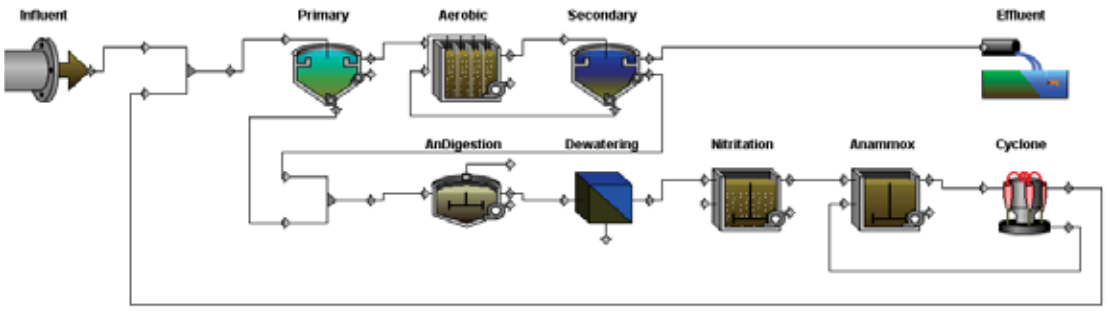
GPS-X™

Dynamic Wastewater Treatment Plant Simulation

GPS-X™, the first commerically released simulator, is the most advanced tool available for the mathematical modeling, simulation, optimization and management of wastewater treatment plants. The user-friendly drag and drop interface and comprehensive database of unit processes allows users to quickly and easily assemble a treatment plant model, enter characterization data, and run simulations.



Advanced Features

- **Influent Advisor** - Validate the accuracy and consistency of your influent data prior to simulation
- **Quick Display Panel with easy data export** - An auto-summary of your key engineering parameters, updating in real-time, with simple export to Excel
- **Dynamic Simulations** - GPS-X offers the fastest dynamic solver in the industry allowing you to perform simulations in a fraction of the time it takes other tools.
- **Extensive Library** of unit process models provide users with tools to design and optimize the widest range of WWTPs including MBR, IFAS, UASB, denitrification filter, sludge pretreatment, anaerobic digester, and comprehensive full-plant biological models for advanced sidestream nutrient removal
- **Advanced Controllers** - Investigate merits of different control strategies using easy to implement PID, On/Off, Flow, Timer and Schedule controllers in GPS-X layouts. Different ammonia based aeration control strategies are easy to setup.
- **Powerful Sensitivity Analysis Tools** - with the Analyzer, Optimizer and Monte Carlo Analysis tools, you can perform automatic multi-parameter sensitivity analysis to determine optimum setpoints for process parameters.

System Requirements

- *Windows 7/8/10 (32/64 bit)*
- *3 Ghz processor*
- *8 GB of RAM*
- *500 MB of free disk space*

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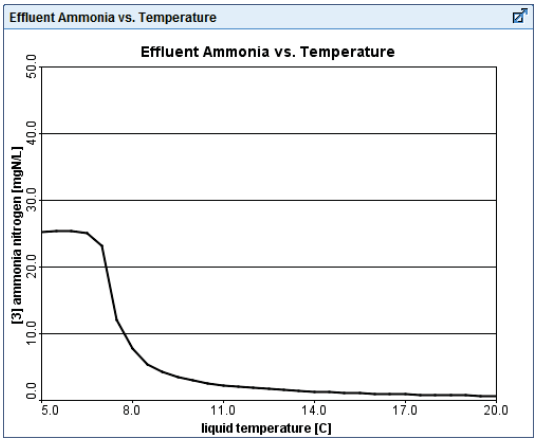
Analyzer

The Analyzer module allows you to automatically perform steady-state or dynamic sensitivity analyses on model parameters, saving users a significant amount of time and effort. The Analyzer module has several applications, such as:

- Evaluating how changes in process and operating parameters (e.g. SRT setpoint, DO setpoint, temperature, etc.) affect various measures of plant performance.
- Determining the relationship between kinetic parameters (e.g., nitrification rate) and system variables such as Temperature, pH, etc.
- Examining how operational variables like SRT, MLSS and DO in the aeration tank affects the effluent ammonia concentration.
- Identifying critical parameters for plant calibration.

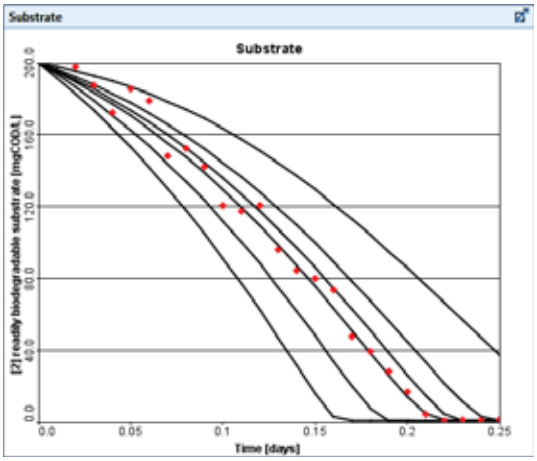


Automatic Steady-State Sensitivity Analysis
Effluent Ammonia
vs.
Wastewater Temperature

Optimizer

The Optimizer module is an extremely powerful tool that can save you a significant amount of time and effort. The Optimizer module has two main uses:

- Model Calibration: used to automatically find parameter values (e.g. kinetic coefficients, settling parameters, etc.) that minimize the difference between measured data and modeled results.
- Process Control Optimization: used to find the best design and process control parameter values (e.g. tank sizes, flow rates, etc.). The Optimizer module uses a robust multi-dimensional search routine that can easily handle multi-variable optimizations.



Kinetic parameter optimization showing successive guesses getting closer to the measured data points as the GPS-X optimizer automatically calibrates the model.

Typical Uses

- **Optimization and Cost Saving Analysis** - Evaluate opportunities to improve control processes, reduce costs (energy, additives, etc.) and develop benchmarking and auditing statistics.
- **Planning and Capacity Analysis** - Design and test possible upgrades without costly consulting expenditures. What is our capacity? Can we postpone a costly upgrade and for how long?
- **Training and Education** - Educate and train your staff with a dynamic model of your plant. Offer troubleshooting and "what-if" exercises geared to the specifics of your facility as part of a comprehensive development program
- **Knowledge Capture** - Capture and document important process information held by key individuals in your plant and get everyone on the same page with regard to plant operation.

Our other products:

Toxchem™ CapdetWorks™ WatPro™

Hydromantis offers expert modelling services for treatment plant design and optimization and is the developer and owner of the industry's most popular modelling and simulation software including: GPS-X, SimuWorks, Toxchem, CapdetWorks and WatPro.

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GPS-X™

Industry Leading

Wastewater Process Simulation, Design, and Optimization Software

Key Features

Interface
Flexible and Easy-to-Use Drag-and-Drop Layout Drawing Board
Easy and Intuitive Data Input into Model
Scenario Manager for Modelling Applications under Various Operational Conditions
Interactive Controller for Dynamic Analysis
Quick Panels with Operational Parameters
One-click Generation of Excel/Word Reports
One-click Sankey, Energy and Mass Balance Diagram
Foreign Language Support
Models
Steady-State and Dynamic Simulations
IWA Activated Sludge Models (ASM1, ASM2d, ASM3)
Anaerobic Digestion Models (ADM1)
Mantis2 Whole Plant Model, Sulfur Model, GHG model
Add-on Model for Water treatment and Industrial Wastewater Treatment
Largest Collection of Unit Processes
Built-in Controllers (PID, ON/OFF, Scheduler, Timer etc.)
Operating Cost Models (energy usage, chemical dosage)
Pre-configured Plant Layouts for Typical BNR Plant Designs
Fast Dynamic Simulation Speed
Productivity Tools
Integrated Influent Data Characterization Tool
Automated Sensitivity Analysis
Uncertainty Analysis using Monte Carlo Simulations
Multi-Parameter Optimization
Statistical Analysis
Model Developer Tool (model matrix format) and Model Code Customizability
Advanced Tools and Applications
Python Integration
MATLAB Connection
Database Connectivity
Applications in Digital Twin Using Simuworks (e.g. Training Tools) and Mantis.AI
Learning Resources
Online Training Videos, On Demand Training
Regular Live Webinars, Recorded Webinars and Video Tutorials

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GPS-X

Unit Processes

Influent


Wastewater Influent


Batch Influent


COD Chemical Dosage


Water Influent


Rainfall


Acid/Alkali/Nutrient Dosage

Preliminary Treatment


Pumping Station


Equalization Tank


Grit Chamber


In-line Chemical Dosage


Belt Microscreen

Clarification/Settling


Circular Primary Clarifier


Rectangular Primary Clarifier


High Rate Treatment


Circular Secondary Clarifier


Rectangular Secondary Clarifier

Activated Sludge (Suspended Growth)


Completely-Mixed Tank


Anoxic CSTR


Plug-Flow Tank


Dual-Inlet Plug-Flow Tank


PFT with Aeration Header


Closed Basin High Purity Oxygen


Open Basin High Purity Oxygen


Membrane Bioreactor (MBR)


Completely-Mixed MBR


Anaerobic MBR


Oxidation Ditch


Powdered Activated Carbon


Lagoon/Pond


Deep Shaft


Continuous Flow Sequencing Reactor


Sequencing Batch Reactor (SBR)

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Activated Sludge (Attached Growth)


Trickling Filter


Simple/Advanced Aerated Biofilter


Rotating Biological Contactor


Submerged Biological Contactor


Upflow Anaerobic Sludge Blanket


IFAS/MBBR


Membrane-Aerated Bioreactor - Hollow Fibre


Membrane-Aerated Bioreactor - Flat Sheet


Passively Aerated Biofilm


Aerobic Granular Sludge Reactor

Tertiary Treatment


Upflow Denitrification Filter


Downflow Denitrification Filter


Sand Filter


Membrane Filter


Disinfection


Disc Microscreen


UV Disinfection


Advanced Oxidation


Reverse Osmosis

Biosolids & Sidestream Treatment


Dissolved Air Flotation


Thickener


Aerobic Digestion


Anaerobic Digestion


Sludge Pretreatment


Dewatering


Drum Microscreen


Hydrocyclone


Struvite Recovery


Aerobic Digestion


Incinerator


Thermal Hydrolysis Process


Aerated Struvite Recovery


Sludge Drying

Controllers


On Off


Scheduler


Flow Timer


Timer


PID

Tools


Modeling Toolbox


Black Box

Sludge Disposal

Building

Composite Sampler

Pump

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GPS-X PRO

Analyzer

Dynamic Wastewater Treatment Plant Simulation

GPS-X is the most advanced tool available for the mathematical modeling, simulation, optimization and management of wastewater treatment plants. The user-friendly drag and drop interface and comprehensive database of unit processes allows users to quickly and easily assemble a treatment plant model, enter characterization data, and run simulations.

What is the Analyzer?

The Analyzer module allows you to automatically perform steady-state or dynamic sensitivity analyses on model parameters, which will save you a significant amount of time and effort. The Analyzer module has several applications, such as:

- Evaluating how changes in process and operating parameters (e.g. SRT setpoint, DO setpoint, temperature, etc.) effect various measures of plant performance.
- Determining the relationship between the nitrification rate and temperature of the plant.
- Examining how the MLSS concentration in the aeration tank affects the effluent ammonia concentration.
- Identifying critical parameters for plant calibration.

Steady-State Analysis Example

The GPS-X analyzer tool can determine the sensitivity of a nitrifying plant to wastewater temperature. GPS-X performs successive steady-state simulations for a range of conditions (wastewater temperatures in this example) and plots the effluent ammonia as it is calculated. Figure 1 shows effluent ammonia (Y-axis) as a function of wastewater temperature (X-axis). In this example, partial nitrification can be established at around 14 °C, and full nitrification can be established for a wastewater temperature of 20°C and above.

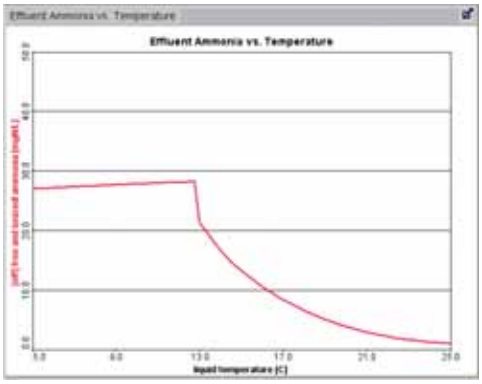

Figure 1. Automatic Steady-State Sensitivity Analysis Effluent Ammonia vs. Wastewater Temperature

Steady-state analysis is useful when you don't need the extra complexity of dynamic changes. However, if dynamic changes are of interest, the analyzer module allows you to incorporate them into your sensitivity analyses.

System Requirements

- *Windows 7/8 (32/64 bit)*
- *3 Ghz processor*
- *8 GB of RAM*
- *500 MB of free disk space*

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Dynamic Analysis Example

An example of a dynamic sensitivity analysis is shown in Figure 2. In this case, GPS-X runs a one-day dynamic simulation with diurnal influent flow rate. This one-day run is repeated for a number of different wastewater temperatures (three in this example), and the results are plotted on the same output graph. In this type of analysis, each line on the graph corresponds to the level of ammonia in the final effluent at a different wastewater temperature.

Observe the effect of plant performance measures, such as:

- Effluent concentrations
- Nutrient removal efficiency
- Pollutant load to receiving waters
- Plant operating variables (e.g. MLSS, DO)
- Sludge production

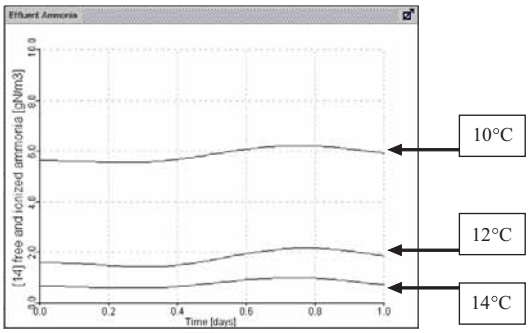


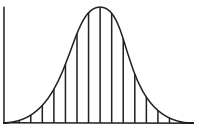
Figure 2. Automatic Sensitivity Analysis Effluent Ammonia vs. Time (for three different temperatures)

Dynamic analysis can be performed on:

- Influent or sidestream (supernatant, etc.) flow rate or loading
- Tank sizes
- Storm flow management (bypass, storage)
- Wasting, recycle, air flow and chemical dose rate
- Automatic controller setpoints and tuning parameters
- Kinetic and stoichiometric parameters
- Settling parameters (e.g. SVI)

Monte Carlo Analysis

A robust Monte Carlo Analysis Tool allows users to evaluate plant performance when not all of the model inputs are well-known. For example, users can now run simulations using a typical distribution of values, rather than being forced to choose a single value, and observe a range of model outputs. For example, users can predict a range of effluent ammonia concentrations given the typical range of nitrifier growth rates, even though the true actual growth rate isn't known. The Monte Carlo Analysis Tool is a valuable addition to the GPS-X toolkit, and provides users with a way to bring the uncertainty of real life into their models.



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GPS-X PRO

Optimizer

Dynamic Wastewater Treatment Plant Simulation

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- **Model Calibration:** used to automatically find parameter values (e.g. kinetic coefficients, settling parameters, etc.) that minimize the difference between measured data and modeled results.
- **Process Control Optimization:** used to find the best design and process control parameter values (e.g. tank sizes, flow rates, etc.). The Optimizer module uses a robust multi-dimensional search routine that can easily handle multi-variable optimizations.

Model Calibration Example

Figure 1 shows an example of using GPS-X for calibrating kinetic parameters based on the results of a lab-scale batch experiment. The small +'s represent measured filtered COD, while the continuous lines are the simulated results of the batch experiment as GPS-X repeatedly searches for the appropriate coefficient values. In this case, the GPS-X optimizer is searching for the heterotrophic maximum specific growth rate and the half saturation coefficient that will minimize the difference between simulated results and actual lab data. The resulting parameter values will provide a close fit to the data.

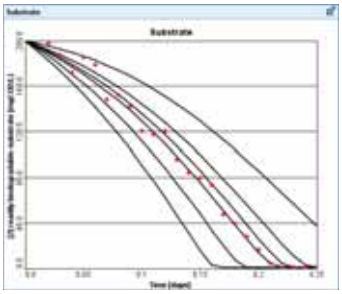

Figure 1. Kinetic parameter optimization showing successive guesses getting closer to the measured data points as the GPS-X optimizer automatically calibrates the model.

A similar calibration exercise using the optimizer can also be based on measurements from a full-scale wastewater treatment facility. For example, the optimizer could be used to find nitrifier growth rates using measured effluent ammonia data.

System Requirements

- *Windows 7/8 (32/64 bit)*
- *3 Ghz processor*
- *8 GB of RAM*
- *500 MB of free disk space*

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Process Control Optimization Example

The GPS-X Optimizer can be used to find appropriate control methods to minimize effluent concentrations from an activated sludge process.

The plant shown in Figure 2 is designed for biological nutrient removal. Under current operating conditions, this plant has an effluent total nitrogen (TN) of 10.0 mg/L. In this example, the optimizer was used to vary the RAS flow, the WAS flow and the mixed-liquor internal recycle (MLIR) flow to meet a more stringent effluent TN objective of 7.0 mg/L. The objective of this optimization is to minimize the effluent TN concentration by finding the best combination of the three flows, while ensuring that the maximum installed pumping capacities at the plant are not exceeded.

Iteration Number	RAS Flow (MGD)	WAS Flow (MGD)	MLIR Flow (MGD)	Effluent TN (mg/L)
Current (0)	17.10	0.134	13.40	10.0
2	13.68	0.134	13.40	10.4
22	15.98	0.143	29.05	7.9
35	15.78	0.165	38.15	7.1
70	15.49	0.161	40.00	7.0

Values determined by GPS-X Optimizer

Figure 3. Optimized Process Control for Minimizing TN

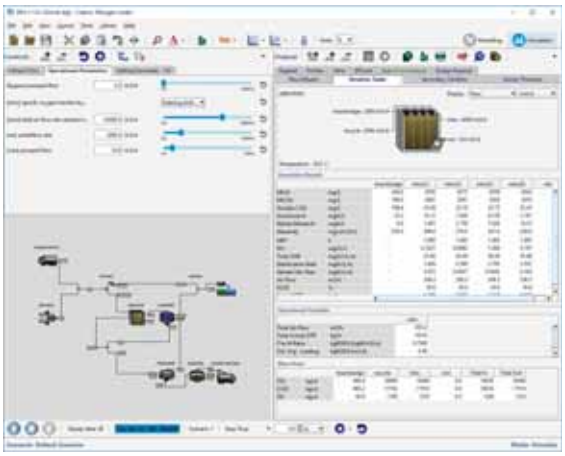

Figure 2. Example GPS-X layout for the process control optimizer runs.

This optimization required 70 iterations to converge. The table in Figure 3 shows the results of the optimization. The iteration number and the three optimized parameter values are shown along with the associated effluent TN concentration.

It can be seen from the results of this optimization that the plant can meet an effluent TN objective of 7.0 mg/L, if the current operating conditions are modified to the values determined by the GPS-X Optimizer.

- **Automated model calibration**
  - Use the optimization module to find model parameter values that provide the best fit between measured and simulated data.
  - Multi-parameter optimization ensures that when multiple parameters impact the same variable, the best set of parameter values can be determined.
- **Evaluate Design and Process Control Options**
  - Use for plant optimization by finding new control option combinations to maximize the use of existing plant infrastructure.
  - Determine the best trade-off between multiple process design options.
  - Optimize SBR cycle settings to maximize biological nutrient removal.
  - Find the most cost effective operating strategy by using the optimizer to minimize total annual operating cost.

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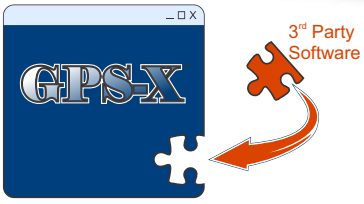
GPS-X PRO+

In addition to the features in GPS-X PRO, the PRO+ configuration includes these powerful tools.

Python Integration

Fit Other Components into GPS-X™

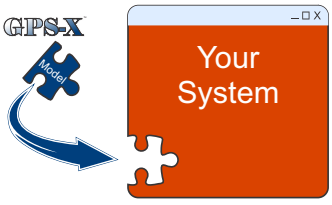


We have developed an integrated interface for creating and executing python scripts from within GPS-X™. The python script can interact with GPS-X™ models to exchange data and allow you to incorporate supplemental analytics on the model data.

By allowing custom scripts to be run in GPS-X™, you can use all of the tools available in python to extend what is possible in GPS-X™. While the applications of GPS-X™ are diverse, it may not always be built generally enough to provide the exact analysis or data visualization options you would like for your project.

By using python, you can do things such as create custom plots, introduce new types of statistical analysis and automate repetitive tasks in ways that are not possible using only GPS-X™.

Fit GPS-X™ into Your System



While you can use python to fit a 3rd party component into GPS-X™, you can also use python to integrate the GPS-X™ model as a component of your bigger enterprise software.

Using the GPS-X™ open API and python, you can programmatically start, communicate and extract results from a model directly from your own software solutions.

GPS-X™ may be the puzzle piece that you've been searching for.

Online Data Reading

The GPS-X™ on-line tool is a powerful tool that allow users to continuously add in new blocks of data rather then using a static input file. In on-line mode, these input files are growing continuously, line by line, and GPS-X™ monitors and reads in the data at a specified sampling rate. If a new line appears in the data file, it will be brought into GPS-X™ (the file input controller updated, or the data appears as a new point on the graph) and the simulation advances to the new time. Thus, the simulation would be continuously updated with data arriving in real time from a plant SCADA system into the input data file, and real-time simulation of the plant would be achieved. This allows you to see a data/model difference from the very moment it starts to emerge, indicating a problem.

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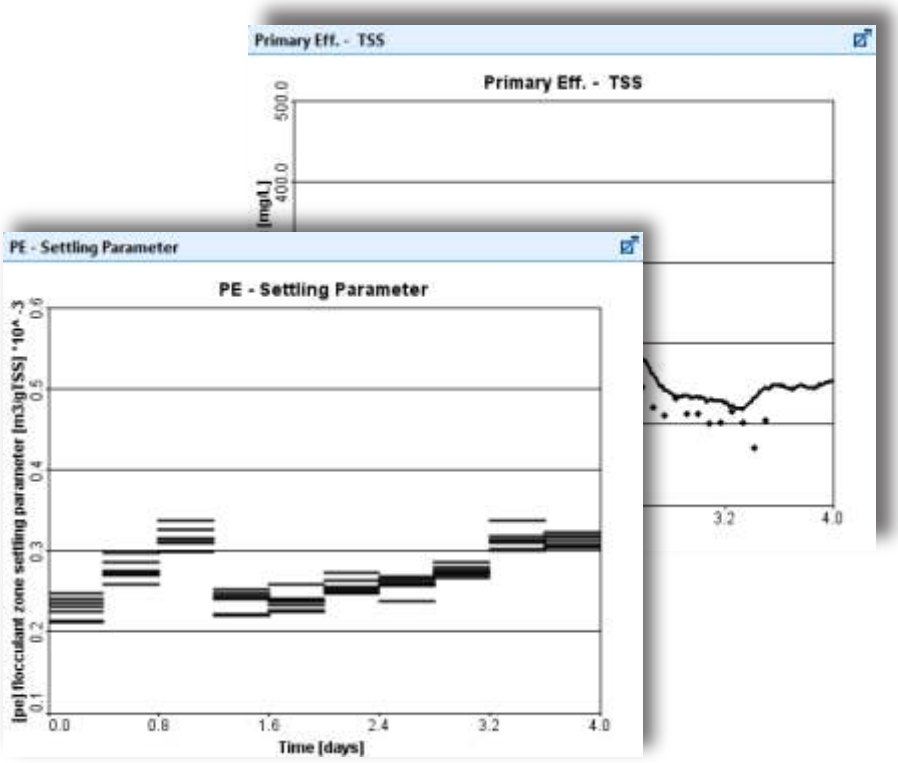
Dynamic Parameter Estimation (Auto Calibration)

Dynamic Parameter Estimator, DPE, is an advanced on-line application allowing you to do a real time simulation and calibration/optimization simultaneously. In this way the model calibration would be automated using the most up to date plant data. When the model only represents the data well over short time intervals, thus suggesting an incorrect model structure, using DPE will help compensate for the model error and allow acceptable fitting of the measured data. As well, if a model parameter is found to be relatively constant during normal process operation but is sensitive to process changes, you can track this parameter using the DPE feature and on-line data to help provide an early warning of process changes or upsets.



MATLAB Link

The MATLAB Link allows the user to call MATLAB code from a GPS-X™ model, sending GPS-X™ model variables as inputs to a special function M-file, and mapping the outputs of that function to other GPS-X™ model variables. In effect, MATLAB is placed "in the loop" during a simulation. This makes it possible to use the MATLAB Link to control a GPS-X™ model using a controller that is implemented in MATLAB, thereby leveraging MATLAB's extensive library of control-related functions. The strength of GPS-X™ lies in its ability to rapidly model and simulate wastewater processes. Controllers are an important part of the plant, and basic PID controllers are built into GPS-X™ - the user sets the controller parameters in the appropriate pop-up windows. The best-performing control systems are designed, rather than tuned heuristically. As described above, the tools in MATLAB's Control System Toolbox provide excellent controller design capabilities. Therefore, by providing an interface between GPS-X™ and MATLAB, you will be able to model wastewater processes in GPS-X™, design suitable controllers for these processes, and evaluate the performance of control systems once the controllers have been transferred back to GPS-X™. Other possible applications of MATLAB with GPS-X™ include data logging, post-run analysis of GPS-X™ simulation results, and displaying data using MATLAB's three-dimensional graphical capabilities.

Database Connectivity

Instead of using files to define input values for GPS-X™, you can connect GPS-X™ to a SQL database and retrieve the input values from the set database.

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GPS-X

How can GPS-X help me?

GPS-X is a software decision support tool that can be used for optimizing existing treatment plants by evaluating the effects of implementing different control strategies, process modifications and low cost retrofits.

The following is a list of examples of how a calibrated GPS-X model can be used in the wastewater industry in terms of design, operations, operator training, cost savings investigations, management and strategic planning or as a teaching aid and research tool in an academic environment.

Design

- Determine the impact of increased organic and hydraulic loading on an existing plant. GPS-X can help determine bottlenecks in the liquid or sludge line.
- Evaluate options for converting an existing plant to meet new nitrogen and phosphorus guidelines under both steady state and dynamic conditions.
- Evaluate the effects of replacing old equipment with new and innovative technologies by modelling the potential impact on performance.
- Model an entire treatment plant including solids or liquid train to understand the impact of recycle streams from the solids train.
- Evaluate the effects of reconfiguring aeration basins from complete mix to plug flow for improving treatment and wet weather flow capacity (step feed).
- Evaluate the effect of including new or improved pre-treatment processes i.e. expanding primary clarifier and adding chemical addition.
- Study the effect of taking units online and offline.
- Evaluate options for wet weather flows from CSO using various control strategies.
- Identify the maximum capacity of the individual unit processes such as aeration tanks, clarifiers, digesters, etc. (under dynamic conditions).
- Estimate how long the digester would take to recover from a specific plant upset.
- Comparisons of various BNR process configurations and control strategies can be easily accomplished.
- Aeration diffuser configuration design layout with varying alpha, beta, fouling factor analysis (based on EPA).

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Operations

- Modelling can be used to confirm if the current plant operational strategies are appropriate.
- GPS-X can determine if an existing plant operation can be optimized. In some cases low cost retrofits can forestall the need for a costly plant upgrade while at the same time maintaining effluent quality. The impact of different operating control strategies can be evaluated such as:
    - Tapered aeration
    - Step feed in plug flow reactors can be useful during storm flow conditions
    - Reduction of dissolved oxygen set points
    - Modifying WAS wasting rates to change SRT and determining the effect on effluent quality and solids handling costs
    - Determining the impact of using different types of diffusers (fine bubble etc) and assessing potential cost savings under dynamic conditions.

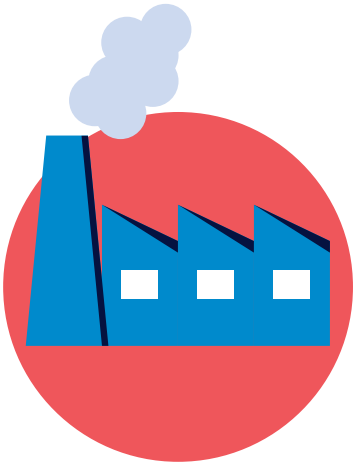
- The impact of varying internal recycle rates, anoxic zones, anaerobic zones on nitrification and denitrification and overall treatability can be assessed.
- Treatment plant calibration requires mass balances of some plant parameters. Methodologies involved in mass balance calculations can result in the identification of flow measuring and instrumentation calibration errors not previously known.
- Valuable biological kinetic parameters can be identified when using online respirometry and input into GPS-X to give a more robust model performance. Conversely, GPS-X can be used to automatically fit online respirometric data and hence identify the effectiveness of autotrophic populations and the amount of carbonaceous and nitrogenous BOD left in the plant.
- GPS-X is decision support tool that is ideal for assisting in treatment plant audits. Plant audits using traditional engineering methodology can provide valuable insight into possible plant operating issues. GPS-X can quantify and provide verification of the magnitude and dynamics of the bottlenecks identified in an audit and demonstrate the effects of planned upgrades or retrofits.

- Optimize solids handling costs by assessing operating strategies that reduce sludge production while maintaining effluent quality within given guidelines.
- GPS-X can be used to automatically optimize chemical addition while maintaining effluent quality and sludge dewaterability. GPS-X can be used to estimate costing issues associated with various operating scenarios involving chemical and energy usage.
- Determine the effect on plant operation of any future increase in industrial loading. (i.e. the increased energy demand, effect on effluent quality, impact of a toxic slug etc). Use this analysis to decide if additional costs should be passed on to an industry planning to discharge to the plant.

Operations - continued

- Investigate which operational strategies could be employed to handle increased industrial loads.
- In the case of an over-designed plant, model and estimate the effect of taking process unit operations out of service (i.e. aeration tanks, clarifiers) before attempting this in the plant.
- Investigate the effect of treatment control strategies during wet weather flows. Under various storm flow conditions determine what is the optimum time to bypass in the primary and secondary clarifiers. GPS-X can be used to generate operational charts and tables for identifying optimal operating conditions.
- Investigate RAS and WAS control strategies for maintaining MLSS objectives.
- By modifying WAS rates SRT can be changed and effects on nitrification and effluent quality determined.
- Estimate the effects on your digesters of dynamic loading by evaluating the following factors:
    - Organic Loading
    - Hydraulic Loading
    - pH effects
    - Temperature effects
    - VSS destruction
    - VFA generation
    - Toxic effects
    - Methane and C02 production

- Model and evaluate the effects of taking specific digesters out of service with the goal to minimize the effect on sludge treatment.
- Modelling of industrial wastewater treatment plants has been accomplished. Various operating scenarios have been investigated including:
    - The optimization of powdered activated carbon for specific chemical removal.
    - The impact of full or partial production shutdown on the wastewater treatment processes.
    - The impact of chemical spills containing high specific chemical concentrations
    - The operation of equalization basins with and without coolers
    - The effect of excessive hydraulic loading on the wastewater facility
    - The impact of tankage downtime
    - The effect of conductivity on settling quality and biological activity



Management and Planning

- By using future organic and hydraulic loading estimates determine when the plant will need to be expanded or upgraded.
- Enhance an existing wastewater treatment master plan or facility plan with a process model so that future impacts can be evaluated quickly and accurately.
- The effects of utilizing high rate treatment plants to reduce combined sewer overflows can be simulated to see the impact on the downstream wastewater treatment plant.
- The effects of flow reduction programs (inflow and infiltration, water conservation, pricing polices, industry pretreatment) will change the influent loading characteristics by reducing the hydraulic component and increasing the organic component. An assessment of the impact of these programs on the wastewater facility can be carried out.
- Flow reduction programs will have an impact on future capital plant expansions or retrofits that may have been planned for the wastewater plant. The financial impact of flow reduction (cost savings in postponed plant expansions) can be estimated.
- Biosolids generated by the treatment plant must eventually be disposed of by land farming, incineration etc. Dynamic simulations of the treatment plant can more accurately estimate the volume of sludge produced under different operating and loading conditions. Model output using different scenarios is valuable as it provides a more accurate input figure for sludge management planning and prediction of sludge disposal requirements. For example it can answer the question Do we have enough land to handle the proposed increases in sludge production given short-term and long-term scenarios?
- Emergency modelling can be carried out quickly to answer any operational questions associated with taking processes out of service and estimating the effects on plant compliance vs. having construction completed faster and more cost effective.
- All plant owners should have a dynamic calibrated model of their wastewater plant. Owners can use GPS-X to evaluate, under dynamic conditions, plant designs being submitted by consultants in response to his tender involving a plant upgrade.
- Pilot plant data can be used effectively to help calibrate plant models. GPS-X can be used to reduce the cost of pilot plant operational studies by reducing the need to operate under certain conditions i.e. long SRT's that require long operating periods and hence increased costs.
- GPS-X is the only process-modelling program designed to be interfaced with online instrumentation. Key model parameters can be updated in real-time thus providing for a constantly updated and calibrated process model. Today more consultants are specifying an interface between online instrumentation and process models in new plant designs.
- GPS-X in a general purpose modelling tool. Process models that do not exist in GPS-X can be created and input into the unit process library.
- GPS-X can provide useful information for Biosolids management plans. It can predict the quantities of sludge generated for plants operating under different conditions or resulting from future plant expansions. Overall plant operating costs can be assessed in conjunction with the implementation of different technologies and operating strategies for reducing biosolids. The effect of the addition of different types of sludge handling technologies to an existing plant can be evaluated.

Cost Savings

- Investigate the potential energy cost savings of implementing dissolved oxygen control or fine tuning DO control strategies given actual dynamic influent data.
- Determine the most cost-effective strategy for using pure oxygen to supplement regular aeration given different dynamic loading scenarios. Use GPS-X to identify the magnitude of cost savings if the use of pure oxygen can be minimized or discontinued without effecting effluent discharge guidelines.
- The selection and evaluation of operational control strategies can be evaluated such as on/off aeration and its impact on nitrification, denitrification and effluent quality. Potential cost savings associated with using various on/off scenarios can be investigated.
- Evaluate the most cost-effective options for upgrading (i.e.: Re-size the reactor, install another reactor, increase the sludge handling capacity, etc.)
- Evaluate phosphorus removal options for operating costs. Compare the operating costs of Bio-P (aeration and pumping costs) vs. Chemical P removal (chemical addition costs) for your plant.
- Balance the cost of sludge hauling and dewatering polymer addition by optimizing polymer dosage. GPS-X can dynamically evaluate the sludge hauling and dewatering polymer costs for your plant at various levels of influent loading. GPS-X's automatic optimization function can be used to minimize costs by determining the best polymer dosage amount.
- Evaluate dynamic aeration costs by determining airflow requirements throughout the day as influent flow changes. GPS-X can simulate diurnal aeration costs, and optimize aeration energy used by aeration more at night when energy is cheaper.

Training

- GPS-X can be used for improving plant operator knowledge and act as a training tool when configured for their plant.
- Specific customized operator interfaces can be developed shielding the operators from direct contact with the plant model, but using their plant model to determine the results of their actions.
- Operators can learn the effects of dynamic process operation and control on their plant.
- Operators can assess their own operational strategies against other plant operators in order to determine which is best.
- Determine the effects of cleaning aeration diffusers and estimate the optimum cleaning frequency thus minimizing costs and aeration tank downtime.

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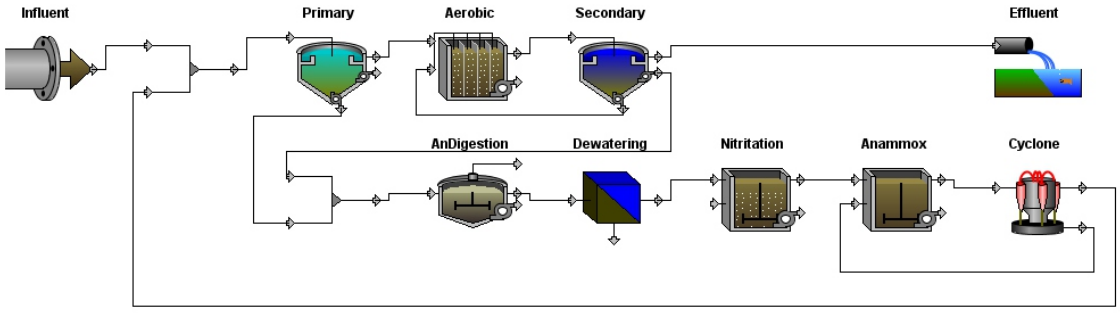
GPS-X™

Advanced Model Libraries

1 Mantis2

Comprehensive Whole Plant Model

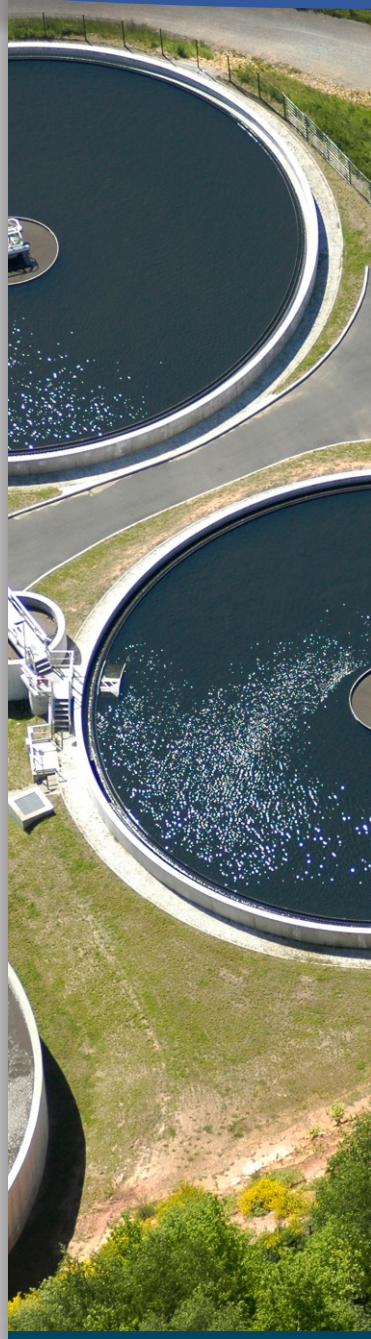
The Mantis2 model in GPS-X™ is a comprehensive bio-chemical whole plant model that allows user to analyze different wastewater treatment plant configurations for biological BOD, nitrogen and phosphorous removal, resource recovery (biogas, struvite) and side stream treatment using the deammonification process.



Some major features of the model includes:

- A single set of state variables for both the liquid (activated sludge) and solid (Anaerobic digestion) processes
- Two step nitrification and denitrification processes
- Methylotrophic denitrification on external substrate like Methanol
- ANAMMOX (Anaerobic ammonium oxidation) process
- Precipitation of common precipitates of Al, Fe, Ca, Mg and PO_4 in the liquid and sludge streams
- pH estimation in both the liquid and solid streams and
- Elemental mass balance for COD, C, N and P and other inorganic components like Ca, Mg, and K.

The model uses a set of 48 state variables (21 soluble + 27 particulate) and 56 biological, chemical and physical reactions. Algebraic equations for estimating pH and alkalinity are implemented in the model. The chemical precipitation reactions of precipitation of $CaCO_3$, $MgHPO_4$, $CaPO_4$, $AlPO_4$, $FePO_4$ and struvite are also included in the model.



System Requirements

- *Windows 7/8/10 (32/64 bit)*
- *3 Ghz processor*
- *8 GB of RAM*
- *500 MB of free disk space*

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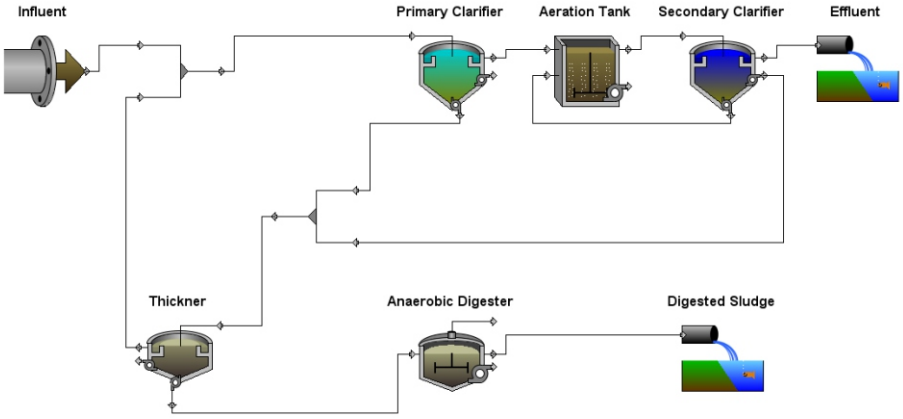
Mantis3

Greenhouse Gas and Carbon Footprint Estimation

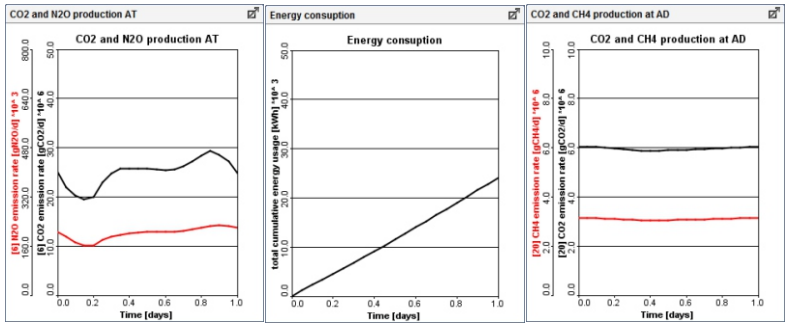
The Mantis3 model for estimation of GHG and carbon footprint extends the Mantis2 biological model to include N_2O production during denitrification. The model also includes biological processes to estimate N_2O production during autotrophic nitrification.

The Mantis3 model considers carbon emissions and offsets across three categories. Emissions in each scope are estimated based on the process emissions, emissions due to energy consumption and emissions due to consumables. The model also considers emission offsets based on non-fossil carbon, carbon capture and heat recovery options at the wastewater treatment plant. The Mantis3 model is a powerful tool for optimizing wastewater treatment process design and operation with a view towards minimizing the carbon footprint of the plant.



Summary of Plant Carbon Footprint	
total scope one emissions	64650 tCO2e/yr
total scope one offset	38100 tCO2e/yr
net scope one emissions	26550 tCO2e/yr
total scope two emissions	7320 tCO2e/yr
total scope two offset	0.0 tCO2e/yr
net scope two emissions	7320 tCO2e/yr
total scope three emissions	0.0 tCO2e/yr
total scope three offset	0.0 tCO2e/yr
net scope three emissions	0.0 tCO2e/yr
total emissions	71970 tCO2e/yr
total offset	38100 tCO2e/yr
net total emissions	33870 tCO2e/yr

Summary of Plant Carbon Footprint



Model Outputs for GHG & Energy Consumption

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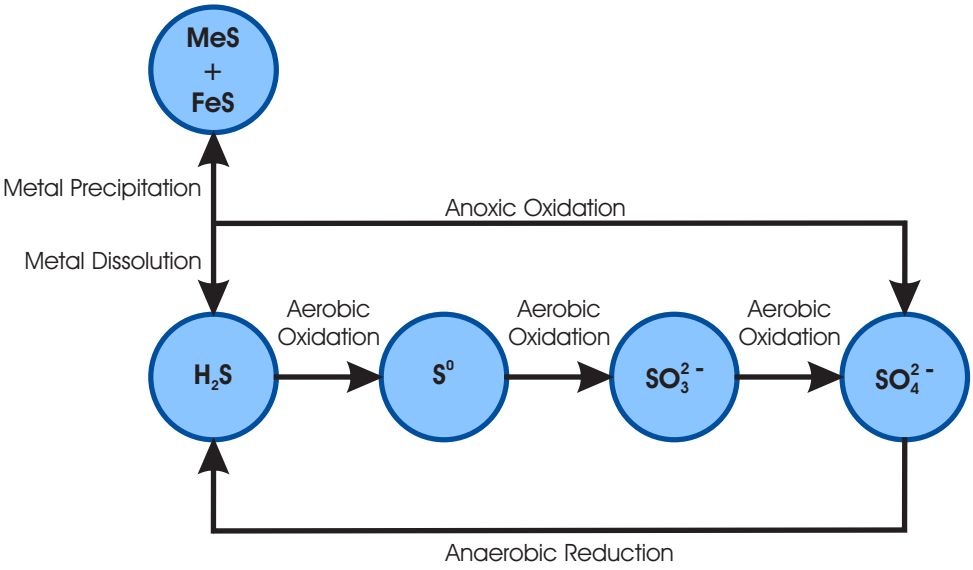
Mantis2S

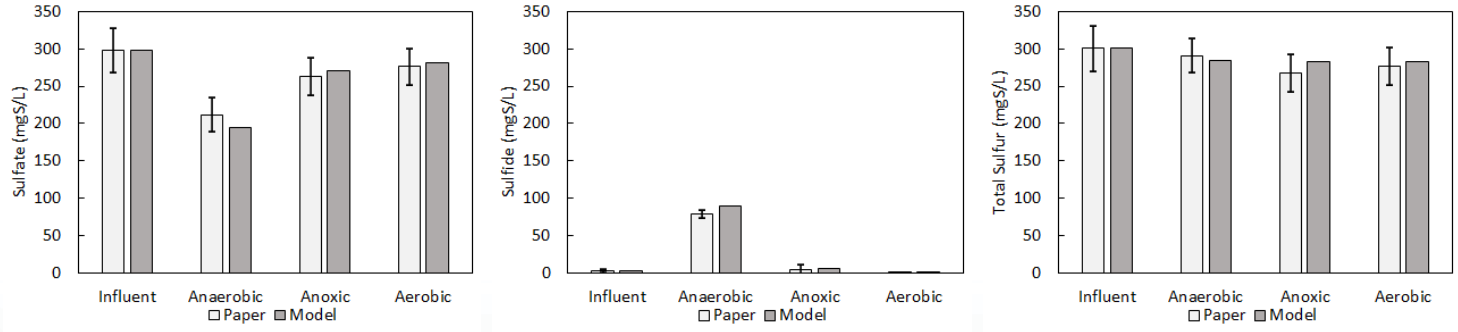
Fate of Sulfur and Selenium Compounds in Wastewater Treatment Plants

The Mantis2S model extends the structure of Mantis2 model by including the biological transformations of sulfur and selenium compounds in wastewater. The oxidized and reduced species of sulfur could be found both in municipal and industrial wastewater. Depending on the inlet concentrations and process configuration, these specifies can have noticeable effect on the biological processes design and operation. Sulfate reducing bacteria in anaerobic digester process can reduce the net yield of biogas and produce hydrogen sulfide which can reduce its beneficial use. Sulfide production is also important for human health and safety, odor, and corrosion control. The oxidation of sulfide in aerobic reactors leads to additional oxygen consumption and change in alkalinity. The Mantis2S model helps quantify the effects of sulfur at different locations of treatment plant.



The Mantis2S model library also includes the biological transformations for selenium oxyanions. The attached growth process to remove selenite and selenate species by biological oxidation to elemental selenium can be easily modelled in this library.

Modelled Sulfer Transformations



Model Output Comparison with Data from Experimental Study of Wu et al. (2016)

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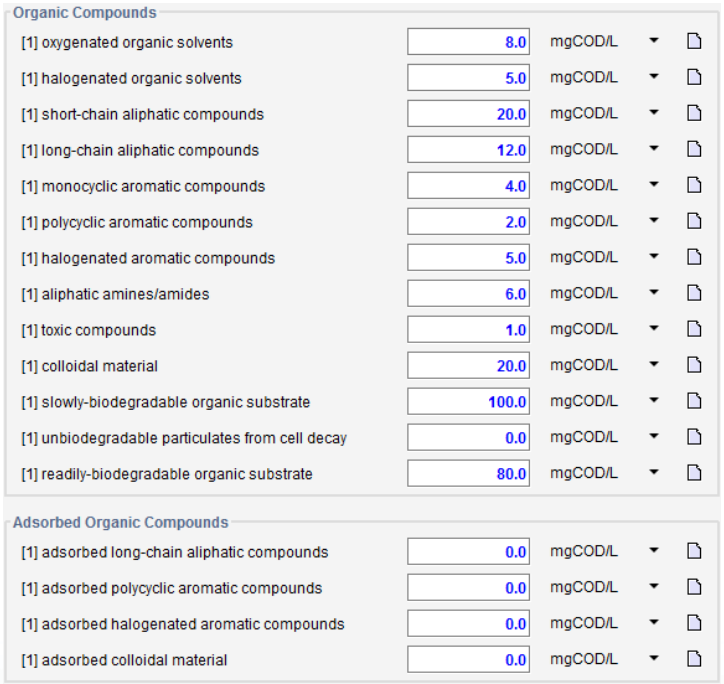
MantisIW

Industrial Library for Petrochemicals

The Industrial Library provides a dynamic-mechanistic model based on chemical oxygen demand (COD), nitrogen, phosphorus, and sulfur balances that include biological and physical transformation processes. The model combines the ASM1 biological model (Henze et al., 1987) with a revised categorization of the influent COD, the modeling of sulfur compounds and toxics, and new biological and physical transformation processes.

In the Industrial Water Library, the influent soluble biodegradable COD fractions (readily biodegradable soluble COD and inert soluble COD) are replaced with the following COD fractions:

1. Aromatic compounds
   - Short-chain (e.g. Benzene and Toluene)
   - Long-chain (e.g. Naphthalene)
2. Aliphatic compounds
   - Short-chain (e.g. hexane to decane, olefins)
   - Long-chain hydrocarbons
3. Halogenated solvents (e.g. chloroform)
4. Inhibitory organic compounds (e.g. phenols)
5. Mixed organics (all other organic biodegradable COD including alcohols and organic acids)



Organic Compounds		
[1] oxygenated organic solvents	8.0	mgCOD/L
[1] halogenated organic solvents	5.0	mgCOD/L
[1] short-chain aliphatic compounds	20.0	mgCOD/L
[1] long-chain aliphatic compounds	12.0	mgCOD/L
[1] monocyclic aromatic compounds	4.0	mgCOD/L
[1] polycyclic aromatic compounds	2.0	mgCOD/L
[1] halogenated aromatic compounds	5.0	mgCOD/L
[1] aliphatic amines/amides	6.0	mgCOD/L
[1] toxic compounds	1.0	mgCOD/L
[1] colloidal material	20.0	mgCOD/L
[1] slowly-biodegradable organic substrate	100.0	mgCOD/L
[1] unbiodegradable particulates from cell decay	0.0	mgCOD/L
[1] readily-biodegradable organic substrate	80.0	mgCOD/L
Adsorbed Organic Compounds		
[1] adsorbed long-chain aliphatic compounds	0.0	mgCOD/L
[1] adsorbed polycyclic aromatic compounds	0.0	mgCOD/L
[1] adsorbed halogenated aromatic compounds	0.0	mgCOD/L
[1] adsorbed colloidal material	0.0	mgCOD/L

The COD categorization is developed by considering the biodegradability and volatility of different organic compounds. Consideration was also given to the classes of compounds that are normally tracked in industrial WWTPs.

Each COD fraction has a portion that is non-biodegradable. The non-biodegradable fractions have been determined using published biodegradability studies and the ToxChem modeling package. Inhibition is modeled using the Haldane (1930) equation. As in ASM1, COD fractions are provided for biodegradable particulate COD and the inert particulate COD.

The industrial library is a useful tool for modeling the fate of some of the common hydrocarbon compounds in the petrochemical industry.

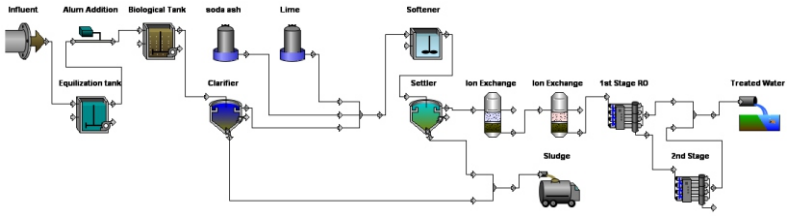
Modeled Compounds

MantisPW

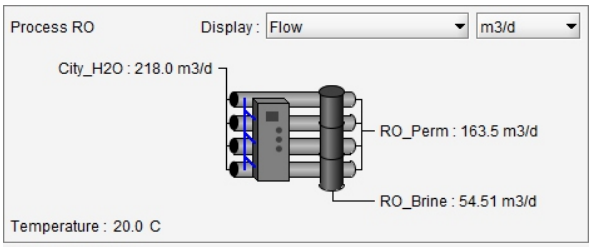
Reuse & Process Water Treatment Model

The Process Water model in GPS-X™ focuses on simulating the water treatment systems which involve interactions and removal of different inorganic compounds from source water. The model allows for the analysis of inorganic soluble compounds like Mg, Ca, K, Cl, HCO_3, Cl_2, Cu, Fe(II), F, HSO_3, Mn, Na, SO_4, S, Zn, SiO_2, PO_4, NH_3, NO_3, NO_2, and inorganic precipitates of Ca, Mg, Fe and silica. By integrating biological degradation of organic compounds, nitrification and denitrification, the model is a powerful tool, for water reuse and water recycling operations. For every stream, important operational parameters like pH, alkalinity, hardness, Langelier stability index (LSI), Ryznar stability index (RSI), Puckorius stability index (PS), Ionic strength, conductivity, resistivity, osmotic pressure, Turbidity and Color are calculated.

The Water Process Library is a valuable tool for users involved in water treatment process design, water reuse and recycling, plant operation, trouble-shooting and optimization.



Plant Layout with Staged RO Units



Simulation Results

		Feed	Filtrate	Brine
Flow	m3/d	218.0	163.5	54.51
TDS	mg/L	724.4	36.22	2789
Ionic Strength	mole/L	0.01362	0.0006812	0.05244
Conductivity	microS/cm	893.7	44.73	3441
pH	-	7.1	7.1	7.1
Soluble PO4-P	mgP/L	0.0	0.0	0.0
Langelier Stability Index	-	-0.14	-2.612	0.9724
Ryznar Stability Index	-	7.38	12.32	5.155
p Alkalinity	mgCaCO3/L	0.3238	0.01837	1.24
M Alkalinity	mgCaCO3/L	304.3	15.22	1172
Total Alkalinity	mgCaCO3/L	307.5	15.37	1184
Carbonate Hardness	mgCaCO3/L	304.3	15.22	1172
Non-carbonate Hardness	mgCaCO3/L	71.46	3.573	275.1
Total Hardness	mgCaCO3/L	375.8	18.79	1447
Turbidity	NTU	0.22	0.0	0.88
Color	mg/L(Pt-Co)	0.0	0.0	0.0

Operational Variables

		RO_Perm
Recovery	%	75.0
Membrane Area	m2	840.0
Flux	L/m2/h	8.112
Standarized Flux	L/m2/h	11.83
Net Driving Pressure (Arithmetic Mean)	kPa	1589
Tempertaure Correction Factor	-	1.159
Flux Change	%	-70.42

Quick Display Panel of the RO Unit

Our other products:

Toxchem™ CapdetWorks™ WatPro™

Hydromantis offers expert modelling services for treatment plant design and optimization and is the developer and owner of the industry's most popular modelling and simulation software including: GPS-X, SimuWorks, Toxchem, CapdetWorks and WatPro.

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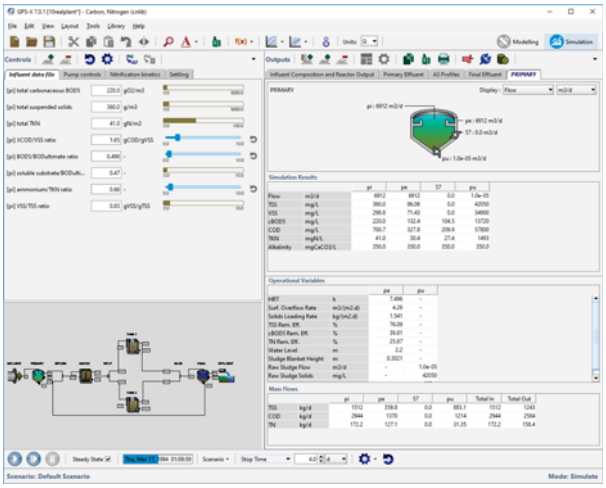
Training

GPS-X™

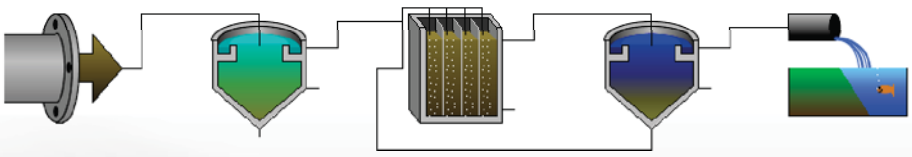
Hydromantis offers a variety of training courses tailored to your unique business environment and requirements. We offer training on-site, web-based and at our headquarters in Hamilton, Ontario Canada. Since 1985 our trainings, taught by seasoned professionals, have been refined based on feedback and results obtained through numerous implementations, and are focused and in-depth to maximize your training investment.



GPS-X Training

GPS-X 2-day training covers all aspects of the use of the software from the basics of wastewater treatment plant modeling and simulation to the application of advanced GPS-X features and concepts.

Training can also begin at no cost to the client with the GPS-X Tutorial Guide, available in Adobe PDF format from the GPS-X Help menu. The booklet contains 10 tutorials that cover how to build models, run simulations and perform advanced analyses. In addition, Hydromantis also offers free video tutorials, also accessed through the Hydromantis website, that are designed to be used in concert with the PDF Tutorial Guide to support a comprehensive, self-paced learning program. If a more formalized approach to training is desired we offer several Instructor-led training options.



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On-Site Training Options

Client-site Training: **$6,500 USD (Plus Instructor Travel and Expenses) 2 Days**

(up to 6 Students)

Client-site training brings the instructor-led course curriculum and Hydromantis Software-certified instructors to you. With several students to train, you can save on travel time and the associated costs.

Our Office Training: **$3,600 USD (Hamilton, Ontario, Canada) 2 Days**

(up to 6 Students)

Training can also be accommodated on-site at our offices in Hamilton, Ontario, Canada, conveniently located half-way between Niagara Falls and Toronto. Away from one's office the training experience can often be much more focused and enjoyable.

Custom Session(s): **Cost TBD**

Clients have the option of having our instructors review client-specific data, layouts and other materials for the purposes of conducting client-specific training and direction in this customized training add-on session. This optional session is an ideal way to conclude a full training program and offers valuable insight from leading professionals on client-specific challenges. It also serves as an introduction and highlights the value clients receive when they sign up for our User Support Program.

Web-Based Training Options

Remote Training: **$3,600 USD (up to 6 Login IDs) 4 Sessions of 2.5 hours**

All the advantages of a live instructor but with the convenience of the location of your choice via the worldwide web. Screen sharing technology connects the instructor to the students offering fully collaborative training with hands-on workshops. The 2.5 hour remote sessions allow students to remain productive at work with no additional travel costs.

Custom Session(s): **Cost TBD**

Clients have the option of having our instructor(s) review client specific questions and address specific challenges in an open forum format. This optional session is an ideal way to conclude a full training program and offers valuable insight from leading professionals on client specific challenges. It also serves as an introduction and highlights the value clients receive when they sign up for our User Support Program.

Our other products:

TOXCHEM™ CAPDET Works™ WATPRO™

Hydromantis offers expert consulting for treatment plant modelling, design and optimization and is the developer and owner of the industry's most popular modelling and simulation software including: GPS-X, Toxchem, CapdetWorks and WatPro.

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Expert Modelling Services

Hydromantis Professional Services

Hydromantis Environmental Software Solutions, Inc. provides expert modelling services for wastewater treatment plant design, commissioning, operational performance and planning improvements.

We meld our advanced modelling expertise with hands-on experience and in-depth knowledge of wastewater treatment design and operational processes to deliver viable solutions firmly grounded in the modern reality of treatment plant operation and design practices. We are practical in our approach, specific in our recommendations, and thorough in our execution.

Specialists in Municipal and Industrial Wastewater Treatment

Owners, Operators and Wastewater Engineering Consultants can take the uncertainty out of critical wastewater design and operational decisions with Hydromantis' advanced process modeling. Hydromantis delivers integrated services and technology solutions that set the world standard in wastewater treatment optimization. Hydromantis' expertise and tools have produced measurable results for a diverse group of enterprises around the world, resulting in millions of dollars in estimated savings.

Our Services

- Review and Optimize new plant designs or re-designs prior to construction to ensure regulatory and cost-saving targets will be met .
- Plant Audit/Optimization analysis to identify potential cost savings and performance enhancements.
- Energy and greenhouse gas reduction audits and solutions.
- Custom treatment plant model and interface development for operational, training and plant analysis.
- Wastewater treatment plant energy use and carbon footprint analysis.

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Customization Services

Your Partner in Innovation

Our clients are at the forefront of innovation in their various segments. As the leading provider of environmental process modeling software, Hydromantis partners with our clients to support them in their projects.

Whether our clients are developing new aerated systems that potentially reduce the energy foot-print of wastewater treatment, processes that enable enhanced nutrient removal, metals removal technologies that allow for the elimination of Selenium, early warning systems that are integrated into a facility's SCADA system, or novel predictive control systems for monitoring reverse Osmosis (RO) membrane fouling, Hydromantis has provided the support and insights required to model these systems. Our work has led to the development of custom modules that address our clients' innovative processes or new modeling equations that allow unique chemistries and biochemical transformations to be robustly modeled.

Contact us today to find out how we can work with you to incorporate your innovative processes and technologies into our suite of products such as GPS-X™, Toxchem™, WatPro™ and CapdetWorks™.

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GPS-X™

The Best Tool for Modeling Wastewater Systems

Client Testimonials

"GPS-X is the best tool to model complex biochemical systems to confirm or enhance my intuition and gain process insight which might not have been readily obvious. It offers intuitive interfaces and an unmatched level of sophistication that reinforces my experience and has made me a better process analyst and designer."

Art K. Umble, Ph.D., P.E., BCEE
MWH Americas, Inc.

"I just wanted to let you have some feedback on my use of GPS-X. Overall, I'm extremely pleased with the mantis2 biological model. It's been very easy to calibrate, particularly using the influent advisor. One of the features I like best is the standard report format in Excel. The ability to generate separate tabs for each graph and process is great – this is vastly superior to the Word output reports used by competing products."

Raymond D. Hamilton, PE, BCEE
Senior Engineering Manager
AMEC - Earth and Environmental

"GPS-X is one of the most powerful tools available in the marketplace and the only one that could accommodate our need for customized interfaces. We have simulated our two regional wastewater treatment facilities and one sub-regional facility with GPS-X. Both the software and the expertise from Hydromantis have offered tremendous help with our planning, process design, and plant operations."

Jing Luo, PhD, PE
Civil Engineering Manager
Pima County Regional Wastewater Reclamation Department (RWRD)

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GPS-X™ The Superior Whole Plant Modeling Platform

Client Testimonials

"I recently spent 30 days analyzing numerous waste streams that enter a refinery wastewater treatment plant. Some of those streams included crude tank water draws, alky unit wastewater, desalter brine, and wastewater stripper effluent. Oxygen uptake rate testing was conducted repeatedly to determine the time to endogenous respiration, the oxygen consumption associated with the individual waste streams, and the total oxygen consumption in the biological reactor. Along the way, numerous data tables and graphs were being generated and communicating the wealth of information very quickly became a difficult task.

All that changed when I ran several GPS-X simulations as part of a presentation. Immediately, everyone, knowledgeable in wastewater treatment or not, could understand and relate to how increasing the COD loading consumed oxygen in the biological reactor. Everyone could see and understand how the biological reactor was deficient in oxygen-generation capacity. The GPS-X model was then used to show how much additional aeration input was going to be required to sustain a dissolved oxygen concentration $\geqslant$ 2.0 mg/L, evaluating both horsepower requirements and pounds of air per day.

The mountains of laboriously collected and compiled data had failed to communicate, to "tell a story." The simulations and the different scenarios modeled using GPS-X succeeded where no amount of data could. This is a tool I cannot imagine being without. Thank you!!"

Rick Fuller
Global Water Senior Technical Advisor
Athlon Solutions

"We developed a whole-plant process model for a large treatment plant in Pennsylvania with the new Mantis2 biological model on the GPS-X platform. The process included primary treatment, high purity oxygen activated sludge, secondary clarification, thickening, anaerobic digestion, dewatering, and advanced side-stream treatment. Two intensive sampling programs were carried out to render dynamic calibration and validation databases. It was clear that the new and more detailed influent characterization framework of the Mantis2 model coupled with the extensive array of dynamic state variables and process rate equations proved to represent both aerobic and anaerobic treatment performance extremely well. This helps establish the new Mantis2 biological model as one of the premier "Super Models" in the wastewater process modeling industry.

In addition, the new multi-tabbed graphical interface of GPS-X Version 6 made tracking each interunit's process performance a breeze. Over 20 ready-made process unit summary tabs and 40 dynamic graphs were created in a matter of minutes, while the excel-based reporting feature made simulation scenario documentation a snap."

Kevin Frank, PE
Wastewater Process Engineer
AECOM

Our other products:

Toxchem™ CapdetWorks SimuWorks™ WATPRO

Hydromantis offers expert modelling services for treatment plant design and optimization and is the developer and owner of the industry's most popular modelling and simulation software including: GPS-X, SimuWorks, Toxchem, CapdetWorks and WatPro.

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