PUGET SOUND 305-A REPORT

Report Number: EPA 910/7-74-001

SURVEILLANCE AND ANALYSIS DIVISION

ENVIRONMENTAL PROTECTION AGENCY

REGION X

Seattle, Washington

October, 1974

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SUMMARY

PUGET SOUND 305-A SUMMARY

I. FRESH WATER

A. Water Quality Status

Each fresh water basin is summarized in the "Water Quality Status" Section of this report.

B. Basin Trends

1. Cedar-Sammamish River Basin

Ship Canal Mid Channel:

(a) Temperature values continue to exceed the Class A Standard regularly during late summer months. (pp. 341)

(b) Dissolved oxygen values continue to exceed the Class A Standard; however, some improvement is apparent. (pp. 342)

(c) Total Coliform bacteria concentrations exhibit a decreasing trend with the Class A Standard however, being frequently exceeded particularly during the periods of high flow. (pp.343)

Sammamish River at Mouth:

(a) Temperature values continue to exceed the Class A Standard regularly during summer months. (pp. 344)

(b) Total Phosphorus values continue to exceed the Limiting Algal Growth Concentration throughout most of the year. (pp. 346)

2. Deschutes River Basin

Deschutes River near Rainier:

(a) There are no dissolved oxygen violations. (pp. 353)

(b) Total Nitrate values indicate an increasing trend throughout most of the year causing the Limiting Algal Growth Concentration to be exceeded during periods of high flow. (pp. 355)

(c) A decreasing trend for dissolved Ortho-Phosphorus values is exhibited with the Limiting Algal Growth Concentration continuing to be exceeded throughout much of the year but on a less frequent basis. (pp. 356)

3. Duwamish - Green River Basin

Duwamish River at Mouth:

(a) Total-Phosphorus values continue to exceed the Limiting Algal Growth Concentration throughout the entire year. (pp. 369)

(b) Total-Coliform concentrations continue to violate the Class B Standard. A significant decrease in the number and magnitude of violations however is due to closure of both the METRO diagonal treatment plant (Oct. 69) and diversion of the Elliot Bay Outfall (Sep. 70). (pp. 370)

4. Nisqually River Basin

(a) pH values during December have increased and presently meet the Class A water quality standard criteria. (pp. 377)

(b) Total Nitrate values exhibit an increasing trend causing the Limiting Algal Bloom Concentration to be exceeded during periods of high flow. (pp. 378)

5. Nooksack River Basin
Nooksack River at Ferndale:

(a) Total Nitrate values indicate the possibility of a minimal increasing trend causing the Limiting Algal Bloom Concentration to be exceeded during periods of high flow. (pp. 386)

(b) Dissolved Ortho-Phosphorus values continue to exceed the Limiting Algal Bloom Concentration throughout the year. (pp. 387)

(c) Total Coliform bacteria concentrations continue to exceed the Class A Standard throughout the year. (pp. 388)

6. Puyallup River Basin
Puyallup River at Puyallup:

(a) Present dissolved oxygen levels appear to show an improvement over 10 years previous levels. (pp. 394)

(b) Total Nitrate values indicate the possibility of a minimal increasing trend causing the Limiting Algal Growth Concentration to be exceeded during months of high flow. (pp. 396)

7. Skagit River Basin
Skagit River at Mt. Vernon

(a) Total Nitrate values exhibit a trend increase while values are below the Limiting Algal Growth Concentration. Due to a lack of data, trends for Total-Phosphorus and Total Coliform cannot be determined. (pp. 403)

8. Snohomish River Basin
Snohomish River at Snohomish:

(a) Dissolved Oxygen values exhibit a minimal increasing trend. There are no violations of the Class A Standards. (pp. 410)

(b) Total Nitrate values indicate the possibility of a minimal increasing trend with the Limiting Algal Growth Concentration continuing to be exceeded during periods of high flow. (pp. 412)

(c) Dissolved Ortho-Phosphorus values continue to exceed the Limiting Algal Growth Concentration throughout much of the year. (pp. 413)

(d) Total Coliform bacteria concentrations continue to violate the Class A Standard throughout the year. (pp. 414)

9. Stillaguamish River Basin
Stillaguamish River near Silvana:

(a) Temperature values continue to exceed the Class A Standard during the month of August. (pp. 418)

(b) A decreasing trend in turbidity values is indicated, particularly during periods of high flow. (pp. 419)

(c) Dissolved Oxygen values exhibit a minimal increasing trend. There are no violations of the Class A Standards. (pp. 420)

(d) Total Nitrate values indicate an increasing trend causing the Limiting Algal Growth Concentration to be exceeded particularly during periods of high flow. (pp. 423)

(e) Dissolved Ortho-Phosphorus values continue to exceed the Limiting Algal Growth Concentration throughout much of the year while possibly exhibiting a decreasing trend. (pp. 424)

(f) Total Coliform values continue to exceed the Class A Standard throughout much of the year, while exhibiting an increasing trend. (pp. 425)

II. MARINE WATER

A. Water Quality Status

1. Strait of Juan De Fuca Basin
Pillar Point Station JDF114:

(a) Sub-Standard Dissolved Oxygen values, due to dense low oxygenated oceanic water entering the strait from its westerly entrance, appear particularly from June through November. (pp. 213)

New Dungeness Station JDF141:

(a) Substandard dissolved oxygen values appear due to the same naturally occuring hydrodynamic process as mentioned for Station Juan De Fuca 114, from early Summer through late Fall. (pp. 214)

2. San Juan Island Basin
Rosario Strait Station RSR835:

(a) Substandard dissolved oxygen values appear from early Summer to late Fall due to deep water from the Strait of Juan De Fuca intruding into this area. (pp. 220)

3. Admiralty Inlet Basin
Admiralty Inlet Station ADM202:

(a) Substandard dissolved oxygen values appear at all depths from July to November, responding to an influx of dense low oxygenated water from the Strait of Juan De Fuca. (pp. 226)

Admiralty Inlet Station ADM001:

(a) Substandard surface dissolved oxygen levels appear in September and October. (pp. 227)

(b) Sulfite Waste Liquor (SWL) values occasionally exceed those surface concentrations which are considered injurious to juvenile forms of fish and shell fish (10-12 mg/l). The primary source of SWL are pulp and paper mills using the Sulfite process. (pp. 229)

4. North Sound Basin
Bellingham - Samish Bay plot:

(a) Primarily surface values of Sulfite Waste Liquor (SWL) exceed those concentrations which are considered injurious to juvenile forms of fish and shell fish (10-12 mg/l) due to discharge from Georgia-Pacific Corporation. Maximum concentrations are found in the rear of Bellingham Bay and decline as Samish Bay is approached. (pp. 240)

(b) Dissolved oxygen values occasionally violate the Class A Standard particularly in the rear of Bellingham Bay due partially to discharges from Georgia-Pacific Corporation.

5. Whidbey Basin
Possession Sound to Deception Pass:

(a) Substandard dissolved oxygen values appear at depth from

the northern end of Possession Sound to Skagit Bay, particularly during periods of low river discharge. (pp. 250-60)

Port Susan and Possession Sound:

(a) Substandard dissolved oxygen values appear occasionally near the surface at Station PSS602, and continue to do so increasingly with depth as the head of Port Susan is approached. (pp. 262-265)

Port Gardner Bay at Weyerhauser Dock:

(a) Surface values of Sulfite Waste Liquor exceed those concentrations injurious to juvenile forms of fish and shell fish (10-12 mg/l) throughout the year due to discharges from the sulfite paper mills in Everett. (pp. 271)

(b) Total Coliform values violate the Class C Standard throughout much of the year. (pp. 272)

6. Puget Sound Main Basin
METRO Station 101 (Richmond Beach Offshore):

(a) Substandard dissolved oxygen values appear from August through November throughout nearly the entire water column. (pp. 280)

METRO Station 115 (Carkeek Park Offshore):

(a) Substandard dissolved oxygen values appear throughout the entire water column from September through October (pp.281)

METRO Station 130 (West Point Offshore):

(a) Substandard dissolved oxygen values appear from August through November occasionally at the surface with increasing frequency at greater depths. (pp. 283)

METRO Station 160 (Alki Point Offshore):

(a) Substandard dissolved oxygen values appear in August and September with increasing frequency at greater depths. (pp. 285)

7. Hood Canal Basin
Dabob Bay:

(a) Dissolved oxygen percent saturation values fall below the suggested water quality indicator value for Class AA waters (85%). This occurs particularly at depth due to natural hydrodynamic processes which limits flushing activity in this region. (pp. 297-8)

Lynch Cove:

(a) Dissolved Oxygen percent saturation values fall below the suggested water quality indicator value for Class AA waters (85%) throughout the entire year at depth with surface values occasionally exceeding this indicator. (pp. 297-8)

Hood Canal Proper:

(a) Dissolved Oxygen percent saturation values generally meet or exceed the suggested 85% quality indicator in the uppermost 20 feet of the water column while at greater depth, the suggested quality indicator value is rarely met or exceeded. (pp. 297-8)

8. Southern Puget Sound
Case Inlet:

(a) Particularly at depths greater than 200 feet, dissolved oxygen percent saturation values generally fall below the suggested Class A water quality indicator (75%). The water column above the 200 foot depth generally meets or exceeds the quality indicator. (pp. 310)

B. Water Quality Trends

1. Strait of Juan De Fuca Basin
Port Angeles Harbor at Rayonier Pier:

(a) Sulfite Waste Liquor concentrations exhibit a substantial decreasing trend as a waste product from the ITT Rayonier Sulfite Pulp Mill. However, during most of the year the SWL values exceed those concentrations considered injurious to juvenile forms of fish and shell fish (10-12 mg/l). (pp. 429)

2. North Sound Basin

Of the two date ranges examined in an effort to identify water quality trends, data during the latter period (72/10/01 - 73/12/31) consists of a significantly fewer number of samples than the earlier (59/11/04 - 63/07/06) date range. Therefore, the degree of confidence in which trends can be defined is reduced.

Bellingham Bay off Post Point:

(a) Available data indicates that a minimal dissolved oxygen increasing trend may exist from the surface to a depth of 100 feet thus eliminating a continuation of previous Class A Standard violations. (pp. 433)

(b) Available data indicates that Sulfite Waste Liquor concentrations, as a waste product from Georgia Pacific Sulfite plant exhibit an increasing trend in the top twenty-five feet of the water column in this particular area of Bellingham Bay. (pp. 435)

Bellingham Bay at South Whatcom Waterway:

(a) Dissolved Oxygen values may possibly exhibit a minimal increasing trend. However, due to temperature fluctuations during sampling periods it has not yet been determined whether this represents a true increase in dissolved oxygen percent saturation or a physical response to temperature decrease. (pp. 438)

(b) Sulfite Waste Liquor concentrations (SWL) exhibit a decreasing trend in this particular portion of Bellingham Bay. However, the values observed continue to exceed the concentration considered injurious to juvenile forms of fish and shell fish (10-12 mg/l) throughout most of the year. (pp. 439)

3. Whidbey Basin
Possession Sound to Port Susan Bayplot:

(a) Dissolved Oxygen levels appear to exhibit a minimal decreasing trend, particularly at depth where substandard values continue to occur with increasing frequency particularly as the head of Port Susan is approached. Whether the indicated dissolved oxygen decrease represents a true percent saturation decrease or a physical response to temperature or salinity variations has not yet been determined. (pp. 450-53)

(b) Dissolved Ortho-Phosphorus values appear to be decreasing with the most pronounced effect observed in the uppermost 25 feet of the water column near the southern end of Whidbey Island. (pp. 450)

4. Main Puget Sound Basin
Elliot Bay METRO Station #184:

(a) Dissolved Oxygen values exhibit an increasing trend thereby eliminating violations of the Class A Standard when considering mean monthly values. This trend is a result of closing the diagonal treatment plant and diverting the Elliot Bay outfall. (pp. 457)

(b) Median monthly total Coliform bacteria counts have decreased markedly to a level where the Class A Standards are not frequently violated. This reduction is due to closing the Diagonal Treatment Plant and diverting the Elliot Bay outfall. (pp. 457)

METRO West Point Offshore Station #130:

(a) Median monthly Total Coliform bacteria counts have decreased substantially to a level where the Class AA Standard is violated on a less frequent and lower magnitude basis. (pp. 458)

Main Puget Sound Bayplot:

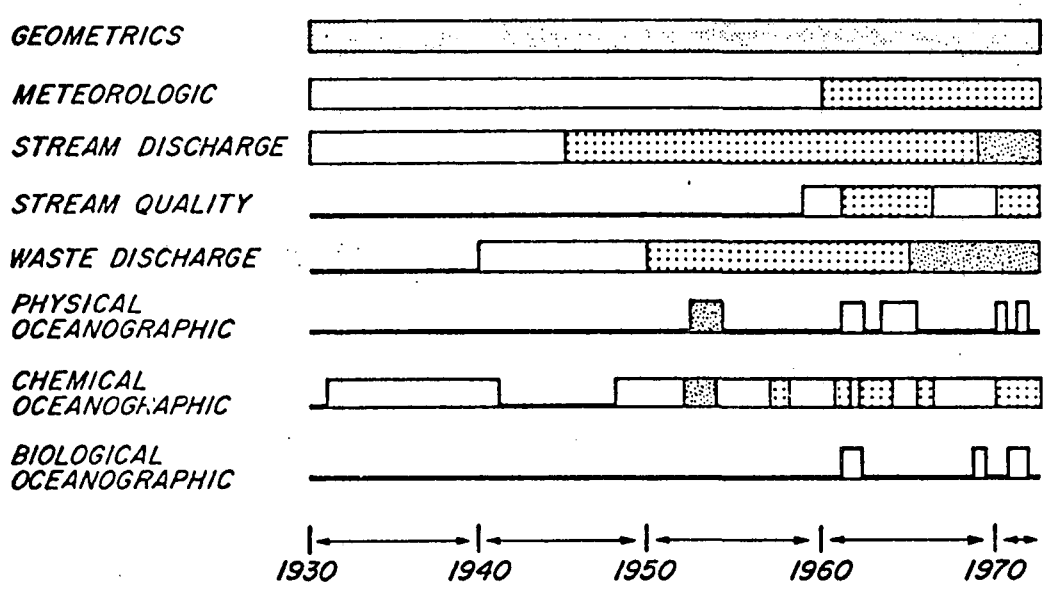
(a) Substandard dissolved oxygen levels occasionally occur in the depth range of 100-200 feet, particularly at Station #130.

C. General Puget Sound Temperature, D.O., & Phosphorus Trends

The following table summarizes the results of a least-squares analysis on monthly average concentrations for the upper layer (0-15 Meters) and the lower layer (15-175 Meters) for the parameters of Temperature, Dissolved Oxygen, and Ortho-Phosphate. Oceanographic subregions under consideration include Central Puget Sound, Southern Puget Sound, Hood Canal, and the Whidbey Basin.

DATA AVAILABILITY

In the Puget Sound Study Area, the availability of data varies from unavailable to complete. The graph below represents a subjective analysis of the availability of each major class of data from 1930 to the present. An overall assessment of availability of data would rank it as very sparse to partial. Important physical, chemical and biological oceanographic data are completely missing in early years. In recent years such data are more available but still incomplete. Circulation data (physical oceanographic data) are very sparse, being unavailable at times, even in later years. Only one comperehensive study collected oceanographic data over an extensive area. Less important, but still essential, meteorological and hydrological data are more abundant in later years. Navigation charts provide all the data needed to define the geometrics of the Study Area. These data can be used for any selected calibration period. Following is a more detailed summary of the availability of each class of data.



SOURCE: Data Review for Ecologic Modeling; Puget Sound and Adjacent Waters. Water Resources Eng., Walnut, Cr., California. Harry M. Nichandros and Gerald T. Orlob. May 1974

I. GENERAL SECTION

A . REPORT ORGANIZATION

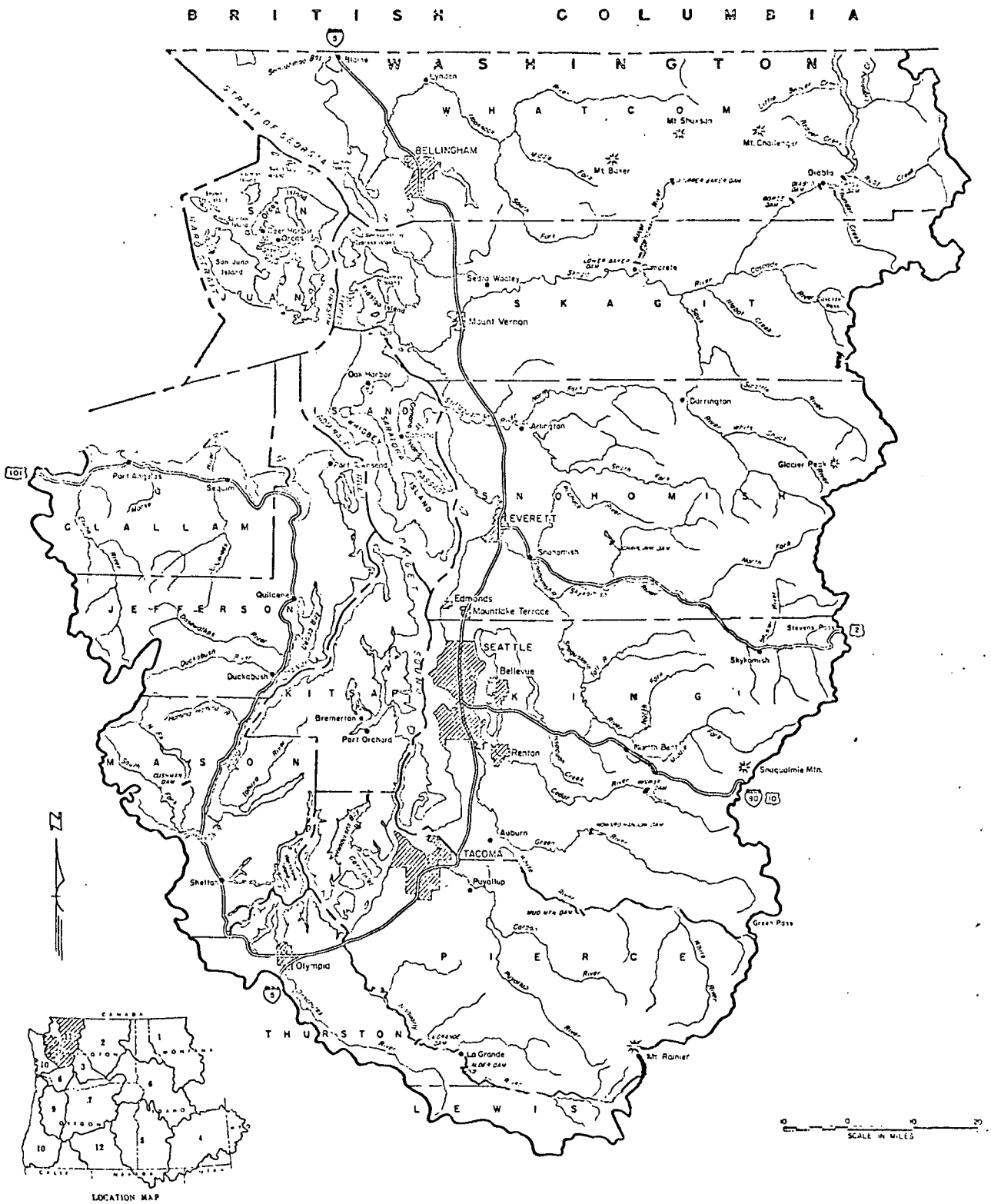
To facilitate examination of the water quality within the Puget Sound Basin, marine and freshwater portions have been created and treated somewhat seperately in this report. This is due partially to the fact that the chemical and physical properties governing these two respective water types differs considerably and also in an attempt to recognize effects of freshwater input to the Puget Sound Complex.

Waste sources, in the form of municipal and industrial point sources also have been categorized into marine and freshwater areas. In general, those point sources discharged into fresh recieving waters (major rivers and their tributaries) are assigned to freshwater basins while those point sources discharged directly to or via minor rivers into salt water and estuaries, are assigned to the marine basins.

A significant portion of the marine water quality data and information contained within this report is a result of research studies conducted by Eugene E. Collias and associates at the University of Washington Department of Oceanography.

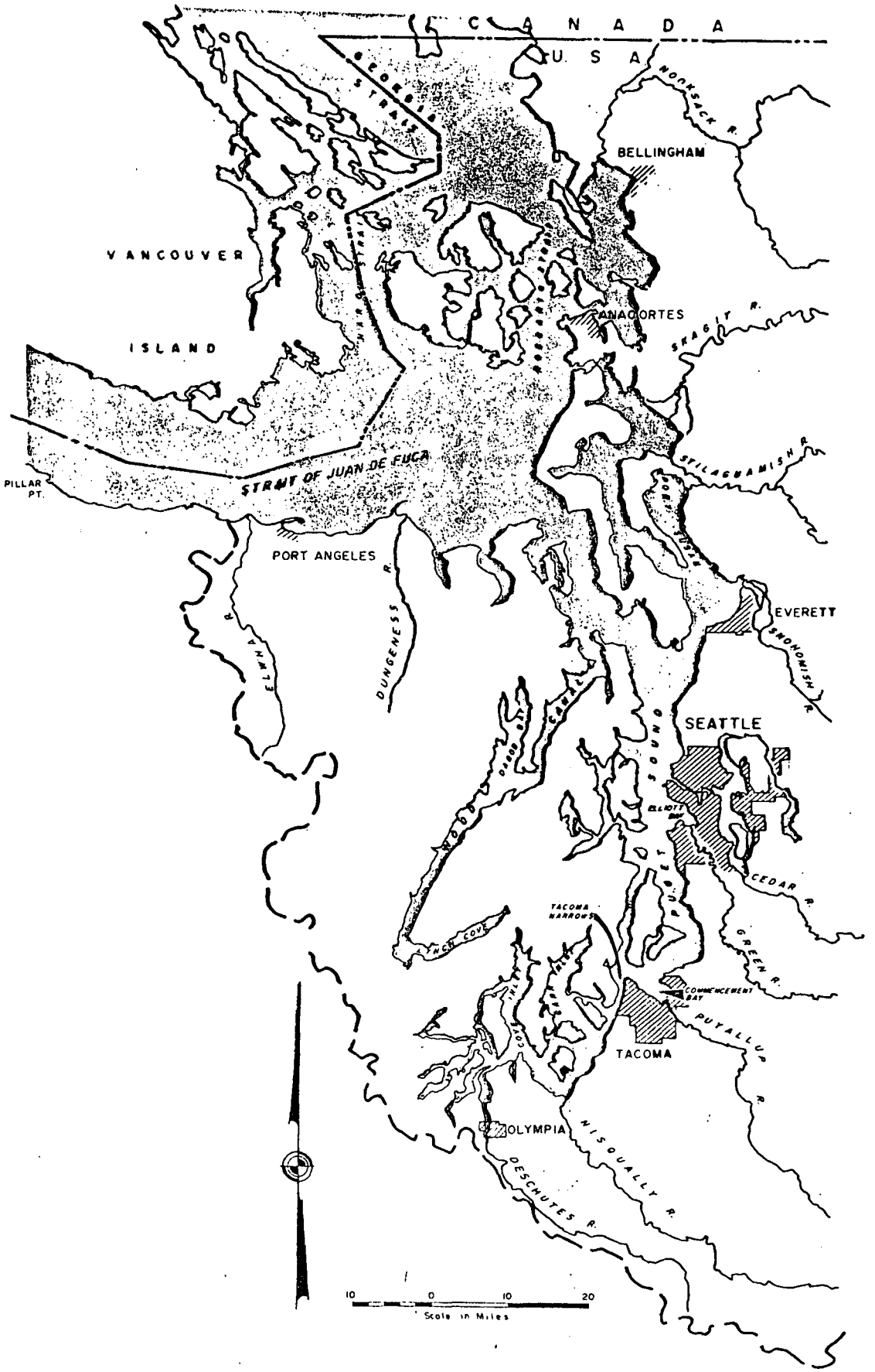
Atlas of Physical and Chemical Properties of Puget Sound and It's Approaches. Eugene E. Collias, Noel McGary and Clifford A. Barnes. University of Washington Press, Copyright 1974. A Washington Sea Grant Publication.

Skagit Bay Study Dynamical Oceanography Final Report. Eugene E. Collias, Clifford A. Barnes and John H. Lincoln. 1973



COLUMBIA-NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

PUGET SOUND SUBREGION



PRINCIPAL RIVERS ENTERING PUGET SOUND COMPLEX

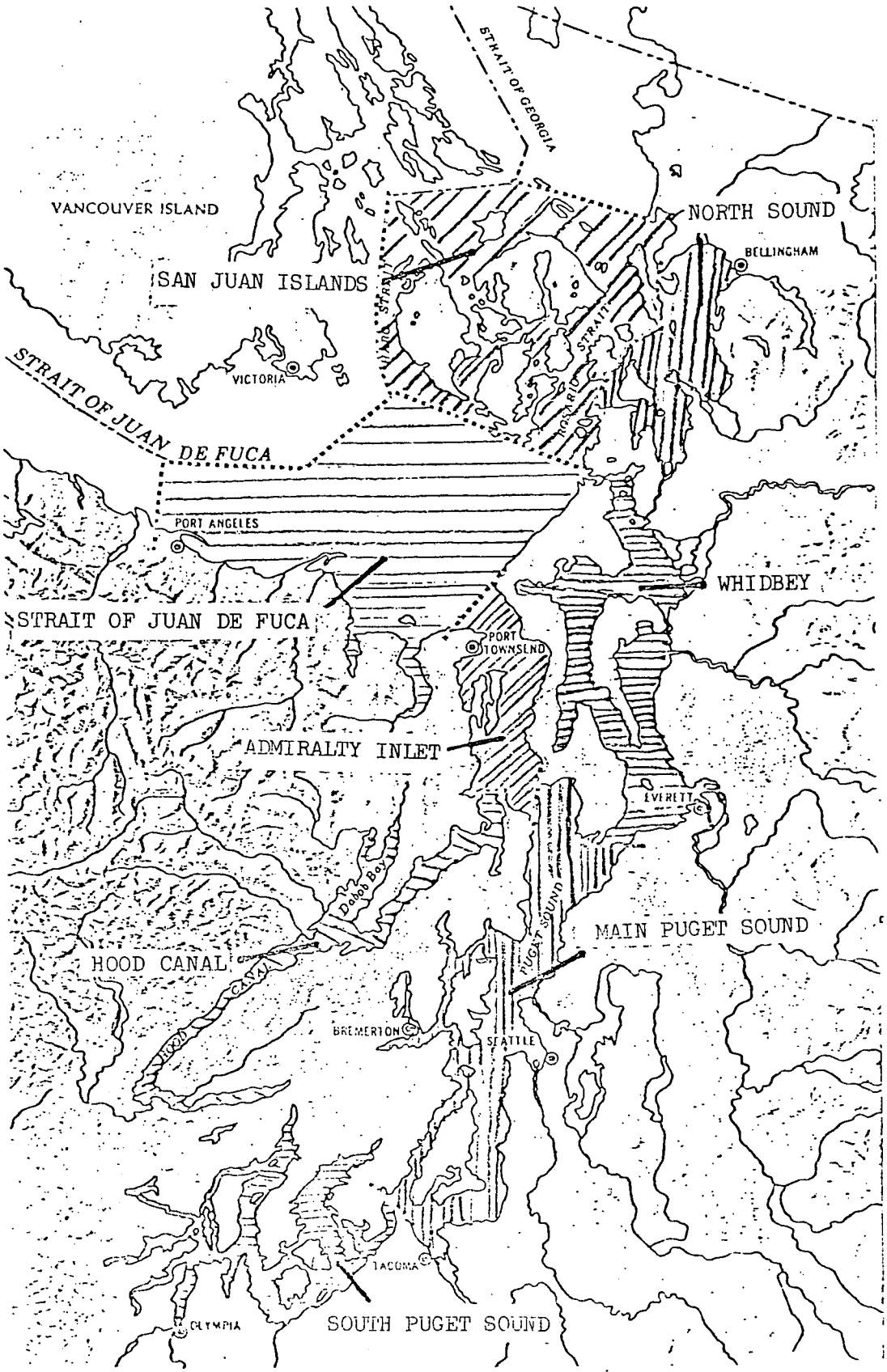
Principal rivers, Puget Sound Area

Basin	River and Location	Drainage Area (sq. mi.)	Discharge (cfs)			Average Annual Runoff (ac. ft.)
			Minimum Daily Mean	Momentary Maximum	Average Annual	
Nooksack-Sumas	Nooksack River nr. Lyndon	636	595	46,200	3,728	2,699,000
Skagit-Samish	Skagit River nr. Mt. Vernon	3,060[1]	2,740	144,000	16,340	11,830,000
Stillaguamish	South Fork, Stillaguamish River nr. Granite Falls	119	55	38,800	1,062	768,900
Snohomish	Snohomish River nr. Snohomish	1,720	—[2]	136,000	9,500	6,885,000
Cedar-Green	Cedar River nr. Renton	197	39	6,640	722	522,700
Cedar-Green	Green River nr. Auburn	382	81	28,100	1,334	965,800
Puyallup	Puyallup River at Puyallup	948	306	57,000	3,350	2,425,000
Nisqually-Deschutes	Nisqually River at McKenna	517	37	20,500	1,415	1,022,000
Nisqually-Deschutes	Deschutes River nr. Rainier	90	21	5,620	275	199,100
West Sound	Skokomish River nr. Potlatch	230	125	27,000	1,188	860,000
Elwha-Dungeness	Elwha River nr. Port Angeles	269	10	41,600	1,487	1,077,000
Elwha-Dungeness	Dungeness River nr. Sequim	156	77	6,820	371	268,600

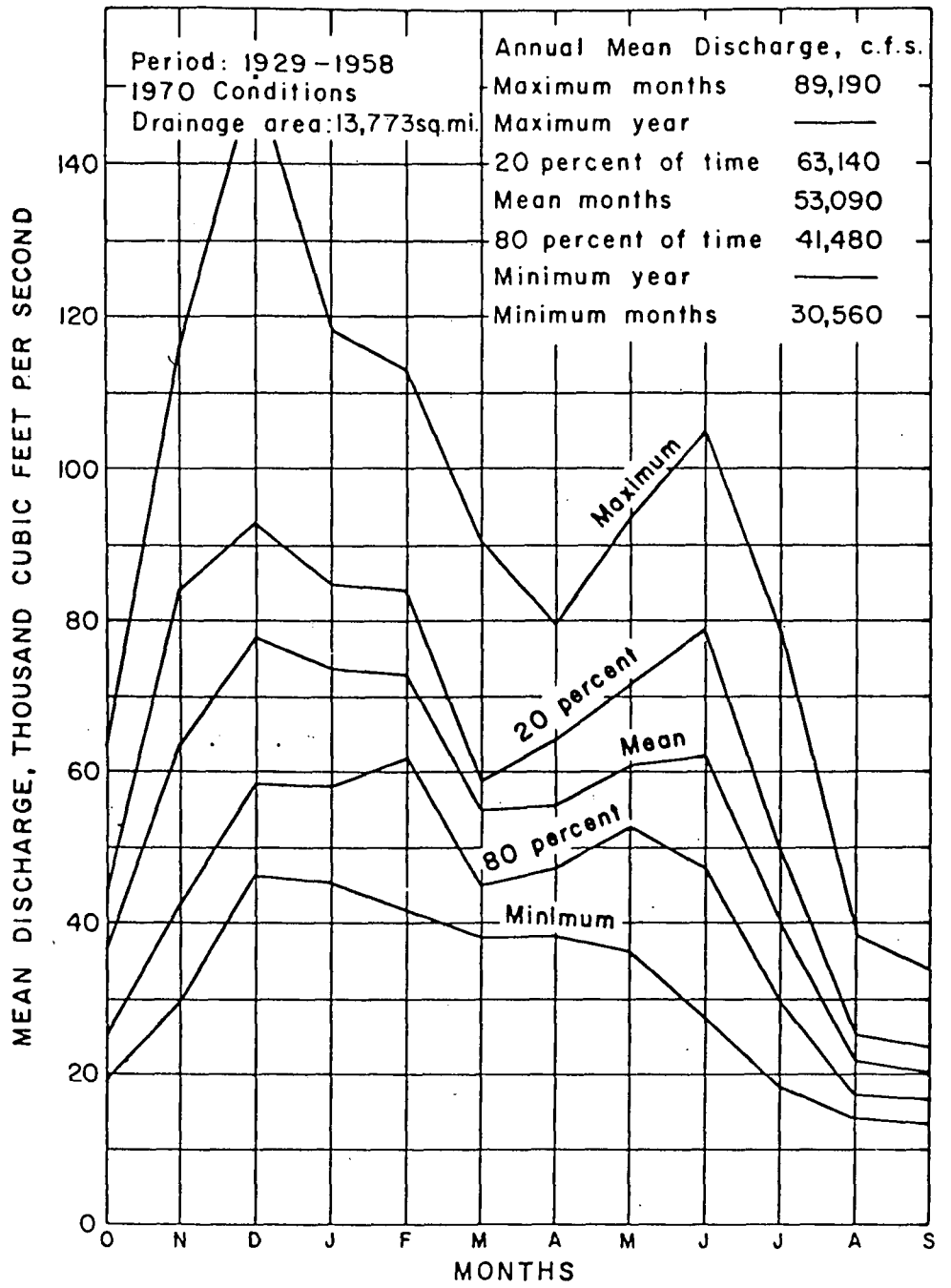
1 Includes drainage area in Canada.

2 Flows less than 10,000 cfs not computed.

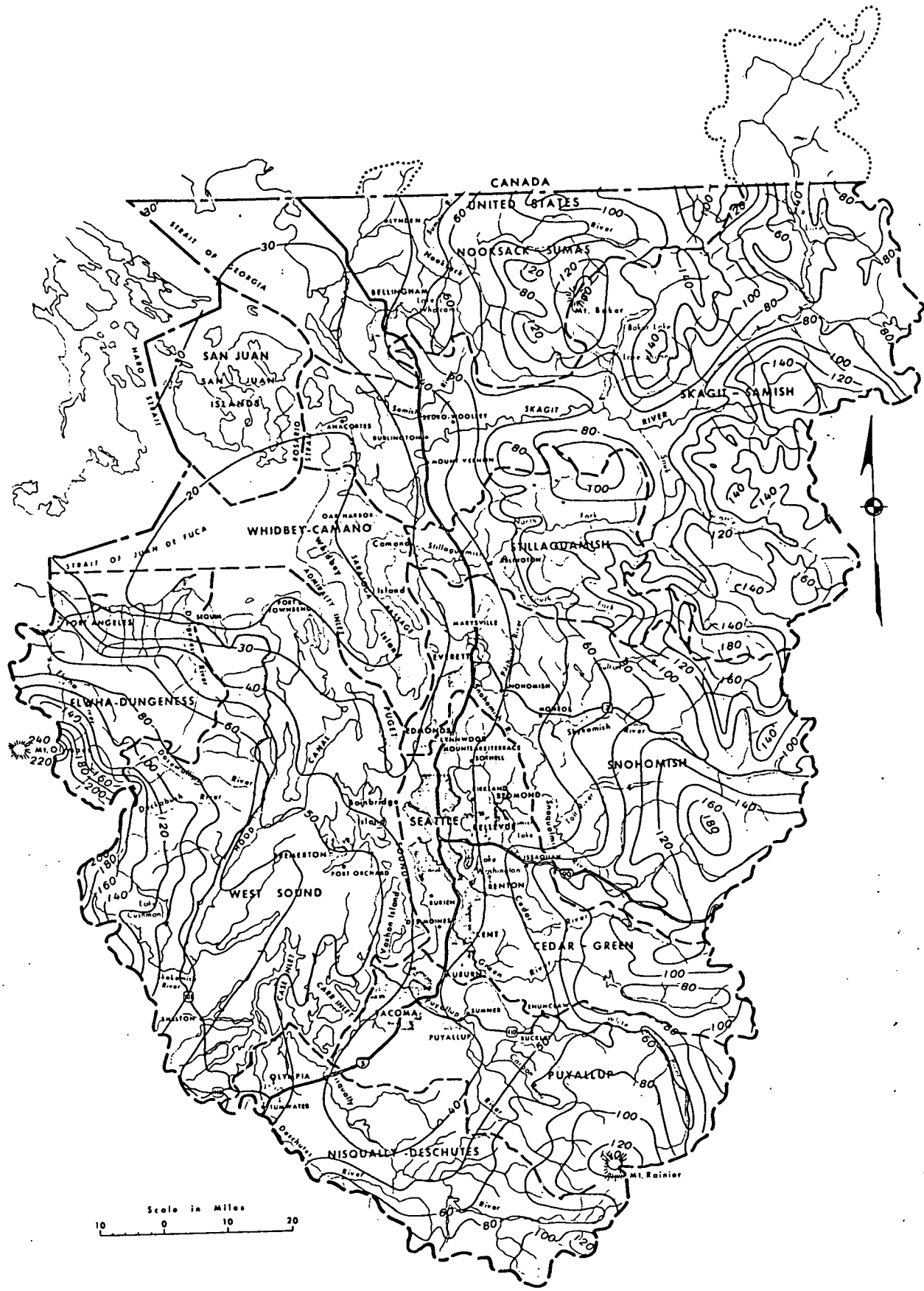
Source: Water Supply Bulletin No. 15, 1962 Washington Department of Conservation (Water Resources) and U.S. Department of the Interior, Geological Survey.



MARINE SUB-BASINS WITHIN PUGET SOUND BASIN



Monthly discharge, Puget Sound Subregion, 1929-58.
(Inflow from Canada is included.)



Mean annual precipitation.

Population projections by basins, Puget Sound Area (in thousands)

Basin	1963	1980	2000	2020
Nooksack-Sumas	74.6	91.6	123.5	168.7
Skagit-Samish	53.8	64.2	86.5	118.2
Stillaguamish	17.6	30.2	48.5	77.8
Whidbey-Camano Islands	19.9	56.0	80.9	115.0
Snohomish	178.2	297.8	467.8	761.4
Cedar-Green	976.9	1,454.8	2,270.0	3,619.9
Puyallup	324.5	449.8	700.0	1,107.5
Nisqually-Deschutes	69.6	74.9	104.5	146.5
West Sound	124.2	175.0	374.1	632.7
Elwha-Dungeness	28.3	29.8	41.0	56.6
San Juan Islands	2.6	2.8	3.7	5.1
Puget Sound Area	1,870.0	2,726.9	4,300.5	6,809.4

Source: Appendix IV, Economic Environment and Appendix V, Water-Related Land Resources.

Reservoirs Having a Total Capacity of 5,000 Acre-Feet or More

Name	Stream	Total Storage (ac-ft)	Active Storage (ac-ft)	Surface Area (acres)	Purpose[1/]
Alder Lake	Nisqually R.	232,000	180,000	3,065	P
Baker Lake	Baker R.	298,000	221,000	4,985	FP
Chester Morse	Cedar R.	56,000	23,000	1,682	MP
Cushman No. 1	N.F. Skokomish R.	453,000	360,000	4,200	PR
Cushman No. 2	N.F. Skokomish R.	8,000	2,000	70	P
Diablo	Skagit R.	89,000	61,000	910	P
Gorge	Skagit R.	8,500	7,000	241	P
Howard Hanson	Green R.	106,000	106,000	2,240	FMR
Lake Aldwell	Elwha R.	30,000	3,000	580	P
Lake Chaplain	Sultan R.	14,000	13,400	444	M
Lake Mills	Elwha R.	39,000	26,000	435	P
Lake Shannon	Baker R.	159,000	142,000	2,218	P
Lake Spada	Sultan R.	20,000	-	1,527	MP
Lake Tapps	White R.	46,600	44,000	2,566	P
Lake Whatcom	Whatcom Cr.	26,400	26,400	5,003	M
Mud Mountain	White R.	106,000	106,000	1,200	F
Ross	Skagit R.	1,434,000	1,052,000	11,678	FP
Terrell Lake	Terrell Cr.	5,600	-	700	R
Tolt	S.F. Tolt R.	60,000	53,000	850	M
Youngs Lake	Cedar R.	11,000	-	700	M

1/ M-municipal, F-flood control, R-recreation, I-irrigation, P-power

STATE OF
WASHINGTON

DEPARTMENT OF ECOLOGY
WATER QUALITY STANDARDS
FOR
STRAIT OF JUAN DE FUCA AND PUGET SOUND COMPLEX

1.	Bellingham Bay east of a line bearing 185° true from entrance of boat basin (light No. 2) except as otherwise noted.	Class B
2.	Bellingham Bay, inner, easterly of a line bearing 142° true through fixed green navigation light at southeast end of dock (approximately 300 yards northeast of bell buoy "2") to the base of the east boat basin jetty.	Class B
3.	Budd Inlet south of latitude 47°04' N. (South of Priest Point Park).	Class B
4.	Commencement Bay from south and east of a line bearing 258° true from "Brown's Point: and north and west of a line bearing 225° true through the Hylebos Waterway light. Special condition - total coliform organisms shall not exceed median values of 1,000 with less than 20% of samples exceeding 2,400 when associated with any fecal source.	Class A
5.	Commencement Bay inner, from south and east of a line bearing 225° true through the Hylebos Waterway light except the city waterway south and east of south 11th street.	Class B
6.	Commencement Bay, city waterway south and east of south 11th Street.	Class C
7.	Drayton Harbor, south of entrance.	Class A
8.	Dyes and Sinclair Inlets west of longitude 122°37' W. Special conditions - Sinclair Inlet and Port Washington Narrows West of longitude 122° 37' W. and south of latitude 47° 36'20" N. Total coliform organisms - shall not exceed median values of 1,000 with less than 20% of samples exceeding 2,400 when associated with any fecal source.	Class A
9.	Elliott Bay east of a line between U.S. Navy Supply Depot and Duwamish Head. Special condition - total coliform organisms shall not exceed median values of 1,000 with less than 20% of samples exceeding 2,400 when associated with any fecal source.	Class A
10.	Everett Harbor east of longitude 122°13'40" W. and southwest of a line bearing 121° true from light "4" (Snohomish River mouth).	Class B
11.	Oakland Bay west of longitude 123° 05' W. (inner Shelton harbor).	Class B
12.	Port Angeles south and west of a line bearing 152° true from buoy "2" at the tip of Ediz Hook. Special condition - total coliform organisms - shall not exceed a median value of 240 with less than 20% of samples exceeding 1,000 when associated with any fecal source.	Class A
13.	Port Gamble south of latitude 47°51'20" N.	Class A
14.	Port Townsend west of a line between Point Hudson and Kala Point.	Class A

15.	Possession Sound, Port Susan, Saratoga Passage and Skagit Bay east of Whidbey Island and longitude 122°38'35" W. (bridge) between latitude 47°57' N. (Mulkilteo) and latitude 48°27'20" N. (Similk Bay) except as otherwise noted.	Class A
16.	Sequim Bay southward of entrance.	Class A
17.	South Puget Sound west of longitude 122°52'30" W. (Brisco Point) and longitude 122° 51' W. (northern tip of Hartstene Island) except as otherwise noted.	" "
18.	Strait of Juan de Fuca and Puget Sound through Admiralty Inlet and South and West to longitude 122°52'30" W. (Brisco Point) and longitude 122°51' W. (northern tip of Hartstene Island), Hood Canal, Possession Sound south of latitude 47°57' N.(Mukilteo) and all North Puget Sound West of longitude 122°39" (Whidbey, Fidalgo, Guemes and Lummi Island) except as otherwise noted.	Class AA

Water Quality Criteria and Classification Puget Sound Area

Water Quality Standards 1/	CLASS AA Extraordinary		CLASS A Excellent		CLASS B Good		CLASS C Fair	
	Fresh	Marine	Fresh	Marine	Fresh	Marine	Fresh	Marine
COLIFORM, TOTAL med. value/100 ml	50	70	240	70	1,000	1,000	1,000	1,000
DISSOLVED OXYGEN (mg/l) 1/	9.5	7.0 or @80-85% Sat.	8.0	6.0 or @75% Sat.	6.5	5.0 or 70% Sat.	5.0	4.0 or 50% Sat.
pH (Standard Units)	6.5-8.5	7-8.5	6.5-8.5	7-8.5	6.5-8.5	7-8.5	6.5-9	7-9
TURBIDITY JTU	5	5	5	5	10	10	10	10

1/ Units may be given as mg at./L

Dissolved Oxygen: 1 mg at./L = 1/16 mg/l
Dissolved Ortho-Phosphate: 1 mg at./L = 1/31 mg/l

* Values not listed in June 19,1973 Washington State DOE Water Quality Standards, but serve as quality indicators. Calculated through Salinity and Temp.

1/ A complete listing of the Washington State Department of Ecology Water Quality Standards are found on the following four pages.

NEW WAC 173-201-030 -------GENERAL WATER USE AND CRITERIA CLASSES. The following criteria shall be applicable to the various classes of waters in the State of Washington:

(1) Class AA (Extraordinary).

(a) General characteristic. Water quality of this class shall markedly and uniformly exceed the requirements for all or substantially all uses.

(b) Characteristic uses. Characteristic uses shall include, but are not limited to the following:

(i) Water supply (domestic, industrial, agricultural).

(ii) Wildlife habitat, stock watering.

(iii) General recreation and aesthetic enjoyment (picnicking, hiking, fishing, swimming, skiing, and boating).

(iv) General marine recreation and navigation.

(v) Fish and shellfish reproduction, rearing, and harvest.

(c) Water quality criteria.

(i) Total coliform organisms shall not exceed median values of 50 (fresh water) or 70 (marine water) with less than 10% of samples exceeding 230 when associated with any fecal source.

(ii) Dissolved oxygen shall exceed 9.5 mg/l (fresh water) or 7.0 mg/l (marine water).

(iii) Total dissolved gas - the concentration of total dissolved gas shall not exceed 110% of saturation at any point of sample collection.

(iv) Temperature - water temperatures shall not exceed 60° F. (fresh water) or 55° F. (marine water) due in part to measurable (0.5° F.) increases resulting from human activities; nor shall such temperature increases, at any time, exceed $t = 75/(T-22)$ (fresh water) or $t = 24/(T-39)$ (marine water); for purposes hereof "t" represents the permissive increase and "T" represents the water temperature due to all causes combined.

(v) pH shall be within the range of 6.5 to 8.5 (fresh water) or 7.0 to 8.5 (marine water) with an induced variation of less than 0.1 units.

(vi) Turbidity shall not exceed 5 JTU over natural conditions.

(vii) Toxic, radioactive, or deleterious material concentrations shall be less than those which may affect public health, the natural aquatic environment, or the desirability of the water for any usage.

(viii) Aesthetic values shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch or taste.

(3) Class B (Good).

(a) General characteristic. Water quality of this class shall meet or exceed the requirements for most uses.

(b) Characteristic uses. Characteristic uses shall include, but are not limited to, the following:

(i) Industrial and agricultural water supply.

(ii) Fishery and wildlife habitat.

(iii) General recreation and aesthetic enjoyment (picnicking, hiking, fishing, and boating).

(iv) Stock watering.

(v) Commerce and navigation.

(vi) Shellfish reproduction and rearing, and crustacea (crabs, shrimp, etc.) harvest.

(c) Water quality criteria.

(i) Total coliform organisms shall not exceed median values of 1,000 with less than 10% of samples exceeding 2,400 when associated with any fecal source.

(ii) Dissolved oxygen shall exceed 6.5 mg/l (fresh water) or 5.0 mg/l (marine water), or 70% saturation, whichever is greater.

(iii) Total dissolved gas - the concentration of total dissolved gas shall not exceed 110% of saturation at any point of sample collection.

(iv) Temperature - water temperatures shall not exceed 70° F. (fresh water) or 66° F. (marine water) due in part to measurable (0.5° F.) increases resulting from human activities; nor shall such temperature increases, at any time, exceed $t = 110/(T-15)$ (fresh water) or $t = 52/(T-32)$ (marine water); for purposes hereof "t" represents the permissive increase and "T" represents the water temperature due to all causes combined.

(v) pH shall be within the range of 6.5 to 8.5 (fresh water) or 7.0 to 8.5 (marine water) with an induced variation of less than 0.5 units.

(vi) Turbidity shall not exceed 10 JTU over natural conditions.

(vii) Toxic, radioactive, or deleterious material concentrations shall be below those which adversely affect public health during the exercise of characteristic usages, or which may cause acute or chronic toxic conditions to the aquatic biota, or which may adversely affect characteristic water uses.

(viii) Aesthetic values shall not be reduced by dissolved, suspended, floating or submerged matter not attributable to natural causes, so as to affect water usage or taint the flesh of edible species.

(4) Class C (Fair).

(a) General characteristic. Water quality of this class shall meet or exceed the requirements of selected and essential uses.

(b) Characteristic uses. Characteristic uses shall include, but are not limited to, the following:

(i) Cooling water.

(ii) Commerce and navigation.

(iii) Fish passage.

(iv) Boating.

(c) Water quality criteria.

(i) Total coliform organisms shall not exceed median values of 1,000 when associated with any fecal source.

(ii) Dissolved oxygen shall exceed 5.0 mg/l (fresh water) or 4.0 mg/l (marine water), or 50% saturation, whichever is greater.

(iii) Total dissolved gas - the concentration of total dissolved gas shall not exceed 110% saturation at any point of sample collection.

(iv) Temperature - water temperatures shall not exceed 75° F. (fresh water) or 72° F. (marine water) due in part to measurable (0.5° F.) increases resulting from human activities; nor shall such temperature increases, at any time, exceed $t = 125/(T-12)$ (fresh water) or $t = 64/(T-29)$ (marine water); for purposes hereof "t" represents the permissive increase and "T" represents the water temperatures due to all causes combined.

(v) pH shall be within the range of 6.5 to 9.0 (fresh water) or 7.0 to 9.0 (marine water) with an induced variation of less than 0.5 units.

(vi) Turbidity shall not exceed 10 JTU over natural conditions.

(vii) Toxic, radioactive or deleterious material concentrations shall be below those which adversely affect public health during the exercise of characteristic usages, or which may cause acute or chronic toxic conditions to the aquatic biota, or which may adversely affect characteristic water uses.

(viii) Aesthetic values shall not be interfered with by the presence of obnoxious wastes, slimes, or aquatic growths or by materials which will taint the flesh of edible species.

(2) Class A (Excellent).

(a) General characteristic. Water quality of this class shall meet or exceed the requirements for all or substantially all uses.

(b) Characteristic uses. Characteristic uses shall include, but are not limited to, the following:

(i) Water supply (domestic, industrial, agricultural).

(ii) Wildlife habitat, stock watering.

(iii) General recreation and aesthetic enjoyment (picnicking, hiking, fishing, swimming, skiing and boating).

(iv) Commerce and navigation.

(v) Fish and shellfish reproduction, rearing and harvest.

(c) Water quality criteria.

(i) Total coliform organisms shall not exceed median value of 240 (fresh water) with less than 20% of samples exceeding 1,000 when associated with any fecal sources or 70 (marine water) with less than 10% of samples exceeding 230 when associated with any fecal sources.

(ii) Dissolved oxygen shall exceed 8.0 mg/l (fresh water) or 6.0 mg/l (marine water).

(iii) Total dissolved gas - the concentration of total dissolved gas shall not exceed 110% of saturation at any point of sample collection.

(iv) Temperature - water temperatures shall not exceed 65° F. (fresh water) or 61° F. (marine water) due in part to measurable (0.5° F.) increases resulting from human activities; nor shall such temperature increases, at any time, exceed $t = 90/(T-19)$ (fresh water) or $t = 40/(T-35)$ (marine water); for purposes hereof "t" represents the permissive increase and "T" represents the water temperature due to all causes combined.

(v) pH shall be within the range of 6.5 to 8.5 (fresh water) or 7.0 to 8.5 (marine water) with an induced variation of less than 0.25 units.

(vi) Turbidity shall not exceed 5 JTU over natural conditions.

(vii) Toxic, radioactive, or deleterious material concentrations shall be below those of public health significance, or which may cause acute or chronic toxic conditions to the aquatic biota, or which may adversely affect any water use.

(viii) Aesthetic values shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch, or taste.

B. P.S. HYDRODYNAMICS

PUGET SOUND GENERAL HYDRODYNAMICS

The waters confined within the boundaries of Puget Sound are actually a small portion of a larger complex that includes the Strait of Georgia and the Strait of Juan de Fuca. The entire complex is composed of many inter-connected inlets, bays, and channels with sea water entering at the western end and freshwater entering at many points along the system. This large complex may be sub-divided into nine major oceanographic regions but are inter-related one to the other. Each oceanographic region will be discussed in a separate section of this report.

Basically, the Puget Sound-Georgia Strait-Juan de Fuca Strait complex is a two layer system with fresher water moving seaward in a surface layer that overrides a more saline layer of inflowing oceanic water. The surface layer contains fresh-water added locally from direct precipitation, river runoff, and other land drainage. The deeper, more saline layer has its origin in the Pacific Ocean off Cape Flattery and has a net flow landward in response to the pressure forces associated with the difference in density between fresh-water and sea water. The boundary between these two layers is most distinct near the freshwater source or on either side of a constriction having strong tidal currents. This boundary becomes more diffuse as the fresh-water layer moves seaward as a result of vertical mixing by winds and the entrainment of deeper, more saline water into the surface layer. The processes that govern the mixing and transport of waters from one part of the complex to another are complicated and are related meteorological conditions and to tidal action.

As one travels eastward from the entrance of the Strait of Juan de Fuca off Cape Flattery to the head of either Georgia Strait or Puget Sound a series of sills are encountered that separate the deeper basins.

The Victoria Green Point sill has a pronounced effect upon the waters of both Puget Sound and Georgia Strait because it effectively prevents oceanic water from entering these regions without becoming somewhat diluted and modified by fresher surface water flowing out of these regions toward the ocean.

The importance of increased density in late summer by the oceanic water intruding into the Strait and then being mixed in the eastern end of the Strait cannot be over emphasized. Because of this more dense water entering in the early fall, most all parts of the Puget Sound-Georgia Strait complex are flushed once a year by a replacement of the less dense water with the more dense water.

Deep channels of the San Juan Archepelago serve as mixing areas for the waters of Georgia Strait and the Strait of Juan de Fuca. Over 90% of the water needed to supply the tidal prism of Georgia Strait must pass through these channels. The water below 150 meters in the Haro Strait is oxygen poor and phosphate rich. Under certain conditions, deep water from the Strait of Juan de Fuca may intrude into Haro Strait without significant modification and as a result low oxygen content water may appear along the west side of the San Juan Island in July or August.

Most of the water entering or leaving Puget Sound must flow through Admiralty Inlet with only a small portion of the water flowing through Deception Pass and the Swinomish Slough at the northern end of Whidbey Island. Admiralty Inlet is a large mixing zone for the deeper waters of the Strait of Juan de Fuca with the fresher surface water from Puget Sound. The mixed water is more dense than the surface water and less dense than Strait water and, therefore, flows back into Puget Sound on a flood tide. Due to the strong currents in Admiralty Inlet, the flushing time is rapid with the various water types

requiring only a few tidal cycles to make the transit through this region. Admiralty Inlet also supplies water to Hood Canal off Tala Point and travels South through the entrance arm.

The Skagit river is the largest river in the Puget Sound drainage basin and contributes about 35% of the total freshwater inflow. The Snohomish river is the second largest river discharging into Puget Sound and contributes about 30.5% of the total freshwater inflow and the Stillaguamish river is the third largest river entering into Puget Sound but contributes only about 8.5%. The combined flow of these rivers on an annual basis accounts for 74% of the total river runoff entering the Puget Sound System and has a pronounced effect upon the hydro-dynamics of the Possession Sound region while also frequently affecting the northend of the Main Puget Sound Basin.

The minimum surface salinity in the main Puget Sound Basin is observed in June because of the influence of the Skagit River which, even though it does not discharge into this basin, the effect of it's discharge is observable as far south as Alki Point. The maximum surface salinity is observed in the middle of October when freshwater contributions have been at a minimum. However, a second minimum is observed in late June and early July in response to large amounts of freshwater being contributed by the Frazer, Skagit, and Snohomish rivers in early summer.

This freshwater is mixed in Admiralty Inlet and the eastern end of the Strait of Juan de Fuca to cause a lowering of the salinity for the water being refluxed back into Puget Sound. Flushing rates for the Main Basin have been estimated to vary from two to four weeks.

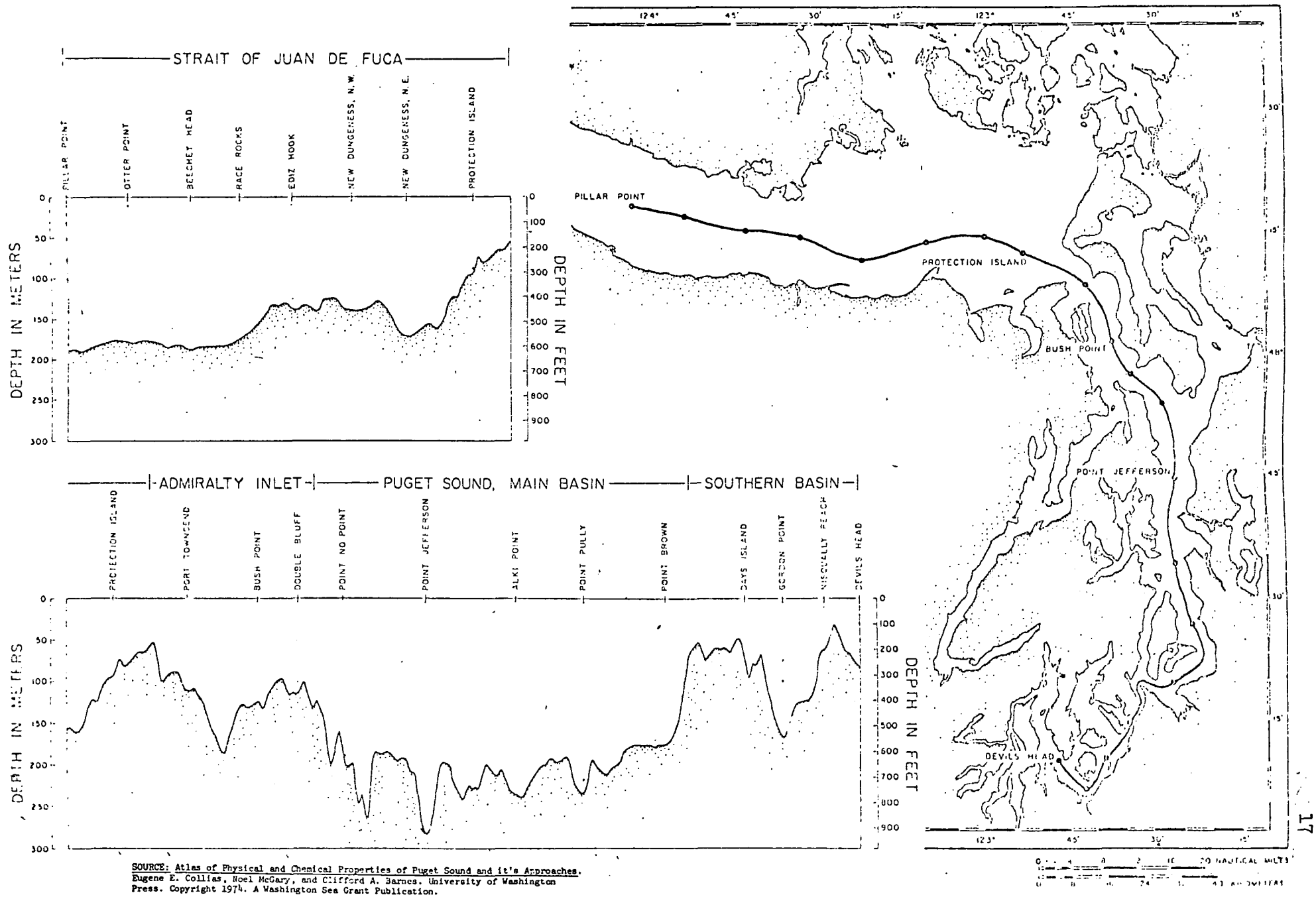
All of the water entering Southern Puget Sound must pass through the Tacoma Narrows which is a mixing zone similar to Admiralty Inlet but on a

smaller scale. Waters from either side of the narrows to a depth of about fifty meters are mixed depending on the direction of the tide. Thus each major oceanographic region is separated from the other by a mixing zone or some geographic feature that controls the flow of water from one region to another. As a result of this geographic structure, the waters of each basin become fresher as one proceeds landward. Also the temperature range from winter to summer becomes greater and the tidal range increases.

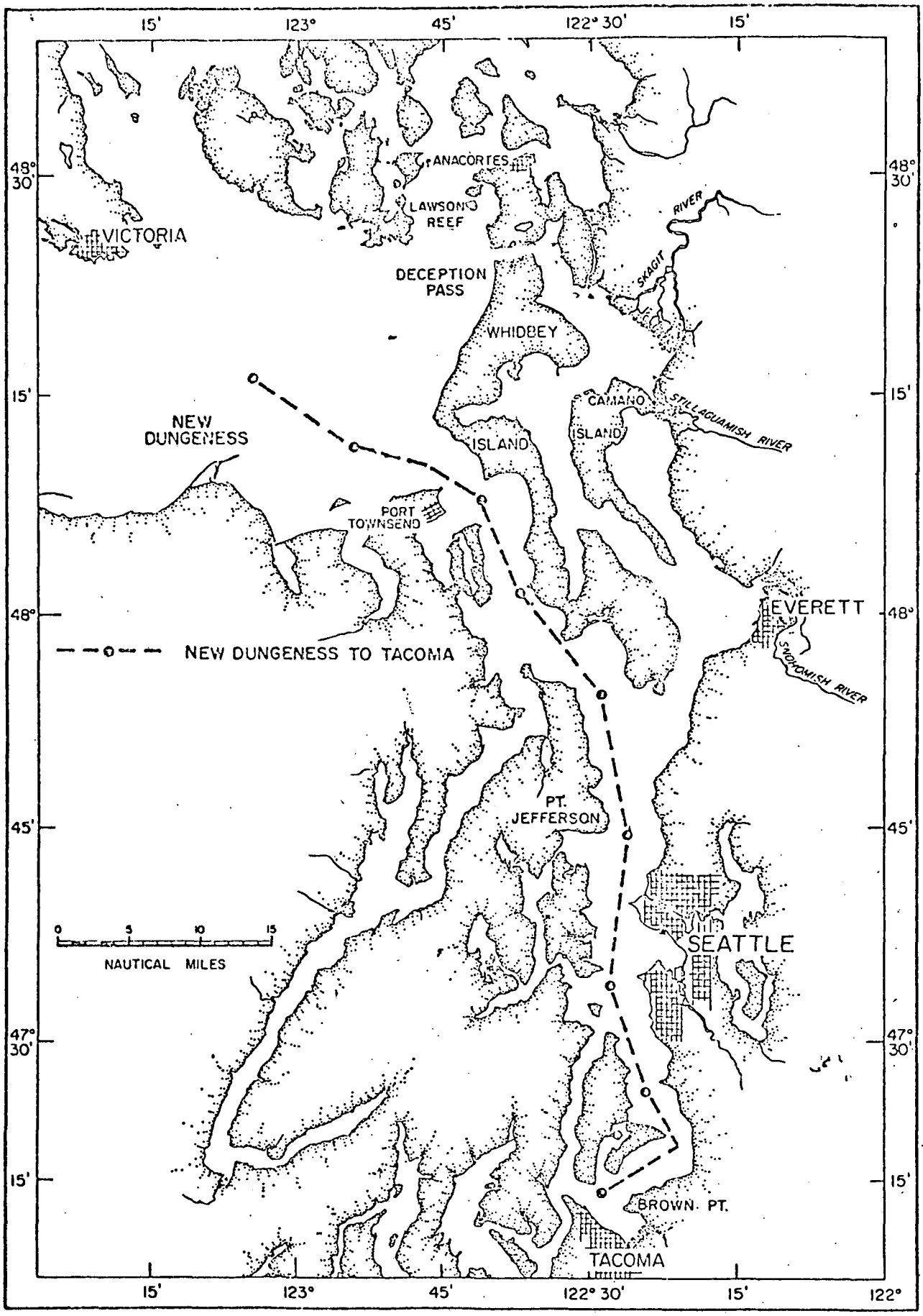
The following longitudinal profile of data shows the general water quality conditions found in the main portion of the Puget Sound complex. Water quality conditions of specific oceanographic subregions and Puget Sound tributaries are discussed in following sections of this report.

LONGITUDINAL DEPTH PROFILE FOR

STRAIT OF JUAN DE FUCA AND PUGET SOUND

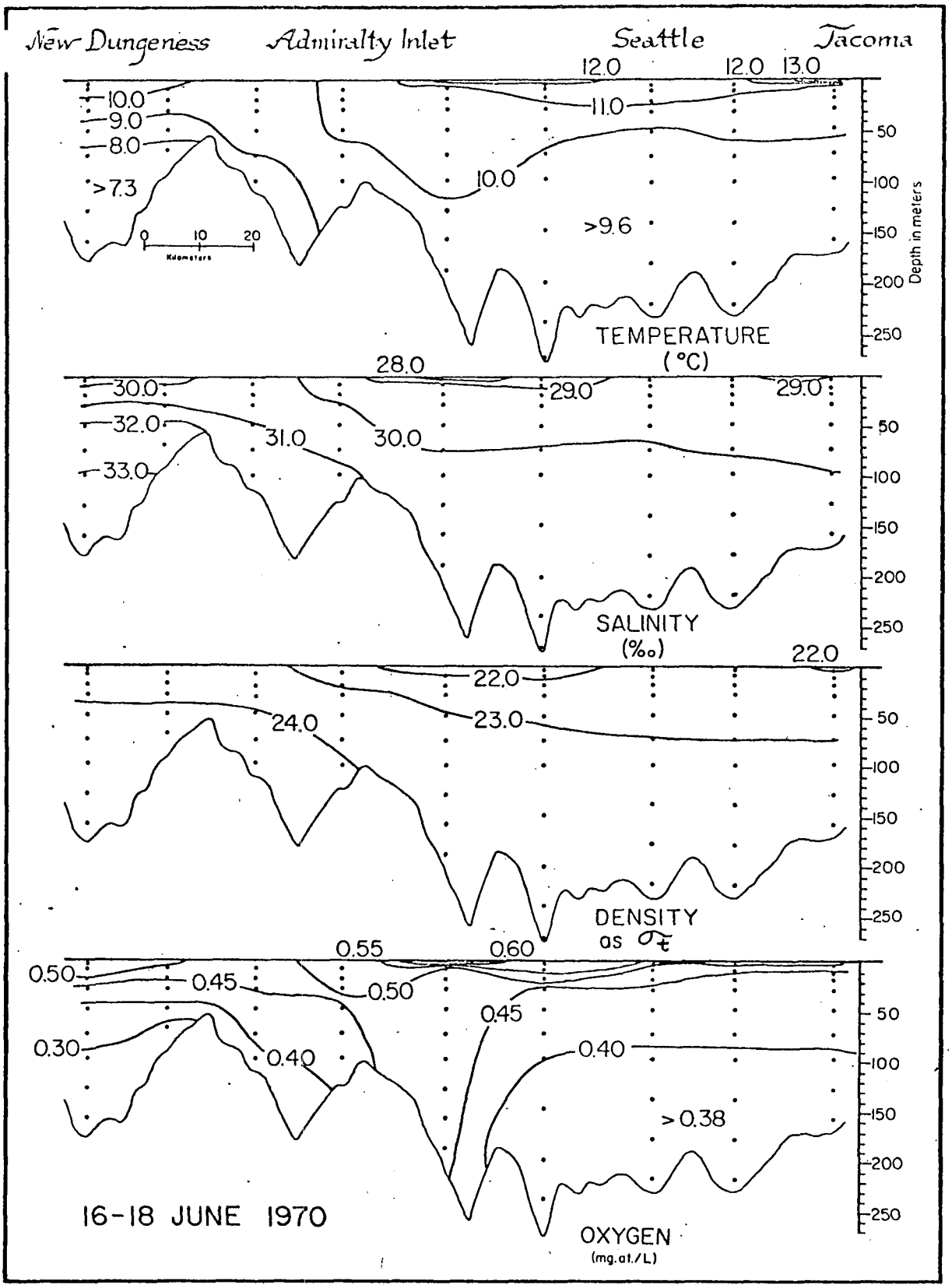


SOURCE: Atlas of Physical and Chemical Properties of Puget Sound and it's Approaches. Eugene E. Collias, Noel McGary, and Clifford A. Barnes. University of Washington Press. Copyright 1974. A Washington Sea Grant Publication.



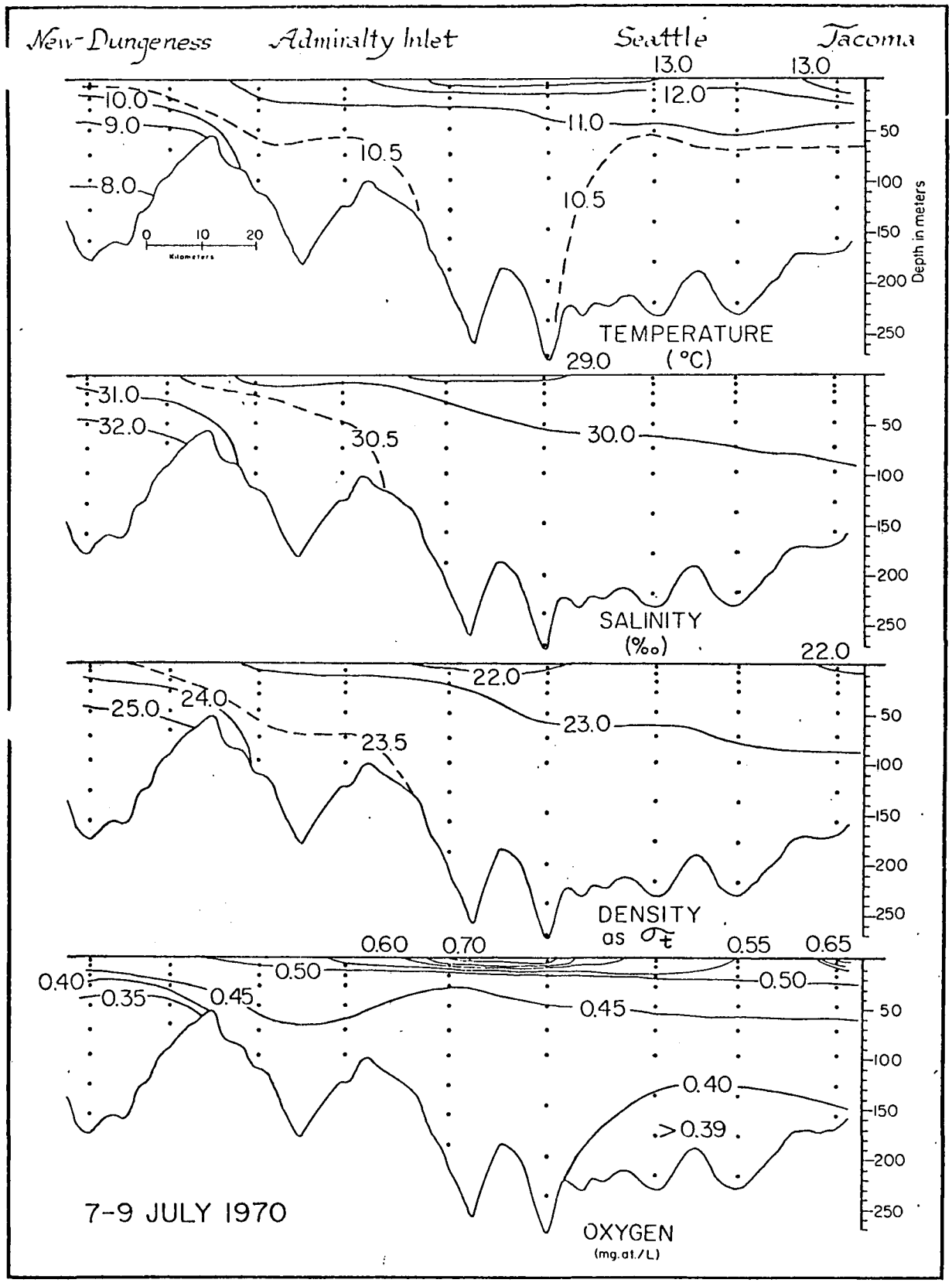
Location of longitudinal profile used to present the data.

SOURCE: Skagit Bay Dynamical Oceanography Final Report. Eugene E. Collias, Clifford A. Barnes, and John H. Lincoln. 1973.



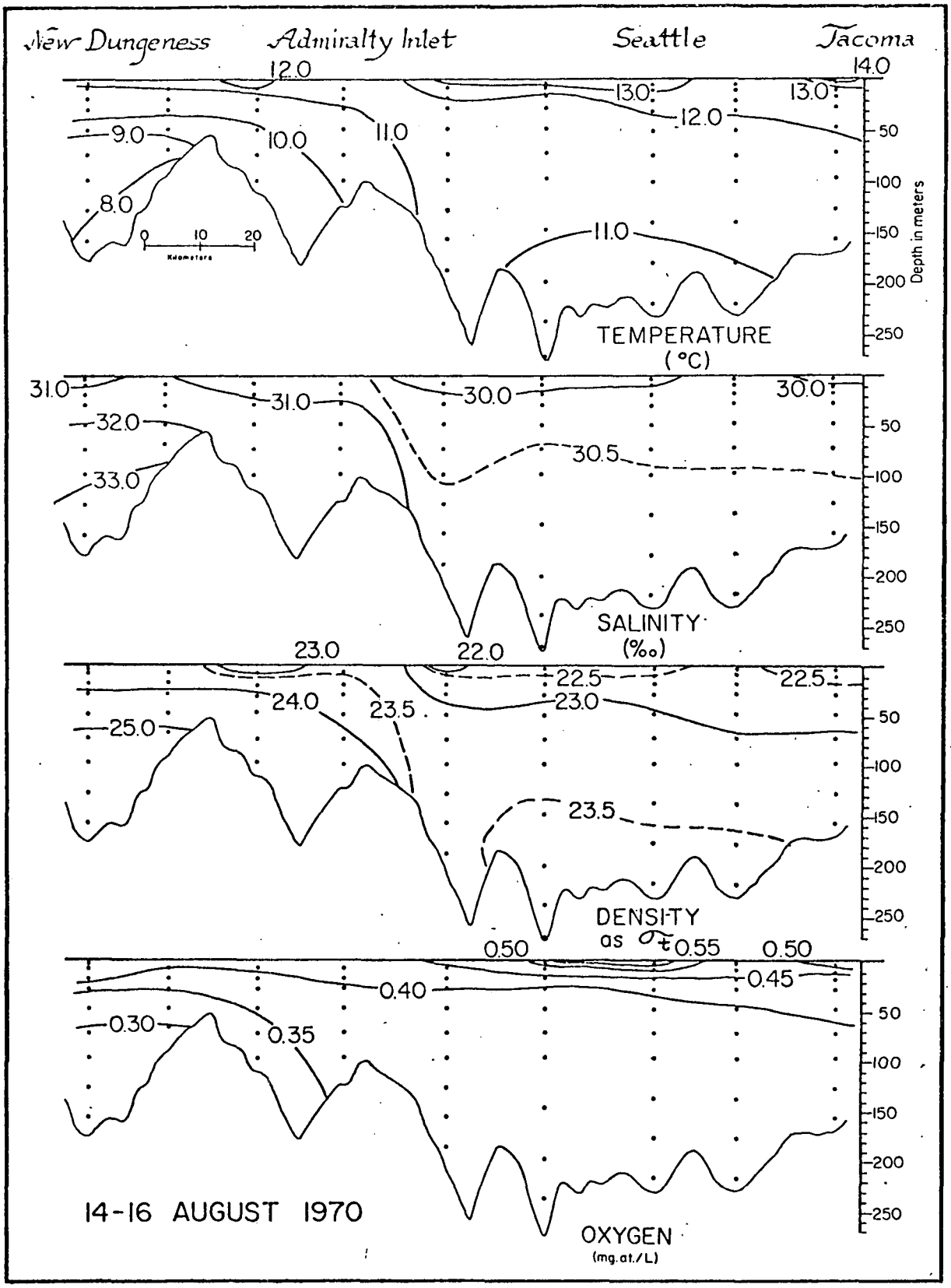
Water properties in Puget Sound main basin
16 - 18 June 1970

SOURCE: Skagit Bay Dynamical Oceanography Final Report. Eugene E. Collias, Clifford A. Barnes, and John H. Lincoln. 1973.



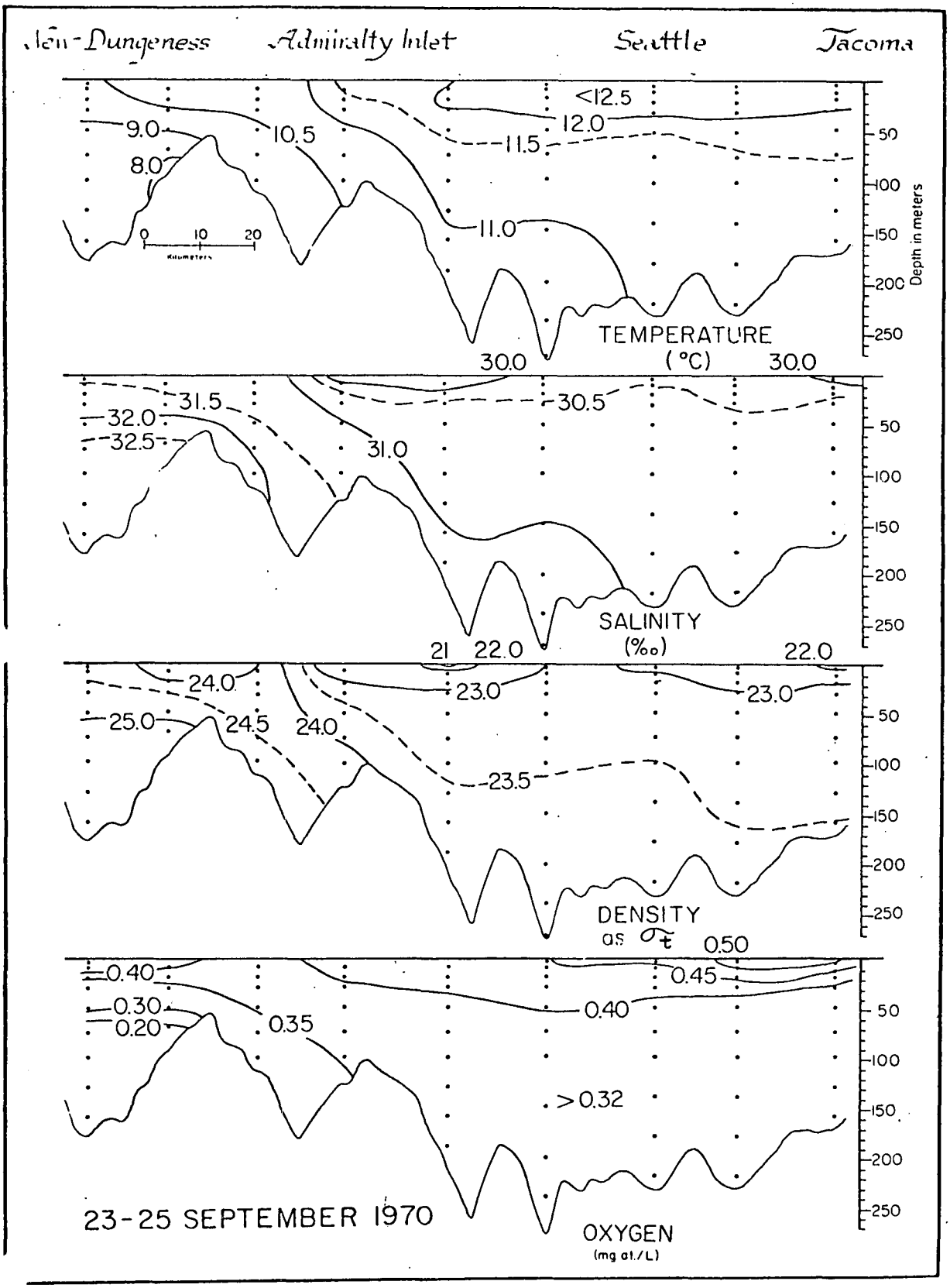
Water properties in Puget Sound main basin
7 - 9 July 1970

SOURCE: Skagit Bay Dynamical Oceanography Final Report. Eugene E. Collias, Clifford A. Barnes, and John H. Lincoln. 1973.



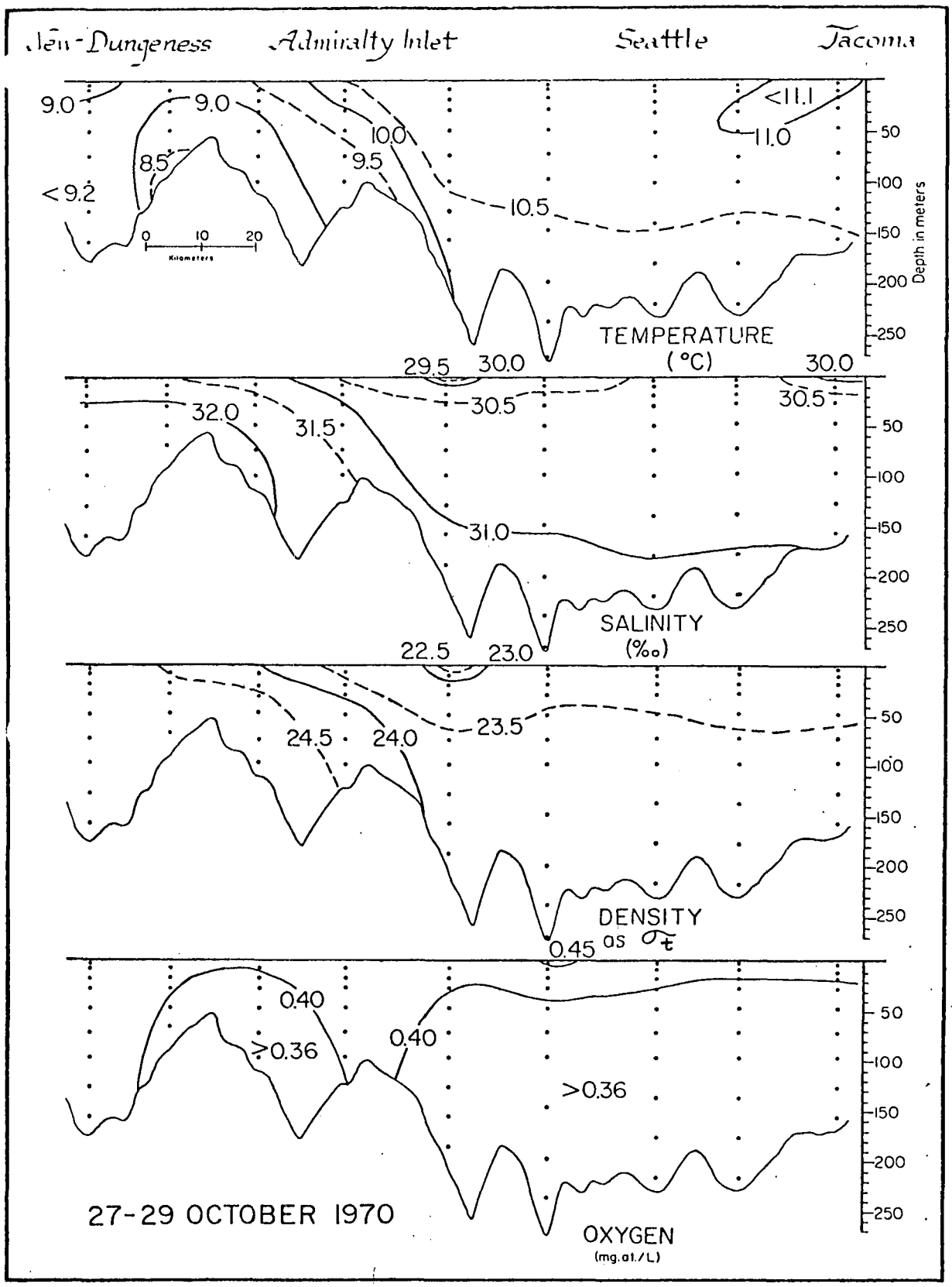
Water properties in Puget Sound main basin
14 - 16 August 1970

SOURCE: Skagit Bay Dynamical Oceanography Final Report. Eugene E. Collias, Clifford A. Barnes, and John H. Lincoln. 1973.



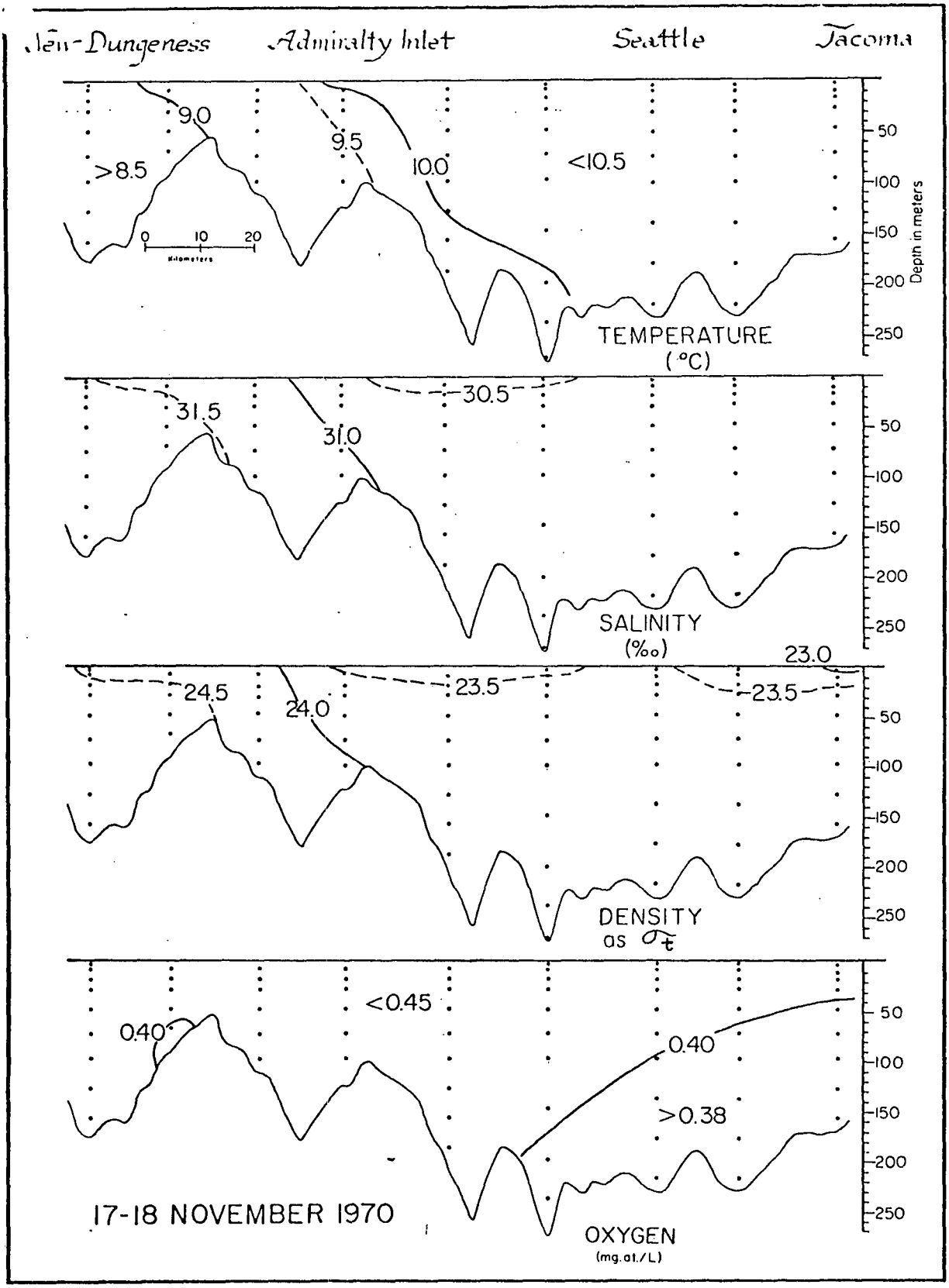
Water properties in Puget Sound main basin
23 - 25 September 1970

SOURCE: Skagit Bay Dynamical Oceanography Final Report. Eugene E. Collias, Clifford A. Barnes, and John H. Lincoln. 1973.



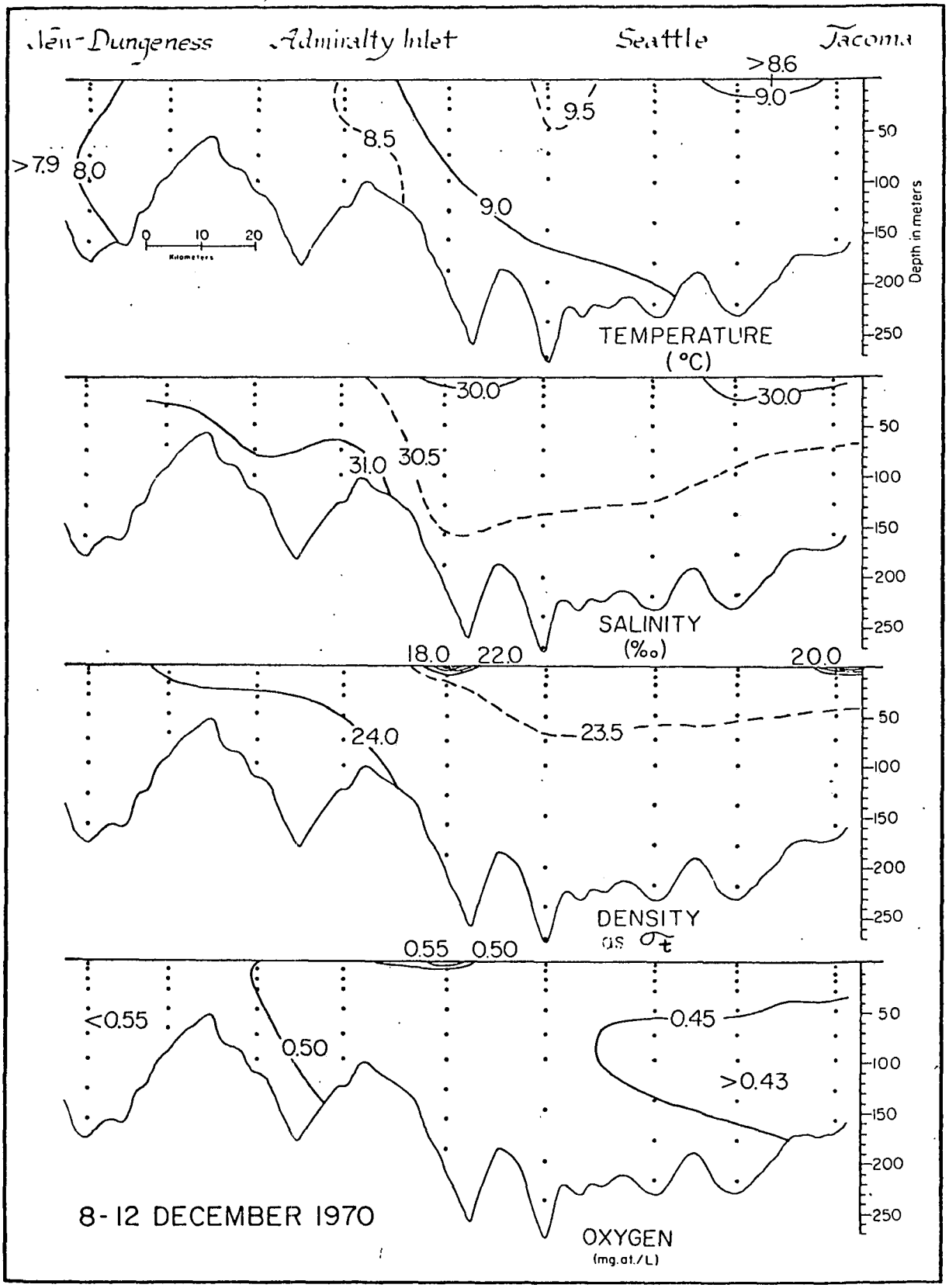
Water properties in Puget Sound main basin
27 - 29 October 1970

SOURCE: Skagit Bay Dynamical Oceanography Final Report. Eugene E. Collias, Clifford A. Barnes, and John H. Lincoln. 1973.



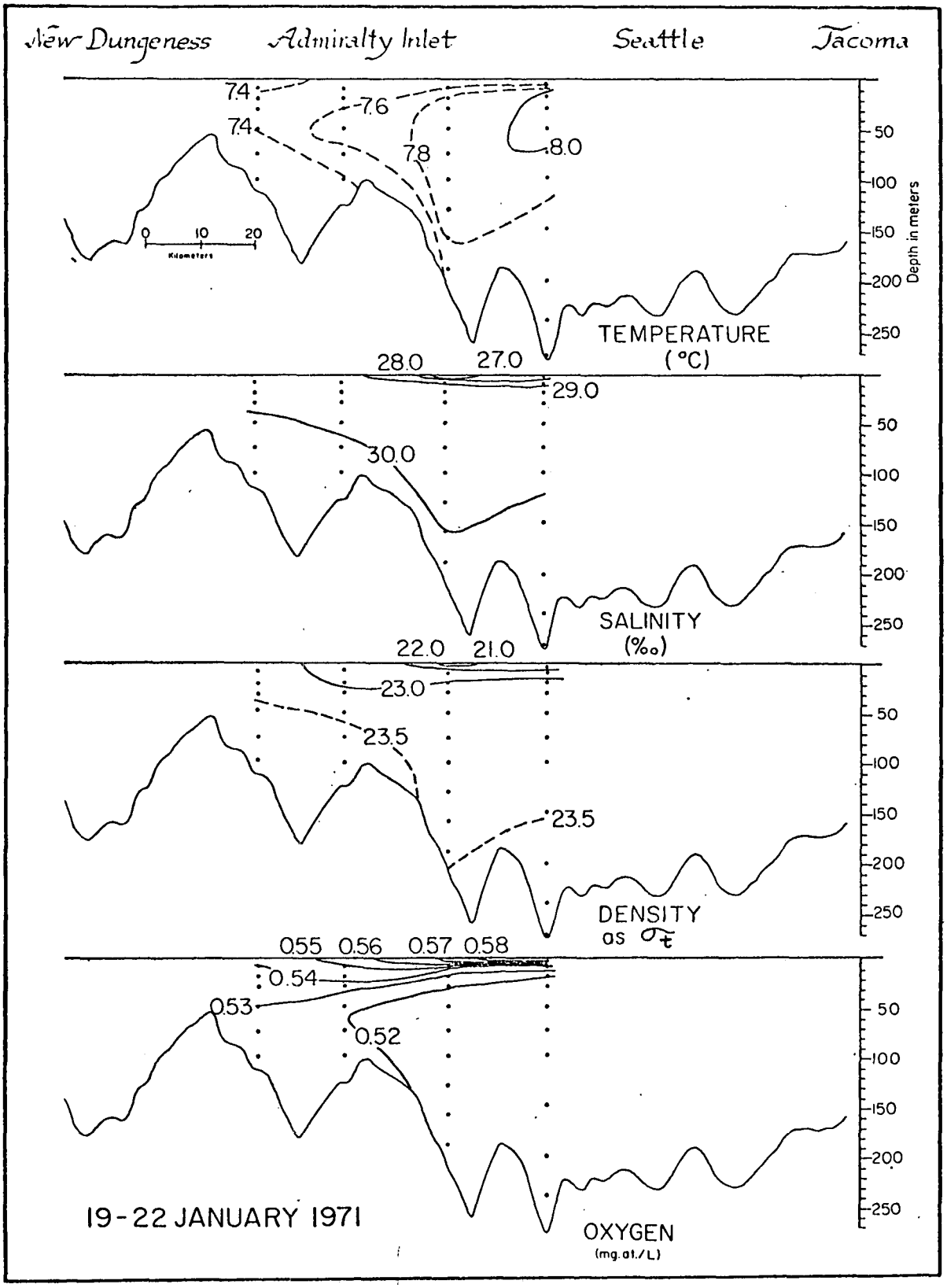
Water properties in Puget Sound main basin
17 - 18 November 1970

SOURCE: Skagit Bay Dynamical Oceanography Final Report. Eugene E. Collias, Clifford A. Barnes, and John H. Lincoln. 1973.



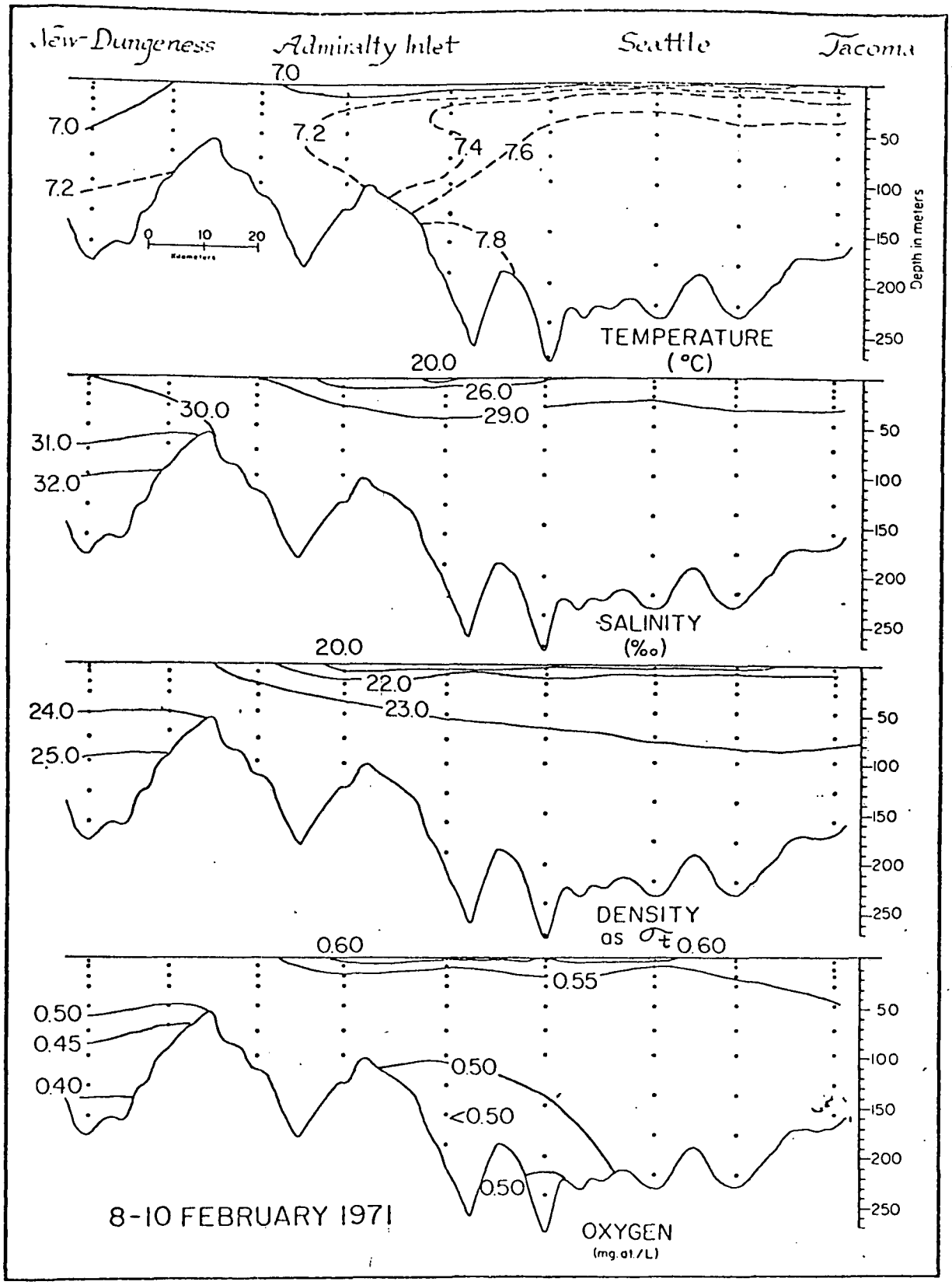
Water properties in Puget Sound main basin
8 - 12 December 1970

SOURCE: Skagit Bay Dynamical Oceanography Final Report. Eugene E. Collias, Clifford A. Barnes, and John H. Lincoln. 1973.



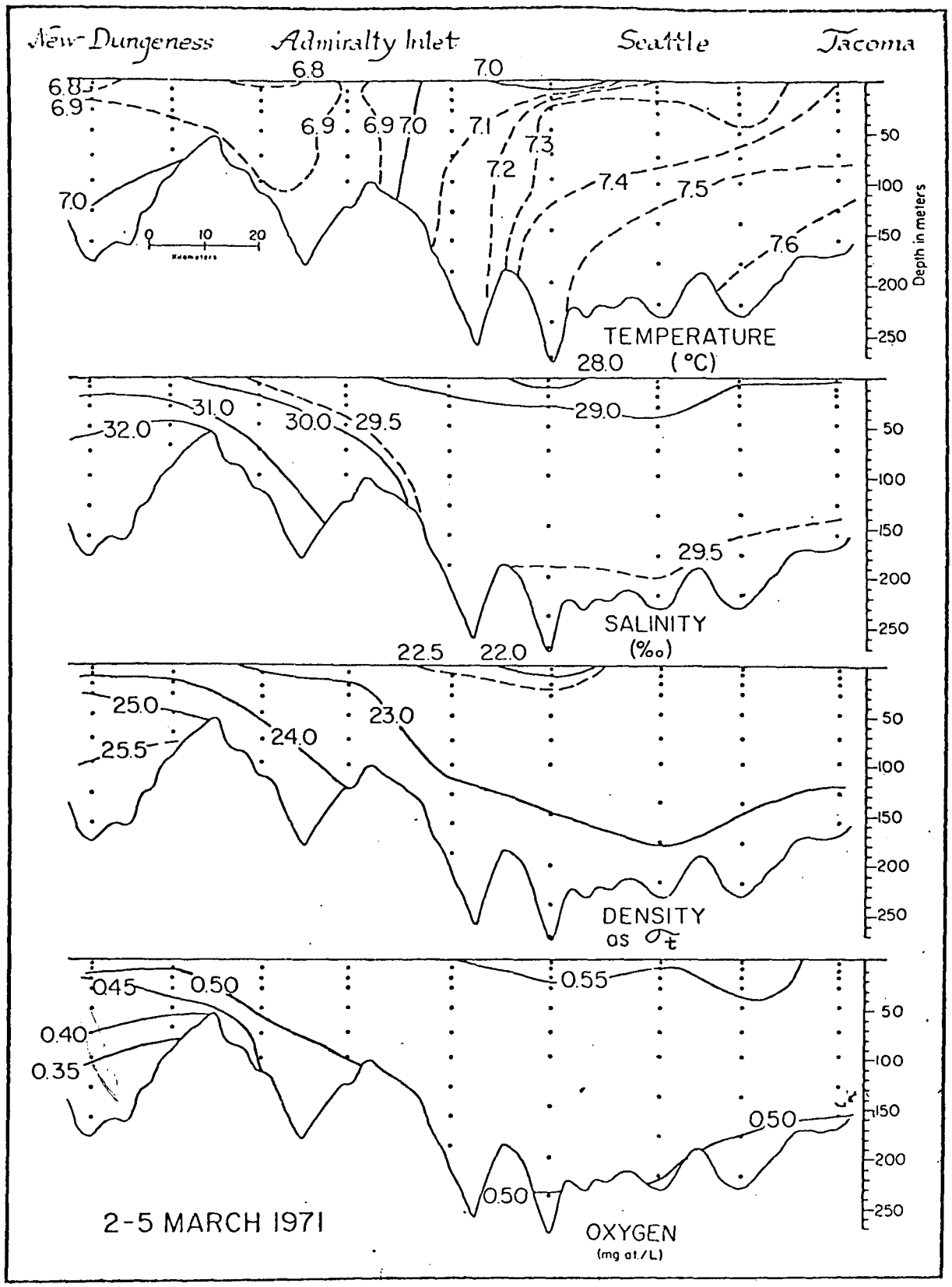
Water properties in Puget Sound main basin
19 - 21 January 1971

SOURCE: Skagit Bay Dynamical Oceanography Final Report. Eugene E. Collias, Clifford A. Barnes, and John H. Lincoln. 1973.



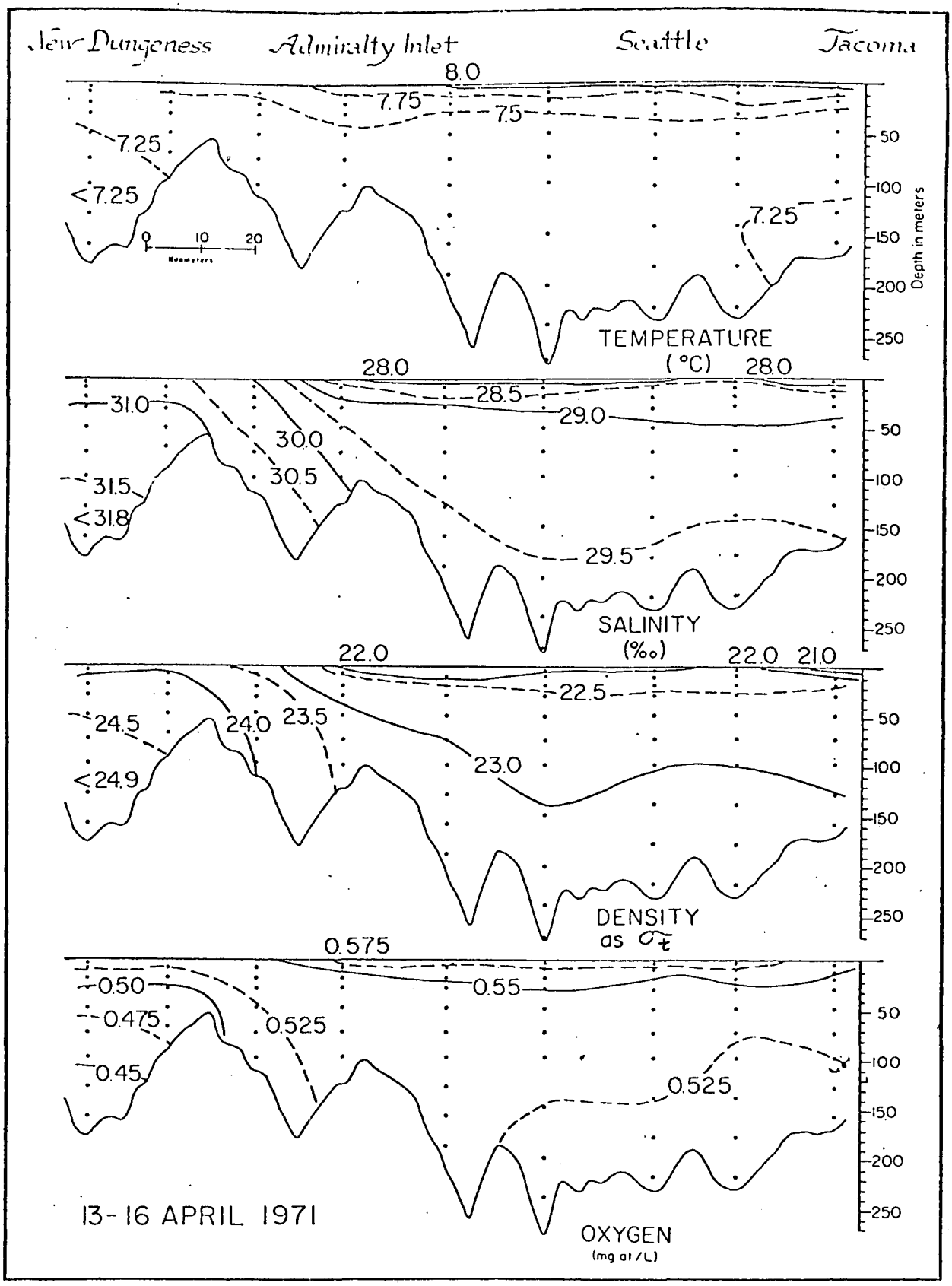
Water properties in Puget Sound main basin
8 - 10 February 1971

SOURCE: Skagit Bay Dynamical Oceanography Final Report. Eugene E. Collias, Clifford A. Barnes, and John H. Lincoln. 1973.



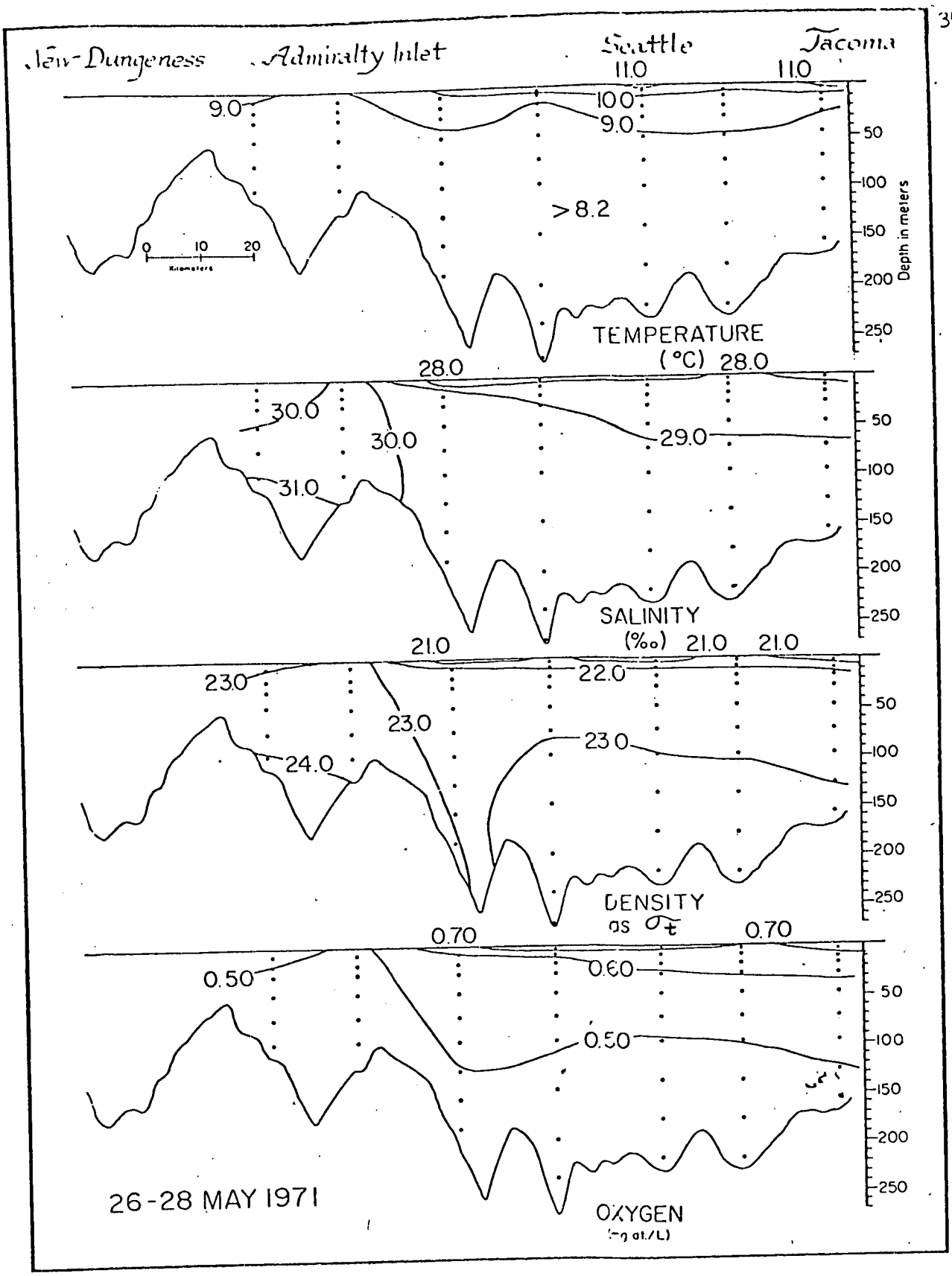
Water properties in Puget Sound main basin
2 - 5 March 1971

SOURCE: Skagit Bay Dynamical Oceanography Final Report. Eugene E. Collias, Clifford A. Barnes, and John H. Lincoln. 1973.



Water properties in Puget Sound main basin
13 - 16 April 1971

SOURCE: Skagit Bay Dynamical Oceanography Final Report. Eugene E. Collias, Clifford A. Barnes, and John H. Lincoln. 1973.



Water properties in Puget Sound main basin
26 - 28 May 1971

SOURCE: Skagit Bay Dynamical Oceanography Final Report. Eugene E. Collias, Clifford A. Barnes, and John H. Lincoln. 1973.

C. MAJOR P. SOURCE INVENT.

INVENTORY OF PUGET SOUND BASIN MAJOR MUNICIPAL AND INDUSTRIAL POINT SOURCE DISCHARGERS

MUNICIPAL

DISCHARGER	BASIN LOCATION	PERMIT NO.
Auburn, City of	Main Puget Sound	WA-002399-0
Bellevue, City of	" " "	Not Available
Bellingham, City of	North Sound	WA-002396-5
Bremerton, City of	Main Puget Sound	Not Available
Des Moines Sewer District	" " "	WA-002095-8
Edmonds, City of	" " "	WA-002405-8
Everett, City of	Whidbey	WA-002449-0
Lakehaven Sewer District	Main Puget Sound	
Lakota Plant		WA-002262-4
Redondo Plant	" " "	WA-002257-1
Monroe, City of	Snohomish	WA-002048-6
Olympia City of	Southern Puget Sound	WA-003706-1
Port Angeles, City of	Juan de Fuca	WA-002397-3
Puyallup, City of	Southern Puget Sound	Not Available
Seattle, City of		
Metro-Alki Point	Main Puget Sound	WA-002901-7
" -Carkeek Park	" " "	WA-002917-2
" -Renton	Cedar-Sammamish	WA-002985-1
" -Richmond Beach	Main Puget Sound	WA-002961-1
" -West Point	" " "	WA-002918-1
Tacoma, City of	Southern Puget Sound	WA-003708-7
Whatcom County Sewer District	North Sound	Not Available

INDUSTRIAL

DISCHARGER	CITY, BASIN LOCATION	PERMIT NO.
American Smelting (ASARCO)	Ruston, South Puget Sound	WA-000064-7
Atlantic Richfield Refinery	Ferndale, Nooksack	WA-000284-4
" " "	" "	WA-002290-0
Crown Zellerbach	Port Angeles, Juan de Fuca	WA-000292-5
Crown Zellerbach	Port Townsend, Admiralty Inlet	WA-000092-2
Fibreboard Corporation	Sumner, Puyallup	WA-000088-4
Georgia Pacific	Bellingham, North Sound	WA-000109-1
Intalco Aluminum	Ferndale, Nooksack	WA-000295-0
I. T. T. Rayonier	Port Angeles, Juan de Fuca	WA-000079-5
Kaiser Aluminum & Chemical	Tacoma, Southern Puget Sound	WA-000093-1
Mobile Oil Corporation	Fernfale, Nooksack	WA-000298-4
Scott Paper Company	Anacortes, North Sound	WA000293-3
Scott Paper Company	Everett, Whidbey	WA-000062-1
Shell Oil Refinery	Anacortes, North Sound	WA-000076-1
Simpson Timber Company	Shelton, South Puget Sound	WA-000317-4
"	"	WA-000152-0
"	"	WA-000316-6
"	"	WA-000319-1
"	"	WA-000318-2
"	"	WA-000315-8
"	"	WA-000070-1
St. Regis Paper Co.	Tacoma, South Puget Sound	WA-000322-1
"	"	WA-000321-2
"	"	WA-000085-1
"	"	WA-000040-0
Texaco Inc.	Anacortes, North Sound	WA-000294-1
Weyerhaeuser Kraft Mill	Everett, Whidbey	WA-000300-0

D. MONITORING SCHEME

PUGET SOUND BASIN WATER QUALITY SAMPLING STATIONS MAINTAINED BY WASHINGTON STATE DEPARTMENT OF ECOLOGY AS OF JULY 1974

MARINE:

BLL002
BLL003
BLL004
BLL008
BUD001
BUD003
BUD005
CMB006
CMB010
CMB012
CMB013
CMB016
DRA001
ELB002
ELB004
ELB006
ELB008
GRG001
HLM001
PAD001
PAD002
PAH003
PAH006
PAH007
PAH008
PNN001
PSB002
PSS002
PSS005
PSS009
PSS020
SAR001
SAR002
SIN001
SKG001
SUZ001

FRESH:

CMB010
CMB012
ELB009
ELB010
ELB012
PSB006
PSB007
PSB008
PSS015
PSS016
PSS018
01A050
01A070
01A090
01A120
01D070
01D090
03A050
03A070
03B050
03C060
03C080
04A060
04A140
05A090
05A110
05B070
05B090
05B110
07A090
07B055
07C070
07C090
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541070
541075
541076

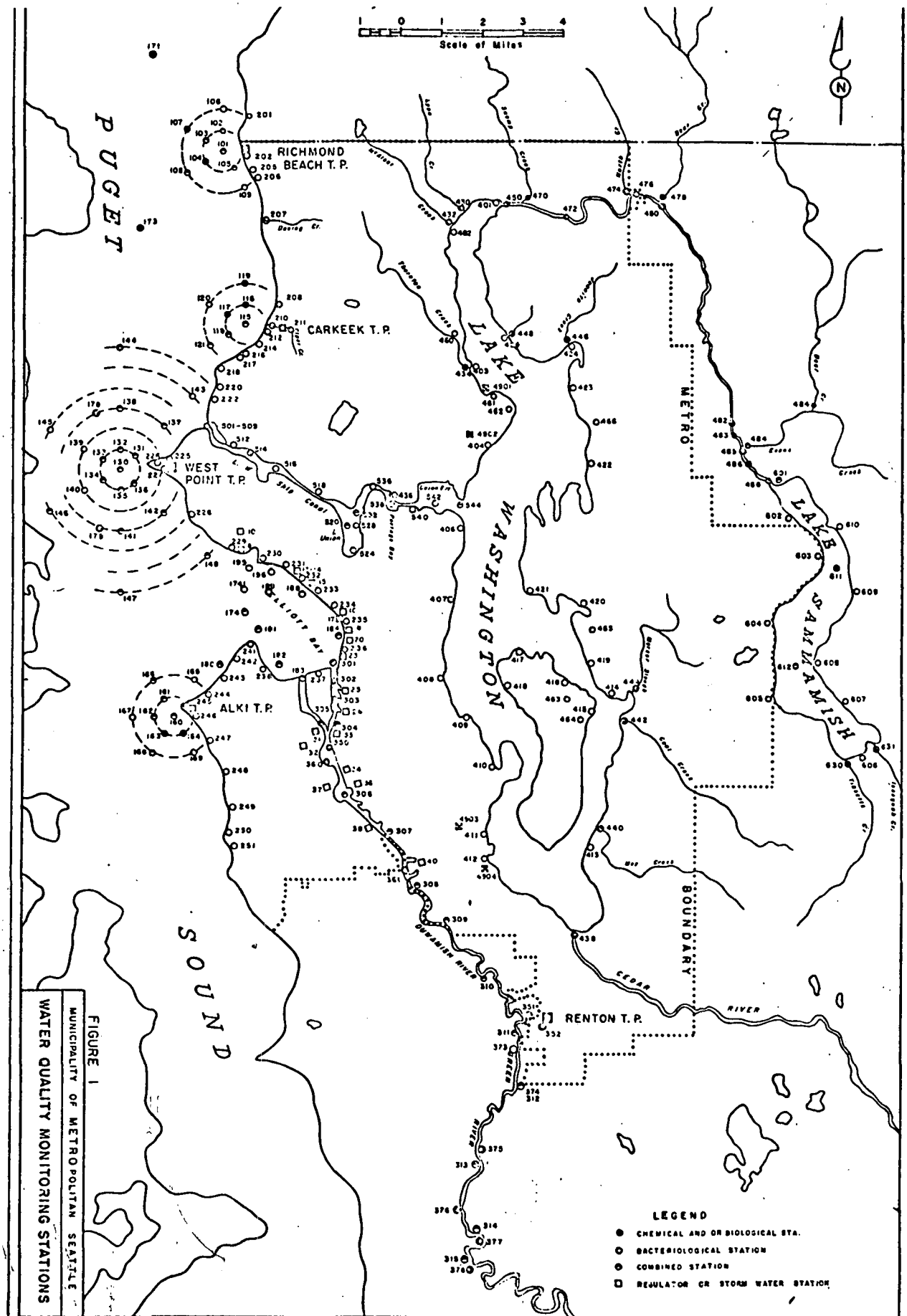


FIGURE 1

MUNICIPALITY OF METROPOLITAN SEATTLE

WATER QUALITY MONITORING STATIONS

II. WATER QUALITY STATUS

A. TRIBUTARY BASINS

CEDAR - SAMMAMISH RIVER BASIN

CEDAR-SAMMAMISH RIVER BASIN
BASIN DESCRIPTION

1. Drainage Area : Cedar - 197 sq. m.
   Sammamish - 240 sq. m.

2. Mean Flow - Cedar nr mouth - 680 cfs

3. Major Diversions - Domestic - 111 cfs

   Industrial - 74 cfs

   Hydropower - 700 acre-feet

4. Surface Water Rights - Municipal - 25.87 cfs

   Irrigation - 84.91 cfs

   Individual & Community Domestic - 66.87 cfs

   Industrial & Commercial - 170.98 cfs

   Fish Propogation -61.86 cfs

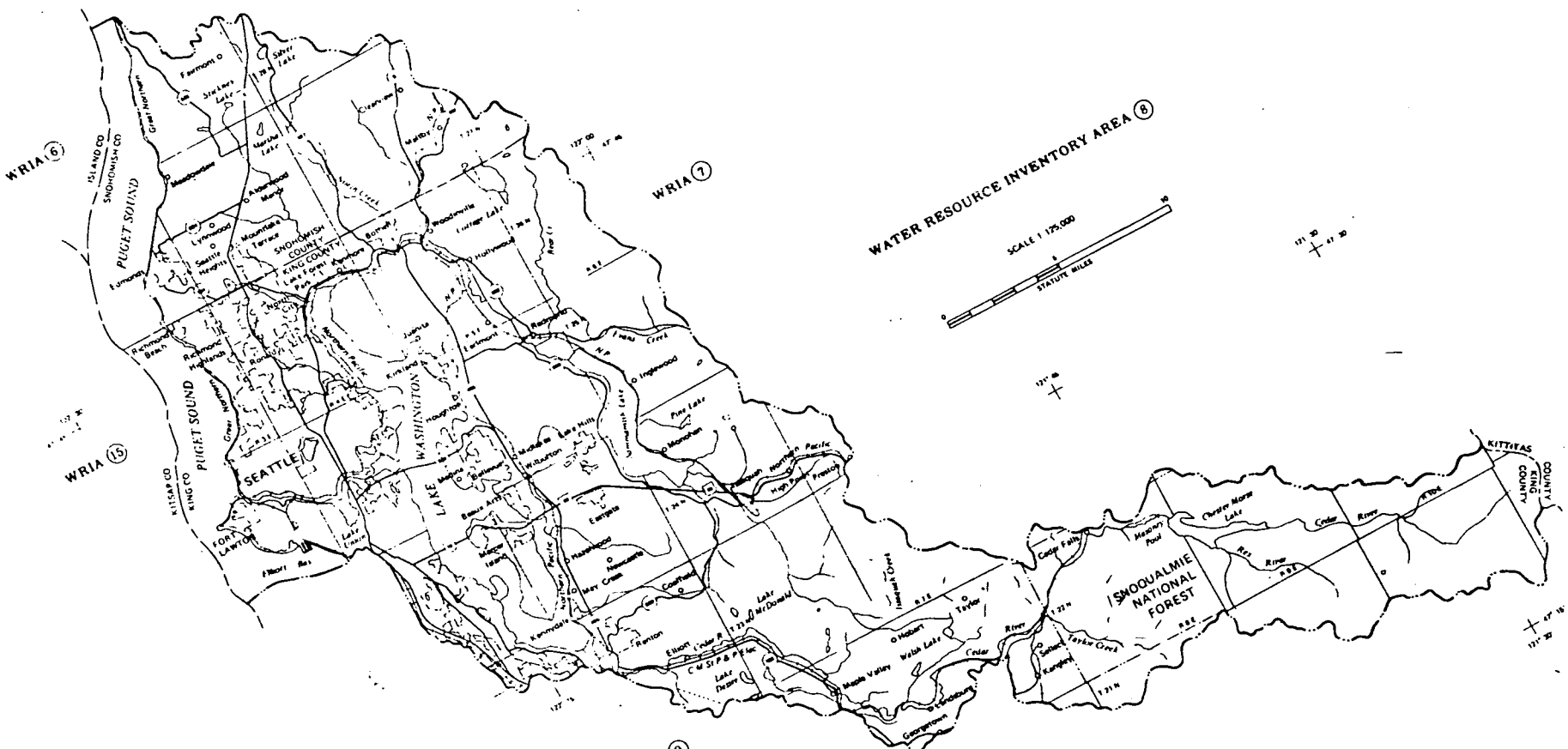
   Stock - .91 cfs

   Total - 568.28 cfs

5. Reservoir Storage Rights - 2,801 acre-feet

6. Projected Population

1980	2000	2020
1,454,800	2,270,000	3,619,900


WATER RESOURCE INVENTORY AREA (8)
SCALE 1:125,000
STATUTE MILES
WRIA (6)
WRIA (7)
WRIA (15)
WRIA (9)
PUGET SOUND
SEATTLE
LAKE WASHINGTON
SNOQUALMIE NATIONAL FOREST
KING COUNTY
SNOHOMISH COUNTY
KITSAP CO
ISLAND CO
SNOHOMISH CO

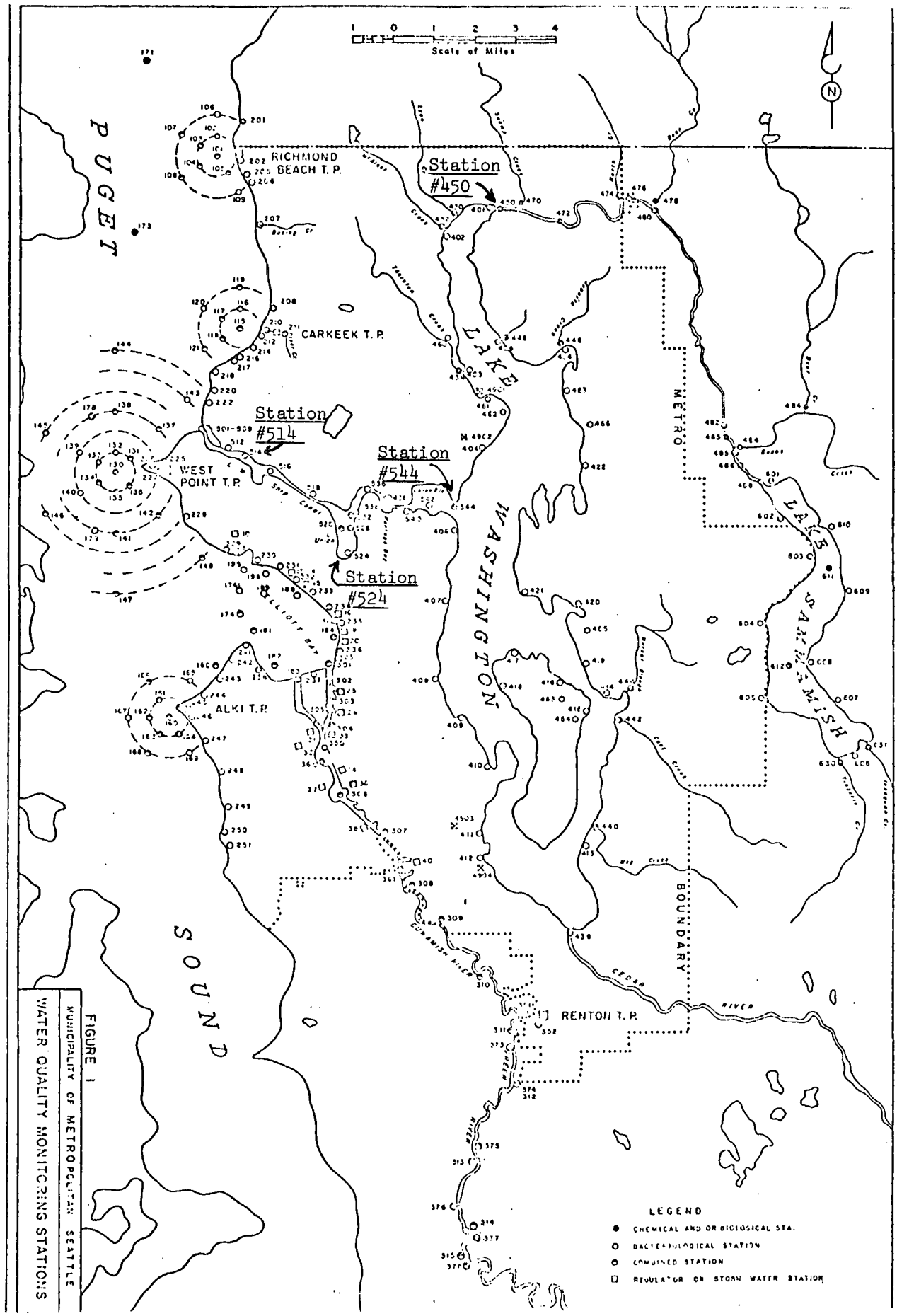


FIGURE 1

MUNICIPALITY OF METROPOLITAN SEATTLE

WATER QUALITY MONITORING STATIONS

CEDAR-SAMMAMISH RIVER BASIN
REPORTED PROBLEMS

1. Water temperature values exceed Class A standards throughout much of the ship canal and Lake Union.

2. Dissolved Oxygen standards are violated on Lake Union and especially the ship canal periodically.

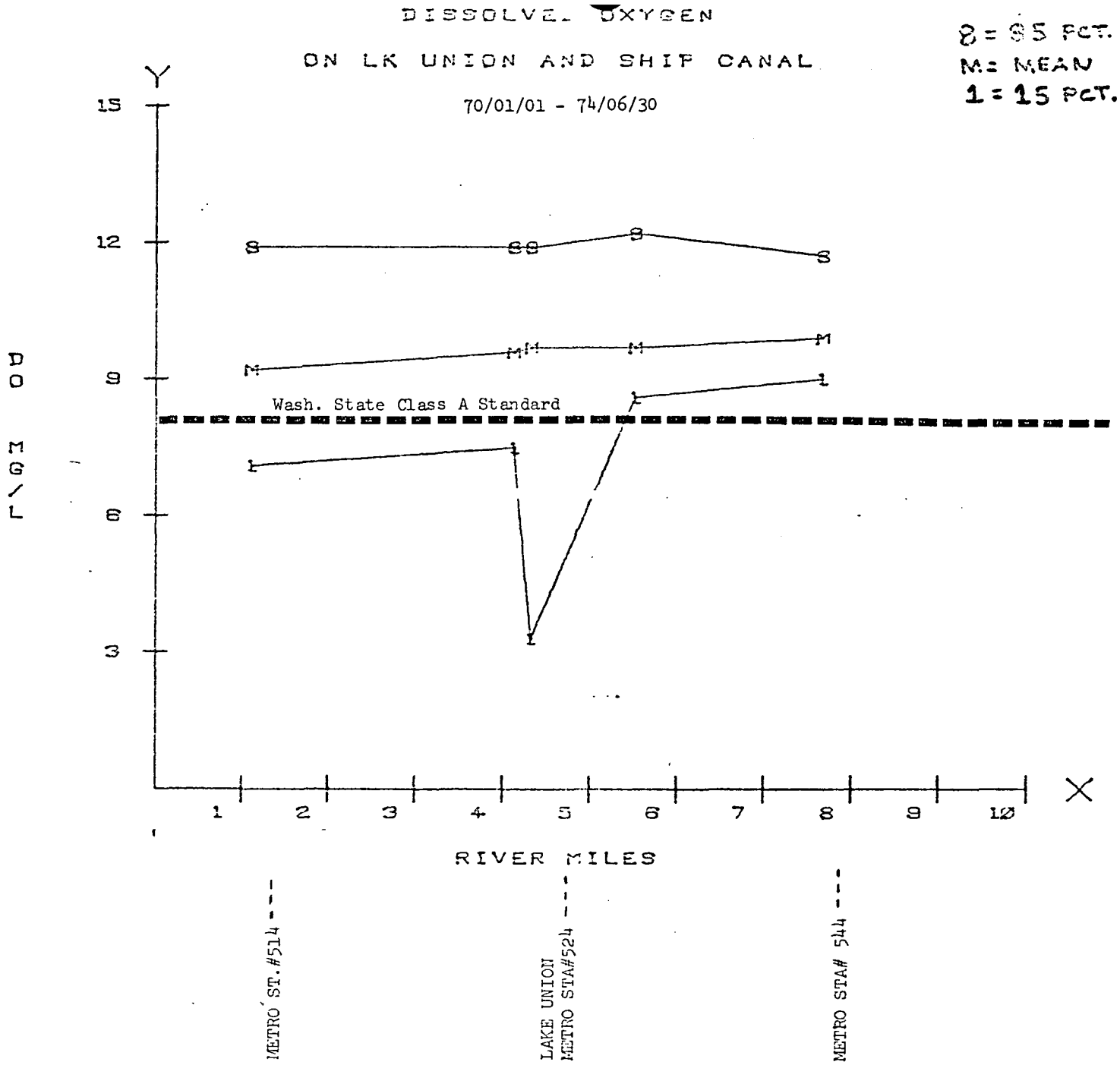
3. Total Coliform values exceed the Class A standard throughout portions of the ship canal and Lake Union, with increasing numbers of violations near the mouth of the ship canal.

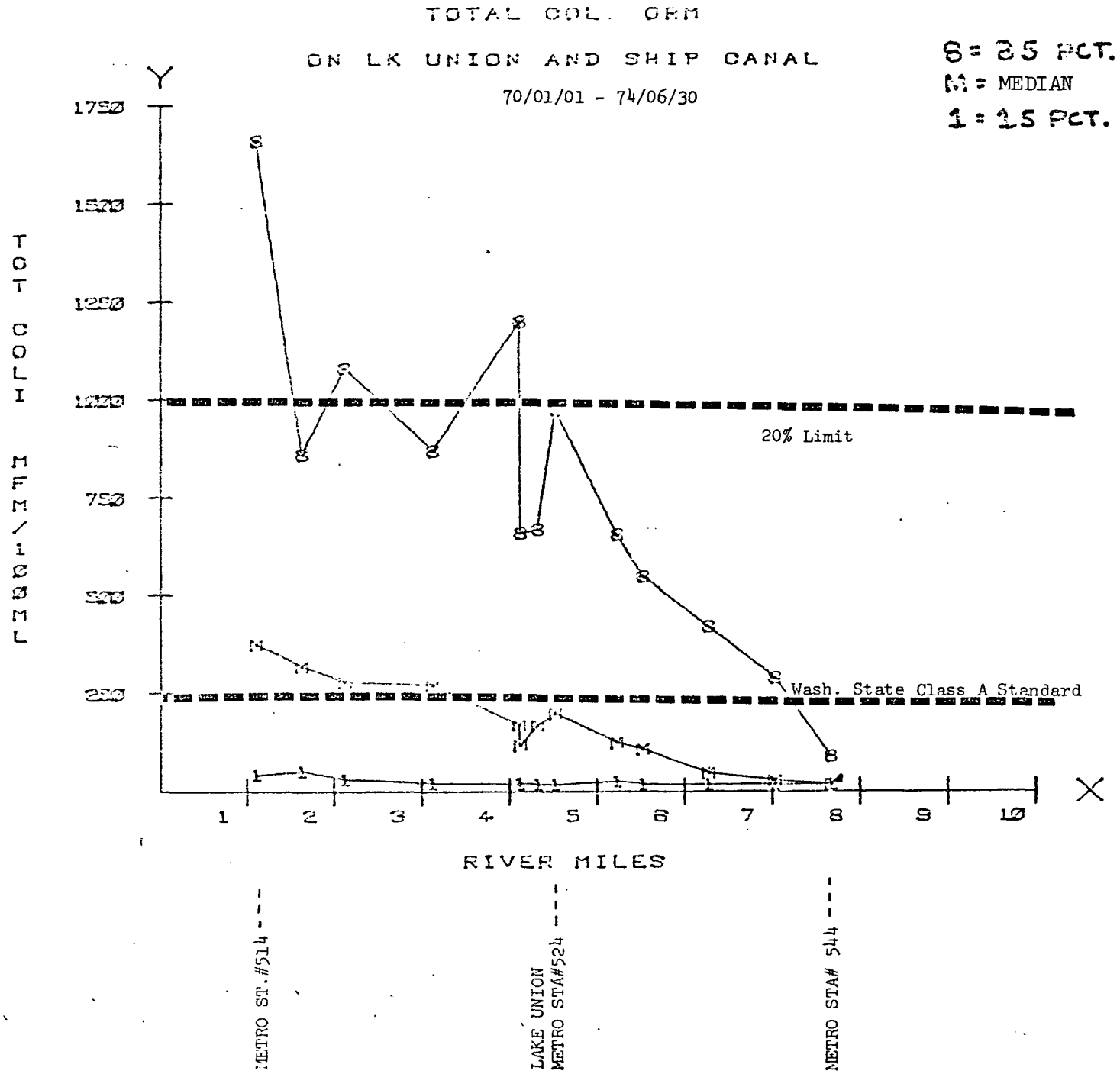
4. At the mouth of the Sammamish River, total Phosphorus values exceed the limiting algal productivity concentration throughout most of the year.

5. Total Coliform values exceed the Class A standard periodically on the Sammamish river near the mouth.

LAKE UNION AND SHIP CANAL

TEMPE TURE
ON LK UNION AND SHIP CANAL
70/01/01 - 74/06/30
8= 85 PCT
M= MEAN
1= 15 PCT
Wash. State Class A Standard
TEMP CENT
21.0
18.0
15.0
12.0
9.0
6.0
3.0
Y
X
1
2
3
4
5
6
7
8
9
10
RIVER MILES
METRO ST.#514
LAKE UNION
METRO STA#524
METRO STA# 544


DISSOLVED OXYGEN
ON LK UNION AND SHIP CANAL
70/01/01 - 74/06/30
S = 95 PCT.
M: MEAN
1 = 15 PCT.
Y
15
12
9
6
3
DO MG\L
Wash. State Class A Standard
1
2
3
4
5
6
7
8
9
10
X
RIVER MILES
METRO ST.#514
LAKE UNION
METRO STA#524
METRO STA# 544


TOTAL COL. ORM
ON LK UNION AND SHIP CANAL
70/01/01 - 74/06/30
8 = 85 PCT.
M = MEDIAN
1 = 15 PCT.
Y
1750
1500
1250
1000
750
500
250
TOT COLI MPN/100ML
20% Limit
Wash. State Class A Standard
1
2
3
4
5
6
7
8
9
10
X
RIVER MILES
METRO ST.#514
LAKE UNION
METRO STA#524
METRO STA# 544

FECAL COLIFORM

ON LK UNION AND SHIP CANAL

70/01/01 - 74/06/30
MEDIAN VALUES

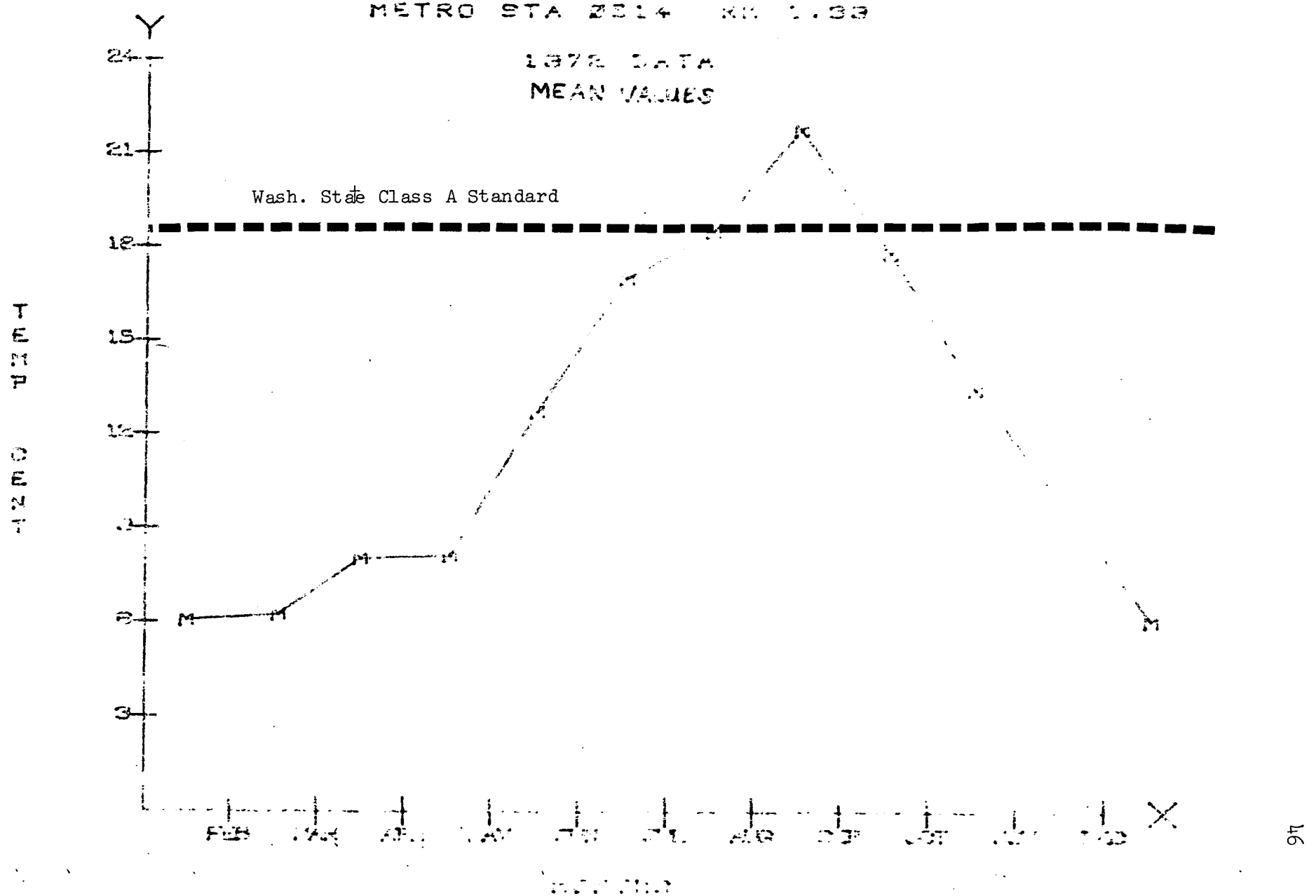
SHIP CANAL MID-CHANNEL

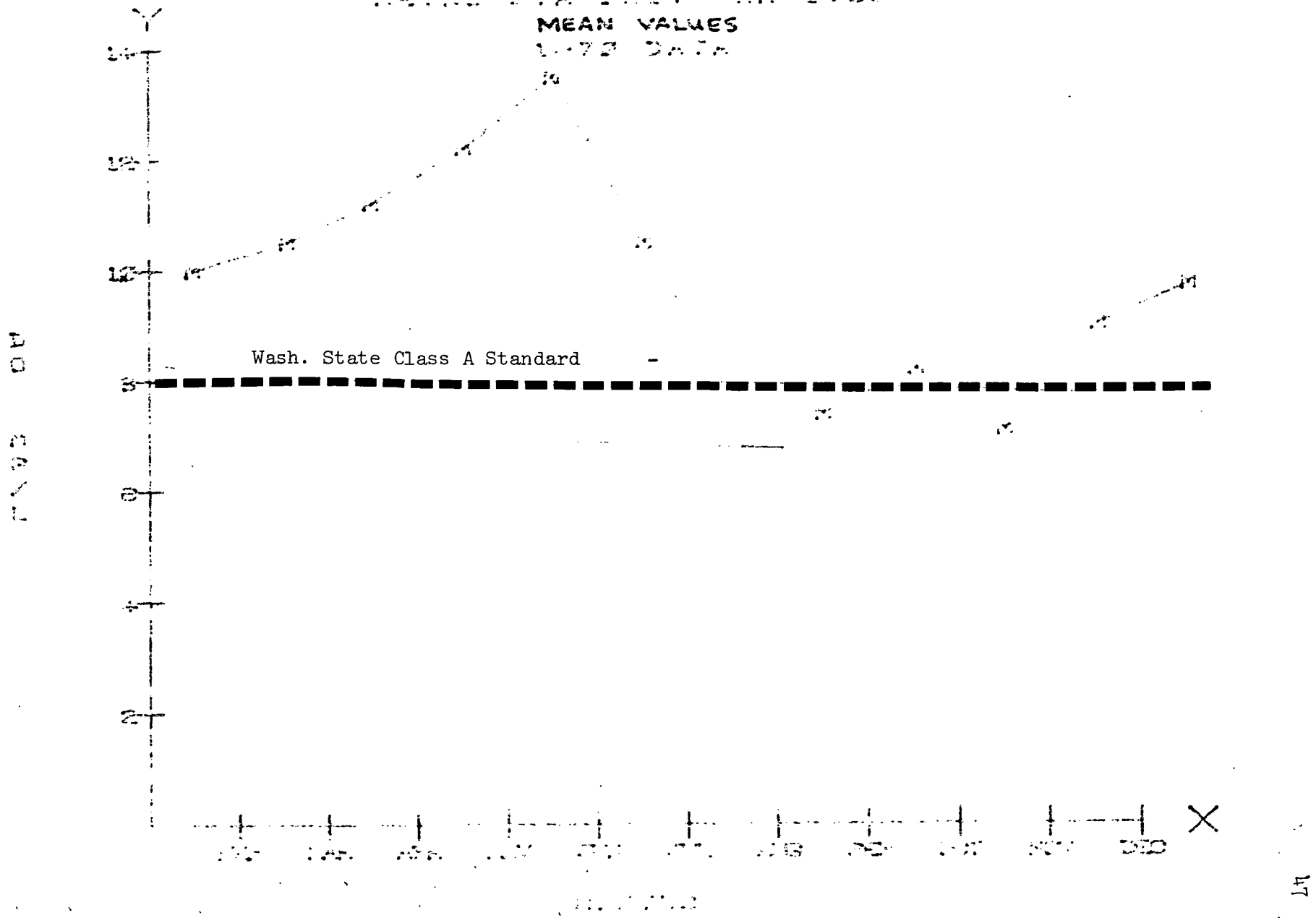
SHIP CANAL MID CHANNEL

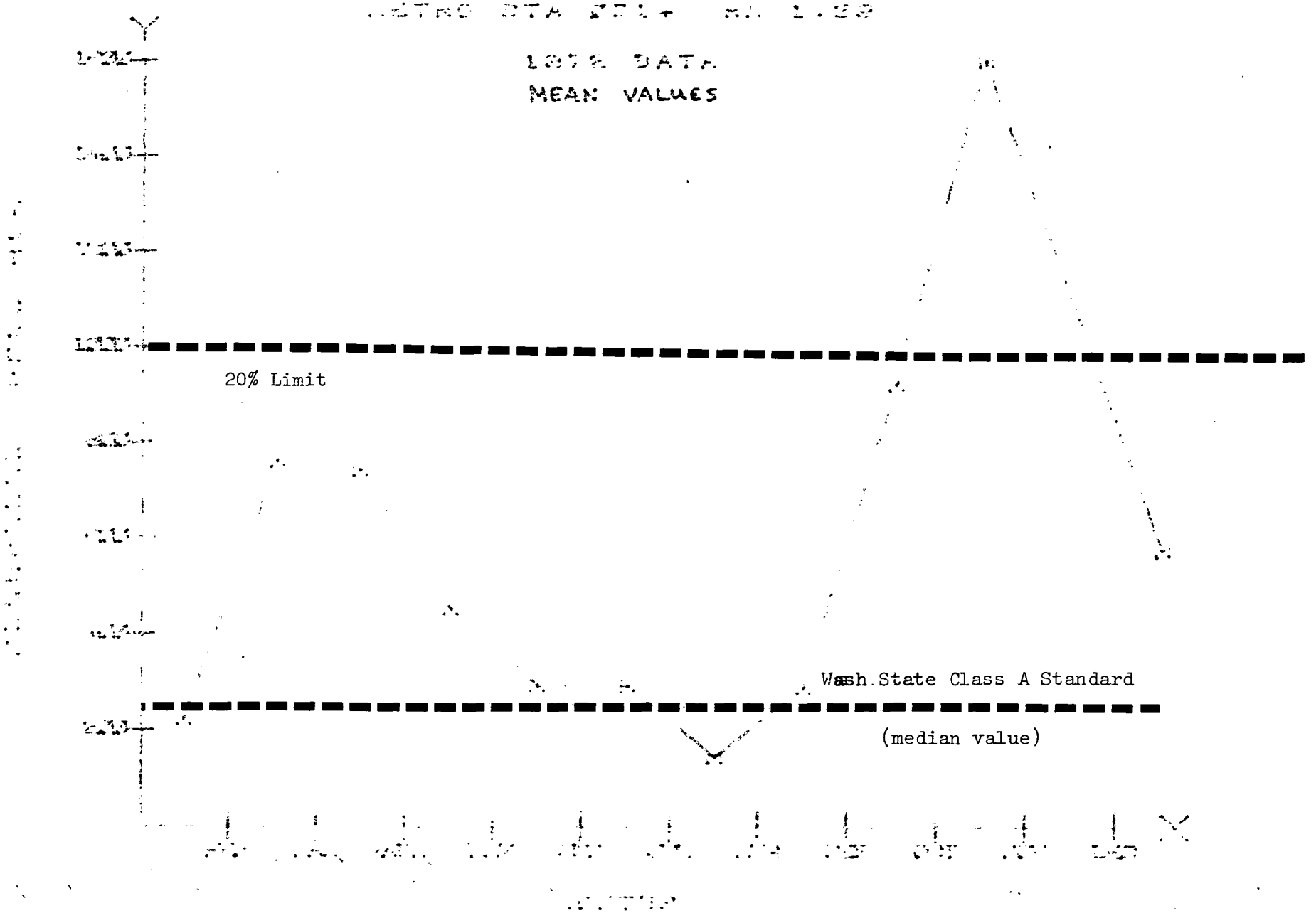
METRO STA 2514 KM 1.93

1972 DATA

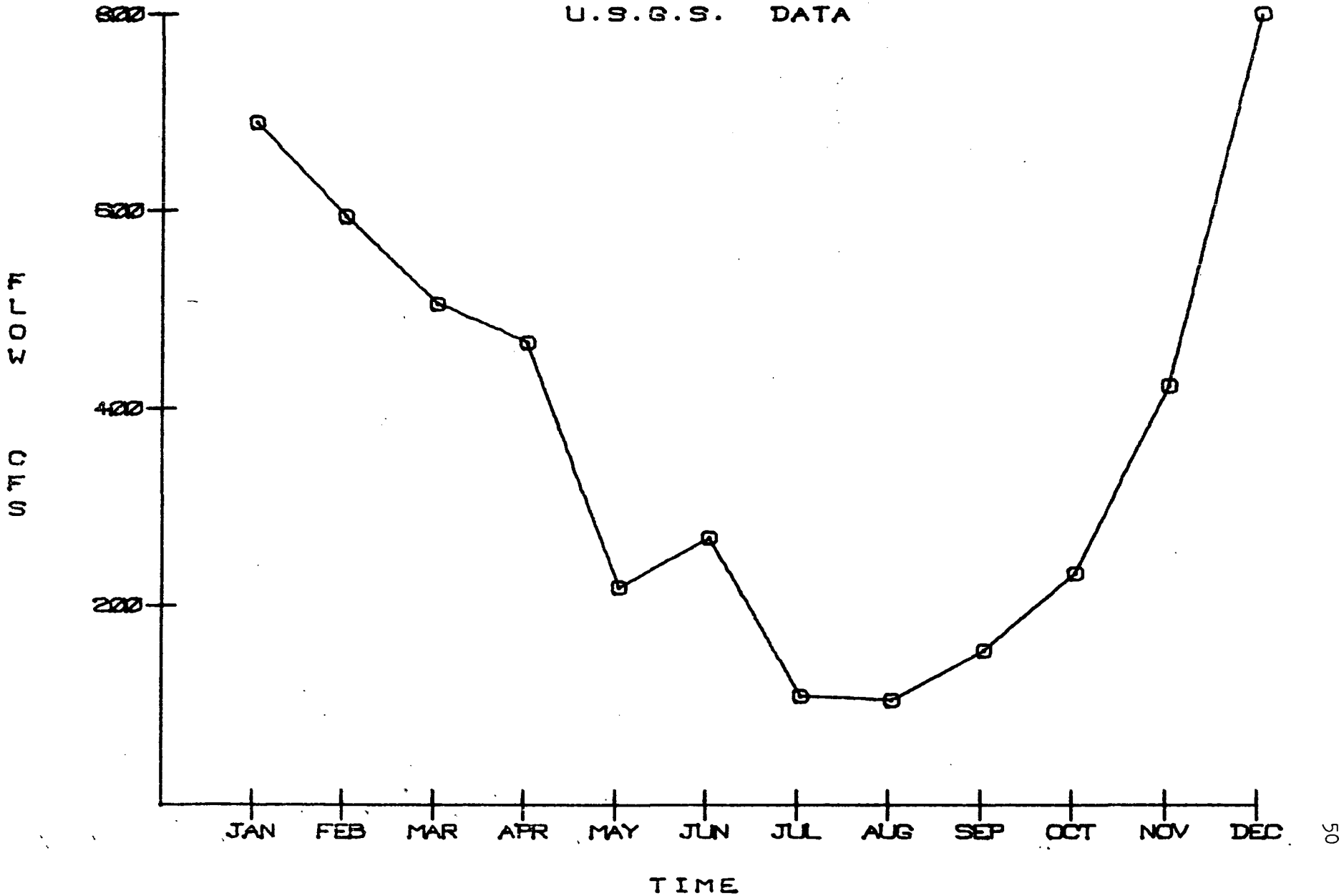
MEAN VALUES

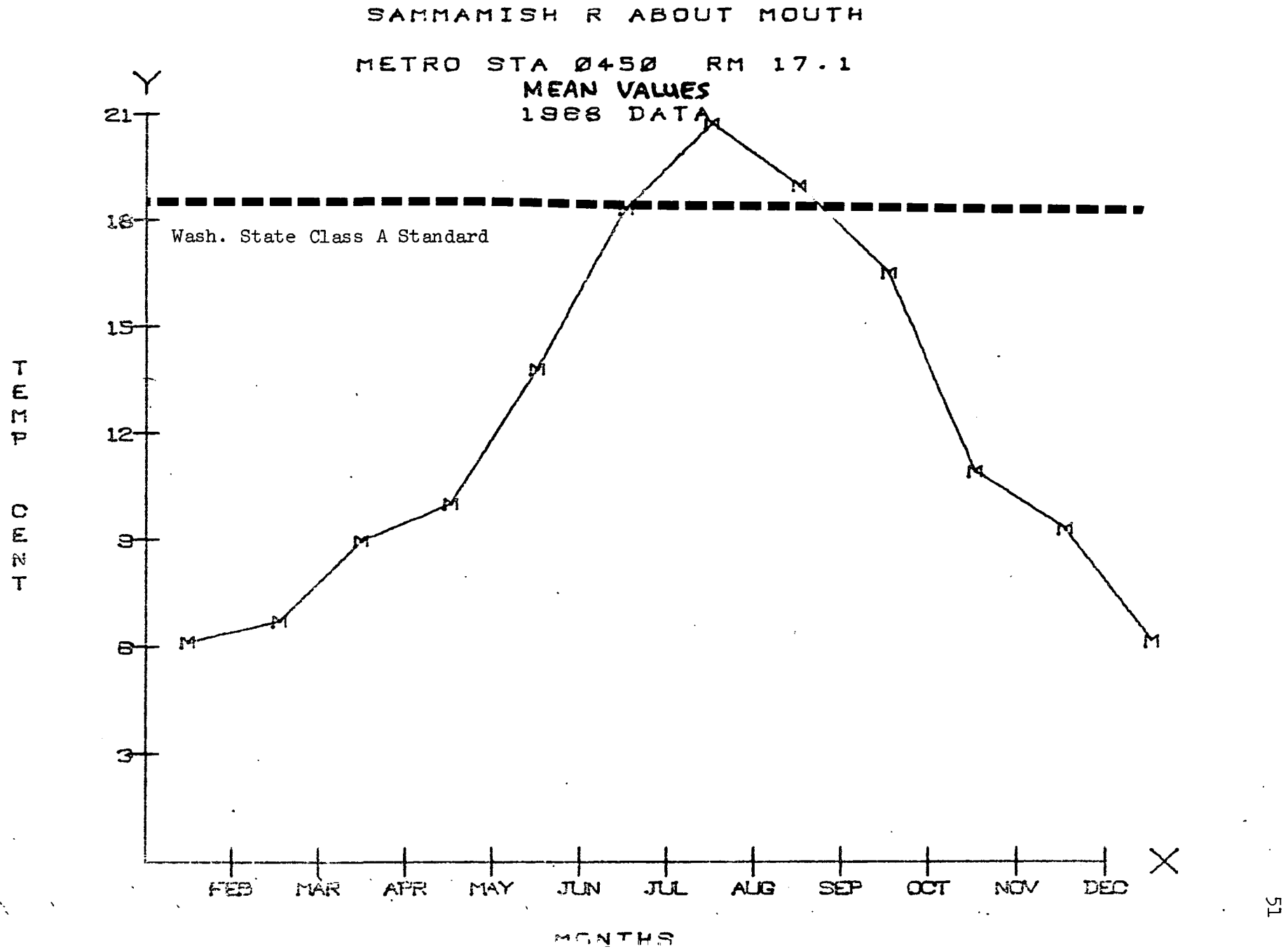


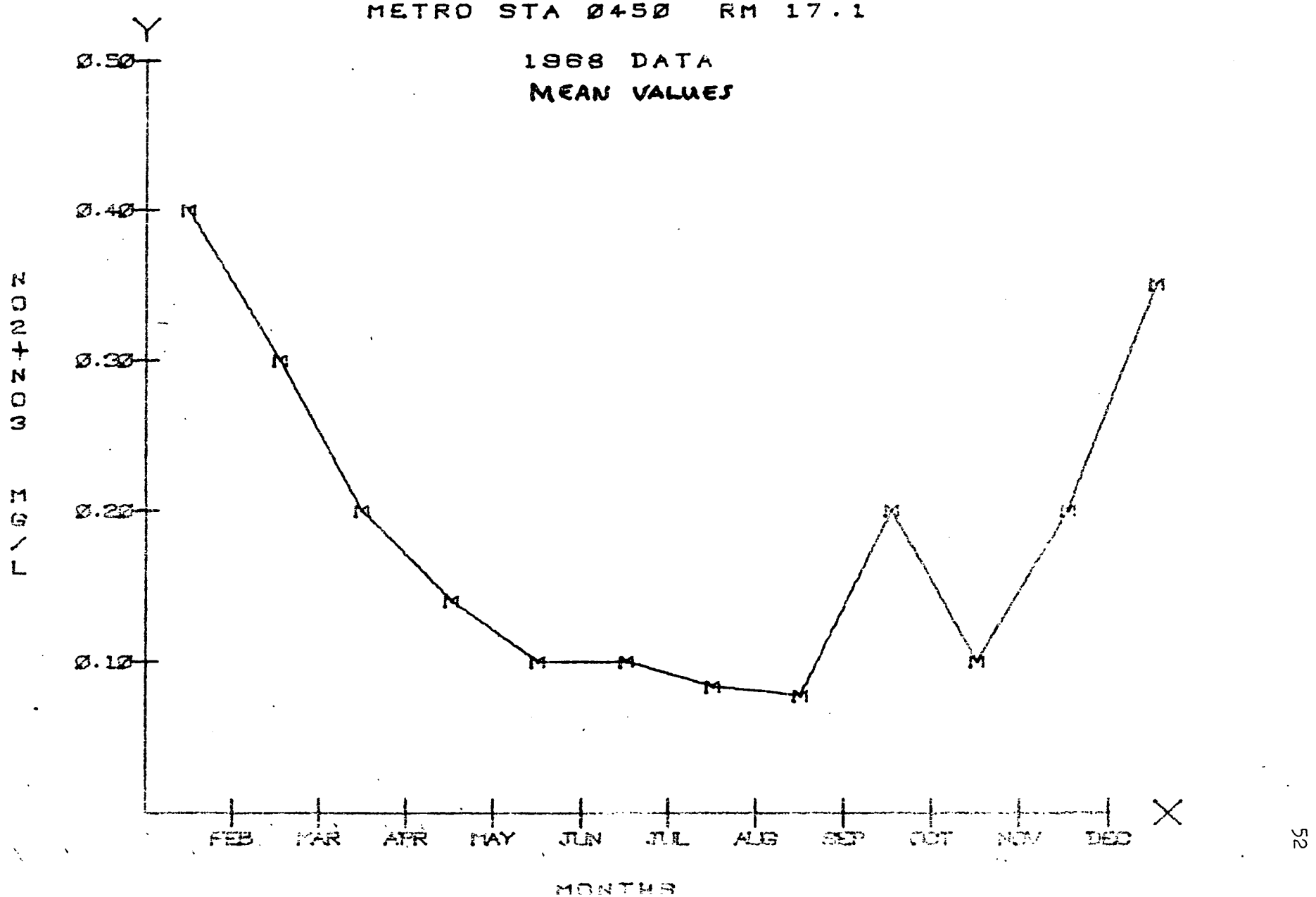

MEAN VALUES
Wash. State Class A Standard
Y
X


1977 DATA
MEAN VALUES
20% Limit
Wash. State Class A Standard
(median value)

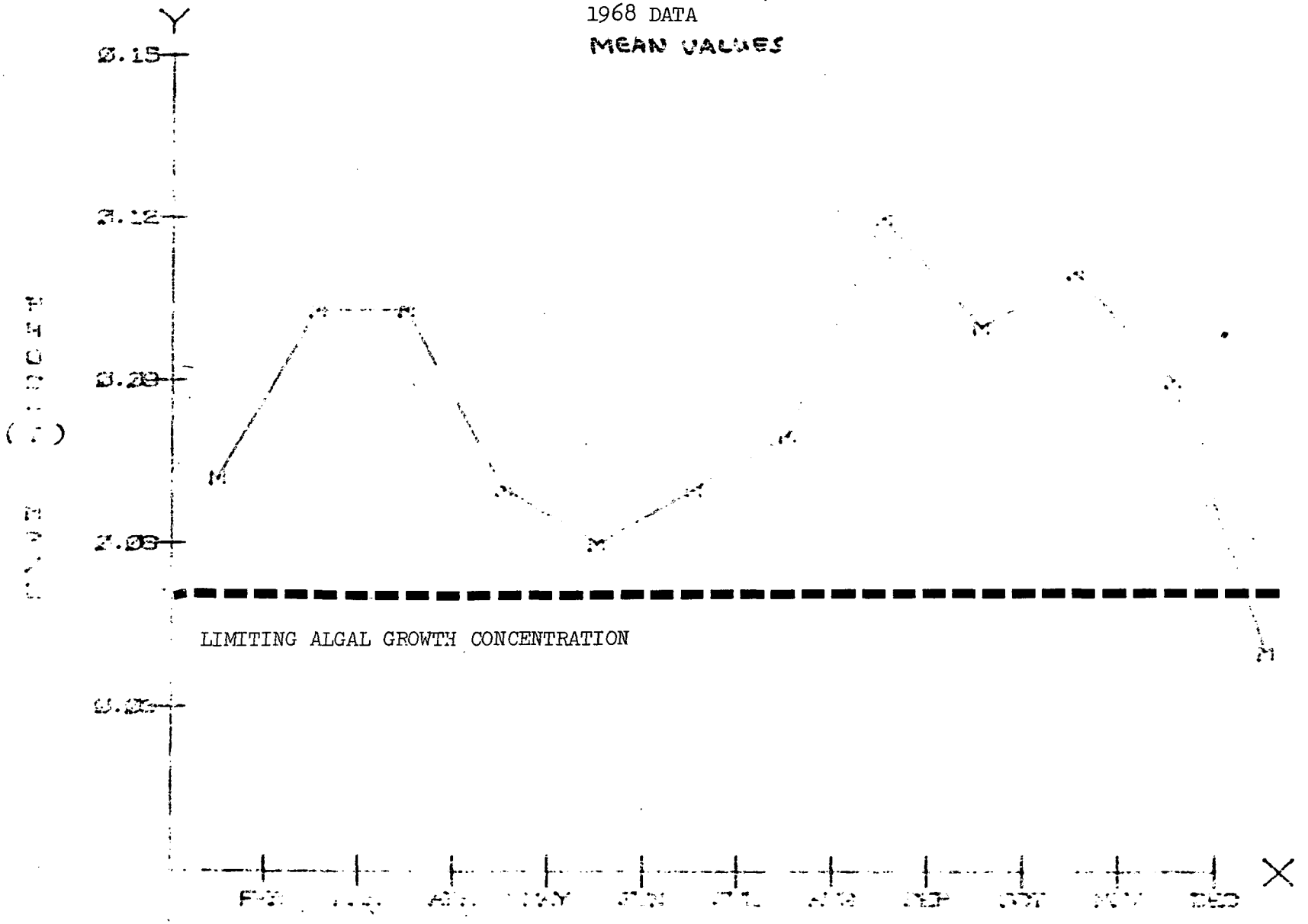
SAMMAMISH RIVER


SAMMAMISH RIVER AT WOODINVILLE
MEAN VALUES JAN.88 - DEC.88
U.S.G.S. DATA
800
600
400
200
FLOW CFS
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
TIME

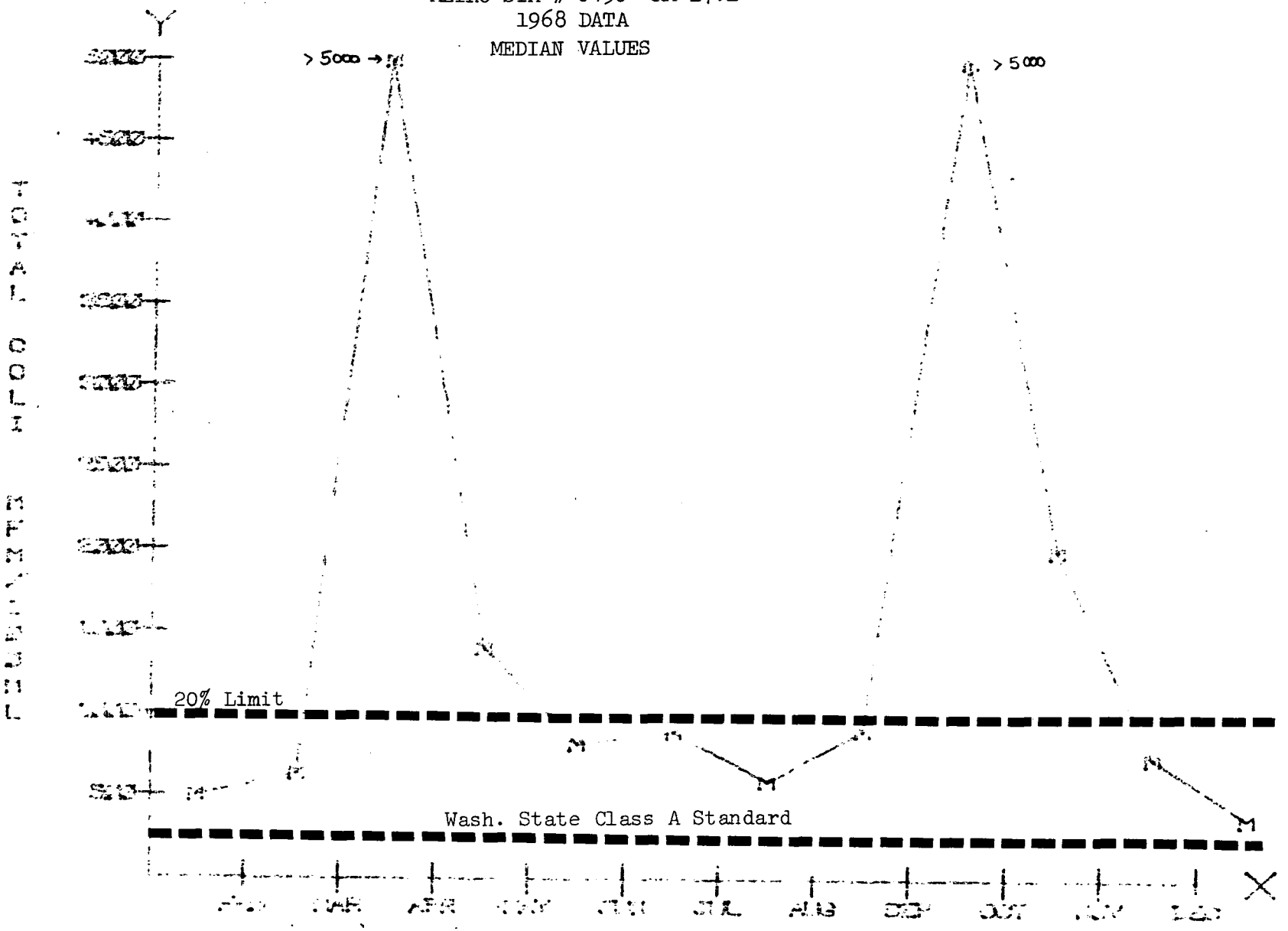

SAMMAMISH R ABOUT MOUTH
METRO STA 0450 RM 17.1
MEAN VALUES
1968 DATA
Y
21
18
15
12
9
6
3
Wash. State Class A Standard
TEMP CENT
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
X
MONTHS

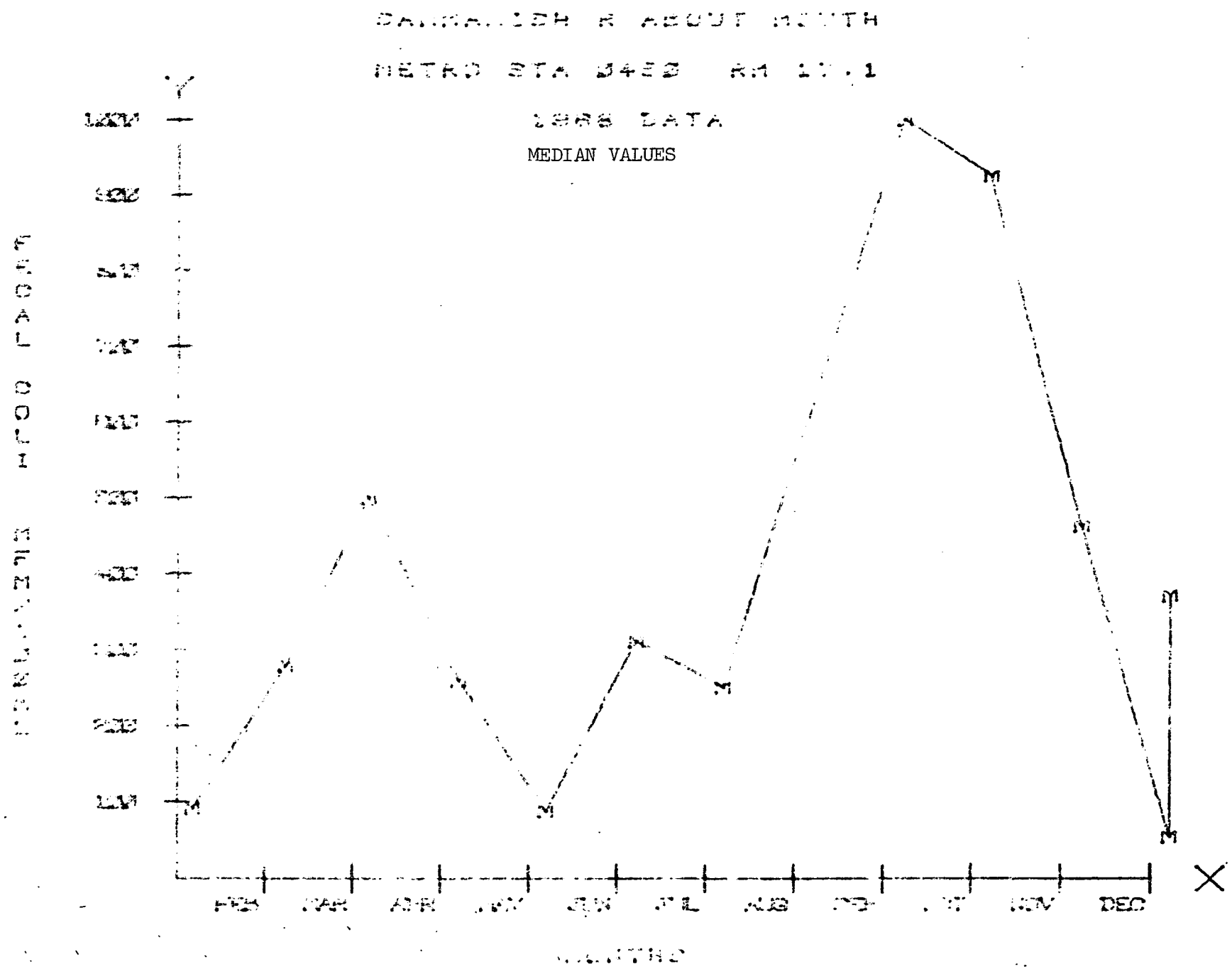

SAMMAMISH R ABOUT MOUTH
METRO STA 0450 RM 17.1
1968 DATA
MEAN VALUES
Y
0.50
0.40
0.30
0.20
0.10
MG/L NO3+NO2 N
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
X
MONTHS

SAMMAMISH R ABOUT MOUTH
METRO STA # 0450 RM 17.1
1968 DATA
MEAN VALUES



SAMMAMISH R ABOUT MOUTH
METRO STA # 0450 RM 17.1
1968 DATA
MEDIAN VALUES




MEDIAN VALUES
Y
X
DEC

DESCHUTES RIVER BASIN

DESCHUTES RIVER BASIN
BASIN DESCRIPTION

1. Drainage Area - 89.8 sq. m.

2. Average Flow - (at Ranier) mean = 327 cfs
max. = 3 400 cfs
min. = 31 cfs

3. Waste Sources - 3

4. Major Diversions - included in Nisqually Total

5. Surface Water Rights - Municipal - 10 cfs

Irrigation - 35.86 cfs

Individual & Community Domestic - 4.53 cfs

Industrial & Commercial - 12.13 cfs

Fish. Propogation - 11.32 cfs

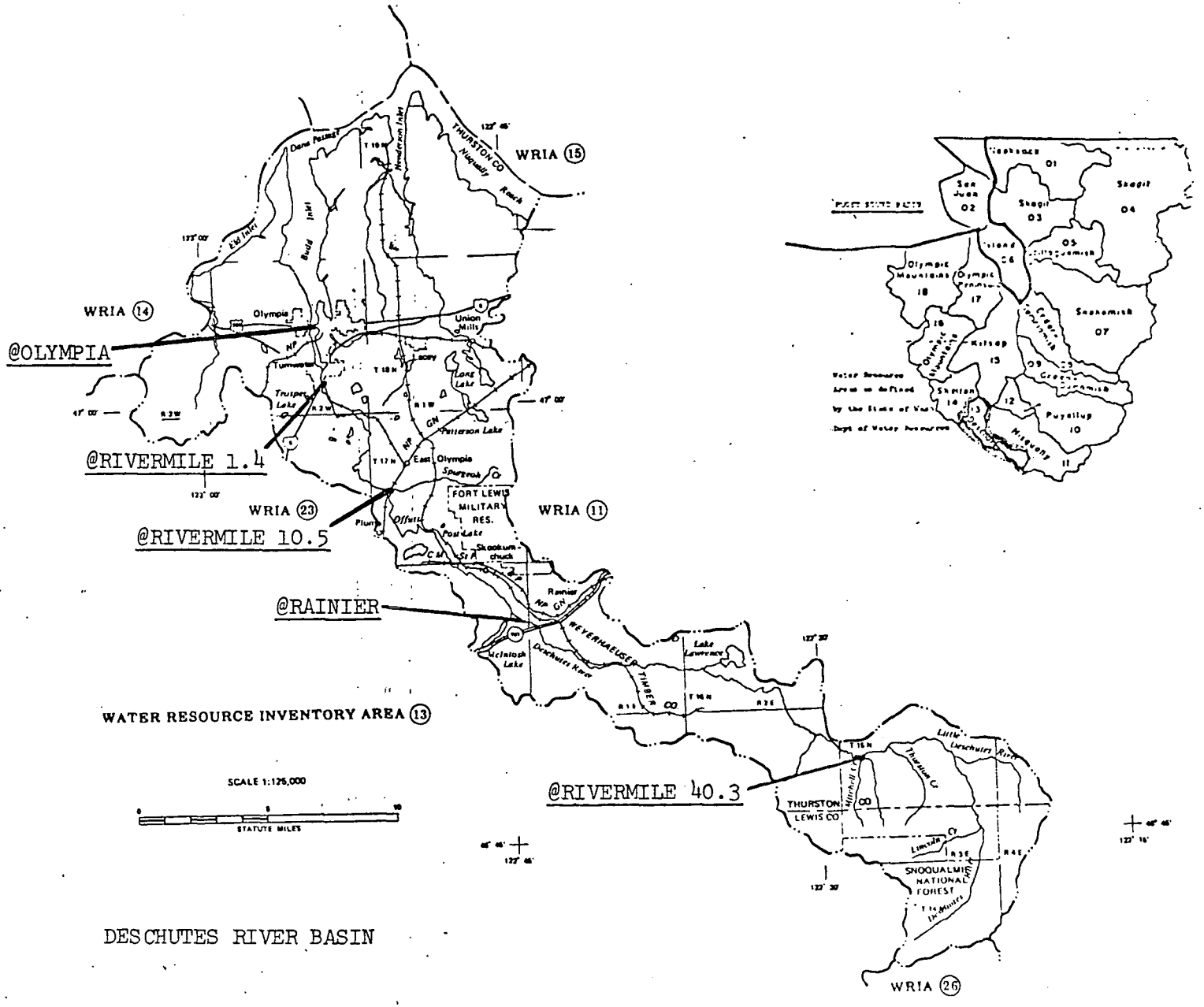
Stock - .37 cfs

Total - 78.38 cfs

6. Reservoir Storage Rights - 414 acre-feet

7. Projected Population -

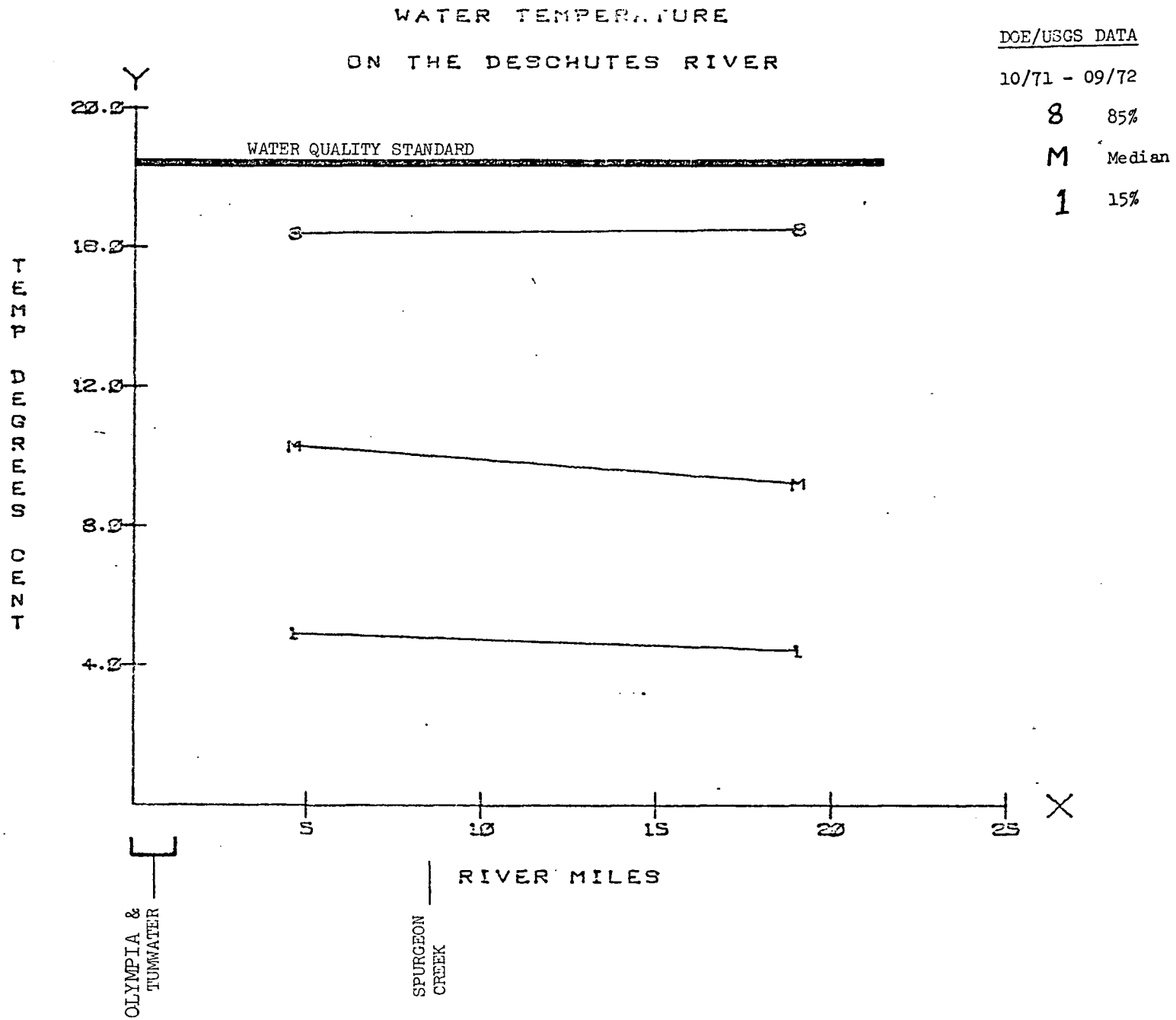
1980	2000	2020
74,900	104,500	146,500

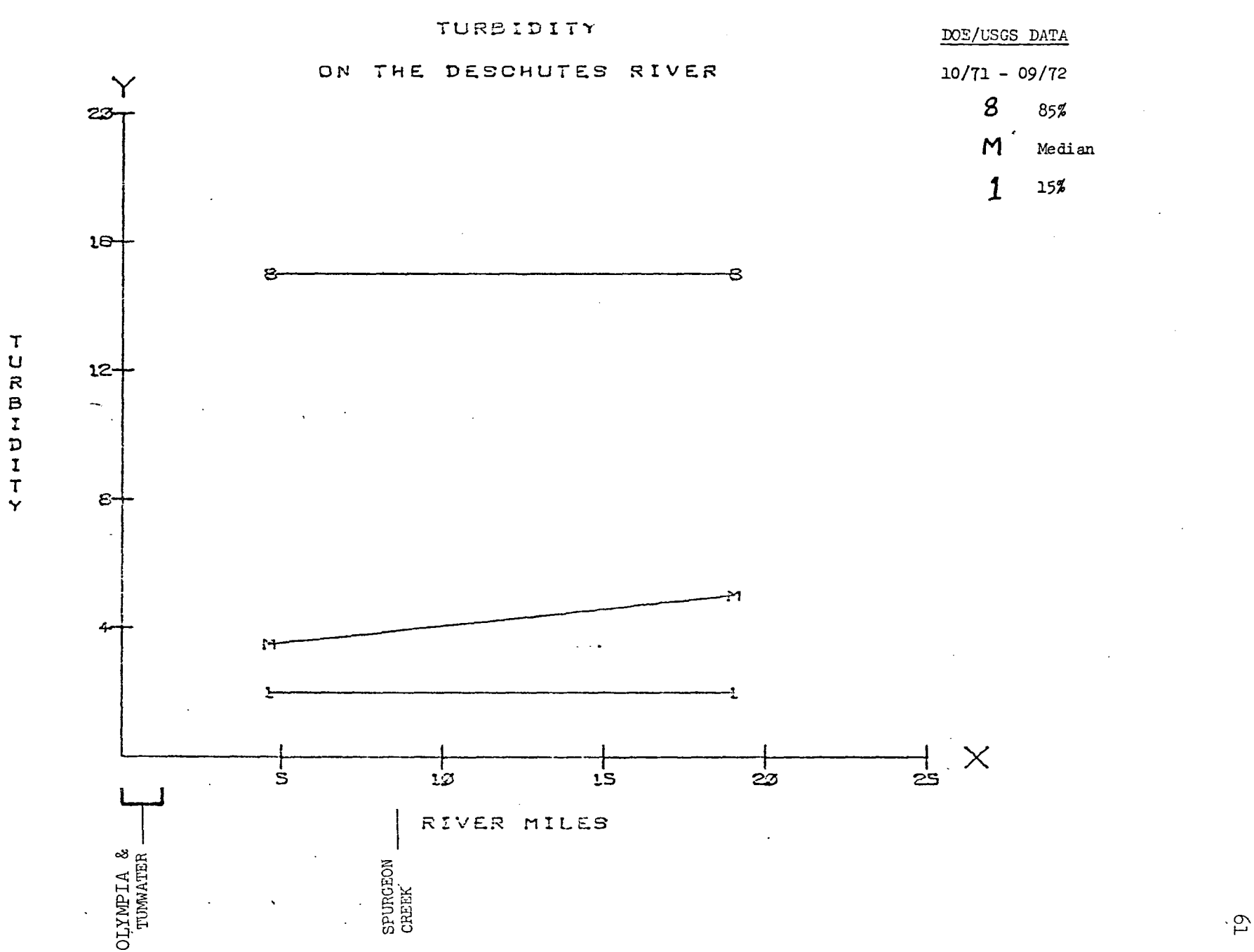

WRIA (15)
WRIA (14)
@OLYMPIA
@RIVERMILE 1.4
WRIA (23)
@RIVERMILE 10.5
WRIA (11)
@RAINIER
@RIVERMILE 40.3
WRIA (26)
WATER RESOURCE INVENTORY AREA (13)
SCALE 1:125,000
STATUTE MILES
DESCHUTES RIVER BASIN

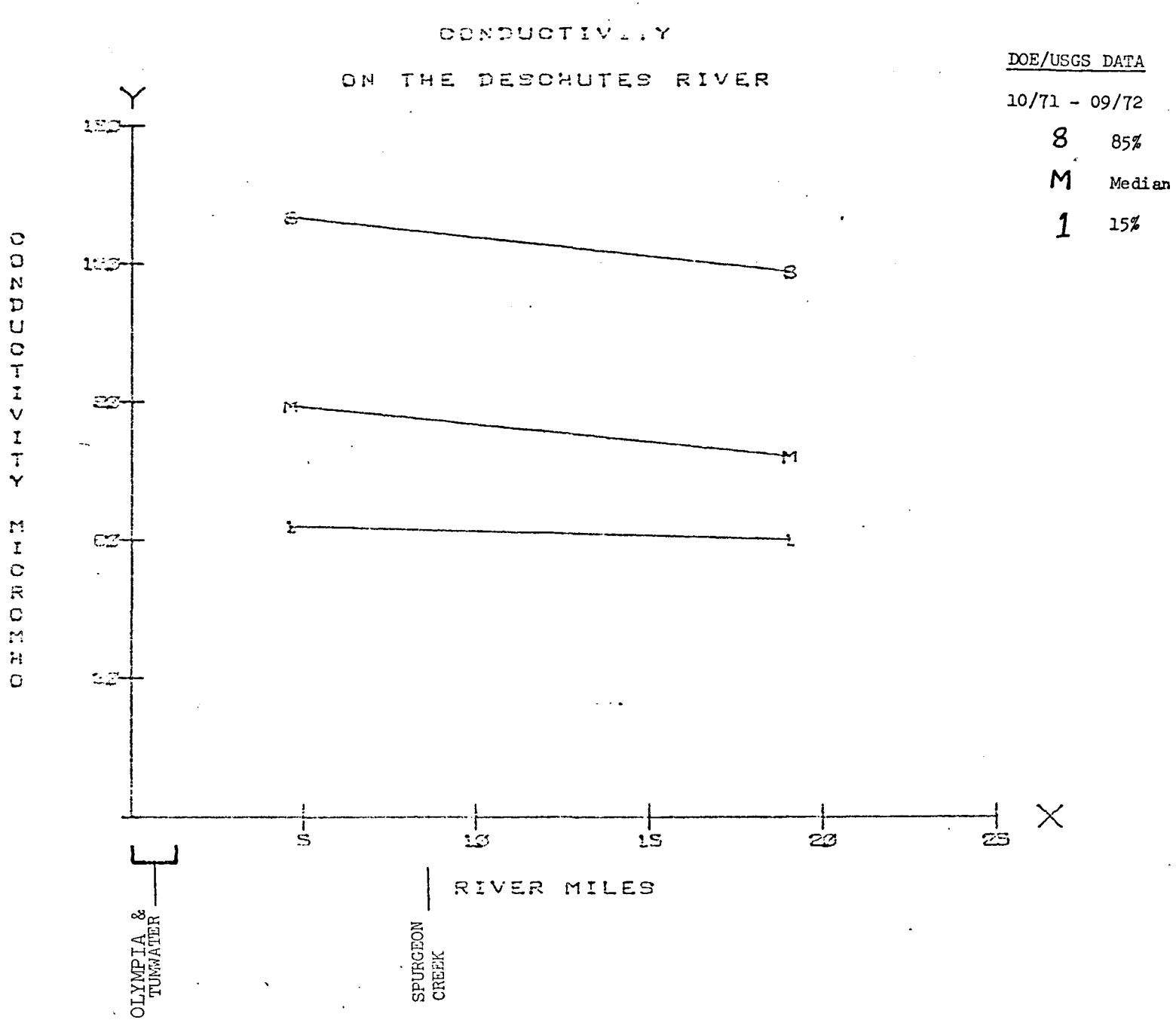
DESCHUTES RIVER BASIN
REPORTED PROBLEMS

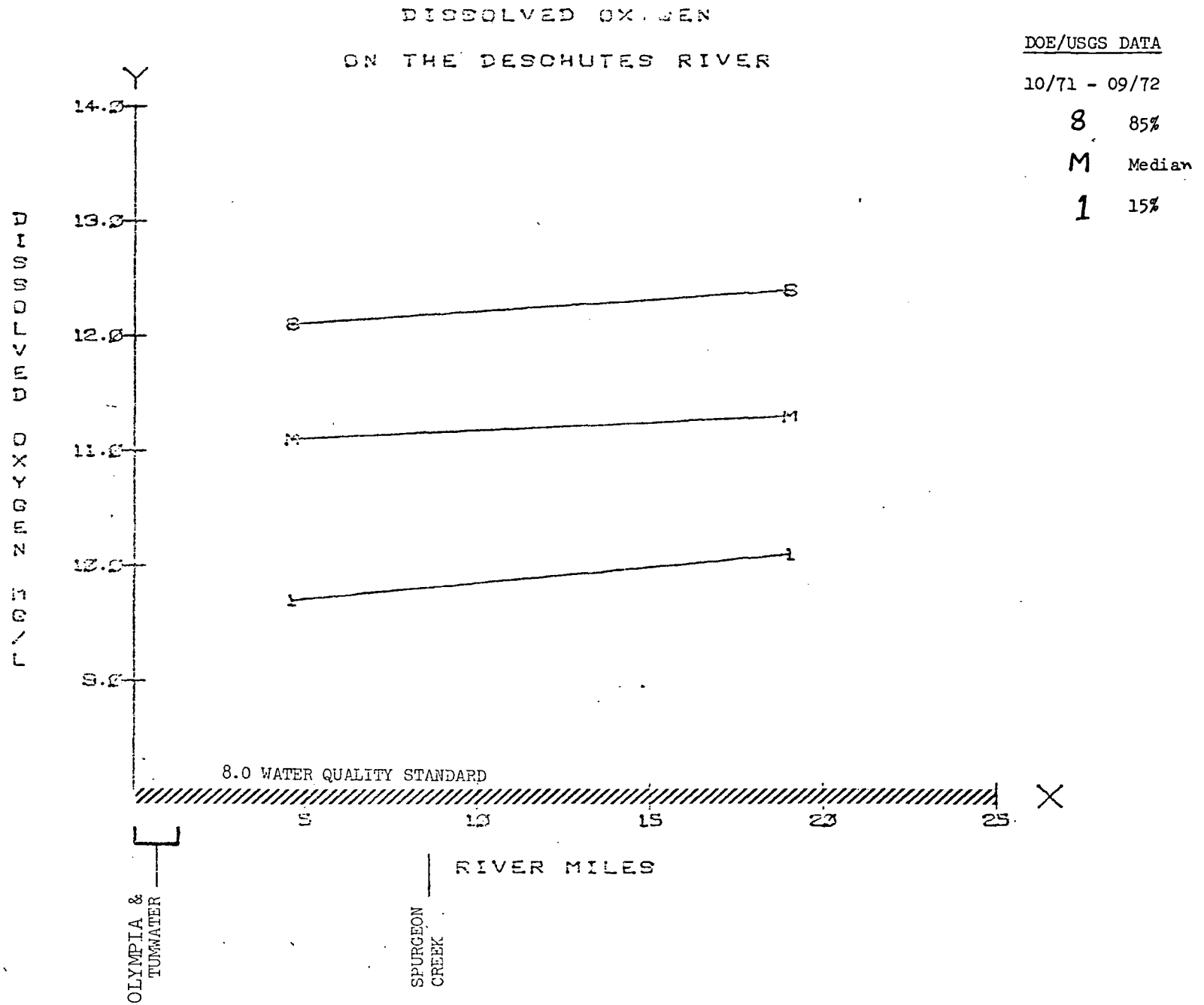
1. Total nitrate and total phosphorous concentrations often exceed the Algal Bloom Potential Concentration during periods of high flow, especially as the river approaches its mouth.

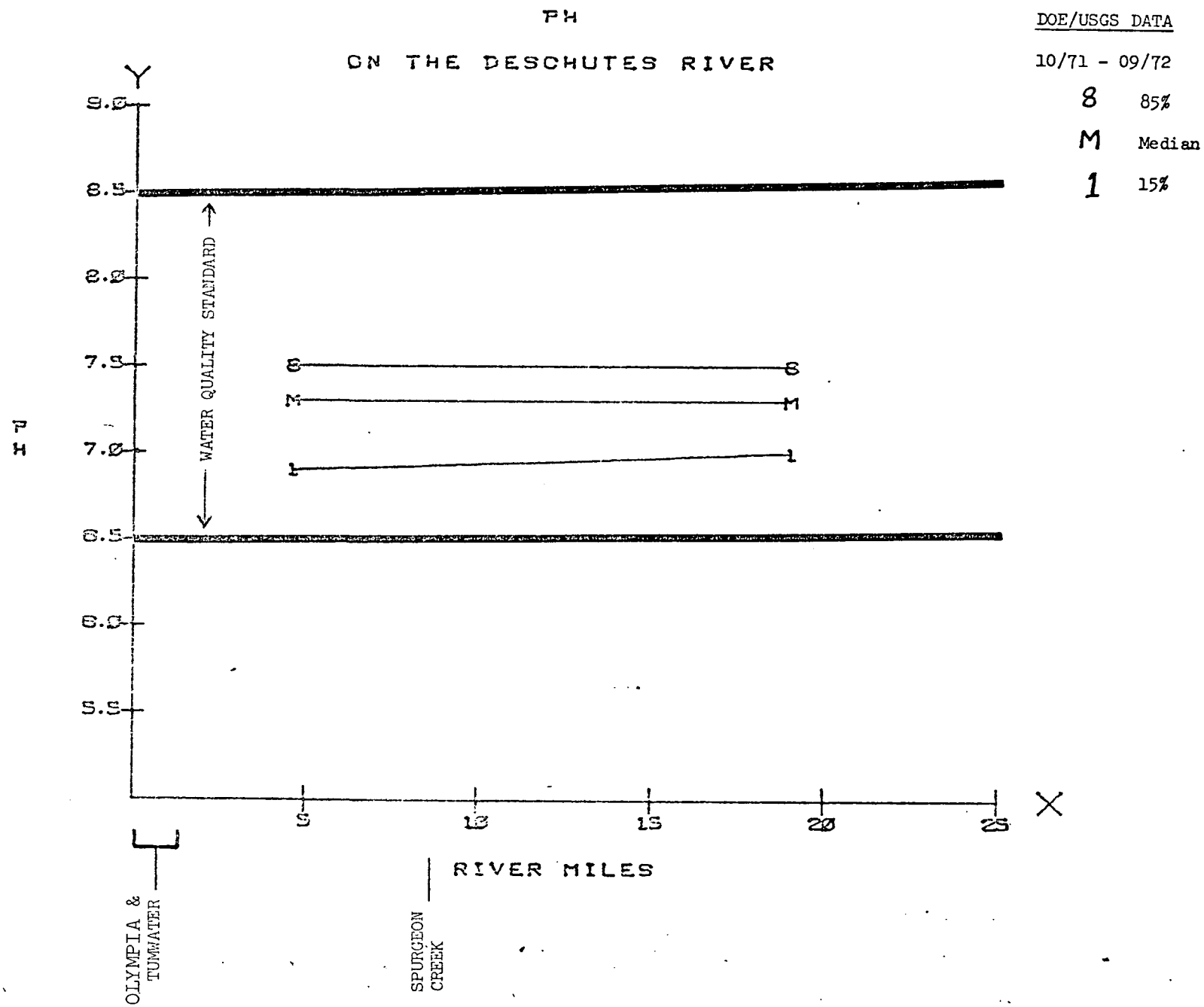
2. Total coliform values occasionally exceed the Water Quality Standard throughout the river.

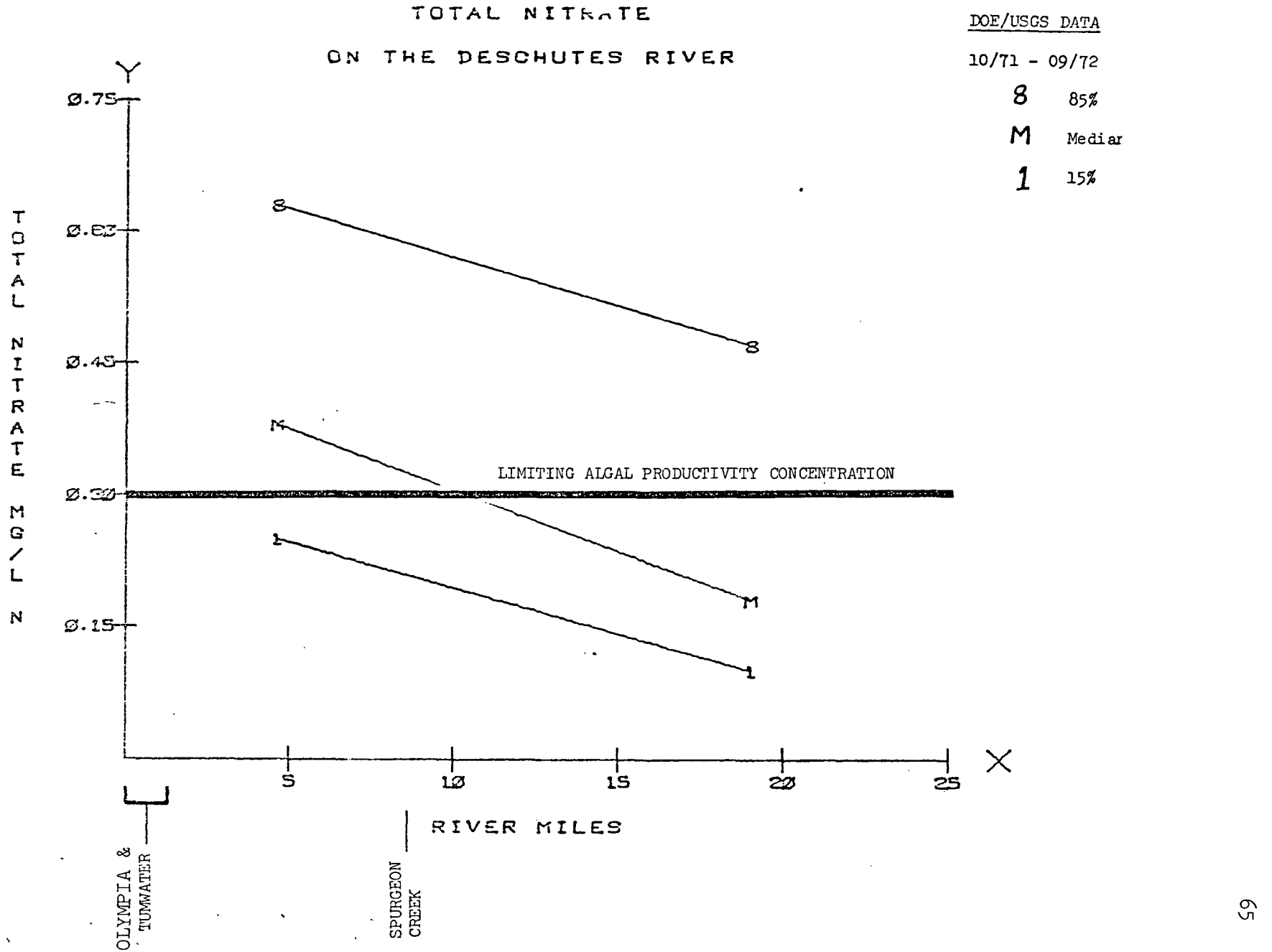

WATER TEMPERATURE
ON THE DESCHUTES RIVER
DOE/USGS DATA
10/71 - 09/72
8 85%
M Median
1 15%
Y
20.0
WATER QUALITY STANDARD
16.0
12.0
8.0
4.0
TEMP DEGREES CENT
8
M
1
5
10
15
20
25
X
RIVER MILES
OLYMPIA & TUMWATER
SPURGEON CREEK

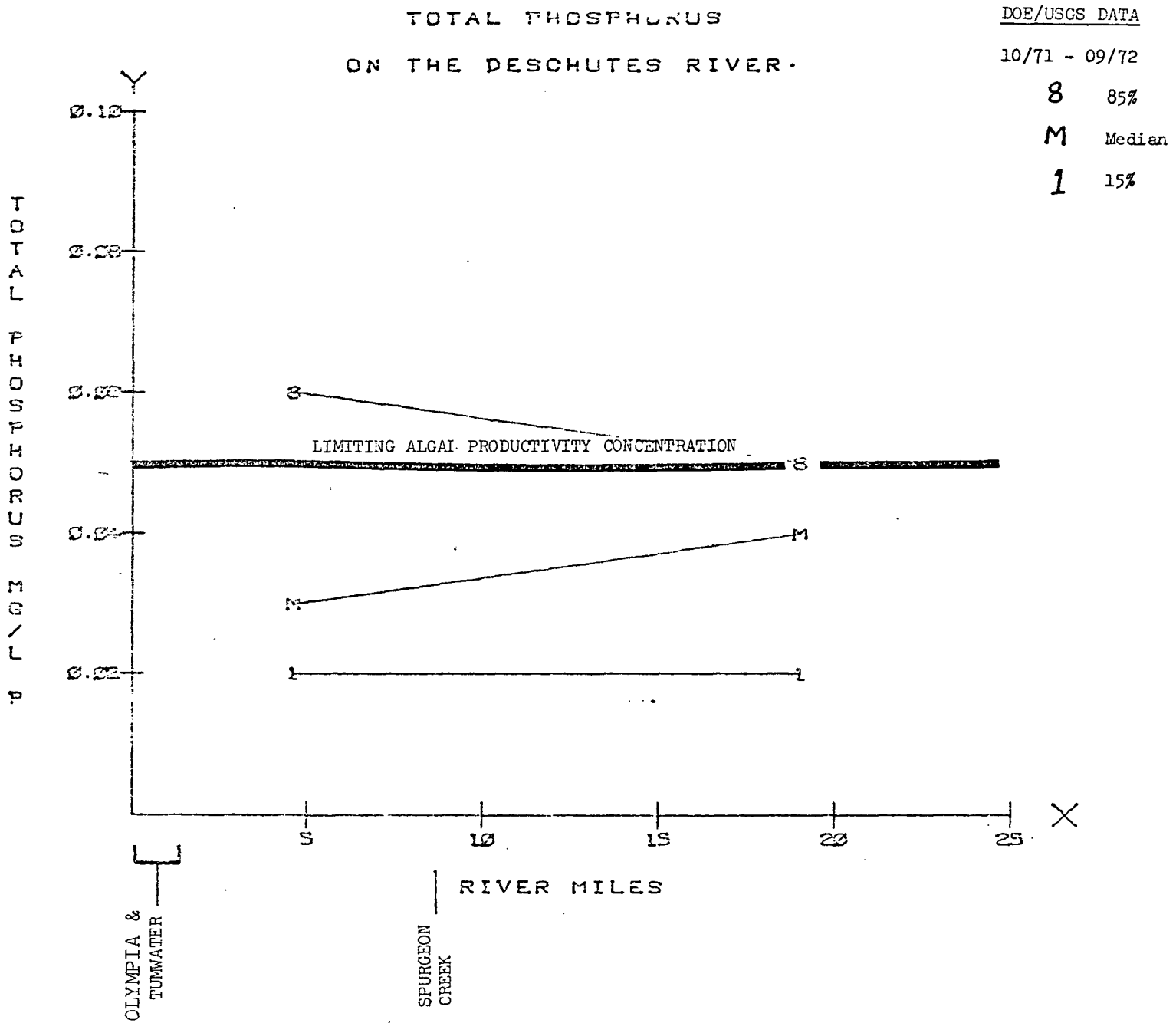

TURBIDITY
ON THE DESCHUTES RIVER
DOE/USGS DATA
10/71 - 09/72
8 85%
M Median
1 15%
Y
20
16
12
8
4
TURBIDITY
8
M
1
5
10
15
20
25
X
RIVER MILES
OLYMPIA & TUMWATER
SPURGEON CREEK

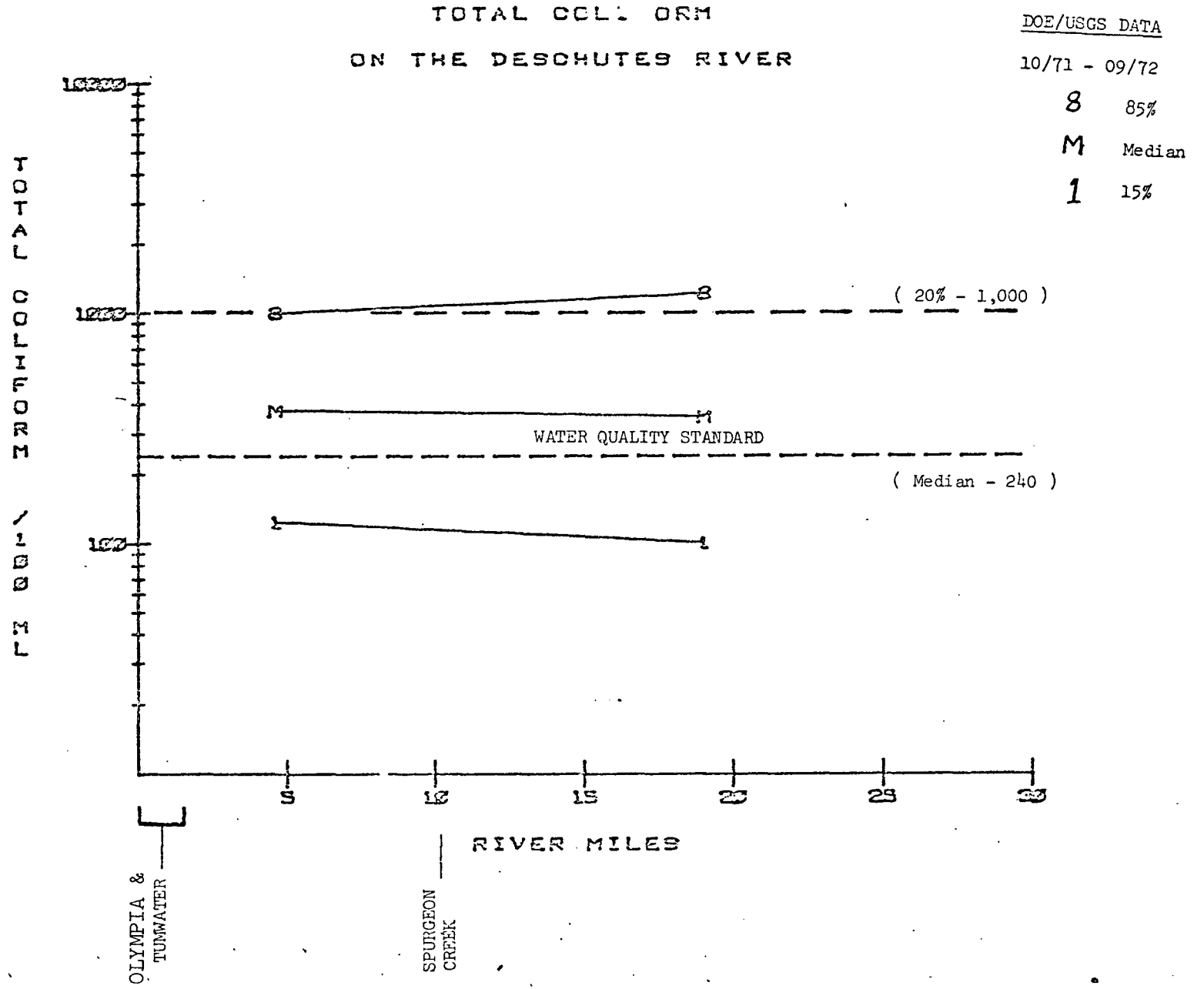

CONDUCTIVITY
ON THE DESCHUTES RIVER
DOE/USGS DATA
10/71 - 09/72
8 85%
M Median
1 15%
CONDUCTIVITY MICROMHOS
Y
X
S
M
1
5
10
15
20
25
RIVER MILES
OLYMPIA & TUMWATER
SPURGEON CREEK


DISSOLVED OXYGEN
ON THE DESCHUTES RIVER
DOE/USGS DATA
10/71 - 09/72
8 85%
M Median
1 15%
DISSOLVED OXYGEN (mg/l)
Y
14.0
13.0
12.0
11.0
10.0
9.0
8
M
1
8.0 WATER QUALITY STANDARD
X
5
10
15
20
25
RIVER MILES
OLYMPIA & TUMWATER
SPURGEON CREEK


PH
ON THE DESCHUTES RIVER
DOE/USGS DATA
10/71 - 09/72
8 85%
M Median
1 15%
Y
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
PH
WATER QUALITY STANDARD
8
M
1
5
10
15
20
25
X
RIVER MILES
OLYMPIA & TUMWATER
SPURGEON CREEK


TOTAL NITRATE
ON THE DESCHUTES RIVER
DOE/USGS DATA
10/71 - 09/72
8 85%
M Median
1 15%
Y
0.75
0.60
0.45
0.30
0.15
TOTAL NITRATE MG/L N
LIMITING ALGAL PRODUCTIVITY CONCENTRATION
8
M
1
5
10
15
20
25
X
RIVER MILES
OLYMPIA & TUMWATER
SPURGEON CREEK


TOTAL PHOSPHORUS
ON THE DESCHUTES RIVER.
DOE/USGS DATA
10/71 - 09/72
8 85%
M Median
1 15%
TOTAL PHOSPHORUS MG/L P
Y
0.10
0.08
0.06
0.04
0.02
8
LIMITING ALGAL PRODUCTIVITY CONCENTRATION
8
M
M
1
1
5
10
15
20
25
X
RIVER MILES
OLYMPIA & TUMWATER
SPURGEON CREEK


TOTAL COLIFORM
ON THE DESCHUTES RIVER
DOE/USGS DATA
10/71 - 09/72
8 85%
M Median
1 15%
TOTAL COLIFORM MPN/100 ML
(20% - 1,000)
WATER QUALITY STANDARD
(Median - 240)
5
10
15
20
25
30
RIVER MILES
OLYMPIA & TUMWATER
SPURGEON CREEK

DUNGENESS-ELWAH RIVER BASIN

DUNGENESS-ELWAH RIVER BASIN
BASIN DESCRIPTION

1. Drainage Area - Dungeness - 156 sq. m.
   Elwah - 269 sq. m.

2. Average Flow - (at Sequim) mean = 371 cfs
   min. = 199 cfs
   max. = 545 cfs
   (at Port Angeles) mean = 1 456 cfs
   min. = 859 cfs
   max. = 2 051 cfs

3. Waste Sources - 2

4. Major Diversions -

	Dung.	Elwah
Fish & Game	25 cfs	
Domestic	2 cfs	4 cfs
Industrial		74 cfs
Hydropower		2800 cfs
Irrigation	75 000 acre-feet	

5. Surface Water Rights (Port Angeles Area)

   Municipal - 31.4 cfs

   Irrigation - 52.46 cfs

   Individual & Community Domestic - 14.7 cfs

   Industrial & Commercial - 190.02 cfs

   Fish. Propogation - 32.94 cfs

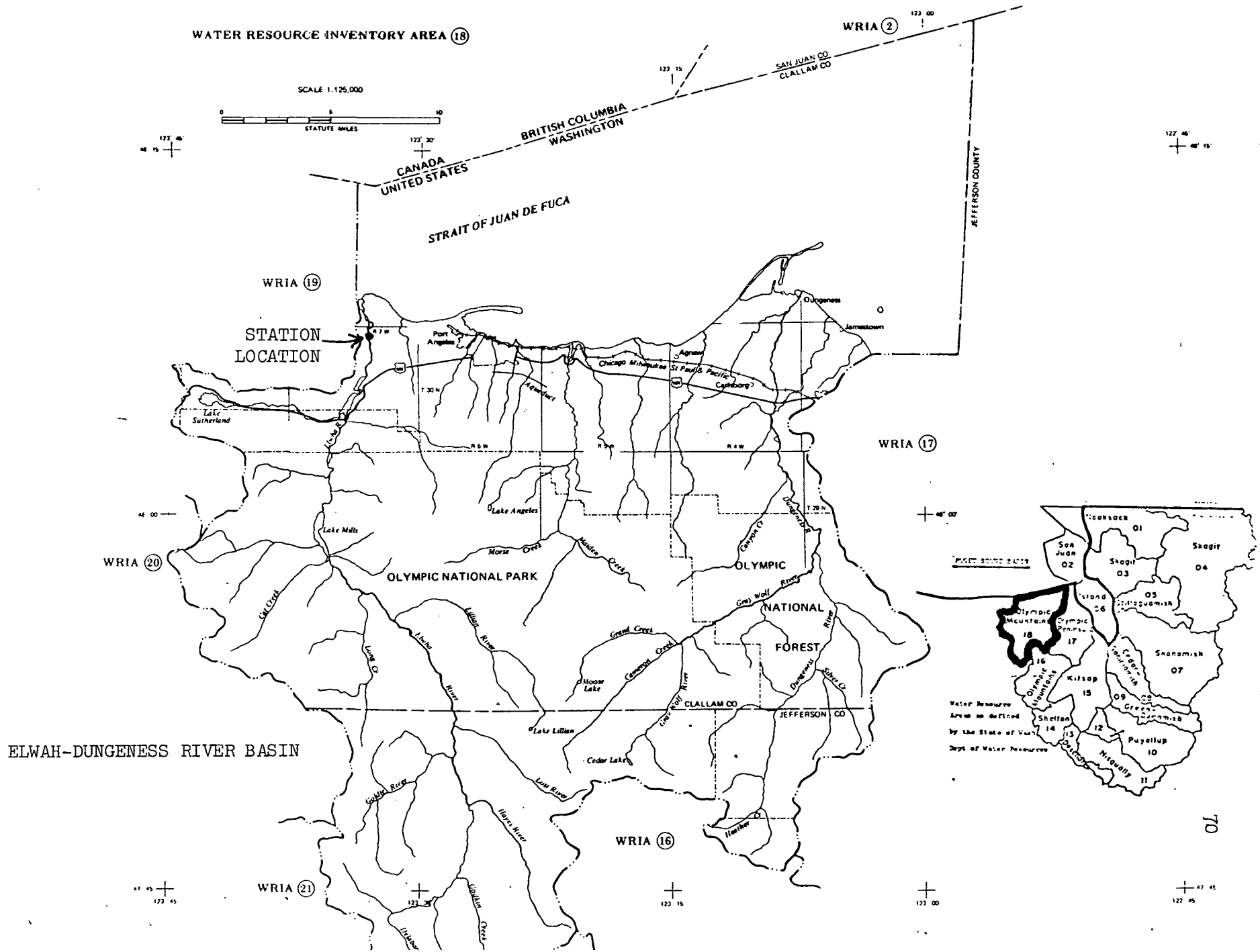
   Stock - 1.53 cfs

   Total - 915.59 cfs

Reservoir Storage Rights - 65,140 acre-feet

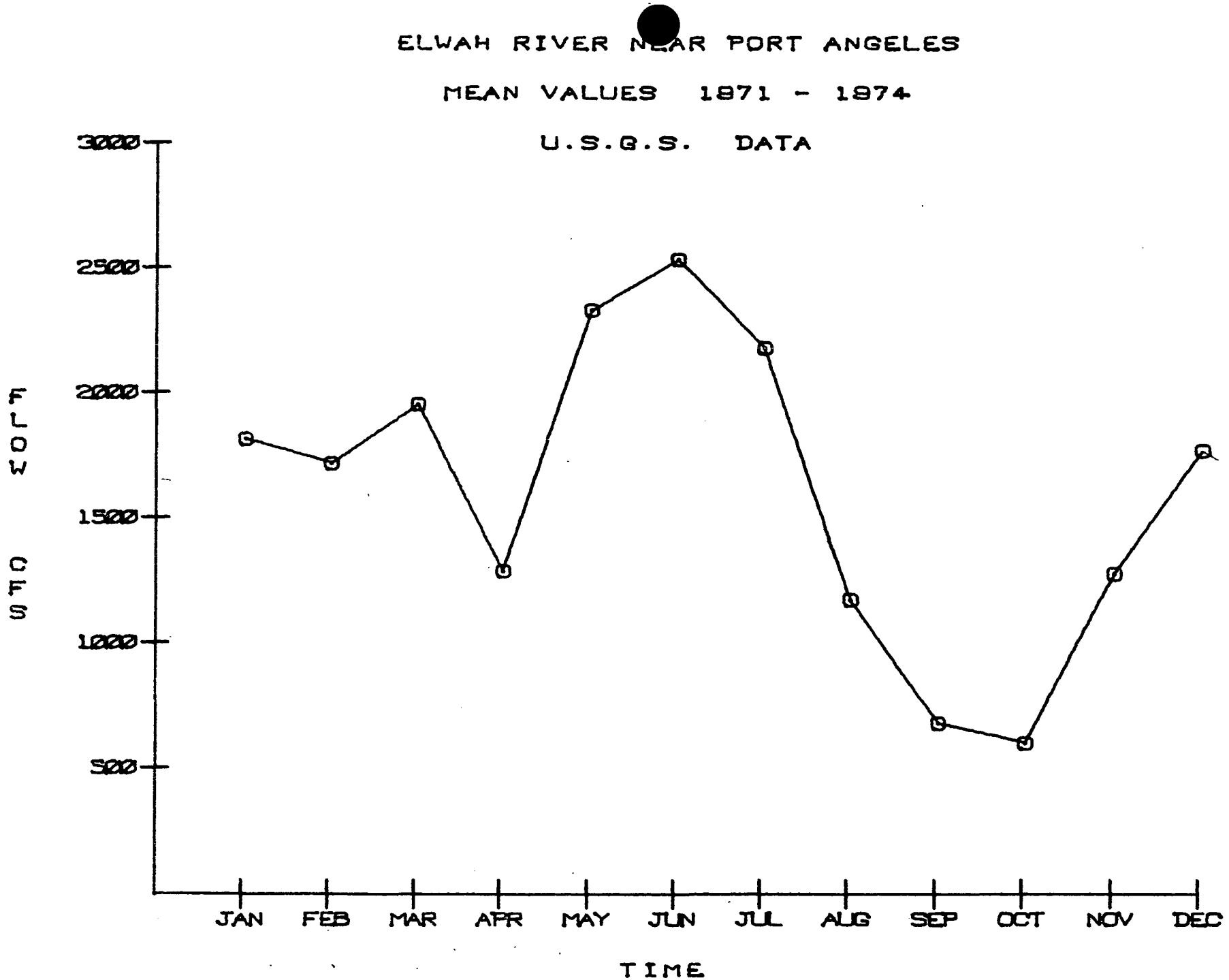
6. Projected Population -

1980	2000	2020
29,800	41,000	56,600

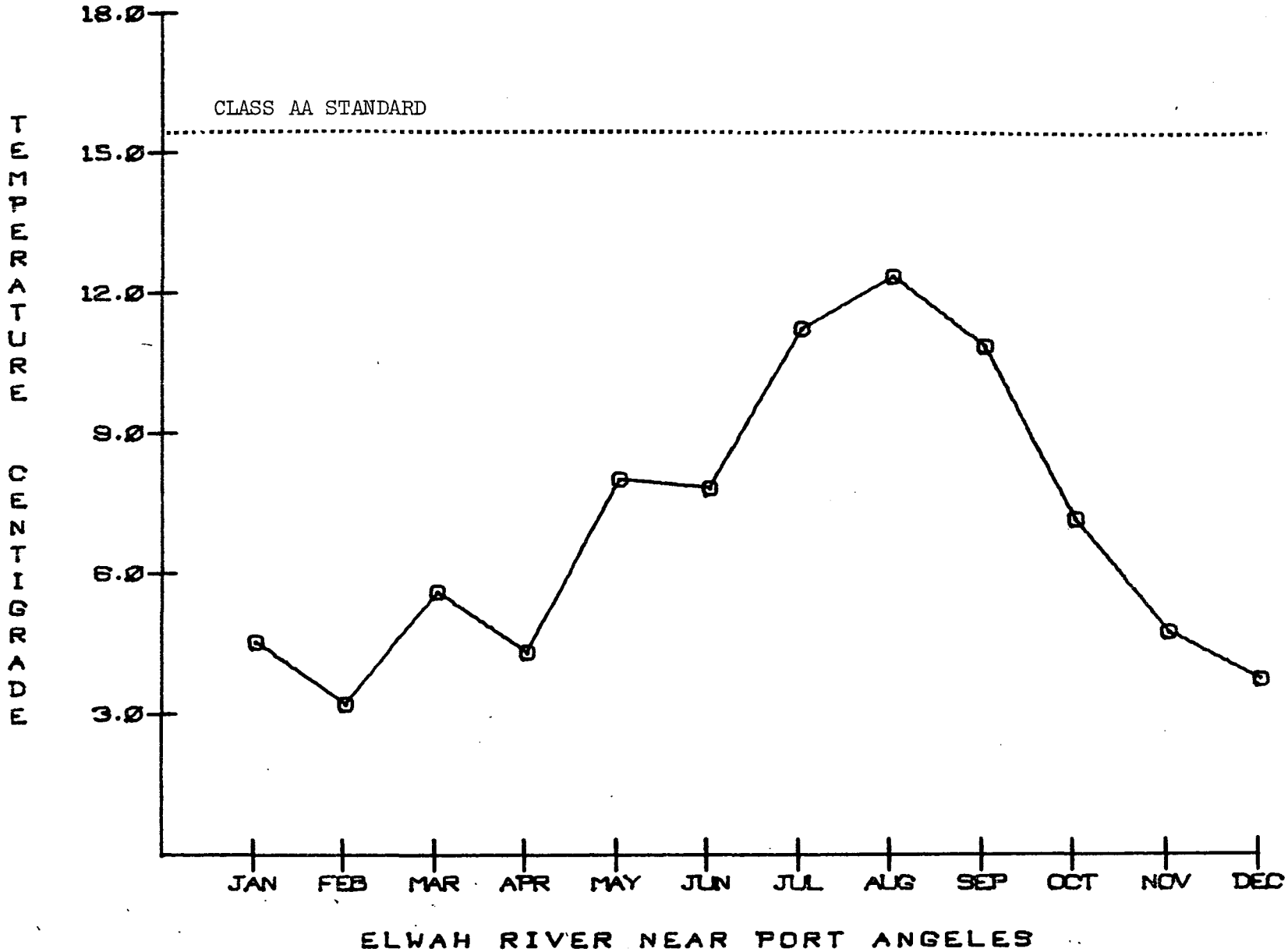

WATER RESOURCE INVENTORY AREA (18)
WRIA (2)
SCALE 1:125,000
STATUTE MILES
SAN JUAN CO
CLALLAM CO
BRITISH COLUMBIA
WASHINGTON
CANADA
UNITED STATES
STRAIT OF JUAN DE FUCA
JEFFERSON COUNTY
WRIA (19)
STATION LOCATION
Port Angeles
Dungeness
Jamestown
Agnew
Chicago Milwaukee St Paul & Pacific
Carlsborg
Aqueduct
Lake Sutherland
Lyre R.
T 30 N
R 6 W
R 5 W
R 4 W
T 29 N
WRIA (17)
Lake Angeles
Lake Mills
Morse Creek
Maiden Creek
Dungeness R.
Canyon Cr
WRIA (20)
OLYMPIC NATIONAL PARK
OLYMPIC
NATIONAL
FOREST
Grey Wolf River
Gold Creek
Long Cr
Lillian River
Grand Creek
Cameron Creek
Moose Lake
Silver Cr
CLALLAM CO
JEFFERSON CO
Lake Lillian
Cedar Lake
Gallagher River
Lost River
Hayes River
WRIA (16)
Hamilton
WRIA (21)
Goodwin Creek
Hoh River
ELWAH-DUNGENESS RIVER BASIN
Water Resource Areas as defined by the State of Wash. Dept of Water Resources
Nooksack 01
San Juan 02
Skagit 03
Skagit 04
Island 06
Stillaguamish 05
Olympic Mountains 18
Olympic Peninsula 17
Snohomish 07
Kitsap 15
Olympic Mountains 16
Cedar-Sammamish 09
Green-Duwamish 08
Shelton 14
Puyallup 10
Nisqually 11
Chambers 13
12

Dungeness-Elwah River Basin
Reported Problems

1. Total Phosphorus concentrations periodically exceed the Limiting Algal Bloom Concentration value, especially during periods of high flow.

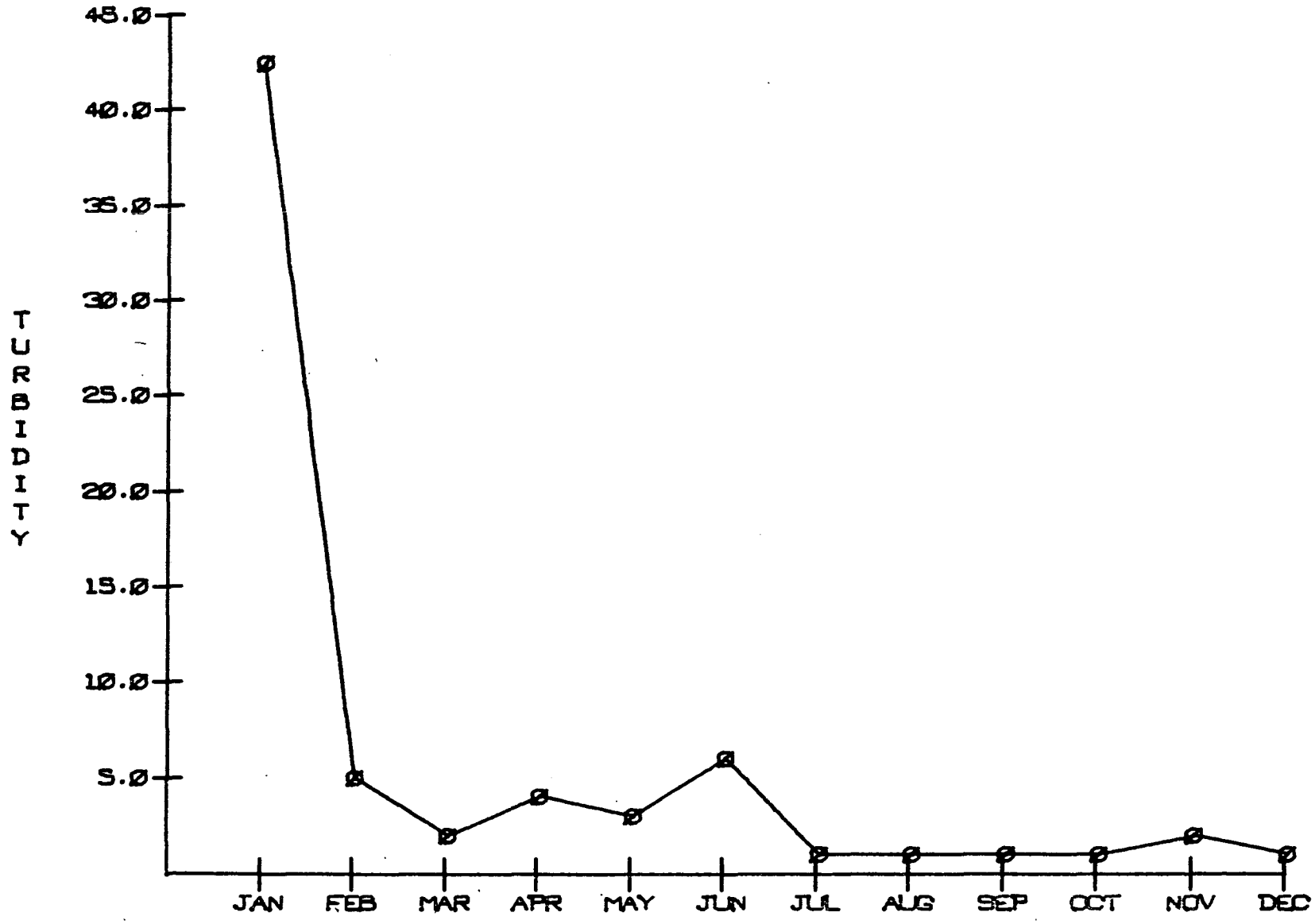

ELWAH RIVER NEAR PORT ANGELES
MEAN VALUES 1871 - 1974
U.S.G.S. DATA
3000
2500
2000
1500
1000
500
FLOW CFS
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
TIME

SINGLE SAMPLE VALUES (711027-740515)

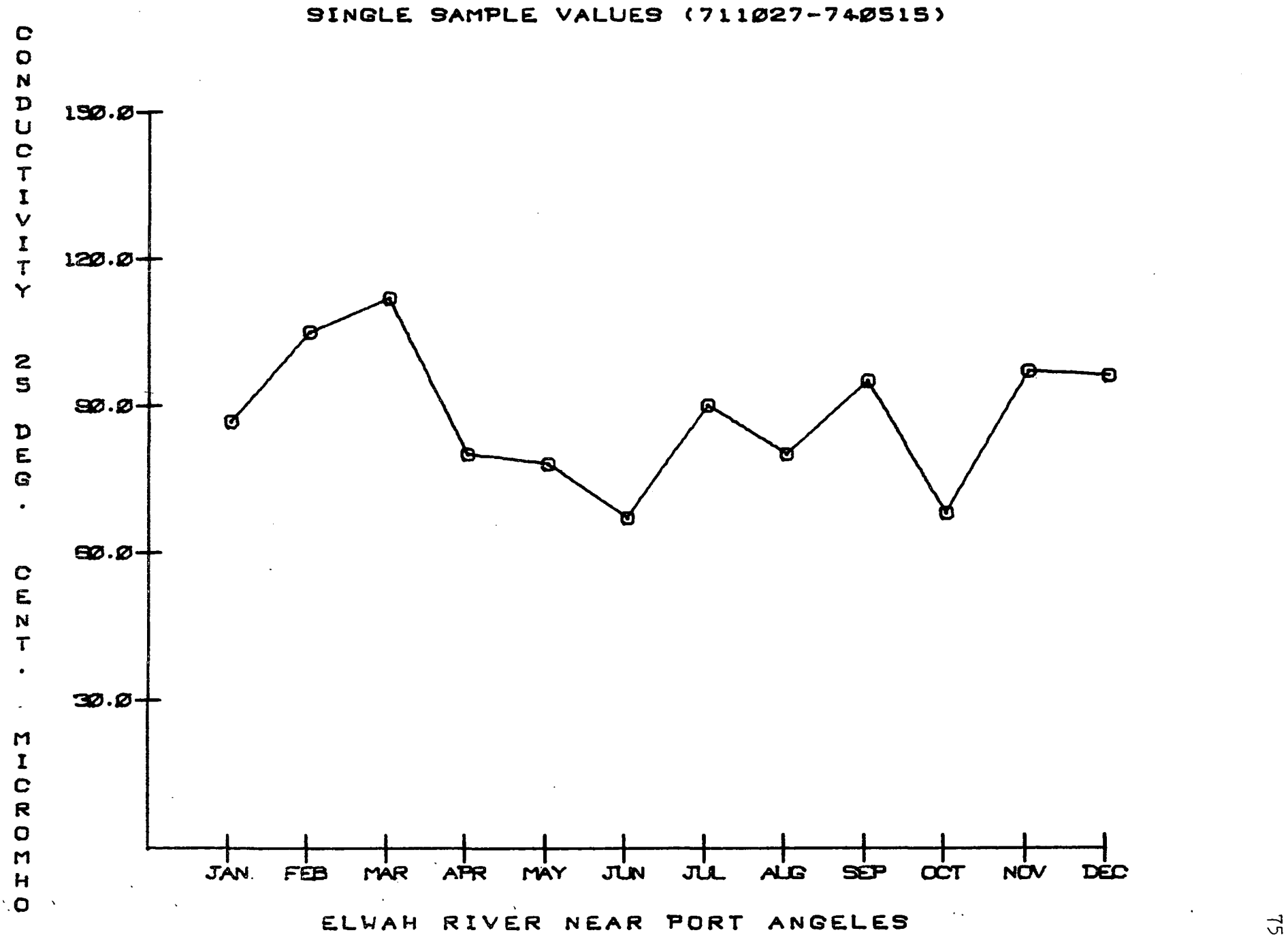


ELWAH RIVER NEAR PORT ANGELES

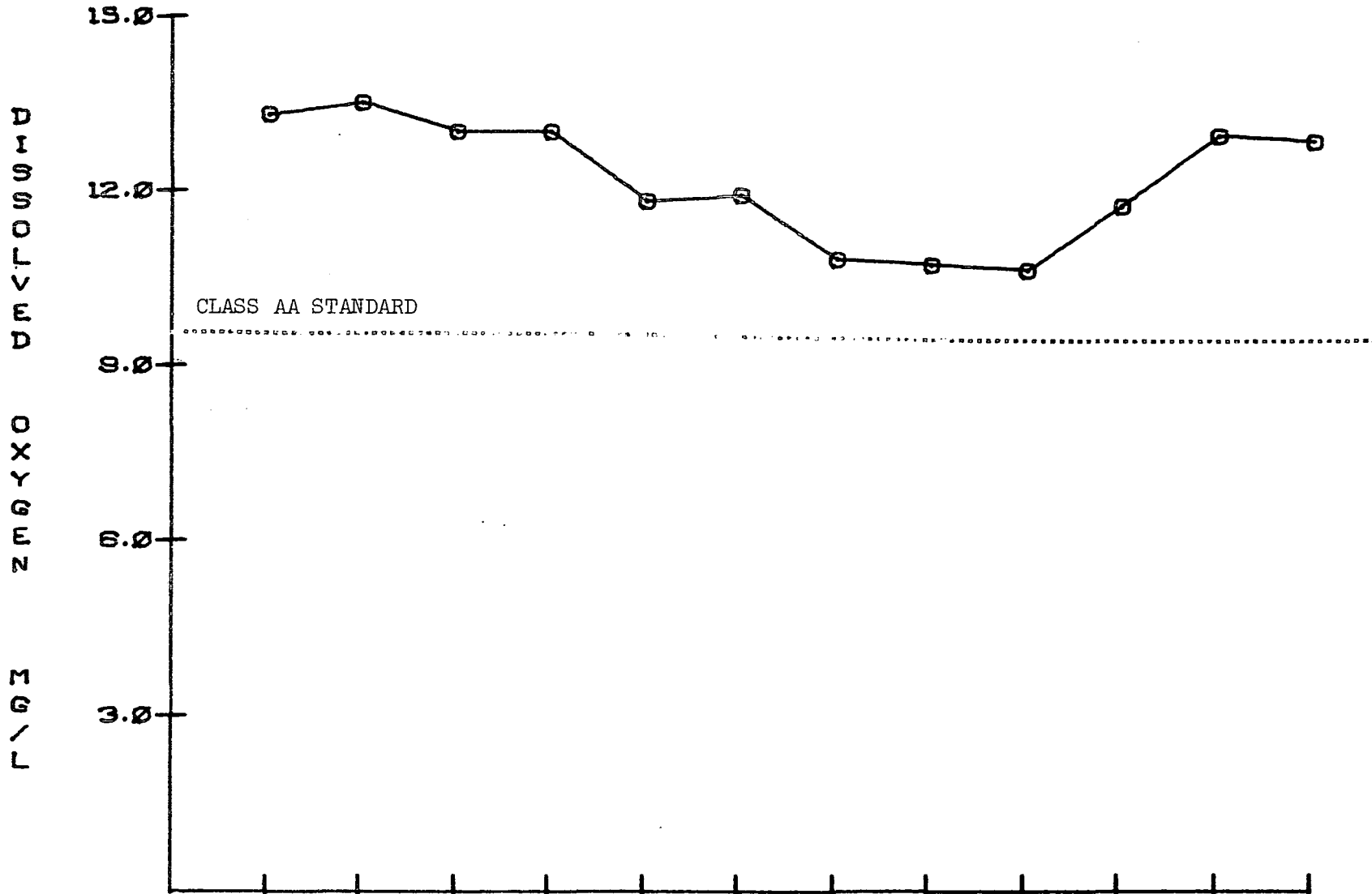
SINGLE SAMPLE VALUES (711027-740515)



ELWHA RIVER NEAR PORT ANGELES

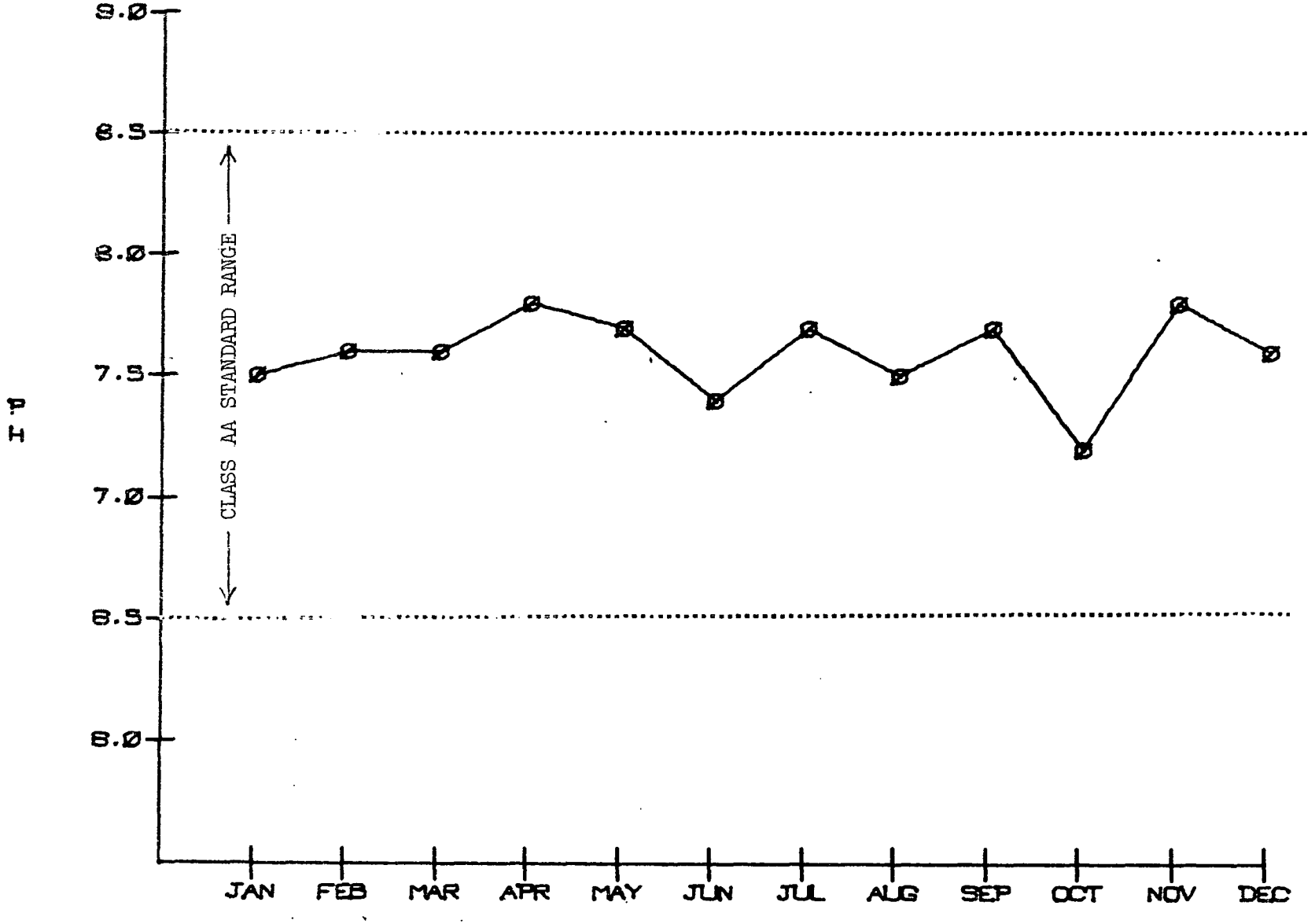

SINGLE SAMPLE VALUES (711027-740515)
CONDUCTIVITY 25 DEG. CENT. MICROMHO
150.0
120.0
90.0
60.0
30.0
JAN.
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
ELWAH RIVER NEAR PORT ANGELES

SINGLE SAMPLE VALUES (711027-740515)



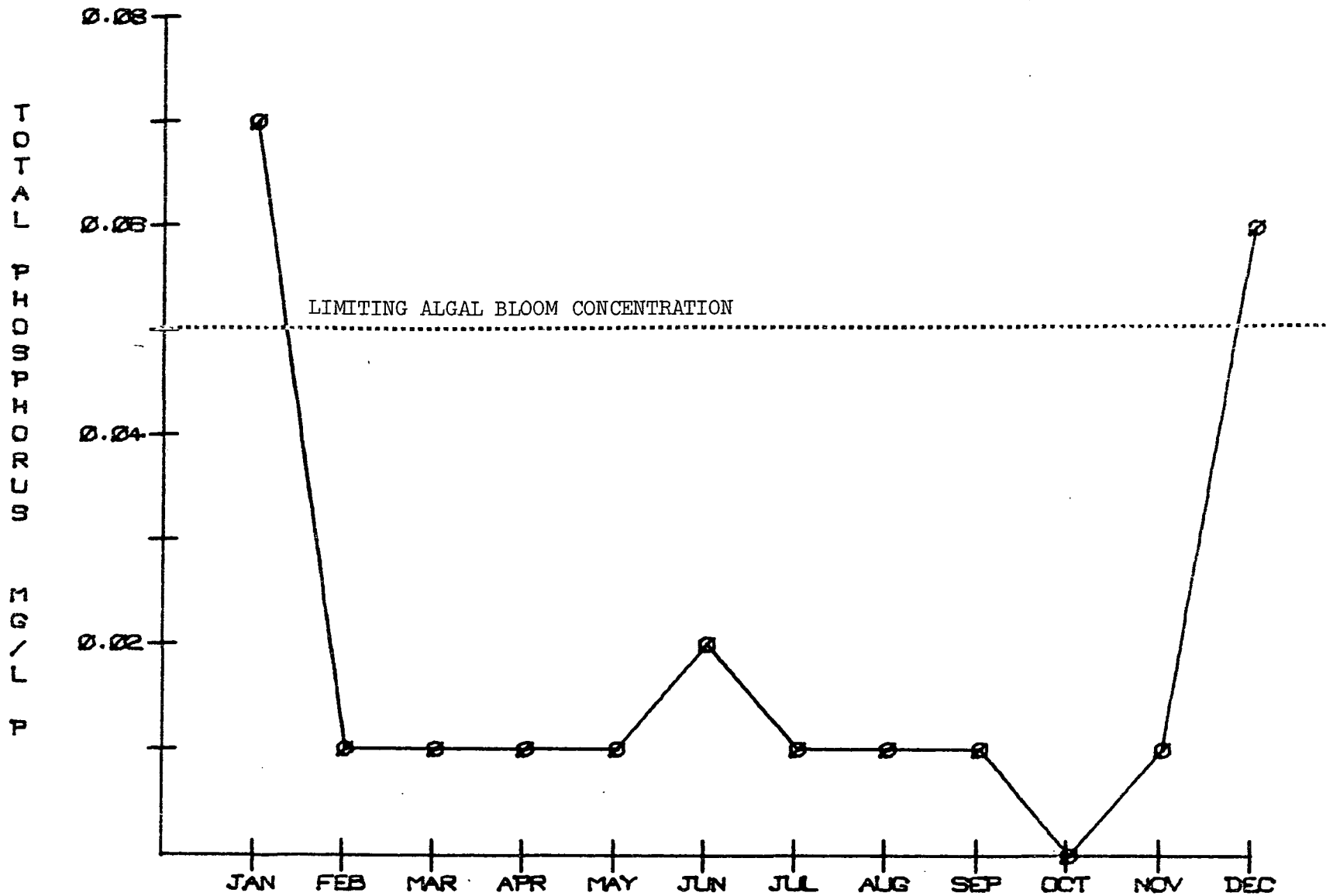
ELWAH RIVER NEAR PORT ANGELES

SINGLE SAMPLE VALUES (711027-740515)



ELWHA RIVER NEAR PORT ANGELES

SINGLE SAMPLE VALUES (711027-740515)



ELWHA RIVER NEAR PORT ANGELES

Duwamish-Green River Basin

DUWAMISH-GREEN RIVER BASIN
BASIN DESCRIPTION

1. Drainage Area - 399 sq. m.

2. Average Flow - (At Auburn) mean = 1 306 cfs
min. = 662 cfs
max. = 1 875 cfs

3. Waste Sources - 22

4. Major Diversions - Domestic - 30 cfs

Industrial - 55 cfs

Irrigation - 4 500 acre-feet

5. Surface Water Rights - Municipal - 118.28 cfs

Irrigation - 58.85 cfs

Individual & Community Domestic - 11.24 cfs

Industrial & Commercial - 11.15 cfs

Fish. Propogation - 39 cfs

Stock - 1.25 cfs

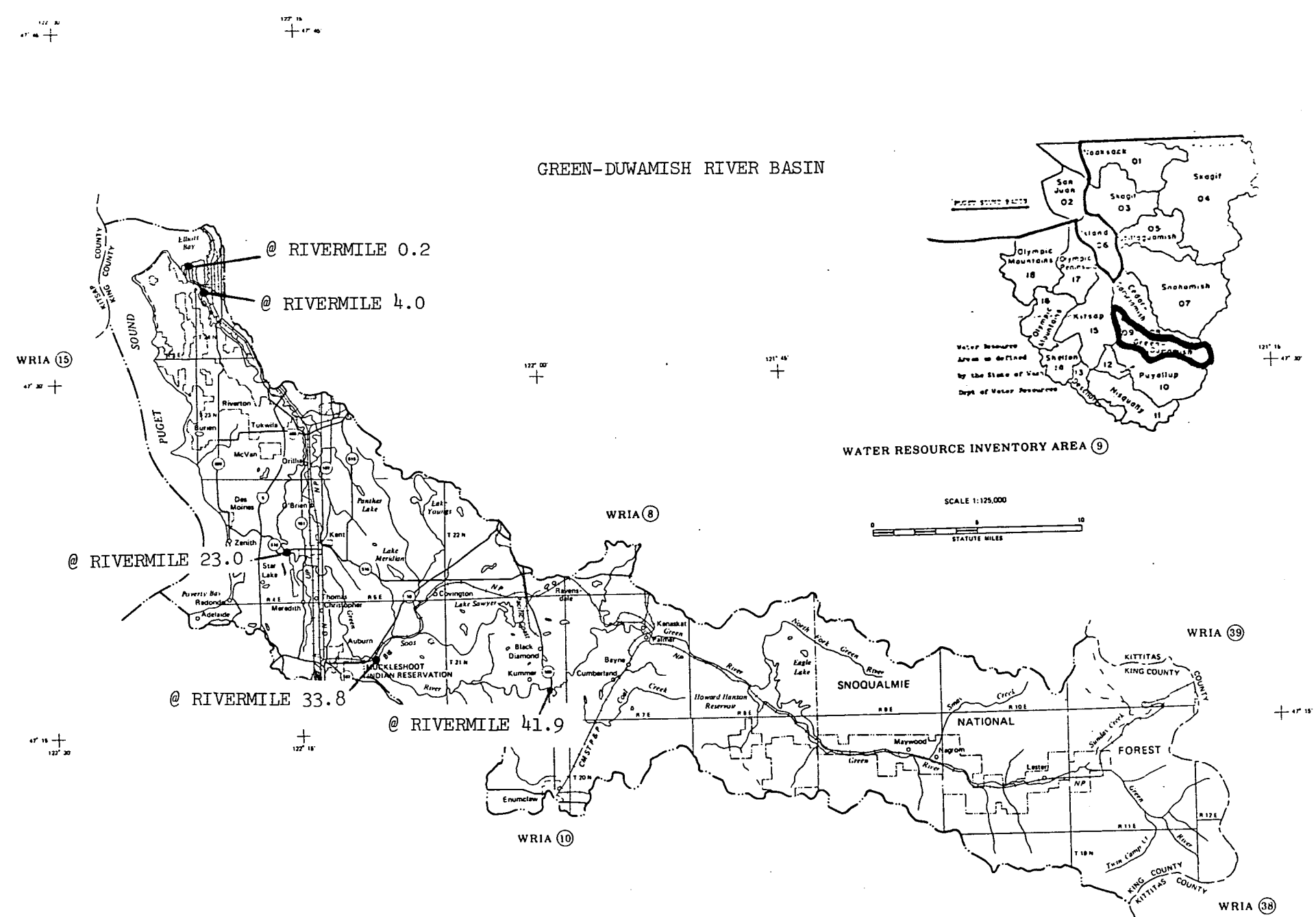
Total 244.47 cfs

6. Surface Water Rights - 42 acre-feet

7. Projected Population -

1980	2000	2020
1,454,800	2,270,000	3,619,900

GREEN-DUWAMISH RIVER BASIN



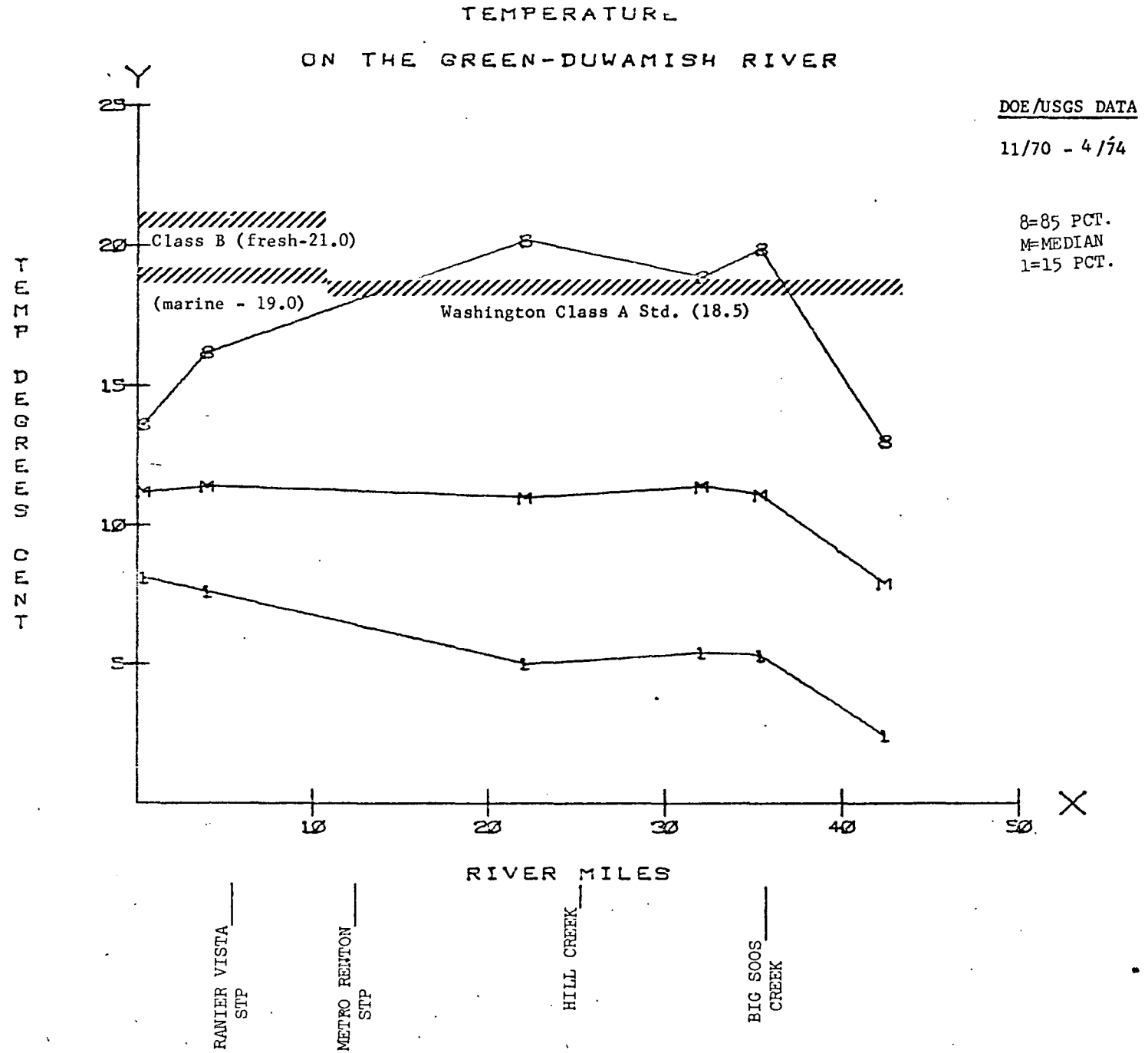
DUWAMISH - GREEN RIVER BASIN
REPORTED PROBLEMS

1. Total Nitrate and total Phosphorus values generally exceed the algal bloom potential concentration as the river approaches it's mouth throughout the year.

2. Total Coliform concentrations occasionally violate Class B standard from river mile 0 to river mile 12, and generally violate Class A standard from river mile 12 upstream.

3. Temperature values have been known to occasionally exceed the Class A standard on the Green-Duwamish River.

4. Dissolved Oxygen values violate standards periodically from the mouth to approximately river mile 15 on the Green-Duwamish river.


TEMPERATURE
ON THE GREEN-DUWAMISH RIVER
DOE/USGS DATA
11/70 - 4/74
8=85 PCT.
M=MEDIAN
1=15 PCT.
Class B (fresh-21.0)
(marine - 19.0)
Washington Class A Std. (18.5)
TEMP DEGREES CENT
RIVER MILES
RANIER VISTA STP
METRO RENTON STP
HILL CREEK
BIG SOOS CREEK

TURBIDITY

ON THE GREEN-DUWAMISH RIVER

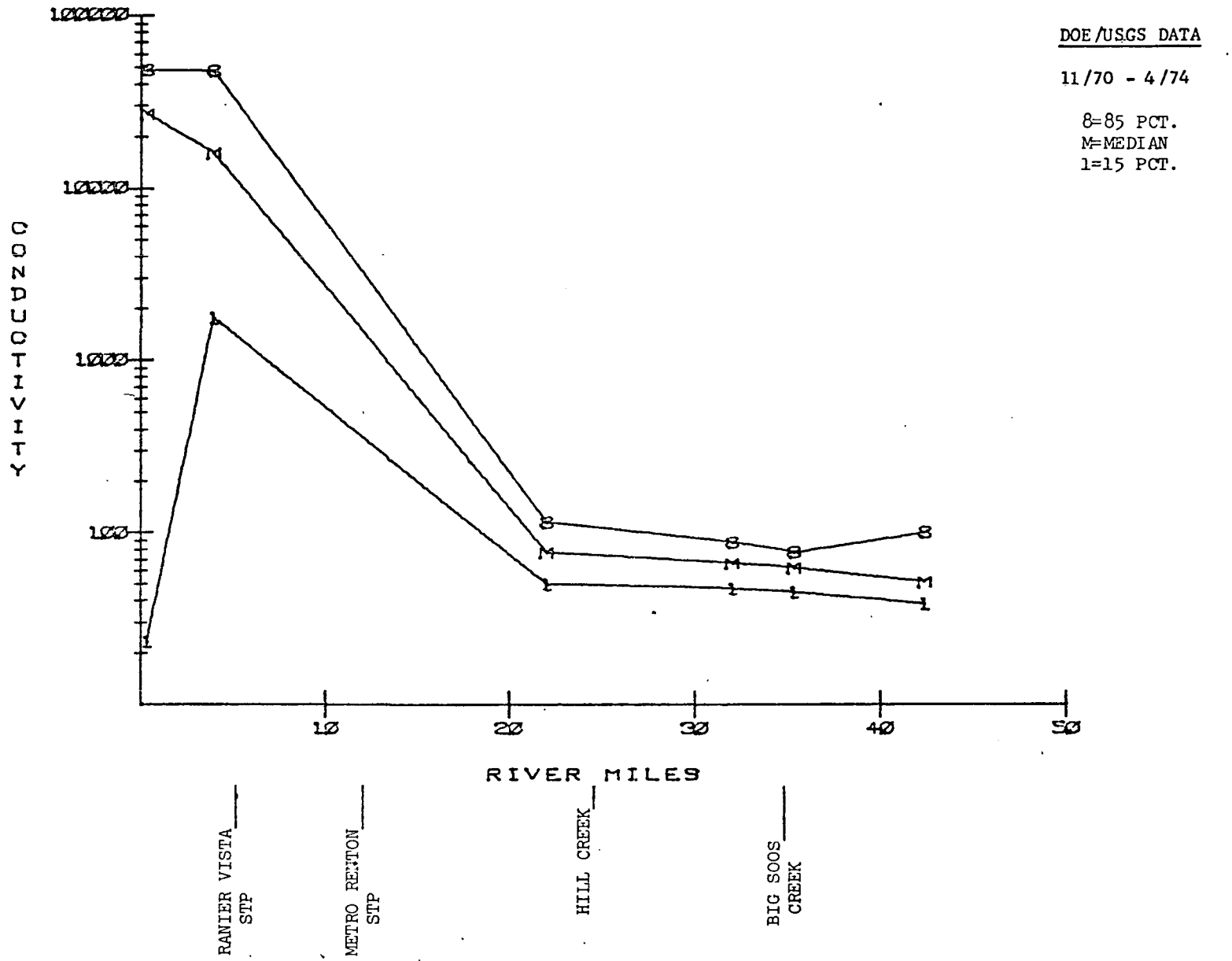
DOE/USGS DATA

11/70 - 4/74

8=85 PCT.
M=MEDIAN
1=15 PCT.

CONDUCTIVITY

ON THE GREEN-DUWAMISH RIVER



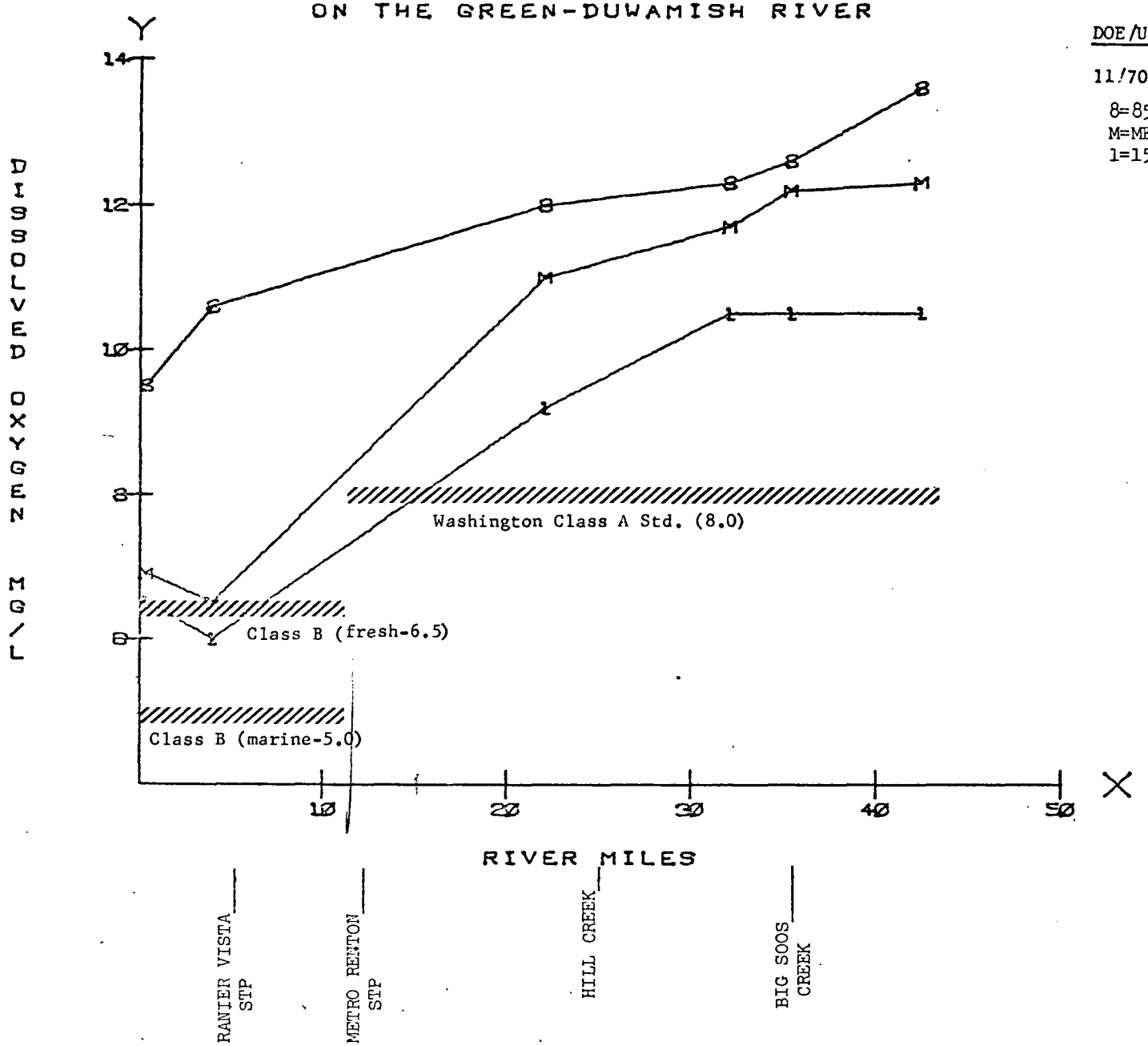
DOE/USGS DATA

11/70 - 4/74

8=85 PCT.
M=MEDIAN
1=15 PCT.

DISSOLVED OXYGEN

ON THE GREEN-DUWAMISH RIVER



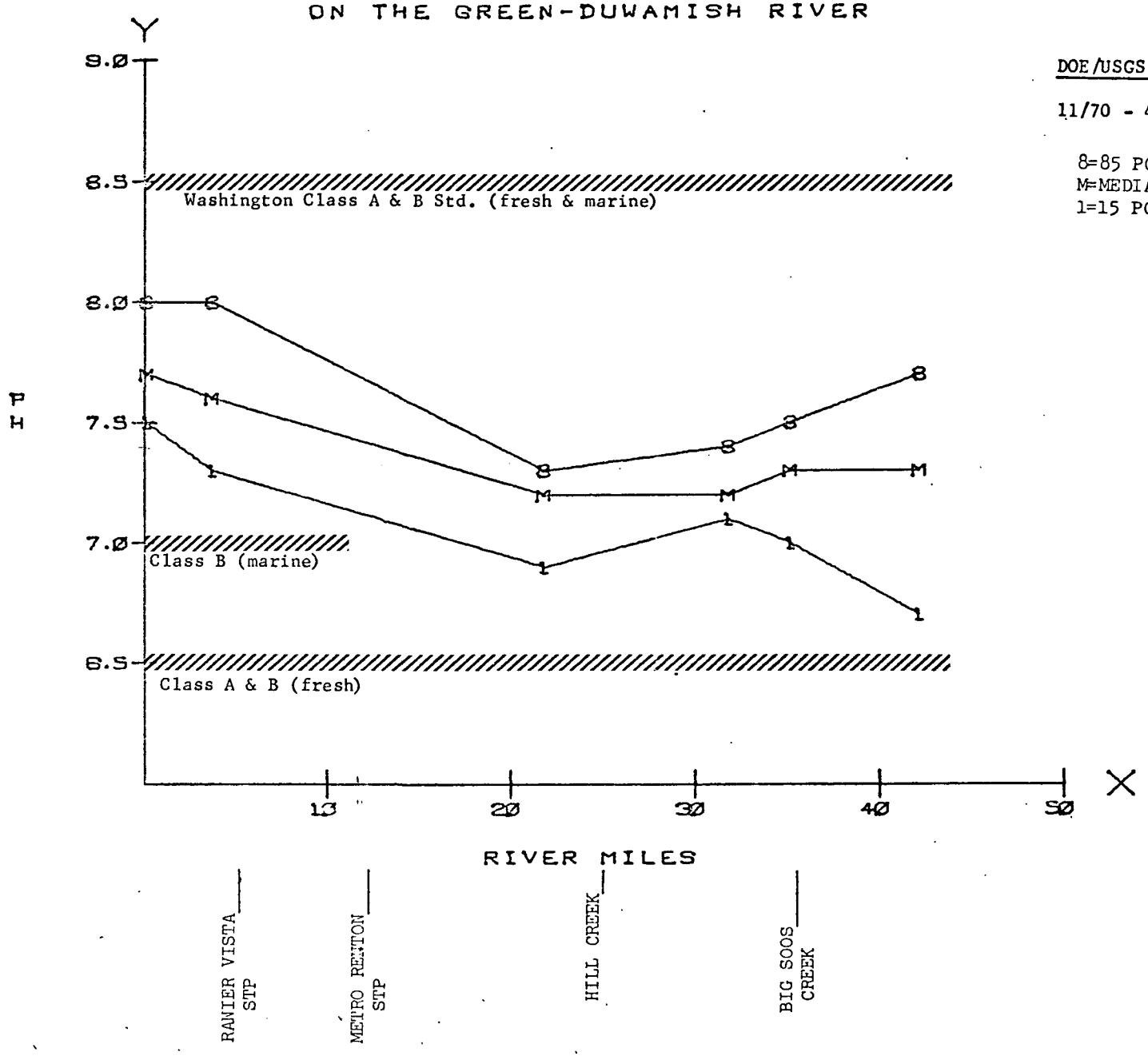
DOE/USGS DATA

11/70 - 4/74

8=85 PCT.
M=MEDIAN
1=15 PCT.

PH

ON THE GREEN-DUWAMISH RIVER



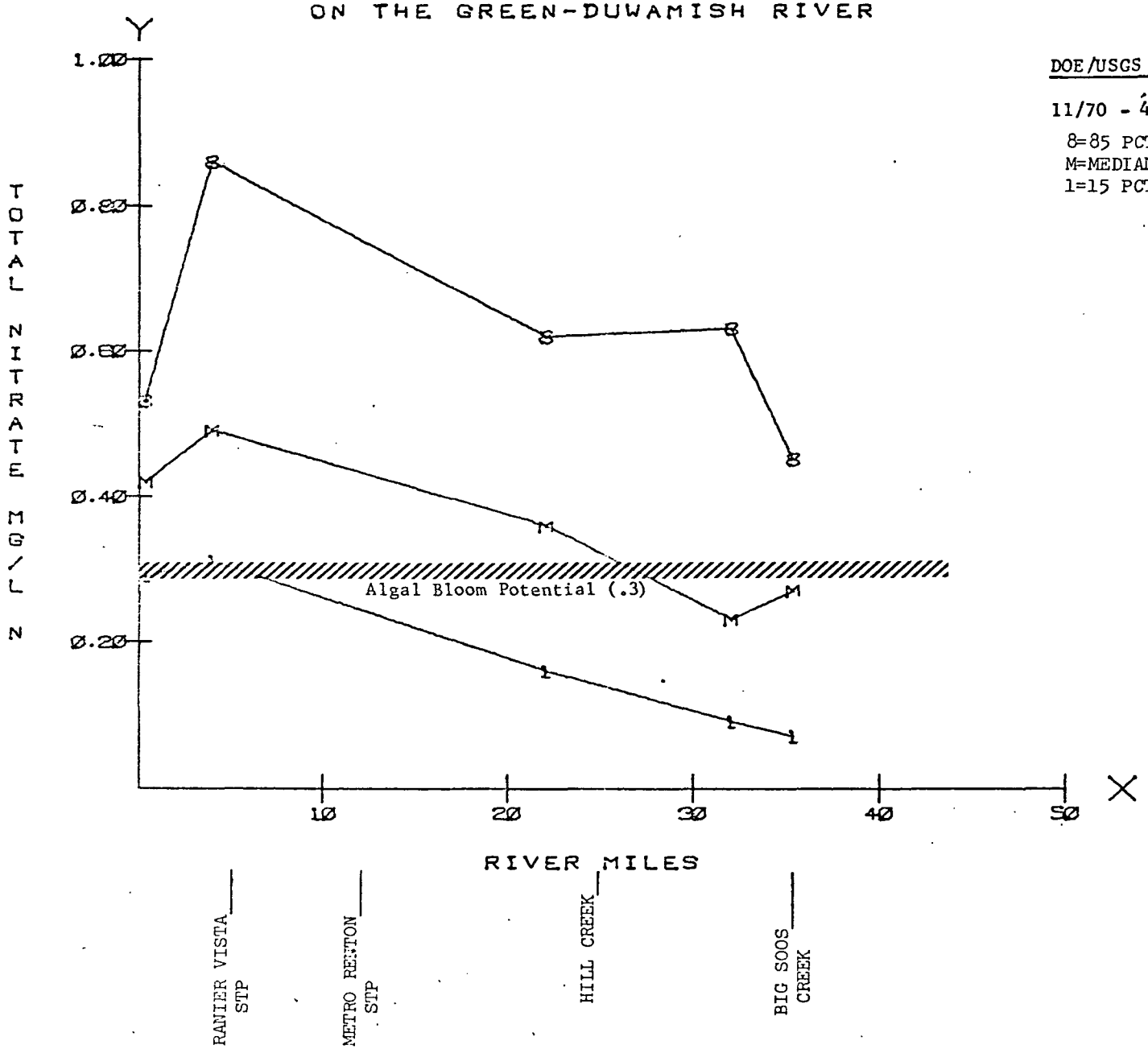
DOE/USGS DATA

11/70 - 4/74

8=85 PCT.
M=MEDIAN
1=15 PCT.

TOTAL NITRATE

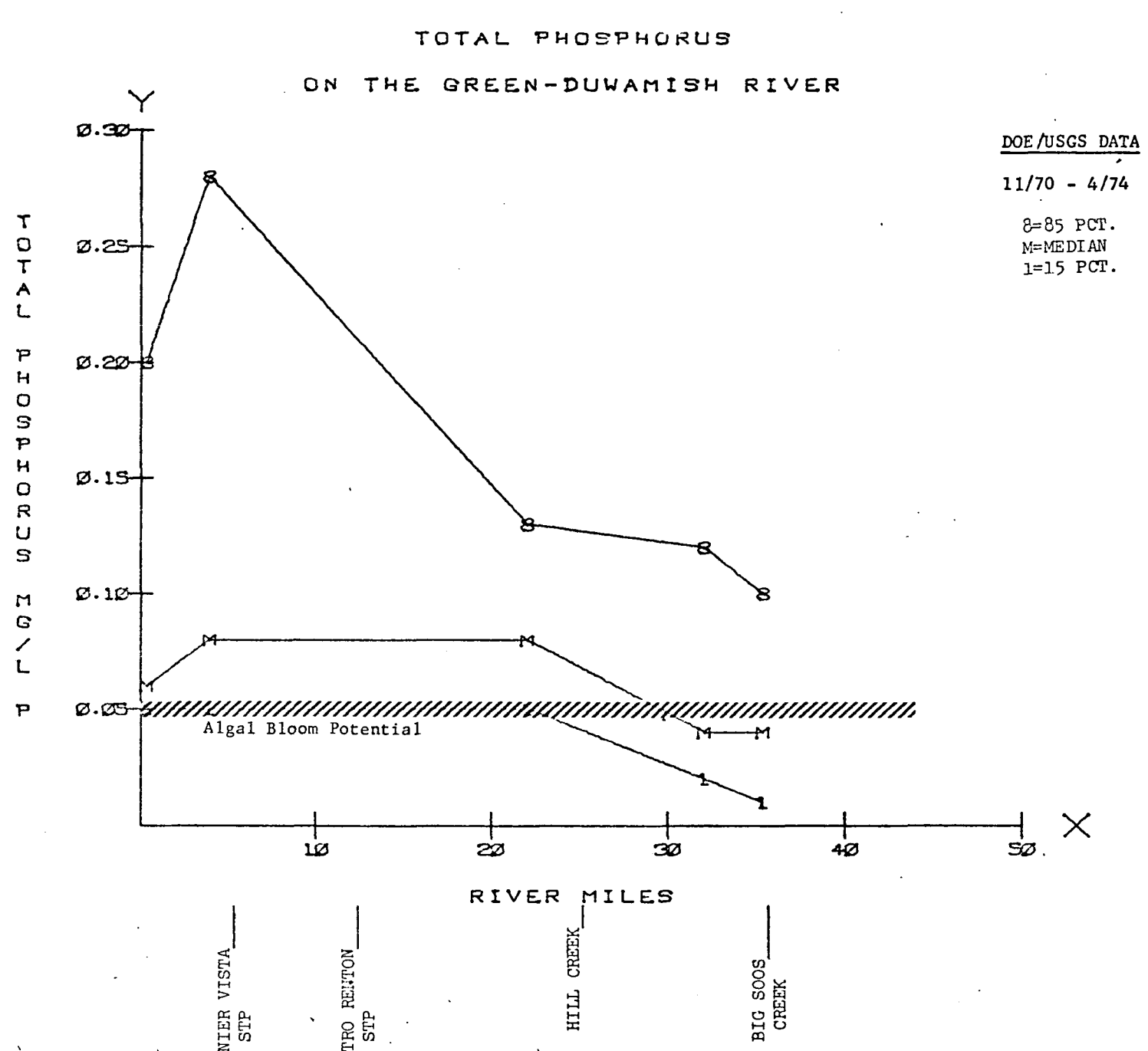
ON THE GREEN-DUWAMISH RIVER



DOE/USGS DATA

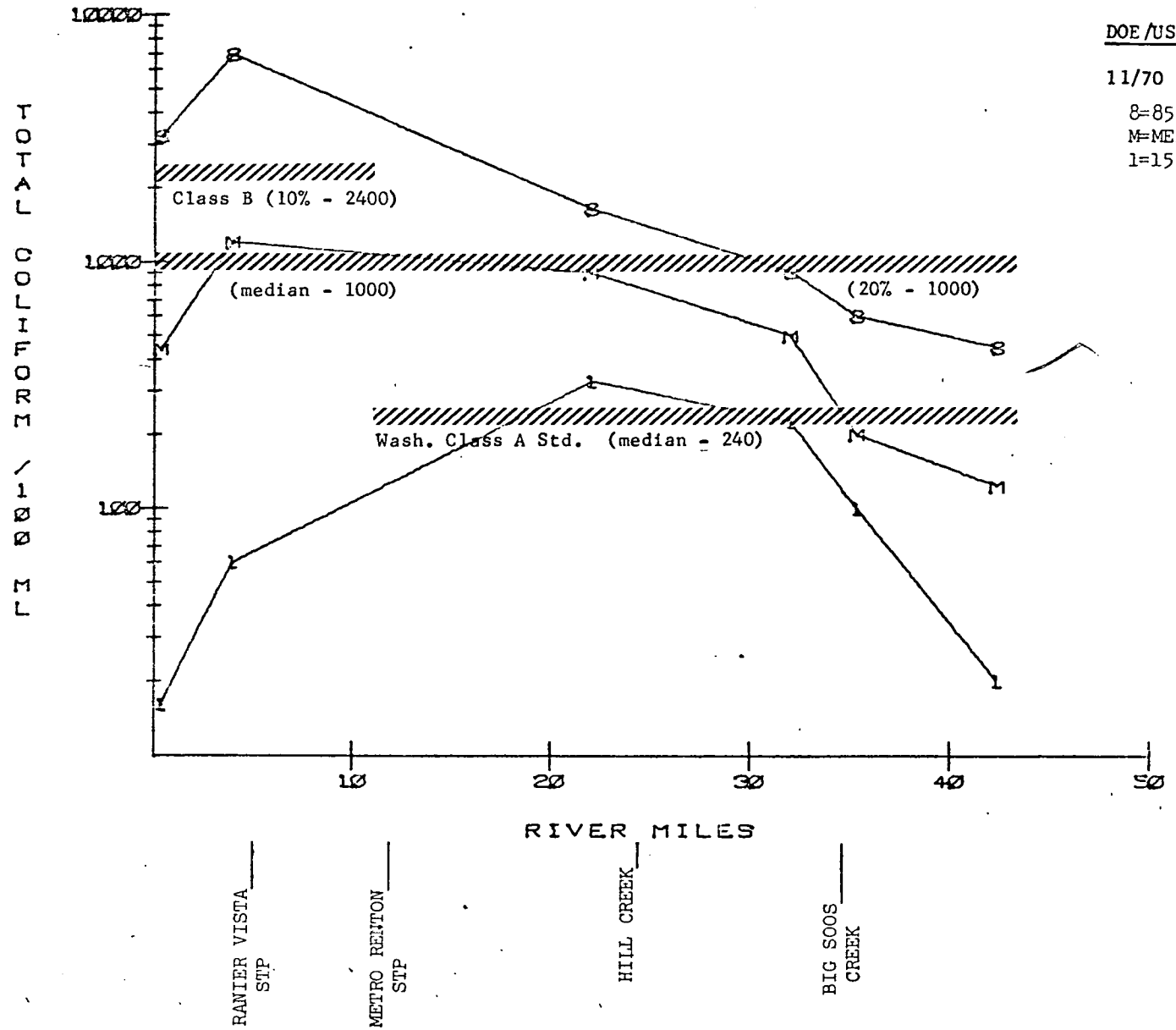
11/70 - 4/74

8=85 PCT.
M=MEDIAN
1=15 PCT.


TOTAL PHOSPHORUS
ON THE GREEN-DUWAMISH RIVER
DOE/USGS DATA
11/70 - 4/74
8=85 PCT.
M=MEDIAN
1=15 PCT.
TOTAL PHOSPHORUS MG/L P
Y
X
Ø.30
Ø.25
Ø.20
Ø.15
Ø.10
Ø.05
Algal Bloom Potential
10
20
30
40
50
RIVER MILES
RANIER VISTA STP
METRO RENTON STP
HILL CREEK
BIG SOOS CREEK

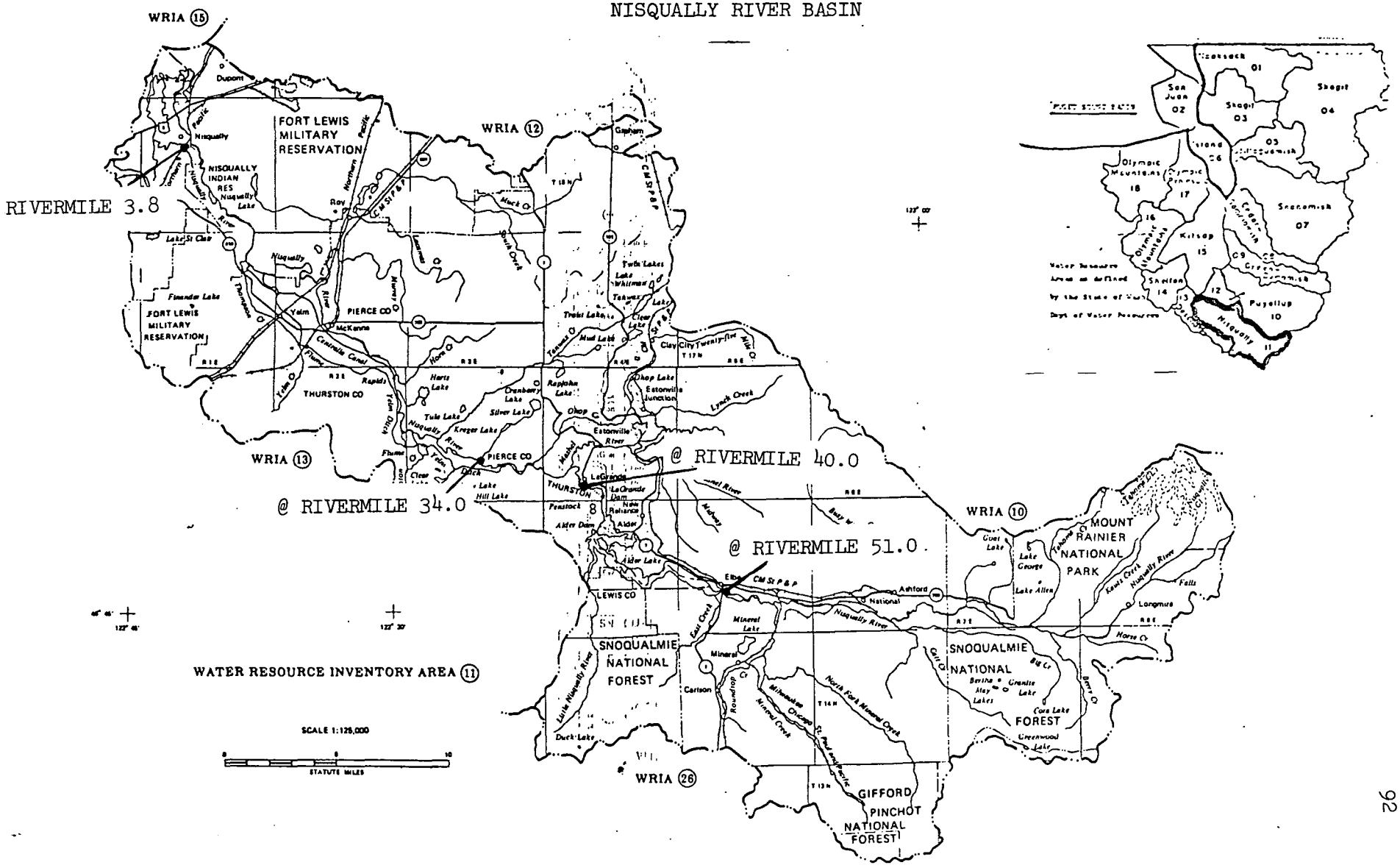
TOTAL COLIFORM

ON THE GREEN-DUWAMISH RIVER



NISQUALLY RIVER BASIN

NISQUALLY RIVER BASIN



NISQUALLY RIVER BASIN
BASIN DESCRIPTION

1. Drainage Area - 292 sq. m.

2. Average Flow - (at La Grande) mean = 1 385 cfs
min. = 803 cfs
max. = 2 092 cfs

3. Waste Sources - 6

4. Major Diversions - Domestic - 12 cfs

Industrial - 10 cfs

Hydropower - 5 650 cfs

Irrigation - 8 000 acre-feet

5. Surface Water Rights - Municipal - 25 cfs

Irrigation - 32.13 cfs

Individual & Community Domestic - 14.13 cfs

Fish. Propogation - 13.16 cfs

Stock - 1.76 cfs

Total - 5,922.85 cfs

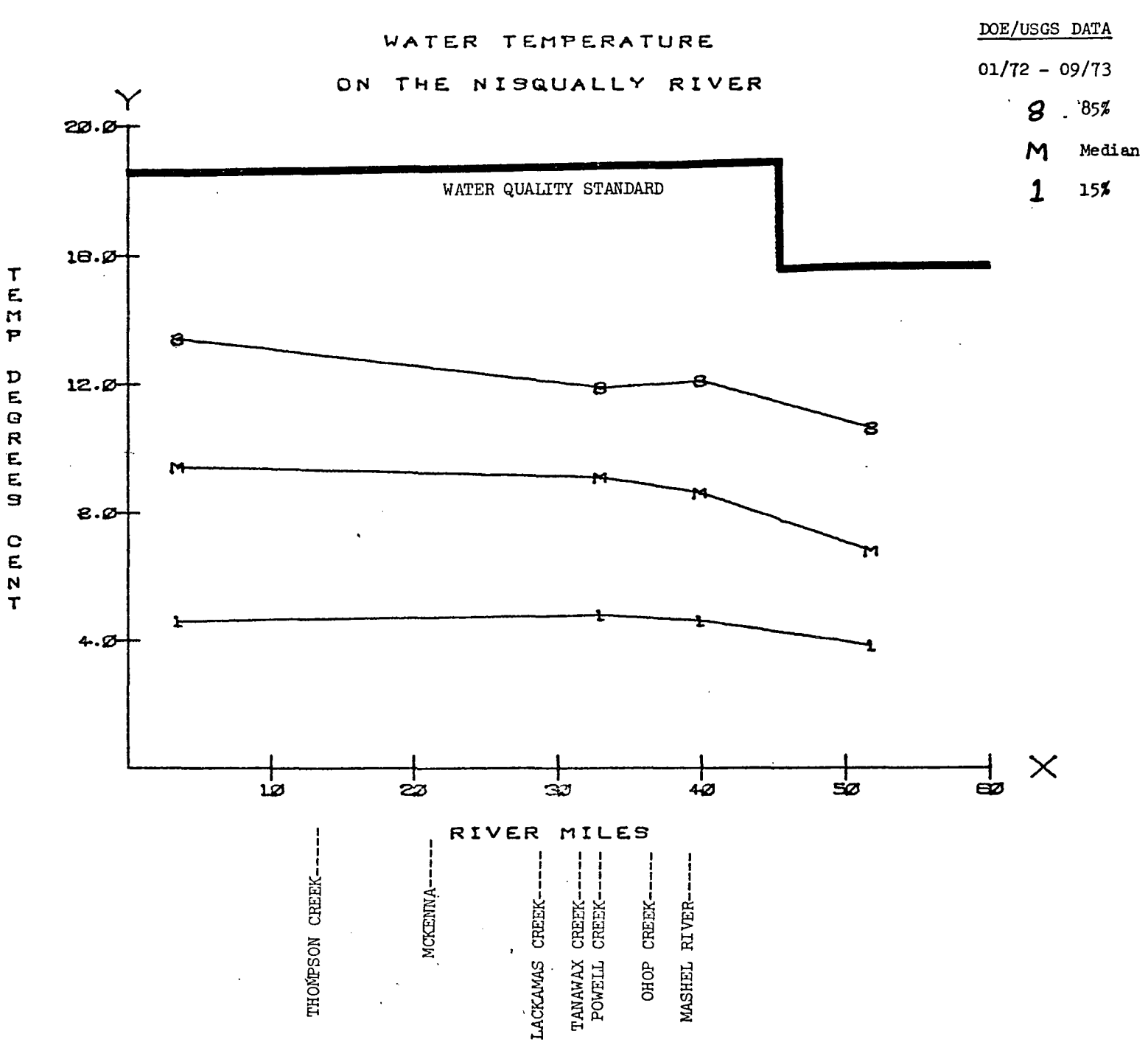
6. Reservoir Storage Rights - 210,060 acre-feet

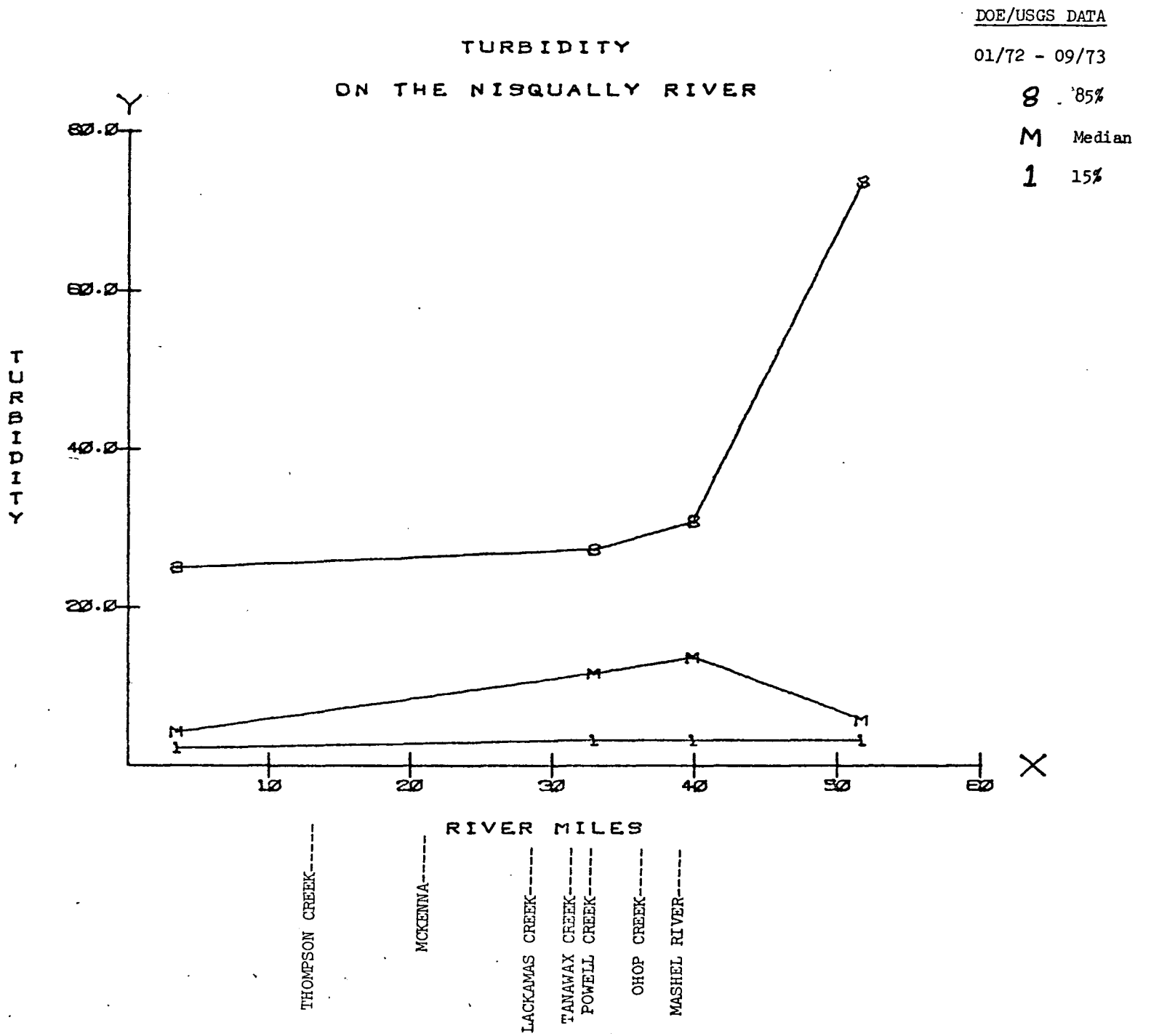
7. Projected Population - included in Deschutes Basin Estimate

NISQUALLY RIVER BASIN
REPORTED PROBLEMS

1. Total Coliform values generally violate current water quality standards from river mile 0 to mile 30.

2. Total Phosphorus occasionally exceeds the limiting algal bloom concentration throughout the river.


WATER TEMPERATURE
ON THE NISQUALLY RIVER
DOE/USGS DATA
01/72 - 09/73
8 85%
M Median
1 15%
WATER QUALITY STANDARD
TEMP DEGREES CENT
Y
X
20.0
16.0
12.0
8.0
4.0
10
20
30
40
50
60
RIVER MILES
THOMPSON CREEK
MCKENNA
LACKAMAS CREEK
TANAWAX CREEK
POWELL CREEK
OHOP CREEK
MASHEL RIVER


TURBIDITY
ON THE NISQUALLY RIVER
DOE/USGS DATA
01/72 - 09/73
8 - 85%
M Median
1 15%
Y
80.0
60.0
40.0
20.0
TURBIDITY
10
20
30
40
50
60
X
RIVER MILES
THOMPSON CREEK
MCKENNA
LACKAMAS CREEK
TANAWAX CREEK
POWELL CREEK
OHOP CREEK
MASHEL RIVER

CONDUCTIVITY

ON THE NISQUALLY RIVER

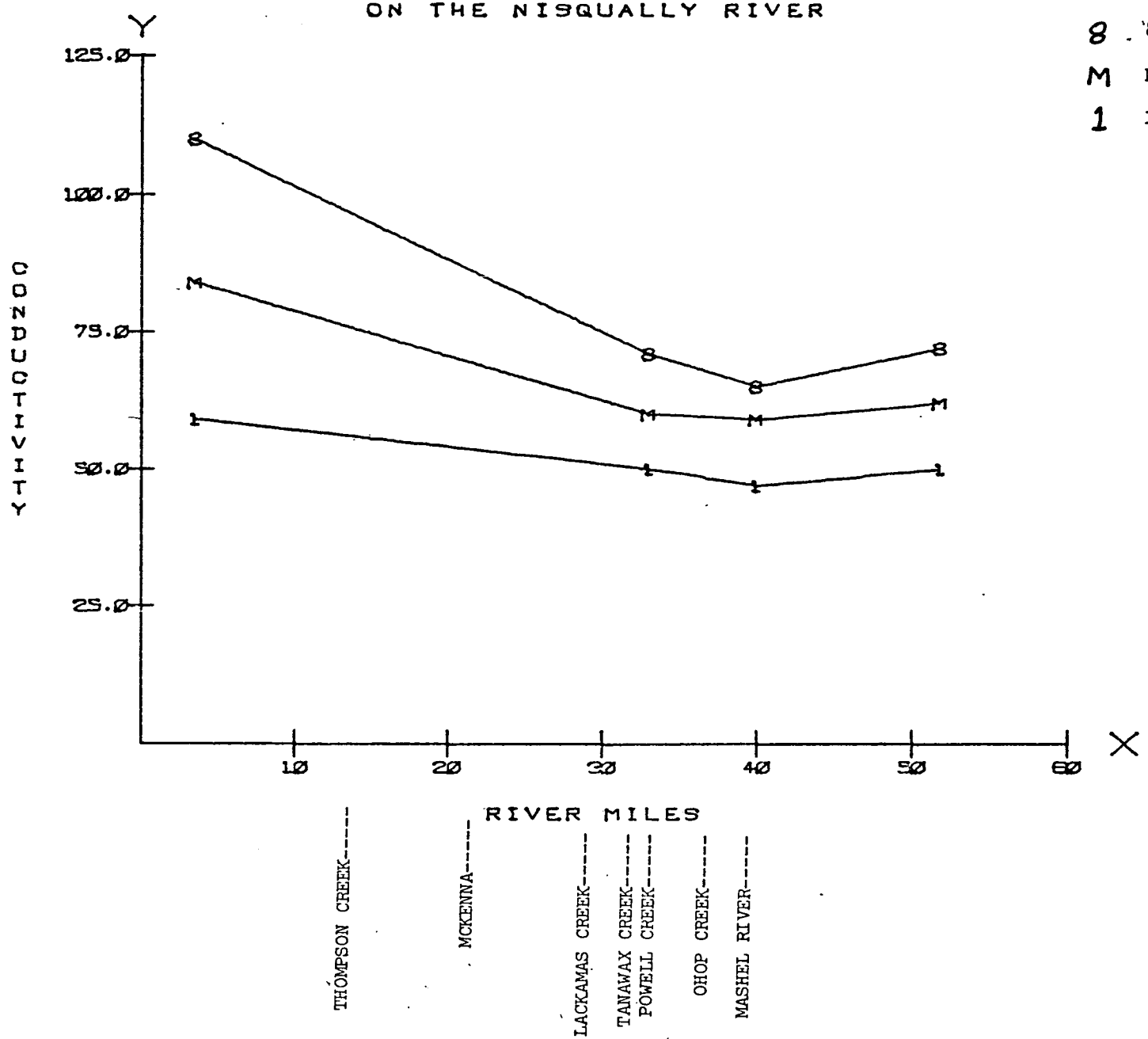
DOE/USGS DATA

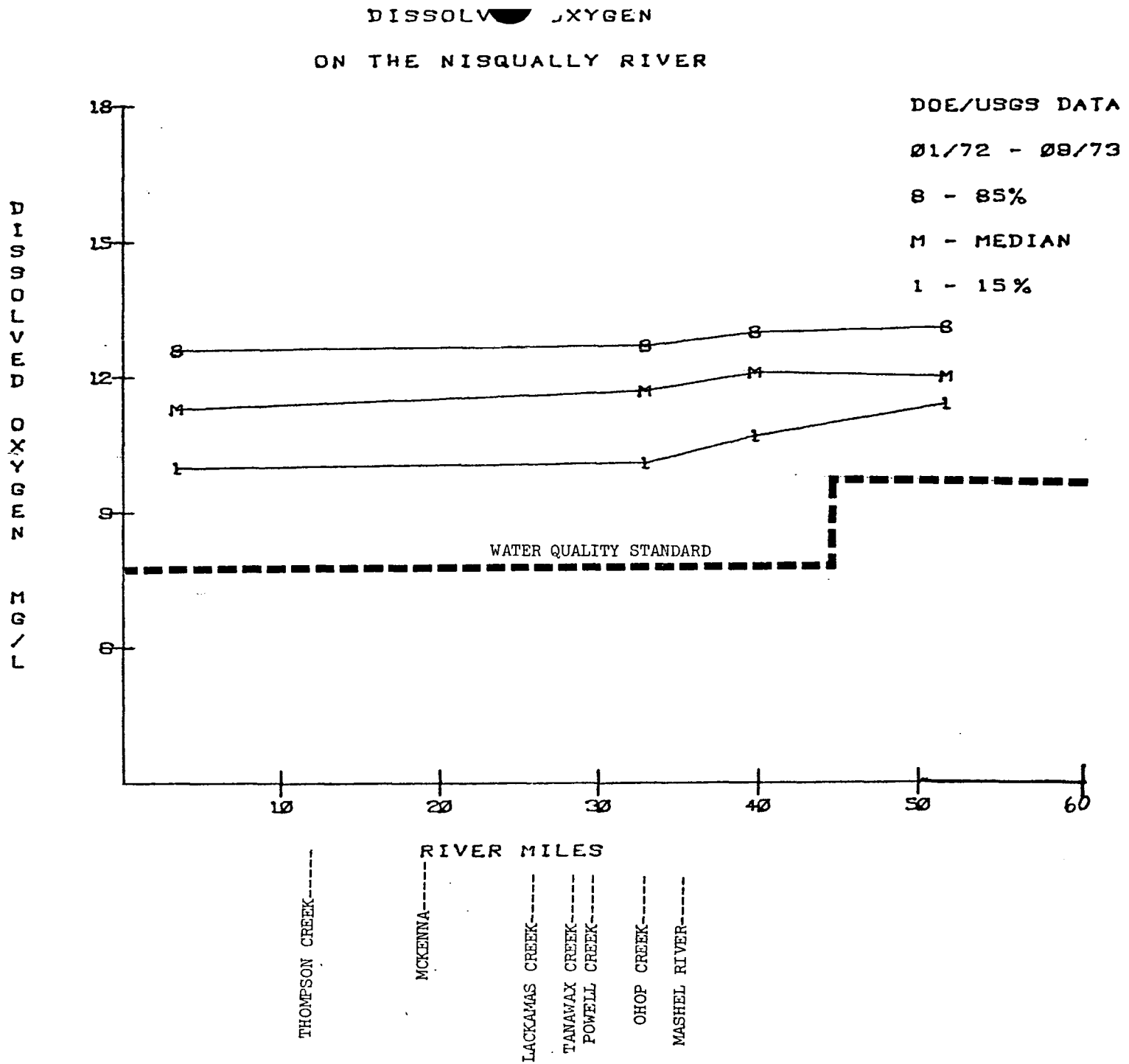
01/72 - 09/73

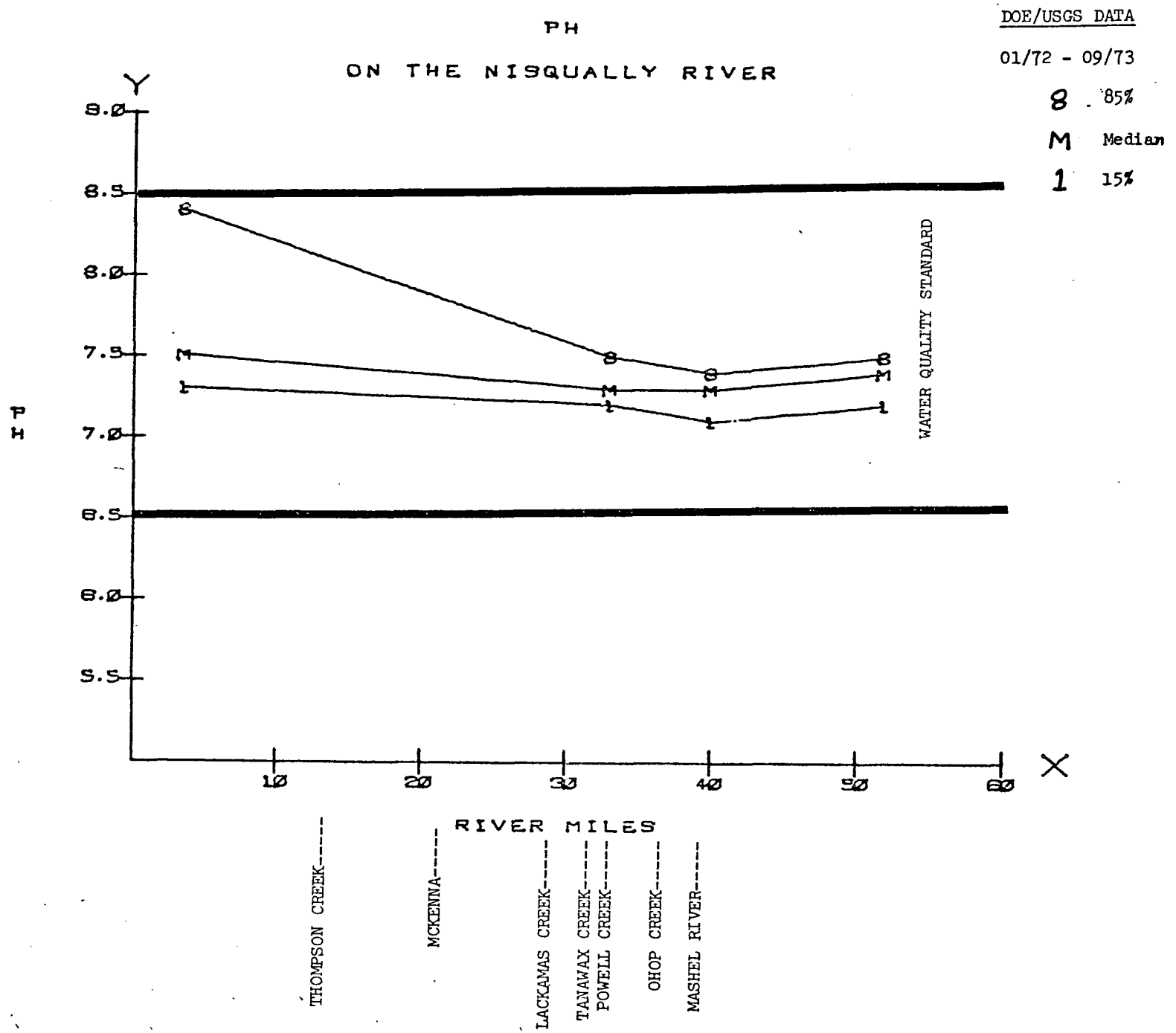
8 - 85%

M Median

1 15%




DISSOLVED OXYGEN
ON THE NISQUALLY RIVER
DOE/USGS DATA
Ø1/72 - Ø8/73
8 - 85%
M - MEDIAN
1 - 15%
DISSOLVED OXYGEN MG/L
18
15
12
9
6
8
M
1
WATER QUALITY STANDARD
10
20
30
40
50
60
RIVER MILES
THOMPSON CREEK
MCKENNA
LACKAMAS CREEK
TANAWAX CREEK
POWELL CREEK
OHOP CREEK
MASHEL RIVER


PH
ON THE NISQUALLY RIVER
DOE/USGS DATA
01/72 - 09/73
8 - 85%
M Median
1 15%
Y
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
PH
WATER QUALITY STANDARD
10
20
30
40
50
60
X
RIVER MILES
THOMPSON CREEK
MCKENNA
LACKAMAS CREEK
TANAWAX CREEK
POWELL CREEK
OHOP CREEK
MASHEL RIVER

DOE/USGS DATA

01/72 - 09/73

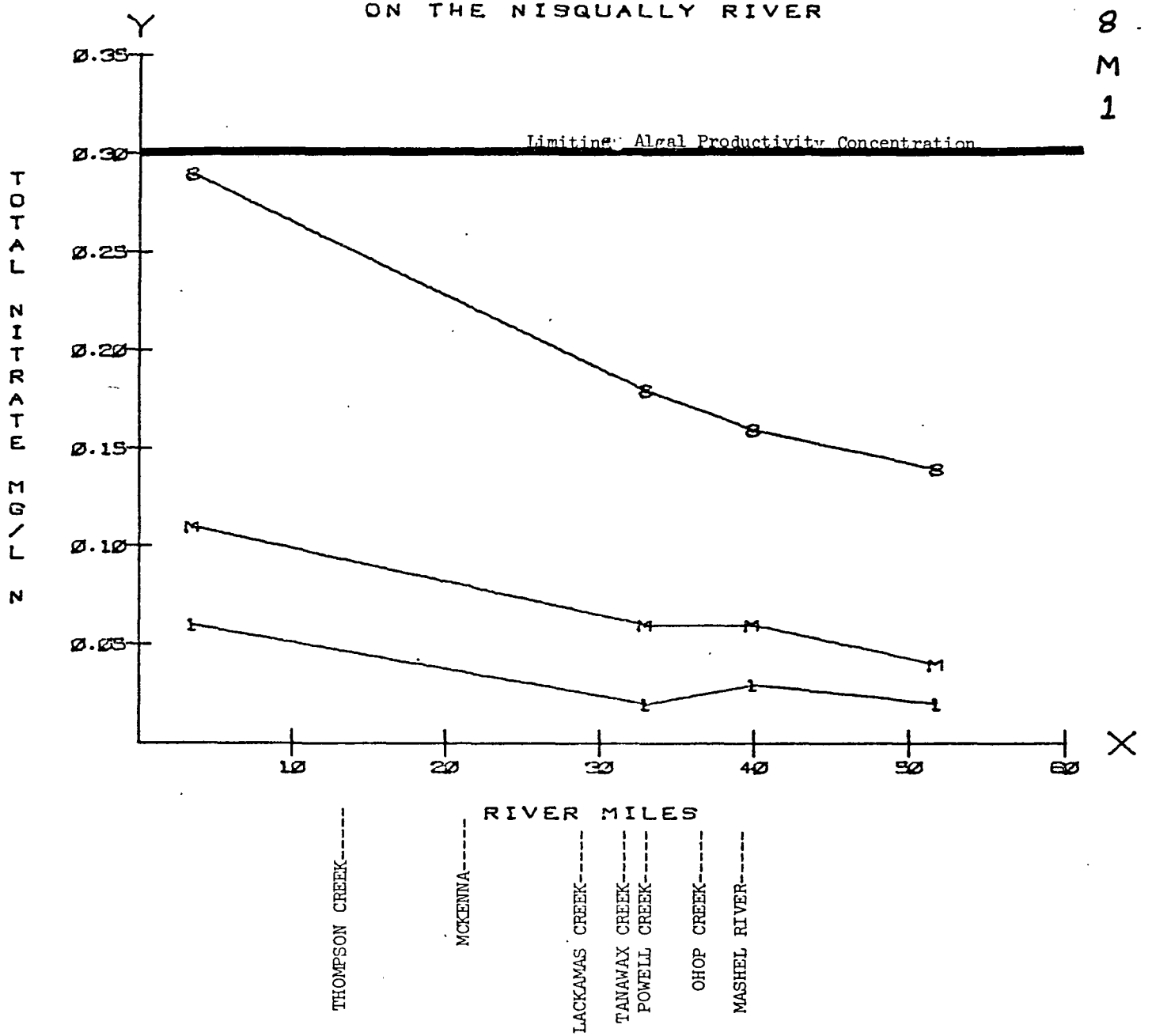
8 85%

M Median

1 15%

TOTAL NITRATE

ON THE NISQUALLY RIVER



DOE/USGS DATA

01/72 - 09/73

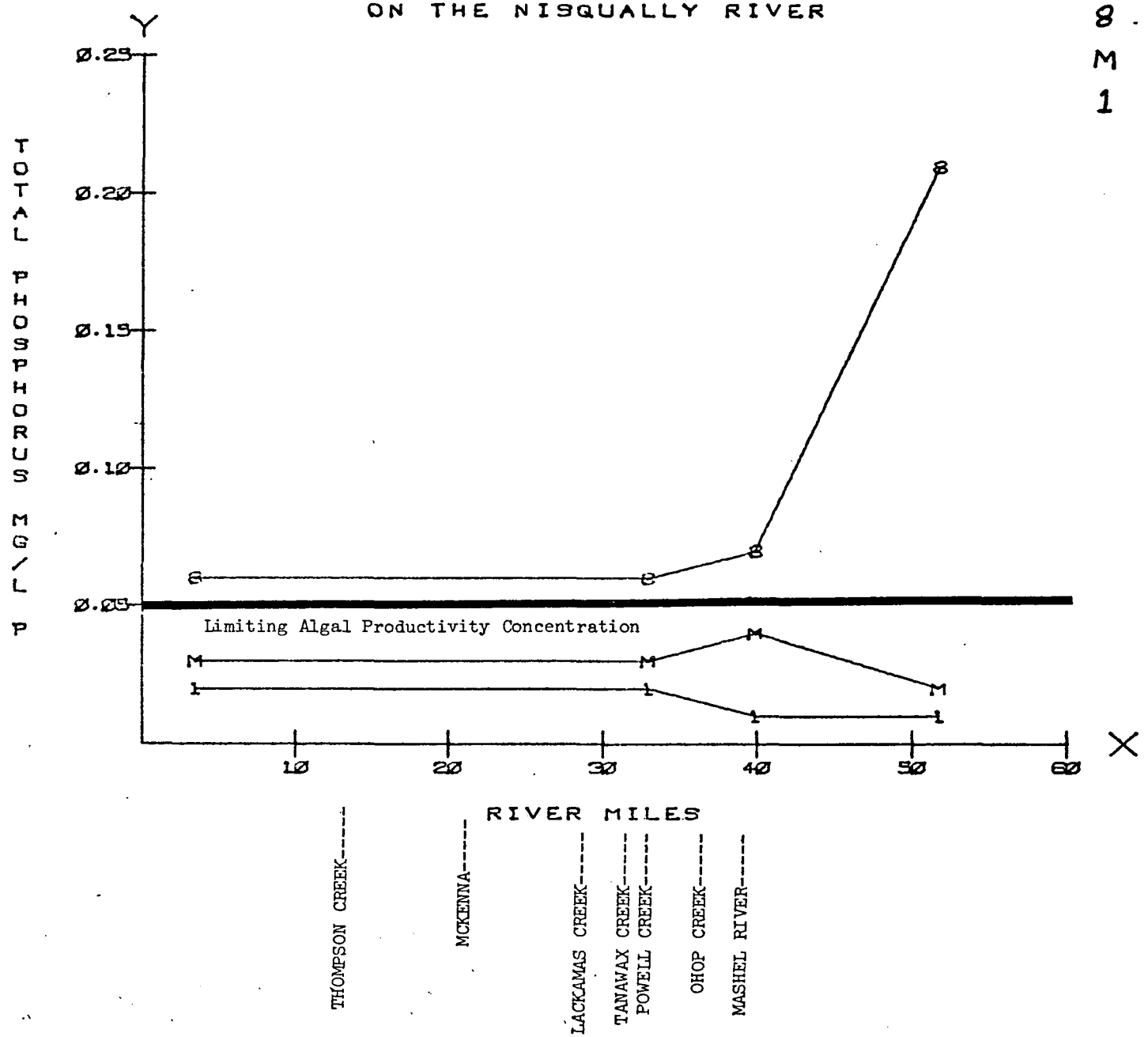
8 . 85%

M Median

1 15%

TOTAL PHOSPHORUS

ON THE NISQUALLY RIVER



TOTAL COLIFORM
ON THE NISQUALLY RIVER

DOE/USGS DATA

01/72 - 09/73

8 - 85%

M - Median

1 - 15%

NOOKSACK RIVER BASIN

NOOKSACK RIVER BASIN
BASIN DESCRIPTION

1. Drainage Area - 584 sq. m.

2. Average Flow - (at Deming) mean = 3 217 cfs
min. = 2 220 cfs
max. = 4 342 cfs

3. Waste Sources - 9

4. Major Diversions - Domestic - 15 cfs

Industrial- 83 cfs

Hydropower- 125 cfs

Irrigation- 12 500 acre feet

5. Surface Water Rights - Municipal - 308.12 cfs

Irrigation - 119.45 cfs

Individual & Community Domestic - 46.27 cfs

Industrial & Commercial - 39.81 cfs

Fish. Propogation - 19.57 cfs

Stock - 3.24 cfs

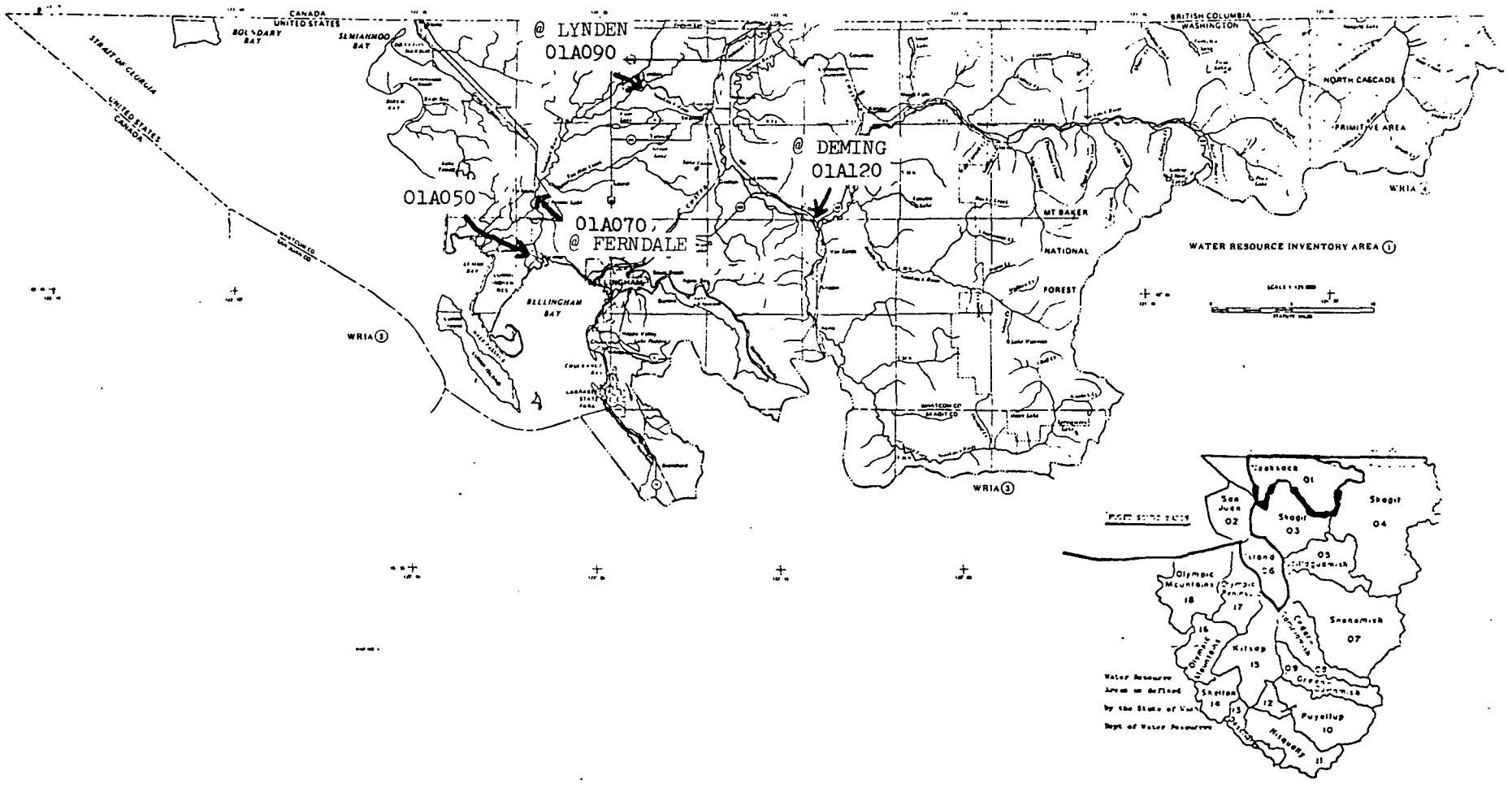
Total - 644.17 cfs

6. Reservoir Storage Rights - 5 671 acre-feet

7. Projected Population -

1980	2000	2020
91,600	123,500	168,700

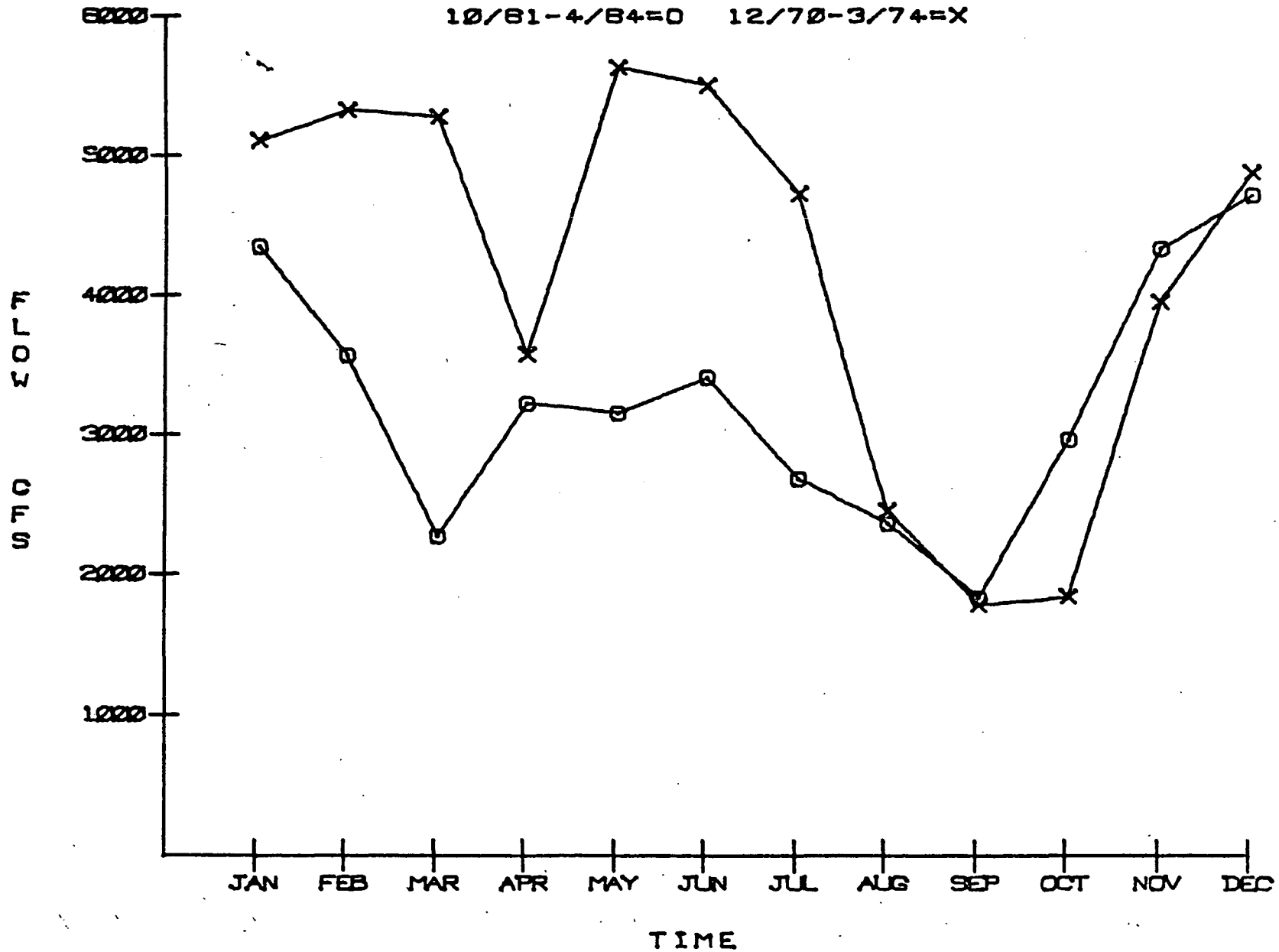
NOOKSACK RIVER BASIN



NOOKSACK RIVER BASIN
REPORTED PROBLEMS

1. Total Nitrate and total Phosphorus values approach, and at points exceed, the algal bloom potential concentration from river mile 0 through 30.

2. Total Coliform values occasionally violate the Washington state Class A standard throughout river miles 0 to 30, with the highest frequency of violation near the mouth.


NOOKSACK RIVER AT LYNDEN
U.S.G.S. DATA MEAN VALUES
10/81-4/84=O 12/70-3/74=X
6000
5000
4000
3000
2000
1000
FLOW CFS
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
TIME

DOE/ℓ S DATA

12/70 - 3/74

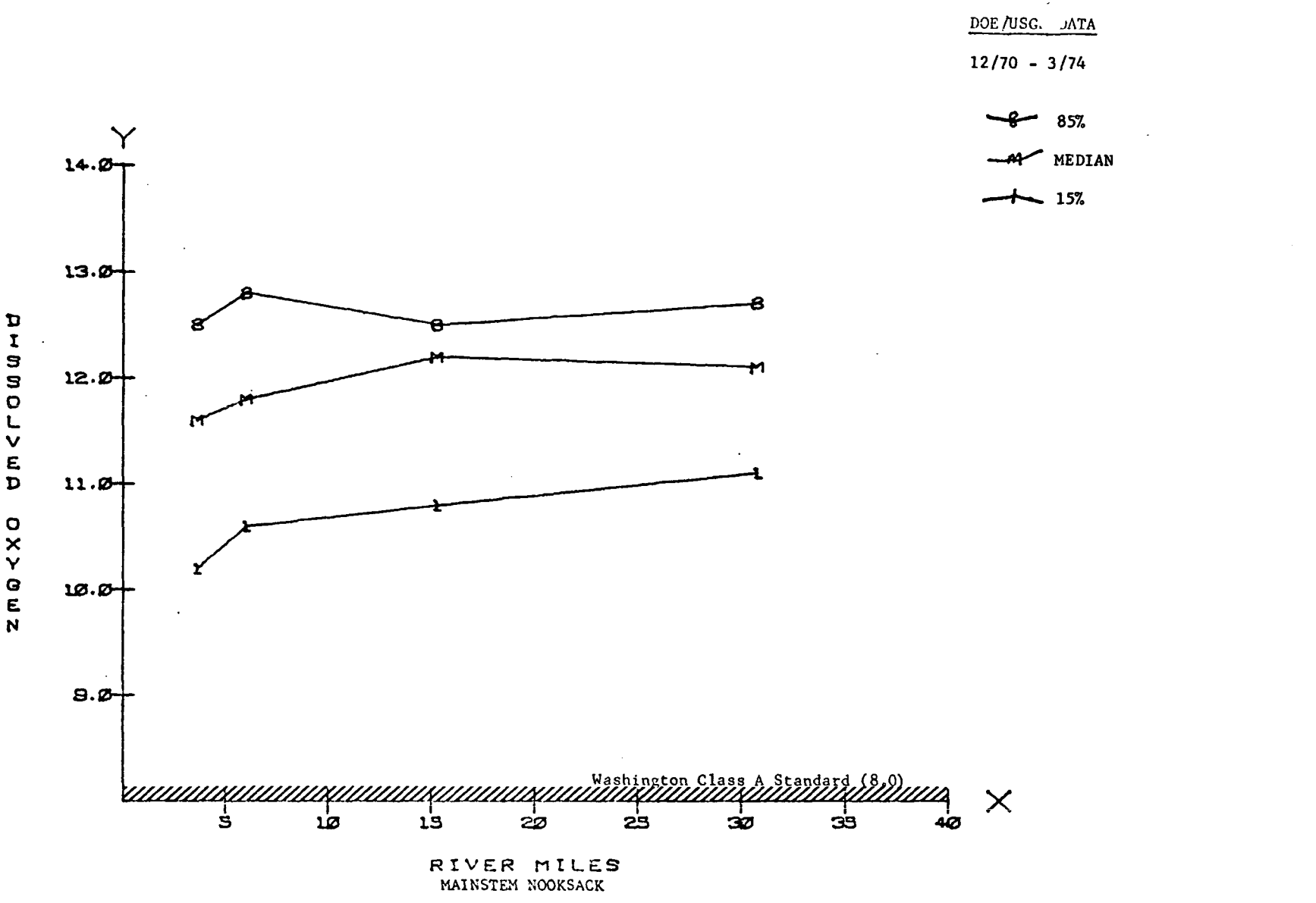
8 85%

M MEDIAN

1 15%

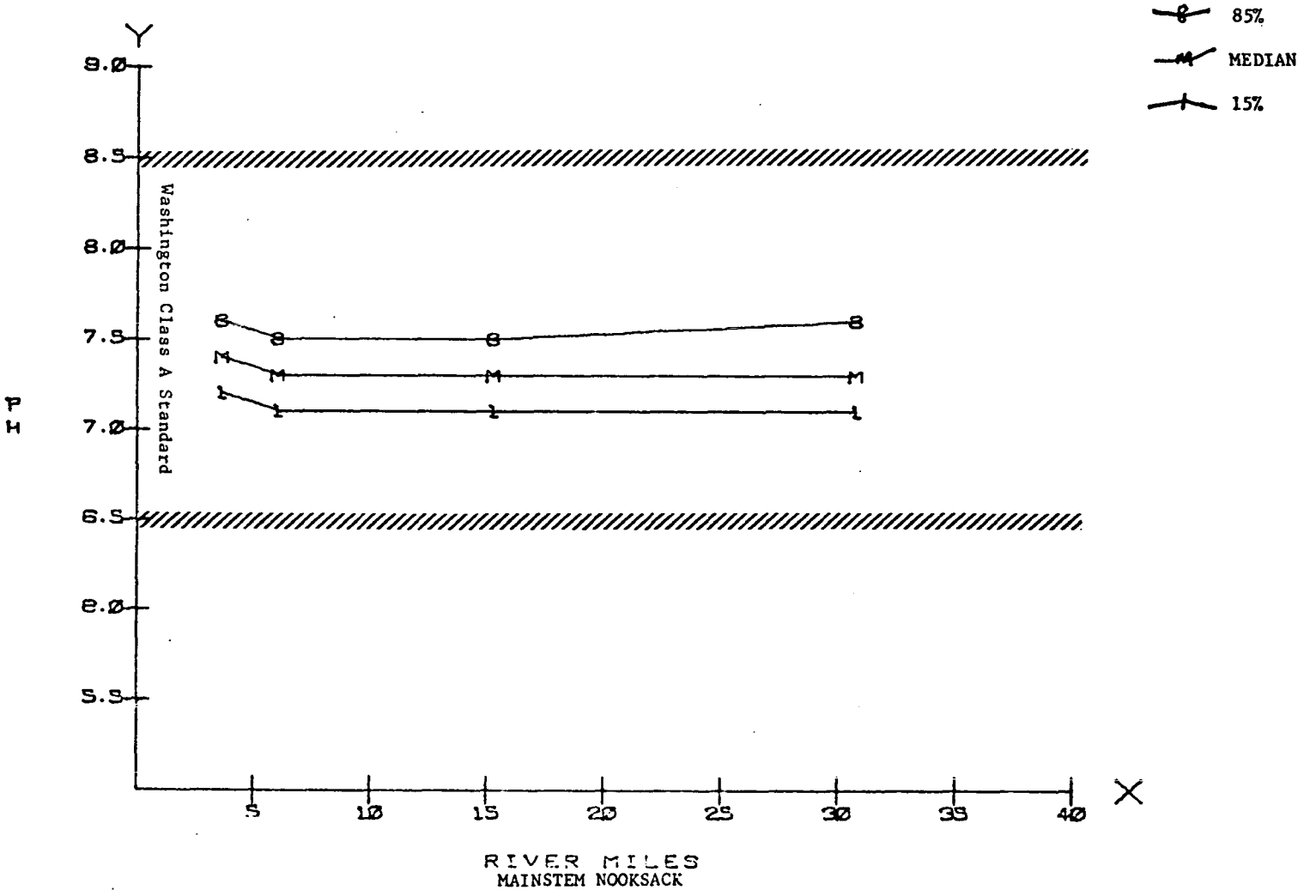
DOE/USGS DAT/
12/70 - 3/74
85%
MEDIAN
15%
TURBIDITY
75
60
45
30
15
01A050: @ BRENNAN
01A070: @ FERNDALE
01A090: nr LYNDEN
01A120: nr DEMING
5
10
15
20
25
30
35
40
RIVER MILES
MAINSTEM NOOKSACK
FERNDALE---
FISHTRAP CREEK---
LYNDEN----
EVERSON---
ANDERSON CREEK----
SMITH CREEK----
DEMING-----
SOUTH FORK----

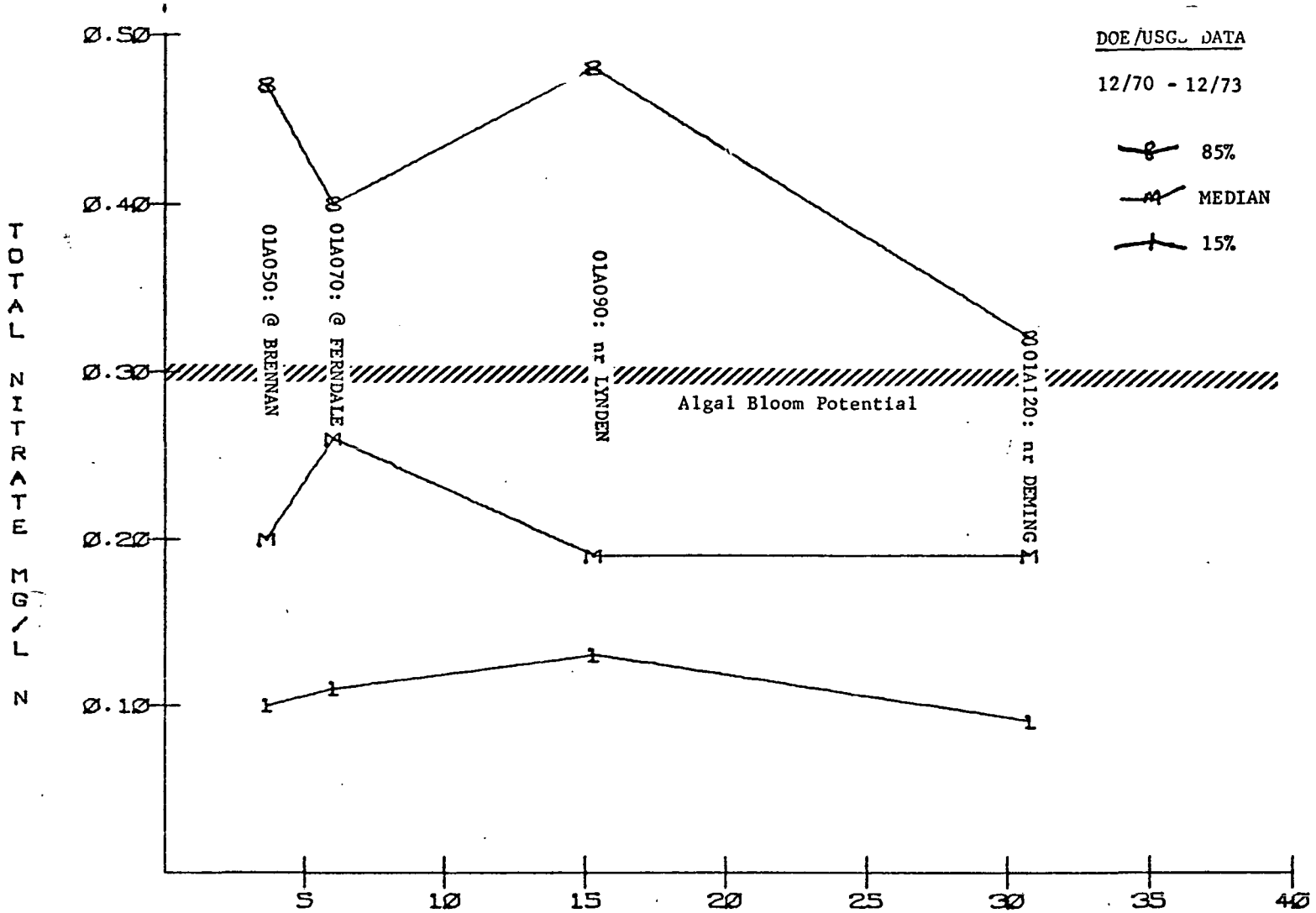
DOE/USGS DATA
12/70 - 3/74
85%
MEDIAN
15%
CONDUCTIVITY MICROMHO
150
120
90
60
30
Y
01A050: @ BRENNAN
01A070: @ FERNDALE
01A090: nr LYNDEN
01A120: nr DEMING
5
10
15
20
25
30
35
40
RIVER MILES
MAINSTEM NOOKSACK
FERNDALE---
FISHTRAP CREEK---
LYNDEN----
EVERSON---
ANDERSON CREEK----
SMITH CREEK----
DEMING----
SOUTH FORK----

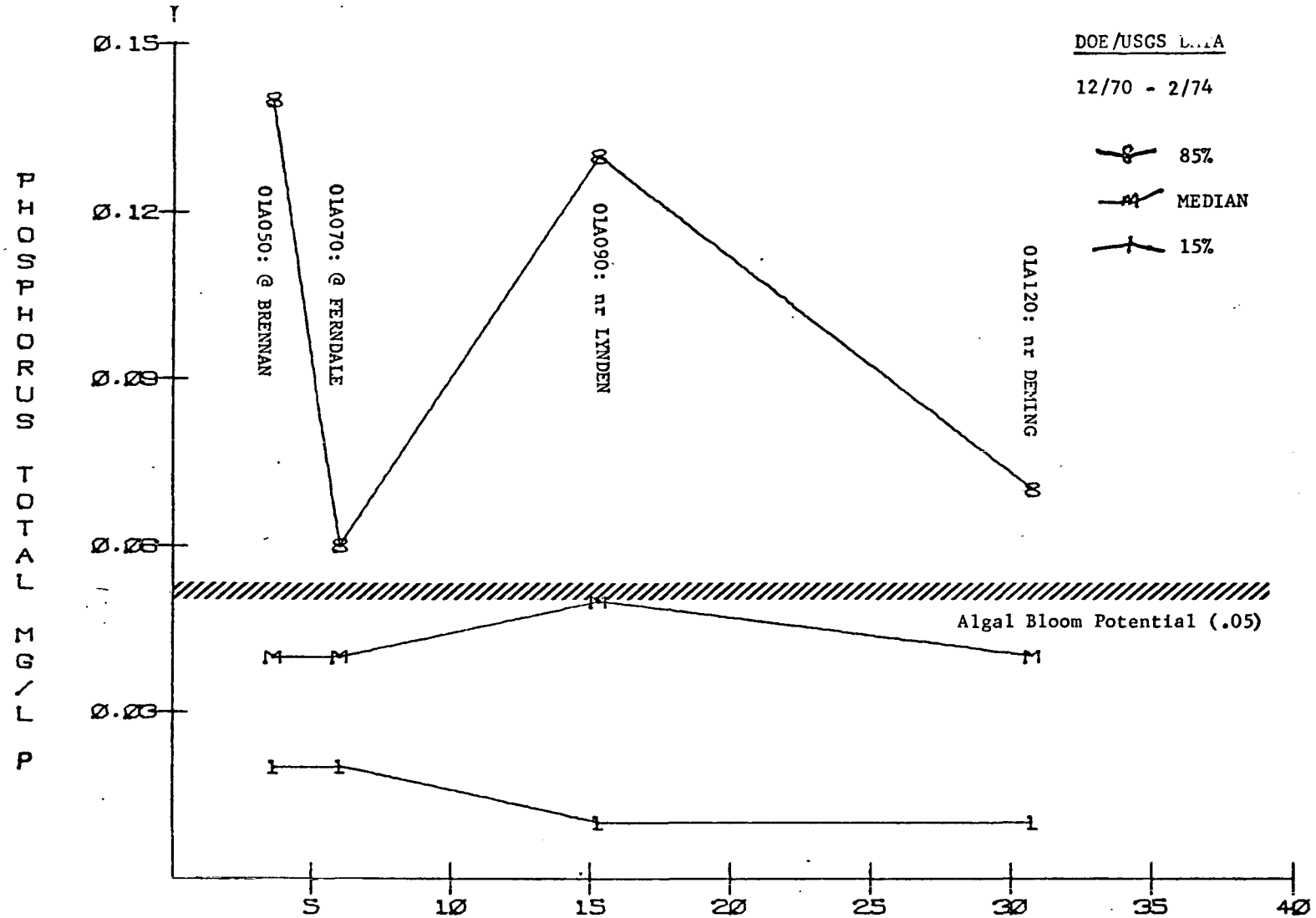

DOE/USG. DATA
12/70 - 3/74
85%
MEDIAN
15%
DISSOLVED OXYGEN
14.0
13.0
12.0
11.0
10.0
9.0
Y
X
Washington Class A Standard (8.0)
5
10
15
20
25
30
35
40
RIVER MILES
MAINSTEM NOOKSACK
FERNDALE
FISHTRAP CREEK
LYNDEN
EVERSON
ANDERSON CREEK
SMITH CREEK
DEMING
SOUTH FORK

DOE/USGS DATA

12/70 - 3/74




DOE/USGS DATA
12/70 - 12/73
85%
MEDIAN
15%
Algal Bloom Potential
01A050: @ BRENNAN
01A070: @ FERNDALE
01A090: nr LYNDEN
01A120: nr DEMING
TOTAL NITRATE MG/L N
0.50
0.40
0.30
0.20
0.10
5
10
15
20
25
30
35
40
RIVER MILES
MAINSTEM NOOKSACK
FERNDALE---
FISHTRAP CREEK---
LYNDEN----
EVERSON---
ANDERSON CREEK----
SMITH CREEK----
DEMING----
SOUTH FORK----


DOE/USGS L...A
12/70 - 2/74
85%
MEDIAN
15%
01A050: @ BRENNAN
01A070: @ FERNDALE
01A090: nr LYNDEN
01A120: nr DENING
Algal Bloom Potential (.05)
PHOSPHORUS TOTAL MG/L P
Ø.15
Ø.12
Ø.09
Ø.06
Ø.03
5
10
15
20
25
30
35
40
RIVER MILES
MAINSTEM NOOKSACK
FERNDALE
FISHTRAP CREEK
LYNDEN
EVERSON
ANDERSON CREEK
SMITH CREEK
DEMING
SOUTH FORK

DOE/USGS Data

12/70 - 3/74

85%

MEDIAN

15%

TOTAL COLIFORM \100 ML

1000000

100000

10000

1000

100

10

Washington Class A Standard

median (240)

01A050: @ BRENNAN

01A070: @ FERNDALE

01A090: nr LYNDEN

01A120: nr DEMING

5 10 15 20 25 30 35 40

RIVER MILES

MAINSTEM NOOKSACK

FERNDALE---

FISHTRAP CREEK---

LYNDEN----

EVERSON---

ANDERSON CREEK----
SMITH CREEK----

DEMING----
SOUTH FORK----

PUYALLUP RIVER BASIN

PUYALLUP RIVER BASIN
BASIN DESCRIPTION

1. Drainage Area - 948 sq. m.

2. Average Flow - (Puyallup R at Puyallup) - 3 292 cfs
   min. - 2 087 cfs
   max. - 4 927 cfs

3. Waste Sources - 16

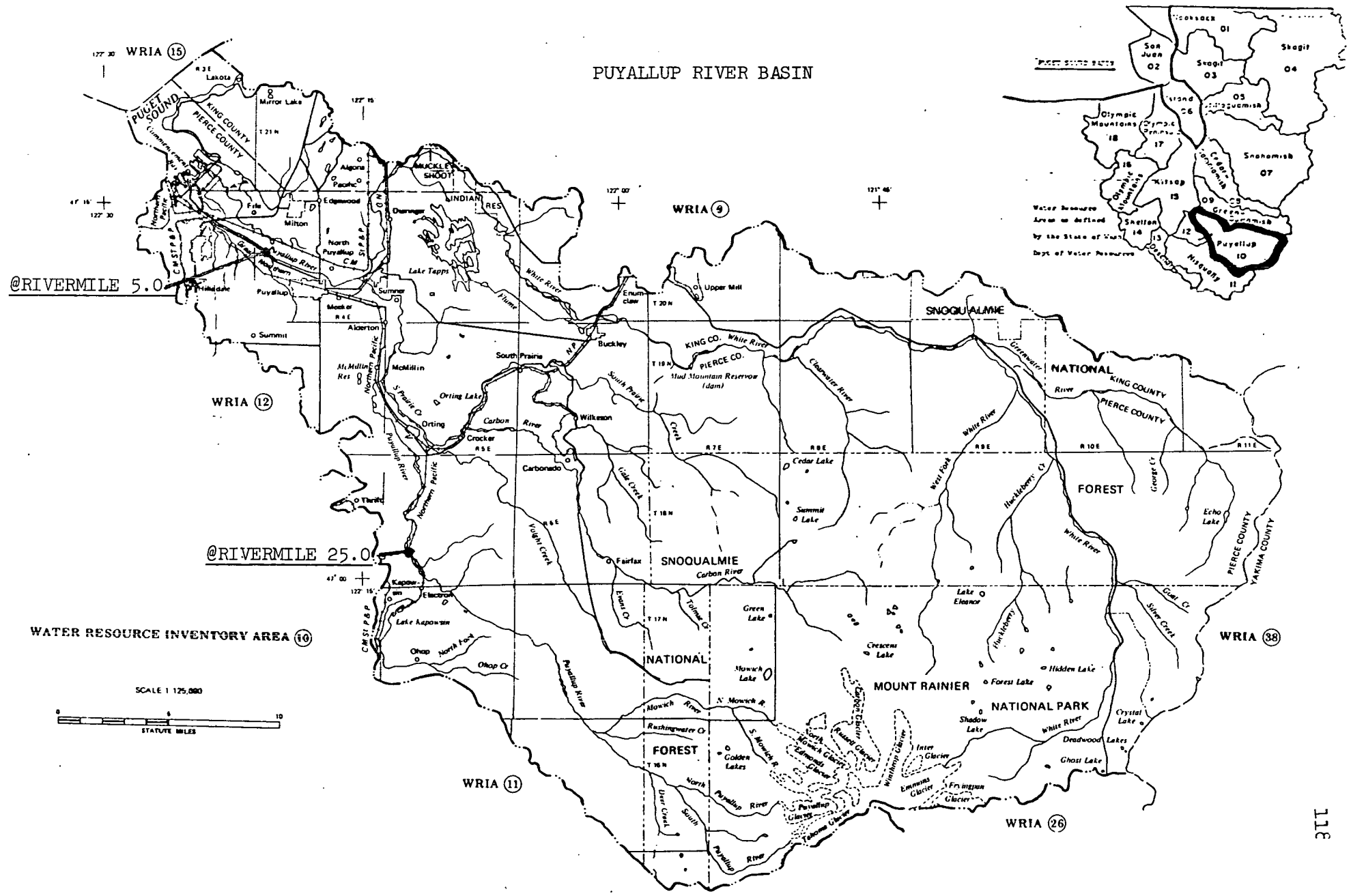
4. Major Diversions : Fish & Game - 28 cfs
   Domestic - 41 cfs
   Industrial - 40 cfs
   Hydropower - 5650 cfs
   Irrigation - 8000 acre-feet

5. Surface Water Rights : Municipal - 725.45 cfs
   Irrigation- 55.59 cfs
   Individual & Community Domestic - 84.22 cfs
   Industrial & Commercial - 40 cfs
   Fish. Propogation - 70.33 cfs
   Stock - 9.28 cfs
   Total - 961.73 cfs

6. Reservoir Storage Rights - 51 671 acre-feet

7. Projected Population -

1980	2000	2020
449,800	700,000	1,107,500



WATER RESOURCE INVENTORY AREA (10)

PUYALLUP RIVER BASIN
REPORTED PROBLEMS

1. Total Nitrate and Total Phosphorus values generally exceed the limiting algal productivity concentration throughout the Puyallup river and the lower miles on the White river.

2. Turbidity values generally exceed the standard throughout the Puyallup and White Rivers.

3. The dissolved oxygen content violates the water quality standard as both the Puyallup and White rivers approach their mouths.

4. The Total Coliform values generally exceed the water quality standard throughout both the Puyallup and White river.

WATER TEMPERATURE

ON THE PUYALLUP RIVER

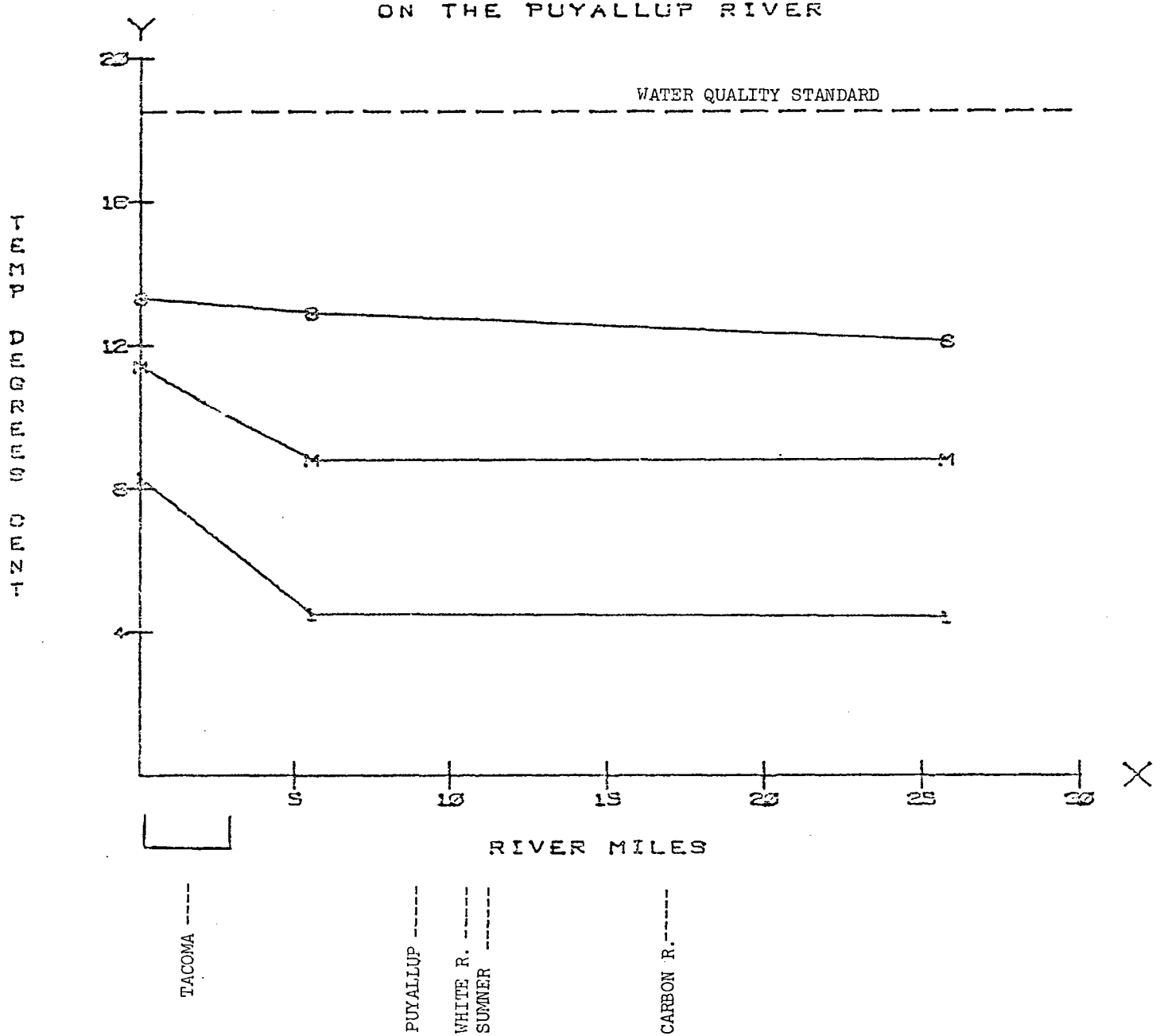
DOE/USGS DATA

11/70 - 09/72

8 85%

M Median

1 15%



TURBIDITY

ON THE PUYALLUP RIVER

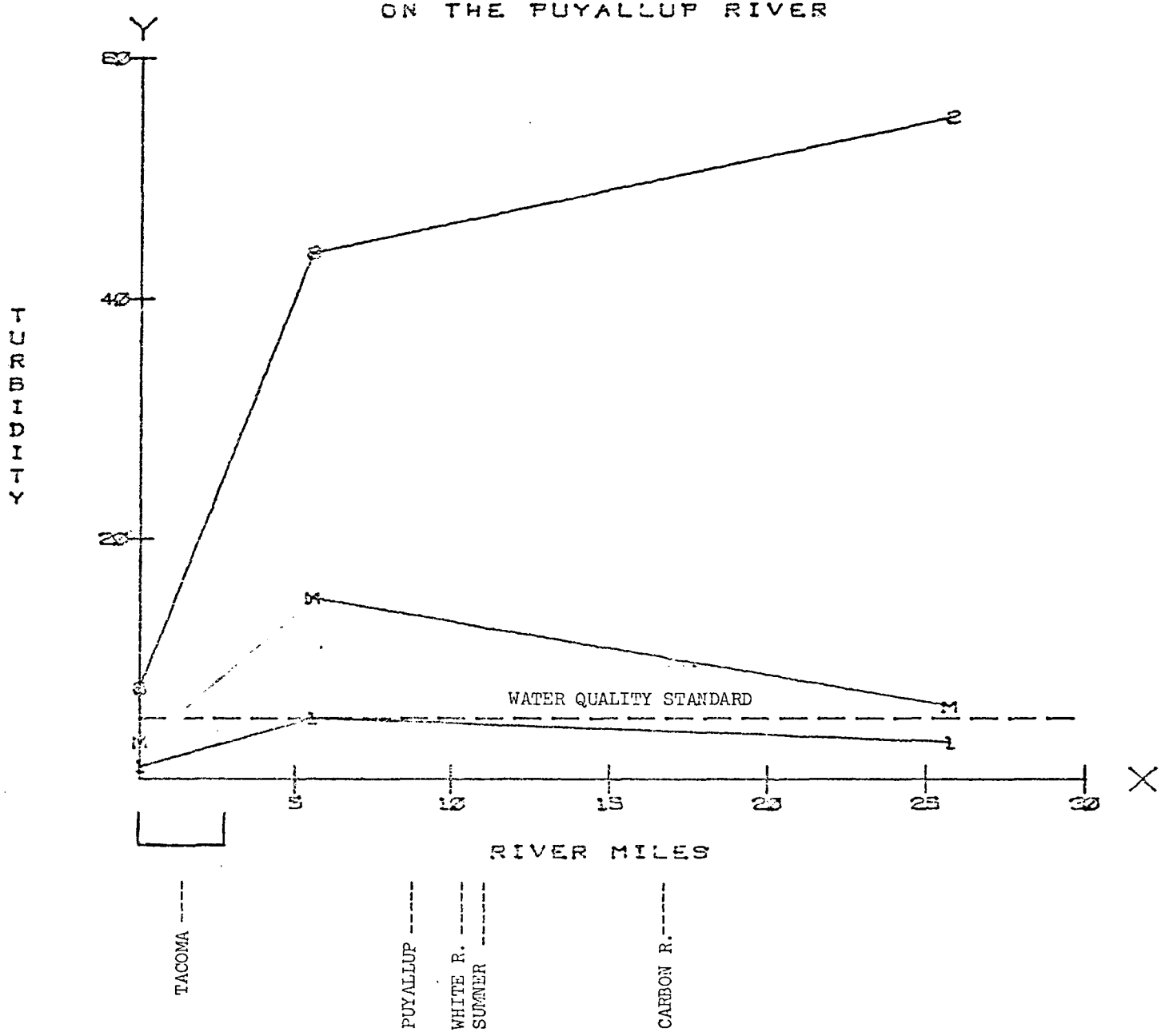
DOE/USGS DATA

11/70 - 09/72

8 85%

M Median

1 15%



CONDUCTIVITY

ON THE PUYALLUP RIVER

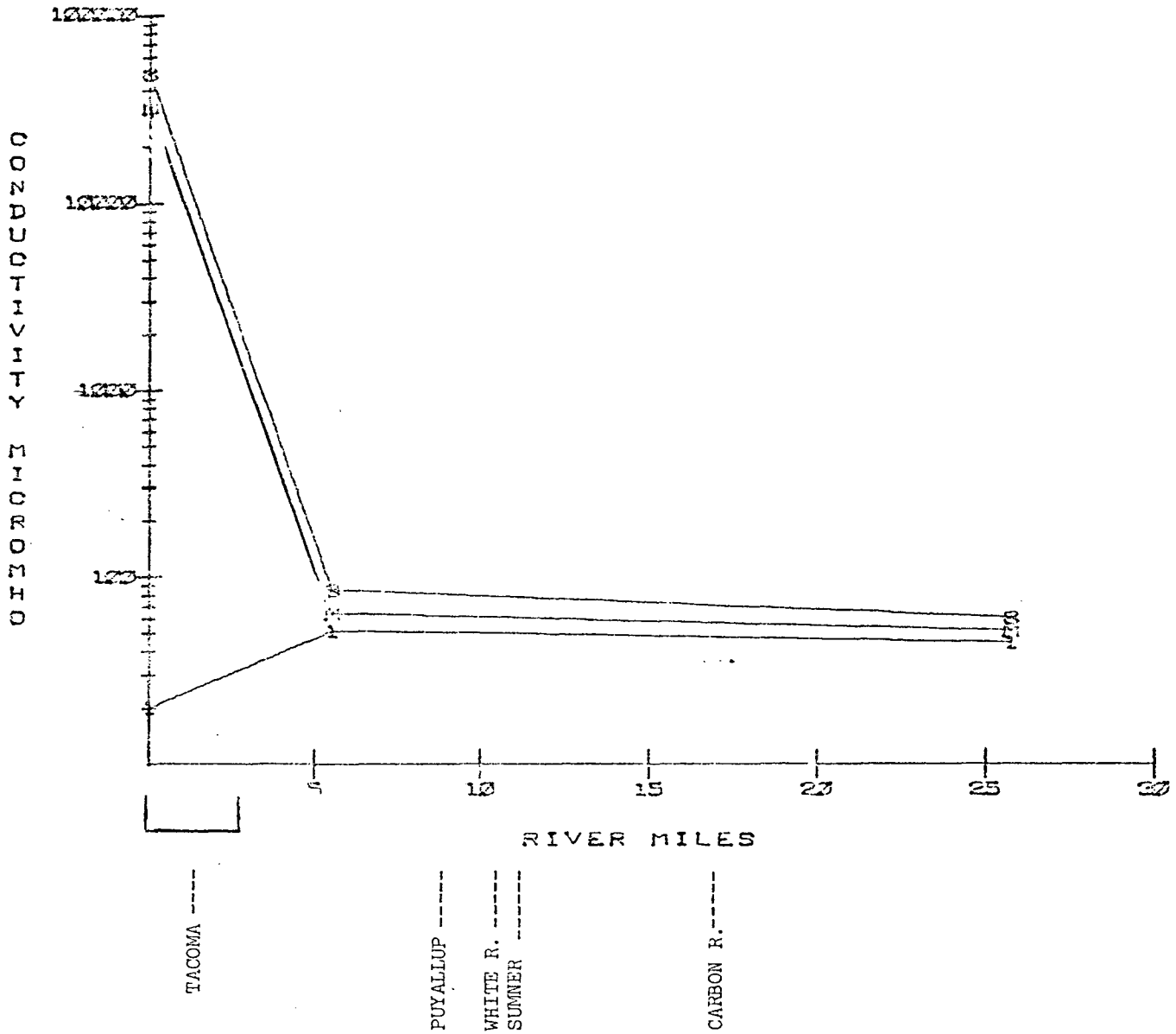
DOE/USGS DATA

11/70 - 09/72

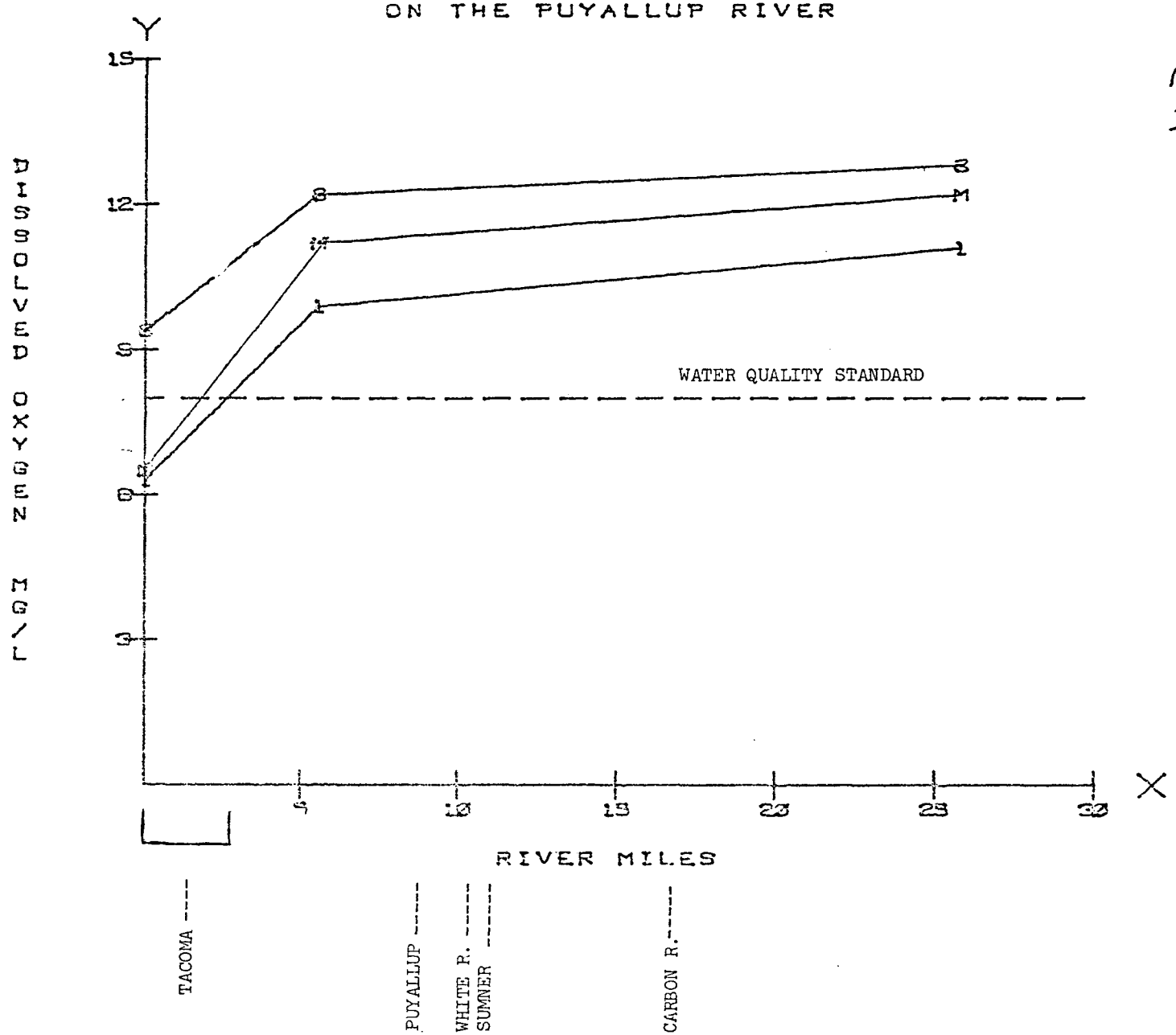
8 85%

M Median

1 15%



DISSOLVED OXYGEN
ON THE PUYALLUP RIVER



EOL/USGS DATA

11/70 - 09/72

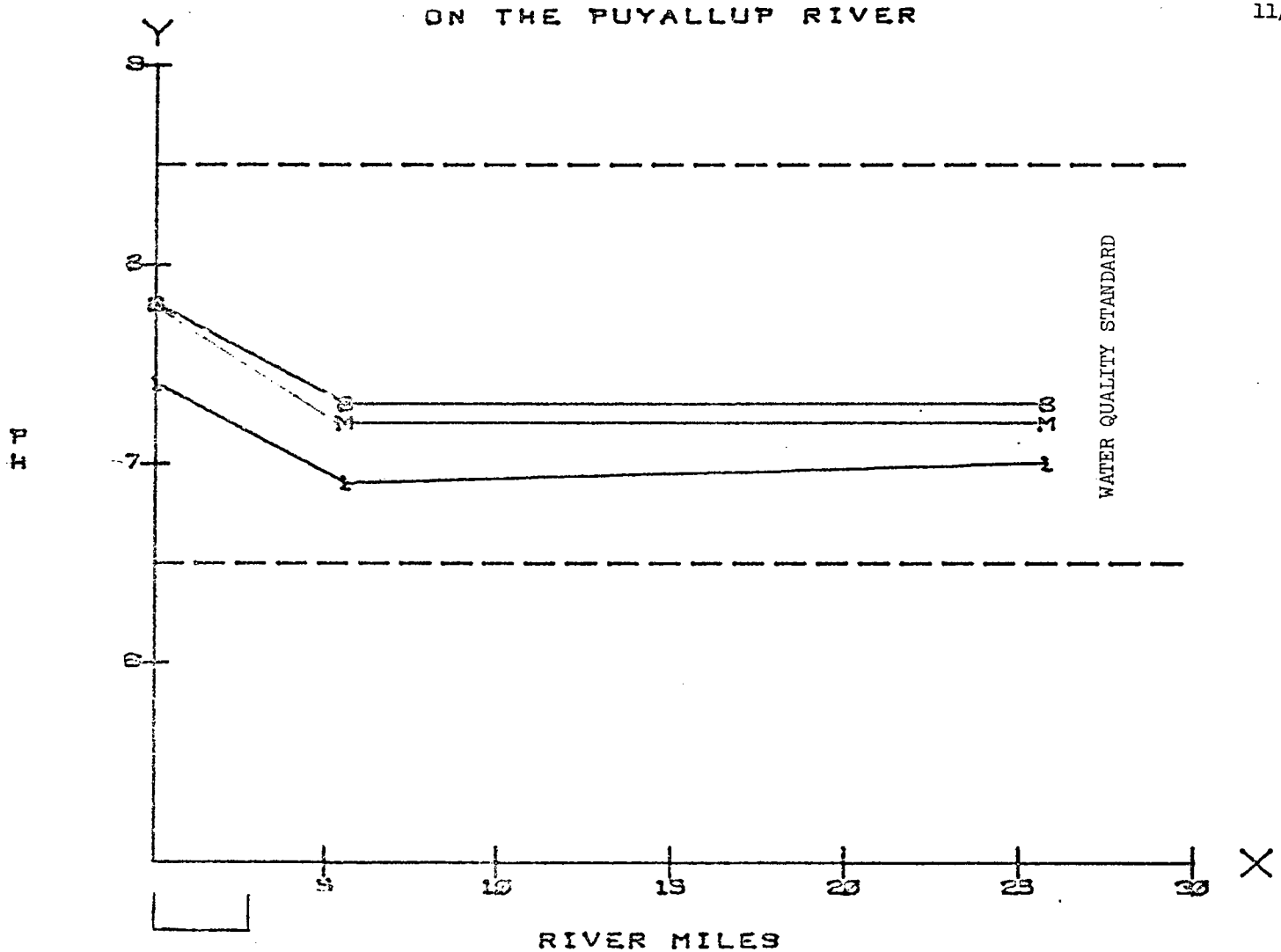
8 85%

M Median

1 15%

PH

ON THE PUYALLUP RIVER



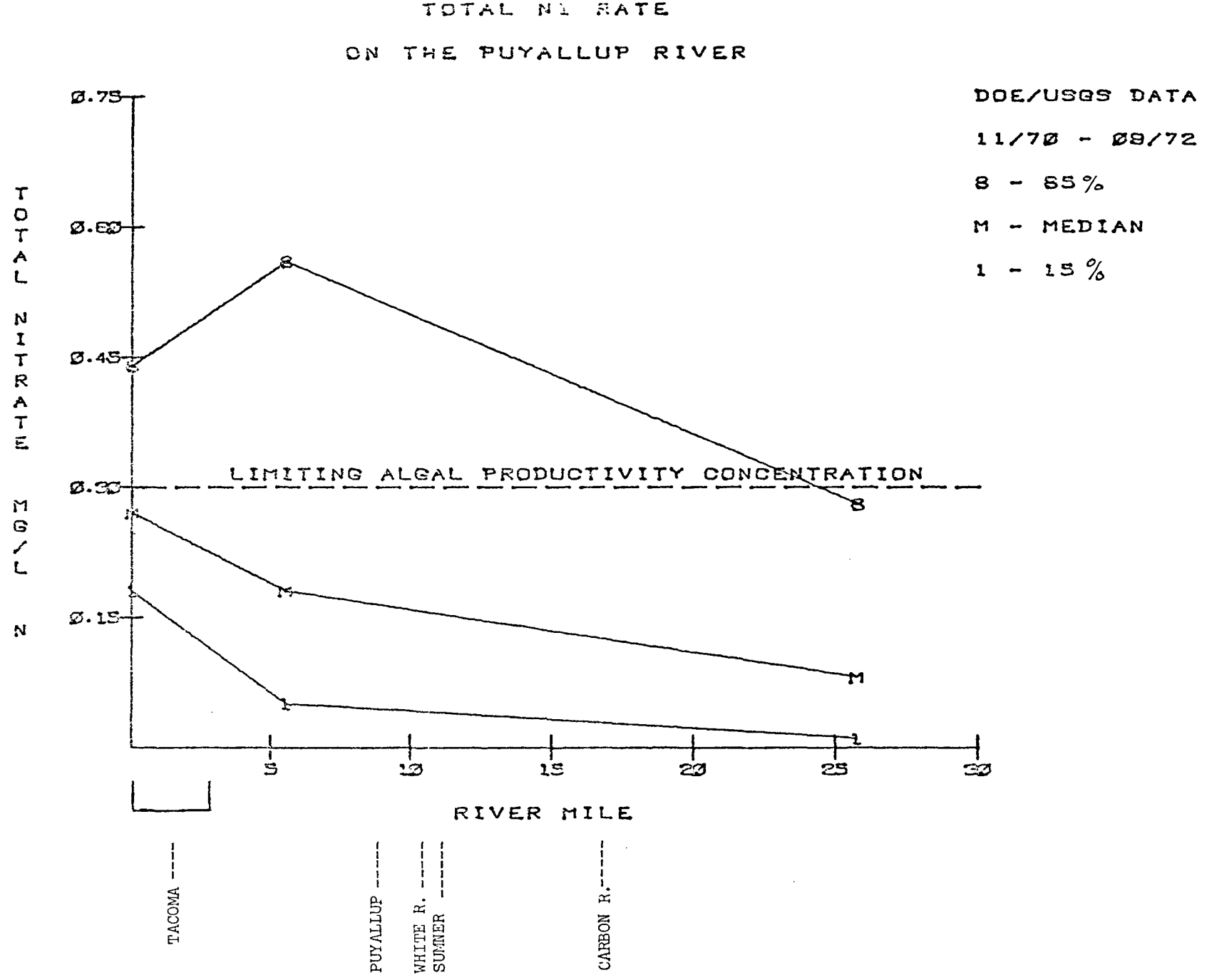
DOE/USGS DATA

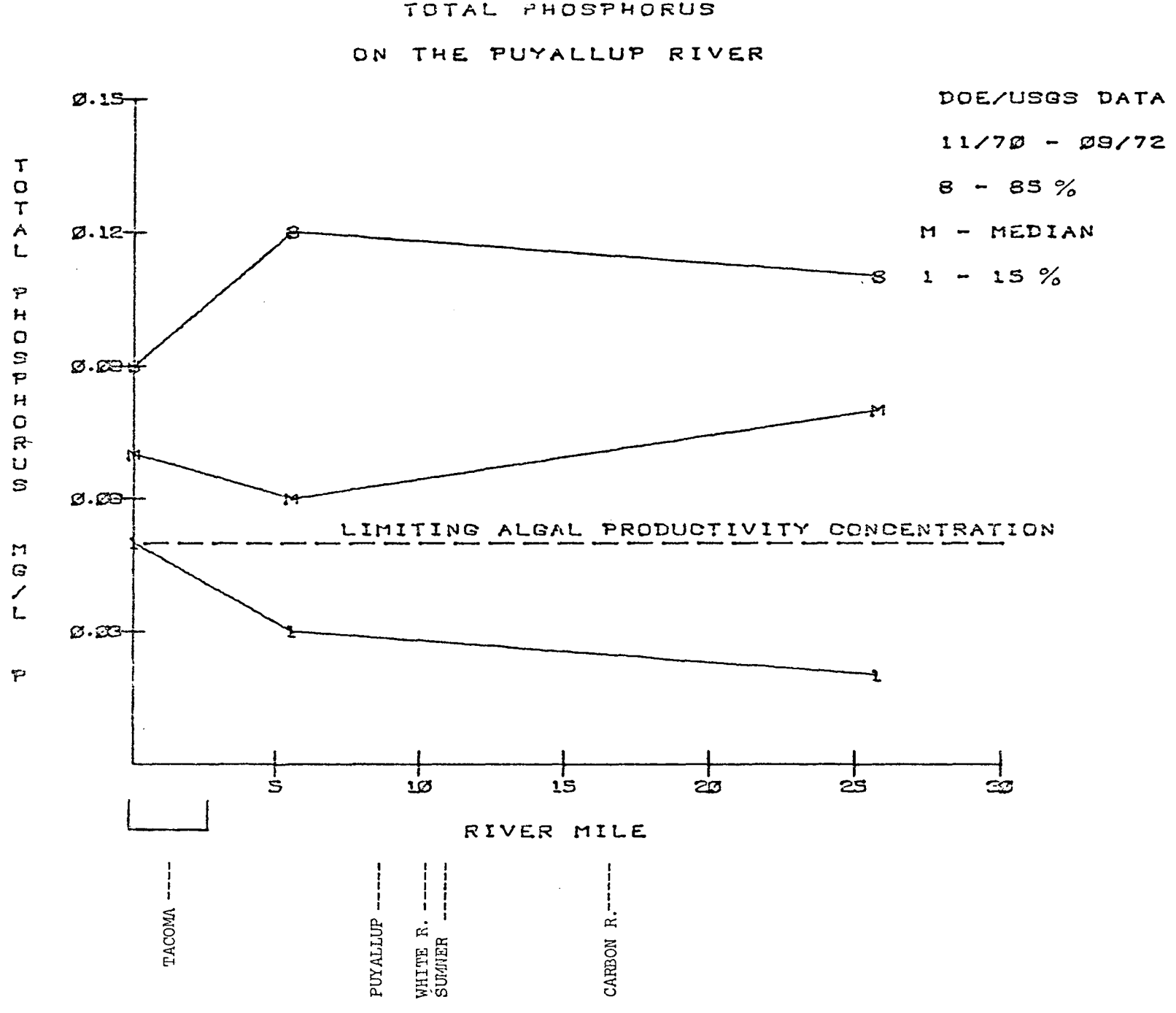
11/70 - 09/72

8 85%

M Median

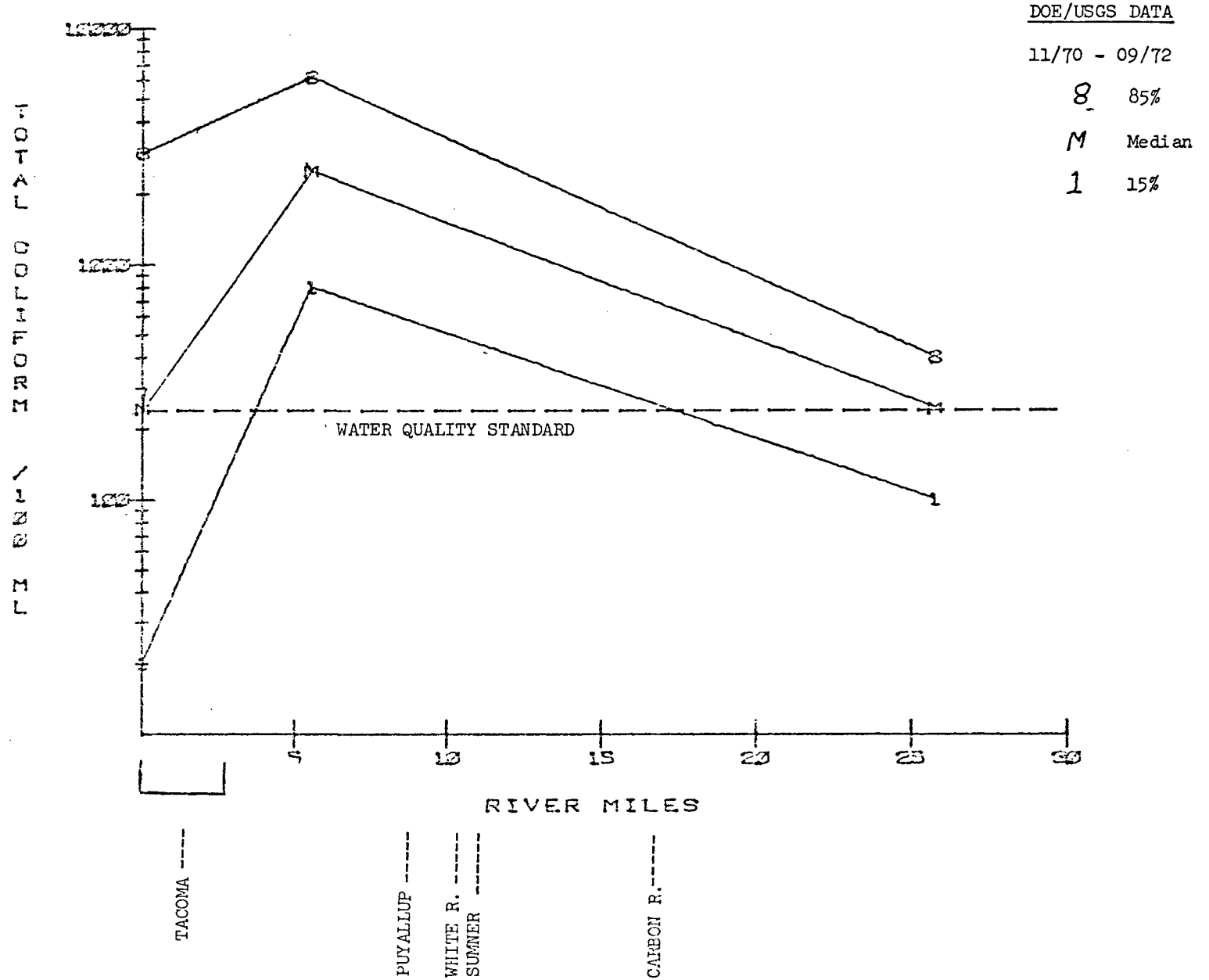
1 15%


TOTAL NITRATE RATE
ON THE PUYALLUP RIVER
DOE/USGS DATA
11/70 - 09/72
8 - 85%
M - MEDIAN
1 - 15%
TOTAL NITRATE MG/L N
0.75
0.60
0.45
0.30
0.15
LIMITING ALGAL PRODUCTIVITY CONCENTRATION
8
M
1
5
10
15
20
25
30
RIVER MILE
TACOMA
PUYALLUP
WHITE R.
SUMNER
CARBON R.

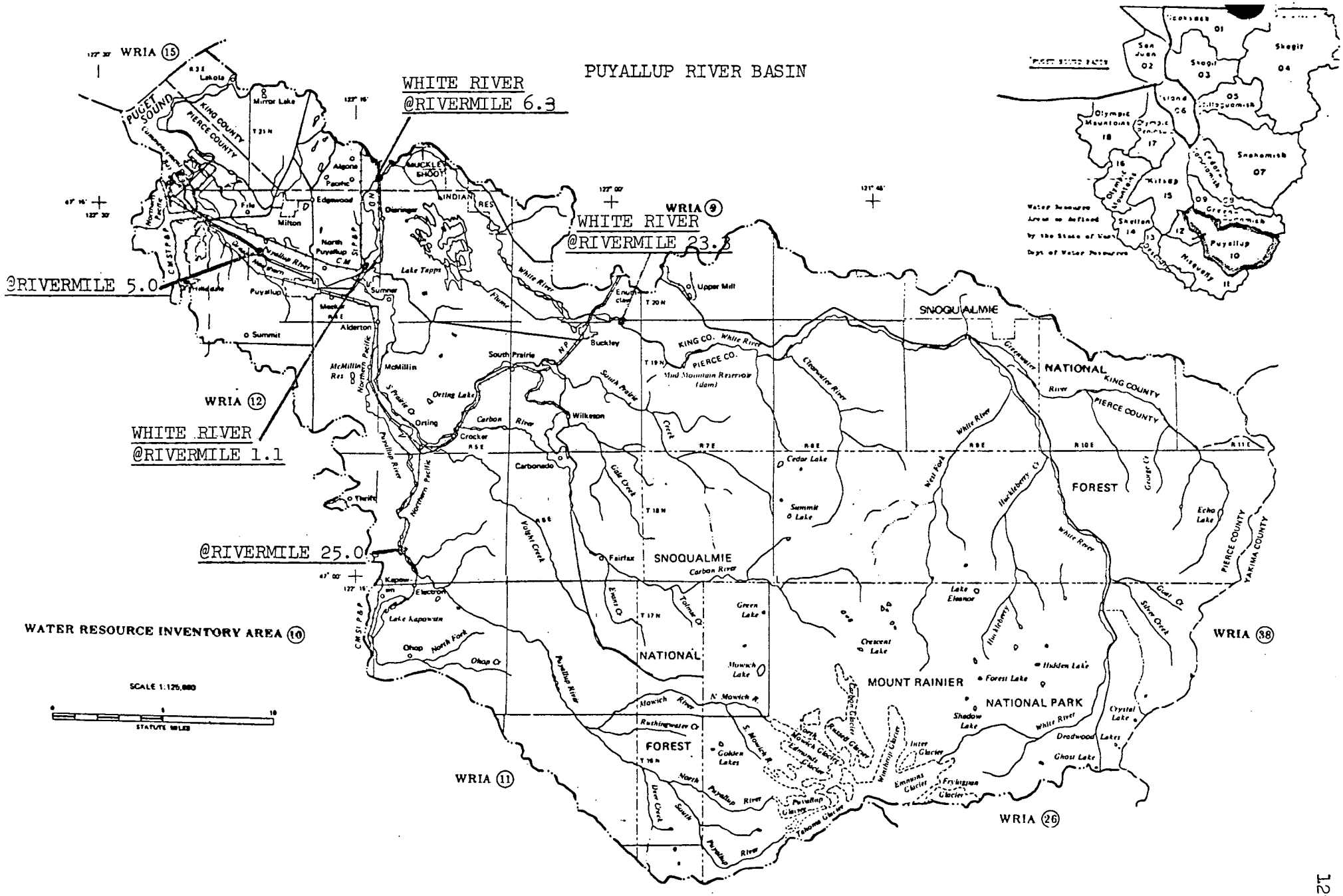

TOTAL PHOSPHORUS
ON THE PUYALLUP RIVER
DOE/USGS DATA
11/70 - 09/72
8 - 85 %
M - MEDIAN
1 - 15 %
TOTAL PHOSPHORUS MG/L P
0.15
0.12
0.09
0.06
0.03
LIMITING ALGAL PRODUCTIVITY CONCENTRATION
5
10
15
20
25
30
RIVER MILE
TACOMA
PUYALLUP
WHITE R.
SUMNER
CARBON R.

TOTAL COLIFORM

ON THE PUYALLUP RIVER



WHITE RIVER


PUYALLUP RIVER BASIN
WHITE RIVER @RIVERMILE 6.3
WHITE RIVER @RIVERMILE 23.3
@RIVERMILE 5.0
WHITE RIVER @RIVERMILE 1.1
@RIVERMILE 25.0
WRIA 15
WRIA 9
WRIA 12
WRIA 11
WRIA 26
WRIA 38
PUGET SOUND
KING COUNTY
PIERCE COUNTY
SNOQUALMIE
NATIONAL FOREST
MOUNT RAINIER NATIONAL PARK
Mud Mountain Reservoir (dam)
WATER RESOURCE INVENTORY AREA 10
SCALE 1:125,000
STATUTE MILES

WATER TEMPERATURE ON THE WHITE RIVER

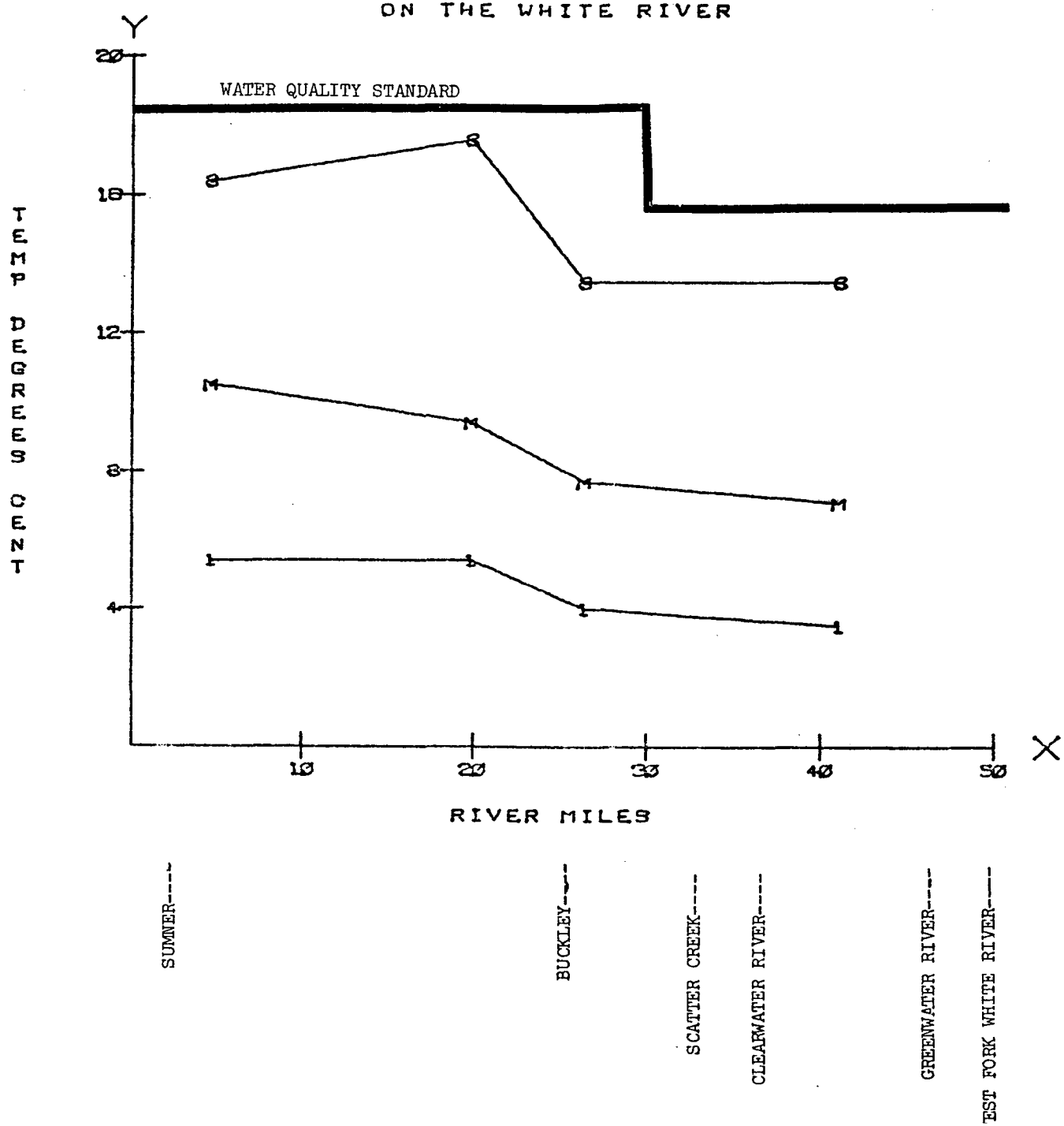
DOE/USGS DATA

11/70 - 09/73

8 85%

M Median

1 15%



TURBIDITY

ON THE WHITE RIVER

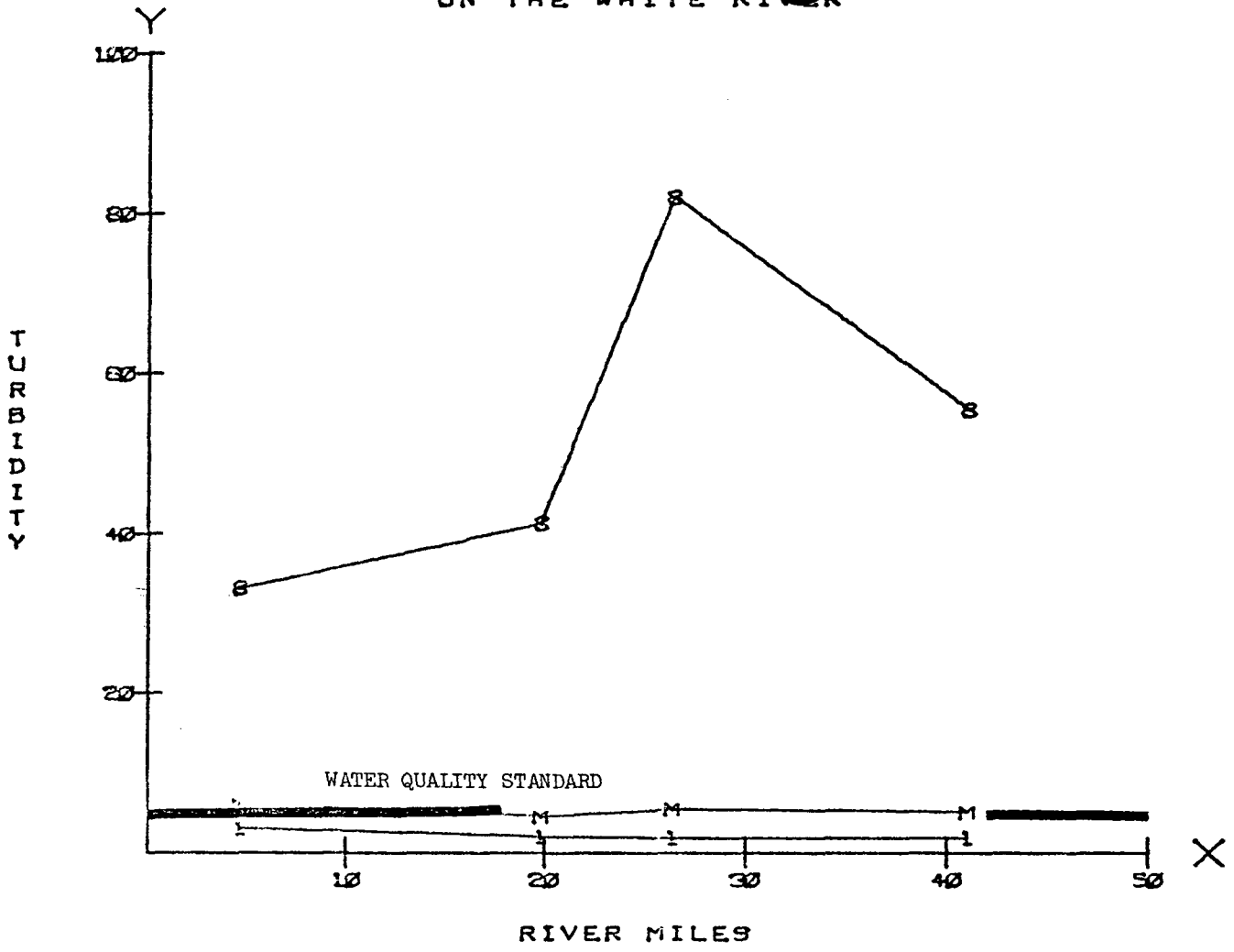
DOE/USGS DATA

11/70 - 09/73

8 85%

M Median

1 15%



CONDUCTIVITY

ON THE WHITE RIVER

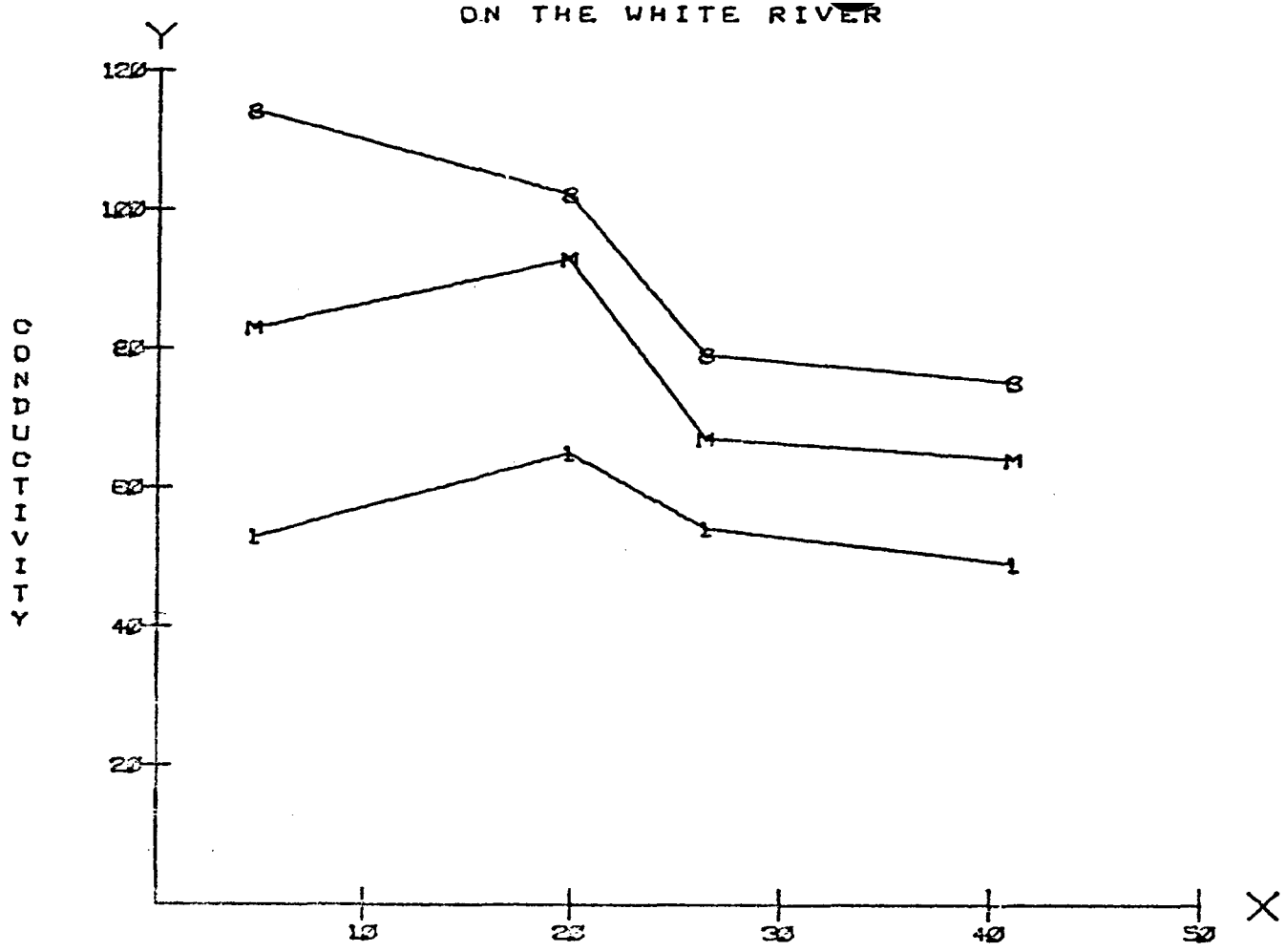
DOE/USGS DATA

11/70 - 09/73

8 85%

M Median

1 15%



SUMNER----

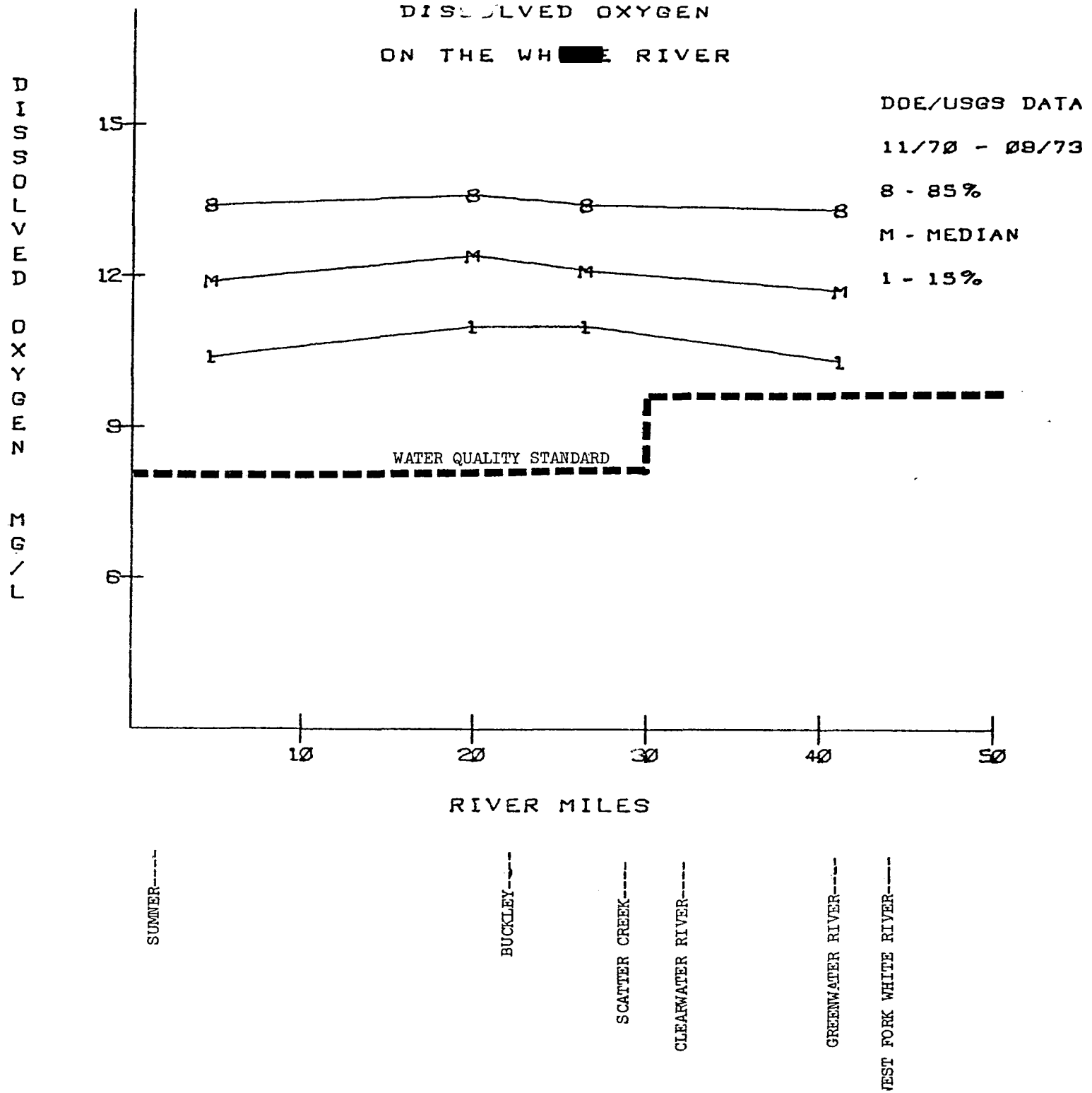
BUCKLEY----

SCATTER CREEK----

CLEARWATER RIVER----

GREENWATER RIVER----

WEST FORK WHITE RIVER----


DISSOLVED OXYGEN
ON THE WHITE RIVER
DOE/USGS DATA
11/70 - 08/73
8 - 85%
M - MEDIAN
1 - 15%
DISSOLVED OXYGEN MG/L
15
12
9
6
WATER QUALITY STANDARD
10
20
30
40
50
RIVER MILES
SUMNER
BUCKLEY
SCATTER CREEK
CLEARWATER RIVER
GREENWATER RIVER
WEST FORK WHITE RIVER

PH

ON THE WHITE RIVER

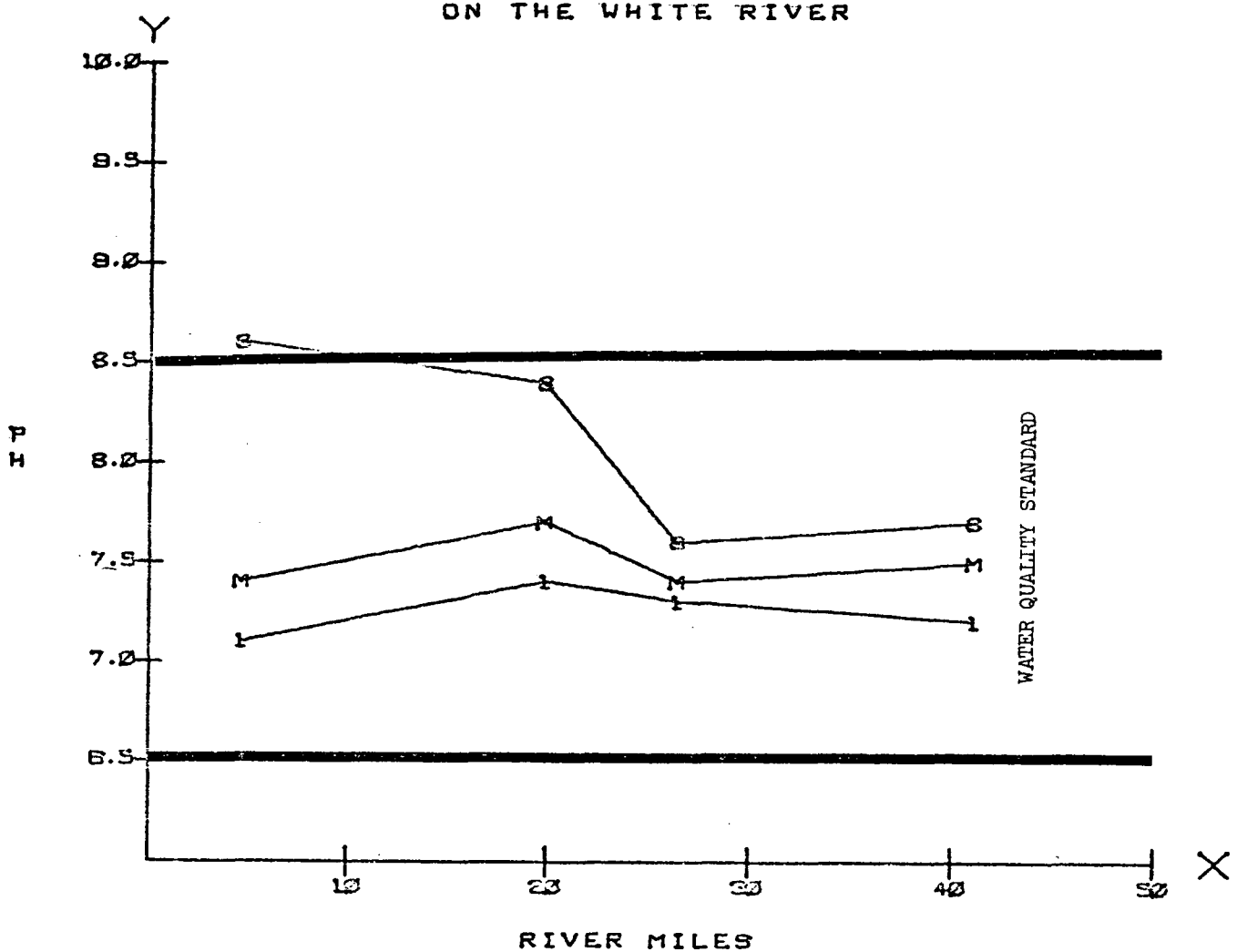
DOE/USGS DATA

11/70 - 09/73

8 85%

M Median

1 15%



TOTAL NITRATE ON THE WHITE RIVER

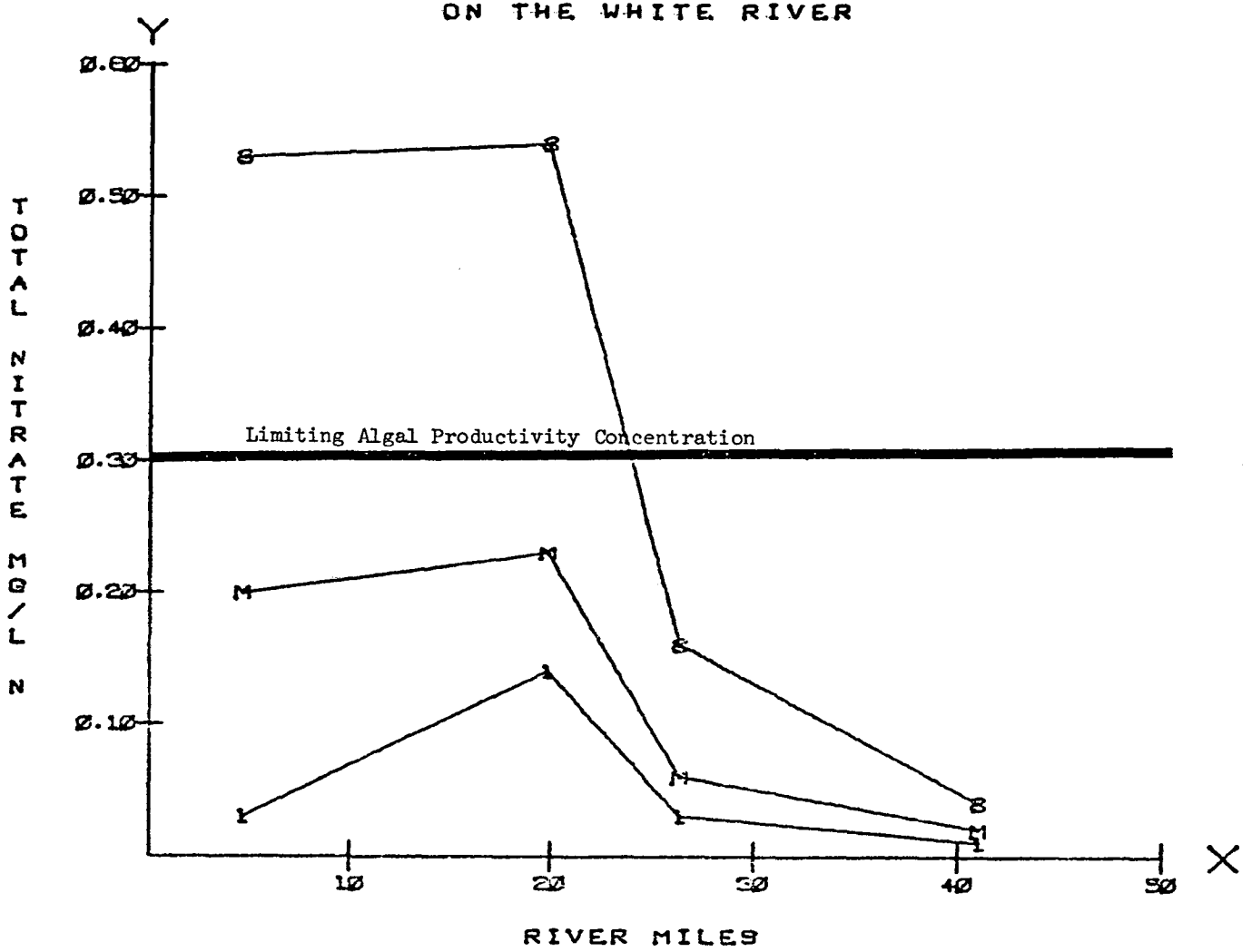
DOE/USGS DATA

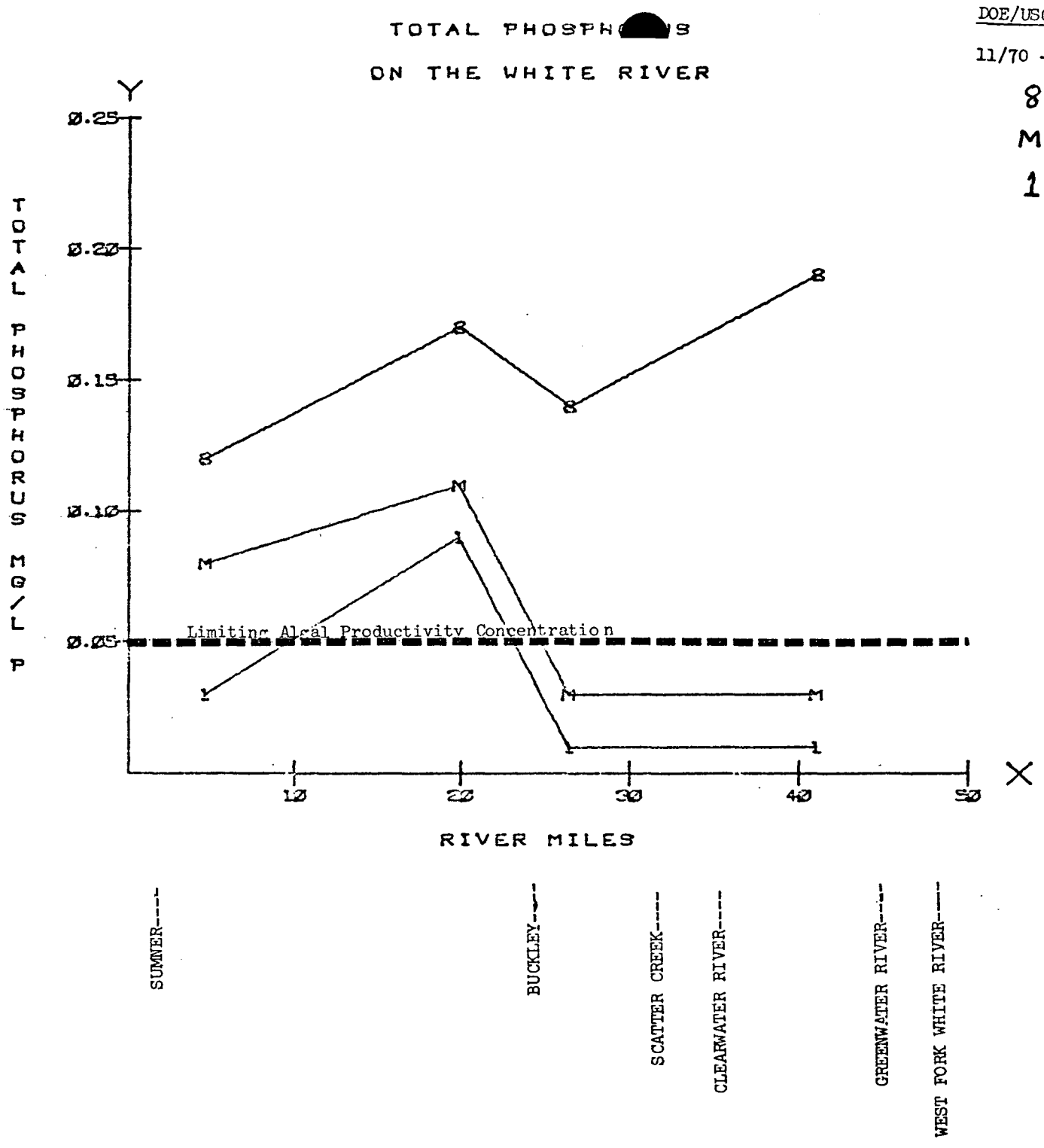
11/70 - 09/73

8 85%

M Median

1 15%




TOTAL PHOSPHORUS
ON THE WHITE RIVER
DOE/USGS DATA
11/70 - 09/73
8 85%
M Median
1 15%
Y
Ø.25
Ø.20
Ø.15
Ø.10
Ø.05
TOTAL PHOSPHORUS MG\L P
Limiting Algal Productivity Concentration
X
10
20
30
40
50
RIVER MILES
SUMNER
BUCKLEY
SCATTER CREEK
CLEARWATER RIVER
GREENWATER RIVER
WEST FORK WHITE RIVER

TOTAL COLIFORM
ON THE WHITE RIVER

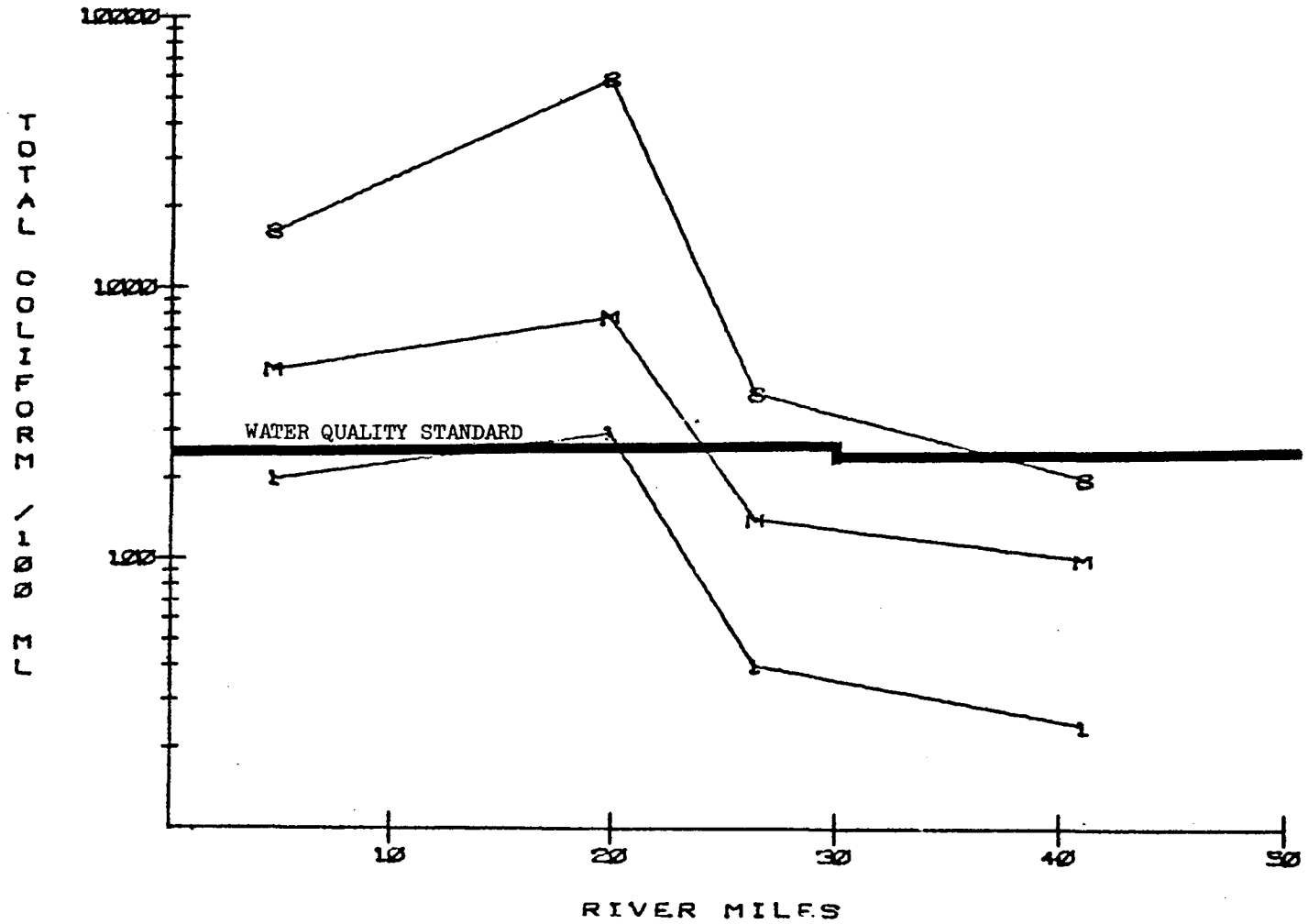
DOE/USGS DATA

11/70 - 09/73

8 85%

M Median

1 15%



SKAGIT RIVER BASIN

SKAGIT RIVER BASIN
BASIN DESCRIPTION

1. Drainage Area - 1 175 sq. m.

2. Average Flow - (at Newhalem) mean = 4 351 cfs
min. = 2 717 cfs
max. = 6 276 cfs

3. Waste Sources - 11

4. Major Diversions - Fish & Game - 25 cfs

Domestic - 5 cfs

Industrial - 29 cfs

Hydropower - 35 240 cfs

Irrigation - 3 000 acre-feet

5. Surface Water Rights - Municipal -161.5 cfs

Irrigation- 48.53 cfs

Individual & Community Domestic - 56.67 cfs

Industrial & Commercial - 29.54 cfs

Fish. Propogation - 106.63 cfs

Stock - .81 cfs

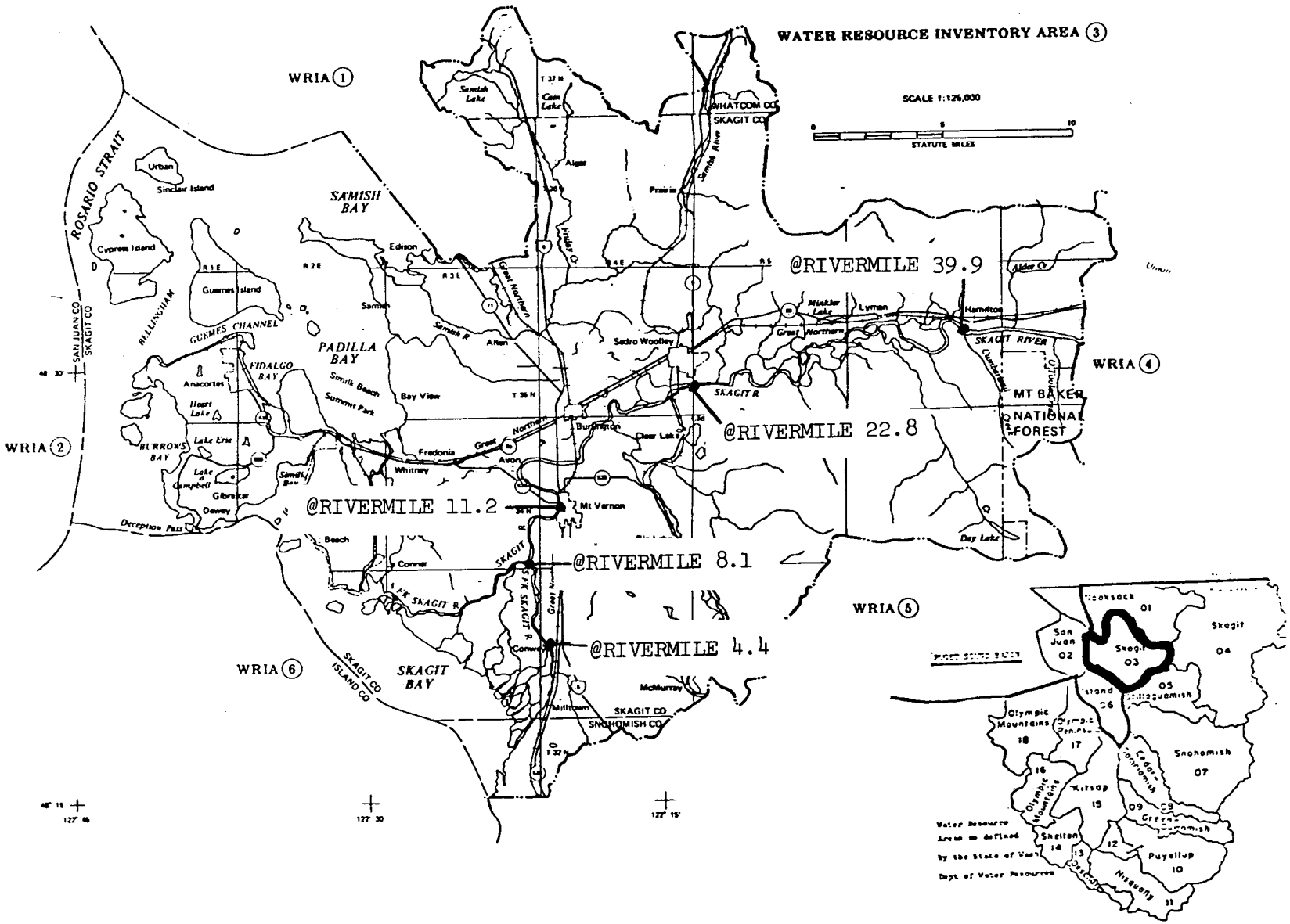
Total - 37 974.22 cfs

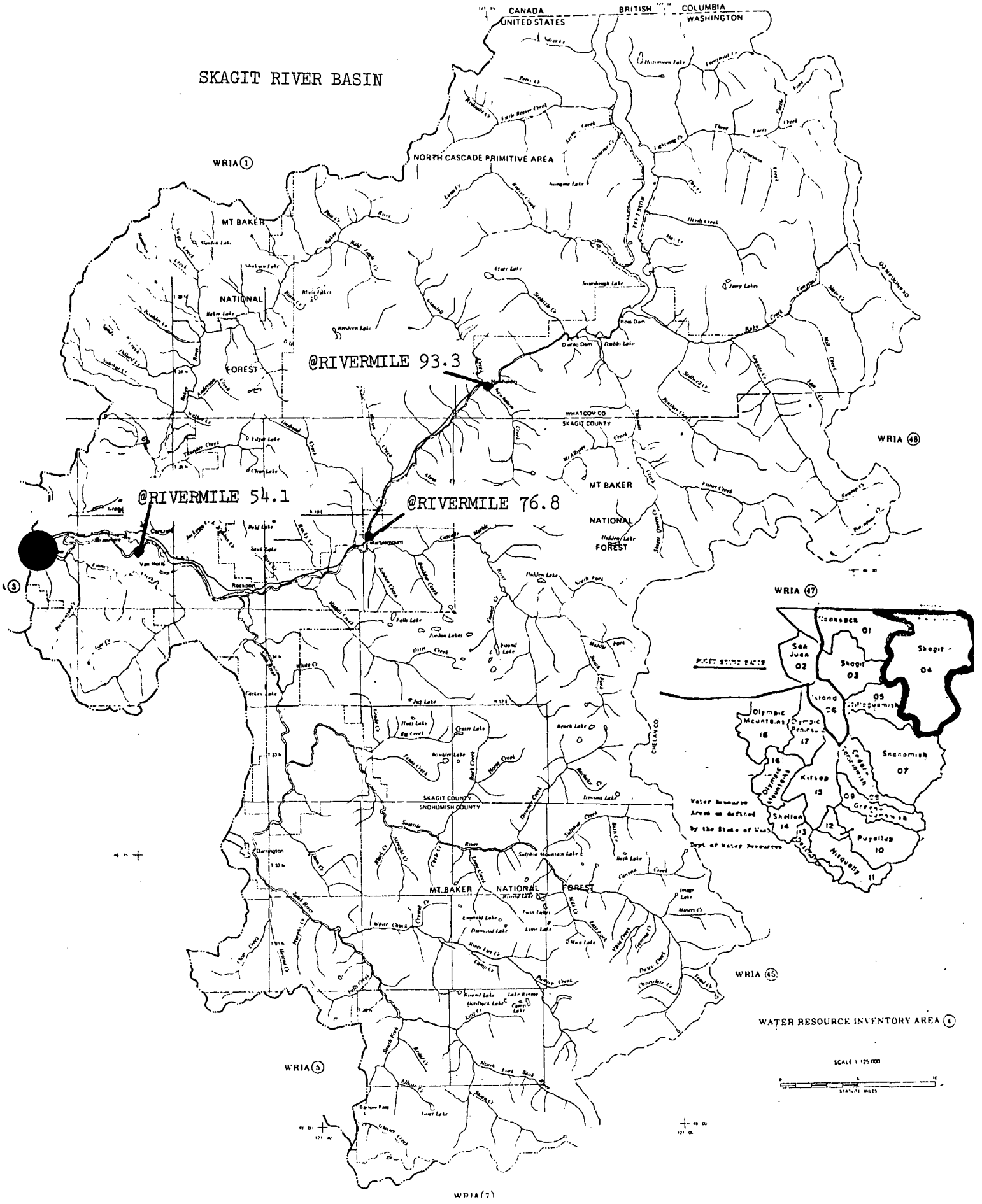
6. Reservoir Storage Rights - 4,414,089

7. Projected Population - 1980 2000 2020

64,200 86,500 118,200

SKAGIT RIVER BASIN




SKAGIT RIVER BASIN
CANADA
UNITED STATES
BRITISH COLUMBIA
WASHINGTON
NORTH CASCADE PRIMITIVE AREA
WRIA 1
MT BAKER
NATIONAL
FOREST
@RIVERMILE 93.3
@RIVERMILE 54.1
@RIVERMILE 76.8
WHATCOM CO
SKAGIT COUNTY
WRIA 48
MT BAKER
NATIONAL
FOREST
WRIA 47
Rockport
SKAGIT COUNTY
SNOHOMISH COUNTY
CHELAN CO.
MT. BAKER NATIONAL FOREST
WRIA 45
WATER RESOURCE INVENTORY AREA 4
WRIA 5
WRIA 7
Olympic Mountains
Kitsap
Shelton
Snohomish
Skagit
San Juan
Water Resource Areas as defined by the State of Wash. Dept of Water Resources

SKAGIT RIVER BASIN
REPORTED PROBLEMS

1. Total Coliform concentrations generally violate the Wash. State Water Quality Class A Standard from river mile 0 to river mile 25, and the Wash. State Class AA Standard from river mile 25 to the end.

2. Total phosphorous concentrations have been known to exceed the Algal Bloom Potential Concentration in the lower river miles on the Skagit River.

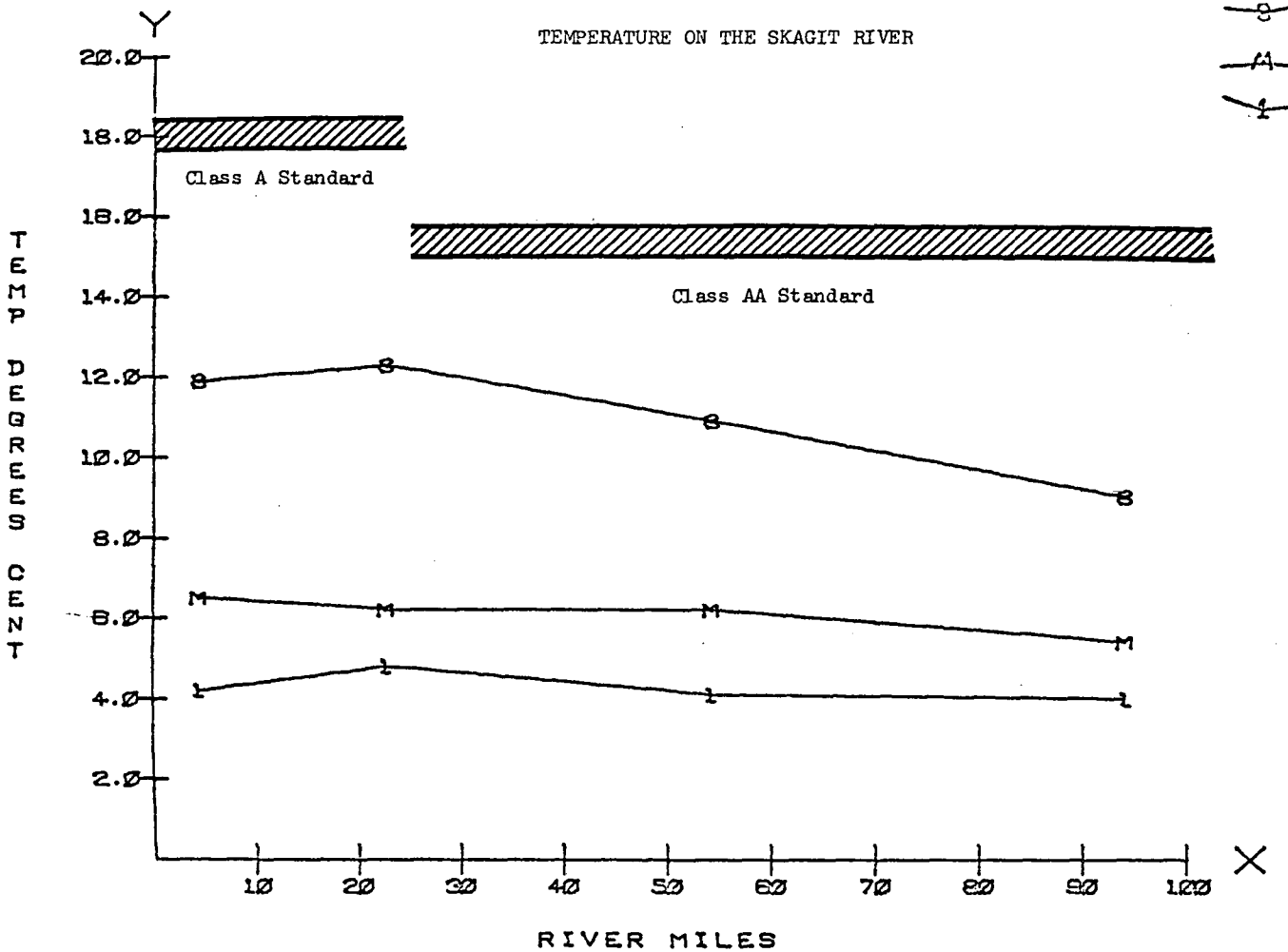
DOE / USGS DATA

12/70 - 3/74

85%

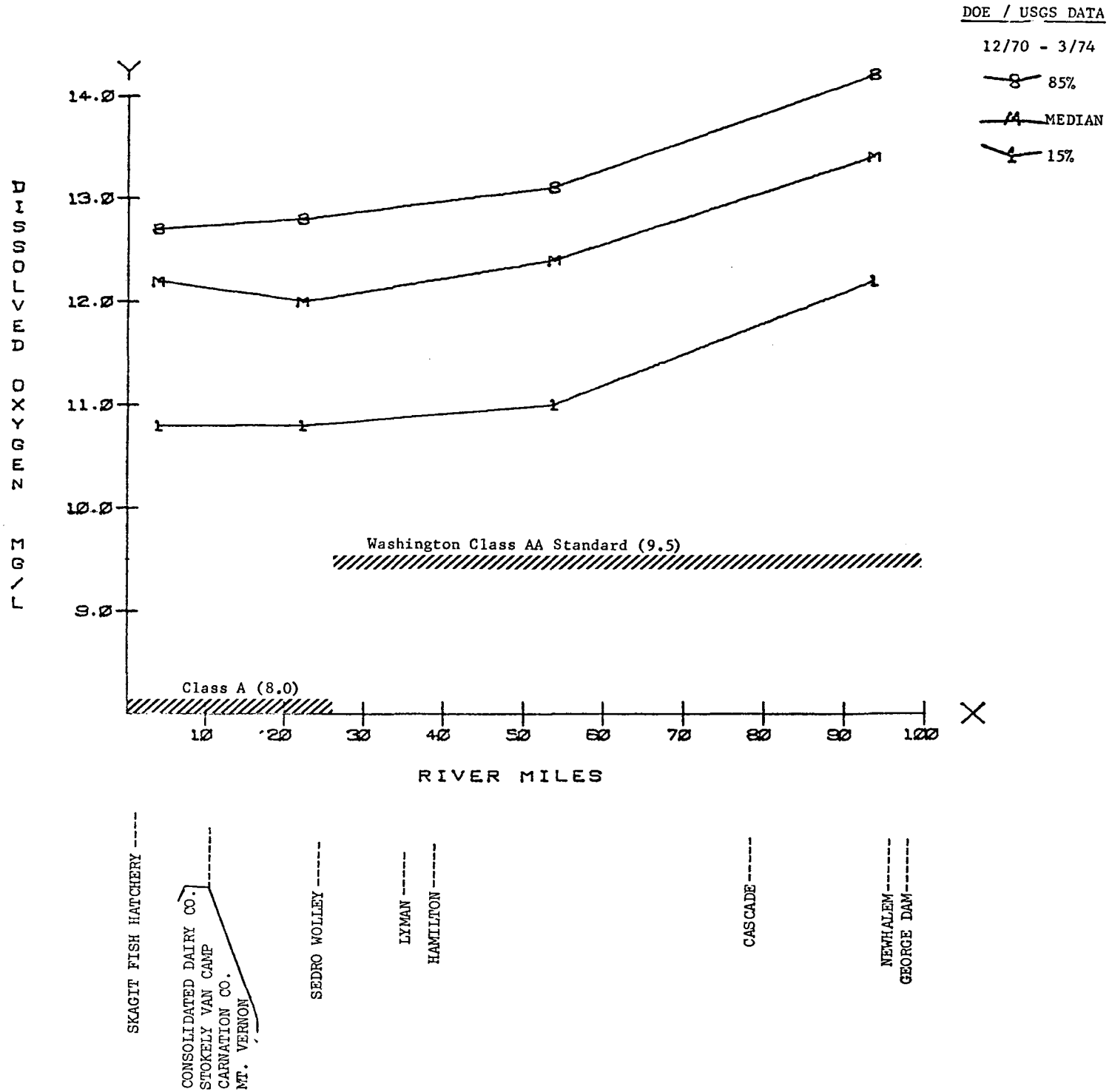
MEDIAN

15%



TURBIDITY ON THE SKAGIT RIVER
DOE/USGS DATA
12/70 - 3/74
85%
Median
15%
03A050: @ CONWAY
03A070: NR. SEDRO WOOLLEY
04A060: @ CONCRETE
04A140: @ NEWHALEM
TURBIDITY
Y
X
25
20
15
10
5
10
20
30
40
50
60
70
80
90
100
RIVER MILES
SKAGIT FISH HATCHERY
CONSOLIDATED DAIRY CO.
STOKELY VAN CAMP
CARNATION CO.
MT. VERNON
SEDRO WOLLEY
LYMAN
HAMILTON
CASCADE
NEWHALEM
GEORGE DAM

CONDUCTIVITY ON THE SKAGIT RIVER


DOE / USGS DATA
12/70 - 3/74
85%
MEDIAN
15%
DISSOLVED OXYGEN MG/L
14.0
13.0
12.0
11.0
10.0
9.0
Washington Class AA Standard (9.5)
Class A (8.0)
10
20
30
40
50
60
70
80
90
100
RIVER MILES
SKAGIT FISH HATCHERY
CONSOLIDATED DAIRY CO.
STOKELY VAN CAMP
CARNATION CO.
MT. VERNON
SEDRO WOLLEY
LYMAN
HAMILTON
CASCADE
NEWHALEM
GEORGE DAM

DOE / USGS DATA

12/70 - 3/74

8 85%

M MEDIAN

1 15%

Y

9.0

8.5

8.0

7.5

7.0

6.5

6.0

5.5

PH

Washington Class A & AA Standard

8 8 8 8

M M M M

1 1 1 1

10 20 30 40 50 60 70 80 90 100

X

RIVER MILES

SKAGIT FISH HATCHERY

CONSOLIDATED DAIRY CO.

STOKELY VAN CAMP

CARNATION CO.

MT. VERNON

SEDRO WOLLEY

LYMAN

HAMILTON

CASCADE

NEWHALEM

GEORGE DAM

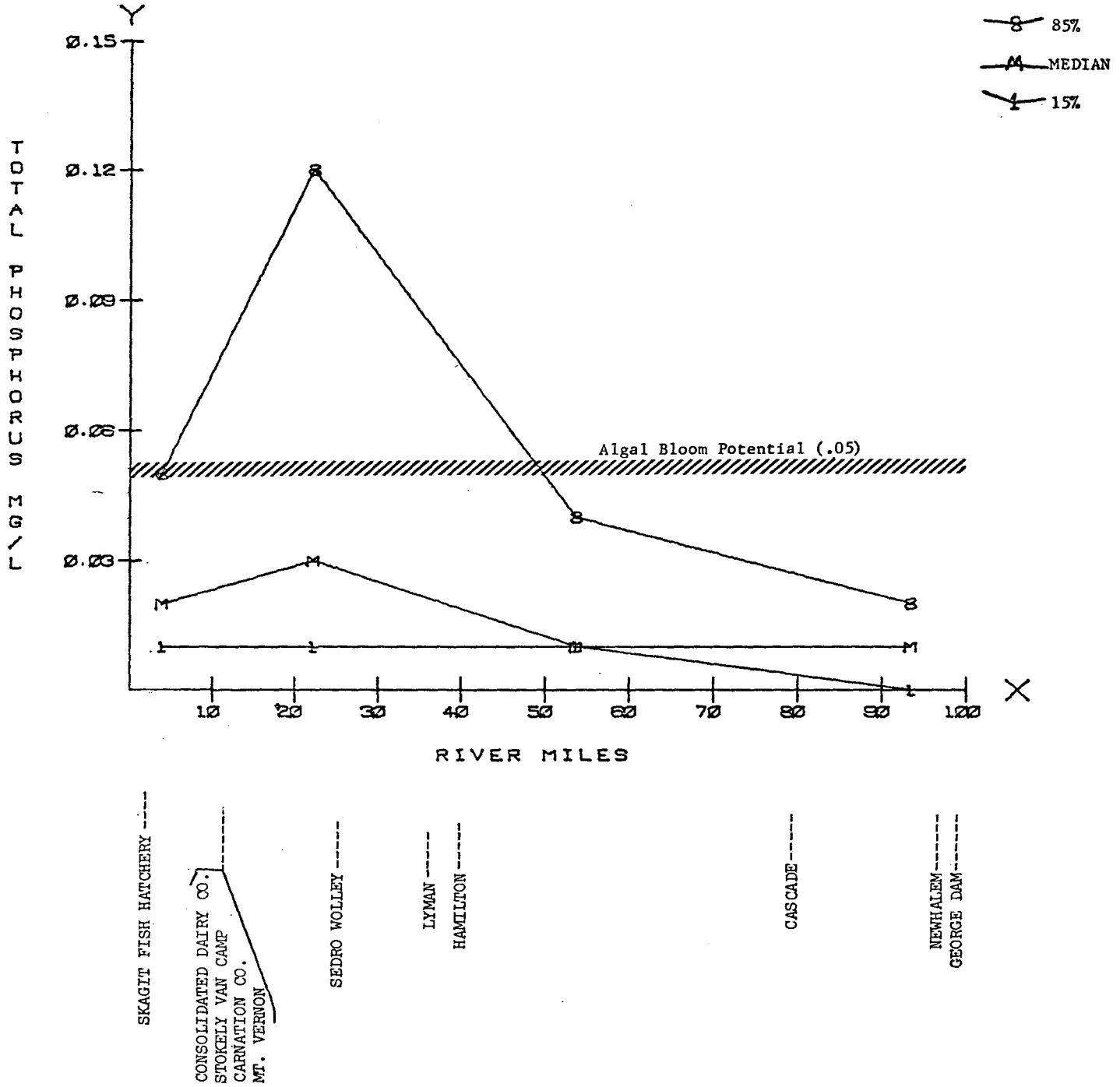
DOE/USGS DATA

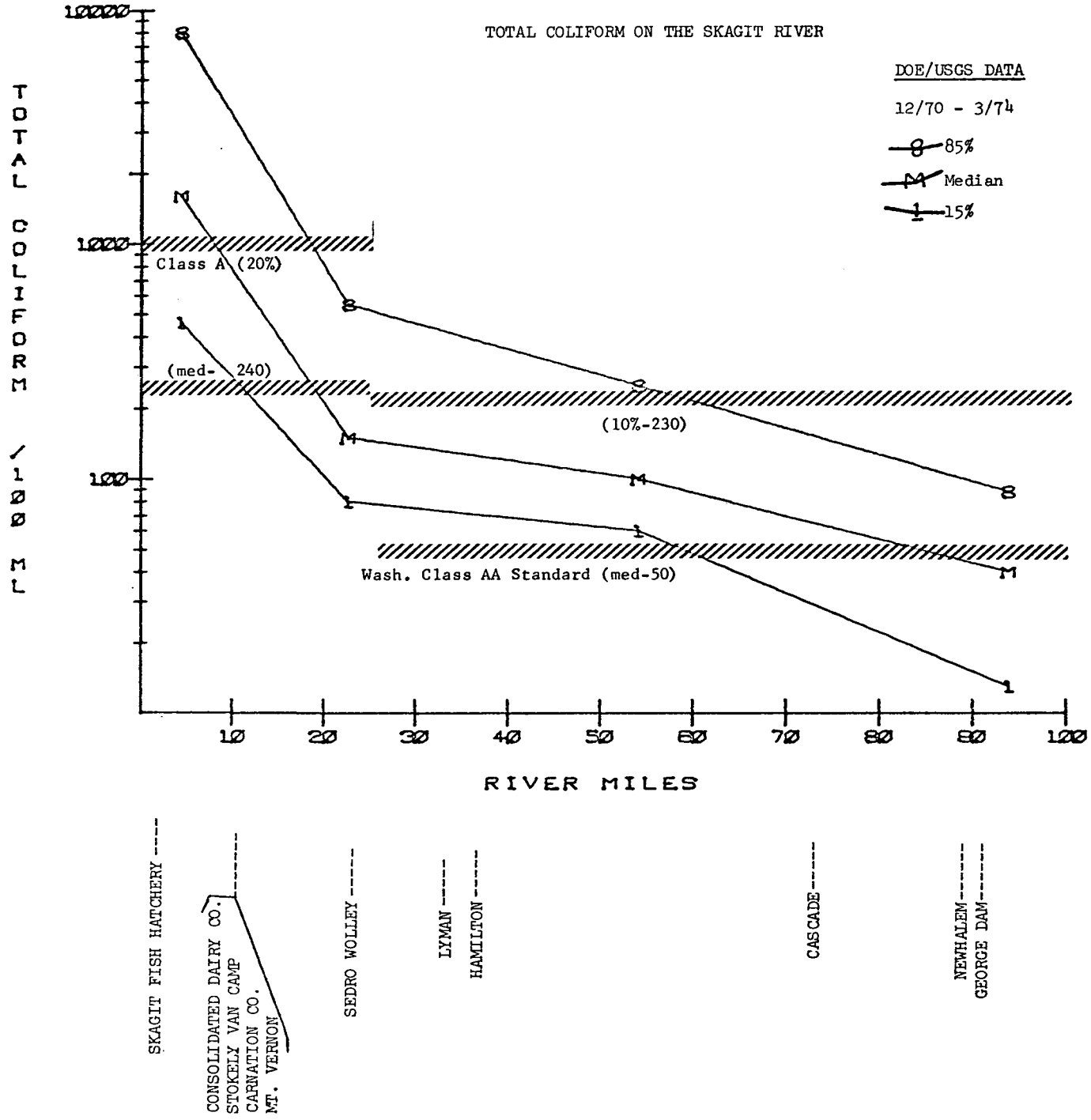
12/70 - 10/73

8 85%

M Median

1 15%


DOE / USGS DATA
12/70 - 3/74
85%
MEDIAN
15%
Y
TOTAL PHOSPHORUS MG/L
Ø.15
Ø.12
Ø.09
Ø.06
Ø.03
Algal Bloom Potential (.05)
10
20
30
40
50
60
70
80
90
100
X
RIVER MILES
SKAGIT FISH HATCHERY
CONSOLIDATED DAIRY CO.
STOKELY VAN CAMP
CARNATION CO.
MT. VERNON
SEDRO WOLLEY
LYMAN
HAMILTON
CASCADE
NEWHALEM
GEORGE DAM


TOTAL COLIFORM ON THE SKAGIT RIVER
DOE/USGS DATA
12/70 - 3/74
85%
Median
15%
TOTAL COLIFORM /100 ML
100000
10000
1000
100
Class A (20%)
(med- 240)
(10%-230)
Wash. Class AA Standard (med-50)
10
20
30
40
50
60
70
80
90
100
RIVER MILES
SKAGIT FISH HATCHERY
CONSOLIDATED DAIRY CO.
STOKELY VAN CAMP
CARNATION CO.
MT. VERNON
SEDRO WOLLEY
LYMAN
HAMILTON
CASCADE
NEWHALEM
GEORGE DAM

SKOKOMISH - HAMMA HAMMA - DUCKABUSH - DOSEWALLIPS RIVER BASIN

SKOKOMISH-HAMMA-HAMMA-DUCKABUSH-DOSEWALLIPS RIVER BASIN
BASIN DESCRIPTION

1. Drainage Area -412.2 sq. m.

2. Average Flow - (at Hoodsport) mean = 487 cfs
min. = 256 cfs
max. = 688 cfs
(at Index) mean = 2 385 cfs
min. = 1 352 cfs
max. = 3 383 cfs

3. Waste Sources - 0

4. Major Diversions - Domestic - 2 cfs

Industrial - 2 cfs

Hydropower - 2 800 cfs

5. Surface Water Rights - Municipal - .5 cfs

Irrigation - 12.35 cfs

Individual & Community Domestic - 41.42 cfs

Industrial & Commercial - .7 cfs

Fish. Propogation - 73.47 cfs

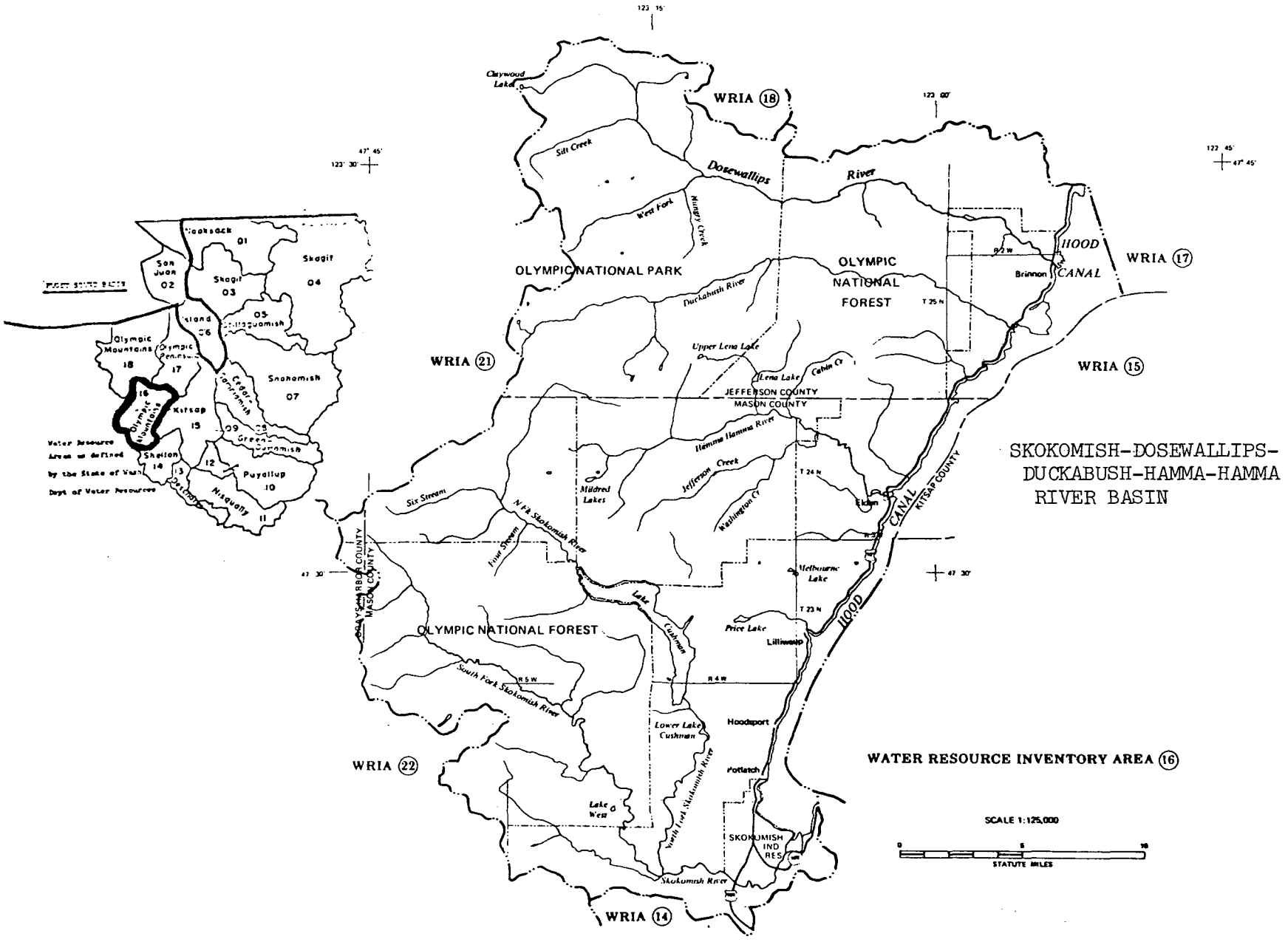
Stock - .15 cfs

Total - 2,709.37 cfs

6. Reservoir Storage Rights - 417,300 acre-feet

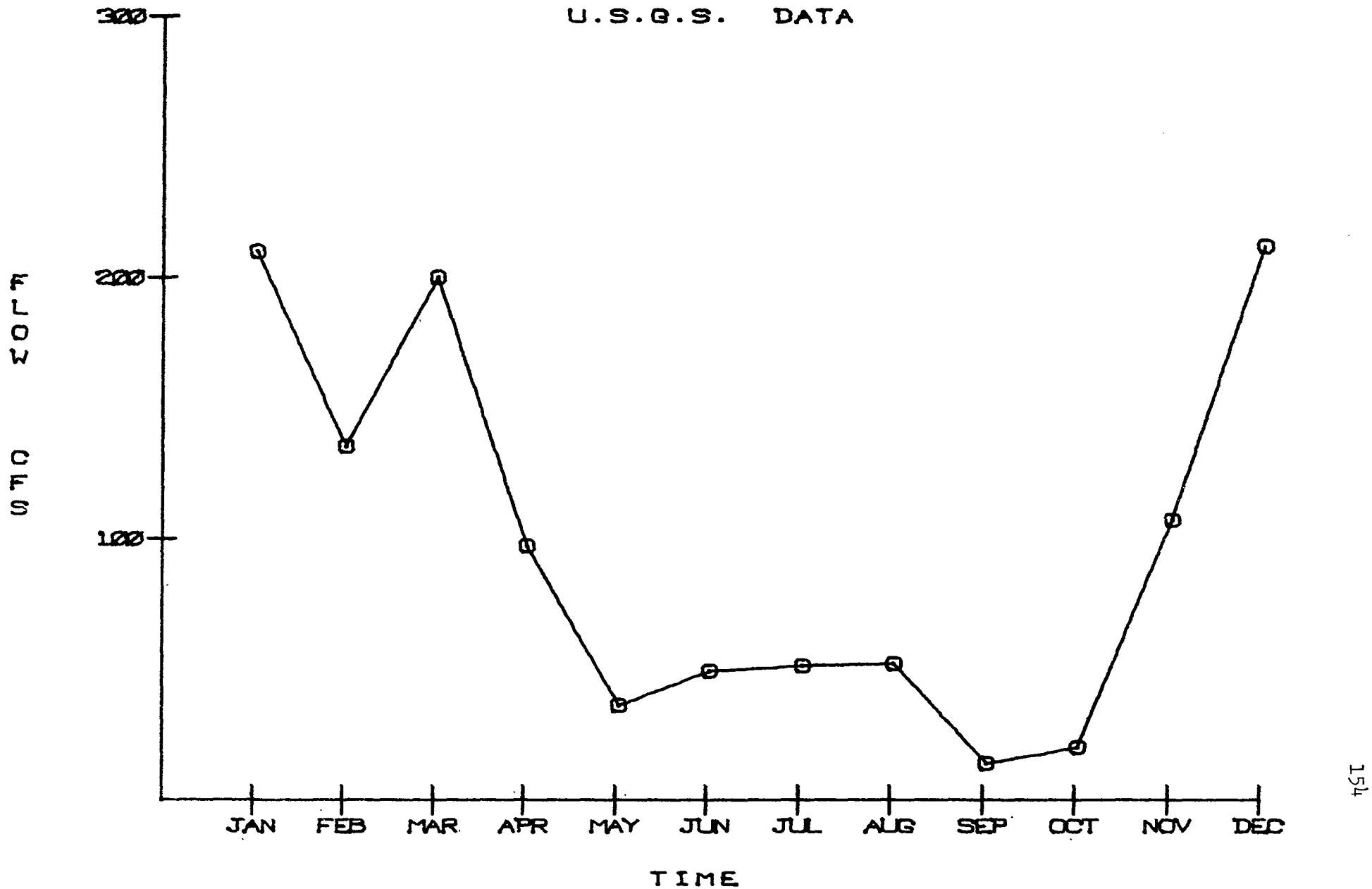
7. Projected Population -

1980	2000	2020
175,000	374,100	632,700

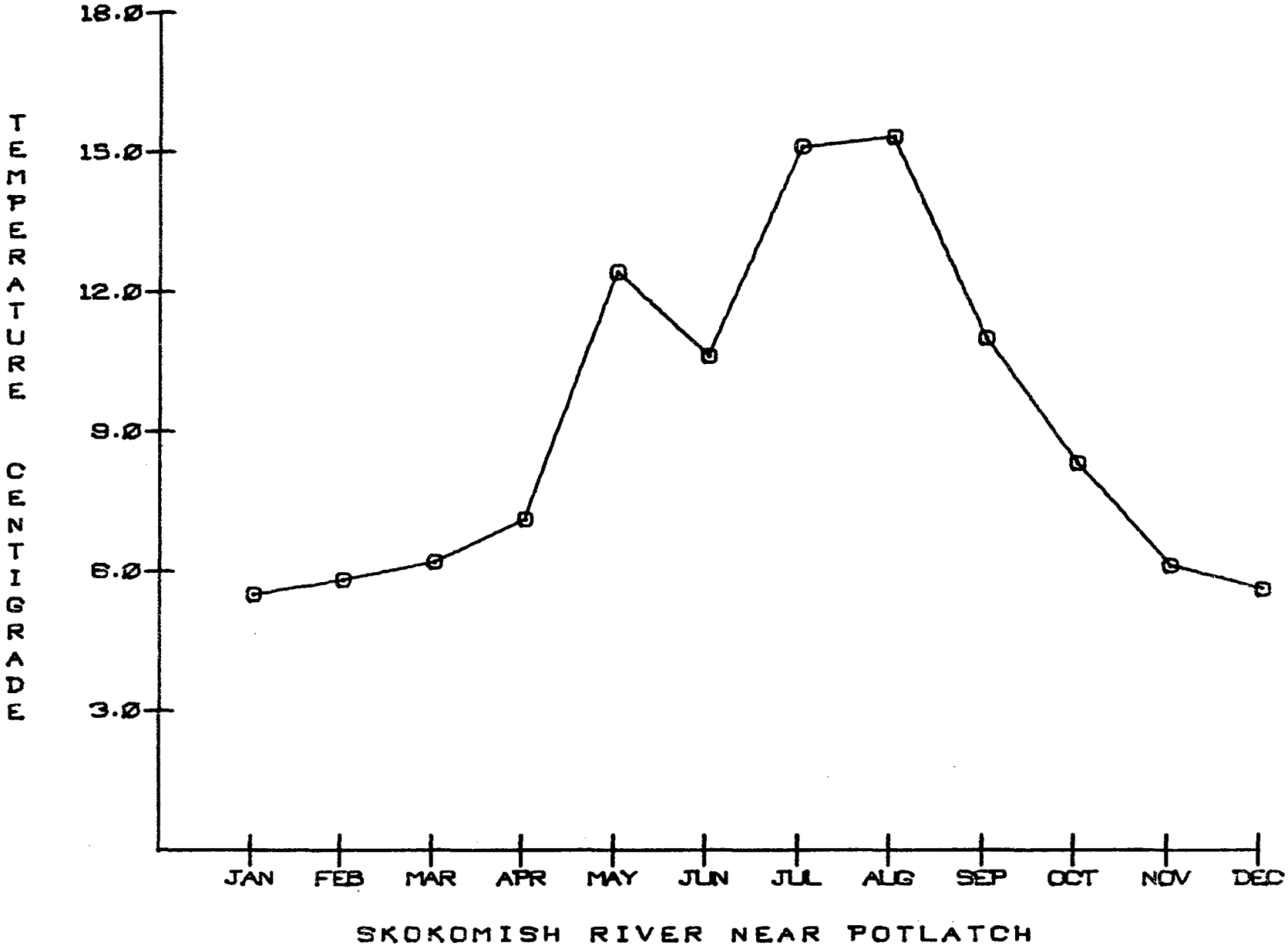


SKOKOMISH-DOSEWALLIPS-DUCKABUSH-HAMMA-HAMMA RIVER BASIN

WATER RESOURCE INVENTORY AREA (16)

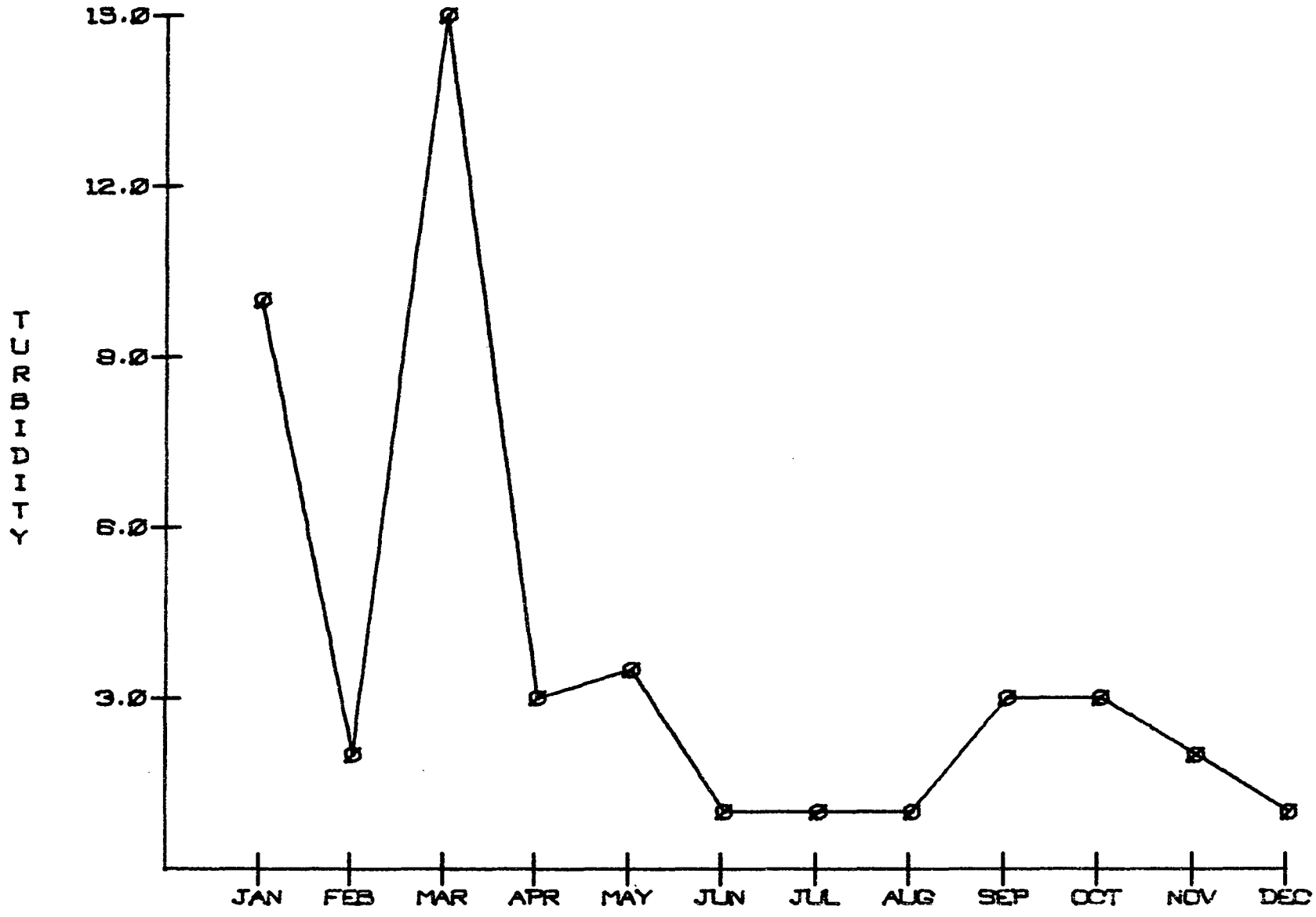

SKOKOMISH RIVER AT POTLATCH
MEAN VALUES 1971-1974
U.S.G.S. DATA
300
200
100
FLOW CFS
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
TIME

SINGLE SAMPLE VALUES (711027-740515)

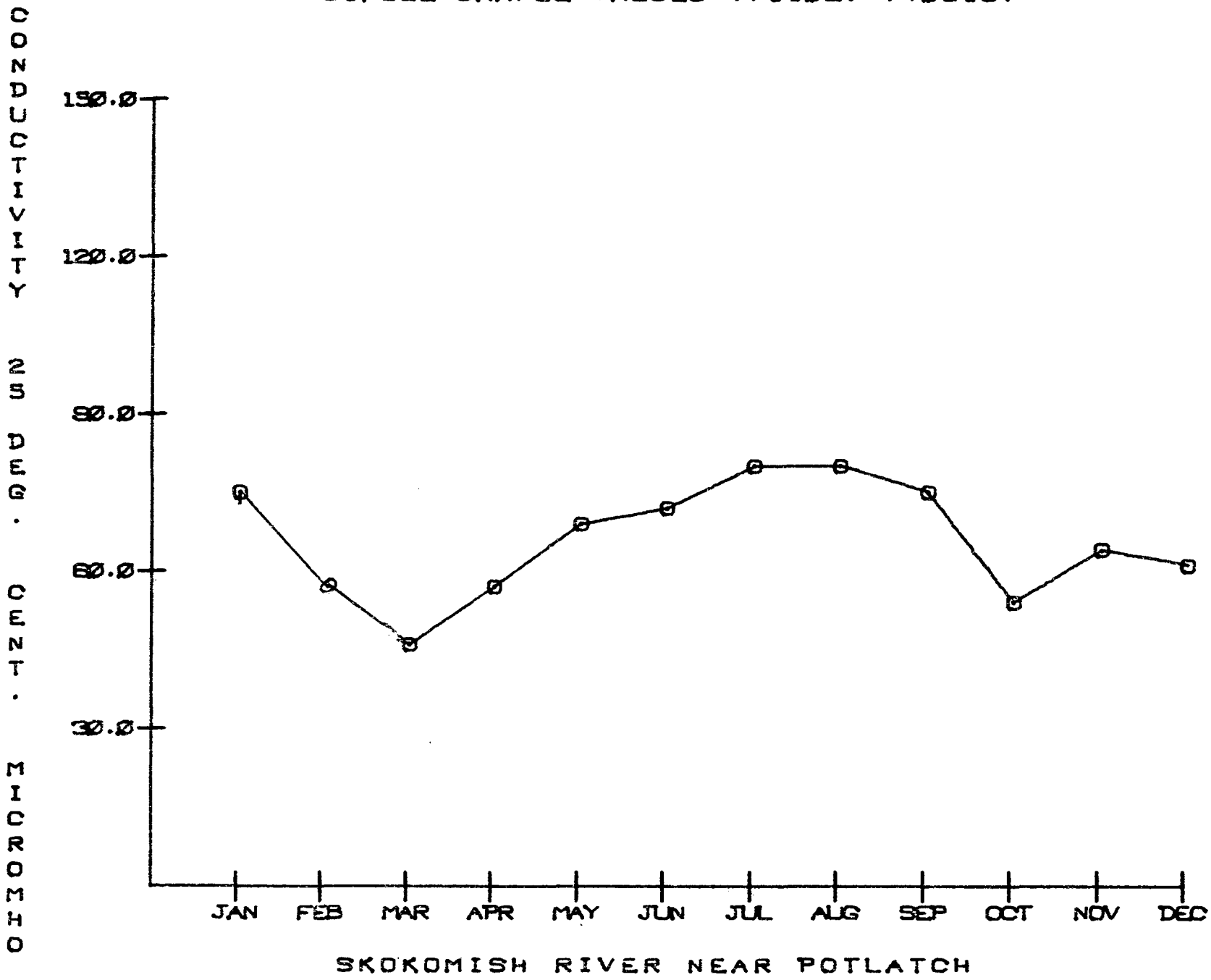


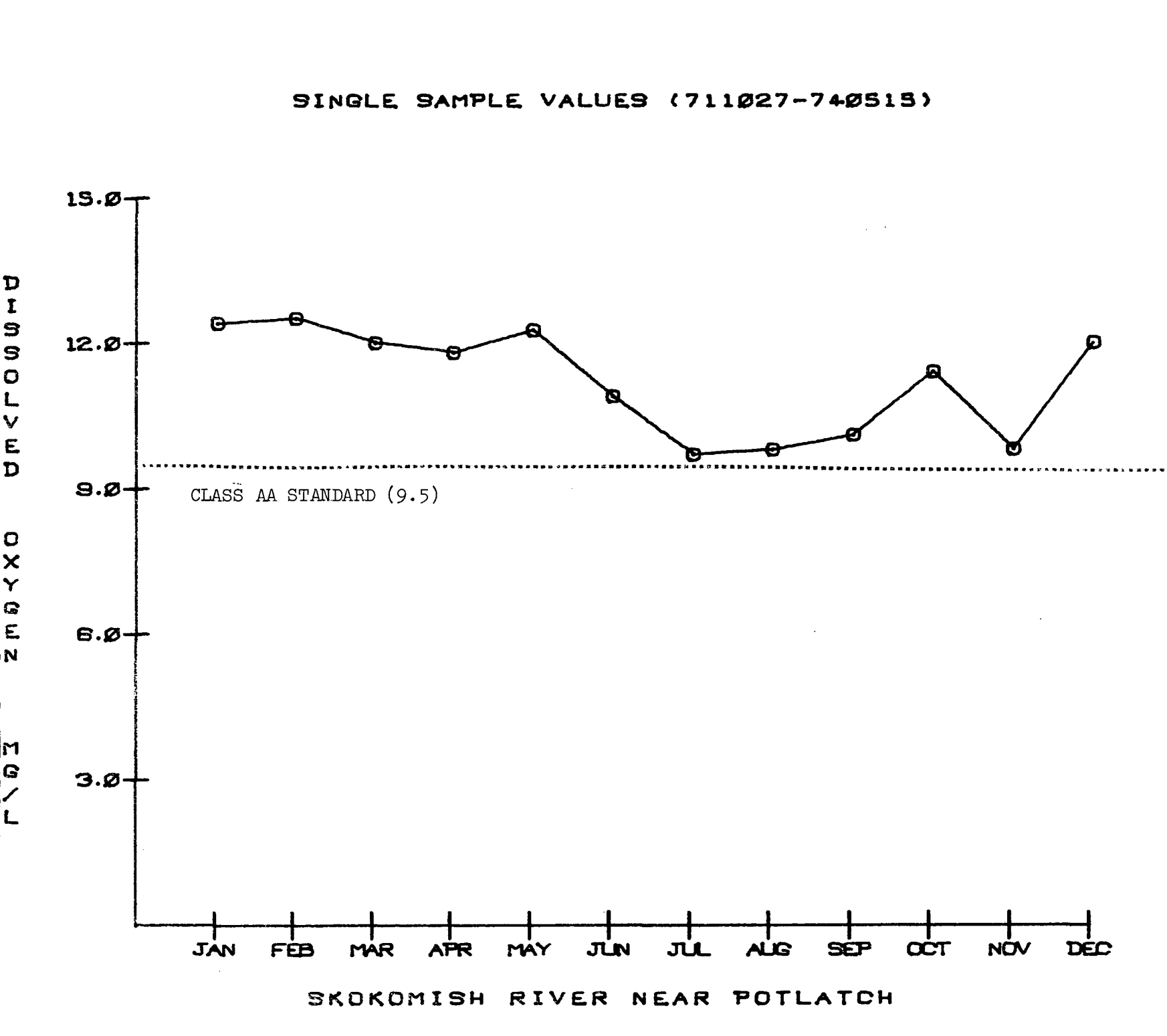
SKOKOMISH RIVER NEAR POTLATCH

SINGLE SAMPLE VALUES (711027-740515)

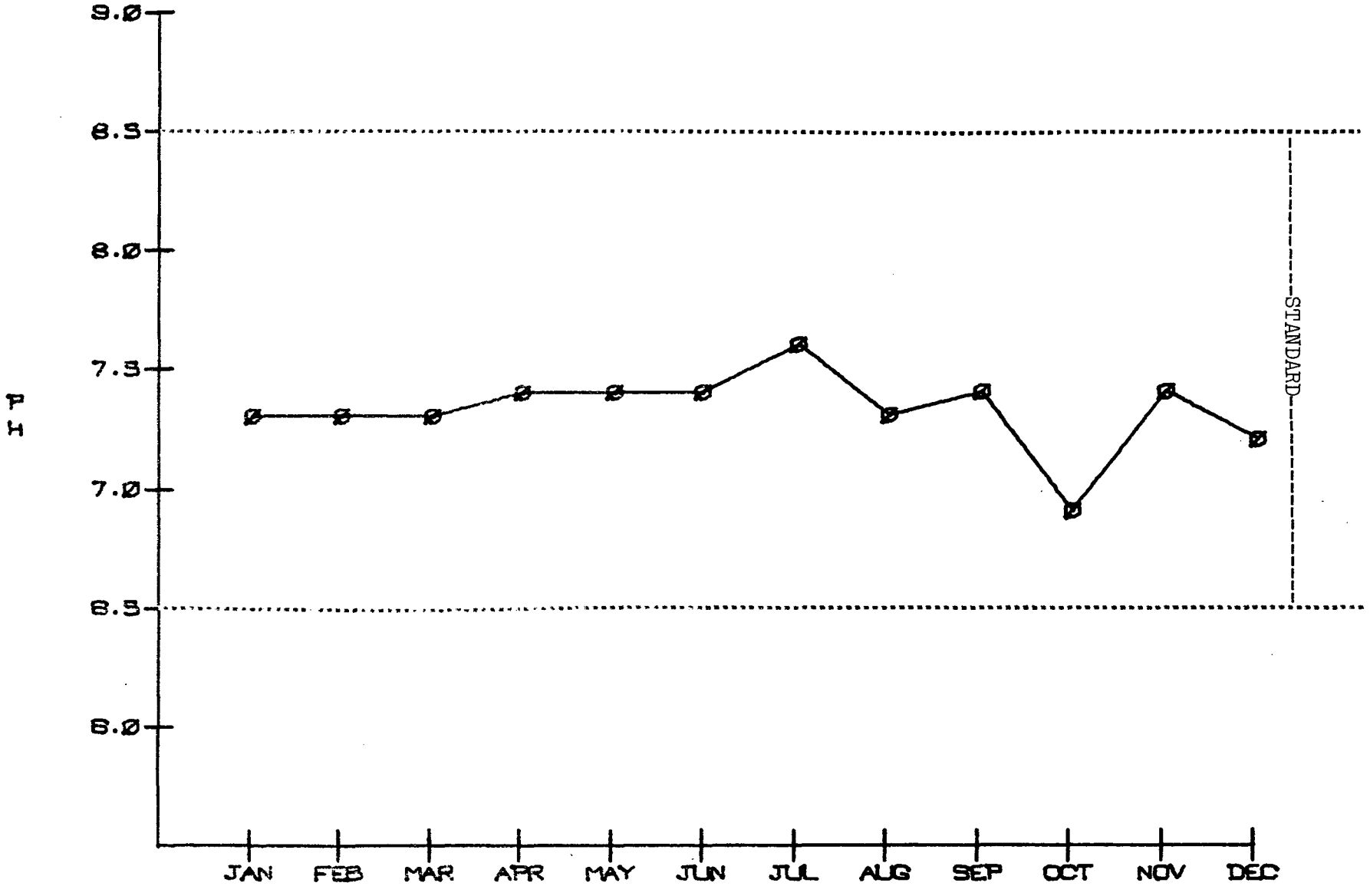


SKOKOMISH RIVER NEAR POTLATCH


SINGLE SAMPLE VALUES (711027-740515)
CONDUCTIVITY 25 DEG. CENT. MICROMHO
150.0
120.0
90.0
60.0
30.0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
SKOKOMISH RIVER NEAR POTLATCH

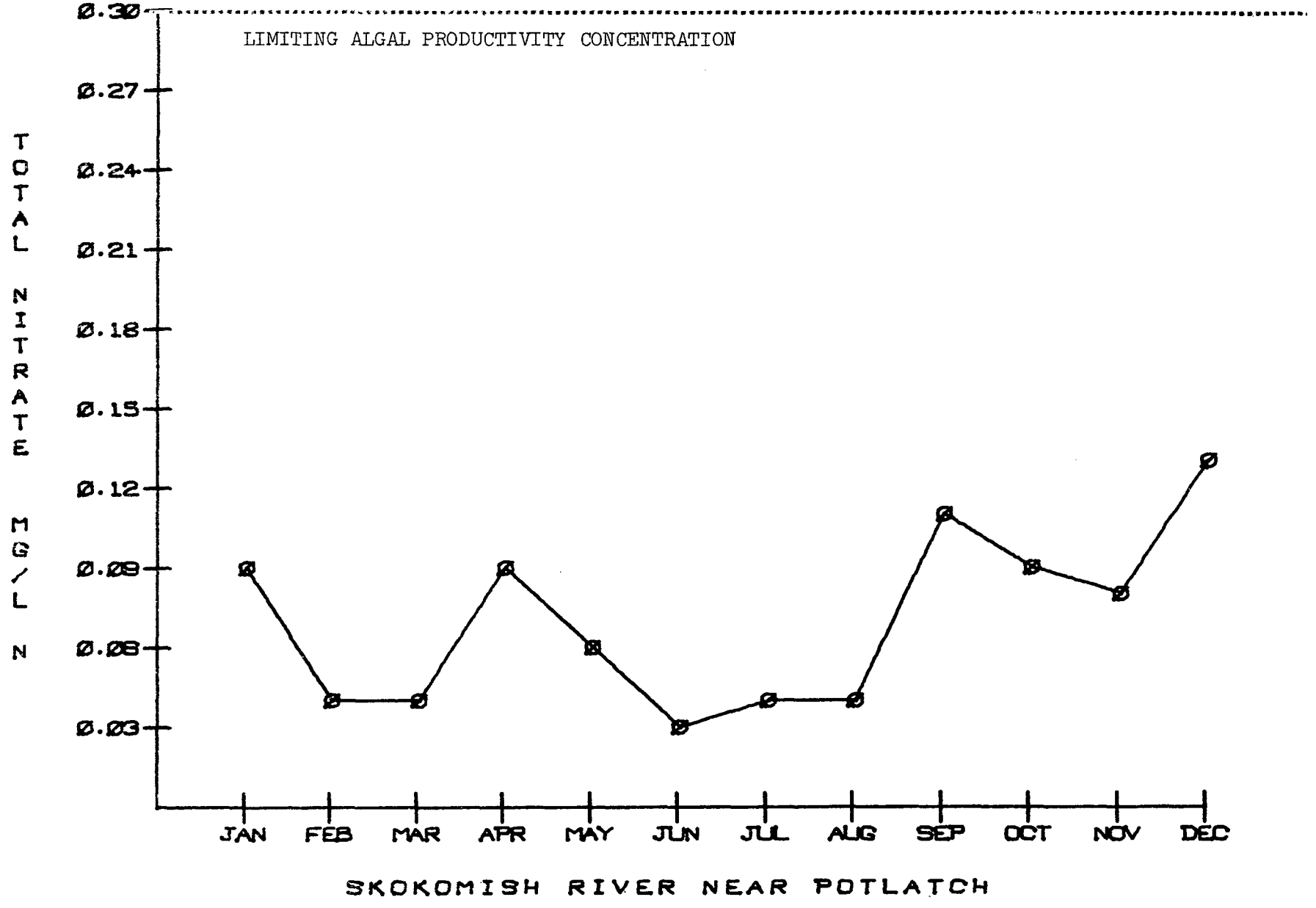

SINGLE SAMPLE VALUES (711027-740515)
15.0
12.0
9.0
6.0
3.0
DISSOLVED OXYGEN MG/L
CLASS AA STANDARD (9.5)
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
SKOKOMISH RIVER NEAR POTLATCH

SINGLE SAMPLE VALUES (711027-740515)



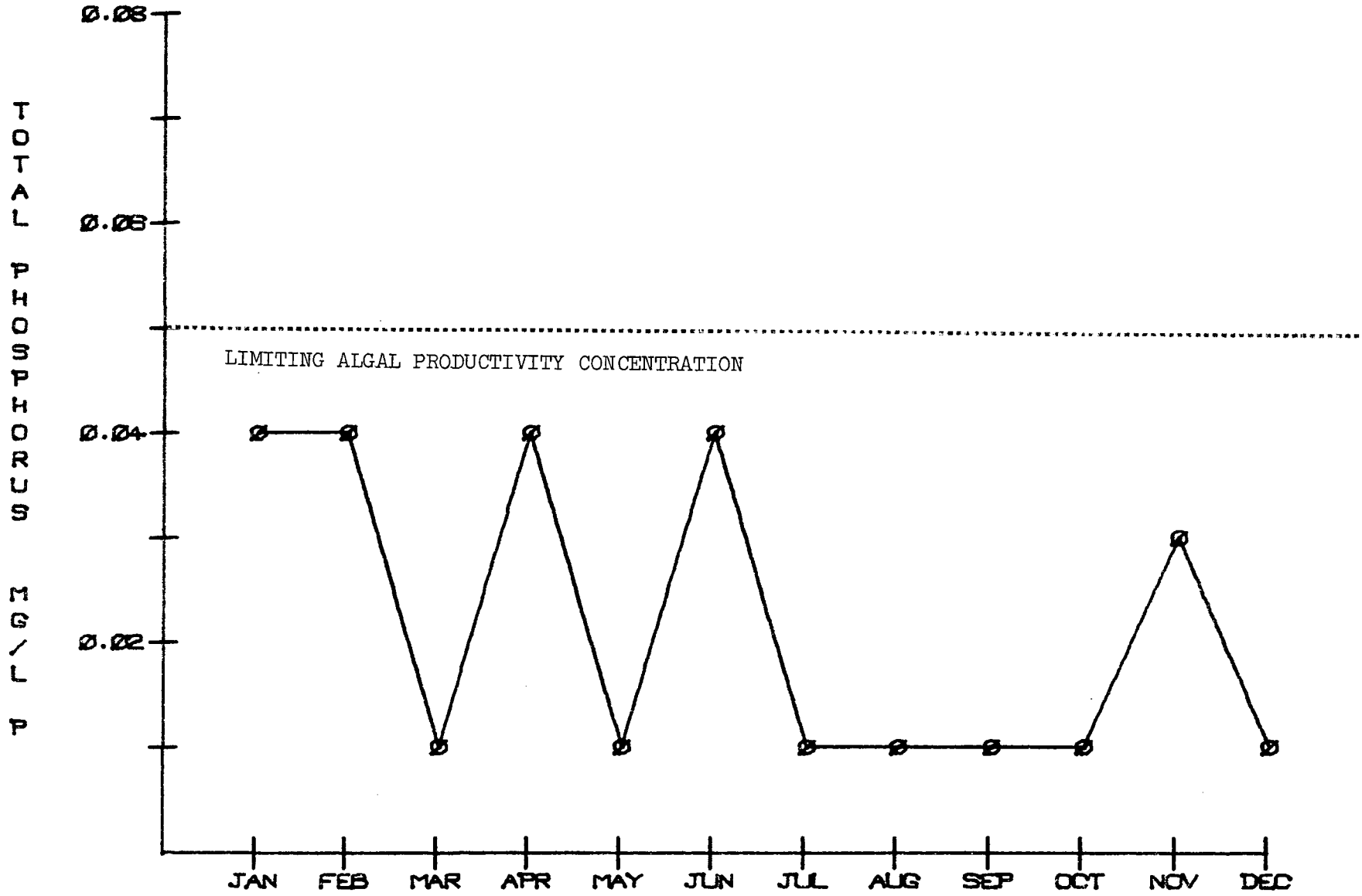
SKOKOMISH RIVER NEAR POTLATCH

SINGLE SAMPLE VALUES (711027-740515)



SKOKOMISH RIVER NEAR POTLATCH

SINGLE SAMPLE VALUES (711027-740515)



SKOKOMISH RIVER NEAR POTLATCH

SNOHOMISH RIVER BASIN

SNOHOMISH RIVER BASIN
BASIN DESCRIPTION

1. Drainage Area - 1 537 sq. m.

2. Average Flow - (nr. Monroe) mean = 11,860 cfs
min. = 1,900 cfs
max. = 55,100 cfs

3. Waste Sources - 14

4. Major Diversions - Domestic - 116 cfs

Industrial- 185 cfs

Hydropower- 2520 cfs

Irrigation- 12,000 acre-feet

5. Surface Water Rights - Municipal - 695.13 cfs

Irrigation- 83.78 cfs

Individual & Community Domestic - 57.69 cfs

Industrial & Commercial - 108.38 cfs

Fish. Propogation - 244.77 cfs

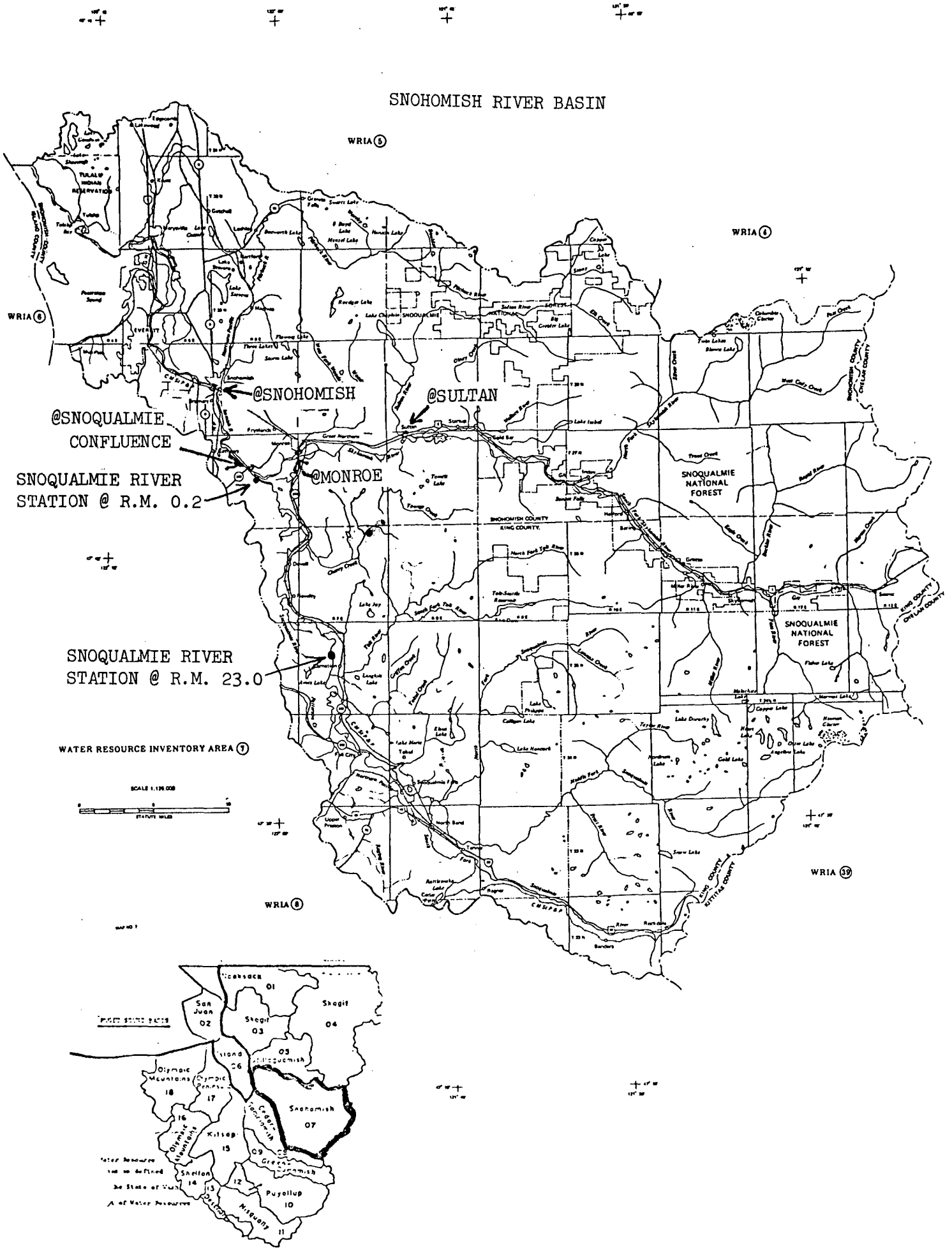
Stock - 1.1 cfs

Total - 1,805 .18 cfs

6. Reservoir Storage Rights - 195,935 cfs

7. Projected Population -

1980	2000	2020
297,800	467,800	761,400


SNOHOMISH RIVER BASIN
WRIA 5
WRIA 4
WRIA 6
WRIA 39
WRIA 8
@SNOHOMISH
@SULTAN
@SNOQUALMIE CONFLUENCE
@MONROE
SNOQUALMIE RIVER STATION @ R.M. 0.2
SNOQUALMIE RIVER STATION @ R.M. 23.0
SNOQUALMIE NATIONAL FOREST
SNOQUALMIE NATIONAL FOREST
SNOHOMISH COUNTY
KING COUNTY
WATER RESOURCE INVENTORY AREA 7
San Juan 02
Skagit 03
Skagit 04
Island 06
Snohomish 07
Kitsap 15
Shelton 14
Puyallup 10
Nisqually 11
Olympic Mountains 18
Olympic Peninsula 17

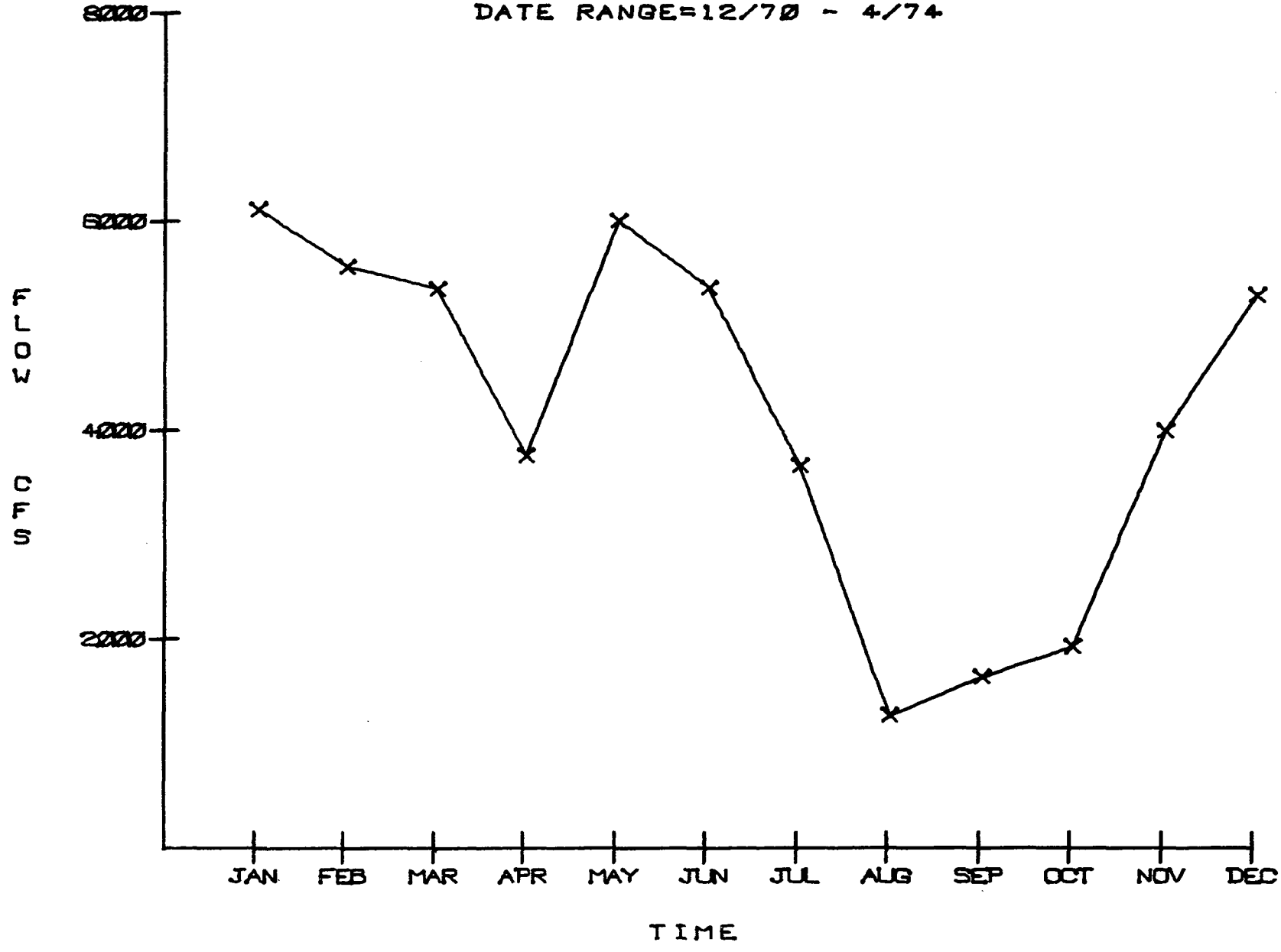
SNOHOMISH RIVER BASIN
REPORTED PROBLEMS

1. Total Nitrate and Total Phosphorus values are occasionally exceeding the limiting algal bloom potential concentration on both the Snohomish and Snoqualmie river.

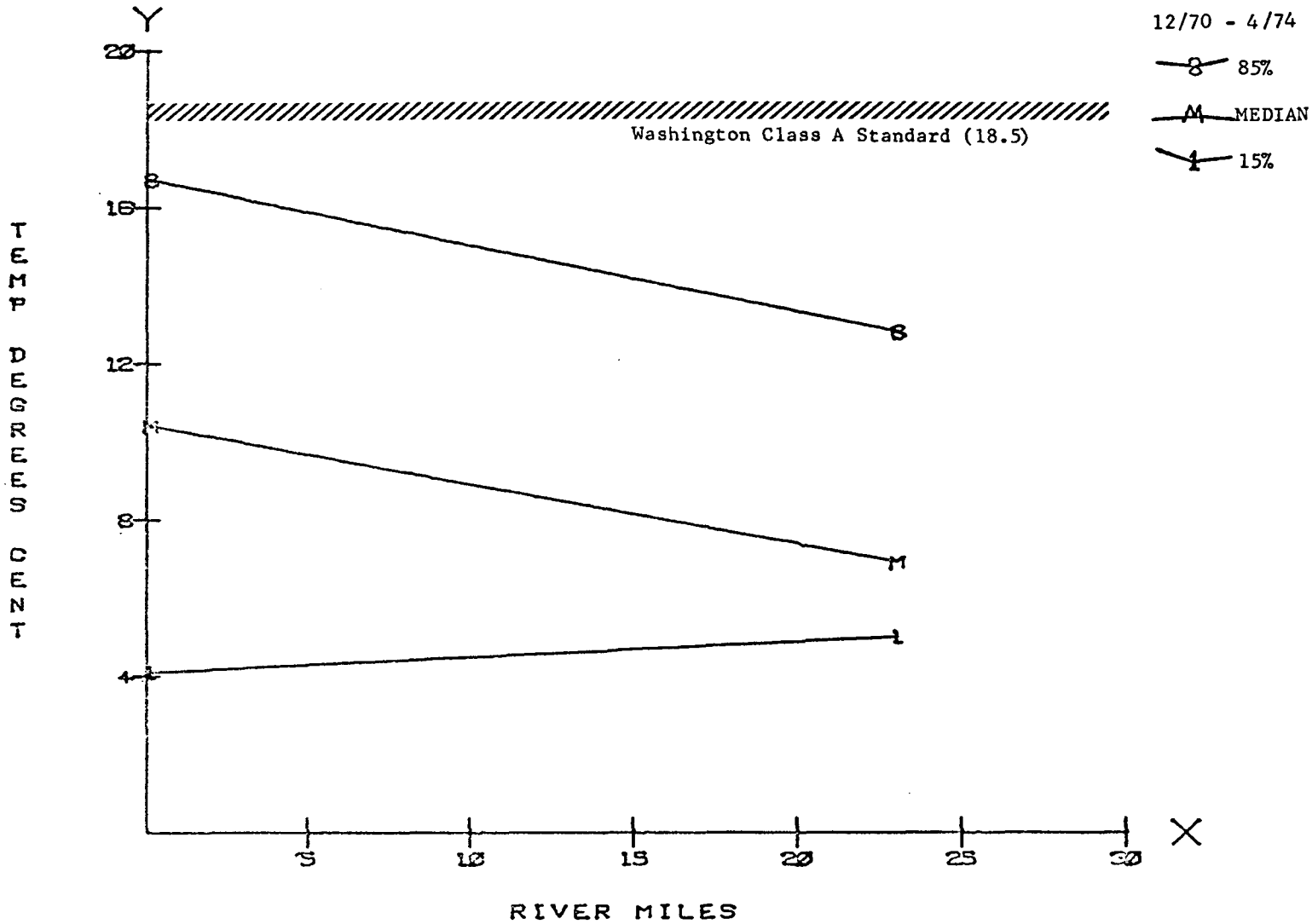
2. Total Coliform concentrations occasionally violate standards on the Snoqualmie with increasing frequency as one travels upstream, while violations occur with increasing frequency on the Snohomish as one approaches it's mouth.

3. Dissolved Oxygen levels fall below standards on the Snoqualmie near the mouth occasionally.

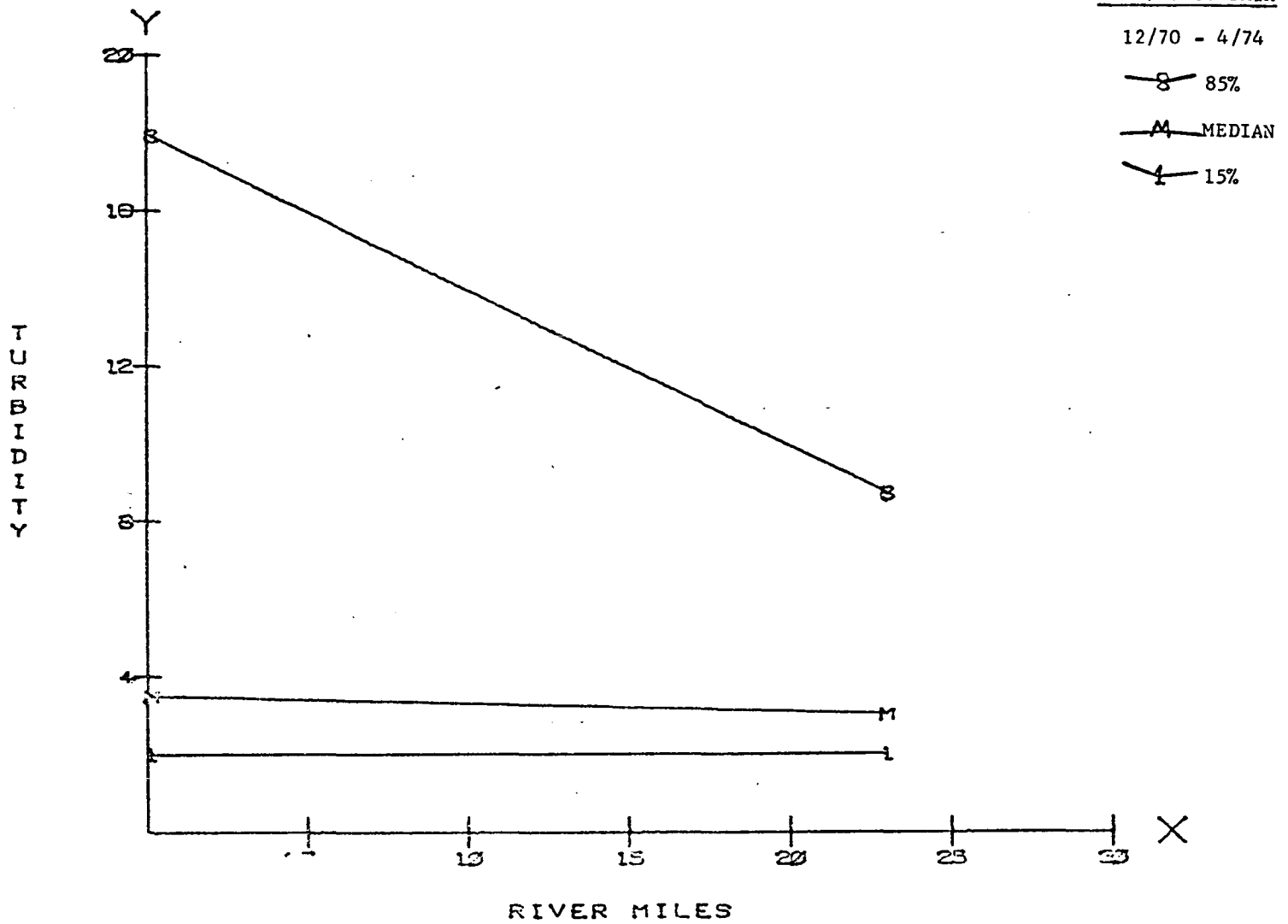
SNOQUALMIE RIVER


SNOQUALMIE RIVER NEAR CARNATION
U.S.G.S. DATA----MEAN VALES
DATE RANGE=12/70 - 4/74
8000
6000
4000
2000
FLOW CFS
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
TIME

TEMPERATURE ON THE SN[redacted]ALMIE RIVER



TURBIDITY ON THE SNO..J[redacted]MIE RIVER



CONDUCTIVITY ON THE SNOQUALMIE RIVER

DOE / USGS DATA

12/70 - 4/74

85%

MEDIAN

15%

CONDUCTIVITY MICROMHO

Y

75

60

45

30

15

8

M

1

X

5

10

15

20

25

30

RIVER MILES

PEOPLES CREEK---

CHERRY CREEK---

TRUCK CREEK---

HARRIS CREEK---

CARNATION COMPANY---

TOLT RIVER---

GRIFFIN CREEK---

DISSOLVED OXYGEN ON THE SNOQUALMIE RIVER

DOE / USGS DATA

12/70 - 4/74

85%

MEDIAN

15%

Y

14

13

12

11

10

9

CLASS AA WATER QUALITY STANDARD

0

5

10

15

20

25

30

X

RIVER MILES

PEOPLES CREEK

CHERRY CREEK

TUCKY CREEK

HARRIS CREEK

WEYERHAUSER COMPANY

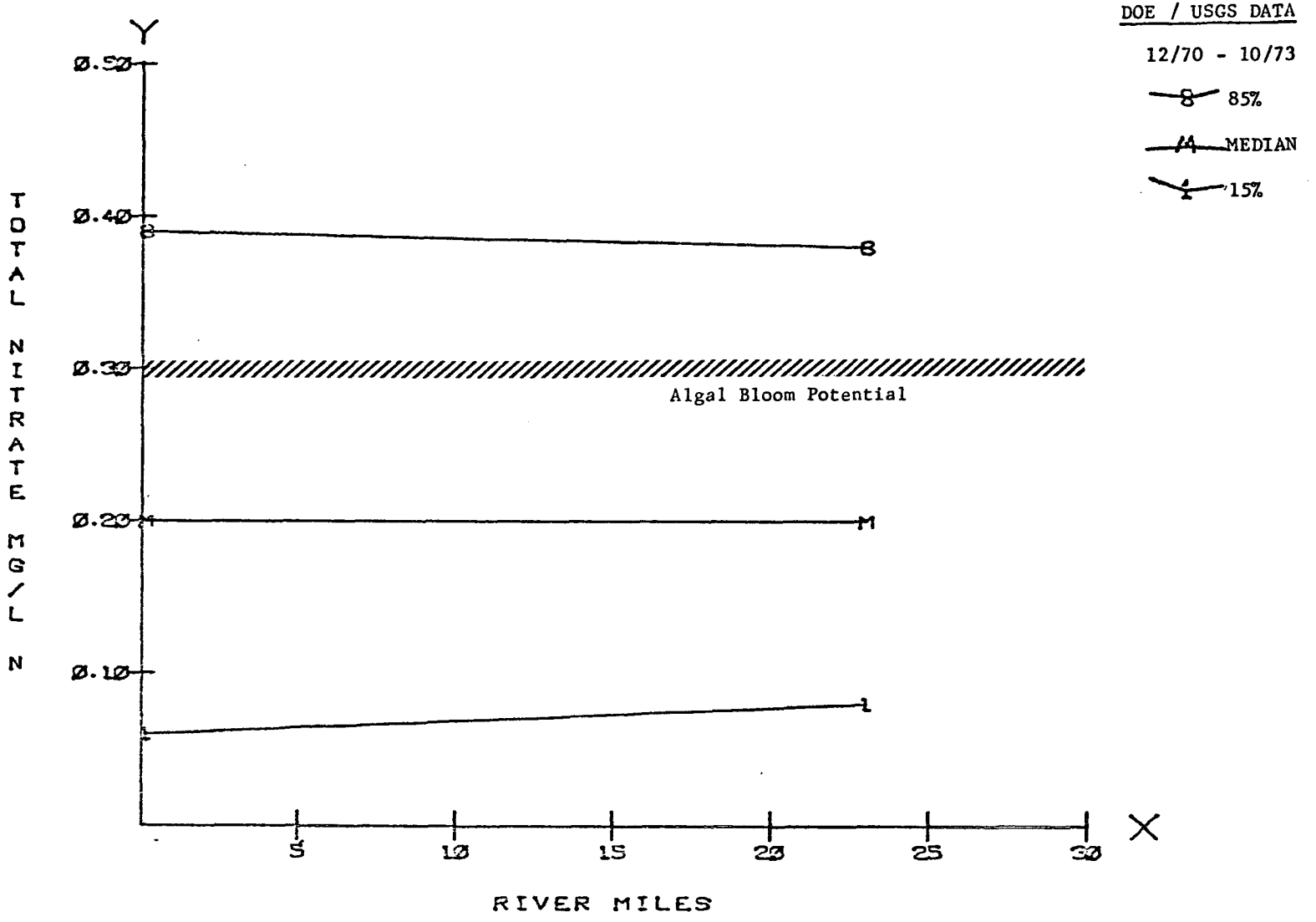
TOLT RIVER

GRIFFIN CREEK

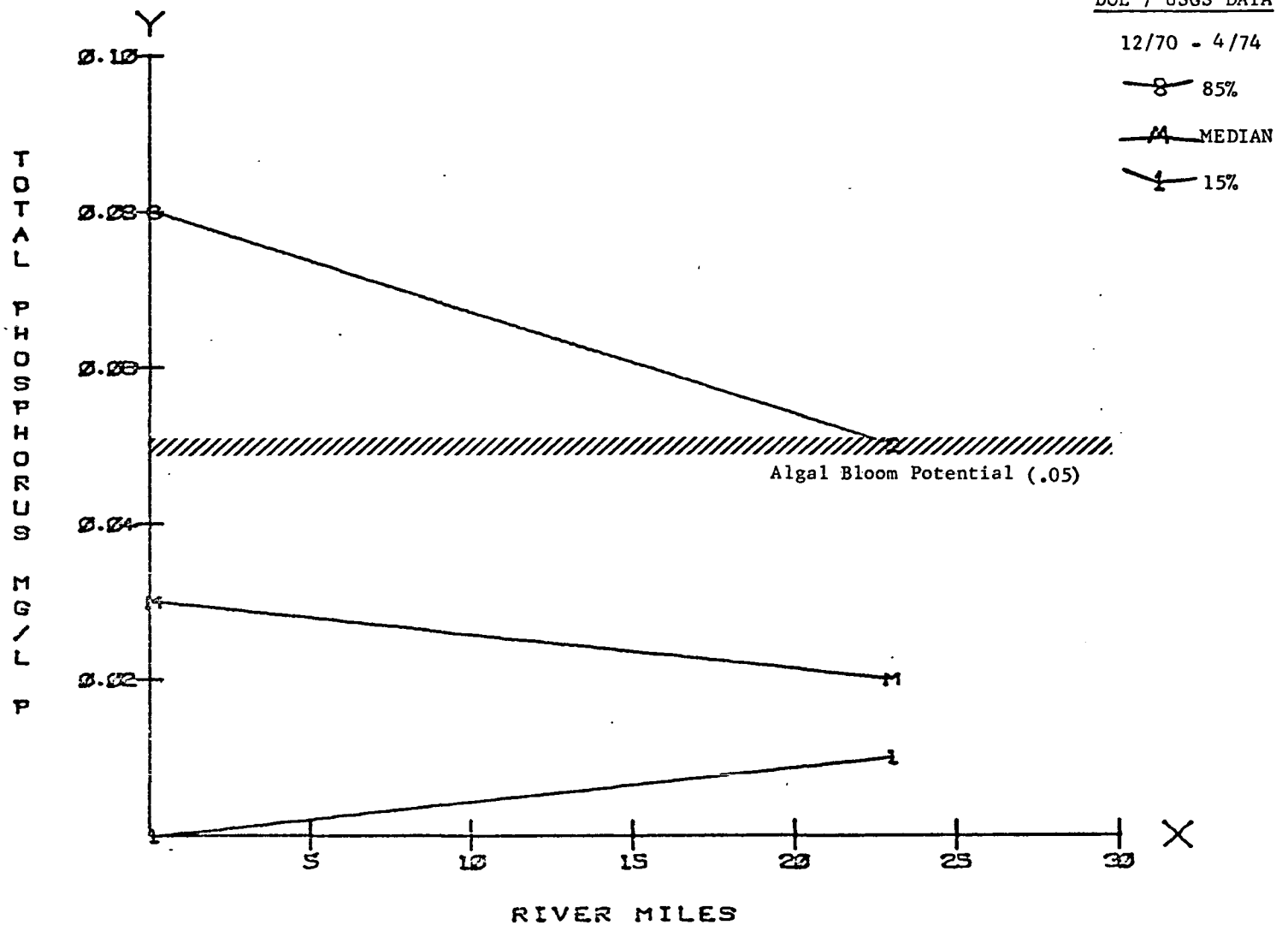
DISSOLVED OXYGEN (mg/l)

PH ON THE SNOQUALMIE RIVER

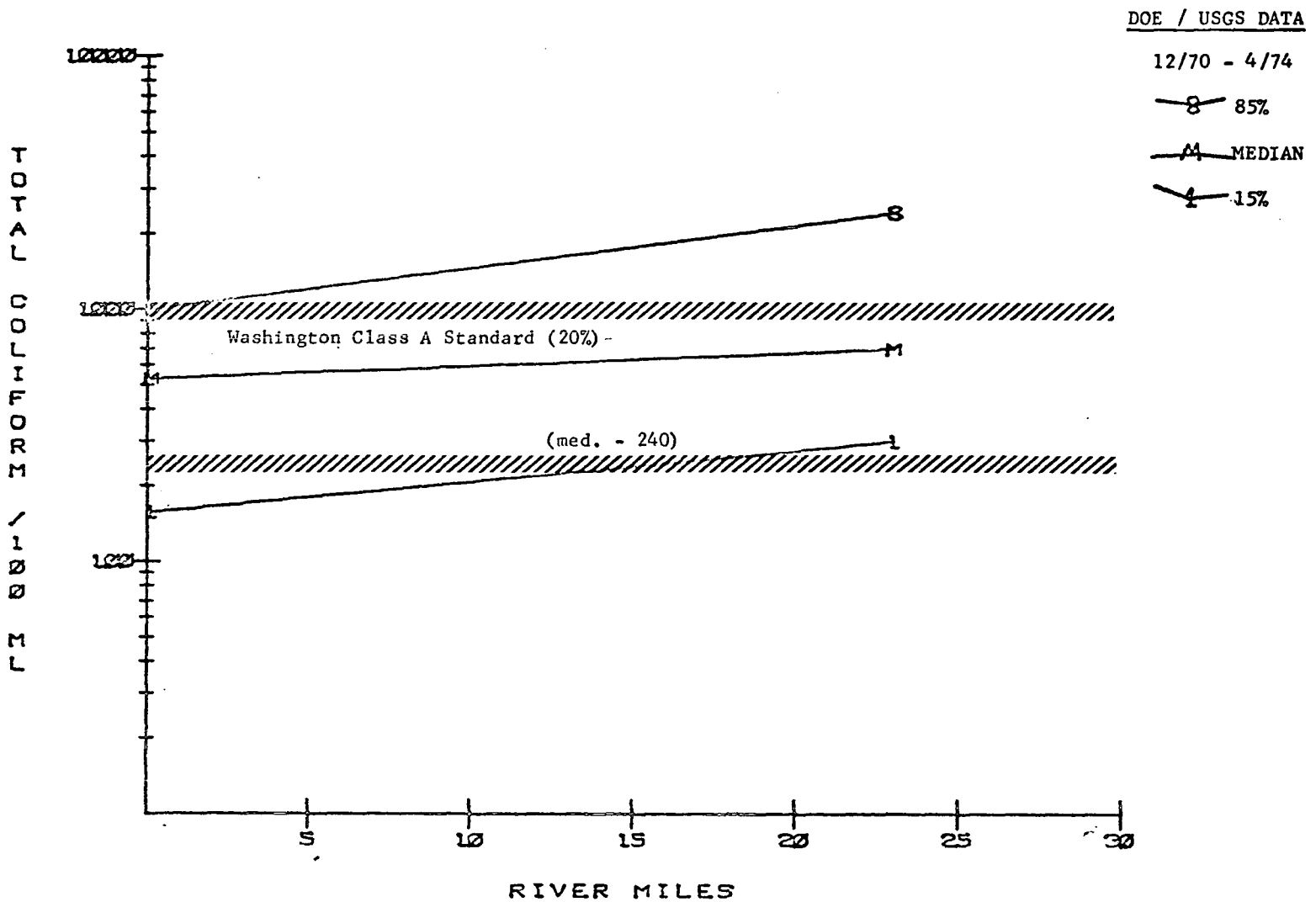
TOTAL NITRATE ON THE SNO[redacted]ALMIE RIVER



TOTAL PHOSPHORUS ON THE SNOQUALMIE RIVER.



TOTAL COLIFORM ON THE S[redacted]QUALMIE RIVER



SNOHOMISH RIVER

WATER TEMPERATURE ON THE SNOHOMISH RIVER

DOE / USGS DATA

12/70 - 4/74

85%

MEDIAN

15%

Washington Class A Standard, RM 8-36 (18.5)

TEMP DEGREES CENT

20

16

12

8

4

@SNOHOMISH

CONFLUENCE

@SNOQUALMIE

@MONROE

@SULTAN

0

12

22

43

50

RIVER MILES

WEYERHAUSER CO.---
EVERETT STP---

LOWELL---

SNOHOMISH STP---

PILCHUCK RIVER---
FRENCH CREEK---

SNOQUALMIE RIVER----

WOODS CREEK----

BARR CREEK----

ELWELL CREEK----

MCCOY CREEK-----
SULTAN RIVER----
WALLACE RIVER---

PUFFEY CREEK----
PROCTOR CREEK

PROCTOR CREEK----

ANDERSON CREEK----
F. SKYKOMISH RIVER----

TURBIDITY ON THE SNOHOMISH RIVER

DOE / USGS DATA

12/70 - 4 /74

8 85%

M MEDIAN

1 15%

TURBIDITY

Y

20

15

12

8

4

X

10 20 30 40 50

RIVER MILES

WEYERHAUSER CO.---
EVERETT STP---
LOWELL---
SNOHOMISH STP---
PILCHUCK RIVER---
FRENCH CREEK---
SNOQUALMIE RIVER---
WOODS CREEK---
BARR CREEK---
ELWELL CREEK---
MCCOY CREEK---
SULTAN RIVER---
WALLACE RIVER---
PUFFEY CREEK---
PROCTOR CREEK
PROCTOR CREEK---
ANDERSON CREEK---
SKYKOMISH RIVER---

CONDUCTIVITY ON THE SNOHOMISH RIVER

DOE / USGS DATA

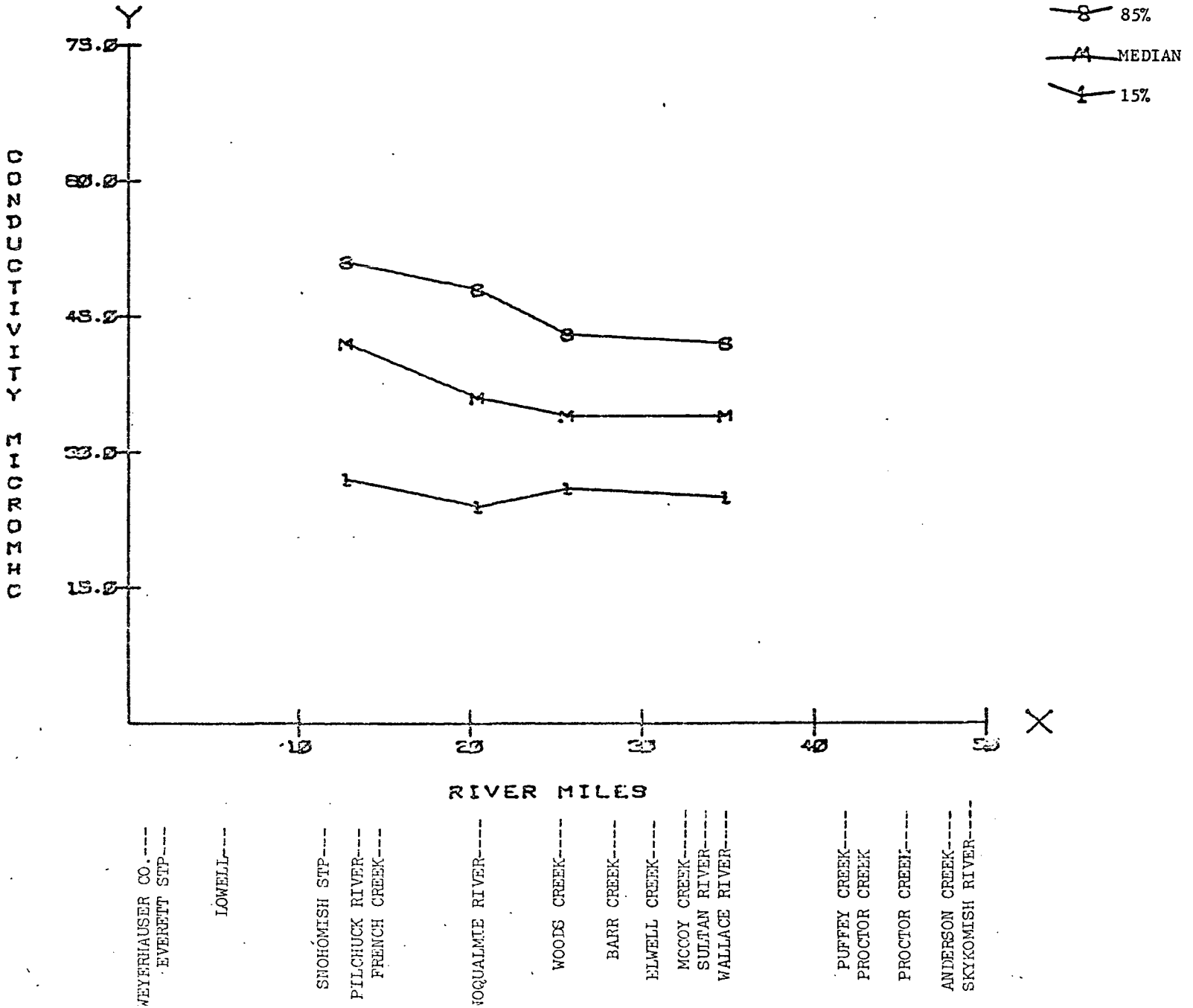
12/70 - 4 /74

85%

MEDIAN

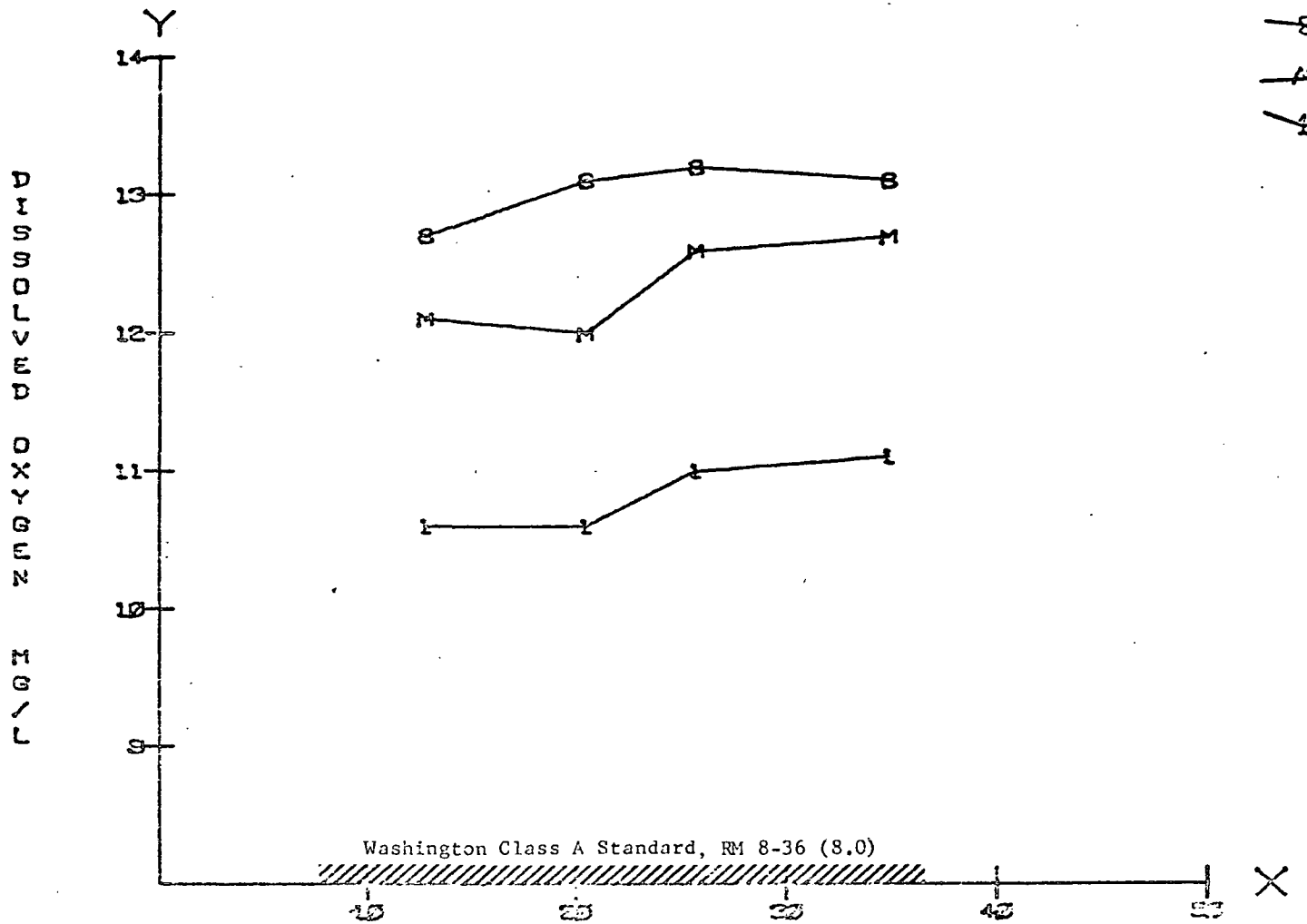
15%

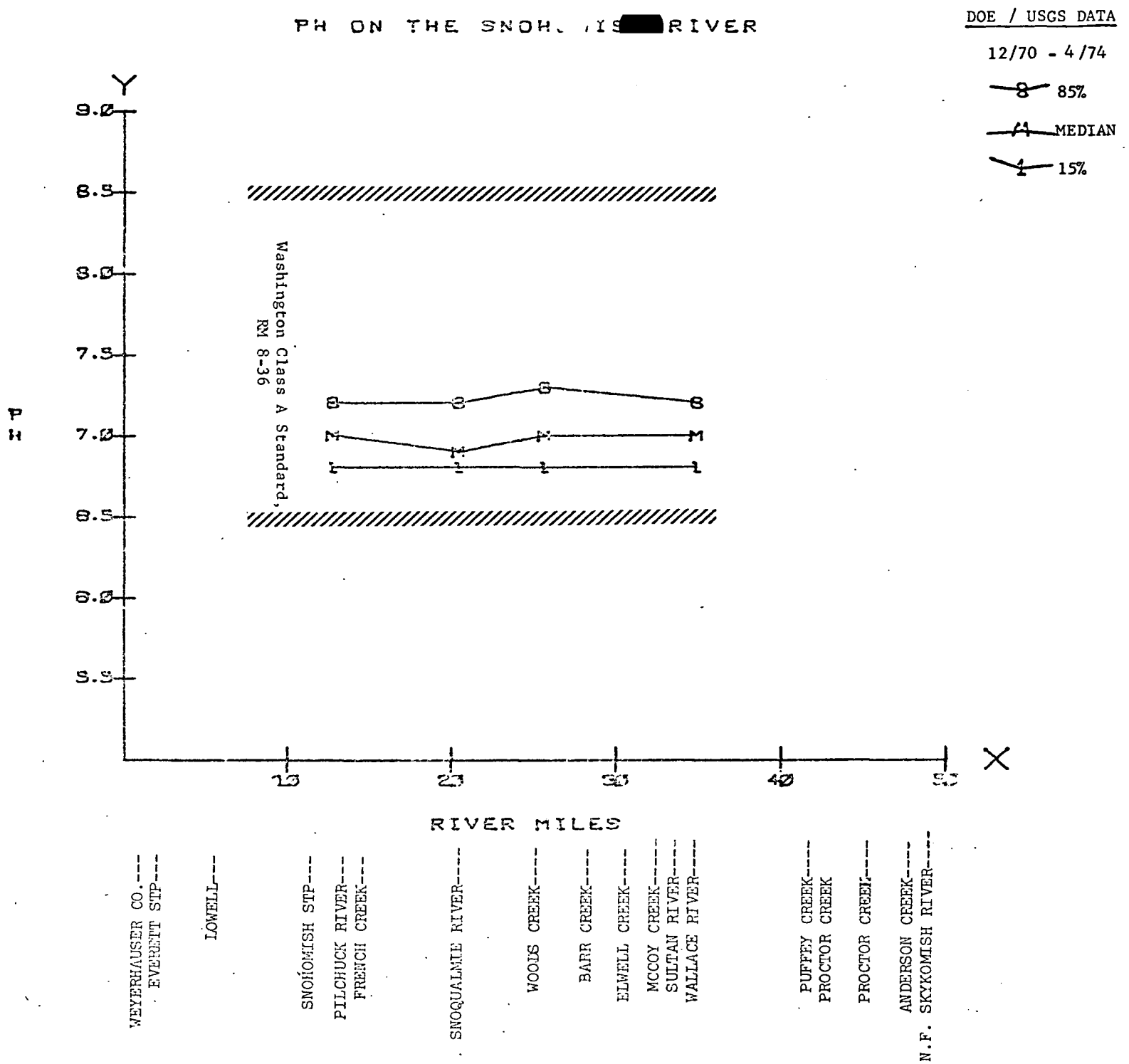
CONDUCTIVITY ON THE SNOHOMISH RIVER



DISSOLVED OXYGEN ON T. [redacted] OHOMISH RIVER

DOE / USGS DATA
12/70 - 4/74
8 85%
M MEDIAN
1 15%




PH ON THE SNOH. IS[redacted]RIVER
DOE / USGS DATA
12/70 - 4/74
85%
MEDIAN
15%
Y
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
PH
Washington Class A Standard, RM 8-36
10
20
30
40
50
X
RIVER MILES
WEYERHAUSER CO.
EVERETT STP
LOWELL
SNOHOMISH STP
PILCHUCK RIVER
FRENCH CREEK
SNOQUALMIE RIVER
WOODS CREEK
BARR CREEK
ELWELL CREEK
MCCOY CREEK
SULTAN RIVER
WALLACE RIVER
PUFFEY CREEK
PROCTOR CREEK
PROCTOR CREEK
ANDERSON CREEK
N.F. SKYKOMISH RIVER

TOTAL NITRATE ON TH. SNOH[redacted]ISH RIVER

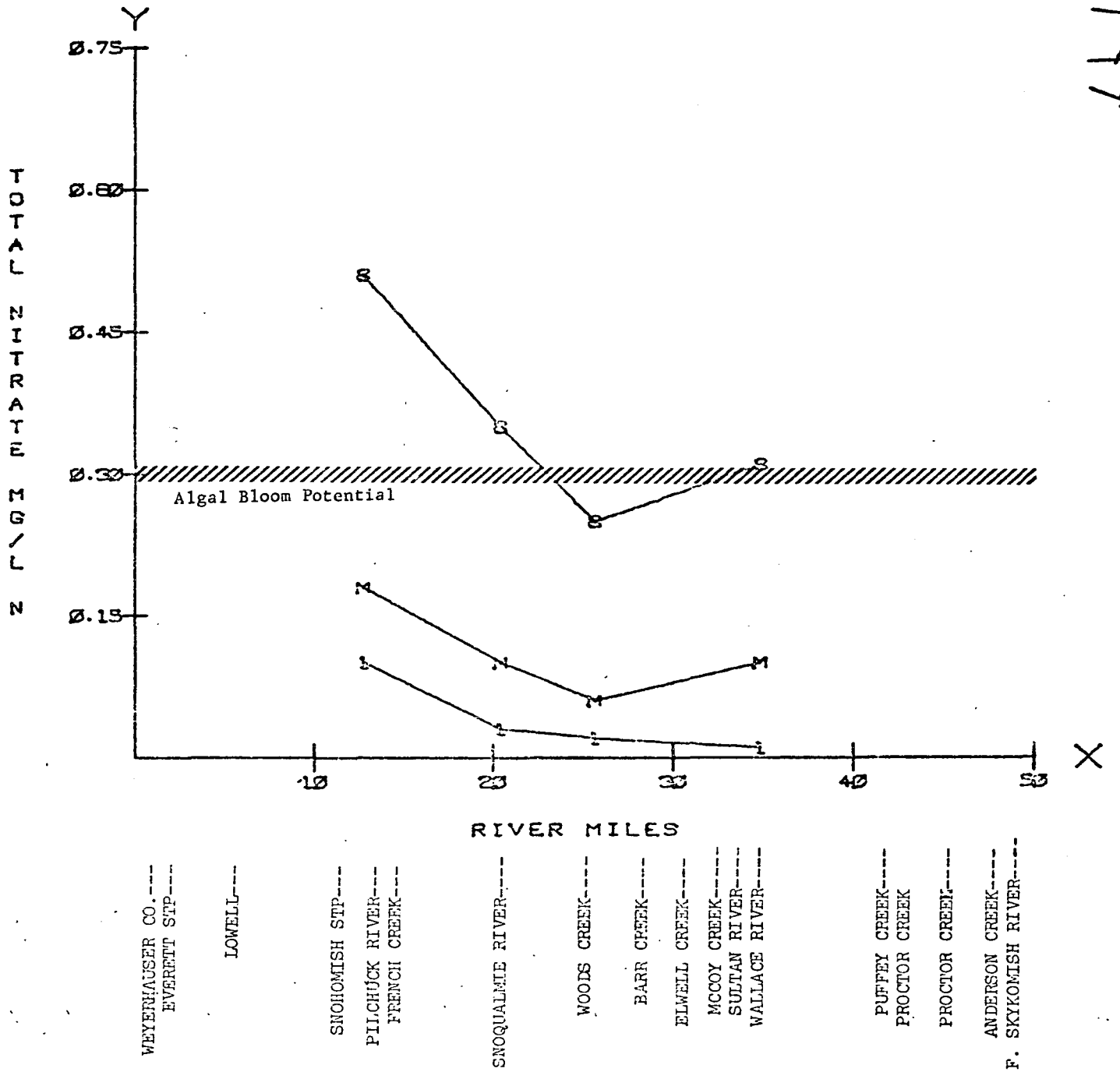
DOE / USGS DATA

12/70 - 10/73

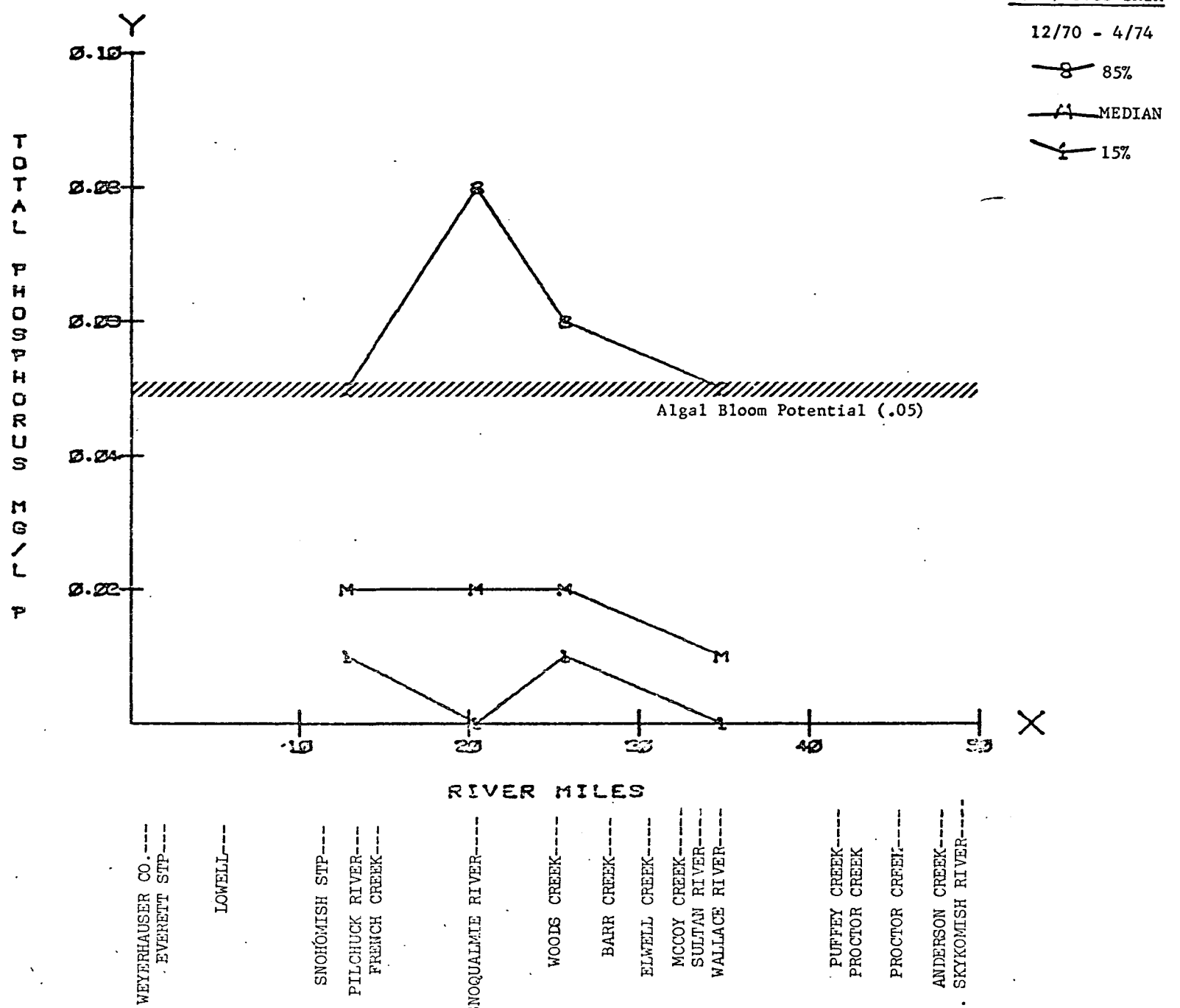
85%

MEDIAN

15%



TOTAL PHOSPHORUS ON T . SNOHOMISH RIVER



TOTAL COLIFORM ON TH SNOHOMISH RIVER.

DOE / USGS DATA

12/70 - 4/74

85%

MEDIAN

15%

TOTAL COLIFORM MPN/100 ML

120000

1000

100

Wash. Class A Std., RM 8-36
(20% - 1000)

(med. - 240)

10 20 30 40 43

RIVER MILES

WEYERHAUSER CO.---
EVERETT STP---
LOWELL---
SNOHOMISH STP---
PILCHUCK RIVER---
FRENCH CREEK---
SNOQUALMIE RIVER---
WOODS CREEK---
BARR CREEK---
ELWELL CREEK---
MCCOY CREEK-----
SULTAN RIVER----
WALLACE RIVER---
PUFFEY CREEK----
PROCTOR CREEK
PROCTOR CREEK---
ANDERSON CREEK----
S.F. SKYKOMISH RIVER----

STILLAGUAMISH RIVER BASIN

STILLIGUAMISH RIVER BASIN
BASIN DESCRIPTION

1. Drainage Area -722 sq. m.

2. Average Flow - (at Arlington) mean = 1,770 cfs
   min. = 1,120 cfs
   max. = 2,439 cfs
   (at Granite Falls) mean = 1 045 cfs
   min. = 702 cfs
   max. = 1 446 cfs

3. Waste Sources - 4

4. Major Diversions - Fish & Game - 30 cfs

   Irrigation - 3 000 acre-feet

5. Surface Water Rights - Municipal - 10.6 cfs

   Irrigation - 35.48 cfs

   Individual & Community Domestic - 16.41 cfs

   Industrial & Commercial - 11.88 cfs

   Fish. Propogation - 52.45 cfs

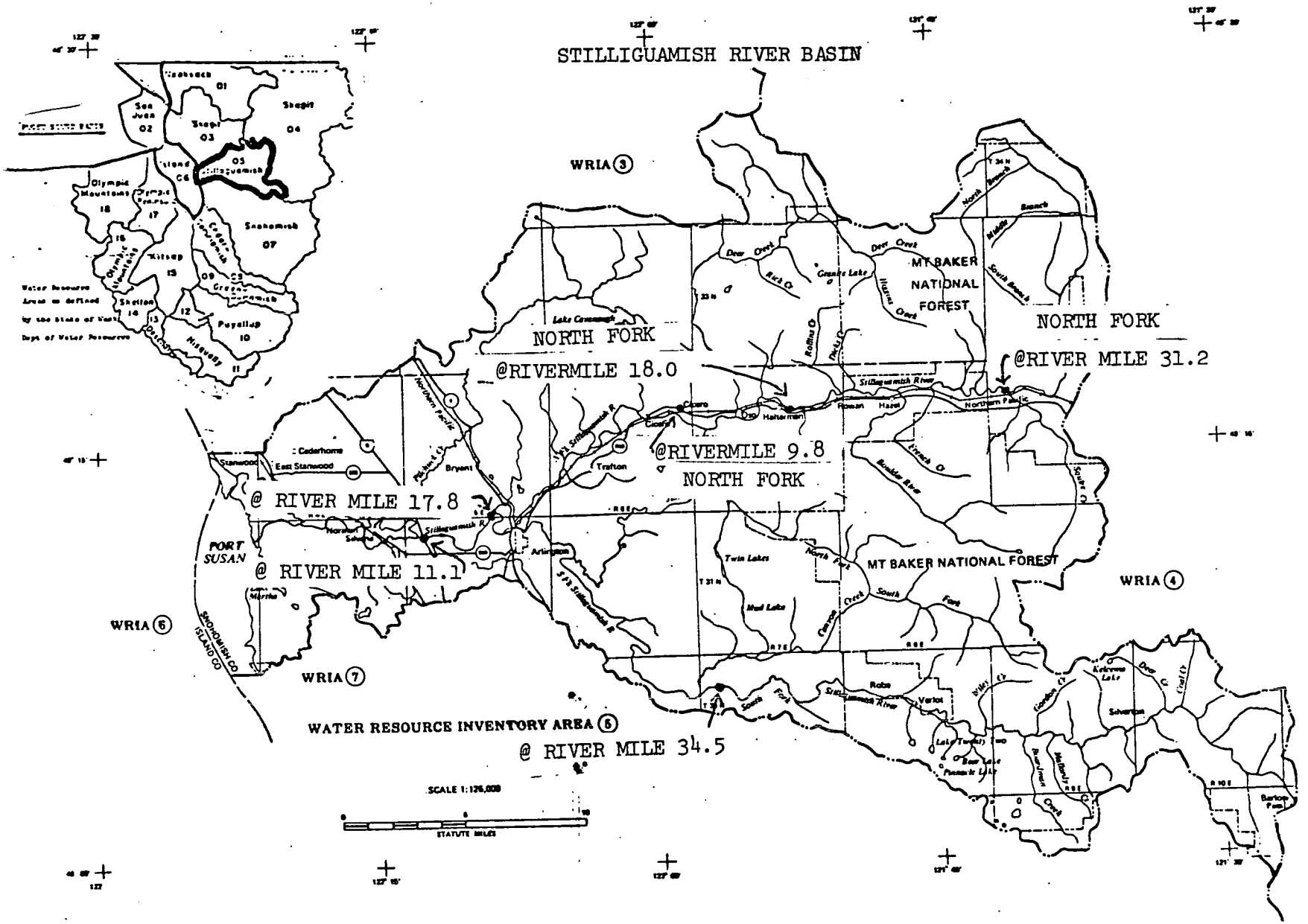
   Stock - .59 cfs

   Total - 114.41 cfs

6. Reservoir Water Rights - 56 acre-feet

7. Projected Population -

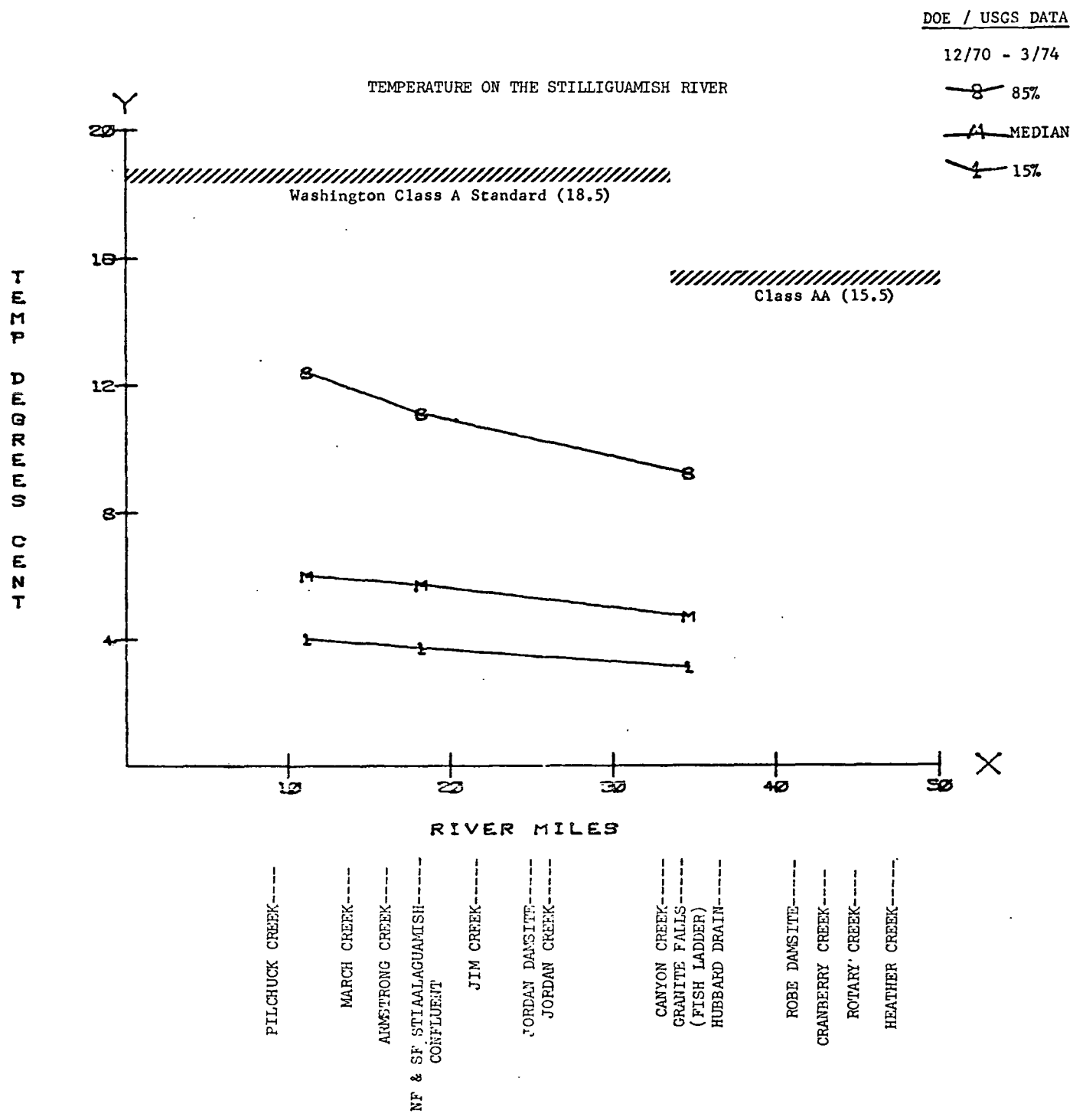
1980	2000	2020
30,200	48,500	77,800


STILLIGUAMISH RIVER BASIN
WRIA 3
NORTH FORK
@RIVERMILE 18.0
NORTH FORK
@RIVER MILE 31.2
@RIVERMILE 9.8
NORTH FORK
@ RIVER MILE 17.8
@ RIVER MILE 11.1
@ RIVER MILE 34.5
MT BAKER NATIONAL FOREST
MT BAKER NATIONAL FOREST
WRIA 4
WRIA 6
WRIA 7
PORT SUSAN
WATER RESOURCE INVENTORY AREA 5
SCALE 1:126,000
STATUTE MILES

STILLAGUAMISH RIVER BASIN
REPORTED PROBLEMS

1. In the lower river miles of both the North Fork and the main stem of the Stillaguamish, Nitrate and Phosphorus values exceed the limiting algal bloom potential concentrations.

2. Total coliform concentrations have at times exceeded Class A Standards on both the main stem and the North Fork during periods of high flow, especially near the mouth,

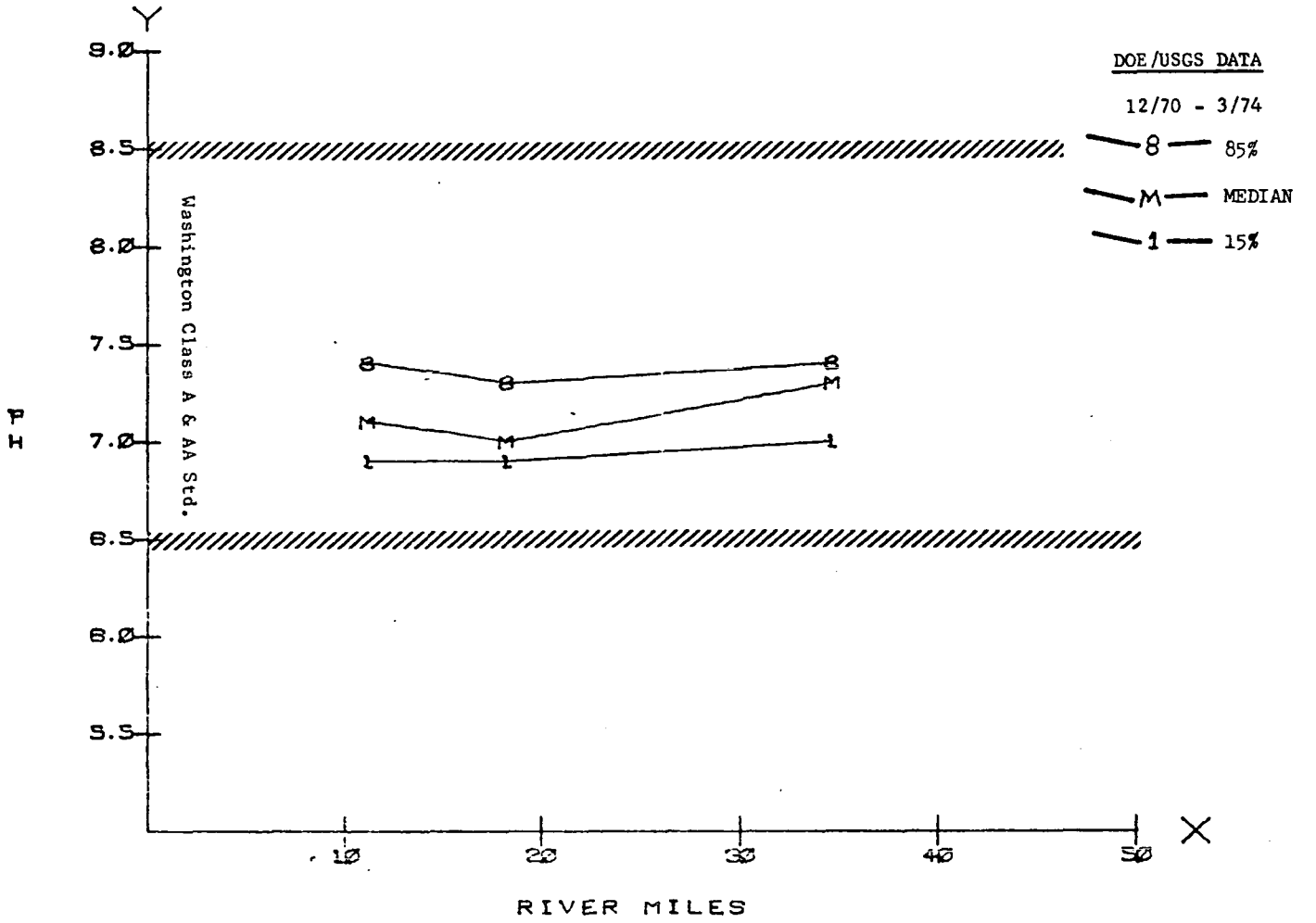

DOE / USGS DATA
12/70 - 3/74
85%
MEDIAN
15%
TEMPERATURE ON THE STILLIGUAMISH RIVER
Washington Class A Standard (18.5)
Class AA (15.5)
TEMP DEGREES CENT
Y
X
20
16
12
8
4
10
20
30
40
50
RIVER MILES
PILCHUCK CREEK
MARCH CREEK
ARMSTRONG CREEK
NF & SF STILLAGUAMISH CONFLUENT
JIM CREEK
JORDAN DAMSITE
JORDAN CREEK
CANYON CREEK
GRANITE FALLS (FISH LADDER)
HUBBARD DRAIN
ROBE DAMSITE
CRANBERRY CREEK
ROTARY CREEK
HEATHER CREEK

TURBIDITY ON THE STILLAGUAMISH RIVER

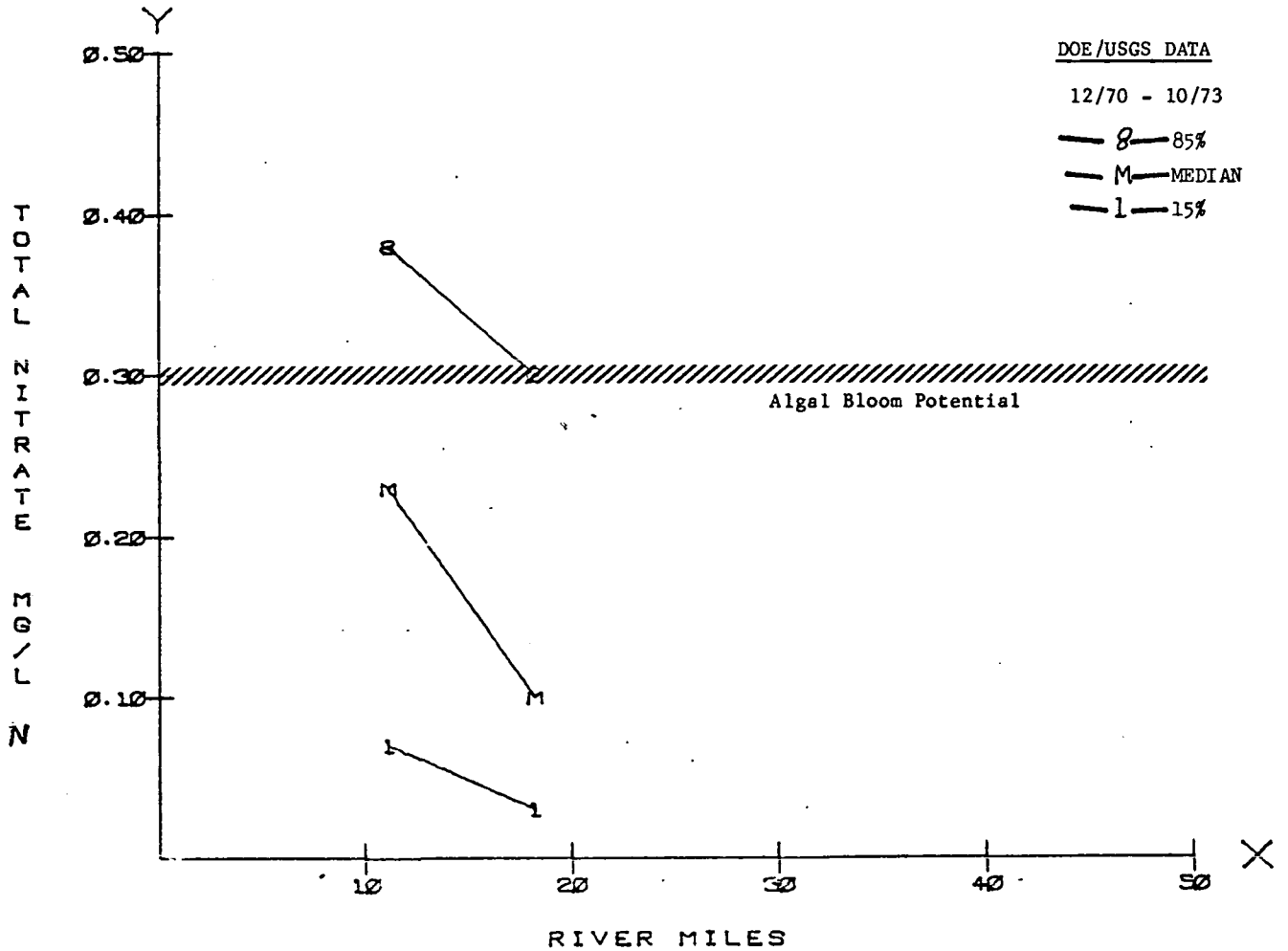
CONDUCTIVITY ON THE STILLAGUAMISH RIVER

DISSOLVED OXYGEN ON THE STILLAGUAMISH RIVER

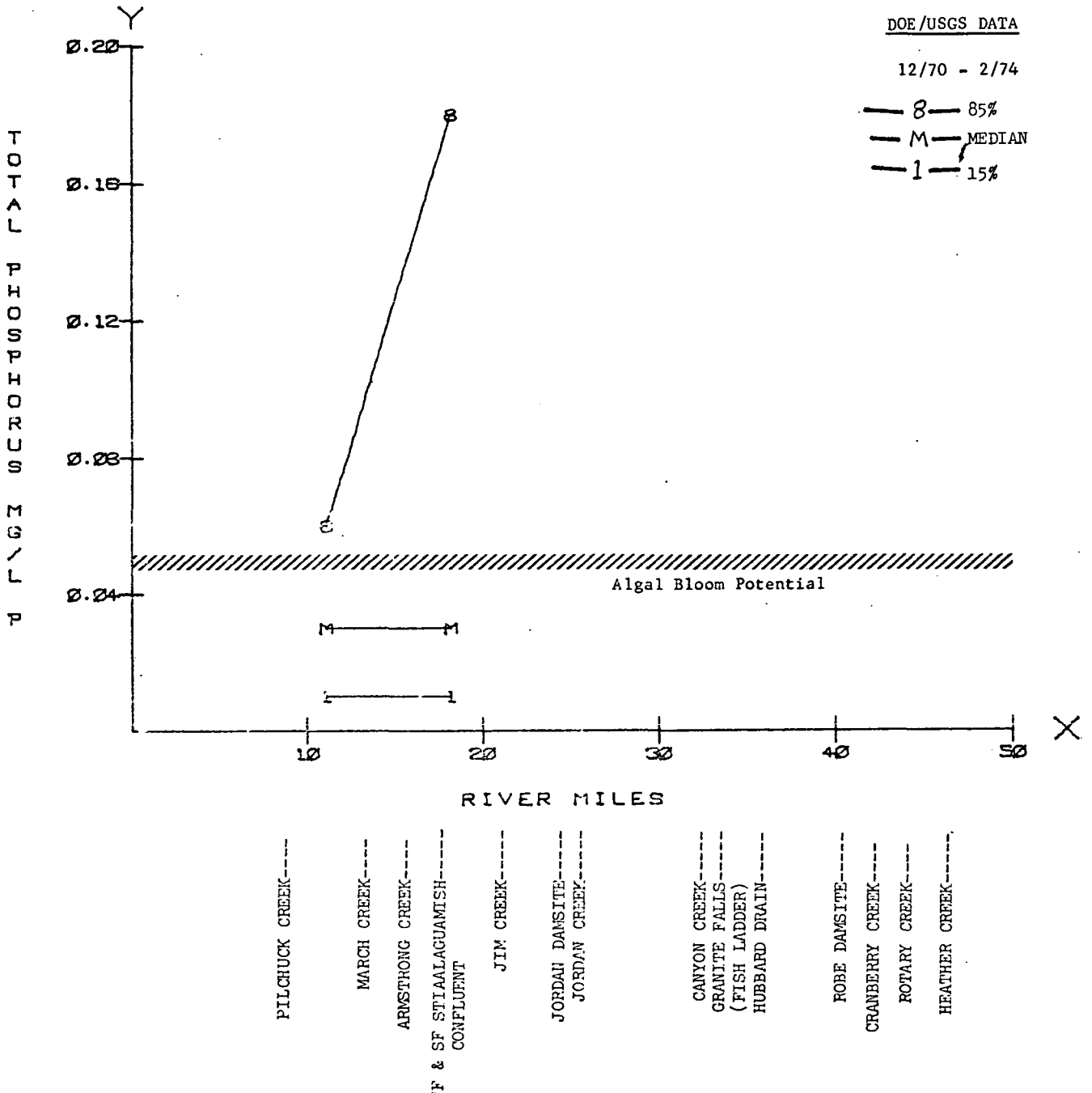
pH ON THE STILLAGUAMISH RIVER



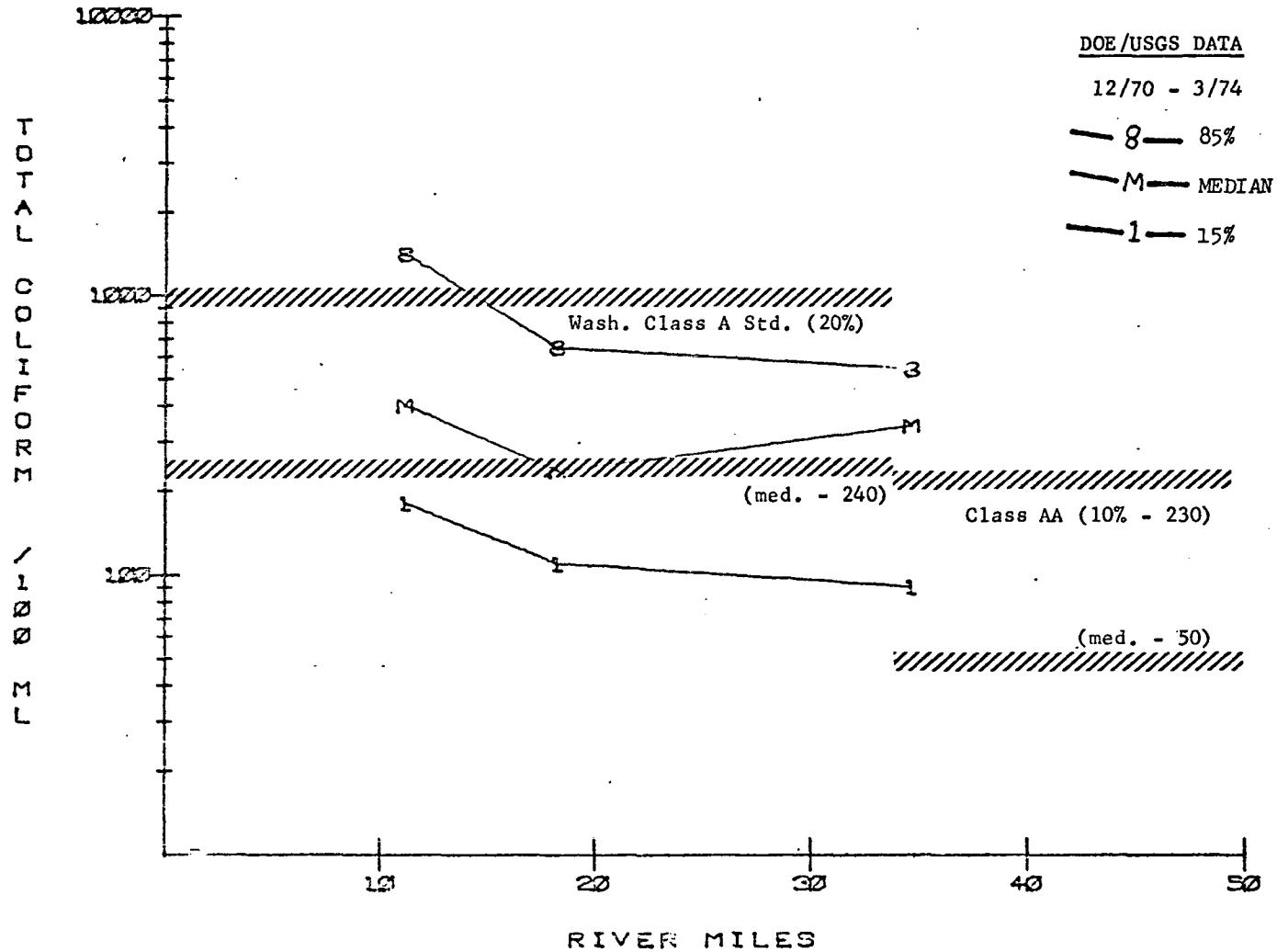
TOTAL NITRATE THE S[redacted]GUAMISH RIVER



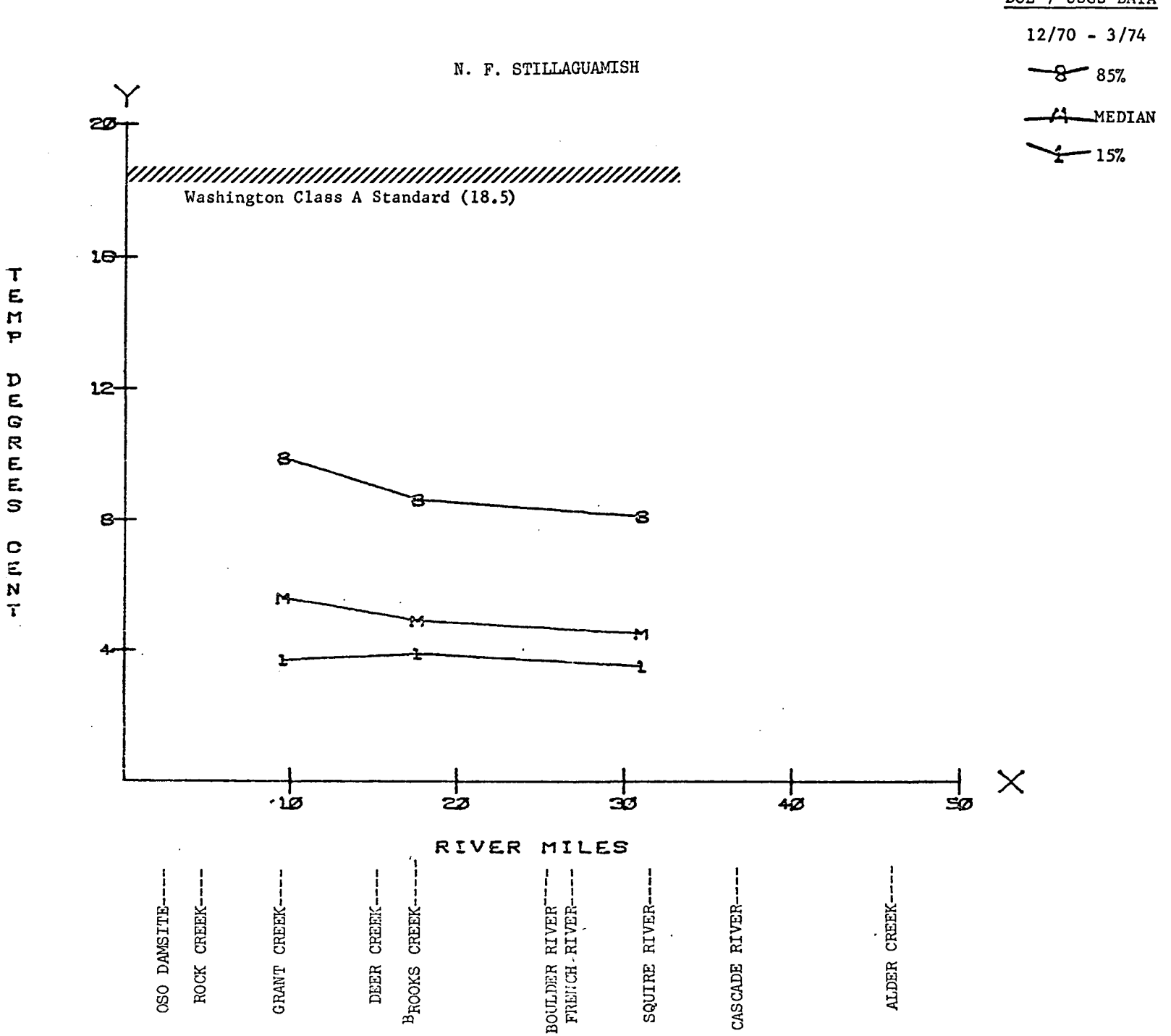
TOTAL PHOSP[redacted] ON THE STILLAGUAMISH RIVER



TOTAL COLIFORM ON THE STILLAGUAMISH RIVER

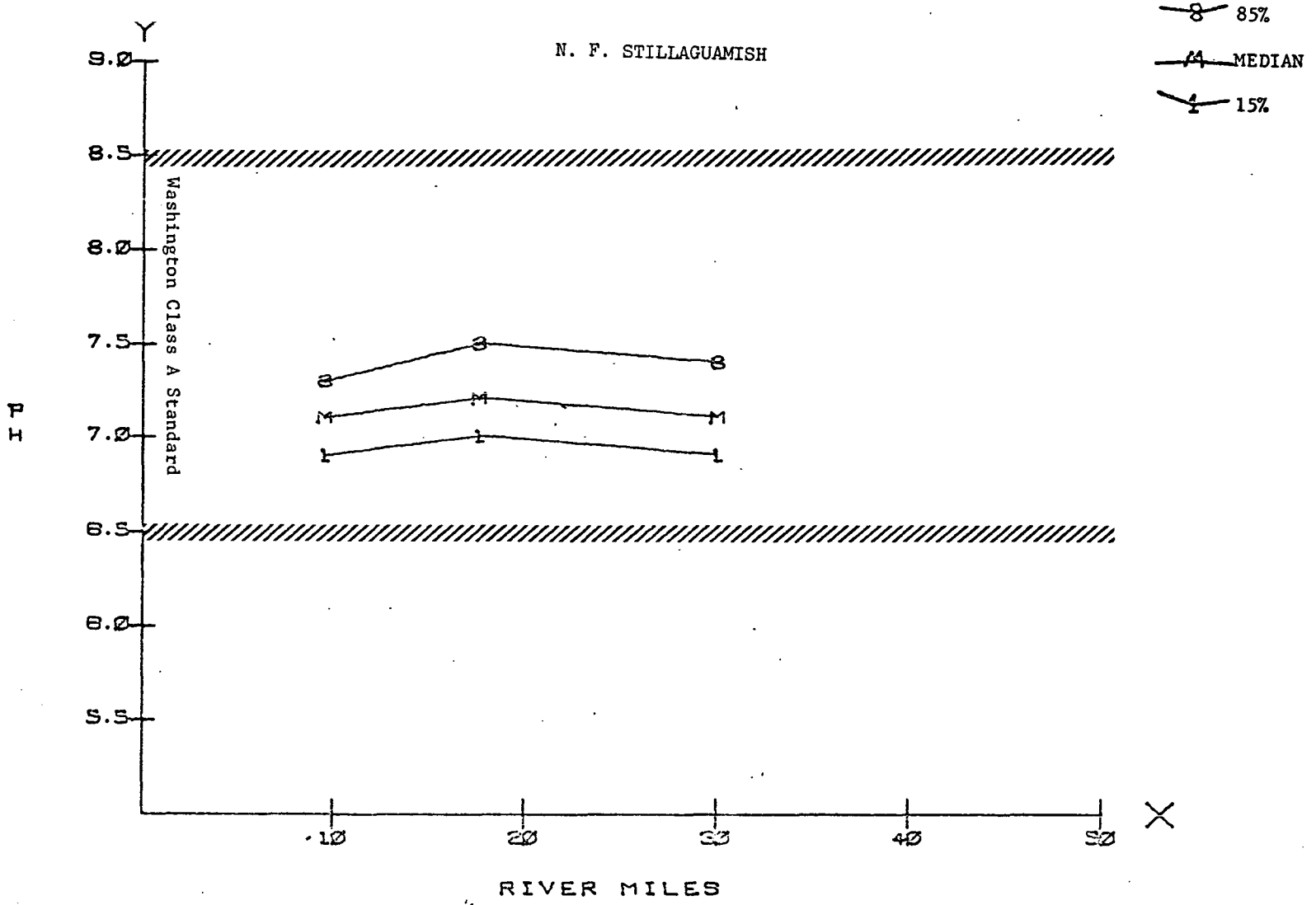


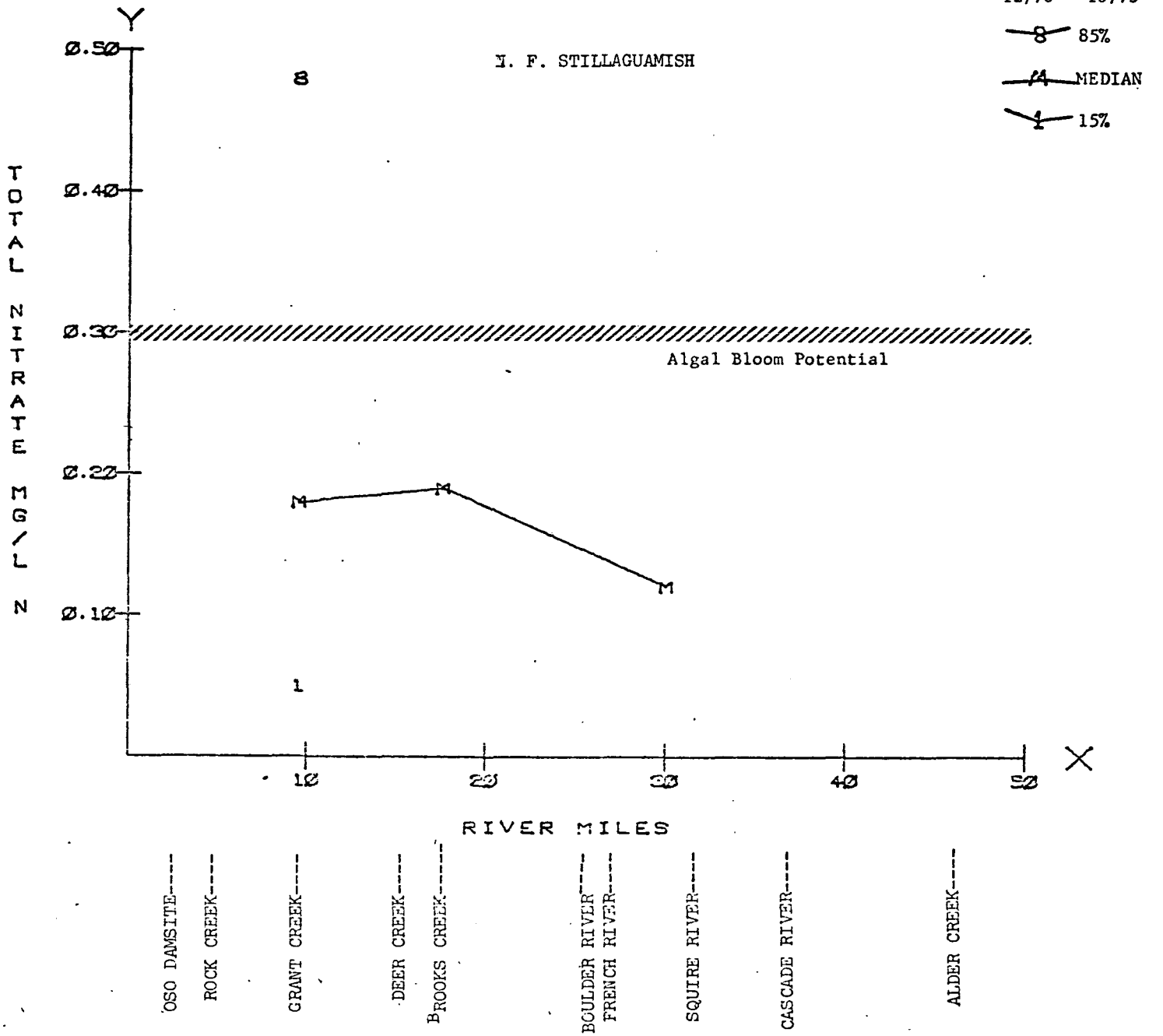
NORTH FORK STILLAGUAMISH

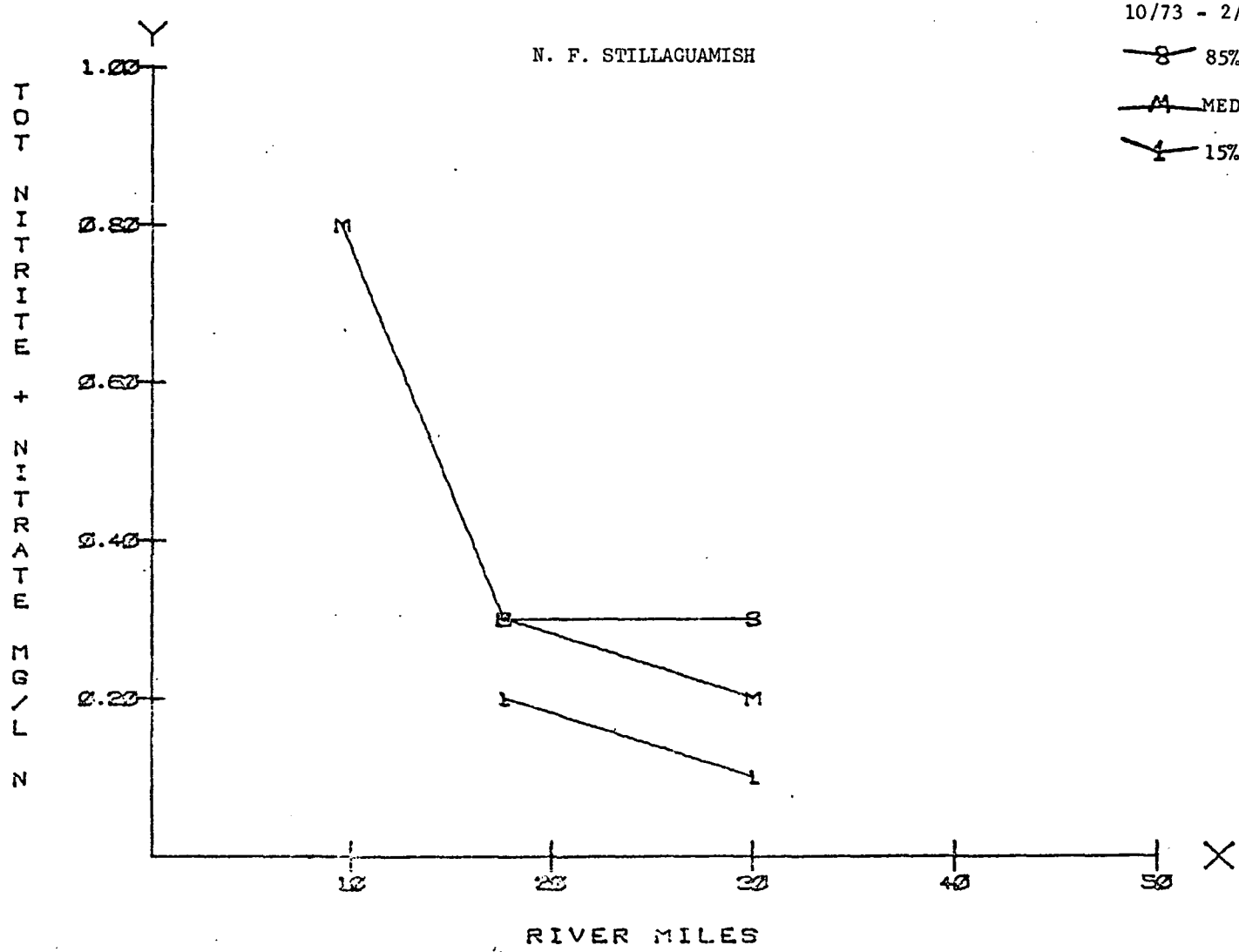

N. F. STILLAGUAMISH
DOE / USGS DATA
12/70 - 3/74
85%
MEDIAN
15%
Washington Class A Standard (18.5)
TEMP DEGREES CENT.
20
16
12
8
4
10
20
30
40
50
RIVER MILES
OSO DAMSITE
ROCK CREEK
GRANT CREEK
DEER CREEK
BROOKS CREEK
BOULDER RIVER
FRENCH RIVER
SQUIRE RIVER
CASCADE RIVER
ALDER CREEK

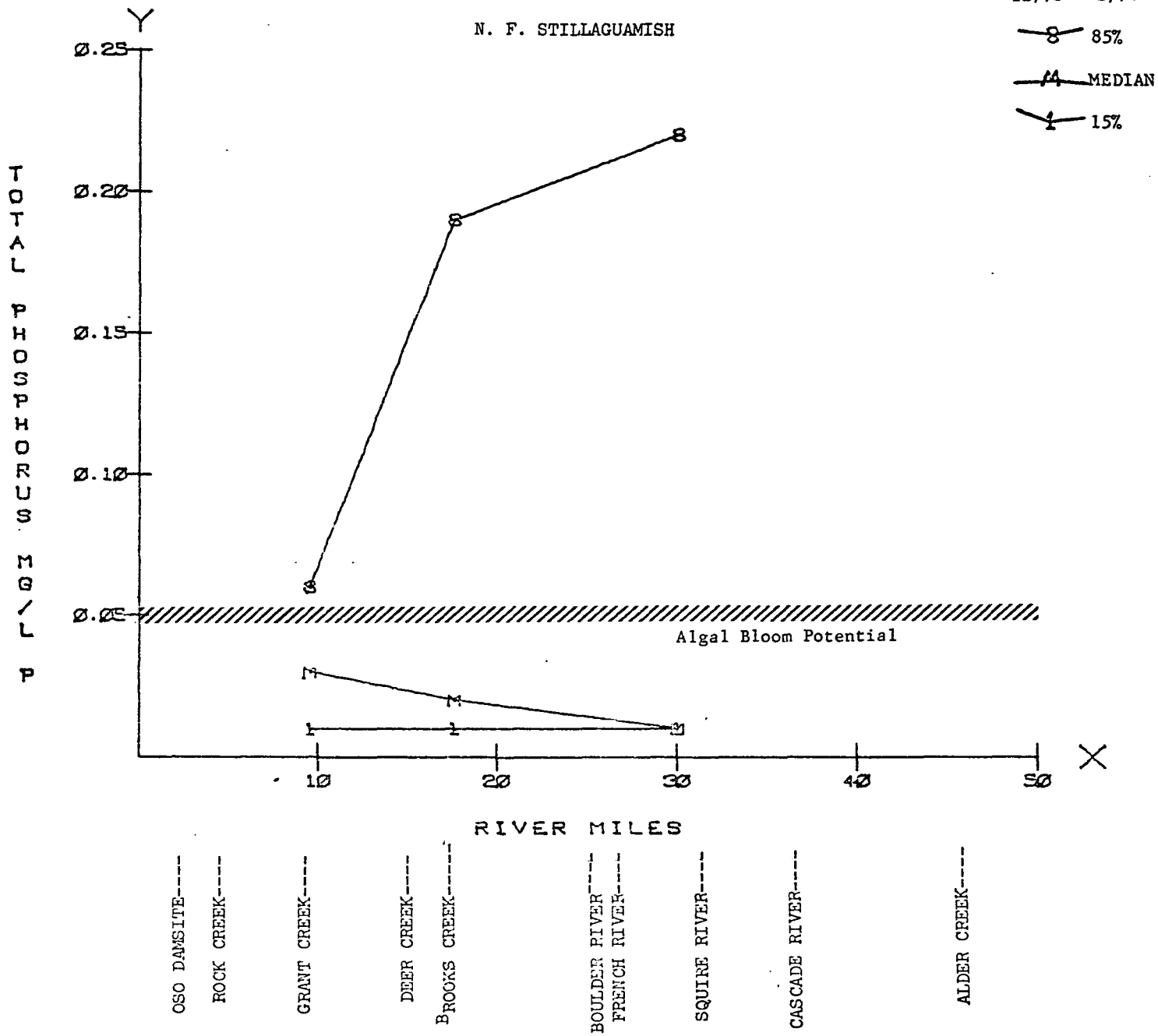
N. F. STILLAGUAMISH
DOE / USGS DATA
12/70 - 3/74
85%
MEDIAN
15%
Y
75
60
45
30
15
CONDUCTIVITY MICROMHO
8
M
1
10
20
30
40
50
X
RIVER MILES
OSO DAMSITE
ROCK CREEK
GRANT CREEK
DEER CREEK
BROOKS CREEK
BOULDER RIVER
FRENCH RIVER
SQUIRE RIVER
CASCADE RIVER
ALDER CREEK

N F. STILLAGUAMISH
DOE / USGS DATA
12/70 - 3/74
85%
MEDIAN
15%
DISSOLVED OXYGEN MG/L
14.0
13.0
12.0
11.0
10.0
9.0
Washington Class A Standard (8.0)
10
20
30
40
50
RIVER MILES
OSO DAMSITE
ROCK CREEK
GRANT CREEK
DEER CREEK
BROOKS CREEK
BOULDER RIVER
FRENCH RIVER
SQUIRE RIVER
CASCADE RIVER
ALDER CREEK


DOE / USGS DATA
12/70 - 3/74
85%
MEDIAN
15%
N. F. STILLAGUAMISH
Y
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
PH
Washington Class A Standard
10
20
30
40
50
X
RIVER MILES
OSO DAMSITE
ROCK CREEK
GRANT CREEK
DEER CREEK
BROOKS CREEK
BOULDER RIVER
FRENCH RIVER
SQUIRE RIVER
CASCADE RIVER
ALDER CREEK

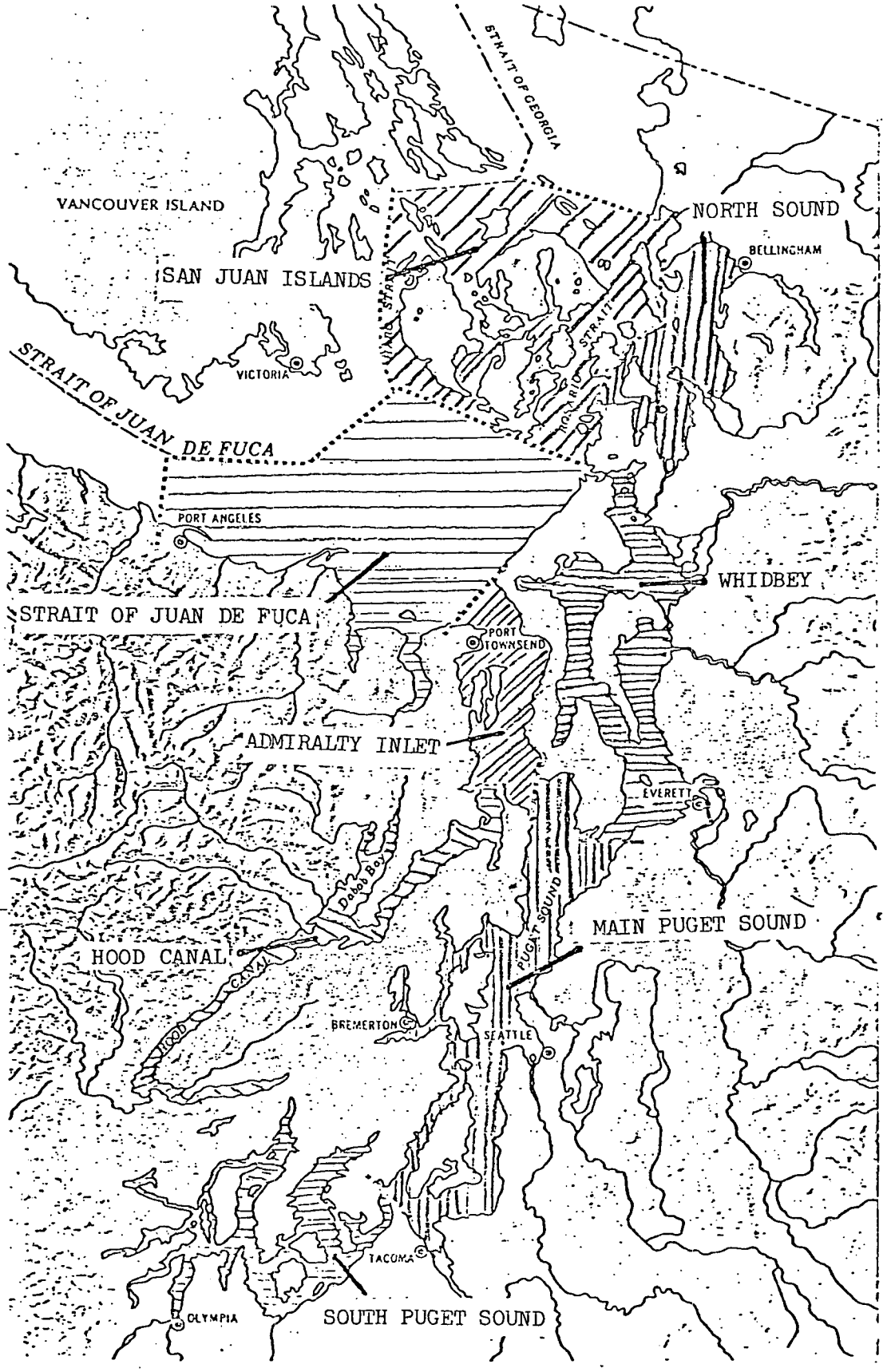

DOE / USGS DATA
12/70 - 10/73
85%
MEDIAN
15%
N. F. STILLAGUAMISH
8
1
Y
0.50
0.40
0.30
0.20
0.10
TOTAL NITRATE MG\L N
Algal Bloom Potential
10
20
30
40
50
X
RIVER MILES
OSO DAMSITE
ROCK CREEK
GRANT CREEK
DEER CREEK
BROOKS CREEK
BOULDER RIVER
FRENCH RIVER
SQUIRE RIVER
CASCADE RIVER
ALDER CREEK


N. F. STILLAGUAMISH
DOE / USGS DATA
10/73 - 2/74
85%
MEDIAN
15%
TOT NITRITE + NITRATE MG\L N
1.00
0.80
0.60
0.40
0.20
Y
X
10
20
30
40
50
RIVER MILES
OSO DAMSITE
ROCK CREEK
GRANT CREEK
DEER CREEK
BROOKS CREEK
BOULDER RIVER
FRENCH RIVER
SQUIRE RIVER
CASCADE RIVER
ALDER CREEK


DOE / USGS DATA
12/70 - 2/74
85%
MEDIAN
15%
N. F. STILLAGUAMISH
Y
Ø.25
Ø.20
Ø.15
Ø.10
Ø.05
TOTAL PHOSPHORUS MG/L P
Algal Bloom Potential
10
20
30
40
50
X
RIVER MILES
OSO DAMSITE
ROCK CREEK
GRANT CREEK
DEER CREEK
BROOKS CREEK
BOULDER RIVER
FRENCH RIVER
SQUIRE RIVER
CASCADE RIVER
ALDER CREEK

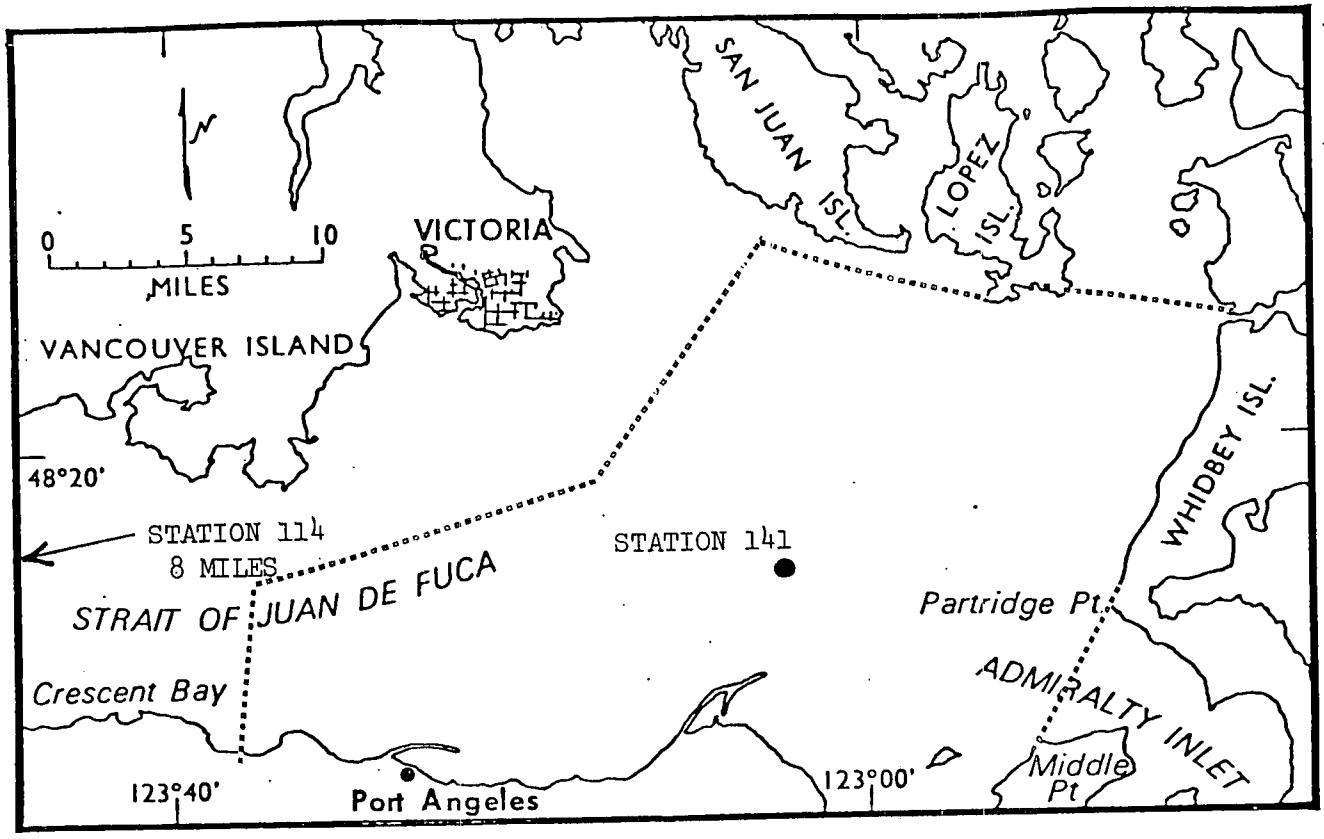
N. F. LLAGUAMISH
DOE / USGS DATA
12/70 - 3/74
85%
MEDIAN
15%
Washington Class A Standard (20% - 1000)
(med - 240)
TOTAL COLIFORM / 100 ML
1000
100
10
10
20
30
40
50
RIVER MILES
OSO DAMSITE
ROCK CREEK
GRANT CREEK
DEER CREEK
BROOKS CREEK
BOULDER RIVER
FRENCH RIVER
SQUIRE RIVER
CASCADE RIVER
ALDER CREEK

B. MARINE WATER BASINS



MARINE SUB-BASINS WITHIN PUGET SOUND BASIN

STRAIT OF JUAN DE FUCA BASIN



STRAIT OF JUAN DE FUCA BASIN

STRAIT OF JUAN DE FUCA

The Strait of Juan de Fuca is the main channel connecting the waters of Puget Sound and Georgia Strait with the Pacific Ocean. It is 158 km (85 naut mi) long, and has an average width of 22 km (12 naut mi). The maximum water depth north of Cape Flattery is 275 m (150 fath) and gradually decreases to 175 m (96 fath) north of Port Angeles. The first major sill in the Strait is located between Victoria and Green Point, about 11 km (6 naut mi) east of Port Angeles, where the water shoals rapidly to 82 m (45 fath). Continuing east towards Whidbey Island, the water again increases in depth to 172 m (94 fath) northeast of New Dungeness and then shoals gradually to an average depth of 73 m (40 fath) from Smith Island to Whidbey Island.

The Victoria-Green Point sill has a pronounced effect upon the waters of both Puget Sound and Georgia Strait because it effectively prevents oceanic water from entering these regions without first becoming somewhat diluted and modified by the fresher surface water flowing out of these regions towards the ocean. Oceanic type water enters the Strait of Juan de Fuca below the surface at the western end off Cape Flattery and travels landward (to the east) without significant modification until it reaches the Victoria-Green Point sill. At this point, most of the oceanic water is stopped but a portion of it is mixed with the fresher surface water to form a water type that becomes the deep water source for both Puget Sound and Georgia Strait. But under proper conditions some oceanic water may penetrate into Haro Strait in late summer.

Surface waters in the Strait of Juan de Fuca are affected by the total river discharge into the complex and by surface winds. There are no major rivers entering into the Strait. Most of the fresh-water is supplied by river discharge entering both Georgia Strait and Puget Sound with only a

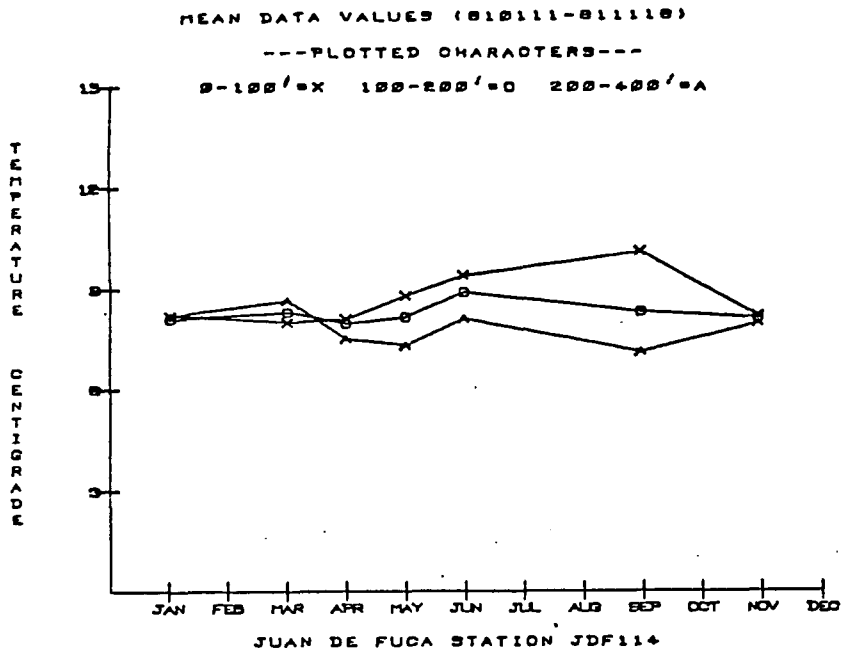
minor portion being contributed locally by small rivers and by land drainage. Two peaks of large river discharge, one from October through March during the rainy season and a second one of equal or greater magnitude in late June or early July occur as a result of snow melting in the mountains. Therefore, the most dilute surface water observed in the Strait occurs in winter with a second minimum occuring in July. Maximum surface salinities are observed in September and October. Surface temperatures are coldest in February and warmest in late summer as a response to the annual cycles in air temperatures of the surface winds.

Water characteristics from the entrance of the Strait of Juan de Fuca to the first sill may be typified by an oceanographic station north of Pillar Point, about 53 km (28 naut mi) east of Cape Flattery.(station JDF114)

The eastern end of the Strait of Juan de Fuca is essentially a large mixing area and the region where the water splits with a portion going south into Puget Sound and the largest part going into Georgia Strait via Haro and Rosario Straits. Because of tidal action, the waters in the eastern end of the Strait exhibit significant changes over a tidal cycle with the water being nearly homogeneous with depth. Very little water of oceanic type invades into this region, but its effects are observed by a density maximum and oxygen minimum occuring in August or early September. This mixed water is cooler, more saline, and of lower oxygen content than might be expected. These waters are typified by a station northeast of New Dungeness.(Station JDF141)

The importance of the increased density in late summer by the oceanic water intruding into the Strait and then being mixed in the eastern end of the Strait can not be over emphasized. Because of this more dense water entering in the early fall, most all parts of the Puget Sound-Georgia Strait complex are flushed once a year by a replacement of the less dense water

with more dense water. The maximum density water does not occur simultaneously in all parts of the complex, but depends upon the distance from the Strait and upon local mixing areas.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12
9
6
3
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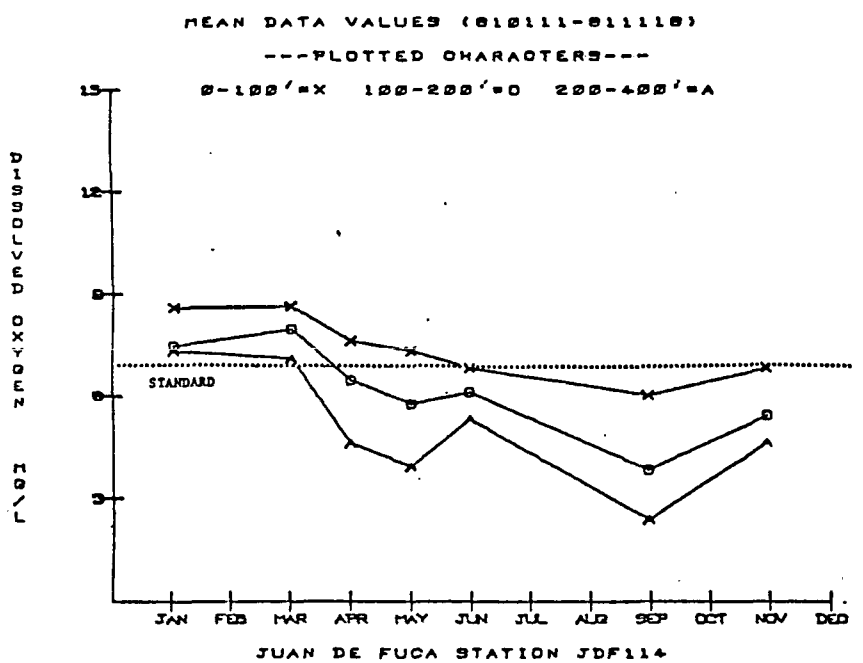
JUAN DE FUCA STATION JDF114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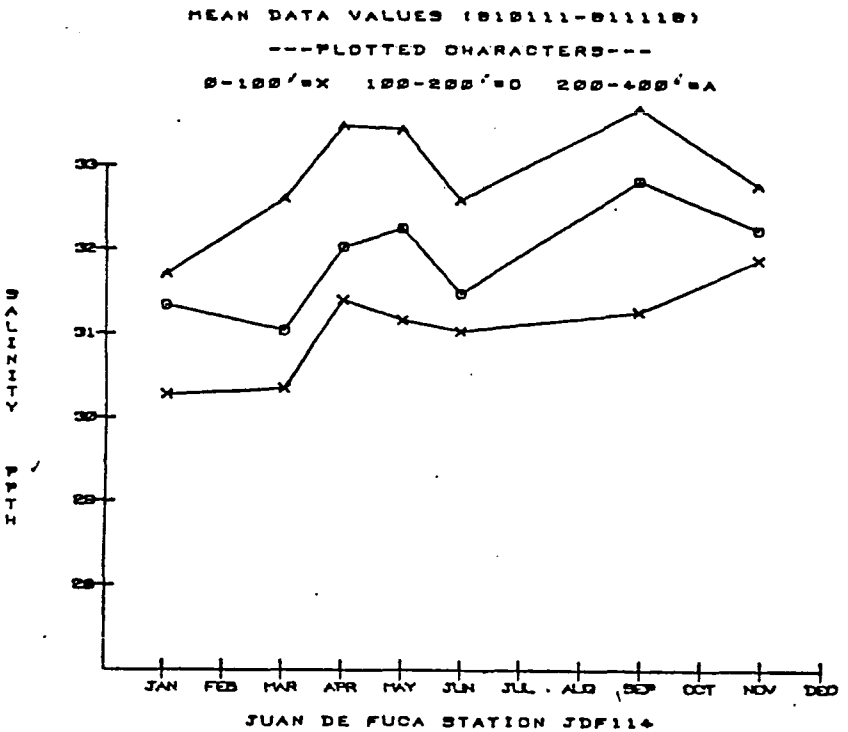
JUAN DE FUCA STATION JDF114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30
29
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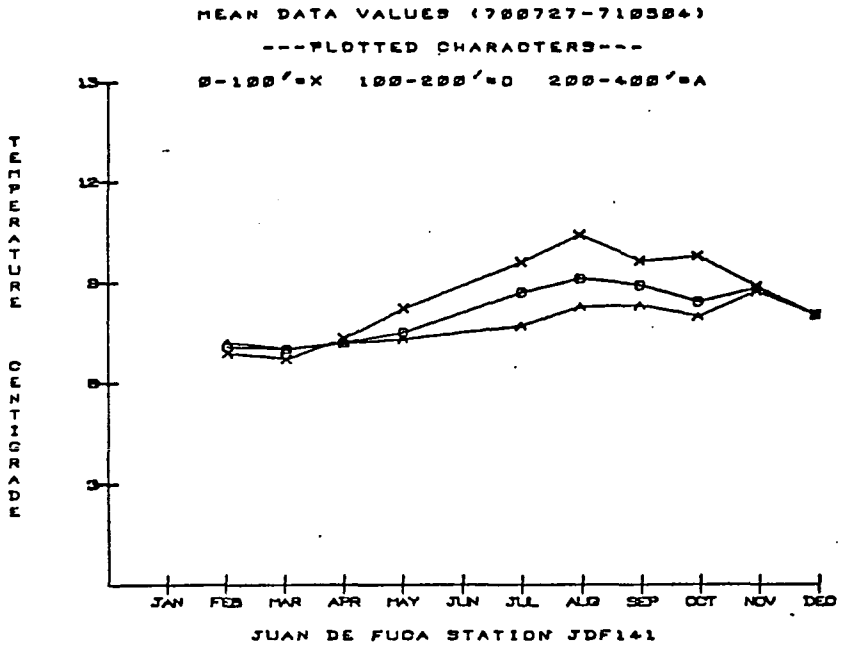
JUAN DE FUCA STATION JDF114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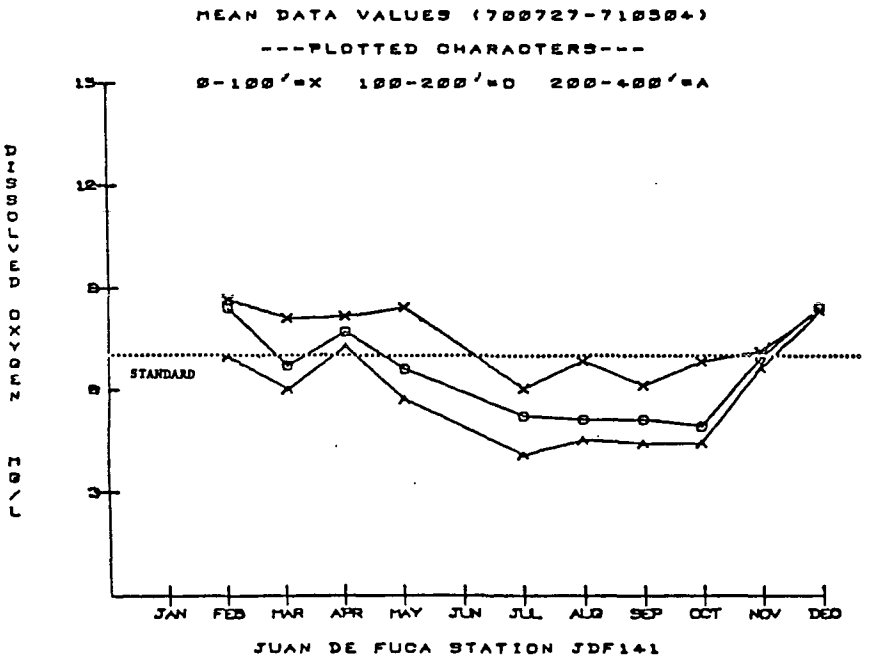
JUAN DE FUCA STATION JDF141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STANDARD
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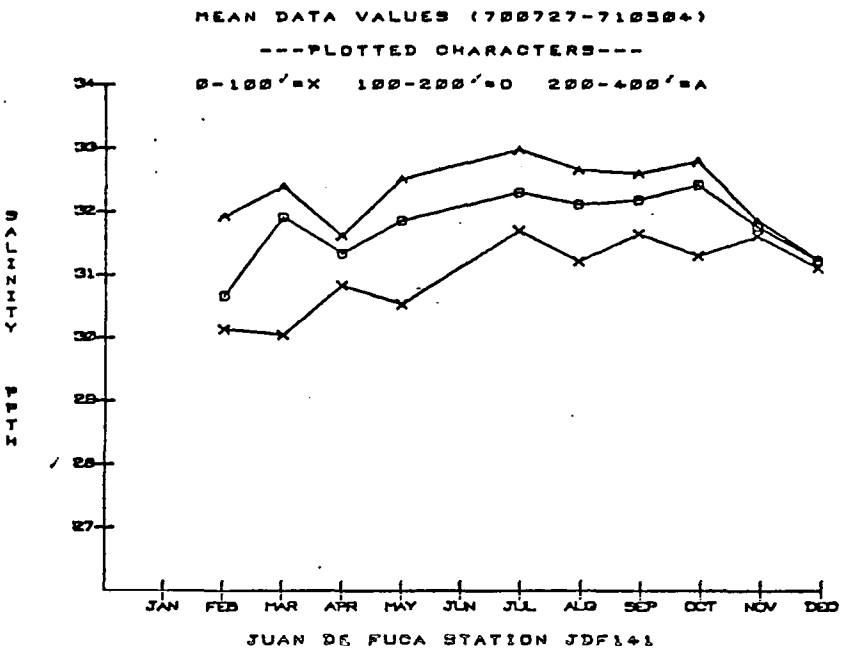
JUAN DE FUCA STATION JDF141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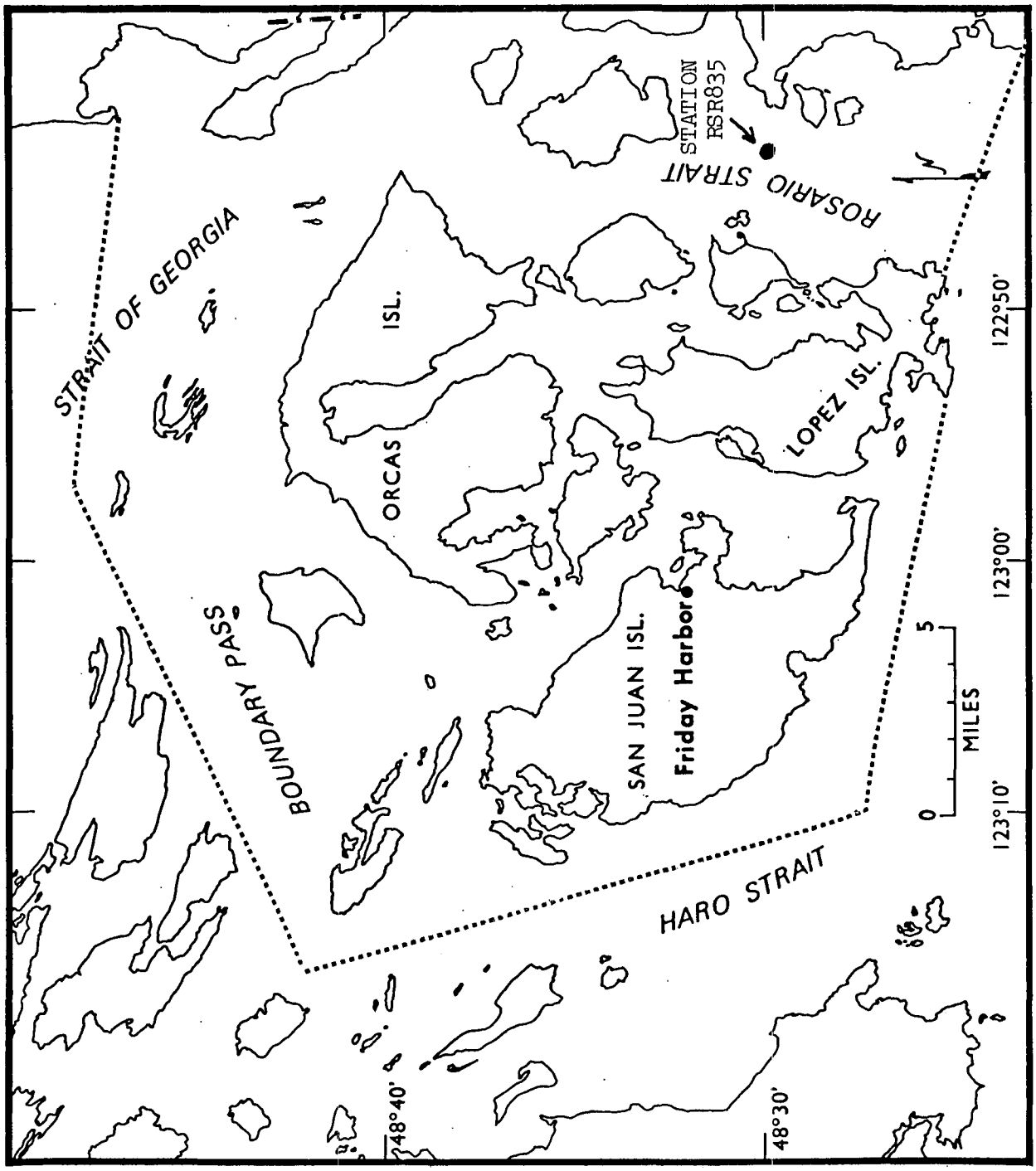
JUAN DE FUCA STATION JDF141

SAN JUAN ISLAND BASIN



SAN JUAN ISLAND BASIN

SAN JUAN ISLAND REGION

The waters in the San Juan Island region are separated from those of the Strait of Juan de Fuca by a line at about 48° 25' North latitude and from the Strait of Georgia at the north end by a line at about 48° 48' North. The major channel through the San Juan Islands are Haro Strait on the west, Rosario Strait on the east, and Middle Channel in the center. Haro Strait is 59 km (32 naut mi) long, averages about 7.5 km (4 naut mi) wide and is over 200 m deep for all of its length. Water depths of 300 m to 370 m (165 to 204 fath) are common in this channel. Rosario Strait is 48 km (26 naut mi) long, 5.5 km (7 naut mi) wide and has an average depth of 60 m (33 fath) from the south end, near Lawson Reef, and remains this deep to off of Lawrence Point on Orcas Island. North of this point, the channel gradually deepens to 180 m (100 fath) where it joins Georgia Strait. Middle Channel is very narrow and only 108 m (60 fath) deep, so it does not contribute significantly to the overall circulation through the San Juan Islands.

The deep channels of the San Juan Archipelago serve as mixing areas for the waters of Georgia Strait and the Strait of Juan de Fuca. Over 90% of the water needed to supply the tidal prism of Georgia Strait must pass through these channels. This produces strong currents accompanied by vigorous mixing even in such a deep channel as Haro Strait. Hence, changes in water characteristics occur along the length of the channel rather than verticall in the the water column. But, surface waters of the Strait of Georgia may penetrate into the various channels when the tide range is small and mixing is reduced. This surface water is observed in many parts of this region during the flood stage of the Fraser River in June and July.

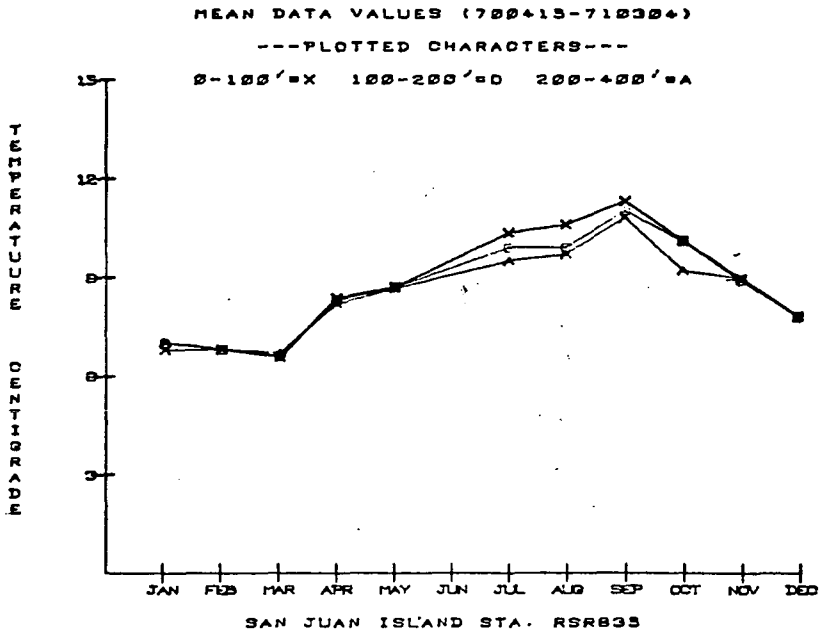
The currents in Haro Strait are quite strong, often being up to 7 km/hr (4 knots) from the surface to near the bottom in water the depths of over 170 meters. In Rosario Strait, the currents are slightly less being in the vicinity of 5 km/hr (2.7 knots) from top to bottom. Currents in the other channels are fairly strong with speed up to 4 km/hr (2.5 knots) being common. The direction of the currents in Haro and Rosario Strait are either dominately northerly on the flood or southerly on the ebb. But the direction of the currents in the many other channels are not as predictable and are influenced by differences in water levels at the ends of the channel in question. The net circulation (i.e., after tidal components have been eliminated), in Haro Strait is characteristic of a two-layer system with a strong outflow at the surface and a moderate inflow at depth. In Rosario Strait, the net circulation at depth is larger than of the surface. Hence, a definite counterclockwise circulation is established around the San Juan Islands (Evans and Collias, 1967).

Three water types are observed in the San Juan island region, namely Georgia Strait surface water, Juan de Fuca deep water, and a mixture of these two known as San Juan intermediate water (Evans and Collias, 1967). The salinity of the Georgia Strait surface water is controlled by the Fraser River runoff. Juan de Fuca deep water has its source in the eastern end of the Strait of Juan de Fuca whereas San Juan intermediate water is a mixture of these two types. This mixed water flows to the north and forms the intermediate water of Georgia Strait.

The water characteristics in Haro and Rosario Strait have not been observed at regular intervals, but sufficient data is available to describe the waters in this region. In Haro Strait, the surface water is coldest in February with an average low of about 6.8°C and a high of about 12°C in July. The highest salinities are observed in winter of about 31.1‰

and the lowest are in July of about 27.6°/oo. The waters below 150 m in Haro Strait show less variability with a winter low of 7.2°C and a high of 8.4°C in October. The maximum salinity of over 32.5°/oo is observed in August in response to the high salinity water intruding into the Strait of Juan de Fuca. This deep water is also oxygen poor and phosphate rich. Under certain conditions, deep water from the Strait of Juan de Fuca may intrude into Haro Strait without significant modification and as a result, low oxygen content water may appear along the west side of San Juan Island in July or August.

The water characteristics in Rosario Strait follow about the same annual cycles as those in Haro Strait. The temperature variations are about the same but the deep water (60 m) is slightly warmer. The surface salinity in Rasario is similar to that of Haro but the salinity of the deep water attains a maximum of only about 32°/oo. The dissolved oxygen content of the waters in the San Juan region vary from a surface high of over 10 mg/l during the spring phytoplankton blooms to a low of 5.6 mg/l in early fall. At depth the winter high is about 6 mg/l and a low of 4.8 mg/l in autumn. On the average the waters are usually above 80% saturated. The nutrient cycle cannot be described for lack of data.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9
6
3
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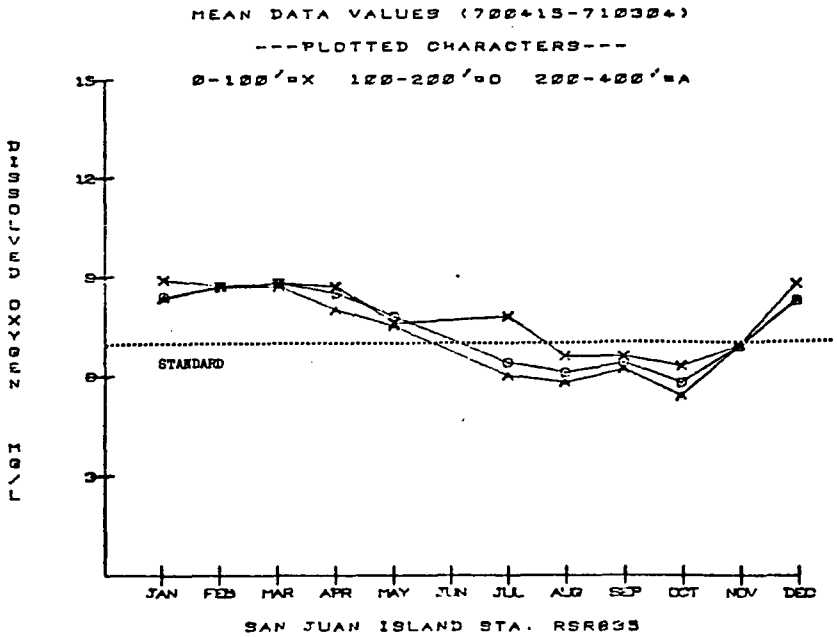
SAN JUAN ISLAND STA. RSR835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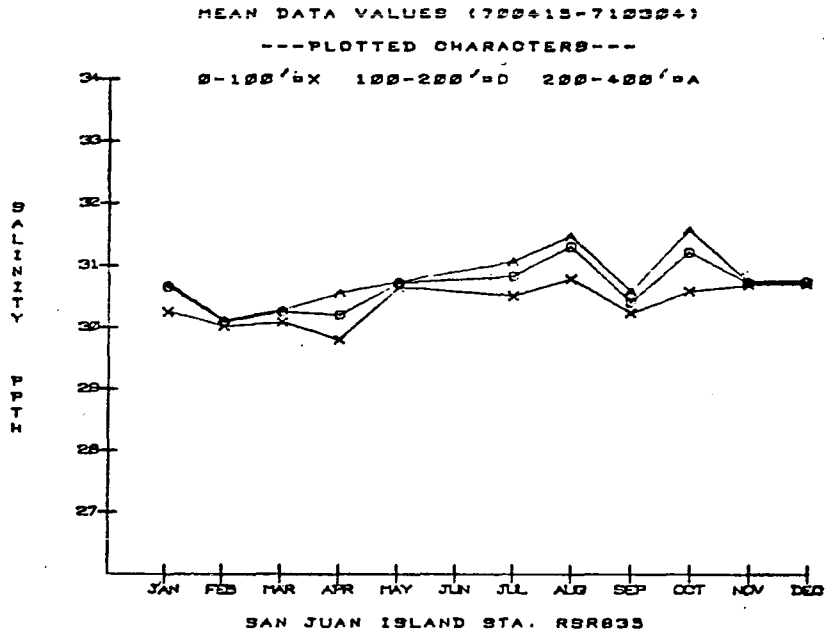
9
6
3
STANDARD
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
SAN JUAN ISLAND STA. RSR835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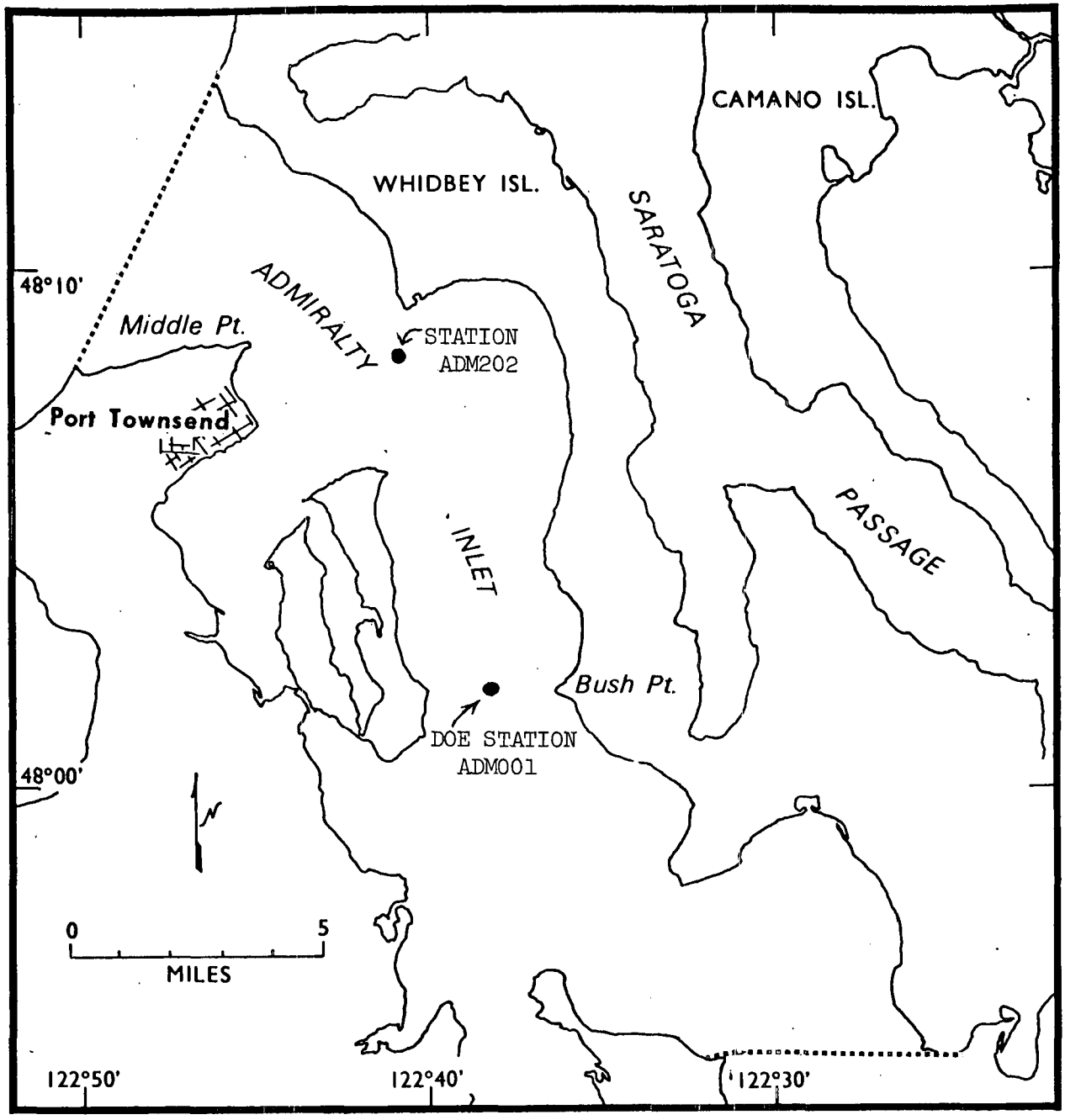
33
32
31
30
29
28
27
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
SAN JUAN ISLAND STA. RSR835

ADMIRALTY INLET BASIN



ADMIRALTY INLET BASIN

ADMIRALTY INLET BASIN

Admiralty Inlet may be considered to be those waters separated from the Strait of Juan de Fuca by a line at the north end between Middle Point and Point Partridge and from the Puget Sound Basin by a line between Point No Point and Scatchet Head. The Inlet is about 31 km (17 naut mi) long, has an average width of 5.5 km (3 naut mi), has a surface area of 400 km^2 (116 sq naut mi) and a volume of 16.8 km^3 (3.41 cubic naut mi) at mean high water. An entrance sill with a controlling depth of 64 m (35 fath) is located at the north end off Point Wilson. The water depth increases rapidly landward of the sill to 180 m (100 fath) east of Marrowstone Point, but this is a deep hole rather than being typical of the Inlet. Most of the water of the Inlet averages about 110 m (60 fath) deep. South of Double Bluff the water deepens rapidly to over 200 m (110 fath) where it enters the Puget Sound Basin.

The prevailing winds in Admiralty Inlet from October through March are from the south at almost 20 km/hr (10 mph). In April and May the winds are variable, but by June become northerly at about 20 to 30 km/hr (10-15 mph). Storm winds often exceed 100 km/hr (50 mph). The main effect of winds in this region is to increase mixing, especially when the wind and tide are in opposite directions.

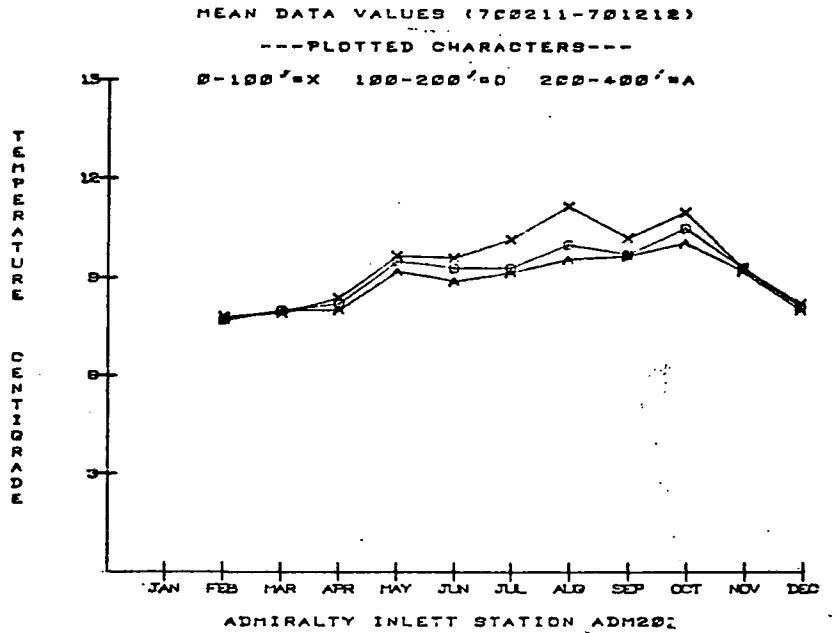
Most of the water entering and leaving Puget Sound must flow through Admiralty Inlet. Only a small portion of water flows through Deception Pass and the Swinomish Slough at the northern end of Whidbey Island. Tidal currents are strong in Admiralty Inlet with speeds frequently over three knots on both ebb and flood with a maximum of nearly five knots during periods of large tidal range. Because of these strong currents, Admiralty Inlet is a large mixing zone for the deeper waters of the Strait

of Juan de Fuca with the fresher surface waters from Puget Sound. The mixed water is more dense than the surface water and less dense than the Strait water and flows back into Puget Sound on a flood tide. The depths at which this mixed water will settle depends upon its density and may be either at the bottom or at some intermediate depth. Thus replacement of water in Puget does not always occur at the bottom. Because of the strong currents in Admiralty Inlet, the flushing time is rapid with the various water types requiring only a few tidal cycles to make the transit through the region.

A considerable difference in the water characteristics frequently exists between the north and south ends of Admiralty Inlet. The waters at the north end are more like those found in the Strait of Juan de Fuca while those at the south end are strongly affected by the Puget Sound Basin. Also water properties vary laterally (east to west) across the channel with fresher water frequently being observed on the Whidbey Island side and more saline water on the west side in response to the Coriolis effect.* Even with these differences, the water characteristics in Admiralty Inlet may be typified by a station east of Port Townsend.(ADM202) On the average, the salinity difference between the surface and bottom waters is less the 1°/oo. The maximum salinity at depth (average 31.8°/oo) occurs in mid-August in response to the maximum intrusion of oceanic water into the Strait of Juan de Fuca. But the maximum surface salinity (averaging 30.9°/oo) does not occur until mid-September when the fresh water contribution from the rivers has decreased to its lowest point. Minimum salinities are observed in winter with a low of 29.8°/oo at the surface and 30.6°/oo at depth. The observed temperatures show a surface maximum of 11.8°C in late August but at depth the maximum of 10.0°C

*Coriolis effect is the apparent change of direction in the path of any object in motion on the earth's surface due to the rotation of the earth. Coriolis effect is perpendicular to and directed to the right of the object's motion in the northern hemisphere. The magnitude is dependent upon the velocity of the object and the sine of the latitude, being most effective at either the north or south pole and zero at the equator.

occured earlier in June or early July when the oceanic water is just coming into the Straits and is making its presence felt. Minimum temperatures of 7.6°C occur at all depths in January. The temperature range from top to bottom is often less than 0.5° but increases to about 2°C in the summer months. Oxygen content will vary from an average maximum of 8.5 mg/l in the winter to an average minimum of 4.8 mg/l in the summer.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9
6
3
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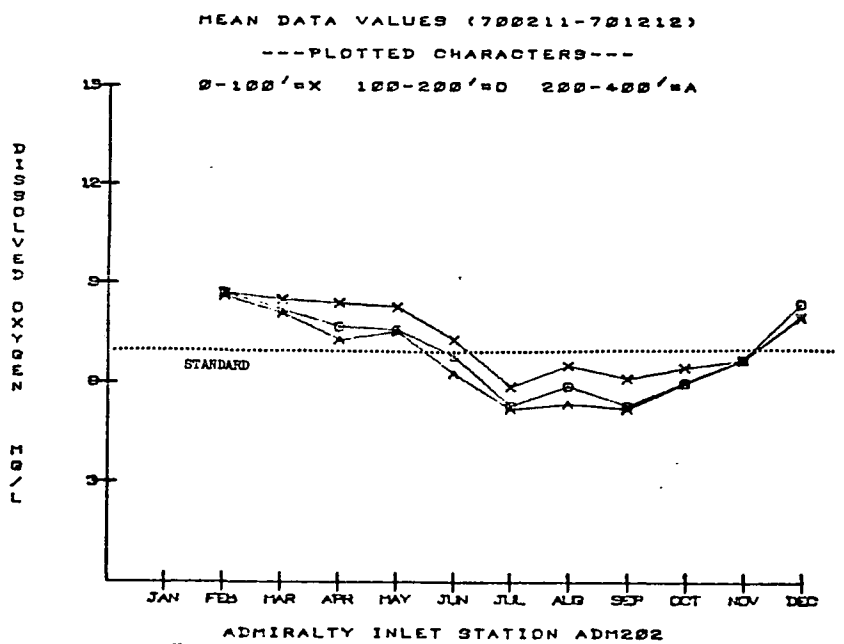
ADMIRALTY INLETT STATION ADM201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9
6
3
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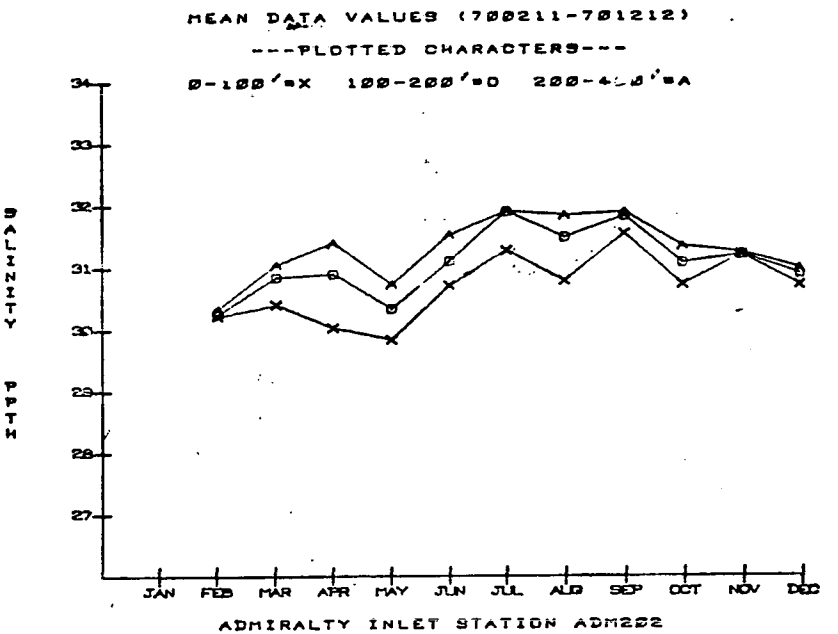
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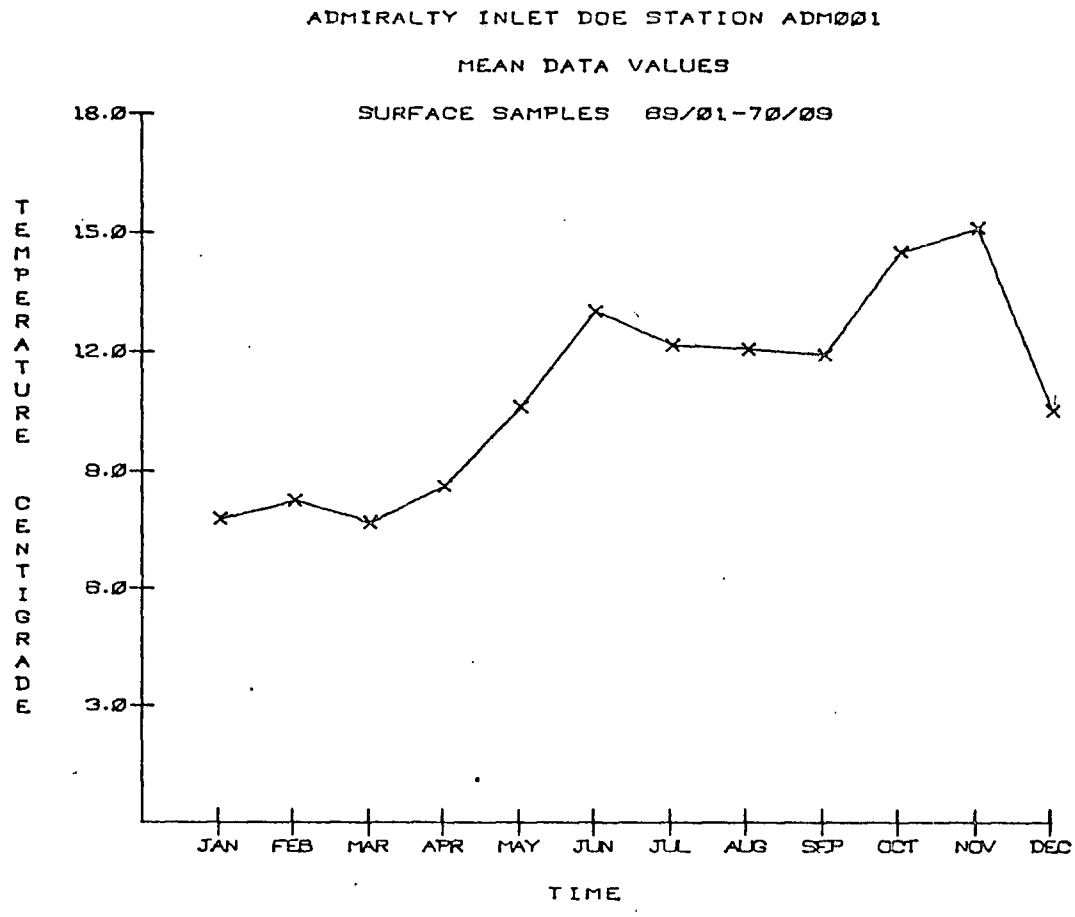
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12.0
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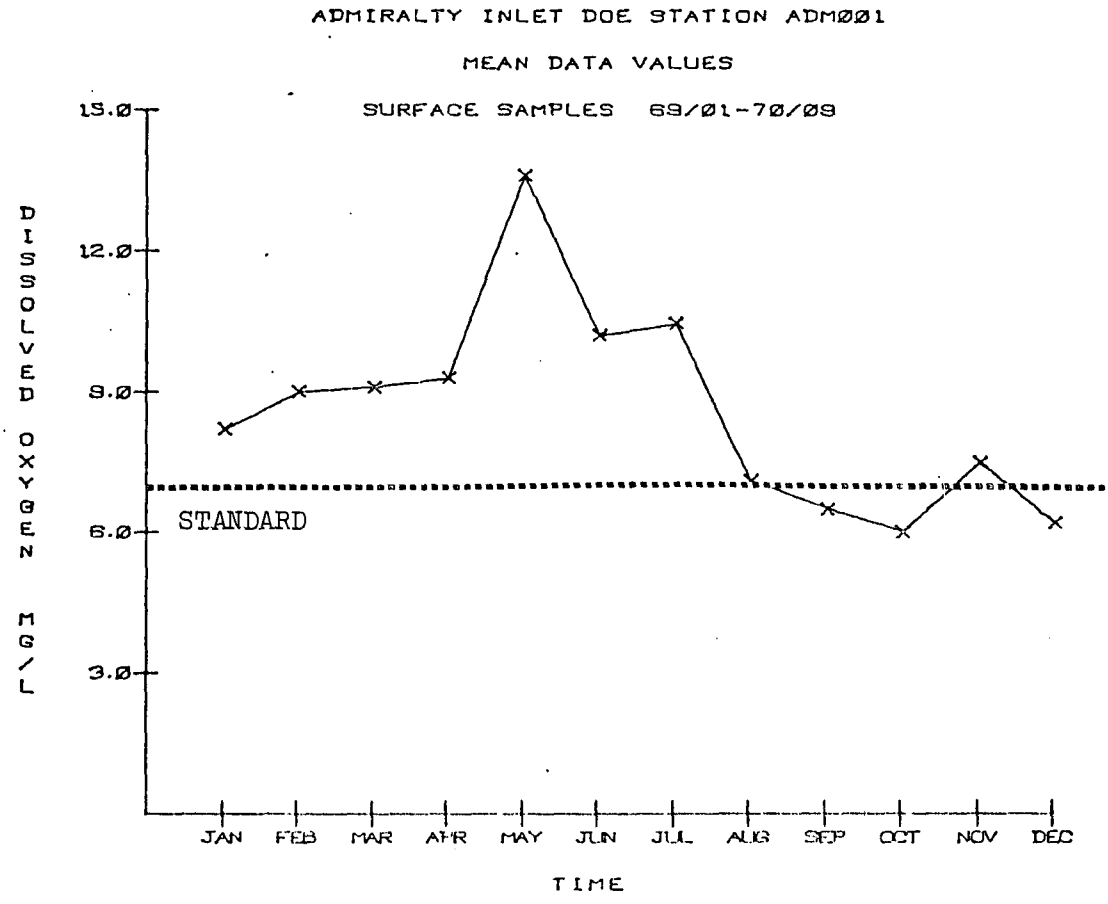
6.0
3.0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
TIME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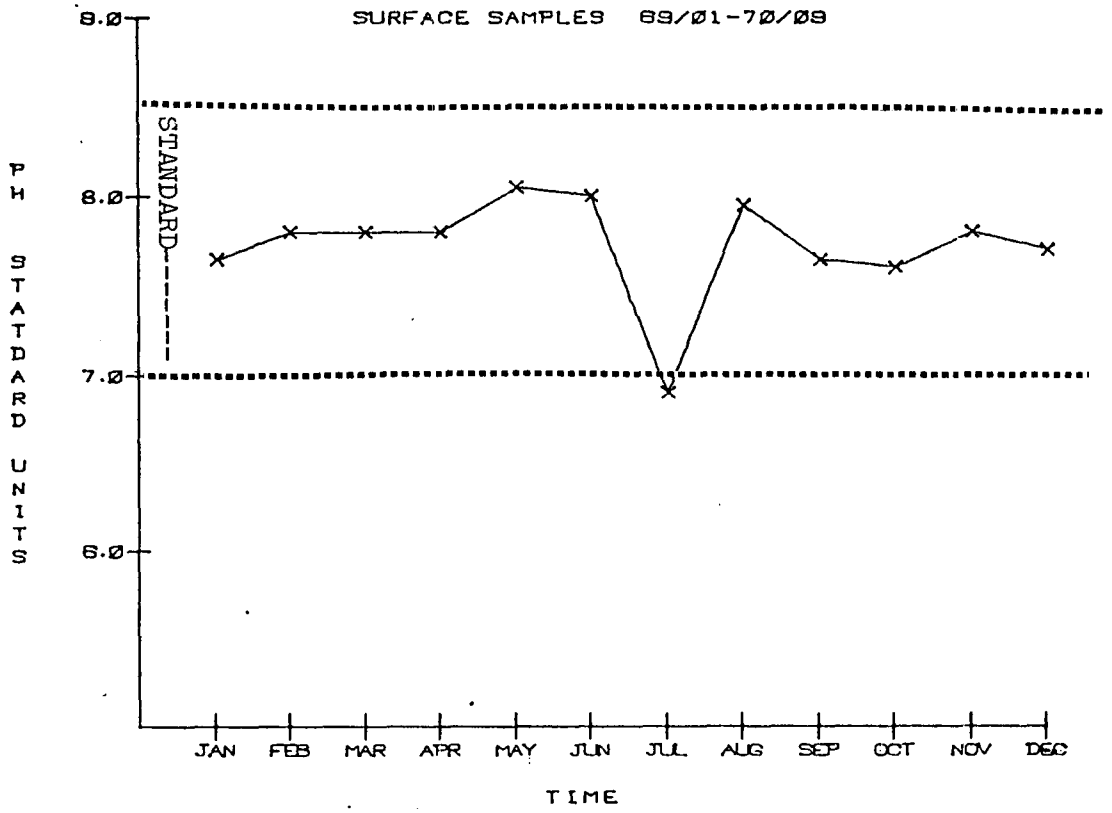
9.0
6.0
3.0
STANDARD
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
TIME

ADMIRALTY INLET DOE STATION ADM001

MEAN DATA VALUES

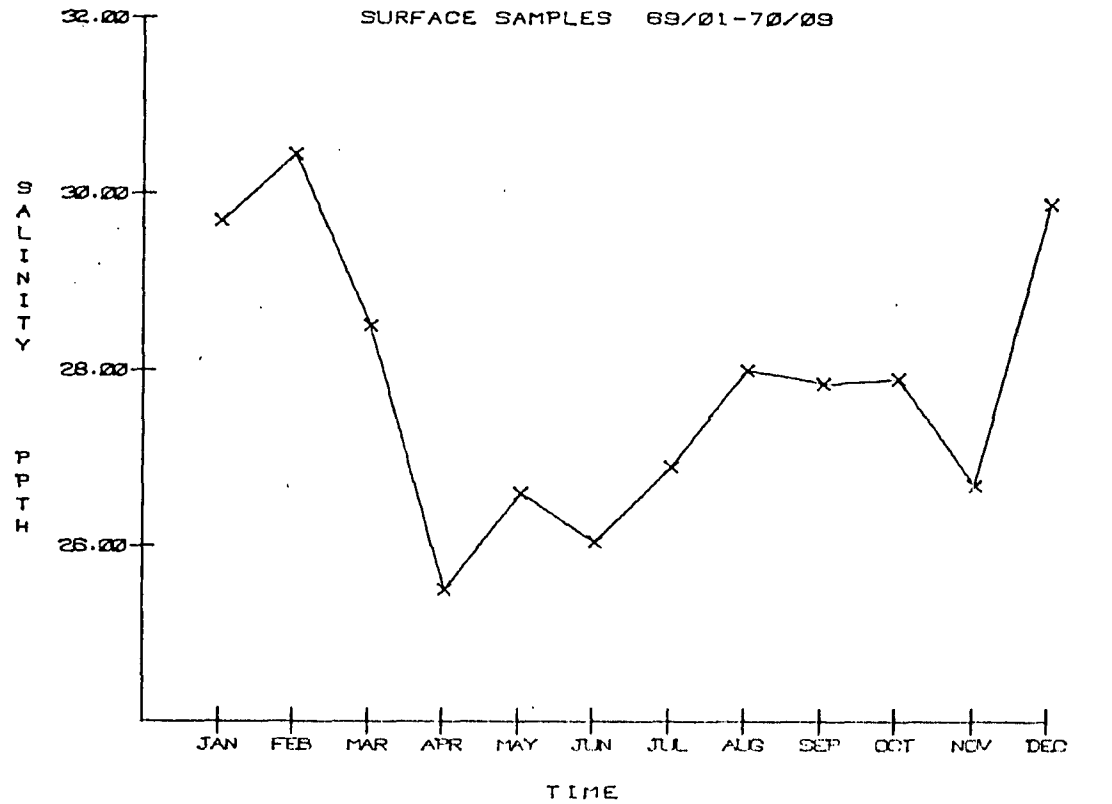
SURFACE SAMPLES 69/01-70/09

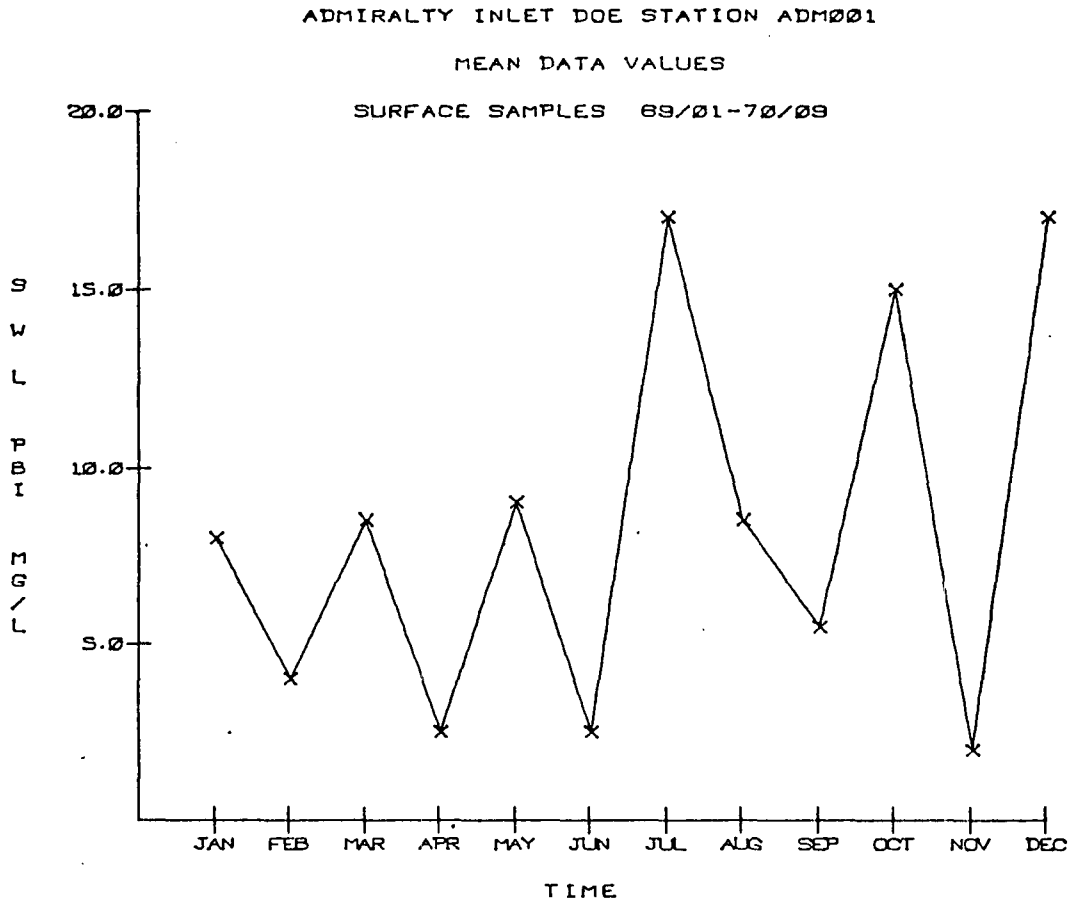


ADMIRALTY INLET DOE STATION ADM001

MEAN DATA VALUES

SURFACE SAMPLES 69/01-70/09




ADMIRALTY INLET DOE STATION ADM001
MEAN DATA VALUES
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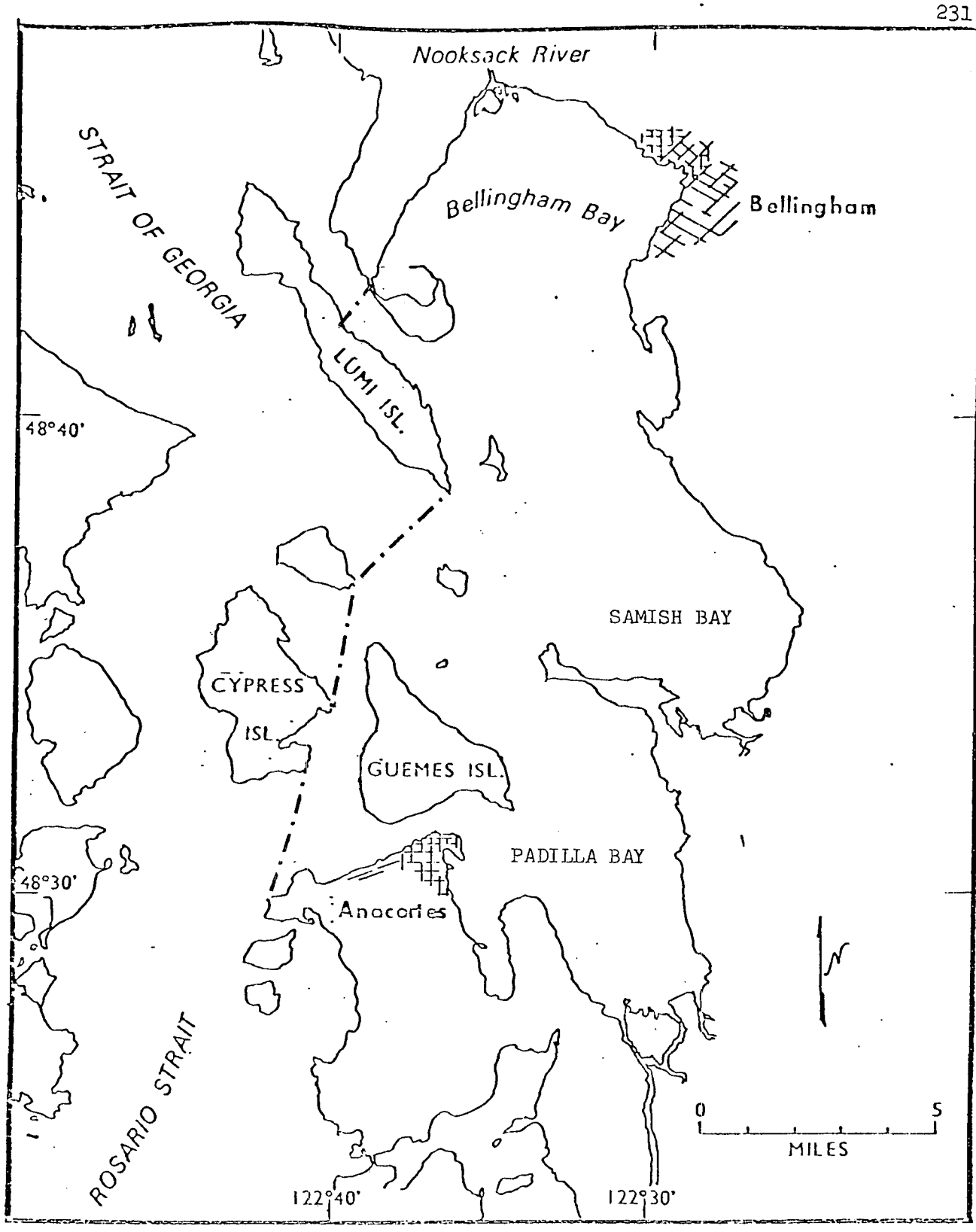
10.0
5.0
S W L P B I M G \ L
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
TIME

NORTH SOUND BASIN



NORTH SOUND BASIN

NORTH SOUND BASIN

The Bellingham region includes Bellingham Bay, Samish Bay, and Padila Bay but basically, it is one oceanographic system. This region is a north-south oriented, kidney-shaped body of water about 35 km (19 naut mi) long, 10 km (5.5 naut mi) wide, and has an average water depth of about 20 m (11 fath) at mean high water. Bellingham and Samish Bays have a combined area of 225 km^2 and a volume of 4 km^3. The area and volume of Padilla Bay have not been determined. This region is connected to Rosario Strait on the west via Guemus Channel, Hale Passage, and a large channel between Lummi and Guemus Islands. The water depth off the southeast tip of Lummi Island is over 100 m (55 fath) and a hole deeper than 100 m is located just east of Eliza Island. The water in Guemus Channel is over 20 m deep to the east of Anacortes where it shoals rapidly. But most of this region is less than 20 m deep with mud flats in upper Bellingham Bay, in the southeast end of Samish Bay and all along the east side of Padilla Bay.

The fresh water sources in this region are the Nooksack River, which discharges into the north end of upper Bellingham Bay, the Samish River, which discharges into the southeast corner of Samish Bay, several small creeks, and land drainage. The Nooksack River exhibits two peak runoff periods, one in the fall and winter in response to local precipitation and the other in June due to snow melt. The discharge of the Samish River is controlled by local rainfall.

Prevailing winds in this region are dominantly from the south and southeast at about 10 to 20 km/hr (5 to 10 mph). But occasionally in both winter and summer, strong northerly winds with speeds over 60 km/hr (30 mph) are observed. When northerly winds occur in the winter, they are

accompanied by very cold air temperatures, frequently as low as -16°C and in the summer they are accompanied by very warm winds with extremes up to 36°C. But the average air temperature, over a thirty year period is 9.4°C (49° F). The average annual rainfall in downtown Bellingham is 86 cm (33.7 inches).

This region has been the subject of oceanographic investigations for many years. The Washington State Pollution Control Commission has made studies in the area (Wagner, Ziebell, and Livingston, 1957) as has the Washington State Department of Fisheries (Westley, 1957, 1958; Westley and Tarr, 1959, 1960; Lindsay, Westley, and Woelke, 1960). The University of Washington conducted an intensive survey of the area in 1960 and 1961 (Collias and Barnes 1962; Collias, Barnes, Murty, and Hanson, 1966) and the Georgia Pacific Company has also made many surveys in the region.

The Nooksack River is the dominant influence in controlling the salinity of the surface layer for this region but is most influential in upper Bellingham Bay. The Samish River, which is much smaller, dilutes the water locally in Samish Bay but has little effect elsewhere. The surface layer in Padilla Bay is affected mostly by local drainage and somewhat by any fresh water coming into the area through the Swinomish Slough. The thickness of the surface layer in Bellingham Bay varies inversely with the amount of Nooksack River discharge. High discharge rates produce a thin, low salinity layer covering a considerable portion of upper Bellingham Bay. But when the river flow decreases, the density difference between the surface and deeper water decreases and hence the water column will afford less resistance to vertical mixing. Thus at a normal river stage the surface layer is quite deep and fairly salty. During periods of very low river flow in September, the surface layer practically disappears and the salinity observed throughout the entire

region approaches that of Rosario Strait.

The effect of winds upon this region is to move the surface water from one part of the system to another with a deep compensating counterflow being established. This counterflow is often cooler and more saline than the original water and may appear at unexpected locations within the region. A strong southwest wind will move the surface layer towards the head of Bellingham Bay causing it to deepen nearshore. When the wind subsides, the surface layer will move seaward at an accelerated rate until equilibrium is again reestablished. On the other hand, northerly winds will move the surface layer out of upper Bellingham Bay and may cause pockets of fresher water to form in the center of the Bay.

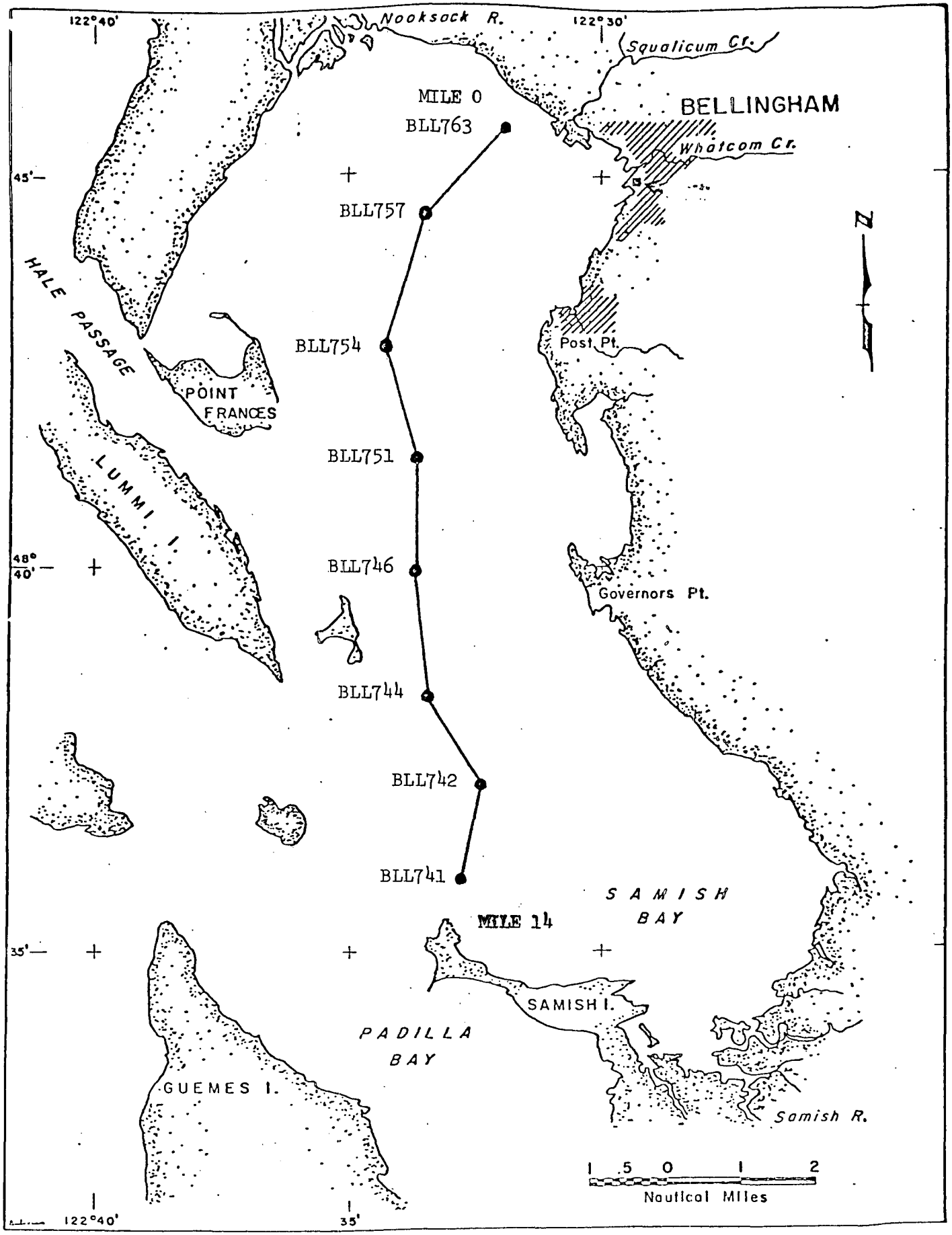
The salinity of the surface layer in this region is quite variable. During periods of high Nooksack runoff, the salinities in upper Bellingham Bay as far south as Post Point may be lower than 12°/oo and then will gradually increase to about 27°/oo off Samish Bay and to about 28°/oo in Padilla Bay. On the other hand, in late summer, the surface salinity will increase to over 30°/oo and be similar to that observed in Rosario Strait. Surface temperatures vary from a winter low of about 6°C to a summer high of 22°C in upper Bellingham Bay, but the summer temperature in Samish Bay and Padilla Bay rarely exceed 15°C. The oxygen content of the surface layer will vary from 7 to 13 mg/l and is somewhat dependent upon biological activity.

The surface water characteristics in Bellingham Harbor are modified to some extent by the effluent from the pulp mill in this vicinity which is the source of spent sulfite liquor (SSL). The concentration of SSL is observed throughout this entire region at all times. Values of SSL greater than 10 ppm are rarely observed below 10 m (33 ft) depth, with

most of the SSL being confined to the upper 5 m (16 ft). Also, high SSL values are usually associated with salinities of less than 28°/oo, but it is possible for high SSL's to be associated with more saline water. Also, on occasion fresher water of low SSL content may cover more saline water with higher SSL content and this combination will move to the other portions of the bay to produce a pocket of high SSL that is below the surface.

The deep water in the Bellingham region has its origin in Rosario Strait. This water moves into the region without significant modification. In general, the deeper water exhibits a maximum salinity of about 30.5°/oo in late autumn and a minimum of about 29.5°/oo in May. The corresponding temperatures are 10.5°C and 7.9°C. The oxygen content will vary from a summer low of 5 mg/l to a winter high of nearly 11 mg/l, while the phosphate content will be between 2 and 3 micro-gram atoms per liter. The spent sulfite liquor content of this deep water rarely exceeds 5 ppm.

The flushing time of Bellingham Bay has been computed according to the definition proposed by Pritchard (1952) and was found to vary from one to ten days with an average of four days for Bellingham Bay. A flushing time of about two days was computed for the inner harbor of Bellingham Bay using the SSL distribution. In general, flushing of this region is active and all the water is changed within a two week period on the average.



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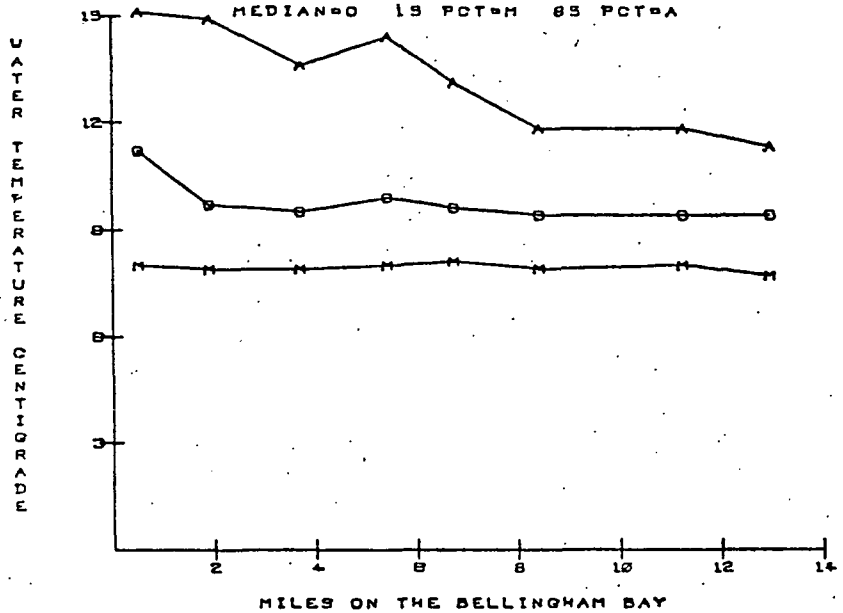

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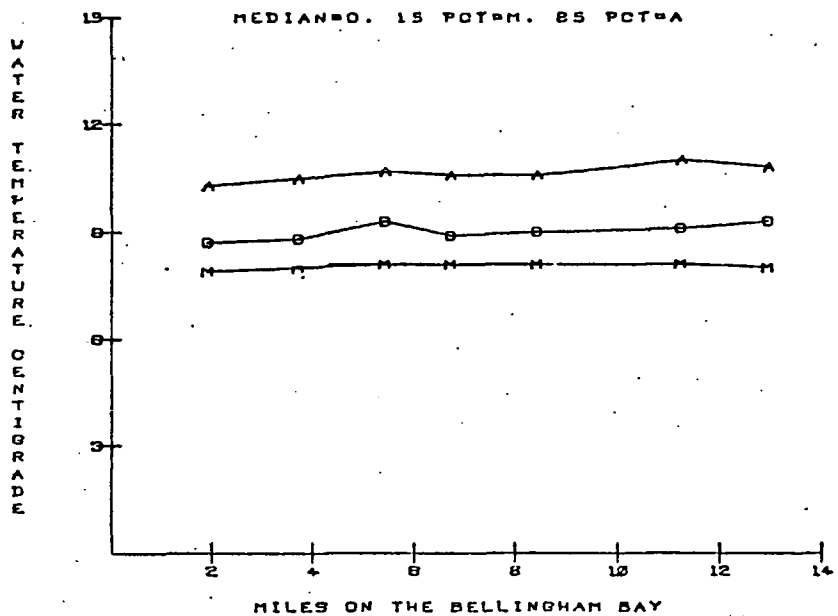

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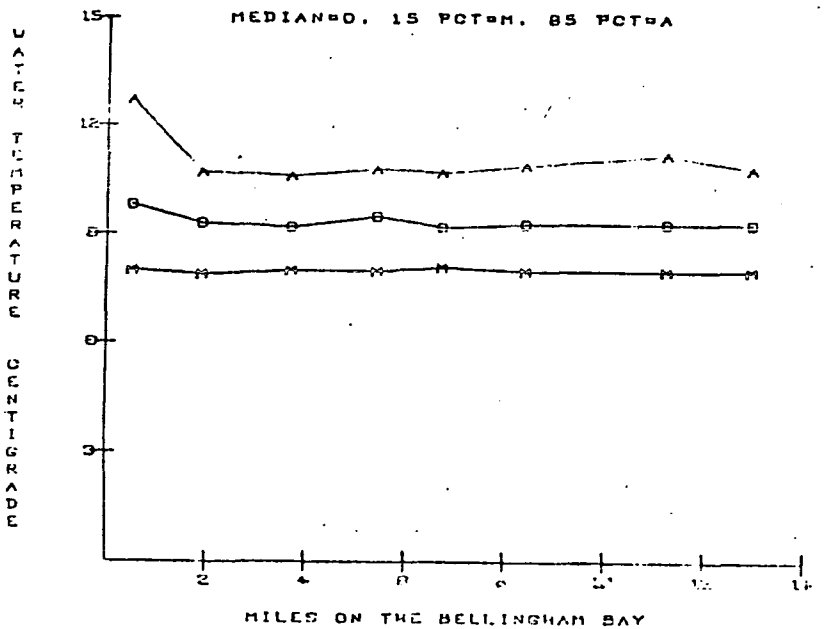

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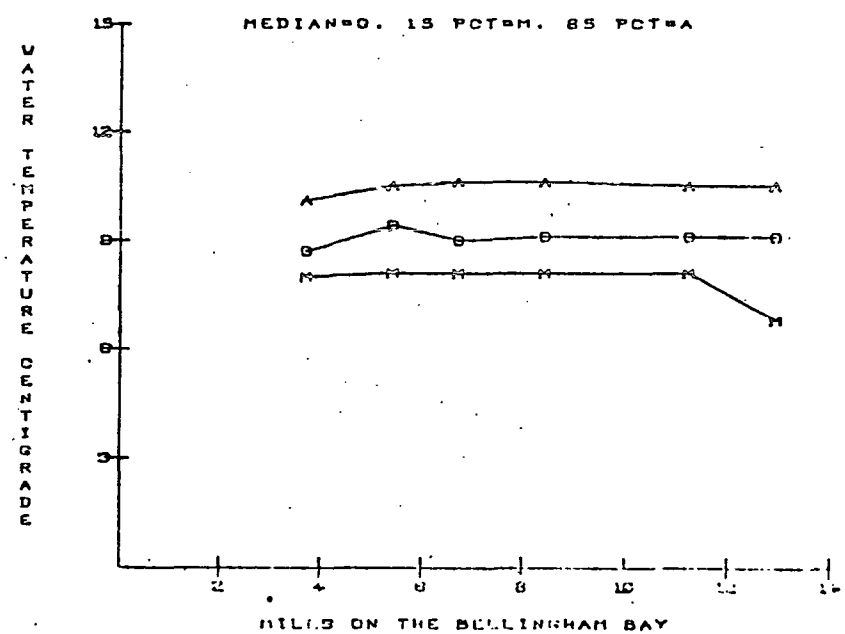

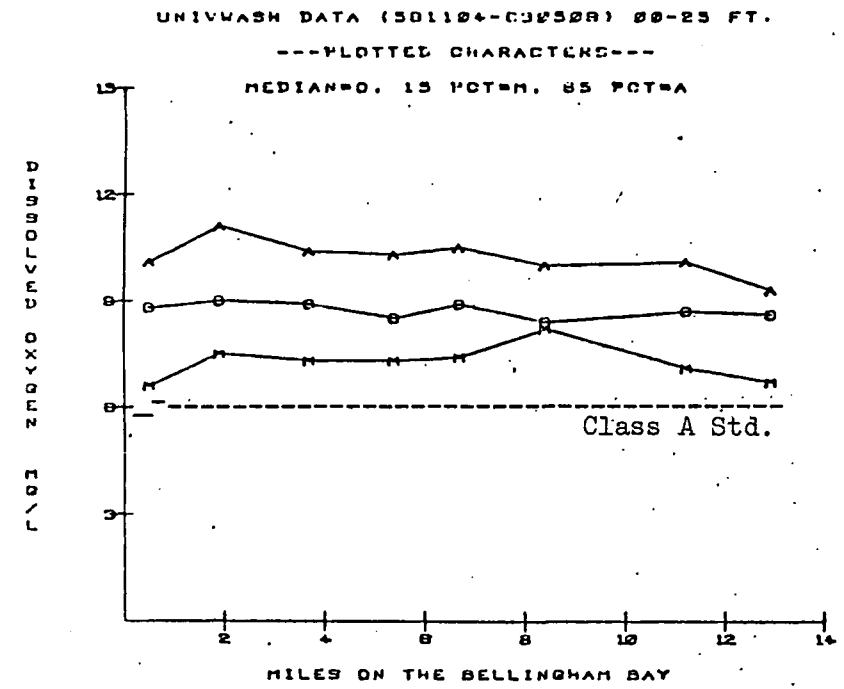
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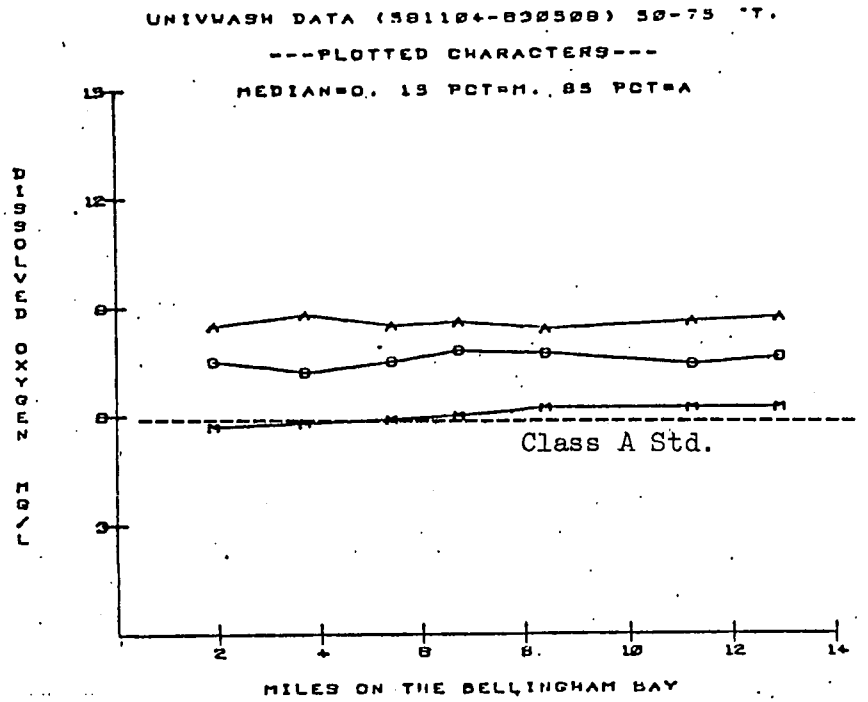
MILES ON THE BELLINGHAM BAY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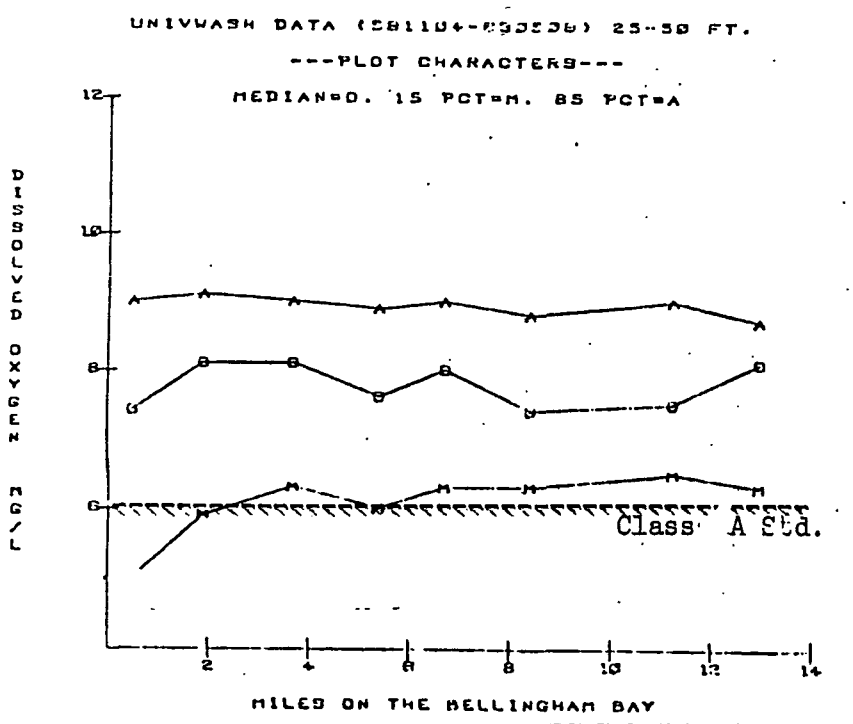
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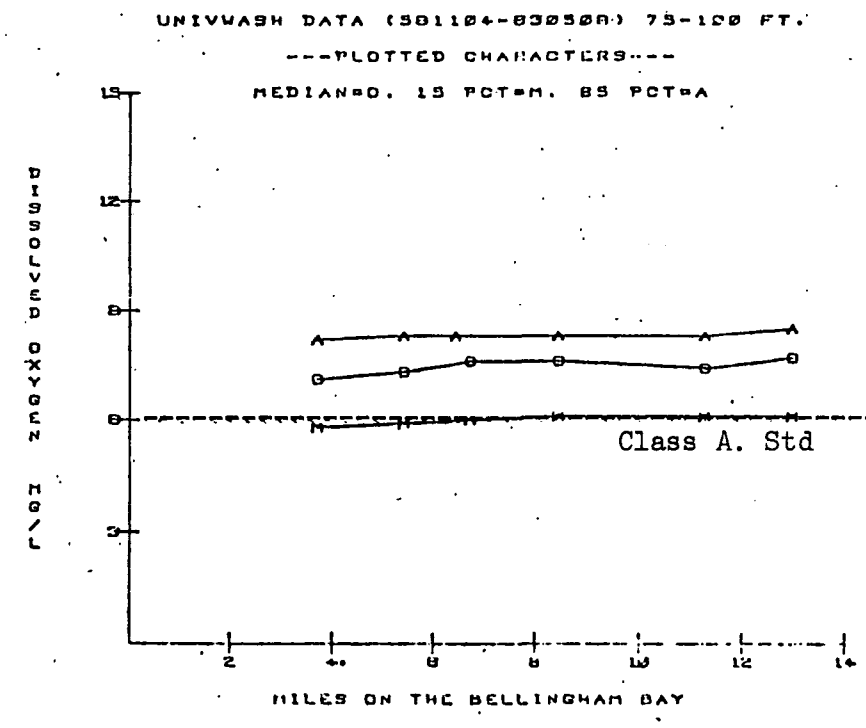
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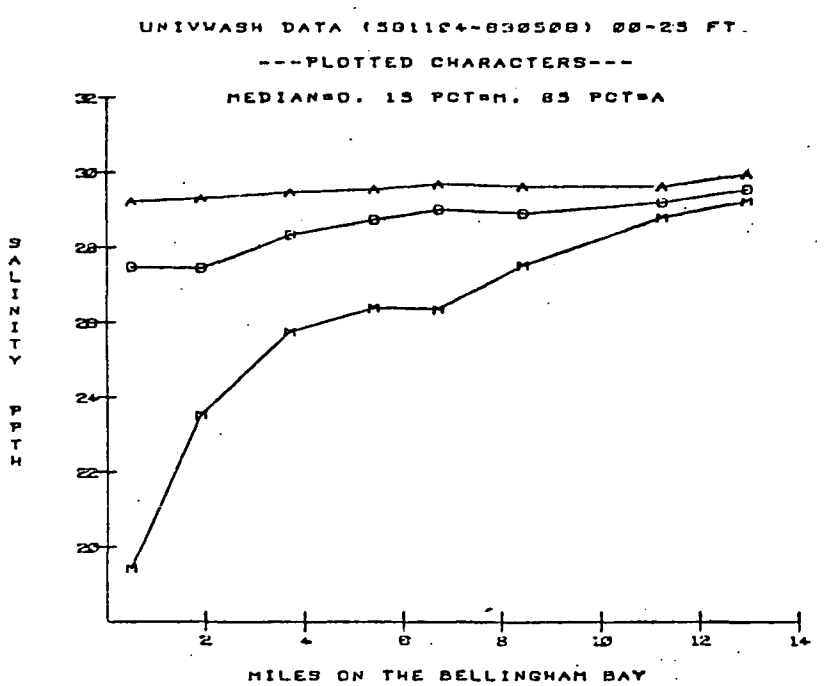
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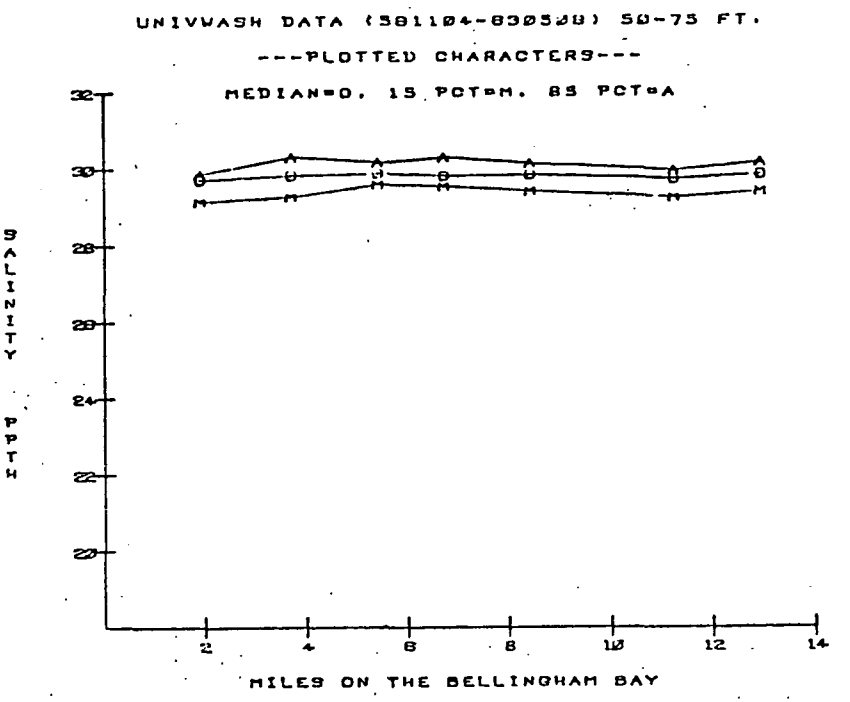
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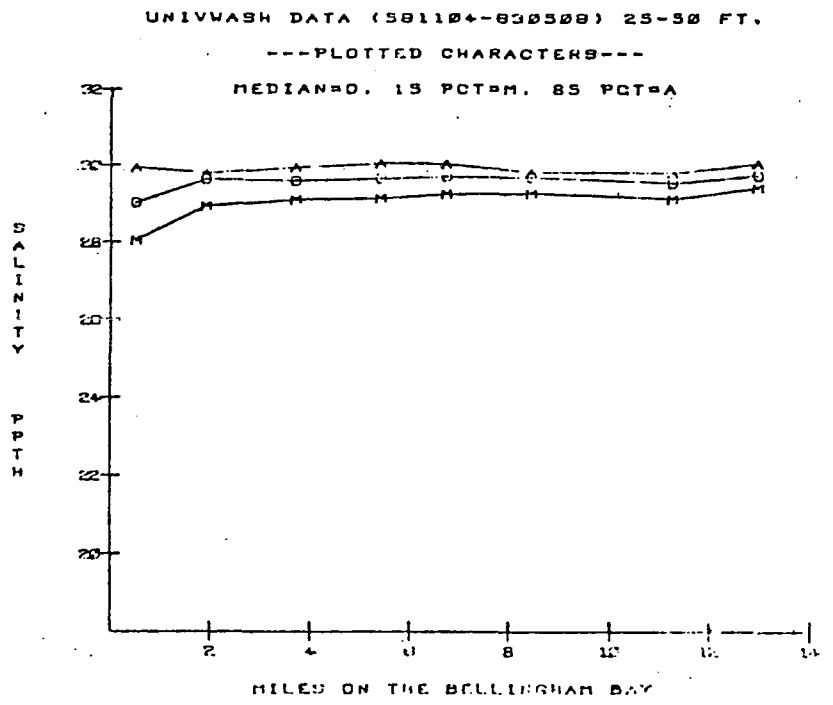
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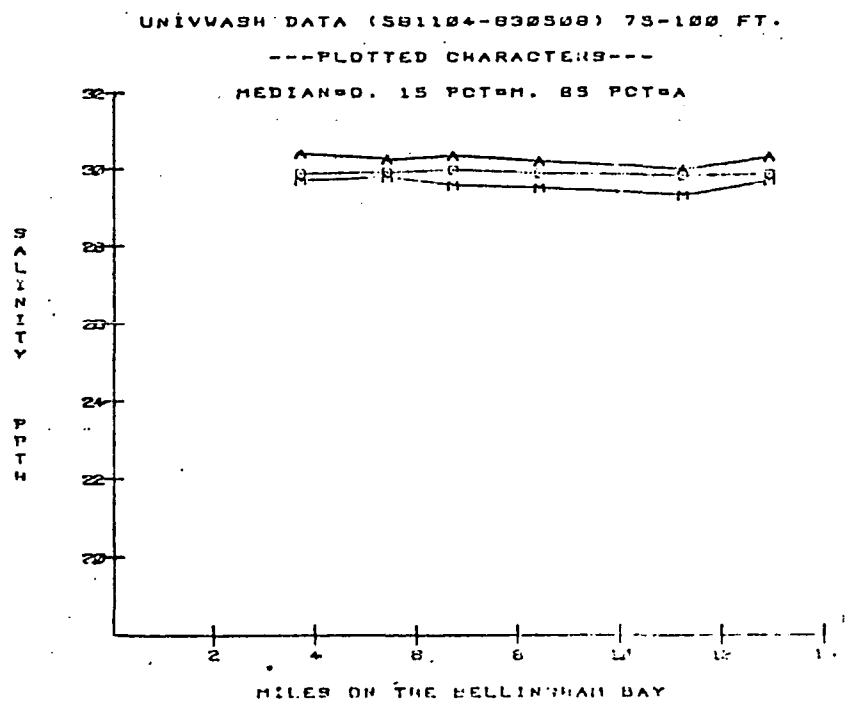
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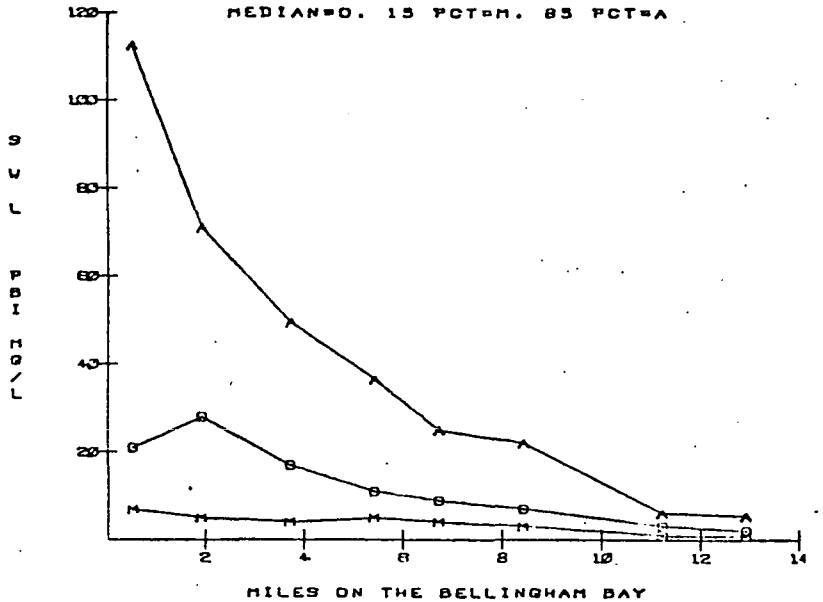

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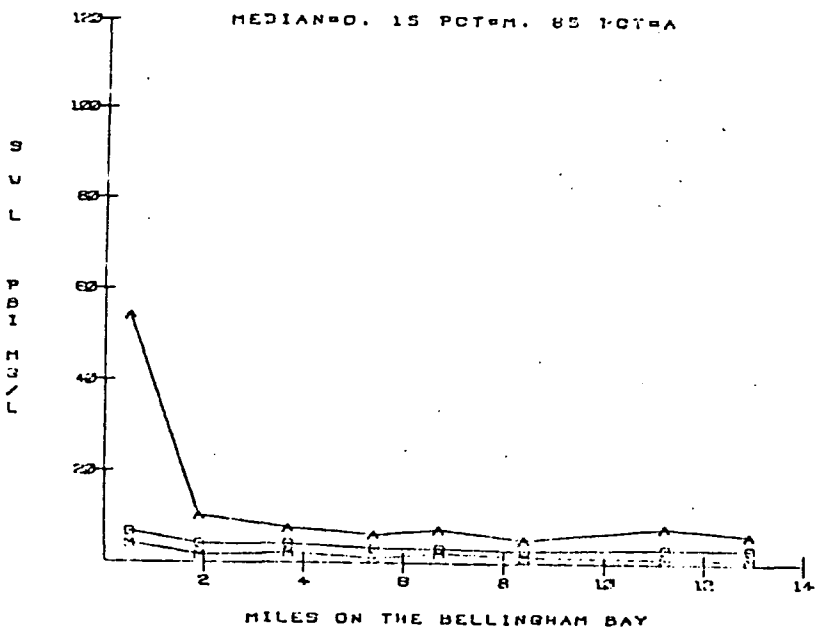

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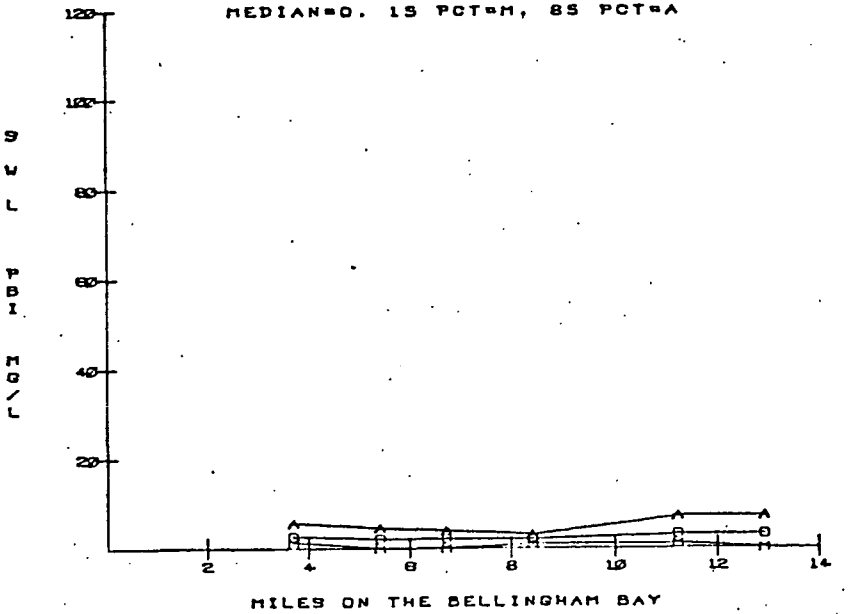

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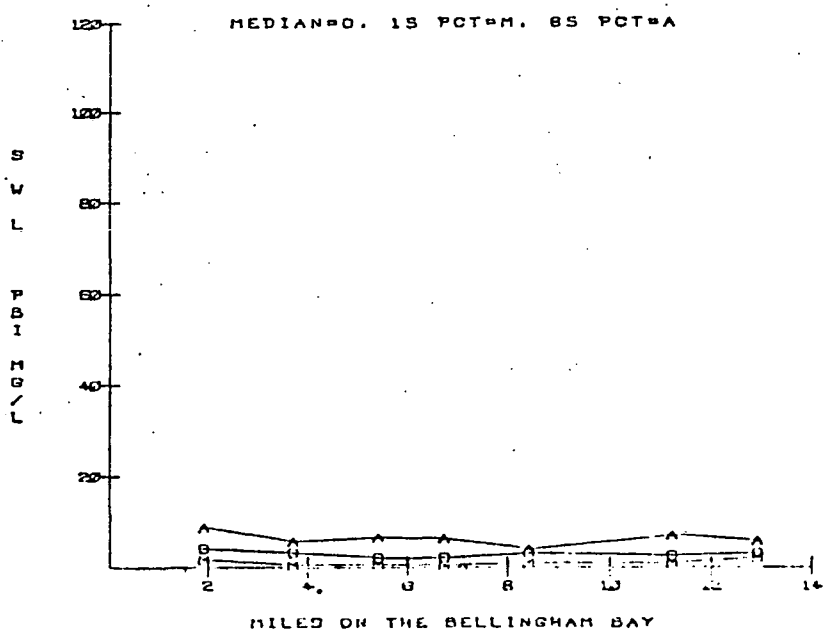
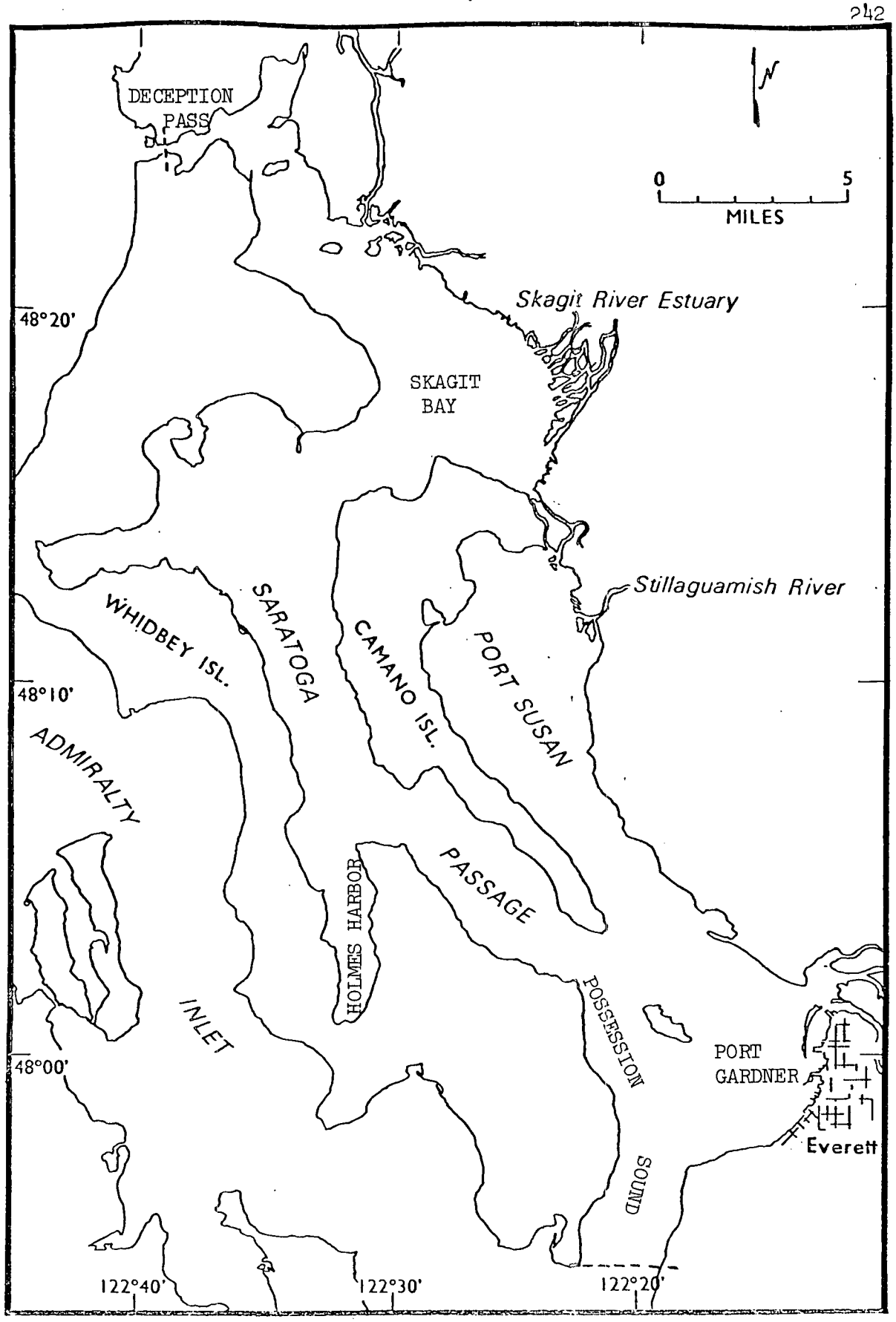


WHIDBEY BASIN



WHIDBEY BASIN

WHIDBEY BASIN

The Possession Sound region consists of the waters confined between Whidbey Island on the west and the mainland on the east. It is connected to the Puget Sound basin at the south end off of Possession Point while at the northern end it is connected to the Strait of Juan de Fuca via Deception Pass. This region may be divided into three oceanographic sub-regions as follows: (a) Possession Sound - Saratoga Passage - Skagit Bay, (b) Port Susan, and (c) Holmes Harbor. The distance from Possession Point to Deception Pass via Saratoga Passage and Skagit Bay is 74 km (40 naut mi) and the width varies from 3.2 km (1.7 naut mi) to 10 km (5.5 naut mi). The total surface area is 635 km^2 (185 sq naut mi) and the volume is 28.1 km^3 (4.58 cu naut mi) at a mean high tide of 3.1 m (10.5 feet). Port Susan is a large bay north of the city of Everett and east of Camano Island. It is 28 km (13.5 naut mi) long and has an average width of 3.7 km (2.0 naut mi). Holmes harbor is a small bay on the southeast side of Whidbey Island and is 10.5 km (5.6 naut mi) long and 1.8 km (1 naut mi) wide.

The water depths from Possession Sound to Skagit Bay vary from 220 m (120 fath) off of Possession Point to extensive mud flats east of Skagit Bay. Saratoga Passage varies in depth from 170 m (93 fath) west of Camano Head to 55 m (30 fath) off Ponell Point. From here it shoals rapidly to 18 m (10 fath) in Skagit Bay but then increases in depth to 60 m (33 fath) in Deception Pass. Port Susan has an entrance sill with a controlling depth of 97 m (53 fath) east of Camano Head but again deepens to an average basin depth of 115 m (63 fath). The deep water of Port Susan is separated from those of Saratoga Passage by a ridge with a maximum water depth of 27 m (15 fath) extending from Camano Head to

Gedney Island (locally known as Hat Island). Holmes Harbor has an entrance sill of 37 m (20 fath) at its north end and an average basin depth of 51 m (28 fath).

Fresh water sources for this region are three major rivers, namely (1) the Skagit which empties into Skagit Bay north of Camano Island, (2) the Snohomish which empties into Everett Harbor, and (3) the Stillaguamish which empties into the northeast corner of Port Susan. The Skagit River is the largest river in the Puget Sound drainage basin and contributes about 35% of the total freshwater flowing into Puget Sound on an annual basis. The Snohomish River is the second largest river discharging into Puget Sound and contributes about 30.5% of the total fresh water. The Stillaguamish River is the third largest river empting into Puget Sound but contributes only about 8.5% of the fresh water. The first two rivers have high water periods occuring during periods of warm weather plus large amounts of precipitation. When snow melts in the mountains in June, a peak runoff will occur that lasts for a longer period of time than from direct precipitation. The Stillaguamish River is primarily rain-fed, so that its peak flow is a reflection of recent rainfall in its watershed. The combined flow of these rivers on an annual basis accounts for 74% of the total river runoff entering the Puget Sound system. This large amount of fresh water has a pronounced effect upon the oceanography of the Possession Sound region and frequently affects that of the north end of the Puget Sound basin.

Prevailing winds in this region are dominately from the south for most of the year except during the summer when they shift to the north. Speeds average about 20 to 30 km/hr (10-15 mph) with many periods of relative calm. Storm speeds frequently exceed 100 km/hr (50 mph). The effect of the winds and other variables are best discussed separately for

for each of the oceanographic sub-regions in Possession Sound.

(1) Possession Sound - Saratoga Passage - Skagit Bay

Because this sub-region receives such a large amount of fresh water from only two rivers, it is dominated most of the year by a relatively thick (5 to 15 m) low salinity, surface layer. The salinity of this layer will vary from less than 5°/oo off the river mouths to about 28°/oo in more distant parts such as near Deception Pass or off of Possession Point. During periods of maximum runoff, the fresh water layer will move southward past Possession Point and frequently is observed off Seattle. Disapation of this layer by wind and tide action occurs within two weeks after the discharge returns to normal. Frequently in the Skagit Flat area, the fresh water layer is observed nearly to the bottom. and will extend from the mouth of the Skagit River north to Deception Pass and south into Saratoga Passage. Surface temperatures will vary from an average low of 6°C in winter to about 17°C in the summer. The extreme temperatures range from a winter low of 0°C and a summer maximum of over 20°C in areas of restricted circulation. The oxygen content of this water is usually above 6 mg/l and is usually completely saturated but may vary from as low as 4 mg/l to over 15 mg/l. The phosphate concentration may vary from a low of 0.5 to over 2.9 micro-gram atom/l with the fresher water usually being deficient in phosphate while being high in oxygen. The surface waters in the vicinity of Everett Harbor receive domestic and industrial wastes as well as a large flow of fresh water from the Snohomish River. Under combinations of low river runoff and a strong southwest wind, it is possible to develop an oxygen deficient area in Everett Harbor that may be harmful to marine life.

The characteristics of the deep water in this sub-region are quite

variable but the variations are associated more with depth than other changes. The deep water off Possession Point and into Possession Sound to as far north as the south end of Camano Island reflect the conditions found in the northern end of the Puget Sound basin. Temperatures will vary from a winter low of 7°C to a summer high of 11°C. Salinities will vary from about 29°/oo in winter to slightly over 31°/oo in late summer. The oxygen content will vary from 5 to 8 mg/l and the phosphate content from 2 to 3 micro-gram atoms/l.

The deep water off Everett Harbor are influenced to a small extent by a submerged outfall serving two pulp mills in Everett. The effluent is mostly fresh water but as it is discharged it mixes with the surrounding seawater. When it reaches a density level equal to its own density, it will form a thin layer below the surface without penetrating the surface. This layer will be characterized by high spent sulfite liquor content (between 100 to 300 ppm) and relatively low oxygen content. The extent of coverage is usually less than 5 km radius and can be considered to be a local disturbance rather than one of great magnitude. This layer was studied intensively by the U.S. Public Health Service in 1964.

(2) Port Susan

Even though Port Susan is Connected to Possession Sound at its southern end, it tends to act apart from the rest of this region. The fresh water supplied by the Stillaguamish River is greatest in winter rather than in summer and in a much less amount so that the surface layer is usually less than 10 m thick. Because of the entrance sill, some of the water below 100 m is trapped and will remain in the inner basin for several months. The oxygen content of this trapped water will decrease with time, becoming less than 1.5 mg/l while the phosphate

content will increase to over 4 micro-gram atoms/l. Flushing of this water will occur in the fall and again in February or March of each year when the deep intruding water is at a greater density than the trapped water. When this low oxygen content water moves out, it may cause pockets of oxygen deficient water to appear at mid-depth or at the surface. This is a naturally occuring phenomenon and is not associated with an industrial or domestic wastes discharged into Port Susan or Everett Harbor.

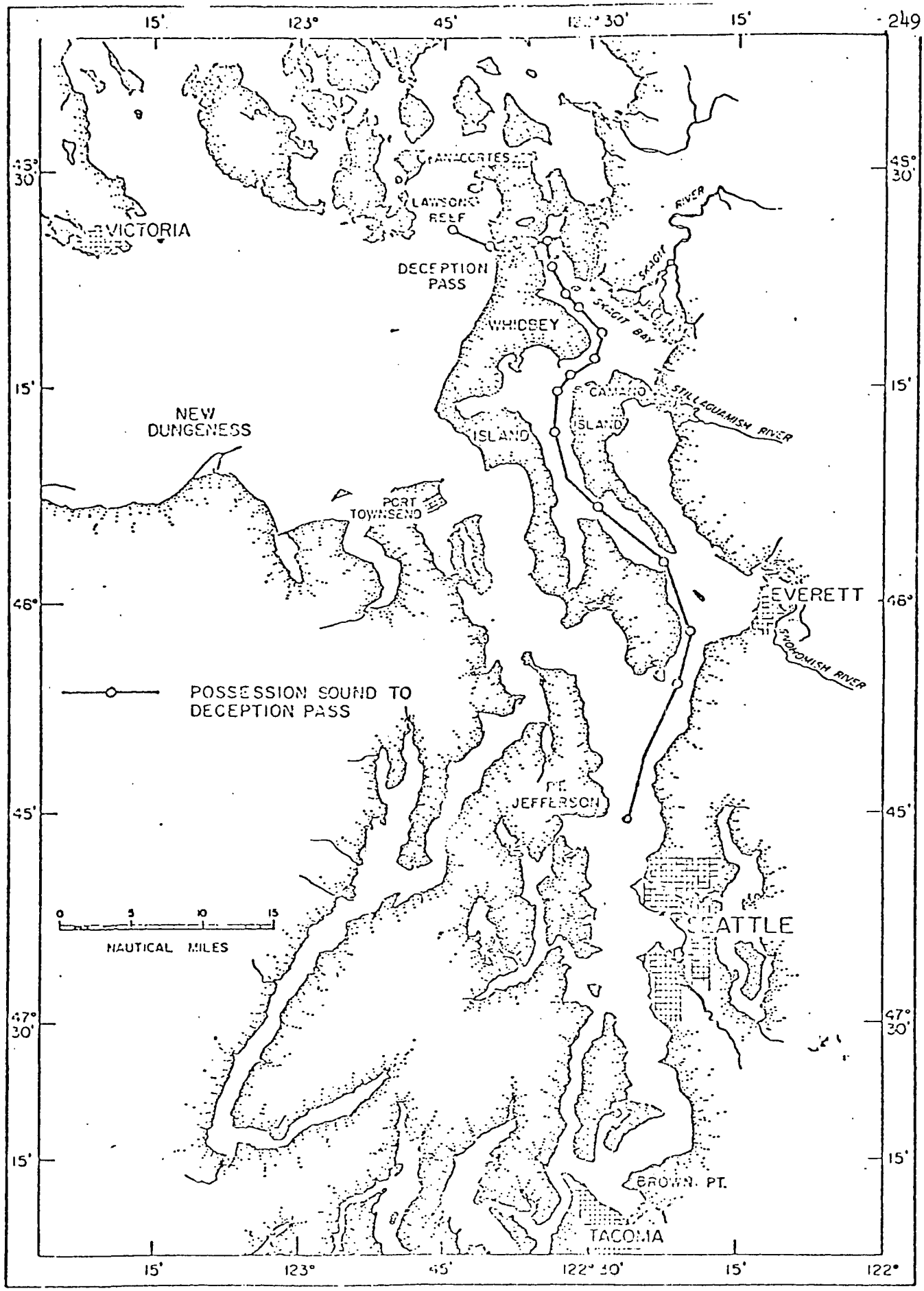
Winds will affect the surface layer and in turn move the deeper water. A southerly wind will confine the surface waters in the head of Port Susan, causing the surface layer to deepen and become more distinct at the bottom edge. This in turn will force some of the deep water to flow southward. But a northerly wind will force the surface layer out of Port Susan thereby permitting deeper cooler water to come to the surface. This water may be oxygen poor especially in late fall.

Water temperatures at the surface will vary from 6°C to about 16°C while the deep water temperatures are more stable varying from 7° to 10°C. The surface salinities are quite variable and reflect both the local contribution of fresh water by the Stillaguamish as well as water from the Snohomish at the southern end. This makes the distribution of the surface layer quite involved and difficult to predict. The waters below the surface layer and above the water trapped in the basin are similar to those found in Possession Sound and have very similar characteristics.

(3) Holmes Harbor

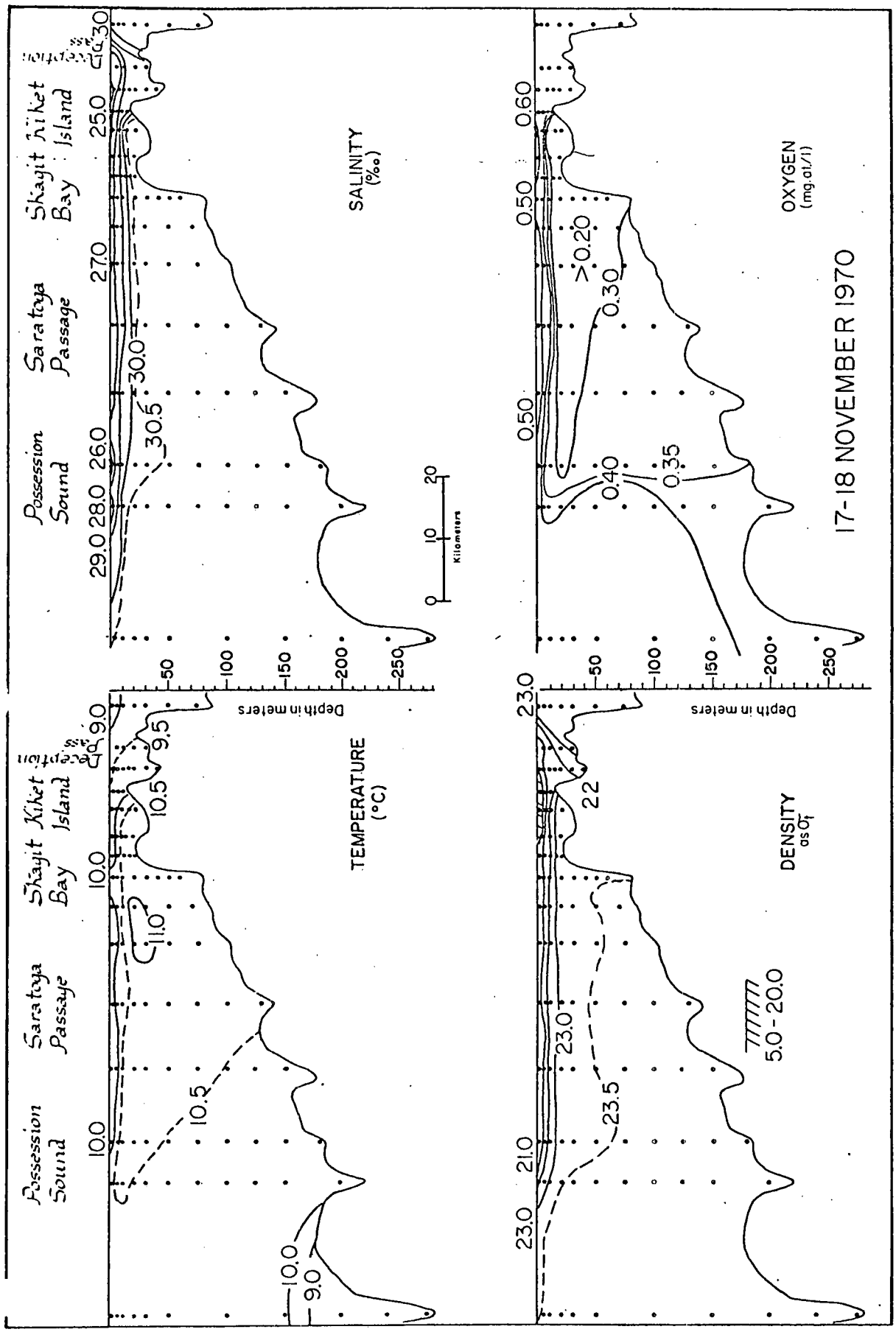
The waters in Holmes Harbor show a surface layer that is actually part of the surface layer found in Saratoga Passage. The deeper water may be trapped behind the sill for a while, but this sub-region flushes more rapidly than Port Susan. Temperatures observed in the waters below

20 m vary from 7° to 12°C, the salinities from 27.5 to 30.5°/oo, the oxygen content from 3 to 8 mg/l, and phosphates from 1 to 3.5 micro-gram atoms/l. Southerly winds will push the surface layer out of Holmes Harbor causing deeper water to move to the surface while northerly winds will cause the surface layer from Saratoga Passage to move into the harbor.



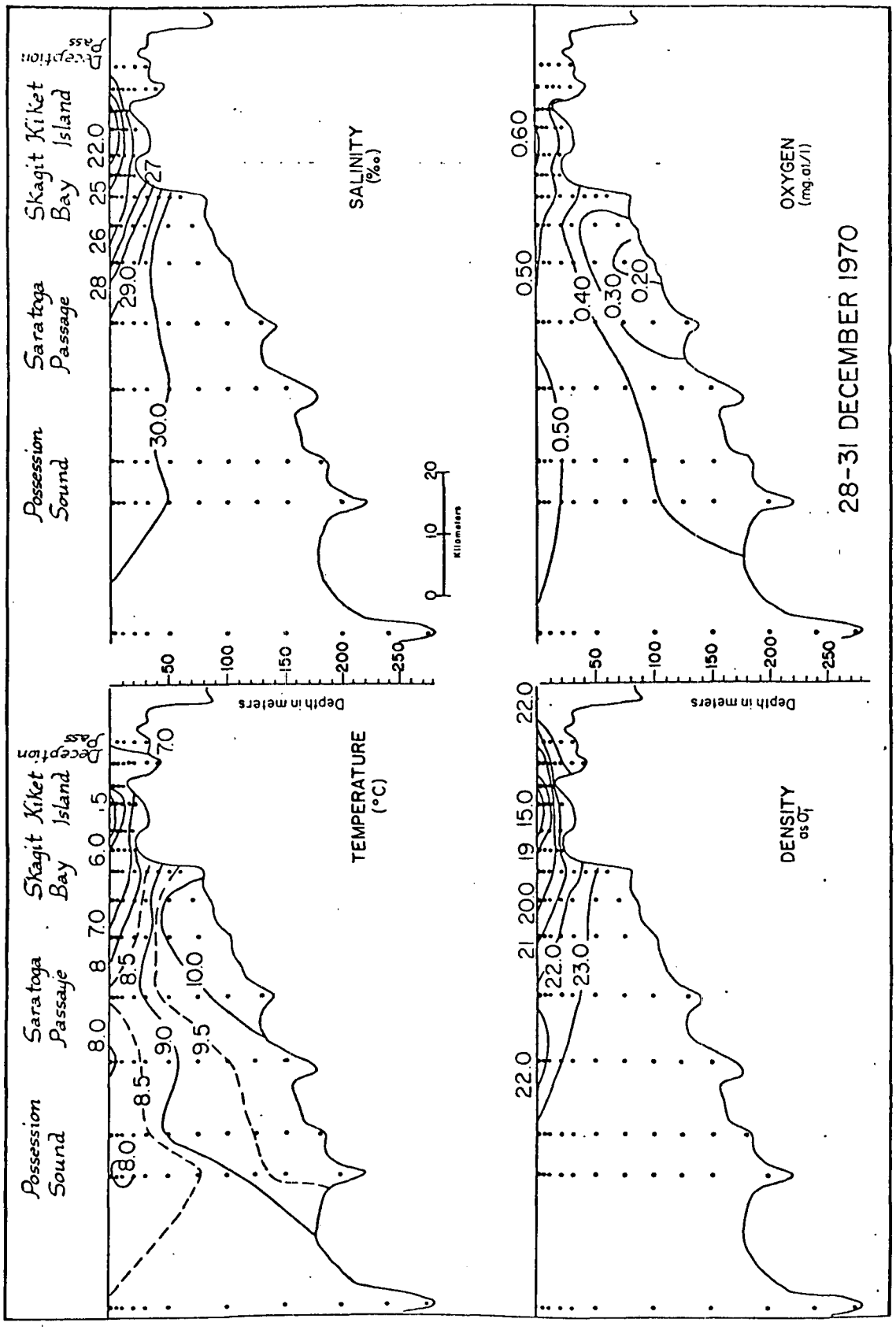
Location of station profile used to present data.

SOURCE: Skagit Bay Dynamical Oceanography Final Report. Eugene E. Collias, Clifford A. Barnes, and John H. Lincoln. 1973.



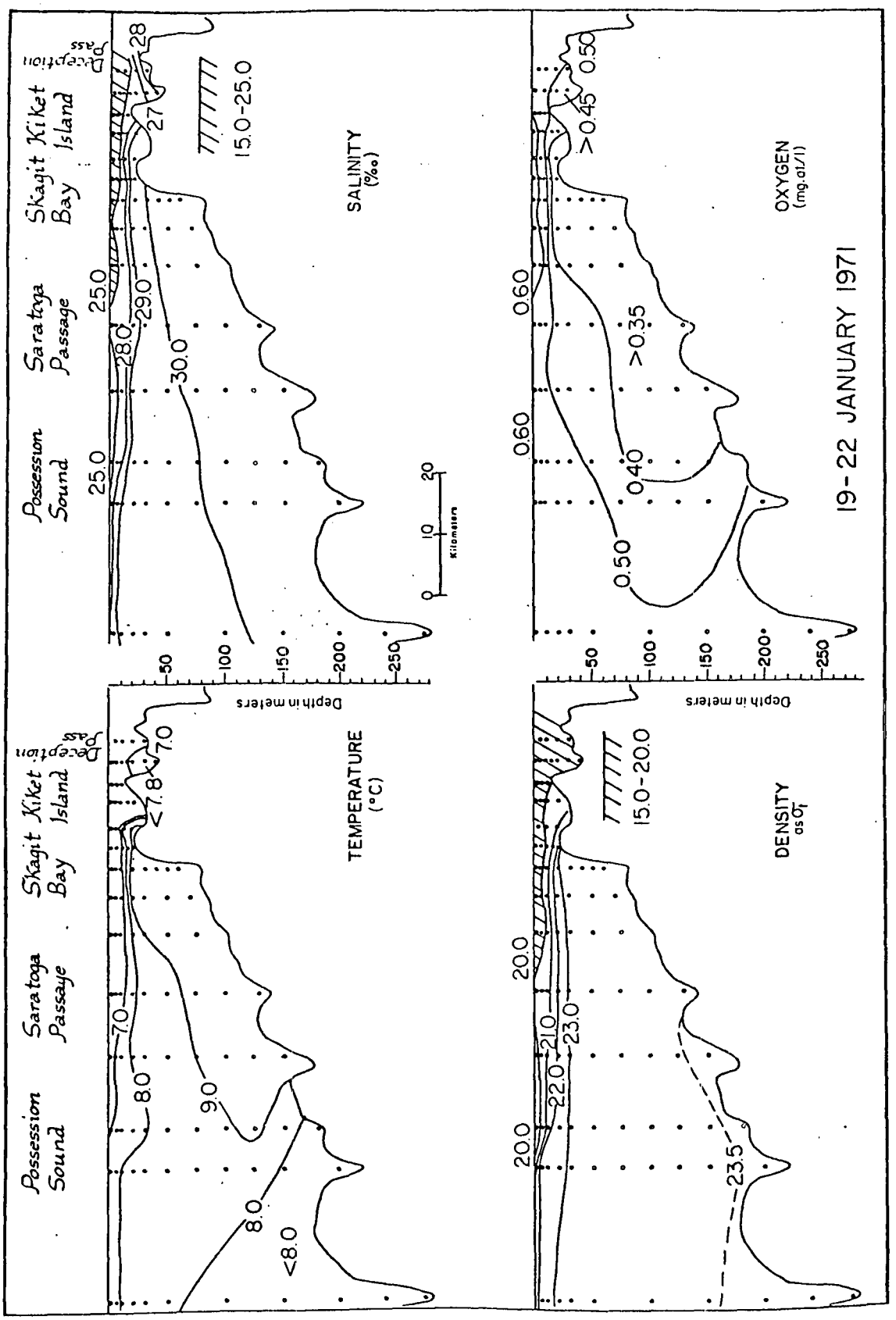
Water properties; Seattle to Deception Pass:
17 - 18 November 1970

SOURCE: Skagit Bay Dynamical Oceanography Final Report. Eugene E. Collias, Clifford A. Barnes, and John H. Lincoln. 1973.



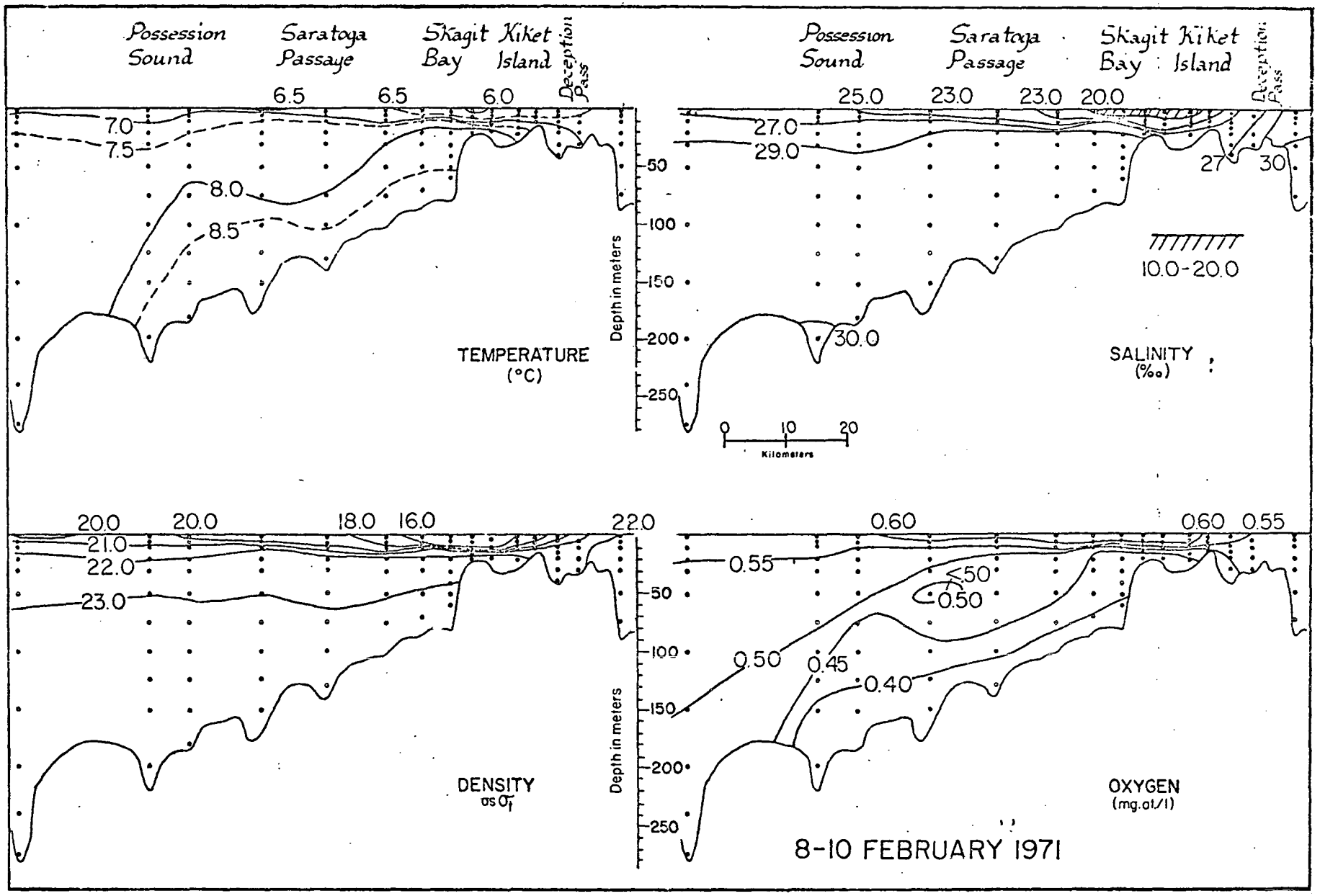
Water properties; Seattle to Deception Pass:
28 - 31 December 1970

SOURCE: Skagit Bay Dynamical Oceanography Final Report. Eugene E. Collias, Clifford A. Barnes, and John H. Lincoln. 1973.



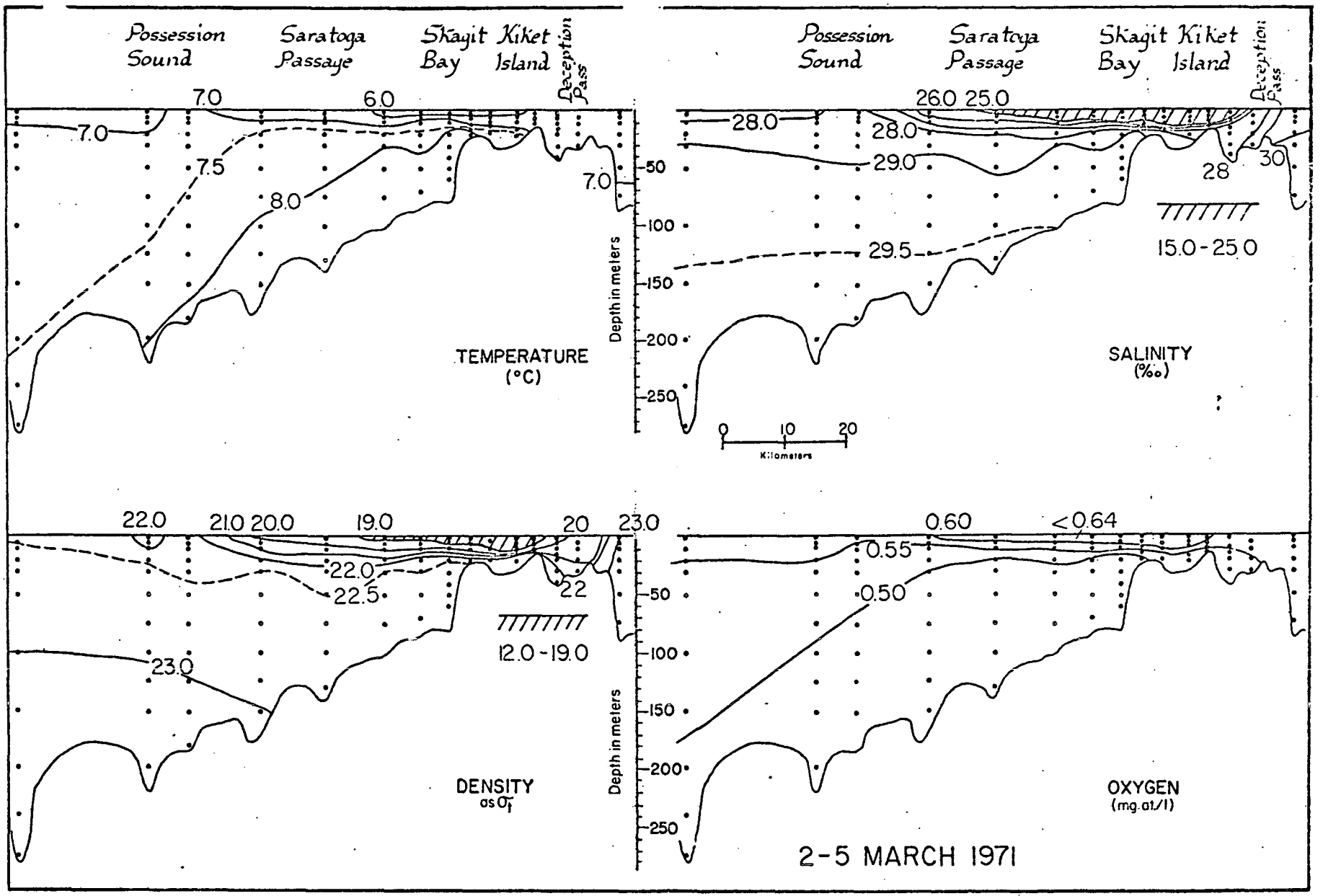
Water properties; Seattle to Deception Pass:
19 - 22 January 1971

SOURCE: Skagit Bay Dynamical Oceanography Final Report. Eugene E. Collias, Clifford A. Barnes, and John H. Lincoln. 1973.



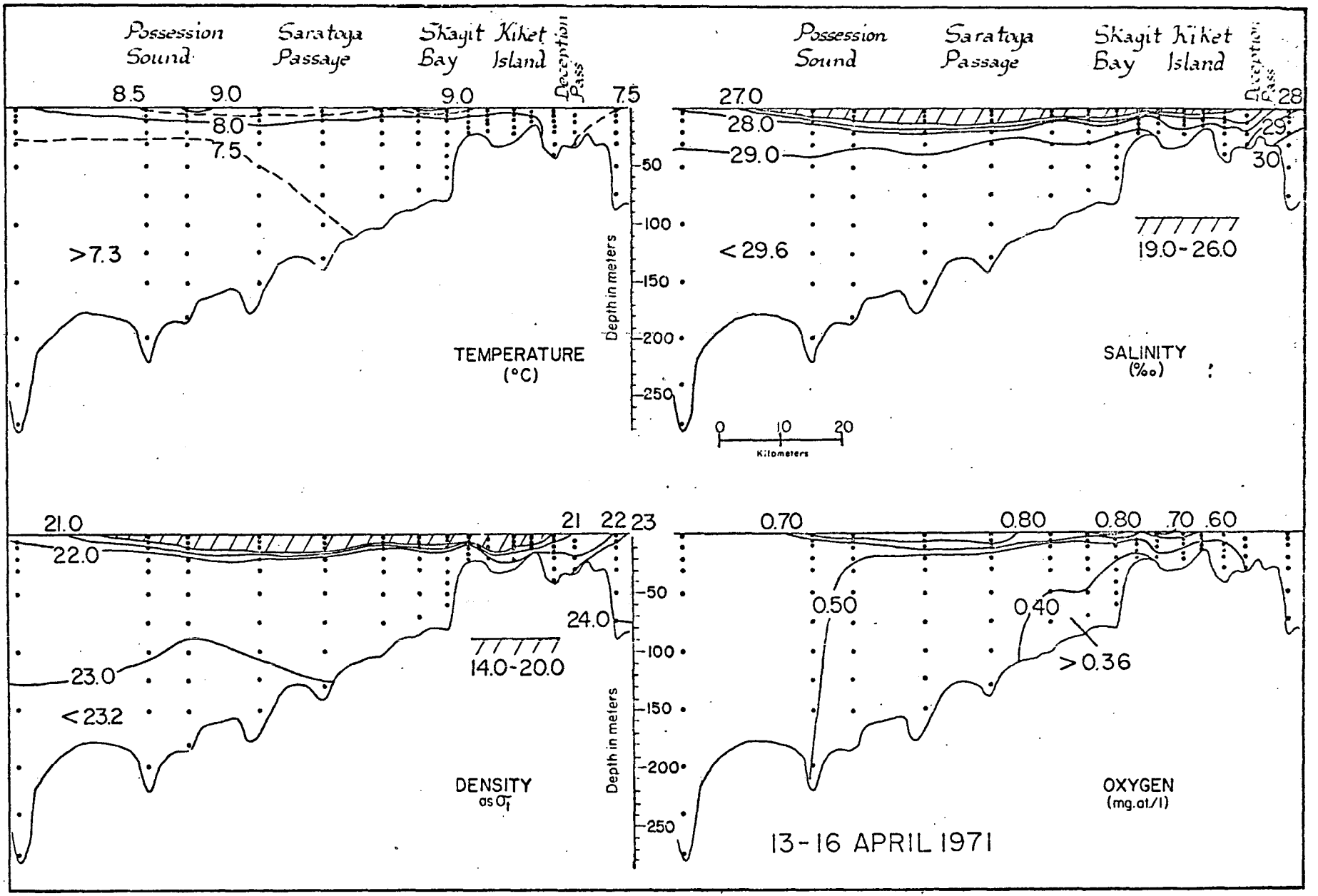
Water properties; Seattle to Deception Pass:
8 - 10 February 1971

SOURCE: Skagit Bay Dynamical Oceanography Final Report. Eugene E. Collias, Clifford A. Barnes, and John H. Lincoln. 1973.



Water properties; Seattle to Deception Pass:
2 - 5 March 1971

SOURCE: Skagit Bay Dynamical Oceanography Final Report. Eugene E. Collins, Clifford A. Barnes, and John H. Lincoln. 1973.



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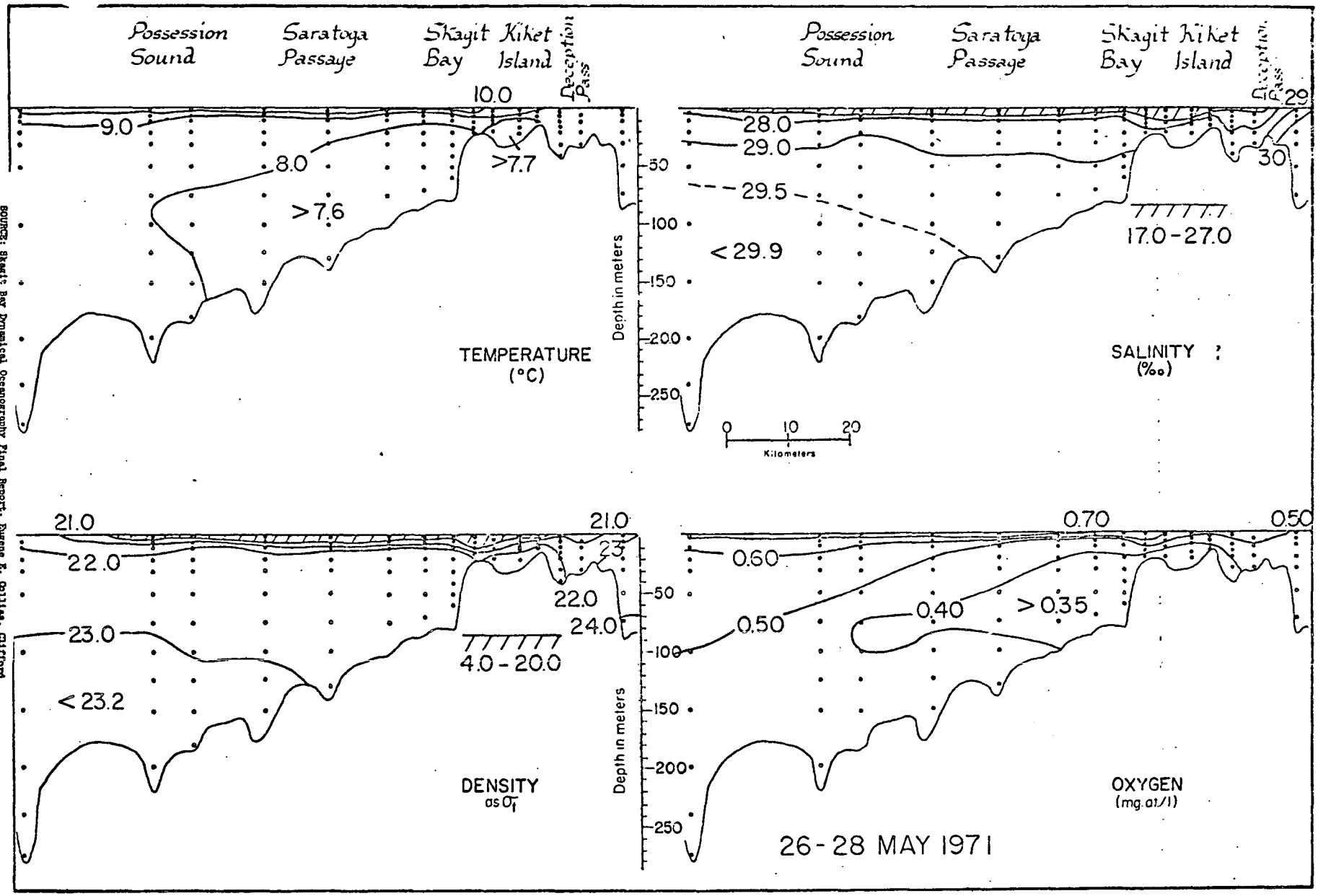
SOURCE: Skagit Bay Dynamical Oceanography Final Report. Eugene E. Collias, Clifford A. Barnes, and John H. Lincoln. 1973.



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26 - 28 May 1971

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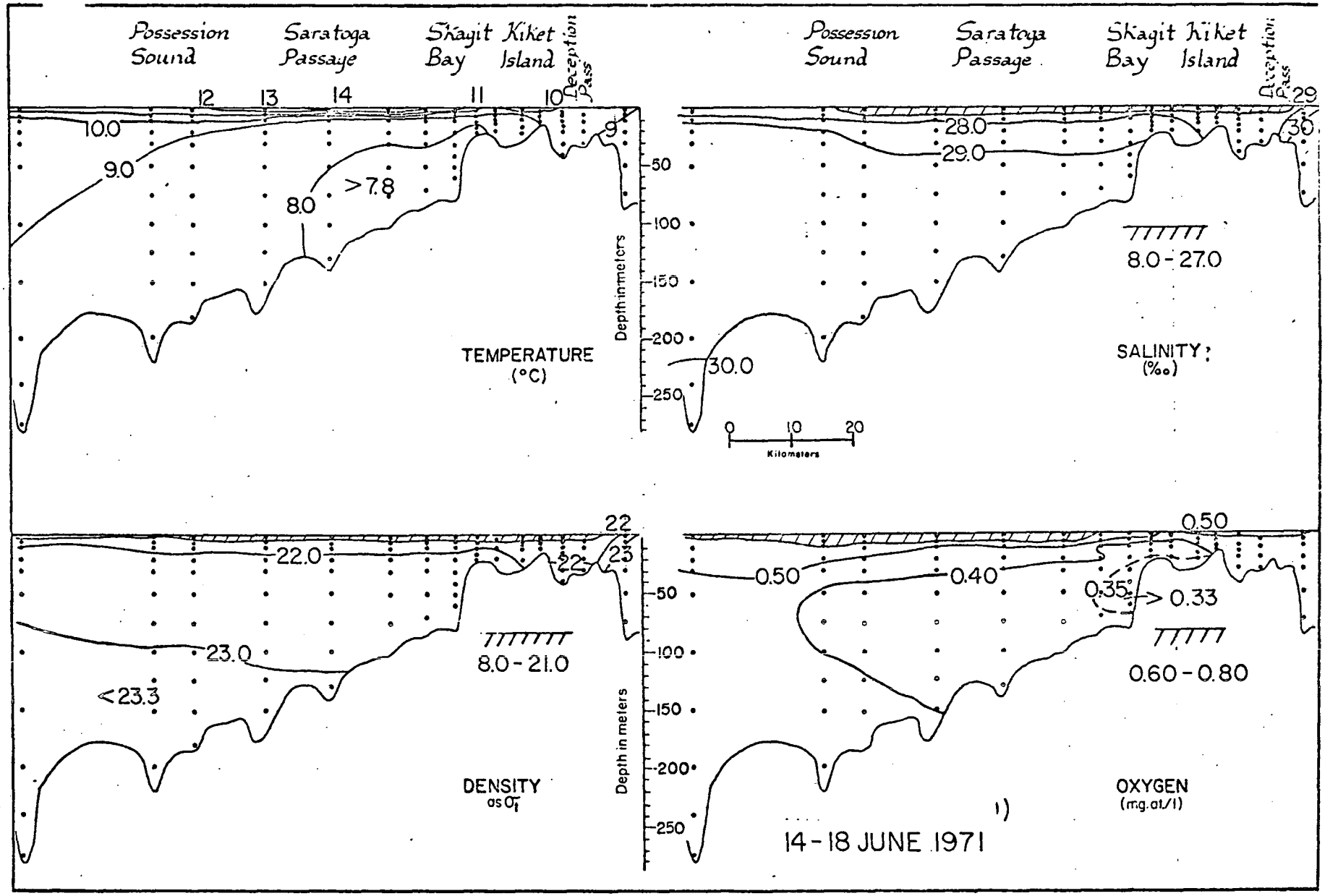
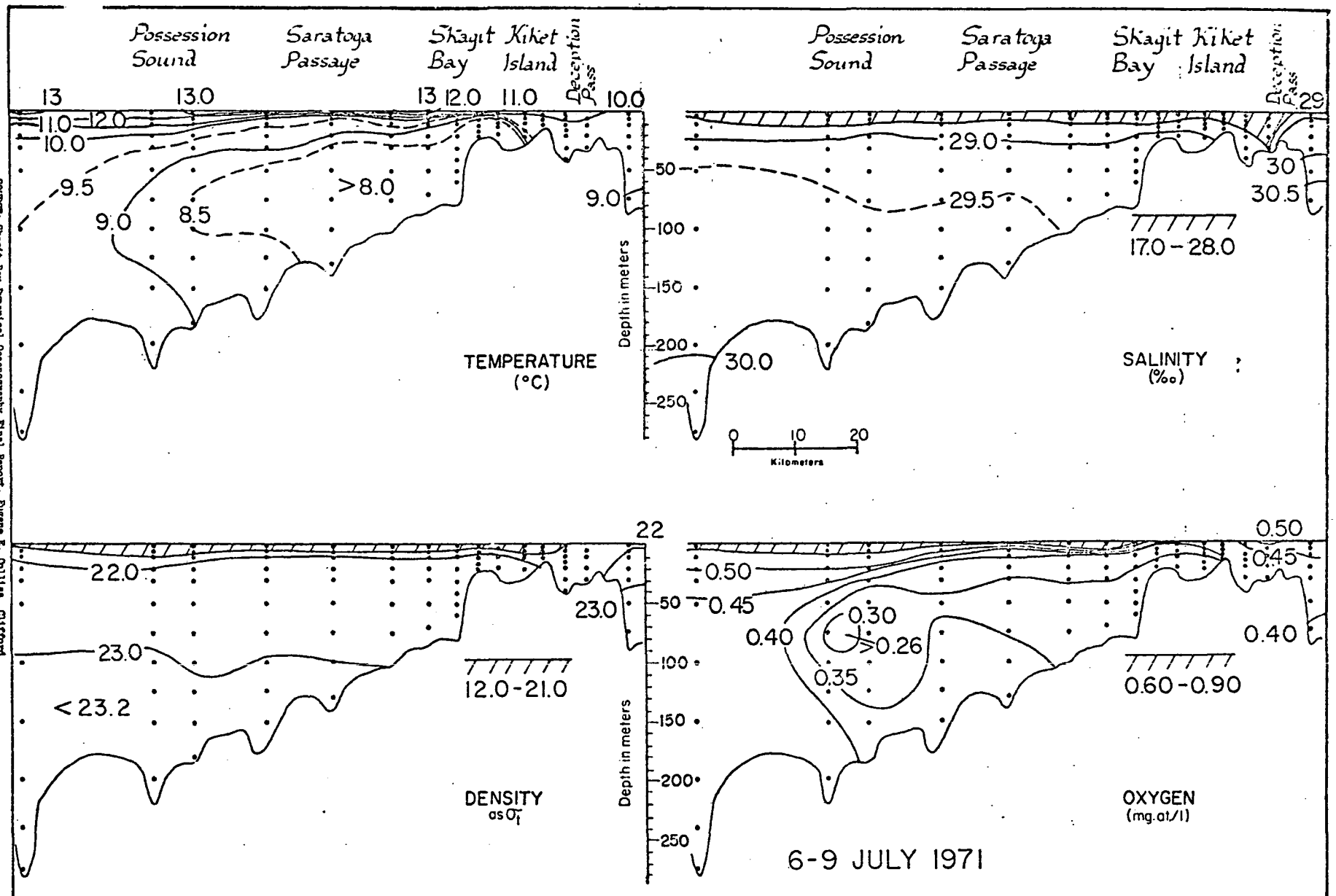


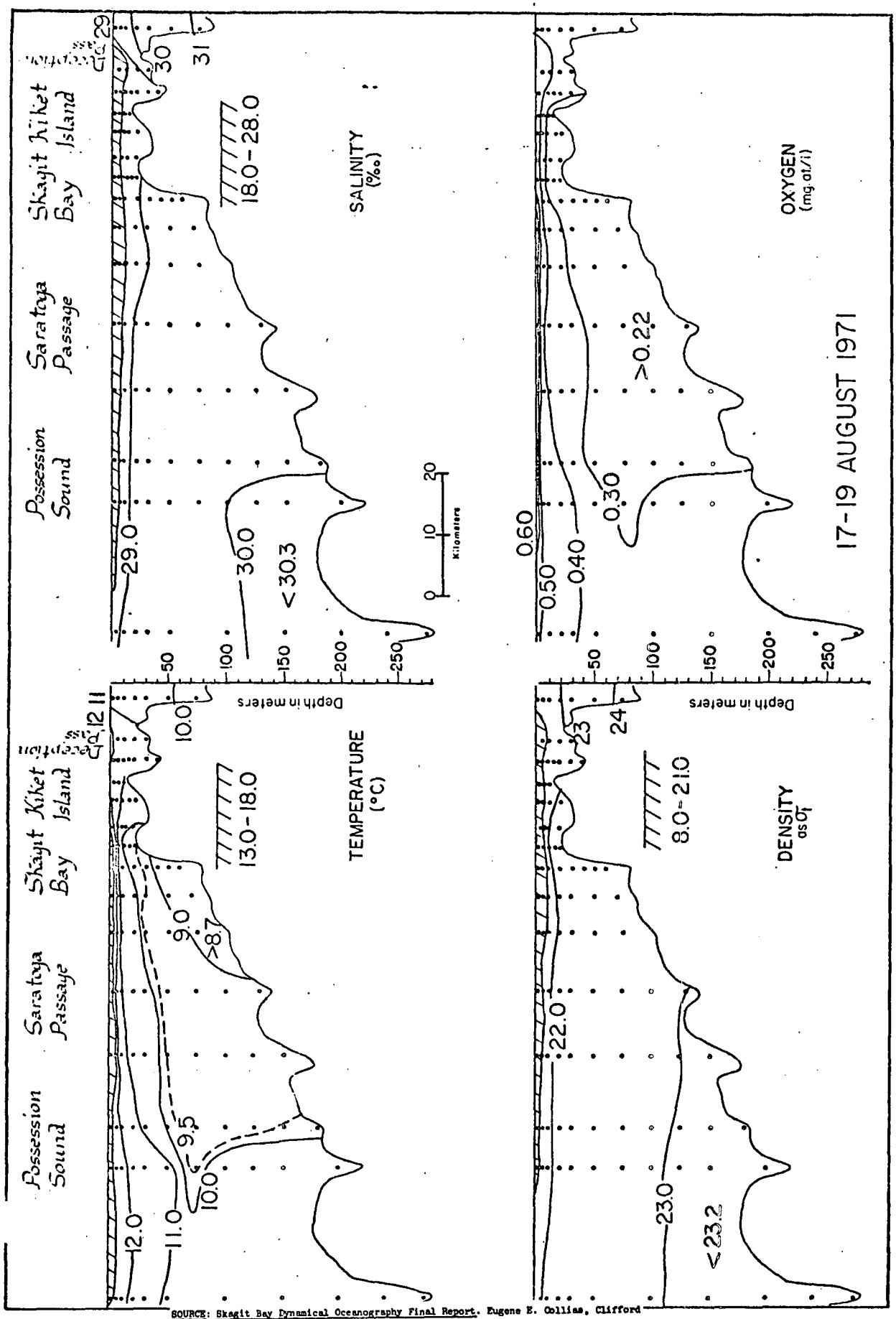
Water properties; Seattle to Deception Pass:
14 - 18 June 1971

SOURCE: Skagit Bay Dynamical Oceanography Final Report. Eugene B. Collias, Clifford A. Barnes, and John H. Lincoln. 1973.



Water properties; Seattle to Deception Pass: 6 - 9 July 1971

SOURCE: Skagit Bay Dynamical Oceanography Final Report. Eugene E. Collias, Clifford A. Barnes, and John H. Lincoln. 1973.



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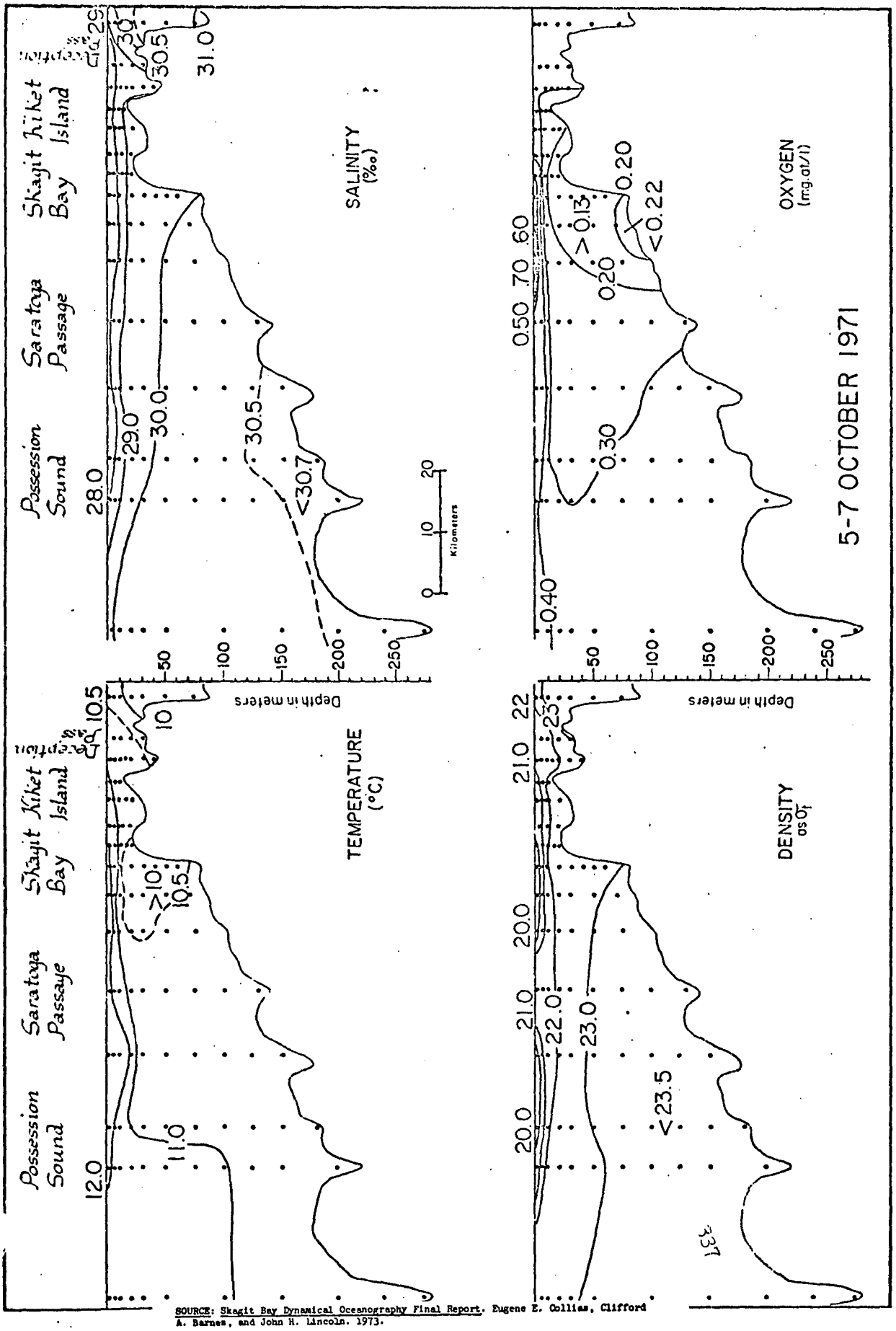
Water properties; Seattle to Deception Pass: 17 - 19 August 1971



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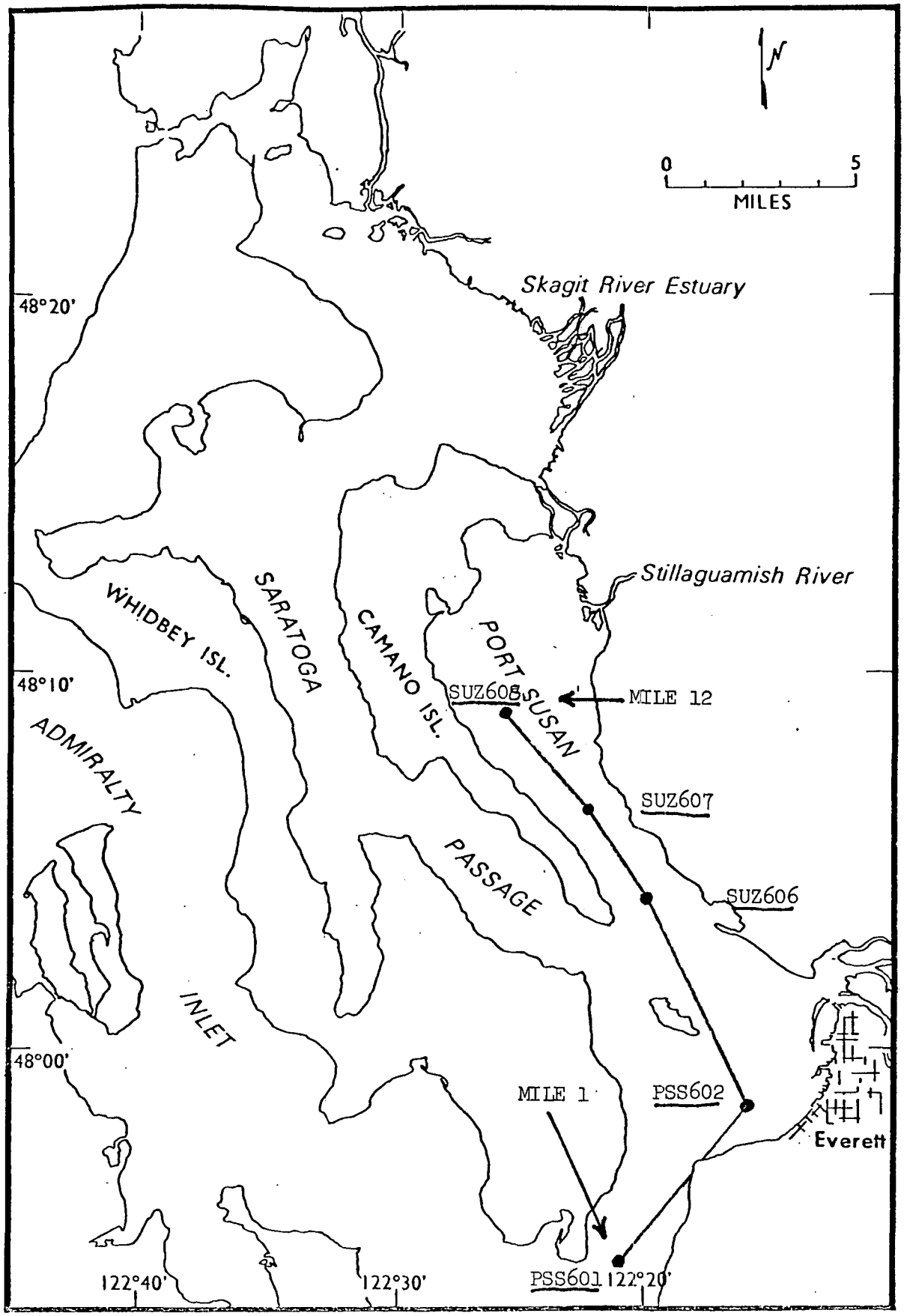
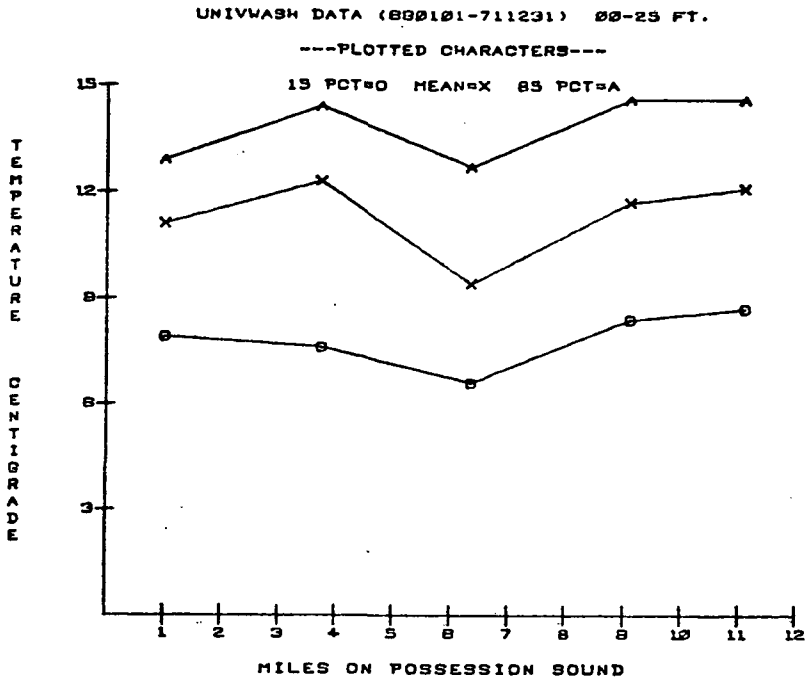
Water properties; Seattle to Deception Pass: 5 - 7 October 1971



POSSESSION SOUND STATION LOCATION CHART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6
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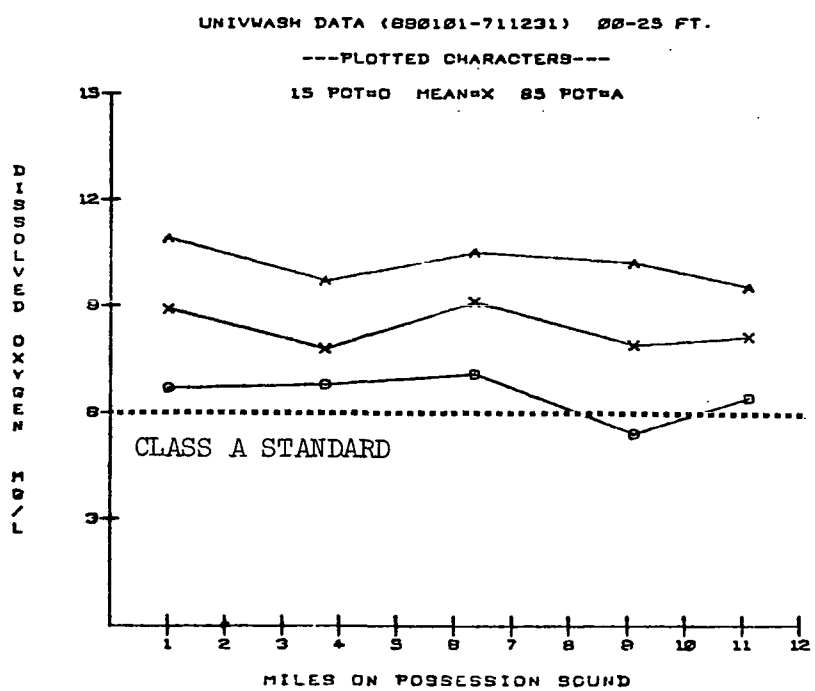
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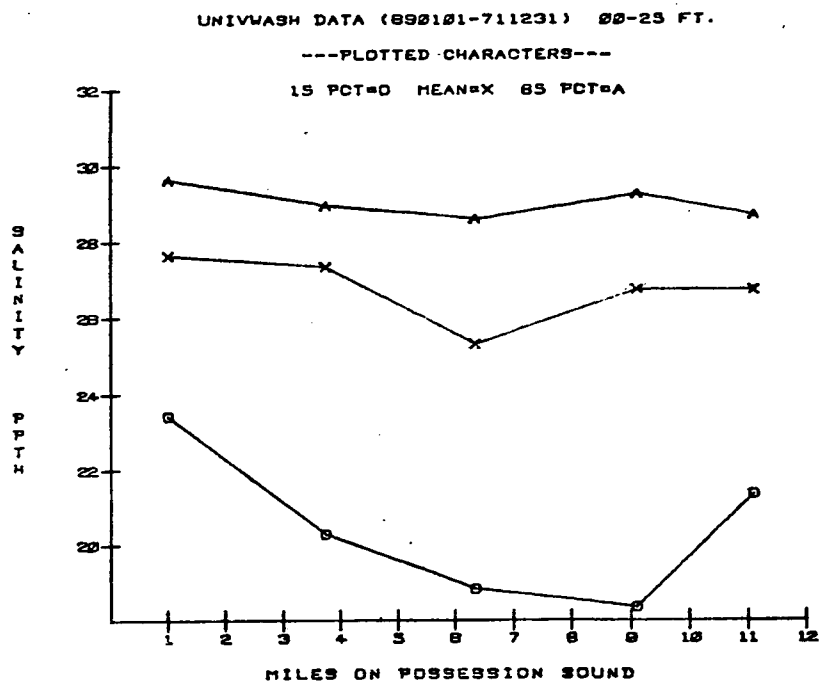
MILES ON POSSESSION SOUND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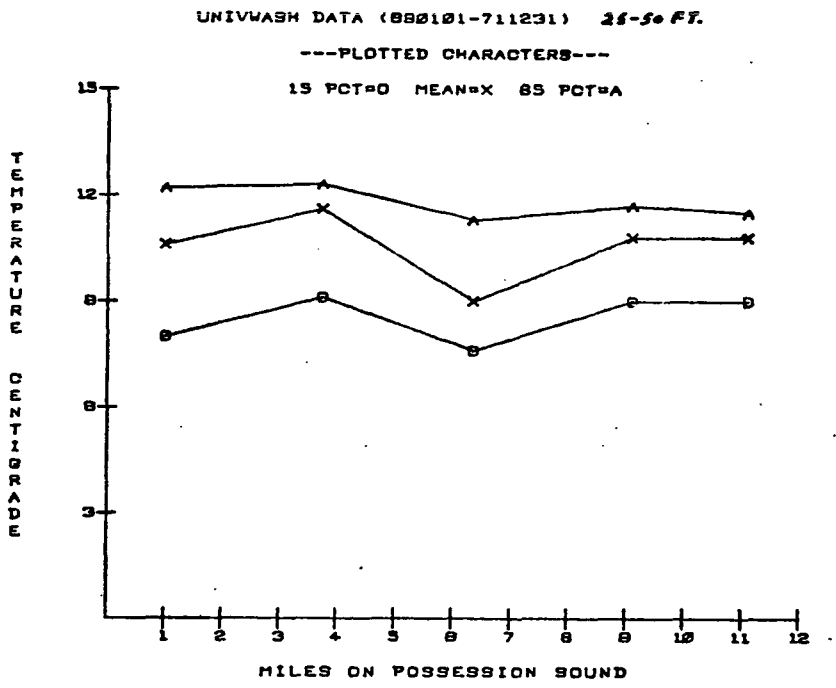
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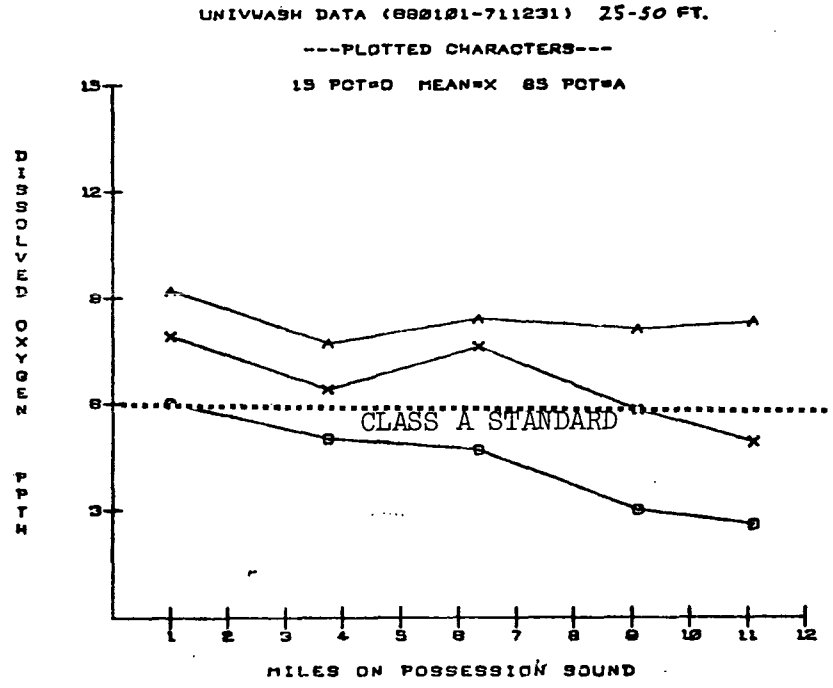
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9
6
3
CLASS A STANDARD
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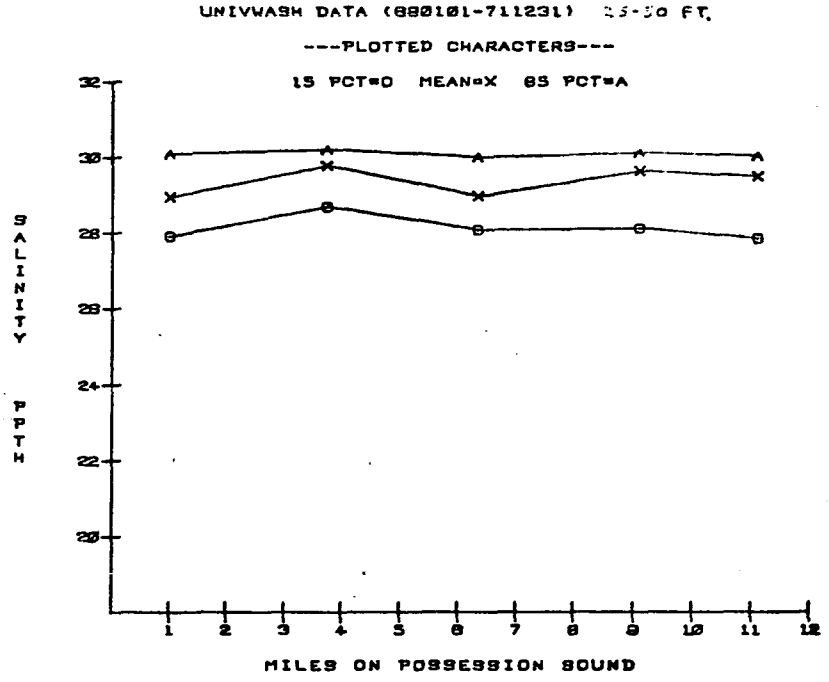
MILES ON POSSESSION SOUND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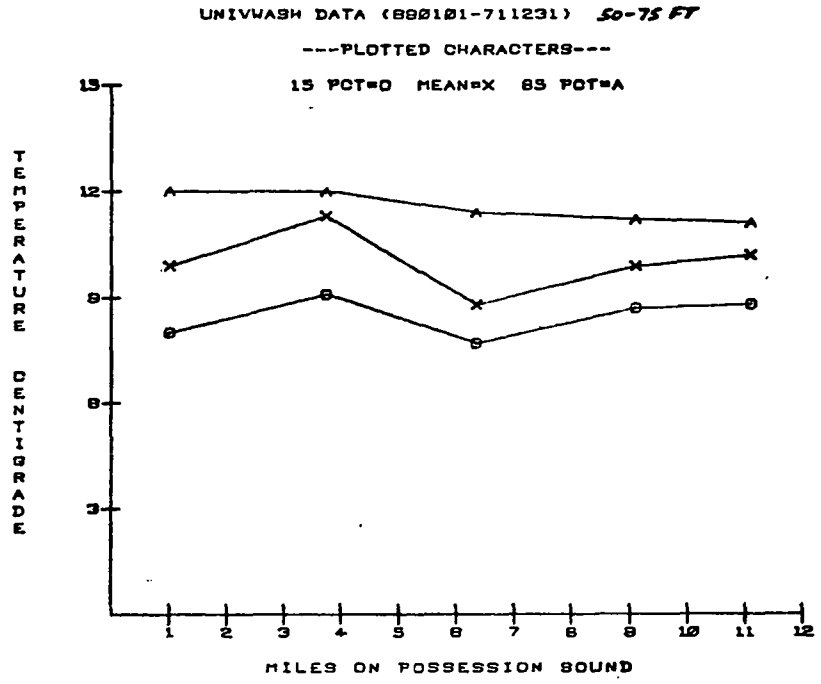
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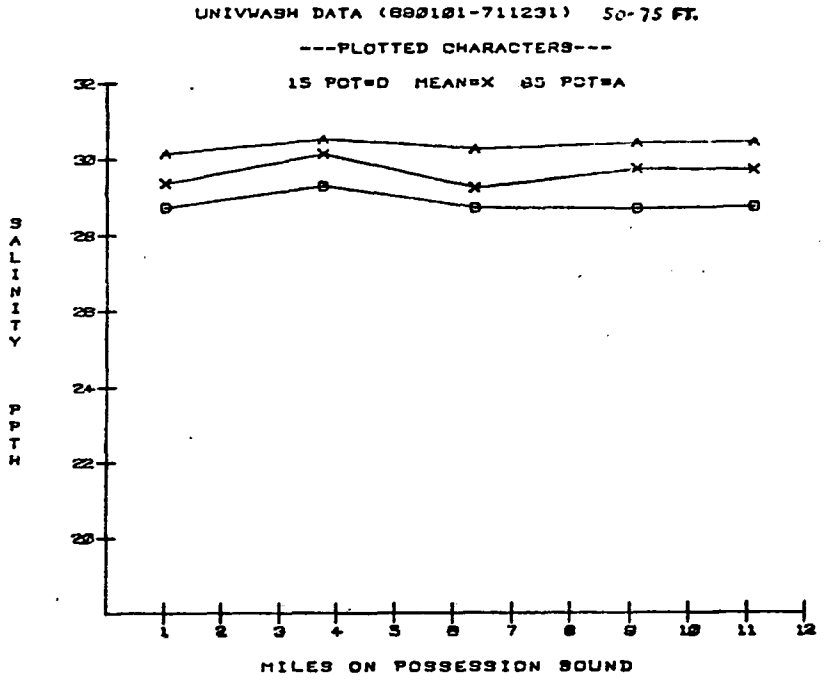
MILES ON POSSESSION SOUND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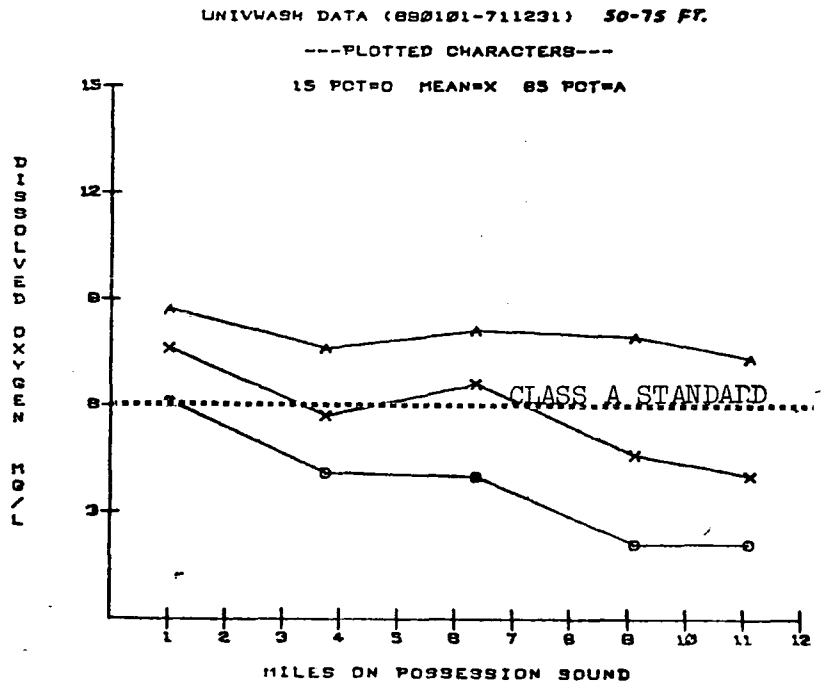
MILES ON POSSESSION SOUND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3
CLASS A STANDARD
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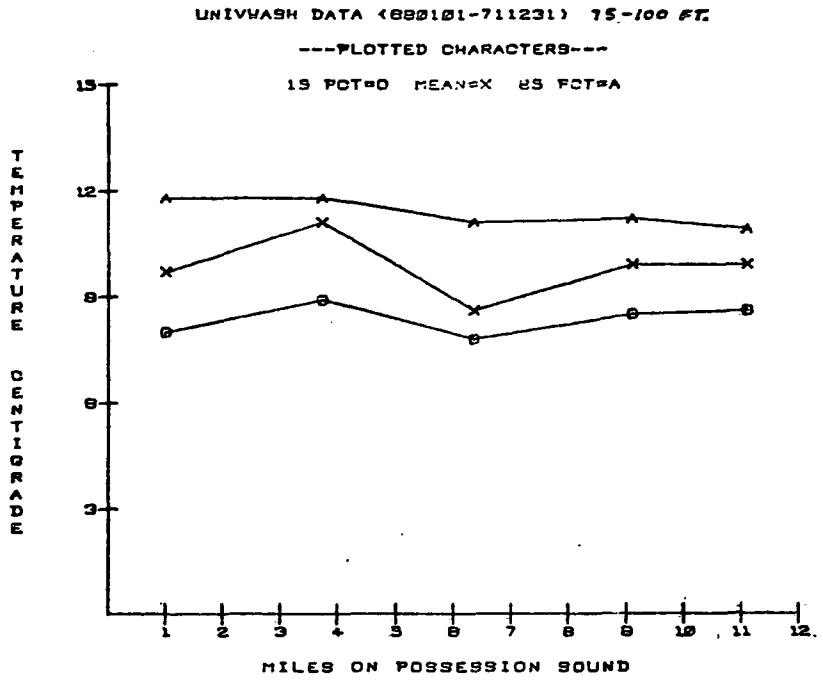
MILES ON POSSESSION SOUND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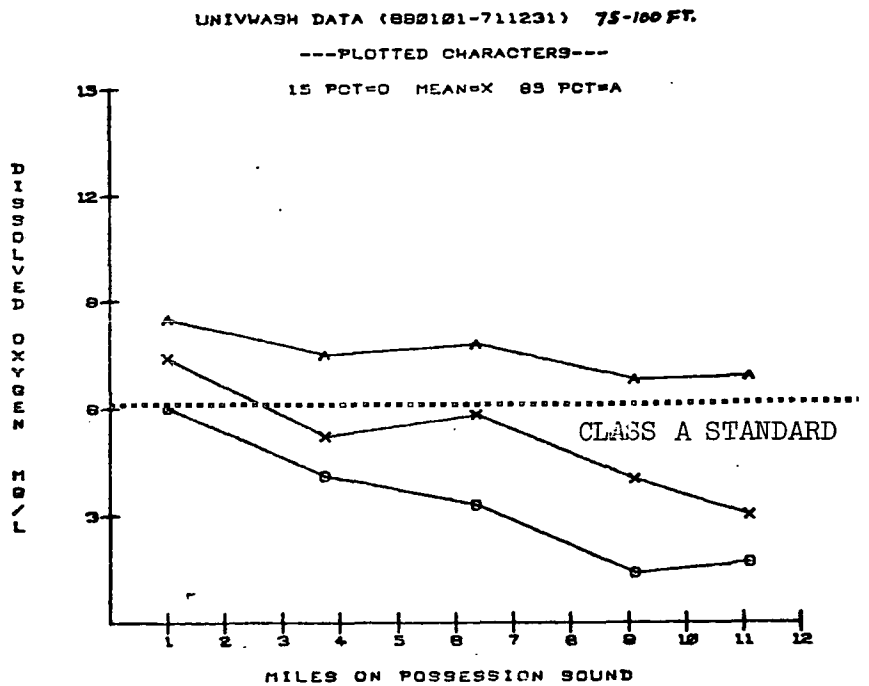
MILES ON POSSESSION SOUND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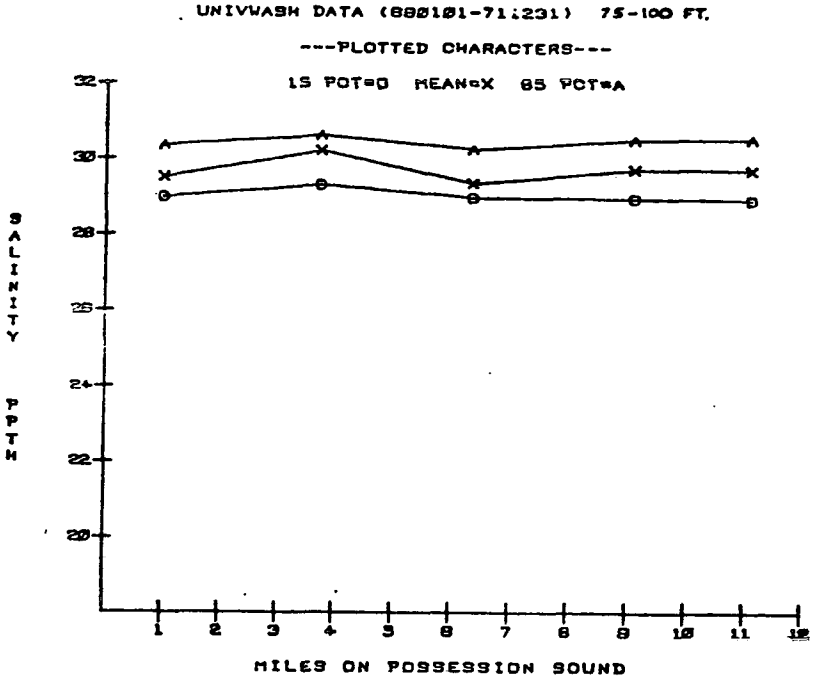
9
6
3
CLASS A STANDARD
1 2 3 4 5 6 7 8 9 10 11 12
MILES ON POSSESSION SOUND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26
24
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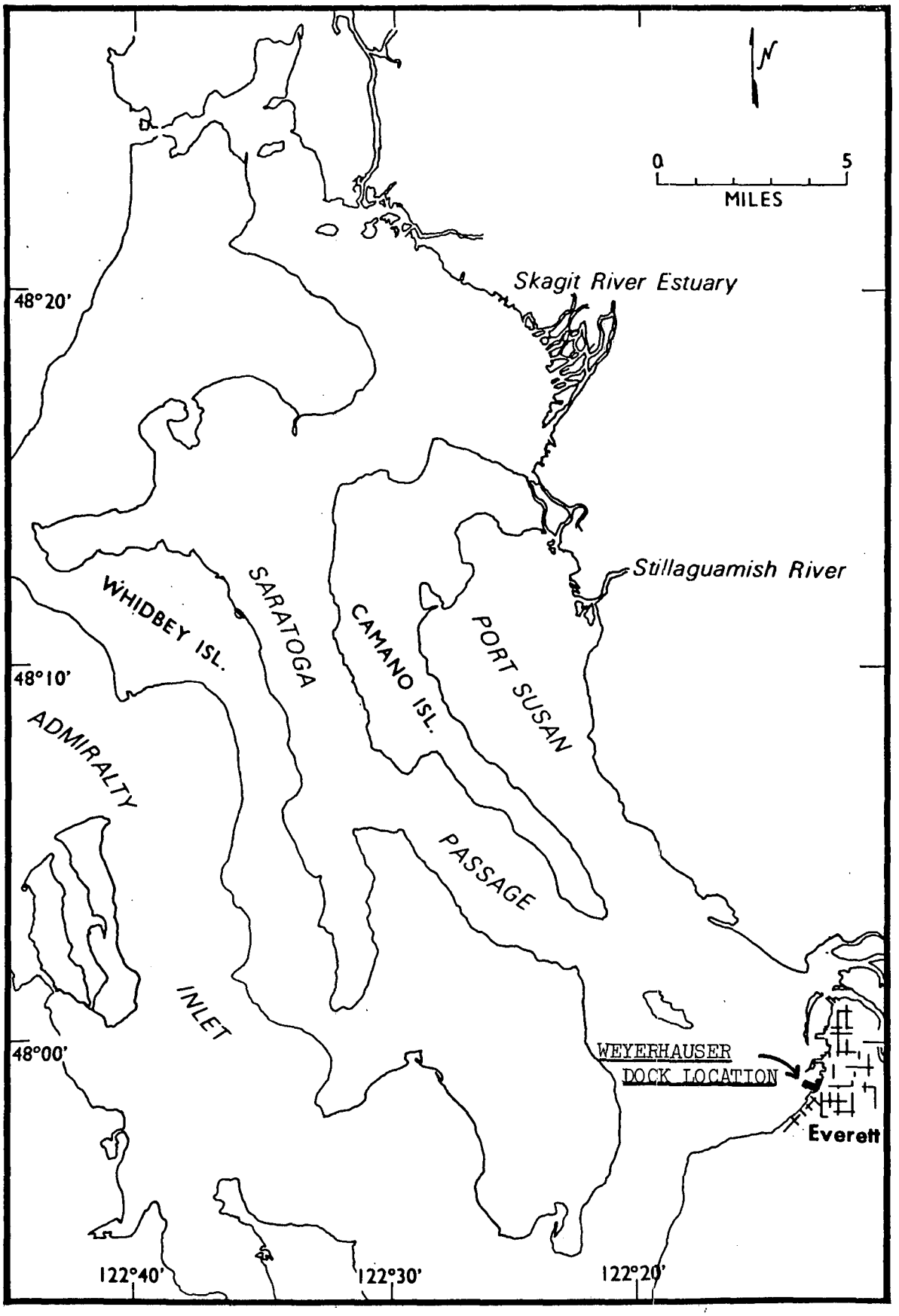
1 2 3 4 5 6 7 8 9 10 11 12
MILES ON POSSESSION SOUND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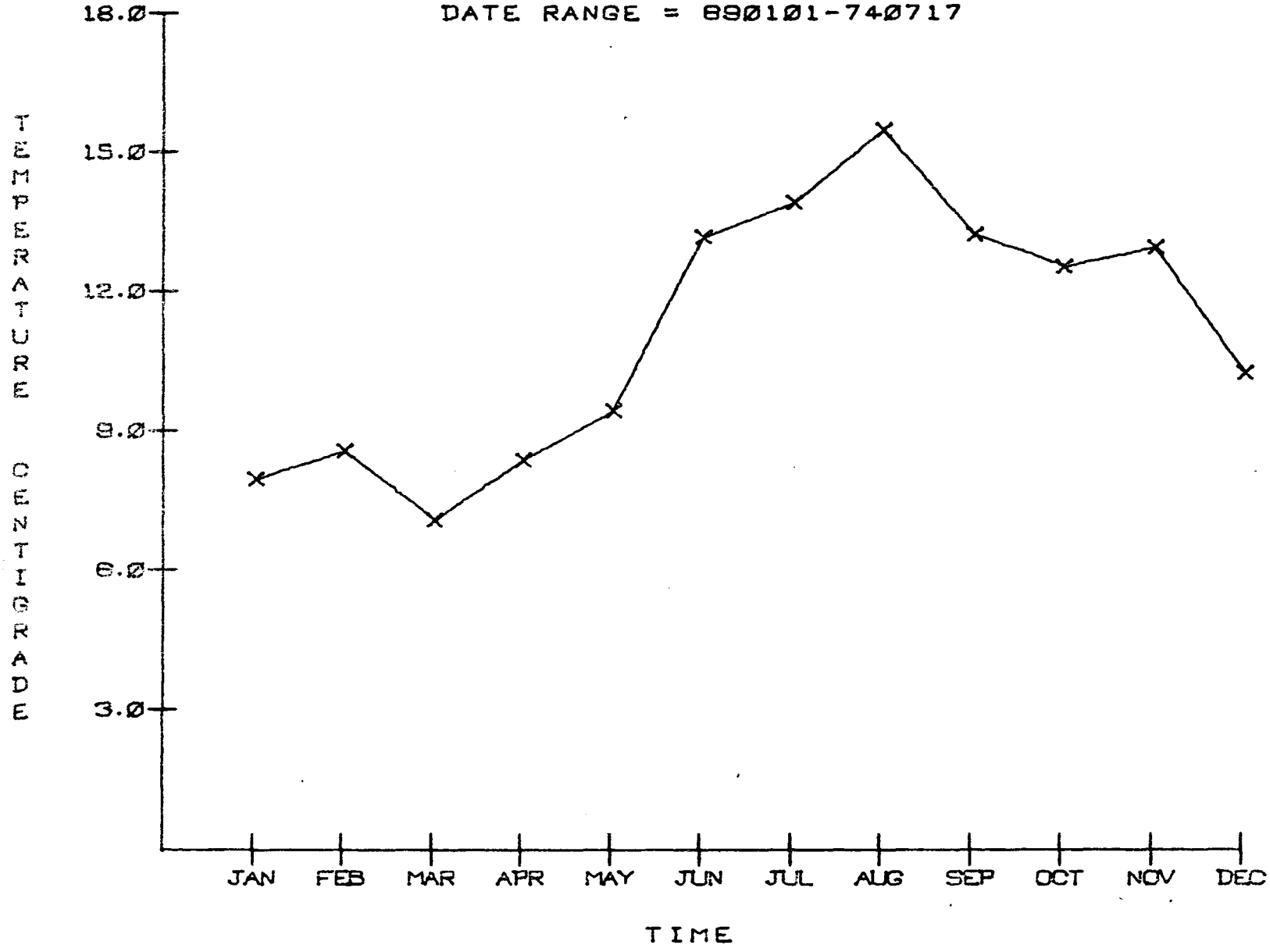
0
5
MILES
Skagit River Estuary
48°20'
Stillaguamish River
WHIDBEY ISL.
SARATOGA
CAMANO ISL.
PORT SUSAN
48°10'
ADMIRALTY
PASSAGE
INLET
48°00'
WEYERHAUSER
DOCK LOCATION
Everett
122°40'
122°30'
122°20'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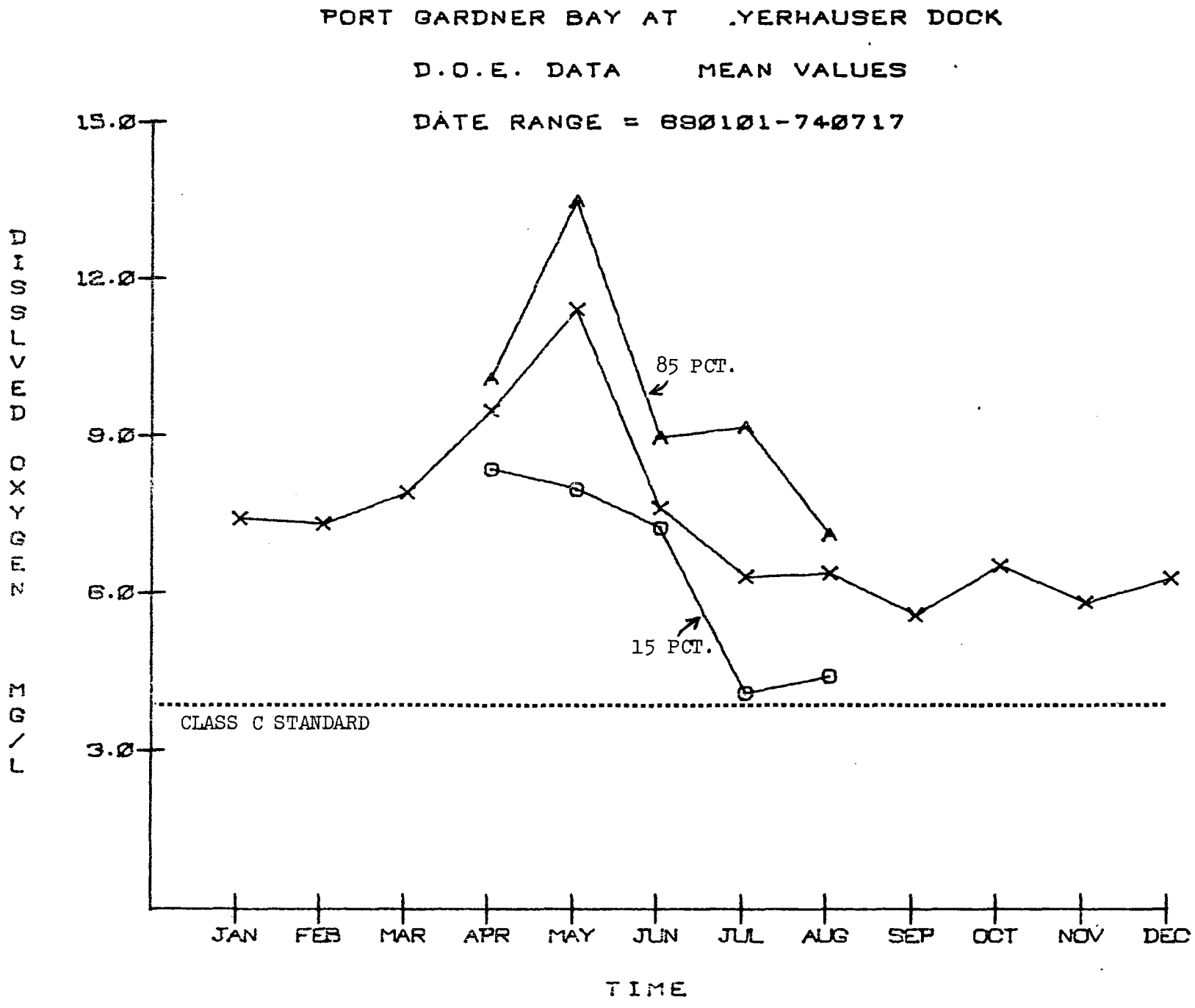
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
TIME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85 PCT.
15 PCT.
CLASS C STANDARD
JAN
FEB
MAR
APR
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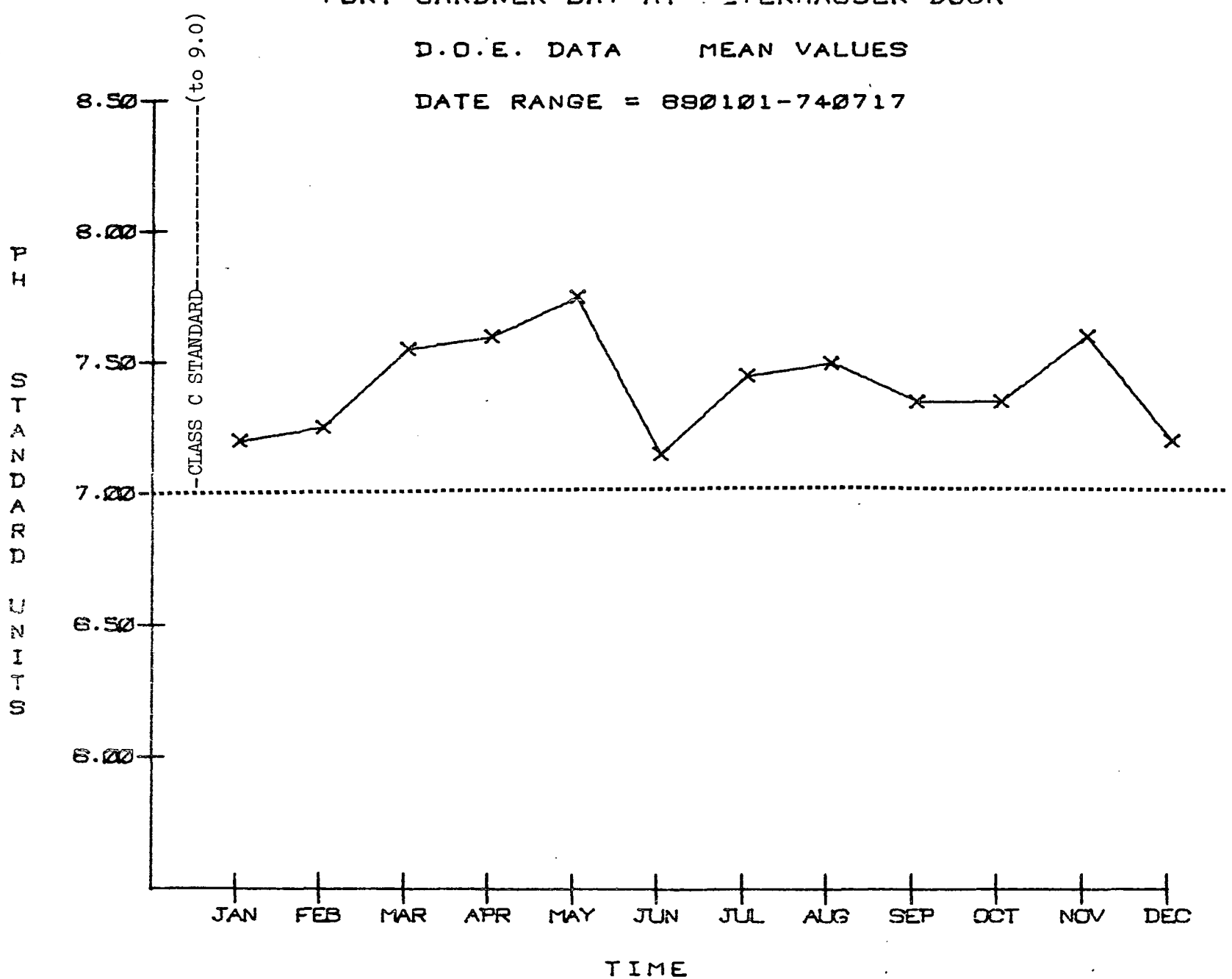
JUN
JUL
AUG
SEP
OCT
NOV
DEC
TIME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(to 9.0)
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8.000
7.500
7.000
6.500
6.000
PH STANDARD UNITS
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
TIME

PORT GARDNER BAY AT WEYERHAUSER DOCK

D.O.E. DATA MEAN VALUES

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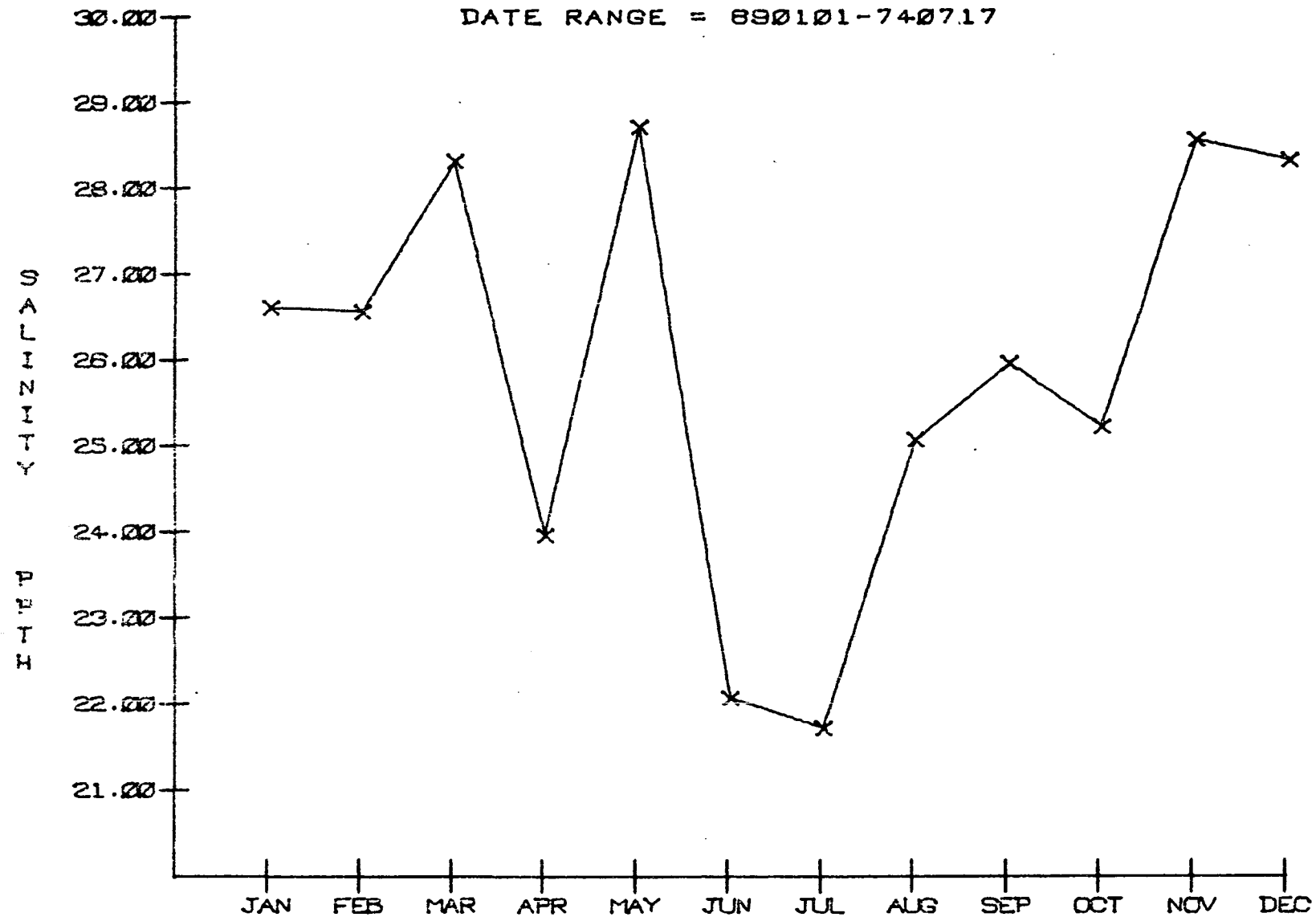

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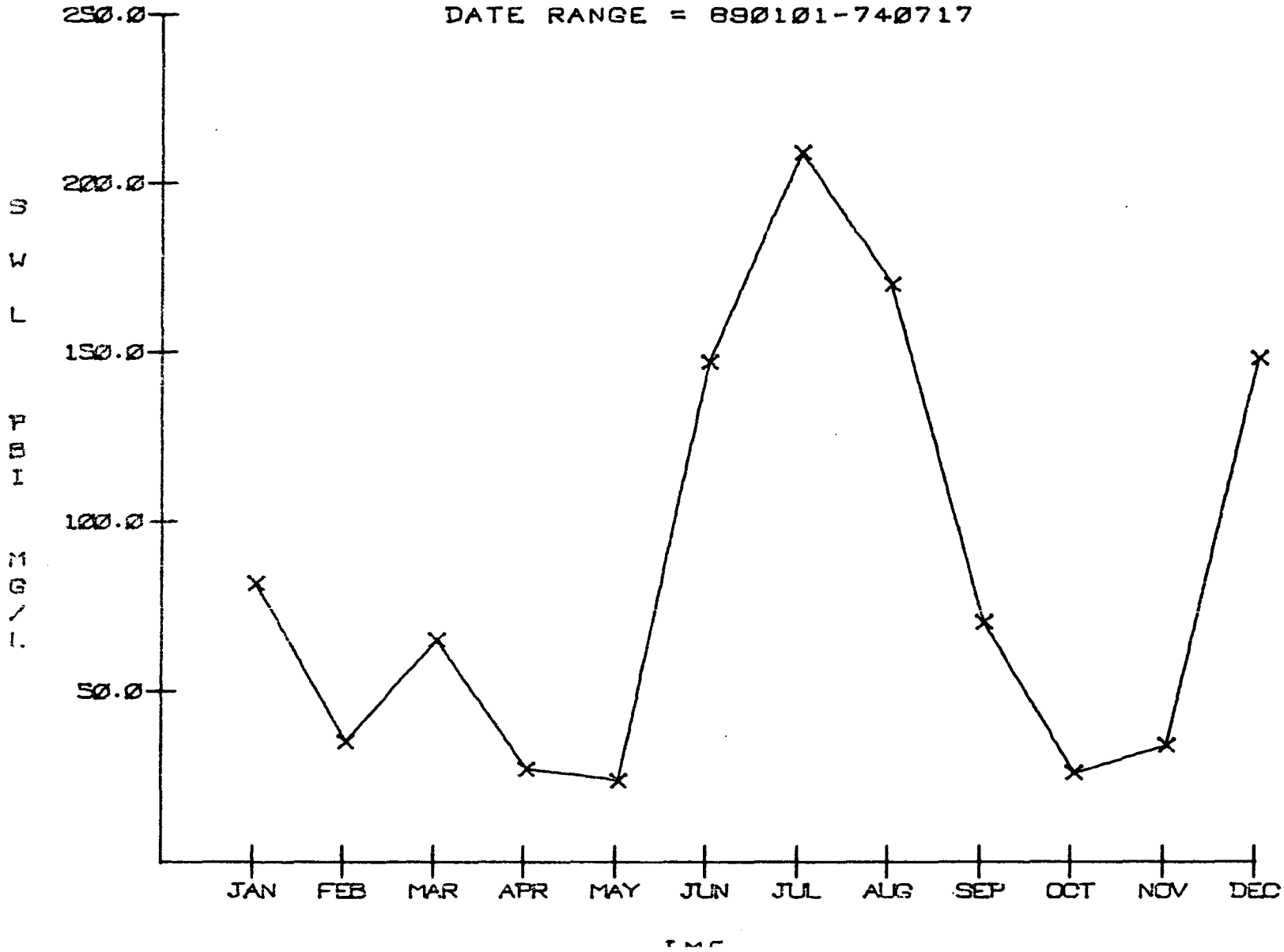

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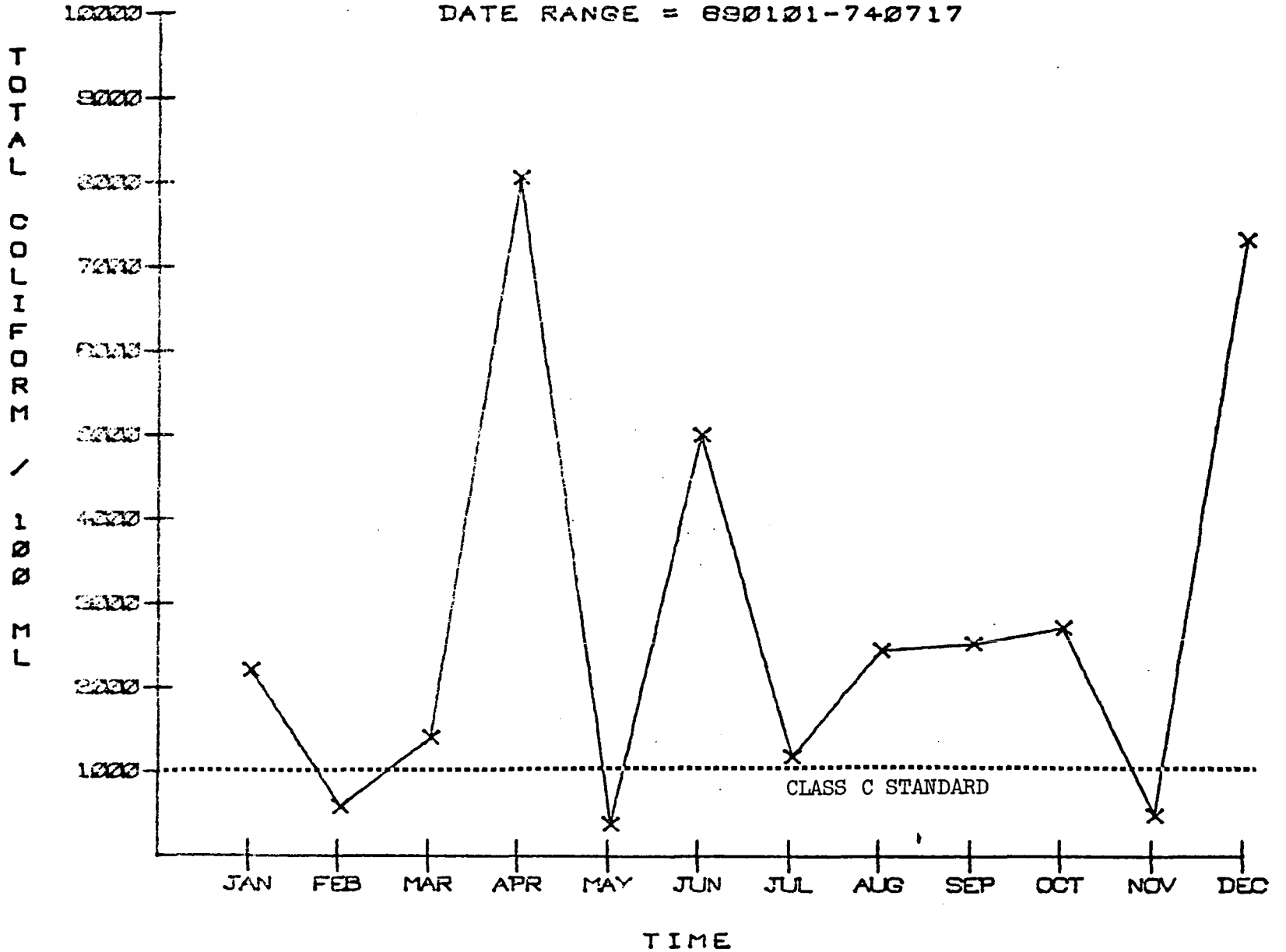
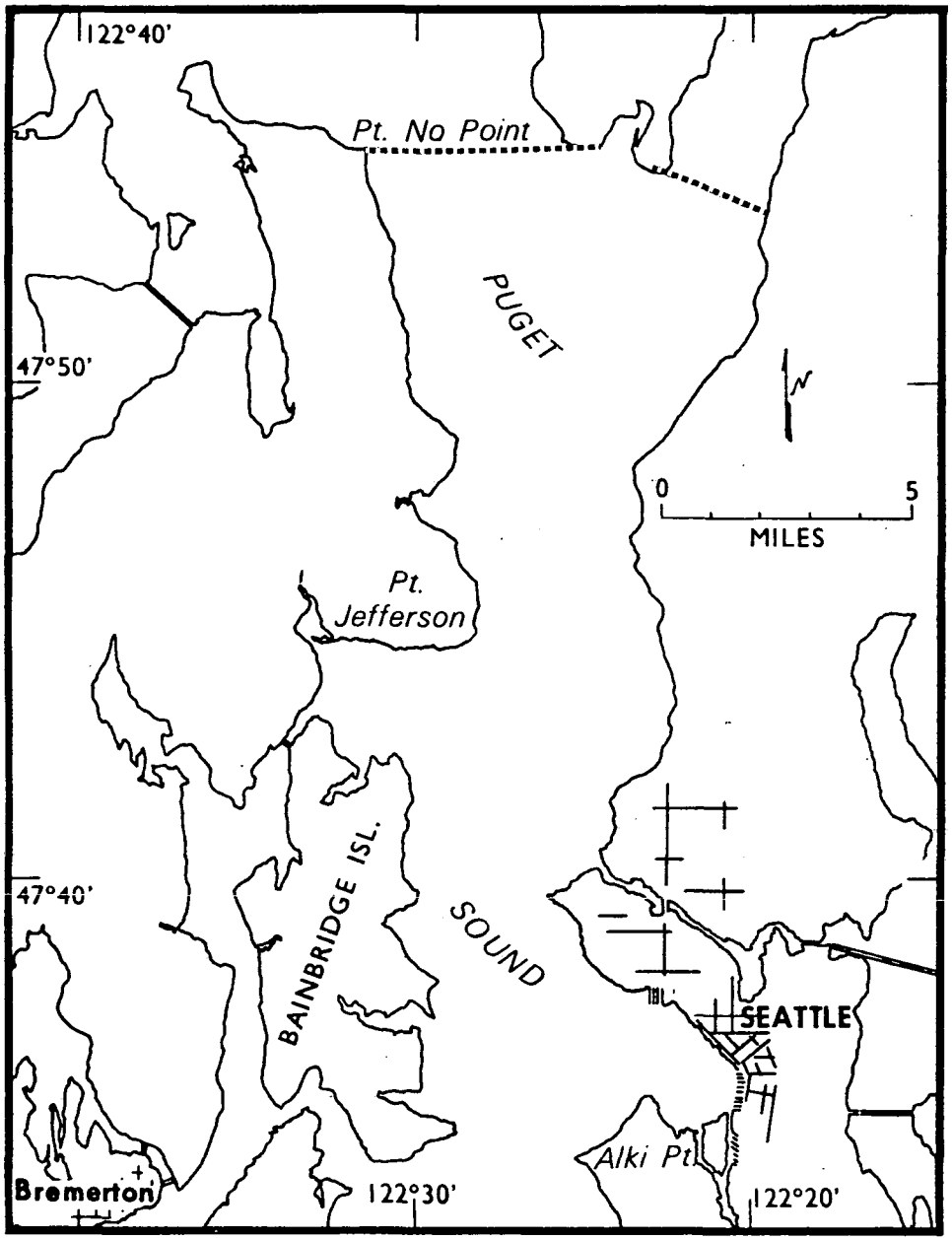
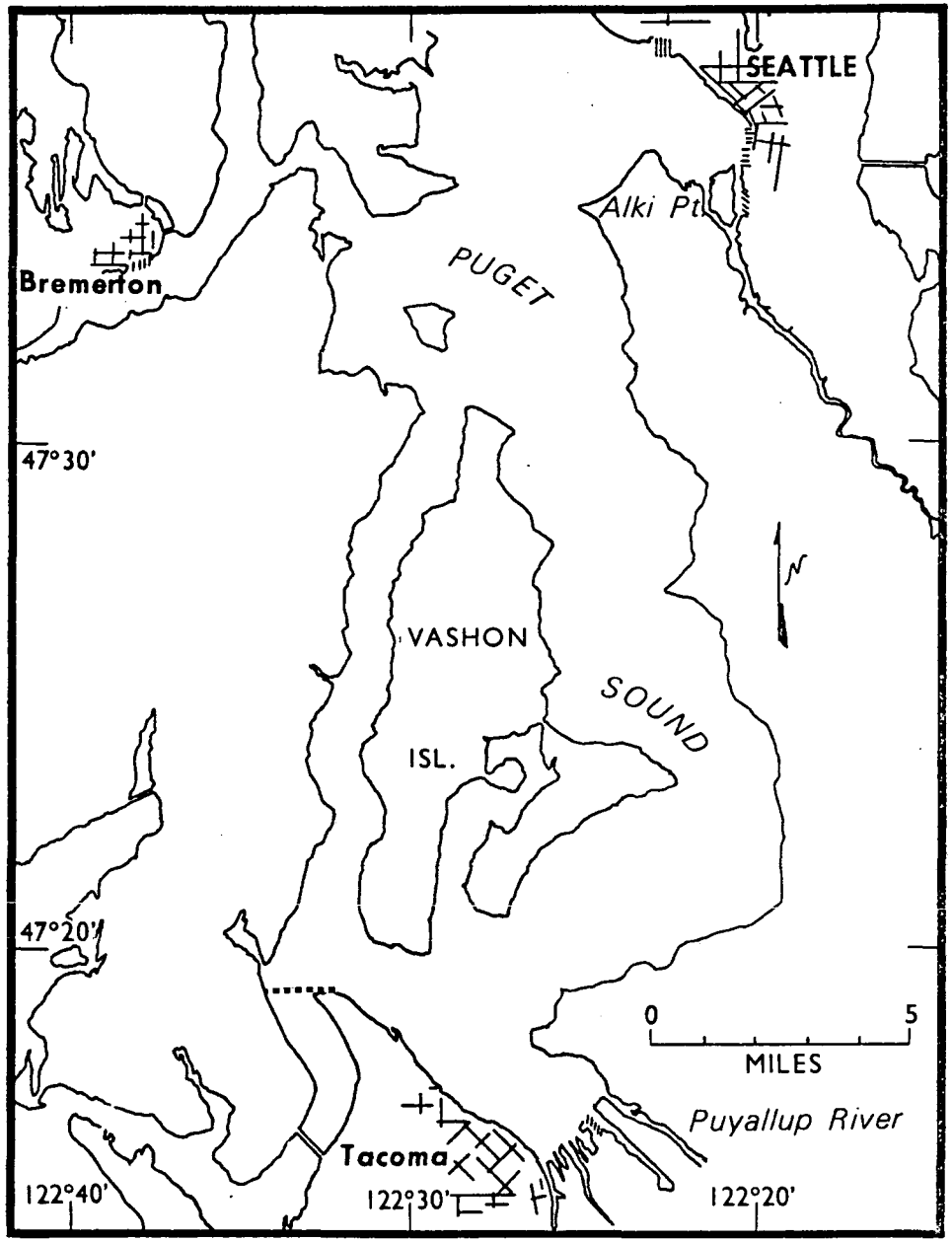


MAIN PUGET SOUND BASIN





MAIN PUGET SOUND BASIN

The main basin of Puget Sound may be considered to extend from the south end of Admiralty Inlet to the north end of the Tacoma Narrows. It is separated from Possession Sound by a line extending eastsoutheast from Possession Point to the main land. The main basin is 77 km (43 naut mi) long, has an average with of 7.2 km (4 naut mi), and an average depth of 100 m (54 fath). The surface area at mean high water is 768 km^2 (224 sq naut mi) and the volume of water contained in this region is 77.p km^3 (12.1 cubic naut mi) with an average tidal prism of 2.42 km^3 (0.38 cubic naut mi). The mean tide range is 3.2 m (1.78 fath). The deepest part of the Puget Sound Basin is located west of Richmond Beach and has a measured depth of over 280 m (159 fath). Another hole of comparable depth is located off West Point. The center of this basin is over 200 m (110 fath) throughout its length except at the southern end where it begins to shoal to 172 m (15 fath) off Brown Point and then rapidly to 54 m (30 fath) at the north end of the Tacoma Narrows.

Several sub-oceanographic regions are found in this basin which include Elliott Bay, Commencement Bay, Colvos Passage, and the waters west of Bainbridge Island. Each of these sub-regions is closely related to the main basin but with somewhat different surface characteristics. The major differences are due to the source and amount of fresh-water entering the sub-region.

The fresh-water sources for this basin are two rivers, serveral small creeks and land drainage. The two rivers are the Duwamish, which discharges into Elliott Bay (Seattle harbor), and the Puyallup, which empties into Commencement Bay (Tacoma harbor). The flow of these two rivers is controlled, but water used for power sources are returned to

them upstream of their mouths. Both the Puyallup and Duwamish Rivers exhibit two peaks, the largest one occurs in the winter because of winter rains and a secondary peak in early summer because of melting snow in the mountains. The major effect of these rivers is observed hear their mouths where a surface layer is formed that dominates both Elliot Bay and Commencement Bay. As one proceeds towards the entrance of either of the bays, a sharp line between the muddy surface layer and the outside water is observed. These lines migrate with the tide and are affected by the surface winds. In general, the fresher surface layer in these bays prefers the northern side of each bay but winds may alter the distribution pattern.

The prevailing surface winds from October through March are from the south with an average speed of about 30 km/hr (15 mph). Storm winds in fall and winter often exceed 100 km/hr (50 mph) with extreme storm speeds in excess of 160 km/hr (80 mph). In April and May the winds become less variable but southerly winds of about 20 km/hr (10 mph) continue to predominate. In summer, the prevailing winds are northerly with an average speed of under 20 km/hr (10 mph). However, northerly winds do occur in the winter and are accompanied with very cold air temperatures.

Water characteristics throughout this basin are quite uniform.

This is in contrast to the distribution observed in Admiralty Inlet. Local flucuations do occur but in general, they are small or confined to a small area because of the uniformity of the waters throughout this basin.

The minimum surface salinity is observed in early June because of the influence of the Skagit River, which even though it does not enter into this basin, the effect of its discharge is observable as far south as Alki Point. The average minimum surface salinity is 27.4°/00, but values of less than 20°/00 have been observed. The maximum surface salinity is observed in the middle of October when fresh water contributions have been at a minimum and reaches a value of 30.4°/00. At depth (below 200m) the salinity is more stable and exhibits a seasonal minimum of 29.8°/00 in early March and then begins to increase. However, a secondary minimum is observed in late June and early July in response to the large amounts of fresh water being contributed by the Frazer, Skagit and Snohomish Rivers in early summer. This freshwater is mixed in Admiralty Inlet and the eastern end of the Strait of Juan de Fuca to cause a lowering of the salinity of the water being refluxed back into Puget Sound. After the secondary minimum at depth, the salinity increases abruptly and remains at about 30.7°/oo from August until early November.

The surface water temperatures (8.2°C) are coldest in February in response to the cold air temperatures but lag behind the minimum air temperatures by about three weeks. As the air temperatures increase toward summer, so do the surface water temperatures, but again with a three to five week lag. The maximum surface temperatures are observed in August with an average maximum of 14.2°C. At depths below 100 meters, the coldest water is observed in late March as a result of mixing and refluxing of water by Admiralty Inlet.

The dissolved oxygen content of the surface waters undergoes large changes because of phytoplankton activity. The resulting oxygen production by the phytoplankton may cause the oxygen content to excel 19 mg/l in some areas with values of 9 to 11 mg/l being common over the entire area. However, this excessively high D.O. is patchy and rather isolated, and the amount of oxygen in true solution is questionable because the oxygen gas given off by the plankton is probably attaches to the individual cells in the form of micro-bubbles. The Winkler method of determining oxygen is such that it is not possible to tell if this large amount is in true solution or in the form of small bubbles. The minimum surface values are observed in late fall and winter when the phytoplankton activity is at a minimum and may be as low as 5 mg/l. At depth, the dissolved oxygen content is more stable with the maximum of about 8 mg/l occuring in May and the minimum of about 5 mg/l in early fall. Only on rare occasions does the oxygen at any depth in this basin decline to less the 5 mg/l, and then only for a brief period of time.

Flushing rates of the main basin have not been computed, but have been estimated to vary from two to four weeks. This is substantiated by the fact that the oxygen content is quite high throughout most of the year.

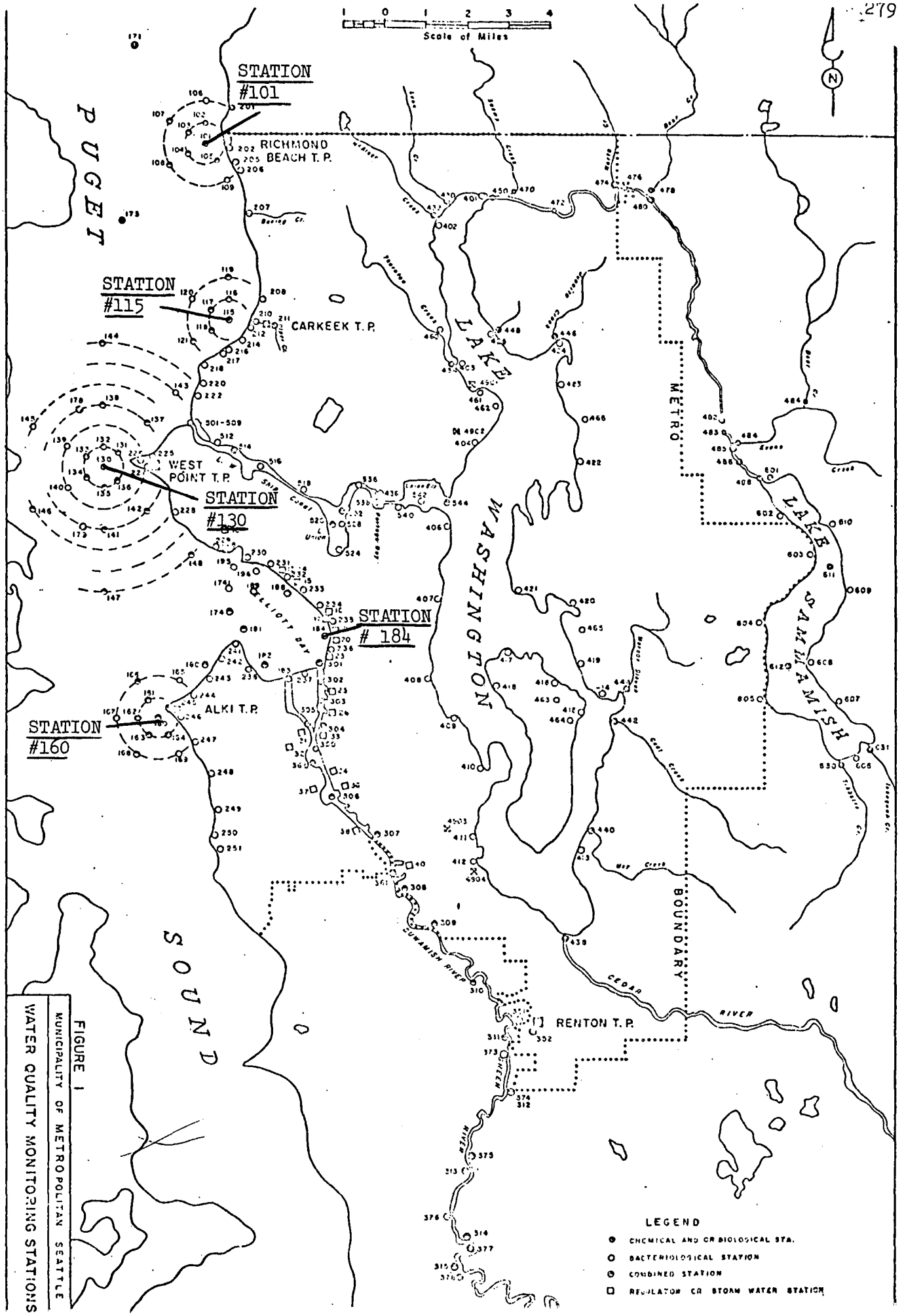
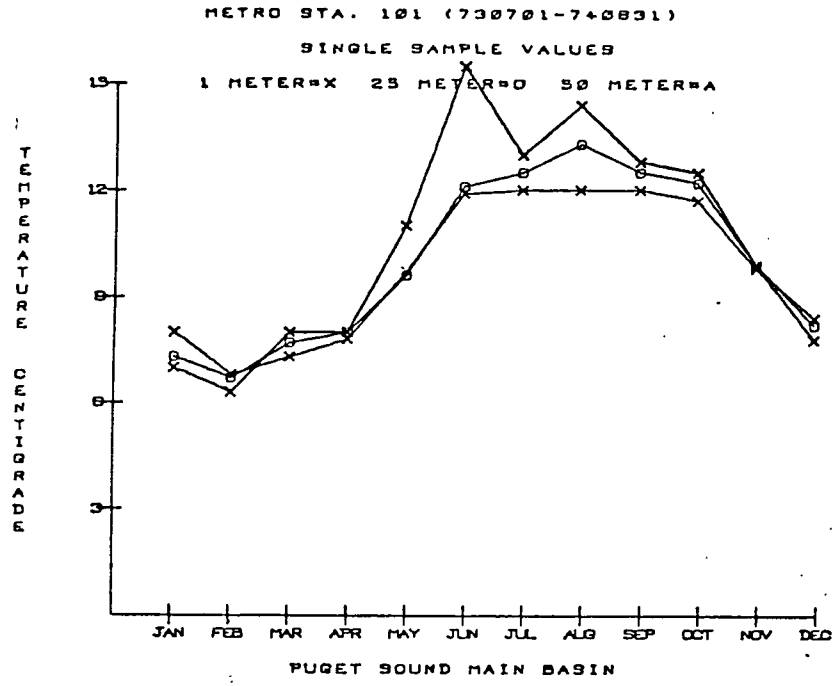
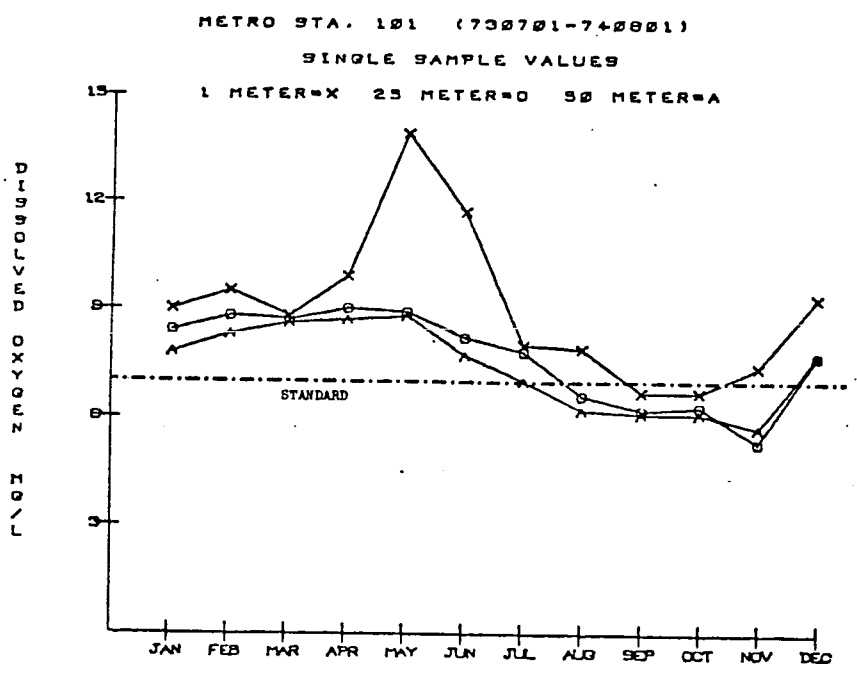


FIGURE 1

MUNICIPALITY OF METROPOLITAN SEATTLE

WATER QUALITY MONITORING STATIONS


METRO STA. 101 (730701-740831)
SINGLE SAMPLE VALUES
1 METER=X 25 METER=O 50 METER=A
TEMPERATURE CENTIGRADE
15
12
9
6
3
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
PUGET SOUND MAIN BASIN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9
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STANDARD
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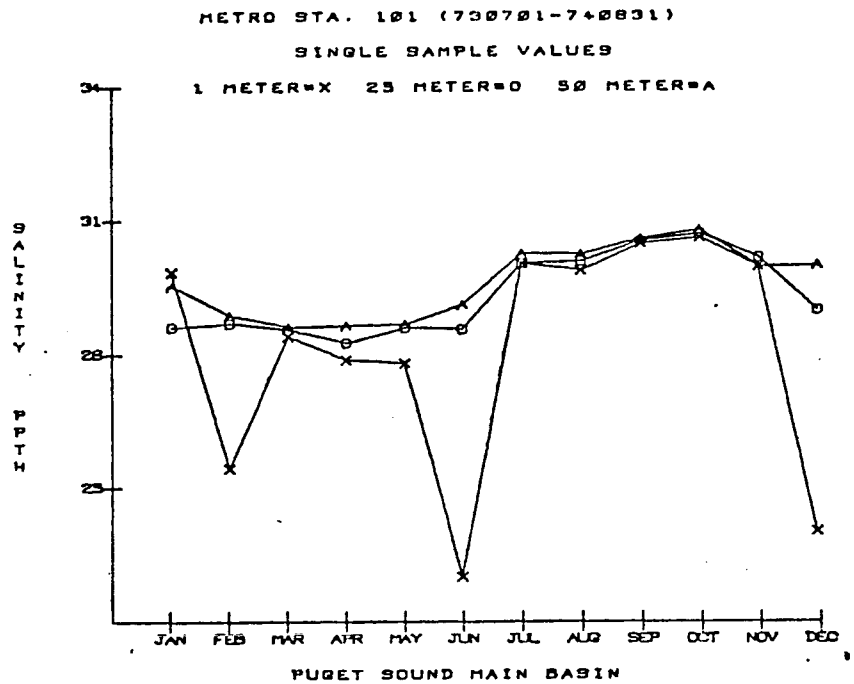
PUGET SOUND MAIN BASIN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SINGLE SAMPLE VALUES
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SALINITY PPTH
34
31
28
25
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
PUGET SOUND MAIN BASIN

METRO STA. 115 (730701-740831)

SINGLE SAMPLE VALUES

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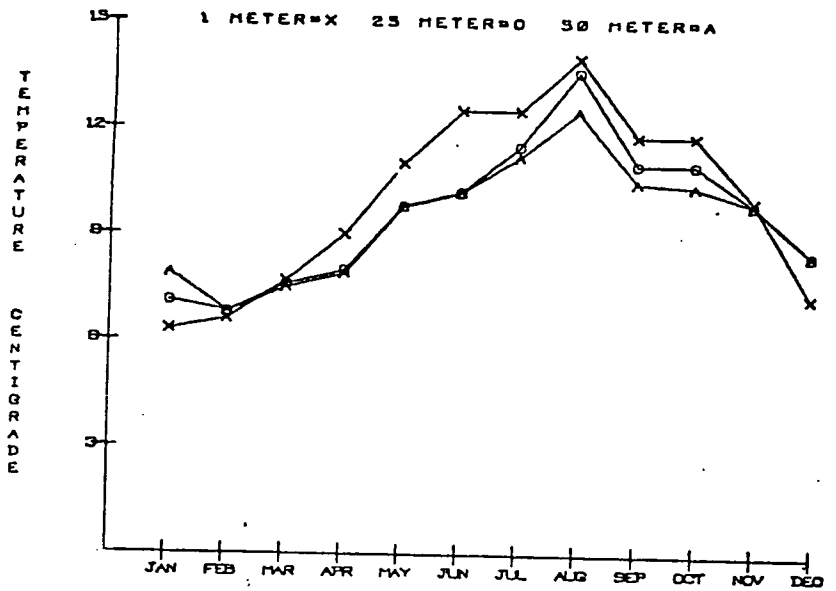

PUGET SOUND MAIN BASIN

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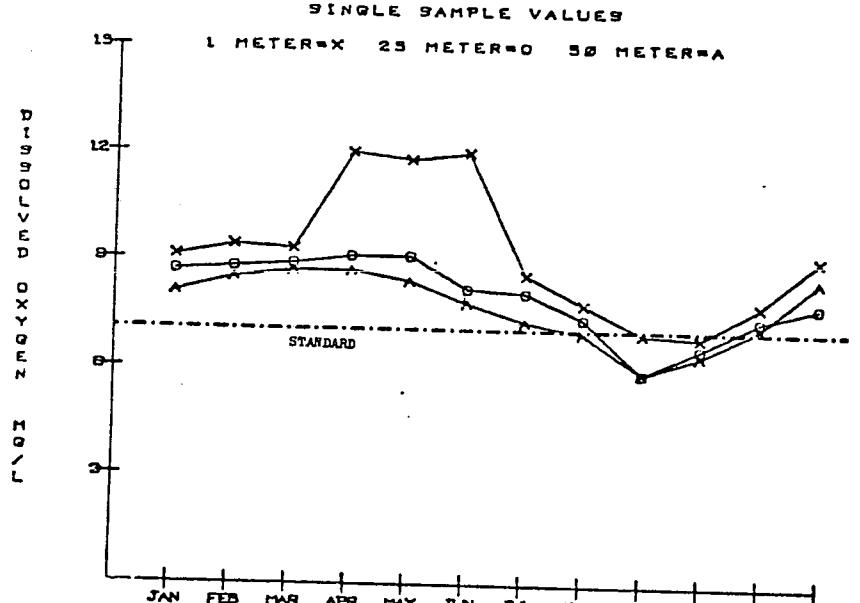

PUGET SOUND MAIN BASIN

METRO STA. 115 (730701-740831)

SINGLE SAMPLE VALUES

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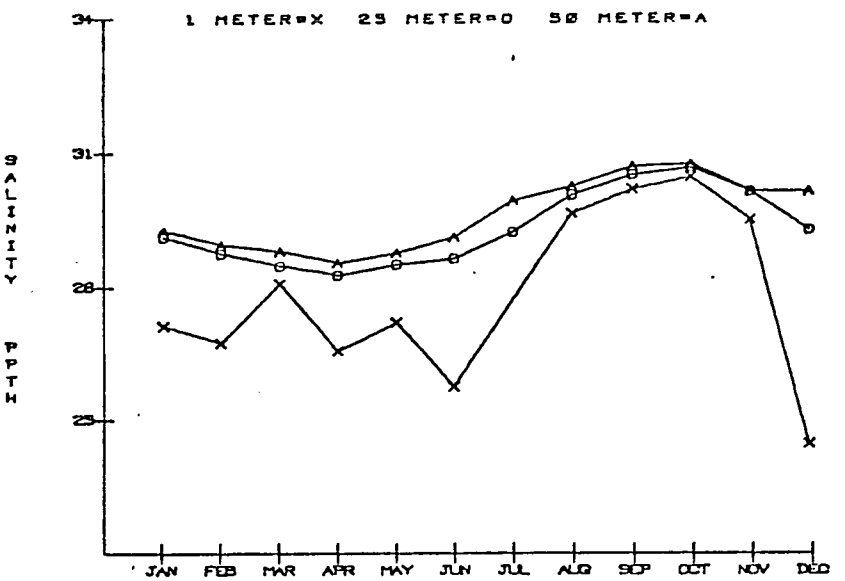

PUGET SOUND MAIN BASIN

METRO. STA.130 (730701-740631)

MEAN VALUES

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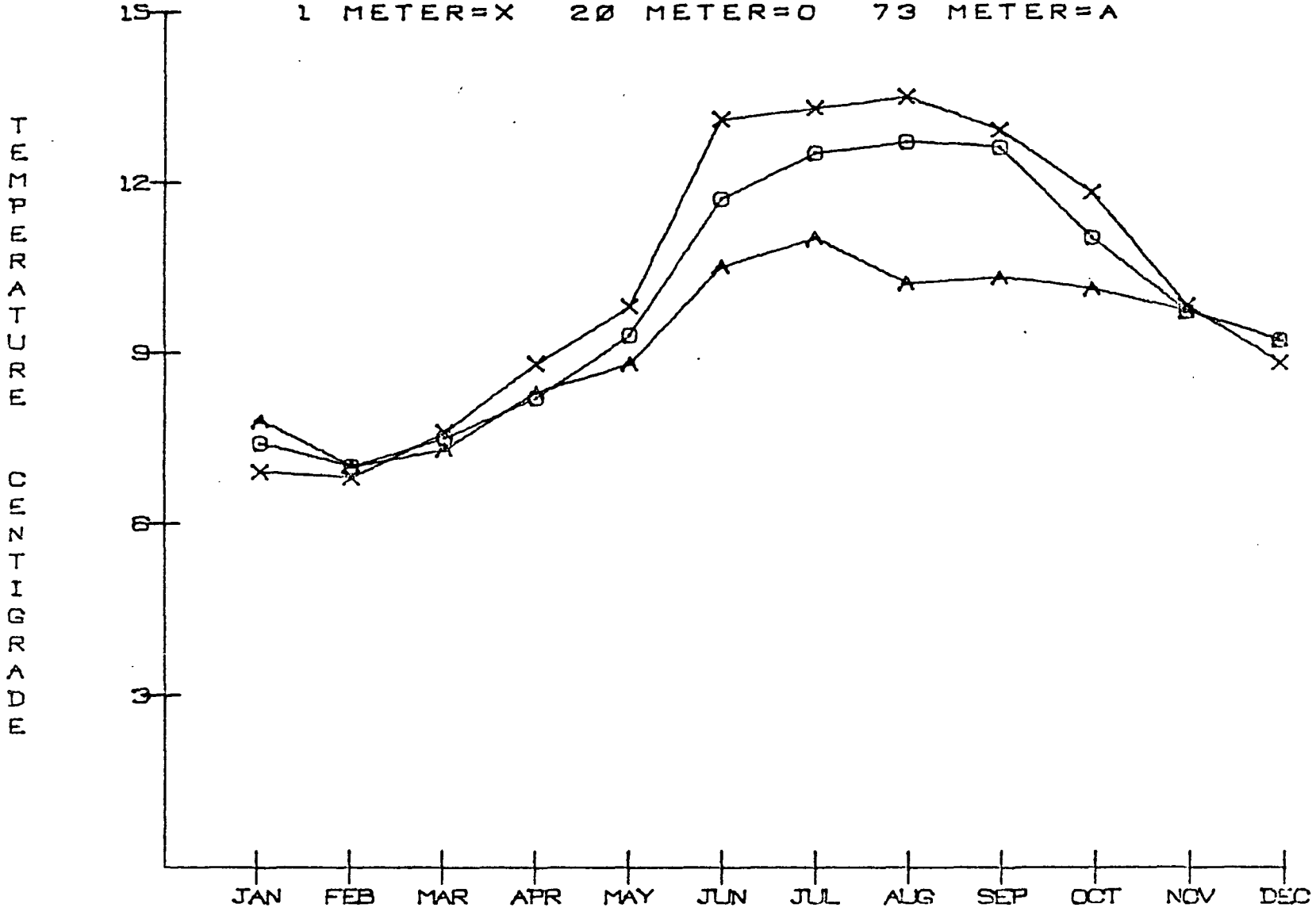
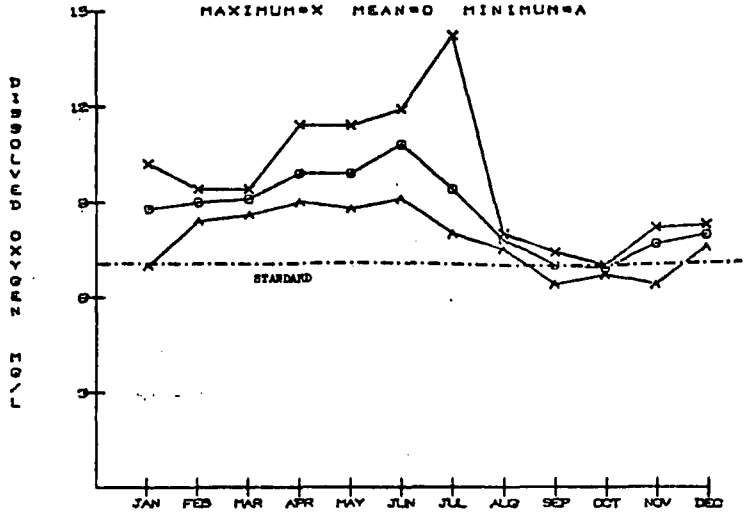


PUGET SOUND MAIN BASIN

METRO STATION 130 (730701-740831)

SAMPLE DEPTH = 1 METER

MAXIMUM=X MEAN=O MINIMUM=A

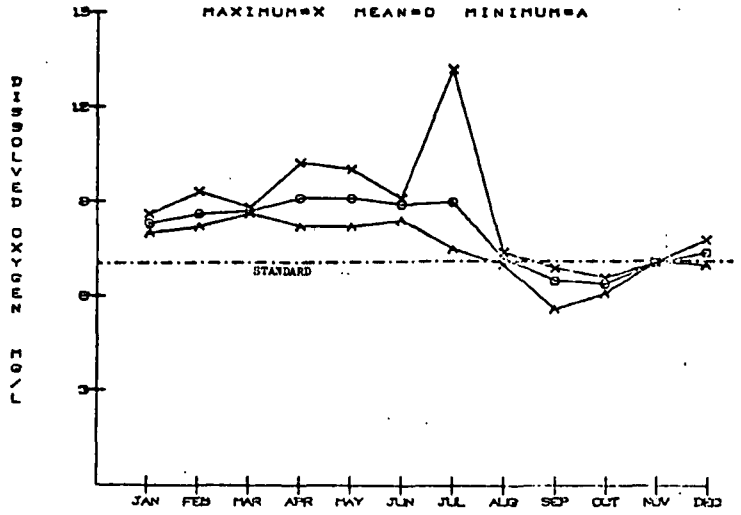


PUGET SOUND MAIN BASIN

METRO STATION 130 (730701-740831)

SAMPLE DEPTH = 20 METERS

MAXIMUM=X MEAN=O MINIMUM=A

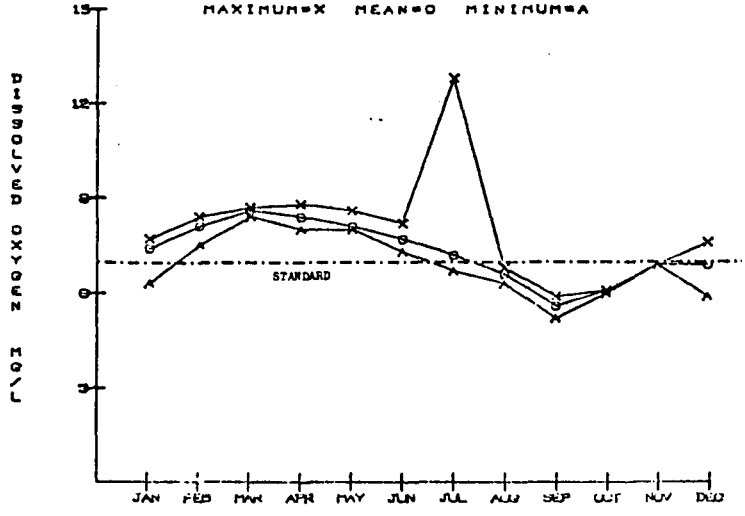


PUGET SOUND MAIN BASIN

METRO STATION 130 (730701-740831)

SAMPLE DEPTH = 73 METERS

MAXIMUM=X MEAN=O MINIMUM=A



METRO. STA.130 (730701-740631)

MEAN VALUES

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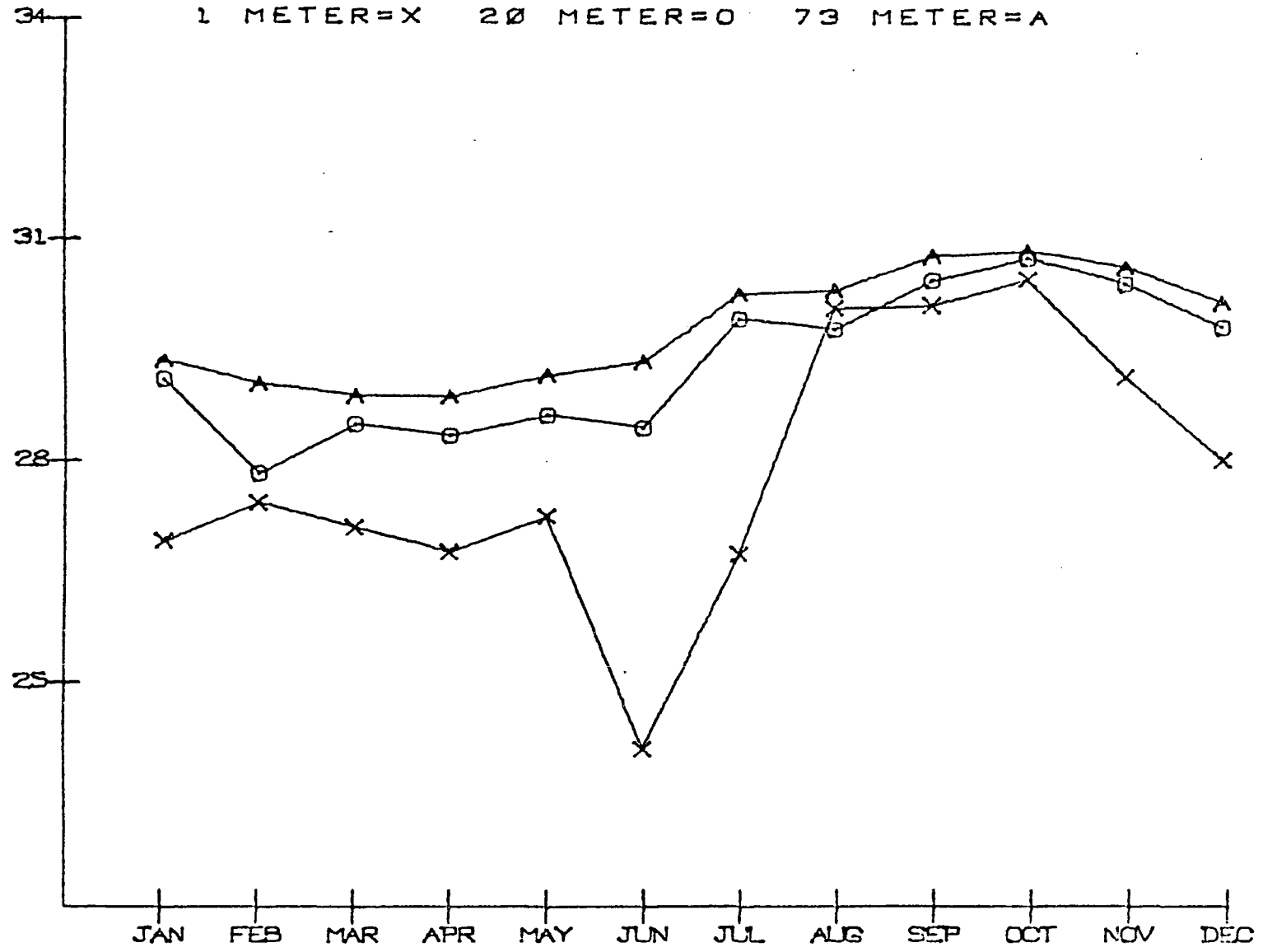

PUGET SOUND MAIN BASIN

METRO. STA. 180 (730701-740831)

SINGLE SAMPLE VALUES

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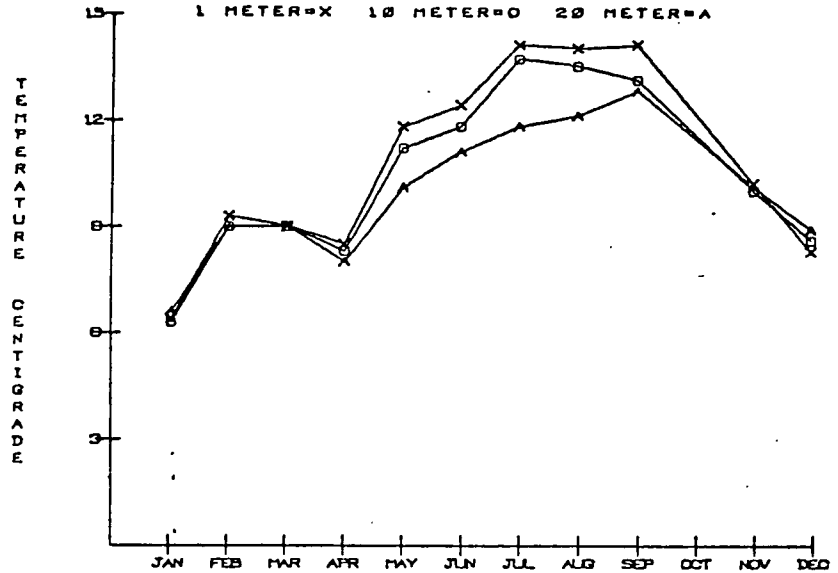

PUGET SOUND MAIN BASIN

METRO STA. 180 (730701-740831)

SINGLE SAMPLE VALUES

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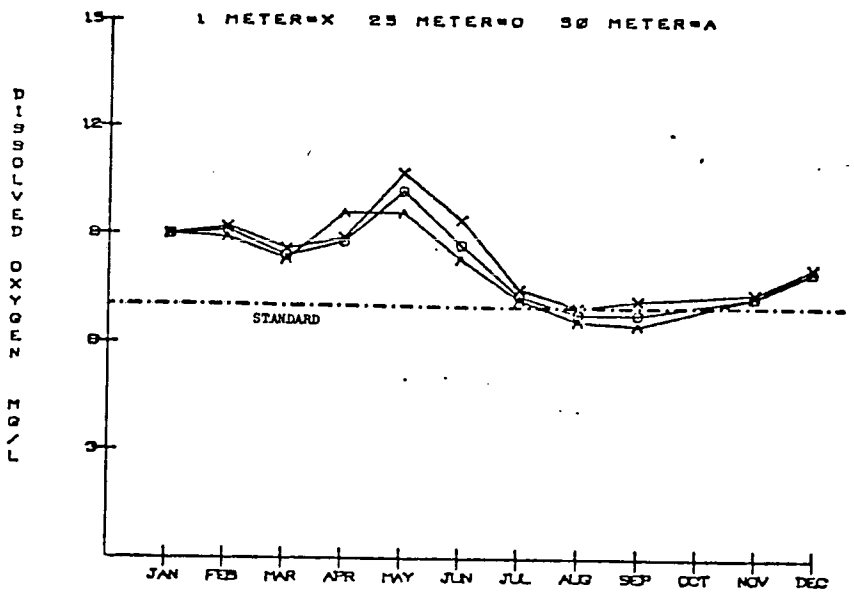

PUGET SOUND MAIN BASIN

METRO STA. 180 (730701-740831)

SINGLE SAMPLE VALUES

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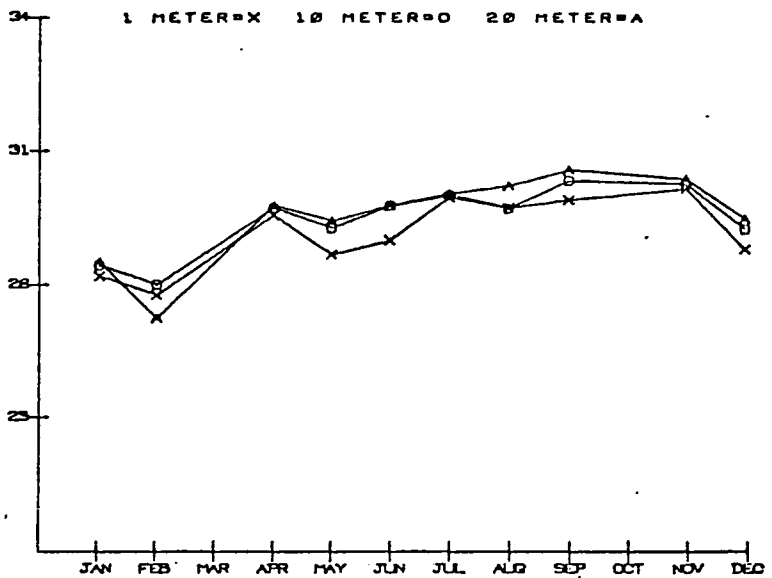
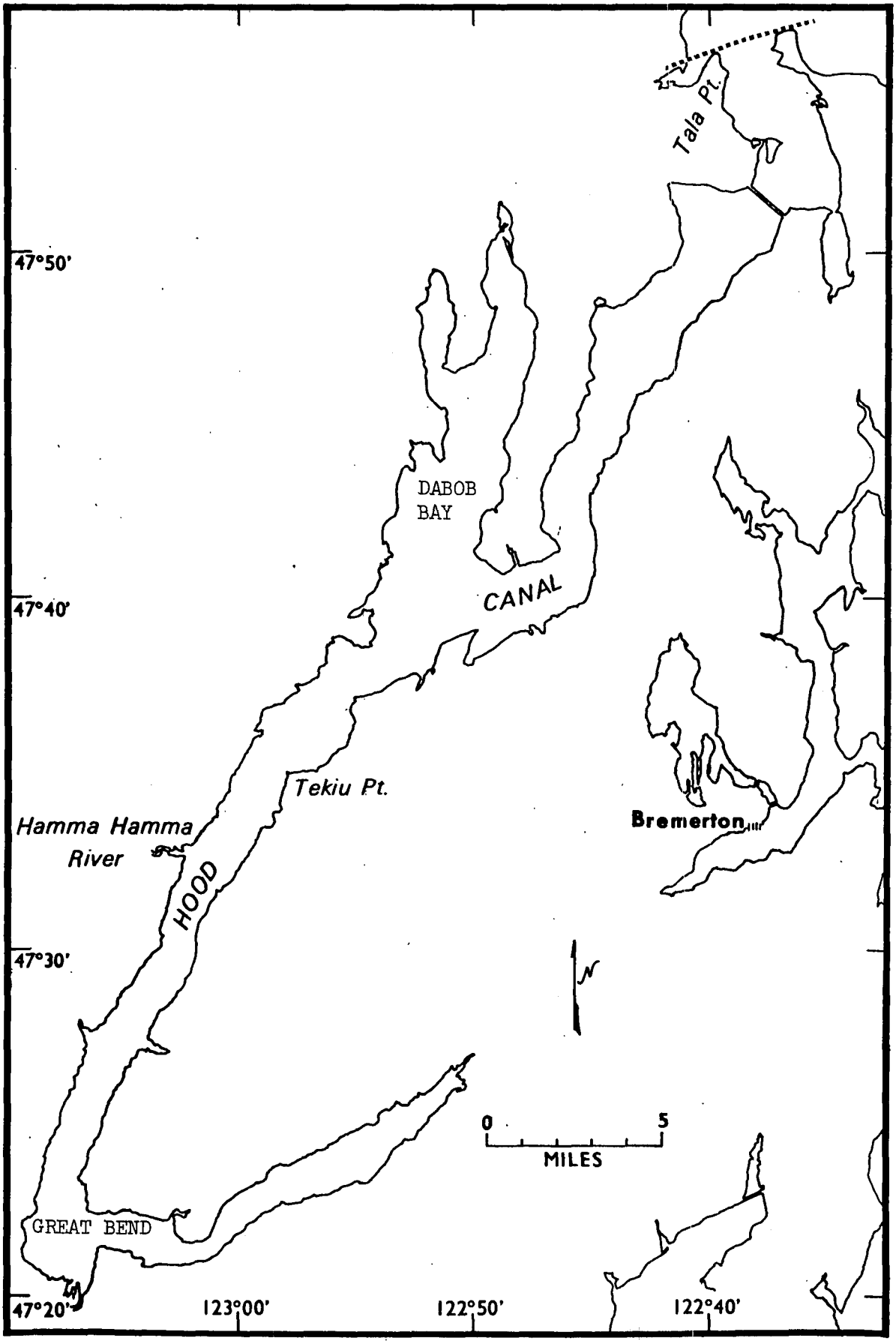


PUGET SOUND MAIN BASIN

HOOD CANAL BASIN



HOOD CANAL BASIN

HOOD CANAL

Hood Canal is the portion of Puget Sound separated from Admiralty Inlet at the north end by a line from Tala Point to Foulweather Bluff. It is bounded on the west by the Olympic Mountains and on the east by the Great Peninsula. Hood Canal is a long, narrow inlet rather than a channel connecting two bodies of water. The entrance arm of Hood Canal extends 35 km (19 naut mi) to the southwest where it branches near Pleasant Harbor. To the north of the juncture is Dabob Bay with a length of 19 km (10.5 naut mi) and to the south is the main basin with a length of 60 km (32.5 naut mi). About 18 km from the end, it bends to the northeast and ends in mudflats at Lynch Cove. The average width of Hood Canal is less than 2.5 km (8,000 feet), has a total surface area of 388 km^2 (113 sq naut mi) and a volume of 26.5 km^3 (3.92 cu naut mi) at mean high water.

The water depth at the entrance to Hood Canal off Tala Point is 115m (63 fath). To the south, the water gradually shoals until a sill with a controlling depth of 56 m (30 fath) is observed near Iofall. The water then deepens until it is 130 m (71 fath) off of Pleasant Harbor. Continuing to the south, the water deepens to 170 m (93 fath) off Quatsap Point and remains deep for the next 12 km when it begins to gradually shoal, and off of Hoodsport the water is 120 meters (65 fath) deep. Rapid shoaling occurs around the Great Bend until the water is only 45 m (24 fath) deep off of Tahuya River. The water in Lynch Cove shoals from 40 m to 18 m (10 fath) near the head. Returning north to Dabob Bay, a deep sill with a controlling depth of 127 m (70 fath) is found about 2 km north of Pleasant Harbor. North of the sill, the water deepens to 194 m (105 fath) and remains deep for the next 4 km before it

slowly shoals to 127 m (70 fath) off of Broad Spit. From here to the head of Dabob Bay the water depth decreases rapidly. A small appendage, Quilcene Bay, is located west of Bolton Peninsula. This bay is quite deep but only 4 km (2 naut mi.) long. The sills and bends of Hood Canal provide the basis for dividing if into four oceanographic sub-regions namely (Fig 2): (a) the entrance arm, (b) the main basin, (c) Lynch Cove; i.e. those waters east of the Great Bend, and (d) Dabob Bay.

The fresh water sources for Hood Canal include land drainage, small creeks, and several rivers. The major rivers, all located on the Olympic Mountain side are the Skokomish, Hamma Hamma, Duckabush, and the Dosewalips. The Skokomish River contributes half of the fresh water on an annual basis, but is regulated by Cushman Dam. All of the rivers exhibit a peak discharge in winter in response to local rainfall, but the largest discharge occurs in June because of snow melting in the mountains. However, since the Skokomish River is controlled, most of the snow melt water is impounded for use by the City of Tacoma's power plant at Hoodsport and released over a longer period of time.

The surface layer in Hood Canal does not show a gradual increase in salinity as it moves seaward, because the fresh water sources enter along the edges rather than in a single river at its head. Instead, a rather thick (3 to 7 m) fresh surface layer is produced that dominates all the main basin and Lynch Cove. Little freshwater is discharged into Dabob Bay so any freshwater layer must move into this area from the south. The surface layer is present at all times of the year, but is most prominent in winter and again in early summer. The salinity of the surface layer is quite variable ranging from nearly $0^{o}/_{oo}$ off the river mouths to nearly the same as the deeper water. But in general the usual salinities range

from about 24°/oo to 28°/oo. The temperatures observed in the surface layer also exhibit extremes and reflect the prevailing surface air temperatures. During the winter, a typical surface temperature is about 6°C while in the summer, the waters of Lynch Cove region are frequently above 22°C and have reached an extreme of 28°C while the main basin may be up to 20°C. The lowest surface temperature recorded was 0°C with ice being present on the surface from the tip of Lynch Cove to about 5 km north of Hoodsport. This was during a very severe winter (1952) when freezing conditions prevailed for nearly six weeks. The oxygen content of the surface waters is quite variable and is dependent upon biological activity. During the spring, phytoplankton bloom, in April and May, oxygen values of over 20 mg/l are common in the main basin. But by the end of summer, the oxygen content may decline to about 5 mg/l. Surface phosphate content is also quite variable and ranges from nearly zero during the spring plankton bloom to over 2 micro-gram atoms per liter in the winter.

The waters at depth in Hood Canal are considerably different than the surface waters. Water from Admiralty Inlet enters off Tala Point and travels south through the entrance arm. Some mixing occurs at the first sill, but not so intense that the water column becomes homogeneous. This water continues towards the main basin at a level depending upon its density. Because it feeds into the side of the main channel rather than at one end, the results are different than those observed in a typical fjord. This incoming water may be dense enough to enter and spread along the bottom or it may form a thin layer at some intermediate depth. Hence, a considerable amount of micro structure in salinity and temperature exists (Glancy 1962; kollmeyer 1965). This makes the flushing mechanism complex and difficult to define.

The water behind the deep sill at the entrance of Dabob Bay tends to operate as a separate unit. This water is frequently trapped in the deep pocket of Dabob Bay for ten months before being replaced. Some of this deep water has been observed to remain in there for over 20 months (Barnes and Collias, 1959). During the time this water was present, its oxygen content decreased to under 0.5 mg/l and the phosphate content increased to nearly 5 micro-gram atoms/l. In order to flush the water trapped behind the Dabob Bay sill, water of a greater density must enter Hood Canal. This occurs only during October of each year when the more dense water entering in the Strait of Juan de Fuca in July and August finally penetrates this far into the Puget Sound system. Flushing of most of Hood Canal may occur without affecting the deep water in Dabob Bay because the incoming water may not be dense enough to replace the deep trapped water.* Also, a sufficient quantity of this water must be present to completely fill the deep basin south of the Dabob sill before it will spill over into Dabob Bay.

The Lynch Cove sub-region is also different than anticipated. Because of biological activity in the surface waters, organic debris rains down into the lower layer. This organic debris has a high oxygen demand and since the deeper water of Lynch Cove remains in the region for some time, the oxygen content of the deeper waters (below 8 meters) of this sub-region is often less than 0.2 mg/l (i.e., less than 2% saturation) while the phosphate content increases to above 4 micro-gram atom/l. When this low oxygen content water moves out of Lynch Cove into the main basin, it does so at a depth corresponding to its density. It can be

*The difference between the existing water and entering water required for flushing is often less than 0.2 mg/ml millilite (i.e., two parts in 10,000).

detected at a depth of 15 to 30 m as far north as Tekiu Point during some years. This is a naturally occuring phenomenon and is observed from May through January of each year. Under proper wind conditions, this low oxygen content water may come to the surface causing fish kills.

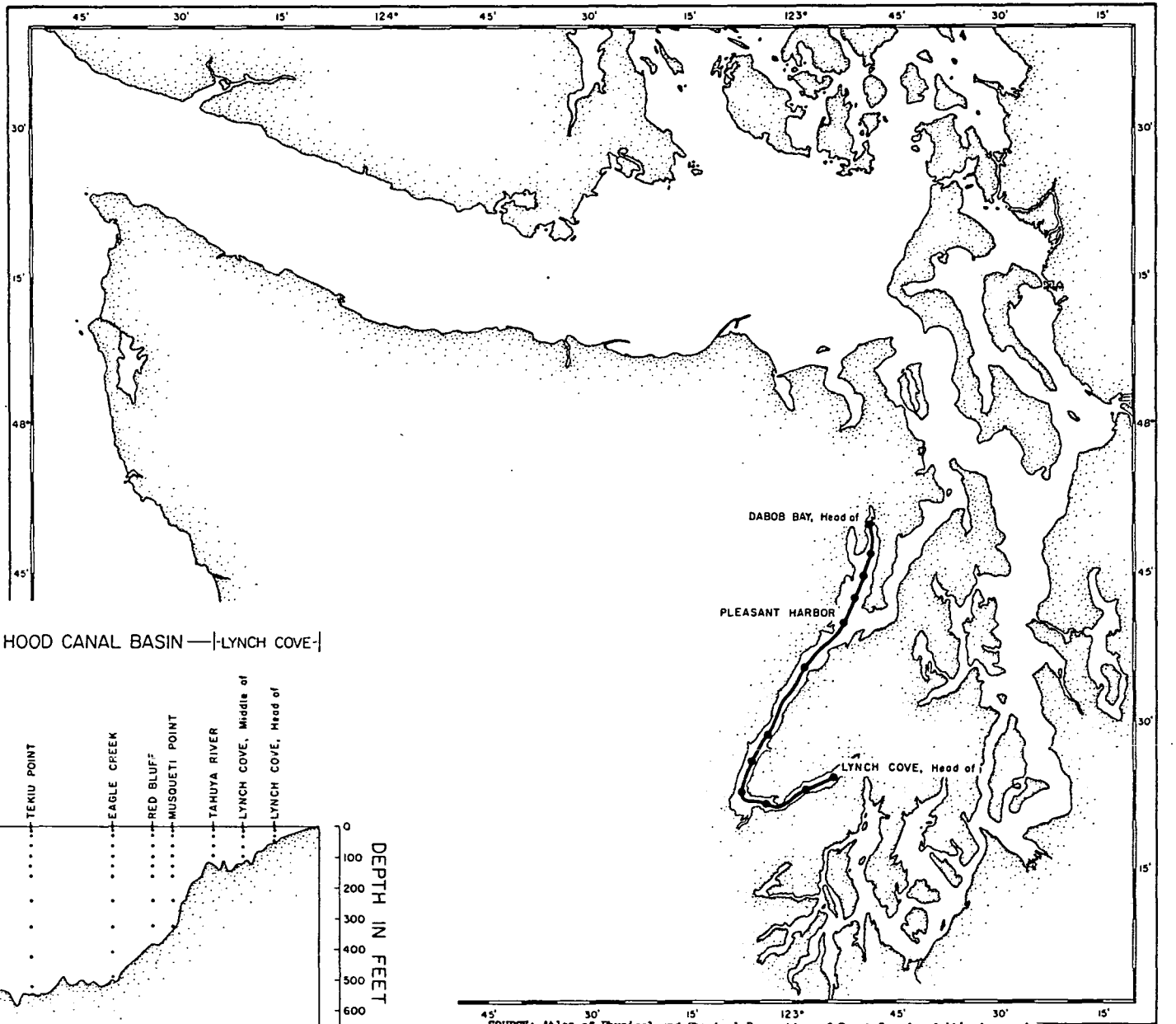
Prevailing winds for most of the year in Hood Canal are from the southwest and follow the contour of the basin. But in summer, northerly winds are frequent. Wind speeds are usually under 20 km/hr (10 mph) but winds up to 60 km/hr (30 mph) are not uncommon. Sever storm winds of over 160 km/hr (80 mph) have been observed (i.e., the Columbus Day storm of 1962). The winds are one of the major driving forces in the circulation of the Hood Canal basin and Dabob Bay. A southerly wind will cause the surface water to move north in the main basin with part of the water piling up in Dabob Bay and part of the water moving out of the entrance arm. In Lynch Cove, the same wind will cause a deepening of the surface layer. As this layer deepens, the deeper water must move out of Lynch Cove. Then, as the surface layer moves north in the main basin, deeper water in the south end of Hood Canal near Union and Hoodsport must replace the surface water. Therefore, as mentioned previously, it is possible for the low oxygen content water from Lynch Cove to be forced to the surface off of Hoodsport in response to wind action. When this phenomon occurs, especially in late fall, a fish kill may occur. At the same time in Dabob Bay, a southerly wind will cause the surface layer to deepen from two to five times its normal depth. The layer will have a very sharp thermocline at its lower boundary. Then as the surface layer deepens, water from depth must move to the south.

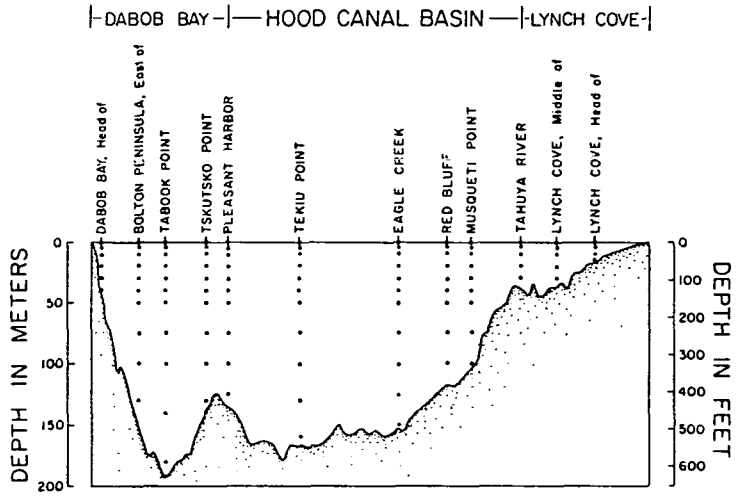
When the winds come from the north, the surface layers in both Dabob Bay and Lynch Cove are moved to the south, and the surface layer in the

south end of the main basin is deepened. As the surface layer moves out of Dabob Bay at Lynch Cove, it is replace by water from depth. When this occurs in summer, the deep water is often seven to ten degrees cooler so that any oyster spat in the north end of Dabob Bay may be killed or reduced in number. Upon subsidence of the winds, either north or south, a period of readjustment occurs with increased surface current speeds. This period of adjustment takes about 24 to 48 hours.

The characteristics of the deeper water are relatively stable. In summer, the temperatures are between 10° and 12°C and the salinity from 30.0°/oo to 30.8°/oo. In the winter, the temperature may drop to about 8° to 9°C and the salinity as low as 29°/oo. Frequently during winter and early spring the deep waters are warmer than the surface. Oxygen content of this water is usually above 5 mg/l with the exceptions previously discussed and the phosphate content is usually above 2 micro-gram atoms/l.

PROFILE LOCATION CHART



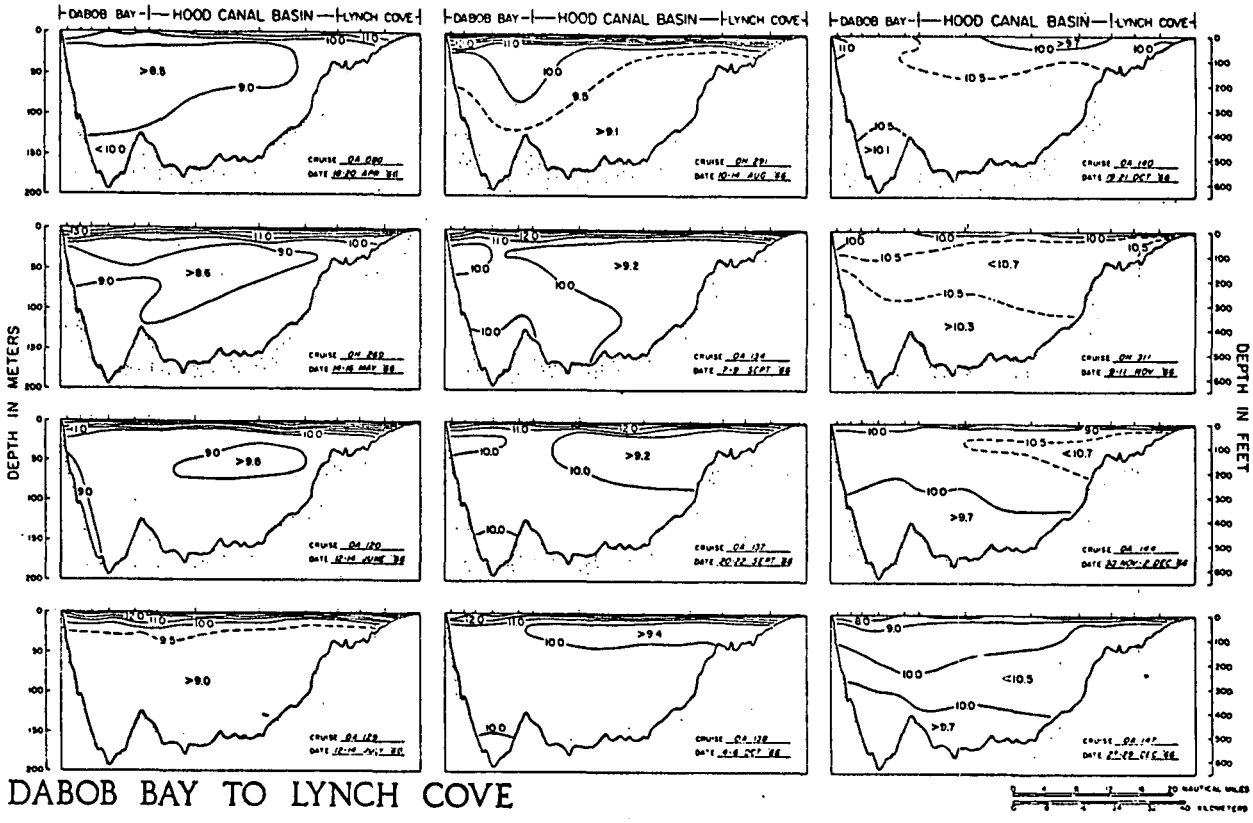


DABOB BAY TO LYNCH COVE

SOURCE: Atlas of Physical and Chemical Properties of Puget Sound and it's Approaches. Eugene E. Collias, Noel McGary, and Clifford A. Barnes. University of Washington Press. Copyright 1974. A Washington Sea Grant Publication.

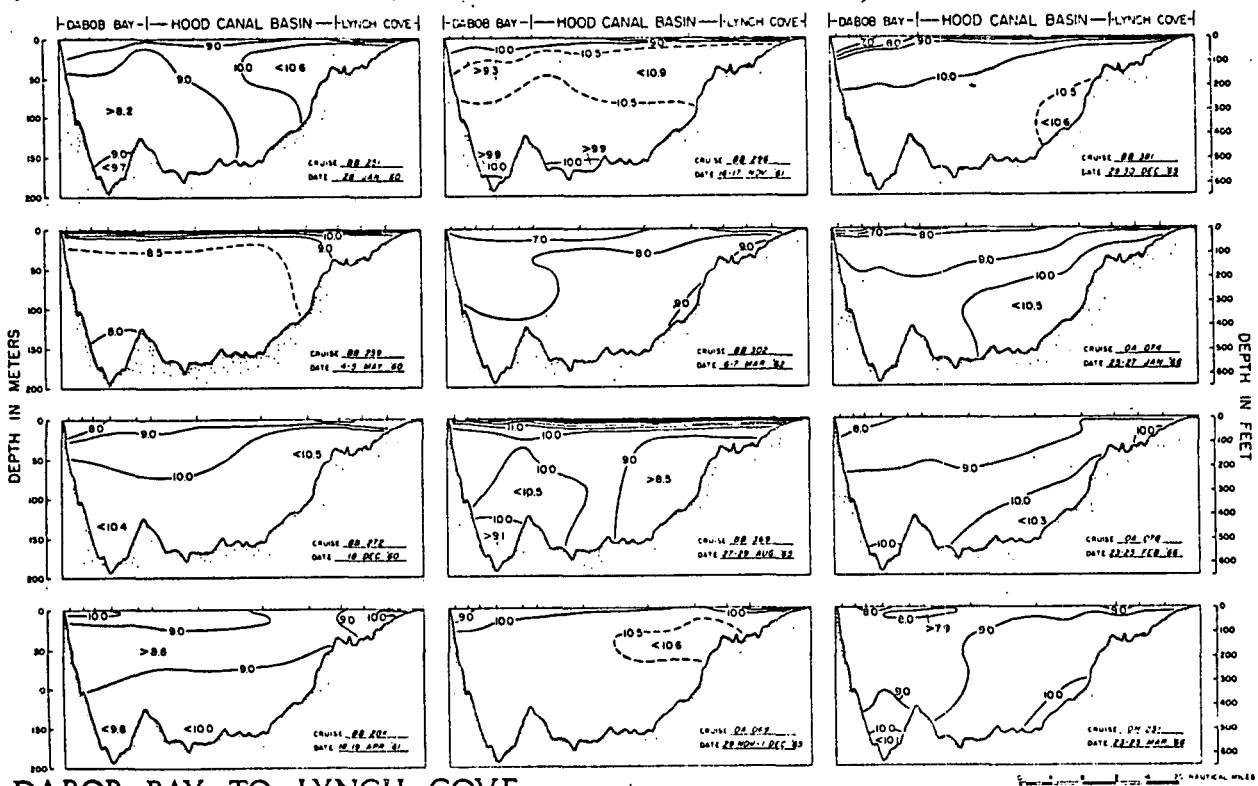
0 4 8 12 16 20 NAUTICAL MILES
0 8 16 24 32 40 KILOMETERS

TEMPERATURE (°C)



DABOB BAY TO LYNCH COVE

TEMPERATURE (°C)



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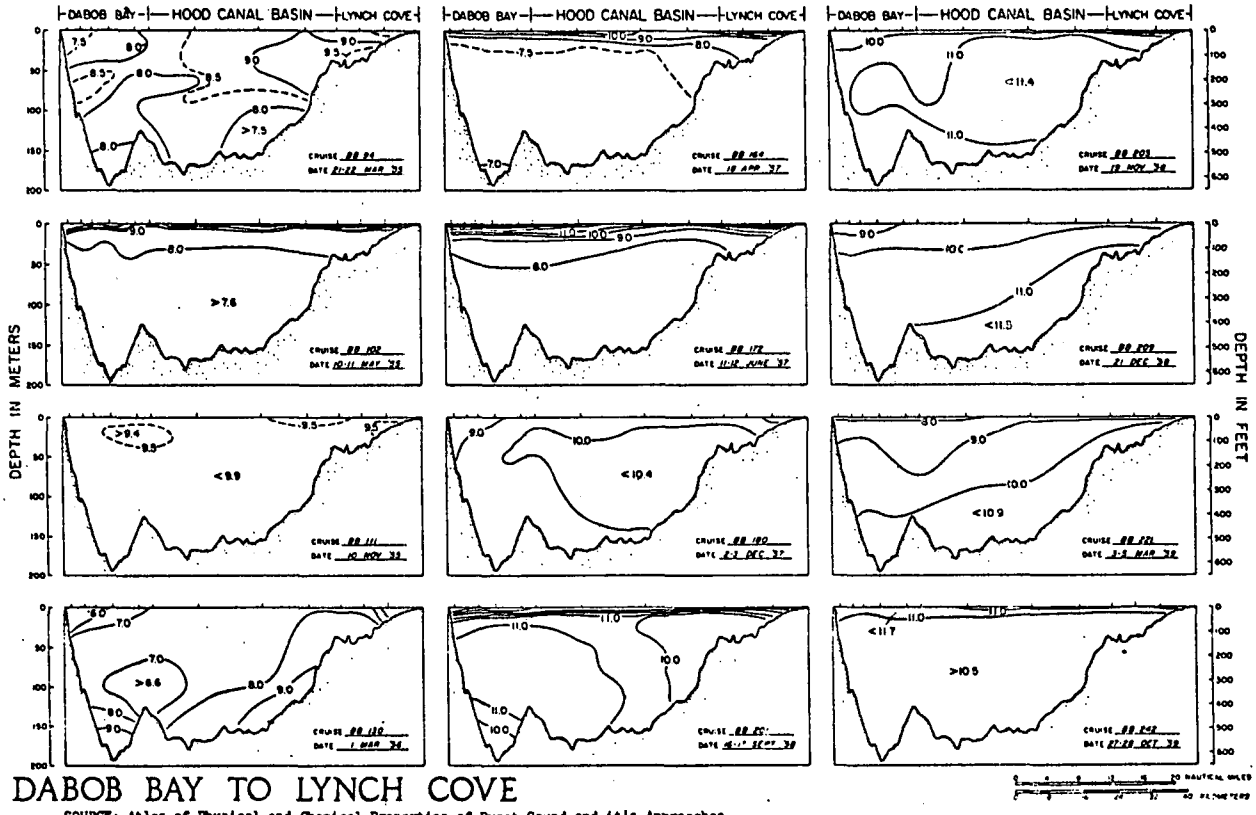
TEMPERATURE (°C)



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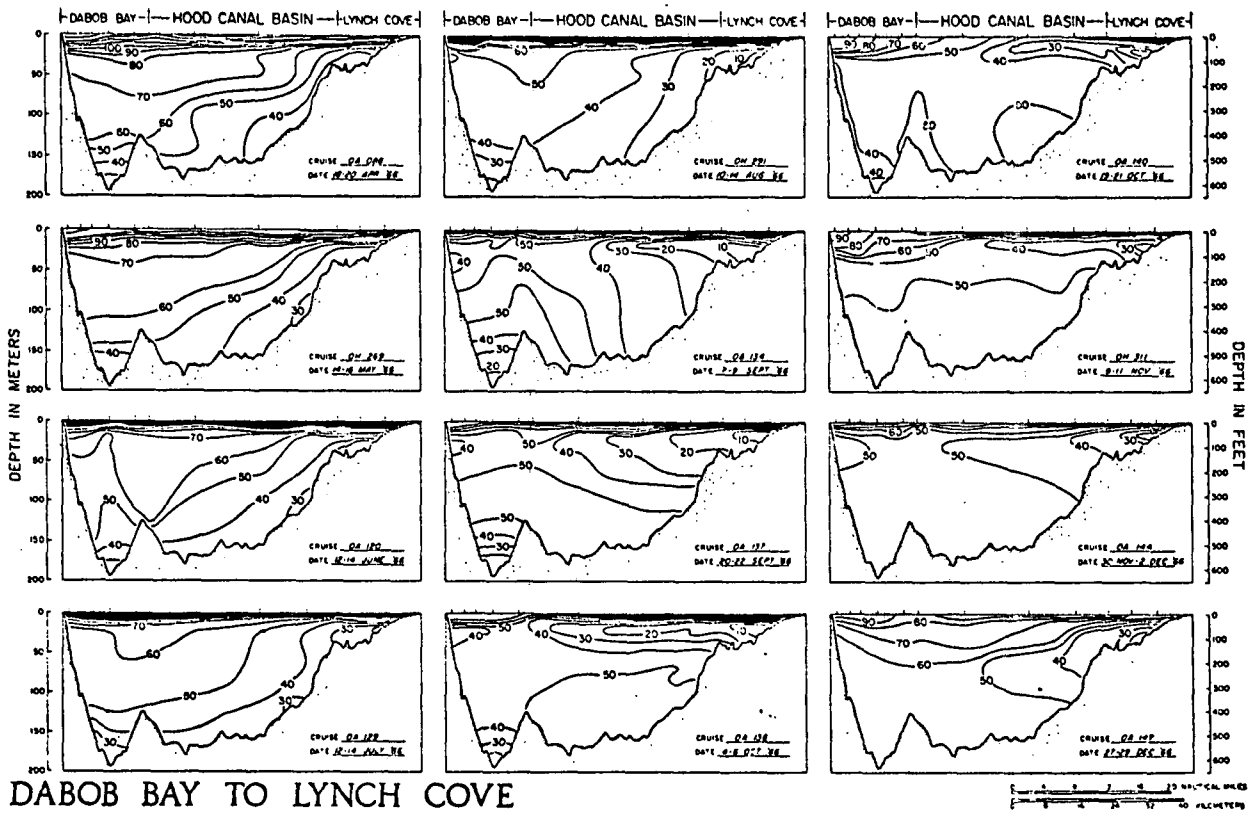
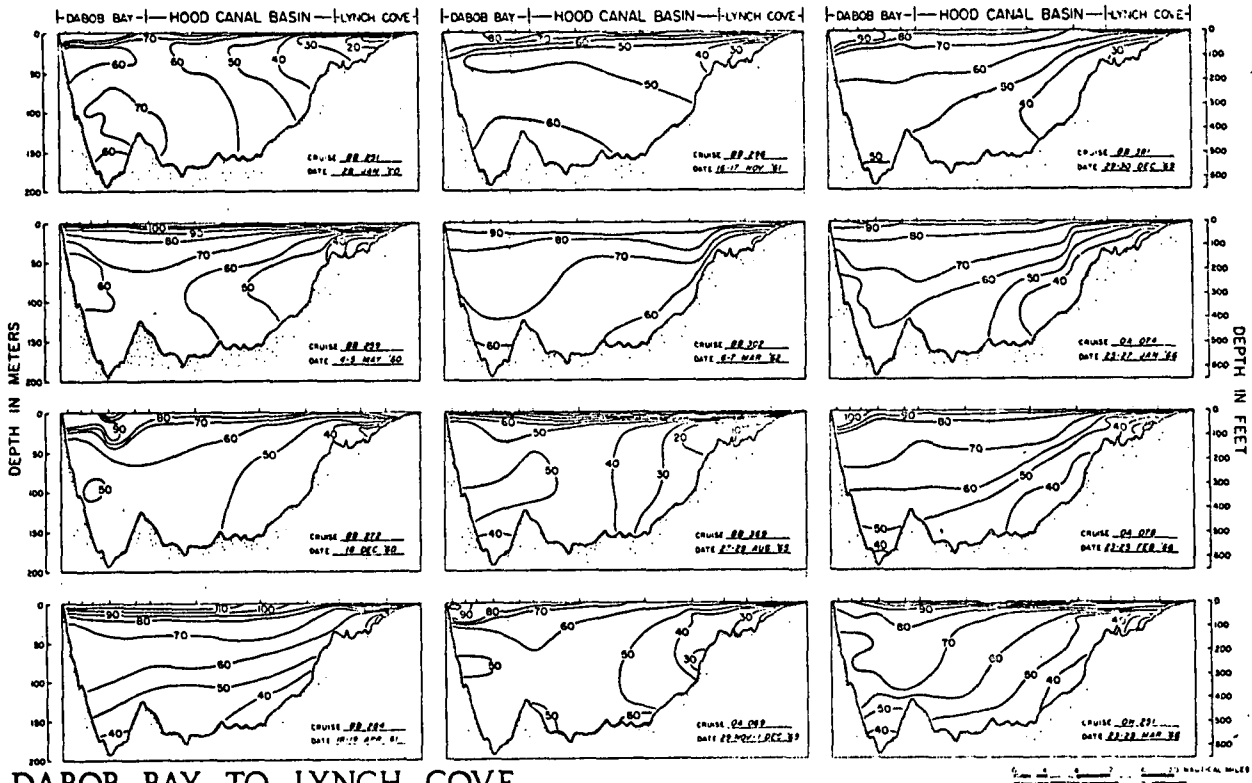
SOURCE: Atlas of Physical and Chemical Properties of Puget Sound and it's Approaches. Eugene E. Collias, Noel McGary, and Clifford A. Barnes. University of Washington Press. Copyright 1974. A Washington Sea Grant Publication.

OXYGEN (% satn.)



DABOB BAY TO LYNCH COVE

OXYGEN (% satn.)



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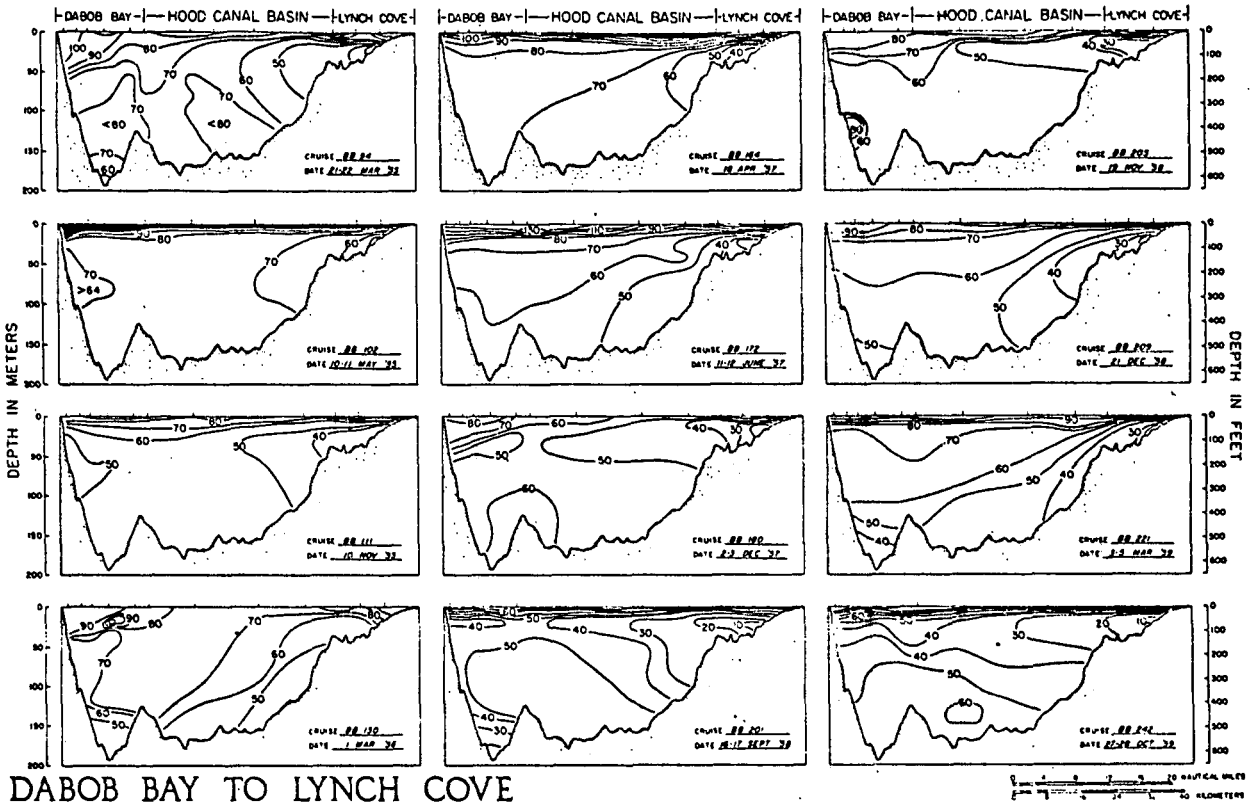
OXYGEN (% satn.)



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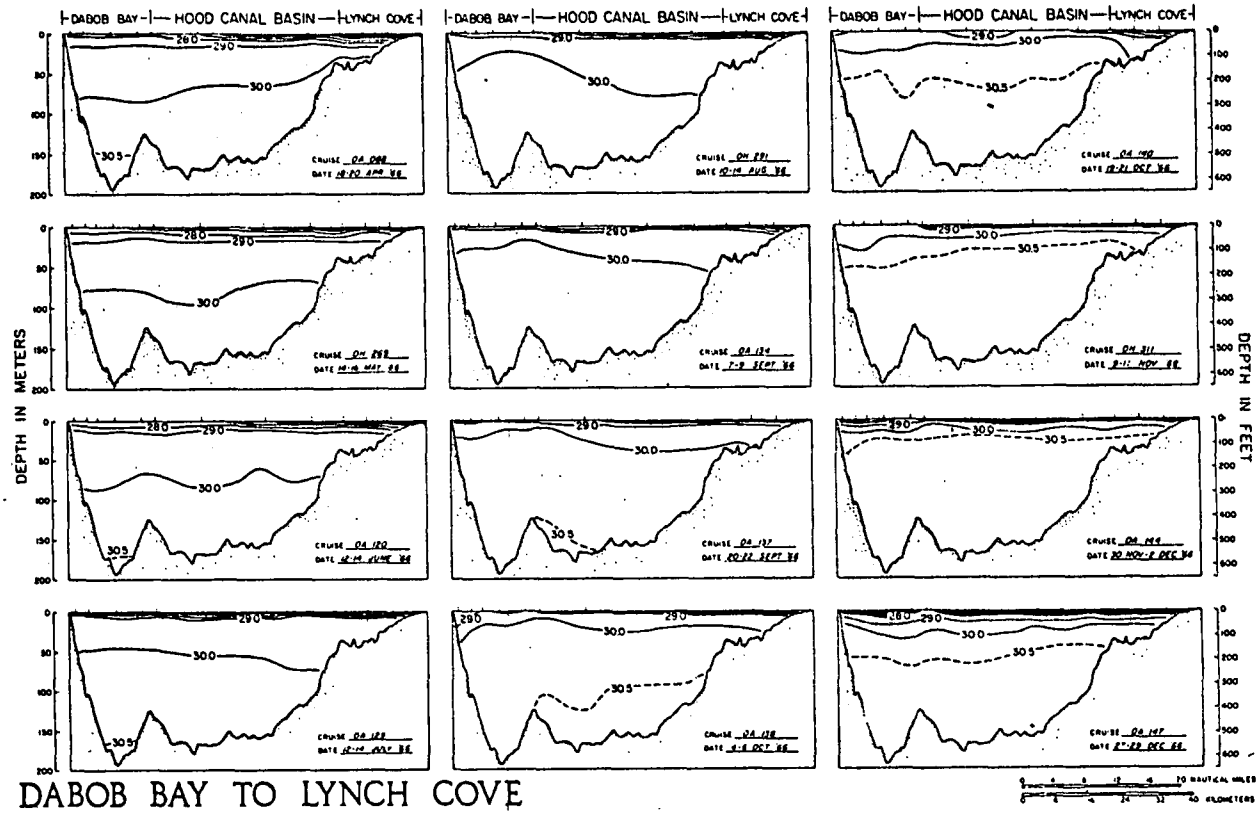
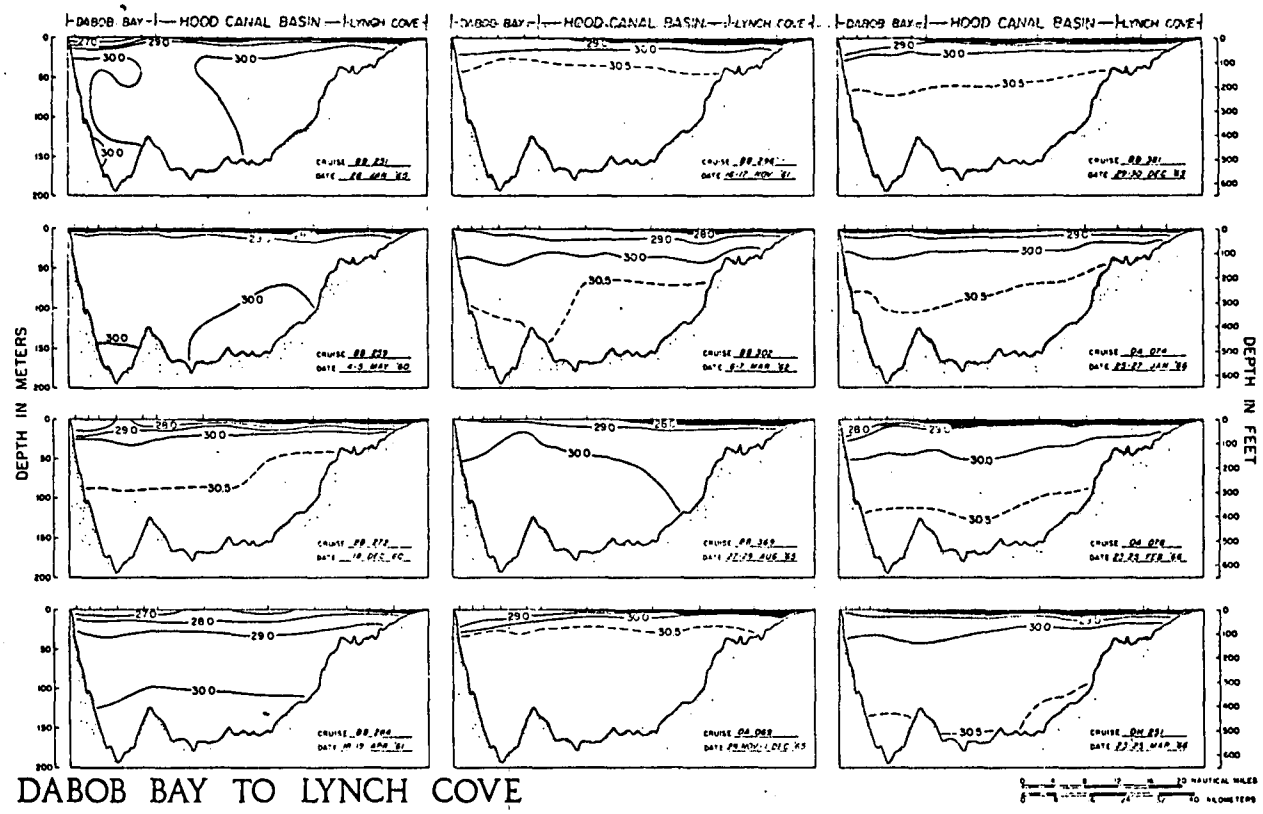
SALINITY (‰)



DABOB BAY TO LYNCH COVE

SALINITY (‰)



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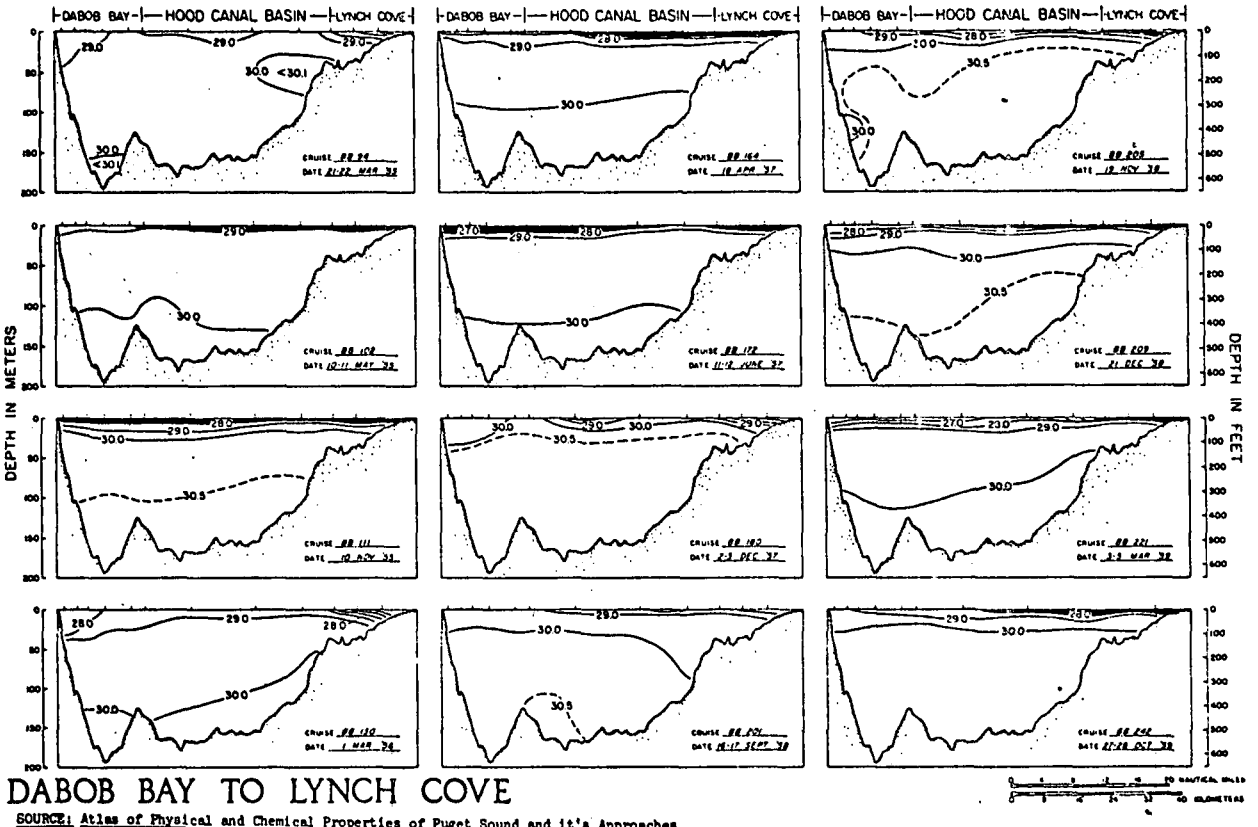
SALINITY (‰)



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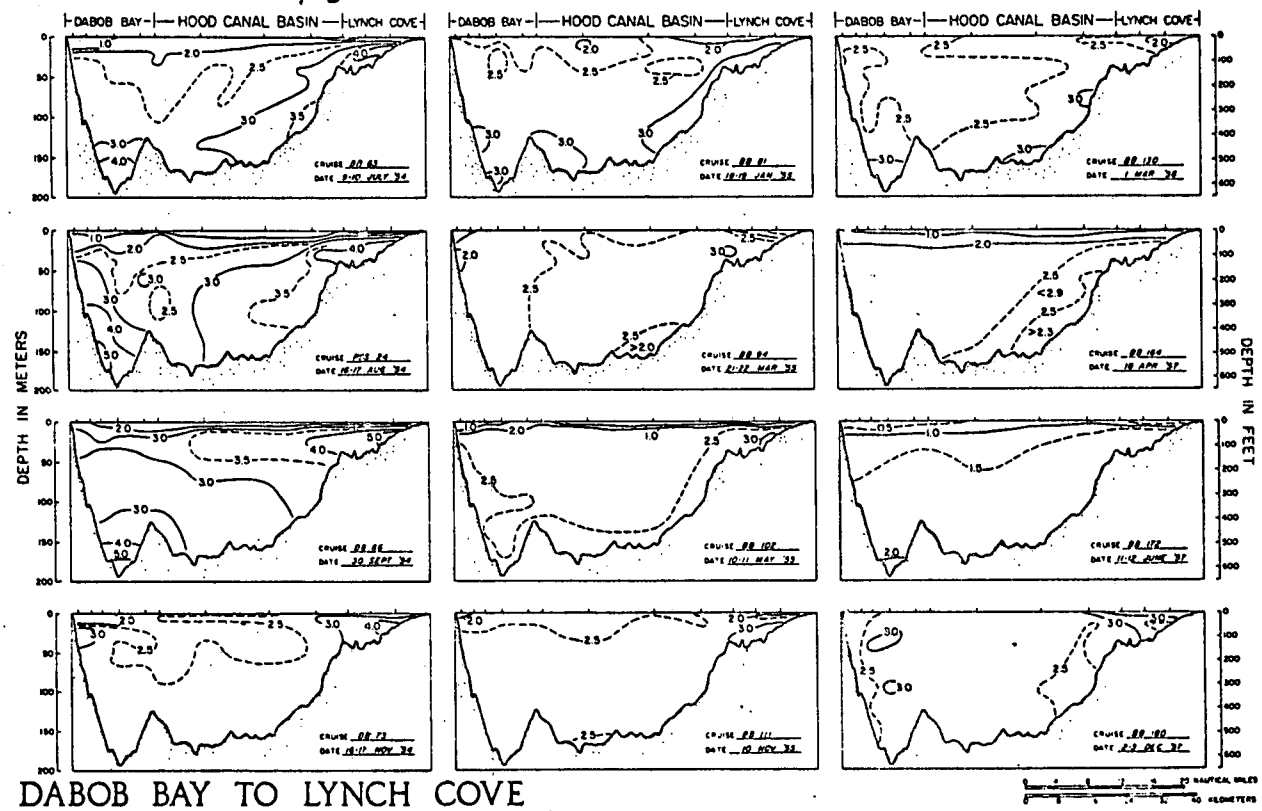
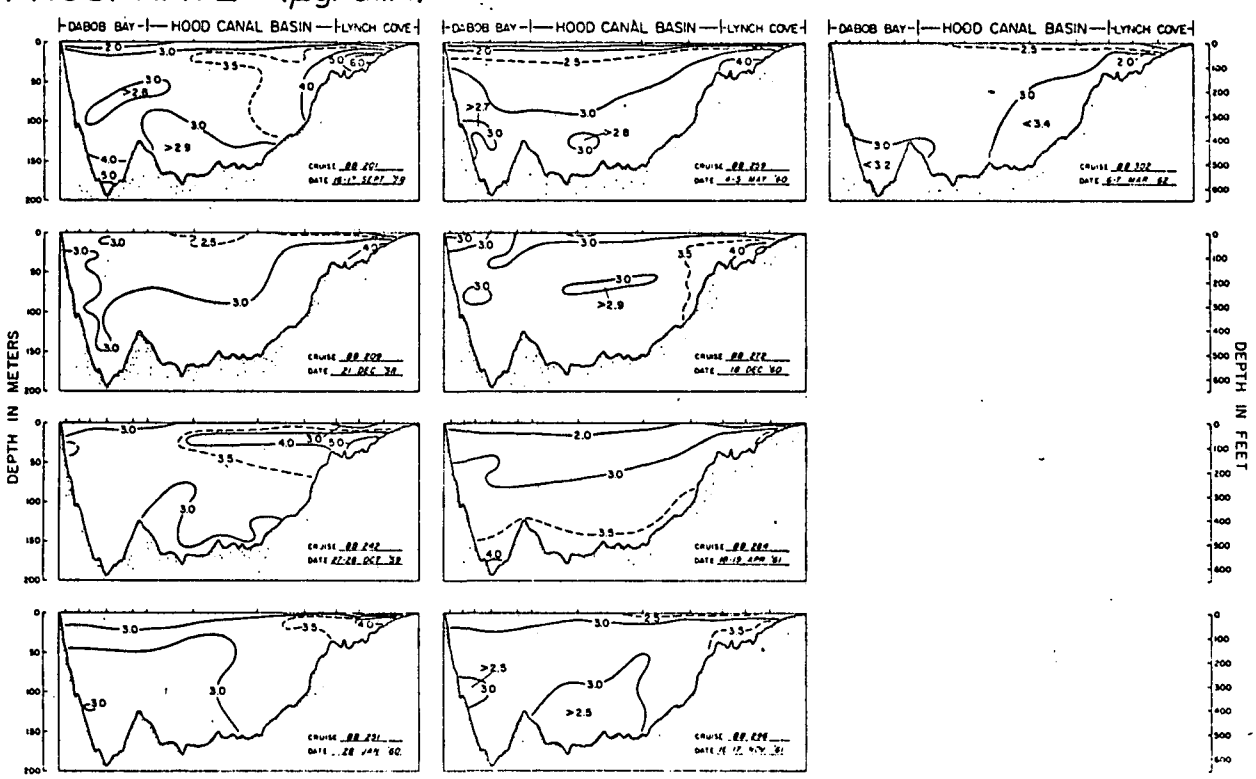
PHOSPHATE (μg. at./l)



DABOB BAY TO LYNCH COVE

PHOSPHATE (μg. at./l)



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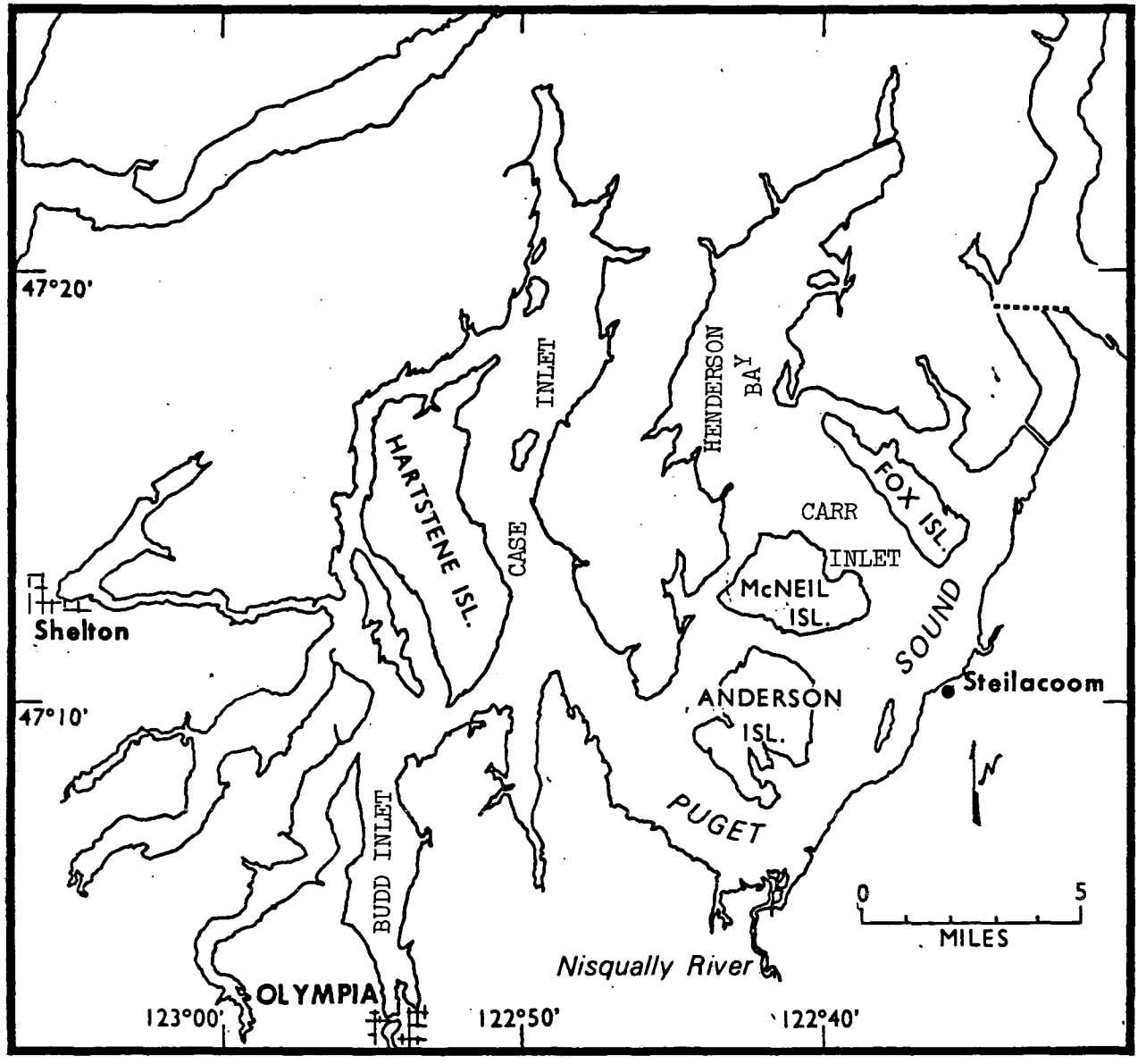
SOUTHERN PUGET SOUND BASIN



SOUTHERN PUGET SOUND BASIN

SOUTHERN PUGET SOUND

Southern Puget Sound consists of all the waters south of the Tacoma Narrows and includes Carr Inlet, Case Inlet, Henderson Inlet, Budd Inlet, Eld Inlet, Totten Inlet, Hammersley Inlet - Oakland Bay, and all the connecting channels. The surface area is 470 km^2 (137 sq naut mi) with a combined volume of 15.8 km^3 (2.49 cu naut mi) refered to mean high water. Water depths vary from 164 m (91 fath) off McNeil Island to mud flats at the head of the various inlets.

The largest river entering southern Puget Sound is the Nisqually which exhibits two runoff peaks. The Deschutes river enters Budd Inlet near Olympia but it is only about 25% as large as the Nisqually. Other sources of fresh-water are from many small creeks, such as Chambers Creek near Steilacoom and Goldsborough Creek near Shelton, and from land drainage.

Prevailing winds are usually southerly most of the year except during the summer when northerlies occur. However, local topographic effects are significant and modify the flow of air over this region to a considerable extent. The winds are usually in the same direction at the same time as observed in the main basin of Puget Sound, but are usually of less intensity.

All of the water entering southern Puget Sound must pass through the Tacoma Narrows. On an average tide of 3.9 m (13 feet), 1.64 km^3 of water pass through the Narrows. Currents are very strong in the Narrows with speeds up to 11 km/hr (6 knots) being common. The Narrows is a mixing zone similar to Admiralty Inlet, but on a smaller scale. In this case, waters from either side to depths of about 50 m are mixed depending upon the tide direction. Complete top to bottom mixing occurs during

during most of the tide cycle. Only on small tides, of less than about 5 m range, does any surface water as an entity penetrate into or past the Narrows. On a flood tide, strong turbulence is observed from the Narrows south to near Nisqually Reach. Currents in Nisqually Reach are often about 5 km/hr (3 knots). Because of this extensive mixing, the waters from the Narrows to Johnson Point are vertically homogeneous with some change in the longitudinal direction. The salinity for a station off Mc Neil Island varies from an average winter low of 28°/oo to an average high of slightly over 30°/oo. Temperatures vary from a winter low of 7.5°C to a summer high of 14°C. Rarely does the vertical temperature difference in the water column exceed 2°C and is usually less than 0.5°C. The oxygen content is fairly uniform varying from a low of 5.9 mg/l to a high of 8.5 mg/l.

The largest inlet in southern Puget Sound is Carr Inlet. It is 22.5 km (12.5 naut mi) long, with an average width of 2.7 km (1.5 naut mi), and has a water depth of 160 meters (89 fath) at its entrance. The depth remains more than 100 m (55 fath) for half of its length. It then gradually decreases to a mud flat at its end near the town of Purdy. Only a small amount of fresh-water enters this inlet and most of that is from a creek near Purdy. An intensive survey of Carr Inlet was made between February 1954 and February 1955 (Barnes, Collias, and Paquette, 1955). The waters of Carr Inlet are usually homogeneous with depth as well as longitudinally and laterally. Salinity differences are usually less than 1°/oo and temperatures are usually within 1°C except during the summer when the surface may be about 3°C higher than the deeper water. Minimum salinities and temperatures are observed in February being 29.6°/oo and 8°C respectively. The surface temperature will increase to about 15.5°C

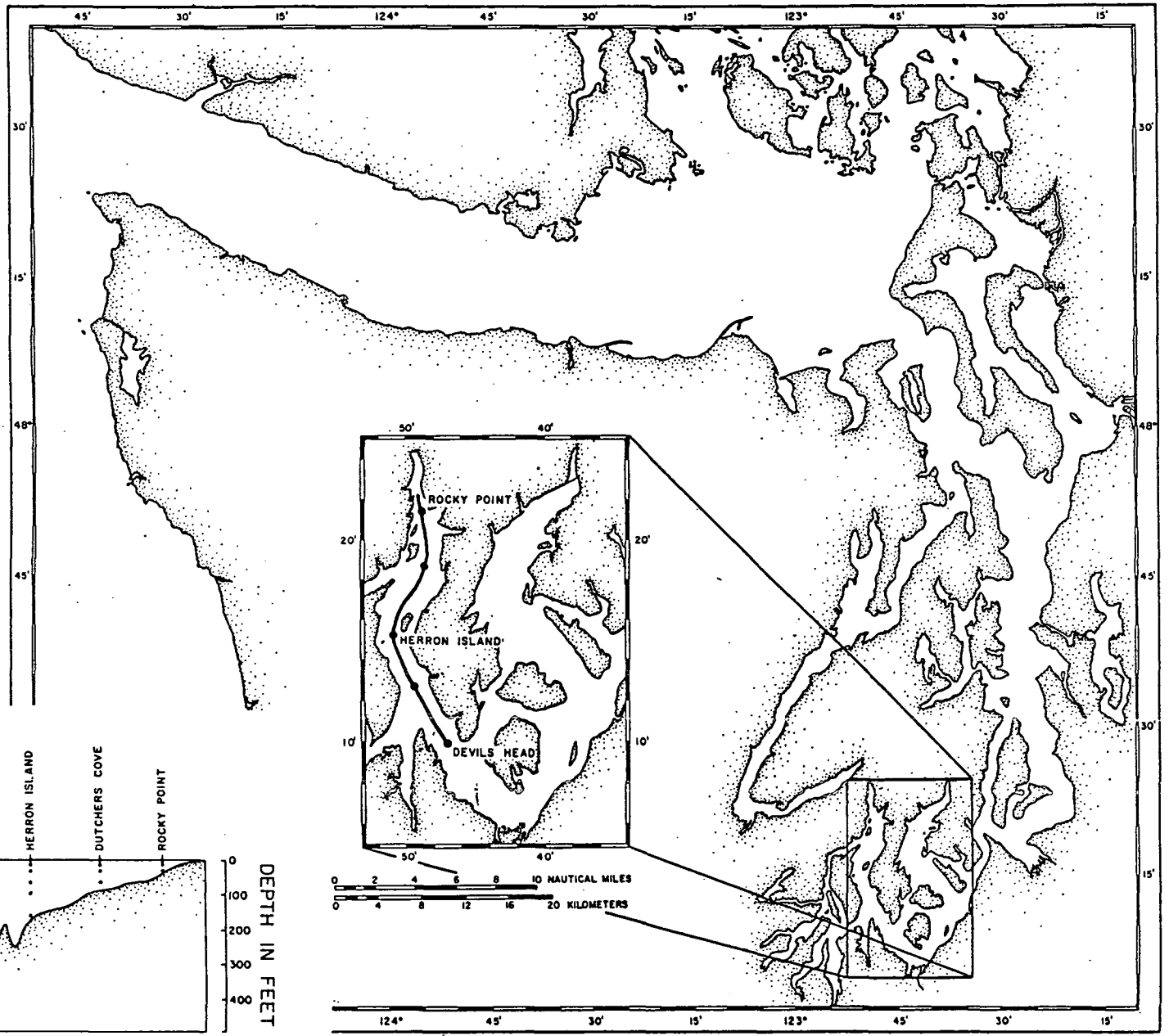
in the summer and will be accompanied with a salinity of about 29.8°/oo. Oxygen content will vary from an autumn low of 5.6 mg/l to a spring high of 9.6 mg/l because of the annual phytoplankton bloom.

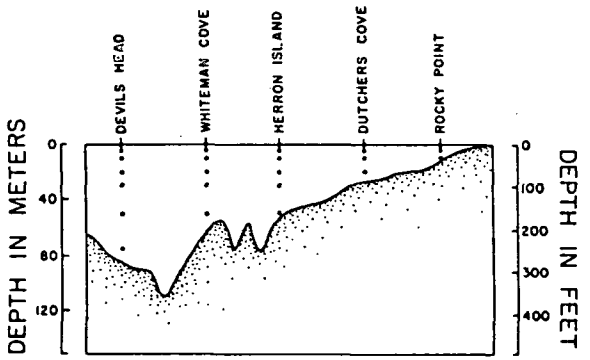
The next largest inlet in southern Puget Sound is Case Inlet with a length of 22 km (12 naut mi) and an average width of 2.7 km (1.5 naut mi). The depth at the entrance is 63 m (35 fath) just north of Johnson Point and remains over 55 m (30 fath) for over 75% of its length. The fresh water source for this inlet is entirely by local land drainage. Any surface layer developed is primarily due to temperature gradients rather than salinity gradients even though some Nisqually River water may penetrate into the southern end. The minimum salinity of 28°/oo at all depths was observed to occur in winter in response to increased rainfall. The lowest temperatures of about 7°C were observed in late winter. During the summer the salinity increased to about 29.5°/oo and the temperature of the surface waters increased to about 16°C and those at depth to over 14°C. The oxygen content of the waters are usually above 6 mg/l at all depths. The surface oxygen content is affected by biological conditions, especially during the large spring phytoplankton bloom. Also, the phosphate content of the water remains between 0.04 and 0.07 milli-grams per liter of phosphate-phosphorus throughout most of the year and is also subject to changes by biological activity.

The remaining inlets are small and exhibit trends in salinity and temperature similar to those of Case Inlet. Budd Inlet is slightly fresher than Case Inlet because the Deschutes River enters at its head. Only two of the inlets, Oakland Bay - Hammersley Inlet and Totten Inlet, are significantly lower in salinity than the neighboring waters throughout the year. This lowering of salinity in Oakland Bay - Hammersley is

due to the relatively large volume of water being discharged by Goldsborough Creek in comparison to the volume of water contained within Oakland Bay.

PROFILE LOCATION CHART



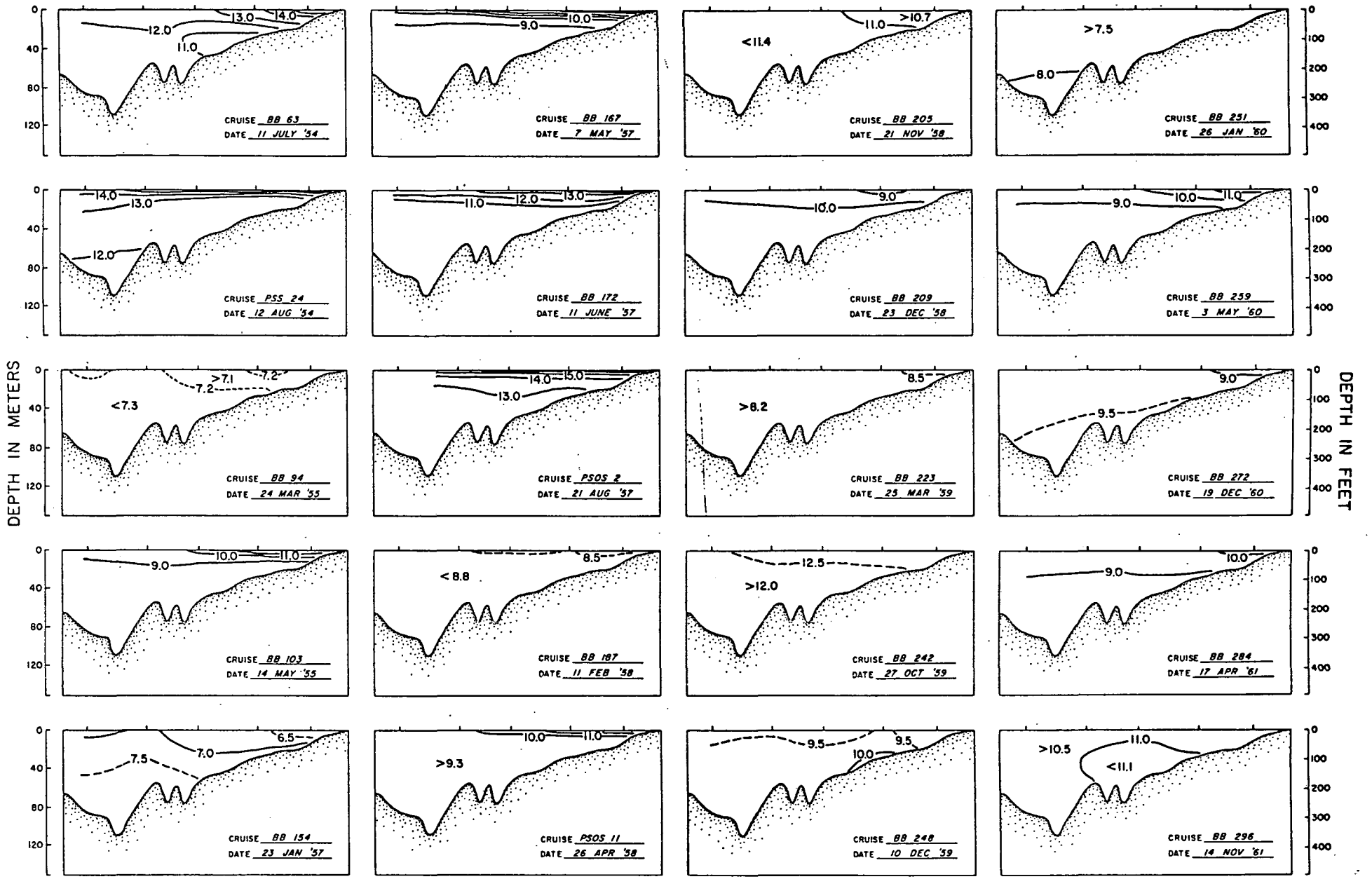


CASE INLET

SOURCE: Atlas of Physical and Chemical Properties of Puget Sound and it's Approaches. Eugene E. Collias, Noel McGary, and Clifford A. Barnes. University of Washington Press. Copyright 1974. A Washington Sea Grant Publication.

0 4 8 12 16 20 NAUTICAL M
0 8 16 24 32 40 KILOMETI

TEMPERATURE (°C)

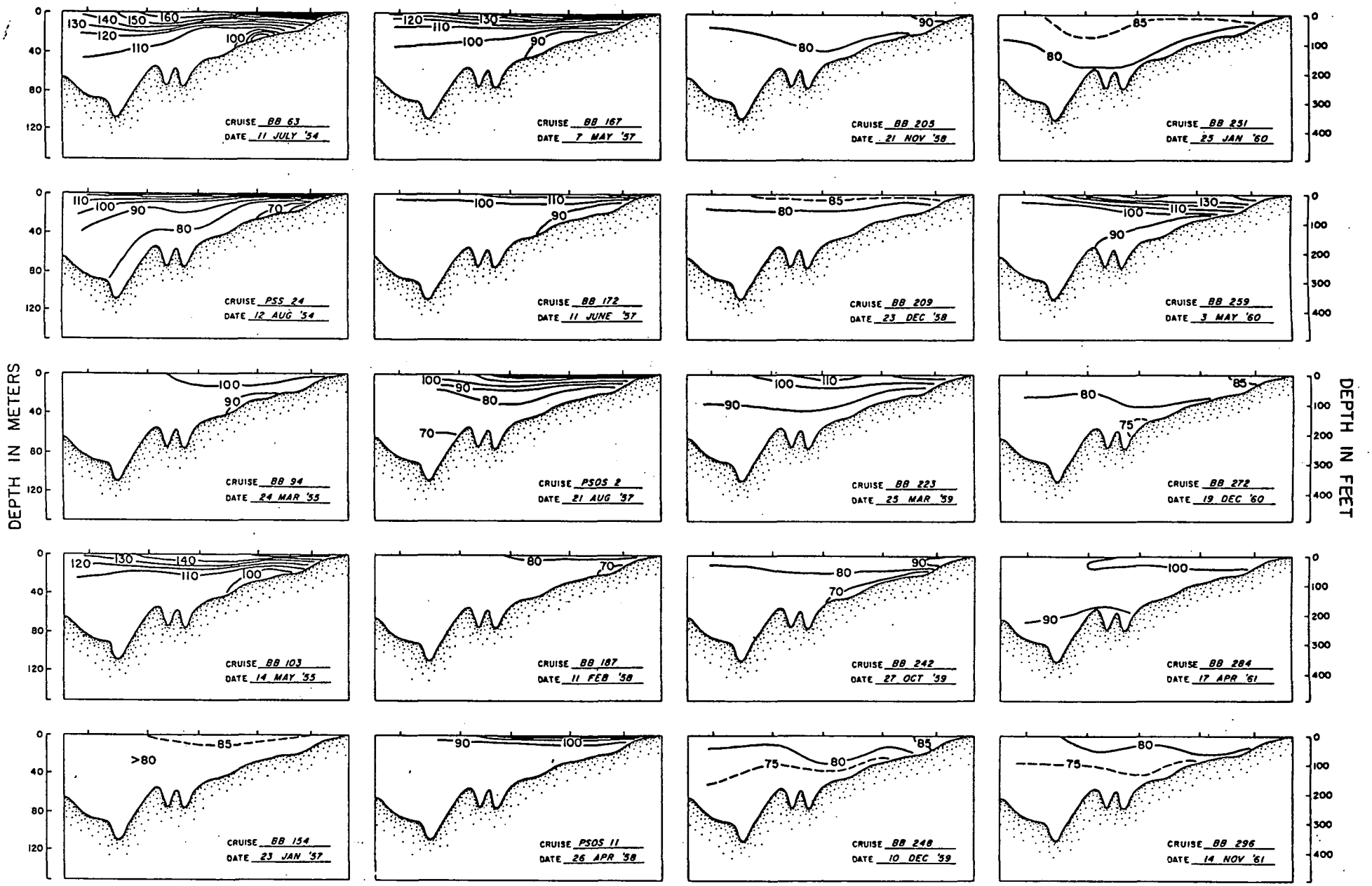


CASE INLET

SOURCE: Atlas of Physical and Chemical Properties of Puget Sound and it's Approaches. Eugene E. Collias, Noel McCary, and Clifford A. Barnes. University of Washington Press. Copyright 1974. A Washington Sea Grant Publication.

0 2 4 6 8 10 NAUTICAL MILES
0 4 8 12 16 20 KILOMETERS

OXYGEN (% satn.)



CASE INLET

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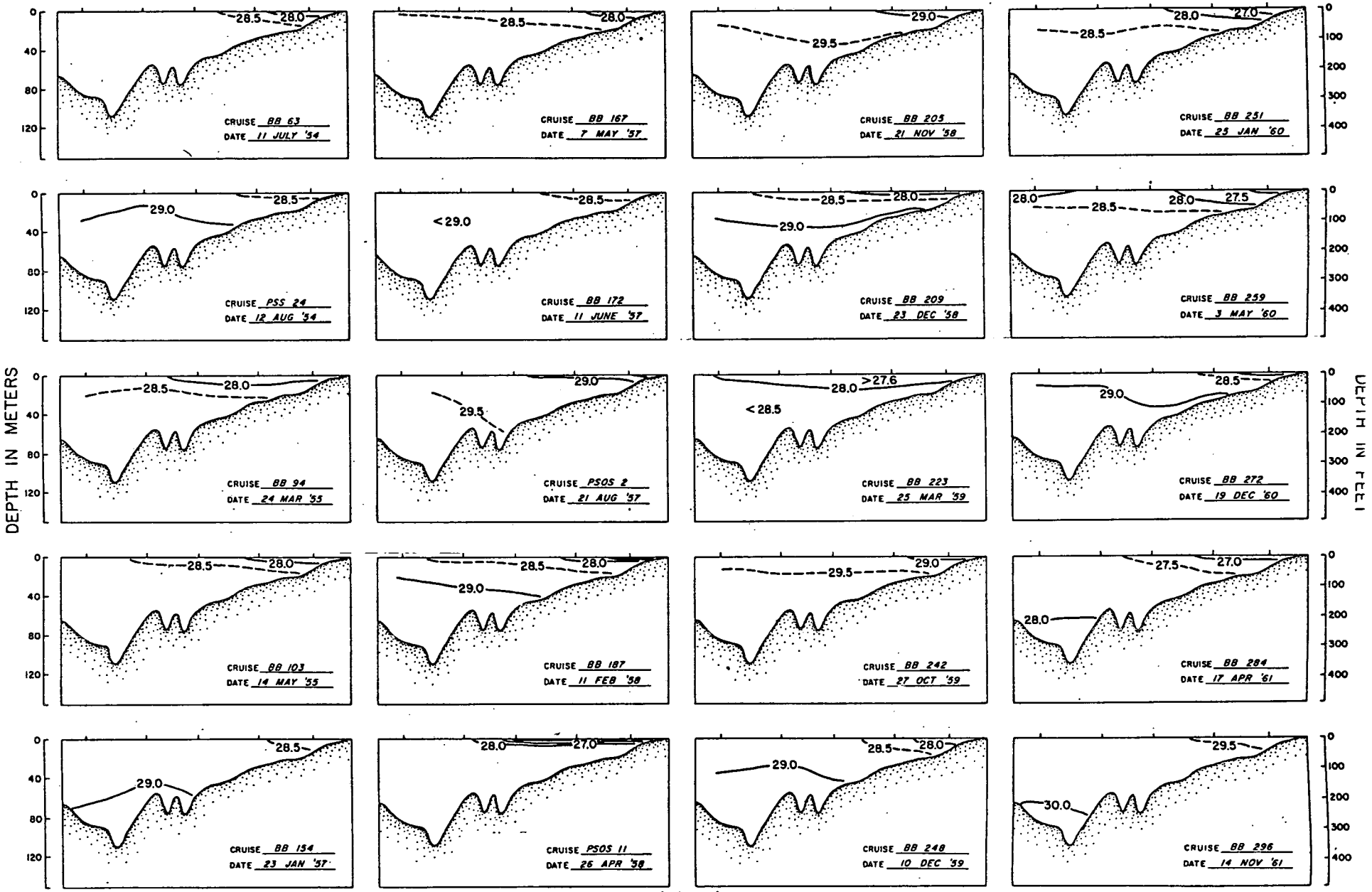
0 2 4 6 8 10 NAUTICAL MILES
0 4 8 12 16 20 KILOMETERS

SALINITY (‰)



CASE INLET

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0 2 4 6 8 10 NAUTICAL
0 4 8 12 16 20 KILOM

III. WASTE SOURCES

A.PT. SOURCE INVENT.

BASIN MUNICIPAL AND INDUSTRIAL POINT SOURCE LOADING COMPARISON AND PERCENT CONTRIBUTIONS

1. FRESH WATER

BASIN MUNICIPAL AND INDUSTRIAL POINT SOURCE LOADING COMPARISON
PUGET SOUND 305-A

FRESH WATER BASINS

BASIN	BOD_5 lbs/day		$N\text{-}NO_3$ lbs/day		T-PHOS lbs/day	
	M	I	M	I	M	I
Cedar-Sammamish	-	576.7	-	3.1	-	0.34
Duwamish-Green	2296.7	8961.2	782.3	19.3	1573.7	0:04
Nisqually	312.8	-	59.8	-	21.5	-
Nooksack	161.9	282.0	75.7	32.1	25.6	48.7
Puyallup	42648.0	8038.0	1160.0	69.3	225.1	23.7
Skagit	1130.0	301.1	393.2	37.8	145.7	11.9
Snohomish	2948.7	488.0	980.3	35.0	520.2	61.2
Stillaguamish	646.7	-	89.6	-	31.9	-

PERCENT CONTRIBUTIONS 1/

Cedar-Sammamish	-	100.0	-	100.0	-	100.0
Duwamish-Green	20.4	79.6	97.5	2.5	100.0	*
Nisqually	100.0	-	100.0	-	100.0	-
Nooksack	36.4	63.6	70.2	29.8	34.4	65.6
Puyallup	84.1	15.6	94.3	5.7	90.4	9.6
Skagit	78.9	21.1	91.2	8.8	92.4	7.6
Snohomish	85.8	14.2	96.5	3.5	89.4	10.6
Stillaguamish	100.0	-	100.0	-	100.0	-

1/ Percent of data available

* Insignificant contribution (less than 1.0%)

\- No major Discharges reported

BASIN MUNICIPAL AND INDUSTRIAL POINT SOURCE LOADING COMPARISON
PUGET SOUND 305-A

MARINE WATER BASINS

BASIN	BOD_5 lbs/day		$N\text{-}NO_3$ lbs/day		T-PHOS lbs/day	
	I	M	I	M	I	M
Strait of JDF	544,266.0	456.3	426.7	67.1	56.3	137.0
San Juan Islands	-	400.3	-	65.4	-	22.3
Admiralty Inlet	15,796.6	409.2	7.5	126.9	42.2	45.3
North Sound	444,631.4	5704.6	968.6	968.6	344.8	344.8
Whidbey	5,684,248.1	3235.5	599.7	1363.0	2692.5	507.3
Main Puget Sound	126,742.5	108,437.0	1039.9	18,714.4	14,265.0	6,745.1
Southern Puget Sound	586,740.8	3,948.7	6436.5	1094.0	21,276.2	389.6
Hood Canal	-	51.3	-	11.25	-	3.9

PERCENT CONTRIBUTIONS 1/

Strait of JDF	100.0	*	86.4	13.6	29.1	70.9
San Juan Islands	-	100.0	-	100.0	-	100.0
Admiralty Inlet	100.0	*	5.6	94.4	48.2	51.8
North Sound	98.7	1.3	50.0	50.0	50.0	50.0
Whidbey	100.0	*	30.5	69.5	84.1	15.9
Main Puget Sound	53.8	46.2	5.2	94.8	67.8	32.2
Southern Puget Sound	100.0	*	85.4	14.6	98.2	1.8
Hood Canal	-	100.0	-	100.0	-	100.0

1/ Percent of data available

* Insignificant contribution (less than 1.0 %)

\- No major discharges reported

MUNICIPAL POINT SOURCE LOADING

MUNICIPAL POINT SOURCE LOADINGS
PUGET SOUND 305-A
PERCENT 1/ CONTRIBUTIONS

MUNICIPALITY	REC. WATER	RIVER MILE	FLOW MGD	BOD_5 lbs/day	BOD_5 % Basin	$N\text{-}NO_3$ lbs/day	$N\text{-}NO_3$ % Basin	T-Phos lbs/day	T-Phos % Basin
DUWAMISH-GREEN BASIN									
Rainier Vista STP	Duwamish R	5.8	1.25	1026.0	44.7	225.0	28.8	80.1	5.1
Metro Renton STP	Green R.	10.25	26.73	1270.7	55.3	557.3	71.2	1493.6	94.9
	Basin Total		27.98	2296.7	100	782.3	100	1573.7	100
NISQUALLY BASIN									
Eatonville STP	Mashel R.	39.2/5.4	-	146.2	46.7	21.2	35.5	8.2	36.0
Elbe Storm Sewer	Nisqually R.	51.2	-	85	27.1	12.3	20.6	4.8	21.1
Longmire	Nisqually R.	74.8	.04	12	3.8	10.5	17.5	4.1	18.0
McKenna House	Nisqually R.	21.8	-	11.4	3.6	2.5	4.2	4	3.9
Paradise Lodge	Nisqually R.	83.0	.06	1.2	*	1.0	1.6	*	1.7
Tahoma Woods	Nisqually R.	68.4	.005	57	18.2	12.3	20.6	4.4	19.3
	Basin Total		0.11	312.8	99.4	59.8	100	21.5	100
NOOKSACK BASIN									
Everson STP	Nooksack R.	23.7	.007	9.1	5.6	13.7	18.1	5.3	6.6
Ferndale	Nooksack R.	5.0	0.3	44.4	27.4	38.9	51.4	15.0	18.7
Lynden STP	Nooksack R.	16.4	0.45	68.4	42.2	23.1	30.5	59.9	74.7
Nooksack	Nooksack R.		-	40.0	24.8	-	-	-	-
	Basin Total		0.75	161.9	100.2	75.7	100	25.6	100
PUYALLUP BASIN									
Buckley STP	White R.	10.8/22.3	.025	91	*	20	1.7	7	1.6
Carbonado STP	Carbon R.	17.7/12	.035	6	*	8	*	3	*
Enumclaw STP	Boise Cr.	10.8/21.1/1.0	1.5	121	*	106	9.1	41	9.2
Orting STP	Carbon R.	17.7/2.1	.32	23	*	35	3.0	13	2.8
Puyallup STP	Puyallup R.	1.6	27.4	42996	98.9	518	44.7	200	44.9
Rainier St. Sch.	White R.	10.8/25	35	35	*	53	4.6	20	4.5
Sumner STP	White R.	10.8/0.01	.7	76	*	420	36.2	162	36.3
	Basin Total		30.33	42648.0	98.9	1160	99.3	225.1	99.3

MUNICIPALITY	REC. WATER	RIVER MILE	FLOW MGD	BOD_5 lbs/day	BOD_5 % Basin	$N\text{-}NO_3$ lbs/day	$N\text{-}NO_3$ % Basin	T-Phos lbs/day	T-Phos % Basin
SKAGIT BASIN									
Burlington STP	Skagit R.	18.1	.75	74	6.5	64.7	16.5	24.9	17.1
Concrete STP	Baker R.		.06	17	1.5	14.7	3.8	5.7	3.9
Diablo STP	Skagit R.	99.8	.028	37	3.3	-	-	-	-
Mt. Vernon STP	Skagit R.	10.7	2.4	923	81.7	202.5	51.5	72.1	49.5
Newhalem Proj. STP	Skagit R.	93.2	.034	12	1.1	10.5	2.6	4.1	2.8
Sedro Wooley STP	Skagit R.	22.7	.97	67	5.9	100.8	25.6	38.9	26.7
Basin Total			4.24	1130	100	393.2	100	145.7	100
SNOHOMISH BASIN									
Duval STP	Snoqualmie R./Snoh.R.	10/20.5		Proposed 1974					
Echo Glen Child Ctr.	Icy Cr.	20.5/25	.038	8.5	*	1.2	*	.5	*
Everett STP	Snohomish R.	2.3	10.0	2419	82.0	735	75.0	425	81.7
Granite Falls	Pilchuck R.	13.4/20	.5	250	8.4	-	-	-	-
Monroe STP	Skykomish R.	25.0	.32	65	2.3	56.6	5.7	21.9	4.2
North Bend STP	S.F. Snoqualmie	20.5/42/1.8	-	38.4	1.3	33.5	3.4	13.0	2.5
Snohomish STP	Snohomish R.	12.1	.001	115.2	4.0	100.6	10.3	39.1	7.5
Snoqualmie STP	Snoqualmie R.	20.5/40.8	.14	25	*	29.3	3.0	11.3	2.2
Sultan STP	Sultan R.	34.6/0.1	.1	27.6	*	24.1	2.5	9.4	1.8
Basin Total			11.01	2948.7	98	980.3	99.9	520.2	99.9
STILLAGUAMISH BASIN									
Arlington	Stillaguamish R.	17.6	.4	534	82.6	56.3	62.8	20.0	62.7
Stanwood	Stillaguamish R.	3.4	.13	112.6	17.4	33.3	37.2	11.9	37.3
Basin Total			.55	646.6	100.0	89.6	100	31.9	100

1/ Percent of available data
- No data available
* Insignificant Basin Contribution

INDUSTRIAL POINT SOURCE LOADING

INDUSTRIAL POINT SOURCE LOADINGS

Discharger	Receiving Waters	Flow MGD	BOD_5 lb/day	NO_3 lb/day	T. Pho.. lb/day
CEDAR SAMMAMISH SUB BASIN					
N. W. Nut & Bolt	Lake Wash. Ship Canal	.01	2.02	.003	—
N. W. Steel Rolling Mill	" "	10.13	506.86	2.53	—
Seattle Cedar Lumber Co.	" "	.74	24.0	—	—
U. S. Plywood Champion Paper	" "	.83	43.9	.64	.34
	BASIN TOTAL	11.71	576.78	3.17	0.34
DESCHUTES SUB BASIN					
Olympia Brewing co.	Deschutes River	.7	0	0	0
DUAMISH - GREEN SUB BASIN					
Liquid Carbomic Co.	Duamish River	1.2	604.2	18.8	—
Airco Welding Prod.	" "	.01	—	.04	—
Montesanto	" "	.34	73.7	.49	.04
Earle M. Joyensen	" "	.05	.54	—	—
Seattle Rendering Works	" "	.1	25.8	—	—
Shell Tank Farm	Black River	.22	8,257.0	—	—
	BASIN TOTAL	1.92	8,961.2	19.33	0.04

— Indicates no data available

Discharger	Receiving Waters	RIVER MILE	Flow MGD	BOD_5 lb/day	NO_3 lb/day	T. Phos. lb/day
NOOKSACK SUB BASIN						
Consolidated Dairy Prod.	Fish Trap Creek	13.2/4.8	.11	0	1.3	3.4
Consolidated Dairy Prod.	Nooksack River	17.0	.66	175	3.3	43.7
Lynden Waste W. T. P.	Nooksack River	17.0	.06	0	0	0
Nooksack Fish Hatchery	Kendall Creek	45.9/0.1	6.34	107	27.5	1.6
Van Werren Trucking	Nooksack River	17.0	.01	0	0	0
	BASIN TOTAL		7.18	282.0	32.1	48.7
PUYALLUP SUB BASIN						
Boeing Co.	Canal to White River	10.8/5	2.15	57	53.8	2.0
Fibre Board Corp.	White River	10.8/1.4	.65	813	1.1	2.2
Standard Brands	" "	10.8/1.0	.72	6,930	14.4	17.9
Weber Inc.	" "	10.8/2.0	.02	130	0	0
Weyerhaeuser	Boise Creek	10.8/21.1/6	1.44	108	0	1.6
	BASIN TOTAL		4.98	8038.0	69.30	23.70
SKAGIT SUB BASIN						
Carnation Co.	Skagit River	11.4	.5	6.0	0	0
Consolidated Dairy Prod.	" "	10.9	.5	0	0	0
Skagit Fish Hatchery	Cascade River	78.3/1.0	7.2	148	37.8	2.4
Stokely - Van Camp	Skagit River	10.8	.06	147	0	7.5
	BASIN TOTAL		8.26	301.1	37.8	11.9

Discharger	Receiving Waters	RIVER MILE	Flow MGD	BOD_5 lb/day	NO_3 lb/day	T. Phos. lb/day
SNOHOMISH SUB BASIN						
Carnation Farms	Snoqualimie River	20.5/24.3	.05	5	0	0
Pan Alaska Fisheries	Skykomish River	20.5/28.4	.07	0	0	0
Skykomish Fish Hatchery	" "	20.5/36.0	3.1	88	22.5	2
Weyerhaeuser Wood Prod.	Snoqualmie River	20.5/41.6	.65	190	0	3.2
Weyerhaeuser	Snohomish	1.7	29.0	205	12.5	56
	BASIN TOTAL		32.87	488.0	35.0	61.2
STILLIQUAMISH SUB BASIN						
PEP Northwest	Stilliguamish River	5.4	.02	0	0	0
Twin City Foods	" "	1.3	.75	0	0	0
	BASIN TOTAL		0.77	0.0	0.0	0.0

INDUSTRIAL POINT SOURCE
PER CENT[1] CONTRIBUTION

INDUSTRY	% of INDUSTRIAL BOD_5	NO_3	T. Phos.
CEDAR SAMMISH SUB BASIN			
N. W. Nut & Bolt	*	*	
N. W. Steel Rolling Mill	87.8	79.7	—
Seattle Cedar Lumber Co.	4.2	-	—
U.S. Plywood Campion Paper	7.6	20.2	100.0
	99 6	99.9	100.0
DESCHUTES SUB BASIN			
Olympia Brewing Co.	-	-	—
DUWAMISH-GREEN SUB BASIN			
Liquid Carbonic Co.	6.7	97.2	—
Airco Welding Prod.	-	*	—
Montesanto	*	2.5	100
Earle M. Joyensen	*	*	—
		-	
Seattle Rendering Works	*	-	—
Shell Tank Farm	92.1	-	—
	98.8	99.7	100.0
NOOKSACK SUB BASIN			
Consolidated Dairy Prod.	-	4.0	7.0
Consolidated Dariy Prod.	62.1	10.0	89.8
Lynden Waste W. T. P.	-	0	0.0
Nooksack Fish Hatchery	37.9	86.0	3.2
Van Werven Trucking	-	0	0.0
	100.0	100.0	100.0
PUYALLUP SUB BASIN			
Boeing Co.	*	77.63	8.4
Fibre Board Corp.	10.1	-	9.3
Standard Brands	86.2	20.77	75.5
Weber Inc.	1.6	-	0.0
Weyerhaeuser	1.4	-	6.8
	99.3	98.4	100.0

INDUSTRY	% of INDUSTRIAL BOD_5	NO_3	T. Phos.
SKAGIT SUB BASIN			
Carnation Co.	2.0	0	0
Consolidated Dairy Prod.	o.0	0	0
Skagit Fish Hatchery	49.2	100	24.2
Stokely - Van Camp	1/ 48.8	0	75.8
BASIN TOTAL	100.0	100.0	100.0
SNOHOMISH SUB BASIN			
Carnation Farms	1.0	0	0
Pan Alaska Fisheries	0	0	0
Skykomish Fish Hatchery	18.0	64.3	3.3
Weyerhaeuser Wood Prod.	38.9	0	5.2
Weyerhaeuser	42.1	35.7	91.5
BASIN TOTAL	100.0	100.0	100.0

1/ Percent of data available
- indicates no data available
* indicates insignificant basin contribution

2. MARINE WATER

MUNICIPAL POINT SOURCE LOADING

MUNICIPAL [redacted]RCE LOADINGS

PUGET SOUND 305-A

DISCHARGER	REC. WATER	FLOW MGD	BOD_5 1/ LBS/DAY	BOD_5 1/ % BASIN	$N\text{-}NO_3$ 2/ LBS/DAY	$N\text{-}NO_3$ 2/ % BASIN	T-PHOS 3/ LBS/DAY	T-PHOS 3/ % BASIN
STRAIT OF JUAN DE FUCA BASIN								
Port Angeles	SJF	1.5	406.83	89.18	349.8	91.5	124.6	90.9
Sequim	SJF	1.75	49.56	10.82	32.14	8.4	12.40	9.0
Basin Total		3.25	456.39	100.00	67.12	100.0	137.00	100.0
SAN JUAN ISLAND BASIN								
Blaine	St. of George	.407	218.9	54.6	48.0	73.3	17.1	73.3
Friday Harbor	Friday Harbor	.110	181.4	45.3	17.4	26.7	6.23	26.7
Basin Total		.517	400.3	100.0	65.4	100.0	23.33	100.0
ADMIRALTY INLET BASIN								
Port Ludlow	Admiralty In.	.002	2.4	0.59	2.09	1.64	0.8	1.79
Port Townsend	Admiralty In.	.44	406.8	99.41	124.9	98.33	44.5	98.21
Basin Total		.442	409.2	100.0	126.99	100.0	45.3	100.0
NORTH SOUND BASIN								
Anacortes	Padilla Bay	4.26	3867.9	67.80	218.6	22.56	77.8	22.56
Bellingham	Bellingham Bay	4.50	1836.7	32.19	750.10	77.43	267.0	77.43
Basin Total		8.76	5704.6	100.0	968.7	100.0	344.8	100.0
WHIDBEY BASIN								
Coupeville	Penn Cove	.150	76.9	2.3	16.87	1.2	6.01	1.1
Everett	Pt. Gardner Bay	10.0	2145.7	66.3	1107.5	81.1	425.25	83.8
Langely	Saratoga Pass.	0.64	53.58	1.6	39.84	2.9	4.19	0.8
Mukilteo	Possession Sd.	.10	24.99	---	33.10	2.4	11.79	2.3
Oak Harbor	Oak Harbor	.55	581.4	17.9	127.45	9.3	45.39	8.9
Penn Cove	Penn Cove	0.3	45.6	1.4	9.9	---	3.56	---
Stanwood	Skagit Bay	0.9	307.34	9.5	28.34	2.0	10.93	2.1
Basin Total		12.64	3235.51	99.7	1363.0	99.6	507.37	99.7
PUGET SOUND MAIN BASIN								
Bremerton	Sinclair In.	5.9	4505.9	4.16	1534.4	8.20	546.6	8.1

MUNICIPAL [redacted]OURCE LOADINGS

PUGET SOUND 305-A

DISCHARGER	REC. WATER	FLOW MGD	BOD_5 1/ LBS/DAY	BOD_5 1/ % BASIN	$N\text{-}NO_3$ 2/ LBS/DAY	$N\text{-}NO_3$ 2/ % BASIN	T-PHOS 3/ LBS/DAY	T-PHOS 3/ % BASIN
PUGET SOUND MAIN BASIN (Cont'd)								
Edmonds	Puget Sound	1.9	3212.8	2.96	649.71	3.47	231.4	3.43
Kitsap Co. Sewer Dist.	Puget Sound	0.71	579.9	---	358.4	1.9	138.2	2.0
LakeHaven	Puget Sound	0.9	749.7	---	249.7	1.34	89.0	1.32
Port Orchard	Sinclair In.	.88	374.7	---	98.72	---	35.16	---
Poulsbo	Liberty Bay	0.18	169.43	---	46.52	---	16.57	---
Ruston	Commencement Bay	*	116.96	---	17.18	---	6.12	---
Seattle:								
Alki Point	Puget Sound	11.8	4407.3	4.06	1087.5	5.81	458.3	6.8
Carkeek	Puget Sound	3.0	2274.1	2.1	625.0	3.34	222.5	3.3
West Point	Puget Sound	118.6	84656.6	78.1	12,350.0	65.9	4396.6	65.1
Richmond Beach	Puget Sound	2.3	2329.0	2.2	412.5	2.2	146.8	2.1
Tacoma:								
Ruston Way	Commencement Bay	3.8	3988.4	3.68	1062.4	5.68	378.37	5.61
Western Slopes	Commencement Bay	1.7	920.4	---	184.1	1.0	65.66	---
Vashon Island S.D.	P.S. East Passage	0.52	7.68	---	6.73	---	2.60	---
Winslow	Eagle Harbor	.037	144.21	---	31.61	---	11.26	---
Basin Total		482.27	108,437.08	99.06	18,714.47	99.9	6745.14	97.84
SOUTHERN PUGET SOUND BASIN								
Dupont	Cass Inlet	*	5110.0	12.94	7.49	.68	2.67	
Fircrest	Narrows	*	595.0	1.5	87.46	7.9	31.15	7.9
Gig Harbor	Gig Harbor	*	243.9	---	35.85	3.28	12.77	3.28
Olympia	Budd Inlet	5.39	20,563.6	52.0	624.7	57.1	222.5	57.1
Shelton	Oakland Bay	*	11,930.2	30.21	156.1	14.27	55.62	14.27
Steilacoom	Nisqually Slough	.750	399.0	---	87.46	7.99	31.15	7.99
Tumwater	Budd Inlet	*	646.0	1.64	94.96	8.68	33.82	8.68
Basin Total		6.14	3948.77	98.29	1094.02	99.9	389.68	99.2

MUNICIPAL [redacted] LOADINGS

PUGET SOUND 305-A

DISCHARGER	REC. WATER	FLOW MGD	BOD_5 1/ LBS/DAY	BOD_5 1/ % BASIN	$N\text{-}NO_3$ 2/ LBS/DAY	$N\text{-}NO_3$ 2/ % BASIN	T-PHOS 3/ LBS/DAY	T-PHOS 3/ % BASIN
HOOD CANAL BASIN								
Bangor USN	Hood Canal	.014	11.4	22.2	2.5	22.2	0.89	22.30
Port Ludlow	Hood Canal	.0065	39.9	77.8	8.75	77.8	3.11	77.70
Basin Total		.0205	51.3	100.0	11.25	100.0	3.99	100.00

Percent contribution based on available data

1/, 2/ and 3/ calculated through degree of treatment and population

- - - indicates insignificant contribution

* indicates no data available

INDUSTRIAL POINT SOURCE LOADING

INDUSTRIAL POINT SOURCE LOADING
PUGET SOUND 305-A

STRAIT OF JUAN DE FUCA BASIN

DISCHARGER	REC. WATER	FLOW MGD	BOD_5 lbs/day	% Basin	$NO_3 - N$ lbs/day	% Basin	T - Phos lbs/day	% Basin	T-Solids lbs/day	% Basin
Crown Zellerbach Co.	St. Joe	14.3	14,266	2.6	125.7	29.4	6.3	11.1	37412	2.5
ITT Rayonier	Pt. Angeles Harbor	32.2	530,000	97.4	301.0	70.6	50.0	88.9	1,414,000	97.5
Basin Total		46.5	544,266	100.0	426.7	100.0	56.3	100.0	1,451,412.0	100.0

INDUSTRIAL POINT SOURCE LOADING
PUGET SOUND 305-A

SAN JUAN ISLAND BASIN

DISCHARGER	REC. WATER	FLOW MGD	OIL lbs/day	OIL % Basin
Atlantic Richfield Co.	St. of Georgia	3.41	73.88	15.62
Intalco Aluminum	St. of Georgia	6.47	293.10	62.00
Mobil Oil Corporation	St. of Georgia	1.30	105.08	22.38
	Basin Total	11.18	472.7	100.00

INDUSTRIAL POINT SOURCE LOADING
PUGET SOUND 305-A

ADMIRALTY INLET BASIN

DISCHARGER	REC. WATER	BOD_5 lbs/day	BOD_5 % Basin	$NO_3 - N$ lbs/day	$NO_3 - N$ % Basin	T-Phos lbs/day	T-Phos % Basin	T - Solids lbs/day	T - Solids % Basin
Crown Zellerbach	Port Townsend Bay	15,769.6	100%	7.53	100%	42.21	100%	918,876.2	100%

INDUSTRIAL POI[redacted]URCE LOADING
PU[redacted] 305-A

NORTH SOUND BASIN

DISCHARGER	REC. WATER	FLOW MGD	N-NO3 lbs/day	T-Phos lbs/day	BOD_5 lbs/day	T-Solids lbs/day	NO3	Phos	BOD	T-Sol	PBI
							% BASIN				
Allied Chemical Corp.	Padilla Bay	.032	*	*	0.26	2820.0	*	*	-	-	
Borastein Seafoods	Bell. Bay	.15	*	*	800	*	*	*	-	*	
Boundary Fish Co.	Drayton Harbor	.003	.014	.017	10.27	3.6	-	-	-	-	
Bumble Bee Seafoods	Bell. Bay	.33	1.41	95.5	10,600	5307.0	-	-	2.35	-	
Dahl Fish Co.	Whatcom Wtrway	.015	*	*	800	*	*	*	-	*	
Georgia Pacific Corp.	Whatcom Wtrway	41.71	2,220.0	283,200.0	100240	523700	85.62	99.79	22.25	28.0	
North Pacific Ocean Prod.	Squalicum Wtrway	.14	*	*	730	*	*	*	-	*	
McRae Packing	N.F. Samish R.	.01	*	*	220.83	264.83	*	*	-	-	
Moore Clark	Guemes Channel	.50	*	*	181,316.0	444,175.0	*	*	40.25	23.75	
N.W. Fur Breeders Corp.	Guemes Channel	.008	*	2.4	15.33	27.46	*	-	-	-	
Oeser Cedar Co.	L. Squalicum River	.032	.01	.4	7.0	28.8	-	-	-	-	
Huley-International Corp.	Bell. Bay	.027	*	.0012	*	.72	*	-	*	-	
Samish Fish Hatchery	Samish R.	4.32	16.56	1.08	64.44	-	-	-	-	-	
Scott Paper Co.	Fidalgo Bay	1.82	8.79	22.9	288.16	487456.0	-	-	-	26.06	
Scott Paper Co.	Guemes Channel	7.23	*	72.3	148,215.0	353065.0	*	-	32.90	18.8	
Sea-K Fish Co. Inc.	Semiahmoo Bay	.0026	*	*	18	*	*	*	-	*	
Sea-Pac Co.	Drayton Harbor	.006	*	*	280	*	*	*	-	*	
Shell Oil Refinery	Fidalgo Bay	2.02	166	2.3	700	30571.0	6.4	-	-	1.6	
Texaco Oil Refinery	Fidalgo Bay	2.88	180	54.7	204	22,000.0	6.9	-	-	1.1	
	Basin Total	61.28	968.68	344.88	444631.4	187,0141.6	98.92	99.79	97.95	99.31	

INDUSTRIAL P[redacted]RCE LOADING
PUGI [redacted] 305-A

WHIDBEY BASIN

DISCHARGER	FLOW MGD	BOD5 lbs/day	BOD5 % Basin	NO3 - N lbs/day	NO3 - N % Basin	T-Phos lbs/day	T-Phos % Basin	PBI lbs/day	PBI % Basin	T-Solids lbs/day	T-Solids % Basin
Associated Sand & Gravel Pidgeon Cr.	.02	2.0	-	.0008	-	.05	-	*	*	81.66	-
Everett Co. Sulfite Mill Port Gardner	10.1	262,431.0	4.6	6.73	1.1	*	*	11,758.0	-	1,019,005.0	19.70
Jansha Tanning Co. Ebey Slough	4.0	*	*	*	*	*	*	*	*	266,666.6	5.5
Scott Paper Co. Port Gardner	68.9	5,338,601.0	93.91	568.42	94.7	2641.16	98.09	1,210,745.2	30.5	49,378.3	-
Weyerhaeuser Sulfite Mill Port Gardner	36.90	79,335.0	1.3	24.60	4.10	51.35	1.90	27,37980.0	69.1	1,363,369.0	26.3
Weyerhaeuser Kraft Mill Steamboat Slough	24.5	3879.16	-	*	*	*	*			2,471,845.0	47.8
Basin Total	144.42	5,684,248.1	99.81	599.75	99.9	2,692.56	99.9	3,960,483	99.7	5,170,345.5	98.95

INDUSTRIAL POINT SOURCE LOADING
PUGET SOUND 305-A

PUGET SOUND MAIN BASIN

DISCHARGER	REC. WATER	FLOW MGD	AVG. BOD_5 lbs/day	NO_3-N lbs/day	T-Phos lbs/day	T-Solids lbs/day	% Basin BOD	% Basin $N\text{-}NO_3$	% BASIN T-Phos	% Basin T-Solids
American Smelting/Refining Co.	Commencement Bay	3.2	18.0	13.5	8550.0	717,900.0	-	1.2	59.93	18.75
Certain Feed Products	Sitcum Wtrway	.084	5.8	*	.18	9,100.0	-	*	-	-
Dickman Lumber Co.	Commencement Bay	.002	0.71	.003	.02	8.9	-	-	-	-
Glacier Sand & Gravel Co.	Hylebos Wtrway	3.6002	.004	*	*	1,202,762.0	-	*	*	31.42
Hibbord Stewart Co.	Blair Wtrway	.0009	1.31	*	.0003	*	-	*	-	*
Hooker Chemical Corp.	Hylebos Wtrway	.000017	.0003	*	.00003	5.54	-	*	-	-
Johnnys Seafoods	City Wtrway	.0013	.010	.00001	.00003	*	-	-	-	*
Kaiser Aluminum Corp.	Hylebos Wtrway	1.32	37.0	0.42	8.96	6785.0	-	-	-	-
Keyport Naval Torpedo Station	Liberty Bay	.130	*	.043	*	*	*	-	*	*
Main Fish Co.	Elliot Bay	.02	37.6	0.0	0.3	91.7	-	-	-	-
Montesano Co.	Duwamish Wtrway	.24	100	.05	.03	323.7	-	-	-	-
Naval Torpedo Station	Dyes Inlet	.075	3.31	*	*	*	-	*	*	*
North Pac. Plywood Corp.	City Wtrway	.04	*	1.33	5.06	289.6	*	-	-	-
Pennwalt Corp.	Hylebos Wtrway	.012	18.3	.04	*	2670	-	-	*	-
Puget Sound Naval Shipyard	Sinclair Inlet	*	31696.6	325.5	2344.5	1,328,210.0	25.0	31.3	16.43	34.69
Reichold Chemical Corp.	Blair Wtrway	*	2080.0	*	2.51	4140	-	*	-	-
Sound Refining Co.	Hylebos Wtrway	.05	9.0	.133	.229	106.1	-	-	-	-
St. Regis Paper Co.	Commencement Bay	30.62	94178.0	691.65	3256.6	565,578.6	74.30	66.54	22.82	14.77

INDUSTRIAL [redacted]OURCE LOADING
PUGET SOUND 305-A

PUGET SOUND MAIN BASIN

DISCHARGER	REC. WATER	FLOW MGD	AVG. BOD_5 lbs/day	lbs/day NO_3 - N	lbs/day T-Phos	lbs/day T-Solids	% Basin BOD	% Basin N-NO_3	% T-Phos Basin	% Basin T-Solid
St. Regis Paper Co.	Puyallup Wtrway	0.83	554.6	0	0.2	305	-	-	-	-
St. Regis Paper Co.	Sitcum Wtrway	0.98	16.3	6.93	104.2	*	-	-	-	*
United Grain Corp.	Commencement Bay	.003	23.4	*	*	82.8	-	*	*	-
U.S. Gypsum Co.	Hylebos Wtrway	.016	0.6	.186	0.06	60.08	-	-	-	-
U.S. Oil & Refining Co.	Blair Wtrway	.08	35.5	.22	.14	220.0	-	-	-	-
U.S. Oil & Refining Co.	Industrial Wtrway	.08	44.26	.4	3.52	8.6	-	-	-	-
	BASIN TOTAL	40.206	126742.5	1039.98	14,265.0	3,838,638.6	99.3	97.84	99.18	99.63

INDUSTRIAL POINT SOURCE LOADING
PUGET SOUND 305-A

SOUTHERN PUGET SOUND BASIN

DISCHARGER	REC. WATER	FLOW MGD	NO3 - N		T-Phos		BOD5		T-Solids	
			lbs/day	% Basin	lbs/day	% Basin	lbs.day	% Basin	lbs/day	% Basin
Cascade Pole Co.	Budd Inlet	.01	0.08	-	.116	-	18.3	-	25.2	-
ITT Rayonier Research Div.	Oakland Bay	1865	3108.3	48.29	4507.0	21.1	310833	52.97	3,419,166.0	78.94
Minter Cr. Fish Hatchery	Henderson Inlet	.50	1.91	-	.125	-	7.58	-	*	*
Simpson Timber Co.	Oakland Bay	20.56	3326.3	51.67	16,769.0	78.8	275,882.0	47.01	911,715.0	21.05
Basin Total		1886.07	6436.5	99.96	21,276.2	99.9	586,740.8	99.98	43,30906.2	99.99

Percent basin contribution based on available data

- indicates insignificant basin contribution

* indicates no data available

INDUSTRIAL AND MUNICIPAL HEAVY METALS POINT SOURCE LOADING

NORTH SOUND BASIN

INDUSTRIAL AND MUNICIPAL HEAVY METALS POINT SOURCE LOADING

DISCHARGER	REC. WATER	Cu lbs/day	Cu % Basin	Hg lbs/day	Hg % Basin	K lbs/day	K % Basin	Mn lbs/day	Mn % Basin	Pb lbs/day	Pb % Basin
Allied Chemical Corp.	Padilla Bay	.032	1.60	.0004	-	*	*	*	*	0.01	1.29
Georgia Pacific Corp.	Whatcom Wtrway	*	*	2.5	93.61	676.0	99.92	28.0	62.75	*	*
Scott Paper Co.	Guemes Channel	1.67	98.40	0.17	6.36	0.54	-	16.62	37.26	0.77	98.71
	Basin Total	1.99	100%	2.6704	99.97	676.54	99.92	44.62	100%	0.78	100%

WHIDBEY BASIN

DISCHARGER	REC. WATER	Cr lbs/day	Cu lbs/day	Ni lbs/day	Pb lbs/day	Zn lbs/day	% Basin Cr	% Basin Cu	% Basin Ni	% Basin Pb	% Basin Zn
Everett Sulfite Mill	Port Gardner	1.68	50.5	4.20	1.68	8.41	-	4.2	1.96	1.2	1.73
Jansha Tanning Co.	Ebey Slough	600	*	*	*	*	78.17	*	*	*	*
Scott Paper Co.	Port Gardner	20.32	1102.4	131.59	71.82	420.29	2.6	92.59	61.59	53.21	86.47
Weyerhaeuser Sulfite Mill	Port Gardner	144.52	36.9	67.65	49.2	36.90	18.82	3.0	31.66	36.45	7.59
Weyerhaeuser Kraft Mill	Steamboat Slough	1.020	0.81	10.20	12.25	20.41	-	-	4.7	9.07	4.19
Basin Total		767.5	1190.6	213.64	134.95	486.0	99.59	99.79	99.91	99.93	99.98

PUGET SOUND MAIN BASIN

INDUSTRIAL AND MUNICIPAL HEAVY METALS POINT SOURCE LOADING

INDUSTRIAL

DISCHARGER	REC. WATER	lbs/day Cd	Cr	Cu	Pb	Zn	% Basin 1/ Cd	Cr	Cu	Pb	Zn
American Smelting & Refining	Commencement Bay	.15	.056	3.02	3.93	18.78	-	-	-	-	2.7
Certain Feed Products	Sitcum Wtrway	*	.109	.056	*	*	-	-	-	*	*
Hibbard Stewart Co.	Blair Wtrway	*	*	.0003	.0003	.015	*	*	-	-	-
Hooker Chemical Corp.	Hylebos Wtrway	*	*	.000016	.000016	*	*	*	-	-	*
Keyport Naval Torpedo St.	Liberty Bay	.119	.86	.086	*	*	-	-	-	*	*
Puget Sound Naval Shipyard	Sinclair Inlet	0.003 ~~53.82~~	0.028 ~~30.71~~	0.003 ~~30.71~~	* ~~174.5~~	0.017 ~~8.48~~	90.82	5.0	4.99	7.45	1.2
Puget Sound Naval Shipyard	Liberty Bay	*	480	480	1920	240	*	79.5	78.07	81.98	34.56
St. Regis Paper Co.	Commencement Bay	*	7.91	9.18	137.8	59.4	*	1.3	1.49	5.88	8.55
St. Regis Paper Co.	Puyallup Wtrway	*	.027	.037	*	.797	*	-	-	*	-
St. Regis Paper Co.	Sitcum Wtrway	.081	.408	.408	8.16	4.08	-	-	-	-	-
U.S. Oil & Refining Co.	Blair Wtrway	*	.034	*	.34	.041	*	-	*	-	-
MUNICIPAL	Basin Sub-Total	~~54.1~~ .353	520.6	523.4	2244.7	331.5	90.82	85.8	84.55	95.31	44.31
SEATTLE:											
Alki Pt. STP	Puget Sound	0.1	1.0	12.3	6.8	17.7	-	-	2.0	-	2.54
Carkeek STP	Puget Sound	.07	0.17	2.5	0.1	4.5	-	-	-	-	-
Richmond Beach STP	Puget Sound	.09	0.28	3.2	1.0	4.2	-	-	-	-	-
West Point STP	Puget Sound	4.9	82.0	73.2	89.0	336.3	8.2	13.5	12.2	3.80	48.43
	Basin Total	59.26	603.5	614.76	2341.85	694.35	99.02	99.33	98.75	99.11	97.98

SOUTHERN PUGET SOUND BASIN

DISCHARGER	Rec. Water	Cr lbs/day	Cu lbs/day	Hg lbs/day	Pb lbs/day	Zn lbs/day	% Basin Contribution Cr	Cu	Hg	Pb	Zn
ITT Rayonier Research Div.	Oakland Bay	373.0	450.7	1.4	373.0	528.4	99.9	99.9	87.5	97.27	97.78
Simpson Timber Co.	Oakland Bay	.342	4.2	0.2	10.6	12.1	-	-	12.5	2.73	2.22
Basin Total		373.342	454.9	1.6	383.6	540.5	99	99.9	100.0	100.0	100.0

1/ Percent Cr data available

B.NON-PT. SOURCE INVENT

At the present time there is insufficient data available to asess the non-point source contribution in the Puget Sound Basin.

E. ANTICIPATED WATER QUALITY INPROVEMENTS

IV. PROGRESS TOWARDS WATER QUALITY GOALS

A.LOAD REDUCTION TABLE

B. WATER QUALITY TRENDS
FRESH WATER

CEDAR - SAMMAMISH RIVER BASIN

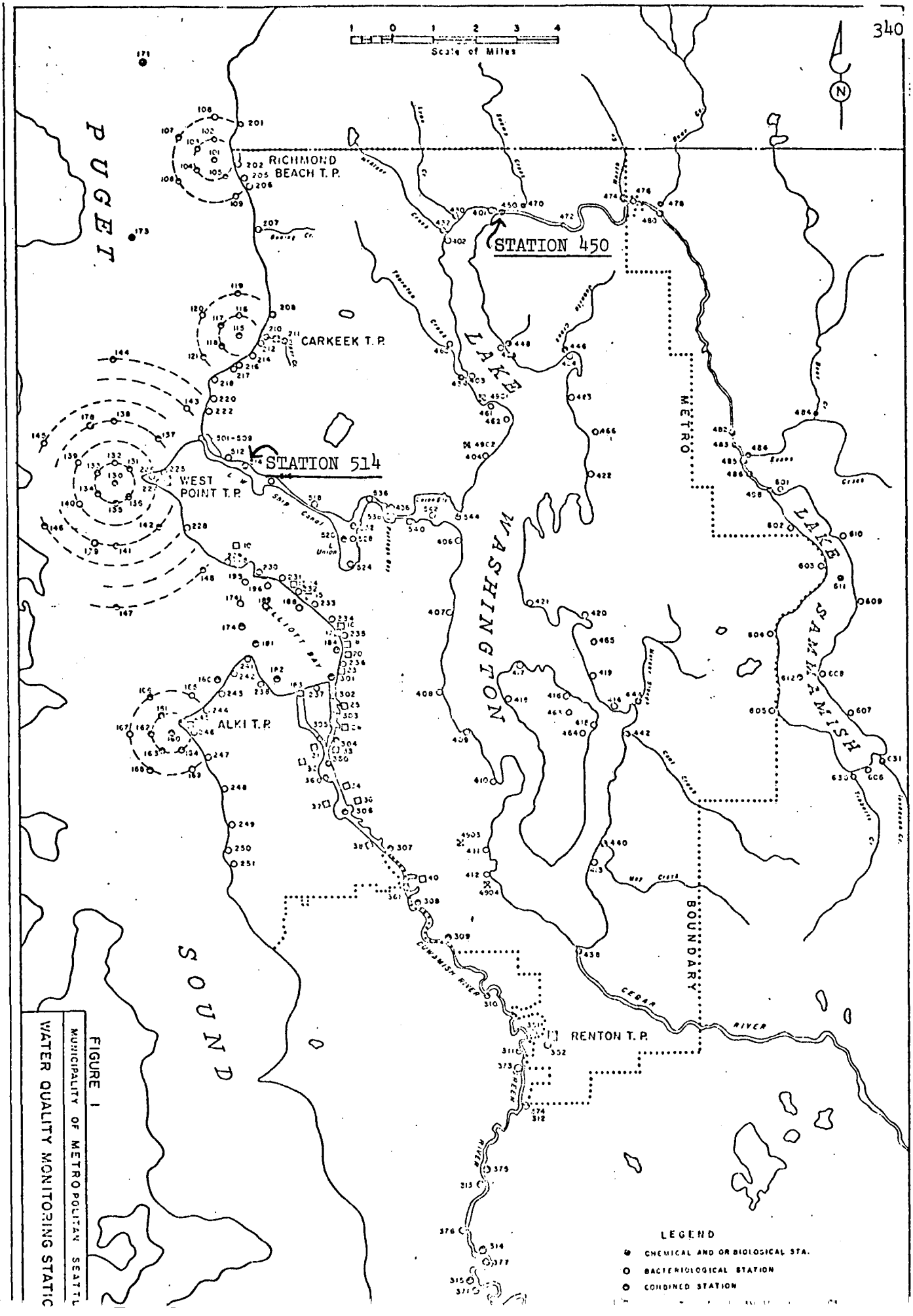
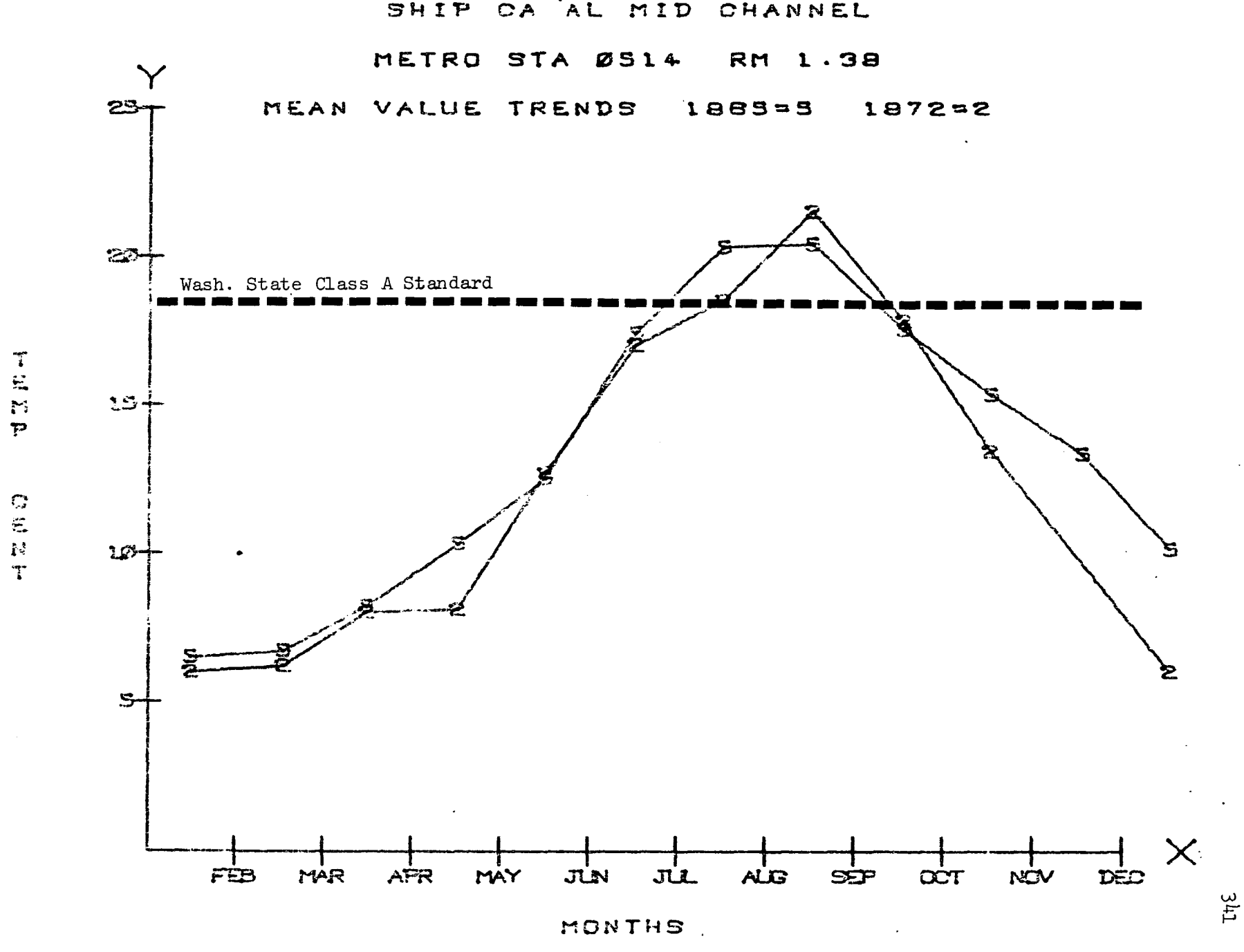
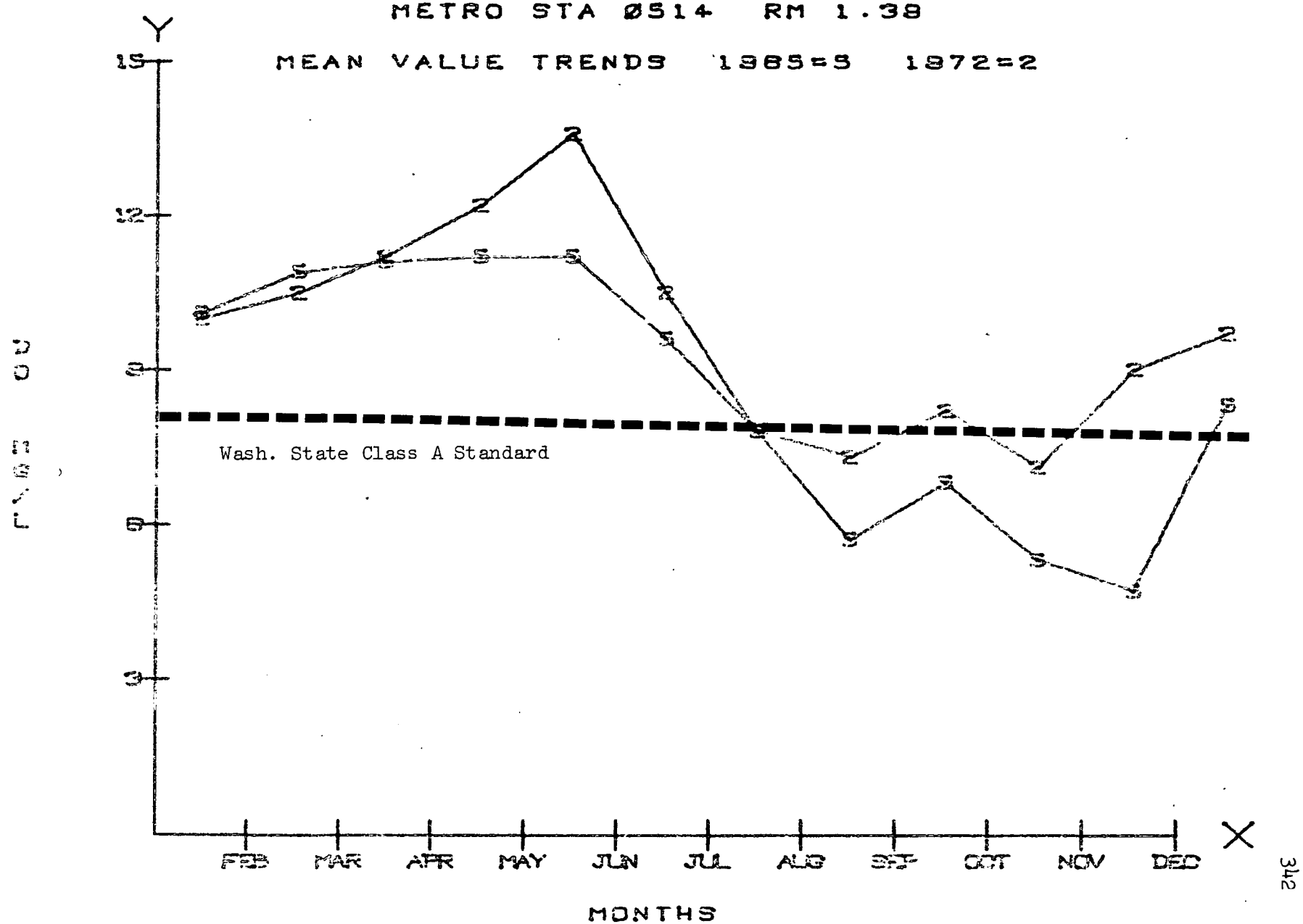


FIGURE 1

MUNICIPALITY OF METROPOLITAN SEATTLE

WATER QUALITY MONITORING STATIONS


SHIP CA AL MID CHANNEL
METRO STA Ø514 RM 1.38
MEAN VALUE TRENDS 1869=5 1872=2
Y
25
20
15
10
5
TEMP DEGF
Wash. State Class A Standard
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
X
MONTHS


SHIP CANAL MID CHANNEL
METRO STA Ø514 RM 1.38
MEAN VALUE TRENDS 1985=5 1972=2
Y
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12
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Wash. State Class A Standard
FEB
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SEP
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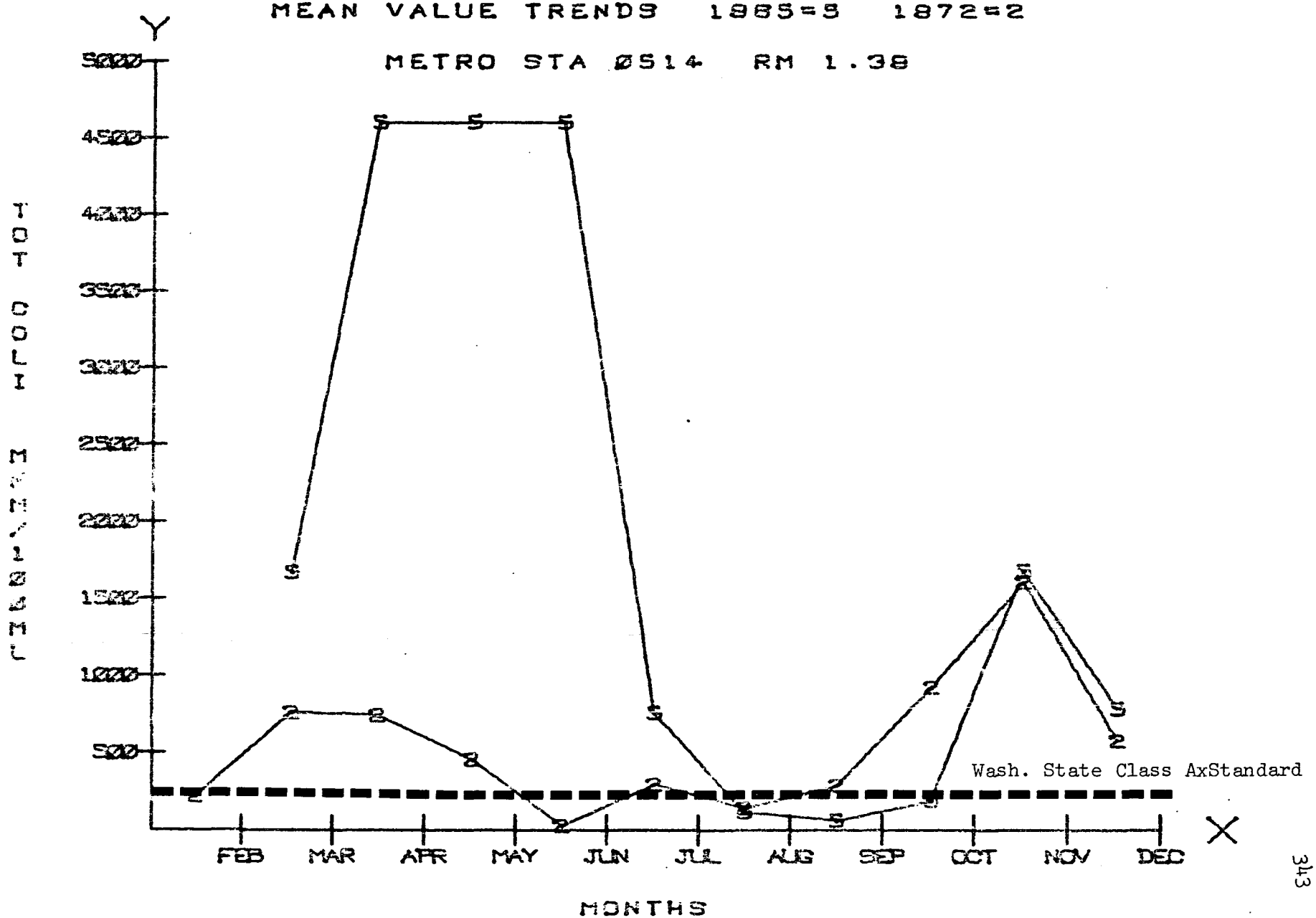
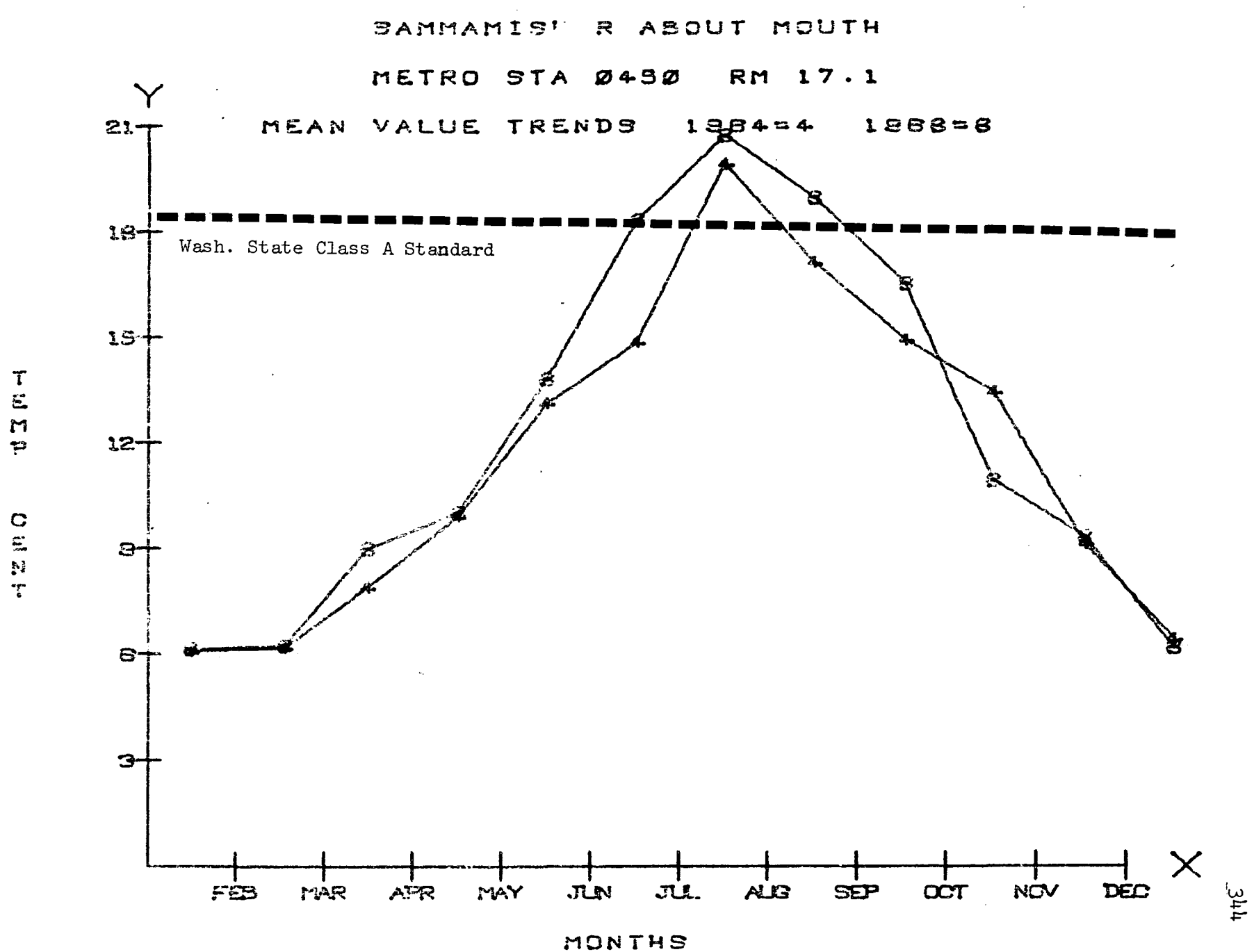
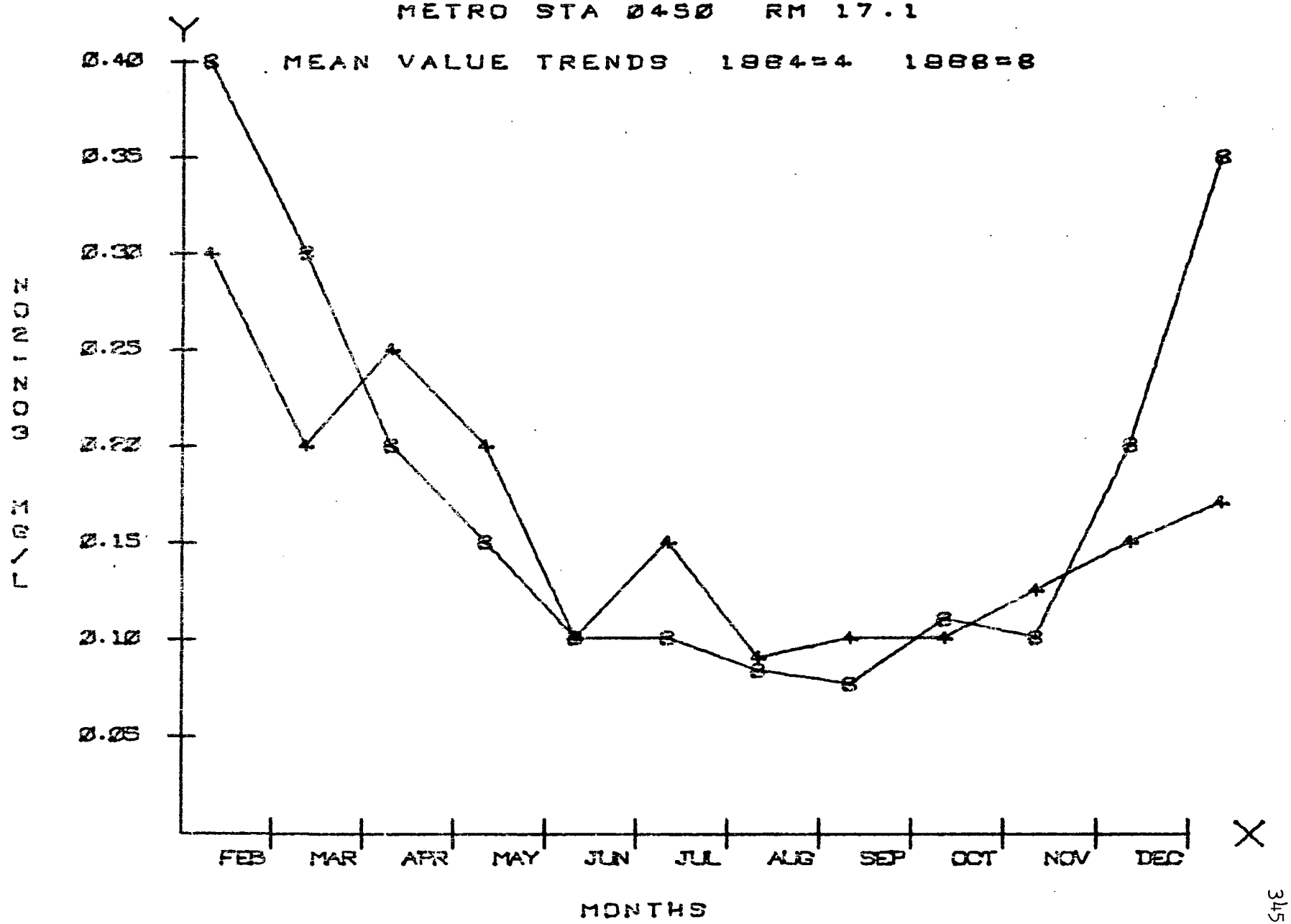
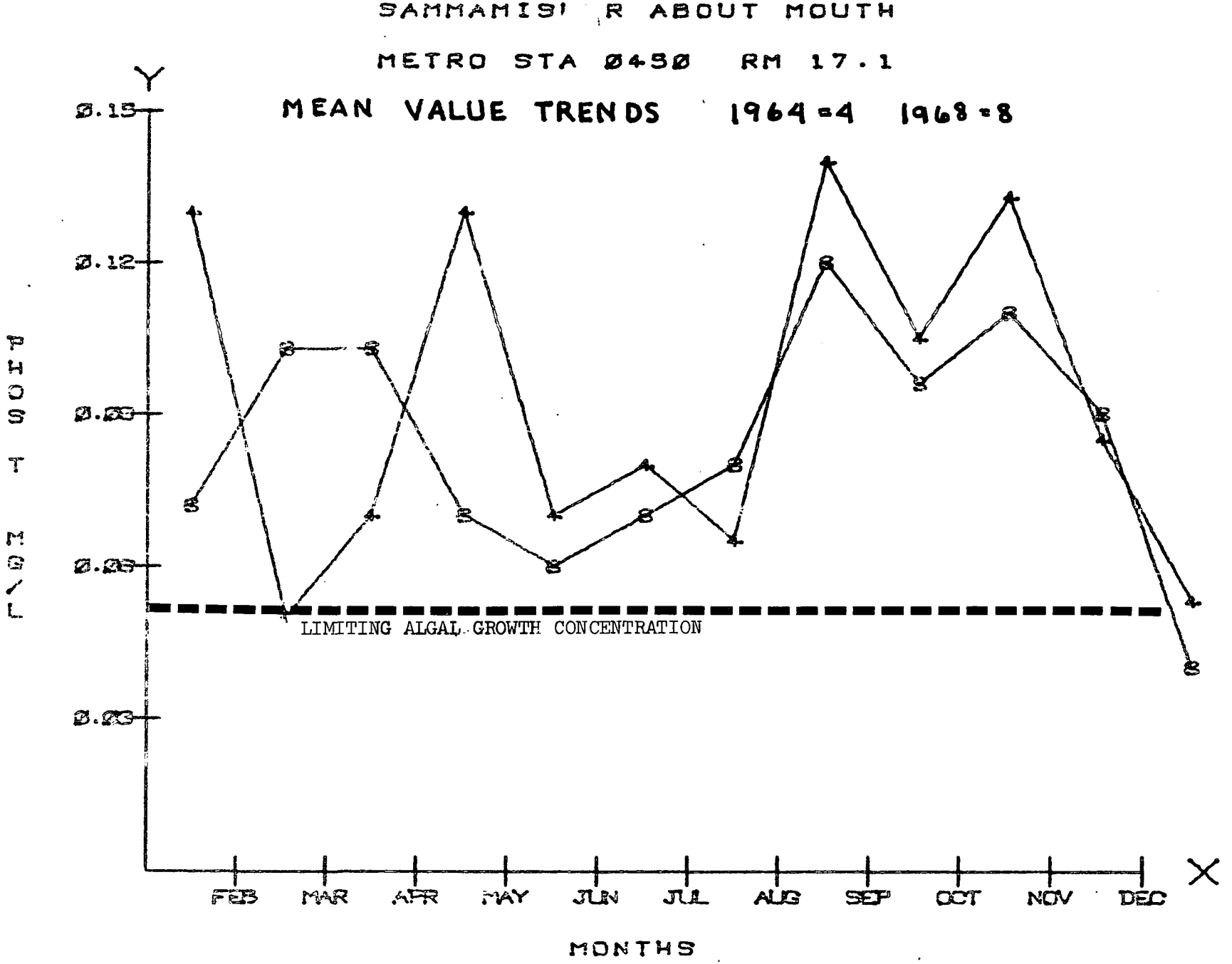
DEC
X
MONTHS

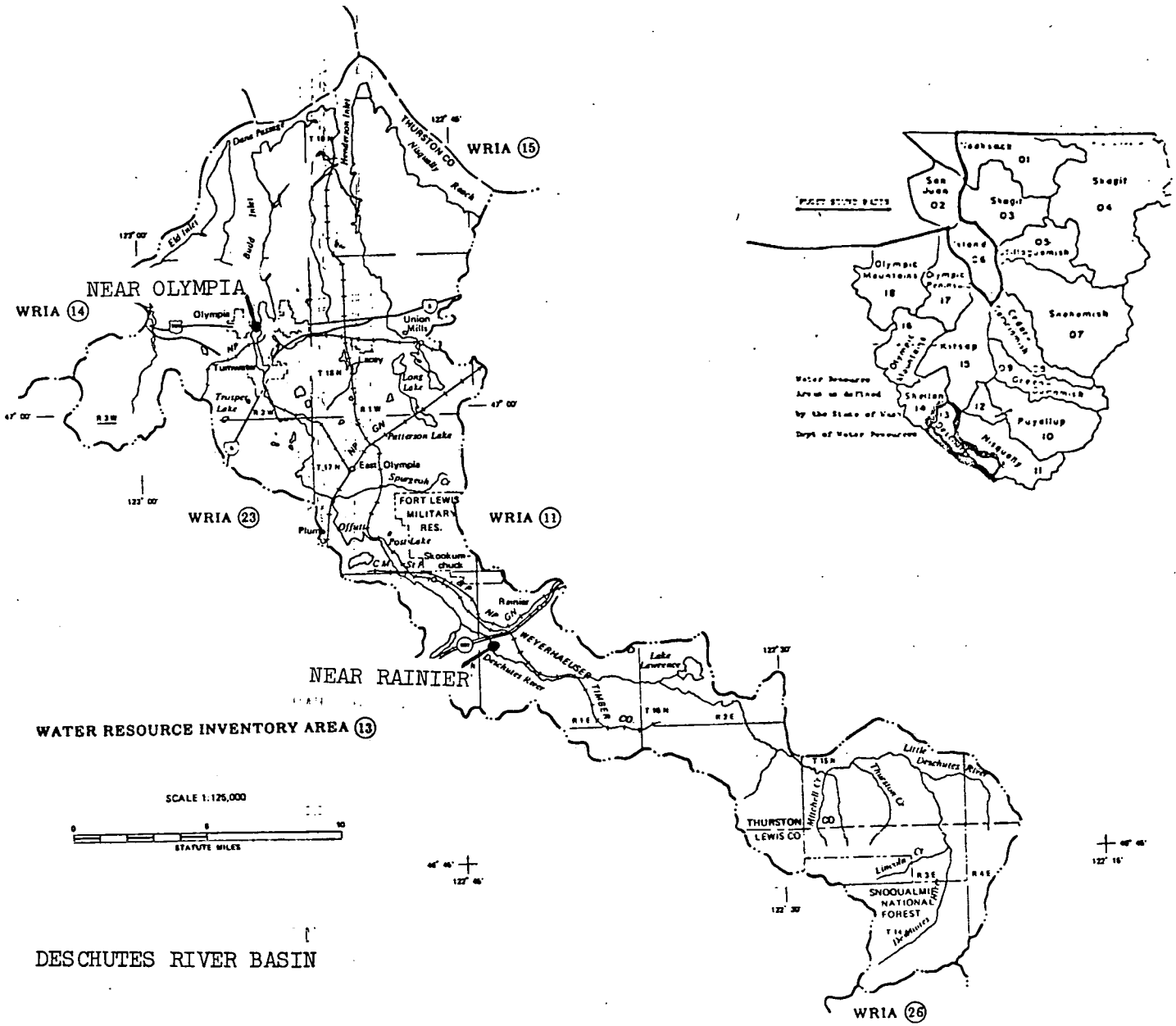

SHIP CANAL MID CHANNEL
MEAN VALUE TRENDS 1885=5 1872=2
METRO STA Ø514 RM 1.38
Y
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
TOT COLI MPN/100ML
Wash. State Class AxStandard
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
X
MONTHS


SAMMAMISH R ABOUT MOUTH
METRO STA 0450 RM 17.1
MEAN VALUE TRENDS 1984=4 1988=8
Y
21
18
15
12
9
6
3
Wash. State Class A Standard
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
X
MONTHS


SAMMAMISH R ABOUT MOUTH
METRO STA 0450 RM 17.1
MEAN VALUE TRENDS 1984=4 1988=8
Y
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
FLOW NOZINOZ
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
X
MONTHS


SAMMAMISH R ABOUT MOUTH
METRO STA 0450 RM 17.1
MEAN VALUE TRENDS 1964-4 1968-8
Y
0.15
0.12
PHOS T MG/L
LIMITING ALGAL GROWTH CONCENTRATION
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
X
MONTHS

DESCHUTES RIVER BASIN

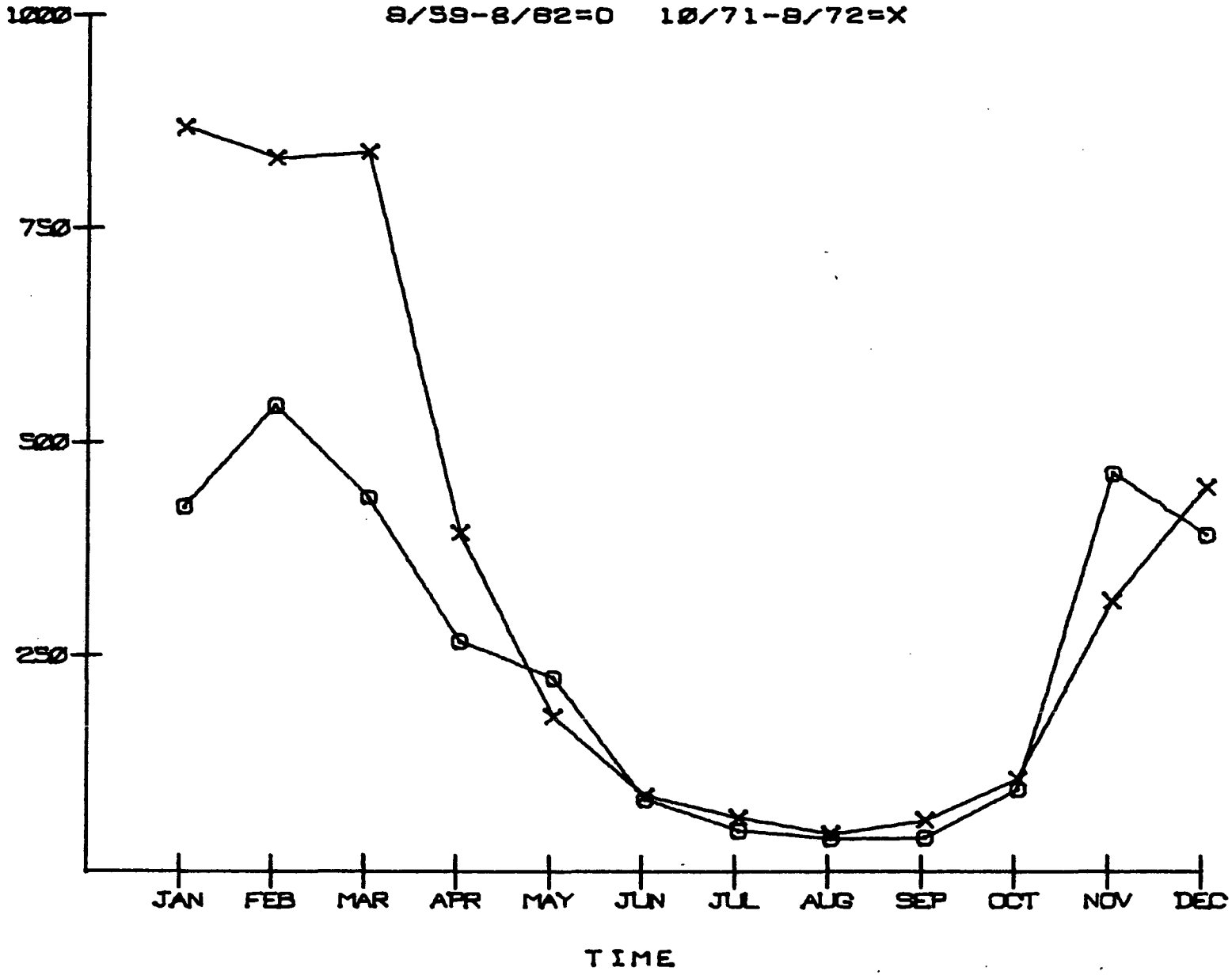

NEAR OLYMPIA
WRIA 14
WRIA 15
WRIA 23
WRIA 11
WRIA 26
NEAR RAINIER
WATER RESOURCE INVENTORY AREA 13
SCALE 1:125,000
STATUTE MILES
DESCHUTES RIVER BASIN
Olympia
Union Mills
Tumwater
Trosper Lake
Long Lake
Patterson Lake
East Olympia
Spurgeon Creek
FORT LEWIS MILITARY RES.
Offutt Lake
Skookumchuck
Rainier
Deschutes River
WEYERHAEUSER TIMBER CO
Lake Lawrence
THURSTON CO
LEWIS CO
Little Deschutes River
Thurston Cr
Hitchen Cr
Limedale Cr
SNOQUALMIE NATIONAL FOREST
Dana Passage
Eld Inlet
Budd Inlet
Henderson Inlet
Nisqually Reach
San Juan 02
Skagit 03
Island 06
Olympic Mountains 18
Olympic Peninsula 17
Kitsap 15
Skagit 04
Snohomish 07
Pierce 12
Puyallup 10
Nisqually 11
Skokomish 14
Water Resource Areas as defined by the State of Washington Dept of Water Resources

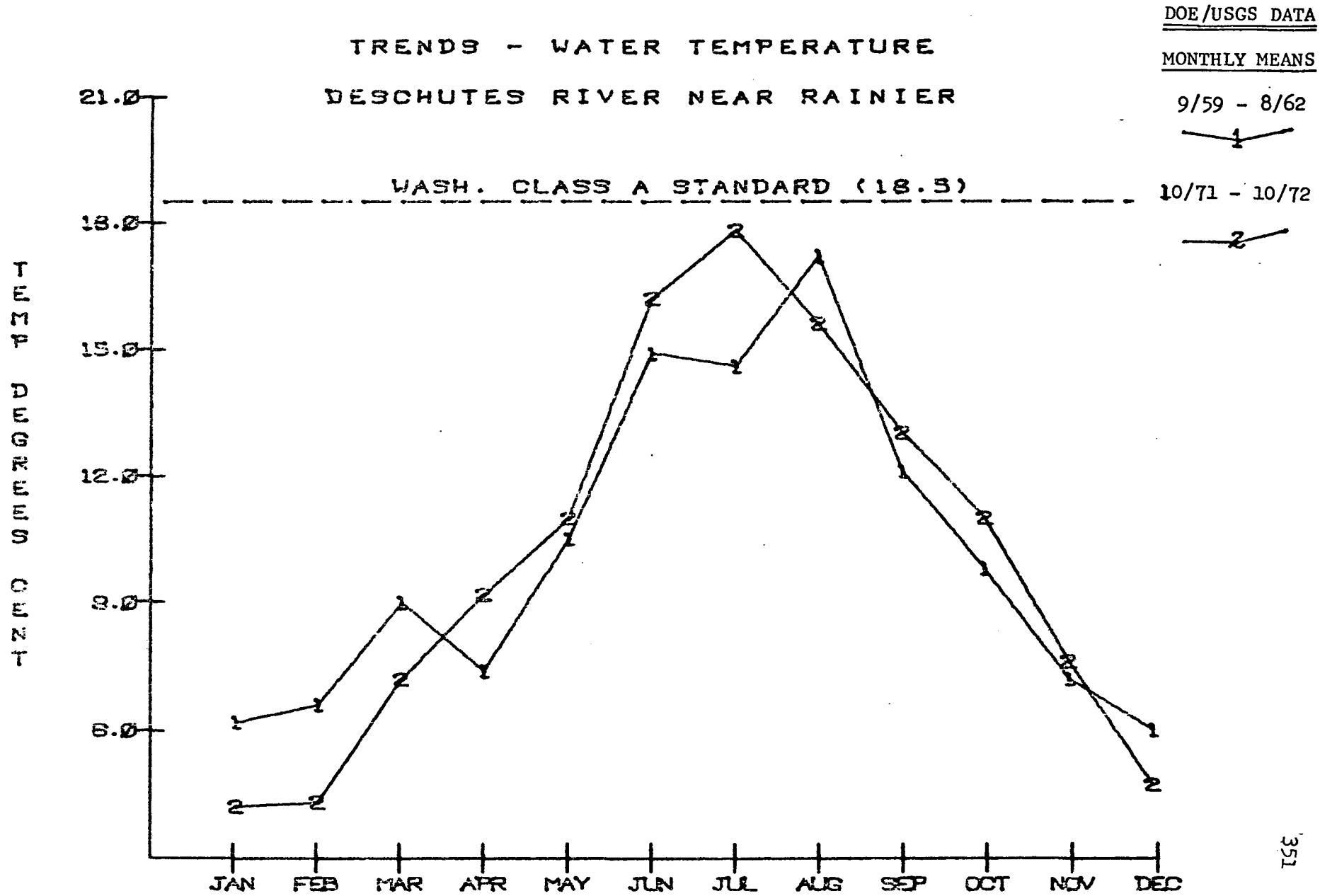
DESCHUTES RIVER NEAR RAINIER

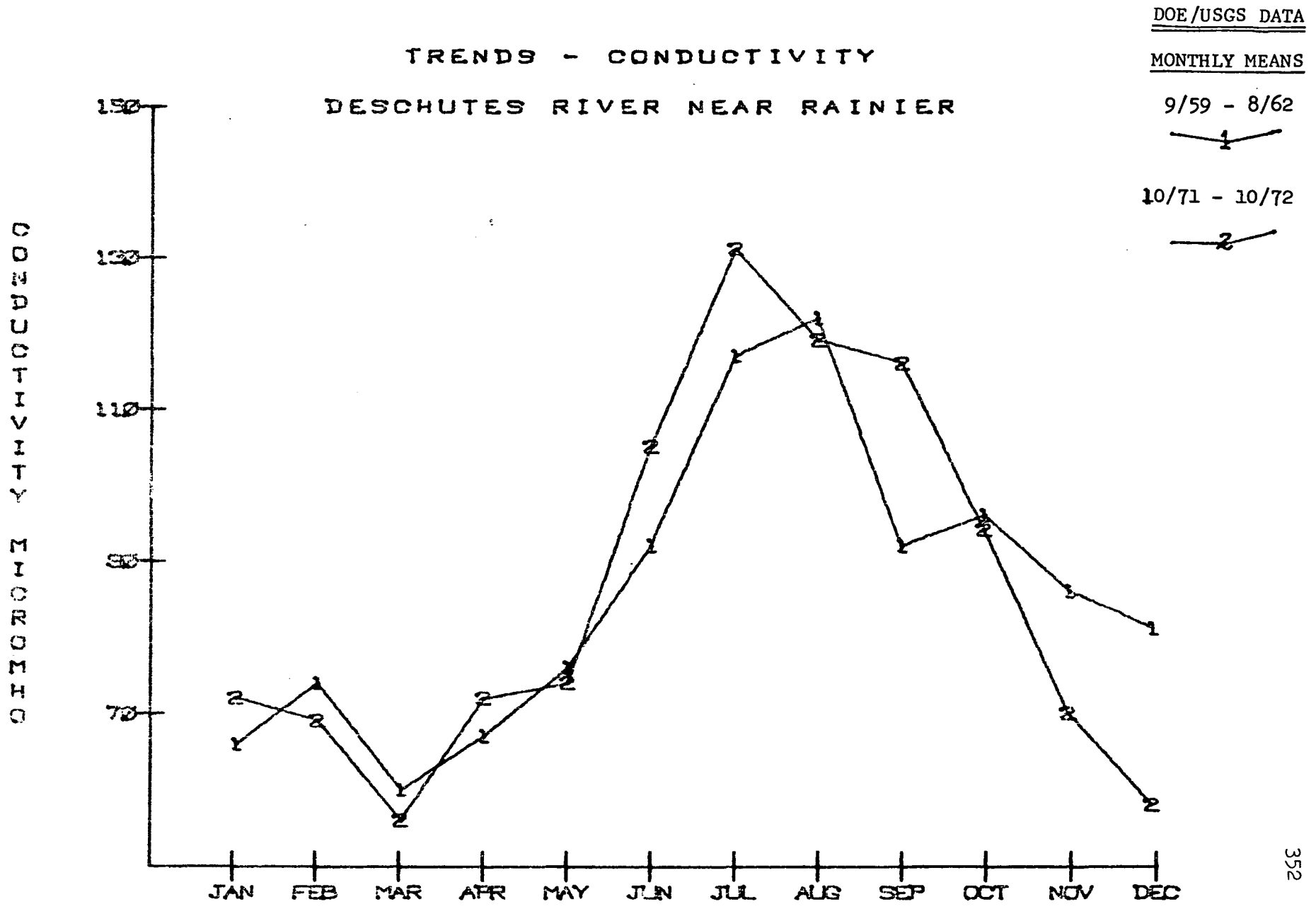
DESCHUTES RIVER AT RAINIER

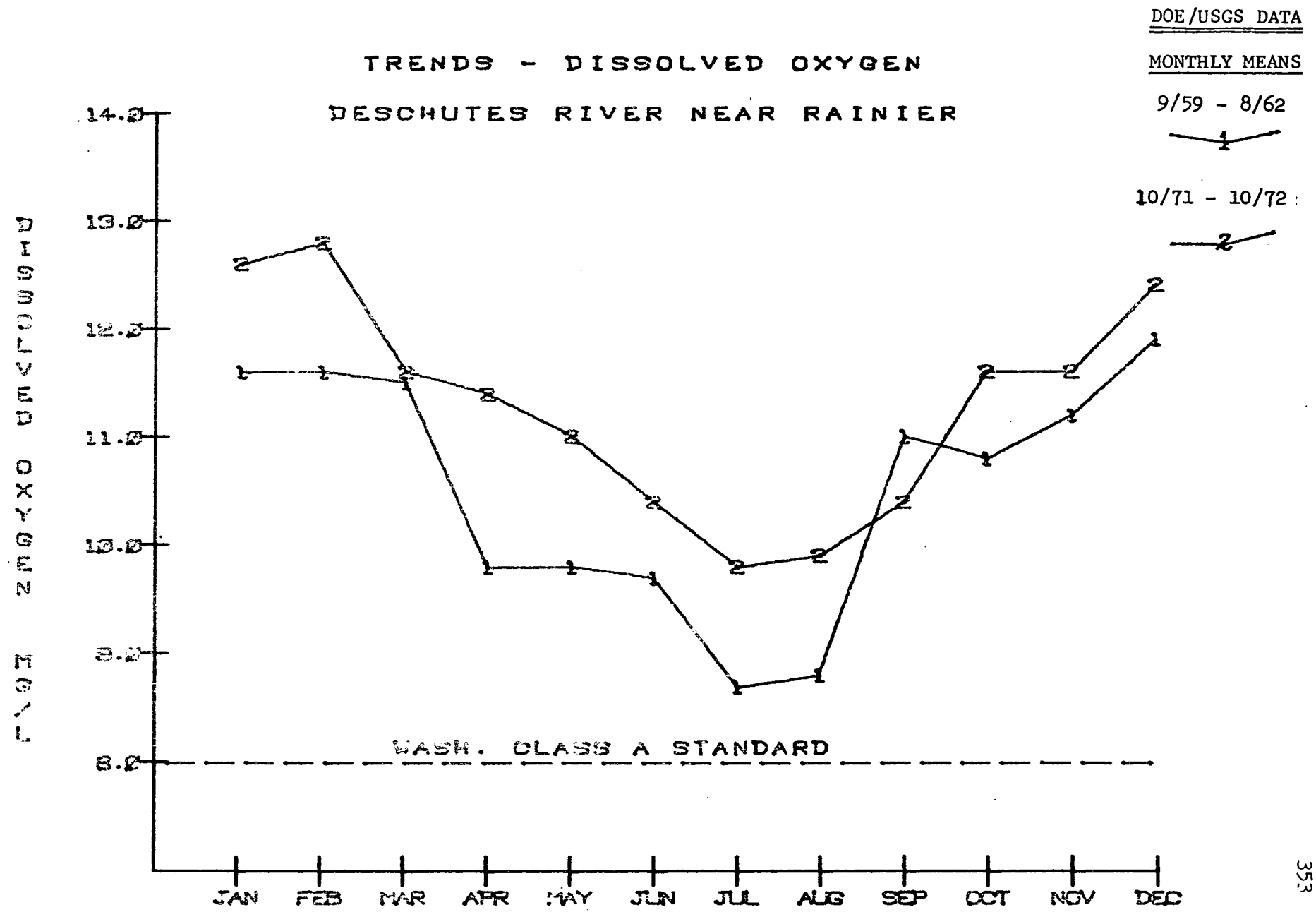
MEAN VALUES U.S.G.S. DATA

8/59-8/82=O 10/71-8/72=X




TRENDS - WATER TEMPERATURE
DESCHUTES RIVER NEAR RAINIER
DOE/USGS DATA
MONTHLY MEANS
9/59 - 8/62
10/71 - 10/72
WASH. CLASS A STANDARD (18.5)
TEMP DEGREES CENT
21.0
18.0
15.0
12.0
9.0
6.0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC


TRENDS - CONDUCTIVITY
DESCHUTES RIVER NEAR RAINIER
DOE/USGS DATA
MONTHLY MEANS
9/59 - 8/62
10/71 - 10/72
CONDUCTIVITY MICROMHO
150
130
110
90
70
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC


TRENDS - DISSOLVED OXYGEN
DESCHUTES RIVER NEAR RAINIER
DOE/USGS DATA
MONTHLY MEANS
9/59 - 8/62
10/71 - 10/72
DISSOLVED OXYGEN MG/L
14.0
13.0
12.0
11.0
10.0
9.0
8.0
WASH. CLASS A STANDARD
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

DOE/USGS DATA

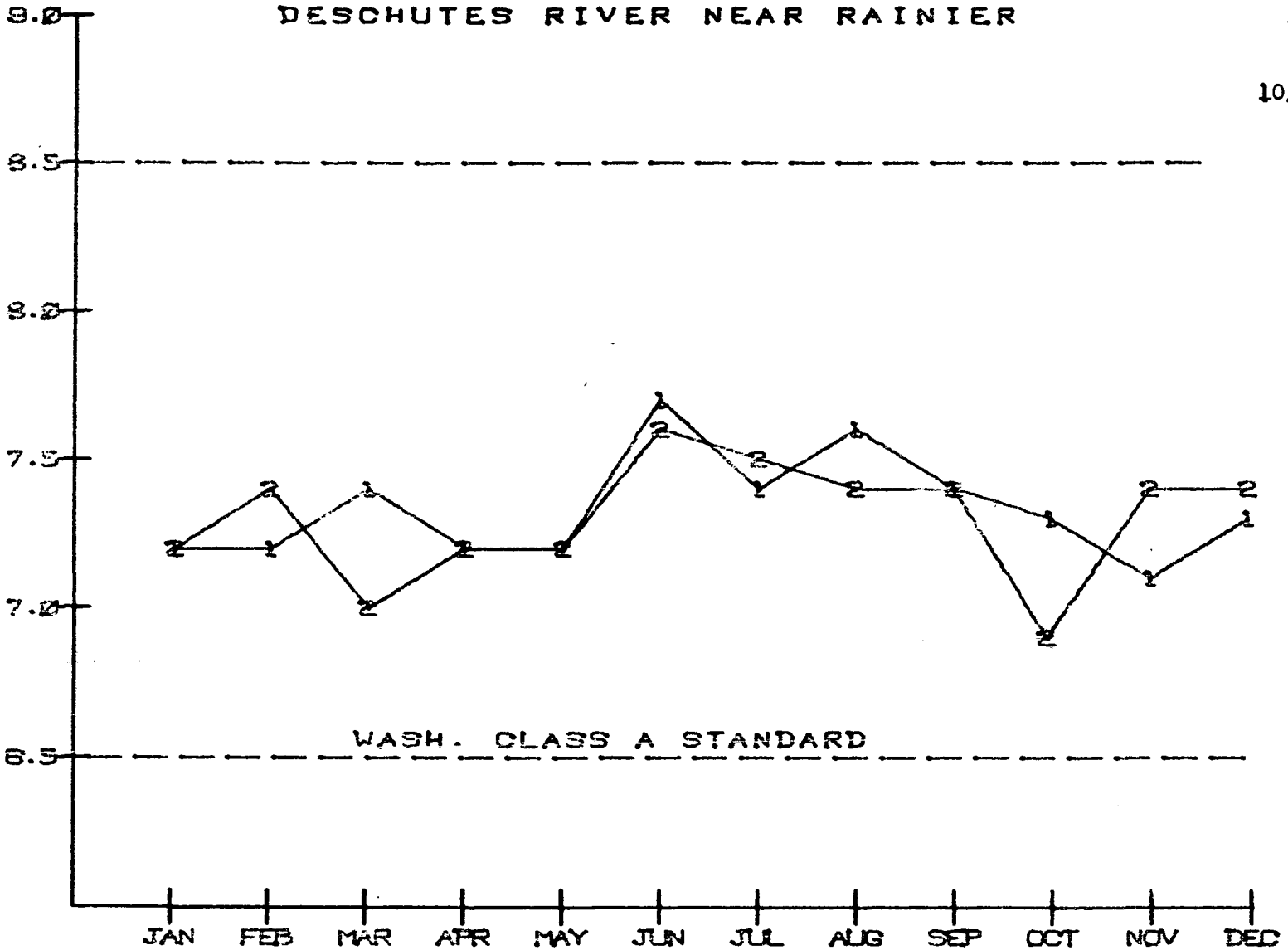
MONTHLY MEANS

9/59 - 8/62

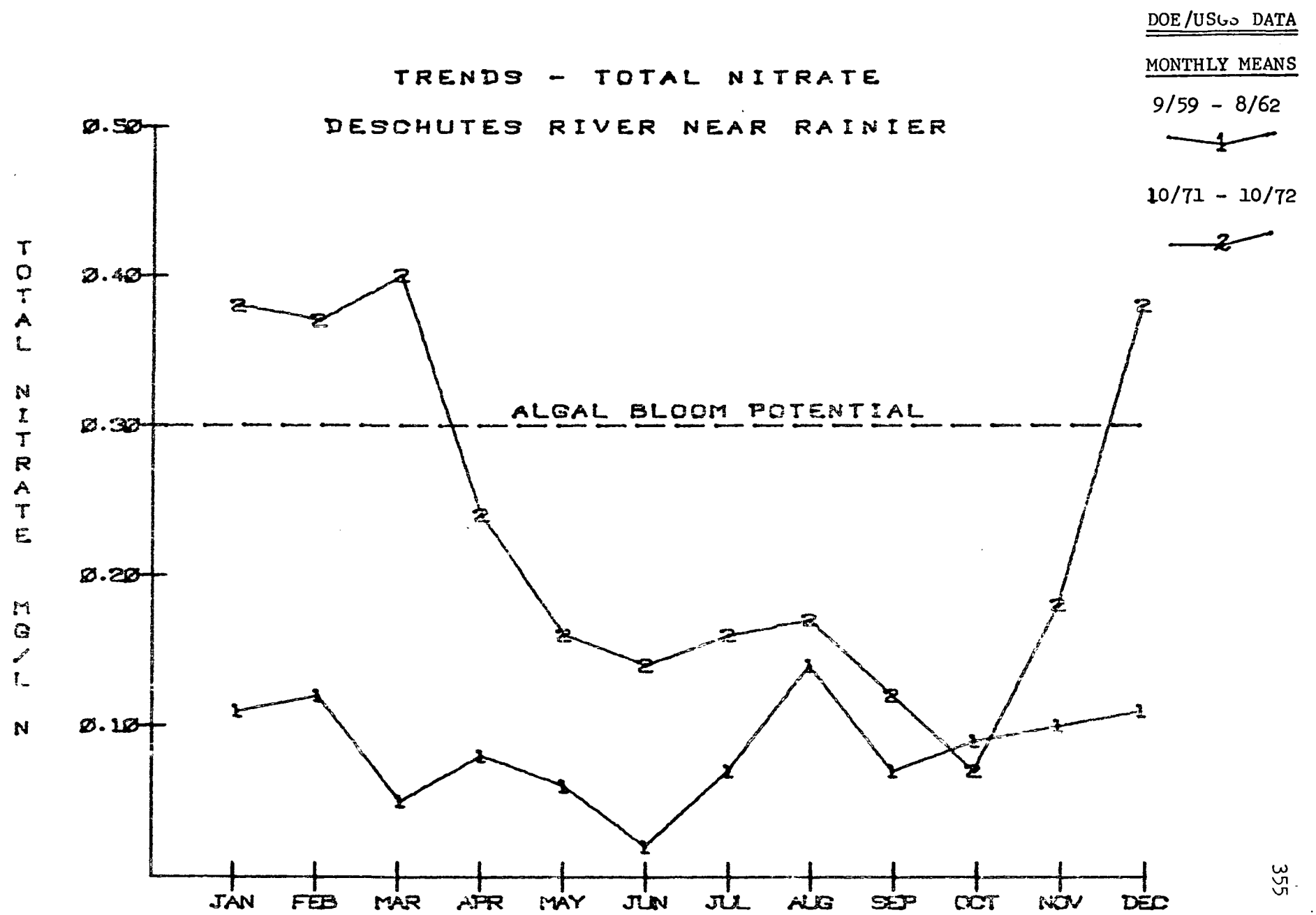
10/71 - 10/72

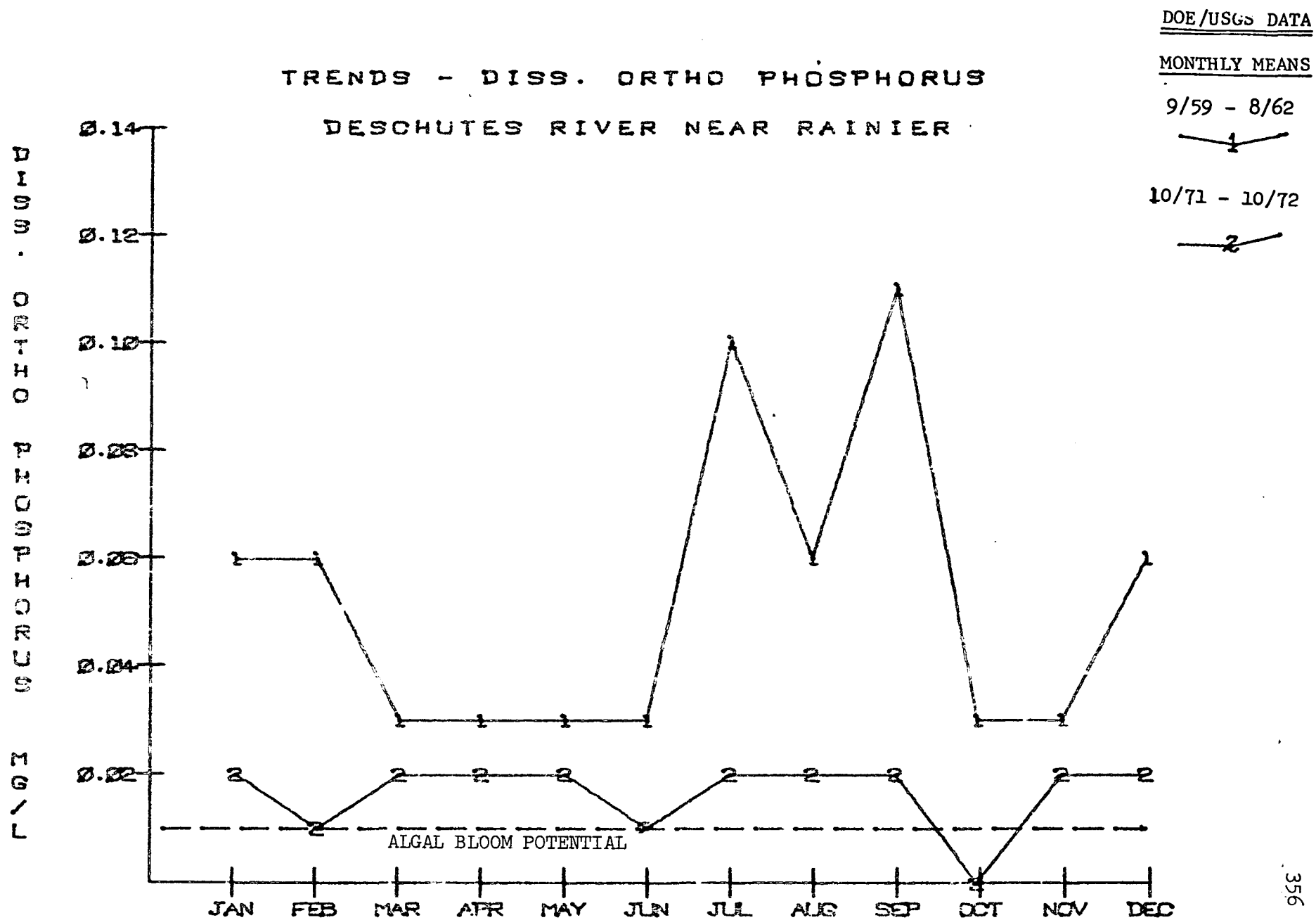
TRENDS - PH

DESCHUTES RIVER NEAR RAINIER



P.1


TRENDS - TOTAL NITRATE
DESCHUTES RIVER NEAR RAINIER
DOE/USGS DATA
MONTHLY MEANS
9/59 - 8/62
10/71 - 10/72
TOTAL NITRATE MG/L N
0.50
0.40
0.30
0.20
0.10
ALGAL BLOOM POTENTIAL
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

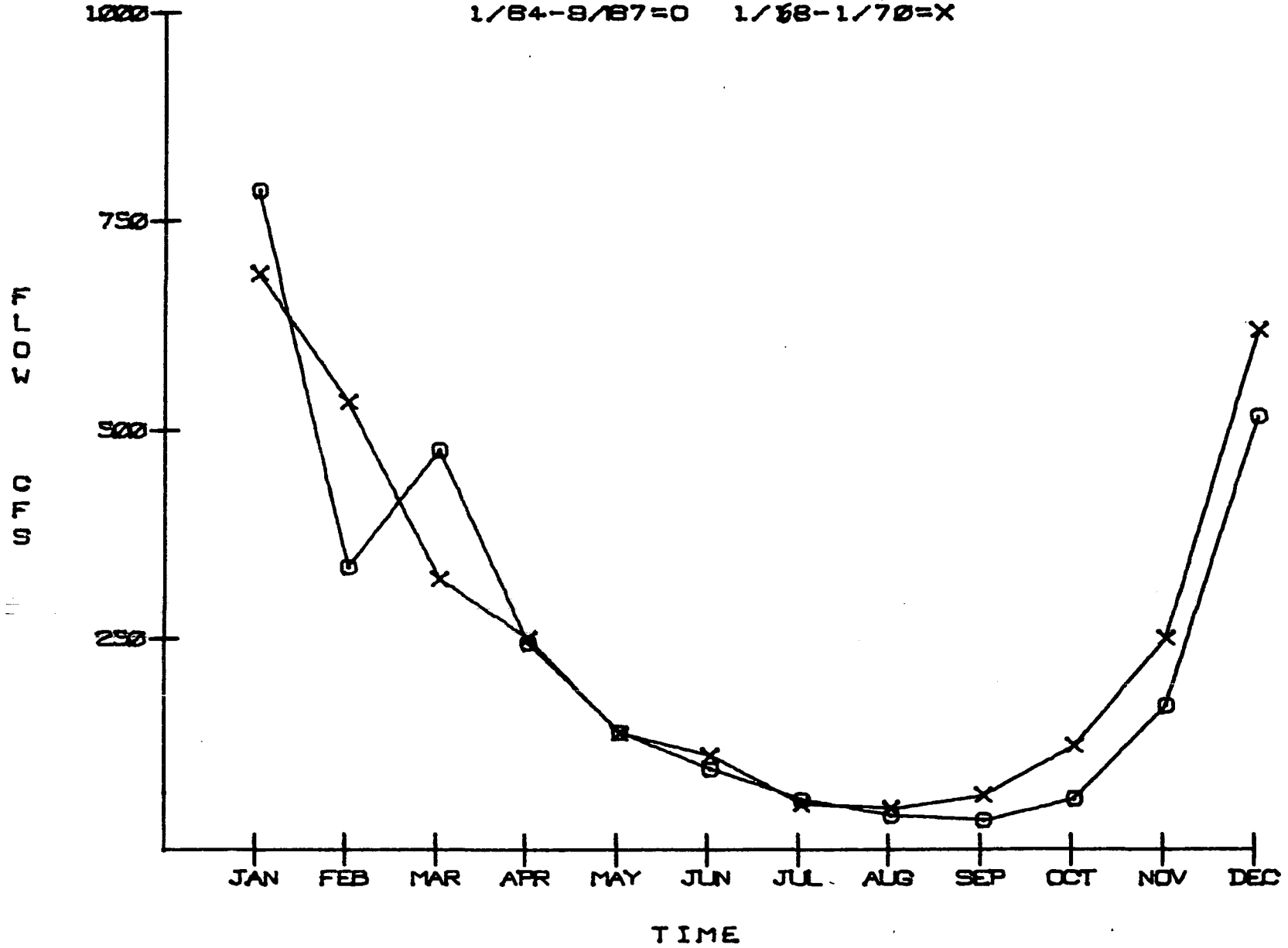

TRENDS - DISS. ORTHO PHOSPHORUS
DESCHUTES RIVER NEAR RAINIER
DOE/USGS DATA
MONTHLY MEANS
9/59 - 8/62
10/71 - 10/72
DISS. ORTHO PHOSPHORUS MG/L
0.14
0.12
0.10
0.08
0.06
0.04
0.02
ALGAL BLOOM POTENTIAL
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

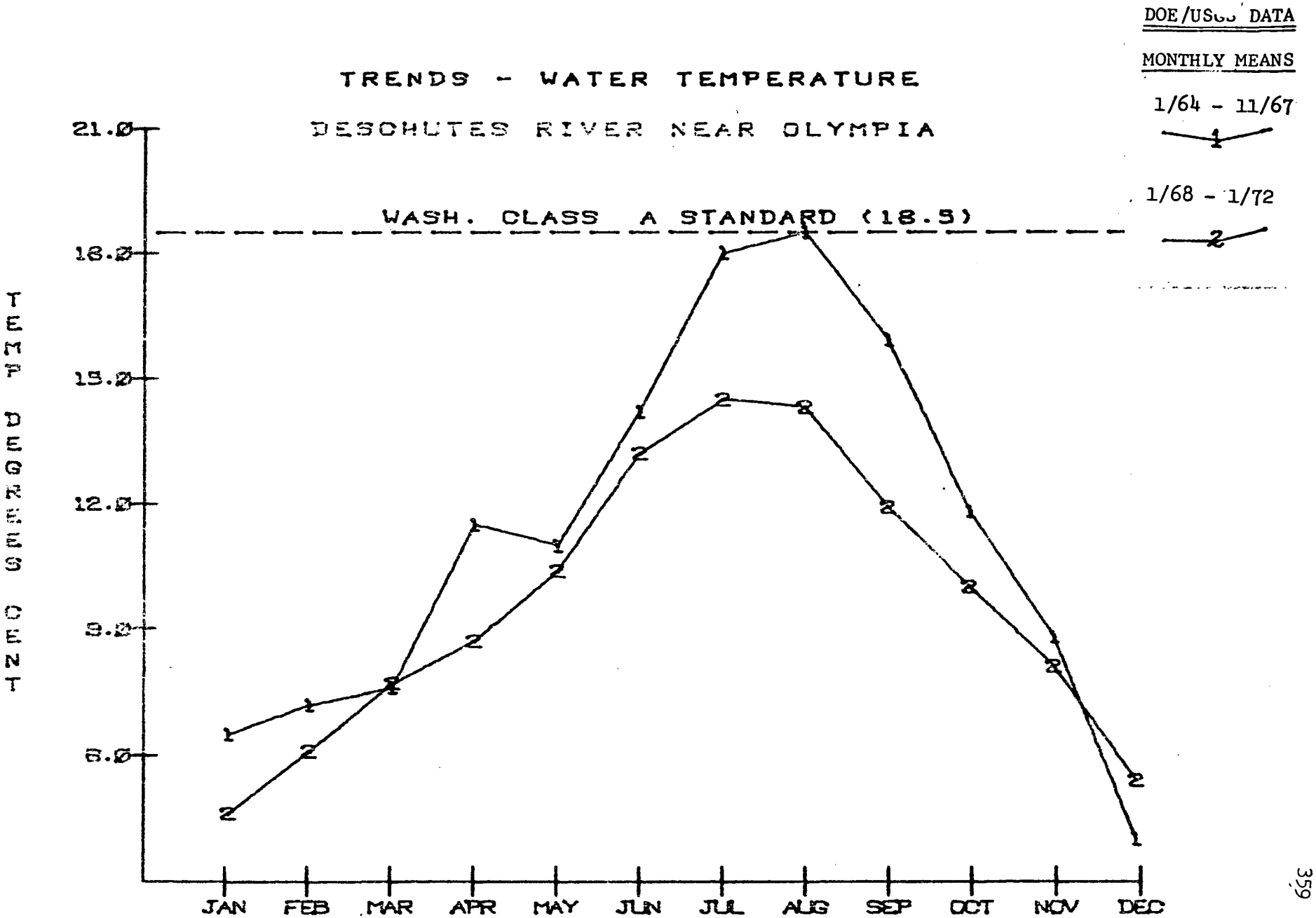
DESCHUTES RIVER NEAR OLYMPIA

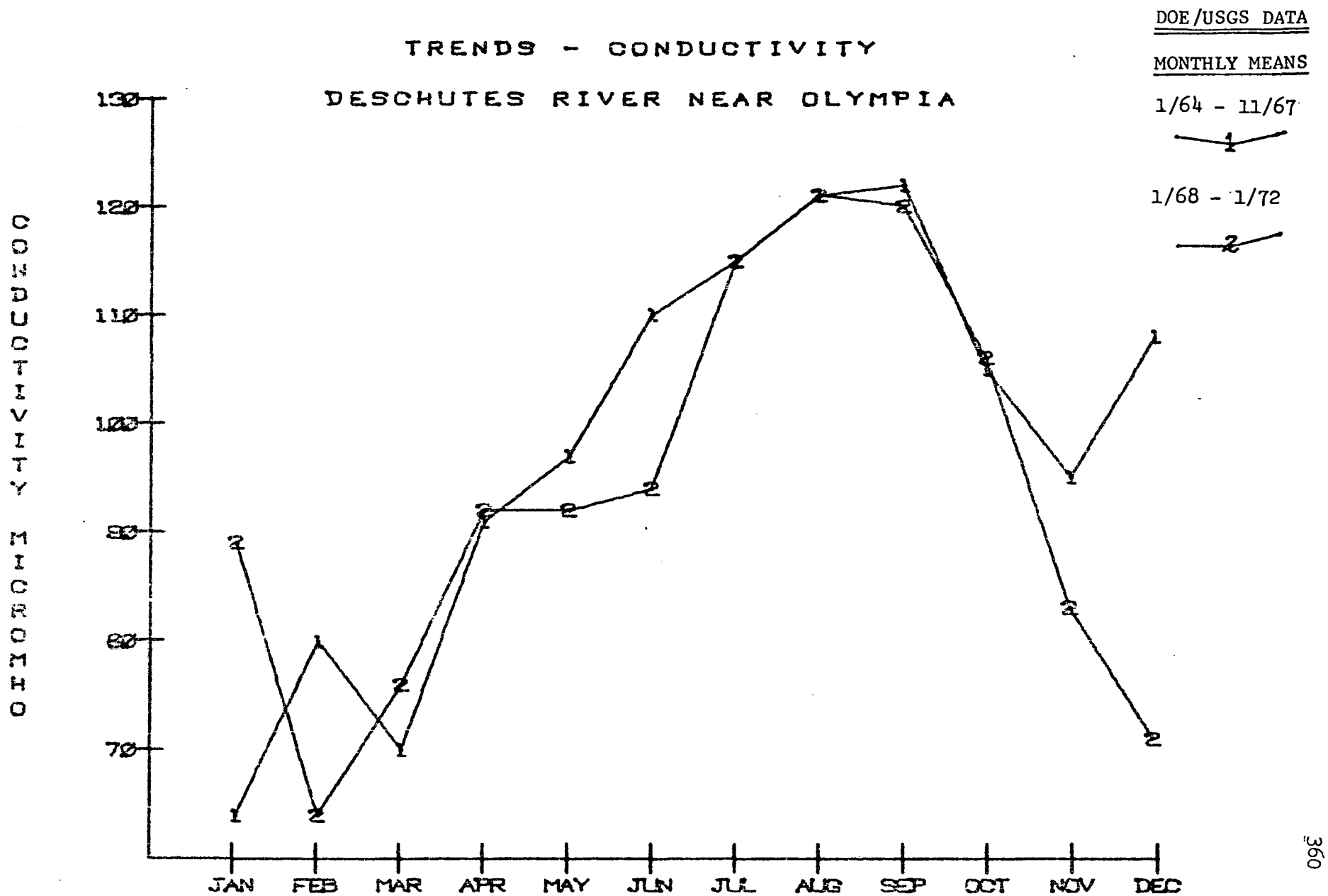
DESCHUTES RIVER AT RAINIER

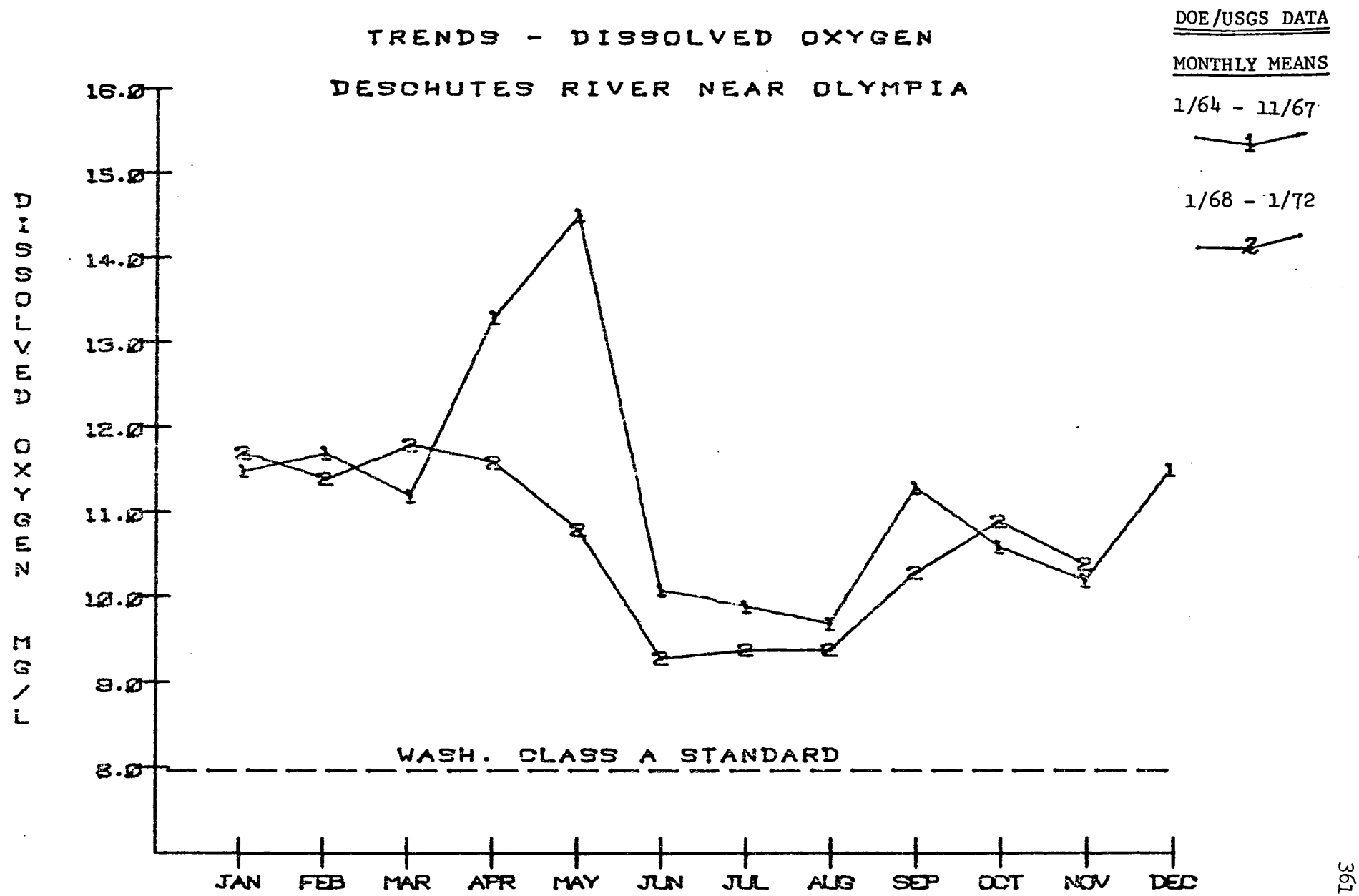
MEAN VALUES U.S.G.S. DATA

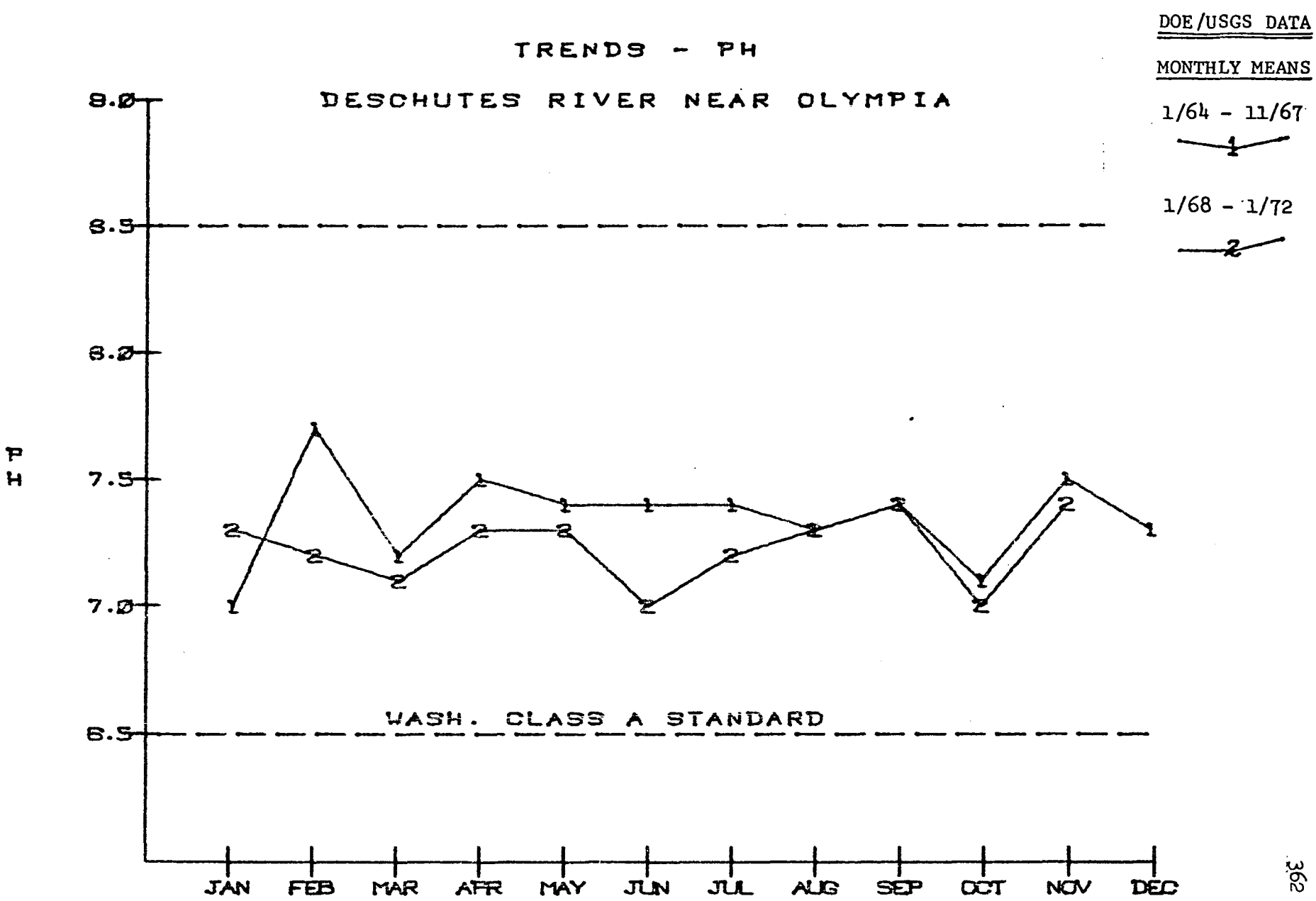
1/64-8/67=O 1/68-1/70=X

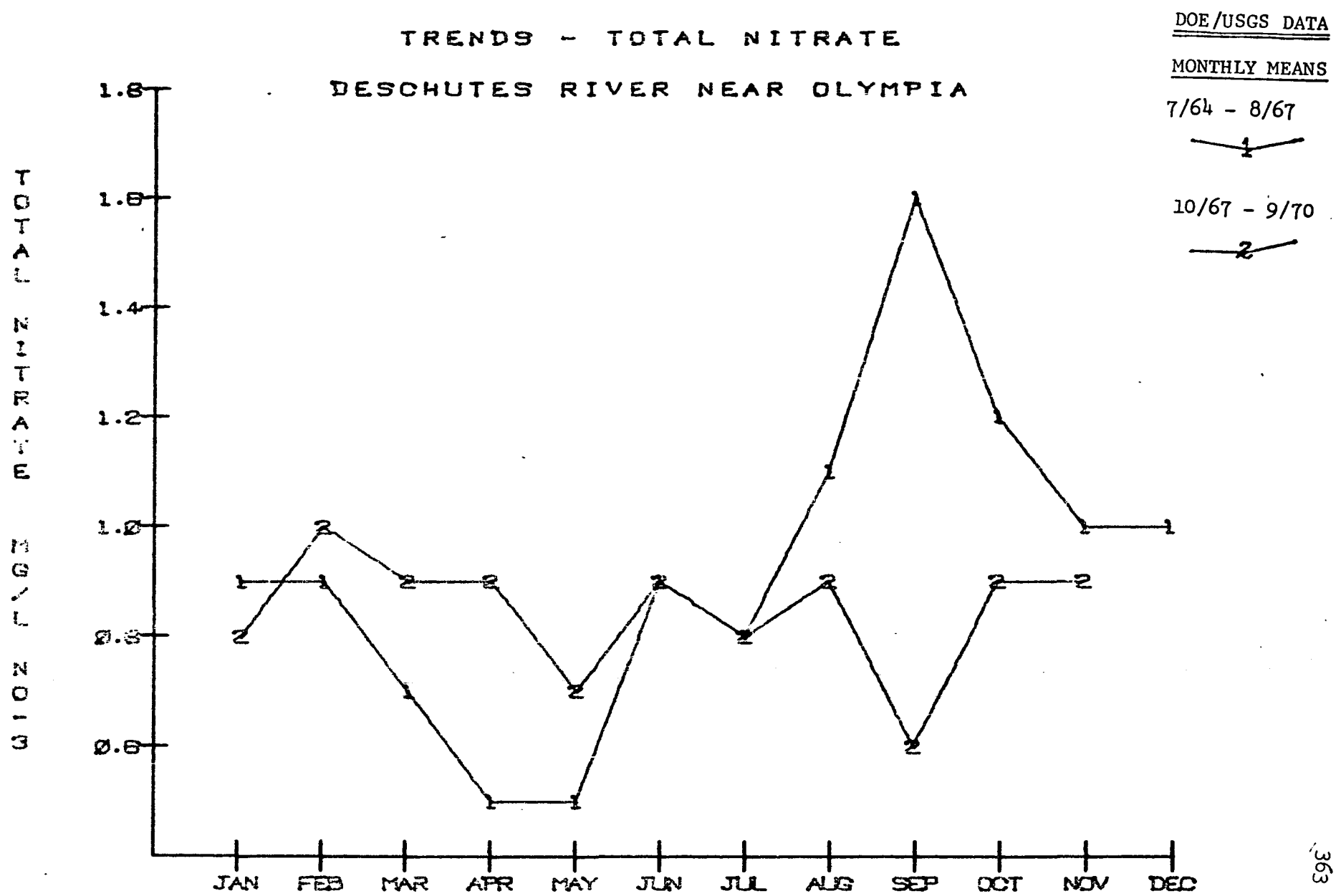



TRENDS - WATER TEMPERATURE
DESCHUTES RIVER NEAR OLYMPIA
DOE/USGS DATA
MONTHLY MEANS
1/64 - 11/67
1/68 - 1/72
WASH. CLASS A STANDARD (18.5)
TEMP DEGREES CENT
21.0
18.0
15.0
12.0
9.0
6.0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC


TRENDS - CONDUCTIVITY
DESCHUTES RIVER NEAR OLYMPIA
DOE/USGS DATA
MONTHLY MEANS
1/64 - 11/67
1/68 - 1/72
CONDUCTIVITY MICROMHO
130
120
110
100
90
80
70
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC


TRENDS - DISSOLVED OXYGEN
DESCHUTES RIVER NEAR OLYMPIA
DOE/USGS DATA
MONTHLY MEANS
1/64 - 11/67
1/68 - 1/72
DISSOLVED OXYGEN MG/L
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
8.0
WASH. CLASS A STANDARD
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC


TRENDS - PH
DESCHUTES RIVER NEAR OLYMPIA
DOE/USGS DATA
MONTHLY MEANS
1/64 - 11/67
1/68 - 1/72
8.0
8.5
8.0
7.5
7.0
6.5
PH
WASH. CLASS A STANDARD
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC


TRENDS - TOTAL NITRATE
DESCHUTES RIVER NEAR OLYMPIA
DOE/USGS DATA
MONTHLY MEANS
7/64 - 8/67
10/67 - 9/70
TOTAL NITRATE MG/L NO3
1.8
1.6
1.4
1.2
1.0
0.8
0.6
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

TRENDS - RESIDUE

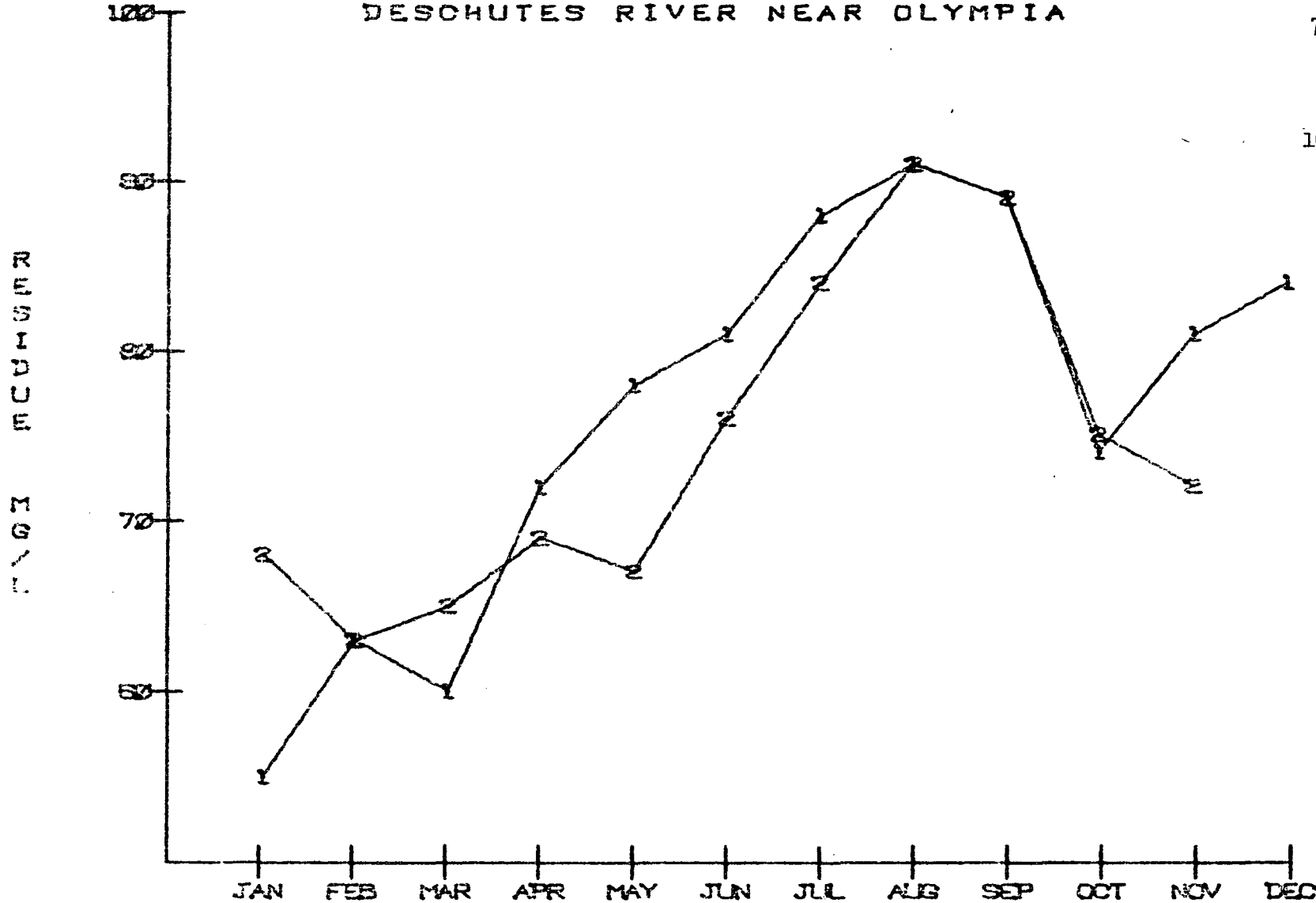
DESCHUTES RIVER NEAR OLYMPIA

DOE/USGS DATA

MONTHLY MEANS

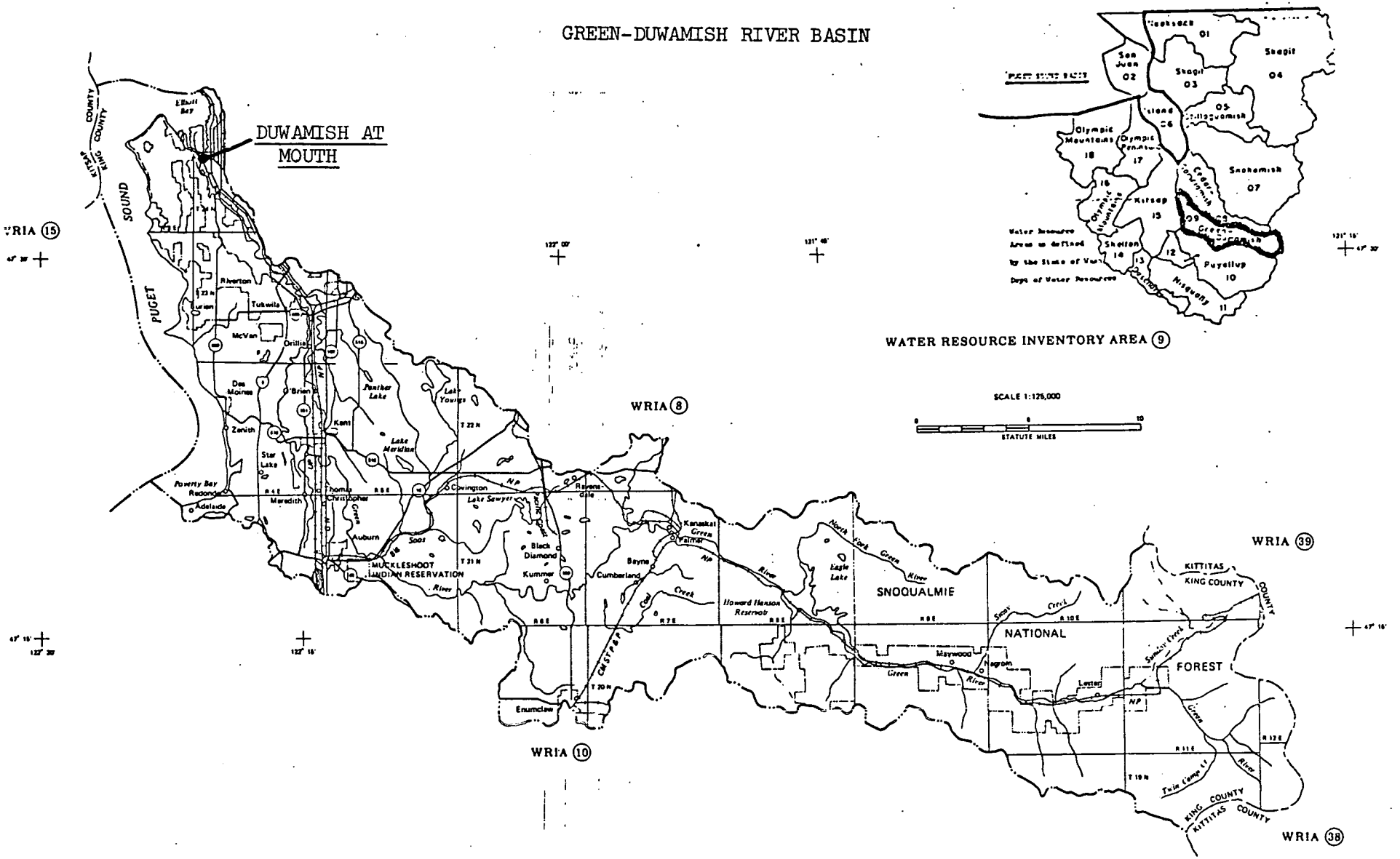
7/64 - 8/67

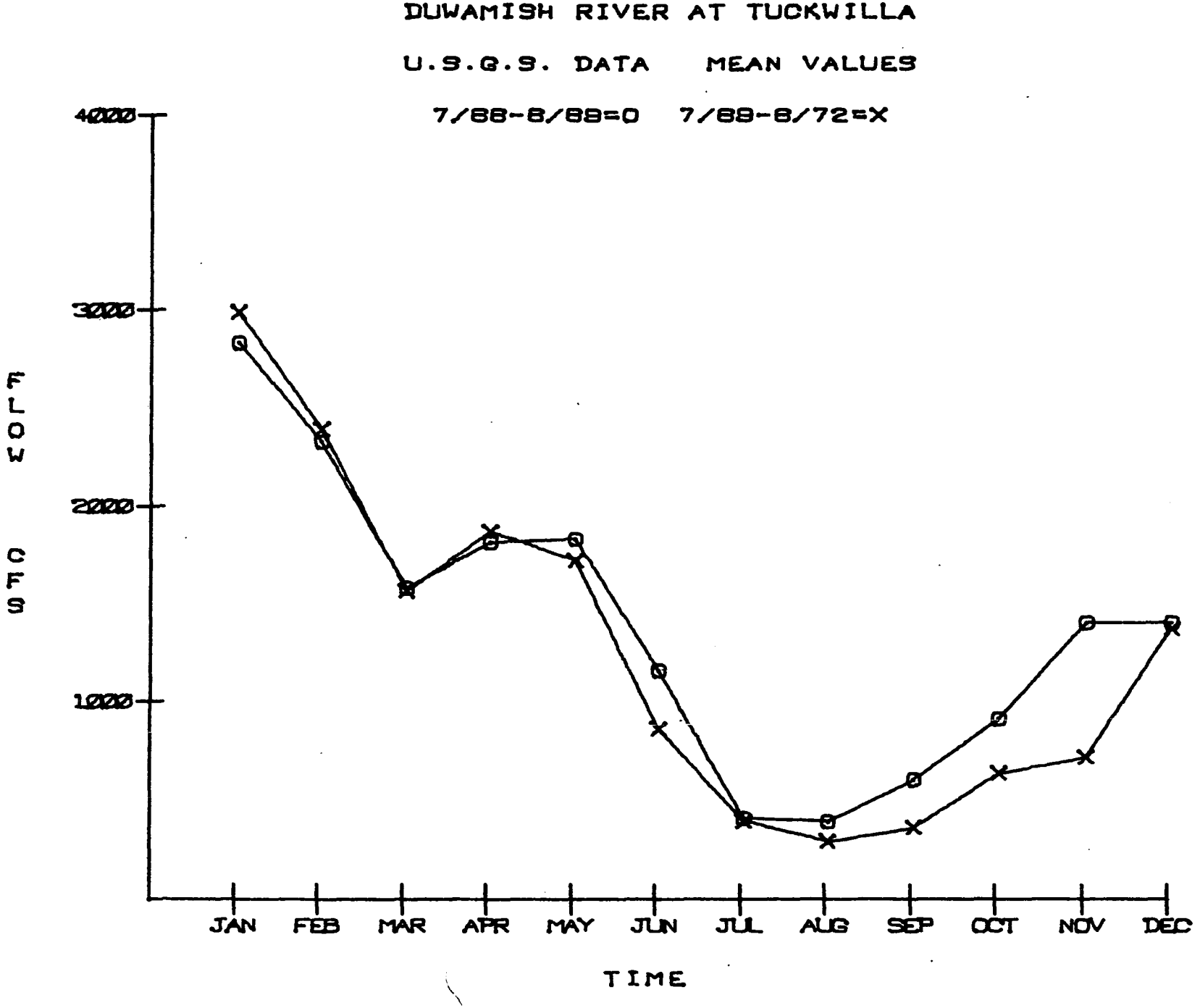
10/67 - 9/70



DUWAMISH - GREEN RIVER BASIN

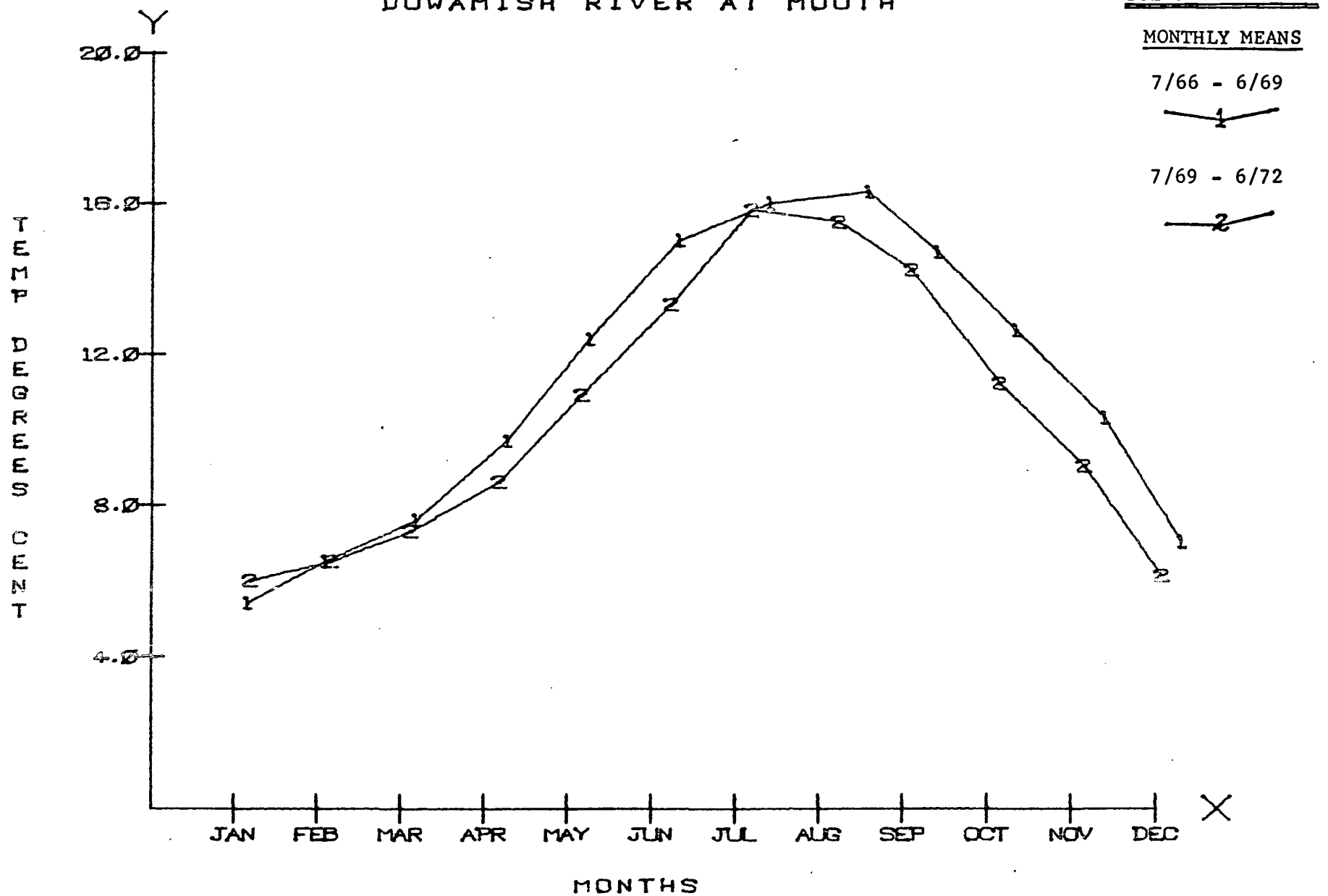
GREEN-DUWAMISH RIVER BASIN

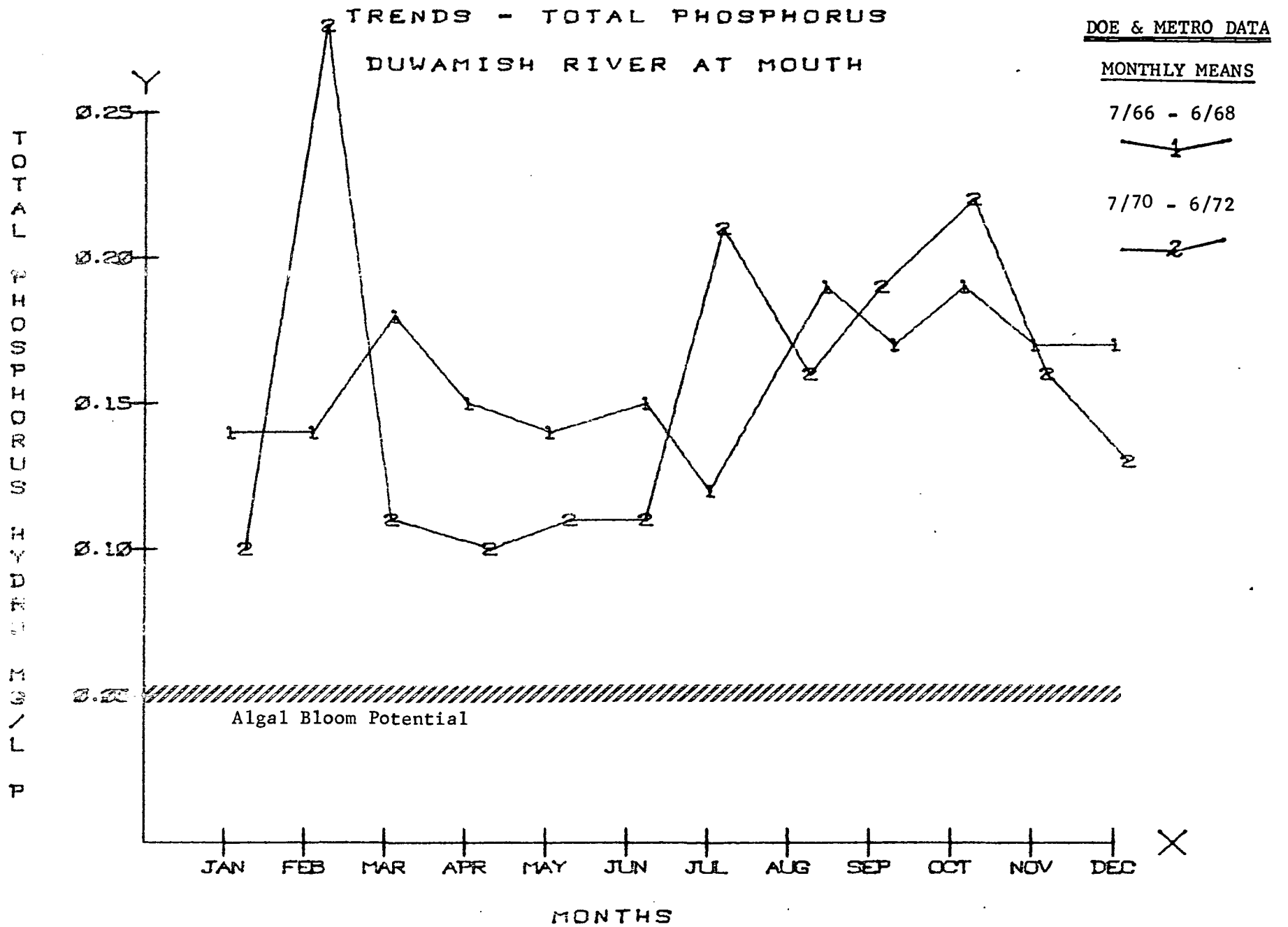



DUWAMISH RIVER AT TUCKWILLA
U.S.G.S. DATA MEAN VALUES
7/68-8/88=O 7/88-8/72=X
40000
30000
20000
10000
FLOW CFS
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
TIME

TRENDS - WATER TEMPERATURE

DUWAMISH RIVER AT MOUTH




TRENDS - TOTAL PHOSPHORUS
DUWAMISH RIVER AT MOUTH
DOE & METRO DATA
MONTHLY MEANS
7/66 - 6/68
7/70 - 6/72
Y
Ø.25
Ø.20
Ø.15
Ø.10
Ø.05
Algal Bloom Potential
TOTAL PHOSPHORUS MG/L P
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
X
MONTHS

TRENDS - TOTAL COLIFORM

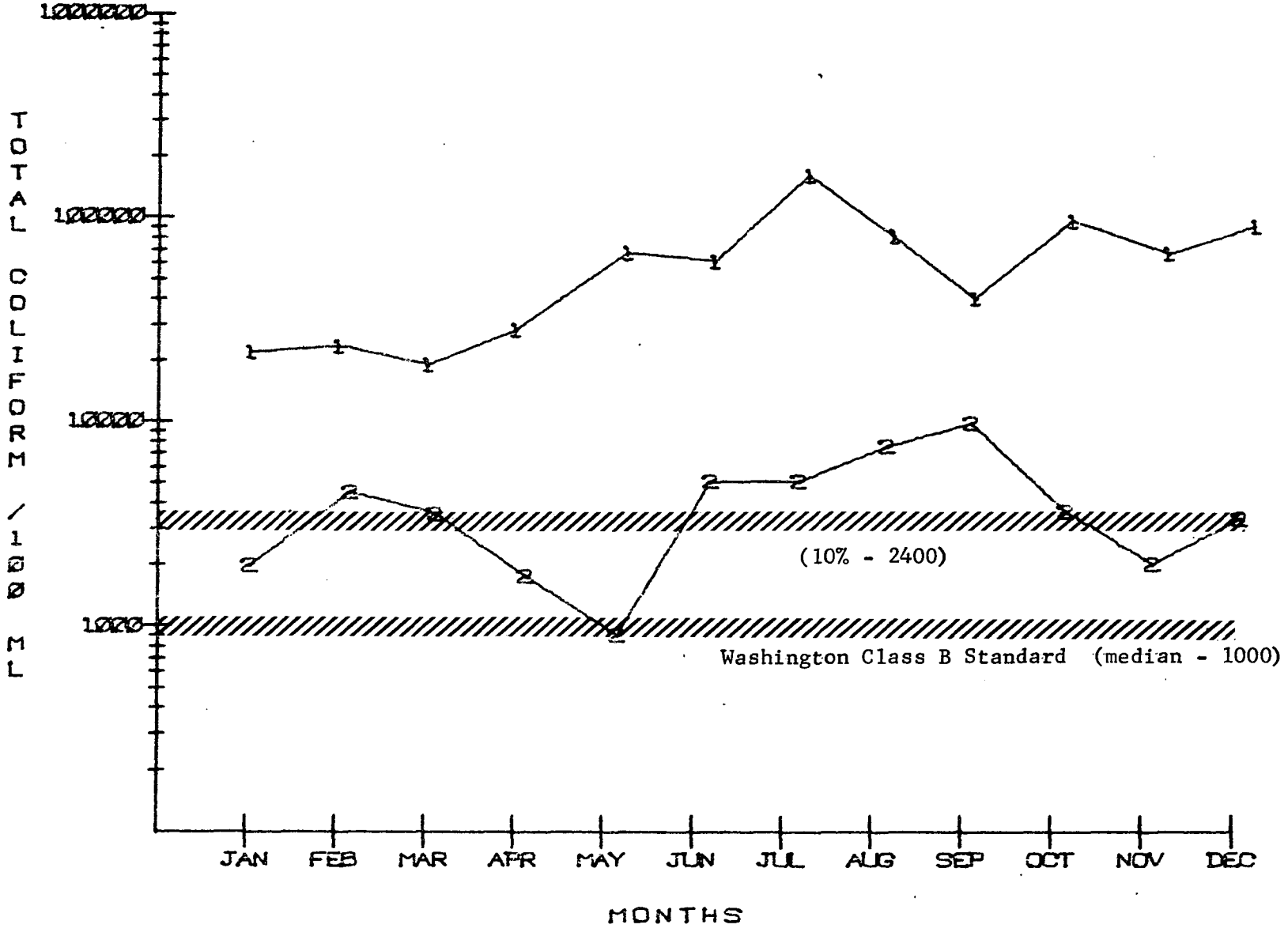
DUWAMISH RIVER AT MOUTH

DOE & METRO DATA

MONTHLY MEANS

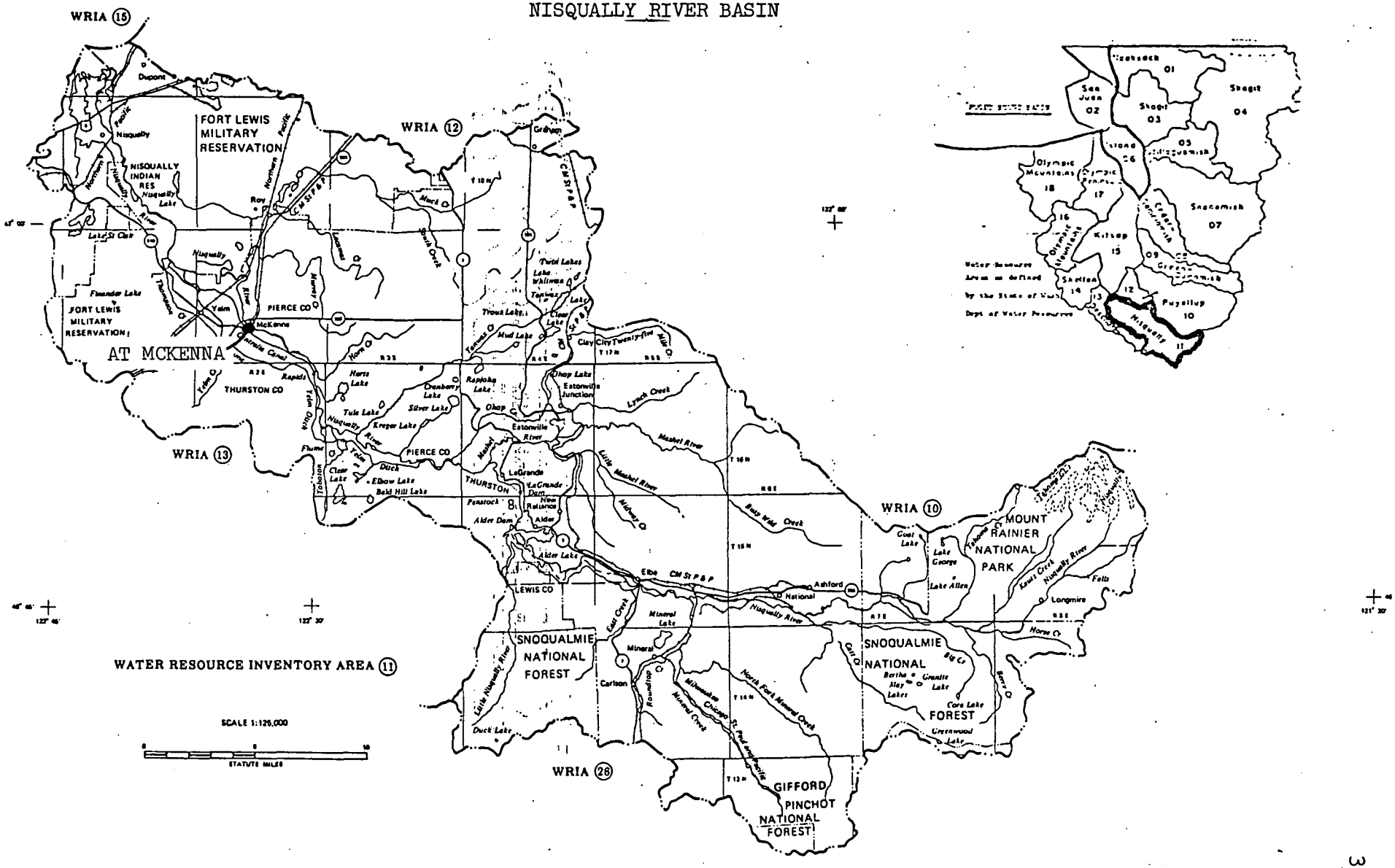
7/66 - 6/69

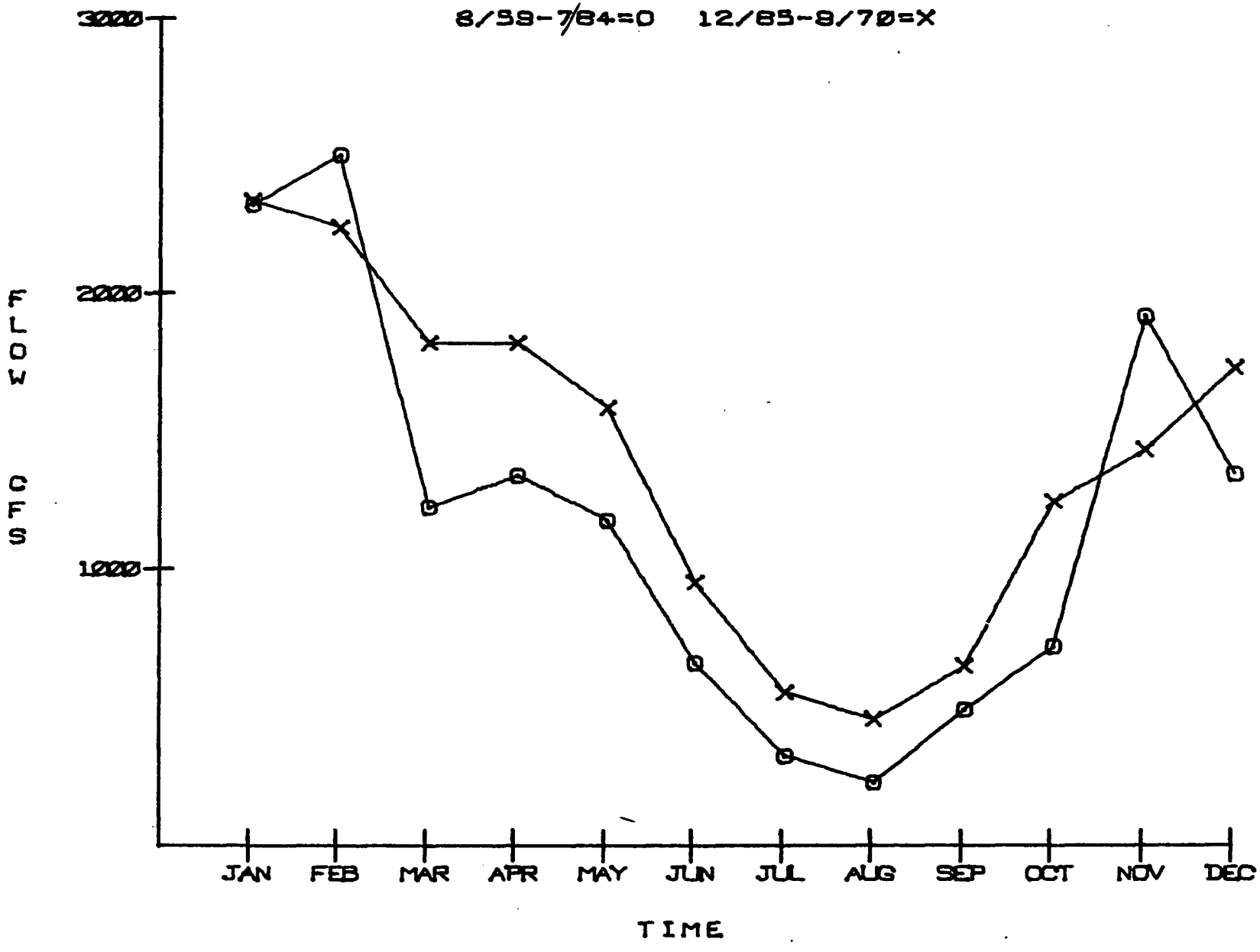
7/69 - 6/72

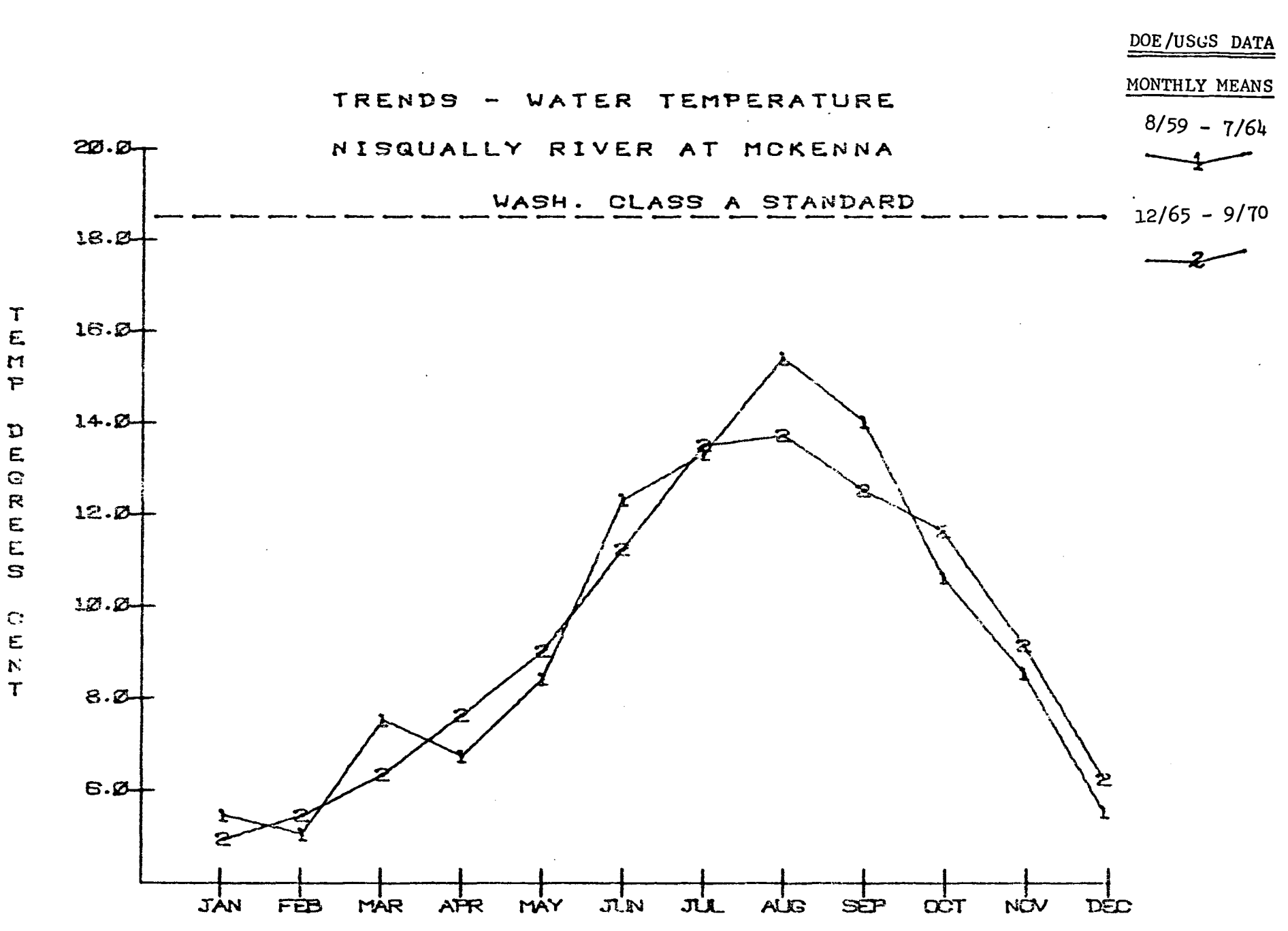


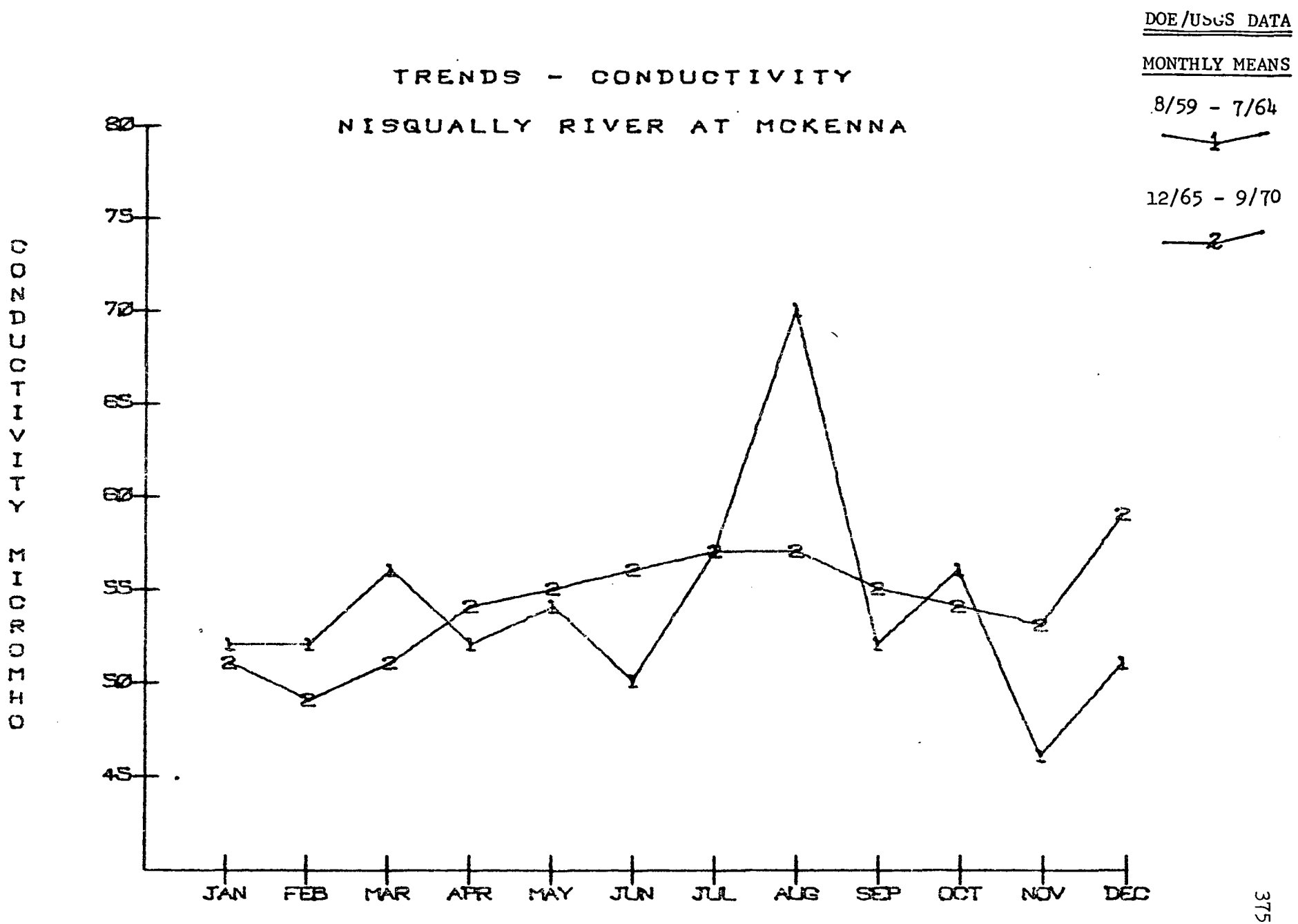
NISQUALLY RIVER BASIN

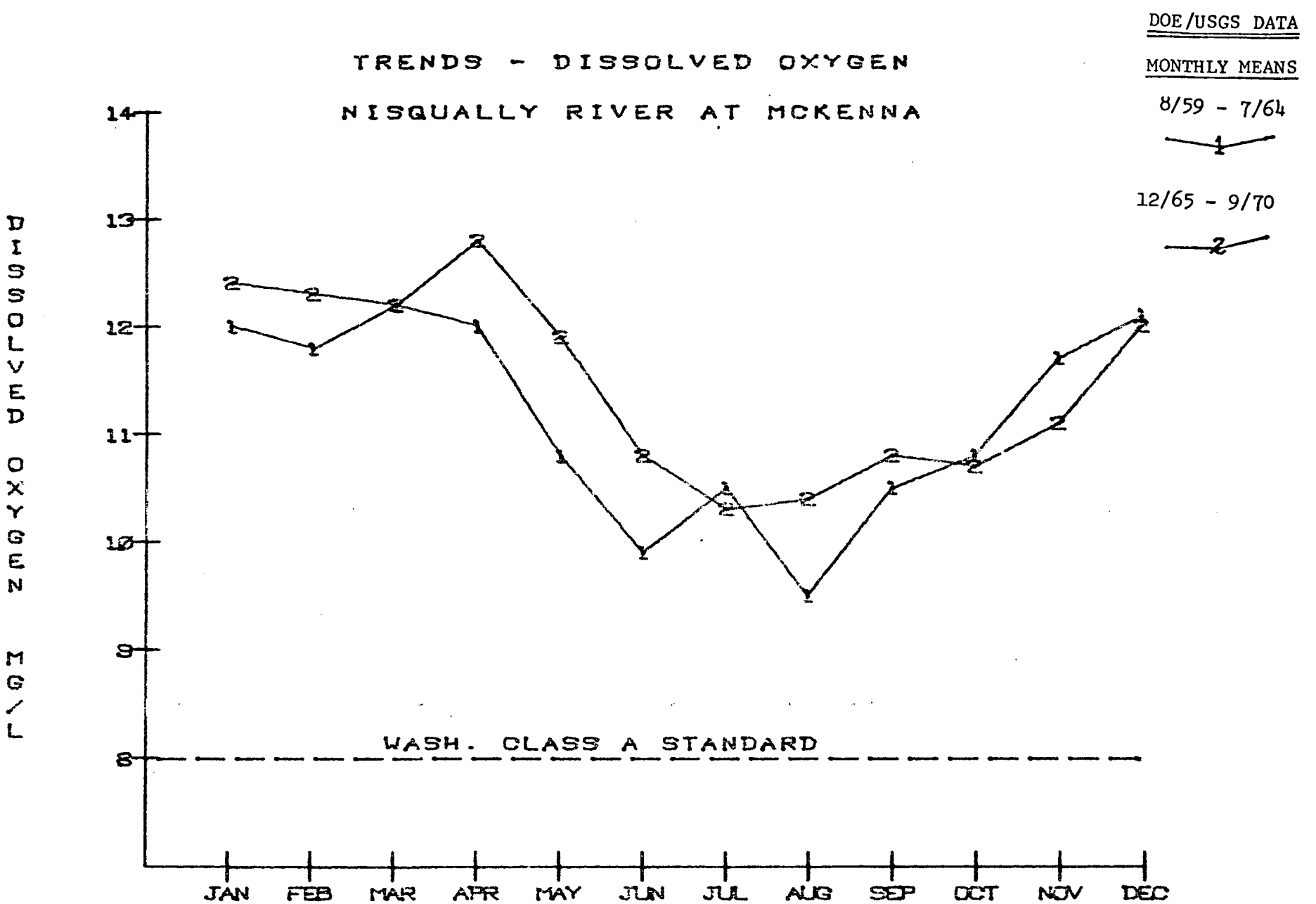
NISQUALLY RIVER BASIN




NISQUALLY RIVER AT MCKENNA
U.S.G.S. DATA MEAN VALUES
8/59-7/84=O 12/85-8/70=X
3000
2000
1000
FLOW CFS
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
TIME


TRENDS - WATER TEMPERATURE
NISQUALLY RIVER AT MCKENNA
WASH. CLASS A STANDARD
DOE/USGS DATA
MONTHLY MEANS
8/59 - 7/64
12/65 - 9/70
TEMP DEGREES CENT
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC


TRENDS - CONDUCTIVITY
NISQUALLY RIVER AT MCKENNA
DOE/USGS DATA
MONTHLY MEANS
8/59 - 7/64
12/65 - 9/70
CONDUCTIVITY MICROMHO
80
75
70
65
60
55
50
45
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC


TRENDS - DISSOLVED OXYGEN
NISQUALLY RIVER AT MCKENNA
DOE/USGS DATA
MONTHLY MEANS
8/59 - 7/64
12/65 - 9/70
DISSOLVED OXYGEN MG/L
14
13
12
11
10
9
8
WASH. CLASS A STANDARD
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

DOE/USGS DATA

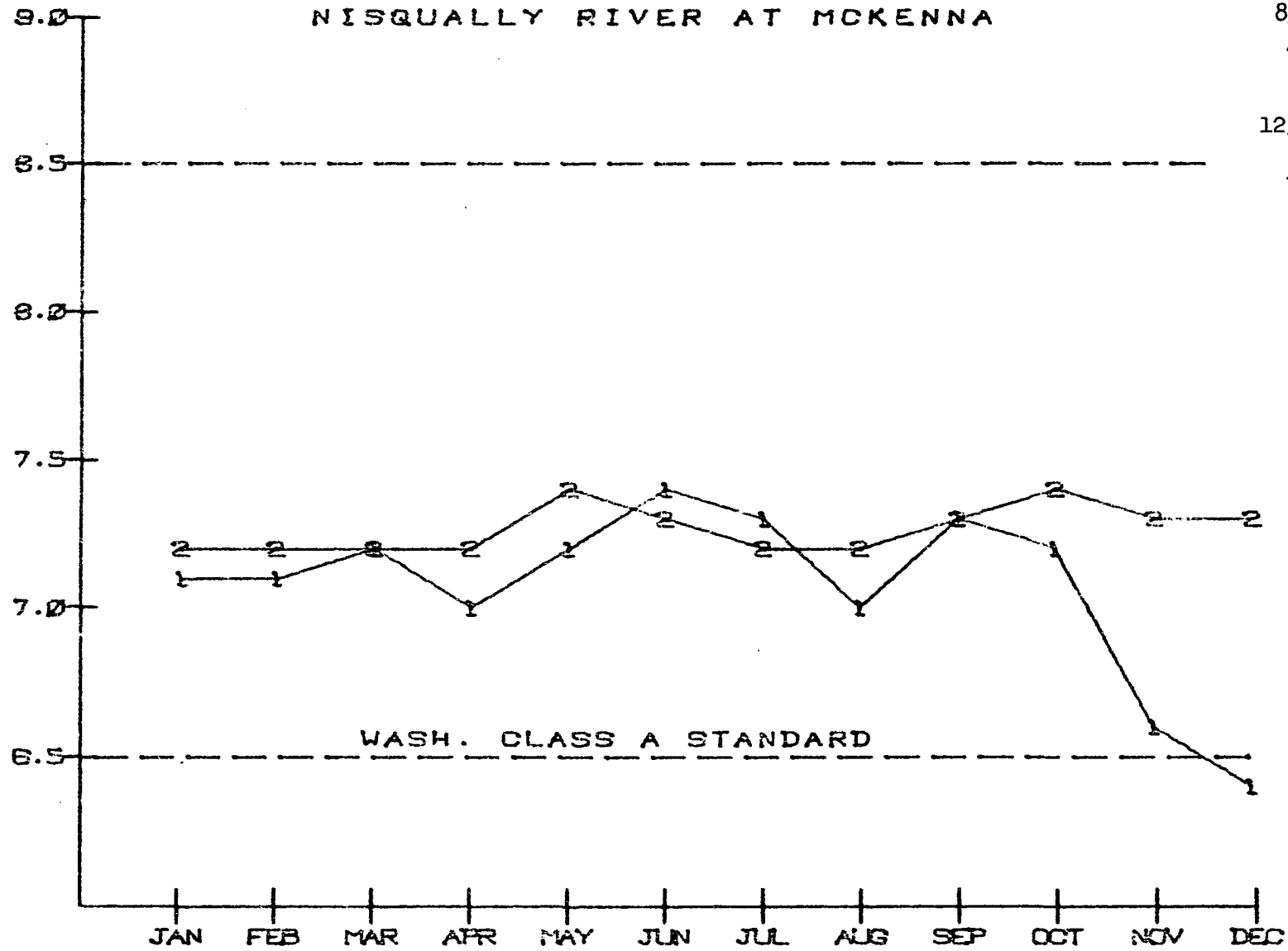
MONTHLY MEANS

8/59 - 7/64

12/65 - 9/70

TRENDS - PH

NISQUALLY RIVER AT MCKENNA

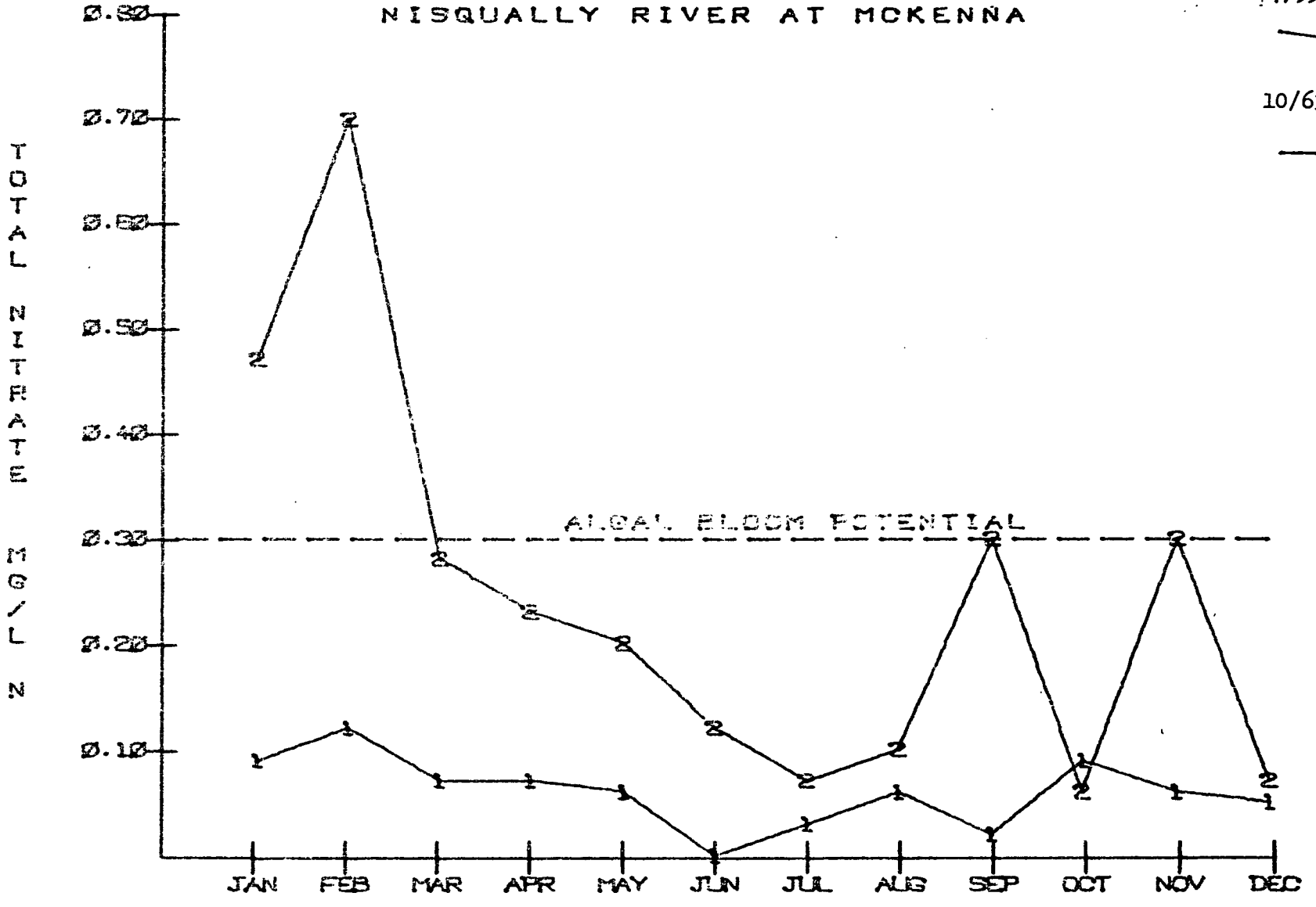


DOE/USGS DATA

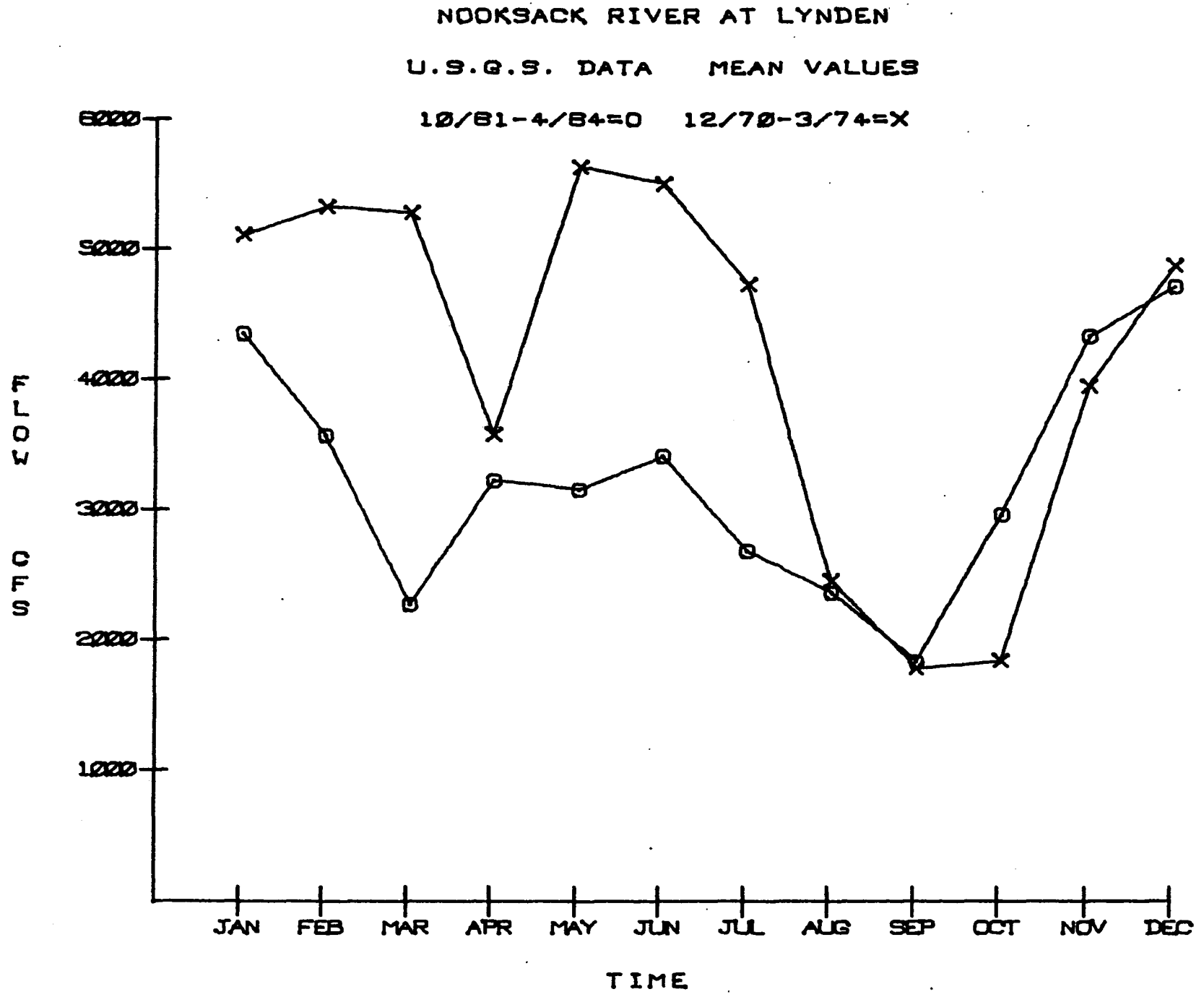
MONTHLY MEANS

7/59 - 7/63

10/63 - 9/67



NOOKSACK RIVER BASIN


NOOKSACK RIVER AT LYNDEN
U.S.G.S. DATA MEAN VALUES
10/81-4/84=O 12/70-3/74=X
6000
5000
4000
3000
2000
1000
FLOW CFS
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
TIME

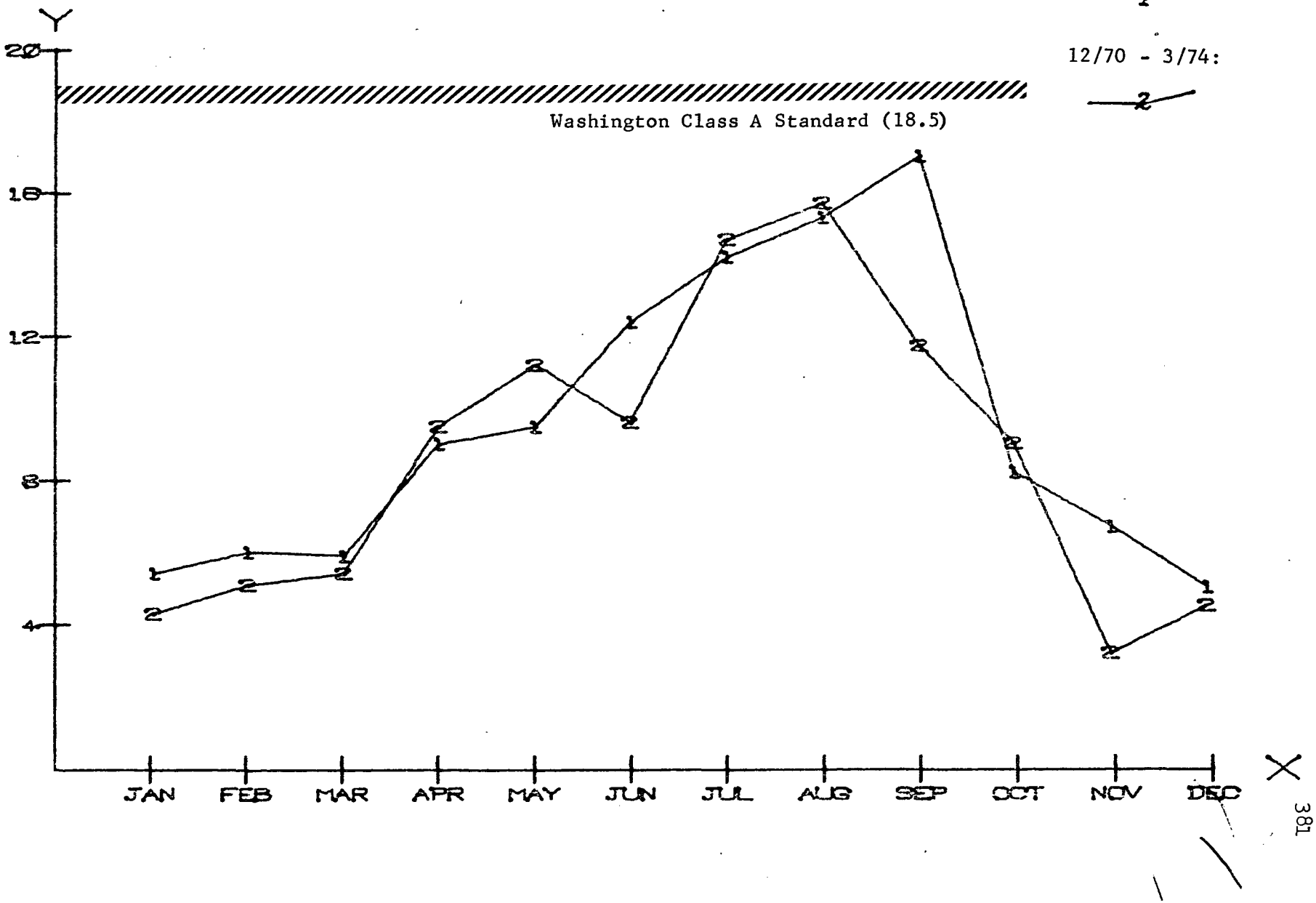
DOE/USGS DATA

MONTHLY MEANS

10/61 - 4/64:

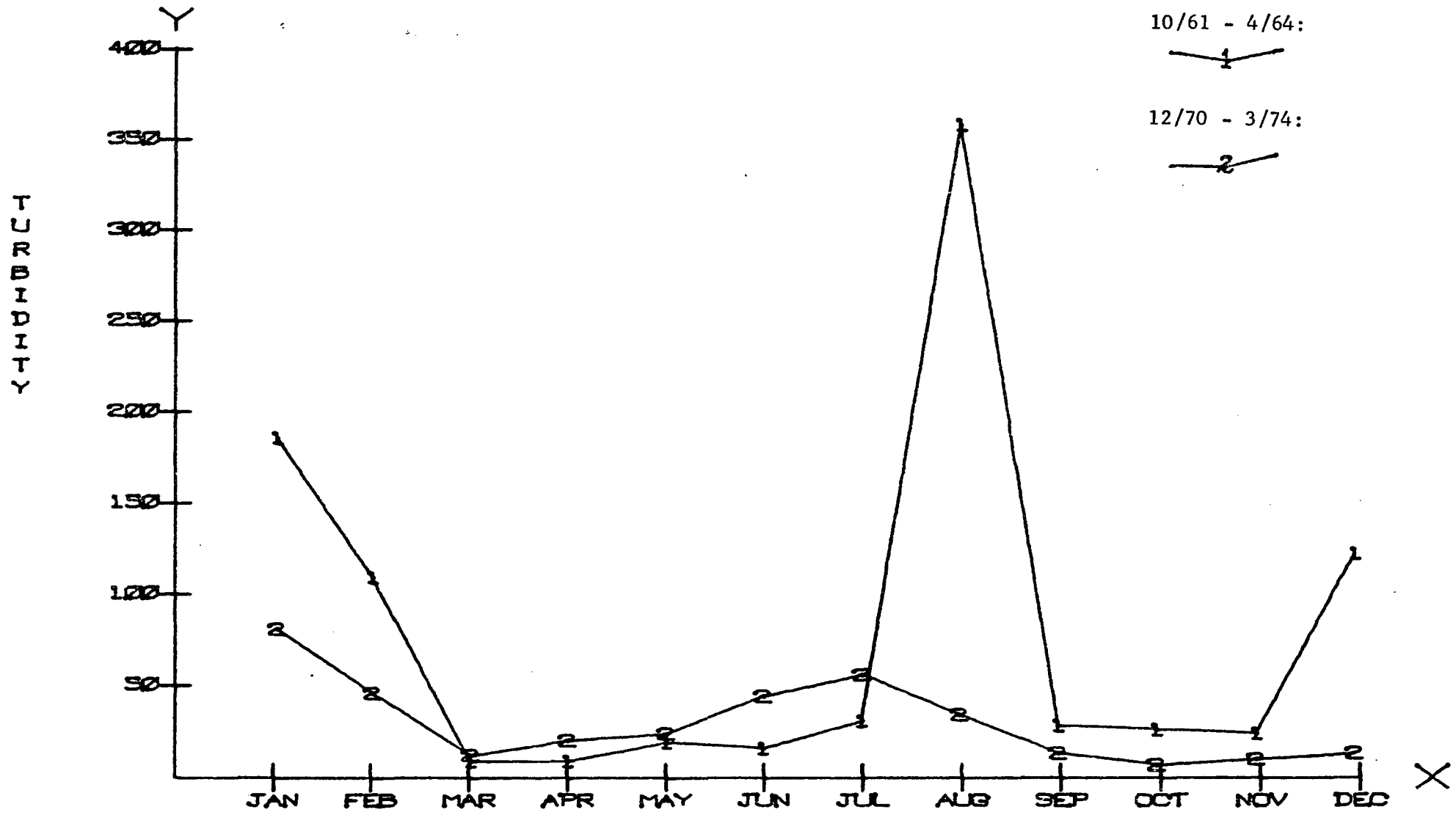
12/70 - 3/74:

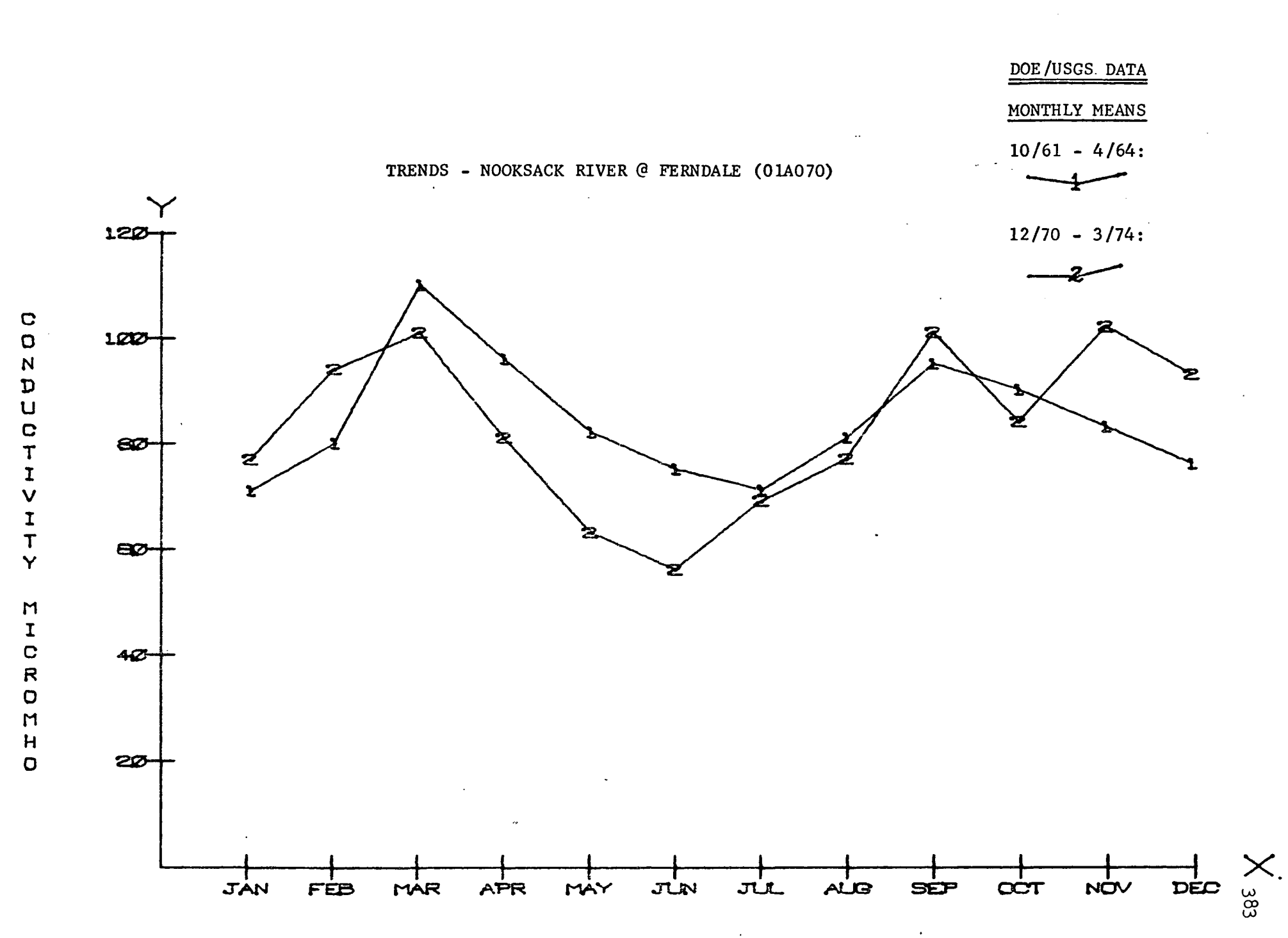
TRENDS - NOOKSACK RIVER @ FERNDALE (01A070)



TEMP DEGREES CENT

TRENDS - NOOKSACK RIVER @ FERNDALE (01A070)




DOE/USGS. DATA
MONTHLY MEANS
10/61 - 4/64:
12/70 - 3/74:
TRENDS - NOOKSACK RIVER @ FERNDALE (01A070)
Y
120
100
80
60
40
20
CONDUCTIVITY MICROMHO
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
X

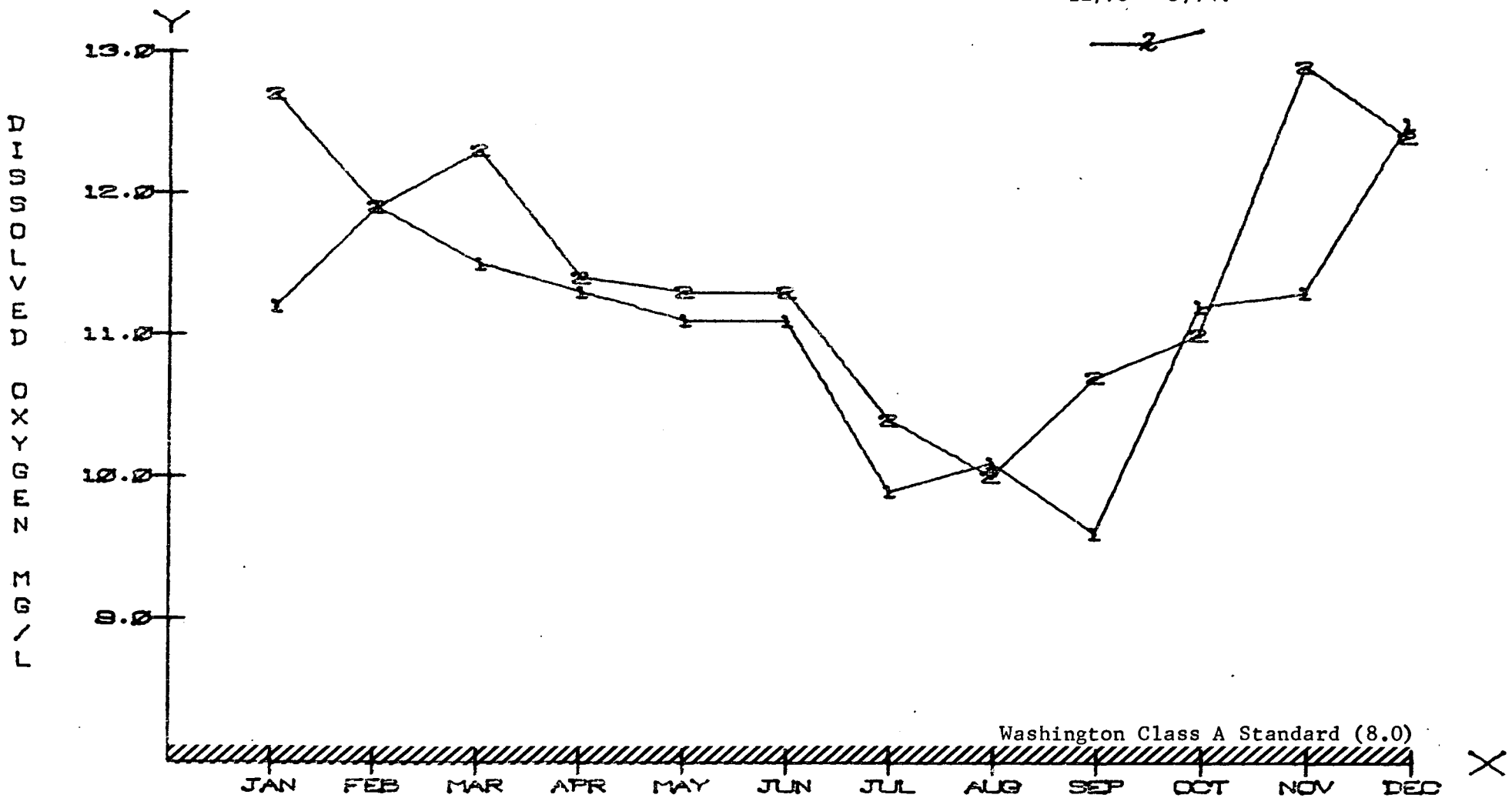
TRENDS - NOOKSACK RIVER @ FERNDALE (01A070)

DOE/USGS DATA

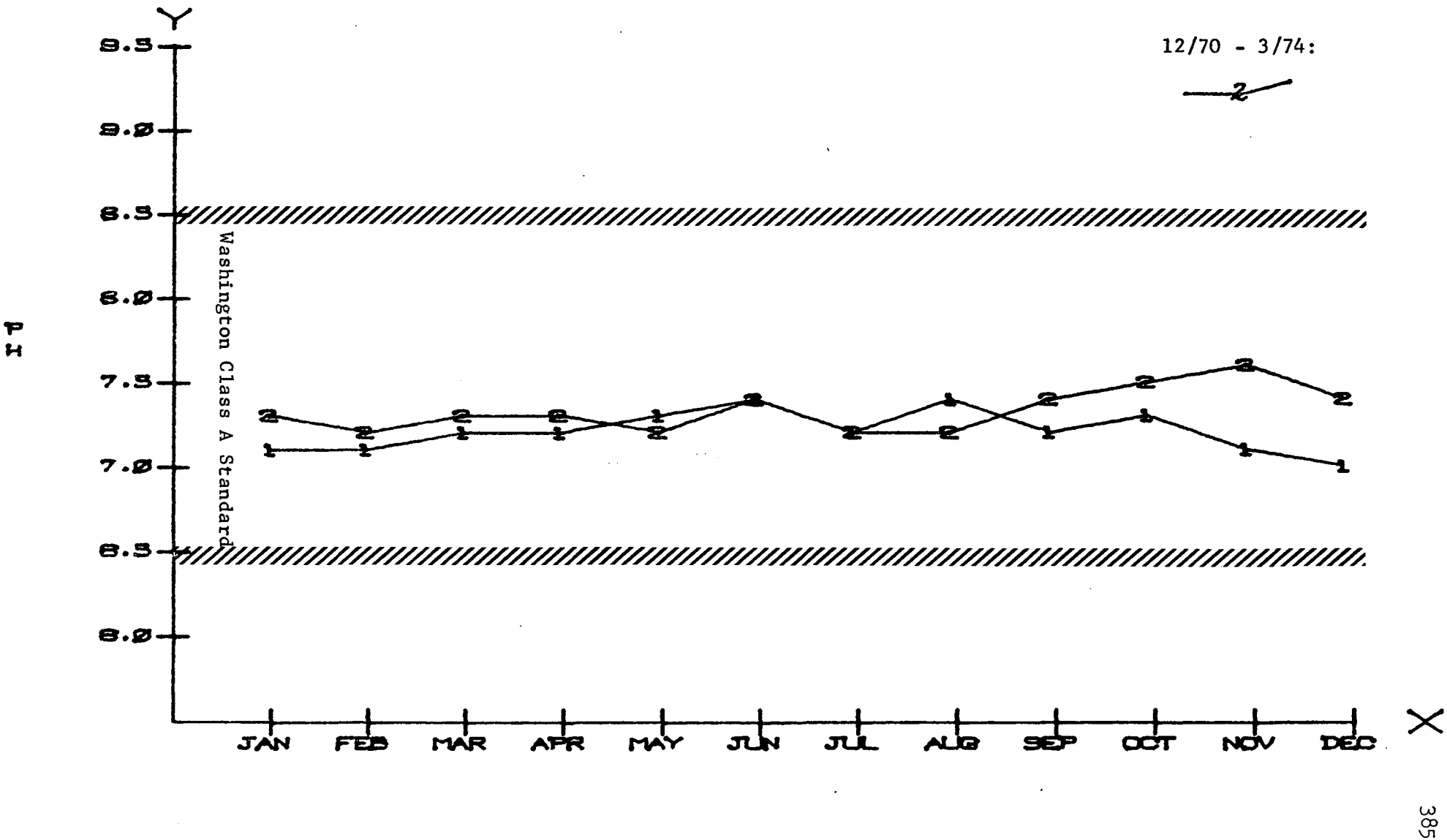
MONTHLY MEANS

10/61 - 4/64:

12/70 - 3/74:



TRENDS - NOOKSACK RIVER @ FERNDALE (01A070)



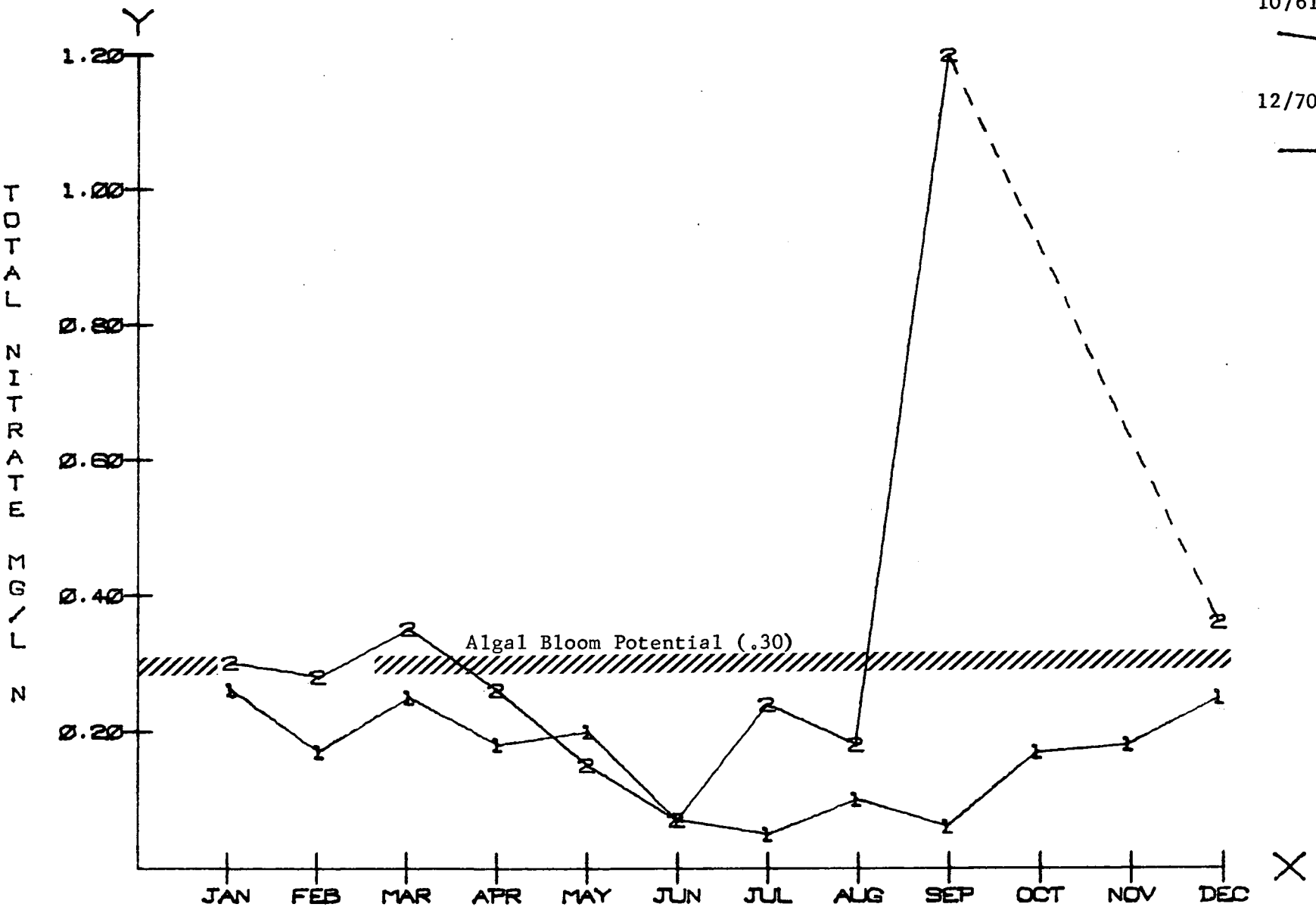
DOE/USGS DATA

MONTHLY MEANS

10/61 - 4/64:

12/70 - 9/71:

TRENDS - NOOKSACK RIVER @ FERNDALE (01A070)



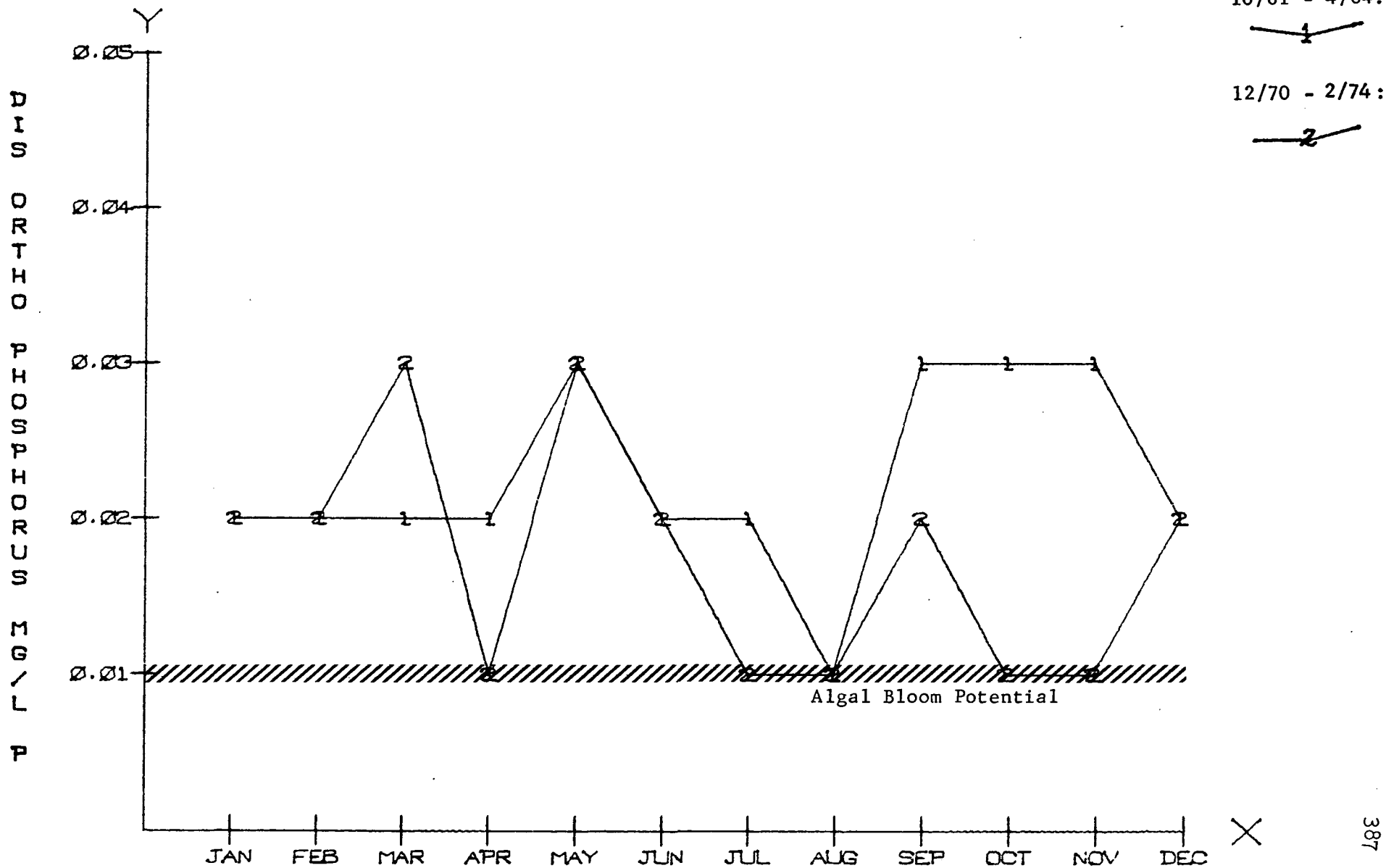
DOE/U[illegible] DATA

MONTHLY MEANS

10/61 - 4/64:

12/70 - 2/74:

TRENDS - NOOKSACK RIVER @ FERNDALE (01A070)



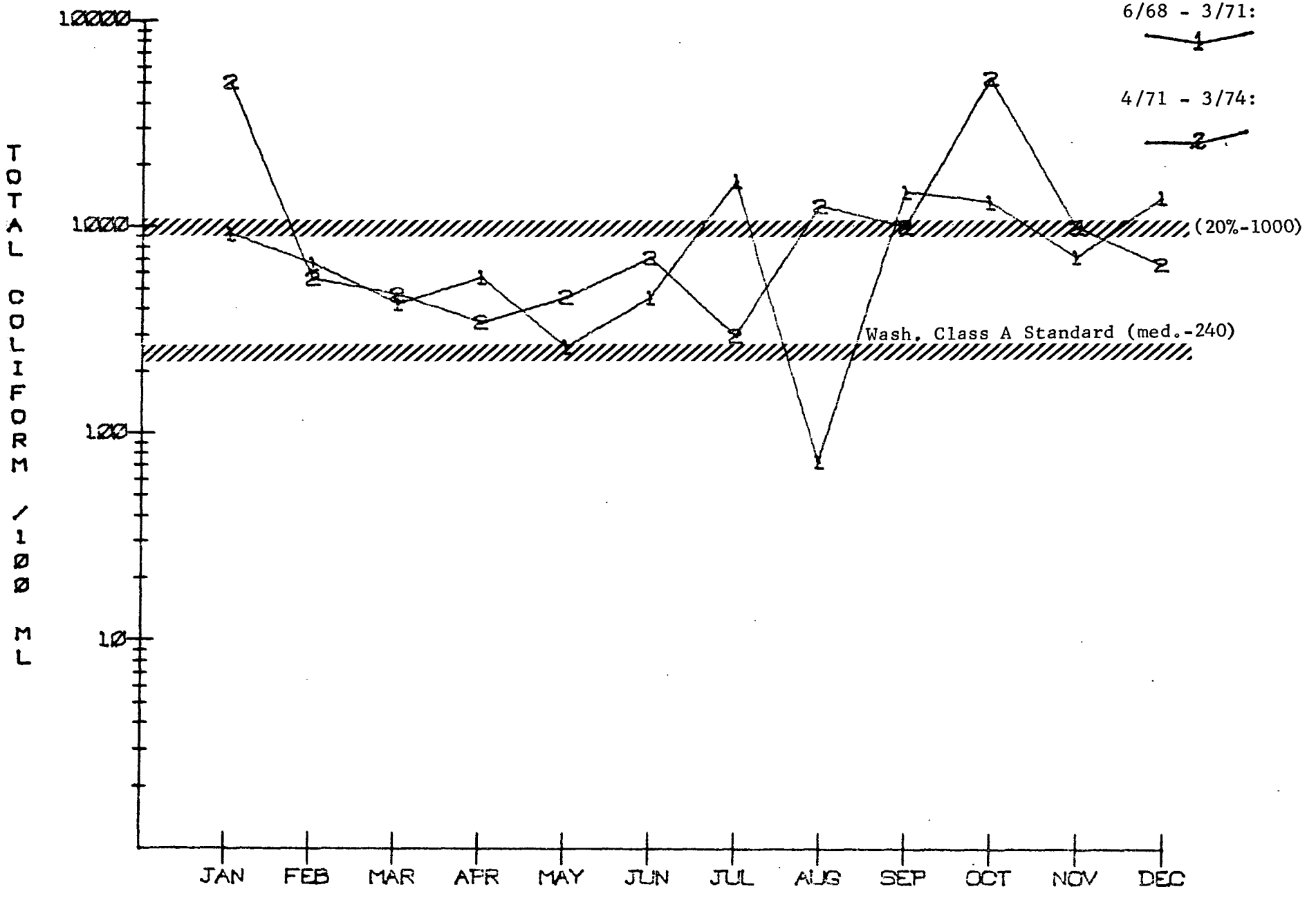
DOE/USG. DATA

MONTHLY MEANS

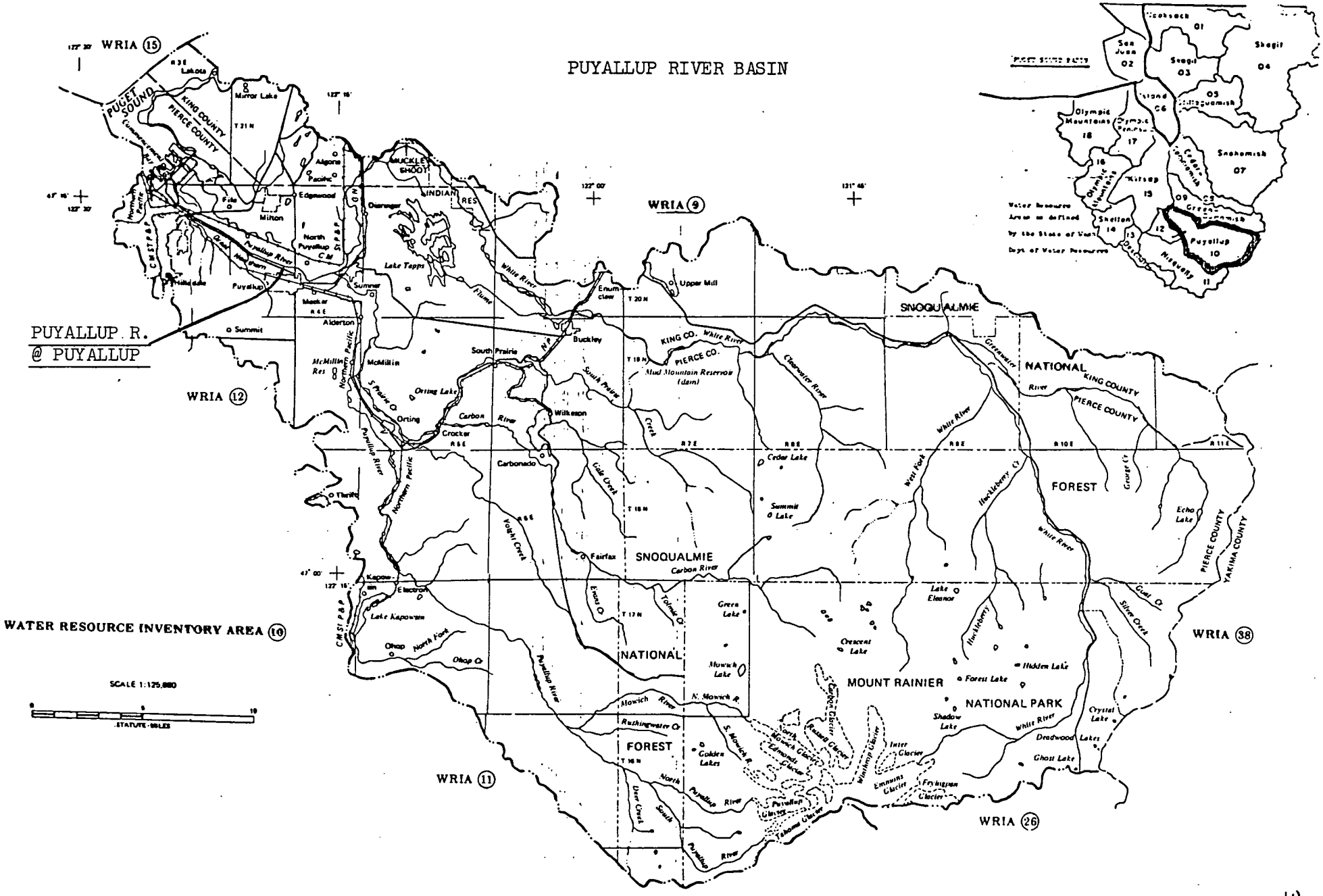
6/68 - 3/71:

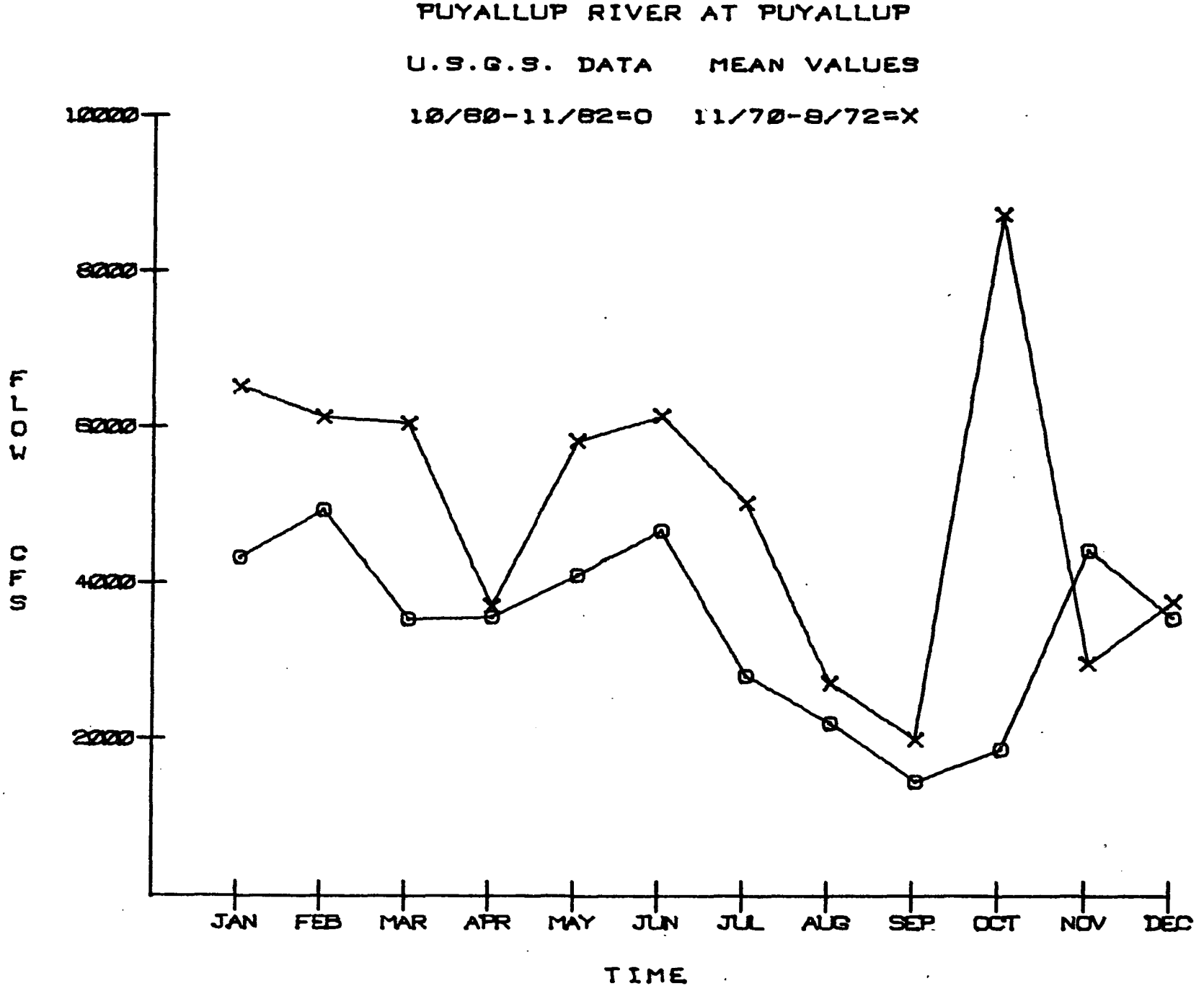
4/71 - 3/74:

TRENDS - NOOKSACK RIVER @ FERNDALE (01A070)



PUYALLUP RIVER BASIN


PUYALLUP RIVER BASIN
PUYALLUP R. @ PUYALLUP
WATER RESOURCE INVENTORY AREA (10)
WRIA (15)
WRIA (12)
WRIA (9)
WRIA (11)
WRIA (38)
WRIA (26)
PUGET SOUND
KING COUNTY
PIERCE COUNTY
SNOQUALMIE
NATIONAL FOREST
MOUNT RAINIER NATIONAL PARK
Mud Mountain Reservoir (dam)
Lake Tapps
Lake Kapowsin
Carbon River
White River
Puyallup River
SCALE 1:125,880
STATUTE MILES


PUYALLUP RIVER AT PUYALLUP
U.S.G.S. DATA MEAN VALUES
10/60-11/62=O 11/70-8/72=X
10000
8000
6000
4000
2000
FLOW CFS
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
TIME

DOE/USGS DATA

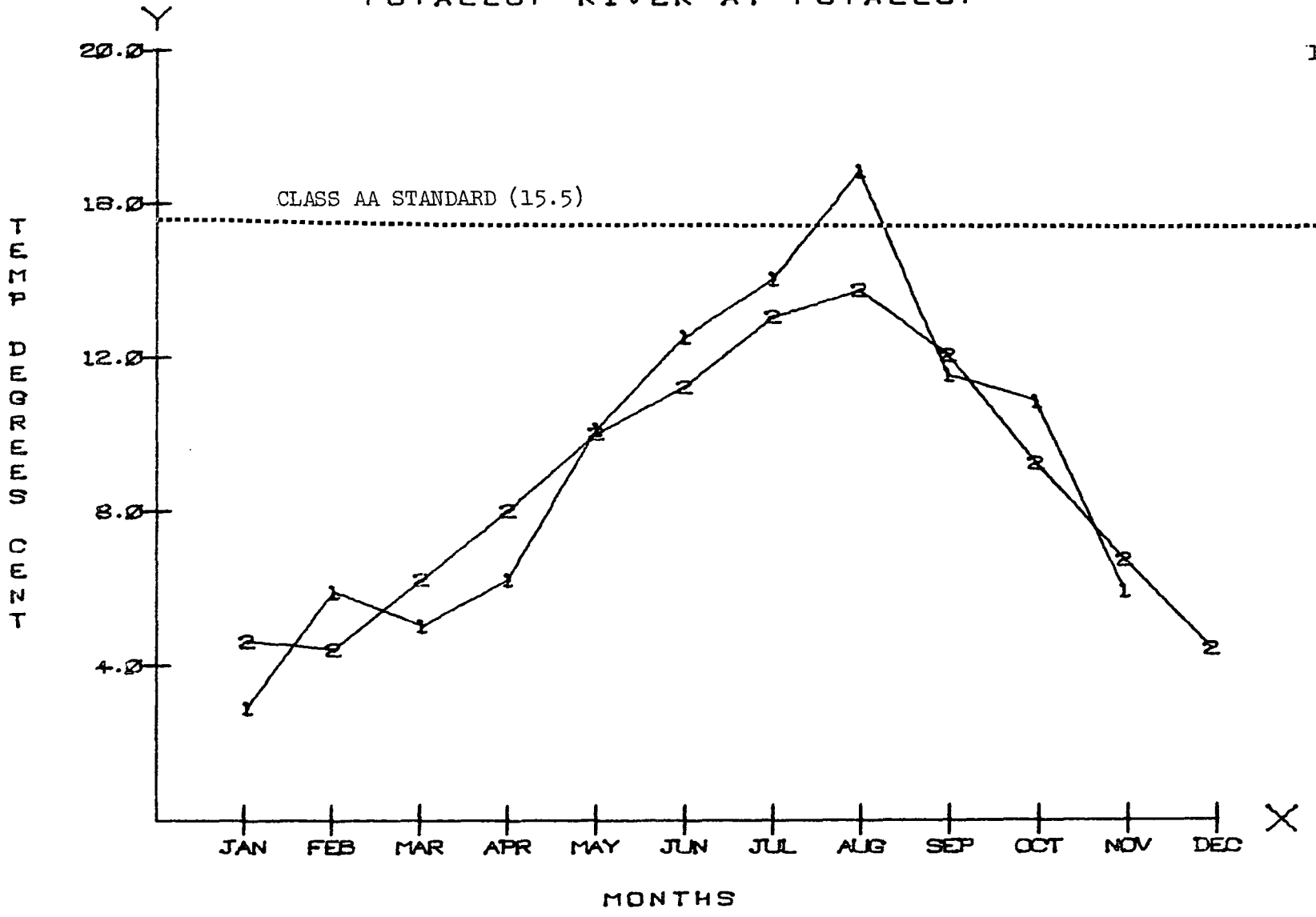
MONTHLY MEANS

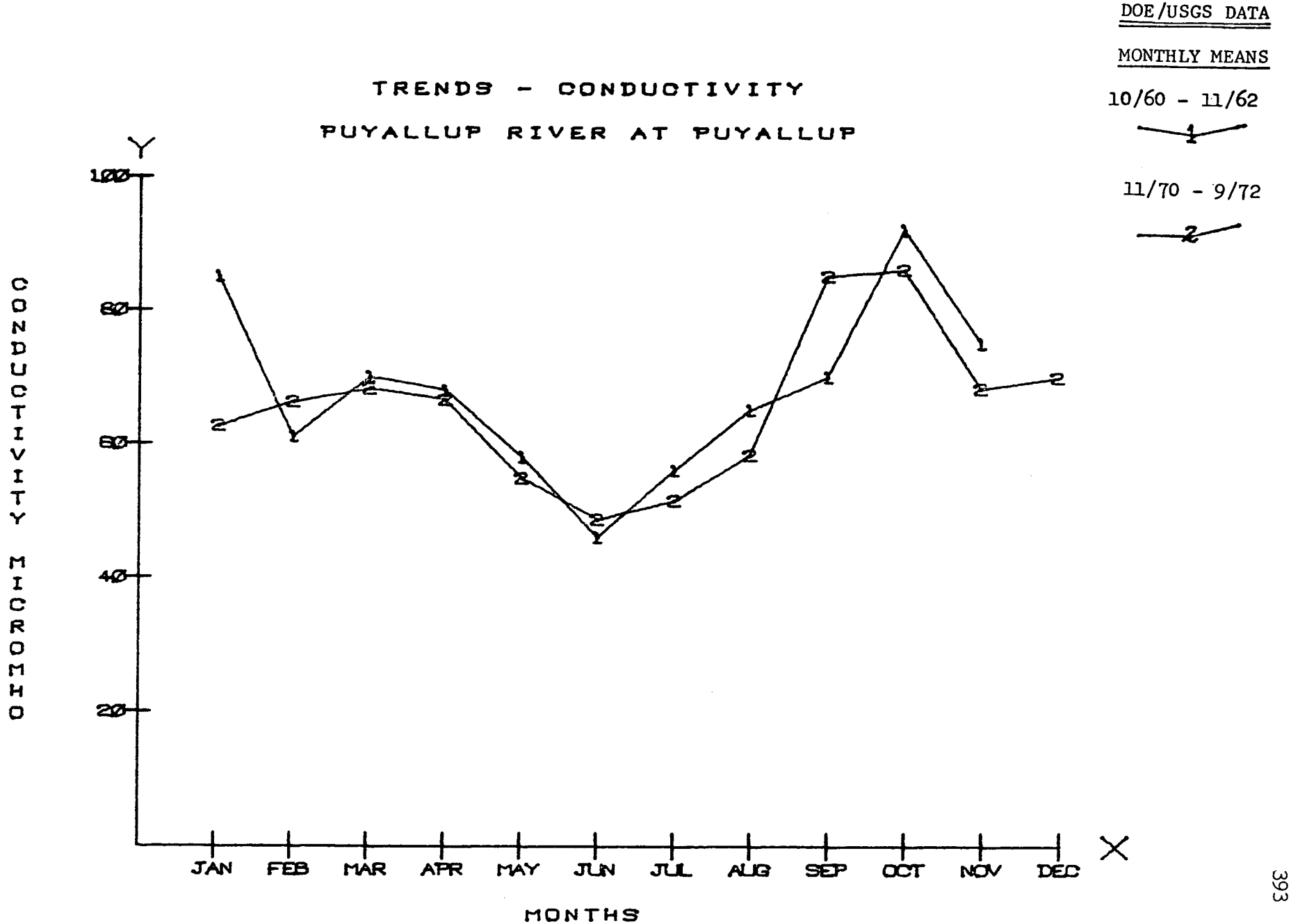
10/60 - 11/62

11/70 - 9/72

TRENDS - WATER TEMPERATURE

PUYALLUP RIVER AT PUYALLUP




TRENDS - CONDUCTIVITY
PUYALLUP RIVER AT PUYALLUP
DOE/USGS DATA
MONTHLY MEANS
10/60 - 11/62
11/70 - 9/72
Y
100
80
60
40
20
CONDUCTIVITY MICROMHO
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
X
MONTHS

DOE/USGS DATA

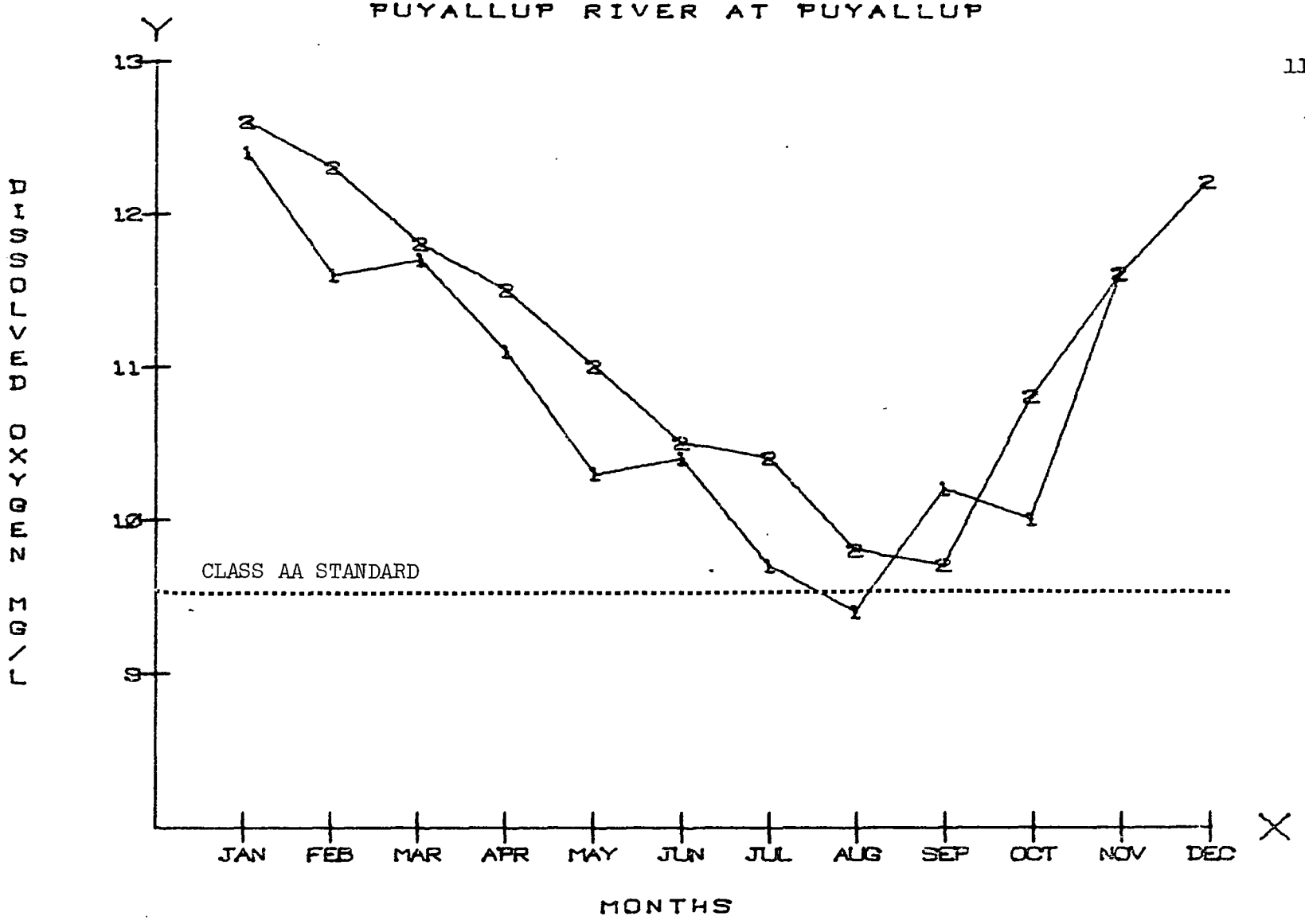
MONTHLY MEANS

10/60 - 11/62

11/70 - 9/72

TRENDS - DISSOLVED OXYGEN

PUYALLUP RIVER AT PUYALLUP



DOE [redacted] DATA

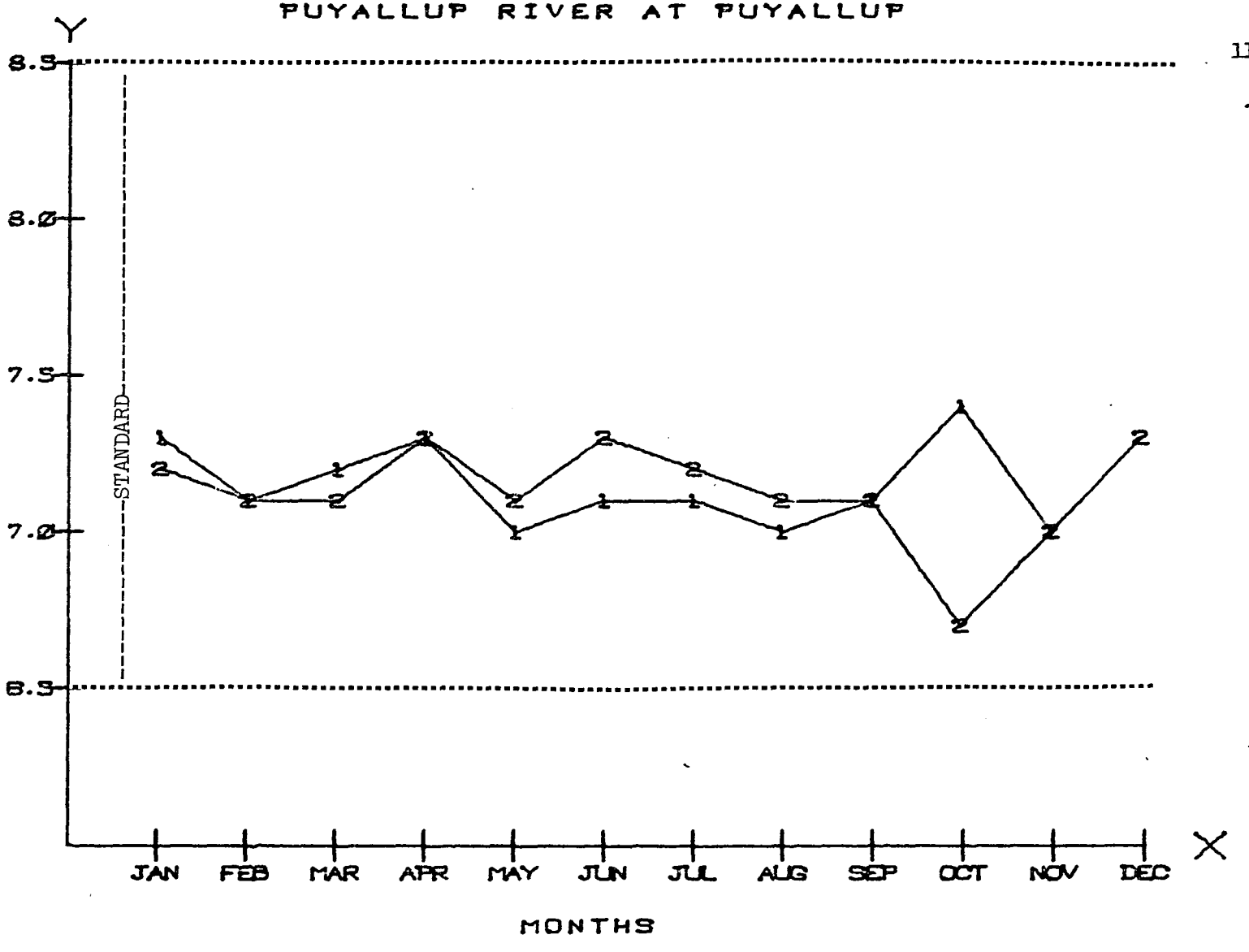
MONTHLY MEANS

10/60 - 11/62

11/70 - 9/72

TRENDS - PH

PUYALLUP RIVER AT PUYALLUP



DOE/USGS DATA

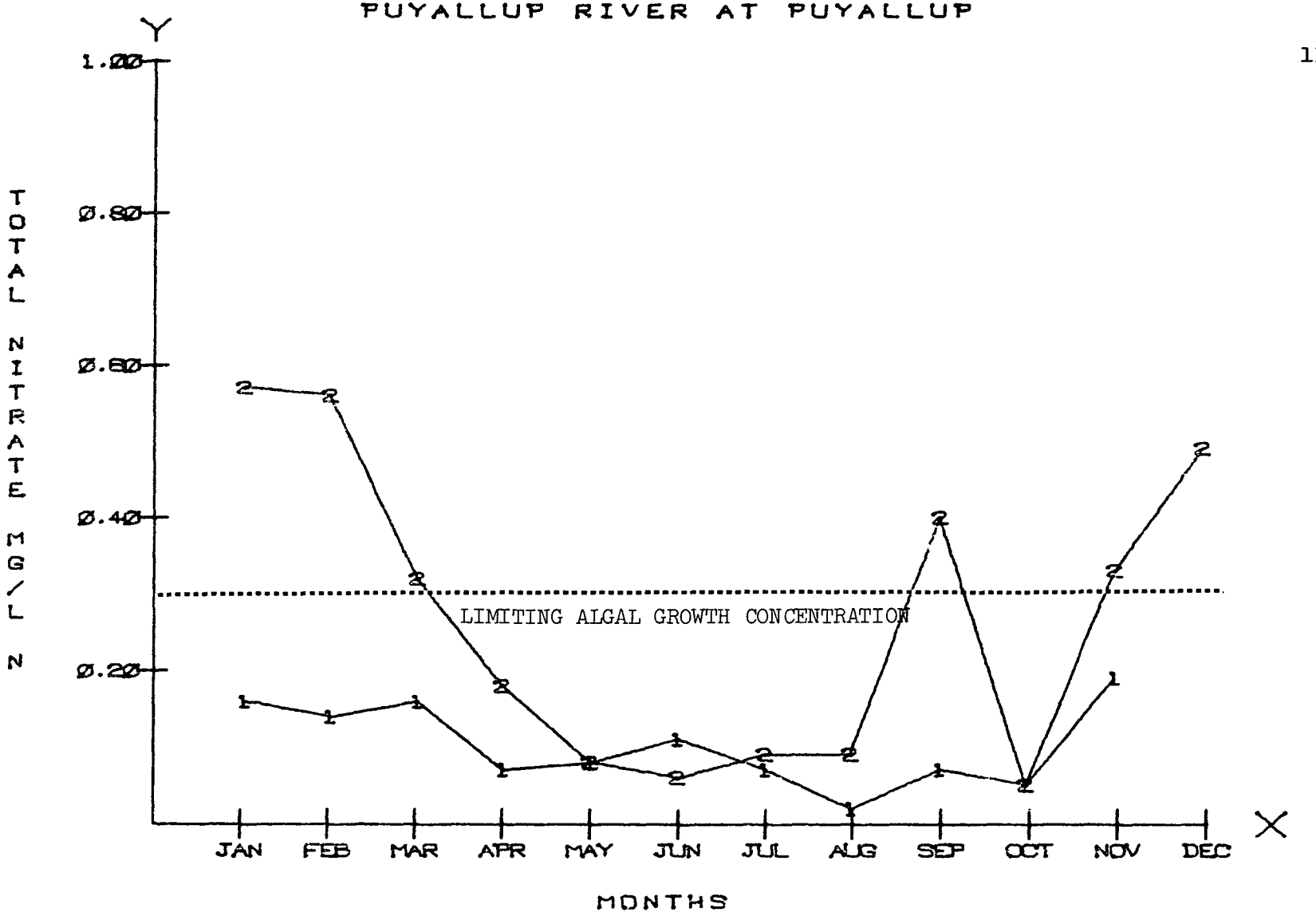
MONTHLY MEANS

10/60 - 11/62

11/70 - 9/72

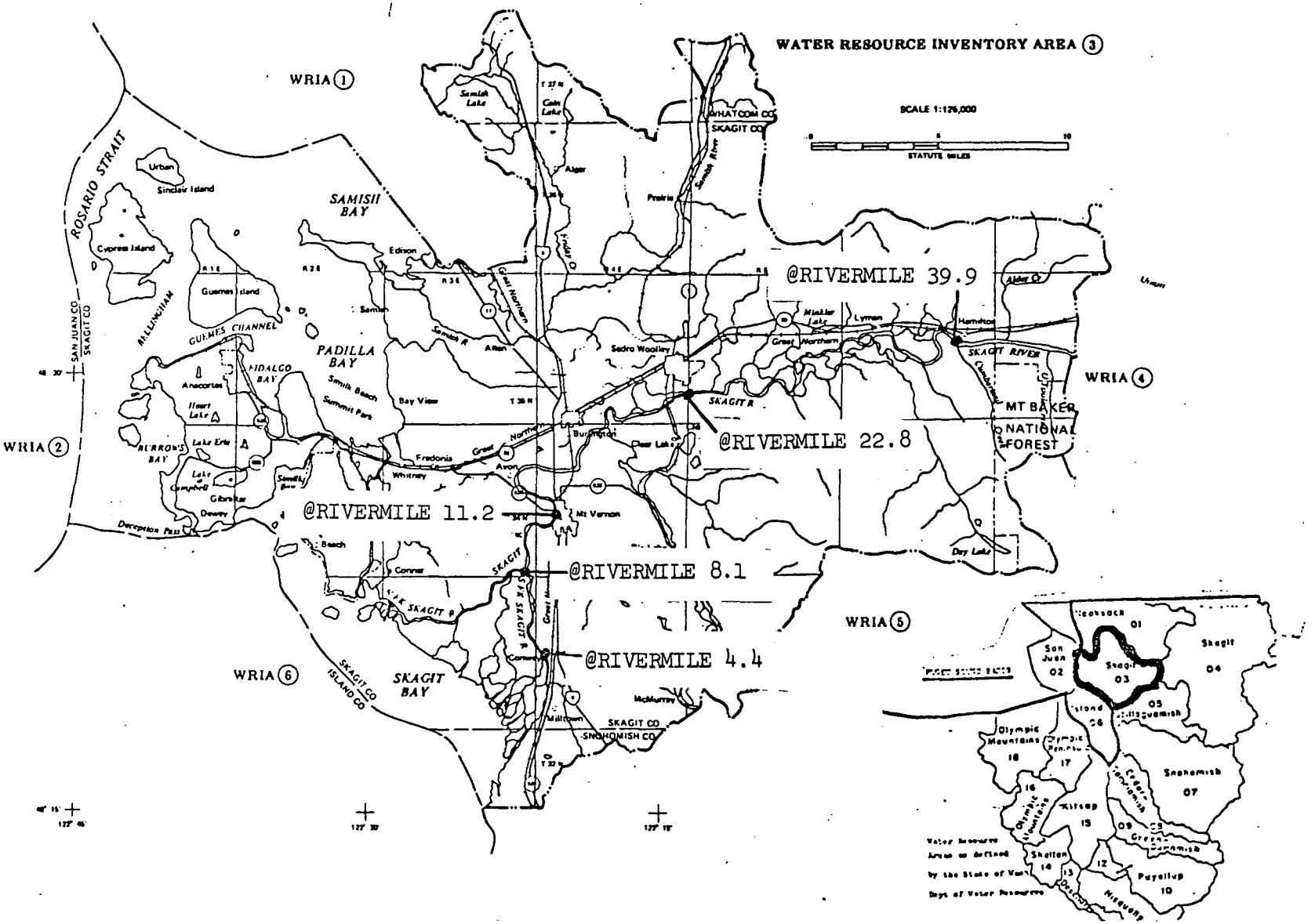
TRENDS - TOTAL NITRATE

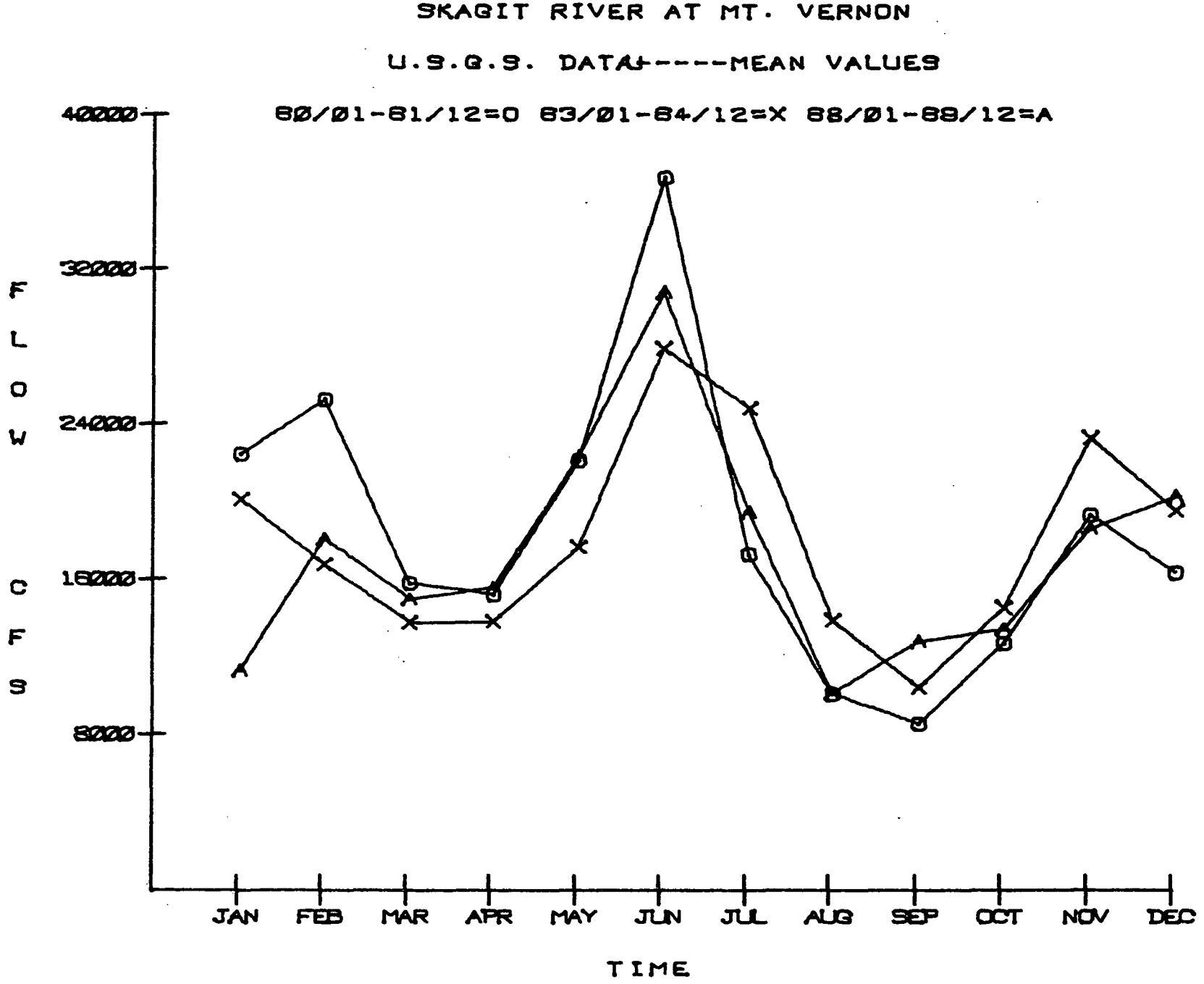
PUYALLUP RIVER AT PUYALLUP



SKAGIT RIVER BASIN

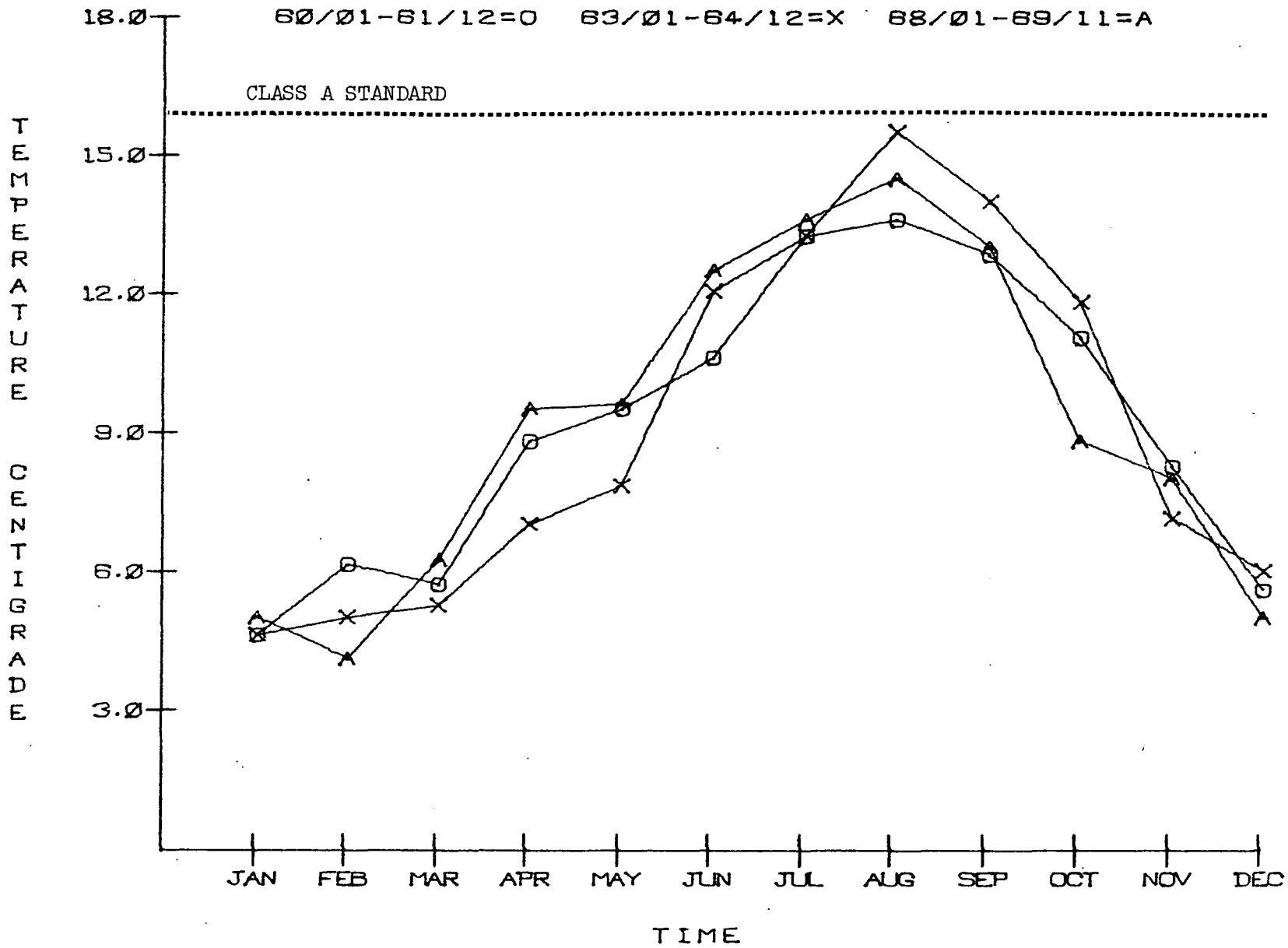
SKAGIT RIVER BASIN

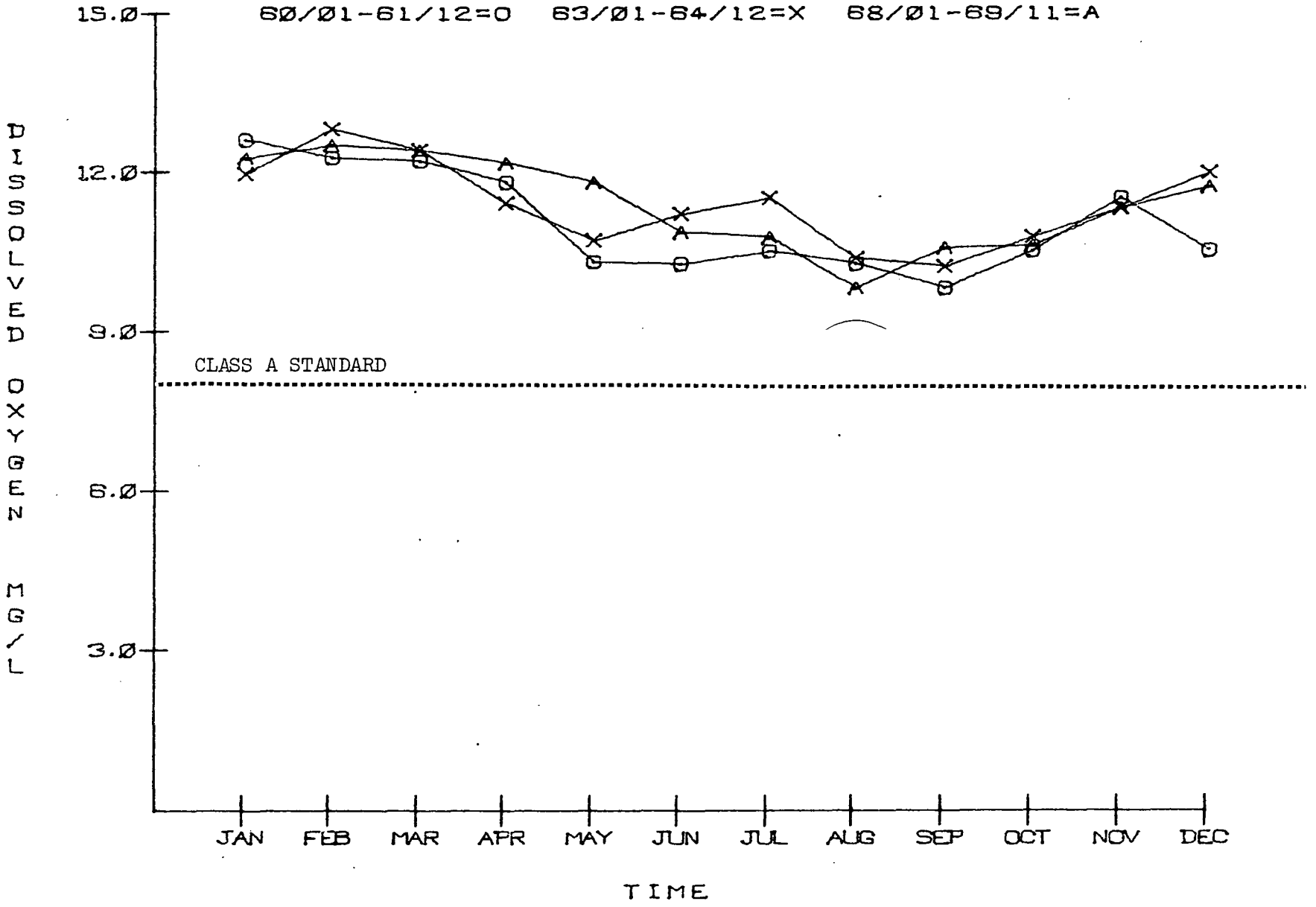


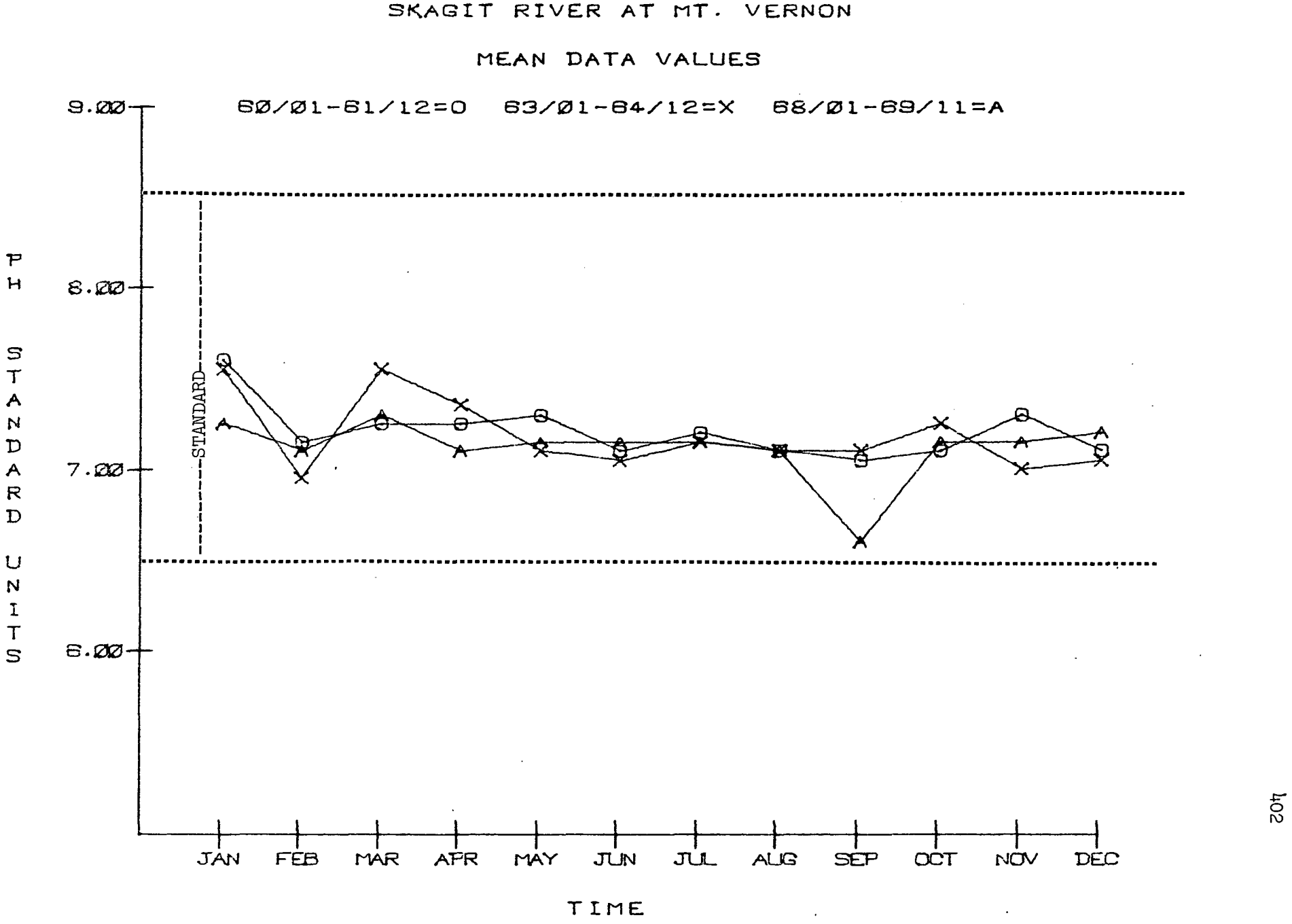

SKAGIT RIVER AT MT. VERNON
U.S.G.S. DATA+----MEAN VALUES
80/01-81/12=O 83/01-84/12=X 88/01-88/12=A
400000
320000
240000
160000
80000
FLOW
CFS
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
TIME

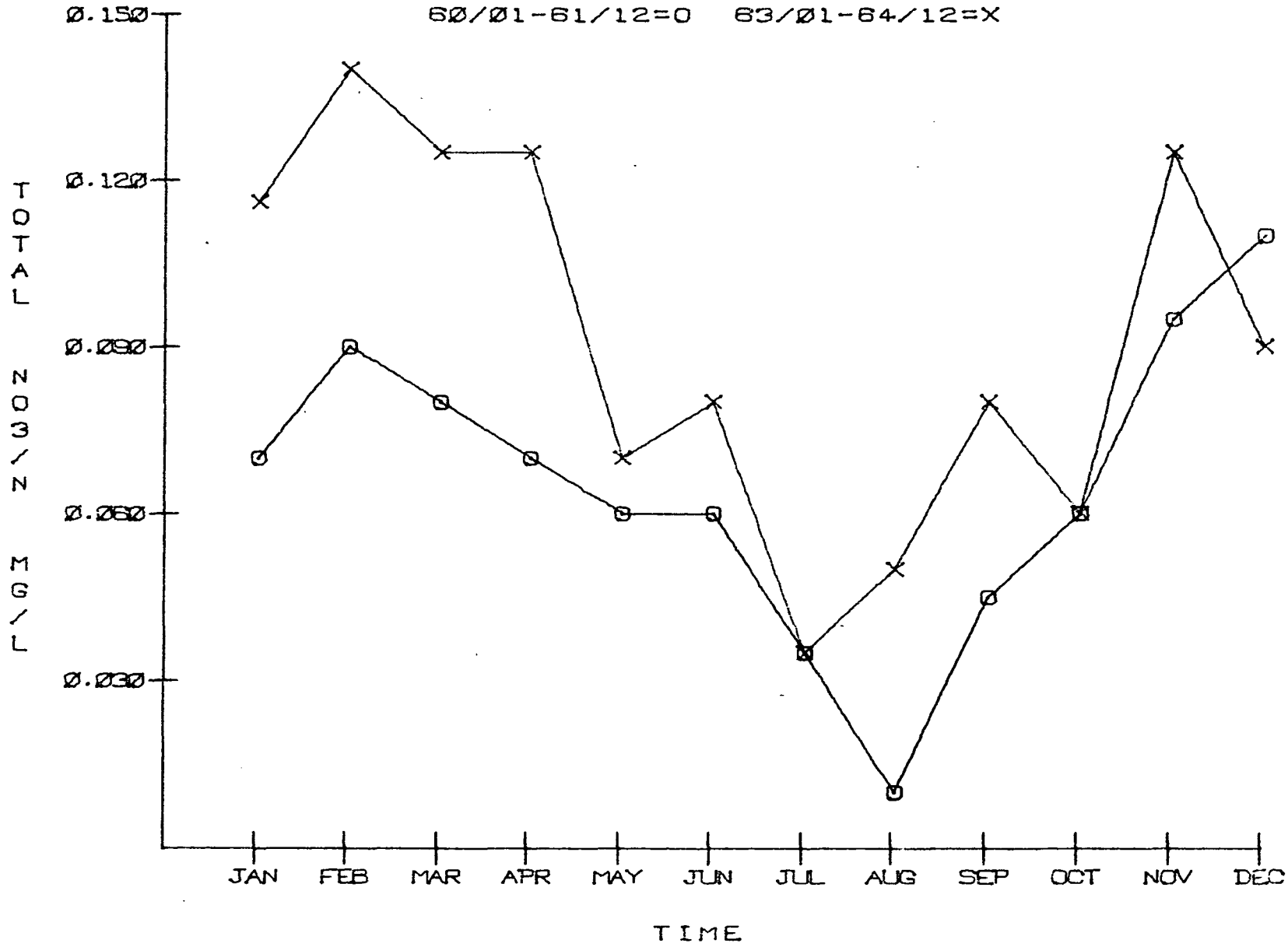
SKAGIT RIVER AT MT. VERNON

MEAN DATA VALUES



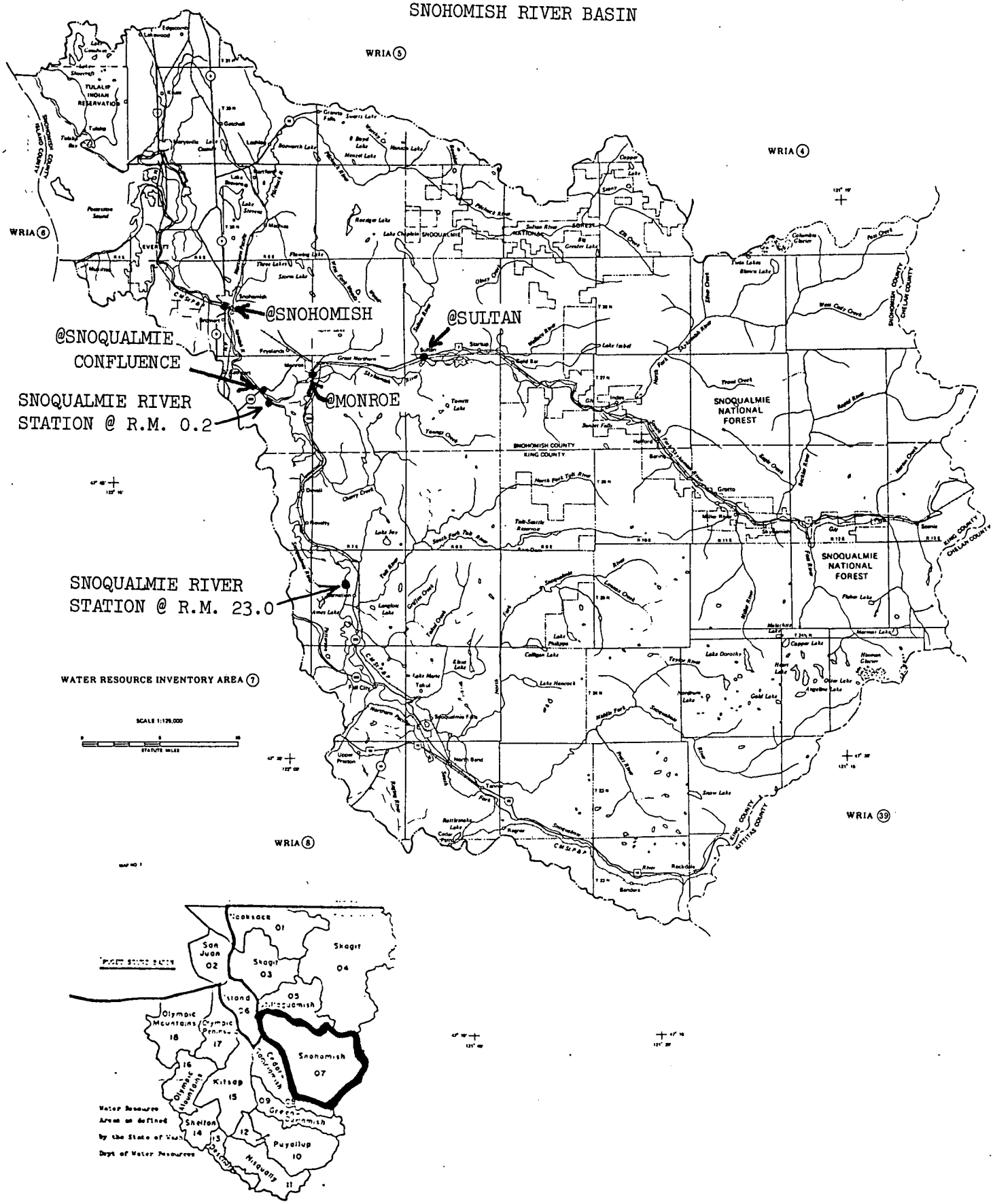

SKAGIT RIVER AT MT. VERNON
MEAN DATA VALUES
60/01-61/12=O 63/01-64/12=X 68/01-69/11=A
15.0
12.0
9.0
6.0
3.0
DISSOLVED OXYGEN MG/L
CLASS A STANDARD
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
TIME

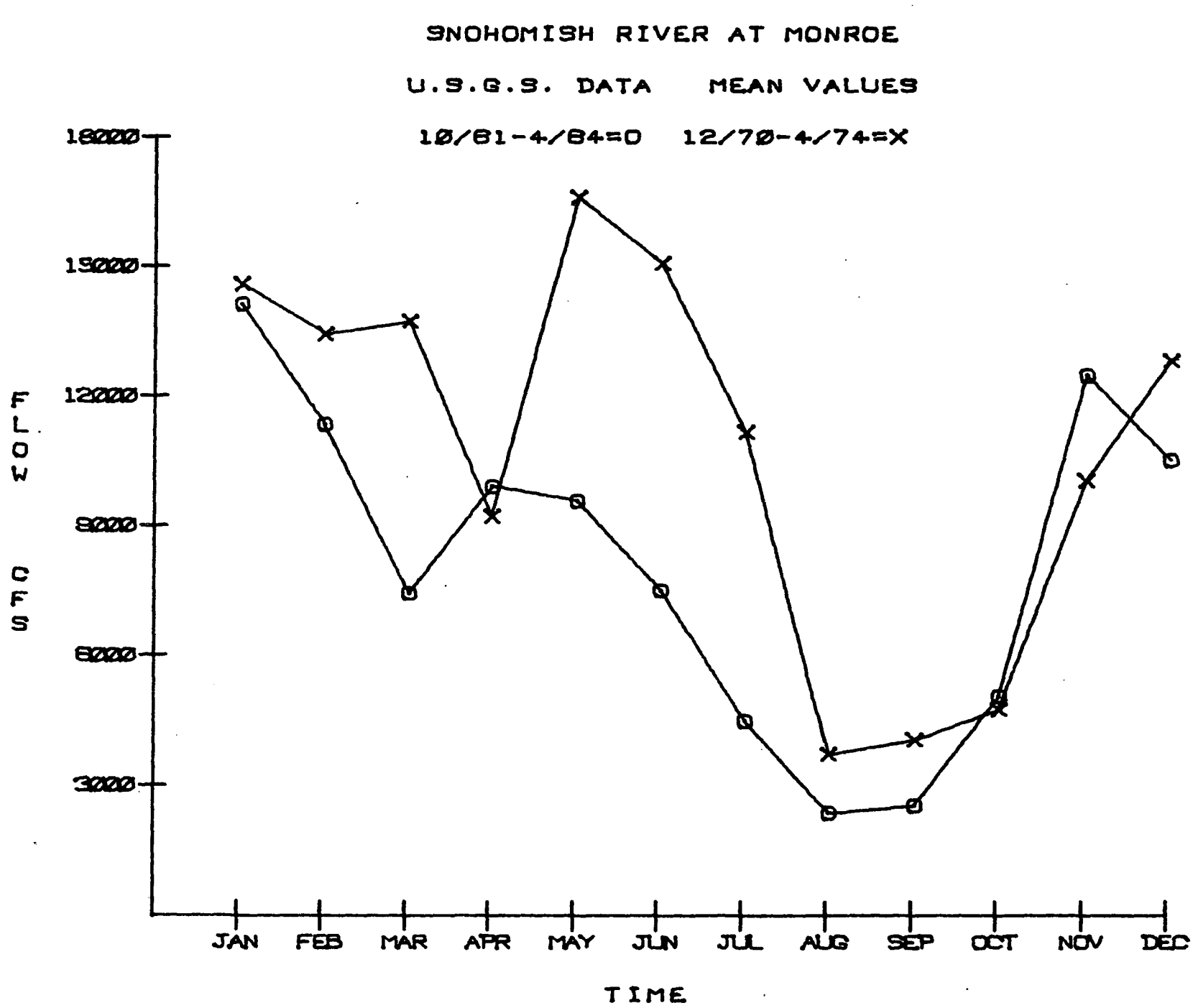

SKAGIT RIVER AT MT. VERNON
MEAN DATA VALUES
60/01-61/12=O 63/01-64/12=X 68/01-69/11=A
9.00
8.00
7.00
6.00
STANDARD
PH STANDARD UNITS
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
TIME

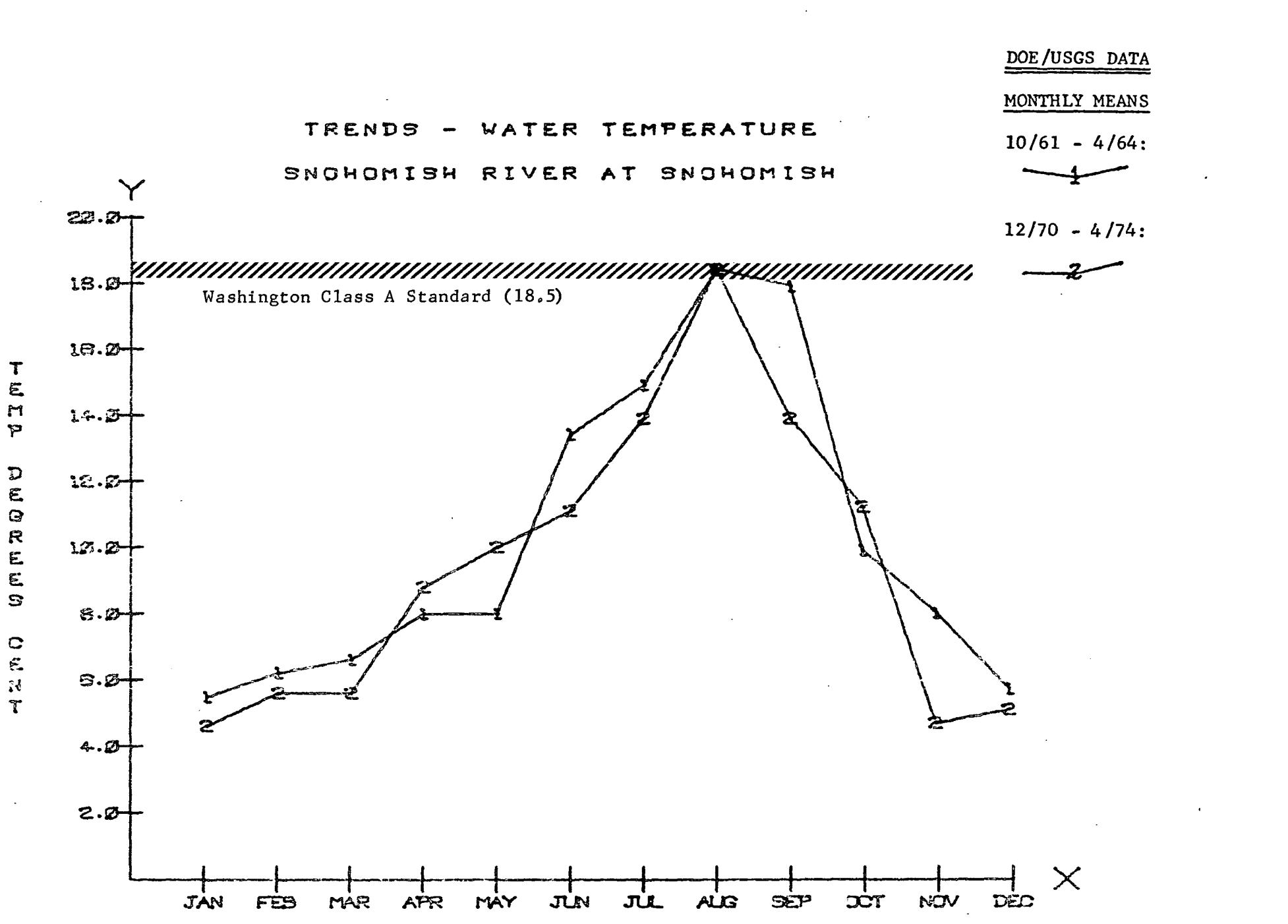

SKAGIT RIVER AT MT. VERNON
MEAN DATA VALUES
60/01-61/12=0 63/01-64/12=X
0.150
0.120
0.090
0.060
0.030
TOTAL NO3\N MG\L
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
TIME

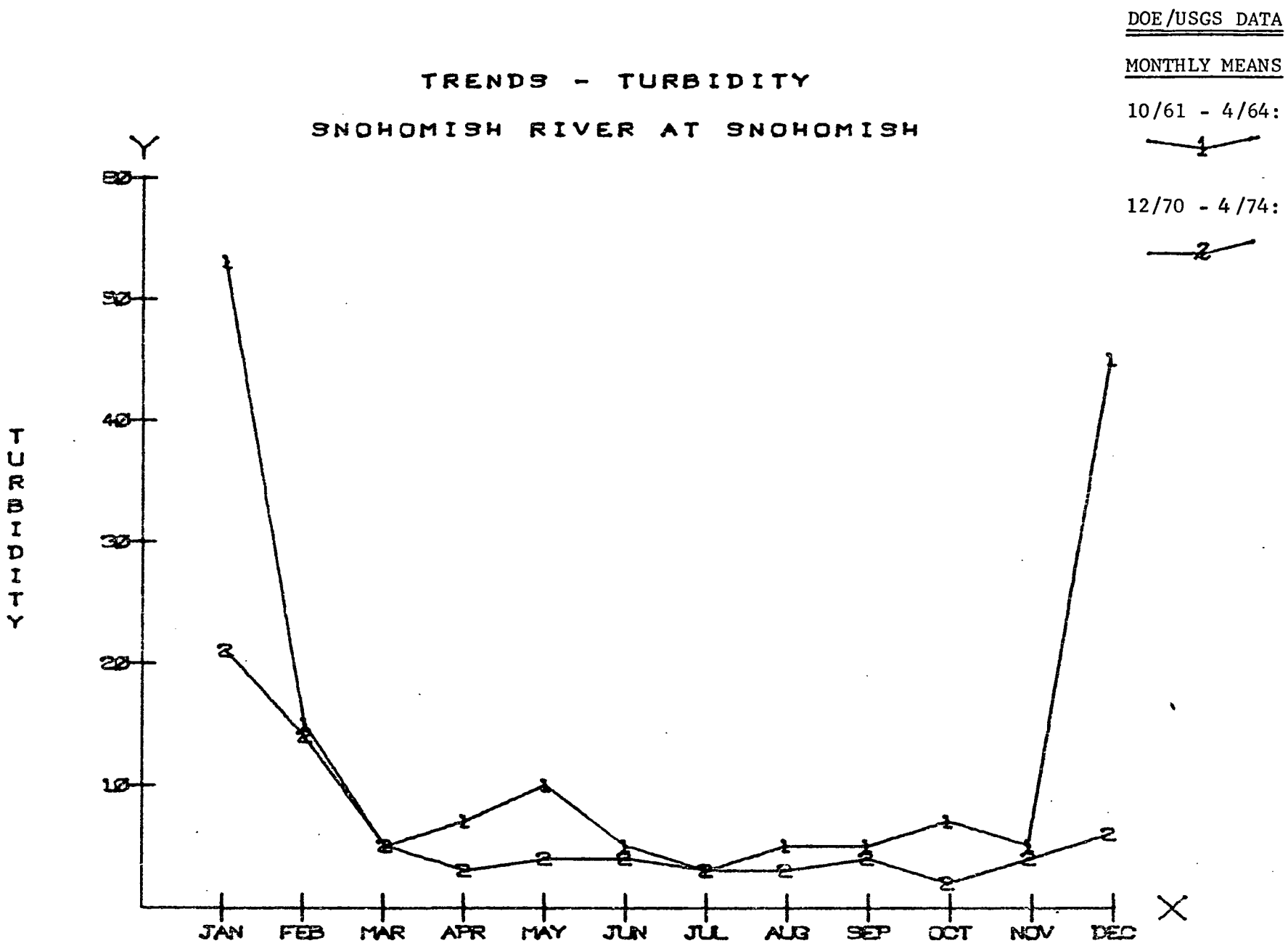
SNOHOMISH RIVER BASIN

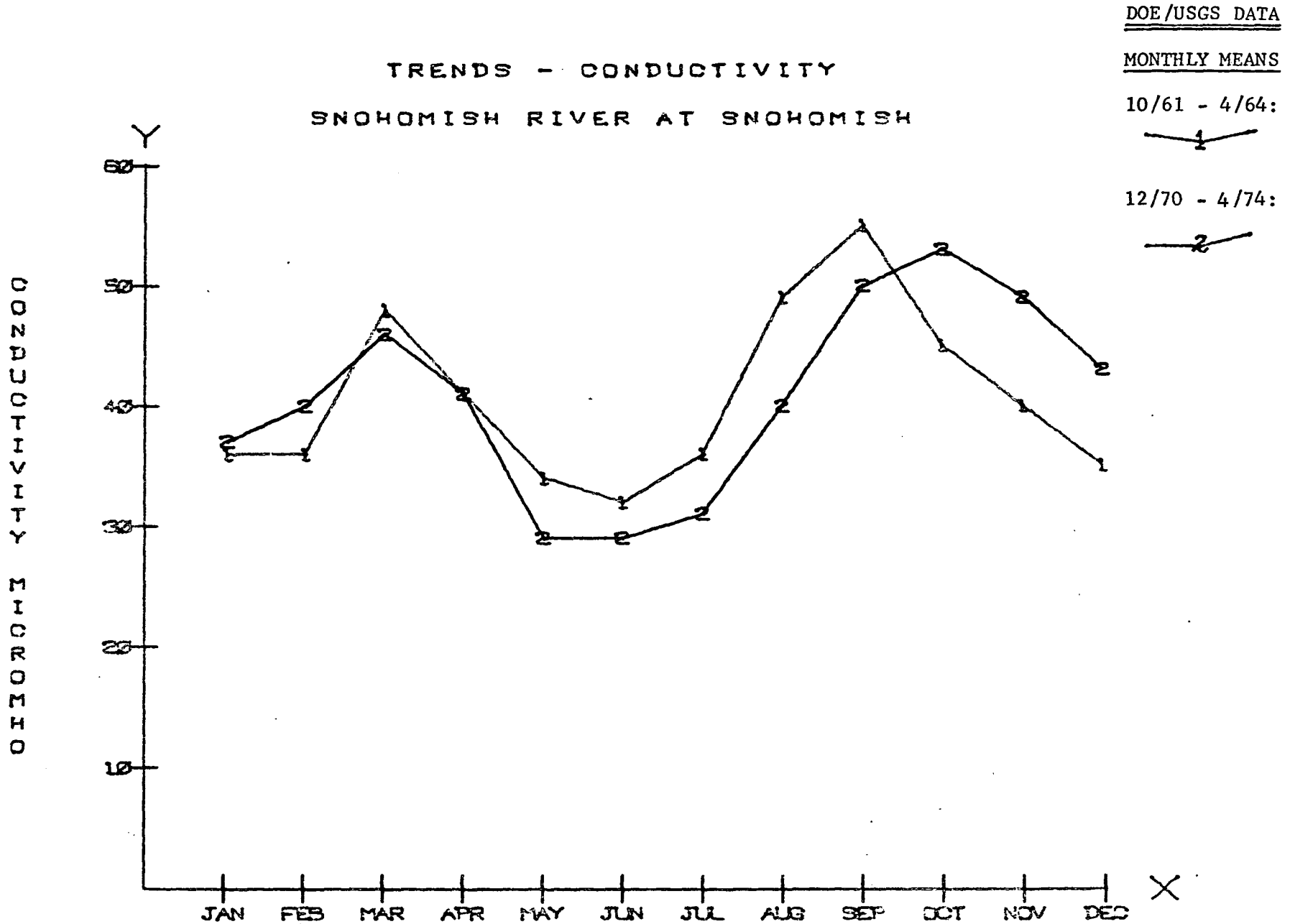
SNOHOMISH RIVER BASIN




SNOHOMISH RIVER AT MONROE
U.S.G.S. DATA MEAN VALUES
10/61-4/84=O 12/70-4/74=X
18000
15000
12000
9000
6000
3000
FLOW CFS
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
TIME


DOE/USGS DATA
MONTHLY MEANS
10/61 - 4/64:
12/70 - 4/74:
TRENDS - WATER TEMPERATURE
SNOHOMISH RIVER AT SNOHOMISH
Washington Class A Standard (18.5)
TEMP DEGREES CENT
Y
X
22.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC


TRENDS - TURBIDITY
SNOHOMISH RIVER AT SNOHOMISH
DOE/USGS DATA
MONTHLY MEANS
10/61 - 4/64:
12/70 - 4/74:
TURBIDITY
Y
X
60
50
40
30
20
10
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC


TRENDS - CONDUCTIVITY
SNOHOMISH RIVER AT SNOHOMISH
DOE/USGS DATA
MONTHLY MEANS
10/61 - 4/64:
12/70 - 4/74:
CONDUCTIVITY MICROMHO
Y
X
60
50
40
30
20
10
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

DOE/USGS DATA

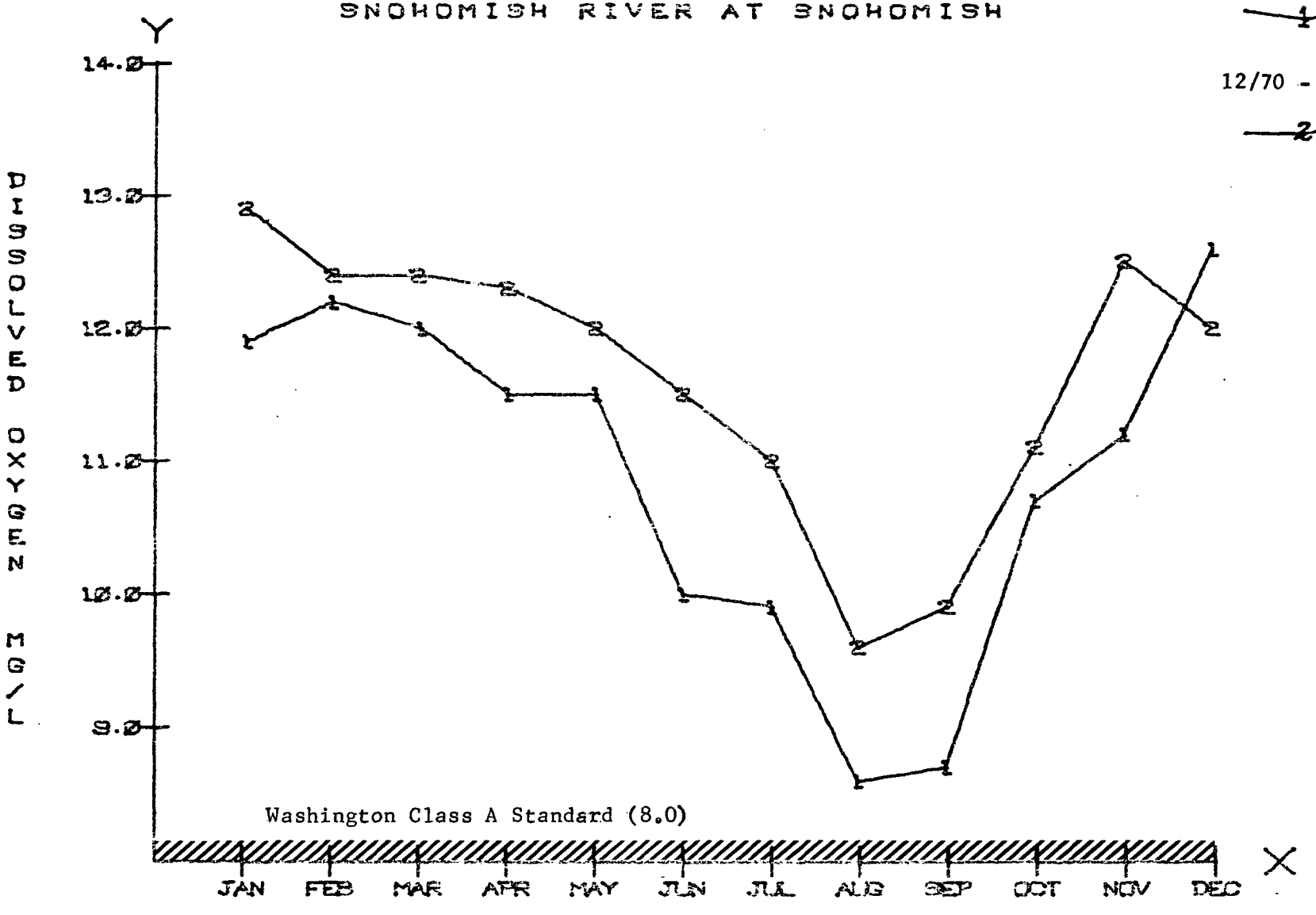
MONTHLY MEANS

10/61 - 4/64: 1

12/70 - 4/74: 2

TRENDS - DISSOLVED OXYGEN

SNOHOMISH RIVER AT SNOHOMISH



DOE/USGS DATA

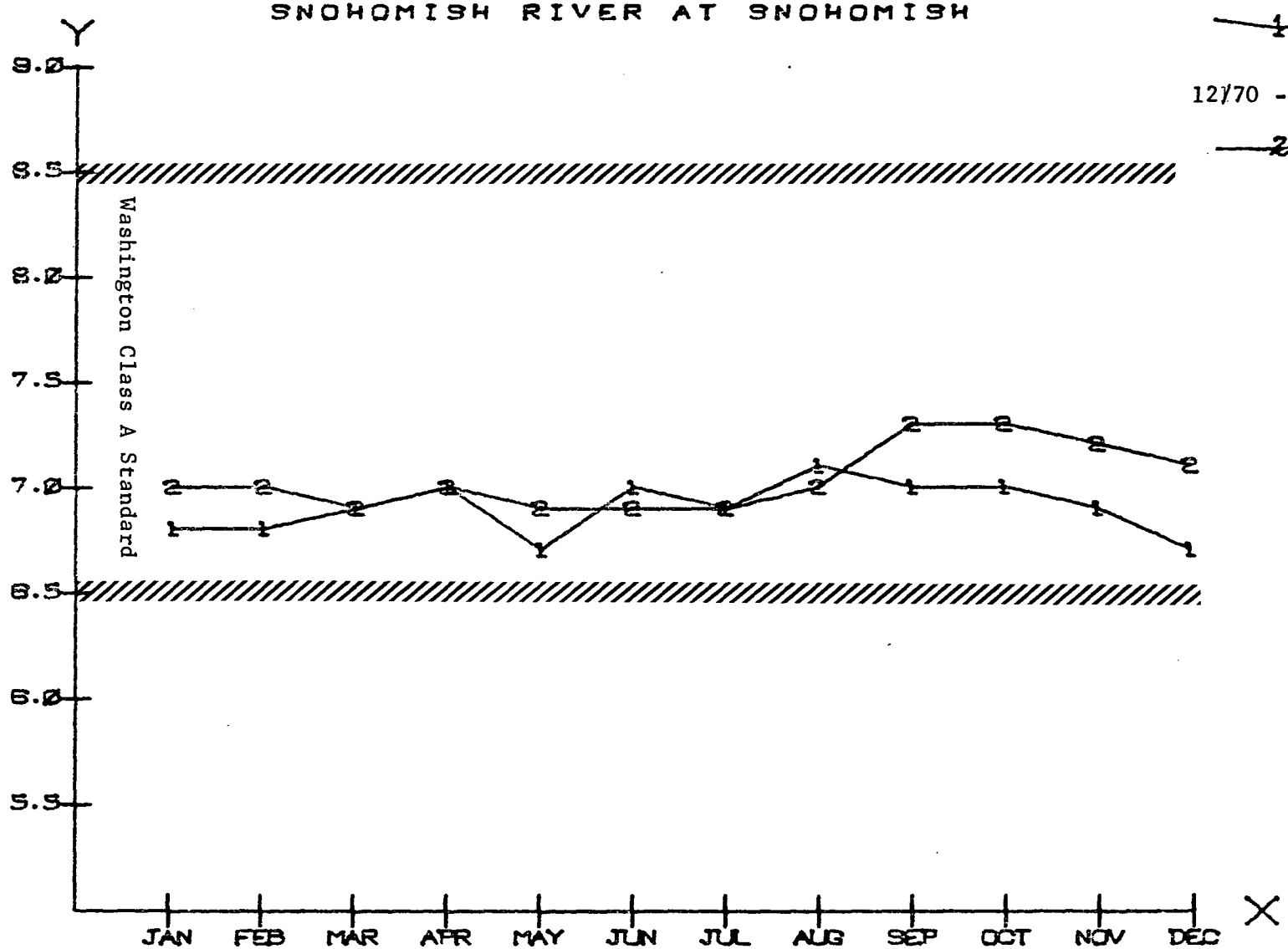
MONTHLY MEANS

10/61 - 4/64:

12/70 - 4/74:

TRENDS - PH

SNOHOMISH RIVER AT SNOHOMISH



PH

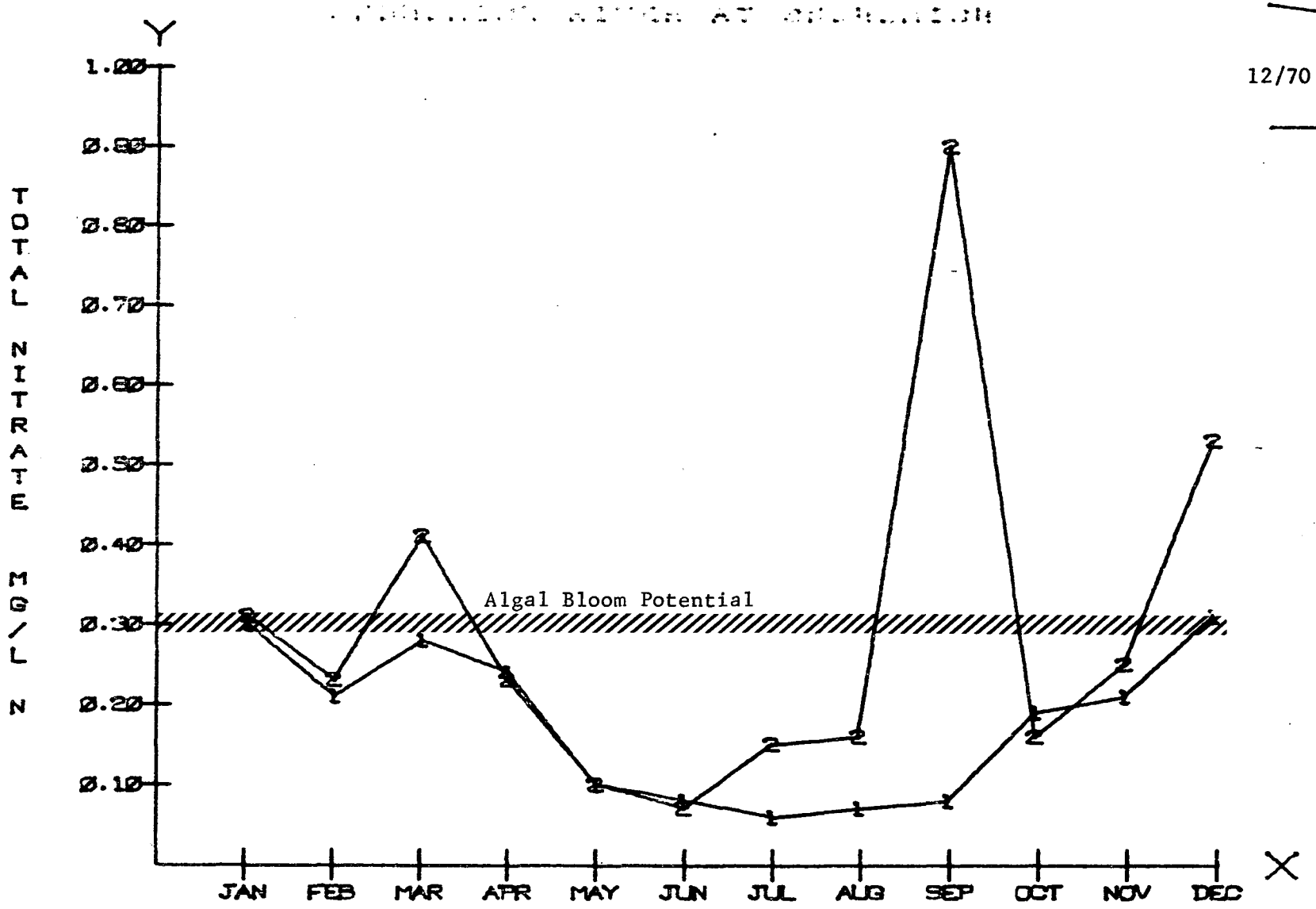
DOE/USGS DATA

MONTHLY MEANS

10/61 - 4/64:

12/70 - 11/73:

TRENDS - TOTAL NITRATE



DOE/USGS DATA

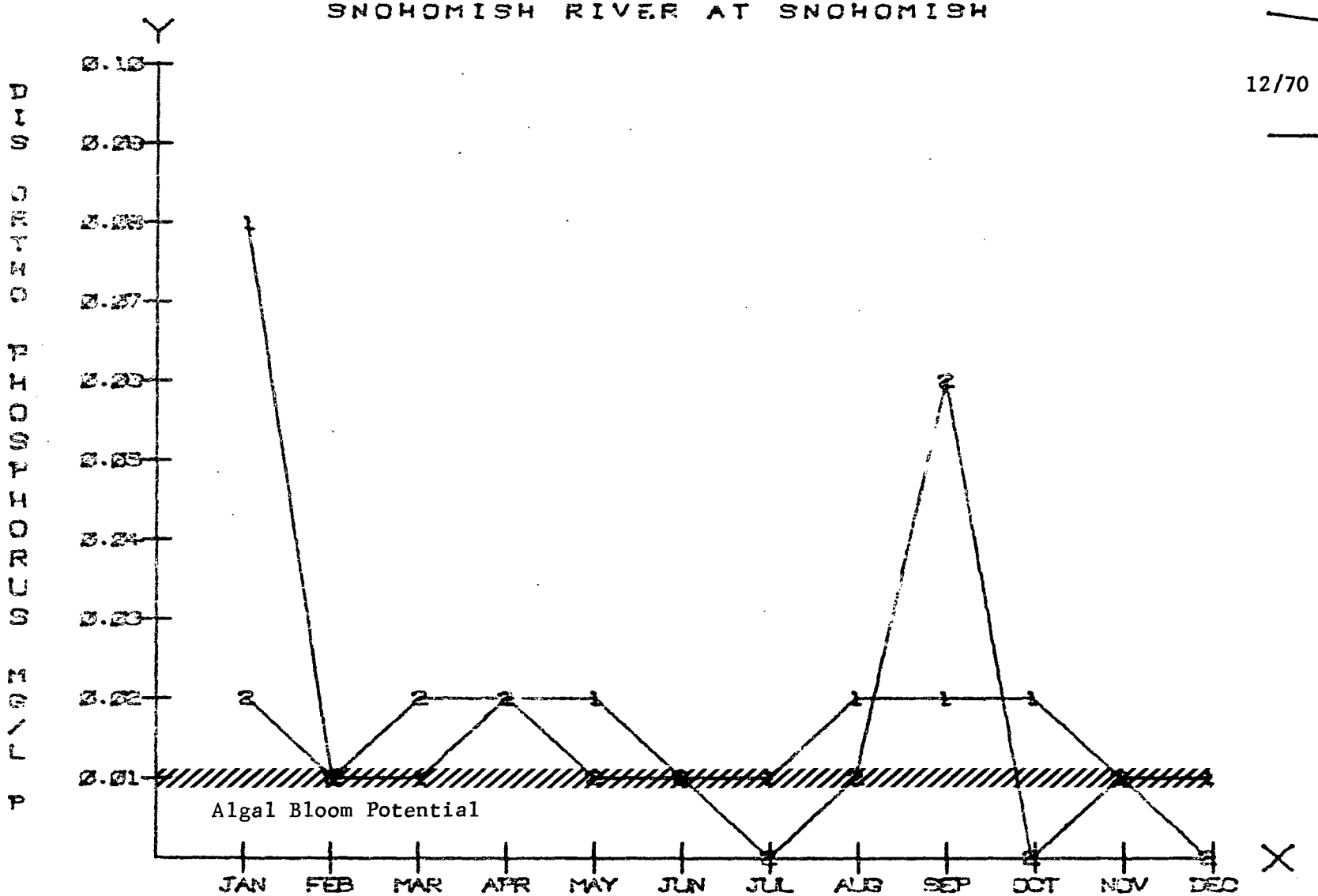
MONTHLY MEANS

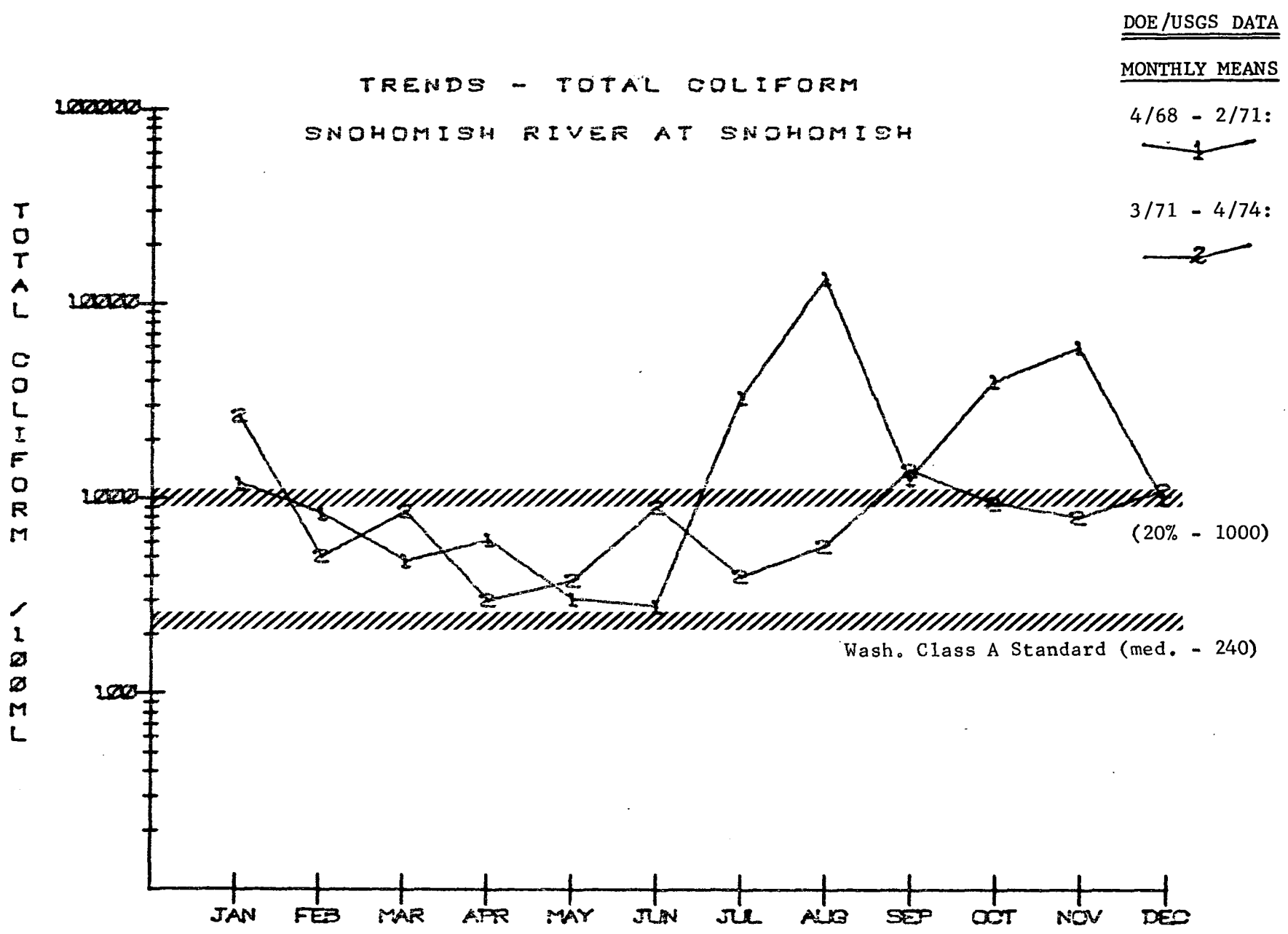
10/61 - 4/64:

12/70 - 2/74:

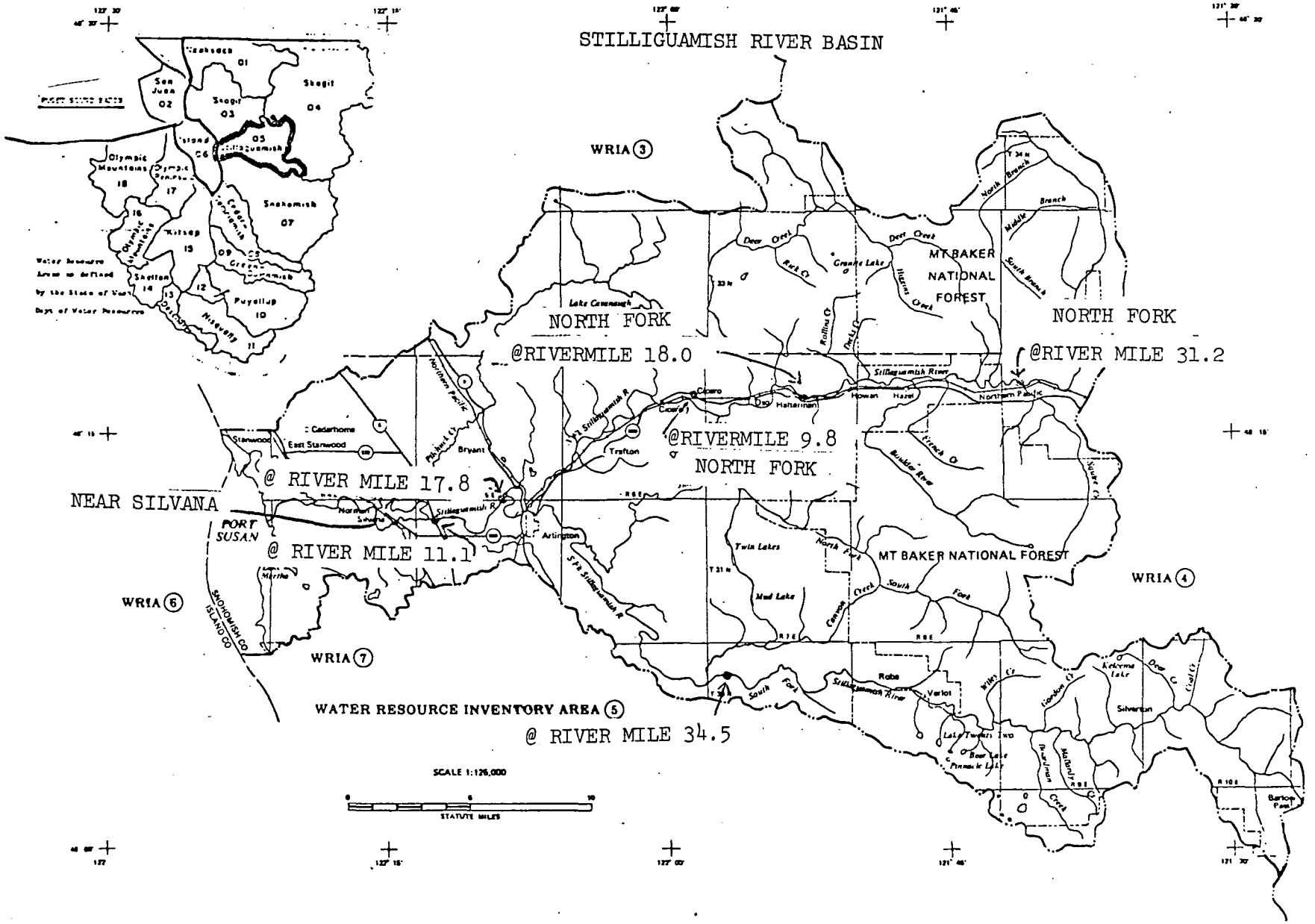
TRENDS - DISSOLVED ORTHO PHOSPHORUS

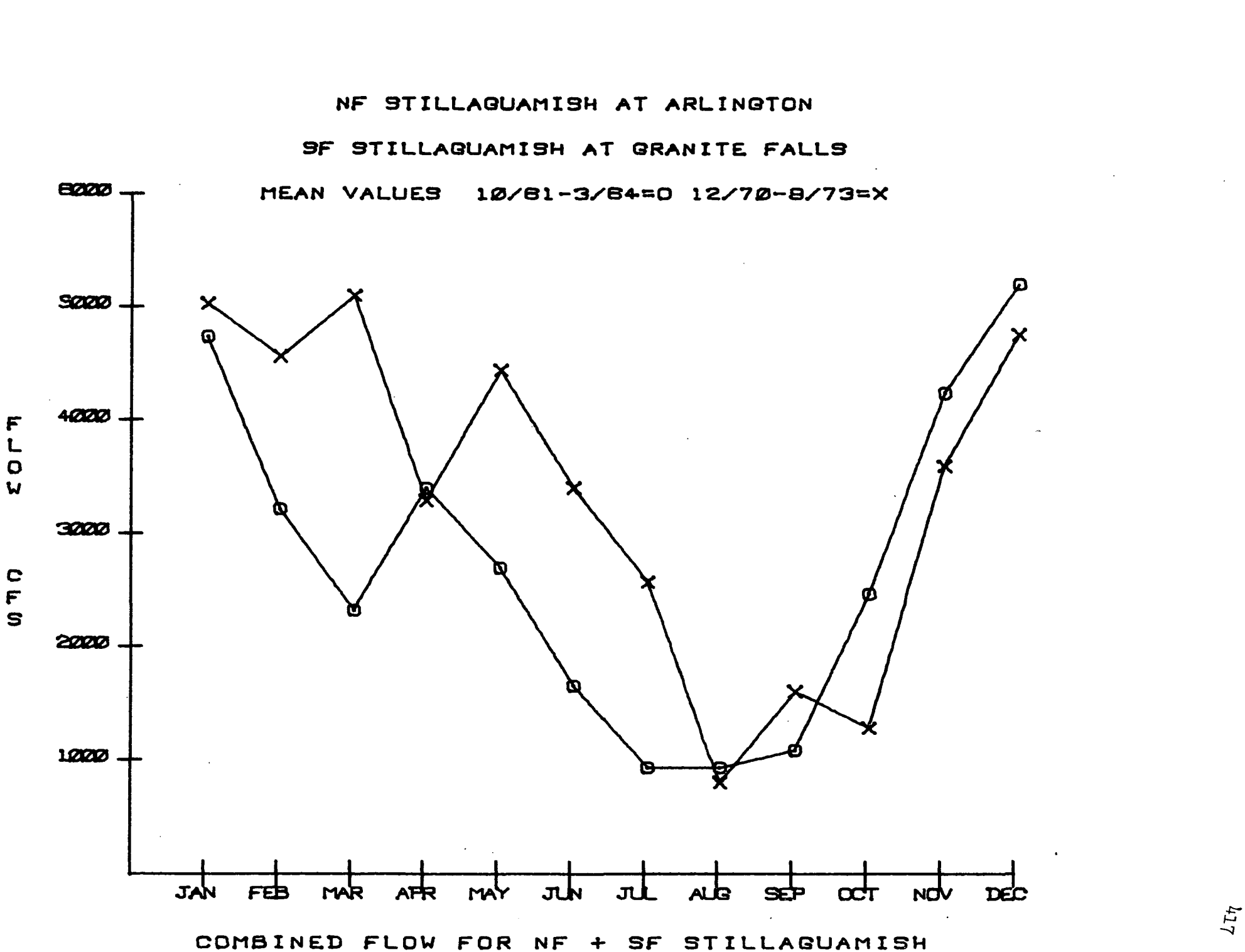
SNOHOMISH RIVER AT SNOHOMISH




TRENDS - TOTAL COLIFORM
SNOHOMISH RIVER AT SNOHOMISH
DOE/USGS DATA
MONTHLY MEANS
4/68 - 2/71:
3/71 - 4/74:
TOTAL COLIFORM /100ML
1000000
100000
10000
1000
(20% - 1000)
Wash. Class A Standard (med. - 240)
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

STILLAGIAMISH RIVER BASIN


STILLIGUAMISH RIVER BASIN
WRIA 3
NORTH FORK
@RIVERMILE 18.0
NORTH FORK
@RIVER MILE 31.2
@RIVERMILE 9.8
NORTH FORK
@ RIVER MILE 17.8
NEAR SILVANA
@ RIVER MILE 11.1
PORT SUSAN
MT BAKER NATIONAL FOREST
MT BAKER NATIONAL FOREST
WRIA 4
WRIA 6
WRIA 7
SNOHOMISH CO
ISLAND CO
WATER RESOURCE INVENTORY AREA 5
@ RIVER MILE 34.5
SCALE 1:126,000
STATUTE MILES


NF STILLAGUAMISH AT ARLINGTON
SF STILLAGUAMISH AT GRANITE FALLS
MEAN VALUES 10/61-3/64=O 12/70-8/73=X
60000
50000
40000
30000
20000
10000
FLOW CFS
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
COMBINED FLOW FOR NF + SF STILLAGUAMISH

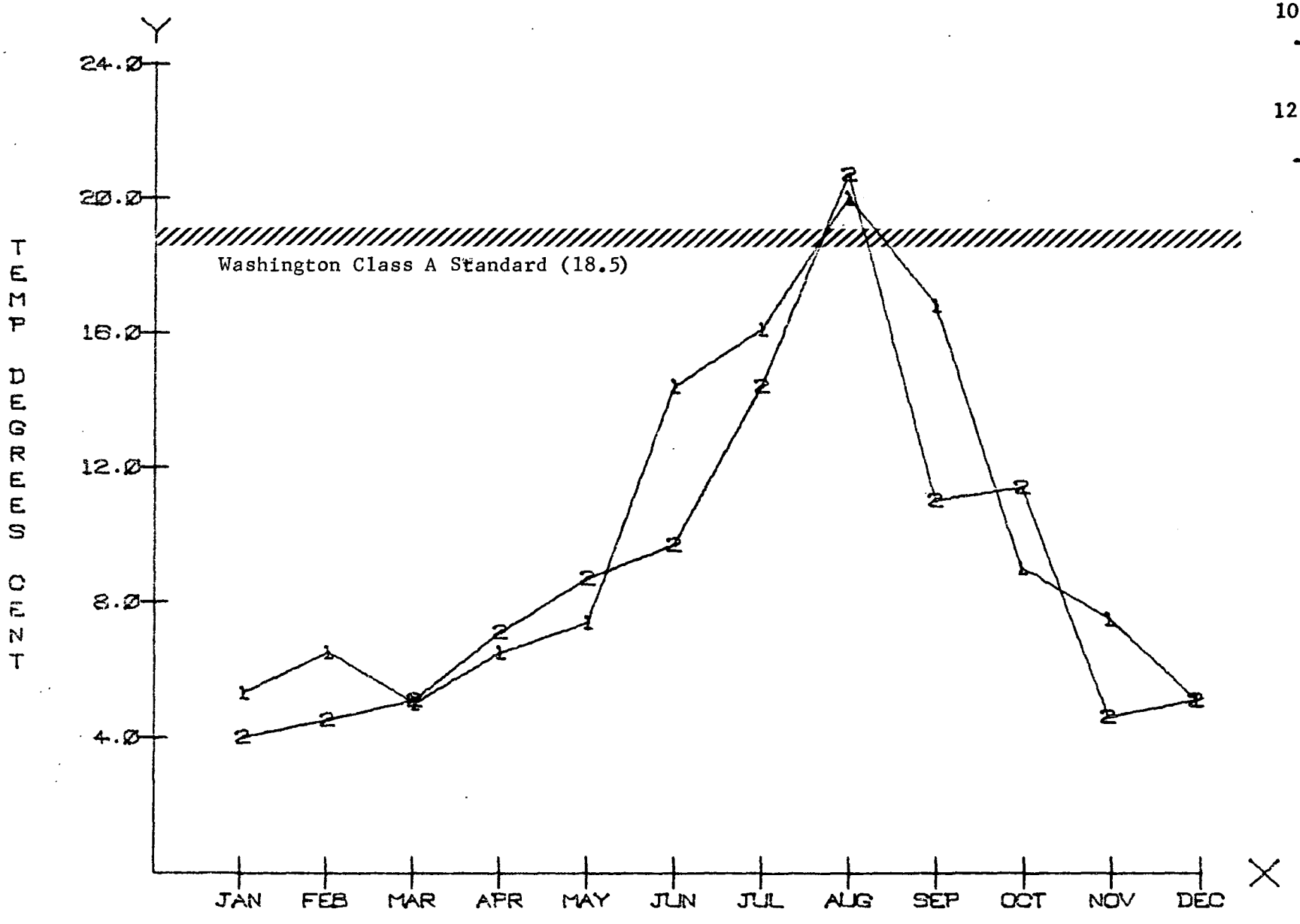
DOE/[redacted]S DATA

MONTHLY MEANS

10/61 - 3/64:

12/70 - 3/74:

TRENDS - STILLAGUAMISH RIVER nr SILVANA (05A070)



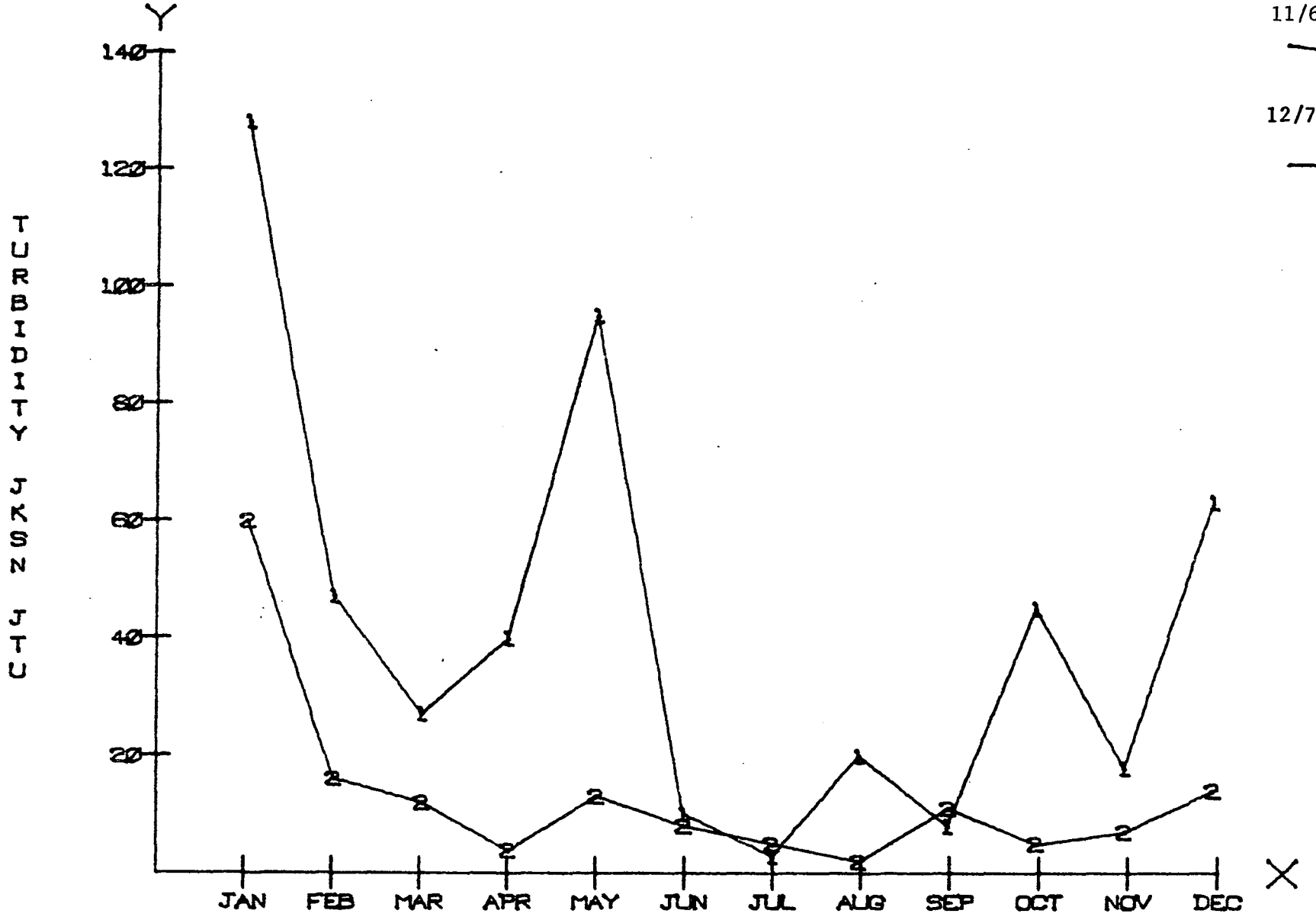
DOE/USGS [redacted]ATA

MONTHLY MEANS

11/61 - 3/64:

12/70 - 3/74:

TRENDS - STILLAGUAMISH RIVER nr SILVANA (05A070)



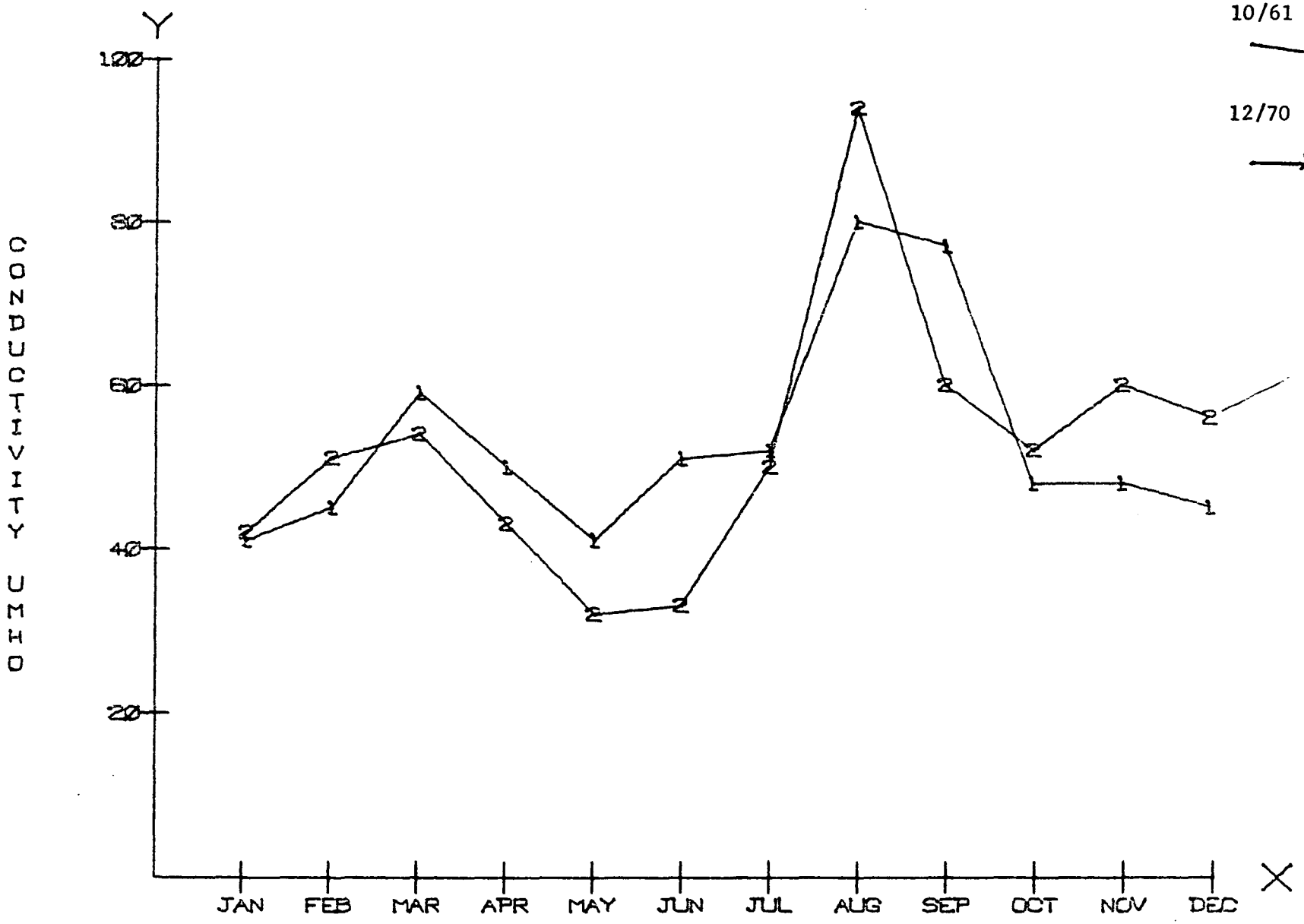
DOE/USGS DATA

MONTHLY MEANS

10/61 - 3/64:

12/70 - 3/74:

TRENDS - STILLAGUAMISH RIVER nr SILVANA (05A070)



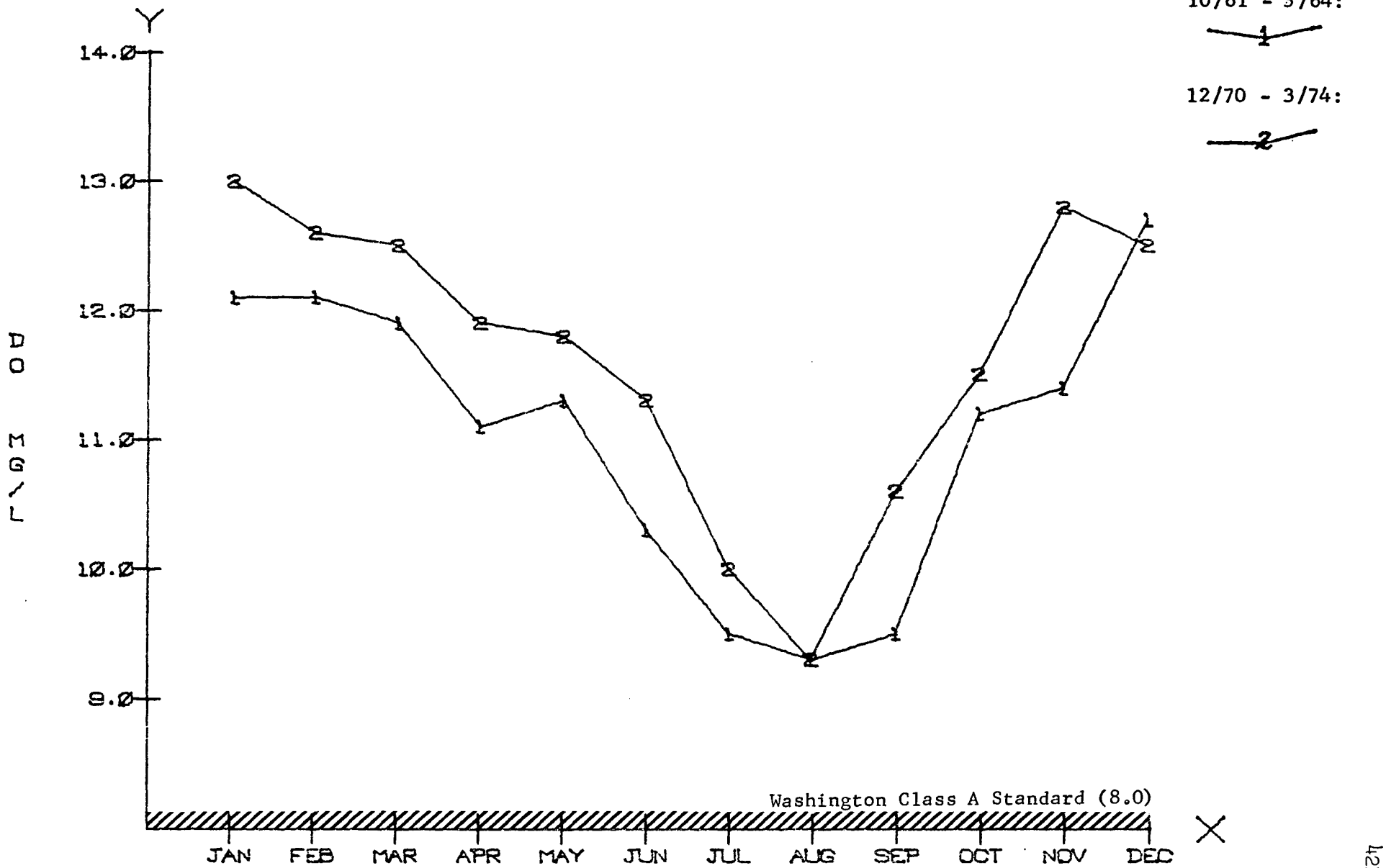
TRENDS - STILLAGUAMISH RIVER nr SILVANA (05A070)

DOE/USGS DATA

MONTHLY MEANS

10/61 - 3/64: 1

12/70 - 3/74: 2



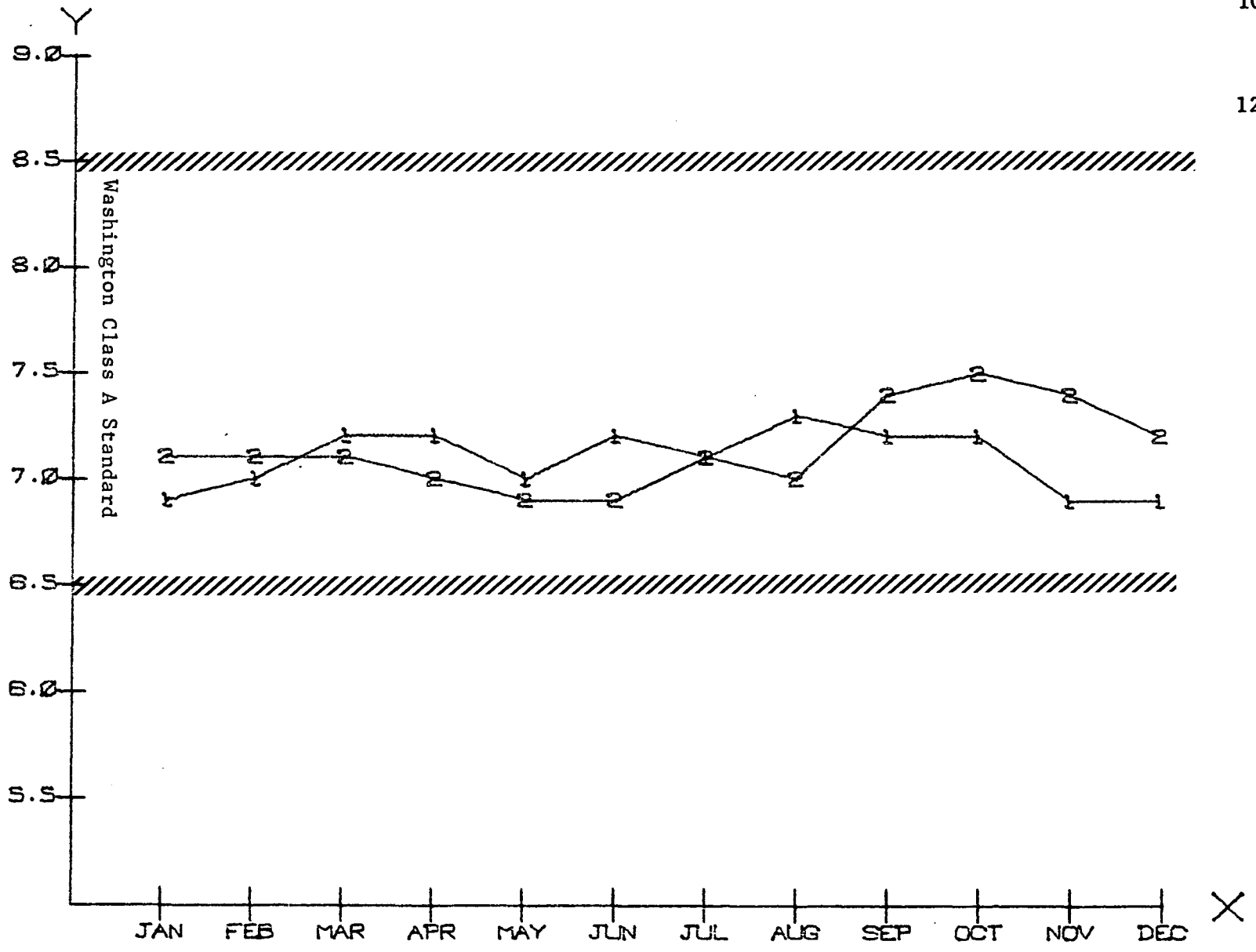
DOE/USGS DATA

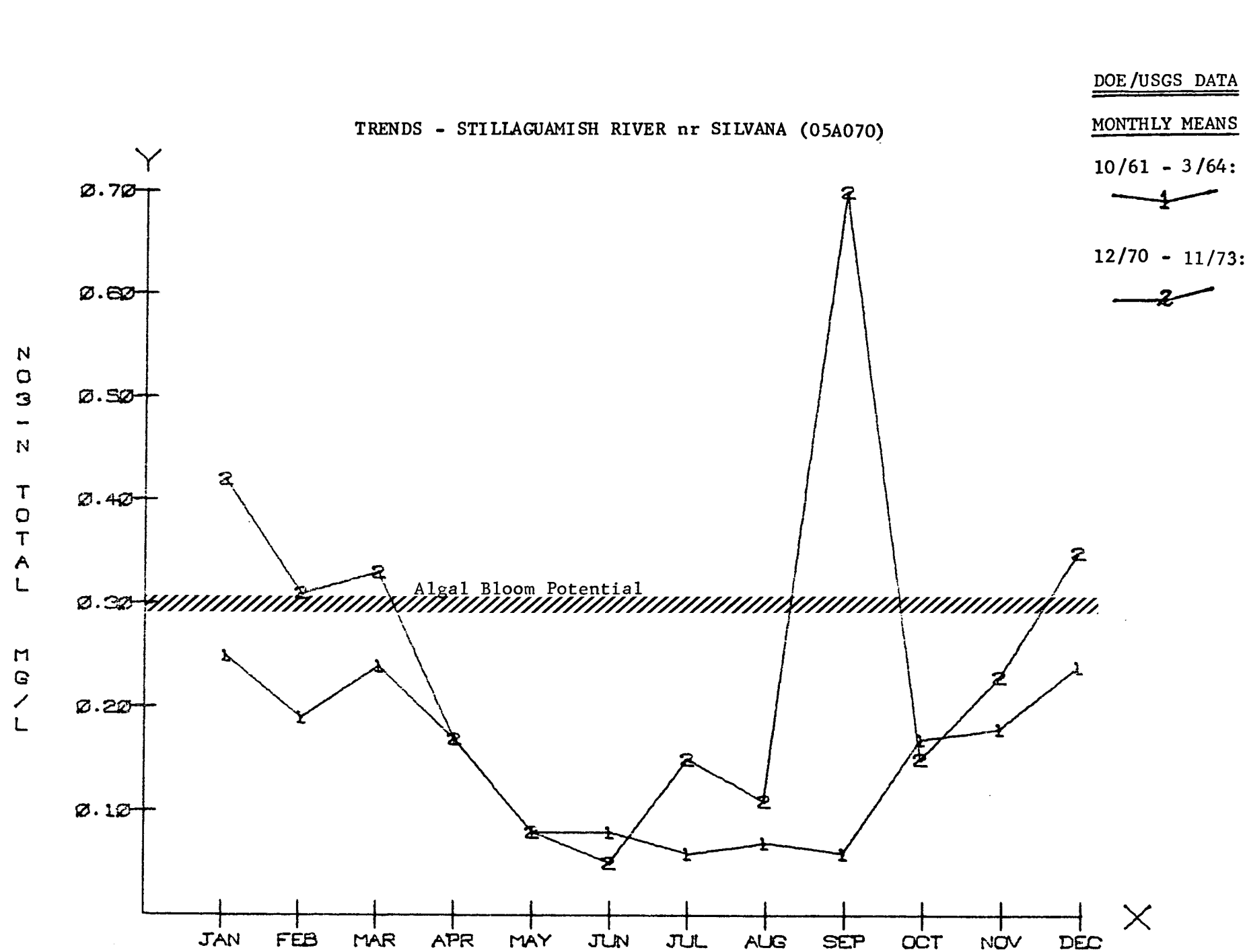
MONTHLY MEANS

10/61 - 3/64:

12/70 - 3/74:

TRENDS - STILLAGUAMISH RIVER nr SILVANA (05A070)




TRENDS - STILLAGUAMISH RIVER nr SILVANA (05A070)
DOE/USGS DATA
MONTHLY MEANS
10/61 - 3/64:
12/70 - 11/73:
Y
X
NO3+NO2 TOTAL MG/L
0.70
0.60
0.50
0.40
0.30
0.20
0.10
Algal Bloom Potential
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

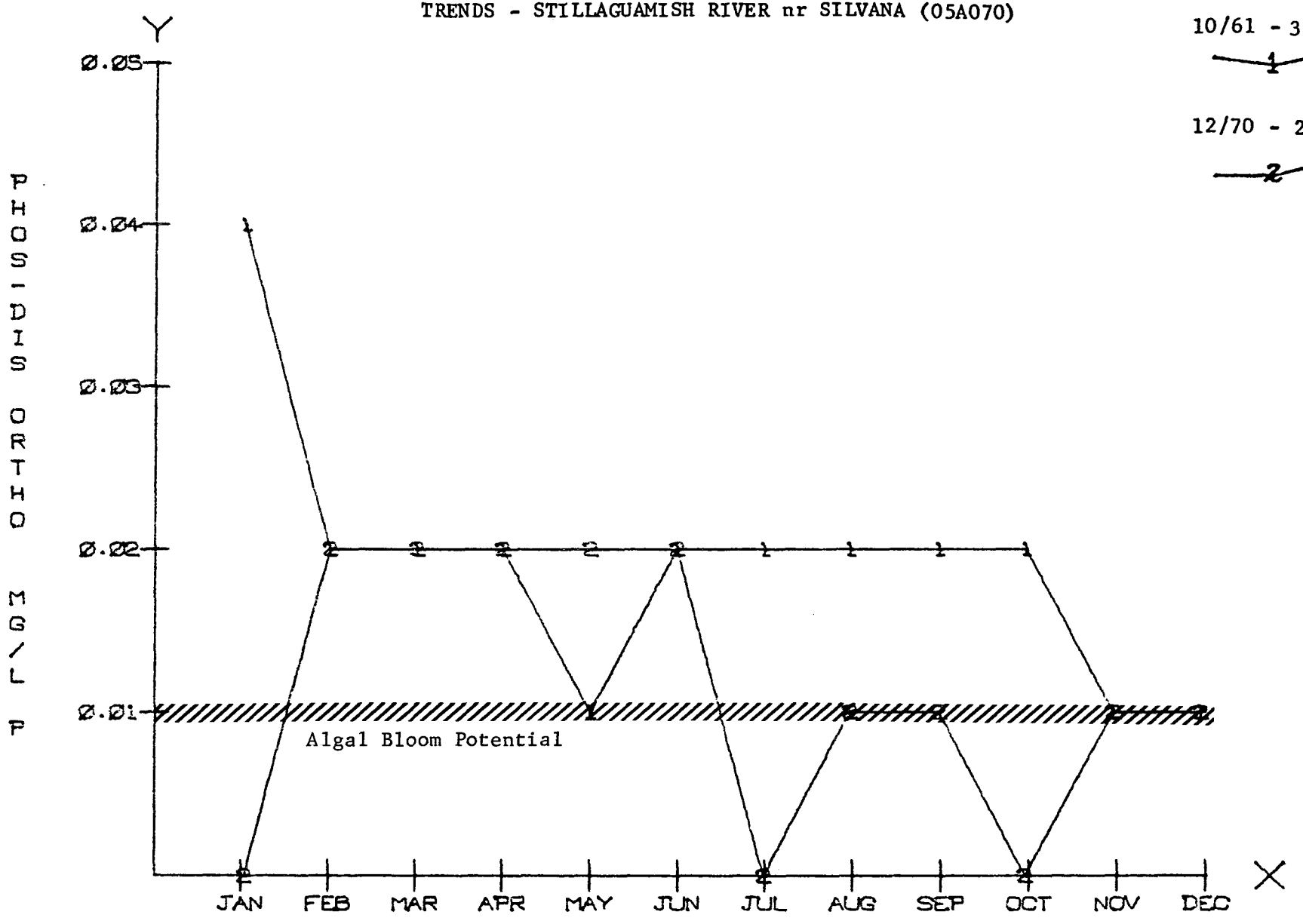
DOE/USGS DATA

MONTHLY MEANS

10/61 - 3/64: 1

12/70 - 2/74: 2

TRENDS - STILLAGUAMISH RIVER nr SILVANA (05A070)



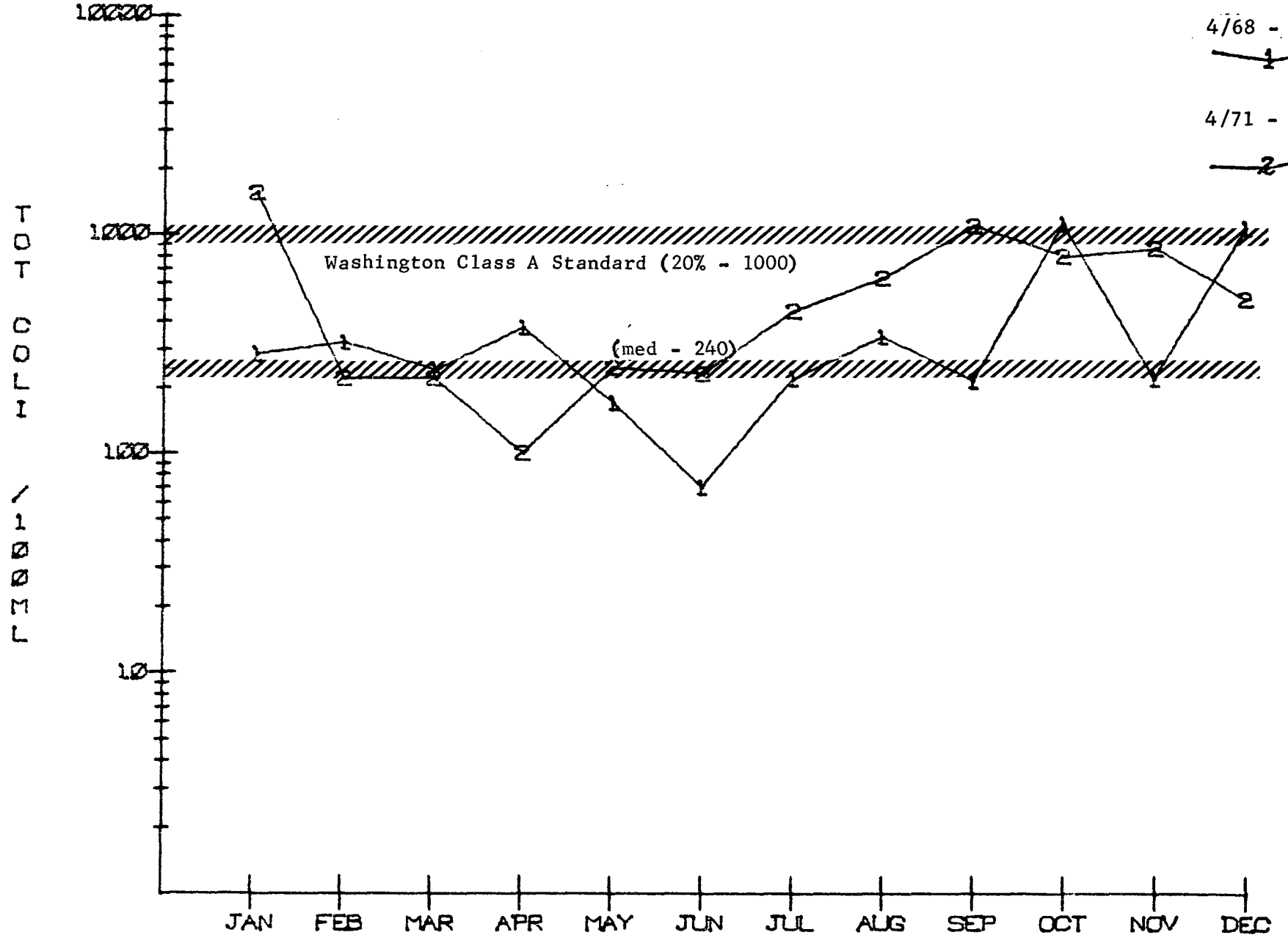
TRENDS - STILLAGUAMISH RIVER nr SILVANA (05A070)

DOE/USGS D[redacted]

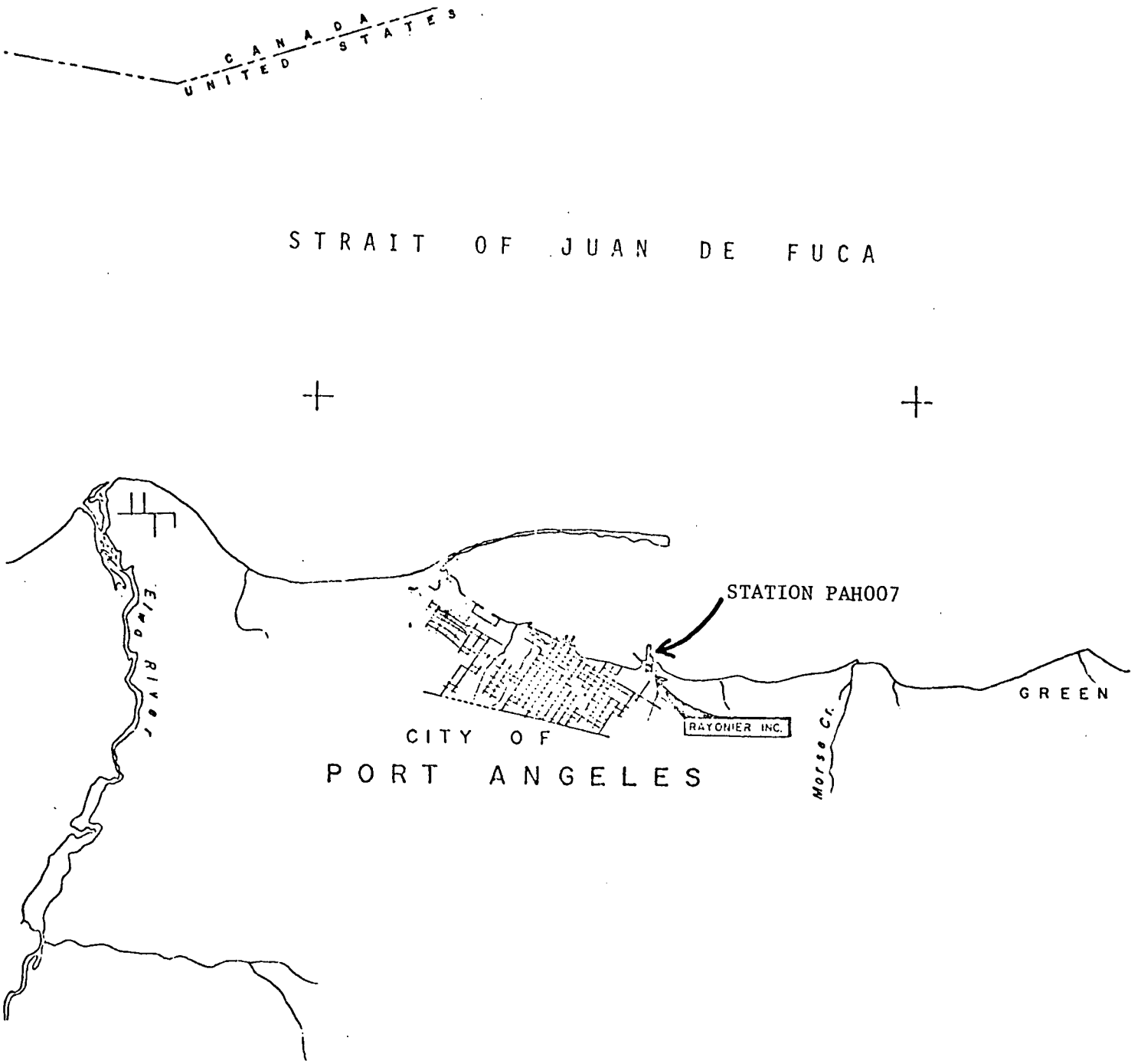
MONTHLY MEANS

4/68 - 3/71:

4/71 - 3/74:



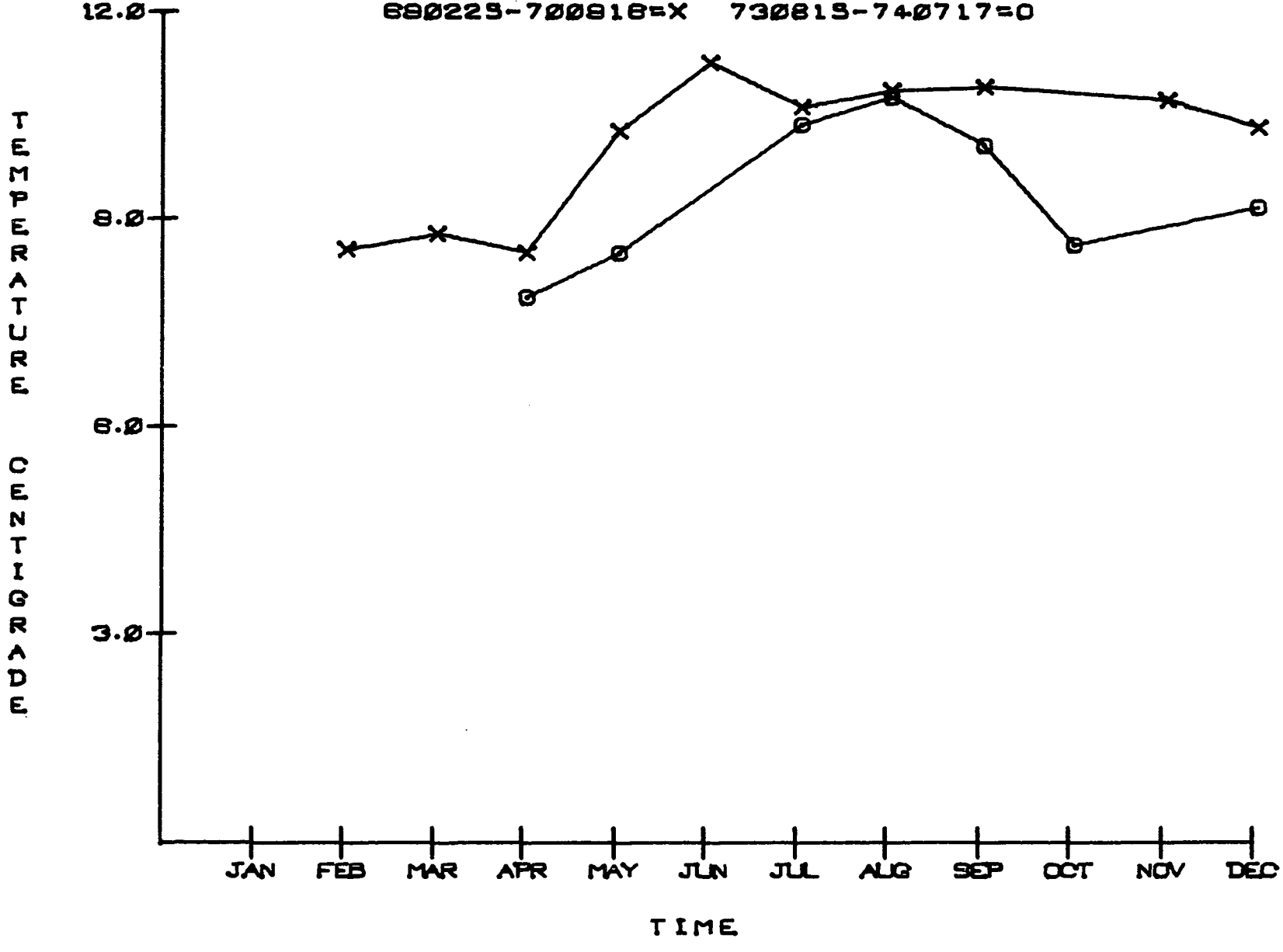
C. WATER QUALITY TRENDS
MARINE WATERS

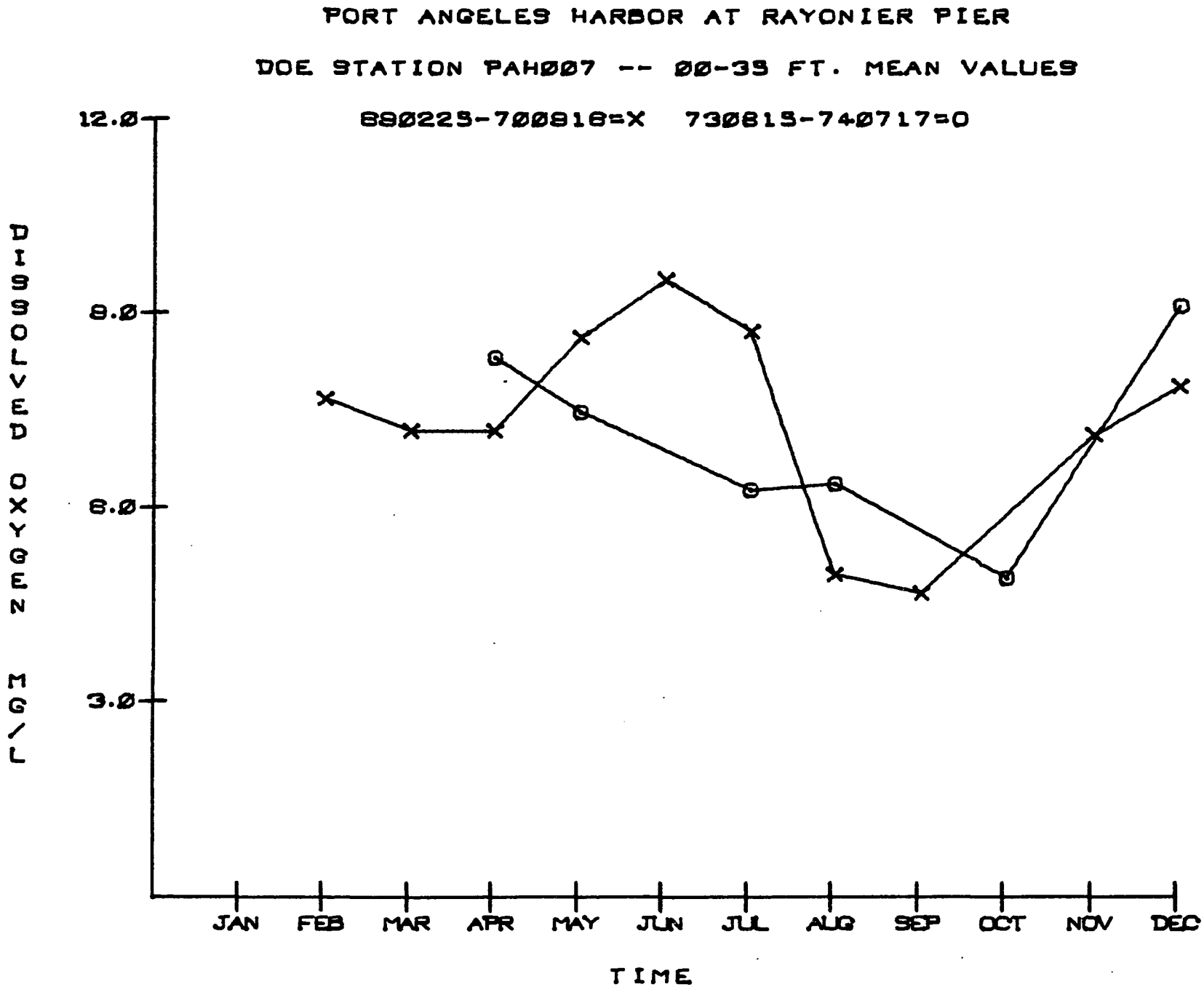

CANADA
UNITED STATES
STRAIT OF JUAN DE FUCA
STATION PAH007
ELWHA RIVER
CITY OF
PORT ANGELES
RAYONIER INC.
Morse Cr.
GREEN
1 1/2 0 1 2 3
Nautical Miles

PORT ANGELES HARBOR AT RAYONIER PIER

DOE STATION PAH007 -- 00-35 FT. MEAN VALUES

680225-700818=X 730815-740717=O

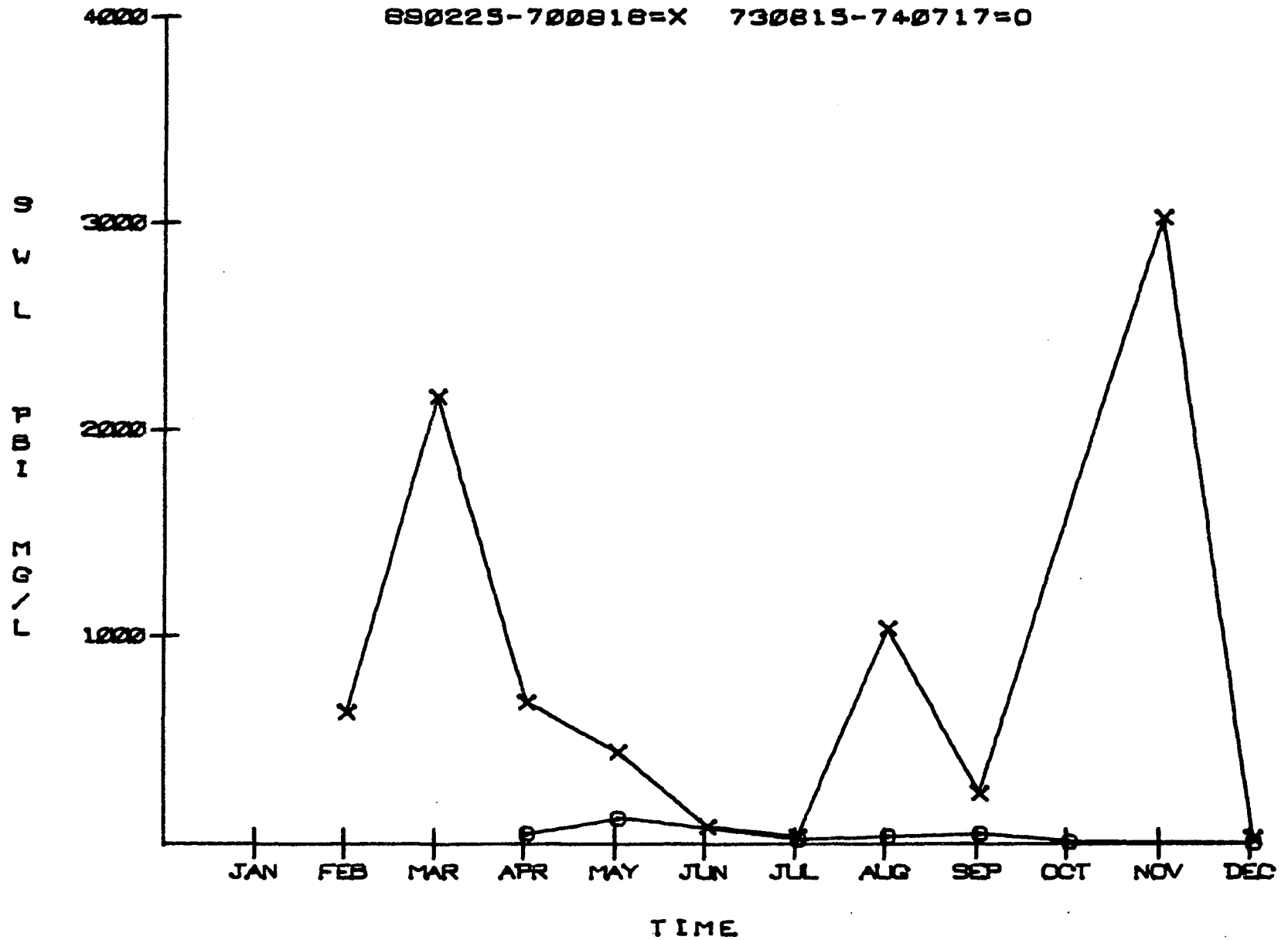



PORT ANGELES HARBOR AT RAYONIER PIER
DOE STATION PAH007 -- 00-33 FT. MEAN VALUES
680225-700816=X 730815-740717=O
12.0
9.0
6.0
3.0
DISSOLVED OXYGEN MG/L
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
TIME

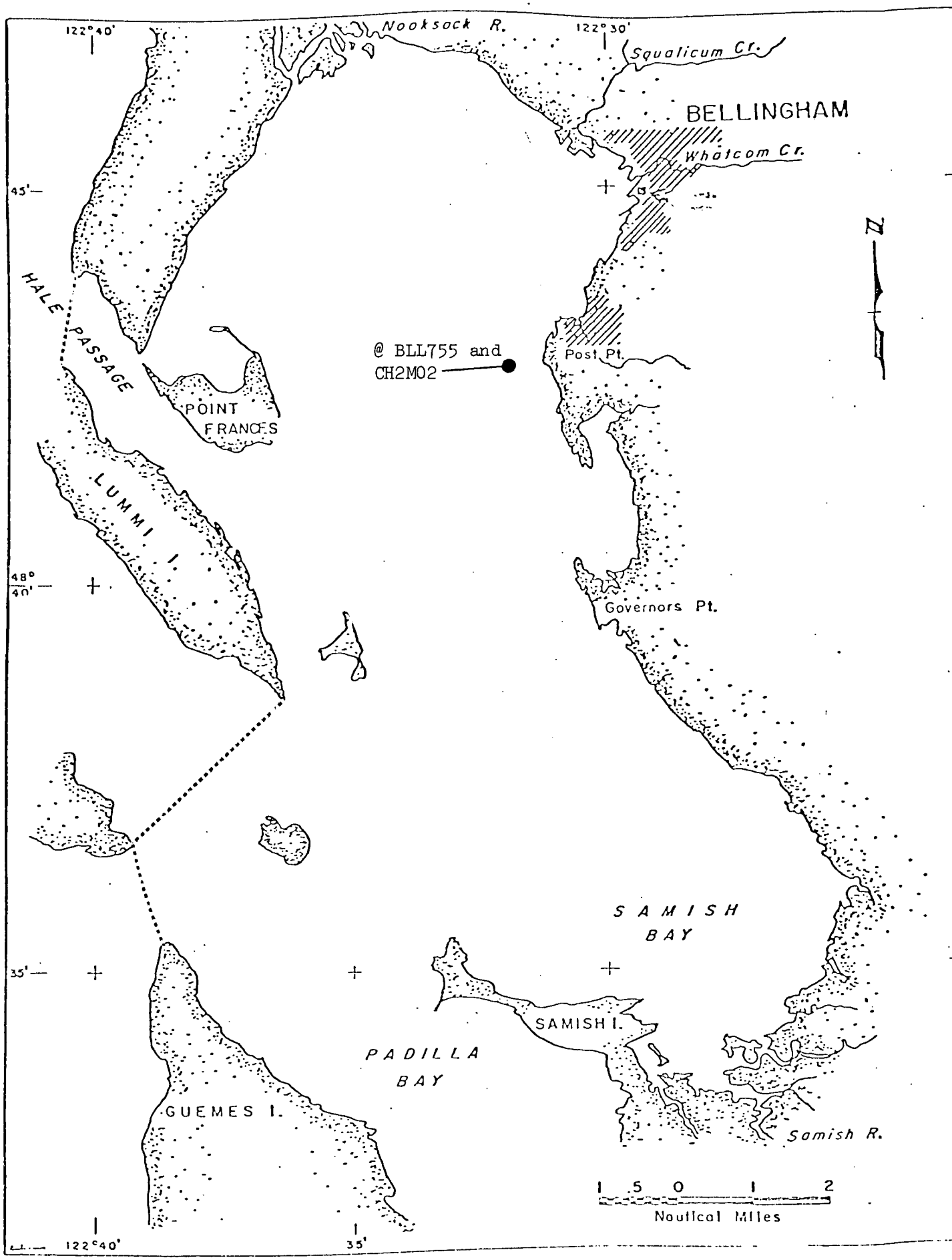
PORT ANGELES HARBOR AT RAYONIER PIER

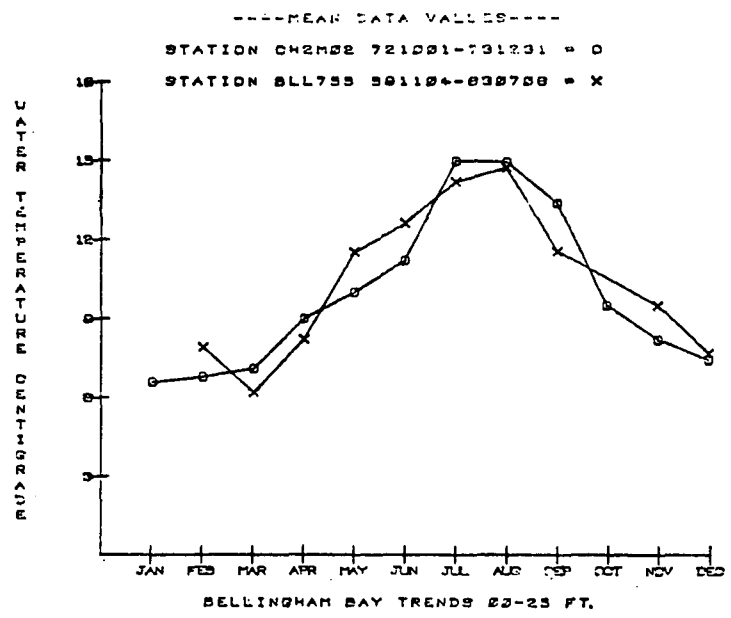
DOE STATION PAH007 -- 00-35 FT. MEAN VALUES

680225-700818=X 730815-740717=0

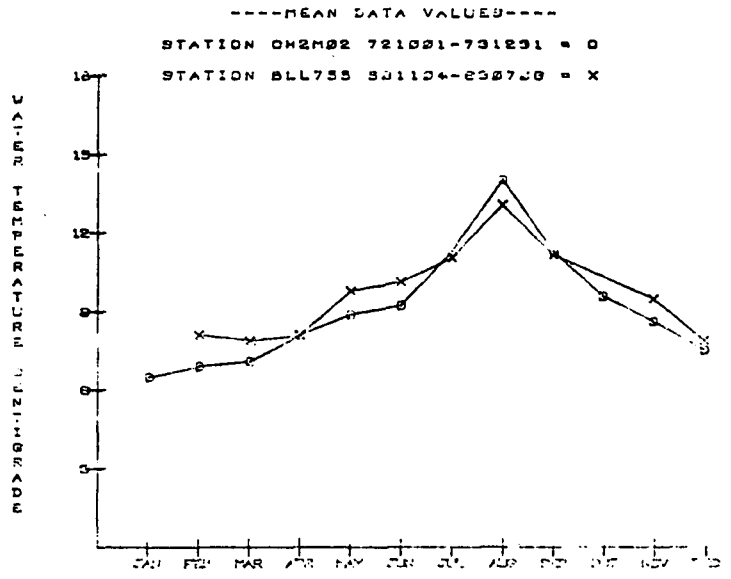


NORTH SOUND BASIN

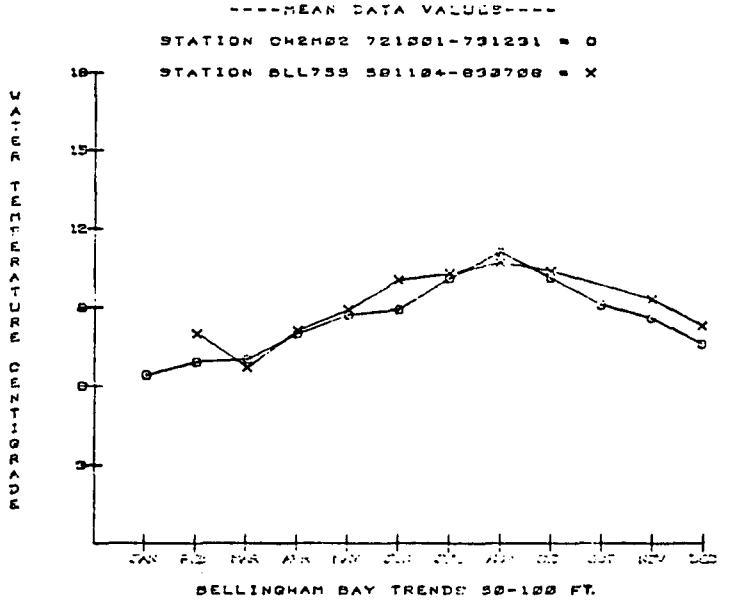

122°40'
Nooksack R.
122°30'
Squalicum Cr.
BELLINGHAM
Whatcom Cr.
45'
N
HALE PASSAGE
@ BLL755 and
CH2M02
Post Pt.
POINT
FRANCES
LUMMI I.
48°
40'
Governors Pt.
SAMISH
BAY
35'
SAMISH I.
PADILLA
BAY
GUEMES I.
Samish R.
1 5 0 1 2
Nautical Miles
122°40'
35'



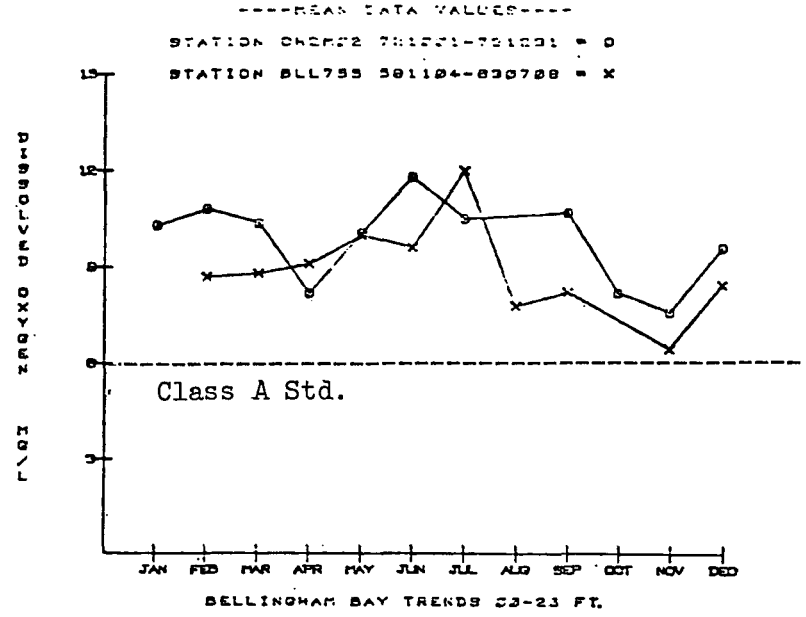
BELLINGHAM BAY TRENDS 03-25 FT.

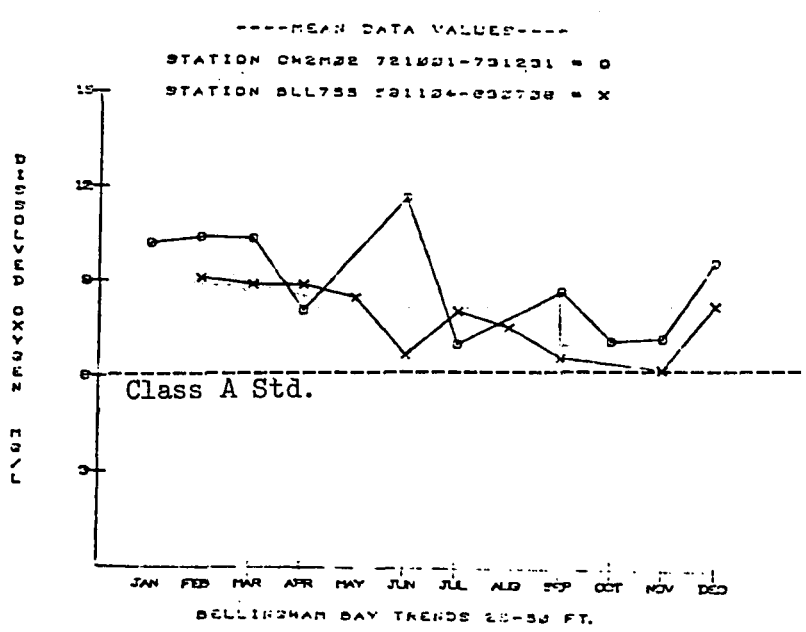


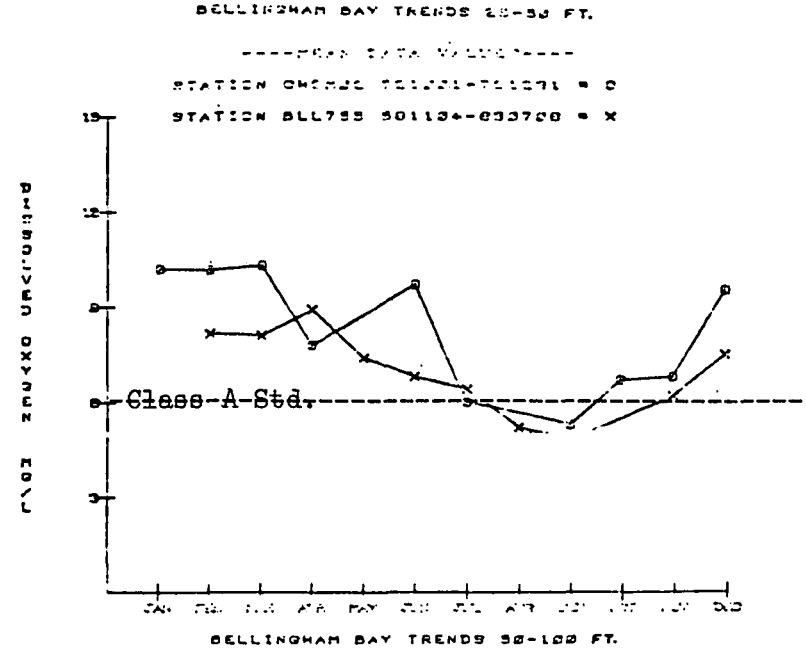
BELLINGHAM BAY TRENDS 25-50 FT.

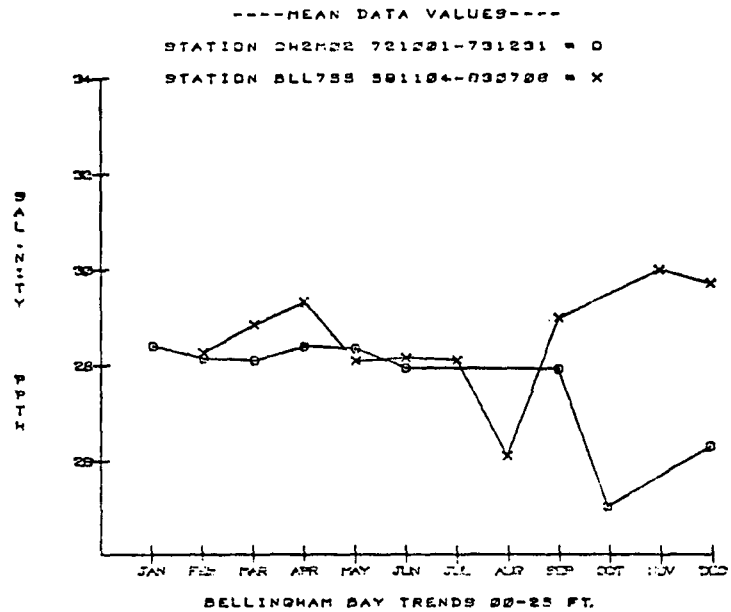


BELLINGHAM BAY TRENDS 50-100 FT.

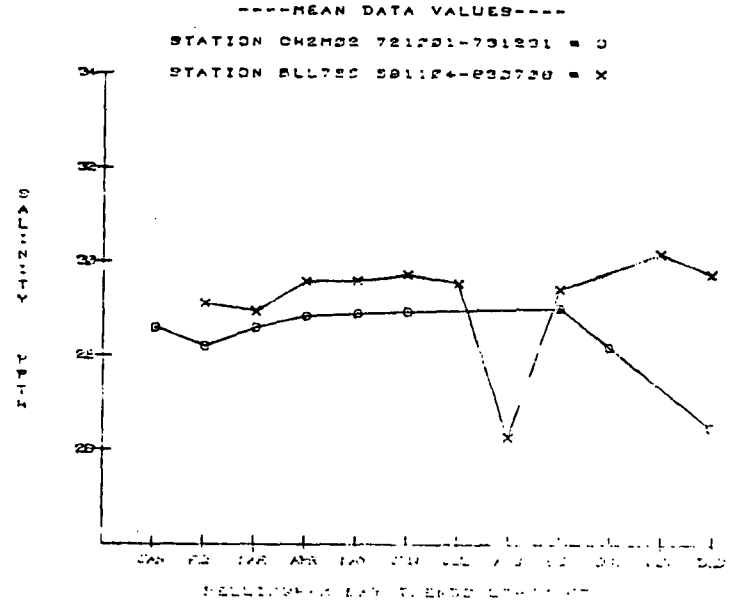

----MEAN DATA VALUES----
STATION CH2M02 721001-731231 = O
STATION BLL755 501104-830708 = X
MG/L DISSOLVED OXYGEN
15
12
9
6
3
Class A Std.
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
BELLINGHAM BAY TRENDS 03-23 FT.

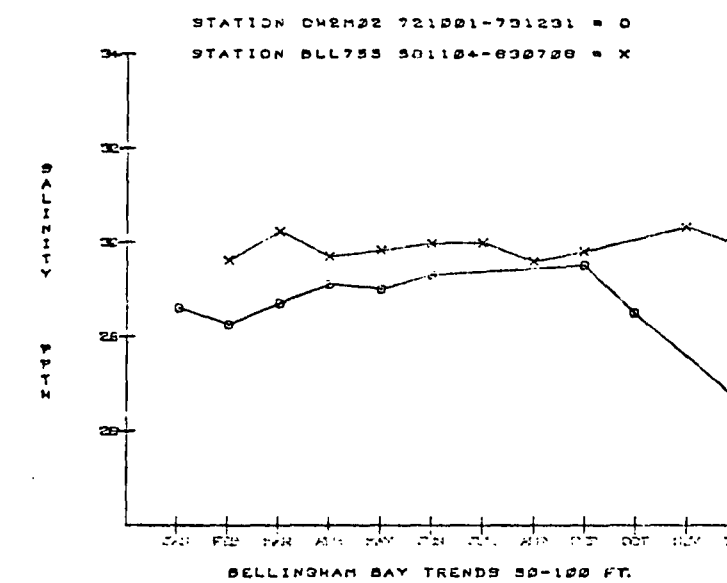

----MEAN DATA VALUES----
STATION CH2M02 721001-731231 = O
STATION BLL755 501104-830708 = X
MG/L DISSOLVED OXYGEN
15
12
9
6
3
Class A Std.
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
BELLINGHAM BAY TRENDS 23-30 FT.


----MEAN DATA VALUES----
STATION CH2M02 721001-731231 = O
STATION BLL755 501104-830708 = X
MG/L DISSOLVED OXYGEN
15
12
9
6
3
Class A Std.
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
BELLINGHAM BAY TRENDS 90-100 FT.

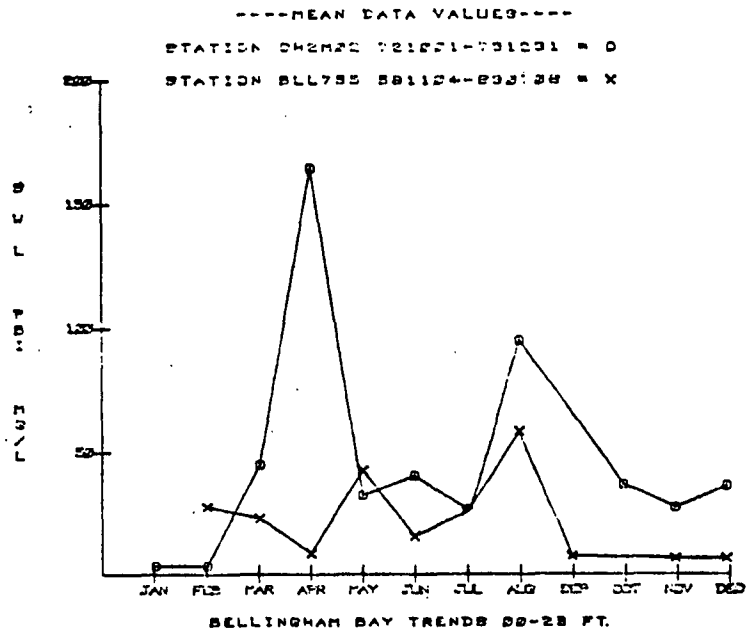


BELLINGHAM BAY TRENDS 00-25 FT.

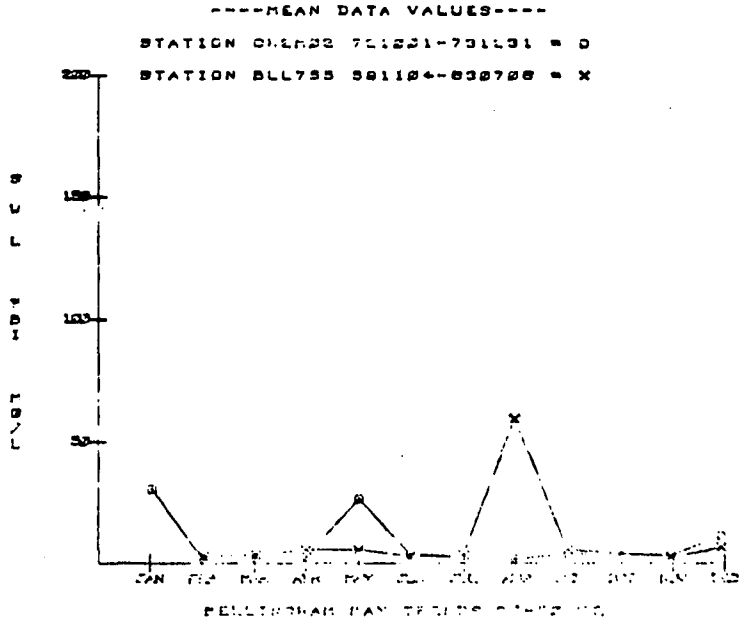




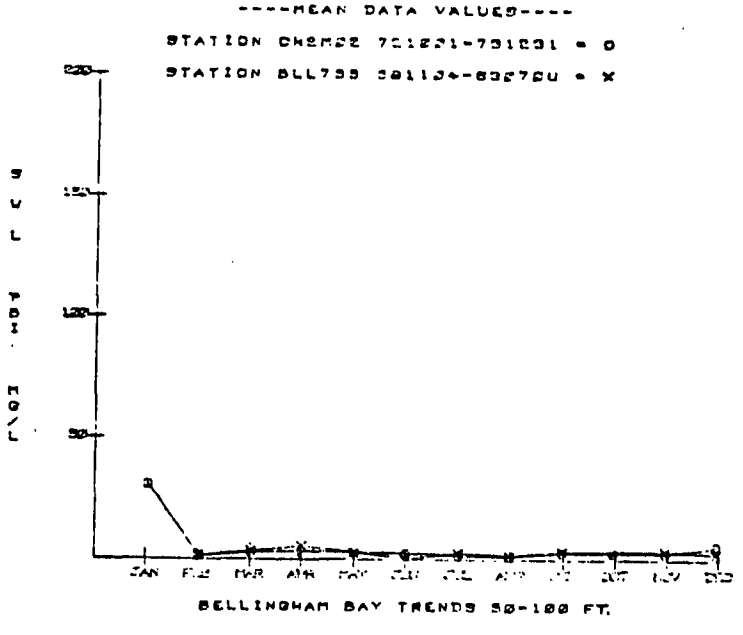
BELLINGHAM BAY TRENDS 50-100 FT.



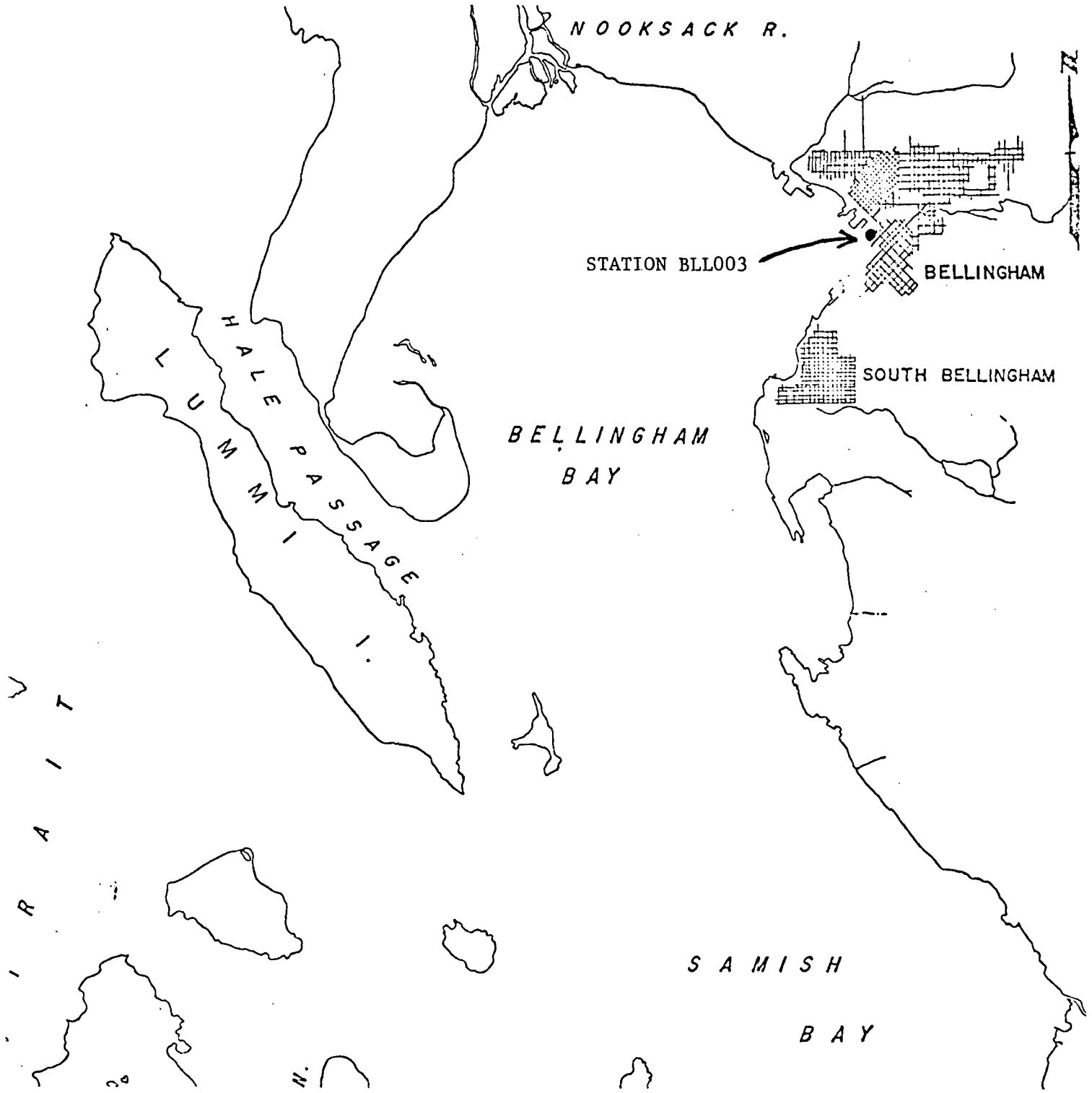
BELLINGHAM BAY TRENDS 20-28 FT.

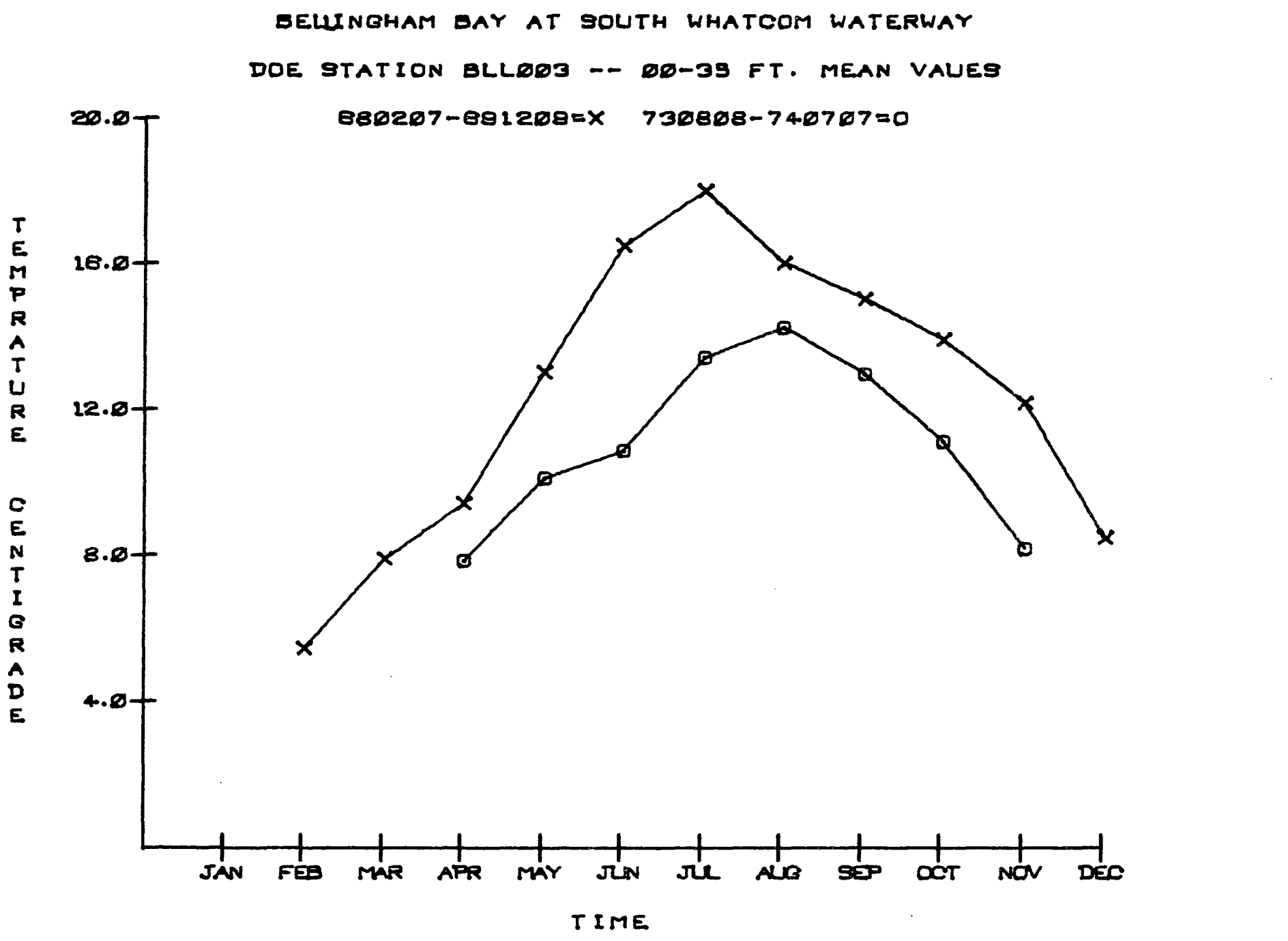


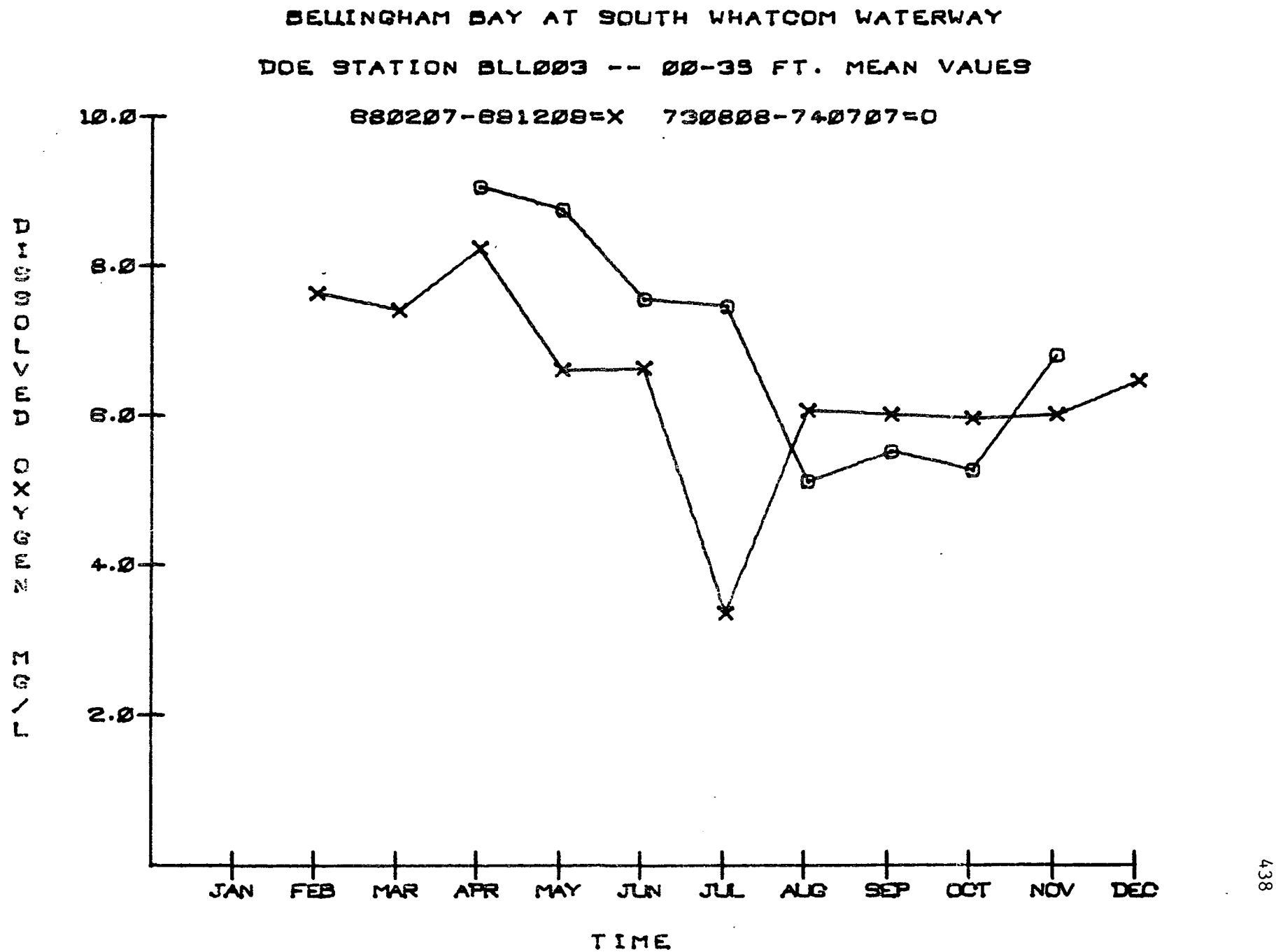
BELLINGHAM BAY TRENDS 50-100 FT.



BELLINGHAM BAY TRENDS 50-100 FT.


NOOKSACK R.
STATION BLL003
BELLINGHAM
SOUTH BELLINGHAM
BELLINGHAM BAY
HALE PASSAGE
LUMMI I.
SAMISH BAY

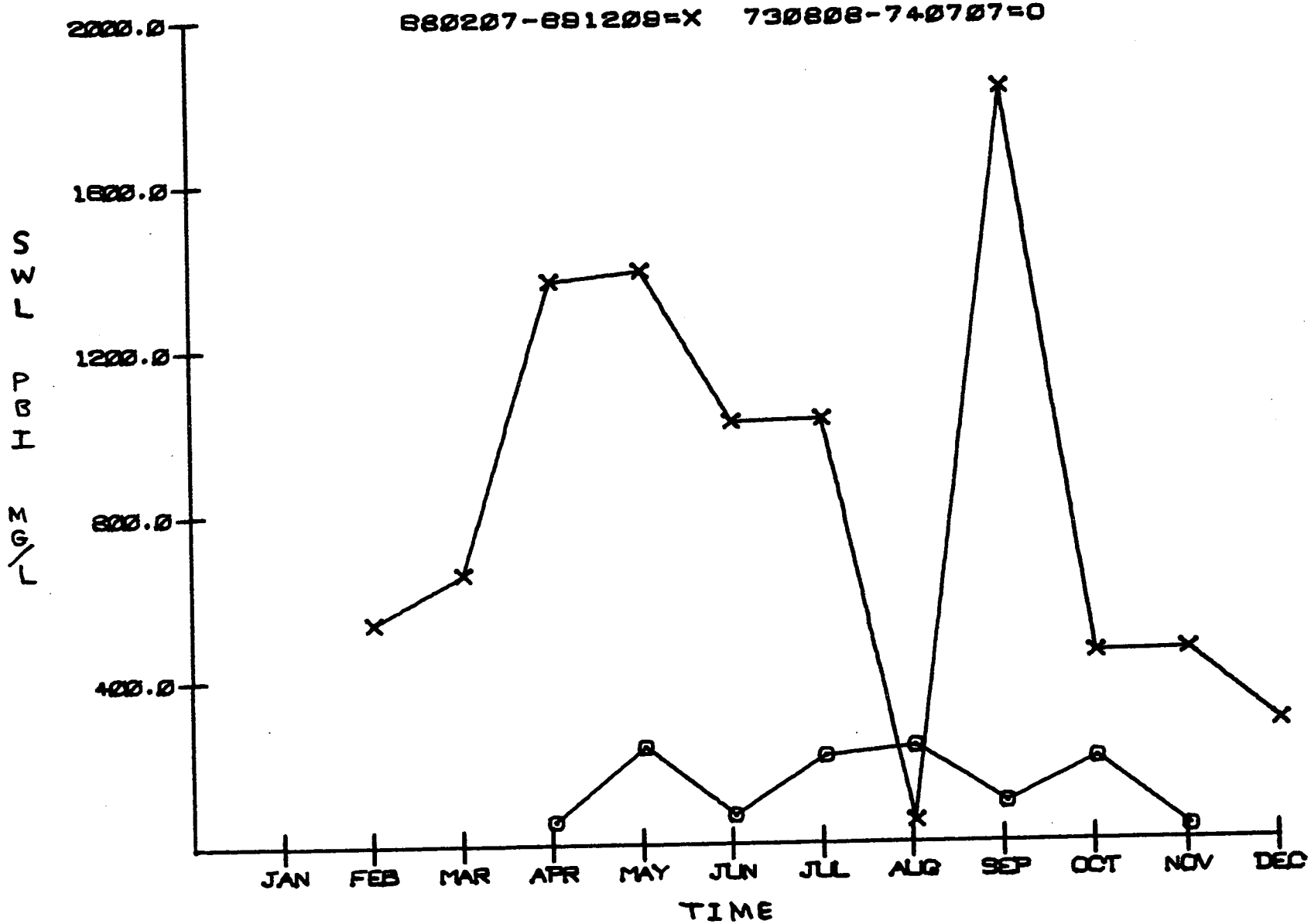

BELLINGHAM BAY AT SOUTH WHATCOM WATERWAY
DOE STATION BLL003 -- 00-35 FT. MEAN VALUES
880207-891208=X 730808-740707=O
20.0
16.0
12.0
8.0
4.0
TEMPRATURE CENTIGRADE
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
TIME


BELLINGHAM BAY AT SOUTH WHATCOM WATERWAY
DOE STATION BLL003 -- 00-35 FT. MEAN VALUES
880207-891208=X 730808-740707=O
10.0
8.0
6.0
4.0
2.0
DISSOLVED OXYGEN MG/L
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
TIME

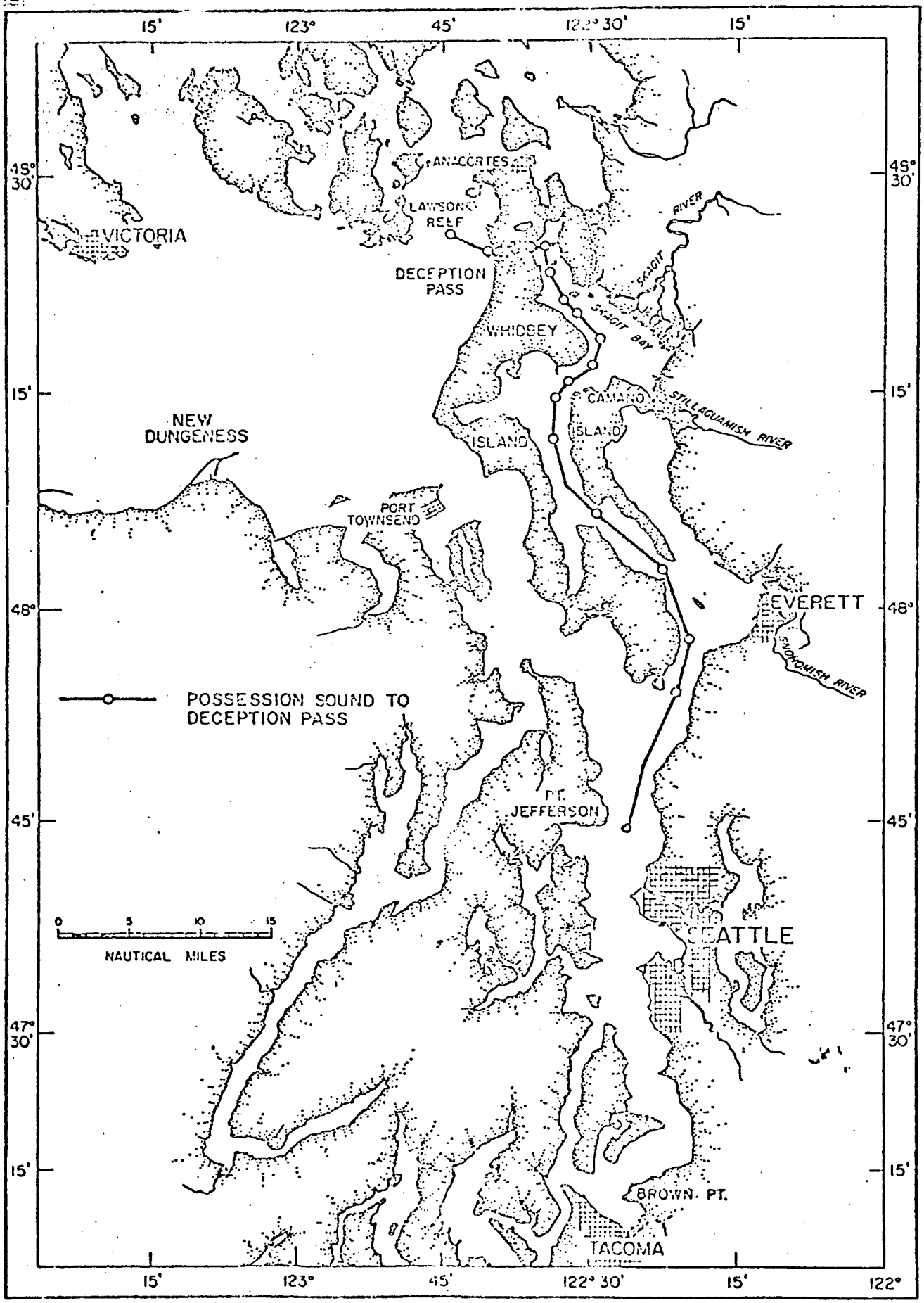
BELLINGHAM BAY AT SOUTH WHATCOM WATERWAY

DOE STATION BLL003 -- 00-35 FT. MEAN VALUES

880207-891209=X 730808-740707=O

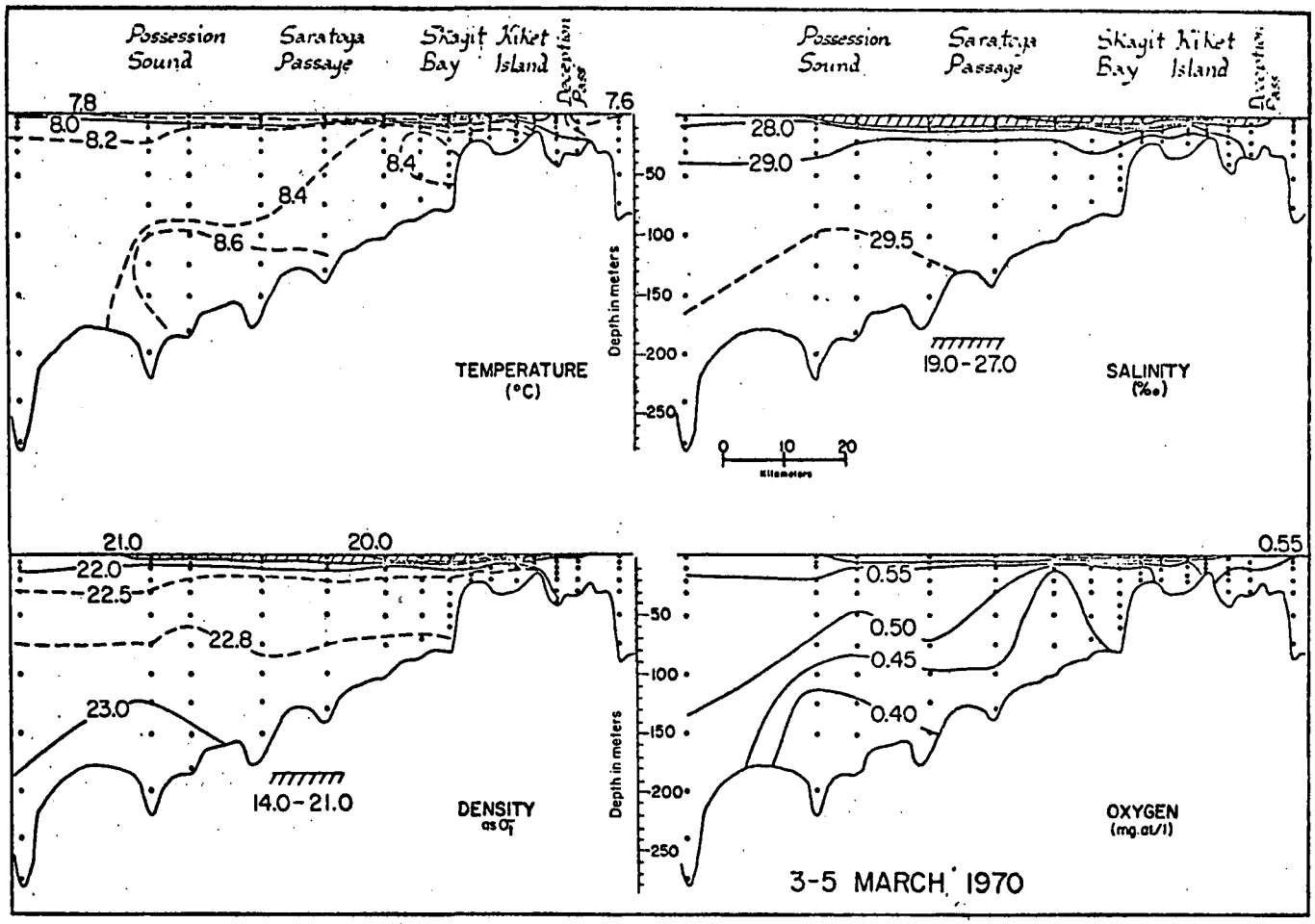


WHIDBEY BASIN

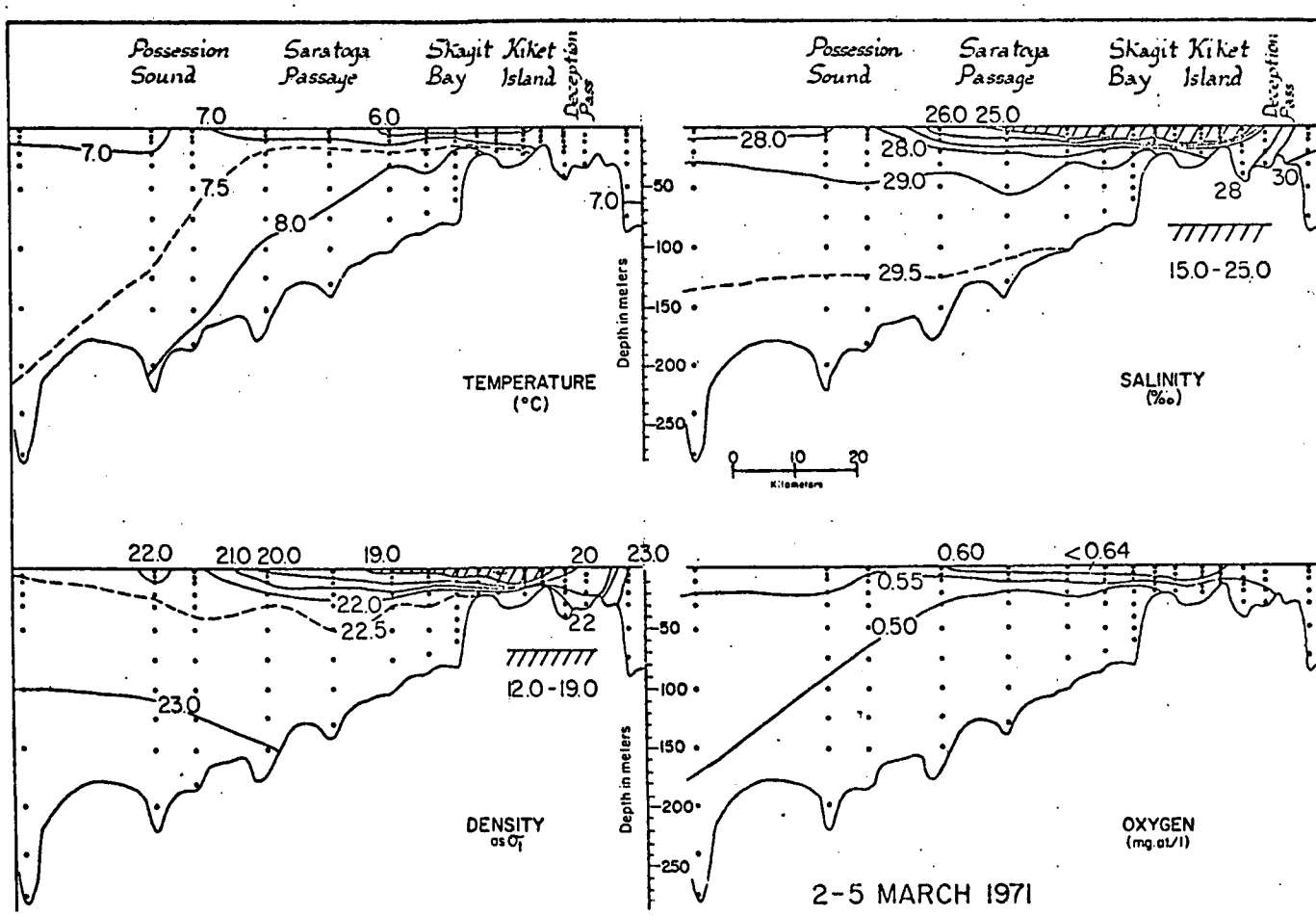


Location of longitudinal profiles used to present the data from the study area.

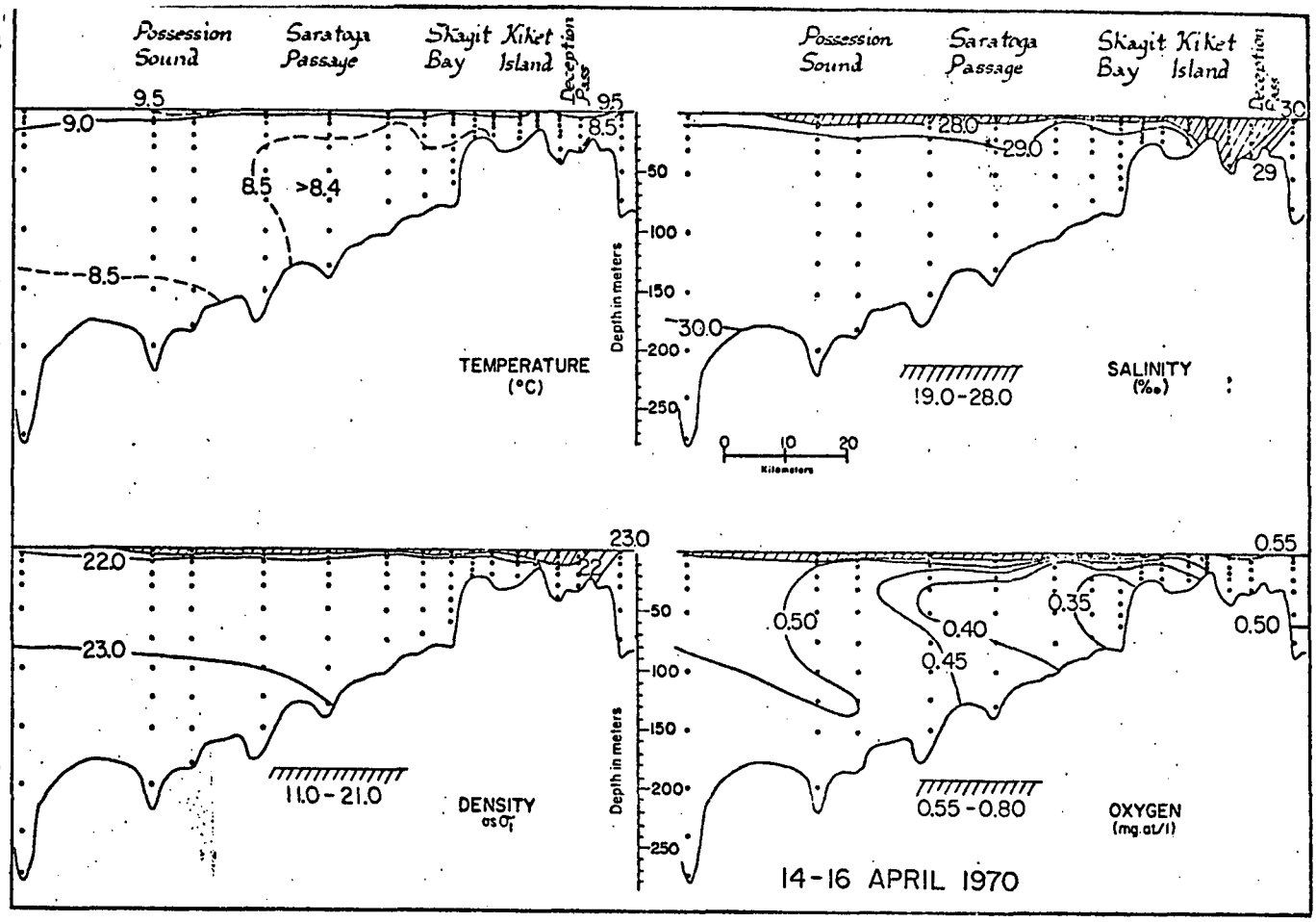
Water properties; Seattle to Deception Pass: 3 - 5 March 1970



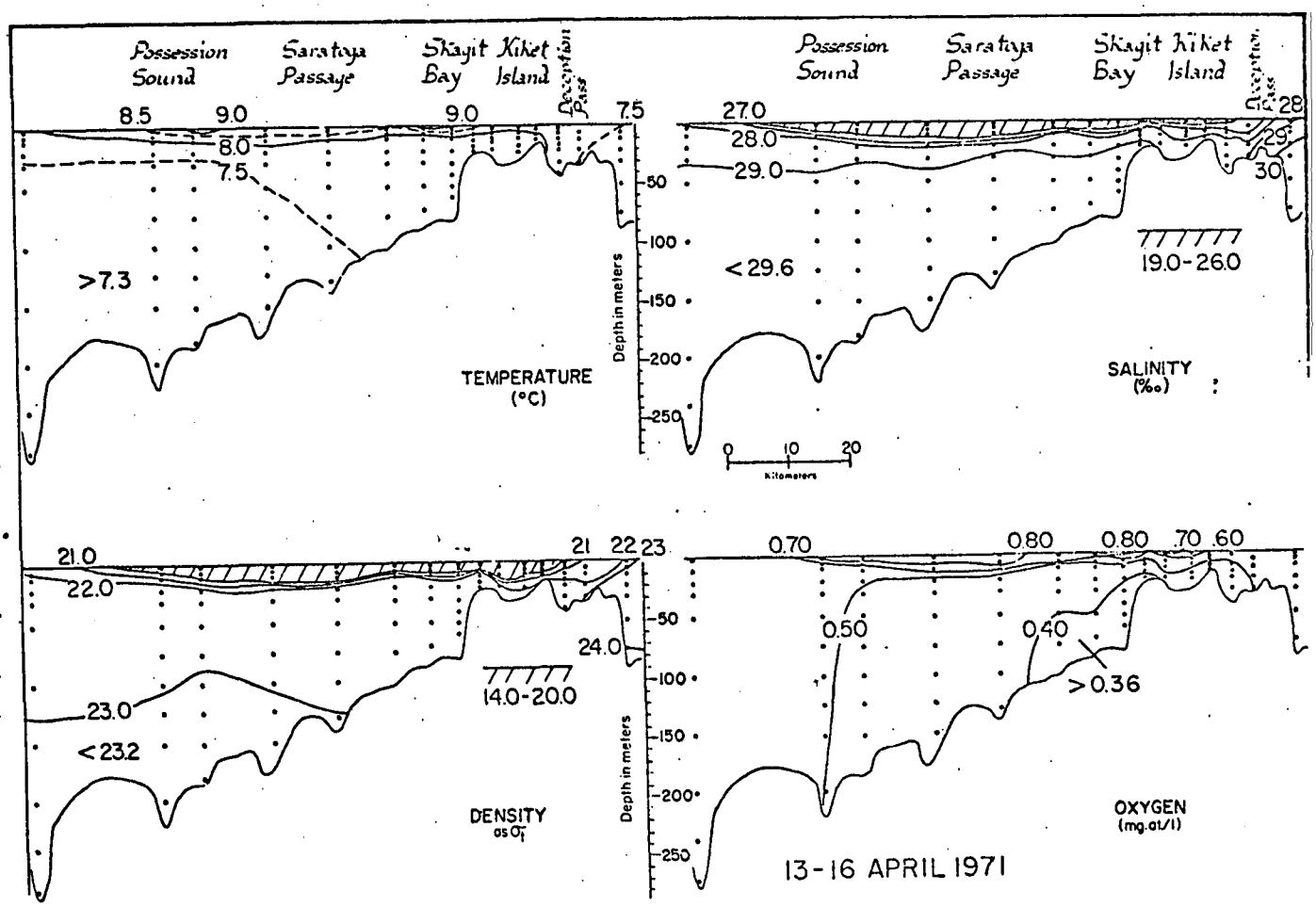
Water properties; Seattle to Deception Pass: 2 - 5 March 1971



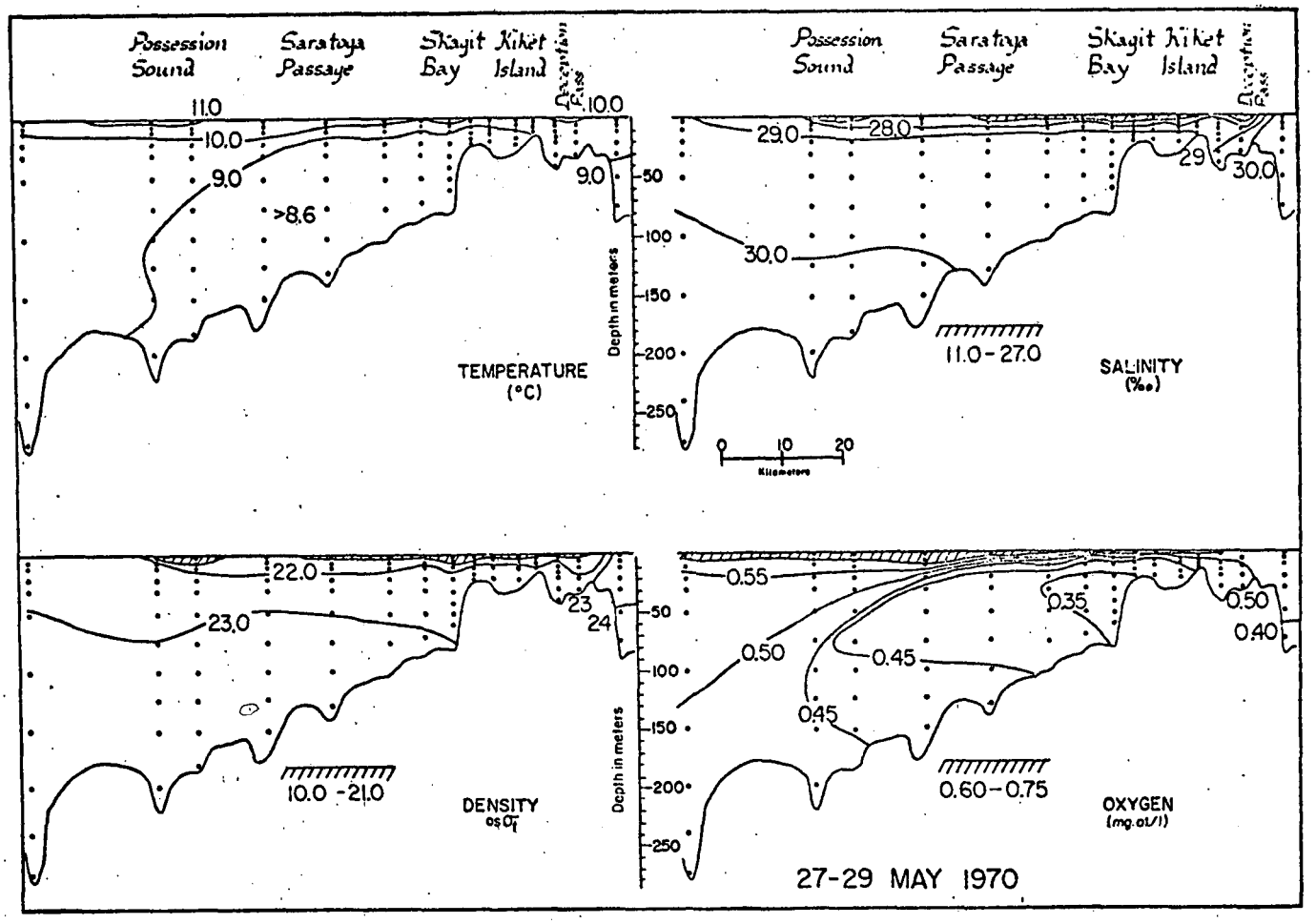
Water properties; Seattle to Deception Pass:
14 - 16 April 1970



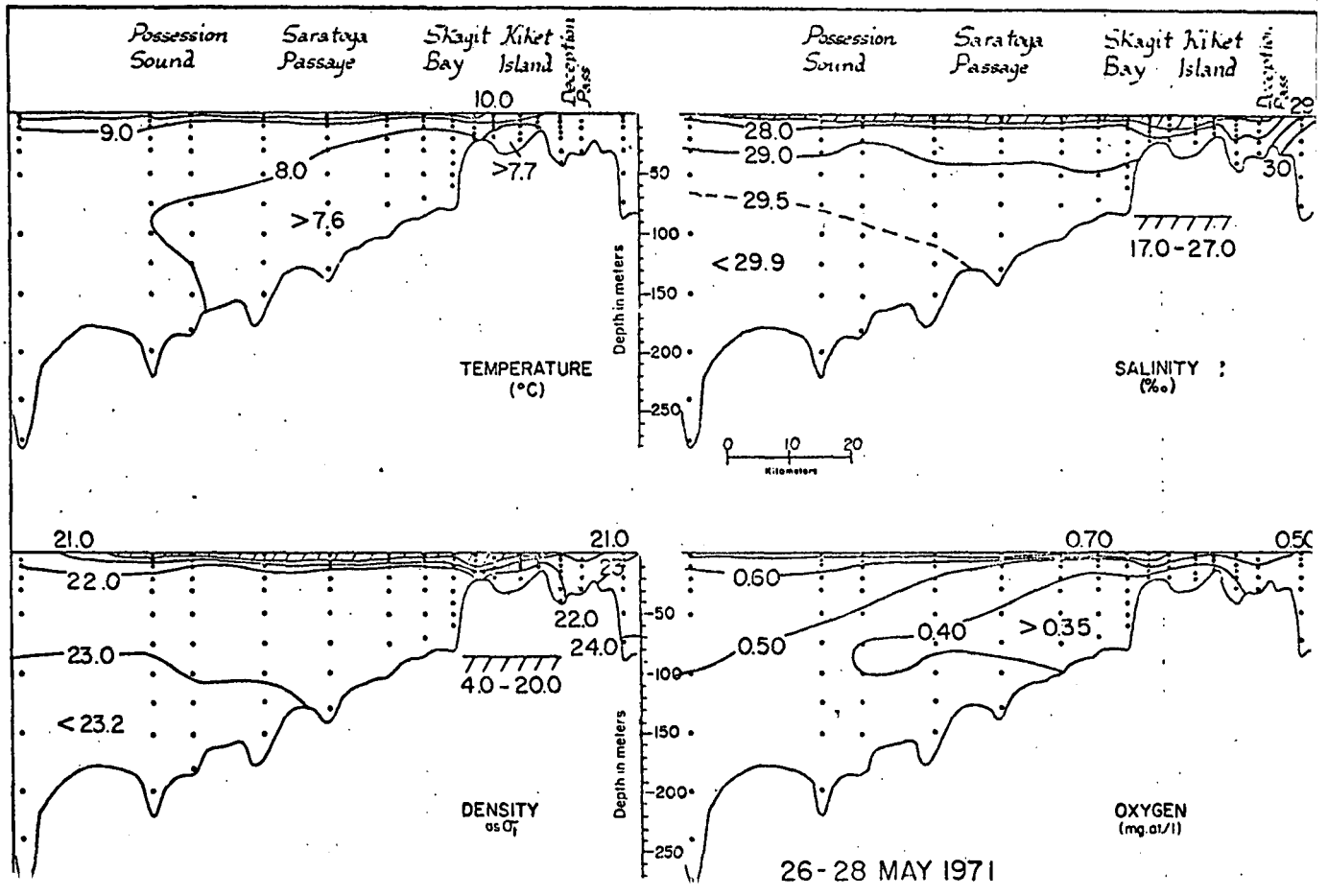
Water properties; Seattle to Deception Pass:
13 - 16 April 1971



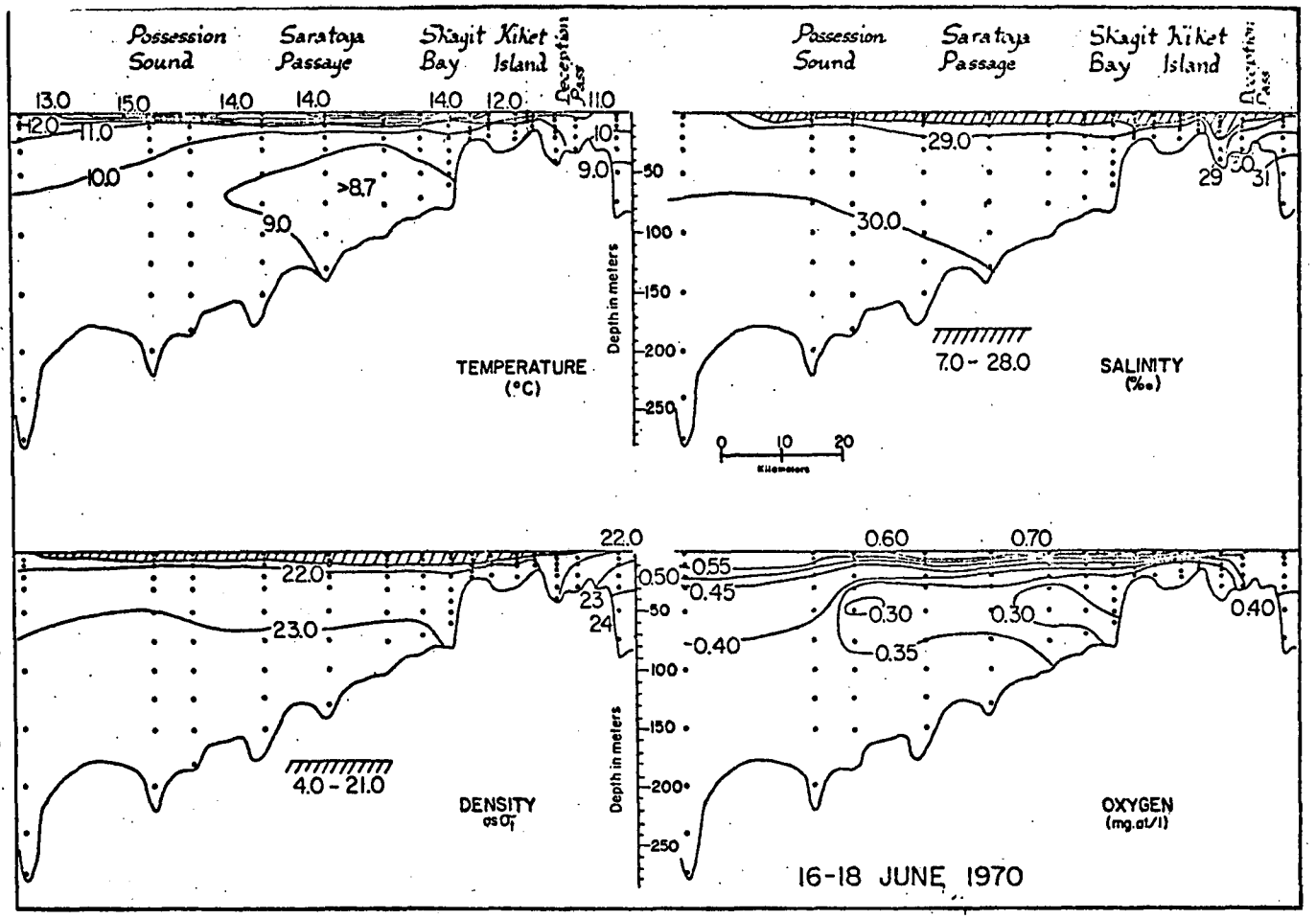
Water properties; Seattle to Deception Pass:
27 - 29 May 1970



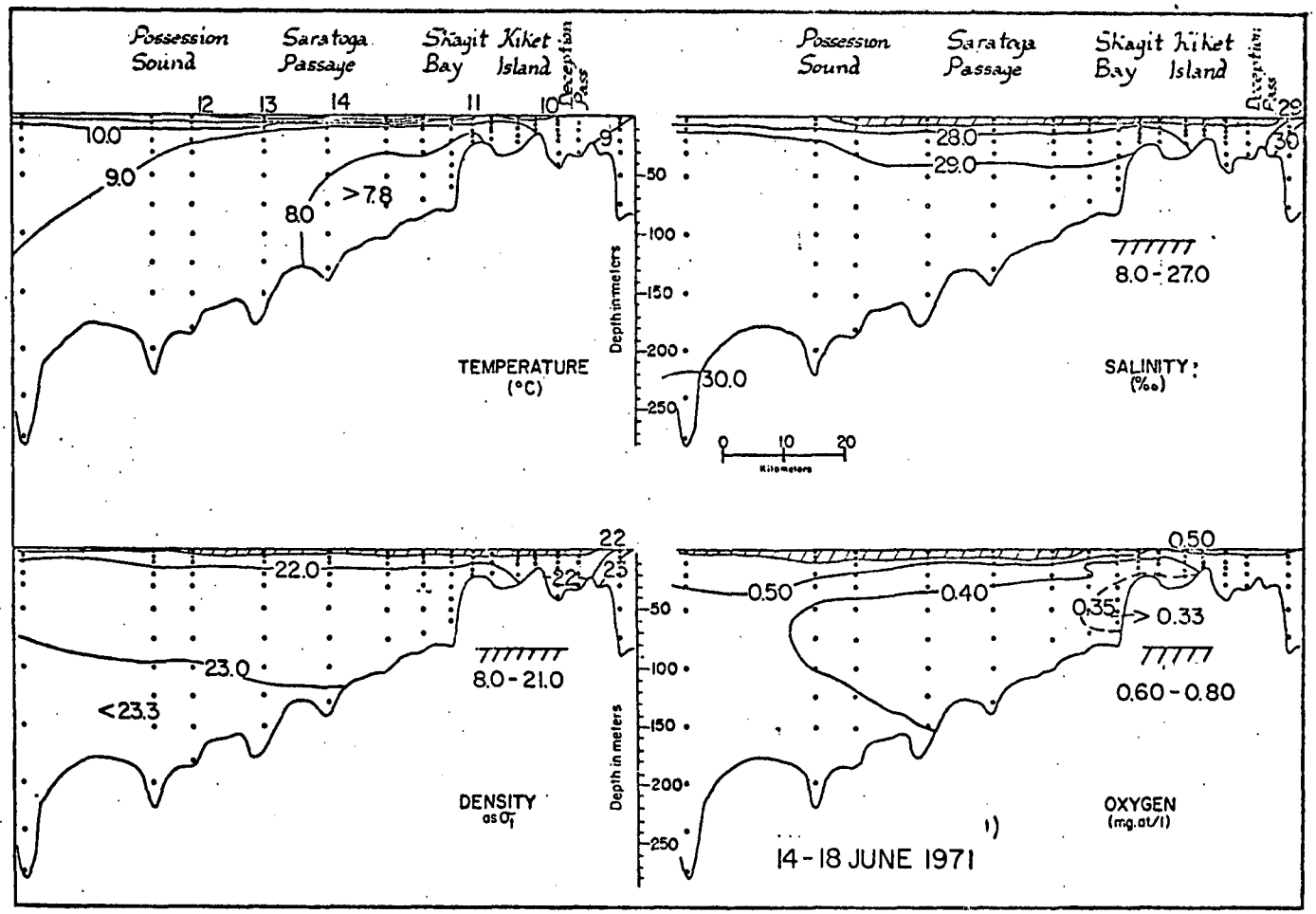
Water properties; Seattle to Deception Pass:
26 - 28 May 1971

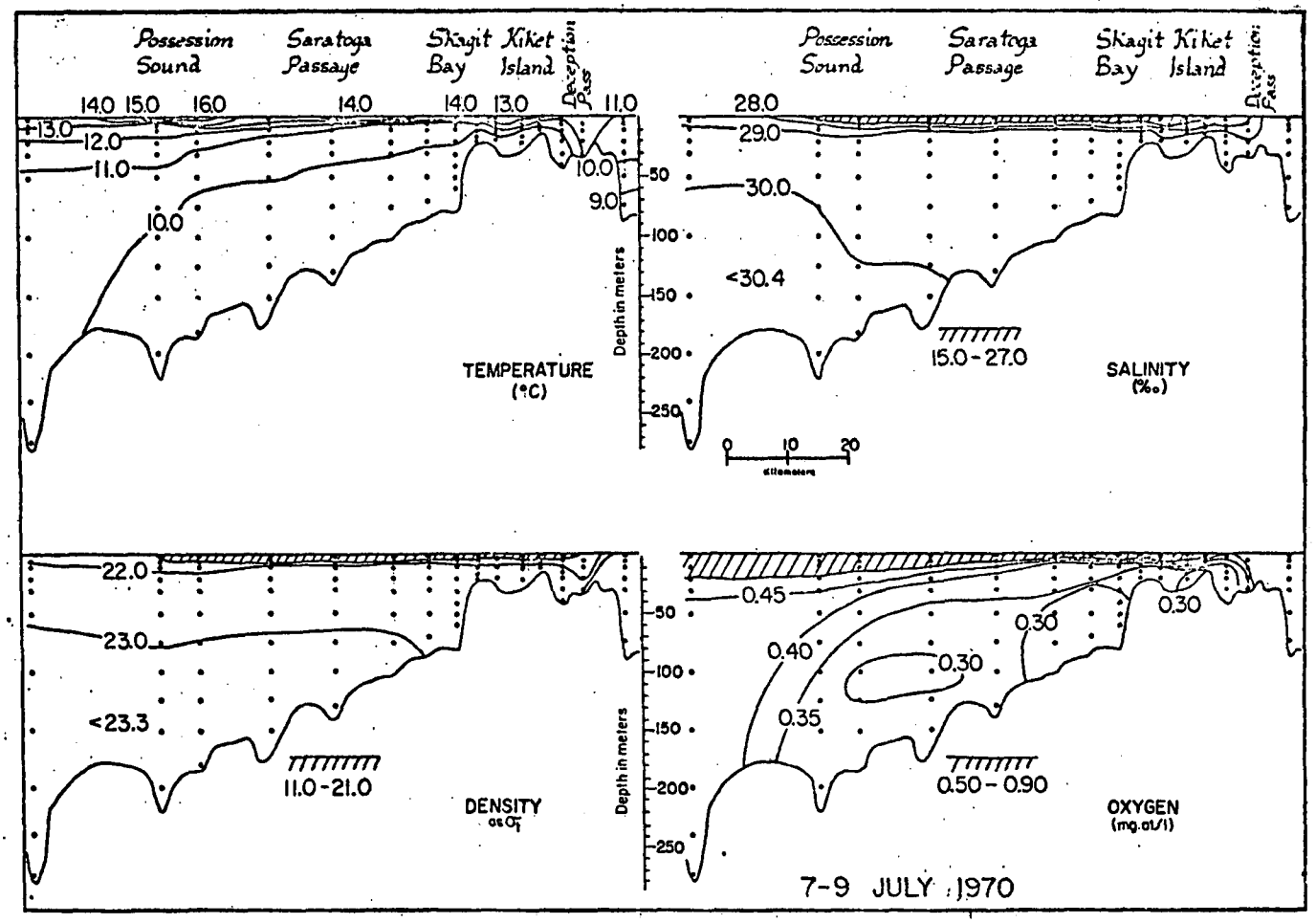


Water properties; Seattle to Deception Pass:
16 - 18 June 1970

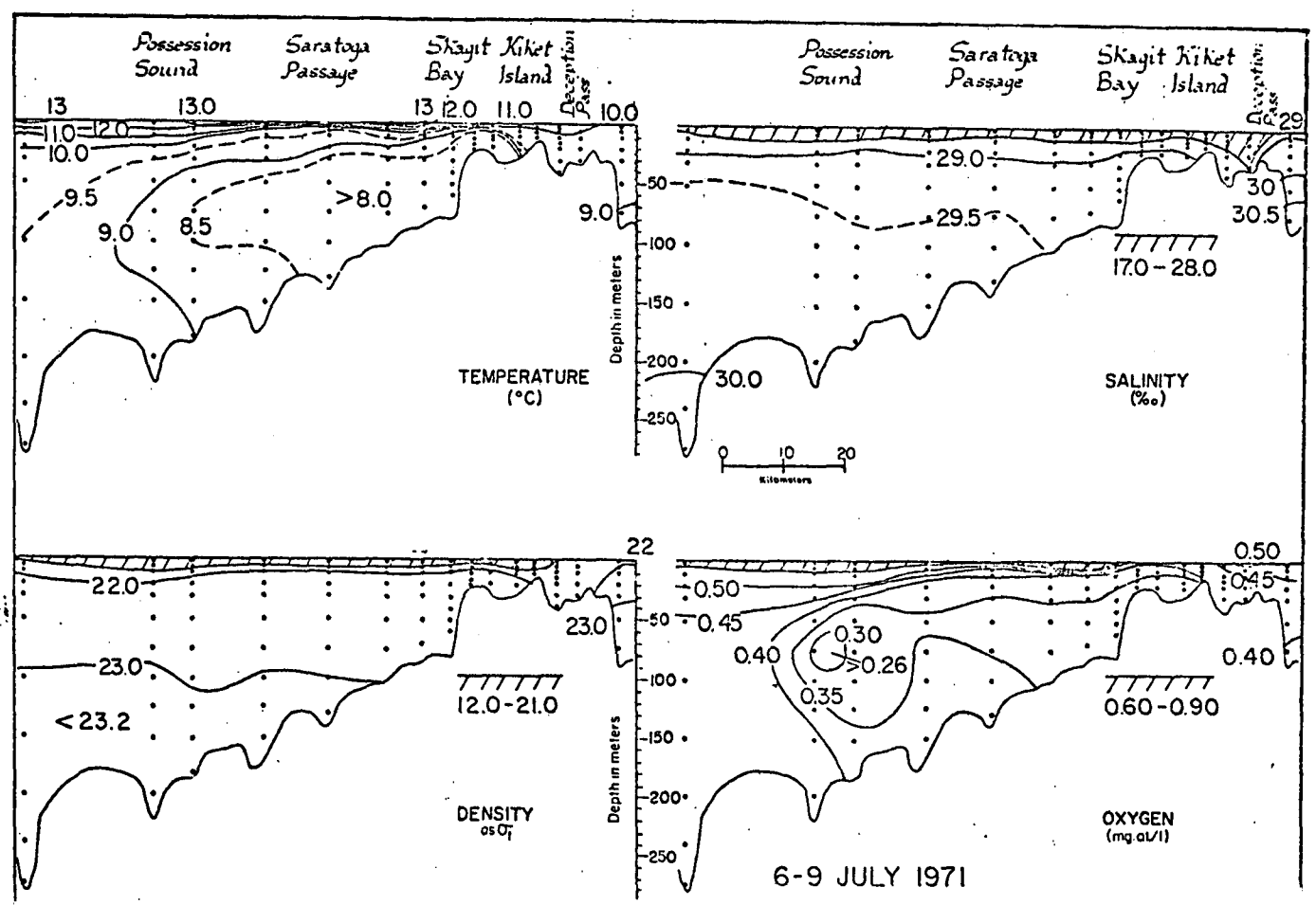


Water properties; Seattle to Deception Pass:
14 - 18 June 1971



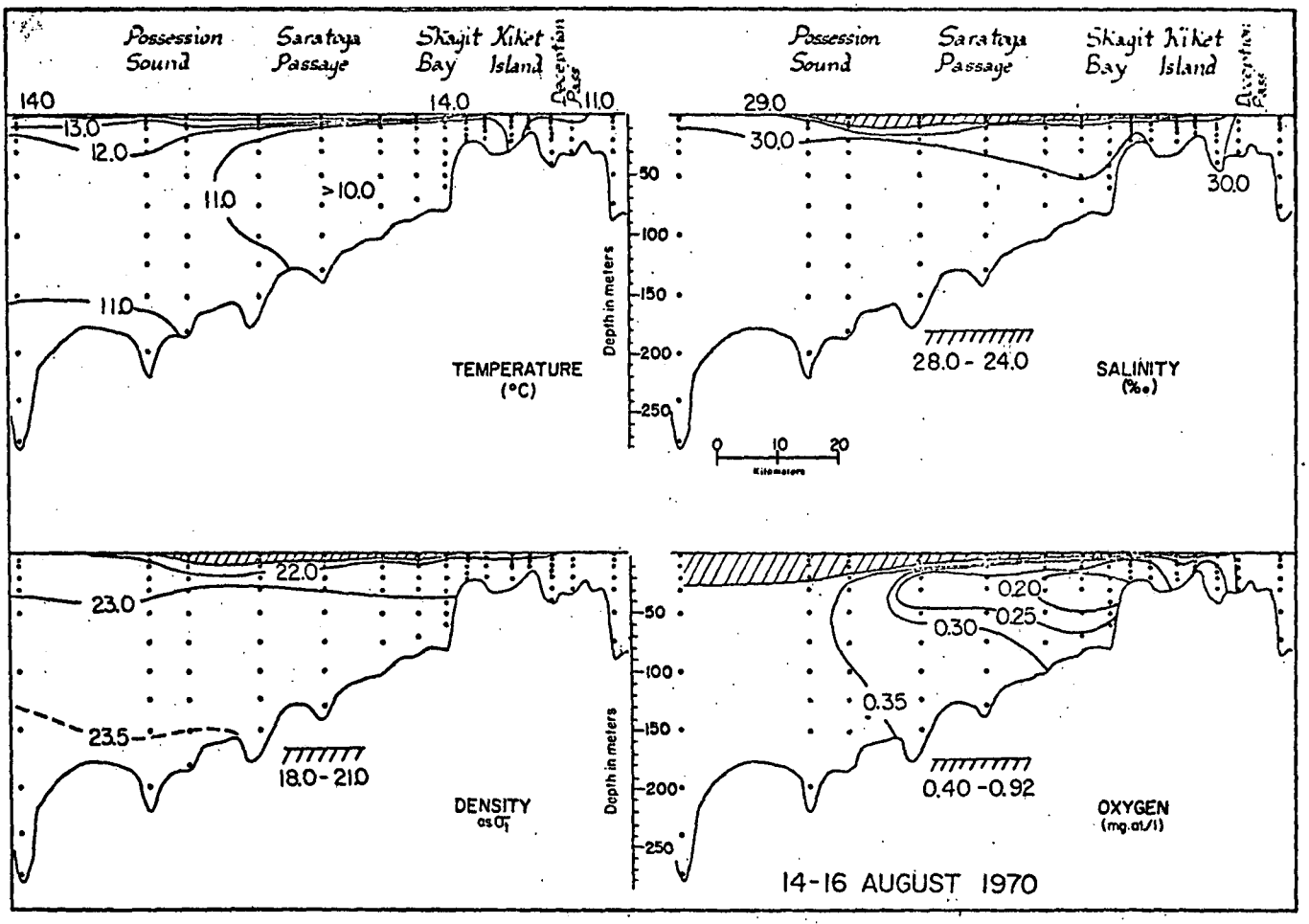


Water properties; Seattle to Deception Pass: 7 - 9 July 1970

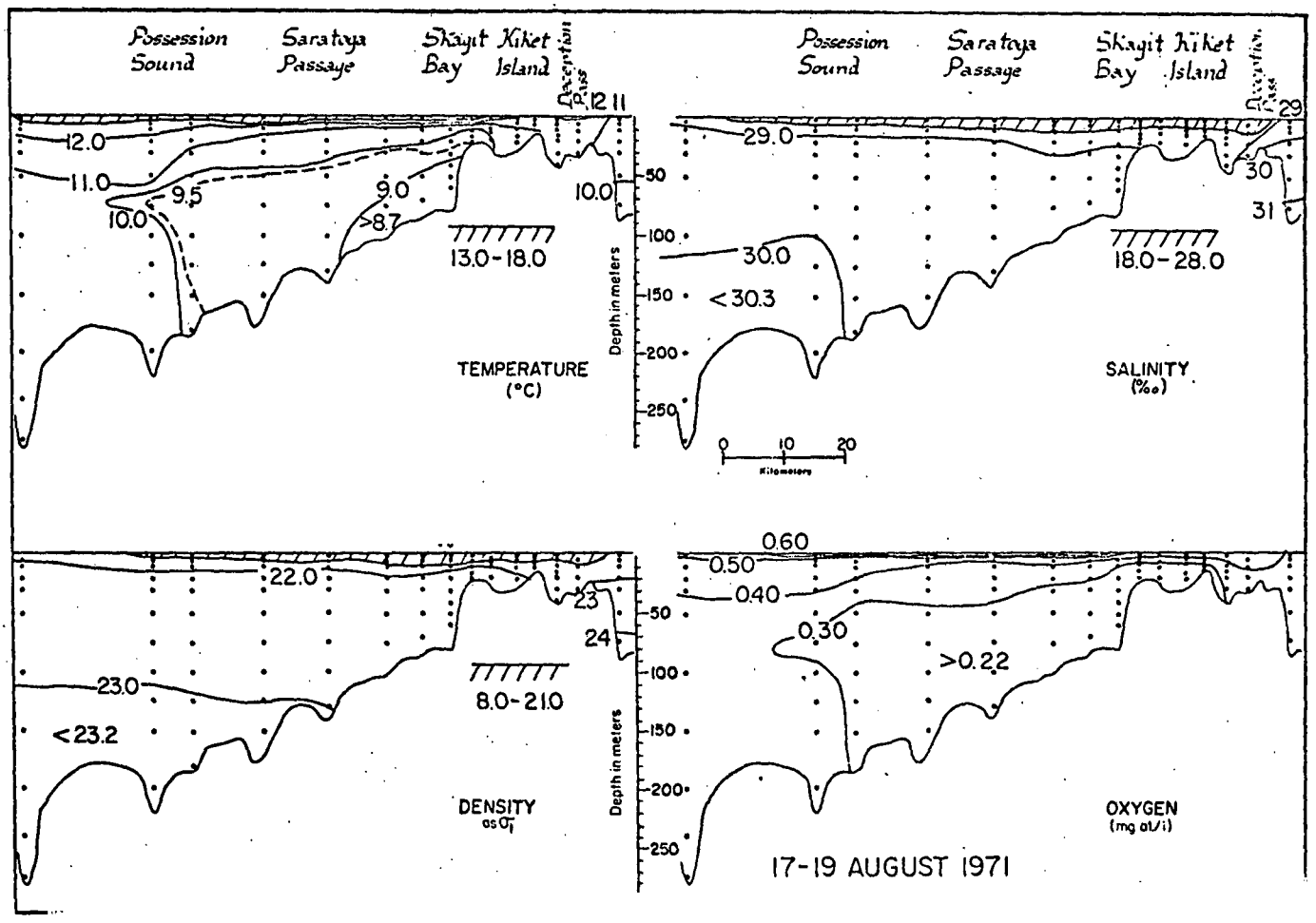


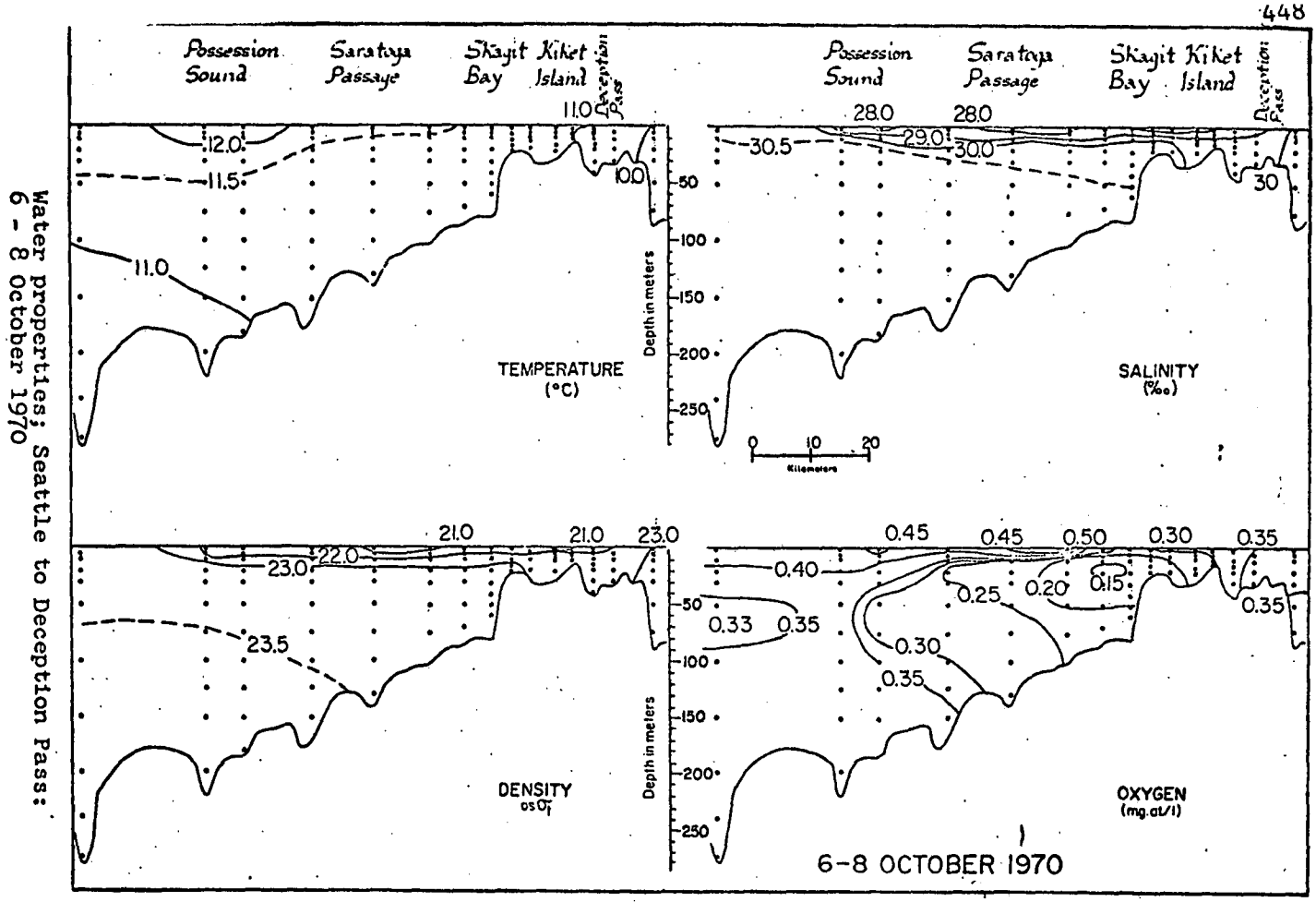
Water properties; Seattle to Deception Pass: 6 - 9 July 1971

Water properties; Seattle to Deception Pass:
14 - 16 August 1970

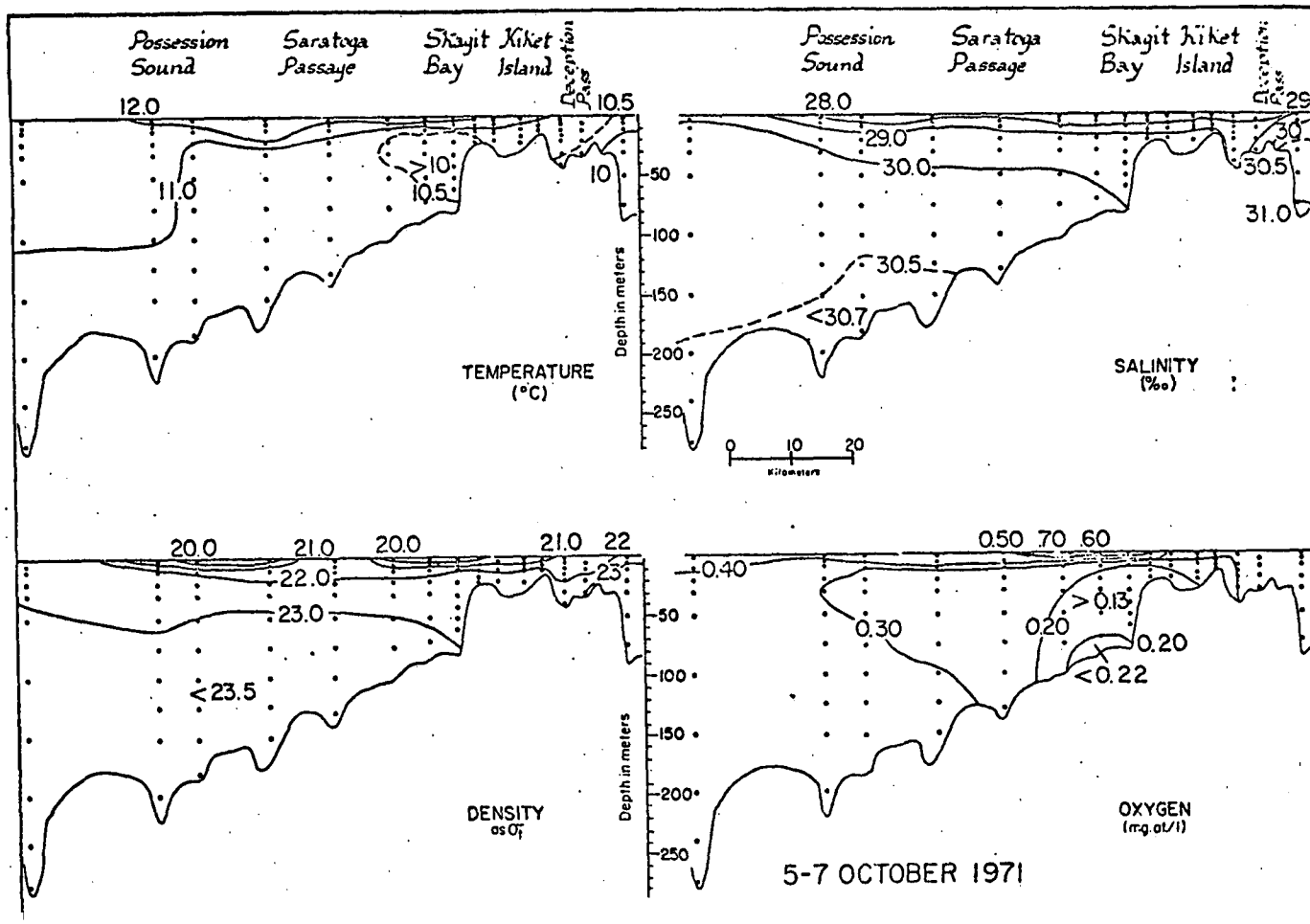


Water properties; Seattle to Deception Pass:
17 - 19 August 1971

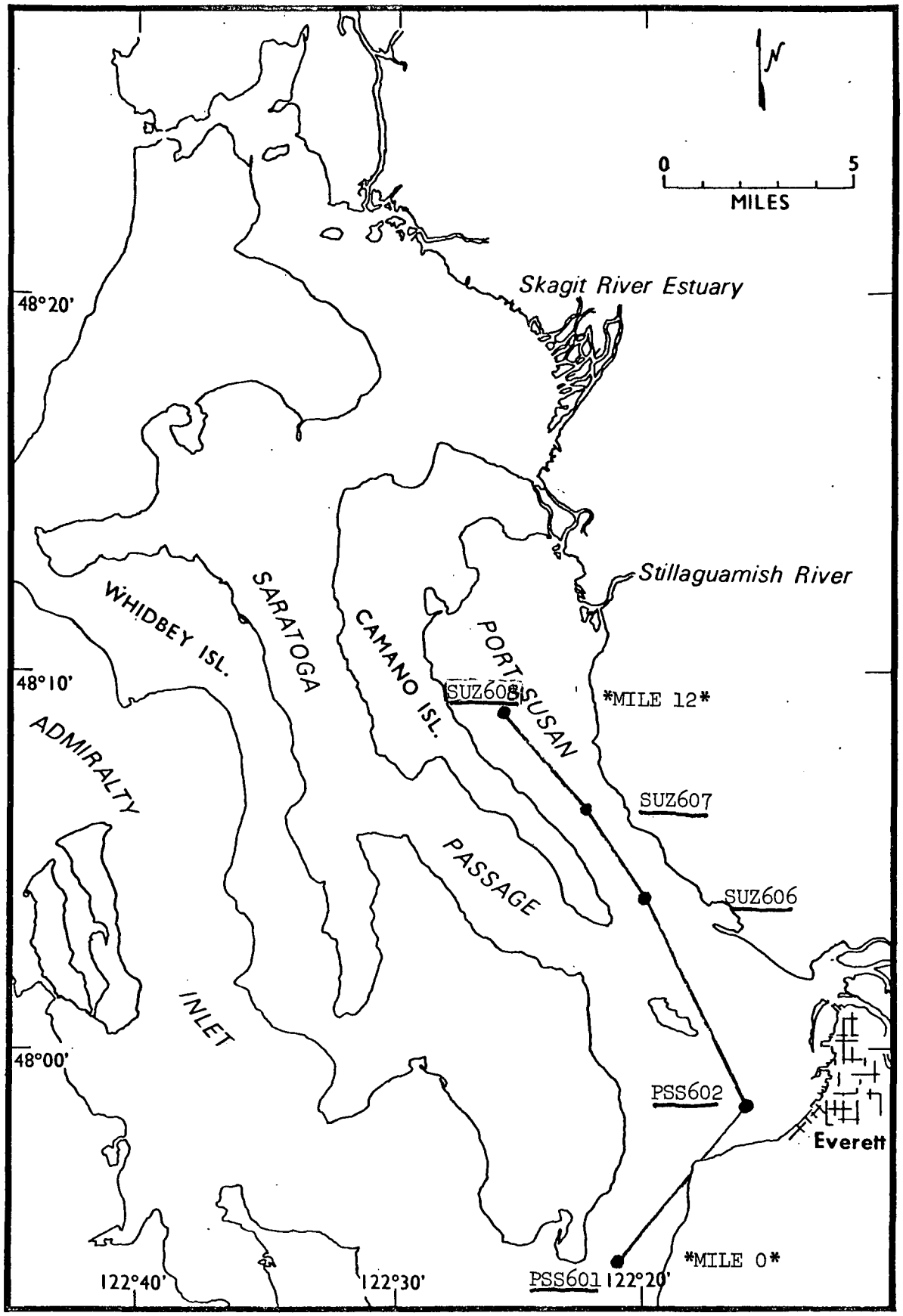




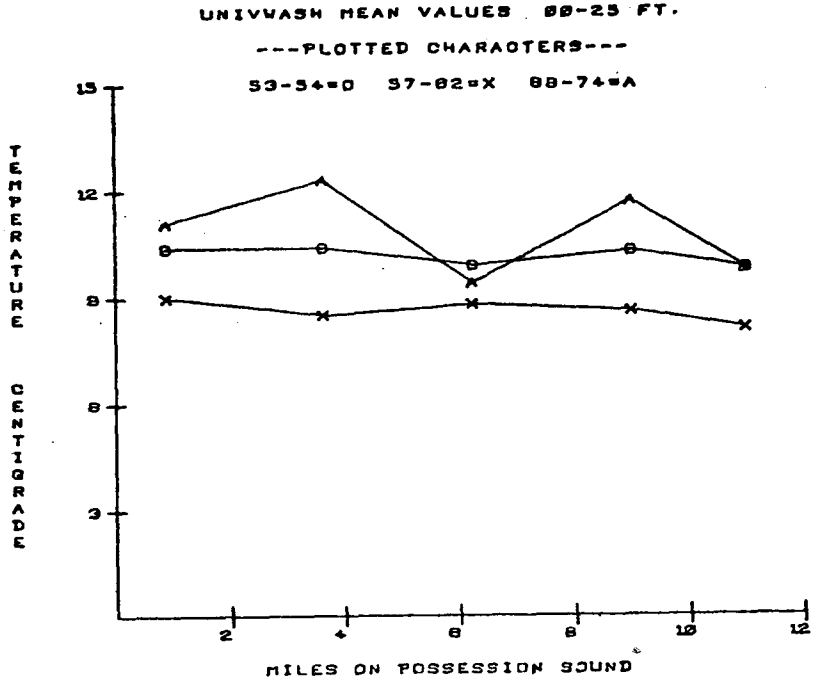
Water properties; Seattle to Deception Pass: 6 - 8 October 1970

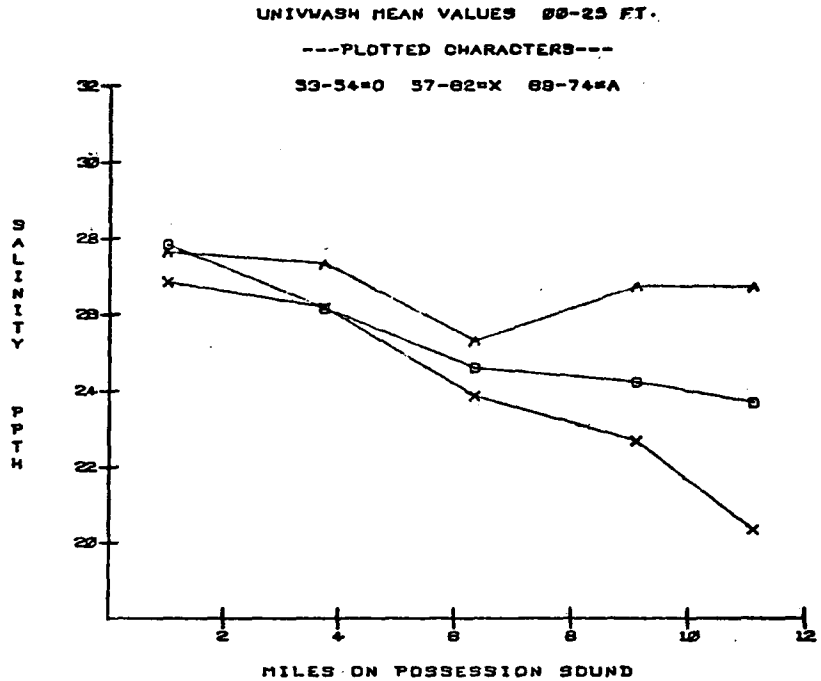


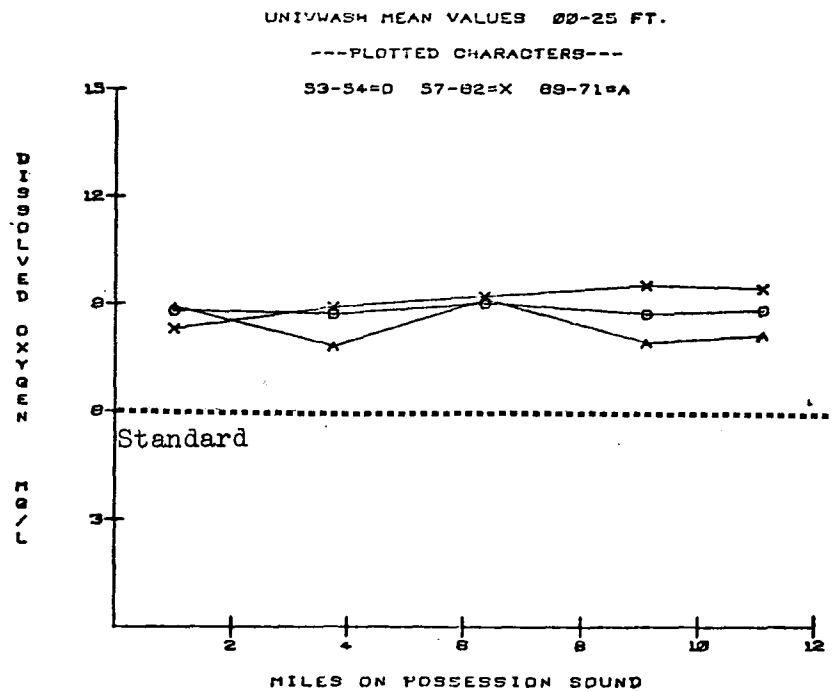
Water properties; Seattle to Deception Pass: 5 - 7 October 1971

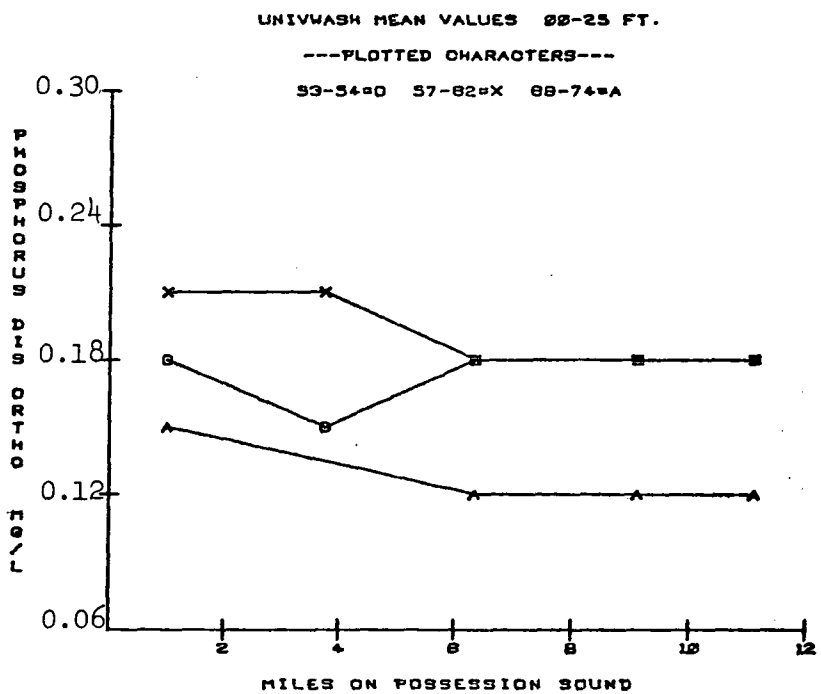


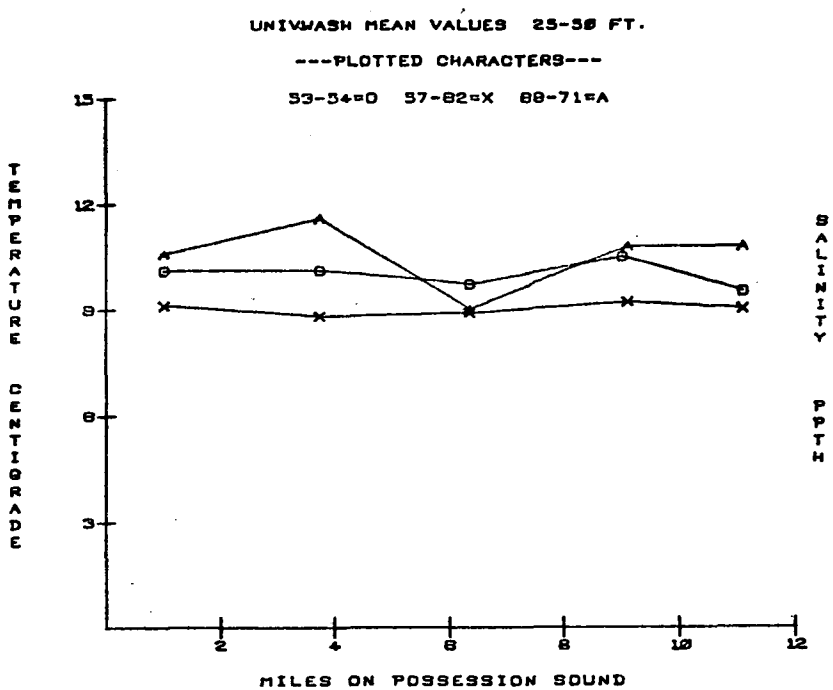
POSSESSION SOUND STATION LOCATION CHART

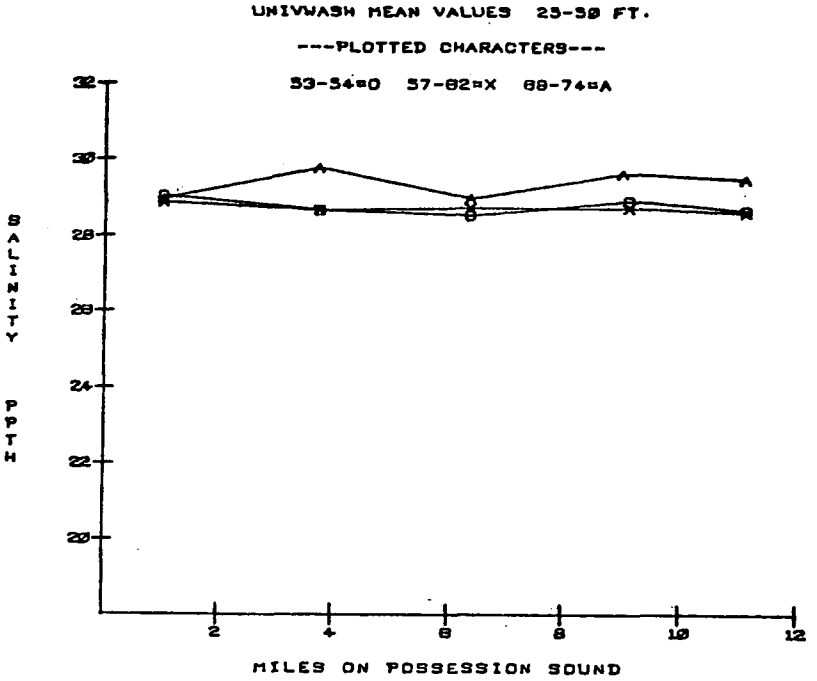

UNIVWASH MEAN VALUES 00-25 FT.
---PLOTTED CHARACTERS---
53-54=0 57-82=X 88-74=A
TEMPERATURE CENTIGRADE
15
12
9
6
3
2
4
6
8
10
12
MILES ON POSSESSION SOUND

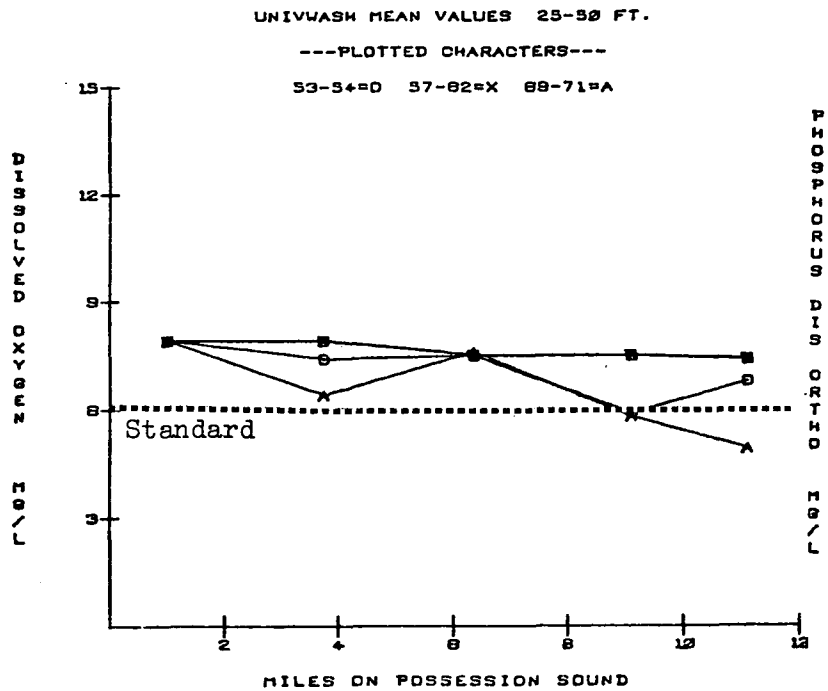

UNIVWASH MEAN VALUES 00-25 FT.
---PLOTTED CHARACTERS---
53-54=0 57-82=X 88-74=A
SALINITY PPTH
32
30
28
26
24
22
20
2
4
6
8
10
12
MILES ON POSSESSION SOUND

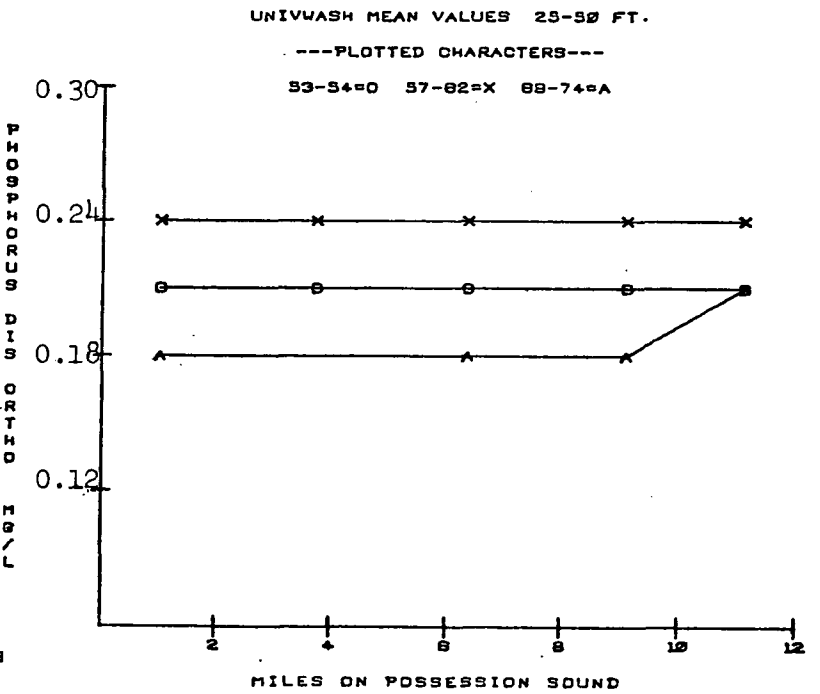

UNIVWASH MEAN VALUES 00-25 FT.
---PLOTTED CHARACTERS---
53-54=0 57-82=X 89-71=A
DISSOLVED OXYGEN MG\L
15
12
9
6
3
Standard
2
4
6
8
10
12
MILES ON POSSESSION SOUND

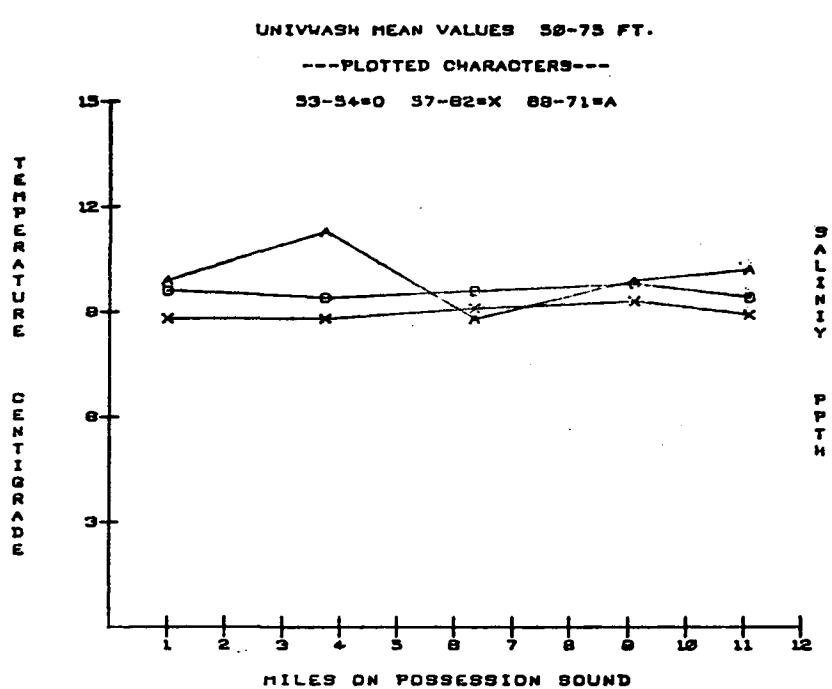

UNIVWASH MEAN VALUES 00-25 FT.
---PLOTTED CHARACTERS---
53-54=0 57-82=X 88-74=A
PHOSPHORUS DIS ORTHO MG\L
0.30
0.24
0.18
0.12
0.06
2
4
6
8
10
12
MILES ON POSSESSION SOUND

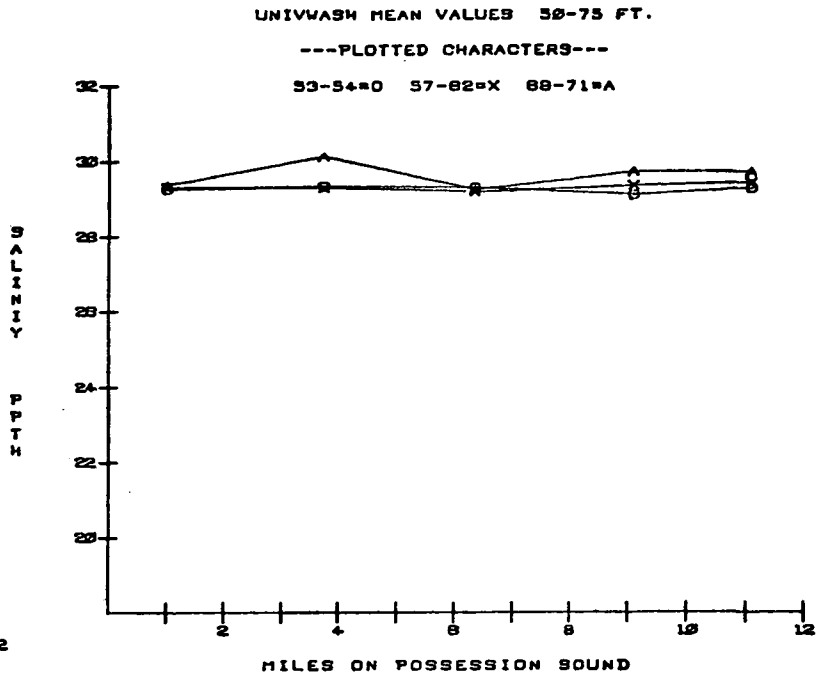

UNIVWASH MEAN VALUES 25-50 FT.
---PLOTTED CHARACTERS---
53-54=O 57-62=X 68-71=A
TEMPERATURE CENTIGRADE
15
12
9
6
3
2
4
6
8
10
12
MILES ON POSSESSION SOUND

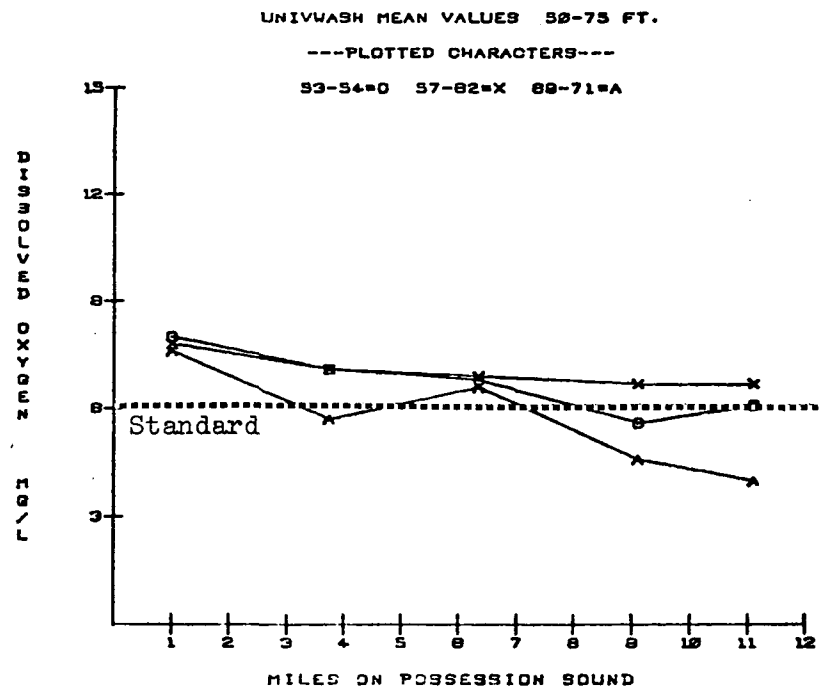

UNIVWASH MEAN VALUES 25-50 FT.
---PLOTTED CHARACTERS---
53-54=O 57-62=X 68-74=A
SALINITY PPTH
32
30
28
26
24
22
20
2
4
6
8
10
12
MILES ON POSSESSION SOUND

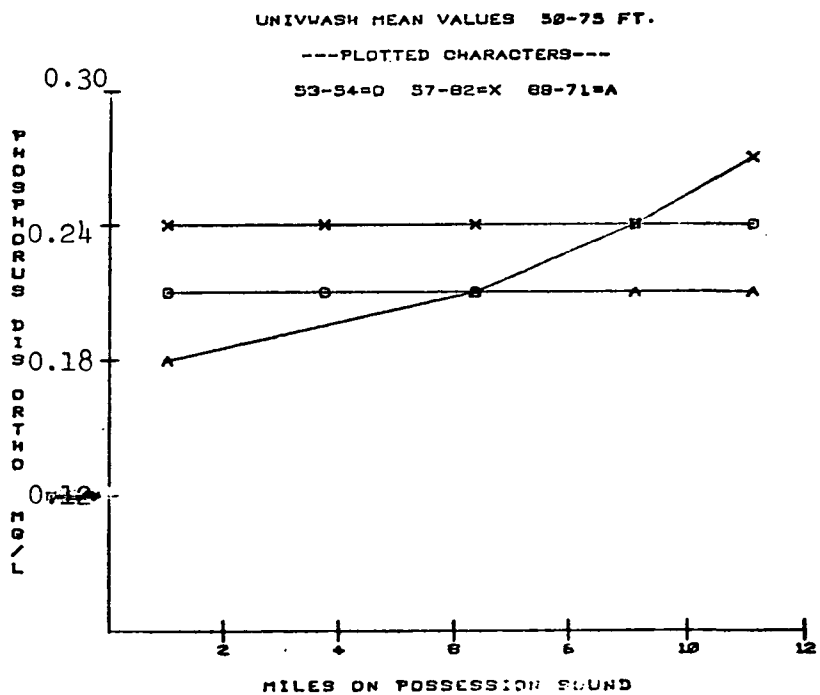

UNIVWASH MEAN VALUES 25-50 FT.
---PLOTTED CHARACTERS---
53-54=O 57-62=X 68-71=A
DISSOLVED OXYGEN MG\L
15
12
9
6
3
Standard
2
4
6
8
10
12
MILES ON POSSESSION SOUND

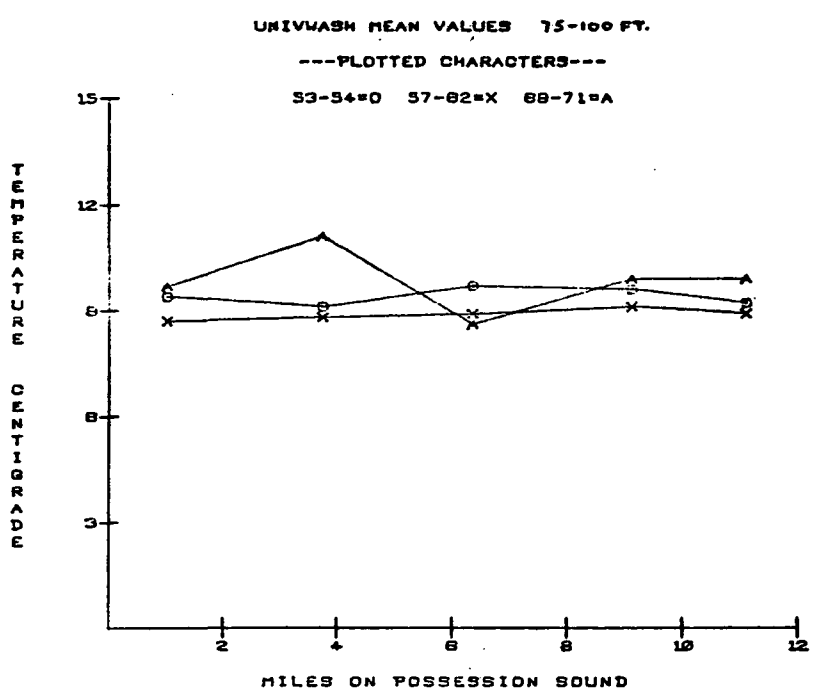

UNIVWASH MEAN VALUES 25-50 FT.
---PLOTTED CHARACTERS---
53-54=O 57-62=X 68-74=A
PHOSPHORUS DIS ORTHO MG\L
0.30
0.24
0.18
0.12
2
4
6
8
10
12
MILES ON POSSESSION SOUND

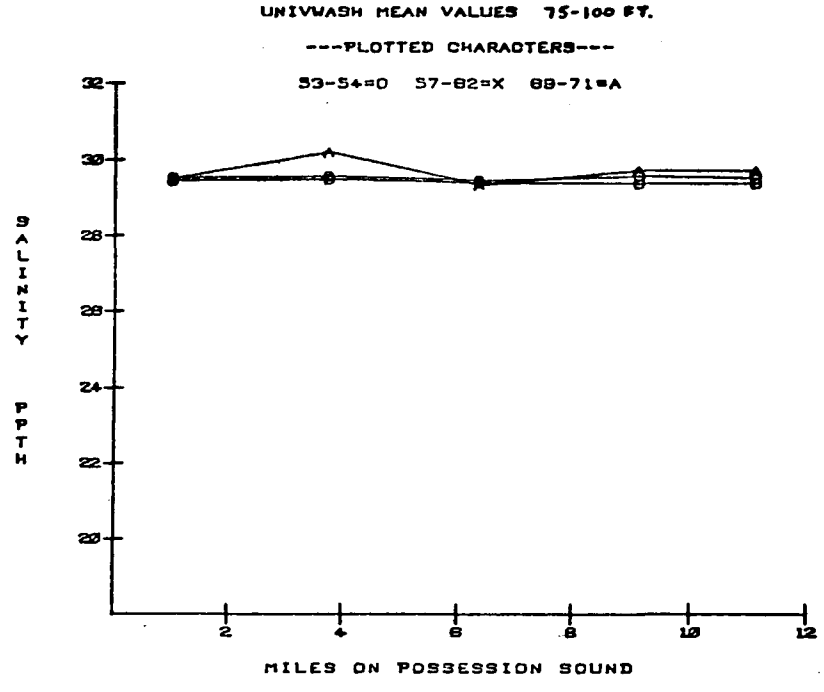

UNIVWASH MEAN VALUES 50-75 FT.
---PLOTTED CHARACTERS---
53-54=O 57-82=X 68-71=A
TEMPERATURE CENTIGRADE
15
12
9
6
3
1 2 3 4 5 6 7 8 9 10 11 12
MILES ON POSSESSION SOUND

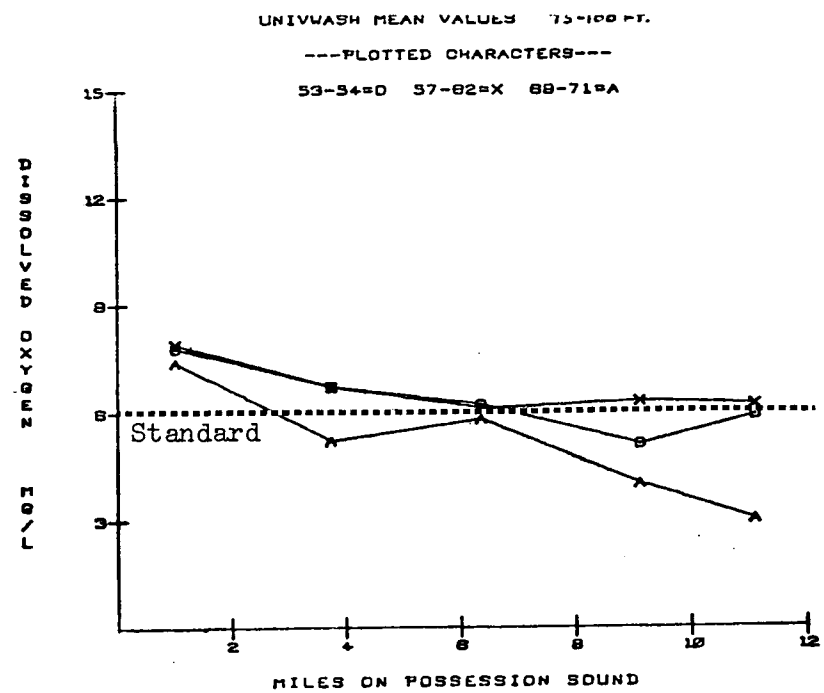

UNIVWASH MEAN VALUES 50-75 FT.
---PLOTTED CHARACTERS---
53-54=O 57-82=X 68-71=A
SALINITY PPTH
32
28
24
22
20
2 4 6 8 10 12
MILES ON POSSESSION SOUND

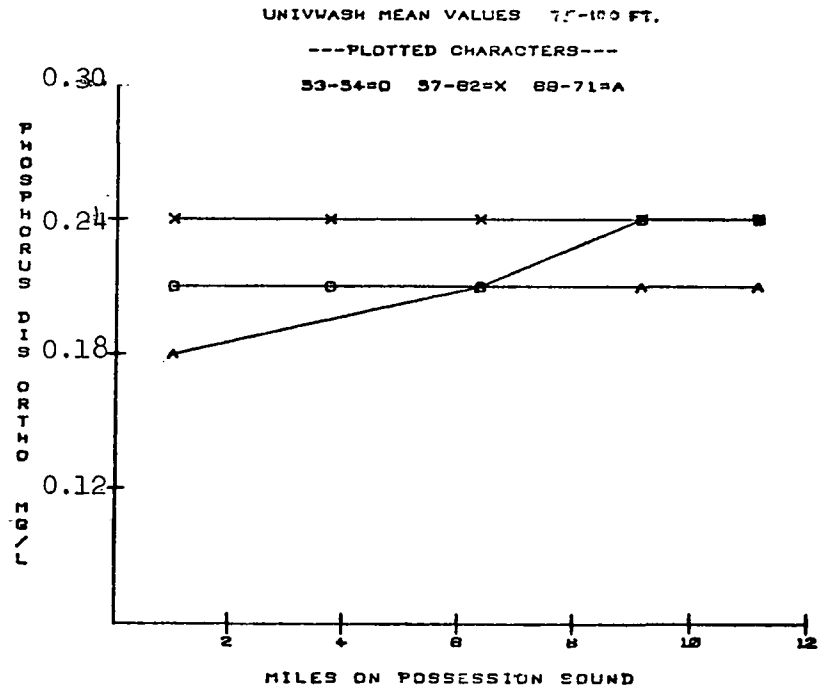

UNIVWASH MEAN VALUES 50-75 FT.
---PLOTTED CHARACTERS---
53-54=O 57-82=X 68-71=A
DISSOLVED OXYGEN MG/L
15
12
9
6
3
Standard
1 2 3 4 5 6 7 8 9 10 11 12
MILES ON POSSESSION SOUND


UNIVWASH MEAN VALUES 50-75 FT.
---PLOTTED CHARACTERS---
53-54=O 57-82=X 68-71=A
PHOSPHORUS DIS ORTHO MG/L
0.30
0.24
0.18
0.12
2 4 6 8 10 12
MILES ON POSSESSION SOUND


UNIVWASH MEAN VALUES 75-100 FT.
---PLOTTED CHARACTERS---
53-54=O 57-62=X 68-71=A
TEMPERATURE CENTIGRADE
15
12
9
8
3
2
4
6
8
10
12
MILES ON POSSESSION SOUND


UNIVWASH MEAN VALUES 75-100 FT.
---PLOTTED CHARACTERS---
53-54=O 57-62=X 68-71=A
SALINITY PPTH
32
30
28
26
24
22
20
2
4
6
8
10
12
MILES ON POSSESSION SOUND


UNIVWASH MEAN VALUES 75-100 FT.
---PLOTTED CHARACTERS---
53-54=O 57-62=X 68-71=A
DISSOLVED OXYGEN MG\L
15
12
9
8
3
Standard
2
4
6
8
10
12
MILES ON POSSESSION SOUND


UNIVWASH MEAN VALUES 75-100 FT.
---PLOTTED CHARACTERS---
53-54=O 57-62=X 68-71=A
PHOSPHORUS DIS ORTHO MG\L
0.30
0.24
0.18
0.12
2
4
6
8
10
12
MILES ON POSSESSION SOUND

MAIN PUGET SOUND BASIN TRENDS

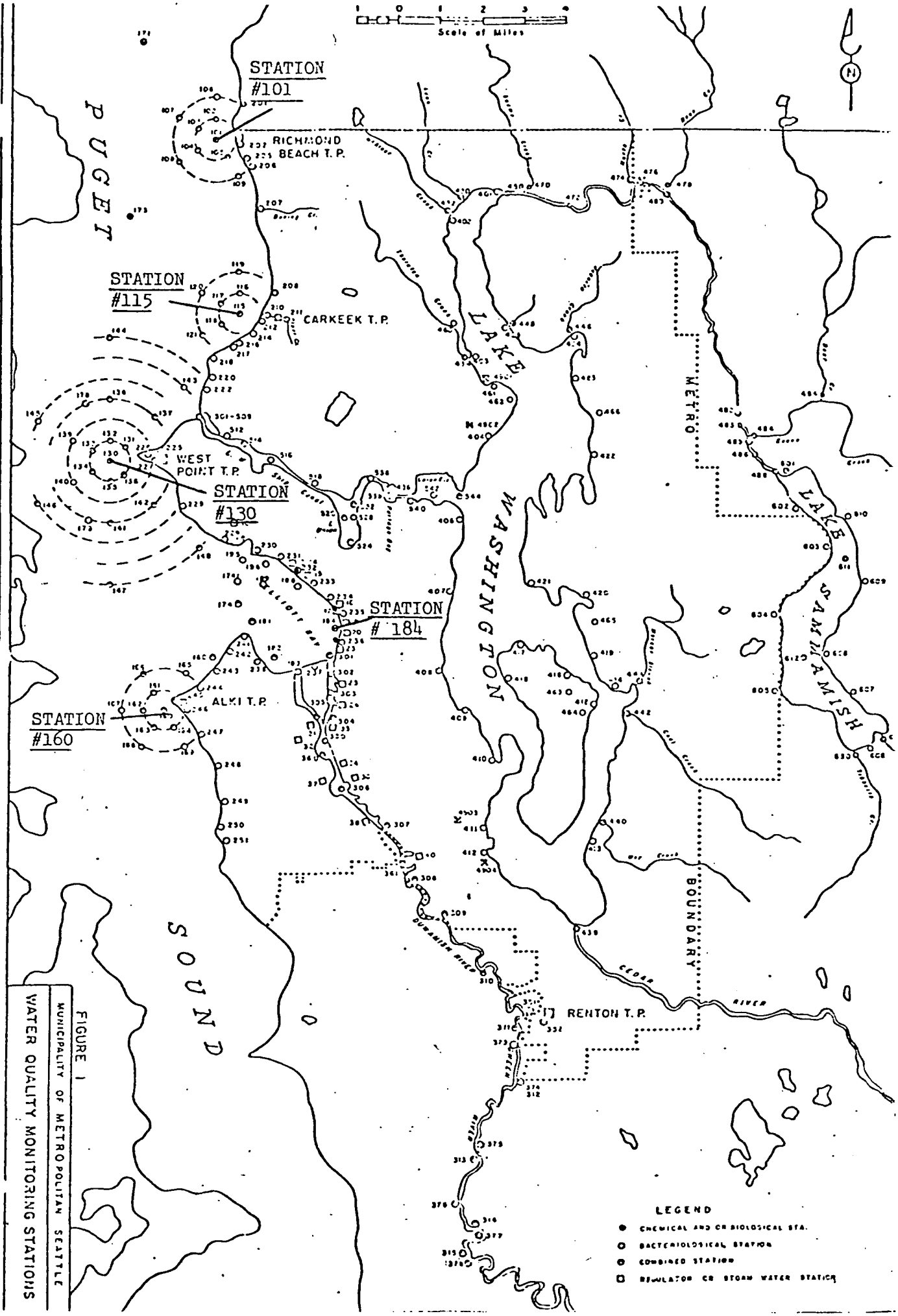
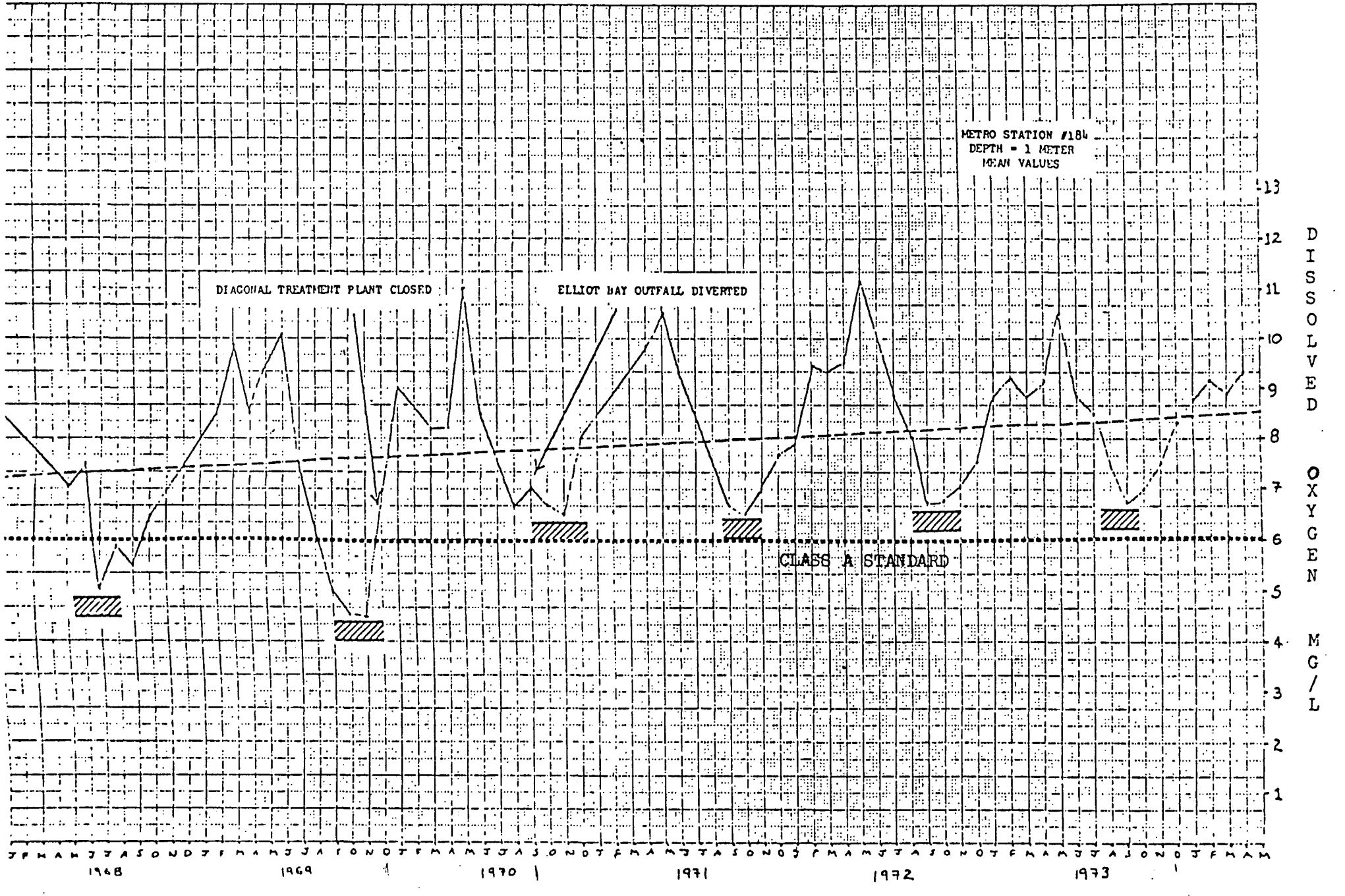
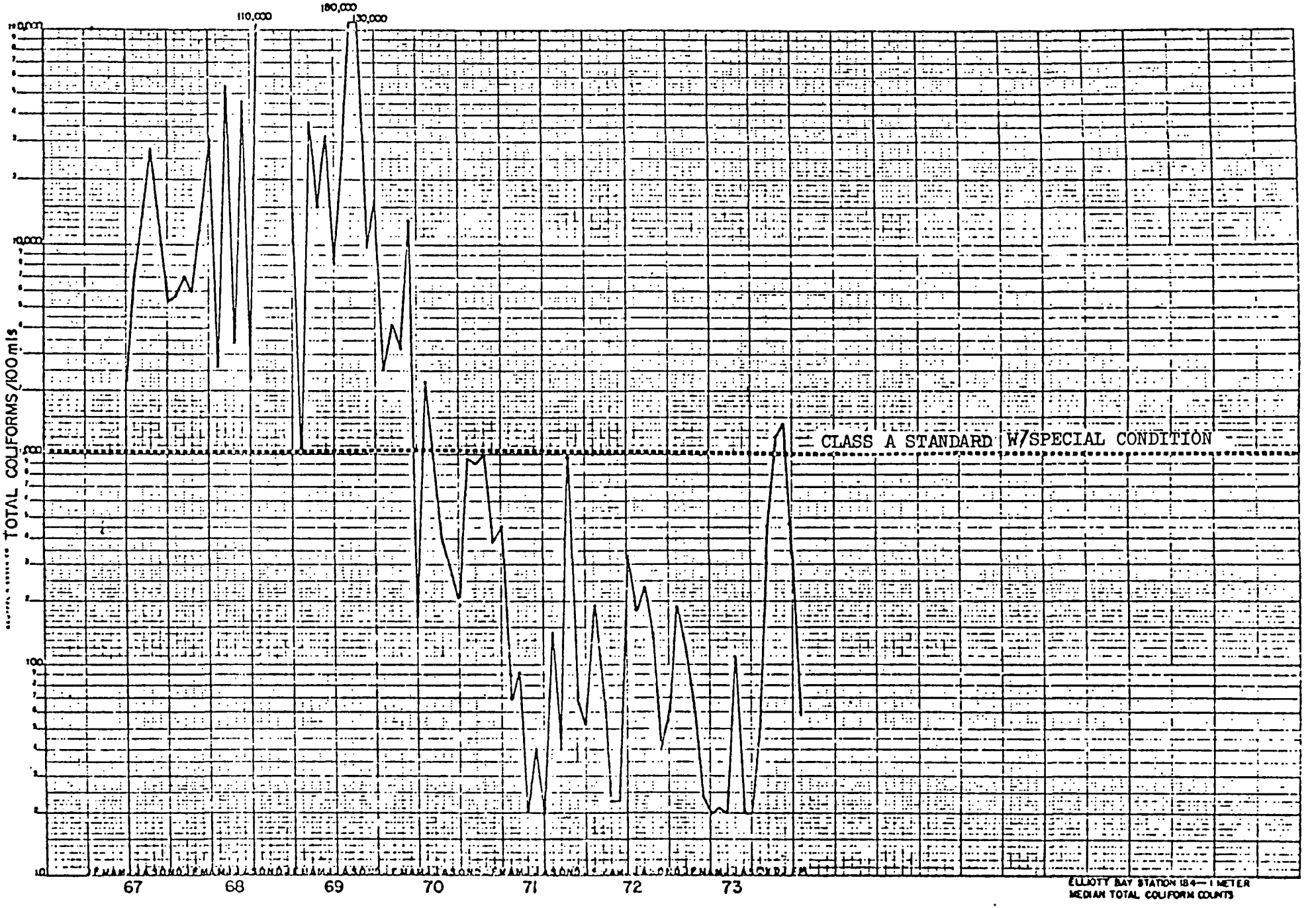


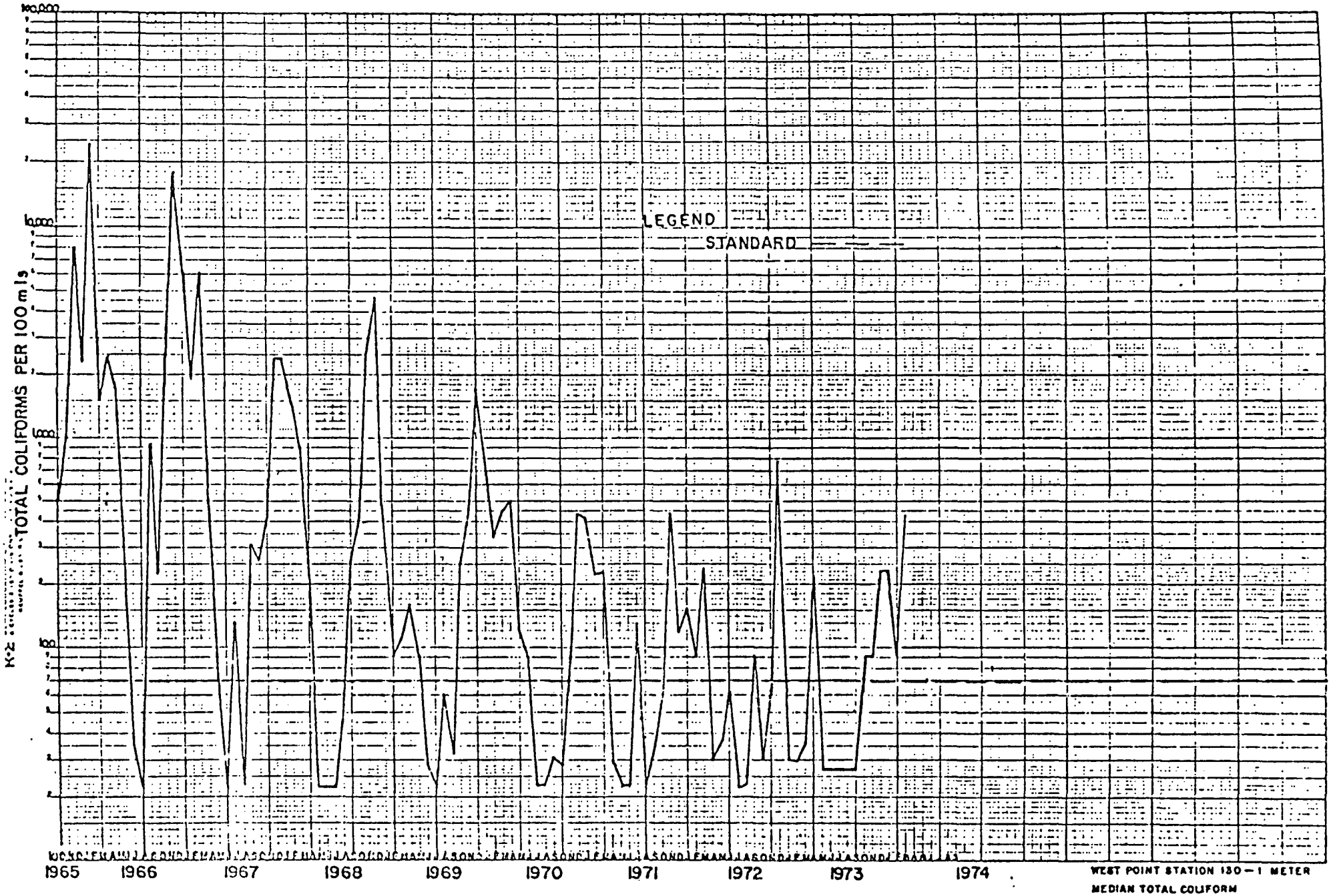
FIGURE 1

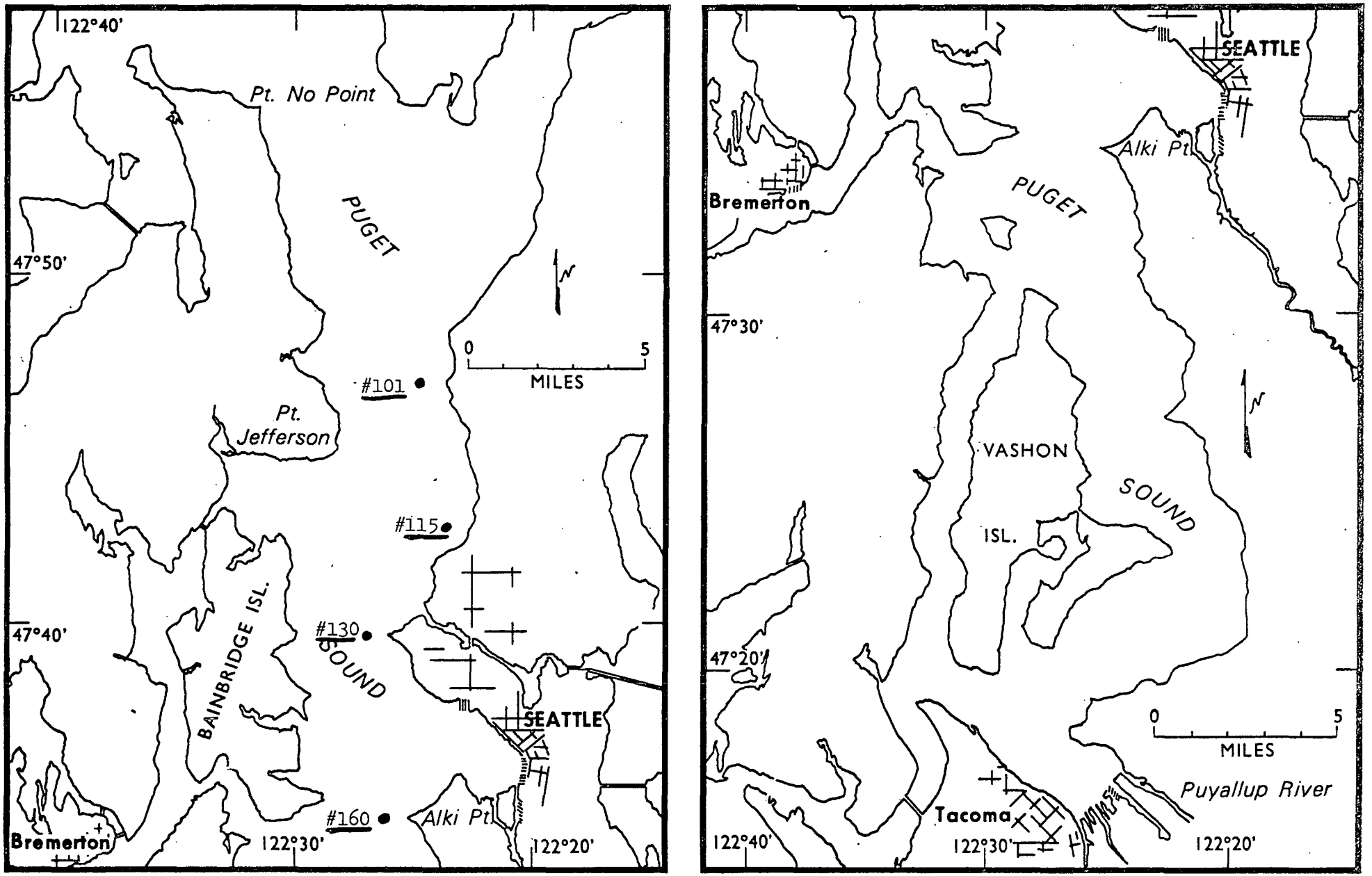
MUNICIPALITY OF METROPOLITAN SEATTLE

WATER QUALITY MONITORING STATIONS


METRO STATION #184
DEPTH = 1 METER
MEAN VALUES
DIAGONAL TREATMENT PLANT CLOSED
ELLIOT BAY OUTFALL DIVERTED
CLASS A STANDARD
DISSOLVED OXYGEN MG/L
13
12
11
10
9
8
7
6
5
4
3
2
1
1968
1969
1970
1971
1972
1973


110,000
180,000
130,000
10,000
1,000
100
10
TOTAL COLIFORMS/100 mls
CLASS A STANDARD W/SPECIAL CONDITION
67
68
69
70
71
72
73
ELLIOTT BAY STATION 184— 1 METER
MEDIAN TOTAL COLIFORM COUNTS


TOTAL COLIFORMS PER 100 ml's
LEGEND
STANDARD
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
WEST POINT STATION 130 — 1 METER
MEDIAN TOTAL COLIFORM

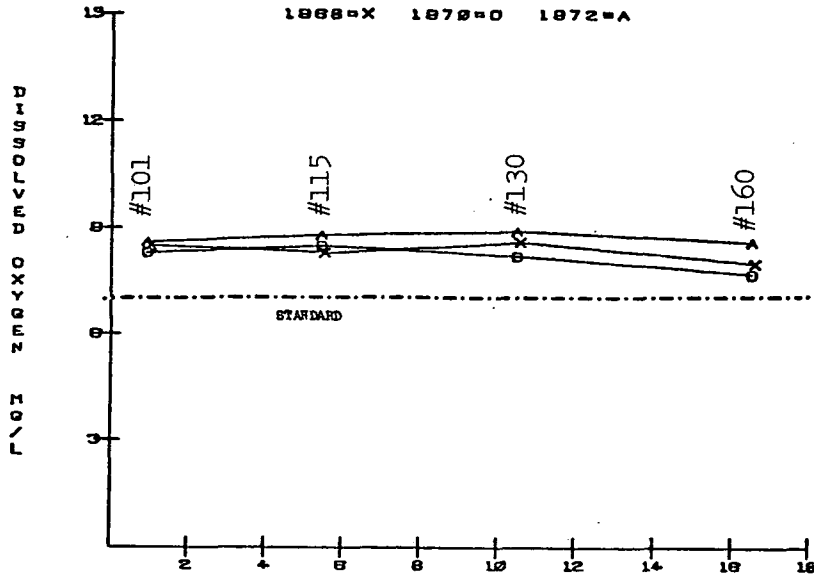


STATION LOCATION FOR DISSOLVED OXYGEN PROFILE (METRO STATIONS)

METRO DATA MEAN VALUES 0-25 FT.

---PLOTTED CHARACTERS---

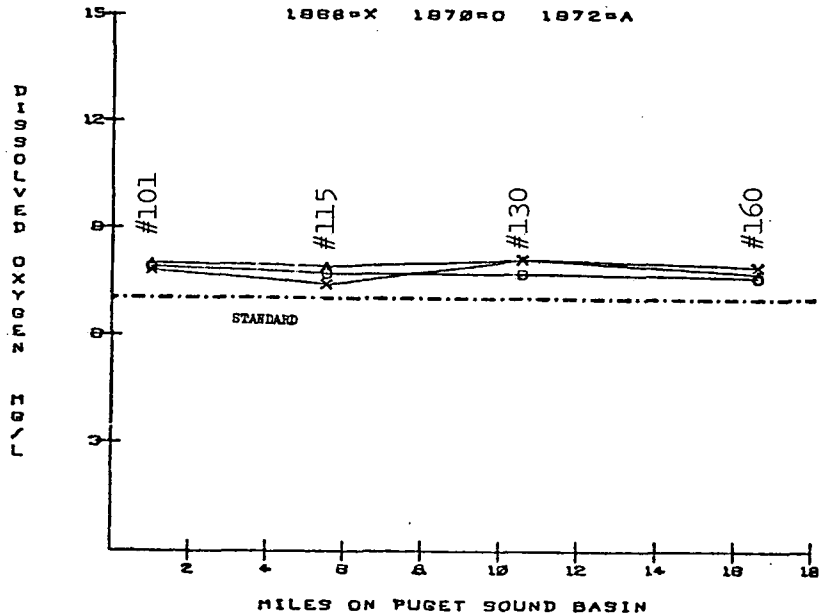
1968=X 1970=O 1972=A



METRO DATA MEAN VALUES 25-50 FT.

---PLOTTED CHARACTERS---

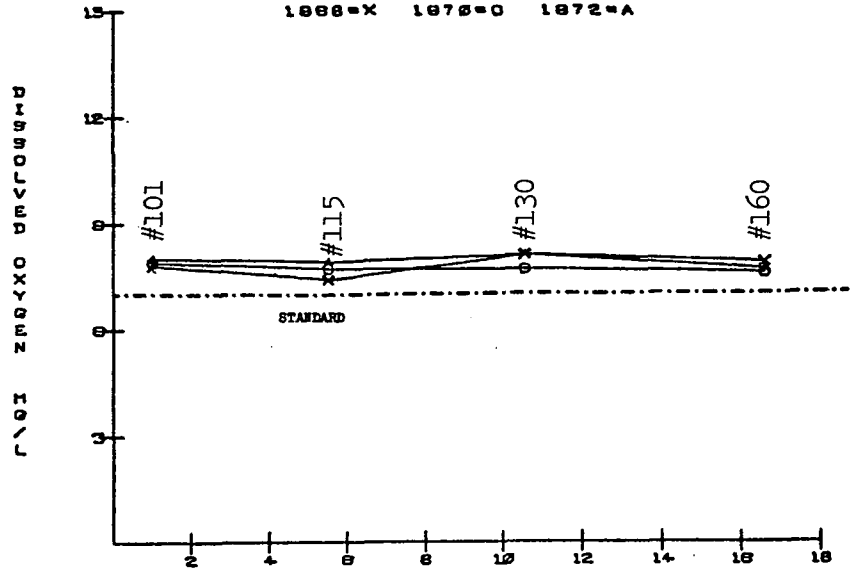
1968=X 1970=O 1972=A



METRO DATA MEAN VALUES 50-100 FT.

---PLOTTED CHARACTERS---

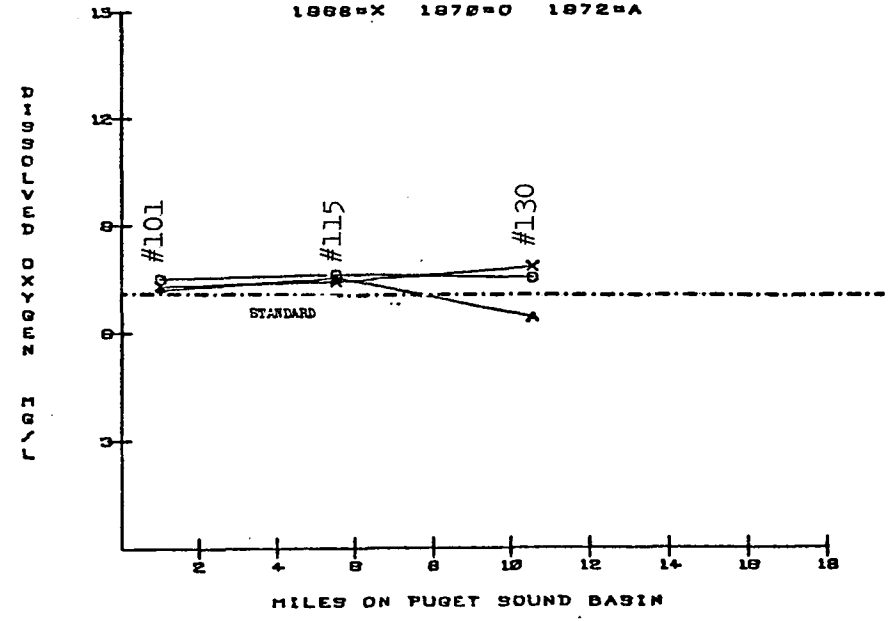
1968=X 1970=O 1972=A



METRO DATA MEAN VALUES 100-200 FT.

---PLOTTED CHARACTERS---

1968=X 1970=O 1972=A



D. TEMP.,D.O.,PHOSPHORUS
TRENDS IN PUGET SOUND

TEMPERATURE, DISSOLVED OXYGEN AND PHOSPHORUS TRENDS IN PUGET SOUND

TEMPERATURE, DISSOLVED OXYGEN AND PHOSPHOROUS TRENDS IN PUGET SOUND

I. INTRODUCTION

For systems with adequate data, mass balance methods are useful for determining many of the large - scale features. In Puget Sound, temperature, dissolved oxygen and orthophosphate measurements have been made since 1932 (Collias 1970). There are numerous gaps in the data, in the sense of both time and space. There is sufficient data available, however, to perform gross balances and examine basic trends in water quality.

This report analyzes the data from key stations in Puget Sound. Where possible, the contributions to temperature, dissolved oxygen and inorganic phosphorous from major sources have been estimated. These sources include river discharge; industrial and municipal discharge; and the transport between various sub-regions of Puget Sound and the Straits of Juan de Fuca.

Monthly averaged storage terms for each constituent were estimated for the upper layer (0-15 meters) and the lower layer (15-175 meters) in each of the sub-regions. The storage terms have been converted to average concentrations so that water quality trends can be analyzed.

The above analyses have been performed for the following four oceanographic sub-regions in Puget Sound:

1. Central Puget Sound (Main Basin)
2. South Puget Sound
3. Hood Canal
4. Whidbey Basin

Figure 1 shows the boundaries of the various sub-regions.

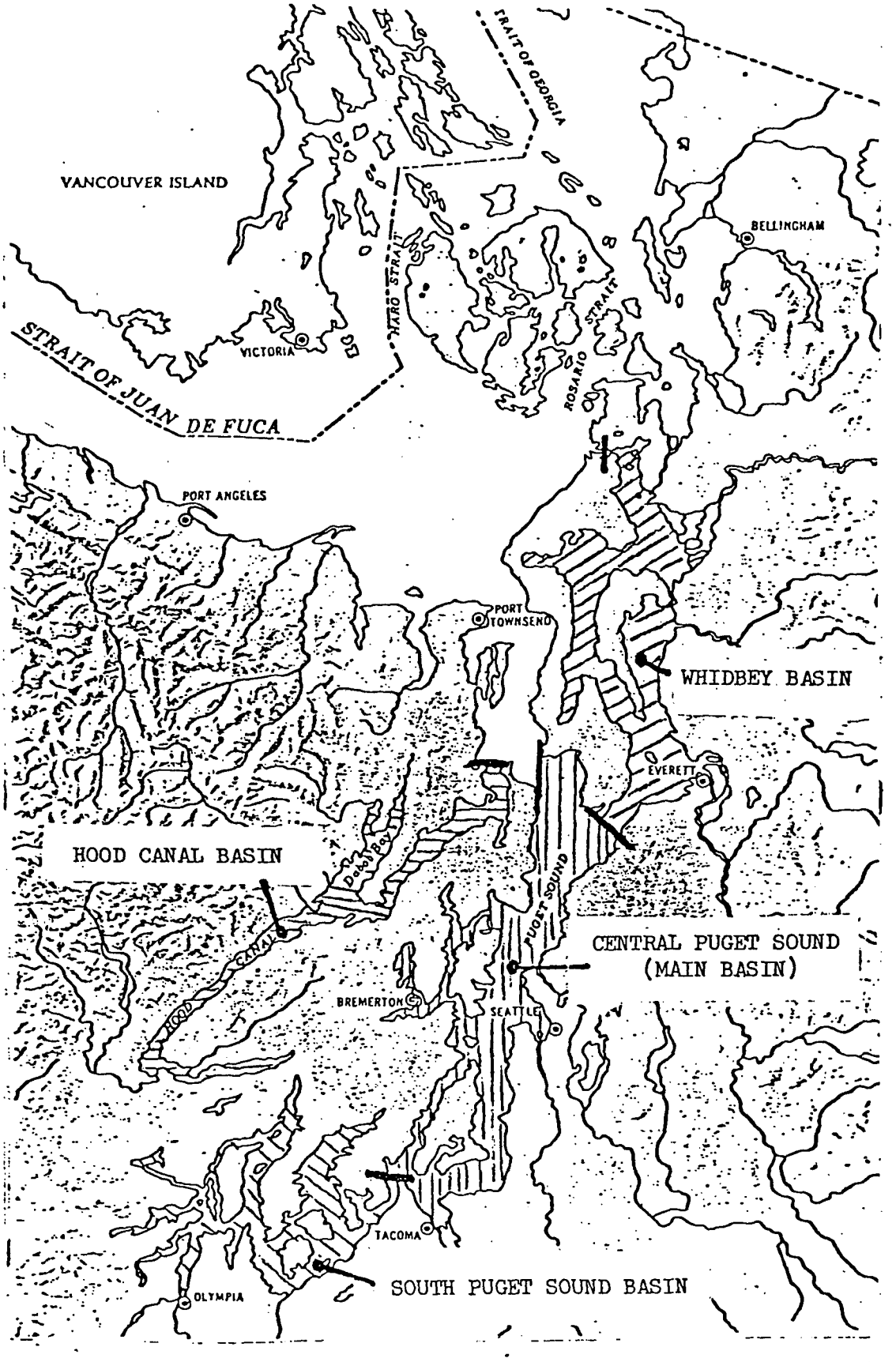


FIGURE 1: Puget Sound Subregions

II. METHODS

Temperature, dissolved oxygen and inorganic phosphorous data collected by the University of Washington (Collias (1970)) were used to estimate monthly storage terms, monthly average concentrations and inter-basin mass transport. Hydrographic stations and the period of record used for the analysis are shown in Table I.

The data from all stations in each sub-region were grouped within the following depth ranges: 0-15 meters, 15-25 meters, 25-40 meters, 40-62.5 meters, 62.5-87.5 meters, 87.5-125 meters and 125-175 meters. The data from each depth range was then averaged by month. Monthly storage terms for each layer were estimated from the product of the monthly average concentration in each depth range and the volume associated with the depth range. Summing all the storage terms in the top layer (0-15 meters) and the bottom layer (15-75 meters) and dividing by the respective volumes provided an estimate of the monthly average concentration of each constituent analyzed. Volumes were determined from the work of McClellan (1954).

Estimates of dissolved oxygen and total phosphorous transport from rivers in Puget Sound were obtained from water quality data in the STORET system and U.S. Geological Survey river gaging data.

Total phosphorous and carbonaceous biological oxygen demand (BOD) transport were also determined for municipal and industrial sources. Waste inventories compiled from EPA monitoring programs and discharge permits comprised the data base.

Estimates of inter-basin transport for the top layer (0-15 meters) and the bottom layer (15-175 meters) were obtained form the work of Friebertabauser and Duxbury (1972). These transports were used to estimate mass flow rates. Net mass flow rates were computed for South Puget Sound,

Hood Canal and the Whidbey Basin. Inter-basin transport for Central Puget Sound were not estimated by Friebertshauser and Duxbury (1972). Net mass flow, Δ(QT), was estimated from: Δ(QT) = Qin Tin - Qouz Tout

where

Qin = the average flux of inflowing water (Table 5 in Friebertshauser Duxbury (1972))

Tin = the volume averaged concentration in the bottom layer of the adjacent sub-region,

Qout = the average flux of outflowing water (Table 5 in Friebertshauser and Duxbury (1972)),

Tout = the volume averaged concentration in the top layer of the sub-region under consideration.

It is important to point out that data used to estimated the contributions from these sources consist of only a very few samples. Friebertshauser and Duxbury (1972) estimate that their transport calculations may be accurate to ±30%. The resulting mass flow rates can, therefore, be considered only as order-of magnitude approximations, and should be treated as such.

III. RESULTS

Monthly averaged temperatures, dissolved oxygen and orthophosphate in the top and bottom layers of each sub-region are shown in Figures 2 through 25. Linear relationships, estimated in the least squares sense for each of these plots are given in Table 2.

The net inter-basin mass transports for each constituent are given in Tables 3 through 5.

BOD and total phosphorous from industrial and municipal sources in each sub-region are shown in Tables 6 and 7.

Estimated of net monthly dissolved oxygen and total phosphorous for rivers in Puget Sound are given in Tables 8 and 9.

BIBLIOGRAPHY

Collias, E.E. 1970. Index to physical and chemical oceanographic data of Puget Sound and its approaches, 1932-1966. Special report No. 43. University of Washington Department of Oceanography.

Friebertshauser, M.A. and A.C. Duxbury. 1972. A water budget study of Puget Sound and its sub-regions. Limnology and Oceanography. 17:237-247.

Figure 2. Monthly averaged temperature for the upper layer of South Puget Sound

Figure 3. Monthly averaged dissolved oxygen for the upper layer of South Puget Sound

Figure 4. Monthly averaged orthophosphate for the upper layer of South Puget Sound

Figure 5. Monthly averaged temperature for the lower layer of South Puget Sound

Figure 6. Monthly averaged dissolved oxygen for the lower layer of South Puget Sound

Figure 7. Monthly averaged orthophosphate for the lower layer of South Puget Sound

Figure 8. Monthly averaged temperature for the upper layer of Central Puget Sound

Figure 9. Monthly averaged dissolved oxygen for the upper layer of Central Puget Sound

Figure 10. Monthly averaged orthophosphate for the upper layer of Central Puget Sound

Figure 11. Monthly averaged temperature for the lower layer of Central Puget Sound

Figure 12. Monthly averaged issolved oxygen for the lower layer of Central Puget Sound

Figure 13. Monthly averaged orthosphate for the lower layer of Central Puget Sound

Figure 14. Monthly averaged temperature for the upper layer of Hood Canal

Figure 15. Monthly averaged dissolved oxygen for the upper layer of Hood Canal

Figure 16. Monthly averaged orthophosphate for the upper layer of Hood Canal

Figure 17. Monthly averaged temperature for the lower layer of Hood Canal

Figure 19. Monthly averaged orthophosphate for the lower layer of Hood Canal

Figure 20. Monthly averaged temperature for the upper layer of Whidbey Basin

Figure 21. Monthly averaged dissolved oxygen for the upper layer of Whidbey Basin

Figure 22. Monthly averaged orthophosphate for the upper layer of Whidbey Basin

Figure 23. Monthly averaged temperature for the lower layer of Whidbey Basin

Figure 24. Monthly averaged dissolved oxygen for the lower layer of Whidbey Basin

Figure 25. Monthly averaged orthophosphate for the lower layer of Whidbey Basin

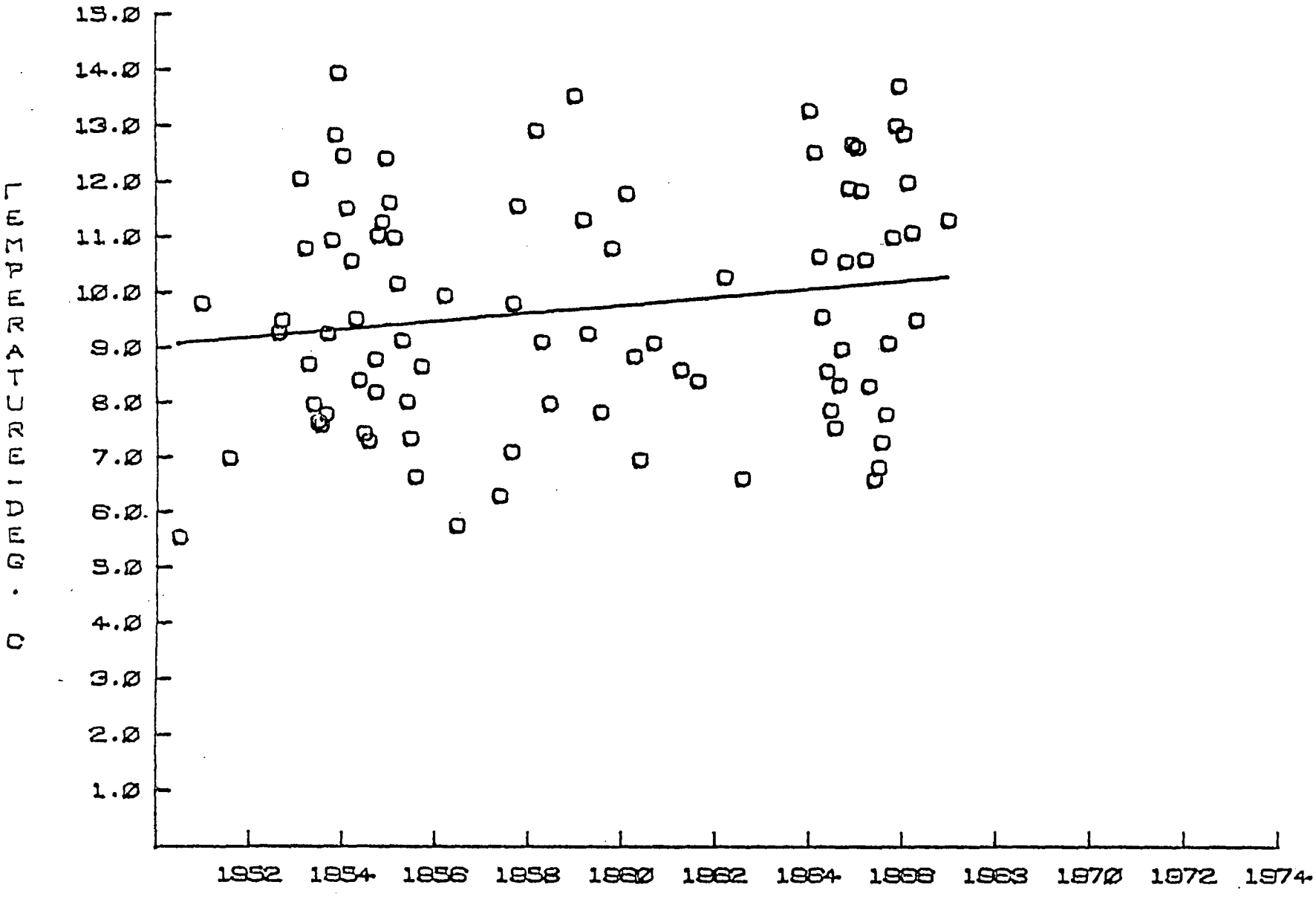


FIGURE 2: Upper Layer South Puget Sound

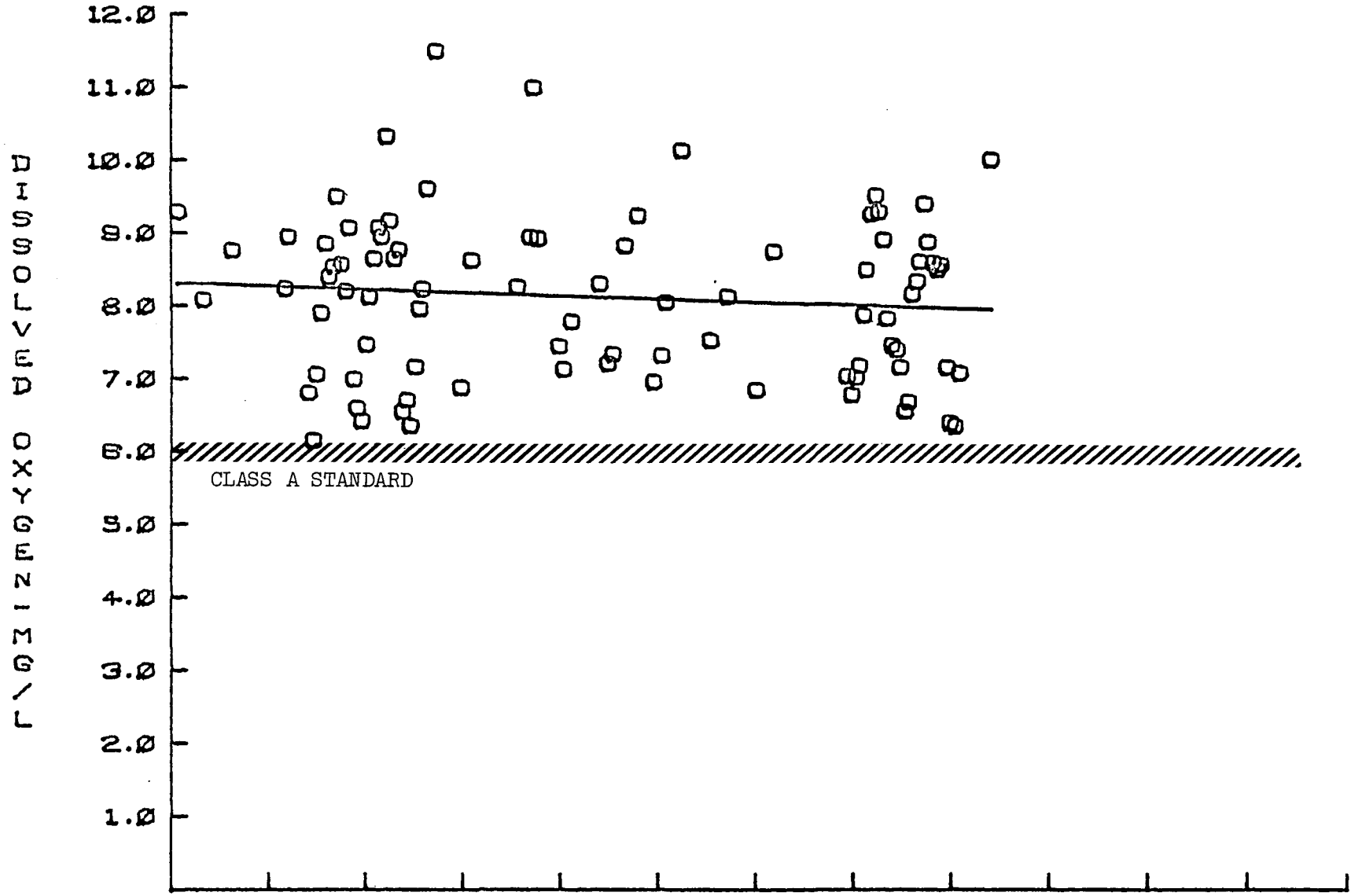


FIGURE 3: Upper Layer South Puget Sound

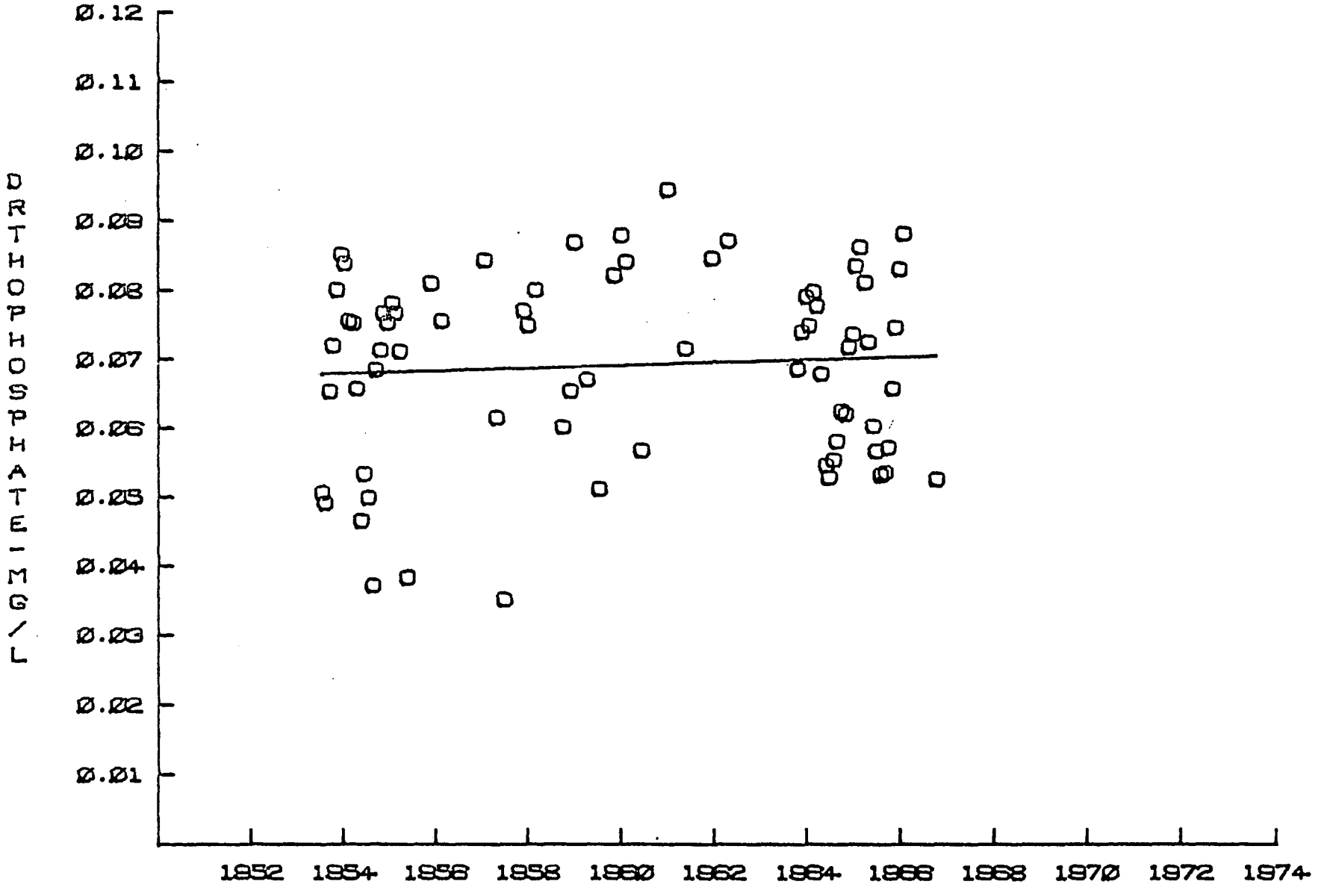


FIGURE 4: Upper Layer South Puget Sound

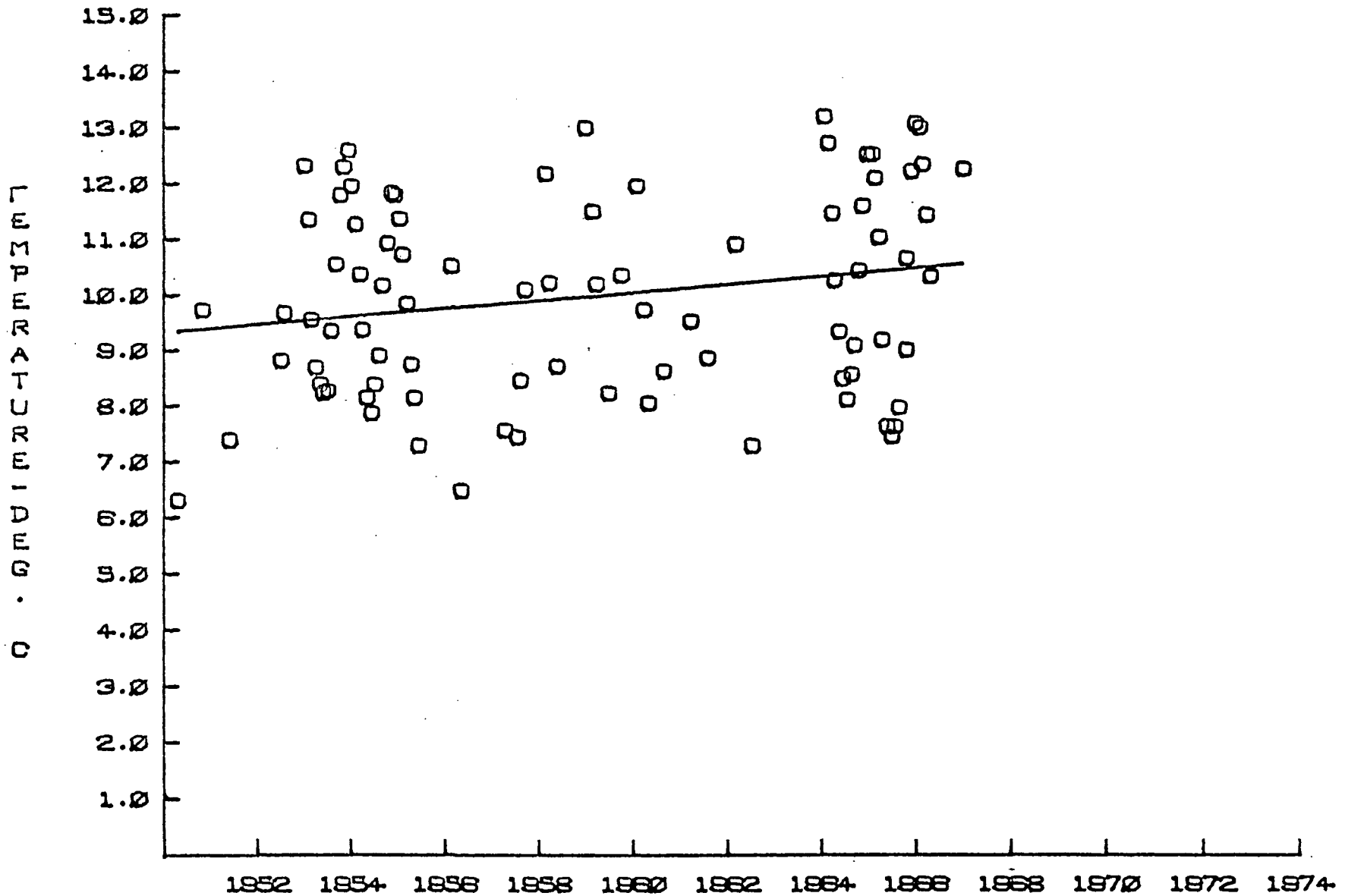


FIGURE 5: Lower Layer South Puget Sound

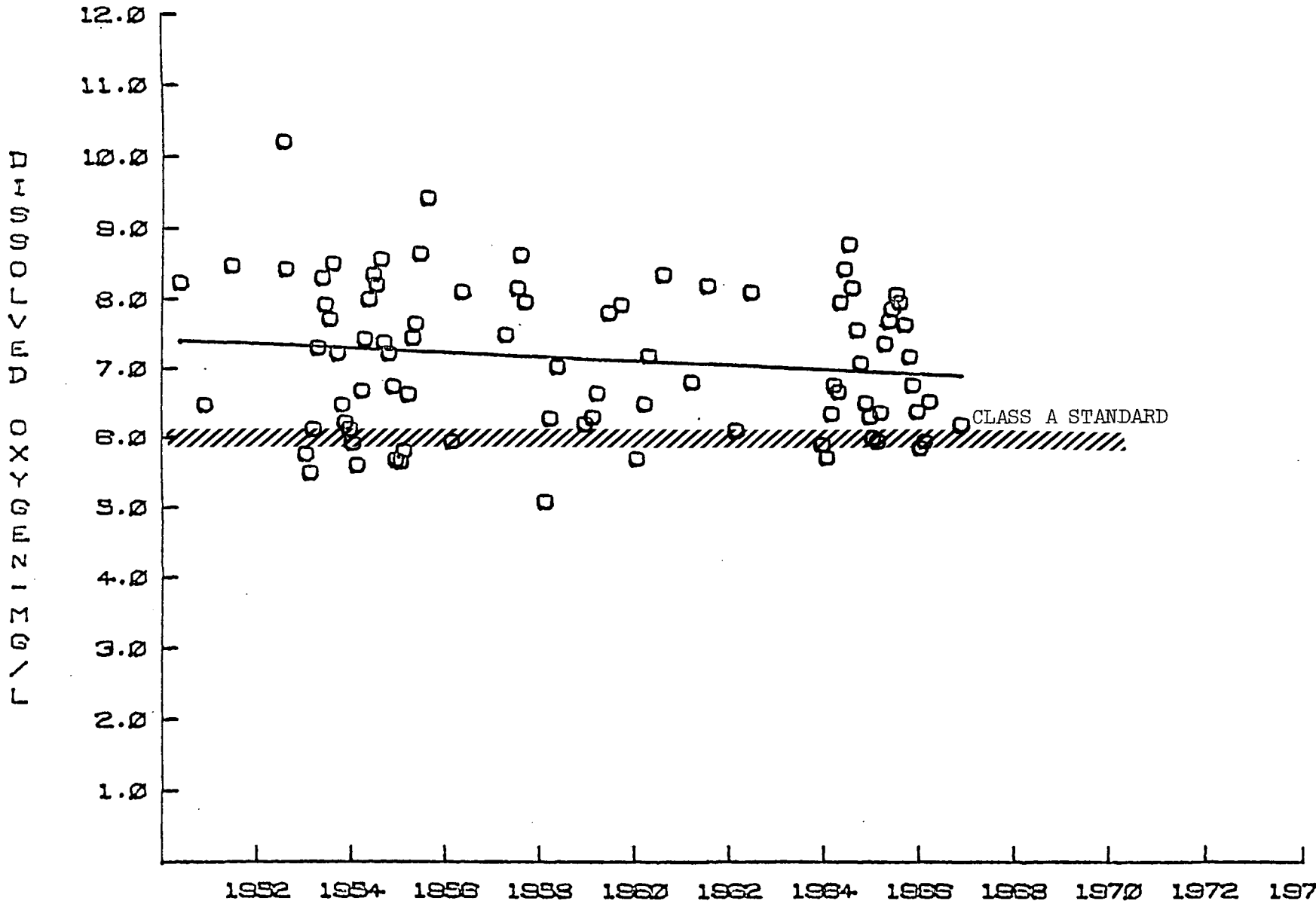


FIGURE 6: Lower Layer South Puget Sound

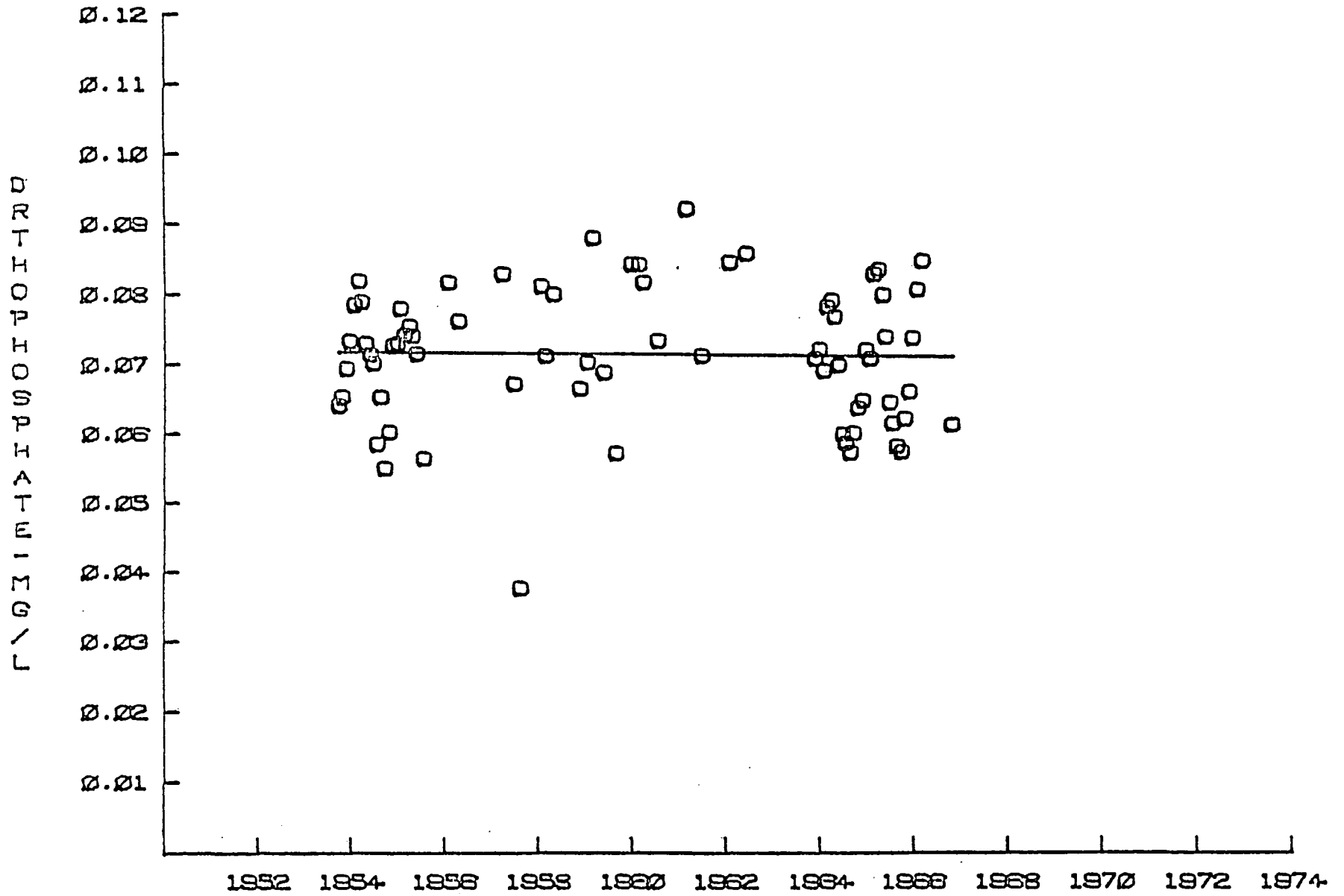


FIGURE 7: Lower Layer South Puget Sound

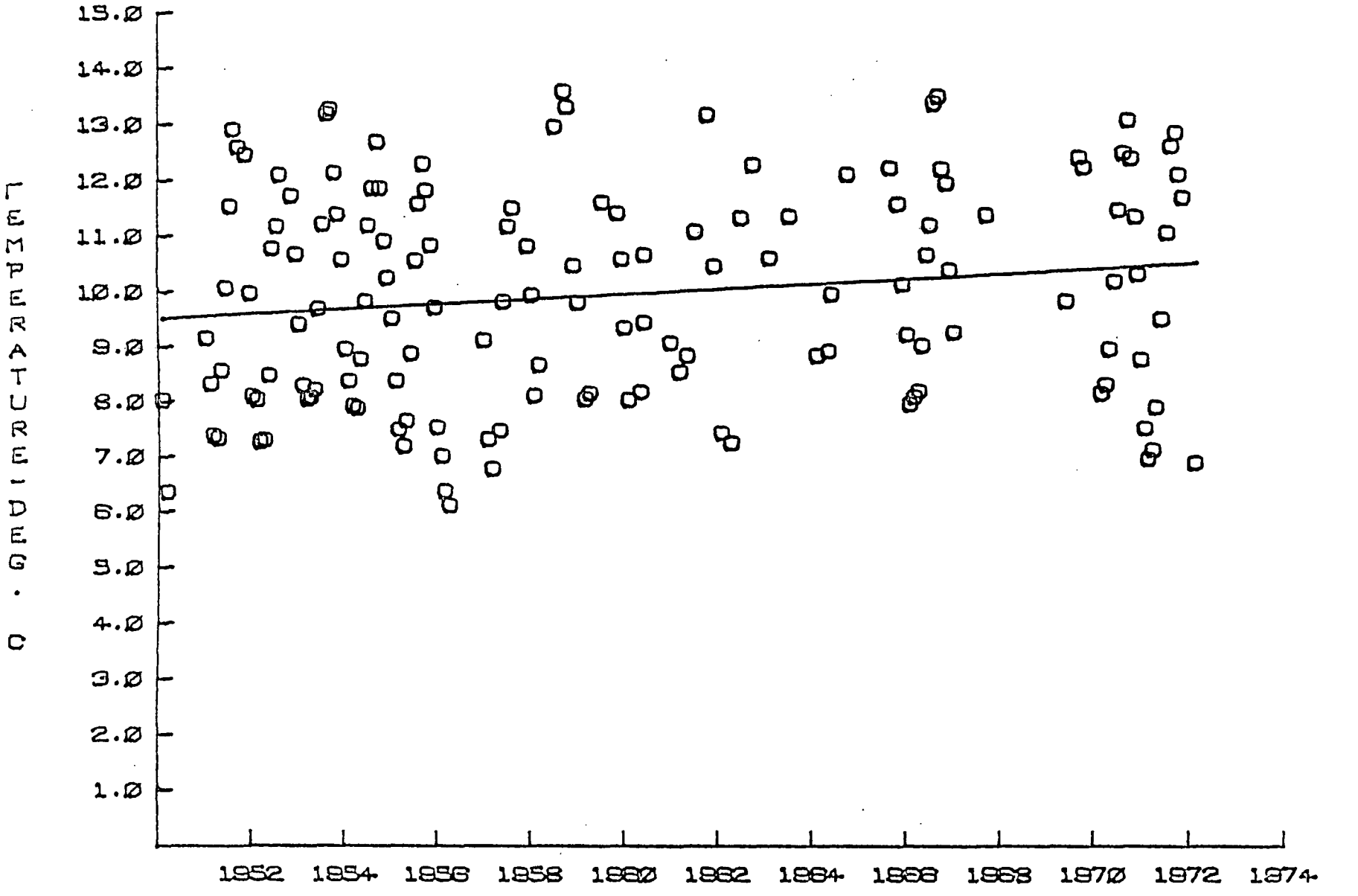


FIGURE 8: Upper Layer Central Puget Sound

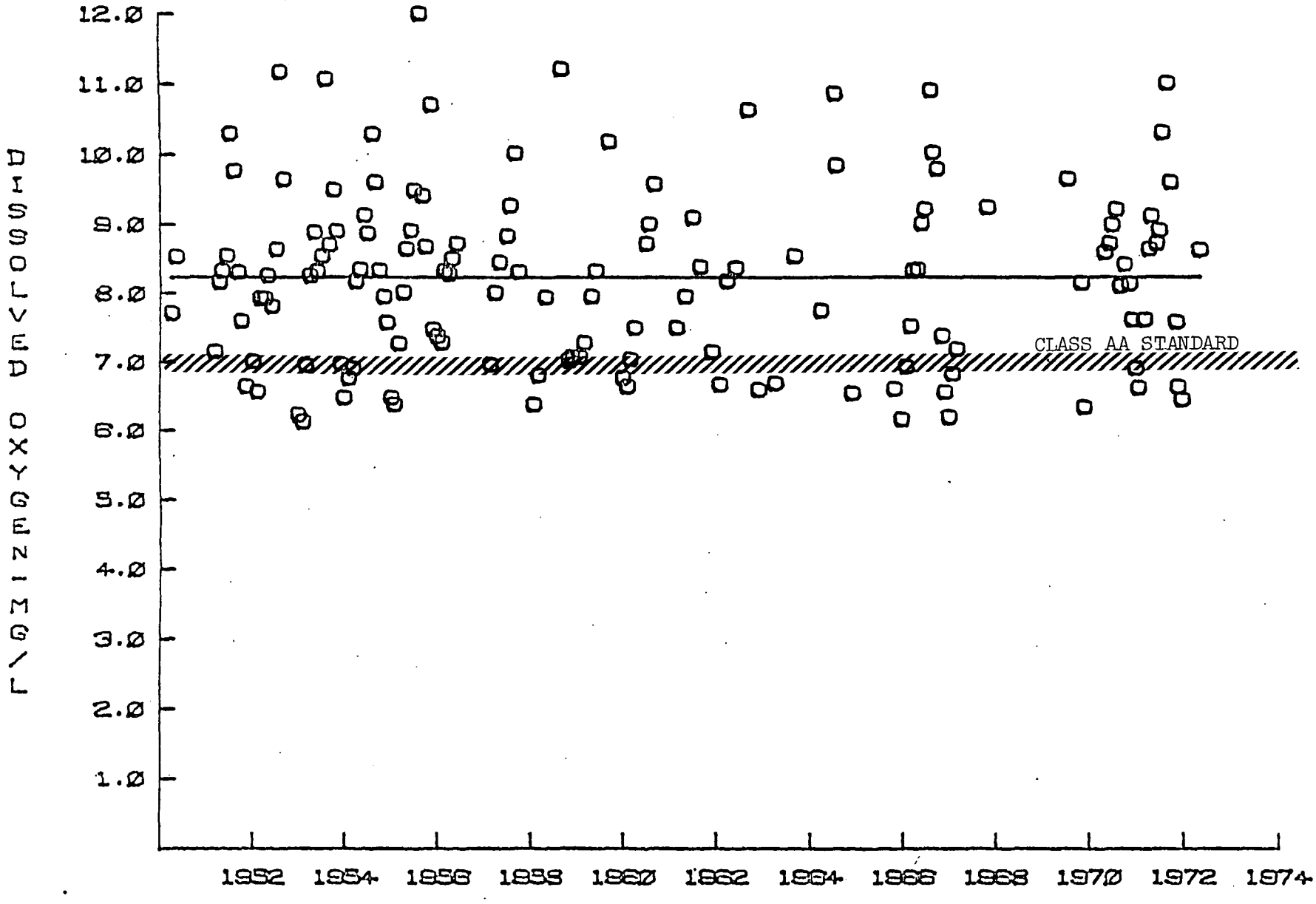


FIGURE 9: Upper Layer Central Puget Sound (Main Basin)

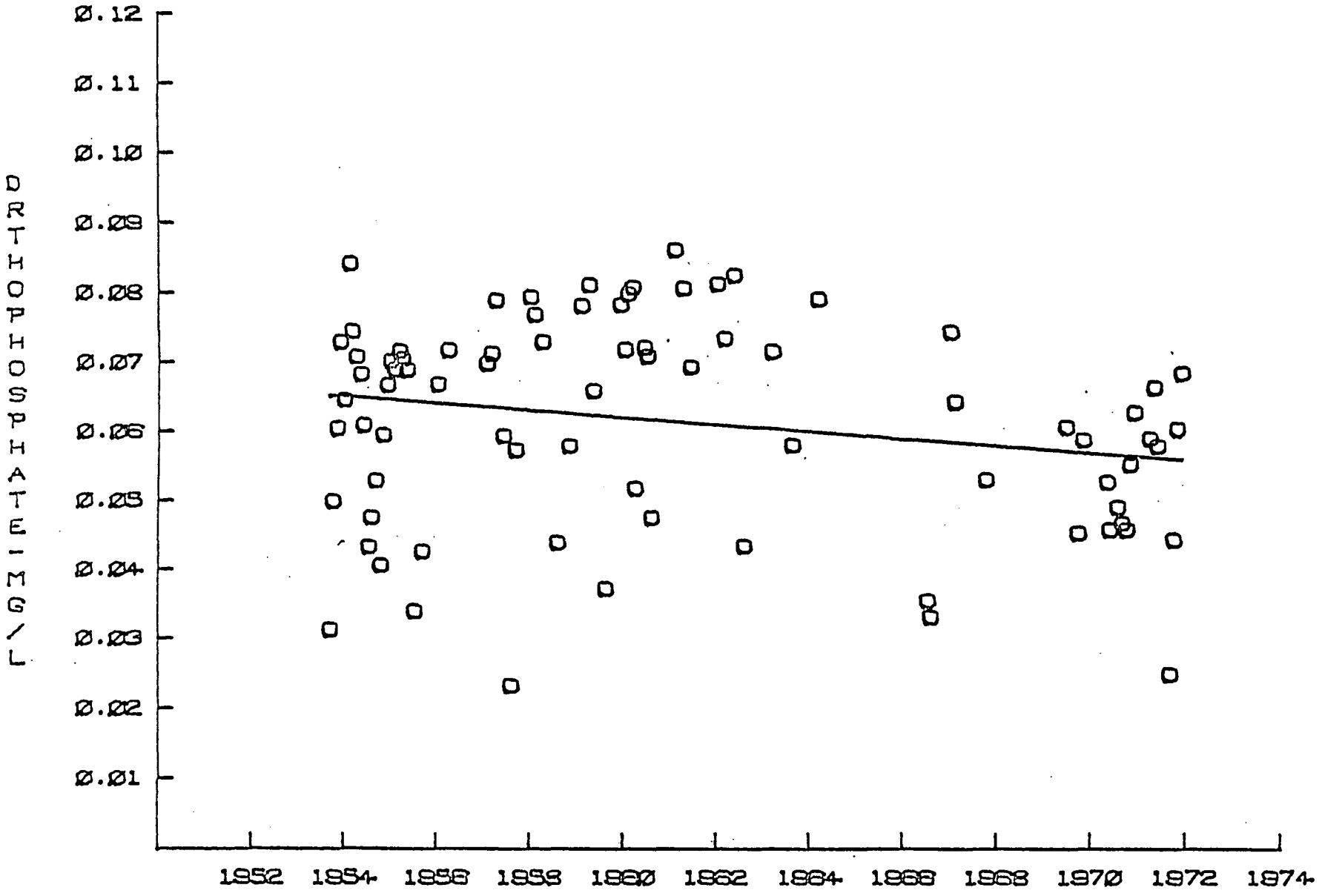


FIGURE 10: Upper Layer Central Puget Sound (Main Basin)

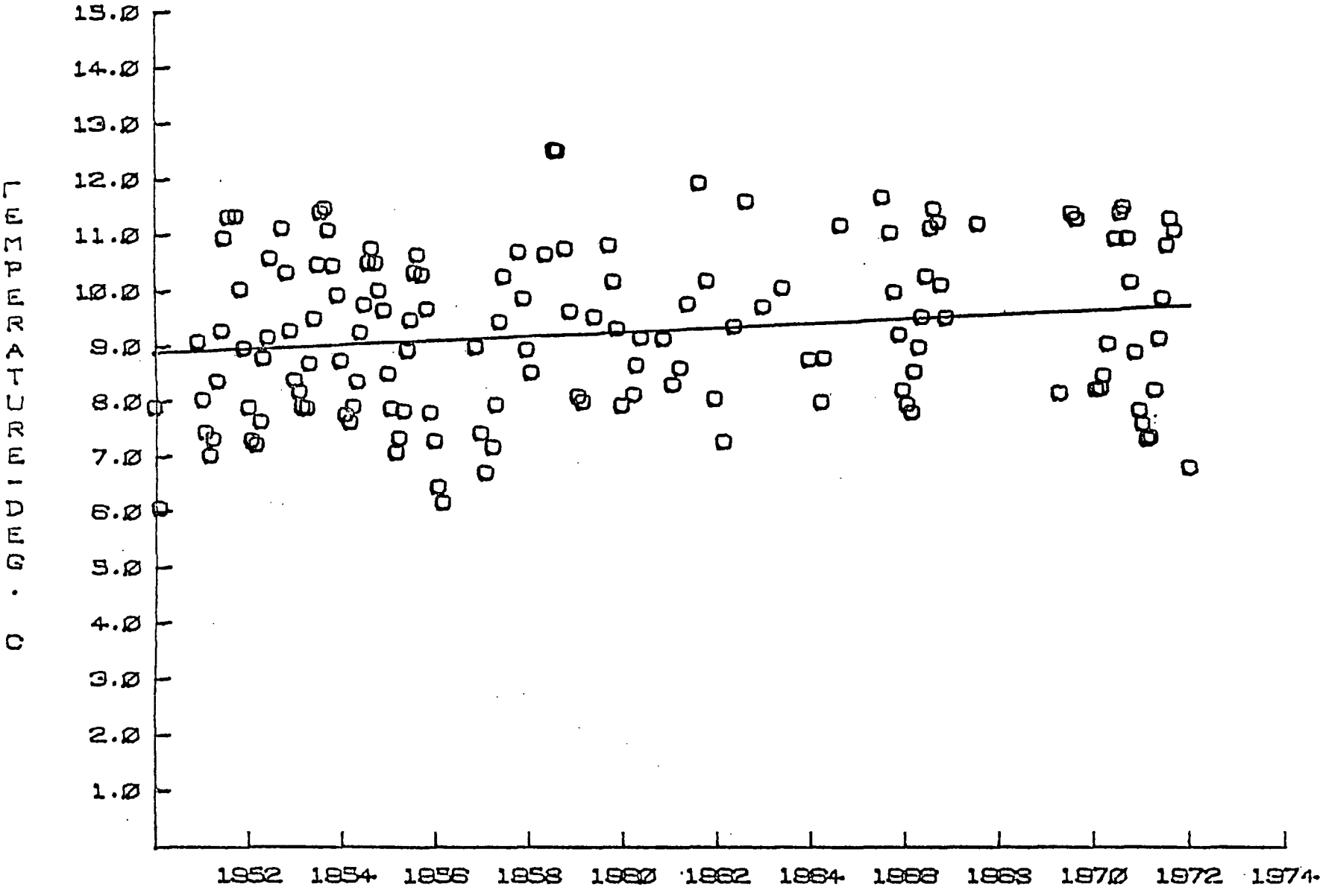


FIGURE 11: Lower Layer Central Puget Sound (Main Basin)

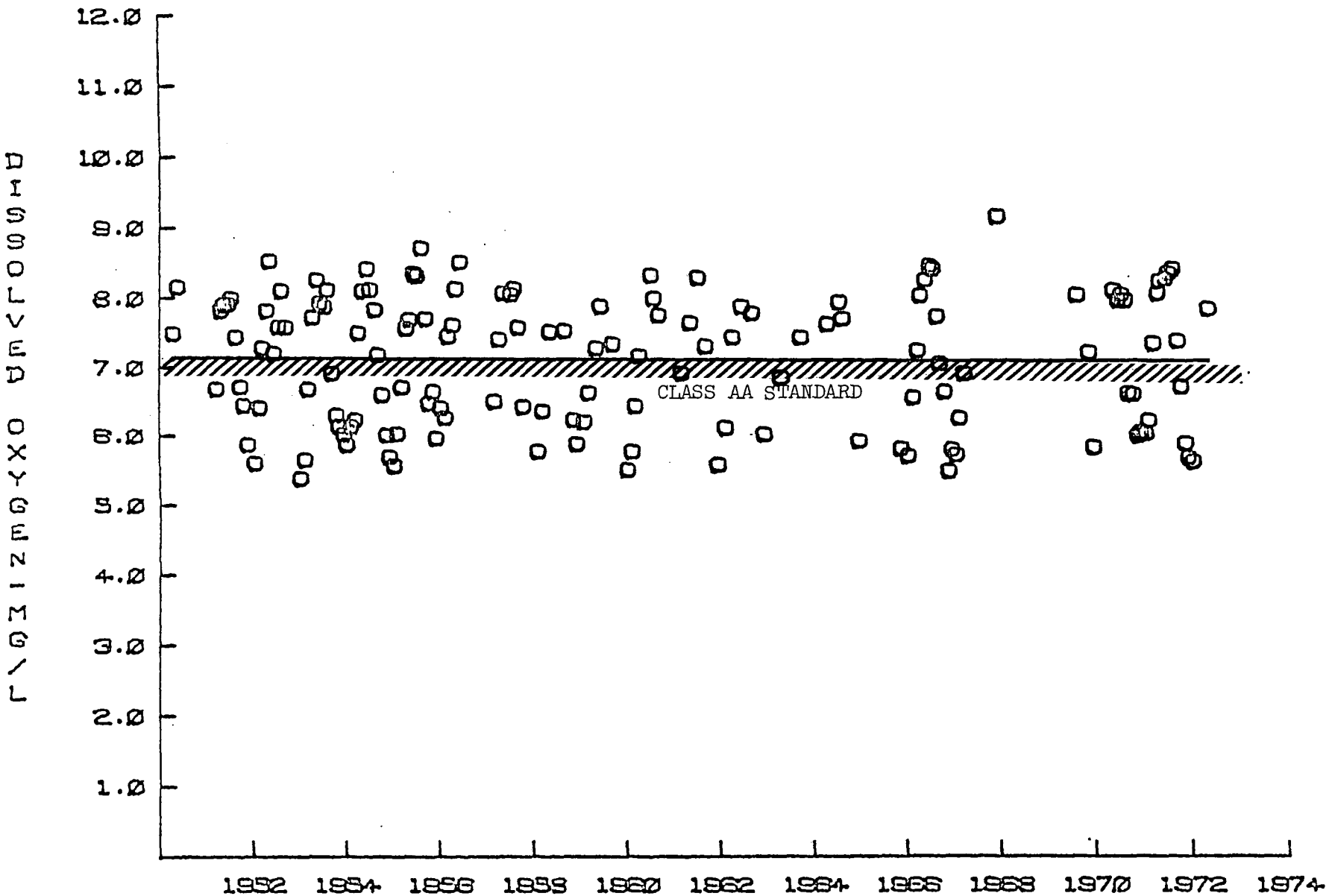
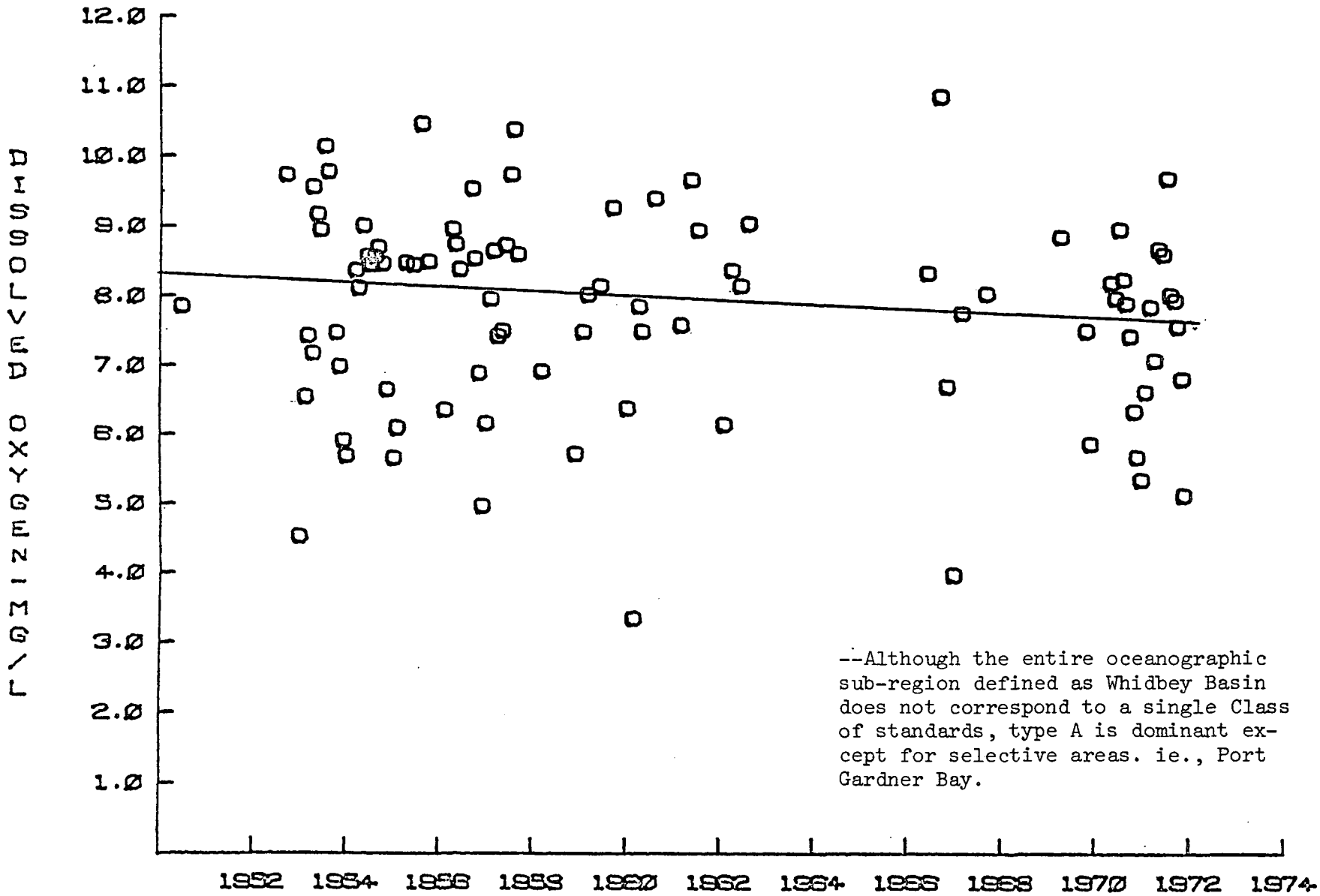


FIGURE 12: Lower Layer Central Puget Sound (Main Basin)



--Although the entire oceanographic sub-region defined as Whidbey Basin does not correspond to a single Class of standards, type A is dominant except for selective areas. ie., Port Gardner Bay.

FIGURE 21: Upper Layer Whidbey Basin

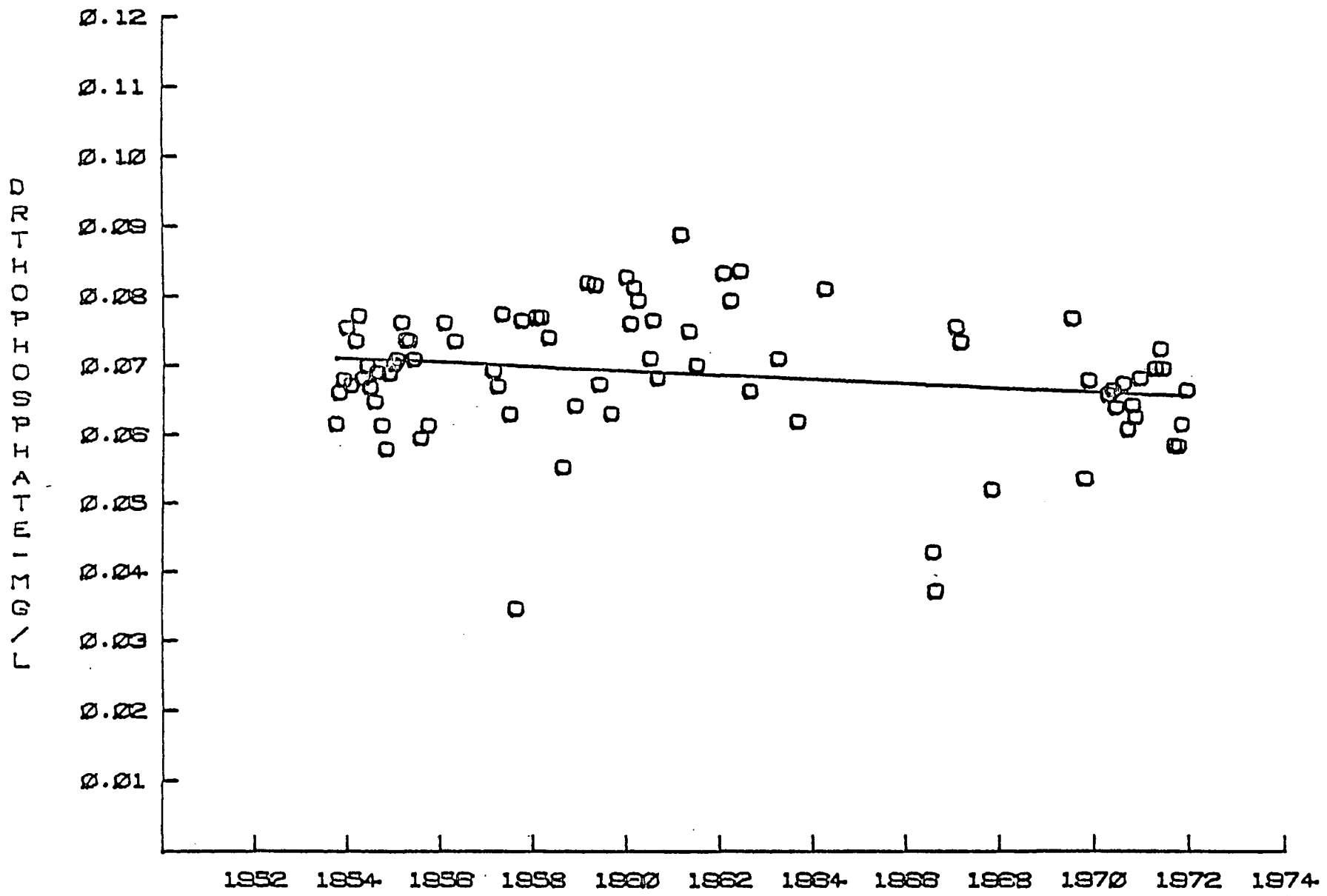


FIGURE 13: Lower Layer Central Puget Sound (Main Basin)

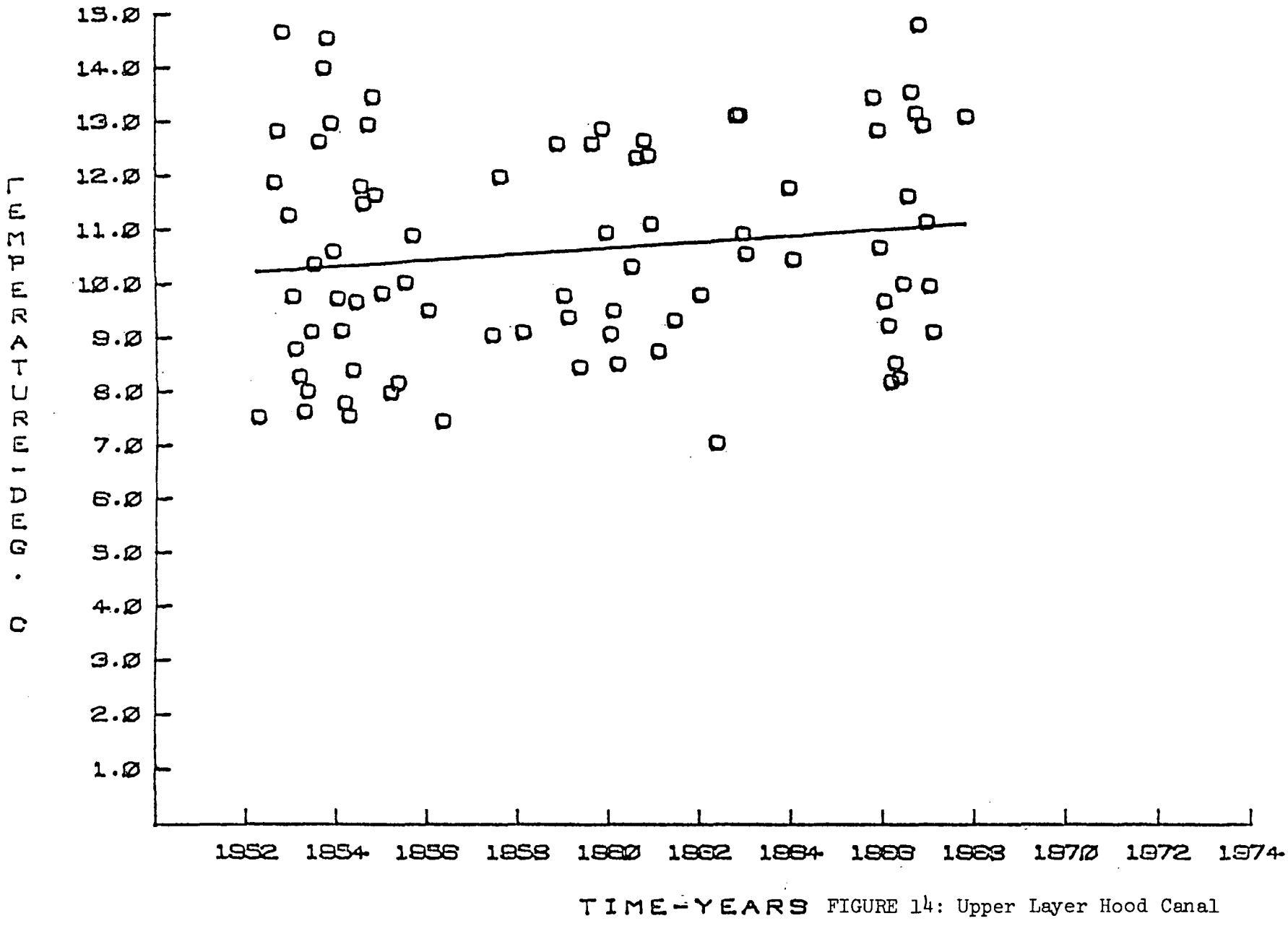


FIGURE 14: Upper Layer Hood Canal

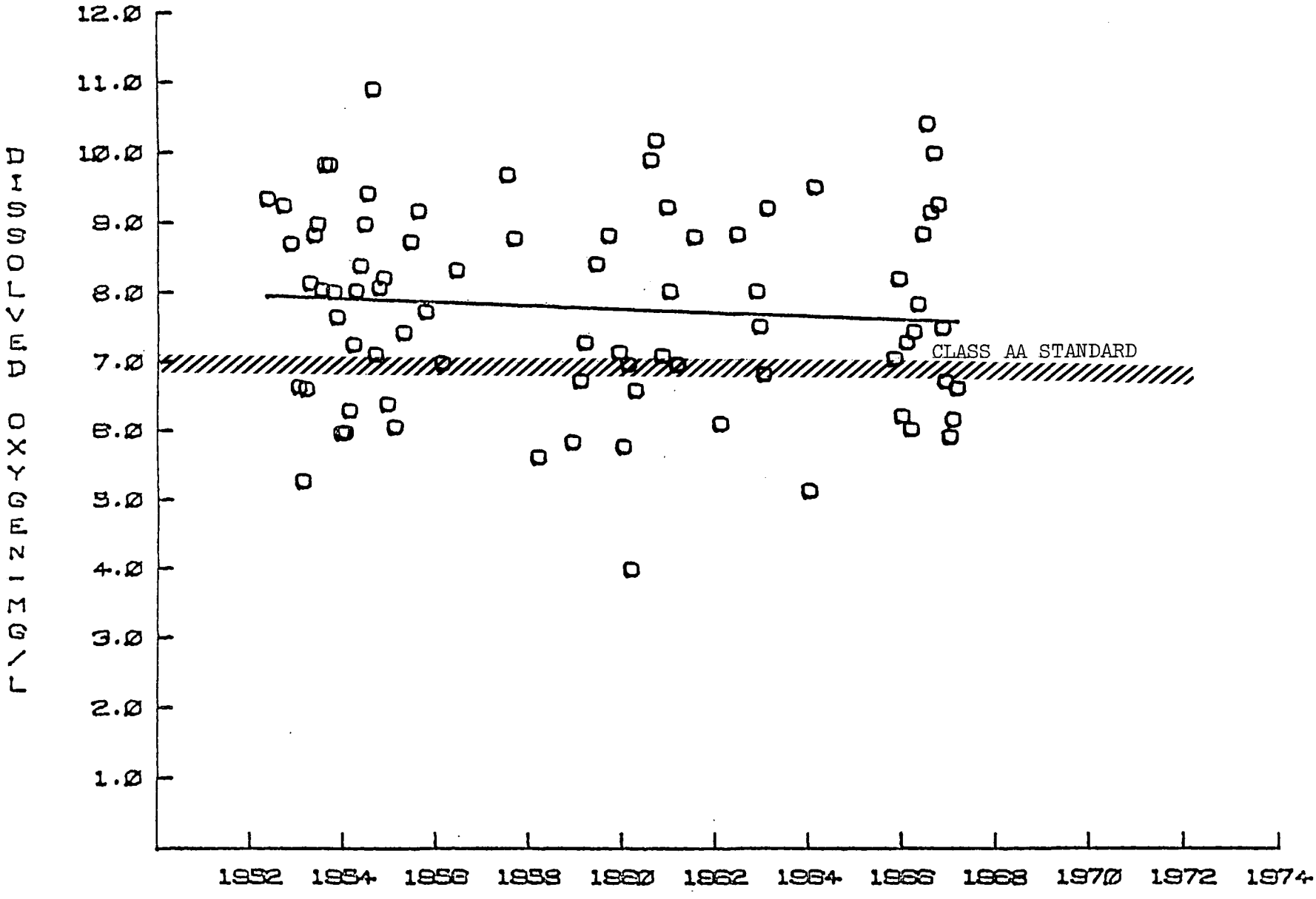


FIGURE 15: Upper Layer Hood Canal

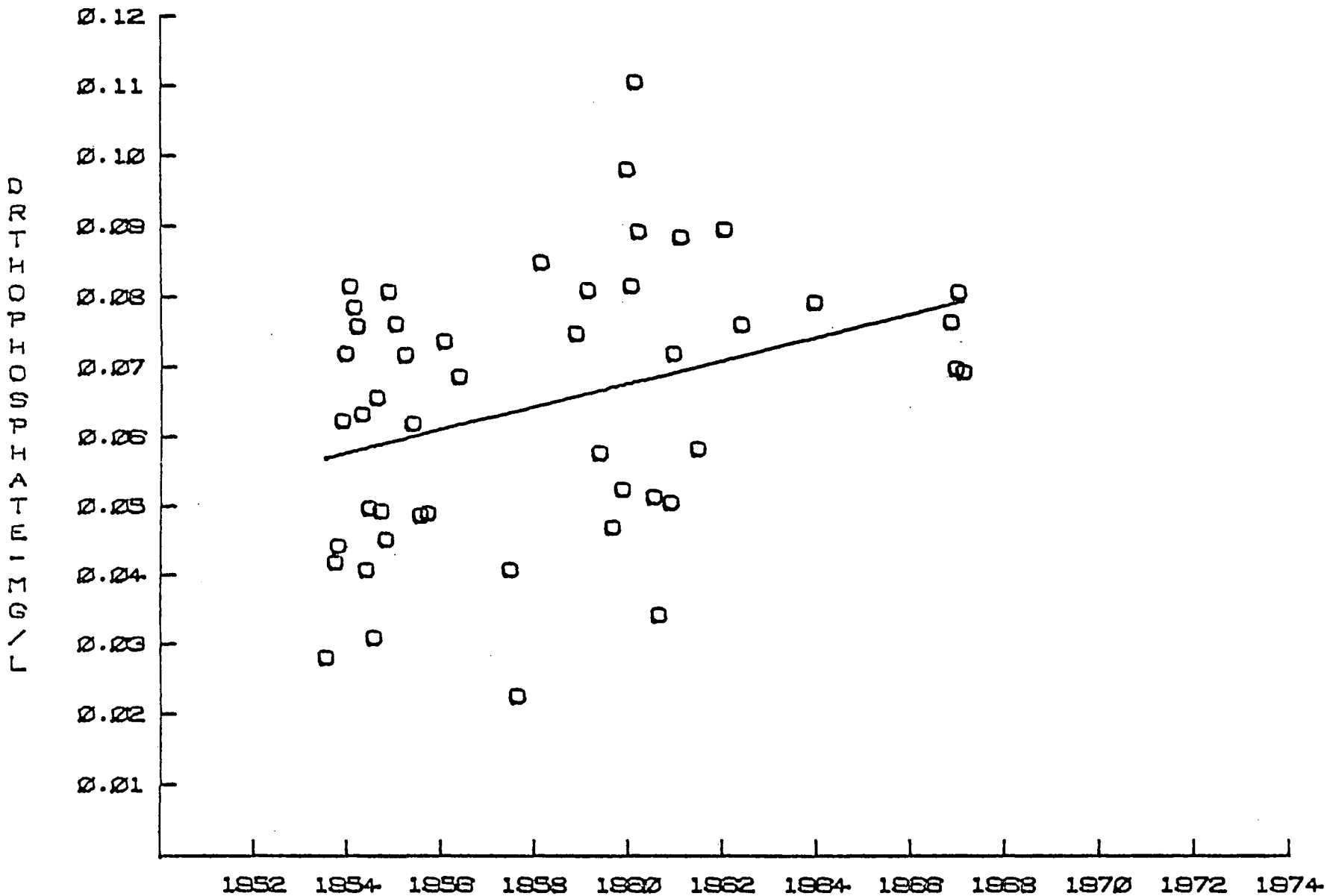


FIGURE 16: Upper Layer Hood Canal

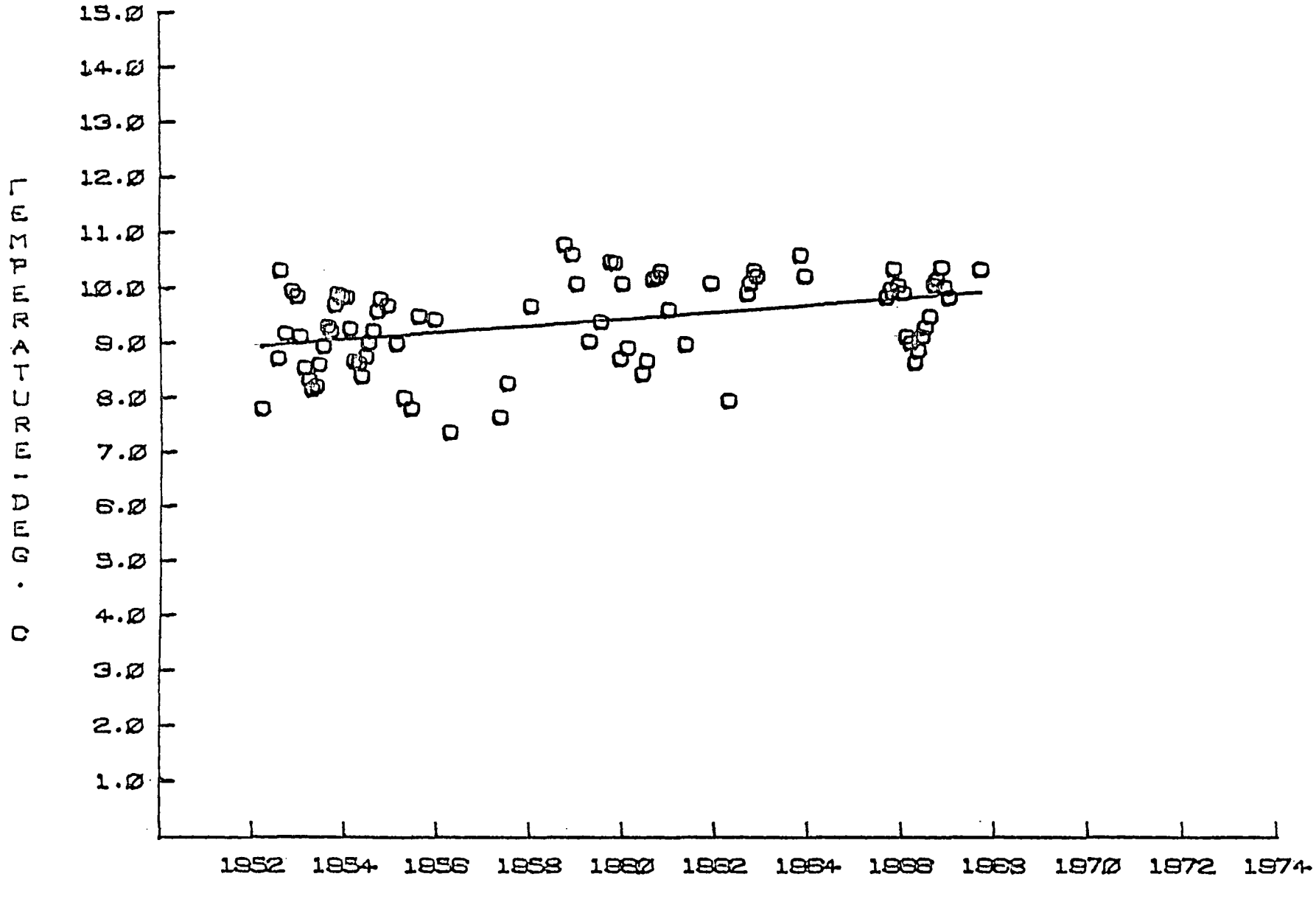


FIGURE 17: Lower Layer Hood Canal

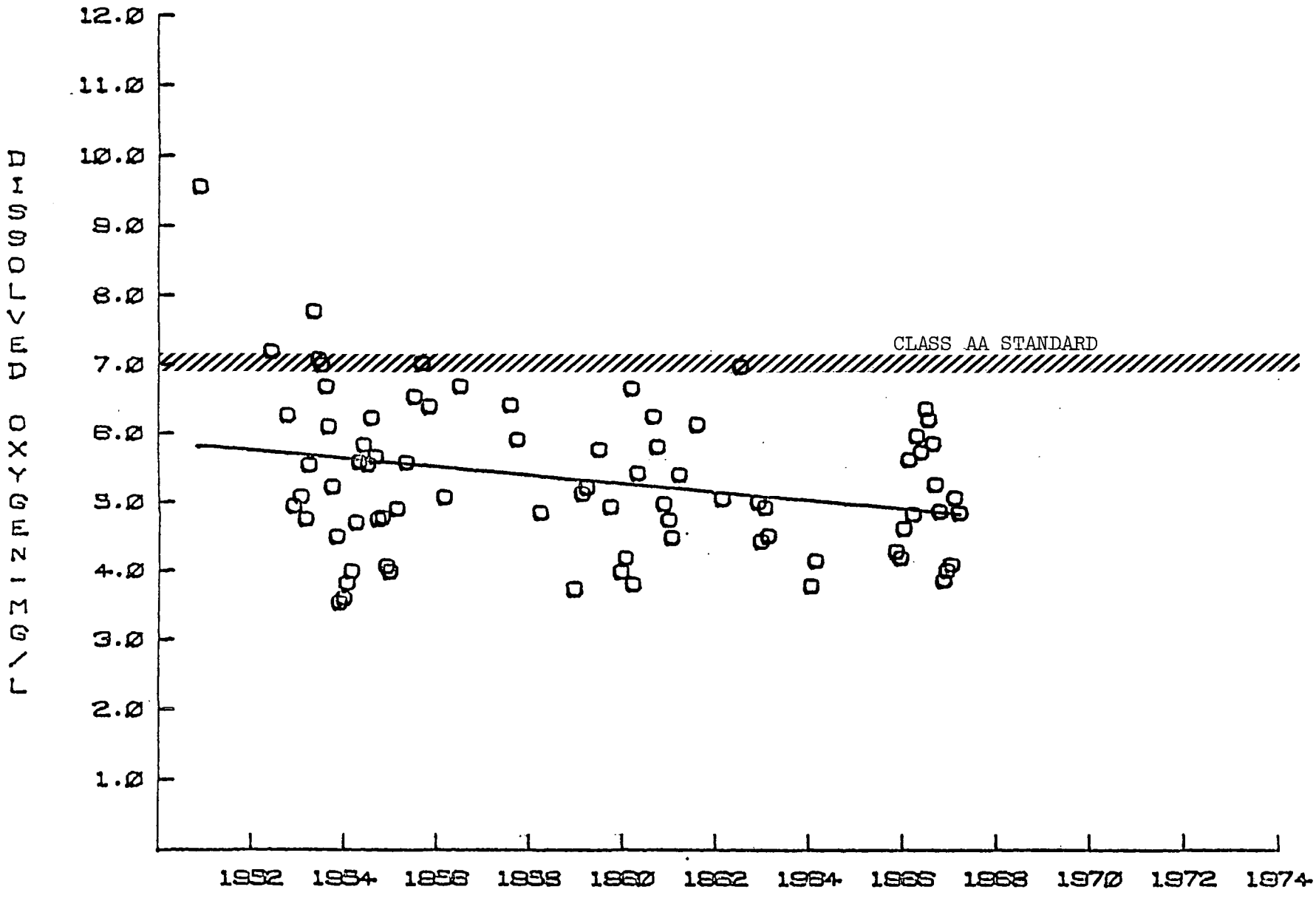


FIGURE 18: Lower Layer Hood Canal

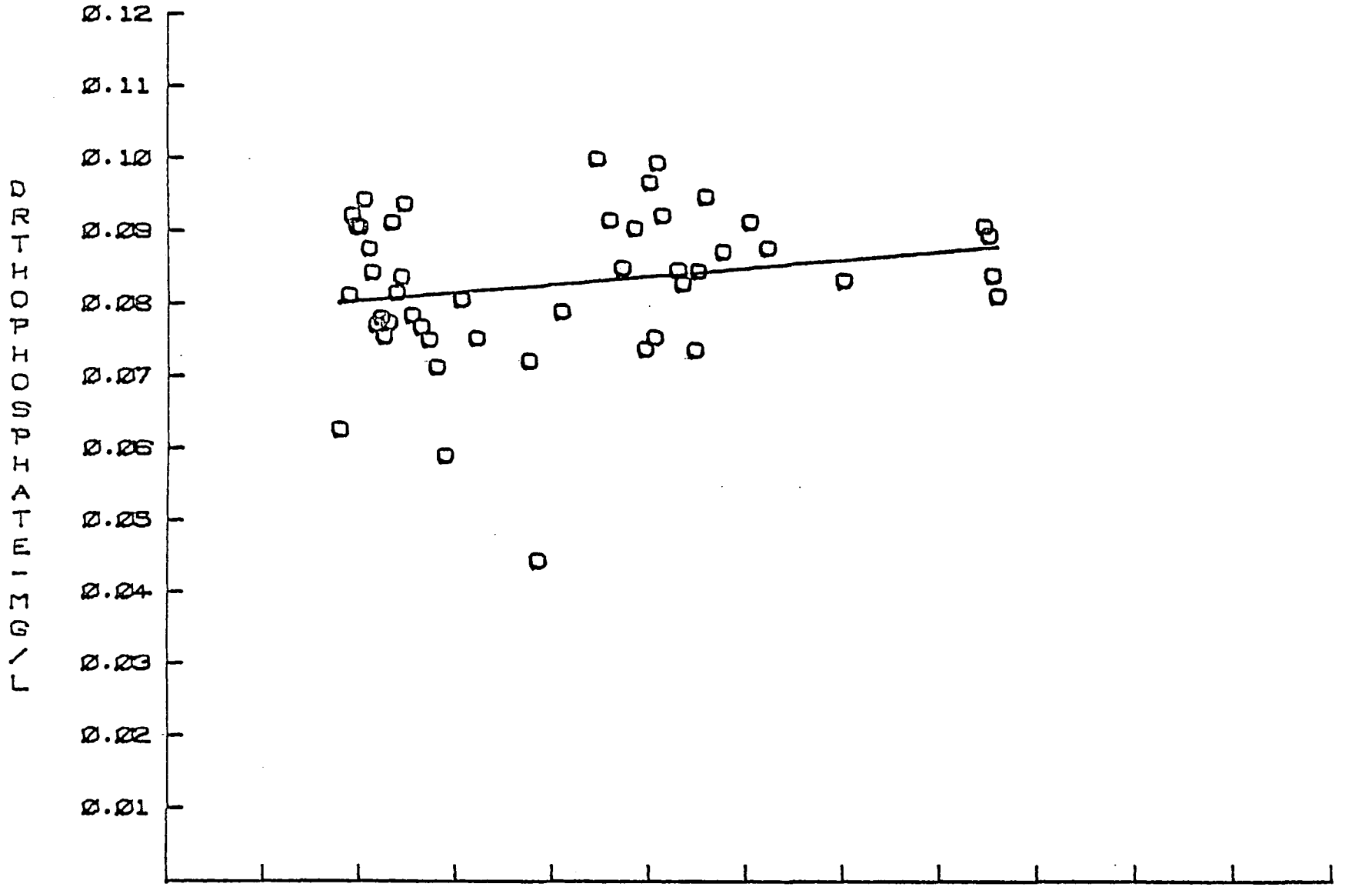


FIGURE 19: Lower Layer Hood Canal Basin

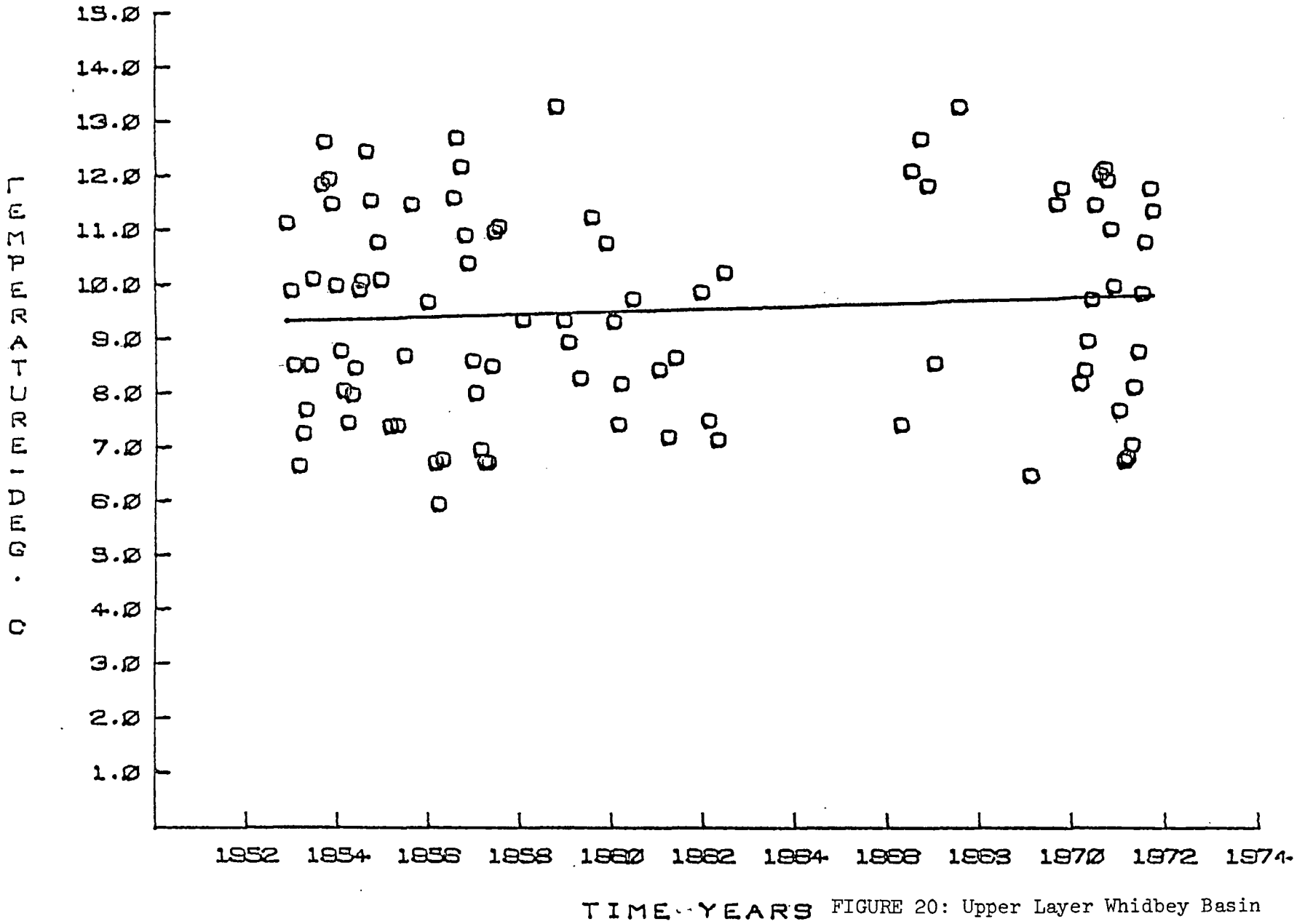


FIGURE 20: Upper Layer Whidbey Basin

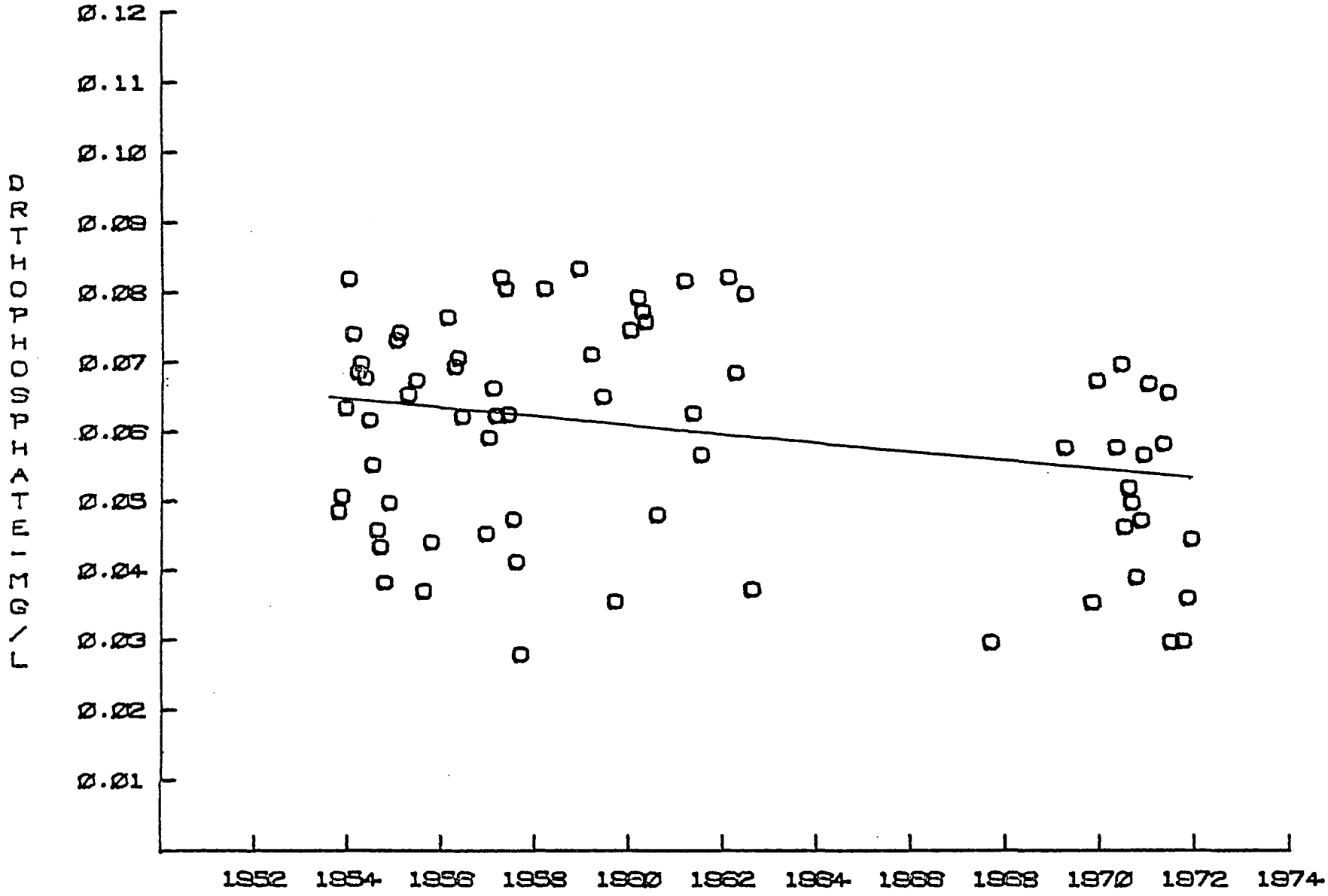


FIGURE 22: Upper Layer Whidbey Basin

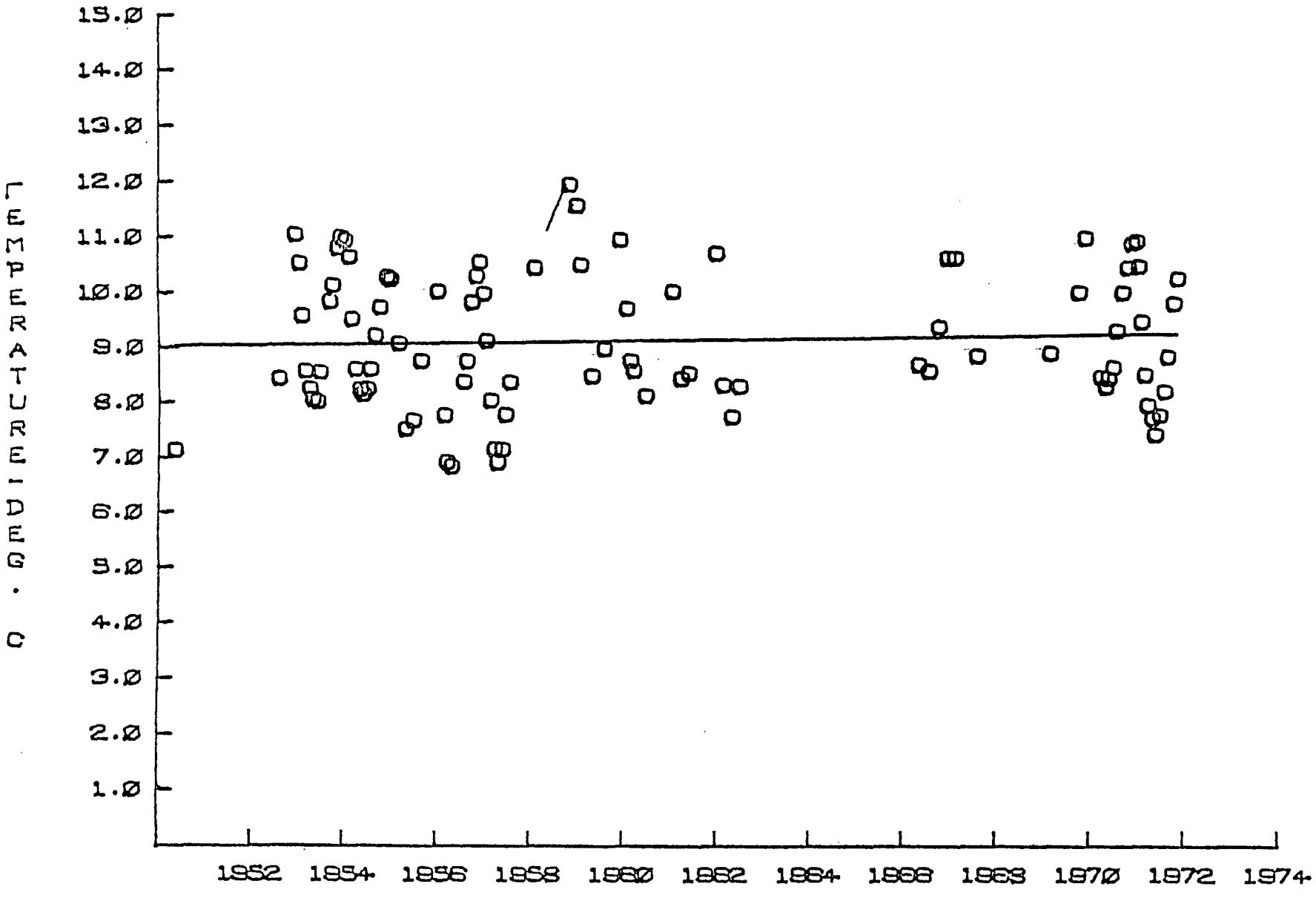
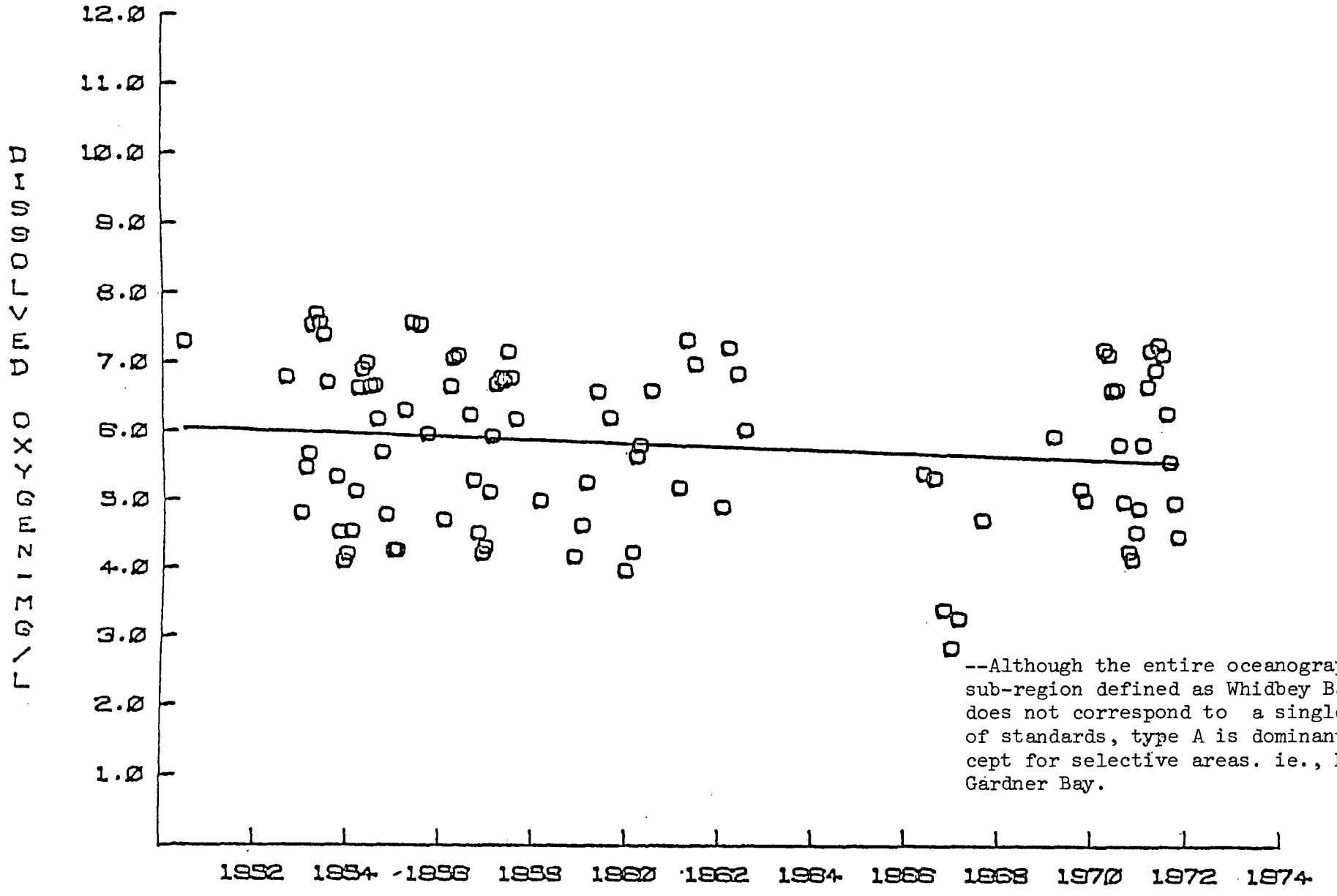


FIGURE 23: Lower Layer Whidbey Basin



--Although the entire oceanographic sub-region defined as Whidbey Basin does not correspond to a single Class of standards, type A is dominant except for selective areas. ie., Port Gardner Bay.

FIGURE 24: Lower Layer Whidbey Basin

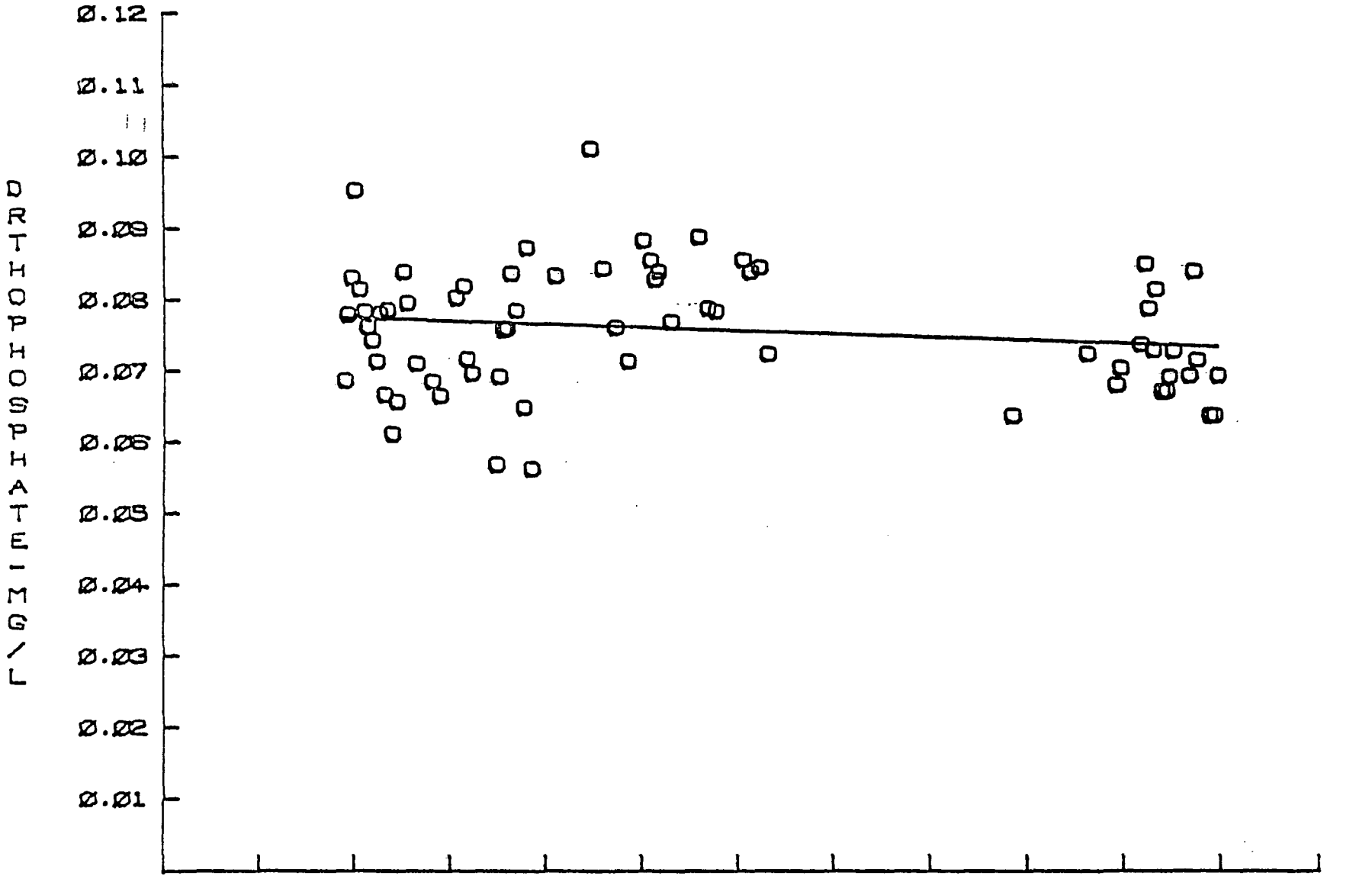


FIGURE 25: Lower Layer Whidbey Basin

STATION NO. *	PERIOD OF RECORD
PSB 301	1951-1971
PSB 305	1951-1972
PSB 318	1951-1972
PSB 320	1951-1971
PSB 322	1950-1971
NRR 403	1950-1962
NSQ 405	1950-1962
NSQ 406	1950-1962
NSQ 407	1951-1967
CRR 419	1950-1967
CSE 433	1950-1962
TOT 474	1957-1960
HCE 501	1952-1968
HCE 510	1952-1968
DAB 524	1950-1966
HCB 544	1952-1967
PSS 601	1952-1971
SUZ 607	1952-1970
SAR 611	1950-1971
SAR 614	1952-1971
SKG 619	1952-1971

TABLE 1. List of stations and associated period of record used to determine water quality trends in Puget Sound. *Station numbers correspond to those given by Collias (1970).

		SOUTH PUGET SOUND	CENTRAL PUGET SOUND	HOOD CANAL	WHIDBEY BASIN
Temperature	Upper Layer	$T=-75.2+4.352*10^{-2}t$	$T=-75.2+4.352*10^{-2}t$	$T=-103.6+5.834*10^{-2}t$	$T=-31.1+2.080*10^{-2}t$
	Lower Layer	$T=-53.3+3.198*10^{-2}t$	$T=-53.3+3.198*10^{-2}t$	$T=-103.2+5.753*10^{-2}t$	$T=-18.5+1.417*10^{-2}t$
Dissolved Oxygen	Upper Layer	$C=50.9-2.179*10^{-2}t$	$C=5.4+1.515*10^{-3}t$	$C=57.9-2.555*10^{-2}t$	$C=64.4-2.878*10^{-2}t$
	Lower Layer	$C=66.5-3.009*10^{-2}t$	$C=13.2-3.011*10^{-3}t$	$C=87.0-4.167*10^{-2}t$	$C=58.2-2.669*10^{-2}t$
Orthophosphate	Upper Layer	$P=-0.31+1953*10^{-4}t$	$P=1.08-5.202*10^{-4}t$	$P=3.22+1.680*10^{-3}t$	$P=1.53-7.494*10^{-4}t$
	Lower Layer	$P=0.10-1.454*10^{-4}t$	$P=0.64-2.920*10^{-4}t$	$P=-0.99+5.509*10^{-4}t$	$P=0.61-2712*10^{-4}t$

TABLE 2. Linear relationships for temperature, dissolved oxygen and orthophosphate in sub-regions of Puget Sounds. Relationships determined from least squares fit of monthly averaged data spanning the period 1950-1971.

	SOUTH PUGET SOUND	HOOD CANAL	WHIDBEY BASIN
January	-32	-153	-85
February	-119	-149	-338
March	-97	-155	-624
April	-94	-372	-1067
May	-30	-91	-1525
June	-582	-219	-2949
July	-469	-398	-2120
August	-405	-374	-844
September	-368	-366	-509
October	-482	-250	-660
November	-238	-	-551
December	-294	-343	-2

TABLE 3. Net monthly advected heat flow for sub-regions of Puget Sound (10^9 Kcal/day)

	SOUTH PUGET SOUND	HOOD CANAL	WHIDBEY BASIN
January	-658	-169	-1345
February	-240	-222	-1262
March	-421	-220	-670
April	-503	-358	-1877
May	-285	-91	-1479
June	-506	-166	-2712
July	-361	-374	-1584
August	-552	-262	-506
September	-245	-243	-59
October	-361	-159	-175
November	-151	-	-779
December	-349	-127	-1705

TABLE 4. Net Monthly advected dissolved oxygen for sub-regions of Puget Sound 10^3 (Kg/day)

	SOUTH PUGET SOUND	HOOD CANAL	WHIDBEY BASIN
January	-6080	-1530	-6920
February	-2050	110	-3240
March	-5060	-620	-5720
April	-560	2990	9740
May	1540	70	5560
June	1430	460	12590
July	1920	2450	10790
August	1180	1380	3390
September	-320	450	-1390
October	-2860	-1160	-6810
November	-1720	-	-7580
December	-5050	-3620	-7990

TABLE 5. Net monthly advected ortho-phosphate for sub-regions of Puget Sound (kg/day)

	SOUTH PUGET SOUND	CENTRAL PUGET SOUND	HOOD CANAL	WHIDBEY BASIN
Municipal Discharge	17.9	98.2	-	1.5
Industrial Discharge	271.6	50.8	-	2578.4

TABLE 6. Annual average discharge of carbonoceous biological oxygen demand (five day) from municipal and industrial sources to sub-regions of Puget Sound (10^3 Kg/day)

	SOUTH PUGET SOUND	CENTRAL PUGET SOUND	HOOD CANAL	WHIDBEY BASIN
Municipal Discharge	178	6139	-	230
Industrial Discharge	9651	6505	-	1451

TABLE 7. Annual average discharge of total phosphorous from Municipal and Industrial sources to sub-regions of Puget sound (Kg/day)

	SOUTH PUGET SOUND	CENTRAL PUGET SOUND	HOOD CANAL	WHIDBEY BASIN
January	114	249	150	1234
February	91	229	123	1054
March	78	146	104	813
April	54	136	65	797
May	32	139	52	1002
June	34	123	62	1257
July	21	81	31	758
August	23	55	17	385
September	21	51	26	353
October	36	72	75	651
November	46	95	109	872
December	71	201	160	1187

TABLE 8. Net monthly dissolved oxygen from river discharge for sub-regions of Puget Sound (10^3 Kg/day)

	SOUTH PUGET SOUND	CENTRAL PUGET SOUND	HOOD CANAL	WHIDBEY BASIN
January	365	3461	230	6747
February	146	3328	189	5950
March	124	2660	508	4483
April	144	3467	318	1306
May	62	2562	134	1713
June	88	6244	158	3279
July	40	3278	0	4289
August	42	2556	0	8307
September	86	4511	23	659
October	145	4858	65	355
November	186	2013	85	977
December	284	2766	125	2515

TABLE 9. Net Monthly total phosphorous from river discharge for sub-regions of Puget Sound (kg/day)