集水區水質模式分析

閱讀資料:劉成均,水質模式分析, 2016(pp.4-18~4-24)

BASINS/PLOAD 模式原理

Simple Method

If the Simple Method is designated for calculating pollutant loads in PLOAD, then two equations are required to calculate the loads for each specified pollutant type. First, the runoff coefficient for each land use type must be derived with the equation:

$R_{VU} = 0.05 + (0.009 * I_U)$

Where: R_{VU} = Runoff Coefficient for land use type u, inchesrun/inchesrain
I_U = Percent Imperviousness

- $L_p = \sum(P \cdot P_j \cdot R_{vu} \cdot C_u \cdot A_u \cdot 2.72)\frac{1}{12}$
  - L_p:Pollutant load, lbs
  - P:Precipitation, inches/year
  - P_j:Ratio of storms producing runoff (default = 0.9)
  - R_{vu}:Runoff Coefficient for land use type u, inchesrun/inchesrain
  - C_u:Event Mean Concentration for land use type u, milligrams/liter
  - A_u:Area of land use type u, acres

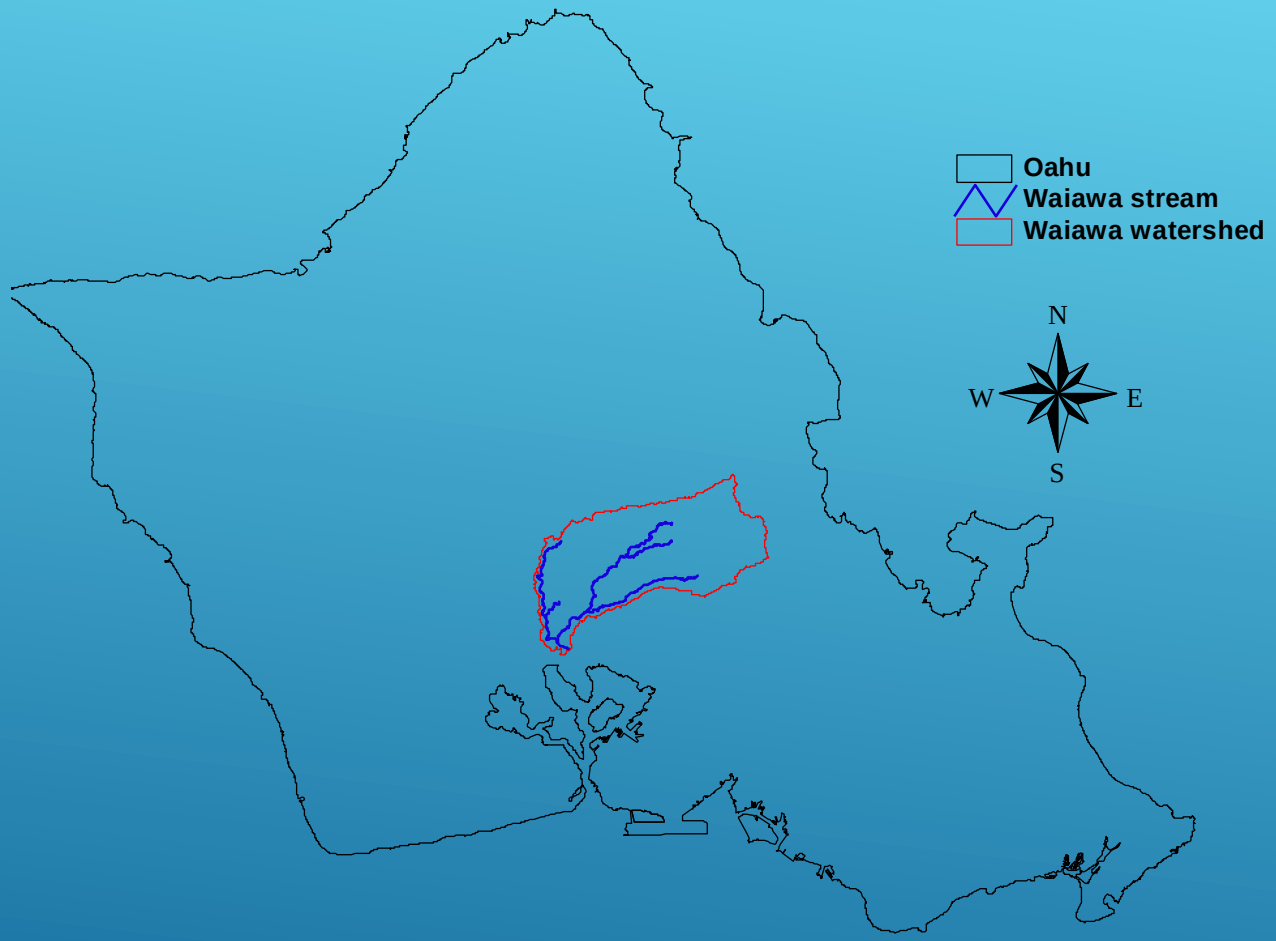

Figure1 Investigation area, **Waiawa** watershed, Oahu

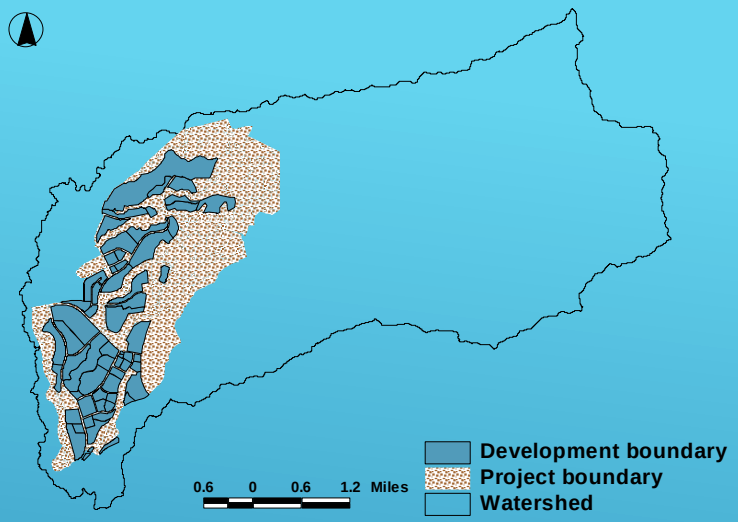

Figure2 Project boundary, Development boundary and Waiawa watershed

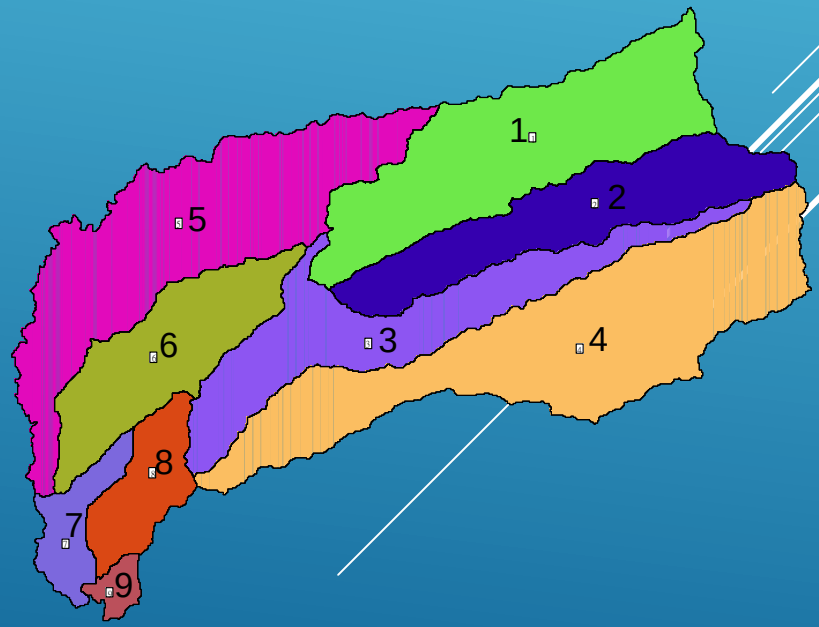

Figure3 Subwatershed of Waiawa watershed

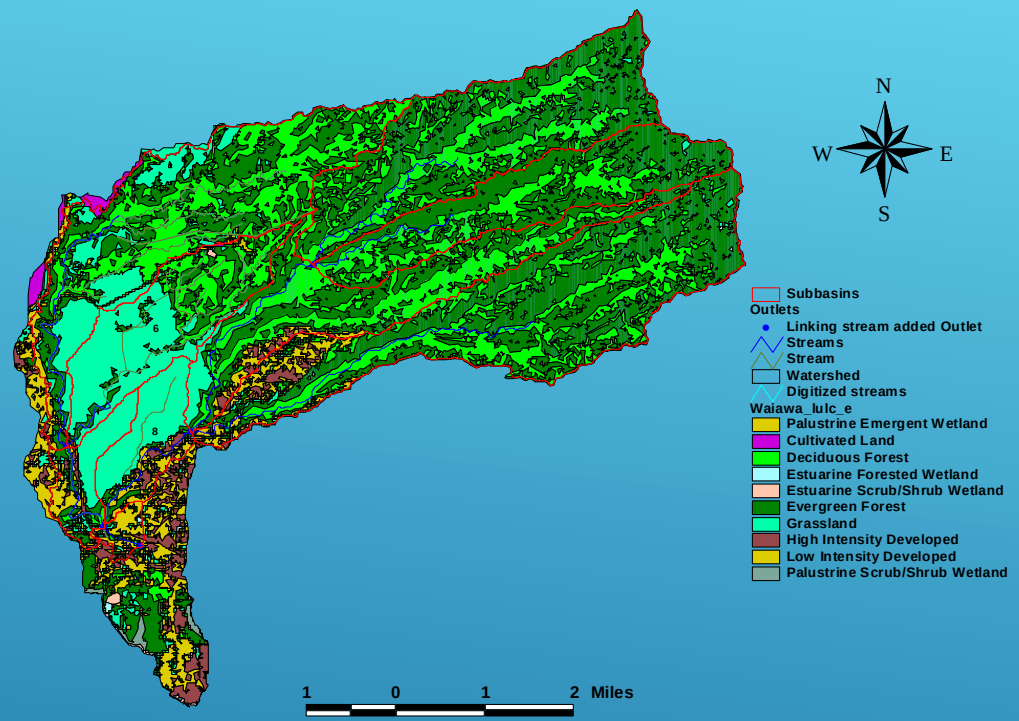

Figure4 GIS data of Waiawa watershed (existing condition)

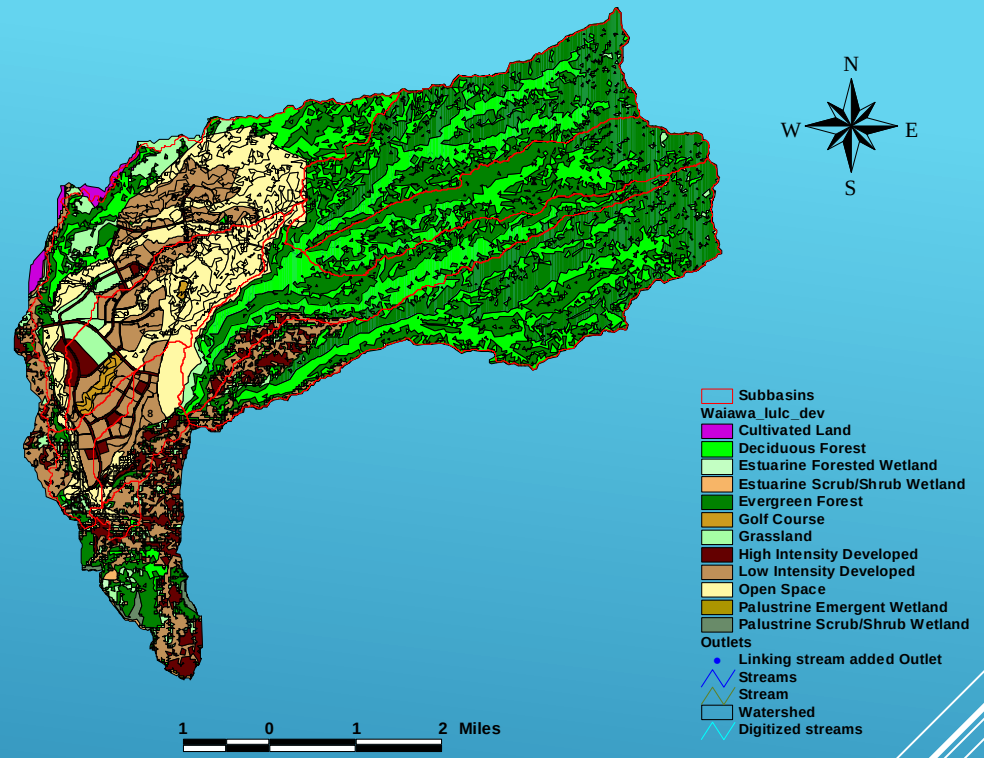

Figure5 GIS data of Waiawa watershed (developed condition)

Table1 Input data (existing condition)

Land use	EMCs(mg/l)			Imperviousness (%)	Source
	TSS	TP	TN		
High Intensity Developed(1)	83	0.40	2.7	85	NVPDC, 1979.
Low Intensity Developed(2)	85	0.30	1.7	65	NVPDC, 1979.
Cultivated Land(3)	780	0.20	1.1	45	Novotny and Olem, 1993.
Grassland(4)	70	0.20	1.1	40	Raird, et al, 1996.
Deciduous Forest(5)	32	0.14	1.1	35	NVPDC, 1979.
Evergreen Forest(6)	19.7	0.14	1.1	30	CH2M HILL, 2000.
Palustrine Scrub/Shrub Wetland(7)	19	0.14	1.1	30	CH2M HILL, 2000.
Palustrine Emergent Wetland(7)	19	0.14	1.1	30	CH2M HILL, 2000.
Estuarine Forested Wetland(7)	19	0.14	1.1	30	CH2M HILL, 2000.
Estuarine Scrub/Shrub Wetland(7)	19	0.14	1.1	30	CH2M HILL, 2000.

Notes:
(1) EMCs of High density developed is assumed to be similar to High density residential including School, Industrial, Commercial, Industrial/commercial, and Major Roadways.
(2) EMCs of Low density developed is assumed to be similar to Low density residential including Mauka Golf course/clubhouse, Parks, Low density apartment, Medium density apartment, Single-family residential, other(Open space, utility)
(3) EMCs of Cultivated land is assumed to be similar to Agriculture
(4) EMCs of Grassland is assumed to be similar to undeveloped open space
(5) EMCs of Deciduous forest is assumed to be similar to forested
(6) EMCs is assumed to be similar to upland forest
(7) EMCs is assumed to be similar to forest wetland

Table3 Input data (Developed Condition)

Land use	EMCs(mg/l)			Imperviousness (%)	Source
	TSS	TP	TN		
High Intensity Developed(1)	83	0.40	2.7	85	NVPDC, 1979.
Low Intensity Developed(2)	85	0.30	1.7	65	NVPDC, 1979.
Cultivated Land(3)	780	0.20	1.1	45	Novotny and Olem, 1993.
Grassland(4)	70	0.20	1.1	40	Raird, et al, 1996.
Deciduous Forest(5)	32	0.14	1.1	35	NVPDC, 1979.
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Estuarine Forested Wetland(7)	19	0.14	1.1	30	CH2M HILL, 2000.
Estuarine Scrub/Shrub Wetland(7)	19	0.14	1.1	30	CH2M HILL, 2000.
Golf Course	38	0.32	0.43	40	Geosyntec Consultants Los Angeles, 2007.
Open Space(8)	19	0.14	1.1	30	CH2M HILL, 2000.

Output data of TN (existing condition)

Subbasin	Area(Ac)	Storm Runoff (Ac-ft/yr)	TN(kg/yr)	EMCs(mg/L)
1	2,643	3,321	4,451	1.100
2	1,766	2,213	2,966	1.100
3	1,924	2,643	3,978	1.235
4	3,588	4,844	7,375	1.250
5	3,032	4,113	5,736	1.145
6	1,469	2,086	2,843	1.119
7	455	755	1,339	1.457
8	662	1,118	1,965	1.443
9	142	278	604	1.781
Sum	15,681	21,372	31,259	11.630

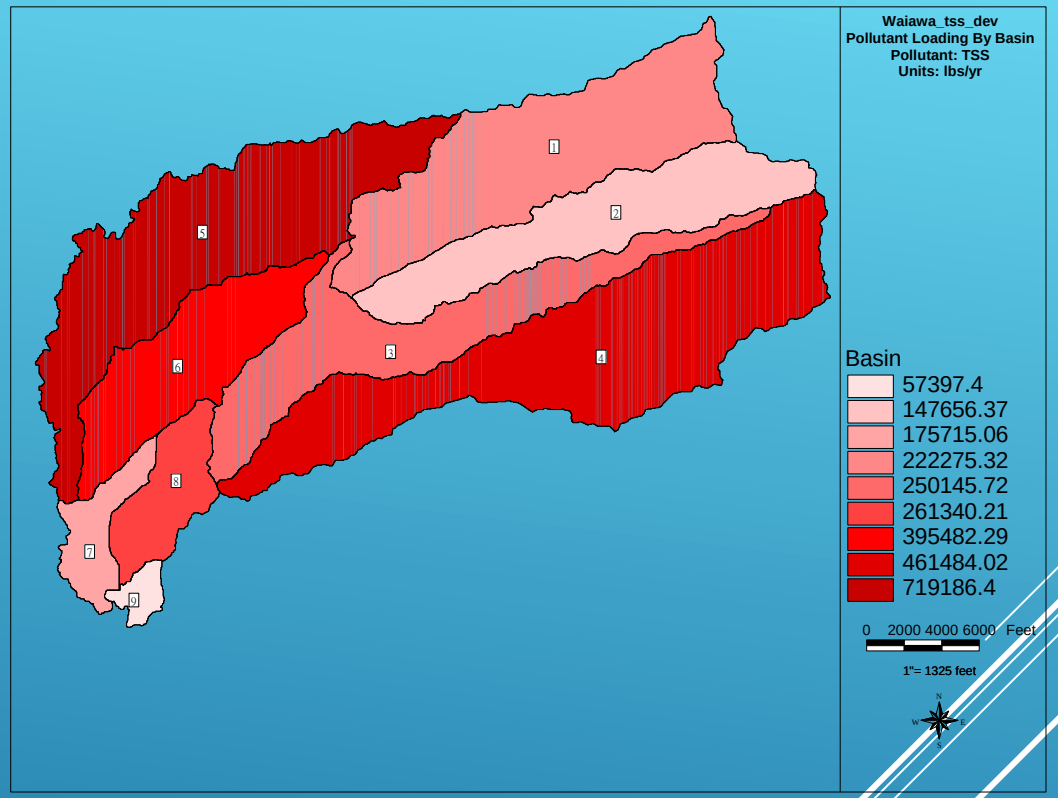
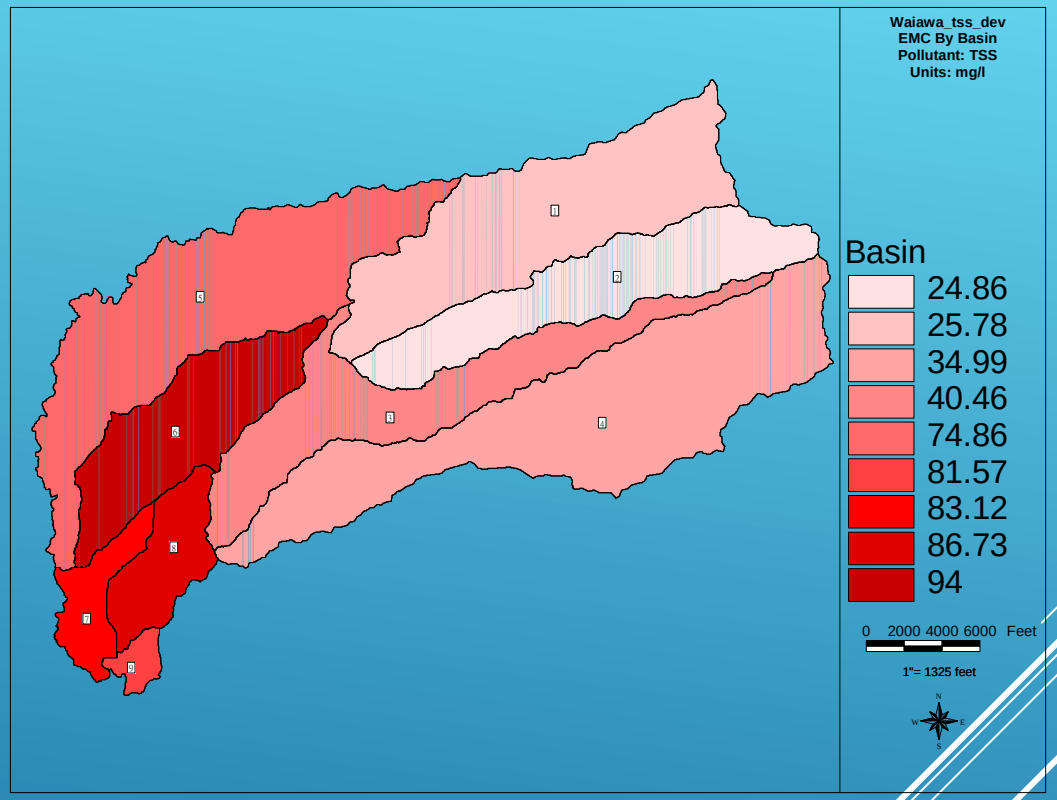


Figure6 PLOAD viewing showing the result of pollutant loading by watershed as existing condition

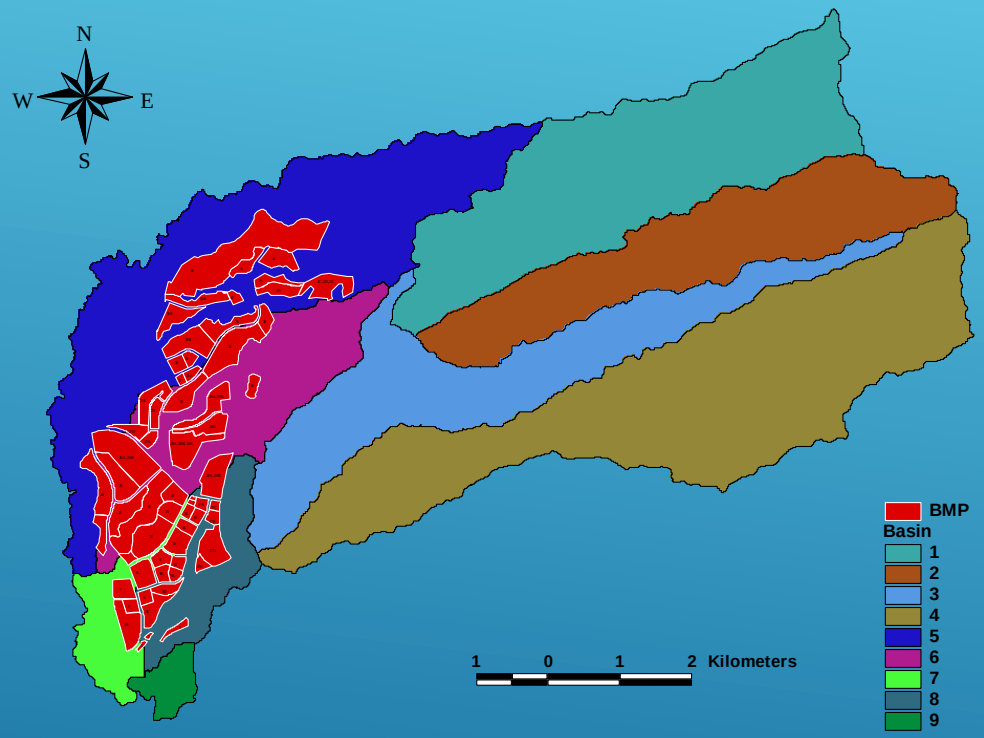
Output data of TSS (Developed Condition)

Subbasin	Area(Ac)	Storm Runoff (Ac-ft/yr)	TSS(kg/yr)	EMCs(mg/L)
1	2,643	3,319	100,913	25
2	1,766	2,213	67,036	25
3	1,924	2,646	113,566	35
4	3,588	4,915	209,514	35
5	3,032	4,745	326,511	56
6	1,469	2,505	179,549	59
7	455	919	79,775	71
8	662	1,366	118,648	71
9	142	292	26,058	73
Sum	15,681	22,920	1,221,570	451



PLOAD viewing showing the result of EMCs as developed condition

Development with BMPs



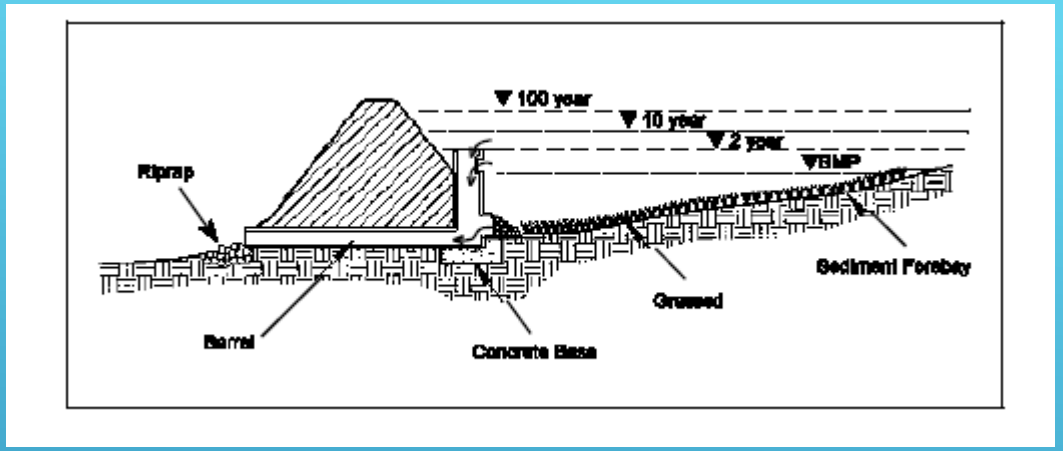


Figure Detention Basin (Source: USEPA, 1999)

BMP Type	Typical Pollutant Removal(%)				
	Suspended Solids	Nitrogen	Phosphorus	Pathogens	Metals
Dry Detention Basins	30 - 65	15 - 45	15 - 45	< 30	15 - 45
Retention Basins	50 - 80	30 - 65	30 - 65	< 30	50 - 80
Constructed Wetlands	50 - 80	< 30	15 - 45	< 30	50 - 80
Infiltration Basins	50 - 80	50 - 80	50 - 80	65 - 100	50 - 80
Infiltration Trenches/ Dry Wells	50 - 80	50 - 80	15 - 45	65 - 100	50 - 80
Porous Pavement	65 - 100	65 - 100	30 - 65	65 - 100	65 - 100
Grassed Swales	30 - 65	15 - 45	15 - 45	< 30	15 - 45
Vegetated Filter Strips	50 - 80	50 - 80	50 - 80	< 30	30 - 65
Surface Sand Filters	50 - 80	< 30	50 - 80	< 30	50 - 80
Other Media Filters	65 - 100	15 - 45	< 30	<30	50 - 80

ID	Land use	Parcel_No	BMPs Type[1]	Area(ac)	Removal Efficiency (%)[2]		
					TSS	TP	TN
1	I	1	Detention	8.46	84	9	20
2	C	2	Detention	1.68	84	9	20
3	C	3	Detention	2.35	84	9	20
4	MDA	4A	Detention	38.66	84	9	20
4	MDA	4B	Detention	15.35	84	9	20
5	SCHOOL	5	Detention	9.20	84	9	20
6	C	6	Detention	9.42	84	9	20
7	PK	7	Detention	19.97	84	9	20
8	SCHOOL	8	Detention	12.92	84	9	20
9	MDA	9C	Detention	26.49	84	9	20
9	MDA	9E	Detention	24.04	84	9	20
9	MDA	9D	Detention	13.53	84	9	20
9	MDA	9A	Detention	7.73	84	9	20
9	MDA	9B	Detention	9.95	84	9	20
10	SF	10	Detention	24.18	84	9	20
11	PK	11	Detention	8.48	84	9	20
12	SF	12	Detention	51.44	84	9	20
13	LDA	13	Detention	17.13	84	9	20
14	LDA	14	Detention	10.57	84	9	20
15	GC	15	Detention	82.95	84	9	20
16	PK, REC	16B	Detention	1.76	84	9	20
16	C	16A	Detention	1.00	84	9	20
17	SF	17E	Detention	7.45	84	9	20
17	SF	17B	Detention	8.01	84	9	20
17	SF	17A	Detention	45.00	84	9	20
17	SF	17C	Detention	4.92	84	9	20
17	SF	17D	Detention	39.77	84	9	20
18	PK	18	Detention	6.41	84	9	20
19	SCHOOL	19	Detention	8.22	84	9	20
20	LDA, SF	20A, 20B	Detention	45.74	84	9	20
21	MDA, C, I	21A,21B	Detention	16.44	84	9	20
22	MDA	22	Detention	36.99	84	9	20
23	MDA	23	Detention	18.57	84	9	20
24	C, I	24	Detention	42.94	84	9	20

input data of Vortech BMPs

Output data of TSS (development with Vortech BMPs)

Subbasin	Area(Ac)	Storm Runoff (Ac-ft/yr)	TSS(kg/yr)	EMCs(mg/L)
1	2,643	3,319	100,913	26
2	1,766	2,213	67,036	25
3	1,924	2,646	113,566	40
4	3,588	4,915	209,514	35
5	3,032	4,627	205,870	60
6	1,469	2,462	82,693	63
7	455	920	45,488	52
8	662	1,269	73,627	64
9	142	292	26,058	82
Sum	15,681	22,662	924,766	447

The change of flow, EMCs and loading between existing condition(EC) and development conditions(DC)

Sub Basins	Area (acres)	Storm Runoff			TSS			TP			TN		
		EC (Ac-ft/yr)	DC (Ac-ft/yr)	Change (%)	EC (kg/yr)	DC (kg/yr)	Change (%)	EC (kg/yr)	DC (kg/yr)	Change (%)	EC (kg/yr)	DC (kg/yr)	Change (%)
1	2,643	3,321	3,319	0	100,913	100,913	0	568	568	0	4,451	4,448	0
2	1,766	2,213	2,213	0	67,036	67,036	0	379	379	0	2,966	2,966	0
3	1,924	2,643	2,646	0	117,879	113,566	-4	548	547	0	3,978	4,002	1
4	3,588	4,844	4,915	1	202,161	209,514	4	1,010	1,036	3	7,375	7,522	2
5	3,032	4,113	4,745	15	229,736	326,511	42	823	1,239	51	5,736	8,065	41
6	1,469	2,086	2,505	20	135,957	179,549	32	453	768	70	2,843	4,796	69
7	455	755	919	22	61,776	79,775	29	221	318	44	1,339	1,959	46
8	662	1,118	1,366	22	96,400	118,648	23	331	487	47	1,965	3,044	55
9	142	278	292	5	25,814	26,058	1	99	101	2	604	618	2
Sum	15,681	21,372	22,920	7	1,037,996	1,221,570	18	4,432	5,443	23	31,257	37,420	20

Note:
EC: Existing condition
DC: Development condition without BMPs
% Change = 100*(DC – EC)/ EC

- A. Building a BASINS project and Download the Data
  1. Open the program " BASINS 4" and the following interface will appear on the screen
  2. As the project is not exists, the first exercise is to build the project. Click on the " Build New BASINS Project"
  3. Zoom Out the BASINS interface by using this tool until all the map of US territory is appeared
  4. Using the Zoom-in tool and point into the Hawaii Island
  5. Select the Oahu Island by using the Selection tool
  6. Click the "Build" to build the BASINS project
  7. Set the Projection: Most of the available GIS data for Oahu is in the projection
  8. 3 layers will be generated and the BASINS Project
  9. Download additional data from EPA BASINS Download data center by using the BASINS Download data tool
  10. Download: "NHD", "Met Stations", "Daily Discharge"

- B. Import the external data into a BASINS project
  1. Import the GIS data into the BASINS project
  2. Delineate the watershed

- C. PLOAD Application

  Exercise of PLOAD application for existing land use