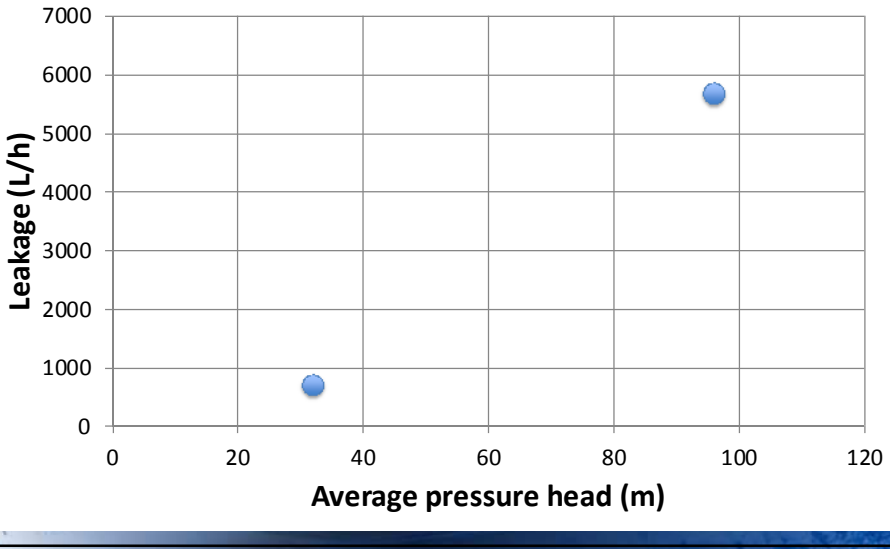
Leakage fundamentals

- Orifice equation (from conservation of energy):

$$Q = C_d A\sqrt{2gh}$$

- Leaks are orifices

Amanzimtoti CBD



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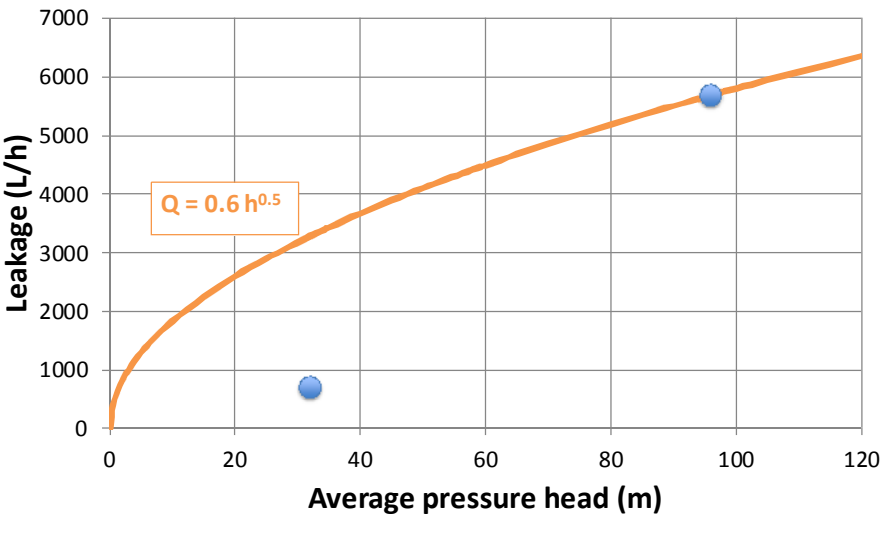
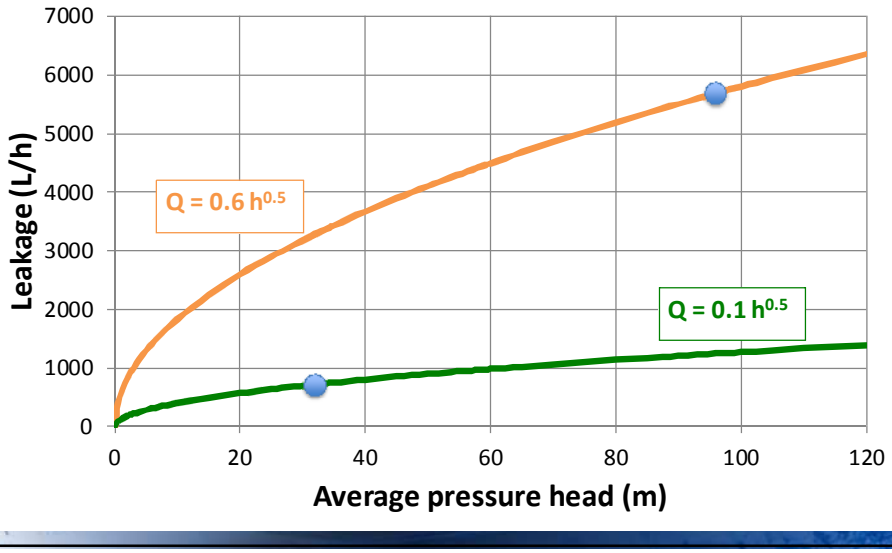


Amanzimtoti CBD



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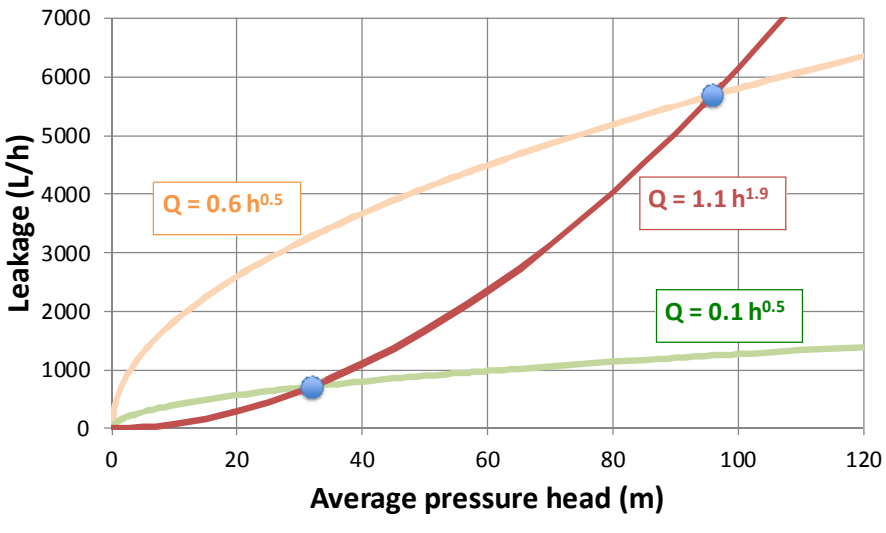


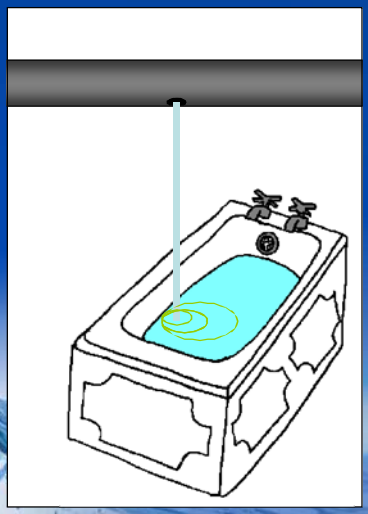
Empirical N1 power equation

$$Q = ch^{N1}$$

- For orifice flow: N1 = 0.5
- Reported field values: 0.5 ≤ N1 ≤ 2.8

$$\frac{Q_1}{Q_2} = \left(\frac{h_1}{h_2}\right)^{N1}$$

Effect of N1



- Hole diameter: 1 mm
- Pressure: 50 m
- Time to fill bath for
  - N1 = 0.5 → 3 h
  - N1 = 2.6 → 3 s

So why not use the N1 equation?

$$Q = ch^{N1}$$

- No fundamental scientific basis
- Empirical equation - only be apply in measured range
- C and N1 are not constant
- Dimensionally awkward

Reasons for N1 range

- Orifice hydraulics
- Soil hydraulics
- Leak area variation
- Night-time water demand
- Combination of many leaks
- Mathematical incompatibilities

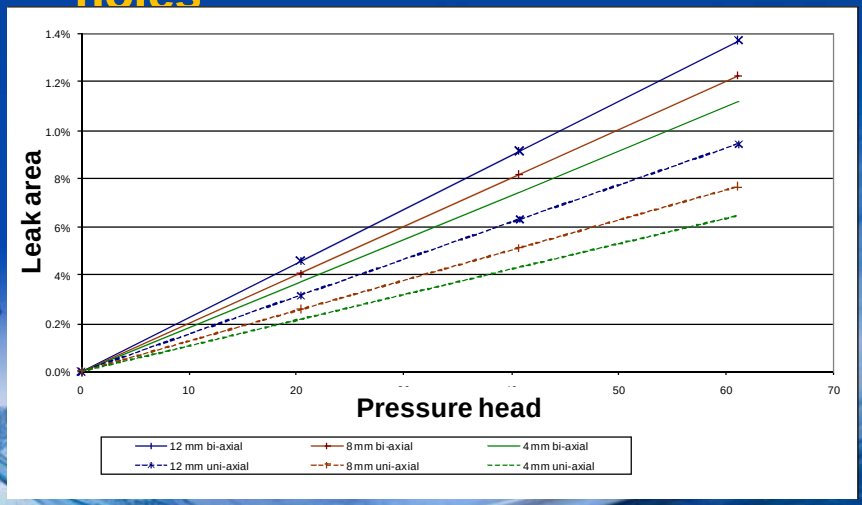
Reasons for N1 range

- Orifice hydraulics
- Soil hydraulics
- **Variation in leak area**
- Night-time water demand
- Combination of many leaks
- Mathematical incompatibilities

How can leak area change?

- ~~Fixed leak~~
- Elastic deformation
- Viscoelastic deformation
- ~~Plastic deformation~~
- ~~Fracture~~

Elastic deformation - round holes



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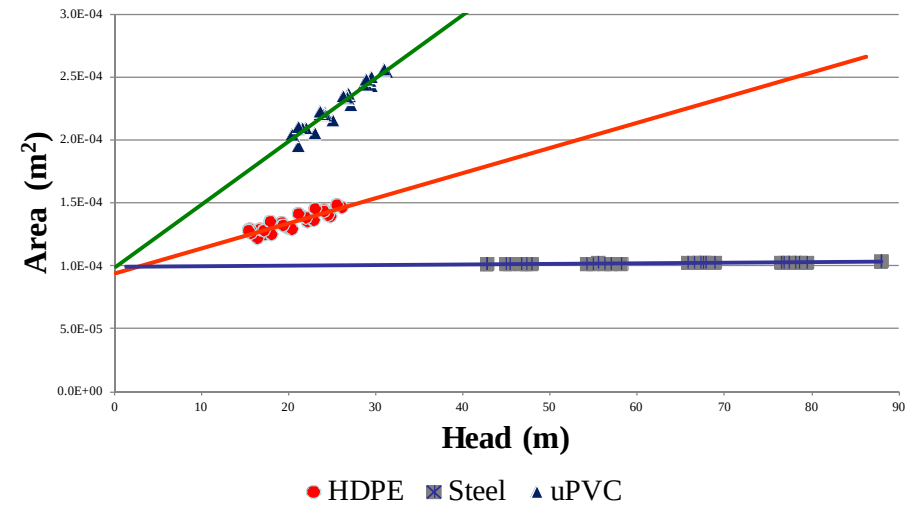
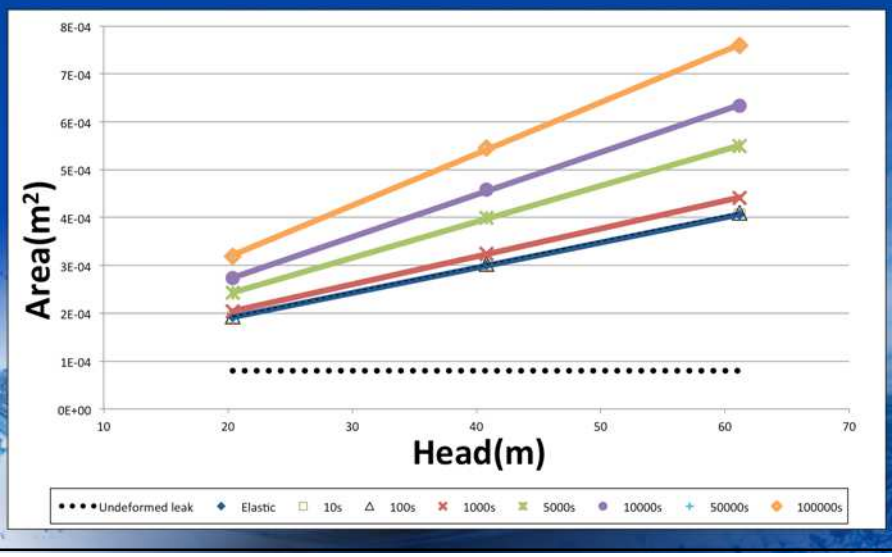
Elastic deformation - 100 mm crack



Viscoelastic deformation – longitudinal crack



FAVAD Equation

$$Q = C_d A\sqrt{2gh}$$

$$A = A_0 + mh$$

$$Q = C_d\sqrt{2g}\left(A_0 h^{0.5} + mh^{1.5}\right)$$

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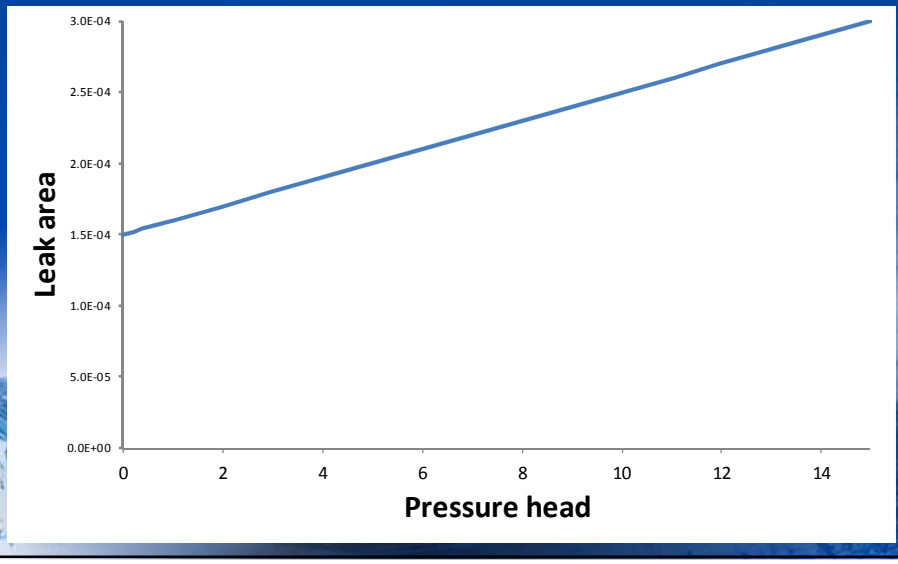
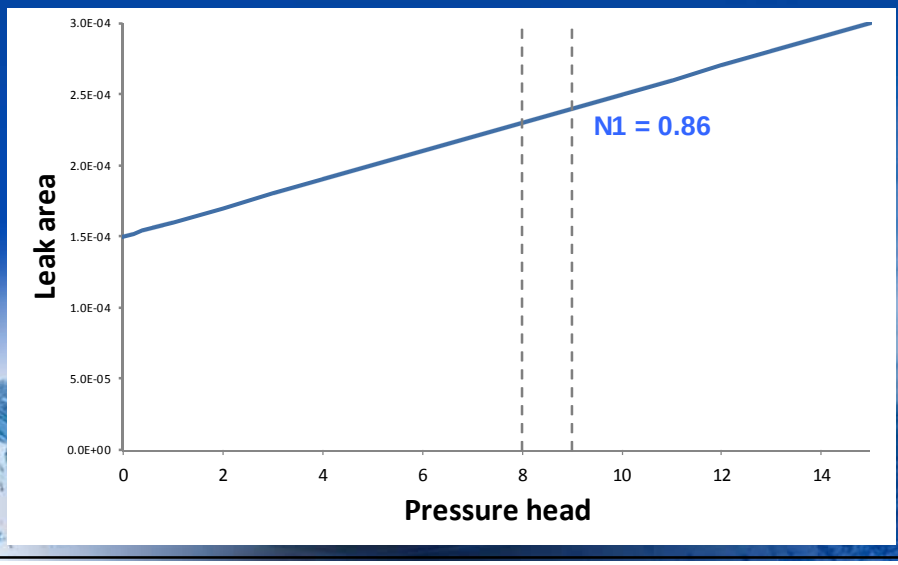
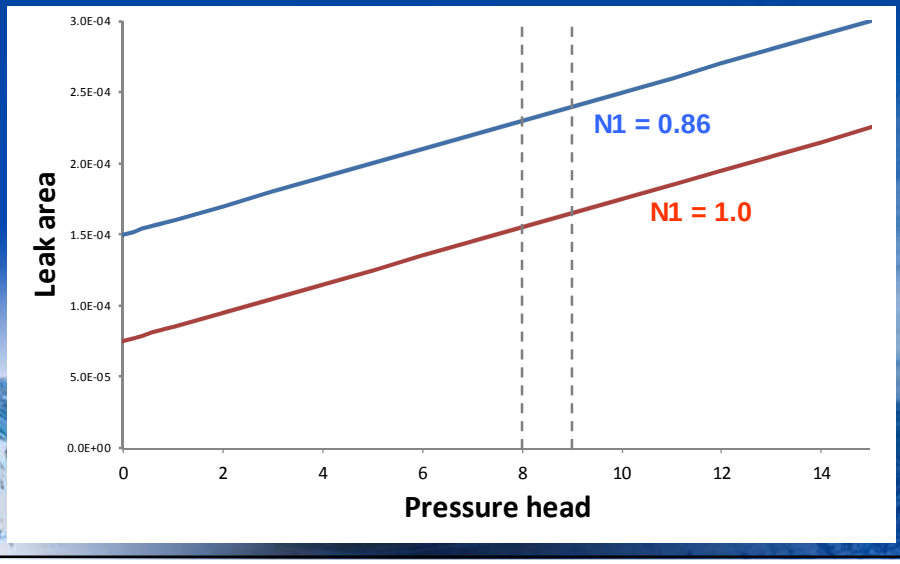
N1 for longitudinal crack with fixed length



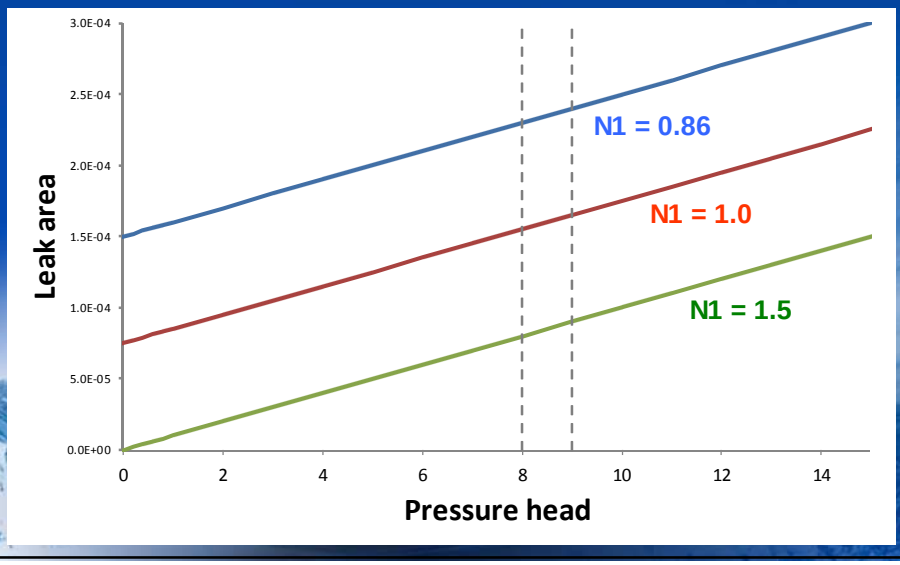
N1 for longitudinal crack with fixed length



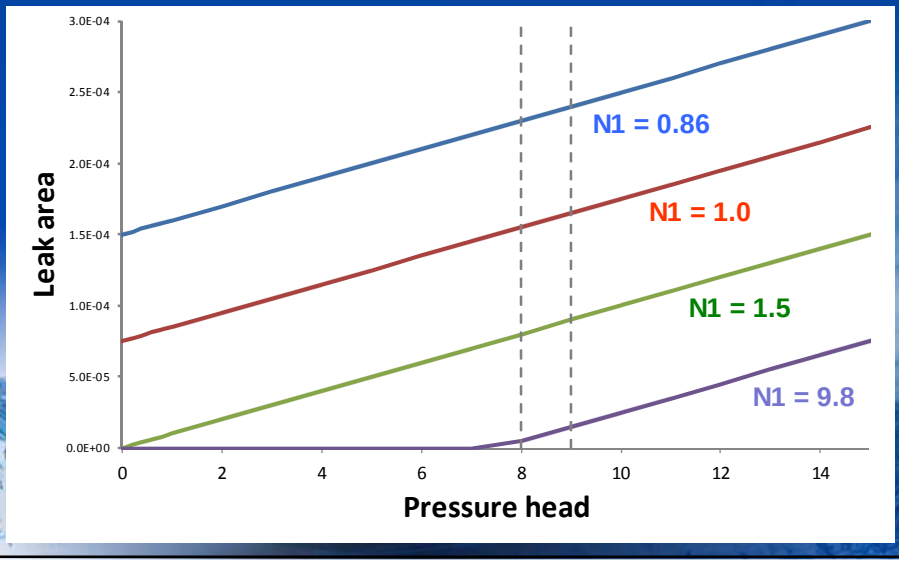
N1 for longitudinal crack with fixed length



N1 for longitudinal crack with fixed length



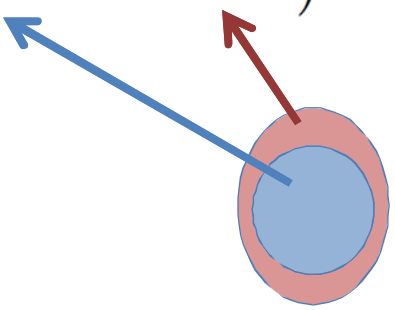
N1 for longitudinal crack with fixed length



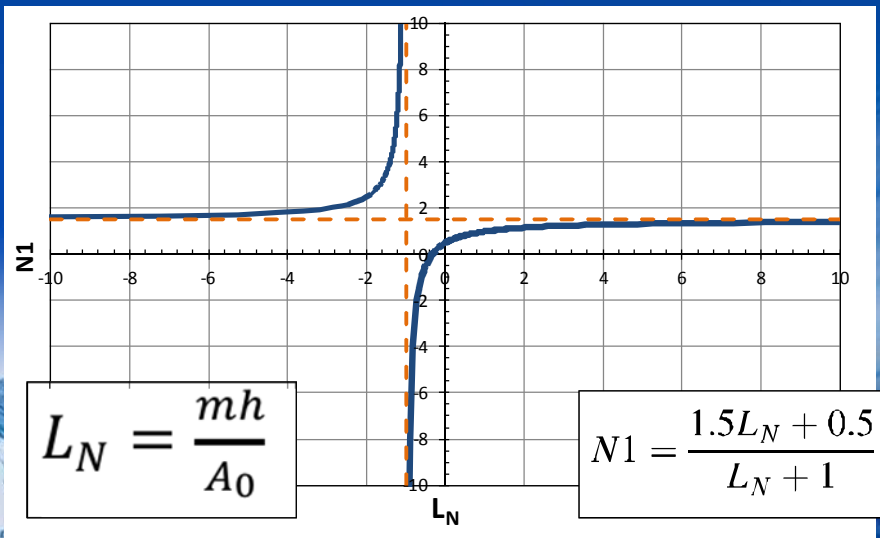
Leakage Number

$$Q = C_d \sqrt{2g}\left(A_0 h^{0.5} + m h^{1.5}\right)$$

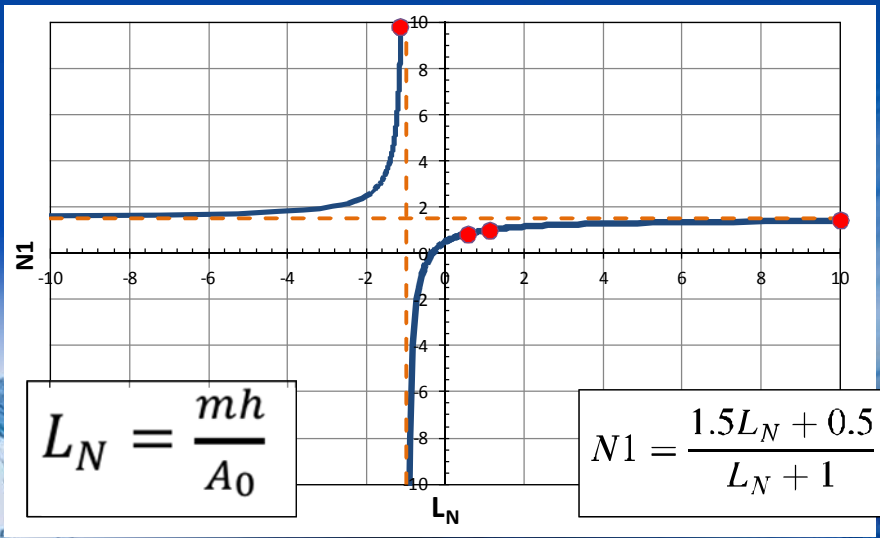
$$L_N = \frac{mh}{A_0}$$



Relationship between N1 and L_N



Relationship between N1 and L_N



Conclusion

- Use N1 with care
- N1 > 1.5 is meaningless
- Try the leakage number

Pressure Management in Water Distribution Systems

2015

saice

In conjunction / association with the SAICE Water Engineering Division

20 July	Midrand (Gallagher Convention Centre)	3 August	Cape Town (Lagoon Beach Hotel)
24 August	Durban (Sica's Guest House)	21 September	Port Elizabeth (The Kelway Hotel)

Introduction

Municipal water distribution systems often supply water at pressures significantly higher than the minimum required for good service. International research over the last two decades has shown that these excessive pressures have several negative effects on distribution systems, including higher pipe failure rates, larger leakage rates and reduced capital service life.

This has led to the wide use of pressure management, in which pressure control valves are used to optimally manage

- Thank You -