Notes About Constructed Wetlands

Engineers Without Borders Virginia Tech

k-C* Model (1996)

$$A = (\frac{0.0365 * Q}{k}) \ln (\frac{C_i - C^*}{C_e - C^*}) \tag{1}$$

$$C_o = C^* + (C_i - C*) \exp (-\frac{kA}{0.0365Q}) \tag{2}$$

$C_o =$ outlet concentration (mg/L)

$C_i =$ inlet concentration (mg/L)

$C^* =$ background concentration (mg/L)

$k =$ modified first order areal constant (m/d)

$A =$ area (m^2/d)

$Q =$ design flow (m^3/d)

Table 1: Typical Media Characteristics for Subsurface Flow Wetlands

	BOD	TSS	Organic N	NH_4-N	NO_xN	TN	TP	FC
k20, m/yr	180	1000	35	34	50	27	12	95
Θ	1.0	1.0	1.05	1.04	1.09	1.05	1	1
C*, mg/L	3.5+0.053 C_i	7.8+0.063 C_i	1.5	0	0	1.5	0.02	10

Table 2: Possible Effluent Values at Certain Areas

Area (m^2	BOD	TSS	Organic N	NH_4-N	NO_xN	TN	TP	FC
500	9.12	13.16	4.16	13.4	6.01	13.38	5.51	47105.1
1000	8.84	13.16	2.27	4.49	1.2	6.4	3.75	2227.97
10000	8.84	13.16	1.36	0	0	1.36	0.02	10

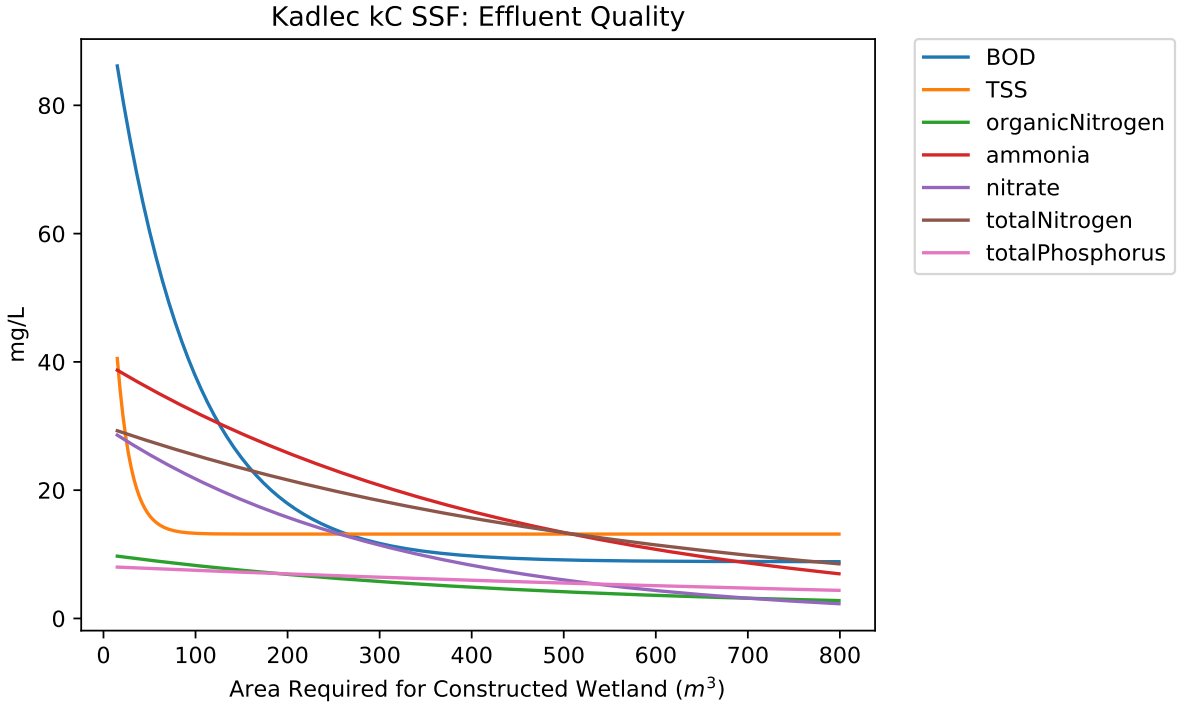

Figure 1: Effluent

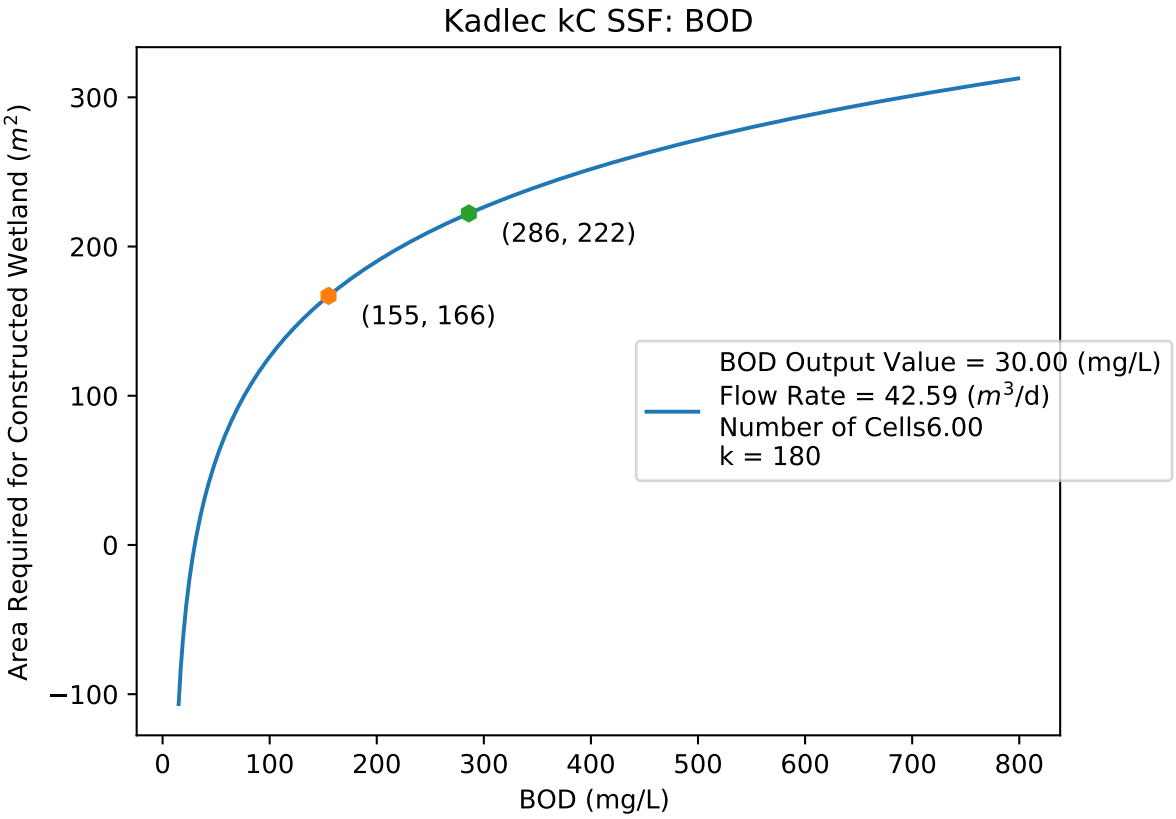

Figure 2: Area

P-k-C* Model (2009)

$$\frac{(C_o - C^*)}{(C_i - C^*)} = \frac{1}{(1 + k/Pq)^P} \tag{3}$$

$C_o =$ outlet concentration (mg/L)

$C_i =$ inlet concentration (mg/L)

$C^* =$ background concentration (mg/L)

$k =$ modified first order areal constant (m/d)

$p =$ number of cells

$q =$ hydrolic loading rate (m/d)

$$k_T = k_{20}\theta^{(T-20)} \tag{4}$$

$$q = Q/A \tag{5}$$

$q =$ hydrolic loading rate

$Q =$ inflow rate, m^3/d

$A =$ area, m^2

$$Q_1 = Q_i + A_1(P - ET - I) \tag{6}$$

$A_1 =$ area of the first segment (tank), m^3

$ET =$ evapotranspiration, m/d

$I =$ infiltration, m/d

$P =$ precipitation, m/d

$Q_i =$ inlet flow rate, m^3/d

$Q_1 =$ outlet flow rate from first segment, m^3/d

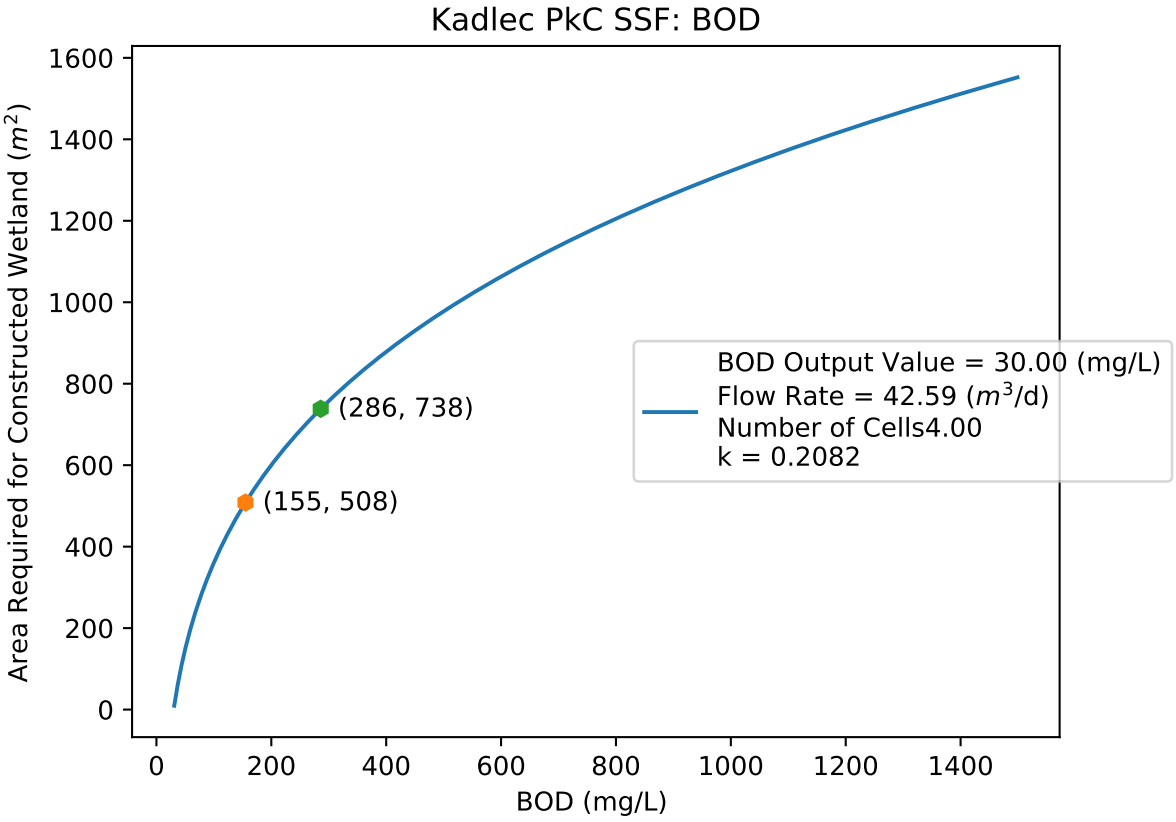

Figure 3: Area

Table 3: Calculations from Kadlec Second Edition

Input Parameters		
Flow rate, Q:	42.59	(m^3/d)
Cells, P:	4	(system)
Area, A:	1000	(m^2)
Cell Area:	250.0	(m^3)
C_i:	100.8	(mg/L)
C*:	8.8424	(mg/L)
k:	76.0	(m/yr)
k:	0.208	(m/d)

Calculated Values		**System In**	**Exit Cell 1**	**Exit Cell 2**	**Exit Cell 3**	**Exit Cell 4**	**System Out**
Net flow	(m^3/d)	42.59	42.59	42.59	42.59	42.59	42.59
HLR, q	(m/d)	0.04	0.17	0.17	0.17	0.17	0.04
Concentration	(mg/L)	100.8	50.22	27.46	17.22	12.61	12.61
HRT	(days)	N/A	N/A	N/A	N/A	N/A	N/A

Table 4: Summary of First-Order Rate Constants for Selected Parameters

C_i (mg/L)	BOD Tertiary 0-30 (mg/L)	BOD Tertiary 30-100 (mg/L)	BOD Tertiary 100-200 (mg/L)	BOD Tertiary >200 (mg/L)
FWS				
P	1	1	1	1
C^*, (mg/L)	2	5	10	20
30th %ile (k, m/yr)	16	16	23	54
50th %ile (k, m/yr)	33	**41**	**36**	189
70th %ile (k, m/yr)	79	67	112	439
HSSF				
P	3	3	3	3
C^*, (mg/L)	1	5	10	15
30th %ile (k, m/yr)	36	24	15	21
50th %ile (k, m/yr)	86	**37**	**25**	66
70th %ile (k, m/yr)	224	44	44	114
VFSF				
P	6	6	6	6
C^*, (mg/L)	0	0	0	0
30th %ile (k, m/yr)	22	40	53	48
50th %ile (k, m/yr)	63	**56**	**76**	71
70th %ile (k, m/yr)	105	79	122	93

Table 5: Summary of First-Order Rate Constants for Selected Parameters

C_i (mg/L)	ORG-N	NH_4-N	NO_x-N	TKN	TN	TP	FC
FWS							
P	3	3	3	3	3	3.4	3
C^*, (mg/L)	1.5	0	0	1.5	1.5	0.002	40
30th %ile (k, m/yr)	10.7	8.7	18.5	6.1	6.6	4.5	49
50th %ile (k, m/yr)	**17.3**	**14.7**	**26.5**	**9.8**	**12.6**	**10.0**	**83**
70th %ile (k, m/yr)	27.4	45.1	33.6	13.6	24.2	16.7	177
HSSF							
P	6	6	8	6	6	•	6
C^*, (mg/L)	1	0	0	1	1	•	0
30th %ile (k, m/yr)	8.8	5.2	32	4.8	4.7	•	56
50th %ile (k, m/yr)	**19.6**	**11.4**	**42**	**9.1**	**8.4**	•	**103**
70th %ile (k, m/yr)	38.0	18.8	73	14.6	14.2	•	181

How to Call Python Functions

Function:	changeWetlandType(newType)
Purpose:	Changes between Free Water Surface or Subsurface Wetland
Inputs	**Input Options**
newType	“FWS”
	“SSF”

Function:	changeModel(newModel)
Purpose:	Controls which model is used for calculations
Inputs	**Input Options**
newType	“reed”
	“kadlec2009”
	“kadlecPkC”
	“kadlec1996”
	“KadleckC”

Function:	area(qualityType)
Purpose:	Calculates necessary area
Inputs	**Input Options**
qualityType	“BOD”
	“TSS”
	“organicNitrogen”
	“ammonia”
	“nitrate”
	“totalNitrogen”
	“totalPhosphorus”
	“fecalColiform”
cells=	integer value
k=	integer value
c_i=	integer value

Function:	printArea(qualityType)
Purpose:	Prints area to console
Inputs	**Input Options**
qualityType	“BOD”
	“TSS”
	“organicNitrogen”
	“ammonia”
	“nitrate”
	“totalNitrogen”
	“totalPhosphorus”
	“fecalColiform”

cells=	integer value
k=	integer value
c_i=	integer value
Function:	effluent(qualityType)
Purpose:	Calculates an effluent value for a certain area
Inputs	**Input Options**
qualityType	“BOD”
	“TSS”
	“organicNitrogen”
	“ammonia”
	“nitrate”
	“totalNitrogen”
	“totalPhosphorus”
	“fecalColiform”
cells=	integer value
k=	integer value
area=	integer value
Function:	printFffluent(qualityType)
Purpose:	Prints effluent value to console
Inputs	**Input Options**
qualityType	“BOD”
	“TSS”
	“organicNitrogen”
	“ammonia”
	“nitrate”
	“totalNitrogen”
	“totalPhosphorus”
	“fecalColiform”
cells=	integer value
k=	integer value
area=	integer value

Table 16.3: Predesign Checklist

Potential Weltand Site Data

Site name: CEFONMA

- City/Community: Xix, Guatemala
- Current Population: 150 (Half day students, half boarding students)
- Future Population: 450

Other anticipated Wetland Uses (nature study, hunting, aquaculture, other):

Key/sensitive wildlife habitat:

Site substrate material (e.g., sand, clay, muck, sandy clay, clayey sand, etc.):

- Substrate permeability: high medium low

%Vegitation Cover:

- Submergent:
- Emergent:
- Meadow:
- Forest:

Land area available:

Proximity to water/wastewater source:

- Zoning:
- Ownership:

Adjacent land use:

- Zoning:
- Ownership:

Presence of existing or potential limiting land use (e.g., environmentally sensitive areas, etc.):

Protected species historical or archealogical resources on or near site:

Aquifers, aquitards, or natural wetlands (note location):

% of Available land area covered by natural wetlands:

Type of natural wetland (marsh, openwater, floating aquitic, etc):

Dominant plant species:

Site topography (flat, rolling, steep, other):

- Is the wetland/site landlocked? Yes No

- If no, what water body will/does teh treatment wetland discharge to?

Water body classification:

Wetland outlet location and description:

Upland buffer zone description:

Climatic Factors

Site elevation:

Number of frost-free days:

Annual and monthly temperature

Table 6: Annual and Monthly Temps

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
14.6	15.1	16.6	17.4	17.5	17.5	16.7	16.7	16.8	16.1	15.7	15.2	16.33

Table 7: Annual and Monthly Snowfall

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
—	—	—	—	—	—	—	—	—	—	—	—	—

Table 8: Annual and Monthly Rainfall

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
65	42	50	66	128	306	264	230	251	224	127	64	1818

Table 9: Annual and Monthly Evapotranspiration

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
—	—	—	—	—	—	—	—	—	—	—	—	—

Potential Influent Quantity and Quality

Design flows:

Stormwater to watershed area:

Define watershed border and note watershed area: ha

Runoff coefficient:

Wastewaters (municipal, industrial, etc):

Wastewater pretreatment:

Operating season (months):

Period of record

- Start year
- End year

Average flow (m^3/d):

Metals (list):

Pesticides/herbicides (list):

Organics (list):

Parameter Concentrations and Loadings

Parameter				
BOD_5	_____	mg/L	_____	kg/d
TSS	_____	mg/L	_____	kg/d
NH_4-N	_____	mg/L	_____	kg/d
NO_3+NO_2	_____	mg/L	_____	kg/d
TN	_____	mg/L	_____	kg/d
TKN	_____	mg/L	_____	kg/d
Organic Nitrogen	_____	mg/L	_____	kg/d
TP	_____	mg/L	_____	kg/d
SO_4/S_2	_____	mg/L	_____	kg/d
Alkalinity	_____	mg/L	_____	kg/d
Chloride	_____	mg/L	_____	kg/d
Dissolved Oxygen	_____	mg/L	_____	kg/d
Conductivity	_____			
pH	_____			
Temperature	_____	(°C)		
Fecal Coliform	_____	(CFU/100 mL)		
E. coli	_____	(CFU/100 mL)		

Treatment Wetland System Outflow Targets

Approval permit limits to be met at:

- wetland inflow:
- wetland outflow:

Approved flow (per day, week, month, year):

Approval duration:

Parameter				
BOD_5	_____	mg/L	_____	kg/d
TSS	_____	mg/L	_____	kg/d
NH_4-N	_____	mg/L	_____	kg/d
TN	_____	mg/L	_____	kg/d
TP	_____	mg/L	_____	kg/d
Dissolved Oxygen	_____	mg/L		
Fecal Coliform	_____	(CFU/100 mL)		
pH	_____			