# Bentley Water Solutions

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Bentley
Sustaining Infrastructure

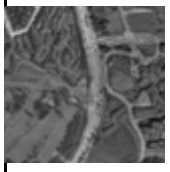
# Agenda

1. Bentley Solutions
2. Water Industry Scope
3. Water Solutions Overview
4. Water Products Description
5. Application Examples
6. Demo
7. Contact Information

# Solutions

Bridges

Buildings



Cadastre and Land Development

Campuses

Communications

Electric and Gas Utilities

Factories

Metals and Mining

Oil and Gas

Power Generation

Rail and Transit

Roads

**Water and Wastewater**

# Bentley Solutions

1. Intra-operable infrastructure software portfolio
   - Multi-discipline built on a common V8*i* platform
   - Supports the Design-Build-Operate lifecycle
   - Encompasses the full spectrum of infrastructure
2. Professional services and learning
   - Support for implementation and all change issues
3. Professional communities networking
   - Local and global communication opportunities

V8i
Bentley
Sustaining Infrastructure

# NEW in Water and Wastewater Solution V8*i*

**WaterGEMS** delivers advanced functionality for GIS and model synchronization

**Bentley Water** includes enhanced reports, queries, multi-workflows and enterprise stores

**WaterGEMS** and **HAMMER** feature native support for Oracle spatial data model

**StormCAD** features seamless integration with GEOPAK and Bentley PowerCivil

**WaterGEMS** advances leakage calibration for locating leaks and quantifying background water losses

**Bentley Expert Designer Water** supports high productivity design and dynamic cost estimating for potable water networks

**ProjectWise** features significant performance improvements and linear reference system-based storage

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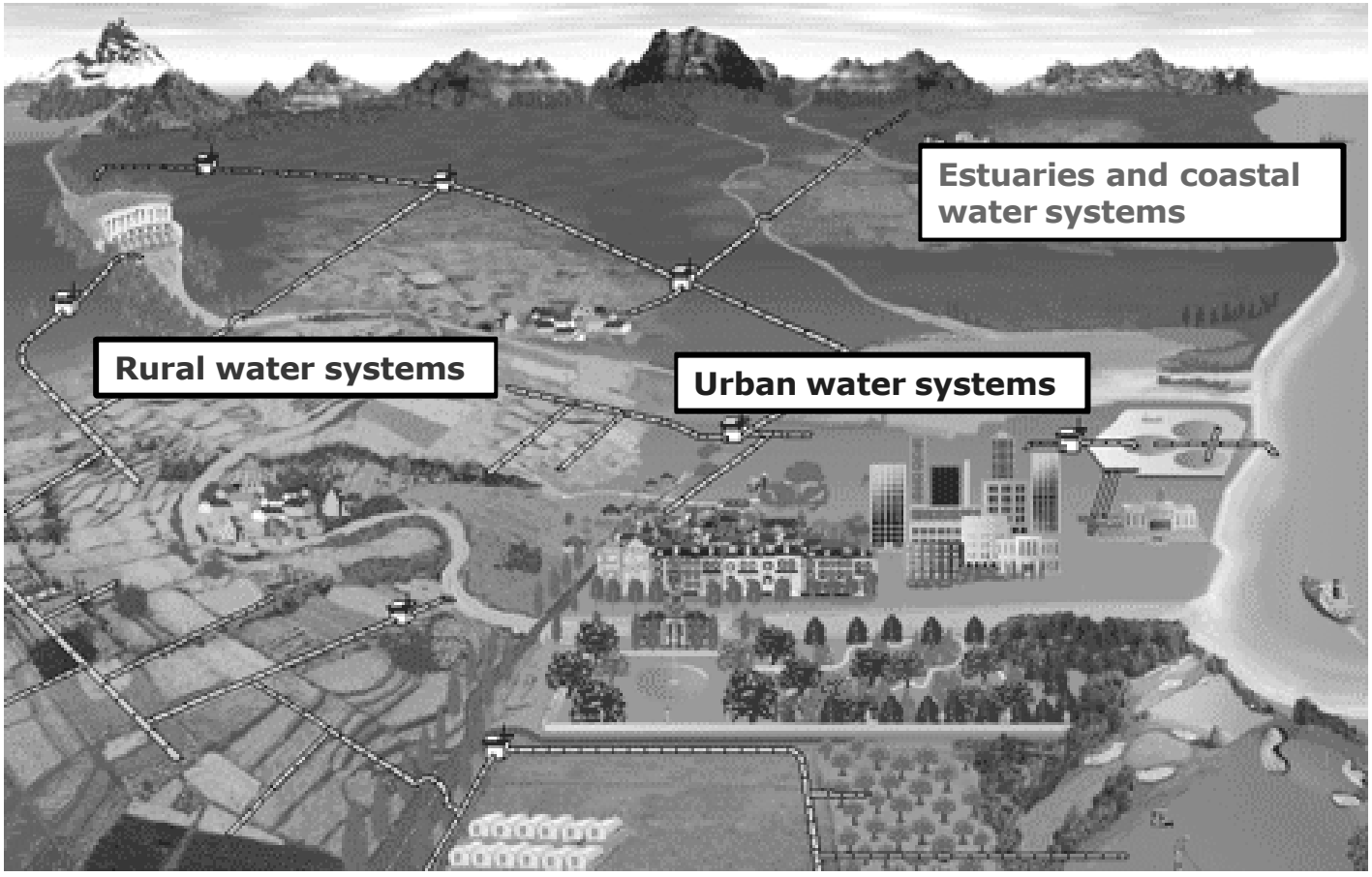
# The World of Water



# Water: The next Oil ?

- Water is more vital for human life than oil
- Only 2.5% of water of the planet is usable
- Less than 3% of the world's Fresh Water is potable
- More than 20% of the world's people will not have aces to freshwater by 2010
- Water infrastructure (clean and waste) is rapidly deteriorating in Europe
- Water is a $400 Billion global industry !

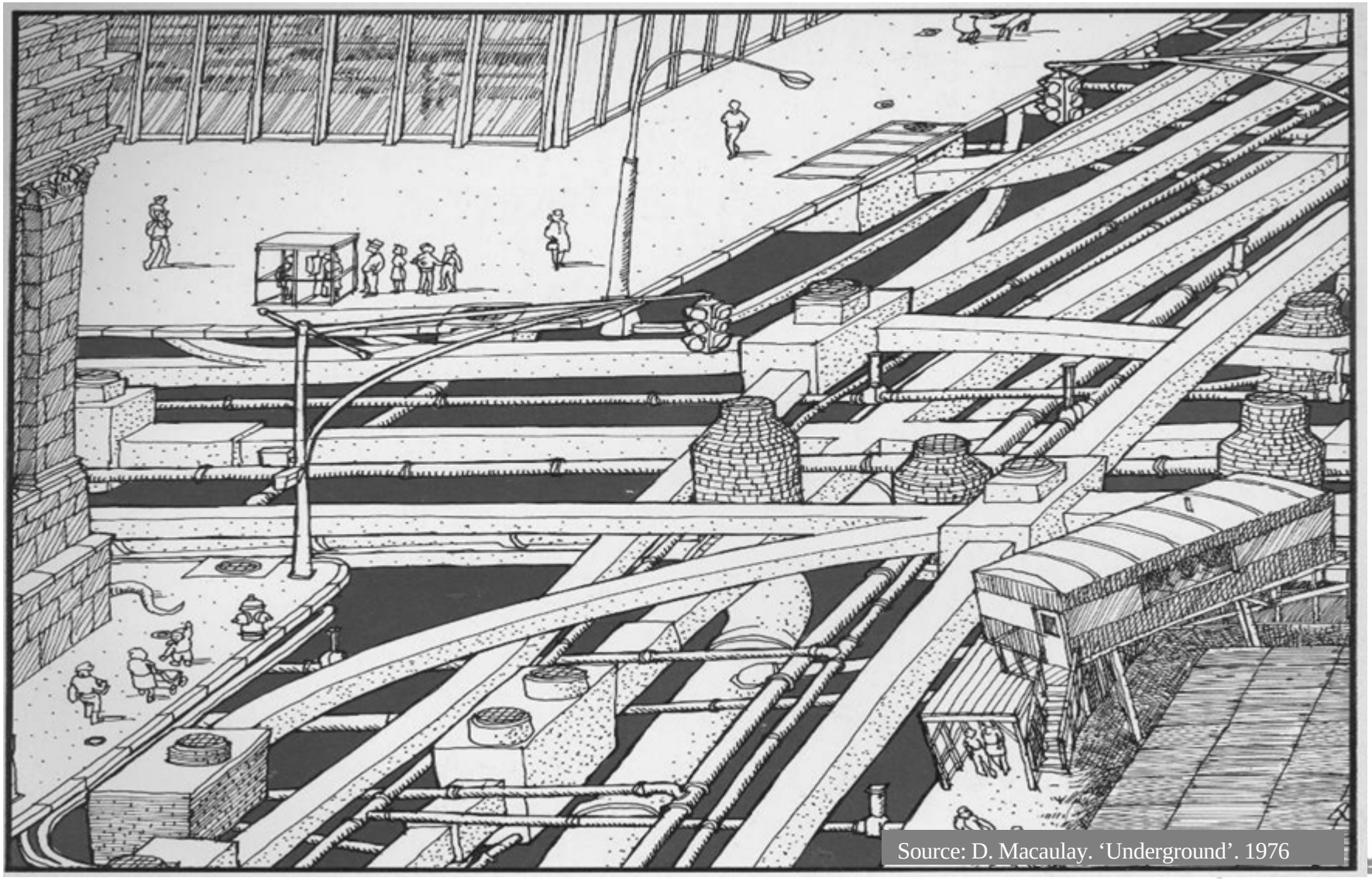
# The Water Industry Scope

- The **Water Industry** provides:
  1. Drinking water services
  2. Wastewater services (including sewage treatment) and
  3. Drainage and flood protection services

  To: households, industry and governmental organizations.

- The Haestad family of products integrated within Geospatial framework is a backbone of the Bentley Water Solutions offer to the Water Industry market segments

# The Urban Water Challenges



Source: D. Macaulay. 'Underground'. 1976

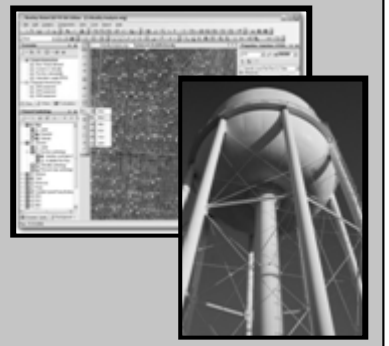
# Water & Wastewater Industry Challenges

- Regulatory Compliance
  - –Adequate Supply & Treatment capacity
  - –Protecting Water Quality
  - –Business performance
- Reliability
  - –Consistently achieving target levels of services
  - –Maintaining aging infrastructure
  - –Avoiding failure
- Budget
  - –Reducing costs while improving services
  - –Asset investment planning for aging infrastructure
  - –Aging workforce

# The Water Solutions Product Map

## Water

- WaterGEMS
- WaterCAD
- HAMMER
- Bentley Water V8 XM
- Geo Web Publisher for Water
- Expert  Designer for Water
- PowerMap Field for Water

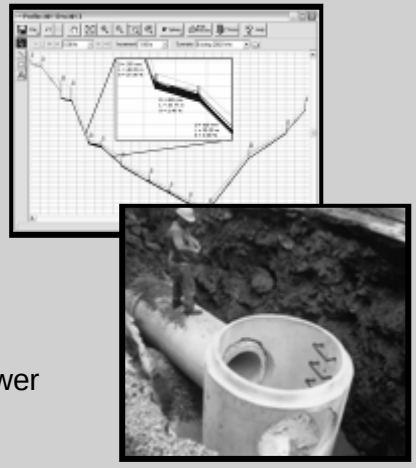


## GIS, Mapping and Asset Management

- Bentley Water V8 XM
- Bentley Sewer V8 XM
- Bentley Cadastre
- IRAS / B
- Bentley Descartes
- Bentley CadScript
- Geo Web Publisher for Water Sewer
- PowerMap Field for Water Sewer

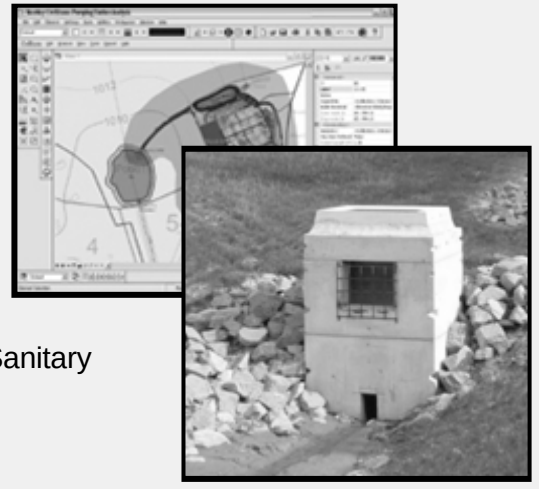
## Sewer

- SewerGEMS
- SewerCAD
- FlowMaster
- Bentley OnSite
- Bentley WasteWater
- Bentley Sewer V8 XM
- PowerCivil
- InRoads Storm & Sanitary
- GEOPAK
- Geo Web Publisher for Sewer
- PowerMap Field for Sewer

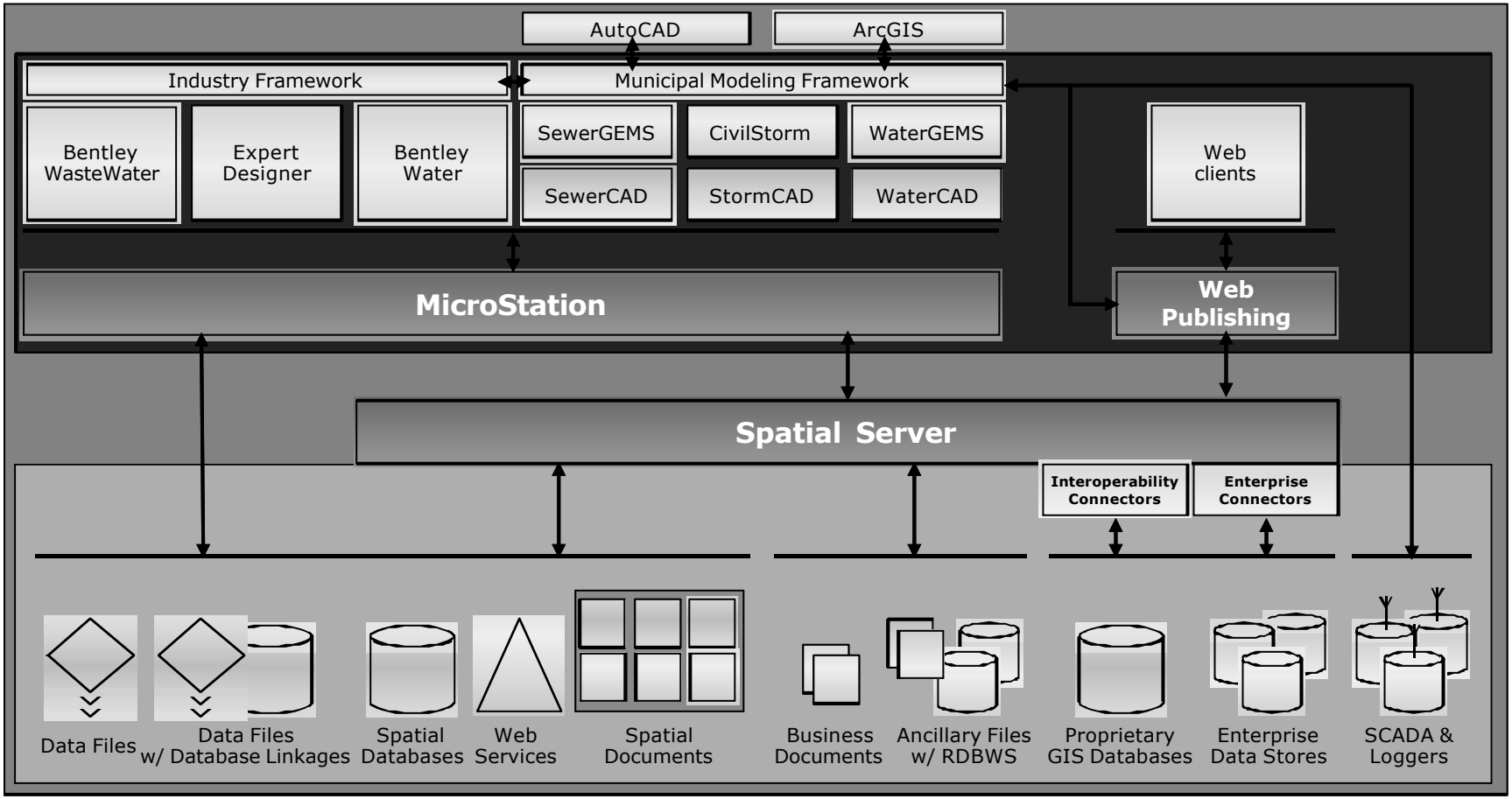


## Storm

- CivilStorm
- StormCAD
- PondPack
- CulvertMaster
- FlowMaster
- PowerCivil
- GEOPAK
- InRoads Storm & Sanitary
- MXROAD
- Bentley OnSite

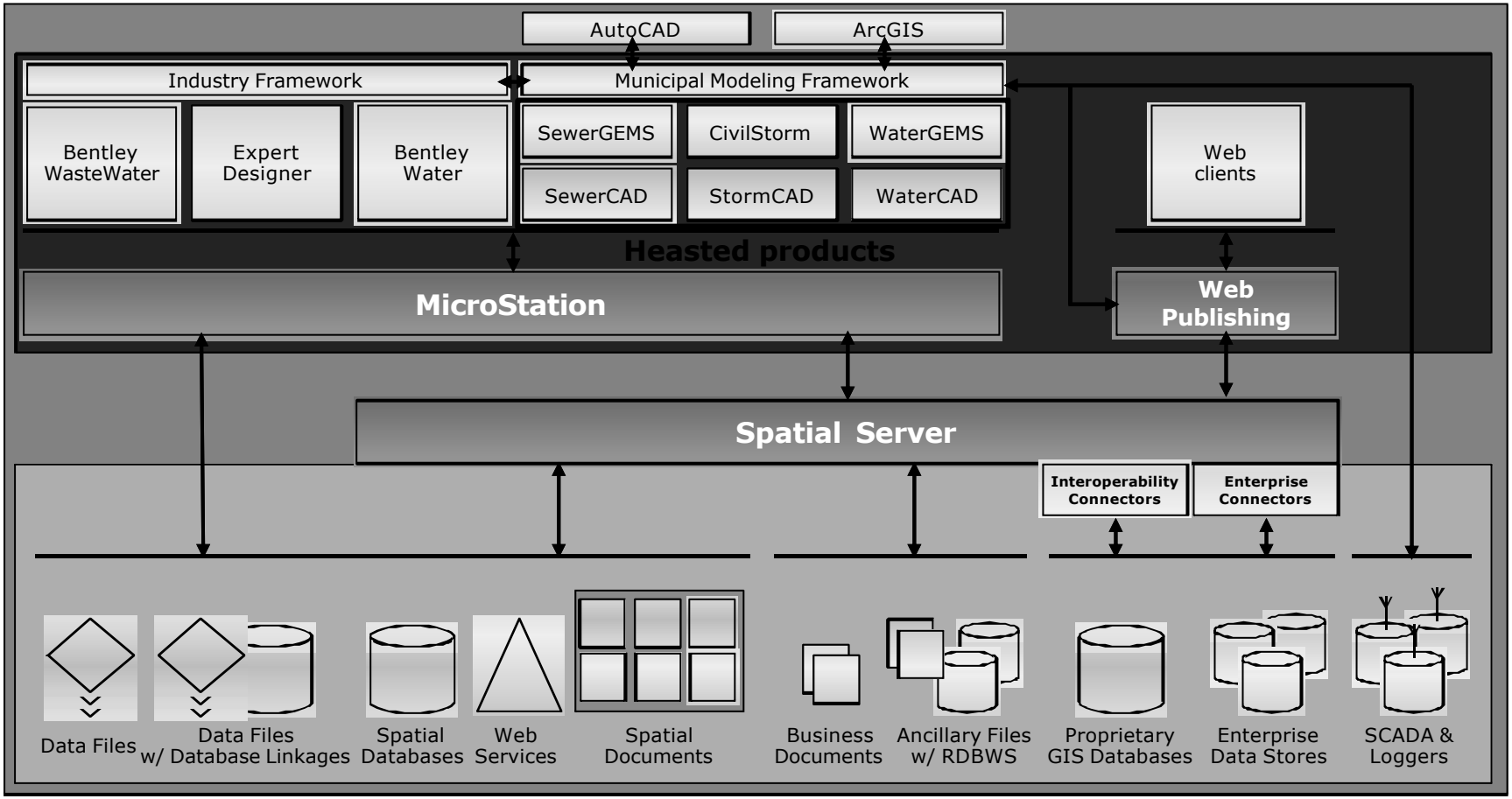


# Water Solutions Architecture




Hydrology & Hydraulics Products

# Haested Products




Hydrology & Hydraulics Products

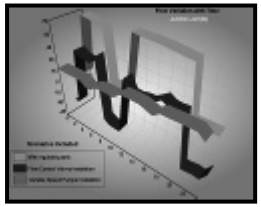
# Bentley Haestad Product Line

HAESTAD METHODS
WATER SOLUTIONS

**26 years**
**130,000 users**
**170 countries**

| | |
|---|---|
| WATER | WaterGEMS. Water distribution modeling with geospatial integration |
| | WaterCAD. Water distribution modeling and design |
| | Darwin Designer. Network design automation |
| | Darwin Calibrator. Model calibration optimization |
| | WaterSAFE. Advanced water quality and security |
| | Skelebrator. Network reduction or simplification |
| | HAMMER. Transient flow analysis and modeling |
| | SCADAConnect. Supervisory and control data integration |
| SEWER | SewerGEMS. Urban sewer modeling with GIS integration |
| | SewerCAD. Sanitary sewer design and modeling |
| STORM | CivilStorm. Stormwater management and dynamic modeling |
| | StormCAD. Storm sewer design and modeling |
| | PondPack. Detention pond design and analysis |
| | HEC-Pack. Floodplain modeling |
| | CulvertMaster. Culvert design and analysis |
| | FlowMaster. Hydraulics calculator |
| Other… | GISConnect. CAD / GIS Interoperability |
| | WaterObjects. .Net development environment |
| | Mohid. Catchment, costal and estuarial modelling solution |

# The Water Solutions: Our Users



Engineering Analysis and Modeling

Mapping & Data Management

Information Sharing & Collaboration

Water and sewer utilities

Publicly-owned utilities (L & C Gov)

Water suppliers

SMEs, Consulting firms & EPC

Research and Academia

Design

Construction, Inspection, & Field Engineering

Real-time Operations & Automation

-

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# What Makes our Water Solutions Great?

## 1. Multi platform environment

An environment for every user with full GIS integration

## 2. Model building

Leverage virtually any data source

## 3. Model management

Streamlined editing with hydraulic intelligence

## 4. Hydraulic analysis

Engineering tools for real world decisions

## 5. Results interpretation

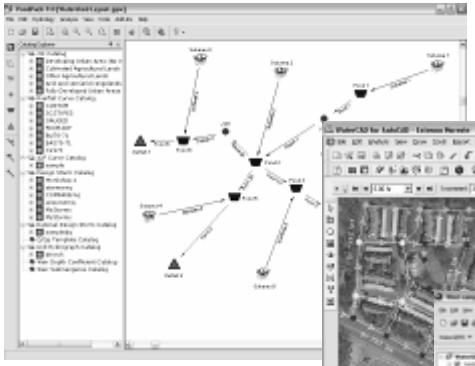
From model results to engineering knowledge

# 1. Multi Platform Environment

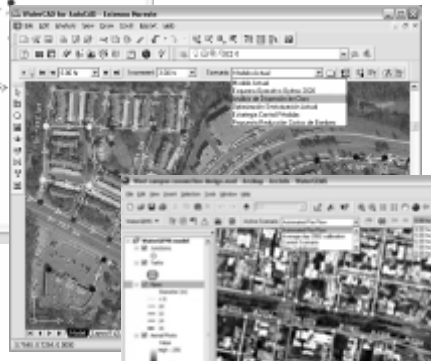
An environment for every user

**BENEFITS**

- ✓ Less data duplication. More integration
- ✓ Facilitate learning curve
- ✓ Increased team communication
- ✓ Users of different backgrounds can collaborate



**Stand-Alone**
PondPack shown

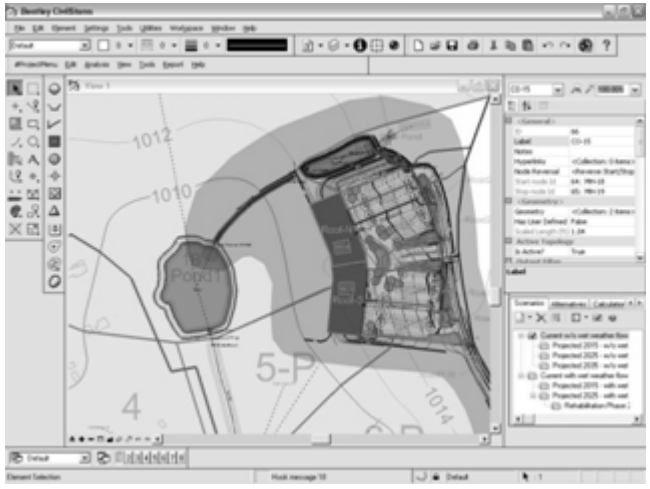


**AutoCAD**
WaterCAD shown

**ArcGIS**
SewerGEMS shown

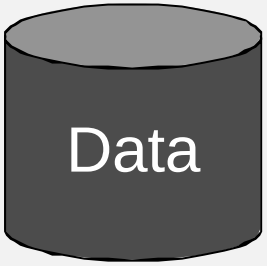
## …and MicroStation!

**Available for:**
CivilStorm
WaterGEMS
SewerGEMS



# 2. Model Building

Leverage virtually any data source




**CAD drawings**

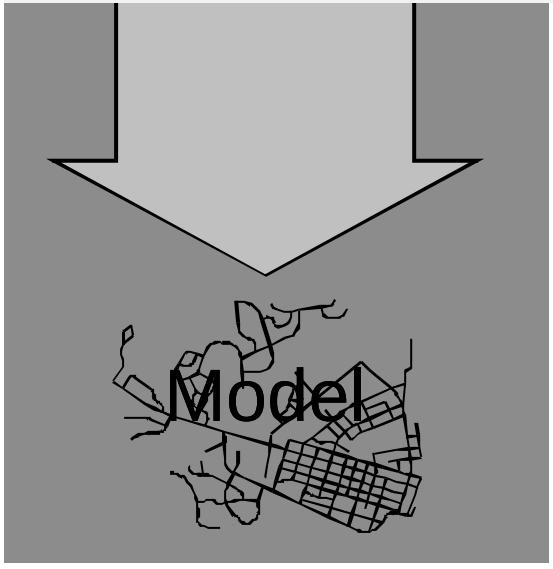
Network topology, node elevations, scaled lengths, some physical data, etc.

**Databases & spreadsheets**

Demand information, operational strategies, field data, water quality, etc.

**Geospatial data**

Network topology, water consumption data, node elevations, diameters, materials, etc.




## Model building tools

ModelBuilder. Multi-source model creation

LoadBuilder. Demand assignment from geospatial data

Shapefile & database synch. Synchronized model connections

TRex. Automated elevation extraction

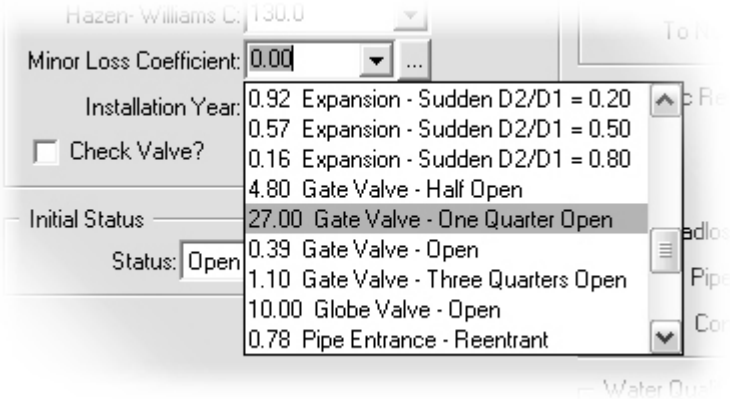
Polyline to Pipe. CAD to hydraulic model conversion utility

# 3. Model Management

Streamlined editing with hydraulic intelligence

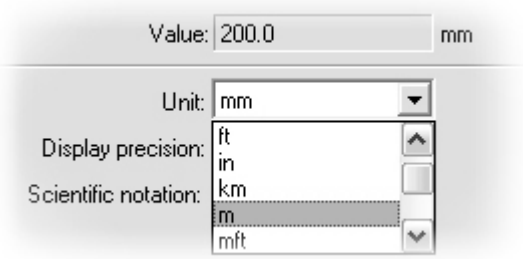
## Engineering Libraries & Prototypes

Enter information once, use it many times



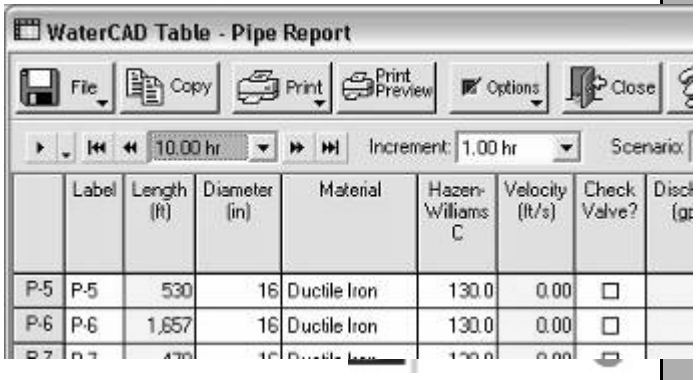

## FlexUnits

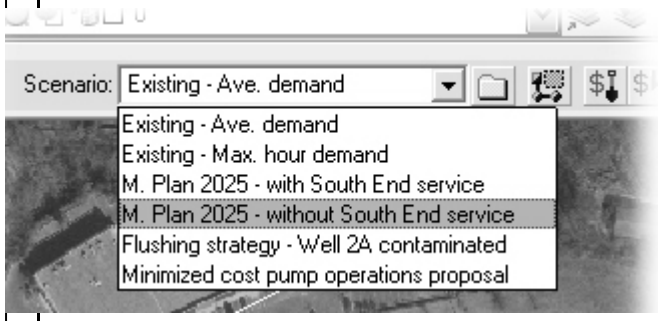
Change units on the fly




## FlexTables

Fast and easy data edition




## Scenario Control Center

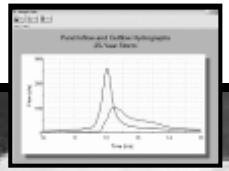
Unlimited “what if” alternatives

# 4. Hydraulic Analysis

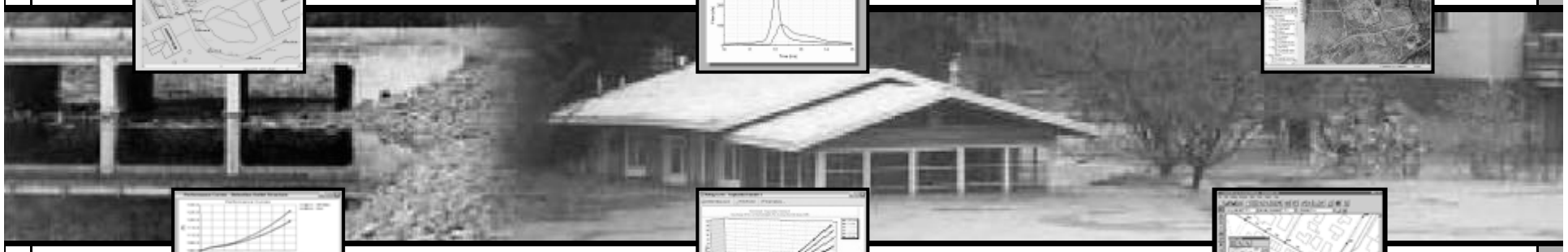
Engineering tools for real world decisions

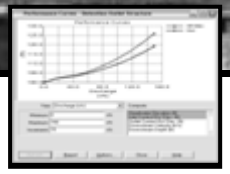
Avoid street flooding with **StormCAD**

Keep rainfall runoff problems at control with **PondPack**

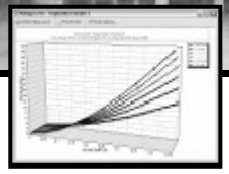


Analyze complex systems with **CivilStorm**





Comply with local regulations with **CulvertMaster**



Save time with quick calculations from **FlowMaster**

Find optimum designs staying under budget with **SewerCAD**

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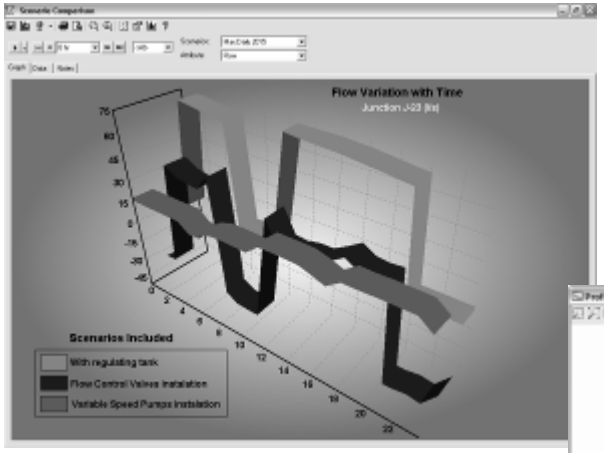
# 5. Results Interpretation

From model results to engineering knowledge

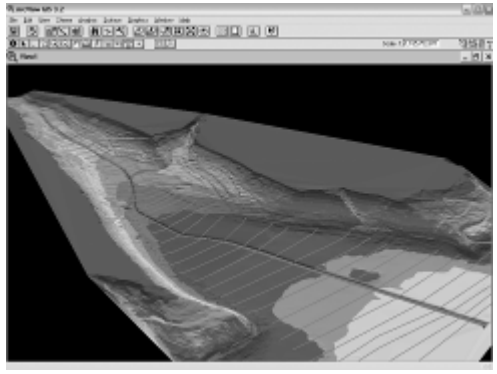
**Multi scenario, time variable graphs**

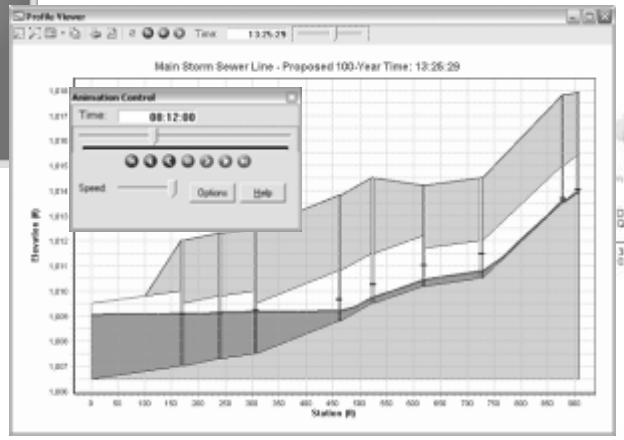



**Customizable reporting**

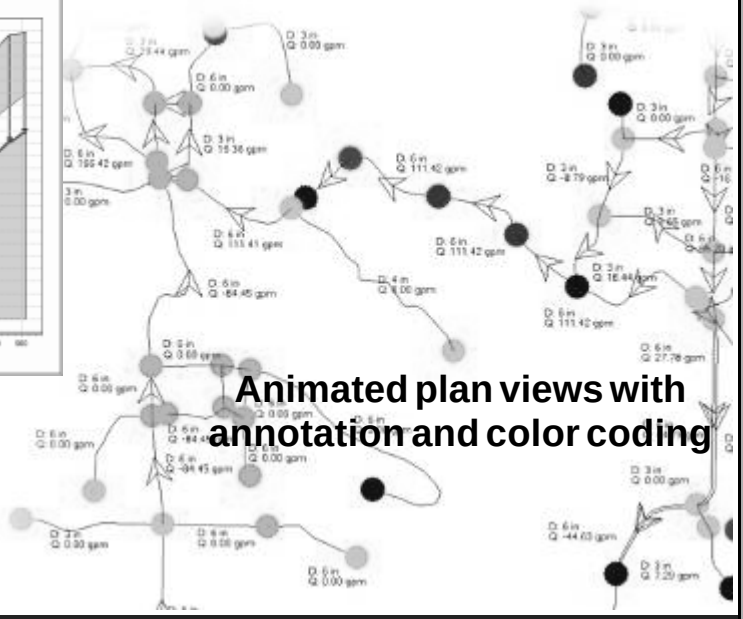
| | Label | Length (ft) | Diameter (in) | Material | Hazen-Williams C | Velocity (ft/s) | Check Valve? | Discharge (gpm) | Upstream Structure Hydraulic Grade (m) |
|---|---|---|---|---|---|---|---|---|---|
| 5 | P-5 | 530 | 16 | Ductile Iron | 130.0 | 0.00 | ☐ | -0 | 198.08 |
| 6 | P-6 | 1,657 | 16 | Ductile Iron | 130.0 | 0.00 | ☐ | -0 | 198.08 |
| 7 | P-7 | 479 | 16 | Ductile Iron | 130.0 | 0.00 | ☐ | -1 | 198.08 |
| 8 | P-8 | 1,883 | 16 | Ductile Iron | 130.0 | 0.02 | ☐ | -12 | 198.08 |
| 9 | P-9 | 364 | 24 | Ductile Iron | 130.0 | 0.02 | ☐ | -23 | 198.08 |

**Geospatial visualization**






**Advanced engineering profiling with animation**



**Animated plan views with annotation and color coding**

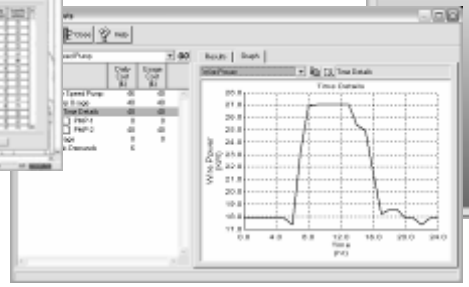
# Products

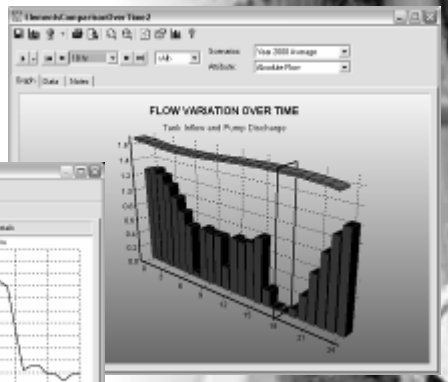
# WaterCAD

## Water distribution design, modelling and management

- Stand-Alone and AutoCAD environments
- Quick model building from any data source
- Easy-to-use layout and editing tools
- Unrivaled hydraulic analysis features
- Stunning results presentation tools

Automated fire flow analysis
Source trace and water age analysis
Easy-to-use native layout tools
Active topology alternatives
Variable speed pumping
Constituent water quality analysis
Drawing review tools
System head & hydrant curves
Tank mixing models
Rule-based & logical controls
Elevation Extraction (AutoCAD version)
Leakage and sprinkler modeling
Capital cost & energy analysis
Comprehensive demand management
Unidirectional flushing modeling
Shapefile synchronized connections
CAD to model automated conversion
Statistical result analysis
Persistent database connections
Scaled and schematic layout
Sub model management
Multi layer backgrounds for model layout
Integration with HAMMER for transient analysis
Animated pump and head loss curves





# WaterCAD modules

Available for WaterCAD
Included with WaterGEMS

## Darwin Calibrator

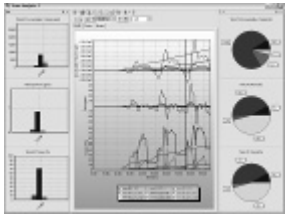
Automated model calibration

## Darwin Designer

Optimized and automated network design.

## Skelebrator

Hydraulic-smart network reduction



## WaterSAFE

Advanced water quality and system vulnerability

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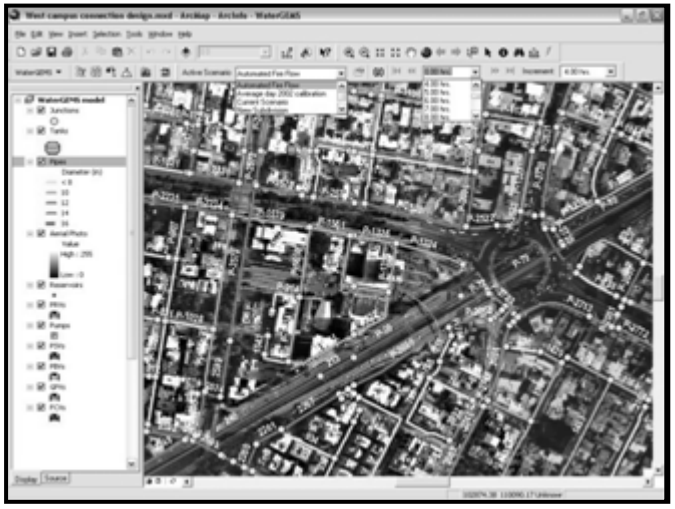
# WaterGEMS

Water distribution design and modeling with GIS integration

## Hydraulic modeling



WaterCAD's hydraulic tools

& ALL available modules

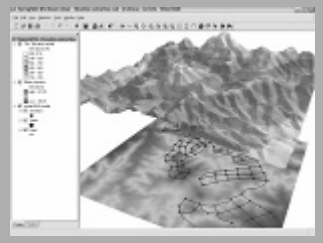
## ESRI Integration

ArcGIS integration and streamlined model building

**LoadBuilder**

Water demand assignment

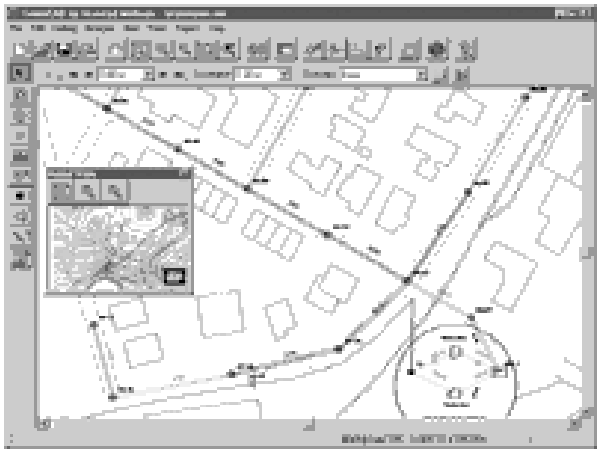
**TRex**



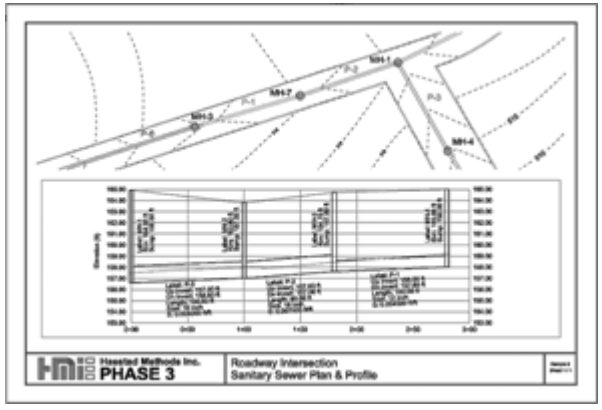
Automated elevation extraction

# SewerCAD

Sanitary Sewer Design & Modeling



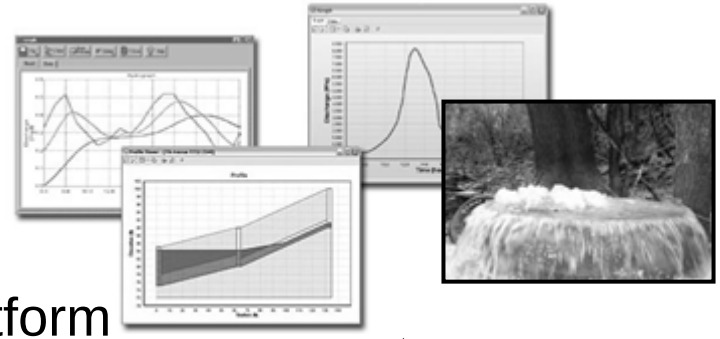
- Sanitary and wet-weather modeling
- Steady-state & Extended Period
- Pressure & gravity systems
- Automated design for pipes & inlets



# SewerGEMS

Sanitary and Combined Dynamic Sewer Modeling

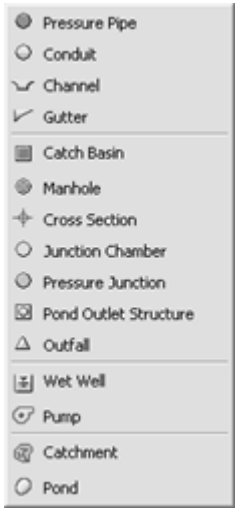
Multi platform environment



Dynamic modeling

Automatic sanitary loading allocation

Sanitary and combined sewer system element

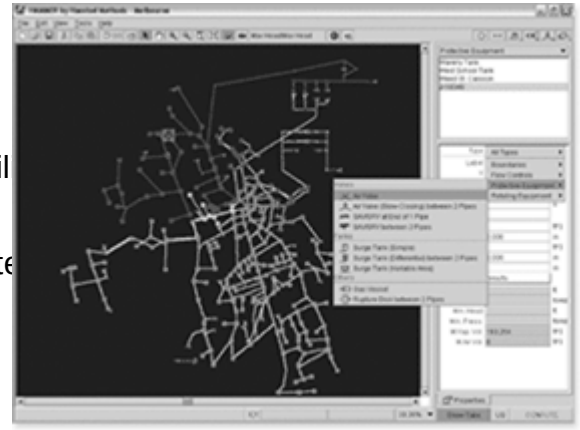


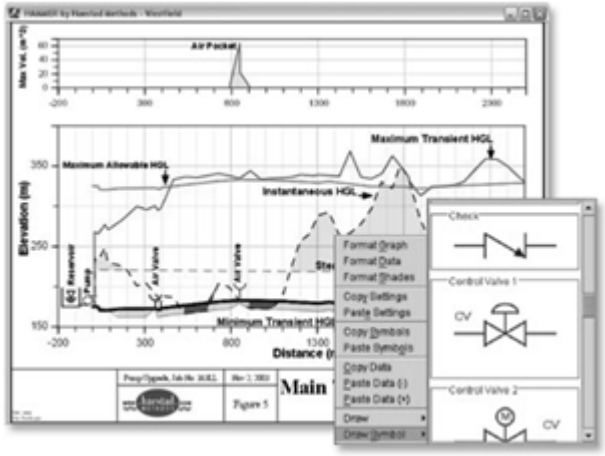
# HAMMER

## Transient analysis and water hammer modeling

- Avoid catastrophic failure of pipes & equipment
- Use the rigorous Method of Characteristics
- Model any transient event
- Simulate any surge protection device
- Complete integration with WaterGEMS/CAD

Prevent system damage
Develop cost-effective surge control strategies
Trim construction and O&M budgets
Model any surge protection device
Minimize wear and tear on pipes
Simulate any transient condition
Design and operate with greater reliabil
Eliminate costly over design
Ensure the longevity of your water syste
Prepare for power failures
Protect your operators
Improve water quality
Minimize service interruptions



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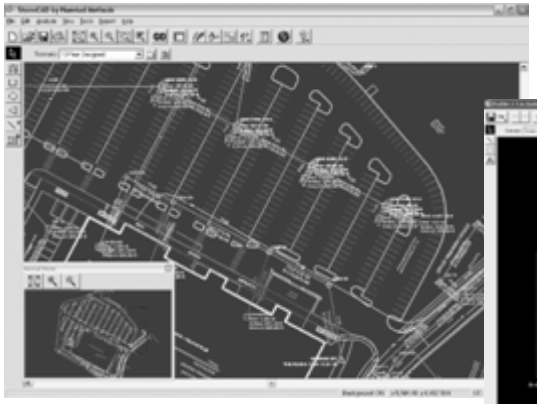
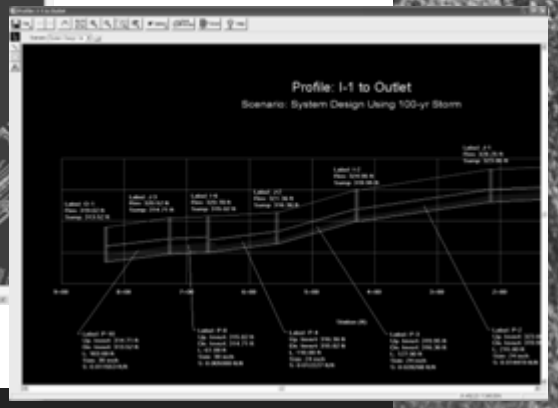
# StormCAD

## Storm sewer modeling and design

- Capital cost analysis
- Rational method hydrology
- Gradually-varied flow analysis
- HEC-22 methodology
- Drawing review tools
- Shapefile synchronized connections
- Persistent database connections
- Scenario manager
- Scaled and schematic layout
- Background support for model layout
- CAD to model automated conversions
- Profile manager
- HEC-22 and AASHTO detailed reports
- Curved pipe alignments
- System capacity analysis
- Accepted by FEMA

- Stand-Alone & AutoCAD interface
- Quick model building tools
- Easy-to-use layout & editing tools
- Automated system design
- Stunning result presentation tools



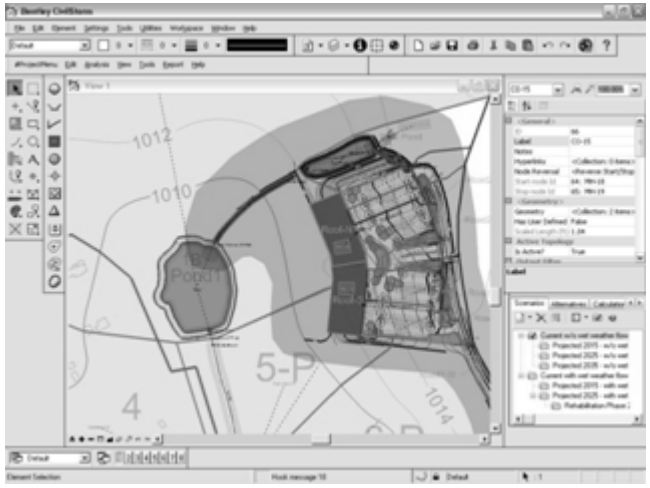


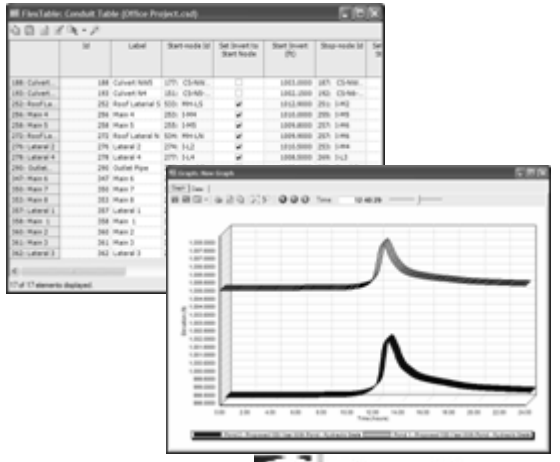
# CivilStorm

## Fully-dynamic stormwater analysis

- Model in geospatial environments
- Analyze complex stormwater systems
- Optimize system performance
- Present comprehensive results
- Experience the dynamic calculation engine

Stand-Alone , Micro Station and AutoCAD interface
Fully-dynamic modeling
Interconnected system modeling
Water quality assessments
Complex flow regime analysis
NPDES permit modeling
Scaled layout in Stand-Alone interface
Variety of methods for computing runoff
Profile manager
Scenario manager
Comprehensive engineering libraries
Model looped systems and diversions
Attenuate hydrographs due to storage



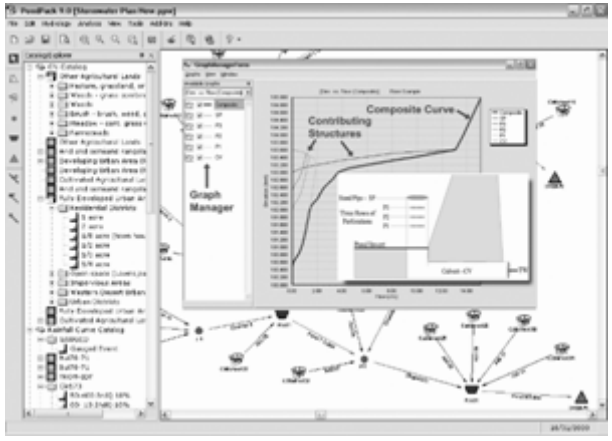


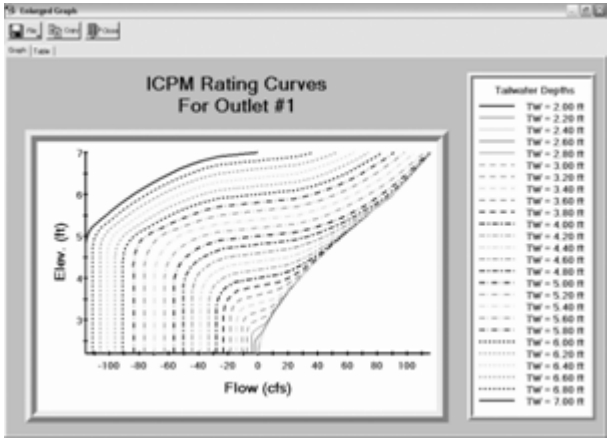
# PondPack

## Detention pond design and urban hydrology analysis

- Automate pond and outlet design
- Track project history
- Model interconnected ponds
- Account for travel time and time of concentration
- Perform complete system analyses

Interconnected pond modeling
Limited water quality analysis
Detailed graphing and reporting
ProjectWise integration
Accepted by FEMA
Intuitive interface
Unlimited number of storm events
Industry-standard runoff methods
Time of concentration calculator
Numerous peak flow methods
Water quality BMP calculations

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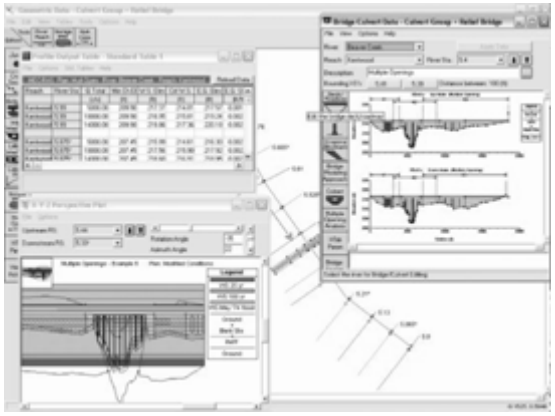
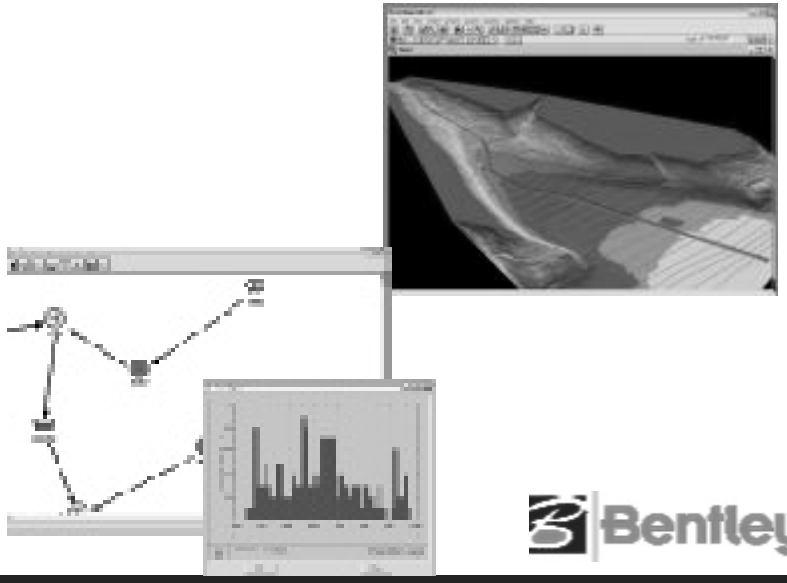
# HEC-Pack

## From Floodplain Hydrology to River Analysis



- Graphical HEC-1 for flood hydrology calculations
- HEC-HMS for hydrologic modeling
- HEC-RAS for river (floodplain) analysis
- Optimize system performance
- HEC-GIS for data sharing between HEC-RAS and ArcGIS

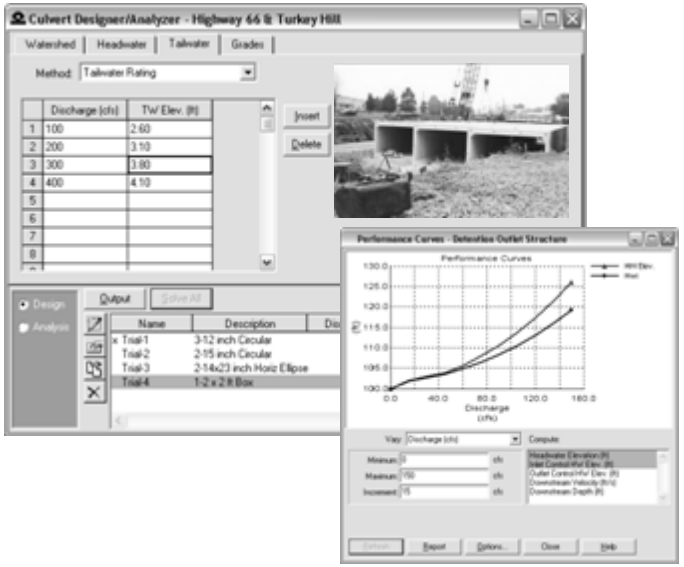
Bentley provides thousands of engineers with HEC software, documentation, and support for a variety of modeling tasks, from floodplain hydrology to river analysis to GIS integration. These important programs are all included in the HEC-Pack.

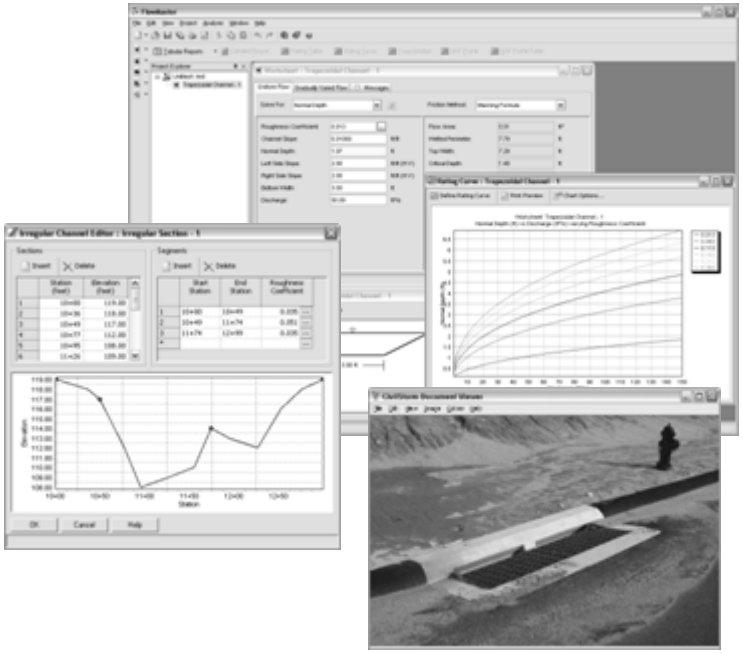


# CulvertMaster

## Culvert Design & Analysis

Model any situation that requires the design or evaluation of a culvert using HDS-5 methods, including roads, driveways, embankments, etc.



# FlowMaster

## Hydraulics calculator

Evaluate the hydraulics of virtually any type of hydraulic structure, including pipes, ditches, open channels, weirs, orifices, and inlets.

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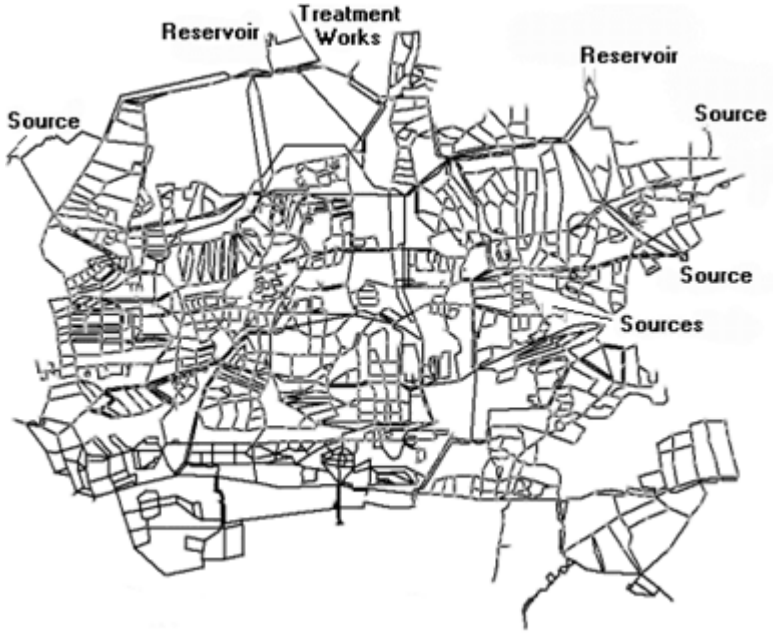
# Example Applications

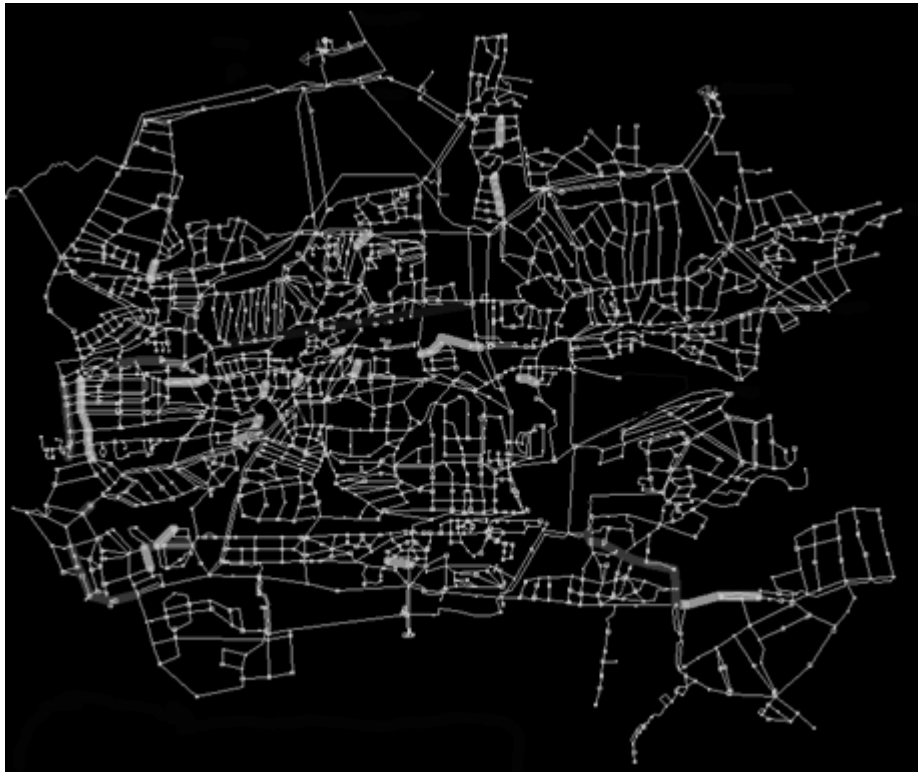
# Rehabilitation Planning

- Pipe network rehabilitation
- Find the most cost-effective solution
- Overcome pressure deficiencies
- Projected demand increases (20 years ahead)
- WaterCad and Darwin Designer (genetic algorithm optimisation)




**Thames Water DMA in UK: 1,500 pipes**

# Rehabilitation Planning (cont.)



**"Manual" Solution**

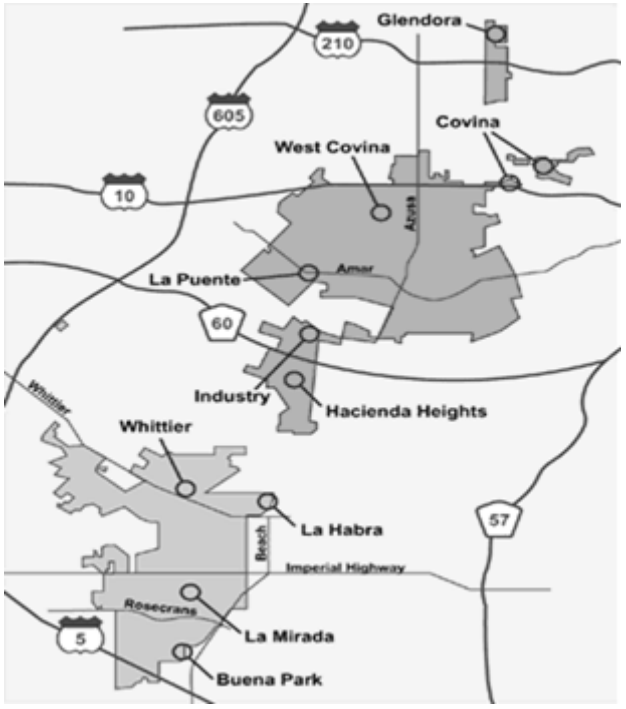
**£4.16M**

**GA Optimised Solution**

**£2.14M**

# Capital Investment Planning (CIP)

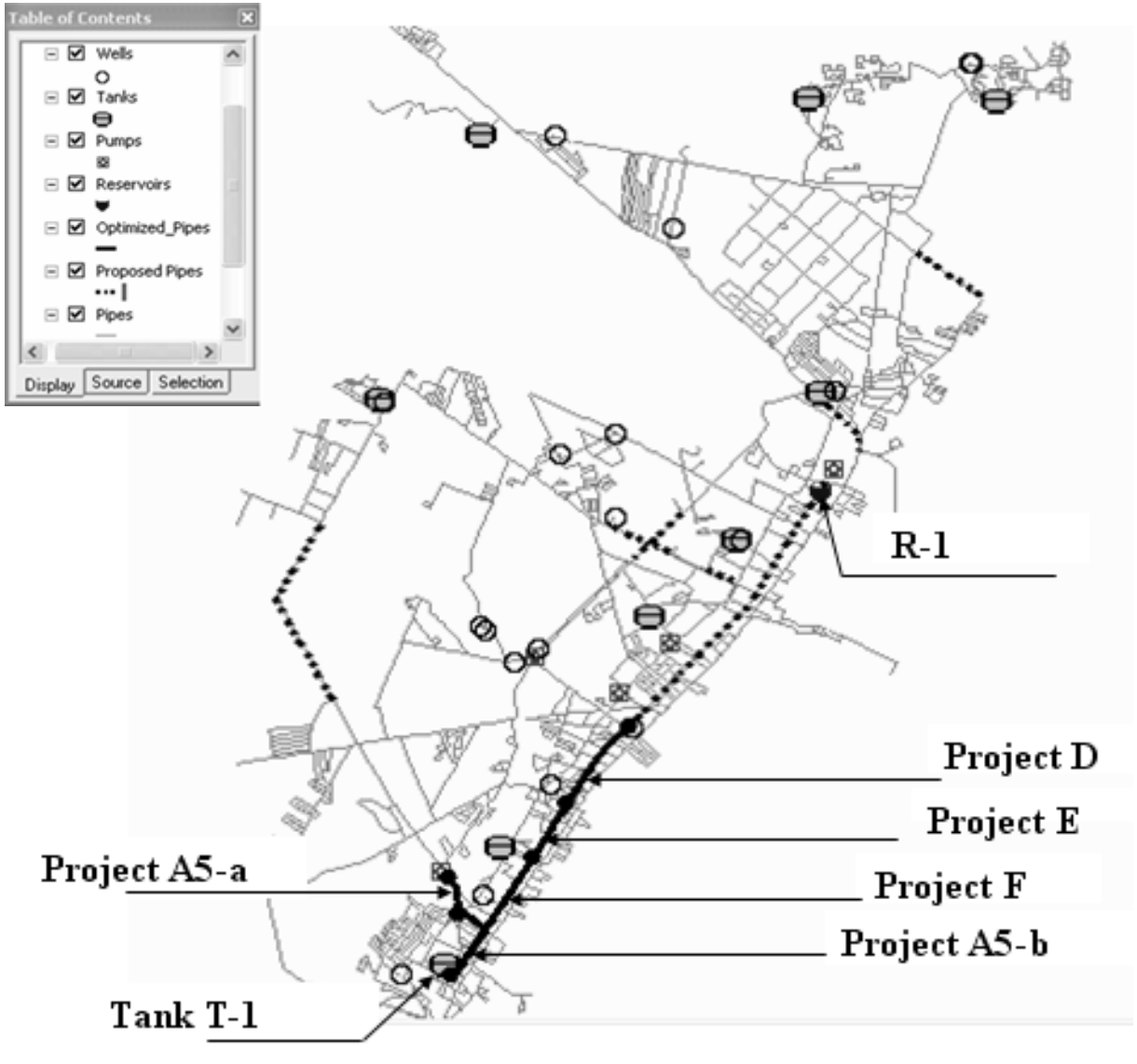
- Growing demand
- Service level improvements
- Optimise design
- Meet criteria
  - Flow
  - Pressure
  - Tank storage
  - Minimum cost
- Master plan




**City in USA:**

- **300 000 inhabitants**
- **Contain 31 reservoirs, 14 wells, 116 pumps and more than 1600 km of pipelines**

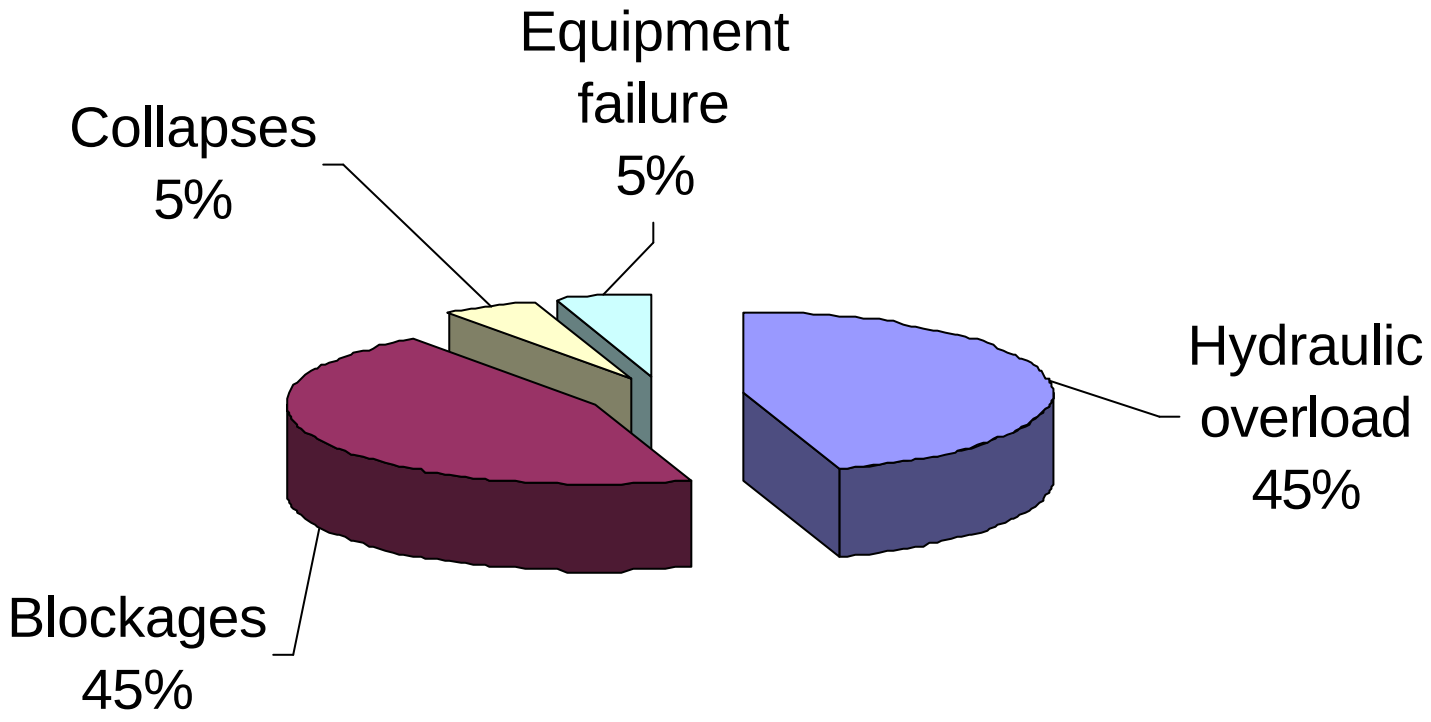
# CIP: Example Results



# CIP: Pipe Installation Priority

| Pipeline Project | 8% Growth (20.06 mgd) | | 13% Growth (21.00 mgd) | | 18% Growth (21.92 mgd) | | 24% Growth (23.03 mgd) | | 30.4% Growth (24.22 mgd) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Dia | Cost ($10^3$) | Dia | Cost ($10^3$) | Dia | Cost ($10^3$) | Dia | Cost ($10^3$) | Dia | Cost ($10^3$) |
| PROJECT A5-a | 12 | 169.8 | 16 | 212.3 | 16 | 212.3 | 16 | 212.3 | 24 | 283.0 |
| PROJECT A5-b | 20 | 511.3 | 20 | 511.3 | 24 | 568.1 | 16 | 426.0 | 24 | 568.1 |
| PROJECT E | 0 | 0 | 0 | 0 | 0 | 0 | 16 | 340.0 | 24 | 453.3 |
| PROJECT F | 0 | 0 | 0 | 0 | 0 | 0 | 20 | 874.8 | 24 | 972.0 |
| PROJECT D | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 24 | 681.9 |
| Total Cost ($) | 681,090 | | 723,540 | | 780,350 | | 1,853,100 | | 2,958,300 | |

# Sewer Deterioration Modelling

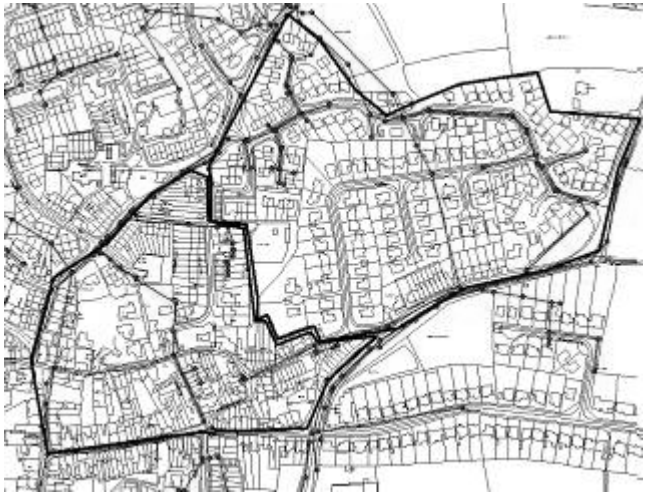



**Causes of Sewer Flooding**

# Sewer Deterioration Modelling

## Sewer Attribute Base

- Pipe performance
- Pipe service
- Installation age / era
- Size
- Material
- Depth
- Gradient
- Function
- Cross section
- Soil, traffic load, mining etc.

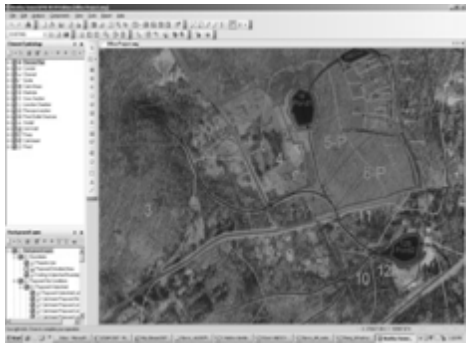


**Timisoara city in Romania: combined sewer system**

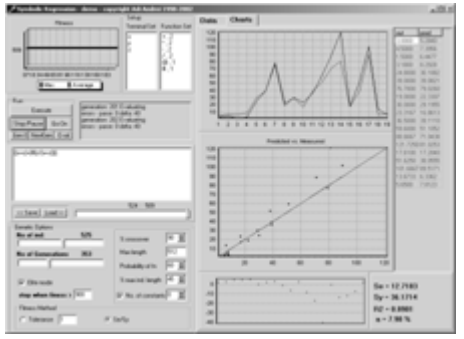
# Solution Techniques

- Bentley SewerGEMS for Hydraulic performance assessment
- Genetic Programming for deterioration modeling
- Bayesian Probabilistic Network for Failure Risk Assessment and Uncertainty

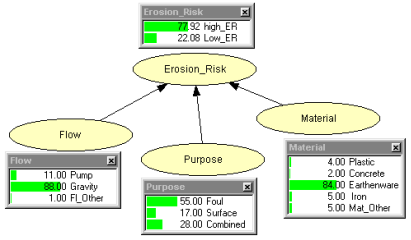
**SewerGEMS**



**Bentley GP kernel**

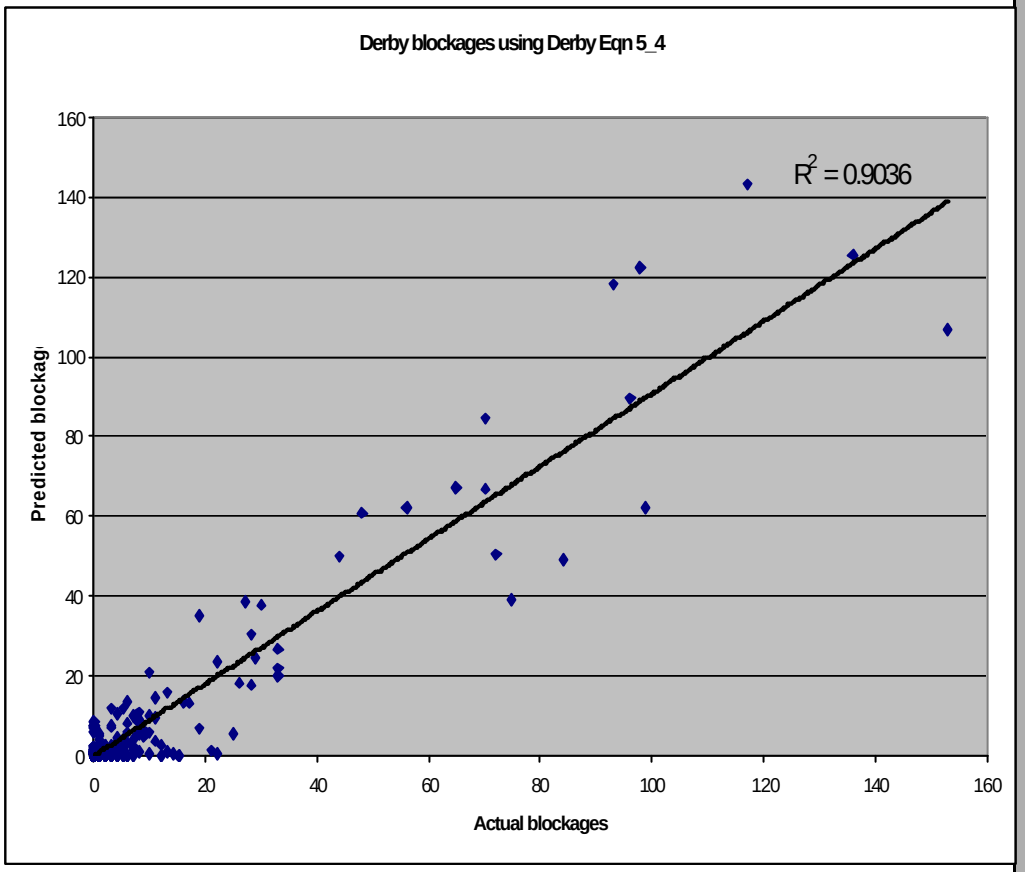


**Bayesian Network**



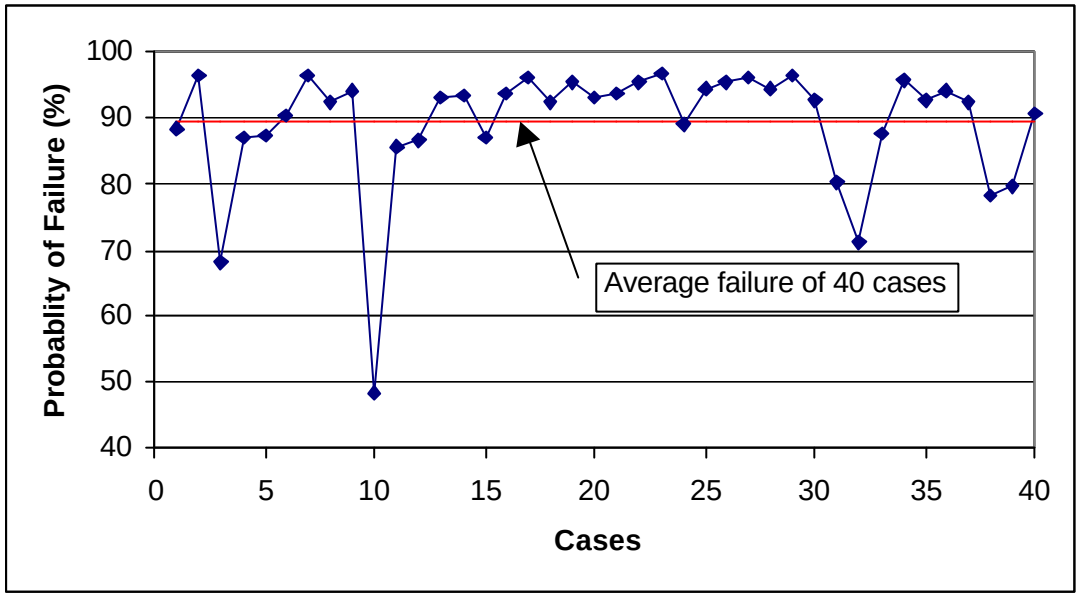
# Deterioration Model Example

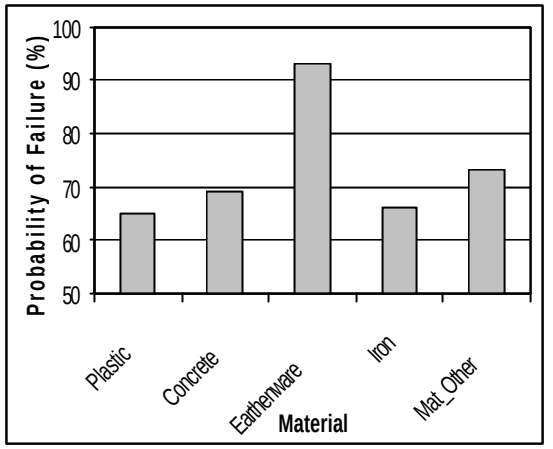
- CoD = 90%
- op – operational condition grade
- Age – age of sewer
- s24 – 'section 24 sewers' (old, small bore)

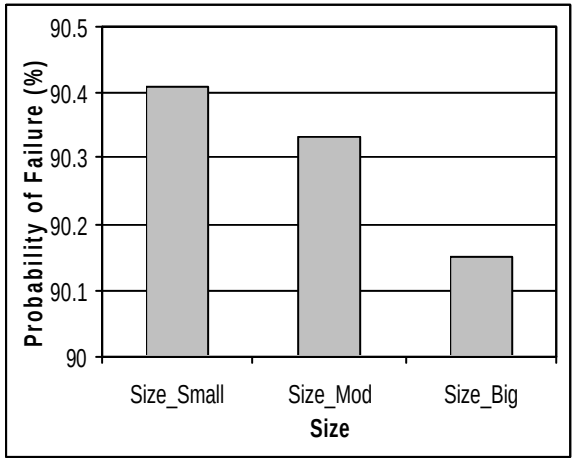


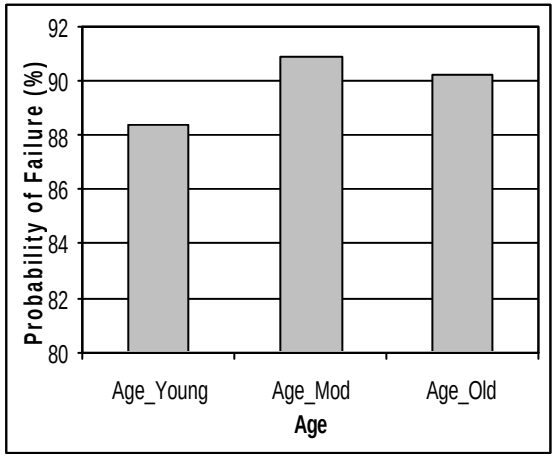

$$BL = 0.091978 \cdot \text{op} + 0.10927 \cdot \text{Age} \cdot \text{s24}$$

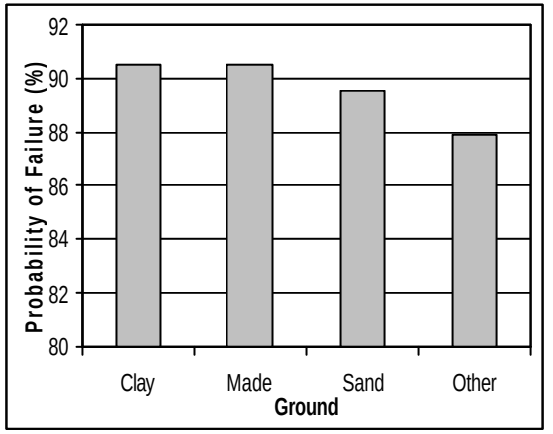
# Failure Risk Model Example



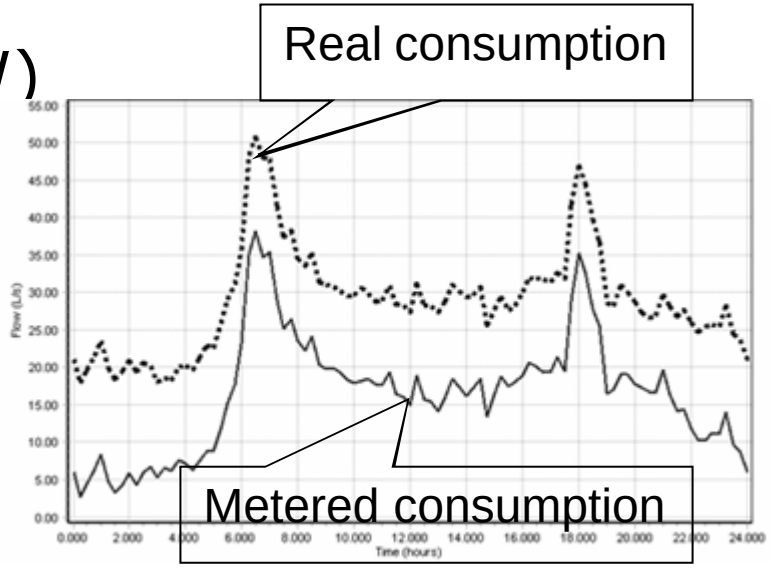



# Leakage Detection

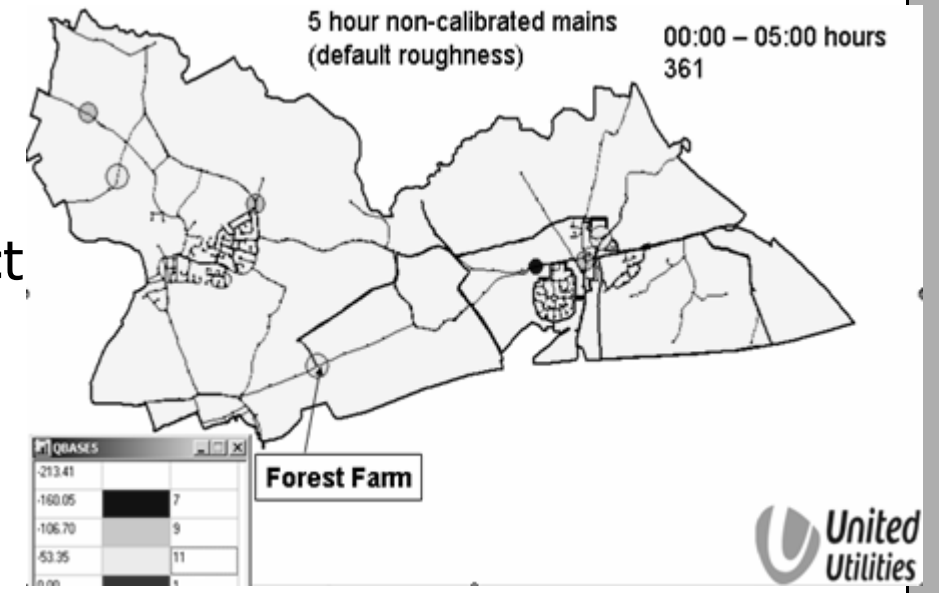
- Cause water companies / utilities lose revenues (NRW)
- Use hydraulic model as a base
- Integrate with optimization technology
- Predict leakage hotspots (unreported leakages)

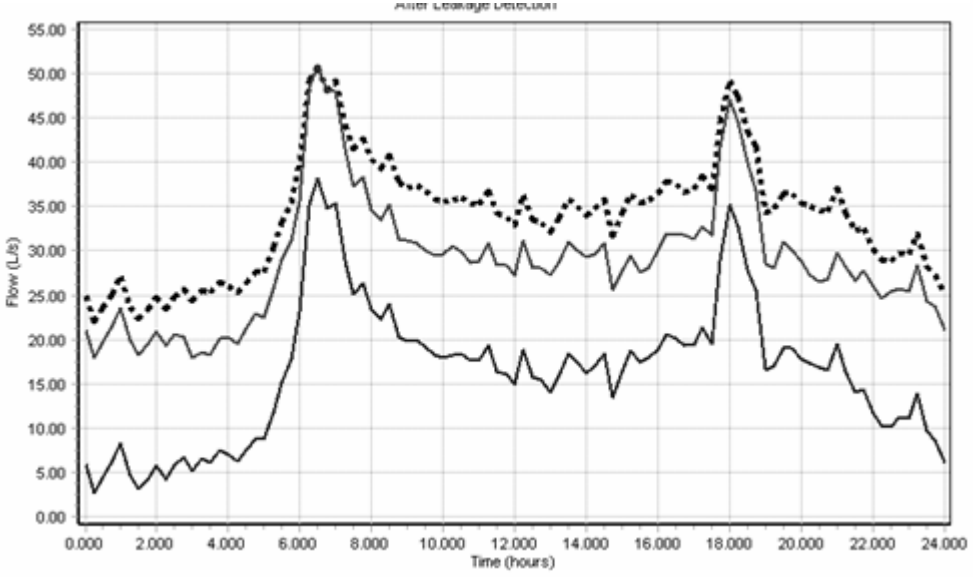


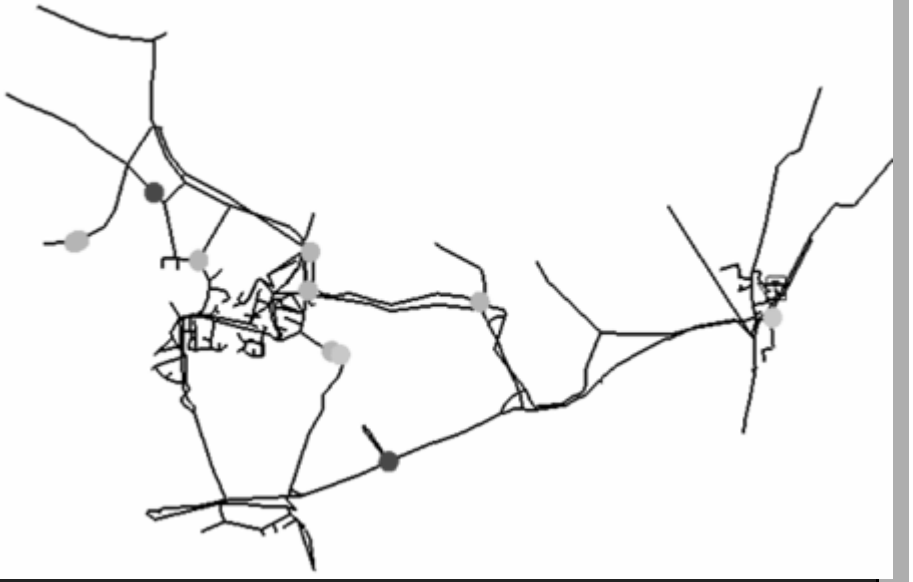

**DMA in UK: Oldham area**

# Leakage Detection Benchmark

- A DMA water system in UK
- High leakage rate
- Apply the latest leakage detect model in **WaterGEMS**
- Enable informed field survey



# Real-time SCADA Modelling

## Security

- Planning and outage analysis
- Real time predictions
- Leakage detection & Demand inversion
- Forensics

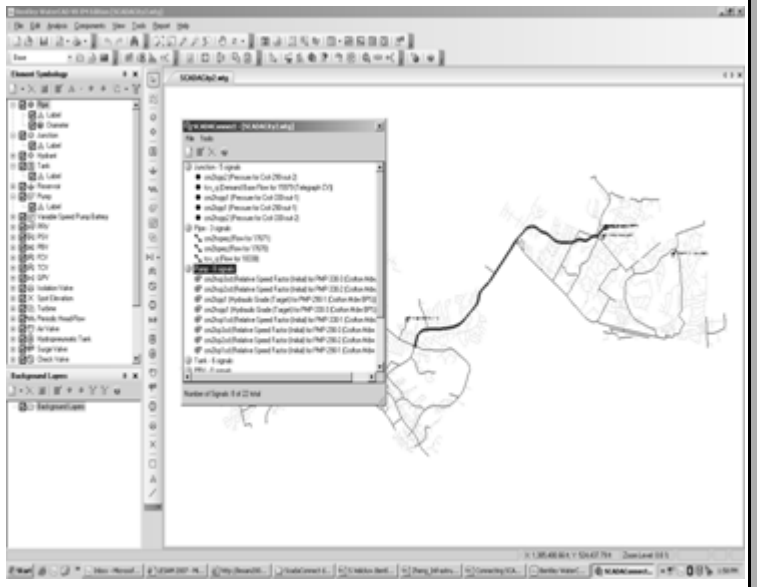
## Energy Management

- Optimal pumps scheduling

## Water Quality

- Emergency management
- Planning
- Forensics

## Operator Training & Learning



**City in Greece:**

**- 47 signals were mapped and used in WaterGEMS for real-time decision support**

# Contact Information and Resources

**www.bentley.com/water**
**communities.bentley.com**
**www.bentley.com/waterloss**

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# Tank You for Your Attention

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