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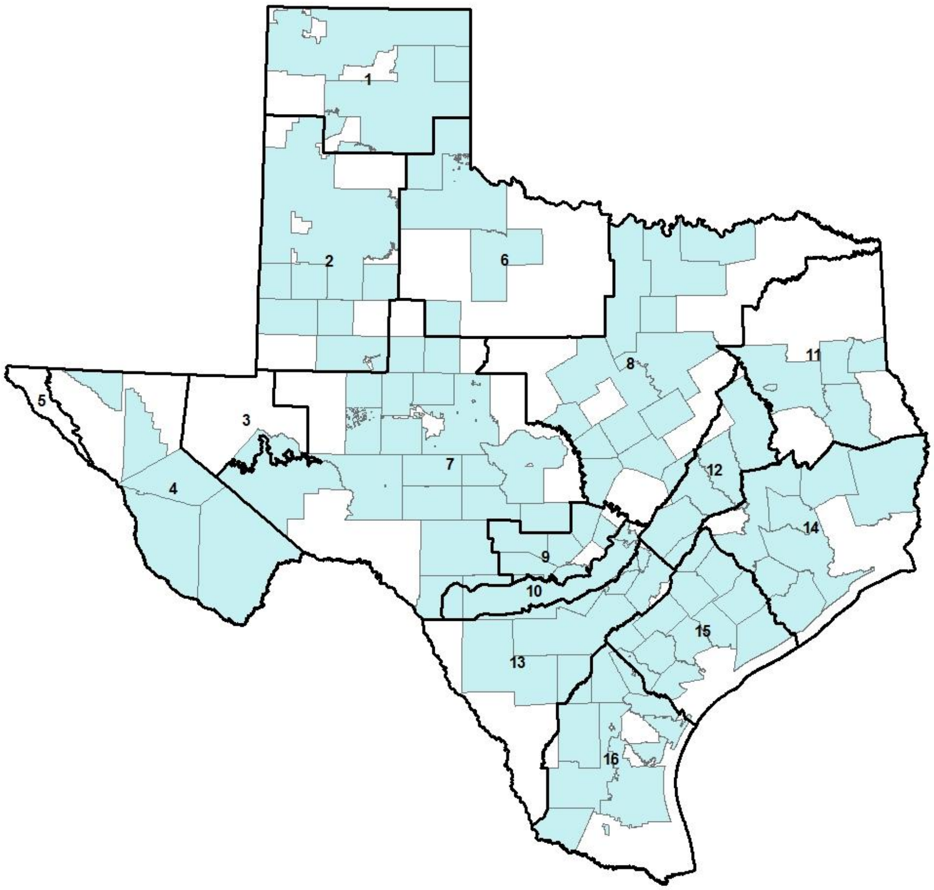
GIS in Water Resources
12/03/2010

Visualizing Texas Groundwater Policy

Groundwater Conservation Districts:

Municipal, industrial and agricultural groundwater withdrawals currently account for 60% of water use in Texas. Since groundwater plays a crucial role in both municipal and business markets, effective management ensuring the longevity of supply is essential. Unlike surface water resources, which are controlled by the regulating agencies, such as the Texas Commission on Environmental Quality (TCEQ), groundwater in Texas is managed primarily by landowners. Decision support for effective groundwater management begins within Groundwater Conservation Districts (GCD), which are formed by landowners, and generally follow county lines. If a landowner would like to begin the petition process for a GCD formation, signature must be obtained from a majority of landowners within the proposed district (Lesikar et al., pg. 14). Petitions are approved by the Texas Water Development Board, under the stipulation that funding and an interim board of directors are available to begin the management process. Under the Rule of Capture, by which Texas groundwater is governed, landowners are given the right to pump any quantity of water that resides under their land. Although amendments continually add exceptions to the rule, the essential idea that groundwater is regulated by property owners is still in effect. Incentives for the formation of GCD's includes scientific studies to determine total available groundwater, and access to state funding for proposed water planning projects (Mace et al., 2006, pg. 6). Estimation of total available groundwater resources provides valuable information in setting desired future conditions (DFC). A DFC is a projection of water use derived from water availability over 50 years. Parameters such as storage, recharge, and population growth are considered in determining available water supplies. A DFC can then be established based on water supply estimations. Each GCD must plan accordingly with other GCD's in a groundwater management area, so a single desired future condition is reported to the Texas Water Development Board.

Figure 1:

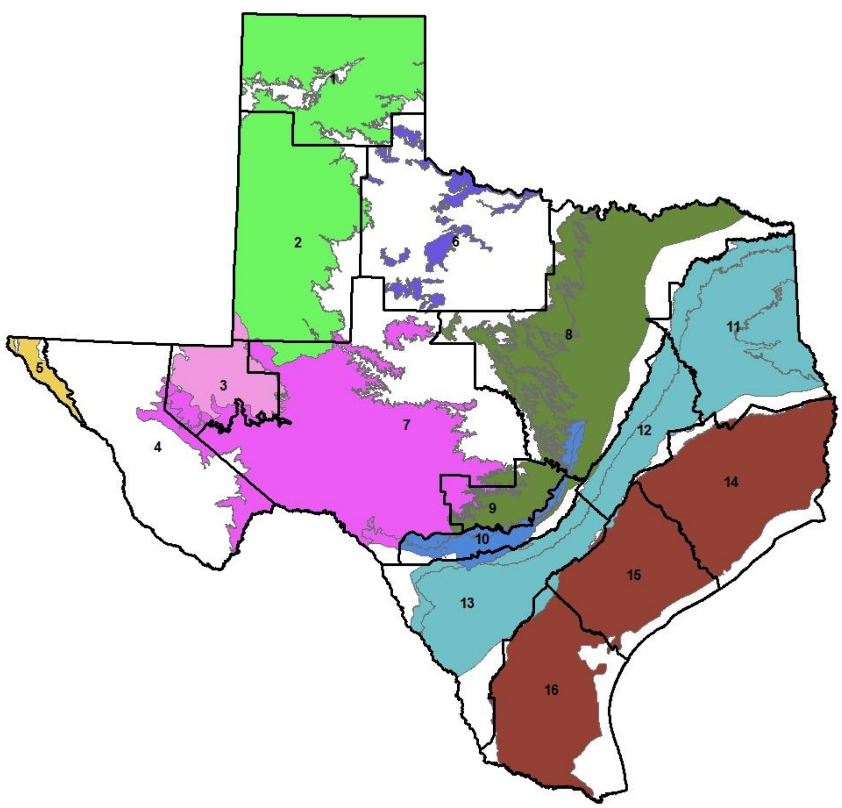


Source: Texas Water Development Board, 2010

Groundwater Management Areas:

Groundwater management areas (GMA) are arranged according to the major aquifers in Texas (see Figure 2). Some aquifers are managed by multiple GMA's, which is based on hydrogeologic boundaries, such as a groundwater divide, or water use patterns (Mace et al., 2006, pg. 2). GMA's are essentially a forum where conjunctive planning can take place between groundwater conservation districts. Since GMA's cover an area that coincides with major aquifers, the final decision on desired future conditions conveniently applies to the aquifer located in the management area. When a GMA, and its related GCD's, agree to a desired future condition, the information is reported to TWDB, which approves the figures and calculates managed available groundwater for the next 50 years. This information is relayed to Regional Water Planning Groups, the endpoint for finalized water resource information in Texas. If managed available groundwater is determined to be short of total demand within 25 years, a GMA falls under consideration for PGMA status, or a Priority Groundwater Management Area. PGMA's are closely monitored by TCEQ, and receive input from the agency on a proper path for water conservation. If groundwater conservation districts do not cover the entire area in a PGMA, GCD's must be formed, or the remaining landowners annexed to an established GCD within 2 years (Lesikar et al., pg. 16).

Figure 2:



Source: Texas Water Development Board, 2010

Regional Water Planning Groups:

After desired future conditions are submitted to the Texas Water Development Board, groundwater availability figures are calculated through Groundwater Availability Models. Groundwater availability data is submitted to Regional Water Planning Groups, to be included in a State Water Plan encompassing both groundwater and surface water resources. Since RWPG's receive a finalized and consolidated form of information for water demand and water supply, they are a superior source for water planning information. Formation of RWPG's (Figure 3) is based on the following variables, but this list is not comprehensive (McKirmon, 2006, pg. 2):

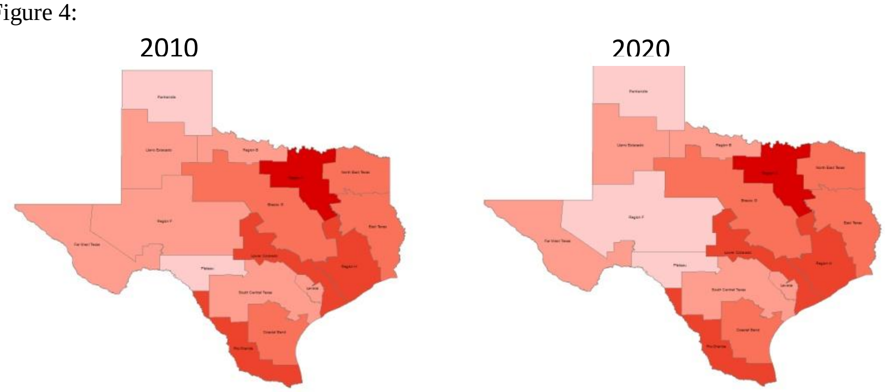
- cities,
- surface water systems,
- groundwater systems,
- large water service areas,
- metropolitan statistical areas,
- existing regional water supply studies and areas, and
- groundwater management districts

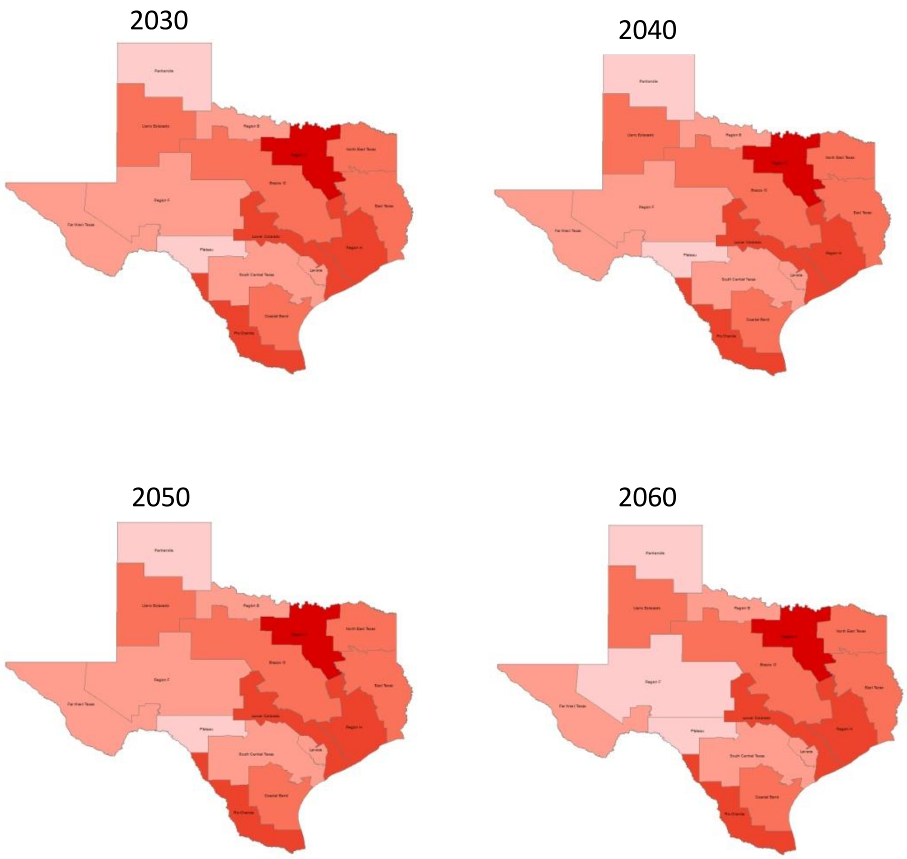
Figure 3:

Source: Texas Water Development Board, 2010

In order to better represent groundwater availability across Texas in a cohesive format, data was extracted from the regional water plans concerning water demand and supply. Regional water report formats are not ubiquitous, so comparing data across all regions is dependent on available information. For example, displaying groundwater demand as a percent of groundwater supply is more useful than total water demand as a percentage of groundwater supply. Regions with extensive surface water supply, and little groundwater would be misrepresented as water stressed areas. Unfortunately, total groundwater demand is not available for every region, so total water demand must be used for the purposes of this project. Below, in Figure 4, is a map of total water demand as a percent of groundwater supply for the decades 2010 – 2060. This water availability data originates from GMA's, as many GCD's continue to work on finalizing their desired future conditions. After extracting data from regional water plans, excel tables can then be imported to ArcGIS, where a join is created between a Regional Water Planning Group shape file, provided by Texas Water Development Board, and an excel table containing water demand/supply through a unique feature ID. Color symbology shows demand/supply, with darker colors representing areas of greater water stress:

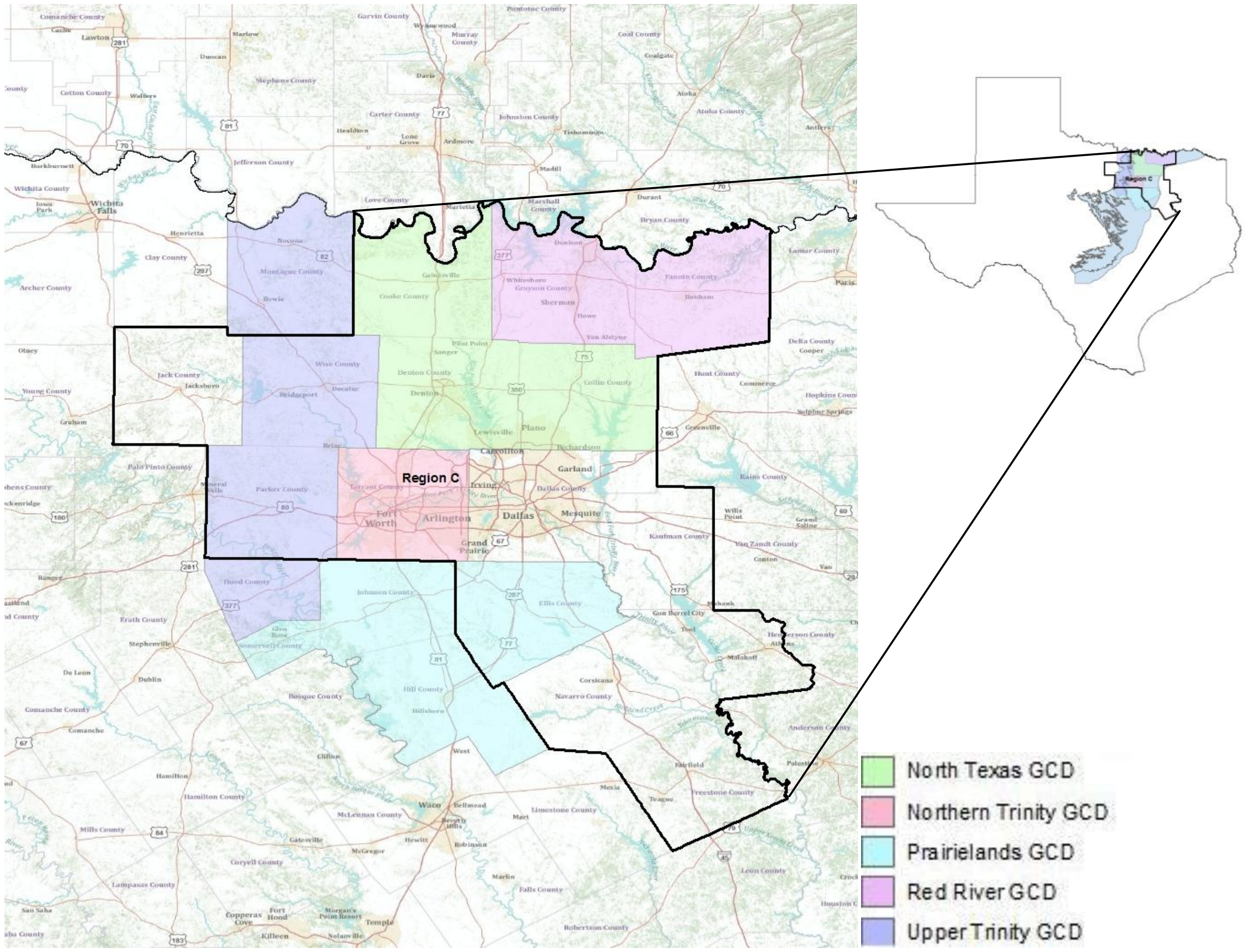
Figure 4:





All regions do not show increasing levels of water stress over time, but one region remains darker than all others for every decade between 2010 and 2060. Region C, shown below (Figure 5), overlies the Trinity Aquifer and includes the Dallas-Fort Worth Metroplex. Considering Dallas-Fort Worth is the second largest metropolitan area in Texas, it's of little surprise this area could face groundwater shortages in the near future. Five Groundwater Conservation Districts are located within Region C, and Region C is located within GMA 8 (Figure 2). All GCD's within GMA 8 will eventually need to decide on a desired future condition for the trinity aquifer.

Figure 5:



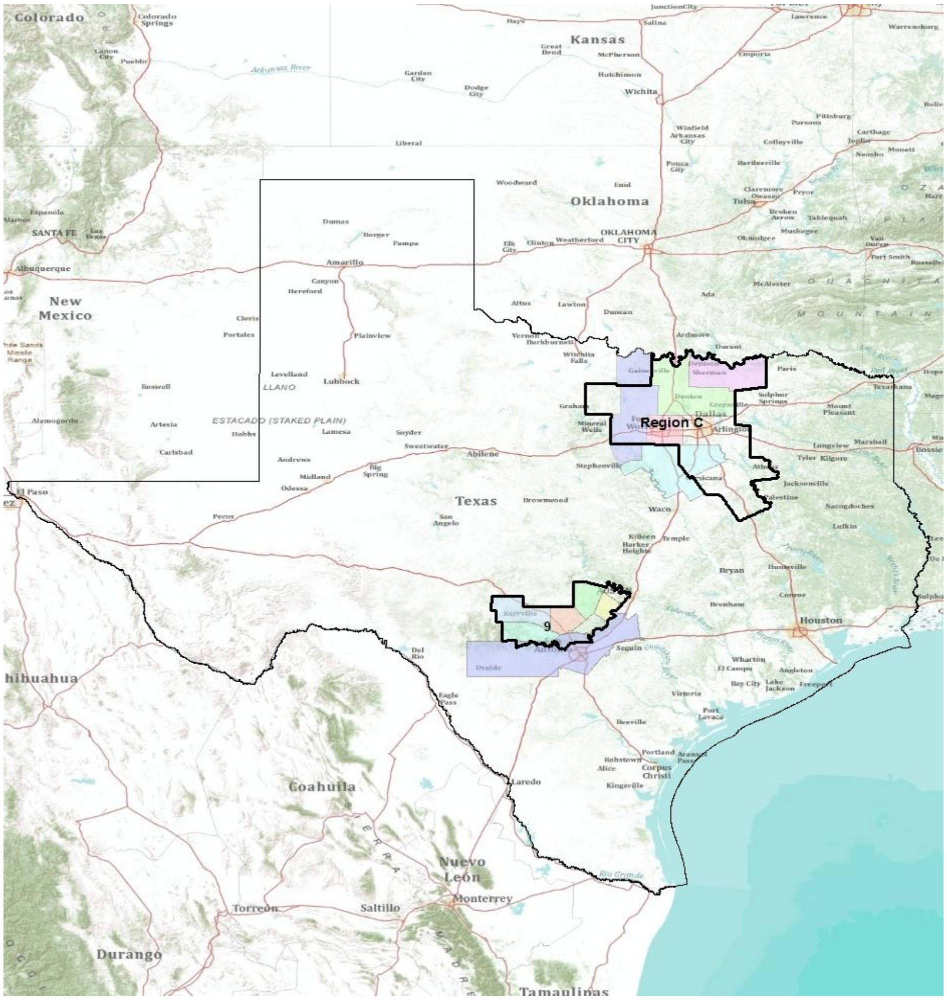
Source: Texas Water Development Board, 2010

The Trinity Aquifer extends from the Red River to the North through the Texas Hill Country to the South, and runs downdip from west to east. This Cretaceous Age aquifer contains sandstones, limestones, clays and evaporites, and can range up to 1000 ft. in thickness, although, it’s usually much thinner. Groundwater withdrawals are greatest in the Dallas-Fort Worth Metroplex where maximum drawdown is estimated at 550 ft. (Langley, 1999, pg.6). Water levels are recovering in some areas as surface water resources replace groundwater. However, when considering current groundwater demand and population growth, the Trinity Aquifer is not likely to recover to levels of pre-anthropogenic influence. Combined with a total recharge estimate below 1 inch/yr, drawdown will occur over time (Langley, 1999, pg. 18).

Only one groundwater conservation district (Upper Trinity; Figure 5) within Region C, the Upper Trinity GCD, reported their desired future condition of 90,777 acre-ft/yr, which is not enough information to estimate water availability through 2060. Each GCD within Region C and GMA 8 will eventually need to arrive at their desired future condition, with no guarantees that the numbers will be close to 90,777 acre-ft/yr. Many problems arise from conjunctive planning within GMA's, based on variations in aquifer parameters. Spatial variation in saturated thickness results in a different quantity available for each landowner. Therefore, a desired future condition might be suitable for landowners overlying extensive saturated thickness and unsuitable for those overlying thin sections of the same aquifer. Groundwater availability models are also a subject of debate. Recharge and pumping simulations are performed in MODFLOW through a grid of 1 square mile cells, with each cell calculating unique values of water availability. For current simulations, if a pump is located in a cell, pumping is simulated for the entire cell. As a result, drawdown occurs over a 1 square mile area, rather the specific location of each pump (Harden et al., 2007, pg. 45).

Spatial inaccuracy of groundwater availability models is already producing controversial results in certain parts of Texas. GMA 9 (Figure 6) is currently in disagreement with GCD's about the desired future condition set at 30 ft. of drawdown over 50 years. The Hays County groundwater conservation district, highlighted in yellow, is appealing the decision over concerns that 30 ft. of drawdown will dry up their wells (Davis, 2010, pg. 1). Current options for Hays County include gathering signatures of landowners to successfully appeal the decision for reevaluation, or to dig a deeper well to find more water. Extending a well is only an option where water quality remains consistent at greater depths. With the combination of scarce water resources and growing demand in Region C, GCD's within GMA 8 will likely experience similar disagreements in the near future.

Figure 6:



Source: Texas Water Development Board, 2010

Conclusions:

Groundwater management in Texas is a process beginning with individual landowners. Each participant expresses their needs to a groundwater conservation district, which undertakes studies on available supplies and whether the needs can be satisfied. This is unique compared to other water regulating agencies that exist only at a state level. Effective management of a resource begins with the best possible information about supplies compared to demand. Integrating water management with water users provides a forum for accurate demand data from industrial, agricultural and municipal users.

Directing funding towards GCD's for local studies on aquifers acquires greater specificity in spatial data, which can vary between GCD's and landowners. However, the process is not perfect, and problems arise in the form of disagreements between GMA's and GCD's over the total quantity of water available for use. The primary concern is justified by the argument that a single desired future condition is not suitable for aquifers with varying hydrogeologic parameters. Similar to other areas of science, accuracy is based on models simulating reality. Groundwater availability models are relatively new in water management and continue to be refined by scientists considering other variables such as urbanization and climate change. With greater computing efficiency, MODFLOW grid cells will shrink in size, and eventually, management agencies should be able to address problems of data with spatial variability. More importantly, Texas is addressing a crucial need for water conservation through a reformed management structure beginning at the ground level. The architecture is in place for when science and technology catch up.

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