

# Notes About Constructed Wetlands

Engineers Without Borders Virginia Tech

## k-C\* Model (1996)

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

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

$C_o$  = 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<sup>2</sup>/d)

$Q$  = design flow (m<sup>3</sup>/d)

Table 1: Typical Media Characteristics for Subsurface Flow Wetlands

	BOD	TSS	Organic N	NH <sub>4</sub> -N	NO <sub>x</sub> N	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 <sub>i</sub>	7.8+0.063 C <sub>i</sub>	1.5	0	0	1.5	0.02	10

Table 2: Possible Effluent Values at Certain Areas

Area (m <sup>2</sup> )	BOD	TSS	Organic N	NH <sub>4</sub> -N	NO <sub>x</sub> N	TN	TP	FC
500	18.64	13.16	5.98	21.79	12.28	19.04	6.54	183093
1000	12.65	13.16	3.83	11.87	5.02	12.27	5.28	33529.6
10000	12.4	13.16	1.36	0	0	1.36	0.13	10

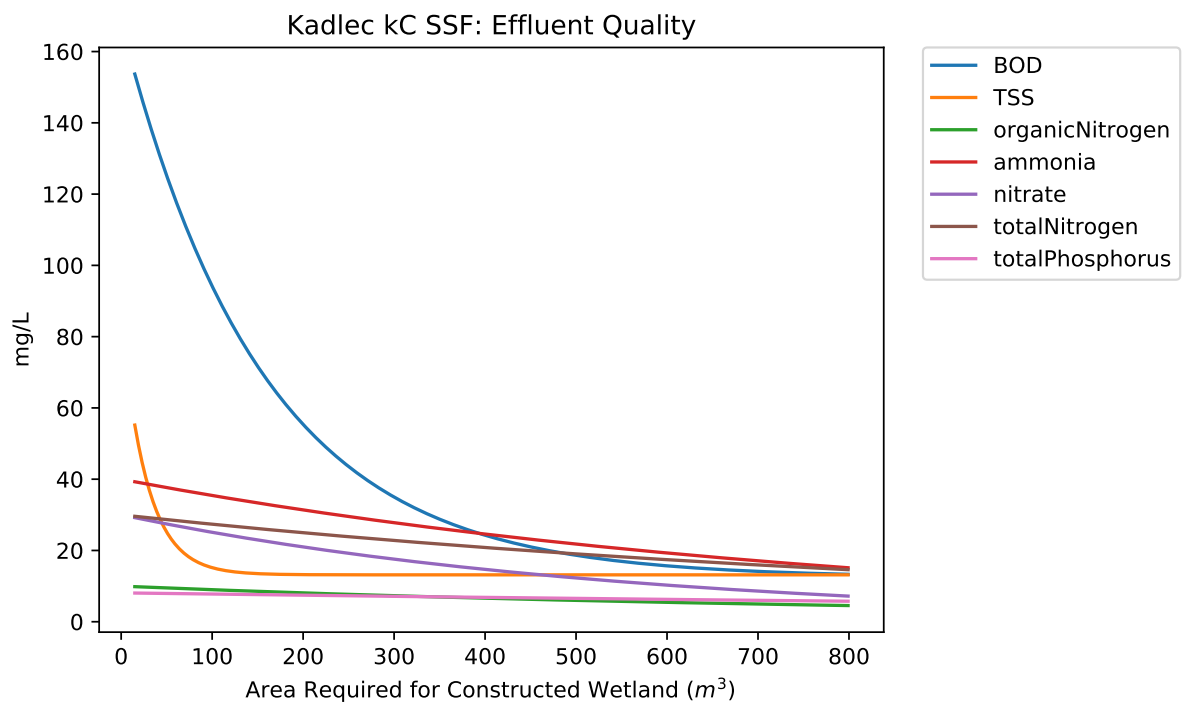


Figure 1: Effluent

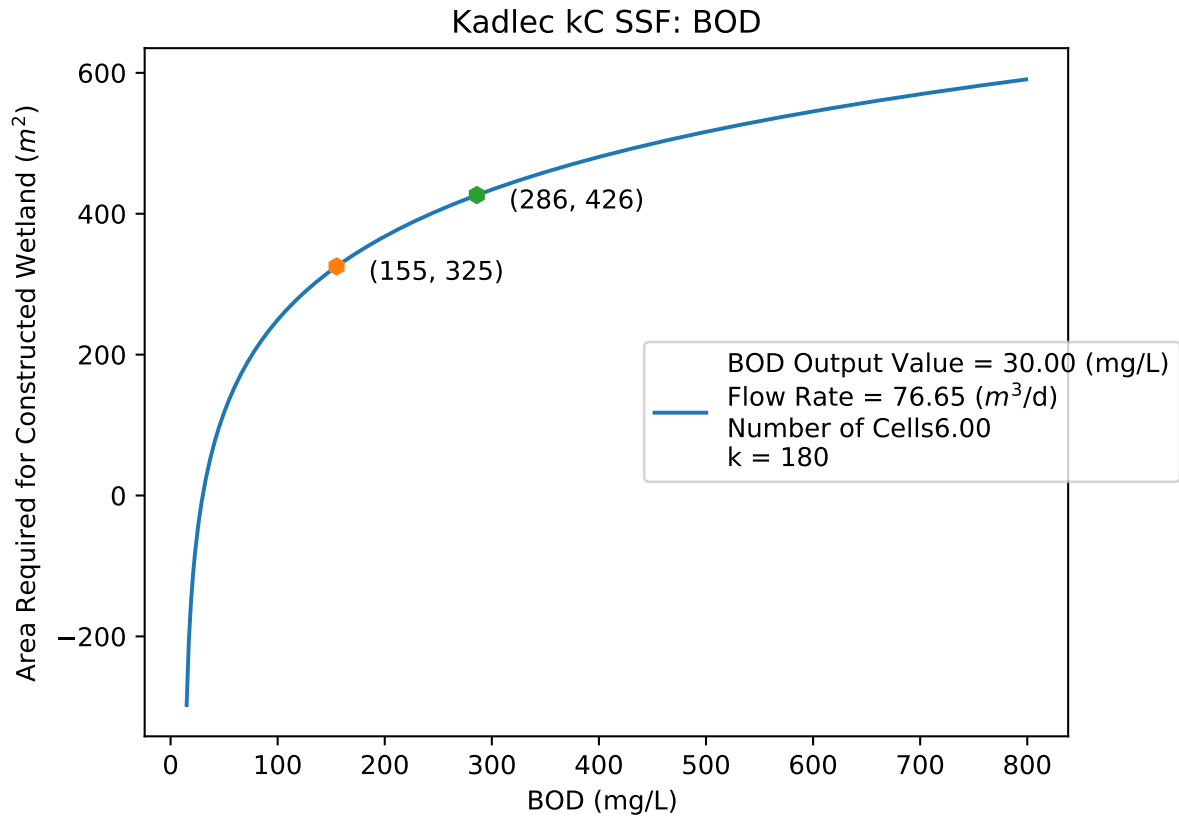


Figure 2: Area

## P-k-C\* Model (2009)

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

$C_o$  = 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)

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

$$q = Q/A \quad (5)$$

$q$  = hydrolic loading rate

$Q$  = inflow rate, m<sup>3</sup>/d

$A$  = area, m<sup>2</sup>

$$Q_1 = Q_i + A_1(P - ET - I) \quad (6)$$

$A_1$  = area of the first segment (tank), m<sup>3</sup>

$ET$  = evapotranspiration, m/d

$I$  = infiltration, m/d

$P$  = precipitation, m/d

$Q_i$  = inlet flow rate, m<sup>3</sup>/d

$Q_1$  = outlet flow rate from first segment, m<sup>3</sup>/d

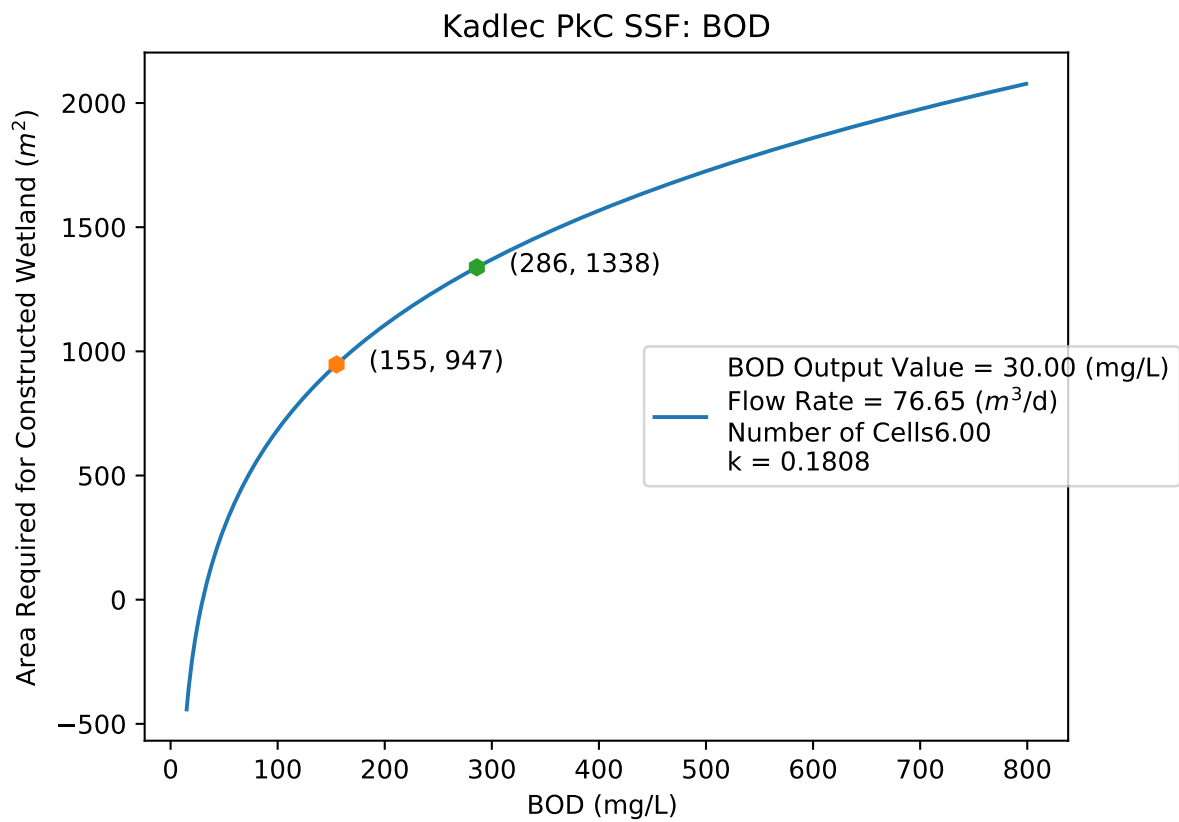


Figure 3: Area

Table 3: Calculations from Kadlec Second Edition

Input Parameters						
Flow rate, Q:	76.65	(m <sup>3</sup> /d)				
Cells, P:	4	(system)				
Area, A:	1000	(m <sup>2</sup> )				
Cell Area:	250.0	(m <sup>3</sup> )				
C <sub>i</sub> :	168	(mg/L)				
C*:	8	(mg/L)				
k:	25.0	(m/yr)				
k:	0.068	(m/d)				
Calculated Values	System In	Exit Cell 1	Exit Cell 2	Exit Cell 3	Exit Cell 4	System Out
Net flow (m <sup>3</sup> /d)	76.65	76.65	76.65	76.65	76.65	76.65
HLR, q (m/d)	0.08	0.31	0.31	0.31	0.31	0.08
Concentration (mg/L)	168	138.78	114.9	95.38	79.43	79.43
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

<b>C<sub>i</sub> (mg/L)</b>	<b>BOD Tertiary 0-30 (mg/L)</b>	<b>BOD Tertiary 30-100 (mg/L)</b>	<b>BOD Tertiary 100-200 (mg/L)</b>	<b>BOD Tertiary &gt;200 (mg/L)</b>
<b>FWS</b>				
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	<b>41</b>	<b>36</b>	189
70th %ile (k, m/yr)	79	67	112	439
<b>HSSF</b>				
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	<b>37</b>	<b>25</b>	66
70th %ile (k, m/yr)	224	44	44	114



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

<b>C<sub>i</sub> (mg/L)</b>	<b>ORG-N</b>	<b>NH<sub>4</sub>-N</b>	<b>NO<sub>x</sub>-N</b>	<b>TKN</b>	<b>TN</b>	<b>TP</b>	<b>FC</b>
<b>FWS</b>							
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)	<b>17.3</b>	<b>14.7</b>	<b>26.5</b>	<b>9.8</b>	<b>12.6</b>	<b>10.0</b>	<b>83</b>
70th %ile (k, m/yr)	27.4	45.1	33.6	13.6	24.2	16.7	177
<b>HSSF</b>							
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)	<b>19.6</b>	<b>11.4</b>	<b>42</b>	<b>9.1</b>	<b>8.4</b>	•	<b>103</b>
70th %ile (k, m/yr)	38.0	18.8	73	14.6	14.2	•	181

## Table 16.3: Predesign Checklist

### Potential Wetland 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

%Vegetation 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 archeological 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 aquatic, etc):

Dominant plant species:

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

- Is the wetland/site landlocked? Yes No
- If no, what water body will/does the 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<sup>3</sup>/d):

Metals (list):

Pesticides/herbicides (list):

Organics (list):

### Parameter Concentrations and Loadings

Parameter				
BOD <sub>5</sub>	_____	mg/L	_____	kg/d
TSS	_____	mg/L	_____	kg/d
NH <sub>4</sub> -N	_____	mg/L	_____	kg/d
NO <sub>3</sub> +NO <sub>2</sub>	_____	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 <sub>4</sub> /S <sub>2</sub>	_____	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 <sub>5</sub>	_____	mg/L	_____	kg/d
TSS	_____	mg/L	_____	kg/d
NH <sub>4</sub> -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	_____			