Lake Granbury Water Quality Modeling Study

David Harkins, Ph.D., P.E.
Espey Consultants, Inc.

Overview

• WQ Modeling 101 recap
• WPP modeling overview
• Data evaluation
  – Whole lake
  – Cove by cove
  – Water quality, septic systems, land use, population, precipitation
• Modeling approach
Point-source contamination can be traced to specific points of discharge from wastewater treatment plants and factories or from combined sewers.

Air pollution spreads across the landscape and is often overlooked as a major nonpoint source of pollution. Airborne nutrients and pesticides can be transported far from their area of origin.

Eroded soil and sediment can transport considerable amounts of some nutrients, such as organic nitrogen and phosphorus, and some pesticides, such as DDT, to streams and streams.

---

**Water Quality Parameters**

- pH
- Total Suspended Solids (TSS)
- Total Dissolved Solids (chloride)
- Temperature
- Dissolved Oxygen (DO)
- Nutrients (Nitrogen, Phosphorus, Ammonium)
- Bacteria (fecal, E. coli)
- Algae (chlorophyll $a$)
What are water quality models?

- Water quality models are approximations of real-world conditions.
- Mathematical tools/equations to study each parameter:
  - Amount or loading – how much?
  - Movement, distribution or transport – where does it come from, where does it go?
  - Chemical Reaction, decay, reproduction – how does it change?
  - Ecological Impact of sediments and chemicals on water quality – how do other parameters affect it?

Why do we need models?

- To understand and learn from the events of past and plan for the future
  - Protection and sustainable use of water resources.
- To evaluate how changes in watershed, stream or reservoir characteristics change water quality
  - Assist in improving or preventing water quality problems.
How are these models used?

- **Status**: assess current environmental conditions
- **Trend**: evaluate historical change
- **Prediction**: evaluate future impact as a result of change
- **Decisions**: evaluate alternative management plans

Watershed Protection Plan Examples

- **Texas**
  - Concho River
  - Lake Granger
  - Little Wichita River
  - North Bosque River
  - Pecos River
  - Plum Creek
  - Arroyo Colorado
  - Caddo Lake
  - Dickinson Bayou
  - Hickory Creek
  - Upper San Antonio River

- **National**
  - Lake Ochechobee, FL
  - Grand Traverse Bay, MI
  - Cuyuga Lake, NY
  - Pine Creek Watershed, PN
  - Stoney Creek Watershed, MI
  - Santa Clara River, CA
  - Wachusett Reservoir, MA
Data evaluation – data sources

- USGS water quality study (1976)
- BRA/APA water quality study (1982)
- BRA water quality study (1995)
- Canal dye studies (1996)
- TCEQ/EPA – discharge permit records
- BRA/TCEQ – monitoring data
  - Lake Granbury 1972 – current
  - Selected coves 2001 – current
- Hood County Environmental Health Department – OSSF records
- UT Bureau of Economic Geology – geology maps
- NRCS - SSURGO soil maps
- USGS - Lake elevation, topography (NED)
- TWDB – Lake bathymetry, volume, evaporation
- NCDC – Precipitation, wind, weather
- Time series of land use maps

Lake Granbury

- Designated Uses
  - Aquatic Life Use
  - Contact Recreation
  - Public water supply

Standards
- DO > 5.0 mg/L
- pH 6.5 to 9.0
- Indicator Bacteria
  - Geometric mean < 126MPN/100ml
  - 25% or less exceed 394 MPN/100ml
- Chlorides < 1,000 mg/L
- Sulfates < 600 mg/L
- Nitrite + Nitrate < 0.32 mg/L
- Phosphorus < 0.05 mg/L
Data evaluation

- Main body Lake Granbury
  - Relatively constant inflow
  - Constant rainfall
  - Stable lake levels
  - Rising chlorides last two years
  - No bacteria problem indicated
  - 10 discharge permits
Station 11861
Lake Granbury
near Granbury
Data evaluation

- Coves
  - 4 coves nearing bacteria impairments, 1 site impaired
  - Watershed source not indicated
  - 4 cove sites exceed DO standard
  - 8 cove sites exceed Chloride standard
  - 1 cove site approaching N screening level
Watersheds and sub-watersheds

SSURGO soil map and watersheds

Detail area of next slide
Port Ridglea
all stations 18031 to 18040

Port Ridglea – all stations 18031 to 18040
### Watershed modeling

- **Determine loads entering water body**
- **Bacteria**
  - Rainfall-runoff model to determine inflow
  - Statistical relation with pathogen, SPARROW, to determine bacteria load
- **Nutrients**
  - SWAT – Soil and Water Assessment Tool
Sources of Bacteria

- **Potential Point Sources**
  - Waste Water Treatment Plants
  - Combined Sewer Overflow and Sanitary Sewer Overflow
  - Direct discharges

- **Potential Non-Point Sources**
  - Animals
    - Livestock - pasture/rangeland, holding facilities, auctions
    - Pets - homes, parks, kennels
    - Wildlife
  - Humans
    - Malfunctioning septic systems
  - Land application of manure/wastewater

Lake modeling

- **Bacteria**
  - Consider each cove individually
  - Load introduced from watershed modeling
  - One dimensional, segmented hydraulic model
    - Inflow from cove watershed
    - Exchange between lake and cove
  - Decay rate to determine persistence of bacteria
  - Influenced by rainfall and circulation

- **Nutrients**
  - Characterize current status, estimate loads
  - WASP, CE-QUAL-W2 – multidimensional models
    - Wind, temperature, water balance
    - Temporal and spatial relationships need to be explicitly quantified
Data needs

- Additional data collection
  - Septic tracer studies
  - Lake and cove water exchange
  - Monitoring points
  - Storm sampling
  - Tributary inflow measurements
  - Bacterial Source Tracking

Questions?