

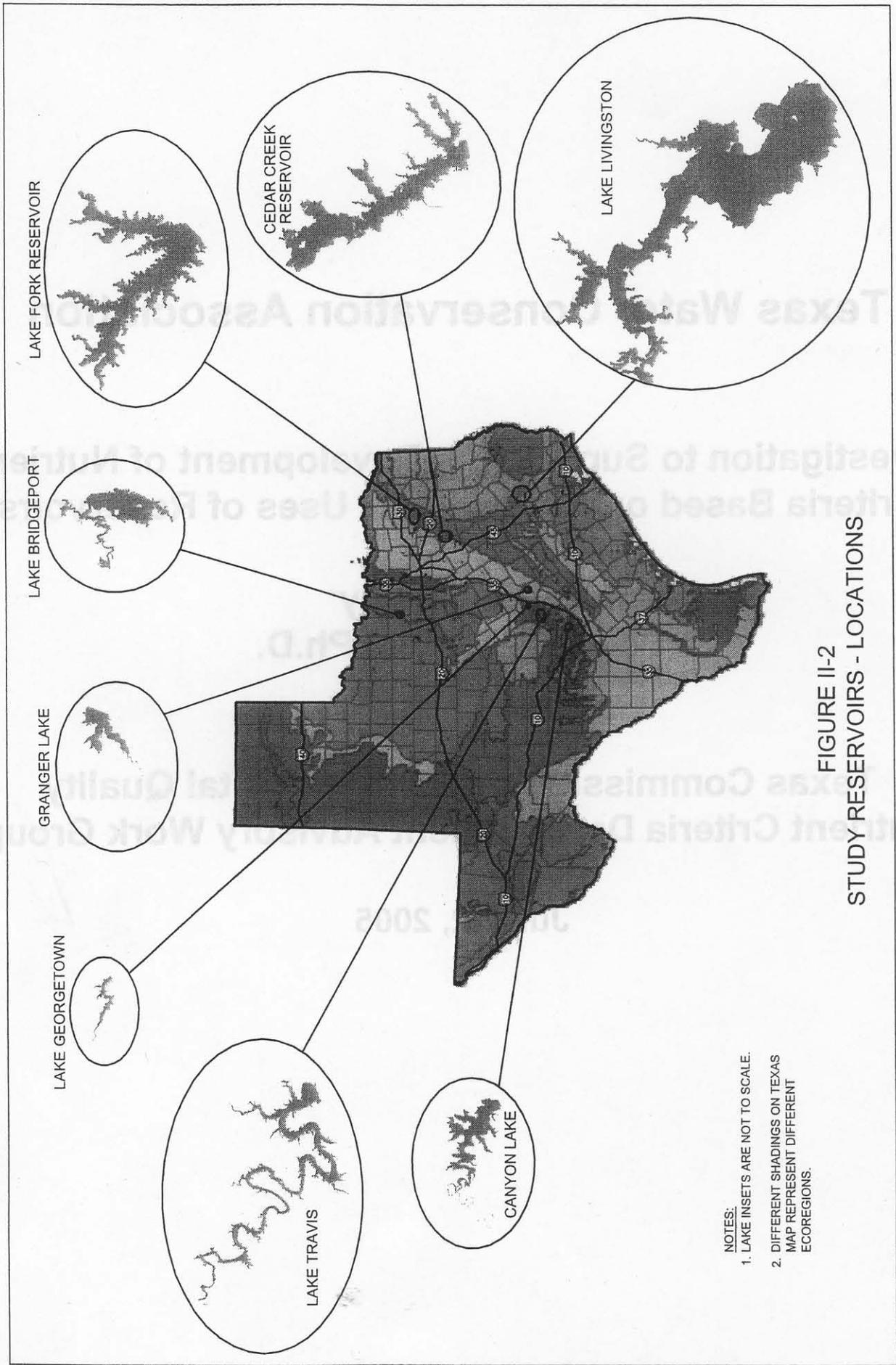
Texas Water Conservation Association

**Investigation to Support the Development of Nutrient
Criteria Based on Recreational Uses of Reservoirs**

**Presented by
Peggy W. Glass, Ph.D.**

**Presented to
Texas Commission on Environmental Quality
Nutrient Criteria Development Advisory Work Group**

July 12, 2005



**FIGURE II-2
STUDY RESERVOIRS - LOCATIONS**

- NOTES:**
1. LAKE INSETS ARE NOT TO SCALE.
 2. DIFFERENT SHADINGS ON TEXAS MAP REPRESENT DIFFERENT ECOREGIONS.

TABLE III-1
NUMBER OF USER SURVEYS BY RESERVOIR

Reservoir	2003	2004	Total
Canyon Lake	96	117	213
Cedar Creek Reservoir	129	145	274
Granger Lake	72	70	142
Lake Bridgeport	124	175	299
Lake Fork Reservoir	84	151	235
Lake Georgetown	72	67	139
Lake Livingston	124	190	314
Lake Travis	93	97	190
Total	794	1012	1806

TABLE III-2

RESERVOIR CHARACTERISTICS
 NUTRIENTS, DISSOLVED OXYGEN, pH

Reservoir	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	DO (mg/L)	pH
Canyon Lake	0.70	0.05	8.6	8.1
Cedar Creek Reservoir	1.26	0.10	7.8	8.4
Granger Lake	0.62	0.10	7.0	8.1
Lake Bridgeport	0.77	0.06	7.4	8.1
Lake Fork Reservoir	0.95	0.04	7.6	7.7
Lake Georgetown	0.35	0.11	7.4	8.1
Lake Livingston	1.34	0.24	9.3	8.4
Lake Travis	0.36	0.01	8.2	8.4

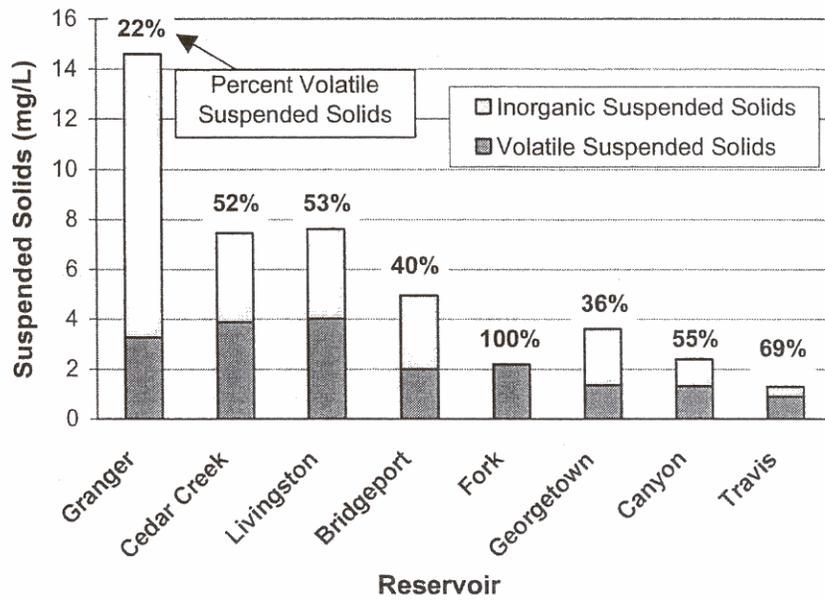
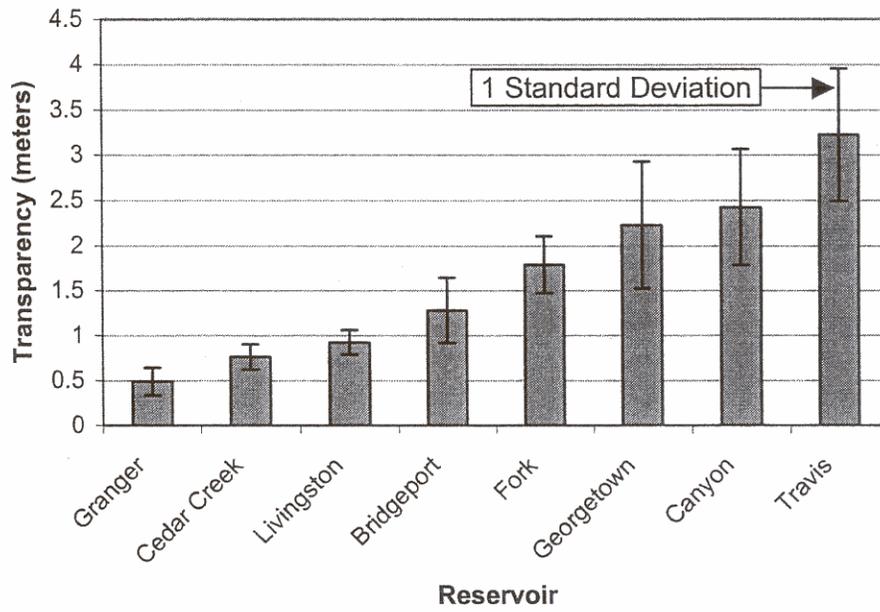


FIGURE III-2
MEAN SUMMER RESERVOIR SUSPENDED SOLIDS
CONCENTRATIONS
MAIN BODY



**FIGURE III-1
MEAN SUMMER RESERVOIR TRANSPARENCY
MAIN BODY**

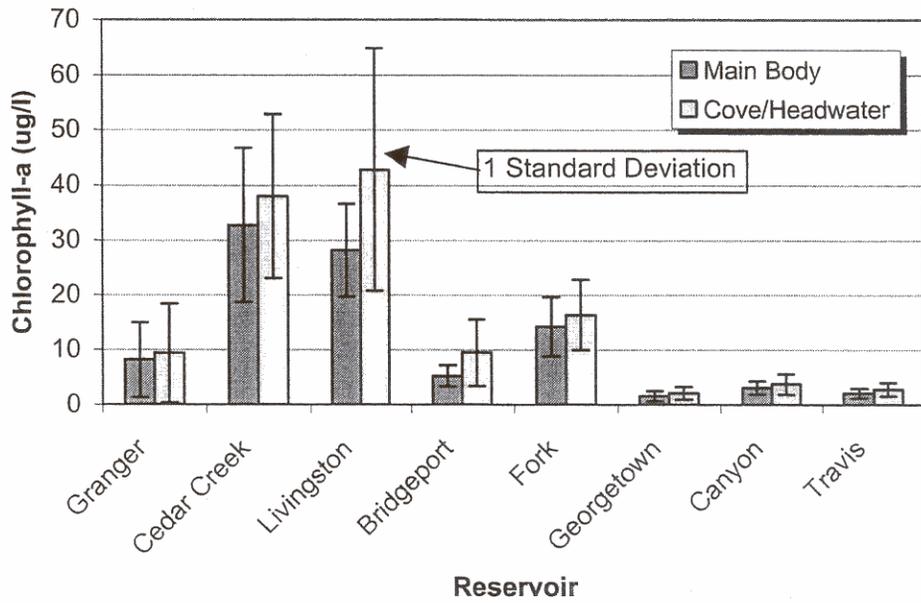


FIGURE III-5
MEAN SUMMER CHLOROPHYLL-a CONCENTRATIONS
MAIN BODY AND COVE/HEADWATER

TABLE III-3

MAXIMUM AND MINIMUM CHLOROPHYLL-A CONCENTRATIONS
 COMBINED DATA FOR MAIN BODY AND COVE/HEADWATER SITES

Reservoir	Maximum Chlorophyll-a (ug/L)	Minimum Chlorophyll-a (ug/L)*
Canyon Lake	7	1
Cedar Creek Reservoir	64	10
Granger Lake	36	1
Lake Bridgeport	32	3
Lake Fork Reservoir	27	5
Lake Georgetown	5	1
Lake Livingston	115	8
Lake Travis	5	1

*Values reported as < 2.0 ug/L are included in the summary as 1.0 ug/L

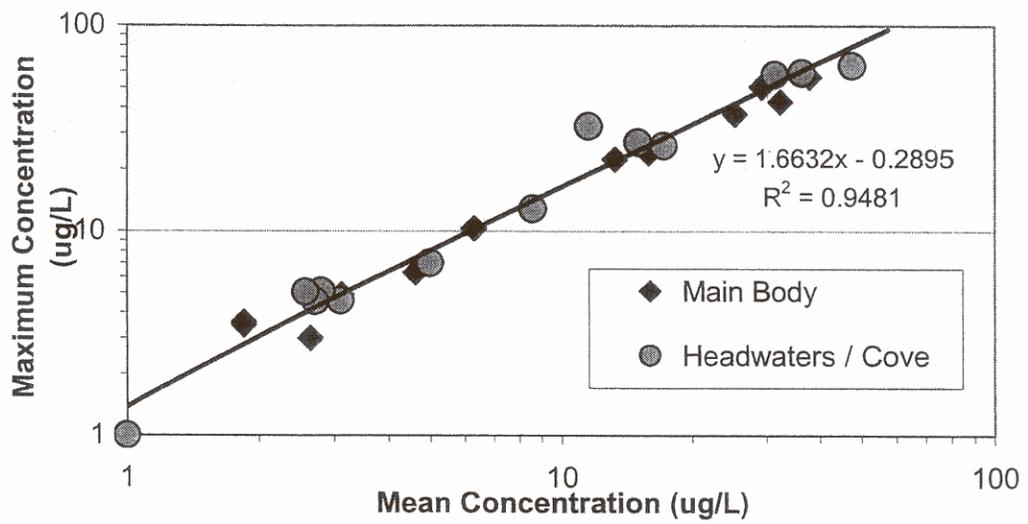


FIGURE IV-10
RELATIONSHIP BETWEEN CHLOROPHYLL-A SEASONAL
MAXIMUM AND SEASONAL MEAN CONCENTRATIONS
 (Each data point represents a reservoir and a specific year)

TABLE III-4

COMPARISON OF MEAN SUMMER RESERVOIR CHLOROPHYLL-a
 MAIN BODY
 THIS STUDY AND TCEQ DATABASE

Reservoir	TCEQ*			This Study		
	Mean** Chlorophyll-a (ug/L)	Std. Dev.	N	Mean Chlorophyll-a (ug/L)	Std. Dev.	N
Canyon Lake	2	2	17	3	1	15
Cedar Creek Reservoir	24	16	20	33	14	20
Granger Lake	3	2	9	8	7	17
Lake Bridgeport	5	2	25	6	2	17
Lake Fork Reservoir	13	10	25	14	5	19
Lake Georgetown	2	1	9	2	1	16
Lake Livingston	20	12	26	28	8	20
Lake Travis	3	4	22	2	1	19

*Values reported as < 0.5 ug/L or < 0.25 ug/L not included in the analysis

Values reported as < 1.0 ug/L included in analysis as 0.5 ug/L

Values reported as < 2.0 ug/L included in analysis as 1.0 ug/L

**Data averaged for the period 1993–2003

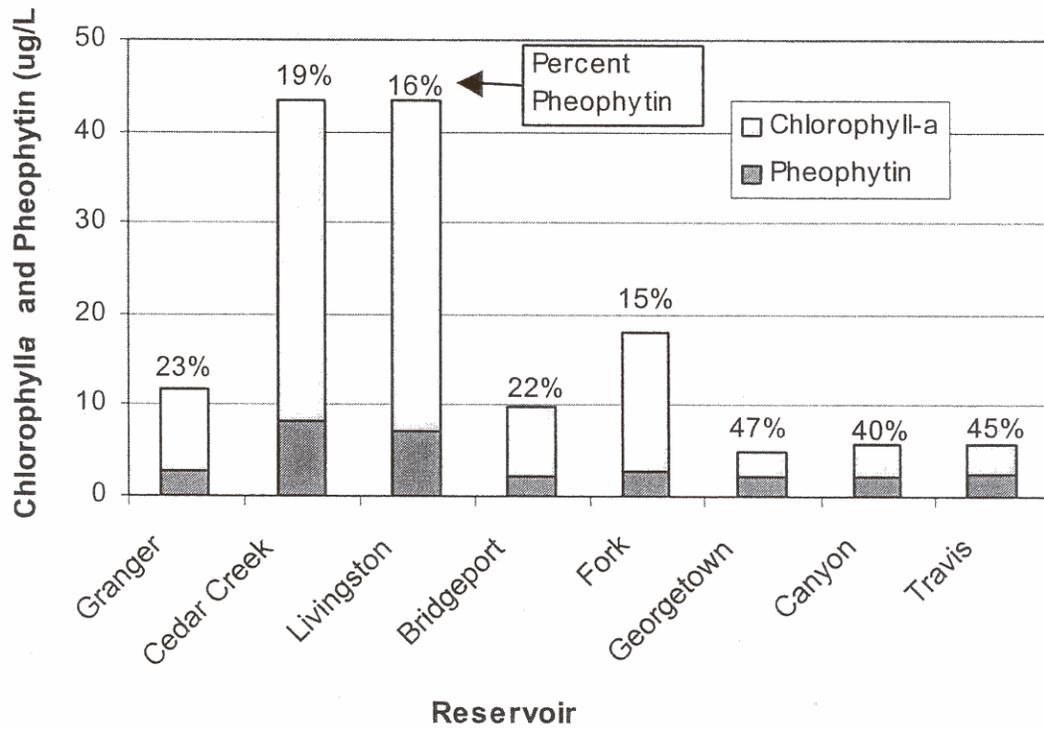


FIGURE III-6
MEAN SUMMER RESERVOIR CHLOROPHYLL-a AND PHEOPHYTIN
CONCENTRATIONS
MAIN BODY

TABLE III-7

USER GROUP CHARACTERISTICS BY PRIMARY ACTIVITY

Reservoir	Number of Users							Total Responses by Reservoir
	Swimming	Fishing	Boating	Skiing/ Windsurfing	On-shore Activity	Sampling Crew	Other	
Granger Lake	11	42	17	2	15	56	18	161
Cedar Creek Reservoir	15	82	68	8	22	64	21	280
Lake Livingston	45	113	44	13	60	56	38	369
Lake Bridgeport	17	107	27	27	15	77	31	301
Lake Fork Reservoir	10	139	14	3	4	60	17	247
Lake Georgetown	21	16	14	7	19	56	19	152
Canyon Lake	31	27	67	13	9	46	43	236
Lake Travis	46	14	51	13	12	72	18	226
Total	196	540	302	86	156	487	205	1,972

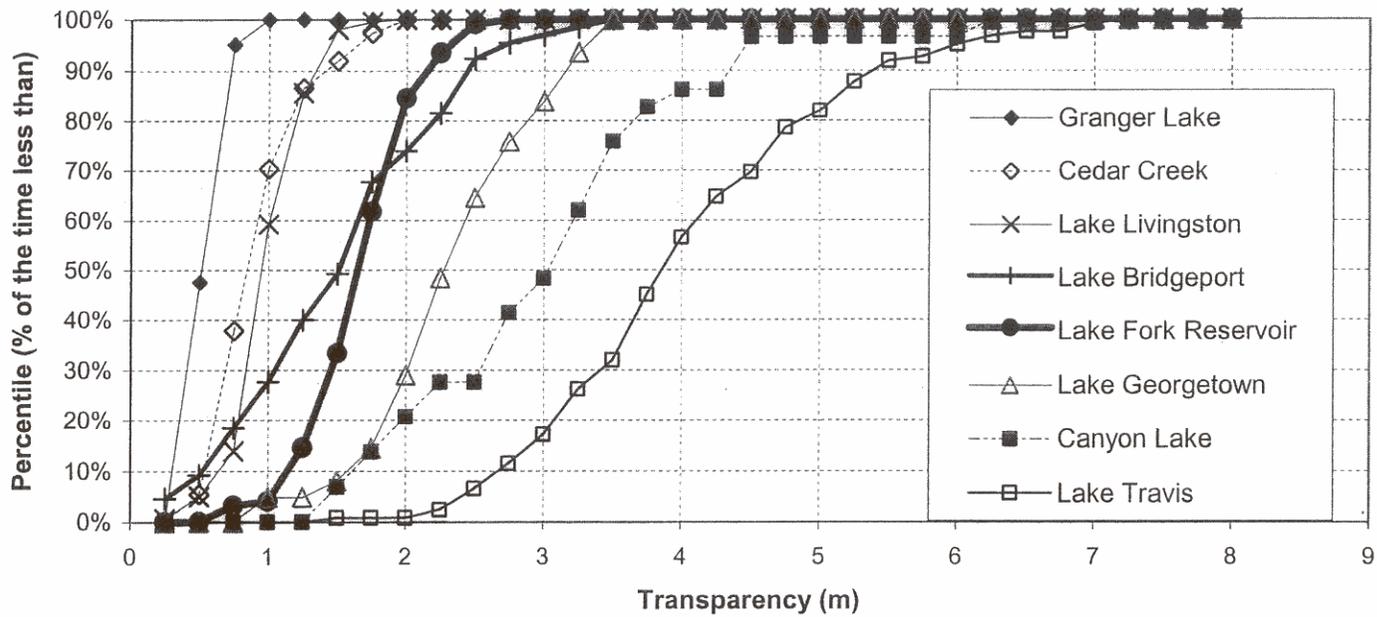
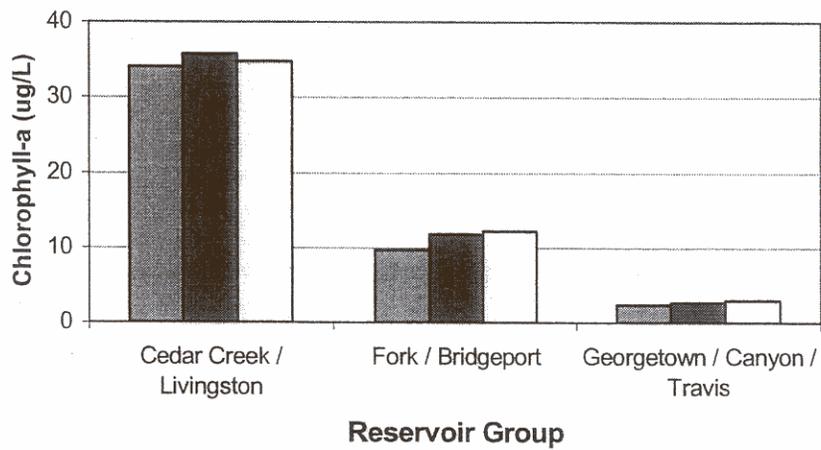


FIGURE IV-2
TRANSPARENCY CHARACTERISTICS OF RESERVOIRS

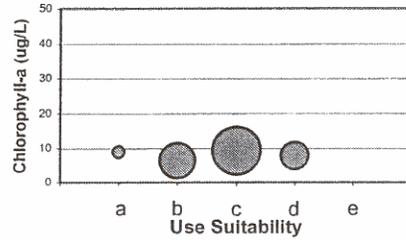


- a - beautiful, could not be any nicer
- b - very minor aesthetic problems, excellent for swimming, boating enjoyment
- c - swimming and aesthetic enjoyment slightly impaired
- or
- d - desire to swim and level of enjoyment of the lake substantially reduced
- or
- e - swimming and aesthetic enjoyment of the lake nearly impossible

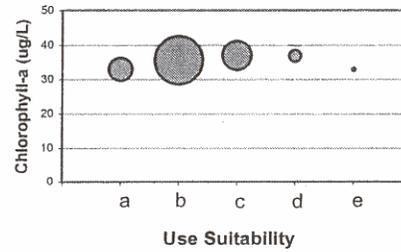
FIGURE IV-3

**RECREATIONAL SUITABILITY BASED ON CHLOROPHYLL-A
CONCENTRATION RESULTS FOR RESERVOIR GROUPS**

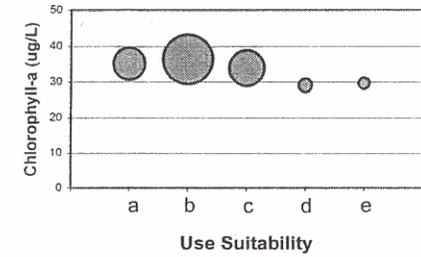
Granger Lake



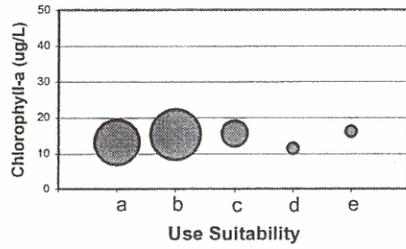
Lake Livingston



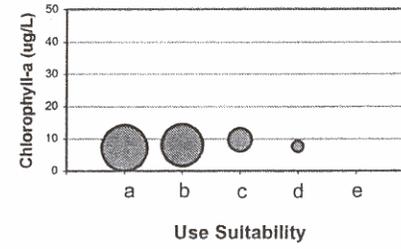
Cedar Creek Reservoir



Lake Fork Reservoir



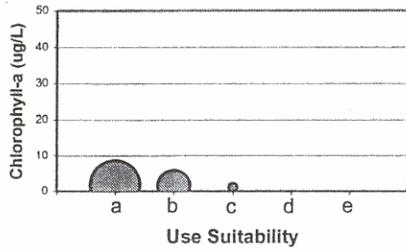
Lake Bridgeport



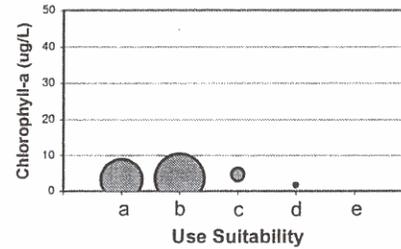
Use Suitability Categories

- a) beautiful, could not be any nicer
- b) very minor aesthetic problems, excellent for swimming, boating enjoyment
- c) swimming and aesthetic enjoyment slightly impaired
- d) desire to swim and level of enjoyment of the lake substantially reduced
- e) swimming and aesthetic enjoyment of the lake nearly impossible

Lake Georgetown



Canyon Lake



Lake Travis

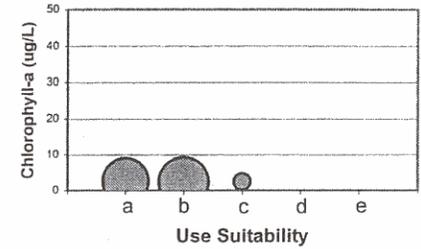
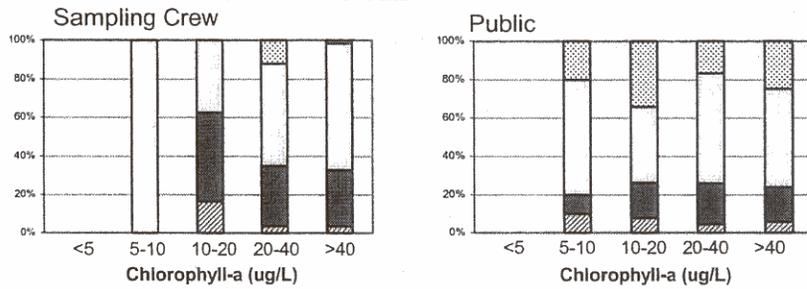
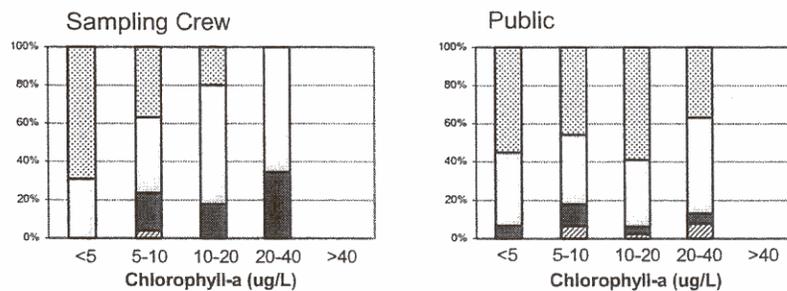


FIGURE IV-1
PERCEIVED IMPACTS ON RECREATIONAL USE VERSUS CHLOROPHYLL-a CONCENTRATIONS
FOR EACH RESERVOIR

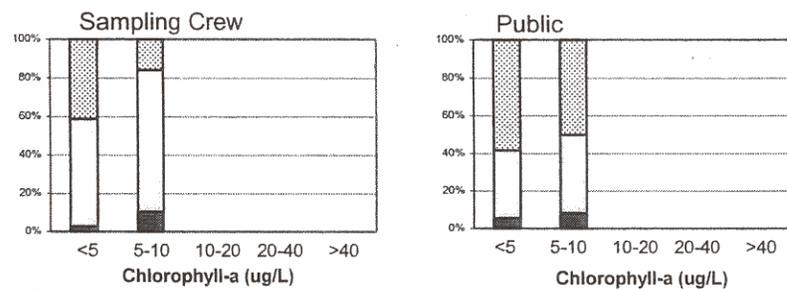
Cedar Creek Reservoir and Lake Livingston



Lake Fork Reservoir and Lake Bridgeport



Lake Georgetown, Canyon Lake, and Lake Travis

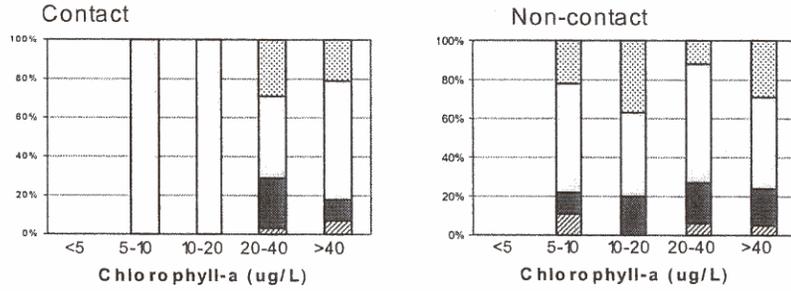


- a - beautiful, could not be any nicer
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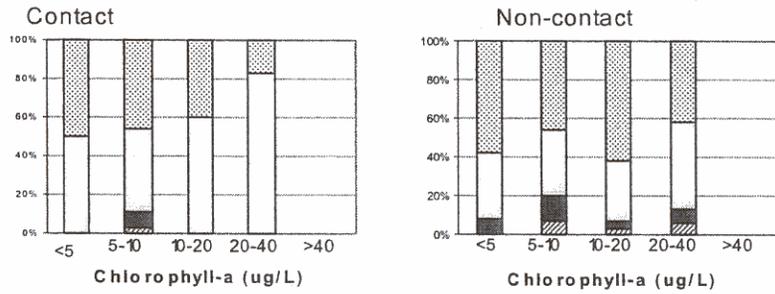
FIGURE IV-4

COMPARISON OF EVALUATION OF RECREATIONAL SUITABILITY BY SAMPLING CREW AND BY PUBLIC BASED ON RESERVOIR GROUPS

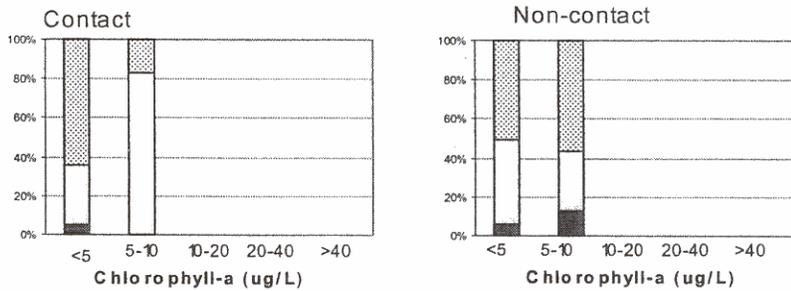
Cedar Creek Reservoir and Lake Livingston



Lake Fork Reservoir and Lake Bridgeport



Lake Georgetown, Canyon Lake, and Lake Travis



- a - beautiful, could not be any nicer
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- c - swimming and aesthetic enjoyment slightly impaired
- d - desire to swim and level of enjoyment of the lake substantially reduced or
- e - swimming and aesthetic enjoyment of the lake nearly impossible

FIGURE IV-5

COMPARISON OF EVALUATION OF RECREATIONAL SUITABILITY BY CONTACT RECREATIONAL USERS VERSUS NON-CONTACT RECREATIONAL USERS BASED ON RESERVOIR GROUPS

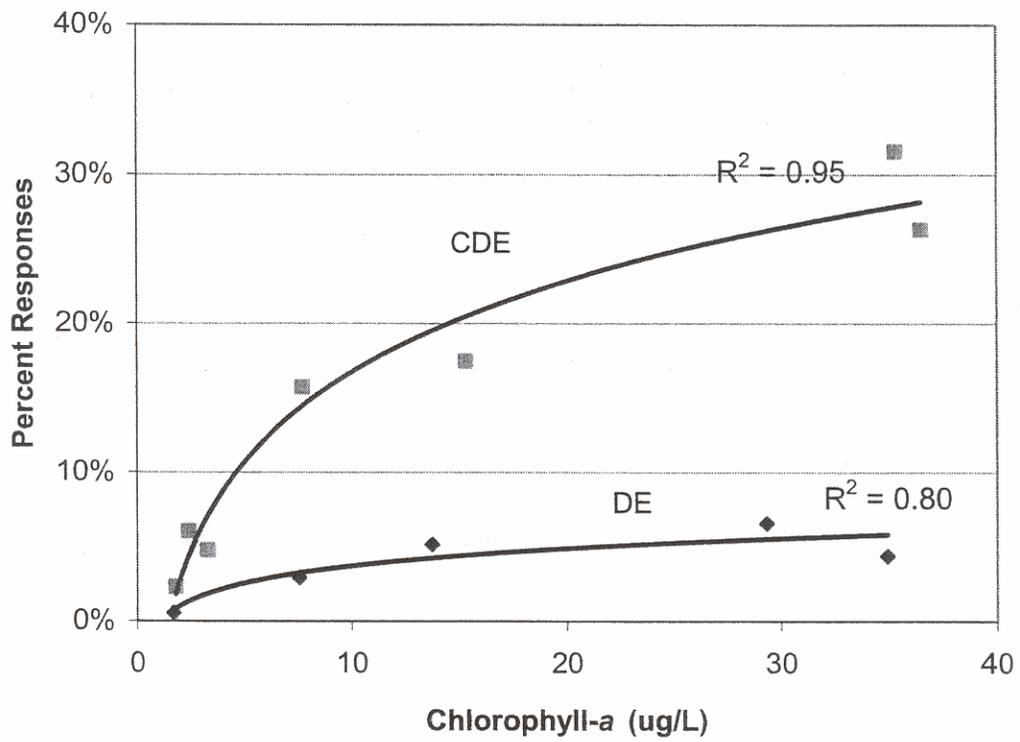


FIGURE IV-7
FREQUENCY OF RESPONSE OF USE IMPAIRMENT
VERSUS CHLOROPHYLL-A CONCENTRATION
COMPARISON BETWEEN RESERVOIRS
(Granger Not Included)

Each data point represents a reservoir

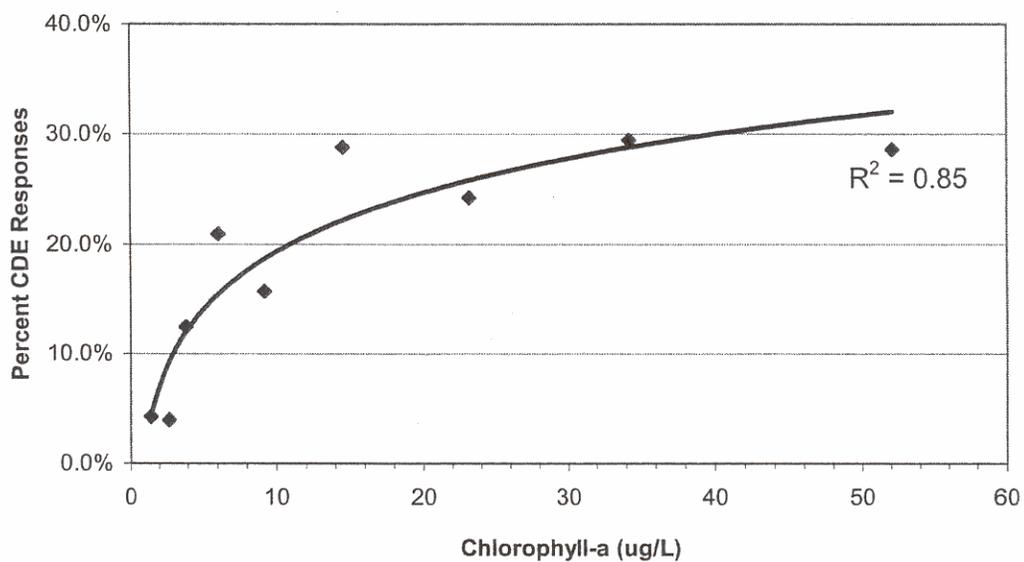
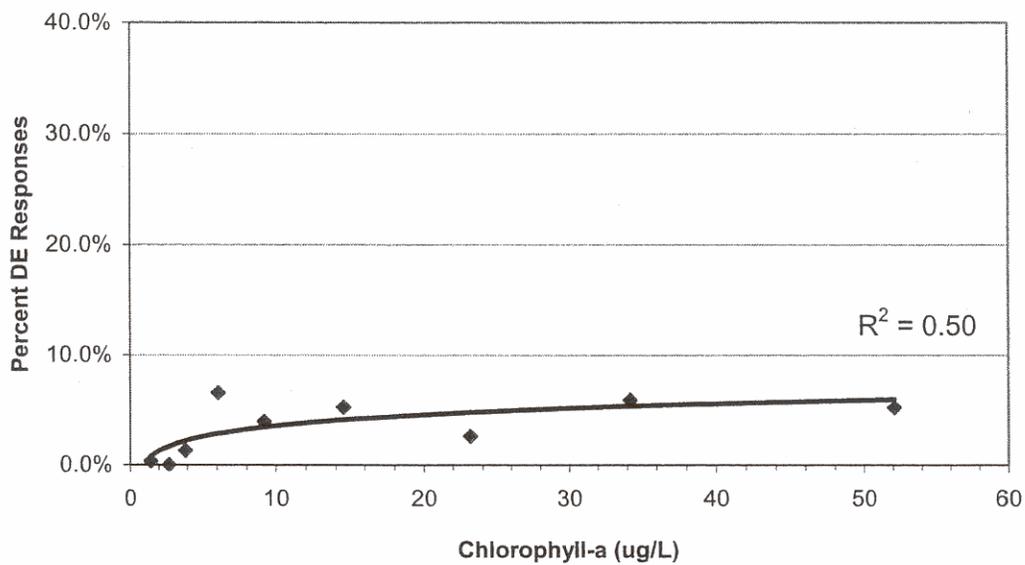


FIGURE IV-8
FREQUENCY OF RESPONSE OF USE IMPAIRMENT VERSUS
CHLOROPHYLL-a CONCENTRATION
COMPARISON BASED ON CONCENTRATIONS
 (Each data point represents a concentration interval)

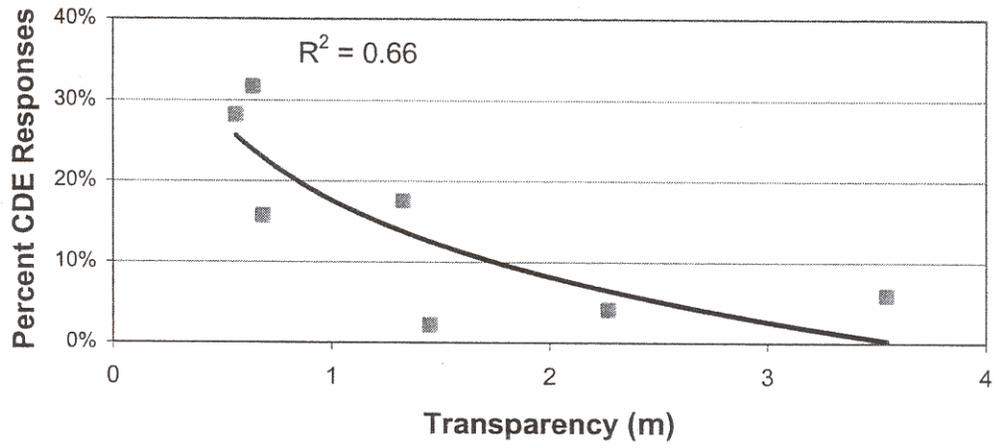
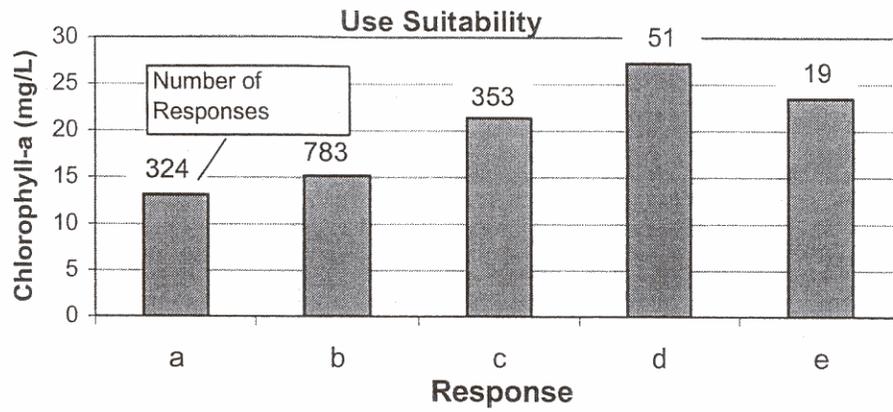
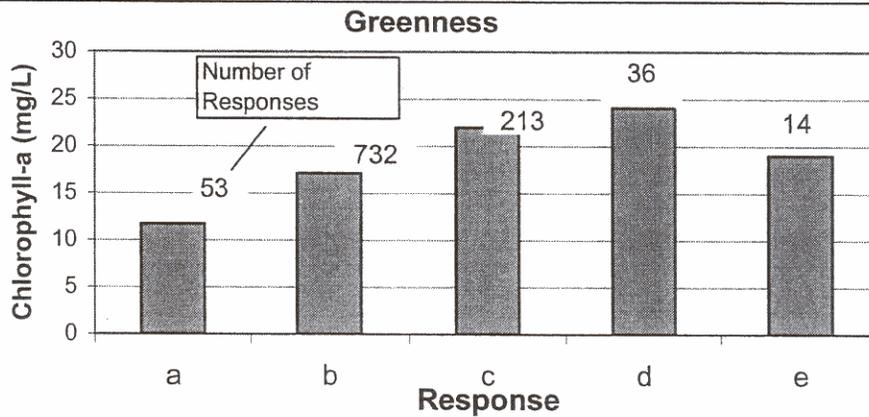


FIGURE IV-11
FREQUENCY OF RESPONSE OF USE IMPAIRMENT
VERSUS TRANSPARENCY
COMPARISON BETWEEN RESERVOIRS
(Each data point represents a reservoir)



Use Suitability

a - beautiful, could not be any nicer
 b - very minor aesthetic problems
 c - swimming and aesthetic enjoyment slightly impaired
 d - desire to swim and level of enjoyment of the lake substantially reduced
 e - swimming and aesthetic enjoyment of the lake nearly impossible



Greenness

a - no algae, or crystal clear water
 b - a little algae visible
 c - definite algal visible
 d - very green, some scum present and/or mild odor apparent
 e - pea-soup green with one or more of the following: massive floating scums on lake or washed up on shore, strong foul odor, or fish kill

FIGURE IV-9
AVERAGE CHLOROPHYLL-A CONCENTRATION
FOR EACH CATEGORY OF USE SUITABILITY AND GREENNESS
ALL DATA POOLED