Proposal

Update of wellhead protection area delineations for the Lewes-Rehoboth Beach area, Delaware

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1. Introduction

The 1986 Amendments to the Safe Drinking Water Act requires State to establish Wellhead Protection programs (WHP) to "protect wellhead areas within their jurisdiction from contaminants which may have any adverse effect on the health of persons". One of the major elements of WHP program is the delineation of wellhead protection areas (WHPAs) within which contaminant source assessment and management can be determined. Several methods have been adopted in WHPA delineation. From simply arbitrary fixed radii, to analytical/semi-analytical methods, as well as more sophisticated numerical flow/transport models. Typically, numerical models are considered more accurate and reliable in delineating WHPAs where boundary and hydrogeology conditions are complex.

In Delaware, the Source Water and Assessment Protection Program (SWAPP) is charged with the responsibility to delineate WHPA's for public water supply sources, including public water wells. In 2001, requested by SWAPP, the Delaware Geological Survey (DGS) conducted a study to delineate WHPAs around 15 major pumping wells that were owned by the three largest public water systems (Lewes Board of Public Works, Rehoboth Beach Water Department and Tidewater Utilities, Inc) in Lewes-Rehoboth Beach area, Delaware. In this study, a steady-state, three-dimensional numerical groundwater flow model was constructed and calibrated to pre-pumping conditions using MODFLOW. The WPHAs are then delineated as the areas in which water at the water table will travel to the well intake in a period of 5 years or less. This was done by particle trace analysis using MODPATH program.

However, the change of land use/land cover (LULC), especially the transformation of natural vegetation to agricultural and urban uses, will alter the groundwater recharge, which may change the local groundwater levels and flow paths that directly influence the size and shape of wellfield capture zones. In the past decades, the land use within the City limits and surrounding area has been changing rapidly, mainly toward more housing development (Figure 1). As the area's population grows, the groundwater demand will increase concomitantly in the Lewes-Rehoboth Beach area. The Lewes Board of Public Works is proposing to increase the allocation at the wellfield between Kings Hwy and Savannah Road, as well as possibly develop a new well field (location is yet to be determined) to augment their current supply. The new development will pose increasing risk to the water supply sources in this area. To address these concerns, DNREC requested that DGS update the DGS 2003 model and re-evaluate the WHPAs delineations in Lewes-Rehoboth Beach area.

2. Objective

The objective of the project is to determine whether the change in groundwater recharge caused by LULC changes accompanied by increasing water use will affect groundwater flows and flow paths induced by the wellfield. We propose to update the DGS 2003 model with latest LULC data and proposed groundwater withdraws using an unstructured grid (USG) approach. USG model framework is a relatively new development within the MODFLOW code that allows efficient application and greater resolution in areas of interest. The updated flow model will be used with particle tracking analysis for evaluation of WHPAs. The groundwater flow model is normally calibrated to find a single optimum parameter set for which the model output gives an adequate representation of observed field measurements (water table, stream gage, et al). However, due to the ill-posed nature of inverse problems, the "optimum" set is often not unique. Consequently, multiple "optimum" set parameters may produce widely ranging estimates of the prediction of capture zone. In this study, we propose to apply a probabilistic approach to produce a range of plausible outcomes with different levels of uncertainty.

3. Project narration

The workflow for this proposed project includes the tasks listed below:

(1) Gather field data (accurate water use data, land use data, hydrogeological data including pumping test data, slug test data, and geophysical log data).
(2) Rebuild the DGS 2003 flow model with MODFLOW-USG approach. The pre- and post-processing of model construction will be conducted using Visual MODFLOW Flex, a sophisticated modeling product by Waterloo Hydrogeologic. The initial hydraulic properties, including conductivity and recharge, will be adopted from the original model.
(3) Compare the modeling results with field measurements and DGS 2003 model results.
(4) Update the MODFLOW-USG model with new recharge map created from latest LULC data and proposed groundwater withdrawal.
(5) Use particle tracking MODPATH3D to delineate WHPAs (5-year, 10-year and 50-year).
(6) Repeat step 4 and step 5 for different scenarios with different parameter sets, evaluate the impacts of recharge change due to LULC change, and analyze uncertainty.
(7) Prepare report

4. Timeline

The anticipated timeline for this effort is 18 months from the designated grant start date.

5. Project Deliverable

An updated delineation map of wellhead protection areas in Lewes-Rehoboth Beach, DE with uncertainty analysis

6. Budget

Category		Cost
Salary and Fringe Benefits	$	57,972.00
Supplies and Expenses	$	800.00
Total Direct Cost	$	57,772.00
Total Indirect Cost (38%)	$	21,953.00
Total Cost	$	79,725.00

Budget Justification
1. Salary and fringe benefit are requested for 5 month of staff time for PI He and 1 month of staff time for a Research Associate III..
2. Supplies and expenses will be charged to cover the costs of fuel used to drive for fieldwork,
3. Indirect cost rate is the current UD-State of Delaware research rate.

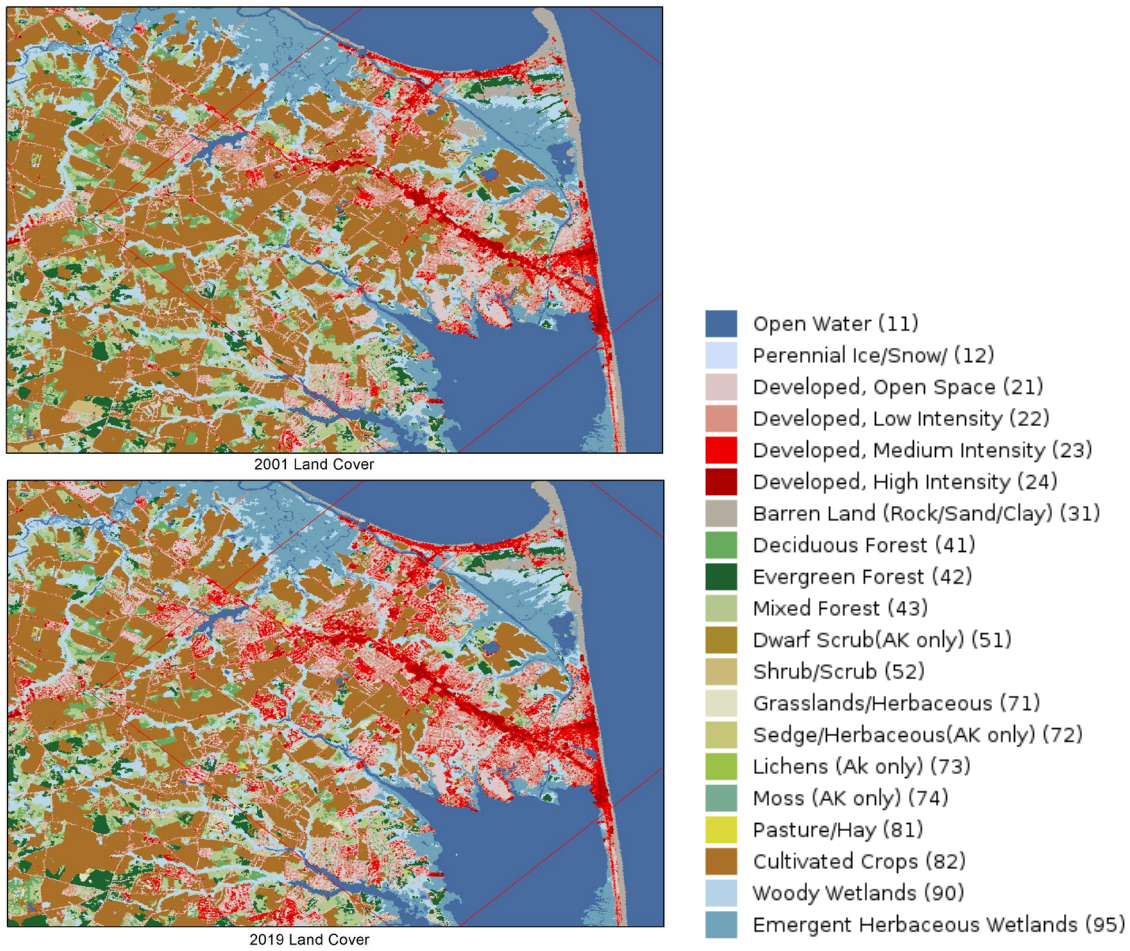

Figure 1. Comparison of LULC in Lewes-Rehoboth Beach area between 2001 and 2019. Data source: Multi-Resolution Land Characteristics (MRLC) Consortium.