Water Quality Modeling Lake Granbury

Espey Consultants, Inc.

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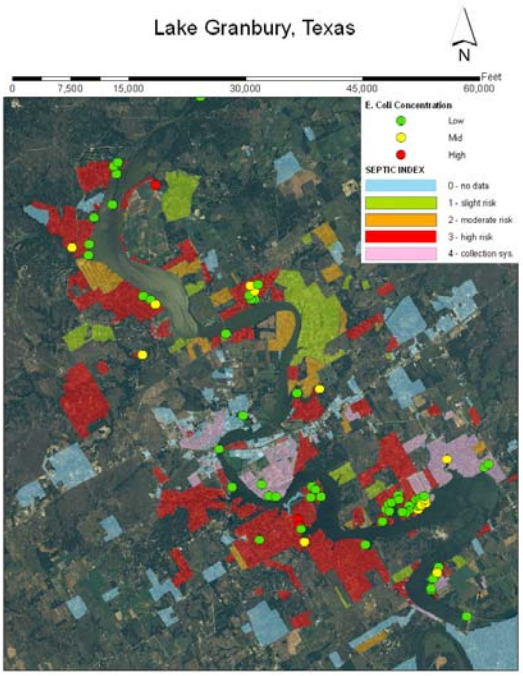
Presentation Outline

- Monitoring update
- Field work
- Model update
- Model parameter discussion
- Model sensitivity and alternatives analysis



E. Coli and DO Summary

				through December 2007						
				E. coli (MPN/100mL)				Dissolved Oxygen (DO, mg/L)		
					≥ 394	≥ 126	≥ 394		≤5	≤ 3
Site	Subdivision	Bank	Septic Index	N	25% exc.	gMean	Max	N	Average	Min
70031	Lake Country Acres - BR	<--		15	90	27	8664	15	8.28	6.21
70020	Long Creek	<--	3	15	294	172	2420	15	6.82	4.31
17930	Rolling Hills Shores	-->	3	42	27	13	770	29	4.11	0.63
17931	Rolling Hills Shores	-->	3	50	22	7	142	44	6.75	1.25
18004	Rolling Hills Shores	-->	3	63	58	24	2420	57	4.83	0.18
70010	Rolling Hills Shores	-->	3	19	92	24	1300	18	5.76	3.07
18005	The Live Oaks	-->	3	19	8	29	210	5	5.54	1.94
18006	Arrowhead Shores	-->	3	48	22	10	548	42	7.29	3.06
18007	Arrowhead Shores	-->	3	58	34	15	1733	52	7.34	2.9
70027	Arrowhead Shores - Robinson Creek	-->	3	15	273	83	921	15	6.68	4.46
18008	Oak Trail Shores	-->	3	65	114	39	2419	57	7.23	3.43
18009	Oak Trail Shores - Tee	-->	3	62	106	36	2420	55	6.71	1.43
18010	Oak Trail Shores - Tee	-->	3	64	210	83	2420	58	6.56	1.87
70028	Thorp Spring - Strouds Creek	-->		15	239	89	1120	15	7.12	4.47
11862	**Lake Granbury Segment 3**			**564**	**0**	**1**	**166**	**137**	**8.85**	**3.85**
18011	Sky Harbor	<--	3	50	52	27	1733	43	8.77	4.85
18012	Sky Harbor	<--	3	49	30	15	2419	42	8.97	4.99
18013	Sky Harbor	<--	3	54	66	26	2420	52	8.85	4.92
18014	Sky Harbor - Tributary	<--	3	58	101	66	2420	52	7.25	2.18
18015	Sky Harbor - Tributary	<--	3	58	260	122	2419	52	7.32	3.27
18016	Sky Harbor - Tributary	<--	3	59	136	54	2420	47	9.04	1.27
70021	Mallard Pointe	<--	2	15	98	19	261	15	8.77	6.45
70022	Mallard Pointe	<--	2	15	273	83	613	15	7.95	5.96
70019	Lambert Branch - COG	-->	OSCS	15	102	30	460	15	9.51	7.02
11861	**Lake Granbury Segment 2**			**757**	**0**	**1**	**261**	**139**	**8.85**	**3.52**

= less than 10 samples
= screening
= standard violation

E. Coli and DO Summary

Site	Subdivision	Bank	Septic Index	through December 2007 E. coli (MPN/100mL) N	≥ 394 25% exc.	≥ 126 gMean	≥ 394 Max	Dissolved Oxygen (DO, mg/L) N	≤5 Average	≤ 3 Min
70014	Rough Creek Cove	-->	3	15	43	11	249	15	9.09	6.34
90037	Rough Creek			6	1	2	5	3	7.75	7.17
90038	Rough Creek			6	2	5	7	3	6.99	5.94
90039	Rough Creek			5	6	5	11	7	9.18	6.95
18017	Waters Edge - COG WWTP	<--	OSCS	23	44	24	727	21	9.39	7.76
18018	Waters Edge - COG WWTP	<--	OSCS	38	73	26	1986	36	9.64	6.92
18019	Waters Edge	<--	OSCS	18	43	13	91	13	8.74	7.01
18020	Waters Edge	<--	OSCS	17	39	19	145	13	8.97	6.5
18021	Ports O' Call	-->	3	22	39	18	649	17	8.89	6.2
18022	Indian Harbor - Lagoon	-->	3	22	59	23	260	17	9.28	6.01
18023	Indian Harbor - Lagoon	-->	3	22	23	9	81	17	8.81	5.94
18024	Indian Harbor - Lagoon	-->	3	34	20	7	122	29	9.01	5.88
70015	Indian Harbor - Canal	-->	3	15	271	138	1414	15	8.82	5.03
70016	Indian Harbor - Canal	-->	3	15	342	165	1733	15	9.08	6.28
70017	Indian Harbor - Canal	-->	3	15	151	44	2420	15	9.46	6.72
70018	Indian Harbor - Canal	-->	3	14	135	72	435	14	8.49	6.12
18025	Holiday Estates	<--	3	64	77	26	1414	59	8.57	5.27
90030	Holiday Estates			14	36	16	66	14	8.60	6.23
90031	Holiday Estates			12	28	18	36	14	8.40	5.49
90033	Holiday Estates			12	19	8	26	14	7.65	4.88
90034	Holiday Estates			12	5	4	21	14	8.15	5.75
18026	Nassau Bay II	<--	3	26	27	20	2419	21	8.60	6.3
18027	Nassau Bay II	<--	3	26	29	16	770	21	8.43	5.45
18028	Nassau Bay II	<--	3	26	22	15	142	21	8.63	6.29
90029	Nassau Bay II	<--	3	29	88	40	921	28	8.76	5.91
18029	Sandy Beach	<--	3	27	118	37	2419	22	8.17	4.91
18030	Sandy Beach	<--	3	25	58	23	411	21	8.31	6.36
70023	Port Ridglea	<--	3	15	80	40	1120	15	9.47	7.24
70024	Port Ridglea	<--	3	15	169	55	613	15	9.21	7.05
70025	Port Ridglea	<--	3	15	55	34	727	15	9.02	6.98
70026	Port Ridglea	<--	3	15	57	35	488	15	8.95	5.64

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E. Coli and DO Summary

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18031	Port Ridglea East, West canals	<--	3	66	184	79	2420	59	8.39	5.54
18032	Port Ridglea East, West canals	<--	3	51	91	35	1553	42	8.18	5.68
18033	Port Ridglea East, West canals	<--	3	66	128	55	2420	59	8.10	5.19
18034	Port Ridglea East, West canals	<--	3	66	136	52	2419	59	7.79	4.21
18035	Port Ridglea East, West canals	<--	3	66	126	59	1120	59	7.86	4.52
18036	Port Ridglea East, West canals	<--	3	51	99	44	613	43	8.28	5.5
18037	Port Ridglea East, West canals	<--	3	66	143	64	921	58	8.36	5.81
18038	Port Ridglea East, East canals	<--	3	66	255	117	2400	59	8.33	4.89
18039	Port Ridglea East, East canals	<--	3	64	122	70	866	57	8.26	4.16
18040	Port Ridglea East, East canals	<--	3	50	96	49	687	43	8.36	5.73
18739	Canyon Creek Cove	-->	3	25	12	6	461	25	8.69	5.56
70029	DeCordova Bend Estates - Walnut Creek	<--	OSCS	15	163	117	770	15	9.91	5.92
18041	Lusk Branch	<--	OSCS	24	13	7	117	21	7.96	5.11
18042	Lusk Branch	<--	OSCS	21	22	13	613	21	7.70	4.82
90011	Lusk Branch			12	25	12	49	13	8.12	5.8
18043	Blue Water Shores, N	<--	OSCS	61	166	39	2420	55	8.63	5.36
18044	Blue Water Shores, N	<--	OSCS	60	260	52	2420	55	8.42	4.74
18738	Blue Water Shores, S	<--	OSCS	38	22	10	225	38	8.32	4.5
18740	Blue Water Shores, N	<--	OSCS	39	36	15	228	38	8.57	5.69
18741	Blue Water Shores, N	<--	OSCS	39	248	82	2420	38	8.24	4.58
18742	Blue Water Shores, S	<--	OSCS	25	30	12	86	24	8.60	6.06
11860	**Lake Granbury Segment 1**			**1004**	**0**	**1**	**326**	**119**	**8.49**	**3.91**
11863	Brazos River at US 281			21	48	25	579	21	8.63	5.45
11864	Brazos River at FM 4			24	19	12	133	23	9.15	4.53
13543	Brazos River at Dennis			74	3	24	517	73	8.36	4.24
13696	Brazos River at SH 16			3	11	9	172	6	9.57	4.23
16408	Palo Pinto Creek at FM 4			75	40	83	1203	72	7.74	2.72
18743	Brazos River Downstream of Allied Rock Mine			19	28	21	201	18	8.75	6.05
18744	Brazos River at I-20			20	32	21	345	22	8.73	6.57
18745	Brazos River Downstream of US 281			21	50	27	579	21	8.58	5.57
18746	Brazos River Upstream of US 281			18	44	25	1203	17	8.45	5.27
18747	Palo Pinto Creek 0.5mi West of confl with Br. R.			19	13	12	816	16	7.43	4.4
18749	Brazos River Downstream of Vulcan Rock Mine			15	33	28	272	17	8.52	6.05

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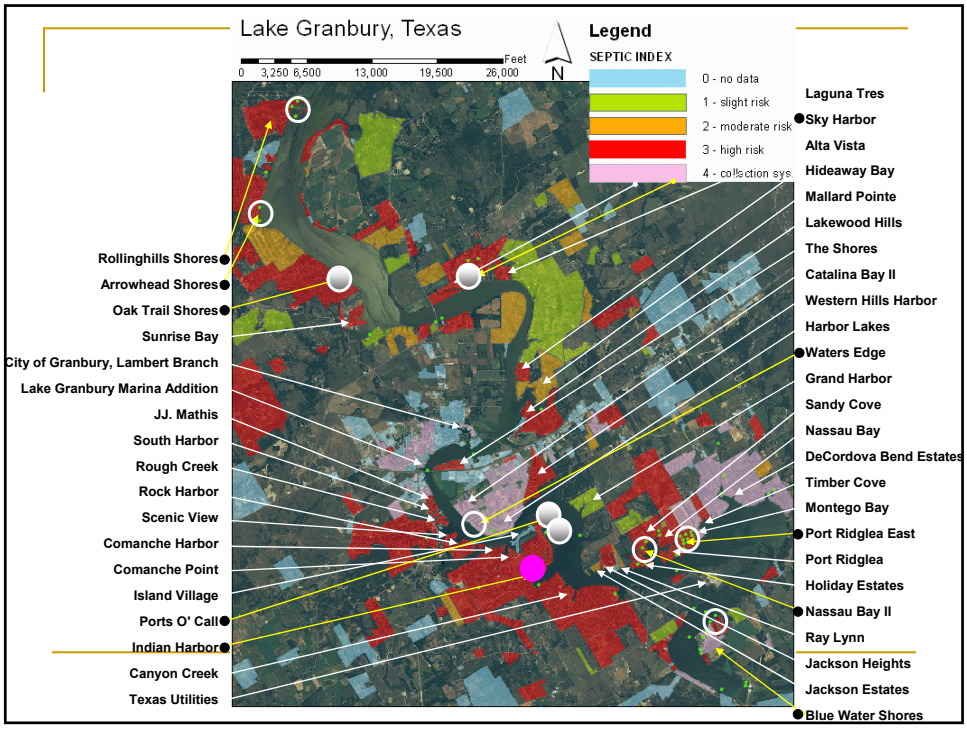
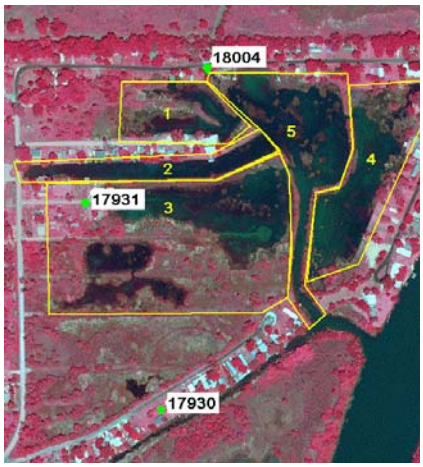
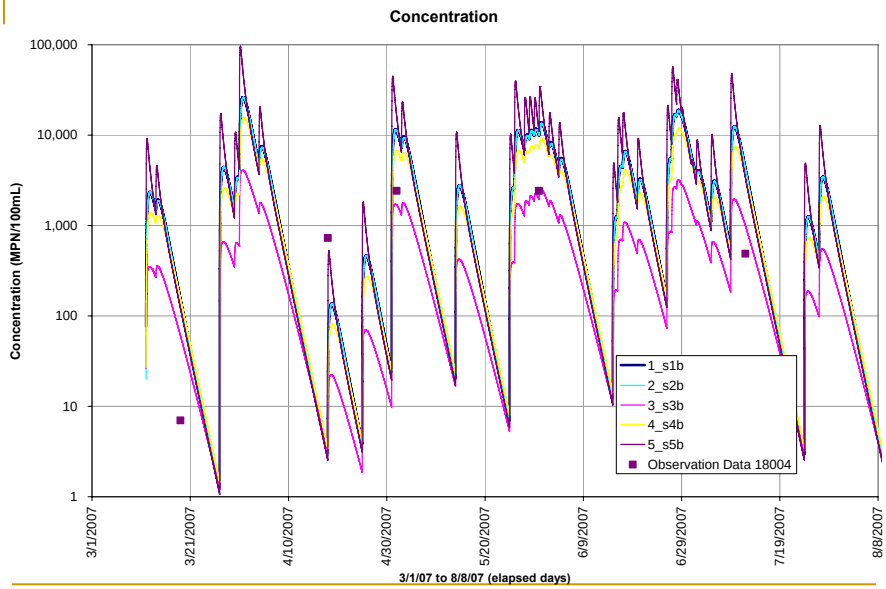


Rolling Hills Shores

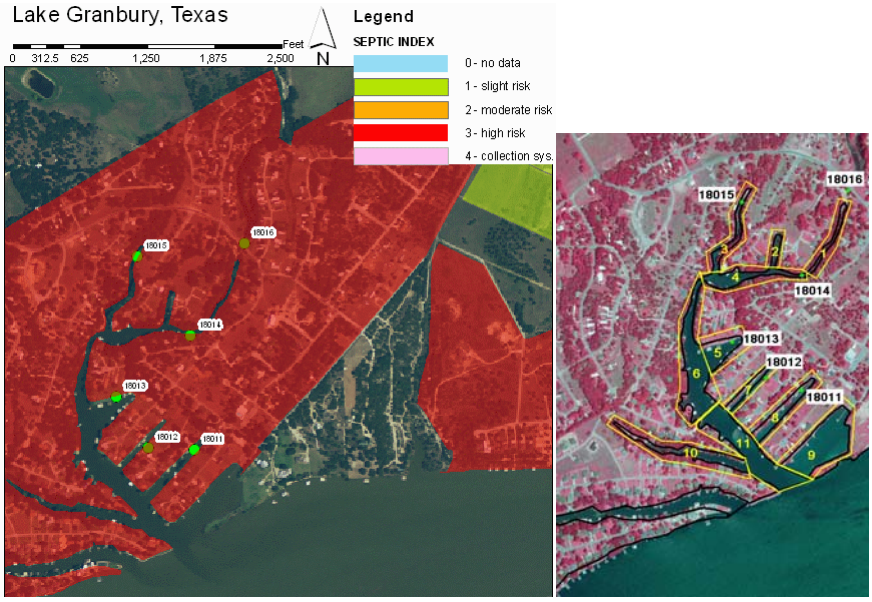


Rolling Hills Shores – assumed Non-Point Source based on observed rainfall



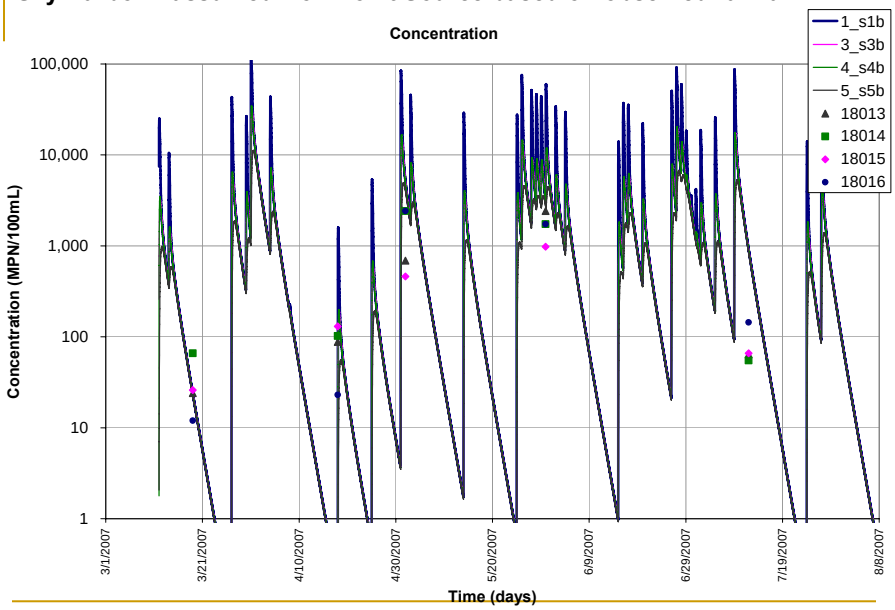
Bacteria concentration from NPS loading, using observed rainfall

Sky Harbor



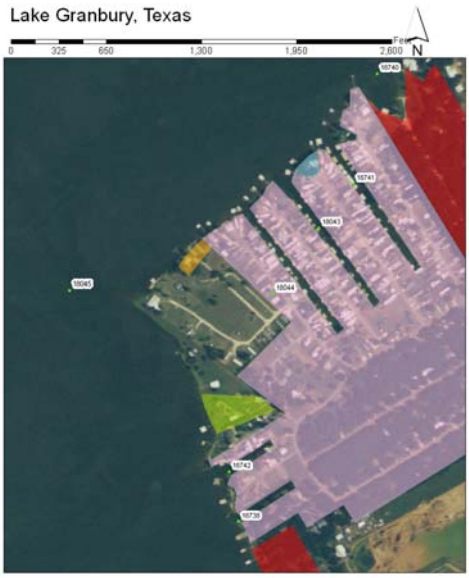
Bacteria concentration from NPS loading, using observed rainfall

Sky Harbor – assumed Non-Point Source based on observed rainfall

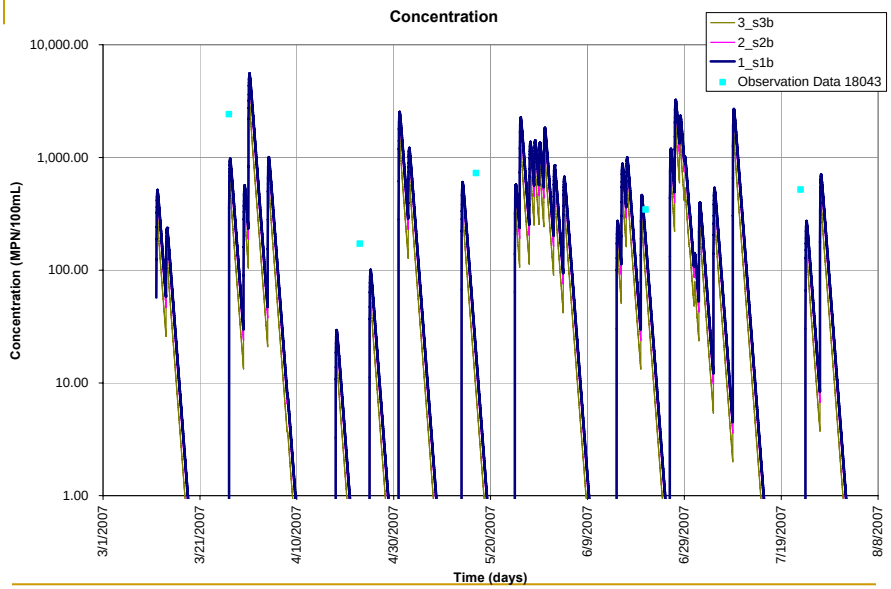


Bacteria concentration from NPS loading, using observed rainfall

Blue Water Shores



Blue Water Shores – assumed Non-Point Source based on observed rainfall



Bacteria concentration from NPS loading, using observed rainfall

Literature Values for Bacteria Sources

Indicator	Concentration (mpn/100 ml)	Source	Reference
Fecal Coliforms (FC)	8,400	Urban Runoff (Texas)	City of Austin Environmental Criteria Manual, 2007
FC	19,743 } Mean **16,048**	**Urban Runoff** (Texas)	Corpus Christi CCBNEP, 1996
FC	20,000 }	Urban Runoff (Texas)	Galveston Bay CRWR Report, 1996
FC	960 - 430,000	Urban Runoff	USEPA, 2001 (referred to Doran et al., 1981)
FC	1,000,000 - 10,000,000	Raw Sewage	USEPA, 2001 (referred to Metcalf and Eddy, 1991)
FC	6,300,000	Raw Sewage	USEPA, 2001 (referred to Overcash and Davidson, 1980)
FC	**550,000**	**Raw Sewage** (Georgia)	Kuntz, 2003
FC	125,000	Raw Sewage	Lisle, 2004
E. Coli	50,000	Raw Sewage	Lisle, 2004

BE IT RESOLVED by the Lake Granbury Watershed Protection Plan Stakeholders Group that the literature value to be used for Urban Runoff in the Lake Granbury WPP Water Quality Model be 16,048 mpn/100 mL based on a mean of City of Austin, Corpus Christi and Galveston Bay urban runoff data.

BE IT RESOLVED by the Lake Granbury Watershed Protection Plan Stakeholders Group that the literature value to be used for Raw Sewage in the Lake Granbury WPP Water Quality Model be 550,000 mpn/100 mL based on Raw Sewage from Georgia (Kuntz, 2003).

Canal Water Quality Modeling – Assumptions for Input Parameters

- Two modeling scenarios
  - Point
    - 550,000 MPN per 100 ml FC in raw sewage (EPA)
    - 200 gallons/day wastewater generation from one residence (TCEQ)
  - Non-point source
    - 16,048 MPN per 100mL Fecal Coliform (FC) in runoff (EPA)
    - Rainfall with 6-hour duration (SCS curve number for runoff)

BE IT RESOLVED by the Lake Granbury Watershed Protection Plan Stakeholders Group that the literature value to be used for wastewater generation from a single residence in the Lake Granbury WPP Water Quality Model be 200 gallons/day based on TCEQ recommended values.

Canal Water Quality Modeling – Assumptions for Input Parameters

- **Bacteria FC:EC ratio**
  - Required so we can relate modeling results to E. Coli. monitoring data
  - 1:1.64 (HGAC, winter '99-'00 data)
  - 1:0.85 to 1:1.15 (HGAC, anecdotal)
  - 1:1 (conservative)
  - **1:0.75 (EPA 2001)**
  - **1:0.6 to 1:0.7 (BRA Lake Granbury 2002-2004)**
  - 1:0.5 (TCEQ)

BE IT RESOLVED by the Lake Granbury Watershed Protection Plan Stakeholders Group that the ratio to be used to relate fecal coliform to *E. coli* in the Lake Granbury WPP Water Quality Model be 1:0.7 based on BRA Generated Data from Lake Granbury.

Canal Water Quality Modeling – Assumptions for Input Parameters

- **Bacteria decay rate (Kd)**
  - FC: 0.27/day (Anderson et al. 2005)
  - FC and EC: 0.5/day @ 37-44`C (EPA 2001/Baudisova 1997, 12 days)
  - EC: 0.1/day @ 5`C (EPA 2001/Madema et al. 1997, 42 days)
  - **EC: 0.2/day @ 15`C (EPA 2001/Madema et al. 1997, 14 days)**
  - FC: 0.95 to 1.1/day (Salado Creek, TAMU05?/EPA85)
  - FC (saline): 0.5 to 1.5/day (Copano Bay) and 0.9/day (East Bay)
- **Temperature**
  - 32`C (99th summer, 6-10), **28`C (median summer)** and winter 13.5`C (median winter)
  - Temperature correction, K = K1* Θ ^ (T – T1)
    - **Θ = 1.07 (Thomann and Mueller 1987) (Kd = 0.482 @ 28`C)**
    - Correction coefficient 0.1 to 1.0 (EPA 2001)

BE IT RESOLVED by the Lake Granbury Watershed Protection Plan Stakeholders Group that the literature value to be used for bacteria decay rates in the Lake Granbury WPP Water Quality Model be 0.2/day based on 2001 EPA Study.

Canal Water Quality Modeling – Assumptions for Input Parameters

- Advection transport and flow through canals (rainfall/runoff)
- Dispersive and diffusive transport
- Dispersion values
  - Literature 0.02 to 0.3 to **1** to 3 m2/s (Peeters et al. 1996 0.02-0.3; Goodwin 1991 .1-1, Thomann and Mueller 1987 0.3-3)
  - Measured on-site **0.5** to 44 m2/s (1996-7)
    - Medians: 4m2/s for calm conditions and 13 m2/s for windy conditions
  - New on-site measurements in coming months

Sensitivity Analysis and Results