NAME:

2 HOURS; HAND IN YOUR 1 SHEET OF NOTES WITH THE EXAM; ASK FOR EXTRA PAPER IF NEEDED. CHECKING WHETHER THE ANSWER MAKES SENSE MAY HELP YOU EARN PARTIAL CREDIT IF YOU WENT WRONG SOMEWHERE.

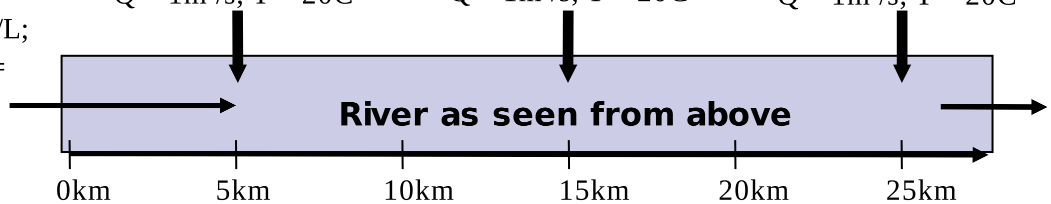
PROBLEM 1 (20 pts):

Source1 at 5km
BOD = 100mg/L;
DO = 1 mg/L;
Q = 1m^3/s; T = 20C

Source2 at 15km
BOD = 100mg/L;
DO = 1mg/L;
Q = 1m^3/s; T = 20C

Source3 at 25km
BOD = 100mg/L;
DO = 1mg/L;
Q = 1m^3/s; T = 20C

River at 5km
BOD = 5mg/L;
DO = DO_{sat} = 9.09 mg/L;
Q = 20 m^3/s;
T = 20C;
V = 1 m/s



There are a great many BOD sources that affect the water quality of surface waters near urban areas. In this problem, three urban runoff sources enter a river through CSOs during a rainfall event, as illustrated above.

(a) Give the general assumptions associated with applying the Streeter-Phelps model here:

1. Are concentrations steady?

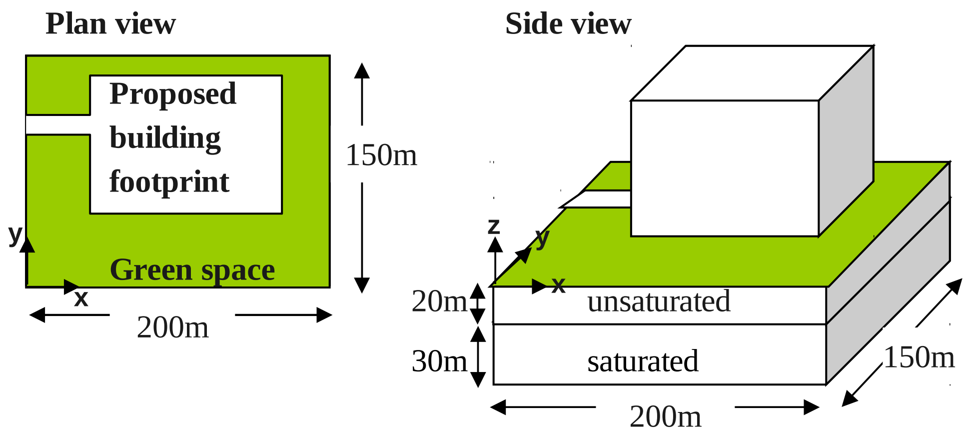
2. Are concentrations uniform?

3. Other assumptions?

(b) Sketch qualitatively river BOD and DO as functions of x between 0km and 25km. Do not calculate anything, but do label the curves so it is clear which is for BOD and which is for DO

(c) Determine the concentration of BOD and DO at 10km if k_d (20C)= 0.2 d^{-1}, k_r (20C)= 0.8 d^{-1}.

PROBLEM 2 (20 pts):

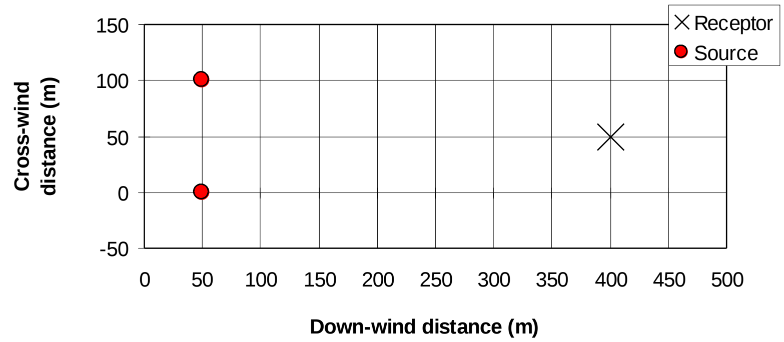


Engineers are estimating the area of green space needed for a new housing development to meet NYC's policy to increase infiltration and reduce runoff.

Borings reveal that both the unsaturated and saturated zone soils are made up of Carnegie sandy loam, with f_c = 4.50 cm/h, f_o = 35.52 cm/h, k = 19.64/h, K = 0.4 m/day, η = 0.3, ρ = 1400 kg/m^3, f_{oc} = 0.005.

Determine the amount of exposed soil (green space), as an area and as a percentage of the lot area, needed to infiltrate 750 m^3 water over the first 30 minutes of a rainstorm.

PROBLEM 3 (20 pts):



Silica fume is often mixed into concrete for strength. It is a fine powder and can easily become suspended in the air during mixing as $PM_{2.5}$.

Urban; wind speed at 10m is 5 m/s.

Upwind $PM_{2.5}$ concentration is 10 μg/m^3.

The atmospheric stability class is B between 0 and 300m above ground, and F above 300m.

The two emission sources are identical, each with emission rate of 0.5 g/s and an effective height (h+Δh) of 10m.

Use the Gaussian Plume model to estimate the $PM_{2.5}$ concentration at the receptor (in g/m^3). Be sure to determine which form of the Gaussian Plume model to use first. Specify any assumptions you are making in applying the GPM.

PROBLEM 4 (20 pts):
When traffic gets rerouted around a project site, some communities can experience more traffic than usual. In this problem, you will estimate the impact of formic acid, HCOOH(g), emissions from rerouted vehicles on water quality at a nearby lake.

The ONLY two relevant reactions are:

$$1)\ HCOOH\,(\mathrm{aq}) \Leftrightarrow HCOOH\,(\mathrm{g}),\quad K_1 = 0.00028\,\frac{atm}{M} = 1.17\times10^{-5}\,\frac{M_g}{M}$$

$$2)\ HCOOH\,(\mathrm{aq}) \Leftrightarrow HCOO^-\,(\mathrm{aq}) + H^+\,(\mathrm{aq}),\quad K_2 = 1.78\times10^{-4}\,M$$

a) Write the equilibrium rate expression for the two reactions that are given above, using "*" to show concentrations at equilibrium.

b) If the equilibrium pH is 5 and the equilibrium concentration of HCOOH (g) in the air is $4.16 \times 10^{-11}\ M_g = 10^{-9}$ atm, determine the equilibrium concentrations of HCOOH (aq) and $HCOO^-$ (aq) in the lake in M. Assume that the air CV is 85,000,000 m^3 and the water CV is 125,000 m^3.

PROBLEM 5 (20 pts):
Below are extracts from the EIS for the Cape Wind offshore wind energy project, completed by the US Department of the Interior in 2009. Based on the information given as well as on what you learned in class and in your group project,

(a) Concisely describe the project alternatives that were analyzed, and explain how these relate to EQR requirements.

(b) Concisely describe the main potential impacts of the project (which may be negative and/or positive) on the attributes of (1) Natural Resources, (2) Transportation, (3) Air Quality, (4) Greenhouse Gas Emissions.

The Cape Wind Energy Project developer, Cape Wind Associates, LLC (the applicant), proposes to build, operate, and eventually decommission an electric generation facility with a maximum electric output of 454 megawatts and an average output of 182.6 megawatts, in Nantucket Sound off the coast of Massachusetts (proposed action). The proposed action would generate electricity from wind energy resources on the Outer Continental Shelf. The applicant seeks to commence construction in 2009 and begin operation in 2010.
...
The proposed action requires environmental review for Federal approval under Subsection 8(p) of the Outer Continental Shelf Lands Act. The National Environmental Policy Act provides the framework under which Federal agencies perform environmental review of projects for which they would be authorizing, funding, or undertaking on their own behalf. In this instance, the proposed federal actions resulting in the need for environmental review under the National Environmental Policy Act are the issuance of a lease, easement or right-of-way and related approvals by the Minerals Management Service for authorizing the construction, operation and eventual decommissioning of the Cape Wind Energy Project (the proposed action).
...
Project Purpose and Need
The underlying purpose and need to which the agency is responding is to develop and operate an alternative energy facility that utilizes the unique wind resources in waters offshore of New England employing a technology that is currently available, technically feasible, and economically viable, that can interconnect with and deliver electricity to the New England Power Pool, and make a substantial contribution to enhancing the region’s electrical reliability and achieving the renewable energy requirements under the

Massachusetts and regional renewable portfolio standards.

...

Solid dielectric submarine inner-array cables (33 kilovolt) from each wind turbine generator would interconnect within the grid and terminate on an electrical service platform. The electric service platform would serve as the common interconnection point for all of the wind turbine generators. The proposed submarine transmission cable system (115 kilovolt) is approximately 12.5 miles in length ... from the electric service platform to the landfall location in Yarmouth. The submarine transmission cable system consists of two parallel cables that would travel north to northeast in Nantucket Sound into Lewis Bay past the westerly side of Egg Island, and then make landfall at New Hampshire Avenue. The proposed onshore transmission cable system route from the landfall area to its intersection with the NSTAR electric right-of-way would be located entirely along existing paved right-of-ways where other underground utilities already exist.

...

Installation of the proposed action components would comprise five activities: (1) installation of the foundation monopiles; (2) erection of the wind turbine generators and electric service platform; (3) installation of the inner-array cables; (4) installation of the transmission cables from the electric service platform to the Barnstable Switching Station; and (5) installation of the scour protection around the monopiles and electric service platform piles. The electric service platform design is based on a piled jacket/template design with a superstructure mounting on top. The platform jacket and superstructure would be fully fabricated on shore and delivered to the work site by barges, where it would be installed.

The proposed method of installation of the submarine cables (both the inner array cables and the submarine transmission cables) would be accomplished by the Hydroplow embedment process, commonly referred to as jet plowing. This method involves the use of a positioned cable barge and a towed hydraulically-powered jet plow device that simultaneously lays and embeds the submarine cable in one continuous trench from wind turbine generator to wind turbine generator and then to the electric service platform, or from the electric service platform to the landfall area.

Summary Description of Alternatives Assessed

In order to conduct a comprehensive evaluation of reasonable alternative locations for an offshore wind energy facility that would be capable of serving the New England region, Minerals Management Service identified and initially screened nine alternative locations (in addition to the proposed location on Horseshoe Shoal) along the coast from Maine to Rhode Island. The sites were chosen based on geographic diversity, having at least some potential in terms of wind resources, and the necessary area required for the proposed facility size. In addition, in development of the alternatives, Minerals Management Service took into account comments received as a part of the scoping process. Specifically, the Phelps Bank Alternative was selected as a result of interest expressed in this location by the Massachusetts Office of Coastal Zone Management, and Offshore Nauset Alternative was chosen as a result of public interest in a deep water alternative.

...

In addition to the sites screened above, Minerals Management Service also screened three non- geographic based alternatives to the proposed action to see if they could produce electricity at a reasonable cost range to that of the proposed action. These design alternatives included:

- Smaller Project (half the megawatt capacity of the Proposed Alternative at the same location);
- Condensed Array (same number of turbines but closer together);

and • Phased Development (two phases of 65 turbines each)

The No Action Alternative was also included in the screening process. The analysis of the No Action Alternative provides a benchmark for Minerals Management Service in which to compare the magnitude of environmental impacts of the proposed action. The No Action alternative considers other strategies for addressing the demand for electricity in New England if the proposed action were not constructed, and the viability of those strategies and or impacts associated with those other strategies. This includes an assessment of energy efficiency, and the assessment of other energy options including fossil fuel technologies, and other alternative energy technologies.

GIVEN INFORMATION

1 m^3 = 1000 L, 1 mg = 10^{-3} g, 1 µg = 10^{-6} g

T(degK) = T(degC) + 273.15, 1 atm = 101325 Pa

Eq. 4.3 $PV=nRT$ where R=0.08206 L atm mol^{-1} K^{-1}

Eq. 4.4 $\rho_{air}=\frac{mass\ air}{volume\ air}=\frac{n_{air}\times MW_{air}}{V_{air}}=\frac{n_{air}}{V_{air}}\times MW_{air}=\frac{P}{RT}\times MW_{air}$

Eq. 4.13 $y_i\approx\frac{mass\ i\ /\ V_{air}}{P\times MW_i\ /\ RT}=\frac{m_i}{P\times MW_i\ /\ RT}$ **Eq. 4.14** $P_i=y_iP$

$\text{Lifetime risk of death}=\text{Chronic Daily Intake}\times\text{Potency Factor}$

$\text{Chronic Daily Intake}=\frac{\text{Exposure concentration}\times\text{Intake rate}\times\text{Exposure duration}}{\text{Body weight}\times\text{Lifetime}}$

$0.5\times C(0)=C(0)e^{-kt_{1/2}}$ and $k=-\ln(0.5)\ /\ t_{1/2}$

$\text{Exposure concentration}=C(0)\times e^{-kt}\times\text{Bioconcentration factor}$

$\text{Lifetime hazard quotient}=\frac{\text{Chronic Daily Intake}}{\text{Reference Dose}}$

Eq. 6.27 $\frac{d}{dt}\int_{cv}\rho\ d\forall=-\int_{cs}\rho\ V(A)\cdot n\ dA$ **Eq. 6.28** $\frac{d}{dt}\int_{cv}\rho\ d\forall=\frac{dm}{dt}$ **Eq. 6.29**

$\int_{cs}\rho\ V(A)\cdot n\ dA=-\int_{cs,in}\rho\ V(A)\ dA+\int_{cs,out}\rho\ V(A)\ dA=\sum_{cs,in}\rho\ \bar{V}\ A-\sum_{cs,out}\rho\ \bar{V}\ A=\sum_{cs,in}\dot{m}-\sum_{cs,out}\dot{m}$

Eq. 6.30 $\frac{d}{dt}\int_{cv}C_i\ d\forall=-\int_{cs}C_i\ V(A)\cdot n\ dA\pm\sum\dot{R}_i$ **Eq. 6.31** $\frac{d}{dt}\int_{cv}C_i\ d\forall=\frac{dn_i}{dt}$

Eq. 6.32

$\int_{cs}C_i\ V(A)\cdot n\ dA=-\int_{cs,in}C_i\ V(A)\ dA+\int_{cs,out}C_i\ V(A)\ dA=\sum_{cs,in}C_i\ \bar{V}\ A-\sum_{cs,out}C_i\ \bar{V}\ A=\sum_{cs,in}\dot{n}_i-\sum_{cs,out}\dot{n}_i$

Eq. 6.33 $R_i=\pm\sum_{j=1,J}\left[k_j\forall\left(\prod_{h=1,H}C_{i,h}\right)\right]$ **Eq. 6.34** $K=\frac{\prod_{h=1,H\ \text{products}}[C_{i,h}]^{c^*}}{\prod_{h=1,H\ \text{reactants}}[C_{i,h}]^{c^*}}$

Eq. 6.35 $K=10^{-pK}$ **Eq. 6.41** $\sum_{i=1,I}n_{i,j^*}=\sum_{i=1,I}n_{i,j^o}$

Eq. 7.1 $P_1+\rho g\ z_1+\frac{\rho V_1^2}{2}=P_2+\rho g\ z_2+\frac{\rho V_2^2}{2}$

Eq. 7.2 $V(z)=V(z_{\text{ref}})\left(\frac{z}{z_{\text{ref}}}\right)^p$ **Eq. 7.3** $Q=\int_A V(A)\ \text{dA}\ =\frac{Y\ V(z_{\text{ref}})}{z_{\text{ref}}^p}\left(\frac{Z^{p+1}}{p+1}\right)$

Eq. 7.8 $E=A\times EF\times(1-ER/100)$

Eqns 7.12 and 7.15: $\Delta h=2.6\left(\frac{F}{u_hS}\right)^{1/3}$ **(stable);** $\Delta h=1.6\frac{F^{1/3}x_f^{1/3}}{u_h}$ **(neutral/unstable)**

Eq. 7.13 $F = gr^2 v_s \left(1 - \frac{T_a}{T_s}\right)$, **Eq. 7.14** $S = \frac{g}{T_a}\left(\frac{\Delta T_a}{\Delta z} + 0.01\right)$, **Eq. 7.16** $x_f = 120 F^{0.4}\ for\ F \geq 55$
$= 50 F^{5/8}\ for\ F < 55$

Eq. 7.17 $H = h + \Delta h$ **Eq. 7.19** $E_i = Qm_i$

Stability	a	c ($x \leq 1$ km)	d ($x \leq 1$ km)	f ($x \leq 1$ km)	c ($x \geq 1$ km)	d ($x \geq 1$ km)	f ($x \geq 1$ km)
A	213	440.8	1.941	9.27	459.7	2.094	−9.6
B	156	106.6	1.149	3.3	108.2	1.098	2.0
C	104	61.0	0.911	0	61.0	0.911	0
D	68	33.2	0.725	−1.7	44.5	0.516	−13.0
E	50.5	22.8	0.678	−1.3	55.4	0.305	−34.0
F	34	14.35	0.740	−0.35	62.6	0.180	−48.6

Note: The computed values of σ will be in meters when x is given in kilometers.

Atmospheric stability class		Value of exponent p in Equation 7.2	
		Rough terrain	Smooth terrain
A	Very unstable	0.15	0.09
B	Moderately unstable	0.15	0.09
C	Slightly unstable	0.20	0.12
D	Neutral	0.25	0.15
E	Slightly stable	0.40	0.24
F	Stable	0.60	0.36

	Actual temperature lapse rate range (deg K/100m)
A	dT/dz < -1.9 degC/100m
B	-1.9 ≤ dT/dz < -1.7
C	-1.7 ≤ dT/dz < -1.5
D	-1.5 ≤ dT/dz < -0.5
E	-0.5 ≤ dT/dz < 0
F	0 ≤ dT/dz

Eq. 7.18 $x_L = \left(\frac{0.47(L-H) - f}{c}\right)^{1/d}$, **Eq. 7.21** $\sigma_y = a\ x^{0.894}$, and **Eq. 7.22** $\sigma_z = c\ x^d + f;$ x in km

Eq. 7.23 $C(x,y,0) = \frac{E}{\pi u_H \sigma_y \sigma_z} \exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right] \exp\left[-\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2\right]\ for\ x < 2x_L$

Eq. 7.24 $C(x,y,0) = \frac{E}{\sqrt{2\pi} u \sigma_y L}\ for\ x \geq 2x_L\ and\ |y| \leq 3\sigma_y$ **Eq. 7.25** $C^{\text{total}}_{\text{x, y, 0}} = C_u + C^{\text{plume}}_{\text{x, y, 0}}$

Eq. 8.3 $f(t) = f_c + (f_0 - f_c) e^{-kt}$ **Eq. 8.5** $v' = \frac{K}{\eta}\frac{dh}{dL}$

Eq. 8.9 $\not{V} \frac{d(\text{DO})}{dt} = \not{V} k_r (\text{DO}_s - \text{DO}) - \not{V} k_d L_0 e^{-k_d t}$

Eq. 8.17 $\text{DO}(t) = \text{DO}_{\text{sat}}(T_0) - \frac{k_d L_0}{k_r - k_d}[e^{-k_d t} - e^{-k_r t}] - D_0 e^{-k_r t}$

Eq. 8.19 $t_c = \frac{1}{k_r - k_d} \ln[\frac{k_r}{k_d}(1 - \frac{D_0}{L_0}\frac{k_r - k_d}{k_d})]$

Eq. 8.20 $R = 1 + \frac{\rho_s}{\eta} K_{oc} f_{oc} = 1 + \frac{\rho_s}{\eta} K_d$ **Eq. 8.21** $f_i(t) = \frac{f(t)}{R}$ **Eq. 8.22** $v_i' = \frac{v'}{R}$

Eq. 9.1 Erosion rate $= R \times K \times LS \times C \times P$