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FILE NO. UU-1274-WS1-AA
3104

June 2, 1982

Mr. Charles Carelli,
Chief, Water Quality Planning
Department of Ecology
M/S PV-11
Olympia, Washington 98504

Dear Chuck:

Subject: Lake Chelan "208"
Water Quality Study

In response to our telephone conversation last week, the following further describes our proposed modified scope of work for the referenced study.

At your request last fall, we contacted Mr. McCall of the DOE water quality lab to arrange for the priority pollutant sample analysis. After a discussion with Mr. McCall, it was decided to analyze samples only for the priority pollutants throught to be of concern at Lake Chelan: pesticides/herbicides and heavy metals. This approach will allow us to analyze samples from several locations, which would not have been the case with the full priority pollutant scan. If this is not acceptable to you, we will contact Mr. McCall to arrange for a full scan on as many stations as possible. One approach might be to analyze the data from the first survey prior to deciding about the full scan.

As can be seen from our previously submitted historical data summary (copy attached), our data fall within the ranges expected on the basis of the limited existing data. Our biological sampling data were very similar to the County's recent coliform data.

Our sampling locations are shown on the figure in the data summary. These stations have now been field located with compass readings.

We would be agreeable to substituting ammonia-nitrogen sampling for Kjeldahl-nitrogen sampling at some stations. However, review of the historical data (Table 3 - Data Review), suggests that sampling for ammonia would be waste of resources unless on a wastewater plume, either from a septic tank or leaky sewers, was known to be present in some location.

In considering the dye testing of the south shore sewer, assume the pipeline is under a pressure of 20 psi (which converts to a pressure head of 46.2 feet). I do not know what the depth of the force main is, but I am relatively sure that it is not over 46 feet beneath the water surface.

Finally, your interpretation of our nutrient sampling program was correct. We shifted multiple station sampling to profiles in order to stay within our existing budget. We feel that we will have enough time to sample each station if you direct us to do so. However, this will require an increase to our contract with the County. We have calculated the added cost of the increased nutrient sampling to be $1,122 ($34. per sample). We believe that the County has enough grant monies allocated to cover this increase, due to our previous modifications to their original work plan.

If you have any questions, please call.

Very truly yours,

R. W. BECK AND ASSOCIATES

Lee Fortier
Executive Engineer

LF/cgo
cc: Sylvia Burges
Harold Porath, DOE, Yakima

Lake Chelan "208" Study
Data Review

LAKE CHELAN - REVIEW OF EXISTING DATA

Physical Data

Lake Chelan is a narrow fiord-like lake lying in a narrow, glacially cut valley. The dominant bedrock of the 924-square-mile drainage area consists of coarsely crystalline rocks ranging from granites to high-grade schists and gneisses.

The lake consists of two basins separated by a shallow constriction. The Lucerne Basin, at the upstream end of the lake, is much larger than the lower Wapato Basin. Water depth in the Lucerne Basin exceeds 450 meters (m), while the maximum depth of Wapato Basin is about 115 m. Sediment thickness in the Wapato Basin ranges from 140 to 178 m at several locations; depths of 10 to 100 m were recorded for the upper basin (Whetten, 1967). Substantial exchange probably occurs between the two basins of the lake. The water at the narrows is deep enough (42 m) to allow considerable circulation. In addition, strong winds generally blow across the lake in the afternoon. Physical and cultural data on the lake are given in Table 1.

A water balance developed for the lake by Projects Northwest (1981) using data for calendar years 1976 through 1980 is shown in Table 2 (Howton, 1981). Continuity requires that net inflow to the lake (rate of change of lake volume) equals the sum of surface inflow, precipitation on the lake, irrigation return, net ground water inflow minus outflow, evaporation, and diversions. Net inflow data were provided by the Chelan County PUD. The balance assumes that the Stehekin River inflow represents 82% of the total surface water inflow. Precipitation is from records at Stehekin, evaporation is based on data from Wenatchee and Quincy, and irrigation withdrawals are based on information from the Soil Conservation Service. Ground water input was calculated by difference and does not include irrigation return flows. The budget indicates that ground water provides one-third of the inflow to the lake.

Both basins of Lake Chelan stratify during the summer. Temperature-depth profiles taken by Cunningham and Pine (1968) in both basins on September 12, 1967 showed that the thermocline (region of rapid temperature change) occurred between 30 and 45 m in both basins. Temperature-depth measurements were made at least monthly by the USGS (1971, 1972) from June 1971 to August 1972. These data show that the Lucerne Basin was completely mixed from October 27 through May 31, 1971. Some warming of the surface waters occurred through June and July of both years. By mid-August, a strong thermocline was present between 26 and 36 m. The thermocline moved lower in the fall until reaching the bottom at the station (44 to 53 m) in late October. Temperature of the entire lake had dropped 3 degrees by late November, suggesting that in 1971 lake overturn occurred in November.

Chemical Data

Some basic chemical data for Lake Chelan are listed in Table 3. Data for the irrigation drains, measured in 1976, are also included. The lake is a colorless, soft-water lake, with moderate levels of the principal algal nutrients. A nutrient balance developed by Projects Northwest (1981) is included as Table 4. An analysis of the lake using the Vollenweider approach indicated that the lake is presently mesotrophic (Projects Northwest, 1981).

Bacteria

Bacteriological quality of Lake Chelan water is of concern because the lake is the source of 90% of the municipal/domestic water supply in the area around the lake, and because of the extensive recreational use of the lake. Lake Chelan has been classified as "Lake Class" by the State of Washington (WAC, 1978). Fecal coliform levels in waters of this class are not to exceed a median value of 50 MPN/100 ml, nor are more than 10% of the samples to contain more than 100 MPN/100 ml. Potential sources of bacterial contamination to Lake Chelan include effluent from substandard septic tanks or septic tank installations on the south side of the lake, recreational boating and swimming, and urban and agricultural runoff.

The most detailed data available on the bacteriological quality of the lake are provided by a 9-month sampling program conducted by the Chelan-Douglas Health District (1980). The results of this study indicate that the median fecal coliform level throughout the lake as a whole is well below 50 MPN/100 ml. Only about 7% of the samples contained more than 100 MPN/100 ml from mid-May to mid-August. Levels greater than 100 MPN/100 ml were recorded at least 10% of the time at several stations near the City of Chelan (City marina, Lakeshore Park near the marina, and the City dock), at an irrigation return drain east of Manson, at an urban runoff outfall near Lakeside Park, near a residence along the sewered portion of the South Shore, and below Granite Falls. High levels were frequent at the Lakeshore Park, City dock, and Lakeside Park beach sites, with some values exceeding 2,300 MPN/100 ml. Midlake coliform levels were low (less than 3 MPN/100 ml) throughout the study. Similarly, the USGS samples (Bortleson, et al., 1976) taken at midlake stations in July 1974 had low fecal coliform values (less than 5 MPN/100 ml).

Productivity

Lake Chelan has not had serious algal blooms and is relatively free of nuisance aquatic plants. Therefore, few studies of productivity (the rate at which organic matter is formed from raw materials supplied to the biological community) have been carried out.

Cunningham and Pine (1968) assessed algal productivity in the lake using glass slides immersed at 15 locations in the Wapato Basin and two locations in the Lucerne Basin. They also measured light penetrations at one mid-channel site in each basin. Net production rates in Lucerne Basin were low, ranging from 0.2 to 5.3 mg/cm^2/day. The highest productivity was observed during the month of August. Net production rates were relatively uniform, and slightly higher in the Wapato Basin. For most stations, productivity ranged from 0.2 to 8.6 mg/cm^2/day; no seasonal trends were apparent. Higher productivity (7.5 to 20.1 mg/cm^2/day) was observed at one station adjacent to a sawmill log storage area. Three stations in Manson Cove had elevated productivity (37.6 to 85.5 mg/cm^2/day) in May.

Secchi disk readings, a measure of light penetration, suggest that productivity in the lower basin may be higher than in the uppber basin. Light penetration in February and May was measured to be 9 m greater in the Lucerne Basin (Cunningham and Pine, 1968). The high secchi disk transparency (9 to 23 m) indicates excellent water clarity. USGS observations (Bortleson, et al., 1976) at deep stations in July 1974 of secchi depth readings ranging from 9 to 11 m confirm the earlier findings, as do the measurements (USGS, 1971, 1972) made at two stations near R.M. 19 that report secchi depths of 7.5 to 14 m during the summer-fall growing season. Similarly, the supersaturation of the epilimnion, in the Wapato Basin but not the Lucerne Basin, in September 1967 (Cunningham and Pine, 1968) suggests greater primary productivity in the former basin.

Chlorophyll a data from a 1975 EPA survey (EPA, 1981) indicate that more algae are present in July and September than in April. In contrast to the earlier light penetration data, these data indicate comparable conditions in the two basins. Both have low concentrations of chlorophyll a.

A brief survey conducted in 1969 (Department of Oceanography, 1969) provides some data on the plankton of the lake. In subsurface tows off the State park in the Wapato Basin, the phytoplankton consisted of green algae, dinoflagellates and diatoms; only green algae were observed at 15 m. Zooplankters present included rotifers, ciliates, water fleas, copepods, and amphipods. (See Table 5.) While some of these algae are nuisance species when the population is large, relatively small numbers of the organisms were present during the survey.

Proposed Sampling Program

The sampling program will be initiated in January. Sampling stations will be established at the 12 points shown on the accompanying figure and described in Table 6. Bacteriological samples will be taken at all 12 stations and at the 6 raw water intakes. Nutrient analyses will be carried out on samples from the midchannel sites (1, 5, 7), the sites near drains (4, 6), and the Chelan intake site (10). In-situ measurements (temperature, DO, conductivity, secchi depth) will be made at all 12 stations, if sufficient time is available.

The preceding review of data shows that although much data have been collected on Lake Chelan, the data are not sufficiently detailed to provide an adequate understanding of the lake. Intensive surveys, such as that planned for the July 4 weekend, are more likely to provide useful data. It may be advisable, therefore, to schedule additional intensive survey work in place of routine monthly sampling. The available temperature data reviewed above definitely indicate that an intensive survey should be performed in late summer or early fall to obtain data when the lake is thermally stratified and most likely to experience excessive algal growth and coliform problems.

PHYSICAL AND CULTURAL DATA

Physical Data

Drainage area	924 sq. mi.
Altitude	1110 ft.
Lake area	33,000 ac.
Lake volume (est.)	35,000,000 ac.-ft.
Mean depth (est.)	1,000 ft.
Maximum depth	1,600 ft.
Shoreline length	110 mi.
Bottom slope	3.7%
Basin geology	Igneous
Inflow	Perennial
Outflow channel	Present

Cultural Data

Residential Development	27%
No. of nearshore homes	682
Land use in drainage basin	
Residential urban	1%
Residential suburban	1%
Agricultural	2%
Forest or unproductive	92%
Lake surface	6%
Public boat access to lake ..	Yes

Source: Bortleson, et al., 1976.

TABLE 2

WATER BUDGET LAKE CHELAN
($M^3 \times 10^6$)
CALENDAR YEARS 1976-80

	Net Inflow	Stehekin River	Rivers and Creeks	Net Ground Water	Precipitation	Evaporation	Irrigation Use	Irrigation Return(1)
Jan.	56.35	38.51	8.47	-9.77	19.14			
Feb.	56.35	33.98	7.45	1.72	13.20			
Mar.	67.68	38.23	8.38	11.57	9.50			
Apr.	137.90	72.77	15.97	65.93	4.17	12.93	8.01	
May	376.61	238.71	52.39	108.79	2.61	17.88	8.01	
Jun.	489.88	311.49	68.24	136.62	2.34	20.80	8.01	
Jul.	622.97	214.64	47.01	391.12	1.39	23.18	8.01	
Aug.	143.00	116.67	25.60	23.87	3.53	18.66	8.01	
Sep.	65.13	57.48	12.63	6.90	6.72	10.59	8.01	
Oct.	39.36	42.19	9.26	-19.96	7.87			
Nov.	52.67	47.01	10.34	-15.88	11.20			
Dec.	87.50	46.16	10.14	13.52	17.68			
Yearly Total	2,195.40	1,257.84	275.88	714.43	99.35	104.04	48.06	28.84

(1) Sylvester and Seabloom (1962) - time of entry unknown; data not included in calculation of Yearly Total Ground Water

Source: Projects Northwest (1981)

TABLE 3

CHEMICAL DATA - LAKE CHELAN

Parameter	Wapato Basin	Lucerne Basin	Irrigation Drains
pH	6.6-8.0	6.9-8.2	7.4-8.3
Specific conductance ($umho/cm^2$)	32-70	31-61	398-1,301
Alkalinity (mg $CaCO_3$/l)	14-25	11-39	--
COD (mg/l)	0.8-16	--	7-2,058
NO_3 + NO_2 - N (mg/l)	.01-.49	0-.56	1.36-8.12
NH_3 - N (mg/l)	0-.030	.02-.04	0-.68
Kjeldahl - N (mg/l)	.16	.2-.2	.24-.47
Total Phosphorus (mg/l)	0-.04	0-.02	.09-2.62
Chlorophyll a (ug/l)	0.3-1.5	0.3-1.5	--

TABLE 4

SOURCES AND AMOUNTS OF NUTRIENT INPUTS TO LAKE CHELAN
(kg/year)

	Orchard Irrigation Return	Chelan City Golf Course	Chelan City Park	Forest Surface Runoff	Ground Water	Precipitation	Dry Fallout(1)
Nitrogen	2.27(a) x 10^5	1.17(e) x 10^3	2.59(e) x 10^3	1.78(f) x 10^5	5.71(j) x 10^5	9.2(k) x 10^3	1.84 x 10^4
				2.93(g) x 10^5		7.2(k) x 10^4	9.22 x 10^4
	3.29(b) x 10^3			6.67(g) x 10^5			1.44 x 10^5
							7.22 x 10^5
Phosphorus	2.71(c) x 10^3	1.46(e) x 10^1	2.89(e) x 10^1	3.6(h) x 10^4		2.68(h) x 10^3	5.36 x 10^3
	2.14(d) x 10^2			8.64(i) x 10^4			2.68 x 10^4

Sources and Computations of Mass Loadings:

(a) Sylvester and Seabloom (1962)
Johnson (personal communication)
(Acres fertilized) (fertilizer applied) (loss to drains) = mass loading
(7,000 acres) (45 kg/n/ac/yr) (.72) = 2.27 x 10^5 kg/n/yr/

(b) U.S. Dept. of Water and Power Res. (1976)
(Mean conc. of eight drains) (irrigation return flow) = mass loading
(3.22 mg/n/l) (1.02 x 10^9l yr) = 3.29 x 10^3 kg/n/yr/

(c) Sylvester and Seabloom (1962)
(Acres fertilized) (fertilizer applied) (loss to drains) = mass loading
(7,000 acres) (4.5 kg/P/ac/yr/) (0.86) = 2.71 x 10^3 kg/P/yr/

(d) U.S. Dept. of Water and Power Res. (1976)

(e) Turfgo Northwest, (personal communication)
Sylvester and Seabloom (1962)

(f) U.S. Forest Service
USGS
(River flow) (River conc.) = mass loading
(1,534 x 10^6, m^3 yr/) (116 mg/m^3) = 1.78 x 10^5 kg/n/yr/

(g) Sylvester (1961)
(Forest loading) (hectares of forests) = mass loading
(3.32 kg ha/yr/) (2.01 x 10^5 ha) = 6.67 x 10^5 kg yr/
(1.46 kg ha/yr/) (2.01 x 10^5 ha) = 2.93 x 10^5 kg yr/

(h) Gilliom (1980)

(i) Gilliom (1978)
Average of three methods

(j) (Conc. in ground water) (ground water inflow) = mass loading
(0.8 mg/n/l/) (7.14 x 10^{11} l) = 5.7 x 10^5 kg/n/yr/

(k) Uttormark (1974)

(l) Uttormark (1974)
Values calculated are probable boundaries of dry fallout, 2-10 times precipitation.

Source: Projects Northwest (1981)

TABLE 5

PLANKTON OBSERVED IN LAKE CHELAN
August 13, 1969

Subsurface Tow	15 Meters
Green algae	Green algae
Dictyosphaerium	*Dictyosphaerium*
Euglena	
Dinoflagellates	
Ceratium	
Diatoms	
Fragilaria	
Rotifers	Rotifers
Philodina	*Rotifera*
Keratella	
Ciliates	Ciliates
Vorticella	*Vorticella*
Water fleas	Water fleas
**Daphnia*	**Bosmina*
Copepods	Copepods
**Limnocalanus*	**Limnocalanus*
Canthocamptus	**Diaptomus*
Cyclops	*Cyclops*
Amphipods	
Hyalella	

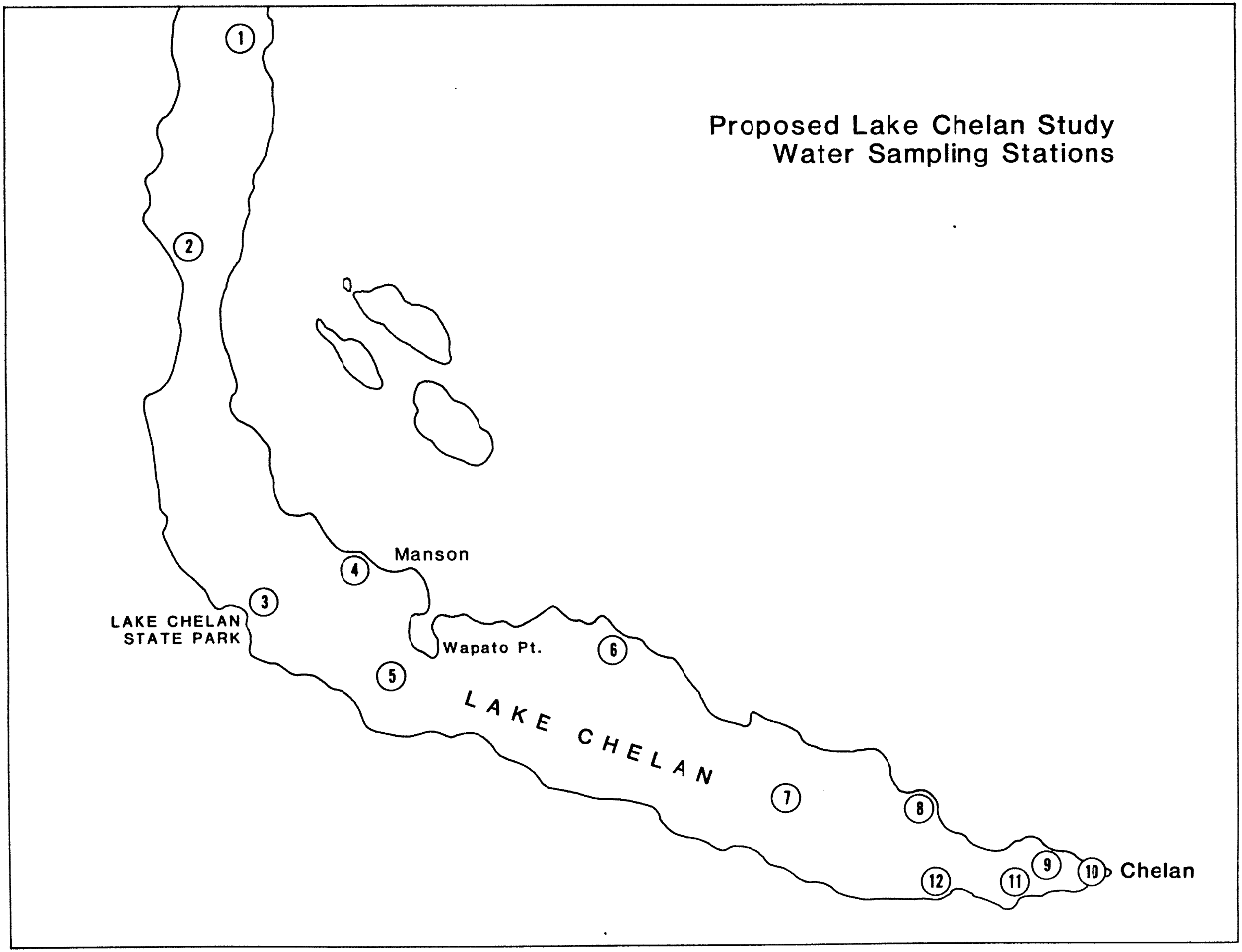
* - Indicates relatively abundant

Source: Department of Oceanography, 1969

TABLE 6

PROPOSED SAMPLING STATIONS

Station Number	Description	River Mile
1	Midchannel, Lucerne Basin, USGS 12452000	19
2	Upper Hollywood Beach	17
3	Lake Chelan State Park	13.5
4	Keupkin St. in Manson; near drains 7 and 8	13
5	Midlake at Wapato Point	12
6	Bennet Road; near drain 10	10
7	Midlake	8
8	Northshore agricultural area	6.7
9	Lakeshore Park	5.2
10	Chelan near intakes	4.8
11	Southshore commercial	5.7
12	Lakeside Park	6.5


Proposed Lake Chelan Study
Water Sampling Stations
1
2
Manson
4
3
LAKE CHELAN
STATE PARK
Wapato Pt.
5
6
LAKE CHELAN
7
8
9
10
Chelan
11
12

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