Eurycea rathbuni*.

Some aquifer species occur in both the Trinity and the Edwards aquifers, demonstrating that at least some aquifer fauna are not bound by these geologic units. Other rare salamanders and aquifer invertebrates occur in the Trinity (Heitmuller and Reece 2007), including *Eurycea* species (Chippindale et al. 2000) and crustaceans. The Trinity Aquifer receives less environmental regulation than the Edwards Aquifer.

Recommendations

In order to rank sensitivity, consider probabilities of species ranges, and in general further subdivide the map of karst terranes included herein, a Karst Fauna Region and karst zone map needs to be created. The data accumulated during this project is the first step toward creating that product, and other elements of KFRs and karst zones are covered in the discussion section. Other steps that will help create a robust analysis of Karst Faunal Regions and karst zones involve gathering biological data on more of the known caves and locating more of the approximately 70 caves on record which do not currently have viable locations. Datasets including phylogenetics and analyses of endemicity can help make and test biogeographical hypotheses (e.g. Krejca 2005).

Karst surveys should be conducted in all the karst terranes discussed in this document. Furthermore, areas adjacent to currently defined karst terranes should also be searched for karst features, as the regional-scale geologic mapping on which the karst terranes are based may not be precise at the local scale.

Biological investigations on the species discussed herein are needed to better manage the habitat. Most of the species are only mentioned in the literature by their species descriptions and taxonomic standing. The species descriptions provide the basics of their physical characteristics, their range, and occasionally information on collection methods. Subsequent papers use preserved specimens to refine taxonomy, while biological, life history, or field investigations are entirely absent.

Taxonomy is needed for all of the species lacking a description, and also needed for overlooked groups such as mites, ostracods and copepods. Two copepods, *Cyclops cavernarum* and *Cyclops learii* are likely aquifer adapted and known only from the Artesian Well, but the descriptions are useless for identification (*nomina dubia*), therefore they were not considered herein. Placing names on known species is extremely important to further taxonomy of higher groups and to serve as a first step to performing more in-depth research.

This map delineates sensitive karst terranes but does not rank these areas or give specific recommendations for land management practices in these sensitive areas. Examples of land management practices include impervious cover restrictions, runoff filtration, and the use of best management practices around karst features and caves. Future work should include ranking and creation of management recommendations.

Acknowledgements

The Texas Speleological Survey is an archive for karst data in the State of Texas. It is an all-volunteer, non-profit organization. Years of dedicated work by its directors make projects such as this possible. Future investigators are encouraged to communicate with the TSS on karst projects to better understand the areas in which they are working, and to provide information on their work and discoveries with the TSS in order to allow them to better fulfill their mission. This study benefited from consultation with several biospeleologists familiar with the karst of Hays County, including James Reddell of the Texas Memorial Museum, William Russell of the Texas Speleological Survey, Randy Gibson and Pat Connor of the U.S. Fish & Wildlife Service, Dave Hillis of The University of Texas, Dee Ann Chamberlain, Nico Hauwert and Nate Bendick of the City of Austin, Andy Gluesenkamp of the Texas Memorial Museum, Chris Thibodaux of Karst Tec Consulting, Andy Grubbs, Pierre Paquin of SWCA, and Peter Sprouse of Zara Environmental. Robin Gary of the USGS provided considerable help with the GIS database for the second map iteration which included aquatic species. Editing of the document was performed by Clif Ladd and Amanda Aurora of Loomis Austin, Inc., Alan Glen of Smith|Robertson, and Kellie Cowan and Krista McDermid of Zara Environmental.

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Personnel

Bev Shade, M.Sc., P.G., took this document from the inception as a list of cave locations to the original version of this map, including providing interpretation of the caves and karst features, writing all parts of the geology oriented text, and creating the first version of the map. Bev wrote her thesis on a silicate karst region in northeastern Minnesota, characterizing a heterogeneous karst flow system that clearly demonstrates multiple porosities. As part of the research lab of Dr. Calvin Alexander, she assisted with all aspects of dye tracing tests, including preparation of dye lots and charcoal detectors, field implementation, QA/QC, lab analysis of samples and calculation of actual dye concentrations through linear regression on known standards compared with non-gaussian curve models of spectra. Bev worked for six years professionally with central Texas karst issues.

Dr. Jean Krejca performed the biological reviews of all the species, managed the project, and wrote the non-geological text. She is a subterranean species specialist. Jean has a Bachelor's degree in Zoology, and a Ph.D. in Evolution, Ecology and Behavior from the University of Texas. Her dissertation work focused on cave adapted aquatic fauna, biogeography and hydrology of Texas and North Mexico. Since 1991 she has worked as a cave biologist and her experience in that area spans across the United States (Arkansas, California, Texas, Nevada, Illinois, Missouri, Indiana, Tennessee, North and South Carolina) as well as Mexico, Belize, Thailand and Malaysia. Her publication list on these areas is extensive. Texas cave biology experience started in 1997 and includes detailed collections of aquatic cave fauna for research, monitoring for endangered species, and working as a Karst Invertebrate Specialist for the U.S. Fish and Wildlife Service. In 2003 she co-founded Zara Environmental LLC where she continued her work from independent consulting and expanded to perform land management for landowners with endangered species, consult on endangered species permits, and perform custom research projects. In addition she has been involved with a variety of public outreach efforts such as public talks, field trips, and cave biology photography. She holds a USFWS endangered species permit (TE028652-0) and several state permits covering karst invertebrates and salamanders in Texas.

Marcus O. Gary created the second round of maps, including reorganizing the GIS files into a database format. Marcus is a Ph.D. candidate hydrogeologist specializing in karst forming processes and the implications that karst geology has on natural resource management. Marcus received an Associate of Science degree in Marine Technology at the College of Oceaneering, a B.S. degree in hydrogeology and environmental geology at the University of Texas, and is currently working on a volcanogenic karst dissertation project at the University of Texas. His research has been internationally recognized for investigating of the world's deepest underwater sinkhole and interpreting the geologic mechanisms that formed the karst system. For eight years he worked in the Texas Water Science Center of the U.S. Geological Survey, performing a multitude of tasks related to water resources. Projects included developing methods to quantify spring flow using acoustic technology, monitoring stage and water chemistry parameters at springs, performing a geochemical investigation of the Barton Springs Segment of the Edwards Aquifer, providing diving support for coring and karst monitoring projects, serving as a dive safety officer for the Central Region, and designing and implementing a variety of continuous monitoring projects at locations across Texas. His work at Zara since 2007 includes geologic assessments, drainage basin delineation, and dye tracing.

Table 1. List of karst and aquatic Evaluation and Additional Species of Concern in Hays County. Additional Species of Concern are federally listed and marked with a double asterisk. Abbreviations are as follows: Co. = County; dist. = distribution; TMM = Texas Memorial Museum; JKK = Jean K. Krejca; JRR = James R. Reddell; WWD = Wonder World Drive.

Order	**Family**	**Species**	**Hays County cave name**	**Notes on rarity**	**Range**	**source of information**
Tricladida	Kenkiidae	*Sphalloplana mohri*	Artesian Well, Ezell's Cave	6 sites	Hays, Kendall, Mason, San Saba, Travis	TMM database 2001, Kenk 1977
Taenioglossa	Hydrobiidae	*Phreatodrobia micra*	Artesian Well, San Marcos Springs	6 reliable sites	Comal, Hays, Kendall	TMM database 2001
Taenioglossa	Hydrobiidae	*Phreatodrobia plana*	Artesian Well, San Marcos Springs	3 sites	Comal, Hays	TMM database 2001
Taenioglossa	Hydrobiidae	*Phreatodrobia punctata*	San Marcos Springs	2 sites	Hays, Travis	TMM database 2001
Taenioglossa	Hydrobiidae	*Phreatodrobia rotunda*	Artesian Well, San Marcos Springs	2 sites	Hays	TMM database 2001
Pharyngobdellida	Erpobdellidae	*Mooreobdella* n.sp.	Artesian Well, Ezell's Cave, San Marcos Springs	3 sites	Hays	TMM database 2001, R. Gibson pers. comm. 2008
Thermosbaenacea	Thermosbaenidae	*Tethysbaena texana*	Artesian Well, Diversion Spring, Ezell's Cave	7 sites	Comal, Bexar, Hays, Uvalde	Stock and Longley 1981, Gibson et al. 2008, R. Gibson pers. comm. 2008
Amphipoda	Bogidiellidae	*Artesia subterranea*	Artesian Well, Ezell's Cave	3 sites	Comal, Hays, Val Verde	Holsinger and Longley 1980, Gibson et al. 2008
Amphipoda	Crangonyctidae	*Stygobromus balconis*	Autumn Woods Well, Boyett's Cave	4 sites	Hays, Travis	TMM database 2001, R. Gibson pers. comm.
Amphipoda	Crangonyctidae	*Stygobromus flagellatus*	Artesian Well, San Marcos Springs, Ezell's Cave, Rattlesnake Cave	6 sites	Comal, Hays, Travis	Holsinger 1966, Holsinger 1967, Holsinger and Longley, 1980, Gibson et al. 2008
Amphipoda	Hadziidae	*Allotexiweckelia hirsuta*	Artesian Well	3 sites	Hays, Bexar	TMM database 2001
Amphipoda	Hadziidae	*Holsingerius samacos*	Artesian Well	1 site	Hays	TMM database 2001
Amphipoda	Hadziidae	*Texiweckelia texensis*	Artesian Well, Ezell's Cave, San Marcos Springs	3 sites	Hays	Holsinger and Longley, 1980, R. Gibson pers. comm.
Amphipoda	Hadziidae	*Texiweckeliopsis insolita*	Artesian Well, San Marcos Springs	3 sites	Bexar, Hays	Holsinger and Longley, 1980

Table 1, continued. List of karst and aquatic Evaluation and Additional Species of Concern in Hays County

Order	**Family**	**Species**	**Hays County cave name**	**Notes on rarity**	**Range**	**source of information**
Amphipoda	Sebidae	*Seborgia relicta*	Artesian Well, Ezell's Cave	5 sites	Comal, Hays, Medina	Holsinger and Longley 1980, Holsinger 1992, Gibson et al. 2008
Isopoda	Asellidae	*Lirceolus smithii*	Artesian Well, Diversion Springs	2 sites	Hays	Bowman and Longley 1976, Gibson et al. 2008
Decapoda	Palaemonidae	*Palaemonetes antrorum*	Artesian Well, Ezell's Cave, Johnson's Well, Wonder Cave	8-10 sites	Bexar, Hays, possibly Uvalde	TMM database 2001
Decapoda	Palaemonidae	*Calathaemon holthuisi*	Artesian Well, Ezell's Cave	2 sites	Hays	TMM database 2001, Strenth 1976, R. Gibson, pers. comm. 2008
Aranae	Dictynidae	*Cicurina ezelli*	Ezell's Cave, Grapevine Cave	2 sites	Hays	TMM database 2001
Aranae	Dictynidae	*Cicurina russelli*	Boyett's Cave	1 site	Hays	TMM database 2001
Aranae	Dictynidae	*Cicurina ubicki*	Fern Cave, McGlothlin Sink	2 sites	Hays	TMM database 2001
Aranae	Leptonetidae	*Neoleptoneta* n. sp. eyeless	Katy's Cave	1 site	Hays	Pierre Paquin, pers. comm. 2007
Aranae	Leptonetidae	*Neoleptoneta* n. sp. 1	Burnett Ranch Cave	1 site	Hays	TMM database 2001
Aranae	Leptonetidae	*Neoleptoneta* n. sp. 2	Boyett's Cave	1 site	Hays	TMM database 2001
Aranae	Nesticidae	*Eidmanella* n. sp.	Ezell's Cave, McCarty Cave, McGlothlin Sink	1-3 sites	Hays	TMM database 2001
Pseudoscorpionidae	Neobisiidae	*Tartarocreagris grubbsi*	Wissman's Sink	1 site	Hays	TMM database 2001 and Muchmore 2001
Opiliones	Phalangodidae	*Texella diplospina*	Ladder Cave	1 site	Hays	TMM database 2001
Opiliones	Phalangodidae	*Texella grubbsi*	Burnett Ranch Cave, Wissman's Sink, Wissman's Sink #2	7 sites	Hays, Travis, Burnet	TMM database 2001 (Burnett Ranch Cave), Ubick and Briggs 2004 (all others)

Table 1, continued. List of karst and aquatic Evaluation and Additional Species of Concern in Hays County

Order	**Family**	**Species**	**Hays County cave name**	**Notes on rarity**	**Range**	**source of information**
Opiliones	Phalangodidae	*Texella mulaiki*	Boggus Cave, Ezell's Cave, Fern Cave, Ladder Cave, McCarty Cave, McGlothlin Sink, Michaelis Cave, Tricophorous Cave	15 sites	Hays, Travis	Ubick and Briggs 2004 (Ezell's Cave, Tricophorous Cave), TMM database 2001 (Ezell's Cave and all others)
Opiliones	Phalangodidae	*Texella renkesae*	Ezell's Cave, Maggens Sink Hole	2 sites	Hays	TMM database 2001 (Ezell's Cave), Ubick and Briggs 2004 (Maggens Sink Hole)
Collembola	Sminthuridae	*Arrhopilites texensis*	Grapevine Cave, Wissman's Sink No. 2	7-8 sites	Bandera, Bexar, Hays, Travis, Williamson	TMM database 2001
Coleoptera	Carabidae	*Rhadine insolita*	Grapevine Cave	2 sites	Hays, Comal	TMM database 2001
Coleoptera	Carabidae	*Rhadine* n. sp. 2 [*subterranea* grp.]	Ezell's Cave, Lime Kiln Quarry Cave, McCarty Cave	3 sites	Hays	JRR pers. comm. 10 April 2007 and JKK personal collections (Ezell's Cave), TMM database 2001 (all others)
Coleoptera	Carabidae	*Rhadine* sp. [*subterranea* group] eyed	Boyett's Cave	1 site	Hays	TMM database 2001
Coleoptera	Carabidae	*Rhadine* sp. cf. *austinica*	Dahlstrom Cave, Michaelis Cave	2 sites	Hays	JRR pers. comm. 10 April 2007 (Dahlstrom Cave), TMM database 2001 (Michaelis Cave)
Coleoptera	Dytiscidae	*Comaldessus stygius*	Fern Bank Springs	2 sites	Comal, Hays	Gibson et al. 2008
Coleoptera	Dytiscidae	*Haideoporus texanus*	Artesian Well	2 sites	Comal, Hays	Young and Longley 1976
Coleoptera	Pselaphidae	*Batrisodes grubbsi*	Grapevine Cave	1 site	Hays	Muchmore 2001

Table 1, continued. List of karst and aquatic Evaluation and Additional Species of Concern in Hays County.

Order	**Family**	**Species**	**Hays County cave name**	**Notes on rarity**	**Range**	**source of information**
Caudata	Plethodontidae	*Eurycea pterophila*	Ben McCulloch Springs, Blanco River Spring, Cypress Creek Spring, Fern Bank Springs, Grapevine Cave, Jacob's Well, Rancho Cima Dam Spring, Smith Creek Lower and Upper Springs, Spring 1 mi. SE Signal Hill, Spring 1.5 mi. E Payton	Over 10 sites	Blanco, Hays, Kendall, possibly Comal	Sweet 1977, Chippindale et al. 2000, J. Krejca, pers. comm. 2008
Caudata	Plethodontidae	*Eurycea robusta*	Underneath Blanco River at I-35	1 site	Hays	
Coleoptera	Elmidae	*Heterelmis comalensis* **	San Marcos Springs	2 sites	Comal, Hays	Gibson et al. 2008
Coleoptera	Dryopidae	*Stygoparnus comalensis* **	Fern Bank Springs	2 sites	Comal, Hays	Gibson et al. 2008
Caudata	Plethodontidae	*Eurycea nana* **	San Marcos Springs	1 site	Hays	
Caudata	Plethodontidae	*Eurycea rathbuni* **	Diversion Spring, Ezell's Cave, Johnson's Well, Primer's Well, Rattlesnake Cave, Side seeps in Sessom's Creek, Artesian Well, Wonder Cave	8 sites	Hays	Chippindale et al. 2000, Glenn Longley, pers. comm. 2008, Bill Russell pers. comm. 2008
Caudata	Plethodontidae	*Eurycea* sp. federally listed **	Spillar Ranch Springs, Stuart Springs	5 sites	Hays, Travis	Dave Hillis, Dee Ann Chamberlain, and Nate Bendik, pers. comm. 2008

Table 2. List of all 301 localities and alternate names.

Name	Alternate Names	Feature Type	Name	Alternate Names	Feature Type
967 Blowhole		Sinkhole	Cave (Ogden 18)		Cave
A.J. Rod Cave	T.H.E. Cave, Katy's Cave, probably is Cady's Cave (as in biology table)	Cave	Cave (Ogden 19)		Cave
Academy Cave	Cave (Ogden 6)	Cave	Cave (Ogden 2)		Cave
Amber Cave		Cave	Cave (Ogden 3)		Cave
Antioch Cave		Cave	Cave (Ogden 4)	could be Reider Cave #1	Cave
Anyway Cave	WWD-29	Cave	Cave (Ogden 5)	could be Reider Cave #2	Cave
Artesian Well	Old Federal Fish Hatchery well (or U.S. Fish Commission well), Artesian Well at/in San Marcos, San Marcos Artesian Well, Artesian well on (TSU/SWT) campus	Well	Cave (Ogden 8)		Cave
Artisan's Caves (1)		Cave	Cave on old Haupt Place		Cave
Artisan's Caves (2)		Cave	Connie's Cave		Cave
Arrowhead Cave		Cave	Contour Cave		Cave
Ash Cave	Cave (Odgen 1)	Cave	Corrie Smith Cave No. 1		Cave
Autumn Woods Well		Well	Corrie Smith's Filled-In Cave		Cave
Backyard Cave	Back Yard Cave	Cave	County Line Bat Cave		Cave
Ballroom Cave		Cave	Coyote Cave		Cave
Barbed Wire Pot		Cave	Cripple Crawfish Cave	Crippled Crawfish Cave	Cave
Barber Falls Pool		Cave	Cypress Creek Spring		Spring
Barton Creek Springs		Spring	Dahlstrom Cave		Cave
Bear Cave		Cave	Dakota Ranch Cave		Cave
Ben McCulloch Spring		Spring	Dead Man's Hole	Dead Man's Cave	Cave
Bell Spring		Spring	Deep hole on old Cox Place		Cave
Bethke Ranch Cave		Cave	Diamond Cave		Cave
Big Mouth Cave		Cave	Donaldson Cave	WWD-25	Cave
Blackwell Sinkhole		Sinkhole	Dripping Springs		Spring
Blanco River Spring		Spring	Dupont Spring		Spring
Blue Monday Cave		Cave	Easy Breeze Cave		Cave
Boggus Cave	WWD-17	Cave	Electrical Cord Cave	WWD-76T	Cave
Bonnie's Cave		Cave	Elm Cave		Cave
Bonnie's Cave No. 2		Cave	Ezell's Cave		Cave
Boyett's Cave	Devil's Backbone Cave	Cave	Fenceline Sink	WWD-24	Feature
Burnett Ranch Cave		Cave	Fern Bank Spring	Little Arkansas Spring	Cave
Calamity Cave	WWD-132	Cave	Fern Cave		Cave
Calhoun's Pit	Calhoun's Cave	Cave	Finger Cave		Cave
Calvin's Cave		Cave	Flatrock Cave		Cave
Cam Shaft Cave	MAY be Stephens' Sink (Hanson & Small 1995)	Cave	Formation Cave	Boy Scout Cave	Cave
Cave (Ogden 14)		Cave	Fox Cave	WWD-86	Cave
Cave (Ogden 15)		Cave	Fritz's Cave		Feature
Cave (Ogden 16)		Cave	G.W. Sink		Cave
Cave (Ogden 17)		Cave	Grapevine Cave	Ice Box Cave	Cave

Table 2, continued. List of all 301 localities and alternate names.

Name	Alternate Names	Type	Name	Alternate Names	Feature Type
Gweyn's Cave		Cave	Pseudosink		Sinkhole
Hagemann's Well		Well	Pucker Cave	Puckett's Cave	Cave
Halifax Bat Cave	Goat Cave Nance Bat Cave, prob. Also Halifax Mine	Cave	Pulpit Cave	Treehouse Cave	Cave
Hoskins Hole		Cave	Puzzle Pit		Cave
Indian Run Sink and Collapse Area	WWD-23 (Indian Run Sink)	Sinkhole	Quarry Sink		Cave
Ingrahm Sink		Sinkhole	Quarry Cave	King Quarry Cave, Lime Kiln Quarry Cave	Cave
Jacob's Well		Cave	Rancho Cima Dam Spring		Spring
Jacobs Well Spring	NOTE: this is what everyone means by "Jacob's Well"	Spring	Radiance Sink		Cave
Johnson's Well	Johnson Well, Frank Johnson Well, Frank Johnson's Well, WWD-67	Well	Rattlesnake Cave	Frank Johnson's Cave, Salamander Cave, Natural Well, Natural Well Cave	Cave
Kali Kate's Cave	Cal Cave, Calcate Cave, Kate Cave	Cave	Rattlesnake Cave (2)	This is NOT in San Marcos	Cave
Ken Barnes' Cave	predominant name is probably Big Mouth Cave	Cave	Rattlesnake Spring	Rattlesnake Sink	Spring
Kira's Karst Park		Cave	Rattlesnake Well		Well
Kirby Spring		Spring	Rector Williams' Cave	Williams' Pit	Cave
Koenig Ranch Spring		Spring	Reider Cave No. 1		Cave
Koenig Ranch Spring	S45A	Spring	Reider Cave No. 2	could be Cave (Ogden 5)	Cave
Kunkel Cave		Cave	Root Beard Cave		Cave
Ladder Cave		Cave	Runoff Cave		Cave
Little Wilkins Cave		Cave	Rutherford Ranch Sink		Sinkhole
Magen's Sink	Maggens Sink Hole	Cave	San Marcos Spring		Spring
Marcia's Well		Cave	San Marcos Springs: Cabomba Spring		Spring
McCarty Cave	McCarty Bat Cave McCarty Lane Bat Cave	Cave	San Marcos Springs: Catfish Hotel Spring		Spring
McGlothin Sink	McGlothin Cave, Cave (Ogden 7)	Cave	San Marcos Springs: Crater Spring	Crater Bottom Spring	Spring
Michaelis Cave	Michaelis Sink	Cave	San Marcos Springs: Cream of Wheat Spring		Spring
Morton's Cave	Morton Ranch Cave	Cave	San Marcos Springs: Deep Hole Spring		Spring
Mouse Cave		Cave	San Marcos Springs: Diversion Spring		Spring
Mustang Branch Sink		Sinkhole	San Marcos Springs: Hotel Spring		Spring
North Bank Sinks		Sinkhole	San Marcos Springs: Kettleman Spring		Spring
North Bank Sinks		Cave	San Marcos Springs: Mystery Spring		Spring
Plum Tree Cave		Cave	San Marcos Springs: Ossified Forest Spring		Spring
Primer's Well	Primer's Fissure, WWD-3	Cave	San Marcos Springs: Riverbed Spring		Spring

Table 2, continued. List of all 301 localities and alternate names.

Name	Alternate Names	Feature Type	Name	Alternate Names	Feature Type
San Marcos Springs: Salt & Pepper Spring 1		Spring	Spring 012		Spring
San Marcos Springs: Salt & Pepper Spring 2		Spring	Spring 013		Spring
San Marcos Springs: Weissmuller Spring	Johnnie Spring	Spring	Spring 014		Spring
Seep on Sessoms Creek		Spring	Spring 015		Spring
Sink (Ogden 10)		Sinkhole	Spring 1.5 mi E Payton		Spring
Sink (Ogden 11)		Sinkhole	Spring 1 mi SE Signal Hill		Spring
Sink (Ogden 12)	could be Rattlesnake Cave	Sinkhole	Stephens' Sink	may be Cam Shaft Cave	Sinkhole
Sink (Ogden 13)		Sinkhole	Stonehaven Sink		Sinkhole
Sink (Ogden 20)		Sinkhole	Stuart Springs	Taylor Springs, Springs on Little Bear Creek, Ann Ashmun's Springs	Spring
Sink (Ogden 9)		Sinkhole	Tarbutton's Cave	Dugger Cave, Tarbutton's Showerbath Cave	Cave
Sink Spring		Spring	Taylor Bat Cave	Bat Cave Pandora's Box Cave	Cave
Sites' Cave	Site's Pit	Cave	Technical Cave	WWD-41	Cave
Slip Cave	WWD-78T	Cave	Tower Dig		Feature
Small holes near Plum Creek		Feature	Tricopherous Cave	WWD-121, Tricoferous Cave	Cave
Smith Rattlesnake Cave		Cave	Twin Entrance Cave		Cave
Smith Creek Upper Spring		Spring	Unnamed Spring (new)		Spring
Smith Creek Lower Spring		Spring	Underneath Blanco River at I-35		Feature
Snake Cave	WWD-131	Cave	Walnut Spring		Spring
Sofa Cave		Cave	Warton No. 1		Cave
Spillar Ranch Springs		Spring	Warton No. 2		Cave
Spring (on Blanco River south of Turkey Hollow)		Spring	Weismuller Spring		Spring
Spring 001		Spring	Wenger's Cave		Cave
Spring 002		Spring	Wimberley Bat Cave		Cave
Spring 003		Spring	Windy Cave	WWD-22	Cave
Spring 004		Spring	Winnie Phillips Bat Cave	Winnie Phillips Cave	Cave
Spring 005		Spring	Wissman's Sink		Cave
Spring 006		Spring	Wissman's Sink #2		Cave
Spring 007		Spring	Wonder Cave	Bevers' Cave, Beaver Cave, San Marcos Cave	Cave
Spring 008		Spring	WWD-10		Feature
Spring 009		Spring	WWD-100		Feature
Spring 010		Spring	WWD-101		Feature
Spring 011		Spring	WWD-102		Feature

Table 2, continued. List of all 301 localities and alternate names.

Name	Alternate Names	Feature Type	Name	Alternate Names	Feature Type
WWD-103		Feature	WWD-52		Feature
WWD-104		Feature	WWD-53		Feature
WWD-105		Feature	WWD-55		Feature
WWD-106		Feature	WWD-56		Feature
WWD-11		Feature	WWD-57T		Feature
WWD-110		Feature	WWD-58		Feature
WWD-111		Feature	WWD-58T		Feature
WWD-112		Feature	WWD-59		Feature
WWD-113		Feature	WWD-59T		Feature
WWD-114		Feature	WWD-6		Feature
WWD-116		Feature	WWD-60		Feature
WWD-117		Feature	WWD-60T		Feature
WWD-119		Feature	WWD-61		Feature
WWD-12		Feature	WWD-61T		Feature
WWD-120		Feature	WWD-62		Feature
WWD-123		Feature	WWD-62T		Feature
WWD-124		Feature	WWD-63		Feature
WWD-127		Feature	WWD-63T		Feature
WWD-129		Feature	WWD-64		Feature
WWD-13		Feature	WWD-64T		Feature
WWD-14		Feature	WWD-65		Feature
WWD-15		Feature	WWD-66		Feature
WWD-16		Feature	WWD-66T		Feature
WWD-17		Feature	WWD-67T		Feature
WWD-18	Rabbit Sink	Feature	WWD-68		Feature
WWD-20		Feature	WWD-68T		Feature
WWD-21		Feature	WWD-69		Feature
WWD-27		Feature	WWD-69T		Feature
WWD-28		Feature	WWD-7		Feature
WWD-30		Feature	WWD-70T		Feature
WWD-31		Feature	WWD-71		Feature
WWD-32		Feature	WWD-71T		Feature
WWD-33		Feature	WWD-72		Feature
WWD-34		Feature	WWD-72T		Feature
WWD-35		Feature	WWD-74T		Feature
WWD-36		Feature	WWD-75		Feature
WWD-37		Feature	WWD-77T		Feature
WWD-38		Feature	WWD-8		Feature
WWD-4		Feature	WWD-80		Feature
WWD-40		Feature	WWD-83		Feature
WWD-42		Feature	WWD-84		Feature
WWD-43		Feature	WWD-87		Feature
WWD-44		Feature	WWD-88		Feature
WWD-45		Feature	WWD-89		Feature
WWD-46		Feature	WWD-90		Feature
WWD-47		Feature	WWD-91		Feature
WWD-48		Feature	WWD-92		Feature
WWD-49		Feature	WWD-93		Feature
WWD-50		Feature	WWD-95		Feature
WWD-51		Feature	WWD-96		Feature
			WWD-97		Feature