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CIPDSS National Water Model Overview

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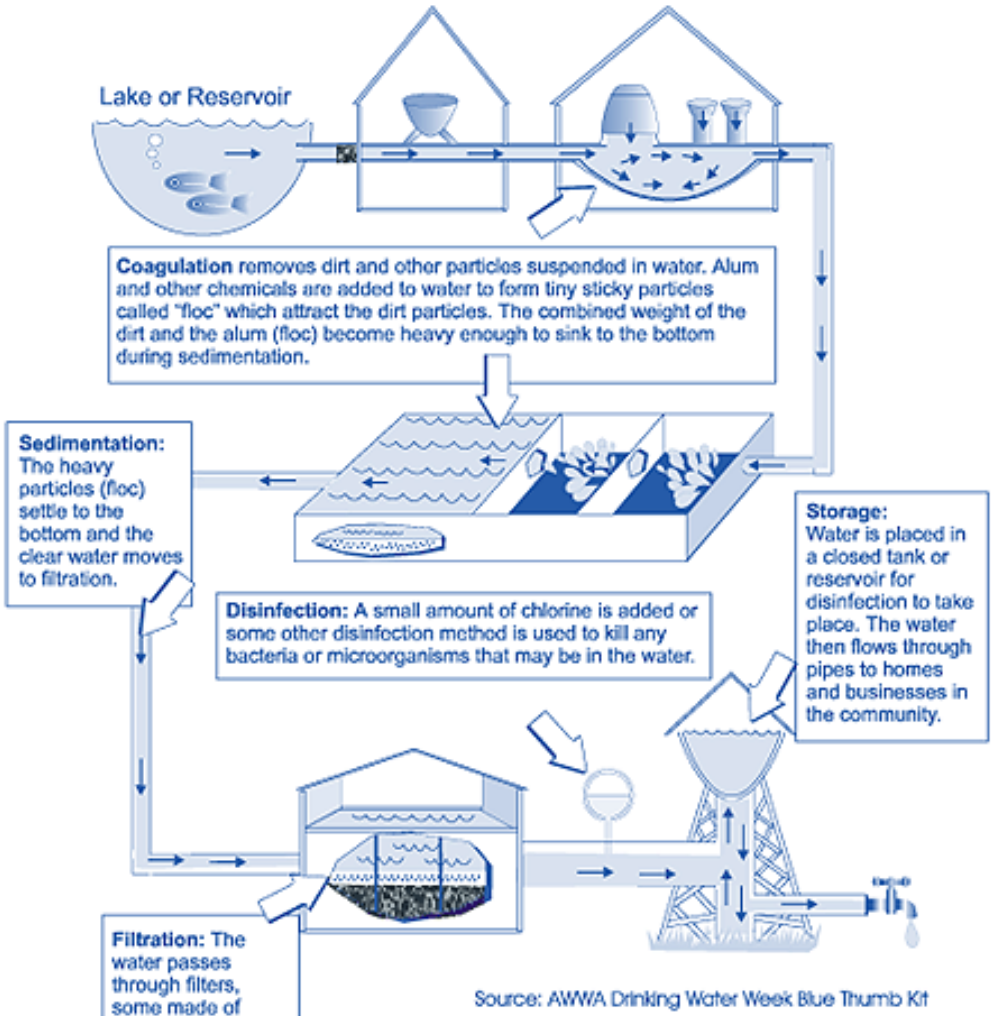
- High-Level Requirements
- Water Infrastructure Overview
- Water Supply
- Wastewater Treatment
- Actions

High-Level Requirements

- **Estimate the regional/national consequences of disruptions to water supply and wastewater treatment as a function of time, given the current configuration of the infrastructure.**
  - Water distribution is deliberately excluded here – handled in Metro model
- **Estimate the consequences of disruptions to critical inputs for water treatment, distribution, and wastewater treatment as a function of time.**
- **Estimate the impact of a sudden shift in consumption (demand) of water on the water infrastructure as a function of time.**
- **Allocate available water to the consumer classes and infrastructures in the CIPDSS National Model.**

- **Example usage: Estimating water supply impacts resulting from a regional electric power outage**

Water Treatment Process Overview



Source: AWWA Drinking Water Week Blue Thumb Kit

Key elements:
- Pumping system
- Storage (initial holding tanks, sedimentation and final)
- SCADA (not critical)

Critical inputs
- Water
- Electric Power

Additional Key Inputs
- Chlorine
- Coagulants
- Telecommunications for SCADA systems

- Distribution is highly localized and reserved for the Metro model
- Water treatment capacity problems do not translate into water shortages but relate to whether the water is potable or not

Source: *EPA Safe Drinking Water Act 30th Anniversary Information Kit: Drinking Water Treatment*, EPA 816-F-04-034, June 2004.

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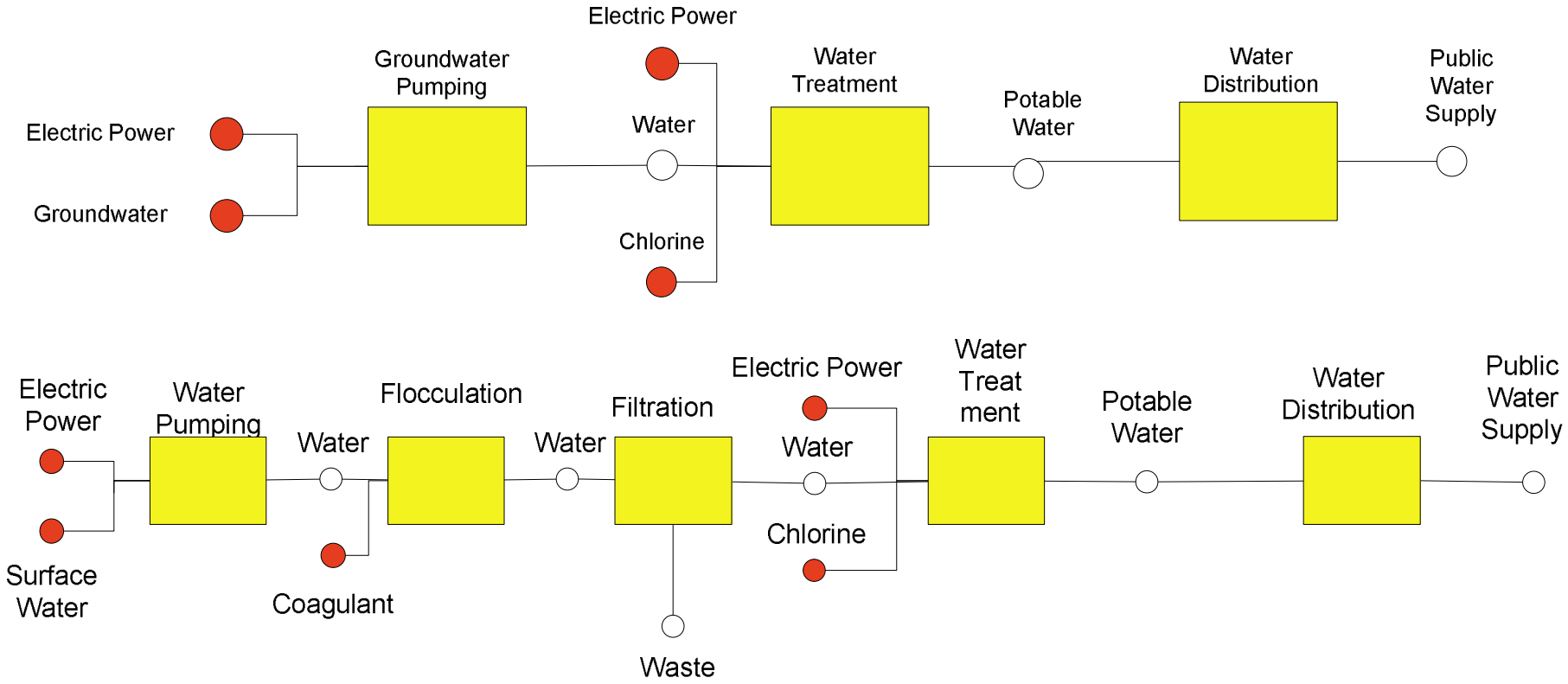
Water Supply and Distribution: Processes and Key Inputs



- **Processes vary slightly for groundwater and surface water**
- **Red circles denote critical external inputs**
- **Yellow boxes denote processes**
  - **The primary process outputs (e.g., potable water) provide critical input to next process but are internal to the overall process illustrated and are not color coded)**

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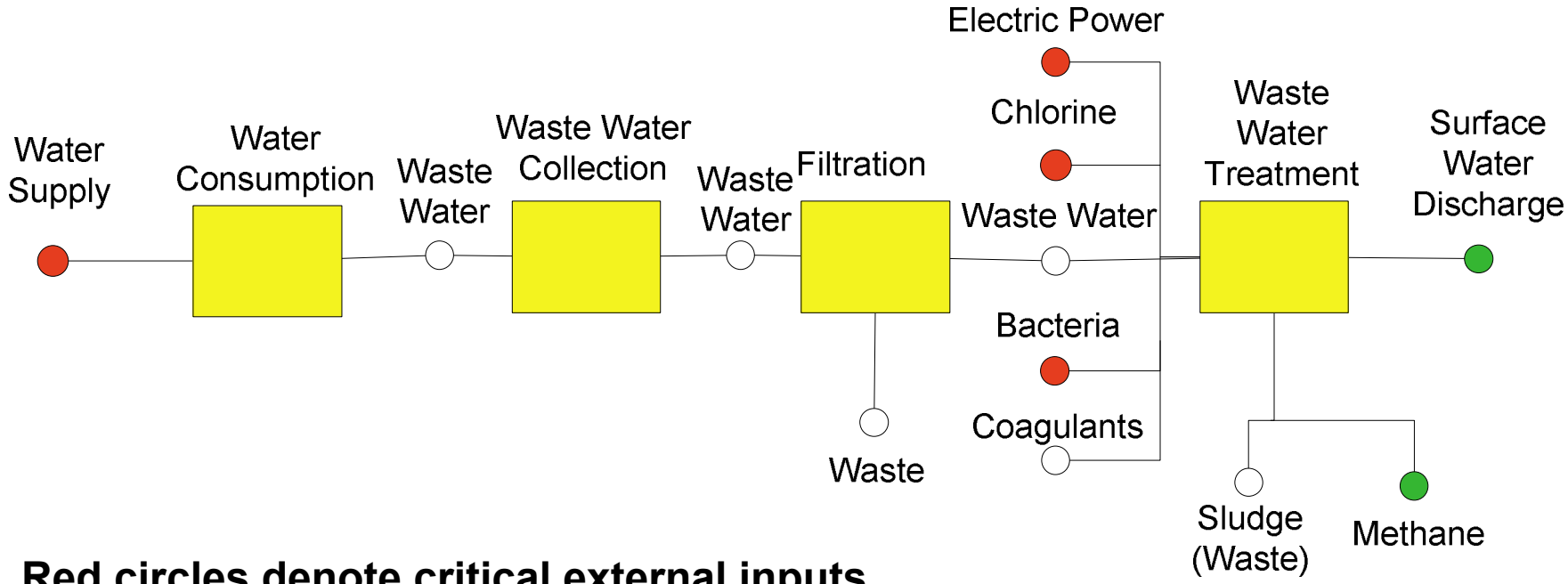
Waste Water Treatment: Processes and Key Inputs

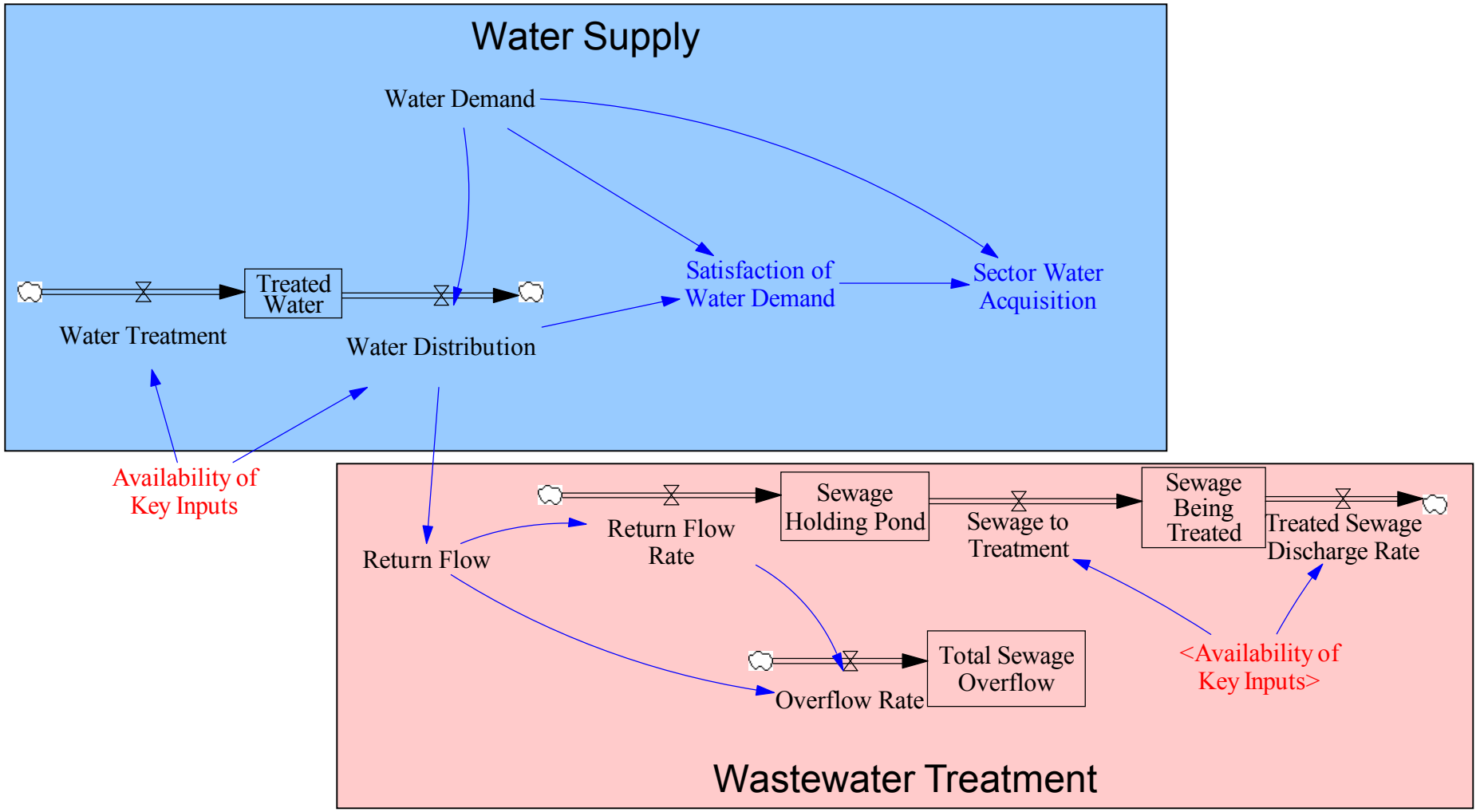


- **Red circles denote critical external inputs**
- **Yellow boxes denote processes**
  - **The primary process outputs (e.g., potable water) provide critical input to next process but are internal to the overall process illustrated and are not color coded)**
- **Green circles denote output that may impact other infrastructures (e.g., methane could be used for energy production) or creates feedback into the system (e.g., discharge increases available surface water supply (downstream)**

Modeling Choices and Assumptions

- **Model Focus:**
  - Status of regional storage systems
  - Ability of water storage to offset disruptions
  - Potential for sewage overflows as a result of disruptions to EP or telecomm
- **State-level aggregation for water supply and water treatment**
- **Water treatment and sewage treatment processes are treated as aggregate capacities**
- **Water treatment capacity dependent on availability of chlorine**
  - There are other disinfectants, but chlorine is most common

Key Flows



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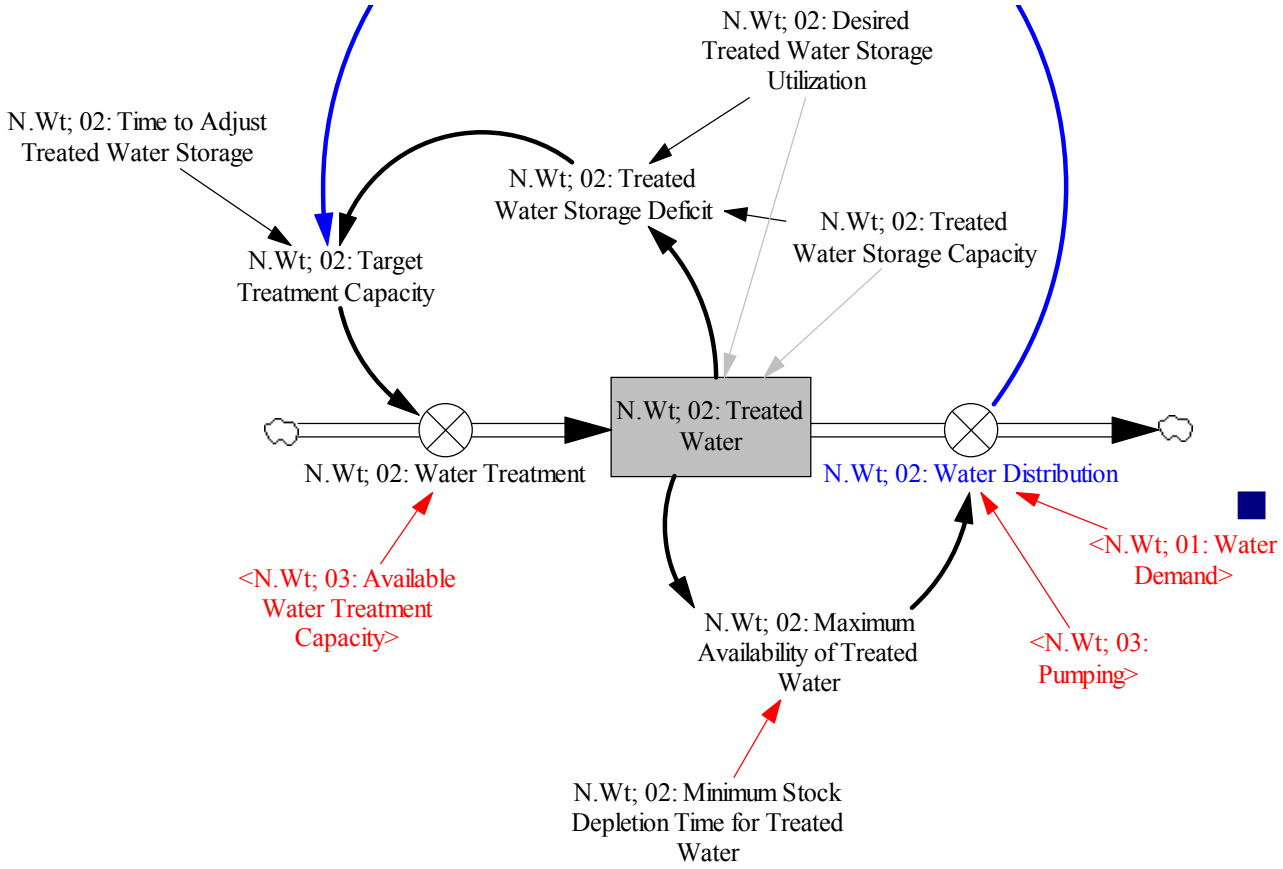
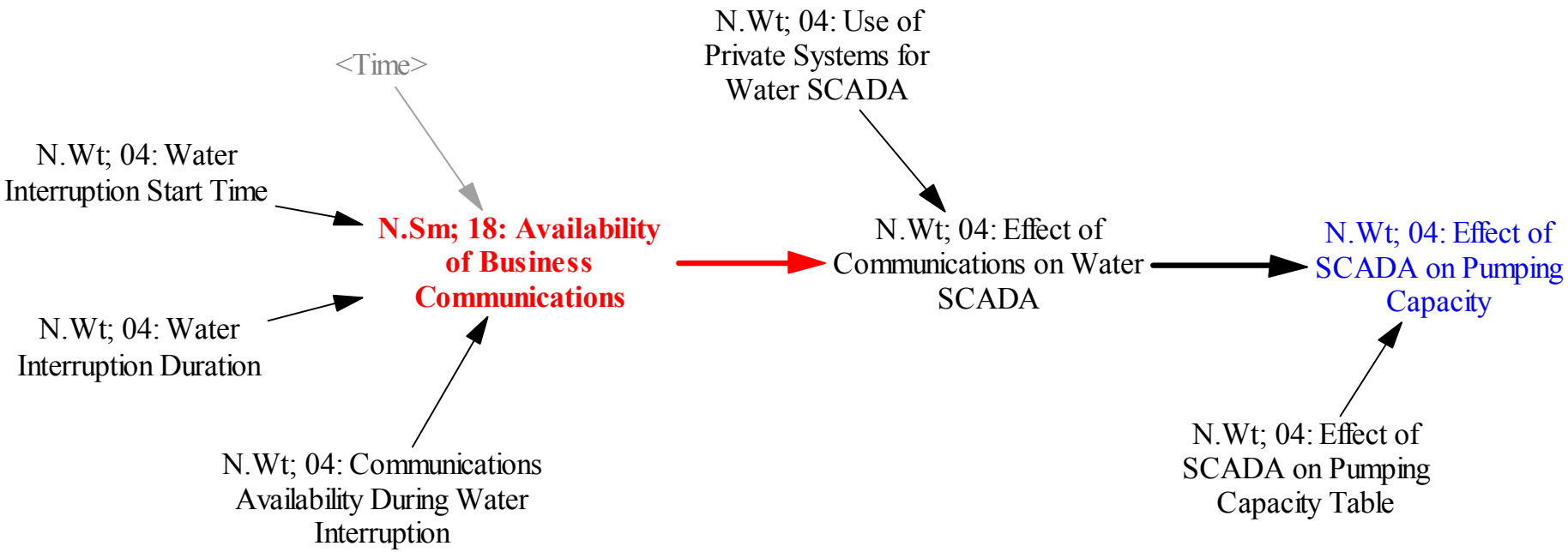
Treated Water



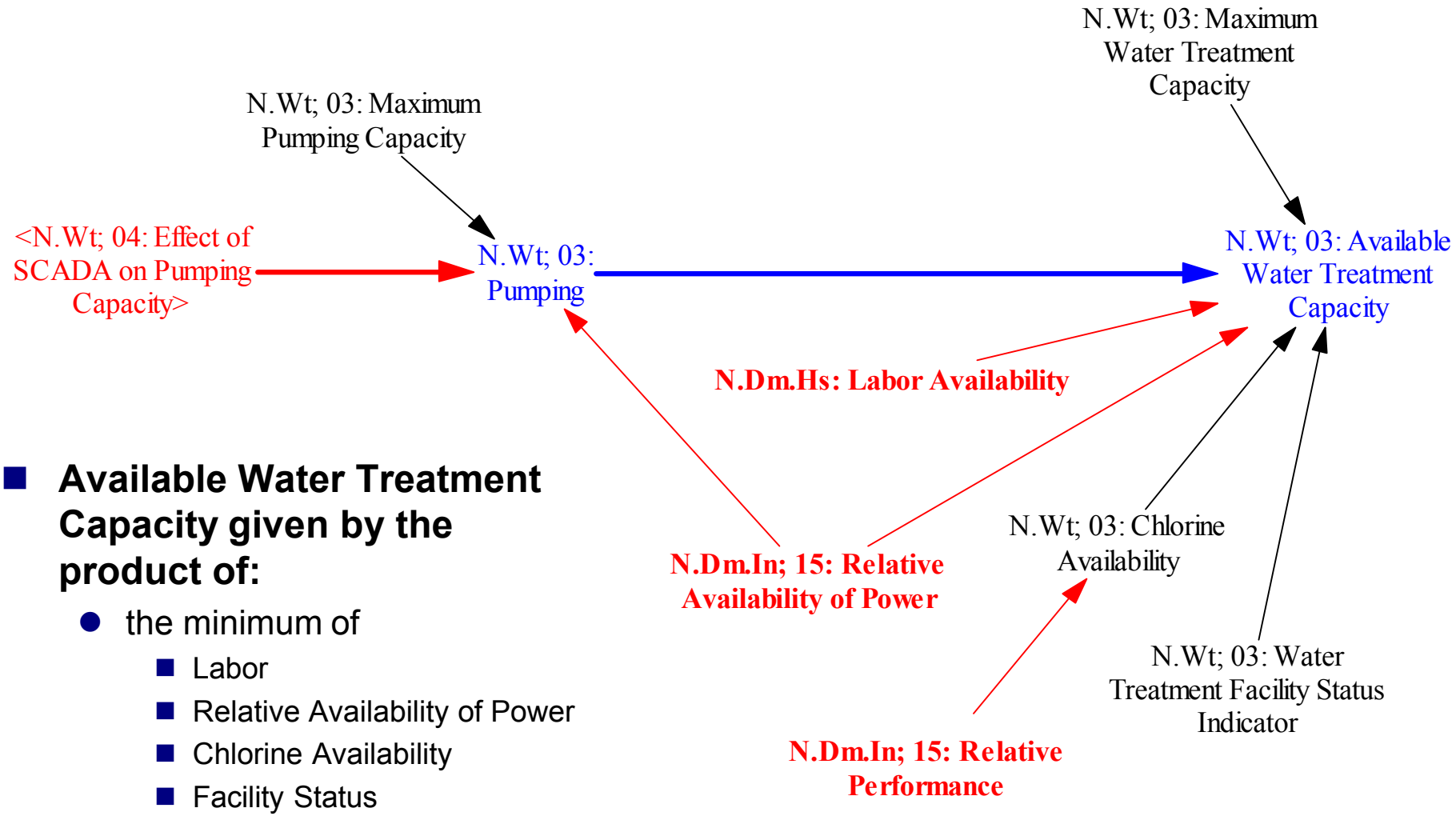
- **Nominal conditions:**
  - Demand-driven
  - Maximum water treatment capacity set to 2x avg. hourly usage rate
  - Maximum pumping capacity set to 3x avg. hourly usage rate
  - Storage capacity set to 1x daily usage
- **Planned addition:**
  - Target treatment capacity proportional to average consumption when demand-driven

Effect of SCADA on Pumping Capacity



- **Availability of Business Communications is a feed from the Telecommunications Sector**
- **Need to estimate fraction of water systems that use private vs. public telecommunication systems**
- **Need to estimate effect of SCADA on pumping capacity**
  - SCADA helps systems run more effectively, but they can run without SCADA
  - We assume a simple linear relationship with 50% of pumping capacity available at zero SCADA availability

Available Water Treatment Capacity



- **Available Water Treatment Capacity given by the product of:**
  - the minimum of
    - Labor
    - Relative Availability of Power
    - Chlorine Availability
    - Facility Status
  - The minimum of
    - Pumping and
    - Max Water Treatment Capacity

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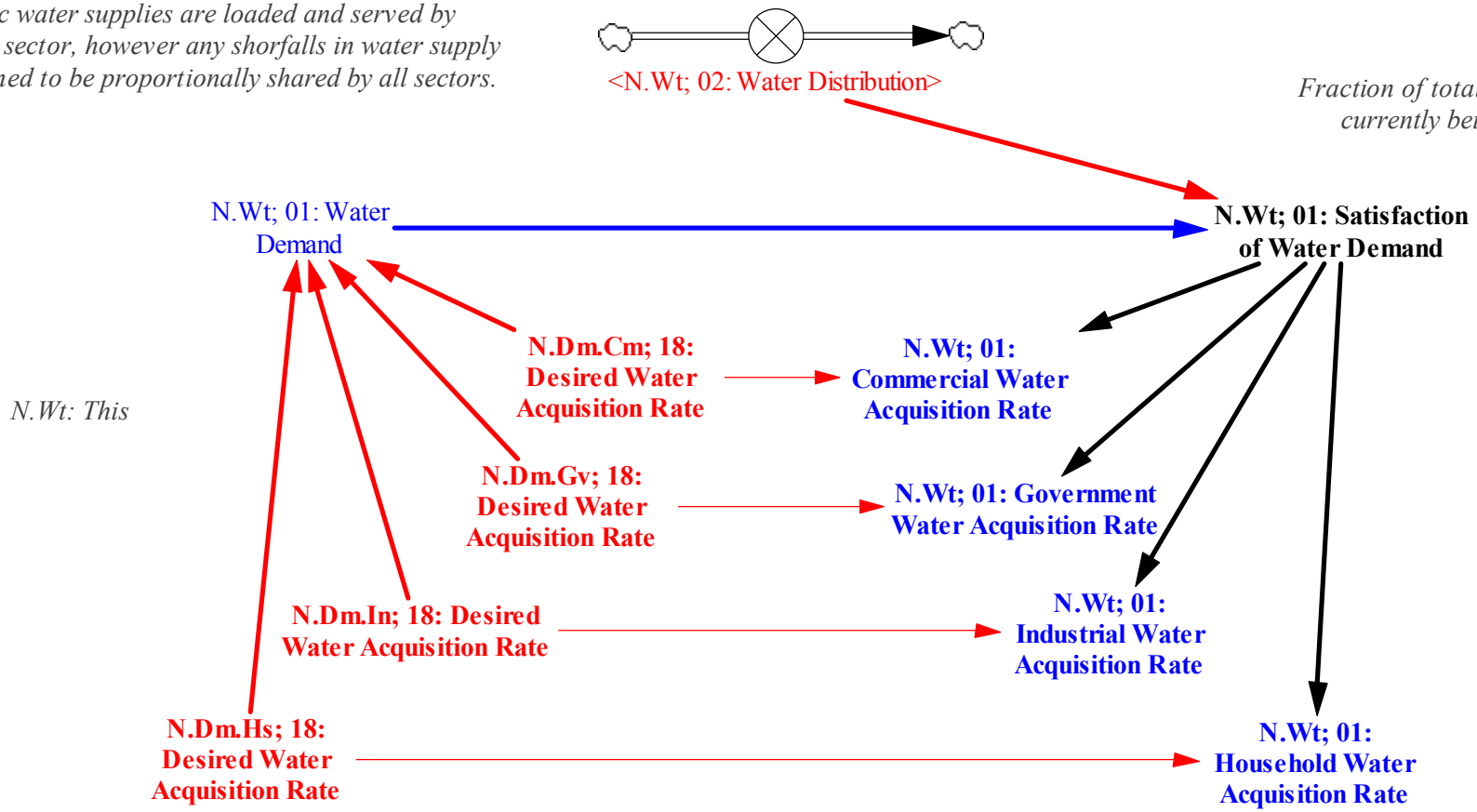
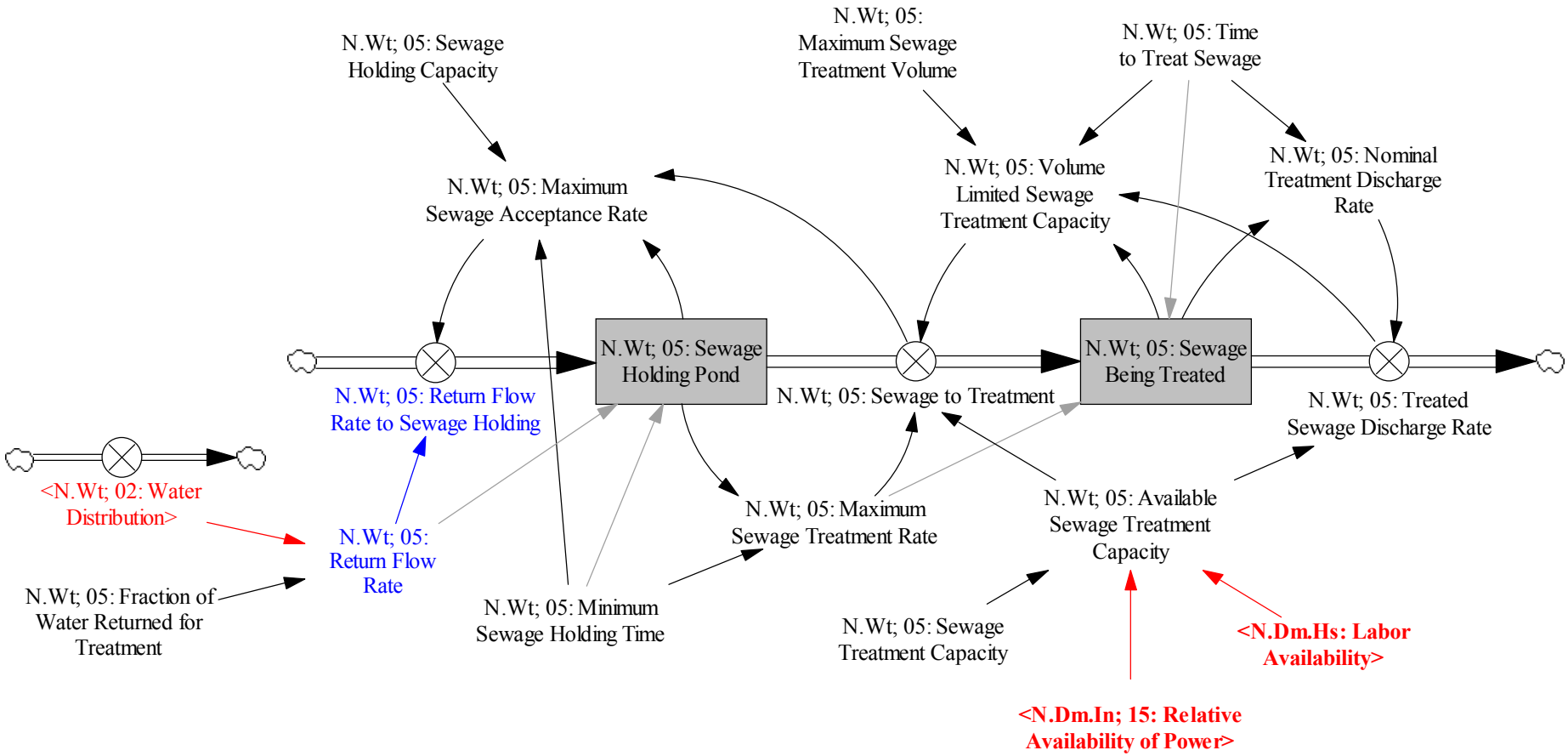
Satisfaction of Water Demand

Public water supplies are loaded and served by economic sector, however any shorfalls in water supply are assumed to be proportionally shared by all sectors.



- **Demand and actual Water Distribution are use to determine how much of demand is satisfied and to allocate the water to consumer classes**

Sewage Treatment Sub-Model



Observations – Water Treatment Piece

- **In isolation, with constant demand, two behaviors:**
  - Demand-driven ~ $(1-\exp(-t/t_s))$
  - Constrained: linear growth or decline
- **Under nominal conditions, the system tries to maintain storage at about 50% full**
- **An analytic solution is available**
  - RK4 cannot maintain expected accuracy if the goal is “far away”
- **Consumption is not limited unless storage is essentially exhausted.**

Potential Improvements

- **Relate the water treatment rate to an average distribution/consumption rate**
  - Current model is targeted towards an average daily demand
  - Would need to be modified to respond to diurnal variation in demand
- **Track water treatment/contamination state (as a co-flow)**
  - Provide an indicator of the need/ability to boil water
- **Validation of SCADA effects is challenging**