MATHEMATICAL MODELING

WHAT MM OFFERS

MM Spa has developed extensive experience in hydraulic modeling over the years. Since 2008 it has invested significant human, hardware and software resources in developing mathematical models both for the city of Milan water supply system and for its sewer network.

Through its Innovation and Hydraulic Works Feasibility Studies function, MM is now working on the gradual implementation of two models, each simulating the operation of a different system (IWS and sewer).

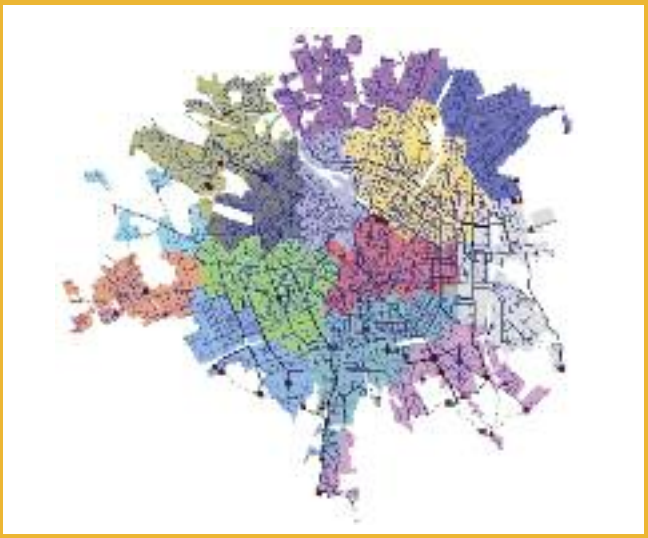
MM uses mathematical modeling to further develop knowledge of the operation of the complex water supply and wastewater collection systems.

The objectives include optimization of flow management and improvement in system efficiency in order to reduce operating costs, ensure compliance with laws and regulations, and protect the environment.

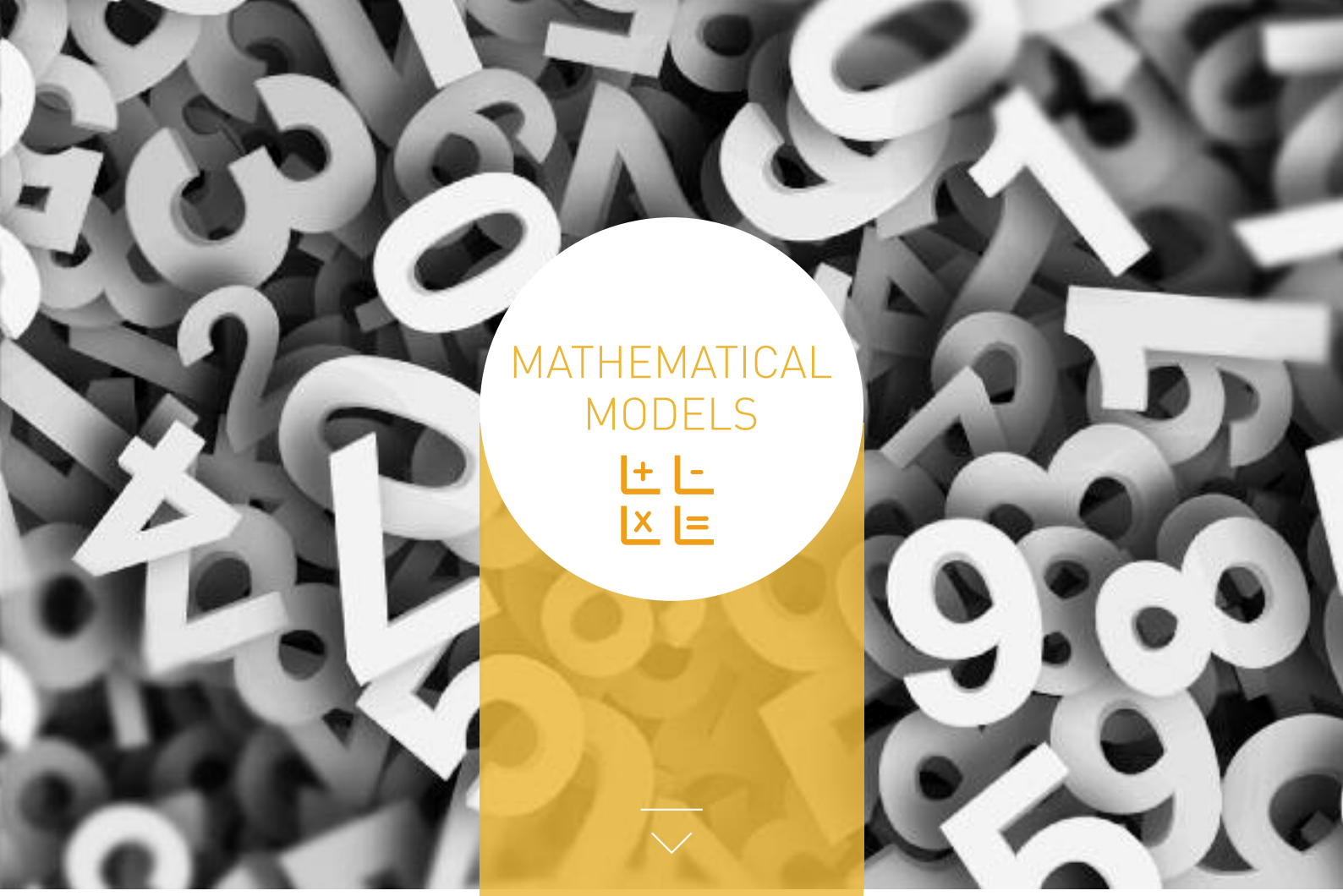
MM uses two HR Wallingford software applications, InfoWorks WS and InfoWorks ICM, which use highly sophisticated algorithms to allow the dimensioning and verification of networks of any size or degree of complexity, from small urban centers to large metropolises.

The results are displayed instantly in the form of plans, longitudinal profiles, graphs, tables, and 3D views. The applications are able to process data from a variety of platforms: AutoCAD, ArcView/ArcGIS, Excel, SCADA systems.

.



Rain profile zones in Milan



MATHEMATICAL MODELS

Mathematical models of water supply or collection systems belong to the category of physically-based, distributed models. Based on system spatial and time variables, they simulate hydraulic and hydrological processes through basic equations of physics that describe them.

Mathematical models of a phenomenon or system are implemented in order to:

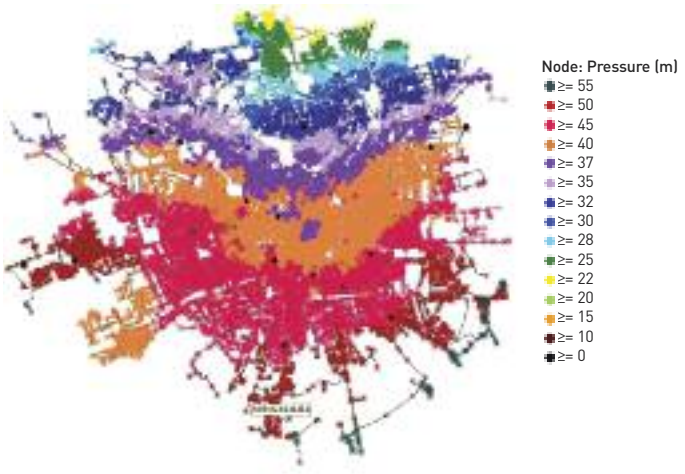
- reconstruct events happening in the past;
- simulate what is happening now;
- forecast what will happen in the future on the basis of user-provided input data.

Model performance is evaluated and models are calibrated by comparing model outputs with actual measurements of the phenomenon or system. Mathematical models of varying complexity are used in various sectors, from meteorology to economics.

The age of computers has made it possible to create increasingly sophisticated mathematical models, favoring their use among all sorts of organizations, institutions and public and private corporations.

SCIENTIFIC SUPPORT FOR INVESTMENTS

The growing need for optimization makes mathematical models a very important technical and scientific tool to support investment decisions and operational management of the Integrated Water Service in order to improve the service offered. Instead of relying on partial, empirical practices, they allow a systematic and scientific approach to knowledge gathering. They are also flexible and safe because they simulate hypothetical scenarios without the risks associated with field experimentation.



Network pressures - Peak hours

WATER SUPPLY AND SEWER SYSTEMS

WATER SUPPLY SYSTEM MODEL

The mathematical model of the Milan water supply system encompasses a multitude of integrated physical, hydraulic and electromechanical elements:

- 30,000 interconnected pipelines extending for a total of approximately 2,300 km;
- 500 extraction wells and submersible pumps;
- 30 water storage tanks;
- 30 pumping stations with 120 high-lift pumps;
- 27,000 junctions and 25,000 valves;
- 180 pressure gauges and 40 flow meters;
- 50,000 user take-offs.

Using the topological data on system elements (pipes, pumps, valves, tanks, wells, etc.) and consumption data from water demand analyses as inputs, the behavior of the system can be studied under various operating conditions. It is possible to obtain precise information on user service levels, the characteristics of the water in the system (concentration of dissolved substances, residence time, etc.), the energy consumed and the efficiency of the system or of its component parts (plants and/or process phases).

System elements

APPLICATIONS

- **Assessment of system flow distribution and pressures;**
- **Immediate development of emergency management plans (breakage, blackout) or maintenance plans (overhauls, upgrades);**
- **Planning and design of new systems and networks;**
- **Districting to control pressures;**
- **Pumping optimization;**
- **Assessment of degree of storage tank use;**
- **Assessment of water quality in the system;**
- **Fire-water assessments.**

SEWER SYSTEM MODEL

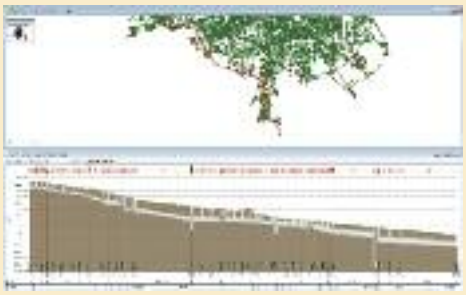
The Milan sewer system is quite complex, delivering wastewater to three treatment plants. It is characterized as follows:

- a total of some 1,500 km of interconnected pipes;
- circular, oval and polycentric pipe sections (320 different types of section);
- closed-grid layout (no "dead end" pipes);
- combined system;
- gravity flow;
- low slopes.

Hydrological and hydraulic calculations are completely integrated into a unified analysis environment.
Using the system elements with their geometrical and functional characteristics (utility vaults, pipework, traps, spillways, pumping systems, etc.) and the sub-catchments with their hydrological characteristics as inputs, the behavior of the system can be studied under both dry conditions (only residential wastewater) and wet conditions (stormwater and residential wastewater combined).

APPLICATIONS

- **Assessment of flowrates and water levels in the network;**
- **Identification of critical points/areas;**
- **Network development, modification, expansion or upgrade planning;**
- **Planning and design of new sewer systems;**
- **Estimation of "invasive" discharges (e.g. stormwater);**
- **Assessment of spillways;**
- **Water quality studies;**
- **Flooding and hydraulic risk studies.**



Longitudinal profile of a water main

POTENTIALS OF THE MODELS

- Determine possible new functional configurations of the systems;
- Assessment of actions and priorities in the Water Infrastructure Management Plan [Piano d'Ambito] depending on developments in consumption, sources and objectives for improvement;
- Redefinition of management rules and procedures in keeping with assumed objectives;
- Interfacing with the remote control system for real-time operational support, particularly for contingency and emergency response in order to minimize user inconvenience.

3D rendering of a trap

ABOUT MM

MM Spa
is a leading Italian engineering firm specialized in the design and construction of public transportation infrastructure and urban redevelopment projects promoting the sustainable development of the local area.

Founded in Milan in 1955, MM is responsible for the construction of the city's entire metropolitan rail system - 108 stations and over 100 km of track - and for major traffic and hydrological engineering projects.

MM is now able to export the solid experience it has developed in this sector to other major projects throughout Italy and abroad. It has participated, for example, in the construction of the metropolitan rail systems in Naples, Rome, Brescia, Turin, Copenhagen and Thessaloniki, the light rail systems in Padua and Venice, and the Autostrada 35 (BreBeMi).

MM Spa offers services ranging from project design to technical and financial assessments, from preliminary characterization to work supervision, and from design validation to inspections, testing and quality control.

MM is now a business partner to public agencies on major public works, whose cost and complexity demand consolidated management capabilities and absolutely reliable technical and administrative support.

Since 2003 MM is also in charge of Milan's Water Supply Service, which includes abstracting, purifying and distributing groundwater, collection and treatment of municipal wastewater, and generally, planning maintenance and investments for the water supply and sewer systems.

In 2014, MM also undertook management of the real estate assets of the City of Milan, comprising over 38,000 subsidized housing units, parking garages and other facilities. To accomplish this, MM created the new organizational unit "MM Casa", which works alongside other company structures that are already managing city services.

Infrastructure, Building and Hydraulic Works Office
Tel. +39 02 7747.330
Tel. +39 02 7747.391 (front office)
m.recalcati@mmspa.eu

MM Spa
Via del Vecchio Politecnico, 8
20121 Milan, Italy
Tel. +39 02 77471
info@mmspa.eu
www.mmspa.eu
www.milanoblu.com

follow us on:

engineering experience