Sanitary Sewer Exfiltration Status Update

Sanitary Sewer Exfiltration

- Method testing
  - Changes from February
- Continued method development
  - Defining inputs
  - Parameter selection

Sanitary Sewer Exfiltration Testing

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Preliminary model structure

- A default exfiltration value as a percent of treated volume will be defined by expert judgement and literature
- Spatially exfiltration will be mediated by optional factors identified as drivers of exfiltration by expert judgement and literature.
  - Geologic basin as a metric of water table depth
  - The proportion of the system which is gravity fed
  - The proportion of the system which is new or recently rehabilitated

Exfiltration Vol. = Fraction exfiltration * Annual system treatment volume * Geologic coef. * Fraction gravity line * (Fraction new or rehabbed*Rehabbed coef.)

Exfiltrated nutrient mass = Exfiltration Vol. * concentration in raw WW[1]

Workgroup Defined, Required State Provided Input, Optional State Provided Input

[1]Chesapeake Bay Program, (2014). "Final Expert Panel Report on Removal Rates for the Elimination of Discovered Nutrient Discharges from Grey Infrastructure"

Expanding literature search to focus on exfiltration as a percent of treatment volume

Study	Exfiltration Vol.	Exfiltrated N	% treated volume
Nguyen and Venohr, 2021	228 gal/day/km	20.8 lb N/year/km	2%
Delesantro et al., 2022	365 gal/day/km	33.2 lb N/year/km	2.40%
Steele et al., in review	630 gal/day/km	56.6 lb N/year/km	0.60%
Lerner and Halliday, 1994	246 gal/day/km	22.5 lb N/year/km	
Amik et al., 2000			11.40%
Ellis et al., 2003			5-10%
Wakida and Lerner, 2005			13%
Fenz, 2003			1-5%
Rieckermann et al., 2005			11%
Karpf and Krebs, 2004			2.80%

Notes:

- Values are the mean for each study or study region
- N load may be estimated assuming 35mg/l N in raw WW
- Delesantro et al., 2022: Assuming NO_3^- proportion from WW ~ TN proportion from WW
- Studies estimate exfiltration from pipe, to GW, or to streams
- Studies may estimate treated volume based on total flow or DWF

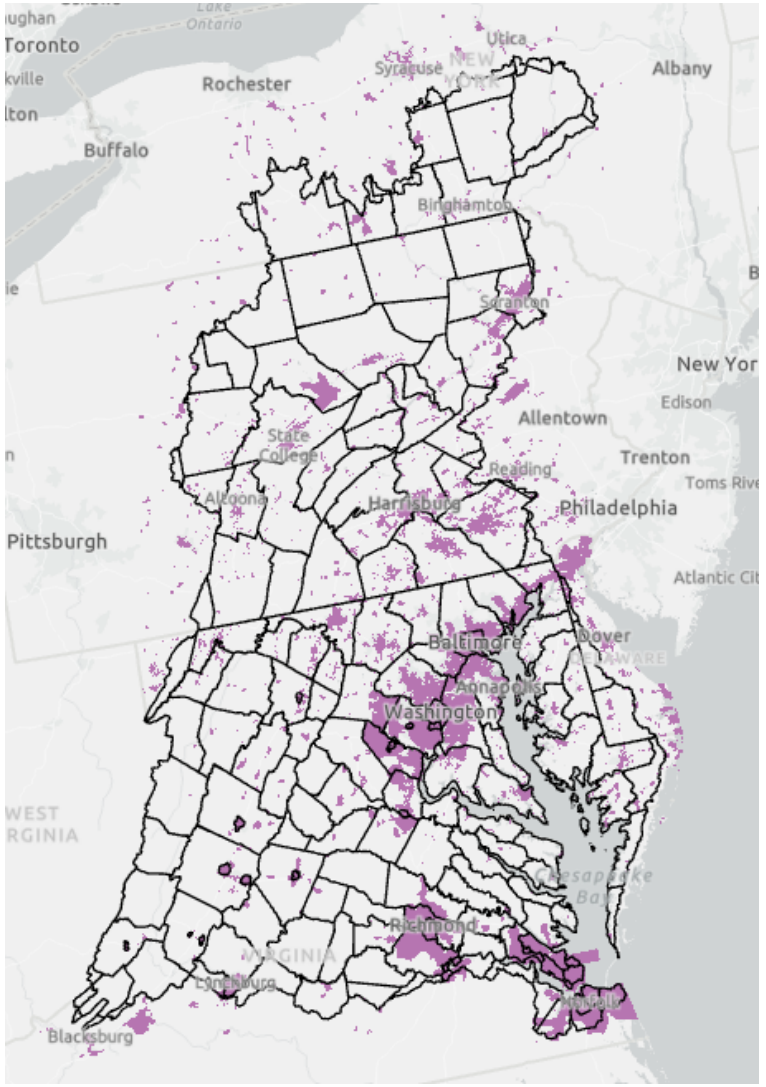
Testing

Goals:

- Evaluate whether the model can produce reasonable results given a range of inputs
- Quickly evaluate load estimates in a regional context while iterating through model formulations and parameter selection

Test cases were chosen to facilitate comparisons to urban CAST ‘23 load estimates.

- Service boundaries are well contained within few model units
- Minimize urban land that is not served by sanitary sewer
- Initial testing uses median and midpoint literature values for parameters, but these are only meant to be a starting point.



CBW WWTP Service Boundaries

Exfiltration as a percent of treated flow

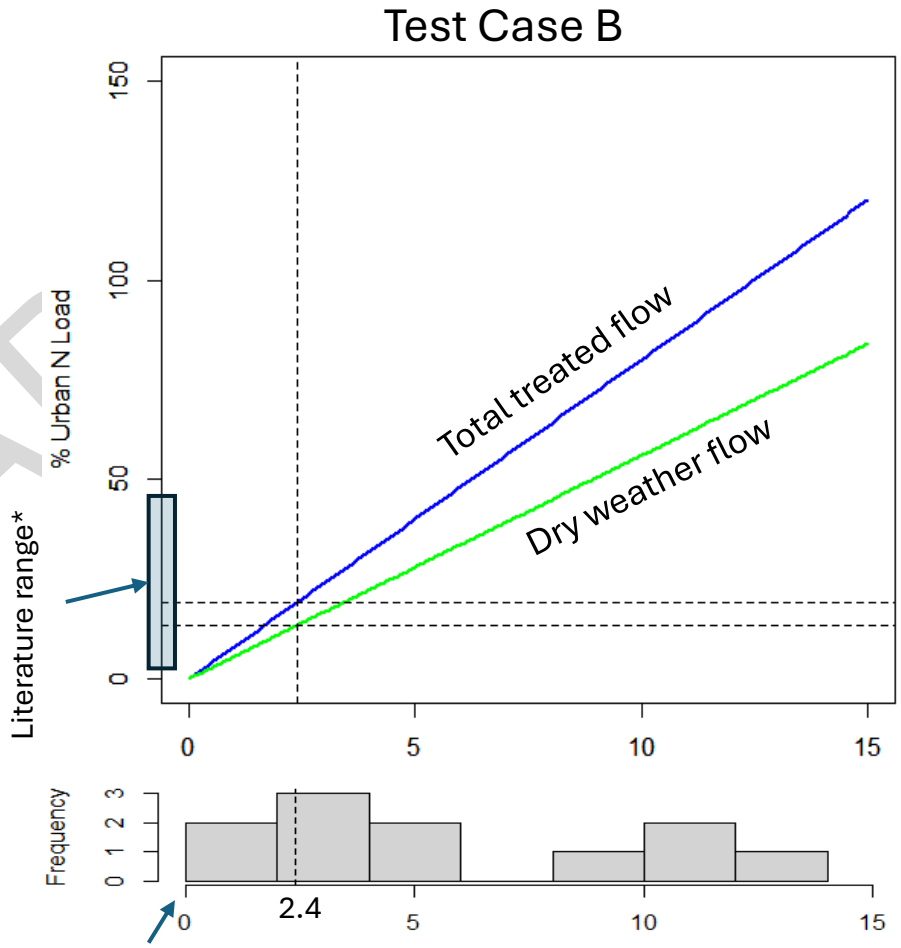
Exfiltration Vol. = Fraction exfiltration * Annual system treatment volume * Fraction gravity line* Geologic coef. * New or rehabbed coef.

- This is the default or initial estimate of exfiltration.
- Additional factors will mediate this load.
- For Test Case B, 98% of the system is gravity fed
- For Test Case B, the median of literature values was selected excluding the values greater than 10 which appear impractical.
- Compared to urban N load to streams (CAST ’23)

Decisions:

- The initial/default percent exfiltrated value
- Use total treatment volume or dry weather flow

Test Case B at this step:
342277 - 488967 lbs. N/yr
13.5 - 19.2 % of Urban Load



Need to parse these values, total vs dry weather flow

*3-48%
Divers et al., 2013
Recommendations of the Expert Panel to Define Removal Rates for the Elimination of Discovered Nutrient Discharges from Grey Infrastructure, 2014
Nguyen and Venohr, 2021
Delesantro et al. 2022, 2024

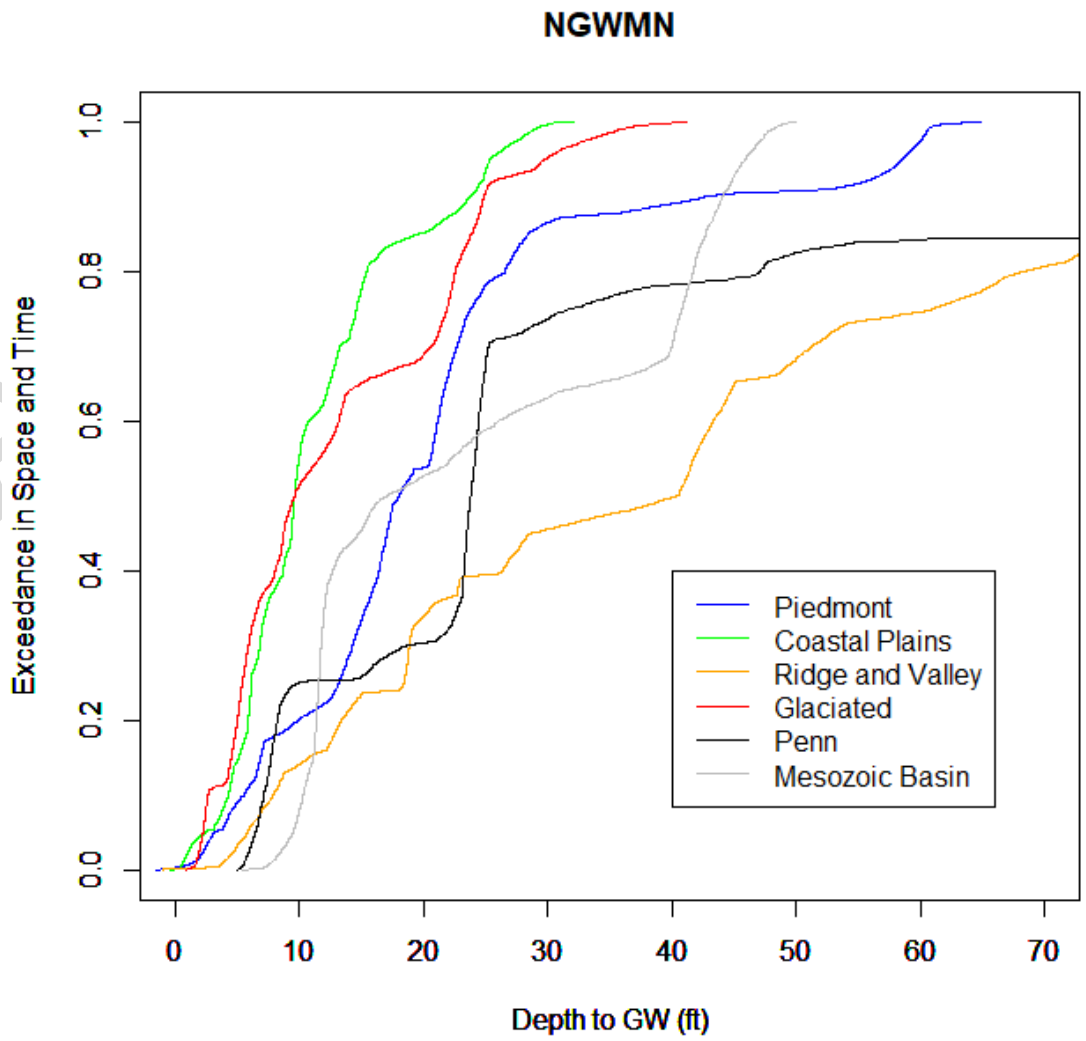
Groundwater Coefficient

Exfiltration Vol. = Fraction exfiltration * Annual system treatment volume * Fraction gravity line* Geologic coef. * New or rehabbed coef.

The depth to groundwater fraction exceedance in space and time has been calculated for each Geobasin. This value represents the fraction of time/space that is inundated at a given depth to GW.

Decisions

- Selection of Depth to GW critical value or range over which to average the inundation period.
- Where service boundaries cross multiple geobasins: area weighted, or population weighted
- Mean groundwater depth taken from the entire Geobasin or other geographic subset (ecoregion, state, etc.)



For initial test, I used a critical value of 8 ft for which the test case region fraction exceedance was 0.28. Coef.=(1-0.28)

Test Case B at this step:
246440 - 352057 lbs. N/yr
11.8 – 16.8 % of Urban Load

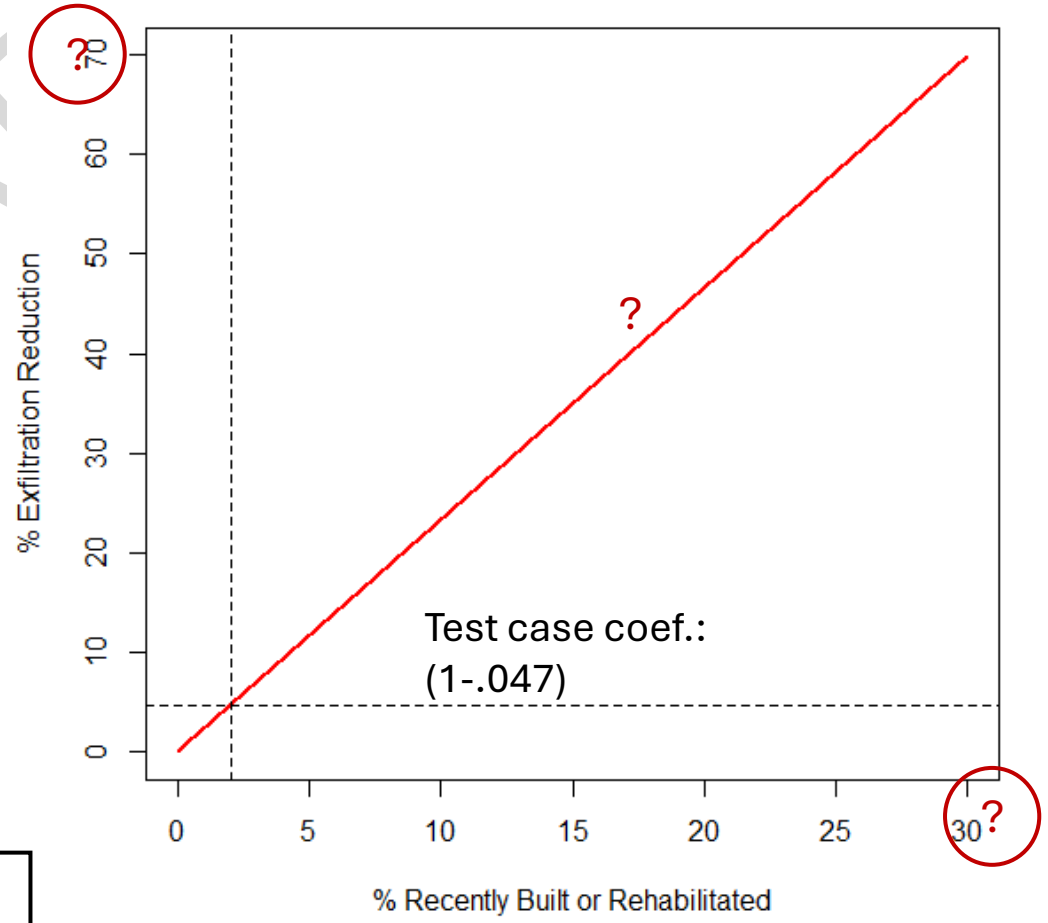
New and Newly Rehabilitated Sewer Coefficient

Exfiltration Vol. = Fraction exfiltration * Annual system treatment volume * Fraction gravity line* Geologic coef. * New or rehabbed coef.

- Exfiltration primarily occurs from a fraction of the total system, 20-50%.
- Rehabilitation reduces exfiltration by 50-90%.
- Example uses 10-year timeframe

Decisions

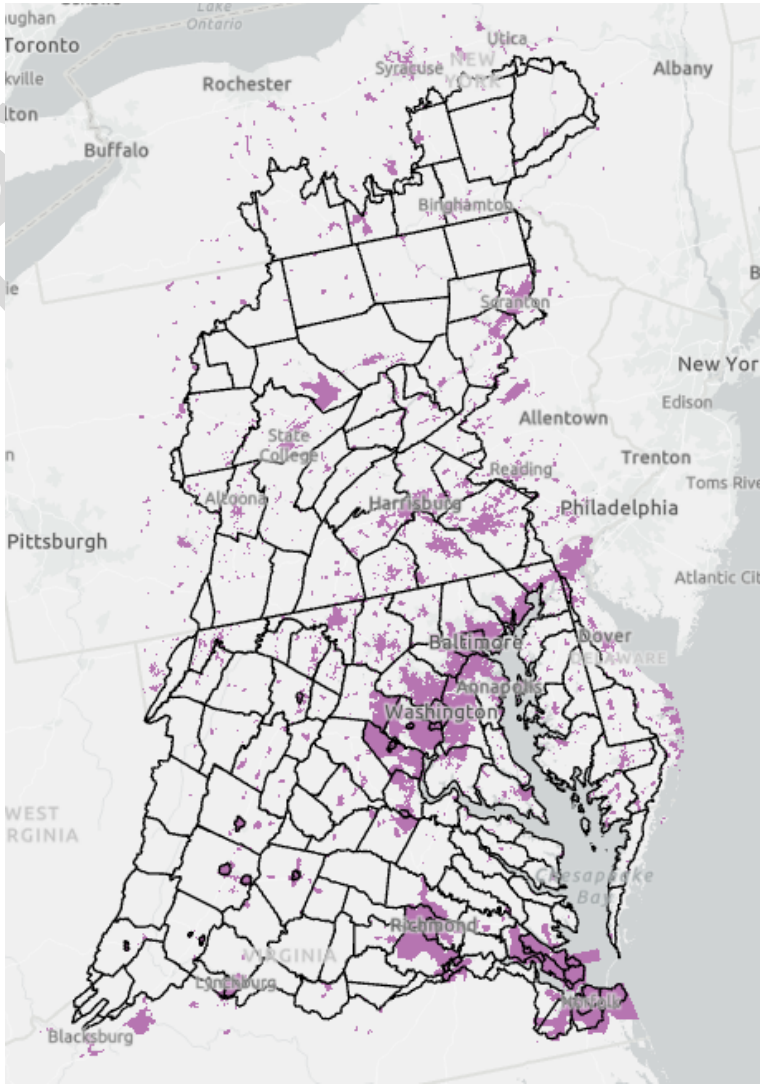
- How does this interact with BMPs
- Timeframe
- Max reduction and max system percent rehabilitated
- Numerical function



Test Case B at this step:
234956 - 335650 lbs. N/yr
11.3 – 16.1 % of Urban Load

Summary

- Values are within the literature range as a percent of the urban load, however there is a lot of opportunity for refinement.
- The percent exfiltration relative to treatment volume or dry weather flow will have the most leverage
- Rehabilitation sensitivity will need to be determined with consideration of available BMP credits



CBW WWTP Service Boundaries

End of February Small Group Slides

Defining inputs and parameters

Green represents decided points, yellow represents points that have received input

Percent system exfiltration

- **Initial or default percent exfiltration as a function of dry weather system volume.**
- **How should a timeseries of dry weather volume be defined.**

Groundwater coefficient

- **Critical groundwater depth or depth range which represents the inundation of a significant portion of system pipes such that pipes cannot exfiltrate.**
- **At what spatial scale should the groundwater depth be aggregated?**
- **Where system service boundaries cross multiple groundwater units (e.g., Geobasins), should the groundwater coefficient be calculated based on area or population weighted average?**

Newly built and newly rehabilitated sewer coefficient (Optional method inputs)

- A basic framework has been discussed where X% of system rehabilitation reduces exfiltration by Y%, where X is <100% because exfiltration primarily occurs from a fraction of the total system (roughly 20-50% from literature), and Y is <100% because rehabilitation is not 100% effective (roughly 50-90% from literature). If using this framework**, what are the values of X and Y and the function relating them.**
- **What is the timeframe defined as newly built or newly rehabilitated?**
- **How can double counting sewer rehabilitation be prevented given the potential BMP credit** (which is not widely used).

Others

- **How should N and P concentration values in exfiltrated wastewater be defined?** I suggest using the expert panel values to reduce reporting requirements.
- **Should sanitary sewer exfiltration be considered a CAST nonpoint source or a “direct load” (still a nonpoint source, but without land-to-water factors)?**