Trophic Classification of Texas Reservoirs

2004 Water Quality Inventory and 303(d) List

(May 13, 2005)

Reservoirs and lakes become more eutrophic as they age. Eutrophication of reservoirs and lakes in southern states is enhanced due to warm, fertile climates. Human activities can accelerate the process by increasing the rate at which nutrients and organic substances enter the impoundments and their surrounding watersheds. Sewage discharges, agricultural and urban runoff, leaking septic tanks, and erosion of stream banks can increase the flow of nutrients and organic substances into reservoirs and lakes. These substances often times overstimulate the growth of algae and aquatic plants, creating conditions that interfere with contact recreation (swimming), boating (noncontact recreation), and the health and diversity of native fish, plant, and animal populations. Over-production of bacteria, fungi, and algae may also impart foul odors and tastes to the water.

Section 314 of the CWA of 1987 requires all states to classify lakes and reservoirs according to trophic state. The trophic state of a reservoir refers to its nutritional status. Various classification schemes or indices have been developed that group reservoirs into discrete quality (trophic) states along a continuum from oligotrophic (poorly nourished) to hypereutrophic (over nourished) . The basis for the trophic state index concept is that, in many reservoirs, the degree of eutrophication may be related to increased nutrient concentrations. Typically, phosphorus is the nutrient of concern, and an increase in its concentration may trigger a responding increase in the amount of algae (estimated by chlorophyll *a*) in the reservoir. Due to increased algal biomass, water transparency, as measured by a Secchi disk or submarine photometer, decreases.

Table 1 - 1. Types of Trophic States in Reservoirs and Lakes

Trophic State	Water Quality Characteristics
Oligotrphic	Clear waters with extreme clarity, low nutrient concentrations, little organic matter or sediment, and minimal biological activity.
Mesotrophic	Waters with moderate nutrient concentrations and, therefore, more biological productivity. Waters may be lightly clouded by organic matter, sediment, suspended solids or algae.
Eutrophic	Waters extremely rich in nutrient concentrations, with high biological productivity. Waters clouded by organic matter, sediment, suspended solids, and algae. Some species may be eliminated.
Hypereutrophic	Very murky, highly productive waters due to excessive nutrient loading. Many clearwater species cannot survive.

Major Texas reservoirs have been evaluated and ranked by the TCEQ using Carlson's Trophic State Index (TSI). Carlson's Index was developed to compare among reservoirs Secchi disk depths, chlorophyll *a* concentrations, and total phosphorus concentrations obtained by in-reservoir sampling (Carlson, 1977). These three variables are highly correlated and are considered estimators of algal biomass. By using regression analysis, Carlson related Secchi disk depth to total phosphorus concentration and to chlorophyll *a* concentration. The TSI is determined from any of the three computational equations:

TSI (Secchi Disk) = $10\left(6 - \frac{\ln SD}{\ln 2}\right)$

TSI (Chlorophyll *a*) = $10\left(6 - \frac{2.04 - 0.68 \ln Chl}{\ln 2}\right)$

TSI (Total Phosphorus) = $10\left(6 - \frac{\ln \frac{48}{TP}}{\ln 2}\right)$

Although chlorophyll *a* is the most direct measure of algal biomass, Carlson used Secchi disk depth as the primary indicator. The index was scaled, so that TSI = 0 represents the largest measured Secchi disk depth (64 m) among reservoirs. Each halving of transparency represents an increase of 10 TSI units (Table 1-2). The relationships between Secchi disk and chlorophyll *a* was nonlinear, so a 10-unit TSI (Chl *a*) change does not correspond to a factor-of-two change for chlorophyll *a*. Instead, chlorophyll *a* approximately doubles for each 7-unit increase in TSI (chl *a*).

Table 1 - 2. Carlson's Trophic State Index and Associated Parameters

Trophic State Index	Secchi Disc (m)	Total Phosphorus (mg/m^3)	Chlorophyll *a* (mg/m^3)
0	64	0.75	0.04
10	32	1.5	0.12.
20	16	3	0.34
30	8	6	0.94
40	4	12	2.6
50	2	24	6.4
60	1	48	20.0
70	0.5	96	56
80	0.25	192	154
90	0.12	384	427
100	0.062	768	1,183

Carlson's Index provides a useful tool for assessing a reservoir's current condition and monitoring for change over time. For instance, the index would provide a quantitative estimate of the degree of improvement for a reservoir in which the TSI (Chl *a*) decreased from 60 to 40 units following implementation of rehabilitation measures. The index provides useful information in cases where the values are different, e.g., if TSI (TP) > TSI (Chl *a*), phosphorus is probably not the limiting nutrient; TSI (SD) > TSI (Chl *a*) indicates the presence of nonalgal turbidity. Carlson's Index has the advantage of presenting trophic state on a continuous numeric scale and can approximate the oligotrophic-hypereutrophic nomenclature required by the EPA. Secchi disk depths and total phosphorus and chlorophyll *a* concentrations are routinely determined at TCEQ and CRP fixed monitoring stations on reservoirs and lakes, so input data are readily available for computation of Carlson's Index. The index does not perform well for certain water quality conditions: (1) where transparency is affected by suspended erosional materials rather than phytoplankton, (2) where primary production is controlled by attached algae or aquatic macrophytes rather than phytoplankton, and (3) when phosphorus is not the nutrient limiting phytoplankton growth. Although the index can be used to classify and rank Texas reservoirs as to trophic state, priority ranking for restoration is difficult. Carlson's Index is not the same as a water quality index. Assessment of reservoir water quality depends to a large degree on the assignment of beneficial uses and determinations to evaluate if the uses are being maintained and/or impaired. For this reason, the 305(b) assessment and 303(d) list provide a ranking of priorities for protection and restoration for all water bodies including reservoirs.

Texas reservoirs are ranked in Table 1 - 3 according to Carlson's TSI for chlorophyll *a* as an average calculated from 10 years of SWQM data (March 1, 1993 - February 28, 2003). In order to maximize comparability among reservoirs, data from the station nearest the dam in the main pool of each reservoir were utilized if available. For many reservoirs, these are the only sites monitored by the TCEQ and the CRP. Chlorophyll *a* was given priority as the primary trophic state indicator, because it is best for estimating algal biomass in most reservoirs. A minimum of four chlorophyll *a* measurements and at least two total phosphorus and Secchi disk measurement were required for a reservoir to be included in the ranking. Based on this assessment, one reservoir is considered oligotrophic (Joe Pool Lake), and 93 reservoirs are mesotrophic through hypereutrophic, showing a range of eutrophication (Table 1 - 4). Rankings are also provided for total phosphorus (TP) and Secchi disk transparency (SD).

Table 1 - 3. Trophic Classification of Major Texas Reservoirs Using Carlson's Trophic State Index (TSI)

Segment Number	SWQM Station ID	Reservoir Name	Chlorophyll *a*					Total Phosphorus				Secchi Disk			
			Rank *	No. Meas.	Mean mg/m^3 **	TSI Chl *a* **	Trend ***	Rank	No. Meas.	Mean mg/m^3	TSI TP	Rank	No. Meas.	Mean m	TSI SD
0838	11073	Joe Pool Lake	1	12	1.43	34.19	+0.28	2	16	21.87	48.21	32	12	1.27	57.15
1249	12111	Lake Georgetown	2	15	2.22	35.30	-0.69	1	15	21.33	44.66	5	58	2.26	48.95
1805	12598	Canyon Lake	3	79	2.62	36.60	+0.62	40	121	52.83	57.60	2	2	3.65	41.33
1404	12302	Lake Travis	4	55	2.84	36.60	-0.63	21	51	74.15	55.10	1	67	4.03	41.06
0821	11020	Lake Lavon	5	8	2.74	37.18	-2.12	48	7	45.71	58.63	59	8	0.84	63.71
0834	11063	Lake Amon G. Carter	6	7	2.11	37.46	-0.31	33	7	42.86	56.59	14	2	1.84	51.43
1403	12294	Lake Austin	7	90	3.79	37.72	+3.90	29	88	60.63	56.09	6	50	2.21	49.15
1247	12095	Granger Lake	8	15	3.03	38.36	-1.28	14	15	35.40	53.28	80	58	0.50	70.42
0102	10036	Lake Meredith	9	25	2.80	39.04	+3.99	7	24	34.58	51.88	8	25	2.33	49.31
1236	12010	Lake Fort Phantom Hill	10	6	4.20	41.02	-1.77	60	6	56.67	61.52	46	2	0.50	60.00
0223	10173	Greenbelt Reservoir	11	21	3.27	41.02	+5.78	3	21	17.86	49.20	11	21	2.03	50.35
1904	12825	Medina Lake	12	13	2.67	41.43	+10.30	9	15	19.33	52.14	4	6	2.82	46.12

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1233	12002	Hubbard Creek Reservoir	13	7	2.72	41.56	+4.93	42	7	50.71	58.24	21	3	1.63	54.46
0811	10970	Lake Bridgeport	14	6	3.40	41.62	-1.00	26	6	40.00	55.92	36	60	1.28	57.74
1220	11921	Belton Reservoir	15	16	2.99	41.77	+5.84	11	16	26.25	52.63	10	62	2.08	50.22
0217	10159	Lake Kemp	16	18	3.12	42.14	+6.14	15	18	26.11	53.70	20	10	1.75	53.82
0228	10188	Lake Mackenzie	17	22	6.52	42.54	+7.84	8	22	26.14	51.92	27	22	1.42	55.70
1234	12005	Lake Cisco	18	13	2.95	42.63	+7.30	13	14	22.50	52.97	18	10	1.66	53.48
1429	12476	Town Lake	19	119	6.72	42.81	+7.05	28	89	59.66	56.03	12	203	1.96	51.16
1203	11851	Lake Whitney	20	10	3.45	43.11	+4.15	18	10	26.00	54.83	17	65	1.70	53.12
0408	10329	Lake Bob Sandlin	21	10	3.94	43.27	+2.03	23	10	33.50	55.51	24	10	1.43	55.01
1216	11894	Stillhouse Hollow Lake	22	11	3.12	43.66	+12.2	12	11	21.82	52.92	3	56	3.20	43.78
1419	12398	Lake Coleman	23	10	4.06	43.97	+4.2	4	10	21.00	50.24	34	5	1.24	57.28

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1418	12395	Lake Brownwood	24	15	3.45	44.11	+4.18	10	15	52.33	52.49	47	7	1.07	60.09
0213	10143	Lake Kickapoo	25	7	4.35	44.51	+1.67	43	7	43.57	58.26	79	4	0.62	69.88
1224	11939	Leon Reservoir	26	13	4.72	44.63	+6.38	31	14	31.07	56.36	40	9	1.18	58.10
0215	10157	Diversion Lake	27	14	4.50	44.64	+8.46	34	14	28.21	56.82	42	9	1.14	58.61
0210	10139	Farmers Creek Reservoir	28	17	4.45	44.71	+5.21	20	17	28.53	54.96	44	8	1.11	59.48
0209	10138	Pat Mayse Reservoir	29	6	6.45	44.91	-1.71	44	6	39.17	58.29	37	5	1.23	57.80
1002	11204	Lake Houston	30	35	5.75	44.92	+3.03	88	50	220.20	80.19	88	41	0.40	75.20
1433	12511	O.H. Ivie Reservoir	31	14	4.73	45.12	+3.83	25	14	71.07	55.80	15	18	1.89	51.55
1408	12344	Lake Buchanan	32	52	7.15	45.23	+1.32	50	50	74.46	59.01	9	58	2.20	50.12
0401	10283	Caddo Lake	33	37	7.52	45.30	+0.60	54	34	79.16	59.74	57	57	0.84	63.48

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0610	14906	Sam Rayburn Reservoir	34	24	3.54	45.37	+9.26	65	40	87.32	62.14	7	38	2.17	49.21
1254	12127	Aquilla Reservoir	35	24	5.48	45.46	+5.82	52	24	41.88	59.14	69	34	0.66	66.99
1405	12319	Lake Marble Falls	36	53	6.76	45.63	-0.10	19	50	49.00	54.93	25	55	1.54	55.11
1406	12324	Lake Lyndon B. Johnson	37	50	7.21	45.78	+0.92	37	48	55.73	57.21	29	50	1.41	56.50
1230	11977	Lake Palo Pinto	38	9	4.51	46.00	+15.43	59	8	41.25	60.72	74	9	0.80	67.80
1225	11942	Lake Waco	39	23	5.56	46.17	+1.58	76	128	85.75	66.97	55	135	0.88	62.76
1231	11979	Lake Graham	40	11	3.82	46.24	+7.06	32	10	34.00	56.56	63	7	0.72	65.12
0404	14473	Ellison Creek Reservoir	41	12	5.02	46.40	+3.79	5	11	23.64	51.51	28	13	1.33	56.02
0302	10213	Wright Patman Lake	42	10	8.98	46.56	-0.97	80	10	101.50	70.02	71	10	0.69	67.15
0614	10639	Lake Jacksonville	43	16	3.72	46.66	+12.58	30	17	22.35	56.30	13	18	1.86	51.24

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0212	10142	Lake Arrowhead	44	17	4.91	47.00	+4.74	86	17	172.06	77.80	77	8	0.61	69.37
0613	10637	Lake Tyler	45	19	5.19	47.11	+5.66	27	18	26.94	56.01	38	21	1.17	57.97
1235	12006	Lake Stamford	46	11	7.71	47.50	+3.14	69	10	73.50	63.61	70	6	0.50	66.99
0613	10638	Lake Tyler East	47	28	6.65	48.39	+4.56	17	25	26.20	54.48	38	26	1.16	58.20
0403	10296	Lake O the Pines	48	49	7.83	48.55	+4.01	51	47	56.68	59.03	30	48	1.30	56.86
1209	11792	Country Club Lake	49	12	12.80	48.71	+2.10	92	12	749.17	98.23	85	12	0.44	72.91
1252	12123	Lake Limestone	50	8	9.75	48.80	+2.95	45	6	49.17	58.13	58	55	0.84	63.60
2454	12514	Cox Lake	51	20	8.89	49.01	+1.66	90	19	348.42	87.01	93	20	0.38	85.22
1407	12336	Inks Lake	52	51	10.98	49.37	+2.11	55	44	63.80	59.82	16	55	1.78	52.14
1423	12422	Twin Buttes Reservoir	53	14	9.93	49.37	+7.69	67	14	81.07	62.86	78	11	0.83	69.76
0807	10942	Lake Worth	54	6	13.03	49.58	+2.71	64	6	46.67	61.90	67	6	0.70	66.16
0813	10973	Houston County Lake	55	16	5.62	49.87	+10.18	46	16	29.69	58.38	23	17	1.50	54.67

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0836	15168	Richland-Chambers Reservoir	56	5	8.22	49.97	NC	41	5	44.60	57.61	31	44	1.28	57.07
0204	15447	Moss Lake	57	10	5.55	50.25	+14.29	62	10	32.50	61.59	54	8	1.04	62.68
0512	10458	Lake Fork	58	54	9.87	50.29	+3.42	24	34	48.24	55.73	19	122	1.60	53.65
2312	13267	Red Bluff Reservoir	59	22	11.50	50.42	+1.71	16	22	28.41	53.81	53	23	0.89	61.82
0504	10402	Toledo Bend Reservoir	60	47	8.68	50.53	+1.42	36	35	49.40	57.05	22	117	1.53	54.59
0605	16159	Lake Palestine	61	20	10.29	50.69	+5.72	57	18	35.28	60.36	52	18	0.90	61.80
0816	10980	Lake Waxahachie	62	11	10.66	50.79	+7.40	49	11	40.45	58.81	62	10	0.79	64.75
0199	10005	Palo Duro Reservoir	63	20	10.98	50.87	+1.49	82	20	154.75	71.66	87	20	0.41	74.67
1240	12027	White River Lake	64	8	8.15	51.76	+16.92	66	8	46.25	62.64	81	12	0.49	71.44
0603	10582	B.A. Steinhagen Reservoir	65	15	6.65	52.11	+6.87	77	14	87.50	67.32	86	15	0.39	74.41

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0405	10312	Lake Cypress Springs	66	19	9.45	52.20	+5.23	47	19	31.58	58.61	35	20	1.20	57.65
0832	11061	Lake Weatherford	67	9	9.88	52.55	+2.97	56	9	38.89	60.00	65	9	0.71	65.17
0826	16113	Grapevine Lake	68	5	11.24	52.56	NC	22	7	34.29	55.30	45	7	1.09	59.51
1012	11342	Lake Conroe	69	13	15.19	52.56	+0.77	38	56	50.71	57.28	60	10	0.83	64.16
0817	10981	Navarro Mills Reservoir	70	10	7.89	52.66	+4.27	68	10	58.50	63.16	83	8	0.43	72.43
1422	12418	Lake Nasworthy	71	33	9.94	52.69	+9.79	61	33	49.85	61.58	76	32	0.58	68.70
1434	17020	Lake Bastrop	72	26	13.23	52.90	+2.10	35	23	41.13	56.90	26	23	1.43	55.38
1222	11935	Proctor Lake	73	13	13.99	53.01	+1.75	73	14	76.43	66.51	73	54	0.62	67.44
1209	11798	Fin Feather Lake	74	15	22.42	53.10	+1.31	91	15	424.00	88.09	85	14	1.22	58.92
0307	15211	Cooper Lake	75	15	9.50	53.12	+3.95	79	13	89.62	67.63	84	14	0.47	72.67
1411	12359	E.V.Spence	76	7	16.93	53.19	+5.28	6	7	32.14	51.77	39	9	1.41	58.09
0815	10979	Bardwell Reservoir	77	11	12.31	53.61	+1.34	63	11	45.00	61.90	72	16	0.62	67.25

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2303	13189	Falcon Lake	78	9	10.89	54.26	+1.16	78	10	113.00	67.34	56	8	0.87	63.13
0830	15151	Benbrook Lake	79	6	16.80	54.31	NC	70	6	63.83	63.62	51	36	1.09	60.78
1210	14238	Lake Mexia	80	27	15.77	54.48	+1.53	89	26	208.46	80.64	91	24	0.28	78.99
1212	11881	Somerville Lake	81	11	22.79	54.68	+3.30	74	11	79.09	66.57	61	56	0.77	64.36
1425	12429	O.C. Fisher Reservoir	82	14	19.34	54.87	+9.15	81	14	122.86	71.06	82	11	0.69	71.91
0803	10899	Lake Livingston	83	58	15.82	55.70	+0.78	84	70	157.64	74.55	66	94	0.75	65.67
0229	10192	Lake Tanglewood	84	30	22.92	55.89	+3.47	93	30	1148.07	101.88	75	27	0.67	67.87
0507	10434	Lake Tawakoni	85	61	20.39	56.61	+1.32	53	47	54.15	59.53	48	120	1.03	61.16
1402	17017	Fayette Reservoir	86	27	24.54	58.54	+2.11	39	27	54.00	57.40	33	23	1.26	57.21
1253	16247	Springfield Lake	87	20	24.48	59.24	+6.70	85	20	163.50	77.46	90	16	0.28	78.60
0809	10944	Eagle Mountain Reservoir	88	5	24.46	60.98	NC	75	5	79.40	66.66	49	44	1.01	60.42

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1242	16781	New Marlin City	89	14	26.45	61.05	+2.27	83	14	138.57	73.69	89	13	0.36	75.66
0818	16749	Cedar Creek Reservoir	90	16	26.66	61.22	NC	72	16	69.13	65.03	50	25	0.97	60.68
1412	12167	Lake Colorado City	91	6	30.65	61.31	+5.31	58	6	60.83	60.67	68	20	0.65	66.56
0509	10444	Lake Murvaul	92	15	29.31	62.75	-1.25	71	13	63.46	64.76	64	13	0.71	65.14
1242	16783	Old Marlin City Lake	93	14	43.83	65.30	+4.57	87	14	206.79	79.84	92	14	0.27	79.89
0105	10060	Rita Blanca Lake	94	12	182.42	68.78	+0.70	94	13	3346.92	119.44	94	14	0.07	92.80

* Reservoirs are ranked in priority by TSI (Chl)

** The equations for Carlson's TSI (Chl), (TP), and (SD) involve converting each parameter value to its respective natural log (ln). The Carlson's TSI (Chl), (TP), and (SD) were computed for each reservoir by calculating the arithmetic average for the TSI values from each sample date. The effect of these computations is that the ranking of Carlson's TSI (Chl), (TP), and (SD) values may vary slightly from a ranking based on the arithmetic average of chlorophyll *a*, total phosphorus, and Secchi disk values.

*** A minus(-) preceding a value in the trend column indicates decreased algal content between the 1998 and 2000 reporting cycles; a plus (+) indicates increased algal content; NC indicates no change in values; a dotted line (-----) indicates absence of comparable data.

Table 1 - 4. Number of Texas Reservoirs Assessed in Each Trophic Class

Trophic Class	TSI (Chl a) Index Range	Number of Reservoirs
Oligotrophic	0 - 35	1
Mesotrophic	>35 - 45	29
Eutrophic	>45 - 55	52
Hypereutrophic	>55	12

This presentation permits comparison of individual TSI indicators for each reservoir, provides indications of the clearest reservoirs (low TSI SD), and identifies reservoirs with low and high total phosphorus concentrations.

Reservoirs with the clearest water (highest Secchi disk transparency) occur primarily in the central portion of the state and are listed in descending order are: Lake Travis (Segment 1404), Canyon Lake (Segment 1805), Stillhouse Hollow (Segment 1216), Medina Lake (Segment 1904), and Lake Georgetown (Segment1249). Reservoirs with the poorest light transparency (lowest Secchi disk transparency) listed in descending order are: Rita Blanca Lake (Segment 0105), Cox Lake (in Segment 2454), Old Marlin City Lake (Segment 1242), Lake Mexia (Segment 1210), and Springfield Lake (1253).

Reservoirs with the lowest total phosphorus concentrations listed in descending order are: Lake Georgetown (Segment 1249), Joe Pool Lake (Segment 0838), Greenbelt Reservoir (Segment 0223), Lake Coleman (Segment 1419), and Ellison Creek Reservoir (Segment 0404). Reservoirs enriched with the highest total phosphorus concentrations listed in descending order are: Rita Blanca Lake (Segment 0105), Lake Tanglewood (Segment 0230), Country Club Lake (Segment 1209), Finfeather Lake (Segment 1209), and Cox Lake (Segment 2454).

Water Quality Trends in Reservoirs

Carlson's TSI Chl *a* values for 94 reservoirs from the 2002 and 2004 reporting cycles were compared to indicate temporal trends (Table 1 - 3). The period of record for the 2002 reporting cycle was September 1991-August 2001; for 2004, the period of record was March 1, 1993 - February 28, 2003. TSI Chl *a* values, which estimate the amount of algal biomass, indicate improvement (decrease in values) in 11 of 94 (12%) reservoirs. Increases in algal biomass (increase in TSI Chl *a* values) are indicated in 78 of 93 (83%) reservoirs. Reservoirs with the largest trends for increasing algal content (substantial positive TSI Chl *a* values) are White River Lake (Segment 1240), Lake Palo Pinto (Segment 1230), Moss Lake (Segment 0204), Lake Jacksonville (Segment 0614), and Stillhouse Hollow Lake (Segment 1216). These changes are for a two-year period and may not represent longer term trends. No reservoirs in the 2004 reporting cycle showed significant decreasing trends of TSI Chl *a* values of 3 units or more. The TSI Chl *a* values were remarkably different among the 94 reservoirs between the two reporting cycles, with 49 of 94 (52%) reservoirs changing by 3 units or more. In 16 of 94 reservoirs (17%), values changed by 1 unit or less.

Reservoir Control Programs

Texas employs several reservoir pollution control procedures to ensure high-quality water for recreational, domestic, and industrial uses. Surface water quality standards have been adopted for significant reservoirs throughout the state. The standards establish designated uses for classified segments and presumed uses for unclassified segments and include numerical criteria to protect those uses. Designated uses are determined by taking into account the reservoir's physical and biological characteristics, natural water quality, and existing uses. Criteria, depending on parameter, are based on background levels or accepted levels for protection of human health and aquatic life. TMDLs are conducted to determine the assimilative capacity of the segment and to determine discharge treatment levels and nonpoint source loads necessary to meet the criteria. These treatment levels are then required when issuing wastewater permits to dischargers. In some cases, TMDLs may recommend no discharge of wastewater. Compliance with wastewater permits is monitored through on-site inspections by TCEQ personnel and through self-reporting procedures. When noncompliance with permits is found, enforcement actions may be required to attain compliance. The uses, criteria, TMDLs, and permits are periodically reviewed and, if necessary, revised. Each major reservoir is routinely monitored to assess the overall condition of the water body and determine short- or long-term water quality trends. The Carlson's Trophic State Index is used to score reservoirs according to trophic conditions based on Secchi disk transparency, total phosphorus levels, and chlorophyll *a* levels. Reservoirs with nonsupported uses are placed on the State of Texas 303(d) List.

The TCEQ has several specific rules that prescribe permit limitations for discharges of domestic wastewater into reservoirs. Chapter 309 of the effluent standards portion of the TCEQ rules requires discharges located within five river miles upstream of certain reservoirs to achieve a minimum effluent quality of 10 mg/L BOD_5 and 15 mg/L TSS as a 30-day average. This rule applies to reservoirs that are subject to private sewage facilities regulation or that may be used as a source for a public drinking water supply. Currently, 92 Texas reservoirs are designated for the public water supply use. Additional rules under Chapter 311, Watershed Protection, have been promulgated that protect specific reservoirs:

Subchapter D: §§311.31-311.36.

This rule requires all domestic and industrial permittees in the entire Lake Houston watershed to meet effluent limitations equal to or commensurate with 10 mg/L BOD_5, 15 mg/L TSS, and 3 mg/L NH_3-N as a 30-day average. All wastewater effluents disposed of on land shall meet an effluent quality of 20 mg/L BOD_5 and 20 mg/L TSS. Domestic facilities must submit a solids management plan. Additionally, all domestic and industrial facilities with gaseous chlorination disinfection systems must have dualfeed chlorination systems and must meet a minimum chlorine residual of 1 mg/L and a maximum chlorine residual of 4.0 mg/L.

Subchapter A, B and F: §§311.1-.5, 311.11-.15 and 311.51-.55.

These rules apply to a series of reservoirs on the Colorado River, which are commonly referred to as the Highland Lakes, including Lake Austin (Segment 1403), Lake Travis (Segment 1404), Lake Marble Falls (Segment 1405), Lake LBJ, (Segment 1406), Inks Lake (Segment 1407), and Lake Buchanan (Segment 1408). Water quality areas, those portions of the watersheds within 10 river miles of the reservoirs, were established for each reservoir. New wastewater facilities constructed in these areas will be issued no-discharge permits, which means that treated wastewater will not be discharged to surface waters. Any existing facility that requires a permit amendment for expansion or is not meeting permit requirements because of sewage overloading will be issued a no-discharge permit. Proposed new or expanded treatment facilities in the watersheds of these reservoirs will be issued no-discharge permits unless the applicant can establish that any alternative proposed wastewater disposal will protect and maintain the existing quality of the reservoirs.

Subchapter G: §§311.61.-311.66.
This rule applies to Lakes Worth, Eagle Mountain, Bridgeport, Cedar Creek, Arlington, Benbrook, and Richland-Chambers. With the exception of oxidation pond systems, domestic discharges within the water quality areas of the watersheds of these reservoirs are required to meet advanced treatment limits of 10 mg/L BOD_5, and filtration is required to supplement suspended solids removal by January 1, 1993. In addition to water quality monitoring and creation of rules to regulate the permitting of wastewater discharges to reservoirs, the TCEQ maintains an extensive inspection program of wastewater treatment facilities. When permit limitations are not being met, the appropriate enforcement action is pursued.

Reservoir and Lake Restoration Efforts

Section 314 of the Clean Water Act makes federal grant funds available to states under the Clean Lakes Program. The TCEQ is currently not administering any grant funding under this program.

Low pH in Texas Waterbodies

Four reservoirs, six freshwater streams, and three tidal streams have shown low pH (high acidity). TCEQ is continuing routine monitoring and is initiating a project to identify waterbodies requiring special studies to determine if a TMDL or review of the standard is needed. In many cases, the pH standard may not be accurate.

Table 1 - 5. Texas Reservoirs and Lakes With Low pH

Segment Number	Reservoir Name
0402	Caddo Lake
0504	Toledo Bend Reservoir
0510	Lake Cherokee
1212	Lake Somerville