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# A PRELIMINARY STUDY OF RUNOFF HYDROGRAPHS AND POLLUTANT CONCENTRATIONS FOR TURKEY CREEK BASIN

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## ABSTRACT

The Storage, Treatment, Overland, Runoff Model (STORM) was selected for this study to simulate total runoff hydrographs and pollutant concentrations (suspended solids, BOD, total nitrogen, and orthophosphate), and determine the effects of urbanization on total runoff hydrographs and pollutant concentrations for Turkey Creek Basin. The Soil Conservation Service (SCS) methodology was used for computing runoff hydrographs and the pollutant accumulation method for calculating pollutant concentrations contributed from storm runoff. Simulated results indicate that runoff volumes and peak discharges will be significantly increased by urbanization. Significant increases in pollutant concentrations are largely due to the conversion of pine forest and unused vegetation into residential, commercial, and industrial usage. Results suggest that varying dry-weather discharge and pollutant concentrations reflect only minor changes in peak discharge and pollutant concentrations.

# INTRODUCTION

## Background

Recent increases in urbanization and population growth in Turkey Creek Basin (Figure 1) have caused concerns on water resources of the basin. Urbanization results in higher runoff volume and peak runoff, which in turn increases flooding problems in the low-lying areas adjoining the waterways. Increases in urbanization and population add pollutant loadings to the receiving waters. Degradation would occur if pollutant loadings exceed the assimilative capacity of the receiving waters. In addition, there is also concern about the water quality of flows discharged from C-1 Canal into Turkey Creek through the MS-1 Structure (Figure 1). In order to develop a sound surface water management plan for the protection and conservation of water resources of the basin, information on runoff quantity and quality of Turkey Creek is needed.

## Scope of Study

A detailed study of water quality requires a good monitoring program of streamflow and pollutant loading data. Due to the limited resources (money, man-power, laboratory capacity) and the lack of a good data collection program, this study was limited to a preliminary level. Specific objectives of the study include: (1) determination of total runoff hydrographs and pollutant loadings for the selected pollutants (suspended solids, biochemical oxygen demand, total nitrogen, and orthophosphate) under existing land-use conditions and future development, and (2)

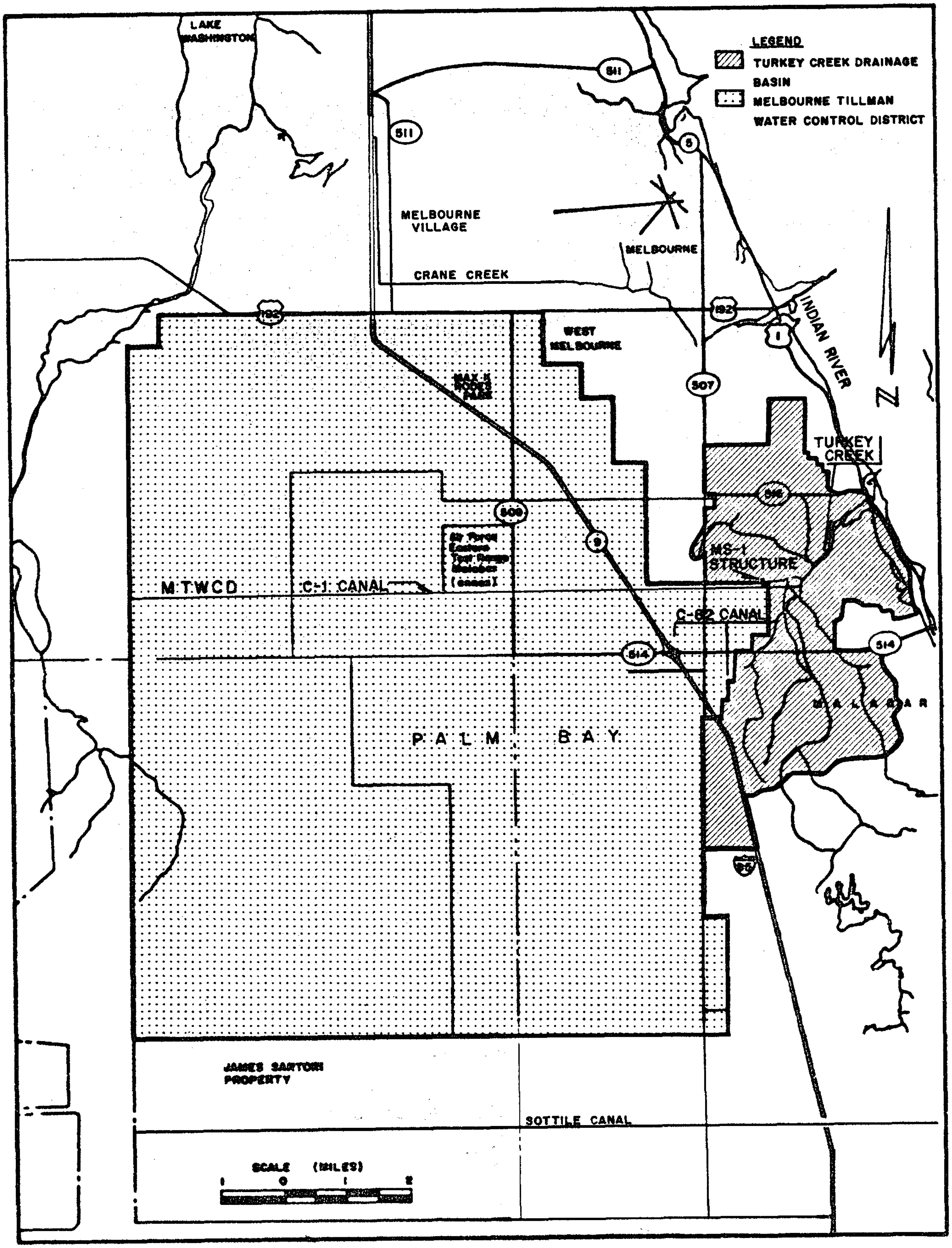


Figure 1. Location of Turkey Creek Basin

determination of effects of urbanization on total runoff hydrographs and pollutant concentrations.

# DESCRIPTION OF STUDY AREA

## Location

Turkey Creek Basin (Figure 1) is located in Brevard County on the east central coast of Florida. The upper half of the basin (Sub-basins 1 and 3 in Figure 2) lies in the City of Palm Bay and the lower half (Sub-basin 2) is located in the Town of Malabar. It is bordered on the north by Crane Creek Basin, on the west by Melbourne-Tillman Water Control District (MTWCD), on the south by Goat Creek Basin, and on the east by Indian River.

## Topography

The topography of Turkey Creek Basin is relatively flat with some gently rolling hills. Ground elevations in the basin range from less than 1.00 ft. NGVD to 35.00 ft. NGVD. The total drainage area of Turkey Creek Basin is 13.3 square miles. The basin has two inflow sources from the MTWCD which drains approximately 98 square miles. The first source is inflow from the C-1 Canal which discharges into Turkey Creek through the MS-1 Structure.

The second source is inflow from the C-82 Canal which discharges into Turkey Creek at Weber Road. In addition to the preceding two inflow sources, other tributaries also discharge into Turkey Creek in Sub-basin 2 (Figure 2). The creek then flows northeasterly to meet Indian River at the outlet of the basin.

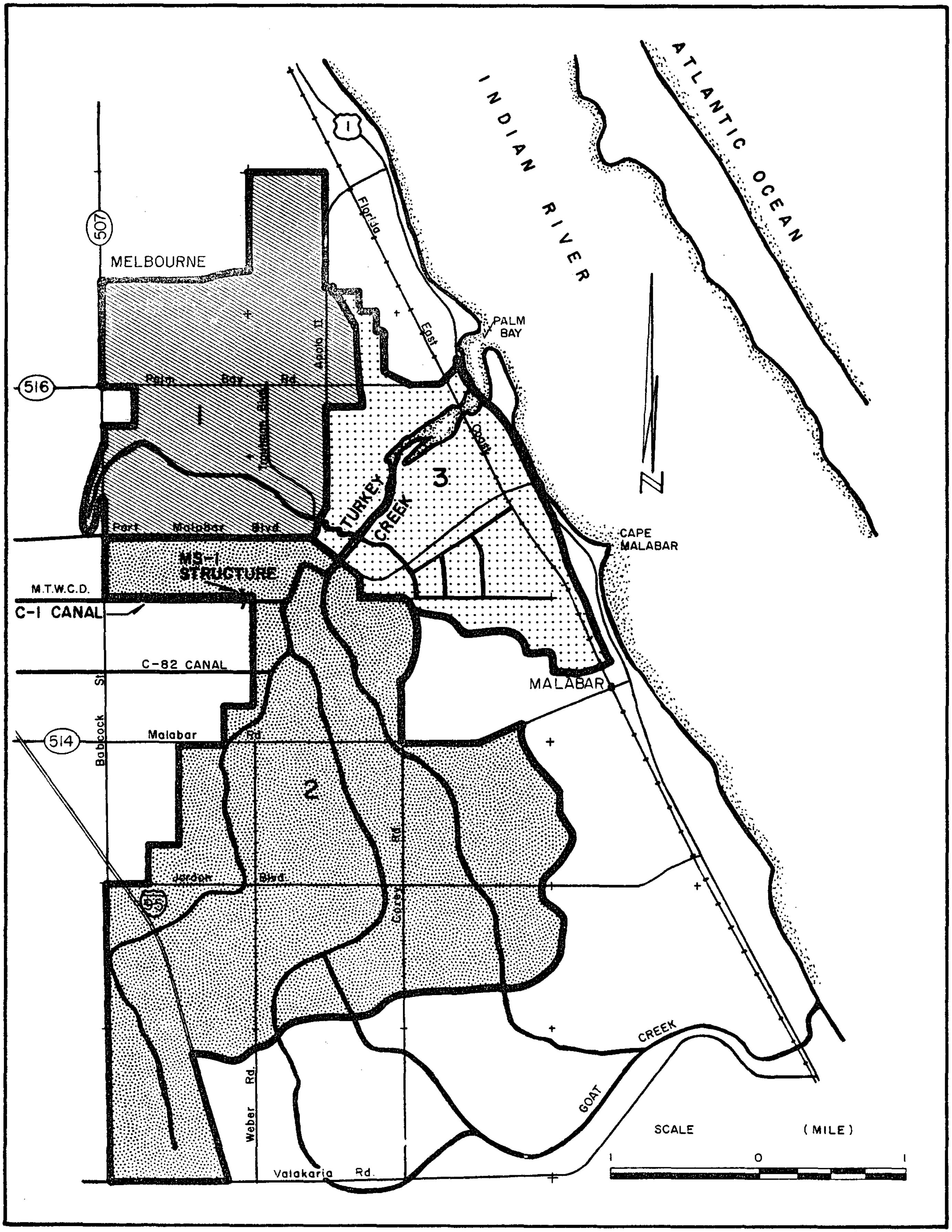


Figure 2. Detailed Breakdown of Turkey Creek Basin

Climate

The study area is located in subtropical zone, characterized by warm, humid summers and mild, dry winters. Average daily temperatures range from 50 degrees Fahrenheit in winter to 90 degrees Fahrenheit in summer. The average annual precipitation over the study area is about 51 inches. On the average, about 65 percent of the annual precipitation falls during June through October. The remainder is distributed throughout the rest of the year [1].

Population

The population of Turkey Creek Basin is growing at a considerable rate. It was estimated that by early 1990 the population in Sub-basins 1, 2, and 3 would increase 100 percent, 120 percent, and 20 percent from the current level, respectively. The average population increase in Turkey Creek Basin would be 68.2 percent. Estimates of present and future population are summarized in Table 1.

TABLE 1. Estimates of Present and Future Population.

| | POPULATION (Persons) | | | |
|---|---|---|---|---|
| DESCRIPTION | Sub-basin 1 | Sub-basin 2 | Sub-basin 3 | Combined |
| Present | 7,000 | 5,000 | 10,000 | 22,000 |
| Future | 14,000 | 11,000 | 12,000 | 37,000 |

## METHODOLOGY

For the purpose of this study, Turkey Creek Basin was divided into three sub-basins based on hydrologic and hydraulic characteristics (Figure 2). The area of each sub-basin is listed in Table 2.

TABLE 2. Summary of Sub-basin Areas.

| SUB-BASIN | AREA (Acres) |
| --- | --- |
| 1 | 2066 |
| 2 | 4901 |
| 3 | 1577 |
| Total | 8544 |

In Sub-basin 1, the basin runoff is drained into the north tributary of Turkey Creek. The runoff at the outlet of Sub-basin 1 is controlled by two 9 ft. X 9 ft. box culverts located beneath Troutman Boulevard, where a flow gauge was installed in order to measure the runoff generated by this sub-basin. In addition to the basin runoff, Sub-basin 2 also receives discharges from the C-1 and C-82 canals as described earlier. The basin runoff combined with the C-1 and C-82 inflows is drained into the south tributary and then discharges into Turkey Creek at Port Malabar Boulevard, where the U.S.G.S. gauge is located. Originally, there were two flow gauges installed for this study to measure inflows from the C-1 and C-82 canals. The first gauge is located at the MS-1 Structure and operated by MIWCD. The second gauge was located near Weber Road. However, the second gauge was vandalized in July 1983 and was not operated since then. Sub-basin 3 receives runoff from Sub-basins 1 and 2. The total runoff in Turkey Creek resulting from all sub-basins is discharged into the Indian River at U.S. 1.

No calibrations of runoff hydrographs and pollutant concentrations were performed in this study. Runoff hydrograph for Sub-basin 1 was not calibrated because no continuous streamflow records were available. Due to backwater effect from Indian River, runoff hydrographs for Sub-basins 2 and 3 were not calibrated either. Although calibration of pollutant concentrations is generally recommended, no calibration was made on pollutant concentrations because no water quality data were collected for this study.

The Storage, Treatment, Overflow, Runoff Model (STORM) released by U. S. Army Corps of Engineers was used to simulate runoff hydrographs and pollutant concentrations for Turkey Creek Basin. This model was chosen for this study because it was readily available through the District computer system and it requires less input data than other water quality models. The model version used only provides runoff hydrograph and pollutant concentrations at the outlet of each sub-basin. It does not consider the assimilative capacity of the receiving water body. Furthermore, the model does not include runoff quantity/quality routings and does not allow the addition of flows and pollutant loadings at the junction of flows. As a result, all sub-basin areas were combined into one single drainage area in order to simulate the total runoff hydrographs and pollutant concentrations at the outlet of the basin. Inflows and pollutant loadings contributed from MTWCD (C-1 and C-82 canals) were not included in this study because no stormwater quality data were available.

Description of Input Data

Input data used in this study can be divided into two major groups. The first group of data is used for determination of total runoff hydrographs and the second group is required in simulation of total pollutant concentrations. Data in the first group consists of rainfall, evaporation, exponential constants for evapotranspiration (ET) and percolation, SCS Runoff Curve Number, lag time, and average daily dry-weather flow. Data in the second group include average daily pollutant concentrations and pollutant accumulation rates. Since water quality data were not collected for this study, input data related to water quality were extracted from the STORM users manual [3] and the literature [4, 5, 6, 7].

Rainfall

Rainfall data were obtained from the MTWCD station which has a recording rain gauge. The station is located at the MS-1 Structure (Figure 2). Hourly rainfall data for 13 months from October 1982 through November 1983 was available for this study. (STORM requires hourly rainfall as input data.) The total rainfall depth for the chosen period was 60.1 inches.

Evaporation

The closest average daily evaporation data to the study area were obtained from the Vero Beach station which is located approximately 60 miles south of the basin. The pan evaporation rate at this station ranged from 0.09 inches/day to 0.26 inches/day with the lowest rate occurring in December and the highest rate in June

ET and Percolation Exponential Constants

Since STORM is a continuous runoff simulation model, a procedure is needed to calculate the water losses resulting from ET, infiltration, and percolation during periods of no rainfall. Therefore, input data such as exponential constants for ET and percolation are also required. Preliminary studies at Hydrologic Engineering Center indicate that the constants range from 1.0 to 5.0 [4]. In this study, the ET exponential constant was assumed to be 3.0 for all cases. The percolation exponential constant was assumed to be 3.5 for Sub-basins 1 and 3, 2.5 for Sub-basin 2, and 3.0 for the combined sub-basin. The same constants were applied to both existing conditions and future development.

Soil

Soil data were taken from the U. S. Department of Agricultural Soil Conservation Service (SCS) soil surveys [1]. There are 25 soil associations in the basin. These soil associations were grouped into three SCS hydrologic soil groups based on their drainage properties. Hydrologic soil groups A, C, and D have areas of 10.3 percent, 17.9 percent, and 67.4 percent, respectively. The remaining 4.4 percent is occupied by open water and depressions.

Land Use

The existing and proposed land-use maps were provided by the City of Palm Bay. There are 20 different land-uses in the basin. The major existing land-uses in Sub-basin 1 are pine forest, residential, and industrial. In Sub-basin 2 the dominant land-uses are pine forest, improved and unimproved rangelands, and low-density residential. The major land-uses in Sub-basin 3 are residential, unused vegetation, and pine forest. Summaries of existing and proposed land-uses are given in Tables 3 and 4.

SCS Runoff Curve Number

The SCS runoff curve number (CN) was used to determine soil moisture storage of a given soil and land-use complex, which in turn was used to compute storm runoff (Appendix A). Estimates of CN for the selected soil and land-use complexes are given in Table 5. These estimates were based on soil moisture condition II. The estimated CN's for the existing conditions and future development are listed in Table 6.

Lag Time

The basic function of lag time is to provide timing of flows. It is primarily a function of the length of overland flow, slope of drainage basin, and surface cover. Lag time was calculated using the equation developed by the SCS (See Appendix A). Estimates of lag time for existing conditions and future development are listed in Table 6.

TABLE 3. Summary of Existing Land Uses.

| DESCRIPTION OF LAND USE | AREA (%) Sub-basin 1 | Sub-basin 2 | Sub-basin 3 | Combined |
|---|---|---|---|---|
| Sand, Gravel | - | Ø.2 | 1.5 | Ø.4 |
| Mobile Home | 3.1 | 1.3 | 1.8 | 1.8 |
| Commercial | 2.4 | Ø.8 | 2.8 | 1.6 |
| Industrial | 1Ø.3 | - | Ø.4 | 2.6 |
| Park, Recreation | - | Ø.3 | - | Ø.2 |
| Open Space | Ø.7 | Ø.1 | 3.6 | Ø.9 |
| High Density Residential (>4 units/acre) | 6.2 | - | Ø.5 | 1.6 |
| Low Density Residential (<4 units/acre) | 11.7 | 3.2 | 47.5 | 13.4 |
| Institutional | Ø.2 | Ø.1 | 1.9 | Ø.5 |
| Open Water | Ø.8 | 2.8 | 6.5 | 3.Ø |
| Residential Farm | 1.6 | 4.7 | Ø.7 | 3.2 |
| Agriculture, Crop, Hay | - | 3.7 | - | 2.1 |
| Unimproved Rangeland | Ø.2 | 24.4 | - | 14.Ø |
| Improved Rangeland | - | 21.5 | - | 12.3 |
| Citrus | - | Ø.9 | - | Ø.5 |
| Graded Land | 3.4 | 1.4 | 3.4 | 2.3 |
| Unused Vegetation | - | 3.4 | 15.6 | 4.8 |
| Pine Forest | 55.7 | 19.3 | 7.6 | 25.9 |
| Cypress | 3.7 | 3.3 | 5.3 | 3.8 |
| Marsh | - | 8.6 | Ø.9 | 5.1 |
| Total | 1ØØ.Ø | 1ØØ.Ø | 1ØØ.Ø | 1ØØ.Ø |
| Total area in acres | 2Ø66.Ø | 49Ø1.Ø | 1577.Ø | 8544.Ø |

TABLE 4. Summary of Future Land Uses.

| DESCRIPTION OF LAND USE | AREA (%) Sub-basin 1 | Sub-basin 2 | Sub-basin 3 | Combined |
|---|---|---|---|---|
| Sand, Gravel | - | Ø.2 | 1.5 | Ø.4 |
| Mobile Home | 3.1 | 1.3 | 1.8 | 1.8 |
| Commercial | 14.7 | 6.8 | 9.9 | 9.3 |
| Industrial | 17.2 | - | 2.9 | 4.7 |
| Park, Recreation | - | Ø.3 | - | Ø.2 |
| Open Space | 1.Ø | Ø.3 | 3.6 | 1.2 |
| High Density Residential (>4 units/acre) | 17.9 | 5.Ø | 4.5 | 8.Ø |
| Low Density Residential (<4 units/acre) | 28.1 | 14.5 | 58.4 | 25.8 |
| Institutional | Ø.5 | Ø.3 | 2.Ø | Ø.8 |
| Open Water | Ø.8 | 2.8 | 6.5 | 3.Ø |
| Residential Farm | 1.6 | 4.7 | Ø.7 | 3.2 |
| Agriculture, Crop, Hay | - | 3.7 | - | 2.1 |
| Unimproved Rangeland | - | 13.8 | - | 7.8 |
| Improved Rangeland | - | 21.5 | - | 12.3 |
| Citrus | - | Ø.9 | - | Ø.5 |
| Graded Land | - | - | - | - |
| Unused Vegetation | - | - | - | - |
| Pine Forest | 11.4 | 12.Ø | 2.Ø | 1Ø.Ø |
| Cypress | 3.7 | 3.3 | 5.3 | 3.8 |
| Marsh | - | 8.6 | Ø.9 | 5.1 |
| Total | 1ØØ.Ø | 1ØØ.Ø | 1ØØ.Ø | 1ØØ.Ø |
| Total area in acres | 2Ø66.Ø | 49Ø1.Ø | 1577.Ø | 8544.Ø |

TABLE 5. Runoff Curve Numbers for Selected Soil and Land-Use Complexes [2].

| DESCRIPTION OF LAND USE | HYDROLOGIC SOIL GROUP A | B | C | D |
|---|---|---|---|---|
| Sand, Gravel, Dirt | 76 | 85 | 89 | 91 |
| Mobile Home | 69 | 80 | 86 | 89 |
| Commercial | 89 | 92 | 94 | 95 |
| Industrial | 81 | 88 | 91 | 93 |
| Park, Recreation | 49 | 69 | 79 | 84 |
| Open Space | 49 | 69 | 79 | 84 |
| High Residential (>4 units/acre) | 77 | 85 | 90 | 92 |
| Low Residential (<4 units/acre) | 57 | 72 | 81 | 86 |
| Institutional | 77 | 85 | 90 | 92 |
| Open Water | 98 | 98 | 98 | 98 |
| Residential Farm | 51 | 68 | 79 | 84 |
| Agriculture, Crops, Hay | 63 | 74 | 82 | 85 |
| Unimproved Rangeland | 39 | 61 | 74 | 80 |
| Improved Pasture | 66 | 77 | 85 | 89 |
| Citrus | 72 | 81 | 88 | 91 |
| Graded Land | 63 | 82 | 85 | 88 |
| Unused Vegetation | 45 | 66 | 77 | 83 |
| Pine Forest | 25 | 55 | 70 | 77 |
| Cypress | 95 | 95 | 95 | 95 |
| Marsh | 95 | 95 | 95 | 95 |

TABLE 6. Estimates of Runoff Curve Number and Lag Time For Existing Conditions and Future Development.

| | EXISTING CONDITIONS | | FUTURE DEVELOPMENT | |
|---|---|---|---|---|
| SUB-BASIN | CN | Lag Time (hrs.) | CN | Lag Time (hrs.) |
| 1 | 79.2 | 11.1 | 87.1 | 8.5 |
| 2 | 78.3 | 15.7 | 80.2 | 14.8 |
| 3 | 75.5 | 6.1 | 76.9 | 5.8 |
| Combined | 78.0 | 17.1 | 80.5 | 16.3 |

Average Daily Flows and Pollutant Concentrations

Average daily flow for Sub-basin 1 during dry periods was estimated from field measurements taken at the Northwest Tributary (Station 18) given in the Wieckowicz study (Tables 2.8 and 2.9). To estimate average daily flows for Sub-basins 2 and 3, it was assumed that flow per unit area was equal for the study area. Since Sub-basin 1 has a sewage treatment plant which contributes 1.5 MGD to flow at Station 18, flow per unit area for the study area was calculated from the following equation:

$$\text{Flow per unit area} = \frac{\text{Flow (Station 18)} - 1.5 \text{ MGD}}{\text{Area of Sub-basin 1}}$$

Therefore, average daily flows for Sub-basins 2 and 3 were computed by multiplying the flow per unit area by the corresponding sub-basin area. Average daily flow during dry periods for the study area was determined by adding flows from Sub-basins 1, 2, and 3.

Average daily pollutant concentrations were also estimated from field data given in the Wieckowicz report. The average daily pollutant concentrations used for Sub-basins 1, 2, 3, and combined were extracted from field data at Station Number 18, 20, 21, 22, 25, and 29 (Wieckowicz, Pages 74-92).

The estimated average daily flows and pollutant concentrations were used for both existing conditions and future development. These estimates are listed in Table 7. By using the same estimates for both conditions, the effect of future land-use changes on storm runoff and pollutant concentrations can be determined and isolated. Although the actual average daily

TABLE 7. Estimates of Average Daily Flow and Pollutant Loading Concentrations.

| SUB-BASIN | DAILY FLOW (cfs) | SUSPENDED SOLIDS (mg/l) | BOD (mg/l) | TOTAL N (mg/l) | $PO_4$ (mg/l) |
|---|---|---|---|---|---|
| 1 | 5.8 | 49.3 | 5.0 | 6.3 | 2.4 |
| 2 | 8.3 | 4.0 | 1.0 | 1.1 | 0 |
| 3 | 2.7 | 4.0 | 1.3 | 0.4 | 0 |
| Combined | 16.7 | 12.0 | 1.5 | 1.2 | 0.1 |

flows and pollutant concentrations for both conditions could be different, these differences would have minor effect on the results of this study which is shown in the discussion of results.

## Pollutant Accumulation Rates

The pollutant accumulation rates for each pollutant were used to compute the quality of storm runoff contributed from each land use. Estimates of pollutant accumulation rates for each land use were extracted from different sources [3, 4, 5, 6, 7]. These estimates are presented in Table 8. The typical residential areas in this basin are generally composed of curbs and gutters, or swales, depending on location. In this study, however, it was assumed that curb and gutter was the dominant factor. As a result, the pollutant accumulation rates used for residential areas were based on curb and gutter. If residential areas are dominated by swales, then the pollution accumulation rates would be much lower than the values used in this study.

## Determination of Total Runoff Hydrographs

Determination of total runoff hydrograph includes computation of dry-weather flow and computation of storm runoff. There are four options for computing the quantity of dry-weather flow (STORM Users Manual, Page 15-16). Option 1, which requires the input of average daily flow, was chosen for this study.

Storm runoff can be determined from one of the three options provided in STORM. In this study, storm runoff was computed by the SCS Runoff Curve Number method. The input data required in this method are rainfall and Runoff Curve Number. The computed

TABLE 8. Estimates of Pollutant Accumulation Rate for Each Pollutant and Land Use.

| DESCRIPTION OF LAND USE | POLLUTANT ACCUMULATION RATES (lbs/acre/day) Suspended Solids | BOD | TOTAL N | $PO_4$ |
|---|---|---|---|---|
| Sand, Gravel (2) | 2.500 | 0.020 | 0.003 | - |
| Mobile Home (1) | 0.120 | 0.040 | 0.016 | 0.005 |
| Commercial (1) | 1.900 | 0.310 | 0.043 | 0.010 |
| Industrial (1) | 1.900 | 0.260 | 0.043 | 0.007 |
| Park, Recreation 2) | 0.050 | 0.020 | 0.007 | - |
| Open Space (2) | 0.050 | 0.020 | 0.007 | - |
| High Density Residential (4) | 0.440 | 0.070 | 0.028 | 0.006 |
| Low Density Residential (1) | 0.120 | 0.040 | 0.016 | 0.005 |
| Institutional | 1.400 | 0.080 | 0.010 | 0.007 |
| Open Water | - | - | - | - |
| Residential Farm (3) | 2.800 | 0.040 | 0.044 | 0.002 |
| Agriculture, Crop, Hay (3) | 2.800 | 0.040 | 0.044 | 0.002 |
| Unimproved Rangeland (2) | 0.710 | 0.030 | 0.023 | 0.004 |
| Improved Rangeland (2) | 0.710 | 0.030 | 0.023 | 0.004 |
| Citrus (3) | 2.800 | 0.040 | 0.044 | 0.002 |
| Graded Land (2) | 2.500 | 0.020 | 0.007 | - |
| Unused Vegetation (4) | 0.012 | 0.010 | 0.002 | - |
| Pine Forest (4) | 0.012 | 0.010 | 0.002 | - |
| Cypress (4) | 0.012 | 0.010 | 0.002 | - |
| Marsh (4) | 0.012 | 0.010 | 0.002 | - |

(1) from Ref. 5, Tables D-3 and D-4

(2) from Ref. 7, Table 8.

(3) from Ref. 6, Table V-3.

(4) from Ref. 3, Table C-2.

storm runoff was then routed to the outlet of each sub-basin by the SCS unit hydrograph method to obtain storm hydrograph. The total runoff hydrograph of each sub-basin was determined by adding storm hydrograph to dry-weather flow.

Determination of Total Pollutant Concentrations

Determination of total pollutant concentrations consists of computation of pollutant concentrations from dry-weather flow and storm runoff. Four options are provided in STORM for computation of dry-weather flow quality. Since STORM requires that the same option be used for computing quantity and quality of dry-weather flows, Option 1, which requires the input of average daily pollutant concentrations, was chosen for this study.

Two methods are available for computing pollutant concentrations of storm runoff. The dust and dirt method assumes all pollutants are associated with the dust and dirt accumulation on the streets. The input data required in this method are: dust and dirt accumulation rate for each land use, pollutant fractions for each pollutant, length of street gutters, and the frequency and efficiency of street sweeping. The second method is the pollutant accumulation method which requires pollutant accumulation rates as input data. Since the input data required in the first method were not available in this study, the pollutant accumulation method was used to simulate the pollutant concentrations of storm runoff under both existing conditions and future development.

## DISCUSSION OF RESULTS

For the purpose of discussion, the results obtained from the storm event dated January 20, 1983 were chosen. This storm event was the most critical event among the storm events considered. It yielded the highest peak discharge and pollutant concentrations. The total rainfall for this storm event was 3.94 inches, which was estimated to have a return period of one year with a 12-hour duration [8].

### Total Runoff Hydrographs

The simulated total runoff volumes under existing conditions and future development are presented in Table 9. The increase in total runoff volumes resulting from future land-use changes was 52.8 percent, 15.1 percent, and 15.0 percent for Sub-basins 1, 2, and 3, respectively. The average increase in total runoff volume for the entire basin was 20.3 percent.

The simulated peak discharges under existing conditions and future development are also presented in Table 9. The increase in peak discharges for Sub-basins 1, 2, and 3 due to future development was 100.0 percent, 22.6 percent, and 22.6 percent, respectively. The average increase in peak discharge for the entire basin was 28.1 percent.

The simulated total runoff hydrographs for existing conditions and future development are shown in Figures 3 and 4. The shapes of these hydrographs are very similar. The times to peak under both conditions were nearly the same for every sub-basin

TABLE 9. Summary of Simulated Total Runoff Volumes and Peak Discharges under Existing Conditions and Future Development

| SUB-BASIN | EXISTING CONDITIONS | | | FUTURE DEVELOPMENT | | |
|---|---|---|---|---|---|---|
| | Total Runoff Volume (in.) | Peak Discharge (cfs) | Time to Peak (hrs) | Total Runoff Volume (in.) | Peak Discharge (cfs) | Time to Peak (hrs) |
| 1 | 1.42 | 119 | 20 | 2.17 | 238 | 17 |
| 2 | 1.26 | 181 | 25 | 1.45 | 222 | 24 |
| 3 | 1.07 | 106 | 15 | 1.23 | 130 | 15 |
| Combined | 1.23 | 281 | 26 | 1.48 | 360 | 25 |

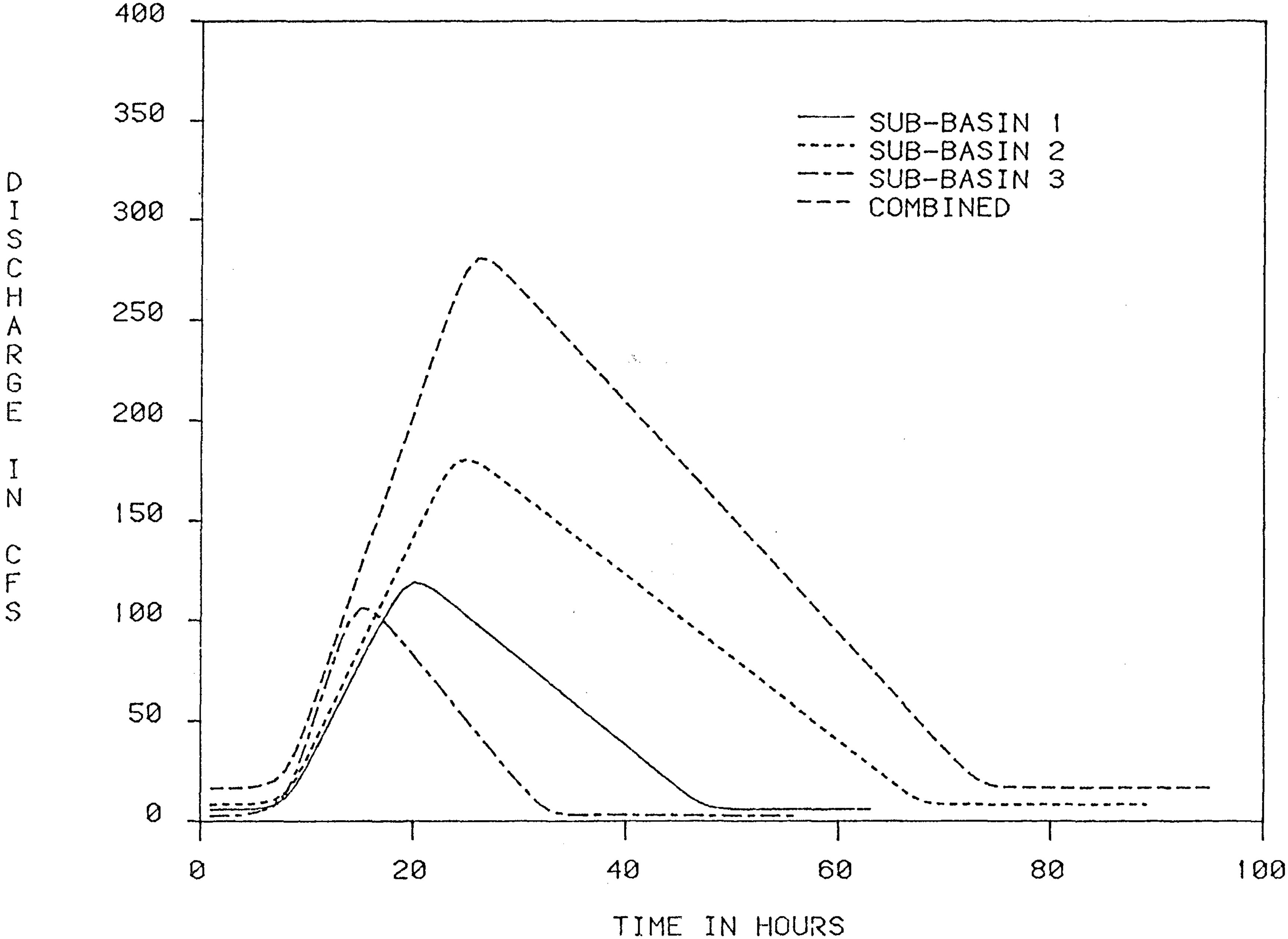

Figure 3. Runoff Hydrographs under Existing Conditions

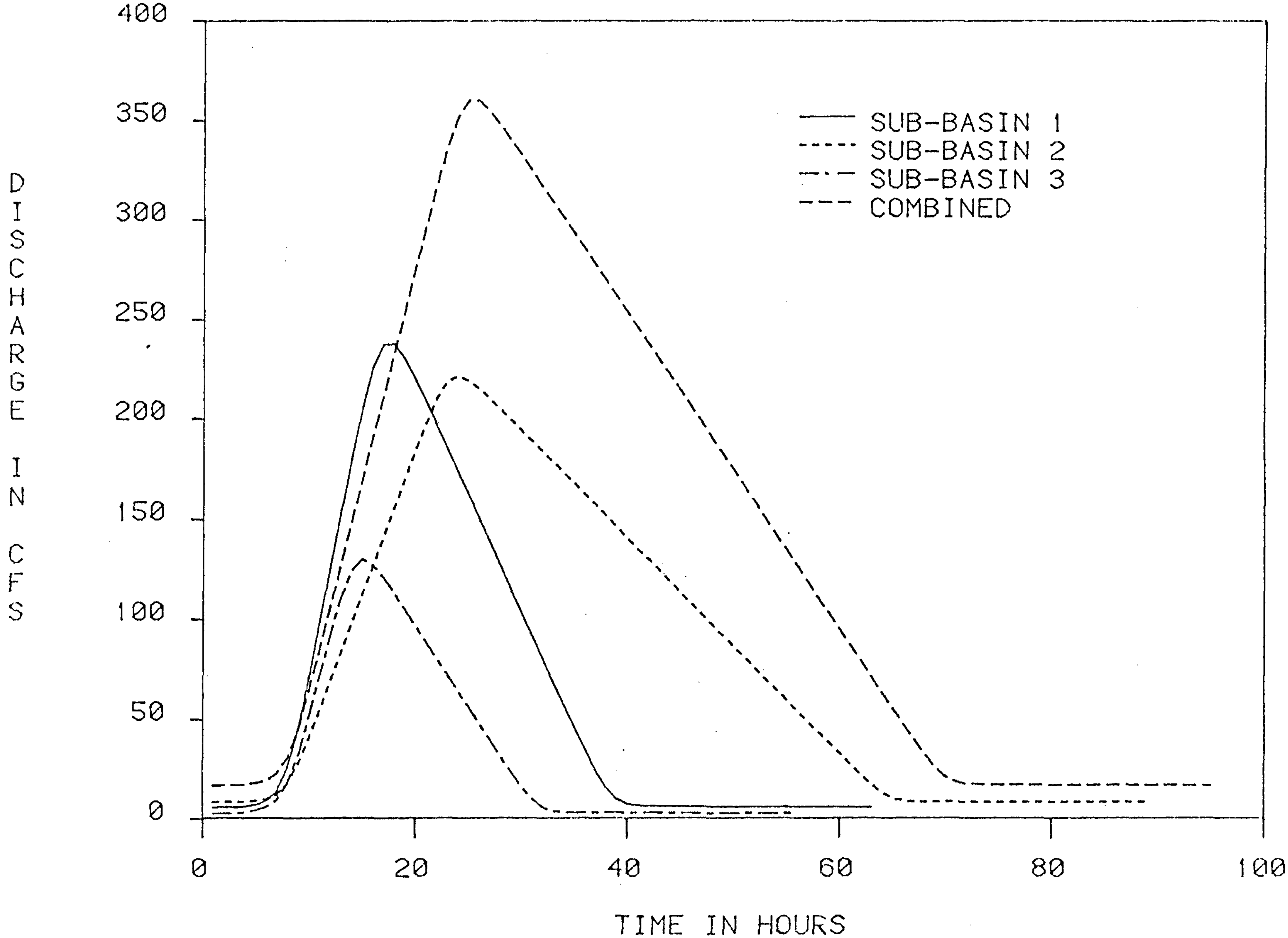


Figure 4. Runoff Hydrographs under Future Development

except for Sub-basin 1. The difference in times to peak for Sub-basin 1 was the largest because there was a significant decrease in lag time (Table 6).

Total Pollutant Concentrations

Each land use contributes a different amount of pollutant load depending on its washoff rate potential. For example, if pine forest is converted into low-density residential, the concentration of suspended solids would be greatly increased since low-density residential has a much higher washoff rate than pine forest (Table 8). On the other hand, concentration of suspended solids would be significantly decreased if citrus is converted into low-density residential.

The peak pollutant concentrations under existing conditions and future development are summarized in Table 10. In Sub-basin 1, the future peak pollutant concentrations were increased by 83.5 percent, 97.5 percent, 71.2 percent, and 4.2 percent for suspended solids, BOD, total nitrogen, and orthophosphate, respectively. These increases resulted from the conversion of 80 percent of pine forest into low and high density residential, commercial, and industrial lands under future development.

In Sub-basin 2, the peak pollutant concentrations for suspended solids, BOD, total nitrogen, and orthophosphate were increased by 7.7 percent, 27.6 percent, 5.5 percent, and 20 percent, respectively. This increase in peak pollutant concentrations was mainly due to the replacement of pine forest by residential and commercial.

TABLE 10. Summary of Peak Pollutant Concentrations under Existing Conditions and Future Development.

| | SUSPENDED SOLIDS (mg/l) | | BOD (mg/l) | | TOTAL NITROGEN (mg/l) | | ORTHOPHOSPHATE (mg/l) | |
|---|---|---|---|---|---|---|---|---|
| SUB-BASIN | EXISTING | FUTURE | EXISTING | FUTURE | EXISTING | FUTURE | EXISTING | FUTURE |
| 1 | 69.1 | 126.8 | 19.6 | 38.7 | 7.3 | 12.5 | 2.4 | 2.5 |
| 2 | 100.9 | 108.7 | 16.3 | 20.8 | 9.1 | 9.6 | 1.0 | 1.2 |
| 3 | 43.2 | 65.8 | 16.7 | 29.6 | 5.8 | 8.6 | 1.2 | 1.9 |
| Combined | 80.5 | 102.9 | 16.4 | 24.1 | 7.6 | 9.3 | 1.0 | 1.3 |

In Sub-basin 3, future peak pollutant concentrations were increased by 52.3 percent, 77.3 percent, 48.3 percent, and 58.3 percent for suspended solids, BOD, total nitrogen, and orthophosphate, respectively. The increase in peak pollutant concentrations was caused by the conversion of unused vegetation and pine forest into residential, commercial, and industrial.

On the average, future peak pollutant concentrations were increased by 27.8 percent, 47.0 percent, 22.4 percent, and 30.0 percent for suspended solids, BOD, total nitrogen, and orthophosphate, respectively.

The simulated pollutographs under existing conditions and future development for suspended solids, BOD, total nitrogen, and orthophosphate are shown in Figures 5 through 12. One common characteristic can be observed from these pollutographs: the pollutant concentrations rise very sharply at the early part of storm runoff, drop very rapidly near the end of storm runoff, and reach their initial values at the end of storm runoff. The sharp increase in pollutant concentrations is due to the fact that the pollutant concentrations contributed from storm runoff are normally higher than the pollutant concentrations of dry-weather flow and are highest during the first inch of storm runoff.

In Figure 11, however, the orthophosphate pollutograph for Sub-basin 1 is quite different from those for other sub-basins since the orthophosphate concentration is highest during dry-weather flow, drops very sharply at the beginning of storm runoff, rises rapidly near the end of storm runoff and reaches

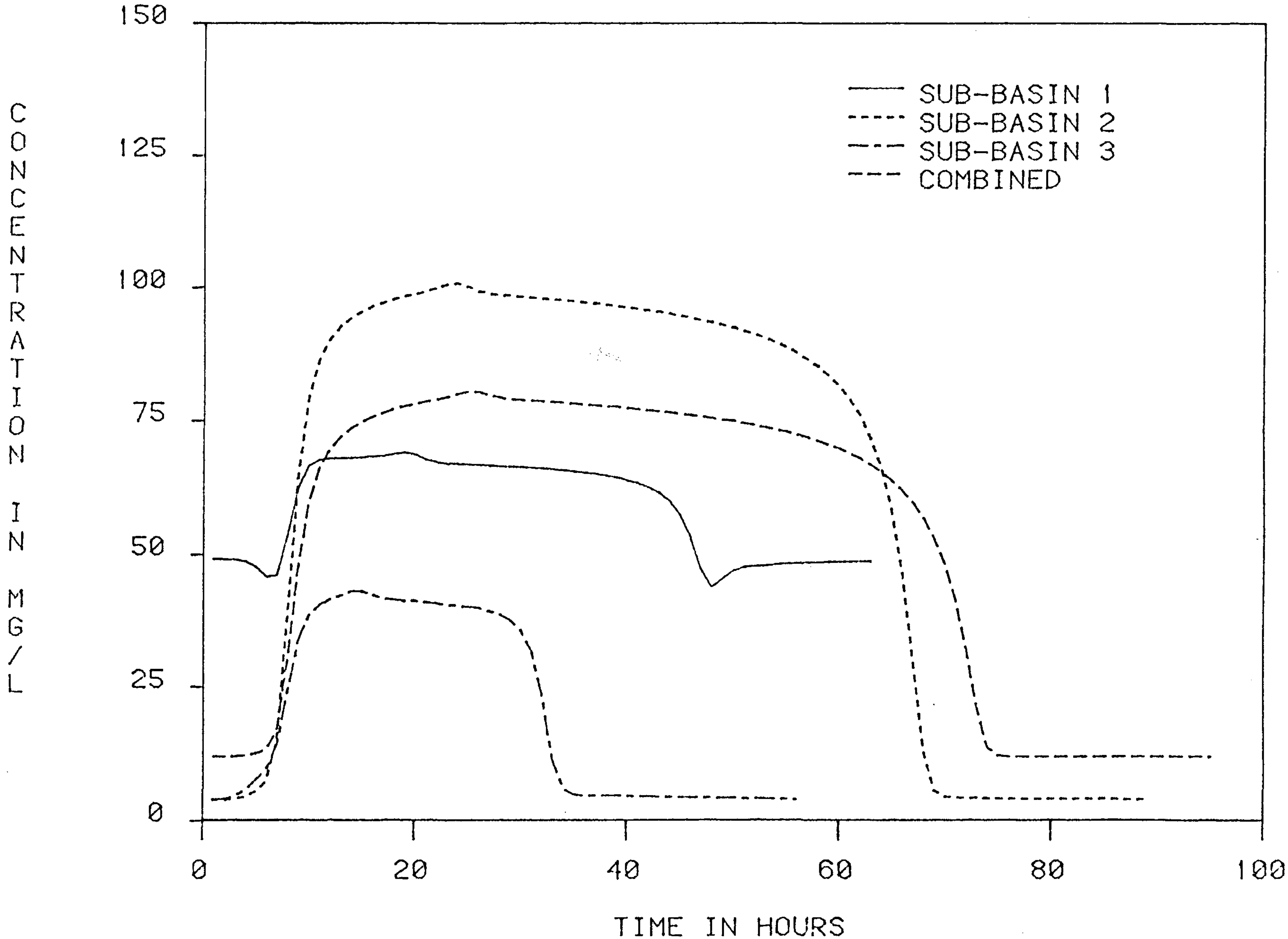


Figure 5. Suspended Solid Pollutographs under Existing Conditions

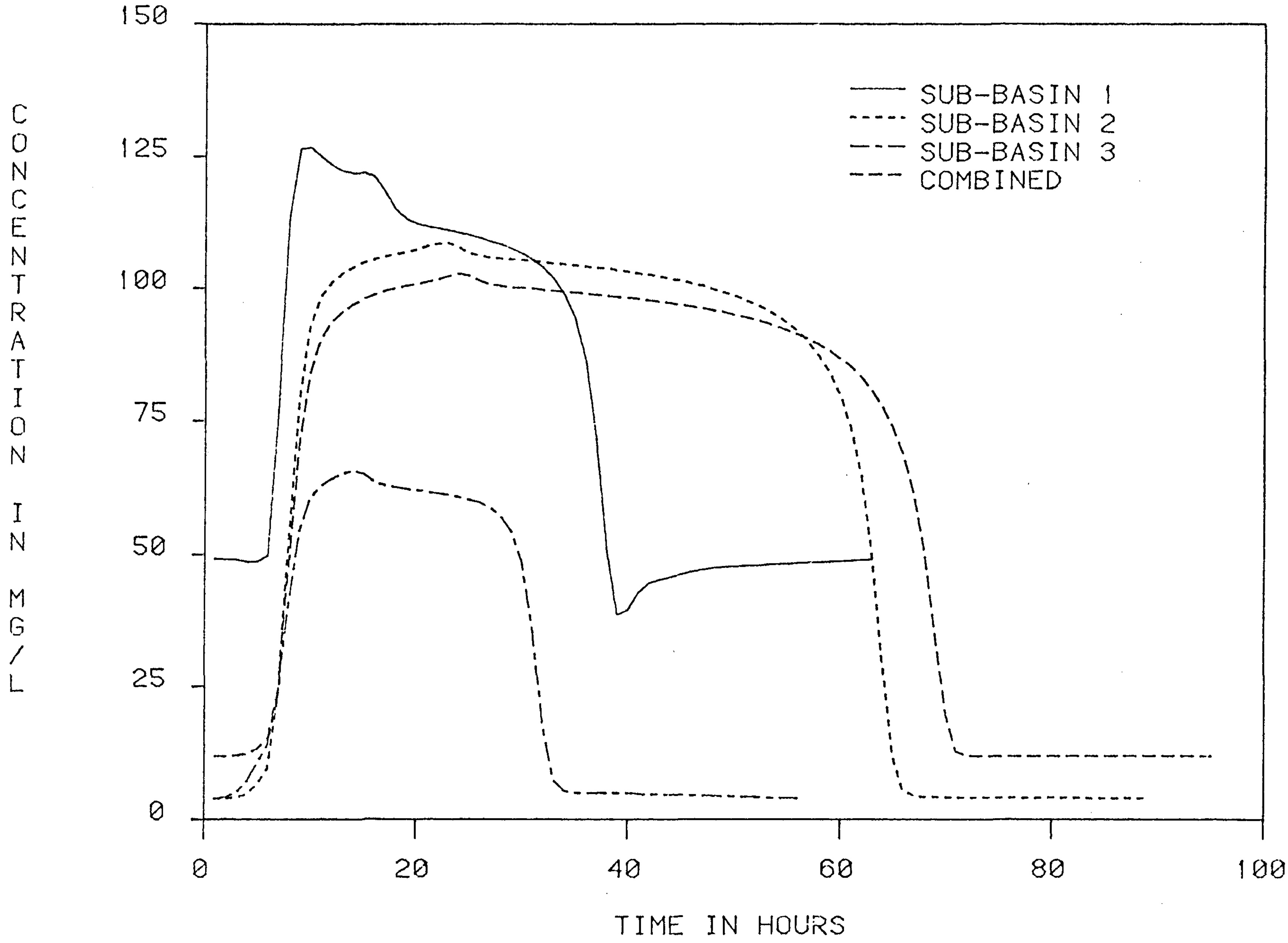


Figure 6. Suspended Solid Pollutographs under Future Development

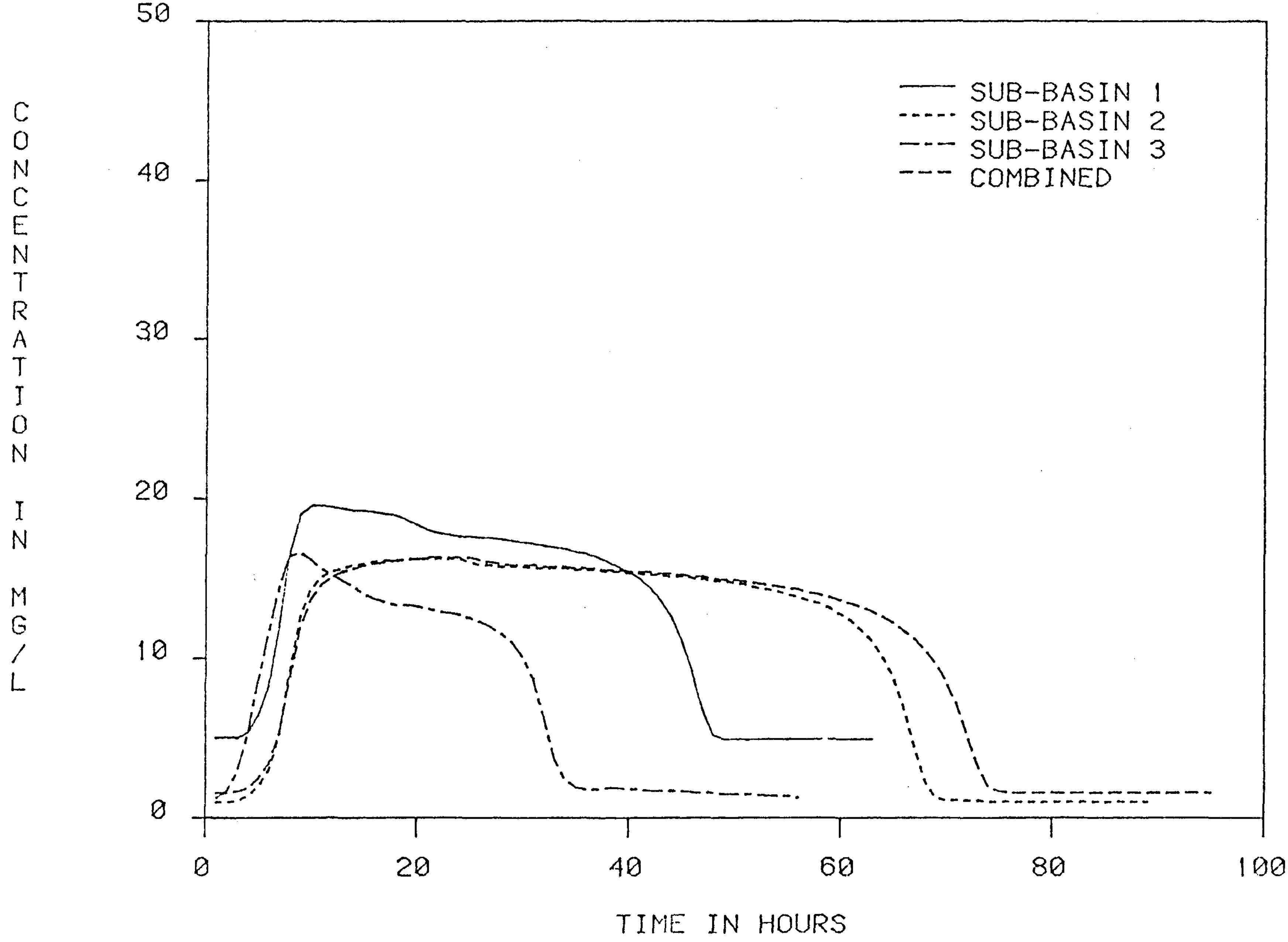


Figure 7. BOD Pollutographs under Existing Conditions

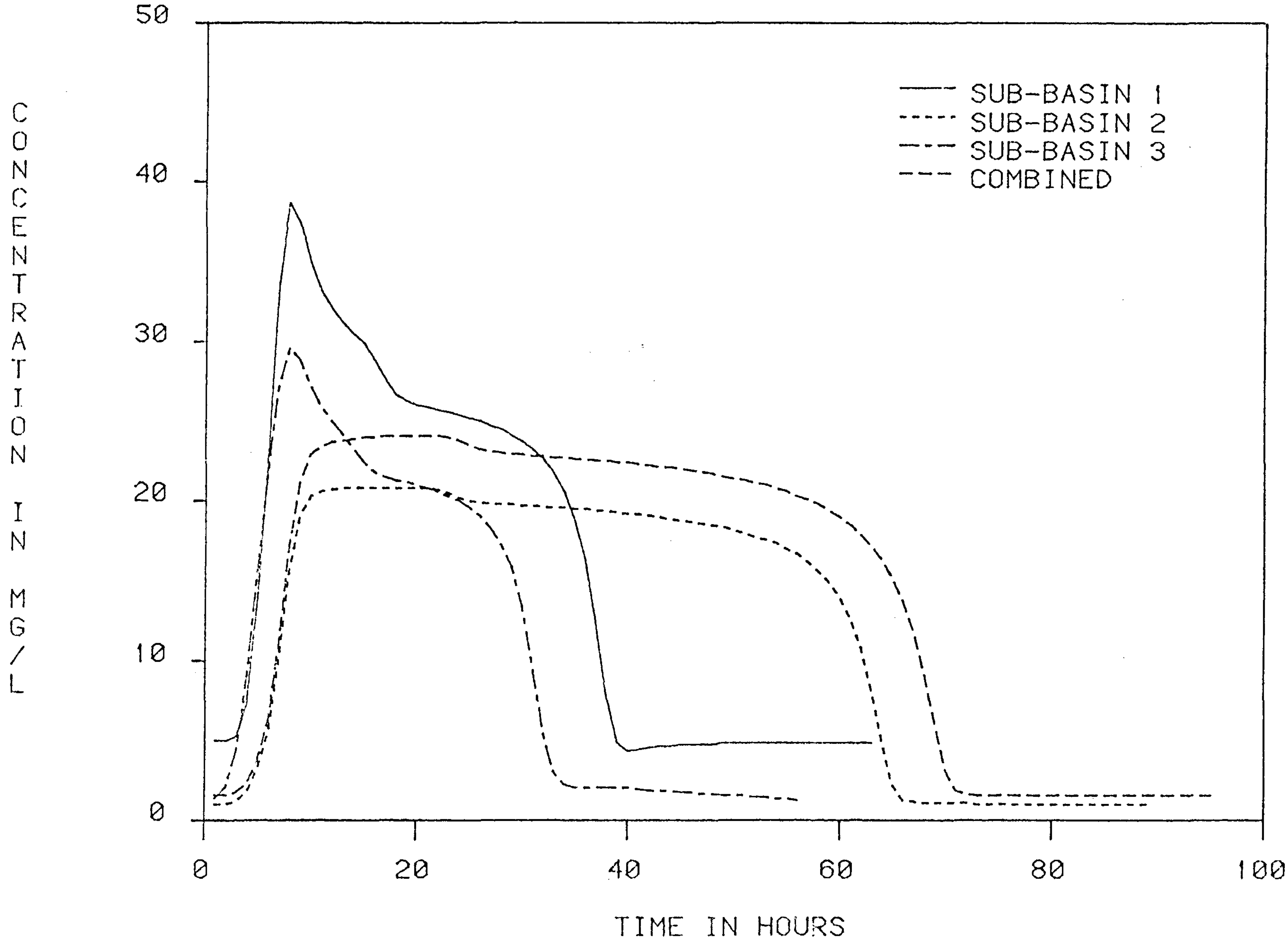


Figure 8. BOD Pollutographs under Future Development

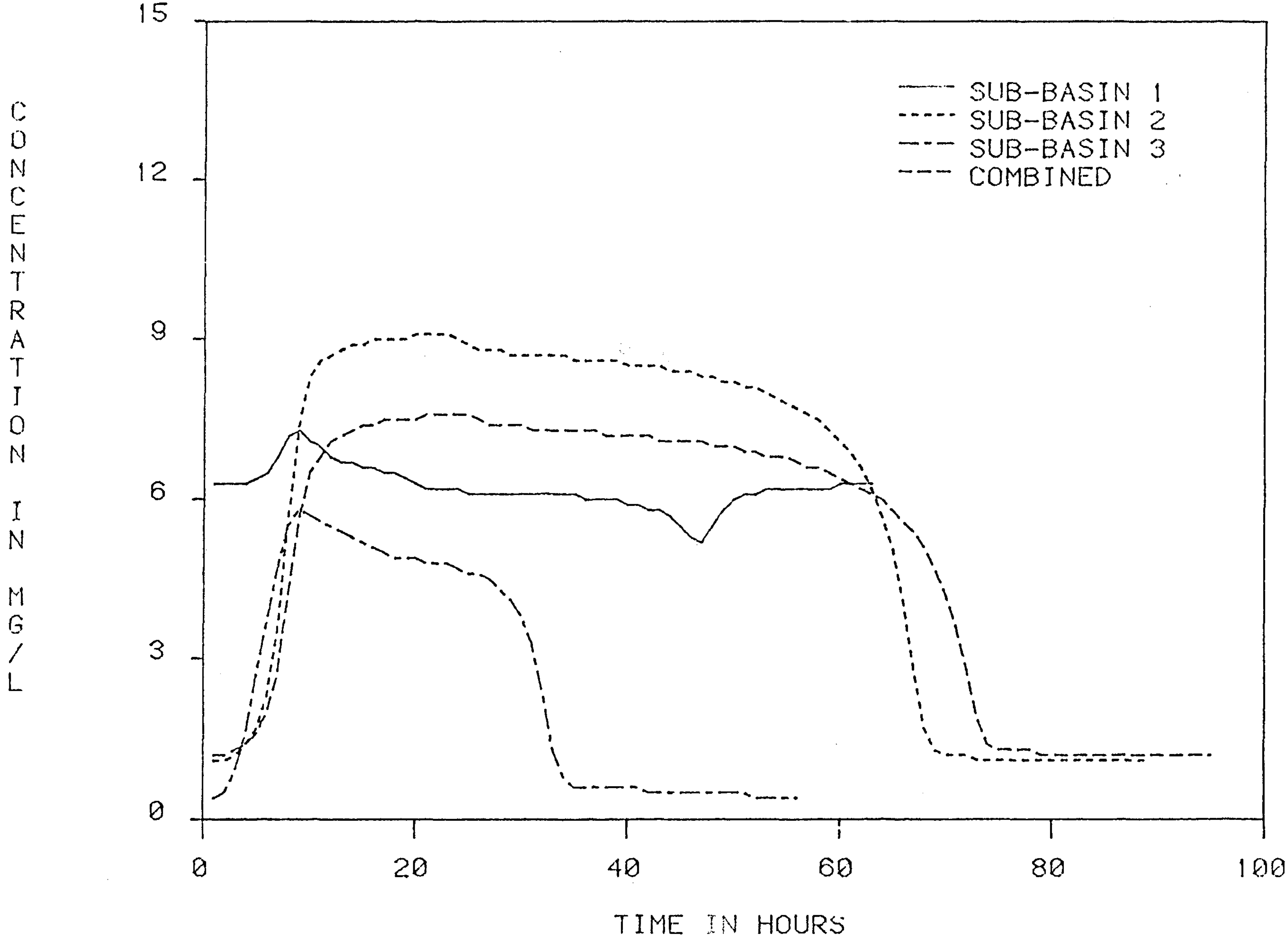


Figure 9. Total Nitrogen Pollutographs under Existing Conditions

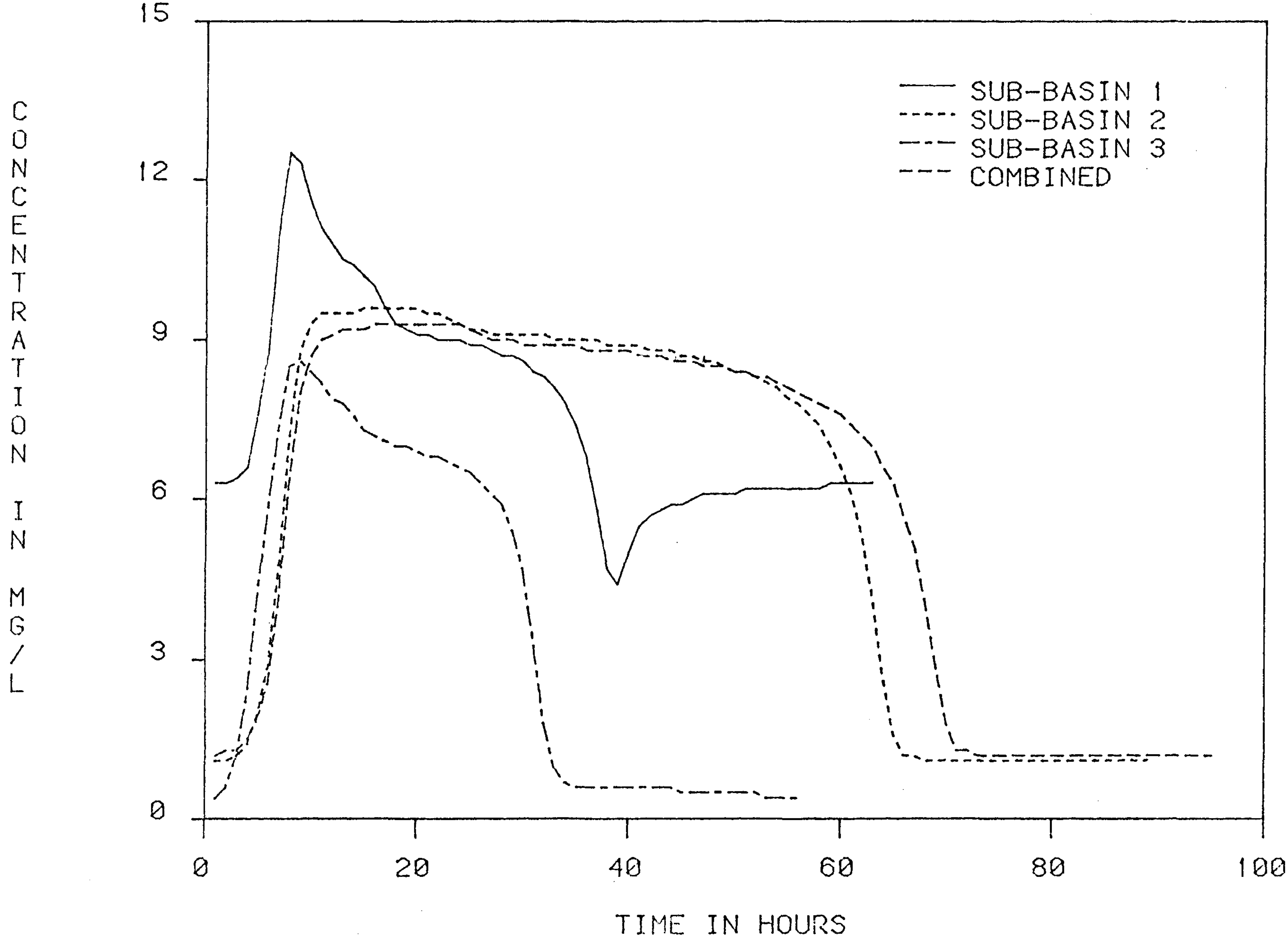


Figure 10. Total Nitrogen Pollutographs under Future Development

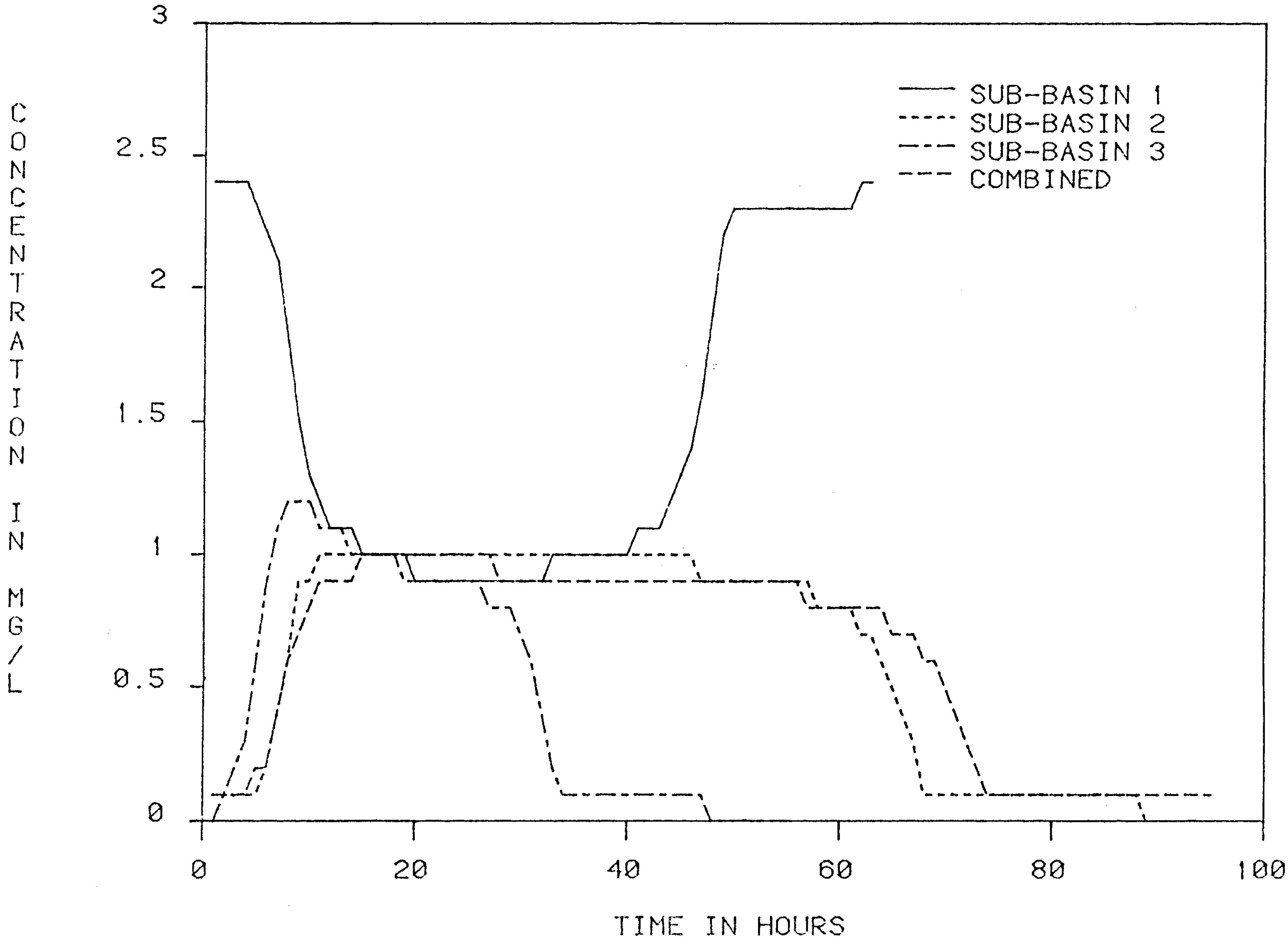


Figure 11. Orthophosphate Pollutographs under Existing Conditions

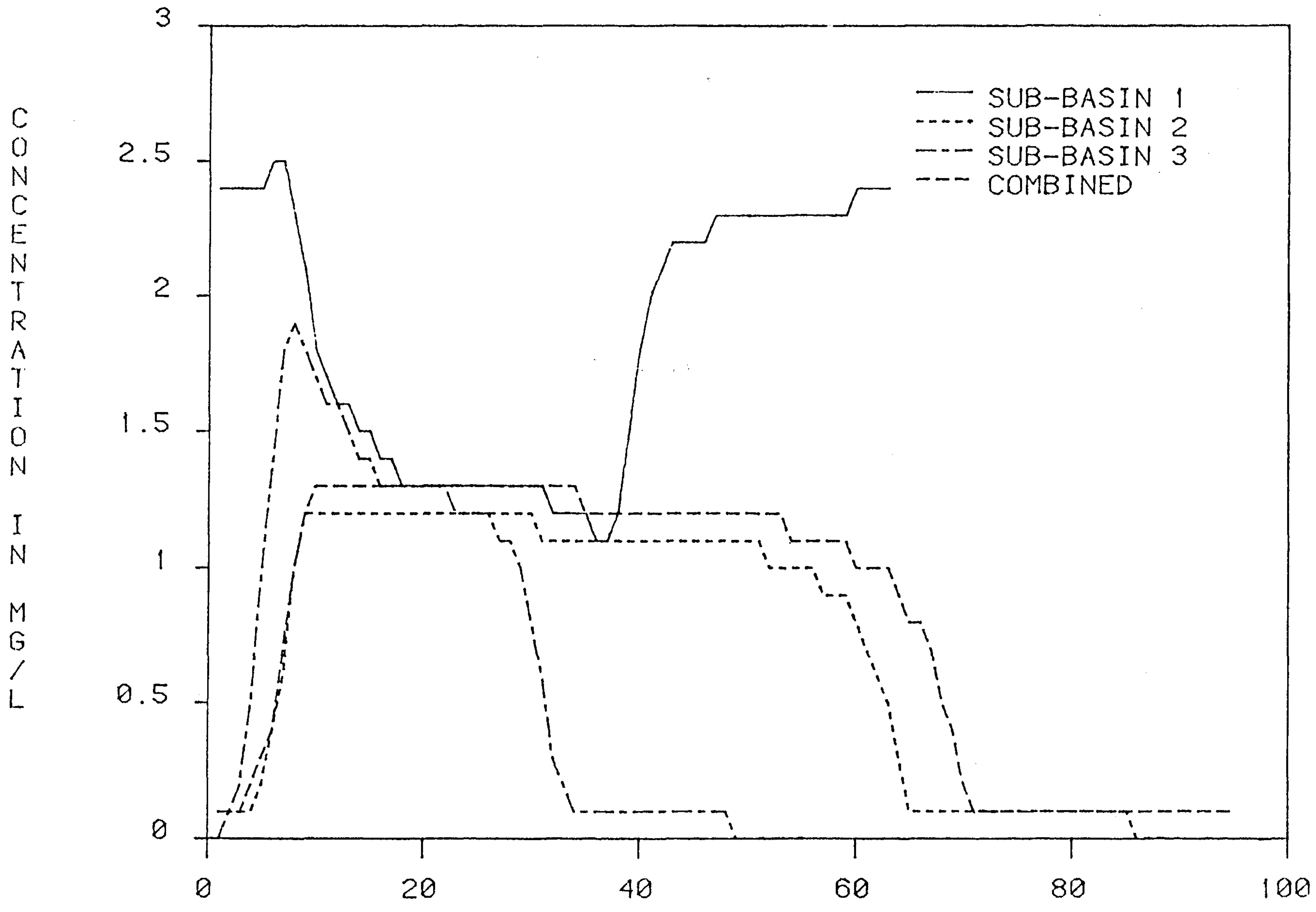

Figure 12. Orthophosphate Pollutographs under Future Development

peak again at the end of storm runoff. This incidence can be rationalized by the fact that the orthophosphate concentration of dry-weather flow in this sub-basin, which is greatly affected by the existing sewage treatment plant, is much higher than the pollutant concentration generated from storm runoff. When storm runoff is added to dry-weather flow, the total orthophosphate concentration is decreased substantially due to dilution. Similarly, the same rationale can be used to explain the orthophosphate pollutograph for Sub-basin 1 shown in Figure 12.

Beginning in 1987, the Port Malabar wastewater treatment plant in Sub-basin 1 will terminate its discharge to Turkey Creek and switch to the injection well disposal method [9]. This proposed plan has been approved by the Department of Environmental Regulation (DER) under DER Permit Number DT05-79139 (Appendix B). As a result, the initial discharge would be 1.5 MGD less and initial pollutant concentrations for the sub-basin would be much lower than the current level. However, additional results indicate that changes in initial discharge and pollutant concentrations have little effect on peak discharge and peak pollutant concentrations (Table 11 and Figures 13-16). These results suggest that the assumptions made on initial discharge and pollutant concentrations will have little effect on peak discharge and peak pollutant concentrations given by STORM.

TABLE 11. Comparison of Peak Discharges and Pollutant Concentrations for Sub-Basin 1 Using Different Initial Discharges and Pollutant Concentrations.

| DESCRIPTION | DISCHARGE (cfs) Intl. | Peak | SUSPENDED SOLIDS Intl. | Peak | BOD (mg/l) Intl. | Peak | TOTAL NITROGEN (mg/l) Intl. | Peak | $PO_4$ (mg/l) Intl. | Peak |
|---|---|---|---|---|---|---|---|---|---|---|
| W/O STP (1) | 3.5 | 236 | 11.9 | 127.6 | 1.5 | 41.5 | 1.2 | 12.3 | 0.1 | 2.0 |
| W/O STP (2) | 3.5 | 236 | 29.7 | 129.1 | 3.0 | 41.7 | 3.0 | 12.6 | 0.7 | 2.1 |
| With STP | 5.8 | 238 | 49.3 | 126.8 | 5.0 | 38.7 | 6.3 | 12.5 | 2.4 | 2.5 |

(1) Without sewage treatment plant, first run.

(2) Without sewage treatment plant, second run.

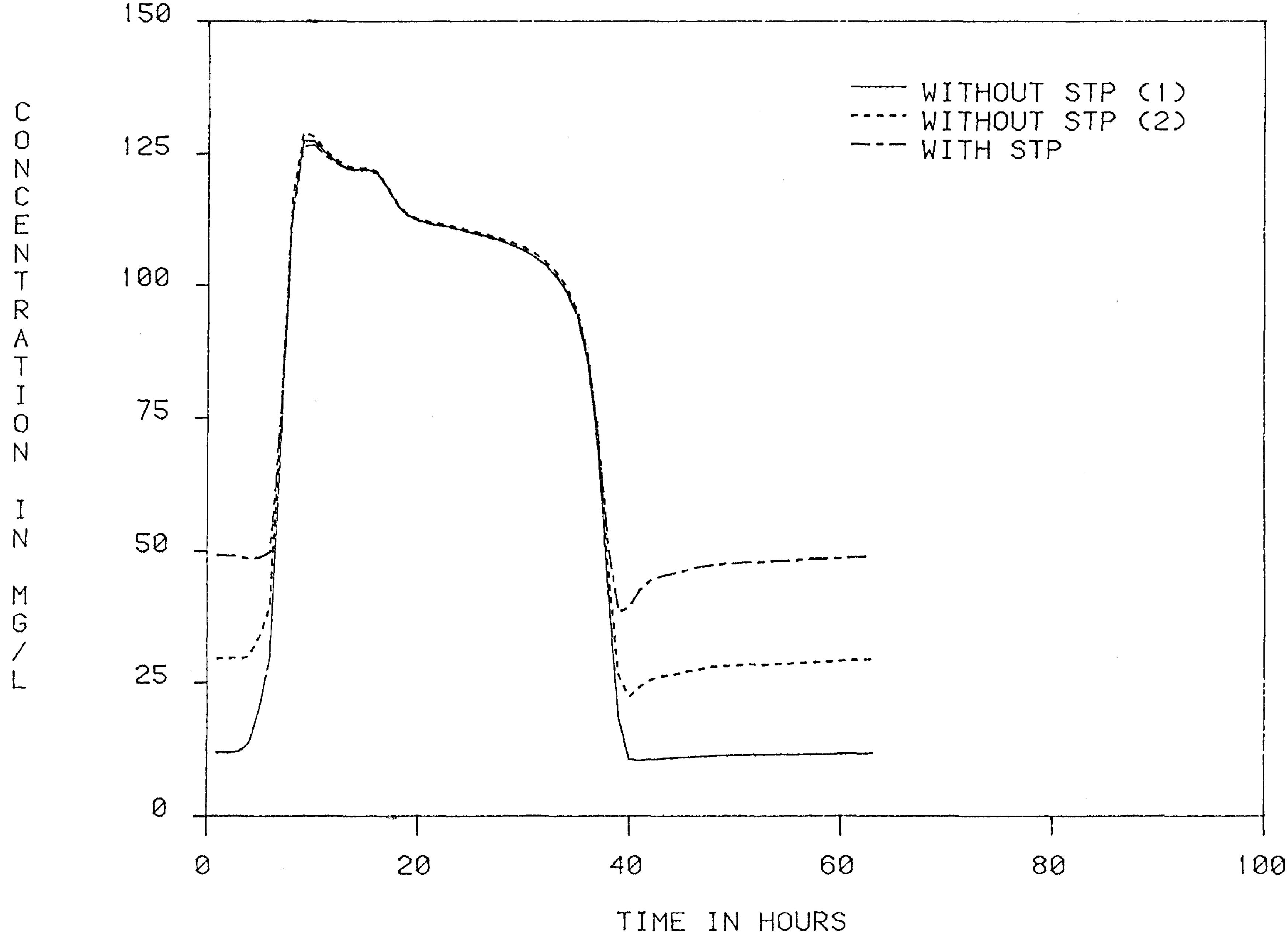


Figure 13. Comparison of Suspended Solid Pollutographs for Sub-basin 1 Using Different Initial Pollutant Concentrations

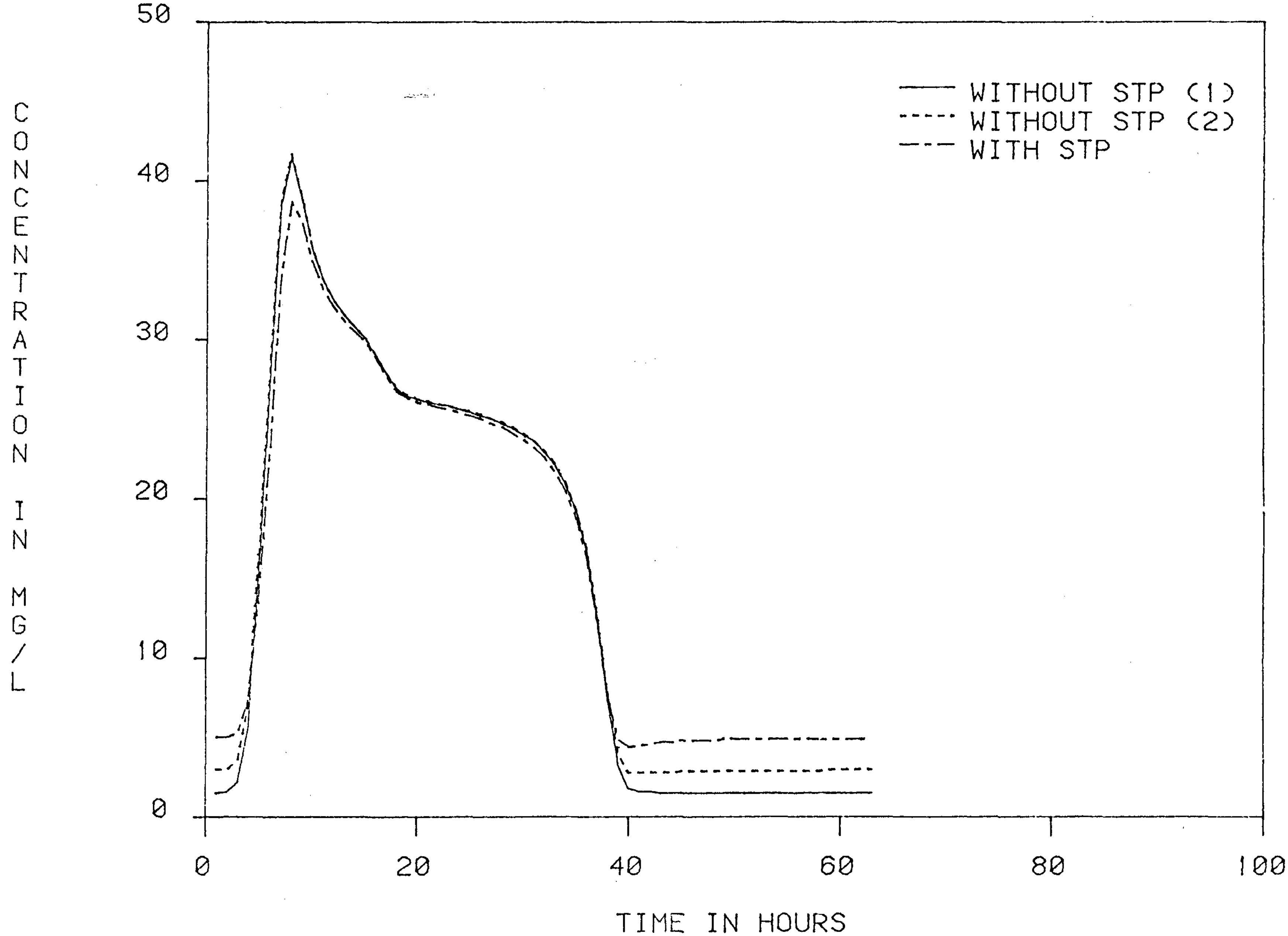


Figure 14. Comparison of BOD Pollutographs for Sub-basin 1 Using Different Initial Pollutant Concentrations

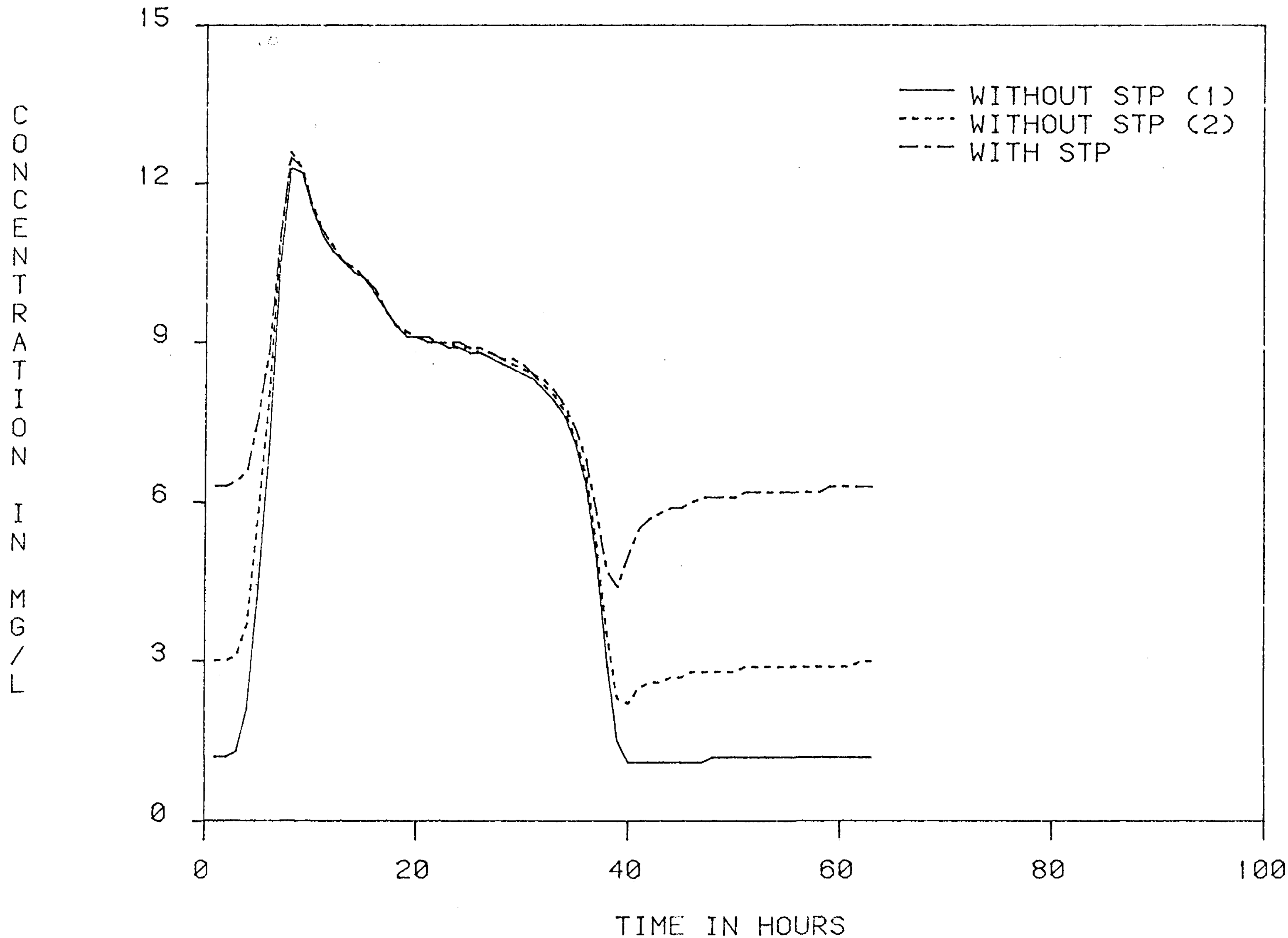


Figure 15. Comparison of Total Nitrogen Pollutographs for Sub-basin 1 Using Different Initial Pollutant Concentrations

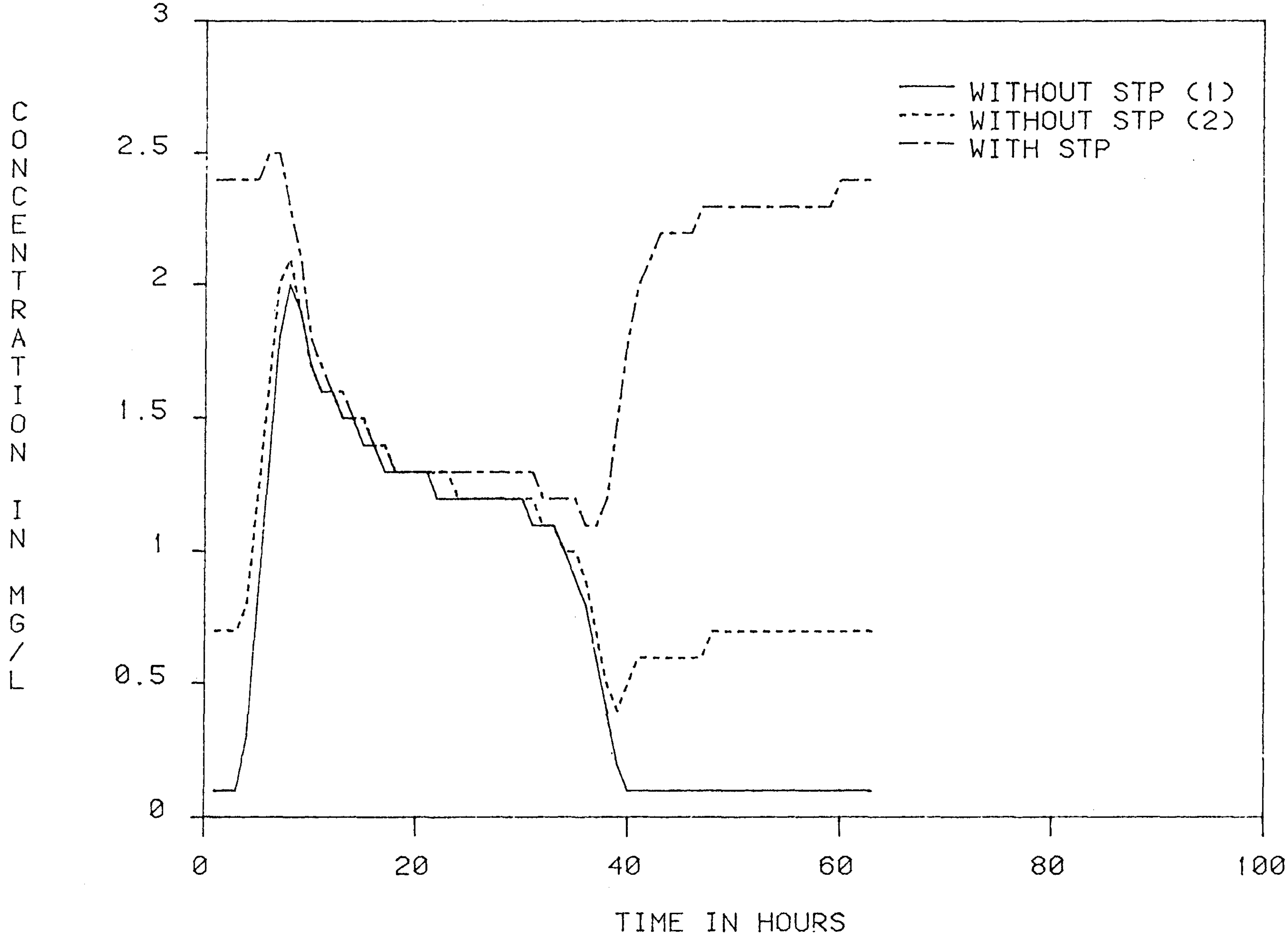


Figure 16. Comparison of Orthophosphate Pollutographs for Sub-basin 1 Using Different Initial Pollutant Concentrations

## CONCLUSIONS

1. Preliminary results indicate that future increases in runoff volumes and peak discharges will be significant for every sub-basin, particularly for Sub-basin 1. Future increase in BOD concentration will be great for every sub-basin. Large increases in concentrations of suspended solids and nitrogen are anticipated for Sub-basins 1 and 3. Future increase in orthophosphate concentration will be significant for Sub-basins 2 and 3. Future increases in pollutant concentrations are largely due to the conversion of pine forest and unused vegetation into residential, commercial, and industrial.
2. The runoff hydrographs and pollutant concentrations presented in this study did not account for the inflows and pollutant concentrations contributing from the C-1 and C-82 canals. If they were included in the study, then the runoff hydrographs would be much higher and pollutant concentrations could be different from the values given in this report.
3. This preliminary study has determined the relative effects of future land-use changes on runoff volume, peak discharge, and pollutant concentrations in Turkey Creek Basin. However, it is not recommended to use the results of this report as predictions of present and future runoff quantity and quality for the basin. For more accurate predictions, a monitoring program for collecting streamflows and water quality data must be established before a more comprehensive simulation

model (e.g. EPA's Storm Water Management Model, Hydrocomp Simulation Program) can be used.

4. Future study will include refinements of this study and development of a surface water management plan for Turkey Creek Basin. While the management plan is not yet established, future increases in peak runoff, runoff volume and pollutant loadings could be minimized through the following management practices:
   a. Post-development peak discharge should not exceed pre-development peak discharge.
   b. Construction of detention/retention structures for water quality enhancement.
   c. Installation of swales in residential areas instead of curbs and gutters.

## REFERENCES


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12. Luzkow, S.M., "An Evaluation of Storm Generated Pollutant Contributions from a Small Residential Catchment, Palm Bay, Florida," M.S. Thesis, Florida Institute of Technology, 1978.

13. Briley, Wild, and Associates, Inc., Stormwater Management Master Plan, City of Palm Bay, Florida, April 1979.

# APPENDIX A

# EQUATIONS

The following equations developed by Soil Conservation Service (SCS) were used in the computation of direct runoff and peak discharge. Computation of direct runoff is given as:

$$S = \frac{1000}{CN} - 10$$

$$Q = \frac{(P-IA)^2}{P-IA+S}$$

where S = potential maximum retention in inches

CN = SCS Runoff Curve Number

Q = accumulated direct runoff in inches

P = accumulated rainfall in inches

IA = initial abstraction in inches

Computation of peak discharge is given by the following:

$$L = \frac{\ell^{0.8}(S+1)^{0.7}}{1900y^{0.5}}$$

$$T_c = 1.67\ L$$

$$D = 0.133\ Tc$$

$$T_p = D/2 + L$$

$$q_p = \frac{484\ AQ}{T_p}$$

where

L = lag time in hours

$\ell$ = hydraulic length of watershed in feet

S = potential maximum retention in inches

Y = average watershed land slope in percent

$T_c$ = time of concentration in hours

D = duration of unit excess rainfall in hours

A = watershed area in square miles

$T_p$ = time to the peak in hours

$q_p$ = peak discharge in cubic feet per second

Q = runoff in inches

The equation used in the pollutant accumulation method to compute pollutant washoff rates is:

$$M = [C*A*N+X]*(1-e^{-KR})$$

where M = pollutant washoff rate in lbs/hr

C = loading rates in lbs/acre/day for each pollutant

A = area in acres

N = number of days without runoff since the last storm

X = remaining of pollutant on land at the end of the previous storm in pounds

K = washoff decay coefficient

R = runoff rate in inches/hour

The pollutant washoff rates are multiplied by the runoff duration for the total pounds of washoff, or divided by the runoff rate for concentrations.

# APPENDIX B

## PROPOSED PLAN FOR PORT MALABAR WASTEWATER TREATMENT PLANT

STATE OF FLORIDA

# DEPARTMENT OF ENVIRONMENTAL REGULATION


ST. JOHNS RIVER DISTRICT
3319 MAGUIRE BOULEVARD
SUITE 232
ORLANDO, FLORIDA 32803-3767

BOB GRAHAM
GOVERNOR

VICTORIA J. TSCHINKEL
SECRETARY

A. ALEXANDER
DISTRICT MANAGER


Permittee:
Gordon J. Pfersich
Senior Vice President
General Development
Utilities, Inc.
1111 South Bayshore Drive
Miami, Florida 33131

I. D. Number: 05P02746
Permit/Certification
Number: DT05-79139
Date of Issue:
Expiration Date: 3-1-87
County: Brevard
Latitude/Longitude:
28°01'35"/80°37'57"
Section/Township/Range:
Project: Port Malabar WWTP

This permit is issued under the provisions of Chapter(s) 403, Florida Statutes, and Florida Administrative Code Rule(s) 17-3, 17-4 and 17-6. The above named permittee is hereby authorized to perform the work or operate the facility shown on the application and approved drawing(s), plans, and other documents attached hereto or on file with the department and made a part hereof and specifically described as follows:

Temporary Operate: a 2.0 MGD design capacity contact stabilization sewage treatment facility. The disinfected effluent is discharged to surface water via Turkey Creek hence to the Indian River.

Location: 440 Southeast Dixie Highway, Port Malabar, Brevard County, Florida.

Treatment Required: Secondary treatment and basic disinfection.

Operators Required: This is a Class B, Level II treatment facility. In accordance with Chatper 17-16, F.A.C. an operator of minimum certification Class C shall be on-site at least 16 hours a day, 7 days a week. The lead operator shall have at least a Class B certification.

Other Permits: DO05-7043 - expired 12-31-82.

**General Conditions 1 through 15 are attached to be distributed to the permittee and engineer only.**

GENERAL CONDITIONS:

1. The terms, conditions, requirements, limitations, and restrictions set forth herein are "Permit Conditions" and as such are binding upon the permittee and enforceable pursuant to the authority of Sections 403.161, 403.727, or 403.859 through 403.861, Florida Statutes. The permittee is hereby placed on notice that the department will review this permit periodically and may initiate enforcement action for any violation of the "Permit Conditions" by the permittee, its agents, employees, servants or representatives.

2. This permit is valid only for the specific processes and operations applied for and indicated in the approved drawings or exhibits. Any unauthorized deviation from the approved drawings, exhibits, specifications, or conditions of this permit may constitute grounds for revocation and enforcement action by the department.

3. As provided in Subsections 403.087(6) and 403.722(5), Florida Statutes, the issuance of this permit does not convey any vested rights or any exclusive privileges. Nor does it authorize any injury to public or private property or any invasion of personal rights, nor any infringement of federal, state or local laws or regulations. This permit does not constitute a waiver of or approval of any other department permit that may be required for other aspects of the total project which are not addressed in the permit.

4. This permit conveys no title to land or water, does not constitute state recognition or acknowledgement of title, and does not constitute authority for the use of submerged lands herein provided and the necessary title or leasehold interests have been obtained from the state. Only the Trustees of the Internal Improvement Trust Fund may express state opinion as to title.

DER FORM 17-1.201(5) Effective November 30, 1982

5. This permit does not relieve the permittee from liability for harm or injury to human health or welfare, animal, plant or aquatic life or property and penalties therefor caused by the construction or operation of this permitted source, nor does it allow the permittee to cause pollution in contravention of Florida Statutes and department rules, unless specifically authorized by an order from the department.

6. The permittee shall at all times properly operate and maintain the facility and systems of treatment and control (and related appurtenances) that are installed or used by the permittee to achieve compliance with the conditions of this permit, as required by department rules. This provision includes the operation of backup or auxiliary facilities or similar systems when necessary to achieve compliance with the conditions of the permit and when required by department rules.

7. The permittee, by accepting this permit, specifically agrees to allow authorized department personnel, upon presentation of credentials or other documents as may be required by law, access to the premises, at reasonable times, where the permitted activity is located or conducted for the purpose of:
   a. Having access to and copying any records that must be kept under the conditions of the permit;

   b. Inspecting the facility, equipment, practices, or operations regulated or required under this permit; and

   c. Sampling or monitoring any substances or parameters at any location reasonably necessary to assure compliance with this permit or department rules.

   Reasonable time may depend on the nature of the concern being investigated.

DER FORM 17-1.201(5) Effective November 30, 1982

8. If, for any reason, the permittee does not comply with or will be unable to comply with any condition or limitation specified in this permit, the permittee shall immediately notify and provide the department with the following information:

   a. a description of and cause of non-compliance; and

   b. the period of noncompliance, including exact dates and times; or, if not corrected, the anticipated time the non-compliance is expected to continue, and steps being taken to reduce, eliminate, and prevent recurrence of the non-compliance.

   The permittee shall be responsible for any and all damages which may result and may be subject to enforcement action by the department for penalties or revocation of this permit.

9. In accepting this permit, the permittee understands and agrees that all records, notes, monitoring data and other information relating to the construction or operation of this permitted source, which are submitted to the department, may be used by the department as evidence in any enforcement case arising under the Florida Statutes or department rules, except where such use is proscribed by Sections 403.73 and 403.111, Florida Statutes.

10. The permittee agrees to comply with changes in department rules and Florida Statutes after a reasonable time for compliance, provided however, the permittee does not waive any other rights granted by Florida Statutes or department rules.

11. This permit is transferable only upon department approval in accordance with Florida Administrative Code Rules 17-4.12 and 17-30.30, as applicable. The permittee shall be liable for any non-compliance of the permitted activity until the transfer is approved by the department.

12. This permit is required to be kept at the work site of the permitted activity during the entire period of construction or operation.

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13. This permit also constitutes:

- ( ) Determination of Best Available Control Technology (BACT)
- ( ) Determination of Prevention of Significant Deterioration (PSD)
- ( ) Certification of Compliance with State Water Quality Standards (Section 401, PL 92-500)
- ( ) Compliance with New Source Performance Standards

14. The permittee shall comply with the following monitoring and record keeping requirements:

    a. Upon request, the permittee shall furnish all records and plans required under department rules. The retention period for all records will be extended automatically, unless otherwise stipulated by the department, during the course of any unresolved enforcement action.

    b. The permittee shall retain at the facility or other location designated by this permit records of all monitoring information (including all calibration and maintenance records and all original strip chart recordings for continuous monitoring instrumentation), copies of all reports required by this permit, and records of all data used to complete the application for this permit. The time period of retention shall be at least three years from the date of the sample, measurement, report or application unless otherwise specified by department rule.

    c. Records of monitoring information shall include:

    - the date, exact place, and time of sampling or measurements;
    - the person responsible for performing the sampling or measurements;
    - the date(s) analyses were performed;
    - the person responsible for performing the analyses;
    - the analytical techniques or methods used; and
    - the results of such analyses.

15. When requested by the department, the permittee shall within a reasonable time furnish any information required by law which is needed to determine compliance with the permit. If the permittee becomes aware that relevant facts were not submitted or were incorrect in the permit application or in any report to the department, such facts or information shall be submitted or corrected promptly.

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PERMITTEE:
Gordon J. Pfersich

I. D. Number: 05P02746
Permit/Certification Number:
DT05-79139
Date of Issue:
Expiration Date: 3-1-87

SPECIFIC CONDITIONS:

1. The required sampling shall be as follows:

| Parameter | Recording or sampling frequency |
|---|---|
| TSS | 1 per week |
| $BOD_5$ | 1 per week |
| pH | continous |
| chlorine residual | continous |
| Flow | continous |
| Fecal coliform | 1 per week |
| TP, TKN, $NO_2$ and $NO_3$ | 1 per week |
| DO | Daily |

The sampling and analysis required above shall be in accordance with Chapter 17-19, F.A.C. and approved standard methods. Properly executed reports shall be submitted to this office and the Brevard County Environmental Services on a monthly basis, by the 15th day of the following month.

2. Operational difficulties shall be immediately reported to both the local pollution control program and to the Department of Environmental Regulation.

3. The permittee shall submit the prescribed application and supporting data for an operation permit no later than 60 days prior to expiration of this permit.

4. The effluent delivered to the effluent disposal system shall be adequately chlorinated at all times so as to maintain 0.5 mg/l total chlorine residual after a minimum contact period of 15 minutes (based upon peak flow).

PERMITTEE:
Gordon J. Pfersich

I. D. Number: 05P02746
Permit/Certification Number: DT05-79139
Date of Issue:
Expiration Date: 3-1-87

SPECIFIC CONDITIONS:

5. Schedule of Compliance

Purpose: Under the following schedule the Port Malabar Wastewater Treatment Plant shall achieve compliance with the "no discharge" requirement for Turkey Creek and Indian River (I-10).

| | Action | Deadline |
|---|---|---|
| 1. | Submit preliminary underground injection control plans to Technical Advisory Committee | June, 1984 |
| 2. | Submit well construction permit application | January 1, 1985 |
| 3. | Start construction pursuant to underground injection control permit | January 1, 1986 |
| 4. | Complete construction and testing of well | October 1, 1986 |
| 5. | Commence operation of injection well in accordance with permit | November 1, 1986 |
| 6. | Terminate discharge to Turkey Creek | January 1, 1987 |

6. Should the proposed injection well disposal method prove to be unacceptable, the permittee shall terminate discharge to surface waters by permitted alternatives by the January 1, 1987 deadline.

Issued this 14 day of Feb 1984

STATE OF FLORIDA DEPARTMENT OF ENVIRONMENTAL REGULATION

A. Alexander
District Manager
A. Alexander, P.E.

2 Pages attached.

DER FORM 17-1.201(5) Effective November 30, 1982 Page 3 of 3