Multi-objective decision model for urban water use: Planning for a regional water reuse ordinance

- Illinois Institute of Technology
- Illinois Waste Management Research Center
- Chicago Metropolitan Agency for Planning
NE Illinois: Growing demand for water

Projected water use (mgd)

Baseline Scenario

Conservation Scenario

NIPC

Dziegielewski et al. (2005)
NE Illinois: Limited water sources

- **Lake Michigan**: 86%
- **Aquifers**: 11%
- **Inland Surface Water**: 3%
- **Unknown resources**: Falling water table

Northeastern Illinois regional non-cooling water source allocation (NIPC, 2001)

- 54% municipal
- 30% diverted runoff
- 16% direct diversion

Limited by Supreme Court decree
Toward sustainable water resources planning

- Realize natural capital of treated wastewater
- Water reuse can be part of the solution
- Multi-objective decision model
  - Identify and balance competing issues:
    - Economics, technology, policy, regulations, human health and ecosystem risk, public perception
Planning for water reuse

- Identify industrial users (quality, volume)
- Identify industrial clusters near WRP
  - Volume and location determine reuse cost
- Minimize cost subject to constraints
Water reuse priorities

- Industrial
  - Process/cooling

- Commercial/Domestic
  - Car wash
  - Toilet flush
  - Firefighting

- Irrigation

- Groundwater recharge

- Potable water
Industrial hydrologic footprints

- Measure of industry interaction with water
  - Conventional direct water use
  - Evaporative loss associated with electricity use
  - Stormwater runoff from industry property
  - Supply chain direct water use
  - Supply chain evaporative loss with electricity
- Consider 50 largest volume water dischargers
- Supply chain data from eiolca.net
- Data normalized to economic activity (gal/$)
Hydrologic footprints for

four SIC codes

SIC code

2066
Chocolate & Cocoa Products

2047
Dog & Cat Food

2011
Meat Packing

2046
Wet Corn Milling

 Industry direct  Industry electricity  Supply chain direct  Supply chain electricity  On-site stormwater
Water & electricity use for 31 industry sectors

- Direct water use (10^9 gallons)
- Direct electricity use (MkWh)
- Water evaporated with electricity use (10^9 gallons)

High volume & electricity use
Mid-volume & electricity use
Low volume & electricity use
Supply chain water & electricity use

Supply chain dominated by less than 60 unique SIC codes
Hydrologic footprint summary

- Indirect use (stormwater, electricity) are small
- Direct use (industry or supply chain) dominates
- Supply chains are often important
- Supply chains dominated by a few industries
- 10% have relatively big footprints (gal/$)
  - Is reuse cost-effective for these industries?
A case study on industry near the Kirie WRP
Is wastewater reuse economical?

Objective:
- Minimize cost

Constraints:
- Demand
- Mass balance
- Capacity
- Water withdrawal
- Water quality
Pipeline costs dominate

- Pipeline CC: 91%
- Pumping CC: 1%
- Pumping O&M: 5%
- Disinfection O&M: 3%
- Revenue loss: <1%

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Spatial relationships are important
Cost depends on volume & distance

(i = 6%, τ = 40 years, Pipeline US$75/feet)

Flow rate (MGD)

Cost depends on volume & distance

(i = 6%, τ = 40 years, Pipeline US$75/feet)

Cost depends on volume & distance

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Chicago reuse study summary

- Pipeline installation costs dominate
- Spatial relationship affects supply cost
- Reuse can be cost effective
- Chicago is an unusual case study:
  - Municipal water is very cheap
  - MWRDGC has little incentive for reuse
  - Successful water conservation efforts
What about Wayne’s World?

- Aurora, IL - 40 miles west of Chicago
- 2nd largest city in Illinois
- Rapidly growing area
- Municipal water
  - Groundwater supplies uncertain
  - Surface water up to 35% treated effluent
Aurora study advantages

- Recent severe drought
- $4.81 / 1000 gallons
- WRD exploring marketing effluent
- Experience with heat pump
Aurora study issues

- No industrial clusters
- Potential non-industrial users:
  - Park district, golf course
  - Limited seasonal demand
- Water quality requirements for recharge?
Surprising results

“…implement a policy before there is a need…”

Little economic incentive in Chicago
- MWRDGC funding: Property tax
- Chicago municipal water: $1.38/1,000 gal

Change is hard
- Public perception: Water is plentiful
- Industry is risk averse: Why change?
Update on partners

- **Current partners**
  - Chicago Metropolitan Agency for Planning
  - Waste Management and Research Center

- **New partners**
  - Fox Metro Water Reclamation District study

- **Potential partners**
  - Other water reclamation districts
  - Suburban municipalities
Benefits of CNS funding

- Current collaborators
  - ILWMRC, CMAP, Fox Metro WRD

- Potential collaborators
  - IL Regional Water Supply Planning Group
  - Chicago Waste-to-Profit Network
  - Professor Fan, Hungkuang University (Taiwan)
Feedback, questions, and contacts

- Great Lakes and Eastern US applications?
- Industry water quality requirements?
- US DOE water & energy integrated efforts?
- US DOC industrial water use survey?
- International (Taiwan) cooperation?
- Water quality limits for recharge & irrigation?