Nonpoint Source Model Development and Basin Management Strategies for Lemon Bay

Final Report

Prepared for:

SOUTHWEST FLORIDA
WATER MANAGEMENT DISTRICT

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SECTION 5

EVALUATION OF NONPOINT SOURCE LOADINGS TO LEMON BAY

A watershed nonpoint source loading model was developed for the Lemon Bay basin based upon site-specific land use characteristics, soil types, runoff characteristics, and conveyance mechanisms. This model, identified as the Lemon Bay Watershed Model, was calibrated based upon the field monitoring program performed by ERD from March-November 2002. The model is then used to provide estimates of nonpoint source loadings to Lemon Bay under future built-out conditions as well as under undeveloped conditions within the basin prior to current development. The model can also be used to evaluate changes in nonpoint source loadings associated with land use changes, stormwater regulations, and source controls. Details of the model, along with estimates of nonpoint source loadings under undeveloped, current, and future conditions, are provided in the following sections.

5.1 Model Documentation

5.1.1 Introduction

The Lemon Bay Watershed Model (LBWM) is an Excel spreadsheet model that estimates total annual stormwater runoff volumes and pollutant loadings for seven basins draining to Lemon Bay. LBWM calculates the total generated runoff volumes, the total generated pollutant loads and applies attenuation factors to account for losses in stormwater and conveyance systems. Runoff volumes are calculated using site-specific land use and hydrologic soil groups, derived from SWFWMD GIS themes, percent imperviousness determined from aerial examination of basin photography, and percent directly connected impervious areas (DCIA) calculated as a percent of the total impervious area. Typical pollutant concentrations are applied to the runoff volumes to generate pollutant loads for the basins. The results of the model are used to identify potential runoff related pollution problem areas, sources of major pollutants, and to assist in prioritization of areas for potential treatment options. A digital copy (CD version) of the Lemon Bay Watershed Model is given in Appendix C.

5.1.2 Model Organization

A flow chart of LBWM is presented in Figure 5-1. The model is organized into four computation modules; runoff volume generation, runoff volume attenuation, pollutant load generation and pollutant load attenuation. The runoff volume generation module consists of seven spreadsheets that calculate the total generated wet and dry season runoff volumes for each basin. The runoff volume attenuation module is a single sheet which applies attenuation factors to account for losses in stormwater and conveyance systems. The pollutant load generation module calculates the loads for total nitrogen, total phosphorus, BOD and TSS on a separate sheet. The pollutant load attenuation module is calculated on the same four sheets as the pollutant load generation module. The model contains two other sheets labeled "Parameters" and "Summary" respectively. The "Parameters" sheet contains input data necessary to calculate pollutant loads and apply attenuations. The "Summary" sheet provides a summary of the model output and compares it with field measured values.

The generated runoff volume is calculated incrementally using separate wet and dry season rainfall frequency distributions and 14 land use areas subdivided into five hydrologic soil group categories. The generated runoff volume is summarized by land use and basin and passed to the runoff volume attenuation and the pollutant load modules. The pollutant loads are then passed to the pollutant attenuation stage.

The model incorporates an attenuation factor representing stormwater system treatment by multiplying attenuation factors times the generated runoff volumes and generated pollutant loads for each basin and land use combination. The amount of stormwater treatment potential for each land use is based on the ratio of pond and lake area to land use area. A pond/land use ratio of 0.1 or greater is assumed to receive the full assumed attenuation rate for stormwater treatment. No stormwater system attenuation is applied to the generated runoff volume and pollutant loads from the "Water (ponds and lake)" land use since this is included in the

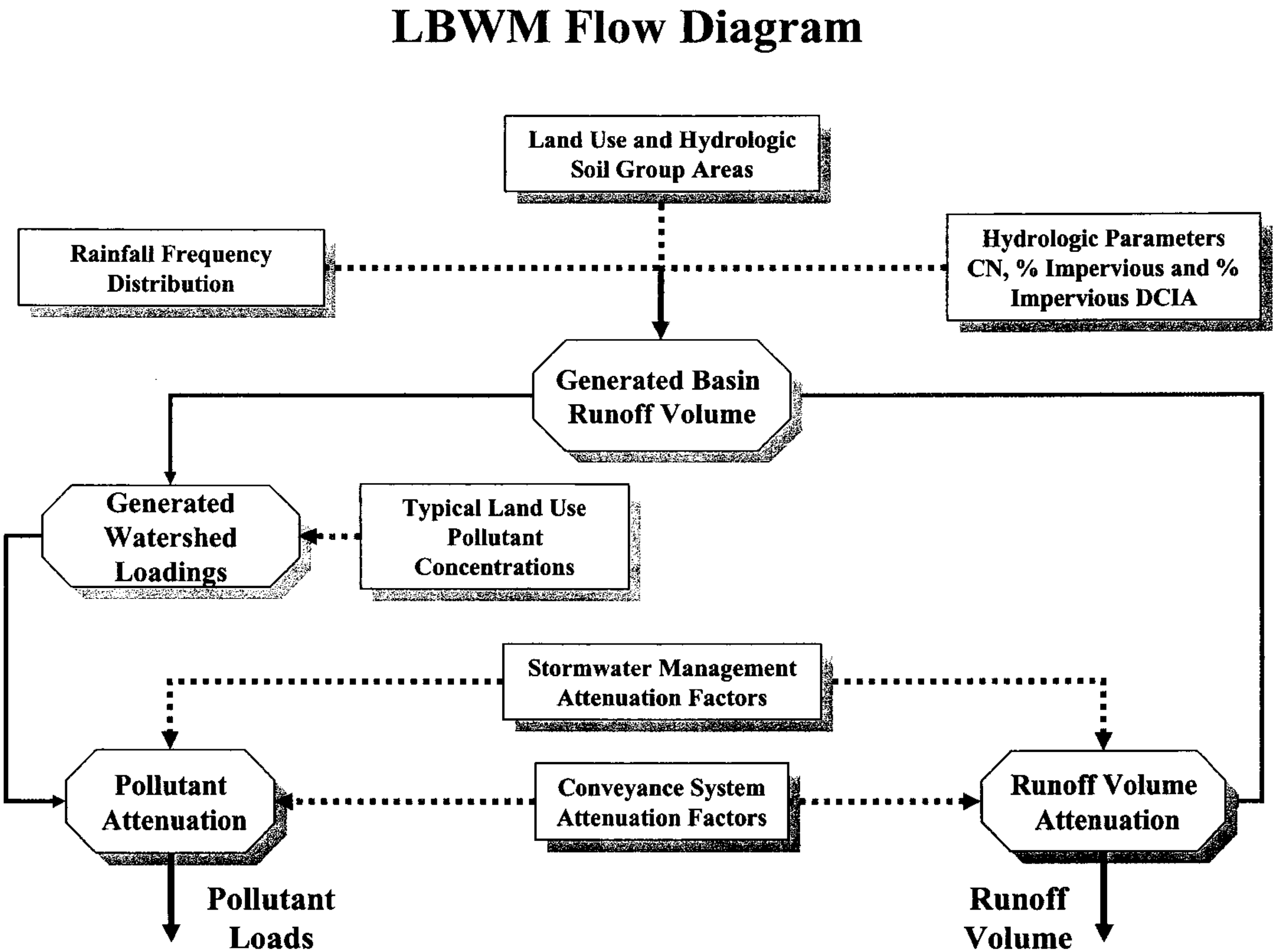


Figure 5-1. Flow Chart of the Lemon Bay Watershed Model.

attenuation applied to the other land uses. Conveyance attenuation factors are applied globally to the stormwater system attenuated runoff volume and pollutant loads. The amount of conveyance attenuation for each basin is based on the ratio of conveyance system area to basin area. A ratio of 0.04 or greater is assumed to receive 100 percent of the specific conveyance attenuation factor.

5.1.3 Hydrologic Input Data

The hydrologic data for runoff volume generation is derived from land use information, hydrologic soil group classifications and estimates of impervious and directly connected impervious areas (DCIA). Land use and soil information was obtained from Southwest Florida Water Management District (SWFWMD) GIS data using the "sarasota_se" and "charlotte_ne" data sets. FLUCCS land use classifications were consolidated into 14 land use categories as shown in Table 4-1. The water category was subdivided into two categories, "Water (ponds and lakes)" and "Water (conveyance)". The "Water (ponds and lakes)" category is used to represent potential stormwater treatment areas and includes the FLUCCS land uses for intermittent ponds, reservoirs and lakes. Each pond and lake area is associated with the predominant land use which drains to it based on aerial examination. The "Water (conveyance)" category includes bays, estuaries, streams, and waterways.

Estimation of the percent imperviousness for each land use category is based upon measurements from 1999 one-meter resolution ortho quads. For the residential land use categories, the percent imperviousness is estimated based on the average of measurements from several typical samples for each land use areas. Percent DCIA is calculated as a percentage of the impervious areas using values typical for the given land use. The assumed percent imperviousness and percent DCIA used for the various land use categories is summarized in Table 5-1.

Wet and dry season rainfall frequency distributions for the Lemon Bay watershed were calculated from National Climatic Data Center (NCDC) hourly rainfall for St. Petersburg and Ft. Myers and SWFWMD daily rainfall from Englewood and Cape Haze. The hourly NCDC rainfall data was used to develop an average rainfall event distribution. This distribution was modified on an event volume basis (number of events times the average rainfall depth) so the total seasonal rainfall for the distribution equaled the average seasonal rainfall for the Englewood and Cape Haze data. The wet and dry season rainfall distribution used in the model are given in Table 5-2.

TABLE 5-1

PERCENT IMPERVIOUS AND DCIA ASSUMPTIONS BY LAND USE FOR THE LEMON BAY WATERSHED

LAND USE	PERCENT IMPERVIOUS	PERCENT IMPERVIOUS THAT IS DCIA
Agriculture	0	0
Commercial	65	75
Extractive	50	25
Industrial	50	25
Low-Density Residential	15	20
Medium-Density Residential	40	40
High-Density Residential	60	65
Transportation	50	90
Institutional	45	60
Open	0	0
Recreational	6	0
Wetland	0	0

Wet and dry season curve numbers (CN) are adjusted using the SCS modified antecedent moisture condition (AMC) factors which are presented in Table 5-3. The curve numbers for condition II represent average moisture conditions. Conditions I and III represent dry and wet antecedent moisture conditions. For the Lemon Bay watershed the AMC I is assumed to exist during the dry season if the preceding 5-day rainfall is less than 1.7 inches and during the wet season if the preceding 5-day rainfall is less than 0.6 inches. AMC III is assumed to exist during the dry season if the preceding 5-day rainfall is greater than 2.4 inches and during the wet season if the preceding 5-day rainfall is greater than 1.4 inches.

TABLE 5-2

WET AND DRY SEASON RAINFALL DISTRIBUTIONS FOR LEMON BAY

RAINFALL EVENT RANGE (INCHES)	DRY SEASON		WET SEASON	
	RAINFALL INTERVAL POINT (INCHES)	NUMBER OF ANNUAL EVENTS IN RANGE	RAINFALL INTERVAL POINT (INCHES)	NUMBER OF ANNUAL EVENTS IN RANGE
0.00-0.10	0.062	21.622	0.061	24.794
0.11-0.20	0.168	6.203	0.165	8.351
0.21-0.30	0.270	4.585	0.270	5.847
0.31-0.40	0.374	2.342	0.376	3.510
0.41-0.50	0.468	2.045	0.471	3.200
0.51-1.00	0.726	5.654	0.744	9.021
1.01-1.50	1.236	2.298	1.246	3.848
1.51-2.00	1.751	1.226	1.735	1.797
2.01-2.50	2.248	0.669	2.266	0.830
2.51-3.00	2.744	0.336	2.745	0.469
3.01-3.50	3.241	0.260	3.182	0.273
3.51-4.00	3.632	0.103	3.727	0.159
4.01-4.50	4.260	0.040	4.293	0.077
4.51-5.00	4.540	0.044	4.753	0.094
5.01-6.00	5.600	0.022	5.549	0.094
6.01-7.00	0.000	0.000	6.540	0.037
7.01-8.00	7.800	0.018	0.000	0.000
8.01-9.00	0.000	0.000	8.445	0.057
>9.00	0.000	0.000	9.690	0.020

TABLE 5-3

SCS CURVE NUMBER ADJUSTMENT FACTORS FOR ANTECEDENT MOISTURE CONDITION

CURVE NUMBER FOR CONDITION II	FACTOR TO CONVERT CN FOR CONDITION II TO ...	
	I	III
10	0.40	2.22
20	0.45	1.85
30	0.50	1.67
40	0.55	1.50
50	0.62	1.40
60	0.67	1.30
70	0.73	1.21
80	0.79	1.14
90	0.87	1.07
100	1.00	1.00

Seasonal curve numbers are calculated by using the fraction of events which fall into each AMC based on the daily rainfall data from Cape Haze from 1958 to 2001. The fractions of annual events for each condition are shown in Table 5-4. The seasonal AMC fractions are then used to calculate the weighted wet and dry season curve numbers for each of the AMC II curve numbers shown in Table 5-3. The weighted seasonal curve numbers are presented in Table 5-5. Regression equations were developed to estimate the weighted seasonal curve numbers from the AMC II curve numbers in the model. The regression equations are of the form:

$$\text{Dry Season } CN =$$

$$0.0021(CN)^{2.5}-0.0374(CN)^{2.0}+0.2499(CN)^{1.5}+0.0930(CN)^{1.0}+0.0231(CN)^{0.5}+0.0049$$

$$\text{Wet Season } CN =$$

$$0.0031(CN)^{2.5}-0.0683(CN)^{2.0}+0.4526(CN)^{1.5}+0.1803(CN)^{1.0}+0.0480(CN)^{0.5}+0.0108$$

Where CN is the AMC II curve number.

TABLE 5-4

FRACTION OF WET AND DRY ANTECEDENT RAINFALL CONDITIONS OCCURING AT LEMON BAY

CONDITION	FRACTION OF SEASON	
	DRY	WET
I	0.778	0.279
II	0.101	0.268
III	0.122	0.453

TABLE 5-5

SEASONALLY WEIGHTED CURVE NUMBERS FOR THE LEMON BAY WATERSHED

CURVE NUMBER FOR AMC II	SEASONAL WEIGHTED CURVE NUMBER	
	DRY	WET
10	6.8	13.9
20	13.5	24.6
30	20.8	34.9
40	28.4	44.1
50	37.7	53.8
60	46.8	62.6
70	57.1	71.4
80	68.3	80.4
90	81.7	89.6
100	100.0	100.0

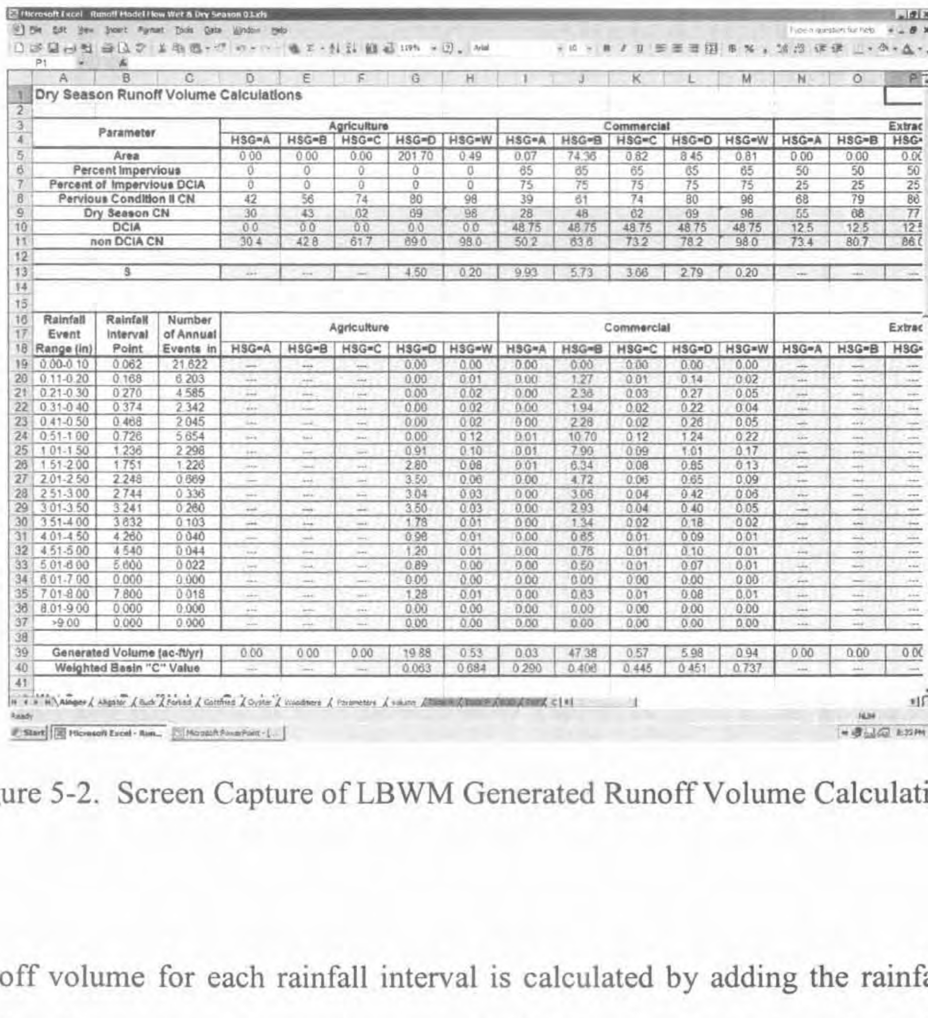
5.1.4 Runoff Volume Spreadsheet

Data in the model are color coded. Only cells shaded yellow or red have been left unprotected and can be modified. The yellow shaded cells contain direct input data for the model while the red cells contain links other input data cells to avoid entering input data common to the model. Green shaded cells generally contain summary information which may or may not be used in further calculations, and cyan shaded cells contain the general model computations.

LBWM contains seven generated runoff volume sheets, one for each basin with each sheet divided into a series of calculations for the wet and dry season. A screen capture showing the dry season generated runoff volume calculations is shown in Figure 5-2. A similar series of calculations for the wet season is performed directly below the dry season calculations. The calculations extend out of view in Figure 5-2 out to column BM.

Input data are entered into cells in the rows labeled "Area", "Percent Impervious", "Percent or Impervious DCIA" and "Pervious Condition II CN". The row labeled "Area" contains the basin areas subdivided by land use and hydrologic soil groups. The "Percent Impervious" row contains the percent imperviousness determined for the various land uses from

Table 5-1. The "Percent or Impervious DCIA" contains the percent of the impervious area that is directly connected from Table 5-1. The "Pervious Condition II CN" row contains the pervious curve number for each land use hydrologic soil group combination. The seasonal rainfall distribution data from Table 5-2 is entered in the columns labeled "Rainfall Interval Point" and "Number of Rainfall Events in Interval". The same hydrologic values are used for all the basins except Buck Creek. The only difference for Buck Creek is the "Open" land use is 7.5% impervious.



Dry Season Runoff Volume Calculations

Parameter	Agriculture					Commercial					Extrac		
	HSG=A	HSG=B	HSG=C	HSG=D	HSG=W	HSG=A	HSG=B	HSG=C	HSG=D	HSG=W	HSG=A	HSG=B	HSG=
Area	0.00	0.00	0.00	201.70	0.49	0.07	74.36	0.82	8.45	0.81	0.00	0.00	0.0
Percent Impervious	0	0	0	0	0	65	65	65	65	65	50	50	50
Percent of Impervious DCIA	0	0	0	0	0	75	75	75	75	75	25	25	25
Pervious Condition II CN	42	56	74	80	98	39	61	74	80	98	68	79	86
Dry Season CN	30	43	62	69	98	28	48	62	69	98	55	68	77
DCIA	0.0	0.0	0.0	0.0	0.0	48.75	48.75	48.75	48.75	48.75	12.5	12.5	12.
non DCIA CN	30.4	42.8	61.7	69.0	98.0	50.2	63.6	73.2	78.2	98.0	73.4	80.7	86.
S	---	---	---	4.50	0.20	9.93	5.73	3.66	2.79	0.20	---	---	---

Rainfall Event Range (in)	Rainfall Interval Point	Number of Annual Events in	Agriculture					Commercial					Extrac		
			HSG=A	HSG=B	HSG=C	HSG=D	HSG=W	HSG=A	HSG=B	HSG=C	HSG=D	HSG=W	HSG=A	HSG=B	HSG=
0.00-0.10	0.062	21.622	---	---	---	0.00	0.00	0.00	0.00	0.00	0.00	0.00	---	---	---
0.11-0.20	0.168	6.203	---	---	---	0.00	0.01	0.00	1.27	0.01	0.14	0.02	---	---	---
0.21-0.30	0.270	4.585	---	---	---	0.00	0.02	0.00	2.38	0.03	0.27	0.05	---	---	---
0.31-0.40	0.374	2.342	---	---	---	0.00	0.02	0.00	1.94	0.02	0.22	0.04	---	---	---
0.41-0.50	0.468	2.045	---	---	---	0.00	0.02	0.00	2.28	0.02	0.26	0.05	---	---	---
0.51-1.00	0.726	5.654	---	---	---	0.00	0.12	0.01	10.70	0.12	1.24	0.22	---	---	---
1.01-1.50	1.236	2.298	---	---	---	0.91	0.10	0.01	7.90	0.09	1.01	0.17	---	---	---
1.51-2.00	1.751	1.226	---	---	---	2.80	0.08	0.01	6.34	0.08	0.85	0.13	---	---	---
2.01-2.50	2.248	0.669	---	---	---	3.50	0.06	0.00	4.72	0.06	0.65	0.09	---	---	---
2.51-3.00	2.744	0.336	---	---	---	3.04	0.03	0.00	3.06	0.04	0.42	0.06	---	---	---
3.01-3.50	3.241	0.260	---	---	---	3.50	0.03	0.00	2.93	0.04	0.40	0.05	---	---	---
3.51-4.00	3.632	0.103	---	---	---	1.78	0.01	0.00	1.34	0.02	0.18	0.02	---	---	---
4.01-4.50	4.260	0.040	---	---	---	0.98	0.01	0.00	0.65	0.01	0.09	0.01	---	---	---
4.51-5.00	4.540	0.044	---	---	---	1.20	0.01	0.00	0.76	0.01	0.10	0.01	---	---	---
5.01-6.00	5.600	0.022	---	---	---	0.89	0.00	0.00	0.50	0.01	0.07	0.01	---	---	---
6.01-7.00	0.000	0.000	---	---	---	0.00	0.00	0.00	0.00	0.00	0.00	0.00	---	---	---
7.01-8.00	7.800	0.018	---	---	---	1.28	0.01	0.00	0.63	0.01	0.08	0.01	---	---	---
8.01-9.00	0.000	0.000	---	---	---	0.00	0.00	0.00	0.00	0.00	0.00	0.00	---	---	---
>9.00	0.000	0.000	---	---	---	0.00	0.00	0.00	0.00	0.00	0.00	0.00	---	---	---
Generated Volume (ac-ft/yr)			0.00	0.00	0.00	19.88	0.53	0.03	47.38	0.57	5.98	0.94	0.00	0.00	0.0
Weighted Basin "C" Value			---	---	---	0.063	0.684	0.290	0.408	0.445	0.451	0.737	---	---	---

Figure 5-2. Screen Capture of LBWM Generated Runoff Volume Calculations.

The runoff volume for each rainfall interval is calculated by adding the rainfall excess from the non-directly connected impervious area (nDCIA) of each land use-hydrologic soil group combination to the rainfall excess generated from the DCIA of the same land use-hydrologic soil group. Rainfall excess from the nDCIA areas is calculated using the following set of equations:

$$nDCIA\ CN = \frac{(CN * 100 - IMP) + 98\ (IMP - DCIA)}{(100 - DCIA)}$$

$$Soil\ \ Storage,\ S = \left(\frac{1000}{nDCIA\ CN)} - 10\right)$$

$$Q_{nDCIA_i} = \frac{(P_i - 0.2S\ )^2}{(P_i + 0.8S)}$$

where:

CN	=	AMC weighted seasonal curve number for pervious area
Imp	=	percent impervious area
DCIA	=	percent directly connected impervious area
nDCIA CN	=	curve number for non-DCIA area
P_i	=	rainfall event interval (i)
Q_{nDCIAi}	=	rainfall excess for non-DCIA for rainfall event interval (i)

For rainfall events where P_i is less than 0.2S, the rainfall excess (Q_{nDCIAi}) is assumed to be zero. For the DCIA portion, rainfall excess is calculated using the following equation:

$$Q_{DCIA_i} = (P_i - 0.1)$$

The 0.1 represents the amount of initial abstraction. Except for the water land use, when P_i is less than 0.1, Q_{DCIAi} is equal to zero. For the two water land use categories the amount of initial abstraction is set at zero. The total volume for a rainfall event interval is calculated using the following equation:

$$RO_i = [Q_{nDCIA_i}\ x\ A\ x\ (100 - DCIA) + Q_{DCIA_i}\ x\ A\ x\ DCIA]\ x\ \frac{1}{12}\ x\ \frac{1}{100}\ x\ N$$

where:

A = area for specific land use-HSG (ac)

RO_i = runoff volume for rainfall interval (i)

N = number of annual runoff events in interval (i)

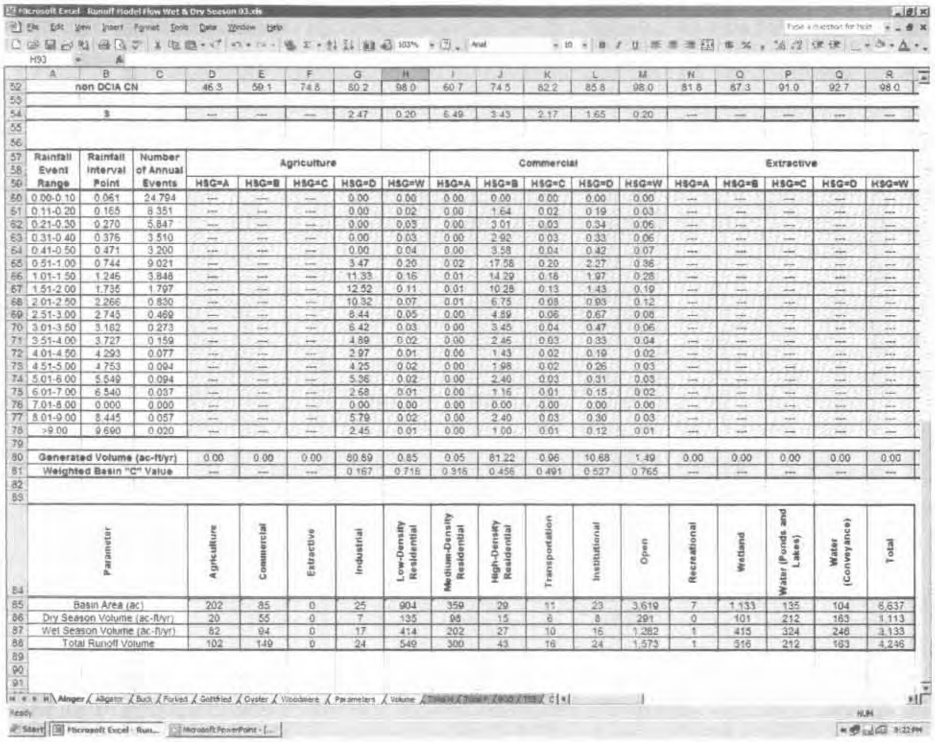
The sum of all the runoff volumes (RO_i) for each rainfall event interval is the total annual rainfall volume. The total annual generated runoff volume is shown in row 39 in Figure 5-2. The weighted basin "C" value is calculated in row 40 using the following equation:

$$C \ Value = \frac{Generated \ Volume \ (ac - ft \ / \ yr)}{Area \ x \ Total \ Annual \ Rainfall \ (inches)} \ x \ \frac{12 \ inches}{1 \ ft}$$

Not shown in Figure 5-2 are columns BO and BP which provide a summary of the rainfall and runoff volumes for each interval. Figure 5-3 shows a summary of the runoff volume by land use and season which is located below the wet season calculations.

5.1.5 Parameters Sheet

The "Parameters" sheet contains input parameters which the model uses to calculate basin loadings, runoff volume attenuation and loading attenuation. The input data is organized into several tables. The input table for stormwater concentrations, based on the concentrations summarized in Table 3-7, and a summary table of basin land use area, based on information contained in Section 4.1, is shown in Figure 5-4. Figure 5-5 shows the input table for the pond and lake areas associated with each land use and a table of the ratio of the pond and lake area to land use area. Figure 5-6 shows the input tables for the stormwater and conveyance system attenuation factors.

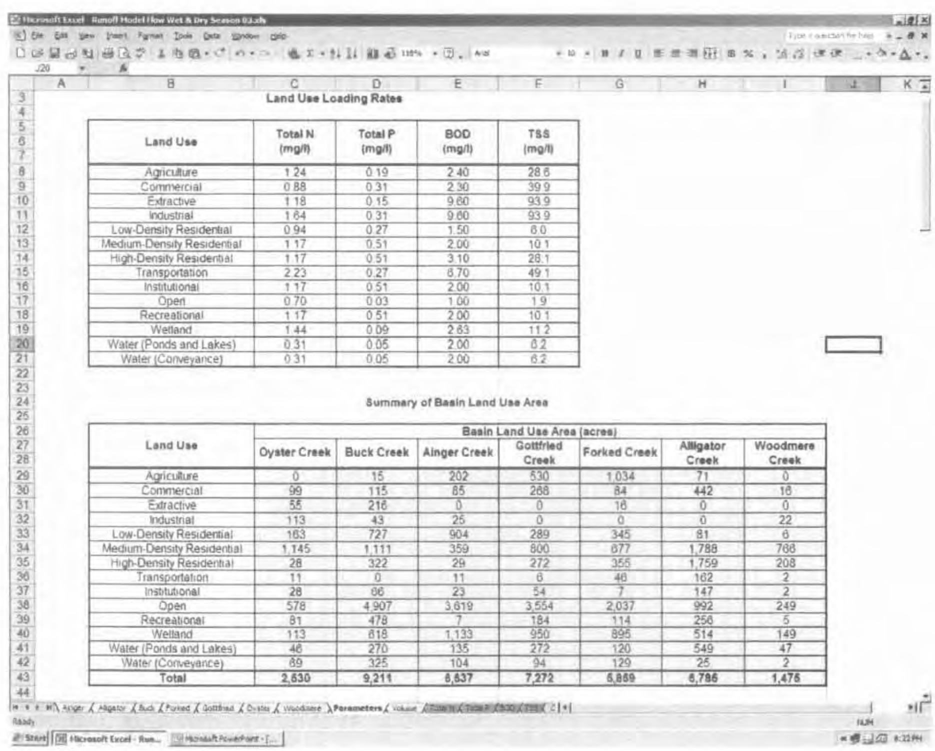


	HSG=A	HSG=B	HSG=C	HSG=D	HSG=W	HSG=A	HSG=B	HSG=C	HSG=D	HSG=W	HSG=A	HSG=B	HSG=C	HSG=D	HSG=W
non DCIA CN	46.3	59.1	74.8	80.2	98.0	60.7	74.5	82.2	85.8	98.0	81.8	87.3	91.0	92.7	98.0
S	---	---	---	2.47	0.20	6.49	3.43	2.17	1.65	0.20	---	---	---	---	---

Rainfall Event Range	Rainfall Interval Point	Number of Annual Events	Agriculture					Commercial					Extractive				
			HSG=A	HSG=B	HSG=C	HSG=D	HSG=W	HSG=A	HSG=B	HSG=C	HSG=D	HSG=W	HSG=A	HSG=B	HSG=C	HSG=D	HSG=W
0.00-0.10	0.061	24.794	---	---	---	0.00	0.00	0.00	0.00	0.00	0.00	0.00	---	---	---	---	---
0.11-0.20	0.165	8.351	---	---	---	0.00	0.02	0.00	1.64	0.02	0.19	0.03	---	---	---	---	---
0.21-0.30	0.270	5.847	---	---	---	0.00	0.03	0.00	3.01	0.03	0.34	0.06	---	---	---	---	---
0.31-0.40	0.376	3.510	---	---	---	0.00	0.03	0.00	2.92	0.03	0.33	0.06	---	---	---	---	---
0.41-0.50	0.471	3.200	---	---	---	0.00	0.04	0.00	3.58	0.04	0.42	0.07	---	---	---	---	---
0.51-1.00	0.744	9.021	---	---	---	3.47	0.20	0.02	17.58	0.20	2.27	0.36	---	---	---	---	---
1.01-1.50	1.246	3.848	---	---	---	11.33	0.16	0.01	14.29	0.16	1.97	0.28	---	---	---	---	---
1.51-2.00	1.735	1.797	---	---	---	12.52	0.11	0.01	10.28	0.13	1.43	0.19	---	---	---	---	---
2.01-2.50	2.266	0.830	---	---	---	10.32	0.07	0.01	6.75	0.08	0.93	0.12	---	---	---	---	---
2.51-3.00	2.745	0.469	---	---	---	8.44	0.05	0.00	4.89	0.06	0.67	0.08	---	---	---	---	---
3.01-3.50	3.182	0.273	---	---	---	6.42	0.03	0.00	3.45	0.04	0.47	0.06	---	---	---	---	---
3.51-4.00	3.727	0.159	---	---	---	4.89	0.02	0.00	2.46	0.03	0.33	0.04	---	---	---	---	---
4.01-4.50	4.293	0.077	---	---	---	2.97	0.01	0.00	1.43	0.02	0.19	0.02	---	---	---	---	---
4.51-5.00	4.753	0.094	---	---	---	4.25	0.02	0.00	1.98	0.02	0.26	0.03	---	---	---	---	---
5.01-6.00	5.549	0.094	---	---	---	5.36	0.02	0.00	2.40	0.03	0.31	0.03	---	---	---	---	---
6.01-7.00	6.540	0.037	---	---	---	2.68	0.01	0.00	1.16	0.01	0.15	0.02	---	---	---	---	---
7.01-8.00	0.000	0.000	---	---	---	0.00	0.00	0.00	0.00	0.00	0.00	0.00	---	---	---	---	---
8.01-9.00	8.445	0.057	---	---	---	5.79	0.02	0.00	2.40	0.03	0.30	0.03	---	---	---	---	---
>9.00	9.690	0.020	---	---	---	2.45	0.01	0.00	1.00	0.01	0.12	0.01	---	---	---	---	---
Generated Volume (ac-ft/yr)			0.00	0.00	0.00	80.89	0.85	0.05	81.22	0.96	10.68	1.49	0.00	0.00	0.00	0.00	0.00
Weighted Basin "C" Value			---	---	---	0.167	0.718	0.316	0.456	0.491	0.527	0.765	---	---	---	---	---

Parameter	Agriculture	Commercial	Extractive	Industrial	Low-Density Residential	Medium-Density Residential	High-Density Residential	Transportation	Institutional	Open	Recreational	Wetland	Water (Ponds and Lakes)	Water (Conveyance)	Total
Basin Area (ac)	202	85	0	25	904	359	29	11	23	3,619	7	1,133	135	104	6,637
Dry Season Volume (ac-ft/yr)	20	55	0	7	135	98	15	6	8	291	0	101	212	163	1,113
Wet Season Volume (ac-ft/yr)	82	94	0	17	414	202	27	10	16	1,282	1	415	324	246	3,133
Total Runoff Volume	102	149	0	24	549	300	43	16	24	1,573	1	516	212	163	4,246

Figure 5-3. Screen Capture of LBWM Generated Runoff Volume Summary.



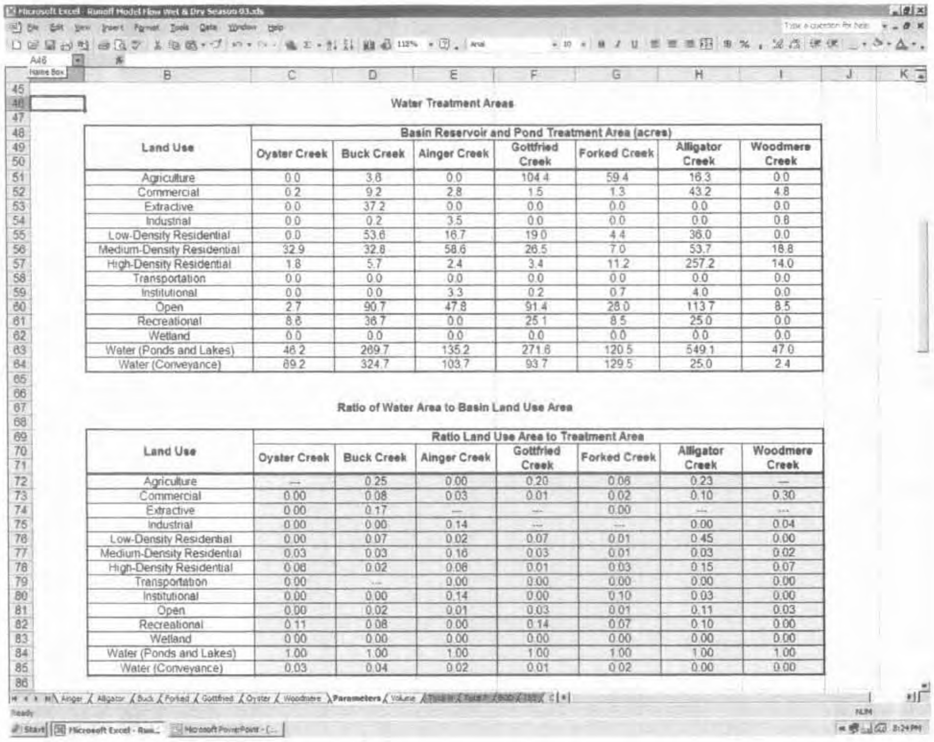
Land Use Loading Rates

Land Use	Total N (mg/l)	Total P (mg/l)	BOD (mg/l)	TSS (mg/l)
Agriculture	1.24	0.19	2.40	28.6
Commercial	0.88	0.31	2.30	39.9
Extractive	1.18	0.15	9.60	93.9
Industrial	1.64	0.31	9.60	93.9
Low-Density Residential	0.94	0.27	1.50	8.0
Medium-Density Residential	1.17	0.51	2.00	10.1
High-Density Residential	1.17	0.51	3.10	28.1
Transportation	2.23	0.27	6.70	49.1
Institutional	1.17	0.51	2.00	10.1
Open	0.70	0.03	1.00	1.9
Recreational	1.17	0.51	2.00	10.1
Wetland	1.44	0.09	2.63	11.2
Water (Ponds and Lakes)	0.31	0.05	2.00	6.2
Water (Conveyance)	0.31	0.05	2.00	6.2

Summary of Basin Land Use Area

Land Use	Basin Land Use Area (acres)						
	Oyster Creek	Buck Creek	Ainger Creek	Gottfried Creek	Forked Creek	Alligator Creek	Woodmere Creek
Agriculture	0	15	202	530	1,034	71	0
Commercial	99	115	85	268	84	442	16
Extractive	55	216	0	0	16	0	0
Industrial	113	43	25	0	0	0	22
Low-Density Residential	163	727	904	289	345	81	6
Medium-Density Residential	1,145	1,111	359	800	677	1,788	766
High-Density Residential	28	322	29	272	355	1,759	208
Transportation	11	0	11	6	46	162	2
Institutional	28	66	23	54	7	147	2
Open	578	4,907	3,619	3,554	2,037	992	249
Recreational	81	478	7	184	114	256	5
Wetland	113	618	1,133	950	895	514	149
Water (Ponds and Lakes)	46	270	135	272	120	549	47
Water (Conveyance)	89	325	104	94	129	25	2
Total	**2,630**	**9,211**	**6,637**	**7,272**	**5,869**	**6,786**	**1,476**

Figure 5-4. Screen Capture of LBWM "Parameters" Sheet Showing Loading Rate Concentrations and a Summary of Basin Land Use Areas.



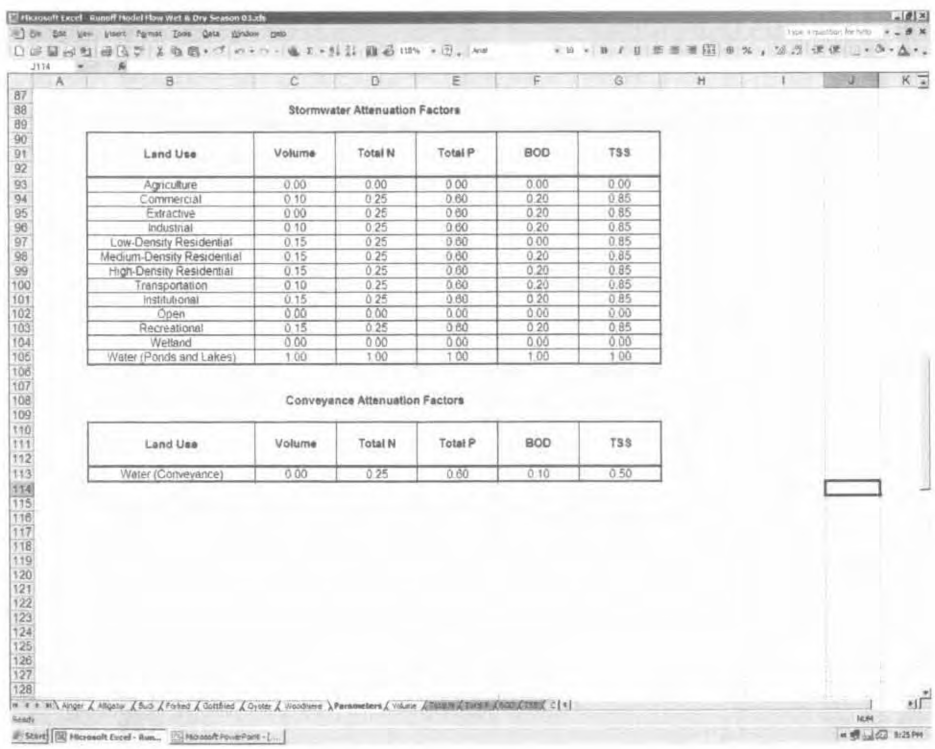
Water Treatment Areas

Land Use	Basin Reservoir and Pond Treatment Area (acres)						
	Oyster Creek	Buck Creek	Ainger Creek	Gottfried Creek	Forked Creek	Alligator Creek	Woodmere Creek
Agriculture	0.0	3.8	0.0	104.4	59.4	16.3	0.0
Commercial	0.2	9.2	2.8	1.5	1.3	43.2	4.8
Extractive	0.0	37.2	0.0	0.0	0.0	0.0	0.0
Industrial	0.0	0.2	3.5	0.0	0.0	0.0	0.8
Low-Density Residential	0.0	53.6	16.7	19.0	4.4	36.0	0.0
Medium-Density Residential	32.9	32.8	58.6	26.5	7.0	53.7	18.8
High-Density Residential	1.8	5.7	2.4	3.4	11.2	257.2	14.0
Transportation	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Institutional	0.0	0.0	3.3	0.2	0.7	4.0	0.0
Open	2.7	90.7	47.8	91.4	28.0	113.7	8.5
Recreational	8.8	36.7	0.0	25.1	8.5	25.0	0.0
Wetland	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Water (Ponds and Lakes)	46.2	269.7	135.2	271.6	120.5	549.1	47.0
Water (Conveyance)	89.2	324.7	103.7	93.7	129.5	25.0	2.4

Ratio of Water Area to Basin Land Use Area

Land Use	Ratio Land Use Area to Treatment Area						
	Oyster Creek	Buck Creek	Ainger Creek	Gottfried Creek	Forked Creek	Alligator Creek	Woodmere Creek
Agriculture	---	0.25	0.00	0.20	0.06	0.23	---
Commercial	0.00	0.08	0.03	0.01	0.02	0.10	0.30
Extractive	0.00	0.17	---	---	0.00	---	---
Industrial	0.00	0.00	0.14	---	---	0.00	0.04
Low-Density Residential	0.00	0.07	0.02	0.07	0.01	0.45	0.00
Medium-Density Residential	0.03	0.03	0.16	0.03	0.01	0.03	0.02
High-Density Residential	0.06	0.02	0.06	0.01	0.03	0.15	0.07
Transportation	0.00	---	0.00	0.00	0.00	0.00	0.00
Institutional	0.00	0.00	0.14	0.00	0.10	0.03	0.00
Open	0.00	0.02	0.01	0.03	0.01	0.11	0.03
Recreational	0.11	0.08	0.00	0.14	0.07	0.10	0.00
Wetland	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Water (Ponds and Lakes)	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Water (Conveyance)	0.03	0.04	0.02	0.01	0.02	0.00	0.00

Figure 5-5. Screen Capture of LBWM "Parameters" Sheet Showing Water Treatment Areas and the Ratios of Stormwater Treatment Areas to Basin Areas.



Stormwater Attenuation Factors

Land Use	Volume	Total N	Total P	BOD	TSS
Agriculture	0.00	0.00	0.00	0.00	0.00
Commercial	0.10	0.25	0.60	0.20	0.85
Extractive	0.00	0.25	0.60	0.20	0.85
Industrial	0.10	0.25	0.60	0.20	0.85
Low-Density Residential	0.15	0.25	0.60	0.00	0.85
Medium-Density Residential	0.15	0.25	0.60	0.20	0.85
High-Density Residential	0.15	0.25	0.60	0.20	0.85
Transportation	0.10	0.25	0.60	0.20	0.85
Institutional	0.15	0.25	0.60	0.20	0.85
Open	0.00	0.00	0.00	0.00	0.00
Recreational	0.15	0.25	0.60	0.20	0.85
Wetland	0.00	0.00	0.00	0.00	0.00
Water (Ponds and Lakes)	1.00	1.00	1.00	1.00	1.00

Conveyance Attenuation Factors

Land Use	Volume	Total N	Total P	BOD	TSS
Water (Conveyance)	0.00	0.25	0.60	0.10	0.50

Figure 5-6. Screen Capture of LBWM "Parameters" Sheet Showing Stormwater Treatment and Conveyance System Attenuation Factors.

5.1.6 Runoff Volume Sheet

The sheet labeled "Volume" contains a summary of the wet and dry season runoff volumes, stormwater and conveyance system attenuation calculations, "C" value calculations and a summary table of the attenuated runoff volumes. A screen capture of the wet and dry season generated runoff volume tables is given in Figure 5-7. The generated runoff volume tables summarize data from the seven generated runoff volume sheets by land use.

Below the generated seasonal runoff volume tables are two tables labeled "Attenuated Dry Season Runoff Volume" and "Attenuated Wet Season Runoff Volume" which are shown in Figure 5-8. These tables contain the runoff volume attenuation calculations. The column labeled "Land Use Attenuation Factors" contains values from the "Stormwater Attenuation Factor Table on the "Parameters" sheet. The attenuation factor in the row labeled "Water (conveyance) is passed from the "Conveyance Attenuation Factor" table on the "Parameters" sheet. The cyan shaded cells to the right of each land use contain the stormwater system attenuation calculations. The attenuation is calculated as follows:

When the pond and lake area to land use area ratio is less than 0.1:

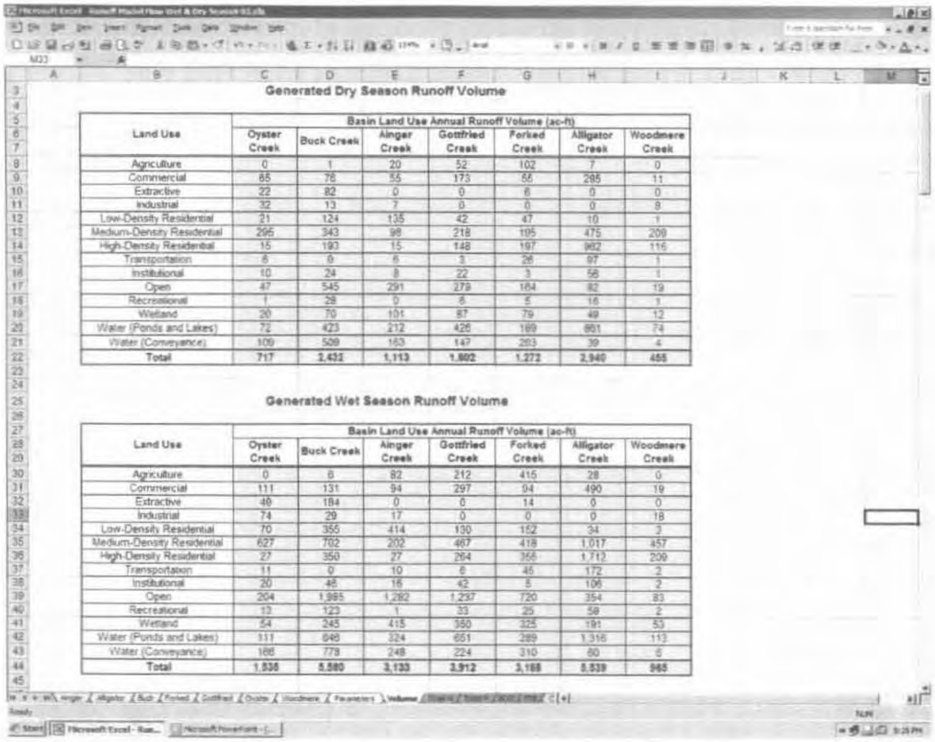
$$\textit{Attenuated Runoff Volume} = GRV*(1\text{-}AF)*(PA{:}LU/0.1)$$

When the pond and lake area to land use area ratio is greater than or equal to 0.1:

$$\textit{Attenuated Runoff Volume} = GRV*(1\text{-}AF)*(PA{:}LU/0.1)$$

where:

GRV	=	generated runoff volume from tables shown in Figure 5-7
AF	=	stormwater system attenuation factor from table shown in Figure 5-6
LU:PA	=	the ratio of pond and lake areas to land use area from table shown in Figure 5-5



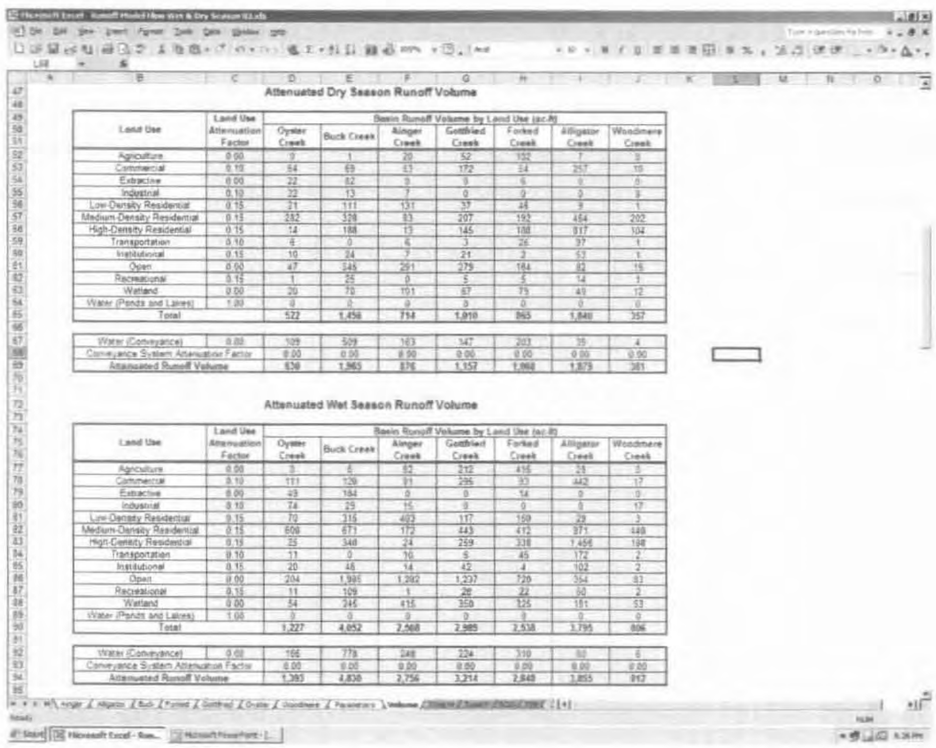
Generated Dry Season Runoff Volume

Land Use	Basin Land Use Annual Runoff Volume (ac-ft)						
	Oyster Creek	Buck Creek	Ainger Creek	Gottfried Creek	Forked Creek	Alligator Creek	Woodmere Creek
Agriculture	0	1	20	52	102	7	0
Commercial	65	76	55	173	56	285	11
Extractive	22	82	0	0	6	0	0
Industrial	32	13	7	0	0	0	8
Low-Density Residential	21	124	135	42	47	10	1
Medium-Density Residential	295	343	98	218	195	475	209
High-Density Residential	15	193	15	148	197	982	116
Transportation	6	0	6	3	26	97	1
Institutional	10	24	8	22	3	56	1
Open	47	545	291	279	164	82	19
Recreational	1	28	0	6	5	16	1
Wetland	20	70	101	87	79	49	12
Water (Ponds and Lakes)	72	423	212	426	189	861	74
Water (Conveyance)	109	509	163	147	203	39	4
Total	717	2,433	1,113	1,802	1,272	2,940	455

Generated Wet Season Runoff Volume

Land Use	Basin Land Use Annual Runoff Volume (ac-ft)						
	Oyster Creek	Buck Creek	Ainger Creek	Gottfried Creek	Forked Creek	Alligator Creek	Woodmere Creek
Agriculture	0	6	82	212	415	28	0
Commercial	111	131	94	297	94	490	19
Extractive	40	184	0	0	14	0	0
Industrial	74	29	17	0	0	0	18
Low-Density Residential	70	355	414	130	152	34	3
Medium-Density Residential	627	702	202	467	418	1,017	457
High-Density Residential	27	350	27	264	366	1,712	209
Transportation	11	0	10	6	45	172	2
Institutional	20	46	16	42	5	106	2
Open	204	1,985	1,282	1,237	720	354	83
Recreational	12	123	1	33	25	58	2
Wetland	54	245	415	350	325	191	53
Water (Ponds and Lakes)	111	646	324	651	289	1,316	113
Water (Conveyance)	166	779	248	224	310	60	6
Total	1,536	5,580	3,133	3,912	3,188	5,539	965

Figure 5-7. Screen Capture of LBWM "Volume" Sheet Showing a Summary of Wet and Dry Season Generated Stormwater Runoff Volume.



Attenuated Dry Season Runoff Volume

Land Use	Land Use Attenuation Factor	Basin Runoff Volume by Land Use (ac-ft)						
		Oyster Creek	Buck Creek	Ainger Creek	Gottfried Creek	Forked Creek	Alligator Creek	Woodmere Creek
Agriculture	0.00	0	1	20	52	102	7	0
Commercial	0.10	54	69	43	172	54	257	10
Extractive	0.00	22	82	0	0	6	0	0
Industrial	0.10	22	13	7	0	0	0	8
Low-Density Residential	0.15	21	111	131	37	44	9	1
Medium-Density Residential	0.15	282	328	83	207	192	454	202
High-Density Residential	0.15	14	188	13	145	188	817	104
Transportation	0.10	6	0	6	3	26	87	1
Institutional	0.15	10	24	7	21	3	53	1
Open	0.00	47	545	291	279	164	82	19
Recreational	0.15	1	25	0	5	5	14	1
Wetland	0.00	20	70	101	87	79	49	12
Water (Ponds and Lakes)	1.00	0	0	0	0	0	0	0
Total		522	1,456	714	1,010	865	1,840	357

Water (Conveyance)	0.00	109	509	163	147	203	39	4
Conveyance System Attenuation Factor		0.00	0.00	0.00	0.00	0.00	0.00	0.00
Attenuated Runoff Volume		630	1,965	876	1,157	1,068	1,879	361

Attenuated Wet Season Runoff Volume

Land Use	Land Use Attenuation Factor	Basin Runoff Volume by Land Use (ac-ft)						
		Oyster Creek	Buck Creek	Ainger Creek	Gottfried Creek	Forked Creek	Alligator Creek	Woodmere Creek
Agriculture	0.00	0	6	82	212	415	28	0
Commercial	0.10	111	120	91	296	93	442	17
Extractive	0.00	40	184	0	0	14	0	0
Industrial	0.10	74	29	15	0	0	0	17
Low-Density Residential	0.15	70	316	403	117	150	29	3
Medium-Density Residential	0.15	609	671	172	443	412	871	448
High-Density Residential	0.15	25	348	24	259	338	1,456	198
Transportation	0.10	11	0	10	5	45	172	2
Institutional	0.15	20	46	14	42	4	102	2
Open	0.00	204	1,985	1,282	1,237	720	354	83
Recreational	0.15	11	109	1	28	22	50	2
Wetland	0.00	54	245	415	350	325	191	53
Water (Ponds and Lakes)	1.00	0	0	0	0	0	0	0
Total		1,227	4,052	2,568	2,985	2,538	3,795	806

Water (Conveyance)	0.00	166	778	248	224	310	60	6
Conveyance System Attenuation Factor		0.00	0.00	0.00	0.00	0.00	0.00	0.00
Attenuated Runoff Volume		1,393	4,830	2,756	3,214	2,848	3,855	812

Figure 5-8. Screen Capture of LBWM "Volume" Sheet Showing Attenuated Wet and Dry Season Stormwater Runoff Volume Calculations.

The rows labeled "Total" sum the attenuated runoff volumes for each basin. The "Water (conveyance)" row contains the conveyance attenuation factor from the "Parameters" sheet and the generated runoff volume for the "Water (conveyance) land use shown in Figure 5-7. The "Conveyance System Attenuation Factor" rows contain the weighted conveyance system attenuation factors and are calculated using the following equation:

When the conveyance system area to basin area ratio is less than 0.04:

*Weighted Conveyance System Attenuation Factor (WCSAF) =CSAF*CSA:BA/0.04)*

When the conveyance system area to basin area is greater than or equal to 0.04:

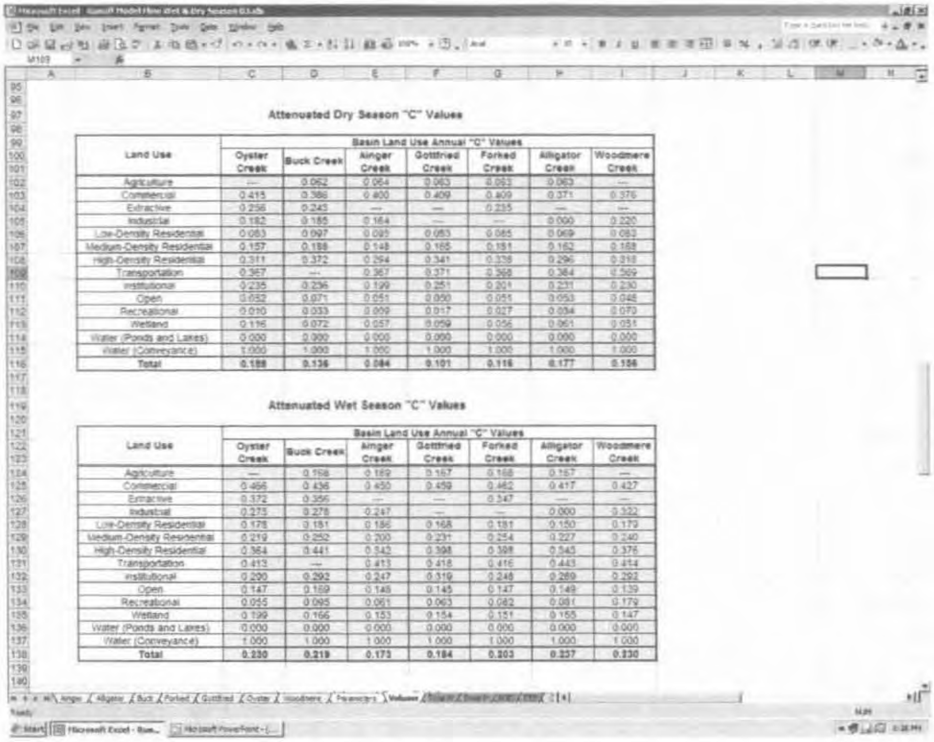
Weighted Conveyance System Attenuation Factor (WCSAF) = CSAF

where:

CSAF	=	Conveyance System Attenuation Factor shown in Figure 5-7
CSA:BA	=	The ratio of conveyance system area to basin area from table shown in Figure 5-5

The final attenuated runoff volume is calculated by multiplying values in the "Total" row by (1-WCSAF) and adding the values from the row labeled "Water (conveyance)" multiplied by (1-WCSAF(0.5)).

Below the "Attenuated Runoff Volume Tables" are the wet and dry season attenuated "C" values shown in Figure 5-9. The "C" values are computed using the attenuated runoff volumes from the "Volume" sheet, the land use areas from the "Parameters" sheet and the wet and dry season rainfall depth.



Attenuated Dry Season "C" Values

Land Use	Basin Land Use Annual "C" Values						
	Oyster Creek	Buck Creek	Ainger Creek	Gottfried Creek	Forked Creek	Alligator Creek	Woodmere Creek
Agriculture	---	0.062	0.064	0.063	0.063	0.063	---
Commercial	0.415	0.386	0.400	0.409	0.409	0.371	0.376
Extractive	0.256	0.243	---	---	0.235	---	---
Industrial	0.182	0.185	0.164	---	---	0.000	0.220
Low-Density Residential	0.083	0.097	0.095	0.083	0.085	0.069	0.083
Medium-Density Residential	0.157	0.188	0.148	0.165	0.181	0.162	0.168
High-Density Residential	0.311	0.372	0.294	0.341	0.338	0.296	0.318
Transportation	0.367	---	0.367	0.371	0.368	0.384	0.369
Institutional	0.235	0.236	0.199	0.251	0.201	0.231	0.230
Open	0.052	0.071	0.051	0.050	0.051	0.053	0.048
Recreational	0.010	0.033	0.009	0.017	0.027	0.034	0.070
Wetland	0.116	0.072	0.057	0.059	0.056	0.061	0.051
Water (Ponds and Lakes)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Water (Conveyance)	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Total	**0.188**	**0.136**	**0.084**	**0.101**	**0.116**	**0.177**	**0.156**

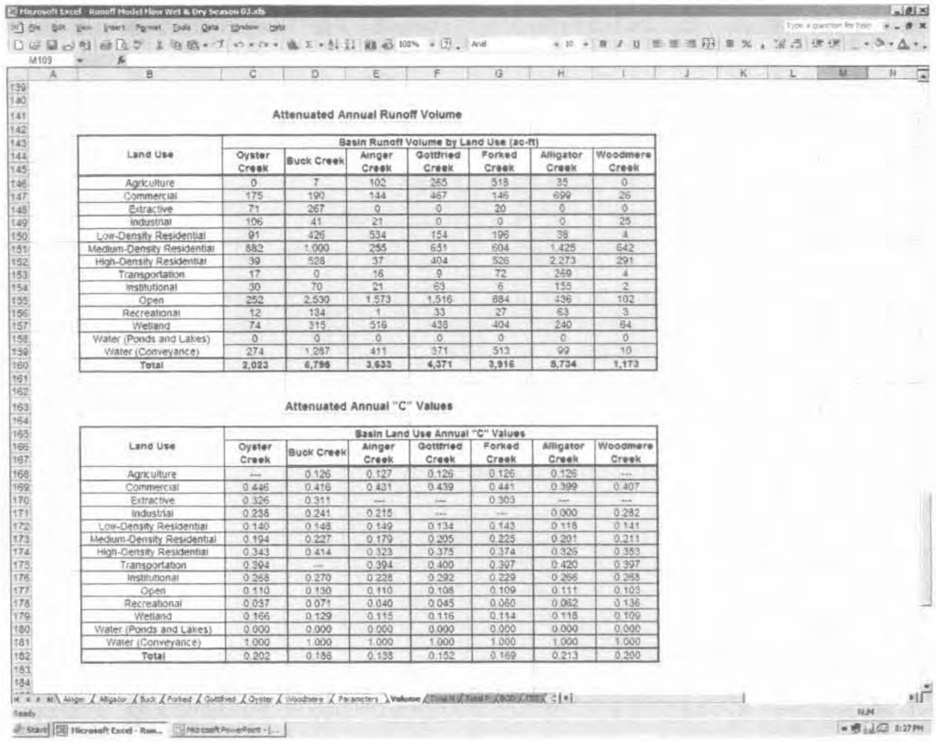
Attenuated Wet Season "C" Values

Land Use	Basin Land Use Annual "C" Values						
	Oyster Creek	Buck Creek	Ainger Creek	Gottfried Creek	Forked Creek	Alligator Creek	Woodmere Creek
Agriculture	---	0.168	0.169	0.167	0.168	0.167	---
Commercial	0.466	0.436	0.450	0.459	0.462	0.417	0.427
Extractive	0.372	0.356	---	---	0.347	---	---
Industrial	0.273	0.278	0.247	---	---	0.000	0.322
Low-Density Residential	0.178	0.181	0.186	0.168	0.181	0.150	0.179
Medium-Density Residential	0.219	0.252	0.200	0.231	0.254	0.227	0.240
High-Density Residential	0.364	0.441	0.342	0.398	0.398	0.343	0.376
Transportation	0.413	---	0.413	0.418	0.416	0.443	0.414
Institutional	0.290	0.292	0.247	0.319	0.248	0.289	0.292
Open	0.147	0.169	0.146	0.145	0.147	0.149	0.139
Recreational	0.055	0.095	0.061	0.063	0.082	0.081	0.179
Wetland	0.199	0.166	0.153	0.154	0.151	0.155	0.147
Water (Ponds and Lakes)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Water (Conveyance)	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Total	**0.230**	**0.219**	**0.173**	**0.184**	**0.203**	**0.237**	**0.230**

Figure 5-9. Screen Capture of LBWM "Volume" Sheet Showing "C" Value Tables for the Wet and Dry Season.

Summaries of the wet and dry season attenuated runoff volumes are provided in two tables, shown in Figure 5-10, below the attenuated "C" value tables. Another table beneath the attenuated runoff volume summaries provides a summary by land use for the overall Lemon Bay watershed and is shown in Figure 5-11.

Pollutant loads for total nitrogen, total phosphorus BOD and TSS are calculated in separate sheets for each pollutant. Computationally the calculations for each pollutant are identical, with only the stormwater concentrations and attenuation factor values different. An example of the pollutant load calculation is shown in Figure 5-12 for total nitrogen. The column labeled "Total N (mg/l)" contains the typical land use stormwater concentration values from the table on the "Parameters" sheet. The loads are calculated by multiplying the land use pollutant concentration with the appropriate generated runoff volume from the "Volume" sheet and converting the values to kilograms. The rows labeled "Total" present the sum of the generated loads for each basin.



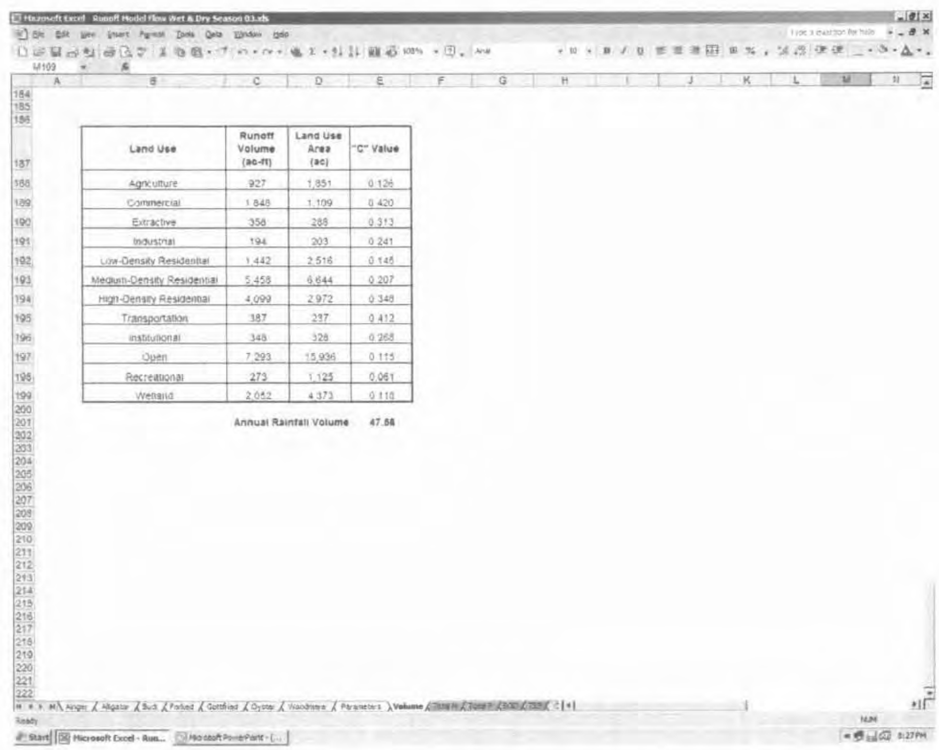
Attenuated Annual Runoff Volume

Land Use	Basin Runoff Volume by Land Use (ac-ft)						
	Oyster Creek	Buck Creek	Ainger Creek	Gottfried Creek	Forked Creek	Alligator Creek	Woodmere Creek
Agriculture	0	7	102	265	518	35	0
Commercial	175	190	144	467	146	699	26
Extractive	71	267	0	0	20	0	0
Industrial	106	41	21	0	0	0	25
Low-Density Residential	91	426	534	154	196	38	4
Medium-Density Residential	882	1,000	255	651	604	1,425	642
High-Density Residential	39	528	37	404	526	2,273	291
Transportation	17	0	16	9	72	269	4
Institutional	30	70	21	63	6	155	2
Open	252	2,530	1,573	1,516	884	436	102
Recreational	12	134	1	33	27	63	3
Wetland	74	315	516	438	404	240	64
Water (Ponds and Lakes)	0	0	0	0	0	0	0
Water (Conveyance)	274	1,287	411	371	513	99	10
Total	**2,023**	**6,796**	**3,633**	**4,371**	**3,916**	**5,734**	**1,173**

Attenuated Annual "C" Values

Land Use	Basin Land Use Annual "C" Values						
	Oyster Creek	Buck Creek	Ainger Creek	Gottfried Creek	Forked Creek	Alligator Creek	Woodmere Creek
Agriculture	---	0.126	0.127	0.126	0.126	0.126	---
Commercial	0.446	0.416	0.431	0.439	0.441	0.399	0.407
Extractive	0.326	0.311	---	---	0.303	---	---
Industrial	0.238	0.241	0.216	---	---	0.000	0.282
Low-Density Residential	0.140	0.148	0.149	0.134	0.143	0.118	0.141
Medium-Density Residential	0.194	0.227	0.179	0.205	0.225	0.201	0.211
High-Density Residential	0.343	0.414	0.323	0.375	0.374	0.326	0.353
Transportation	0.394	---	0.394	0.400	0.397	0.420	0.397
Institutional	0.268	0.270	0.228	0.292	0.229	0.266	0.263
Open	0.110	0.130	0.110	0.108	0.109	0.111	0.103
Recreational	0.037	0.071	0.040	0.045	0.060	0.062	0.136
Wetland	0.166	0.129	0.115	0.116	0.114	0.118	0.109
Water (Ponds and Lakes)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Water (Conveyance)	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Total	0.202	0.186	0.138	0.152	0.169	0.213	0.200

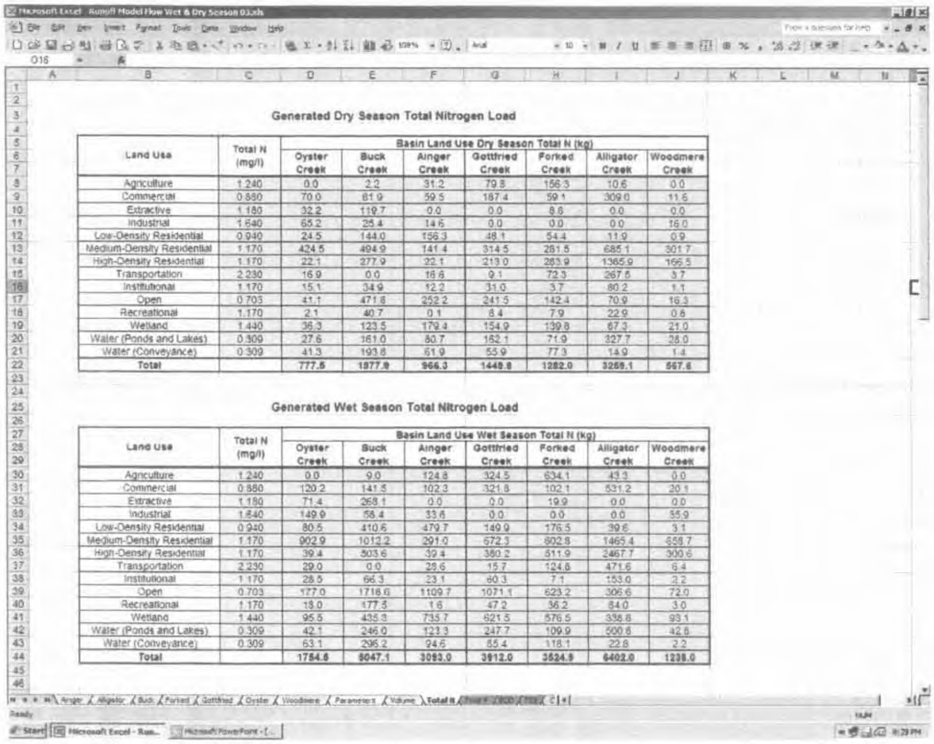
Figure 5-10. Screen Capture of LBWM "Volume" Sheet Showing a Summary of Runoff Volume and "C" Value for the Wet and Dry Season.



Land Use	Runoff Volume (ac-ft)	Land Use Area (ac)	"C" Value
Agriculture	927	1,851	0.126
Commercial	1,848	1,109	0.420
Extractive	358	288	0.313
Industrial	194	203	0.241
Low-Density Residential	1,442	2,516	0.148
Medium-Density Residential	5,458	6,644	0.207
High-Density Residential	4,099	2,972	0.348
Transportation	387	237	0.412
Institutional	348	328	0.268
Open	7,293	15,936	0.115
Recreational	273	1,125	0.061
Wetland	2,052	4,373	0.118

Annual Rainfall Volume **47.58**

Figure 5-11. Screen Capture of LBWM "Volume" Sheet Showing a Summary of Overall Annual Runoff Characteristics by Land Use.



Generated Dry Season Total Nitrogen Load

Land Use	Total N (mg/l)	Basin Land Use Dry Season Total N (kg)						
		Oyster Creek	Buck Creek	Ainger Creek	Gottfried Creek	Forked Creek	Alligator Creek	Woodmere Creek
Agriculture	1.240	0.0	2.2	31.2	79.8	156.3	10.6	0.0
Commercial	0.880	70.0	81.9	59.5	187.4	59.1	309.0	11.6
Extractive	1.180	32.2	119.7	0.0	0.0	8.6	0.0	0.0
Industrial	1.640	65.2	25.4	14.6	0.0	0.0	0.0	16.0
Low-Density Residential	0.940	24.5	144.0	156.3	48.1	54.4	11.9	0.9
Medium-Density Residential	1.170	424.5	494.9	141.4	314.5	281.5	685.1	301.7
High-Density Residential	1.170	22.1	277.9	22.1	213.0	283.9	1365.9	166.5
Transportation	2.230	16.9	0.0	16.6	9.1	72.3	267.6	3.7
Institutional	1.170	15.1	34.9	12.2	31.0	3.7	80.2	1.1
Open	0.703	41.1	471.6	252.2	241.5	142.4	70.9	16.3
Recreational	1.170	2.1	40.7	0.1	8.4	7.9	22.9	0.6
Wetland	1.440	36.3	123.5	179.4	154.9	139.8	67.3	21.0
Water (Ponds and Lakes)	0.309	27.6	161.0	80.7	162.1	71.9	327.7	28.0
Water (Conveyance)	0.309	41.3	193.8	61.9	55.9	77.3	14.9	1.4
Total		**777.6**	**1877.9**	**966.3**	**1448.8**	**1282.0**	**3269.1**	**567.6**

Generated Wet Season Total Nitrogen Load

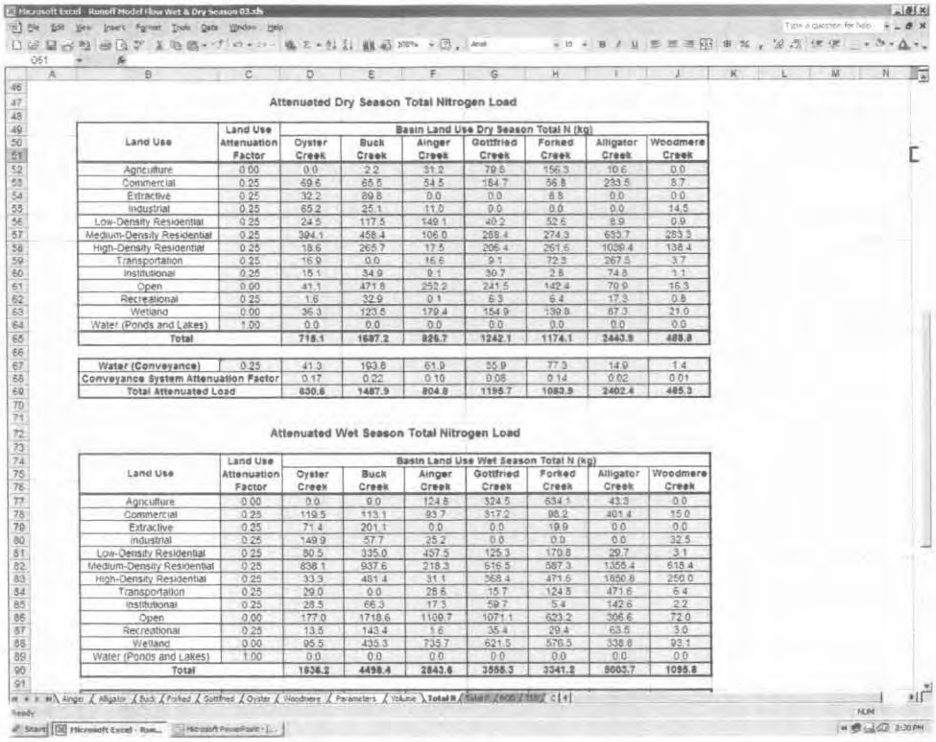
Land Use	Total N (mg/l)	Basin Land Use Wet Season Total N (kg)						
		Oyster Creek	Buck Creek	Ainger Creek	Gottfried Creek	Forked Creek	Alligator Creek	Woodmere Creek
Agriculture	1.240	0.0	9.0	124.8	324.5	634.1	43.3	0.0
Commercial	0.880	120.2	141.5	102.3	321.8	102.1	531.2	20.1
Extractive	1.180	71.4	268.1	0.0	0.0	19.9	0.0	0.0
Industrial	1.640	149.9	58.4	33.6	0.0	0.0	0.0	55.9
Low-Density Residential	0.940	80.5	410.6	479.7	149.9	176.5	39.6	3.1
Medium-Density Residential	1.170	902.9	1012.2	291.0	672.3	602.8	1465.4	658.7
High-Density Residential	1.170	39.4	503.6	39.4	380.2	511.9	2467.7	300.6
Transportation	2.230	29.0	0.0	28.6	15.7	124.8	471.6	6.4
Institutional	1.170	28.5	66.3	23.1	60.3	7.1	153.0	2.2
Open	0.703	177.0	1718.6	1109.7	1071.1	623.2	306.6	72.0
Recreational	1.170	18.0	177.5	1.6	47.2	36.2	84.0	3.0
Wetland	1.440	95.5	435.3	735.7	621.5	576.5	338.8	93.1
Water (Ponds and Lakes)	0.309	42.1	246.0	123.3	247.7	109.9	500.6	42.8
Water (Conveyance)	0.309	63.1	296.2	94.6	85.4	118.1	22.8	2.2
Total		**1764.6**	**5047.1**	**3093.0**	**3912.0**	**3524.9**	**6402.0**	**1238.0**

Figure 5-12. Screen Capture of LBWM "Total N" Sheet Showing Loading Rate Calculations for the Wet and Dry Season.

Attenuation of the generated pollutant loads is calculated the same as the runoff volume attenuation except the generated pollutant loads are substituted for the generated runoff volumes and the appropriate pollutant attenuation factors are substituted for the volume attenuation factors. An example from the "Total N" sheet is shown in Figure 5-13. A summary of the attenuated annual loads is provided at the bottom of the sheet.

5.1.7 Summary Sheet

The last sheet in the model is the "Summary" sheet. This sheet contains a summary of the basin runoff volumes and the pollutant loads on a seasonal and annual basis. These tables are used to generate a series of bar charts which compare the model predictions by basin.



Attenuated Dry Season Total Nitrogen Load

Land Use	Land Use Attenuation Factor	Basin Land Use Dry Season Total N (kg)						
		Oyster Creek	Buck Creek	Ainger Creek	Gottfried Creek	Forked Creek	Alligator Creek	Woodmere Creek
Agriculture	0.00	0.0	2.2	31.2	79.5	156.3	10.6	0.0
Commercial	0.25	69.6	65.5	54.5	164.7	56.8	233.5	8.7
Extractive	0.25	32.2	89.8	0.0	0.0	8.8	0.0	0.0
Industrial	0.25	65.2	25.1	11.0	0.0	0.0	0.0	14.5
Low-Density Residential	0.25	24.5	117.5	149.1	40.2	52.6	8.9	0.9
Medium-Density Residential	0.25	394.1	458.4	106.0	288.4	274.3	635.7	283.3
High-Density Residential	0.25	18.6	265.7	17.5	206.4	261.6	1039.4	138.4
Transportation	0.25	16.9	0.0	16.6	9.1	72.3	267.5	3.7
Institutional	0.25	15.1	34.9	9.1	30.7	2.8	74.8	1.1
Open	0.00	41.1	471.8	252.2	241.5	142.4	70.9	16.3
Recreational	0.25	1.6	32.9	0.1	6.3	6.4	17.3	0.8
Wetland	0.00	36.3	123.5	179.4	154.9	139.8	67.3	21.0
Water (Ponds and Lakes)	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total		**718.1**	**1687.2**	**826.7**	**1242.1**	**1174.1**	**2443.9**	**488.8**
Water (Conveyance)	0.25	41.3	193.8	61.9	55.9	77.3	14.9	1.4
Conveyance System Attenuation Factor		0.17	0.22	0.10	0.06	0.14	0.02	0.01
Total Attenuated Load		**630.6**	**1487.9**	**804.8**	**1195.7**	**1083.9**	**2402.4**	**485.3**

Attenuated Wet Season Total Nitrogen Load

Land Use	Land Use Attenuation Factor	Basin Land Use Wet Season Total N (kg)						
		Oyster Creek	Buck Creek	Ainger Creek	Gottfried Creek	Forked Creek	Alligator Creek	Woodmere Creek
Agriculture	0.00	0.0	9.0	124.8	324.5	634.1	43.3	0.0
Commercial	0.25	119.5	113.1	93.7	317.2	98.2	401.4	15.0
Extractive	0.25	71.4	201.1	0.0	0.0	19.9	0.0	0.0
Industrial	0.25	149.9	57.7	25.2	0.0	0.0	0.0	32.5
Low-Density Residential	0.25	80.5	335.0	457.5	125.3	170.8	29.7	3.1
Medium-Density Residential	0.25	838.1	937.6	218.3	616.5	587.3	1355.4	618.4
High-Density Residential	0.25	33.3	481.4	31.1	368.4	471.6	1850.8	250.0
Transportation	0.25	29.0	0.0	28.6	15.7	124.8	471.6	6.4
Institutional	0.25	28.5	66.3	17.3	59.7	5.4	142.6	2.2
Open	0.00	177.0	1718.6	1109.7	1071.1	623.2	306.6	72.0
Recreational	0.25	13.5	143.4	1.6	35.4	29.4	63.5	3.0
Wetland	0.00	95.5	435.3	735.7	621.5	576.5	338.8	93.1
Water (Ponds and Lakes)	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total		**1636.2**	**4498.4**	**2843.6**	**3558.3**	**3341.2**	**5003.7**	**1095.8**

Figure 5-13. Screen Capture of LBWM "Total N" Sheet Showing Pollutant Load Attenuation Calculations for the Wet and Dry Season.

5.2 Comparison of Measured and Modeled Loadings to Lemon Bay

The Lemon Bay tributary loading model, summarized in Section 5.1, was used to generate estimates of runoff volume as well as mass loadings of total nitrogen, total phosphorus, TSS, and BOD entering Lemon Bay from the evaluated tributaries under existing conditions. For purposes of this evaluation, existing conditions are based upon the land use summaries for Alligator Creek, Woodmere Creek, Forked Creek, Gottfried Creek, Ainger Creek, Oyster Creek, and Buck Creek summarized in Section 4.1.

Measured inputs of runoff volumes and mass loadings are based on the summary of estimated mass loadings from tributaries to Lemon Bay given in Section 2.5. The measured runoff inputs and mass loadings, summarized in Section 2.5, are used primarily for calibration purposes for the modeled parameters. However, as described in Section 2, the field measurements performed by ERD represent only a portion of an annual period. For calibration purposes, the measured loadings are extrapolated to provide estimates of the total mass loadings which would have been observed if the monitoring had been performed for a complete annual cycle. However, for purposes of this evaluation, estimates of loadings to Lemon Bay under current conditions are assumed to be reflected by the loadings predicted by the Lemon Bay Watershed Model. These modeled volumes and loadings under existing conditions are used as the basis of comparison for future loadings as well as pre-development loadings within the basin.

A summary of measured and modeled runoff inputs from primary tributaries in Lemon Bay is given in Table 5-6. This information is presented graphically in Figure 5-14. Differences between the measured and modeled runoff volumes for the evaluated tributaries appear to be relatively small during both dry and wet season conditions. In dry season conditions, the modeled volumes appear to be slightly lower than the measured volumes, while the modeled volumes appear to be slightly greater than measured volumes under wet season conditions. However, on an annual basis, the measured and modeled volumes appear to be very similar. On an overall basis, a difference of only 3% exists between the total discharge volume from the six tributaries under modeled and measured conditions.

A summary of measured and modeled total nitrogen loads from primary tributaries to Lemon Bay is given in Table 5-7. The measured total nitrogen mass loads reflect values summarized in Section 2.5, while the modeled total nitrogen loads reflect outputs from the Lemon Bay Watershed Model. A graphical comparison of measured and modeled mass loadings of total nitrogen to Lemon Bay from the evaluated tributaries is given in Figure 5-15. Similar to the trend exhibited by runoff volume, the modeled total nitrogen loads appear to be slightly lower in most sub-basins during dry season conditions, while higher modeled loadings are observed during wet season conditions. On an annual basis, estimated total nitrogen loadings in

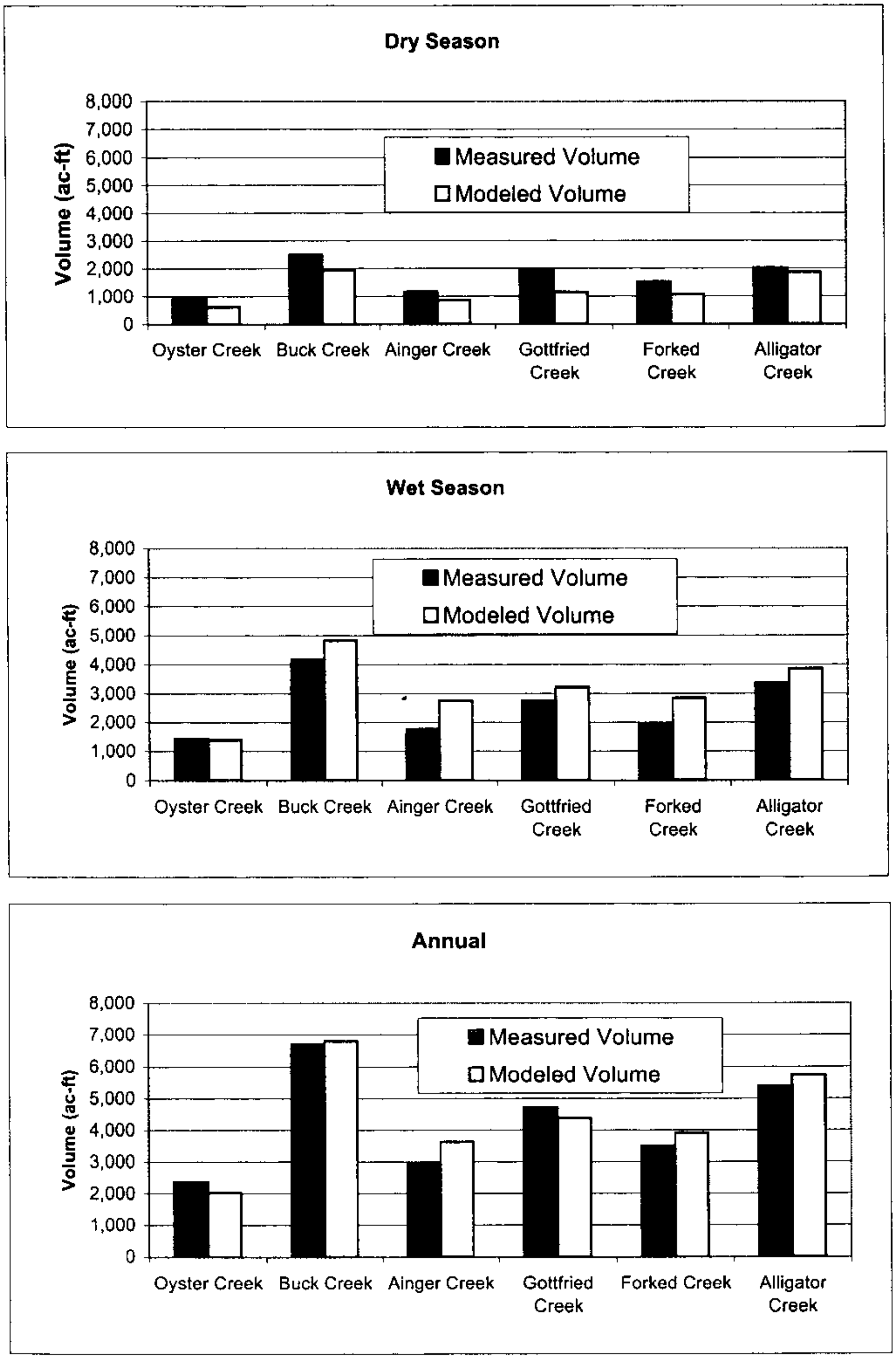


Figure 5-14. Comparison of Measured and Modeled Volumetric Runoff Inputs from Primary Tributaries to Lemon Bay.

TABLE 5-6

SUMMARY OF MEASURED AND MODELED RUNOFF INPUTS FROM PRIMARY TRIBUTARIES TO LEMON BAY

SEASON	MEASURED VOLUME (ac-ft)							
	OYSTER	BUCK	AINGER	GOTTFRIED	FORKED	ALLIGATOR	WOODMERE	TOTAL
Dry	927	2,500	1,177	1,978	1,540	2,024	--	10,145
Wet	1,437	4,188	1,764	2,734	1,956	3,356	--	15,435
Total	2,364	6,688	2,941	4,711	3,496	5,380	--	25,581

SEASON	MODELED VOLUME (ac-ft)							
	OYSTER	BUCK	AINGER	GOTTFRIED	FORKED	ALLIGATOR	WOODMERE	TOTAL
Dry	630	1,965	876	1,157	1,068	1,879	361	7,576
Wet	1,393	4,830	2,756	3,214	2,848	3,855	812	18,896
Total	2,023	6,795	3,633	4,371	3,916	5,734	1,173	26,472

TABLE 5-7

SUMMARY OF MEASURED AND MODELED TOTAL NITROGEN LOADS FROM PRIMARY TRIBUTARIES TO LEMON BAY

SEASON	MEASURED TOTAL N MASS (kg)							
	OYSTER	BUCK	AINGER	GOTTFRIED	FORKED	ALLIGATOR	WOODMERE	TOTAL
Dry	718	2,243	1,143	1,318	1,339	1,693	--	8,454
Wet	1,599	4,620	1,484	2,913	1,765	3,195	--	15,576
Total	2,317	6,863	2,627	4,230	3,104	4,888	--	24,030

SEASON	MODELED TOTAL N MASS (kg)							
	OYSTER	BUCK	AINGER	GOTTFRIED	FORKED	ALLIGATOR	WOODMERE	TOTAL
Dry	631	1,488	805	1,196	1,084	2,402	485	7,605
Wet	1,414	3,771	2,656	3,351	2,990	4,911	1,087	19,093
Total	2,045	5,259	3,461	4,547	4,074	7,313	1,572	26,698

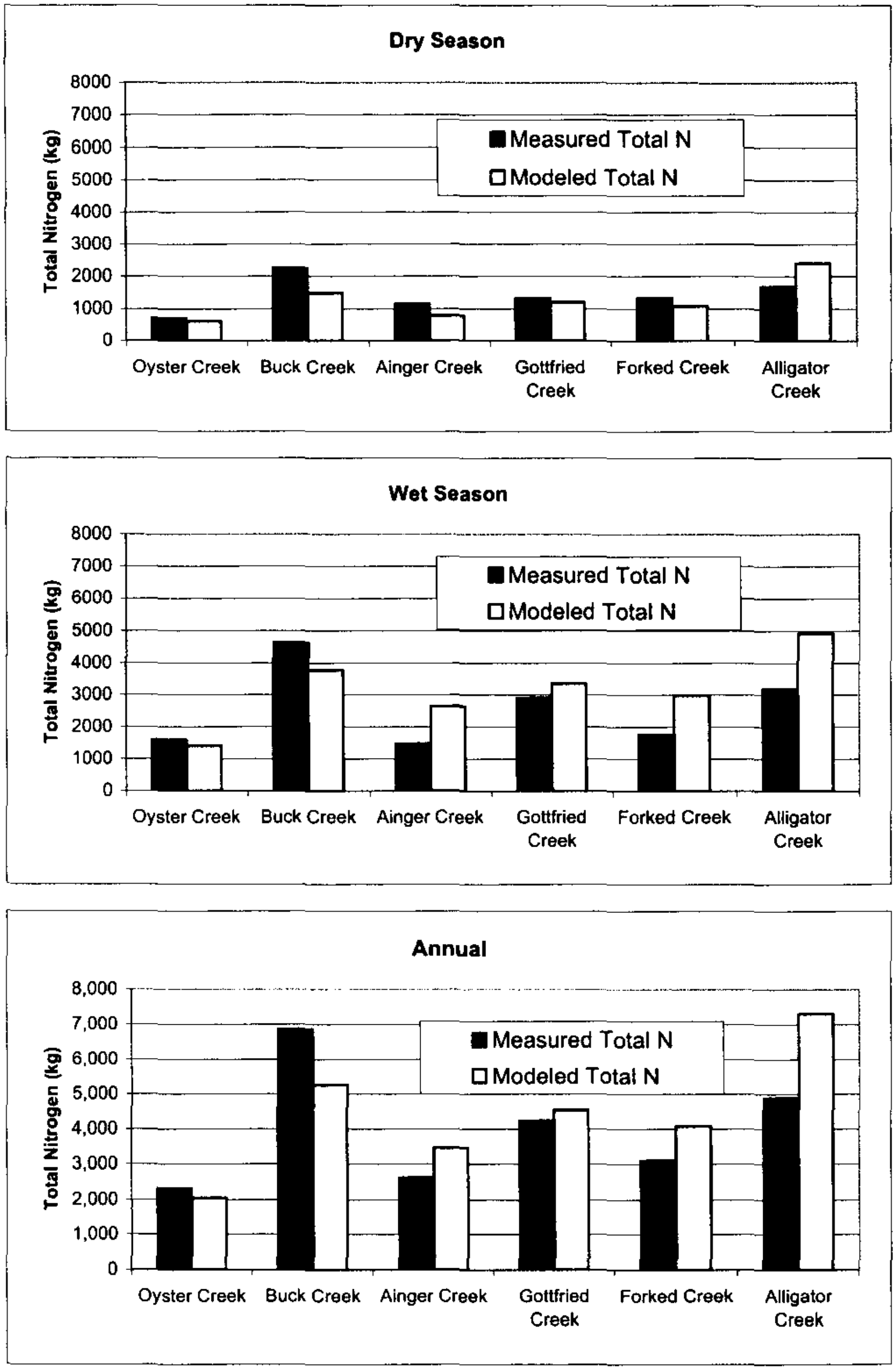


Figure 5-15. Comparison of Measured and Modeled Mass Loadings of Total Nitrogen from Primary Tributaries to Lemon Bay.

Oyster Creek, Ainger Creek, Gottfried Creek, and Forked Creek appear to be relatively similar between the measured and modeled values. However, the measured total nitrogen loads in Buck Creek appear to be somewhat greater than the modeled nitrogen loads, while the reverse situation appears to exist in Alligator Creek. On an annual basis, the difference between the modeled and measured nitrogen loadings is approximately 11%. For purposes of this evaluation, the modeled nitrogen loadings reflected in Table 5-7 and in Figure 5-15 are assumed to represent nitrogen loadings under existing conditions.

A summary of measured and modeled total phosphorus loads from primary tributaries to Lemon Bay is given in Table 5-8. The measured total phosphorus mass loadings are based upon the calculations summarized in Section 2.5, while the modeled total phosphorus loadings reflect the output from the Lemon Bay Watershed Model. A graphical comparison of measured and modeled mass loadings of total phosphorus from primary tributaries to Lemon Bay is given in Figure 5-16. Measured and modeled loading estimates appear to be relatively similar under dry season conditions, although the modeled total phosphorus loadings appear to be somewhat greater in most sub-basins under wet season conditions. On an annual basis, the modeled values suggest higher phosphorus loadings than the measured estimates in five of the six basins. Overall, a difference of approximately 24% exists in estimated phosphorus loadings between the measured and modeled values. However, for purposes of this evaluation, the modeled loadings are assumed to reflect actual phosphorus inputs into Lemon Bay.

A summary of measured and modeled BOD loads from primary tributaries to Lemon Bay is given in Table 5-9. The measured BOD loadings summarized in Table 5-9 are based upon the information provided in Section 2.5, while the modeled BOD loads represent the output data from the Lemon Bay Watershed Model. A graphical comparison of measured and modeled mass loadings of BOD to Lemon Bay from primary tributaries is given in Figure 5-17. Estimates of

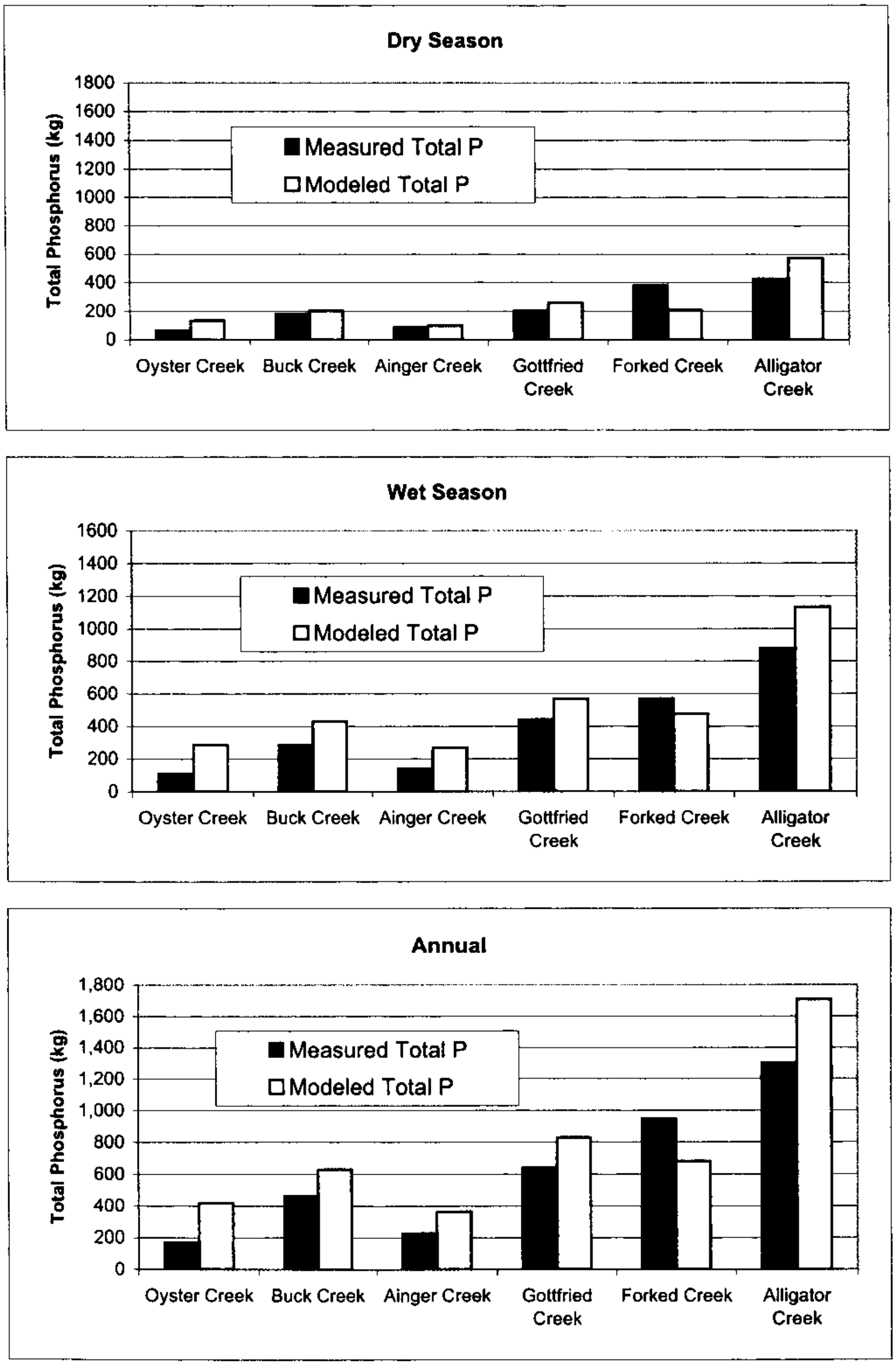


Figure 5-16. Comparison of Measured and Modeled Mass Loadings
of Total Phosphorus from Primary Tributaries to Lemon Bay.

TABLE 5-8

SUMMARY OF MEASURED AND MODELED TOTAL PHOSPHORUS LOADS FROM PRIMARY TRIBUTARIES TO LEMON BAY

SEASON	MEASURED TOTAL P MASS (kg)							
	OYSTER	BUCK	AINGER	GOTTFRIED	FORKED	ALLIGATOR	WOODMERE	TOTAL
Dry	63	177	85	202	379	425	--	1,331
Wet	107	284	141	439	567	877	--	2,416
Total	170	461	226	642	946	1,302	--	3,747

SEASON	MODELED TOTAL P MASS (kg)							
	OYSTER	BUCK	AINGER	GOTTFRIED	FORKED	ALLIGATOR	WOODMERE	TOTAL
Dry	134	202	98	260	209	573	158	1,476
Wet	284	430	268	568	476	1,133	333	3,158
Total	417	632	366	829	684	1,706	491	4,634

TABLE 5-9

SUMMARY OF MEASURED AND MODELED BOD LOADS FROM PRIMARY TRIBUTARIES TO LEMON BAY

SEASON	MEASURED BOD MASS (kg)							
	OYSTER	BUCK	AINGER	GOTTFRIED	FORKED	ALLIGATOR	WOODMERE	TOTAL
Dry	1,143	3,079	1,450	3,897	1,896	2,493	--	13,957
Wet	2,965	15,732	4,942	8,418	9,095	11,264	--	52,416
Total	4,107	18,811	6,392	12,315	10,991	13,757	--	66,373

SEASON	MODELED BOD MASS (kg)							
	OYSTER	BUCK	AINGER	GOTTFRIED	FORKED	ALLIGATOR	WOODMERE	TOTAL
Dry	1,939	4,721	1,852	2,762	2,828	5,994	1,066	20,095
Wet	4,151	10,579	5,348	6,957	6,965	11,723	2,307	45,725
Total	6,090	15,300	7,200	9,719	9,793	17,717	3,372	65,820

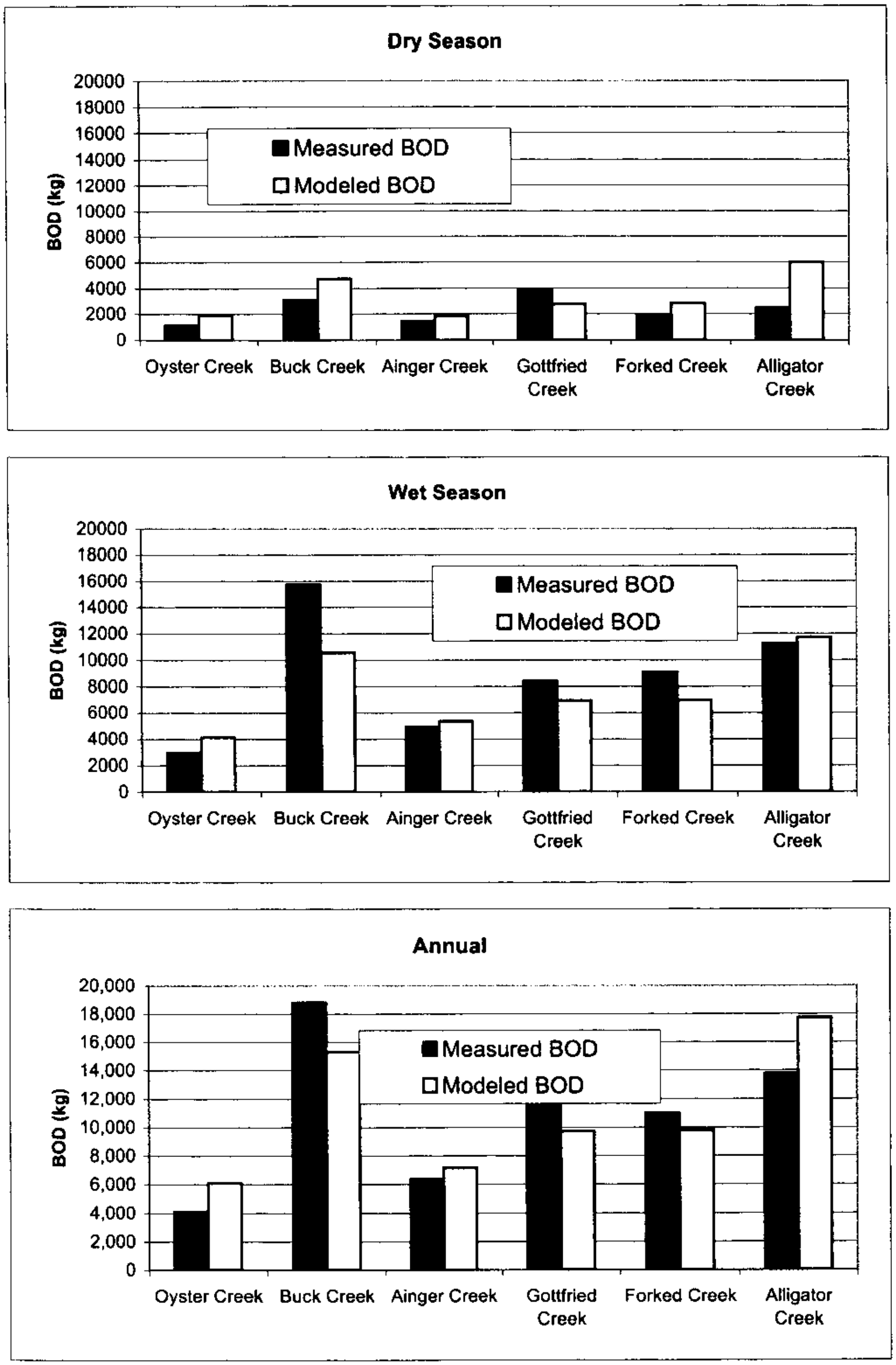
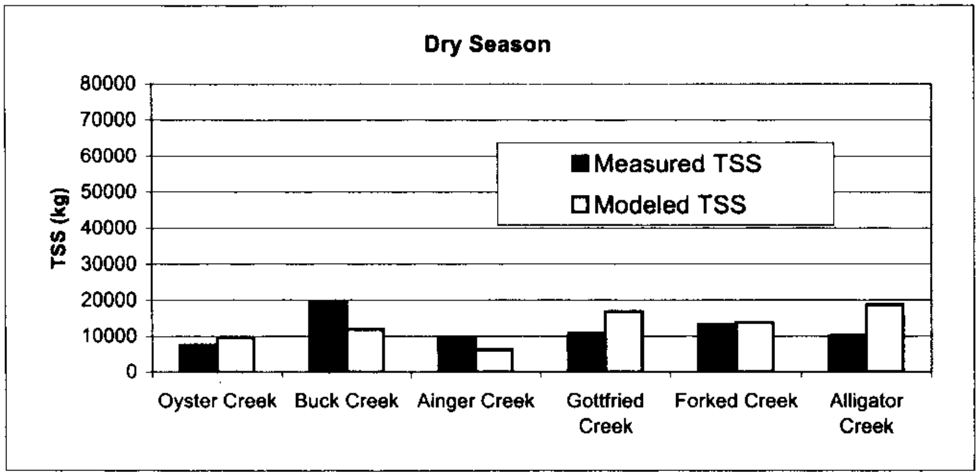
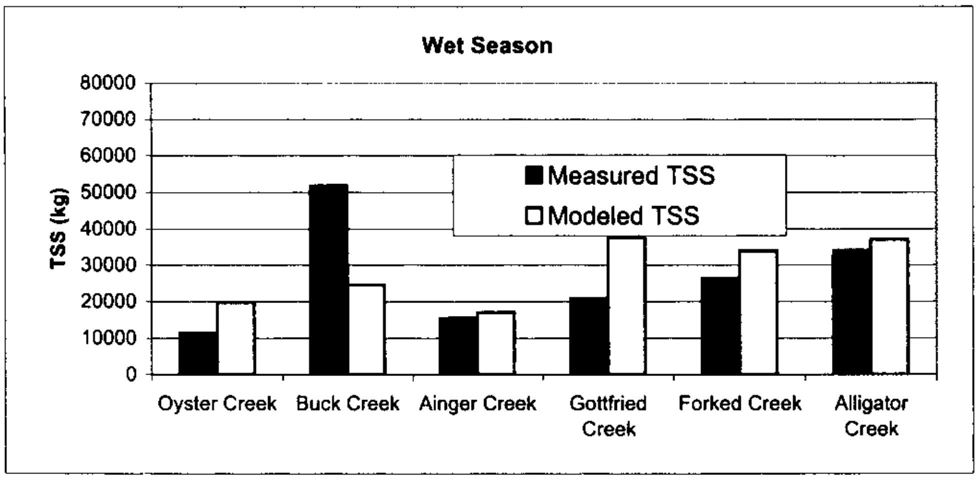


Figure 5-17. Comparison of Measured and Modeled Mass Loadings of BOD from Primary Tributaries to Lemon Bay.

wet season and dry season loadings appear to be relatively similar in most watersheds between the measured and modeled values. The only exception to this may be Buck Creek which exhibits a somewhat greater measured BOD load under wet season conditions. However, on an overall basis, the difference between annual total loads of BOD to Lemon Bay is less than 1% between the measured and modeled values. For purposes of this evaluation, the modeled BOD loads summarized in Table 5-9 and in Figure 5-17 are assumed to represent BOD loads under existing conditions.

A summary of measured and modeled TSS loads from primary tributaries to Lemon Bay is given in Table 5-10. Measured TSS mass loadings are based upon the information provided in Section 2.5, while the modeled TSS loadings reflect output data from the Lemon Bay Watershed Model. A graphical comparison of measured and modeled TSS loadings to Lemon Bay from primary tributaries is given in Figure 5-18. In general, the measured and modeled TSS loads appear to be relatively similar between the evaluated watersheds with the exception of the Buck Creek watershed. This difference is even more noticeable when the loads are compared on an annual basis. Overall, the difference between measured and modeled TSS loadings to Lemon Bay on an annual basis is approximately 7%. For purposes of this evaluation, the modeled TSS loadings summarized in Table 5-10 and in Figure 5-18 are assumed to represent TSS loadings to Lemon Bay under existing conditions.





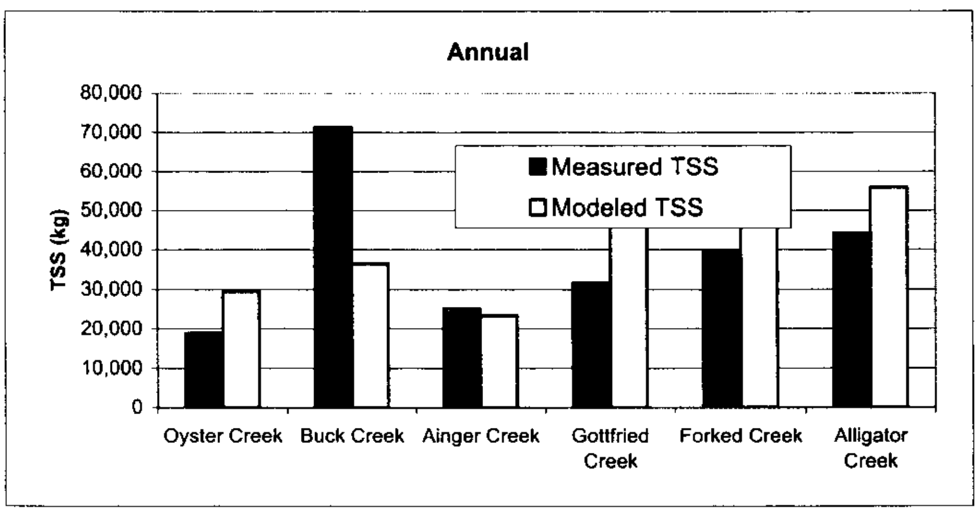


Figure 5-18. Comparison of Measured and Modeled Mass Loadings of TSS from Primary Tributaries to Lemon Bay.

TABLE 5-10

SUMMARY OF MEASURED AND MODELED TSS LOADS FROM PRIMARY TRIBUTARIES TO LEMON BAY

SEASON	MEASURED TSS MASS (kg)							
	OYSTER	BUCK	AINGER	GOTTFRIED	FORKED	ALLIGATOR	WOODMERE	TOTAL
Dry	7,497	19,552	9,762	10,717	13,273	10,138	--	70,940
Wet	11,374	51,839	15,451	20,960	26,382	33,998	--	160,003
Total	18,871	71,391	25,213	31,677	39,656	44,136	--	230,943

SEASON	MODELED TSS MASS (kg)							
	OYSTER	BUCK	AINGER	GOTTFRIED	FORKED	ALLIGATOR	WOODMERE	TOTAL
Dry	9,556	11,944	6,275	16,904	13,822	18,754	4,719	77,255
Wet	19,860	24,546	17,083	37,461	33,911	37,091	10,084	169,954
Total	29,417	36,491	23,359	54,365	47,733	55,844	14,803	247,209

5.3 Estimates of Future Loadings to Lemon Bay

Estimates of runoff volume and mass loadings to Lemon Bay under future conditions were evaluated for each of the primary tributary basins. For purposes of this evaluation, future conditions are assumed to be the built-out conditions which are summarized in Section 4.2. These estimates assume that all available land within the basin has been converted to developed land based upon current developed land use ratios within the overall Lemon Bay watershed. The estimates of future loadings were generated using the Lemon Bay Watershed Model by substituting the future land use characteristics within the basin, summarized in Section 4.2, for the existing land use characteristics. For purposes of this evaluation, it is assumed that all future development will be constructed with stormwater management systems designed according to current design criteria. It is also assumed that these systems will achieve a reduction of approximately 25% for total nitrogen, 60% for total phosphorus, 85% for TSS, and 60% for BOD.

A summary of estimated loadings from primary tributaries to Lemon Bay under future built-out conditions is given in Table 5-11. Estimates of runoff volume and mass loadings are provided for Oyster Creek, Buck Creek, Ainger Creek, Gottfried Creek, Forked Creek, Alligator creek, and Woodmere Creek.

A graphical comparison of current and future runoff inputs to Lemon Bay from the primary tributaries is given in Figure 5-19. Current runoff volumes are assumed to be the modeled runoff volumes summarized in Section 5.2. Future runoff volumes are calculated using the Lemon Bay Watershed Model based upon the future land use characteristics summarized in Section 4.2. As seen in Figure 5-19, runoff inputs into Lemon Bay are expected to increase for each of the evaluated basins under built-out conditions during both dry and wet season conditions. Relatively large increases in annual runoff inputs to Lemon Bay are anticipated in Buck Creek, Ainger Creek, Gottfried Creek, and Forked Creek, while minimal increases in runoff volumes are anticipated in Oyster Creek, Alligator Creek, and Woodmere Creek. Overall, the volume of runoff entering Lemon Bay under future conditions is estimated to increase by approximately 27% compared with modeled existing conditions.

A comparison of current and future nitrogen loads to Lemon Bay from the primary tributaries is given in Figure 5-20. Increases in nitrogen loadings are anticipated in each of the evaluated basins under future conditions compared with values existing under current conditions. On an annual basis, relatively significant increases in total nitrogen are anticipated in Buck, Ainger, Gottfried, and Forked Creeks, with smaller increases predicted for Oyster, Alligator, and Woodmere Creeks. Overall, total nitrogen loadings to Lemon Bay are expected to increase by approximately 44% under future conditions compared with existing modeled loadings.

A graphical comparison of current and future phosphorus loads to Lemon Bay from the primary tributaries is given in Figure 5-21. Phosphorus loads under future conditions are predicted to increase in each evaluated watershed under both dry and wet season conditions. Relatively significant increases in annual phosphorus loads are anticipated in Buck, Ainger, Gottfried, and Forked Creeks, with minimal increases predicted for Oyster, Alligator, and Woodmere Creeks. Overall, phosphorus loads to Lemon Bay are expected to increase approximately 53% compared with predicted loads under current conditions.

TABLE 5-11

ESTIMATED LOADINGS FROM PRIMARY TRIBUTARIES TO LEMON BAY UNDER FUTURE BUILT-OUT CONDITIONS

SEASON	VOLUME (ac-ft)							
	OYSTER	BUCK	AINGER	GOTTFRIED	FORKED	ALLIGATOR	WOODMERE	TOTAL
Dry	725	2,798	1,618	1,900	1,654	2,074	411	11,180
Wet	1,468	5,553	3,432	3,816	3,397	4,032	867	22,564
Total	2,193	8,351	5,050	5,716	5,050	6,106	1,278	33,744

SEASON	TOTAL N LOAD (kg)							
	OYSTER	BUCK	AINGER	GOTTFRIED	FORKED	ALLIGATOR	WOODMERE	TOTAL
Dry	735	2,276	1,683	2,075	1,702	2,641	548	11,660
Wet	1,616	5,354	4,155	4,738	3,944	5,680	1,242	26,729
Total	2,351	7,630	5,838	6,813	5,646	8,321	1,790	38,839

SEASON	TOTAL P LOAD (kg)							
	OYSTER	BUCK	AINGER	GOTTFRIED	FORKED	ALLIGATOR	WOODMERE	TOTAL
Dry	153	278	292	460	334	638	174	2,330
Wet	322	564	626	926	690	1,260	368	4,756
Total	475	842	919	1,386	1,024	1,898	542	7,086

SEASON	BOD LOAD (kg)							
	OYSTER	BUCK	AINGER	GOTTFRIED	FORKED	ALLIGATOR	WOODMERE	TOTAL
Dry	2,051	5,608	2,857	3,767	3,476	6,213	1,129	25,101
Wet	4,247	11,208	6,153	7,634	7,089	11,828	2,367	50,527
Total	6,298	16,816	9,010	11,401	10,565	18,041	3,496	75,628

SEASON	TSS LOAD (kg)							
	OYSTER	BUCK	AINGER	GOTTFRIED	FORKED	ALLIGATOR	WOODMERE	TOTAL
Dry	9,790	9,408	8,853	18,702	13,623	19,265	4,917	84,558
Wet	20,184	17,745	18,475	35,571	26,824	36,747	10,303	165,848
Total	29,974	27,153	27,328	54,273	40,447	56,012	15,220	250,406

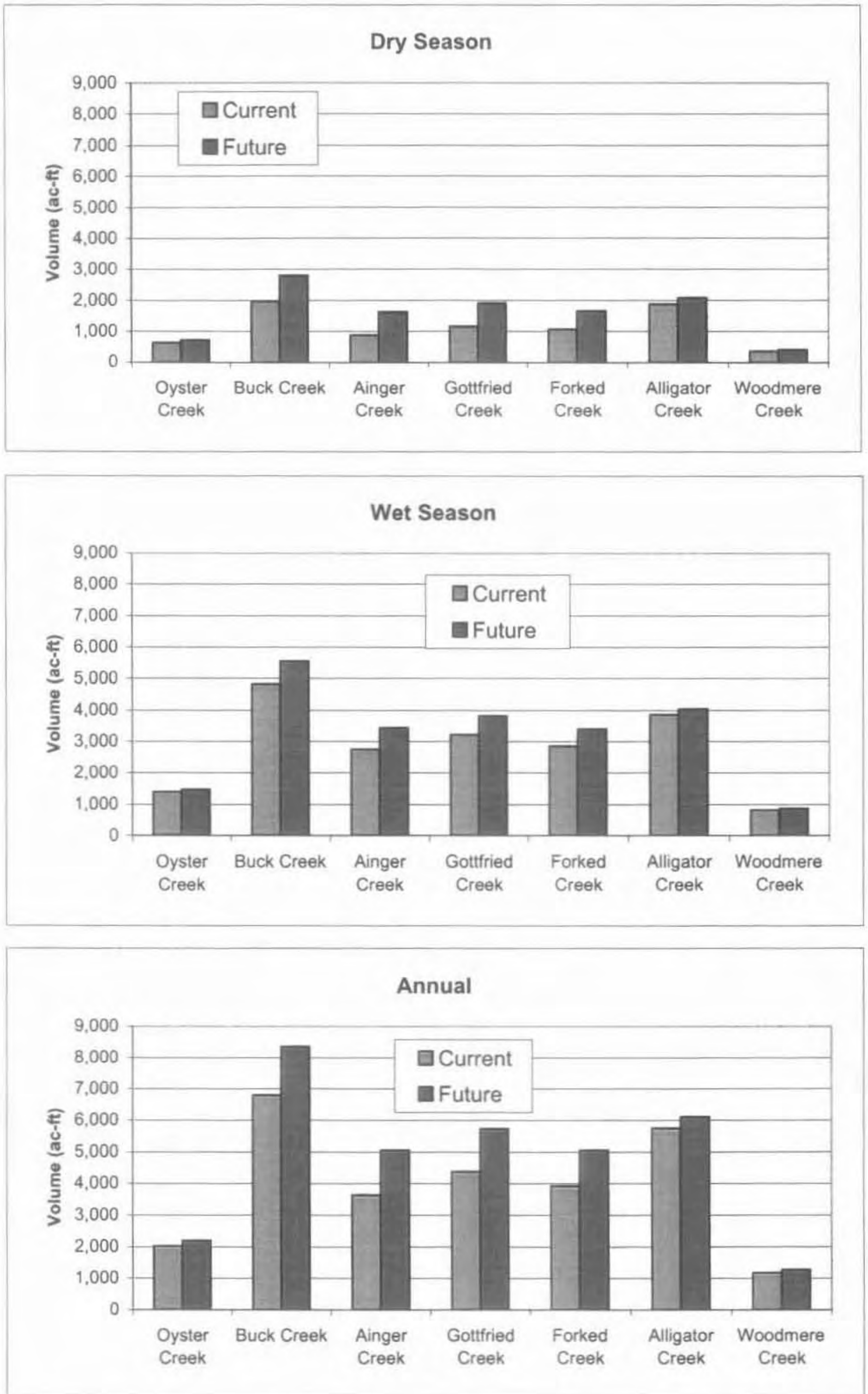


Figure 5-19. Comparison of Current and Future Runoff Inputs to Lemon Bay from Primary Tributaries.

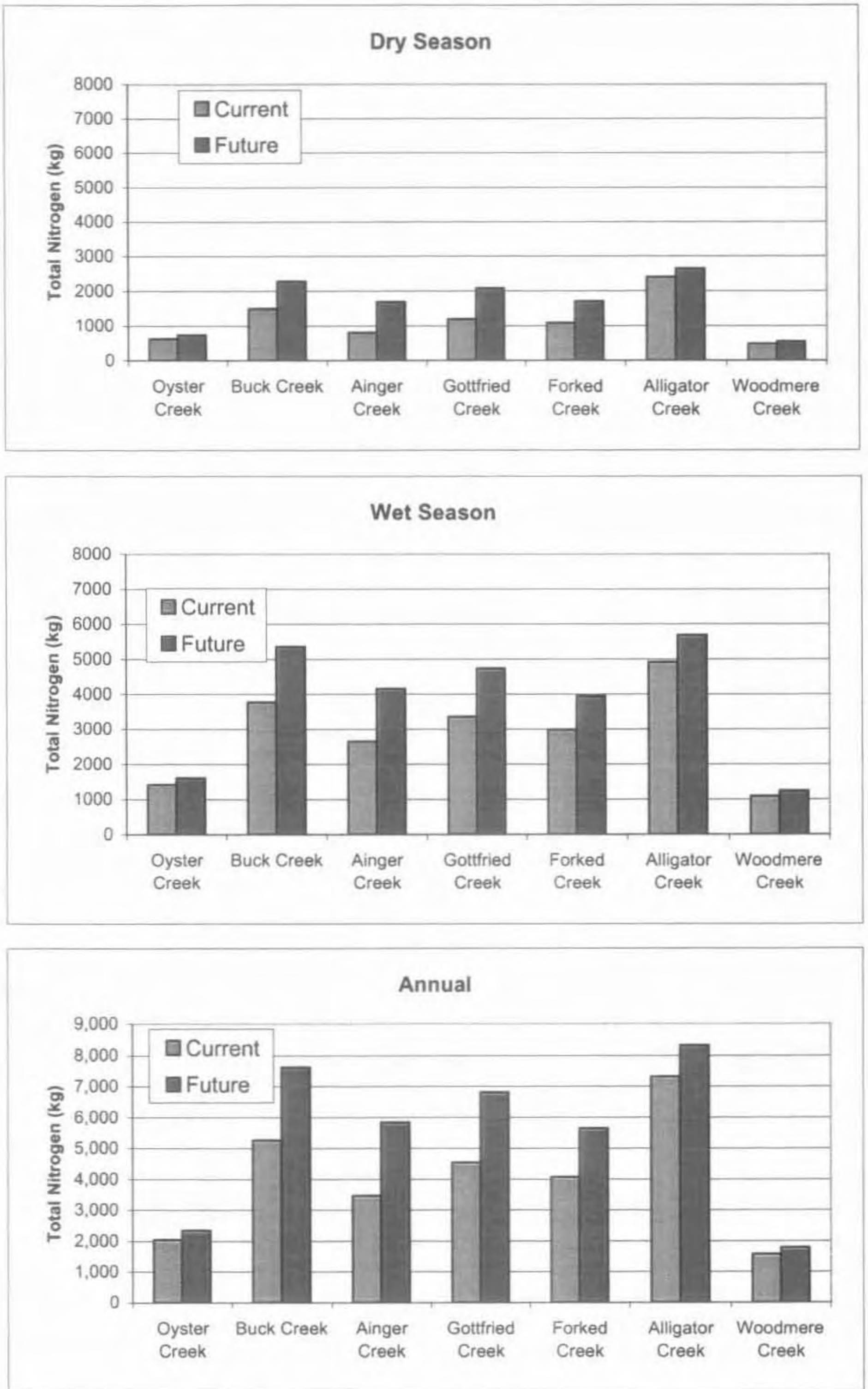


Figure 5-20. Comparison of Current and Future Nitrogen Loads to Lemon Bay from Primary Tributaries.

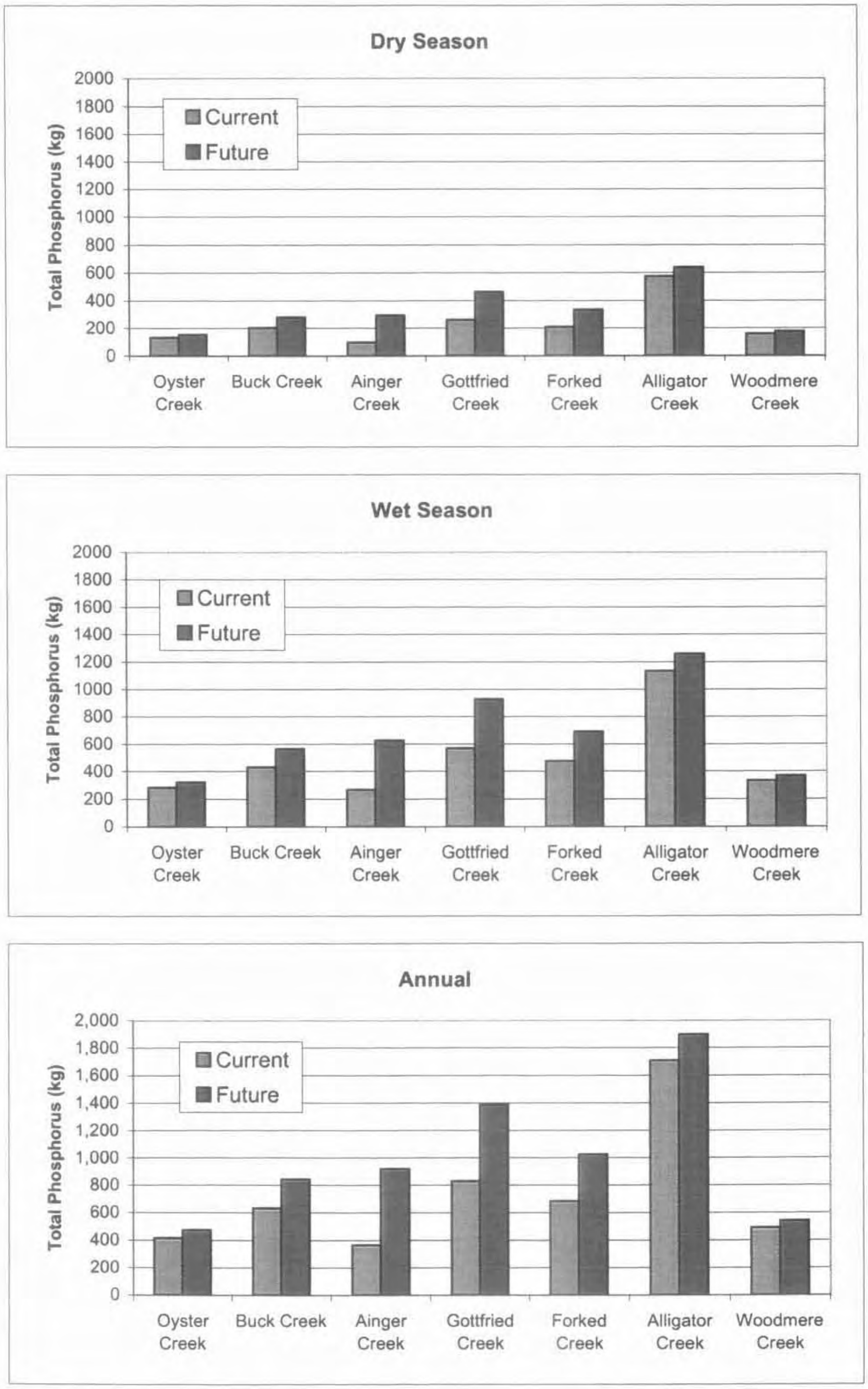


Figure 5-21. Comparison of Current and Future Phosphorus Loads to Lemon Bay from Primary Tributaries.

A graphical comparison of current and future BOD loads to Lemon Bay from the primary tributaries is given in Figure 5-22. Under future conditions, BOD loads are expected to increase in each of the seven watersheds under both dry and wet season conditions. However, on an annual basis, the predicted increases in BOD under future conditions appear to be relatively small. Overall, a BOD increase of approximately 15% is anticipated under future conditions compared with existing estimates.

A graphical comparison of current and future TSS loads to Lemon Bay from the primary tributaries is given in Figure 5-23. In contrast to the trends observed for the previously evaluated parameters, no significant increase is TSS is expected under future built-out conditions. This difference is due primarily to two factors. First, several of the basins have large areas of agricultural lands under existing conditions which exhibit a relatively high loading for suspended solids. Under future conditions, these land uses will be converted to residential areas which will be equipped with stormwater treatment systems. Second, the high efficiency for suspended solids achieved in stormwater management systems serves to substantially reduce any potential impacts of suspended solids under future conditions. Under future conditions, suspended solids are projected to increase by approximately 1% within the basin.

5.4 Estimates of Watershed Loadings Under Undeveloped Conditions

Estimates of mass loadings from the Lemon Bay watershed were estimated for each of the seven primary tributaries for undeveloped conditions prior to significant human impact within the Lemon Bay basin. For purposes of this analysis, areas identified as containing wetland soils on the soils maps for the basin are assumed to have been wetlands under pre-development conditions. Ponds and lakes which appear to have been naturally occurring are also assumed to have existed under undeveloped conditions. The remaining current developed areas and agricultural areas are allocated to the categories of open land and wetlands based upon the assumptions that a wetland loss of approximately 20% has occurred within the basin as a result

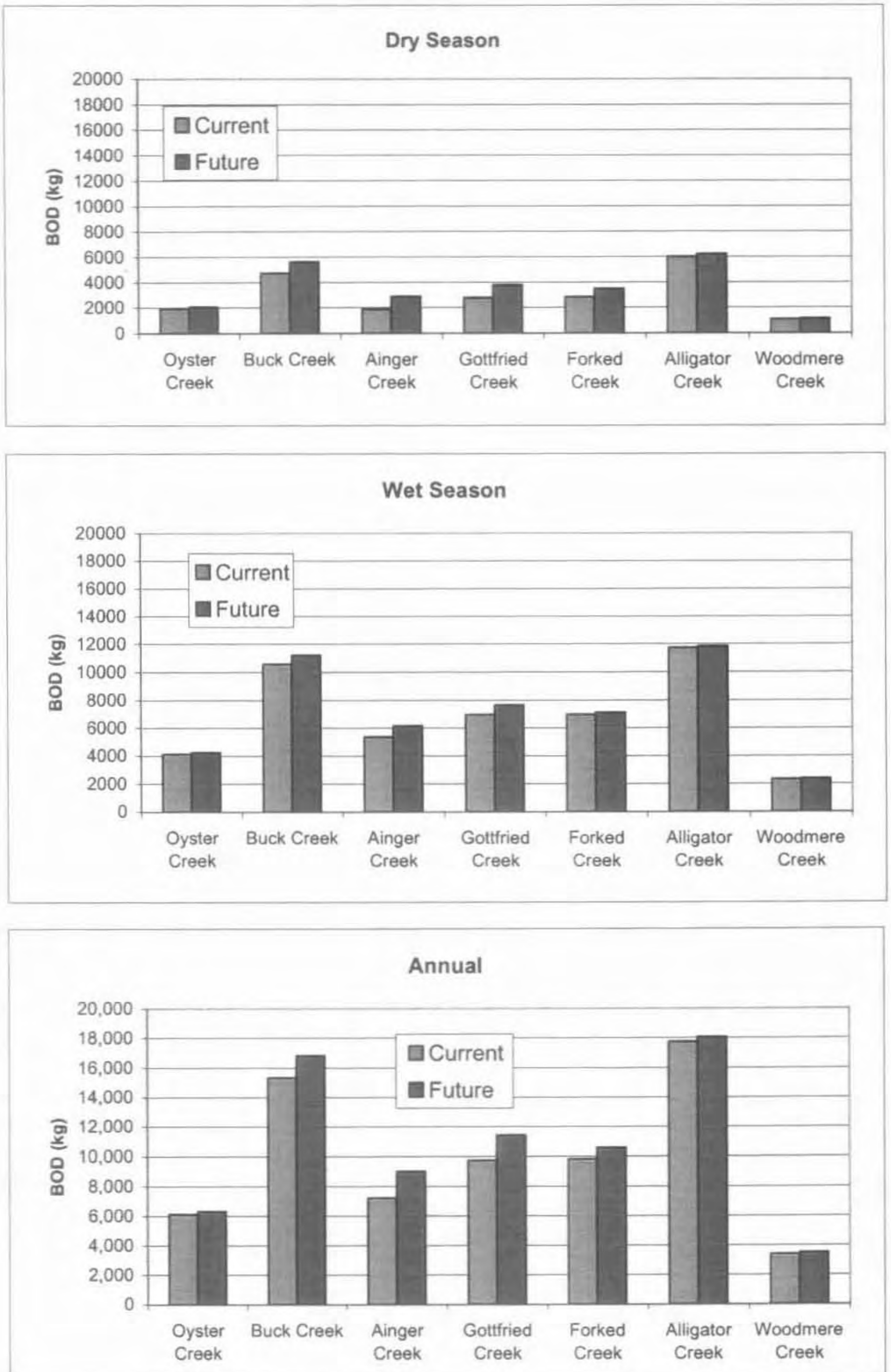


Figure 5-22. Comparison of Current and Future BOD Loads to Lemon Bay from Primary Tributaries.

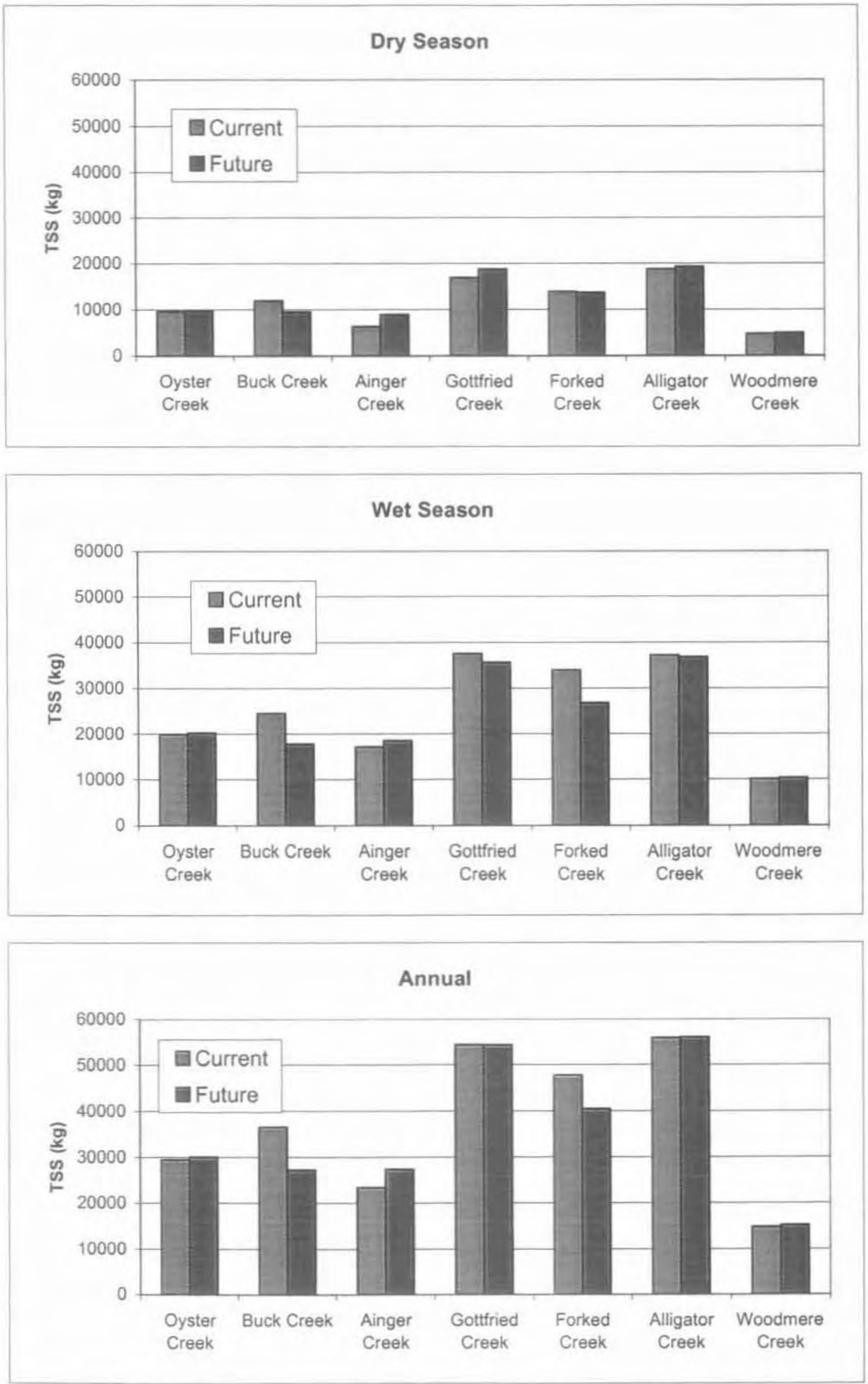


Figure 5-23. Comparison of Current and Future TSS Loads to Lemon Bay from Primary Tributaries.

of development within the basin. The resulting assumed undeveloped land use characteristics for each of the basins are given in Table 5-12.

TABLE 5-12

SUMMARY OF ASSUMED BASIN LAND USE AREAS FOR UNDEVELOPED CONDITIONS

LAND USE	LAND USE AREA (acres)						
	Oyster Creek	Buck Creek	Ainger Creek	Gottfried Creek	Forked Creek	Alligator Creek	Woodmere Creek
Agriculture	0	0	0	0	0	0	0
Commercial	0	0	0	0	0	0	0
Extractive	0	0	0	0	0	0	0
Industrial	0	0	0	0	0	0	0
Low-Density Residential	0	0	0	0	0	0	0
Medium-Density Residential	0	0	0	0	0	0	0
High-Density Residential	0	0	0	0	0	0	0
Transportation	0	0	0	0	0	0	0
Institutional	0	0	0	0	0	0	0
Open	1,934	7,359	4,918	5,483	4,170	4,841	1,071
Recreational	0	0	0	0	0	0	0
Wetland	530	1,531	1,576	1,502	1,568	1,827	396
Water (ponds and lakes)	0	19	40	199	78	95	8
Water (conveyance)	67	302	102	88	44	25	0
TOTAL:	**2,530**	**9,211**	**6,637**	**7,272**	**5,860**	**6,787**	**1,475**

The land uses summarized in Table 5-12 were input into the Lemon Bay Watershed Model to generate estimated loadings from the primary tributaries to Lemon Bay under undeveloped conditions. A summary of estimated loadings from primary tributaries to Lemon Bay under undeveloped conditions is given in Table 5-13 for runoff volume, total nitrogen, total phosphorus, BOD, and TSS.

TABLE 5-13

ESTIMATED LOADINGS FROM PRIMARY TRIBUTARIES TO LEMON BAY UNDER UNDEVELOPED CONDITIONS

SEASON	VOLUME (ac-ft)							
	OYSTER	BUCK	AINGER	GOTTFRIED	FORKED	ALLIGATOR	WOODMERE	TOTAL
Dry	342	1,581	773	716	601	847	128	4,988
Wet	1,078	4,431	2,660	2,637	2,206	2,730	517	16,259
Total	1,420	6,013	3,434	3,353	2,807	3,577	644	21,247

SEASON	TOTAL N LOAD (kg)							
	OYSTER	BUCK	AINGER	GOTTFRIED	FORKED	ALLIGATOR	WOODMERE	TOTAL
Dry	270	1,160	718	651	584	1,089	154	4,626
Wet	896	3,347	2,538	2,501	2,122	3,206	588	15,198
Total	1,166	4,507	3,256	3,152	2,706	4,294	742	19,824

SEASON	TOTAL P LOAD (kg)							
	OYSTER	BUCK	AINGER	GOTTFRIED	FORKED	ALLIGATOR	WOODMERE	TOTAL
Dry	14	51	38	35	27	62	8	234
Wet	38	125	121	120	91	171	31	696
Total	52	177	159	155	117	233	39	931

SEASON	BOD LOAD (kg)							
	OYSTER	BUCK	AINGER	GOTTFRIED	FORKED	ALLIGATOR	WOODMERE	TOTAL
Dry	679	3,010	1,540	1,352	1,178	1,959	255	9,973
Wet	1,885	7,416	4,774	4,552	3,951	5,478	957	29,014
Total	2,564	10,427	6,314	5,904	5,129	7,437	1,212	38,988

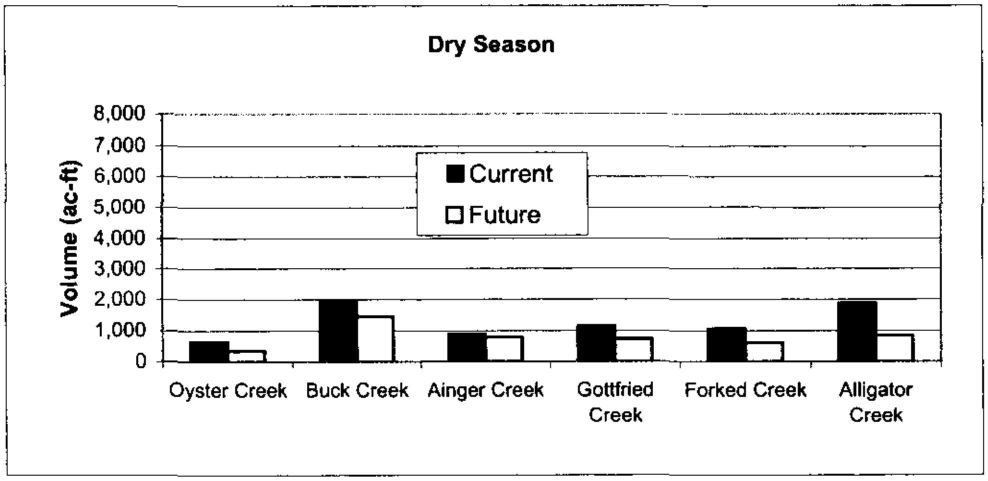
SEASON	TSS LOAD (kg)							
	OYSTER	BUCK	AINGER	GOTTFRIED	FORKED	ALLIGATOR	WOODMERE	TOTAL
Dry	1,663	6,548	4,301	3,727	3,079	6,912	846	27,075
Wet	4,245	14,580	12,562	11,928	9,735	17,794	3,000	73,845
Total	5,908	21,128	16,863	15,655	12,814	24,706	3,846	100,920

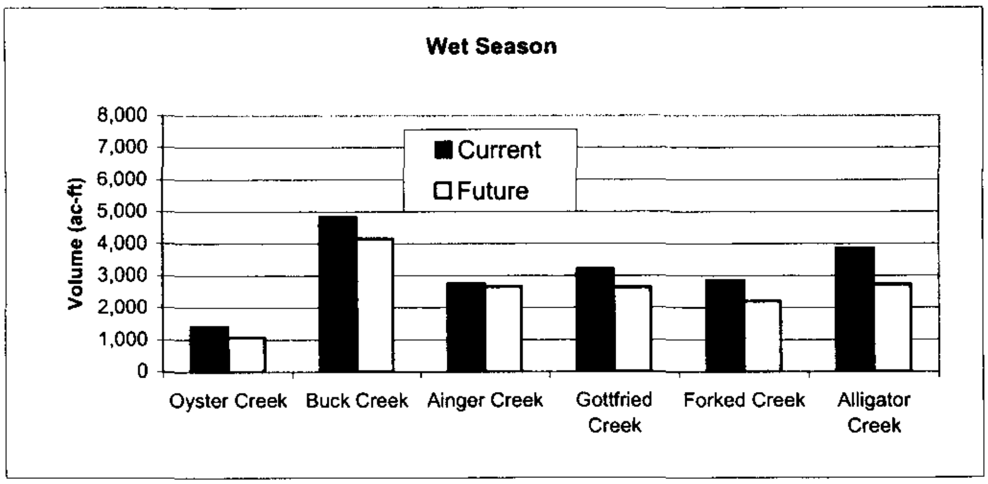
A graphical comparison of current and undeveloped runoff inputs to Lemon Bay from the primary tributaries is given in Figure 5-24. The estimated undeveloped runoff inputs discharging to Lemon Bay are less than the current estimated inputs under both wet and dry season conditions. These differences appear even greater on an annual basis. Based upon the estimated annual volumetric inputs to Lemon Bay under current conditions, summarized in Table 5-6, and the estimated annual volumetric inputs under undeveloped conditions, summarized in Table 5-14, a volumetric increase of approximately 25% has occurred within the Lemon Bay watershed as a result of development activities.

A graphical comparison of current and undeveloped nitrogen loadings to Lemon Bay from the primary tributaries is given in Figure 5-25. Estimates of current nitrogen loadings to Lemon Bay exceed pre-development loadings under both dry and wet season conditions. The differences appear to be even more extreme when evaluated under annual loading conditions. The increases in nitrogen loadings are particularly apparent in the Gottfried, Forked, and Alligator Creek basins. Overall, nitrogen loadings to Lemon Bay appear to have increased approximately 35% under existing conditions compared with estimates occurring under undeveloped conditions.

A graphical comparison of current and undeveloped phosphorus loadings to Lemon Bay from the primary tributaries is given in Figure 5-26. Current phosphorus loadings to Lemon Bay appear to be significantly higher than undeveloped loadings under both wet season and dry season conditions, as well as on an average annual basis. Increases in phosphorus loadings are particularly apparent in the Gottfried, Forked, and Alligator Creek basins. Overall, phosphorus loadings appear to have increased approximately 398% within the basin under existing conditions compared with estimates of pre-development loadings.

A graphical comparison of current and undeveloped BOD loadings to Lemon Bay from the primary tributaries is given in Figure 5-27. BOD loadings appear to have increased under existing conditions during both wet and dry season flows. On an annual basis, significant increases in BOD loadings are apparent in Buck, Gottfried, Forked, and Alligator Creek basins under current conditions compared with estimates of undeveloped values. Overall, BOD loadings





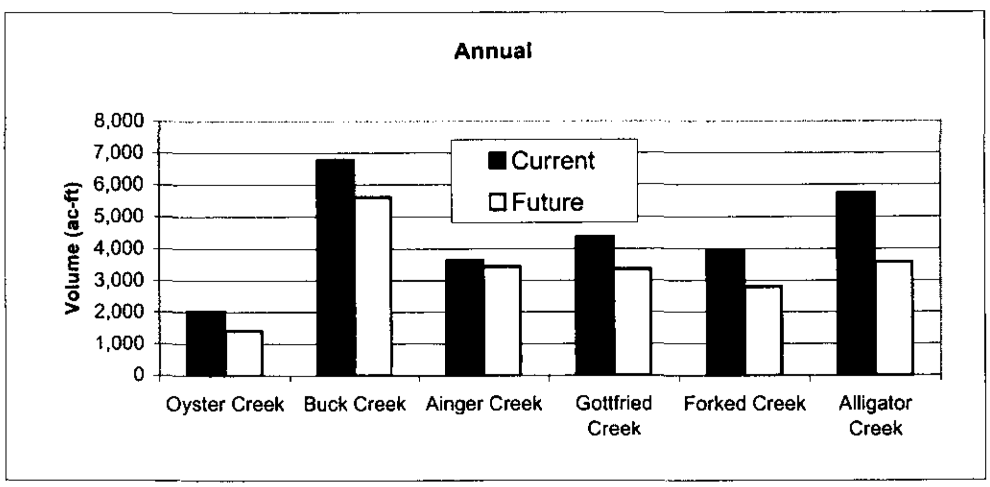
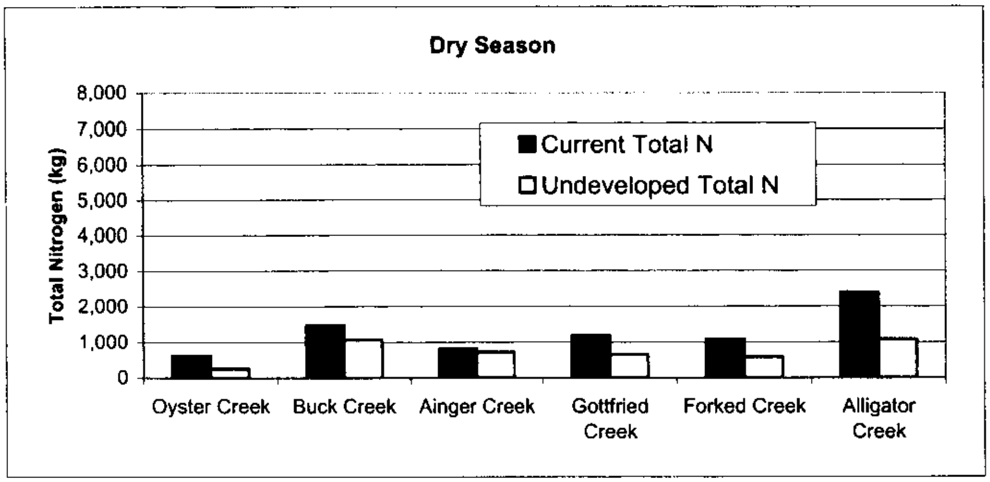
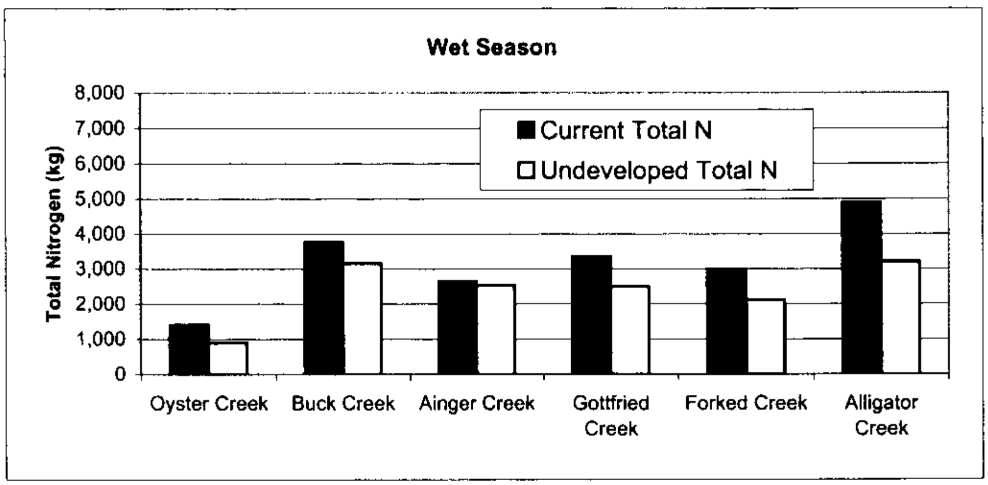


Figure 5-24. Comparison of Current and Undeveloped Runoff Inputs to Lemon Bay from Primary Tributaries.





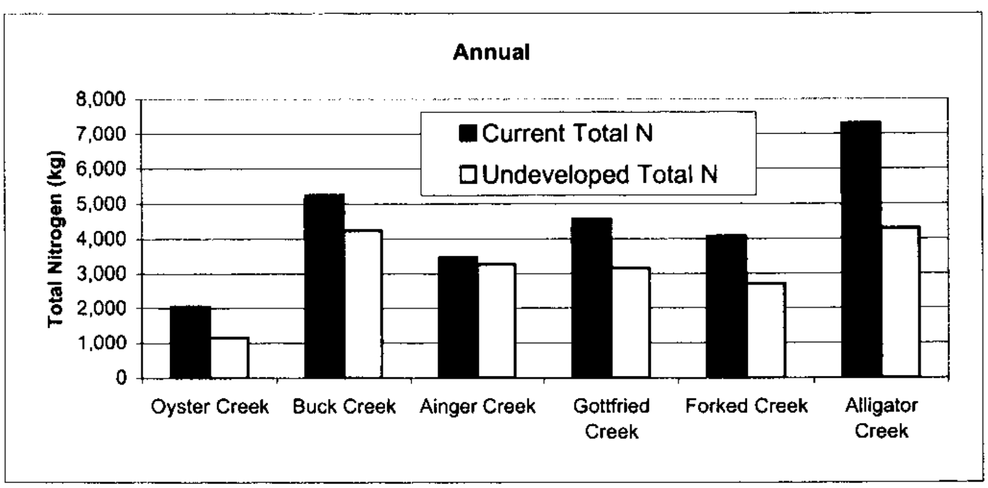


Figure 5-25. Comparison of Current and Undeveloped Nitrogen Loads to Lemon Bay from Primary Tributaries.

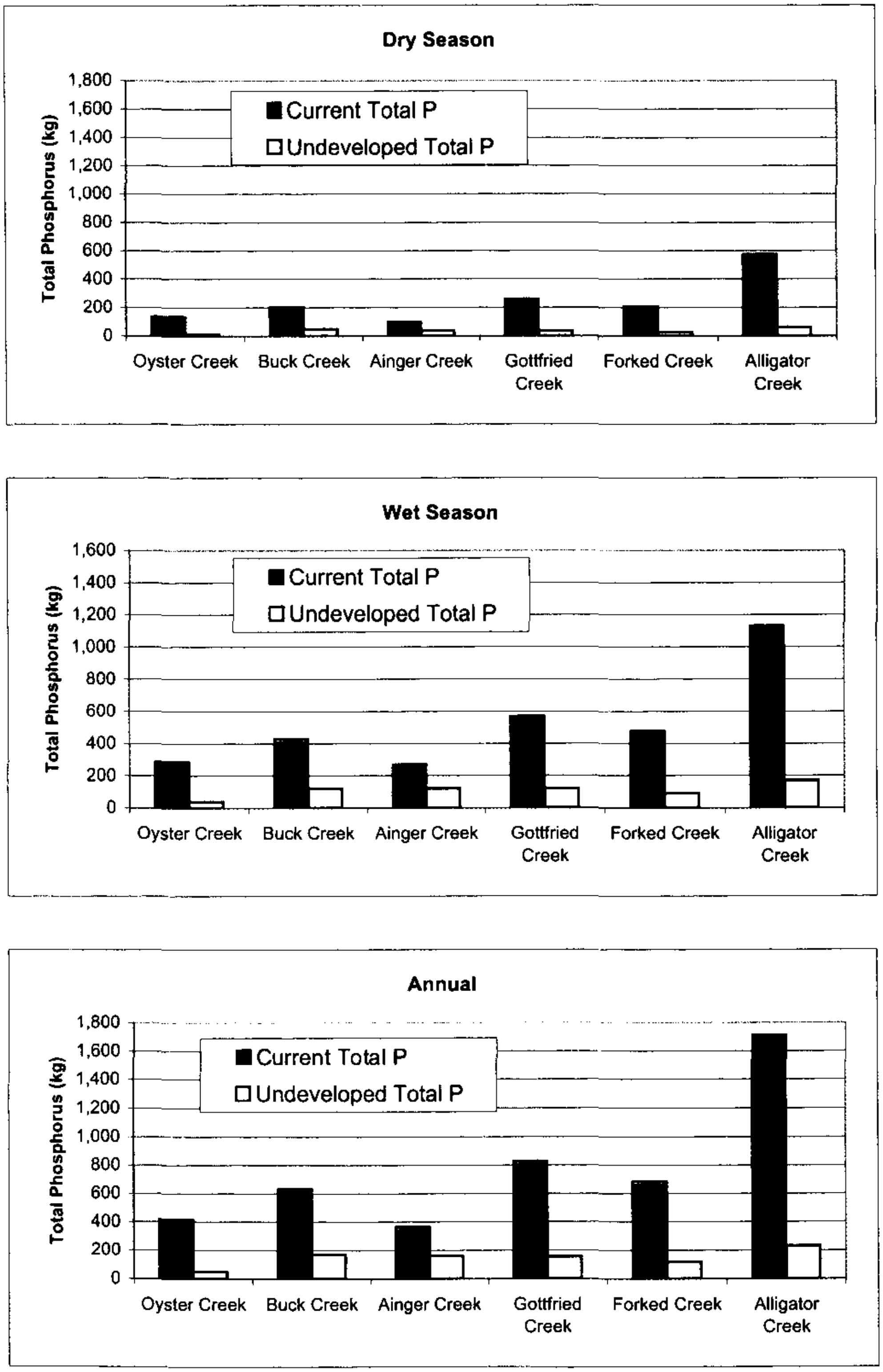


Figure 5-26. Comparison of Current and Undeveloped Phosphorus Loads to Lemon Bay from Primary Tributaries.

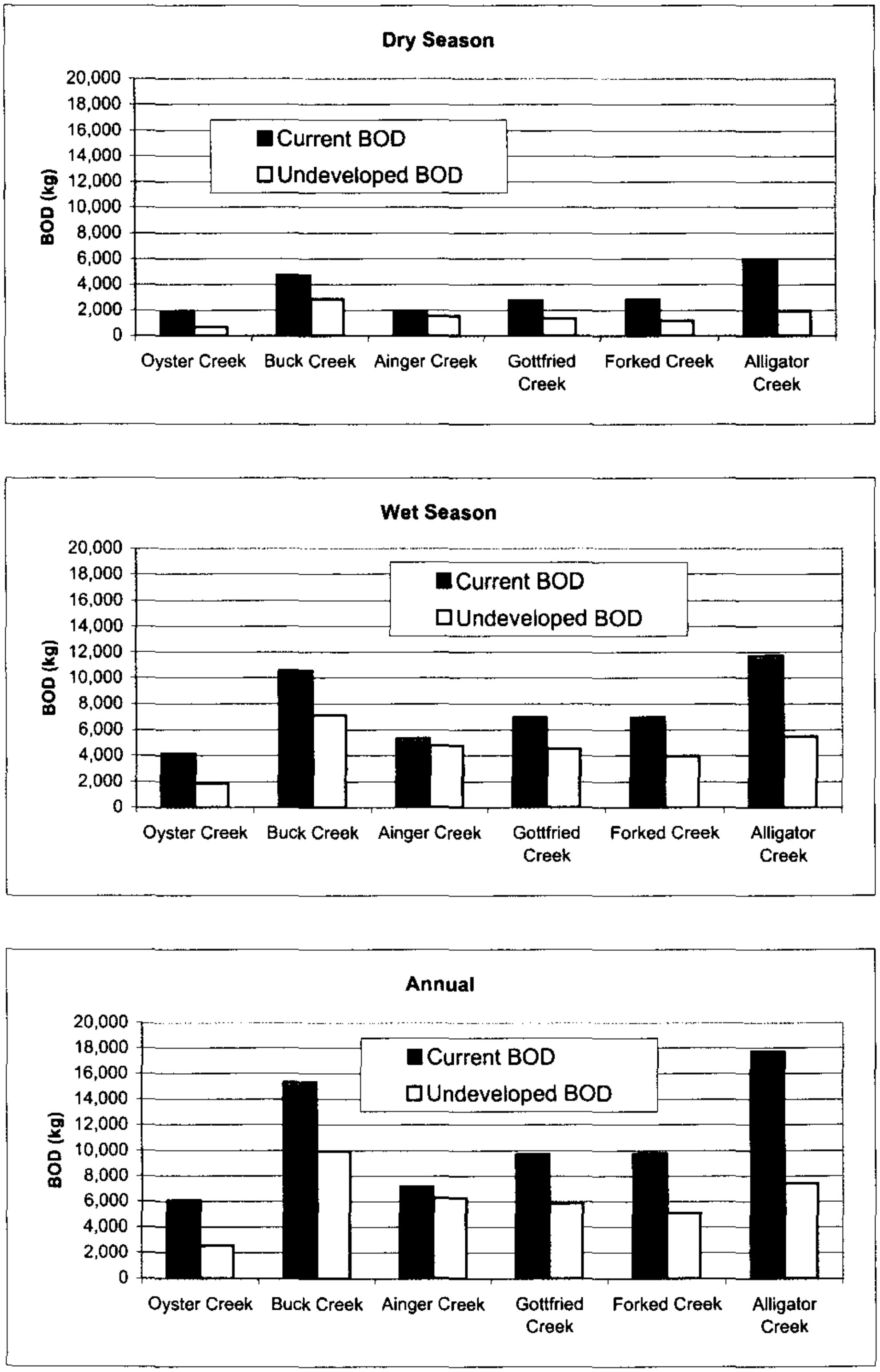


Figure 5-27. Comparison of Current and Undeveloped BOD Loads to Lemon Bay from Primary Tributaries.

to Lemon Bay under existing conditions appear to have increased approximately 69% compared with pre-development estimates.

A graphical comparison of current and undeveloped TSS loadings to Lemon Bay from the primary tributaries is given in Figure 5-28. Current loadings of TSS into Lemon Bay appear to be greater under existing conditions than under undeveloped conditions for each of the evaluated watersheds. Significant increases in TSS loadings to Lemon Bay are apparent in Oyster, Gottfried, Forked, and Alligator Creeks. Overall, TSS loadings to Lemon Bay appear to have increased by approximately 145% under current conditions compared with historic undeveloped values.

5.5 Comparison of Undeveloped, Current, and Future Loading Estimates

A graphical comparison of undeveloped, current, and future runoff inputs to Lemon Bay from the primary tributaries is given in Figure 5-29. In each of the evaluated basins, runoff estimates increase from pre-development to current to future conditions. In the Buck and Ainger Creek basins, the anticipated increase in runoff volume under future conditions is greater than the increase from undeveloped to current conditions. However, in Oyster, Creek, Alligator, and Woodmere Creek basins, the most significant increases in runoff volumes have already occurred as a result of development in these basins.

A comparison of undeveloped, current, and future nitrogen loadings to Lemon Bay from the primary tributaries is given in Figure 5-30. Significant increases in nitrogen loads are anticipated under future conditions, particularly when compared to pre-development conditions. It should be noted that the estimates of nitrogen load increases to Lemon Bay consider the impacts of stormwater management systems which will be constructed for the newly developed areas under built-out conditions.

A comparison of undeveloped, current, and future phosphorus loadings to Lemon Bay from the primary tributaries is given in Figure 5-31. Significant increases in phosphorus

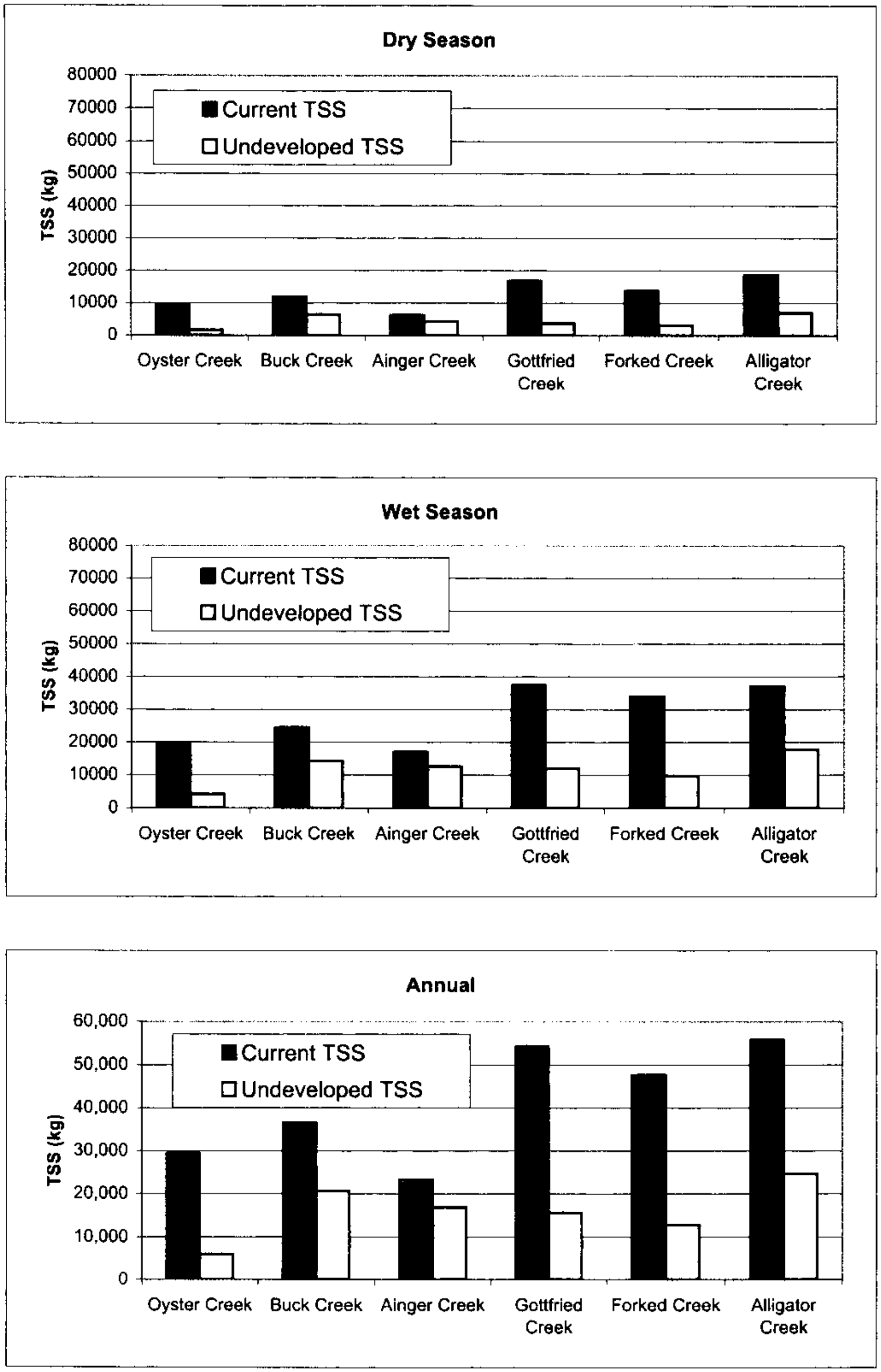


Figure 5-28. Comparison of Current and Undeveloped TSS Loads to Lemon Bay from Primary Tributaries.

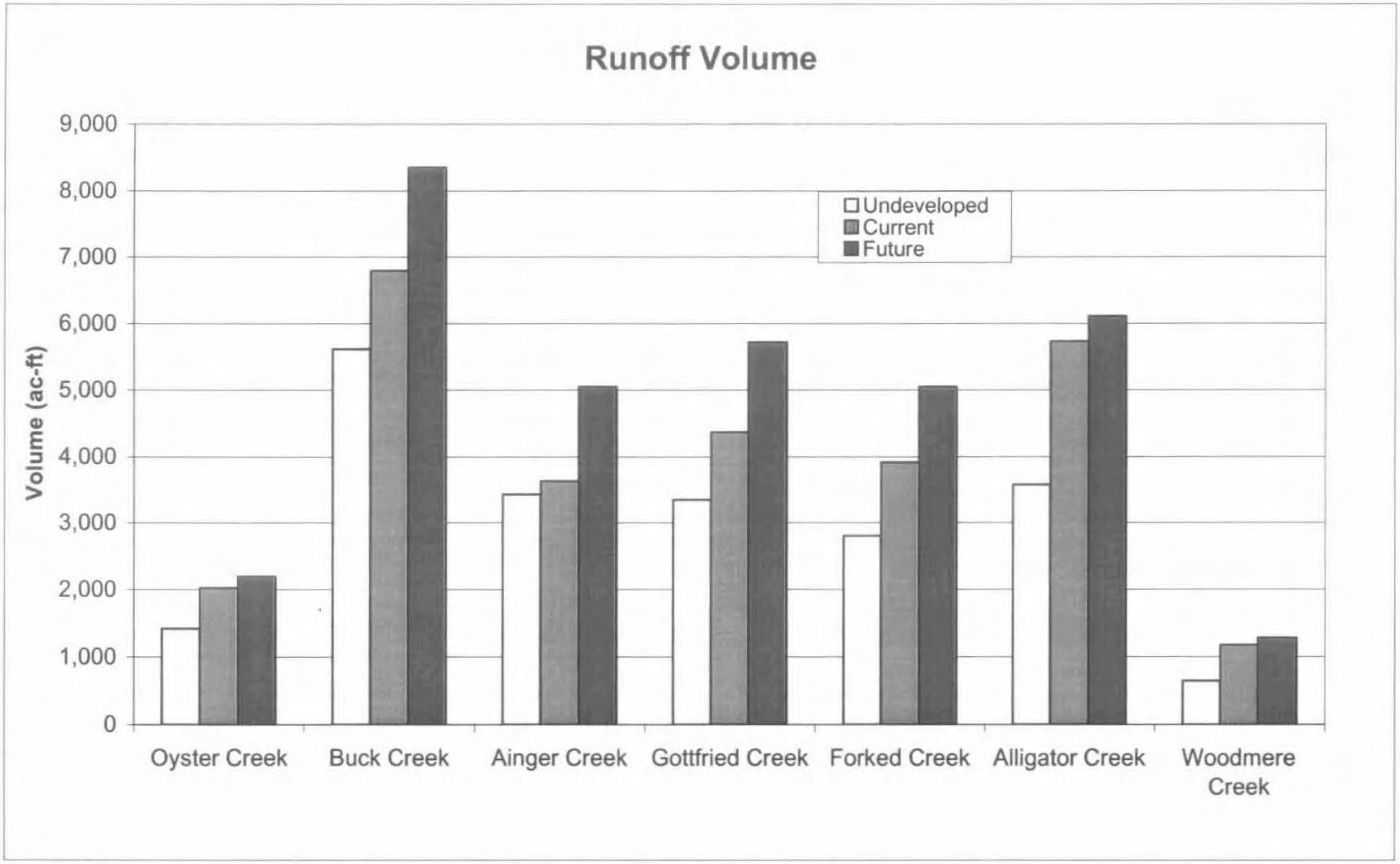


Figure 5-29. Comparison of Undeveloped , Current and Future Runoff Inputs to Lemon Bay from the Primary Tributaries.

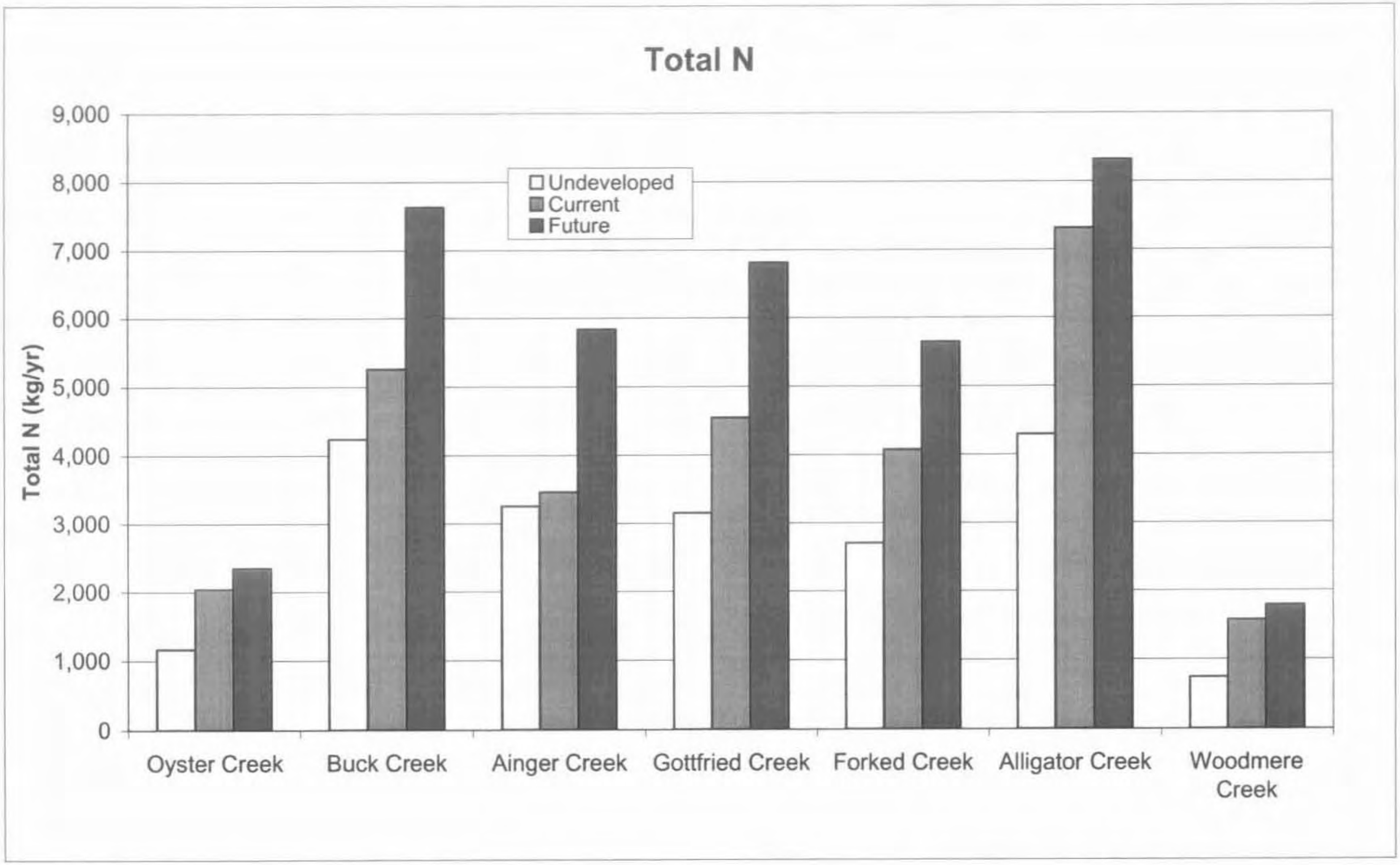


Figure 5-30. Comparison of Undeveloped , Current and Future Nitrogen Loads to Lemon Bay from the Primary Tributaries.

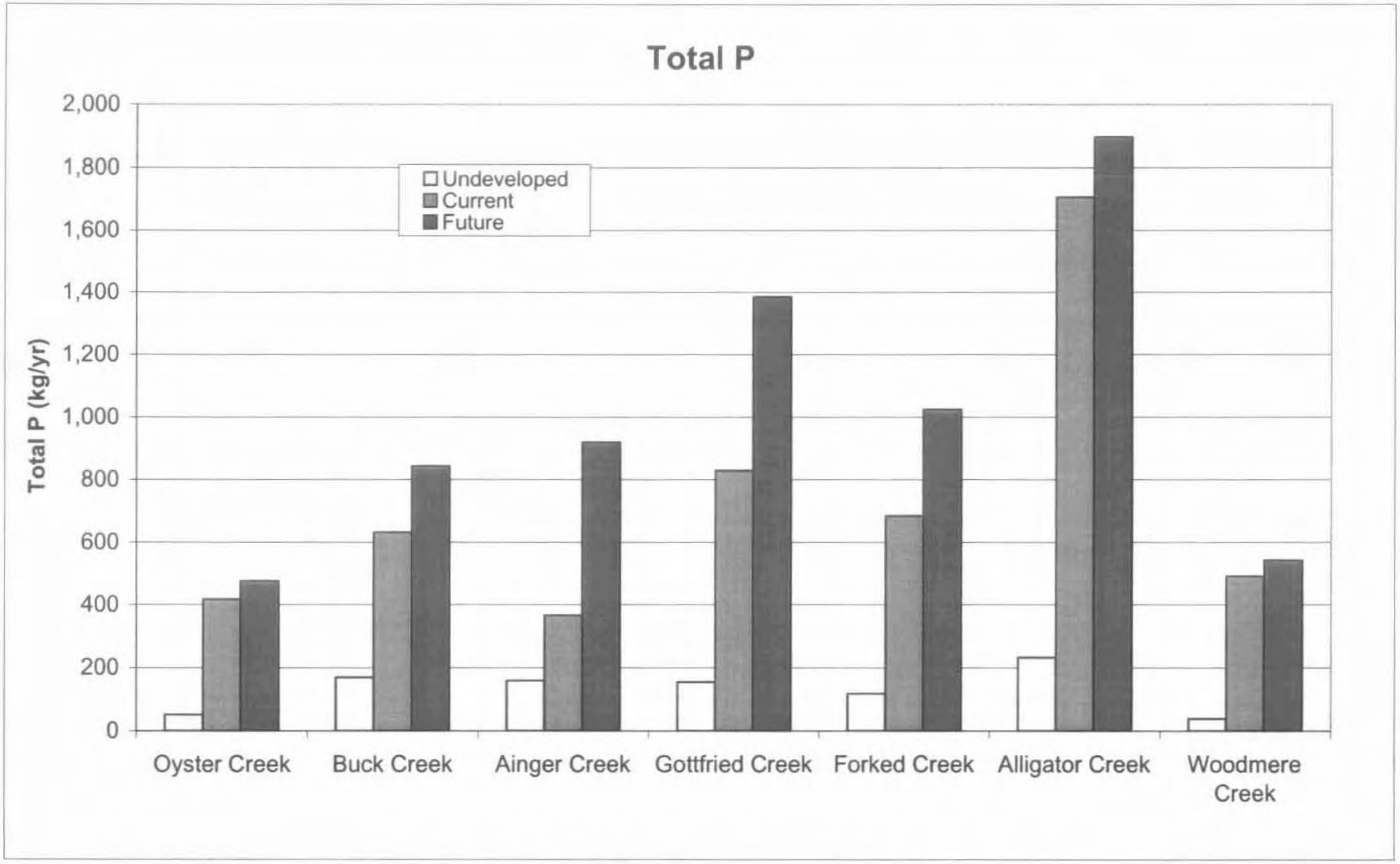


Figure 5-31. Comparison of Undeveloped , Current and Future Phosphorus Loads to Lemon Bay from the Primary Tributaries.

loadings are anticipated under future conditions with both existing and future loadings substantially greater than phosphorus loadings anticipated under pre-development conditions.

A comparison of undeveloped, current, and future BOD loadings to Lemon Bay from the primary tributaries is given in Figure 5-32. Significant increases with BOD loadings appear to have occurred within the basin as a result of the existing development. No substantial increases in BOD are anticipated under future conditions.

A comparison of undeveloped, current, and future TSS loadings to Lemon Bay from the primary tributaries is given in Figure 5-33. The vast majority of the anticipated increases in TSS appear to have already occurred within the basin as a result of current development. Future development may actually lower loadings of TSS within the basin as a result of excellent removal efficiencies for TSS achieved in the stormwater management facilities.

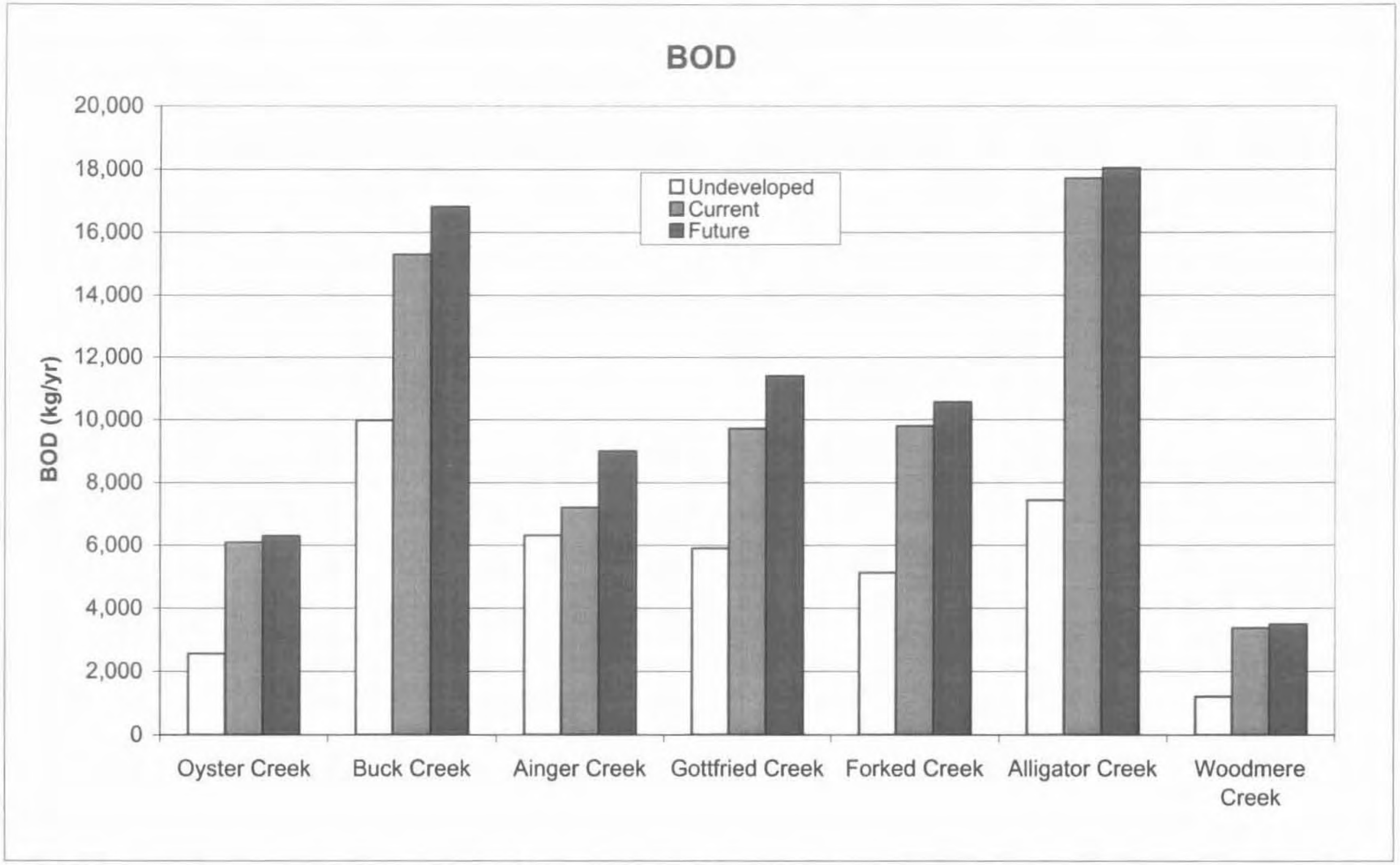


Figure 5-32. Comparison of Undeveloped , Current and Future BOD Loads to Lemon Bay from the Primary Tributaries.

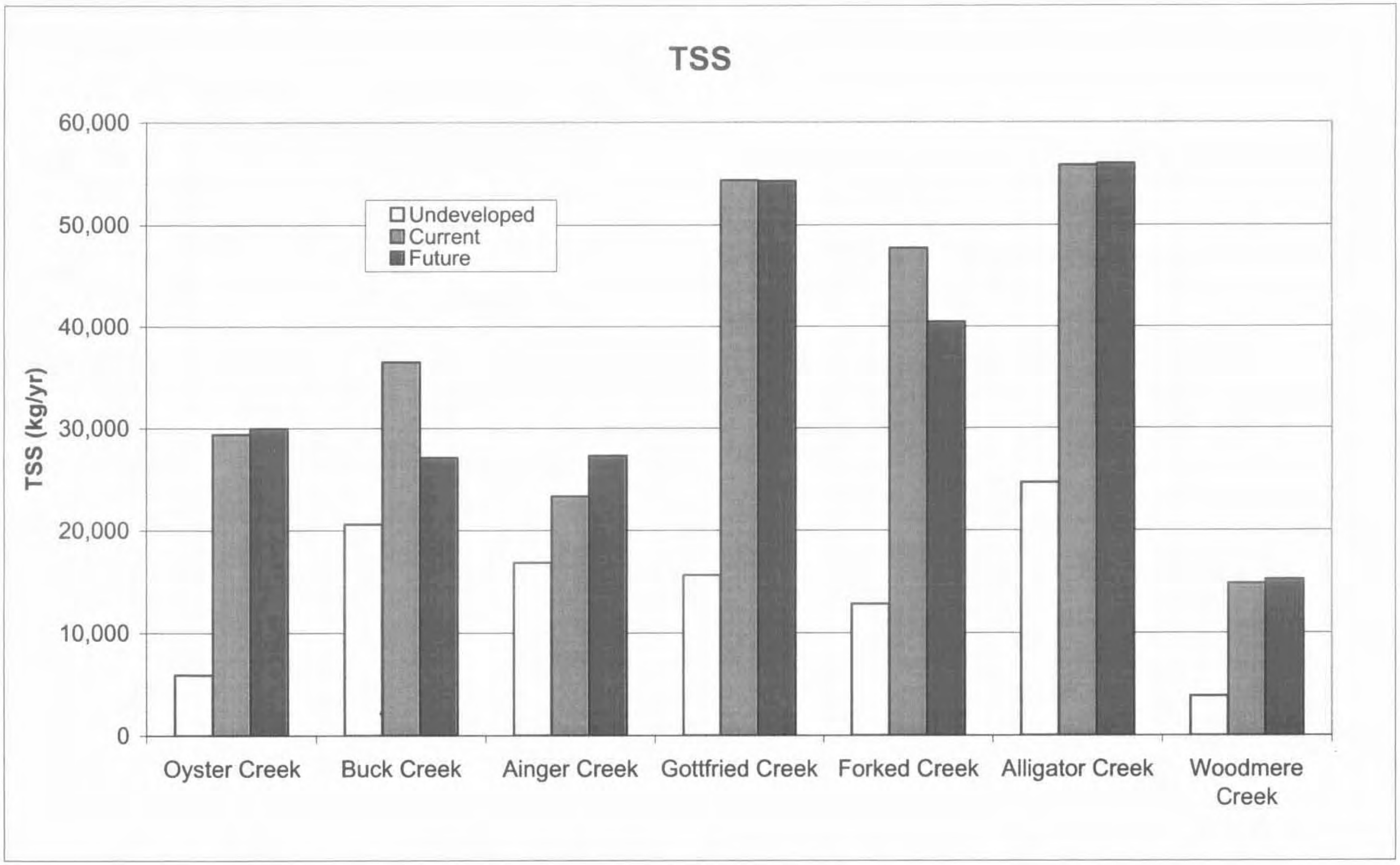


Figure 5-33. Comparison of Undeveloped , Current and Future TSS Loads to Lemon Bay from the Primary Tributaries.

SECTION 6

EVALUATION OF WATER QUALITY IMPROVEMENT ALTERNATIVES

A variety of alternatives were evaluated by ERD to reduce nonpoint source loadings from the Lemon Bay watershed to Lemon Bay. Each of the evaluated alternatives are designed to reduce nonpoint source loadings by either reduction in the total volume of runoff discharged to Lemon Bay or a reduction in concentrations of nonpoint source constituents discharging from the evaluated tributaries. The evaluated alternatives include: (1) enhanced stormwater regulations; (2) public education; (3) volume reduction alternatives; (4) proposed projects by Sarasota County in Alligator Creek, Forked Creek, Gottfried Creek, and Ainger Creek basins; and (5) water quality improvement options for the Oyster Creek and Buck Creek watersheds developed by ERD. A discussion of each of the evaluated water quality improvement alternatives is given in the following sections.

6.1 Alternative Stormwater Regulations

6.1.1 Justification for Alternative Regulations

The overall objective of the alternative stormwater regulations option is to limit the post-development annual mass pollutant loadings from a developed site to no more than the annual mass pollutant loadings for the undeveloped site. Pre- and post-development mass loadings are calculated by multiplying the annual runoff volume for each land use times the estimated runoff concentrations for each constituent. Estimated runoff characteristics for various land use types in the Lemon Bay watershed are summarized in Table 3-7. Runoff volumes were determined by multiplying the assumed mean annual rainfall of 47.58 inches per year, as measured at the Englewood monitoring site, times the mean basin runoff coefficient (C value) for each land use type, as summarized in Section 5. Estimated areal pollutant loadings for undeveloped land and the primary developed land use types in the Lemon Bay watershed, including commercial, low-density residential, medium-density residential, and high-density residential, were calculated by multiplying the mean runoff characteristics given in Table 3-7 times the estimated annual runoff volume generated by each land use category.

A summary of estimated runoff generated loadings, in terms of kg per acre per year, is provided in Table 6-1 for commercial, low-density residential, medium-density residential, high-density residential, and undeveloped/open land uses. Also listed in Table 6-1 are the modeled mean runoff "C" values for the various land uses in the evaluated basin areas. Undeveloped land has significantly lower mean annual pollutant loads of total nitrogen, total phosphorus, BOD, and TSS than the developed land use categories. Commercial land use generates the highest mean annual pollutant loadings for TSS, while high-density residential land use has the highest estimated annual loadings of total nitrogen, total phosphorus, and BOD.

TABLE 6-1

ESTIMATED MEAN ANNUAL RUNOFF GENERATED LOADINGS FOR LAND USE TYPES IN THE LEMON BAY WATERSHED

LAND USE	WEIGHTED "C" VALUE	MEAN ANNUAL GENERATED LOAD (kg/ac-yr)			
		TOTAL N	TOTAL P	BOD	TSS
Commercial	0.420	1.81	0.63	4.72	81.9
Low-Density Residential	0.145	0.67	0.19	1.06	4.25
Medium-Density Residential	0.207	1.18	0.51	2.02	10.2
High-Density Residential	0.348	1.99	0.86	5.27	47.8
Open/Undeveloped	0.115	0.40	0.017	0.56	1.07

A summary of the estimated percent reductions necessary to match pre-development loadings are provided in Table 6-2. The required total nitrogen load reduction varies from 40-80%, total phosphorus from 91-98%, BOD from 47-89%, and TSS from 76-98%. The most restrictive parameters appear to be total phosphorus and TSS. The lowest reductions in runoff loadings are required for low-density residential land use which requires 40% reduction for total nitrogen, 91% for total phosphorus, 47% for BOD, and 75% for TSS.

TABLE 6-2

ESTIMATED PERCENT REDUCTIONS IN DEVELOPED LAND USE LOADINGS REQUIRED TO MATCH PRE-DEVELOPMENT LOADINGS

LAND USE	REQUIRED PERCENT REDUCTION (%)			
	TOTAL N	TOTAL P	BOD	TSS
Commercial	78	97	88	98
Low-Density Residential	40	91	47	75
Medium-Density Residential	66	97	72	90
High-Density Residential	80	98	89	98
Undeveloped	0	0	0	0

The percentage reductions summarized in Table 6-1 represent the general load reductions required for each developed land use category to achieve no net increase in runoff loadings following development. As seen in Table 3-12, wet detention and dry detention with filtration, the two most commonly used stormwater management techniques in the Lemon Bay basins, fail to achieve the required percentage reductions in the developed land use categories for at least two or more of the evaluated nonpoint source constituents. Wet detention and dry detention with filtration produce removal efficiencies which fall short of the required removal efficiencies for total nitrogen, total phosphorus, BOD, and TSS in commercial, medium-density residential, and high-density residential land uses. Wet detention and dry detention with filtration systems fail to produce the required percentage reductions for total nitrogen and total phosphorus in low-density residential developments. As a result, a methodology is provided in the following sections for alternative stormwater regulations which limit post-development annual mass loadings from a developed site to no more than the annual mass pollutant loadings for the undeveloped site.

6.1.2 Alternative Methodology

The estimated percentage reductions summarized in Table 6-2 are estimates of the generalized overall reductions in pollutant loadings required for each of the developed land use categories. These removal efficiencies are based on "mean" hydrologic conditions throughout the entire Lemon Bay basin for each developed land use category. However, to provide the most reasonable assurance of no net increase in pollutant loadings following development, a site-specific evaluation of pre- and post-development loadings should be performed for each proposed development based upon pre- and post-land use and hydrologic characteristics within each specific development. An alternative methodology is outlined in the following sections to estimate site-specific pre- and post-development loadings for a new development and the characteristics of the stormwater management system required to achieve no net increase in pollutant loadings. Tables of proposed alternative stormwater regulations designed to achieve no net increase in pollutant loadings within the Lemon Bay watershed are also provided.

6.1.2.1 Estimation of Pre- and Post-Development Loadings

For purposes of this evaluation, both pre- and post-development loadings are calculated using the concentration-based method. This method is more accurate than the areal loading method since the concentration-based method considers site-specific hydrologic characteristics in estimation of pollutant loadings. Pre- and post-development loadings are calculated by generating estimates of runoff volumes and runoff characteristics for pre- and post-development conditions.

6.1.2.1.1 Calculation of Runoff Volumes

A methodology was developed to evaluate the annual runoff volume generated from a given parcel under both pre- and post-development conditions. This analysis is based upon an evaluation of runoff volumes generated by common rain events which occur in the vicinity of the project site during an average year. After reviewing the available meteorological records, Ft. Myers is the only major city in Southwest Florida which has sufficient long-term meteorological data for estimation of rainfall trends. Hourly meteorological data was obtained from the National Climatic Data Center (NCDC) for the Ft. Myers Meteorological Station from 1960-1993.

The continuous hourly rainfall record from Ft. Myers was scanned to determine the total rainfall depth for individual rain events occurring at the monitoring site. A rain event is defined as a period of continuous rainfall. For purposes of this analysis, rain events separated by less than three hours of dry conditions are considered to be one continuous event. Rain events separated by three hours or more of dry conditions are assumed to be separate events.

Rainfall events were divided into 19 rainfall event ranges which include 0.00-0.10 inches, 0.11-0.20 inches, 0.21-0.30 inches, 0.31-0.40 inches, 0.41-0.50 inches, 0.51-1.00 inch, 1.01-1.50 inches, 1.51-2.00 inches, 2.01-2.50 inches, 2.51-3.00 inches, 3.01-3.50 inches, 3.51-4.00 inches, 4.01-4.50 inches, 4.51-5.00 inches, 5.01-6.00 inches, 6.01-7.00 inches, 7.01-8.00 inches, 8.01-9.00 inches, and greater than 9 inches. For each rainfall event range, the mean depth of rain events within the interval was calculated. A probability distribution was performed on all rainfall events within each rainfall event range to determine the average number of rain events and the mean rainfall duration for each rainfall event range.

The rainfall distribution obtained for the Ft. Myers area is based upon a mean annual rainfall of 53.13 inches. However, long-term rainfall records surveyed for the Englewood monitoring site suggest an average annual rainfall of approximately 47.58 inches for the Lemon Bay watershed. Unfortunately, the Englewood rainfall data is only available as daily totals which cannot be extrapolated into individual rain events. Therefore, for purposes of this evaluation, the rainfall distribution obtained from the Ft. Myers area is assumed to be similar to the distribution of rainfall events which occur in the Lemon Bay watershed. The overall distribution for the Ft. Myers area was scaled back, based upon the proportion of annual rainfall in each of the 19 rainfall event ranges, to reflect an annual average rainfall of 47.58 inches rather than the 53.13 inches typical of the Ft. Myers area. The resulting distribution, reflecting 47.58 inches of annual rainfall, is used for development of alternative stormwater regulations for the Lemon Bay watershed.

A summary of rain event characteristics assumed for the Lemon Bay watershed is provided in Table 6-3. Of the 110 average annual rain events, 83 events have rainfall amounts of

0.5 inches or less, 97 events have rainfall amounts of 1.00 inches or less, and 106 events have rainfall amounts of 2.00 inches or less.

TABLE 6-3

SUMMARY OF ASSUMED RAINFALL EVENT CHARACTERISTICS FOR THE LEMON BAY WATERSHED

RAINFALL EVENT RANGE (inches)	RAINFALL INTERVAL POINT (inches)	MEAN RAINFALL DURATION (hours)	FRACTION OF ANNUAL RAIN EVENTS	NUMBER OF ANNUAL EVENTS IN RANGE
0.00-0.10	0.061	0.774	0.422	46.4
0.11-0.20	0.166	1.405	0.132	14.6
0.21-0.30	0.270	1.730	0.095	10.4
0.31-0.40	0.375	2.034	0.053	5.9
0.41-0.50	0.470	2.372	0.048	5.2
0.51-1.00	0.737	2.751	0.133	14.7
1.01-1.50	1.242	3.700	0.056	6.1
1.51-2.00	1.742	5.015	0.027	3.0
2.01-2.50	2.258	5.455	0.014	1.5
2.51-3.00	2.745	6.483	0.007	0.81
3.01-3.50	3.211	7.955	0.005	0.53
3.51-4.00	3.690	5.966	0.002	0.26
4.01-4.50	4.282	10.937	0.001	0.12
4.51-5.00	4.685	11.683	0.001	0.14
5.01-6.00	5.559	12.012	0.001	0.12
6.01-7.00	6.540	34.500	0.000	0.04
7.01-8.00	7.800	11.000	0.000	0.02
8.01-9.00	8.445	26.750	0.001	0.06
> 9.00	9.690	28.000	0.000	0.02
			TOTAL:	**109.9**

Average Annual Rainfall: **47.58 inches**

Estimates of annual runoff coefficients (C value) were generated for a wide variety of combinations of directly connected impervious area (DCIA) and non-DCIA curve numbers. An impervious area is considered connected if runoff from it flows directly into the drainage system. It is also considered directly connected if runoff from it occurs as concentrated shallow flow that runs over a pervious area, such as a roadside swale, and then into a drainage system. Non-DCIA areas include all pervious areas and portions of impervious areas not considered to be directly connected.

Runoff calculations were performed for combinations of DCIA values ranging from 0-100%, in 5% increments, and for non-DCIA curve numbers ranging from 25-95, in 5 unit increments. Non-DCIA curve numbers of 96, 97, and 98 were also included in the analysis. For each combination of DCIA and non-DCIA curve number, the estimated annual runoff coefficient was calculated by estimating the annual runoff volume generated by the typical annual storm events summarized in Table 6-3.

The runoff volume for each rainfall interval is calculated by adding the rainfall excess from the non-DCIA portion for each DCIA and curve number combination to the rainfall excess created from the DCIA portion of the same combination. Rainfall excess from the non-DCIA areas is calculated using the following set of equations:

$$nDCIA\ CN = \frac{CN * (100 - Imp) + 98\ (Imp - DCIA)}{(100 - DCIA)}$$

$$Soil\ Storage,\ S = \left(\frac{1000}{nDCIA\ CN} - 10\right)$$

$$Q_{nDCIA_i} = \frac{(P_i - 0.2S)^2}{(P_i + 0.8S)}$$

where:

CN	=	curve number for pervious area
Imp	=	percent impervious area
DCIA	=	percent directly connected impervious area
nDCIA CN	=	curve number for non-DCIA area
P_i	=	median rainfall for rainfall event interval (i)
Q_{nDCIAi}	=	rainfall excess for non-DCIA for rainfall event interval (i)

For rainfall events where P_i is less than 0.10, the rainfall excess (Q_{nDCIAi}) is assumed to be zero. For the DCIA portion, rainfall excess is calculated using the following equation:

$$Q_{DCIA_i} = (P_i - 0.1)$$

When P_i is less than 0.1, Q_{DCIAi} is equal to zero.

The total volume for a rainfall event interval is calculated using the following equation:

$$RO_i = \left[[Q_{nDCIAi} \ x \ A \ x \ (100 - DCIA)] + [Q_{DCIAi} \ x \ A \ x \ DCIA] \right] x \ \frac{1}{12} \ x \ \frac{1}{100} \ x \ N$$

where:

A	=	area for specific land use-HSG (ac)
RO_i	=	runoff volume for rainfall interval (i)
N	=	number of annual runoff events in interval (i)

The sum of all the runoff volumes (RO_i) for each rainfall event interval is the total annual rainfall volume for a given DCIA and curve number combination. The weighted basin "C" value is calculated using the following equation:

$$C\ Value = \frac{Generated\ Runoff\ Volume\ (ac\text{-}ft/yr)}{Area\ x\ Total\ Annual\ Rainfall\ (inches)}\ x\ \frac{12\ inches}{1\ ft}$$

The assumed average total annual rainfall for the Lemon Bay watershed is 47.58 inches. The process summarized above is repeated for each of the 378 combinations of DCIA and curve number.

A summary of calculated runoff coefficients, as a function of curve number and DCIA, for the Lemon Bay watershed is given in Table 6-4 based upon the methodology outlined previously. The estimated annual runoff volume for a given parcel under either pre- or post-development conditions is calculated by multiplying the mean annual rainfall depth for the given area times the appropriate runoff coefficient based upon DCIA and curve number characteristics for the parcel under the evaluated development option, as follows:

$$Annual\ Runoff\ Volume\ (ac\text{-}ft) =$$

$$Area\ (acres)\ x\ Mean\ Annual\ Rainfall\ (inches)\ x\ C\ Value\ x\ \frac{1\ ft}{12\ in}$$

Linear interpolation can be used to estimate curve numbers for specific combinations of DCIA and curve number not provided in Table 6-4.

6.1.2.1.2 <u>Loading Calculations</u>

Both pre- and post-development loadings are calculated using the concentration-based methodology. The annual runoff volume for each pre- and post-development land use is estimated using the methodology outlined in the previous section. The runoff volume is then multiplied times the estimated chemical characteristics of the selected runoff constituent in each land use category. The computational formula for these calculations is summarized in the following equation:

Table 6-4

Calculated Annual Runoff Coefficients as a Function of Curve Number and DCIA for the Lemon Bay Watershed

DCIA	Non DCIA Curve Number																	
	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	96	97	98
0	0.000	0.004	0.006	0.008	0.012	0.017	0.026	0.038	0.055	0.079	0.111	0.159	0.229	0.335	0.516	0.570	0.634	0.712
5	0.041	0.044	0.046	0.048	0.051	0.057	0.065	0.076	0.092	0.115	0.146	0.191	0.258	0.359	0.531	0.582	0.642	0.717
10	0.081	0.084	0.086	0.088	0.091	0.096	0.104	0.115	0.130	0.152	0.181	0.224	0.287	0.382	0.545	0.594	0.651	0.722
15	0.121	0.125	0.126	0.128	0.131	0.136	0.143	0.153	0.168	0.188	0.216	0.256	0.315	0.406	0.560	0.606	0.660	0.727
20	0.162	0.165	0.166	0.168	0.171	0.175	0.182	0.192	0.205	0.224	0.250	0.289	0.344	0.430	0.575	0.617	0.668	0.731
25	0.202	0.205	0.206	0.208	0.210	0.215	0.221	0.230	0.243	0.261	0.285	0.321	0.373	0.453	0.589	0.629	0.677	0.736
30	0.242	0.245	0.246	0.248	0.250	0.254	0.260	0.269	0.280	0.297	0.320	0.353	0.402	0.477	0.604	0.641	0.686	0.741
35	0.283	0.285	0.286	0.288	0.290	0.294	0.299	0.307	0.318	0.334	0.355	0.386	0.431	0.500	0.618	0.653	0.694	0.745
40	0.323	0.325	0.326	0.328	0.330	0.333	0.338	0.345	0.356	0.370	0.390	0.418	0.460	0.524	0.633	0.665	0.703	0.750
45	0.363	0.365	0.366	0.367	0.370	0.373	0.377	0.384	0.393	0.406	0.424	0.451	0.489	0.547	0.647	0.677	0.712	0.755
50	0.404	0.406	0.406	0.407	0.409	0.412	0.416	0.422	0.431	0.443	0.459	0.483	0.518	0.571	0.662	0.688	0.720	0.760
55	0.444	0.446	0.446	0.447	0.449	0.452	0.455	0.461	0.468	0.479	0.494	0.515	0.547	0.595	0.676	0.700	0.729	0.764
60	0.484	0.486	0.486	0.487	0.489	0.491	0.494	0.499	0.506	0.516	0.529	0.548	0.576	0.618	0.691	0.712	0.738	0.769
65	0.525	0.526	0.526	0.527	0.529	0.531	0.533	0.538	0.544	0.552	0.563	0.580	0.605	0.642	0.705	0.724	0.746	0.774
70	0.565	0.566	0.567	0.567	0.568	0.570	0.573	0.576	0.581	0.588	0.598	0.613	0.633	0.665	0.720	0.736	0.755	0.779
75	0.605	0.606	0.607	0.607	0.608	0.610	0.612	0.615	0.619	0.625	0.633	0.645	0.662	0.689	0.734	0.748	0.764	0.783
80	0.646	0.646	0.647	0.647	0.648	0.649	0.651	0.653	0.656	0.661	0.668	0.677	0.691	0.713	0.749	0.760	0.772	0.788
85	0.686	0.686	0.687	0.687	0.688	0.688	0.690	0.692	0.694	0.698	0.703	0.710	0.720	0.736	0.763	0.771	0.781	0.793
90	0.726	0.727	0.727	0.727	0.727	0.728	0.729	0.730	0.732	0.734	0.737	0.742	0.749	0.760	0.778	0.783	0.790	0.797
95	0.767	0.767	0.767	0.767	0.767	0.767	0.768	0.768	0.769	0.770	0.772	0.775	0.778	0.783	0.792	0.795	0.798	0.802
100	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807

$$Load\ (kg/yr) =$$

$$\frac{\overset{i=1}{\sum}}{n}\left[(A_i)\ x\ \frac{43{,}560\ ft^2}{acre}\ x\ R\ x\ CV_i\ x\ \frac{1\ ft}{12\ inches}\ x\ \frac{7.48\ gal}{ft^3}\ x\ \frac{3.785\ liter}{gal}\ x\ C_i\ x\ \frac{1\ kg}{10^6\ mg}\right]$$

where:

A_i	=	area of land use category, i (acres)
n	=	number of different land use categories
C_i	=	concentration of selected runoff constituent in land use category, i (mg/l)
R	=	annual rainfall at site (inches/yr)
CV_i	=	runoff "C" value for land use category i (dimensionless)

The concentration-based methodology is utilized since it incorporates site-specific hydrologic characteristics for each evaluated site. This technique is thought to be substantially more accurate than the areal loading methodology which assumes that the hydrologic characteristics are identical throughout a given land use category.

After estimation of pre- and post-development loadings, the required removal efficiency to achieve no net increase in pollutant loading for a given runoff constituent following development is calculated utilizing the following equation:

$$Required\ Removal\ Efficiency\ (\%) = \left[\frac{Post\text{-}Dev.\ Load\ -\ Pre\text{-}Dev.\ Load}{Post\text{-}Dev.\ Load}\right]\ x\ 100$$

The removal efficiency calculated utilizing this procedure is then used to select the required stormwater treatment options which will achieve the desired goal of no net increase in pollutant loadings for the evaluated constituent.

6.1.3 Treatment Options

To achieve the goal of no net increase in loadings under post-development conditions, pollutant removal efficiencies as high as 95% may be required for a selected runoff constituent. Based upon the literature review summarized in Section 3, only two common stormwater management systems appear to be capable of consistently achieving pollutant removal efficiencies in this range. These stormwater management systems include dry retention, which disposes of stormwater runoff by evaporation and infiltration into the ground in such a manner to prevent direct discharge of stormwater runoff into receiving waters, and wet detention, which acts similar to a natural lake system. As a result, the evaluated treatment options are limited to dry retention and wet detention systems only.

The performance efficiencies of dry retention and wet detention systems were evaluated under a wide range of operational conditions. The purpose of these evaluations is to develop a generalized methodology for evaluating removal efficiencies achieved by these systems for typical stormwater constituents as a function of runoff volume treated or residence time. Each of the performance evaluations for the two stormwater management systems is based upon common assumptions used during the evaluation process. A summary of these assumptions is given below:

1. Watershed areas contributing to each stormwater management facility do not exhibit first-flush effects with respect to runoff concentrations. Although small, highly impervious watershed areas, typically less than 5-10 acres in size, may exhibit first- flush effects under certain conditions, there is no scientific evidence to indicate that larger sub-basin areas exhibit a first-flush effect on a continuous basis. Therefore, the analyses presented in this report may be somewhat conservative for small basins which exhibit a first-flush effect.

2. The stated treatment volume is fully recovered prior to the next storm event.

3. Pollutant loads from various runoff depths are constant throughout the year.

4. Pollutant removal efficiencies for runoff constituents are constant throughout the year.

6.1.3.1 <u>Dry Retention</u>

Since runoff concentrations are assumed to be constant from rain event to rain event, the calculated performance efficiency of a dry retention stormwater management system is based entirely upon the percentage of water retained during each storm event. For a dry retention system, it is assumed that a pollutant removal efficiency of 100% is achieved for the entire treatment volume retained within the system. As a result, removal efficiencies of 100% are achieved for all rainfall events which generate runoff volumes less than or equal to the design treatment volume for the pond. Removal efficiencies for rainfall events which generate runoff in excess of the treatment volume are assumed to be 100% for all generated runoff up to the treatment volume, with a removal efficiency of 0% for runoff inputs which enter the pond in excess of the treatment volume. This analysis may be slightly conservative for rain events which generate runoff in excess of the required treatment volume, since settling of discrete particles would occur as the runoff inputs are detained within the pond prior to ultimate discharge.

Pollutant removal efficiencies were calculated for selected dry retention treatment volumes for each of the combinations of DCIA and non-DCIA curve number given in Table 6-4 based upon the assumptions outlined in the previous paragraphs. Removal efficiencies were calculated for retention treatment volumes ranging from 0.25-inch to 4.0-inch of runoff in 0.25-inch increments. The results of these analyses are summarized in Appendix C. In general, the removal efficiency increases as the retention treatment volume increases. Also, treatment efficiency decreases as the DCIA and non-DCIA curve number increases. Removal efficiencies summarized in these tables are valid for all stormwater constituents since the efficiencies are based upon total retention of a specific runoff volume within the pond. As a result, the stated removal efficiencies are assumed to be valid for all stormwater constituents, including total nitrogen, total phosphorus, TSS, and BOD.

To determine the required retention volume for a given project, the specific combination of DCIA and non-DCIA curve number is evaluated for the project under post-development conditions. The tables in Appendix C are then scanned to determine which retention depth is required to achieve the desired pollutant removal efficiency for the specific combination of DCIA and curve number for the given project. This methodology can be used if retention is selected as the sole method of stormwater treatment or if retention is selected as part of a treatment train.

To achieve the desired goal of no net increase in pollutant loadings under post-development conditions, a retention pond must be capable of providing adequate levels of stormwater treatment under a wide range of operating conditions. The most significant factor regulating the performance efficiency of a dry retention basin is the stored treatment volume and the ability of the pond to recover the treatment volume between storm events. In the Southwest Florida area, the mean antecedent dry period between rain events under dry season conditions is approximately 5.3 days. However, under wet season conditions, the mean antecedent dry period between rain events decreases to approximately 1.66 days (40 hours). In order for a dry retention pond to achieve the target removal efficiencies, the stored treatment volume must be evacuated within a minimum of 40 hours, reflecting the mean antecedent dry period under wet season conditions.

A summary of recommended design criteria for dry retention ponds is given in Table 6-5. Recovery of the required treatment volume must be achieved within 40 hours or less. Ability of the pond to achieve this recovery rate must be certified by a registered geotechnical engineer. All side slopes and bottom areas of the pond must be sodded with water-tolerant grass species. Inlets and outlets must be located as far apart as possible to prevent short-circuiting. Oil and grease skimmers must be provided at all outfall structures. Other requirements related to side slopes, fencing, maintenance berms, and access will adhere to applicable local or regulatory agency criteria.

TABLE 6-5

RECOMMENDED DESIGN CRITERIA FOR DRY RETENTION PONDS

PARAMETER	DESIGN CRITERIA
Treatment Volume	Selected from App. C based on required removal efficiencies
Recovery of Treatment Volume	<40 hours (certified by registered geotechnical engineer)
Side Slopes and Bottom	Sodded with water-tolerant grass species
Inlet and Outlet	Located as far apart as possible to prevent short-circuiting
Oil and Grease Skimmers	Provided at outlet structure
Requirements related to side slopes, fencing, maintenance berms, and access	According to applicable local or regulatory agency criteria

6.1.3.2 Wet Detention

Current research on wet detention systems clearly indicates that the performance efficiency for this type of stormwater management technique is primarily a function of residence time within the system. Residence time within the system is determined by the relationship between the permanent pool volume and the annual runoff inputs, as follows:

$$Detention\ \ Time,\ t_d\ (days)\ =\ \frac{PPV}{RO}\ x\ \frac{365\ \ days}{year}$$

where:

PPV = permanent pool volume (ac-aft)

RO = annual runoff inputs (ac-ft/yr)

For purposes of this calculation, the permanent pool volume is considered to include the total volume of water within the pond below the control elevation. The permanent pool volume is unrelated to the concept of treatment volume which is a common wet detention design criterion used to regulate drawdown of the runoff inputs.

The required permanent pool volume is calculated based upon the required removal efficiency to achieve no net increase in post-development loadings for the evaluated constituents. Removal relationships for total nitrogen, total phosphorus, TSS, and BOD as a function of residence time in a wet detention pond are provided in Figures 3-14 through 3-17, respectively. The required removal efficiencies for nitrogen and phosphorus typically result in relatively long residence times which are substantially longer than the residence times required to achieve no net increase in loadings for TSS and BOD. As a result, the wet detention system should be designed based upon residence time requirements for nitrogen and phosphorus. When the residence times for phosphorus and nitrogen are met, the required removal efficiencies for TSS and BOD will have already been achieved.

A summary of recommended design criteria for wet detention ponds is given in Table 6-6. Based upon the information presented previously, the most important factor in regulating the performance efficiency of a wet detention pond is the residence time for runoff inputs within the system. Since residence time is determined primarily by the permanent pool volume, this volume becomes the single most important design parameter for wet detention ponds. The required volume of the permanent pool can be calculated based upon the removal relationships for nitrogen and phosphorus presented in Figures 3-14 and 3-15. Design criteria are also listed for the treatment volume, which represents the water volume stored on top of the permanent pool during an individual rain event. Pond requirements for treatment volume and recovery time for the treatment volume are based upon current SWFWMD criteria.

The design criteria for pond depth recommends that 25-50% of the pond area be deeper than 12 ft. These deeper areas provide storage for accumulation of solids within the pond and minimize the frequency of maintenance activities. No restrictions are placed on the configuration of the pond, provided that the inlet and outlet from the system are located as far apart as possible. In addition, it is recommended that at least 35% of the pond surface be planted with a littoral zone consisting of a combination of submergent and emergent aquatic vegetation. Creation of a littoral zone will create a more stable environment and will probably enhance the overall performance efficiency of the wet detention system.

TABLE 6-6

RECOMMENDED DESIGN CRITERIA FOR WET DETENTION PONDS

PARAMETER	DESIGN CRITERIA
Treatment Volume	1-inch runoff or 2.5 inch x impervious percent (current SWFWMD criteria)
Recovery Time	Bleed-down of treatment volume in 120 hours (current SWFWMD criteria)
Permanent Pool	Volume based on required removal efficiency using Figures 3-14 to 3-17
Pond Depth/ Configuration/ Side Slopes	Depth: 25-50% of the pond area to be deeper than 12 ft Configuration: no restriction provided that the inlet and outlet are located as far apart as possible Side Slopes: 4:1 minimum
Littoral Zone	At least 35% of the pond surface (current SWFWMD criteria)

A more detailed evaluation of the general design methodology to achieve no net increase in post-development loadings is contained in the document titled "Evaluation of Alternative Stormwater Regulations for Southwest Florida", published by Harper (2003). This document provides a more detailed overview of the justification for selection of loading rates and determination of pre- and post-development loadings, as well as several detailed design examples which outline the methodology for evaluation of required stormwater treatment volumes. The Harper (2003) methodology is now the standard utilized in Lee and Collier Counties for development projects which involve 5 acres of wetland impacts or more.

6.1.4 Anticipated Load Reduction Efficiency

The overall objective of the alternative stormwater regulations option is to limit post-development annual mass pollutant loadings from a developed site to no more than the annual mass pollutant loadings discharging from the site in an undeveloped condition. The recommended design criteria for dry retention and wet detention systems, outlined in Tables 6-5 and 6-6, specify that the treatment system be designed to achieve no net increase in pollutant loadings under post-development conditions for the most restrictive of the four evaluated parameters. If a dry retention system is chosen as the alternative stormwater treatment option, the analysis assumes that the removal efficiencies for the four evaluated pollutants are identical for a given retention basin volume. Therefore, the dry retention system will be designed to meet the percent reduction efficiency which is the most restrictive of the four evaluated pollutants. As seen in Table 6-2, which provides estimates of required removal efficiencies to achieve no net increase in stormwater loadings, the highest percentage removal efficiencies are typically required for total phosphorus. When a system is designed to achieve no net increase in total phosphorus loadings, the removal efficiencies achieved for the remaining parameters will likely exceed the percentage required to achieve no net increase in loadings. As a result, when a system is designed to meet the treatment criteria for the most restrictive pollutant, the removal efficiencies achieved for the remaining constituents will likely exceed the required efficiencies, resulting in loadings for the remaining constituents which may be actually less than loadings discharging from the site under pre-development conditions.

A similar situation occurs when wet detention is chosen as the treatment alternative. The residence time within a wet detention pond required to achieve no net increase in phosphorus loadings will likely exceed the detention requirements to achieve no net increases in total nitrogen, BOD, and TSS. As a result, when a pond is designed to achieve no net increase in total phosphorus, loadings of total nitrogen, BOD, and TSS discharging from the pond under post-development conditions may actually be less than the loadings of these parameters discharging from the site under pre-development conditions.

A summary of anticipated load reduction efficiencies for the alternative stormwater regulation option is given in Table 6-7. Assuming that a system is designed to achieve no net increase in total phosphorus, in most cases, this will result in higher than required treatment efficiencies for the remaining constituents.

TABLE 6-7

ANTICIPATED LOAD REDUCTION EFFICIENCIES
FOR ALTERNATIVE STORMWATER REGULATIONS

PARAMETER	ANTICIPATED LOAD REDUCTION EFFICIENCY
Total N	Less than pre-development loads
Total P	Equal to pre-development loads
BOD	Less than pre-development loads
TSS	Less than pre-development loads

6.1.5 Cost of the Anticipated Alternative Stormwater Regulation Option

Costs for the alternative stormwater regulation option will be borne primarily by the developer. Other than the cost which may be involved in adopting the alternative regulations, no significant costs should be incurred by either SWFWMD or the local counties. Assurance that the alternative stormwater regulations have been met in the final design will become part of the ordinary review process for each project. Although these regulations may increase the review time initially, this should be reduced as the reviewers become familiar with the objectives and typical calculations.

6.2 Development of Stormwater Pollution Prevention Plans

6.2.1 Components of a Stormwater Pollution Prevention Plan

Development of stormwater pollution prevention plans should be required for all new developments in the Lemon Bay watershed. Pollution prevention plans discuss non-structural controls which are intended to improve the quality of stormwater runoff by reducing the generation and accumulation of potential stormwater runoff contaminants at or near the respective sources for each constituent. A stormwater pollution prevention plan should include guidelines in the areas of: (1) nutrient and pesticide management; (2) street sweeping; (3) solid waste management; and (4) stormwater treatment system operation and maintenance. An example of a generic stormwater pollution prevention plan is given in Appendix D.

Many of the methodologies and procedures outlined in a stormwater pollution prevention plan are general best management practices (BMPs) which may be used for attenuating pollutants in many types of urban settings. However, each stormwater pollution prevention plan should be tailored to meet the specific character of each proposed development, including the surrounding and constructed drainage features.

One of the primary aspects of a stormwater pollution prevention plan is a discussion of nutrient and pesticide management. This usually consists of a series of practices designed to manage the use of fertilizers and pesticides so as to minimize the loss of these compounds into stormwater runoff and the resulting water quality impacts on adjacent waterbodies. Nutrient and pesticide management plans typically discuss landscape planning, application of fertilizers and pesticides, and guidelines to minimize the necessity for the use of pesticides and fertilizers. The nutrient management program can also place restrictions on the percentage of nutrients contained in fertilizers which are used within the development. This can be used to target specific nutrients, such as nitrogen in the Lemon Bay watershed, which are problematic in the ultimate receiving waterbody. Pesticide management programs typically restrict the use of pesticides, fungicides, or herbicides to products which are consistent with the USDA NRCS soil rating for the specific soils, and which minimize the potential of leaching into groundwater or surface water.

Another aspect of a comprehensive stormwater pollution prevention plan is street sweeping. This practice is becoming increasingly more popular to minimize inputs of pollutants into stormwater runoff. Street sweeping activities can be particularly effective during periods of high leaf fall by removing solid leaf material and the associated nutrient loadings from roadside areas where they can easily become transported by stormwater flow. Previous research has indicated that leaves release large quantities of both nitrogen and phosphorus into surface water within 24-48 hours after becoming saturated in an aquatic environment. Loadings to waterbodies from leaf fall are often the most significant loadings to receiving waters during the fall and winter months. Street sweeping operations are typically performed on a monthly basis, with increased frequency during periods of high leaf fall.

A comprehensive stormwater pollution prevention plan may also contain information regarding the type and operation of stormwater management systems for the community. This document will describe the basic elements of the stormwater management system to better inform the residents who may potentially impact the operation of the system. The plan will also discuss maintenance of the detention pond, and emphasize that the proper operation of the system depends on cooperation from all homeowners involved.

Stormwater pollution prevention plans are typically attached as deed restrictions for new developments. As such, the provisions of the stormwater pollution prevention plan can be enforced by the Property Owners Association (POA), including assessing fines and placing liens on the property of homeowners who do not adopt the pollution prevention procedures.

Although it seems reasonable that a properly designed stormwater pollution prevention plan can reduce inputs of pollutants into stormwater runoff, no comprehensive studies have been conducted to document the reductions in loadings which can be achieved by this mechanism. Several studies are currently underway within the State of Florida which will address this issue during the next few years.

6.2.2 Anticipated Load Reduction Efficiency

Anticipated load reductions for implementation of stormwater pollution prevention plans can be highly variable, depending upon the degree of implementation by the impacted homeowners. Load reductions as high as 20% can be achieved for total nitrogen, total phosphorus, and BOD, based upon full implementation of the nutrient and pesticide management aspects of the stormwater pollution prevention plan. Assuming a sweeping frequency of approximately once per month, street sweeping has been shown to remove approximately 15% of the total nitrogen load, 20% of the total phosphorus load, 25% of BOD, and 50% of TSS. Street sweeping is also a non-structural control which can be used outside of the stormwater pollution prevention plan to reduce pollutant loadings from existing developed land uses which may not have stormwater treatment facilities. Anticipated load reductions for implementation of stormwater pollution prevention plans are summarized in Table 6-8.

TABLE 6-8

ANTICIPATED LOAD REDUCTIONS FOR IMPLEMENTATION OF STORMWATER POLLUTION PREVENTION PLANS

PARAMETER	PLAN ELEMENT	
	NUTRIENT AND PESTICIDE MANAGEMENT[1]	STREET SWEEPING[2]
Total N	0-20	15
Total P	0-20	20
BOD	0-20	25
TSS	0-50	50

1. Depending upon degree of implementation
2. Based on a sweeping frequency of once per month

6.2.3 Costs for Development and Implementation of Stormwater Pollution Prevention Plans

The costs for development and implementation of a stormwater pollution prevention plan will fall primarily on the developer and the homeowners of the developed community. The costs to governmental agencies for implementation of this option are considered to be negligible.

The only foreseeable economic impact on homeowners for implementation of a nutrient and pesticide management plan may be the increased cost of specially-formulated fertilizers which meet the nutrient content restrictions outlined in the nutrient management plan. Assuming that the specialized formulations increase the cost of the fertilizer approximately $10 per 50-pound bag, and assuming that the average homeowner applies five 50-pound bags of fertilizer twice each year, the average cost per homeowner would be approximately $100 per year.

The cost for street sweeping activities would be spread out among the homeowners within the community, and the fee per individual will depend upon the number of homeowners within a given community. Street sweeping costs are currently approximately $40/curb mile for brush-type street sweepers, with slightly increased costs for the newer vacuum-type machines.

6.3 Public Education

6.3.1 Components of a Public Education Program

Although public education is an element of stormwater pollution prevention plans, as presented in the previous section, additional opportunities for public education should be undertaken in the Lemon Bay watershed. These opportunities are particularly important for existing residents which are not part of a planned community and are not covered by a stormwater pollution prevention plan. Public education is one of the most important nonpoint source controls which can be used in a watershed. Many residents appear to be unaware of the direct link between watershed activities and the water quality in adjacent waterbodies and estuaries. The more a resident or business owner understands the relationship between nonpoint source loadings and receiving water quality, the more that person may be willing to implement source controls.

Several national studies have indicated that it is an extremely worthwhile and cost-effective activity to periodically remind property owners and occupants of the potential for water quality degradation which can occur due to misapplication of fertilizers and pesticides. Periodic information pamphlets can be enclosed with water and sewer bills which will reach virtually all residents within the watershed. These educational brochures should emphasize the fact that taxpayer funds are currently being utilized to treat nonpoint source water pollution, and the homeowners have the opportunity to reduce this tax burden by modifying their daily activities. A comprehensive public education program should concentrate, at a minimum, on the following topics:

1. Relationship between land use, stormwater runoff, and pollutants
2. Functions of stormwater treatment systems
3. How to reduce stormwater runoff volume
4. Impacts of water fowl and pets on runoff characteristics and surface water quality
5. County stormwater program goals and regulations
6. Responsible use of fertilizer, pesticides and herbicides

7. Elimination of illicit connections to the stormwater system

8. Controlling erosion and turbidity

9. Proper operation and maintenance of stormwater systems

The public education program can be implemented in a variety of ways, including homeowner and business seminars, newsletters, performing special projects with local schools (elementary, middle and high schools), Earth Day celebrations, brochures, and special signage at stormwater treatment construction sites. Many people do not realize that stormsewers eventually drain to area lakes. Many cities and counties in Florida have implemented a signage program which places a small engraved plaque on each stormsewer inlet indicating "Do Not Dump, Drains to Lake (Estuary or Bay)". ERD recommends that an aggressive public education program be implemented in the Lemon Bay watershed which incorporates all of the elements discussed previously.

6.3.2 Anticipated Load Reduction Efficiency

Anticipated load reductions for implementation of public education programs are difficult to predict and depend highly upon the degree of implementation by the homeowners within the basin. The impacts of public education programs also depend, to a large extent, on the degree to which water quality within the Lemon Bay basin is currently being impacted by uneducated and uninformed activities by current homeowners.

Virtually no previous studies have been conducted to evaluate the water quality impacts resulting from improved homeowner education programs. Several regional and national studies are currently being performed which will attempt to document the results of public education programs. However, the actual load reductions achieved by public education programs will probably be relatively small, probably in the range of 10% each for nitrogen, phosphorus, BOD, and TSS.

6.3.3 Costs for Public Education Programs

Costs for public education programs can be highly variable depending upon the intensity of the education program and the types of media used to reach individual homeowners. A simple newsletter placed in a utility bill would be a relatively inexpensive method of reaching many of the residents in the Lemon Bay watershed. Government agencies could also sponsor seminars or special projects with local schools which would be relatively inexpensive.

6.4 Description of Sarasota County Projects

The draft Sarasota County Comprehensive Watershed Management Plan, dated August 2003, outlines a number of proposed capital improvement projects which have the potential to impact water quality within the Lemon Bay watershed. The proposed Sarasota County projects are listed under the general categories of hydrologic restoration, conversion of effluent ponds to stormwater management systems, and conversion of wastewater treatment plants to stormwater treatment plants. A general overview of the objectives of the three programs is given in the following sections. A summary of proposed Sarasota County watershed management projects in the Lemon Bay watershed is given in Table 6-9.

TABLE 6-9

PROPOSED SARASOTA COUNTY WATERSHED MANAGEMENT PROJECTS IN THE LEMON BAY WATERSHED

PROGRAM	PROGRAM GOAL	POTENTIAL PROJECTS
Hydrologic Restoration	Restore freshwater systems that have been altered through man-made drainage activities	1. Alligator Creek Restoration 2. Forked Creek Western Branch Restoration Site 3. Forked Creek Eastern Branch Restoration Site 4. Manasota Key Restoration Site 5. Gottfried Creek Restoration Site 6. River Road Wetland Restoration Site 7. Ainger Creek Restoration
Conversion of Effluent Ponds to Stormwater Management Systems	Eliminate wastewater discharge and improve stormwater quality	1. Florida Pines MHC 2. Japanese Gardens MHP 3. Polynesian Village MHP 4. Englewood Utility
Conversion of Wastewater Treatment Plants to Stormwater Treatment Plants	Reduce stormwater pollutant loads and excess volumes to Bays; provide beneficial irrigation uses	1. Venice Gardens WRF 2. Plantation

6.4.1 Hydrologic Restoration Project

The objective of the hydrologic restoration program is to restore freshwater systems that have been altered by man-made drainage activities. These projects are seen as opportunities to restore freshwater flows to estuary systems, enhance existing floodplain storage, and improve surface water quality through increased residence times in the restored freshwater systems. A total of seven hydrologic restoration projects have been identified in Sarasota County portions of the Lemon Bay watershed. Approximate locations of the proposed hydrologic restoration projects are indicated on Figure 6-1.

Specific details for the hydrologic restoration projects have not been developed by Sarasota County and, therefore, estimates of pollutant load reductions or water quality benefits resulting from the proposed projects cannot be performed at this time. With the exceptions of the Forked Creek Western Branch Restoration Site and the Manasota Key Restoration Site, indicated on Figure 6-1, most of the proposed restoration sites are located in upstream portions of the respective watersheds where the projects would impact only a small portion of the drainage discharging through each basin. These restoration sites are also located upstream of the major development areas within each watershed which generate a large portion of the pollutant loadings discharging into the Bay. As a result, although the proposed projects will restore valuable hydrologic habitat, the overall impact of these projects on mass loadings reaching Lemon Bay is expected to be relatively small. Further evaluations of potential water quality impacts can be performed when additional information is available concerning each of the proposed projects.

6.4.2 Conversion of Effluent Wastewater Ponds to Stormwater Management Systems

This initiative involves elimination of overflow discharges of wastewater effluent from existing effluent ponds and conversion of the effluent ponds to stormwater management systems. A total of four effluent ponds have been identified by Sarasota County in the Lemon Bay watershed for potential conversion to stormwater treatment systems. Locations of these proposed sites are indicated on Figure 6-1. One of the sites is located in the Alligator Creek basin, with one in the

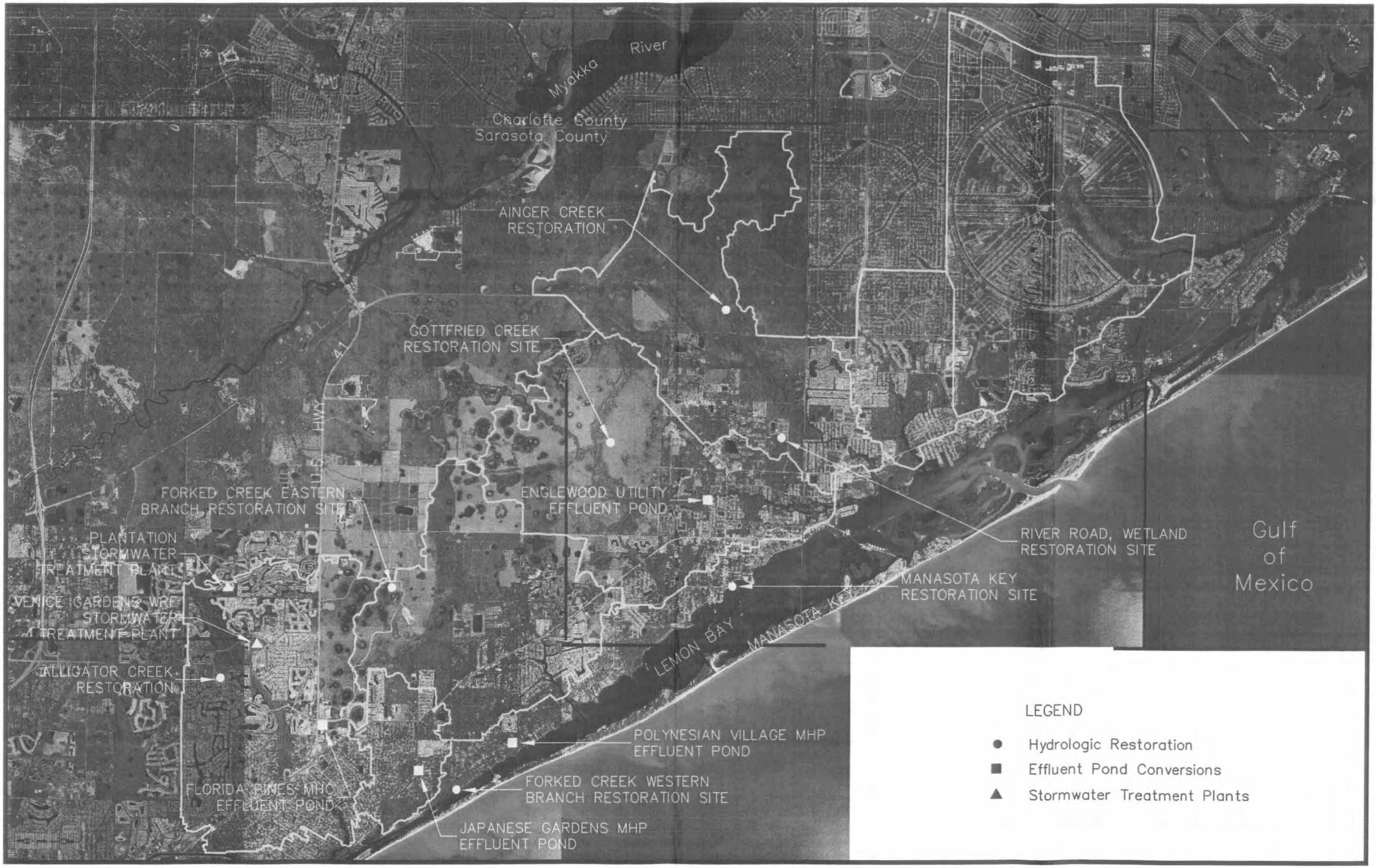


Figure 6-1. Planned Sarasota County Watershed Management Projects.

Woodmere Creek basin, one in the Gottfried Creek basin, and a site located west of the Forked Creek basin adjacent to Lemon Bay.

Each of the effluent pond conversion sites identified by Sarasota County consists of small-package wastewater treatment systems which are located adjacent to waterbodies. These package wastewater treatment systems are viewed as potential water quality concerns by Sarasota County, and the County desires to convert the existing customers to the centralized public Wastewater Utility. Many of the communities serviced by these package plants pre-date current stormwater regulations and discharge untreated stormwater to the receiving waterbodies. Conversion of the effluent ponds to stormwater management systems has the dual water quality benefit of removing the loadings associated with the wastewater effluent discharges as well as providing stormwater treatment for areas which currently are untreated. Many of these areas are located in highly urbanized environments which would be difficult to otherwise retrofit for stormwater treatment.

Although the specific details for conversion of effluent ponds to stormwater management systems have not been developed at this time, this initiative appears to have a potential for significantly impacting loadings discharging to Lemon Bay from each of the affected watersheds. More detailed evaluations of potential water quality impacts will be possible when details of the proposed project have been completed. However, the combined impacts of eliminating wastewater discharging and providing stormwater treatment may reduce pollutant loadings by as much as 10-20% in each of the impacted watersheds.

6.4.3 Conversion of Wastewater Treatment Plants to Stormwater Treatment Plants

Over the past several years, the Sarasota County Water and Sewer Utility has been acquiring major wastewater treatment plants associated with private franchised areas. After purchase of these facilities, the County plans to put the plants in an "off-line" mode over the next few years. Sarasota is currently undergoing discussions to convert these wastewater treatment plants to stormwater treatment plants after the wastewater treatment plants are no longer used for effluent treatment. Each of the wastewater treatment plants would be modified to intake stormwater from adjacent drainage features and to provide yet unidentified removal processes for stormwater pollutants. The treated stormwater would then be reintroduced back into the drainage system. These facilities also have the possibility to provide augmentation for the County's irrigation reuse supply system.

A total of two wastewater treatment facilities have been identified in the Lemon Bay watershed with the potential for conversion to a stormwater treatment plant. These facilities are identified as the Venice Gardens Stormwater Treatment Facility and the Plantation Stormwater Treatment Facility. Feasibility investigations are currently underway for these two facilities by Sarasota County. Based upon the results of these preliminary feasibility investigations, more detailed engineering evaluations may be conducted in 2004. Locations of the proposed wastewater treatment plant conversions are indicated on Figure 6-1.

The proposed wastewater conversion initiatives have the potential to impact water quality by reducing inputs of treated wastewater into waterbodies adjacent to Lemon Bay and to cost-effectively reduce stormwater pollutant loads and excess freshwater inputs to Lemon Bay. These conversion plants have the opportunity to provide significant improvements in water quality characteristics in areas impacted by the treatment facilities. Unfortunately, each of the two proposed conversion plants in the Lemon Bay watershed is located in upper portions of the Alligator Creek basin. As a result, these plant conversions will only impact loadings discharging from Alligator Creek, and since these plants are located in upper portions of the watershed, the overall impacts on loadings discharging from Alligator Creek to Lemon Bay will be substantially reduced.

6.5 Water Quality Improvement Projects for Oyster Creek and Buck Creek

The Oyster Creek and Buck Creek watersheds are located primarily in Charlotte County and are not included in the water quality initiatives proposed by Sarasota County discussed in the previous section. No current water quality improvement projects are proposed for these sub-basin areas by Charlotte County. Therefore, separate water quality treatment options were evaluated by ERD for the Oyster Creek and Buck Creek sub-basins to reduce pollutant loadings from these basins to Lemon Bay.

When developing stormwater treatment options to reduce pollutant loadings to receiving waterbodies, it is commonly most economical and effective to construct the treatment systems as close as possible to the point of discharge into the ultimate receiving waterbody. For the Oyster Creek and Buck Creek watersheds, this would involve construction of stormwater treatment facilities near the western edge of each watershed boundary upstream of the point of discharge into Lemon Bay. One constraint which affects the feasibility of stormwater treatment options for each of the two watersheds is the low land elevation in western portions of the drainage basins, with wet season groundwater tables being near the land surface in most areas. Due to the low land elevation and high groundwater table conditions, dry retention systems may not be applicable in these areas. As a result, a wet detention system or chemical treatment system appear to be the most feasible potential treatment alternatives. These types of stormwater treatment systems provide the highest pollutant removal efficiencies of the feasible retrofit alternatives.

Construction of a wet detention or chemical treatment system will require significant amounts of land for construction of wet detention ponds or settling ponds for the chemical treatment option. Land costs involved in purchasing privately owned parcels can often be the most expensive component of a retrofit project. Land costs can often be substantially reduced if publicly owned lands are available in the vicinity of the desired stormwater treatment systems. An overview of public owned lands in the Oyster and Buck Creek watersheds is given on Figure 6-2. No publicly owned lands currently exist in the Oyster Creek basin. Publicly owned lands in the Buck Creek watershed consist primarily of wooded wetland areas along the southern portion of the Rotunda Development. These publicly owned lands appear to be located in the wrong position within the watershed, and are probably unavailable for stormwater treatment purposes due to the significant habitat provided by these areas. Therefore, privately owned lands will need to be purchased for construction of any significant stormwater treatment alternative project within these basins.

Figure 6-2. Public Owned Lands in the Oyster Creek and Buck Creek Watersheds.

6.5.1 Wet Detention Alternative

Separate wet detention treatment alternatives were evaluated for the Oyster Creek and Buck Creek watersheds. Each of these wet detention ponds would be constructed as close as possible to the point of discharge from Oyster Creek and Buck Creek into Lemon Bay. However, since the availability of land in the desired locations is not known at this time, specific sites for the two wet detention ponds could not be evaluated. Therefore, the evaluations for wet detention ponds for the two sub-basins include only estimates of the pond site and construction costs without costs associated with required land purchases.

The wet detention options for Oyster Creek and Buck Creek are based upon constructing a wet detention pond which will provide a 14-day residence time at the normal water flow rate under wet season conditions. Water would be diverted from each tributary into the wet detention pond and returned back into the tributary following treatment. The average wet season flow rate is calculated as the wet season inflow volume, obtained from Section 5, divided by the wet season duration of 122 days. The permanent pool volume is calculated as the average water flow rate times 14 days. The required land area can be estimated by assuming an average permanent pool depth and multiplying that area by a factor to account for side slopes and the maintenance berm.

A summary of wet detention pond requirements for Oyster Creek and Buck Creek is given in Table 6-10. Based upon the modeling performed by ERD, the average annual flow rate in Oyster Creek is approximately 2.8 cfs, with an average annual flow rate of approximately 9.4 cfs in Buck Creek. Based upon a minimum 14-day residence time under wet season conditions, a wet detention pond for the Oyster Creek basin will have a permanent pool volume of approximately 160 ac-ft, with a permanent pool volume of approximately 554 ac-ft for the Buck Creek basin. Construction of these ponds will require approximately 21.1 acres in the Oyster Creek basin and 62.7 acres in the Buck Creek basin, assuming the ponds are constructed near the point of inflow into Lemon Bay.

TABLE 6-10

WET DETENTION POND REQUIREMENTS
FOR OYSTER CREEK AND BUCK CREEK

BASIN	ANNUAL DISCHARGE VOLUME (ac-ft)	AVERAGE FLOW RATE (cfs)	POND PERMANENT POOL VOLUME (ac-ft)	REQUIRED LAND AREA (acres)
Oyster	2023	2.8	160	21.1
Buck	6795	9.4	554	62.7

6.5.2 Inflow Chemical Treatment

Since at least Roman times, salts of aluminum have been added to drinking water and surface water to reduce turbidity and improve appearance. Alum has been used extensively as a flocculating agent in the treatment of wastewater for over 100 years. In 1970, Jernelov was apparently the first to use alum to remove phosphorus from the water column of a lake as part of a lake restoration project on Lake Langsjon in Sweden. The first U.S. lake to be treated was Horseshoe Lake which received a surface application of 2.6 mg Al/liter in May 1970. Twelve years later, phosphorus concentrations were still below the pre-treatment level (Garrison and Knauer, 1984).

The addition of alum to water results in the production of chemical precipitates which remove pollutants by two primary mechanisms. Removal of suspended solids, algae, phosphorus, heavy metals and bacteria occurs primarily by enmeshment and adsorption onto aluminum hydroxide precipitate according to the following net reaction:

$$Al^{+3} + 6H_2O \rightarrow Al(OH)_{3(s)} + 3H_3O^{+}$$

Removal of additional dissolved phosphorus occurs as a result of direct formation of $AlPO_4$ by:

$$Al^{+3} + HnPO_4^{n-3} \leftrightarrow AlPO_{4(s)} + nH^{+}$$

The aluminum hydroxide precipitate, $AlOH_3$, is a gelatinous floc which attracts and adsorbs colloidal particles onto the growing floc, thus clarifying the water. Phosphorus removal or entrapment can occur by several mechanisms, depending on the solution pH. Inorganic phosphorus is also effectively removed by adsorption to the $AlOH_3$ floc. Removal of particulate phosphorus is most effective in the pH range of 6-8 where maximum floc occurs (Cooke and Kennedy, 1981). At higher pH values, OH^- begins to compete with phosphate ions for aluminum ions, and aluminum hydroxide-phosphate complexes begin to form. At lower pH values and higher inorganic phosphorus concentrations, the formation of aluminum phosphate ($AlPO_4$) is favored.

The alum precipitates formed during coagulation of stormwater can be allowed to settle in receiving waterbodies or collected in small settling basins. Alum precipitates are exceptionally stable in sediments and will not redissolve due to changes in redox potential or pH under conditions normally found in surface waterbodies. Over time, the freshly precipitated floc ages into even more stable complexes, eventually forming gibsite. The solubility of dissolved aluminum in the treated water is regulated entirely by chemical equilibrium. As long as the pH of the treated water is maintained within the range of 5.5-7.5, dissolved aluminum concentrations will be minimal. In many instances, the concentration of dissolved aluminum in the treated water will be less than the concentration in the raw untreated water due to adjustment of pH into the range of minimum solubility.

Once alum has been identified as an option in a retrofit project, extensive laboratory testing must be performed to verify the feasibility of alum treatment and to establish process design parameters. The feasibility of alum treatment for a particular stormwater stream is typically evaluated in a series of laboratory jar tests conducted on representative runoff samples collected from the project watershed area. This extensive laboratory testing is an essential part of the evaluation process necessary to determine design, maintenance and operational parameters such as the optimum coagulant dose required to achieve the desired water quality goals, chemical pumping rates and pump sizes, the need for additional chemicals to buffer receiving water pH, post-treatment water quality characteristics, floc formation and settling characteristics of the floc, required detention time of treated water to provide maximum settling, floc accumulation, annual chemical costs and storage requirements, ecological effects, and maintenance procedures. In addition to determining the optimum coagulant dose, jar tests can also be used to determine floc strength and stability, and required mixing intensity and duration.

In a typical alum stormwater treatment system, alum is injected into the tributary flow on a flow-proportioned basis so that the same dose of alum is added to the stormwater flow regardless of the discharge rate. A variable speed chemical metering pump is typically used as the injection pump. The operation of the injection pump is regulated by a flow meter device attached to a stormwater line to be treated. Measured flow from the stormwater flow meter is transformed into a 4-20 mA electronic signal which instructs the metering pump to inject alum according to the measured flow of runoff discharging through each individual stormsewer line. Mixing of the alum and stormwater occurs as a result of turbulence in the system. If sufficient turbulence is not available within the system, artificial turbulence can be generated using aeration or physical stormsewer modifications.

Mechanical components for the alum stormwater treatment system, including chemical metering pumps, stormsewer flow meters and electronic controls, are typically housed in a central facility which can be constructed as an above-ground or below-ground structure. A fiberglass or polyethylene storage tank is typically used for bulk alum storage. Alum feed lines and electrical conduits are run from the central facility to each point of alum addition and flow measurement. Alum injection points can be located as far as 1000 ft or more from the central pumping facility. Early designs for alum stormwater treatment systems utilized individual chemical metering pumps and stormsewer flow meters for each point of alum addition. However, in an effort to reduce overall system costs and complexity, current alum stormwater treatment systems often feed alum to multiple points using a single chemical metering pump and either manual or electronic control valves. Over the years, systems have been developed to automatically remove alum floc from treated stormwater with disposal in the sanitary sewer system.

ERD has conducted laboratory investigations on stormwater runoff collected from a wide range of land uses typical of urban areas to quantify the amount of alum floc generated as a result of alum treatment of stormwater runoff at various treatment doses. After initial formation, alum floc appears to consolidate rapidly for a period of approximately 6-8 days, consolidating to approximately 20% of the initial floc volume. Additional consolidation appears to occur over a settling period of approximately 30 days, after which collected sludge volumes appear to approach 90-95% of maximum consolidation (Harper, 1990).

Estimates of maximum anticipated sludge production, based upon literally hundreds of laboratory tests involving coagulation of stormwater runoff with alum at various doses, and based upon a consolidation period of approximately 30 days, is given in Table 6-11. At alum doses typically used for treatment of stormwater runoff, ranging from 5-10 mg Al/liter, sludge production is equivalent to approximately 0.16-0.28% of the treated runoff flow. Sludge production values listed in Table 6-11 reflect the combined mass generated by alum floc as well as solids settling from the stormwater sample.

TABLE 6-11

ANTICIPATED PRODUCTION OF ALUM SLUDGE FROM ALUM TREATMENT OF STORMWATER AT VARIOUS DOSES

ALUM DOSE (mg/l Al)	SLUDGE PRODUCTION[1]		
	AS PERCENT OF TREATED FLOW	PER 1000 m^3 TREATED	PER 10^6 GALLONS TREATED
5	0.16	1.6 m^3	214 ft^3
7.5	0.20	2.0 m^3	268 ft^3
10	0.28	2.8 m^3	374 ft^3

1. Based on a minimum settling time of 30 days

The inflow chemical treatment alternative was evaluated for the Buck Creek and Oyster Creek tributaries. This treatment alternative involves diverting water discharging through Buck Creek and Oyster Creek into a floc settling pond. Water flow rate would be measured and the appropriate dose of alum would be maintained at a wide range of water flow rates entering the floc settling pond. During the Design Phase, water discharging through each tributary would be collected and laboratory jar testing would be performed to determine the optimum alum dose and floc settling characteristics. The required floc settling pond water volume is calculated as the design water flow rate multiplied times the desired detention time. The required land area for the floc settling pond is calculated as the required wet pond volume divided by a water depth times a factor to allow for side slopes and maintenance berm.

A summary of requirements for the tributary chemical treatment alternative is provided in Table 6-12. The required wet pond volume was calculated as the design flow rate times a 24-hour detention time. The actual required detention time to allow floc settling to occur may be significantly lower. Some previously completed projects have required only a 3-hour floc settling time which would reduce the required wet pond volume to only 12.5% of the values listed in Table 6-12. The estimated land area requirement for each of the facilities was calculated based on an assumed 10-ft wet pond water depth and a factor of 1.5 to allow for pond slopes and maintenance berm. The required wet pond volume and land area for the inflow chemical treatment alternative are approximately 20-25% of the permanent pool volume and land area required for the wet detention treatment alternative.

Pollutant removal efficiencies for alum treatment are substantially greater than the pollutant removal efficiencies for wet detention treatment. A chemical treatment system designed to treat approximately 50% of the annual water volume would achieve approximately the same mass pollutant load reduction as a wet detention system designed to treat the entire annual water volume. Based on the previous 35 alum stormwater treatment projects completed by ERD, an alum dose of 7.5 mg/l as aluminum was selected for completing the preliminary engineering analysis for the chemical treatment alternative. An alum dose of 7.5 mg/l as aluminum would result in an estimated annual floc volume of approximately 0.2% of the treated water volume. A summary of annual water volume treated, estimated annual alum use, and estimated floc production for each of the inflow tributaries is presented in Table 6-13.

TABLE 6-12

SETTLING POND VOLUME AND LAND AREA REQUIREMENTS FOR THE INFLOW CHEMICAL TREATMENT ALTERNATIVE

TRIBUTARY	DESIGN FLOW RATE[1] (cfs)	REQUIRED WET POND VOLUME[2] (ac-ft)	SETTLING POND REQUIRED LAND AREA[3] (ac)	FLOC DRYING LAND AREA (ac)
Oyster Creek	14.0	27.8	4.2	8.4
Buck Creek	47.0	93.2	14.0	28.0

1. Based on 5 times the annual average flow rate
2. Based on 24-hour detention time at design flow rate
3. Calculated as (wet pond volume/10 ft) x 1.5

TABLE 6-13

ESTIMATED ANNUAL ALUM REQUIREMENTS AND FLOC VOLUME PRODUCTION FOR THE INFLOW CHEMICAL TREATMENT ALTERNATIVE

TRIBUTARY	ANNUAL WATER VOLUME TREATED[1] (ac-ft)	ESTIMATED ANNUAL ALUM USE[2] (gal)	ESTIMATED ANNUAL FLOC PRODUCTION[3] (ac-ft)
Oyster Creek	1,517	63,281	3.0
Buck Creek	5,096	212,576	10.2

1. Based on treating 75% of annual inflow volume
2. Based on alum dose of 7.5 mg aluminum/liter
3. Based on floc volume = 0.2% of treated water volume

6.5.3 Anticipated Load Reduction Efficiency

A summary of anticipated load reduction efficiencies for the wet detention and chemical treatment options evaluated for Oyster Creek and Buck Creek is given in Table 6-14. Typical removal efficiencies for constructed wet detention and chemical treatment systems are provided based upon the results of the literature review summarized in Section 3 and previous experience by ERD. Estimated removal efficiencies for the tributary treatment systems are also provided based upon the assumption that approximately 75% of the annual volume discharging through Buck Creek and Oyster Creek will be diverted into the wet detention or chemical treatment system for attenuation of tributary pollutants.

TABLE 6-14

ESTIMATED PERFORMANCE EFFICIENCIES OF THE WET DETENTION AND CHEMICAL TREATMENT OPTIONS

PARAMETER	WET DETENTION		CHEMICAL TREATMENT	
	TYPICAL REMOVAL[1] (%)	TRIBUTARY REMOVAL[2] (%)	TYPICAL REMOVAL[1] (%)	TRIBUTARY REMOVAL[2] (%)
Total N	25	19	50	38
Total P	65	49	90	68
BOD	65	49	70	53
TSS	75	56	90	68

1. Typical removal efficiencies for constructed systems
2. Estimated removal for tributary treatment system based on treatment of 75% of annual volume

Based upon the assumption that approximately 75% of the annual volume will be treated within each system, the wet detention system is expected to reduce mass loadings from the two tributaries by approximately 19% for total nitrogen, 49% for total phosphorus, 49% for BOD, and 56% for TSS. The chemical treatment system will reduce mass loadings discharging from each tributary by approximately 38% for total nitrogen, 68% for total phosphorus, 53% for BOD, and 68% for TSS.

6.5.4 Cost of the Wet Detention and Chemical Treatment Options

6.5.4.1 Probable Construction Costs

A conceptual opinion of probable construction cost for the wet detention option in Buck Creek is given in Table 6-15. Construction costs are included for mobilization, clearing and grubbing, earthwork, sodding, structures, fencing, and plantings. The construction costs are based upon a constructed permanent pool volume of approximately 554 ac-ft covering a land area of 62.7 acres. The construction costs outlined in Table 6-15 do not include land costs which will be additional. The estimated construction cost for the wet detention pond in the Buck Creek watershed is approximately $7,510,800 which includes a 20% contingency.

TABLE 6-15

CONCEPTUAL OPINION OF PROBABLE CONSTRUCTION COST FOR THE WET DETENTION OPTION IN BUCK CREEK

ITEM NO.	DESCRIPTION	UNIT	QUANTITY	UNIT COST ($)	TOTAL COST ($)
1.	Mobilization, bonds, etc.	LS	--	--	$ 569,000.00
2.	Clearing and grubbing	AC	50	5,000.00	250,000.00
3.	Earthwork	CY	1,105,000	4.00	4,420,000.00
4.	Sodding	SY	20,000	2.25	45,000.00
5.	6-inch diameter concrete riprap	SY	1,000	80.00	80,000.00
6.	Floating turbidity barrier	LF	1,000	5.00	5,000.00
7.	Staked silt fence	LF	8,000	2.50	20,000.00
8.	Precast concrete box culvert	LF	500	1,000.00	500,000.00
9.	Manhole	EA	4	15,000.00	60,000.00
10.	Box culvert endwall	EA	3	10,000.00	30,000.00
11.	Outfall structure	LS	--	--	20,000.00
12.	Fencing	LF	6,000	10.00	60,000.00
13.	Plantings	LS	--	--	200,000.00
				Sub-Total:	$ 6,259,000.00
				20% Contingency:	1,251,800.00
				TOTAL:	**$ 7,510,800.00***

*Land cost not included

A conceptual opinion of probable construction cost for the wet detention option for Oyster Creek is given in Table 6-16. The construction costs summarized in Table 6-16 are based upon a pond with a permanent pool volume of 160 ac-ft covering an area of 21.1 acres. The estimated construction cost is $2,577,630 including a 20% contingency.

TABLE 6-16

CONCEPTUAL OPINION OF PROBABLE CONSTRUCTION COST FOR THE WET DETENTION OPTION IN OYSTER CREEK

ITEM NO.	DESCRIPTION	UNIT	QUANTITY	UNIT COST ($)	TOTAL COST ($)
1.	Mobilization, bonds, etc.	LS	--	--	$ 195,275.00
2.	Clearing and grubbing	AC	17	5,000.00	85,000.00
3.	Earthwork	CY	331,000	4.00	1,324,000.00
4.	Sodding	SY	15,000	2.25	33,750.00
5.	6-inch diameter concrete riprap	SY	500	80.00	40,000.00
6.	Floating turbidity barrier	LF	500	5.00	2,500.00
7.	Staked silt fence	LF	4,000	2.50	10,000.00
8.	Precast concrete box culvert	LF	500	500.00	250,000.00
9.	Manhole	EA	4	10,000.00	40,000.00
10.	Box culvert endwall	EA	3	7,500.00	22,500.00
11.	Outfall structure	LS	--	--	10,000.00
12.	Fencing	LF	3,500	10.00	35,000.00
13.	Plantings	LS	--	--	100,000.00
				Sub-Total:	$ 2,148,025.00
				20% Contingency:	429,605.00
				TOTAL:	**$ 2,577,630.00***

*Land cost not included

The conceptual opinion of probable construction cost for the off-line alum treatment system in the Buck Creek watershed is given in Table 6-17. Construction costs are included for mobilization, earthwork, structures, electronics, and chemical storage and feed systems. The construction costs are based upon a settling pool volume of approximately 93.2 ac-ft covering a land area of 14.0 acres. The construction costs outlined in Table 6-17 do not include land costs since a specific site has not been selected at this time. The estimated construction costs for the off-line alum treatment alternative in Buck Creek is approximately $2,906,310 which includes a 20% contingency.

A conceptual opinion of probable construction cost for the off-line alum treatment alternative in the Oyster Creek watershed is given in Table 6-18. The construction costs are based upon a constructed settling pool volume of approximately 27.8 ac-ft covering a land area of 4.2 acres. The construction costs outlined in Table 6-18 do not include land costs since a specific site has not been selected at this time. The estimated construction cost for the off-line alum treatment alternative in the Oyster Creek watershed is approximately $1,339,140 which includes a 20% contingency.

6.5.4.2 Operation and Maintenance Costs

A summary of estimated operation and maintenance (O&M) costs for the wet detention pond options is given in Table 6-19. Estimated annual costs are included for general pond maintenance which includes mowing, periodic inspections, and removal of accumulated debris. The labor costs are based upon a rate of $15/hour. Costs are also included for maintenance of the vegetated plant communities within the pond based upon an annual fee equivalent to approximately 2.5% of the initial planting costs. Fees associated with removing accumulated solids and debris are also included in Table 6-19. The overall estimated O&M cost is approximately $12,216/year for the Oyster Creek wet detention pond, with an estimated O&M cost of $21,617/year for the Buck Creek wet detention pond.

TABLE 6-17

CONCEPTUAL OPINION OF PROBABLE CONSTRUCTION COST FOR THE OFF-LINE ALUM TREATMENT ALTERNATIVE IN THE BUCK CREEK WATERSHED

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT COST ($)	TOTAL COST ($)
1.	Mobilization, Bonds, etc.	--	LS	--	$ 220,175.00
2.	Clearing and Grubbing	13	AC	5,000.00	65,000.00
3.	Excavation - Settling Ponds	250,000	CY	4.00	1,000,000.00
4.	Embankment - Drying Areas	50,000	CY	3.00	150,000.00
5.	Sodding	14,000	SY	2.25	31,500.00
6.	6-inch Diameter Concrete Riprap	1,000	SY	80.00	80,000.00
7.	Floating Turbidity Barrier	500	LF	5.00	2,500.00
8.	Staked Silt Fence	3,500	LF	2.50	8,750.00
9.	Precast Concrete Box Culvert	500	LF	300.00	150,000.00
10.	Manhole	4	EA	15,000.00	60,000.00
11.	Box Culvert Endwall	3	EA	10,000.00	30,000.00
12.	Outfall Structure	1	EA	20,000.00	20,000.00
13.	Fencing	3,500	LF	10.00	35,000.00
14.	Alum Equipment Building	--	LS	--	75,000.00
15.	Chemical Storage Tanks	--	LS	--	50,000.00
16.	Chemical Pumps and Controls	--	LS	--	75,000.00
17.	Building Piping, Valves, Fittings	--	LS	--	10,000.00
18.	1-inch PRGS (signal conduit)	1,000	LF	15.00	15,000.00
19.	2-inch PVC (chemical, air)	1,000	LF	10.00	10,000.00
20.	Air Compressor	--	LS	--	2,500.00
21.	Chemical Meters	--	LS	--	20,000.00
22.	Water Flow Meters	--	LS	--	50,000.00
23.	Water Service	--	LS	--	2,500.00
24.	12-inch HDPE Floc Suction Line	1,500	LF	20.00	30,000.00
25.	18-inch HDPE Floc Discharge Line	1,500	LF	30.00	45,000.00
26.	12-inch HDPE Floc Discharge Line	1,200	LF	20.00	24,000.00
27.	12-inch Plug Valve	10	EA	1,000.00	10,000.00
28.	Duplex Floc Pump Station	--	LS	--	100,000.00
29.	Electrical/Mechanical	--	LS	--	50,000.00
				Sub-Total:	$2,421,925.00
				20% Contingency:	484,385.00
				PROJECT TOTAL:	**$2,906,310.00***

* Land Cost Not Included

TABLE 6-18

CONCEPTUAL OPINION OF PROBABLE CONSTRUCTION COST FOR THE OFF-LINE ALUM TREATMENT ALTERNATIVE IN THE OYSTER CREEK WATERSHED

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT COST ($)	TOTAL COST ($)
1.	Mobilization, Bonds, etc.	--	LS	--	$ 101,450.00
2.	Clearing and Grubbing	5	AC	5,000.00	25,000.00
3.	Excavation - Settling Ponds	75,000	CY	4.00	300,000.00
4.	Embankment - Drying Areas	15,000	CY	3.00	45,000.00
5.	Sodding	7,000	SY	2.25	15,750.00
6.	6-inch Diameter Concrete Riprap	500	SY	80.00	40,000.00
7.	Floating Turbidity Barrier	500	LF	5.00	2,500.00
8.	Staked Silt Fence	2,300	LF	2.50	5,750.00
9.	Precast Concrete Box Culvert	500	LF	150.00	75,000.00
10.	Manhole	4	EA	10,000.00	40,000.00
11.	Box Culvert Endwall	3	EA	7,500.00	22,500.00
12.	Outfall Structure	1	EA	10,000.00	10,000.00
13.	Fencing	2,300	LF	10.00	23,000.00
14.	Alum Equipment Building	--	LS	--	50,000.00
15.	Chemical Storage Tanks	--	LS	--	35,000.00
16.	Chemical Pumps and Controls	--	LS	--	55,000.00
17.	Building Piping, Valves, Fittings	--	LS	--	10,000.00
18.	1-inch PRGS (signal conduit)	1,000	LF	15.00	15,000.00
19.	2-inch PVC (chemical, air)	1,000	LF	10.00	10,000.00
20.	Air Compressor	--	LS	--	2,500.00
21.	Chemical Meters	--	LS	--	10,000.00
22.	Water Flow Meters	--	LS	--	50,000.00
23.	Water Service	--	LS	--	2,500.00
24.	8-inch HDPE Floc Suction Line	1,000	LF	15.00	15,000.00
25.	12-inch HDPE Floc Discharge Line	1,000	LF	20.00	20,000.00
26.	12-inch HDPE Floc Discharge Line	800	LF	15.00	12,000.00
27.	12-inch Plug Valve	10	EA	800.00	8,000.00
28.	Duplex Floc Pump Station	--	LS	--	75,000.00
29.	Electrical/Mechanical	--	LS	--	40,000.00
				Sub-Total:	$1,115,950.00
				20% Contingency:	223,190.00
				PROJECT TOTAL:	**$1,339,140.00***

* Land Cost Not Included

TABLE 6-19

ESTIMATED ANNUAL OPERATION AND MAINTENANCE COSTS FOR THE WET DETENTION POND OPTIONS

WATERSHED	ESTIMATED ANNUAL O&M COST ($)			
	GENERAL MAINTENANCE[1]	PLANT MAINTENANCE[2]	SOLIDS REMOVAL[3]	TOTAL
Oyster	8,640	2,500	1,076	12,216
Buck	12,960	5,000	3,657	21,617

1. Based on hourly rate = $15/hour

2. Based on 2.5% of initial planting cost

3. Based on handling semi-dry material @ $10/yd^3; volume = 1/3 of estimated floc volume

Estimated annual O&M costs for the off-line alum treatment alternatives are summarized in Table 6-20. Labor costs are included for routine system inspection, maintenance, and operation. Chemical costs are included based upon the estimated alum use summarized in Table 6-13. Annual power requirements and cost for the systems are estimated based upon previous experience by ERD. Renewal and replacement costs are included based upon a 20-year life for the system components. Fees for solids handling and floc disposal are also included. The estimated annual O&M cost for the off-line alum treatment system in the Oyster Creek basin is approximately $55,803, with an estimated annual cost of $145,134 for the Buck Creek system.

TABLE 6-20

ESTIMATED ANNUAL OPERATION AND MAINTENANCE COSTS FOR THE OFF-LINE ALUM TREATMENT ALTERNATIVES

WATERSHED	ESTIMATED ANNUAL O&M COST ($)					
	LABOR[1]	CHEMICALS[2]	POWER	RENEWAL AND REPLACEMENT[3]	SOLIDS HANDLING[4]	TOTAL
Oyster	10,560	31,641	3,000	7,375	3,227	55,803
Buck	12,000	106,288	6,000	9,875	10,971	145,134

1. Based on hourly rate = $15/hour
2. Based on an alum cost = $0.50/gallon
3. Based on an equipment 20-year useful life
4. Based on handling semi-dry material @ $10/yd^3

6.5.4.3 Life Cycle Costs

A summary of estimated life cycle costs, based upon a 20-year life, for the wet detention and off-line alum treatment alternatives is given in Table 6-21. The costs summarized in Table 6-21 include the total construction cost for each system plus 20 years of routine maintenance based upon the annual O&M costs summarized in Tables 6-19 and 6-20. The 20-year life cycle costs for the off-line alum treatment alternative, which has a lower capital construction cost but higher annual O&M cost, appears to be lower in both Oyster Creek and Buck Creek than the wet detention alternative, which has a higher capital construction cost but lower annual O&M cost. As indicated in Table 6-14, the alum treatment system also has a higher estimated removal efficiency for the evaluated parameters compared with estimates for the wet detention option.

TABLE 6-21

ESTIMATED 20-YEAR LIFE CYCLE COST FOR WET DETENTION AND OFF-LINE ALUM TREATMENT ALTERNATIVES

WATERSHED	WET DETENTION ALTERNATIVE (%)	OFF-LINE ALUM TREATMENT ALTERNATIVE ($)
Oyster	2,821,950	2,455,200
Buck	7,943,140	5,808,990

1. Based on construction cost plus 20-years O&M cost

6.5.4.4 Normalized Pollutant Removal Costs

A comparison of normalized pollutant removal costs for the wet detention and alum treatment alternatives is given in Table 6-22. Estimates of the annual mass pollutant removal achieved by the proposed wet detention and alum treatment systems are calculated based upon the modeled mass loadings for total nitrogen, total phosphorus, BOD, and TSS under current conditions and the estimated performance efficiencies for the two systems outlined in Table 6-14. Normalized pollutant removal costs are calculated by dividing the estimated mass removal over a 20-year period into the estimated 20-year life cycle costs summarized in Table 6-21 for the two systems.

As seen in Table 6-22, the alum treatment alternative has a lower normalized pollutant removal cost for each of the two evaluated watersheds compared with the wet detention option. The normalized total nitrogen removal is approximately 50% less for the alum treatment alternative than the wet detention alternative. Normalized costs for total phosphorus, BOD, and TSS for the alum treatment alternative are approximately 50% or less of the cost for the wet detention alternative. Based upon the comparisons presented in Table 6-22, alum treatment appears to be the most cost-effective alternative for removal of nonpoint source constituents in the Oyster Creek and Buck Creek watersheds.

TABLE 6-22

COMPARISON OF NORMALIZED POLLUTANT REMOVAL COSTS FOR THE WET DETENTION AND ALUM TREATMENT ALTERNATIVES

SYSTEM	TOTAL N		TOTAL P		BOD		TSS	
	Mass Removal (kg/yr)	Cost/kg Removed ($)	Mass Removal (kg/yr)	Cost/kg Removed ($)	Mass Removal (kg/yr)	Cost/kg Removed ($)	Mass Removal (kg/yr)	Cost/kg Removed ($)
Wet Detention								
Oyster Creek	389	363	204	692	2,984	47	16,474	8.56
Buck Creek	999	398	310	1,281	7,497	53	20,395	19.47
Alum Treatment								
Oyster Creek	777	158	284	432	3,227	38	20,004	6.14
Buck Creek	1,998	145	430	675	8,109	36	24,765	11.73

SECTION 7

CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

Based upon the analyses and results presented in the previous sections, the following conclusions are reached concerning nonpoint source loadings discharging to Lemon Bay:

1. Based upon assumed land use characteristics within the Lemon Bay watershed under undeveloped conditions, substantial increases in runoff volumes and mass loadings of total nitrogen, total phosphorus, BOD, and TSS have already occurred within the Lemon Bay watershed as a result of current development within the basin. The Lemon Bay watershed model, developed as part of this project, estimates that pre-development runoff inputs into Lemon Bay have increased approximately 25% as a result of current development. The model also predicts that pre-development mass loadings of total nitrogen have increased by approximately 35% under existing conditions, with a 398% increase in total phosphorus, 69% increase in BOD, and 145% increase in TSS. The substantial increases in mass loadings under existing conditions are related primarily to the lack of significant stormwater treatment facilities within the Lemon Bay watershed. The vast majority of development within the basin occurred prior to implementation of stormwater regulations and, therefore, does not have existing stormwater treatment facilities.

2. Assuming that future development will be constructed with stormwater management systems designed to current criteria, nonpoint source loadings to Lemon Bay are anticipated to increase substantially under future built-out conditions compared with estimates of loadings under current conditions. Under future built-out conditions, runoff inputs to Lemon Bay will increase by approximately 27%, with a 44% increase in total nitrogen, 53% increase in total phosphorus, 15% increase in BOD, and 1% increase in TSS.

3. Current stormwater design criteria applicable within the Lemon Bay basin appear to be insufficient to mitigate additional runoff generated pollutant loadings into Lemon Bay under future built-out conditions.

7.2 Recommendations

As a result of the evaluations summarized in the previous sections, ERD makes the following recommendations for reduction of nonpoint source loadings to Lemon Bay. These recommendations are based upon the goal of reducing future loadings to levels which are equal to or less than loadings which occur into the basin under existing conditions.

1. Based upon the discussions presented in Sections 5 and 6, the alternative stormwater regulation option appears to be the only feasible option which is capable of providing load reductions necessary to achieve no net increase in loadings within the basin under future built-out conditions. Therefore, it is recommended that local governments, the State of Florida, and the Southwest Florida Water Management District investigate the feasibility of adopting alternative stormwater regulations similar to those outlined in Section 6.1. Information contained in Section 6.1 could be used to develop a basin-specific set of alternative stormwater regulations for the Lemon Bay area similar to those developed by Harper (2003) for Lee and Collier Counties. Development of these alternative regulations will limit post-development discharges of the most sensitive pollutant to loadings which are equal to loadings under current conditions. For the remaining constituents, the required reductions will likely decrease loadings to less than values which exist under current conditions. This alternative will not only maintain water quality within Lemon Bay, but may actually result in improvements in water quality over time. Local and regional government agencies should work to educate developers on the value of alternative stormwater designs, with the option to go above and beyond the performance rates of existing regulations.

2. Sarasota County should aggressively implement the currently proposed water quality improvement projects outlined in Section 6.4. These projects have the potential to improve water quality in Sarasota portions of the watershed which, combined with the alternative stormwater regulations, may actually result in improvements in water quality characteristics within Lemon Bay.

3. In addition to development of alternative stormwater regulations, stormwater pollution prevention plans should be required of all future planned developments. These pollution prevention plans should address issues such as nutrient and pesticide management, street sweeping, solid waste management, and stormwater treatment system operation and maintenance. These structural controls have the ability to improve the quality of stormwater runoff by reducing pollutants at the source. The cost for implementation of this option will fall primarily on the development community, with little or no financial impact on local governments.

4. The wet detention and alum stormwater treatment options evaluated by ERD for the Oyster and Buck Creek watershed are not recommended at this time. Implementation of the alternative stormwater regulations will prevent further increase in nutrient loadings in these basins and limit future loadings to those which exist under current conditions. However, smaller water quality projects should be undertaken within these basins when opportunities arise as part of restoration or stormwater management projects.

5. A strong public education plan should be implemented within the Lemon Bay basin to inform homeowners about the link between homeowner activities and water quality within Lemon Bay. This type of education program has the potential to reduce loadings at the source, further improving the quality of water discharging from the watershed into Lemon Bay. This is a relatively inexpensive option which can potentially have significant water quality impacts.

APPENDICES

Calibration Data

Event Date: 11/12/2002
Observer(s): H. Harper / H. Seenauth
Station: Gottfried Creek
Meter: General Oceanics Model 2030RL

Data	Time	Counter Reading	Measured Flow (cfs)	Mean Flow (cfs)	Interval Counts	ft^3/count
11/12/2002	15:30	0	32.7			
11/12/2002	16:40	3547	91.26	61.98	3547	73.4

Event Date: 1/25/2003
Observer(s): H. Harper / H. Seenauth
Station: Forked Creek
Meter: General Oceanics Model 2030RL

Data	Time	Counter Reading	Measured Flow (cfs)	Mean Flow (cfs)	Interval Counts	ft^3/count
1/25/2003	15:10	9253226	193.94			
1/25/2003	17:05	9258532	139.8	166.87	5306	217.0

Event Date: 11/12/2002
Observer(s): H. Harper / H. Seenauth
Station: Ainger Creek
Meter: General Oceanics Model 2030RL

Data	Time	Counter Reading	Measured Flow (cfs)	Mean Flow (cfs)	Interval Counts	ft^3/count
11/12/2002	15:12	6866521	152.07			
11/12/2002	18:07	6839802	173.64	162.855	-26719	-64.0

Event Date: 10/18/2002
Observer(s): H. Harper / H. Seenauth
Station: Aligator Creek
Meter: General Oceanics Model 2030RL

Data	Time	Counter Reading	Measured Flow (cfs)	Mean Flow (cfs)	Interval Counts	ft^3/count
10/18/2002	15:25	9247687	57.37			
10/18/2002	16:25	9243906	64.41	60.89	-3781	-58.0

Event Date: 1/20/2003 Station: Oyster Creek
Observer(s): H. Harper / H. Seenauth Meter: General Oceanics Model 2030RL

Data	Time	Counter Reading	Measured Flow (cfs)	Mean Flow (cfs)	Interval Counts	ft^3/count
1/20/2003	14:11	243700	36.74			
1/20/2003	15:13	245980	41.06	38.9	2280	63.5

Event Date: 1/20/2003 Station: Buck Creek
Observer(s): H. Harper / H. Seenauth Meter: General Oceanics Model 2030RL

Data	Time	Counter Reading	Measured Flow (cfs)	Mean Flow (cfs)	Interval Counts	ft^3/count
1/20/2003	12:11	8512950	27.65			
1/20/2003	13:13	8515342	31.59	29.62	2392	46.1

Lemon Bay Water Quality Data Collection Project
Stream Discharge Measurements - Calibration Event

Observers(s): H. Harper / D. Scarboro
Meter: Marsh-McBirney Model 201
Method: Velocity/Cross - Section
Beginning Underwater Meter Reading: 243700 @ 14:11

Station: Oyster Creek
Date: 1/20/03 Time: 14:15
Channel Type: Open Channel

North Side					
Distance From Initial Point (ft)	Water Depth (ft)	Flow Velocity At 60% Depth (ft/sec)	Mean Section Velocity (fps)	Section Area (ft^2)	Section Discharge (cfs)
0	1.3	0.11	-------	-------	-------
5	1.5	0.09	0.10	6.88	0.69
10	2.1	0.17	0.13	9.00	1.17
15	2.1	0.35	0.26	10.50	2.73
20	2.5	0.33	0.34	11.50	3.91
25	2.2	0.45	0.39	11.75	4.58
30	2.4	0.38	0.42	11.50	4.77
35	2.4	0.46	0.42	12.00	5.04
36	2.5	0.41	0.44	2.45	1.07
37.5	2.6	0.45	-------	-------	-------
40	2.8	0.46	0.46	6.75	3.07
45	3.0	0.33	0.40	14.50	5.73
50	3.0	0.07	0.20	15.00	3.00
55	2.6	0.07	0.07	14.00	0.98
			Totals	125.83	36.74

Measured Flow Rate: 36.74
Flow Direction: Downstream

Lemon Bay Water Quality Data Collection Project
Stream Discharge Measurements - Calibration Event

Observers(s): H. Harper / D. Scarboro
Meter: Marsh-McBirney Model 201
Method: Velocity/Cross - Section
Ending Underwater Meter Reading: 245980 @ 15:13

Station: Oyster Creek
Date: 1/20/03 Time: 14:56
Channel Type: Open Channel

North Side					
Distance From Initial Point (ft)	Water Depth (ft)	Flow Velocity At 60% Depth (ft/sec)	Mean Section Velocity (fps)	Section Area (ft^2)	Section Discharge (cfs)
0	1.3	0.15	-------	-------	-------
5	1.7	0.27	0.21	7.38	1.55
10	2.3	0.34	0.31	10.00	3.05
15	2.2	0.45	0.40	11.25	4.44
20	2.5	0.38	0.42	11.75	4.88
25	2.3	0.52	0.45	12.00	5.40
30	2.4	0.45	0.49	11.75	5.70
35	2.4	0.51	0.48	12.00	5.76
36	2.5	0.48	0.50	2.45	1.21
37.5	2.6	0.39	-------	-------	-------
40	2.8	0.52	0.46	6.75	3.07
45	2.0	0.12	0.32	12.00	3.84
50	3.2	0.05	0.09	13.00	1.11
55	2.8	0.09	0.07	15.00	1.05
			Totals	125.33	41.06

Measured Flow Rate: 41.06
Flow Direction: Downstream

Lemon Bay Water Quality Data Collection Project
Stream Discharge Measurements - Calibration Event

Observers(s): H. Harper / D. Scarboro
Meter: Marsh-McBirney Model 201
Method: Velocity/Cross - Section
Beginning Underwater Meter Reading: 6866521 @ 15:12

Station: Ainger Creek
Date: 11/12/02 Time: 15:24
Channel Type: Open Channel

North Side					
Distance From Initial Point (ft)	Water Depth (ft)	Flow Velocity At 60% Depth (ft/sec)	Mean Section Velocity (fps)	Section Area (ft^2)	Section Discharge (cfs)
0	7.5	0.12	-------	-------	-------
5	8.0	0.32	0.22	38.75	8.53
10	8.0	0.21	0.27	40.00	10.60
15	7.5	0.32	0.27	38.75	10.27
20	5.7	0.32	0.32	33.00	10.56
25	4.9	0.46	0.39	26.50	10.34
30	4.5	0.38	0.42	23.50	9.87
35	4.0	0.44	0.41	21.25	8.71
40	3.9	0.43	0.44	19.75	8.59
			Totals	241.50	77.46

South Side					
Distance From Initial Point (ft)	Water Depth (ft)	Flow Velocity At 60% Depth (ft/sec)	Mean Section Velocity (fps)	Section Area (ft^2)	Section Discharge (cfs)
0	3.0	0.35	-------	-------	-------
5	4.0	0.49	0.42	17.50	7.35
10	4.0	0.46	0.48	20.00	9.50
15	4.0	0.45	0.46	20.00	9.10
20	4.0	0.48	0.47	20.00	9.30
25	4.2	0.49	0.49	20.50	9.94
30	4.7	0.38	0.44	22.25	9.68
35	5.2	0.40	0.39	24.75	9.65
40	6.0	0.32	0.36	28.00	10.08
			Totals	173.00	74.60

Measured Flow Rate: **152.07**
Flow Direction: **Downstream**

Lemon Bay Water Quality Data Collection Project
Stream Discharge Measurements - Calibration Event

Observers(s): H. Harper / D. Scarboro
Meter: Marsh-McBirney Model 201
Method: Velocity/Cross - Section
Ending Underwater Meter Reading: 6839802 @ 18:07

Station: Ainger Creek
Date: 11/12/02 Time: 17:30
Channel Type: Open Channel

North Side

Distance From Initial Point (ft)	Water Depth (ft)	Flow Velocity At 60% Depth (ft/sec)	Mean Section Velocity (fps)	Section Area (ft^2)	Section Discharge (cfs)
0	7.0	0.22	-------	-------	-------
5	7.9	0.49	0.36	37.25	13.22
10	8.0	0.22	0.36	39.75	14.11
15	7.2	0.53	0.38	38.00	14.25
20	5.0	0.52	0.53	30.50	16.01
25	4.8	0.45	0.49	24.50	11.88
30	4.2	0.55	0.50	22.50	11.25
35	3.8	0.55	0.55	20.00	11.00
40	3.5	0.57	0.56	18.25	10.22
			Totals	230.75	101.95

South Side

Distance From Initial Point (ft)	Water Depth (ft)	Flow Velocity At 60% Depth (ft/sec)	Mean Section Velocity (fps)	Section Area (ft^2)	Section Discharge (cfs)
0	3.8	0.37	-------	-------	-------
5	3.7	0.53	0.45	18.75	8.44
10	3.8	0.48	0.51	18.75	9.47
15	4.0	0.49	0.49	19.50	9.46
20	4.0	0.49	0.49	20.00	9.80
25	4.2	0.42	0.46	20.50	9.33
30	5.0	0.33	0.38	23.00	8.63
35	5.2	0.33	0.33	25.50	8.42
40	5.0	0.31	0.32	25.50	8.16
			Totals	171.50	71.69

Measured Flow Rate: **173.64**
Flow Direction: **Downstream**

Lemon Bay Water Quality Data Collection Project
Stream Discharge Measurements - Calibration Event

Observers(s): H. Harper / D. Scarboro
Meter: Marsh-McBirney Model 201
Method: Velocity/Cross - Section
Beginning Underwater Meter Reading: 000000 @ 15:30

Station: Gottfried Creek
Date: 11/12/02 Time: 15:30
Channel Type: Open Channel

Distance From Initial Point (ft)	Water Depth (ft)	Flow Velocity At 60% Depth (ft/sec)	Mean Section Velocity (fps)	Section Area (ft^2)	Section Discharge (cfs)
0	1.8	0.11	------	-------	-------
3	2.5	0.11	0.11	6.45	0.71
8	5.5	0.11	0.11	20.00	2.20
13	4.0	0.15	0.13	23.75	3.09
18	4.0	0.17	0.16	20.00	3.20
23	3.8	0.16	0.17	19.50	3.22
28	3.2	0.15	0.16	17.50	2.71
33	2.8	0.15	0.15	15.00	2.25
38	2.3	0.17	0.16	12.75	2.04
43	2.0	0.07	0.12	10.75	1.29
48	2.0	0.15	0.11	10.00	1.10
53	2.0	0.35	0.25	10.00	2.50
58	2.0	0.37	0.36	10.00	3.60
63	1.5	0.20	0.29	8.75	2.49
68	1.0	0.11	0.16	6.25	0.97
73	1.2	0.05	0.08	5.50	0.44
78	0.6	0.08	0.07	4.50	0.29
83	1.0	0.06	0.07	4.00	0.28
88	0.8	0.08	0.07	4.50	0.32
			Totals	209.20	32.70

Measured Flow Rate: **32.70**
Flow Direction: **Downstream**

Lemon Bay Water Quality Data Collection Project
Stream Discharge Measurements - Calibration Event

Observers(s): H. Harper / D. Scarboro
Meter: Marsh-McBirney Model 201
Method: Velocity/Cross - Section
Ending Underwater Meter Reading: 003547 @ 16:40

Station: Gottfried Creek
Date: 11/12/02 Time: 16:05
Channel Type: Open Channel

Distance From Initial Point (ft)	Water Depth (ft)	Flow Velocity At 60% Depth (ft/sec)	Mean Section Velocity (fps)	Section Area (ft^2)	Section Discharge (cfs)
0	1.5	0.55	-------	-------	-------
3	2.0	0.65	0.60	5.25	3.15
8	5.5	0.45	0.55	18.75	10.31
13	5.0	0.48	0.47	26.25	12.21
18	4.0	0.65	0.57	22.50	12.71
23	3.5	0.53	0.59	18.75	11.06
28	3.3	0.50	0.52	17.00	8.76
33	2.8	0.40	0.45	15.25	6.86
38	2.8	0.35	0.38	14.00	5.25
43	1.8	0.34	0.35	11.50	3.97
48	1.7	0.44	0.39	8.75	3.41
53	1.9	0.35	0.40	9.00	3.56
58	3.0	0.35	0.35	12.25	4.29
63	1.5	0.32	0.34	11.25	3.77
68	1.0	0.11	0.22	6.25	1.34
73	0.9	0.04	0.08	4.75	0.36
78	0.7	0.00	0.02	4.00	0.08
83	0.8	0.03	0.02	3.75	0.06
88	0.8	0.03	0.03	4.00	0.12
			Totals	213.25	91.26

Measured Flow Rate: 91.26
Flow Direction: Downstream

Lemon Bay Water Quality Data Collection Project
Stream Discharge Measurements - Calibration Event

Observers(s): H. Harper / D. Scarboro
Meter: Marsh-McBirney Model 201
Method: Velocity/Cross - Section
Beginning Underwater Meter Reading: 9253226 @ 15:10

Station: Forked Creek
Date: 1/25/03 Time: 15:15
Channel Type: Open Channel

Distance From Initial Point (ft)	Water Depth (ft)	Flow Velocity At 60% Depth (ft/sec)	Mean Section Velocity (fps)	Section Area (ft^2)	Section Discharge (cfs)
0	0.3	0.00	-------	-------	-------
5	1.3	0.02	0.01	4.00	0.04
10	1.9	0.06	0.04	8.00	0.32
15	2.5	0.10	0.08	11.00	0.88
20	3.1	0.10	0.10	14.00	1.40
25	3.5	0.15	0.13	16.50	2.06
30	3.9	0.15	0.15	18.50	2.78
35	3.9	0.16	0.16	19.50	3.02
40	4.2	0.18	0.17	20.25	3.44
45	4.7	0.23	0.21	22.25	4.56
50	4.7	0.36	0.30	23.50	6.93
55	5.1	0.47	0.42	24.50	10.17
60	5.5	0.58	0.53	26.50	13.91
65	5.5	0.65	0.62	27.50	16.91
70	5.8	0.63	0.64	28.25	18.08
75	5.8	0.61	0.62	29.00	17.98
80	5.8	0.58	0.60	29.00	17.26
85	5.9	0.50	0.54	29.25	15.80
90	5.9	0.47	0.49	29.50	14.31
95	5.8	0.51	0.49	29.25	14.33
100	5.0	0.38	0.45	27.00	12.02
105	4.0	0.34	0.36	22.50	8.10
110	3.1	0.28	0.31	17.75	5.50
115	2.3	0.16	0.22	13.50	2.97
120	1.6	0.08	0.12	9.75	1.17
125	0.5	0.04	0.00	5.25	0.00
			Totals	506.00	193.94

Measured Flow Rate: **193.94**
Flow Direction: **Downstream**

Lemon Bay Water Quality Data Collection Project
Stream Discharge Measurements - Calibration Event

Observers(s): H. Harper / D. Scarboro
Meter: Marsh-McBirney Model 201
Method: Velocity/Cross - Section
Ending Underwater Meter Reading: 9258532 @ 17:05

Station: Forked Creek
Date: 1/25/03 Time: 16:15
Channel Type: Open Channel

Distance From Initial Point (ft)	Water Depth (ft)	Flow Velocity At 60% Depth (ft/sec)	Mean Section Velocity (fps)	Section Area (ft^2)	Section Discharge (cfs)
0	0.8	0.05	-------	-------	-------
5	1.8	0.07	0.06	6.50	0.39
10	2.1	0.07	0.07	9.75	0.68
15	2.7	0.07	0.07	12.00	0.84
20	3.3	0.05	0.06	15.00	0.90
25	3.8	0.09	0.07	17.75	1.24
30	4.0	0.11	0.10	19.50	1.95
35	4.4	0.21	0.16	21.00	3.36
40	4.8	0.22	0.22	23.00	4.95
45	5.2	0.36	0.29	25.00	7.25
50	5.4	0.43	0.40	26.50	10.47
55	5.5	0.44	0.44	27.25	11.85
60	5.5	0.42	0.43	27.50	11.83
65	5.6	0.42	0.42	27.75	11.66
70	5.6	0.45	0.44	28.00	12.18
75	5.7	0.44	0.45	28.25	12.57
80	5.8	0.44	0.44	28.75	12.65
85	5.9	0.28	0.36	29.25	10.53
90	5.8	0.23	0.26	29.25	7.46
95	5.5	0.18	0.21	28.25	5.79
100	5.1	0.17	0.18	26.50	4.64
105	4.5	0.11	0.14	24.00	3.36
110	3.3	0.07	0.09	19.50	1.76
115	2.5	0.06	0.07	14.50	0.94
120	1.6	0.05	0.06	10.25	0.56
125	0.7	0.08	0.00	5.75	0.00
			Totals	530.75	139.80

Measured Flow Rate: **139.80**
Flow Direction: **Downstream**

Lemon Bay Water Quality Data Collection Project
Stream Discharge Measurements - Calibration Event

Observers(s): H. Harper / D. Scarboro
Meter: Marsh-McBirney Model 201
Method: Velocity/Cross - Section
Beginning Underwater Meter Reading: 9247687 @ 15:25

Station: Alligator Creek
Date: 10/18/02 Time: 15:35
Channel Type: Open Channel

Distance From Initial Point (ft)	Water Depth (ft)	Flow Velocity At 60% Depth (ft/sec)	Mean Section Velocity (fps)	Section Area (ft^2)	Section Discharge (cfs)
0	1.0	0.01	-------	-------	-------
5	3.0	0.02	0.02	10.00	0.15
10	3.8	0.06	0.04	17.00	0.68
15	4.1	0.28	0.17	19.75	3.36
20	4.5	0.31	0.30	21.50	6.34
25	4.0	0.31	0.31	21.25	6.59
30	3.5	0.59	0.45	18.75	8.44
35	3.0	0.69	0.64	16.25	10.40
40	2.5	0.58	0.64	13.75	8.73
45	2.0	0.49	0.54	11.25	6.02
50	1.5	0.48	0.49	8.75	4.24
55	1.0	0.21	0.35	6.25	2.16
60	0.0	0.00	0.11	2.50	0.26
			Totals	167.00	57.37

Measured Flow Rate: 57.37
Flow Direction: Downstream

Lemon Bay Water Quality Data Collection Project
Stream Discharge Measurements - Calibration Event

Observers(s): H. Harper / D. Scarboro
Meter: Marsh-McBirney Model 201
Method: Velocity/Cross - Section
Ending Underwater Meter Reading: 9243906 @ 16:25

Station: Alligator Creek
Date: 10/18/02 Time: 16:05
Channel Type: Open Channel

Distance From Initial Point (ft)	Water Depth (ft)	Flow Velocity At 60% Depth (ft/sec)	Mean Section Velocity (fps)	Section Area (ft^2)	Section Discharge (cfs)
0	1.5	0.07	-------	-------	-------
5	2.2	0.02	0.05	9.25	0.42
10	3.5	0.08	0.05	14.25	0.71
15	3.9	0.25	0.17	18.50	3.05
20	4.2	0.25	0.25	20.25	5.06
25	4.3	0.44	0.35	21.25	7.33
30	3.5	0.65	0.55	19.50	10.63
35	3.0	0.63	0.64	16.25	10.40
40	2.7	0.71	0.67	14.25	9.55
45	2.0	0.70	0.71	11.75	8.28
50	1.7	0.59	0.65	9.25	5.97
55	1.0	0.22	0.41	6.75	2.73
60	0.0	0.00	0.11	2.50	0.28
			Totals	163.75	64.41

Measured Flow Rate: **64.41**
Flow Direction: **Downstream**

Lemon Bay Flow Meter Readings

Date	Buck Creek		Oyster Creek		Ainger Creek		Gottfried Creek		Forked Creek		Alligator Creek	
	Time	Counter Reading	Time	Counter Reading	Time	Counter Reading	Time	Counter Reading	Time	Counter Reading	Time	Counter Reading
3/29/2002	12:35	889,599	13:35	9,683,000	14:10	8,498,911	14:45	8,468,008	16:25	839,375	17:00	9,661,836
4/21/2002	12:51	941,327	14:17	9,723,057	15:03	8,524,993	15:47	8,480,191	15:48	855,875	17:32	9,681,435
6/8/2002	16:05	828,980	16:42	9,300,173	17:05	8,361,272	17:30	8,314,898	18:05	778,139	18:55	9,389,262
7/10/2002	15:10	535,707	16:05	8,089,757	16:45	8,009,627	17:40	7,924,662	18:30	632,509	19:15	8,891,826
7/31/2002	14:30	134,068	15:25	7,029,690	16:10	7,802,166	16:25	7,396,657	16:55	517,374	17:40	7,849,608
9/15/2002	11:45	-440,912	12:48	5,648,786	13:40	7,173,078	14:30	6,703,574	15:25	396,219	16:23	6,855,959
10/18/2002	13:21	-784,946	14:21	5,256,594	15:00	7,037,092	15:42	6,511,365	16:25	345,765	17:24	6,636,439
11/12/2002	13:33	-832,791	14:33	5,065,083	15:12	6,967,893	16:40	6,370,112	17:23	323,695	18:22	6,498,635

APPENDIX B

WATER QUALITY CHARACTERISTICS OF TRIBUTARY INFLOW FROM MARCH - NOVEMBER 2002

1. **Field Data**
2. **Laboratory Data**

PHYSICAL-CHEMICAL PROFILES COLLECTED IN LEMON BAY ON JUNE 8, 2002

DEPTH (m)	BUCK (15:46)							
	TEMP. (°C)	pH	SPEC. COND. (μS/cm)	SALINITY (ppt)	DISS. OXYGEN (mg/l)	DISS. OXYGEN (% Sat.)	ORP (mV)	TURBIDITY (NTU)
0.25	29.96	7.95	47,300	30.8	3.8	61	547	4.9
0.5	29.98	7.94	47,800	31.2	3.6	58	544	4.6
0.9	29.97	7.94	47,900	31.3	3.5	56	542	4.7

DEPTH (m)	OYSTER (16:31)							
	TEMP. (°C)	pH	SPEC. COND. (μS/cm)	SALINITY (ppt)	DISS. OXYGEN (mg/l)	DISS. OXYGEN (% Sat.)	ORP (mV)	TURBIDITY (NTU)
0.25	30.57	8.08	50,000	32.8	4.8	78	625	2.4
0.5	30.57	8.07	50,800	33.4	4.6	75	616	2.3
1.0	30.58	8.07	51,000	33.6	4.5	74	608	2.7
1.2	30.57	8.07	51,000	33.6	4.3	71	605	2.6

DEPTH (m)	AINGER (16:53)							
	TEMP. (°C)	pH	SPEC. COND. (μS/cm)	SALINITY (ppt)	DISS. OXYGEN (mg/l)	DISS. OXYGEN (% Sat.)	ORP (mV)	TURBIDITY (NTU)
0.25	30.16	7.87	50,600	33.3	3.6	58	627	2.1
0.5	30.17	7.86	50,800	33.4	3.5	57	621	1.6
1.0	30.17	7.86	50,800	33.4	3.5	56	613	1.6
1.1	30.17	7.85	50,900	33.5	3.3	54	609	1.5

PHYSICAL-CHEMICAL PROFILES COLLECTED IN LEMON BAY ON JUNE 8, 2002
(Page 2)

DEPTH (m)	GOTTFRIED (17:15)							
	TEMP. (°C)	pH	SPEC. COND. (μS/cm)	SALINITY (ppt)	DISS. OXYGEN (mg/l)	DISS. OXYGEN (% Sat.)	ORP (mV)	TURBIDITY (NTU)
0.25	30.26	7.87	50,000	32.8	4.3	70	635	1.0
0.5	30.31	7.87	50,200	33.0	4.1	67	628	0.8
1.0	30.39	7.86	50,300	33.0	3.9	63	618	0.8
1.5	30.44	7.85	50,400	33.1	3.8	61	608	0.8
1.7	30.46	7.85	50,500	33.2	3.7	61	602	0.8

DEPTH (m)	FORKED (19:27)							
	TEMP. (°C)	pH	SPEC. COND. (μS/cm)	SALINITY (ppt)	DISS. OXYGEN (mg/l)	DISS. OXYGEN (% Sat.)	ORP (mV)	TURBIDITY (NTU)
0.25	30.23	8.21	45,300	29.4	7.1	112	664	2.0
0.5	30.43	8.16	45,700	29.7	6.1	98	654	2.0
1.0	30.65	8.10	47,500	31.0	4.9	79	644	4.0

DEPTH (m)	ALLIGATOR (18:46)							
	TEMP. (°C)	pH	SPEC. COND. (μS/cm)	SALINITY (ppt)	DISS. OXYGEN (mg/l)	DISS. OXYGEN (% Sat.)	ORP (mV)	TURBIDITY (NTU)
0.25	30.51	7.65	41,900	26.9	2.8	44	639	0.3
0.4	30.50	7.65	42,000	27.0	2.7	43	630	0.3

PHYSICAL-CHEMICAL PROFILES COLLECTED IN LEMON BAY ON JULY 10, 2002

DEPTH (m)	BUCK (14:53)							
	TEMP. (°C)	pH	SPEC. COND. (µS/cm)	SALINITY (ppt)	DISS. OXYGEN		ORP (mV)	TURBIDITY (NTU)
					(mg/l)	(% Sat.)		
0.25	28.77	8.07	44261	28.6	5.2	80	659	4.6
0.5	28.81	8.08	44342	28.7	5.3	82	657	4.4
1.0	28.85	8.09	44626	28.9	5.3	82	653	4.4
1.2	28.86	8.10	44807	29.0	5.4	84	651	4.3

DEPTH (m)	OYSTER (15:48)							
	TEMP. (°C)	pH	SPEC. COND. (µS/cm)	SALINITY (ppt)	DISS. OXYGEN		ORP (mV)	TURBIDITY (NTU)
					(mg/l)	(% Sat.)		
0.25	29.46	8.20	46781	30.5	5.6	88	634	3.4
0.5	29.50	8.20	47382	30.9	5.5	87	633	3.6
1.0	29.50	8.20	47547	31.0	5.4	85	633	3.6

DEPTH (m)	AINGER (16:27)							
	TEMP. (°C)	pH	SPEC. COND. (µS/cm)	SALINITY (ppt)	DISS. OXYGEN		ORP (mV)	TURBIDITY (NTU)
					(mg/l)	(% Sat.)		
0.25	29.21	8.11	44585	28.9	4.8	74	641	2.7
0.5	29.26	8.13	45434	29.5	4.7	74	641	2.7
1.0	29.27	8.13	45320	29.4	4.8	75	635	4.2
1.4	29.27	8.13	45560	29.6	4.8	74	626	4.1

PHYSICAL-CHEMICAL PROFILES COLLECTED IN LEMON BAY ON JULY 10, 2002
(Page 2)

DEPTH (m)	GOTTFRIED (17:18)							
	TEMP. (°C)	pH	SPEC. COND. (μS/cm)	SALINITY (ppt)	DISS. OXYGEN (mg/l)	DISS. OXYGEN (% Sat.)	ORP (mV)	TURBIDITY (NTU)
0.25	29.37	8.12	41533	26.7	5.3	82	636	1.7
0.5	29.36	8.12	41726	26.8	5.2	80	636	1.6
1.0	29.36	8.11	41708	26.8	5.1	79	634	1.8
1.6	29.38	8.10	41667	26.8	5.0	76	632	2.3
1.9	29.37	8.10	41667	26.8	4.9	76	631	2.3

DEPTH (m)	FORKED (18:15)							
	TEMP. (°C)	pH	SPEC. COND. (μS/cm)	SALINITY (ppt)	DISS. OXYGEN (mg/l)	DISS. OXYGEN (% Sat.)	ORP (mV)	TURBIDITY (NTU)
0.25	29.24	8.30	40740	26.1	8.3	128	625	2.2
0.5	29.35	8.31	40885	26.2	8.3	127	629	2.4
1.0	29.40	8.26	42270	27.2	6.9	107	630	3.3
1.1	29.18	8.22	43126	27.8	5.7	88	629	4.3

DEPTH (m)	ALLIGATOR (18:58)							
	TEMP. (°C)	pH	SPEC. COND. (μS/cm)	SALINITY (ppt)	DISS. OXYGEN (mg/l)	DISS. OXYGEN (% Sat.)	ORP (mV)	TURBIDITY (NTU)
0.25	28.98	7.82	27814	17.1	5.1	74	626	3.3
0.4	28.99	7.81	27862	17.1	5.1	74	625	3.3

PHYSICAL-CHEMICAL PROFILES COLLECTED IN LEMON BAY ON JULY 31, 2002

DEPTH (m)	BUCK (14:31)							
	TEMP. (°C)	pH	SPEC. COND. (μS/cm)	SALINITY (ppt)	DISS. OXYGEN		ORP (mV)	TURBIDITY (NTU)
					(mg/l)	(% Sat.)		
0.3	34.45	8.11	26,861	16.4	7.2	113	595	7.9
0.5	34.40	8.10	34,293	21.5	6.7	108	592	7.8
1.0	33.86	8.04	35,423	22.3	5.5	89	588	8.2
1.3	33.47	7.99	36,115	22.8	4.7	75	579	8.8

DEPTH (m)	OYSTER (15:09)							
	TEMP. (°C)	pH	SPEC. COND. (μS/cm)	SALINITY (ppt)	DISS. OXYGEN		ORP (mV)	TURBIDITY (NTU)
					(mg/l)	(% Sat.)		
0.3	34.05	8.09	43,472	28.1	5.4	91	591	5.7
0.5	34.02	8.08	43,531	28.1	5.3	88	589	5.8
0.6	34.00	8.06	43,830	28.3	4.8	80	584	5.4

DEPTH (m)	AINGER (15:40)							
	TEMP. (°C)	pH	SPEC. COND. (μS/cm)	SALINITY (ppt)	DISS. OXYGEN		ORP (mV)	TURBIDITY (NTU)
					(mg/l)	(% Sat.)		
0.3	34.19	8.14	40,822	26.2	7.0	116	613	45.9
0.5	34.08	8.14	41,404	26.6	6.7	111	611	11.3
0.8	33.83	8.14	42,568	27.4	6.0	99	606	7.2

PHYSICAL-CHEMICAL PROFILES COLLECTED IN LEMON BAY ON JULY 31, 2002
(Page 2)

DEPTH (m)	GOTTFRIED (16:04)							
	TEMP. (°C)	pH	SPEC. COND. (μS/cm)	SALINITY (ppt)	DISS. OXYGEN (mg/l)	DISS. OXYGEN (% Sat.)	ORP (mV)	TURBIDITY (NTU)
0.3	33.67	8.14	42,813	27.6	7.0	117	616	3.8
0.5	33.51	8.21	43,832	28.3	7.6	126	617	4.0
0.9	33.04	8.23	45,335	29.4	6.9	115	615	4.7

DEPTH (m)	FORKED (16:48)							
	TEMP. (°C)	pH	SPEC. COND. (μS/cm)	SALINITY (ppt)	DISS. OXYGEN (mg/l)	DISS. OXYGEN (% Sat.)	ORP (mV)	TURBIDITY (NTU)
0.3	34.14	8.36	42,970	27.7	9.4	158	622	16.0
0.5	33.91	8.36	43,151	27.8	9.3	156	620	15.5
1.0	33.05	8.31	43,793	28.3	7.8	129	616	15.1
1.1	32.81	8.30	43,987	28.4	7.4	122	615	16.0

DEPTH (m)	ALLIGATOR (17:29)							
	TEMP. (°C)	pH	SPEC. COND. (μS/cm)	SALINITY (ppt)	DISS. OXYGEN (mg/l)	DISS. OXYGEN (% Sat.)	ORP (mV)	TURBIDITY (NTU)
0.3	34.98	8.13	27,697	17.0	8.4	135	603	22.5
0.5	35.14	8.11	27,494	16.9	8.0	128	597	29.4

PHYSICAL-CHEMICAL PROFILES COLLECTED IN LEMON BAY ON AUGUST 30, 2002

DEPTH (m)	BUCK (11:48)							
	TEMP. (°C)	pH	SPEC. COND. (μS/cm)	SALINITY (ppt)	DISS. OXYGEN (mg/l)	DISS. OXYGEN (% Sat.)	ORP (mV)	TURBIDITY (NTU)
0.25	29.79	7.55	14374	8.3	2.6	36	618	2.6
0.5	29.76	7.54	14565	8.4	2.6	36	610	2.4
1.0	29.68	7.57	16278	9.5	2.4	34	605	2.6
1.2	29.29	7.65	30486	18.9	1.6	23	498	5.4

DEPTH (m)	OYSTER (12:26)							
	TEMP. (°C)	pH	SPEC. COND. (μS/cm)	SALINITY (ppt)	DISS. OXYGEN (mg/l)	DISS. OXYGEN (% Sat.)	ORP (mV)	TURBIDITY (NTU)
0.25	30.28	7.59	25592	15.6	2.8	42	565	1.7
0.5	30.13	7.55	27789	17.1	2.7	39	561	1.5
0.9	29.73	7.66	31949	19.9	2.3	35	562	2.4

DEPTH (m)	AINGER (13:18)							
	TEMP. (°C)	pH	SPEC. COND. (μS/cm)	SALINITY (ppt)	DISS. OXYGEN (mg/l)	DISS. OXYGEN (% Sat.)	ORP (mV)	TURBIDITY (NTU)
0.25	29.93	7.47	16229	9.5	2.5	35	539	1.2
0.5	29.78	7.47	16886	9.9	2.3	32	536	1.3
1.0	29.48	7.46	21280	12.7	2.1	30	532	1.7
1.2	29.50	7.46	21116	12.6	2.0	29	528	1.7

PHYSICAL-CHEMICAL PROFILES COLLECTED IN LEMON BAY ON AUGUST 30, 2002

(Page 2)

DEPTH (m)	GOTTFRIED (13:59)							
	TEMP. (°C)	pH	SPEC. COND. (μS/cm)	SALINITY (ppt)	DISS. OXYGEN (mg/l)	DISS. OXYGEN (% Sat.)	ORP (mV)	TURBIDITY (NTU)
0.25	30.02	7.58	22786	13.7	2.9	41	566	7.8
0.5	30.06	7.54	22684	13.6	2.8	40	560	6.3
1.0	29.96	7.54	23900	14.4	2.7	38	557	6.9
1.5	29.53	7.63	29817	18.4	2.3	34	556	7.1
1.9	29.53	7.68	28368	17.4	2.3	33	539	7.0

DEPTH (m)	FORKED (15:06)							
	TEMP. (°C)	pH	SPEC. COND. (μS/cm)	SALINITY (ppt)	DISS. OXYGEN (mg/l)	DISS. OXYGEN (% Sat.)	ORP (mV)	TURBIDITY (NTU)
0.25	32.17	8.47	26303	16.0	> 20	> 200	598	59.0
0.5	31.15	8.36	27923	17.1	10.25	154	600	5.3
1.0	28.87	8.01	32860	20.5	4.2	62	588	7.3
1.5	28.43	8.01	34089	21.4	3.5	52	503	10.25

DEPTH (m)	ALLIGATOR (15:38)							
	TEMP. (°C)	pH	SPEC. COND. (μS/cm)	SALINITY (ppt)	DISS. OXYGEN (mg/l)	DISS. OXYGEN (% Sat.)	ORP (mV)	TURBIDITY (NTU)
0.25	30.23	7.70	3797	2.1	4.9	66	559	8.3
0.4	30.24	7.62	3826	2.1	4.8	65	557	13.7

PHYSICAL-CHEMICAL PROFILES COLLECTED IN LEMON BAY ON SEPTEMBER 22, 2002

DEPTH (m)	BUCK (18:27)							
	TEMP. (°C)	pH	SPEC. COND. (μS/cm)	SALINITY (mg/l)	DISS. OXYGEN (mg/l)	DISS. OXYGEN (% Sat.)	ORP (mV)	TURBIDITY (NTU)
0.25	33.27	8.27	35755	22.6	7.9	127	599	7.2
0.5	33.30	8.27	35922	22.7	7.9	127	600	7.2
1.0	33.32	8.27	36020	22.7	7.8	125	600	7.4
1.3	33.24	8.21	36243	22.9	6.5	104	596	9.5

DEPTH (m)	OYSTER (15:44)							
	TEMP. (°C)	pH	SPEC. COND. (μS/cm)	SALINITY (mg/l)	DISS. OXYGEN (mg/l)	DISS. OXYGEN (% Sat.)	ORP (mV)	TURBIDITY (NTU)
0.25	33.01	7.91	41194	26.4	5.8	95	606	25.7
0.5	33.01	7.91	41501	26.6	5.6	91	596	5.7
0.7	33.00	7.90	41570	26.7	5.4	89	593	6.0

DEPTH (m)	AINGER (16:10)							
	TEMP. (°C)	pH	SPEC. COND. (μS/cm)	SALINITY (mg/l)	DISS. OXYGEN (mg/l)	DISS. OXYGEN (% Sat.)	ORP (mV)	TURBIDITY (NTU)
0.25	32.59	7.96	36761	23.3	5.9	94	588	4.5
0.5	32.64	7.96	37069	23.5	6.0	96	590	5.3
0.8	32.65	7.97	38520	24.5	6.0	96	590	5.6

PHYSICAL-CHEMICAL PROFILES COLLECTED IN LEMON BAY ON SEPTEMBER 22, 2002
(Page 2)

DEPTH (m)	GOTTFRIED (16:29)							
	TEMP. (°C)	pH	SPEC. COND. (μS/cm)	SALINITY (mg/l)	DISS. OXYGEN (mg/l)	DISS. OXYGEN (% Sat.)	ORP (mV)	TURBIDITY (NTU)
0.25	32.62	7.97	39000	24.9	6.0	97	594	3.7
0.5	32.39	8.00	39769	25.4	5.9	95	597	4.6
1.0	32.15	8.04	40529	25.9	6.3	101	598	4.4
1.5	31.96	8.05	40918	26.2	5.9	95	598	4.5
2.0	31.93	8.04	41066	26.3	5.7	92	595	4.8

DEPTH (m)	FORKED (17:07)							
	TEMP. (°C)	pH	SPEC. COND. (μS/cm)	SALINITY (mg/l)	DISS. OXYGEN (mg/l)	DISS. OXYGEN (% Sat.)	ORP (mV)	TURBIDITY (NTU)
0.25	32.47	8.29	37790	24.0	9.1	145	590	4.7
0.5	32.47	8.29	37844	24.0	8.9	143	593	4.6
1.0	32.11	8.26	38422	24.4	8.1	129	597	4.6
1.5	31.21	8.21	39988	25.6	5.7	90	593	9.4
1.6	30.97	8.19	40491	25.9	4.8	76	591	8.2

DEPTH (m)	ALLIGATOR (17:36)							
	TEMP. (°C)	pH	SPEC. COND. (μS/cm)	SALINITY (mg/l)	DISS. OXYGEN (mg/l)	DISS. OXYGEN (% Sat.)	ORP (mV)	TURBIDITY (NTU)
0.25	33.19	7.81	31116	19.3	6.2	98	583	14.7
0.5	33.36	7.77	31753	19.8	5.9	94	585	13.4

PHYSICAL-CHEMICAL PROFILES COLLECTED IN LEMON BAY ON OCTOBER 18, 2002

DEPTH (m)	OYSTER (14:23)							
	TEMP. (°C)	pH	SPEC. COND. (µS/cm)	SALINITY (mg/l)	DISS. OXYGEN		ORP (mV)	TURBIDITY (NTU)
					(mg/l)	(% Sat.)		
0.25	25.80	8.21	48354	31.6	6.8	101	563	3.3
0.5	25.80	8.21	48504	31.7	6.7	99	565	3.6
1.0	25.73	8.19	48640	31.8	5.9	87	564	3.8
1.2	25.70	8.18	48739	31.9	5.6	84	563	3.2

DEPTH (m)	AINGER (14:57)							
	TEMP. (°C)	pH	SPEC. COND. (µS/cm)	SALINITY (mg/l)	DISS. OXYGEN		ORP (mV)	TURBIDITY (NTU)
					(mg/l)	(% Sat.)		
0.25	25.96	8.27	44692	28.9	8.0	118	601	4.7
0.5	25.96	8.26	44905	29.1	7.7	113	597	3.8
1.0	25.96	8.25	44921	29.1	7.5	111	595	3.4

DEPTH (m)	FORKED (13:54)							
	TEMP. (°C)	pH	SPEC. COND. (µS/cm)	SALINITY (mg/l)	DISS. OXYGEN		ORP (mV)	TURBIDITY (NTU)
					(mg/l)	(% Sat.)		
0.25	25.92	8.11	39599	25.3	7.4	107	574	13.6
0.5	25.81	8.11	39833	25.4	7.2	103	572	13.9
1.0	25.17	8.13	41124	26.4	7.0	100	574	13.2
1.4	24.94	8.14	41407	26.6	7.0	100	574	12.7

DEPTH (m)	ALLIGATOR (15:09)							
	TEMP. (°C)	pH	SPEC. COND. (µS/cm)	SALINITY (mg/l)	DISS. OXYGEN		ORP (mV)	TURBIDITY (NTU)
					(mg/l)	(% Sat.)		
0.25	26.69	7.87	23813	14.4	6.6	90	560	4.5
0.5	26.85	7.89	30240	18.7	7.2	101	566	4.9

PHYSICAL-CHEMICAL PROFILES COLLECTED IN LEMON BAY ON OCTOBER 18, 2002

DEPTH (m)	GOTTFRIED (15:31)							
	TEMP. (°C)	pH	SPEC. COND. (μS/cm)	SALINITY (mg/l)	DISS. OXYGEN (mg/l)	DISS. OXYGEN (% Sat.)	ORP (mV)	TURBIDITY (NTU)
0.25	28.74	7.99	44459	28.8	7.2	112	580	8.8
0.5	28.74	7.97	44626	28.9	7.2	111	578	4.5
1.0	28.75	7.97	44572	28.9	6.9	106	577	4.9
1.4	28.73	8.00	44419	28.7	7.3	112	578	4.4

Characteristics of Lemon Bay Tributary Samples Collected During 2002

Site	Date	pH s.u.	Salinity (ppt)	Alkalinity (mg/l)	Ammonia (µg/l)	Nitrate (µg/l)	Org. N (µg/l)	Total N (µg/l)	Ortho P (µg/l)	Total P (µg/l)	Color (Co-Pt)	TSS (mg/l)	Fecal (#/100ml)	BOD (mg/l)
Ainger	4/21/02	8.08	32.7	133	18	6	1037	1061	12	73	32	5.0	4	1.0
Ainger	6/8/02	7.86	33.4	142	63	69	298	430	7	32	18	5.8	69	1.0
Ainger	7/10/02	8.13	29.4	132	41	12	714	767	9	50	27	<0.7	88	2.0
Ainger	7/31/02	8.14	26.7	130	16	6	707	729	16	57	8	14.8	15	3.4
Ainger	8/30/02	7.47	11.2	97.3	219	42	553	814	64	109	151	4.9	168	1.0
Ainger	9/22/02	7.96	23.8	136	<5	12	408	423	17	44	17	8.4	<2	2.7
Ainger	10/18/02	8.26	29.0	143	24	11	839	874	12	71	28	9.4	10	1.0
Alligator	4/21/02	8.15	31.4	141	<5	8	374	385	84	135	34	3.7	4	1.0
Alligator	6/8/02	7.65	27.0	133	89	29	365	483	168	201	32	1.9	84	1.0
Alligator	7/10/02	7.82	17.1	136	32	11	544	587	112	194	32	6.6	25	2.5
Alligator	7/31/02	8.12	17.0	157	30	9	720	759	180	296	5	11.8	9	3.1
Alligator	8/30/02	7.66	2.1	145	133	139	737	1009	144	225	73	9.4	450	1.0
Alligator	9/22/02	7.79	19.6	165	53	17	667	737	116	134	44	5.1	<2	4.3
Alligator	10/18/02	7.88	16.6	157	159	38	972	1169	103	175	10	6.6	59	1.0
Buck Creek	4/21/02	8.13	32.4	141	47	7	738	792	3	78	42	6.2	12	1.0
Buck Creek	6/8/02	7.94	31.1	151	111	40	514	665	8	37	24	6.5	111	1.0
Buck Creek	7/10/02	8.09	28.8	132	38	11	742	791	1	31	36	5.6	34	2.4
Buck Creek	7/31/02	8.06	20.8	156	20	6	955	981	30	54	14	12.3	65	3.1
Buck Creek	8/30/02	7.58	11.3	159	94	14	959	1067	23	66	54	4.3	43	1.0
Buck Creek	9/22/02	8.26	22.7	159	337	9	398	744	<1	69	55	18.0	<2	5.7
Forked	4/21/02	7.97	30.8	145	46	6	547	599	110	206	33	9.6	4	1.0
Forked	6/8/02	8.16	30.0	125	261	20	518	799	147	187	19	5.2	480	1.0
Forked	7/10/02	8.27	26.8	125	54	12	953	1019	88	189	18	5.7	61	3.9
Forked	7/31/02	8.33	20.1	137	<5	8	632	643	212	363	4	19.7	21	4.0
Forked	8/30/02	8.21	18.8	145	28	<5	772	803	146	254	43	8.0	30	3.2
Forked	9/22/02	8.25	24.8	154	31	<5	431	465	93	136	22	10.4	4	4.0
Forked	10/18/02	8.12	25.9	151	85	<5	633	721	87	206	14	6.2	7	1.0

Characteristics of Lemon Bay Tributary Samples Collected During 2002

Site	Date	pH s.u.	Salinity (ppt)	Alkalinity (mg/l)	Ammonia (µg/l)	Nitrate (µg/l)	Org. N (µg/l)	Total N (µg/l)	Ortho P (µg/l)	Total P (µg/l)	Color (Co-Pt)	TSS (mg/l)	Fecal (#/100ml)	BOD (mg/l)
Gottfried	4/21/02	7.98	31.9	135	21	35	361	417	36	77	33	3.2	4	1.0
Gottfried	6/8/02	7.86	33.0	140	222	48	359	629	34	58	16	4.3	132	1.0
Gottfried	7/10/02	8.11	26.8	132	37	12	516	565	33	82	25	3.0	65	2.4
Gottfried	7/31/02	8.19	28.4	138	<5	6	628	637	96	127	7	7.0	8	3.7
Gottfried	8/30/02	7.59	15.5	138	224	26	1056	1306	214	221	95	4.6	80	1.0
Gottfried	9/22/02	8.02	25.7	145	155	5	792	952	77	92	12	10.3	6	2.9
Gottfried	10/18/02	7.98	28.8	133	35	10	532	577	61	114	88	5.7	15	2.8
Oyster	4/21/02	8.16	32.8	134	<5	<5	601	606	9	76	34	6.3	4	1.0
Oyster	6/8/02	8.07	33.4	128	287	44	338	669	10	26	15	4.4	81	1.0
Oyster	7/10/02	8.20	30.8	123	57	17	567	641	7	45	25	6.0	40	1.0
Oyster	7/31/02	8.08	28.1	126	28	15	526	569	31	49	6	5.9	16	2.5
Oyster	8/30/02	7.60	17.5	119	167	30	1371	1568	73	108	69	4.3	36	1.0
Oyster	9/22/02	7.91	26.6	129	258	13	564	835	11	40	18	9.5	1	2.2
Oyster	10/18/02	8.20	31.8	137	58	9	545	612	7	64	30	9.0	29	1.0

APPENDIX C

LEMON BAY WATERSHED MODEL

APPENDIX D

EXAMPLE STORMWATER POLLUTION PREVENTION PLAN

STORMWATER POLLUTION PREVENTION PLAN
FOR THE ________________ DEVELOPMENT
____________________ COUNTY, FLORIDA

Introduction

This document provides details of the Stormwater Pollution Prevention Plan for the __________________ Development in _____________________County, Florida. This Plan discusses non-structural controls, intended to improve the quality of stormwater runoff by reducing the generation and accumulation of potential stormwater runoff contaminants at or near the respective sources for each constituent, along with significant structural components of the primary stormwater treatment system. Although many of the methodologies and procedures outlined in this document are general Best Management Practices (BMPs) which can be useful in attenuating pollutants in many types of urbanized settings, the implementation of these practices has been optimized, to the maximum extent possible, to reflect the unique character of the _________________ Development and the surrounding drainage features.

Pollution prevention guidelines are provided for the areas of: (1) nutrient and pesticide management; (2) street sweeping; (3) solid waste management; and (4) stormwater treatment system operation and maintenance. A discussion of each of these activities is given in the following sections.

Nutrient and Pesticide Management

Nutrient and pesticide management consists of a series of practices designed to manage the use of fertilizers and pesticides so as to minimize loss of these compounds into stormwater runoff and the resulting water quality impacts on adjacent waterbodies. Implementation of a management plan will also maximize the effectiveness of the nutrients and pesticides which are applied.

Each homeowner must commit themselves to the practice of responsible and careful landscape design and maintenance of each lot to prevent contamination of surface waters. The guidelines included in this section are intended to help homeowners make educated environmental choices regarding the maintenance of individual yards within the community. These maintenance and management guidelines are meant to promote an attractive neighborhood that preserves the health of adjacent waterways.

General Requirements

A landscape plan must be developed for each residence. The plan must be comprehensive in nature and follow the landscape design guidelines established by the ________________ POA and must promote revegetation of each lot as quickly as possible.

Commercial applicators of chemical lawn products must register with the POA annually and provide a copy of their current occupational license, proof of business liability insurance, and proof of compliance with applicable education and licensing requirements. Individual employees working under the direction of a licensed commercial applicator are exempt from the educational requirements.

Only registered commercial applicators and individual lot owners are permitted to apply chemicals within the property on a private lot. All chemical products must be used in accordance with the manufacturer's recommendations. The application of any chemical product within five (5) feet of any surface water, including but not limited to ponds, lakes, drainage ditches or canals, is prohibited. The use of any chemical product in a manner that will allow airborne or waterborne entry of such products into surface waters is prohibited.

Nutrient Management Program

Management and application of nutrients and fertilizers in the ________________ Development will adhere to the provisions outlined below:

A. All fertilizers shall be stored in a dry storage area protected from rainfall and ponding.

B. No fertilizer containing in excess of 2% phosphate/phosphorus (P_2O_5) per guaranteed analysis label (as defined by Chapter 576, Florida Statutes) shall be applied to turfgrass, pastures, paddocks, or used in nurseries unless justified by a soil test.

C. Fertilizer containing in excess of 2% phosphate/phosphorus (P_2O_5) per guaranteed analysis label shall not be applied within 5 feet of the edge of water or within 5 feet of a drainage facility.

D. All fertilizer shall be applied such that spreading of fertilizer on all impervious surfaces is minimized.

E. Liquid fertilizers containing in excess of 2% phosphate/phosphorus (P_2O_5) per guaranteed analysis label shall not be applied through an irrigation system within 10 feet of the edge of water or within 10 feet of a drainage facility.

F. Liquid fertilizers containing in excess of 2% phosphate/phosphorus (P_2O_5) per guaranteed analysis label shall not be applied through high or medium mist application or directed spray application within 10 feet of the edge of water or within 10 feet of a drainage facility.

G. The POA shall establish a procedure for registration of persons and firms which apply fertilizer in __________________.

H. The POA shall establish a public education program that is focused on the following: proper irrigation of landscaped areas, application rates of fertilizer, appropriate types of fertilizer for different plants, and proper use of organic fertilizers and soil amendments.

Pest Management Program

Proper maintenance of plants and turf areas will minimize the ability of pests to successfully attack landscaping. Several general guidelines follow:

A. Apply fertilizer and water only when needed and in moderate amounts. Excessive amounts of either can cause rapid growth which is attractive to insects and disease.

B. Mow St. Augustine grass to a height of 3-4 inches. If cut shorter, the plants may become stressed and more vulnerable to pest infestation. Each mowing should remove no more than one-third of the leaf blade, and those cuttings should remain on the lawn to decompose.

It is recommended that pesticides, fungicides, and herbicides be used only in response to a specific problem and in the manner and amount recommended by the manufacturer to address the specific problem. Broad application of pesticides, fungicides, and herbicides as a preventative measure is strongly discouraged.

The use of pesticides, fungicides, or herbicides is limited to products that meet the following criteria:

A. Must be consistent with the USDA-NRCS Soil Rating for Selecting Pesticides

B. Must have the minimum potential for leaching into groundwater or loss from runoff

C. Products must be EPA-approved

D. The half-life of products used shall not exceed seventy (70) days

Street Sweeping

This practice involves sweeping and vacuuming streets, parking lots, and other paved traffic areas to remove dry weather accumulation of pollutants, especially particulate matter, before wash-off of these pollutants can occur during a storm event. This practice reduces the potential for pollution impacts on receiving waterbodies by removing particulate matter and associated chemical constituents. Although street cleaning operations are frequently conducted primarily for aesthetic purposes, the primary objective of the street sweeping program for the __________________ Development is to improve the quality of stormwater runoff generated from impervious traffic areas. Street sweeping activities can be particularly effective during periods of high leaf fall by removing solid leaf material and the associated nutrient loadings from roadside areas where they could easily become transported with stormwater flow.

Street sweeping operations will be performed in the __________________ Development at a frequency of one event per month. All street sweeping activities will be performed by a licensed vendor using a vacuum-type sweeping device. Sweeping activities during each event will include all road surfaces, impervious parking areas, and other impervious vehicular areas. Disposal of the collected solid residual will be the responsibility of the street sweeping vendor.

Solid Waste Management

Maintenance of adequate sanitary facilities for temporarily storing refuse on private premises prior to collection is considered the responsibility of the individual homeowner. Local requirements for refuse collection will be brought to the attention of every homeowner at closing for the sale of the property. Information will be distributed as necessary stating specifications for containers, separation of waste by type, where to place containers prior to collection, and established collection schedules.

Fallen tree leaves and other vegetation, along with grass clippings, may become direct water pollutants when they are allowed to accumulate in swales and street gutters. All homeowners will receive periodic educational materials which address proper disposal of leaves and other vegetation to minimize water quality impacts.

Stormwater Management and Treatment System

The stormwater management system for the ________________ Development is designed to maximize the attenuation of stormwater generated pollutants, particularly phosphorus, prior to discharge to the adjacent off-site canal and drainage system. Operational details and maintenance requirements of the various system components are given in the following sections.

Wet Detention Lakes and Canals

The basic element of the stormwater management system consists of a series of interconnected wet detention lakes and canals which provide stormwater treatment through a variety of physical, biological, and chemical processes. A wet detention pond acts similar to a natural lake by temporarily detaining stormwater runoff, allowing opportunities for treatment processes to occur, prior to slow controlled discharge of the treated water through the outfall structure. Pollutant removal processes in wet detention systems occur during the quiescent period between storm events. Significant removal processes include gravity settling of particulate matter; biological uptake of nutrients and other ions by aquatic plants, algae and microorganisms; along with natural chemical flocculation and complexation processes.

Maintenance of the wet detention ponds will consist of an annual inspection by the project engineer or other qualified registered professional engineers. During each annual inspection, the following items will be reviewed and corrected as necessary:

A. Inspect the outfall structure and orifices to ensure free-flowing conditions and overall engineering stability of the outfall system.

B. Review the banks of the lakes and canals to ensure proper side slope stabilization and inspect for signs of excessive seepage which may indicate areas of excessive groundwater flow and possible subsurface channeling.

C. Physically evaluate each of the lakes and canals for evidence of excessive sediment accumulation or erosion.

D. Inspect the planted aquatic vegetation in the littoral zone to ensure that the desired vegetation species, percent coverage, and density are maintained.

At the completion of the inspection, a written inspection report will be prepared, listing any deficiencies which need to be addressed or corrected by the POA.