PINKHAM & GREER
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June 27, 2013
File: 11161

Ms. Jeanie Bourke, Code Office
City of Portland
389 Congress St
Portland, ME 04101

RE: COMMUNITY SEPTIC SYSTEM
CLIFF ISLAND COMMUNITY SEPTIC SYSTEM ASSOCIATION

Dear Jeanie,

Attached are 3 copies of the HHE-200 application by Mark Hampton for a community septic system located on Cliff Island. It includes engineered drawings by Pinkham & Greer, as well as a Mounding Analysis and a Groundwater Impact Study by Sweet Associates.

The island residents have formed the Cliff Island Community Septic System Association (CICSSA) for the sole purpose of constructing and maintaining the septic system and collection system. The Association will own all of the piping system from and including the septic tanks, piping, and pump station to the beds, as well as the beds.

The beds are located on property owned by Land Associates of Cliff. The final agreement between the two entities is being worked out. No construction will take place until that agreement is signed.

The construction of the system will be by Anderson Construction. The final contract will be signed once all of the approvals are in place.

Based on current events, we plan to start construction in September of this year and be complete by January of 2014. This meets the DEP deadlines for the overboard discharge.

The system is designed for 5,120 gallons per day. This will be monitored at the pump station with a flow meter. We expect peak flows in the summer to approach this flow with much smaller flows in the winter.

The pump station and forcemain are located within the City's right-of-way. South Road is a gravel road and will be returned to equal or better condition once the work is complete. We have sent plans to Mike Famer in Engineering for their review.

With this project, the discharge of wastewater directly to the ocean will be eliminated. This project will be a successful community program.

Sincerely,

PINKHAM AND GREER,

Thomas S. Greer, P.E.

cc: Roger Berle, Steve Little, Robert Anderson, File

Enclosures

TSG/rjs

Sweet Associates
HYDROGEOLOGY | SITE EVALUATIONS

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April 2, 2013

WASTEWATER MOUNDING AND TRANSMISSION ANALYSIS
CLIFF ISLAND SEPTIC SYSTEM ASSOCIATION
CLIFF ISLAND (PORTLAND), MAINE

INTRODUCTION:

The purpose of this study is to determine the extent of mounding and wastewater effluent movement beneath proposed engineered subsurface wastewater disposal fields serving the Cliff Island Septic System Association. The total design flow of the proposed subsurface wastewater disposal fields is 5,120 gallons per day. The disposal field design by Pinkham and Greer Consulting Engineers, test pit logs by Mark Hampton, S.E. 263, and available literature were used to estimate the parameters used for these calculations.

SUBSURFACE WASTEWATER DISPOSAL SYSTEM:

The proposed subsurface wastewater disposal fields each consist of 176 Eljen In-drains covering an area of 91 feet by 31 feet. The two disposal fields are separated by 75 feet. The design flow of each disposal field is 2,560 gallons per day (gpd). The uniform infiltration rate of 2,560 gpd over a 31 foot by 91 foot area is 0.126 feet per day (ft/day). The ground surface slope beneath the disposal fields average 3% then increases to 11% ten feet downslope of the northernmost disposal field, based on existing grade contours shown on the disposal field design.

WASTEWATER MOUNDING AND TRANSMISSION ANALYSIS:

Groundwater mounding is anticipated to occur beneath the proposed disposal fields due to the presence of a low hydraulic conductivity layer (bedrock) beneath the disposal field. The following analysis is a three-step approach used to estimate the height of a groundwater mound beneath a wastewater disposal field on a sloping site and estimate the size of a fill extension to prevent wastewater breakout. The first step is to use an analytical model (Khan *et al.* 1976) to estimate the geometry of a groundwater mound assuming that the ground surface below the disposal field is level. The second step is to evaluate the analytical modeling results using Darcy's Law. The third step is to use the analytical modeling results to determine the appropriate down-slope fill extension length.

The ground surface below the proposed disposal fields slopes easterly toward the ocean at an initial slope of 3% then at 11% starting 10 feet from the disposal field and ending at the wetland 245 feet away. Since all wastewater will flow predominately in one direction (down-slope), rather than uniformly around the disposal field in all directions, the one-half width of the disposal field (w) is assumed to be the actual width of the disposal field parallel to the direction of groundwater flow (31 feet). Hydraulic conductivity K_1 is estimated to be 275 ft/day, based on values found in literature and previous constant head permeameter tests of septic system sand from gravel pits in Southern and Central Maine completed by Sweet Associates. The existing soil was assumed to be too thin to be of consequence in the calculation.

Based on the values of the abovementioned parameters, the maximum height of the mound above the K_2 layer at the center of the disposal field (H_{max}) is 1.96 feet.

Step 2 - Validate Analytical Model Results:

The low conductivity layer beneath the disposal field is sloping, which violates an assumption of the analytical model. Darcy's Law will be used to examine whether the calculated mound height from the analytical model is appropriate. Darcy's Law is expressed as:

$$Q = K\, i\, A$$

where,

Q	=	flow of water (cubic feet per day)
i	=	hydraulic gradient (unitless) - in this case the ground surface slope
A	=	cross section area (square feet)

Given a design flow of 2,560 gpd (684.4 ft^3), a hydraulic conductivity of 100 ft/day and a hydraulic gradient of 3%, the required cross-sectional area of sand fill below the disposal field is 200 ft^2. The results suggest that a 2.28 foot groundwater mound would occur beneath the downslope margin of the disposal field. This result is considered to be in the same order of magnitude as the Khan model.

Step 3 - Estimate Length of Down-Slope Fill Extension:

The length of the fill extension required to prevent the possibility of wastewater breakout on nearby side slopes can be determined by rearranging and solving the Khan *et al.* (1976) equations for a distance where the height of the mound is zero (Poeter *et al.*, 2005):

$$L = w * (q'/K_2)\,,$$

where,

L	=	length of fill extension required from center of disposal field (ft),
w	=	½ width of the disposal area (ft) - *full width used for this analysis*,
q'	=	uniform recharge rate into the disposal area (ft/day),
K_2	=	hydraulic conductivity of the lower soil layer (ft/day).

REFERENCES

Khan, M.Y., *et al.*, 1976, "Shapes of Steady State Perched Groundwater Mounds," *Water Resources Research*, 12(3), 429-436.

Poeter, E., *et al.*, 2005, *Guidance for Evaluation of Potential Groundwater Mounding Associated with Cluster and High-Density Wastewater Soil Absorption Systems*, International Groundwater Modeling Center of Colorado School of Mines, Golden Colorado, p. 3-5 to 3-8.

U.S.D.A. Soil Conservation Service in cooperation with Maine Agricultural Experimentation Station and Maine Soil and Water Conservation Commission, Soil Survey of York County, Issued June 1982, U.S. Government Printing Office.

Ayotte, J.D., Nielsen, M.G., Robinson, G.R., Moore, R.B. (1999) Relation of Arsenic, Iron, and Manganese in Ground Water to Aquifer Type, Bedrock, Lithogeochemistry, and Land Use in the New England Coastal Basins. U.S.G.S. Water-Resources Investigations Report 99-4162.

GREEN Cells for Data Entry | RED Cells for Solutions

Khan Mounding Model (Khan et al, 1976)

K1 (ft/day)	K2 (ft/day)	*1/2 Width of Field* w (ft)	*Flow into Field Footprint* q' (ft/day)	*Distance from Center of Field* x (ft) - Use 0 for Max Mound
275	0.01	31	0.11	0

EQUATION TERMS

3.63636E-05
10
11
0.063245553

Mound Height

1.960612149 feet

Length of Fill extension required to prevent the possibility of wastewater breakout on side slopes

L=	341	feet from middle of disposal field
	310	feet from edge of disposal field

Calculate Equivalent Hydraulic Conductivity of Two Layers

Layer 1	Thickness	1.5	ft
	Hydraulic Conductivity	275	ft/day
	Transmissivity	412.5	ft2/day
Layer 2	Thickness	100	ft
	K	0.01	ft/day
	Transmissivity	1	ft2/day
	Equivalent Hydraulic Conductivity	4.073891626	ft/day

Calculate Flow into Field Footprint (q')

Design Flow	2560	gpd
Field Length	100	
Field Width	31	ft
Flow into Field Footprint (q')	0.110387174	ft/day

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April 2, 2013

GROUNDWATER IMPACT STUDY
CLIFF ISLAND SEPTIC SYSTEM ASSOCIATION
CLIFF ISLAND (PORTLAND)

INTRODUCTION:

The purpose of this study is to make an assessment of the hydrogeologic conditions of the abovementioned site and estimate the groundwater quality impact caused by the proposed on-site subsurface wastewater disposal system serving the houses currently on the Association overboard discharge system. The proposed disposal field location is shown on the site plan. Data used for this project includes a site plan provided by Pinkham and Greer Engineers, soil evaluations done by Mark Hampton, S.E., and existing regional maps and literature.

DISPOSAL FIELDS AND WATER WELLS:

The proposed disposal field is designed for a total wastewater flow of 5,120 gallons per day. All houses to be connected to this system are served by private, individual septic tanks and by individual or community drilled wells.

SURFICIAL GEOLOGY AND TOPOGRAPHY:

The site is located on the *U.S.G.S. South Harpswell, Maine Quadrangle 7.5 Minute Series*. The *Surficial Materials* and *Surficial Geology Maps of the South Harpswell Quadrangle* show that the entire island is underlain by a thin layer of glacial till overlying shallow bedrock. This soil is identified as Hollis very rocky fine sandy loam by the Soil Conservation Service. There is no *Significant Sand and Gravel Aquifer Map of the South Harpswell Quadrangle* and no sand and gravel aquifer is present on the Island.

HYDROGEOLOGY:

Precipitation falling on this site enters the open pore spaces in the upper soil horizons, and percolates vertically downward through the sandy loam till until the water table and or bedrock is encountered. Thereupon, flow is largely downslope or downgradient following the slope of the underlying bedrock surface. An unknown percentage of the precipitation captured by the soils will enter the fractured bedrock and the remaining water will move through the soil above the bedrock surface. Wetlands and the ocean will be discharge points for the groundwater moving through the soil. It is assumed that the groundwater in the bedrock will also discharge to wetlands, however, some percentage of the bedrock groundwater may not discharge until reaching the ocean. We are assuming that all surface

$$C(x,y,z,t)=\left[\frac{CoVo}{8(\pi t)^{1.5}\sqrt{DxDyDz}}\right]\exp\left[-\frac{(x-vt)^2}{4Dxt}-\frac{y^2}{4Dyt}-\frac{z^2}{4Dzt}\right] \; ;$$

where,

C(x,y,z,t)	=	NO_3-N concentration at specified location and time (mg/L)
x	=	specified distance from source parallel to the direction of groundwater flow (ft)
y	=	specified distance from source perpendicular to the direction of groundwater flow (ft)
z	=	specified vertical distance from source (ft)
Co	=	initial concentration at the source (mg/L)
Vo	=	volume of source (ft^3)
t	=	time elapsed (day)
Dx,Dy,Dz	=	dispersion coefficient along the x,y,z axes (ft^2/day)
v	=	average linear velocity (ft/day).

Assuming that groundwater flow is horizontal, the dispersion coefficient can be calculated as follows:

$D_{x,y,z}$ = v $_{x,y,z}$;

where $_{x,y,z}$ is dispersivity (ft).

The contaminant velocity of a solute subject to sorption/adsorption is calculated as follows:

V_p = v/R_d;

where V_p is the contaminant velocity (ft/day) and R_d is the retardation factor (unitless). The retardation factor for NO_3-N is equal to one, however, so the contaminant velocity is equal to the average linear velocity ($V_p = v$).
Dispersivity is estimated by an equation based on a weighted least-squares statistical analysis of collected longitudinal dispersivity data versus scale (Xu, Eckstein, 1995). Longitudinal dispersivity can be estimated based on the following calculation:

$_x$ = $(0.83)[\log_{10}(L_p)]^{2.414}$;

where $_x$ is longitudinal dispersivity (ft), and L_p is the plume length (ft). The plume length is a function of the elapsed time and is calculated by the following equation:

L_p = $V_p t$.

It has already been established that for NO_3-N, the contaminant velocity (V_p) is equal to the average linear velocity (v). Thus, $L_p = vt$.
The transverse and vertical dispersivities are related to the longitudinal dispersivity, as shown below:

$_y$ = $_x/3$
$_z$ = $_x/20$.

REFERENCES

Baetsle, L. H., 1969, *Migration of Radionuclides in Porous Media*, Progress in Nuclear Energy, Series XII, Health Physics, A.M.F. Duhamel (ed.), Pergamon Press, Elmsford, N.Y. pp.707-730.

Chang, Tan-yuch, Winkley, W., Montgomery, J., *Utilizing Baetsle's Equation to Model the Fate and Transport of MTBE in Groundwater*, Proceedings of the Petroleum Hydrocarbons and Organic Chemicals in Ground Water Prevention, Detection, and Remediation Conference, 1998, Houston, TX.

Department of Human Services, *et al.*, Maine Subsurface Waste Water Disposal Rules, 144A CMR 241.

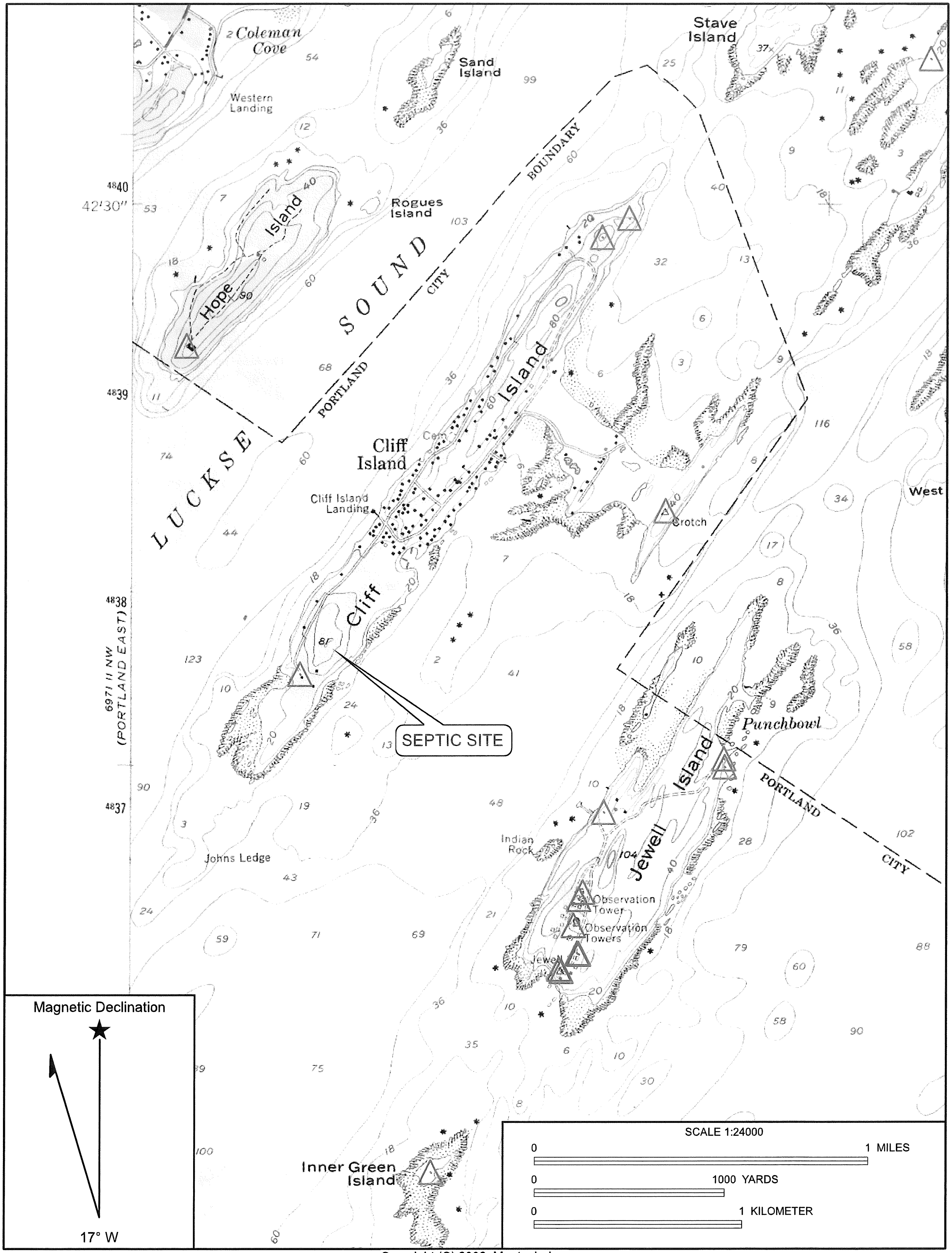
Fetter, C.W., 1994, Applied Hydrogeology, 3rd Edition, Prentice Hall.

Maine Association of Professional Soil Scientists and USDA Soil Conservation Service of Maine, *Soil Series of Maine Soil Interpretations*.

Maine Geological Survey, South Harpswell Quadrangle, Maine, Surficial Geology.

U.S.G.S., South Harpswell Quadrangle (Maine) 7.5' Quadrangle 1:24,000, Topographic Map.

Xu, M. and Y. Eckstein, 1995, *Use of Weighted Least-Squares Method in Evaluation of the Relationship Between Dispersivity and Field Scale*: Ground Water, vol.33, No.6, pp.905-908.


Coleman Cove
Western Landing
Sand Island
Stave Island
Rogues Island
Hope Island
LUCKSE SOUND
PORTLAND CITY BOUNDARY
Cliff Island
Cliff Island Landing
Cliff
Crotch
SEPTIC SITE
Punchbowl
Jewell Island
Indian Rock
Johns Ledge
Observation Tower
Observation Towers
Inner Green Island
West
6971 II NW (PORTLAND EAST)
42'30"
Magnetic Declination
17° W
SCALE 1:24000
0
1 MILES
0
1000 YARDS
0
1 KILOMETER

Surficial Geology - South Harpswell Quadrangle
Map Unit and Symbol Descriptions

Pmn

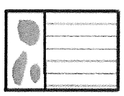
Marine nearshore deposits - Deposits of sand, interbedded with gravel and silt. Formed as a result of erosion and reworking of surficial sediments during the late-glacial regression of the sea. Occurs as a thin cover over bedrock or older glacial deposits.

Hms

Marine shoreline deposits - Modern beach deposits consisting of sand, pebbles, and cobbles. Formed by the reworking of older surficial sediments by the ocean.

Ptd

Thin drift, undifferentiated - Thin, patchy cover of till and/or nearshore deposits overlying bedrock.



Thin drift area - Black areas are individual bedrock outcrops with little or r surficial sediment cover. Ruled pattern indicates areas of abundant bedroc outcrop and/or areas where the surficial sediments are generally less than 10 ft (m) thick.