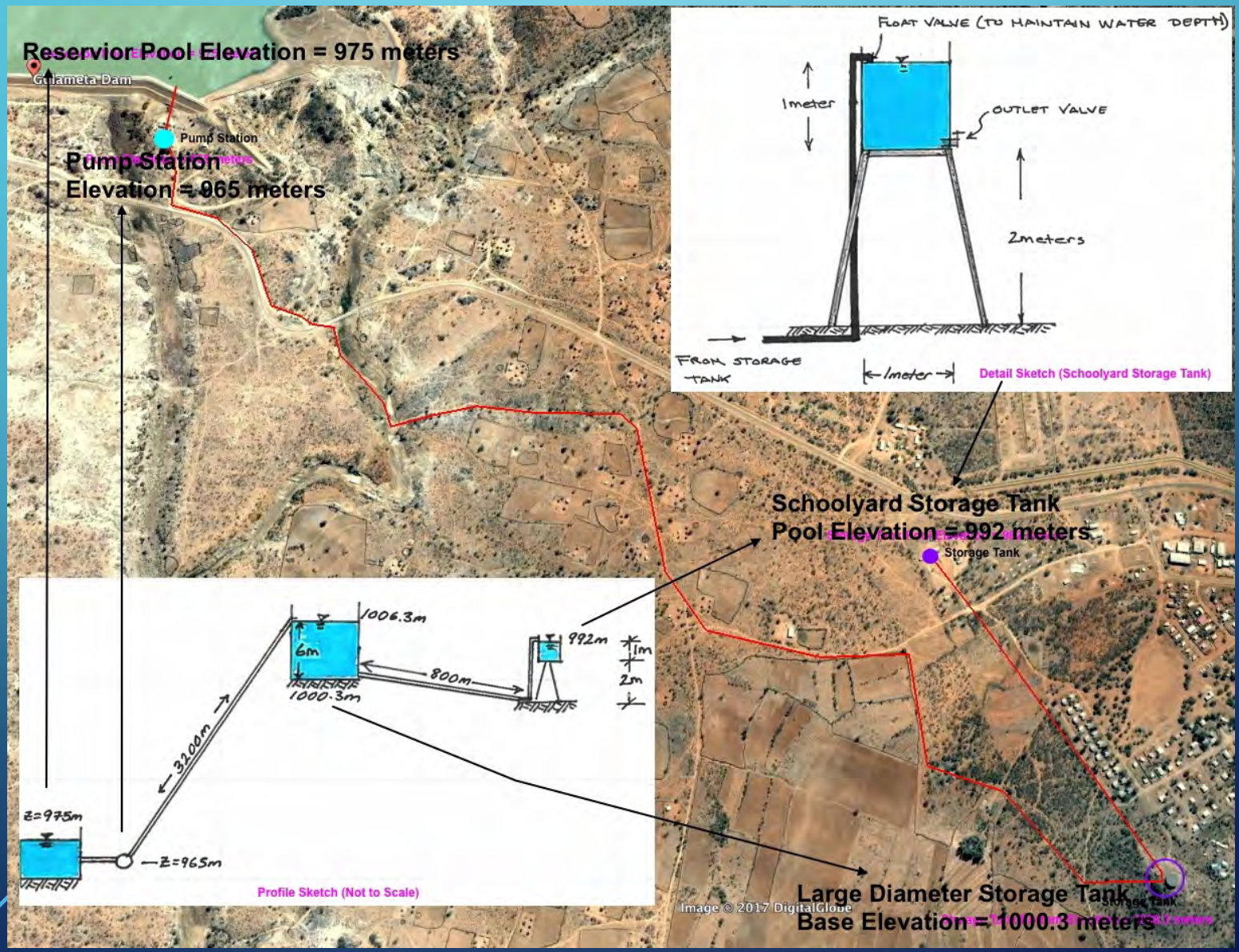
# CE 3372 WATER SYSTEMS DESIGN

PIPELINE HYDRAULICS EXAMPLES : PART 2

# LINKING SYSTEMS

- A hydraulic system can be analysed as a set of linked components to make an otherwise complicated system easier to analyze.
- Idea is to break system into independent parts, analyze the parts then reassemble to answer questions about the whole system
- Best illustrated by an example

# LINKING SYSTEMS

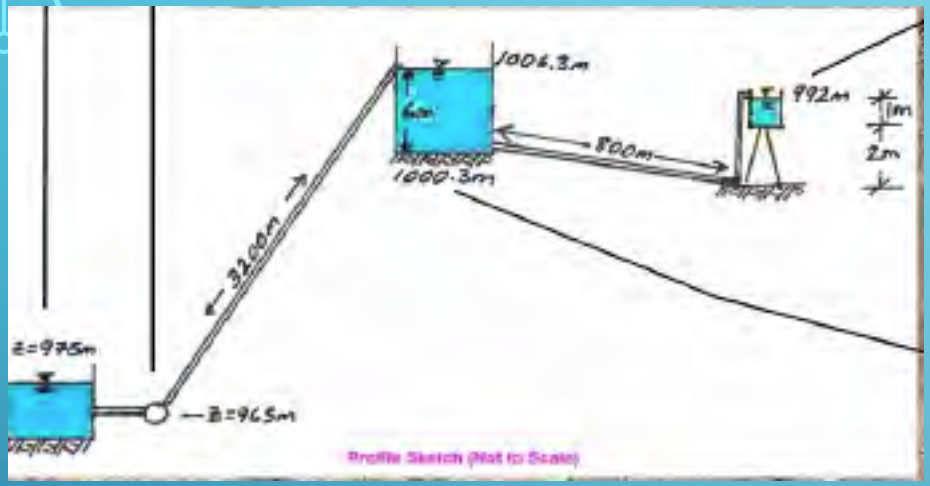


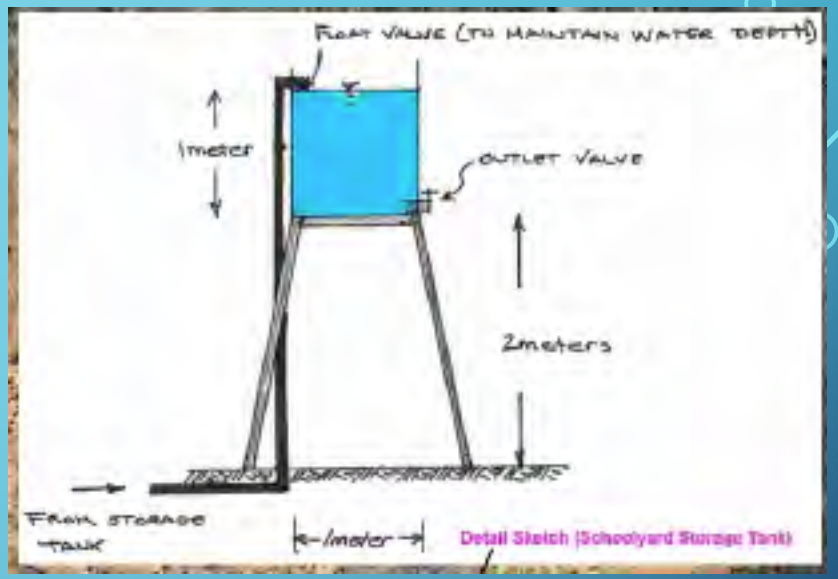
# LINKING SYSTEMS

- Analyze proposed system to determine anticipated behavior
  - Float valve fails at school
  - Outlet valve accidently left open
  - Pump operation under worst failure mode
  - Pump fails, time until system fails
    - Float valve limited
    - Oultet valve limited

# LINKING SYSTEMS

- Float valve fails at school




- Upstream head = 1006.3 m
  (pump working, supply tank stays full)
- Downstream head = 992 m
  (pool elevation at schoolyard tank overflow)

# LINKING SYSTEMS

- Float valve fails at school
- $Z_1$= 1006.3 m ; $Z_2$ = 992 m
- 2 bends, K =1.5 each
- 1 inlet K =0.5
- Upstream valve K =0.15
- Float valve K = 70
- Viscosity = 1.0 E-06sq.m/s
- Ks (HDPE) = 0.007mm
  0.000007m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Water Properties (SI) using Python

Water Properties (SI)
adapted from Table A5 in Elger, Crowe, Roberson 2013. Engineering Fluid Mechanics. Wiley&Sons.

Machine Name : theodore-macbookpro.ttu.edu
Run Date : Tue Aug 11 14:54:11 2020

------ INPUT VALUES ------
Temperature = 20.0 (degrees C)
------ LOOKUP VALUES -----
Density = 998 (kg/m^3)
Specific Weight = 9790 (N/m^3)
Dynamic Viscosity = 0.001 (N-s/m^2)
Kinematic Viscosity = 1e-06 (m^2/s)
Vapor Pressure = 2340 (N/m^2) - absolute

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Absolute Roughness Lookup using Python

Absolute Roughness Height (in millimeters) Lookup

Database Last Updated 10 AUG 2020

Machine name : atomickitty.ddns.net
Run Date : Tue Aug 11 14:48:16 2020

------ DATABASE QUERY VALUES ------
Description = PVC and plastic pipe
Absolute Roughness (millimeters) = 0.007
Reference = adapted from https://www.nuclear-power.net/nuclear-engineering/fluid-dynamics/major-head-loss-friction-loss/relative-roughness-of-pipe/

# LINKING SYSTEMS

- Hydraulic Model

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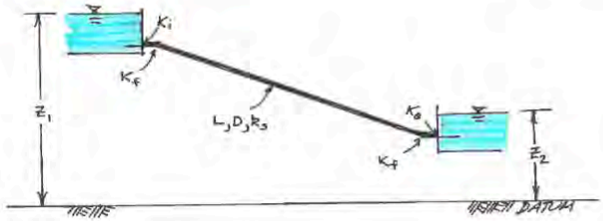
NewANTS

## Discharge Between Two Reservoirs (SI Units)



Pipeline connecting two reservoirs. Pool elevations are Z1 and Z2.
Pipeline length is L, diameter is D, sand roughness height is ks.
Pipeline can be analyzed with entrance and exit loss coefficients (Ki and Ke).
Pipline can be analyzed with 2 fitting (Kf) loss coefficients.
Calculator solves for flow rate in the pipeline.

Uses Jain equation to make initial flow estimate,then Newton's method to refine the estimate.

Detailed Explaination (Under Construction)

Pipeline Parameters
Pool Elevation (Z1):
1006.3
Pool Elevation (Z2):
992
Pipeline Length (L) :
800
Pipeline Diameter (D) :
0.127
Sand Roughness Height (ks) :
0.000007
Kinematic Viscosity (nu) :
1e-6
Gravitational Acceleration (g) :
9.8
9.8

Fittings Parameters
Inlet Loss (Ki):
0.5
Exit Loss (Ke) :
70
Fitting Loss (Kf) :
0.15
Fitting Loss (Kf) :
3

Use zero fitting values to ignore minor losses

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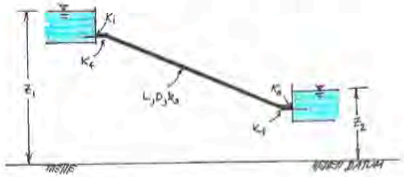
Discharge Between Two Reservoirs (SI units)(Update: 2020-0811)

Machine Name : atomickitty.ddns.net
Run Date : Tue Aug 11 15:45:32 2020
COMMAND TO RUN : /usr/bin/Rscript 2QReservoir.R

Return Code : 0

| INPUT VALUES | | |
|---|---|---|
| Pool Elevation 1 (Z1) = | 1006.3 | meters |
| Pool Elevation 2 (Z2) = | 992.0 | meters |
| Pipeline Length (L) = | 800.0 | meters |
| Pipeline Diameter (D) = | 0.127 | meters |
| Sand Roughness Height (ks) = | 7e-06 | meethers |
| Kinematic Viscosity (nu) = | 1e-06 | meters^2/second |
| Gravitational Acceleration (g) = | 9.8 | meters/second^2 |
| Inlet Loss Coefficient (Ki) = | 0.5 | |
| Outlet Loss Coefficient (Ke) = | 70.0 | |
| Fitting Loss Coefficient (Kf) = | 0.15 | |
| Fitting Loss Coefficient (Kf) = | 3.0 | |



| COMPUTED RESULT | | |
|---|---|---|
| Discharge = | 0.01586378 | m^3/sec |
| Friction Factor = | 0.01667988 | |
| EGL Slope = | 0.017875 | m/m |

~ 16 liters/second