

ANDREA BEATTY RINKER
Director



STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY

7272 Cleanwater Lane LU-11 • Olympia Washington 98504-6811 • (206) 753-2353

May 27, 1986

Mr. Oliver R. Beach
Winchester Creek Company
P.O. Box 27
Cusick WA 99119

Dear Mr. Beach:

Your letter of December 18, 1985, to Ms. Carol Jolly cited evidence of declining water quality in the Pend Oreille River. As a result, I performed the following preliminary analysis of water quality data from the Pend Oreille River.

The data for our analysis were obtained from two ambient water quality monitoring stations. The upstream site (62A150) is at Newport, Washington, near the Idaho border. It was sampled by Ecology twice a month from October 1975 to September 1976. After a year's respite, monthly sampling has occurred to the present.

The other site (62A080) is about 70 miles downstream at the international boundary with Canada. This site was sampled monthly by Ecology and the U.S. Geological Survey (USGS) cooperatively from February 1974 to June 1981. Since then, USGS has sampled every two months or quarterly. The data used after September 1983 were provisional and subject to revision.

Table 1 shows most of the parameters used in this analysis, the analytical methods, the reasons for sampling, and the applicable water quality standard. This section of the Pend Oreille River is classified A by the state Water Quality Standards (Chapter 173-201 WAC).

The major issue is whether water quality has become degraded over time, resulting in eutrophication. In order to detect a trend, the data were initially graphed at each ambient water quality site. The results are shown in Figures 1 and 2. Temperature and dissolved oxygen show strong seasonal behavior at each site. In winter, dissolved oxygen is generally high and temperature is low. In summer, the opposite can be true. This behavior is typical of a minimally productive body of water in the temperate zone in which oxygen levels are controlled by the temperature. There is little evidence of very high daytime oxygen concentrations in spring or summer, typical of eutrophic waters affected by excessive productivity of aquatic plants.

Inorganic nutrients are essential for the production of aquatic plants and algae. These include nitrate ($\text{NO}_3\text{-N}$), nitrite ($\text{NO}_2\text{-N}$), ammonia ($\text{NH}_3\text{-N}$), and total phosphorus (T-P). A visual comparison between Figures 1 (Newport) and 2 (international boundary) for each nutrient shows little difference in concentrations between sites. Streamflow also was comparable. Thus there is

Table 1. Parametric coverage, rationale, and associated water quality standards (Ecology, 1982).

| Parameter | Method | Reason for Sampling | Water Quality Standard (Class A) |
|---|----------------------------|--|---|
| Temperature (°C) | YSI Tele-thermometer | Used with oxygen to determine percent saturation. Temperature also affects gas solubility and rates of biological processes. | Not to exceed 18.0°C due to human activities. When natural conditions exceed 18°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C. |
| Dissolved Oxygen (mg/L) | Winkler Titration | Elevated, relatively constant oxygen levels are essential for stable aquatic communities. Highly variable levels downflow from a source may be indicative of an organic load in excess of the ability of the system to assimilate it. | Shall exceed 8.0 mg/L; when natural conditions (e.g., upwelling) depress D.O. near or below 6.0, natural D.O. levels can be degraded by up to 0.2 mg/L by man-caused activities. |
| Nutrients ^{1/} (mg/L) NO ₃ -N; NO ₂ -N; NH ₃ -N; T-PO ₄ -P | EPA (1979); APHA (1980) | Inorganic nutrients are readily available for assimilation by algae and other aquatic plants. Excessive levels with abundant light may lead to massive algae production at the expense of other plants and animals. Ammonia (NH ₃ -N) is an immediate byproduct of the breakdown of urine and therefore may be useful to trace animal wastes in water. | Excessive levels of un-ionized ammonia are toxic to freshwater organisms (EPA, 1976; Willingham et al., 1979). The current freshwater standard for total ammonia-N ranges from 29 mg/L (at temp. = 0; pH = 6.50) to 47 mg/L (at temp. = 30°C, pH = 9.0). Un-ionized ammonia limits are 0.007 mg/L to 0.21 mg/L under temp., pH conditions discussed above (Fed. Register 50:145 July 29, 1985). |
| pH (S.U.) | pH Meter | pH affects the carbonic acid-carbon dioxide balance in water. pH also affects the activity of un-ionized ammonia, sulfide, and metals. | Shall be within the range of 6.5 to 8.5 with man-caused variation within a range of less than 0.5 unit. |
| Total Suspended Solids or Total Non-Filterable Residue (mg/L) | EPA (1979); APHA (1980) | Measures water-column transparency and light availability, and is an estimate of suspended material in water column. Sufficient light is essential to aquatic plant growth. Excessive suspended materials may stress plants and animals by light reduction or smothering. | No numerical standard. |
| Turbidity (NTU) | Hach Turbidity meter | Measures water-column transparency and light availability, and is an estimate of suspended material in water column. Turbidity is a function of the quantity and light scattering characteristics of the suspended material. Sufficient light is essential to aquatic plant growth. Excessive suspended material may stress plants and animals by light reduction or smothering. | Not to exceed 5 NTU over background if background is 50 NTU or less, or have more than a 10 percent increase in turbidity when background turbidity is more than 50 NTU. |

^{1/}Kjeldahl nitrogen analysis was run on samples from the international boundary site. This analysis measures nitrogen that is bound up in organic matter plus inorganic nitrogen (NH₃-N). Total nitrogen is measured by adding Kjeldahl nitrogen to NO₂ + NO₃ (APHA, 1980).

Figure 1. Ambient data from Pend Oreille River at Newport, MA.

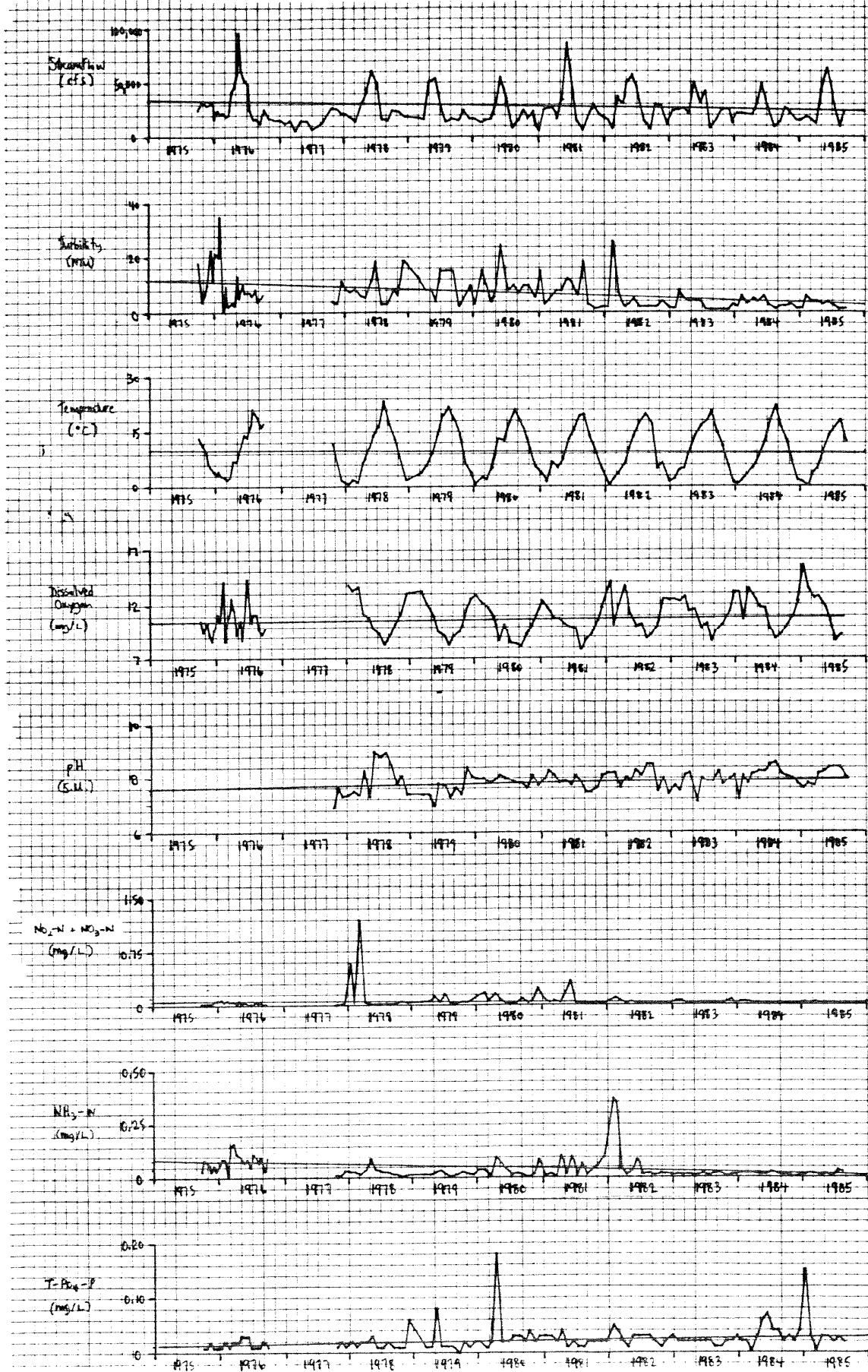
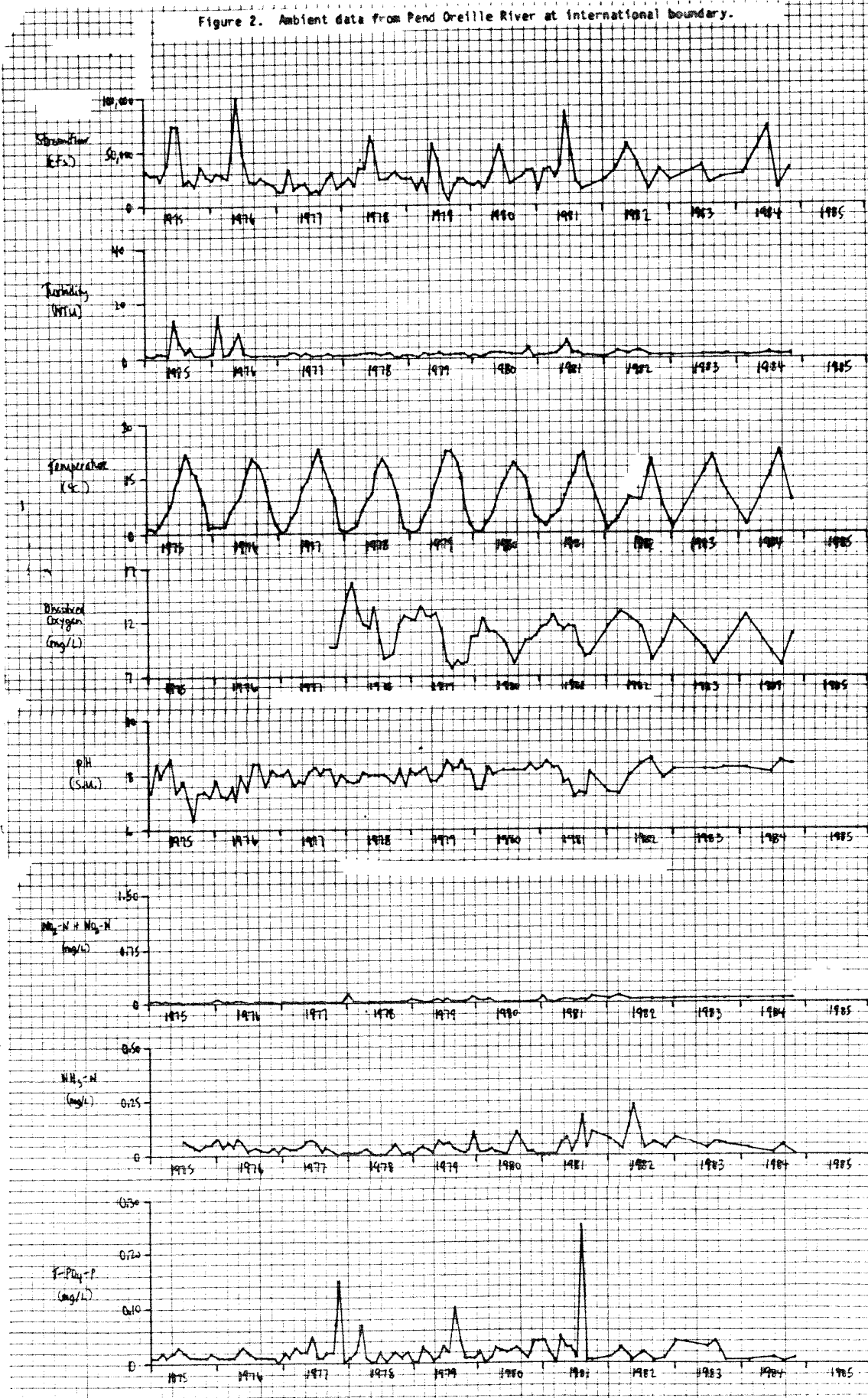


Figure 2. Ambient data from Pend Oreille River at international boundary.



Mr. Oliver R. Beach
May 27, 1986
Page Two

little evidence for significant contributions from streamside sources within this stretch of stream. Ammonia may be slightly higher, although the levels generally are quite low. Ammonia at both sites is well below the maximum allowable total ammonia criteria for protection of fish and wildlife from toxic effects.

Figure 1 shows regression lines calculated for several parameters for the period of record at Newport. Least-squares regression was calculated using a programmable calculator. Note that the slopes of the regression lines are very slight. Nitrate-nitrite and ammonia show downward trends. Total phosphorus has a very slight upward trend. However, given the variability of the data, a significant trend is unlikely.

Loads were calculated for nutrients at Newport by using the method of IHD-WHO (1978):

$$L = f \times c \times d$$

where L = load (lb/day)
c = nutrient concentration (mg/L)
d = stream flow (cfs)

and f = 5.3936 (conversion factor)

The loads and regression lines are shown in Figure 3. Trends are similar to those in Figure 1. Nitrogen loads are slightly downward and total phosphorus is very slightly (probably insignificantly) upward.

Table 2 summarizes nutrient data from the two sites for the entire record. The results in Table 2 are compared with data from two sets of criteria used to estimate the potential for eutrophication. The first set of criteria was first suggested by Sawyer (1947) as described in Welch (1980). The criteria are based on concentrations of total inorganic nitrogen ($\text{NO}_3\text{-N}$, $\text{NO}_2\text{-N}$, and $\text{NH}_3\text{-N}$) and dissolved inorganic phosphate (most of which is orthophosphate or $\text{O-PO}_4\text{-P}$). For this analysis, orthophosphate data were used. Only data from November through February were used. At this time of year most nutrients are dissolved. Only minimal amounts are incorporated in plants because plant production is low. Orthophosphate data from the international boundary were available from July 1975 through August 1977 only. Despite the limited data, it seems clear that both sites have been well below the threshold values for nutrients, on the average.

Results also are compared with more recent data from Wetzel (1983) derived from samples taken from over 200 lakes and reservoirs. This comparison is probably appropriate because the flow of Pend Oreille River is reduced substantially by several dams. Thus, the river in this stretch resembles a lake. Total nitrogen and phosphorus were used in this case because each is a sum of both dissolved inorganic substances and particulate organic (living) material. This means that the time of year does not matter since nearly all nutrients are accounted for. Thus all the data could be used.

Figure 3. Loads from Pend Oreille River at Newport.

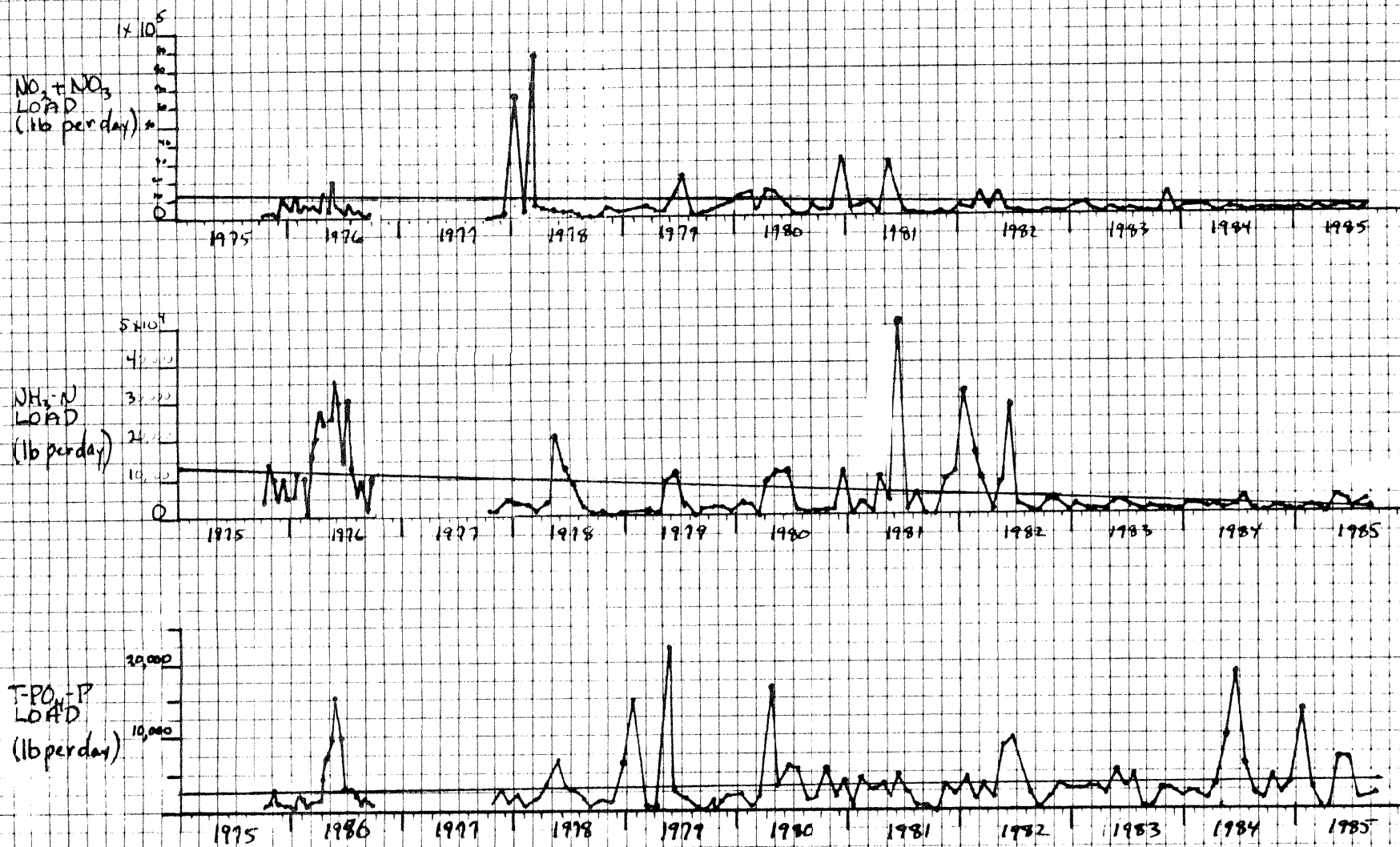


Table 2. Values for nitrogen and phosphorus from two sites on the Pend Oreille River, eastern Washington.

| Parameter | Pend Oreille River | | Critical Levels abv which blooms may occur (Welch, 1980) | General Lake Trophic Classi- fication ^{1/} (from Wetzel, 1983) | | |
|---|--------------------|--------------------|--|--|------------------|----------------|
| | Newport | Intn'l Boundary | | Oligo- trophic | Meso- trophic | Eu- trophic |
| Total nitrogen (mg/L, N) ^{2/} (inorganic + organic) | | | | | | |
| mean | -- | 0.38 | -- | 0.66 | 0.75 | 1.88 |
| minimum | -- | 0.09 | | 0.31 | 0.36 | 0.39 |
| maximum | -- | 2.25 | | 1.63 | 1.39 | 6.10 |
| N | -- | 98 | | 11 | 8 | 37 |
| Total inorganic nitrogen (mg/L, N) ^{3/} | | | | | | |
| mean | 0.11 | 0.07 | 0.3 | -- | -- | -- |
| minimum | 0.01 | 0.00 | | -- | -- | -- |
| maximum | 0.61 | 0.22 | | -- | -- | -- |
| N | 37 | 30 | | -- | -- | -- |
| Total phosphorus (mg/L, P) ^{2/} | | | | | | |
| mean | 0.02 | 0.02 | -- | 0.008 | 0.027 | 0.084 |
| minimum | 0.00 | 0.00 | | 0.003 | 0.011 | 0.016 |
| maximum | 0.15 | 0.15 | | 0.018 | 0.097 | 0.386 |
| N | 116 | 104 | | 21 | 19 | 71 |
| Dissolved inorganic phosphate (mg/L, P) ^{3/} | | | | | | |
| mean | 0.007 | 0.001 | 0.01 | -- | -- | -- |
| minimum | 0.00 | 0.00 | | -- | -- | -- |
| maximum | 0.03 | 0.01 | | -- | -- | -- |
| N | 37 | 8 | | -- | -- | -- |

^{1/}Annual mean values

^{2/}Period of record

^{3/}Measured before start of active growing season (minimal organic fraction; maximum supply available).

Mr. Oliver R. Beach
May 27, 1986
Page Three

In Table 2, total nitrogen levels were calculated by adding Kjeldahl nitrogen (organic nitrogen plus ammonia, APHA 1980) to $\text{NO}_3\text{-N} + \text{NO}_2\text{-N}$. Kjeldahl nitrogen data were available from the international boundary site only. At this site, total nitrogen was generally within limits typical of systems with low plant productivity (oligotrophic) and far below highly enriched (eutrophic) systems. Total phosphorus levels average slightly higher, suggesting a status between oligotrophic and mesotrophic classification.

The ratio of the weights of nitrogen to phosphorus required to produce 1 weight-equivalent of plant tissue is about 7:1 (Welch, 1980). If conditions of light and temperature were ideal, plant production would proceed until the supply of either phosphorus or nitrogen was exhausted. Production would then stop because the ecosystem would become limited for that nutrient. In Table 2, the ratio of total nitrogen to total phosphorus = $0.38/0.002$ or 19/1 by weight. This ratio indicates that the system is limited by phosphorus which is typical of freshwater streams and lakes (Welch, 1980). The key to controlling excessive plant production (eutrophication) is to control phosphorus loads to the stream.

Table 3 shows total phosphorus loads from several municipal point sources along the Pend Oreille River between Newport and the international boundary. The river load coming from upstream is included for comparison. Source loads were calculated using flow data from NPDES permits. Total phosphorus was estimated to be 20 mg/L (Metcalf and Eddy, 1972). The total load from municipal sources is slightly higher than two percent of the total Pend Oreille River load. This very small contribution is dominated by the Newport sewage treatment plant (STP) (66.7 percent) and the Metaline Falls STP (26.7 percent).

Several industrial sources are located along this section of the Pend Oreille River. Lehigh Cement Company near Metaline Falls uses 144,000 gallons of water per day for cooling. The cooling water does not pick up materials in the manufacturing process. Pintlar Corporation pumps 60,000 gallons of water per day from a zinc mine shaft. The mine has not operated for over a decade (J. Prudente, Ecology Eastern Regional Office, personal communication). Since neither industry appeared to be a significant nutrient source, they were not included in Table 3.

Agricultural sources did not seem to be important in this stretch of river, either. Most land in the region is unsuitable for cattle production. Cattle herds have remained stable in size for the past ten years (R. Ray, Ecology Eastern Regional Office, personal communication).

Table 4 shows 1984 water quality indices (WQI) for several eastern Washington rivers. A WQI is a unitless number based on Ecology water quality criteria for temperature, dissolved oxygen, pH, fecal coliform bacteria, and nutrients (trophic status). Aesthetic criteria are defined by turbidity. The trophic status (nutrients) on the Pend Oreille River was well within acceptable limits (<20). Other criteria met federal goals also, except for temperature which (due to summertime low flows) was slightly above the "met-goal" limit. The WQI demonstrates that Pend Oreille River does not suffer water quality problems shown by other streams in the region.

Table 3. Calculated phosphorus loads from several point-sources along a stretch of Pend Oreille River between Newport, WA. and the international boundary.

| Source | Average Flow (MGD) | [T-P04-P] (mg/L) ^{1/} | Load (lbs/day) | Relative Contribution (percent) |
|--|--------------------|--------------------------------|--------------------|---------------------------------|
| City of Newport Secondary STP | 0.500 | 20 | 41.7 | 66.7 |
| City of Metaline Falls STP | 0.310 | 20 | 16.7 | 26.7 |
| City of Metaline | 0.045 | 20 | 3.7 | 5.9 |
| Selkirk High School | 0.005 | 20 | 0.4 | 0.7 |
| Total Municipal Sources | -- | -- | 62.5 | -- |
| Pend Oreille River at Newport | -- | -- | 2685 ^{2/} | -- |
| Total Municipal Sources/ Pend Oreille River | | | | 2.3 |

^{1/}Estimated value obtained from Metcalf and Eddy (1972).

^{2/}Geometric mean (approximates the median), n = 116 for period of record.

Table 4. Water quality status of several eastern Washington streams.
Water quality indices were calculated in 1984.

| SURFACE WATER SEGMENT | | STREAM MILES | WATER QUALITY INDEX CATEGORIES | | | | | | | | | | OVERALL INDEX RATING | PROBABLE CAUSES OF HIGH WQI RATINGS | |
|-----------------------|---|--------------|--------------------------------|-----|----|------|-------|------|-------------|-----|---------|----------|----------------------|--|--|
| SEGMENT NUMBER | SEGMENT NAME STATION NUMBER | | TEMP | ORX | pH | BACT | TROPH | AEST | SUSP SOLIDS | RAD | ORG TOX | AMMO TOX | | | |
| 23-62-05 | Pend Oreille R. & tribs. | | | | | | | | | | | | | | |
| | 624060 | 44 | 27 | 14 | 11 | 3 | 8 | 2 | 5 | 0 | 0 | 6 | 15 | | |
| | 624150 | 44 | 22 | 12 | 7 | 5 | 8 | 7 | 3 | 0 | 0 | 2 | 10 | | |
| 21-45-01 | Wenatchee R. & tribs. | | | | | | | | | | | | | | |
| | 454070 | 25 | 17 | 8 | 18 | 15 | 5 | 4 | 4 | 0 | 0 | 3 | 11 | | |
| | 454110 | 30 | 11 | 9 | 3 | 4 | 4 | 3 | 3 | 0 | 0 | 0 | 4 | | |
| 24-34-01 | Spokane R., mouth to Mangum Cr. | | | | | | | | | | | | | | |
| | 544070 | 33 | 25 | 34 | 7 | 19 | 17 | 19 | 4 | 0 | 0 | 3 | 24 | TROPH - Recent declines in nutrient loading from Spokane - SIP not accurately reflected by high trophic WQI. D.O. - Eutrophication in Long Lake. TEMP - Impounded water, summer low flows. Metal toxicity from Kellogg ID mining district has been a historical problem - recent trend analysis indicates metals are declining. | |
| | 544120 | 18 | 18 | 9 | 13 | 19 | 21 | 26 | 28 | 0 | 0 | 6 | 25 | | |
| 18-37-01 | Yakima R. & tribs. from mouth to Sunnyside Dam bridge | | | | | | | | | | | | | | |
| | 374090 | 80 | 33 | 8 | 18 | 20 | 23 | 12 | 22 | 0 | 0 | 4 | 30 | TROPH; TEMP; SUSP SOLIDS - Irrigation return flow system and SIPs. BACT - Agricultural runoff. pH - Phytoplankton blooms. | |
| 16-34-01 | Palouse R. & tribs. | | | | | | | | | | | | | | |
| | 344070 | 120 | 30 | 15 | 20 | 25 | 40 | 57 | 38 | 0 | 0 | 8 | 42 | TEMP - Low flows - irrigation projects; removal of bankside vegetation. BACT; TROPH; AEST; SUSP SOLIDS - S.F. Palouse R., agricultural runoff - cattle and dryland; removal of bankside vegetation; small municipal SIPs. | |

Score criteria: 0 - 20: meets goals of federal Water Pollution Control Act
20 - 60: marginal status
>60: unacceptable status

Mr. Oliver R. Beach
May 27, 1986
Page Four

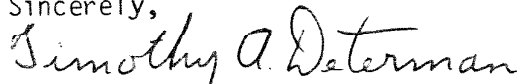
In summary, it does not appear that seasonal abundance of aquatic weeds and algae can be explained by a general regional decline in water quality. This conclusion is based on results of sampling at stations located 70 miles apart. They describe regional or generalized water quality. For this reason, this analysis cannot address conditions in highly localized sections of river where aquatic plants may be abundant. The larger plants, such as milfoil, may act as "nutrient pumps," drawing inorganic nutrients from the sediments via their root system and releasing them in the water for other plants. Large aquatic plants also physically alter the system in such a way that plant growth is promoted. For example, large plants may reduce the water motion, therefore raising temperature and increasing light by reducing silt. The milfoil thus provides a favorable niche or habitat for other plants near the water surface. Collectively these conditions change localized water quality and are compounded with the continued spread of Eurasian Milfoil.

Here are some conclusions derived from this analysis:

- o Long-term trends shows generally good water quality. There is evidence that nitrogen concentrations and loads have decreased over time. Phosphorus may have increased slightly, but the significance of the trend is doubtful.
- o Plant production in the Pend Oreille River seems to be limited by the amount of phosphorus available. Its trophic status suggests very low nutrient enrichment with little potential for wide-scale blooms of aquatic plants.
- o Municipal discharges add a little over two percent of the phosphorus load to the Pend Oreille River in the stretch between Newport and the international boundary. This additional load is insufficient to stimulate widespread blooms of aquatic plants.
- o The Water Quality Index shows that the Pend Oreille River meets the goals of the Federal Water Pollution Control Act.

I hope that this analysis contributes to some understanding of the issue. Please inform me if you need clarification of any part of the analysis.

Sincerely,



Timothy A. Determan
Water Quality Investigations Section

TAD:cp

Enclosures

cc: Carol Jolly
Norm Glenn
Lynn Singleton
Roger Ray

REFERENCES

- American Public Health Association, 1980. Standard Methods for the Examination of Water and Wastewater. 15th Ed., Washington DC. 1134 pp.
- DeGraeve, G.M., W.J. Blogoslawski, W.A. Brungs, J.A. Fava, B.J. Finlayson, T.P. Frost, T.M. Krischan, J.W. Meldrim, D.T. Michaud, R.E. Nakatani, and G.L. Seegert, 1979. Chlorine. In: A Review of the EPA Red Book: Quality Criteria for Water. Water Quality Section, American Fisheries Society, Bethesda, MD. 67-75 pp.
- EPA (Environmental Protection Agency), 1976. Quality Criteria for Water. U.S. Gov't. Printing Office, Washington, DC. 256 pp.
- EPA, 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020. Cincinnati, OH. 460 pp.
- IHD-WHO Working Group on Quality of Water, 1978. Water quality surveys: a guide for the collection and interpretation of water quality data. UNESCO, WHO, Geneva.
- Metcalf and Eddy, 1972. Wastewater Engineering. McGraw-Hill Book Co., New York, NY.
- Redfield, A.C., 19058. The biological control of chemical factors in the environment. American Scientist 46:3. p. 205-221.
- Sawyer, C.N., 1947. Fertilization of lakes by agriculture and urban drainage. J.N. Eng. Water Works Assoc. 61(2): 109-127.
- Welch, E.B., 1980. Ecological Effects of Waste Water. Cambridge U. Press. Cambridge. 337 pp.
- Wetzel, R.G., 1983. Limnology. Saunders College Publishing Co., Philadelphia, PA. 767 pp.
- Willingham, W.T., J.E. Colt, J.A. Fava, B.A. Hillaby, C.L. Ho, M. Katz, R.C. Russo, D.L. Swanson, and R.V. Thurston, 1979. Ammonia. In: A Review of the EPA Red Book: Quality Criteria for Water. Water Quality Section, American Fisheries Society, Bethesda, MD. 6-18 pp.
- WDOE, 1982. Water quality standards for waters of the State of Washington. Chapter 173-201 WAC.