WASTE LOAD ALLOCATION STUDY
for
MOUNTAIN VIEW, ARKANSAS

September 1982

Report to:

Arkansas Department of Pollution
Control & Ecology
Little Rock, Arkansas

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SECTION I. INTRODUCTION

BACKGROUND

This report presents the results of a study conducted by Summerlin Associates Inc. (SAI) and Camp Dresser & McKee Inc. (CDM) to determine an acceptable waste load allocation (WLA) for the City of Mountain View's municipal wastewater treatment plant. This work was performed under contract to the Arkansas Department of Pollution Control and Ecology (ADPC&E) in accordance with provisions and requirements of the Region 6 office of the U.S. Environmental Protection Agency (EPA).

OVERALL STUDY SCOPE

The fundamental purpose of a waste load allocation study is to determine mathematically the level of treatment necessary for wastewaters discharged into surface water bodies in order for adopted water quality standards to be satisfied and maintained during the life of the treatment facility. Since enactment of the Federal Water Pollution Control Act of 1972 and its amendments and subsequent legislation (1977 Clean Water Act), WLA studies have been conducted nationwide, and wastewater treatment facilities have been designed and constructed accordingly.

Typically, emphasis for WLA studies by the Environmental Protection Agency and state water pollution control authorities has been placed on analyzing the larger dischargers most likely to significantly impact the quality of receiving waters, or on analyzing problems complicated by complex hydraulics, existing degraded water quality conditions or unique natural ecosystems. With the extreme increases, however, in capital and operation and maintenance costs during the past few years for wastewater treatment facilities, particularly for plants which provide effluent quality levels beyond that of conventional secondary treatment, the requirement for accurate WLA determinations has been broadened by the regulatory agencies to include all treatment facilities for which advanced levels of treatment are proposed, regardless of plant size or receiving water conditions. The City of Mountain

View is one of these smaller communities for which a WLA study has been required as part of EPA's 201 Construction Grants Facilities Planning Program.

The Region 6 office of EPA has established a set of guidelines for performance of WLA studies. Basically, for cities the size of Mountain View, the guidelines require the use of a mathematical computer model to simulate the water quality response of the stream, or stream system, into which the wastewater treatment plant effluent is discharged. The model must be calibrated to satisfactorily reproduce natural instream quality conditions using a minimum of one data set measured during the WLA study. To determine the WLA for a specific plant discharge, the calibrated model must be systematically operated for critical hydrologic, meteorologic and background pollutant loading conditions with varying and increasingly more stringent levels of treatment assumed for the plant effluent. The minimum level of treatment for which the simulated water quality results do not indicate violations of stream quality standards then is selected as the treatment requirement for the plant and is used in developing design effluent criteria. This basic procedure has been used in this study to determine an acceptable WLA for Mountain View.

PROJECT ORGANIZATION

For this study, Summerlin Associates Inc. of Little Rock, Arkansas, served as the prime contractor with the ADPC&E; Camp Dresser & McKee Inc. was a subcontractor to SAI. Mr. James C. Summerlin, President of SAI, was the designated project manager, and Dr. Robert J. Brandes, CDM Vice President, served as technical director for the work. Mr. Robert H. Seay coordinated the SAI effort, and CDM's work was supervised by Ms. S. Lynn Coles. All laboratory analyses of water quality samples were performed by the University of Arkansas at Little Rock under contract to SAI.

During the course of the study, SAI provided local coordination and liaison with the City and the ADPC&E and assisted with general data collection and compilation activities, as well as review and analysis of results. CDM performed the water quality modeling and waste load allocation assessment, including calibration of the receiving water quality model and operation of the model to evaluate water quality conditions under alternative wastewater treatment levels. The recommended treatment level and waste load allocation for the Mountain View plant was determined by SAI and CDM in collaboration with the ADPC&E, the City and the City's 201 facilities planning engineer.

SECTION II. PROJECT SETTING

STUDY AREA

The City of Mountain View, Arkansas, is the county seat of Stone County, located in the White River Basin planning area in north central Arkansas. The population of Mountain View is presently estimated to be approximately 2,100, with an average of 600 tourists per day visiting the area during the months of June through October. Mountain View is situated in an area that is dominated by moderately to steeply sloped terrain, with ground elevations ranging from 600 to 850 feet above mean sea level. The scenic views provided by this terrain, along with the abundant streams, enhance the area as one of the most popular in the state for hiking and camping. The surrounding terrain, characterized by wide valleys, is rural and used predominantly for livestock grazing and agricultural purposes.

The normal annual rainfall in the vicinity of Mountain View is approximately 49 inches, with March, April and May being the wettest months. August through October is the driest season, however, about ten inches of rainfall normally falls during this period.

A map of the study area is presented in Figure 1. The location of the receiving water streams with respect to the City of Mountain View, the proposed wastewater treatment plant outfall, and instream water quality sampling stations used in this study are identified in the figure.

The treated effluent from the City's existing wastewater treatment facility is discharged directly to Hughes Creek approximately 2,000 feet north of the State Highway 66 bridge crossing. Flow is directed from Hughes Creek northwest to Lick Fork (approximately 2.1 miles), north to South Sylamore Creek (approximately 2.5 miles), and thence to the White River (approximately 8.9 miles). These streams are listed in Segment 4G of the White River Basin Water Quality Management Plan.

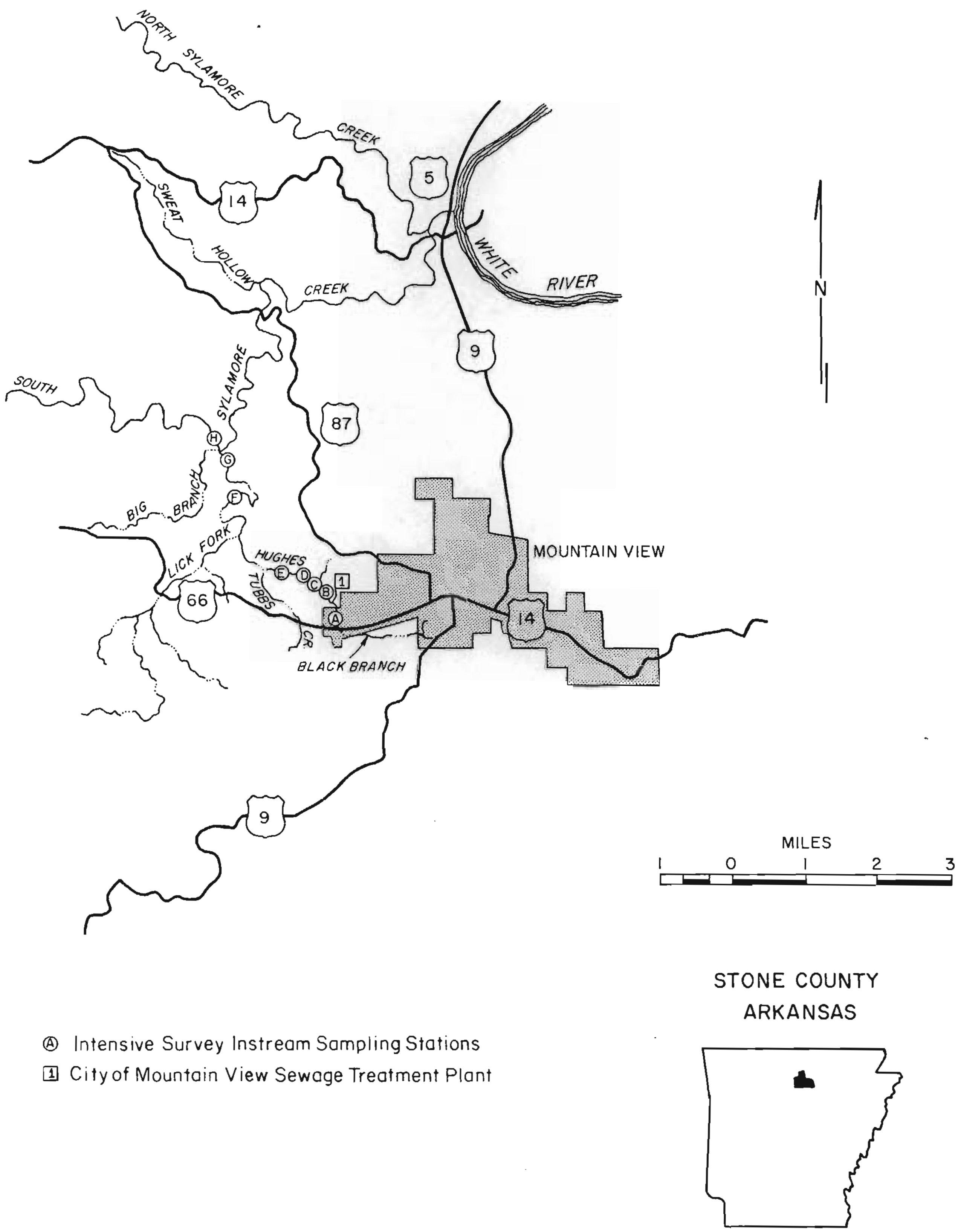

Figure 1

MAP OF STUDY AREA

Within the study area, Hughes Creek is a small, spring fed, scenic stream. Its waters flow over exposed carbonate rock throughout most of this area. Flow in Hughes Creek is intermittent, with effluent from the City's wastewater treatment plant comprising the majority of the flow during periods of low runoff. Under normal flow conditions, flow in Hughes Creek has been observed to completely disappear into the substrata approximately a mile downstream of the outfall from the treatment plant.

Lick Fork and Tubbs Creek (a tributary to Hughes Creek in the study area) are also steep, rocky streams which, like Hughes Creek, flow intermittently during the summer months. South Sylamore Creek runs generally less than six inches deep during the summer months. The water is clear, and swimming in the several deep holes along the reach from Lick Fork to the White River is a popular form of recreation in the area. The White River is a cool-water stream fed by releases from Bull Shoals and Norfork Lakes. Fishing for trout and other game species in the river is a popular sport.

WATER QUALITY STANDARDS

The White River and its tributaries from Bull Shoals Dam to Lock & Dam #3, the segment which includes the study area, have been assigned Use Class "A" and Fishery Class "T" by the ADPC&E. South Sylamore Creek (to which Lick Fork and Hughes Creek are tributaries) and its tributaries have been assigned Use Class "A" and Fishery Class "S" by the ADPC&E. Usage Class "A" is defined as being "suitable for primary contact recreation, propagation of desirable species of fish, wildlife and other aquatic life, raw water source for public water supplies, and other compatible uses". The Fishery Classes "T" and "S" indicate that the water is suitable for a trout fishery and a smallmouth bass fishery, respectively. The numerical water quality standards for South Sylamore Creek (which also apply to Lick Fork and Hughes Creek) are listed in the following table.

Parameter	Criteria
Dissolved Oxygen	Minimum 6.0 mg/L*
Temperature	Maximum of 86°F
Total Phosphorus	Maximum of 0.10 mg/L
pH	Range 6.0 - 9.0
Fecal Coliform Bacteria (April 1 to September 30)	Log mean not to exceed 200/100 ml
Fecal Coliform Bacteria (October 1 to March 31)	Log mean not to exceed 1000/100 ml
Chlorides**	Maximum of 20 mg/L
Sulfates**	Maximum of 20 mg/L
Total Dissolved Solids**	Maximum of 180 mg/L

* A non-nuisance level of 1.0 mg/L for dissolved oxygen has been suggested by ADPC&E and approved by EPA for those streams having been granted a formal intermittent stream status. Assuming that this regulation is adopted by the ADPC&E as part of the new Arkansas Water Quality Standards and that Lick Fork and Hughes Creek (tributaries to the South Sylamore Creek) are formally designated intermittent streams, then the revised DO standard for Lick Fork and Hughes Creek would be 1.0 mg/L. Until the intermittent status is officially granted, however, the DO standard for South Sylamore Creek, Lick Fork and Hughes Creek is 6.0 mg/L.

** These numerical criteria are for the White River (Bull Shoals to L&D #3) and its tributaries since there are none specifically for South Sylamore Creek.

These standards apply at all times except when stream flows are less than the 7-day minimum average flow with a recurrence interval of ten years (or a 10% probability of occurring in any one year) for the existing hydrological conditions. The criterion for dissolved oxygen represents the minimum allowable concentration at the critical deficit point of the dissolved oxygen profile. The temperature standard is the maximum allowable level for smallmouth bass fisheries. According to the ADPC&E standards for temperature, "during any month of the year, heat shall not be added to any stream in excess of the amount that will elevate the temperature of the water more than 5°F, based upon the monthly average of the maximum daily temperatures as measured at mid-depth or five feet, whichever is less". The total phosphorus criterion represents the concentration that is not to be exceeded as a result of municipal, industrial, agricultural, or other waste discharges. The allowable range for pH should not be violated due to wastes discharged to receiving waters, nor should the pH in the stream fluctuate in excess of 1.0

pH unit over a period of 24 hours. The fecal coliform criteria are consistent with the Arkansas State Board of Health rules and regulations pertaining to the water uses. For Use Class "A", the fecal coliform content between April 1 and September 30 should not exceed a geometric mean of 200/100 ml based on a minimum of not less than five samples taken over a period of not more than 30 days, nor should more than 10 percent of total samples during any 30-day period exceed 400/100 ml. For the remainder of the calendar year, Class A waters shall have the same protection as Class B waters (i.e. the fecal coliform content shall not exceed a geometric mean of 1000/100 ml, nor equal or exceed 2000/100 ml in more than 10 percent of the samples taken in any 30-day period). Water quality criteria for chlorides, sulfates and total dissolved solids represent concentrations not to be exceeded in more than one in ten samples.

EXISTING TREATMENT FACILITIES

The existing treatment facilities were constructed in 1968 and have been operated by the City of Mountain View. The system consists of a bar screen, a comminutor, a parshall flume, a primary clarifier, a trickling filter, a final clarifier, an effluent chlorination system, an anaerobic sludge digester, and sludge drying beds. The plant has performed well in dry weather periods, but has been hydraulically overloaded from excessive infiltration/inflow during wet weather periods. The average flow through the plant during 1980 was 0.45 MGD (0.70 cfs) with an average effluent 5-day biochemical oxygen demand (BOD_5) of 12 mg/L and an average effluent total suspended solids concentration (TSS) of 10 mg/L. The City of Mountain View is presently permitted (NPDES #AR0020117; Arkansas #695 W) to discharge an average flow of 0.5 MGD (0.77 cfs) with 30-day average effluent quality limits of 35 mg/L of BOD_5 and 35 mg/L of TSS.

PROPOSED PROJECT

The proposed project involves the renovation and expansion of the existing wastewater treatment facility and the rehabilitation of portions of the wastewater collection facilities in the City of Mountain View. Phase 1 of the expansion is designed to treat the City's wastewater for approximately 10 years and consists of the addition of an equalization basin with aerator, a 10" inverted siphon to the influent line, continuous backwash filters, and renovation of the existing plant equipment. There will be no increase in the existing design capacity of the plant, 0.5 MGD (0.77 cfs), as a result of the Phase 1 improvements.

Phase 2 is to include the addition of three rotating biological contactors, a final clarifier, and a recycle pump station to the existing plant. These improvements will result in an increase in the average overall capacity of the treatment facility to 0.729 MGD (1.13 cfs). The average dry weather flow capacity of the new plant will be 0.579 MGD (0.90 cfs).

Both phases of the plant are being designed to meet advanced secondary treatment levels of 10 mg/L of 5-day biochemical oxygen demand (BOD_5) and 15 mg/L of total suspended solids (TSS).

EXISTING WATER QUALITY

Being small intermittent streams, Hughes Creek and Lick Fork are not classified for water quality purposes in the White River Basin Water Quality Management Plan. No data have been collected on these streams to characterize historical water quality conditions. A reconnaissance survey of the streams in the study area was conducted by SAI and CDM in August, 1981, and no continuous flow in the streams was observed. Intermittent pools were subject to pollution from local point sources such as the existing Mountain View wastewater treatment plant and from nonpoint sources such as cattle and farming operations. The observed water quality ranged from poor to good.

South Sylamore Creek is a clear shallow stream of high water quality used for fishing and swimming. It is listed in the White River Basin Water Quality Management Plan as effluent quality limited with a target wasteload of 54 lbs/day of BOD_5. The White River at Sylamore is a good quality fishing stream with water temperatures normally less than 27°C year around (highest recorded temperature since 1966 was 30.5°C - USGS Gage No. 07060660).

No current data are available indicating water quality in South Sylamore Creek. In 1972, the ADPC&E monitored South Sylamore Creek near Blanchard Springs (about five miles downstream of the Lick Fork confluence), and these data are shown in Table 1. Generally, these data indicate good water quality.

The nearest point to Mountain View on the White River that is monitored for water quality is near Norfork, Arkansas, some 30 to 40 miles upstream of the South Sylamore Creek confluence. Table 2 presents water quality data collected during 1977 and 1978 at this site.

Table 1

Water Quality of South Sylamore Creek Near Blanchard Springs*

Parameters	8/17/72	8/18/72	8/19/72	8/20/72
Temp. °C	26.0	26.5	26.0	-
Turbidity, JTU	25.0	25.0	25.0	25.0
Color, Cobalt Units	5.0	5.0	5.0	5.0
Conductivity (umhos)	294.0	277.0	277.0	277.0
DO (mg/L)	8.2	8.2	7.8	11.1
BOD (mg/L)	1.7	1.0	1.5	2.0
pH	6.4	6.2	7.1	7.0
TDS (mg/L)	101.0	141.0	138.0	194.0
TSS (mg/L)	0	0	8.0	6.0

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*Analysis completed by the Arkansas Department of Pollution Control and Ecology.

Table 2

Water Quality of White River Near Norfork*

Parameters	1/24/78	9/08/77
Temperature, °C	13	13
Turbidity, JTU	34	4
Color, Cobalt Units	11	6
Conductivity, micromhos	273	238
DO, mg/L	10.35	9.88
BOD, mg/L	1.35	0.87
pH	8.1	8.0
Dissolved Solids, mg/L	162	141
Suspended Solids, mg/L	52	6
Ammonia Nitrogen, mg/L	0.12	0.08
Nitrite Nitrogen, mg/L	0.01	0.05

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*Analysis completed by the Arkansas Department of Pollution Control and Ecology.

SECTION III. WATER QUALITY SURVEY

INTRODUCTION

As previously mentioned, the EPA Region 6 office has established guidelines and criteria for conducting waste load allocation studies. Basically, the level of detail required in a WLA study for a particular community is dependent upon the projected effluent flow rate of the wastewater treatment facility. For Mountain View, with an average discharge of 0.579 MGD projected for the new plant, a Level B study is required according to the EPA criteria. A Level B study involves the application of a stream water quality model that has been calibrated using one set of water quality data.

To obtain the data set necessary for calibrating a water quality model of Mountain View's STP effluent receiving water system, an intensive data collection survey was conducted during October 7-8, 1981. The following sections describe the general conditions of the study area at the time of the data collection survey, the location of the sampling stations and the sampling techniques used, and a qualitative discussion of the survey results is presented.

STUDY AREA CONDITIONS

The study area included in the survey was primarily a segment of Hughes Creek in Stone County west of the City of Mountain View. This segment extended from a point on Hughes Creek immediately upstream of the City's wastewater treatment plant outfall to a point approximately 1.1 miles downstream. It is at this downstream point, under low flow conditions, that surface flows in Hughes Creek have been observed to be diminished due to instream seepage losses.

Additional sampling was conducted downstream in stagnant pools and flowing reaches of Lick Fork, as well as, in South Sylamore Creek. These measurements were made to provide a basis for assessing the significance of any downstream water quality impacts resulting from the City of Mountain View's STP discharge.

Normal flow conditions existed during the survey period. No rain occurred during the survey, skies were partly cloudy to cloudy, and daytime temperatures ranged from 40° to 70°C.

SAMPLING STATION LOCATIONS

The survey was conducted at sampling stations located on Hughes Creek, Lick Fork and South Sylamore Creek, and at one point source discharge (Mountain View's sewage treatment plant effluent). The stations are identified in Figure 1. Table 3 provides descriptions of the sampling stations.

SAMPLING TECHNIQUES

Table 4 lists the water quality parameters which were measured at each sampling station during the intensive field data collection survey. In summary, in situ dissolved oxygen, temperature, pH, and specific conductivity measurements were made once every 3-4 hours at each station. Additionally, alkalinity was measured at each sampling station once during the day (at midday) and chlorine was measured in the sewage treatment plant effluent and at all instream stations where a chlorine residual was exhibited. At selected stations (Sta. 1,B,&E), grab samples and a composite sample were collected four times during the survey so that diurnal variations could be adequately described. At all other stations (Sta. A,C,D,F,G,&H), only time composite samples were collected.

All the tributaries (Tubbs Creek and Lick Fork headwaters) were dry at the time the intensive survey was conducted, and therefore, no samples were collected. A spring flowing into Hughes Creek near the headwater station (Sta. A), however, was grab sampled.

All in-situ measurements and all sample collection, preservation, and laboratory analyses were conducted in accordance with the EPA Region 6 approved methods and procedures.

Table 3

Intensive Survey Sampling Stations

Station Identification	Location	River Mile*
A	Hughes Creek immediately upstream of Mountain View STP outfall	1.80
1	City of Mountain View STP Effluent	1.78
B	Hughes Creek at end of pool below STP outfall	1.76
C	Hughes Creek on private property	1.60
D	Hughes Creek on private property	1.10
E	Hughes Creek on private property	0.77
F	Lick Fork on private property	1.60
G	Lick Fork immediately above confluence with South Sylamore Creek	0.02
H	South Sylamore Creek immediately upstream of Lick Fork inflow	9.17

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*Measured upstream from mouth of identified streams.

Table 4

Parameters Measured During Intensive Survey

Parameters	Mountain View STP Effluent	Receiving Stream Stations
Dissolved Oxygen*	x	x
Temperature*	x	x
BOD, 1 day	x	
3 day	x	
5 day	x	x
10 day	x	
20 day	x	
Total Kjeldahl Nitrogen	x	x
Ammonia Nitrogen	x	x
Nitrite Nitrogen	x	x
Nitrate Nitrogen	x	x
Total Phosphorus	x	x
Ortho Phosphorus	x	x
Suspended Solids	x	x
Fecal Coliform	x	x
pH*	x	x
Chlorophyll _a_		x
Conductivity*	x	x
Chlorides	x	x
Sulfates	x	x
Alkalinity*	x	x
Flow*	x	x
Total Dissolved Solids	x	x

Notes: 1. Number of samples taken during 24-hour period for each station category were as follows:

° STP Effluent - One time composite sample; two grab samples, predawn and evening

° Receiving Stream - DO and temperature were measured a minimum of once every four hours, and grab samples accompanied composite samples at selected instream stations.

2. Time series BOD analyses were performed using laboratory dilution water, with nitrification suppression, on samples from the City's STP effluent and from selected receiving stream stations; all other BOD analyses were performed using composite samples.

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* These parameters were measured in the field; all other parameters were analyzed in the laboratory.

FLOW MEASUREMENTS

Flow measurements were made once during the intensive survey in the main stream channel of Hughes Creek at Stations A,B,C,D and E and at one point on South Sylamore Creek (Station H). The average flow entering the Mountain View STP on the day of the intensive survey was estimated from the rating curve for the parshall flume at the plant site.

Flows were determined based on measured cross-sectional areas and average velocities. Upon selection of a suitable (free of obstructions, uniform streambed, and laminar flow) site at each station to determine streamflow, the surface width of the stream was measured and then divided into subsections of equal width. Using a pygmy current meter, the velocity at the mid-point of each subsection was measured at 0.6-depth for total water depths less than 70 cm and at 0.2- and 0.8-depth for total water depths greater than 70 cm. The flow through each subsection was then calculated according to the continuity equation, i.e. $Q = AV$, where Q = flow, A = cross-sectional area, and V = velocity. Finally, the total streamflow was determined as the sum of flows through the individual subsections.

A time-of-travel dye study was conducted on Hughes Creek immediately downstream of the STP discharge point to determine specific stream reach velocities in the area where it was anticipated that the dissolved oxygen sag resulting from the proposed wastewater discharge would occur. The time-of-travel studies were performed in accordance with the methodologies described in Book 3, Applications of Hydraulics; Chapter A9, Measurement of Time of Travel and Dispersion by Dye Tracing in Technologies of Water Resources Investigations of the United States Geological Survey. The time-of-travel measurements of peak dye concentrations downstream of a slug release, together with the distance between dye monitoring stations, were used to determine velocities through specific stream reaches. Using these average velocities and the flows and widths measured (as described previously), average depths for the reaches were then calculated.

These stream flows, average velocities, and average depths were used to determine model hydraulics, as is described in a later section of this report. The hydraulic measurements and the time-of-travel results for the intensive survey are summarized in Appendix A.

SURVEY WATER QUALITY RESULTS

From the survey results, the background quality of Hughes Creek, as measured at the control station (Sta. A) upstream from the Mountain View wastewater treatment plant discharge, can be characterized by low levels of nutrients, oxygen demanding materials, fecal coliform bacteria, and salt content (chlorides and sulfates). Dissolved oxygen levels at Station A remained above 5 mg/L throughout the diurnal sampling period and the range (2.8 mg/L) between minimum and maximum values indicated stable background conditions.

The effluent quality of the Mountain View STP was excellent ($BOD_5 \leq 7.1$ mg/L; TSS $\leq$ 6.0 mg/L, NH_3-N $\leq$ 2.81 mg/L, DO $\geq$ 5.2 mg/L). The effluent did contain elevated levels of nutrient compounds (ortho-phosphorus $\geq$ 2.4 mg/L; nitrate nitrogen $\geq$ 4.55 mg/L). The presence of significant nitrate nitrogen levels in the effluent suggests that nitrification is occurring prior to discharge.

The introduction of the City of Mountain View's treated sewage effluent directly to Hughes Creek had noticeable effects on various water quality parameters downstream of the discharge point. Dissolved oxygen levels were severely depressed at Station C, ranging from 2.1 to 3.9 mg/L throughout the diurnal sampling period.

The nutrient compounds discharged with the STP effluent appeared to have caused growth and proliferation of algae in Hughes Creek. Although planktonic algal populations were not abundant (low chlorophyll a levels), dense growths of attached filamentous and benthic algae were observed throughout the stream channel in the study area. The resulting metabolism of these algae was a likely cause of the relatively wide fluctuations in dissolved oxygen levels observed at Stations D and G (3.3 mg/L and 6.9 mg/L, respectively).

Elevated levels of BOD_5 (9.4 mg/L), TSS (31.6 mg/L), and ammonia nitrogen (1.38 mg/L) were observed at Station F, a stagnant pool with no inflow or outflow on Lick Fork well downstream of the apparent DO recovery zone resulting from the City's STP discharge. These conditions were probably due to the presence of livestock in the area.

A violation of the DO standard (measured DO of 4.0 mg/L versus standard of 6.0 mg/L) was observed at Station H on South Sylamore Creek above the confluence with Lick Fork. The cause is unknown at this time; however, it cannot be attributed to the Mountain View wastewater treatment plant effluent since the observed DO violation occurred upstream of the point where the flow from Lick Fork enters South Sylamore Creek.

The data collected during the October 7-8, 1981, intensive survey are summarized in Appendix A.

SECTION IV. WATER QUALITY MODELING

INTRODUCTION

As stated previously, the determination of an acceptable waste load allocation for a specific point source discharge involves modeling receiving water quality for a range of alternative wastewater treatment levels. Although this modeling exercise may address a number of different water quality parameters, it generally is focused on dissolved oxygen because of the importance of oxygen as a life sustaining constituent for aquatic organisms and because the dissolved oxygen concentration in a stream can be significantly reduced by organic wastewater loadings.

The mathematical simulation of dissolved oxygen levels in a natural stream basically involves an organized accounting of the major sources and sinks of oxygen in a system composed of a number of complex interacting subsystems (reaches), each with its own set of physical characteristics. The primary sources of oxygen are: 1) dissolved oxygen in headwaters, incremental runoff, and point sources, and 2) atmospheric reaeration. In some cases, the action of algae, through photosynthesis, also will add significant amounts of oxygen to water. The primary sinks for oxygen are: 1) carbonaceous oxidation of organic materials, 2) nitrogenous oxidation of organic materials, 3) benthic demands, and 4) biological respiration.

MODEL DESCRIPTION

The steady-state model used for purposes of simulating water quality in the stream segments impacted by the City of Mountain View's wastewater treatment plant effluent was the QUAL-TX model, the Texas Department of Water Resources' updated version of QUAL-II. The QUAL-TX model was chosen because of its ability to rapidly predict water quality profiles in an advective and dispersive system and because its precursor, QUAL-II, is well-known and widely used for water quality planning purposes. The QUAL-II model was originally developed by members of CDM's present staff.

QUAL-TX uses a set of interrelated differential mass transport equations which are numerically integrated over time and space for each water quality constituent simulated, using an implicit finite-difference technique under the assumption that transport occurs along the longitudinal axis of the stream channel. These equations describe the effects of advection, dispersion, dilution, constituent reactions and interactions, and external sources and sinks for all water quality constituents modeled.

QUAL-TX is a comprehensive and versatile stream water quality model which can simulate up to 12 water quality constituents in any combination desired by the user. Constituents which can be simulated are:

Dissolved Oxygen
Biochemical Oxygen Demand
Temperature
Algae as Chlorophyll a
Ammonia as N
Nitrites as N
Nitrates as N
Ortho Phosphorus as P
Coliform Bacteria
One Arbitrary Nonconservative Constituent
Two Arbitrary Conservative Constituents

QUAL-TX includes the major components of the nitrogen and phosphorus nutrient cycles, algal photosynthesis and respiration, benthic oxygen demand, oxygen uptake due to carbonaceous biodegradation, and atmospheric reaeration. Figure 2 illustrates the conceptualization of these interactions. It should be noted that the arrows on the figure indicate the direction of normal system progression in a moderately polluted environment; the directions may be reversed in some circumstances for some constituents. For example, under conditions of oxygen supersaturation, which could occur during periods of high algal activity, oxygen might be driven from solution, opposite to the indicated direction of the flow path.

Coliform bacteria and the arbitrary nonconservative constituent are modeled as nonconservative decaying constituents, and do not interact with other constituents. First order kinetics are used to describe the decaying process. The conservative constituents, of course, neither decay nor interact in any way with other constituents.

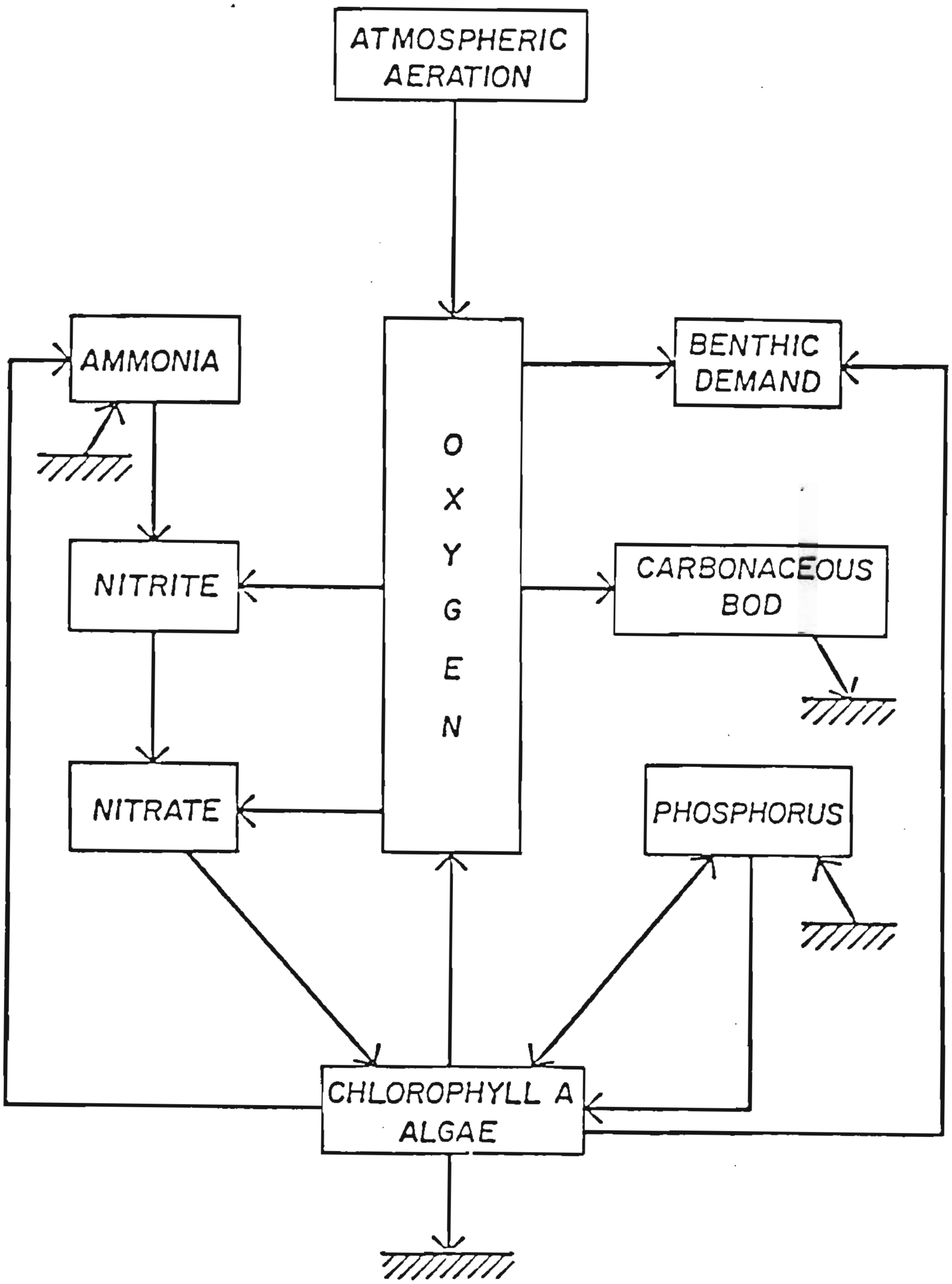


Figure 2
MAJOR CONSTITUENT INTERACTIONS IN QUAL-TX MODEL

The QUAL-TX model is applicable to dendritic streams which are well mixed. It assumes that the major transport mechanisms, advection and dispersion, are significant only along the main direction of flow (longitudinal axis of the stream). It allows for multiple waste discharges, withdrawals, tributary flows, and incremental inflow. It also has the capability to compute required dilution flows for flow augmentation to meet any prespecified dissolved oxygen level.

Hydraulically, QUAL-TX is limited to the simulation of time periods during which the stream flows are essentially constant. Input waste loads must also be held constant over time.

QUAL-TX permits any branching, one-dimensional stream system to be simulated. The first step involved in approximating the prototype is to subdivide the stream system into reaches of constant hydraulic and physical characteristics. Generally, reaches are established according to changes in channel cross-sectional areas, depth, width, velocity, stream slope or roughness. Inflow from tributaries or wastewater discharges also may require that additional reaches be identified. Spatial variation of reaction rates and coefficients such as benthal demand rates or photosynthesis and respiration parameters may also require additional segmentation. Each reach is divided into individual computational elements of equal length within reaches.

Figure 3 shows a stream reach "n" which has been subdivided into a number of subreaches or "computational elements" each of length Δx. For each of these computational elements, the hydraulic balance shown can be written in terms of flows into the upstream face of the element (Q_{i-1}), external sources or withdrawals (Q_{xi}), and the outflow (Q_i) through the downstream face of the element. Similarly, a materials balance for any constituent "C" can be written for the element. In the materials balance, both transport ($Q \cdot C$) and dispersion ($A \frac{DL}{\Delta x} \frac{\partial C}{\partial x}$) are considered as the movers of mass along the stream axis. Mass can be added to the system via wasteloads ($Q_x C_x$) and added or removed via internal sources or sinks (S_i) such as benthic sources and biological transformations.

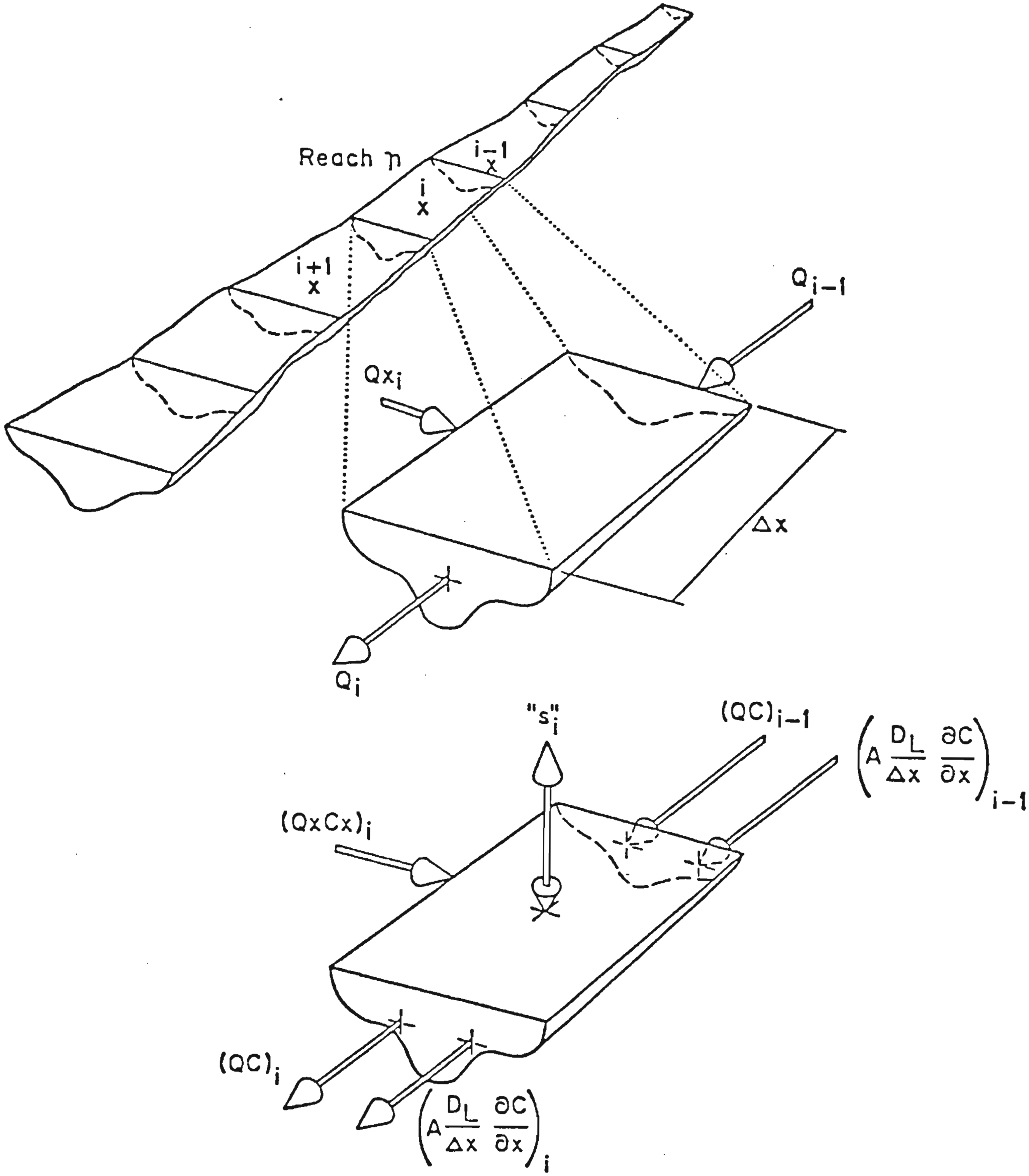


Figure 3
QUAL-TX DISCRETIZED STREAM SYSTEM

In total, there are seven different types of computational elements that can be specified to describe prototype conditions. These are:

1. Headwater element
2. Standard element
3. Element just upstream from a junction
4. Junction element
5. Last element in system
6. Input element
7. Withdrawal element

Headwater elements begin every tributary as well as the main river system, and as such, they are always the first element in a reach. A standard element is one that does not qualify as one of the other six element types. Since incremental inflow is permitted in all element types, the only input permitted in a standard element is incremental inflow or outflow. A Type 3 element is used to designate an element on the mainstem that is just upstream from a junction element (Type 4), which is an element that has a simulated tributary entering it. Element Type 5 identifies the most downstream computational element in the river system; there is only one Type 5 element in a given model segmentation network. Element Types 6 & 7 represent elements which have inputs (waste loads and unsimulated tributaries) and water withdrawals, respectively. River reaches, which are aggregates of computational elements, are the basis of most data input. Hydraulic coefficients and exponents, reaction rate coefficients, initial conditions, and incremental runoff data are constant for all computational elements within a reach.

A segmentation network comprised of computational elements and reaches was developed for the stream segments impacted by the Mountain View wastewater treatment plant effluent as observed during the intensive data collection survey. The reach network adopted is illustrated in Figure 4. Points of potential tributary inflow to the system and the City's STP outfall are indicated at their respective locations. In the model, the six reaches were subdivided into 29 elements for computational purposes.

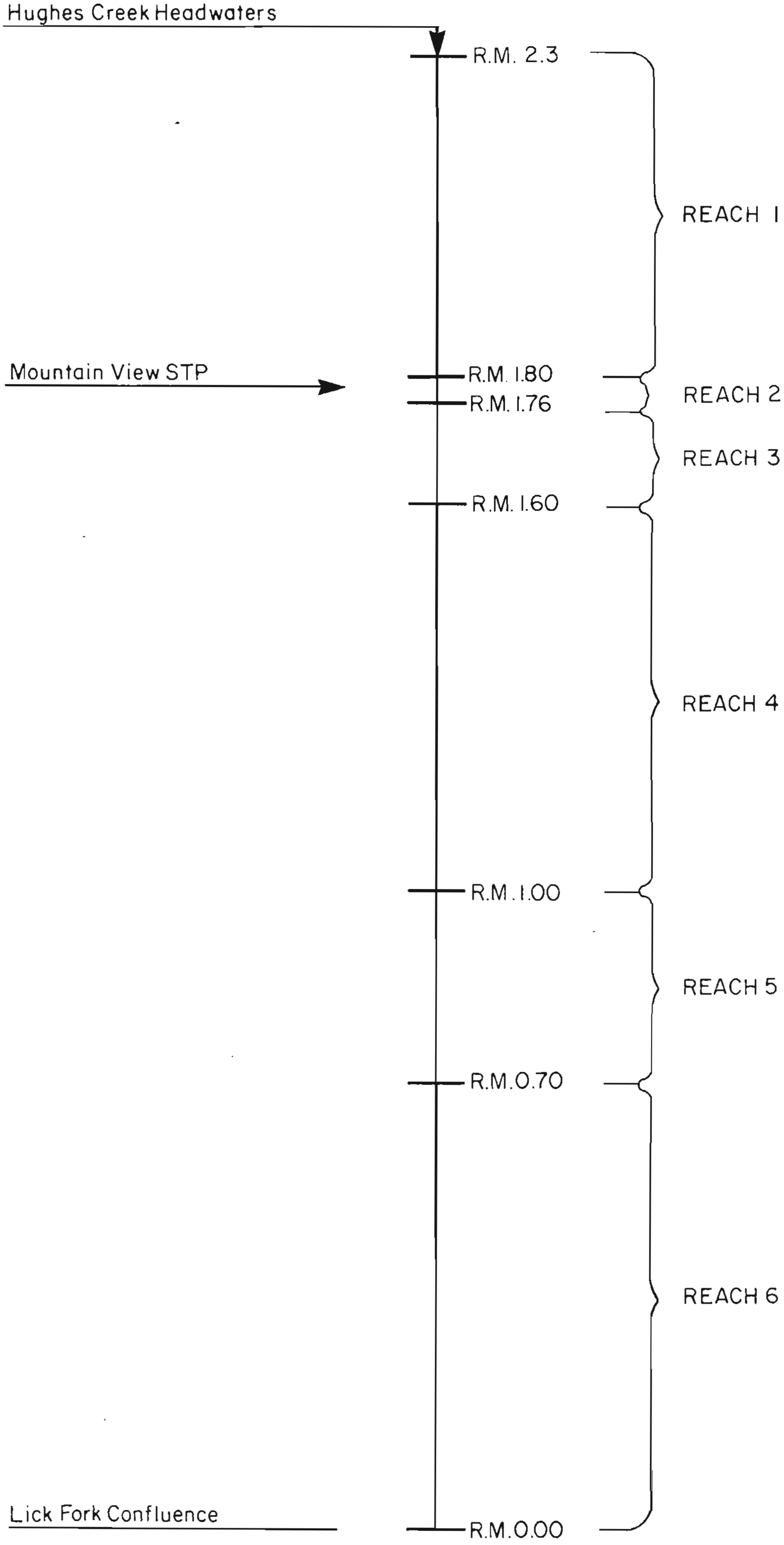


Figure 4

SEGMENTATION REACH NETWORK USED IN MODEL CALIBRATION

GENERAL WLA PROCEDURE

Utilizing the results of the background information inventory and the intensive data collection survey, the QUAL-TX model was applied to the receiving water system and was calibrated using field data. It was then appropriately operated to determine the waste assimilative capacity of the receiving water system. This modeling effort consisted of the following steps:

1. Determine Rate Coefficients
2. Calibrate QUAL-TX Model
3. Develop WLA Model Inputs
4. Operate Model for Alternative Treatment Levels
5. Perform Sensitivity Analysis

These steps are described in more detail in the following sections.

Determine Rate Coefficients

Utilization of the QUAL-TX stream quality model required determination of the following coefficients and rates for the several reaches defined to describe the receiving water system:

- Reaeration rates
- BOD oxidation rates
- BOD sedimentation rates
- BOD removal rates
- Nitrification rates
- Benthal oxygen demand rates
- Net algal productivity rates

These coefficients were determined utilizing EPA Region 6 approved techniques which are described in more detail in a later section of this report. BOD oxidation, sedimentation and removal rates and nitrification rates were determined from measurements made during the field survey. Atmospheric reaeration rates were calculated based on a procedure developed by the Texas

Department of Water Resources specifically for streams similar to those in the study area. An attempt to measure benthal oxygen demand rates was made using the ADPC&E benthal respirometer, however, in most cases, either the stream was too shallow or a good bottom seal could not be maintained due to the rocky streambed characteristics for the respirometer to be used effectively. As a result, benthal oxygen demand rates were initially estimated based on typical ranges presented in the literature, and then were adjusted in accordance with calibrated results.

Calibrate QUAL-TX Model

The data collected during and developed as a result of the 24-hour intensive survey were used to debug and calibrate the QUAL-TX water quality model of the receiving water system. In the calibration process, simulated values of dissolved oxygen, BOD, ammonia nitrogen, ortho phosphorus, and chlorides were evaluated in terms of measured values. Longitudinal profiles for these parameters were used to evaluate the simulation accuracy of the model.

Develop WLA Model Inputs

The QUAL-TX model input data for the waste load allocation simulations included critical background conditions (low flow, water temperature, headwater quality, etc.), the complete effluent characteristics (flow rate, temperature, DO, BOD, NH_3, NO_3, etc.) for the proposed plant, and the complete water quality and flow rates for other point source discharges, incremental inflows, and tributary loadings. These inputs were compiled from existing historical records or were based on "typical" values considered likely to occur during periods of low streamflow under conditions similar to those of the study area.

Operate Model for Alternative Treatment Levels

The calibrated QUAL-TX model for the study area was used to project the water quality impacts of the proposed treatment plant discharge for various treatment levels and critical stream conditions (low streamflows, warm water temperatures, etc.). The alternative treatment levels that were evaluated included secondary treatment ($BOD_5/TSS/NH_3$-N/DO = 30/30/10/5), advanced secondary treatment without effluent aeration ($BOD_5/TSS/NH_3$-N/DO = 10/15/10/5), advanced secondary treatment with effluent aeration ($BOD_5/TSS/NH_3$-N/DO = 10/15/10/6) and advanced waste treatment (AWT; $BOD_5/TSS/NH_3$-N/DO = 10/15/2/5 and $BOD_5/TSS/NH_3$-N/DO = 5/5/2/5). Coefficients and rates were changed for the alternatives modeling in accordance with the effluent quality produced by the various treatment levels (e.g. higher carbonaceous deoxygenation, nitrogenous decay and benthal demand rates were assumed for the secondary treatment level than were for the AST & AWT levels). Literature sources and experience performing similar investigations were used as the basis for changes in the rates and coefficients.

Perform Sensitivity Analysis

As described above, the WLA results are dependent upon the hydraulics, reaction rates and coefficients, and waste loads which are input to the model. It is useful to determine the sensitivity of the model to changes in these input values. In a sensitivity analysis, all but one parameter are held constant and the remaining parameter is varied ± 20% (or ± 2°C for temperature) about its calibrated or normal value, and the resulting changes in simulated water quality are noted. A sensitivity analysis was performed for the recommended treatment level alternative to insure that minor variations in critical reaction rates and coefficients and other parameters did not result in significant changes in the predicted quality response of the receiving water system.

Sensitivity analysis simulation runs were made varying input rates and coefficients and other parameters, including:

- Temperature
- Mean stream depths and velocities
- Reaeration rates
- Wasteload BOD concentration
- Wasteload dissolved oxygen concentration
- Wasteload ammonia nitrogen concentration
- Wasteload discharge flow rate
- Benthal oxygen demand rates
- Waste decay and deoxygenation rates

The effect of each input variation was evaluated in terms of the resulting change in the dissolved oxygen profile compared to that originally simulated for the recommended treatment level during the WLA assessment. Plots of dissolved oxygen concentration vs. distance along the receiving water system downstream of the STP outfall were used in these evaluations. In this analysis, a change in dissolved oxygen of less than 1.0 mg/L as a result of a ±20% variation in a given input parameter was considered to be insignificant. Changes in dissolved oxygen levels greater than 1.0 mg/L have been identified and evaluated in order to verify utilization of the input parameter value causing the change.

MODEL CALIBRATION

Introduction

Calibration of the QUAL-TX model was performed using data gathered during an intensive water quality monitoring survey conducted October 7-8, 1981, on Hughes Creek, Lick Fork and South Sylamore Creek. In this process, the model was set up to represent as accurately as possible the actual conditions which occurred on the sampling date. The streamflows measured in the natural system (Hughes Creek headwater flow = 0.05 cfs) were specified in the model, as were background water temperatures and headwater quality. The flow rate (0.35 cfs, 0.23 MGD) and effluent quality of the wastewater treatment plant discharge also were specified in the model as measured. As noted previously, there were no flowing tributaries or nonpoint sources within the modeled segment of the receiving water system during the intensive survey period; therefore, it was not necessary to account for any such external loadings in the model for the calibration runs.

Rate Coefficients

As previously mentioned, utilization of the QUAL-TX stream quality model required determination of reaeration, BOD oxidation, BOD sedimentation, BOD removal, nitrification, benthal oxygen demand, and net algal productivity rates for the several reaches defined to described the receiving water system. The final values of reaction rates as determined through the calibration process are presented in Table 5, and a discussion of how these rates were determined is presented in the following paragraphs.

Atmospheric reaeration rates were calculated according to the Texas Department of Water Resources' reaeration equation which has been proven to provide a meaningful representation of reaeration effects in shallow streams subject to low or intermittent flows.

The equation is formulated similar to the O'Connor-Dobbins relationship as a function of stream depth and velocity.

$$K_2 \text{ (1/day @ 20°C)} = 2.8 \frac{u^{0.24}}{H^{0.54}}$$

where:

u = mean stream velocity (L/T)
H = mean stream depth (L)
K_2 = reaeration rate (1/T)

This equation was developed based on the results of a program involving the measurement of reaeration rates in Texas streams using the Tsivoglou gas-tracer technique. This equation was chosen following an unsuccessful attempt to use the O'Connor-Dobbins or Owens equations of the same form which calculated exceedingly high reaeration rates. This choice was based on the similarity between the Texas streams (primarily effluent dominated) on which these reaeration studies were performed and the conditions which exist at Mountain View (i.e. the proposed discharge to an intermittent stream).

Carbonaceous BOD decay, settling and overall removal rates are usually determined by plotting (on semi-log paper) measured BOD concentrations downstream of a discharge against the distance downstream or the time of travel downstream. In this study, plots of BOD_5 vs. distance downstream (see example in Appendix A) were prepared and used to determine the carbonaceous BOD reaction rates initially applied in the model calibration process. The

Table 5

Reaction Rates[1] Used in Model Calibration

Reach No.[2]	BOD Decay Rate (1/day)	Benthal Oxygen Demand Rate (mg/ft^2/day)	NH_3-NO_2 Oxidation Rate (1/day)	Average Reaeration Rate (1/day)
1[3]	-	-	-	0.00
2	0.5	186.0	0.4	1.87
3	0.5	186.0	0.4	1.67
4	0.5	39.0	0.4	1.71
5	0.1	39.0	0.2	1.69
6	0.1	39.0	0.2	1.78

[1] All rates are to the Base e @ 20°C

[2] See Figure 4.

[3] Reach No. 1 was used only to specify headwater conditions; water quality variations were not simulated.

BOD reaction rates were determined by multiplying the slope of the lines by the average stream velocity. Generally, the slope of this line is steeper immediately below the STP outfall where both BOD decay (K_d) and BOD settling (K_s) occur. The sum of these rates is known as the BOD removal rate (K_r). Further downstream, beyond where the effects of BOD settling are apparent, the slope of the line represents BOD decay only; therefore, the BOD sedimentation rate can be calculated as the difference between the slopes of the two segments of the curve. Initial values of BOD rates were determined in this manner and then adjusted to provide better agreement between simulated and observed water quality conditions during the model calibration process. Final values of these rates were compared with those from other studies as reported in Rates, Constants and Kinetics Formulations in Surface Water Quality Modeling (EPA, 1978) to assure reasonableness and consistency.

Various nitrogen compounds exert an oxygen demand as they change from one form to another. The conversion of ammonia nitrogen to nitrite nitrogen exerts an oxygen demand of 3.43 mg oxygen/mg nitrogen. The conversion of nitrite nitrogen to nitrate nitrogen exerts an oxygen demand of 1.14 mg oxygen/mg nitrogen. The speed at which these conversions take place also are controlled in the model by specified reaction rates which are representative of actual stream quality conditions. Initial estimates of NH_3-N oxidation rates were determined in the same manner as the carbonaceous BOD rates (see example for BOD rates in Appendix A), and these values, along with those for Org-N hydrolysis and NO_2-N oxidation were refined based on typical values reported by other investigators in the literature (EPA, 1978).

Bottom deposits, usually in the form of sludges discharged from municipal or industrial treatment plants, also can exert an oxygen demand. These sludges accumulate below wastewater outfalls when stream velocities are not sufficient to keep solids particles in suspension, and they can exert an oxygen demand of 0.05 to 10.0 grams of oxygen per square meter of bottom area per day (5 to 1,000 mg O_2/ft^2-day). For higher treatment levels, this benthal demand is reduced due to the reduction in discharged solids. Benthal oxygen demand rates were initially estimated using literature values (EPA, 1978 and Thomann, 1972) and then adjusted through the calibration process. General ranges of these rates are presented in Table 6 for various stream conditions and effluent quality levels.

Table 6

Benthal Oxygen Demand Rates

	Uptake (gm O_2/m^2-day) @ 20°C		Uptake (mg O_2/ft^2-day) @ 20°C	
	Range	Approximate Average	Range	Approximate Average
Secondary Treatment Effluent Level	2-10	4.0	186-929	372
Advanced Secondary Treatment Effluent Level	1-2	1.5	93-186	139
Advanced Waste Treatment Effluent Level & Background Level				
Estuarine Mud	1-2	1.5	93-186	139
Sandy Bottom	0.20-1.0	0.5	19-93	46
Mineral Soils	0.05-0.1	0.07	4.6-9.3	6.5

The presence of algae can also have an effect on dissolved oxygen in surface waters. During periods of daylight, oxygen is produced as a by-product of algal photosynthesis and consumed during algal respiration, whereas, at night, oxygen is only consumed during respiration. This complex system involving both a source and a sink of oxygen frequently results in a diurnal variation in dissolved oxygen concentrations which can range up to several mg/L. The photosynthesis/respiration processes depend on a number of conditions which influence algal productivity, including light intensities, available nutrients, and turbidity. The presence of algae can be determined from chlorophyll a concentrations, and in this study, an attempt was made to estimate the net oxygen production (gm/m^2/day) based on chlorophyll a according to the following equations (EPA, 1978).

$$P_s = 0.25\ Chl_a$$

where:

P_s = light saturated rate of oxygen production in mg/L-day
Chl_a = chlorophyll a concentration in ug/L

$$R = r \cdot Chl_a$$

where:

R = mg oxygen utilized/L-day
Chl_a = chlorophyll a concentration in ug/L
r = constant, commonly 0.025

Using these equations, the net photosynthesis can be calculated as:

$$P_n = (P_s - R)\ H$$

where:

P_n = net oxygen production in g/m^2/day
H = depth in meters

This technique provides an estimate of oxygen production from planktonic algae without regard to benthic or attached algae or rooted plants, and therefore, the algal productivity values calculated using this method could be significantly lower than the actual oxygen production. To account for these other biological oxygen sources or sinks in the model, background chlorophyll a concentrations were adjusted through the calibration process to more accurately reflect observed aquatic conditions in the natural system.

Temperature Correction Factors

Many of the reactions which determine water quality in natural systems are dependent on temperature. This dependence is usually considered by changing the various rate constants according to the following equation:

$$K_T = K_{20} \cdot \theta^{(T-20)}$$

where K_T and K_{20} are rate constants at temperatures, T, and 20° centigrade, respectively, and θ is a temperature correction factor which depends on the reaction being considered. The temperature correction factors used in the simulations are summarized in Table 7.

Stream Hydraulics

After a stream has been segmented for modeling, it is necessary to specify the hydraulic and physical characteristics of each reach in the stream system. Two equations are generally used to describe the advective hydraulic characteristics in the QUAL-TX model. The equations represent the relationship between discharge and velocity and discharge and depth, and are expressed as follows:

$$V = aQ^b$$

$$H = cQ^d$$

Table 7

Reaction Rate Temperature Correction Factors

Reaction Rate	θ, Temperature Correction Factor
Ammonia Decay Rate	1.047
Benthal Demand Rate	1.065
BOD Deoxygenation Rate	1.047
BOD Settling Rate	1.024
Organic Nitrogen Decay Rate	1.047
Organic Nitrogen Settling Rate	1.024
Algal Productivity	1.047
Atmospheric Reaeration	1.017-1.024

where:

V = mean velocity (L/T)
Q = mean discharge (L^3/T)
H = mean depth (L)
a, c = coefficients
b, d = exponents

The velocity and depth equations can be formulated in one of two ways; (1) both the exponents (b and d) and the coefficients (a and c) can be calculated, if sufficient data exist, as the slope and intercept, respectively, of a log-log plot of streamflow vs. velocity or depth, or (2) the exponents can be assumed and then the coefficients can be calculated using the flow, average velocities, and the average depths determined from time-of-travel studies. The depth exponent (d) typically ranges between 0.4 and 0.6 and the velocity exponent (b) typically ranges between 0.2 and 0.4 for free-flowing streams of approximate rectangular cross section, unaffected by backwater conditions (O'Connor and Mueller, 1980).

For Hughes Creek and Lick Fork, the exponents were assumed based on typical values for similar streams and the coefficients were calculated as previously described. The hydraulic coefficients used in the simulations are summarized in Table 8.

Summary of Calibration Results

With the inputs and background conditions specified in the model, including initial estimates of reaction rates and coefficients, steady-state simulations of water quality along the length of the receiving water system were performed, and results were evaluated in terms of measured quality levels. Appropriate adjustments in rates and coefficients were then made, and the water quality throughout the system was resimulated. This process was repeated until the agreement between the simulated and measured quality levels was considered acceptable for purposes of the WLA study.

In the calibration process, primary emphasis was placed on properly simulating those constituents directly related to or most likely to be

Table 8

Hydraulic Coefficients

Reach	Velocity = aQ^b		Depth = cQ^d	
	a	b	c	d
1	0.091	0.36	1.589	0.54
2	0.059	0.36	2.017	0.54
3	0.068	0.36	1.045	0.54
4	0.068	0.36	1.045	0.54
5	0.103	0.36	0.431	0.54
6	0.091	0.36	1.589	0.54
7	0.091	0.36	1.589	0.54
8	0.091	0.36	1.589	0.54
9	0.091	0.36	1.589	0.54

impacted by the STP discharge. These included dissolved oxygen, biochemical oxygen demand, and nutrients (NH_3 and PO_4). In addition, a conservative constituent (chlorides) also was given special attention to assure that the model was properly accounting for the hydraulics and mass balance of the system. Final calibration profile plots for these constituents and the corresponding observed data values are illustrated in Figure 5. Generally, good agreement is indicated between the simulated and measured values, and these results are considered to be acceptable for purposes of performing the waste load allocation assessment.

It should be noted that the simulated dissolved oxygen profile in Figure 5 tracks the minimum DO levels observed over a diurnal period during the intensive survey. This calibration of the model was made at the request of the ADPC&E in order for the simulated DO levels to be consistent with the State's application of its dissolved oxygen standards, i.e. the DO standard for a given stream is considered to be the minimum value that shall occur at any point in time and it "shall be the critical deficit point of the dissolved oxygen profile". In natural streams subject to organic pollutant loadings, the minimum DO level during the day generally occurs around dawn when algae and aquatic plants are respiring (taking up oxygen), but not photosynthesizing (producing oxygen). This condition was observed in Hughes Creek, and hence, this was the critical condition for which the model was calibrated. This calibration required special adjustments in the model to properly describe algal/macrophyte background conditions and related biotic dynamics, particularly since the model was operated in a steady-state mode and since the influence of attached filamentous algae was observed to be significant in the receiving stream segment downstream of the STP outfall.

HUGHES CREEK

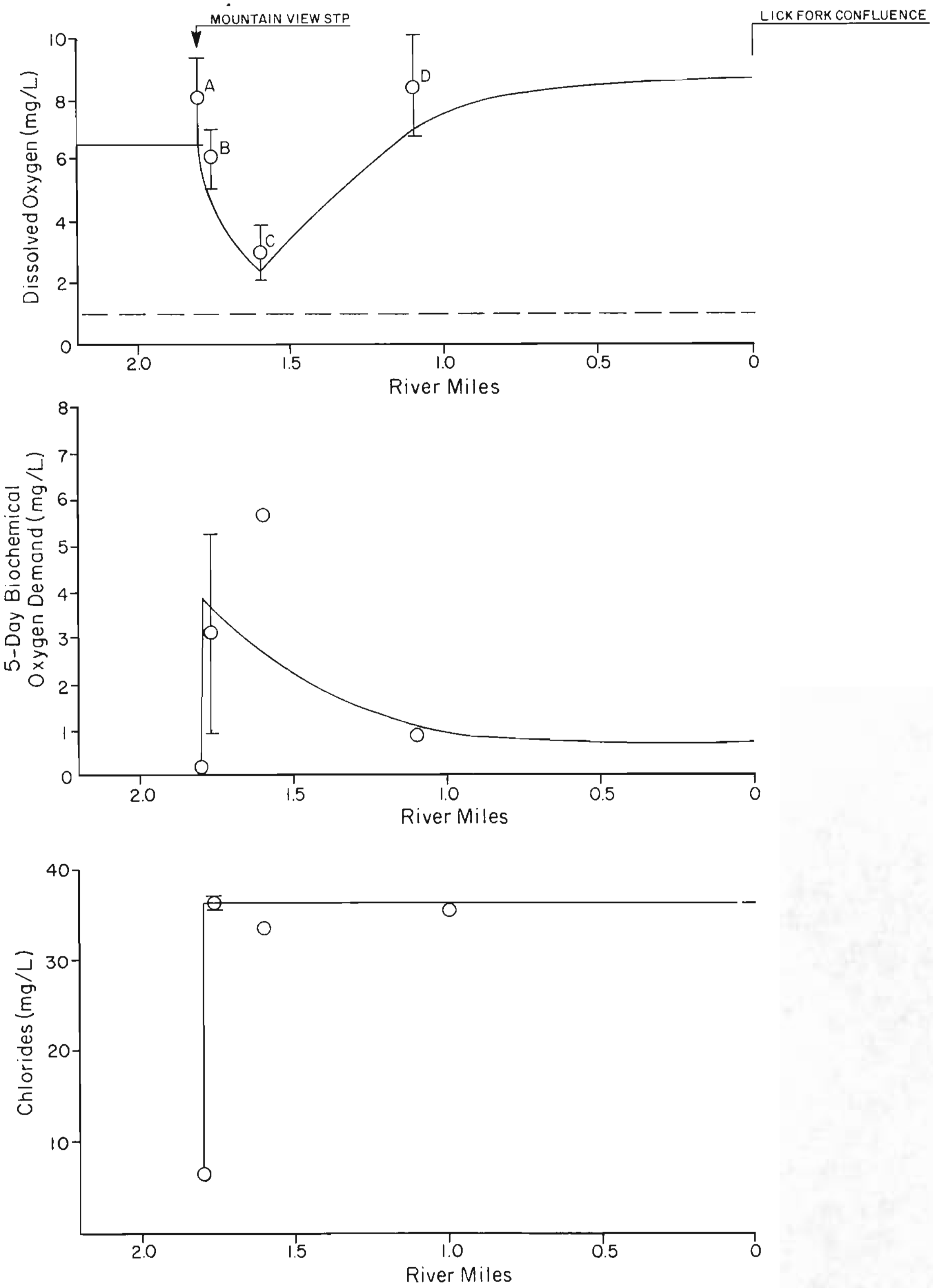
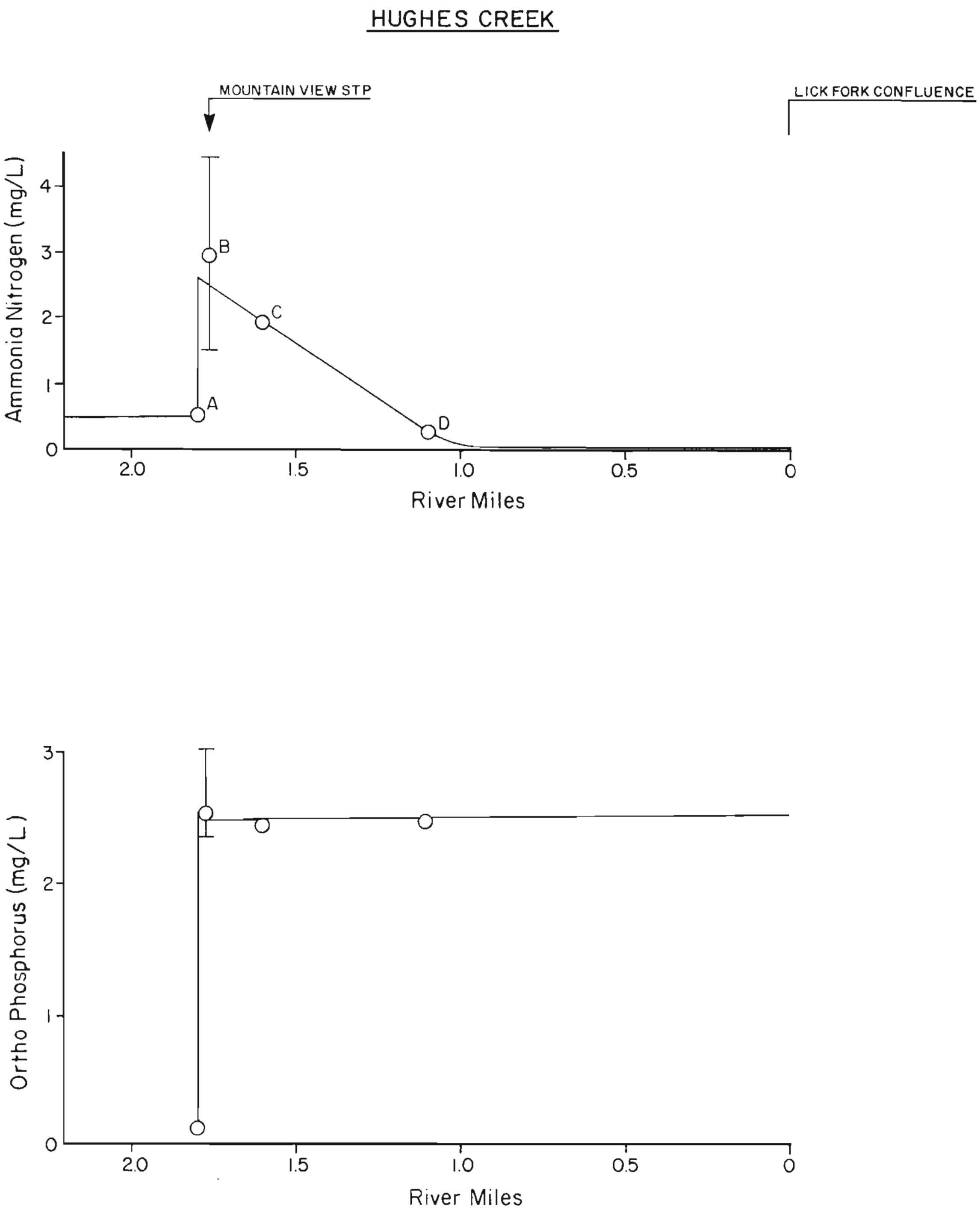


Figure 5

MODEL CALIBRATION RESULTS



HUGHES CREEK

Figure 5, cont'd

SECTION V. ANALYSIS OF ALTERNATIVES

TREATMENT LEVELS

In accordance with procedures set forth by the EPA Region 6 office for conducting waste load allocation studies, the water quality impacts of progressively-more-stringent wastewater treatment levels for the proposed plant were evaluated with the model. This process was continued until the least stringent level of treatment was identified which produced an effluent quality that resulted in no violations of dissolved oxygen standards. For Mountain View, this procedure resulted in the following levels of treatment, and effluent quality, being evaluated for the proposed 0.579 MGD (average dry weather flow) treatment plant.

Alternative Treatment Levels	Discharge Rate (cfs)	BOD_5 (mg/L)	TSS (mg/L)	NH_3-N (mg/L)	Effluent DO (mg/L)
Secondary Treatment	0.9	30	30	10	5
Advanced Secondary Treatment	0.9	10	15	10	5
Advanced Secondary with Supplemental Aeration	0.9	10	15	10	6
Advanced Waste Treatment	0.9	10	15	2	5
Advanced Waste Treatment	0.9	5	5	2	5

MODEL SEGMENTATION

For the simulations of stream water quality with alternative levels of treatment, the network of reaches and elements used for model calibration was extended downstream to include Lick Fork from the Hughes Creek confluence to

South Sylamore Creek. These reaches were added and the system of reaches was renumbered as illustrated in Figure 6. In this new model network, Reach Nos. 2-7 are identical to Reach Nos. 1-6 in the original network used for model calibration.

The three additional reaches, covering 2.6 miles, were necessary in the model to extend the water quality simulations downstream to the point where flow enters South Sylamore Creek. These reaches were not required for the calibration simulations since no flow occurred in the receiving water system downstream of the Hughes Creek-Lick Fork confluence, however, with the increased discharge rate from the STP for the alternatives simulations, flow is projected to travel farther downstream through Lick Fork and ultimately into South Sylamore Creek.

BACKGROUND CONDITIONS

The calibrated mathematical water quality model (QUAL-TX) for the receiving water system was used to evaluate the water quality impacts of the projected waste loadings from the Mountain View STP under critical stream conditions. These conditions and the rates and coefficients used for the alternatives simulations are described in the following sections.

Critical Temperature and Flow

The average summertime (June-September) water temperature, increased by one standard deviation, was used as the critical stream temperature for the water quality simulations in the WLA assessment. Daily stream temperature data from the USGS station on the White River at Sylamore (No. 07060660) for the period of record from October, 1975, through September, 1979, were used to aid in estimating a critical temperature level for Hughes Creek and Lick Fork, since no historical temperature data existed for these creeks.

The monthly temperature means and standard deviations for the White River station at Sylamore are presented in Table 9. The average of the June-September monthly means is 17.7°C and the average of the June-September standard deviations is 2.2°C. Therefore, the critical summertime temperature

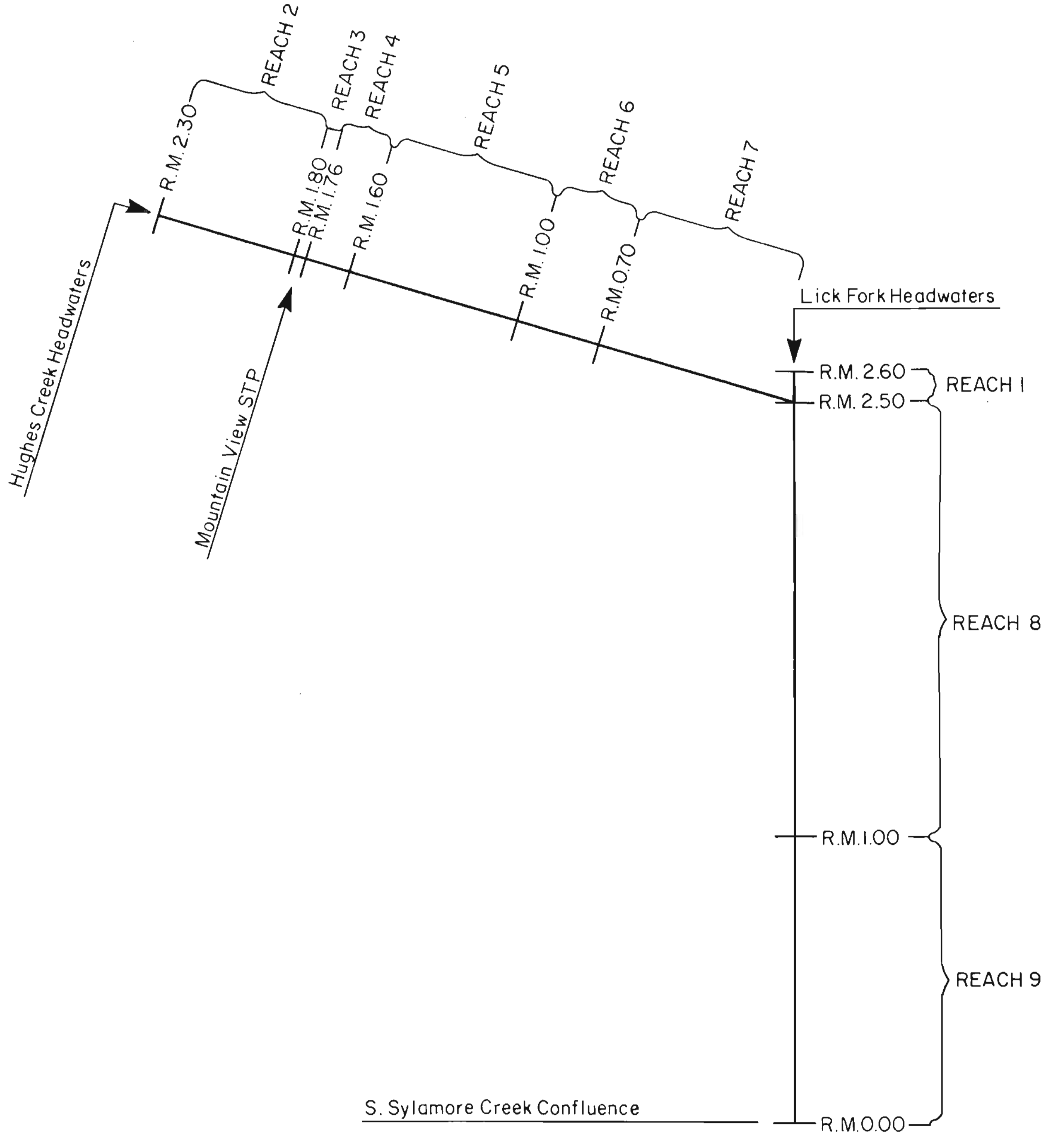


Figure 6
SEGMENTATION REACH NETWORK USED IN ALTERNATIVES SIMULATIONS

Table 9

Temperature Data

Month	Mean Value °C	Standard Deviation °C
January	5.3	1.5
February	5.6	3.4
March	9.7	2.1
April	10.3	3.8
May	12.4	3.8
June	17.7	2.2
July	17.0	2.6
August	18.1	2.0
September	18.1	2.1
October	14.5	2.2
November	12.2	2.0
December	8.5	2.1

based on these data would be 19.9°C. However, since the White River receives cold-water releases from two upstream reservoirs, it is likely that this calculated critical temperature is probably low for a stream such as Hughes Creek whose normal flow is comprised primarily of treated wastewater. In conversations with personnel from the City of Mountain View (Mr. James Henderson), it was detemined that the average temperature of the STP effluent during the summer was approximately 75°F (23.9°C). This value was subsequently used in the model simulations for alternative treatment levels.

For background streamflow, the seven-day average low flow with a ten-year recurrence interval (7Q10) was used in the alternative modeling. According to a fact sheet prepared by the ADPC&E, the 7Q10 flow for the receiving stream (Hughes Creek) is zero. For modeling purposes, a headwater flow of 0.01 cfs was used to facilitate the computational procedures. The headwater dissolved oxygen concentration was assumed to be eighty percent of the saturation concentration at the critical temperature (23.9°C); all other headwater quality parameters were estimated from the actual values measured at the headwater station (Sta. A) during the intensive water quality survey.

Rates and Coefficients

As noted earlier, model rates and coefficients determined during the calibration process were modified for the alternatives simulations to reflect changes in the effluent quality produced by the various treatment levels considered. Literature sources and experience performing similar investigations were used as the basis for changes in the rates and coefficients. Following is a brief summary of the changes made, and Table 10 presents a listing of the various rates specified in each reach of the model network.

- Hydraulics - The coefficients and exponents specified in the calibrated model to describe velocity vs. flow and depth vs. flow relationships in the receiving water system were not changed for the alternatives simulations. Since the calibration values were based on measurements made during a low flow period, they were

Table 10

Reaction Rates[1] Used in Treatment Alternative Simulations

Reach No.	Secondary Treatment[2]				Advanced Secondary Treatment[3]			
	Kd (1/day)	K_n (1/day)	K_2 (1/day)	BnOD ($mg/ft^2/day$)	K_d (1/day)	K_n (1/day)	K_2 (1/day)	BnOD ($mg/ft^2/day$)
1[6,7]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.8	0.5	3.19	93.0	0.3	0.5	3.19	93.0
3	0.8	0.5	2.07	93.0	0.3	0.5	2.07	93.0
4	0.8	0.5	1.60	186.0	0.3	0.5	1.60	186.0
5	0.8	0.5	2.91	39.0	0.3	0.5	2.91	39.0
6	0.1	0.2	1.44	39.0	0.1	0.2	1.44	39.0
7	0.1	0.2	1.48	39.0	0.1	0.2	1.48	39.0
8[7]	0.1	0.2	1.61	39.0	0.1	0.2	1.61	39.0
9[7]	0.1	0.2	1.83	39.0	0.1	0.2	1.83	39.0

Reach No.	Advanced Waste Treatment[4]				Advanced Waste Treatment[5]			
	Kd (1/day)	K_n (1/day)	K_2 (1/day)	BnOD ($mg/ft^2/day$)	K_d (1/day)	K_n (1/day)	K_2 (1/day)	BnOD ($mg/ft^2/day$)
1[6,7]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.3	0.4	3.19	93.0	0.2	0.4	3.19	93.0
3	0.3	0.4	2.07	93.0	0.2	0.4	2.07	93.0
4	0.3	0.4	1.60	139.0	0.2	0.4	1.60	93.0
5	0.3	0.4	2.91	39.0	0.2	0.4	2.91	39.0
6	0.1	0.2	1.44	39.0	0.1	0.2	1.44	39.0
7	0.1	0.2	1.48	39.0	0.1	0.2	1.48	39.0
8[7]	0.1	0.2	1.61	39.0	0.1	0.2	1.61	39.0
9[7]	0.1	0.2	1.83	39.0	0.1	0.2	1.83	39.0

[1] Reaction rates: K_d = Carbonaceous BOD decay rate, K_n = Nitrogenous oxidation rate, K_2 = Average reaeration rate, BnOD = Benthal oxygen demand rate

[2] Secondary treatment = 30/30/10/5 ($BOD_5/TSS/NH_3$-N/DO)

[3] Advanced secondary treatment, including AST with supplemental aeration = 10/15/10/5 and 10/15/10/6 ($BOD_5/TSS/NH_3$-N/DO)

[4] Advanced waste treatment (AWT) = 10/15/2/5

[5] Advanced waste treatment (AWT) = 5/5/2/5

[6] Reach No. 1 was used only to specify headwater conditions; water quality variations were not simulated.

[7] To account for increased flow from the STP for the alternative simulations, additional reaches were added to the model network in order to simulate water quality in Lick Fork (See Figure 6).

considered to be representative of the 7Q10 low flow condition used in the WLA assessment.

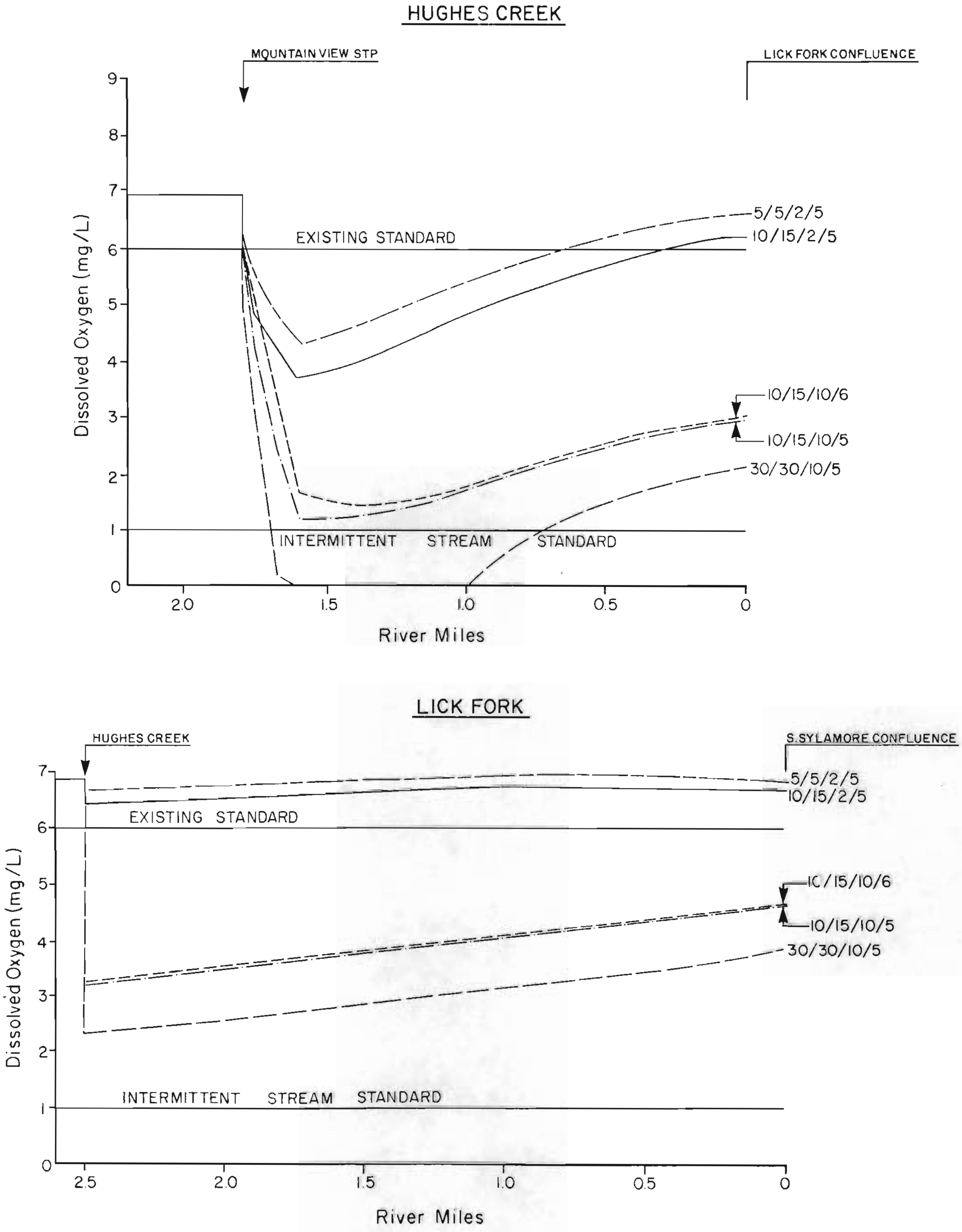
- Oxidation/Decay - Carbonaceous BOD decay rates (K_d) and nitrogenous oxidation rates (K_n) were adjusted to account for the critical water temperature (23.9°C) assumed for the alternatives simulations. In addition, these rates also were modified to reflect the variations in effluent quality corresponding to the different treatment levels, i.e. higher rates were used for the lower treatment levels. These adjustments were based on past experience and a review of literature values.

- Benthal Rates - Benthal oxygen demand rates (BnOD) were adjusted for water temperature and for the different levels of treatment evaluated. High levels of treatment typically result in low benthal oxygen demand rates because of lesser amounts of organic materials being deposited on the stream bottom downstream of the plant outfall. General ranges of these rates were presented in Table 5 for various treatment levels and bottom conditions.

- Reaeration Rates - Reaeration rates were adjusted to account for the critical water temperature (23.9°C).

SIMULATED RESULTS

The simulated dissolved oxygen profiles for Hughes Creek and Lick Fork for the five alternative treatment levels evaluated are illustrated in Figure 7. As shown, all of the treatment levels result in dissolved oxygen concentrations in Hughes Creek and Lick Fork which are below the existing DO standard of 6.0 mg/L for the streams. With the exception of secondary treatment (30/30/10/5), all other treatment levels, however, do provide for



TREATMENT LEVEL DEFINITION: 10/15/2/5 = BOD_5/TSS/NH_3-N/DO

Figure 7

SIMULATED D.O. PROFILES FOR ALTERNATIVE TREATMENT LEVELS instream DO levels that are above the intermittent stream standard of 1.0 mg/L. Similarly, only the secondary treatment level results in a DO level in South Sylamore Creek less than 6.0 mg/L, the applicable standard for a smallmouth bass fishery. Application of secondary treatment results in severely depressed dissolved oxygen levels (<1.0 mg/L) in Hughes Creek between River Miles 1.7 and 0.7 with anaerobic conditions (DO = 0 mg/L) occurring between River Miles 1.6 and 1.0.

Table 11 presents a summary of the minimum dissolved oxygen concentrations simulated in the receiving water streams for the different treatment levels. Based on these results, it is apparent that even the most stringent advanced waste treatment level (5/5/2/5) will not provide sufficient effluent quality to maintain dissolved oxygen concentrations in Hughes Creek above the existing 6.0 mg/L standard. This suggests that a "zero discharge" condition for the proposed STP effluent will be required. Assuming that Hughes Creek and Lick Fork can be formally designated as intermittent streams with a DO standard of 1.0 mg/L, however, the zero discharge condition would not be necessary, but an advanced secondary treatment level (10/15/10/5) would be required to meet the 6.0 mg/L standard in South Sylamore Creek. Certainly, Hughes Creek and Lick Fork should qualify as intermittent streams since they are dry most of the time, and advanced secondary treatment at the indicated level should be sufficient to satisfy ADPC&E and EPA requirements.

One final point to note regarding the required treatment for the Mountain View STP pertains to phosphorus. As indicated in Section II of this report, all of the receiving water streams within the study area have a total phosphorus standard of 0.1 mg/L. It will not be possible to meet this standard on intermittent streams such as Hughes Creek and Lick Fork when the flow in the stream is comprised primarily of treated effluent. Even natural background levels of total phosphorus in South Sylamore Creek and its various tributaries in the study area exceeded 0.1 mg/L during the intensive sampling survey conducted as part of this study (see Appendix A). Resolution of the phosphorus problem will require special consideration by the ADPC&E and EPA.

Table 11

Minimum Dissolved Oxygen Concentrations for Different Treatment Levels

Alternative Treatment Level	Hughes Creek		Lick Fork		South Sylamore Creek*
	Minimum DO (mg/L)	River Mile	Minimum DO (mg/L)	River Mile	Dissolved Oxygen (mg/L)
Secondary Treatment	0.0	1.6-1.0	2.3	2.5	5.9
Advanced Secondary Treatment	1.2	1.6	2.4	2.5	6.1
Advanced Secondary with Supplemental Aeration	1.5	1.4	2.4	2.5	6.1
Advanced Waste Treatment (10/15/2/5)	3.7	1.6	6.4	2.5	6.7
Advanced Waste Treatment (5/5/2/5)	4.4	1.6	6.7	2.5	7.0

* The dissolved oxygen concentration in South Sylamore Creek immediately downstream of the Lick Fork confluence was calculated by a mass balance between the flow and simulated DO concentration in Lick Fork prior to entering S. Sylamore Creek and the 7Q10 flow for S. Sylamore Creek of 3.8 cfs (from USGS #07060700 - Arkansas Geological Commission, Water Resources Circular No. 12, 1975) and an assumed dissolved oxygen concentration of 8.4 mg/L (0.8 DO_{sat} @ 23.9°C).

SEASONAL DISCHARGE

In some cases, when the model results of the waste load allocation assessment are not definite or when the required level of treatment is so stringent that it appears to be uneconomical to implement, consideration is given to accepting a less stringent level of treatment, but allowing discharge only on a seasonal basis. The rationale for this practice is that the critical background conditions (7Q10 flow and high summer temperatures) upon which the WLA results are based are most likely to occur in the natural system only during a short period (few months) of the year, and therefore, rather than apply an expensive, high degree of treatment all of the time it may be more cost-effective to construct a lower-level treatment facility and allow effluent discharges only when stream conditions warrant, or construct a high-level treatment facility and operate it only at its design level when necessary, i.e. during critical low flow and high temperature periods.

For the City of Mountain View, the apparent required level of treatment, based on the results presented herein, is advanced secondary with an effluent quality of 10/15/10/5 (BOD_5/TSS/NH_3-N/DO). This is the same level recommended in the White River Basin Water Quality Mangement Plan, and it is the level for which the proposed plant modifications are being designed. Also, considering the DO profiles simulated for the secondary and advanced secondary treatment levels as presented in Figure 7 and the fact that the headwater flow in Hughes Creek is near zero most of the time, it does not appear that secondary treatment on a seasonal basis is a viable alternative. For these reasons, a detailed assessment of the possibility for a seasonal discharge permit for the Mountain View STP has not been undertaken.

SENSITIVITY ANALYSIS

A sensitivity analysis of the water quality model of Hughes Creek and Lick Fork was performed using the advanced secondary treatment alternative as a baseline condition. This analysis was conducted in accordance with procedures set forth by the EPA Region 6 office as described in Section IV of this report. The model input parameters previously listed were evaluated in this analysis, and the results are summarized in Table 12. Comparison plots showing the baseline DO profile and the DO profiles resulting from the (±) parameter changes are illustrated in Figure 8.

RECOMMENDED TREATMENT LEVEL

Based solely on the results of the water quality simulations and the analysis of stream conditions and existing water quality standards in the study area, a zero discharge effluent condition is indicated as the required treatment level for Mountain View's proposed STP facility. Even with the most stringent advanced waste treatment level (5/5/2/5), the plant discharge causes violations of the existing 6.0 mg/L dissolved oxygen standard in Hughes Creek. Furthermore, considering Arkansas' total phosphorus standard of 0.1 mg/L for streams, it is unlikely that any practical degree of treatment for phosphorus removal from the effluent will result in acceptable instream phosphorus levels, particularly in Hughes Creek and Lick Fork which have no natural flow much of the time.

The effluent treatment requirements could be reduced considerably if a formal intermittent stream designation is granted for Hughes Creek and Lick Fork. With this designation, the 1.0 mg/L dissolved oxygen standard for Hughes Creek and Lick Fork can be satisfied with all effluent treatment levels except secondary (30/30/10/5). Still, however, in order to meet the 6.0 mg/L DO standard in South Sylamore Creek, an advanced secondary treatment level of 10/15/10/5 will be necessary. The phosphorus problem would not be alleviated by the intermittent stream designation.

It is strongly recommended that the City of Mountain View immediately initiate action to have Hughes Creek and Lick Fork formally designated as intermittent streams. Based on observations made during this study, the creeks should definitely qualify since both had reaches which were essentially dry at the time of the intensive survey. The intermittent stream designation will allow the City to provide acceptable effluent water quality from its proposed STP facility with advanced secondary treatment (10/15/10/5).

Table 12

Summary of Sensitivity Analysis Results

	Hughes Creek @ RM 1.60			Lick Fork @ RM 2.50		
Parameter	-20%*	+20%*	Difference	-20%*	+20%*	Difference
Temperature	1.54	0.87	0.67	3.54	3.06	0.48
Depth	1.12	1.23	0.11	3.72	2.79	0.93
Velocity	0.74	1.61	0.87	3.50	3.03	0.47
Reaeration Rae	0.99	1.40	0.41	2.31	3.97	1.66
Waste Load BOD	1.29	1.10	0.19	2.61	3.13	0.52
Waste Load DO	0.79	1.68	0.89	3.16	3.26	0.10
Waste Load NH_3-N	1.61	0.87	0.74	3.88	2.63	1.25
Waste Load Flow	1.00	1.35	0.35	3.71	2.85	0.86
Benthal Oxygen Demand Rate	1.37	1.02	0.35	3.38	3.03	0.35
BOD Decay Rate	1.28	1.10	0.18	3.27	3.15	0.12
NH_3-N Oxidation Rate	1.58	0.89	0.69	3.59	2.88	0.17

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*For Temperature, ± 2°C.

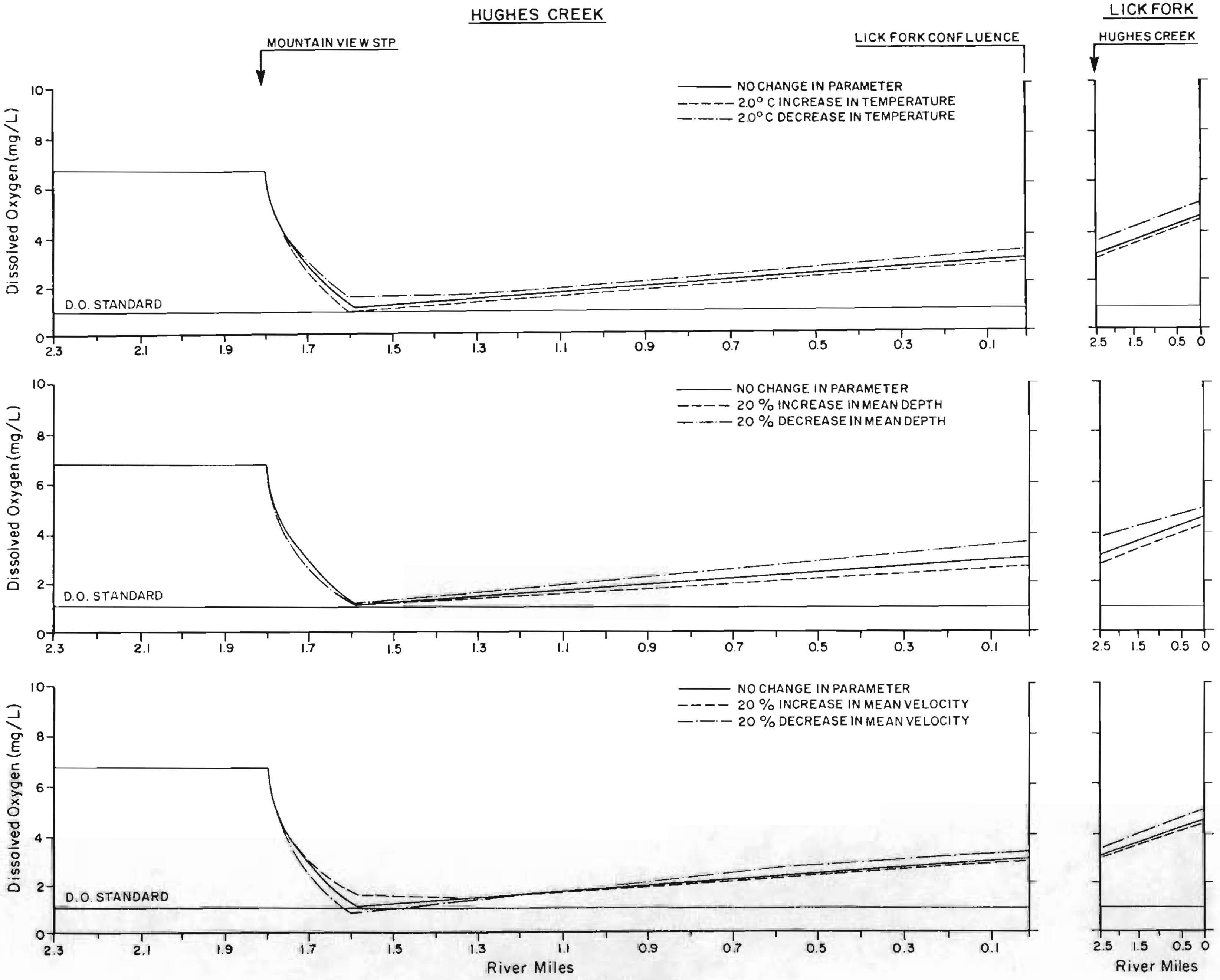

Figure 8
RESULTS OF SENSITIVITY ANALYSIS

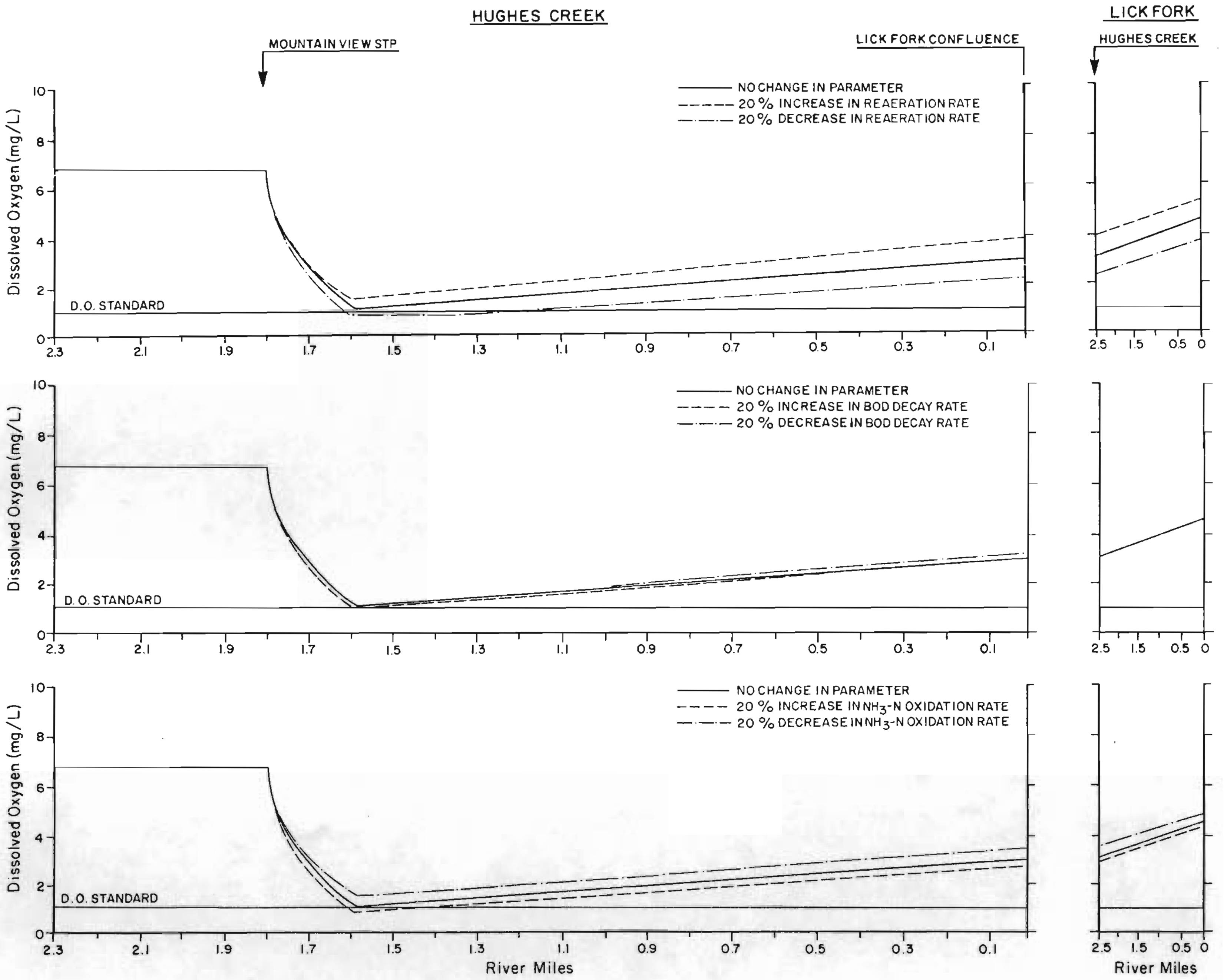

Figure 8, cont'd

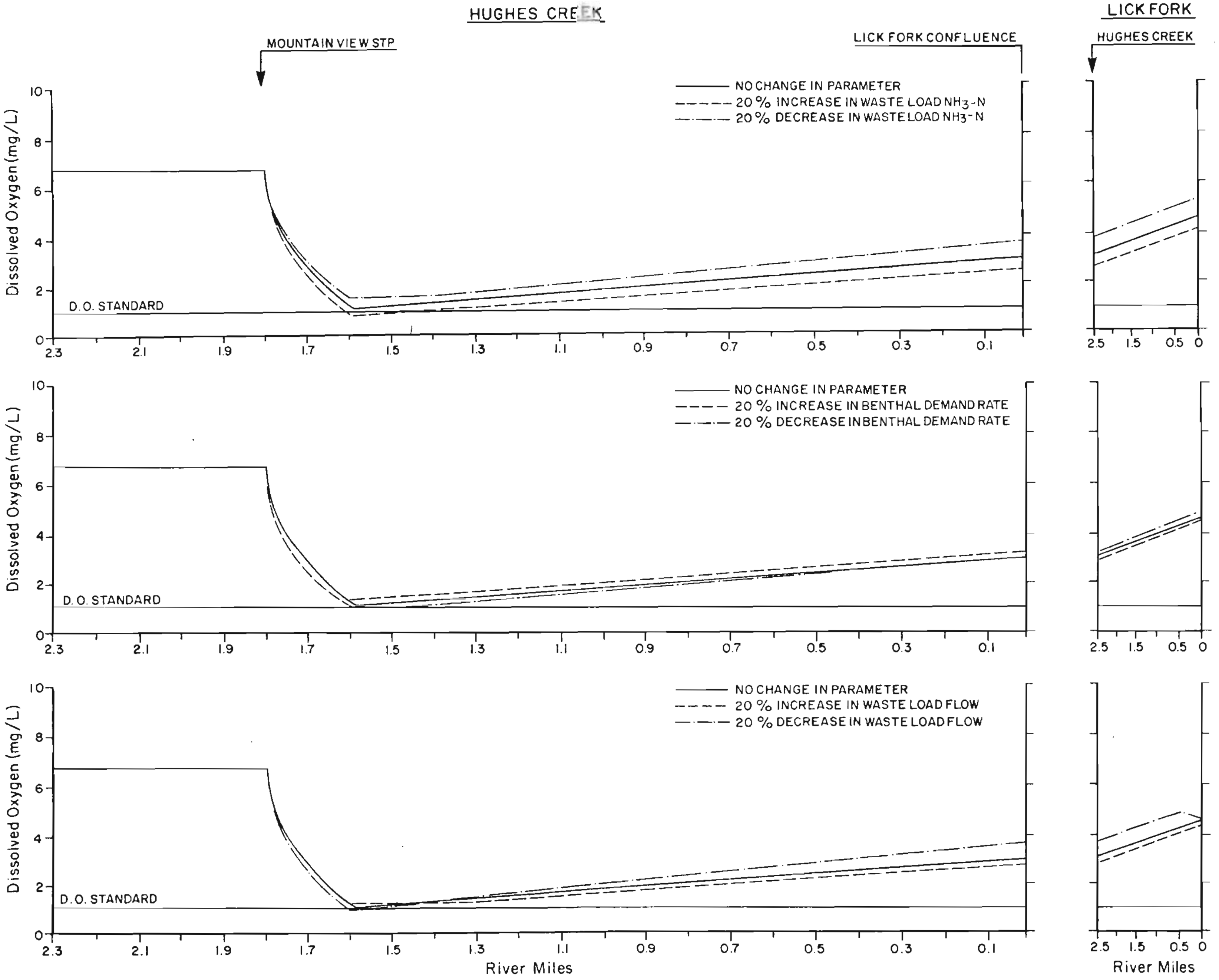

Figure 8, cont'd

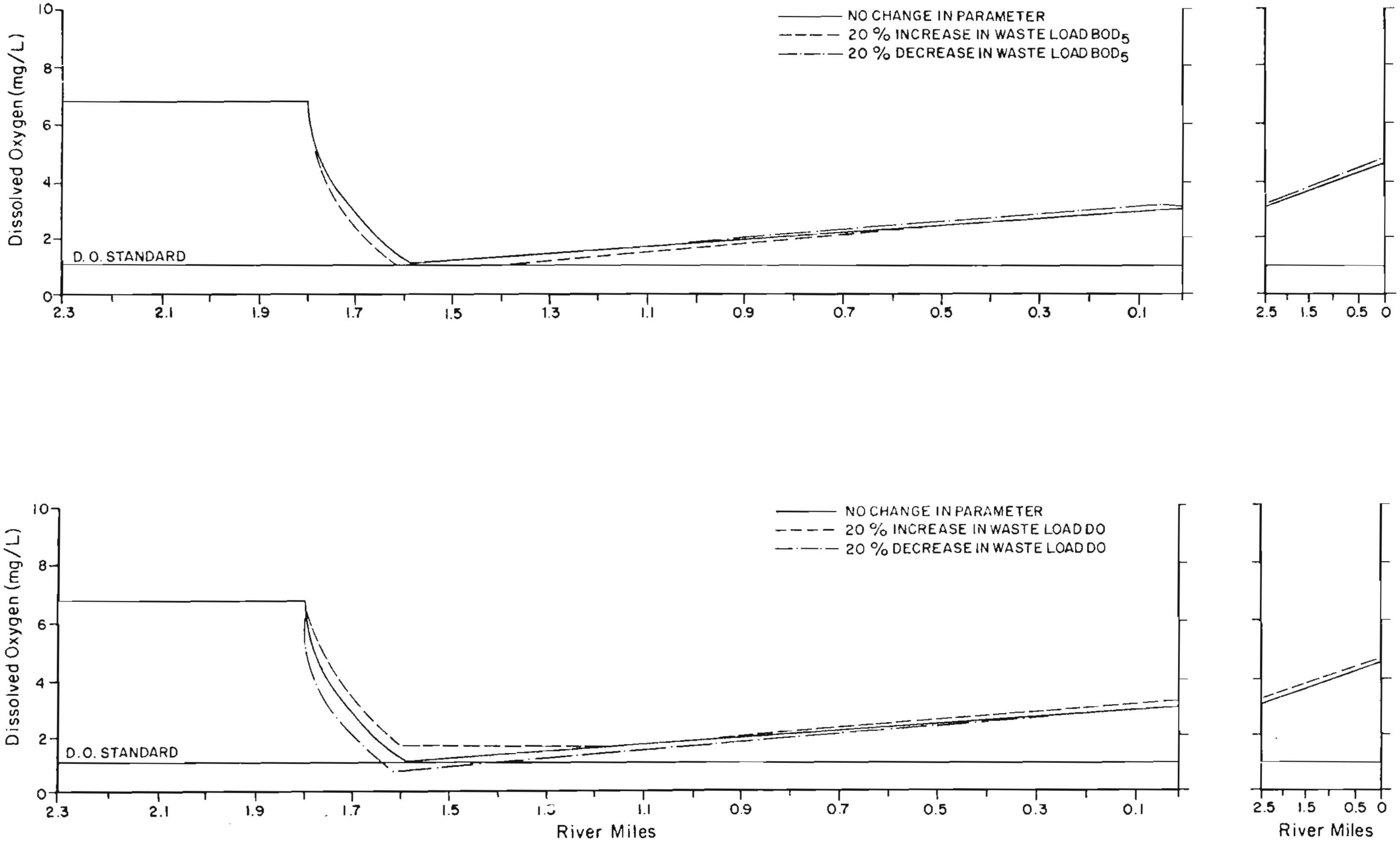

Figure 8, cont'd

COST EFFECTIVE ANALYSIS

The results of the water quality modeling identify the level of treatment necessary for attainment of the State's stream water quality standards, and based solely on these results, a required treatment level has been recommended for the Mountain View STP facility as indicated in the preceding section. It is important that before effluent limitations are finally established, however, that careful consideration be given to the practical aspects of providing the required wastewater treatment. In particular, consideration should be given to the costs of the required treatment facilities and to the City's ability to pay these costs, taking into account the benefits to be derived.

In this regard, the estimated costs for constructing the treatment facilities necessary to provide the several effluent quality levels analyzed in this study have been determined by the 201 facilities planning engineer. These costs are summarized in Table 13.

As indicated, the estimated cost for the advanced secondary treatment facility with an effluent quality of 10/15/10/5, as required to meet stream standards, assuming intermittent status for Lick Fork and Hughes Creek, is approximately $400,000 more than that for the next less-stringent level of treatment, i.e. secondary treatment (30/30/10/5).

Table 13

Total Project Costs of Different Treatment Levels

Alternative Treatment Level	Treatment Costs*
Secondary Treatment (30/30/10/5)	$857,400
Advanced Secondary Treatment (10/15/10/5)	$1,286,110
Advanced Secondary Treatment with Supplemental Aeration (10/15/10/6)	$1,386,110
Advanced Waste Treatment (10/15/2/5)	$1,286,110
Advanced Waste Treatment with Supplemental Aeration (10/15/2/6)	$1,386,110
Advanced Waste Treatment (5/5/2/5)	$1,543,330

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* Treatment costs were provided by the 201 Facilities Planning Engineer.

LIST OF REFERENCES

1. United States Geological Survey; Technologies of Water Resources Investigations of the United States Geological Survey; Book 3, Applications of Hydraulics; Chapter A9, Measurement of Time of Travel and Dispersion by Dye Tracing; Washington, D.C.; 1968.

2. U.S. Environmental Protection Agency; Rates, Constants and Kinetics Formulations in Surface Water Quality Modeling; Cincinnati, Ohio; 1978.

3. O'Connor, Donald J. and J.A. Mueller; Basic Models of Natural Water Systems Applications to Waste Load Allocations; Twenty-Fifth Summer Institute in Water Pollution Control; Manhattan College; Bronx, New York; 1980.

4. Thomann, Robert V.; Systems Analysis and Water Quality Management; McGraw Hill Book Company; St. Louis, Missouri; 1972.

5. United States Geological Survey; Water Resources Data for Arkansas; Data Report AR-79-1, Water Year 1979, Little Rock, Arkansas.

APPENDIX A

SUMMARY OF INTENSIVE SURVEY RESULTS

October 7-8, 1981

HYDRAULIC MEASUREMENTS

Waste Load Allocation Study
Mountain View, Arkansas
October 7-8, 1981

Station Name	Time of Flow Measurement	Flow[1] (cfs)	Width (ft.)
Hughes Creek - Station A (RM 1.80)	10/8/81 - 1615	0.05	8.0
Hughes Creek - Station B (RM 1.76)	10/8/81 - 1639	0.24	4.0
Hughes Creek - Station C (RM 1.60)	10/8/81 - 1528	0.67	5.0
Hughes Creek - (RM 1.38)	10/8/81 - 1452	0.67	4.4
Hughes Creek - Station D (RM 1.10)	10/8/81 - 1400	0.44	5.5
Hughes Creek - Station E (RM 0.77)	10/8/81 - 1615	0.05[2]	1.0 0.45 6.0
S. Sylamore Creek - Station H (RM 9.17)	10/8/81 - 1400	0.81	27.0 14.0
Mountain View STP - Station 1 (RM 1.78)	10/8/81	0.35[3]	-

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[1] Unless otherwise indicated, all flows were determined in the field using a pygmy meter.

[2] Estimated using float method.

[3] From Parshall flume rating curve.

TIME-OF-TRAVEL STUDY

Waste Load Allocation Study
Mountain View, Arkansas
October 7-8, 1981

Reach Identification	Release or Peak	Distance (mi.)	Time of Dye Release or Peak	Peak Time of Travel (hrs.)	Velocity (fps)	Average Flow (cfs)	Average Width (ft.)	Average Depth (ft.)
Hughes Creek - Station A (RM 1.80)	Release		10/8/81 - 0600					
		0.04		1.50	0.039	0.30	12.0	0.64
Hughes Creek - Station B (RM 1.76)	Peak		10/8/81 - 0730					
		0.38		9.35	0.060	0.30	8.0	0.63
Hughes Creek - (RM 1.38)	Peak		10/8/81 - 1651					

FIELD MEASUREMENTS
October 7-8, 1981, Intensive Water Quality Survey

Waste Load Allocation Study
Mountain View, Arkansas

Station Name	Dissolved Oxygen (mg/L)		Temperature (°C)		Conductivity (umhos/cm)		pH		Chlorine Residual (mg/L)	Total Alkalinity (mg/L)
	Average	Range	Average	Range	Average	Range	Average	Range	Average	Average
Hughes Creek-Station A (RM 1.80)	8.0	6.5- 9.3	14.5	13.0-16.0	171	169-175	7.4	7.0-7.6	-	90
Springs - Station A1	7.6	-	14.0	-	-	-	-	-	-	-
Hughes Creek-Station B (RM 1.76)	6.1	5.1- 7.0	17.5	17.0-19.0	456	380-500	7.2	7.0-7.6	-	160
Hughes Creek-Station C (RM 1.66)	3.0	2.1- 3.9	17.2	15.9-18.5	364	390-500	7.2	7.1-7.5	-	145
Hughes Creek-Station D (RM 1.24)	8.3	6.8-10.1	14.3	13.0-16.0	419	380-467	7.7	7.5-7.9	-	-
Hughes Creek-Station E (RM 0.77)	5.8	5.3- 6.2	15.2	14.5-16.0	406	402-410	7.5	7.3-7.9	-	153
Lick Fork-Station G (RM 0.02)	11.6	7.9-14.8	15.3	13.0-17.0	281	270-290	7.7	7.2-8.2	-	147
S. Sylamore Creek-Station H	5.9	4.0- 7.4	18.0	16.5-19.0	272	264-284	6.7	5.7-7.6	-	150
Mountain View STP-Station 1	5.5	5.2- 5.7	19.5	19.0-20.0	543	520-580	7.4	7.1-7.5	0.1	189

RESULTS OF LABORATORY ANALYSES
October 7-8, 1981, Intensive Water Quality Survey

Waste Load Allocation Study
Mountain View, Arkansas

Parameter	Station Number[1]				
	Spring Grab @ 0900 (HC RM 1.79)	Hughes Ck - A Composite (RM 1.80)	Mtn. View STP-1 Grab @ 0715 (HC RM 1.78)	Mtn. View STP-1 Grab @ 1730 (HC RM 1.78)	Mtn. View STP-1 Composite (HC RM 1.78)
BOD_5[2] (mg/L)	1.0	<0.1	0.4	4.0	4.6
BOD_{20}[2] (mg/L)	-	-	-	-	21.2
Total Kjeldahl Nitrogen (mg/L)	0.66	0.56	5.35	5.76	5.68
Ammonia Nitrogen (mg/L)	0.08	0.50	2.81	1.69	2.01
Nitrite Nitrogen (mg/L)	0.05	0.05	0.30	0.31	0.30
Nitrate Nitrogen (mg/L)	1.31	1.31	9.00	4.55	9.14
Total Phosphorus (mg/L)	0.09	0.15	4.0	3.83	4.0
Ortho Phosphorus (mg/L)	0.07	0.12	2.6	2.4	2.8
Chlorophyll a (ug/L)	-	2.40	-	-	-
Chloride (mg/L)	10.2	6.3	42.0	39.9	40.3
Sulfate (mg/L)	10.3	6.2	51.7	47.5	51.6
Total Dissolved Solids (mg/L)	150.6	265.2	403.4	301.0	388.6
Fecal Coliform (#/100 ml)	-	300[3]	-	-	<100[3]
Total Suspended Solids (mg/L)	0.4	6.8	3.6	6.0	4.4

[1] See Table 3 for station identification and location.
[2] Nitrogen suppressed.
[3] Estimated

RESULTS OF LABORATORY ANALYSES (Cont'd)
October 7-8, 1981, Intensive Water Quality Survey

Waste Load Allocation Study
Mountain View, Arkansas

Parameter	Station Number[1]				
	Hughes Ck - B Grab @ 0535 (RM 1.76)	Hughes Ck - B Grab @ 0914 (RM 1.76)	Hughes Ck - B Grab @ 1327 (RM 1.76)	Hughes Ck - B Grab @ 1705 (RM 1.76)	Hughes Ck - B Composite (RM 1.76)
BOD_5[2] (mg/L)	-	1.0	3.0	3.2	5.2
BOD_{20}[2] (mg/L)	-	-	-	-	-
Total Kjeldahl Nitrogen (mg/L)	4.53	4.06	3.85	5.65	3.65
Ammonia Nitrogen (mg/L)	1.89	2.81	3.60	4.39	2.59
Nitrite Nitrogen (mg/L)	0.34	0.33	0.33	0.36	0.34
Nitrate Nitrogen (mg/L)	5.77	6.61	8.56	7.97	7.16
Total Phosphorus (mg/L)	3.17	3.67	3.50	2.67	3.30
Ortho Phosphorus (mg/L)	3.00	2.40	2.40	2.40	2.40
Chlorophyll a (ug/L)	-	-	-	-	1.7
Chloride (mg/L)	29.9	35.1	-	36.9	37.0
Sulfate (mg/L)	37.2	41.7	-	44.3	42.5
Total Dissolved Solids (mg/L)	278.2	305.4	-	243.8	287.2
Fecal Coliform (#/100 ml)	-	-	-	-	<100
Total Suspended Solids (mg/L)	2.8	3.6	5.6	5.2	4.8

[1] See Table 3 for station identification and location.
[2] Nitrogen suppressed.
[3] Estimated

RESULTS OF LABORATORY ANALYSES (Cont'd)
October 7-8, 1981, Intensive Water Quality Survey

Waste Load Allocation Study
Mountain View, Arkansas

Parameter	Station Number[1]				
	Hughes Ck - C Composite (RM 1.60)	Hughes Ck - D Composite (RM 1.10)	Hughes Ck - E Grab @ 1600 (RM 0.77)	Hughes Ck - E Grab @ 1800 (RM 0.77)	Hughes Ck - E Composite (RM 0.77)
BOD_5[2] (mg/L)	5.6	0.9	1.2	-	2.3
BOD_{20}[2] (mg/L)	-	-	-	-	-
Total Kjeldahl Nitrogen (mg/L)	2.82	0.21	1.45	0.32	0.65
Ammonia Nitrogen (mg/L)	1.92	0.16	0.55	0.18	0.40
Nitrite Nitrogen (mg/L)	1.50	0.08	0.09	0.08	0.09
Nitrate Nitrogen (mg/L)	7.53	9.09	5.33	5.61	5.05
Total Phosphorus (mg/L)	2.50	2.50	3.00	3.17	3.00
Ortho Phosphorus (mg/L)	2.40	2.40	2.40	2.40	2.20
Chlorophyll <u>a</u> (ug/L)	0.7	0.3	-	-	1.9
Chloride (mg/L)	33.0	35.5	34.9	33.7	35.4
Sulfate (mg/L)	42.5	47.9	47.3	46.4	48.1
Total Dissolved Solids (mg/L)	275.6	268.8	251.4	244.6	245.2
Fecal Coliform (#/100 ml)	25,000	800	-	-	10,000
Total Suspended Solids (mg/L)	0.4	1.2	7.6	6.4	14.8

[1] See Table 3 for station identification and location.

[2] Nitrogen suppressed.

[3] Estimated

RESULTS OF LABORATORY ANALYSES (Cont'd)
October 7-8, 1981, Intensive Water Quality Survey

Waste Load Allocation Study
Mountain View, Arkansas

Parameter	Station Number[1]				
	Lick Fork - F Composite (RM 1.60)	Lick Fork - G Composite (RM 0.02)	S. Sylamore - H Composite (RM 9.17)		
BOD_5[2] (mg/L)	9.4	0.3	0.3		
BOD_{20}[2] (mg/L)	-	-	-		
Total Kjeldahl Nitrogen (mg/L)	2.71	0.54	0.48		
Ammonia Nitrogen (mg/L)	1.38	0.52	0.33		
Nitrite Nitrogen (mg/L)	0.05	0.05	0.04		
Nitrate Nitrogen (mg/L)	0.70	1.62	1.21		
Total Phosphorus (mg/L)	0.28	0.62	0.33		
Ortho Phosphorus (mg/L)	0.07	0.07	0.23		
Chlorophyll _a_ (ug/L)	-	2.1	1.9		
Chloride (mg/L)	7.7	13.0	7.9		
Sulfate (mg/L)	1.9	25.9	16.9		
Total Dissolved Solids (mg/L)	57.4	129.8	157.6		
Fecal Coliform (#/100 ml)	-	1,100	400		
Total Suspended Solids (mg/L)	31.6	3.2	2.4		

[1] See Table 3 for station identification and location.

[2] Nitrogen suppressed.

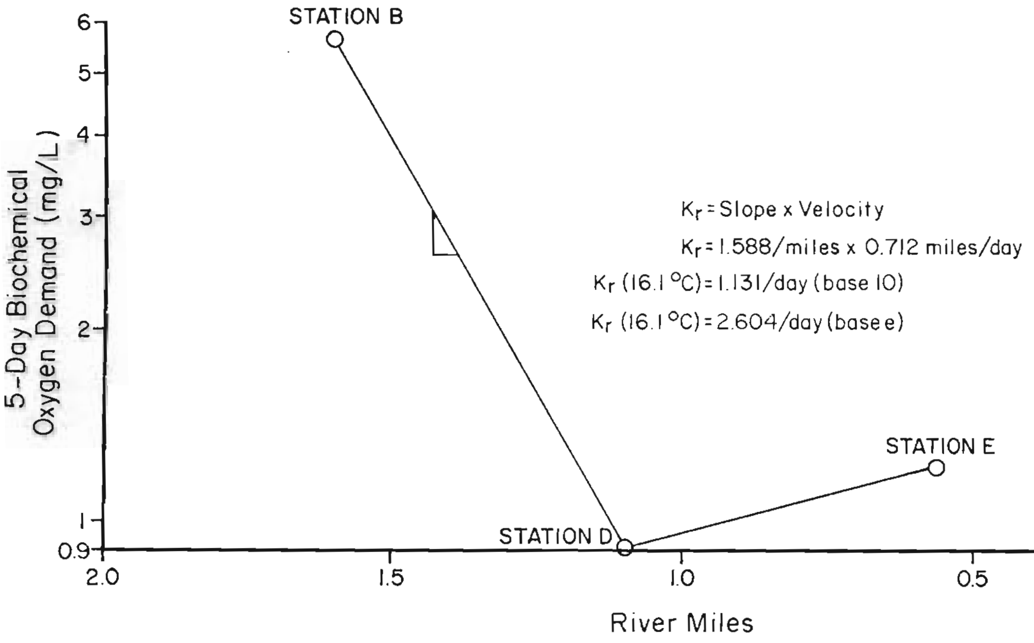
[3] Estimated

BOD SERIES

Waste Load Allocation Study
Mountain View, Arkansas
October 7-8, 1981

Station	BOD_1 (mg/L)	BOD_2 (mg/L)	BOD_3 (mg/L)	BOD_4 (mg/L)	BOD_5 (mg/L)	BOD_{10} (mg/L)	BOD_{20} (mg/L)	$\frac{BOD_u}{BOD_5}$* Ratio
Mountain View STP - 1 (RM 1.78)	<0.1	0.5	0.1	2.4	4.6	12.1	21.2	4.6
Hughes Creek - Station B (RM 1.76)	1.0	2.1	3.1	4.1	5.2	9.5	15.7	3.0
Hughes Creek - Station E (RM 0.77)	0.5	1.0	1.5	1.9	2.3	3.2	4.9	2.1

* Ratio of ultimate biochemical oxygen demand (BOD_u) to 5-day biochemical oxygen demand (BOD_5).



Sample BOD Reaction Rate Calculation

Hughes Creek
October 7-8, 1981

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION VI
1201 ELM STREET
DALLAS, TEXAS 75270

May 2, 1983

Mr. Larry Wilson
Construction Grants Branch
Arkansas Department of Pollution
  Control and Ecology
8001 National Drive
Little Rock, Arkansas 72209

Dear Mr. Wilson:

We have reviewed information provided by Camp Dresser and McKee, Inc. on the Mountain View WLA modeling effort. The responses are satisfactory. The effluent limits recommended the report are as follows:

BOD_5 = 10 mg/l
TSS = 15 mg/l
NH_3 = 10 mg/l
Effluent D.O. = 5 mg/l

These effluent limits will meet the water quality standards if Hughes Creek and Lick Creek are designated as intermittent streams. In addition, the phosphorus problem will not be alleviated by the intermittent stream designation.

The report is sufficient to be included as a part of the information necessary prior to approval of AT funding. As stated previously, we cannot formally approve the WLA until the intermittent stream designations are approved.

Sincerely yours,

Robert B. Elliott

Robert B. Elliott
Chief, Water Quality Management Branch, 6W-Q

cc: Mr. Robert J. Brandes
    Camp Dresser & McKee, Inc.