WATER QUALITY AND DEVELOPMENT IN TEXAS HILL COUNTRY

Opportunities for sustainable growth

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CONTENTS

INTRODUCTION

In mid-August, Pilot Flying J – the biggest truck stop operator and diesel producer in the country – began construction on a major truck stop in Junction, Texas. The facility's construction, largely due to increased traffic caused by shale gas production in the region, sparked a debate in the small town between citizens in favor environmental protection and those in favor of economic growth. These two values are not mutually exclusive; however, they can stifle each other when managed poorly. The debate in Junction highlights a tension between these two values that is likely to reoccur throughout Texas hill country, a region predicted to experience rapid growth and development over the next twenty years.

THE JUNCTION CASE

The planned truck stop sits partially in the flood plain of the North Fork of the Llano River, on a land surface that slopes towards the river, making it a possible contamination risk. There are two risk factors involved in the Flying J site:

1) Pollution from surface runoff: Impervious surfaces with high traffic volumes, like the Flying J Travel Center, accumulate dirt, dust, rubber and metal deposits from tire wear, antifreeze, engine oil and other litter, which get picked up by runoff after major rain events.[1] This is a type of non-point pollution, so while the direct impacts of the Junction Flying J site may be small, overtime, rapid, uncontrolled development has the potential to degrade water quality in the Llano River and other water bodies throughout hill country;
2) Damage to underground storage tanks located in the floodplain: Aside from runoff impacts, underground storage tanks (USTs) in the floodplain are vulnerable to damage, product displacement, and potential leaks.[2] While having underground storage tanks in the flood plain is not against state or federal regulations, it does come with environmental risk that can be minimized by a number of precautionary actions.

[1] U.S. Environmental Protection Agency. *Polluted Runoff (Nonpoint Source Pollution)*. EPA Office of Water, August 1995. Accessed on 11/14/2014 at: http://www.epa.gov/owow/NPS/roads.html

[2] U.S Environmental Protection Agency. *Underground Storage Tank Flood Guide.* US EPA, November 2012. Accessed 11/14/2014 at: http://www.epa.gov/oust/pubs/ustfloodguide.pdf

While the effects of the Junction Flying J Site on the Llano River are yet to be determined, growth of this kind throughout the Hill country at large could greatly degrade the regions' water bodies. One way to dampen the effects of rapid development is through zoning, which allows county and municipal governments to control what kind of development can occur where. Texas is the only state in the union wherein counties have no zoning power or growth management mechanism.[3] Instead, zoning power is delegated almost exclusively to municipalities and many small municipalities do not exercise their zoning power. As a result, there are large swaths of land expected to experience rapid growth over the next 50 years with no zoning regulations in place, a fact that will directly affect water quality in the region. In fact, according to the Hill Country's Regional Water Quality Protection Plan, a mere 5 to 18 percent increase in impervious cover could prompt significant water quality impacts in the area.[4]

The purpose of this paper is twofold:

1) To identify existing statutes that counties can use to monitor growth;
2) To identify sites under municipal authority with similar physical attributes to the Junction Flying J Site throughout Kimble, Kerr, Mason, and Llano County.

Through these three tasks, this paper hopes to serve as a reference for Hill Country county and municipal employees over the upcoming high-growth decades.

[3] Capital Area Council of Governments. *County Land Use Authority in Texas*. CACOG, November 2009. Accessed at: http://data.capcog.org/Information_Clearinghouse/presentations/2009-11-03%20County%20Land%20Use%20Report%20-%20final%20for%20Publication.pdf

[4] Fourqurean, Margot, *Issue Brief: County Authority in Texas Compared to Other States*. Hill Country Alliance, November 2007. http://www.hillcountryalliance.org/uploads/HCA/cacountyauthority.pdf

PART 1

Current Policy Environment

Texas is the only state in the U.S. that does not have some legal avenue for zoning unincorporated areas. Most states allocate this power to counties, where many even have the ability to leverage impact fees for new developments. County land use authority in Texas has remained stagnant since 2001 when the Texas Local Government Code passed. In the early 2000s, debate over expanding county authority centered on private property rights and a push for small county government, rather than the benefits of increased authority regarding non-point source pollution, population density, traffic, and protection of property values.[5] More recently, however, as growth in Hill Country has become more pronounced, there has been a push to increase county authority with respect to land use. Currently, a number of groups, including the Hill Country Alliance, and the Capital Area Council of Governments, have sought to raise awareness on this issue.

Local Government Code and the Texas Water Code are two Texas state codes with the most potential for strengthening county authority. This section will go over a number of previsions in both and discuss ways that county governments have used these statutes to broaden their regulatory powers in the past.

LOCAL GOVERNMENT CODE

The Code most applicable to zoning and growth in the Texas Hill Country is the Local Government Code. This code describes the powers of counties and municipal government – from the establishment of boundaries and budgets to water and sewer management to parking rules. As mentioned earlier, zoning is a power primarily given to municipalities, however many small municipalities do not fully exercise it; Junction, for example, has no zoning regulations.[6] County regulatory authority in this area is limited, and what exists deals primarily with regulation of transportation, water supply, and drainage management; however, there are a number of examples of Texas counties using these powers to directly control land use and development.

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[5] CACOG, 2009

[6] City of Junction. *Code of Ordinances. May 2012.* Accessed on 11/15/2014 at: http://z2.franklinlegal.net/franklin/Z2Browser2.html?showset=junctionset

County Zoning: Local Government Code Chapter 231

Chapter 231 of the Local Government Code outlines the zoning authorities that counties currently possess. There are no general provisions given to all counties in Texas, however, there are a number of area-specific zoning laws, including on Padre Island, in various recreational areas and military zones, and around certain lakes. To obtain zoning authority for a specific area, it must be delegated to counties by the legislature.

County Land Use Regulation: Local Government Code Chapter 232

Chapter 232 of the Local Government Code details County regulation authority with respect to land use, structures, businesses and related activities.[7] This section gives counties the authority to review and regulate the subdivision of land.

Counties have the authority to review subdivision applications, but the process must be completed within 60 days and be completely transparent. These approvals are the primary tool through which counties regulate growth in unincorporated areas, because counties can specify requirements regarding transportation, drainage, and water contracts. This power, given in section 232.003 reads as follows:

"By an order adopted and entered in the minutes of the commissioners court, and after a notice is published in a newspaper of general circulation in the county, the commissioners court may:

(1) Require a right-of-way on any other street or road in a subdivision of not less than 40 feet or more than 70 feet;
(2) Require a right-of-way on any other street or road in a subdivision of not less than 40 feet or more than 70 feet;
(3) Require that the shoulder-to shoulder width on collectors or main arteries within the right-of-way be not less than 32 feet or more than 56 feet and that the shoulder-to shoulder width on any other street or road be not less than 25 feet or more than 35 feet;
(4) Adopt, based on the amount and kind of travel over each street or road in a subdivision, reasonable specifications relating to the construction of each street or road;

[7] Texas Local Government Code, Chapter 232. Accessed November 15 at: http://www.statutes.legis.state.tx.us/Docs/LG/htm/LG.232.htm

(5) Adopt reasonable specifications to provide adequate drainage for each street or road in a subdivision in accordance with standard engineering practices;

(6) Require that each purchase contract made between a subdivider and a purchaser of land in the subdivision contain a statement describing the extent to which water will be made available to the subdivision and, if it will be made available, how and when;

(7) Require that the owner of the tract to be subdivided execute a good and sufficient bond in the matter provided by section 232.004

(8) Adopt reasonable specifications that provide for drainage in the subdivision to:

a. Efficiently manage the flow of storm water runoff in the subdivision; and

b. Coordinate subdivision drainage with the general storm drainage patter for the area; and

(9) Require lot and block documentation to be set by a registered professional surveyor before recordation of the plat."

These statutes outline the basic authority counties possess to steer residential development, and they focus on transportation, drainage, or water supply. The Texas Water Development Board provides model subdivision rules (MSRs) under section 16.343 of the State Water Code to ensure that subdivisions meet minimum standards for safe and sanitary water supply and sewer services.[8] Commissioner's courts that adopt regulations for roads, potable water, and flood management that meet the minimum standards lined out by the TWDB and state and federal law are eligible to receive funding via subchapter 15 of the water code.

Transportation Management and Drainage

Transportation management, including certain drainage infrastructure requirements, are one of the avenues counties can use to control their growth going forward. Through the establishment of proper drainage management, counties can mitigate runoff impacts from increased impervious cover.

Section 232.0031 of the Texas Local Government Code states that the standard for streets and roads in a subdivision cannot be higher than the county road standards, which limits the reach of

[8] Texas Local Government Code, Chapter 232 and Texas Water Code, Section 16.343.

county regulations. Despite this, Kendall County has used its authority over transportation regulations to improve a number of development challenges related to water quality, including road drainage, requiring set-backs, and establishing buffer zones. The County's rules also cite Transportation Code Section 254.005, which gives counties the authority to provide drainage on public roadways. They also cite section 233.032 of the Local Government Code, which allows the commissioners court to determine set-back lines on all public roads.

Most counties that exercise significant control over unincorporated development refer to Chapter 232, but it is most often used in tandem with other statutes specific to the county involved. For example, Kendall County sites statutes that only apply to counties with Priority Groundwater Management areas, while Travis County cites a number of statutes that only apply to counties with large populations.

Water Supply

According to Section 232.006, counties can require developers to provide them with information concerning the water supply for a subdivision before permit approval. Counties have the freedom to choose the requirements for water supply, and are able to prevent unsustainable development by establishing requirements that include long-term provisions. For example, Comal County requires applicants to prove that their water supplier has the capacity to meet water demand for the proposed subdivision, plus all other subdivisions they are committed to for 20 years. As a result, they have rejected a number of subdivisions that may have encountered water supply issues had they been approved.[9]

TEXAS WATER CODE

Texas water code describes Texas water management. It includes topics such as water rights, water quality control, municipal water treatment and distribution, and wastewater treatment.

Floodplain Management: Texas Water Code Chapter 16

The other big area that Texas counties use to manage their growth are statutes related to floodplain management. According to Texas Water Code 16.315, all political subdivisions are "authorized to take all necessary and reasonable actions that are not less stringent than the requirements and criteria of the National Flood Insurance Program, including but not limited to:

[9] COCAG, 2009

(1) Making appropriate land use adjustments to constrict the development of land which is exposed to flood damage and minimize damage caused by flood losses;

(2) Guiding the development of proposed future construction, where practicable, away from location which is threatened by flood hazards;

(3) Assisting in minimizing damage caused by floods;

(4) Authorizing and engaging in continuing studies of flood hazards in order to facilitate a constant reappraisal of the flood insurance program and its effect on land use requirements;

(5) Engaging in floodplain management, adopting and enforcing permanent land use and control measures that are not less stringent than those established under the National Flood Insurance Act, and providing for the imposition of penalties on landowners who violate this subchapter or rules adopted or orders issued under this subchapter.

(6) declaring property, when such is the case, to be in violation of local laws, regulations, or ordinances which are intended to discourage or otherwise restrict land development or occupancy in flood-prone areas and notifying the director, or whomever the director designates, of such property;

In addition to these sections, section 16.315(14) includes adopting "more comprehensive floodplain management rules that the political subdivision determines are necessary for planning and appropriate to protect public health and safety." Counties also have eminent domain to acquire property in connection in order to implement flood control and drainage activities (section 561.001).

Counties can petition the Texas Commission on Environmental Quality (TCEQ) for the creation of a Storm Water Control District, according to Section 66.014 of the Texas State Water Code.[10] These districts are able to raise funds, acquire land, construct stormwater retention ponds, construct drainage ditches and other facilities, and use the land with the retention ponds for park and recreational areas. An elected board of directors manages Storm Water Control Districts. In some areas, Storm Water Control Districts could assist in dampening the effects of rapid development.

Floodplain management authority is a direct and effective way that counties can control development, and the impacts of those developments on surface water bodies; however, the

[10] Texas Water Code, Section 66.014

floodplain is only a small portion of land in any given county. If regulations exist only within the floodplain, impervious cover will increase regardless and non-point source pollution will continue to compound.

The authority given to counties in Section 16.315 of the Texas State Water Code and Section 232.00 of the Texas State Local Government Code alone gives counties significant power to mitigate the water quality risks posed by rapid development. While all counties have the authority to implement certain regulations that could mitigate environmental damage from development, most do not have the funding for such programs.

Table 1: Statutes discussed in this section

Code	Section	Subject
Water Code	**16.315**	**All political subdivisions have authority to implement floodplain management at least as strict as federal regulations.**
Water Code	15	Texas Water Assistance Program
Water Code	16.343	TWDB model subdivision rules
Local Government Code	231	County zoning statutes
Local Government Code	232.002	Counties must approve subdivisions
Local Government Code	**232.003**	**Counties have authority to create regulations for subdivision development, including regulations concerning transportation infrastructure, water supply guarantees, and drainage**
Local Government Code	232.030	TWDB model subdivision rules
Local Government Code	232.0031	Standards for subdivision roads cannot be higher than standards for county roads.
Local Government Code	233.032	Counties have authority to determine set-back lines on all public roads.
Transportation Code	254.005	Counties have authority to provide drainage on public roadways
Local Government Code	561.001	Counties have eminent domain to acquire property in connection with flood control activities

PART 2

Sites in Hill Country Municipalities

METHODS

Municipalities in Texas have zoning powers. According to section 211.003 of the Local Government Code, governing bodies of municipalities are authorized to regulate the height, number of stories, size of buildings, the percentage of a lot that can be occupied, population density, as well as the size of yards, courts and other open spaces.[11] Municipal governments should take advantage of this broad zoning power, especially in an ecologically vulnerable area like hill country; however many small municipalities do not have any zoning rules. The purpose of this section is to identify areas in Kimble, Kerr, Mason and Llano counties that constitute high-risk development areas, i.e. areas where development could degrade water quality, with the hopes that providing this information will aid in the zoning process. These counties were chosen as the study area because they are transected by major traffic corridors, namely I-10, US 83, US 87, SH 27, SH 71, and SH 39.

The criteria for site identification was multifaceted. Sites eligible for evaluation had to be within the boundaries of a municipality that currently does not exercise zoning authority. The municipalities that fit this criterion in the study area were Junction, Ingram, and Kingsland in Kimble, Kerr, and Llano counties respectively. Next, potential sites were narrowed based on their proximity to major traffic corridors, proximity to waterways, and their development potential. After choosing a site for evaluation, runoff risk was analyzed in ArcMap 10.2, using overland flow direction and potential maximum soil water retention as the primary indicators.

The criteria used to identify the sites in this section are as follows:

1) Within municipal boundaries of a town without zoning ordinances
2) Proximity to major roadway (Average Daily Traffic >3000)

[11] Texas Local Government Code, Chapter 211: Municipal Zoning Authority

3) Adjacent to major waterway

Sites evaluation was based on:

1) Drainage into waterway (Overland Flow analysis)
2) Runoff risk (Potential Maximum Soil Water Retention)

Potential at-risk sites were evaluated in ArcMap using the National Elevation Dataset (30m, 10m and 3m), SSURGO Soil dataset, 2006 National Land Use Data (2011), USGS National Hydrography Dataset, and TxDOT Average Daily Traffic data (2013). A curve number grid produced by HEC-GeoHMS and an overland flow shapefile delineated from the National Elevation Dataset's 3 and 10 meter grid size were the primary tools used for analysis.

Curve Numbers and PMSWR

Curve numbers are an empirically derived method of approximating runoff potential. They range from 30 – 100 and are essentially a coefficient that converts precipitation values into runoff – the higher the curve number the higher the runoff. The curve number for a tract of land is determined by the soil type and land use category of the tract. Soil types range from A – D, with A having the highest water retention capacity and D having the lowest (See Table 2).[12] Each soil category has an empirically derived number for various land uses. This study used the ten land use categories, as listed in Table 3.

Table 2: Soil types

Soil Type	Description
A	Deep soils with high infiltration rates, even when thoroughly wetted. Chiefly of deep well drained sands of gravels.
B	Soils with moderate infiltration rates, primarily moderately fine to moderately coarse textures.
C	Soils with slow infiltration rates when thoroughly wetted. Predominately fine in texture.
D	Soils with very slow infiltration rates consisting of chiefly clay.

[12] Halley, Mary C. et al. *ArcView GIS Extension for Estimating Curve Numbers.* Esri User Conference, 2006. Accessed 11/5/2014 at: http://proceedings.esri.com/library/userconf/proc00/professional/papers/PAP657/p657.htm

Description	A	B	C	D
Developed, open space	39	61	74	80
Developed, low intensity	48	66	78	83
Developed, medium intensity	57	72	81	86
Developed, high intensity	77	85	90	92
Barren land	76	85	89	91
Forest	30	55	70	77
Schrub	43	65	76	82
Hay/Pasture	30	58	71	78
Cultivated crops	67	77	83	87
Water/Wetlands	100	100	100	100

Table 3: Curve numbers for different combinations of land use and soil type

The resulting curve number grid was converted into a Potential Maximum Soil Water Retention (PMSWR) raster, which is essentially the amount of water, in inches, that soil can retain during a major rainfall event. Curve numbers are related to PMSWR through the following equations:

(1) $PMSWR_{0.20} = [1000/(\text{Curve Number})] - 10$

(2) $PMSWR_{0.05} = 1.33 \times PMSWR_{0.20}^{1.15}$

Equation 1 was derived empirically by the USDA Natural Resources Conservation Service, based on the assumption that initial abstraction (the amount of precipitation that infiltrates or gets absorbed by plants before runoff begins) is usually ~20 percent of the PMSWR. Recent studies suggest that initial abstraction is closer to 5 percent of the PMSWR, so equation (2) provides the necessary adjustment.[13] Areas with small PMSWR values represent high runoff potentials, increased erosion, and degraded runoff quality. PMSWR values are the primary parameter used to assess runoff risk for various sites throughout Hill Country in this report.

[13] Lim, K. J., Engel, B. A., Muthukrishnan, S. and Harbor. *Effects of Initial Abstraction and urbanization on estimated runoff using CN technology*. JAWRA Journal of the American Water Resources Association, 2006. 42: 629–643. doi: 10.1111/j.1752-1688.2006.tb04481.x

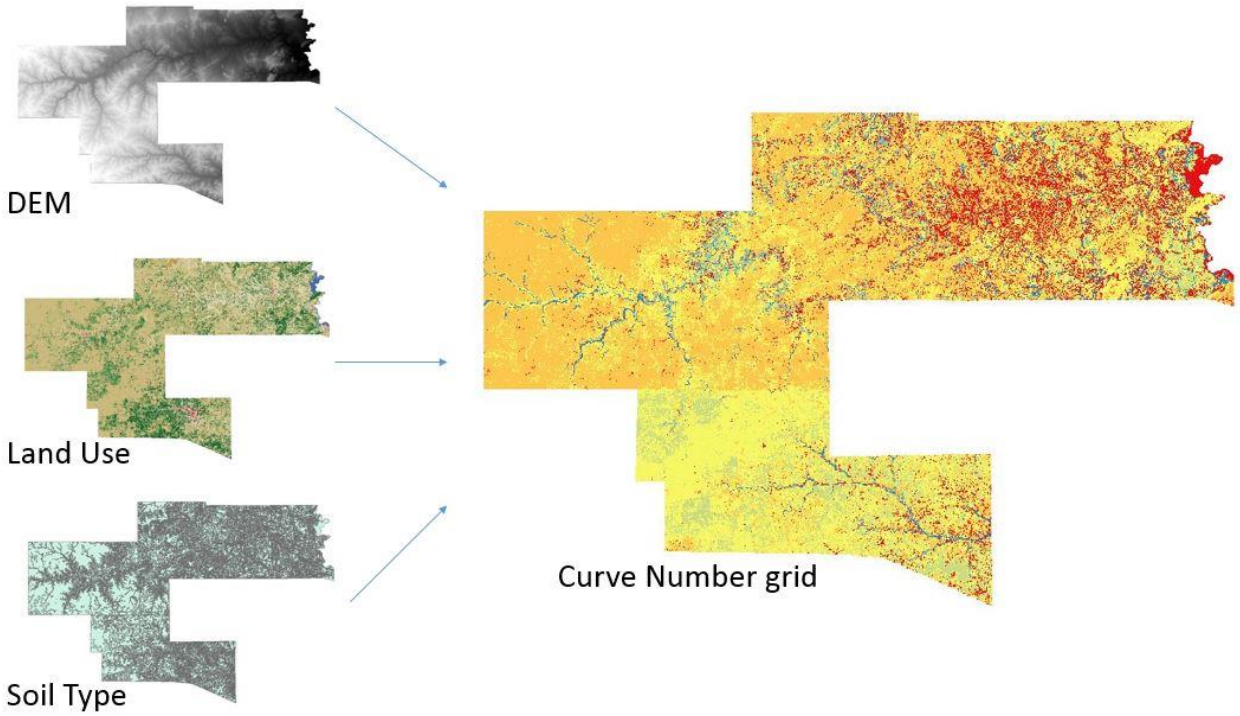

Figure 1: Generating the Curve Number Grid

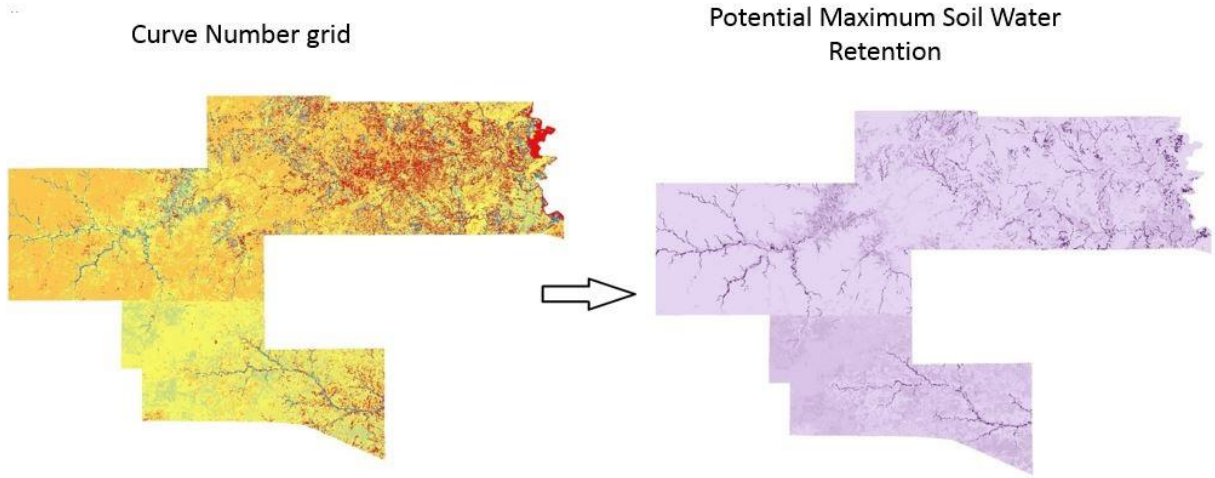

Figure 2: Generating PMSWR Grid

Analysis

Two sites in Junction were analyzed for this report, the Pilot Flying J Site, and a site on the eastern edge of the town next to I-10. The Pilot Flying J truck stop site is at-risk due to the a TxDOT drainage ditch adjacent to the site, while the East Junction site is vulnerable due to low potential maximum soil water retention, steep slope, and one of the overland flow paths lacking proper riparian buffers. Both Junction sites are located in the 100-year floodplain.

Figure 3: Sites in Junction

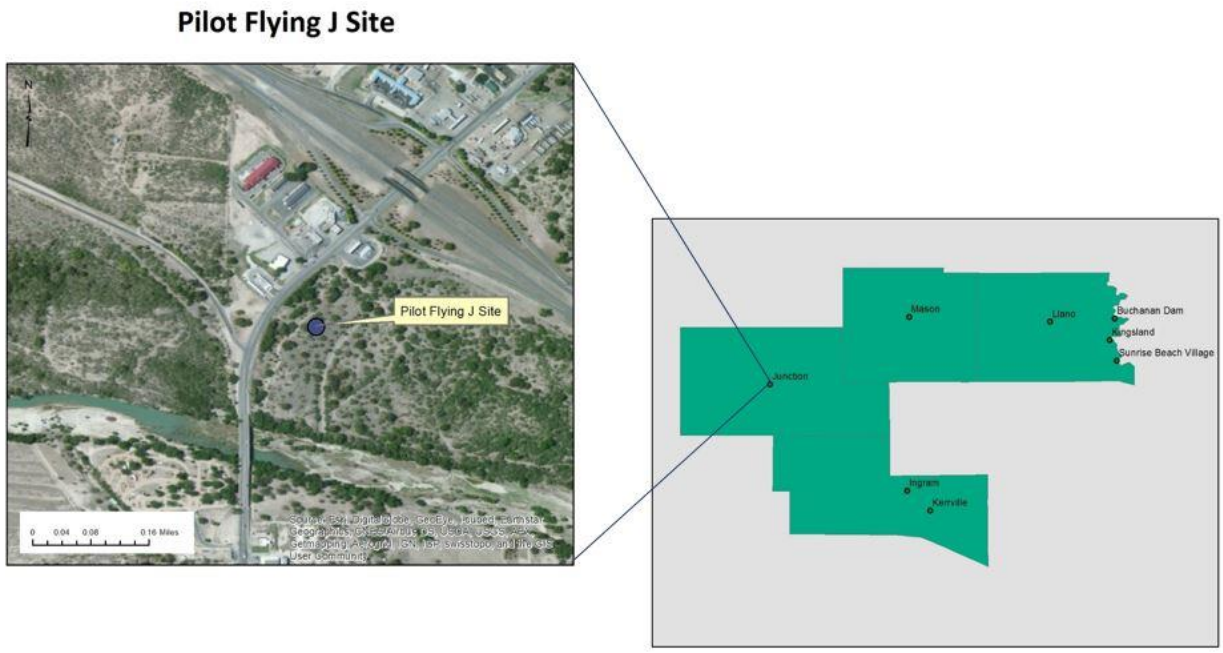

Figure 4: Flying J Site

PILOT FLYING J SITE ANALYSIS

The City of Junction is located in Kimble County, nestled in the fork of the Llano River and the North Llano River. It is, appropriately, located at the junction of I-10 and US 83. The town, only incorporated in 1927, has a population of 2,576 as of 2007.

The site of the Flying J truck stop is south of the intersection of I-10 and US 83, immediately adjacent to the North Llano River. These roadways have relatively high Average Daily Traffic values for Hill Country, with I-10 accommodating more than 10,000 vehicles per day and US 83 serving more than 5,000.[14]

The site itself is in the 100-year floodplain and half of the site is in the floodway – the portion of the flooded channel that experiences high velocity flows during a flooding event. Behind the site is a TxDOT-owned concrete drainage ditch constructed to carry runoff from I-10 to the North Llano. Between the drainage ditch and I-10 there is a buffer zone that forces runoff to slow down and partially drop its load before entering the drainage ditch and then the river. A large portion of the Flying J site, however, drains directly into the drainage ditch with no buffer zone to allow particulate matter to settle. The land slope is relatively low, (0.2 – 0.9 percent rise).

[14] Texas Department of Transportation. *Average Daily Traffic Data*. TxDOT, 2013.

Overland flow at the site generates two main flow paths, one to the west of the site and the other through the TxDOT drainage ditch on the east edge of the site. Both of these flow paths go directly to the North Llano. The soil below the site has a decently high potential maximum soil water retention, ranging from 4 – 6.5 inches. Because of this reasonable retention capacity, the soil between the impervious truck stop surface and the river could act as a buffer, making the runoff that leaves the site via the western flow less of a concern. However, a large portion of the runoff from the site flows directly into the drainage ditch.

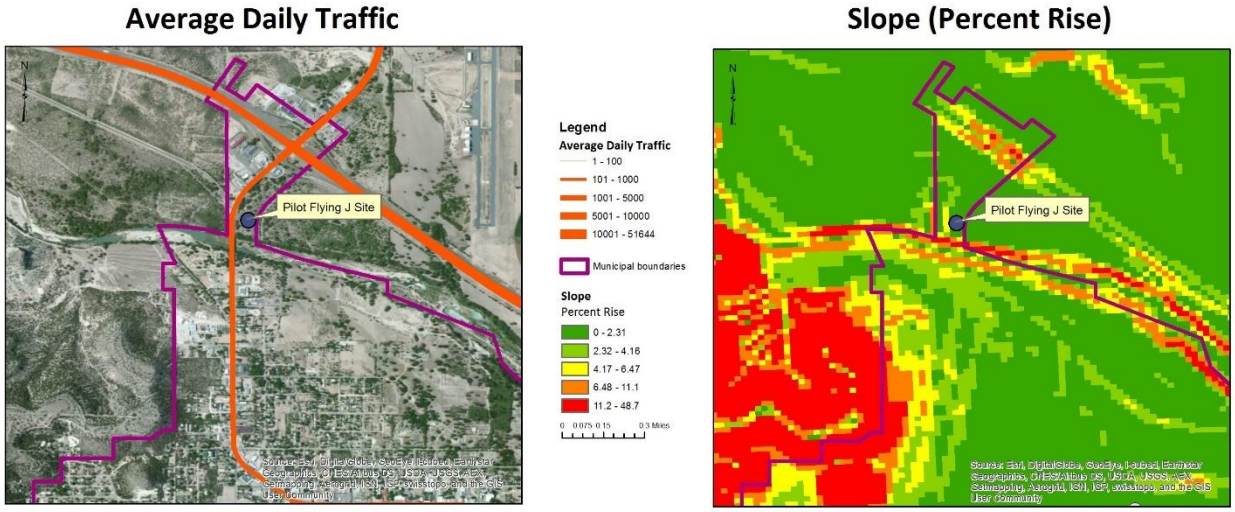

Figure 5: Average Daily Traffic and Slope at Flying J Site

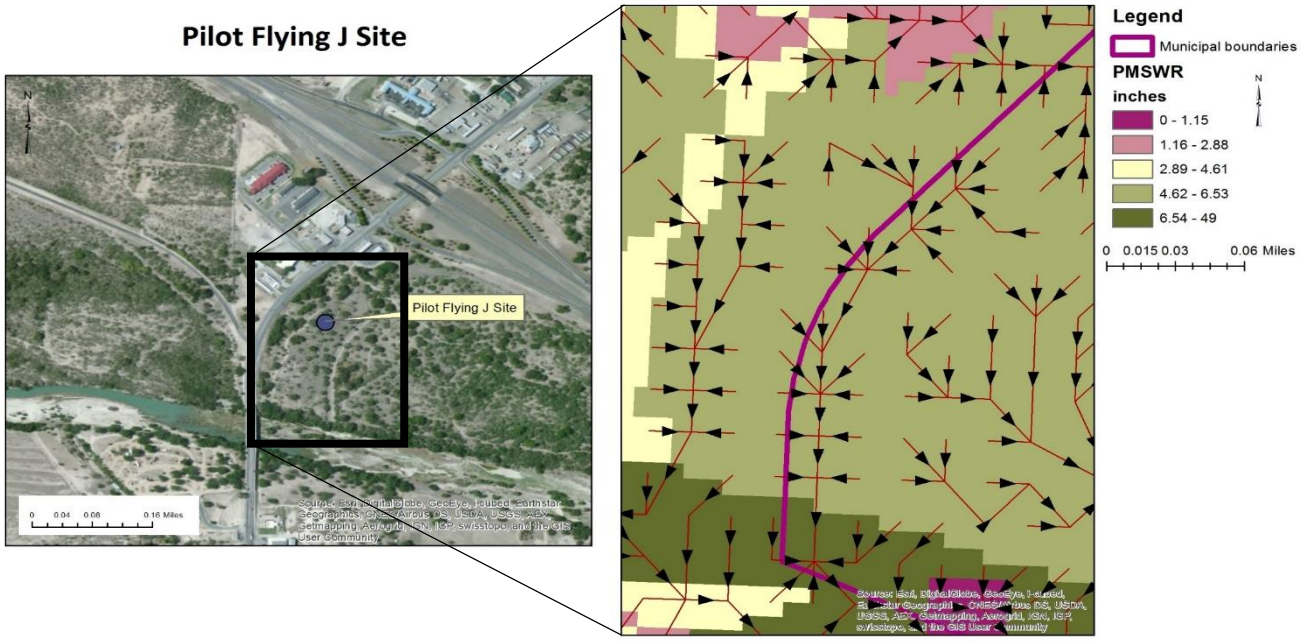

Figure 6: PMSWR at Flying J Site

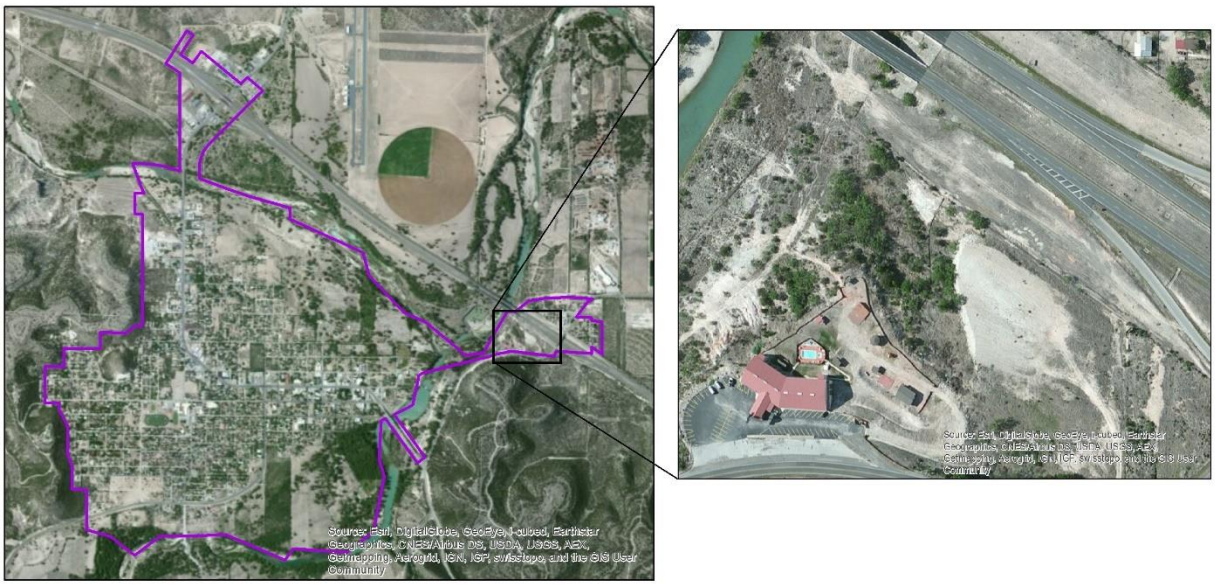

Figure 7: East Junction Site

Site in East Junction Analysis

This site is along I-10 next to the Junction Days Inn and the Llano River. Much of the lot is vacant with very little vegetation or soil structure, which increases the likelihood of high sediment loads in runoff. Additionally, the land area between the site and the Llano has a very steep slope (~6 percent rise); therefore, runoff velocity and load carrying capacity may be very high.

The overland flow analysis shows two main routes of overland flow. Runoff from the lot moves over the lot's surface eastward, before entering a ditch next to I-10 and flowing into the Llano. The other overland path moves northwest around the outside of the lot, and then into the river. This route has a sizable shrub-covered area that could potentially act as a buffer, however the flow path through the ditch has no such buffer and is a potential risk.

PMSWR for the site is between 2.25 and 3.78 inches, which indicates that this site has high runoff potential. Due to the lack of vegetation, high slope, and vulnerable soil quality, development on this site should be required to meet building standards aimed at reducing runoff and managing drainage (Figure 9).

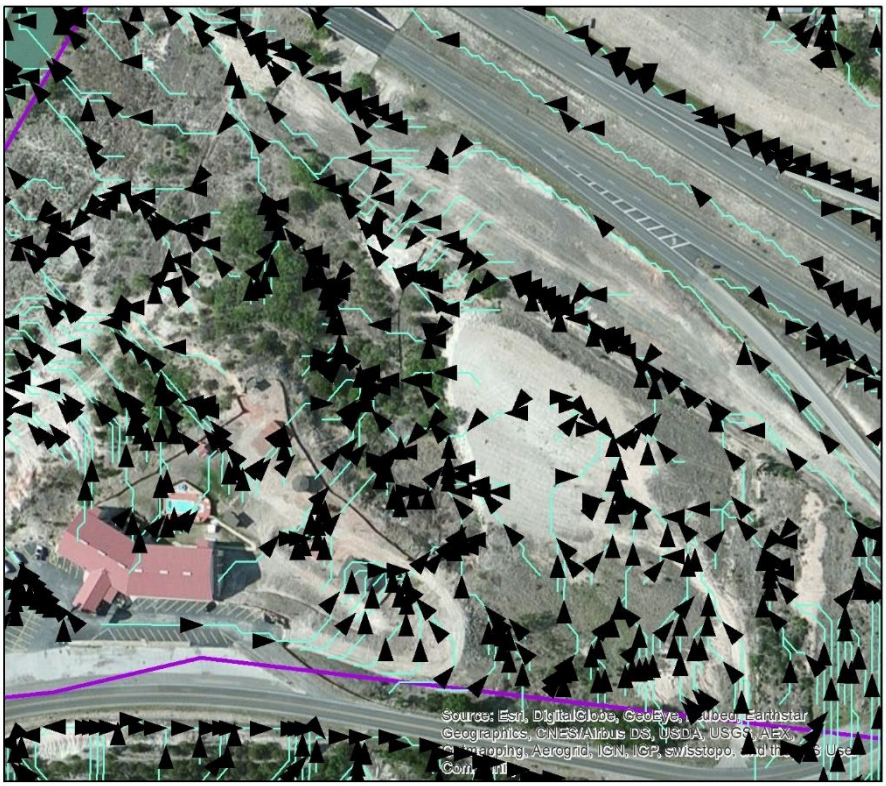

Figure 8: Overland Flow at East Junction Site

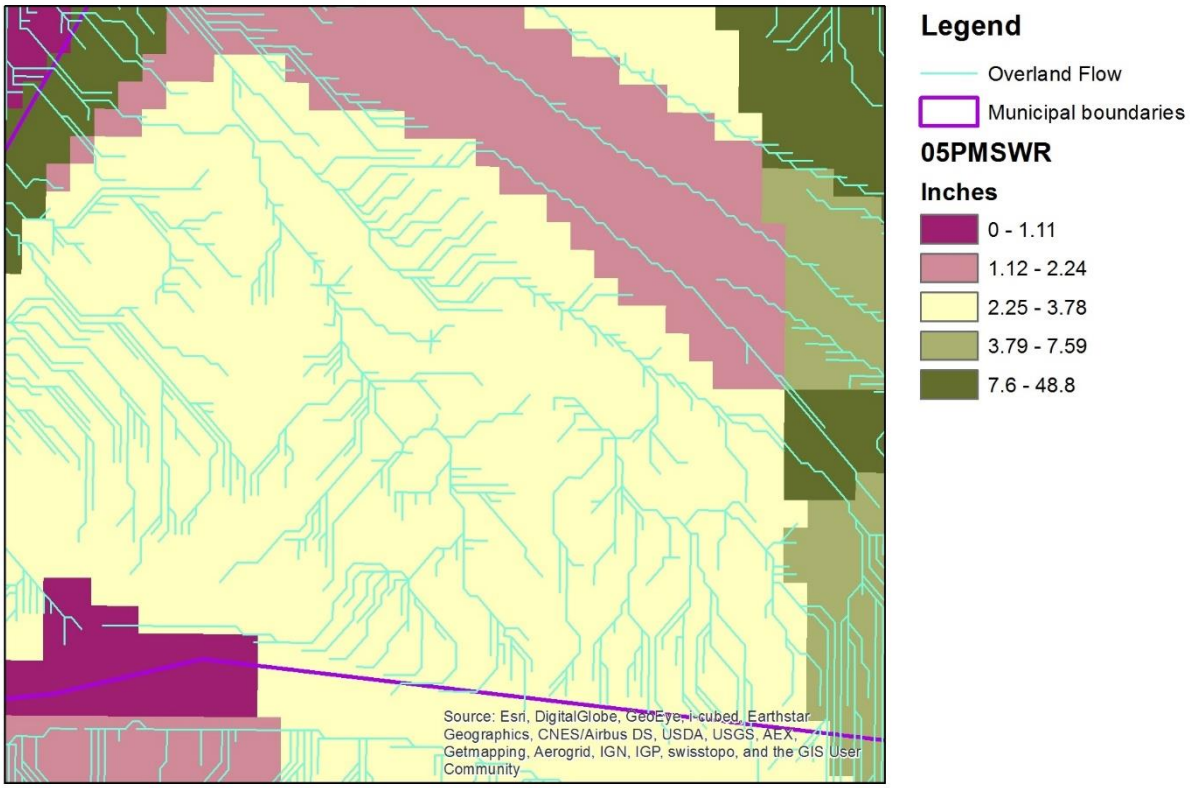

Figure 9: PMSWR of East Junction Site

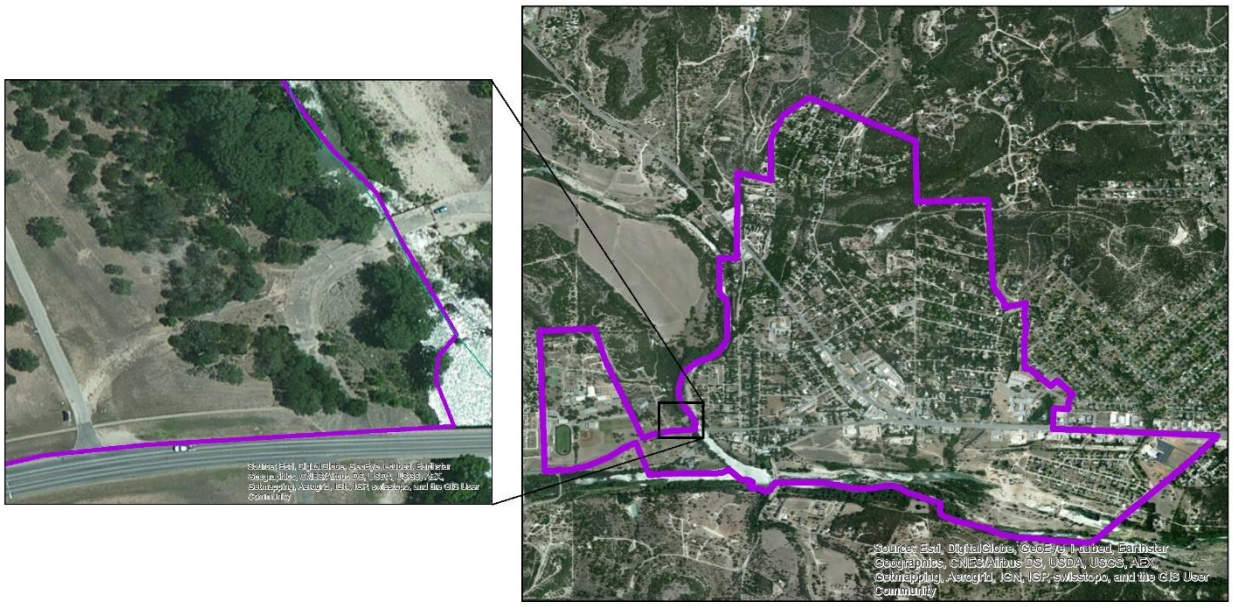

Figure 10: Ingram Site

INGRAM SITE

Ingram is a small town in Kerr county seven miles outside of Kerrville. The town has a population of less than 2000 people and no zoning ordinances in place. The Guadalupe River runs through the town, and is the main recreational attraction. The site in Ingram is in the western section of the town, immediately adjacent to where Johnson Creek flows into the Guadalupe River. Currently, the land cover is a combination of open grassland, road, and forest.

According to the overland flow analysis, runoff flows over the site into Johnson Creek, following multiple pathways (Figure 11), most of which go through a wooded area that acts as a buffer for the waterway. The PMSWR ranges from 2.9 to 10.4 inches with the higher values being indicative of tree-cover. The soil itself is has relatively low PMSWR if developed, so development on this site could be at risk for increased runoff and surface water contamination if the tree-cover were removed (Figure 12). Additionally, approximately half of the site is in the 100-year floodplain, making it both cheaper and therefore more likely to be developed, and more likely to impact water quality.

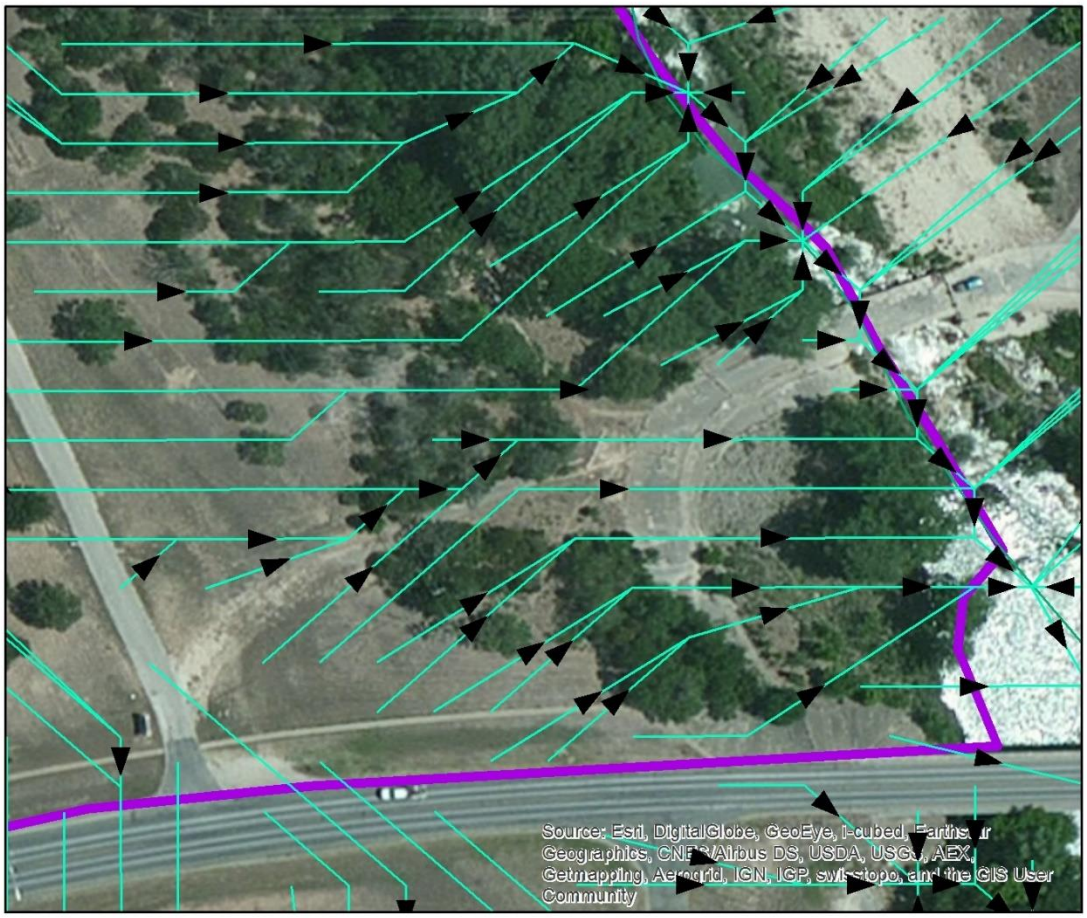

Figure 11: Overland Flow at Ingram Site

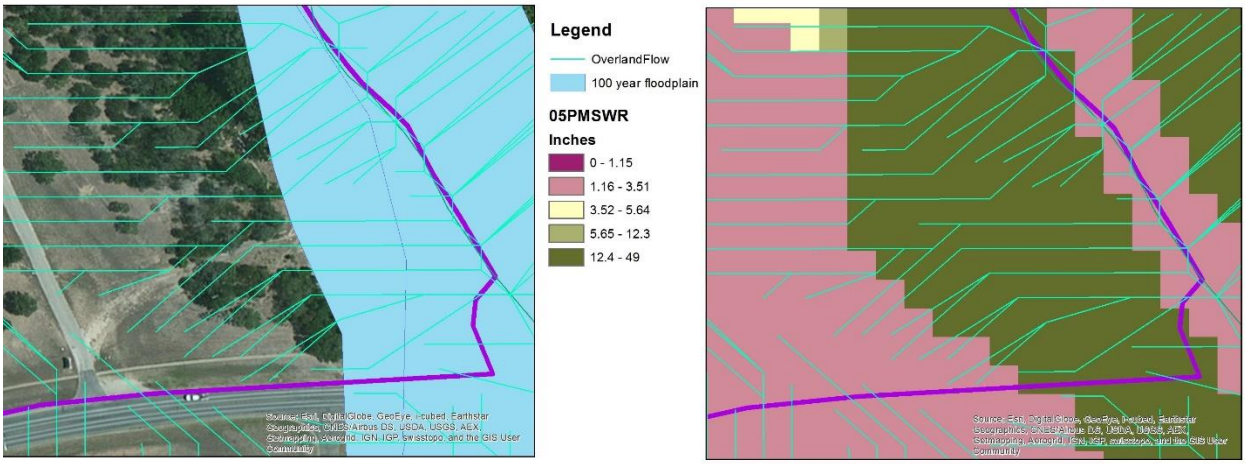

Figure 12: Floodplain and PMSWR at Ingram Site

CONCLUSION

A number of policy recommendations come out of this analysis:

1) Counties should use their authority to regulate development in the floodplain.
2) For other areas, implement subdivision regulations stricter than the TWDB's model ordinances for subdivision approval. This has the potential to regulate development in a way that ensures at least some level of environmental protection, and prevent unsustainable subdivisions from being created.
3) Municipalities without zoning laws should begin developing zoning laws, especially around water bodies.
4) Counties with rapid population growth projections should be given more regulatory power over development outside of municipal boundaries. Funding should be made available to those that choose to actively regulate development using a set of model rules, similar to the TWDB model subdivision regulations.

Recommendations 1, 2, and 3 can be implemented without significant legislative action; however, funding for implementation of regulations is a limiting factor for many rural counties and small municipalities. The Texas Water Assistance Program can help aid these political subdivisions with costs, however other forms of assistance might be necessary.

As Hill Country continues to develop, non-point source pollution from increased impervious cover promises to increase. There are currently a number of statutes that grant counties the authority to regulate development that contributes to non-point source pollution, including floodplain development and subdivision development. Though taking advantage of these statutes counties could significantly reduce the risk of degraded water quality that comes with development. Municipalities should use their zoning authority to steer development in a sustainable direction, and thus mitigate environmental risk from development within municipal boundaries. The analysis done in this paper is just one approach, but small municipalities without zoning regulations should carry out similar analysis of their jurisdictions.

BIBLIOGRAPHY

Capital Area Council of Governments. *County Land Use Authority in Texas*. CACOG, November 2009. Accessed at: http://data.capcog.org/Information_Clearinghouse/presentations/2009-11-03%20County%20Land%20Use%20Report%20-%20final%20for%20Publication.pdf

City of Junction. *Code of Ordinances. May 2012.* Accessed on 11/15/2014 at: http://z2.franklinlegal.net/franklin/Z2Browser2.html?showset=junctionset

Fourqurean, Margot, *Issue Brief: County Authority in Texas Compared to Other States*. Hill Country Alliance, November 2007. http://www.hillcountryalliance.org/uploads/HCA/cacountyauthority.pdf

Gesch, D.B., 2007, The National Elevation Dataset, in Maune, D., ed., Digital Elevation Model Technologies and Applications: The DEM Users Manual, 2nd Edition: Bethesda, Maryland, American Society for Photogrammetry and Remote Sensing, p. 99-118.

Halley, Mary C. et al. *ArcView GIS Extension for Estimating Curve Numbers.* Esri User Conference, 2006. Accessed 11/5/2014 at: http://proceedings.esri.com/library/userconf/proc00/professional/papers/PAP657/p657.htm

Lim, K. J., Engel, B. A., Muthukrishnan, S. and Harbor. *Effects of Initial Abstraction and urbanization on estimated runoff using CN technology*. JAWRA Journal of the American Water Resources Association, 2006. 42: 629–643. doi: 10.1111/j.1752-1688.2006.tb04481.x

Jin, S., Yang, L., Danielson, P., Homer, C., Fry, J., and Xian, G. 2013. A comprehensive change detection method for updating the National Land Cover Database to circa 2011. *Remote Sensing of Environment*, 132: 159 – 175.

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at http://websoilsurvey.nrcs.usda.gov/. Accessed 11/4/2014.

Texas Department of Transportation. *Average Daily Traffic Data*. TxDOT, 2013.

Texas Local Government Code, Chapter 211

Texas Local Government Code, Chapter 232

Texas Local Government Code, Section 232.003

Texas Water Code, Section 16.343.

Texas Water Code, Section 66.014

U.S. Environmental Protection Agency. *Polluted Runoff (Nonpoint Source Pollution)*. EPA Office of Water, August 1995. Accessed on 11/14/2014 at: http://www.epa.gov/owow/NPS/roads.html

U.S Environmental Protection Agency. *Underground Storage Tank Flood Guide.* US EPA, November 2012. Accessed 11/14/2014 at: http://www.epa.gov/oust/pubs/ustfloodguide.pdf