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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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OFFICE OF WATER

MEMORANDUM

SUBJECT: Final Technical Guidance on Supplementary Stream Design Conditions for Steady State Modeling

FROM: Martha G. Prothro, Director [signature]
Office of Water Regulations and Standards (WH-551)

TO: Water Management Division Directors
Regions I - X

Attached is a copy of the final Technical Guidance on Supplementary Stream Design Conditions for Steady State Modeling. This guidance was reviewed by State, Regional and Headquarters offices and their comments were considered in developing the final manual.

As you know, critical stream design flow, temperature, pH, alkalinity and hardness are necessary parameters for steady-state models to assess impacts of pollutants on water quality. Our technical guidance on stream design flow was made final in August, 1986 and has since been in use. This new technical guidance will help the water quality analysts and NPDES permit writers select critical stream design conditions for temperature, pH, alkalinity, and hardness. Stream design temperature, pH, and alkalinity are necessary for controlling toxicity caused by unionized ammonia; design temperature is needed to assess biochemical oxygen demand caused by oxygen demanding pollutants; and design hardness is necessary to assess needs for controlling heavy metals.

We greatly appreciate the effort of those persons who have contributed to the development of this document. If you have any comments or would like to share your field experiences with us, it will help us in updating the manual as it becomes necessary. All questions or comments regarding the contents of this manual should be directed to:

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TECHNICAL GUIDANCE ON SUPPLEMENTARY STREAM DESIGN CONDITIONS FOR STEADY STATE MODELING

December 1988

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ABBREVIATIONS

ASL	allowable stream loading
CCC	criterion continuous concentration
CMC	criterion maximum concentration
CV	coefficient of variation
DO	dissolved oxygen
UOD	ultimate oxygen demand
WLA	waste load allocation
WQC	water quality criteria

SECTION 1
INTRODUCTION

1.1 Purpose

The purpose of this guidance document is threefold:

1. to describe a computer-based method that may be used to calculate design conditions for flow and such supplemental water quality variables as temperature, pH, alkalinity, hardness, and dissolved oxygen;

2. to describe DESCON, a computer program for calculating design conditions;

3. to provide examples of the use of DESCON in calculating design conditions for a variety of pollutants, rivers, and water quality criteria.

This document is fully consistent with the approaches recommended in the Technical Guidance on Stream Design Flow (US EPA, 1986c) and extends it to include other design condition variables besides streamflow.

1.2 BACKGROUND

Water quality criteria (WQC) define minimally acceptable pollutant concentrations, averaging periods, and allowable excursion frequencies that are protective of aquatic life. The waste load allocation (WLA) process determines the maximum allowable pollutant load that can be introduced into a receiving water and still satisfy the WQC.

When a steady state water quality model is used to deter a WLA, the pollutant loading introduced into the model under given set of assumed water quality conditions (e.g., streamfl temperature, pH) will produce an in-stream pollutant concentr tion that just satisfies the WQC concentration limit. The val of the water quality conditions used as input to the model ar called design conditions. Design conditions should be chosen that waste loads derived from a WLA will also satisfy the applicable WQC excursion frequency.

To achieve this goal, design conditions must somehow be on conditions that define the critical event in the receiving water. Under these conditions, the capacity of the stream to receive waste without violating the WQC concentration has a frequency of occurrence identical to that a. owed by the WQC excursion frequency. The material presented in this guidance document shows how the characteristics of this critical event be identified approximately and used to derive a rational set WLA design conditions.

Most regulatory agencies currently use the 7Q10 or some other extreme value-based low flow as the design flow, and the most critical monthly mean value for all other design conditions. It is difficult to ascertain whether such design conditions will in fact produce WLA's that satisfy the requir excursion frequency. Figure 1.1 shows that the values of the condition variables (flow and temperature in this case) need be at their individual critical levels to produce the critica loading that satisfies the WQC excursion frequency. In this f the critical allowable UOD loading occurs in August, based on and temperature conditions that occur in that same month. The not the same as the individual critical flow and temperature occur in September and July, respectively.

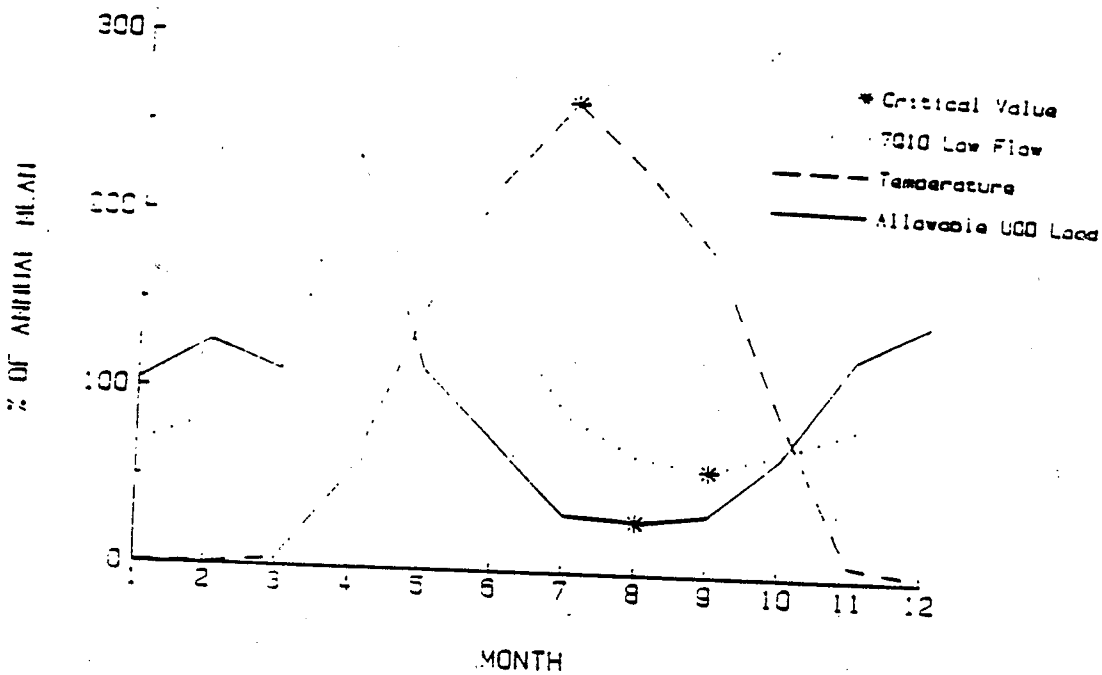

FIGURE 1.1 Occurrence of Critical Conditions For Ultimate Oxygen Demand For the Sheyenne River Near Kindred, ND

Current practice also typically uses the same set of design conditions for several different classes of pollutants. Yet critical events can occur at different times of the year for different pollutants. For example, the critical event for UOD may occur at a different time (e.g., under a different combination of flow and temperature) than the critical event for ammonia toxicity. The practice of using the same design conditions to analyze both pollutants can therefore be questioned.

This guidance document addresses the calculation of design conditions for five categories of pollutants. The pollutants and their corresponding set of design conditions are given in Table 1.1. In simple single discharger settings, design conditions are produced for both the ambient upstream flow and the discharger flow streams. Design conditions for other categories of pollutants may be addressed at a later date, depending on the specific needs of regulatory agencies. The concept of design streamflow and WQC excursion frequency has recently been discussed in the Technical Guidance on Stream Design Flow (U.S. EPA, 1986c). The procedures described in this document utilize the same two methods of defining excursion frequency -- the extreme value method (referred to as the hydrologically-based method) and the biologically-based method. The extreme value method limits the number of years in which one or more excursions occur. The biologically-based method limits the total number of excursions that can occur.

The design conditions discussed in this document are only applicable to constant, year-round WLA policies. They do not pertain to time-varying or seasonal allocations that assign different allowable discharge loads during different periods of the year.

TABLE 1.1 Pollutants and Design Conditions Considered By DESCON

Pollutant	Design Conditions w/o Discharger	Design Conditions w/ Discharger
General toxicant	Flow	Flow Toxicant
Ammonia	Flow Temperature pH	Flow Temperature pH Alkalinity Ammonia
Heavy Metals Cadmium Chromium III Copper Lead Nickel Zinc	Flow Hardness	Flow Hardness Metal
Pentachlorophenol	Flow pH	Flow pH Temperature Alkalinity Pentachlorophenol
Ultimate Oxygen Demand	Flow Temperature Dissolved oxygen	Flow Temperature Dissolved oxygen UOD

Notes: 1. General toxicant refers to any other chemical-spec: pollutant not listed above as well as to generic toxicity (as determined through biomonitoring).

2. Ultimate Oxygen Demand can be simply carbonaceous biochemical oxygen demand or combined carbonaceous and nitrogenous biochemical oxygen demand.

The data necessary to derive design conditions using the procedures described in this document are as follows:

1. historical daily streamflows;
2. historical data (or estimates) of in-stream values of the water quality variables relevant to the pollutant being analyzed;
3. historical data (or estimates) of flow and water quality a discharger if one is considered.

While long-term, multi-year streamflow records are required, methodology makes the best use of whatever water quality data available, no matter how sparse they may be.

1.3 USE OF THIS GUIDANCE

The methodology described in this guidance is implemente means of a computer program called DESCON. DESCON is installe the Agency's IBM mainframe computer in Research Triangle Park North Carolina, and can be accessed through remote telecommunications services. It is a menu-driven, interactive pro that provides automatic linkages with the Agency's STORET dat. to retrieve streamflow and water quality data. The basic step using DESCON to calculate design conditions can be summarized follows:

1. Select the pollutant and type of WQC to use.
2. Retrieve historical stream flow and water quality data u DESCON.
3. If the stream segment contains a single discharger, asse data or estimates for discharger flow and pertinent water quality variables.

4. Run DESCON to find design stream flows and other pertin design conditions.

Figure 1.2 summarizes a typical run of the DESCON progr This run used stream data from the Quinnipiac River near Wallingford, CT to derive design conditions for chronic amm toxicity using the biologically-based method for excursion frequency. The resulting design conditions are:

Design Stream Flow	=	34.8	cfs
Design Stream Temperature	=	23.9	deg. C
Design Stream pH	=	7.6	
Design Stream Alkalinity	=	72.2	mg/L as $CaCO_3$

These were derived from the critical event which occurred c 25, 1957.

1.4 LIMITATIONS AND ASSUMPTIONS

The methodology used in this guidance to derive design conditions for streamflow and other water quality parameters subject to the following limitations and assumptions:

1. Design condition variables (aside from streamflow) inclu temperature, pH, alkalinity, hardness, dissolved oxygen upstream pollutant concentration.
2. The pollutants for which these design conditions are computed include ammonia, six heavy metals, pentachloro-phenol, and dissolved oxygen. All other pollutants are treated as "general toxicants" whose design conditions include only flow and upstream pollutant concentration.
3. In general, the methodology derives different design conditions for different pollutants. The analyst has the option though, of fixing in advance the design streamflc

SUMMARY OF DESCON INPUT DATA

LOCATION	: QUINNIPIAC R, WALLINGFORD
POLLUTANT	: AMMONIA
COLD WATER SPECIES PRESENT	: YES
WQC EXCURSION METHOD	: BIOLOGICALLY-BASED
AVERAGING PERIOD, DAYS	: 4.0
RETURN PERIOD, YEARS	: 3.0
CONCENTRATION LIMIT	: EPA NATIONAL CCC
PERIOD OF RECORD	: ENTIRE RECORD
FLOW ADJUSTMENT FACTOR	: 1.0
DISCHARGER LOCATION	: BELOW FLOW GAGE
RANGE OF UPSTREAM POLLUTANT	: 0.0 TO 0.0 MG/L
RANGE OF UPSTREAM TEMPERATURE	: 1.2 TO 24.0 DEG. C
RANGE OF UPSTREAM PH	: 5.5 TO 8.2
RANGE OF UPSTREAM ALKALINITY	: 25.0 TO 86.0 MG/L
RANGE OF DISCHARGE FLOW	: 32.0 TO 32.0 CFS
RANGE OF DISCHARGE TEMPERATURE	: 14.2 TO 25.3 DEG. C
RANGE OF DISCHARGE PH	: 7.0 TO 7.0
RANGE OF DISCHARGE ALKALINITY	: 245.0 TO 245.0 MG/L

CRITICAL DESIGN CONDITIONS

CRITICAL DAY OF RECORD	: JULY 25, 1957
UPSTREAM FLOW, CFS	: 34.8
UPSTREAM AMMONIA-N, MG/L	: 0.0
UPSTREAM TEMPERATURE, DEG C	: 23.9
UPSTREAM PH	: 7.6
UPSTREAM ALKALINITY, MG/L	: 72.2
DISCHARGE FLOW, CFS	: 32.0
DISCHARGE AMMONIA, MG/L	: 1.9
DISCHARGE TEMPERATURE, DEG C	: 25.0
DISCHARGE PH	: 7.0
DISCHARGE ALKALINITY, MG/L	: 245.0

FIGURE 1.2 Typical Results From the DESCON Program

4. Analyses can be made either with or without considering the effects of a single point discharge to the receiving water. When a discharge source is included, design condit are derived for both the source and the upstream receivir water. Effects of multiple discharges are not considerec
5. Only year-round design conditions are addressed -- not seasonal ones that vary with time of year.
6. Design conditions are based on the long-term variability of daily streamflows and other relevant water quality parameters. Streamflow variability is derived from a mult year historical record of daily streamflows. The daily variation of other design condition variables is assumed follow a deterministic annual pattern that repeats each y
7. When computing design conditions, all pollutants (except ultimate oxygen demand) are assumed to exert their greate in-stream impact at the point of discharge. A simple mass balance (i.e., dilution) equation is used to estimate the degree of this impact for each day of the historical flow record. For oxygen demanding material, a steady-state solution of the Streeter-Phelps dissolved oxygen sag equation determines the maximum in-stream dissolved oxyge impact for each day of the flow record.

1.5 OVERVIEW

Section 2 of this guidance reviews the two methods used to define WQC excursion frequency. Following this review is a discussion of how these methods are used by the DESCON prograr compute design conditions. Section 4 provides a step by step example of how design conditions can be derived for an actual situation. It also demonstrates how these conditions can vary pollutant, WQC excursion criteria, and hydrological regime. Finally, some useful guidelines for utilizing DESCON in the WL process are offered in Section 5.

SECTION 2
WQC EXCURSION FREQUENCIES

2.1 INTRODUCTION

The term "water quality excursion" denotes an unfavora condition occurring with respect to a specific WQC. This cou either be an in-stream toxicant concentration in excess of a upper limit, or, as in the case of dissolved oxygen (DO), a concentration level below a specified lower limit. Because the many stochastic factors that influence water quality, it impractical to specify a WLA that guarantees zero risk of excursions.

Most aquatic communities can either tolerate or readily recover from infrequent, non-catastrophic environmental stre It is therefore statistically necessary and toxicologically reasonable to base a WLA on some acceptably small frequency excursion, providing one carefully defines how excursions an their frequency of occurrence are to be determined. It is th definition which constitutes the meaning of the term "WQC excursion frequency".

Design conditions are the connecting link between WLA's based on steady-state analyses and the time-varying water qu responses that are produced in reality. Design conditions sh be set so that the allowable load derived from a WLA using a steady-state water quality model results in the allowed freq of WQC excursions when the loading is analyzed in a dynamic time-varying) setting.

In conformance with previous guidance developed for des streamflow (US EPA, 1986c), this document acknowledges the u two alternative methods for defining excursion frequencies. following sections reviews each of these in turn.

2.2 EXTREME VALUE-BASED METHOD

This method (referred to as the hydrologically-based approach in the Technical Guidance on Stream Design Flow (US 1986c)) is a logical outgrowth of the customary practice of the xQy low flow in WLA studies. (The xQy, e.g., 7Q10, low f is the lowest annual x-day average flow that occurs an avera once every y years.) When applied to WQC instead of flows, method specifies that on average, one out of every y years w contain one or more excursions. No excursions will occur in other years. Because only the maximum (or for DO, the minimu yearly concentration needs to be examined under this method, is known as an "extreme value" approach.

The parameters x and y of this method are called the averaging period and the return period, respectively. The averaging period should coincide with the averaging period specified within the relevant WQC or state water quality sta (but see below). The return period corresponds to the allowe frequency of occurrence of years containing excursions -- to the frequency of individual excursions. (In this method, there is no control over the number or duration of excursio within an "excursion year".)

In accordance with the recommendations made in the desi streamflow guidance document (US EPA, 1986c), a 10-year retu period should be used with this method. For toxicants with established CMC (Criterion Maximum Concentration) limits, a 1-hour averaging period applies. If this is impractical to implement, a 1-day averaging period can be used instead. For toxicants with an established CCC (Criterion Continuous Concentration), a 7-day averaging period should be used. Alt a 4-day averaging period is normally associated with the CCC criteria (US EPA, 1985f), this recommendation is made mainly achieve consistency with the widespread use of 7Q10 design f

In addition, a 30-day averaging period can be used at the analyst's discretion, when considering the CCC for ammonia toxicity or for any other WQC based on chronic human health effects.

2.3 BIOLOGICALLY-BASED METHOD

The extreme value method has been criticized for its fai to account for the effects of multiple excursions that may oc within the years in which excursions are allowed. It is also difficult to find any biological justification for employing specific return period (e.g., 10 years) when the actual numbe individual excursions within a year is not controlled.

In response to these shortcomings the US EPA's Office of Research and Development proposed a method that uses the averaging periods and excursion frequencies specified in the EPA's national water quality criteria for aquatic life. The biological basis for this method is the concept of providing safe, excursion-free average recovery period between excursio so that ecosystem recovery can occur. A 3-year recovery peric was proposed for normal stresses and a 15-year period was dee reasonable for major stresses associated with prolonged droug

The biologically-based method allows an average of one w quality excursion every three years. A water quality excursic counted for each distinct, non-overlapping x-day period where average in-stream concentration exceeds the WQC concentration limit (or falls below a DO limit). ('x' is the averaging peri specified in the WQC). For example, if each day in a block of consecutive days belonged to a 4-day average that was above t WQC limit then the number of excursions for this block would 10/4 = 2.5. However, within any period of 120 days, no matter great is the actual number of excursions, a maximum of 5 will only be counted. This allows for the maximum recovery period

15 years since if each excursion "consumes" on average 3 yea for recovery, the most severely stressed periods would consu years if no more than 5 excursions were counted (3 x 5 = 15)

An example will help clarify how this method might be applied to a proposed allowable discharger load resulting fr WLA. Using this allowable load and a historical record of da streamflows and other pertinent water quality variables, a l term record (i.e., 20 or more years) of daily in-stream wate quality concentrations can be generated. (Methods for accomplishing this are discussed in the next section of this document.) Suppose that the WQC specifies a 4-day averaging period. Figure 2.1 shows what the resulting long-term record 4-day average concentrations might look like, at least at the start of the record.

Beginning on day 4 there is a period of 8 days, each belonging to a 4-day average that exceeds the WQC limit. The number of excursions counted for this period is 8/4 = 2. Likewise, starting on day 14, a second excursion period of 5 occurs yielding another 5/4 = 1.25 excursions. Since both of these periods fall within the same 120 day window, they are s to belong to the same "excursion cluster". The maximum number excursions counted per cluster is limited to 5. This method c counting excursions would continue over the entire length of simulated water quality response record. If the period of rec were, say, 40 years, then the total excursion count could not exceed 40/3 = 13.33 in order for the biologically-based excur frequency criterion to be satisfied.

In summary, the parameters that define the biologically-based method and their recommended values are as follows:

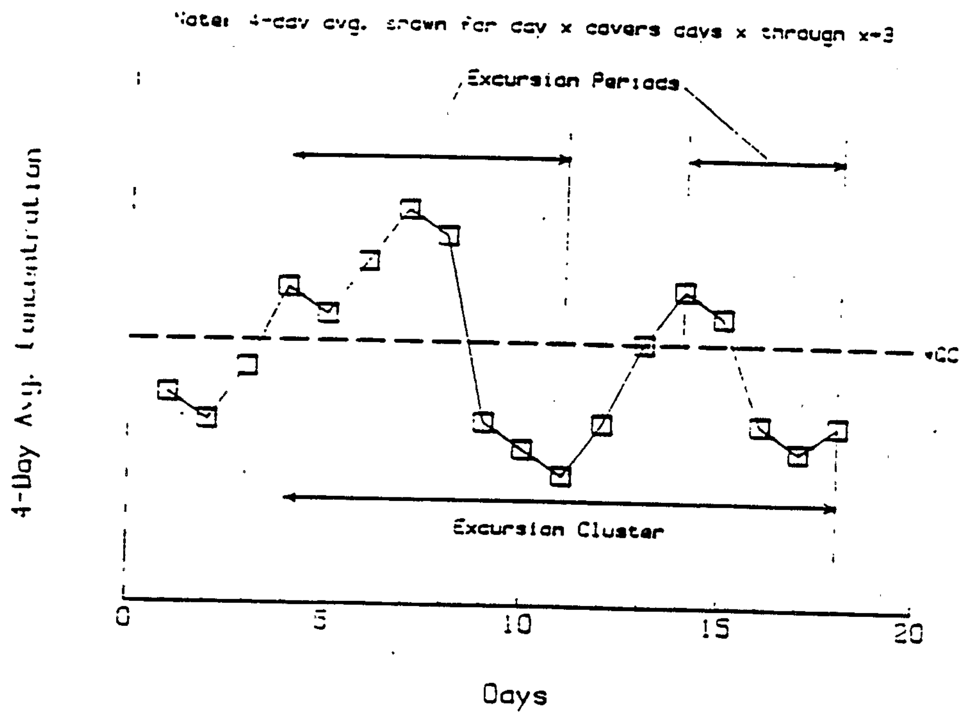

FIGURE 2.1 Illustration of Biologically-Based Method of Counting WQC Excursions

4 days for CCC normally;

30 days for ammonia CCC or for chronic human health crite

Allowed excursion frequency:

once every three years, on average;

Length of time used to group excursion periods into clusters

120 days;

Maximum number of excursions per cluster:

5.

SECTION 3
COMPUTATIONAL METHOD

3.1 INTRODUCTION

This section describes the computational steps utilized the computer program DESCON to derive a set of situation-spec design conditions. DESCON computes design conditions accordin the following four step procedure (see Figure 3.1):

1. A long-term record of daily streamflow and water quality parameter values is assembled for the stream segment in quest

. The allowable stream load (i.e., the pollutant load that meets the WQC concentration limit) is computed for conditions occur over each day of the period of record.

3. The synthesized record of allowable stream loads is searc for the critical load, i.e., the load whose frequency of not exceeded just satisfies the frequency specified in the WQC excursion criterion.

4. Design conditions are based on conditions realized during period of record when the allowable stream load is closest to critical load.

The following sections elaborate on each of these steps.

3.2 ASSEMBLING DAILY STREAM DATA RECORDS

Long-term daily streamflow records are automatically ext from the STORET system and linked to the computations by DESC Similar detailed records on stream temperature, pH, etc., are likely to exist so some approximate assumptions have to be ma

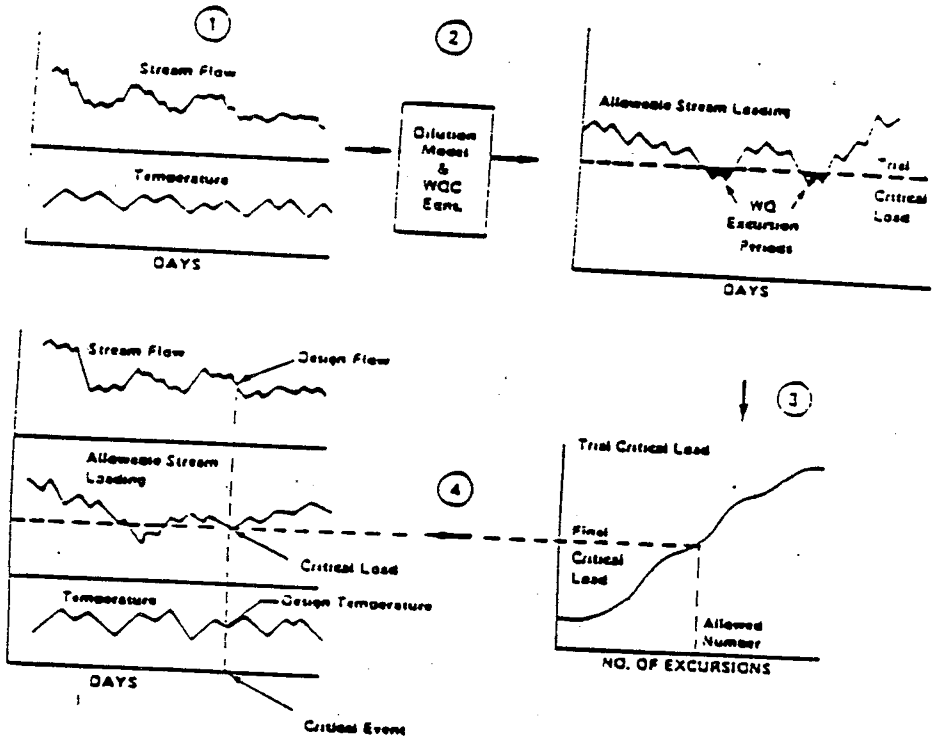

FIGURE 3.1 Computational Scheme for Deriving Design Conditions

DESCON assumes that daily values of these supplementary c variables follow a deterministic annual pattern that repeats e 365 days. The DESCON user supplies the day of the year and its corresponding water quality parameter v- le for each relevant design variable. Linear interpolation is used to fill in value missing days.

Figure 3.2 shows how this method can accommodate various levels of data availability. Case A indicates the general case where data are available throughout the year although no gener seasonal pattern is evident. In Case B, the historical data ha been fitted to a sinusoidal function. This type of representat is most appropriate for stream temperature and dissolved oxyge C and D are cases where the historical data for each month of year are best represented by a single value, either the mean, median, or perhaps the most critical value. In Case C, this va is placed at the midpoint of the month and DESCON uses linear interpolation to find values for the intervening days. For Cas the value is placed at each endpoint of the month. Interpolati then results in a constant value throughout the month.

DESCON contains a utility routine that can extract whatever daily parameter measurements are available from STORET ar compute their overall means for any day or month of the year. routine can also fit a sinusoidal function to the daily values provide the user with a goodness of fit measure, and then, if instructed, use the fitted function to compute daily parameter values. These are then stored in a file for future processing. When DESCON requires that daily discharger flow ar water quality parameter data be provided for each day of the y the same representation schemes can be applied.

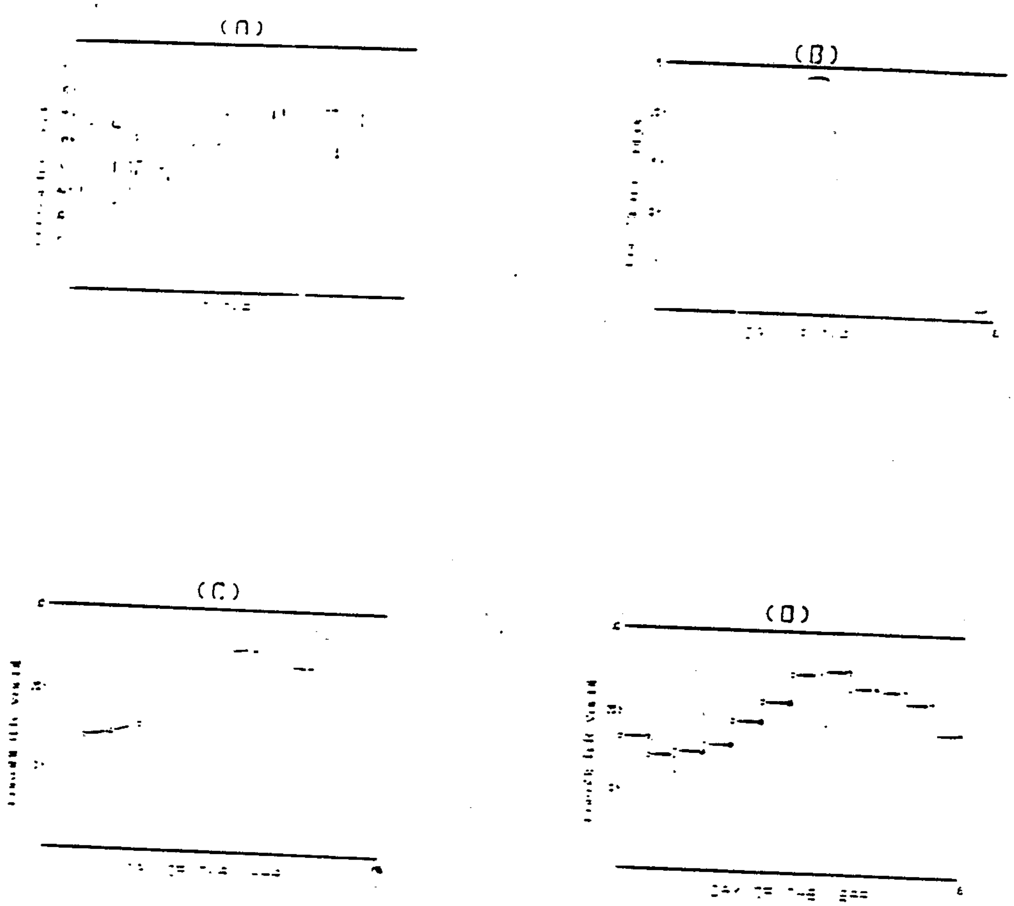

FIGURE 3.2 Schemes for Representing Daily Variation in Water Quality Parameters

More sophisticated methods that generate daily values in stochastic fashion can also be employed by DESCON. However, t approach taken in this guidance manual assumes that it is mor important to capture the predictable seasonal variability of quality variables rather than their random fluctuations.

3.3 DERIVATION OF ALLOWABLE STREAM LOADINGS

The allowable stream loading (ASL) is defined to be the maximum amount of pollutant the water body can receive over a specified averaging period and still meet the applicable WQC concentration limit. In general the ASL will depend on the streamflow, temperature, pH, etc., that occur during the peri averaging.

The ASL is based on the simple dilution (or mass balance equation that adds discharge flow to upstream flow:

$$C3 * Q3 = C1 * Q1 + C2 * Q2$$

where: C1 = upstream pollutant concentration
C2 = discharger pollutant concentration
C3 = downstream pollutant concentration
Q1 = upstream streamflow
Q2 = discharger flow
Q3 = Q1 + Q2

The ASL is found by manipulating this expression as follows:

1. solve for C3,
2. average each side of the resulting expression over the duration specified in the WQC,
3. replace the average value of C3 with the WQC concentrat limit,
4. solve the resulting expression for C2 and set this equa ASL.

The final result is

$$ASL = ([WQC]_{avg} - [C1*Q1/Q3]_{avg}) / [Q2/Q3]_{avg}$$

where WQC is the criterion concentration limit and the notati[on] [ ]avg represents the x-day average of the quantity in brack[ets]. Under this definition, allowable stream loading is expressed [in] concentration units (mass/volume).

Some situations might require that design conditions be established without knowledge of discharger characteristics. [An] example would be a stream segment containing multiple dischar[gers] that cannot be lumped together into a single equivalent disch[arge] for analysis purposes. In this case DESCON can compute an in-[stream] ASL defined as

$$ASL = [WQC]_{avg} / [1/Q1]_{avg}$$

based on the same method of averaging used previously. This f[orm] of the ASL is expressed in units of mass/time. Naturally, it [is] preferable to run DESCON with discharger information supplied [to] it whenever possible.

DESCON evaluates the ASL expression for each day of the historical flow record. As an example, consider an analysis t[hat] uses a 4-day averaging period with Eq. 2. DESCON would first collect values of Q1, Q2, C1 and any supplementary water qual[ity] variables it needs to compute WQC for the first four days of period of record. It then computes the 4-day averages of the [WQC], [C1*Q1/(Q1+Q2)], and [Q2/(Q1+Q2)]. These are then combin[ed] using Eq. 2 to compute an ASL for day 1. The same procedure i[s] followed to compute an ASL for day 2, using averages compile[d] data for days 2 through 5. This process is repeated for each succeeding day in the period of record. A 50-year record woul[d] therefore result in 50*365 = 18,250 evaluations.

The values of Q1 come directly from the historical stream record. Values for C1 and Q2 come from the daily records of upstream pollutant concentration and discharger flow, respecti that are supplied by the user (see the discussion in Section 3 above). Values of the WQC limit can be functions of such supplementary design variables as temperature, pH, and hardnes For example, Figure 3.3 shows how the US EPA's CCC limit on to ammonia is related to stream temperature and pH. Sections A.1 through A.3 of Appendix A describe the equations used to compu WQC limits for ammonia, heavy metals, and pentachlorophenol, respectively.

Note that in Eq. 1, the WQC value refers to the criterior limit that exists in the mixture of upstream and discharge flo Prior to using the WQC equations in Appendix A, DESCON first computes the mixture values of any supplementary variables suc temperature, pH, or hardness. To properly compute a mixture pH knowledge of upstream and discharger alkalinity is also requir This is why alkalinity is also considered to be a supplementar design variable. Section A.5 of Appendix A describes the equat that carry out the mixing computations.

The use of Eq. 1 to derive ASL values for Ultimate Oxygen Demand (UOD) requires some special discussion. First of all, is no in-stream concentration criterion limit placed on UOD pe Rather, it is dissolved oxygen (DO) that is regulated. However effective WQC limit for UOD can be established by computing th maximum initial UOD that the stream can tolerate without havin downstream DO drop below the applicable DO criterion concentr Section A.4 of Appendix A describes how this UOD limit can be derived from a simple Streeter-Phelps DO sag analysis that ta into account the effects of temperature on saturation DO and rates of UOD decay, reaeration, and benthic demand.

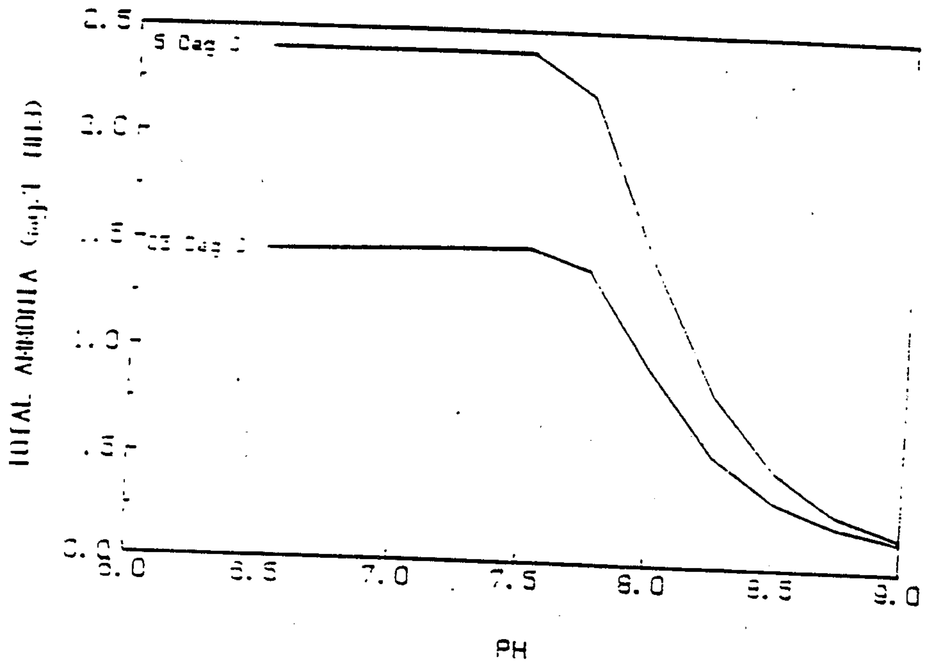

FIGURE 3.3 Criterion Continuous Concentration for Total Ammoni

The method of averaging used with Eq. 1 will not be valic UOD because the Streeter-Phelps model used in Appendix A is or applicable to steady-state conditions. It does not take into account the effect that varying times of travel over the peric averaging will have on the location and magnitude of the crit: DO sag . To cope with this problem, Eq. 1 can be used as a ste state approximation to the actual day-to-day variations that c over the averaging period. As a result, the ASL equations for are as follows:

$$ASL = \frac{[UOD * Q3]_{avg} - [C1]_{avg} * [Q1]_{avg}}{[Q2]_{avg}} \qquad \text{with discharger present}$$

$$ASL = [UOD * Q1]_{avg} \qquad \text{without discharger}$$

where UOD is the maximum initial UOD that meets the DO criter under the average flow, temperature, and upstream DO conditio

One other exception was made to the way Eq. 1 was used t compute ASL's. For the case of the extreme value WQC excursio criterion applied to a general toxicant with no discharger da considered, the ASL expression is

$$ASL = [WQC]_{avg} * [Q1]_{avg}$$

as opposed to Eq. 3. In this situation, the only design condi is a design streamflow of the xQy (e.g., 7Q10) variety. This equation allows DESCON to produce xQy design flows equal to t based on current practice (i.e., a Log Pearson Type 3 frequen analysis of the annual minimum x-day average flows). Table 3. summarizes the various equations used to compute an ASL for e day of the historical flow record.

TABLE 3.1 Expressions for Allowable Stream Loading Over a Specified Averaging Period

Pollutant	With Discharger	Without Discharger
Ammonia, Heavy Metals, Pentachlorophenol, and General Toxicant[1]	$\frac{[WQC]_{avg} - [C1*Q1/Q3]_{avg}}{[Q2/Q3]_{avg}}$	$\frac{[WQC]_{avg}}{[1/Q1]_{avg}}$
General Toxicant[2]	Same as above	$[WQC]_{avg}*[Q1]_{avg}$
Ultimate Oxygen Demand	$\frac{UOD*[Q3]_{avg} - [C1]_{avg}*[Q1]_{avg}}{[Q2]_{avg}}$	$UOD*[Q1]_{avg}$

Notes: 1. Under biologically-based WQC excursion criterion
2. Under extreme value WQC excursion criterion

3.4 DETERMINATION OF CRITICAL LOADS

DESCON defines the critical load as the largest constant amount of pollutant the water body can receive and still satis the applicable WQC excursion frequency. For a proposed critica load, excursions will occur during any period of the synthesiz ASL record where this load exceeds the ASL. DESCON searches fo the largest critical load whose resulting pattern of excursion meets the WQC excursion frequency. This search is carried out two different ways, depending on whether the extreme value or biologically-based method is employed.

For the extreme value method, a Log Pearson Type 3 freque analysis is used to find the minimum annual ASL with the requi return period (typically 10 years). This value then becomes th critical load. The analysis begins by first identifying the lo ASL value for each year of the simulated record. Thus if a 50 record was being used, there would be 50 minimum annual ASL's. Then the mean (u), standard deviation (s), and skewness coefficient (g) of the natural logarithms of these numbers are found. The critical load (L^*) is found from the following equa

$$L^* = \exp(u - K(g,y)*s)$$

where y is the return period (years) on extreme value excursic and K is a frequency factor expressed as a function of skewnes (g) and return period (y). The frequency factor, K, can be calculated from the following equation given in Loucks, et al. [1981]:

$$K(g,y) = (2/g)[(1 - (g*z)/6 - g^2/36)^3 - 1]$$

where z is the frequency factor for the standard normal probab distribution at probability level 1/y. The latter can be found using [Joiner and Rosenblatt, 1971]:

$$z = 4.91\left[(1/y)^{.14} - (1 - 1/y)^{.14}\right].$$

Under the biologically-based method, a particular critic. load L will produce a certain number of excursions E, when co: with the synthesized ASL time series. The larger is L, the mo excursions will result over the period of record as shown in 3.4. Of course, the exact shape of this relationship is not k: at the outset of the analysis. DESCON uses a numerical root-f procedure known as the Method of False Position to find the critical load L* that results in E* = N/3 where N is the leng· record in years. The term N/3 represents the allowed number o excursions in the biologically- based method (i.e., one excu every 3 years on average).

Figure 3.4 depicts how the iterative search for L* is ca out. At any given stage of the process two points have been identified on the E versus L relation [(L1,E1) and (L2,E2)] t. are known to bracket the desired point (L*,E*). A new trial critical load, L3, is found by interpolating at E* on the str. line connecting these two points. The number of excursions, E resulting from L3 is then found. If this number is within a s: tolerance of E* the process stops with L* = L3. Otherwise it continues with (L3,E3) replacing (L1,E1) if E3 < E* or (L3,E3 replacing (L2,E2) if E3 E*.

3.5 DERIVATION OF DESIGN CONDITIONS

Design conditions can be derived from the critical load finding the values of streamflow and the supplementary water quality variables that satisfy the simple dilution equation (Table 3.1). From a strictly mathematical view, all sets of va that satisfy the equation would be acceptable since they prod the same critical load in a simple WLA analysis. However, intuitively it is more appealing if they represent conditions

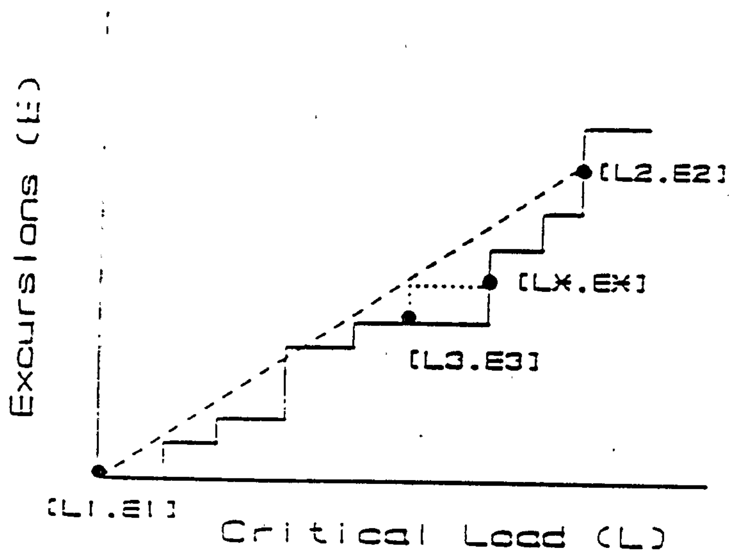

FIGURE 3.4 Relationship Between Critical Load and Number of Biologically-Based WQC Excursions

occurring during the critical event in the period of record.

DESCON defines the critical event in the period of recorc the day whose ASL value comes closest to the critical load. Th average streamflow and supplementary water quality parameter occurring over the WQC averaging period starting on this day a used as the design conditions (see panel 4 of Figure 3.1).

One result of this procedure is that analyses made on dif pollutants in the same stream segment will produce different c conditions. This is to be expected because the critical condit for say Ultimate Oxygen Demand may occur at a different time t those for ammonia since their dependence on such factors as st flow, temperature, and pH are quite different. The analyst may however, want to maintain at least the same design streamflow all pollutants undergoing a WLA. In some states this may be a requirement as in those which mandate the use of the 7Q10 low In this case DESCON can be asked to find the minimal adjustme the original supplementary design conditions that will satisf dilution equation under the calculated critical load and user-prescribed design flow.

SECTION 4
EXAMPLE CASE STUDIES

Two rivers located in different geographic regions were (to illustrate the calculation of design conditions using DESC(The Quinnipiac River in Connecticut is first analyzed in some detail to give the reader a step by step guide to using the program. Then results for a second river, the Uncompahgre in Colorado, are summarized to illustrate how design conditions (change under a different hydrological and climatological regi

4.1 QUINNIPIAC RIVER

The Quinnipiac River in Connecticut is an example of a s where the low flow and high temperature seasons coincide. Thu would expect the critical design event for most pollutants to in this period (late summer to early fall). The 7Q10 low flow this river is approximately 32 cfs.

DESCON was used to estimate design conditions for chroni ammonia toxicity in this river. The 4-step procedure for usin DESCON, first presented in Section 1.3, was followed and is repeated here:

1. Select the pollutant and type of WQC to use.
2. Retrieve historical daily streamflow and water quality d using DESCON.
3. Assemble data or estimates for discharger flow and perti water quality variables, if possible.
4. Run DESCON to find design streamflow and other pertinent design conditions.

How each of these steps was applied to the Quinnipiac River w be discussed in the sections that follow.

4.2 POLLUTANT AND WQC SELECTION

The pollutant of concern for this example was taken to b ammonia. The WQC concentration limit was the US EPA National ((Criterion Continuous Concentration) for protection against c aquatic toxicity. This limit is a function of both stream temperature and pH as depicted in Figure 3.3. This criterion a distinguishes between streams that support cold water species those that do not. This example assumed that cold water specie were present in the Quinnipiac.

The initial run of DESCON used the biologically-based met of defining WQC excursion frequencies. Recall that the default definitions of the parameters for this method are as follows (Section 2.3):

Averaging Period:	4 days
Excursion Frequency:	once every three years
Length of time used to group excursion periods into clusters:	120 days
Maximum number of excursions counted per cluster:	5

In subsequent runs the averaging period was changed to 30 days the analysis was repeated using the extreme value method of defining WQC excursions.

4.3 RETRIEVAL OF STREAM DATA

The first operation performed with DESCON itself was the retrieval of daily streamflow data from STORET. This data was automatically saved in a file named FLOW.DATA and could be use over and over again in subsequent design condition calculation for this stream. This particular example used the flow records

USGS gage number 01196500 located near Wallingford, Connectic
Figure B.1 in Appendix B depicts the dialogue used with DESCC
perform this retrieval.

The supplementary design condition variables for ammonia
include temperature, pH, and, since discharger data was provi
for this example, alkalinity and upstream ammonia (see Table
The DESCON user must be prepared to provide representative da
values of these quantities at various times of the year. To a
in this task, DESCON was asked to retrieve selected water qua
data from STORET. This data was automatically saved in a file
PARAM.DATA. Figure B.2 illustrates how this retrieval was ma
For this example, water quality data was taken from the same
station that recorded the flow data.

The next step was to perform further analysis on the
retrieved water quality data. For each parameter, DESCON dete
how much data there was, how it varied from day to day and ye
year, and whether its daily variation could be represented wi
sinusoidal function or not. Figure B.3 shows part of the dial
used with DESCON to perform such an analysis for temperature
Quinnipiac.

As a result of these analyses, the daily variation in st
temperature was represented by the following sinusoidal funct

$$T = 12.56 - 4.3\sin(0.0172\ d) - 10.6\cos(0.0172\ d)$$

where T is temperature (degrees C) and d is day of the year (
January 1 being day 1). The coefficient of determination (i.e
squared) of the fit for this expression was 93 percent. DESCO
was instructed to compute the temperature for each day of the
with this formula and save the resulting values in a file nam
STREAM.DATA. These daily temperature values are depicted in
Figure 4.1.

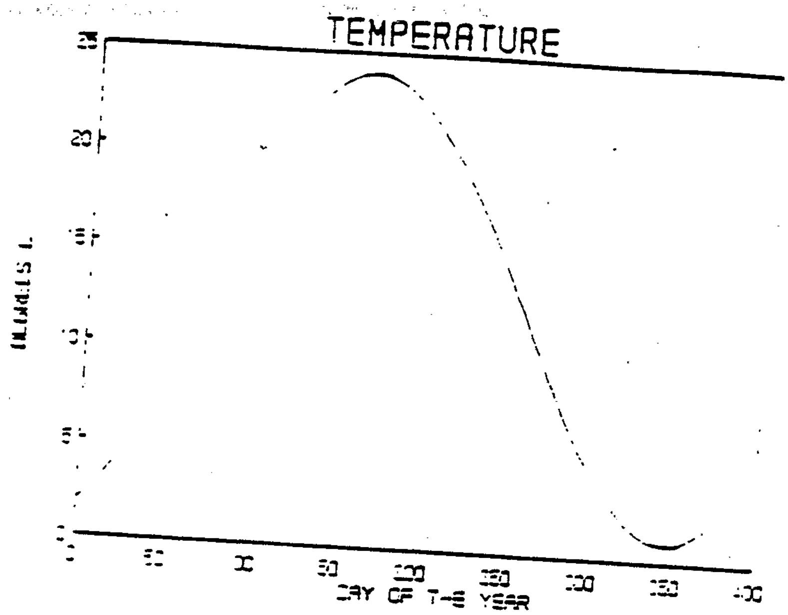

FIGURE 4.1 Daily Temperatures in the Quinnipiac River

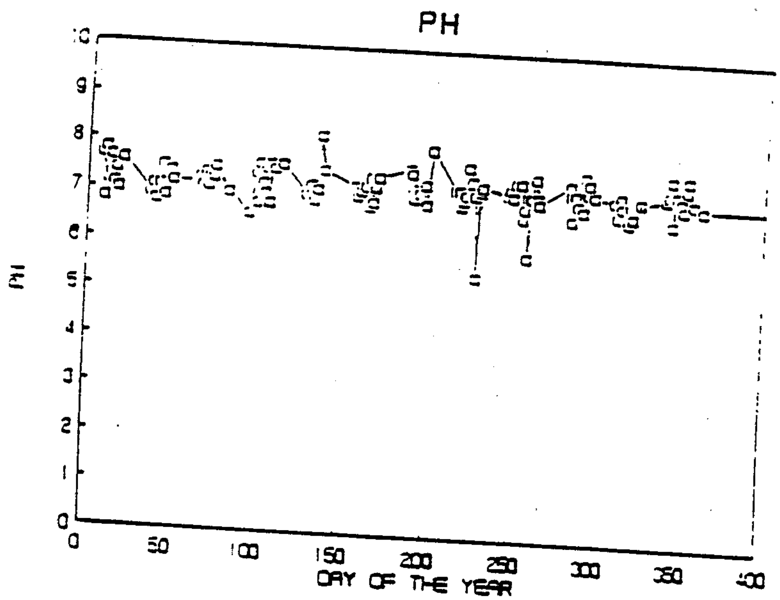

FIGURE 4.2 Daily pH in the Quinnipiac River

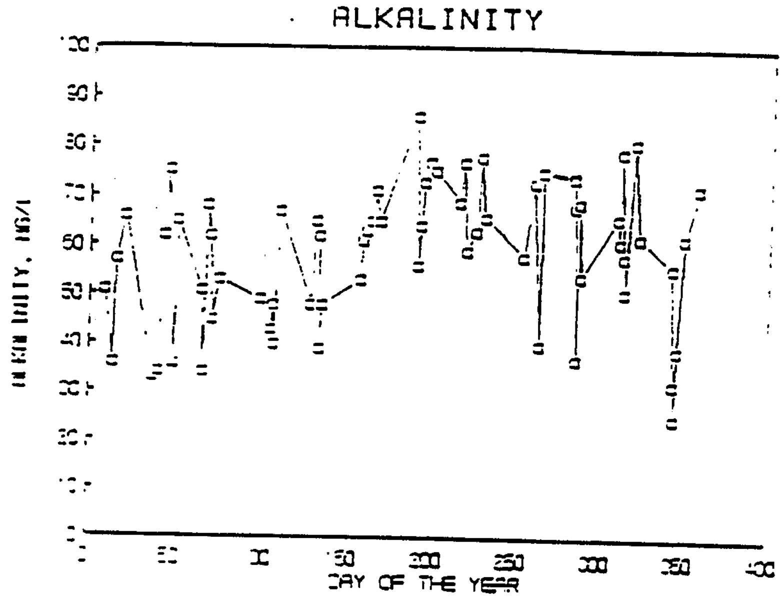

FIGURE 4.3 Daily Alkalinity in the Quinnipiac River

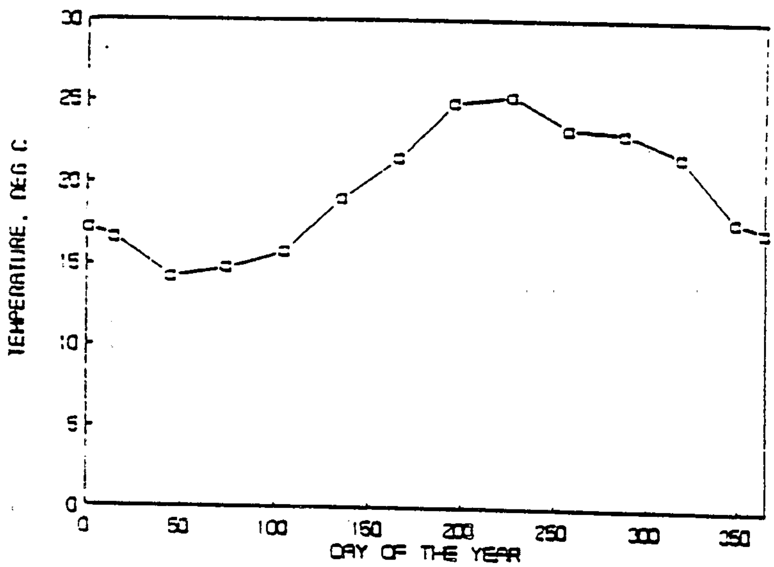

FIGURE 4.4 Daily Temperature of Discharge to the Quinnipiac River

A similar analysis was made for pH and alkalinity. These parameters had 129 and 66 days of the calendar, respectively, which measurements were recorded since 1970. There was no appa cyclical trend to this data. Therefore DESCON was instructed save the daily means for each of these parameters in the file STREAM.DATA. These data are shown in Figures 4.2 and 4.3. The straight lines between the observed points represents the mann in which DESCON interpolates for days with no data. The examp. assumed that no upstream ammonia data were available. A consta background concentration of zero was used in all subsequent computations.

4.4 SPECIFICATION OF DISCHARGER DATA

The ammonia discharger in this example was assumed to be located just downstream of the gage location at which streamf: was recorded. This meant that the recorded streamflows did not to be modified to account for runoff or abstractions between t gage and the discharger.

Detailed daily records on flow, pH, and alkalinity were r available for the discharger. Instead these parameters were as to have constant values as follows:

Flow = 32 cfs (equal to the 7Q10 streamflow)
pH = 7
Alkalinity = 245 mg/L as $CaCO_3$

Temperature was assumed to vary throughout the year as shown . Figure 4.4

4.5 COMPUTATION OF DESIGN CONDITIONS

At this point of the analysis the following preliminary had been carried out:

1. Daily streamflow data were extracted from STORET and pla in the file FLOW.DATA.

Daily water quality parameter data were extracted from STORET and placed in the file PARAM.DATA.

3. The water quality data in file PARAM.DATA were converted into representative daily values of stream temperature, pH, and alkalinity which were then stored in the file STREAM.DATA.

4. Representative daily discharger data for flow, temperat pH, and alkalinity were specified.

With this data on hand, DESCON was ready to compute design conditions.

Figure 4.5 below presents a summary of the input data fe DESCON and the resulting design conditions that it computed. entire interactive dialogue is shown in Figure B.4 of Appendi The critical conditions were observed to occur in July at a critical ammonia loading of 1.9 mg/L from the discharger. The resulting design conditions were:

Parameter	Upstream	Discharge
Flow, cfs	34.8	32.0
Temperature, deg C	23.9	25.0
pH	7.6	7.0
Alkalinity, mg/L	72.2	245.0
Ammonia, mg/L	0.0	1.9

The WQC excursions produced by this loading are shown in Figu 4.6. The most severe excursion occurred during seven days in of 1936. The most prolonged excursion occurred during the sum of 1966.

```
                    SUMMARY OF DESCON INPUT DATA
=====================================================================
LOCATION
POLLUTANT                            : QUINNIPIAC R, WALLINGFORD
COLD WATER SPECIES PRESENT           : AMMONIA-N
WQC EXCURSION METHOD                 : YES
AVERAGING PERIOD, DAYS               : BIOLOGICALLY-BASED
RETURN PERIOD, YEARS                 :     4.0
CONCENTRATION LIMIT                  :     3.0
PERIOD OF RECORD                     : EPA NATIONAL CCC
FLOW ADJUSTMENT FACTOR               : ENTIRE RECORD
DISCHARGER LOCATION                  :     1.0
RANGE OF UPSTREAM POLLUTANT          : BELOW FLOW GAGE
RANGE OF UPSTREAM TEMPERATURE        :     0.0    TO    0.0    MG/L
RANGE OF UPSTREAM PH                 :     1.2    TO   24.0    DEG. C
RANGE OF UPSTREAM ALKALINITY         :     5.5    TO    8.2
RANGE OF DISCHARGE FLOW              :    25.0    TO   36.0    MG/L
RANGE OF DISCHARGE TEMPERATURE       :    32.0    TO   32.0    CFS
RANGE OF DISCHARGE PH                :    14.2    TO   25.3    DEG. C
RANGE OF DISCHARGE ALKALINITY        :     7.0    TO    7.0
                                         245.0    TO  245.0    MG/L

                    CRITICAL DESIGN CONDITIONS
=====================================================================
CRITICAL DAY OF RECORD
UPSTREAM FLOW, CFS                   :   JULY 25, 1957
UPSTREAM AMMONIA-N, MG/L             :            34.8
UPSTREAM TEMPERATURE, DEG C          :             0.0
UPSTREAM PH                          :            23.9
UPSTREAM ALKALINITY, MG/L            :             7.6
DISCHARGE FLOW, CFS                  :            72.2
DISCHARGE AMMONIA-N, MG/L            :            32.0
DISCHARGE TEMPERATURE, DEG C         :             1.9
DISCHARGE PH                         :            25.0
DISCHARGE ALKALINITY, MG/L           :             7.0
                                                 245.0
```

FIGURE 4.5 Design Conditions on Ammonia in the Quinnipiac Ri

HISTORICAL EXCURSIONS FOR PERIOD 1931 - 1986				
EXCURSION CLUSTERS		EXCURSION PERIODS		
START DATE	NUMBER OF EXCURSIONS	START DATE	DURATION (DAYS)	MAGNITUDE*
JUL 21, 1932	1.50	JUL 21, 1932	6	4.6
JUL 27, 1933	1.00	JUL 27, 1933	4	0.4
AUG 14, 1936	.75	AUG 14, 1936	-	21.1
JUL 25, 1941	1.00	JUL 25, 1941	4	1.1
AUG 4, 1955	1.00	AUG 4, 1955	4	2.5
AUG 8, 1957	1.00	AUG 8, 1957	4	0.2
JUL 11, 1966	5.00	JUL 11, 1966	18	9.2
		JUL 30, 1966	16	16.2
		AUG 18, 1966	18	17.3
		SEP 6, 1966	6	9.3
AUG 1, 1970	2.25	AUG 1, 1970	4	3.0
		AUG 13, 1970	5	6.8
AUG 16, 1986	1.00	AUG 16, 1986	4	3.0
TOTAL	15.50			

* % BY WHICH CRITERION CONCENTRATION IS EXCEEDED

FIGURE 4.6 WQC Excursions Under Ammonia Design Conditions

A 30-day averaging period may also be used when analyzing chronic ammonia toxicity. A second run of DESCON was made kee all input values the same except that a 30-day averaging peri was used in computing the WQC. The resulting design condition contrasted with those listed above (based on 4-day averages) Table 4.1. The design streamflow increased from 34.9 to 54.4 and the critical ammonia discharge load increased from 1.9 to mg/L. Another set of DESCON runs were made for both 7-day and day averaging periods using the extreme value method of defin WQC excursions. A ten year return period was specified. The r of these runs are also given in Table 4.1 and show only minor differences with those derived from the biologically-based me

4.6 DESIGN CONDITIONS FOR OTHER POLLUTANTS

DESCON was also used to compute design conditions for lea Ultimate Oxygen Demand (UOD) in the Quinnipiac River. Chronic criteria for both the biologically-based and extreme value WQ excursion methods were analyzed. Daily stream dissolved oxyge (for UOD analysis) and hardness (for lead analysis) were retr from STORET and placed in the file STREAM.DATA by DESCON. Tab summarizes the DESCON input used for these pollutants. The resulting design conditions, including those already computed ammonia, are displayed in Table 4.3.

The results show that critical conditions occur in eithe or August for all three pollutants. The design streamflows fo ammonia and UOD are similar (slightly higher than the 7Q10 fl 32 cfs) while the design flow for lead is considerably below 7Q10 flow. The differences in design conditions based on the definitions WQC excursion frequencies are minor.

TABLE 4.1 Comparison of Design Conditions for Ammonia in the Quinnipiac River

	4-Day Averages Upstream	4-Day Averages Discharge	30-Day Averages Upstream	30-Day Averages Discha[rge]
A. Biologically-Based WQC Excursion Method				
Critical Period	July	July	July	[illegible]
Flow, cfs	34.8	32.0	54.4	[illegible]
Temperature, deg.	23.9	25.0	23.5	[illegible]
pH	7.6	7.0	7.3	[illegible]
Alkalinity, mg/L	72.2	245.0	68.5	[illegible]
Ammonia, mg/L	0.0	1.9	0.0	[illegible]
B. Extreme Value-Based WQC Excursion Method				
Critical Period	July	July	July	[illegible]
Flow, cfs	35.9	32.0	48.7	[illegible]
Temperature, deg. C	23.7	24.4	23.8	[illegible]
pH	7.2	7.0	7.4	[illegible]
Alkalinity, mg/L	70.3	245.0	70.0	24
Ammonia, mg/L	0.0	1.9	0.0	[illegible]

TABLE 4.2 DESCON Input Data for Lead and UOD in the Quinnip River

Location	: Quinnipiac R at Wallingford			
Pollutant	: Lead UOD			
K1 Coefficient at 20 Deg. C	: 0.23 1/days			
K2 Coefficient at 20 Deg. C	: 0.46 1/days			
Benthic Demand at 20 Deg. C	: 0.0 mg/L/day			
Averaging Period, Days	: 4 (Bio-Based Method) 7 (Extreme Value Method)			
Return Period, Years	: 3 (Bio-Based Method) 10 (Extreme Value Method)			
Concentration Limit.	: EPA National CCC (Lead) 5.0 mg/L (UOD)			
Period of Record	: Entire Record			
Flow Adjustment Factor	: 1.0			
Discharger Location	: Below Flow Gage			
Range of Upstream Pollutant	: 0.0	to	0.0	mg/L
Range of Upstream Temperature	: 1.0	to	24.0	Deg.
Range of Upstream Hardness	: 39.0	to	120.0	mg/L
Range of Upstream Diss. Oxygen	: 4.2	to	15.0	mg/L
Range of Discharge Flow	: 32.0	to	32.0	cfs
Range of Discharge Temperature	: 14.2	to	25.3	Deg.
Range of Discharge Hardness	: 250.0	to	250.0	mg/L
Range of Discharge Diss. Oxygen	: 5.5	to	5.5	mg/L

TABLE 4.3 Design Conditions for Ammonia, Lead, and UOD in the Quinnipiac River

A. Biologically-Based WQC Excursion Method (4-Day Averages)

	UPSTREAM			DISCHARGE		
	NH_3	Lead	UOD	NH_3	Lead	UC
Critical Period	July	August	August	July	August	Auç
Flow, cfs	34.8	17.4	37.1	32.0	32.0	32.
Temperature, deg. C	23.9	-	23.6	25.0	-	25.
PH	7.6	-	-	7.0	-	-
Alkalinity, mg/L	72.2	-	-	245.0	-	-
Hardness, mg/L	-	103.8	-	-	250.0	-
Diss. Oxygen, mg/L	-	-	7.0	-	-	5.
Pollut. Concen., mg/L	0.0	0.0	0.0	1.9	11.9 (ug/L)	21.

B. Extreme Value-Based WQC Excursion Method (7-Day Averages)

	UPSTREAM			DISCHARGE		
	NH_3	Lead	UOD	NH_3	Lead	UC
Critical Period	July	August	August	July	August	Auç
Flow, cfs	35.9	23.8	38.7	32.0	32.0	32.
Temperature, deg. C	23.7	-	23.6	24.4	-	25.
PH	7.2	-	-	7.0	-	-
Alkalinity, mg/L	70.3	-	-	245.0	-	-
Hardness, mg/L	-	97.6	-	-	250.0	-
Diss. Oxygen, mg/L	-	-	7.3	-	-	5.
Pollut. Concen., mg/L	0.0	0.0	0.0	1.9	12.2 (ug/L)	22.

4.7 UNCOMPAHGRE RIVER

In contrast to the Quinnipiac River, the low flow seaso: the Uncompahgre River in Colorado occurs in winter. It is no· clear any more which season is most critical for different categories of pollutants. Design conditions for this river we computed with DESCON and compared to those for the Quinnipiac

The same pollutants and WQC excursion methods were used before. A hypothetical discharger was placed just downstream the flow gage at Delta, Colorado (USGS Station 09149500). The from this discharger was set equal to the 7Q10 river flow, 5: Table 4.4 summarizes the input data fed to DESCON. The Uncomp is a colder stream than the Quinnipiac and has considerably h alkalinity and hardness.

The resulting design conditions are displayed in Table 4 The critical period for lead occurs in April rather than Augu for the Quinnipiac River. The design streamflow for lead is slightly higher than the 7Q10 (as opposed to being lower than 7Q10 for the Quinnipiac). Because the critical periods for am and UOD fall in the summer, which is not the low flow period, design streamflows for these pollutants are almost twice as l as the 7Q10 flow. The greater hardness and lower temperatures this river result in higher critical design discharge concent tions for lead and UOD than for the Quinnipiac River. Once ag differences between conditions computed with the two methods defining WQC excursions were minor.

The design conditions computed for these two rivers are obviously site- and pollutant-specific. Changes in the monito station location or in discharger characteristics would most produce different results. The discharger data used in these examples were not taken from any facilities actually discharg to these rivers.

TABLE 4.4 DESCON Input Data for the Uncompahgre River

Location	: Uncompahgre R at Delta, CO
Pollutant	: Ammonia Lead UOD
K1 Coefficient at 20 Deg. C	: 0.23 1/days
K2 Coefficient at 20 Deg. C	: 0.46 1/days
Benthic Demand at 20 Deg. C	: 0.0 mg/L/day
Averaging Period, Days	: 4 (Bio-Based Method) 7 (Extreme Value Method)
Return Period, Years	: 3 (Bio-Based Method) 10 (Extreme Value Method)
Concentration Limit	: EPA National CCC (Ammonia) : EPA National CCC (Lead) 5.0 mg/L (UOD)
Period of Record	: Entire Record
Flow Adjustment Factor	: 1.0
Discharger Location	: Below Flow Gage

Range of Upstream Pollutant	:	0.0	to	0.0	mg/L
Range of Upstream Temperature	:	1.3	to	18.2	Deg.
Range of Upstream PH	:	7.1	to	8.7	
Range of Upstream Alkalinity	:	100.0	to	272.0	mg/L
Range of Upstream Hardness	:	300.0	to	1300.0	mg/L
Range of Upstream Diss. Oxygen	:	7.4	to	13.6	mg/L
Range of Discharge Flow	:	51.0	to	51.0	cfs
Range of Discharge Temperature	:	14.2	to	25.3	Deg.
Range of Discharge PH	:	7.0	to	7.0	
Range of Discharge Alkalinity	:	245.0	to	245.0	mg/L
Range of Discharge Hardness	:	250.0	to	250.0	mg/L
Range of Discharge Diss. Oxygen	:	5.5	to	5.5	mg/L

TABLE 4.5 Design Conditions for Ammonia, Lead, and UOD in th Uncompangre River

A. Biologically-Based WQC Excursion Method (4-Day Averages)

	UPSTREAM			DISCHARGE		
	NH_3	Lead	UOD	NH_3	Lead	UO
Critical Period	August	April	July	August	April	Jul
Flow, cfs	91.8	64.6	96.8	51.0	51.0	51.
Temperature, deg. C	17.8	-	17.9	25.3	-	24.
PH	7.6	-	-	7.0	-	-
Alkalinity, mg/L	234.0	-	-	245.0	-	-
Hardness, mg/L	-	367.5	-	-	250.0	-
Diss. Oxygen, mg/L	-	-	7.7	-	-	5.
Pollut. Concen., mg/L	0.0	0.0	0.0	3.3	31.1 (ug/L)	39.

B. Extreme Value-Based WQC Excursion Method (7-Day Averages)

	UPSTREAM			DISCHARGE		
	NH_3	Lead	UOD	NH_3	Lead	UO
Critical Period	July	April	July	July	April	Jul
Flow, cfs	89.4	56.7	97.1	51.0	51.0	51.
Temperature, deg. C	18.0	-	18.0	24.7	-	24.
PH	8.1	-	-	7.0	-	-
Alkalinity, mg/L	208.8	-	-	245.0	-	-
Hardness, mg/L	-	433.6	-	-	250.0	-
Diss. Oxygen, mg/L	-	-	7.8	-	-	5.
Pollut. Concen., mg/L	0.0	0.0	0.0	3.3	32.8 (ug/L)	39.

SECTION 5
UTILIZATION GUIDELINES

This section provides some useful guidelines for utilizir DESCON in the WLA process. It covers such topics as input data availability, choice of analysis options, and the interpretati of the program's results. A question and answer format is usec simplify the presentation.

5.1 DATA AVAILABILITY

Q: Can DESCON be used if no streamflow data or water quality parameter data exist for the site in question?

A: DESCON cannot be used if streamflow data do not exist. If c on some water quality variables (such as temperature) are unavailable, it may be possible to substitute values from anot river which is climatologically and hydrologically similar.

Q: Suppose a streamflow record exists but the gage is not clos the site being analyzed?

A: DESCON allows the user to specify a streamflow adjustment factor, F, so that site streamflow can be related to recorded streamflow as follows:

Daily Site Streamflow = F * Daily Gage Streamflow

The factor F is usually established as the ratio of the upstr drainage area of the site to that of the gage location. In addition, if the gage is located downstream of the discharger DESCON will adjust the streamflow records to account for the discharge flow when computing an upstream design flow.

Q: What minimum length of flow record is recommended?

A: The longer the flow record, the more reliable will be the estimated design conditions. Figure 5.1 shows how the spread the 90% confidence limits on an extreme value-based quantity a 10-year return period decreases with increasing period of r (This figure was derived from log Pearson Type 3 statistics w zero skew (Stedinger, 1983).) Results are shown for extreme v quantities with both low variability (CV = .2) and high varia (CV = .8). Based on the behavior of these curves, it appears 20 to 30 years of record is a reasonable minimum requirement an extreme value analysis at a 10-year return period.

The case for the biologically-based method is less definitive. Recall that it uses the record of ASL values gene from historically observed streamflows to find the critical A that produces the required WQC excursion count. It therefore assumes that sequences of future ASL's below the critical val will occur no more frequently than they have in the past. Bec it lacks the extrapolative power provided by a fitted probabi distribution, a longer period of record should probably be us with the biologically-based method than with the extreme valu method if equal levels of confidence in predicted design cond are to be achieved.

Q: What is the minimum number of days of the year for which supplementary water quality data is required to run DESCON.

A: DESCON will produce results even if only a single day of w quality data is provided. In such cases, it assumes that the of this water quality variable remains constant throughout th year, and therefore the design condition becomes this single There may be circumstances where a lack of water quality measurements may force the analyst to employ such an approach

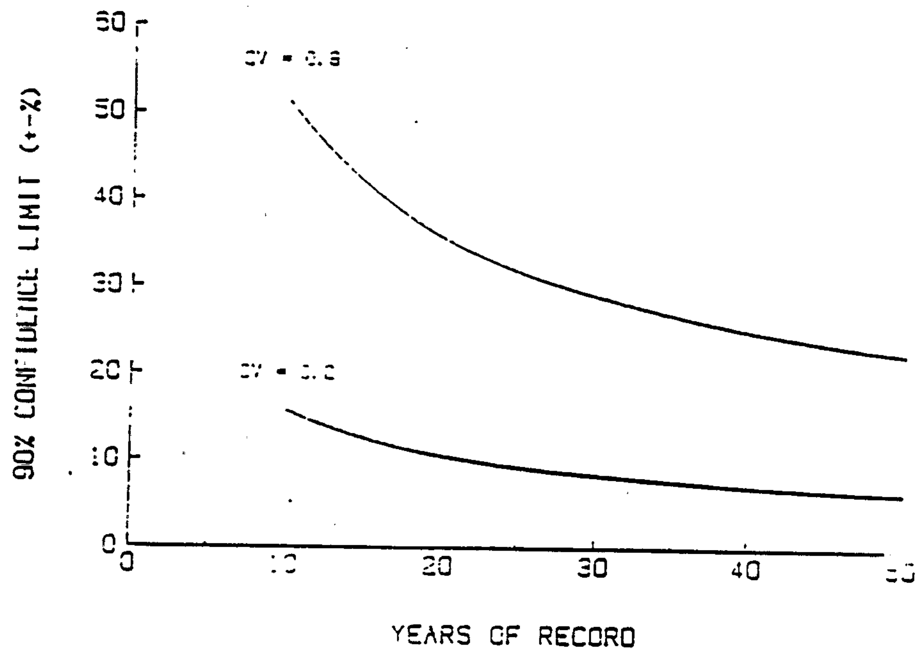

FIGURE 5.1 Spread in 90 Percent Confidence Limits on a 10-Year Return Period Quantile

DESCON will also work with daily water quality values t are not actual measurements, but rather are the analyst's b estimate of what conditions might exist in the receiving str or the discharger stream throughout the year. As an example, might be far easier to estimate the monthly average dischar flow rather than the daily flow for each day of the year. Th monthly flows could be used with DESCON by specifying th values at the first and last days of their respective mont DESCON's interpolation procedure would then produce a dischar flow for each day of the month equal to the monthly mean.

Needless to say, the analyst should exercise extreme care making sure that the water quality data fed into DESCON are t most representative for the stream, the discharger, and the t of water quality criterion being analyzed.

5.2 CHOICE OF ANALYSIS OPTIONS

Q: Which method of defining WQC excursion frequency, extre value or biologically-based, is recommended?

A: Following the recommendation made in the Technical Guidan on Stream Design Flow (US EPA, 1986c), either method can be use If the extreme value method is used, a 10-year return per should be employed. The parameters recommended for use with t biologically-based method are summarized at the end of secti 2.3.

Q: DESCON can be run with or without discharger data. How shou one decide which option to use?

A: If the WLA problem involves only a single discharger whos general characteristics are known, then DESCON should be ru using discharger data. If there are multiple dischargers c similar characteristics and the pollutant in question will b treated as a conservative material (as is often done simplified analyses of heavy metals) then DESCON can also be using discharger data derived from adding together the flows each discharger. For other multi-discharger situations DE cannot properly account for the effects that discharger loca has on resulting stream water quality. In such circumstance when discharger characteristics are unknown, DESCON can be without discharger data supplied.

Q: For ammonia, heavy metals, and pentachlorophenol, DESCON a matically uses the U.S. EPA's national two-number water qua criteria for concentration limits. What if a state ha criterion concentration that is different than the nati numbers.

A: The national numbers for these pollutants are functions temperature, pH, or hardness. If a state has a diffe concentration limit that is some fixed value, then the pollut can be analyzed as if it were a general toxicant for which only design conditions are on streamflow, discharger flow, and upstream pollutant concentration.

Q: Strictly speaking, computation of the CMC (acute) WQC sho be based on hourly water quality data, although daily avera can be used instead as a practical alternative. If hourly d (or the most extreme value over the day) are available for s parameter, how can they be used by DESCON?

A: When DESCON asks for representative daily values for these parameters throughout the year, the user can respond with the most critical hourly value for each day when such data is available. For example, with pH used for ammonia toxicity, the most critical value is the hourly maximum. With hardness used for heavy metal toxicity it would be the hourly minimum value.

Q: How can DESCON be used to derive design conditions for b carbonaceous and nitrogenous Biochemical Oxygen Demand (BOD)?

A: DESCON can derive approximate design conditions for th pollutants by considering them lumped together as a sin category called Ultimate Oxygen Demand (UOD). When DESCON u the simple Streeter-Phelps dissolved oxygen model to compute allowable stream loading of UOD for each day of record, it is able to use separate decay rates for the carbonaceous nitrogenous components of UOD (see Appendix A). Hence resulting design conditions are subject to more uncertainty t normal. DESCON's design flow, temperature, and upstream dissol oxygen design conditions should be used as input to a m refined water quality model that takes proper account of separate fate of the carbonaceous and nitrogenous BOD componen

5.3 INTERPRETATION OF RESULTS

Q: When analyzing pollutants with supplementary design conditi (e.g., ammonia, heavy metals, pentachlorophenol, and Ultima Oxygen Demand), DESCON will most likely produce a design strea flow that is different than the 7Q10 flow, even if a 7-c averaging period and 10-year return period on extreme value w excursions were asked for. Some states may require that the 7Q (or some other low-flow statistic) flow be used as a design f for WLA's. How can DESCON accommodate such requirements?

A: After DESCON completes its initial estimate of des conditions it asks the user if another set of conditions shou be computed based on a specified design streamflow. At this po the user can enter the 7Q10 flow (or any other flow) and a set of supplementary design conditions will be produced. As w described at the end of section 3.5, these new conditi represent the minimal adjustment needed on the original ones

that the applicable WQC is met under the critical pollutant l
and specified design streamflow.

DESCON can also be used to compute "stand-alone" des
streamflows, either extreme value-based flows such as a 7Q10
biologically-based flows, in the same manner as a previ
software package called DFLOW (US EPA, 1986c). To do this
user would choose the following options from the program's men

1. Pollutant to be analyzed --- general toxicant,
2. Method of defining WQC excursion frequency --- either extr value or biologically-based,
3. WQC concentration limit --- any value will do (e.g., 1 ug/l
4. Include the effects of a discharger --- no.

SECTION 6
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APPENDIX A
WATER QUALITY CRITERIA

This Appendix describes methods for computing water quality criteria (WQC) as functions of design condition variables The pollutants to be covered include ammonia, heavy metals pentachlorophenol, and Ultimate Oxygen Demand (UOD).

I. Ammonia (US EPA, 1985a)

WQC for un-ionized ammonia are functions of stream temperatur (T) and pH (PH). In addition, the dissociation of total ammoni into ionized and un-ionized fractions is also governed by thes variables.

The equation for the Criterion Maximum Concentration (CMC) c un-ionized ammonia is

CMCo = 0.52 / FT / FPH / 2.

where FT = 10^[.03 (20 - T*)]
T* = 20 if salmonids present and T > 20
= 25 if salmonids not present and T > 25
= T otherwise
FPH = [1 - 10^(7.4 - PH*)] / 1.25 if PH* < 8
= 1. otherwise
PH* = PH if PH > 6.5
= 6.5 otherwise

The equation for the Criterion Continuous Concentration (CCC of un-ionized ammonia is

CCCo = 0.8 / FT / FPH / R
where FT = as above
T* = 15 if salmonids present and T > 15
= 20 if salmonids not present and T > 20
= T otherwise
FPH = as above
R = 24 [10^(7.7 - PH)] / [1 + 10^(7.4 - PH)]
if PH < 7.7
= 16. otherwise

To convert the CMCo and CCCo into concentrations of tota ammonia-N, the following equations are used:

CMC = 0.822 CMCo / F
CCC = 0.822 CCCo / F

where F = 1 / [1 + 10^(PKA - PH)]
PKA = 0.09 + 2730 / (T + 273.2)

II. Heavy Metals

WQC for heavy metals are functions of stream hardness (
(expressed in mg/L as CaCO3). The general expressions for the C
and CCC are as follows:

$$CMC \text{ or } CCC = \exp[a\ LN(H) - b] \quad (ug/L)$$

where the constants "a" and "b" are given by:

Metal	CMC a	CMC b	CCC a	CCC b	Reference
Cadmium	1.128	-3.828	.7852	-3.490	US EPA, 1985b
Copper	.9422	-1.464	.8545	-1.465	US EPA, 1985c
Chromium (III)	.8190	3.688	.8190	1.561	US EPA, 1985d
Lead	1.273	-1.460	1.273	-4.705	US EPA, 1985e
Nickel	.8460	3.3612	.8460	.5703	US EPA, 1986a
Zinc	.8213	.8141	.8213	-.1541	US EPA, 1986b

III. Pentachlorophenol (US EPA, 1986a)

The WQC for pentachlorophenol is a function of pH:

$$CMC = \exp[1.005\ PH - 4.954] \quad (ug/L)$$
$$CCC = \exp[1.005\ PH - 5.412] \quad (ug/L)$$

IV. Ultimate Oxygen Demand

There is no WQC established for UOD per se, but rather o
dissolved oxygen. The classical Streeter-Phelps model can be use
to determine the maximum initial in-stream UOD concentration tha
results in a DO just equal to the criterion at the critical poin
of the downstream DO profile.

This value can then serve as an effective WQC for UOD. The
equation used to compute this value is:

$$Cs - Cc = L\,[\exp(-K1\ Tc) - \exp(-K2\ Tc)][K1/(K2-K1)] + (Cs-Co)\exp(-K2\ Tc) - [S/K2][1 - \exp(-K2\ Tc)]$$

where $Tc = Ln[(K2/K1)(1 + Y/L)]$

and $Y = [(S/K2) - Cs + Co]\ [K2 - K1]\ /\ K1$

with
- L = initial UOD
- Co = initial DO
- Cc = DO criterion
- Cs = saturation DO = $14.652 - .41022\ T + .007991\ T^2 - .000077774\ T^3$
- T = temperature
- K1 = $K1o\ 1.024^{(T - 20)}$
- K1o = UOD decay rate coefficient at 20 deg. C

K2 = K2o 1.047^(T - 20)
K2o = reaeration rate coefficient at 20 deg. C
S = So 1.065^(T - 20)
So = benthic DO demand (mg/L/day) at 20 deg.

Note that because L appears in the term Tc, the first equatic above cannot be solved directly for L. Instead an iterativ process, such as the method of successive approximations, must b used.

V. Mixing Equations

When discharger data are supplied to DESCON, downstreamvalue of temperature, hardness, and dissolved oxygen used in the abov equations can be found from the simple mixing equation:

C3 = [C1 Q1 + C2 Q2] / [Q1 + Q2]

where

C1 = upstream concentration (or temperature)
C2 = discharger concentration (or temperature
C3 = downstream concentration (or temperature
Q1 = upstream flow
Q2 = discharger flow.

To find the mixture pH, a more involved procedure is required based on carbonate equilibrium chemistry. At the pH's found in natural waters the major form of alkalinity is carbonate alkalinity. This fact can be used to simplify the computations The procedure to find the downstream pH (PH3) given:

a) upstream and discharger temperatures T1 and T2,
b) upstream and discharger pH's PH1 and PH2,
c) upstream and discharger alkalinities A1 and A2,
d) upstream and discharger flows Q1 and Q2

consists of the following steps:

1. Find the carbonic acid-carbonate equilibria ionization constant for streams 1 and 2 (PKA1 and PKA2) using the following equations derived from Table 4-7 of Snoeyink and Jenkins (1980):

PKA1 = 6.57 - .0118 T1 + .00012 T1^2
PKA2 = 6.57 - .0118 T2 + .00012 T2^2

2. Find the corresponding ionization fractions (F1 and F2):

F1 = 1 / [1 + 10^(PKA1 - PH1)]
F2 = 1 / [1 + 10^(PKA2 - PH2)]

3. Find the total inorganic carbon in each stream (CT1 and CT2):

CT1 = A1 / F1

$$CT2 = A2 / F2$$

4. Find the downstream temperature (T3), alkalinity (A3), and total inorganic carbon (CT3):

$$T3 = (T1\ Q1 + T2\ Q2) / (Q1 + Q2)$$
$$A3 = (A1\ Q1 + A2\ Q2) / (Q1 + Q2)$$
$$CT3 = (CT1\ Q1 + CT2\ Q2) / (Q1 + Q2)$$

5. Find the downstream ionization constant (PKA3):

$$PKA3 = 6.57 - .0118\ T3 + .00012\ T3^2$$

6. Find the downstream pH (PH3):

$$PH3 = PKA3 - \mathrm{Log10}(CT3/A3 - 1)$$

APPENDIX B

HOW TO RUN THE DESCON PROGRAM

DESCON is an interactive menu-driven computer program th computes simple waste load allocations and derives critical d conditions for either seasonal or nonseasonal discharge polic The program is written in FORTRAN and currently resides on EP NCC-IBM system at Research Triangle Park, North Carolina. It be accessed in the TSO environment by issuing the command EXE 'MRFURSR.DESCON.CLIST'.

The main DESCON menu is shown in Figure B.1. Five option available as follows:

1. Retrieve flow data from STORET
2. Retrieve water quality data from STORET
3. Analyze retrieved water quality data
4. Calculate design conditions
5. Exit the program

Each of the first four will be discussed in turn.

The first option retrieves streamflow records for the st segment being analyzed. Design conditions cannot be made witho first obtaining a flow record with this option. As shown in Fi B.1, the only information required is an 8-digit USGS gaging station number and the STORET code for the state in which the station is located. The retrieved flow data is saved in a file named FLOW.DATA and is automatically accessed on any future pr runs.

```
            D E S C O N   M A I N   M E N U
    ========================================================

    ENTER THE NUMBER OF THE PROCEDURE YOU WISH TO EXECUTE:

    1 - RETRIEVE STREAMFLOW DATA
    2 - RETRIEVE WATER QUALITY DATA
    3 - ANALYZE WATER QUALITY DATA
    4 - COMPUTE DESIGN CONDITIONS
    5 - EXIT THE PROGRAM

    CHOICE ===     1


    ENTER 8-DIGIT USGS STATION NUMBER ====>  01196500

    ENTER 2-DIGIT STORET STATE CODE  =====>  09

    SAVED
    JOB XXX(JOB01234) SUBMITTED
    FLOW DATA WILL BE STORED IN FILE FLOW.DATA
```

FIGURE B.1 Streamflow Retrieval With DESCON

The second option from the main menu retrieves water qu. data from STORET for a particular monitoring station. This n not be the flow gaging station used in option one. The user supply a six-character monitoring station agency code and an eight-digit monitoring station number. Any set of water qual parameters can be retrieved by entering their STORET codes. required format is shown in Figure B.2. The retrieved water quality data are saved in a file named PARAM.DATA.

Retrieval of stream quality data is not mandatory, but help provide values for additional input data required by DE: The third option from the main menu allows the retrieved wat quality data to be analyzed in a number of different ways. B.3 illustrates the use of this option. Yearly, monthly, or average parameter values can be calculated over any specifie period of record. The daily averages can be represented by s different seasonal models and placed automatically in a file STREAM.DATA for future processing.

Option four from the main menu computes design conditio including design waste loads. Two types of situations can be analyzed. One includes discharger data while the other does Table B.1 summarizes the pollutants and design conditions th DESCON accommodates under both types of situations.

Option four requires that representative water quality conditions for each day of the year be entered into DESCON. B.2 indicates the parameters needed for each type of polluta This data is made available to DESCON by either entering it directly when prompted by the program or by placing it in a file prior to selecting option four. In the latter case, str data are placed in a file named STREAM.DATA and discharge da DISCH.DATA. Figure B.4 shows the format of these files.

```
             D E S C O N    M A I N    M E N U
==========================================================

ENTER THE NUMBER OF THE PROCEDURE YOU WISH TO EXECUTE:

1 - RETRIEVE STREAMFLOW DATA
2 - RETRIEVE WATER QUALITY DATA
3 - ANALYZE WATER QUALITY DATA
4 - COMPUTE DESIGN CONDITIONS
5 - EXIT THE PROGRAM

CHOICE ===    2


ENTER 6-CHARACTER MONITORING STATION AGENCY CODE  112WRD

ENTER 8-DIGIT MONITORING STATION NUMBER ====    01196500

STORET CODES FOR PARAMETERS OF MOST INTEREST ARE:
  WATER TEMPERATURE, DEG C                        10
  DISSOLVED OXYGEN, MG/L                         300
  PH                                             400
  ALKALINITY, MG/L CACO3                         410
  TOTAL AMMONIA, MG/L N                          608
  TOTAL HARDNESS, MG/L CACO3                     900

ENTER THE STORET CODES OF THE PARAMETERS YOU WISH TO
RETRIEVE, ALL ON ONE LINE ENCLOSED IN QUOTES WITH FORMAT:
'P =  CODE 1 , P =  CODE 2>, ... ETC.'

'P=10,P=300,P=400,P=410,P=900'

SAVED
JOB XXX(JOB01235) SUBMITTED
PARAMETER DATA WILL BE STORED IN FILE PARAM.DATA
```

FIGURE B.2 Water Quality Data Retrieval With DESCON

```
        D E S C O N    M A I N    M E N U
=====================================================
ENTER THE NUMBER OF THE PROCEDURE YOU WISH TO EXECUTE:

1 - RETRIEVE STREAMFLOW DATA
2 - RETRIEVE WATER QUALITY DATA
3 - ANALYZE WATER QUALITY DATA
4 - COMPUTE DESIGN CONDITIONS
5 - EXIT THE PROGRAM

CHOICE ===     3


STATION NO. 01196500
QUINNIPIAC R AT WALLINGFORD, CT
=======================================================
PARAMETERS CURRENTLY IN FILE PARAM.DATA ARE:
1     00010     WATER         TEMP        CENT
2     00300     DO                        MG/L
3     00400     PH                        SU
4     00410     T ALK         CACO3       MG/L
5     00900     T HARD        CACO3       MG/L


HOW SHOULD THE WATER QUALITY DATA BE ANALYZED:
1  PRODUCE A YEARLY SUMMARY
2  PRODUCE A MONTHLY SUMMARY
3  PRODUCE A DAILY SUMMARY
4  FIT A SEASONAL MODEL
5  SET CUT-OFF LIMITS
6  RETURN TO MAIN MENU
?
1


WHICH PARAMETER DO YOU WISH TO ANALYZE:
1     00010     WATER         TEMP        CENT
2     00030     DO                        MG/L
3     00400     PH                        SU
4     00410     T ALK         CACO3       MG/L
5     00900     T HARD        CACO3       MG/L
?
1
```

FIGURE B.3 Analysis of Retrieved Water Quality Data With DESC

WHAT ARE THE FIRST & LAST YEARS OF PERIOD ANALYZED
(ENTER 1900, 1999 FOR ENTIRE PERIOD OF RECORD)
?
1970, 1999

SUMMARY BY YEAR OF WATER TEMP

YEAR	#GRABS	MEAN	#COMPOSITES	MEAN	OVERALL VALUES MIN	MAX	MEAN
1970	15	14.5	0	0	1.0	30.0	14.5
1971	13	13.8	0	0	2.0	27.0	13.8
1972	12	10.8	0	0	2.0	21.0	10.8
1973	14	14.6	0	0	1.0	26.0	14.6
		data for 1974 - 1984 not shown					
1985	12	14.9	0	0	1.5	23.0	14.9
1986	[illegible]	14.4	0	0	4.0	22.0	14.4

HOW SHOULD THE WATER QUALITY DATA BE ANALYZED:
1 PRODUCE A YEARLY SUMMARY
2 PRODUCE A MONTHLY SUMMARY
3 PRODUCE A DAILY SUMMARY
4 FIT A SEASONAL MODEL
5 SET CUT-OFF LIMITS
6 RETURN TO MAIN MENU
?
3

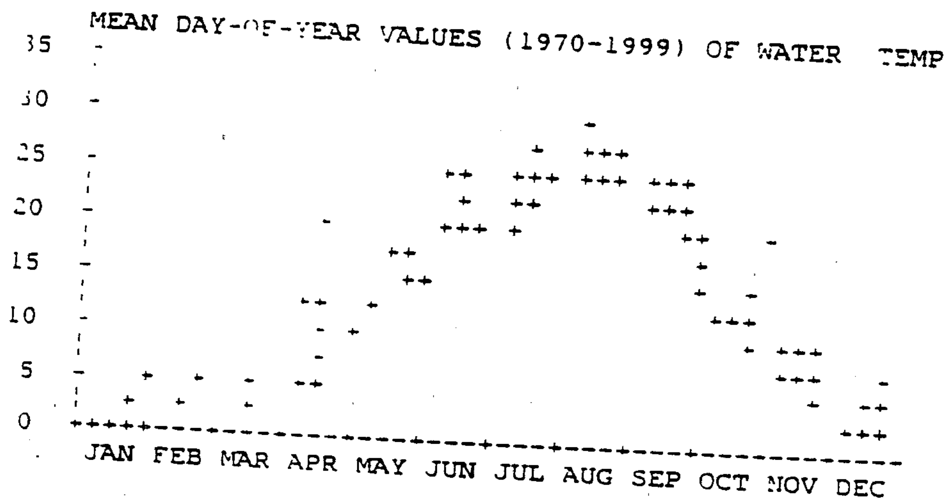
WHICH PARAMETER DO YOU WISH TO ANALYZE
?
1

WHAT ARE FIRST & LAST YEARS OF PERIOD ANALYZED
(ENTER 1900, 1999 FOR ENTIRE PERIOD OF RECORD)
?
1970, 1999

FIGURE B.3 Continued from previous page.

INCLUDE WHICH TYPE OF SAMPLE:
1 GRAB
2 COMPOSITE
3 BOTH
?
3

LOG TRANSFORM THE DATA:
1 YES
2 NO
?
2



HOW SHOULD THE WATER QUALITY DATA BE ANALYZED:
1 PRODUCE A YEARLY SUMMARY
2 PRODUCE A MONTHLY SUMMARY
3 PRODUCE A DAILY SUMMARY
4 FIT A SEASONAL MODEL
5 SET CUT-OFF LIMITS
6 RETURN TO MAIN MENU

4

FIGURE B.3 Continued from previous page.

```
WHICH PARAMETER DO YOU WISH TO ANALYZE:
?
1

WHAT ARE FIRST & LAST YEARS OF PERIOD ANALYZED
(ENTER 1900, 1999 FOR ENTIRE PERIOD OF RECORD)
?
1970, 1999

INCLUDE WHICH TYPE OF SAMPLE:
1  GRAB
2  COMPOSITE
3  BOTH
?
3

LOG TRANSFORM THE DATA:
1  YES
2  NO
?
2

USE WHICH TYPE OF SEASONALITY MODEL:
1  NONE
2  MONTHLY
3  DAILY
4  SINUSOUDAL
?
4

      RESULTS OF SINUSOIDAL SEASONAL MODEL FOR
      DAILY VALUES (1970-1999) OF WATER  TEMP
==========================================================
      FITTED PARAMETER VALUE Y ON DAY D IS:

      Y = A * SIN(.0172*D) + B * COS(.0172*D) + C

      WHERE               A = -4.292
                          B = -10.55
                          C =  12.56
                 STD. ERROR =  2.201
                % R-SQUARED =  93.24
             # OBSERVATIONS =    206
          MEAN MODEL ERROR = 0.0000
      COEFF. OF VARIATION = 0.1706
            GOODNESS OF FIT =    15%
```

FIGURE B.3 Continued from previous page.

```
FIT ANOTHER SEASONALITY MODEL TO SAME DATA:
1   YES
2   NO
?
2

SAVE MODEL PARAMETERS IN FILE STREAM.DATA
1   YES, WITH RANDOM VARIABILITY INCLUDED
2   YES, WITHOUT RANDOM VARIABILITY
3   NO
?
2


HOW SHOULD THE WATER QUALITY DATA BE ANALYZED:
1   PRODUCE A YEARLY SUMMARY
2   PRODUCE A MONTHLY SUMMARY
3   PRODUCE A DAILY SUMMARY
4   FIT A SEASONAL MODEL
5   SET CUT-OFF LIMITS
6   RETURN TO MAIN MENU
?
6
```

FIGURE B.3 Continued from previous page.

TABLE B.1 Pollutants and Design Conditions Considered By DESCON

Pollutant	Design Conditions w/o Discharger	Design Conditions w/ Discharger
General toxicant	Flow	Flow Toxicant
Ammonia	Flow Temperature pH	Flow Temperature pH Alkalinity Ammonia
Heavy Metals Cadmium Chromium III Copper Lead Nickel Zinc	Flow Hardness	Flow Hardness Metal
Pentachlorophenol	Flow pH	Flow pH Temperature Alkalinity Pentachlorophenol
Ultimate Oxygen Demand	Flow Temperature Dissolved oxygen	Flow Temperature Dissolved oxygen UOD

TABLE B.2 Supplementary Water Quality Variables Required By DESCON

Pollutant	Water Quality Values Supplied to DESCON		
	w/o Discharger	w/ Discharger	
	In-stream	Upstream	Discharge
General Toxicant		Toxicant	Flow
Ammonia	Temperature pH	Temperature pH Alkalinity Ammonia	Temperatur pH Alkalinity Flow
Heavy Metal	Hardness	Hardness Metal	Hardness Flow
Pentachloro-phenol	pH	pH Temperature Alkalinity Pentachloro-phenol	pH Temperatur Alkalinity Flow
Ultimate Oxygen Demand (UOD)	Temperature Oxygen	Temperature Oxygen UOD	Temperatur Oxygen Flow

File Entry	Comments
Stream Data for Quinnipiac River	File header
10	STORET parameter code
1.	Nominal parameter value[1]
0,0	Random variability factor
12	Number of seasonal factor
1,15,1.8	Month, day, seasonal fact
2,14,2.4	.
3,15,4.3	.
4,15,10.1	.
5,15,15.4	.
6,15,21.3	.
7,15,23.9	.
8,15,24.5	.
9,15,20.0	.
10,15,14.3	.
11,17,5.9	.
12,15,3.2	.
400	Next parameter code
1.	Nominal parameter value
0,0	Random variability factor
12	Number of seasonal factor
1,15,7.2	Month, day, seasonal fact
2,14,7.2	.
3,15,7.2	.
4,15,7.1	.
5,15,7.1	.
6,15,7.1	.
7,15,7.2	.
8,15,6.9	.
9,15,7.0	.
10,15,7.2	.
11,15,7.0	.
12,15,7.1	.

[1]The actual parameter value for a given day of the year equal the nominal parameter value times a seasonal factor for that

[2]These factors indicate the type of random variability to imp around the deterministic annual cycle of parameter values. Zeroes indicate that no random variability is to be included

FIGURE B.4 Format of Files STREAM.DATA and DISCH.DATA

The STREAM.DATA file shown in the figure contains data f stream temperature and pH. There are twelve entries for each variable. They are placed at the mid-point of each month. Whe values for intervening days are needed by DESCON, the progran interpolate between the values on either side of the day in question. If the user had wanted to use the monthly average temperature as the daily value for each day of the month, the would be entered as follows:

```
1, 1, 2.1
1, 31, 2.1
2, 1, 3.4
2, 28, 3.4
etc.
```

Using files STREAM.DATA and DISCH.DATA is purely optiona They will help save time and reduce typing errors when many r are made for the same stream segment. They can be created and edited outside of the DESCON program using the TSO text edito <u>THEY MUST BE SAVED WITH LINE NUMBERING TURNED OFF</u>. It is not necessary to place all of the water quality data required by in these files. If DESCON cannot find the data in these files will ask the user to provide it directly during the run.

Figure B.5 illustrates how DESCON's fourth option prompt user for the information needed to compute design conditions. this example, chronic ammonia toxicity was analyzed with resp to the biologically-based method of defining WQC excursion frequency. A discharger was present just below the streamflow location. The file STREAM.DATA supplied daily values for upst temperature, pH, and alkalinity. Discharger parameter data wa supplied directly by the user rather than through the DISCH.D: file.

The results for this run are displayed in Figure B.6. Af the table of critical design conditions appears the user is presented with a menu that offers the following additional an options:

* viewing the dates and durations of the WQC excursions that would have occurred over the historical flow record under current design loading,
* computing alternative design conditions and a WQC excursio frequency for a user-specified design load,
* computing alternative design conditions for a particular user-defined streamflow,
* repeating the analysis for a new division of the year into different seasons.

Figure B.6 concludes with the results of selecting the first these options.

One final operational reminder; at times the program wil display the following prompt:

***

and pause to allow the user to read the currently displayed o Execution will resume when the Enter key is pressed.

```
                DESCON   MAIN   MENU
=====================================================

ENTER THE NUMBER OF THE PROCEDURE YOU WISH TO EXECUTE:

1 - RETRIEVE STREAMFLOW DATA
2 - RETRIEVE WATER QUALITY DATA
3 - ANALYZE WATER QUALITY DATA
4 - COMPUTE DESIGN CONDITIONS
5 - EXIT THE PROGRAM

CHOICE ===>    4


DESIGN CONDITIONS FOR USGS STATION 01196500
===========================================
(QUINNIPIAC R AT WALLINGFORD, CT           )

WHICH POLLUTANT SHOULD BE ANALYZED
1  GENERAL TOXICANT
2  AMMONIA-N
3  HEAVY METAL
4  PENTACHLOROPHENOL
5  ULTIMATE OXYGEN DEMAND
?
2

ARE SALMONIDS OR OTHER COLD WATER SPECIES PRESENT
1  YES
2  NO
?
1

WHICH WATER QUALITY CRITERION (WQC) APPLIES
1  NATIONAL CMC (ACUTE)
2  NATIONAL CCC (CHRONIC)
3  SITE-SPECIFIC
?
2

WHICH TYPE OF WQC EXCURSION FREQUENCY APPLIES
1  EXTREME VALUE
2  BIOLOGICALLY-BASED
?
2
```

FIGURE B.5 DESCON Input Session for Computing Design Conditi

```
USE DEFAULT DEFINITION OF EXCURSION PARAMETERS
1  YES
2  NO
?
1

ENTER THE STARTING AND ENDING YEARS OF THE FLOW RECORD
(ENTER 1900, 1999 TO INCLUDE ENTIRE RECORD)
?
1900, 1999

WHAT IS THE FLOW GAGE ADJUSTMENT FACTOR
(WHERE SITE FLOW = FACTOR * GAGE FLOW)
?
1.0

WHERE IS THE DISCHARGER IN RELATION TO THE FLOW GAGE
1  ABOVE THE GAGE
2  BELOW THE GAGE
3  THERE IS NO DISCHARGER
?
2

WHAT IS SIZE OF MIXING ZONE (% OF STREAM X-SECTION)
?
100

CONSIDER DAILY VARIABILITY OF EFFLUENT AMMONIA-N
1  YES
2  NO
?
2
```

FIGURE B.5 Continued from previous page.

```
ENTER THE FOLLOWING VARIABILITY DATA FOR
UPSTREAM AMMONIA-N

NOMINAL YEAR-ROUND VALUE
?
0

USE FILE STREAM.DATA TO DESCRIBE VARIABILITY OF
UPSTREAM TEMPERATURE, DEG C
1  YES
2  NO
?
1

USE FILE STREAM.DATA TO DESCRIBE VARIABILITY OF
UPSTREAM PH
1  YES
2  NO
?
1

USE FILE STREAM.DATA TO DESCRIBE VARIABILITY OF
UPSTREAM ALKALINITY, MG/L
1  YES
2  NO
?
1

ENTER THE FOLLOWING VARIABILITY DATA FOR
DISCHARGE FLOW, CFS

NOMINAL YEAR-ROUND VALUE
?
32

NUMBER OF DAILY SEASONALITY FACTORS
?
0

TYPE OF RANDOM VARIATION TO INCLUDE
1  NORMAL
2  LOGNORMAL
3  NONE
?
3
```

FIGURE B.5 Continued from previous page.

```
ENTER THE FOLLOWING VARIABILITY DATA FOR
DISCHARGER TEMPERATURE, DEG C

YEAR-ROUND NOMINAL VALUE
?
1.

NUMBER OF DAILY SEASONALITY FACTORS
?
12

MONTH, DAY OF MONTH, AND FACTOR VALUE FOR EACH
?
1 15 16.6     2 14 14.2     3 15 14.8     4 15 15.8
5 15 19.0     6 15 21.5     7 15 24.9     8 15 25.3
9 15 23.3    10 15 23.1    11 15 21.7    12 15 17.8

TYPE OF RANDOM VARIATION TO INCLUDE
1  NORMAL
2  LOGNORMAL
3  NONE
?
3

ENTER THE FOLLOWING VARIABILITY DATA FOR
DISCHARGE PH

NOMINAL YEAR-ROUND VALUE
?
7.0

NUMBER OF DAILY SEASONALITY FACTORS
?
0

TYPE OF RANDOM VARIATION TO INCLUDE
1  NORMAL
2  LOGNORMAL
3  NONE
?
3
```

FIGURE B.5 Continued from previous page.

```
ENTER THE FOLLOWING VARIABILITY DATA FOR
DISCHARGE ALKALINITY, MG/L

NOMINAL YEAR-ROUND VALUE
?
245

NUMBER OF DAILY SEASONALITY FACTORS
?
0

TYPE OF RANDOM VARIATION TO INCLUDE
1  NORMAL
2  LOGNORMAL
3  NONE
?
3


                 SUMMARY OF DESCON INPUT DATA
==============================================================
LOCATION                          : QUINNIPIAC R, WALLINGFORD
POLLUTANT                         : AMMONIA-N
COLD WATER SPECIES PRESENT        : YES
WQC EXCURSION METHOD              : BIOLOGICALLY-BASED
AVERAGING PERIOD, DAYS            :     4.0
RETURN PERIOD, YEARS              :     3.0
CLUSTERING PERIOD, DAYS           :   120.0
MAX. EXCURSIONS PER CLUSTER       :     5.0
CONCENTRATION LIMIT               : EPA NATIONAL CCC
PERIOD OF RECORD                  : ENTIRE RECORD
FLOW ADJUSTMENT FACTOR            :     1.0
DISCHARGER LOCATION               : BELOW FLOW GAGE
SIZE OF MIXING ZONE, %            :   100.0

ENTER "Q" TO QUIT, ANYTHING ELSE TO CONTINUE...
```

FIGURE B.5 Continued from previous page.

```
PARAMETER                              NOMINAL RANGE RANDOM VARIATIC
--------------------------------------------------------------------
UPSTREAM AMMONIA-N, MG/L                 0.0 -   0.0      NONE
UPSTREAM TEMPERATURE, DEG C              1.2 -  24.0      NONE
UPSTREAM PH                              5.5 -   8.2      NONE
UPSTREAM ALKALINITY, MG/L               25.0 -  86.0      NONE
DISCHARGE FLOW, CFS                     32.0 -  32.0      NONE
DISCHARGE TEMPERATURE, DEG C            14.2 -  25.3      NONE
DISCHARGE PH                             7.0 -   7.0      NONE
DISCHARGE ALKALINITY, MG/L             245.0 - 245.0      NONE

ENTER "Q" TO QUIT, ANYHTING ELSE TO CONTINUE...


10 YEARS OF FLOW RECORD PROCESSED
20 YEARS OF FLOW RECORD PROCESSED
30 YEARS OF FLOW RECORD PROCESSED
40 YEARS OF FLOW RECORD PROCESSED
50 YEARS OF FLOW RECORD PROCESSED


SHOULD A SEASONAL ANALYSIS BE MADE
1  YES
2  NO
?
2
```

FIGURE B.5 Continued from previous page.

```
                    CRITICAL DESIGN CONDITIONS
==================================================================
PARAMETER
                                              SEASON       VALUE
------------------------------------------------------------------
UPSTREAM   FLOW, CFS                          APR-MAR       34.8
UPSTREAM   AMMONIA-N, MG/L                    APR-MAR        0.0
UPSTREAM   TEMPERATURE, DEG C                 APR-MAR       23.9
UPSTREAM   PH                                 APR-MAR        7.6
UPSTREAM   ALKALINITY, MG/L                   APR-MAR       72.2
DISCHARGE AMMONIA-N, MG/L                     APR-MAR        1.9
DISCHARGE FLOW, CFS                           APR-MAR       32.0
DISCHARGE TEMPERATURE, DEG C                  APR-MAR       25.0
DISCHARGE PH                                  APR-MAR        7.0
DISCHARGE ALKALINITY, MG/L                    APR-MAR      245.0
DISCHARGE LOAD ADJUSTMENT FACTOR              APR-MAR        1.0
CRITICAL DAY OF HISTORICAL RECORD             APR-MAR    7-25-57
------------------------------------------------------------------
AVG. LOADING OF AMMONIA-N, LB/D                  =         59.38
RETURN PERIOD ON WQC EXCURSIONS                  =     3.2 YEARS

WHICH ADDITIONAL ANALYSIS SHOULD BE MADE
1  DISPLAY DATES AND DURATIONS OF WQC EXCURSIONS
2  ANALYZE A DIFFERENT LEVEL OF POLLUTANT LOADING
3  BASE DESIGN CONDITIONS ON A SPECIFIC STREAMFLOW
4  USE ANOTHER DEFINITION OF SEASONS
5  RETURN TO MAIN MENU
?
1
```

FIGURE B.6 Design Conditions Computed by DESCON

HISTORICAL EXCURSIONS FOR PERIOD 1931-1986

EXCURSION CLUSTERS		EXCURSION PERIODS		
START DATE	NUMBER OF EXCURSIONS	START DATE	DURATION (DAYS)	MAGNITUDE*
JUL 21, 1932	1.50	JUL 21, 1932	6	4.6
JUL 27, 1933	1.00	JUL 27, 1933	4	0.4
AUG 14, 1936	1.75	AUG 14, 1936	7	21.1
JUL 25, 1941	1.00	JUL 25, 1941	4	1.1
AUG 4, 1955	1.00	AUG 4, 1955	4	2.5
AUG 8, 1957	1.00	AUG 8, 1957	4	0.2
JUL 11, 1966	5.00	JUL 11, 1966	18	9.2
		JUL 30, 1966	16	16.2
		AUG 18, 1966	18	17.3
		SEP 6, 1966	6	9.3
AUG 1, 1970	2.25	AUG 1, 1970	4	3.0
		AUG 13, 1970	5	6.8
AUG 16, 1986	1.00	AUG 16, 1986	4	3.0
TOTAL	15.50			

* % BY WHICH CRITERION CONCENTRATION IS EXCEEDED

FIGURE B.6 Continued from previous page.