

Fecal Coliform TMDL Development for Holly Beach

Basic Information

Title:	Fecal Coliform TMDL Development for Holly Beach
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Principal Investigators:	Zhi-Qiang Deng

Publications

1. Sun, S.W., Deng, Z.-Q., and Gang, D.-D. (2010). "Nonpoint Source Pollution." Water Environment Research, 82(10).
2. Patil, A., and Deng, Z.-Q. (2010). "Analysis of uncertainty propagation through model parameters and structure." Water Science and Technology (in press).
3. Jung, H.-S. and Deng, Z.-Q. (2010). "Modeling of Nitrogen Retention in Amite River." Water, Air, & Soil Pollution, DOI: 10.1007/s11270-010-0487-9.
4. Ghimire, B., and Deng, Z.-Q. (2010). "Event flow hydrograph-based method for shear velocity estimation." Journal of Hydraulic Research (in review).

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Zhi-Qiang Deng

RESEARCH

Problem and Research Objectives

The Federal Clean Water Act requires states under section 303(d) to list waters impaired for recreation (fishing, swimming) and further requires states under section 305(b) to report on the status of those waters. USEPA requires states to develop Total Maximum Daily Load (TMDL) studies on impaired waters for the pollutants causing impairment. Holly Beach is one of the two most attractive beaches in Louisiana. Use of this 3.5 mile beach is very high and thus the importance of Holly Beach to the local economy is high. Unknown sources of bacterial contamination frequently place the Cameron Parish beaches, especially Holly Beach, in the advisory category, significantly increasing beachgoers' risk of bacterial infection and thus reducing the use of the beaches and adversely affecting local economic development.

The **primary goal** of this research is thus to present an efficient and effective approach to bacterial source area tracking and to the development of fecal coliform TMDL (Total Maximum Daily Load) for Holly Beach, Louisiana. To achieve the goal, the research is split into five specific **objectives** (tasks): (1) gathering and processing of water quality and remote sensing data, (2) mapping of watershed time of concentration of bacteria carrying runoff, (3) inverse tracking of priority source area of bacterial pollution, and (5) sea outfall diffuser design for meeting current fecal coliform TMDL for Holly Beach.

Methodology

The US EPA programs BASINS and HSPF (Hydrologic Simulation Program Fortran) were utilized to obtain the time-series data of water quality parameter for the Calcasieu River Basin (drainage basin of the Holly beach), LA, as shown in Figure 1. In HSPF, key input parameters are weather and landuse data. The hourly weather time-series data for the period of 2001-2009 were collected from USEPA, that included rainfall, air temperature, wind, evapo-transpiration, humidity, dew-point temperature, solar radiation, and cloud cover. The landuse data was developed using Landsat TM imagery data (30 m resolution) for year 2001 acquired from Global Land Cover Facility (GLCF) at University of Maryland. The landuse data was classified into 25 classes by using un-supervised classification. These classes were then categorically classified using visual interpretation to re-classify it into six major classes as per HSPF requirement. This input data and methodology was used as base scenario for further simulations. The model was calibrated and validated using observed data obtained



from Louisiana Department of Environmental Quality. Applications of HSPF involves the segmentation of the Calcasieu River Basin, preparation of input data, and model calibration. The sub-watersheds were generated using the delineation tool in BASINS. Sub-watershed delineation and creation of river-reach segments utilized the NED (national elevation dataset) digital elevation model (DEM) and national land cover data (NLCD) representing land use type in 2001 for computing watershed boundaries, overland flow-path length and slopes, stream segment slopes, and pervious and impervious surface areas and forested areas in each delineated sub-watershed, as shown in Figure 2.

Based on the HSPF simulation results and measured fecal coliform data, a design discharge of $12 \text{ m}^3/\text{s}$ and enterococci concentration of 2005 (MPN/100ml) are employed to design a sea outfall to meet beach water quality standard under the current total maximum daily load. The Holly Beach diffuser design required several steps to create a well designed diffuser that was successful at creating adequate dilution. The first step involved utilizing course material to begin initial steps for the diffuser design. It involved the use of known water depth and sea bed slope (Figure 3), desired initial dilution, port diameter options, and the flow rate. After creating a rough diffuser design, the computer programs CorHYD and VISJET were employed for the diffuser design. After the initial dilution was calculated using VISJET, another Excel file was created and the far field dilution was modeled using the Brooks' Method. This was the final determination if a well designed diffuser would meet the effluent requirements for the bacterial contaminants at Holly Beach.

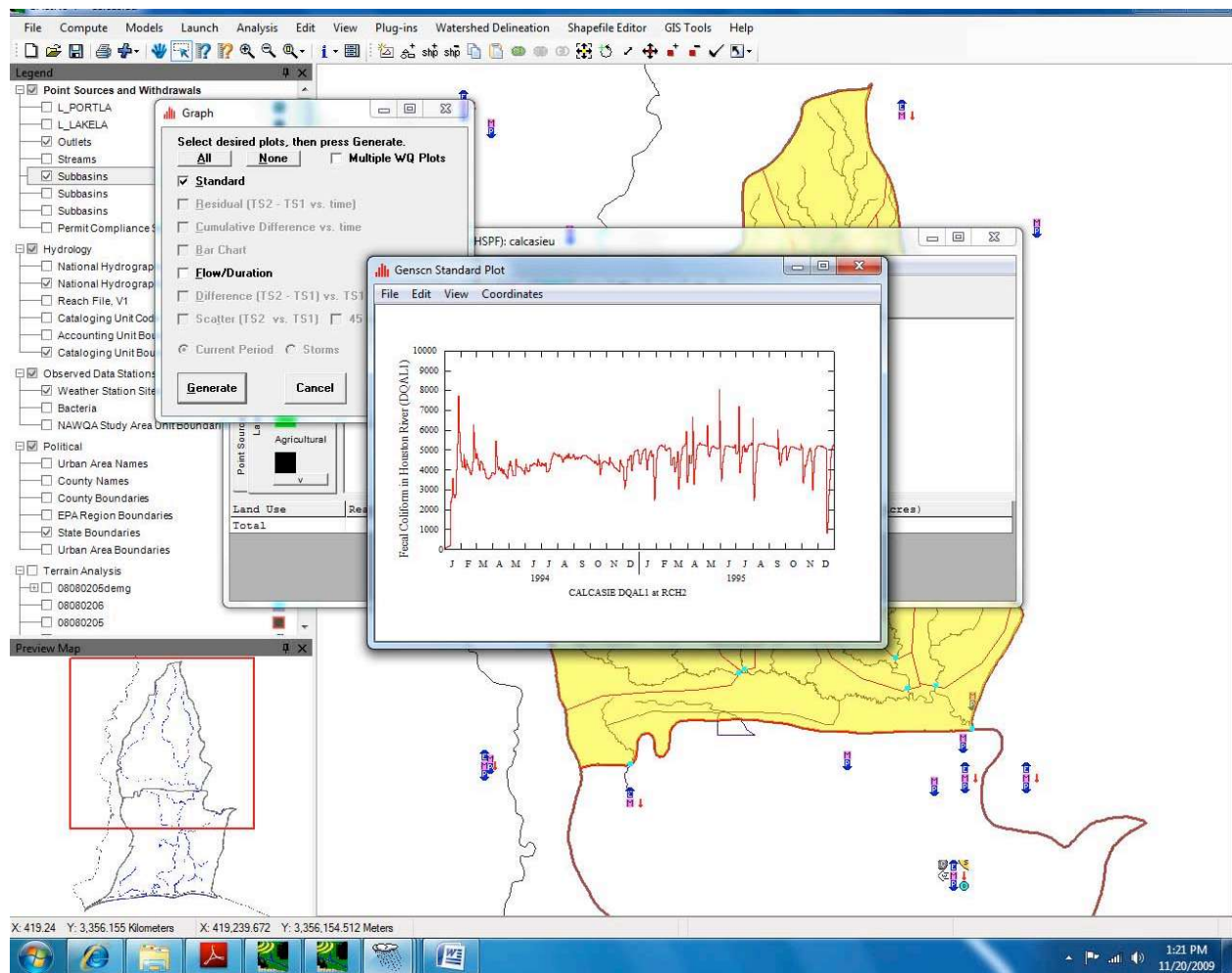


Figure 2. Sub-watersheds used in HSPF model for the Calcasieu River Basin.



Figure 3. Bathymetry at Holly Beach, Louisiana

PRINCIPAL FINDINGS AND SIGNIFICANCE

1. Identification of priority sources of fecal indicator bacteria contaminating Cameron Parish beaches

Based on the mapping of watershed time of concentration and inverse tracking of priority source areas of contaminants, we found that the ditch along the LA 82 Highway is the primary source of bacteria discharging into the Holly beaches. As shown in the top photo in Figure 4, bacterial levels in the ditch water are much higher than the beach water. The ditch is connected to the beaches through some distributed culvert outfalls that directly discharge runoff containing high bacterial levels to Holly beaches, as shown in the two bottom photos in Figure 4. The ditch drains from the upstream watershed where the wildlife refuges are located. This finding may be used by Louisiana Beach Monitoring Program to address the bacterial sources.



Figure 4. Bacterial source for the Holly beach in the Calcasieu River Basin.

2. Sea Outfall Size Determined Using CorHYD

The dimension of the sea outfall diffuser determined using the computer program CorHYD is given in Figure 5.

Ambient Data Input

Water level elevation (Hd) m
 Density (rho_0) kg/m³

Effluent Data Input

Density of effluent (rho_e) kg/m³
 Viscosity (ny) 10⁻⁶ m²/s
 Flow Rate Qd Total Head [m³/s]

Run

Output

- Text File (report.txt)
- Egl, Hgl
- Discharges & velocities
- Setup of Diffuser

Diffuser/Feeder Pipe Configuration

Total number of pipe sections (Nd) [-]

x-coordinate of pipe centerline at seaward end (x0) m
 y-coordinate of pipe centerline at seaward end (y0) m
 z-coordinate of pipe centerline at seaward end (z0) m

EXTRA: Y- or T-diff.

Feeder / Diffuser pipe geometries per section

Section # (counting from end: seaward --> land)	1	2	3	4	5	6	7	8	9	1	1	1
x coordinate of centerline at section end [m]	22300	22200	22100	22000	21900	21800	21700	21600	21500	21400	21300	21200
y coordinate of centerline at section end [m]	0	0	0	0	0	0	0	0	0	0	0	0
z coordinate of centerline at section end [m]	0	0	0	0	0	0	0	0	0	0	0	0
Diffuser/feeder pipe diameter (Dd,i) [m]	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1
Equivalent sand roughness (Ks,d,i) [m]	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.0003	0.0003
Radius of bend between sections (R0,i) [m]	1	1	1	1	1	1	1	1	1	1	1	1
Angle of diameter change btw. sections (beta,i) [°]	45	45	45	45	45	45	45	45	45	45	45	45

Port / Riser Configurations

Port/Riser group configurations

Number of different port / riser groups (Ng) [-]

Group Number (counting from the end)	1	2	3	4	5	6	7	8	9	10	11	12
Number of risers per group (Ngp) [-]	20	20	20	20	20	20	20	20	20	20	20	20
Group located in Section # (SecNo) [-]	1	2	3	4	5	6	7	8	9	10	11	12
Spacing between two groups (Lg) [m]	1	1	1	1	1	1	1	1	1	1	1	1
space between risers (s) [m]	5	5	5	5	5	5	5	5	5	5	5	5
Port elevation (Lr) [m]	2	2	2	2	2	2	2	2	2	2	2	2
Diameter of riser (Dr) [m]	0.12	0.12	0.12	0.12	0.11	0.11	0.11	0.11	0.1	0.1	0.1	0.1
Roughness of riser (Ks,r) [m]	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Number of openings (ports per riser) (Np) [-]	1	1	1	1	1	1	1	1	1	1	1	1
Length of port (Lp) [m]	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Individual port opening diameter (Dp) [m]	0.11	0.11	0.11	0.11	0.1	0.1	0.1	0.1	0.09	0.09	0.09	0.09
Roughness of port (Ks,p) [m]	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002

EXTRA: Add losses EXTRA: Blocked ports

Figure 5. Internal hydraulic design for Holly Beach Outfall

3. Sea Diffuser Size Determined Using VISJET

The parameter values produced in the CorHYD program output were used as input of the VISJET program, as shown in Figure 6. The diffuser system produces an initial dilution of 100 and total dilution of 651724, resulting in a design fecal coliform concentration of 20 MPN/100ml at Holly beach and meeting beach water quality standard.

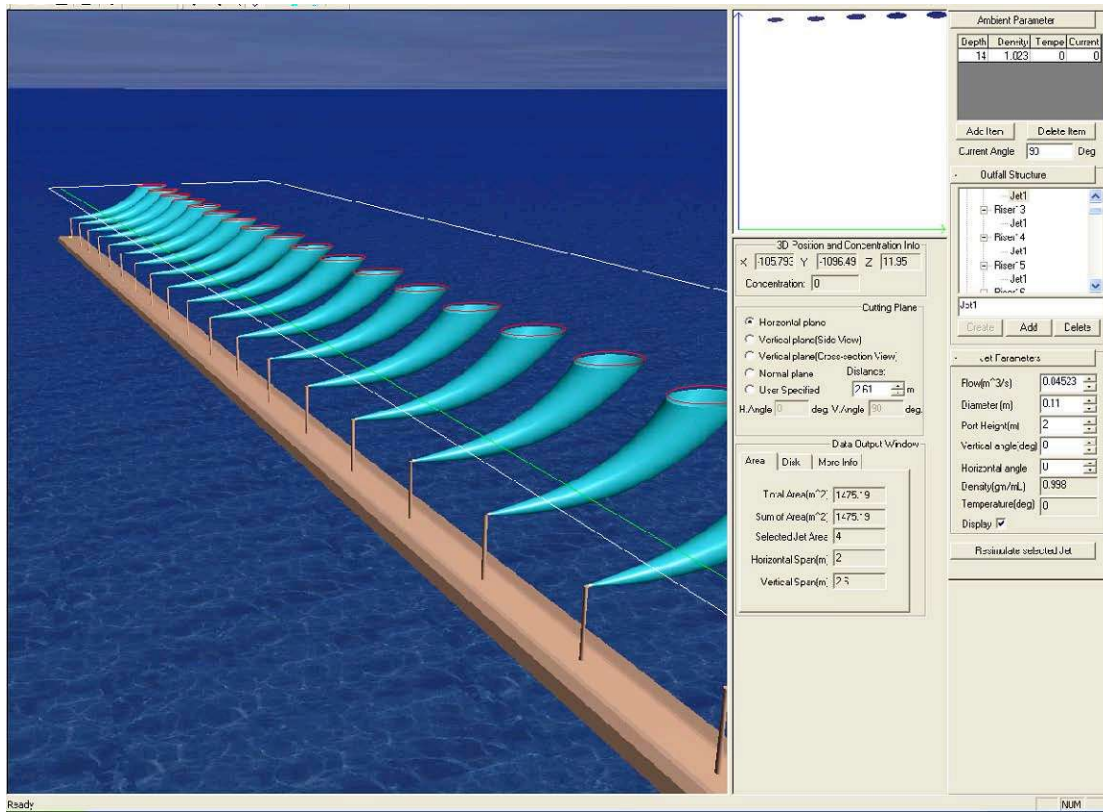


Figure 6. VISJET horizontal plane Screen capture of the effluent plume.

If constructed, the designed diffuser system is able to treat the current total maximum daily load and meet water quality standard at the Holly beach site.

INFORMATION TRANSFER

The findings obtained in this project will be transferred to the Beach Monitoring Program of Louisiana Department of Health and Hospitals and the NPS (nonpoint source) Program of Louisiana Department of Environmental Quality for applications in TMDL implementation and Holly beach restoration.

STUDENT SUPPORT

Name of supported graduate student: Shaowei Sun (Male)

Degree Program: Ph.D. in Civil Engineering with concentration in Water Resources

Dissertation Title: Development of Downwelling-Upwelling System for Urban Stormwater Treatment

Anticipated Graduation Date: Spring 2013

FOLLOW-ON FUNDING

Title: Development of Sensor Assisted Water Quality Nowcasting and Forecasting Environment for Coastal Beaches

PI: Zhi-Qiang Deng

Co-PIs: Kelly Rusch (LSU) and Fulbert Namwamba (Southern University)

Agency: NASA

Program: Applied Sciences Program

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