Future Need Analysis:
Risk-Based Planning For Water Supply Expansions to Meet Uncertain Growing Demand

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Outline

1. Uncertainty in demand growth, supply availability, and planning
2. Demand forecasting with uncertainty
3. Surface water supply modeling with uncertainty
4. Future need analysis
Uncertainty in demand growth, supply availability, and planning
Timing Of New Water Supply Development

- Growing service population or demand: potential need to develop new supply
  - Development lead time usually several years
  - Develop too late: severe reliability costs
  - Develop too early: potentially severe unnecessary overdevelopment costs
  - Ideal development: new supply comes online “just in time” as need emerges
Future Need Analysis (FNA)

- Support just-in-time development with forecasts
  - Generate supply and demand time series forecasts
  - Combine into forecasts of future need (demand minus supply)
  - Size of new supply, time that new supply should be online

![Graph showing future need, future supply, and future demand with annual average daily supply or demand in mgd from 2010 to 2030.](image-url)
Must Acknowledge Uncertainty

- Future demand and supply are uncertain
  - Uncertain growth in service population
  - Uncertain future per capita use due to uncertain weather, socioeconomic characteristics
  - Surface water sources: uncertain future supply availability due to uncertain weather
Effect of Uncertainty of Future Need

Future Need can be larger or smaller than expected.

Future Need can emerge sooner or later than expected.
Risk-Based Future Need Analysis

1. Characterize uncertainty in supply and demand forecasts
   • Probability distributions: likely ranges over time

2. “Subtract” supply ranges from demand ranges
   • Future need ranges over time

3. Base expansion timing/sizing on avoiding high probability of future need
   • Build big enough, soon enough to keep probability low
Risk-Based FNA Experience: Tampa Bay Water

- Regional water wholesaler serving 6 Member Governments in the Tampa Bay region
- Growing population, demand
  - Tampa Bay historically one of the fastest growing regions in the state
  - Demand ~250 mgd now
  - At least 300 mgd by 2025
- Variable water supply
  - Limited groundwater permits
  - Remainder made of surface water (streams, desal)
Demand forecasting with uncertainty
Demand Model Development

- Regression models for various regions and customer sectors
- Relate historical monthly demand to
  - number of customers in region
  - regional weather
  - regional socioeconomic characteristics
  - regional policies
Single Demand Forecast

• Estimate future time series of input variables for each region, sector
  • Planning agencies
  • Weather trends and models

• Apply to model
  • Calculate demand for each region and sector at each future time
  • Sum across regions, sectors for totals
Demand Model: Forecast With Uncertainty

- Monte Carlo simulation
  - Time series models or probability distributions for inputs
  - Generate multiple input time series
  - Model output: multiple corresponding time series of demand
Surface water supply modeling with uncertainty
Tampa Bay Water Supply Components

- Several groundwater sources (permit-limited)
- Desalination plant
- Enhanced Surface Water System
  - 66-mgd SWTP
  - 15-bg off-stream reservoir
  - 3 surface stream sources
  - Withdrawal permits based on % of streamflow
Time Series Models of Source Flows

- Model generates time series simulations of source flows
  - Seasonal patterns
  - Flow autocorrelation
  - Flow cross-correlation
  - Correlation w/ simulated rainfall
  - Random fluctuation
- Collectively, series reflect observed flow distributions over time
Surface Water Supply Simulation with Uncertainty

- Monte Carlo simulation
  - Input to ESWS Model: multiple simulated flow time series
  - Output from ESWS Model: corresponding series of ESWS production (forms distributions of production over time)
4 Future Need Analysis
Developing the need distributions

- Monte Carlo simulation
  - Subtract series of supply from series of demand, produce corresponding future need series

- Collection of Future Need series reflect ranges of need over time.
Interpreting FNA results
2003: First TBW Future Need Analysis

- Decided that 8-12 mgd new supply would be needed by 2013
  - Current demand model
  - Previous models of the surface system and stream flows (not the models presented today)
Currently Under Way: FNA II

- New Demand Forecast Models
  - More demand data now available
- Revisions to Source Flow Models
  - Incorporate climate and drought dynamics
- Revisions to Surface Water System Models
  - Include planned system upgrades
- Incorporate new Water Shortage Mitigation Plan
  - Include demand reductions, supply augmentations whenever Source Flow Models simulate droughts
How Could FNA Help Water Planning in South Carolina?

- Significant growth areas
- Significant variability in supply in some cases
- FNA provides the necessary framework for implementing a just-in-time philosophy
Thank You!

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Clemson Class of 1994
1. Based on stream flows...
2. Determine allowable withdrawals according to Water Use Permit, then...
3. Route water to maximize SWTP production, reservoir level subject to allowable withdrawals.
Components of Tampa Bay Water’s future need

- Demand: forecasted regional demand distributions from demand model
- Supply: modeled surface production distributions plus sum of other sources (shift distributions upward)
Characterizing risk through time:
An analogy
Future Need Analysis results

- Time series of need probability distributions
  - Distribution of need at each future month, year
- Summarize with median, confidence intervals
  - Probability of need having certain values at certain future times
Like a point forecast, but with a random trace for each variable

Like generating many input traces, a corresponding output trace for each variable