# The Systems Approach to Lift Station Design, Operation, Installation and Maintenance

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# FAIRBANKS NIJHUIS™ MUNICIPAL PUMP PRODUCTS

# Speakers

**Barry Jongsma**
*Manager of Product Engineering*
Pentair

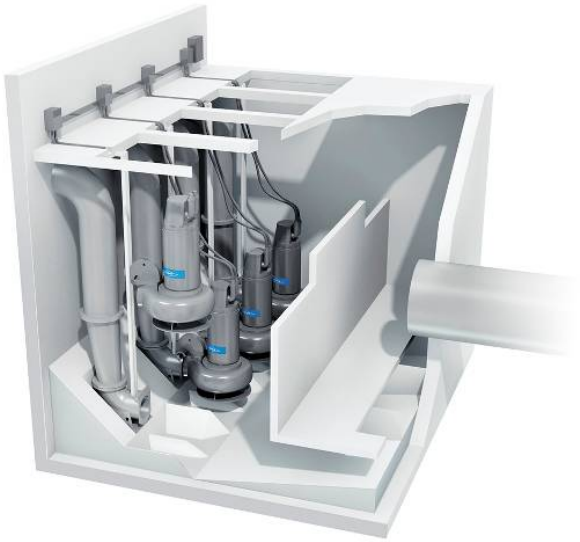
**Ernest C. Sturtz, P.E., BCEE**
*Associate*
CDM Smith

**Jim Vukich**
*Application Engineer*
Xylem – Flygt Products

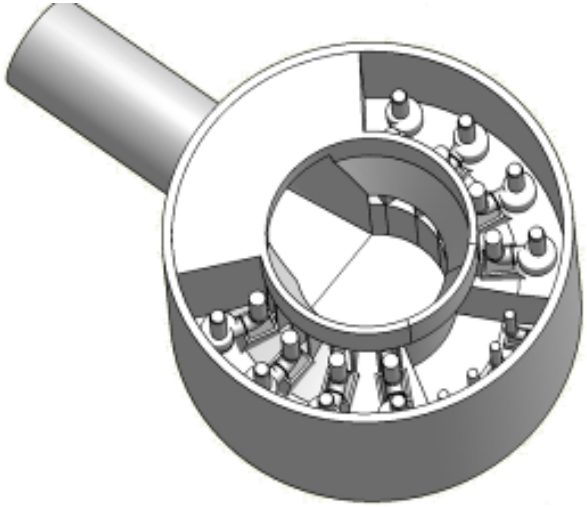
# Station Classifications

Packaged

Pre-Engineered



Custom



Complexity

# What is the Systems Approach?

Charlotte, N.C.
200 MGD
Sugar Creek WRF
Influent PS (2009)

Images Used with
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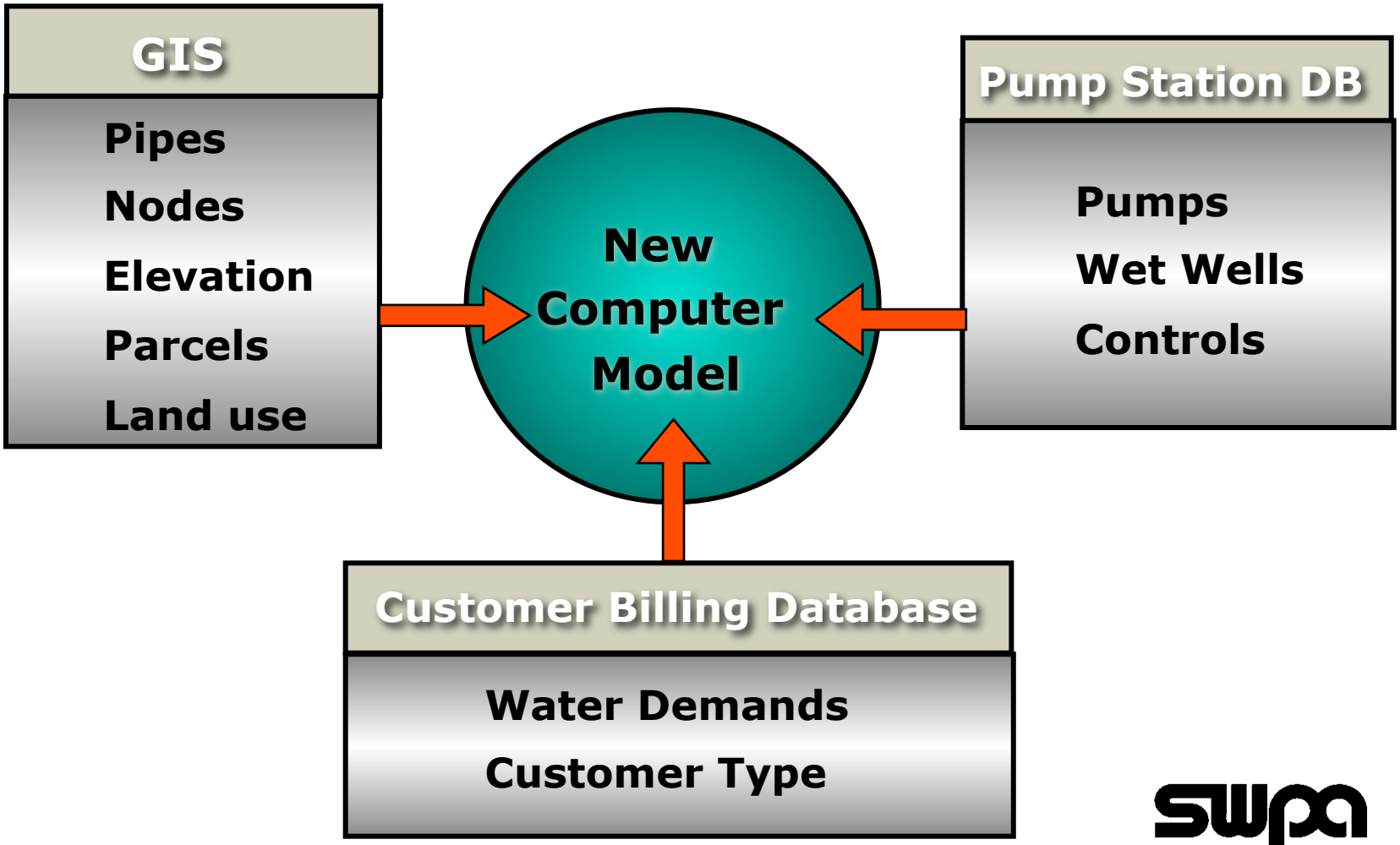
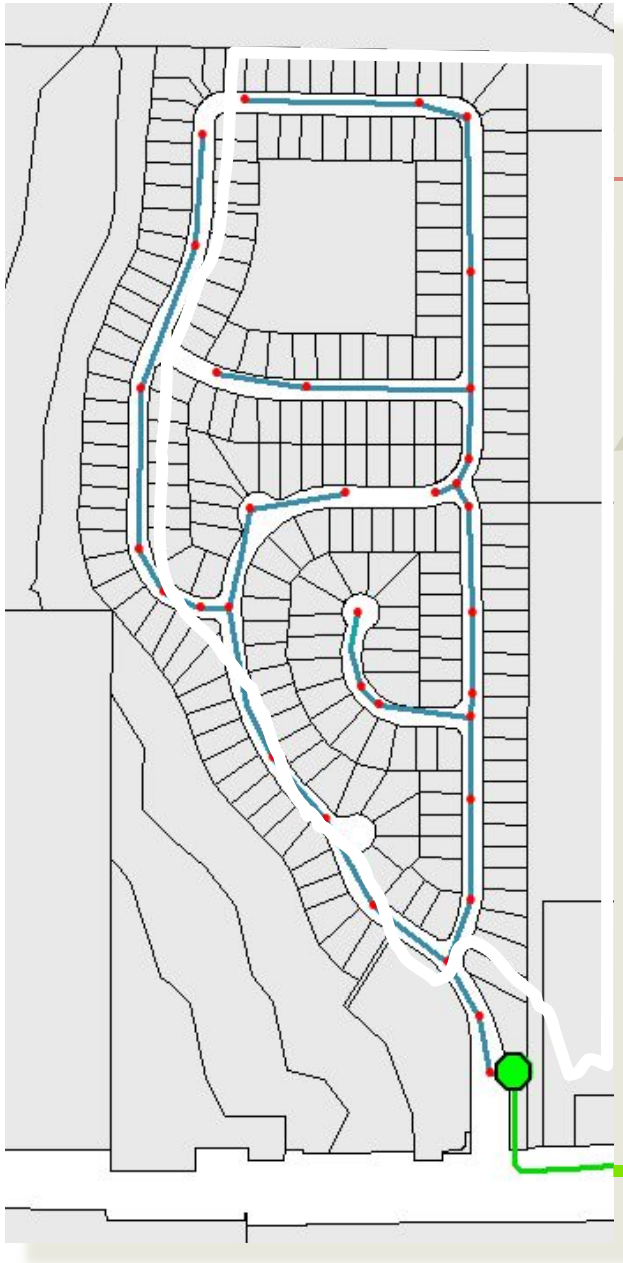
# Available Data for Creation of a Computer Model (Existing Systems)



# Design of a Single Pump Station

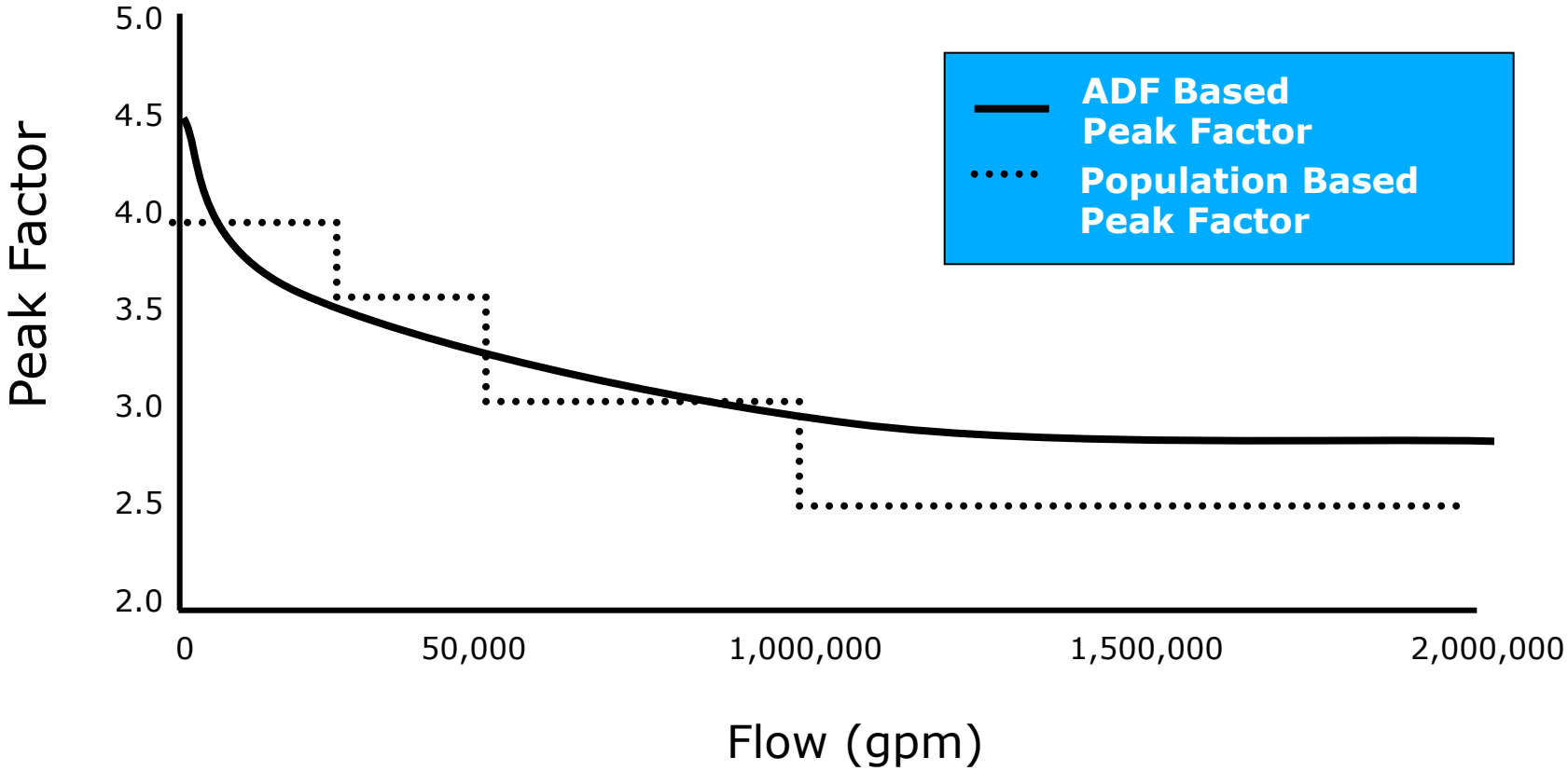


**Gravity Collection System Boundary**

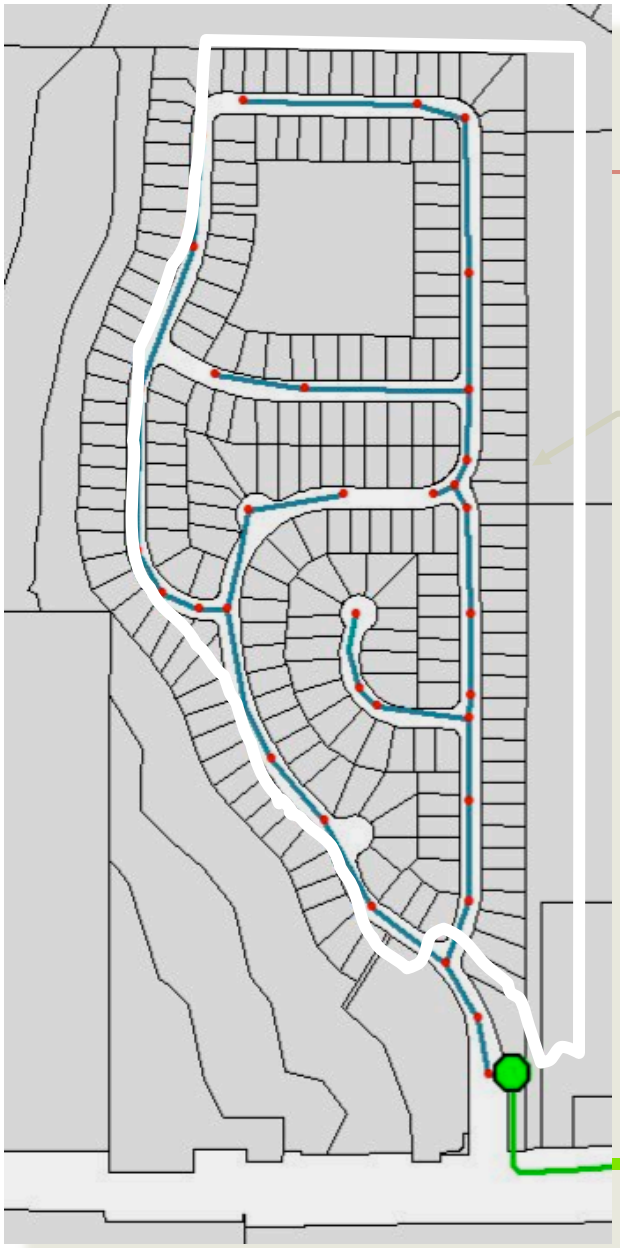
**Population - 1,000**
**ADF - 60 gpm**

**Peak factor - ?**
**Design flow - ?**

# Examples of ADF and Population Based Peak Factors



# Design of a Single Pump Station



**Gravity Collection System Boundary**

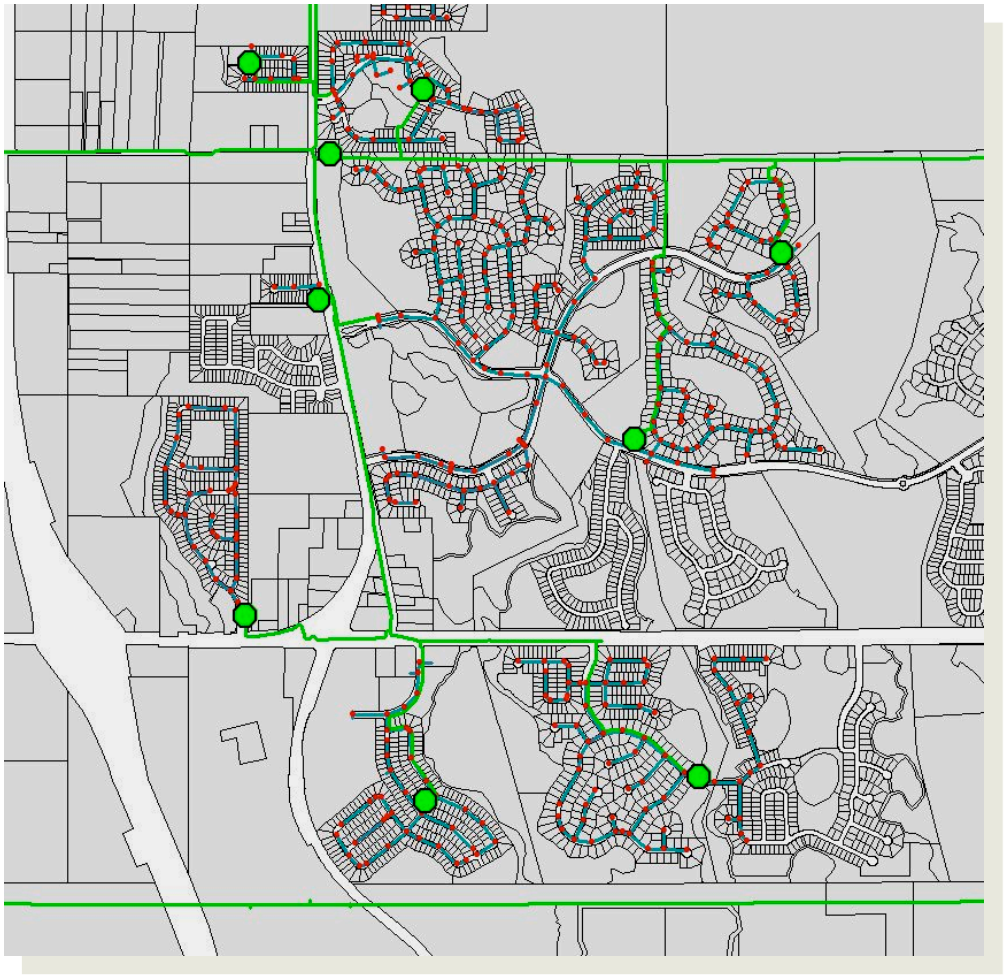
**Population - 1,000**
**ADF - 60 gpm**

**Peak factor - 3.80**
**Design flow - 230 gpm**

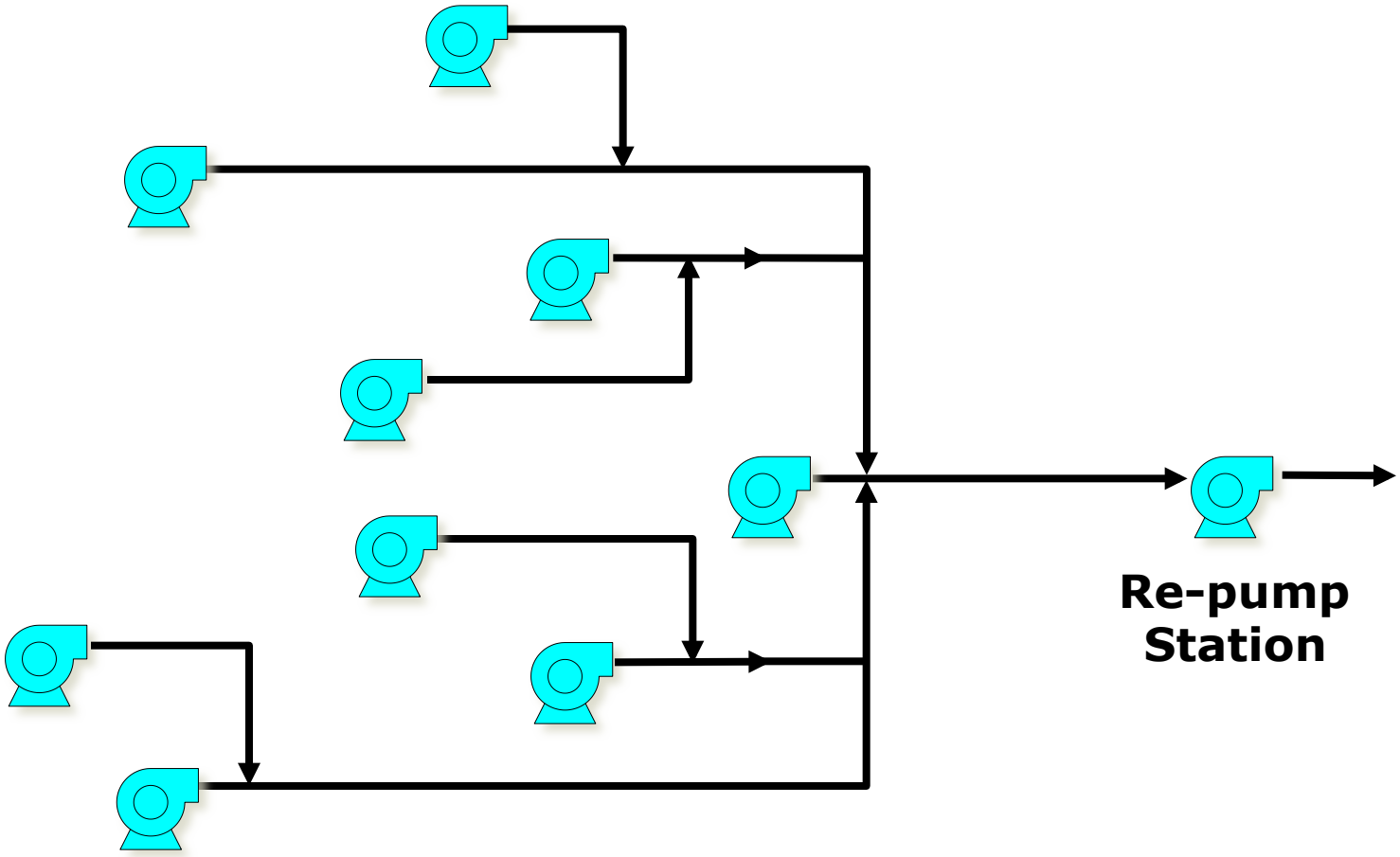
# Small Systems Are "Easy" to Design


**Capacity of pump station #2 must be equal to capacity of pump station #1**

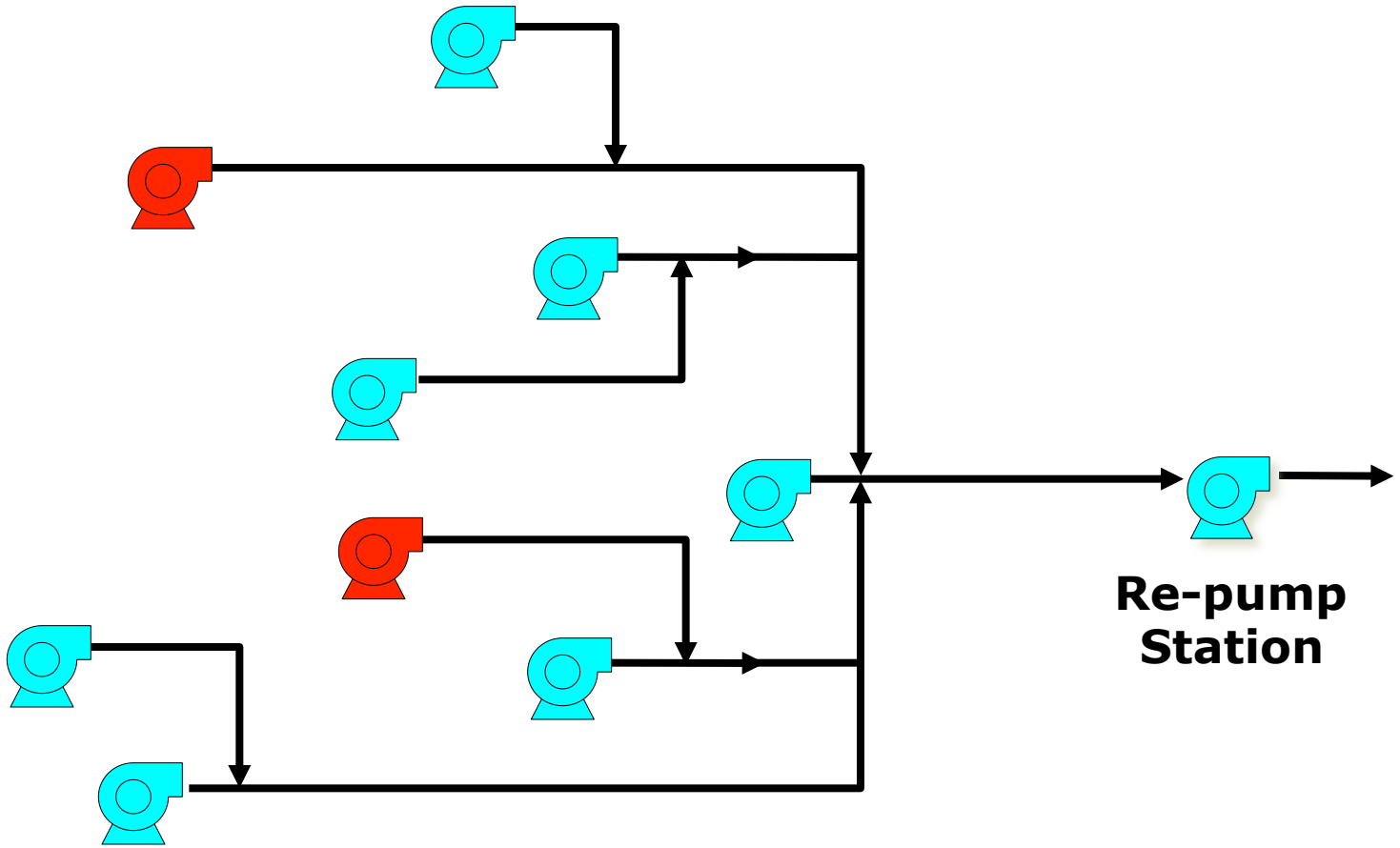
# Large Manifolded Systems Are Another Matter



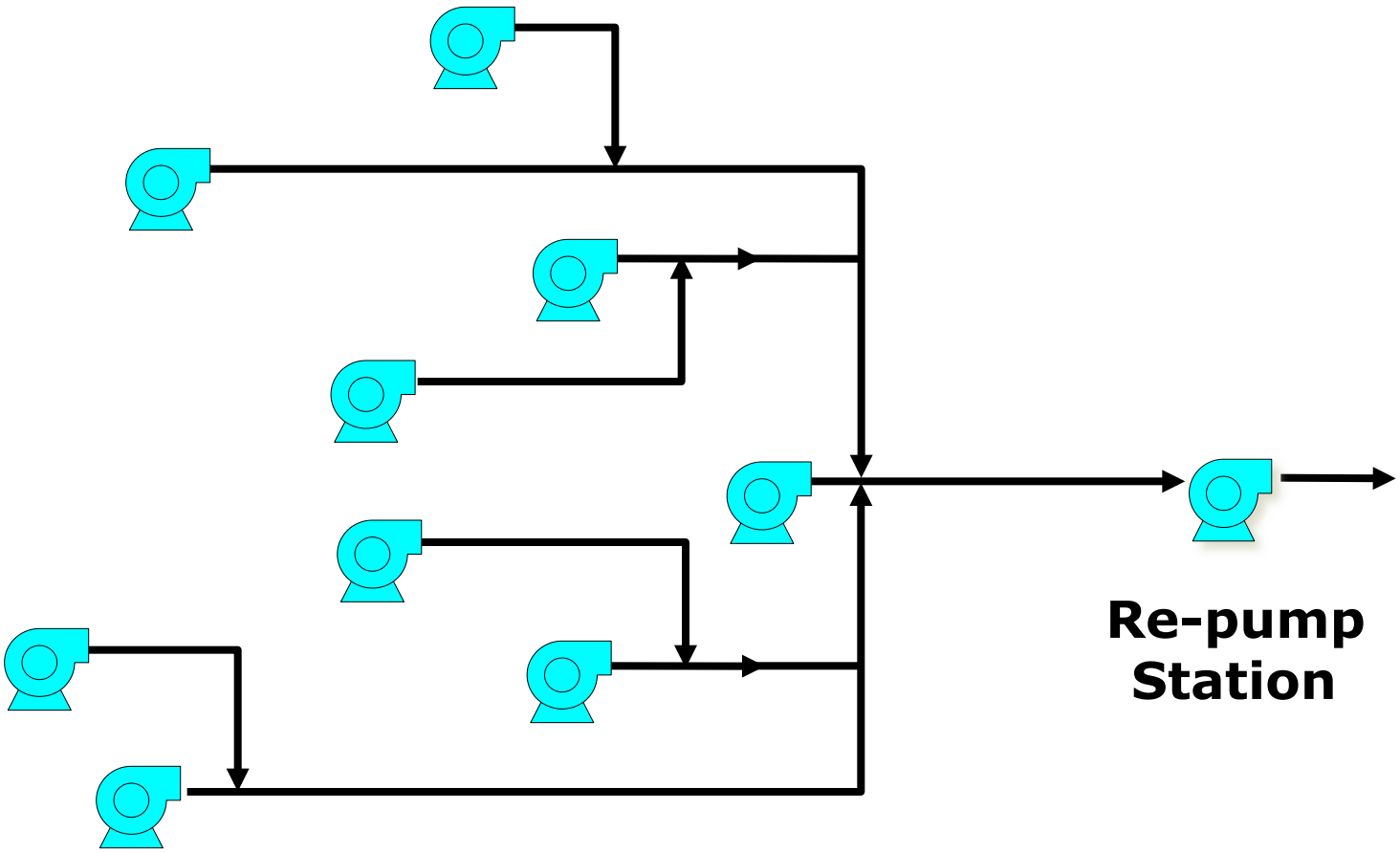
# What is the Appropriate Size of the Re-Pump Station ?



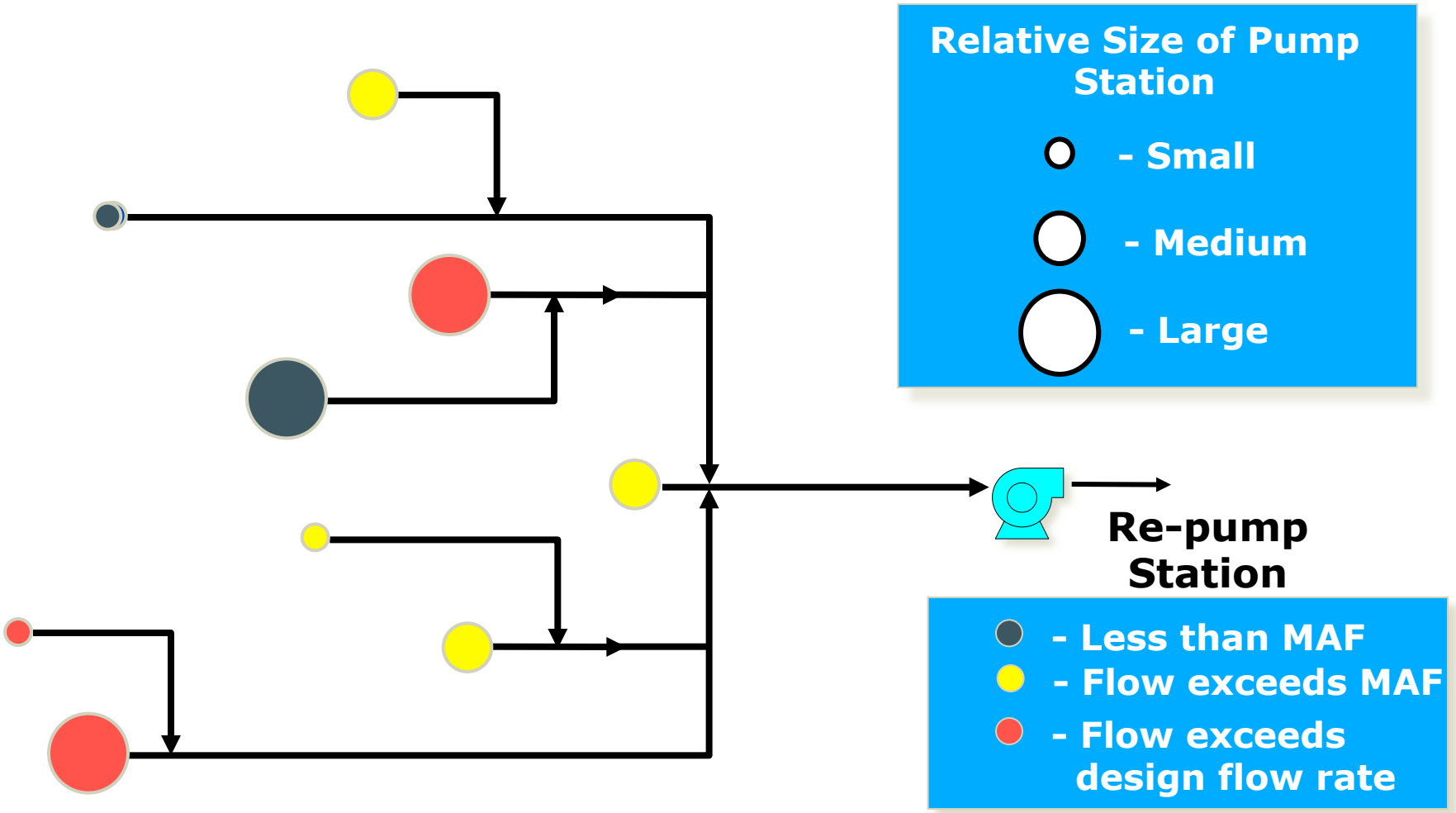
# Modeling Practice – Limit Pumps in Operation



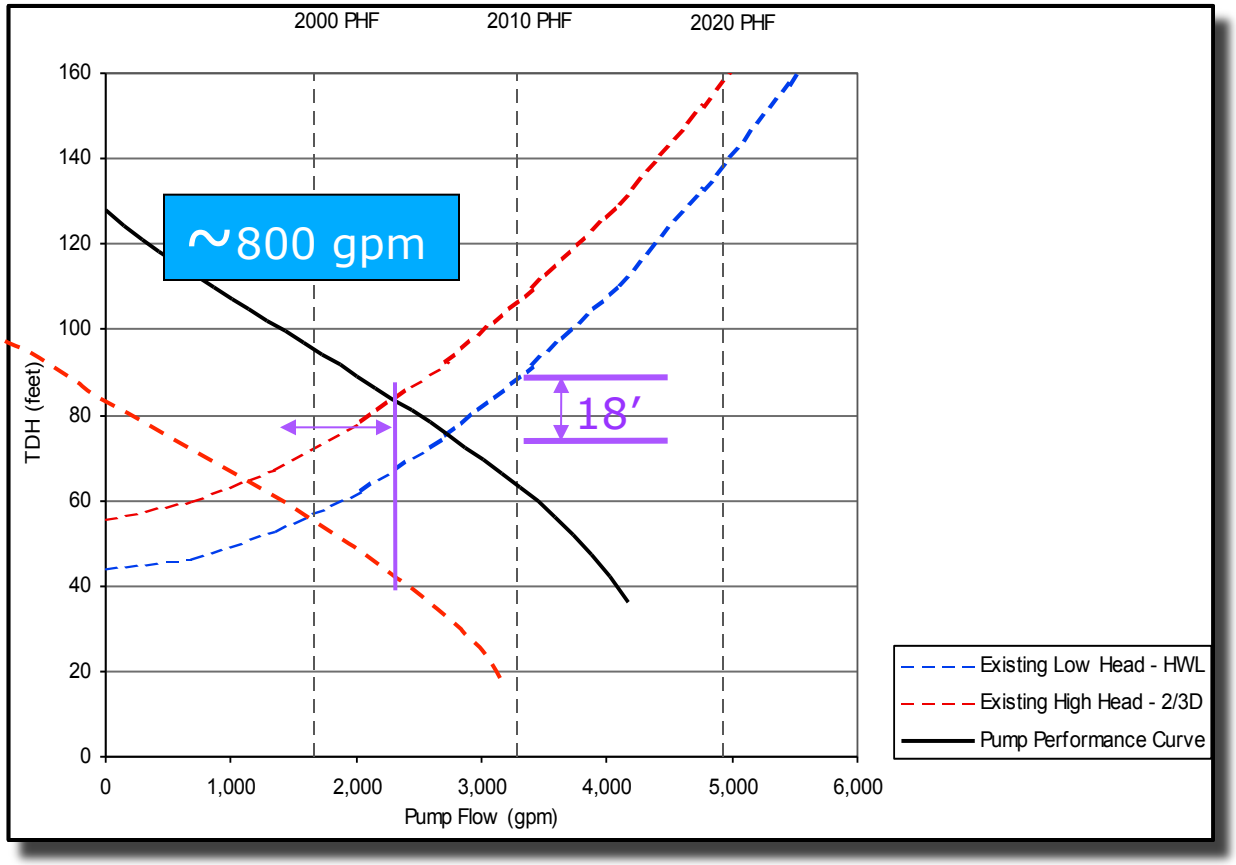
# Modeling Practice – Discount Flows



# Preliminary Evaluation of Manifolded Systems



# Over Sizing Facilities can Cause as Much Trouble as Under Sizing



# Step by Step Design of a Typical Pump Station

# Municipal Design Code Requirements


How many pumps are needed?

A typical design should include permanently-installed redundant pumping capacity equaling the largest single pump in a station

Firm capacity = with one largest pump out of service

First

# Understand Your Project

New, upgrade or retrofit?

New or existing force main?

Present and future conditions?

First

# Understand Your Project

- Owner expectations?
- Present and future conditions?
  - ✓Demographics?
  - ✓Zoning?
  - ✓Land usage?

First

# What do We do First?

Establish relevant design information

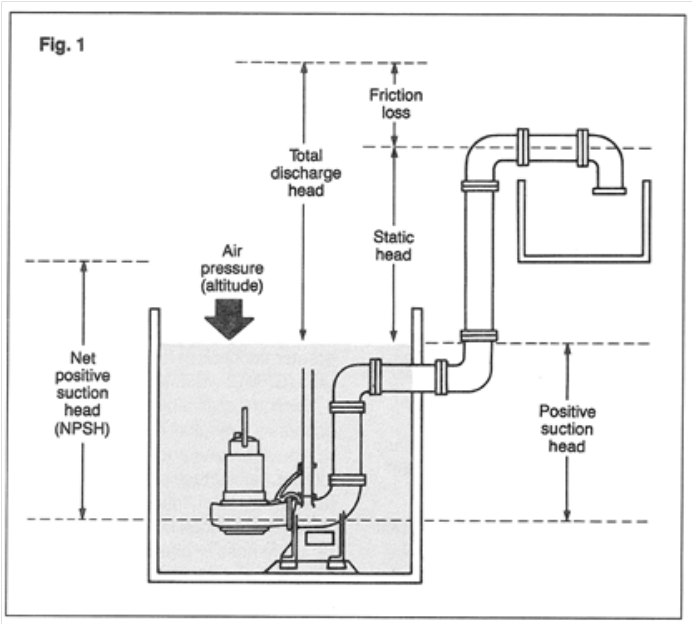
- Location of station
  - ✓Go visit the site!
- Location of discharge point
- Electrical requirements
  - ✓Find out actual line voltages
  - ✓Back-up power needs
  - ✓Utility supply limitations

First

# What do We do First?

## Establish relevant design information, cont.

- Condition of existing installation and equipment
- Verify static head
- Find flow duration data
  - ✓ Daily peak flows
  - ✓ Daily min. flows
  - ✓ 10, 25, 50 or 100 year flows
- Research existing force main data

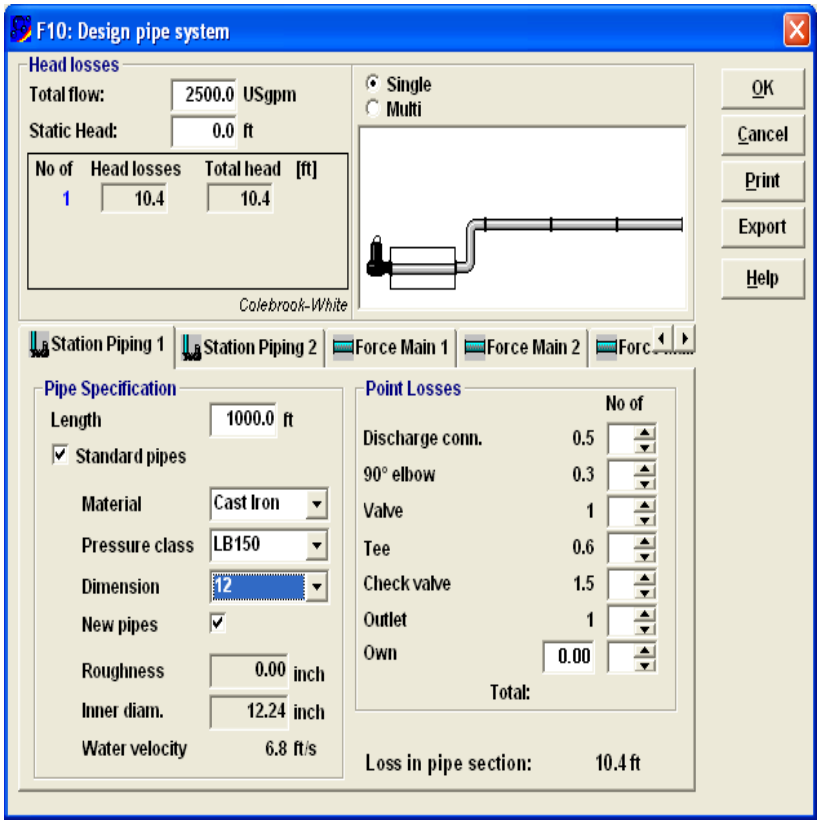


NEXT

# Quick and rough design take-off

## System head loss calcs

- Use 6fps (based on daily peak flow) to rough out a force main size
  - ✓ Calculate FM head loss
  - ✓ Add ~5ft for station piping losses
  - ✓ Don't add unnecessary safety factors!



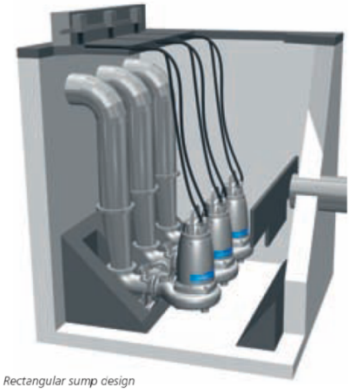
NEXT

# Quick and rough design take-off

Establish station design flow based on one of the year daily peak flows

- Duplex station
  - 2 equal pumps, each sized for daily peak flow
  - Standard concept
- Triplex station
  - 3 equal pumps, each sized for ½ daily peak flow
  - May yield better energy efficiency, more redundancy, and a lower LCC

Circular sump design

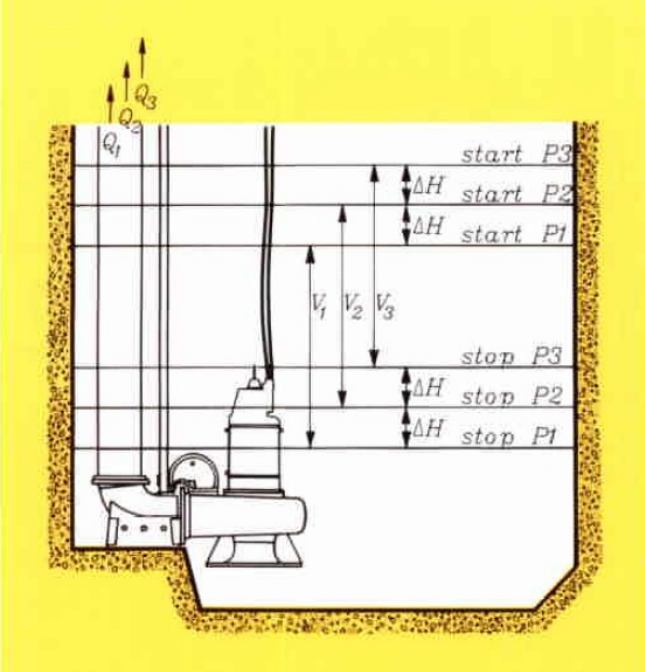


Rectangular sump design

NEXT

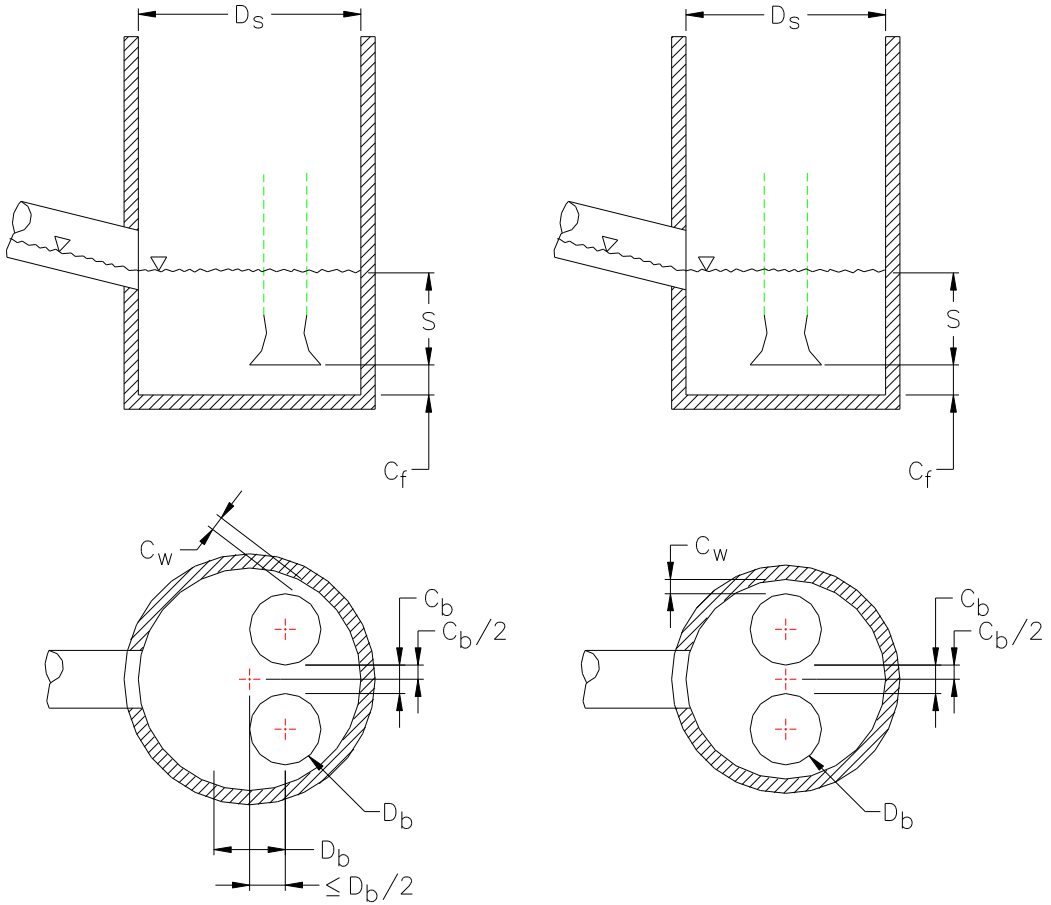
# Quick and rough design take-off

- Select pumps for both the duplex and triplex scenarios
- Establish the minimum station inside diameter based on:
  - ✓ HI 9.8 intake design formula (section 9.8.2.3)
  - ✓ I.D. based on the required minimum active wet pit volume
  - ✓ Pump manufacturer's recommendations
- Decide on preliminary start-stop levels



NEXT

# HI 9.8 intake design formula for minimum station ID




Warning: This formula may give a sump diameter that is too small – verify pump start/hour and active sump volume

$$D_{S\min} = 2 \cdot D_b + 2 \cdot C_w + C_b$$

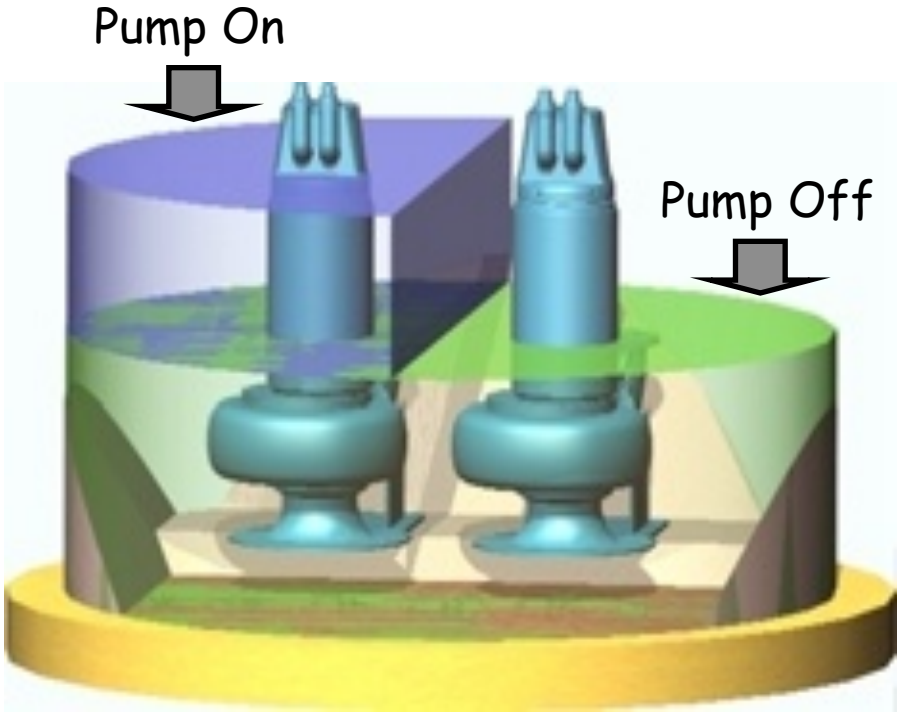
$$D_{S\min} = 2.5 \cdot D_b + 2 \cdot C_w + C_b$$

# Station Diameter & Minimum Active Volume

NEXT

- Active volume is the volume between pump "on" and pump "off" (in a duplex station)

- Min. volume is dictated by allowed motor starts/hour



# How To Determine Minimum Active Volume

NEXT

$$V_{min.} = (T_{min.} \times Q) \div 4$$

Where:

$V_{min}$ = minimum active sump volume

$T_{min}$ = minimum cycle time for fill-up and draw-down

Q = pump flow rate

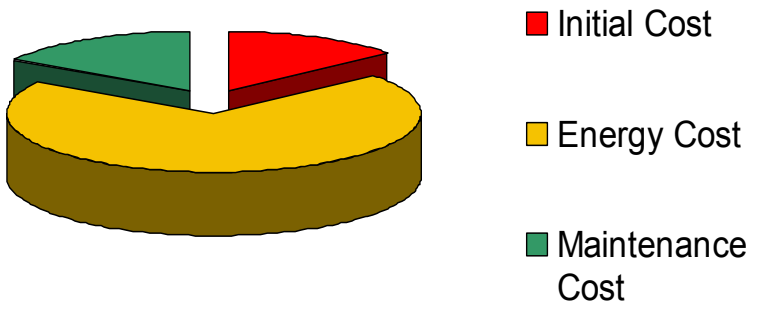
To keep the size of the sump at a reasonable minimum, the pump capacity should be two times the inflow at critical or peak flow times

NEXT

# Quick and rough design take-off

## Make a decision

- Analyze the two station designs based on:
  - ✓ Excavation volume ($/c.y.)
  - ✓ Pump, valve, piping, accessory, and control cost ($)
  - ✓ Energy usage (kW-hr)
  - ✓ Redundancy (subjective value?)
  - ✓ Complexity and general attractiveness (subjective value?)
  - ✓ Calculate station LCC (total $ for life of station)

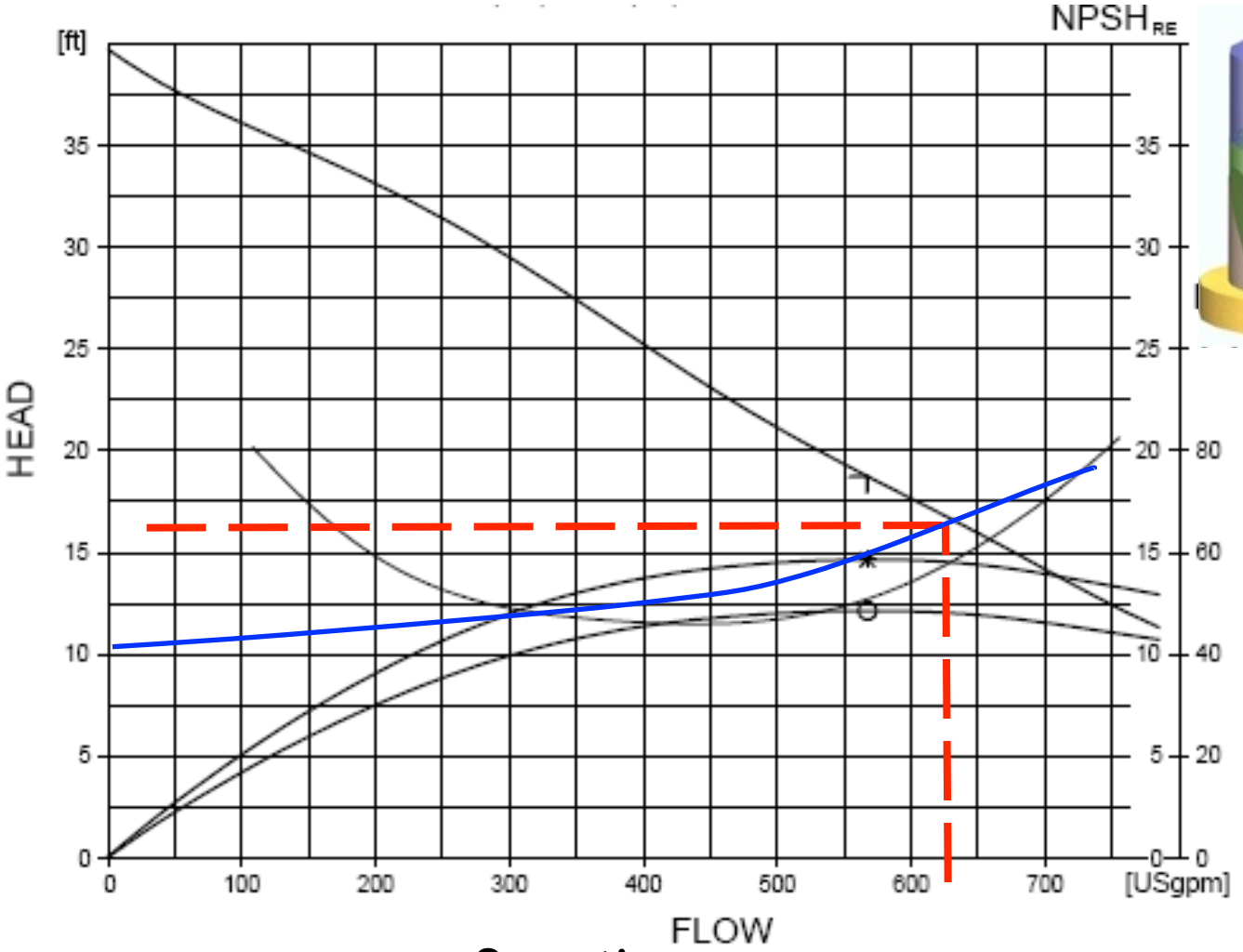


Final

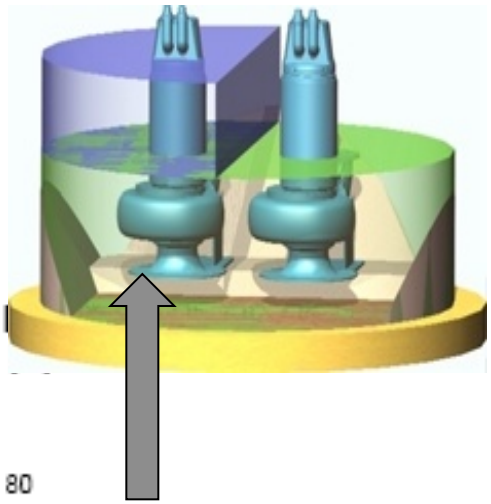
# Final Design Process

- Use the "Quick & Rough" design as a basis to lay out final station and FM piping
  - ✓ Make adjustments based on findings during the preliminary pump selections
    - ➢ Be flexible with head loss and flow rates so that you can select pumps that operate close to BEP
  - ✓ Use station piping that gives an average liquid velocity of 3-6 fps through fittings
  - ✓ Use a FM diameter that satisfies your LCC analysis (often 4-7 fps)

# Pump Selection– Full Sump




**Operating range**



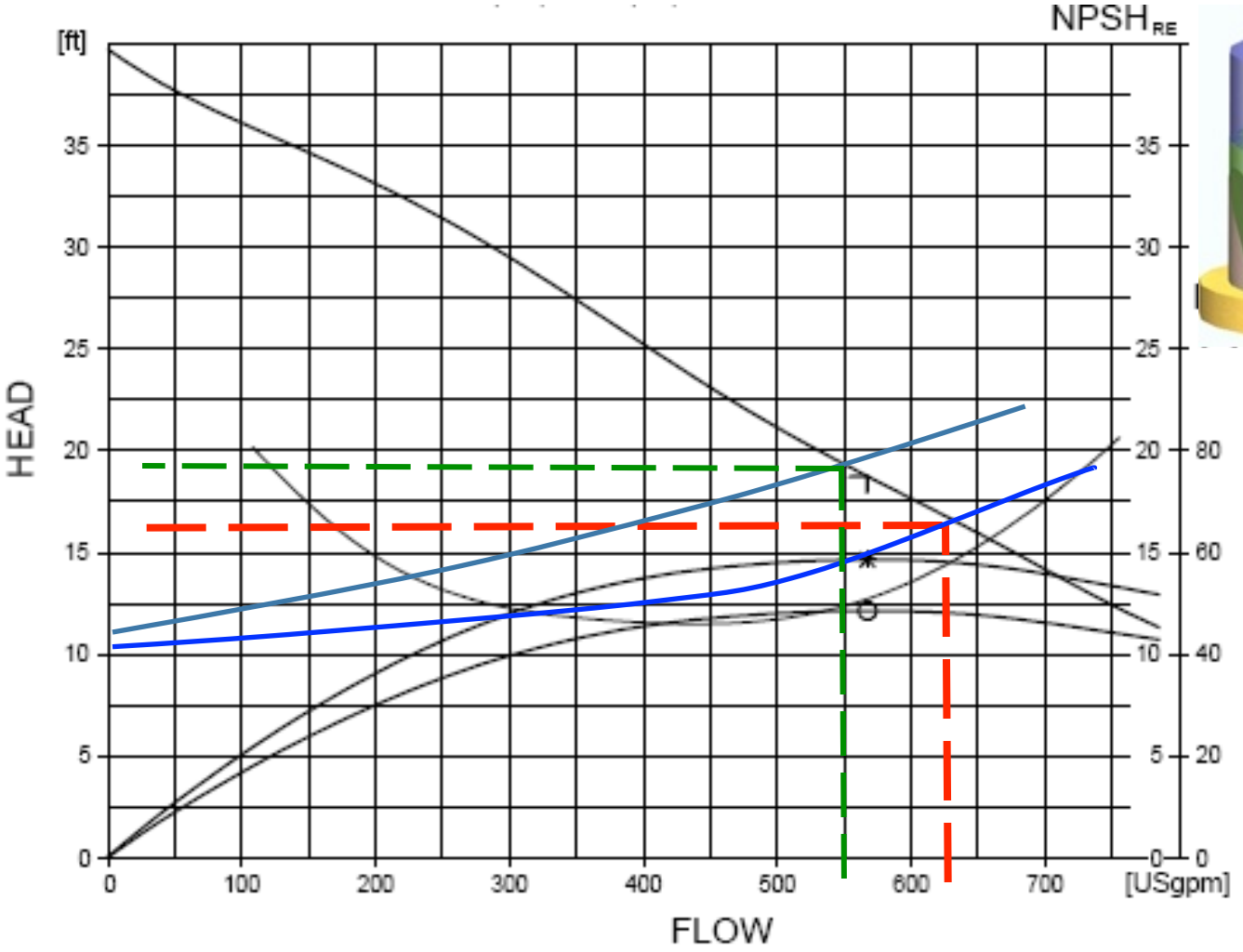
## Full Sump

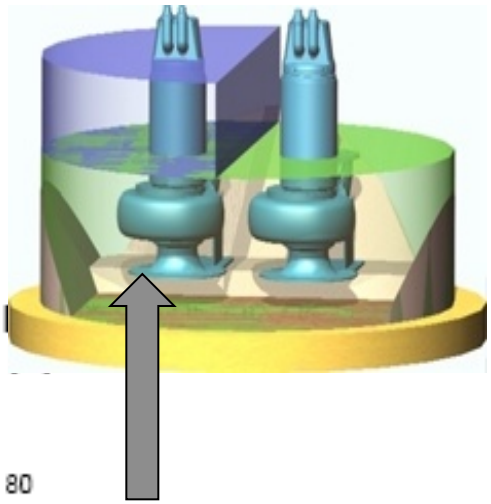
Min Static Head

New Pipe

Minimum Friction

# Pump Selection – Head loss increase



**Full Sump**

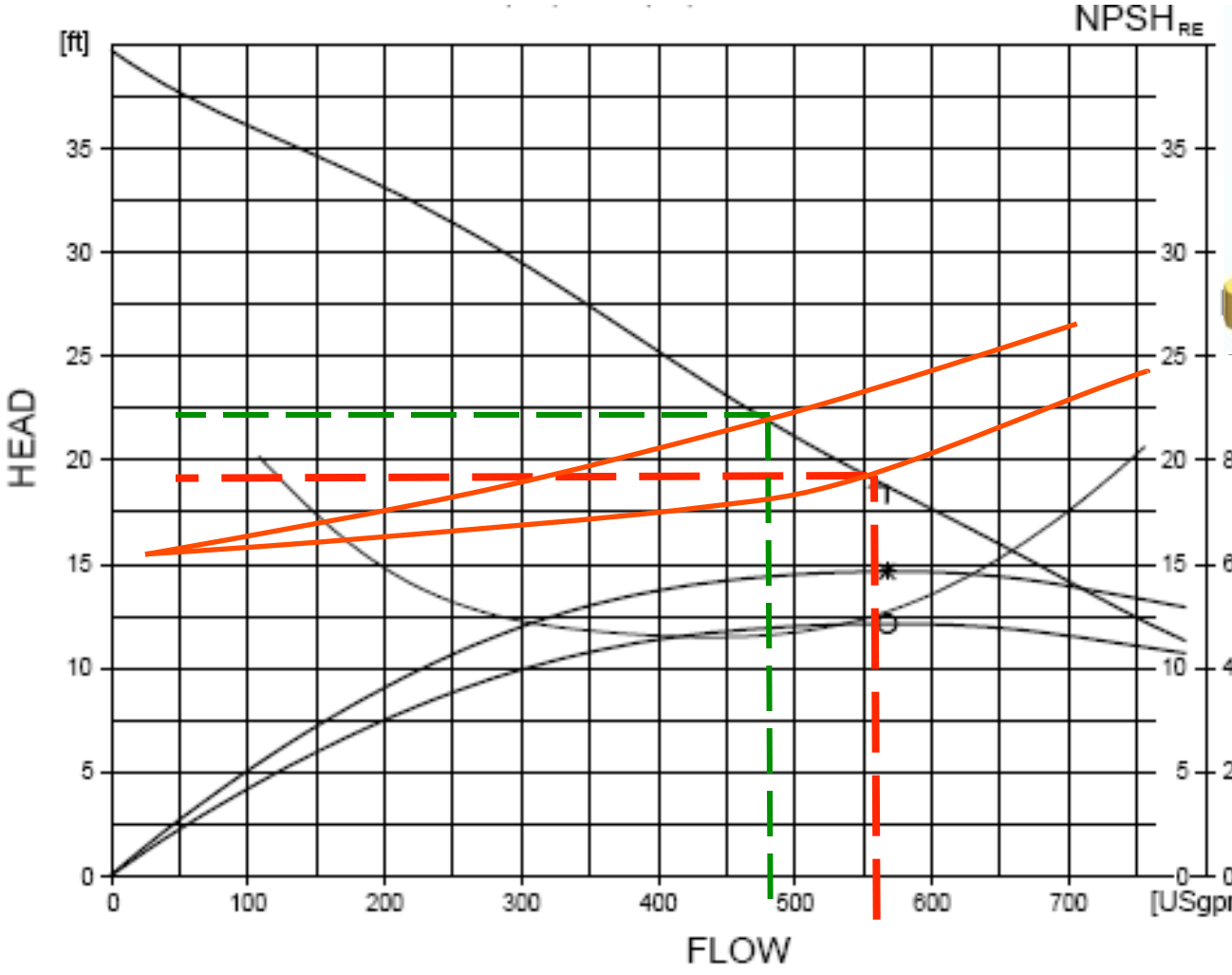
Min Static Head

Old Pipe

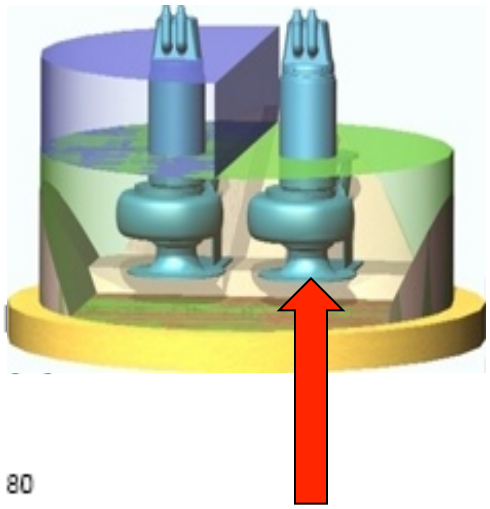
Maximum Friction

**Operating range**

# Pump Selection– Empty Sump




Operating range



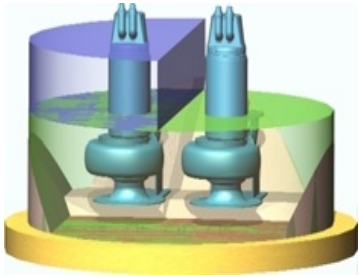
**Empty Sump**

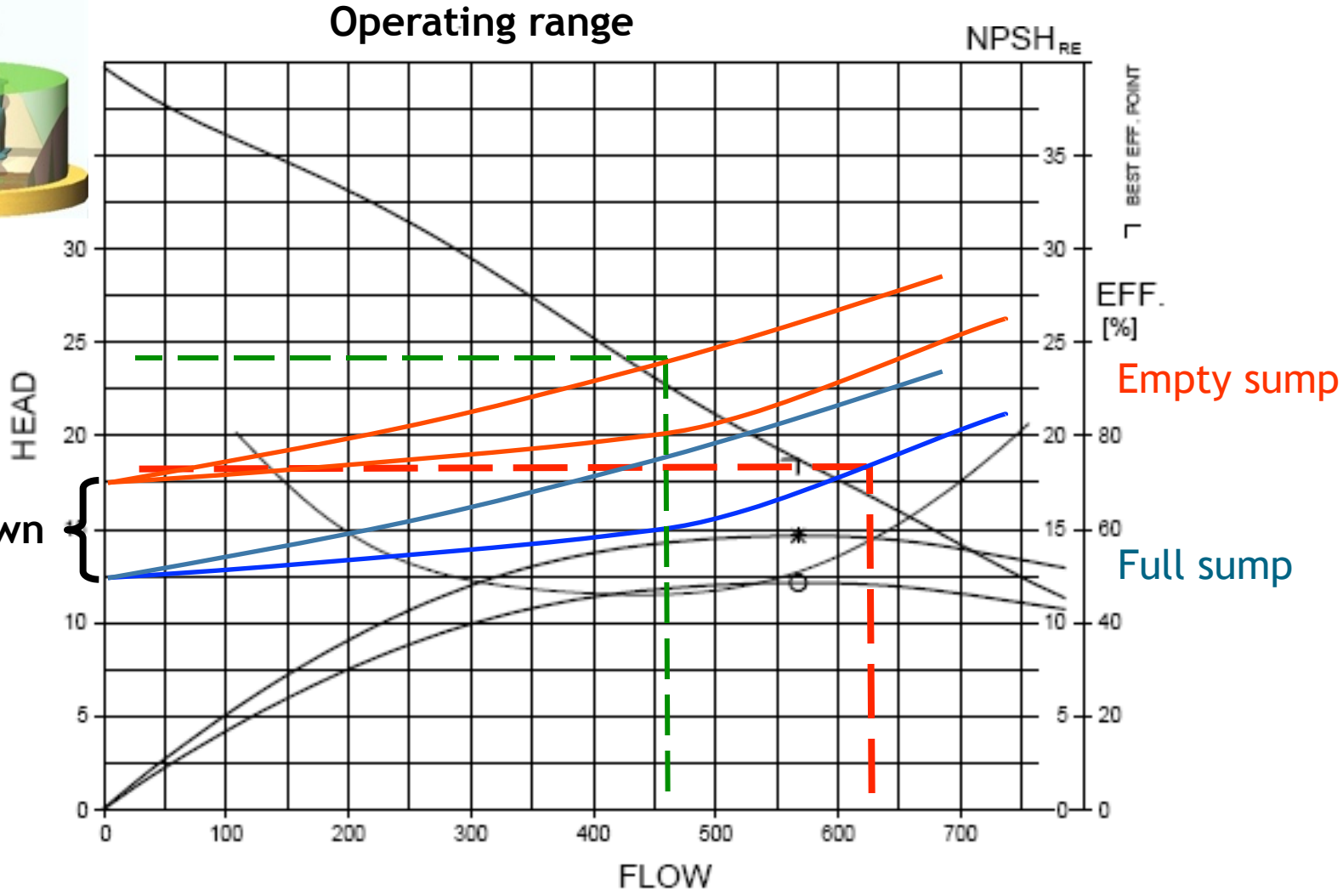
Min Static Head

New Pipe

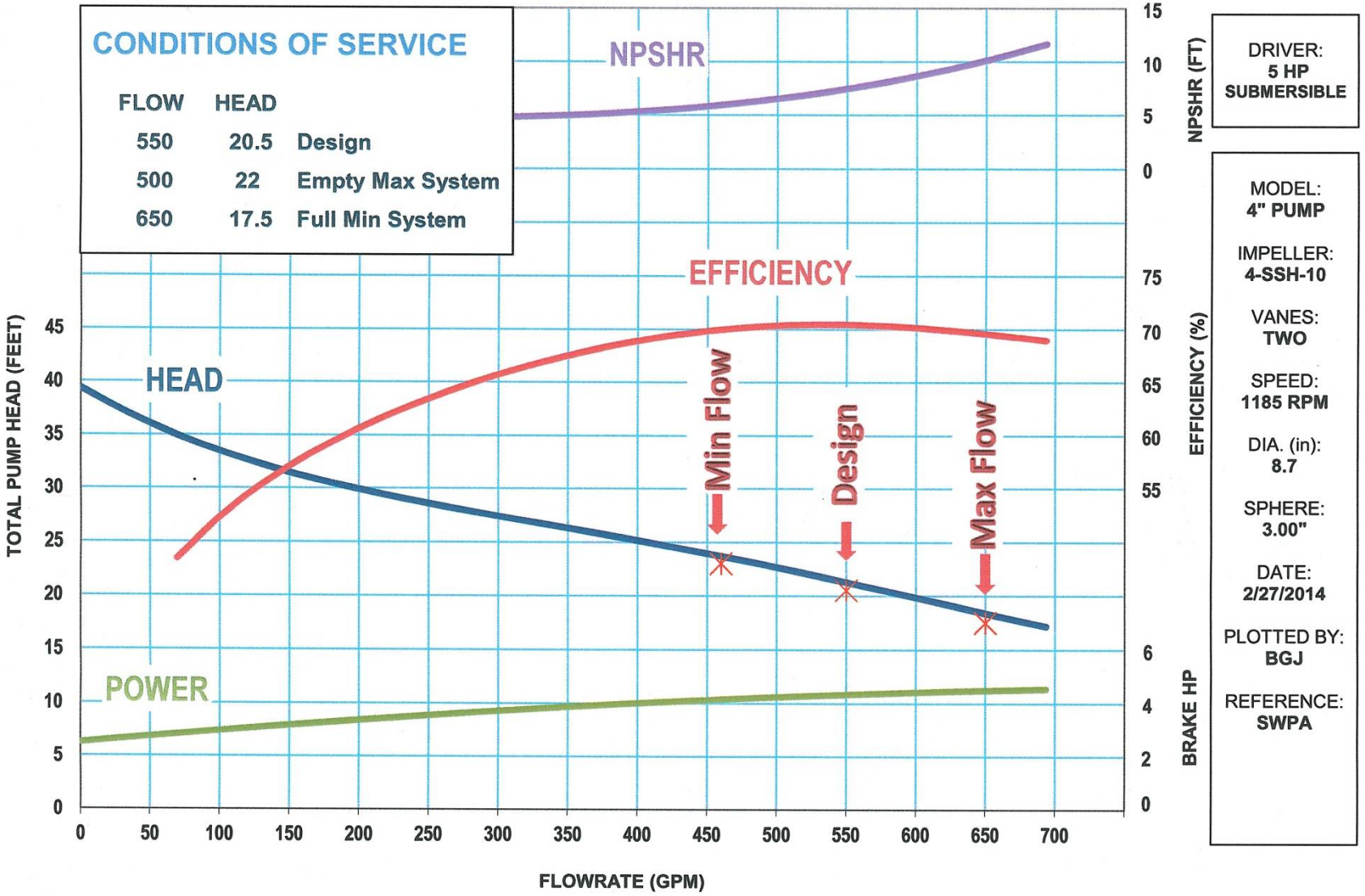
Old Pipe

# Pump Selection – All Together

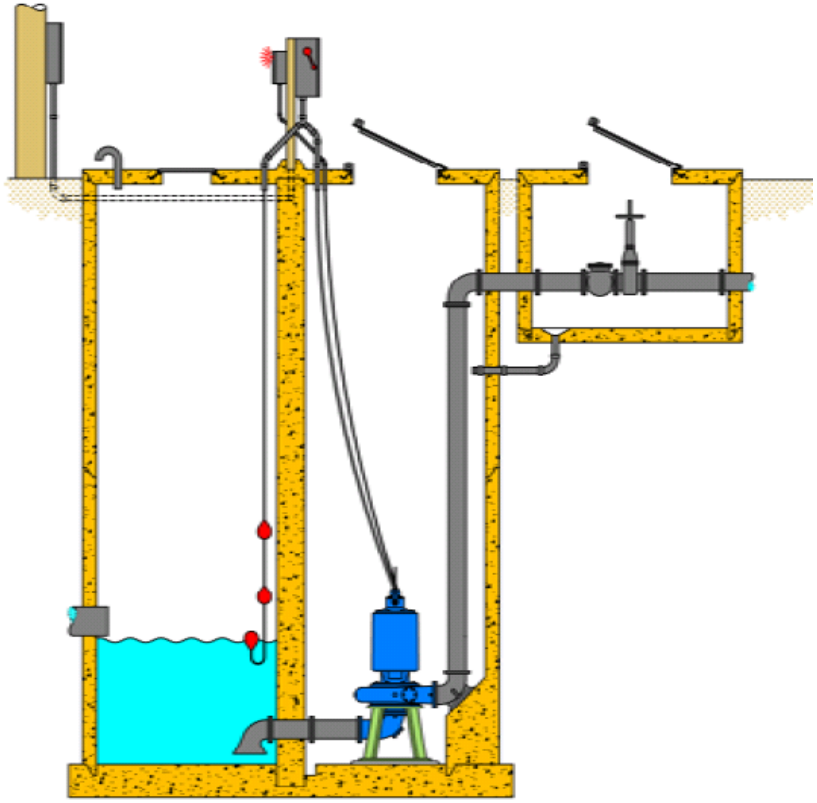




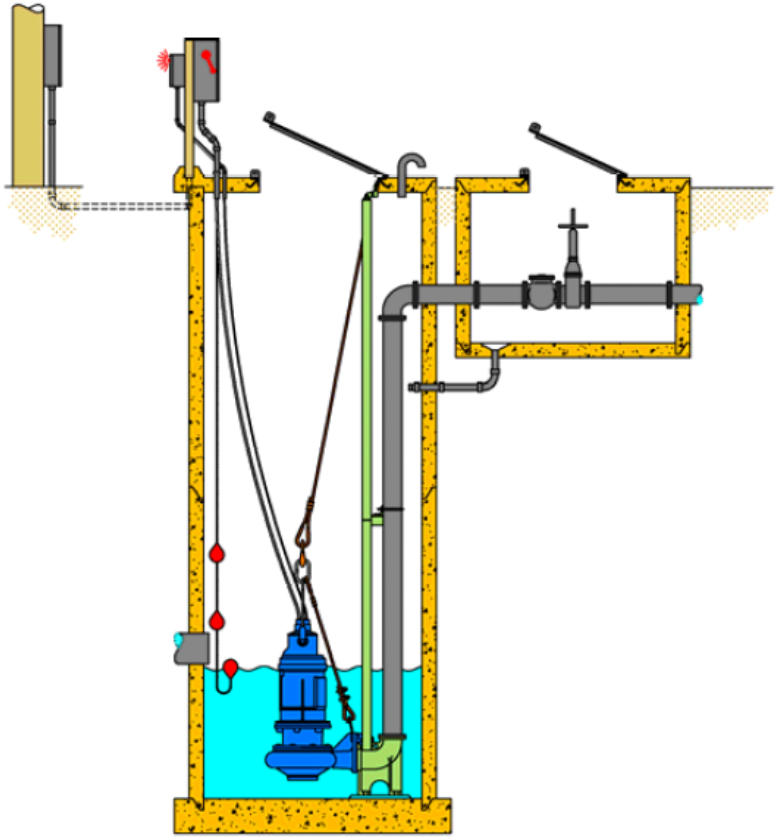
# Pump Operating Range



# Summary



Dry Well Pumping Station



Wet Well Pumping Station

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# Q & A


## To contact today's presenters, email:

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Ernest C. Sturtz - sturtzec@cdmsmith.com

Jim Vukich – jim.vukich@xyleminc.com

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