Texas Water Development Board

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TO: Board Members

THROUGH: Melanie Callahan, Executive Administrator
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FROM: Larry French, Director, Groundwater Resources
Joe Reynolds, Attorney
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DATE: January 25, 2012

SUBJECT: **Briefing, discussion, and possible action** on appeals of the reasonableness of the Desired Future Condition adopted by the groundwater conservation districts in Groundwater Management Area 9 for the Trinity Aquifer

ACTION REQUESTED

Staff recommends that the Board find that the desired future condition (DFC) adopted by the groundwater conservation districts (Districts) in Groundwater Management Area 9 (GMA 9) for the Trinity Aquifer is reasonable based on the analysis set out in this report.

BACKGROUND

This report and the attached technical report constitute the staff analysis of petitions filed by legally defined interests in groundwater in Groundwater Management Area 9 (GMA 9). These petitions appeal the adoption of the DFC for the Trinity Aquifer. This analysis discusses whether the DFC is unreasonable based on the evidence in the record.

Legislative History

The 79th Legislature provided that a person with a legally defined interest in the groundwater in a groundwater management area (GMA) could file a petition with the Texas Water Development Board (TWDB) appealing the approval of a DFC by the Districts in that GMA. The Legislature placed the burden on the petitioner to provide evidence that the Districts did not establish a reasonable DFC. But the Legislature did not define "reasonable," nor did it provide any guidelines for the TWDB to use in determining whether a DFC is reasonable.[1] The final determination of a DFC is, in fact, the responsibility of the Districts in the GMA.[2]

[1] *See* Tex. Water Code § 36.108(l)-(n).
[2] *See* Tex. Water Code § 36.108(n).

The 82nd Legislature amended the statute to provide a more detailed process for groundwater conservation district to follow in approving a DFC.[3] Groundwater conservation districts will now be required to prepare a detailed report on the DFC approval process that documents the consideration of certain criteria and the application of a balancing test, and to develop a record of public participation and responses to any public comments. The 82nd Legislature, however, did not change the basic process for an appeal of a DFC to the TWDB.[4] Notwithstanding any findings by the TWDB that a DFC is unreasonable, the final determination of a DFC remains the responsibility of the Districts in the GMA.[5]

These revised statutory requirements for adoption of a DFC do not apply, however, to the GMA 9 DFC review under consideration, as the DFC was adopted before the changes made by the 82nd Legislature became effective. The determination to review appeals of DFCs adopted before the changes in statute under the statute in place at the time of adoption was discussed by the Board on October 19, 2011.

Procedural History

On July 26, 2010, the Districts in GMA 9[6] adopted the following DFC for the Hill Country Trinity Aquifer, pursuant to Texas Water Code § 36.108:

> [A]llow for an increase in average drawdown of approximately 30 feet through 2060 consistent with "Scenario 6" in TWDB Draft GAM Task 10-005.

Administratively complete petitions were submitted by the Wimberley Valley Watershed Association (Wimberley Valley) on June 13, 2011, and by the Flying "L" Guest Ranch, Ltd. (Flying L) on July 25, 2011. Petitioner Wimberley Valley filed its petition to appeal the DFC "as it applies to the Trinity Aquifer within the boundaries of the Hays Trinity Groundwater Conservation District."[7] While Petitioner Flying L challenges the reasonableness of the DFC applicable to all of GMA 9, Flying L's petition focuses on the impact of the DFC in Bandera County. In considering both petitions, however, it is important to keep in mind for this analysis that the DFC approved by the Districts for GMA 9 is a GMA-wide DFC.[8]

TWDB staff held hearings on the Flying L petition on November 7, 2011, in Kerrville, Texas, and on the Wimberley Valley petition on November 16, 2011, in Wimberley, Texas, to take testimony and evidence from the petitioners and the Districts. The record for the Flying L petition remained open until November 21, 2011, to receive additional evidence from other interested persons, as required by 31 Tex. Admin. Code § 356.44(f). The record for the Wimberley Valley petition

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[3] Acts 2011, S.B. 727 and S.B. 660, 82nd Leg., R.S..
[4] *See* new Tex. Water Code § 36.1083, eff. 9/1/2011.
[5] *See* new Tex. Water Code § 36.1083(d), eff. 9/1/2011 comp. to former Tex Water Code § 36.108(n).
[6] Bandera County River Authority and Ground Water District, Barton Springs/Edwards Aquifer Conservation District, Blanco-Pedernales Groundwater Conservation District, Cow Creek Groundwater Conservation District, Edwards Aquifer Authority, Hays Trinity Groundwater Conservation District, Headwaters Groundwater Conservation District, Medina County Groundwater Conservation District, and Trinity-Glen Rose Groundwater Conservation District.
[7] WVWA Pet. Pg. 1.
[8] *See* Tech. Analysis, Fig. 1

remained open until December 1, 2011. The TWDB received additional evidence on the Flying L petition from 1 interested person and on the Wimberley Valley petition from 160 interested persons.

The Arguments

Petition of Flying L Ranch

Petitioner Flying L owns and operates the Flying "L" Guest Ranch in southeast Bandera County, within GMA 9. Flying L owns seven water wells permitted by the Bandera County River Authority and Ground Water District (Bandera District) for an aggregate total of 2,096 acre-feet per year. Flying L also owns 100 acres adjacent to its guest ranch intended for new development. Flying L may apply for an additional permit to authorize the drilling and operation of a well on this second tract for up to 100 acre-feet per year.[9]

Flying L challenges the reasonableness of the DFC adopted by GMA 9 on several grounds that will be discussed in detail below. To summarize, Flying L finds the DFC unreasonable because:

(1) it is based on a groundwater availability model (GAM) that does not incorporate current pumping amounts authorized under permits issued by the Districts;

(2) it adopts a single average drawdown limit for the three aquifer units that make up the Trinity Group, rather than specifying a drawdown for each unit, thereby failing to meet the definition of a DFC;

(3) it is based on an average drawdown that is too vague, ambiguous and inherently arbitrary to be an effective management goal;

(4) it is not physically possible;

(5) it negatively impacts private property rights;

(6) implementation of the DFC is reasonably expected to result in adverse socio-economic impacts;

(7) it does not allow for a reasonable and prudent development of the state's groundwater resources; and

(8) it conflicts with the state's policy of encouraging economic development.

Petition of Wimberley Valley Watershed Association

Petitioner Wimberley Valley is a non-profit corporation and the owner of real property located in Hays County, within the Hays Trinity Groundwater Conservation District (Hays Trinity District). Wimberley Valley challenges the DFC as "unreasonable" because:

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[9] Flying L Pet. pg. 2.

(1) it allows the issuance of permits for the withdrawal of such a high quantity of groundwater that implementation of an adaptive management strategy will be difficult or impossible;

(2) the combination of non-exempt permitted pumping and pumping by exempt wells already exceeds the amount of available groundwater;

(3) it allows more pumping than the current Hays Trinity management plan's available groundwater, which may itself be unsustainable;

(4) it will have unreasonably harmful environmental impacts, including adverse impacts on spring flow at Jacobs Well and other springs in Hays County;

(5) it will have unreasonably harmful impacts on the use of private water wells in Hays County;

(6) it will have unreasonably harmful economic impacts;

(7) it fails to ensure the reasonable and prudent development of the state's groundwater resources and does not prohibit "aquifer mining" or ensure sustainable management of the groundwater;

(8) it fails to address desired future conditions of the aquifer and impacts on spring flow and groundwater levels during droughts;

(9) it fails to account for reasonably foreseeable water uses in Hays County;

(10) it fails to consider environmental and economic impacts related to changes in surface water flows that will result from lowered aquifer levels;

(11) it fails to ensure conservation and protection of groundwater in the Trinity Aquifer;

(12) it is not adequately quantified because the term "average drawdown" lacks adequate specificity to reasonably determine the baseline or method for measurement; and

(13) it does not properly account for the distinctive characteristics of the Upper, Middle, and Lower Trinity aquifers, each of which functions in a manner that is sufficiently independent to justify separate DFC criteria for each aquifer.[10]

Analysis of Issues Raised
Attachment A is staff's technical analysis of certain issues raised by the petitions. Reference to that analysis will be made as appropriate throughout this discussion.

[10] WVWA Pet. pg. 2-3.

TWDB rules provide that the Board shall base any recommended revisions to the desired future conditions only on evidence in the hearing record.[11] In addition, the Board is to consider the following criteria when determining whether a desired future condition is reasonable:

(1) the adopted desired future conditions are physically possible and the consideration given groundwater use;

(2) the socio-economic impacts reasonably expected to occur;

(3) the environmental impacts including, but not limited to, impacts to spring flow or other interaction between groundwater and surface water;

(4) the state's policy and legislative directives;

(5) the impact on private property rights;

(6) the reasonable and prudent development of the state's groundwater resources; and

(7) any other information relevant to the specific desired future condition.[12]

Consequently, this report will be organized around the criteria listed above. Arguments from the Petitioners and from the Districts will be presented, followed by staff's analysis.

1. The DFC is physically possible.

Flying L Ranch

Flying L asserts that the DFC is unreasonable because it is based on faulty inputs and assumptions that do not accurately reflect existing pumping, permitted pumping or reasonably anticipated future pumping, making the DFC unreasonable and unachievable.[13] Flying L states that existing usage and authorized permitted pumping in Bandera County are grossly underestimated and result in a predicted managed available groundwater (MAG) amount that is substantially less than actual use, permitted production, and anticipated growth in exempt use.[14] In addition, Flying L claims that by adopting a single average drawdown limit for the three aquifer units that make up the Trinity Group, the DFC does not meet the definition of a "desired future condition" as promulgated by the Board.

The Districts

The Districts respond that the GAM that was used to define the DFC (Scenario 6 in Draft GAM Task 10-005) is a regional model and is not site-specific. It cannot address every well, every property, and every permit.[15] Finally, the Districts state that the Trinity Aquifer is defined and accepted as a "Major Aquifer" for which a single DFC is authorized.[16]

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[11] 31 TAC § 356.45(c).
[12] *Id.*
[13] Flying L Pet. Pg. 4.
[14] *Id.*
[15] Dist. Resp. 11/7/11, pg. 5
[16] *Id.* at pg. 4-5

Wimberley Valley

While not directly addressing whether the DFC is physically possible, Wimberley Valley does argue that incongruity exists between model results and assumptions (as a planning tool) and implementing the proposed DFC (as a policy). There is too much averaging in model results and assumptions to make predictions about local conditions. The DFC does not clearly articulate critical drought management considerations under future conditions. Projections of growth in groundwater pumping from exempt wells vary greatly, making it difficult to effectively estimate the actual water available. Model predictions do not incorporate the complexity of multiple aquifer layers in the Trinity. And Wimberley Valley asserts that no proper baseline has been established from which to measure the estimated 19 ft drawdown of the Trinity Aquifer in Hays County.[17]

The Districts

The Districts counter that average drawdown is a well-established aquifer metric. There is no requirement that the DFC include a monitoring program to measure the drawdown. The responsibility for monitoring and measurement lies with the local districts, not in the DFC itself.[18] The DFC process does not mandate that the drought of record be considered or incorporated into the DFC. In addition, drought, being so unpredictable in location, duration, and severity, is more appropriately and effectively managed by the local Districts through their drought rules and management plans.[19]

The Districts testify that Wimberley Valley and Hays Trinity District have reached an agreement to incorporate recent studies by HDR Engineering, Inc. on exempt-well use projections in Hays County.[20]

Staff

In general, both Wimberley Valley and Flying L rest their claims that the DFC is not physically possible in large part on criticisms of the modeling. But the petition process is not intended for the appeal of issues related to the modeling process or modeling assumptions. The petition process is limited to addressing the reasonableness of an adopted desired future condition on the merits of the DFC itself. Flying L combines estimates of exempt use and its own calculation of permitted production to conclude that the MAG is much too low to account for all the use associated with production from the Trinity Aquifer in Bandera County. Flying L's assertion that the estimates of exempt use are too low are not supported by any calculations. In addition, Flying L's focuses on amounts authorized for withdrawal under permits rather than amounts actually withdrawn.[21] This distinction is discussed more fully under Section Two below, relating to socio-economic impacts.

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[17] WVWA Pet. Pg. 10-13.
[18] Dist. Resp. 11/16/11 pg 8.
[19] *Id.* at pg. 6.
[20] *Id.* at pg. 7.
[21] *See, for example,* Flying L Pet., pg. 3, "The DFC is unreasonable because it is based on a GAM that does not incorporate current pumping amounts authorized under permits issued by the Districts." *And* Flying L Test., Power Point slide 53, "The selected DFC for Bandera County is arbitrary because it is based on 2008 pumpage numbers that fail to give due consideration to groundwater use in the county: ignores amounts of groundwater authorized by withdrawal under permits previously issued . . . ."

Wimberley Valley claims that the combination of non-exempt permitted groundwater pumping and pumping by exempt wells already exceeds the amount of available groundwater, based on the 2005 Hays Trinity management plan. First, as shown on Figure 5 of the technical analysis (Attachment A), the MAG for Hays County of approximately 9,100 acre-feet per year is higher than the trend in the TWDB-estimated use or the District-estimated exempt use.[22] Second, the DFC does not have to conform to the existing management plan. Rather, the Districts are required to address the DFC as they develop their next management plans.[23] The management plans, and not the DFC, also are the place where the Districts address drought management.[24]

Both petitioners refer to the definition of a desired future condition as proof that the DFC is unreasonable because it does not provide a separate DFC for each segment of the Trinity Aquifer and therefore fails to meet the definition. Under the relevant statute and regulations, a *regional* DFC is not inherently unreasonable. The definition of a DFC in TWDB rules states that a DFC is the desired, quantified condition of groundwater resources for a specified aquifer within a management area at a specified time or times in the future.[25] Section 36.108 of the Water Code also states that the Districts *may* establish different desired future conditions for each aquifer, subdivision of an aquifer, or geologic strata located in whole or in part within the boundaries of the management area.[26] The fact that the Trinity Aquifer is comprised of three distinct zones does not mean that the Districts *must* adopt different DFCs for the different zones. The language in the rule is discretionary, not mandatory. In fact, as the Districts point out, GAM Task 10-005 shows not only the overall drawdown for the management area but also specific drawdown estimates for each subdivision of the aquifer in each district and each county. This, according to the Districts, is one of the reasons that the Districts in GMA 9 chose to designate the DFC as they did, referencing Scenario 6 in Draft GAM Task 10-005.

Staff also agrees that the agreement described by the Districts between the Hays Trinity District and Wimberley Valley is a positive step toward resolving some matters of disagreement between them regarding calculation of exempt well use specific to Hays County.

2. Consider socio-economic impacts that are reasonably expected to occur.

Flying L Ranch

Flying L makes three assertions regarding socio-economic impacts reasonably expected to occur if the DFC is implemented. First, Flying L claims that an immediate 76 percent proportionate reduction of existing permits issued for irrigation, including those issued to Flying L, and all other permits issued by the Bandera District would be required to achieve the adopted DFC. Second, Flying L claims to have identified 83 public water system wells that are operating without permits and noted that the DFC makes no water available for existing unpermitted wells. Third, with a projected increase in water demand during the 50-year planning period, the DFC makes no water available for growth in municipal use.[27] In sum, Flying L notes that the DFC yielded a MAG of a

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[22] Staff Tech. Analysis, pg. 11-12.
[23] Tex. Water Code § 36.1071(a)(8)
[24] *Id.* at 36.1071(a)(6).
[25] 31 TAC 356.2(8)
[26] Tex. Water Code § 36.108(d)(1).
[27] Hearing 11/7/11 Trans. pg. 62-63.

constant 7,284 acre-feet per year through the 50-year planning cycle and that such a MAG is inadequate to address current and future needs.

The Districts

The Districts respond that it is not surprising that the GAM would yield a nearly constant annual pumping limit for the MAG when the DFC is based on drawdown. With drawdown and pumping closely related, the annual withdrawal would change very little, if any, year to year.[28] The Districts claim that, based on the 2008 estimated demands, the approved DFC would meet virtually all current and future demands in each district during the next 50 years.

The Districts also point out that planning is an iterative process, reviewed and refined on both an annual and a five-year cycle. Revisions to the DFC may occur during this cycle to address growth, changing water demands, and other factors. By July 2015, in fact, the Districts in GMA 9 must review and adopt new or revised DFCs under the statutory provisions in force after September 1, 2011.[29]

Wimberley Valley

Wimberley Valley states that the adopted DFC will result in an excessive and significant increase in pumping from the Trinity Aquifer in Hays County that could cause individual wells to dry up. At a minimum, Wimberley Valley claims that the economic impact per individual well owner could be several thousand dollars paid for hauling water during dry periods and upwards of $15,000 for drilling new, deeper wells.[30] In addition, Wimberley Valley claims that the proposed DFC will reduce base flows to springs and rivers that sustain aquatic habitats and will impact recreational uses of the rivers.[31] Surface waters, such as the Blanco River, provide a significant source of revenue for local businesses engaged in recreation and tourism. Significant reductions in base and spring flow, such as those modeled for the proposed DFC, will have excessive negative impact on local economies.[32]

The Districts

The Districts state that the most appropriate way to achieve preservation of base flow, consistent with stakeholder input, is to protect the primary source water, that is, spring flow. As the primary threat to such spring flow is increased pumpage, GMA 9 decided that it would be prudent, conservative, and appropriate to set a DFC that "would meet current demand, projected exempt demands, and have a bit left over for non-exempt use."[33]

Staff

Economic impacts of different pumping scenarios are difficult to quantify. Reduced water levels and outflow to surface water caused by natural events, such as a period of drought, or increases in population with concomitant increases in pumping may result in economic impacts. But economic

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[28] Hearing 11/7/11 Trans. pg. 83-84.
[29] Tex. Water Code § 36.108(2)(c) and (d).
[30] WVWA Pet. pg. 4.
[31] *Id.* at 5.
[32] *Id.* at 7.
[33] Dist. Resp. 11/16/11 pg. 7

impacts may also occur from limiting pumping of groundwater that would otherwise be put to a beneficial use.

Flying L's assertion of negative socio-economic impacts is predicated, in part, on how it calculates pumping, permits, and demand. Flying L states that it has a permit authorizing withdrawal of 2,096 acre-feet per year, but that the simulation used by the Districts to produce the DFC includes only 12 acre-feet per year in the area covered by Flying L's permitted wells.[34]

In other words, Flying L argues that the DFC is unreasonable based on the disparity between Flying L's calculation of the amount of water authorized under permits that have been issued by Bandera District and the numbers offered by the Districts and by the TWDB for pumping. Flying L's argument raises a policy question that has not previously been presented to the Board: whether a DFC must fully protect the amount of production qthorized by permits and for exempt uses in order to be reasonable. Staff recommends that the Board decide this question is reserved to local, collective decision-making by the groundwater conservation districts within a GMA. There is no one-to-one correlation between permits—the amount of water one is authorized to withdraw from the aquifer—and pumping—the amount of water actually withdrawn from the aquifer. Nor is there any requirement for the DFC to honor historic permits. In situations such as this where permitted amounts exceed the MAG, Districts will need to carefully consider how they address existing permits and use and future permit requests.

The Districts have articulated their decision in their testimony to the effect that "when used in the GAM to generate what total pumping could be utilized without exceeding the DFC, estimated current pumping demand was the consideration, not an estimate of what could be permitted."[35] The Districts also note that to address the DFC, the Districts needed to know "what could be pumped," not "what might be pumped under permit." They go on to note that "many permit holders are permitted to withdraw far more than they actually pump."[36] This is a choice for the Districts to make; and the choice is not, in itself, unreasonable.

Flying L's response is to claim that water under permits "can be pumped at every minute of every day all year, as long as it doesn't constitute waste, and we're legally authorized to pump that amount of water."[37] To the comment that nobody pumps at their maximum allowable rate 24 hours a day, 7 days a week, 365 days a year, Flying L counters "there are people that do."[38] The DFC and the models used to derive the MAG from the DFC are based on data related to pumping, not permits, and Flying L offers no evidence—no business plan, no use projections—to support a reasonable expectation that it might, in fact, pump the maximum allowed under its permit. Nor does it provide any evidence that other permit holders intend to pump or are pumping the maximum allowed under their permits.

Flying L assumes that a massive reduction in existing permit authorizations will be required the day after the DFC is implemented in order to achieve the DFC, including shutting down a large number

[34] Flying L Pet. pg. 3.
[35] Dist. Resp. 11/7/11, pg. 4.
[36] *Id.*
[37] Hearing Trans. 11/7/11, pg. 94.
[38] *Id.*

of existing, unpermitted public water supply wells. But these are assumptions at best, based on Flying L's use of permit numbers, as discussed above, not on data related to actual pumping.Figure 4 in the technical analysis shows that the amount of groundwater production authorized under permits issued in Bandera County (22,251 acre-feet per year) exceeds the MAG for the County. However, District-estimated current use, which presumably includes Flying L's current production, is less than the MAG; and total demand from all sources, according to the 2012 State Water Plan, is expected to be less than the MAG in 2060.

Socio-economic impacts of the DFC are one of three major issues for Wimberley Valley; the others being environmental impacts and effects on private property rights. But whereas Flying L expressed concern that the DFC adopted by GMA 9 does not provide adequate water to cover anticipated new demands, Wimberley Valley fears that the DFC will allow water levels to decline to the degree that surface waters will be negatively affected. These surface waters, Wimberley Valley asserts, provide a significant source of revenue for local businesses engaged in recreation and tourism.

Population growth is expected over most of GMA 9. The use in Hays County is shown on the chart in Figure 5, along with the trend line of estimated use from the current 3,000 acre-feet per year to 7,955 acre-feet per year in 2060. Even with a zero pumping scenario, modeling indicates some streams and creeks will experience periodic reductions in flow because water levels trend with precipitation. The consequences that concern Wimberley Valley may be unavoidable. Consequently, the question is whether the DFC adopted by the Districts is a reasonable attempt to balance growing needs with conservation of resources.

Section 4 of the Technical Report provides a summary of scenarios showing different pumping conditions for Hays and Bandera counties. Based on Table 5, attempts to set pumping at less than 6,000 acre-feet per year for the Hays Trinity District may not be practicable. Scenario 6 in Table 5 (approximately 6,000 acre-feet per year) results in an average drawdown of 13 feet. This approximates the estimate provided by the Districts of the amount of production that will be exempt from permitting for 2060. A DFC that results in a MAG value below that amount may not be achievable because Hays Trinity District does not regulate exempt use. The DFC, approximated in the chart at the 9,000 acre-feet per year level, thus appears to be a reasonable attempt on the part of GMA 9 to, as the Districts testified, "set a ceiling on the pumping and resulting impacts, while allowing for some future growth." Various future demands, such as an increase in exempt wells in the Jacob's Well area, can best be regulated or mitigated through the development and implementation of district rules specific to a given area. That is the task assigned to the local district as it develops and adjusts its management plan over time. A regional DFC is not inherently unreasonable because it fails to adequately address specific local issues better addressed by the local district through its management plan, rules, and site-specific information appropriate to individual permit applications.

3. Consider environmental impacts including but, not limited to, impacts to spring flow or other interaction between groundwater and surface water.

Flying L

Flying L does not raise any environmental concerns.[39]

Wimberley Valley

Wimberley Valley claims that the adopted DFC will have unreasonably harmful environmental impacts, including impacts on spring flow at Jacob's Well and other springs in Hays County. Specifically, Wimberley Valley argues that reduction in spring and base flows, resulting from implementation of the DFC, will reduce instream flows to sustain aquatic habitats. Reductions in spring and base flows will result in more frequent water quality impairments in surface waters. Declining water quality, particularly low dissolved oxygen resulting from reduced flow, is a critical concern to survival of endangered species during drought. Reduction in spring and base flows resulting from the DFC will result in higher concentrations of pollutants in streams. By allowing the permitting of pumping that will intercept what would otherwise be significant lateral, subsurface inflow from the Trinity Aquifer, Wimberley Valley claims the proposed DFC will have a detrimental impact on Barton Springs and will place an unreasonable economic burden on downstream users of the Edwards Aquifer who may soon be obligated to maintain specific target flow levels in these critical springs. The DFC is unreasonable, Wimberley Valley states, because it fails to explicitly articulate a desired future condition for the aquifer during drought conditions, the time when prudent groundwater management is most critical.[40]

Districts

The Districts respond by noting that today, during the worst one-year drought in history, there is water at ground level in Jacob's Well. Water levels in monitored wells proximal to Jacob's Well have not varied more than a few feet during the past eight to ten years. A drop of two to three feet will cause Jacob's Well to stop flowing. The Districts claim that this is the result of a lack of substantial recharge during a drought and the continued drilling and pumping of new, exempt domestic wells in the basin.

The Districts state that the most appropriate way to achieve preservation of base flow consistent with stakeholder input would be to protect the primary source water, that is, spring flow. As the primary threat to such spring flow is increased pumpage, GMA 9 decided to establish a DFC that will "help set a ceiling on the pumping and resulting impacts, while allowing some future growth."[41] The Districts conclude that the challenge for Districts with unique local conditions such as Jacob's Well is not the DFC, but how the resulting MAG will be managed by the individual groundwater districts, given increases in pumping—especially exempt pumping—over time.[42]

Staff

Assessing the environmental impact of the DFC is difficult because a number of factors affect instream flows and outflows from the Trinity Aquifer. Pumping is one factor, and precipitation is another factor. As noted above and in Section 5 of the attached Technical Analysis, water levels in springs and wells correlate with precipitation. As Wimberley Valley notes, under the DFC flow across the Trinity-Edwards interface could be reduced by more than 30 percent. But that 30 percent

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[39] Flying L Test. Slide 54 "no evidence in the record that serious adverse environmental impacts will occur if current pumping is not reduced."
[40] WVWA Pet. pg. 8-10.
[41] *Id.*
[42] *Id.* at 5.

constitutes less than 10 percent of the total recharge from various sources to the Edwards Aquifer.[43] Thus, while the DFC may reduce flow across the interface, the potential impact is not reasonably expected to be as great as Wimberley Valley suggests.

In addition, as the Districts note, the DFC was selected with the entire GMA 9 region in mind. Each District is responsible for implementing the DFC in its management plan and taking account of district-specific issues. A number of studies have been prepared on the various interconnections with the Edwards Aquifer. Each of those presented by Wimberley Valley and reviewed by staff recommend additional studies to better understand the interactions between various parts of the Trinity Aquifer and the Edwards Aquifer. The task before the GMA and the individual Districts is to be attentive to the technical work being done and incorporate such new data as it becomes available and is appropriate. Work already under way by the Hays Trinity District to incorporate recent studies by HDR point toward the kind of specific actions by the Districts that will make the DFC achievable while addressing specific needs in different segments of the GMA. Presently, studies do not suggest that the DFC is unreasonable with regard to environmental issues.

In fact, there is no requirement that the DFC ensure the aquifer is managed sustainably. The DFC represents a policy decision by the Districts to balance competing goals of conserving the water in the aquifer and using that water to meet water demands.

4. Consider the state's policy and legislative directives.

Flying L

Flying L asserts that the DFC is not reasonable because it conflicts with the state's policy of encouraging economic development. But Flying L does not point to any statutory statement of this policy. Part of Flying L's argument rests on language from SB 660 that requires Districts, in selecting a DFC, to provide a "balance between the highest practicable level of groundwater production, and the conservation, preservation, protection, recharging, and prevention of waste of groundwater."

Flying L argues that the DFC fails to provide sufficiently for the production and development side of the equation because the DFC creates an artificial shortage of groundwater available for permitting in Bandera County.[44] Flying L uses its calculations comparing the 2011 Plateau (Region J) Regional Water Plan estimate of available groundwater with the available groundwater under the MAG to conclude that the DFC creates an artificial shortage in groundwater available for permitting.

Districts

The Districts respond that the setting of a DFC is not a guarantee of social or economic stability, development opportunities, or prosperity. That said, the Districts claim that economic development was one of many considerations that went into the DFC decision-making process. The Districts believe that the approved DFC will not unduly impact economic development, particularly since

[43] Tech. Analysis, pg 23.
[44] *See* discussion on page 8 *supra*.

most of the projected future demands within GMA 9 will be in the form of exempt domestic and livestock wells, not public water supply, commercial, or industrial wells.[45]

Wimberley Valley

The petition and testimony of Wimberley Valley do not address this issue.

Staff

Flying L's dependence upon SB 660 is misplaced. At the October Work Session, staff presented a report on the pending appeals of DFCs and how those appeals were to be managed. Staff took the position at that time that, if a DFC was adopted before September 1, 2011, the statutes and rules in effect at the time of adoption would apply to any revision or amendment made as a result of an appeal to the TWDB. The portion of Tex. Water Code § 36.108 to which Flying L refers, relating to the balancing test, was not in effect when the DFC was deliberated and adopted. Therefore, it is not used as a measure of the reasonableness of the DFC.

The Legislature, in Chapter 36 of the Water Code, has included the following statement of purpose:

> In order to provide for the conservation, preservation, protection, recharging, and prevention of waste of groundwater, and of groundwater reservoirs or their subdivisions, and to control subsidence caused by withdrawal of water from those groundwater reservoirs or their subdivisions, consistent with the objectives of Section 59, Article XVI, Texas Constitution, groundwater conservation districts may be created as provided by this chapter. Groundwater conservation districts created as provided by this chapter are the state's preferred method of groundwater management through rules developed, adopted, and promulgated by a district in accordance with the provisions of this chapter.[46]

The objectives of Section 59, Article XVI, Texas Constitution, include the "conservation and development of all of the natural resources of the State" and "the preservation and conservation of all such natural resources." Economic development is but one goal of the state. Another, specifically directed to groundwater conservation districts, is the protection, preservation, and management of groundwater. Good management includes providing for beneficial uses that support economic development. But the shortage that Flying L claims is the result of its own focus on permitted use, as noted above.

The 2011 Plateau (Region J) Regional Water Plan states that a major consideration is maintenance of spring flow in the region. As shown by Table 4 and Figure 4 of the Technical Report, each incremental increase in pumping of 5,000 acre-feet per year in Bandera County results in a decrease in outflow to springs and rivers of approximately 2,000 acre-feet per year.[47] If economic development is indeed related to preservation and use of the springs, rivers and the lands around those natural features, then the efforts of the Districts in the adoption of the DFC do not appear to unreasonably impact economic development.

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[45] Dist. Resp. 11/7/11 pg. 7-8.
[46] Tex. Water Code § 36.0015.
[47] Tech. Analysis, pg. 14.

In adopting the additional requirements for approval of DFCs, the Legislature in SB 660 also provided that each regional water plan be consistent with the DFCs adopted under Section 36.108 for the relevant aquifers located in the regional water planning area.[48] Even without taking this new law into account, the 2011 Plateau (Region J) Regional Water Plan acknowledges that “the definition of ‘groundwater availability’ as contained in this Plan is an interim definition pending completion of the Groundwater Management Area (GMA) ‘desired future condition’ process by those GMAs setting the conditions for the various portions of aquifers lying within the Plateau Region.”[49] The 2011 Plateau (Region J) Regional Water Plan acknowledges the role of the DFC in the planning process, but it also recognizes that a temporal disconnect in the approval of a DFC and the planning process may affect how these two management tools work together. Amendments to the statutes effective September 1, 2011, attempt to address this disconnect. A DFC is not unreasonable because of differences in the timing and approach of different planning documents that describe and assess conditions in a given area.

5. Consider the impact on private property rights.

Flying L

Flying L asserts that the DFC will result in a reduction of Flying L's authorized production permits. Thus, Flying L will suffer direct harm by the unreasonable, arbitrary, and unsupported actions of the Districts.

Districts

The Districts respond that any management strategy or scenario, other than unlimited pumping, can be said to have an impact on private property rights. The Districts claim that, when used in the GAM to generate what total pumping could be utilized without exceeding the DFC, estimated current pumping demand was the consideration, not an estimate of what was "permitted." To address the DFC, the Districts wanted to know what could be pumped in actuality, not what might be pumped under permit, as many permit holders are permitted to withdraw far more than they actually pump.

Wimberley Valley

Wimberley Valley claims that the anticipated increase in pumping as a result of the DFC will increase the number of existing and operating wells that will go dry or have to lower pumps putting excessive and unnecessary costs on individual well owners. In addition, a significant reduction in stream flow could cause a drop in market values for stream-adjacent properties. And decreased water quality could result in a decline in market values of property.

Districts

The Districts state that short-term fluctuations in water levels in private wells are not a direct result of the DFC but are more a result of localized pumping demands, weather patterns, and hydrogeologic characteristics. The Districts note that the DFC is descriptive, describing the maximum increase in those fluctuations that would be desirable or acceptable over the next 50 years of projected use and growth.

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[48] Tex. Water Code § 16.053(e)(2-a).
[49] Plateau Region Water Plan, January 2011, pg. 3-16.

Staff

Part of Flying L's concern is related to the way in which it uses figures for pumping and figures for permitting, as noted in previous sections. Taken on its face, Flying L has permits for 2,096 acre-feet per year. The underlying issue is Flying L's reliance on its permitted amount as the guiding principle for actual use. A more telling comparison is between total permits and estimated current use. TWDB's Water Use Survey estimates total current use as of 2008 as 2,998 acre-feet per year. The Districts estimate current use at around 4,370 acre-feet per year. The trend in use is shown in Figure 4 of the technical analysis (Attachment A). Based on the figures in Table 1 of the technical analysis, the MAG is 7,284 acre-feet per year over the 50-year projection. Exempt use projections are expected to grow to approximately 4,787 acre-feet per year by 2060. Table 1 in the technical analysis includes permitted pumping and thus, presumably, Flying L's current actual pumping. Compared to the figure of 7,284 acre-feet per year, by 2060, total demand from the 2012 State Water Plan, which includes groundwater and surface use, is still less than the MAG.

Contrary to Flying L's assertion, there has been no reduction in authorized production for Flying L and no evidence establishing adverse impacts to existing authorized production. Flying L has not established its assertion.

The average drawdown associated with the DFC in Hays County is 19 feet.[50] As the Districts note, fluctuations in private well water levels are the result of short-term and localized characteristics, including precipitation. Wimberley Valley's argument illustrates the conflict over reduction of impacts on spring flow and protection of the individual exempt landowner's investment.

Wimberley Valley would like for the Districts to adopt a DFC that would allow for less drawdown of the aquifer, thereby protecting the private, exempt water wells that might otherwise go dry due to excessive pumping. To achieve that DFC, the Districts might have to limit permits for production, as the Districts cannot control exempt production.

Flying L would like for the Districts to adopt a DFC that would allow for more drawdown of the aquifer, thereby presumably protecting the property interests of those producing under permits. The risk is that increased drawdown could negatively impact the availability of water to exempt well owners and possibly, eventually, to permit-holders themselves.

A number of factors affect well water levels—the nature of the aquifer, precipitation amounts, the proximity of one well to another, and the nature of the use. The point is that each petitioner represents a segment of private property interests in groundwater. The question may be whether achieving the DFC adopted by the Districts in GMA 9 reasonably accommodates the needs of all groundwater users in the GMA. Neither Wimberley Valley nor Flying L provided substantial, compelling evidence that any user or user group is, under the current facts, unreasonably harmed.

6. Consider the reasonable and prudent development of the state's groundwater resources.

Flying L

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[50] Tech Analysis, Table 5.

Flying L claims that the DFC does not allow for a reasonable and prudent development of the state's groundwater resources. The DFC would preclude development of the available groundwater resources in the face of significant increases in water demand.

Districts

Districts respond that one of the primary considerations in setting the DFC was the widespread support and almost universal insistence on protection of the base flow to springs, creeks, and rivers. GMA 9 decided that the most appropriate way to achieve preservation of base flow was to protect the primary source water. As the primary threat to such spring flow would be increased pumpage, GMA 9 decided it would be prudent, conservative, and appropriate to set a DFC that would meet current demand, projected exempt demands, and have something left over for non-exempt use, in spite of water availability quantities provided in the 2011 Plateau (Region J) Regional Water Plan.

Wimberley Valley

Wimberley Valley asserts that the DFC fails to ensure the reasonable and prudent development of the state's groundwater resources because it does not prohibit "aquifer mining" or ensure sustainable management of groundwater. In addition, the DFC is counter to the regional water planning groups' stated commitment to sustainable management of the Trinity Aquifer.[51]

Districts

The Districts respond by noting that Districts in some GMAs have actually approved DFCs that allow for "aquifer mining." Though the DFC does not "prohibit" aquifer mining, neither does it guarantee that aquifer mining will occur. The actual management of the aquifer in a sustainable manner is the responsibility of the local district.

Staff

Staff notes that the statutes do not contain a requirement that the DFC ensure the aquifer is managed sustainably. One petitioner essentially focuses on the term "development" while the other focuses on "prudent" in the language of the rule. The technical analysis (Attachment A) notes that "sustainability" can be defined many different ways. "Maximum sustainable pumping" may be defined as pumping that can occur without adversely affecting baseflow (groundwater discharge) to area effluent streams and without causing adverse water-level declines and related encroachment of poor quality water. It may also be defined as the maximum rate of pumping that can be maintained indefinitely and eventually result in stabilized water levels. In any case, estimates of maximum sustainable pumping contain significant uncertainty. The DFC represents a policy decision by the Districts balancing the competing goals of conserving the water in the aquifer and using it to meet water demands. Whatever "reasonable and prudent development" may mean—the terms are not defined in statute—they must be interpreted in a manner consistent with the objectives of Section 59, Article XVI, Texas Constitution and the intent of the legislature that districts be the state's preferred method of groundwater management.

Closing

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[51] WVWA Pet. pg. 12-13, *citing* Plateau Regional Water Plan (Region J) 2010, ES-7; Lower Colorado Regional Water Plan (Region K) 2010, ES-18, and ES-20–ES22; South Central Texas Regional Water Plan (Region L) 2010, ES-9 and ES-13.

In the previous GMA 9 petitions, the DFC was found unreasonable because the Districts had not considered exempt use. In this DFC, the Districts testify that they have considered current demand, projected exempt demands, and non-exempt use.[52] The history of GAM analyses presented in Section 2 of the technical analysis (Attachment A) shows the efforts by the Districts to consider a number of pumping scenarios before adopting the DFC. The success of this effort will depend, to some degree, on the management plans and rules that implement that DFC.

RECOMMENDATION

Staff recommends that the Board find that the DFC adopted by the Districts in GMA 9 for the Trinity Aquifer is reasonable based on the petitions, the testimony and evidence presented at the hearings, and staff's summary and analysis of that evidence. The reasonableness of the DFC with respect to socio-economic impacts, environmental impacts, and the exercise of personal property rights will depend on the way in which the Districts incorporate the MAG into their management plans and rules and make related decisions regarding permit authorizations and administration.

Attachment(s): Technical Analysis of Petitions

[52] Dist. Resp. 16/11, pg. 7.

TECHNICAL ANALYSIS OF PETITIONS

Challenging the Reasonableness of the Desired Future Condition for the Trinity Aquifer in Groundwater Management Area 9

Petitioners:
Flying "L" Guest Ranch, LTD.,
Wimberley Valley Watershed Association

Prepared by:
Wade A. Oliver, P.G.
Texas Water Development Board
Groundwater Resources Division

Prepared for:
Texas Water Development Board
February 2, 2012 Board Meeting

January 25, 2012

The seal appearing on this technical analysis was authorized by Wade A. Oliver, P.G. 11112 on January 25, 2012.

EXECUTIVE SUMMARY

The following technical analysis accompanies the Texas Water Development Board staff analysis of the issues raised by petitioners appealing the reasonableness of the desired future condition adopted by the groundwater conservation districts in Groundwater Management Area 9 of an average drawdown of 30 feet for the Trinity Aquifer. Specifically, the two petitioners have appealed the desired future condition as it relates to Bandera and Hays counties in the management area. The report is organized into individual, and largely distinct, sections that document both existing relevant information as well as the results of additional analyses.

Section 1 gives a brief background on the approach used in this technical analysis. Section 2 summarizes the 10 groundwater availability modeling analyses considered by the members of Groundwater Management Area 9 when developing the desired future condition. The districts based the desired future condition on “Scenario 6” of GAM Task 10-005, discussed in this section. Section 3 contains comparisons between the modeled available groundwater as a result of the desired future condition and water planning demands and availability, estimates of current use, the estimated volume of water stored in the aquifer, the estimated recharge from precipitation, and estimates of the maximum sustainable pumping. Section 4 contains the methods and results of 20 additional groundwater availability model simulation scenarios for Hays and Bandera counties. See the Appendix for the full results of these scenarios for each county in Groundwater Management Area 9. Section 5 contains a brief analysis of the relationship between precipitation, spring flow, and water levels in the Trinity Aquifer in Hays County along with discussion of trends over the last decade. Section 6 contains a discussion about the interaction between the Trinity Aquifer and the Edwards Aquifer along the Balcones Fault Zone. We discuss the limitations and proper use of groundwater models in Section 7. Finally, Section 8 documents the materials referenced throughout this report.

SECTION 1 - INTRODUCTION

This document presents a technical analysis prepared to provide context to the issues raised by the petitioners appealing the reasonableness of the desired future condition (DFC) for the Trinity Aquifer adopted by the groundwater conservation districts within Groundwater Management Area 9 (GMA 9). The two petitioners – Flying "L" Guest Ranch, LTD. and the Wimberley Valley Watershed Association – have appealed the DFC as it relates to Bandera County River Authority and Ground Water District and Hays Trinity Groundwater Conservation District (Figure 1), respectively. Consequently, the information presented here focuses on the Trinity Aquifer in Bandera and Hays counties, the primary aquifer in GMA 9 (Figure 2).

The sections below include both a compilation of existing relevant information as well as documentation of several additional analyses performed. This technical report supports the staff evaluation of the issues raised in the petitions. We do not, therefore, draw conclusions here about the merits of the issues raised in the petitions challenging the reasonableness of the DFC for the Trinity Aquifer in GMA 9.

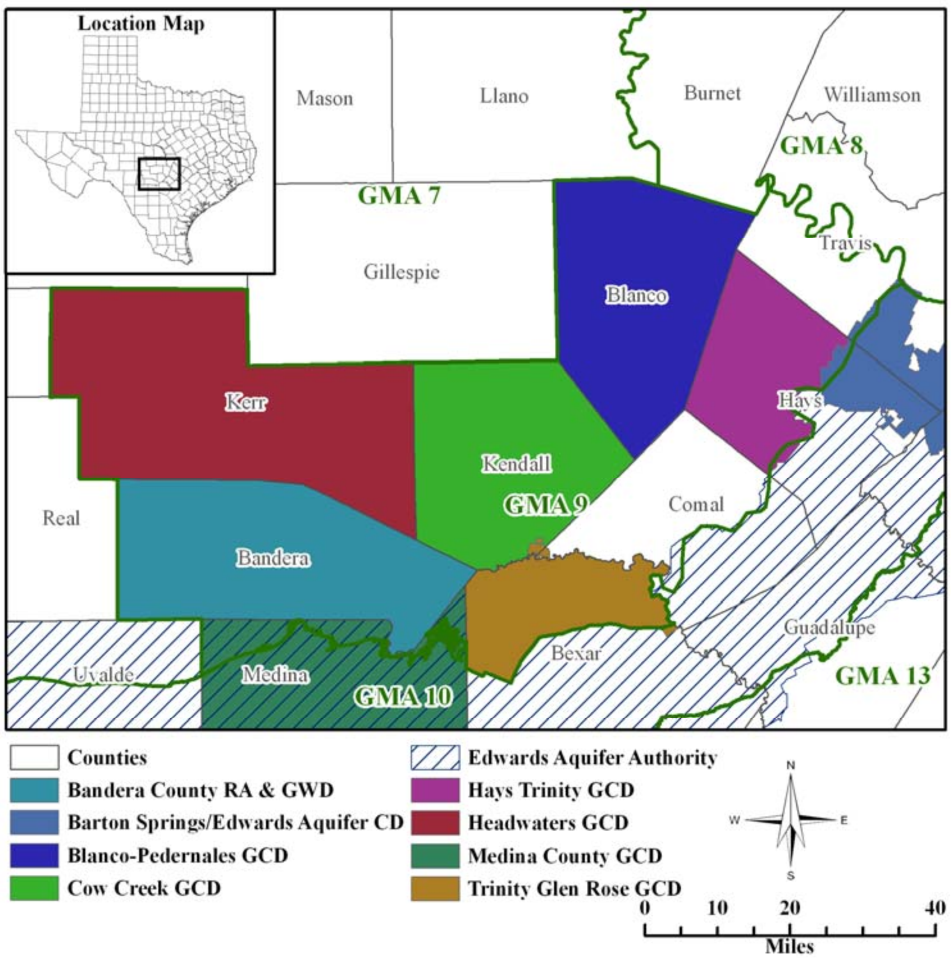

Figure 1. Groundwater conservation districts within GMA 9 (CD = conservation district; GCD = groundwater conservation district; RA = River Authority; GMA = groundwater management area).

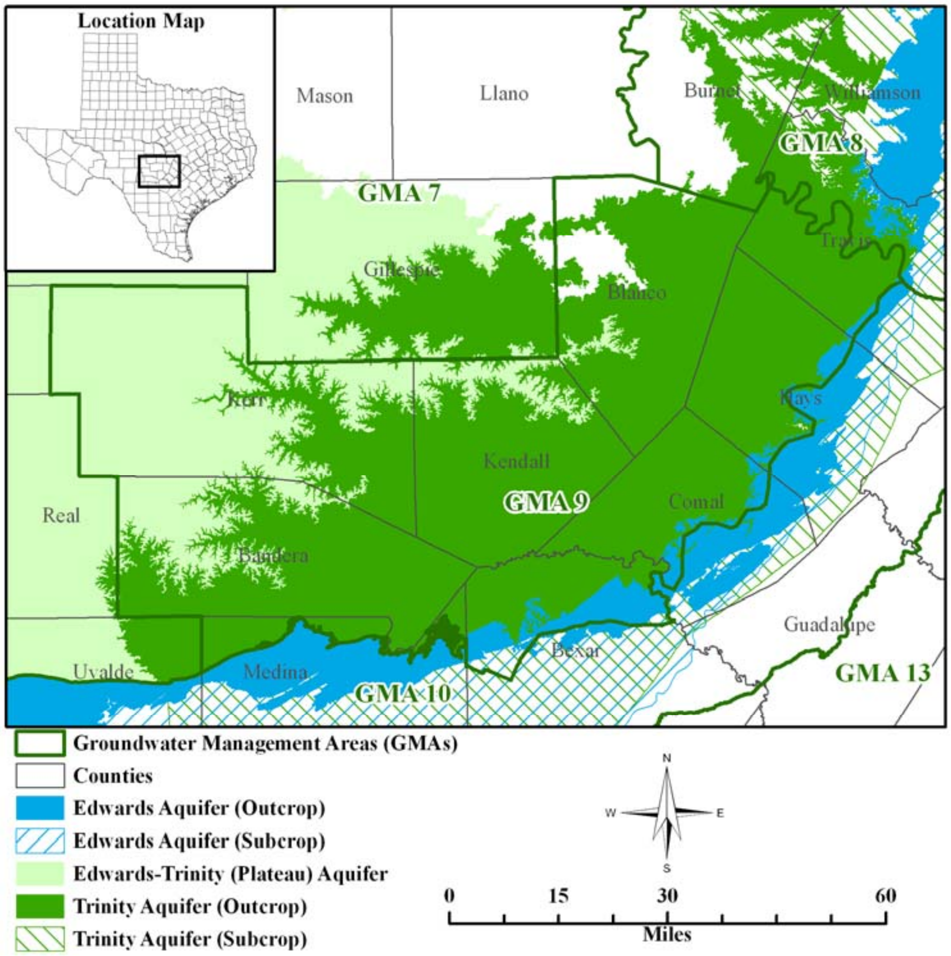

Figure 2. Location map showing the major aquifers in Groundwater Management Area 9.

SECTION 2 – SUMMARY OF PREVIOUS GAM ANALYSES

This section contains a brief summary of each of the 10 groundwater availability modeling (GAM) analyses developed by TWDB staff relating to the Trinity Aquifer in GMA 9. The groundwater conservation districts based the desired future condition of an average drawdown of 30 feet for the Trinity Aquifer on the simulation documented as Scenario 6 in GAM Task 10-005. These analyses utilized various approaches, assumptions, and versions of the groundwater availability model for the Hill County portion of the Trinity Aquifer, as described below.

TWDB Report 353
Mace and others (2000)

TWDB Numbered Report 353 documents the development of version 1.01 of the groundwater availability model for the Hill County portion of the Trinity Aquifer and contains the first predictive simulations using the model. This report, completed in September 2000, predates the passage of the legislation in 2005 that created the joint planning process (House Bill 1763 during the 79th Texas Legislature). There are six predictive simulations documented in the report; one with average recharge and five which ended with drought-of-record recharge ending in 2010, 2020, 2030, 2040, and 2050. Pumping for the runs came from demand estimates by the regional water planning groups. Results for each of the six predictive simulations include full water budget information and contour maps of drawdown.

GAM Run 07-18
Chowdhury (2007)

Mr. Michael Ciarleglio of The University of Texas at Austin, Department of Geological Sciences, requested GAM Run 07-18 on behalf of the districts in GMA 9. The report compares predictive model results for the model described in TWDB Report 353 to the results of a simulation using a modified version of the same model. The modifications included updates to aquifer top and bottom elevations and some changes in how interaction with surface water was implemented in several model cells.

The report documents five simulations of varying lengths, ending in 2010, 2020, 2030, 2040, and 2050. The simulations contained pumping from the 2002 State Water Plan and average recharge, except during the last seven years of each simulation. Those seven years included drought-of-record recharge. Results included water budgets, which distinguished between interaction with rivers and streams and outflow to springs, contour maps of drawdown in the Middle Trinity Aquifer, and a comparison of simulated versus estimated flow at 19 springs in the study area.

GAM Run 08-15
Chowdhury (2008a)

Mr. Ron Fieseler, the General Manager of the Blanco-Pedernales Groundwater Conservation District, requested GAM Run 08-15 and each of the subsequent GAM runs described below on behalf of the districts in GMA 9. This does not include GAM Tasks 10-005 and 10-031, which the TWDB initiated after informal coordination with the districts. GAM Run 08-15 documents the results of a single model simulation using estimates of “current” pumping provided by the districts and applied for a single year (2008) based on the assumption that water-levels will reach a dynamic equilibrium and appropriately represent 2008 after one year. The predictive period (2009 through 2060) included increased pumping in the Middle Trinity Aquifer to achieve an average drawdown of 35 feet in the aquifer, assuming average recharge conditions. Over the management area, an increase from the baseline pumping of approximately 57,000 acre-feet per year to 100,000 acre-feet per year achieved the requested drawdown.

GAM Run 08-20
Chowdhury (2008b)

GAM Run 08-20, also requested by Mr. Ron Fieseler, is similar in methodology to GAM Run 08-15. The districts provided updated baseline pumping, intended to represent "current" pumping, totaling approximately 54,800 acre-feet per year over the management area. We then increased this pumping to achieve no more than 15 feet of average drawdown in the Middle Trinity Aquifer assuming average recharge conditions. Results indicate that an increase in pumping to approximately 56,400 acre-feet per year over the management area achieves an average drawdown of 13 feet for the Middle Trinity Aquifer.

GAM Run 08-30
Chowdhury (2008c)

GAM Run 08-30 used similar methods as in the previous GAM runs 08-15 and 08-20, except the districts in GMA 9 requested drawdowns for three individual zones: 35 feet in Blanco, Bandera, Kerr, and Kendall counties; 15 feet in Comal, Hays, and Travis counties; and 55 feet in Bexar and Medina counties. As with the previous simulations, GAM Run 08-30 utilized average recharge. The simulation that achieved 34, 15, and 44 feet of drawdown in each of the above zones, respectively, resulted from increased pumping to 99,500 acre-feet per year from the baseline of approximately 54,800 acre-feet per year. The requested drawdown of 55 feet in Bexar and Medina counties was not met due to the occurrence of dry cells in the model.

GAM Run 08-70
Chowdhury (2008d)

As with GAM Runs 08-30, 08-20, and 08-15 above, GAM Run 08-70 used 2008 baseline pumping provided by the districts and presented predictive results based on modifications to this pumping. The report includes three separate simulations: Part A reflected a pumping increase of 25 percent between 2009 and 2060; Part B reflected a 50 percent pumping increase; and Part C was a steady-state simulation with no pumping to estimate predevelopment water levels. For Part A, the increase in pumping from 54,800 acre-feet per year to 67,200 acre-feet per year over the management area resulted in an average drawdown of 17 feet. For Part B, the increase in pumping to 79,600 acre-feet per year resulted in an average drawdown of 26 feet.

GAM Runs 09-11, 09-12, and 09-24 (single report)
Chowdhury (2010)

The report titled "GAM Runs 09-11, 09-12, and 09-24" is the first GAM Run report containing results from version 2.01 of the groundwater availability model, which includes the lower portion of the Trinity Aquifer and a more accurate representation of recharge along Cibolo Creek in Bexar County (Jones and others, 2009). The report contains the results of three different model runs from 2009 through 2060 to assess the impacts of pumping and drought. All runs used average recharge conditions and 1.5 times the estimated 2008 pumping conditions between 2009 and 2053. Run 1 used drought-of-record recharge conditions and pumping reduced to 2008 levels (a 33 percent reduction) for the last seven years of the simulation (2054 through 2060). In Run 2, the last seven years of the simulation contained average recharge conditions with pumping reduced to 2008 levels. Run 3 used average recharge conditions and the higher pumping at 1.5 times the estimated 2008 pumping throughout the entire simulation.

Run 1 had the highest average drawdown for the Trinity Aquifer of 33 feet along with the lowest outflow to surface water (98,000 acre-feet per year) and flow to the Edwards (Balcones Fault Zone) Aquifer (66,000 acre-feet per year). Run 3 had the second highest average drawdown of 15 feet, with outflow to surface water of 162,000 acre-feet per year and flow to the Edwards (Balcones Fault Zone) Aquifer of 79,000 acre-feet per year. In Run 2, with pumping reduced to 2008 levels under average recharge conditions, the average drawdown was only 1 foot, indicating that the aquifer can recover once higher pumping levels are reduced. The report also contains a “spread analysis” on each of the above runs, with increased and decreased pumping by 10, 20, and 30 percent.

GAM Runs 09-11, 09-12, and 09-24 Supplement
Hutchison (2010a)

The supplement to the report titled “GAM Runs 09-11, 09-12, and 09-24” addresses the request for information about the effects of pumping and drought on water levels and groundwater flows using very different methods than the original report. The supplement contains the results of seven model simulation scenarios, each of which consisted of 430 separate 7-year simulations based on tree-ring precipitation estimates from 1537 to 1972. As with the previous runs, initial conditions for these simulations represented 2008 water levels. Results include drawdown, outflow to surface water, and flow into the Edwards (Balcones Fault Zone) Aquifer as statistics based on the amount of the time certain conditions were exceeded.

The “base” pumping used for the simulations was the greater of regional water planning availability and the estimated 2008 pumping provided by the districts. Scenarios 1 through 3 represent constant pumping of 100 percent, 75 percent, and 50 percent of the base scenario for the varying recharge conditions. Scenarios 4 through 7 represent constant pumping of 75 percent of the base scenario, except during drought years, during which the pumping is reduced by 33 percent. Each of these last four scenarios contains a different threshold for defining a year as a drought year.

GAM Task 10-005
Hutchison (2010b)

The groundwater conservation districts in GMA 9 requested GAM Task 10-005 during the management area meeting held on May 10, 2010. Similar to the approach used in the supplement to GAM Runs 09-11, 09-12, and 09-24, each of the scenarios presented in this report consisted of several hundred separate simulations using tree-ring precipitation estimates from 1537 to 1972 to evaluate the frequency of different impacts on the aquifer. Unlike the supplement report, however, each of the scenarios in GAM Task 10-005 contained 387 50-year simulations and did not consider reduced pumping during times of drought. The seven scenarios presented ranged from almost zero pumping to approximately 120,000 acre-feet per year (Figure 3). Scenario 4 in this report, containing approximately 60,000 acre-feet per year of pumping, approximates 2008 pumping estimated by the groundwater conservation districts. Scenario 6 in this report, containing approximately 100,000 acre-feet per year of pumping, is the scenario on which the DFC is based with, on average, 30 feet of drawdown in the Trinity Aquifer.

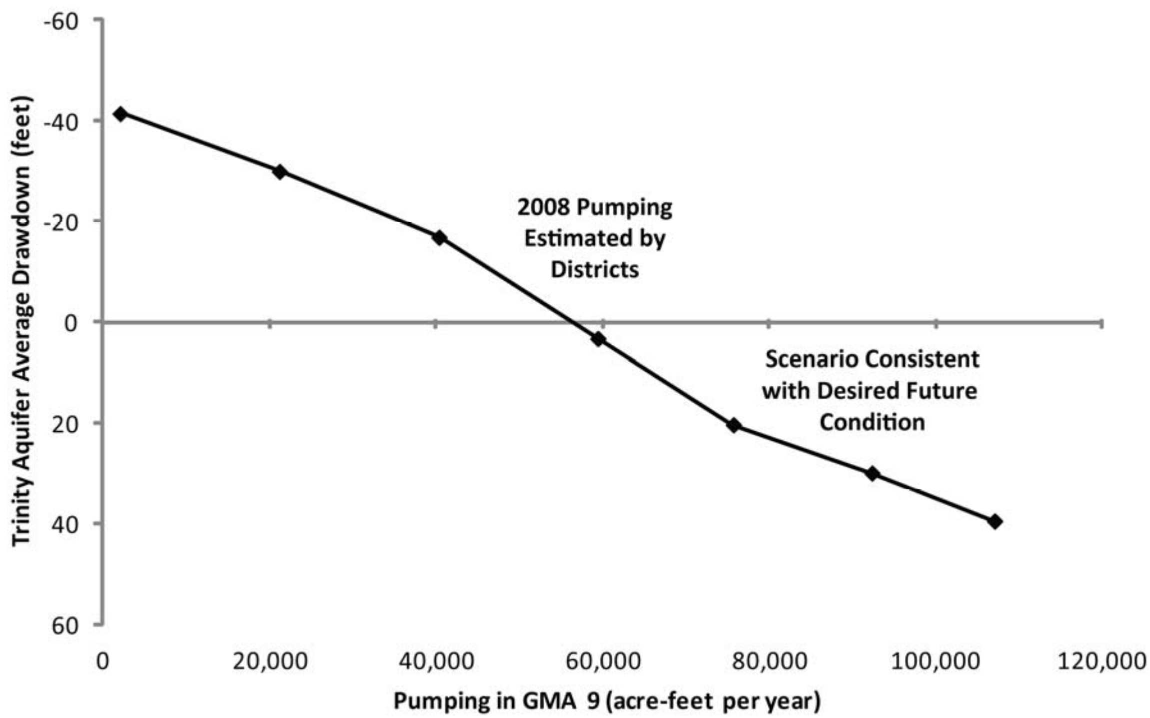

Figure 3. Average drawdown in the Trinity Aquifer versus pumping in Groundwater Management Area 9 for the seven scenarios presented in GAM Task 10-005 (Hutchison, 2010b)

GAM Task 10-031
Hutchison and Hassan (2011)

GAM Task 10-031 is a supplemental report to GAM Task 10-005 containing contour maps of drawdown and full water budget information by county for scenarios 4 through 7 of the original report. These scenarios represent pumping at levels for 2008 estimated by the groundwater conservation districts (Scenario 4) to approximately twice this amount (Scenario 7). Unlike the water budget information shown in GAM Task 10-005, this report shows inflows and outflows to neighboring counties and the volume of water removed from storage.

SECTION 3 – REVIEW OF GROUNDWATER AVAILABILITY ESTIMATES

In this section, we compare the modeled available groundwater (MAG) as a result of the DFC to several other indicators that relate to groundwater availability for the Trinity Aquifer in both Bandera and Hays counties (Tables 1 and 2, respectively). This includes the availability defined in the 2007 and 2012 State Water Plans (TWDB, 2007; TWDB, 2012), the projected demands for water (from all sources), estimates of current use, estimates of production exempt from permitting by groundwater conservation districts, the estimated recharge and volume of water stored in the aquifer, and two estimates of the maximum sustainable pumping from the aquifer. A brief description of each of these items is included below.

2007 State Water Plan Groundwater Availability

This is the groundwater availability established in the 2007 State Water Plan (TWDB, 2007). Methods to establish these numbers varied considerably among the regional water planning areas throughout the state. For Bandera County, the availability is the "maximum level of aquifer withdrawal that results in an acceptable level of long-term aquifer impact such that the base flow in rivers and streams is not significantly affected beyond a level that would be anticipated due to naturally occurring conditions" (Plateau Water Planning Group, 2006). Using the groundwater availability model, the Plateau Water Planning Group adjusted pumping to achieve an acceptable impact. However, they did not specifically define what constituted an acceptable impact.

The Trinity Aquifer in Hays County includes portions of both regional water planning areas K (Lower Colorado) and L (South Central Texas). Region K developed availability for the aquifer in Hays County using the groundwater availability model for the Edwards-Trinity (Plateau) Aquifer to assess how much pumping could occur to maintain 90 percent of surface water outflows relative to a zero pumping scenario under drought-of-record conditions (Lower Colorado RWPG, 2006). Region L carried over availability from the 2001 Regional Water Plan to the 2006 Regional Water Plan (South Central Texas RWPG, 2006). However, Region L did not clearly describe the methods used for developing availability in the 2001 Regional Water Plan (South Central Texas RWPG, 2001).

2012 State Water Plan Groundwater Availability

This is the groundwater availability established in the 2012 State Water Plan. For the Trinity Aquifer in Bandera and Hays counties, the availability in the 2012 State Water Plan is identical to the availability described for the 2007 State Water Plan above except for Region L in Hays County in 2050 and 2060. For the 2012 State Water Plan, Region L kept availability for the Trinity Aquifer in Hays County constant at the same level as for 2010 through 2040.

Projected Demand in 2012 State Water Plan from All Sources

This is the projected amount of water that would be needed in the future during a drought for six water use categories (municipal, manufacturing, mining, steam-electric, livestock, and irrigation). Since demand is only estimated at the county level, the projected demand for all of Hays County is shown (Table 2). Note that projected demand is from all sources, both groundwater and surface water, in each county. All other values described in this section only relate to groundwater in the Trinity Aquifer in Groundwater Management Area 9.

Estimated Exempt Use

This is the projected amount of pumping from the aquifer that is exempt from permitting by a groundwater conservation district. Examples of exempt uses include domestic, livestock, and oil and gas exploration. Each district may also exempt additional uses as defined by its rules or enabling legislation. TWDB staff developed a standardized method for estimating exempt use for domestic and livestock purposes based on projected changes in population and the distribution of domestic and livestock wells. However, because other exempt uses can vary significantly from district to district and there is much higher uncertainty associated with estimating use due to oil and gas exploration, TWDB staff did not include estimates of exempt pumping outside domestic and livestock uses.

TWDB invited groundwater conservation districts to provide updated estimates of projected exempt use if they believed their estimate would be more appropriate than that developed by the TWDB. Hays Trinity Groundwater Conservation District provided updated estimates (Table 2).

Estimated Current Use

As described in Section 1, the groundwater conservation districts in GMA 9 provided estimates of the current production from the Trinity Aquifer (representing 2008) for use as baseline pumping in several of the groundwater availability model simulations. TWDB also develops groundwater pumping estimates based on TWDB Water Use Survey information. These estimates, also representing 2008, are shown below for comparison and are generally lower than the estimates developed by the districts.

Estimated Recharge

Recharge is the amount of water that infiltrates to the aquifer from precipitation falling on the outcrop (where the aquifer is exposed at land surface). These values represent the estimated average recharge to the Trinity Aquifer in Bandera and Hays counties in GMA 9. We developed the estimates from the average recharge over the historical period in the groundwater availability model (1980 through 1997).

Estimated Storage Volume

Storage volume is the estimated amount of water stored within the pores and other openings in the rock formations that make up the aquifer. TWDB staff developed the estimates of storage volume using the thickness, storage properties, and water levels in the groundwater availability model. It is important to note, however, that even under ideal conditions it is very difficult to completely capture all of the drainable water in an aquifer.

Estimated Maximum Sustainable Pumping

We report two estimates of the maximum "sustainable" pumping from the Trinity Aquifer in Hays and Bandera counties because "sustainability" can be defined many different ways (Tables 1 and 2). The first estimate of maximum sustainable pumping comes from TWDB Report 339 (Bluntzer, 1992). As defined in that report, sustainable pumping is the pumping that could occur "without adversely effecting baseflow (ground-water discharge) to area effluent streams, and without causing adverse water-level declines and related encroachment of poor quality water" (Bluntzer, 1992).

TWDB staff developed the second estimate of maximum sustainable pumping for each county using the groundwater availability model. For this analysis, we defined maximum sustainable pumping as the maximum rate of pumping that can be maintained indefinitely and eventually result in stabilized water levels. This does not take into consideration the cost associated with a certain level of pumping or possible impacts of pumping such as reduced water quality and decreased outflow to streams and springs.

These estimates of maximum sustainable pumping contain significant uncertainty. As noted in Bluntzer (1992), there was limited data available on pumping distributions, aquifer characteristics, and water-levels to develop the estimates presented in that report. Similar uncertainties are associated with the estimate developed using the groundwater availability model as the model was generally not designed to make this type of calculation.

Table 1. Comparison of several indicators relating to groundwater availability for the Trinity Aquifer in Bandera County in GMA 9. All values in acre-feet per year unless otherwise indicated.

Bandera County	Decade					
	2010	2020	2030	2040	2050	2060
Modeled Available Groundwater	7,284	7,284	7,284	7,284	7,284	7,284
2007 State Water Plan Availability	18,558	18,558	18,558	18,558	18,558	18,558
2012 State Water Plan Availability	18,558	18,558	18,558	18,558	18,558	18,558
Projected Demand in 2012 State Water Plan (all sources)*	3,671	4,725	5,774	6,341	6,528	6,900
Exempt Use Projections (TWDB-estimated)	2,062	2,939	3,850	4,351	4,493	4,787
Estimated Current Use (2008 - district-provided)	4,370					
Estimated Current Use (2008 - Water Use Survey)	2,998					
Estimated Recharge	38,665					
Estimated Storage Volume (acre-feet)	353,780					
Estimated Maximum Sustainable Pumping from Bluntzer (1992) *Considers impacts on spring flow, water levels, and water quality*	6,500					
Estimated Maximum Sustainable Pumping by TWDB (2011) *Does not consider impacts on spring flow, water levels, or water quality*	24,603					

*Total projected demand in the 2012 State Water Plan is from all sources, both groundwater and surface water. All other values shown relate to groundwater in the Trinity Aquifer.

Table 2. Comparison of several indicators relating to groundwater availability for the Trinity Aquifer in Hays County in GMA 9. All values in acre-feet per year unless otherwise indicated.

Hays County	Decade					
	2010	2020	2030	2040	2050	2060
Modeled Available Groundwater	9,131	9,120	9,117	9,116	9,116	9,116
2007 State Water Plan Availability	3,713	3,713	3,713	3,713	3,494	3,494
2012 State Water Plan Availability	3,713	3,713	3,713	3,713	3,713	3,713
Projected Demand in 2012 State Water Plan (all sources - whole county)*	27,410	37,859	46,589	56,015	67,051	76,252
Exempt Use Projections (TWDB-estimated)	1,484	1,978	2,490	3,004	3,622	4,108
Exempt Use Projections (district-provided)	3,300	4,153	4,831	5,306	5,635	5,784
Estimated Current Use (2008 - district-provided)	5,665					
Estimated Current Use (2008 - Water Use Survey)	3,325					
Estimated Recharge	33,355					
Estimated Storage Volume (acre-feet)	163,160					
Estimated Maximum Sustainable Pumping from Bluntzer (1992) *Considers impacts on spring flow, water levels, and water quality*	1,800					
Estimated Maximum Sustainable Pumping by TWDB (2011) *Does not consider impacts on spring flow, water levels, or water quality*	31,039					

*Total projected demand in the 2012 State Water Plan is from all sources, both groundwater and surface water, and reflects Hays County as a whole. All other values shown relate to groundwater in the Trinity Aquifer in GMA 9.

The figures below display several of the above items for Bandera and Hays counties to better illustrate how they are related (Figures 4 and 5, respectively). For Bandera County, the modeled available groundwater is compared to district-estimated current groundwater use, the trend in TWDB-estimated use, availability in the 2012 State Water Plan, TWDB-estimated exempt use, and the maximum production authorized by permits issued by Bandera County River Authority and Ground Water District according to the Petitioner. Additionally, the total projected demand from all sources in the 2012 State Water Plan is shown. It's important to note that projected demand includes both groundwater and surface water demands, whereas all other numbers only relate to groundwater in the Trinity Aquifer.

Of note, both the 2012 State Water Plan availability and the maximum production authorized under permits in Bandera County, which assumes constant pumping by each permit-holder at the maximum authorized rate throughout the year, are significantly higher than the modeled available groundwater, the trend in use estimated by the TWDB, and the total demand from all sources projected in the 2012 State Water Plan. Also note that the TWDB-estimated exempt use is very close to the trend in TWDB-estimated use developed from Water Use Survey information between 2030 and 2040. This is not to say, however, that TWDB predicts all use will be exempt from permitting during this time period since the trend in estimated use does not constitute a prediction.

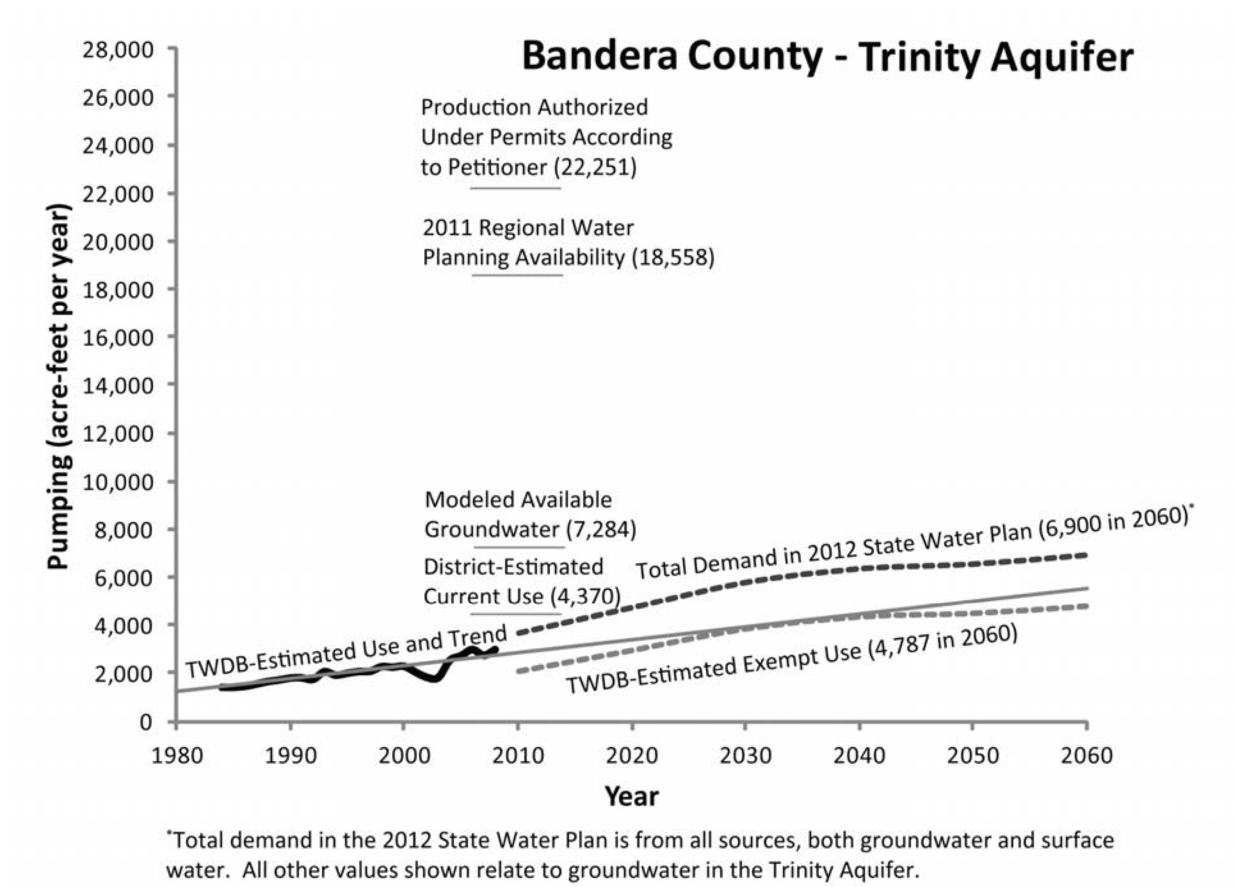

Figure 4. Graphical comparison of several indicators relating to groundwater availability for the Trinity Aquifer in Bandera County.

The figure for Hays County below contains much of the same information as above but does not show the amount of pumping authorized under permits issued by the district as this information was not available (Figure 5). Of note, the modeled available groundwater of approximately 9,100 acre-feet per year is higher than the trend in the TWDB-estimated use (7,955 in 2060) and the district-estimated exempt use (5,784 in 2060). Additionally, the 2012 State Water Plan availability of 3,713 acre-feet per year is below both the TWDB- and district-estimated pumping exempt from permitting for 2060.

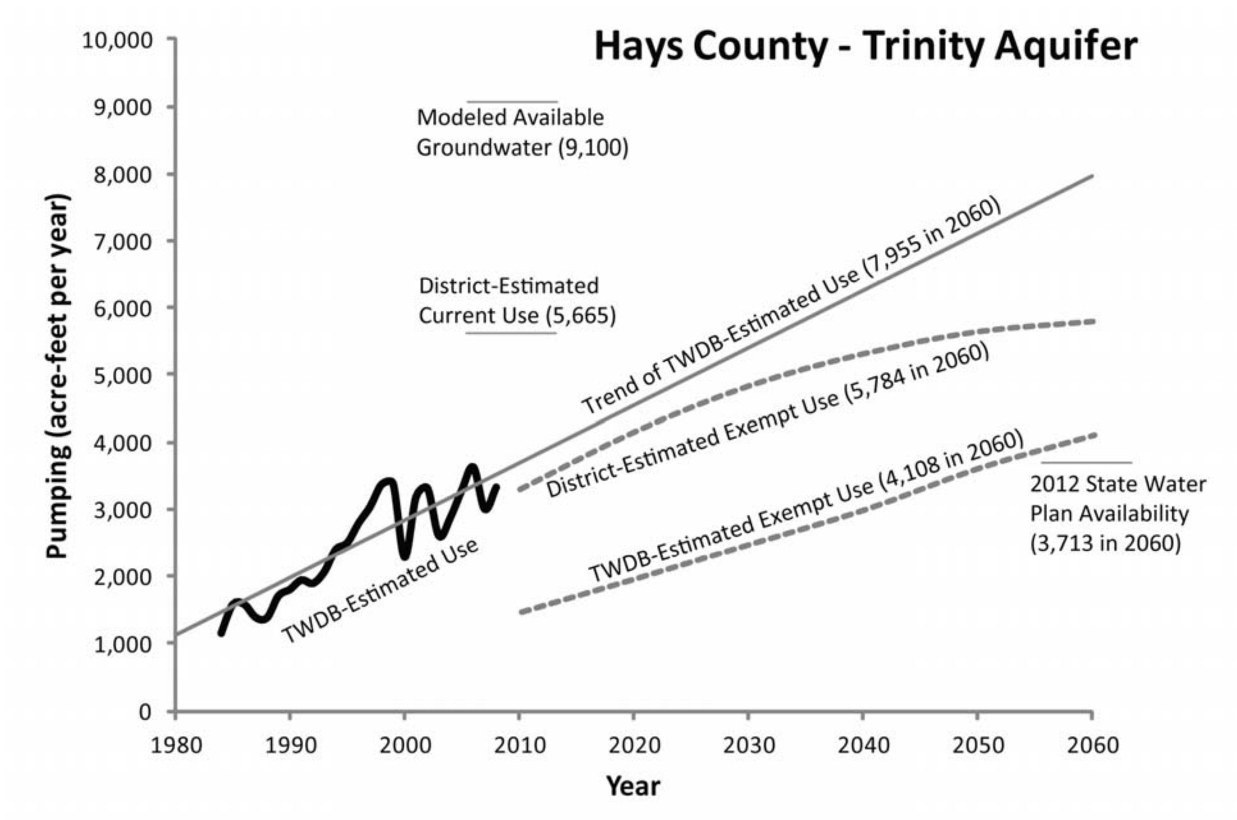

Figure 5. Graphical comparison of several indicators relating to groundwater availability for the Trinity Aquifer in Hays County.

We created a similar figure for the Trinity Aquifer representing all of GMA 9 (Figure 6). The modeled available groundwater of approximately 91,000 acre-feet per year is higher than both the district- and TWDB-estimated current use. It is also higher than the availability in the 2012 State Water Plan. Since availability in the State Water Plan is not subdivided by GMA, we considered the Trinity Aquifer availability for those counties only partially within GMA 9 to be proportional to the GMA 9 fraction of the total modeled available groundwater for the aquifer from all groundwater management areas.

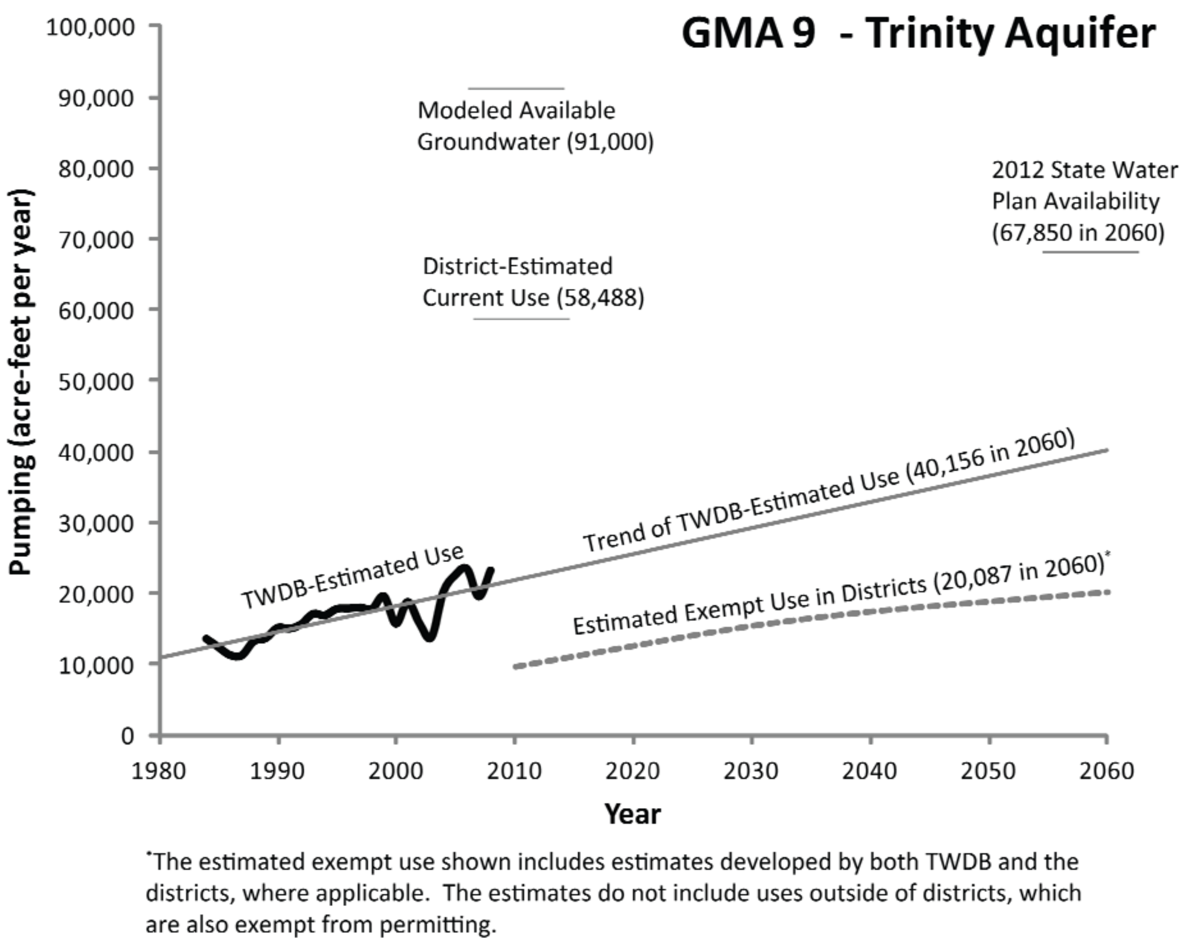

Figure 6. Graphical comparison of several indicators relating to groundwater availability for the Trinity Aquifer in Groundwater Management Area 9.

SECTION 4 – RESULTS OF GAM SIMULATIONS

This section contains the methods and a discussion of the results of several groundwater availability model simulation scenarios completed to evaluate the impacts of changes in pumping in Hays and Bandera counties. This analysis consisted of 20 scenarios using the methods described in GAM Task 10-005 (Hutchison, 2010b). Each scenario consisted of 387 individual 50-year model simulations using variable recharge based on tree-ring precipitation estimates from 1537 to 1972. The range of results presented, therefore, reflects highly variable recharge conditions including the 1950s drought-of-record.

The scenario index provided below shows the scenario number that corresponds to the varying pumping conditions in Hays and Bandera counties (Table 3). Pumping in all other areas comes from "Scenario 6" in GAM Task 10-005, which meets the DFC of an average drawdown of 30 feet for the Trinity Aquifer in GMA 9.

We systematically decreased the pumping in Hays County from the modeled available groundwater of approximately 9,000 acre-feet per year (scenarios 1 through 5) to approximately 6,000 acre-feet per year (scenarios 6 through 10), 3,000 acre-feet per year (scenarios 11 through 15), and to zero pumping (scenarios 16 through 20) in the Trinity Aquifer to investigate how the aquifer might respond to pumping amounts lower than the managed available groundwater. Similarly, we systematically increased pumping in Bandera County from the modeled available groundwater of approximately 7,000 acre-feet per year (scenarios 1, 6, 11, and 16) to approximately 12,000 acre-feet per year (scenarios 2, 7, 12, and 17), 17,000 acre-feet per year (scenarios 3, 8, 13, and 18), 22,000 acre-feet per year (scenarios 4, 9, 14, and 19), and 27,000 acre-feet per year (scenarios 5, 10, 15, and 20) to investigate how the aquifer responds to pumping amounts greater than the managed available groundwater. The scenarios containing 22,000 acre-feet of pumping per year approximate what the Petitioner has stated is the production authorized under existing permits issued by the district. The highest pumping scenarios for Bandera County, with 27,000 acre-feet of pumping per year, approximate the maximum production authorized under existing permits according to the Petitioner plus the production exempt from permitting estimated by TWDB.

Table 3. Index of the 20 simulation scenarios with adjusted pumping in Hays and Bandera counties. Pumping in all other counties for all scenarios was kept at the levels presented as "Scenario 6" in GAM Task 10-005 (Hutchison, 2010b).

Scenario Index		**Approximate Bandera County Pumping (acre-feet per year)**				
		7,000	**12,000**	**17,000**	**22,000**	**27,000**
Approximate Hays County Pumping (acre-feet per year)	**Zero**	16	17	18	19	20
	3,000	11	12	13	14	15
	6,000	6	7	8	9	10
	9,000	1*	2	3	4	5

*Scenario consistent with desired future conditions adopted July 26, 2010

Through this analysis we found that the changes in pumping in each county do not meaningfully affect the other county. For this reason, only scenarios 1 through 5 are shown for Bandera County (Table 4). Similarly, only scenarios 1, 6, 11, and 16 are shown for Hays County (Table 5). It is important to note, however, that impacts exist for some counties neighboring the areas with adjusted pumping. See the Appendix for full results for each scenario shown above for each county in GMA 9 as well as for the groundwater management area as a whole.

For Bandera County, each incremental increase in pumping of 5,000 acre-feet per year results in a decrease in outflow to springs and rivers of approximately 2,000 acre-feet per year (Table 4). This relationship holds both during drought periods (the “minimum” case) and wet periods (the “maximum” case). The increased pumping also results in decreased outflow to (or induced inflow from) the Edwards Aquifer along the Balcones Fault Zone and other neighboring areas. The additional pumping removes additional water from storage as reflected in the drawdown increase from 29 feet to 98 feet with the pumping increase from 7,000 acre-feet per year to 27,000 acre-feet per year. As shown in the Appendix, the average drawdown in the Trinity Aquifer for GMA 9 ranges from 30 feet to 51 feet among the scenarios due to the adjusted pumping in Bandera County.

For Hays County, with each incremental decrease in pumping of approximately 3,000 acre-feet per year, both outflow to surface water and outflow to the Edwards Aquifer across the Balcones Fault Zone increase by approximately 1,000 acre-feet per year (Table 5). This represents an increase in surface water outflow of approximately 5.6 percent during average recharge conditions and 7.1 percent during drought conditions (the “minimum” case). The reduced pumping also results in less water removed from storage as reflected in the reduced drawdown. The average drawdown in the Trinity Aquifer in Hays County declines from 19 feet to 1 foot when pumping is reduced from the scenario consistent with the DFC containing 9,000 acre-feet per year to zero pumping.

Scenario 6 in this report (not to be confused with the scenario of the same number in GAM Task 10-005 which meets the current DFC) contains approximately 6,000 acre-feet of pumping per year in Hays County. This scenario, which results in an average drawdown in the Trinity Aquifer of 13 feet, approximates the district-provided estimate of the amount of production that will be exempt from permitting for 2060. This is significant because a DFC that results in a modeled available groundwater value below this amount may not be achievable because the district cannot regulate exempt uses of the aquifer. It should be noted that the TWDB estimate of exempt use, which was developed using a uniform methodology throughout the state and did not consider exempt uses due to district-specific rules or enabling legislation, is somewhat lower (4,108 acre-feet per year in 2060).

Reduced pumping in Hays County also impacts water levels and groundwater flows in neighboring areas. As shown in the Appendix, the average drawdown in GMA 9 declines from 30 feet to 27 feet with reduced pumping in Hays County. See the Appendix for full results for each county, and for GMA 9 as a whole, for each of the simulation scenarios presented here.

Table 4. Results of scenarios 1 through 5 depicting increased pumping in Bandera County relative to the scenario consistent with the desired future condition. Pumping in all other counties was kept at the levels presented as "Scenario 6" in GAM Task 10-005 (Hutchison, 2010b). The minimum, average, and maximum pumping shown reflects both the Trinity and Edwards-Trinity (Plateau) aquifers, where applicable.

Bandera County

Component	Case	Approximate Trinity Aquifer Pumping in the County				
		7,000 [1]	12,000	17,000	22,000 [2]	27,000 [3]
Pumping (acre-feet per year)	Minimum	7,910	12,997	18,388	23,583	28,051
	Average	7,910	13,021	18,412	23,732	28,824
	Maximum	7,910	13,021	18,447	23,872	29,298
Spring and River Base Flow (acre-feet per year)	Minimum	24,868	23,086	21,400	20,676	20,198
	Average	30,620	28,733	26,802	25,250	24,628
	Maximum	37,946	35,964	34,370	33,138	32,002
Outflow Across the Balcones Fault Zone (acre-feet per year)	Minimum	5	-445	-965	-1,665	-2,385
	Average	535	120	-334	-859	-1,538
	Maximum	1,259	1,081	874	658	441
Overall Trinity Drawdown after 50 years (feet)	Minimum	5	8	12	16	21
	Average	29	43	59	77	98
	Maximum	35	49	67	88	111
Edwards Group Drawdown after 50 Years (feet)	Minimum	-5	-4	-3	-2	0
	Average	1	2	3	4	5
	Maximum	3	4	5	6	8
Upper Trinity Drawdown after 50 Years (feet)	Minimum	-11	-10	-9	-9	-9
	Average	13	13	14	15	15
	Maximum	15	15	16	17	17
Middle Trinity Drawdown after 50 Years (feet)	Minimum	6	11	17	23	29
	Average	38	58	81	108	139
	Maximum	45	66	91	122	155
Lower Trinity Drawdown after 50 Years (feet)	Minimum	6	11	17	23	29
	Average	38	58	81	108	140
	Maximum	45	66	91	122	157

[1]Scenario 1, which is consistent with desired future conditions adopted July 26, 2010

[2]Scenario 4, which approximates maximum production under existing permits according to the Petitioner

[3]Scenario 5, which approximates maximum production under existing permits according to the Petitioner plus estimated exempt use

Table 5. Results of scenarios 1, 6, 11, and 16 depicting decreased pumping in Hays County relative to the scenario consistent with the desired future condition. Pumping in all other counties was kept at the levels presented as "Scenario 6" in GAM Task 10-005 (Hutchison, 2010b). The minimum, average, and maximum pumping shown reflects both the Trinity and Edwards-Trinity (Plateau) aquifers, where applicable.

Hays County

Component	Case	Approximate Trinity Aquifer Pumping in the County			
		Zero	3,000	6,000 [1]	9,000 [2]
Pumping (acre-feet per year)	Minimum	33	2,930	5,828	9,115
	Average	33	2,930	5,828	9,115
	Maximum	33	2,930	5,828	9,130
Spring and River Base Flow (acre-feet per year)	Minimum	16,931	16,055	15,139	14,104
	Average	20,825	19,977	19,054	18,025
	Maximum	25,334	24,453	23,595	22,630
Outflow Across the Balcones Fault Zone (acre-feet per year)	Minimum	5,364	4,443	3,404	2,155
	Average	7,287	6,277	5,221	3,995
	Maximum	9,277	8,292	7,365	6,509
Overall Trinity Drawdown after 50 years (feet)	Minimum	-14	-7	-1	5
	Average	1	7	13	19
	Maximum	3	8	14	21
Edwards Group Drawdown after 50 Years (feet)	Minimum	-	-	-	-
	Average	-	-	-	-
	Maximum	-	-	-	-
Upper Trinity Drawdown after 50 Years (feet)	Minimum	-9	-8	-8	-7
	Average	10	11	11	11
	Maximum	12	12	13	13
Middle Trinity Drawdown after 50 Years (feet)	Minimum	-16	-6	2	8
	Average	-2	6	13	22
	Maximum	0	7	15	24
Lower Trinity Drawdown after 50 Years (feet)	Minimum	-16	-6	2	8
	Average	-2	6	13	22
	Maximum	0	7	15	24

[1]Scenario 6, which approximates district-estimated exempt use for 2060

[2]Scenario 1, which is consistent with desired future conditions adopted July 26, 2010

SECTION 5 – EVALUATION OF PRECIPITATION AND GROUNDWATER LEVELS

This section addresses the relationship of precipitation to water levels and spring flow in the Trinity Aquifer in the Hays Trinity Groundwater Conservation District. Evidence presented at the hearing on the petition filed by the Wimberley Valley Watershed Association held on November 16th, 2011 included a hydrograph of water levels at the Henley Church well located in the Trinity Aquifer in the district. This has been reproduced below over approximately the same time period using data from the Hays Trinity Groundwater Conservation District website (Figure 7a; Hays Trinity Groundwater Conservation District, 2011). The Petitioner attributed the general downward trend in water levels in this well to pumping in the Trinity Aquifer. Additionally, the trend was extrapolated into the future to argue that, even at current rates of pumping, drawdowns exceeding the desired future condition may occur.

Extrapolating a trend in water levels, especially in an aquifer such as the Trinity in Hays County, can be highly dependent on the time period chosen to develop the trend. For example, during the first half of the period for the Henley Church well, the trend actually shows a water-level rise before the declining trend shown in the latter half (Figure 7b).

Precipitation can also influence water-level trends. The same hydrograph for the Henley Church well overlain by the total precipitation in Hays Trinity Groundwater Conservation District over the preceding 18-month period shows that the water levels very closely follow the precipitation throughout the period (Figure 7c). This indicates a high sensitivity of water levels to changes in precipitation.

A similar relationship exists between precipitation and discharge at Jacob's Well spring (Figure 8). Discharge information was available from United States Geological Survey Gage 08170990 at Jacobs Well from 2005 through 2011 (United States Geological Survey, 2011). Discharge, unlike the water levels for the Henley Church well, varies logarithmically with changes in precipitation. Precipitation for the preceding nine-month period for Jacob's Well spring best matched the changes in discharge (Figure 8). This indicates that the discharge at Jacob's Well responds to changes in precipitation more quickly than water levels at the Henley Church well.

We developed the precipitation for Hays Trinity Groundwater Conservation District used above by spatial analysis of monthly precipitation information reported by the PRISM Climate Group at Oregon State University (PRISM Climate Group, 2011). The Trinity Aquifer responds to changes in precipitation over varying time periods. For this reason we developed rolling total precipitation for periods of 12, 24, and 48 months (Figure 9). In each of these cases, the general trend in precipitation is downward between 1999 and 2011, the same time period covered in the Henley Church well hydrograph. This is significant because the general downward trend in water levels at the Henley Church well may not be due to pumping, but rather decreasing precipitation. This is not to say that pumping does not impact water levels in the aquifer. As described in Section 4 above, there is a direct relationship between the amount of pumping and water-level declines. However, impacts to the aquifer due to pumping occur on the backdrop of significant changes in the aquifer due to changes in precipitation. It is, therefore, more difficult to identify and separate impacts due to pumping when analyzing hydrographs.

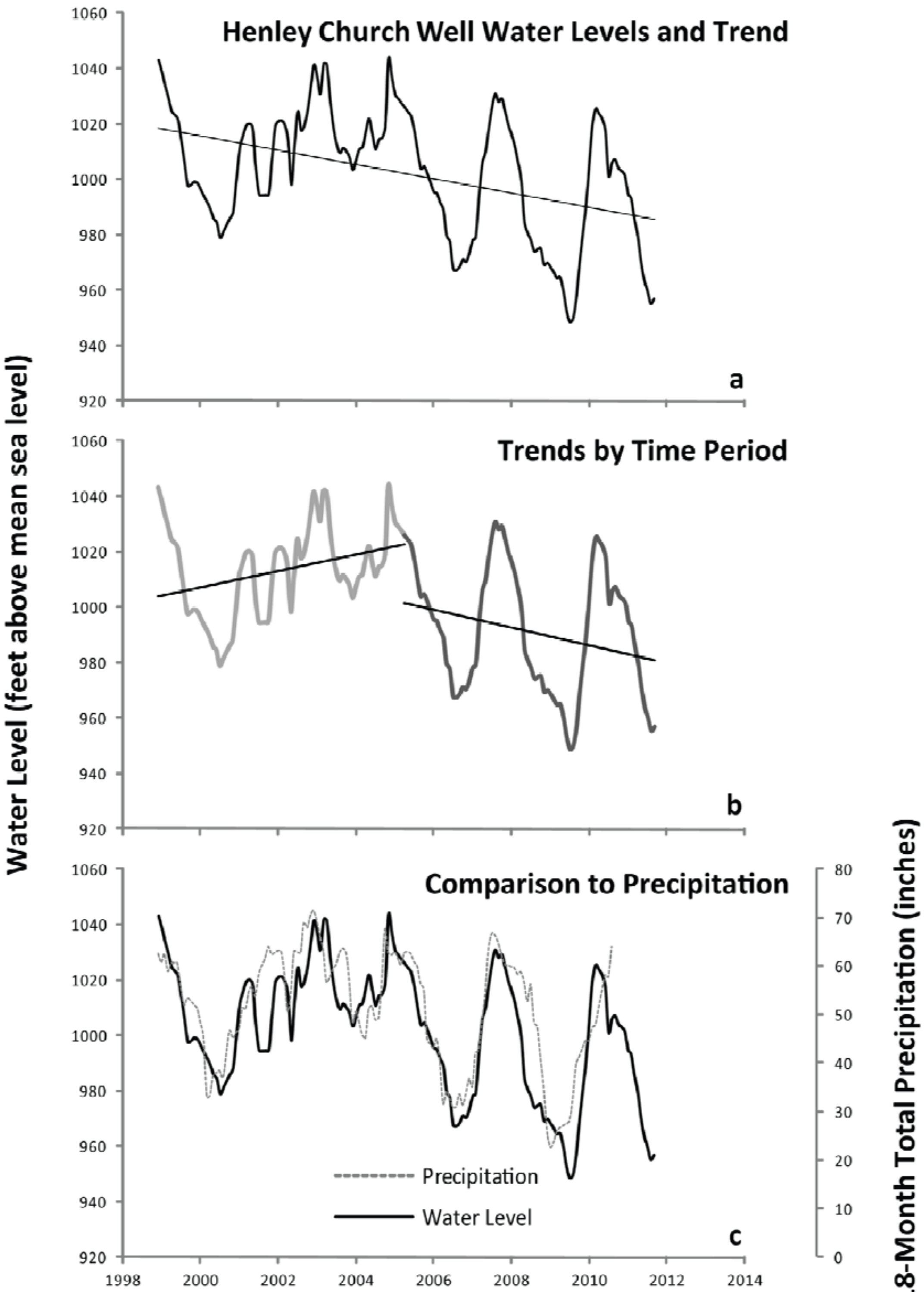

Figure 7. Water-level trends and a comparison to precipitation for the Henley Church well in Hays Trinity Groundwater Conservation District.

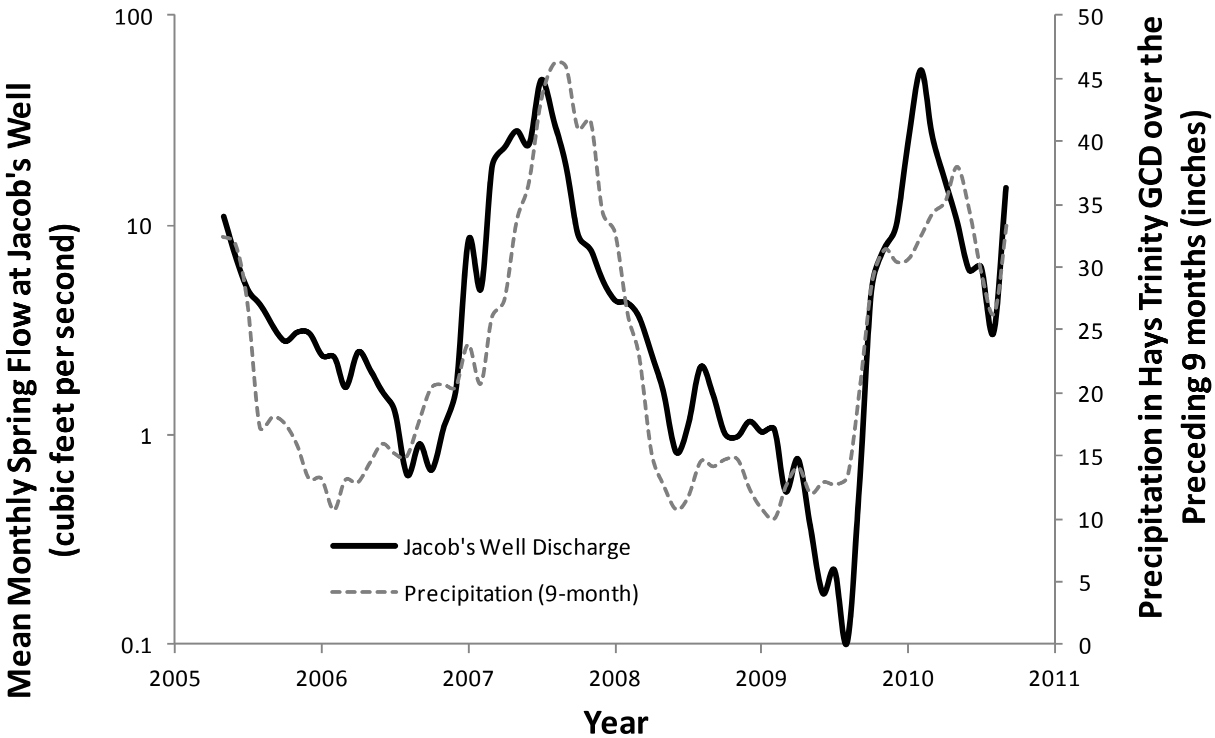

Figure 8. Mean monthly discharge and a comparison to precipitation over the preceding nine months for Jacob's Well spring.

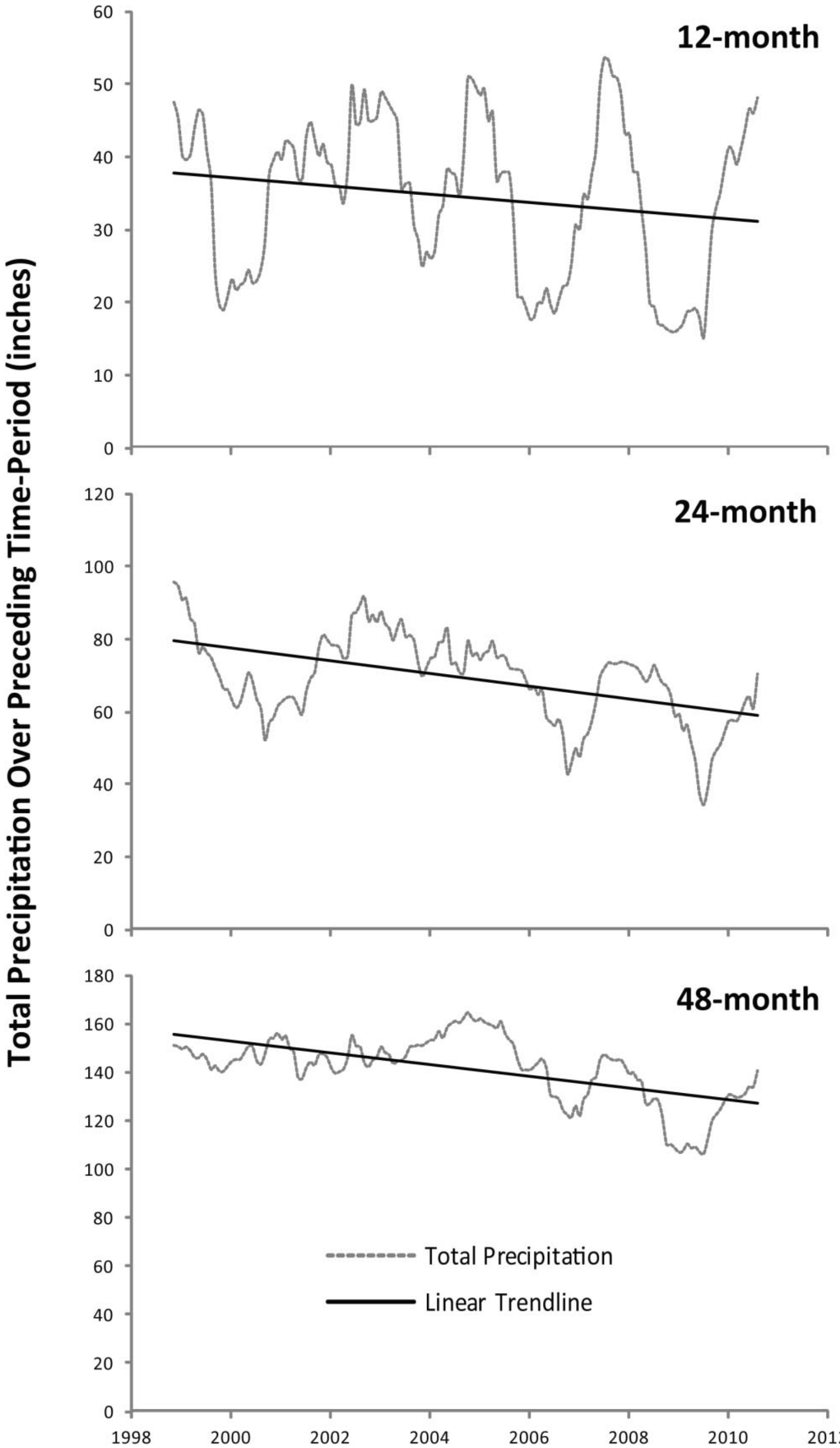

Figure 9. Rolling total precipitation and trends for Hays Trinity Groundwater Conservation District for periods of 12, 24, and 48 months.

SECTION 6 – INTERACTION BETWEEN THE TRINITY AND EDWARDS AQUIFERS

This section provides a brief discussion on the interaction between the Hill Country portion of the Trinity Aquifer and the Edwards (Balcones Fault Zone) Aquifer. In the petition, Wimberley Valley Watershed Association mentioned several potential impacts of the drawdowns associated with the DFC including impacts to the Edwards (Balcones Fault Zone) Aquifer. As noted in Jones and others (2009), there is considerable evidence suggesting there is interaction between the Trinity Aquifer and the Edwards Aquifer along the Balcones Fault Zone. Estimates of the magnitude of flow between the aquifers vary widely from approximately 40,000 acre-feet per year to 360,000 acre-feet per year (Jones and others, 2009; Lindgren and others, 2004; Kuniansky and Holligan, 1994). This represents a range from 6 percent to over 50 percent of the estimated total recharge to the Edwards (Balcones Fault Zone) Aquifer. The estimate by Kuniansky and Holligan (1994) of 360,000 acre-feet per year, however, is likely too high (Mace and others, 2000). The majority of estimates suggest that the actual volume of flow is on the low end of this range (Mace and others, 2000; Lindgren and others, 2004; Woodruff and Abbott, 1986).

The volume of flow between the aquifers, typically outflow from the Trinity Aquifer and inflow to the Edwards (Balcones Fault Zone) Aquifer, depends on the water levels in each aquifer and the local aquifer properties that define how easily flow can occur. Interaction between the two aquifers can also occur indirectly. Some streams which receive water from the Trinity Aquifer in the Hill Country serve as sources of recharge to the Edwards (Balcones Fault Zone) Aquifer farther downstream. Examples of this include Onion Creek, which serves as a source of recharge to the Barton Springs segment of the Edwards (Balcones Fault Zone) Aquifer during normal rainfall conditions (Hunt and others, 2006; Hauwert, 2011) and the Blanco River, which a recent study suggests may serve as an important source of recharge to the Barton Springs segment of the aquifer during drought conditions (Hauwert, 2011).

The manner in which the groundwater availability models depict this flow varies considerably. The model for the Hill Country portion of the Trinity Aquifer simulates this interaction using the MODFLOW General Head Boundary package. As applied, the volume of flow across the Balcones Fault Zone between the aquifers changes as water levels change in the Trinity Aquifer, but it does consider the effect of changing water levels in the Edwards (Balcones Fault Zone) Aquifer (Jones and others, 2004). In the model for the San Antonio Segment of the Edwards (Balcones Fault Zone) Aquifer used in the Edwards Aquifer Recovery Implementation Program investigation, the volume of flow from the Trinity Aquifer was fixed at a constant rate using the MODFLOW Well Package. As noted in the report by the Edwards Aquifer Area Expert Science Subcommittee (2009), the actual flow likely varies through time with changes in the water levels in each aquifer. Finally, the groundwater availability model for the Barton Springs Segment of the Edwards (Balcones Fault Zone) Aquifer does not consider any direct interaction with the Trinity Aquifer.

The volume of flow from the Trinity Aquifer into the Edwards (Balcones Fault Zone) Aquifer among the simulations described in Section 3 above ranges from approximately 41,000 acre-feet per year to 51,000 acre-feet per year for GMA 9 as a whole (see Appendix). While many reports support the existence of this interaction between the Trinity Aquifer and the Edwards (Balcones Fault Zone) Aquifer, the existing estimates of both the volume of flow and how that flow changes with varying water levels in each aquifer are not well constrained.

SECTION 7 – LIMITATIONS

The groundwater model used in completing this analysis is the best available scientific tool that can be used to meet the stated objectives. To the extent that this analysis may be used for planning purposes and/or regulatory purposes related to future pumping, it is important to recognize the assumptions and limitations associated with the use of the results. In reviewing the use of models in environmental regulatory decision making, the National Research Council (2007) noted:

> *"Models will always be constrained by computational limitations, assumptions, and knowledge gaps. They can best be viewed as tools to help inform decisions rather than as machines to generate truth or make decisions. Scientific advances will never make it possible to build a perfect model that accounts for every aspect of reality or to prove that a given model is correct in all respects for a particular regulatory application. These characteristics make evaluation of a regulatory model more complex than solely a comparison of measurement data with model results."*

One aspect of using the groundwater model to evaluate the impacts of future pumping is the need to make assumptions about the location in the aquifer where future pumping will occur. In addition, certain assumptions have been made regarding future precipitation, recharge, and stream flow in evaluating the impacts of future pumping.

Given these limitations, users of this information are cautioned that the results should not be considered a definitive, permanent prediction of the changes in groundwater storage, stream flow and spring flow. Because the application of the groundwater model was designed to address regional scale questions, the results are most effective on a regional scale (Jones and others, 2009). The TWDB makes no warranties or representations relating to the actual conditions of any aquifer at a particular location or at a particular time.

SECTION 8 - REFERENCES

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APPENDIX

Results of 20 Simulation Scenarios with Adjusted Pumping in the Trinity Aquifer in Hays and Bandera Counties

Table A-1. Index of the 20 simulation scenarios with adjusted pumping in Hays and Bandera counties. Pumping in all other counties for all scenarios was kept at the levels presented as "Scenario 6" in GAM Task 10-005 (Hutchison, 2010b). This table is a repeat of Table 3 in the body of this report.

Scenario Index		Approximate Bandera County Pumping (acre-feet per year)				
		7,000	**12,000**	**17,000**	**22,000**	**27,000**
Approximate Hays County Pumping (acre-feet per year)	**Zero**	16	17	18	19	20
	3,000	11	12	13	14	15
	6,000	6	7	8	9	10
	9,000	1*	2	3	4	5

*Scenario consistent with desired future conditions adopted July 26, 2010

Table A-2. Simulation results for Groundwater Management Area 9 for the 20 simulation scenarios described in Section 3. See Table A-1 for an index describing the relationship between the each scenario and the pumping in Hays and Bandera counties. The minimum, average, and maximum pumping shown reflects both the Trinity and Edwards-Trinity (Plateau) aquifers, where applicable.

Groundwater Management Area 9

Component	Case	Scenario									
		1	2	3	4	5	6	7	8	9	10
Pumping (acre-feet per year)	Minimum	90,727	95,731	101,105	106,306	109,995	87,530	92,534	97,908	103,135	106,927
	Average	92,261	97,243	101,981	106,725	111,816	89,022	94,127	98,742	103,486	108,578
	Maximum	94,042	99,153	104,579	110,004	115,430	90,789	95,900	101,325	106,751	112,176
Spring and River Base Flow (acre-feet per year)	Minimum	115,641	114,039	112,343	110,981	110,413	117,163	115,561	113,865	112,503	111,935
	Average	150,359	148,362	146,338	144,626	143,553	152,061	149,946	147,978	146,249	145,220
	Maximum	193,276	191,188	189,474	187,852	186,259	194,812	192,725	191,010	189,389	187,796
Outflow Across the Balcones Fault Zone (acre-feet per year)	Minimum	34,904	32,760	30,318	27,201	23,735	36,187	34,043	31,600	28,484	25,017
	Average	50,163	48,167	46,047	43,569	40,509	51,418	49,415	47,271	44,821	41,771
	Maximum	68,380	67,632	66,737	65,783	64,829	69,334	68,388	67,492	66,538	65,584
Overall Trinity Drawdown after 50 years (feet)	Minimum	6	7	8	9	11	6	7	8	9	10
	Average	30	35	40	45	51	29	34	39	45	51
	Maximum	34	39	45	52	60	33	38	44	52	59
Edwards Group Drawdown after 50 Years (feet)	Minimum	-6	-6	-5	-5	-5	-6	-6	-5	-5	-5
	Average	1	1	1	1	2	0	1	1	1	2
	Maximum	3	4	4	4	5	3	4	4	4	5
Upper Trinity Drawdown after 50 Years (feet)	Minimum	-12	-11	-11	-11	-11	-12	-12	-11	-11	-11
	Average	14	14	14	15	15	14	14	14	15	15
	Maximum	16	16	17	17	17	16	16	16	17	17
Middle Trinity Drawdown after 50 Years (feet)	Minimum	9	10	11	13	14	8	9	11	12	13
	Average	36	43	50	58	67	35	42	49	57	65
	Maximum	42	49	57	67	77	41	48	56	66	76
Lower Trinity Drawdown after 50 Years (feet)	Minimum	9	10	12	13	15	8	9	11	12	14
	Average	37	44	51	59	68	36	42	49	58	67
	Maximum	42	50	58	69	79	41	48	56	67	78

Table A-2. Continued.

Groundwater Management Area 9

Component	Case	Scenario									
		11	12	13	14	15	16	17	18	19	20
Pumping (acre-feet per year)	Minimum	84,805	89,809	95,183	100,384	104,073	81,951	86,955	92,329	97,531	101,219
	Average	86,169	91,174	95,889	100,633	105,724	83,315	87,975	93,035	97,845	102,911
	Maximum	87,935	93,046	98,472	103,897	109,323	85,081	90,192	95,618	101,043	106,469
Spring and River Base Flow (acre-feet per year)	Minimum	118,456	116,854	115,159	113,797	113,228	119,841	118,238	116,543	115,181	114,612
	Average	153,420	151,332	149,337	147,528	146,558	154,708	152,531	150,326	148,440	147,641
	Maximum	196,171	194,083	192,369	190,747	189,155	197,538	195,451	193,736	192,115	190,522
Outflow Across the Balcones Fault Zone (acre-feet per year)	Minimum	37,294	35,150	32,708	29,591	26,124	38,387	36,243	33,801	30,684	27,218
	Average	52,480	50,468	48,304	45,868	42,822	53,459	51,457	49,268	46,795	43,729
	Maximum	70,221	69,156	68,155	67,201	66,247	71,107	70,041	68,818	67,864	66,910
Overall Trinity Drawdown after 50 years (feet)	Minimum	6	6	8	9	10	5	6	7	8	9
	Average	28	33	38	44	50	27	31	36	42	48
	Maximum	32	37	43	51	58	31	37	42	50	57
Edwards Group Drawdown after 50 Years (feet)	Minimum	-6	-6	-5	-5	-5	-7	-6	-6	-6	-5
	Average	0	1	1	1	2	0	0	1	1	1
	Maximum	3	4	4	4	5	3	4	4	4	5
Upper Trinity Drawdown after 50 Years (feet)	Minimum	-12	-12	-11	-11	-11	-14	-14	-13	-13	-13
	Average	14	14	14	14	15	14	14	14	14	15
	Maximum	16	16	16	17	17	16	16	16	17	17
Middle Trinity Drawdown after 50 Years (feet)	Minimum	7	9	10	11	13	7	8	10	11	12
	Average	34	41	48	56	64	32	39	46	54	63
	Maximum	40	47	55	65	75	39	45	53	64	73
Lower Trinity Drawdown after 50 Years (feet)	Minimum	8	9	10	12	13	7	8	10	11	13
	Average	34	41	48	57	66	32	39	46	56	64
	Maximum	40	47	55	66	77	39	46	54	65	76

Table A-3. Simulation results for Bandera County for the 20 simulation scenarios described in Section 3. See Table A-1 for an index describing the relationship between the each scenario and the pumping in Hays and Bandera counties. The minimum, average, and maximum pumping shown reflects both the Trinity and Edwards-Trinity (Plateau) aquifers, where applicable.

Bandera County

Component	Case	Scenario									
		1	2	3	4	5	6	7	8	9	10
Pumping (acre-feet per year)	Minimum	7,910	12,997	18,388	23,583	28,051	7,910	12,997	18,388	23,583	28,051
	Average	7,910	13,021	18,412	23,732	28,824	7,910	13,021	18,412	23,732	28,824
	Maximum	7,910	13,021	18,447	23,872	29,298	7,910	13,021	18,447	23,872	29,298
Spring and River Base Flow (acre-feet per year)	Minimum	24,868	23,086	21,400	20,676	20,198	24,869	23,086	21,400	20,676	20,198
	Average	30,620	28,733	26,802	25,250	24,628	30,624	28,739	26,803	25,250	24,630
	Maximum	37,946	35,964	34,370	33,138	32,002	37,946	35,964	34,370	33,138	32,002
Outflow Across the Balcones Fault Zone (acre-feet per year)	Minimum	5	-445	-965	-1,665	-2,385	5	-445	-965	-1,665	-2,385
	Average	535	120	-334	-859	-1,538	535	119	-335	-860	-1,539
	Maximum	1,259	1,081	874	658	441	1,259	1,081	874	658	441
Overall Trinity Drawdown after 50 years (feet)	Minimum	5	8	12	16	21	5	8	12	16	21
	Average	29	43	59	77	98	29	44	59	77	98
	Maximum	35	49	67	88	111	35	49	67	88	111
Edwards Group Drawdown after 50 Years (feet)	Minimum	-5	-4	-3	-2	0	-5	-4	-3	-2	0
	Average	1	2	3	4	5	1	2	3	4	5
	Maximum	3	4	5	6	8	3	4	5	6	8
Upper Trinity Drawdown after 50 Years (feet)	Minimum	-11	-10	-9	-9	-9	-11	-10	-9	-9	-9
	Average	13	13	14	15	15	13	13	14	15	15
	Maximum	15	15	16	17	17	15	15	16	17	17
Middle Trinity Drawdown after 50 Years (feet)	Minimum	6	11	17	23	29	6	11	17	23	29
	Average	38	58	81	108	139	38	58	81	108	140
	Maximum	45	66	91	122	155	45	66	91	122	155
Lower Trinity Drawdown after 50 Years (feet)	Minimum	6	11	17	23	29	6	11	17	23	29
	Average	38	58	81	108	140	38	58	81	108	141
	Maximum	45	66	91	122	157	45	66	91	122	157

Table A-3. Continued.

Bandera County

Component	Case	Scenario									
		11	12	13	14	15	16	17	18	19	20
Pumping (acre-feet per year)	Minimum	7,910	12,997	18,388	23,583	28,051	7,910	12,997	18,388	23,583	28,051
	Average	7,910	13,021	18,412	23,732	28,824	7,910	13,021	18,412	23,700	28,824
	Maximum	7,910	13,021	18,447	23,872	29,298	7,910	13,021	18,447	23,872	29,298
Spring and River Base Flow (acre-feet per year)	Minimum	24,869	23,086	21,400	20,676	20,198	24,869	23,086	21,400	20,676	20,198
	Average	30,620	28,733	26,800	25,240	24,628	30,596	28,703	26,769	25,202	24,596
	Maximum	37,946	35,964	34,370	33,138	32,002	37,946	35,964	34,370	33,138	32,002
Outflow Across the Balcones Fault Zone (acre-feet per year)	Minimum	5	-445	-965	-1,665	-2,385	5	-445	-965	-1,665	-2,385
	Average	534	117	-337	-864	-1,541	528	110	-349	-874	-1,556
	Maximum	1,259	1,081	874	658	441	1,259	1,081	874	658	441
Overall Trinity Drawdown after 50 years (feet)	Minimum	5	8	12	16	21	5	8	12	16	21
	Average	29	44	59	78	98	29	43	59	77	98
	Maximum	35	49	67	88	111	35	49	67	88	111
Edwards Group Drawdown after 50 Years (feet)	Minimum	-5	-4	-3	-2	0	-6	-5	-4	-2	-1
	Average	1	2	3	4	5	0	2	3	4	5
	Maximum	3	4	5	6	8	3	4	5	6	8
Upper Trinity Drawdown after 50 Years (feet)	Minimum	-11	-10	-9	-9	-9	-12	-12	-11	-11	-11
	Average	13	13	14	15	15	13	13	14	15	15
	Maximum	15	15	16	17	17	15	16	16	17	17
Middle Trinity Drawdown after 50 Years (feet)	Minimum	6	11	17	23	29	6	11	17	23	29
	Average	38	59	81	108	140	38	58	81	108	140
	Maximum	45	66	91	122	155	45	65	91	122	155
Lower Trinity Drawdown after 50 Years (feet)	Minimum	6	11	17	23	29	6	11	17	23	29
	Average	38	59	81	109	141	38	58	81	109	141
	Maximum	45	66	91	122	157	45	65	91	122	157

Table A-4. Simulation results for Bexar County for the 20 simulation scenarios described in Section 3. See Table A-1 for an index describing the relationship between the each scenario and the pumping in Hays and Bandera counties. The minimum, average, and maximum pumping shown reflects both the Trinity and Edwards-Trinity (Plateau) aquifers, where applicable.

Bexar County

Component	Case	Scenario									
		1	2	3	4	5	6	7	8	9	10
Pumping (acre-feet per year)	Minimum	24,856	24,757	24,757	24,757	24,757	24,856	24,757	24,757	24,757	24,757
	Average	24,856	24,856	24,856	24,856	24,856	24,856	24,856	24,856	24,856	24,856
	Maximum	24,856	24,856	24,856	24,856	24,856	24,856	24,856	24,856	24,856	24,856
Spring and River Base Flow (acre-feet per year)	Minimum	9,225	9,223	9,222	9,220	9,218	9,225	9,223	9,222	9,220	9,218
	Average	10,319	10,317	10,315	10,312	10,309	10,319	10,317	10,315	10,312	10,309
	Maximum	11,536	11,534	11,532	11,530	11,528	11,536	11,534	11,532	11,530	11,528
Outflow Across the Balcones Fault Zone (acre-feet per year)	Minimum	20,183	20,080	19,902	19,662	19,372	20,185	20,082	19,904	19,664	19,375
	Average	28,131	27,992	27,838	27,677	27,401	28,138	28,007	27,841	27,675	27,405
	Maximum	37,091	37,004	36,907	36,809	36,710	37,092	37,005	36,908	36,810	36,711
Overall Trinity Drawdown after 50 years (feet)	Minimum	5	5	6	8	9	5	5	6	8	9
	Average	46	47	48	50	51	46	47	48	50	51
	Maximum	49	50	51	53	55	49	50	51	53	55
Edwards Group Drawdown after 50 Years (feet)	Minimum	-	-	-	-	-	-	-	-	-	-
	Average	-	-	-	-	-	-	-	-	-	-
	Maximum	-	-	-	-	-	-	-	-	-	-
Upper Trinity Drawdown after 50 Years (feet)	Minimum	-16	-16	-16	-16	-16	-16	-16	-16	-16	-16
	Average	15	15	15	15	15	15	15	15	15	15
	Maximum	18	18	18	18	18	18	18	18	18	18
Middle Trinity Drawdown after 50 Years (feet)	Minimum	13	14	16	17	20	13	14	16	17	20
	Average	59	60	61	63	66	59	60	62	64	66
	Maximum	63	64	65	68	70	63	64	65	68	70
Lower Trinity Drawdown after 50 Years (feet)	Minimum	13	14	16	17	20	13	14	15	17	20
	Average	59	60	61	63	66	59	60	62	63	66
	Maximum	63	64	65	68	70	63	64	65	68	70

Table A-4. Continued.

Bexar County

Component	Case	Scenario									
		11	12	13	14	15	16	17	18	19	20
Pumping (acre-feet per year)	Minimum	24,856	24,757	24,757	24,757	24,757	24,856	24,757	24,757	24,757	24,757
	Average	24,856	24,856	24,856	24,856	24,856	24,856	24,856	24,856	24,856	24,856
	Maximum	24,856	24,856	24,856	24,856	24,856	24,856	24,856	24,856	24,856	24,856
Spring and River Base Flow (acre-feet per year)	Minimum	9,225	9,223	9,222	9,220	9,218	9,225	9,223	9,222	9,220	9,218
	Average	10,319	10,317	10,315	10,312	10,309	10,319	10,317	10,315	10,312	10,309
	Maximum	11,536	11,534	11,532	11,530	11,528	11,536	11,534	11,532	11,530	11,528
Outflow Across the Balcones Fault Zone (acre-feet per year)	Minimum	20,187	20,084	19,907	19,667	19,377	20,189	20,086	19,909	19,669	19,379
	Average	28,132	27,989	27,836	27,642	27,403	28,029	27,892	27,758	27,502	27,350
	Maximum	37,093	37,006	36,909	36,811	36,712	37,095	37,007	36,910	36,812	36,714
Overall Trinity Drawdown after 50 years (feet)	Minimum	5	5	6	8	9	1	2	3	4	5
	Average	46	47	48	50	51	46	47	48	50	51
	Maximum	49	50	51	53	55	50	51	51	53	55
Edwards Group Drawdown after 50 Years (feet)	Minimum	-	-	-	-	-	-	-	-	-	-
	Average	-	-	-	-	-	-	-	-	-	-
	Maximum	-	-	-	-	-	-	-	-	-	-
Upper Trinity Drawdown after 50 Years (feet)	Minimum	-16	-16	-16	-16	-16	-17	-17	-17	-17	-17
	Average	15	15	15	15	15	15	15	15	15	15
	Maximum	18	18	18	18	18	19	19	18	18	18
Middle Trinity Drawdown after 50 Years (feet)	Minimum	13	14	15	17	20	8	9	11	12	14
	Average	59	60	62	64	66	58	60	61	63	66
	Maximum	63	64	65	68	70	63	64	65	68	70
Lower Trinity Drawdown after 50 Years (feet)	Minimum	13	14	15	17	20	8	9	11	12	14
	Average	59	60	62	63	66	58	60	61	63	66
	Maximum	63	64	65	68	70	63	64	65	68	70

Table A-5. Simulation results for Blanco County for the 20 simulation scenarios described in Section 3. See Table A-1 for an index describing the relationship between the each scenario and the pumping in Hays and Bandera counties. The minimum, average, and maximum pumping shown reflects both the Trinity and Edwards-Trinity (Plateau) aquifers, where applicable.

Blanco County

Component	Case	Scenario									
		1	2	3	4	5	6	7	8	9	10
Pumping (acre-feet per year)	Minimum	2,573	2,573	2,573	2,573	2,573	2,571	2,571	2,571	2,571	2,571
	Average	2,573	2,573	2,573	2,573	2,573	2,571	2,571	2,571	2,571	2,571
	Maximum	2,573	2,573	2,573	2,573	2,573	2,571	2,571	2,571	2,571	2,571
Spring and River Base Flow (acre-feet per year)	Minimum	11,845	11,845	11,845	11,843	11,842	12,012	12,012	12,012	12,012	12,011
	Average	16,312	16,312	16,311	16,329	16,310	16,511	16,506	16,506	16,506	16,506
	Maximum	21,702	21,702	21,701	21,701	21,701	21,843	21,843	21,843	21,843	21,843
Outflow Across the Balcones Fault Zone (acre-feet per year)	Minimum	-	-	-	-	-	-	-	-	-	-
	Average	-	-	-	-	-	-	-	-	-	-
	Maximum	-	-	-	-	-	-	-	-	-	-
Overall Trinity Drawdown after 50 years (feet)	Minimum	-1	-1	-1	-1	-1	-2	-2	-2	-2	-2
	Average	19	19	19	19	19	19	19	19	19	19
	Maximum	22	22	22	22	22	21	21	21	21	21
Edwards Group Drawdown after 50 Years (feet)	Minimum	-	-	-	-	-	-	-	-	-	-
	Average	-	-	-	-	-	-	-	-	-	-
	Maximum	-	-	-	-	-	-	-	-	-	-
Upper Trinity Drawdown after 50 Years (feet)	Minimum	-13	-13	-13	-13	-13	-13	-13	-13	-13	-13
	Average	15	15	15	15	15	15	15	15	15	15
	Maximum	17	17	17	17	17	17	17	17	17	17
Middle Trinity Drawdown after 50 Years (feet)	Minimum	3	3	3	3	3	2	2	2	2	2
	Average	21	21	21	21	21	20	20	20	20	20
	Maximum	25	25	25	25	25	24	24	24	24	24
Lower Trinity Drawdown after 50 Years (feet)	Minimum	3	3	3	3	3	2	2	2	2	2
	Average	21	21	21	21	21	20	20	20	20	20
	Maximum	24	24	25	25	25	23	23	23	23	23

Table A-5. Continued.

Blanco County

Component	Case	Scenario									
		11	12	13	14	15	16	17	18	19	20
Pumping (acre-feet per year)	Minimum	2,570	2,570	2,570	2,570	2,570	2,568	2,568	2,568	2,568	2,568
	Average	2,570	2,570	2,570	2,570	2,570	2,568	2,568	2,568	2,568	2,568
	Maximum	2,570	2,570	2,570	2,570	2,570	2,568	2,568	2,568	2,568	2,568
Spring and River Base Flow (acre-feet per year)	Minimum	12,166	12,166	12,166	12,166	12,166	12,314	12,314	12,314	12,314	12,314
	Average	16,690	16,689	16,689	16,686	16,689	16,797	16,790	16,777	16,744	16,782
	Maximum	21,977	21,977	21,977	21,977	21,977	22,138	22,137	22,137	22,137	22,137
Outflow Across the Balcones Fault Zone (acre-feet per year)	Minimum	-	-	-	-	-	-	-	-	-	-
	Average	-	-	-	-	-	-	-	-	-	-
	Maximum	-	-	-	-	-	-	-	-	-	-
Overall Trinity Drawdown after 50 years (feet)	Minimum	-3	-3	-3	-3	-3	-6	-6	-6	-6	-6
	Average	18	18	18	18	18	17	17	17	17	17
	Maximum	21	21	21	21	21	20	20	20	20	20
Edwards Group Drawdown after 50 Years (feet)	Minimum	-	-	-	-	-	-	-	-	-	-
	Average	-	-	-	-	-	-	-	-	-	-
	Maximum	-	-	-	-	-	-	-	-	-	-
Upper Trinity Drawdown after 50 Years (feet)	Minimum	-13	-13	-13	-13	-13	-14	-14	-14	-14	-14
	Average	15	15	15	15	15	15	15	15	15	15
	Maximum	17	17	17	17	17	18	18	17	17	17
Middle Trinity Drawdown after 50 Years (feet)	Minimum	1	1	1	1	1	-3	-3	-3	-3	-3
	Average	19	19	19	19	19	18	18	18	18	18
	Maximum	23	23	23	23	23	22	22	22	22	22
Lower Trinity Drawdown after 50 Years (feet)	Minimum	1	1	1	1	1	-4	-4	-4	-3	-3
	Average	19	19	19	19	19	17	18	18	18	18
	Maximum	22	22	22	22	22	21	21	21	21	21

Table A-6. Simulation results for Comal County for the 20 simulation scenarios described in Section 3. See Table A-1 for an index describing the relationship between the each scenario and the pumping in Hays and Bandera counties. The minimum, average, and maximum pumping shown reflects both the Trinity and Edwards-Trinity (Plateau) aquifers, where applicable.

Comal County

Component	Case	Scenario									
		1	2	3	4	5	6	7	8	9	10
Pumping (acre-feet per year)	Minimum	10,214	10,214	10,214	10,214	10,214	10,214	10,214	10,214	10,214	10,214
	Average	10,214	10,214	10,214	10,214	10,214	10,214	10,214	10,214	10,214	10,214
	Maximum	10,214	10,214	10,214	10,214	10,214	10,214	10,214	10,214	10,214	10,214
Spring and River Base Flow (acre-feet per year)	Minimum	-3,623	-3,644	-3,672	-3,708	-3,752	-3,370	-3,391	-3,419	-3,455	-3,500
	Average	1,477	1,458	1,433	1,411	1,364	1,735	1,712	1,685	1,653	1,616
	Maximum	8,010	7,996	7,980	7,964	7,948	8,344	8,330	8,315	8,299	8,283
Outflow Across the Balcones Fault Zone (acre-feet per year)	Minimum	28,442	28,430	28,402	28,366	28,322	28,458	28,446	28,419	28,383	28,339
	Average	33,948	33,928	33,907	33,881	33,840	33,965	33,948	33,926	33,897	33,858
	Maximum	40,011	40,001	39,990	39,978	39,967	40,023	40,013	40,002	39,991	39,980
Overall Trinity Drawdown after 50 years (feet)	Minimum	-1	-1	-1	-1	-1	-2	-1	-1	-1	-1
	Average	24	24	24	24	25	24	24	24	24	24
	Maximum	26	26	26	26	27	26	26	26	26	26
Edwards Group Drawdown after 50 Years (feet)	Minimum	-	-	-	-	-	-	-	-	-	-
	Average	-	-	-	-	-	-	-	-	-	-
	Maximum	-	-	-	-	-	-	-	-	-	-
Upper Trinity Drawdown after 50 Years (feet)	Minimum	-14	-14	-14	-14	-14	-14	-14	-14	-14	-14
	Average	15	15	15	15	15	15	15	15	15	15
	Maximum	18	18	18	18	18	18	18	18	18	18
Middle Trinity Drawdown after 50 Years (feet)	Minimum	2	2	2	2	2	1	2	2	2	2
	Average	26	26	26	26	26	25	25	26	26	26
	Maximum	28	28	28	28	29	27	27	28	28	28
Lower Trinity Drawdown after 50 Years (feet)	Minimum	2	2	2	2	2	1	2	2	2	2
	Average	26	26	26	26	26	25	25	26	26	26
	Maximum	28	28	28	28	29	27	27	28	28	28

Table A-6. Continued.

Comal County

Component	Case	Scenario									
		11	12	13	14	15	16	17	18	19	20
Pumping (acre-feet per year)	Minimum	10,214	10,214	10,214	10,214	10,214	10,214	10,214	10,214	10,214	10,214
	Average	10,214	10,214	10,214	10,214	10,214	10,214	10,214	10,214	10,214	10,214
	Maximum	10,214	10,214	10,214	10,214	10,214	10,214	10,214	10,214	10,214	10,214
Spring and River Base Flow (acre-feet per year)	Minimum	-3,156	-3,168	-3,196	-3,232	-3,276	-2,943	-2,952	-2,973	-3,009	-3,053
	Average	1,952	1,935	1,907	1,870	1,826	2,154	2,126	2,097	2,017	2,025
	Maximum	8,636	8,622	8,606	8,590	8,574	8,928	8,914	8,898	8,882	8,867
Outflow Across the Balcones Fault Zone (acre-feet per year)	Minimum	28,472	28,461	28,433	28,398	28,353	28,487	28,476	28,448	28,412	28,368
	Average	33,972	33,953	33,931	33,901	33,870	33,963	33,940	33,911	33,868	33,841
	Maximum	40,034	40,024	40,013	40,002	39,991	40,045	40,035	40,024	40,013	40,002
Overall Trinity Drawdown after 50 years (feet)	Minimum	-2	-2	-1	-1	-1	-4	-3	-3	-3	-3
	Average	24	24	24	24	24	23	24	24	24	24
	Maximum	25	25	26	26	26	26	26	25	26	26
Edwards Group Drawdown after 50 Years (feet)	Minimum	-	-	-	-	-	-	-	-	-	-
	Average	-	-	-	-	-	-	-	-	-	-
	Maximum	-	-	-	-	-	-	-	-	-	-
Upper Trinity Drawdown after 50 Years (feet)	Minimum	-14	-14	-14	-14	-14	-15	-15	-15	-15	-15
	Average	15	15	15	15	15	15	15	15	15	15
	Maximum	18	18	18	18	18	19	19	18	18	18
Middle Trinity Drawdown after 50 Years (feet)	Minimum	1	1	2	2	2	-1	-1	-1	0	0
	Average	25	25	25	26	26	25	25	25	25	26
	Maximum	27	27	27	28	28	27	27	27	27	28
Lower Trinity Drawdown after 50 Years (feet)	Minimum	1	1	2	2	2	-1	-1	-1	0	0
	Average	25	25	25	26	26	25	25	25	25	26
	Maximum	27	27	27	28	28	27	27	27	27	28

Table A-7. Simulation results for Hays County for the 20 simulation scenarios described in Section 3. See Table A-1 for an index describing the relationship between the each scenario and the pumping in Hays and Bandera counties. The minimum, average, and maximum pumping shown reflects both the Trinity and Edwards-Trinity (Plateau) aquifers, where applicable.

Hays County

Component	Case	Scenario									
		1	2	3	4	5	6	7	8	9	10
Pumping (acre-feet per year)	Minimum	9,115	9,115	9,115	9,115	9,115	5,828	5,828	5,828	5,828	5,828
	Average	9,115	9,115	9,115	9,115	9,115	5,828	5,828	5,828	5,828	5,828
	Maximum	9,130	9,130	9,130	9,130	9,130	5,828	5,828	5,828	5,828	5,828
Spring and River Base Flow (acre-feet per year)	Minimum	14,104	14,102	14,101	14,099	14,097	15,139	15,138	15,137	15,135	15,133
	Average	18,025	18,024	18,022	18,022	18,019	19,054	19,053	19,052	19,051	19,049
	Maximum	22,630	22,630	22,629	22,629	22,628	23,595	23,595	23,595	23,594	23,594
Outflow Across the Balcones Fault Zone (acre-feet per year)	Minimum	2,155	2,155	2,155	2,154	2,154	3,404	3,404	3,404	3,404	3,404
	Average	3,995	3,995	3,995	4,001	3,995	5,221	5,221	5,221	5,221	5,220
	Maximum	6,509	6,509	6,509	6,509	6,509	7,365	7,365	7,365	7,364	7,364
Overall Trinity Drawdown after 50 years (feet)	Minimum	5	5	5	5	5	-1	-1	-1	-1	-1
	Average	19	19	19	19	19	13	13	13	13	13
	Maximum	21	21	21	21	21	14	14	14	14	14
Edwards Group Drawdown after 50 Years (feet)	Minimum	-	-	-	-	-	-	-	-	-	-
	Average	-	-	-	-	-	-	-	-	-	-
	Maximum	-	-	-	-	-	-	-	-	-	-
Upper Trinity Drawdown after 50 Years (feet)	Minimum	-7	-7	-7	-7	-7	-8	-8	-8	-8	-8
	Average	11	11	11	11	11	11	11	11	11	11
	Maximum	13	13	13	13	13	13	13	13	13	13
Middle Trinity Drawdown after 50 Years (feet)	Minimum	8	8	8	8	8	2	2	2	2	2
	Average	22	22	22	22	22	13	13	13	13	13
	Maximum	24	24	24	24	24	15	15	15	15	15
Lower Trinity Drawdown after 50 Years (feet)	Minimum	8	8	8	8	8	2	2	2	2	2
	Average	22	22	22	22	22	13	13	13	13	13
	Maximum	24	24	24	24	24	15	15	15	15	15

Table A-7. Continued.

Hays County

Component	Case	Scenario									
		11	12	13	14	15	16	17	18	19	20
Pumping (acre-feet per year)	Minimum	2,930	2,930	2,930	2,930	2,930	33	33	33	33	33
	Average	2,930	2,930	2,930	2,930	2,930	33	33	33	33	33
	Maximum	2,930	2,930	2,930	2,930	2,930	33	33	33	33	33
Spring and River Base Flow (acre-feet per year)	Minimum	16,055	16,055	16,054	16,054	16,053	16,931	16,931	16,930	16,930	16,929
	Average	19,977	19,976	19,975	19,973	19,973	20,825	20,825	20,823	20,807	20,819
	Maximum	24,453	24,453	24,452	24,452	24,451	25,334	25,333	25,333	25,332	25,332
Outflow Across the Balcones Fault Zone (acre-feet per year)	Minimum	4,443	4,443	4,442	4,442	4,442	5,364	5,364	5,364	5,363	5,363
	Average	6,277	6,278	6,278	6,270	6,280	7,287	7,287	7,287	7,279	7,286
	Maximum	8,292	8,292	8,292	8,292	8,291	9,277	9,277	9,277	9,277	9,276
Overall Trinity Drawdown after 50 years (feet)	Minimum	-7	-7	-7	-7	-7	-14	-14	-14	-14	-14
	Average	7	7	7	7	7	1	1	1	1	1
	Maximum	8	8	8	8	8	3	3	3	3	3
Edwards Group Drawdown after 50 Years (feet)	Minimum	-	-	-	-	-	-	-	-	-	-
	Average	-	-	-	-	-	-	-	-	-	-
	Maximum	-	-	-	-	-	-	-	-	-	-
Upper Trinity Drawdown after 50 Years (feet)	Minimum	-8	-8	-8	-8	-8	-9	-9	-9	-9	-9
	Average	11	11	11	11	11	10	10	10	10	10
	Maximum	12	12	12	12	12	12	12	12	12	12
Middle Trinity Drawdown after 50 Years (feet)	Minimum	-6	-6	-6	-6	-6	-16	-16	-16	-16	-16
	Average	6	6	6	6	6	-2	-2	-2	-2	-2
	Maximum	7	7	7	7	7	0	0	0	0	0
Lower Trinity Drawdown after 50 Years (feet)	Minimum	-6	-6	-6	-6	-6	-16	-16	-16	-16	-16
	Average	6	6	6	6	6	-2	-2	-2	-2	-2
	Maximum	7	7	7	7	7	0	0	0	0	0

Table A-8. Simulation results for Kendall County for the 20 simulation scenarios described in Section 3. See Table A-1 for an index describing the relationship between the each scenario and the pumping in Hays and Bandera counties. The minimum, average, and maximum pumping shown reflects both the Trinity and Edwards-Trinity (Plateau) aquifers, where applicable.

Kendall County

Component	Case	Scenario									
		1	2	3	4	5	6	7	8	9	10
Pumping (acre-feet per year)	Minimum	11,450	11,450	11,450	11,450	11,450	11,450	11,450	11,450	11,450	11,450
	Average	11,450	11,450	11,450	11,450	11,450	11,450	11,450	11,450	11,450	11,450
	Maximum	11,450	11,450	11,450	11,450	11,450	11,450	11,450	11,450	11,450	11,450
Spring and River Base Flow (acre-feet per year)	Minimum	17,848	17,746	17,617	17,422	17,239	17,853	17,750	17,621	17,428	17,245
	Average	24,753	24,603	24,439	24,252	24,073	24,767	24,610	24,448	24,257	24,082
	Maximum	34,442	34,384	34,314	34,245	34,176	34,443	34,385	34,316	34,246	34,178
Outflow Across the Balcones Fault Zone (acre-feet per year)	Minimum	-	-	-	-	-	-	-	-	-	-
	Average	-	-	-	-	-	-	-	-	-	-
	Maximum	-	-	-	-	-	-	-	-	-	-
Overall Trinity Drawdown after 50 years (feet)	Minimum	0	1	2	4	5	0	1	2	4	5
	Average	29	30	31	32	34	29	30	31	32	34
	Maximum	33	33	35	36	38	33	33	35	36	38
Edwards Group Drawdown after 50 Years (feet)	Minimum	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
	Average	2	2	2	2	2	2	2	2	2	2
	Maximum	3	3	3	3	3	3	3	3	3	3
Upper Trinity Drawdown after 50 Years (feet)	Minimum	-27	-27	-27	-27	-27	-27	-27	-27	-27	-27
	Average	26	27	27	27	27	26	27	27	27	27
	Maximum	31	31	31	31	31	31	31	31	31	31
Middle Trinity Drawdown after 50 Years (feet)	Minimum	7	8	8	8	9	7	8	8	8	9
	Average	29	31	32	34	36	29	31	32	34	36
	Maximum	33	35	36	39	41	33	35	36	38	41
Lower Trinity Drawdown after 50 Years (feet)	Minimum	7	8	8	8	9	7	8	8	8	9
	Average	29	31	32	34	37	30	31	32	35	37
	Maximum	33	35	36	39	41	33	35	36	39	41

Table A-8. Continued.

Kendall County

Component	Case	Scenario									
		11	12	13	14	15	16	17	18	19	20
Pumping (acre-feet per year)	Minimum	11,450	11,450	11,450	11,450	11,450	11,450	11,450	11,450	11,450	11,450
	Average	11,450	11,450	11,450	11,450	11,450	11,450	11,450	11,450	11,450	11,450
	Maximum	11,450	11,450	11,450	11,450	11,450	11,450	11,450	11,450	11,450	11,450
Spring and River Base Flow (acre-feet per year)	Minimum	17,857	17,754	17,625	17,433	17,250	17,861	17,759	17,630	17,438	17,255
	Average	24,763	24,612	24,446	24,253	24,081	24,708	24,565	24,409	24,203	24,033
	Maximum	34,445	34,387	34,317	34,248	34,179	34,446	34,388	34,319	34,249	34,181
Outflow Across the Balcones Fault Zone (acre-feet per year)	Minimum	-	-	-	-	-	-	-	-	-	-
	Average	-	-	-	-	-	-	-	-	-	-
	Maximum	-	-	-	-	-	-	-	-	-	-
Overall Trinity Drawdown after 50 years (feet)	Minimum	0	1	2	3	5	-4	-4	-2	-1	0
	Average	29	30	31	32	34	28	29	31	32	34
	Maximum	33	33	35	36	38	33	33	35	36	38
Edwards Group Drawdown after 50 Years (feet)	Minimum	-2	-2	-2	-2	-2	-3	-3	-3	-3	-3
	Average	2	2	2	2	2	2	2	2	2	2
	Maximum	3	3	3	3	3	3	3	3	3	3
Upper Trinity Drawdown after 50 Years (feet)	Minimum	-27	-27	-27	-27	-27	-32	-32	-32	-32	-32
	Average	26	27	27	27	27	27	27	27	27	27
	Maximum	31	31	31	31	31	32	32	31	31	31
Middle Trinity Drawdown after 50 Years (feet)	Minimum	7	8	8	8	9	5	6	8	8	9
	Average	29	31	32	34	36	29	30	32	34	36
	Maximum	33	35	36	38	41	33	35	36	38	41
Lower Trinity Drawdown after 50 Years (feet)	Minimum	7	8	8	8	9	5	6	8	8	9
	Average	29	31	32	34	37	29	31	32	34	36
	Maximum	33	35	36	39	41	33	35	36	39	41

Table A-9. Simulation results for Kerr County for the 20 simulation scenarios described in Section 3. See Table A-1 for an index describing the relationship between the each scenario and the pumping in Hays and Bandera counties. The minimum, average, and maximum pumping shown reflects both the Trinity and Edwards-Trinity (Plateau) aquifers, where applicable.

Kerr County

Component	Case	Scenario									
		1	2	3	4	5	6	7	8	9	10
Pumping (acre-feet per year)	Minimum	14,594	14,594	14,594	14,594	13,814	14,594	14,594	14,594	14,594	13,814
	Average	15,952	15,952	15,170	14,594	14,594	15,952	15,952	15,170	14,594	14,594
	Maximum	17,468	17,468	17,468	17,468	17,468	17,468	17,468	17,468	17,468	17,468
Spring and River Base Flow (acre-feet per year)	Minimum	31,127	31,112	31,097	31,081	31,066	31,127	31,112	31,097	31,081	31,066
	Average	37,559	37,521	37,492	37,470	37,449	37,572	37,533	37,503	37,471	37,459
	Maximum	44,225	44,177	44,133	44,091	44,059	44,225	44,177	44,133	44,091	44,062
Outflow Across the Balcones Fault Zone (acre-feet per year)	Minimum	-	-	-	-	-	-	-	-	-	-
	Average	-	-	-	-	-	-	-	-	-	-
	Maximum	-	-	-	-	-	-	-	-	-	-
Overall Trinity Drawdown after 50 years (feet)	Minimum	6	6	7	8	9	6	6	7	8	9
	Average	39	47	55	64	74	39	47	55	64	74
	Maximum	48	55	64	76	86	48	55	64	76	86
Edwards Group Drawdown after 50 Years (feet)	Minimum	-7	-7	-7	-6	-6	-7	-7	-7	-6	-6
	Average	0	0	0	1	1	0	0	0	1	1
	Maximum	4	4	4	4	4	4	4	4	4	4
Upper Trinity Drawdown after 50 Years (feet)	Minimum	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7
	Average	7	7	7	7	7	7	7	7	7	7
	Maximum	10	10	10	10	10	10	10	10	10	10
Middle Trinity Drawdown after 50 Years (feet)	Minimum	8	9	10	11	12	8	9	10	11	12
	Average	57	68	80	94	108	57	68	80	94	108
	Maximum	68	79	92	109	124	68	79	92	109	124
Lower Trinity Drawdown after 50 Years (feet)	Minimum	9	10	11	12	13	9	10	11	12	13
	Average	58	70	83	98	112	58	70	83	98	112
	Maximum	70	81	95	113	129	70	81	95	113	129

Table A-9. Continued.

Kerr County

Component	Case	Scenario									
		11	12	13	14	15	16	17	18	19	20
Pumping (acre-feet per year)	Minimum	14,594	14,594	14,594	14,594	13,814	14,594	14,594	14,594	14,594	13,814
	Average	15,952	15,952	15,170	14,594	14,594	15,952	15,375	15,170	14,594	14,594
	Maximum	17,468	17,468	17,468	17,468	17,468	17,468	17,468	17,468	17,468	17,468
Spring and River Base Flow (acre-feet per year)	Minimum	31,127	31,112	31,097	31,081	31,066	31,127	31,112	31,097	31,081	31,066
	Average	37,558	37,532	37,495	37,465	37,458	37,528	37,496	37,453	37,385	37,410
	Maximum	44,225	44,177	44,133	44,091	44,062	44,225	44,177	44,133	44,091	44,062
Outflow Across the Balcones Fault Zone (acre-feet per year)	Minimum	-	-	-	-	-	-	-	-	-	-
	Average	-	-	-	-	-	-	-	-	-	-
	Maximum	-	-	-	-	-	-	-	-	-	-
Overall Trinity Drawdown after 50 years (feet)	Minimum	6	6	7	8	9	6	6	7	8	9
	Average	39	47	55	65	75	39	46	55	65	75
	Maximum	48	55	64	76	86	47	55	64	76	86
Edwards Group Drawdown after 50 Years (feet)	Minimum	-7	-7	-7	-6	-6	-7	-7	-7	-7	-7
	Average	0	0	0	1	1	0	0	0	0	0
	Maximum	4	4	4	4	4	4	4	4	4	4
Upper Trinity Drawdown after 50 Years (feet)	Minimum	-7	-7	-7	-7	-7	-9	-9	-9	-8	-9
	Average	7	7	7	7	7	6	7	7	7	7
	Maximum	10	10	10	10	10	10	10	10	10	10
Middle Trinity Drawdown after 50 Years (feet)	Minimum	8	9	10	11	12	8	9	10	11	12
	Average	57	68	80	95	109	57	68	81	95	110
	Maximum	68	79	92	110	124	67	79	92	110	124
Lower Trinity Drawdown after 50 Years (feet)	Minimum	9	10	11	12	13	9	10	11	12	13
	Average	59	70	83	99	113	59	70	83	99	115
	Maximum	70	81	95	114	129	69	81	95	114	129

Table A-10. Simulation results for Medina County for the 20 simulation scenarios described in Section 3. See Table A-1 for an index describing the relationship between the each scenario and the pumping in Hays and Bandera counties. The minimum, average, and maximum pumping shown reflects both the Trinity and Edwards-Trinity (Plateau) aquifers, where applicable.

Medina County

Component	Case	Scenario									
		1	2	3	4	5	6	7	8	9	10
Pumping (acre-feet per year)	Minimum	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500
	Average	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500
	Maximum	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500
Spring and River Base Flow (acre-feet per year)	Minimum	4,955	4,937	4,920	4,903	4,886	4,955	4,937	4,920	4,903	4,886
	Average	5,395	5,378	5,361	5,346	5,330	5,395	5,378	5,362	5,347	5,330
	Maximum	5,896	5,883	5,869	5,855	5,841	5,896	5,883	5,869	5,855	5,841
Outflow Across the Balcones Fault Zone (acre-feet per year)	Minimum	3,375	1,682	-292	-2,859	-5,613	3,375	1,683	-292	-2,858	-5,612
	Average	6,647	5,116	3,427	1,481	-1,025	6,648	5,115	3,425	1,478	-1,031
	Maximum	10,924	10,367	9,692	8,969	8,246	10,924	10,367	9,692	8,970	8,246
Overall Trinity Drawdown after 50 years (feet)	Minimum	5	6	8	9	11	5	6	8	9	11
	Average	16	21	26	32	38	16	21	26	32	38
	Maximum	18	23	29	35	42	18	23	29	35	42
Edwards Group Drawdown after 50 Years (feet)	Minimum	-	-	-	-	-	-	-	-	-	-
	Average	-	-	-	-	-	-	-	-	-	-
	Maximum	-	-	-	-	-	-	-	-	-	-
Upper Trinity Drawdown after 50 Years (feet)	Minimum	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5
	Average	6	7	7	7	7	6	7	7	7	7
	Maximum	7	7	8	8	8	7	7	8	8	8
Middle Trinity Drawdown after 50 Years (feet)	Minimum	7	9	12	14	16	7	9	12	14	16
	Average	21	28	36	45	55	21	28	36	45	55
	Maximum	24	31	40	50	60	24	31	40	50	60
Lower Trinity Drawdown after 50 Years (feet)	Minimum	7	9	12	14	16	7	9	12	14	16
	Average	21	29	36	45	55	21	29	36	45	55
	Maximum	24	31	40	50	60	24	31	40	50	60

Table A-10. Continued.

Medina County

Component	Case	Scenario									
		11	12	13	14	15	16	17	18	19	20
Pumping (acre-feet per year)	Minimum	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500
	Average	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500
	Maximum	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500
Spring and River Base Flow (acre-feet per year)	Minimum	4,955	4,937	4,920	4,903	4,886	4,955	4,937	4,920	4,903	4,886
	Average	5,395	5,379	5,362	5,347	5,331	5,396	5,380	5,362	5,345	5,331
	Maximum	5,896	5,883	5,869	5,855	5,841	5,896	5,883	5,869	5,855	5,841
Outflow Across the Balcones Fault Zone (acre-feet per year)	Minimum	3,375	1,683	-292	-2,895	-5,612	3,376	1,683	-291	-2,903	-5,611
	Average	6,644	5,110	3,419	1,460	-1,045	6,605	5,085	3,381	1,396	-1,131
	Maximum	10,924	10,367	9,692	8,970	8,246	10,924	10,367	9,693	8,970	8,247
Overall Trinity Drawdown after 50 years (feet)	Minimum	5	6	8	9	11	5	6	8	9	11
	Average	16	21	26	32	39	16	21	26	32	38
	Maximum	18	23	29	35	42	18	23	29	35	42
Edwards Group Drawdown after 50 Years (feet)	Minimum	-	-	-	-	-	-	-	-	-	-
	Average	-	-	-	-	-	-	-	-	-	-
	Maximum	-	-	-	-	-	-	-	-	-	-
Upper Trinity Drawdown after 50 Years (feet)	Minimum	-5	-5	-5	-5	-5	-6	-6	-6	-5	-5
	Average	6	7	7	7	7	6	7	7	7	7
	Maximum	7	7	8	8	8	8	8	8	8	8
Middle Trinity Drawdown after 50 Years (feet)	Minimum	7	9	12	14	16	7	9	12	14	16
	Average	21	28	36	45	55	21	28	36	45	55
	Maximum	24	31	40	50	60	24	31	40	50	60
Lower Trinity Drawdown after 50 Years (feet)	Minimum	7	9	12	14	16	7	9	12	14	16
	Average	21	29	36	45	55	21	28	36	45	55
	Maximum	24	31	40	50	60	24	31	40	50	60

Table A-11. Simulation results for Travis County for the 20 simulation scenarios described in Section 3. See Table A-1 for an index describing the relationship between the each scenario and the pumping in Hays and Bandera counties. The minimum, average, and maximum pumping shown reflects both the Trinity and Edwards-Trinity (Plateau) aquifers, where applicable.

Travis County

Component	Case	Scenario									
		1	2	3	4	5	6	7	8	9	10
Pumping (acre-feet per year)	Minimum	8,521	8,521	8,521	8,521	8,521	8,563	8,563	8,563	8,563	8,563
	Average	8,697	8,697	8,697	8,697	8,697	8,697	8,697	8,697	8,697	8,697
	Maximum	8,947	8,947	8,947	8,947	8,947	8,947	8,947	8,947	8,947	8,947
Spring and River Base Flow (acre-feet per year)	Minimum	6,895	6,895	6,895	6,895	6,895	7,160	7,160	7,160	7,160	7,160
	Average	9,050	9,050	9,050	9,050	9,050	9,345	9,345	9,345	9,345	9,345
	Maximum	12,312	12,312	12,312	12,312	12,312	12,391	12,391	12,391	12,391	12,391
Outflow Across the Balcones Fault Zone (acre-feet per year)	Minimum	171	171	171	171	171	360	360	360	360	360
	Average	670	670	670	670	670	853	852	852	852	852
	Maximum	1,510	1,510	1,510	1,510	1,510	1,577	1,577	1,577	1,577	1,577
Overall Trinity Drawdown after 50 years (feet)	Minimum	11	11	11	11	11	9	9	9	9	9
	Average	28	28	28	28	28	24	24	24	24	24
	Maximum	29	29	29	29	29	26	26	26	26	26
Edwards Group Drawdown after 50 Years (feet)	Minimum	-	-	-	-	-	-	-	-	-	-
	Average	-	-	-	-	-	-	-	-	-	-
	Maximum	-	-	-	-	-	-	-	-	-	-
Upper Trinity Drawdown after 50 Years (feet)	Minimum	0	0	0	0	0	0	0	0	0	0
	Average	28	28	28	28	28	28	28	28	28	28
	Maximum	31	31	31	31	31	31	31	31	31	31
Middle Trinity Drawdown after 50 Years (feet)	Minimum	11	11	11	11	11	10	10	10	10	10
	Average	28	28	28	28	28	23	23	23	23	23
	Maximum	30	30	30	30	30	25	25	25	25	25
Lower Trinity Drawdown after 50 Years (feet)	Minimum	11	11	11	11	11	10	10	10	10	10
	Average	28	28	28	28	28	23	23	23	23	23
	Maximum	30	30	30	30	30	25	25	25	25	25

Table A-11. Continued.

Travis County

Component	Case	Scenario									
		11	12	13	14	15	16	17	18	19	20
Pumping (acre-feet per year)	Minimum	8,691	8,691	8,691	8,691	8,691	8,691	8,691	8,691	8,691	8,691
	Average	8,697	8,697	8,697	8,697	8,697	8,697	8,697	8,697	8,697	8,697
	Maximum	8,947	8,947	8,947	8,947	8,947	8,947	8,947	8,947	8,947	8,947
Spring and River Base Flow (acre-feet per year)	Minimum	7,321	7,321	7,321	7,321	7,321	7,549	7,549	7,549	7,549	7,549
	Average	9,569	9,569	9,569	9,568	9,571	9,758	9,758	9,758	9,754	9,758
	Maximum	12,462	12,462	12,462	12,462	12,462	12,534	12,534	12,534	12,534	12,534
Outflow Across the Balcones Fault Zone (acre-feet per year)	Minimum	522	522	522	522	522	654	654	654	654	654
	Average	1,011	1,011	1,011	1,011	1,011	1,155	1,154	1,153	1,151	1,153
	Maximum	1,636	1,636	1,636	1,636	1,636	1,710	1,710	1,710	1,710	1,710
Overall Trinity Drawdown after 50 years (feet)	Minimum	6	6	6	6	6	1	1	1	1	1
	Average	21	21	21	21	21	18	18	18	18	18
	Maximum	23	23	23	23	23	20	20	20	20	20
Edwards Group Drawdown after 50 Years (feet)	Minimum	-	-	-	-	-	-	-	-	-	-
	Average	-	-	-	-	-	-	-	-	-	-
	Maximum	-	-	-	-	-	-	-	-	-	-
Upper Trinity Drawdown after 50 Years (feet)	Minimum	0	0	0	0	0	-3	-3	-3	-3	-3
	Average	28	28	28	28	28	28	28	28	28	28
	Maximum	31	31	31	31	31	32	32	31	31	31
Middle Trinity Drawdown after 50 Years (feet)	Minimum	8	8	8	8	8	3	3	3	3	3
	Average	19	19	19	19	19	15	15	15	15	15
	Maximum	20	20	20	20	20	16	16	16	16	16
Lower Trinity Drawdown after 50 Years (feet)	Minimum	8	8	8	8	8	2	2	2	2	2
	Average	19	19	19	19	19	15	15	15	15	15
	Maximum	21	21	21	21	21	16	16	16	16	16