Manila Third Sewerage Project

EPA SWMM5 Training Course Module 2

Watershed/Water Quality Modeling 101

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Model: Mathematical/Numerical Approximation of Reality

- Simulate key hydrologic, hydraulic, and pollutant transport processes
- Simulate cause-and-effect relationships
- Simulate what-if management scenarios
  - Evaluate options for managing sources of pollution to reduce water quality impacts
How good is your model prediction?

- Simple or complex situation
  - Waterbody type
  - Pollutants of interest
  - Sources of pollution
  - Spatial and temporal variability

- Model appropriateness and performance
  - Model selection
  - Model calibration

- Data availability and quality
  - Lumped vs. distributed model
  - Garbage in – Garbage out

- Types of answers needed and decisions to make
  - Screening/comparative, detailed planning, design, operation
Simple Situation Example

- 1-D River
- Continuous Point Source (e.g., STP effluent)
- Low Flow (Dry Season)
- Model is used to support STP effluent permit limit determination
A Little More Complex Situation Example

- 1-D River
- Urban Runoff Contribution to Pollution During Wet Weather
- Model to determine health advisories for contact recreation during or after a storm
Chesapeake Bay Watershed
- Large watershed covering DC and 56 states (VA, MD, PA, DE, NY, WV)
- Several receiving waterbodies of different types and complexities
- Multiple pollutant sources (point and nonpoint)
- Multiple pollutants (N, P, S)
- Multiple endpoints (DO, chlorophyll, SAV)
- Large spatial and temporal variability
- Model is used to develop the Chesapeake Bay TMDL
Model Selection

- “Make everything as simple as possible, but not simpler”, Albert Einstein
- Guidance Documents for Model Selection
  - EPA (2005), TMDL Model and Evaluation Needs
  - WERF (2001), Water Quality Models: A Survey and Assessment
  - EPA (1999), Compendium of Tools for Watershed Assessment and TMDL Development
WERF Model Selection Tool

**Model Type**
- Urban
- Field

**Space-scale**
- Point Sources
- Small Watershed
- Large Watershed
- Lumped
- Distributed

**Time-scale**
- Continuous
- Event

**Pollutants**
- Sediment
- Nutrients
- Chemicals

**Level of Analysis**
- Screening
- Detailed Planning

**Source Release**
- Constant
- Time-varying
- Single
- Multiple

**Processes**
- Transport
- Transformations

**Input Aids**
- GUls
- Linkage to GIS

**Output Aids**
- GUls
- Linkage to GIS

**BMP Evaluation**
- Simple
- Detailed

**Level of Effort**
- Low
- Medium
- High

**Data Requirements**
- Low
- Medium
- High

**Modeler Expertise**
- Low
- Medium
- High

**Documentation**
- Week
- Strong

**Other Support**
- Sponsor Support
- Workshops

**Model Availability**
- Public Domain
- Proprietary

**Models Meeting Criteria**
- BASINS (HSPF)
- HSPF
Model Calibration

- Model is an approximation of the natural system and its response to triggers/stressors

- Model calibration involves adjusting model parameter values within reason until the discrepancy between observed and modeled data are within acceptable levels
Model Calibration/Validation
Calibrated Model

“There is no single, accepted statistic or test that determines whether or not a model is valid”, EPA BASINS Training Course

Rough Calibration Targets

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Percent Difference Between Simulated and Observed Data</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Very Good</td>
</tr>
<tr>
<td>Hydrology/Flow</td>
<td>&lt;10</td>
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<tr>
<td>Sediment</td>
<td>&lt;20</td>
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<tr>
<td>Water Temperature</td>
<td>&lt;7</td>
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<tr>
<td>Water Quality/Nutrients</td>
<td>&lt;15</td>
</tr>
<tr>
<td>Pesticides/Toxics</td>
<td>&lt;20</td>
</tr>
</tbody>
</table>

Source: Donigian (2000)

Comparison Techniques:
- Graphical (time series plots, scatter plots, CFDs)
- Statistical (error statistics, correlation, etc.)
Since water quantity drives water quality, it is important to calibrate the hydrologic and hydraulic model first before calibrating the water quality model.

Parameters
- Annual and monthly runoff volume
- Storm hydrographs
- Flow time series
- Flow frequency (flow duration) curves
Data Needs

- Climate
- Watershed/Receiving Water
- Pollution Sources (Point and Nonpoint)
- Observed Flow and Water Quality Monitoring Data
Climate Data

- Precipitation
- Evaporation
- Temperature
- Wind Speed
- Solar Radiation
- Cloud Cover

Source
- National Weather Stations (PAGASA)
Watershed/Receiving Water

- Watershed boundary
- Hydrography (stream/lake/bay locations, spatial extent, network; cross-sections, bathymetry)
- Land use (Aerial Photography, Satellite Imagery)
- Soil
- Topography (DEM, DRG)
- Political and administrative boundaries (LGU, Barangay)
- Infrastructure (roads, sewer network, parcels, ponds, flow control structures, best management practices, etc)

Source
- Various National Government Agencies
- Local Government Agencies
- Private Organizations
Pollution Sources

- Point Source Effluent Discharge Data
  - Domestic/Commercial Wastewater Treatment Plants, Industrial Treatment Plants
- Septic/On-site Treatment Systems
  - Illegal (straight pipe) connections
  - Leachate contribution (via surface runoff or percolation/groundwater)
- Human and Animal (livestock, pet, wildlife, fishponds) populations
- Landfill and Solid Waste Dump Sites
- Surface Runoff (urban, agricultural, forest, etc.)
- Atmospheric Deposition

Source
- Various National Government Agencies
- Local Government Agencies
- MWCI and MWSI
- Private Industries
Monitoring Data

- **Flow**
  - Daily and hourly time series
  - Surface water elevations and flow rating curve
  - Inflows and outflows (inter-basin water transfers, major withdrawals and discharges)
  - Flow rating curve and surface water elevations/depths

- **Water Quality**
  - Physical, chemical, biological data (in-stream, lake, bay)
  - Continuous or grab samples

**Source**
- Various National Government Agencies
- Local Government Agencies
## Data Challenge – Availability and Accessibility

<table>
<thead>
<tr>
<th>Data</th>
<th>EMB</th>
<th>RBCO</th>
<th>LLDA</th>
<th>PRRC</th>
<th>MMDA</th>
<th>MWSS</th>
<th>Others</th>
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<tbody>
<tr>
<td>Watershed boundary</td>
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<td>DPWH</td>
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<td>LGU boundary</td>
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<td>NSO, NAMRIA, LGU’s</td>
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<td>Barangay boundary</td>
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<td>Stream, canal, estero map</td>
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<td>Storm drain map and outfall locations</td>
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<td>Wastewater and industrial facility location</td>
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<td>Concessionaires</td>
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<td>Informal settlers location and population</td>
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<td>Population by LGU and by barangay</td>
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<td>Locations of flow monitoring stations, flow and stage time series data, flow rating curves</td>
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<td>DPWH</td>
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<td>Locations of water quality monitoring stations and time series data</td>
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<td>MTSP-PMO and Concessionaires</td>
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<td>PAGASA</td>
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<td>Digital Elevation Model/Contour Maps</td>
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<td>Land use</td>
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<td>Aerial photograph/Satellite imagery</td>
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Data Challenge – Incomplete or Inadequate Detail

- Subwatershed/Catchment Boundaries

- High resolution DEMs/DRGs that can be used as a basis for delineating watersheds are not readily available

NOTE: This delineation is for illustration purposes only since the subcatchment boundaries were delineated arbitrarily.
Data Challenge – Data not available or incomplete

- Flow Time Series Data – not available for model calibration
  - Surrogate: Stage data and flow rating curve

- Water Quality Data
  - Very limited number of samples representing different flow situations (low flows, high flows, spill events, etc)
  - Flow rate was not measured during water quality sampling
  - Limited number of locations (e.g., one station in San Juan WQMA)
Data Challenge – Inconsistent data

Different Map Projections:
- UTM/WGS84
- UTM/Luzon–PRS ‘92
- UTM/Luzon Old Format

Spatial shift
Resolving Data Issues

- Watershed Boundary Delineation Team
- Partnership Information Center – Database Information System
- Strengthening and Harmonization of Surface Water Quality Monitoring Programs
- WQMAs – Coordination of watershed–based inter–jurisdictional activities
Questions?