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NARRAWALLEE WATER QUALITY ASSESSMENT

For:
SHOALHAVEN CITY COUNCIL

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ERM Mitchell McCotter Quality System

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Chapter 1

INTRODUCTION

1.1 PURPOSE OF REPORT

The subject land has been identified in the Milton-Ulladulla Structure Plan for urban use to provide for the future growth of Narrawallee. This study focuses on the land proposed for rezoning and subsequent residential development. The land drains to Narrawallee Inlet which has the following sensitive environments:

- 378 hectares of mangroves;
- 14 hectares of seagrasses; and
- 91 hectares of saltmarsh.

Because of the receiving environment's sensitivity, a comprehensive assessment of development impacts within the catchment and formulation of effective pollution control strategies for mitigating impacts is important.

The purpose of this study is to document existing stormwater quality characteristics and assess potential impacts resulting from residential development. Using this information, a water pollution control strategy is recommended which aims to prevent water quality impacts through treatment of runoff.

The assessment is required to address likely water quality issues if the subject land is developed for residential/urban purposes and more specifically assess:

- the impact of development on adjacent wetlands and the measures necessary to mitigate any impacts, including water quality controls and provision of suitable buffers; and
- the impact of development on adjacent water bodies and the measures necessary to mitigate any impacts such as water quality controls and sediment/nutrient controls or structures.

1.2 STUDY AREA

The study area is the land proposed to be rezoned which is part of Lot 4, DP 771597 and part of Portion 14 Parish of Ulladulla. It covers about 29.2 hectares and is located on a low ridge immediately west of Narrawallee village. The subject land was identified in the Shoalhaven Local Environmental Plan, 1985 as a Rural 1(d) zone. This zoning identifies areas for future urban expansion. More recently, the land was identified in the Milton-Ulludulla Structure Plan for urban uses. This plan was published by Shoalhaven City Council in September 1996. The site is undulating with a minor ridge running through it.

The land is currently vacant. It has been heavily logged in the past and is grassed and partially vegetated with regrowth. There are freshwater wetlands located along a creek near the site's western boundary and to the north of the site. These wetlands extend approximately 20 to 30 metres into the site. Remains of a disused gravel quarry are located near the southern boundary.

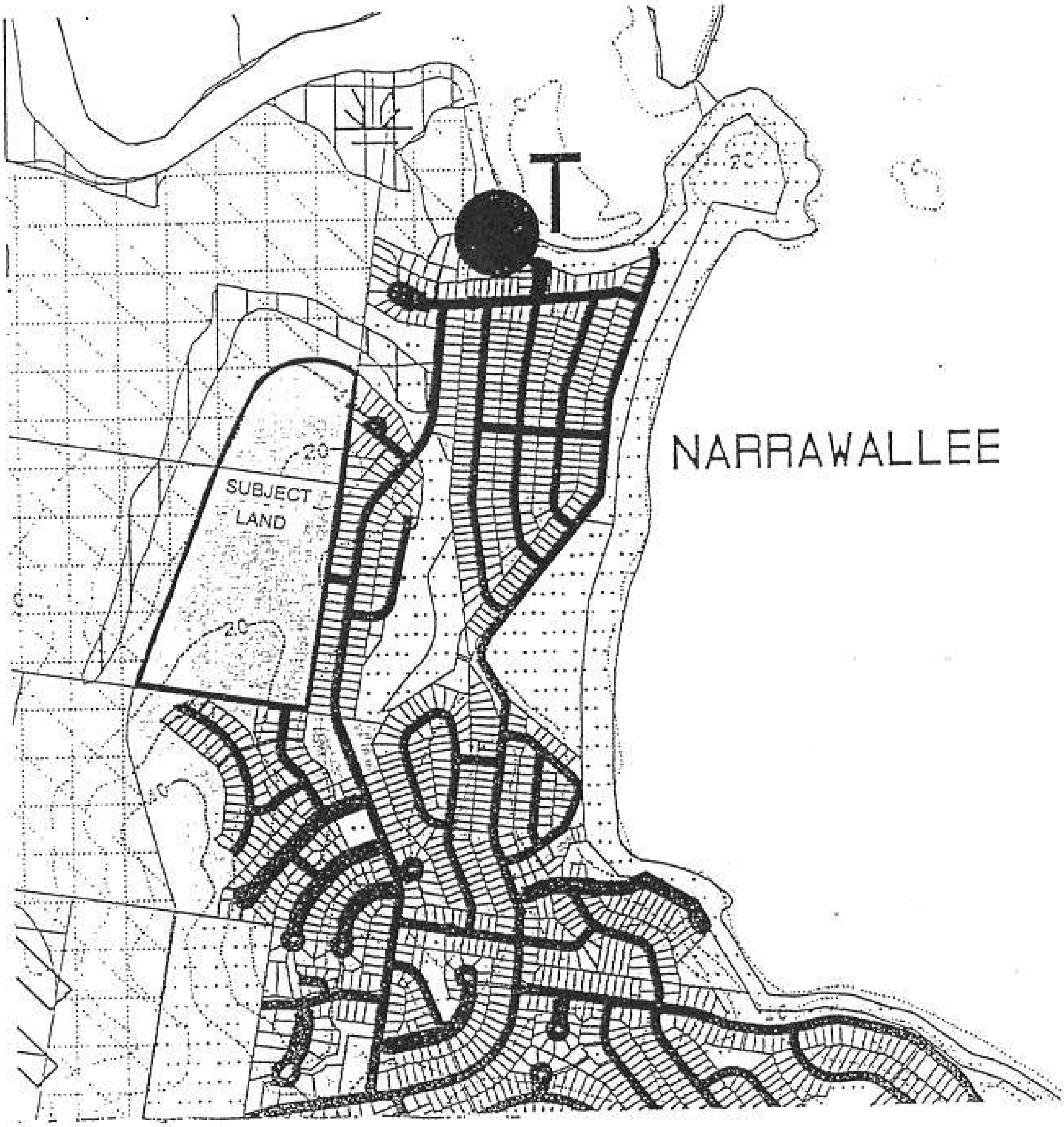
Residential development adjoins the site to the south and east. A creek line adjoins the western edge of the site and drains to Narrawallee Inlet. The total catchment of this unnamed creek is approximately 84.5 hectares. *Figure 1* shows the study area and adjoining freshwater wetland to the north and west as identified in the Milton-Ulludulla Structure Plan. Estuarine wetlands lie further to the north, on the edge of Narrawallee Inlet.

The portion of the site to the west of the minor ridge drains to the creek and has an area of approximately 19.8 hectares. The remainder of the site drains east to Narrawallee Village.

The Narrawallee Inlet Catchment which contains the site has an area of approximately 78 square kilometres and is comprised of two main tributaries, Narrawallee and Croobyar Creeks. These creeks originate in hilly forest country and then run through farmland before entering the ocean at Narrawallee Inlet. Large areas of the lower reaches of this system have been classified as State Environment Planning Policy Number 14 (SEPP No. 14) Wetlands.

The estuarine wetlands on the edge of Narrawallee Inlet to the north of the study area are identified in SEPP No. 14 (wetland No. 287). On review of topographical information it would appear that the site does not drain directly to this wetland but rather drains to Narrawallee Inlet to the west. The freshwater wetlands adjacent to, and within the site are not included in SEPP No. 14.

Given the ecological interactions between the freshwater wetland to the site's west and north and the SEPP 14 identified wetland to the north of the site, it is recommended that a conservative approach to development is taken and that a pollution control strategy is initiated should development take place. This will serve to minimise impact on the areas surrounding the SEPP 14 wetland.



Source Milton-Ulladulla Structure Plan

Not to Scale

N

GENERAL URBAN

EXISTING PARKS & RESERVES

BUSHLAND CONSERVATION

EXISTING ROAD STRUCTURE

WETLANDS

T LOW IMPACT TOURIST RESORT

Figure 1

STUDY ARF

Chapter 2

WATER QUALITY MONITORING

2.1 DATA REVIEW

2.1.1 *Background*

The first European impact on water quality of the Narrawallee Inlet Catchment was caused by clearing of land for forestry activities based in a township established at Milton in late 1828. Farming practices and drainage of swamps beginning in the late 1850s may also have impacted on water quality through acidic drainage high in aluminium. No testing has been done to confirm this. Continued clearing and changes to the land associated with agricultural use have continued to impact on water quality since this time and 50 to 75 per cent of the catchment is now cleared.

2.1.2 *Narrawallee Inlet Catchment Water Quality*

Water quality testing in the Narrawallee Inlet Catchment has been carried out since the beginning of 1991 by Shoalhaven City Council for the purpose of developing a water quality database sufficient to allow assessment of water quality impacts within the catchment. Sampling is carried out at seven points, the most relevant to the study area being a point within the Narrawallee Inlet estuary (309). Results at this point are summarised in *Table 2.1*.

Appendix A contains a figure showing the Narrawallee and Croobyar Creek catchments including Council sampling points. Results for the entire catchment indicate incidents of faecal pollution. The upper reaches of the Narrawallee Inlet tributaries also experience low dissolved oxygen levels from time to time. The Narrawallee Inlet estuary sample is however, well flushed by tidal waters and has excellent water quality especially with regard to nutrient levels.

Water quality results for Narrawallee Inlet generally comply with ANZECC water quality guidelines for the protection of Aquatic Ecosystems with the exception of one phosphorus and three nitrogen readings. These results indicate that these are appropriate target guidelines for sites draining to the inlet given its present water quality and ecological significance.

Table 2.1 NARRAWALLEE INLET WATER QUALITY

DATE	Faecal. Coliform (counts /100mL)	pH	DO (mg/L)	Phosphorus (mg/L)	Nitrogen (mg/L)	Ammonia (mg/L)	Cond (µS/cm)
12/02/91	-	-	7.0	-	-	-	47,000
7/05/91	-	8.1	9.0	0.000	-	-	40,000
6/08/91	2	7.6	7.6	0.000	-	-	15,000
19/11/91	100	7.2	9.2	0.000	-	-	45,000
4/02/92	0	7.0	8.0	-	-	-	40,000
12/05/92	-	7.5	8.2	-	-	-	270
27/07/92	8	7.6	11.5	-	-	-	25,000
4/08/92	8	7.2	8.8	-	-	-	30,000
19/10/92	48	8.2	6.9	-	-	-	28,000
27/10/92	100	7.8	8.6	-	-	-	29,000
3/02/93	204	7.6	8.0	-	-	-	29,000
21/04/93	8	7.5	9.3	-	-	-	0
4/01/94	0	7.9	6.7	-	-	-	32,000
4/05/94	0	6.7	8.8	0.019	0.10	0.01	43,000
1/08/94	0	7.8	7.4	0.014	0.05	0.01	42,000
11/10/94	0	7.7	11.3	0.001	0.12	0.01	43,500
31/01/95	8	6.6	8.7	0.010	0.22	0.02	40,000
16/05/95	24	-	13.0	0.018	0.45	0.02	32,000
13/02/96	0	7.9	10.3	-	-	-	39,000
18/04/96	0	9.0	11.1	-	-	-	31,000
05/08/96	0	8.1	7.9	-	-	-	32,000
24/09/96	0	8.1	7.9	-	-	-	34,000
Readings	19	20	22	8	5	5	19*
MAX	204	9	13	0.019	0.45	0.02	47,000
MIN	0	6.6	6.7	0	0.05	0.01	15,000
AVERAGE	27	7.66	8.87	0.00775	0.188	0.014	34,974

Notes: 1. *mg/L is abbreviation for milligrams per litre.*

2. *µS/cm is abbreviation for microSeimens per centimetre.*

3. *DO is abbreviation for Dissolved Oxygen.*

* *excludes unusually low readings.*

2.1.3 *Desirable Water Quality*

Given the sensitive nature of the Narrawallee Inlet wetland environment and good water quality of the inlet, it is recommended that guidelines given in *Table* 2.2 be used for future planning purposes. These guidelines are derived from ANZECC guidelines for the protection of aquatic ecosystems.

Table 2.2 WATER QUALITY GUIDELINES

PARAMETER	Freshwater System Guidelines (mg/L unless otherwise stated)	Guidelines for Estuarine Systems (mg/L unless otherwise stated)	Source
Ammonia-N	0.02 to 0.03	not specified	A
Dissolved Oxygen	> 6	> 6	A
BOD_5	20	20	D
Chloride	400.0	not specified	B
Chromium (Hex.)	0.01	0.05	A
Chromium (total)	0.01	0.05	A
Copper (total)	0.002 to 0.005	0.005	A
Faecal Coliforms	150 cfu/100mL (median)	150 cfu/100mL (median)	C
Iron (total)	1.0	not specified	A
Nitrate-N	10	0.010-0.1	A
Nitrite-N	1.0	0.001-0.01	A
Total Nitrogen	0.1 to 0.75	0.01 to 0.1	A
Total Phosphorus	0.01 to 0.1	0.005-0.015	A
Total Dissolved Solids	1020	not specified	A
Total Grease	< 15 ug/L	not specified	A
Total Kjeldhal Nitrogen	not specified	not specified	no guideline
Total Organic Carbon	not specified	not specified	no guideline
Total Phenolics	0.05	0.05	A
Suspended Solids	25	25	D

Source: *A:* *ANZECC (1992) Guidelines for "The Protection of Aquatic Ecosystems"*
B: *ANZECC (1992) Guidelines for "Raw Water for Drinking Water Supply"*
C: *ANZECC (1992) Guidelines for " Recreational Water Quality and Aesthetics"*
D: *New South Wales Clean Waters Act (1970)*

2.2 MONITORING PROGRAMME

2.2.1 *Methodology*

In order to augment Council's water quality database for the Narrawallee Inlet Catchment and give a localised indication of the quality of runoff, a wet weather monitoring programme was devised for the second half of 1996. Grab samples of surface water were taken from a drainage line before it entered the unnamed western creek. Due to the small contributing area and good drainage characteristics of the soil, surface water was only able to be sampled during extreme wet weather. Samples were tested at a NATA registered laboratory for Total suspended solids, Total phosphorus, NO_x-N (Nitrate and Nitrite) and Total Kjeldahl Nitrogen including ammonia.

2.2.2 *Results*

Results of water quality monitoring at the study site are summarised in *Table* 2.3.

Table 2.3 WATER QUALITY MONITORING RESULTS

Parameter	Date	
	2/09/96	30/09/96
Rainfall[1] *(millimetres per day)*	54.6 *(31/8/96)* 137.0 *(1/9/96)*	26.0 *(29/09/96)* 2.0 *(30/09/96)*
Total Suspended Solids (mg/L)[2]	4.0	1.0
Total Phosphorus (mg/L)	<0.20	<0.20
Total Nitrogen[3] (mg/L)	80	<0.6
NO_x-N (mg/L)	80	<0.1
Total Kjeldahl Nitrogen (mg/L)	<0.05	<0.5
pH	6.1	6.8
F. Coliform.(counts/100 mL)	-	120
Dissolved Oxygen (mg/L)	19.0	9.5
Cond.(µS/cm)[4]	600	580

Notes: Testing for pH, Dissolved Oxygen, E Coli and conductivity conducted by Shoalhaven City Council.

1. *Rainfall data from Milton Station No. 69016.*
2. *mg/L abbreviation for milligrams per litre*
3. *Total Nitrogen is the sum of NOx-N and Total Kjeldal Nitrogen.*
4. *µS/cm abbreviation for microSeimens per centimetre.*

2.3 DISCUSSION ON WATER QUALITY CONDITIONS

2.3.1 *Nutrients*

Nutrient parameters, namely nitrate, nitrite and total nitrogen exist in high concentrations in the sample taken on the 2 September, 1996. These concentrations exceed the guidelines given in *Table* 2.2. Other levels were low. Narrawallee Inlet nitrogen levels reported in *Table 2.1* also exceed guidelines given in *Table* 2.2. Significant portions of nitrogen concentrates are bound in suspended solids which may not be readily available for plant growth. The sample taken during very wet weather contained higher nutrient and suspended solids levels. Commonly during periods of rain and flooding, greater concentrations of nutrients are present in water bodies, largely the result of increased erosion and sedimentation, and an increase in urban runoff (ANZECC, 1992).

High concentrations of dissolved nutrients create the potential for algal blooms and damage to the natural aquatic ecosystem.

2.3.2 *Suspended Solids*

Suspended solids concentrations were relatively low for both samples. Concentrations were greater for the sample taken during the larger rainfall event. The likely source of solids is erosion and scouring. However, low levels indicate that vegetation on site is currently stabilising soils and preventing erosion and sediment run off.

2.3.3 *pH*

The levels of pH in the samples are a little acidic. This can be expected from fresh runoff from well vegetated areas. Levels are well within acceptable criteria.

2.3.4 *Faecal Coliform*

The measured Faecal Coliform level was within guideline limits.

2.3.5 *Dissolved Oxygen*

Dissolved oxygen levels for both dates are high, indicative of freshly fallen rain. The reading of 9.5 milligrams per litre is considered to be a typical level and satisfies guidelines.

2.3.6 *Conductivity*

Used as a indicator for salinity, the conductivity levels recorded are within guideline limits by rule of thumb comparison with Total Dissolved Solids.

2.3.7 *Conclusions*

Monitoring of surface runoff from the site indicates that water quality leaving the site is of good quality and generally suitable for discharge to the Narrawallee Inlet environment. Water Quality guidelines set in Section 2.2.2 are met for the recorded parameters except for nitrogen which was exceeded in study site sampling and sampling conducted by Shoalhaven City Council in Narrawallee Inlet.

The fact that very high rainfall was needed to produce a surface flow able to be sampled shows that the site's soil and subsoil has high permeability. Sealing of portions of the site during urban development has the potential to increase runoff volumes.

Overall, the results indicate that by maintaining the existing water quality leaving the site, there would be minimal impact on Narrawallee Inlet. This of course assumes good water quality is maintained through good management practice throughout the catchment.

Effective maintenance of high water quality from the study site will be of negligible consequence if water quality is allowed to degrade throughout the rest of the catchment. It is important that the effect of rural practices on water quality is controlled to the same level of urban development so that pollution control is effective within the Narrawallee Inlet Catchment as a whole.

Chapter 3

WATER QUALITY MODELLING

3.1 WATER QUALITY ASSESSMENT

3.1.1 Overview of AQUALM

To evaluate potential urban development impacts on the catchment, the AQUALM water quality model was used.

AQUALM has modules with the following capabilities:

- catchment rainfall and runoff water balance simulation; and
- assessment of non-point source pollutants generated from a catchment.

Both these modules have parameters which allows AQUALM to be calibrated to conditions prevailing in the local catchment. Other inputs into the model include catchment areas, land-uses, rainfall and evaporation data. AQUALM also allows incorporation and performance assessment of water pollution controls such as gross pollutant traps and Water Pollution Control Ponds (WQCPs).

3.1.2 Model Setup

The model was initially set up to simulate runoff originating from the site in its present condition. Throughout the report this is referred to as 'rural'. The model was then adjusted to simulate 40 and 60 per cent urban development of the total area draining to the western creek line, representing areas of 7.9 and 11.9 hectares respectively. These proportions of development are based on the concept plan for development of the site presented in the application for rezoning by Cowman Stoddard Pty Lty. Forty per cent is used as an indicative proportion if pavement areas are minimised and nature strips are carefully designed, while 60 per cent is a conservative estimate for a subdivision included large paved areas, small lot sizes and some dual occupancy lots.

The model was also used to simulate the area draining east to the Leo Drive subdivision, representing a total area of 9.4 hectares of which 6.6 hectares has been simulated as urbanised on the basis of the concept development plan.

3.1.3 *Rainfall Runoff Parameters*

The rainfall-runoff module is based on the Broughton moisture balance model, incorporating the processes of interception moisture stores such as evapotranspiration, a drainage store, an upper soil store and a deep storage. The model uses a daily rainfall time step.

No streamflow gauging data is available for model calibration. Therefore, rainfall-runoff parameters for catchments for the Sydney-Illawarra region developed by Sydney Water were used (Sydney Water Board, 1992). Infiltration and soil water store data was based on typical values for the sandy, highly permeable alluvial soil present at the site. Moisture store information used is presented in *Table 3.1.*

Table 3.1 SOIL MOISTURE STORES

Store	Capacity (millimetres)		Initial (millimetres)	
	Urban	Rural	Urban	Rural
Interception	5.0	2.0	0.0	0.0
Drainage	30.0	40.0	0.0	0.0
Upper soil	65.0	80.0	40.0	65.0

3.1.4 *Pollutant Export Parameters*

For the development size, *'Water Quality Assessment Guidelines for New Urban Developments in the Illawarra'* (Illawarra Integrated Approvals Team, 1997) recommends the preferred modelling approach to assess the pollutant loads from a storm event or on a daily basis. It recommends that the number of monitoring samples for calibration be at least six events to account for a range of flows, for seasonal influences and variability in concentrations. This level of detail of monitoring samples was not available for this study.

However, a limited form of model calibration of pollutant export parameters for rural conditions was undertaken using results from the water quality monitoring collected from the site on two occasions during 1996. Coefficients of runoff-pollutant export correlations from studies on unsewered rural Sydney-Illawarra catchments (Sydney Water Board, 1992) were adjusted in this process.

For example the general form of the export equation for total phosphorus under rural conditions (in kilogram per square kilometre) is $aR^{0.57}$; where *'R'* is daily rainfall in millimetres and *'a'* is a calibration coefficient.

Water quality monitoring for total phosphorus has been collected at both Narrawallee Inlet and at the site. The conductivity at the site has been recorded as 600 microSiemens per centimetre which represents fresh-water conditions. The average conductivity at Narrawallee Inlet has been recorded as 35,000 microSiemens per centimetre which indicates that the majority of the estuary water is from ocean water inflow. Tidal flushing mixes catchment runoff with estuary water which then discharges to the ocean with the tidal cycle. Consequently only the monitoring results for the site are representative of total phosphorus concentrations within local runoff.

The imprecise measure of total phosphorus concentration of monitoring samples taken at the site (less than 0.2 milligrams per litre) reduces the potential for an accurate calibration of the pollutant export coefficient. The following coefficients for total phosphorus export equation were considered:

- 0.016 for bushland conditions as used by Sydney Water Board (1992);
- 0.062 for rural conditions as used by Sydney Water Board (1992);
- 0.115 for rural conditions as used by Willing and Partners and Lawrence in the ACT and NSW for Lake Ginninderra, Tuggeranong, Albury and Merimbula; and
- 0.089 based on the mean value between that used by Sydney Water Board and that used by Willing and Partners.

As part of this limited calibration of pollutant export parameters, the AQUALM was simulated for daily rainfall data from Milton from 1st of January 1996 to the 31st December 1996, and from 1st of January 1995 to the 31st December 1995. Simulation results were compared with water quality results from the monitoring programme at the study site, and are summarised in *Table* 3.2 for Total Phosphorus for equation coefficients 0.016 and 0.089. Wet weather was taken as days when the daily runoff from the site predicted by AQUALM reached or exceed 0.10 megalitres.

Table 3.2 CALIBRATION OF TOTAL PHOSPHORUS EXPORT

Date	Concentration (mg/l)		
	Monitored	Simulated by AQUALM	
Export Equation		*$0.016\ R^{0.57}$*	*$0.089\ R^{0.57}$*
31.08.96		0.002	0.012
01.09.96		0.008	0.044
02.09.96	< 0.200	0.010	0.056
30.09.96	< 0.200	0.032	0.180
Wet Weather 1995			
25th Percentile		0.010	0.018
50th Percentile		0.013	0.055
75th Percentile		0.017	0.071
Wet Weather 1996			
25th Percentile		0.010	0.055
50th Percentile		0.015	0.083
75th Percentile		0.018	0.100

Table 3.2 shows that the pollutant export coefficient 0.089 is acceptable based on the monitored concentration of total phosphorus. Consequently this value was adopted for this assessment. *Table 3.3* shows the pollutant export relationships adopted.

Table 3.3 RUNOFF-POLLUTANT EXPORT CORRELATIONS

Pollutant	Export Rate kg/km²	
	Urban	Rural
Total Phosphorus	$0.292\ R^{0.8}$	$0.089\ R^{0.57}$
Total Nitrogen	$2.5\ R^{0.84}$	$0.45\ R^{1.3}$
Total Kjeldahl Nitrogen	$1\ R^{0.84}$	$0.04\ R^{1.3}$
Suspended solids	$42.2\ R^{1.4}$	$2.5\ R^{1.1}$

Notes: *R = runoff millimetres per day*

kg/km^2 = kilograms per square kilometre

3.1.5 *Simulation Results*

The AQUALM model was simulated for daily rainfall data from Milton from 1st of January 1996 to the 31st December 1996. This twelve month period had a total rainfall of 921 millimetres which is less than the average annual rainfall of 1,269 millimetres. An additional twelve month period of daily rainfall data from 1st of January 1995 to the 31st December 1995 was also simulated with a total rainfall of 1,211 millimetres, close to the annual average.

Monthly simulation results are reproduced in Appendix A. Graphical representation of pollutant concentrations is included as Appendix B. Summaries of pollutant load results are given in *Table 3.4* and *Table 3.5*.

Table 3.4 SIMULATION RESULTS (WESTERN DRAINING)

Parameter	1995			1996		
	Rural	40 % Urban	60 % Urban	Rural	40 % Urban	60 % Urban
Rainfall (millimetres)	1,192.8	1,192.8	1,192.8	910.8	910.8	910.8
Runoff (megalitres)	67.1	80.9	87.9	49.7	57.4	61.3
BOD_5 (kilograms)	15	200	300	11	140	200
Suspended solids (kilograms)	200	1,700	2,400	160	1,200	1,700
Total Kjeldahl nitrogen (kilograms)	4.6	35	50	5	23	33
Total nitrogen (kilograms)	51	110	140	56	85	99
Total phosphorus (kilograms)	4.4	11	15	3.0	7.5	9.7

Table 3.5 SIMULATION RESULTS (EASTERN DRAINING)

Parameter	1995		1996	
	Rural	Urban	Rural	Urban
Rainfall (millimetres)	1,192.8	1192.8	910.8	910.8
Runoff (megalitres)	31.9	43.4	23.6	30.5
BOD_5 (kilograms)	7	160	5.4	110
Suspended solids (kilograms)	93	1,300	76	910
Total Kjeldahl nitrogen (kilograms)	2	27	2	18
Total nitrogen (kilograms)	24	74	26	51
Total phosphorus (kilograms)	2.1	8.0	1.4	5.2

These predictions suggest that residential development would increase pollutant loads leaving the site over present conditions. Pollutant concentrations during storm events are also predicted to increase. Concentrations are represented graphically in Appendix B and a summary of results for the western draining simulation is contained in *Table 3.6* and *Table 3.7*.

Table 3.6 1995 POLLUTANT CONCENTRATIONS (milligrams per litre)

Parameter	Maximum Discharge Concentration			No. Exceedances per year[1]		
	Rural	40 % Urban	60 % Urban	Rural	40 % Urban	60 % Urban
Suspended solids	3.62	37.00	37.77	0	21	32
Total nitrogen	1.37	2.54	2.76	0	majority of events	majority of events
Total phosphorus	0.54	0.59	0.64	0	majority of events	majority of events

Notes: 1. Based on guidelines from Table 2.2.

Table 3.7 1996 POLLUTANT CONCENTRATIONS (milligrams per litre)

Parameter	Maximum Discharge Concentration			No. Exceedances per year[1]		
	Rural	40 % Urban	60 % Urban	Rural	40 % Urban	60 % Urban
Suspended solids	3.98	36.29	37.44	0	24	25
Total nitrogen	1.81	3.42	4.00	0	majority of events	majority of events
Total phosphorus	0.86	0.69	0.66	3	majority of events	majority of events

Notes: 1. Based on guidelines from Table 2.2.

Simulation results indicate that urban development would increase both runoff volume and pollutant loads discharged from the site over those predicted for current conditions. Predicted 1996 pollutant concentrations compare well with those recorded in water quality monitoring of the site.

3.2 POLLUTION CONTROL STRATEGY

To minimise the impact of development on Narrawallee Inlet water quality it is recommended that a pollution control strategy be developed. The recommended strategy is outlined in the following sections.

3.2.1 *Strategy Development*

The following steps should be adopted in the development of stormwater treatment measures:

- define the site specific objectives for the design, including water quality requirements of downstream receiving waters;
- define existing conditions at the site and of downstream receiving waters;
- define design parameters for optimum performance, considering the required level of water quality control;
- identify site constraints which may compromise optimum design parameters to achieve a balanced environmental outcome that is cost effective from a capital and operations/ maintenance perspective;
- evaluate tradeoffs between site constraints and optimum performance and develop final design parameters;
- evaluate the design; and
- develop operations, maintenance and monitoring plans.

Previous sections of this study have identified water quality goals and existing site and downstream conditions. The following sections identify design parameters and site constraints, and recommend appropriate control measures.

3.2.2 *Water Quality Control Pond*

i. General Features

Trials to assess inclusion of a Water Quality Control Pond (WQCP) were performed using pond design principles developed by the Department of Housing (Soil and Water Management for Urban Development, 1993). More detailed design was derived from Cullen (1992) and Phillips (1992). An indicative unit pond size is 250 to 350 cubic metres per hectare of urban land (Phillips, 1992). Pond options have the following common features:

- sediment basin prior to open water zone to reduce sediment load and remove litter and larger grit particles;

- macrophyte zone 0.3 to 0.6 metres deep, covering approximately 30 per cent of the pond surface area. Macrophytes are large aquatic plants which filter finer particles and take up nutrients and other pollutants such as some organic chemicals. Some oil is also trapped. Continued maintenance of macrophyte zones is required to maintain a viable bed and encourage the growth of emergent macrophytes; and

- open water zone approximately 2.5 metres deep. This is a deeper zone that allows time for fine particles to flocculate to the bed, and allows sunlight to kill bacteria. Decomposition of organic matter will occur in this zone. Periodic algal growth also traps dissolved nutrients.

ii. Performance

The original AQUALM model for the site was adjusted to simulate pollution mitigation via suitably sized water pollution control ponds. A number of different pond sizes were trialed in an attempt to optimise pond size and achieve the most effective pollutant reduction within site constraints.

Ponds used in the simulations are summarised in *Table 3.8*.

Table 3.8 WQCP OPTIONS

Pond	Maximum Depth (metres)	Surface Area (square metres)	Volume[1] (cubic metres)
1	2.5	2,500	5,900
2	2.5	3,170	6,600
3	2.5	3,990	8,320
4	2.5	4,560	9,500

Notes: 1. 20 per cent added for sedimentation zone.

The performance of each pond was simulated for both western draining development scenarios. Total phosphorus retention, total nitrogen retention and suspended solids retention for macrophyte systems was referenced from the Department of Land and Water Conservation (in press) as outlined by the EPA (1996). Adopted retention relationships are provided in *Table 3.9*.

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Table 3.9 RETENTION RELATIONSHIPS FOR WQCP

Retention time (days)	Percentage of Pollutant Retained		
	Suspended Solids	Total Phosphorus	Total Nitrogen
0.5	10		10
1		3	
5	30	30	30
10	39	35	39
15	42	40	42
20	46	45	46
25	49	50	49
30	51	55	51
35	53	60	53
40	55	65	55
45	57		57
50	60		60
100		80	

Results are summarised in *Table 3.10* and *Table 3.11* and full data outputs are included as Appendix C.

Table 3.10 WQCP SIMULATION RESULTS FOR 40 PER CENT DEVELOPMENT

Parameter	Pollutant Export (kilograms per year)[1]					
	Existing	Developed	Pond 1	Pond 2	Pond 3	Pond 4
Runoff	67.11	80.89	76.74	76.31	75.10	74.31
Susp. Solids	200	1,700	210	200	170	170
Total nitr.	51	110	60	58	52	48
Total phos.	4.4	11.0	5.8	5.6	4.9	4.6

Notes: 1. except for runoff which is megalitres per year

Table 3.11 WQCP SIMULATION RESULTS FOR 60 PER CENT DEVELOPMENT

Parameter	Pollutant Export (kilograms per year)[1]					
	Existing	Developed	Pond 1	Pond 2	Pond 3	Pond 4
Runoff	67.11	87.87	83.72	83.28	82.06	81.27
Susp. Solids	200	2,400	320	310	260	250
Total nitr.	51	140	77	74	67	63
Total phos.	4.4	15	8.0	7.7	6.9	6.4

Notes: 1. except for runoff which is megalitres per year

iii. Recommended Configuration

Simulation results indicate that the ponds achieve substantial pollutant reductions. However, these reductions are not sufficient to reduce levels to predevelopment loads. As a result of the high removal efficiency and the extreme retention period (approximately 40 days for 80 per cent phosphorus removal) needed, a pond with an extremely large volume would be required to reproduce predevelopment pollutant loads. Area constraints make this impractical and it is considered that Pond 3 represents a balance between surface area required and removal efficiency provided. Pond 3 removal efficiencies are as follows:

- suspended solids 89 per cent;
- total nitrogen 52 per cent; and
- total phosphorus 57 per cent.

On this basis it is recommended that should development proceed a WQCP with the general characteristics of Pond 3 be used as part of the site's water pollution control strategy. This pond achieves significant pollutant reduction for those parameters simulated, while not having an excessive demand for land area.

It should be noted that the WQCP does not achieve sufficient pollutant removal to return pollutant export to predicted existing levels. An increase in annual pollutant load is predicted for both development scenarios. It is important to note that this increase will not necessarily correspond to higher instantaneous concentrations as the runoff volume is also increased. The further control measures recommended are expected to achieve additional pollutant reduction and therefore it is expected that Pond 3 in conjunction with these measures and careful urban design can reduce pollutant loads such that there will be no impact on Narrawallee Inlet water quality as a result of the development of the site.

3.2.3 *Other Control Measures*

Control measures to compliment the recommended WQCP are detailed below.

i. Riparian Buffer

Much of a stream's sediment load, particularly at high flows, can result from bank erosion. Riparian vegetation is important in maintaining channel and streambank stability. Suspended solids concentrations increase quickly during storm events when riparian vegetation is absent. By comparison, levels of suspended solids increase at a slower rate in more stable channels. The normal width of streamside vegetation is five to ten metres but the maximum benefits of a riparian buffer are achieved at widths of 20 to 30 metres (Department of Conservation and Environment, 1990). The creek along the western boundary of the site is an integral part of the freshwater wetland environment of that area, meaning that wetland vegetation extends further from the creek's banks. Consequently, riparian buffers within 50 metres of the western creek boundary are recommended as shown in *Figure* 2. The buffer is conservative given the flow expected in the creek and represents a slightly larger area than that specified in Kevin Mills preliminary flora and fauna assessment (Mills and Associates, 1994) which recommended a 30 metre buffer area. This area should not be disturbed and native riparian vegetation should be encouraged to grow, providing the following characteristics:

- additional treatment of shallow overland flow;
- reduction of runoff volumes and delay runoff; and
- additional removal of particulate matter and associated pollution.

ii. Level Spreader

A level spreader would be situated at the outlet of the WQCP to spread the flow such that it proceeds into the riparian buffer as sheet flow with non-erosive velocities.

iii. Reduced Runoff

Runoff volumes from an urban development can be reduced by reducing impervious surface areas. Measures include:

- use of relatively porous brick pavers on footpaths in preference to concrete;
- limiting residential road widths to a maximum of 6.5 to 7 metres;
- paved footpaths not exceeding 1.5 metres width;
- native tree lined grassed verges should be provided adjacent to footpaths; and
- no more than 50 per cent of each lot area should be covered by impervious areas (including buildings, driveways and car parks).

3.2.4 *Strategy Details*

Main components of the recommended water pollution control strategy are shown in *Figure 2*. The figure shows the riparian buffer area and approximate dimensions and placement of the WQCP. The required open water zone can only be achieved by using steeper than ideal gradients on the eastern and western banks. Final recommended dimensions of the pond are summarised in *Table 3.12*.

Table 3.12 WQCP DETAILS

Characteristic	Dimension
Length (including sedimentation zone)	130 metres
Open water zone width	30 metres
Open Water Zone depth	2.5 metres
Southern bank slope	5 horizontal to 1 vertical
Northern bank slope	5 horizontal to 1 vertical
Eastern and western bank slopes	3 horizontal to 1 vertical
Sedimentation zone volume	1,600 cubic metres

Due to the grade of the site and potential for erosion, stormwater should be directed to the WQCP by concrete culverts and piped drainage. The pond should outlet to the riparian buffer via a level spreader.

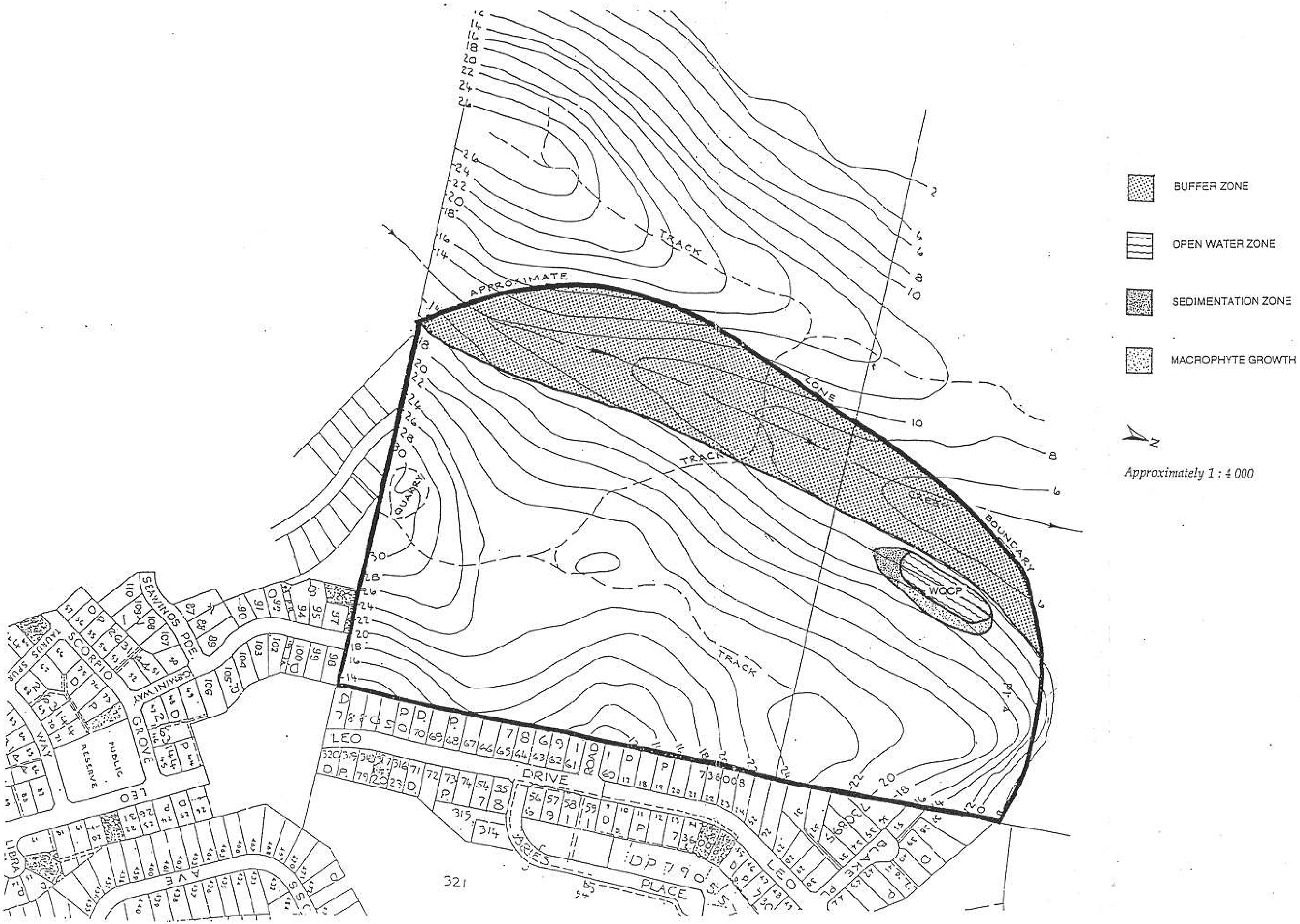

Figure 2

POLLUTION CONTROL
STRATEGY COMPONENTS

In constructing the pond an exposed bank will be formed on the eastern side. This bank should be vegetated with the same riparian vegetation located near the creek making the pond a naturally attractive feature of the development.

3.2.5 *Alternatives*

The use of two ponds to treat westward draining runoff in preference to a single dam may be possible. This has advantages in allowing staged subdivision development. A concept design is shown in *Figure 3*. This strategy would however, be more expensive in terms of construction and maintenance and require more land area as each pond would need separate sedimentation zones, pipework and infrastructure.

Another alternative is to locate the WQCP outside the study area, again with the advantage of not impinging on the area available for subdivision. This option is possible, however the pond must not be located within the riparian buffer and it is questionable whether there is sufficient area to the west or north of the site to allow placement and construction of the pond without impacting on the freshwater wetlands.

3.2.6 *Eastern Runoff Strategy*

Eastward runoff volumes and quality have been estimated. Should development take place, eastward runoff from the site would enter the stormwater drainage system of the urban area to the east which is presumed to drain to Garrods lagoon. The most practical way of treating this water is as combined urban runoff with the other developed areas. It is not known whether stormwater from these areas receive any treatment. The developer may be responsible for contributing towards treatment on a runoff proportionality basis.

3.2.7 *Monitoring and Maintenance*

It is important that the pond does not cause environmental problems. Maintenance is required to prevent the ponds contributing to mosquito or other insect problems. Careful design and management is also required to prevent odours caused by eutrophication or excessive macrophyte growth. A typical pond configuration is shown in *Figure 4*.

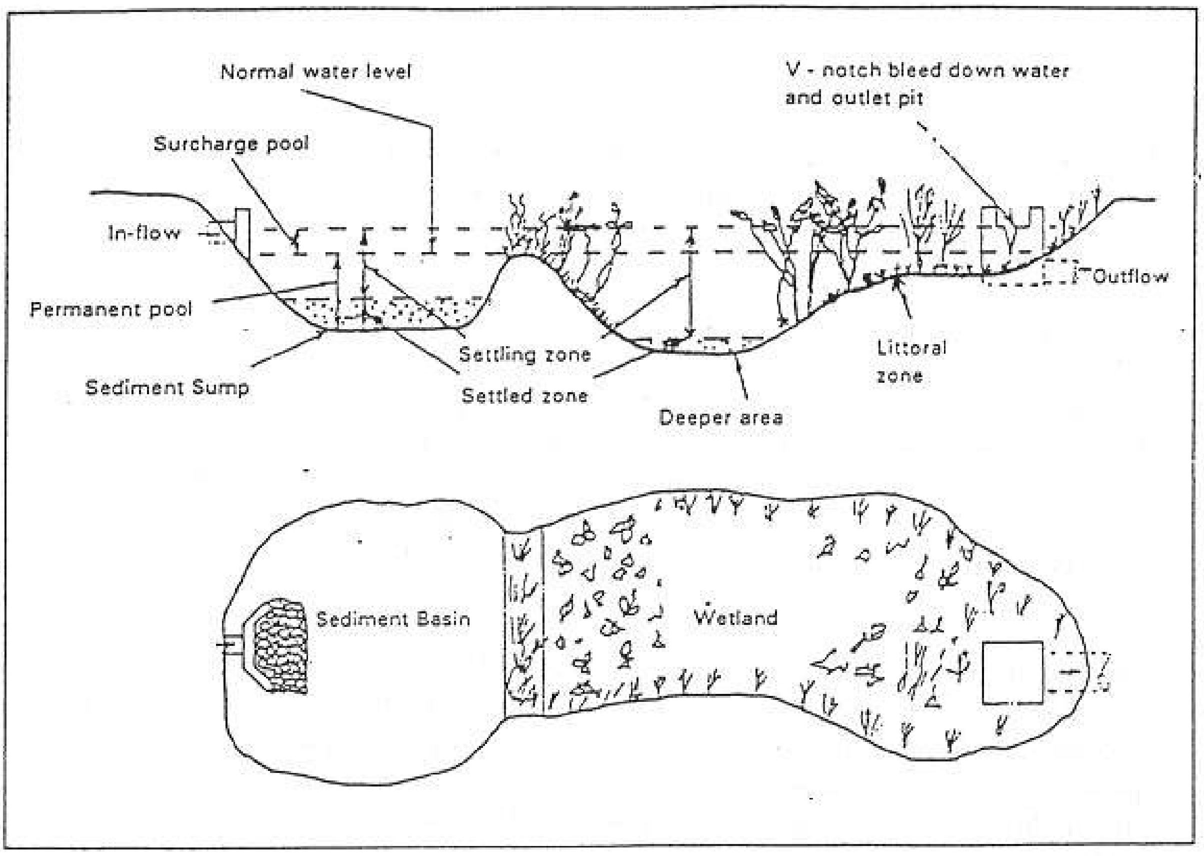

Figure 4 WQCP CONFIGURATION

Mosquito problems can be avoided through good design. Many WQCPs have been established in residential areas without mosquitos causing problems. Design considerations to minimise mosquito problems include:

- minimising sections of water isolated from the main water body;
- efficient drainage of overflow channels to ensure isolated ponds are not left following overflow;
- minimising shading by trees; and
- minimising turbidity to enhance predation.

A proposed monitoring and maintenance programme is summarised in *Table 3.13*. The actions are usually performed by Council staff or contractors approved by Council. Inspection is usually carried out by an environmental officer.

Table 3.13 WQCP MONITORING AND MAINTENANCE PROGRAMME

Action	Timing
Weed removal and mowing if required	fortnightly
Inspection for odour and mosquito breeding	monthly
sediment removal	six-monthly
macrophyte cropping	six-monthly
inspection of: • structural integrity; • subsidence; • cracking or tree growth on embankments; outlet performance; • upstream and downstream erosion; • emergency spillway condition; and performance of pretreatment measures.	six-monthly

Figure 3

ALTERNATIVE POLLUTION
CONTROL STRATEGY

Chapter 4

CONCLUSIONS

The study has shown that the general water quality of the Narrawallee Inlet catchment is good and surface water currently leaving the site is also of relatively quality and suitable for discharge to the Narrawallee Inlet environment although elevated nitrogen levels were identified in both the site's runoff and Narrawallee Inlet. By maintaining this water quality no increase in impact on the environment of Narrawallee Inlet and its surrounds can be expected as a result of stormwater discharge from the study site.

Water quality simulation using AQUALM indicates that existing pollutant levels and runoff volumes would be substantially increased by urban development of the site. These estimates are based on conservative estimates for pollutant export and runoff generation. The recommended WQCP pond configuration has been shown by simulation to provide excellent pollutant retention capability while not placing a large demand on land area. The pond does not however, return pollutant loads to estimated predevelopment levels. It is expected however, that in conjunction with other measures recommended pollutant loads will approximate estimated predevelopment loads.

On the basis of this study the urban development of the site is considered to be achievable from the point of view of surface water quality impacts. Provided the development is carefully designed and planned, water quality impacts on the adjoining freshwater wetlands can be minimised. It is however, recommended that a monitoring programme be implemented before, during and after development to identify any impacts on the wetlands and allow appropriate action to be taken.

Prior to this, it should be confirmed that no drainage from the site enters the SEPP 14 wetland to the north (*Figure 1*). A 'walk-through' of drainage lines in the area is recommended. If the site does drain to the SEPP 14 wetland, the proposal may be considered a *designated development* under the Environmental Planning and Assessment Act, 1979 in which case an environmental impact statement would be required.

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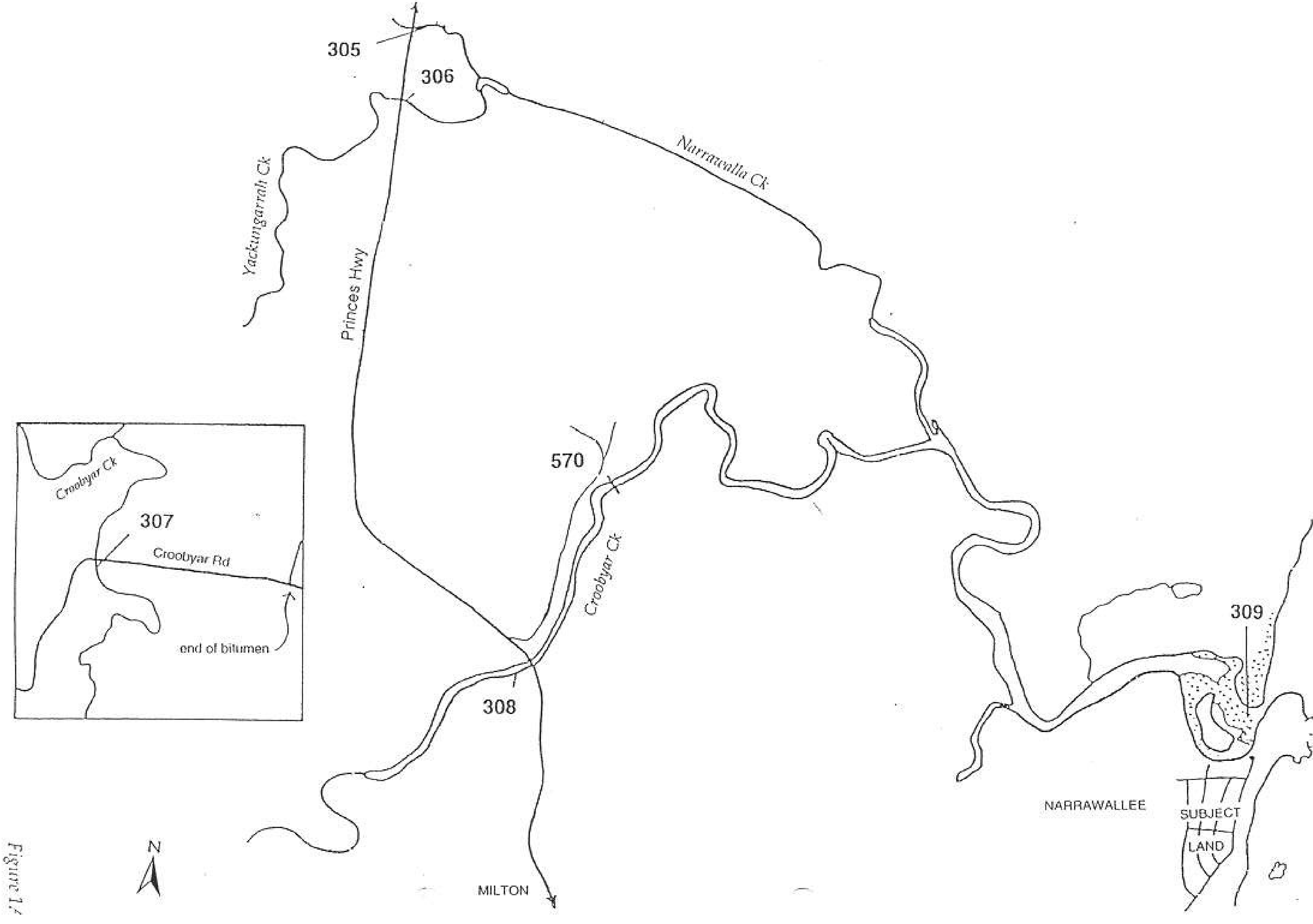
APPENDICES

Appendix A

NARRAWALLEE - CROOBYAR CREEK CATCHMENT

WATER QUALITY MONITORING DATA

Figure 1?



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Appendix B

SIMULATION RESULTS

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nnual Report for Node "NARRUR", 31/12/1995 "RURAL"

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ocal Runoff and Pollutant Loads

onth	Rain mm	Runoff Ml	BOD Kg	SS Kg	TKN Kg	TN Kg	TP Kg
JAN	159.4	9.46	2.2	30	0.8	9	0.47
FEB	75.2	0.85	0.2	1.8	0.02	0.22	0.17
MAR	105.2	4.26	0.98	11	0.18	2	0.4
APR	18.7	0.55	0.13	1.1	0.011	0.12	0.13
MAY	218.8	19.32	4.4	62	1.7	19	0.75
JUN	95.8	12.93	3	38	0.87	9.8	0.69
JUL	6.2	0.93	0.21	2	0.022	0.25	0.18
AUG	40.9	0.25	0.057	0.46	0.004	0.045	0.085
SEP	126.8	2.78	0.64	7	0.12	1.3	0.28
OCT	104.7	4.31	0.99	11	0.19	2.2	0.39
NOV	164.7	8.99	2.1	26	0.57	6.4	0.54
DEC	76.4	2.47	0.57	6.1	0.098	1.1	0.28
otal	1192.8	67.11	15	2E+002	4.6	51	4.4

otal Runoff and Pollutant Loads

onth	Runoff Ml	BOD Kg	SS Kg	TKN Kg	TN Kg	TP Kg
JAN	9.46	2.2	30	0.8	9	0.47
FEB	0.852	0.2	1.8	0.02	0.22	0.17
MAR	4.26	0.98	11	0.18	2	0.4
APR	0.552	0.13	1.1	0.011	0.12	0.13
MAY	19.3	4.4	62	1.7	19	0.75
JUN	12.9	3	38	0.87	9.8	0.69
JUL	0.932	0.21	2	0.022	0.25	0.18
AUG	0.248	0.057	0.46	0.004	0.045	0.085
SEP	2.78	0.64	7	0.12	1.3	0.28
OCT	4.31	0.99	11	0.19	2.2	0.39
NOV	8.99	2.1	26	0.57	6.4	0.54
DEC	2.47	0.57	6.1	0.098	1.1	0.28
otal	67.1	15	2E+002	4.6	51	4.4

AQUALM Version : 2.1; June 1995

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Output File : C:\WPS\AQUALMXP\narra1b.out

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Annual Report for Node "NARURB7.9", 31/12/1995 7.9 ha "URBAN"
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Local Runoff and Pollutant Loads

Month	Rain mm	Runoff Ml	BOD Kg	SS Kg	TKN Kg	TN Kg	TP Kg
JAN	159.4	13.39	38	3.1E+002	5.9	19	1.7
FEB	75.2	1.88	6.6	54	1.4	3.6	0.51
MAR	105.2	7.01	22	1.8E+002	3.8	11	1.3
APR	18.7	0.55	1.1	9	0.31	0.83	0.18
MAY	218.8	20.66	46	3.8E+002	7.4	27	2.2
JUN	95.8	12.76	26	2.1E+002	4.4	16	1.5
JUL	6.2	0.75	1.1	8.6	0.3	0.86	0.2
AUG	40.9	0.69	2.6	21	0.59	1.5	0.23
SEP	126.8	4.07	12	96	2.1	5.8	0.73
OCT	104.7	4.83	11	93	2.1	6.3	0.8
NOV	164.7	10.48	25	2.1E+002	4.3	14	1.4
DEC	76.4	3.81	11	93	2	5.6	0.73
Total	1192.8	80.89	2E+002	1.7E+003	35	1.1E+002	11

Total Runoff and Pollutant Loads

Month	Runoff Ml	BOD Kg	SS Kg	TKN Kg	TN Kg	TP Kg
JAN	13.4	38	3.1E+002	5.9	19	1.7
FEB	1.88	6.6	54	1.4	3.6	0.51
MAR	7.01	22	1.8E+002	3.8	11	1.3
APR	0.548	1.1	9	0.31	0.83	0.18
MAY	20.7	46	3.8E+002	7.4	27	2.2
JUN	12.8	26	2.1E+002	4.4	16	1.5
JUL	0.755	1.1	8.6	0.3	0.86	0.2
AUG	0.692	2.6	21	0.59	1.5	0.23
SEP	4.07	12	96	2.1	5.8	0.73
OCT	4.83	11	93	2.1	6.3	0.8
NOV	10.5	25	2.1E+002	4.3	14	1.4
DEC	3.81	11	93	2	5.6	0.73
Total	80.9	2E+002	1.7E+003	35	1.1E+002	11

QUALM Version : 2.1; June 1995

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nnual Report for Node "NARURB11.9", 31/12/1995 11.9 ha "URBAN"

ocal Runoff and Pollutant Loads

onth	Rain mm	Runoff Ml	BOD Kg	SS Kg	TKN Kg	TN Kg	TP Kg
JAN	159.4	15.38	56	4.6E+002	8.4	24	2.4
FEB	75.2	2.40	9.9	80	2.1	5.3	0.68
MAR	105.2	8.41	32	2.6E+002	5.7	15	1.7
APR	18.7	0.55	1.6	13	0.46	1.2	0.2
MAY	218.8	21.33	67	5.5E+002	10	32	2.9
[illegible]	95.8	12.68	37	3E+002	6.2	19	1.9
JUL	6.2	0.66	1.5	12	0.44	1.2	0.21
AUG	40.9	0.92	3.9	32	0.89	2.2	0.3
SEP	126.8	4.72	17	1.4E+002	3	8	0.96
OCT	104.7	5.10	16	1.3E+002	3.1	8.3	1
NOV	164.7	11.23	37	3E+002	6.2	18	1.9
DEC	76.4	4.49	17	1.4E+002	3	7.9	0.96
otal	1192.8	87.87	3E+002	2.4E+003	50	1.4E+002	15

otal Runoff and Pollutant Loads

onth	Runoff Ml	BOD Kg	SS Kg	TKN Kg	TN Kg	TP Kg
JAN	15.4	56	4.6E+002	8.4	24	2.4
FEB	2.4	9.9	80	2.1	5.3	0.68
MAR	8.41	32	2.6E+002	5.7	15	1.7
[illegible]	0.546	1.6	13	0.46	1.2	0.2
MAY	21.3	67	5.5E+002	10	32	2.9
JUN	12.7	37	3E+002	6.2	19	1.9
JUL	0.665	1.5	12	0.44	1.2	0.21
AUG	0.917	3.9	32	0.89	2.2	0.3
SEP	4.72	17	1.4E+002	3	8	0.96
OCT	5.1	16	1.3E+002	3.1	8.3	1
NOV	11.2	37	3E+002	6.2	18	1.9
DEC	4.49	17	1.4E+002	3	7.9	0.96
otal	87.9	3E+002	2.4E+003	50	1.4E+002	15

AQUALM Version : 2.1; June 1995

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Annual Report for Node "NARRUR", 31/12/1996 RURAL

Local Runoff and Pollutant Loads

Month	Rain mm	Runoff Ml	BOD Kg	SS Kg	TKN Kg	TN Kg	TP Kg
JAN	70.6	1.23	0.28	2.6	0.031	0.35	0.22
FEB	20.9	0.20	0.045	0.36	0.003	0.034	0.073
MAR	13.3	0.15	0.034	0.26	0.002	0.022	0.064
APR	129.6	6.78	1.6	20	0.44	4.9	0.4
MAY	126.6	10.11	2.3	31	0.81	9.1	0.52
JUN	68.1	2.86	0.66	6.8	0.1	1.1	0.33
JUL	43.7	1.11	0.25	2.3	0.027	0.3	0.2
AUG	204.6	21.30	4.9	83	3.3	37	0.41
SEP	42.6	3.39	0.78	8.7	0.16	1.8	0.32
OCT	43.7	0.71	0.16	1.4	0.015	0.17	0.16
NOV	109.9	1.29	0.3	2.8	0.036	0.4	0.21
DEC	37.3	0.54	0.12	1.1	0.011	0.12	0.13
Total	910.8	49.65	11	1.6E+002	4.9	56	3

Total Runoff and Pollutant Loads

Month	Runoff Ml	BOD Kg	SS Kg	TKN Kg	TN Kg	TP Kg
JAN	1.23	0.28	2.6	0.031	0.35	0.22
FEB	0.197	0.045	0.36	0.003	0.034	0.073
MAR	0.147	0.034	0.26	0.002	0.022	0.064
APR	6.78	1.6	20	0.44	4.9	0.4
MAY	10.1	2.3	31	0.81	9.1	0.52
JUN	2.86	0.66	6.8	0.1	1.1	0.33
JUL	1.11	0.25	2.3	0.027	0.3	0.2
AUG	21.3	4.9	83	3.3	37	0.41
SEP	3.39	0.78	8.7	0.16	1.8	0.32
OCT	0.71	0.16	1.4	0.015	0.17	0.16
NOV	1.29	0.3	2.8	0.036	0.4	0.21
DEC	0.536	0.12	1.1	0.011	0.12	0.13
Total	49.6	11	1.6E+002	4.9	56	3

ɔUALM Version : 2.1; June 1995

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ınual Report for Node "NARURB7.9", 31/12/1996 7.9 ha "URBAN"

ɔcal Runoff and Pollutant Loads

ɔnth	Rain mm	Runoff Ml	BOD Kg	SS Kg	TKN Kg	TN Kg	TP Kg
JAN	70.6	2.34	7.8	63	1.6	4.3	0.61
FEB	20.9	0.50	1.8	15	0.51	1.3	0.2
MAR	13.3	0.35	1.3	10	0.37	0.93	0.16
APR	129.6	9.08	25	2E+002	3.8	12	1.2
MAY	126.6	10.22	21	1.8E+002	3.6	13	1.2
J	68.1	3.14	7.1	58	1.4	4.1	0.6
JUL	43.7	1.37	3.5	28	0.77	2.1	0.35
AUG	204.6	22.38	49	4.2E+002	6.9	35	1.5
SEP	42.6	3.42	7.1	58	1.5	4.6	0.6
OCT	43.7	0.83	2	16	0.46	1.2	0.23
NOV	109.9	2.97	11	86	1.9	4.9	0.65
DEC	37.3	0.81	2.4	20	0.62	1.6	0.27
ɔtal	910.8	57.40	1.4E+002	1.2E+003	23	85	7.5

ɔtal Runoff and Pollutant Loads

ɔnth	Runoff Ml	BOD Kg	SS Kg	TKN Kg	TN Kg	TP Kg
JAN	2.34	7.8	63	1.6	4.3	0.61
FEB	0.499	1.8	15	0.51	1.3	0.2
MAR	0.347	1.3	10	0.37	0.93	0.16
	9.08	25	2E+002	3.8	12	1.2
MAY	10.2	21	1.8E+002	3.6	13	1.2
JUN	3.14	7.1	58	1.4	4.1	0.6
JUL	1.37	3.5	28	0.77	2.1	0.35
AUG	22.4	49	4.2E+002	6.9	35	1.5
SEP	3.42	7.1	58	1.5	4.6	0.6
OCT	0.828	2	16	0.46	1.2	0.23
NOV	2.97	11	86	1.9	4.9	0.65
DEC	0.813	2.4	20	0.62	1.6	0.27
ɔtal	57.4	1.4E+002	1.2E+003	23	85	7.5

AQUALM Version : 2.1; June 1995

Input File : C:\WPS\AQUALMXP\narra1a.dat
Output File : C:\WPS\AQUALMXP\narra2c.out

==
Annual Report for Node "NARURB11.9", 31/12/1996 11.9 ha "URBAN"
==

Local Runoff and Pollutant Loads

Month	Rain mm	Runoff Ml	BOD Kg	SS Kg	TKN Kg	TN Kg	TP Kg
JAN	70.6	2.90	12	94	2.5	6.3	0.81
FEB	20.9	0.65	2.7	22	0.76	1.9	0.27
MAR	13.3	0.45	1.9	15	0.55	1.4	0.2
APR	129.6	10.25	37	3E+002	5.4	15	1.6
MAY	126.6	10.28	31	2.5E+002	5	15	1.5
JUN	68.1	3.27	10	85	2.1	5.6	0.73
JUL	43.7	1.50	5.1	41	1.1	3	0.42
AUG	204.6	22.93	71	5.9E+002	8.7	33	2
SEP	42.6	3.44	10	84	2.2	6	0.75
OCT	43.7	0.89	2.9	24	0.69	1.8	0.27
NOV	109.9	3.83	16	1.3E+002	2.8	7.2	0.88
DEC	37.3	0.95	3.6	29	0.93	2.4	0.34
Total	910.8	61.33	2E+002	1.7E+003	33	99	9.7

Total Runoff and Pollutant Loads

Month	Runoff Ml	BOD Kg	SS Kg	TKN Kg	TN Kg	TP Kg
JAN	2.9	12	94	2.5	6.3	0.81
FEB	0.652	2.7	22	0.76	1.9	0.27
MAR	0.448	1.9	15	0.55	1.4	0.2
APR	10.2	37	3E+002	5.4	15	1.6
MAY	10.3	31	2.5E+002	5	15	1.5
JUN	3.27	10	85	2.1	5.6	0.73
JUL	1.5	5.1	41	1.1	3	0.42
AUG	22.9	71	5.9E+002	8.7	33	2
SEP	3.44	10	84	2.2	6	0.75
OCT	0.888	2.9	24	0.69	1.8	0.27
NOV	3.83	16	1.3E+002	2.8	7.2	0.88
DEC	0.954	3.6	29	0.93	2.4	0.34
Total	61.3	2E+002	1.7E+003	33	99	9.7

QUALM Version : 2.1; June 1995

nput File : C:\WPS\AQUALMXP\narra1a.dat
utput File : C:\WPS\AQUALMXP\narra3a.out

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nnual Report for Node "NARRUReast", 31/12/1995 EASTWARD "RURAL"

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ocal Runoff and Pollutant Loads

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onth	Rain mm	Runoff Ml	BOD Kg	SS Kg	TKN Kg	TN Kg	TP Kg
JAN	159.4	4.49	1	14	0.38	4.3	0.22
FEB	75.2	0.40	0.093	0.84	0.0094	0.11	0.079
MAR	105.2	2.02	0.47	5.1	0.086	0.97	0.19
APR	18.7	0.26	0.06	0.52	0.0053	0.059	0.064
MAY	218.8	9.17	2.1	29	0.81	9.1	0.36
JUN	95.8	6.14	1.4	18	0.41	4.6	0.33
JUL	6.2	0.44	0.1	0.93	0.01	0.12	0.086
AUG	40.9	0.12	0.027	0.22	0.0019	0.021	0.04
SEP	126.8	1.32	0.3	3.3	0.055	0.62	0.13
OCT	104.7	2.04	0.47	5.3	0.092	1	0.18
NOV	164.7	4.27	0.98	12	0.27	3	0.26
DEC	76.4	1.17	0.27	2.9	0.047	0.53	0.13
otal	1192.8	31.86	7.3	93	2.2	24	2.1

otal Runoff and Pollutant Loads

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onth	Runoff Ml	BOD Kg	SS Kg	TKN Kg	TN Kg	TP Kg
JAN	4.49	1	14	0.38	4.3	0.22
FEB	0.404	0.093	0.84	0.0094	0.11	0.079
MAR	2.02	0.47	5.1	0.086	0.97	0.19
APR	0.262	0.06	0.52	0.0053	0.059	0.064
MAY	9.17	2.1	29	0.81	9.1	0.36
JUN	6.14	1.4	18	0.41	4.6	0.33
JUL	0.443	0.1	0.93	0.01	0.12	0.086
AUG	0.118	0.027	0.22	0.0019	0.021	0.04
SEP	1.32	0.3	3.3	0.055	0.62	0.13
OCT	2.04	0.47	5.3	0.092	1	0.18
NOV	4.27	0.98	12	0.27	3	0.26
DEC	1.17	0.27	2.9	0.047	0.53	0.13
otal	31.9	7.3	93	2.2	24	2.1

AQUALM Version : 2.1; June 1995

Input File : C:\WPS\AQUALMXP\narra1a.dat
Output File : C:\WPS\AQUALMXP\narra3b.out

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Annual Report for Node "NARRUReast", 31/12/1995 EASTWARD "URBAN"
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Local Runoff and Pollutant Loads

Month	Rain mm	Runoff Ml	BOD Kg	SS Kg	TKN Kg	TN Kg	TP Kg
JAN	159.4	7.78	31	2.5E+002	4.6	13	1.3
FEB	75.2	1.26	5.5	44	1.2	2.9	0.36
MAR	105.2	4.32	18	1.4E+002	3.1	8.1	0.93
APR	18.7	0.26	0.88	7.1	0.26	0.65	0.1
MAY	218.8	10.29	37	3E+002	5.6	16	1.6
JUN	95.8	6.00	20	1.7E+002	3.4	9.5	1
JUL	6.2	0.29	0.8	6.5	0.24	0.63	0.1
AUG	40.9	0.49	2.2	17	0.49	1.2	0.16
SEP	126.8	2.40	9.6	78	1.7	4.3	0.51
OCT	104.7	2.49	9.1	74	1.7	4.4	0.53
NOV	164.7	5.51	20	1.7E+002	3.4	9.2	1
DEC	76.4	2.29	9.3	75	1.7	4.3	0.51
Total	1192.8	43.37	1.6E+002	1.3E+003	27	74	8

Total Runoff and Pollutant Loads

Month	Runoff Ml	BOD Kg	SS Kg	TKN Kg	TN Kg	TP Kg
JAN	7.78	31	2.5E+002	4.6	13	1.3
FEB	1.26	5.5	44	1.2	2.9	0.36
MAR	4.32	18	1.4E+002	3.1	8.1	0.93
APR	0.259	0.88	7.1	0.26	0.65	0.1
MAY	10.3	37	3E+002	5.6	16	1.6
JUN	6	20	1.7E+002	3.4	9.5	1
JUL	0.294	0.8	6.5	0.24	0.63	0.1
AUG	0.489	2.2	17	0.49	1.2	0.16
SEP	2.4	9.6	78	1.7	4.3	0.51
OCT	2.49	9.1	74	1.7	4.4	0.53
NOV	5.51	20	1.7E+002	3.4	9.2	1
DEC	2.29	9.3	75	1.7	4.3	0.51
Total	43.4	1.6E+002	1.3E+003	27	74	8

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QUALM Version : 2.1; June 1995

nput File : C:\WPS\AQUALMXP\narra1a.dat
utput File : C:\WPS\AQUALMXP\narra4b.out

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nnual Report for Node "NARURBeast", 31/12/1996 EASTWARD "RURAL"

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ocal Runoff and Pollutant Loads

onth	Rain mm	Runoff Ml	BOD Kg	SS Kg	TKN Kg	TN Kg	TP Kg
JAN	70.6	0.58	0.13	1.3	0.015	0.17	0.1
FEB	20.9	0.09	0.022	0.17	0.0014	0.016	0.034
MAR	13.3	0.07	0.016	0.12	0.00094	0.011	0.03
APR	129.6	3.22	0.74	9.3	0.21	2.3	0.19
MAY	126.6	4.80	1.1	15	0.39	4.3	0.25
N	68.1	1.36	0.31	3.2	0.047	0.53	0.16
JUL	43.7	0.52	0.12	1.1	0.013	0.14	0.096
AUG	204.6	10.11	2.3	39	1.6	18	0.19
SEP	42.6	1.61	0.37	4.2	0.074	0.84	0.15
OCT	43.7	0.34	0.077	0.68	0.0072	0.081	0.075
NOV	109.9	0.61	0.14	1.3	0.017	0.19	0.099
DEC	37.3	0.25	0.059	0.51	0.0052	0.058	0.062
otal	910.8	23.57	5.4	76	2.3	26	1.4

otal Runoff and Pollutant Loads

onth	Runoff Ml	BOD Kg	SS Kg	TKN Kg	TN Kg	TP Kg
JAN	0.584	0.13	1.3	0.015	0.17	0.1
FEB	0.0937	0.022	0.17	0.0014	0.016	0.034
MAR	0.07	0.016	0.12	0.00094	0.011	0.03
R	3.22	0.74	9.3	0.21	2.3	0.19
MAY	4.8	1.1	15	0.39	4.3	0.25
JUN	1.36	0.31	3.2	0.047	0.53	0.16
JUL	0.525	0.12	1.1	0.013	0.14	0.096
AUG	10.1	2.3	39	1.6	18	0.19
SEP	1.61	0.37	4.2	0.074	0.84	0.15
OCT	0.337	0.077	0.68	0.0072	0.081	0.075
NOV	0.61	0.14	1.3	0.017	0.19	0.099
DEC	0.254	0.059	0.51	0.0052	0.058	0.062
otal	23.6	5.4	76	2.3	26	1.4

AQUALM Version : 2.1; June 1995

Input File : C:\WPS\AQUALMXP\narra1a.dat
Output File : C:\WPS\AQUALMXP\narra4a.out

Annual Report for Node "NARRUReast", 31/12/1996 EASTWARD "URBAN"

Local Runoff and Pollutant Loads

Month	Rain mm	Runoff Ml	BOD Kg	SS Kg	TKN Kg	TN Kg	TP Kg
JAN	70.6	1.51	6.4	52	1.4	3.4	0.43
FEB	20.9	0.35	1.5	12	0.42	1.1	0.14
MAR	13.3	0.24	1	8.3	0.31	0.77	0.11
APR	129.6	5.14	20	1.6E+002	3	8	0.84
MAY	126.6	4.89	17	1.4E+002	2.7	7.8	0.8
JUN	68.1	1.59	5.7	46	1.2	3	0.38
JUL	43.7	0.74	2.8	23	0.63	1.6	0.22
AUG	204.6	11.01	39	3.2E+002	4.5	15	1.1
SEP	42.6	1.64	5.6	46	1.2	3.2	0.39
OCT	43.7	0.44	1.6	13	0.38	0.98	0.14
NOV	109.9	2.02	8.8	71	1.6	4	0.47
DEC	37.3	0.49	2	16	0.51	1.3	0.18
Total	910.8	30.05	1.1E+002	9.1E+002	18	51	5.2

Total Runoff and Pollutant Loads

Month	Runoff Ml	BOD Kg	SS Kg	TKN Kg	TN Kg	TP Kg
JAN	1.51	6.4	52	1.4	3.4	0.43
FEB	0.346	1.5	12	0.42	1.1	0.14
MAR	0.237	1	8.3	0.31	0.77	0.11
APR	5.14	20	1.6E+002	3	8	0.84
MAY	4.89	17	1.4E+002	2.7	7.8	0.8
JUN	1.59	5.7	46	1.2	3	0.38
JUL	0.742	2.8	23	0.63	1.6	0.22
AUG	11	39	3.2E+002	4.5	15	1.1
SEP	1.64	5.6	46	1.2	3.2	0.39
OCT	0.436	1.6	13	0.38	0.98	0.14
NOV	2.02	8.8	71	1.6	4	0.47
DEC	0.486	2	16	0.51	1.3	0.18
Total	30.1	1.1E+002	9.1E+002	18	51	5.2

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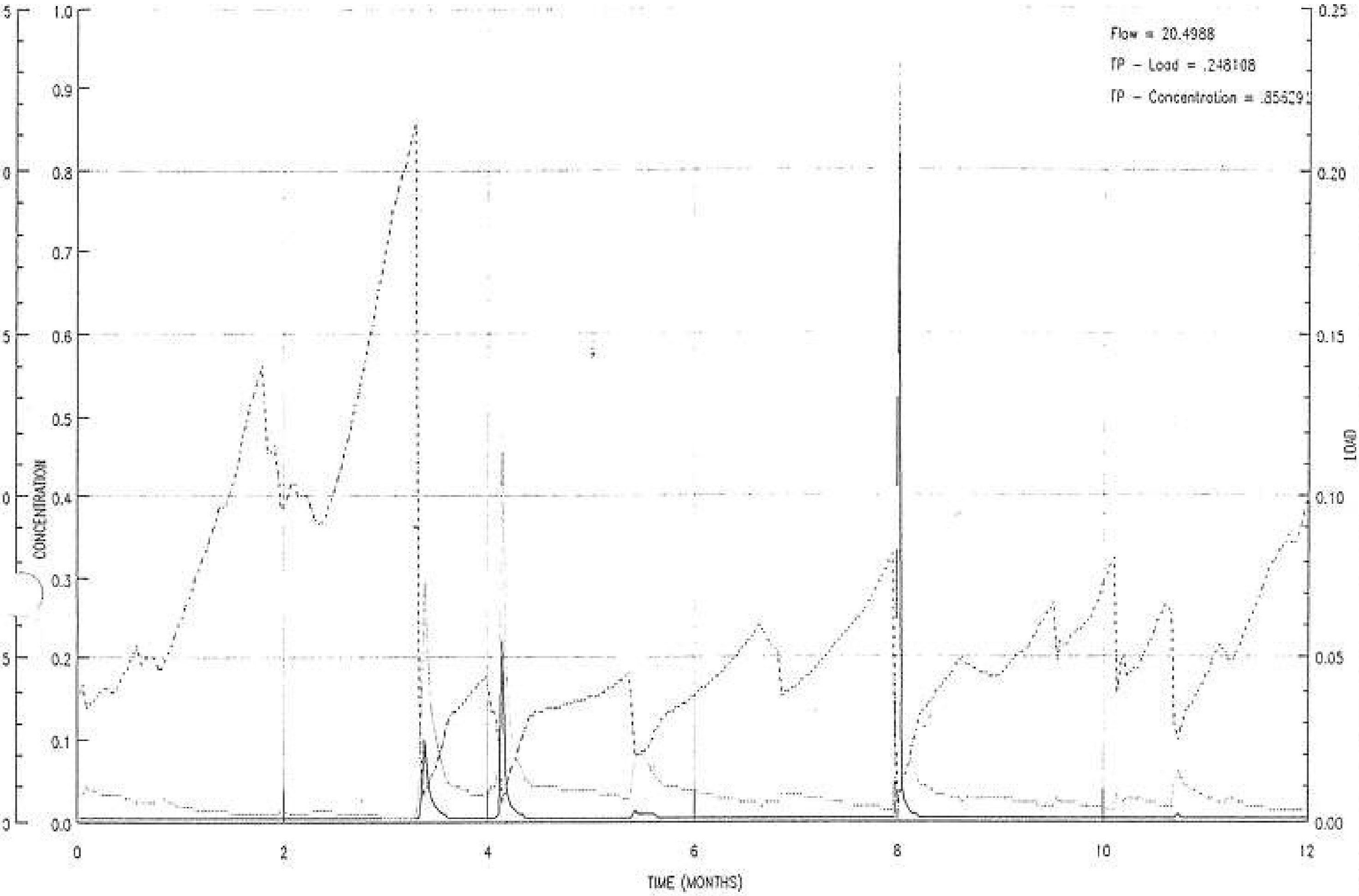
Appendix C

YEARLY POLLUTANT CONCENTRATIONS

NARRUR 1996 "RURAL"

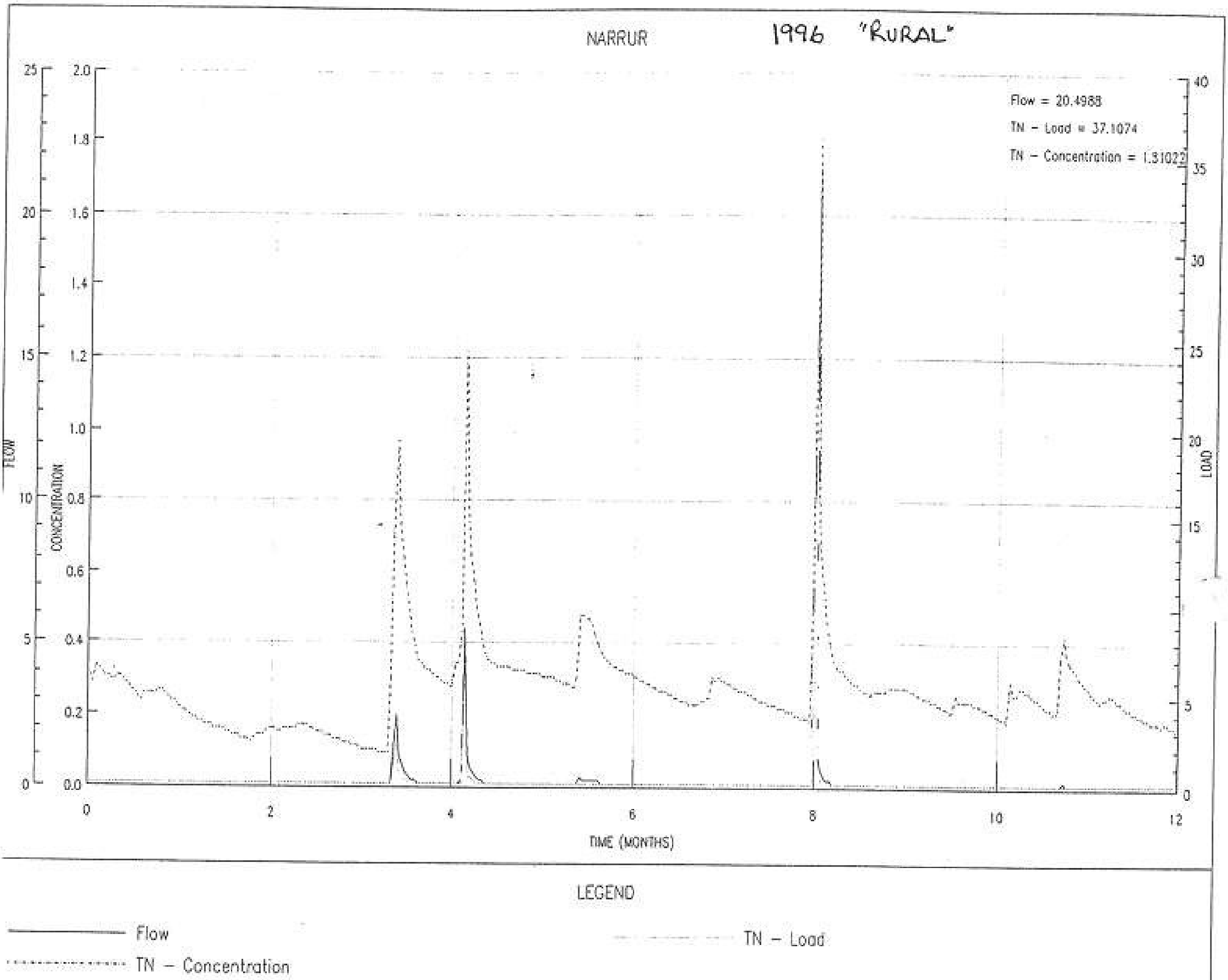


LEGEND

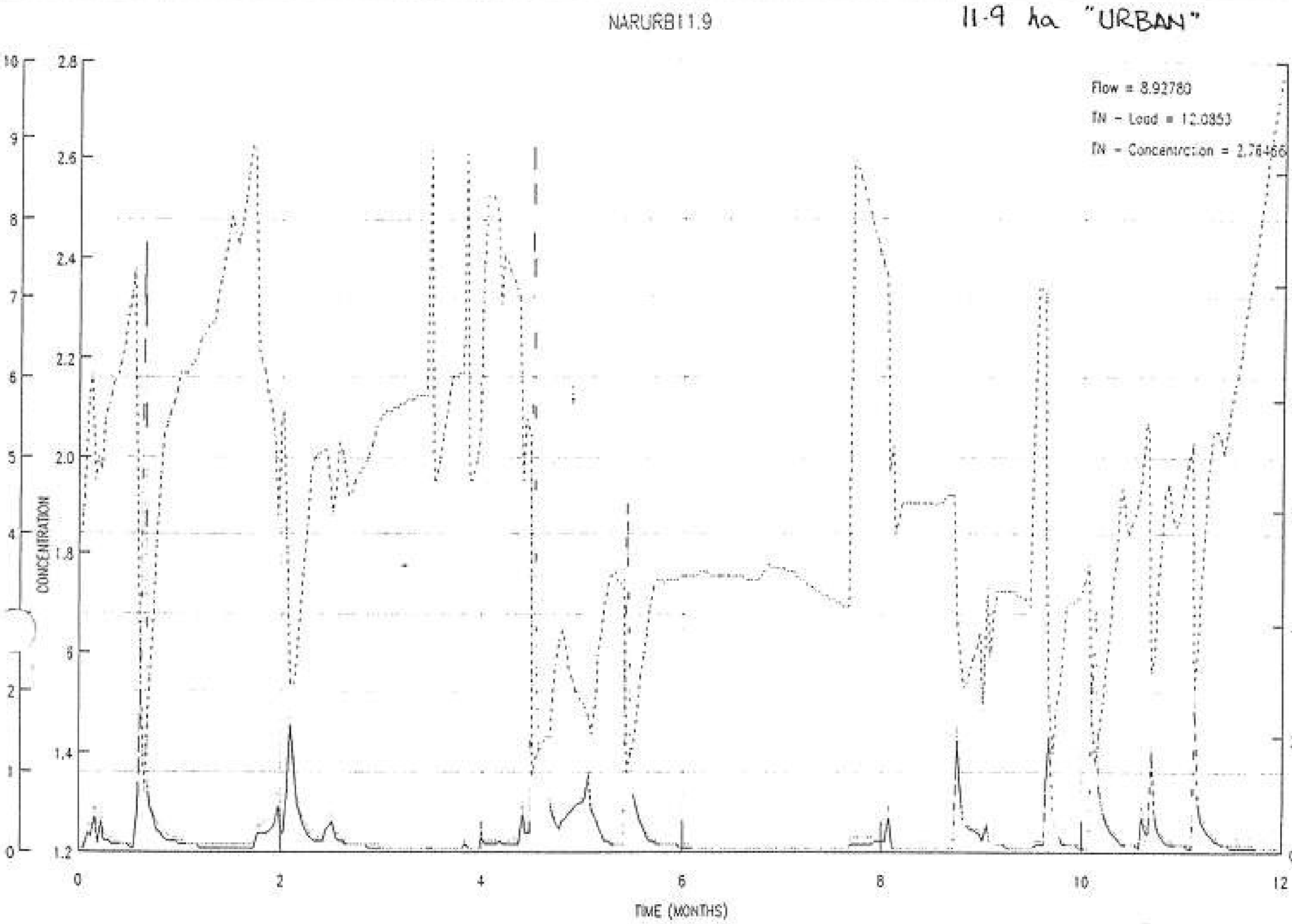
Flow

TP - Concentration

TP - Load



NARRUR
1996 "RURAL"
Flow = 20.4988
TN - Load = 37.1074
TN - Concentration = 1.31022
FLOW
CONCENTRATION
LOAD
TIME (MONTHS)
LEGEND
Flow
TN - Concentration
TN - Load

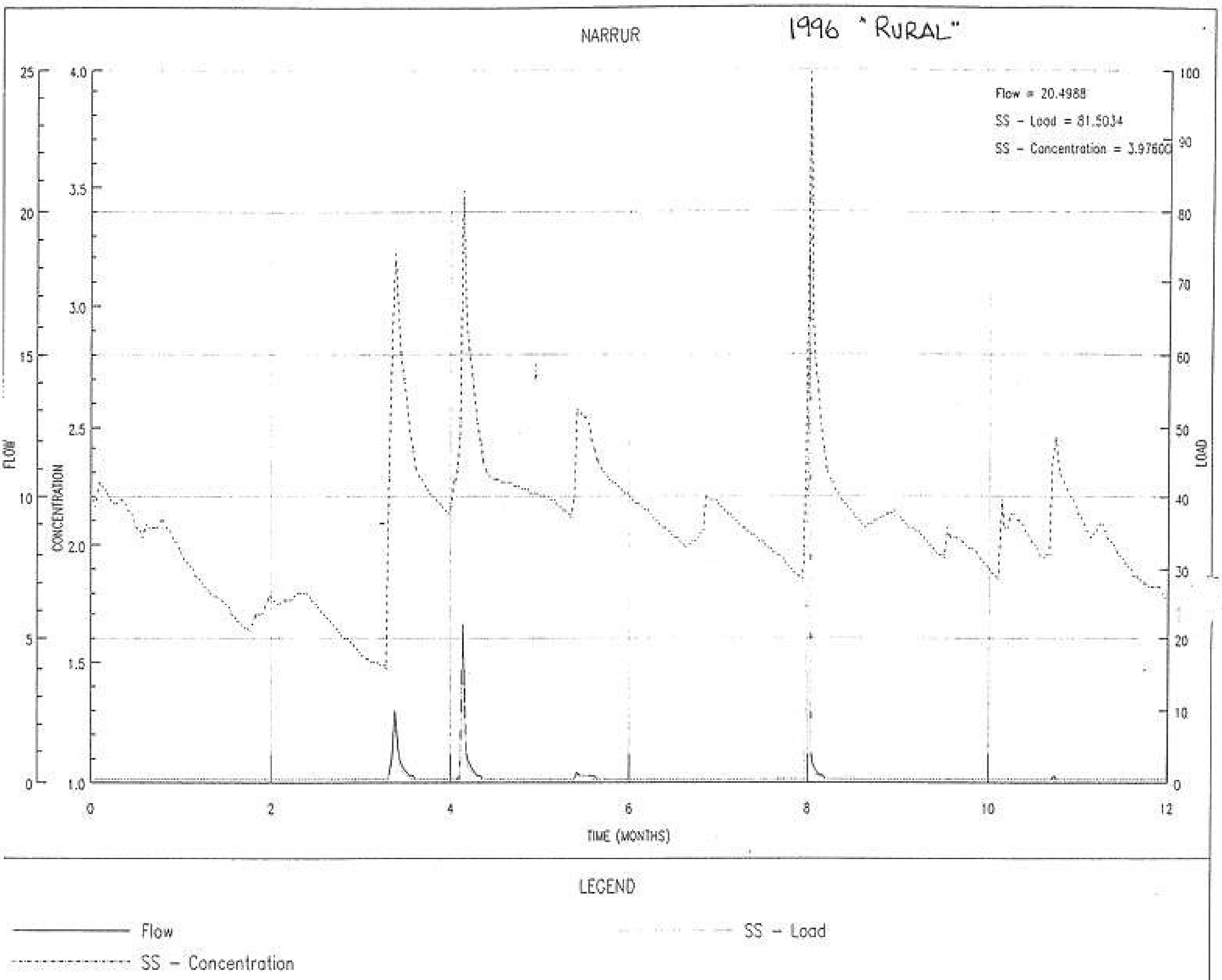


LEGEND

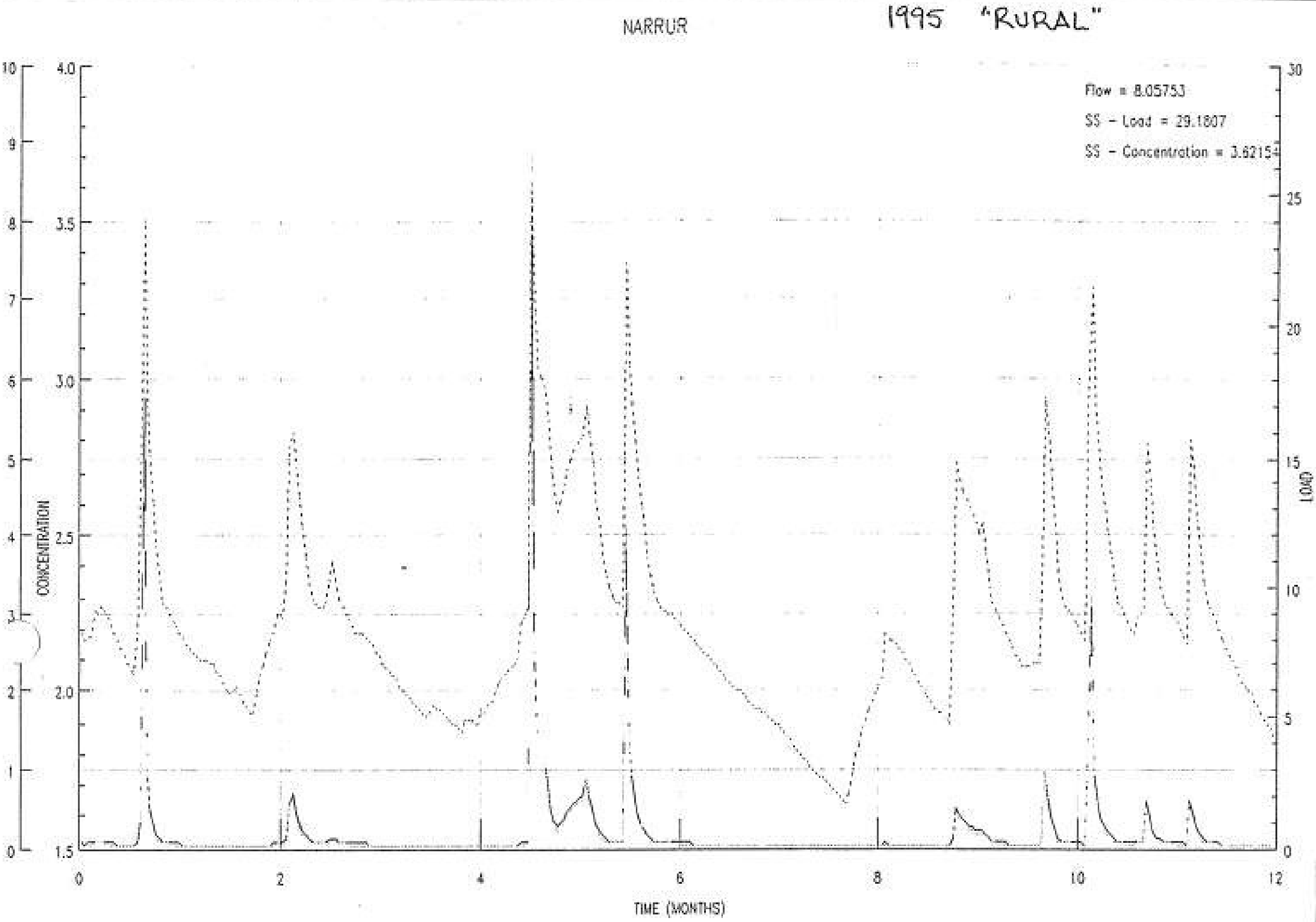
Flow

TN - Concentration

TN - Load


NARRUR
1996 "RURAL"
Flow = 20.4988
SS - Load = 81.5034
SS - Concentration = 3.97600
FLOW
CONCENTRATION
LOAD
TIME (MONTHS)
LEGEND
Flow
SS - Concentration
SS - Load

1995 "RURAL"



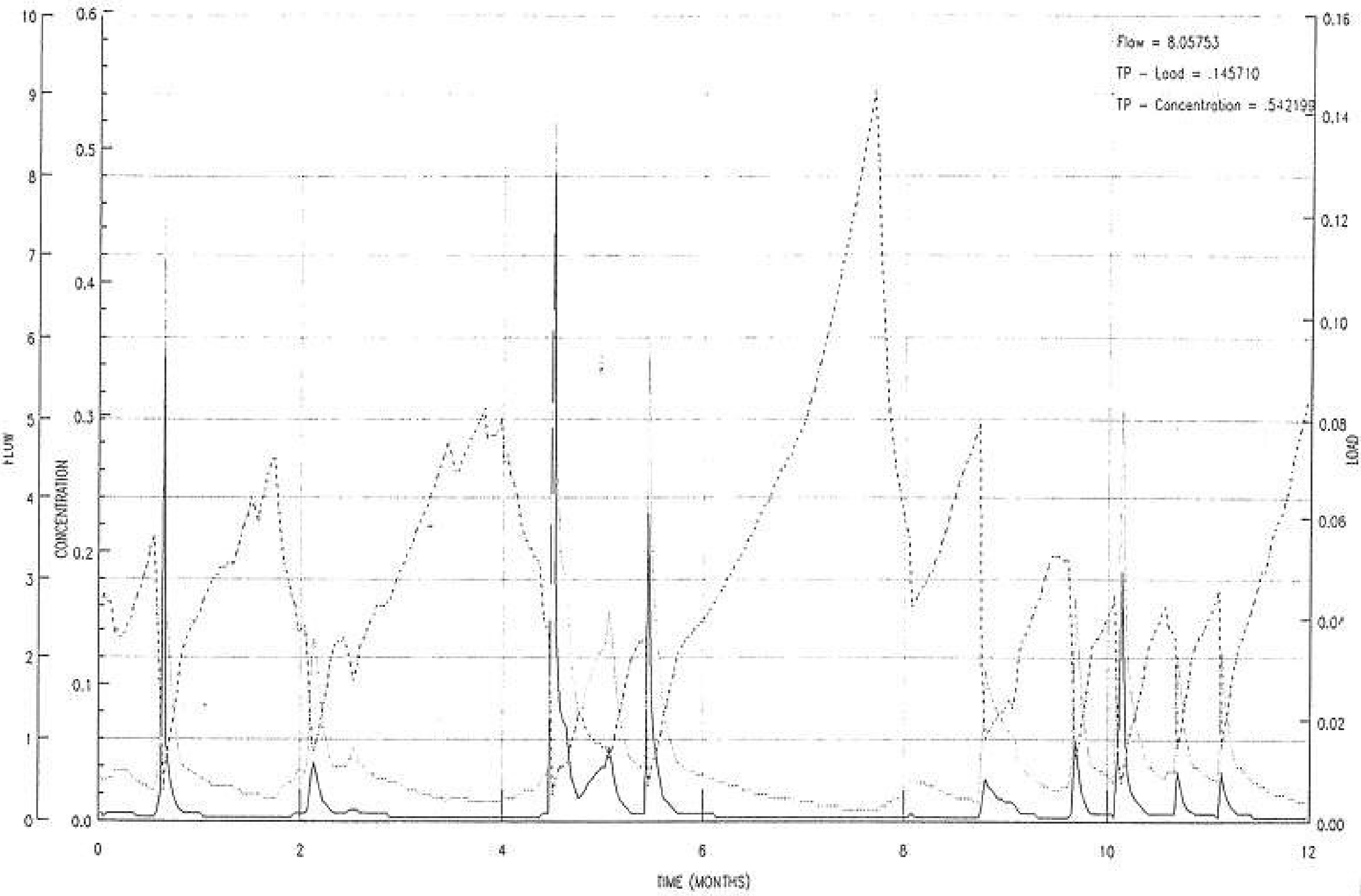
LEGEND

Flow

SS - Load

SS - Concentration

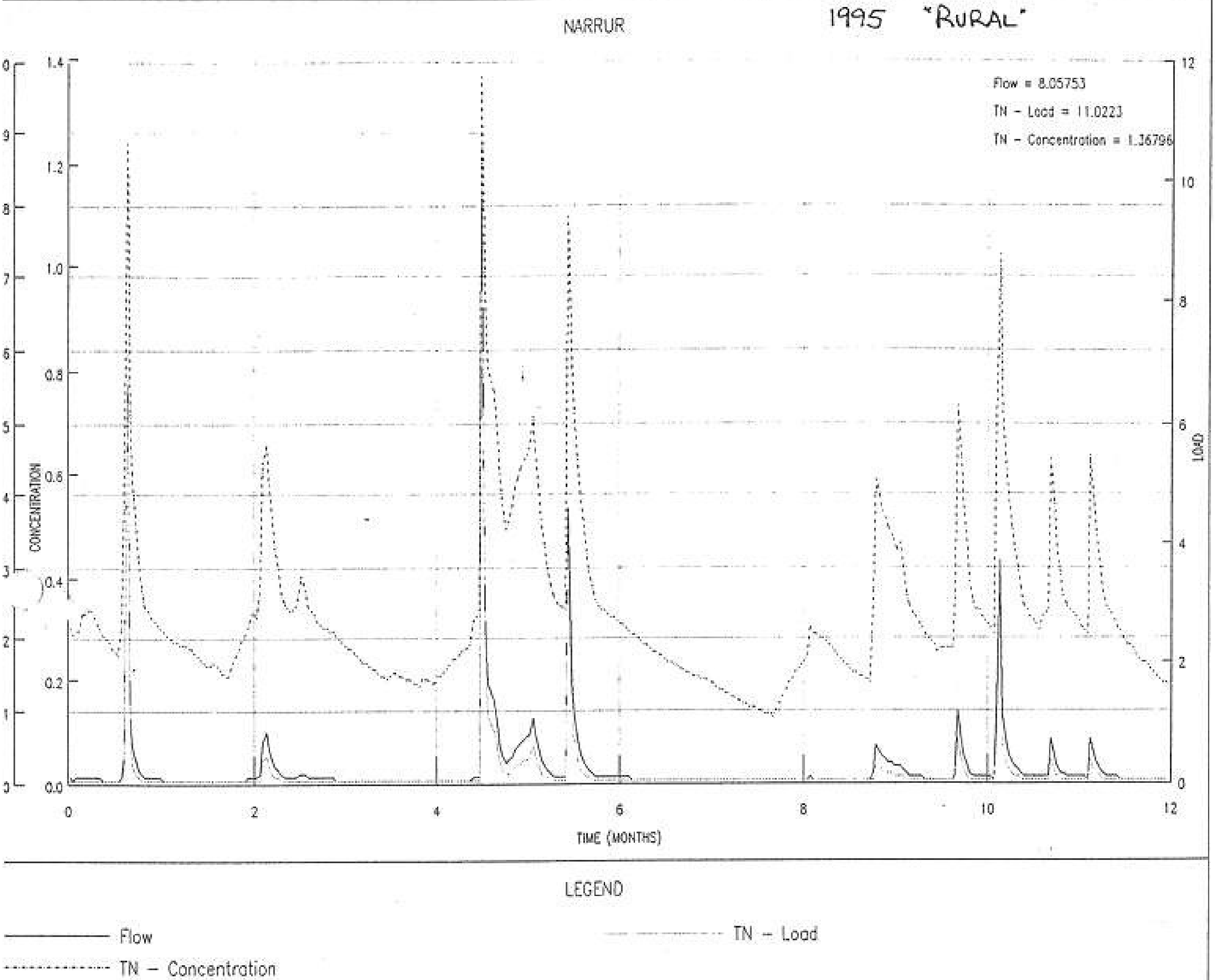
NARRUR 1995 'RURAL'

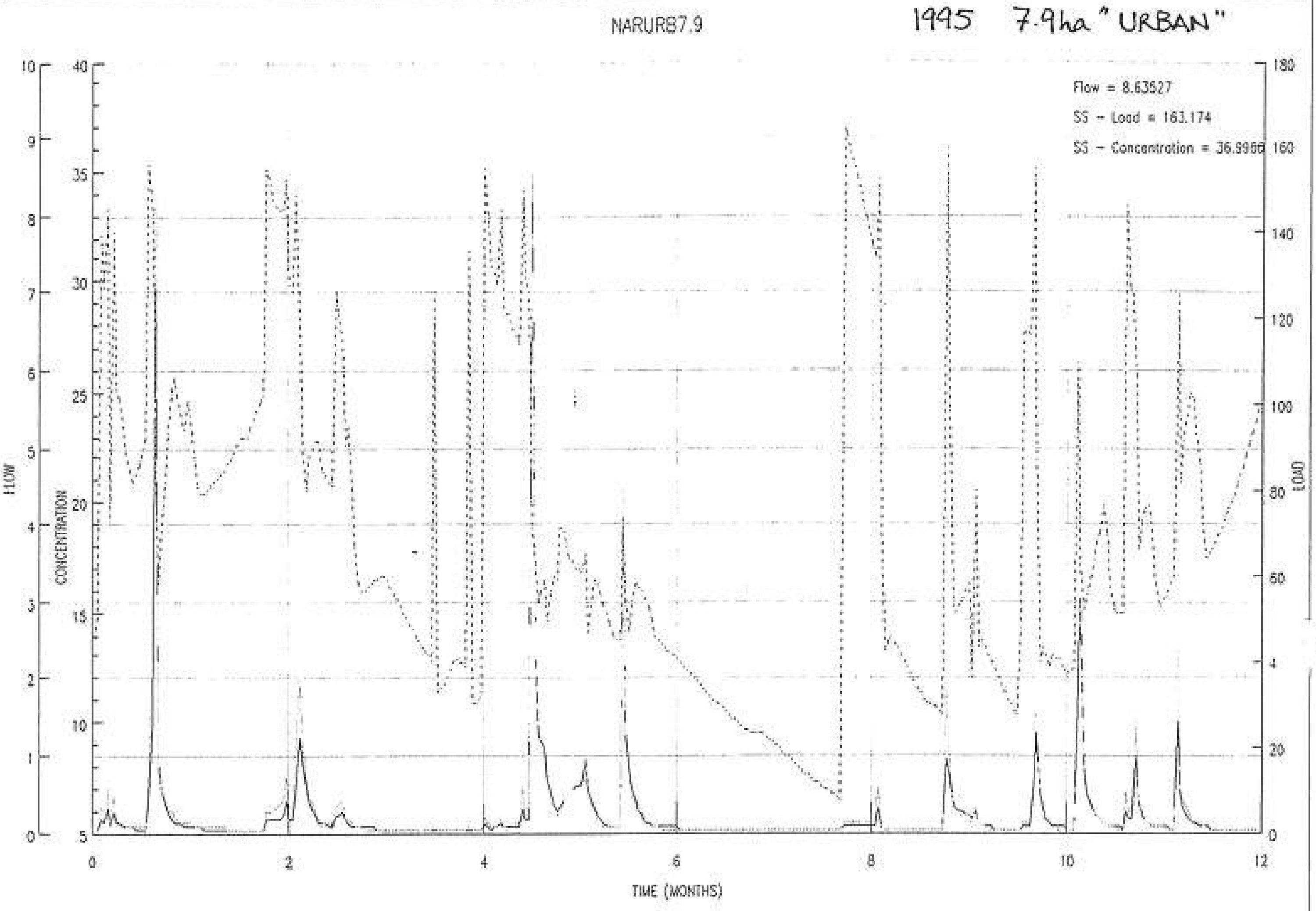


LEGEND

Flow
TP - Concentration
TP - Load

1995 "RURAL"


NARRUR
Flow = 8.05753
TN - Load = 11.0223
TN - Concentration = 1.36796
CONCENTRATION
LOAD
TIME (MONTHS)
0
2
4
6
8
10
12
LEGEND
Flow
TN - Concentration
TN - Load

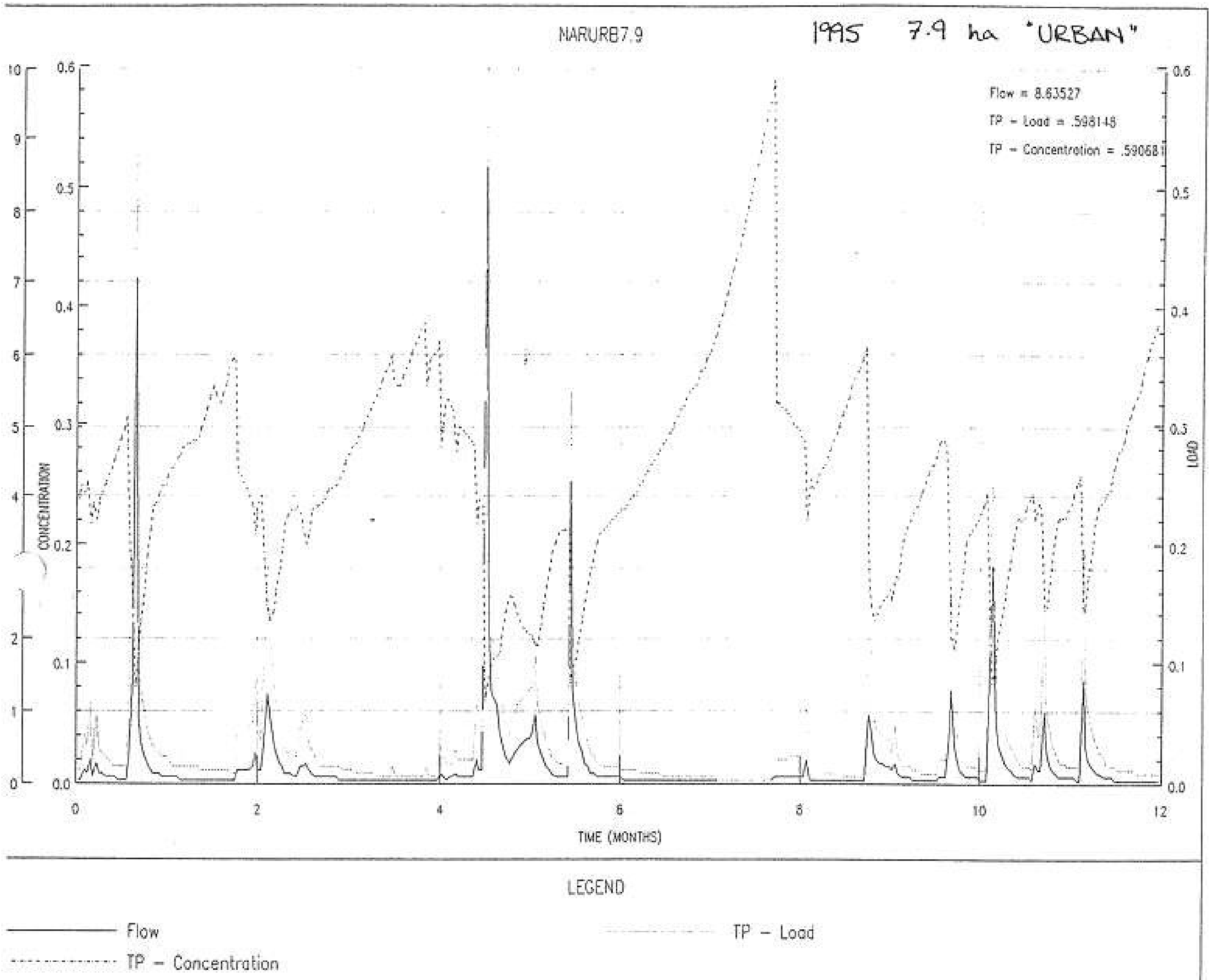


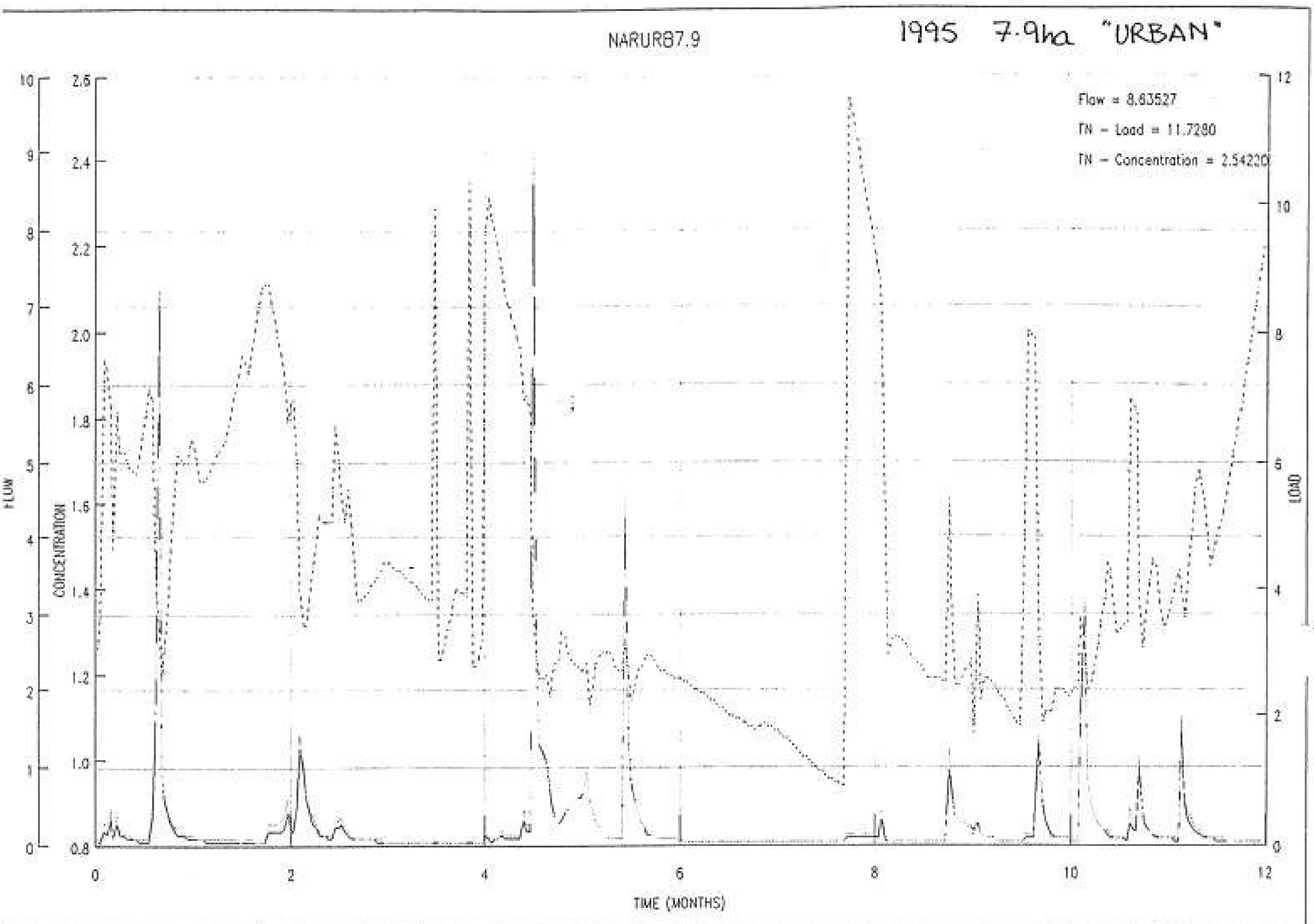
LEGEND

Flow

SS - Load

SS - Concentration


NARURB7.9
1995 7.9 ha "URBAN"
Flow = 8.63527
TP - Load = .598148
TP - Concentration = .59068
CONCENTRATION
LOAD
TIME (MONTHS)
LEGEND
Flow
TP - Concentration
TP - Load



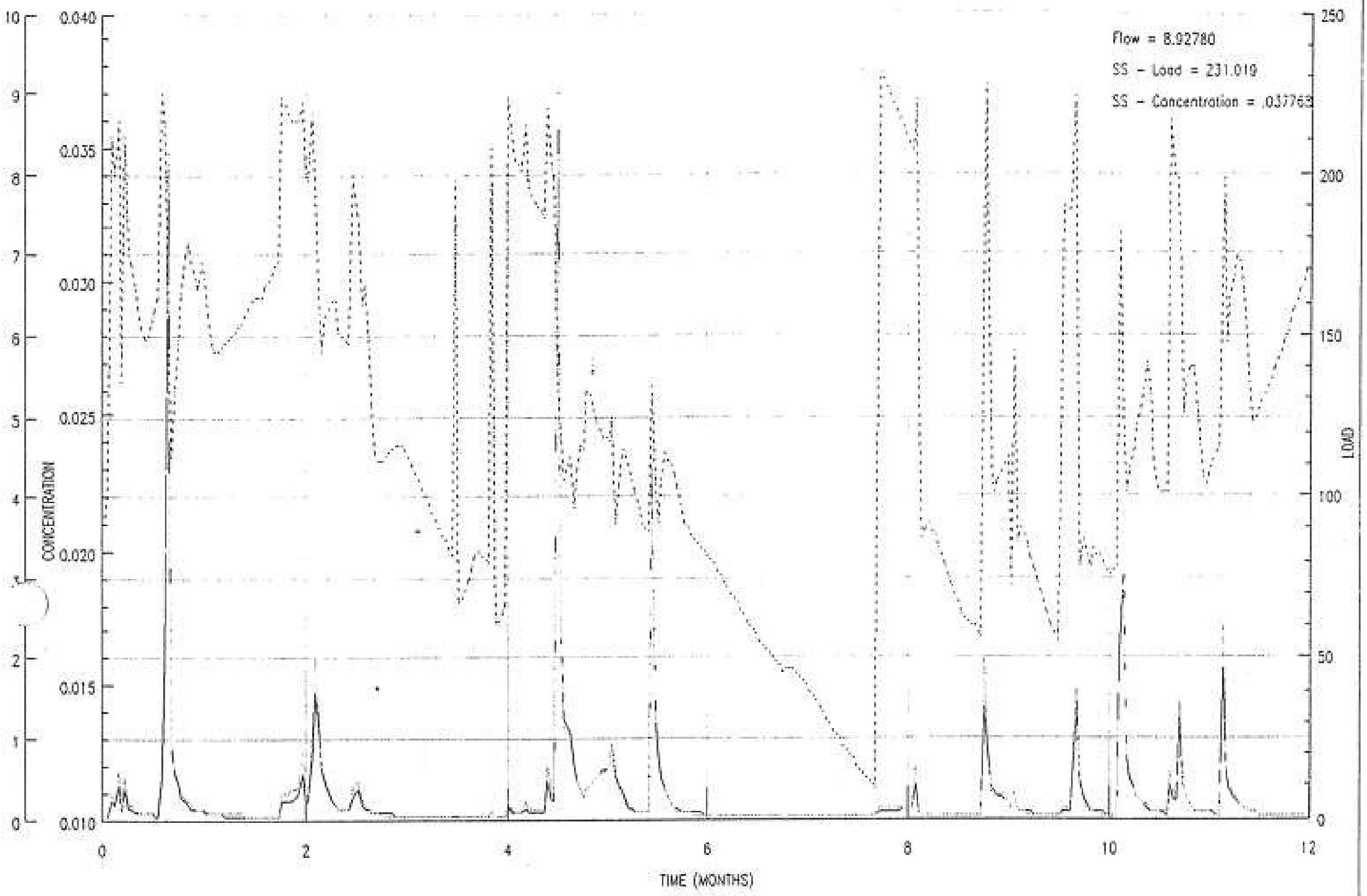
LEGEND

Flow

TN - Concentration

TN - Load

11.9 ha "URBAN"

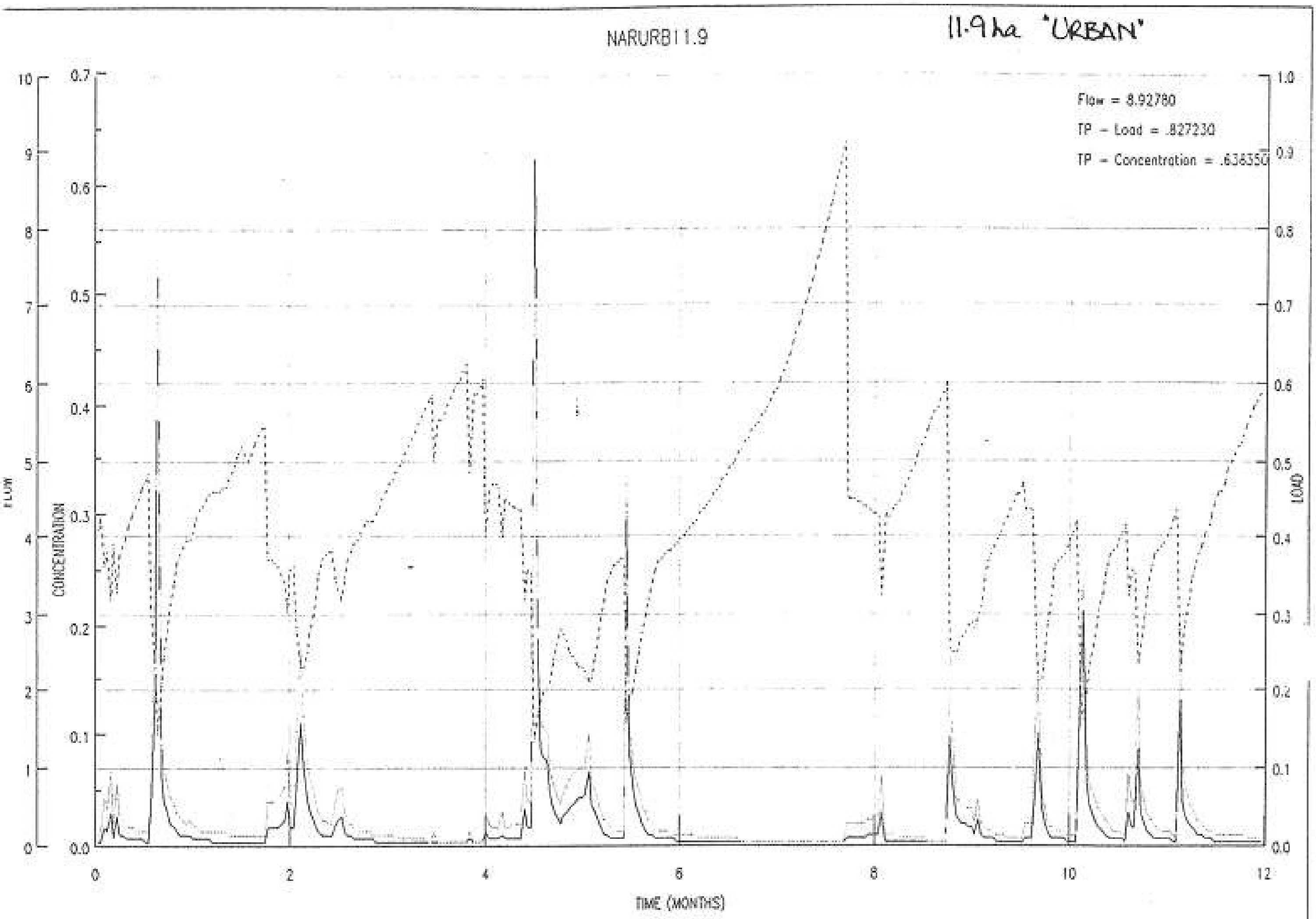


LEGEND

Flow

SS - Concentration

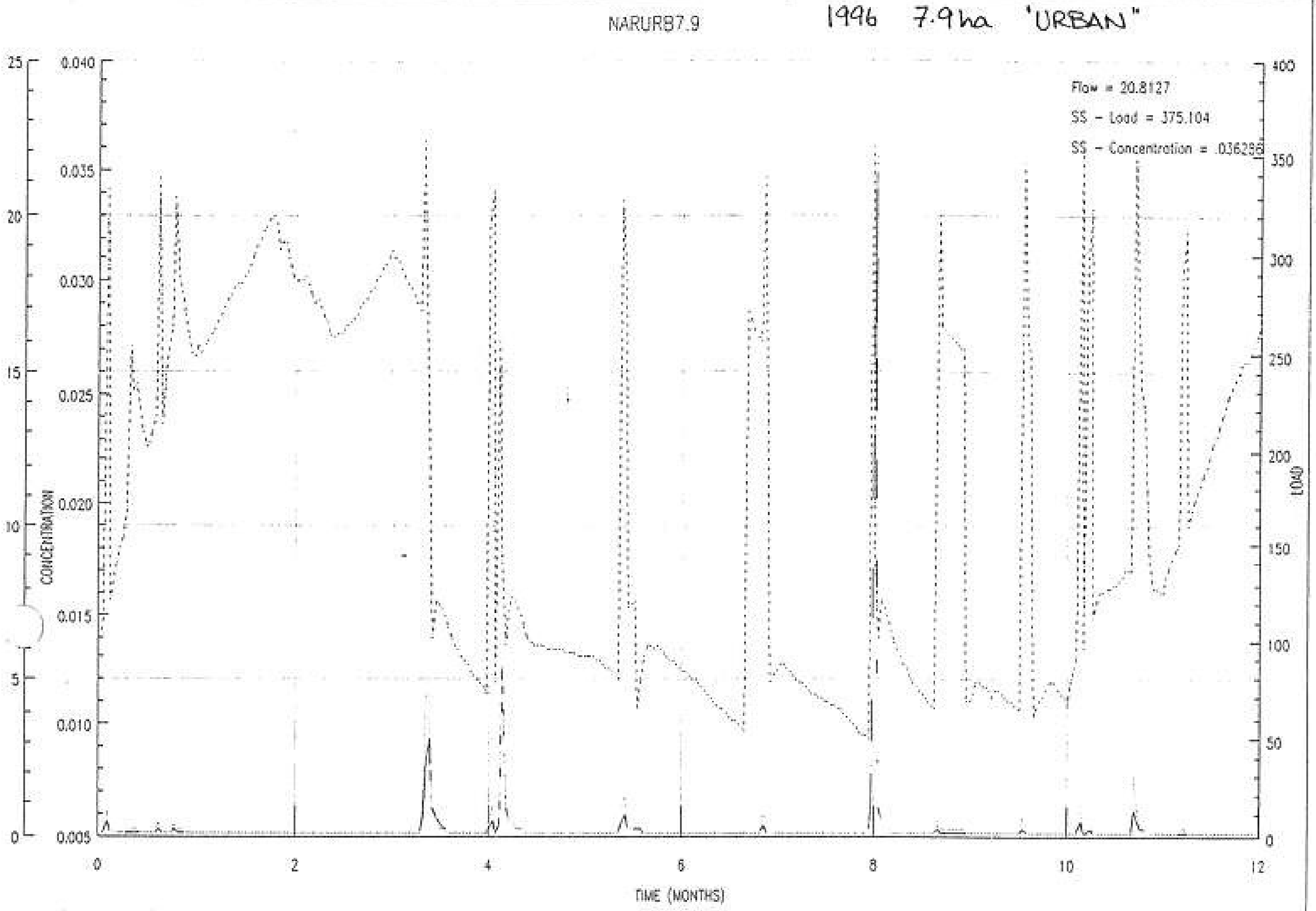
SS - Load



LEGEND

Flow
TP - Load
TP - Concentration

1996 7.9ha 'URBAN"

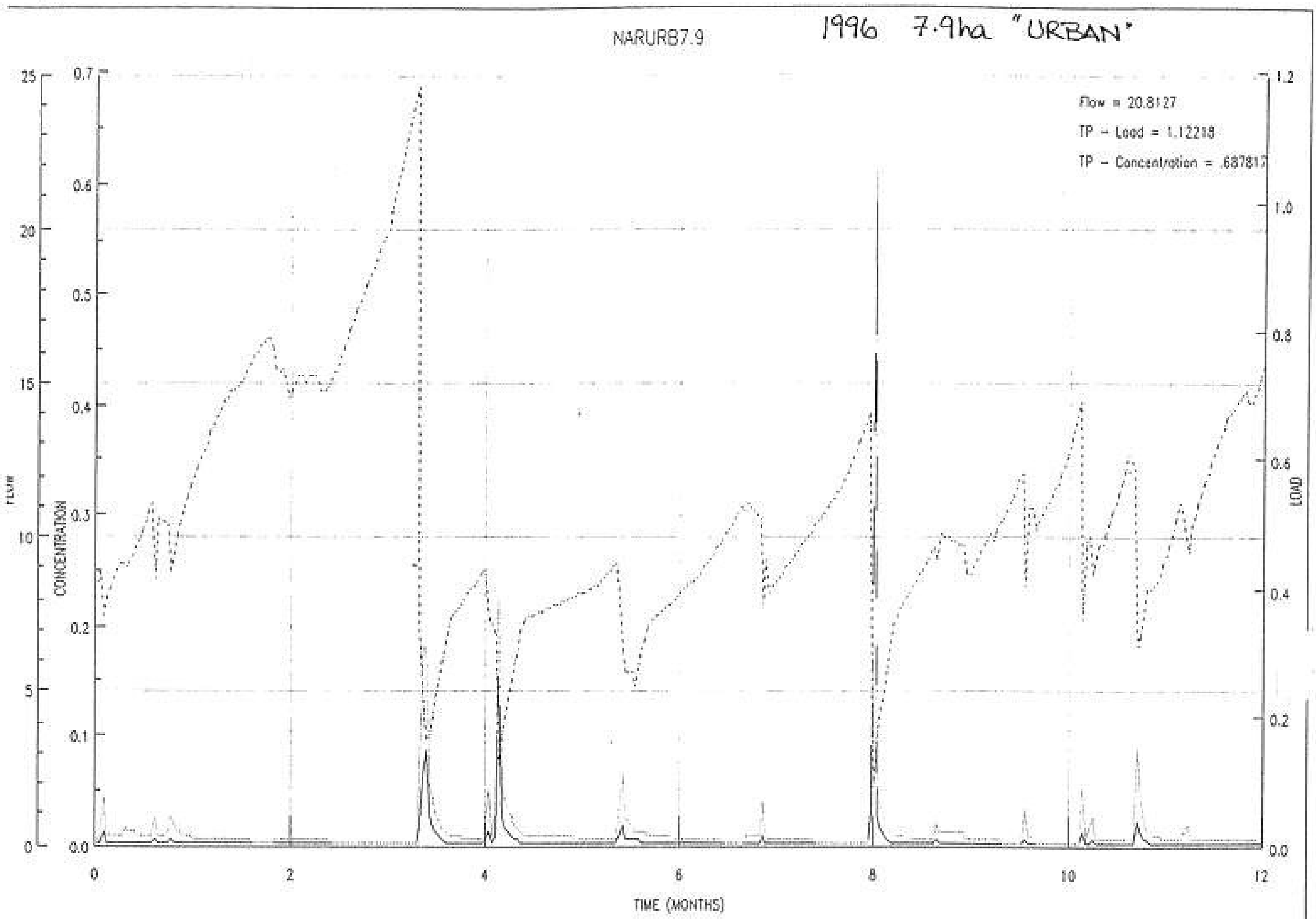


LEGEND

Flow

SS - Concentration

SS - Load



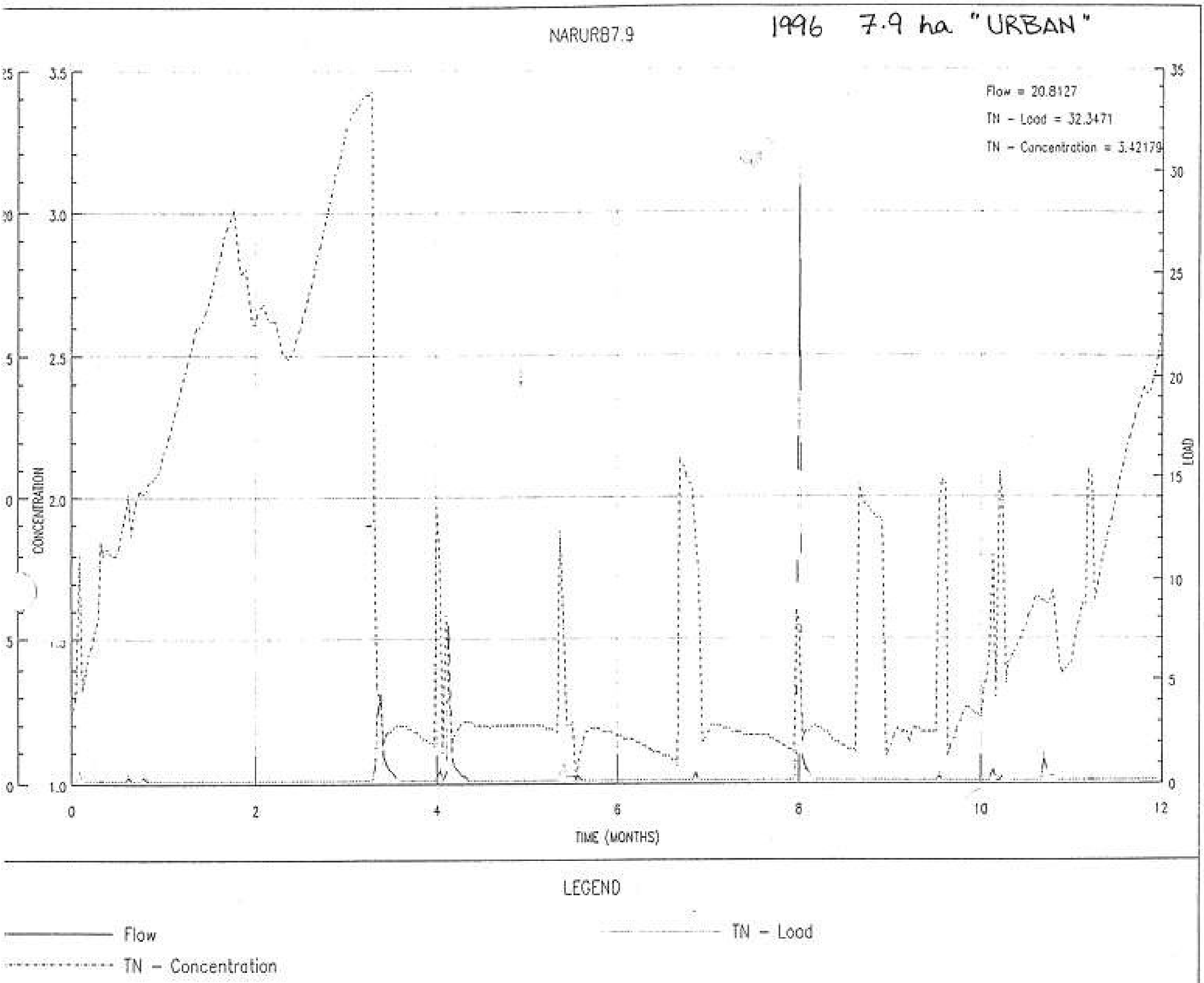
LEGEND

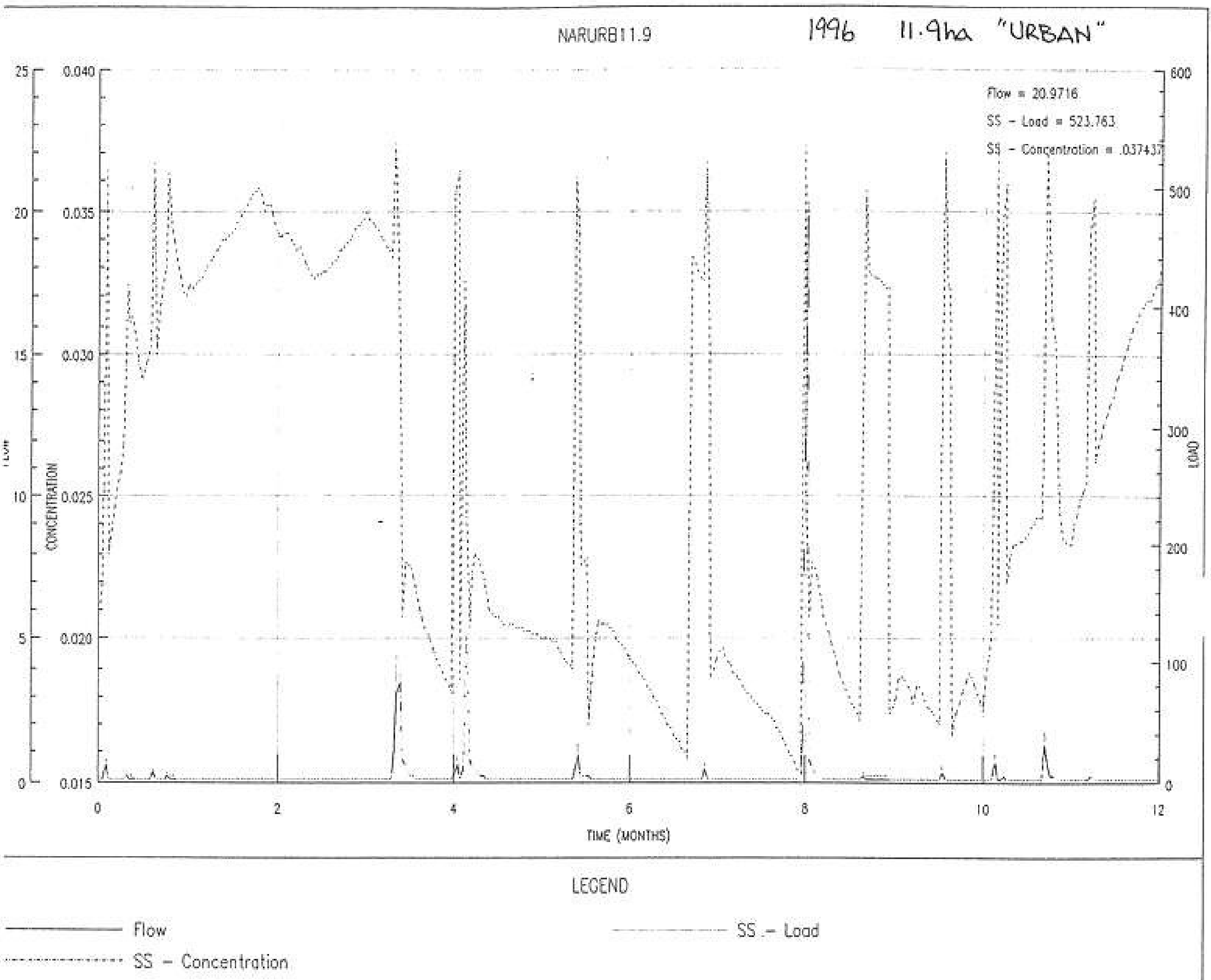
Flow

TP - Load

TP - Concentration

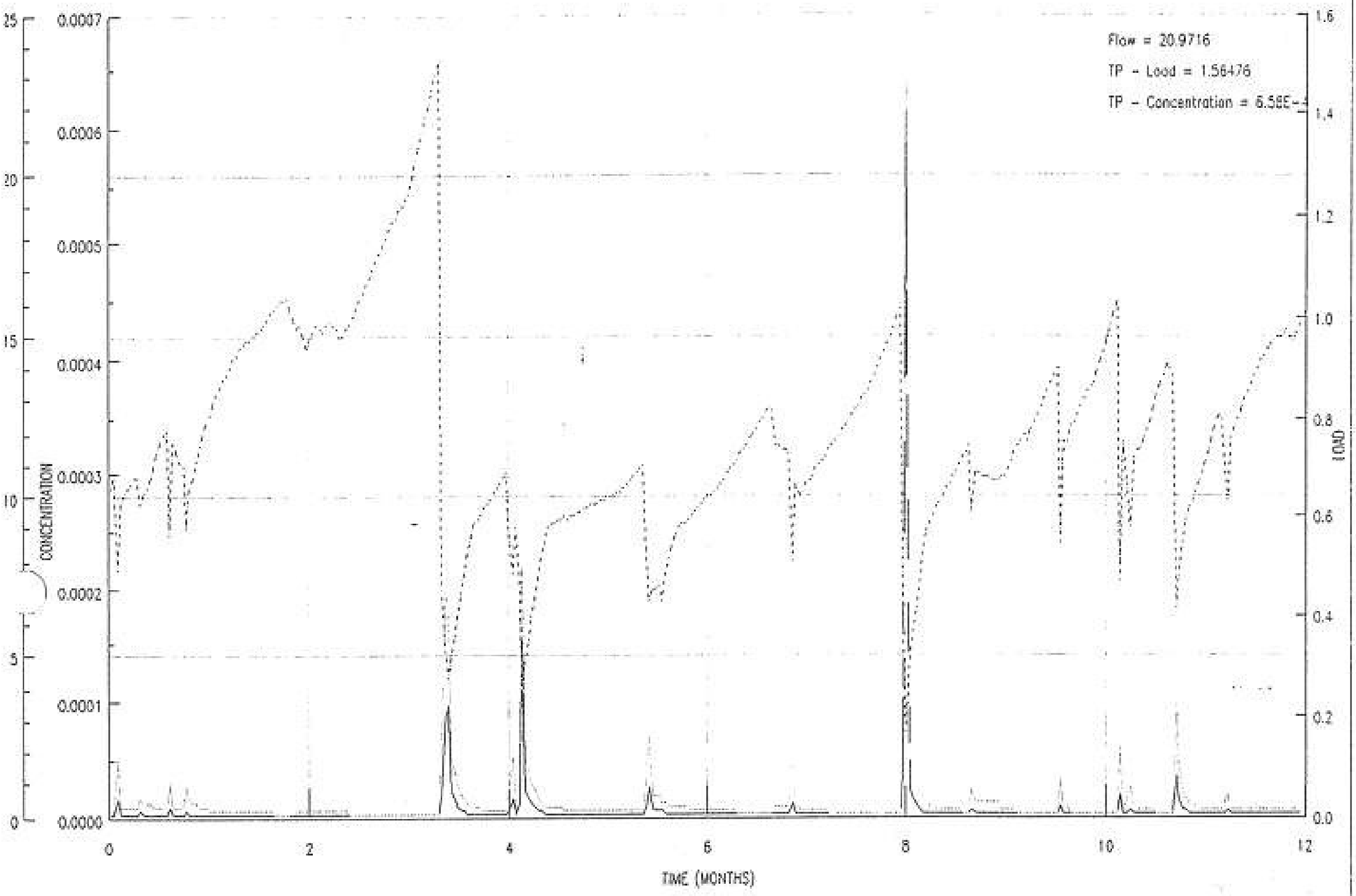
1996 7.9 ha "URBAN"





NARURB11.9
1996 11.9ha "URBAN"
Flow = 20.9716
SS - Load = 523.763
SS - Concentration = .037437
CONCENTRATION
LOAD
TIME (MONTHS)
LEGEND
Flow
SS - Load
SS - Concentration

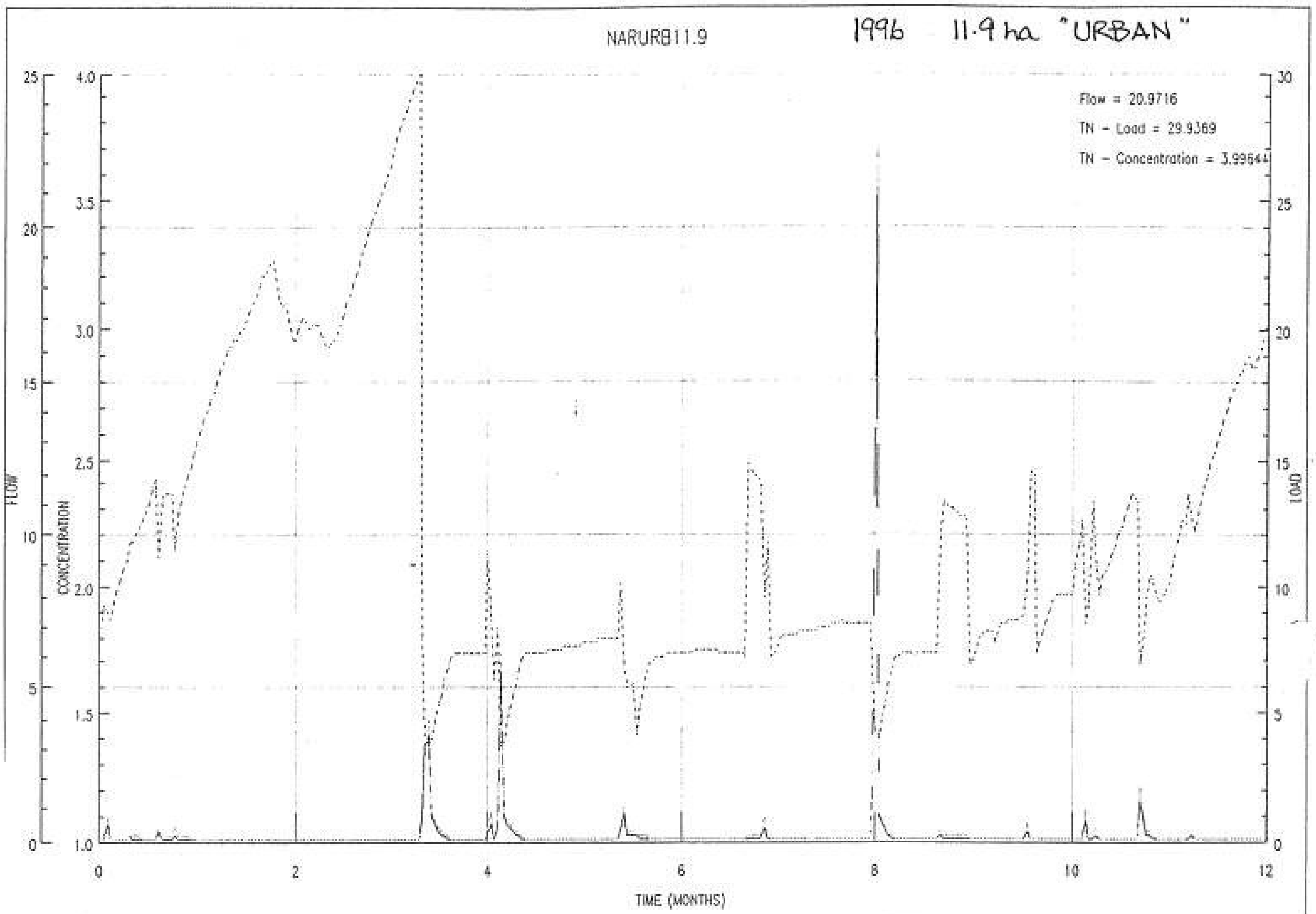
NARURB11.9 1996 11.9ha ^ "URBAN"



LEGEND

Flow
TP - Concentration
TP - Load

1996 11.9 ha "URBAN"



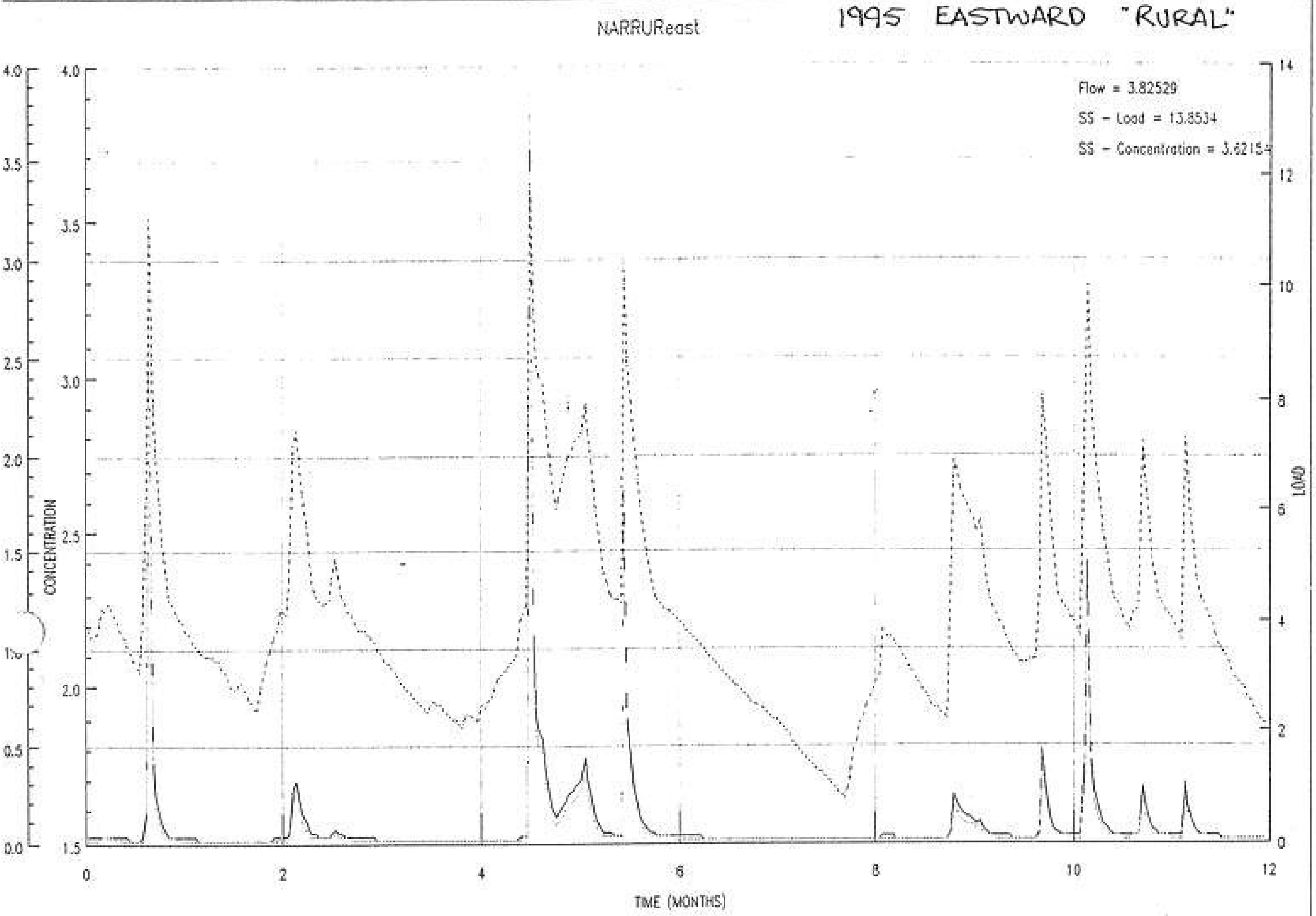
LEGEND

Flow

TN - Load

TN - Concentration

1995 EASTWARD "RURAL"

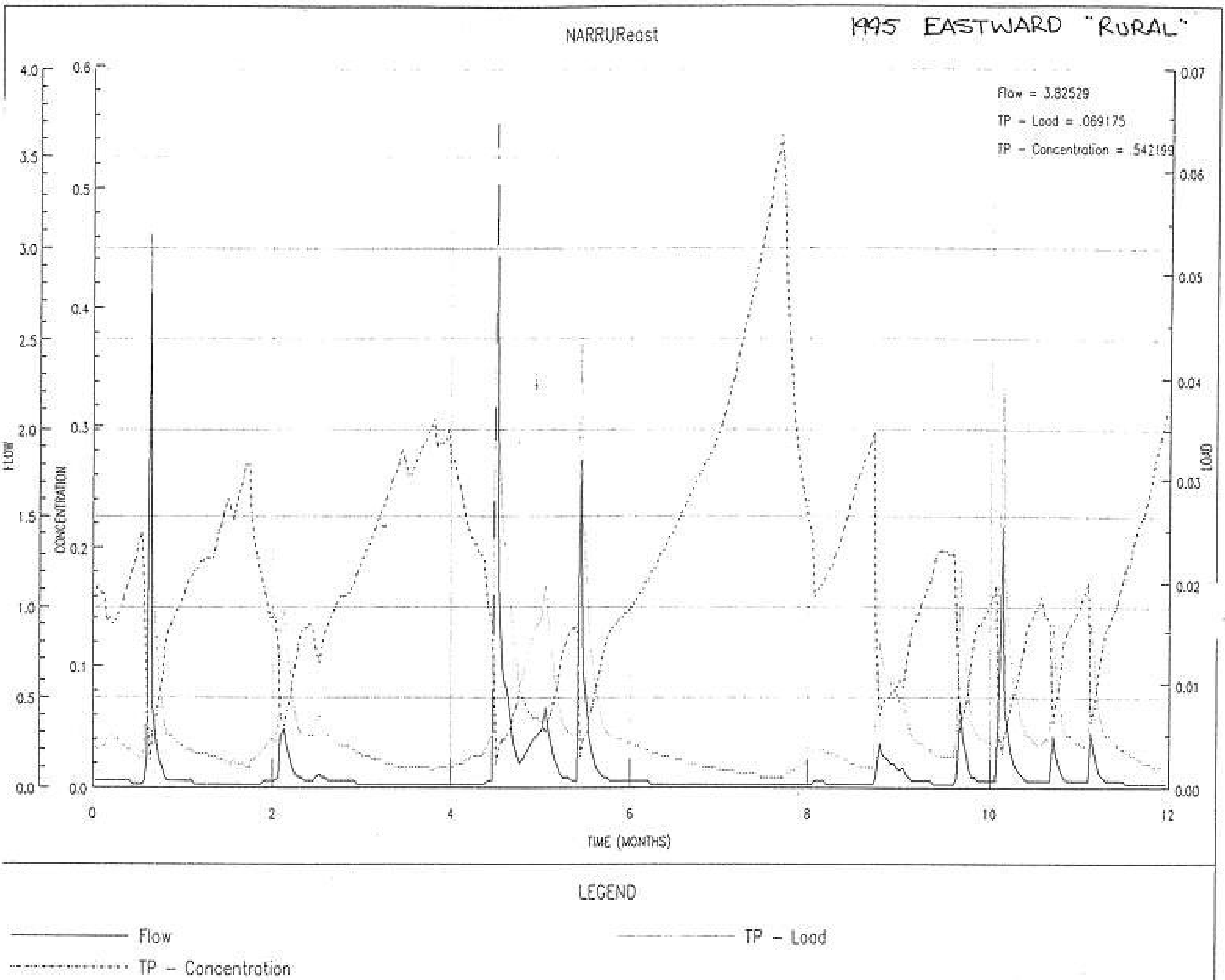


LEGEND

Flow

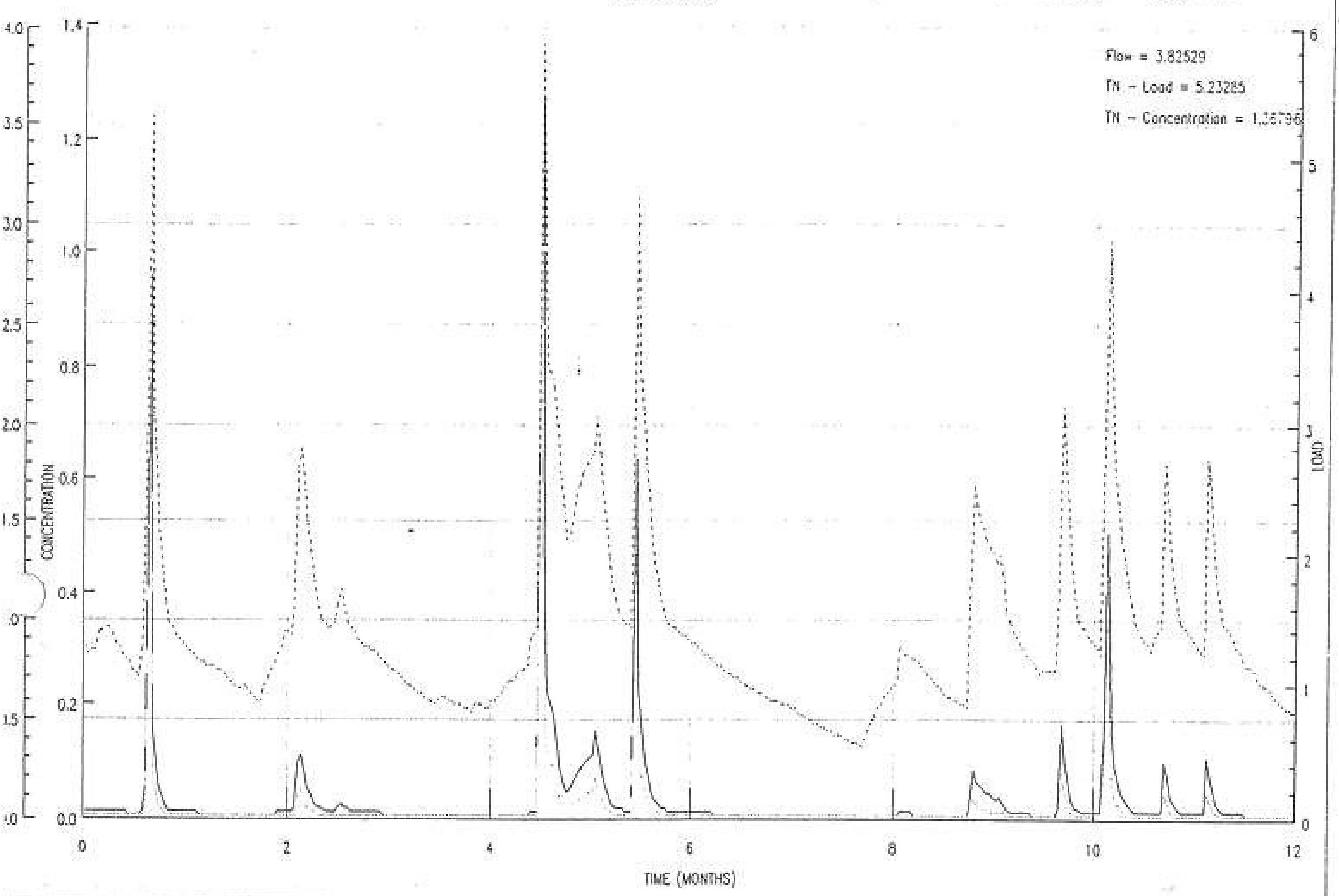
SS - Concentration

SS - Load



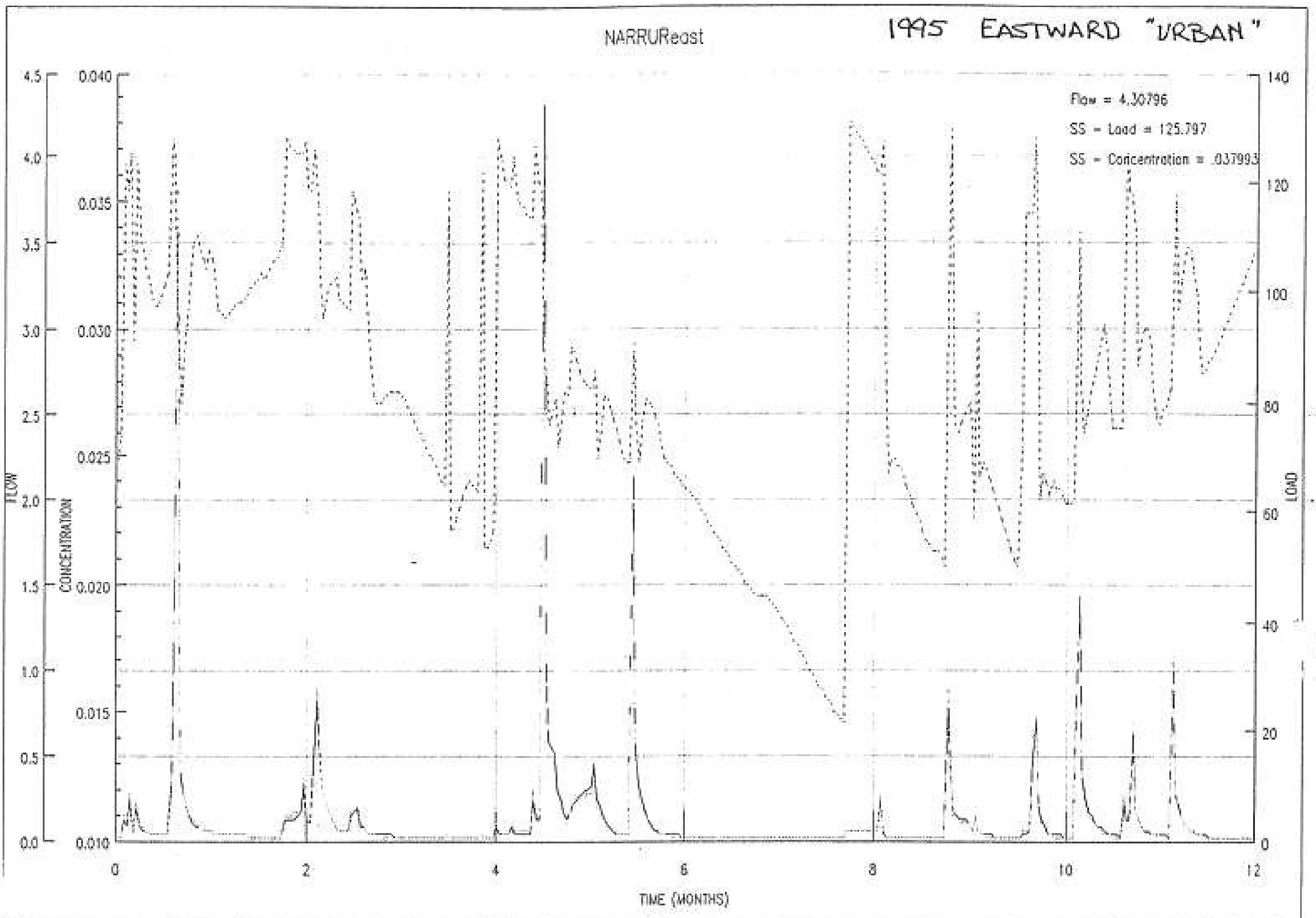
NARRUReast
1995 EASTWARD "RURAL"
Flow = 3.82529
TP - Load = .069175
TP - Concentration = .542199
FLOW
CONCENTRATION
LOAD
TIME (MONTHS)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0
2
4
6
8
10
12
LEGEND
Flow
TP - Concentration
TP - Load

1995 EASTWARD "RURAL"



LEGEND

Flow
TN - Concentration
TN - Load



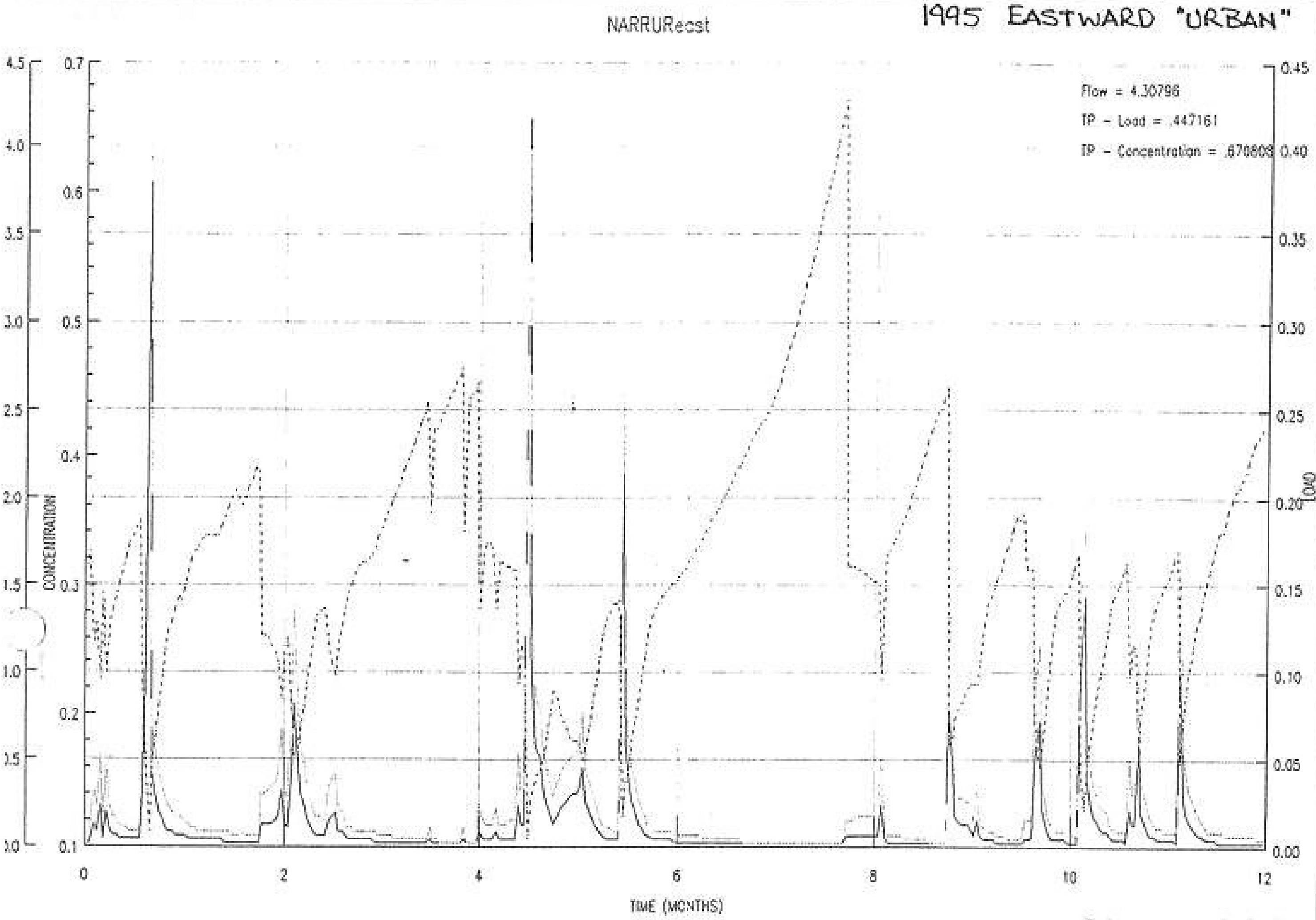
LEGEND

Flow

SS - Load

SS - Concentration

1995 EASTWARD "URBAN"

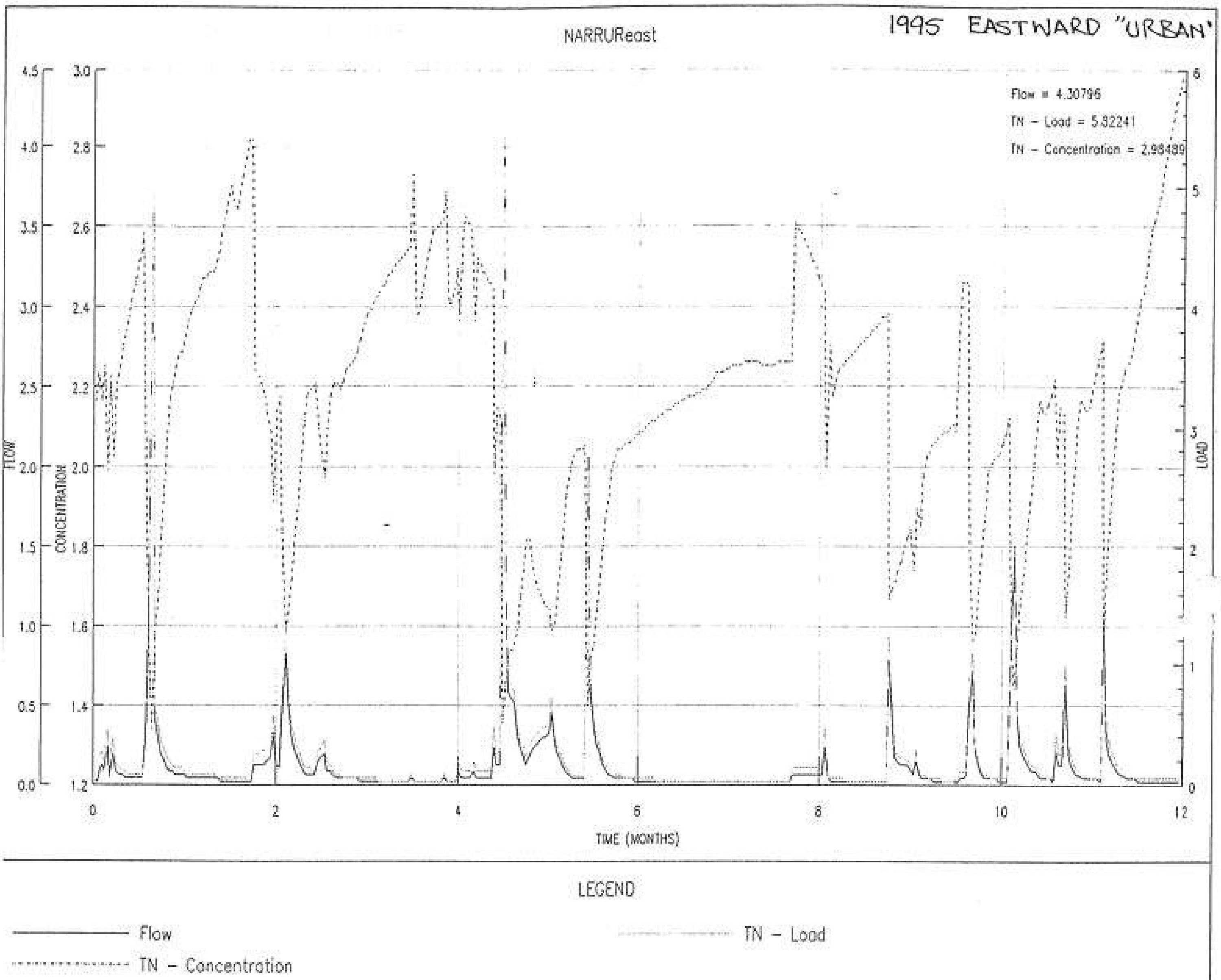


LEGEND

Flow

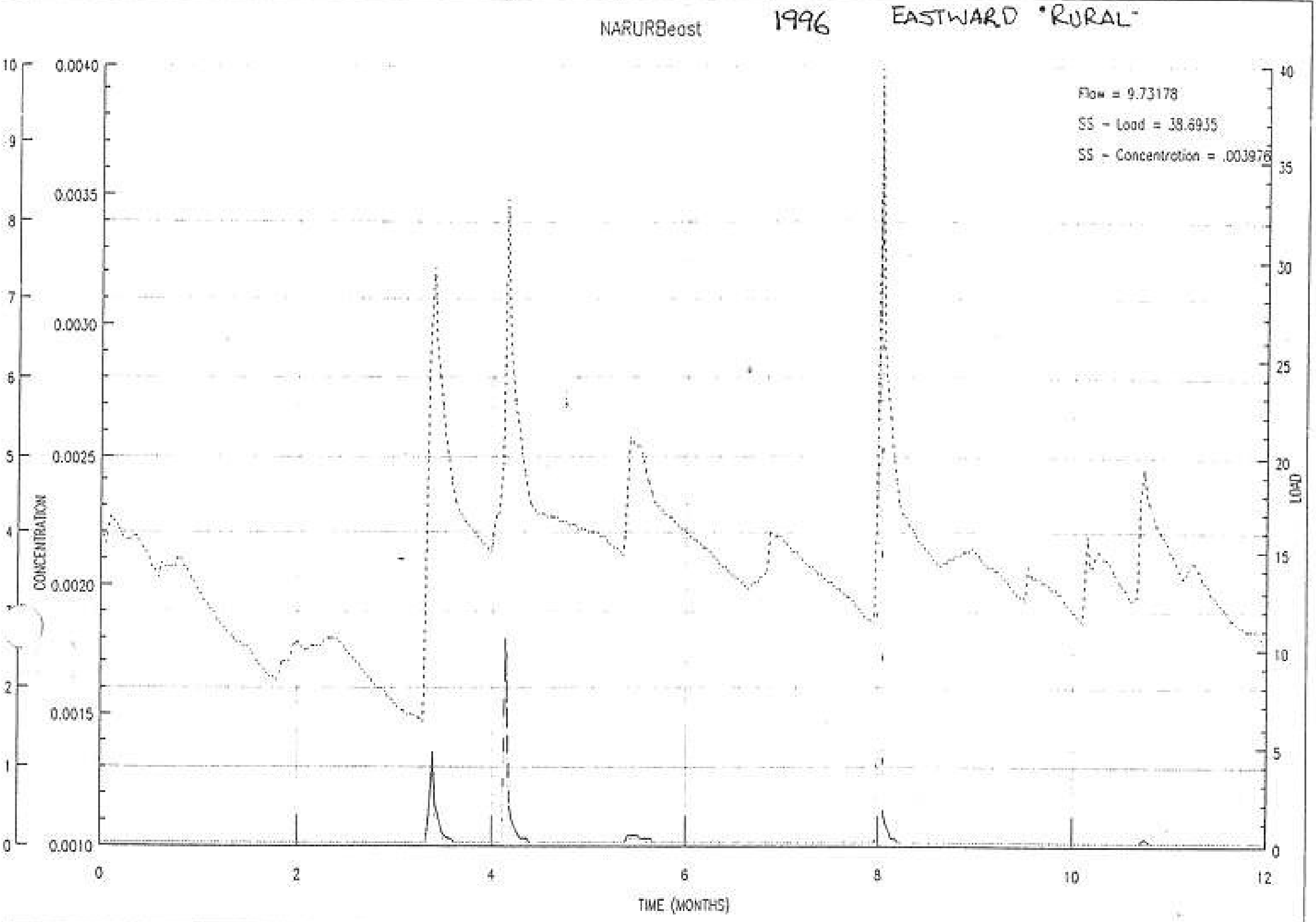
TP - Load

TP - Concentration



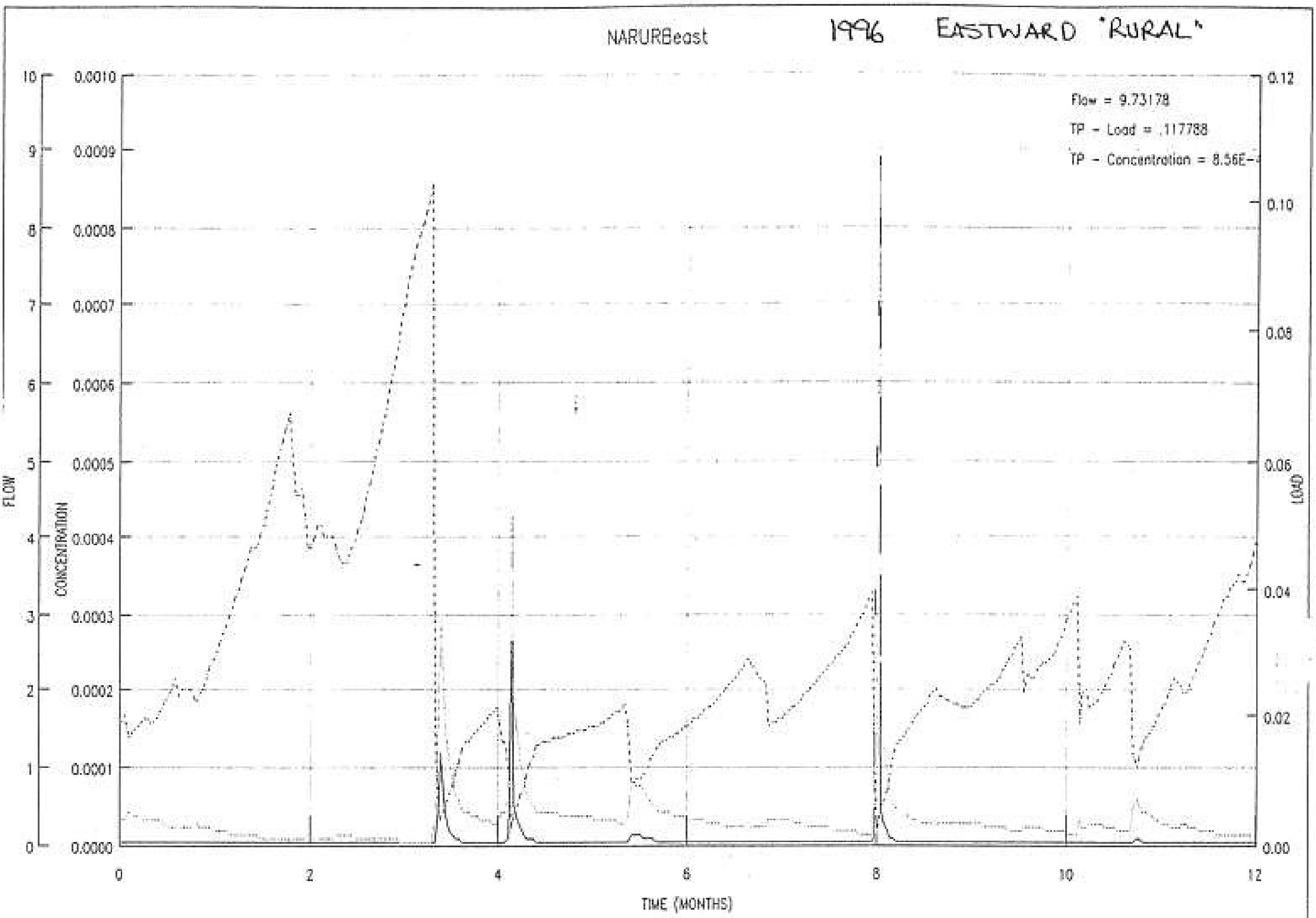
1995 EASTWARD "URBAN"
NARRUReast
Flow = 4.30796
TN - Load = 5.82241
TN - Concentration = 2.98489
FLOW
CONCENTRATION
LOAD
TIME (MONTHS)
LEGEND
Flow
TN - Load
TN - Concentration

1996 EASTWARD "RURAL"



LEGEND

Flow
SS - Concentration
SS - Load



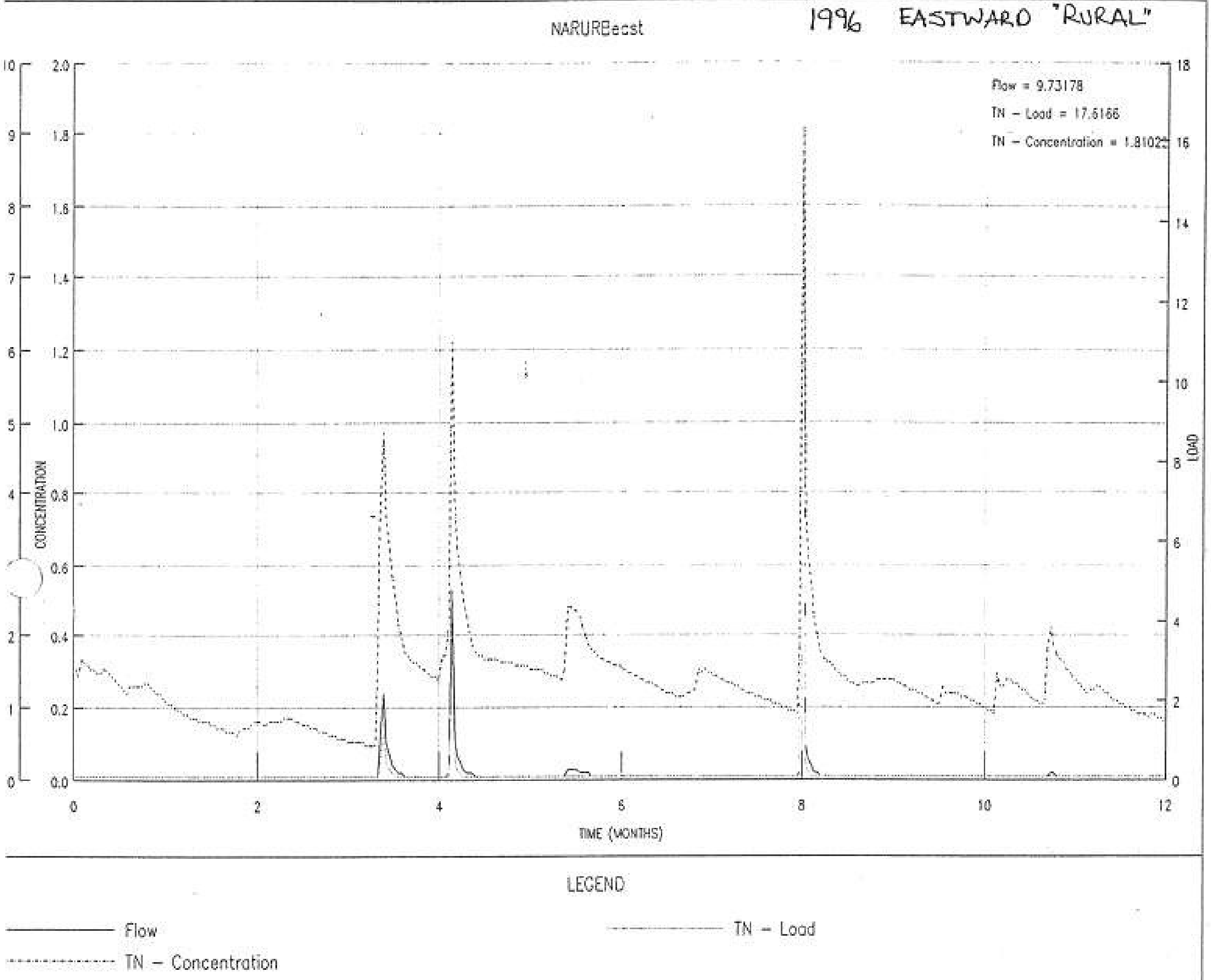
LEGEND

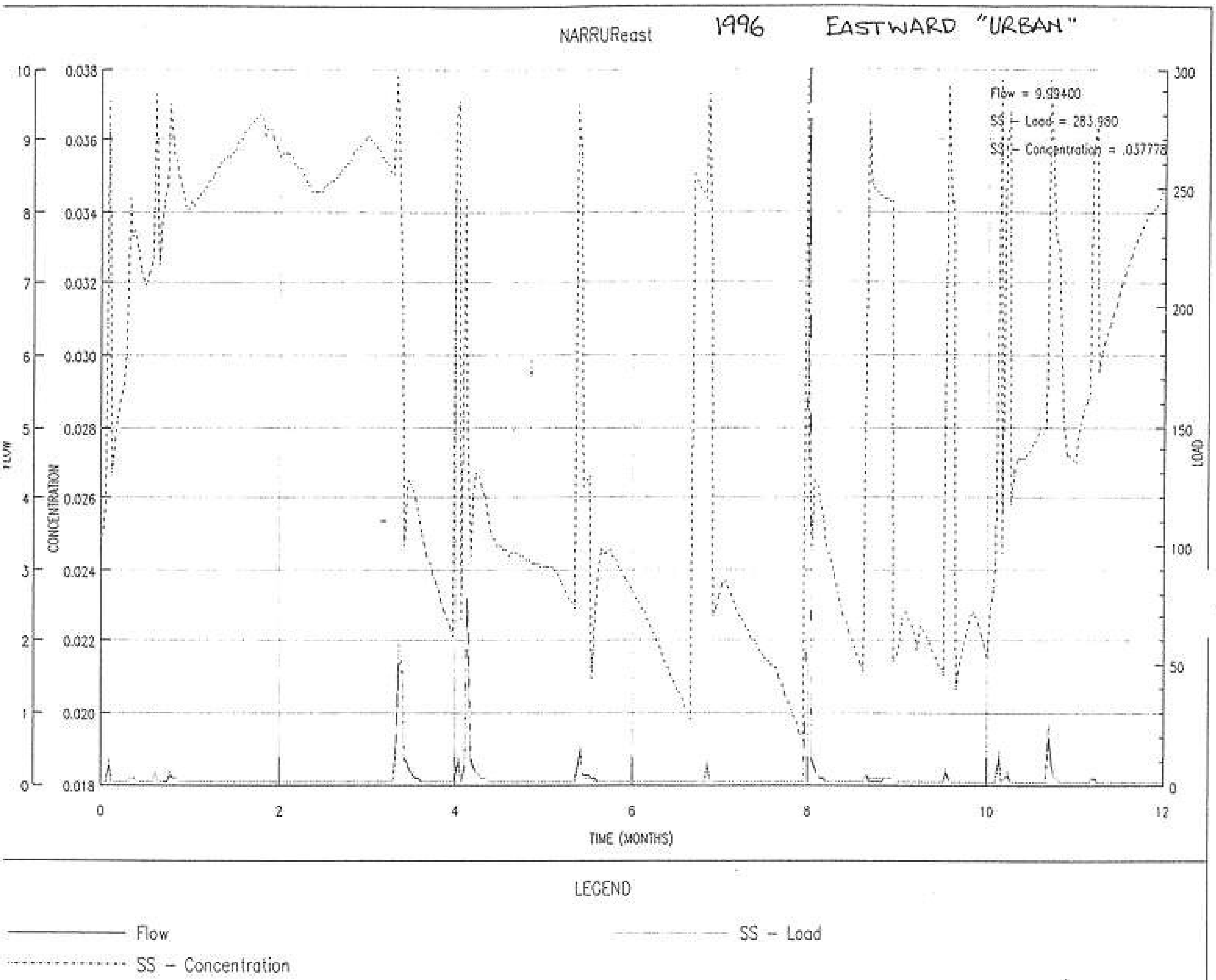
Flow

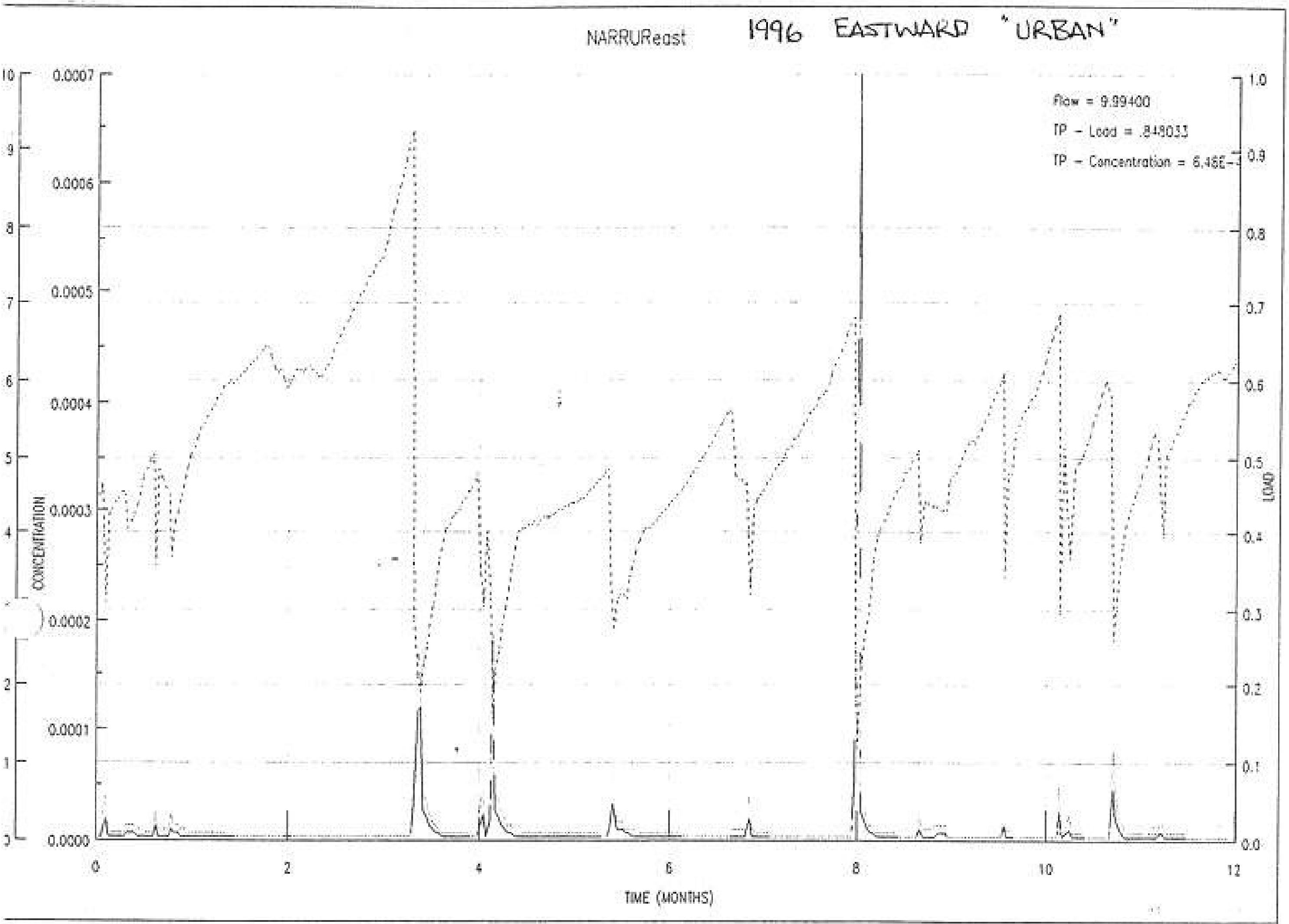
TP - Load

TP - Concentration

1996 EASTWARD "RURAL"




NARRUReast
1996 EASTWARD "URBAN"
Flow = 9.99400
SS - Load = 283.980
SS - Concentration = .037776
FLOW
CONCENTRATION
LOAD
TIME (MONTHS)
LEGEND
Flow
SS - Load
SS - Concentration

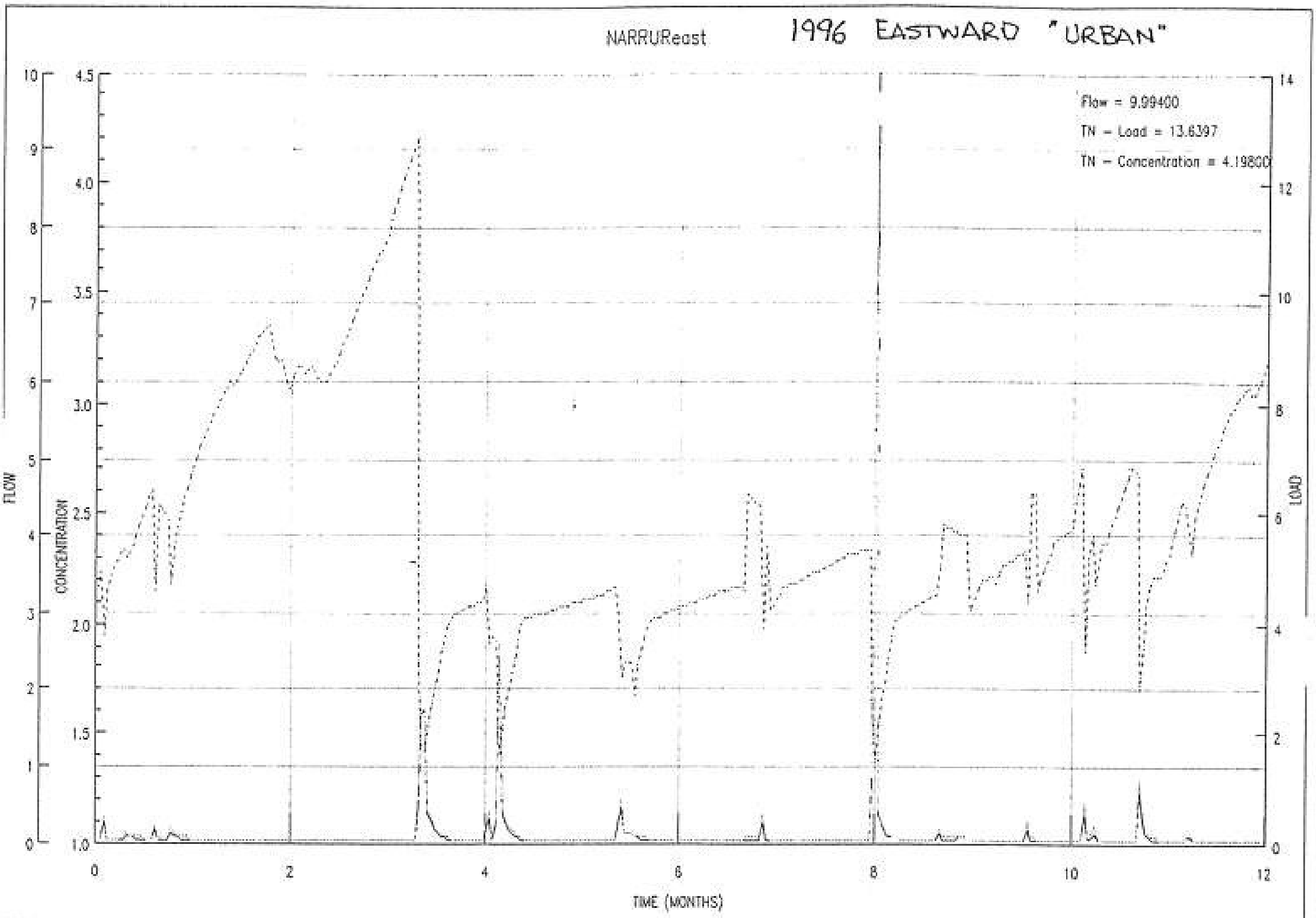


LEGEND

Flow

TP - Load

TP - Concentration



LEGEND

Flow

TN - Load

TN - Concentration

Appendix D

WQCP SIMULATION RESULTS

)UALM Version : 2.1; June 1995

nput File : C:\WPS\AQUALMXP\narra1a.dat
ıtput File : C:\WPS\AQUALMXP\narrap4a.out

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ınual Report for Node "NAR4p7.9", 31/12/1995 POND 4 7.9 ha "URBAN"

===

ocal Runoff and Pollutant Loads
----

onth	Rain mm	Runoff Ml	BOD Kg	SS Kg	TKN Kg	TN Kg	TP Kg
JAN	159.4	13.39	38	3.1E+002	5.9	19	1.7
FEB	75.2	1.88	6.6	54	1.4	3.6	0.51
MAR	105.2	7.01	22	1.8E+002	3.8	11	1.3
APR	18.7	0.55	1.1	9	0.31	0.83	0.18
MAY	218.8	20.66	46	3.8E+002	7.4	27	2.2
JUN	95.8	12.76	26	2.1E+002	4.4	16	1.5
JUL	6.2	0.75	1.1	8.6	0.3	0.86	0.2
AUG	40.9	0.69	2.6	21	0.59	1.5	0.23
SEP	126.8	4.07	12	96	2.1	5.8	0.73
OCT	104.7	4.83	11	93	2.1	6.3	0.8
NOV	164.7	10.48	25	2.1E+002	4.3	14	1.4
DEC	76.4	3.81	11	93	2	5.6	0.73
otal	1192.8	80.89	2E+002	1.7E+003	35	1.1E+002	11

otal Runoff and Pollutant Loads
----

onth	Runoff Ml	BOD Kg	SS Kg	TKN Kg	TN Kg	TP Kg
JAN	13.4	38	3.1E+002	5.9	19	1.7
FEB	1.88	6.6	54	1.4	3.6	0.51
MAR	7.01	22	1.8E+002	3.8	11	1.3
APR	0.548	1.1	9	0.31	0.83	0.18
MAY	20.7	46	3.8E+002	7.4	27	2.2
JUN	12.8	26	2.1E+002	4.4	16	1.5
JUL	0.755	1.1	8.6	0.3	0.86	0.2
AUG	0.692	2.6	21	0.59	1.5	0.23
SEP	4.07	12	96	2.1	5.8	0.73
OCT	4.83	11	93	2.1	6.3	0.8
NOV	10.5	25	2.1E+002	4.3	14	1.4
DEC	3.81	11	93	2	5.6	0.73
otal	80.9	2E+002	1.7E+003	35	1.1E+002	11

ond Simulation Results
----

onth	Inflow (Ml)	Evap (Ml)	Outflow (Ml)	Spill (Ml)	Volume (Ml)	Stage (m)
JAN	13.39	0.74	12.65	0.00	8.54	822.000
FEB	1.88	0.63	1.25	0.00	8.54	822.000
MAR	7.01	0.55	6.46	0.00	8.54	822.000
APR	0.55	0.44	0.12	0.00	8.53	821.998
MAY	20.66	0.36	20.28	0.00	8.54	822.000
JUN	12.76	0.33	12.43	0.00	8.54	822.000

JUL	0.75	0.36	0.40	0.00	8.54	822.000
AUG	0.69	0.47	0.22	0.00	8.44	821.975
SEP	4.07	0.56	3.51	0.00	8.53	821.998
OCT	4.83	0.67	4.16	0.00	8.54	822.000
NOV	10.48	0.68	9.80	0.00	8.54	822.000
DEC	3.81	0.82	3.04	0.00	8.53	821.999
Total	80.89	6.63	74.31	0.00	-	-
Avg.	0.22	0.02	0.20	0.00	8.53	821.998

Basin Pollutant Retention

Pollutant: BOD (Kg)

Month	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
JAN	0.54	38	35	1.5
FEB	0.00	6.6	5.1	2
MAR	27.80	22	21	0.34
APR	28.16	1.1	1.9	0.018
MAY	17.81	46	42	3.1
JUN	8.83	26	25	1.4
JUL	1.17	1.1	0.47	1.2
AUG	0.00	2.6	2.4	0.25
SEP	3.41	12	11	0.43
OCT	30.33	11	11	0.099
NOV	10.99	25	24	1.1
DEC	2.60	11	12	0.25
Total	11.04	2E+002	1.9E+002	12

Pollutant: SS (Kg)

Month	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
JAN	0.54	3.1E+002	2.6E+002	24
FEB	0.00	54	59	17
MAR	27.80	1.8E+002	1.7E+002	3.1
APR	28.16	9	20	0.51
MAY	17.81	3.8E+002	3.2E+002	53
JUN	8.83	2.1E+002	1.9E+002	26
JUL	1.17	8.6	19	11
AUG	0.00	21	22	2
SEP	3.41	96	84	3.1
OCT	30.33	93	91	1.6
NOV	10.99	2.1E+002	1.9E+002	21
DEC	2.60	93	93	4.5
Total	11.04	1.7E+003	1.5E+003	1.7E+002

Pollutant: TKN (Kg)

Month	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
JAN	0.54	5.9	2	1.8
FEB	0.00	1.4	0.83	0.43
MAR	27.80	3.8	2.2	1.2

APR	28.16	0.31	0.86	0.14
MAY	17.81	7.4	2.7	4.6
JUN	8.83	4.4	2.2	2.6
JUL	1.17	0.3	0.49	0.22
AUG	0.00	0.59	0.66	0.084
SEP	3.41	2.1	1.2	0.18
OCT	30.33	2.1	1.5	0.34
NOV	10.99	4.3	2	2.3
DEC	2.60	2	1.4	0.57
otal	11.04	35	18	14

ollutant: TN (Kg)

onth	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
JAN	0.54	19	6.7	5.2
FEB	0.00	3.6	2.4	1.7
MAR	27.80	11	6.1	4
APR	28.16	0.83	2.3	0.37
MAY	17.81	27	9.4	16
JUN	8.83	16	7.6	8.7
JUL	1.17	0.86	1.7	0.84
AUG	0.00	1.5	2.2	0.33
SEP	3.41	5.8	3.6	0.72
OCT	30.33	6.3	4.3	0.9
NOV	10.99	14	6.6	6.9
DEC	2.60	5.6	4	2.2
otal	11.04	1.1E+002	57	48

ollutant: TP (Kg)

onth	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
JAN	0.54	1.7	0.54	0.58
FEB	0.00	0.51	0.38	0.096
MAR	27.80	1.3	0.79	0.29
APR	28.16	0.18	0.38	0.052
MAY	17.81	2.2	0.68	1.4
JUN	8.83	1.5	0.72	0.92
JUL	1.17	0.2	0.31	0.064
AUG	0.00	0.23	0.17	0.022
SEP	3.41	0.73	0.38	0.082
OCT	30.33	0.8	0.58	0.2
NOV	10.99	1.4	0.69	0.77
DEC	2.60	0.73	0.6	0.14
otal	11.04	11	6.2	4.6

ond Sediment Grading Distribution

Grain Size mm	Inflow Kg	Retention Kg	Retention %	Retention Cum %	Outflow Kg
0.000 - 0.002	3.3E+002	1.8E+002	55.10	55.10	1.4E+002
0.002 - 0.004	86	79	91.72	62.56	7
0.004 - 0.010	1.1E+002	1.1E+002	99.17	70.33	0.93
0.010 - 0.020	86	86	100.00	74.43	0.00073

0.020 - 0.040	2.3E+002	2.3E+002	100.00	81.28	0
0.040 - 0.080	2.3E+002	2.3E+002	100.00	85.24	0
0.080 - 0.160	2.3E+002	2.3E+002	100.00	87.81	0
0.160 - 0.320	94	94	100.00	88.63	0
0.320 - 0.500	19	19	100.00	88.79	0
0.500 - 1.000	30	30	100.00	89.02	0
1.000 - 2.000	30	30	100.00	89.25	0
2.000 - 5.000	1.7E+002	1.7E+002	100.00	90.35	0
5.000 - 10.000	33	33	100.00	90.54	0
10.000 - 999.000	0	0	0.00	90.54	0
Total	1.7E+003	1.5E+003	90.54	90.54	1.4E+002

Mean Depth : 2.50 m
Mean Hydraulic Residence Time : 0.1054 yrs
Mean Depth / Hydraulic Residence Time: 23.7 m/yr

UALM Version : 2.1; June 1995

put File : C:\WPS\AQUALMXP\narra1a.dat
tput File : C:\WPS\AQUALMXP\narrap4b.out

nual Report for Node "NAR4p11.9", 31/12/1995 POND 4 11.9 ha "URBAN"

cal Runoff and Pollutant Loads

nth	Rain mm	Runoff Ml	BOD Kg	SS Kg	TKN Kg	TN Kg	TP Kg
AN	159.4	15.38	56	4.6E+002	8.4	24	2.4
EB	75.2	2.40	9.9	80	2.1	5.3	0.68
AR	105.2	8.41	32	2.6E+002	5.7	15	1.7
PR	18.7	0.55	1.6	13	0.46	1.2	0.2
[illegible]	218.8	21.33	67	5.5E+002	10	32	2.9
[illegible]	95.8	12.68	37	3E+002	6.2	19	1.9
UL	6.2	0.66	1.5	12	0.44	1.2	0.21
UG	40.9	0.92	3.9	32	0.89	2.2	0.3
EP	126.8	4.72	17	1.4E+002	3	8	0.96
CT	104.7	5.10	16	1.3E+002	3.1	8.3	1
OV	164.7	11.23	37	3E+002	6.2	18	1.9
EC	76.4	4.49	17	1.4E+002	3	7.9	0.96
tal	1192.8	87.87	3E+002	2.4E+003	50	1.4E+002	15

tal Runoff and Pollutant Loads

nth	Runoff Ml	BOD Kg	SS Kg	TKN Kg	TN Kg	TP Kg
AN	15.4	56	4.6E+002	8.4	24	2.4
EB	2.4	9.9	80	2.1	5.3	0.68
[illegible]	8.41	32	2.6E+002	5.7	15	1.7
[illegible]	0.546	1.6	13	0.46	1.2	0.2
AY	21.3	67	5.5E+002	10	32	2.9
UN	12.7	37	3E+002	6.2	19	1.9
UL	0.665	1.5	12	0.44	1.2	0.21
UG	0.917	3.9	32	0.89	2.2	0.3
EP	4.72	17	1.4E+002	3	8	0.96
CT	5.1	16	1.3E+002	3.1	8.3	1
OV	11.2	37	3E+002	6.2	18	1.9
EC	4.49	17	1.4E+002	3	7.9	0.96
tal	87.9	3E+002	2.4E+003	50	1.4E+002	15

nd Simulation Results

nth	Inflow (Ml)	Evap (Ml)	Outflow (Ml)	Spill (Ml)	Volume (Ml)	Stage (m)
AN	15.38	0.74	14.64	0.00	8.54	822.000
EB	2.40	0.63	1.77	0.00	8.54	822.000
AR	8.41	0.55	7.85	0.00	8.54	822.000
PR	0.55	0.44	0.12	0.00	8.53	821.998
AY	21.33	0.36	20.95	0.00	8.54	822.000
UN	12.68	0.33	12.35	0.00	8.54	822.000

JUL	0.66	0.36	0.32	0.00	8.54	822.000
AUG	0.92	0.47	0.43	0.00	8.43	821.971
SEP	4.72	0.56	4.16	0.00	8.53	821.998
OCT	5.10	0.67	4.43	0.00	8.54	822.000
NOV	11.23	0.68	10.55	0.00	8.54	822.000
DEC	4.49	0.82	3.70	0.00	8.54	821.999
Total	87.87	6.63	81.27	0.00	-	-
Avg.	0.24	0.02	0.22	0.00	8.53	821.997

Basin Pollutant Retention

Pollutant: BOD (Kg)

Month	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
JAN	0.41	56	51	2.7
FEB	0.00	9.9	7.8	2.7
MAR	20.05	32	31	0.86
APR	1.17	1.6	2.6	0.055
MAY	9.97	67	61	4.4
JUN	7.83	37	36	2
JUL	1.77	1.5	0.73	1.7
AUG	0.00	3.9	3.6	0.3
SEP	6.82	17	16	0.56
OCT	28.00	16	16	0.26
NOV	7.05	37	35	1.6
DEC	5.70	17	17	0.44
Total	7.48	3E+002	2.8E+002	18

Pollutant: SS (Kg)

Month	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
JAN	0.41	4.6E+002	3.8E+002	42
FEB	0.00	80	86	22
MAR	20.05	2.6E+002	2.4E+002	12
APR	1.17	13	27	1.2
MAY	9.97	5.5E+002	4.5E+002	75
JUN	7.83	3E+002	2.7E+002	37
JUL	1.77	12	27	14
AUG	0.00	32	33	2.2
SEP	6.82	1.4E+002	1.2E+002	4
OCT	28.00	1.3E+002	1.3E+002	4.2
NOV	7.05	3E+002	2.7E+002	30
DEC	5.70	1.4E+002	1.4E+002	8.4
Total	7.48	2.4E+003	2.2E+003	2.5E+002

Pollutant: TKN (Kg)

Month	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
JAN	0.41	8.4	2.8	3
FEB	0.00	2.1	1.2	0.64
MAR	20.05	5.7	3.1	2.4

R	1.17	0.46	1	0.18
Y	9.97	10	3.6	6.1
N	7.83	6.2	3.1	3.7
L	1.77	0.44	0.71	0.27
G	0.00	0.89	0.96	0.13
P	6.82	3	1.8	0.28
'T	28.00	3.1	2.1	0.79
'V	7.05	6.2	2.9	3.3
:C	5.70	3	2	1
.al	7.48	50	25	22

.llutant: TN (Kg)

ıth	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
AN	0.41	24	8	8.1
[illegible]	0.00	5.3	3.2	2
[illegible]	20.05	15	8.1	6.6
?R	1.17	1.2	2.7	0.45
AY	9.97	32	11	19
JN	7.83	19	9.1	11
JL	1.77	1.2	2.1	0.85
JG	0.00	2.2	2.8	0.41
EP	6.82	8	4.8	0.88
CT	28.00	8.3	5.6	2
OV	7.05	18	8.2	9.1
EC	5.70	7.9	5.3	3.1
tal	7.48	1.4E+002	71	63

llutant: TP (Kg)
----

nth	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
[illegible]	0.41	2.4	0.7	0.89
'EB	0.00	0.68	0.49	0.14
IAR	20.05	1.7	1	0.62
.PR	1.17	0.2	0.45	0.042
IAY	9.97	2.9	0.88	1.7
'UN	7.83	1.9	0.92	1.2
'UL	1.77	0.21	0.38	0.077
.UG	0.00	0.3	0.21	0.034
;EP	6.82	0.96	0.49	0.13
)CT	28.00	1	0.72	0.32
JOV	7.05	1.9	0.89	0.96
)EC	5.70	0.96	0.76	0.26
otal	7.48	15	7.9	6.4

ond Sediment Grading Distribution

Grain Size mm	Inflow Kg	Retention Kg	Retention %	Cum %	Outflow Kg
0.000 - 0.002	4.8E+002	2.6E+002	52.64	52.64	2.1E+002
0.002 - 0.004	1.2E+002	1.1E+002	90.90	60.44	11
0.004 - 0.010	1.6E+002	1.6E+002	98.91	68.60	1.8
0.010 - 0.020	1.2E+002	1.2E+002	100.00	72.94	0.0027

0.020 - 0.040	3.3E+002	3.3E+002	100.00	80.19	0
0.040 - 0.080	3.3E+002	3.3E+002	100.00	84.38	0
0.080 - 0.160	3.3E+002	3.3E+002	100.00	87.10	0
0.160 - 0.320	1.4E+002	1.4E+002	100.00	87.97	0
0.320 - 0.500	28	28	100.00	88.14	0
0.500 - 1.000	44	44	100.00	88.38	0
1.000 - 2.000	44	44	100.00	88.62	0
2.000 - 5.000	2.4E+002	2.4E+002	100.00	89.78	0
5.000 - 10.000	48	48	100.00	89.99	0
10.000 - 999.000	0	0	0.00	89.99	0
Total	2.4E+003	2.2E+003	89.99	89.99	2.2E+002

ean Depth : 2.50 m
ean Hydraulic Residence Time : 0.09698 yrs
ean Depth / Hydraulic Residence Time: 25.75 m/yr

:UALM Version : 2.1; June 1995

:put File : C:\WPS\AQUALMXP\narra1a.dat
:tput File : C:\WPS\AQUALMXP\narrap3a.out

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:nual Report for Node "NAR3p7.9", 31/12/1995 POND 3 7.9ha "URBAN"

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:cal Runoff and Pollutant Loads

:nth	Rain mm	Runoff Ml	BOD Kg	SS Kg	TKN Kg	TN Kg	TP Kg
:AN	159.4	13.39	38	3.1E+002	5.9	19	1.7
:EB	75.2	1.88	6.6	54	1.4	3.6	0.51
:AR	105.2	7.01	22	1.8E+002	3.8	11	1.3
:PR	18.7	0.55	1.1	9	0.31	0.83	0.18
:AY	218.8	20.66	46	3.8E+002	7.4	27	2.2
	95.8	12.76	26	2.1E+002	4.4	16	1.5
:UL	6.2	0.75	1.1	8.6	0.3	0.86	0.2
:UG	40.9	0.69	2.6	21	0.59	1.5	0.23
:EP	126.8	4.07	12	96	2.1	5.8	0.73
:CT	104.7	4.83	11	93	2.1	6.3	0.8
:OV	164.7	10.48	25	2.1E+002	4.3	14	1.4
:EC	76.4	3.81	11	93	2	5.6	0.73
:tal	1192.8	80.89	2E+002	1.7E+003	35	1.1E+002	11

:tal Runoff and Pollutant Loads

:nth	Runoff Ml	BOD Kg	SS Kg	TKN Kg	TN Kg	TP Kg
:AN	13.4	38	3.1E+002	5.9	19	1.7
:EB	1.88	6.6	54	1.4	3.6	0.51
:AR	7.01	22	1.8E+002	3.8	11	1.3
	0.548	1.1	9	0.31	0.83	0.18
:AY	20.7	46	3.8E+002	7.4	27	2.2
:UN	12.8	26	2.1E+002	4.4	16	1.5
:UL	0.755	1.1	8.6	0.3	0.86	0.2
:UG	0.692	2.6	21	0.59	1.5	0.23
:EP	4.07	12	96	2.1	5.8	0.73
:CT	4.83	11	93	2.1	6.3	0.8
:OV	10.5	25	2.1E+002	4.3	14	1.4
:EC	3.81	11	93	2	5.6	0.73
:tal	80.9	2E+002	1.7E+003	35	1.1E+002	11

:nd Simulation Results

:nth	Inflow (Ml)	Evap (Ml)	Outflow (Ml)	Spill (Ml)	Volume (Ml)	Stage (m)
:AN	13.39	0.65	12.74	0.00	7.49	822.000
:EB	1.88	0.55	1.33	0.00	7.49	822.000
:AR	7.01	0.49	6.53	0.00	7.49	822.000
:PR	0.55	0.39	0.17	0.00	7.49	821.999
:AY	20.66	0.32	20.33	0.00	7.49	822.000
:UN	12.76	0.29	12.47	0.00	7.49	822.000

JUL	0.75	0.32	0.44	0.00	7.49	822.000
AUG	0.69	0.41	0.28	0.00	7.42	821.978
SEP	4.07	0.49	3.58	0.00	7.49	821.999
OCT	4.83	0.59	4.25	0.00	7.49	822.000
NOV	10.48	0.60	9.88	0.00	7.49	822.000
DEC	3.81	0.72	3.12	0.00	7.49	821.999
Total	80.89	5.82	75.10	0.00	-	-
Avg.	0.22	0.02	0.21	0.00	7.49	821.998

Basin Pollutant Retention

Pollutant: BOD (Kg)

Month	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
JAN	0.40	38	35	1.8
FEB	0.00	6.6	5.8	1.3
MAR	22.77	22	21	0.47
APR	4.45	1.1	1.8	0.049
MAY	10.62	46	41	3.3
JUN	4.88	26	24	1.6
JUL	0.00	1.1	0.8	0.84
AUG	0.00	2.6	2.3	0.25
SEP	10.23	12	11	0.075
OCT	32.22	11	11	0.19
NOV	9.11	25	24	1.2
DEC	5.94	11	11	0.25
Total	8.47	2E+002	1.9E+002	11

Pollutant: SS (Kg)

Month	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
JAN	0.40	3.1E+002	2.6E+002	30
FEB	0.00	54	57	11
MAR	22.77	1.8E+002	1.7E+002	6.1
APR	4.45	9	19	1
MAY	10.62	3.8E+002	3.1E+002	57
JUN	4.88	2.1E+002	1.9E+002	29
JUL	0.00	8.6	18	7.5
AUG	0.00	21	21	2
SEP	10.23	96	84	0.35
OCT	32.22	93	90	3.5
NOV	9.11	2.1E+002	1.9E+002	22
DEC	5.94	93	92	4.9
Total	8.47	1.7E+003	1.5E+003	1.7E+002

Pollutant: TKN (Kg)

Month	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
JAN	0.40	5.9	1.9	2.2
FEB	0.00	1.4	0.83	0.38
MAR	22.77	3.8	2.1	1.5

APR	4.45	0.31	0.73	0.18
MAY	10.62	7.4	2.5	4.7
JUN	4.88	4.4	2.1	2.7
JUL	0.00	0.3	0.47	0.18
AUG	0.00	0.59	0.6	0.083
SEP	10.23	2.1	1.2	0.14
OCT	32.22	2.1	1.4	0.64
NOV	9.11	4.3	2	2.3
DEC	5.94	2	1.4	0.61
otal	8.47	35	17	16

ollutant: TN (Kg)

onth	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
JAN	0.40	19	6.3	6.4
FEB	0.00	3.6	2.4	1.5
MAR	22.77	11	5.8	4.5
APR	4.45	0.83	2	0.45
MAY	10.62	27	8.7	17
JUN	4.88	16	7.3	9
JUL	0.00	0.86	1.6	0.73
AUG	0.00	1.5	2	0.33
SEP	10.23	5.8	3.5	0.55
OCT	32.22	6.3	4.1	1.7
NOV	9.11	14	6.3	7.1
DEC	5.94	5.6	3.8	2.2
otal	8.47	1.1E+002	54	52

ollutant: TP (Kg)

onth	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
JAN	0.40	1.7	0.51	0.67
FEB	0.00	0.51	0.37	0.085
MAR	22.77	1.3	0.76	0.4
APR	4.45	0.18	0.36	0.045
MAY	10.62	2.2	0.64	1.4
JUN	4.88	1.5	0.68	0.96
JUL	0.00	0.2	0.3	0.048
AUG	0.00	0.23	0.17	0.022
SEP	10.23	0.73	0.38	0.077
OCT	32.22	0.8	0.56	0.28
NOV	9.11	1.4	0.65	0.77
DEC	5.94	0.73	0.58	0.17
otal	8.47	11	5.9	4.9

ond Sediment Grading Distribution

Grain Size mm	Inflow Kg	Kg	Retention %	Cum %	Outflow Kg
0.000 - 0.002	3.3E+002	1.7E+002	50.44	50.44	1.5E+002
0.002 - 0.004	86	76	89.19	58.33	9.2
0.004 - 0.010	1.1E+002	1.1E+002	98.43	66.84	1.8
0.010 - 0.020	86	86	99.99	71.43	0.008

				79.08	0
0.020 - 0.040	2.3E+002	2.3E+002	100.00	83.51	0
0.040 - 0.080	2.3E+002	2.3E+002	100.00	86.38	0
0.080 - 0.160	2.3E+002	2.3E+002	100.00	87.30	0
0.160 - 0.320	94	94	100.00	87.47	0
0.320 - 0.500	19	19	100.00	87.73	0
0.500 - 1.000	30	30	100.00	87.99	0
1.000 - 2.000	30	30	100.00	89.21	0
2.000 - 5.000	1.7E+002	1.7E+002	100.00	89.43	0
5.000 - 10.000	33	33	100.00	89.43	0
10.000 - 999.000	0	0	0.00		
Total	1.7E+003	1.5E+003	89.43	89.43	1.6E+002

ean Depth : 2.50 m
ean Hydraulic Residence Time : 0.09248 yrs
ean Depth / Hydraulic Residence Time: 27.01 m/yr

QUALM Version : 2.1; June 1995

nput File : C:\WPS\AQUALMXP\narra1a.dat
utput File : C:\WPS\AQUALMXP\narrap3b.out

==
nnual Report for Node "NAR3p11.9", 31/12/1995 POND 3 11.9ha "URBAN"
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ocal Runoff and Pollutant Loads
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onth	Rain mm	Runoff Ml	BOD Kg	SS Kg	TKN Kg	TN Kg	TP Kg
JAN	159.4	15.38	56	4.6E+002	8.4	24	2.4
FEB	75.2	2.40	9.9	80	2.1	5.3	0.68
MAR	105.2	8.41	32	2.6E+002	5.7	15	1.7
APR	18.7	0.55	1.6	13	0.46	1.2	0.2
MAY	218.8	21.33	67	5.5E+002	10	32	2.9
JUN	95.8	12.68	37	3E+002	6.2	19	1.9
JUL	6.2	0.66	1.5	12	0.44	1.2	0.21
AUG	40.9	0.92	3.9	32	0.89	2.2	0.3
SEP	126.8	4.72	17	1.4E+002	3	8	0.96
OCT	104.7	5.10	16	1.3E+002	3.1	8.3	1
NOV	164.7	11.23	37	3E+002	6.2	18	1.9
DEC	76.4	4.49	17	1.4E+002	3	7.9	0.96
otal	1192.8	87.87	3E+002	2.4E+003	50	1.4E+002	15

otal Runoff and Pollutant Loads
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onth	Runoff Ml	BOD Kg	SS Kg	TKN Kg	TN Kg	TP Kg
JAN	15.4	56	4.6E+002	8.4	24	2.4
FEB	2.4	9.9	80	2.1	5.3	0.68
MAR	8.41	32	2.6E+002	5.7	15	1.7
APR	0.546	1.6	13	0.46	1.2	0.2
MAY	21.3	67	5.5E+002	10	32	2.9
JUN	12.7	37	3E+002	6.2	19	1.9
JUL	0.665	1.5	12	0.44	1.2	0.21
AUG	0.917	3.9	32	0.89	2.2	0.3
SEP	4.72	17	1.4E+002	3	8	0.96
OCT	5.1	16	1.3E+002	3.1	8.3	1
NOV	11.2	37	3E+002	6.2	18	1.9
DEC	4.49	17	1.4E+002	3	7.9	0.96
otal	87.9	3E+002	2.4E+003	50	1.4E+002	15

ond Simulation Results
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onth	Inflow (Ml)	Evap (Ml)	Outflow (Ml)	Spill (Ml)	Volume (Ml)	Stage (m)
JAN	15.38	0.65	14.73	0.00	7.49	822.000
FEB	2.40	0.55	1.85	0.00	7.49	822.000
MAR	8.41	0.49	7.92	0.00	7.49	822.000
APR	0.55	0.39	0.17	0.00	7.49	821.999
MAY	21.33	0.32	21.00	0.00	7.49	822.000
JUN	12.68	0.29	12.39	0.00	7.49	822.000

UL	0.66	0.32	0.35	0.00	7.49	822.000
UG	0.92	0.41	0.50	0.00	7.41	821.976
EP	4.72	0.49	4.23	0.00	7.49	821.998
CT	5.10	0.59	4.51	0.00	7.49	822.000
OV	11.23	0.60	10.63	0.00	7.49	822.000
EC	4.49	0.72	3.78	0.00	7.49	822.000
tal	87.87	5.82	82.06	0.00	-	-
g.	0.24	0.02	0.22	0.00	7.48	821.998

isin Pollutant Retention

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ollutant: BOD (Kg)

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onth	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
JAN	0.34	56	51	3
FEB	0.00	9.9	9.1	1.3
MAR	12.32	32	31	1.1
APR	1.01	1.6	2.4	0.061
MAY	6.05	67	60	4.7
JUN	4.87	37	35	2.3
JUL	0.00	1.5	1.1	1.3
AUG	0.00	3.9	3.6	0.29
SEP	13.48	17	16	0.15
OCT	57.45	16	16	0.36
NOV	6.04	37	35	1.7
DEC	13.37	17	17	0.49
otal	9.69	3E+002	2.8E+002	17

ollutant: SS (Kg)

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onth	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
JAN	0.34	4.6E+002	3.8E+002	49
FEB	0.00	80	82	10
MAR	12.32	2.6E+002	2.4E+002	17
APR	1.01	13	25	1.2
MAY	6.05	5.5E+002	4.5E+002	81
JUN	4.87	3E+002	2.7E+002	41
JUL	0.00	12	25	11
AUG	0.00	32	32	2.2
SEP	13.48	1.4E+002	1.2E+002	0.88
OCT	57.45	1.3E+002	1.3E+002	7.1
NOV	6.04	3E+002	2.7E+002	33
DEC	13.37	1.4E+002	1.3E+002	9.2
otal	9.69	2.4E+003	2.2E+003	2.6E+002

ollutant: TKN (Kg)

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onth	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
JAN	0.34	8.4	2.7	3.4
FEB	0.00	2.1	1.2	0.55
MAR	12.32	5.7	3	2.7

PR	1.01	0.46	0.91	0.18
AY	6.05	10	3.4	6.3
JUN	4.87	6.2	2.9	3.8
JUL	0.00	0.44	0.68	0.23
UG	0.00	0.89	0.88	0.13
EP	13.48	3	1.8	0.25
CT	57.45	3.1	2	1.2
OV	6.04	6.2	2.8	3.3
EC	13.37	3	1.9	1.2
tal	9.69	50	24	23

llutant: TN (Kg)

nth	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
JAN	0.34	24	7.6	9.3
EB	0.00	5.3	3.2	1.8
[illegible]	12.32	15	7.8	7.3
[illegible]	1.01	1.2	2.4	0.45
AY	6.05	32	10	19
JUN	4.87	19	8.7	11
JUL	0.00	1.2	2	0.73
UG	0.00	2.2	2.5	0.41
EP	13.48	8	4.7	0.77
CT	57.45	8.3	5.4	3
OV	6.04	18	7.9	9.3
EC	13.37	7.9	5	3.4
tal	9.69	1.4E+002	67	67

llutant: TP (Kg)

nth	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
[illegible]	0.34	2.4	0.66	1
[illegible]	0.00	0.68	0.48	0.12
AR	12.32	1.7	0.94	0.75
PR	1.01	0.2	0.41	0.043
AY	6.05	2.9	0.83	1.8
UN	4.87	1.9	0.87	1.2
UL	0.00	0.21	0.36	0.059
UG	0.00	0.3	0.2	0.034
EP	13.48	0.96	0.49	0.13
CT	57.45	1	0.69	0.38
OV	6.04	1.9	0.84	1
EC	13.37	0.96	0.71	0.34
tal	9.69	15	7.5	6.9

nd Sediment Grading Distribution

Grain Size mm	Inflow Kg	Retention Kg	%	Cum %	Outflow Kg
0.000 - 0.002	4.8E+002	2.3E+002	47.91	47.91	2.3E+002
0.002 - 0.004	1.2E+002	1.1E+002	88.45	56.17	14
0.004 - 0.010	1.6E+002	1.6E+002	98.09	65.06	3.1
0.010 - 0.020	1.2E+002	1.2E+002	99.99	69.89	0.017

0.020 - 0.040	3.3E+002	3.3E+002	100.00	77.96	0
0.040 - 0.080	3.3E+002	3.3E+002	100.00	82.62	0
0.080 - 0.160	3.3E+002	3.3E+002	100.00	85.65	0
0.160 - 0.320	1.4E+002	1.4E+002	100.00	86.62	0
0.320 - 0.500	28	28	100.00	86.80	0
0.500 - 1.000	44	44	100.00	87.08	0
1.000 - 2.000	44	44	100.00	87.34	0
2.000 - 5.000	2.4E+002	2.4E+002	100.00	88.63	0
5.000 - 10.000	48	48	100.00	88.86	0
10.000 - 999.000	0	0	0.00	88.86	0
Total	2.4E+003	2.2E+003	88.86	88.86	2.5E+002

Mean Depth : 2.50 m
Mean Hydraulic Residence Time : 0.08512 yrs
Mean Depth / Hydraulic Residence Time: 29.34 m/yr

QUALM Version : 2.1; June 1995

nput File : C:\WPS\AQUALMXP\narra1a.dat
utput File : C:\WPS\AQUALMXP\narrap2a.out

nnual Report for Node "NAR2p7.9", 31/12/1995 POND 2 7.9ha "URBAN"

ocal Runoff and Pollutant Loads

onth	Rain mm	Runoff Ml	BOD Kg	SS Kg	TKN Kg	TN Kg	TP Kg
JAN	159.4	13.39	38	3.1E+002	5.9	19	1.7
FEB	75.2	1.88	6.6	54	1.4	3.6	0.51
MAR	105.2	7.01	22	1.8E+002	3.8	11	1.3
APR	18.7	0.55	1.1	9	0.31	0.83	0.18
MAY	218.8	20.66	46	3.8E+002	7.4	27	2.2
JUN	95.8	12.76	26	2.1E+002	4.4	16	1.5
JUL	6.2	0.75	1.1	8.6	0.3	0.86	0.2
AUG	40.9	0.69	2.6	21	0.59	1.5	0.23
SEP	126.8	4.07	12	96	2.1	5.8	0.73
OCT	104.7	4.83	11	93	2.1	6.3	0.8
NOV	164.7	10.48	25	2.1E+002	4.3	14	1.4
DEC	76.4	3.81	11	93	2	5.6	0.73
otal	1192.8	80.89	2E+002	1.7E+003	35	1.1E+002	11

otal Runoff and Pollutant Loads

onth	Runoff Ml	BOD Kg	SS Kg	TKN Kg	TN Kg	TP Kg
JAN	13.4	38	3.1E+002	5.9	19	1.7
FEB	1.88	6.6	54	1.4	3.6	0.51
MAR	7.01	22	1.8E+002	3.8	11	1.3
APR	0.548	1.1	9	0.31	0.83	0.18
MAY	20.7	46	3.8E+002	7.4	27	2.2
JUN	12.8	26	2.1E+002	4.4	16	1.5
JUL	0.755	1.1	8.6	0.3	0.86	0.2
AUG	0.692	2.6	21	0.59	1.5	0.23
SEP	4.07	12	96	2.1	5.8	0.73
OCT	4.83	11	93	2.1	6.3	0.8
NOV	10.5	25	2.1E+002	4.3	14	1.4
DEC	3.81	11	93	2	5.6	0.73
otal	80.9	2E+002	1.7E+003	35	1.1E+002	11

ond Simulation Results

onth	Inflow (Ml)	Evap (Ml)	Outflow (Ml)	Spill (Ml)	Volume (Ml)	Stage (m)
JAN	13.39	0.51	12.88	0.00	5.91	822.000
FEB	1.88	0.43	1.45	0.00	5.91	822.000
MAR	7.01	0.38	6.63	0.00	5.91	822.000
APR	0.55	0.31	0.24	0.00	5.91	822.000
MAY	20.66	0.25	20.41	0.00	5.91	822.000
JUN	12.76	0.23	12.53	0.00	5.91	822.000

JL	0.75	0.25	0.50	0.00	5.91	822.000
JG	0.69	0.33	0.37	0.00	5.86	821.984
EP	4.07	0.39	3.68	0.00	5.91	822.000
CT	4.83	0.46	4.37	0.00	5.91	822.000
OV	10.48	0.47	10.01	0.00	5.91	822.000
EC	3.81	0.57	3.24	0.00	5.91	822.000
tal	80.89	4.59	76.31	0.00	-	-
g.	0.22	0.01	0.21	0.00	5.90	821.999

sin Pollutant Retention
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llutant: BOD (Kg)
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nth	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
JAN	0.34	38	35	2.3
FEB	0.00	6.6	6.7	0.18
MAR	12.90	22	21	0.78
APR	1.05	1.1	1.6	0.074
MAY	4.14	46	41	3.7
JUN	4.09	26	24	1.9
JUL	0.00	1.1	1.4	0.069
AUG	0.00	2.6	2.3	0.25
SEP	25.82	12	11	0.07
OCT	46.13	11	11	0.36
NOV	3.11	25	24	1.5
DEC	9.59	11	11	0.35
otal	9.01	2E+002	1.9E+002	11

ollutant: SS (Kg)
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onth	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
JAN	0.34	3.1E+002	2.6E+002	39
FEB	0.00	54	54	3.5
MAR	12.90	1.8E+002	1.6E+002	15
APR	1.05	9	16	1.2
MAY	4.14	3.8E+002	3.1E+002	64
JUN	4.09	2.1E+002	1.9E+002	33
JUL	0.00	8.6	15	1.4
AUG	0.00	21	20	2
SEP	25.82	96	84	0.72
OCT	46.13	93	89	7.2
NOV	3.11	2.1E+002	1.8E+002	26
DEC	9.59	93	90	6.6
Total	9.01	1.7E+003	1.5E+003	2E+002

Pollutant: TKN (Kg)

Month	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
JAN	0.34	5.9	1.7	2.6
FEB	0.00	1.4	0.82	0.31
MAR	12.90	3.8	2	1.9

APR	1.05	0.31	0.57	0.14
MAY	4.14	7.4	2.2	4.9
JUN	4.09	4.4	1.9	2.8
JUL	0.00	0.3	0.45	0.12
AUG	0.00	0.59	0.51	0.083
SEP	25.82	2.1	1.1	0.17
OCT	46.13	2.1	1.3	1.1
NOV	3.11	4.3	1.8	2.4
DEC	9.59	2	1.3	0.84
otal	9.01	35	16	17

ollutant: TN (Kg)

onth	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
JAN	0.34	19	5.6	8.2
FEB	0.00	3.6	2.4	1.2
[illegible]	12.90	11	5.4	5.4
APR	1.05	0.83	1.6	0.37
MAY	4.14	27	7.8	18
JUN	4.09	16	6.7	9.7
JUL	0.00	0.86	1.5	0.49
AUG	0.00	1.5	1.6	0.33
SEP	25.82	5.8	3.2	0.59
OCT	46.13	6.3	3.8	2.9
NOV	3.11	14	5.9	7.6
DEC	9.59	5.6	3.5	2.6
otal	9.01	1.1E+002	49	58

ollutant: TP (Kg)

onth	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
[illegible]	0.34	1.7	0.46	0.8
FEB	0.00	0.51	0.35	0.067
MAR	12.90	1.3	0.68	0.59
APR	1.05	0.18	0.31	0.034
MAY	4.14	2.2	0.58	1.5
JUN	4.09	1.5	0.61	1
JUL	0.00	0.2	0.28	0.03
AUG	0.00	0.23	0.16	0.022
SEP	25.82	0.73	0.37	0.1
OCT	46.13	0.8	0.52	0.37
NOV	3.11	1.4	0.59	0.8
DEC	9.59	0.73	0.51	0.29
otal	9.01	11	5.4	5.6

ond Sediment Grading Distribution

Grain Size mm	Inflow Kg	Retention Kg	Retention %	Retention Cum %	Outflow Kg
0.000 - 0.002	3.3E+002	1.4E+002	42.21	42.21	1.8E+002
0.002 - 0.004	86	72	84.02	50.73	14
0.004 - 0.010	1.1E+002	1.1E+002	96.65	60.47	3.8
0.010 - 0.020	86	86	99.93	65.93	0.063

0.020 - 0.040	2.3E+002	2.3E+002	100.00	75.06	1.4E-006
0.040 - 0.080	2.3E+002	2.3E+002	100.00	80.33	0
0.080 - 0.160	2.3E+002	2.3E+002	100.00	83.76	0
0.160 - 0.320	94	94	100.00	84.85	0
0.320 - 0.500	19	19	100.00	85.06	0
0.500 - 1.000	30	30	100.00	85.37	0
1.000 - 2.000	30	30	100.00	85.67	0
2.000 - 5.000	1.7E+002	1.7E+002	100.00	87.14	0
5.000 - 10.000	33	33	100.00	87.39	0
10.000 - 999.000	0	0	0.00	87.39	0
Total	1.7E+003	1.5E+003	87.39	87.39	2E+002

Mean Depth : 2.50 m
Mean Hydraulic Residence Time : 0.07292 yrs
Mean Depth / Hydraulic Residence Time: 34.27 m/yr

QUALM Version : 2.1; June 1995

nput File : C:\WPS\AQUALMXP\narra1a.dat
utput File : C:\WPS\AQUALMXP\narrap2a.out

nnual Report for Node "NAR2p11.9", 31/12/1995 POND 2 11.9 ha 'URBAN"

ocal Runoff and Pollutant Loads

onth	Rain mm	Runoff Ml	BOD Kg	SS Kg	TKN Kg	TN Kg	TP Kg
JAN	159.4	15.38	56	4.6E+002	8.4	24	2.4
FEB	75.2	2.40	9.9	80	2.1	5.3	0.68
MAR	105.2	8.41	32	2.6E+002	5.7	15	1.7
APR	18.7	0.55	1.6	13	0.46	1.2	0.2
Y	218.8	21.33	67	5.5E+002	10	32	2.9
JUN	95.8	12.68	37	3E+002	6.2	19	1.9
JUL	6.2	0.66	1.5	12	0.44	1.2	0.21
AUG	40.9	0.92	3.9	32	0.89	2.2	0.3
SEP	126.8	4.72	17	1.4E+002	3	8	0.96
OCT	104.7	5.10	16	1.3E+002	3.1	8.3	1
NOV	164.7	11.23	37	3E+002	6.2	18	1.9
DEC	76.4	4.49	17	1.4E+002	3	7.9	0.96
otal	1192.8	87.87	3E+002	2.4E+003	50	1.4E+002	15

otal Runoff and Pollutant Loads

onth	Runoff Ml	BOD Kg	SS Kg	TKN Kg	TN Kg	TP Kg
JAN	15.4	56	4.6E+002	8.4	24	2.4
FEB	2.4	9.9	80	2.1	5.3	0.68
R	8.41	32	2.6E+002	5.7	15	1.7
APR	0.546	1.6	13	0.46	1.2	0.2
MAY	21.3	67	5.5E+002	10	32	2.9
JUN	12.7	37	3E+002	6.2	19	1.9
JUL	0.665	1.5	12	0.44	1.2	0.21
AUG	0.917	3.9	32	0.89	2.2	0.3
SEP	4.72	17	1.4E+002	3	8	0.96
OCT	5.1	16	1.3E+002	3.1	8.3	1
NOV	11.2	37	3E+002	6.2	18	1.9
DEC	4.49	17	1.4E+002	3	7.9	0.96
otal	87.9	3E+002	2.4E+003	50	1.4E+002	15

ond Simulation Results

onth	Inflow (Ml)	Evap (Ml)	Outflow (Ml)	Spill (Ml)	Volume (Ml)	Stage (m)
JAN	15.38	0.51	14.87	0.00	5.91	822.000
FEB	2.40	0.43	1.97	0.00	5.91	822.000
MAR	8.41	0.38	8.02	0.00	5.91	822.000
APR	0.55	0.31	0.24	0.00	5.91	822.000
MAY	21.33	0.25	21.08	0.00	5.91	822.000
JUN	12.68	0.23	12.45	0.00	5.91	822.000

JUL	0.66	0.25	0.41	0.00	5.91	822.000
AUG	0.92	0.33	0.59	0.00	5.86	821.982
SEP	4.72	0.39	4.33	0.00	5.90	821.999
OCT	5.10	0.46	4.64	0.00	5.91	822.000
NOV	11.23	0.47	10.76	0.00	5.91	822.000
DEC	4.49	0.57	3.92	0.00	5.91	822.000
Total	87.87	4.59	83.28	0.00	-	-
Avg.	0.24	0.01	0.23	0.00	5.90	821.998

Basin Pollutant Retention

Pollutant: BOD (Kg)

Month	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
JAN	0.33	56	51	3.7
FEB	0.00	9.9	9.9	0.3
MAR	7.81	32	31	1.6
APR	0.00	1.6	2.2	0.059
MAY	8.24	67	60	5.3
JUN	4.09	37	35	2.7
JUL	0.00	1.5	1.7	0.43
AUG	0.00	3.9	3.5	0.29
SEP	24.67	17	16	0.12
OCT	20.05	16	16	0.62
NOV	4.46	37	35	2.2
DEC	3.28	17	17	0.66
Total	6.10	3E+002	2.8E+002	18

Pollutant: SS (Kg)

Month	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
JAN	0.33	4.6E+002	3.7E+002	62
FEB	0.00	80	79	5.7
MAR	7.81	2.6E+002	2.3E+002	28
APR	0.00	13	22	1.1
MAY	8.24	5.5E+002	4.4E+002	91
JUN	4.09	3E+002	2.6E+002	47
JUL	0.00	12	22	4.4
AUG	0.00	32	30	2.2
SEP	24.67	1.4E+002	1.2E+002	1.3
OCT	20.05	1.3E+002	1.3E+002	12
NOV	4.46	3E+002	2.6E+002	39
DEC	3.28	1.4E+002	1.3E+002	13
Total	6.10	2.4E+003	2.1E+003	3.1E+002

Pollutant: TKN (Kg)

Month	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
JAN	0.33	8.4	2.4	4
FEB	0.00	2.1	1.2	0.49
MAR	7.81	5.7	2.8	3.2

APR	0.00	0.46	0.77	0.14
MAY	8.24	10	3.1	6.8
JUN	4.09	6.2	2.7	4
JUL	0.00	0.44	0.63	0.17
AUG	0.00	0.89	0.76	0.13
SEP	24.67	3	1.6	0.34
OCT	20.05	3.1	1.8	1.7
NOV	4.46	6.2	2.6	3.5
DEC	3.28	3	1.8	1.5
otal	6.10	50	22	26

ollutant: TN (Kg)

onth	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
JAN	0.33	24	6.9	11
FEB	0.00	5.3	3.1	1.6
R	7.81	15	7.2	8.2
APR	0.00	1.2	2	0.38
MAY	8.24	32	9.2	21
JUN	4.09	19	8	12
JUL	0.00	1.2	1.8	0.55
AUG	0.00	2.2	2.1	0.41
SEP	24.67	8	4.3	0.98
OCT	20.05	8.3	4.9	4.3
NOV	4.46	18	7.3	9.9
DEC	3.28	7.9	4.6	3.9
otal	6.10	1.4E+002	62	74

ollutant: TP (Kg)

onth	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
N	0.33	2.4	0.6	1.2
FEB	0.00	0.68	0.45	0.11
MAR	7.81	1.7	0.84	0.93
APR	0.00	0.2	0.36	0.034
MAY	8.24	2.9	0.75	1.9
JUN	4.09	1.9	0.78	1.3
JUL	0.00	0.21	0.33	0.043
AUG	0.00	0.3	0.19	0.033
SEP	24.67	0.96	0.48	0.18
OCT	20.05	1	0.64	0.47
NOV	4.46	1.9	0.76	1.1
DEC	3.28	0.96	0.62	0.45
otal	6.10	15	6.8	7.7

ond Sediment Grading Distribution

Grain Size mm	Inflow Kg	Retention Kg	Retention %	Cum %	Outflow Kg
0.000 - 0.002	4.8E+002	1.9E+002	40.01	40.01	2.7E+002
0.002 - 0.004	1.2E+002	1E+002	83.18	48.81	21
0.004 - 0.010	1.6E+002	1.6E+002	96.22	58.87	6.2
0.010 - 0.020	1.2E+002	1.2E+002	99.90	64.54	0.12

0.020 - 0.040	3.3E+002	3.3E+002	100.00	74.04	2.9E-006
0.040 - 0.080	3.3E+002	3.3E+002	100.00	79.53	0
0.080 - 0.160	3.3E+002	3.3E+002	100.00	83.10	0
0.160 - 0.320	1.4E+002	1.4E+002	100.00	84.24	0
0.320 - 0.500	28	28	100.00	84.45	0
0.500 - 1.000	44	44	100.00	84.78	0
1.000 - 2.000	44	44	100.00	85.09	0
2.000 - 5.000	2.4E+002	2.4E+002	100.00	86.61	0
5.000 - 10.000	48	48	100.00	86.88	0
10.000 - 999.000	0	0	0.00	86.88	0
Total	2.4E+003	2.1E+003	86.88	86.88	3E+002

Mean Depth : 2.50 m
Mean Hydraulic Residence Time : 0.06712 yrs
Mean Depth / Hydraulic Residence Time: 37.22 m/yr

JUL	0.75	0.23	0.53	0.00	5.34	822.000
AUG	0.69	0.29	0.40	0.00	5.31	821.987
SEP	4.07	0.35	3.72	0.00	5.34	822.000
OCT	4.83	0.42	4.41	0.00	5.34	822.000
NOV	10.48	0.43	10.05	0.00	5.34	822.000
DEC	3.81	0.52	3.29	0.00	5.34	822.000
Total	80.89	4.15	76.74	0.00	-	-
Avg.	0.22	0.01	0.21	0.00	5.34	821.999

Basin Pollutant Retention

Pollutant: BOD (Kg)

Month	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
JAN	0.33	38	34	2.5
FEB	0.00	6.6	6.6	0.18
MAR	9.19	22	21	0.94
APR	0.00	1.1	1.5	0.051
MAY	6.31	46	41	3.8
JUN	2.80	26	24	2
JUL	0.00	1.1	1.4	0.069
AUG	2.33	2.6	2.5	0.042
SEP	22.56	12	11	0.068
OCT	26.26	11	11	0.45
NOV	3.90	25	24	1.6
DEC	4.93	11	11	0.4
Total	6.60	2E+002	1.9E+002	12

Pollutant: SS (Kg)

Month	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
JAN	0.33	3.1E+002	2.5E+002	43
FEB	0.00	54	53	3.5
MAR	9.19	1.8E+002	1.6E+002	18
APR	0.00	9	16	1
MAY	6.31	3.8E+002	3.1E+002	67
JUN	2.80	2.1E+002	1.8E+002	35
JUL	0.00	8.6	14	1.4
AUG	2.33	21	20	0.42
SEP	22.56	96	84	0.82
OCT	26.26	93	88	8.4
NOV	3.90	2.1E+002	1.8E+002	28
DEC	4.93	93	89	7.7
Total	6.60	1.7E+003	1.5E+003	2.1E+002

Pollutant: TKN (Kg)

Month	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
JAN	0.33	5.9	1.7	2.8
FEB	0.00	1.4	0.79	0.31
MAR	9.19	3.8	1.9	2.1

AQUALM Version : 2.1; June 1995

Input File : C:\WPS\AQUALMXP\narra1a.dat
Output File : C:\WPS\AQUALMXP\narrap1a.out

Annual Report for Node "NAR1p7.9", 31/12/1995 POND 1 7.9 ha 'URBAN'

Local Runoff and Pollutant Loads

Month	Rain mm	Runoff Ml	BOD Kg	SS Kg	TKN Kg	TN Kg	TP Kg
JAN	159.4	13.39	38	3.1E+002	5.9	19	1.7
FEB	75.2	1.88	6.6	54	1.4	3.6	0.51
MAR	105.2	7.01	22	1.8E+002	3.8	11	1.3
APR	18.7	0.55	1.1	9	0.31	0.83	0.18
MAY	218.8	20.66	46	3.8E+002	7.4	27	2.2
JUN	95.8	12.76	26	2.1E+002	4.4	16	1.5
JUL	6.2	0.75	1.1	8.6	0.3	0.86	0.2
AUG	40.9	0.69	2.6	21	0.59	1.5	0.23
SEP	126.8	4.07	12	96	2.1	5.8	0.73
OCT	104.7	4.83	11	93	2.1	6.3	0.8
NOV	164.7	10.48	25	2.1E+002	4.3	14	1.4
DEC	76.4	3.81	11	93	2	5.6	0.73
Total	1192.8	80.89	2E+002	1.7E+003	35	1.1E+002	11

Total Runoff and Pollutant Loads

Month	Runoff Ml	BOD Kg	SS Kg	TKN Kg	TN Kg	TP Kg
JAN	13.4	38	3.1E+002	5.9	19	1.7
FEB	1.88	6.6	54	1.4	3.6	0.51
MAR	7.01	22	1.8E+002	3.8	11	1.3
APR	0.548	1.1	9	0.31	0.83	0.18
MAY	20.7	46	3.8E+002	7.4	27	2.2
JUN	12.8	26	2.1E+002	4.4	16	1.5
JUL	0.755	1.1	8.6	0.3	0.86	0.2
AUG	0.692	2.6	21	0.59	1.5	0.23
SEP	4.07	12	96	2.1	5.8	0.73
OCT	4.83	11	93	2.1	6.3	0.8
NOV	10.5	25	2.1E+002	4.3	14	1.4
DEC	3.81	11	93	2	5.6	0.73
Total	80.9	2E+002	1.7E+003	35	1.1E+002	11

Pond Simulation Results

Month	Inflow (Ml)	Evap (Ml)	Outflow (Ml)	Spill (Ml)	Volume (Ml)	Stage (m)
JAN	13.39	0.46	12.93	0.00	5.34	822.000
FEB	1.88	0.39	1.49	0.00	5.34	822.000
MAR	7.01	0.35	6.67	0.00	5.34	822.000
APR	0.55	0.28	0.27	0.00	5.34	822.000
MAY	20.66	0.23	20.43	0.00	5.34	822.000
JUN	12.76	0.21	12.56	0.00	5.34	822.000

0.020 - 0.040	2.3E+002	2.3E+002	100.00	73.45	5.7E-006
0.040 - 0.080	2.3E+002	2.3E+002	100.00	79.06	0
0.080 - 0.160	2.3E+002	2.3E+002	100.00	82.71	0
0.160 - 0.320	94	94	100.00	83.87	0
0.320 - 0.500	19	19	100.00	84.10	0
0.500 - 1.000	30	30	100.00	84.43	0
1.000 - 2.000	30	30	100.00	84.75	0
2.000 - 5.000	1.7E+002	1.7E+002	100.00	86.31	0
5.000 - 10.000	33	33	100.00	86.58	0
10.000 - 999.000	0	0	0.00	86.58	0
Total	1.7E+003	1.5E+003	86.58	86.58	2.1E+002

ean Depth : 2.50 m
ean Hydraulic Residence Time : 0.06598 yrs
ean Depth / Hydraulic Residence Time: 37.87 m/yr

APR	0.00	0.31	0.53	0.12
MAY	6.31	7.4	2.1	5.1
JUN	2.80	4.4	1.8	2.9
JUL	0.00	0.3	0.42	0.12
AUG	2.33	0.59	0.49	0.064
SEP	22.56	2.1	1.1	0.19
OCT	26.26	2.1	1.2	1.2
NOV	3.90	4.3	1.7	2.4
DEC	4.93	2	1.2	0.91
'otal	6.60	35	15	18

'ollutant: TN (Kg)

Ionth	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
JAN	0.33	19	5.4	8.9
FEB	0.00	3.6	2.3	1.2
MAR	9.19	11	5.2	5.7
APR	0.00	0.83	1.5	0.34
MAY	6.31	27	7.4	19
JUN	2.80	16	6.4	10
JUL	0.00	0.86	1.4	0.49
AUG	2.33	1.5	1.5	0.25
SEP	22.56	5.8	3	0.64
OCT	26.26	6.3	3.6	3.2
NOV	3.90	14	5.6	7.9
DEC	4.93	5.6	3.4	2.7
'otal	6.60	1.1E+002	47	60

'ollutant: TP (Kg)

:onth	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
JAN	0.33	1.7	0.44	0.85
FEB	0.00	0.51	0.34	0.067
MAR	9.19	1.3	0.64	0.65
APR	0.00	0.18	0.29	0.03
MAY	6.31	2.2	0.55	1.5
JUN	2.80	1.5	0.58	1
JUL	0.00	0.2	0.27	0.03
AUG	2.33	0.23	0.16	0.018
SEP	22.56	0.73	0.36	0.12
OCT	26.26	0.8	0.5	0.39
NOV	3.90	1.4	0.57	0.83
DEC	4.93	0.73	0.48	0.32
otal	6.60	11	5.2	5.8

ond Sediment Grading Distribution

Grain Size mm	Inflow Kg	Retention Kg	Retention %	Retention Cum %	Outflow Kg
0.000 - 0.002	3.3E+002	1.3E+002	39.06	39.06	1.9E+002
0.002 - 0.004	86	70	81.65	47.74	16
0.004 - 0.010	1.1E+002	1.1E+002	95.75	57.93	4.8
0.010 - 0.020	86	86	99.86	63.73	0.12

UALM Version : 2.1; June 1995

put File : C:\WPS\AQUALMXP\narra1a.dat
tput File : C:\WPS\AQUALMXP\narrap1b.out

==
nual Report for Node "NAR1p11.9", 31/12/1995 POND 1 11.9ha "URBAN"
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ocal Runoff and Pollutant Loads
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onth	Rain mm	Runoff Ml	BOD Kg	SS Kg	TKN Kg	TN Kg	TP Kg
JAN	159.4	15.38	56	4.6E+002	8.4	24	2.4
FEB	75.2	2.40	9.9	80	2.1	5.3	0.68
MAR	105.2	8.41	32	2.6E+002	5.7	15	1.7
APR	18.7	0.55	1.6	13	0.46	1.2	0.2
Y	218.8	21.33	67	5.5E+002	10	32	2.9
JUN	95.8	12.68	37	3E+002	6.2	19	1.9
JUL	6.2	0.66	1.5	12	0.44	1.2	0.21
AUG	40.9	0.92	3.9	32	0.89	2.2	0.3
SEP	126.8	4.72	17	1.4E+002	3	8	0.96
OCT	104.7	5.10	16	1.3E+002	3.1	8.3	1
NOV	164.7	11.23	37	3E+002	6.2	18	1.9
DEC	76.4	4.49	17	1.4E+002	3	7.9	0.96
otal	1192.8	87.87	3E+002	2.4E+003	50	1.4E+002	15

otal Runoff and Pollutant Loads
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onth	Runoff Ml	BOD Kg	SS Kg	TKN Kg	TN Kg	TP Kg
JAN	15.4	56	4.6E+002	8.4	24	2.4
FEB	2.4	9.9	80	2.1	5.3	0.68
R	8.41	32	2.6E+002	5.7	15	1.7
APR	0.546	1.6	13	0.46	1.2	0.2
MAY	21.3	67	5.5E+002	10	32	2.9
JUN	12.7	37	3E+002	6.2	19	1.9
JUL	0.665	1.5	12	0.44	1.2	0.21
AUG	0.917	3.9	32	0.89	2.2	0.3
SEP	4.72	17	1.4E+002	3	8	0.96
OCT	5.1	16	1.3E+002	3.1	8.3	1
NOV	11.2	37	3E+002	6.2	18	1.9
DEC	4.49	17	1.4E+002	3	7.9	0.96
otal	87.9	3E+002	2.4E+003	50	1.4E+002	15

ond Simulation Results
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onth	Inflow (Ml)	Evap (Ml)	Outflow (Ml)	Spill (Ml)	Volume (Ml)	Stage (m)
JAN	15.38	0.46	14.92	0.00	5.34	822.000
FEB	2.40	0.39	2.01	0.00	5.34	822.000
MAR	8.41	0.35	8.06	0.00	5.34	822.000
APR	0.55	0.28	0.27	0.00	5.34	822.000
MAY	21.33	0.23	21.10	0.00	5.34	822.000
JUN	12.68	0.21	12.47	0.00	5.34	822.000

JUL	0.66	0.23	0.44	0.00	5.34	822.000
AUG	0.92	0.29	0.62	0.00	5.30	821.983
SEP	4.72	0.35	4.37	0.00	5.34	822.000
OCT	5.10	0.42	4.68	0.00	5.34	822.000
NOV	11.23	0.43	10.81	0.00	5.34	822.000
DEC	4.49	0.52	3.97	0.00	5.34	822.000
Total	87.87	4.15	83.72	0.00	-	-
Avg.	0.24	0.01	0.23	0.00	5.34	821.999

Basin Pollutant Retention

Pollutant: BOD (Kg)

Month	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
JAN	0.33	56	51	3.9
FEB	1.37	9.9	9.8	0.3
MAR	6.12	32	31	1.8
APR	1.18	1.6	2.1	0.077
MAY	8.52	67	60	5.5
JUN	2.80	37	35	2.9
JUL	0.00	1.5	2	0.086
AUG	2.39	3.9	3.6	0.23
SEP	21.73	17	16	0.14
OCT	15.46	16	16	0.7
NOV	4.17	37	35	2.4
DEC	2.59	17	17	0.73
Total	5.57	3E+002	2.8E+002	19

Pollutant: SS (Kg)

Month	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
JAN	0.33	4.6E+002	3.7E+002	66
FEB	1.37	80	77	5.7
MAR	6.12	2.6E+002	2.3E+002	31
APR	1.18	13	21	1.2
MAY	8.52	5.5E+002	4.4E+002	95
JUN	2.80	3E+002	2.6E+002	49
JUL	0.00	12	20	1.7
AUG	2.39	32	30	1.8
SEP	21.73	1.4E+002	1.2E+002	2
OCT	15.46	1.3E+002	1.3E+002	13
NOV	4.17	3E+002	2.6E+002	41
DEC	2.59	1.4E+002	1.3E+002	14
Total	5.57	2.4E+003	2.1E+003	3.2E+002

Pollutant: TKN (Kg)

Month	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
JAN	0.33	8.4	2.4	4.2
FEB	1.37	2.1	1.1	0.49
MAR	6.12	5.7	2.7	3.3

.PR	1.18	0.46	0.72	0.14
IAY	8.52	10	3	6.9
'UN	2.80	6.2	2.6	4.1
'UL	0.00	0.44	0.62	0.14
.UG	2.39	0.89	0.72	0.12
;EP	21.73	3	1.6	0.49
)CT	15.46	3.1	1.8	1.7
IOV	4.17	6.2	2.5	3.6
)EC	2.59	3	1.7	1.5
otal	5.57	50	21	27

ollutant: TN (Kg)
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onth	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
JAN	0.33	24	6.7	12
FEB	1.37	5.3	3	1.6
[illegible]	6.12	15	7	8.6
APR	1.18	1.2	1.9	0.38
MAY	8.52	32	8.8	21
JUN	2.80	19	7.7	12
JUL	0.00	1.2	1.8	0.46
AUG	2.39	2.2	2	0.4
SEP	21.73	8	4.1	1.4
OCT	15.46	8.3	4.7	4.4
NOV	4.17	18	7	10
DEC	2.59	7.9	4.5	4.1
otal	5.57	1.4E+002	59	77

ollutant: TP (Kg)
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onth	Retention (Days)	Inflow Kg	Retention Kg	Outflow Kg
N	0.33	2.4	0.57	1.2
FEB	1.37	0.68	0.43	0.11
MAR	6.12	1.7	0.81	0.98
APR	1.18	0.2	0.35	0.034
MAY	8.52	2.9	0.72	2
JUN	2.80	1.9	0.75	1.3
JUL	0.00	0.21	0.32	0.035
AUG	2.39	0.3	0.18	0.034
SEP	21.73	0.96	0.47	0.23
OCT	15.46	1	0.61	0.48
NOV	4.17	1.9	0.73	1.1
DEC	2.59	0.96	0.59	0.47
otal	5.57	15	6.5	8

ond Sediment Grading Distribution

Grain Size mm	Inflow Kg	Retention Kg	Retention %	Retention Cum %	Outflow Kg
0.000 - 0.002	4.8E+002	1.8E+002	37.10	37.10	2.9E+002
0.002 - 0.004	1.2E+002	1E+002	80.79	46.01	24
0.004 - 0.010	1.6E+002	1.6E+002	95.30	56.46	7.7
0.010 - 0.020	1.2E+002	1.2E+002	99.83	62.46	0.22

0.020 - 0.040	3.3E+002	3.3E+002	100.00	72.52	1.4E-005
0.040 - 0.080	3.3E+002	3.3E+002	100.00	78.33	0
0.080 - 0.160	3.3E+002	3.3E+002	100.00	82.11	0
0.160 - 0.320	1.4E+002	1.4E+002	100.00	83.31	0
0.320 - 0.500	28	28	100.00	83.54	0
0.500 - 1.000	44	44	100.00	83.89	0
1.000 - 2.000	44	44	100.00	84.22	0
2.000 - 5.000	2.4E+002	2.4E+002	100.00	85.83	0
5.000 - 10.000	48	48	100.00	86.11	0
10.000 - 999.000	0	0	0.00	86.11	0
Total	2.4E+003	2.1E+003	86.11	86.11	3.2E+002

Mean Depth : 2.50 m
Mean Hydraulic Residence Time : 0.06073 yrs
Mean Depth / Hydraulic Residence Time: 41.14 m/yr