Comments on the Guajolote development proposed for the Helotes Creek watershed

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Introduction

Lennar Homes has plans to build a 2,900 home subdivision on 1,160 acres once part of the historic Guajolote Ranch within the Edwards Aquifer Contributing Zone. Current plans for the development are to discharge wastewater into an ephemeral reach of Helotes Creek. Comments provided here examine the impact that this discharge would have on the trophic state of Helotes Creek and the ultimate recharge to the Edwards Aquifer.

Background

Helotes Creek watershed is wholly contained within the Contributing Zone of the Edwards Aquifer. The landscape consists of Cretaceous-age carbonates with limited soil coverage. Due to the karst nature of the carbonates, recharge from precipitation is rapid as is groundwater flow once the aquifer is recharged (Sharp et al., 2019; Sharp and Green, 2022). All baseflow in the creek recharges the subsurface in the Contributing Zone prior to entering the Edwards Aquifer Recharge Zone. Although the water initially enters the Trinity Aquifer, the recharged water ultimately enters the Edwards Aquifer due to the juxtaposition of the Edwards Aquifer with the Trinity Aquifer along the Balcones Fault Zone. Hence, any degradation of water within the Helotes Creek watershed will degrade water recharged to the Edwards Aquifer.

The Trinity Aquifer exhibits at least three water-bearing horizons in the Helotes Creek watershed:

1. There is an unconfined freshwater horizon that is near the ground surface. It becomes dewatered during periods of limited precipitation and is susceptible to contamination from local recharge.
2. There is a somewhat deeper horizon with poor-quality water due to the dissolution of gypsum.
3. Lastly, there are deeper horizons of good-quality water in the lower Glen Rose and Cow Creek formations.

These three horizons are separated by confining layers and are not locally hydraulically connected, but could be connected downgradient where geologic faulting is prominent. Given the juxtaposition of the Trinity Aquifer to the Edwards Aquifer along the Balcones Fault Zone, waters from these three horizons provide recharge to the Edwards Aquifer.

Water Quality of the Edward Aquifer

The quality of water in the Edwards Aquifer depends on the quality of water that recharges the aquifer. Conventional conceptualization of the Edwards Aquifer asserts that recharge to the aquifer is essentially limited to the Recharge Zone as either: a) autogenic recharge from precipitation that falls on the Recharge Zone, or as b) allogenic recharge that occurs within river and stream beds that traverse the Recharge Zone (Puente, 1978; Lindgren et al., 2004; Slattery and Choi, 2021). As part of this conceptualization, the role of the Contributing Zone was limited to conveying surface water flow to the

Recharge Zone at which point flow could enter the subsurface as recharge. In reality, the Edwards Aquifer is significantly recharged by water infiltrating the Contributing Zone. This infiltrated water is then conveyed to the Edwards Aquifer from the Trinity Aquifer by interformational flow.

The TCEQ rules for the Edwards Aquifer Recharge Zone (SUBCHAPTER A: EDWARDS AQUIFER IN MEDINA, BEXAR, COMAL, KINNEY, UVALDE, HAYS, TRAVIS, AND WILLIAMSON COUNTIES ''213.1 - 213.14 Effective April 24, 2008) are considerably more protective of the Edwards Aquifer Recharge Zone compared with protections of the Edwards Aquifer Contribution Zone (SUBCHAPTER B: CONTRIBUTING ZONE TO THE EDWARDS AQUIFER IN MEDINA, BEXAR, COMAL, KINNEY, UVALDE, HAYS, TRAVIS, AND WILLIAMSON COUNTIES ''213.20 - 213.28 Effective April 24, 2008). The discrepancy between the rules for the Recharge Zone versus the Contributing Zone is not supported by the considerable body of research that has been conducted by a wide range of investigators over the past two decades. These investigations and improved insights on the Edwards Aquifer indicate that the role the Contributing Zone plays in recharge extends beyond only conveying surface water flow to Recharge Zone. Specifically, the upper portions that comprise the Contributing Zone are observed to act more like the Recharge Zone than the conventional characterization of the Contributing Zone; a mostly impermeable horizon that serves only to convey surface water flow to the Recharge Zone.

Evidence supporting this refined conceptualization of the Contributing Zone includes geologic mapping and structural interpretation (Clark, 2003; Veni, 2004; Schindel et al., 2004; Ferrill et al., 2004, 2005, 2008, 2009), gain/loss studies (Gary and Kromann, 2013; Green et al., 2011), multi-level hydraulic measurement (Smith and Hunt, 2008; Hunt et al., 2016), water-budget analyses (Green et al. 2006), and tracer testing (Barton Springs/Edwards Aquifer Conservation District. 2003; Johnson et al., 2010, 2012).

The geologic transition from the lower Edwards Aquifer to the upper Glen Rose Limestone of the Trinity Aquifer is pertinent to the hydraulic relationship between the Edwards Aquifer and the Trinity Aquifer. This hydrologic connection between the Edwards and Trinity aquifers is complex. The structural offset between the Edwards and Trinity aquifers along the Balcones Fault Zone places the stratigraphically lower Trinity Aquifer in the upthrown block topographically higher than the Edwards Aquifer in the downthrown block (Figure 1). A refined assessment of faulting along the Balcones Fault Zone (Ferrill et al., 2004, 2005, 2008) suggests that these faults do not impede cross flow as originally postulated by Maclay and Small (1983) and Maclay and Land (1988).

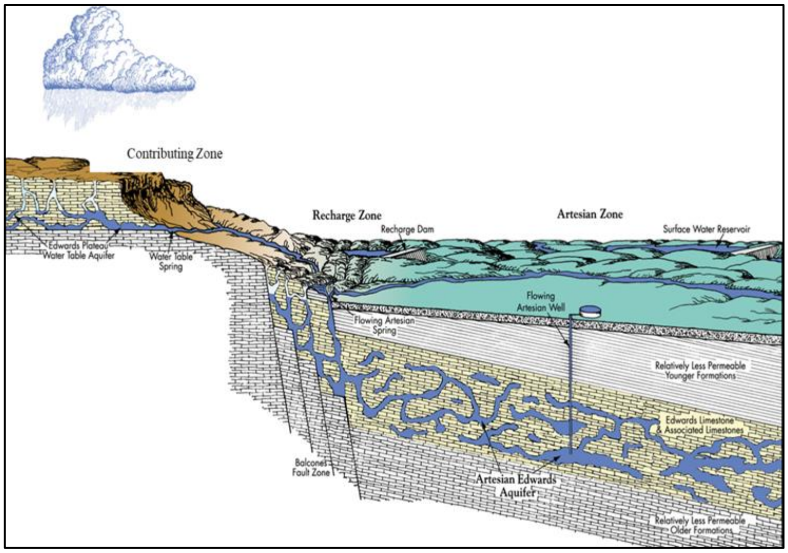

Figure 1. Conventional Geological Cross-Section of the Edwards Aquifer

The Edwards Aquifer was subdivided into eight hydrostratigraphic units (HSU I–VIII) by Maclay and Small (1976). The lower unit is the basal nodular member (HSU VIII). It overlies the Glen Rose Limestone of the Trinity Aquifer. The Trinity Aquifer has been separated into upper, middle, and lower aquifer units. The upper zone of the Trinity Aquifer is in the upper member of the Glen Rose Limestone. The upper Glen Rose Limestone has been delineated as intervals A-E (Clark, 2003) and also provided descriptive names (Clark et al., 2009). Interval A (the cavernous hydrostratigraphic member) is the upper approximately 120-foot-thick section of the upper unit of the Trinity Aquifer that exhibits appreciable permeability. The 120- to 150-foot-thick Interval B (Camp Bullis hydrostratigraphic member) is similar to Interval A but with considerably less permeability.

Based on hydraulic properties, Interval A can be characterized as more similar to the permeable units of the Edwards Aquifer than the low permeability intervals of the upper Glen Rose Limestone (i.e., Intervals B-E) and the remaining lower units of the Trinity Aquifer (Hunt et al., 2016) (Figure 2). Given this refined demarcation, the highly permeable upper Glen Rose Limestone could conceivably be considered as part of the Recharge Zone rather than the Contributing Zone. This simple redesignation of the Contributing Zone/Recharge Zone boundary; however, fails to recognize that other units below Interval A of the upper Glen Rose Limestone also provide the opportunity for recharge of surface water into the subsurface. Thus, simply remapping the Recharge Zone to include Interval A of the upper Glen Rose Limestone does not capture the complexity of the hydrogeologic relationship between the Edwards and Trinity aquifers.

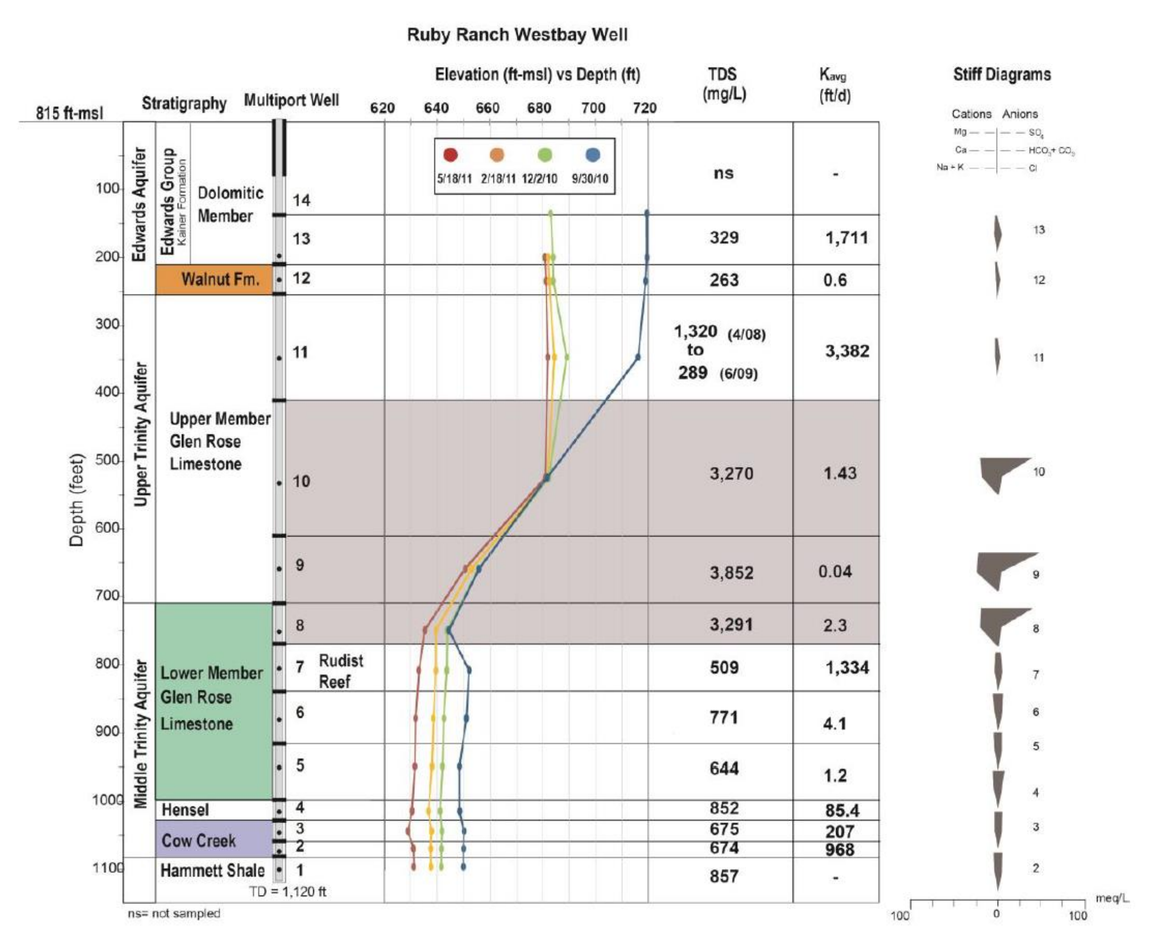

Figure 2. Summary of Data from the Ruby Ranch Well in the Barton Springs/Edwards Aquifer Conservation District Indicating the Upper Glen Rose limestone is Hydraulically Similar to the Edwards Aquifer (Hunt et al., 2016)

Tracer tests conducted in northern Bexar County add insight into this hydrogeologic relationship (Figures 3 and 4)(Johnson et al., 2010). Dyes released in the Panther Spring Creek watershed infiltrated through unsaturated Edwards rocks into the upper Glen Rose Limestone and migrated to the Edwards Aquifer as groundwater (Figure 4)(Johnson et al., 2010). Flow rates of the dyes exceeded one mile per day which demonstrates the rapid conveyance of water that infiltrates into the upper Glen Rose Limestone and flows to the Edwards Aquifer.

Tracer tests have demonstrated that groundwater from the upper Glen Rose Aquifer can flow rapidly to the Edwards Aquifer crossing large faults in the process (Veni, 2004; Schindel and Johnson, 2005). Rapid recharge into the river and stream beds and into karst features in the Edwards Aquifer Contributing Zone, near the Edwards Aquifer Recharge Zone, indicates that the upper portion of the Glen Rose Aquifer exhibits hydraulic properties similar to the permeable portions of the Edwards Aquifer (Ferrill et al., 2008; Schindel and Johnson, 2005; Veni, 2004). As a result, surface water flow in streams is often recharged into the subsurface in the Contributing Zone well before the streams and rivers enter the Recharge Zone. This attribute is exhibited by reaches of rivers and streams that are losing (i.e., recharging the subsurface) within the Contributing before crossing into the Recharge Zone of the Edwards Aquifer (Figure 1) (Slade et al., 2002).

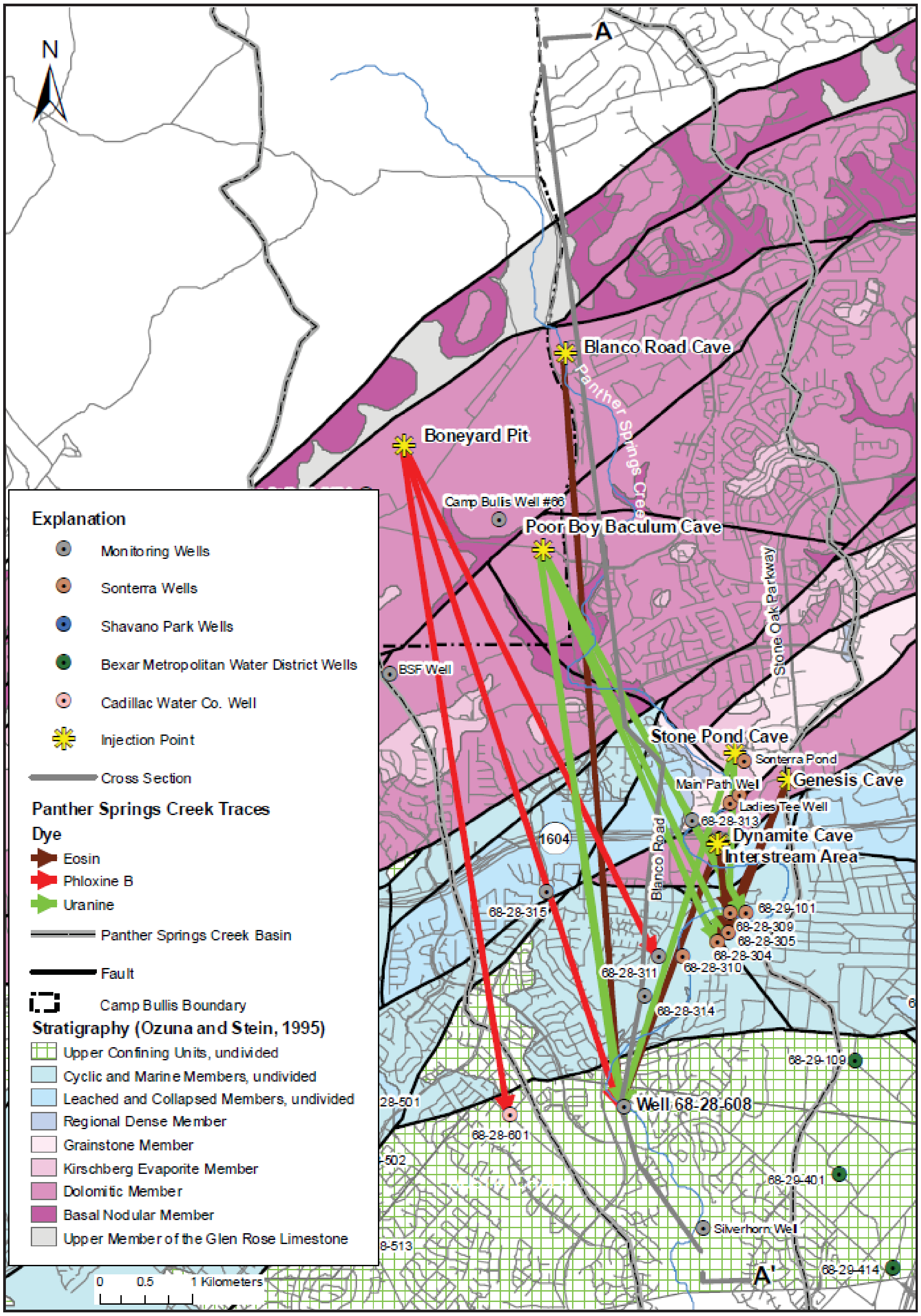

Figure 3. Results of Tracer Test at Panther Springs Creek

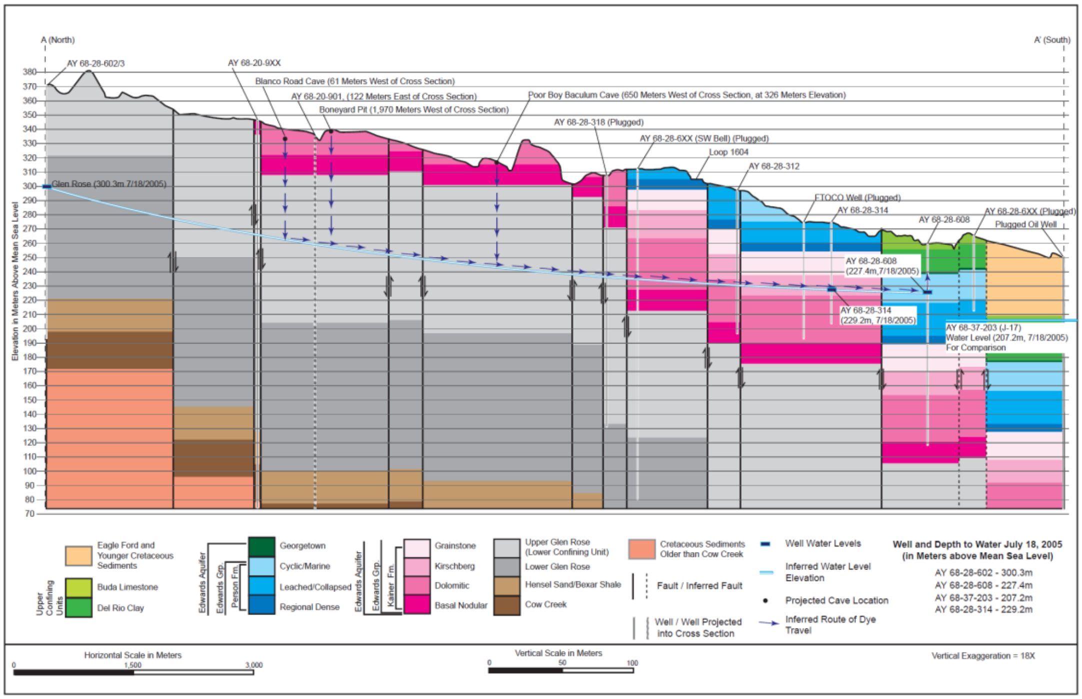

Figure 4. Geologic Cross-Section at the Panther Springs Creek Tracer Test

Gain/loss studies, which measure stream flow at multiple locations, are used to identify where streams are gaining (flow is increased due to contributions from groundwater) or where streams are losing (flow is decreased due to losses to the subsurface). Gain/loss studies were conducted in Helotes and San Geronimo Creeks, both of which are located in northwest Bexar County. The Helotes Creek study was conducted on the reach of Helotes Creek located immediately upstream from the Edwards Aquifer Recharge Zone (Figure 5). The study entailed flow measurements at six locations where Helotes Creek overlies the upper Glen Rose Aquifer. Flow measurements ranged from 0.94 cubic feet per second (cfs) at the most upgradient location (3.6 km upstream from the Recharge Zone), increased to a maximum of 4.24 cfs at approximately 2.4 km upstream from the Recharge Zone, then decreased to no flow at a distance of approximately 0.25 km upstream of the Recharge Zone (Figure 3). All baseflow in Helotes Creek enters the subsurface as recharge within the Edwards Aquifer Contributing Zone. This same phenomenon has been observed in the San Geronimo Creek watershed, located to the immediate west of the Helotes Creek watershed (Figure 6) (Marcus Gary personal communication).

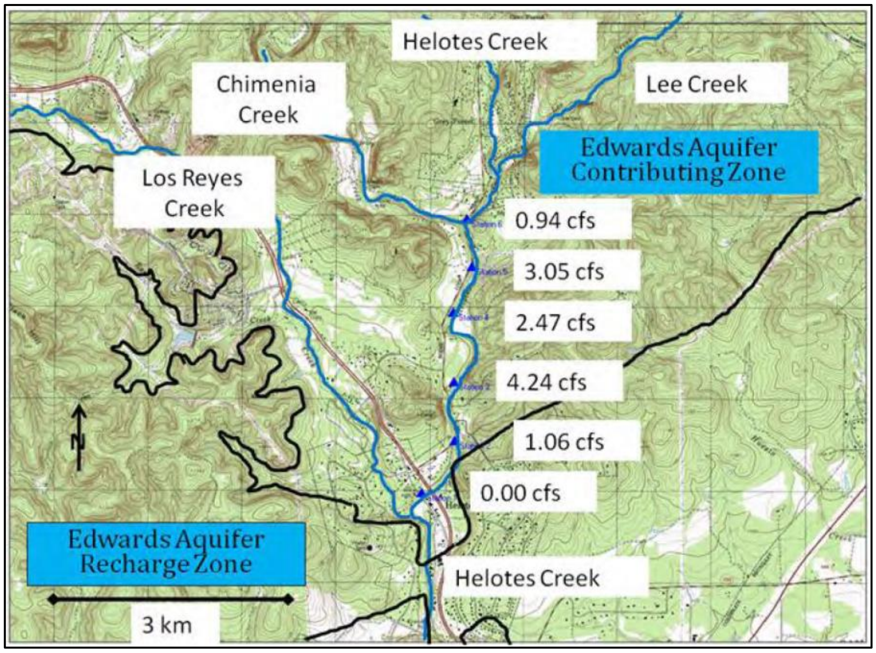

Figure 5. Gain/Loss Flow Study for Helotes Creek

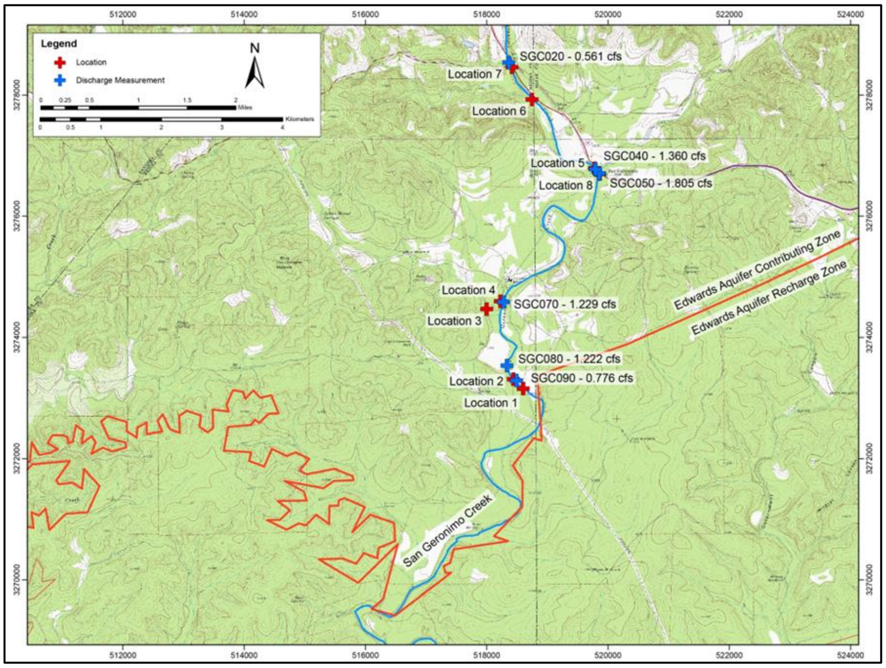

Figure 6. Gain/Loss Flow Study for San Geronimo Creek

Based on these multiple lines of evidence, conceptualization of the role of the Contributing Zone to recharge of the Edwards Aquifer has been refined. The former conceptualization of the Contributing Zone that suggested its role was to simply convey surface flow from the Contributing Zone to the Recharge Zone where it recharges the Edwards Aquifer has been refined to support the concept that significant recharge to the Edwards Aquifer occurs directly in the Contributing Zone (Figure 7) (Sharp et al., 2019; Sharp and Green, 2022).

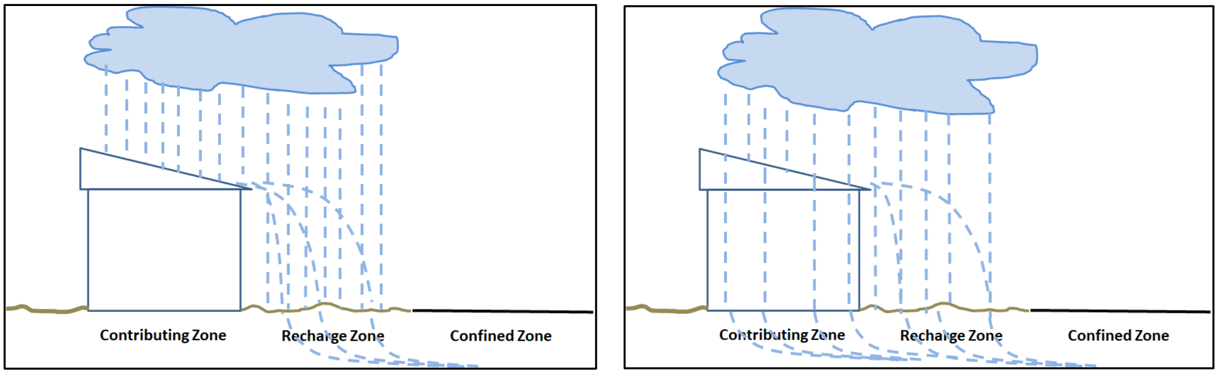

Figure 7. Conventional Conceptualization of the Edwards Aquifer Contributing Zone (left image). Refined Conceptualization of the Edwards Aquifer Contributing Zone (right image)

Accordingly, the vertical geologic cross-section of the Edwards Aquifer (Edwards Aquifer Authority, 2008) should be modified from Figure 8 (left) to Figure 8 (right).

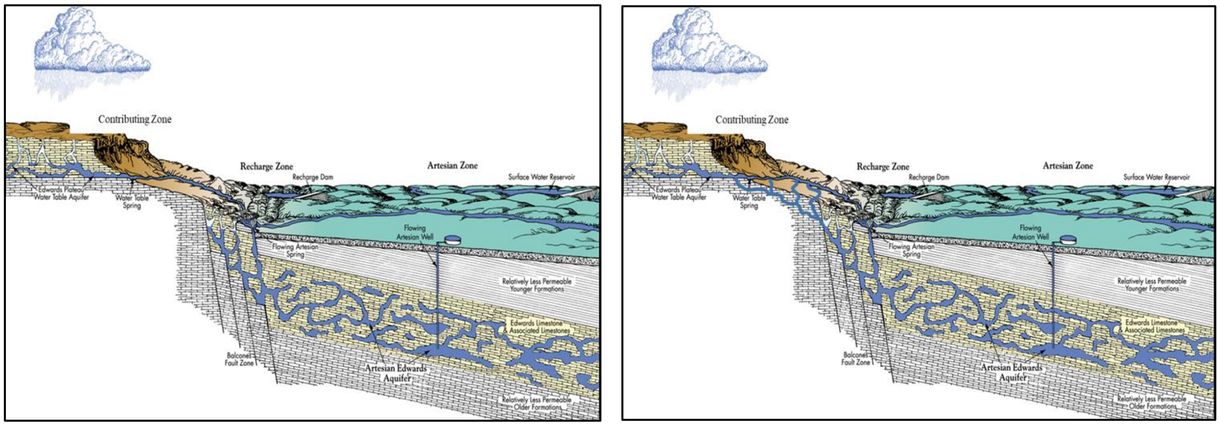

Figure 8. Conventional geological Cross-Section of the Edwards Aquifer (left). Refined Geological Cross-Section of the Edwards Aquifer (right)

Quality of Groundwater in Helotes Creek Watershed

Water was sampled from wells in the deeper freshwater horizon in the Helotes Creek watershed in a study that conducted by staff from the Edwards Aquifer Authority (EAA) and Southwest Research Institute (SwRI). The quality of this water is good, typically with a Total Dissolved Solids (TDS) of less than 500 mg/L. The middle poor-quality horizon was not sampled but is known to have a TDS concentration of 2,000 to 2,500 mg/L. The quality of the upper Glen Rose formation has not been tested; however, anecdotal evidence indicates it can be impacted by surface activities due to the absence of an overlying confining layer. Anecdotal evidence includes the impact of an improperly functioning direct discharge facility (TPDES) at the San Antonio Ranch subdivision in northwest Bexar County that degraded the shallow Trinity Aquifer along Los Reyes Creek and Helotes Creek south of Highway 16. San Antonio Water System (SAWS) ultimately removed the package effluent facility and provided water to the affected community.

Trophic State of Helotes Creek

The trophic state of a creek is a classification system designed to rate water bodies based on the amount of biological productivity they sustain. A healthy creek is classified as oligotrophic and a degraded creek is classified as eutrophic. A creek with moderate biological productivity is classified as mesotrophic. A creek rated as eutrophic will exhibit low dissolved oxygen, algae growth, and high turbidity.

Nutrient concentrations can be used to designate trophic states; however, the detection limits of common nutrients (i.e., nitrogen and phosphorous) are oftentimes too high to detect anything less than eutrophic conditions. More useful is the measurement of periphyton (the slim underneath rocks) and seston (particulate matter floating in surface water). Periphyton and seston are bioaccumulators, providing a more sensitive indicator of trophic state. Trophic state classification is provided in the following table. (Dodds et al., 1998).

Variable	Oligotrophic-mesotrophic boundary	Mesotrophic-eutrophic boundary
Mean benthic chlorophyll (mg/m^2)	20	70
Maximum benthic chlorophyll (mg/m^2)	60	200
Sestonic chlorophyll (µg/L)	10	30
TN (µg/L)	700	1500
TP (µg/L)	25	75

Water-chemistry results were not useful when delineating the trophic state of the Helotes Creek watershed due to the fact that nitrogen and phosphorus sample concentrations were at or below the detection limits (Flores et al., 2020). For this reason, concentrations of nutrients in periphyton and seston samples, which have much lower detection limits compared with similar concentrations in water samples, were considered in order to determine the trophic state of Helotes Creek watershed.

Examination of the Helotes Creek seston data from 2019 indicates that sestonic chlorophyll ranges from 4.04 to 73.9 µg/L (Flores et al., 2020). The average sestonic chlorophyll value is 25.3 µg/L. Two samples may overestimate this value due to the presence of some benthic material in the sample. If potentially overestimated values are excluded, the average sestonic chlorophyll value is 9.74 µg/L. These two averages would indicate that the Helotes Creek watershed was either in a slightly mesotrophic or oligotrophic state during the 2019 sampling period, respectively.

The periphyton (the source of benthic chlorophyll in this project) values for the Helotes Creek watershed range from 17.90 to 47.11 mg/m^2 with an average of 31.04 mg/m^2. This average value indicates that the Helotes Creek watershed is in an oligotrophic state, as it is below the oligotrophic-mesotrophic boundary for maximum benthic chlorophyll. However, the average value is also above the mean benthic chlorophyll value for the oligotrophic-mesotrophic boundary (20 mg/m^2), indicating the watershed could be slightly mesotrophic.

In summary periphyton and seston levels in Helotes Creek indicate the trophic state is oligotrophic to mesotrophic with the highest levels detected near Grey Forest City Hall (Flores et al., 2020). This indicates that the trophic state of Helotes Creek has already been marginally degraded in the City of Grey Forest region.

Comparison of the Impact of Different Wastewater Facility Types on the Water Quality in Helotes Creek Watershed

SwRI conducted a study to evaluate the impact of development in the Helotes Creek watershed. Numerical models were developed to simulate the impact of wastewater on the quality of water in Helotes Creek due to effluent discharged from three types of wastewater facilities: (a) On-Site Septic Facility (OSSF); (b) Texas Land Application Permit (TLAP); and (c) Texas Pollutant Discharge Elimination System (TPDES).

A total of eight scenarios were evaluated. The amount of effluent discharged per household was the same for all scenarios. Scenarios assumed different numbers of additional households constructed in the Helotes Creek watershed and with different wastewater facility types needed to service smaller or larger developments. Nutrients were added to the environment either via the subsurface or as surface runoff, depending on the type of facility. The greatest impact on Helotes Creek was from the construction of a TPDES facility because it allowed the greatest number of additional households and nutrients would be discharged directly into creek beds (Figure 9). The next greatest impacts were from TLAPs, the use of this type of facility also allowed a large number of additional households. The least impact on the trophic state of Helotes Creek was from the use of OSSFs. This is mostly due to a reduced number of additional households given that a minimum lot size of 0.5 acres is required in order to allow an OSSF. The OSSF scenario with the greatest level of nutrient discharge assumed a 13% failure rate of the functionality of the OSSF due to improper construction or improper maintenance. A Texas-wide evaluation of OSSF functionality identified a failure rate of 13% as realistic (Reed et al., 2002).

In summary, the simulations are in agreement with the logic that the trophic state of Helotes Creek will be more impacted by developments that include more households, regardless of wastewater facility type. The sheer number of households is the dominant factor when assessing the impact of development on the environmental health of the Helotes Creek watershed.

That being said, caveats worth nothing come from Flores et al. (2020) study. In this study, the contribution of nutrients from households due to lawns and street runoff was not included in these assessments. Only the impact of wastewater facility effluent was taken into consideration. A second caveat was that the impact of wastewater discharge to the shallow unconfined freshwater horizon in the Helotes Creek watershed was not evaluated because of the inability to sample and analyze the quality of water from that aquifer.

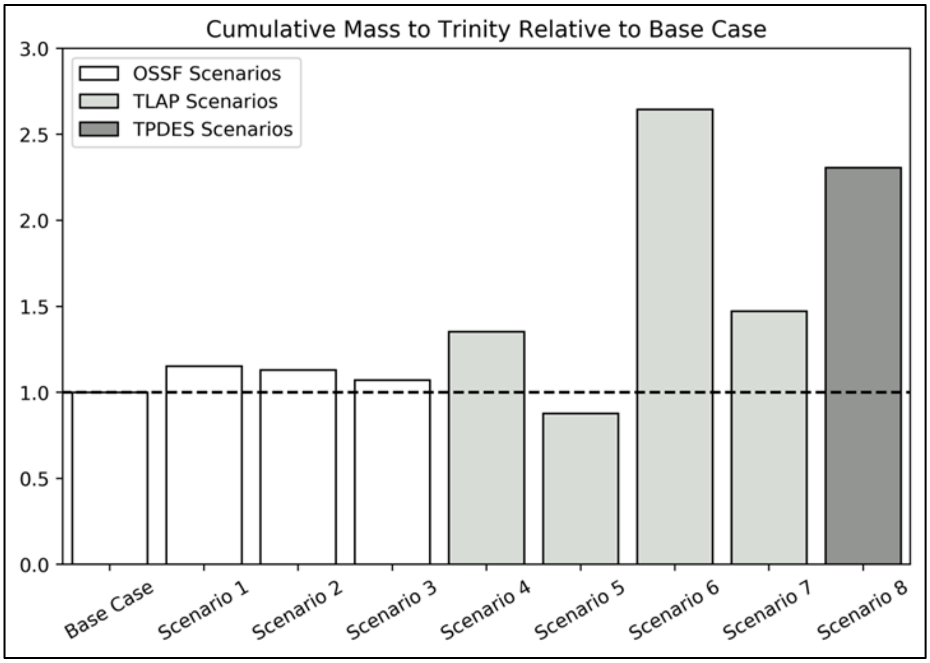

Figure 9. Results of the Southwest Research Institute Simulation of Cumulative Mass Released Due to Type of Wastewater Facility (Flores et al., 2020)

Summary

Development over areas that recharge an aquifer can impact the recharge to an underlying aquifer. That is clearly the case for areas which provide recharge to the Edwards Aquifer near San Antonio, Texas. Investigations over the past two decades indicate that the role of the Contributing Zone to recharge of the Edwards Aquifer is greater than currently represented in protective rules by the TCEQ. The Contributing Zone not only conveys surface flow to the Recharge Zone to facilitate recharge to the Edwards Aquifer, but multiple lines of evidence support the conceptualization that significant recharge to the Edwards Aquifer occurs directly in the Contributing Zone. As a consequence, it is now apparent that development over the Contributing Zone can have a profound impact on recharge to the Edwards Aquifer.

As discussed in this document, the level of development will determine the level of impact on surface waters that flows across the Contributing Zone and ultimately the quality of water that recharges the Edwards Aquifer. Study results cited above indicate that the amount of development (as determined by effluent discharged to the environment) will determine to what degree the environment is impacted. Higher levels of effluent discharge will further degrade Helotes Creek, which has already reflected marginal degradation and will degrade the quality of water that recharges the Edwards Aquifer.

Numerical simulations conducted to ascertain the impact of different types of wastewater facilities indicate that the degree of impact on the environment is largely a function of the mass of effluent discharged into the environment. Hence, the impact on the environment by effluent discharge is a function of the sheer amount of effluent discharged irrespective of discharge methodology. A TLAP and TPDES facility will have a greater impact than OSSFs simply because more effluent is discharged by these centralized facilities. Discharge by OSSFs has less of an impact on the environment due to the reduced density of development as required to use OSSF for effluent discharge.

Analyses discussed in this document suggest that the Lennar development on the Guajolote Ranch would likely degrade the trophic state of Helotes Creek from oligotrophic/mesotrophic to fully mesotrophic or possibly eutrophic. A eutrophic creek will exhibit low dissolved oxygen, algae growth, and high turbidity.

The impact of the Lennar development on the Guajolote Ranch on the quality of the Edwards Aquifer; however, is more difficult to ascertain. This is due to the fact that the Edwards Aquifer is recharged over an area that extends west to Uvalde and north to include the Contributing Zone. Clearly, due to factors such as dilution, development in areas closer to San Antonio will have a greater impact on the quality of water in the Edwards Aquifer compared with development in distal areas. Development over a single tract of 1,160 acres in northwest Bexar County will likely have a marginal impact on the greater Edwards Aquifer. A more serious risk will be incurred; however, if the Lennar development of the Guajolote Ranch occurs; establishing a dangerous precedent that leads to additional extensive development in northwest Bexar County, similar to what has been experienced in northern Bexar County along the Highway 281 corridor.

Currently, users of water from the Edwards Aquifer rely on dilution to maintain the superior quality of pumped water. Of concern is whether continued development will degrade the quality of the Edwards Aquifer to the point where health and safety are threatened. At the moment, insufficient studies have been taken to answer this question. A cursory analysis of data as reported by TCEQ suggests an increasing trend in pathogen detections in San Antonio Water System wells in recent years (Figure 10). It is possible that these data are not comprehensive. As a result, this analysis is compelling, but not conclusive. Additional data acquisition and analysis are required to determine whether there is a trend in the quality of Edwards Aquifer water.

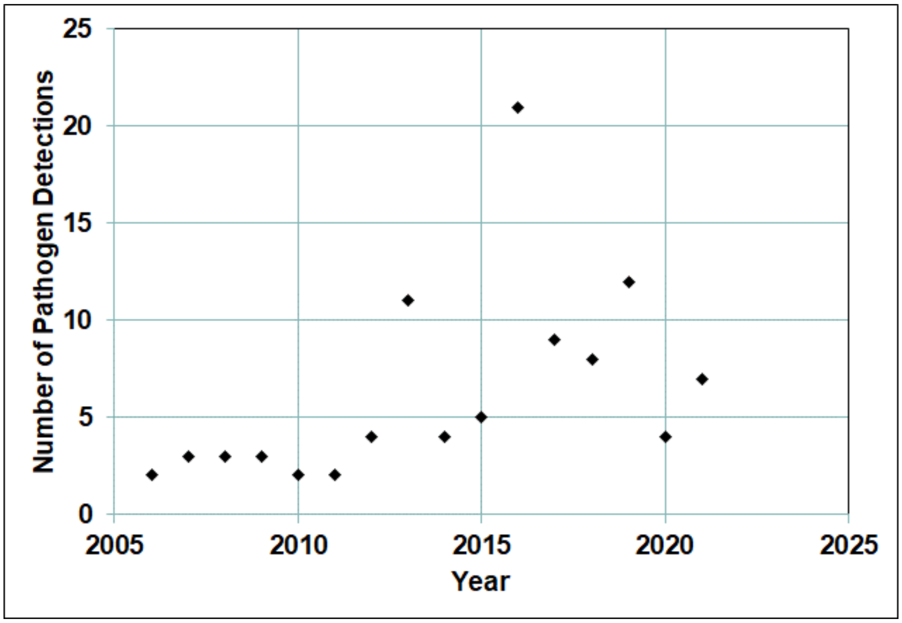

Figure 10. Pathogen Detections in San Antonio Water System Wells

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