Evaluation of Gage Based Cross Section Data to Represent Habitat Conditions for Riverine Resources at the Reach Level

Prepared for:

The Texas Water Development Board

Contract: 1004831143

Prepared by:

Dr. Thomas B. Hardy, Ph.D. The Meadows Center for Water and Environment Texas State University San Marcos, Texas

May 10, 2015

Acknowledgments

Funding for this project was provided by the Texas Water Development Board contract No. 1004831143. The patience and guidance provided by Dr. Mark Wentzel is particularly appreciated. Dr. Nolan Raphelt also provided insightful discussion on the relationships of at-a-station hydraulic properties and response of river channels.

Executive Summary

At-a-station hydraulic properties from multiple gages in all eleven major river drainages across several Ecoregions in Texas were evaluated in light of similarities and differences both over time and from gages on the same longitudinal river segment. The relationship between cross sectional area and discharge was the most consistent in terms of both temporal and spatial scales. Both width and to a larger degree, velocity relationships with changes in discharge was greater spatially and temporally. Previous work that was reviewed clearly indicate that reach average at-a-station exponents of the continuity equations do not reflect the values from specific locations within a river reach. An examination of variability in channel morphology and the relationship in the velocity magnitudes and characteristics between runs (i.e., gage locations) and run versus riffle habitat showed a large difference. Given that velocity profiles are the most sensitive parameter in estimating fisheries habitat in instream flow assessments it is unlikely that use of at-a-station hydraulic parameters from gage locations can be utilized to assess reach level fisheries habitat.

Introduction

The principal research question of this project was to explore if available data at gage locations allow for inference of hydraulic habitat characteristics at the reach scale that could inform the evaluation of instream flow regimes. Reviews of instream flow programs in Texas, including the National Research Council (2005) and Science Advisory Committee (2009), recognized the potential benefit of desk-top methods (i.e. those that can be applied using generally readilyavailable data and information without conducting site-specific field studies). The majority of such methods are based exclusively on statistical relationships derived from hydrologic data. There have been only limited attempts to validate these methods for use in Texas. The Lyons Method, often relied on by Texas Commission on Environmental Quality to evaluate small water rights permits or amendments across the state, was developed based on cross-section data collected from only two locations on the Guadalupe River in Central Texas. To date, attempts to find improved desktop methods for use in Texas have focused on methods that employ only hydrologic data. One such attempt, the Technical Review Group that reported to Texas Commission on Environmental Quality (2008), was unsuccessful in finding a method significantly better than the Lyons Method. Through collaborative discussions with the Texas Water Development Board, the project focused on investigating the potential use of information collected at gage stations to inform relationships between available habitat and discharge at the reach level for use in evaluating ecological flow regimes. The rationale behind this approach in part is that from a regulatory perspective, water rights are associated with specific locations (i.e., gages) that determine flow levels at the corresponding downstream reaches. If it were possible to make inferences of the relationship between habitat characteristics at the reach level based on

characteristics at a gage, it would provide a rapid assessment method for use in screening instream flows and implications of proposed water withdrawals on maintaining ecologically sound riverine conditions.

Background

One of the challenges facing implementation of the Texas Instream Flow Program (TIFP) through the Senate Bill 2 and 3 process is the high data requirements associated with a large number of potential quantification sites (e.g., see Guadalupe, San Antonio, Mission, and Aransas Rivers and Mission, Copano, Aransas, and San Antonio Bays Basin and Bay Expert Science Team, 2011). Quantification approaches identified within the TIFP range from hydrology based methods to high spatial resolution multi-dimensional hydrodynamic models for predicting the relationship between discharge and available physical habitat. Excellent reviews of instream flow approaches in the United States can be found in Reiser et al. (1989), EPRI (1986), Gore and Nestler (1988), and Hardy (1998). Annear et al. (2004) and NRC (2005) synthesize additional work over the past decade and elucidate the multidisciplinary philosophies and application level challenges associated with the assessment of instream flows. A broader view of the status and future directions of instream flow science at the international level can be found in Harby et al. (2004). This later effort reviews the existing status of instream flow science used throughout the European Union and is comprehensive in its coverage of sampling, hydrology, hydraulic, water quality, temperature, and aquatic habitat modeling approaches.

Methods developed for assessing habitat availability vary in data requirements, cost, predictive ability, legal defensibility, and biological realism (Annear et. al. 2004). While some methods require rigorous, site-specific data collection and computer modeling, others rely more heavily on simplified approaches such as application of summary hydrologic-based statistics. Although the application of rigorous site-specific methodologies typically occurs for high-intensity instream flow studies, many management objectives can be achieved with less intensive efforts, especially for early project screening or broad level watershed planning (Stalnaker et al. 1995, NRC 2005).

Several widely applied screening methods allow practitioners to estimate flow requirements with no, or a minimum of, field-data collection efforts such as the Tennant Method and the New England Aquatic Base Flow method (Annear et al. 2004). This is characteristic of the Lyon's Method employed by the Texas Commission for Environmental Quality (TCEQ) in evaluation of water rights applications. Many of these approaches, however, vary in their ability to integrate or relate site-specific data with biological criteria in the assessment process. Some recent efforts to develop alternative methodologies for habitat assessment can be found in Jowett (1990, 1992, 1998), Lamouroux, Capra, and Pouilly (1996), and Annear et al. (2004).

Based on the recommendation of the NRC (2005), and consistent with Maidment et al. (2005), the SAC (2009) led the development of the Hydrology-Based Environmental Flow Regime (HEFR) Methodology. HEFR relies on a framework that quantifies key attributes of four components of the flow regime intended to support a sound ecological environment. These instream flow regime components are: subsistence flows, base flows, high flow pulses, and overbank flows (SAC 2009). For each of these flow regime components, HEFR was designed to assist in characterizing their attributes in terms of magnitude, volume, duration, timing, frequency, and in conjunction with IHA or MBFIT, the rate of change. HEFR results are then integrated with overlays of biology that include fisheries (i.e., physical habitat) and riparian components as well as overlays of water quality and geomorphology. A description of the ecological function of these flow components can be found in Richter et al. (2006), Richter and Thomas (2007), TIFP (2008) and SAC (2009).

Physical heterogeneity of riverine systems influences species richness and abundance (Hynes 1970, Vannote et al. 1980, Ward 1989). Furthermore, in riverine systems, the physical habitat structure (microhabitat and mesohabitat scales) is one of the critical factors that determine the distribution and abundance of aquatic organisms. In general, as spatial heterogeneity increases at the scale of aquatic organisms, there is greater microhabitat and hydraulic diversity that leads to greater biotic diversity. This variability in physical habitat from the microhabitat to mesohabitat scales is primarily derived from the physical processes of flow and sediment both within the channel as well as the lateral connectivity of floodplain habitats. The diversity and availability of these habitats are in turn maintained by variability in the flow regime and is a key process in the evolutionary response of aquatic species life history traits that allow them to exploit this variable and dynamic habitat mosaic. In many instances, the successful completion of various life history requirements requires use of different habitat types. For example, spawning and egg incubation may occur in riffles (turbulent velocities in conjunction with appropriate substrate sizes); upon hatching, the fry move to the slow side margins of the stream, while non-spawning adults may primarily inhabit deep pools. This variability in space and time of the habitat mosaic directly (or indirectly) influences the distribution and abundance of riverine species as well as overall ecosystem function (Poff and Allan 1995, Schlosser 1990, Sparks 1992, Stanford et al. 1996).

Because stream flow is one of the key factors that controls the temporal and spatial availability of stream hydraulics (interaction of depth and velocity), substrate, cover, food, and, to a lesser extent, temperature (e.g., Statzner and Higler 1986), stream flow within a given river system controls the abundance and diversity of physical habitat and ultimately the diversity of species that can exist. Ecological flow regimes are aimed at maintaining the natural diversity of habitats (i.e., riffles may only represent seven percent of available habitat types) rather than the often false assumption that flow regimes should optimize diversity. Optimizing habitat diversity is not the same as maintaining habitat diversity, which is required to maintain ecological integrity of aquatic ecosystems. One method of quantifying the effects of stream flow on riverine biota is to

quantify the quantity and quality of habitat types (types inhabited by typical riverine fish guilds) versus flow (e.g., Aadland 1993, Bowen et al. 1998, BIO-WEST 2008). These relationships, particularly for key bottleneck habitats that may affect, for example, recruitment of fishes at various times of the year (e.g., nursery habitat), can be used to identify stream flows that maintain habitats for a diversity of species and life stages (Bain et al. 1988, Scheidegger and Bain 1995, Nehring and Anderson 1993).

In addition, fish use different microhabitats (depth, velocity) in different mesohabitats (pools, riffles, eddies) (Jackson 1992, Moody and Hardy 1992) and use different microhabitats at different flows (e.g., Shrivell 1994). They also use different habitats depending on localized predation threats (e.g., Power et al., 1985; Schlosser 1982), during different seasons (e.g., Baltz et al. 1991), during different parts of a day (night vs. day) and life stages. Fish swimming capabilities change with temperature (Brett and Glass 1973, Smith and Li 1983, Addley 1993) and the velocities that they use is dependent on temperature.

Clearly, hydraulic characteristics of a river as a function of changing discharge over micro to meso-scales at the reach level are important determinants for assessing quantity and quality of aquatic resource habitats and provide the basis for the evaluation of ecological flow regimes. The principal research question of this paper is to explore to what degree if any, available data at a gage location allow the inference of hydraulic habitat characteristics at the reach scale necessary to inform the evaluation of instream flow regimes. This question is further constrained by the goal of utilizing the gage data within the context of a rapid assessment or 'desk top' methodology that minimizes or eliminates the need for extensive field data collections. The following sections explore this question both from a theoretical perspective as well as from empirical work available from the literature and data from several river systems in Texas.

Theoretical and Empirical Considerations

Hydraulics overview

The basic hydraulic data collected at a gage are channel geometry, stage (or depth), velocity, and wetted width at a variety of discharges. Gage locations are typically located in straight channel sections with stream lines that are parallel to the downstream channel orientation and typically referred to as runs in aquatic habitat classification schemes. Ignoring high gradient step-pool type river channels that are rare and atypical of Texas streams and rivers, most channels are either riffle-pool or riffle-pool-run morphologically (e.g., Figure 1).



Figure 1. Characteristic riffle-pool-run sequence in a river channel.

The data collected at a gage represents the hydraulic geometry of the stream channel and is described by basic equations between discharge (Q) and water surface width (W), depth (D), velocity (V), Manning's roughness factor (n) and slope (S) (Leopold and Maddock, 1953; Park, 1977; Kellerhals and Church, 1989; Mosley, 1992).

$$W = aQ^{b}$$
$$D = cQ^{f}$$
$$V = kQ^{m}$$
$$n = NQ^{p}$$
$$S = sQ^{y}$$

The exponents b, f, m, p and y represent, respectively, the rate of change of the hydraulic variables W, D, V, n and S as Q changes while the coefficients a, c, k, N and s are scale factors that define the values of W, D, V, n and S when Q = 1 (see Figure 2). The hydraulic variables, width, depth and velocity, satisfy the continuity equation:

$$Q = WDV$$

Therefore the coefficients and exponents must satisfy:

ack = 1 and
$$b+f+m = 1$$

Note that this permits the calculation of velocity from:

$$\mathbf{V} = (\mathbf{Q}^{1\text{-b-f}}) / (\mathbf{ac})$$



Figure 2. Variation of hydraulic parameters at a cross section in a river (A: discharge, width, and velocity versus stage; B; width, depth and velocity versus discharge. Adapted from Leopold and Maddock 1953).

These hydraulic geometry relationships can be examined in terms of downstream relationships which describe the variation in hydraulic geometry between reaches at one index discharge (commonly bankfull discharge), whereas 'at-a-station' relationships describe the variation of hydraulic geometry with changing discharge within a reach. The 'at-a-station' relationships are most germane to the present discussion given the desire to make inferences to the reach scale in the vicinity of the gage and not how these relationships change longitudinally at the basin level.

Although Parker (1979) suggests that the scale factors, a, c, and k, vary from locality to locality the exponents, b, f, and m, exhibit a remarkable degree of consistency, and would appear to be independent of location and only weakly dependent on channel type. One might assume that in a somewhat homogeneous reach with small spatial changes in channel topography that the relationships derived from the gage data might be representative of the reach level characteristics. However, Phillips and Harlin (1984) found that hydraulic exponents were not stable over space in a homogeneous subalpine stream. To further complicate the issue, Rhodes (1977, 1978) noted that the exponent values for high flow conditions can be vastly different from those for low flow conditions. Basically, the exponents and coefficients of these hydraulic geometry equations are expected to vary from location to location on the same river and from river to river, as well as from the high flow range to the low flow range. Given these facts, the question then becomes to what degree does this variability impact their potential use to infer hydraulic characteristics at the reach scale given properties at a specific gage (i.e., run) location.

Kolberg and Howard (1995) examined the variability in exponents of hydraulic geometry relations in the Midwestern United States for 318 alluvial channels and 50 Piedmont streams. Both data sets indicated that the width-discharge exponents ranged from 0.35 to 0.46 for groups of streams with width to depth ratios < 45 while in streams with the width to depth ratios > 45, the width-discharge exponents decreased to values below 0.15, suggesting a systematic variation in the exponents and a diminished influence of channel shape and consistent with the work of Osterkamp and Hedman (1982).

At-a-station hydraulic geometry

Kellerhals and Church (1989) demonstrated that the width of large rivers ($Q > 20 \text{ m}^3/\text{s}^{-1}$) from different location around the world are remarkably constant as shown in Figure 3. However, it is unknown to the degree this consistency holds for river systems with lower discharges.



Figure 3. Relationship between magnitude of discharge and channel width from large rivers (adapted from Kellerhals and Church 1989).

Kellerhals and Church (1989) proposed that the geophysical basis of riverine habitat could be characterized by at-a-station relationships based on basic continuity equations:

 $w = a_1 Q^{b1}$ $d = a_2 Q s^{b2}$ Q = w dv

Where Q is the backfull discharge, Qs is the sediment supply, w is the channel width, d is mean channel depth and v is the mean channel velocity. Therefore the velocity and cross sectional area (A) of the flow can be expressed as:

 $v = (1/a_1a_2)Q^{1-(b1+b2)}$ $A = a_1a_2Q^{(b1+b2)}$

In essence the equation for Area describes the storage-discharge (volume) per unit length of channel (or total volume for the length of channel over which A is averaged) as flow varies. The velocity equation gives the relationship of mean velocity in the reach and the width equation will closely approximate the wetted area of the channel per unit length of channel. However, Kellerhals and Church note that these relationships vary widely due to channel cross sectional area characteristics.

Jowett (1998) utilized a large dataset of New Zealand Rivers to examine the use of the at-astation hydraulic geometry equations for use in aquatic habitat assessments. Data collected from between 8 to 47 cross sections covering at least one pool/run/riffle sequence in each of 73 river reaches were examined. The number of cross sections collected in a given river increased with increased channel stream geometry. Field observations were used to develop calibrated hydraulic models. The hydraulic models were then used to simulate hydraulic properties as a function of discharge and the resulting water surface width, mean depth, and mean velocity calculated for each cross-section were then averaged for the reach, with each cross-section weighted by the distance between adjacent cross-sections. Water surface width, mean depth, and mean velocity were calculated at the mean annual discharge for the 73 study reaches. At-astation exponents were calculated by linear regression of the logarithm of flow versus logarithms of water surface width, depth, and velocity at four levels of flow; mean annual, median, mean annual minimum, and 80% of mean annual minimum flow.

Jowett (1998) utilized an objective measure of the channel shape derived from the power relationship between channel width (W) and height or elevation (Y):

$$W = a_c (Y - Y_{min})^{bc}$$

Where bc is the shape exponent and Y_{min} is the height of the lowest point on the cross section (i.e., W = 0). The exponent bc was calculated for each cross section and averaged for the reach. When the shape exponent is less than unity, the cross section of the channel is U-shaped and when greater than unity is indicative of alluvial channels with large increases in channel width with height.

The channel width coefficients and depth coefficients of the hydraulic geometry equations can be determined from two field measurements of the wetted width (W_1, W_2) and mean depth (D_1, D_2) at two flow rates (Q_1, Q_2) as follows:

$$b = \log(W_1 / W_2) / \log(Q_1 / Q_2)$$
$$a = W_1 / Q_1^{b}$$

- 8 -

$$f = log(D_1 / D_2) / log(Q_1 / Q_2)$$

 $c = D_1 / Q_1^{f}$

The simplified field procedure utilized 5 randomly selected cross sections from runs contained in a reach with a mixture of pool/run/riffle habitats. It is important to note that run habitats were selected as they contain depth and velocities intermediate between values in pools and riffles and more reflective of reach level average characteristics. In the context of this paper, runs are analogous to gage locations. To incorporate the change in width with average depth at the second discharge, (D_2) was calculated as:

$$D_2 = (W (D_1 + \Delta L) + (\Delta L (W_2 - W_1)/2) / W_2)$$

Over the range of the two calibration flows used to calculate the hydraulic geometry relationships, predicted depth and velocity was within 2.8% on average (maximum difference less than 8%) of the mean depth and velocity predicted by hydraulic simulation techniques derived from modeling 15 cross-sections located in pool, run, and riffle habitats (see Figure 6 in Jowett 1998). The difference between predictions by the two methods increased with the flow extrapolation range, with less than a 15% difference at half of the lowest calibration flows and less than 10% difference at twice the higher calibration flow. Jowett (1998) concludes that repeated applications of this method would allow relationships between the mean flow of rivers and environmental flow requirements to be developed into regional formulae, similar to the Tennant method (1976) or in the context of Texas, the Lyon's Method.

Leopold and Maddock (1953) proposed the following continuity equations:

$$w = aQ^b$$
 $d = cQ^f$ $v=kQ^m$

Where w is the width, d is the depth, and v is the mean channel velocity. Rhodes (1977) examined the relationship between the hydraulic exponents of these continuity equations utilizing a b-f-m diagram to plot data derived from 315 sets of at-a-station hydraulic geometry equations based on empirical data (Figure 4).



Figure 4. The b-f-m diagram showing plotting position of 315 sets of at-a-station hydraulic geometry exponents (after Rhodes 1977).

These results show a large variation in the relationships between the exponents of the continuity equations that reflect differential responses of the channel to discharge, sediment supply, slope, competence and other factors that relate to channel types as shown in Figure 5 (see Rhodes 1977).



Figure 5. Divided b-f-m diagram showing 10 delineated regions associated with channel types (after Rhodes 1977).

The five main dividing lines represent constant values of width-depth ratio (b=f), competence (m=f), and Froude number (m=f/2), velocity-cross sectional area ratio (m=b+f) and is related to the Darcy-Weisbach friction factor, and slope-roughness ratio (m/f=2/3) which is related to Manning's equation. The ten corresponding regions refer to channel configuration and responses to changes in discharge. For example, if the width-to-depth ratio at a channel cross section does not change with discharge, b=f. If b>f (left side of the line), the width-to-depth ratio increases with increasing discharge. Conversely, f>b (right side of the line), the width to depth ratio decreases with increasing discharge. Rhodes (1977) relates these conditions to the (1) relative stability of bed and bank material; (2) channel shape, and (3) channel adjustment to transport of bed load. Rhodes (1977) provides a discussion of the relationships for each of these dividing lines. Of interest here is that a set of channel cross sections plotting in a particular area of the diagram should experience similar hydrologic and morphologic responses to changes in

discharge regardless of the magnitude of their continuity equation exponents derived from at-astation hydraulics.

However, as Rhodes (1977) demonstrates, use of reach level average values compared to individual at-a-station relationships is highly variable (Figure 6).



Figure 6. Comparison of b-f-m plotting position for individual at-a-station and reach averages (after Rhodes 1977).

It is apparent in Figure 6 that the individual and reach average values from Leopold and Maddock (1953) are markedly different. Note that the reach average value plot is sector 6, while the individual at-a-station values plot in 7 of the 10 regions of the b-f-m diagram indicating a wide variation in channel configuration and responses to changes in discharge. This variability in channel configuration related to the values of the exponents of the continuity equations suggests that reliance on the hydraulic characteristics at a gage site to estimate reach level average conditions, may not be characteristic given the variability of individual cross section locations as suggested by the work of Jowett (1998).

Evaluation of gage data

An initial assessment of the potential utility of gage data was made by selecting a number of gages from each of the major river drainages within Texas. Sites were selected to represent locations in different ecoregions within a given major drainage basin, spatially different locations as well as to include gage locations on the same stream reach. For each gage, the published rating curve data was downloaded from the USGS and several rating curves were selected at each gage to assess the variability over time as well as for comparisons between gage locations. Table 1 shows the river basin, gage number, name, and location of gages used in the evaluation of continuity relationships in Texas. Figure 7 shows an example of selected gage locations within the Brazos River Basin. Appendix A contains figures for all selected gage locations from all eleven river basins evaluated in this work.



Brazos River Basin Gages and Ecoregion Types

Figure 7. Selected gage location within the Brazos River drainage where at-a-station hydraulic geometry relationships were evaluated.

Table 1. USGS gage locations by major river drainages in Texas used in the evaluation of at-astation hydraulic relationships.

General ControlControl Control Contro	River Basin Brazos	Gage	Name	Latitude	Longitude
Colorado Colar F& Brons Nu car No. 31 (1970) 97 2010) COSSOD Nasque R nuer Chino, TX 31 401 07 97 2010) COSSOD Nasque R nuer Chino, TX 31 401 07 97 2010) COLORADO Marsado R nuer Cately, TX 31 101 27 97 121 87 COLORADO Marsado R nuer Cately, TX 31 100 27 97 121 87 COLORADO Marsado R nuer Cately, TX 31 53 507 10 106 17 COLORADO Nasado R nuer Cately, TX 31 53 507 10 106 17 Colarado N nuer Cately, TX 31 53 537 100 73 127 97 124 27 Colarado N nuer Cately, TX 31 53 537 100 73 127 97 124 27 Colarado N nuer Cately, TX 31 53 537 100 73 127 97 124 27 Colarado N nuer Cately, TX 31 53 537 97 73 127 97 124 27 Colarado N nuer Cately, TX 37 03 97 97 73 007 97 23 127 97 127 177 Colarado N nuer Cately Marcoly, TX 27 93 99 97 05 127 97 127 177 Colarado N nuer Cately Marcoly, TX 27 53 73 97 45 127 97 45 127 Colarado N nuer Cately		08083100	Clear Fk Brazos Ry near Roby, TX	32°47'15"	100°23'18"
ColoradoNosque Privation314709"972402"ColoradoSougo Pa vi Valley Mills, TX314709"972102"ColoradoSougo Pa vi Valley Mills, TX3110229612751"ColoradoSougo Pa vi Valley Mills, TX3110229612751"ColoradoSougo Pa vi Valley Mills, TX311032961273"ColoradoSougo Pa vi Valley Mills, TX315352"1010617"ColoradoSougo Pa vi Valley Mills, TX315353"1010617"ColoradoSougo Pa vi Valley Mills, TX315353"1010617"Colorado N va Vinher Sing, TX315353"070357"973425"Goldo Oardo N va Vinher Mills, TX317393"973425"973425"Goldo Oardo N va Vinher Mills, TX275374.56"975374.56"975374.56"Goldo Oardo N va Vinher Mills, TX2753754.56"975372"975502"Goldo Oardo N va Vinher Mills, TX275327"975502"97502"Goldo Oardo Na Vinher Mills, TX275327"975502"97502"Goldo Oardo Na Vinher Mills, TX275327"975602"97402"Goldo Oardo Na Vinher Mills, TX275327"975602"97412"Goldo Oardo Na Vinher Mills, TX275327"975602"97402"Goldo Oardo Na Vinher Mills, TX275327"975602"97402"Goldo Oardo Na Vinher Mills, TX275327"975602"97402"Goldo Oardo Na Vinher Mills, TX275357"97402"97210"NacesGoldo Oardo Na Vinher Mills, TX275357"97402"Goldo Oardo		08083230	Clear Fk Brazos Ry near Noodle, TX	32°40'28"	100°04'20"
Big Sign No Boogue Pri at Valley Mills, TK31/40/2797/2009*10311022Newasota RV near Kightonk, TX31/24/2796/31/34*0309200Navasota RV near Kightonk, TX31/24/2796/31/34*03011020Maraos NV near Kightonk, TX31/25/30*96/42/3*03011020Mil CA near Jeelling City, TX31/25/30*10/196/17*0313020Colorado RV near Kightonk, TX31/25/30*10/196/17*0313020Colorado RV near Kightonk, TX31/25/30*10/196/17*0313020Colorado RV near Kightonk, TX31/25/30*99/34/25*0313020Colorado RV near Kightonk, TX31/25/04*99/34/25*0313020Colorado RV near Kightonk, TX30/03/07*99/34/25*0313020Sandiace Rear Concreto, TX29/55/26*99/53/2*03130200Sandiace Rear Concreto, TX29/53/2*99/25/2*03130200Sandiace Rear Long, TX29/25/3*97/25/3*03130200Sandiace Rear Long, TX29/32/3*97/25/3*03130200Sandiace Rear Long, TX29/32/3*97/25/3*0313020Sandiace Rear Long, TX29/32/3*97/25/3*0313020Sandiace Rear Long, TX29/32/3*97/25/3*0313020Sandiace Rear Long, TX29/32/3*97/25/3*0313020Nucces Rv at Colula, TX29/32/3*97/45/2*0313020Nucces Rv at Gorage Vest, TX29/33/2*97/45/2*0313020Nucces Rv at Gorage Vest, TX29/33/2*97/46/2*0313020Nucces Rv at		08095000	N Bosque Ry near Clifton TX	31°47'09"	97°34'04"
8 8 1000000000000000000000000000000000000		08095200	N Bosque Ry at Valley Mills TX	31°40'10"	97°28'09"
Network <t< td=""><td></td><td>08110325</td><td>Navasota By above Groesbeck TX</td><td>31°34'27"</td><td>96°31'14"</td></t<>		08110325	Navasota By above Groesbeck TX	31°34'27"	96°31'14"
Brazos Riv near Highbank, TX210802"96/4929"Colorado0013230Ni Ck near Bellville, TX217521"96/12/1"Colorado0013320Ni Concho Riv above Sterling City, TX31*5300"100/617"001300Ni Concho Riv above Sterling City, TX31*2937"997342"001300Colorado Riv Vincho Hi TX31*2937"997342"001300Colorado Riv Vincho Hi TX31*2930"997342"001300Colorado Riv Vincho Hi TX297574.886"9875349001300Sinto Riv Confort, TX297574.886"9875349.807001300Sinto Riv Sinto Marcos, TX2975939"997512"001300San Marcos Riv H San Marcos, TX297322"975612"0013700Sandies CK near Weshoft, TX297124"977562"0013700Sandies CK near Weshoft, TX297124"97260"0013700Sandies CK near Weshoft, TX297124"974678"0013700Sandies CK near Mesheton, TX297323"967400"0013700Nueces Ni Han Marcos, TX297323"967400"0013700Sandies CK near Placedo, TX297323"97402"0013700Nueces Ni Han Marcos, TX297323"97402"0013700Nueces Ni Han Cancha, TX297312"97402"00131200Nueces Ni near Aberton, TX297323"97402"00131200Nueces Ni near Aberton, TX297354"97432"00131200Nueces Ni near Chalen, TX397445"1007432"00131200Nueces Ni near Chalen, TX		08110500	Navasota Ry near Easterly, TX	31°10'12"	96°17'51"
Colorado Col		08098290	Brazos Ry near Highbank, TX	31°08'02"	96°49'29"
ColoradoNumerical Control, M.Numerical Control, M.Numerical ControlGaladou N. Concho Rv above Sterling CIV, TX31*53501101/06127Galadou N. Concho Rv near Galabad, TX31*23331100738122Galadou N. Concho Rv near Galabad, TX312/200799*3425°Galadou P.Colorado Rv at Minchell TX312/200799*3425°Galadou P.Colorado Rv at Minchell TX307050799*2312°Galabare Rv at Confort, TX29*5748.88°98*5348.80°Galabare Rv at Confort, TX29*572997*502°Gal7000Sam Aaroos Rv at San Marcos, TX29*529997*502°Gal7000Gandauge Rv at Conralev, TX29*125497*502°Gal7000Gandauge Rv at Conralev, TX29*125497*2117°Gal7000Gandauge Rv at Conralev, TX29*125497*2117°Gal7000Gandauge Rv at Conralev, TX29*125497*2117°Gal7000Gardatas Ck near Inez, TX29*3212°96*407°NuccesGal3000Nucces Rv at Coloralev, TX29*3212°96*407°NuccesGal3000Nucces Rv at Coloralev, TX29*307°97*2117°Gal31000Nucces Rv at Coloralev, TX29*307°97*423°Gal31000Nucces Rv at Coloralev, TX29*307°97*430°Gal31200Nucces Rv at Calalev, TX29*1551°97*432°Gal31200Nucces Rv at Calalev, TX39*1451°100*342°Gal31200Nucces Rv at Calalev, TX33*3151°100*1428°Gal31200Nucces Rv at Calalev, TX <td></td> <td>08111700</td> <td>Mill Ck near Bellville TX</td> <td>29°52'51"</td> <td>96°12'18"</td>		08111700	Mill Ck near Bellville TX	29°52'51"	96°12'18"
Control 08133250 N Concho Rv above Sterling City, TX 31'53'50' 101'06'17' 08134000 N Concho Rv aner Calsbad, TX 31'53'53' 100'37'21' 08136700 Colorado Rv are Stap, TX 31'29'37' 99'34'25' 08136700 Colorado Rv are Stap, TX 31'29'37' 99'34'25' 08136700 Colorado Rv are Stap, TX 31'29'37' 99'34'25' 08137000 Gualaupe Rv at Comfort, TX 29'37'54'84'' 99'50'21'' 08172000 Blanco Rv at Wimberley, TX 29'31'24'' 97'55'48'' 97'36'12'' 08172000 Sundes CK are Stap, TX 29'31'24'' 97'25'12'' 97'35'12'' 08172000 Sundes CK are Westhoff, TX 29'12'' 97'35'12'' 97'35'12'' 0817500 Sundes CK are Placedo, TX 28'33'31'' 97'45'4''' 97'45'12'' Cuasa Guadalupe Gelfad00 Guadalupe Rv at Gonzales, TX 28'33'31'' 97'45'12'' Cuasa Guadalupe Guadalupe Rv at Gonzales, TX 28'33''' 97'45'2'' 97'45'2'' Cuasa Guadalupe Guadalupe Rv at Gonzales, TX 28'33'''	Colorado	00111/00	Nin ek neur benvine, ix	25 52 51	50 12 10
 	colorado	08133250	N Concho Ry above Sterling City, TX	31°53'50"	101°06'17"
Bellarized Colorado Nr une af Stacy, TX 31 '295' 99'342' Guadalupe Bellarized 99'342' 99'342' Guadalupe Colorado Nr une af Stacy, TX 31'282' 99'342'' Guadalupe Nr une af Stacy, TX 31'282'' 99'342'' 99'342'' Guadaupe Nr une af Stacy, TX 31'282'' 99'342'' 99'342'' Guadaupe Nr une af Stacy, TX 30'03'' 99'342'' 99'342'' Guadaupe Nr une Confort, TX 29'57'54'' 99'36''' 97'56''' Guadaupe Nr une Confort, TX 29'12'' 97'56''' 97'56''' Guadaupe Nr une Confort, TX 29'12'' 97'56''' 97'56''' Guadaupe Nr une Confort, TX 29'12'' 97'56''' 97'56''' Guadaupe Nr une Afferton, TX 29'12'' 97'56''' 97'6'''' Colorado Nr une Westhof, TX 28'13''' 97'36'''' 97'36'''' Necces Guadaupe Nr une Afferton, TX 28'13'''' 97'37'''' Necces Nr ear Tilden, TX 28'13'''''''''''''''''''''''''''''''''''		08134000	N Concho Ry near Calshad, TX	31°35'33"	100°38'12"
Gadalupe 693300 Colorado Rv at Winchell TX 312804 997933" Gadalupe 691600 Gadalupe Rv at Comfort, TX 2975754.867 9972312" 605100 Gadalupe Rv at Comfort, TX 2975754.867 9972312" 605100 Gadalupe Rv at Comfort, TX 29759739" 605100 Gadalupe Rv at Comfort, TX 29759739" 605100 Gadalupe Rv at Gonzales, TX 2975930" 972502" 605100 Gadalupe Rv at Gonzales, TX 297303" 972502" 0617000 Gudalupe Rv at Gonzales, TX 297203" 972502" 0617000 Gudalupe Rv at Gonzales, TX 297293" 972700" 0617000 Gudalupe Rv at Gonzales, TX 2972931" 97210" 0617000 Gudalupe Rv at Gonzales, TX 2972931" 97210" 0617000 Gudalupe Rv at Gonzales, TX 297293" 972700" 0617000 Gudalupe Rv at Gonzales, TX 297593" 972700" 0617000 Gudalupe Rv at Gonzales, TX 297593" 972700" 0617000 Nucces Rv at Gonzales, TX 287533" 96400" Nucces Rv at Gonzales, TX 287533" 96400" Nucces Rv at Gonzales, TX 287593" 971422" 97330" 96400" Nucces Rv at Gonzales, TX 287593" 971422" 97330" 974123" 974123" 97432" 97442" 97444 97442" 97444 97442" 97444 97444 97444 9744 97444 97444 97444 97444 974		08136700	Colorado Ry near Stacy TX	31°29'37"	99°34'25"
Guadalupe Distance Distance Distance Distance Distance Guadalupe N K Guadalupe Rv near Hunt, TX 3003507 997534867 997534867 997534287 Guadalupe Rv at Gomfort, TX 2975794.867 9975912" 9975019" Guadalupe Rv at SomMarcos, TX 2975794.867 9975912" 9775012" Guadalupe Rv at SomMarcos, TX 29753207 9775012" 977512" Guadalupe Rv at Gonzales, TX 2971237 972502" 972652" Guadalupe Rv at Gonzales, TX 2971234 972400" 972652" Guadalupe Rv at Gonzales, TX 2971234 972400" 972657" Guadalupe Rv at Gonzales, TX 28735381 9740700" 974054" Neces Placedo Ch near Placedo, TX 28735328" 9740700" Nueces Nueces Rv at Cotulia, TX 2871939" 9974054" OB19900 Nueces Rv at Cotulia, TX 2871939" 9974054" OB21000 Nueces Rv at Cotulia, TX 2871939" 9974052" OB21000 Nueces Rv at Cotulia, TX 2871939" 9974052" <td></td> <td>08138000</td> <td>Colorado Ry at Winchell TX</td> <td>31°28'04"</td> <td>99°09'43"</td>		08138000	Colorado Ry at Winchell TX	31°28'04"	99°09'43"
Control Part 1 OB 165300 N FK Guadalupe Rv at Comfort, TX 30703'50' 99'23'12'' 08157000 Guadalupe Rv at Comfort, TX 29'57'58.86' 99'25'20'' 97'35'02'' 08170000 Sam Arcos Rv at Sam Marcos, TX 29'53'20'' 97'35'02'' 97'35'02'' 08170000 Sam Arcos Rv at Sam Marcos, TX 29'12'S3'' 97'27'00'' 97'25'07'' 08170000 Sam Arcos Rv at Sam Marcos, TX 29'12'S3'' 97'27'00'' 97'25'07'' 08170500 Guadalupe Rv at Gonzales, TX 29'12'S3''' 97'25'''' 97'25'''' 08170500 Garcitas Ck near Inez, TX 22'5'32'''' 97'24''''' 97'40'''''' 08164000 Nueces Rv at Coulia, TX 22'13'''' 97'45'''' 97'45''' 08194000 Nueces Rv at Coulia, TX 22'13''''' 97'45''' 97'45''' 08194000 Nueces Rv at Galalen, TX 22'15'''''' 97'45'''' 97'45'''' 08194000 Nueces Rv at Calalen, TX 25'15'''''' 97'45'''' 97'45''''' 0819400 Nueces Rv at Calalen, TX 25'19'''''''''''''''''''''''''''''''''''	Guadalune	00130000		51 20 04	55 05 45
Red River 000000000000000000000000000000000000	Guudulupe	08165300	N Ek Guadalune Rynear Hunt TY	30°03'50"	00°73'17"
exact Subset Section Se		08167000	Gualaune Ry at Comfort TY	20°57'54 86"	98°53'/9 80"
bit 1000 bit 10000 bit 10000 bit 10000 bit 10000 bit 100000 bit 100000 bit 100000 bit 1000000 bit 1000000 bit 1000000 bit 1000000 bit 1000000 bit 1000000 bit 10000000 bit 100000000 bit 1000000000 bit 1000000000000000000		08171000	Blance By at Wimberley, TX	20°50'20"	08'05'10"
sol 10000 Join Marko SY NZ JANG MARIOS, IX 29 J 320 97 J 300 08173000 Guidalupe NX of Gonzales, TX 29 J 220 97 J 2700 08175000 Sandies CK near Mesthoff, TX 29 J 220 97 J 2700 08175000 Sandies CK near Mesthoff, TX 29 J 321 97 J 17" Lavaca Guadalupe Gali J Adou Garcitas Ck near Inex, TX 29 J 321 97 49 08" 08154800 Placed Ck near Placedo, TX 29 J 321 97 49 408" 08154800 Nueces Rv at Cotula, TX 29 J 321 97 49 408" 08193000 Nueces Rv at Cotula, TX 29 J 321 97 49 23" 08194000 Nueces Rv at Cotula, TX 29 J 19 33" 97 49 23" 08194000 Nueces Rv at Cotula, TX 29 J 19 33" 97 49 23" 08194000 Nueces Rv at Cotula, TX 27 15 25" 97 37 30" Ref River 07 301200 McClellan Ck near McLean, TX 35 J 19 55" 100 70 49 2" 07 301200 McClellan Ck near McLean, TX 33 J 19 70" 100 70 49 2" 07 311500 McHe R N near Shamord, TX 33 J 33 J 10 100 70 4		08171000	San Marcos Pulat San Marcos TV	29 39 39	07°56'02"
exit Control Action Control Action Control Content Contrel Content Control Control Control Control		08170300	Dlum Ck poor Luling TV	29 33 20	97 30 02
0013500 00013500 00013500 0012500 97 2705 0013500 Sandies CK near Westner, TX 29 5323 97 2705 124023 0016400 Garcitas Ck near Mestner, TX 28 5351" 96 74008" 0016400 Garcitas Ck near Inez, TX 28 5328" 96 74008" 0016400 Placedo Ck near Placedo, TX 28 3300" 97 4700 0016400 Nueces Nu ear Asherton, TX 28 3300" 99 40 54" 001900 Nueces Nu ear Asherton, TX 28 5351" 96 74 370" 0021100 Nueces Nu ear Asherton, TX 28 5151" 97 47 473 0021100 Nueces Nu ear Asherton, TX 28 51551" 97 47 473 0021100 Nueces Nu ear Muleuta, TX 27 55 15" 97 47 473 0021100 Nueces Nu at Could, TX 27 55 15" 97 47 473 0021100 Nueces Nu at Could, TX 27 55 15" 97 47 473 0021100 Nueces Nu at Could, TX 27 55 15" 97 47 472 07 31100 McClellan Ck near Muleua, TX 37 37 89 198" 1001 42 2" 07 31100		08172000		20°20'02"	97°97'00"
Bit 2000 Samues & licen resultor, IA 25 12.54 97 25.35 Lavaca Guadalupe 6817600 9174054 972117" Lavaca Guadalupe 68164800 Placedo Ck near Ilez, TX 2873322" 9674600" Nueces 68198000 Nueces Rv act Asherton, TX 2873000" 9974054" 68198000 Nueces Rv act Cottila, TX 2873070" 9974054" 68194000 Nueces Rv act Cottila, TX 2873070" 9974054" 68194000 Nueces Rv act Cottila, TX 2871531" 9974054" 68211200 Nueces Rv at Coulia, TX 2871551" 9774632" 68211200 Nueces Rv at Calallen, TX 275515" 9774632" 68211200 Nueces Rv at Calallen, TX 35'1945" 100'1429" 70311200 McClellan Ck near McLean, TX 35'1945" 100'1429" 70311200 McIchila Rv at Ross Rh near Bejamin, TX 33'33'39" 9978733" 7031200 Wichita Rv aer Maneola, TX 33'25'34" 98'3200" 7031200 Wichita Rv are Charle, TX 32'36'49" 99'323" <t< td=""><td></td><td>08175900</td><td>Sandies Ck near Westhoff TV</td><td>29 29 03 20°12'5/"</td><td>97°26'57"</td></t<>		08175900	Sandies Ck near Westhoff TV	29 29 03 20°12'5/"	97°26'57"
Lavaca Guadalupe Garcias Ck near Inez, TX 26 353.1 97 / 21 J/ Carcias Ck near Inez, TX 28'3328'' 96'49'08'' 08164800 Placedo Ck near Placedo, TX 28'3328'' 96'49'08'' Nueces 0819900 Nueces Rv near Asherton, TX 28'30'' 99'40'54'' 0819400 Nueces Rv at Cotulla, TX 28'30'' 99'41'23'' 0819400 Nueces Rv at Cotulla, TX 28'19'38'' 99'14'23'' 0819400 Nueces Rv at Cotulla, TX 28'19'38'' 99'14'23'' 0821100 Nueces Rv at George West, TX 28'19'58'' 99'14'23'' 0821100 Nueces Rv at Calallen, TX 27'52'58'' 97'46'32'' 0731100 McClellan Ck near McLean, TX 35'19'45'' 100'36'32'' 0731100 Wichita Rv near Mabele, TX 33'38'39''18'' 100'00'49''' 0731100 Wichita Rv near Mabele, TX 33'45'36'' 99'28'3'' 0731200 Wichita Rv near Mabele, TX 33'45'36''' 99'28'3'' 0731200 Wichita Rv near Mabele, TX 33'45'36''' 99'29'28''' 07312		08176550	Fifteenmile Ck near Wesner, TV	29 12 34 28°52'51"	07°21'17"
Carbon SubalantyOB164000Garcitas Ck near Inez, TX28"53/28"96"4908"Nueces08164800Placedo Ck near Placedo, TX28"4330"96"46'07"Nueces08193000Nueces Rv near Asherton, TX28"3000"99"40'54"08194000Nueces Rv at Cotulia, TX28"19331"99"412'31"08195000Nueces Rv near Tilden, TX28"19'58"98"05'08"08211000Nueces Rv at George West, TX28"19'58"98"05'08"08211000Nueces Rv at Gallen, TX28"19'58"98"05'08"08211000Nueces Rv at Callen, TX27"55'15"97"46'32"08211000Nueces Rv at Callen, TX35"19'45"100"36'32"07301200McClellan Ck near McLean, TX35"19'45"100"36'32"07311300N Fk Ref Rv near Seymour, TX33"33'33"90"08'33"07311200Wichita Rv near Seymour, TX33"4'33"99"08'33"07311200Wichita Rv near Galewater, TX33"4'33"99"08'33"0731200Wichita Rv near Galewater, TX32"3'43"95"2200"0731200Wichita Rv near Mineola, TX32"3'43"95"2908"0731200Wichita Rv near Galewater, TX32"3'43"95"2908"0802000Sabine Rv near Mineola, TX32"3'13"94"573"0802000Sabine Rv near Mineola, TX32"3'13"94"573"0802000Sabine Rv near Mineola, TX32"3'14"94"5174"0802000Sabine Rv near Mineola, TX32"13'38"94"5175"0802000Sabine Rv near Mineola, TX32	Lavaca Guadalumo	001/0000	Inteenillie CKiledi Weshel, IA	10 22 02	JI 21 1/
Solition Goldshool Goldshool <thgoldshool< th=""> <thgoldshool< th=""> <thgo< td=""><td>Lavaca Guadalupe</td><td>08164600</td><td>Correitor Ck poor Ipoor TV</td><td>200521201</td><td>069401001</td></thgo<></thgoldshool<></thgoldshool<>	Lavaca Guadalupe	08164600	Correitor Ck poor Ipoor TV	200521201	069401001
Objection Protector CN Hear Francetor, TX 25 4 3 5 0 50 40 07 Nueces 08193000 Nueces RV near Asherton, TX 28"30007 99"4054" 08193000 Nueces RV at Cotulia, TX 28"3007 99"4054" 08194000 Nueces RV at Cotulia, TX 28"19"31" 98"3325" 08210100 Nueces RV at Gorge West, TX 28"19"58" 98"05"08" 08211500 Nueces RV at Bluntzer, TX 27"55"15" 97"46"32" 08211500 Nueces RV at Calallen, TX 27"55"15" 97"46"32" 08211500 Nueces RV at Calallen, TX 35"19"45" 100"36"32" 07301200 McClellan Ck near McLean, TX 35"19"45" 100"36"32" 0731200 Wichita RV near Seymour, TX 33"38"39" 99"48"02" 0731200 Wichita RV near Mabelle, TX 33"45"36" 99"38"3" 0731200 Wichita RV near Galewater, TX 32"36"49" 95"29"08" 0731200 Wichita RV near Galewater, TX 32"36"49" 95"29"08" 0731200 Wichita RV near Charlle, TX 32"36"49" 95"39"3"		08104000	Blacedo Ck near Blacedo TV	20 33 20	96 49 08
Nucces 08193000 Nucces Rv near Asherton, TX 28"3000" 99"40"54" 08194000 Nucces Rv at Cotulla, TX 28"25"34" 99"40"54" 08194500 Nucces Rv at George West, TX 28"18"31" 98"33"25" 0821100 Nucces Rv at George West, TX 28"19"58" 99"60"50" 0821100 Nucces Rv at George West, TX 27"56"15" 97"67"30" Red River 07301200 McClellan Ck near McLean, TX 5"1945" 100"36"22" 07301200 McClellan Ck near McLean, TX 35"1945" 100"36"22" 07311200 Wichita Rv at Ross Rin near Bejamin, TX 33"39" 99"68"33" 07311200 Wichita Rv near Sepamor, TX 33"45"36" 99"08"33" 07311200 Wichita Rv near Sepamor, TX 33"45"36" 99"08"33" 07311200 Wichita Rv near Gladwater, TX 33"45"34" 98"32'00" 07311200 Wichita Rv near Sepamor, TX 32"31"3" 99"68"33" 0731200 Sabine Rv near Gladwater, TX 32"31"3" 99"68"33" 08022000 Sabine Rv near Ben, Wear, TX 32"14"4"	Nueses	08104800		28 43 30	50 40 07
06193000 Nucces NV ited Asher 1001, 1X 28 3000 99 1423" 06194000 Nucces RV at Cotulia, TX 28 '15'31" 99'1423" 06210100 Nucces RV at Gotulia, TX 28'15'31" 99'1423" 0621100 Nucces RV at Gotule, TX 28'15'31" 99'14'23" 0621100 Nucces RV at Gotorge West, TX 28'15'31" 99'14'23" 06211200 Nucces RV at Calallen, TX 27'55'15" 97'46'32" 06211200 Nucces RV at Calallen, TX 35'19'45" 100'36'32" 07301200 McClellan Ck near McLean, TX 35'19'45" 100'36'32" 07311200 Wichita RV near Shamock, TX 33'34'30" 99'23'18" 07311200 Wichita RV near Seymour, TX 33'34'201" 99'23'18" 07311200 Wichita RV near Seymour, TX 33'4'34" 98'32'00" 0731200 Wichita RV near Belex/III, TX 33'4'34" 98'3'2'0" 0731200 Wichita RV near Belex/III, TX 32'3'1''' 98'3'2'0" 0731200 Sabine RV near Belex/III, TX 32'3'1''' 98'3'2'1'4'1'' Sabine RV near	Nueces	08102000	Nueses Burger Acharten, TV	20,20,001	00%40'54"
Sabine 08194000 Nueces Nv at Coultar, TX 28'18'31" 99'33'25" 08211200 Nueces Rv near Tilden, TX 28'19'58" 98'05'08" 08211200 Nueces Rv at George West, TX 28'19'58" 98'05'08" 08211200 Nueces Rv at Calallen, TX 27'52'58" 97'37'30" Red River 07301200 McClellan Ck near McLean, TX 35'19'51" 100'36'32" 07301300 NE Ked Riv near Shamrock, TX 35'19'51" 100'36'32" 07311300 Si Wichita Rv near Sepiamin, TX 33'38'39" 99'23'18" 07311200 Wichita Rv near Seymour, TX 33'45'36" 99'03'31" 07311200 Wichita Rv near Ghallel, TX 33'45'34" 98'32'00" 0731200 Wichita Rv near Charlle, TX 33'45'34" 98'32'00" 0731200 Wichita Rv near Charlle, TX 32'36'49" 95'29'08" 0802000 Sabine Rv near Gladewater, TX 32'36'49" 95'29'08" 0802000 Sabine Rv near Gladewater, TX 32'36'49" 95'29'08" 0802000 Sabine Rv near Gladewater, TX 32'19'38" <td< td=""><td></td><td>08195000</td><td>Nueces Ry near Asherton, TX</td><td>20 50 00</td><td>99 40 54 00°14'22"</td></td<>		08195000	Nueces Ry near Asherton, TX	20 50 00	99 40 54 00°14'22"
0619500 Nucces NV ifeal induct, IX 28 19158" 98 0506" 0621100 Nucces RV at George West, TX 28 1958" 98 0506" 06211200 Nucces RV at George West, TX 27 5615" 97 4632" 08211500 Nucces RV at Calleln, TX 27 5615" 97 4632" 07301200 McClellan Ck near McLean, TX 35 '1945" 100 '36 32" 07301300 NF k Red RV near Shamock, TX 35 '1945" 100 '36 32" 07311300 S Wichita RV at Ross Rh near Bejamin, TX 33 '38 '39" 99 '48'02" 07311200 Wichita RV near Seymour, TX 33 '45 '36" 99 '08'32" 0731200 Wichita RV near Charlle, TX 33 '45 '36" 99 '38'02" 0731200 Wichita RV near Gladewater, TX 33 '45 '36" 98 '32'00" 0731200 Wichita RV near Gladewater, TX 32 '36'49" 95 '29'08" 08022000 Sabine RV near Gladewater, TX 32 '31'38" 94'21'2" 08022000 Sabine RV near Gladewater, TX 32 '31'38" 95'29'08" 08189300 Medio Ck near Beeville, TX 30'14'40" 93'36'30"		08194000	Nueces Ry ac Colulia, 1X	20 23 34	99 14 25
0821000 Nueces Rv at George West, TX 27 5515" 97 4632" 08211200 Nueces Rv at Calallen, TX 27 5515" 97 4632" 08211500 Nueces Rv at Calallen, TX 27 5515" 97 4632" 07301200 McCelellan Ck near McLean, TX 35 51945" 100*3652" 07301300 N Fk Red Rv near Shamrock, TX 35 515'51" 100*1429" 07311790 Wichita Rv near Beljamin, TX 33*39'18" 100*049" 07311900 Wichita Rv near Benjamin, TX 33*34'201" 99*48'02" 07311900 Wichita Rv near Benjamin, TX 33*4'45'36" 99*08'33" 0731200 Wichita Rv near Mabelle, TX 33*4'45'36" 99*08'33" 0731200 Wichita Rv near Charlie, TX 34*0'311" 98*32'00" 0731200 Sabine Rv near Bole Rv near Gadewater, TX 32*13'8" 94*21'12" Sabine 08018500 Sabine Rv near Bon Wier, TX 32*13'8" 94*21'12" 0802040 Sabine Rv near Bon Wier, TX 32*13'8" 94*21'12" 0802000 Sabine Rv near Bon Wier, TX 32*13'30" 97*15'36" </td <td></td> <td>08194500</td> <td>Nueces RV near Tilden, TX</td> <td>28 18 31</td> <td>98 33 25</td>		08194500	Nueces RV near Tilden, TX	28 18 31	98 33 25
08211200 Nueces Rv at Galalleer, TX 27 5913 39 749 32 Red River 07301200 Mcclellan Ck near McLean, TX 35 "1945" 100"36"32" 07301200 Mcclellan Ck near McLean, TX 35 "1945" 100"36"32" 07301200 NF k Red Rv near Shamock, TX 35"195"5" 100"14"29" 07311790 Wichita Rv near Semock, TX 33"39"39" 99"4802" 07311200 Wichita Rv near Benjamin, TX 33"39"39" 99"4802" 07311200 Wichita Rv near Benjamin, TX 33"39"39" 99"4802" 07311200 Wichita Rv near Benjamin, TX 33"35"35"4" 98"32"00" 07312500 Wichita Rv near Abelle, TX 33"54"34" 98"32"00" 07312700 Wichita Rv near Abelle, TX 32"36"31" 99"17"47" Sabine 08018500 Sabine Rv near Beckville, TX 32"3"3"3" 99"17"47" Sabine 08018500 Sabine Rv near Bon Wier, TX 30"44"49" 93"36"30" 08018500 Sabine Rv near Bon Wier, TX 30"14"40" 97"39"23" 08189300 Medio Ck near Bou Wier, TX 30"		08210100	Nueces Ry at Bluetzer, TX	20 19 50	96 05 06
Odd 211500 Nucleis IX at Catalite(I, IX 27 9 2.3 o 97 37 30 Red River 07301200 N Fk Red Rv near Shamrock, TX 35"1945" 100"36'32" 07301300 N Fk Red Rv near Shamrock, TX 35"1945" 100"36'32" 07311800 S Wichita Rv near Selpamin, TX 33"38'39" 99"48'02" 07311800 S Wichita Rv near Seymour, TX 33"34'30" 99"48'02" 07311200 Wichita Rv near Seymour, TX 33"45'36" 99"08'33" 07312100 Wichita Rv near Seymour, TX 33"45'36" 99"08'33" 07312100 Wichita Rv near Charlie, TX 33"45'36" 99"08'33" 07312100 Wichita Rv near Charlie, TX 32"36'49" 98"17'47" Sabine Sabine Rv near Gladewater, TX 32"31'37" 94"57'36" 08022040 Sabine Rv near Beckwille, TX 32"31'37" 94"57'36" 08022040 Sabine Rv near Beeville, TX 32"19'38" 94"21'12" 08022040 Sabine Rv near Beeville, TX 32"19'38" 94"21'12" 08022040 Sabine Rv near Beeville, TX 32"19'38" 95"52"25" <td></td> <td>08211200</td> <td>Nueces Rv at Glallen TV</td> <td>27 50 15</td> <td>97 40 52</td>		08211200	Nueces Rv at Glallen TV	27 50 15	97 40 52
Neel 07301200 McClellan Ck near McLean, TX 35*19/45" 100*36'32" 07301300 N Fk Red Rv near Shamrock, TX 35*15'51" 100*36'32" 07311790 Wichita Rv near Shamrock, TX 33*39'18" 100*06'32" 07311800 S Wichita Rv near Bejamin, TX 33*38'39" 99*48'02" 07311200 Wichita Rv near Seymour, TX 33*34'34" 98*32'00" 07312100 Wichita Rv near Seymour, TX 33*4'34" 98*32'00" 0731200 Wichita Rv near Charlie, TX 33*4'34" 98*32'00" 0731200 Wichita Rv near Charlie, TX 33*36'34" 98*32'00" 0731200 Wichita Rv near Charlie, TX 32*36'49" 95*29'08" 08018500 Sabine Rv near Gladewater, TX 32*31'37" 94*57'36" 08022000 Sabine Rv near Beckville, TX 32*31'37" 94*57'36" 08022000 Sabine Rv near Ben Wier, TX 30*44'49" 93*36'30" San Antonio Nueces 08189500 Medio Ck near Beeville, TX 30*14'40" 95*27'25" 08189500 W K San Jacinto Rv near Conroe, TX 30*14'40"	Ded Diver	08211500		27 52 56	9/ 5/ 50
Or Solzbo Michel Reif Witzer al, IX 35 319-43 100 3452 07311300 N FK Reif Xi near Shamrock, TX 35 1551" 100 71429" 07311700 Wichita Rv near Seymour, TX 33 37 39 39" 99 4402" 07311800 S Wichita Rv near Seymour, TX 33 37 43 34" 99 723 128" 07311200 Wichita Rv near Seymour, TX 33 37 43 34" 99 723 128" 07312100 Wichita Rv near Galdewater, TX 33 37 43 34" 98 73 200" 07312700 Wichita Rv near Charlle, TX 33 27 36 49" 98 73 200" 07312700 Wichita Rv near Gladewater, TX 32 36 49" 95 72 908" 08020000 Sabine Rv near Gladewater, TX 32 37 31 37" 94 75 736" 08020000 Sabine Rv near Bon Wier, TX 32 37 33 37" 94 75 736" 08020000 Sabine Rv near Bon Wier, TX 32 37 37 39" 94 72 112" 0802000 Sabine Rv near Bon Wier, TX 32 37 373" 94 75 736" 0802000 Sabine Rv near Bon Wier, TX 32 31 73" 94 75 736" 08018500 Midole Ck near Beeville, TX 28 28 58" 97 39 72	Red River	07201200	McClollon Cknoor McLoon TV	25910/45	1000261221
07311290 Wickita Rva Ross Rh near Bejamin, TX 33 13 1 100 00/9" 07311290 Wickita Rva Ross Rh near Bejamin, TX 33*38'39" 99*48'02" 07311900 Wichita Rva near Seymour, TX 33*45'36" 99*08'33" 07311200 Wichita Rv near Seymour, TX 33*45'36" 99*08'33" 0731200 Wichita Rv near Seymour, TX 33*45'36" 99*08'33" 0731200 Wichita Rv near Seymour, TX 33*45'36" 99*08'33" 0731200 Wichita Rv near Minelola, TX 33*5'34" 98*32'00" 07312700 Wichita Rv near Gladewater, TX 32*3'13" 94*57'36" 0802000 Sabine Rv near Gladewater, TX 32*19'38" 94*21'12" 08022000 Sabine Rv near Bon Wier, TX 30*44'49" 93*36'30" San Antonio Nucces Medio Ck near Beeville, TX 28*28'58" 97*39'23" 08189500 Medio Ck near Gardewater, TX 30*14'40" 95*27'25" 08189500 Medio Ck near Corroe, TX 30*14'40" 95*27'25" 08068000 W Fk San Jacinto Rv near Cleveland, TX 30*14'40" 95*27'25"		07301200	N Ek Dod Dy poor Shamrock, TV	35 19 45 25°15'51"	100 30 32
0731180 Svichita Rv near Benjamin, TX 33 33 33 100 0495 07311800 Svichita Rv near Seymour, TX 33 34 39" 99"4802" 07311200 Wichita Rv near Seymour, TX 33*34 39" 99"4802" 0731200 Wichita Rv near Mabelle, TX 33*4201" 99"23'18" 0731200 Wichita Rv near Game, TX 33*43" 98"27'47" 0731200 Wichita Rv near Charlie, TX 33*5'34" 98"27'47" Sabine 07312700 Wichita Rv near Charlie, TX 34"03'11" 98"27'08" Sabine 08018500 Sabine Rv near Gladewater, TX 32"3'38" 94"21'12" Sabine Rv near Beckville, TX 32"1'38" 94"21'12" 08022000 Sabine Rv near Beckville, TX 32"1'37" 94"57'36" 08022000 Sabine Rv near Beckville, TX 32"1'37" 94"57'36" 08022000 Sabine Rv near Beckville, TX 32"1'37" 94"57'36" 0802500 Mission RV at Refugio, TX 28"28'58" 97"39'23" 08189500 Mission RV at Refugio, TX 30"14'40" 95"27'25" 08		07301300	Wichita Py at Pacs Ph poar Polamin TV	22°20'19"	100 14 29
0731100 5 Wichita Nv near Seymour, TX 33 34201" 99 23200" 07312100 Wichita Nv near Seymour, TX 33 34201" 99 23200" 07312100 Wichita Nv near Mabelle, TX 33 345136" 99 08'33" 07312200 Wichita Nv near Charlie, TX 33 345136" 99 08'33" 07312700 Wichita Nv near Charlie, TX 34 02'11" 98'32'00" 07312700 Wichita Nv near Charlie, TX 34'03'1" 98'32'00" Sabine 08018500 Sabine Rv near Gladewater, TX 32'36'49" 95'29'08" 0802000 Sabine Rv near Beckville, TX 32'31'37" 94'57'36" 0802000 Sabine Rv near Beckville, TX 32'19'38" 94'21'12" 0802800 Sabine Rv near Bon Wier, TX 30'44'49" 93'36'30" San Antonio Nucces 08189300 Medio Ck near Beeville, TX 28'28'58" 97'39'23" 08189300 Medio Ck near Beeville, TX 28'28'1730" 97'16'44" 08189300 Medio Ck near Conroe, TX 30'14'40" 95'27'25" 08068000 W Fk San Jacinto Rv near Conroe, TX 30'20'11" <td></td> <td>07311790</td> <td>Wichita Du poor Depiamin, TX</td> <td>22,22,10</td> <td>00°48'02"</td>		07311790	Wichita Du poor Depiamin, TX	22,22,10	00°48'02"
0311200 Wichita Rv near Mabelle, TX 33*45'36" 99'08'33" 0731200 Wichita Rv near Mabelle, TX 33*45'36" 99'08'33" 0731200 Wichita Rv near Mabelle, TX 33*45'36" 99'08'33" 0731200 Wichita Rv near Charlie, TX 34'03'11" 98'32'00" 07312700 Wichita Rv near Charlie, TX 34'03'11" 98'17'47" Sabine 08018500 Sabine Rv near Gladewater, TX 32'36'49" 95'29'08" 0802000 Sabine Rv near Gladewater, TX 32'31'37" 94'57'36" 0802800 08028000 Sabine Rv near Bon Wier, TX 32'19'38" 94'21'12" 0802800 08028000 Sabine Rv near Bon Wier, TX 30'44'49" 93'36'30" San Antonio Nueces 08189300 Medio Ck near Beeville, TX 28'28'58" 97'39'23" 08189300 Medio Ck near Beeville, TX 28'28'58" 97'39'23" 08'27'25" 08189300 W Fk San Jacinto Rv near Conroe, TX 30'14'40" 95'27'25" 08068000 Cypress Ck at Grant Rd near Cypress, TX 29'58'24" 95'35'54" Sulphur		07311800	Wichita Ry near Soymour, TY	22°42'01"	00°22'19"
07312500 Wichita RV at Wichita Falls, TX 33 *0 3 30 90 *03 33 07312500 Wichita RV at Wichita Falls, TX 33 *04 '34'' 98 *32 00" 07312700 Wichita RV near Charlie, TX 34 *03 '11" 98 *32 00" 08018500 Sabine RV near Gladewater, TX 32 *36 '49" 95 *29 08" 08020000 Sabine RV near Gladewater, TX 32 *31 '37" 94 *57 '36" 08020000 Sabine RV near Gladewater, TX 32 *19 '38" 94 *21 '12" 08020000 Sabine RV near Beckville, TX 32 *19 '38" 94 *21 '12" 08020000 Sabine RV near Bon Wier, TX 32 *19 '38" 94 *21 '12" 08028500 Sabine RV near Bon Wier, TX 32 *21 '32" 94 *21 '12" 08028500 Sabine RV near Bon Wier, TX 28 *28 '58" 97 *39 '23" San Jacinto 08189300 Medio Ck near Beeville, TX 28 *28 '58" 97 *39 '23" San Jacinto 08068000 W Fk San Jacinto RV near Conroe, TX 30 *0 '14 '40" 95 *27 '25" 08068000 W Fk San Jacinto RV near Cleveland, TX 30 *20 '11" 95 *0 5'54' 08068000 Cypress Ck at Grant Rd near Cypress, TX 29 *5 *4 '50" 95		07311300	Wichita Ry near Mahollo, TY	22°4E'26"	00°09'22"
07312300 Wichita Rv near Charlie, TX 35 39.4 35 32.00 07312700 Wichita Rv near Charlie, TX 34'03'11" 98'17'47" Sabine 08018500 Sabine Rv near Gladewater, TX 32'31'37" 94'57'36" 08022040 Sabine Rv near Gladewater, TX 32'31'37" 94'57'36" 08022040 08022040 Sabine Rv near Beckville, TX 32'19'38" 94'21'12" 08028500 Sabine Rv near Bon Wier, TX 32'19'38" 94'21'12" 08028500 Sabine Rv near Bon Wier, TX 32'19'38" 94'21'12" 08028500 Sabine Rv near Bon Wier, TX 32'19'38" 97'39'23" 08189300 Medio Ck near Beeville, TX 28'28'58" 97'39'23" 08189500 Mission RV at Refugio, TX 28'17'30" 97'16'44" San Jacinto		07312100	Wichita Ry near Wighta Falls, TX	33 43 30 22°E 4'24"	99 08 33 08°33'00"
Sabine 96 17 47 97 10 31 40 96 17 47 Sabine 00011700 10011700 10011700 10011700 Sabine 08018500 Sabine Rv near Mineola, TX 32°36'49" 95°29'08" 08020000 Sabine Rv near Gladewater, TX 32°31'37" 94°57'36" 08028'00" 08022040 Sabine Rv near Beckville, TX 32°19'38" 94'21'12" 08028000 Sabine Rv near Bon Wier, TX 32°19'38" 94'21'12" 08028000 Sabine Rv near Bon Wier, TX 32°19'38" 94'21'12" 08028000 Sabine Rv near Bon Wier, TX 32°19'38" 97'39'23" 08189300 Medio Ck near Beeville, TX 28°17'30" 97'16'44" San Jacinto		07312300	Wichita Ry poor Charlie, TV	2102111	00°17'47"
John 08018500 Sabine Rv near Mineola, TX 32°36'49" 95°29'08" 08018500 Sabine Rv near Gladewater, TX 32°31'37" 94°57'36" 0802000 Sabine Rv near Gladewater, TX 32°11'38" 94°21'12" 0802000 Sabine Rv near Beckville, TX 32°19'38" 94°21'12" 08028500 Sabine Rv near Bon Wier, TX 30°44'49" 93°36'30" San Antonio Nueces 08189300 Medio Ck near Beeville, TX 28°28'58" 97°39'23" 08189500 Mission RV at Refugio, TX 28°17'30" 97°39'23" 08189500 Mission RV at Refugio, TX 28°17'30" 95°27'25" 08068090 W Fk San Jacinto Rv near Conroe, TX 30°14'40" 95°27'25" 08068090 W Fk San Jacinto Rv near Cleveland, TX 30°05'09" 95°35'4" 08070000 E Fk San Jacinto Rv near Cleveland, TX 30°05'09" 95°35'4" 0807000 C Ypress Ck at Grant Rd near Cypress, TX 30°05'20" 95°35'4" 07342480 Middle Sulphur Rv at Commerce, TX 33°12'42" 95°35'4'50" 07342500 S Sulphur Rv near Coope	Sahine	0/312/00		54 05 11	56 17 47
Sold Sold Sabine RV near Minetola, IX 32 3049 32 313" 94"53'6" 08020000 Sabine RV near Gladewater, TX 32"31'3" 94"51'6" 08020000 Sabine RV near Beckville, TX 32"31'3" 94"51'6" 08020000 Sabine RV near Bon Wier, TX 30"44'49" 93"36'30" San Antonio Nueces 08189300 Medio Ck near Beeville, TX 28"28"58" 97"39'23" 08189500 Mission RV at Refugio, TX 28"21"30" 97"39'23" 08189500 Mission RV at Refugio, TX 28"17"30" 97"39'23" 08189500 W K San Jacinto RV near Conroe, TX 30"14'40" 95"27'25" 08068000 W Fk San Jacinto RV near Cleveland, TX 30"20'11" 95"06'14" 08070000 E Fk San Jacinto RV near Cleveland, TX 30"20'11" 95"06'14" 08070000 E Fk San Jacinto RV near Cleveland, TX 30"2'14'40" 95"35'4" Sulphur 07342480 Middle Sulphur RV at Commerce, TX 33"15'59" 95"54'55" 07342500 S Sulphur RV near Cooper, TX 33"17'40" 96"28'58" 08051500 E Fk Trinity RV	Jabine	09019500	Sabina Pungar Mingola, TV	22°26'40"	05°20'09"
0002000 Sabine RV near Beckville, TX 32*19'3" 94*2112" 0802000 Sabine RV near Beckville, TX 32*19'3" 94*2112" 08028500 Sabine RV near Bon Wier, TX 30*44'49" 93*36'30" San Antonio Nueces 08189300 Medio Ck near Beeville, TX 28*28'58" 97*39'23" San Jacinto 08189300 Medio Ck near Beeville, TX 28*28'58" 97*39'23" San Jacinto 08189300 Medio Ck near Beeville, TX 28*28'58" 97*39'23" San Jacinto 08189300 Wek San Jacinto RV near Conroe, TX 30*14'40" 95*27'25" 08068000 W Fk San Jacinto RV near Cleveland, TX 30*05'09" 95*17'59" 08070000 E Fk San Jacinto RV near Cleveland, TX 30*02'011" 95*06'14" 0806800 Cypress Ck at Grant Rd near Cypress, TX 29*58'24" 95*35'55" Sulphur 07342480 Middle Sulphur Rv at Commerce, TX 33*12'42" 95*54'55" 07342465 S Sulphur Rv near Cooper, TX 33*12'42" 95*35'41" Trinity - - - - <tr< td=""><td></td><td>08020000</td><td>Sabine Ry near Gladewater, TY</td><td>32 30 45</td><td>94°57'36"</td></tr<>		08020000	Sabine Ry near Gladewater, TY	32 30 45	94°57'36"
Observation Stability of the able decivitie, fX Stability of fX St		08020000	Sabine Ry near Beckville, TX	32°10'38"	9/°21'12"
San Antonio Nueces So 30 30 30 10 10 10 10 10 10 10 10 10 10 10 10 10		08022040	Sabine Ry near Ben Wier, TX	20°44'40"	02°26'20"
San Antonio Notects 08189300 Medio Ck near Beeville, TX 28°28'58" 97°39'23" 08189500 Mission RV at Refugio, TX 28°17'30" 97°16'44" San Jacinto 08068000 W Fk San Jacinto Rv near Conroe, TX 30°14'40" 95°27'25" 08068000 W Fk San Jacinto Rv near Conroe, TX 30°14'40" 95°27'25" 08068000 W Fk San Jacinto Rv near Cleveland, TX 30°05'09" 95°17'59" 0807000 E Fk San Jacinto Rv near Cleveland, TX 30°05'11" 95°65'4" Sulphur 07342480 Middle Sulphur Rv at Commerce, TX 33°15'59" 95°54'55" 07342480 Middle Sulphur Rv at Commerce, TX 33°15'59" 95°35'41" 07342500 S Sulphur Rv near Cooper, TX 33°12'42" 95°35'41" 07342500 S Sulphur Rv near Cooper, TX 33°17'40" 96°28'58" 08065100 Sister Grove Ck near Blue Ridge, TX 33°17'40" 96°28'58" 08065100 Sister Grove Ck near Blue Ridge, TX 33°17'40" 96°28'58" 08066100 White Rk Ck near Trinity, TX 31°03'06" 95°22'40"	San Antonio Nueces	08028300	Sabile RV field Bolt Wiet, TA	30 44 45	55 50 50
0305300 Mickilo K Neal DCEVINE, IX 20 20 0 57 35 25 08189500 Mission RV at Refugio, TX 28 17'30" 97*16'44" San Jacinto 08068000 W Fk San Jacinto Rv near Conroe, TX 30°14'40" 95*27'25" 08068000 W Fk San Jacinto Rv near Conroe, TX 30°05'09" 95*17'59" 0807000 E Fk San Jacinto Rv near Cleveland, TX 30°05'09" 95*17'59" 0807000 E Fk San Jacinto Rv near Cleveland, TX 30°05'09" 95*35'4" 0806800 Cypress Ck at Grant Rd near Cypress, TX 29*58'24" 95*35'54" 07342480 Middle Sulphur Rv at Commerce, TX 33°15'59" 95*54'55" 07342500 S Sulphur Rv near Cooper, TX 33°12'42" 95*35'4" 07342500 S Sulphur Rv near Cooper, TX 33°17'40" 96*28'58" 08065100 E Fk Trinity Rv near Forney, TX 33°17'40" 96*28'58" 08066100 White Rk Ck near Trinity, TX 31'03'06" 95*22'40" 08065100 Trinity Rv near Forney, TX 33°02'7" 96*30'12" 08066100 White Rk Ck near Trinity, TX 3	San Antonio Nueces	08180300	Medio Ck near Beeville, TX	28°28'58"	07°20'22"
San Jacinto Distributive at Religity, FX Distributive at Religity, FX Distributive at Religity, FX San Jacinto 08068000 W Fk San Jacinto Rv near Conroe, TX 30°14'40" 95°27'25" 08068000 W Fk San Jacinto Rv near Conroe, TX 30°05'09" 95°17'59" 08070000 E Fk San Jacinto Rv near Cleveland, TX 30°20'11" 95'06'14" 0806800 Cypress Ck at Grant Rd near Cypress, TX 29'82'4" 95'35'4" Sulphur 07342480 Middle Sulphur Rv at Commerce, TX 33°12'42" 95'54'55" 07342405 S Sulphur Rv at Commerce, TX 33°12'12" 95'35'4" 07342500 S Sulphur Rv near Cooper, TX 33°17'40" 96'28'58" 08061750 E Fk Trinity Rv near Forney, TX 33°17'40" 96'28'58" 08065000 Trinity Rv near Forney, TX 33°17'40" 96'28'58" 08051130 Elm Fk Trinity Rv near Pilot Point, TX 33'01'1" 97'02'49" 08052100 Elm Fk Trinity Rv near Pilot Point, TX 33'02'1'1" 97'02'49" 08052000 Elm Fk Trinity Rv near Lewisville, TX 33'02'4" 96'57'39"		08189500	Mission RV at Refugio TX	28°17'30"	97°16'44"
O8068000 W Fk San Jacinto Rv near Conroe, TX 30°14'40" 95°27'25" 08068000 W Fk San Jacinto Rv near Conroe, TX 30°05'09" 95°17'59" 0806800 E Fk San Jacinto Rv near Cleveland, TX 30°05'09" 95°17'59" 08070000 E Fk San Jacinto Rv near Cleveland, TX 30°20'11" 95°06'14" 0806800 Cypress Ck at Grant Rd near Cypress, TX 29°58'24" 95°35'54" Sulphur 07342480 Middle Sulphur Rv at Commerce, TX 33°15'59" 95°54'55" 07342465 S Sulphur Rv at Commerce, TX 33°12'42" 95°54'55" 07342500 S Sulphur Rv near Cooper, TX 33°17'40" 96°28'54'50" 07342500 S Sulphur Rv near Cooper, TX 33°17'40" 96°28'58" 08061750 E Fk Trinity Rv near Forney, TX 33°17'40" 96°28'58" 08066100 White Rk Ck near Trinity, TX 31°03'05" 95°22'40" 08066100 Trinity Rv near Point, TX 33°02'44" 96°57'39" 08061130 Elm Fk Trinity Rv near Pilot Point, TX 33°02'44" 96°57'39" 08062500 Trinity Rv near Rosser, TX	San Jacinto	00105500	Nilssion in at herugio, ix	20 17 50	57 10 44
08068090 W Fk San Jacinto Rv above like (vs. rk 30 "14"0" 50 21 * 15" 08068090 W Fk San Jacinto Rv above like Houston near Porter, TX 30"05"09" 95"17"59" 0807000 E Fk San Jacinto Rv above like Houston near Porter, TX 30"05"09" 95"35"54" 08068090 Cypress Ck at Grant Rd near Cypress, TX 29"58"24" 95"35"54" 07342480 Middle Sulphur Rv at Commerce, TX 33"12"42" 95"54"55" 07342405 S Sulphur Rv at Commerce, TX 33"12"42" 95"54"55" 07342500 S Sulphur Rv at Commerce, TX 33"17"40" 96"28"58" 08059400 Sister Grove Ck near Blue Ridge, TX 33"17"40" 96"28"58" 08059400 Sister Grove Ck near Blue Ridge, TX 33"17"40" 96"28"58" 08059400 Sister Grove Ck near Blue Ridge, TX 33"17"40" 96"28"58" 08056100 White Rk Ck near Trinity, TX 31"03"06" 95"22"24" 080661000 Trinity Rv near Pilot Point, TX 33"21"01" 97"02"49" 08051300 Elm Fk Trinity Rv near Pilot Point, TX 33"02"44" 96"57"39" 08062500 <t< td=""><td>Surfacilito</td><td>08068000</td><td>W Ek San Jacinto By near Conroe, TX</td><td>30°14'40"</td><td>95°77'75"</td></t<>	Surfacilito	08068000	W Ek San Jacinto By near Conroe, TX	30°14'40"	95°77'75"
08050000 FK San Jacinto Rv near Cleveland, TX 30'00'11" 95'06'14" 08050000 E FK San Jacinto Rv near Cleveland, TX 30'20'11" 95'06'14" 08068000 Cypress Ck at Grant Rd near Cypress, TX 29'58'24" 95'35'54" Sulphur 07342480 Middle Sulphur Rv at Commerce, TX 33°15'59" 95'54'55" 07342465 S Sulphur Rv at Commerce, TX 33°12'42" 95'854'50" 07342500 S Sulphur Rv at Commerce, TX 33°12'42" 95'854'50" 07342500 S Sulphur Rv near Cooper, TX 33°17'40" 96'28'58" 08059400 Sister Grove Ck near Blue Ridge, TX 33°17'40" 96'28'58" 08051750 E Fk Trinity Rv near Forney, TX 32°46'27" 96'30'12" 08066100 White Rk Ck near Trinity, TX 31'03'06" 95'22'40" 080617500 E Fin Trinity Rv near Pilot Point, TX 33°03'27" 94'49'05" 08051300 Elm Fk Trinity Rv near Pilot Point, TX 33'02'4" 96'57'39" 08052500 Trinity Rv near Rosser, TX 33'02'4" 96'57'39" 08062500 Tinity Rv near Rosser, TX		08068090	W Ek San Jacinto Ry above Lk Houston near Porter TX	30°05'09"	95°17'50"
0805000 E1H sain Jackino IX Incluice Celevising, IX 30 2011 30 0014 08068800 Cypress Ck at Grant Rd near Cypress, TX 29*58*24" 95*35*54" Sulphur 07342480 Middle Sulphur Rv at Commerce, TX 33*15*59" 95*35*54*55" 07342405 S Sulphur Rv at Commerce, TX 33*12*42" 95*35*455" 07342500 S Sulphur Rv near Cooper, TX 33*12*123" 95*35*41" Trinity 08059400 Sister Grove Ck near Blue Ridge, TX 33*17*40" 96*28*58" 08066100 E Fk Trinity Rv near Forney, TX 32*46*27" 96*30*12" 08066100 White Rk Ck near Trinity, TX 31*03*06" 95*22*40" 08067000 Trinity Rv near Forney, TX 33*01*11" 97*02*49" 08065130 Elm Fk Trinity Rv near Pilot Point, TX 33*02*12" 94*49'05" 08061300 Elm Fk Trinity Rv near Pilot Point, TX 33*02*41" 96*5739" 08062500 Trinity Rv near Rosser, TX 32*25*35" 96*27*46" 08065200 Trinity Rv near Goodrich, TX 32*25*35" 96*27*46"		08070000	E Ek San Jacinto Ry near Cleveland TX	30°20'11"	95°06'14"
Sulphur D3000000 Cypless ck at Grant to hear Cypless, FX D3004 D3004 07342480 Middle Sulphur Rv at Commerce, TX 33°15'59" 95°54'55" 07342405 S Sulphur Rv at Commerce, TX 33°12'42" 95°54'55" 07342500 S Sulphur Rv near Cooper, TX 33°12'42" 95°54'50" 07342500 S Sulphur Rv near Cooper, TX 33°17'40" 96°28'58" 08059400 Sister Grove Ck near Blue Ridge, TX 33°17'40" 96°28'58" 08061750 E Fk Trinity Rv near Forney, TX 32°46'27" 96°30'12" 08066100 White Rk Ck near Trinity, TX 31°03'06" 95°22'40" 08067000 Trinity Rv near Pilot Point, TX 33°01'27" 94°49'05" 0805130 Elm Fk Trinity Rv near Pilot Point, TX 33°02'44" 96°57'39" 08065200 Trinity Rv near Rosser, TX 32°25'53" 96°27'46" 08065200 Trinity Rv near Goodrich, TX 32°25'54" 96°27'46"		08068800	Cypress Ck at Grant Rd pear Cypress TX	20°58'24"	95°35'54"
O7342480 Middle Sulphur Rv at Commerce, TX 33°15'59" 95°54'55" 07342465 S Sulphur Rv at Commerce, TX 33°12'42" 95°54'55" 07342500 S Sulphur Rv near Cooper, TX 33°12'42" 95°54'50" 07342500 S Sulphur Rv near Cooper, TX 33°21'23" 95°35'41" Trinity 08059400 Sister Grove Ck near Blue Ridge, TX 33°17'40" 96°28'58" 08061050 E Fk Trinity Rv near Forney, TX 32°46'27" 96°30'12" 08066100 White Rk Ck near Trinity, TX 31'03'06" 95'22'40" 08067000 Trinity Rv near Forney, TX 30'03'27" 94'49'05" 08067000 Trinity Rv near Pilot Point, TX 33°21'01" 97'02'49" 08053000 Elm Fk Trinity Rv near Lewisville, TX 33'02'44" 96'57'39" 08065200 Trinity Rv near Rosser, TX 32'25'5" 96'27'46" 08065200 Trinity Rv near Goodrich, TX 32'25'5" 96'27'46"	Sulphur	00000000	cypress ex at Grant No near cypress, TX	25 38 24	55 55 54
07342465 S Sulphur Rv at Commerce, TX 33°12'42' 95°34'50" 07342650 S Sulphur Rv at Commerce, TX 33°12'42' 95°35'41" Trinity 08059400 Sister Grove Ck near Blue Ridge, TX 33°17'40" 96°28'58" 08061750 E Fk Trinity Rv near Forney, TX 33°17'40" 96°30'12" 08066100 White Rk Ck near Trinity, TX 31°03'05" 95°22'40" 08066100 Trinity Rv near Forney, TX 30°03'27" 94°49'05" 08067000 Trinity Rv near Pilot Point, TX 33°21'01" 97°02'49" 08053000 Elm Fk Trinity Rv near Pilot Point, TX 33°21'44" 96°57'39" 08062500 Trinity Rv near Rosser, TX 32°2'55" 96°27'46" 080662500 Trinity Rv near Goodrich, TX 32°2'55" 96°27'46"	Sulphul	07342480	Middle Sulphur Ry at Commerce, TX	33°15'59"	95°54'55"
Orbitation Display to the decommence, it is an analysis of the decommence		07342465	S Sulphur Ry at Commerce TX	33°12'42"	95°54'50"
Trinity Display in the field copyright of the copyright in the copyr		07342500	S Sulphur Ry near Cooper TX	33°21'23"	95°35'41"
08059400 Sister Grove Ck near Blue Ridge, TX 33°17'40" 96°28'58" 08061750 E Fk Trinity Rv near Forney, TX 32°46'27" 96°30'12" 08066100 White Rk Ck near Trinity, TX 31°03'06" 95°22'40" 08067000 Trinity Rv at Liberty, TX 30°03'27" 94°49'05" 08501130 Elm Fk Trinity Rv near Pilot Point, TX 33°21'01" 97'02'49" 08062500 Elm Fk Trinity Rv near Lewisville, TX 33°02'44" 96°57'39" 08062500 Trinity Rv near Goodrich, TX 32°25'35" 96°27'46" 08066520 Trinity Rv near Goodrich, TX 30°3'24"9" 96°27'46"	Trinity	07342300		55 21 25	55 55 41
08051750 E K Trinity Rv near Forney, TX 32*46'27" 96*30'12" 08061700 E K Trinity Rv near Forney, TX 31°03'06" 95*22'40'' 08066100 White Rk Ck near Trinity, TX 31°03'06" 95*22'40'' 08066100 Trinity Rv at Liberty, TX 30°03'27" 94*49'05" 0805000 Trinity Rv near Pilot Point, TX 33*21'01" 97*02'49" 08053000 Elm Fk Trinity Rv near Lewisville, TX 33*02'44" 96*57'39" 08065500 Trinity Rv near Goodrich, TX 32*25'5" 96*27'46" 08065200 Trinity Rv near Goodrich, TX 30*2*25'5" 96*27'46"		08059400	Sister Grove Ck near Blue Bidge, TX	33°17'/0"	96°28'58"
0000170 ETR Timity Renear Trinity, TX 32 '027 90 '50 '12 0806100 White RK Ck near Trinity, TX 31'03'06'' 95'22'40'' 08067000 Trinity Rv near Pilot Point, TX 30'03'27'' 94'49'05'' 08051130 Elm Fk Trinity Rv near Pilot Point, TX 33'21'01'' 97'02'49'' 0805200 Trinity Rv near Lewisville, TX 33'02'44'' 96'57'39'' 08062500 Trinity Rv near Goodrich, TX 32'22'55'' 96'27'46'' 08066250 Trinity Rv near Goodrich, TX 32'26''55'' 96''27'46''		08061750	E Ek Trinity Ry near Forney TY	32°46'27"	96°30'12"
0000100 Trinity Rv at Liberty, TX 30°03'27" 94°49'05" 08067000 Trinity Rv at Liberty, TX 30°03'27" 94°49'05" 08501130 Elm Fk Trinity Rv near Pilot Point, TX 33°21'01" 97°02'49" 08053000 Elm Fk Trinity Rv near Lewisville, TX 33°02'44" 96°57'39" 08062500 Trinity Rv near Rosser, TX 32°25'35" 96°27'46" 08066250 Trinity Rv near Goodrich, TX 30°3'4'19" 94°4°6'55"		08066100	White Bk Ck near Trinity, TX	31°03'06"	95°22'40"
08007000 Timity Rv near Pilot Point, TX 33°21'01" 94'49'05 08501130 Elm Fk Trinity Rv near Pilot Point, TX 33°21'01" 97°02'49" 08053000 Elm Fk Trinity Rv near Lewisville, TX 33°02'44" 96°57'39" 08062500 Trinity Rv near Rosser, TX 32°25'35" 96°27'46" 08066250 Trinity Rv near Goodrich, TX 30°3'4'19" 94°27'46"		08067000	Trinity Ry at Liberty TX	30°03'27"	94°49'05"
08051300 Elm Fk Trinity Rv near Lewisville, TX 33 2021 97 0249 0805200 Elm Fk Trinity Rv near Lewisville, TX 33 °02'44" 96°57'39" 08062500 Trinity Rv near Rosser, TX 32 °25'35" 96°27'46" 08066250 Trinity Rv near Goodrich, TX 30 °34'19" 94°57'54"		08501120	Elm Ek Trinity Ry near Pilot Point TY	33°21'01"	97°02'49"
08062500 Trinity Rv near Rosser, TX 33 0244 96 37 39 08062500 Trinity Rv near Rosser, TX 32°25'35" 96°27'46" 08066250 Trinity Rv near Goodrich, TX 30°34'19" 94°5'46"		08053000	Elm Ek Trinity Ry near Lewisville TY	33°02'44"	96°57'39"
08066250 Trinity Ry near Goodrich. TX 30°34'19" 94°56'55"		08062500	Trinity Ry near Rosser TX	32°25'35"	96°27'46"
		08066250	Trinity Ry near Goodrich TY	30°34'19"	94°56'55"

Figure 8 provides an example of the hydraulic properties between two gages and several rating curves within the Brazos River Basin for adjacent locations on the same river segment.



Figure 8. Width, area and mean channel velocity comparisons for two gages and different rating curves in the Brazos River Basin.

Figure 9 provides an example of the hydraulic properties between two gages and several rating curves within the San Jacinto River Basin for adjacent locations on the same river segment.



Figure 9. Width, area and mean channel velocity comparisons for two gages and different rating curves in the San Jacinto River Basin.

These results are indicative of the comparative analyses conducted between paired gage locations delineated in Table 1 and Appendix A. The results for all eleven drainages and gages indicated in Table 1 are provided in Appendix B (electronically).

The analyses illustrated in Figures 8 and 9 and in total in Appendix B clearly show that the at-astation hydraulic properties vary considerably for a given gage location and as would be expected vary with spatial location even on the same river segment within all the basins. The results in these figures (and all sites examined) show that the most consistent at-a-station relationships over time are in channel cross sectional area and that both channel width and mean channel velocity relationships have a high degree of variation over time. It is noted that gage locations are typically characterized as 'run habitats' versus riffles or pools which are included in most instream flow assessments. The potential to utilize the at-a-station hydraulic properties to extrapolate to average reach conditions is likely problematic not only due to the variability at a single location over time but also the variation apparent over adjacent stream reaches. It is recognized that the longitudinal comparisons are expected to be highly variable even within river segments located in the same Ecoregion given the distances between these gage locations.

The importance of understanding the potential limitations of utilizing the at-a-station hydraulic properties from gage locations to represent reach level conditions is apparent from the work of Rhodes (1977) discussed above and the analysis of the temporal variation in the hydraulic properties at specific gage locations (see Appendix B). This is further supported by an examination of the data presented in Figure 10 which shows the variation in cross section geometry and differences in both magnitude and characteristics of the velocity profiles in run, pool and riffle habitats simulated over a range of discharge from the Guadalupe River at Victoria. Note that gages are typically associated with "run" habitats and as illustrated in Figure 10, the two run habitats have radically different velocity profiles and magnitudes over the same range of simulated discharges. It is also apparent that the differences in channel morphology and velocity profile relationships between run versus pools versus riffles are indicative of all the Senate Bill 2 study data sets examined.

Implications on reach level habitat versus discharge relationships

It is well known that the most sensitive factor in the calculation of potential habitat for target species and life stages is the habitat suitability for velocity. The results highlighted above clearly show that there is a large degree of variability between gage locations (i.e., runs) and the corresponding differences associated with other mesohabitat types such as riffles and pools within the same longitudinal expanse of a river reach. It would appear that finding some rational relationship to expand the at-a-station hydraulic properties to represent reach level conditions is not likely to be feasible (see Figures 6 and 10).



Figure 10. Channel morphology variation between run, pool, and riffle habitat and associated simulated velocity profiles as a function of discharge.

Other alternative approaches are likely more fruitful for future research. For example Lamouroux et al., (1995), Lamouroux (1998), and Saraeva and Hardy (2009) demonstrated that reach level distributions of depth and velocity as a function of discharge could be derived from channel shape factors. Given the more extensive availability of one meter DEM derived from LIDAR in support of Senate Bill 2 instream flow investigations, there is likely sufficient data within selected river basins where these later approaches might prove viable. The author is currently involved in a research project to evaluate use of channel shape parameters derived from high resolution DEMs over 40 miles of the Trinity River in California where eleven study sites have calibrated and validated two-dimensional hydrodynamic models. Similar efforts should be considered where high resolution DEMs are available that overlap with existing Senate Bill 2 study sites where 2-dimensional hydrodynamic models are available covering a range of different mesohabitats (i.e., run, pool, riffles).

Summary and Conclusions

Examination of at-a-station hydraulic properties from a theoretical and empirical basis shows little promise of using these data from gage locations to adequately represent reach average conditions to support a rapid assessment of fisheries habitat. The variation in at-a-station

hydraulic properties, especially the relationship in velocity varies widely over time at specific locations as evidenced by the comparison of rating curve properties at numerous gages. Evaluations of existing instream flow study cross section data collected as part of Senate Bill 2, shows conclusively that the variation in channel morphology over even relative short stream reaches is highly variable and conditions within runs (i.e., gage locations) do not reflect either the magnitude nor characteristics of the velocity profiles with changing discharge within riffles and pools. The variation in the at-a-station hydraulic continuity equation exponents also suggest that formulating a rational 'translation' of properties using the gage values is not likely (i.e., see Figure 6. It would appear that alternative approaches such as Lamoroux et al., (1995), Lamoroux (1998) and Saraeva and Hardy (2009) may be more viable given the availability of high resolution DEM data over larger river reaches in combination with fine scale two-dimensional hydrodynamic models suitable for use by these later techniques.

References

- Aadland, L. P. 1993. Stream habitat types: their fish assemblages and relationship to flow. North American Journal of Fisheries Management 13:790-806.
- Addley, R.C. 1993. A mechanistic approach to modeling habitat needs of drift feeding salmonids. M.S. thesis, Utah State University, Logan, Utah.
- Annear, T., I. Chisholm, H. Beecher, A. Locke, and 12 other authors. 2004. Instream flows for riverine resource stewardship, revised edition. Instream Flow Council, Cheyenne, WY.
- Baltz, D.M., B. Vondracek, L.R. Brown, and P.B. Moyle. 1991. Seasonal changes in microhabitat selection by rainbow trout in a small stream. Transactions of the American Fisheries Society 120:166-176.
- Bain MB, Finn JT, Booke HE. 1988. Streamflow regulation and fish community structure. Ecology 69: 382–392.
- BIO-WEST, Inc. 2008. Lower Colorado River, Texas instream flow guidelines Colorado River flow relationships to aquatic habitat and state threatened species: blue sucker. Report for the Lower Colorado River Authority and San Antonio Water System. <u>http://www.lcra.org/library/media/public/docs/lswp/findings/BIO_LSWP_IFguidelines_F</u> <u>INAL.pdf</u>
- Bowen, Z. H., M. C. Freeman, and K. D. Bovee. 1998. Evaluation of generalized habitat criteria for assessing impacts of regulated flow regimes on warmwater fishes. Transactions of the American Fisheries Society 127:455–468
- Brett, J. R. and N. R. Glass: 1973. Metabolic rates and critical swimming speeds of sockeye salmon (Oncorhynchus nerku) in relation to size and temperature. J. Fish. Res. Bd Can. 30, 379-387
- EPRI. 1986. Instream Flow Methodologies. Final Report, EA-4819 Research Project 2194-2. Electric Power Research Institute, Palo Alto, California.
- Gore, J.A., and J.M. Nestler. 1988. Instream flow studies in perspective. Regulated Rivers-Research and Management 2:93-101.

- Harby, A., M. Baptist, M.J. Dunbar, and S. Schmutz (editors). 2004. State-of-the-art in data sampling, modeling analysis and applications to river habitat modeling. COST Action 626 Report 313pp.
- Hardy, T.B. 1998. The Future of Habitat Modeling and Instream Flow Assessment Techniques. Regulated Rivers: Research and Management 14:405-420.
- Hynes, H. B. N. 1970. The ecology of running waters. Univ. Toronto Press. xxiv + 555 p.
- Jackson TA. 1992. Microhabitat utilization by juvenile chinook salmon (*Oncorhynchus tshawytscha*) in relation to stream discharge in the lower American River, California [MS thesis]. Oregon State University.
- Jowett, I.G. 1990. Factors related to the distribution and abundance of brown and rainbow trout in New Zealand clear-water rivers. New Zealand Journal of Marine and Freshwater Research 24:429-440.
- Jowett, I.G. 1992. Models of the abundance of large brown trout in New Zealand rivers. North American Journal of Fisheries Management 12:417-432.
- Jowett, I.G. 1998. Hydraulic geometry of New Zealand rivers and its use as a preliminary method of habitat assessment. Regulated Rivers-Research and Management 14:451-466.
- Kellerhals, R. and Church, M. 1989. 'The morphology of large rivers: characterization and management', in Dodge, D.P. (Ed), Proceedings of the International Large River Symposium, Can. Spec. Publ. Fish. Aquat. Sci., 106, 31–48.
- Kolberg, F. J. and Howard, A. D., 1995, Active channel geometry and discharge relations of U.S. piedmont and midwestern streams: The variable exponent model revisited. Water Resources Research, Vol. 31, No. 9, pp. 2353-2365.
- Lamouroux, N., Y. Souchon, and E. Herouin. 1995. Prediciting velocity frequency distributions in stream reaches. Water Resources Research, 31(8), 2367-2375.
- Lamouroux, N. 1998. Depth probability distributions in stream reaches. Journal of Hydraulic Engineering, 124(2), 224-227.
- Lamouroux, N., H. Capra, and M. Pouilly. 1998. Predicting habitat suitability for lotic fish: linking statistical hydraulic models with multivariate habitat use models. Regulated Rivers: Research and Managament, 14: 1-11.
- Leopold, L. B. and Maddock, T. J., 1953, Hydraulic geometry of stream channels and some physiographic implications. U. S. Geological Survey Professional Paper 252, 55 p.
- Maidment, D., Montagna, P., Sansom, A., Ward, G., Winemiller, K. (2005). Scientific Principles for Definition of Environmental Flows. Statement for Environmental Flows Conference, Texas State University, San Marcos, October 31.
- Modde, T. and T. B. Hardy. 1992. Influence of Different Microhabitat Criteria on Salmonid Habitat Simulation. Rivers: 3:1 37-44 pp.
- Mosley, M.P. 1992. 'River morphology', in Mosley, M.P. (Ed.), Waters of New Zealand, New Zealand Hydrological Society, Wellington. pp. 285–304.
- Nehring, R. B., and R. M. Anderson. 1993. Determination of population-limiting critical salmonid habitats in Colorado streams using the Physical Habitat Simulation system. Rivers 4: 1-19.
- NRC (2005). National Research Council. The science of instream flows A review of the Texas Instream Flow Program. Washington, D.C.: National Academy Press. 149pp.
- Osterkamp, W. R. and Hedman, E. R., 1982, Perennial-streamflow characteristics related to channel geometry and sediment in Missouri River basins. U. S. Geological Survey Professional Paper 1242, 37 pp., Washington, D. C.

- Park, C. C., 1977, World-wide variations in hydraulic geometry exponents of stream channels: An analysis and some observations. Journal of Hydrology, Vol. 33, pp. 133-146.
- Parker, G., 1979, Hydraulic geometry of active gravel rivers. Journal of Hydraulic Division, Proc. ASCE, Vol. 105, No. HY9, pp. 1185-1201.
- Phillips, P. J. and Harlin, J. M., 1984, Spatial dependency of hydraulic geometry exponents in a subalpine stream. Journal of Hydrology, Vol. 71, pp. 277-283.
- Poff, N.L., J.D. Allan, M.B. Bain, J.R. Karr, K.L. Prestegaard, B.D. Richter, R.E. Sparks, and J.C. Stromberg. 1997. The natural flow regime: a paradigm for river conservation and restoration. BioScience 47:769-784.
- Power, M. E., W. J. Matthews, and A. J. Stewart. 1985. Grazing minnows, piscivorous bass, and stream algae: dynamics of a strong interaction. Ecology 66:1448–1456.
- Reiser, D. W., Wesche, T. A., and Estes, C. 1989. 'Status of instream flow legislation and practices in North America', Fisheries, 14, 22–29.
- Richter, B. D., and G. A. Thomas. 2007. Restoring environmental flows by modifying dam operations. Ecology and Society 12(1): 12.
- Richter BD, Warner AT, Meyer JL, Lutz K. 2006. A collaborative and adaptive process for developing environmental flow recommendations. River Research and Applications 22: 297–318.
- Rhodes, D. D., 1977, The b-f-m diagram: Graphical representation and interpretation of at-astation hydraulic geometry. American Journal of Science, Vol. 277, pp. 73-96.
- Rhodes, D. D., 1978, World wide variations in hydraulic geometry exponents of stream channels: an analysis and some observations-Comments. Journal of Hydrology, Vol. 33, pp. 133-146.
- Saraeva, E. and T. Hardy. 2009. Prediction of fisheries physical habitat values based on hydraulic geometry and frequency distributions of depth and velocity. Intl. J. River Basin Management, Vol 7, No. 1 (2009), p. 31-41.
- Scheidegger KJ, Bain MB. 1995. Larval fish in natural and regulated rivers: assemblage composition and microhabitat use. Copeia 1995: 125–135
- Schlosser, I.J. 1982. Fish community structure and function along two habitat gradients in a headwater stream. Ecol. Monogr. 52: 395–414
- Schlosser, I. J., 1990. Environmental variation, life history attributes, and community structure in stream fishes: implications for environmental management and assessment. Environmental Management 14: 621–628.
- Shirvell, C. S. 1994. Effect of changes in streamflow on the microhabitat use and movements of sympatric juvenile coho (*Oncorhynchus kisutch*) and chinook salmon (*O. tshawytscha*) in a natural stream. Can. J. Fish. Aquat. Sci. 51:1644-1652.
- Science Advisory Committee [SAC]. 2009. Use of hydrologic data in the development of instream flow recommendations for the environmental flows allocation process and the Hydrology-Based Environmental Flow Regime (HEFR) Methodology. http://www.tceq.texas.gov/assets/public/permitting/watersupply/water_rights/eflows/hydr ologicmethods04202009.pdf
- Smith, J. J. and H. W. Li. 1983 Energetic factors influencing foraging tactics of juvenile steelhead trout, Salmo gairdneri. in Predators and Prey in Fishes. D. L. G. Noakes et al. (eds.). W. Junk Publishers, Netherlands. pp. 173-180

Sparks RE. 1992. Risks of altering the hydrologic regime of large rivers. Pages 119-152 in Cairns J, Niederlehner BR, Orvos DR, eds. Predicting ecosystem risk. Vol XX. Advances in modern environmental toxicology. Princeton (NJ): Princeton Scientific Publishing Co.

Stalnaker, C., B.L. Lamb, J. Henriksen, K. Bovee, and J. Bartholow. 1995. A primer for IFIM. U.S. Department of Interior, Biological Report 29. 44 p.

Stanford JA, Ward JV, Liss WJ, Frissell CA, Williams RN, Lichatowich JA, Coutant CC. 1996. A general protocol for restoration of regulated rivers. Regulated Rivers 12: 391±413.

Statzner B, Higler B (1986) Stream Hydraulics as a Major Determinant of Benthic Invertebrate Zonation Patterns. Freshwat Biol 16: 127–139.

Tennant, D.L. 1976. Instream flow regimens for fish, wildlife, recreation, and related environmental resources, p. 359-373 In J.F. Osborn and C.H. Allman (Ed.). Instream flow needs. Vol. 2. American Fisheries Society, Western Division, Bethesda, Maryland.

Texas Instream Flow Program [TIFP]. 2008. Texas Instream Flow Studies: Technical Overview. Prepared by Texas Commission on Environmental Quality, Texas Parks and Wildlife Department, and Texas Water Development Board. TWDB Report No. 369, Austin, Texas.

http://www.twdb.state.tx.us/publications/reports/GroundWaterReports/GWReports/R369 InstreamFlows.pdf.

- Vannote, R. L., G. W. Minshall, K. W. Cummings, J. R. Sedell, and C. E. Cushing. 1980. The River Continuum Concept. Canadian Journal of Fisheries and Aquatic Sciences 37: 130-137.
- Ward, J.V. 1989. The four-dimensional nature of lotic ecosystems. J. N. Am. Benthol. Soc. 8: 2-9.



Appendix A – Evaluated Gage Data by River Drainage

High Plains South Central Plains Southern Texas Plains Southwestern Tablelands Texas Blackland Prairies Western Gulf Coastal Plain



















Appendix B – Hydraulic Continuity Equations for Evaluated Gage Locations (Electronic)