# Memorandum

**TO:** Bruce Willey, HDR, Inc.

**DATE:** January 2, 2002

**PROJECT:** SPOCFP

**FROM:** Joseph Helfand
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**COPIES:**

**SUBJECT:** Modeling of Dissolved Oxygen in the Spokane River Response to Effluent from Inland Empire Paper and the Proposed Spokane County WWTP

## SUMMARY

Limno-Tech, Inc. performed dissolved oxygen water quality modeling using QUAL2E program input files originally developed by Washington Department of Ecology for waste load allocations for the Inland Empire Paper Company. The model was applied to predict the incremental impact of effluent discharges from the Inland Empire Paper facility and the proposed Spokane County WWTP, during both summer and winter conditions. The combined impact of the two effluents was then estimated by summing the individual DO deficits at each point in the river. This analysis was done for eight different effluent quality scenarios for the Spokane County WWTP – four in the summer and four in the winter. The flow condition for all runs was the seasonal 7Q20 flow.

It was found that there is little overlap between the impacts of the two effluents under summer conditions, whereas winter conditions lead to substantial overlap – the IEP DO deficit is appreciable at and for some distance past the proposed Spokane County WWTP discharge location. Therefore, under summer conditions, the combined impact should meet the objective of a deficit of no more than 0.2 mg/L where the Spokane County WWTP meets that objective. Under winter conditions, the combined impact will exceed the 0.2 mg/L criterion unless a very high level of treatment is provided at the Spokane County WWTP. However, it is expected that instream DO levels will be high in the winter, substantially exceeding the requirement of 8 mg/L. Consequently, DO impacts that are significantly greater than 0.2 mg/L should be allowable, resulting in less stringent effluent quality requirements for the Spokane County WWTP. Further analysis is required to quantify the allowable DO impact during winter 7Q20 flow conditions.

## INTRODUCTION

Spokane County proposes to build a new Waste Water Treatment Plant (WWTP) in the City of Spokane with a design horizon of the year 2025. Among the review requirements of the Washington State Department of Ecology (Ecology) is an assessment of the impact of the plant effluent on dissolved oxygen (DO) levels in the receiving water, the Spokane River. In support of this assessment, Limno-Tech, Inc. (LTI) conducted water quality modeling using the QUAL2E computer program (Brown and Barnwell, 1987), which

performs steady-state one-dimensional modeling. The modeling was based on QUAL2E modeling developed by Ecology (Pelletier, 1994; Pelletier, 1997). Four scenarios were investigated for each of the summer and winter seasons (LTI, 2001). The Ecology modeling, as developed in support of waste load allocation for the Inland Empire Paper Company (IEP), was also used to assess the IEP impact both above and below the proposed location of the WWTP effluent. The combined impacts estimated from the two sets of modeling gives the total impact in the river on DO levels relative to background conditions.

## MODEL INPUTS

### IEP Runs

Model input files originally developed in 1997 (Pelletier, 1997) were used. File names and characteristics are given in Table 1.

***Table 1. IEP Model Inputs***

| File | Season | Impact | Waste Load, lb/day $BOD_5$ |
|---|---|---|---|
| X2C0000.IN | Summer | Base | 0 |
| X2C0390.IN | Summer | IEP Impact | 390 |
| XD0000.IN | Winter | Base | 0 |
| XD4200.IN | Winter | IEP Impact | 4200 |

### Spokane County WWTP Runs

Characteristics of summer and winter scenario runs are given in Tables 2 and 3. All runs assumed an effluent flow rate of 11.9 mgd (18.4 cfs) for the design year 2025.

***Table 2. Spokane County WWTP Summertime Model Inputs***

| | Run No. 1<br>Lowest Loading | Run No. 2<br>Low Loading | Run No. 3<br>Moderate Loading | Run No. 4<br>High Loading |
|---|---|---|---|---|
| **Effluent Concentration, mg/L** | | | | |
| **DO** | 6 | 6 | 4 | 2 |
| **$BOD_5$** | 5 | 10 | 15 | 20 |
| **Ammonia-nitrogen** | 1 | 2 | 3 | 4 |

***Table 3. Spokane County WWTP Wintertime Model Inputs***

| | Run No. 5<br>Lowest Loading | Run No. 6<br>Low Loading | Run No. 7<br>Moderate Loading | Run No. 8<br>High Loading |
|---|---|---|---|---|
| **Effluent Concentration, mg/L** | | | | |
| **DO** | 6 | 6 | 4 | 2 |
| **$BOD_5$** | 20 | 20 | 25 | 30 |
| **Ammonia-nitrogen** | 4 | 8 | 14 | 20 |

## Model Reaches

The model contains four reaches: the 2.8 mile reach from Inland Empire Paper Company to Upriver Dam, the 2.2 mile reach from Upriver to Greene Street, the 3.8 mile reach from Greene Street to Monroe Dam (City Dam), and the 1.4 mile reach below Monroe Dam to the USGS gage location. Modeling of the impact of the proposed Spokane County WWTP discarded the reach above the Upriver Dam and retained the remaining three reaches. The Spokane County WWTP discharge is assumed to be at River Mile 78.5, just above Greene Street.

## Upstream Flow

Ecology requires that assessments be done using seasonal 7Q20 upstream flows when the analysis covers separate summer and winter periods. The 7Q20 flow is defined as the discharge at the 20-year recurrence interval taken from a frequency curve of annual values of the lowest mean discharge for 7 consecutive days. For seasonal 7Q20s the 7 consecutive day periods are limited to the season of interest. The 7Q20 flows used for this study are 623 cfs for summer and 1077 cfs for winter (in both cases measured at the Spokane Gage).

## RESULTS

Incremental DO deficits by river mile are shown in Figures 1-8 for 1) the IEP effluent, 2) the Spokane County WWTP effluent, and 3) the combined effluents. Table 4 summarizes the maximum DO impacts associated with the individual and combined effluents.

***Table 4. Summary of Dissolved Oxygen Impacts***

| Model Run | Maximum Incremental Dissolved Oxygen Impact, mg/L | | |
|---|---|---|---|
| | **Inland Empire Paper Discharge Alone** | **Spokane County WWTP Discharge Alone** | **Combined Discharges (Below Spokane County Discharge)** |
| **Summer Scenarios** | | | |
| Spokane County - Lowest | 0.20[1] | 0.08 | 0.11 |
| Spokane County - Low | 0.20[1] | 0.13 | 0.16 |
| Spokane County - Moderate | 0.20[1] | 0.21 | 0.24 |
| Spokane County - High | 0.20[1] | 0.29 | 0.32 |
| **Winter Scenarios** | | | |
| Spokane County - Lowest | 0.23[1] | 0.09 | 0.23 |
| Spokane County – Low | 0.23[1] | 0.10 | 0.24 |
| Spokane County - Moderate | 0.23[1] | 0.16 | 0.30 |
| Spokane County – High | 0.23[1] | 0.22 | 0.36 |

1. Occurred above Upriver Dam.

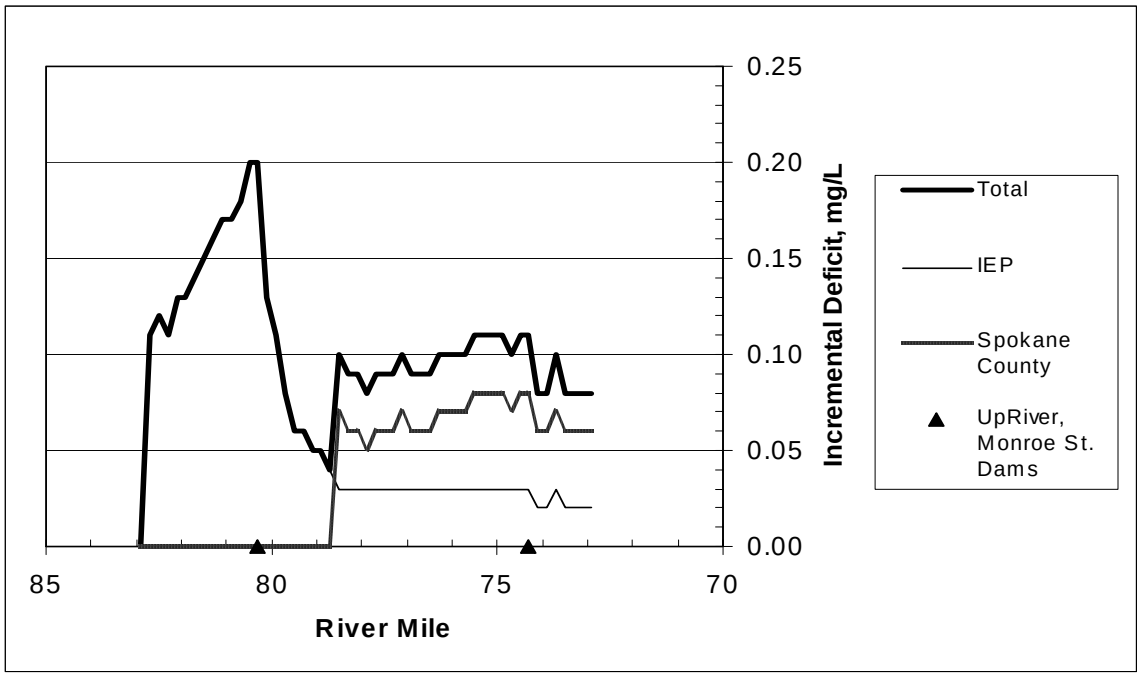


***Figure 1. Summer Incremental DO Deficits by River Mile Including Spokane County WWTP "Lowest" Impact Scenario***

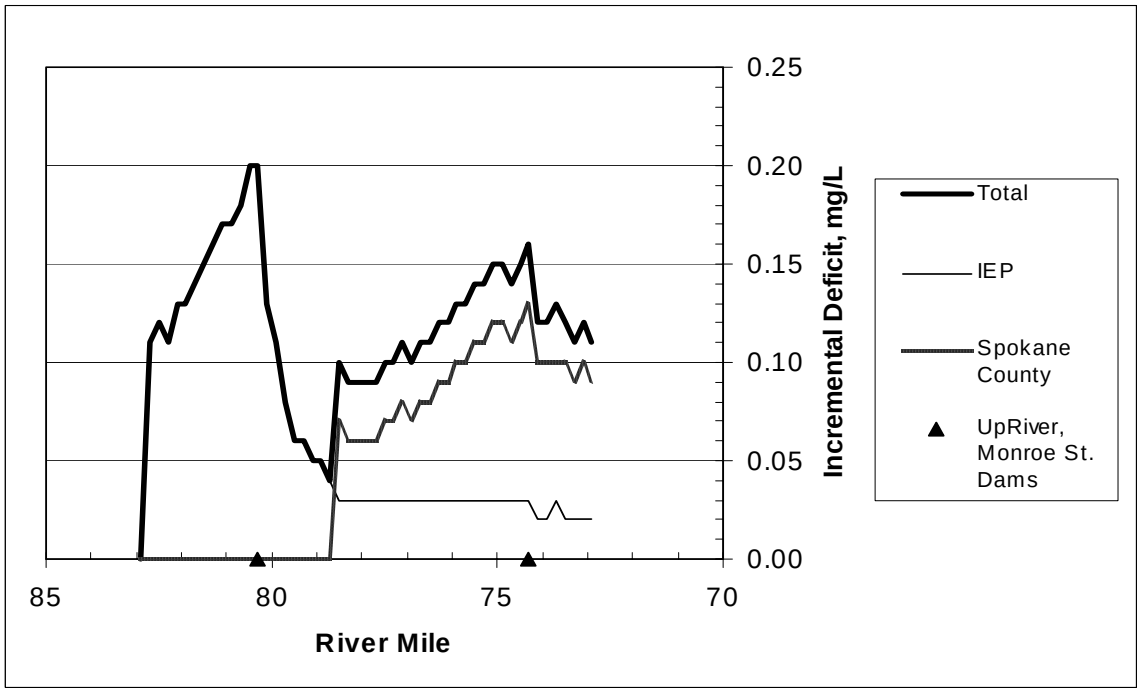


***Figure 2. Summer Incremental DO Deficits by River Mile Including Spokane County WWTP "Low" Impact Scenario***

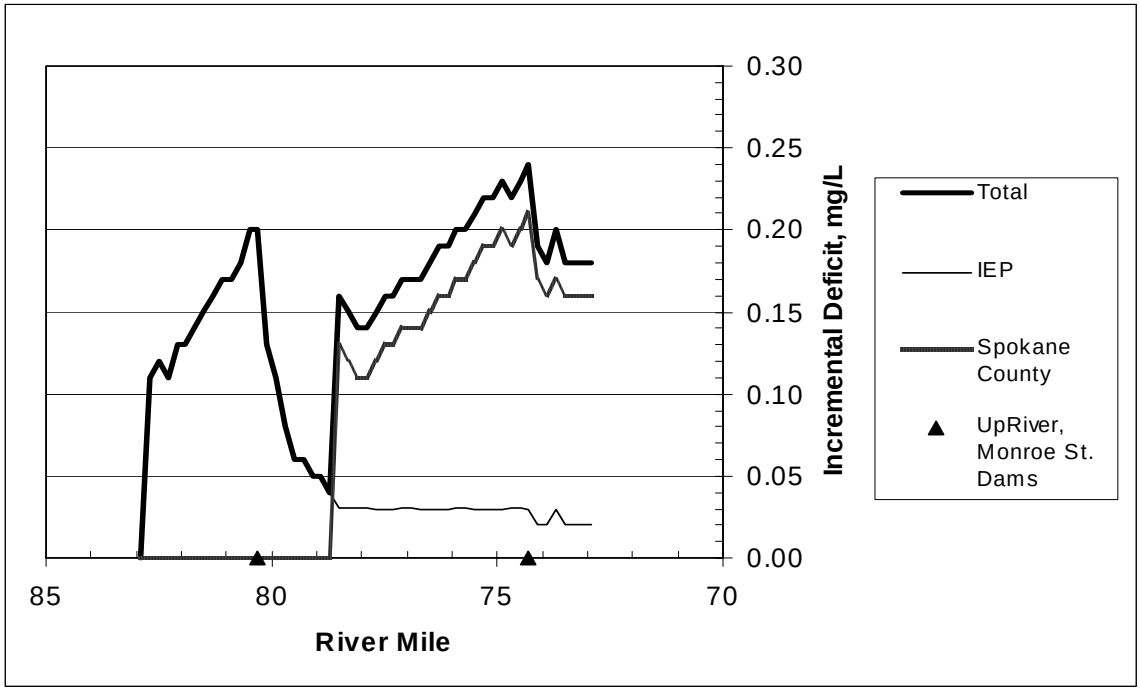


***Figure 3. Summer Incremental DO Deficits by River Mile Including Spokane County WWTP "Moderate" Impact Scenario***

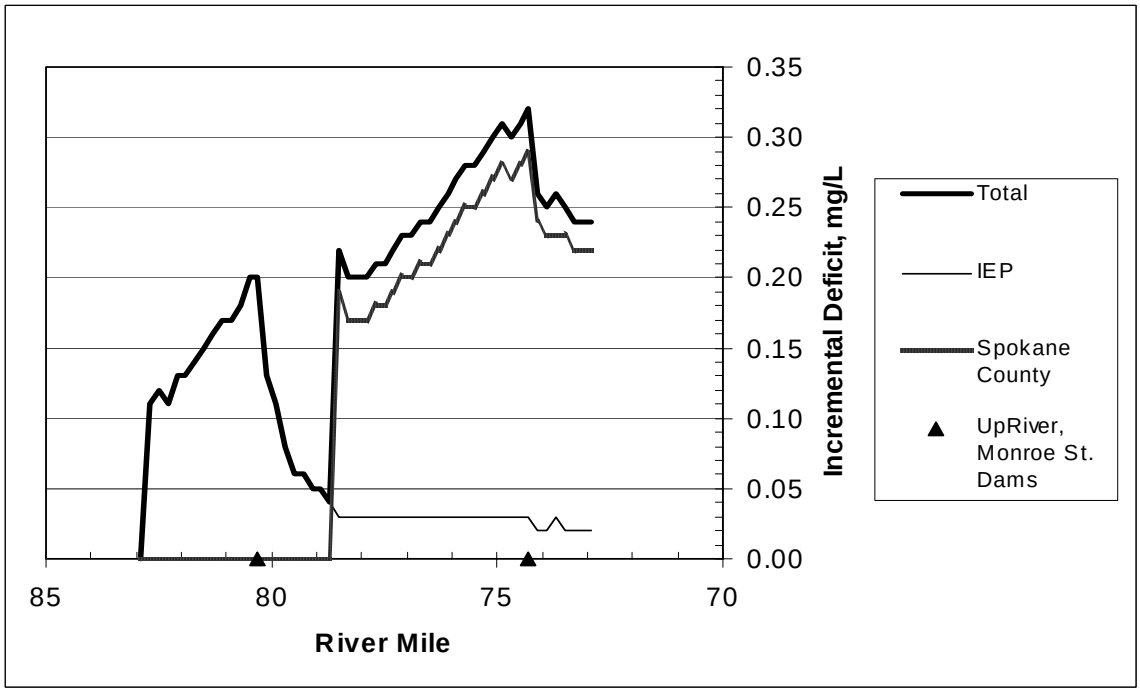


***Figure 4. Summer Incremental DO Deficits by River Mile Including Spokane County WWTP "High" Impact Scenario***

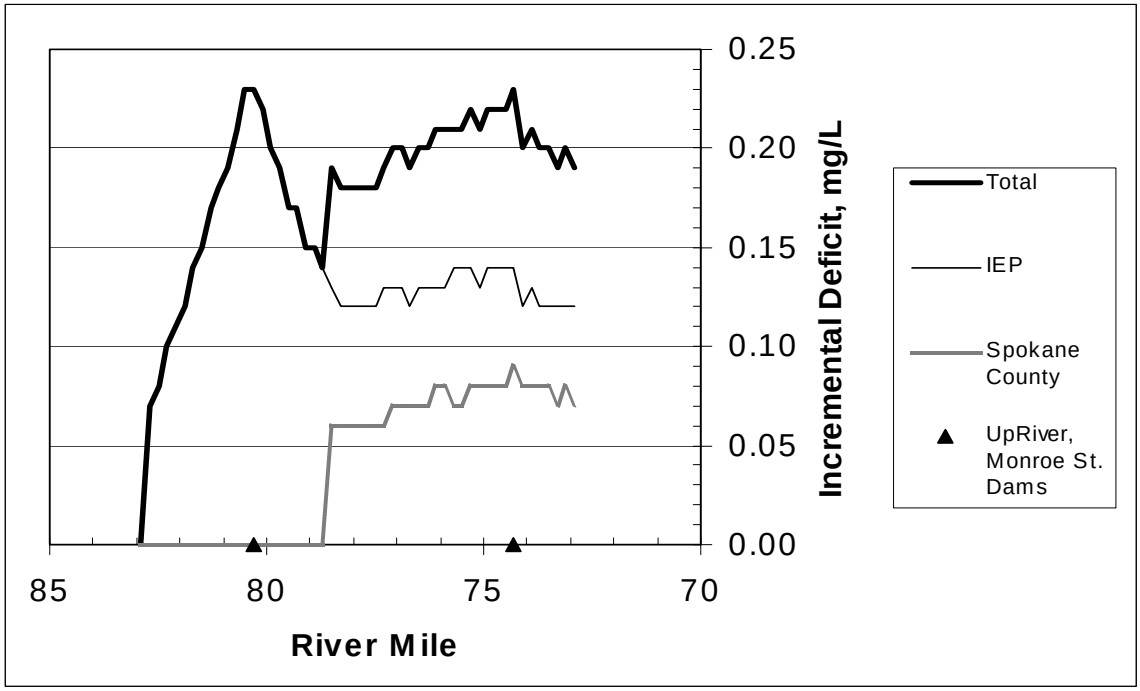


***Figure 5. Winter Incremental DO Deficits by River Mile Including Spokane County WWTP "Lowest" Impact Scenario***

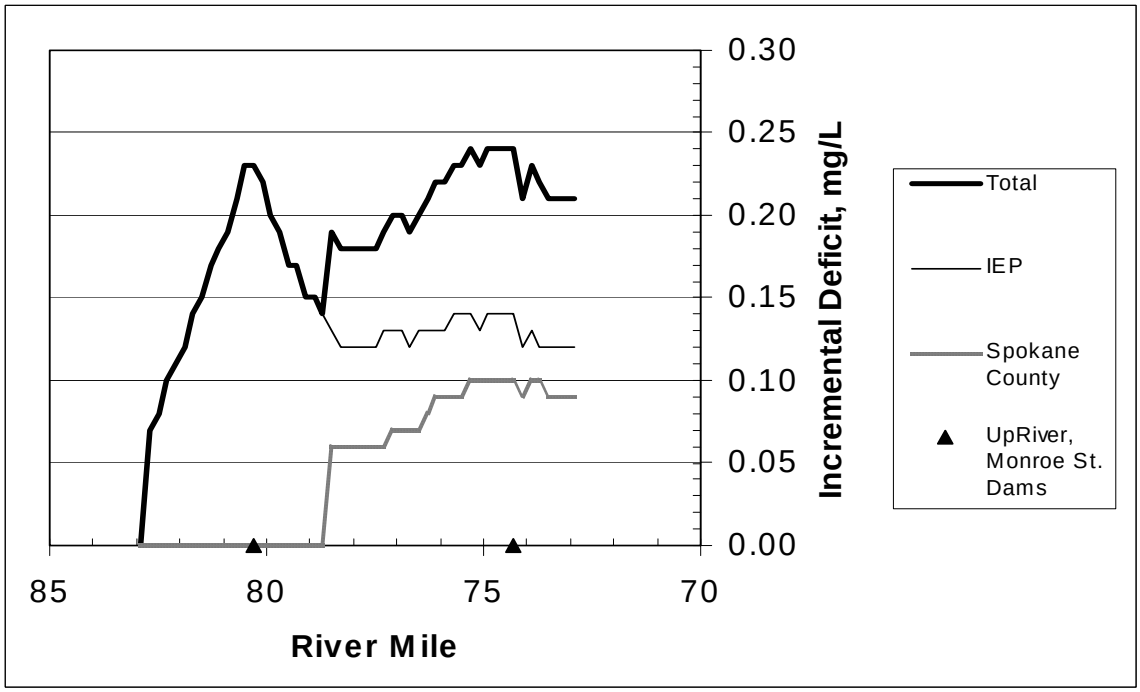


***Figure 6. Winter Incremental DO Deficits by River Mile Including Spokane County WWTP "Low" Impact Scenario***

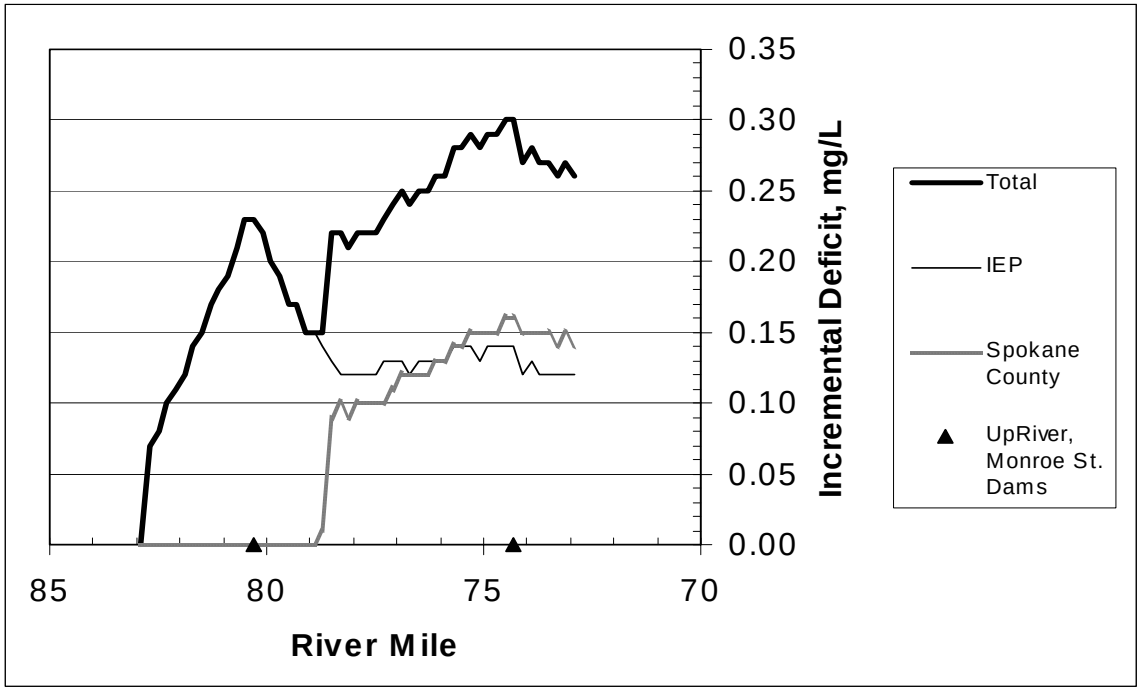


***Figure 7. Winter Incremental DO Deficits by River Mile Including Spokane County WWTP "Moderate" Impact Scenario***

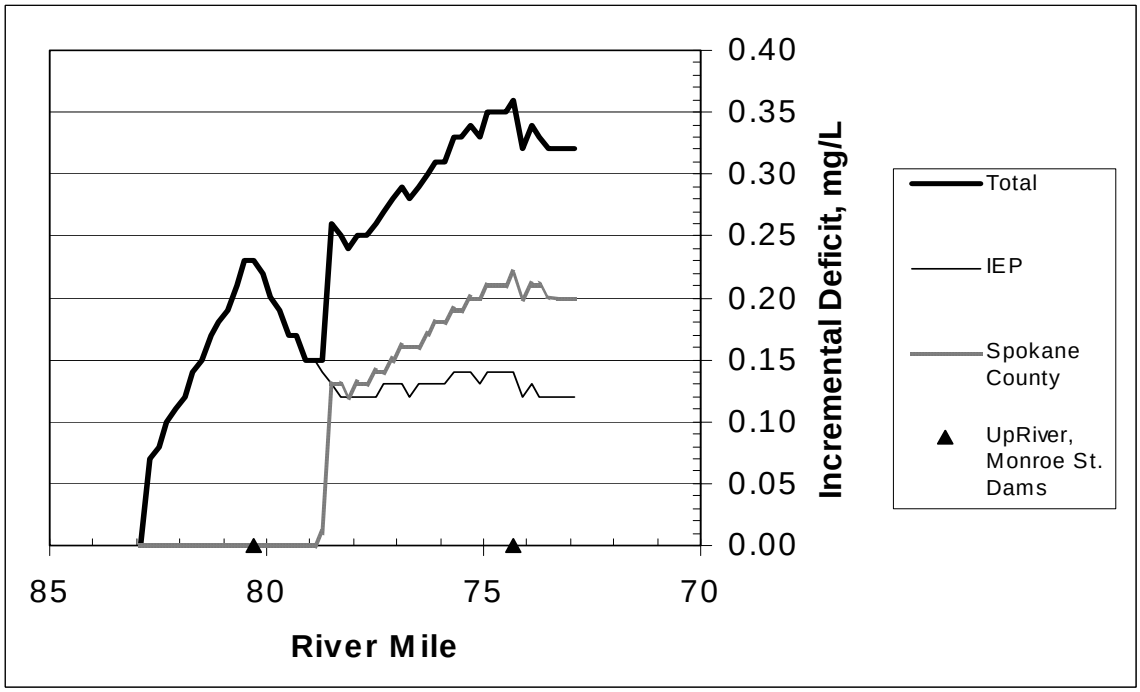


***Figure 8. Winter Incremental DO Deficits by River Mile Including Spokane County WWTP "High" Impact Scenario***

## CONCLUSIONS

There is little overlap between the impacts of the two effluents under summer conditions, as the incremental dissolved oxygen deficit caused by IEP is less than 0.05 mg/l at all locations downstream of the proposed Spokane County discharge. Winter conditions lead to substantial overlap – the IEP DO deficit is appreciable at and for some distance past the Spokane County WWTP effluent location (River Mile 78.5). Under summer conditions, the combined impact should meet the objective of a deficit of no more than 0.2 mg/L for all of the discharge scenarios where the Spokane County WWTP meets that objective. Under winter conditions, the available assimilative capacity for the Spokane County WWTP may be reduced by the effect of the IEP discharge. However, it is expected that absolute DO levels will be higher in the winter, generally exceeding the requirement of 8 mg/L. Thus winter effluent impacts may be less critical.

## REFERENCES

Brown, L. C. and Barnwell, T. O. “The Enhanced Stream Water Quality Models QUAL2E and QUAL2E-UNCAS: Documentation and User Manual”, EPA/600/3-87/007, May, 1987.

LTI. “Modeling of Dissolved Oxygen in the Spokane River in Response to Effluent from the Proposed Spokane County WWTP”, October, 2001.

Pelletier, G. "Waste Load Allocations for Biochemical Oxygen Demand for Inland Empire Paper Company", Washington State Department of Ecology, March, 1997.

Pelletier, G. J. “Dissolved Oxygen in the Spokane River Downstream from Inland Empire Paper Company with Recommendations for Waste Load Allocations for Biochemical Oxygen Demand”, Washington State Department of Ecology, September, 1994.