# Understanding Leakage

Water Balance and Performance Indicator Training
Bangkal, 11/18/10

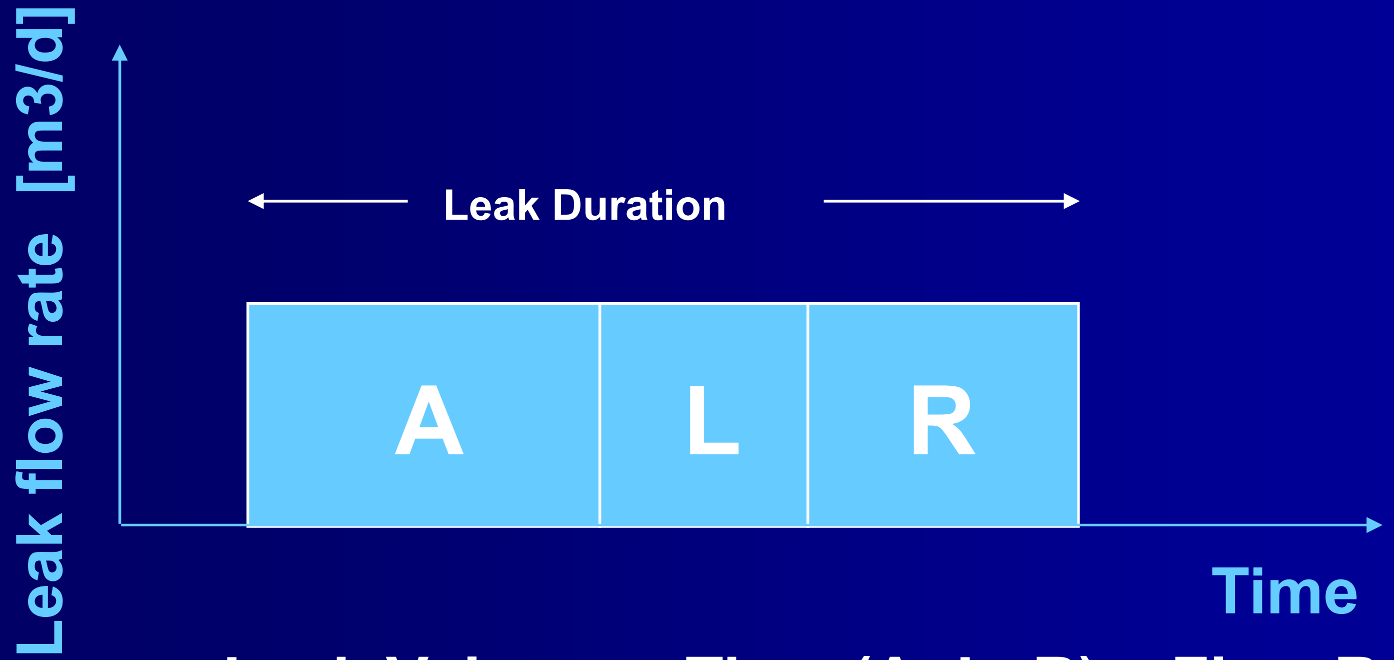
# Leakage Classification

- Reported Bursts
  - visible, phoned in by public, observed by water utility staff, normally large flow rate and short run-time
- Unreported Bursts
  - non-visible, located during a leak detection survey, often smaller but long run-time
- Background Leakage
  - very small leaks;  difficult and uneconomic to detect and repair individually

# Most Leaks are Invisible

- Majority of all leaks
  - does NOT come to the surface
  - is caused by leaking service connections
- absence of an ACTIVE program to detect invisible leaks is a good indication for high levels of leakage

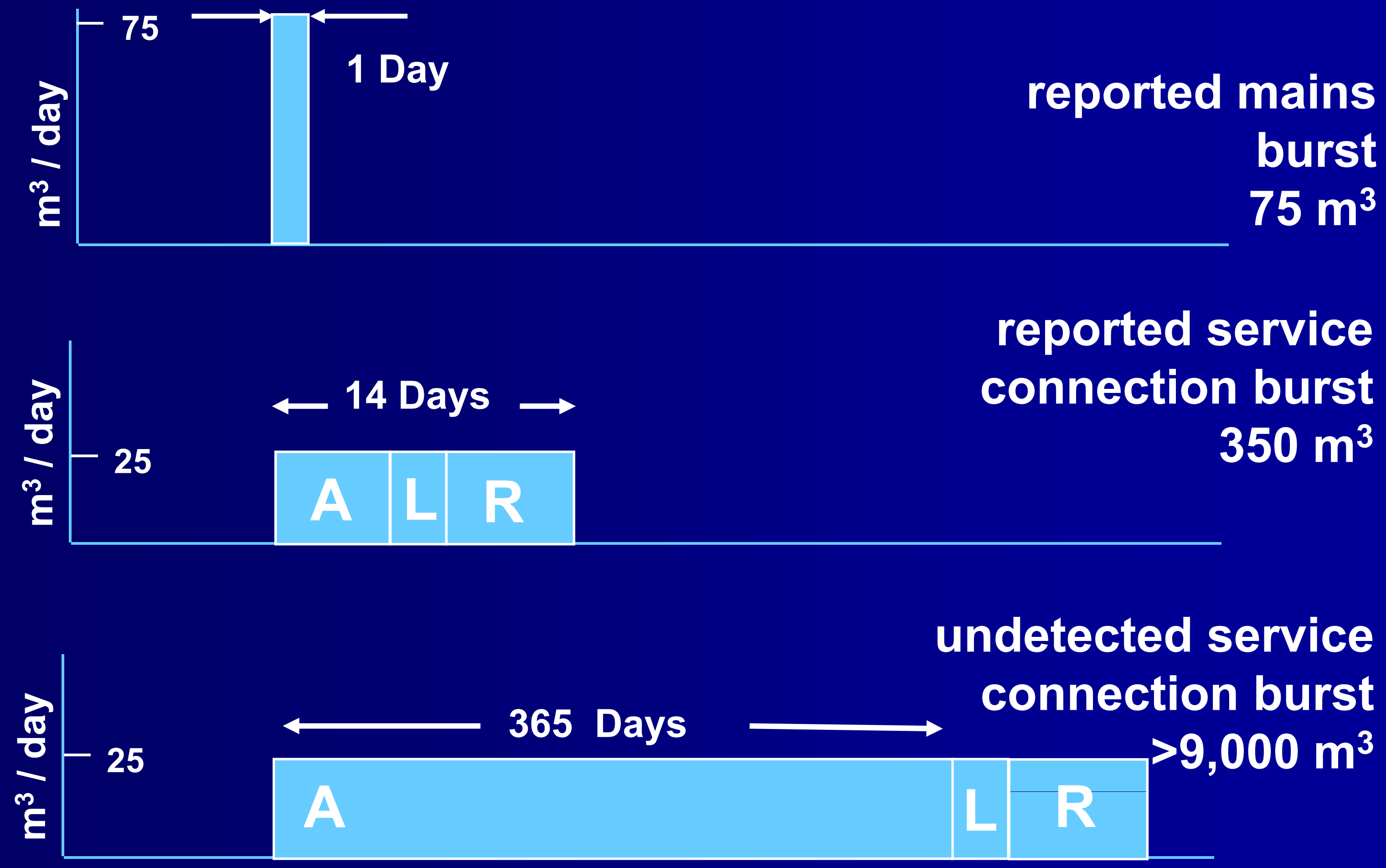
# Leak Volume: A Function of Time and Flow Rate




Leak Volume = Time (A+L+R) x Flow Rate

A: Awareness; L: Localization; R: Repair

# Time Makes a Big Difference



# Theoretical Pressure/Leakage Relationship

- Leakage rates vary with pressure
- According to basic hydraulics (→ Bernoulli), flow through an orifice under pressure is

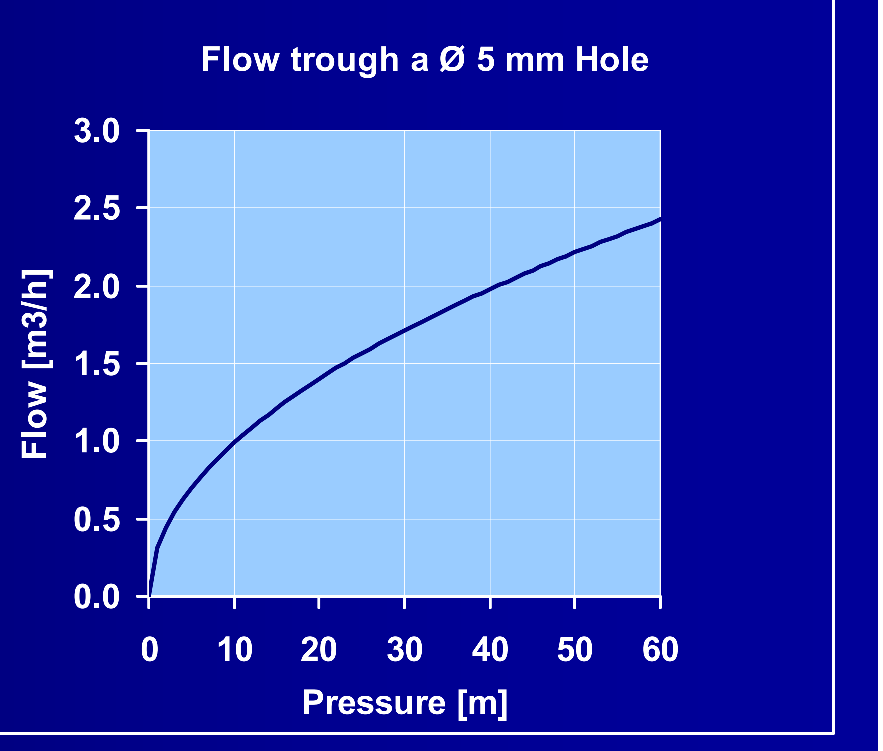
$$Q = C_d \times v \times A = C_d \times (2g \times h)^{0.5} \times A$$

Where:

Q = volume of flow (per unit time)
$C_d$ = discharge coefficient
A = Area (size) of the orifice
v = velocity of flow through the orifice
g = 9.81 $m/s^2$ (acceleration, gravity)
h = meters water head above orifice (= pressure)

# Theoretical Approach only Applicable in Certain Situations

- Square root relationship does not work for most distribution networks
- Applicable only for networks with metallic pipes



# Pressure/Leakage Relationship in Distribution Networks

- More complex than basic hydraulic theory can capture:
  - irregular shape of holes, multiple hole patterns
  - size of holes changes with pressure and pipe material
- Empirical relationship relates leakage and pressure:

But what to use for N1?

$$L_1/L_0 = (P_1/P_0)^{N1}$$

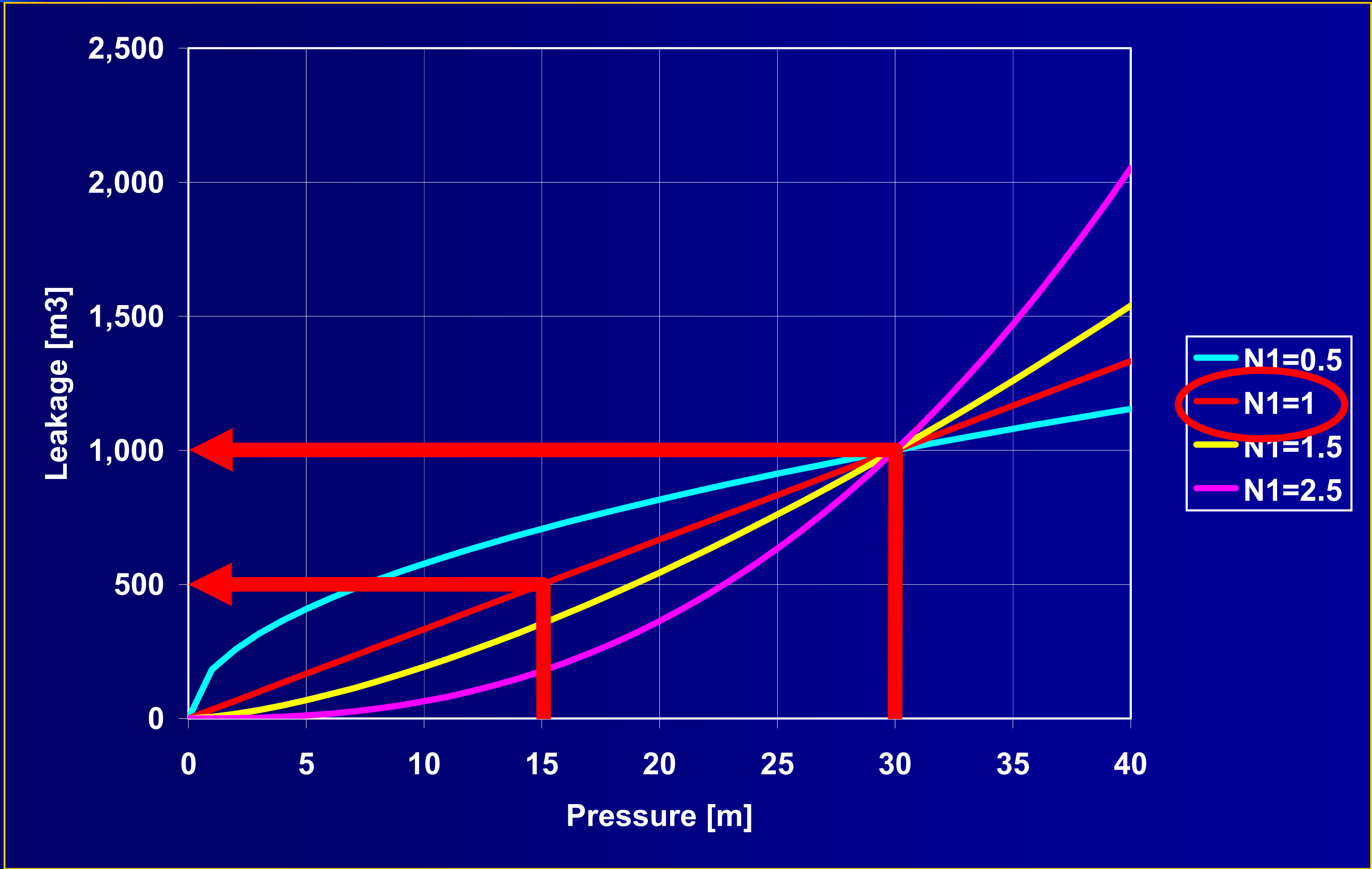
or

$$L_1 = L_0 \times (P_1/P_0)^{N1}$$

# About N1 Values

- Leaks from metallic pipes: N1 = 0.5
- Small leaks at joints and fittings (Background Leakage): N1 = 1.5
- In exceptional cases of splitting of plastic pipes N1 could be up to 2.5
- Large networks with mixed pipe materials tend towards a linear relationship of N1=1
- Can be determined by using data from a "Pressure Step Test"

# Pressure/Leakage Relationship



# Importance of Correct Pressure/Leakage Relationship Simulation

- N1 methodology allows relating changes in pressure to changes in leakage
- Leakage can be calculated for different pressures, example:
  - 24h flow and pressure measurement in combination with minimum night flow analysis <u>and N1 methodology</u> allows calculation of daily leakage
- Major advance to correctly understand pressure / leakage relationship

# Higher Pressure, Higher Leakage

- Objective:
  - increase pressure from 20 m to 30 m
- Consequence:
  - expect leakage to increase by 1,250 m3/day

| Pressure [m] | Leakage | |
|---|---|---|
| | Volume [m3/day] | % of system input volume |
| 20 | 2,500 | 20 % |
| 30 | 3,750 | 27 % |
| 40 | 5,000 | 33 % |

# Pressure Reduction, a Cost Effective Leakage Reduction Strategy

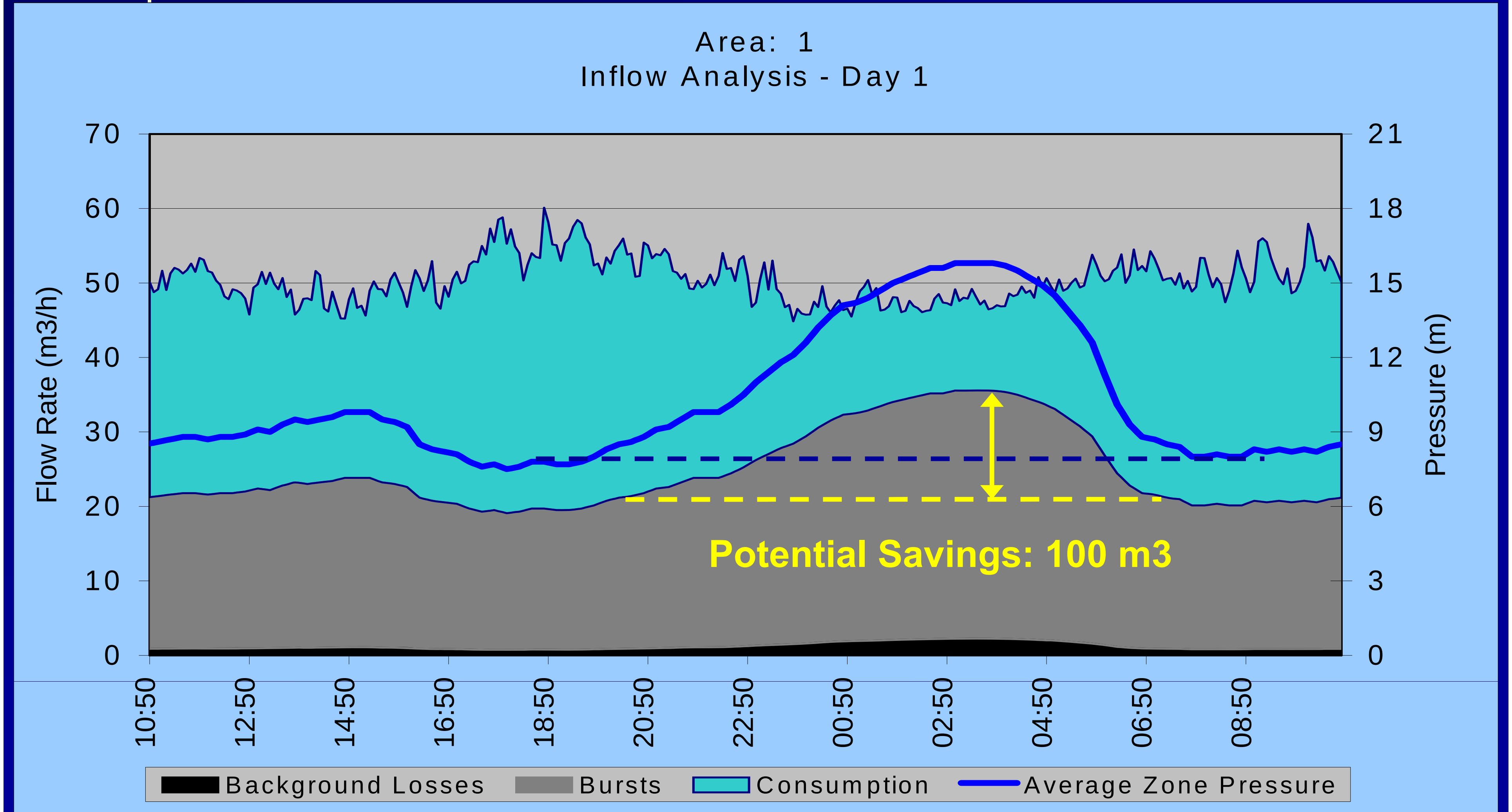
| Pressure [m] | Leakage | |
|---|---|---|
| | Volume [m3/day] | % of system input volume |
| 20 | 2,500 | 20 % |
| 30 | 3,750 | 27 % |
| 40 | 5,000 | 33 % |

- **Objective:**
  - reduce leakge by 25 %; from 5,000 to 3,750
- **Two solutions:**
  - find and fix leaks equivalent to 1,250 m3/day or
  - reduce pressure from 40m to 30m

# Even in Low Pressure Situations, Pressure Management is Beneficial

- Normally not done – PRVs were traditionally installed to reduce excessively high pressures; but: pressure management also beneficial in low pressure situations
- 15 m pressure: a 3 meter pressure increase results in about 20% more leakage!!
- In poor quality networks pressure increases caused by leak repair might compensate all savings!

# Example: Capping of Night Time Pressure



# Pressure / Leakage Relationship

- The higher/lower pressure the higher/lower leakage
- Relationship complex, but a good first assumption is a linear relationship:

  10% more pressure = 10% more leakage

- Pressure management an essential tool for leakage reduction
- Pressure level and pressure cycling strongly influence burst frequency

# Longer Supply Time, More Leakage

| Supply Time [hours/day] | Leakage | |
|---|---|---|
| | Volume [m3/d] | % of system input volume |
| 24 | 2,500 | 20 % |
| 12 | 1,250 | 11% |
| 6 | 625 | 6 % |

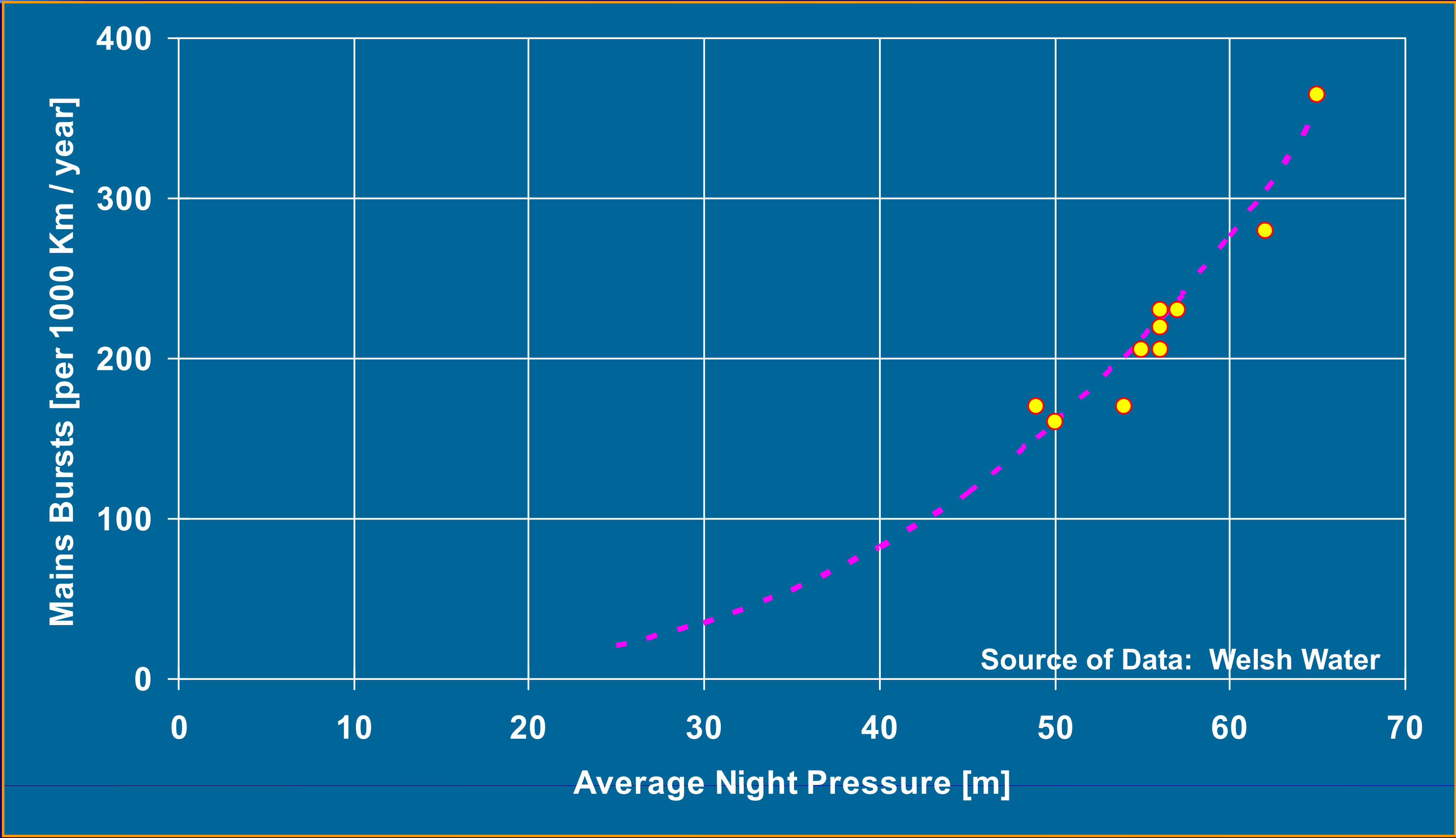
- **Objective:**
  - Increase daily supply time from 12 hours to 24 hours
- **Consequence:**
  - expect leakage to increase from 1,250 m3/d to 2,500 m3/day

# Intermittent Supply: an Acceptable Solution for Leakage Reduction?

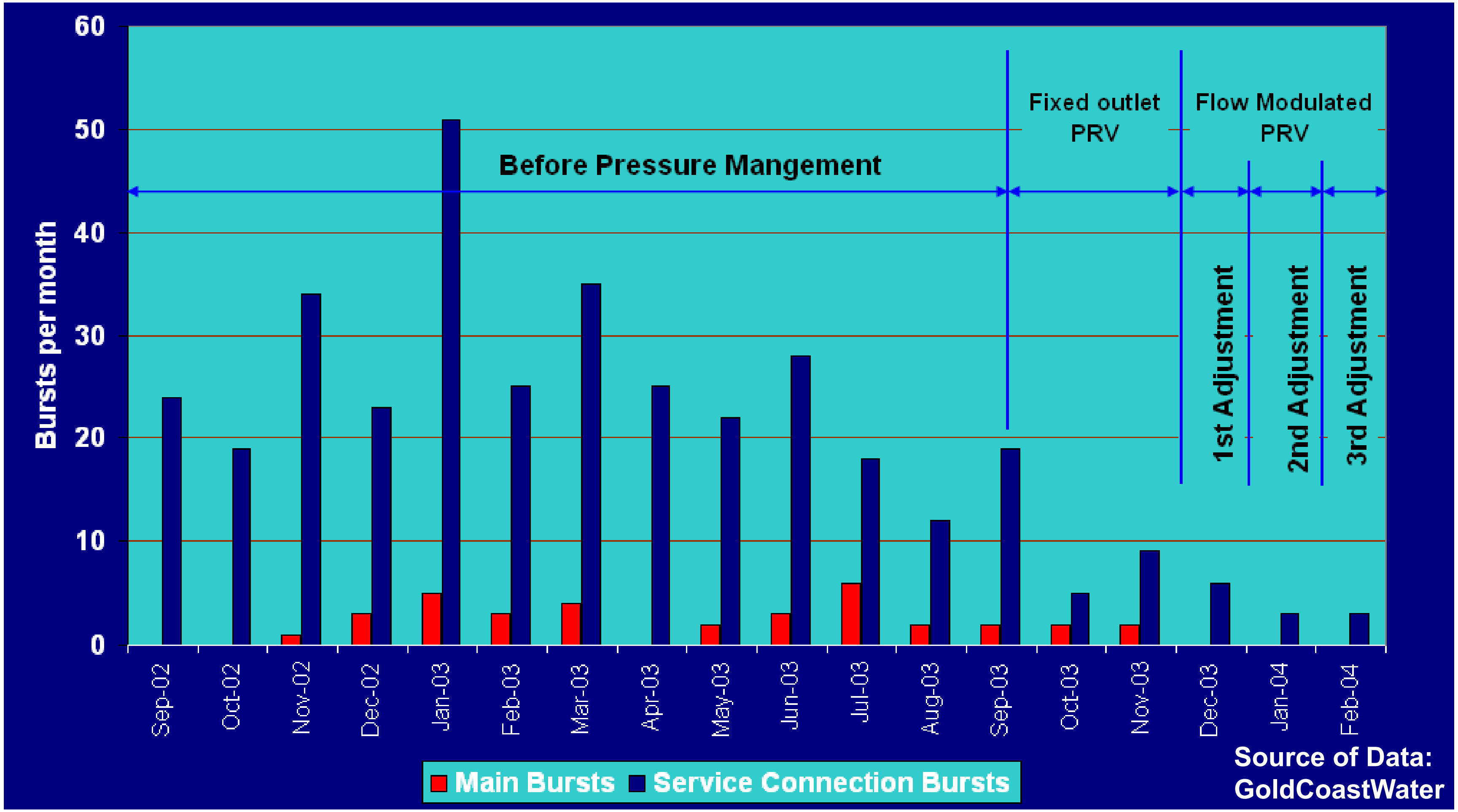
## !!! Absolutely NOT !!!

- Leakage volume reduces, but intermittent supply brings many disadvantages:
  - Hygiene/Public Health: infiltration of polluted ground water when pipes are not under pressure
  - Substantially higher burst frequency
  - Reduced asset life time
  - Water wastage

# Burst Frequency Increases with Pressure



# Reduction in Burst Frequency After Pressure Reduction




Source of Data: GoldCoastWater

# Pressure/Burst Frequency Relationship

- Reducing pressure obviously reduces leakage
- even more important is the reduction in burst frequency
- Asset lifespan can be extended!
- Pressure cycling, sudden changes in pressure and pressure transients increases the occurrence of bursts even further

# Key Messages

- There are clear relationships between pressure, leakage and burst frequency
- Leakage is more sensitive to pressure than traditional wisdom suggests
- Leakage volume from bursts depends on flow rate and time from occurrence to repair
- Undetected smaller bursts are most serious