

# Mass Balance

The Mass Balance Application allows for the monitoring of pressure zones for a quick way to determine zonal mass and energy balance and report non-revenue water by zone in near real time.

Mass Balance Networks are created using the Add/Edit Mass Balance Network window and then designed in the Mass Balance Network interface window. Once inflow, outflow, tank storage, and usage data sources are specified for each zone, the Run Mass Balance tool will compile hourly, daily, and monthly zonal mass balance results for charting and further analysis. If pump power usage data is provided (current and voltage), Mass Balance Networks can also calculate and report on the energy usage and cost for each zone. Results for each zone can either be viewed as a snapshot for each zone in the Mass Balance Network window or zonal data can be used to create Dashlets.

Go to the [Mass Balance Network](#) page for information on setting up and using Mass Balance Networks.

## Calculations used in Mass Balance

### Calculating the Usage

Mass balance calculations are often performed by engineers to estimate the total usage in a zone or system. This is often used by hydraulic modelers to develop diurnal curves of water usage.

Usage can be directly calculated for a given time interval as the sum of inflow volume minus the sum of outflow volume, minus the change in storage in that zone or system.

$$Usage = \sum Inflows - \sum Outflows - \Delta(Storage)$$

Here we apply a negative sign on the change in storage volume, because losses in tank volume represent water used in the zone, while increasing tank levels represent flow returning from the zone to the tank.

These calculations use a backwards difference approach, since in real-time data we only know what happened in the past and not the future. Specifically, the hourly usage value output at 3:00 represents the water that was used in the zone from 2:00 to 3:00.

Inflow/Outflows are converted to volume approximately by simply taking the average flow rate throughout the time interval and multiplying it by the time step.

$$Flow Volume = \int_{t-dt}^t Q(t)dt \approx \frac{1}{n} \sum_{i=1}^n Q_i \Delta t$$

Changes in storage volume are simply the difference in volume between the current time step from the previous time step.

$$Change in Storage Volume = V_i - V_{i-1}$$

In the case of a cylindrical tank, you can take the change in tank level multiplied by the area of the tank.

### Manually validating in a Chart or BizBlock

You can actually reproduce the same results manually in Info360 using the [Volume](#) function. The following could be used in a BizBlock for a zone with two inflows, one outflow, and one tank as a simple example:

$$Usage = Volume(\{@Inf1\}) + Volume(\{@Inf2\}) - Volume(\{@Outflow\}) - Volume(\{@TankA\})$$

\*Note that you will need to be careful with units here and convert as necessary. If flowrates are in gallons per minute, then Volume() will return gallons, while a tank with units of feet will get Volume() outputs in cubic feet.



**Note:**

Outputs from Mass Balance are all in units of volume. Consequently the values will vary based on timestep. Hourly usage values report the water used that hour. The values will be much larger when viewing data in a daily time interval.

## Example Calculation

Lets say we have the following 15 minute data for a zone with two inflows, one outflow, and a cylindrical tank with surface area of 500 square feet.

Time	Inflow 1 [gal/min]	Inflow 2 [gal/min]	Outflow [gal/min]	Tank Level [ft]
0:00	43.3	8.7	34.6	21.0
0:15	44.5	6.9	31.6	19.5
0:30	48.4	8.7	33.3	18.3
0:45	50.2	10.8	32.9	17.1
1:00	54.1	9.1	28.5	19.4

We will calculate the water that is used between 0:00 and 1:00, which is the value Info360 will report for hourly results at 1:00.

The inflows and outflows can be converted to volumes in and out of the zone by taking the average and multiplying by 60 to get total gallons used in the hour. We must be careful though that the values at 0:00 are not included in our 1:00 calculations.

The change in storage volume will be simply  $(19.4 - 21) \times 500$  to get -825 cubic feet, or -6171.4 gallons (multiply by 7.48 gal/ft<sup>3</sup>).

The volume associated with each data feed as well as the resulting usage are calculated as:

Time	Inflow 1 [gal]	Inflow 2 [gal]	Outflow [gal]	Tank Level [gal]	Usage [gal]
1:00	2958.3	531.975	1894.35	-6171.429	7767.4

## Calculating Non-Revenue Water

Non-Revenue water is simply the water that is used minus what is billed. Further description of NRW is given in the following section.

$$NRW = Usage - Billing$$

For many, billing data is only available on a monthly basis and comes in a format that is difficult to bring in to Info360. If this is the case, billing data could be manually brought in to an updatable sensor on a monthly basis. Calculating non-revenue water in each zone for even a monthly interval can reveal a lot about a system.

With the growing adoption of smart meters and Advanced Metering Infrastructure (AMI), non-revenue water can be calculated in near-realtime with excellent temporal resolution.

When implementing AMI or Smart Meters, it is best to cover one full zone at a time, rather than scattered throughout the network. This will enable the data to be utilized as it comes in for each zone.

## Pump Energy and Carbon Footprint

Wherever pump energy usage is available, Info360 can report on the energy costs for a given zone.

Info360 needs pump energy data to come in either feeds of power (Watts) or both current and voltage (Amps x Volts = Watts). Power is then integrated over time to track the KWH (Kilowatt Hours) which is the total energy used. The manually set Power Cost (\$/KWH) for each zone is then used to output the cost of operating all pumps in that zone. Finally, KWH can also be converted to estimated carbon footprint as lbs of CO<sub>2</sub>.



### Note:

The current version of Info360 bills energy usage at a constant rate. For more in-depth cost analysis, construct a BizBlock that bills energy usage with a varying pattern each day. [Contact us](#) if you need help with this.

## Non-Revenue Water Background

An ideal water system would have no water losses and no unaccounted for water. Just enough water would be produced to provide for end user consumption. However, in the real world there are many factors that result in the amount of water billed not equaling the amount of water produced. The difference between produced and billed water is typically referred to as "Non Revenue Water" or NRW.

NRW comes in many forms including:

- Leaks – pipelines, valves, hydrants, and others
- Theft – Unauthorized taps
- Fire Fighting – unmeasured water

- Unbilled water – a water utility may not measure and/or charge internal use such as part watering
- Others

An accurate model requires proper accounting of NRW as part of the model set-up and calibration process. Whether a distribution has a single or multiple pressure zones, the process is the same: the calculated water usage is compared to the billed water usage and the difference is NRW, which can also be shown as a percentage. The Calculated Usage is simply the summation of all Inflows to a pressure zone minus the summation of all Outflows from that pressure zone plus/minus the change in water volume from all storage facilities (tanks). If the net change in tank volume is into the pressure zone than it is added to the zone production, if it is out of the pressure zone than it is subtracted from the zone production. This process is repeated for all pressure zones. Note that in many cases, the Outflow from one pressure zone is the Inflow to another.

Billed water is then subtracted from calculated water to determine NRW. Typical NRW in the United States varies from three to ten percent. In other countries, NRW may be as high as 50%.

## Mass Balance Networks

Mass Balance Networks are used calculate the usage and Non-Revenue Water on the zones of the system based on measured and billed data.

Learn more about the calculations and numerical approach used in [Mass Balance](#).

### Mass Balance Tab

The Mass Balance Tab in the Info360 Ribbon controls the management of Mass Balance Network objects.

Feature	Description
	Click this button to create a new Mass Balance Network and open the New/Edit Mass Balance window where the name, group, and type are assigned.
 	The Ready and Run buttons show the status of the Mass Balance. Click to re-sample and re-run the Mass Balance analysis.
	These are the standard Info360 tools for editing, cloning, and deleting objects.
	Click this button to add the selected Mass Balance Network to the current Workspace. Once added, the Network can be Designed and Viewed.

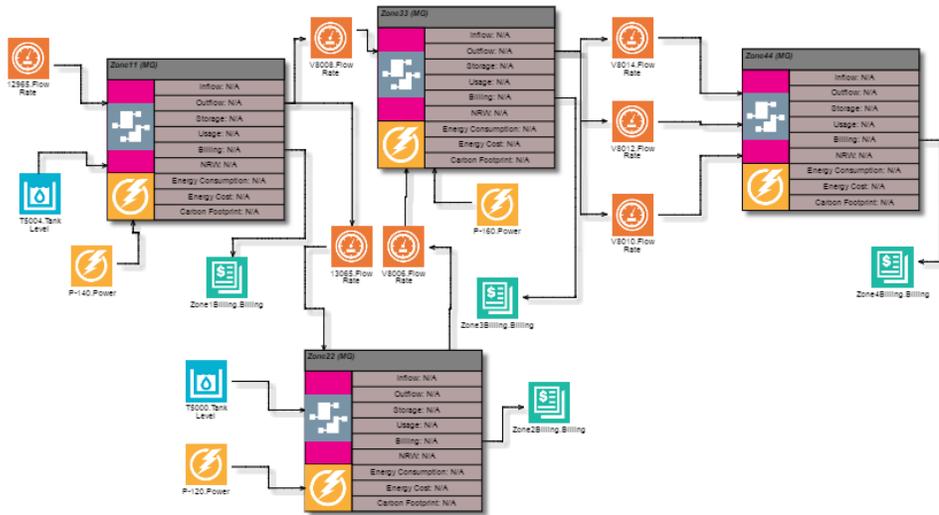
Once a Mass Balance Network is added to the Workspace, it can be customized in Design Mode and reviewed with live data in Snapshot Mode as described below.

### Design Mode

Feature	Description
<b>PZM Import</b>	 <b>PZM Import</b> Click the  icon to import a Pressure Zone Manager (PZM) file exported from InfoWater or InfoWater Pro. For more information, refer to <a href="#">How to Import PZM File into Info360</a> .
<b>Add Elements</b>	 Click the  icon to access the Mass Balance component pane. Simply click and drag to add any component to the Mass Balance canvas.

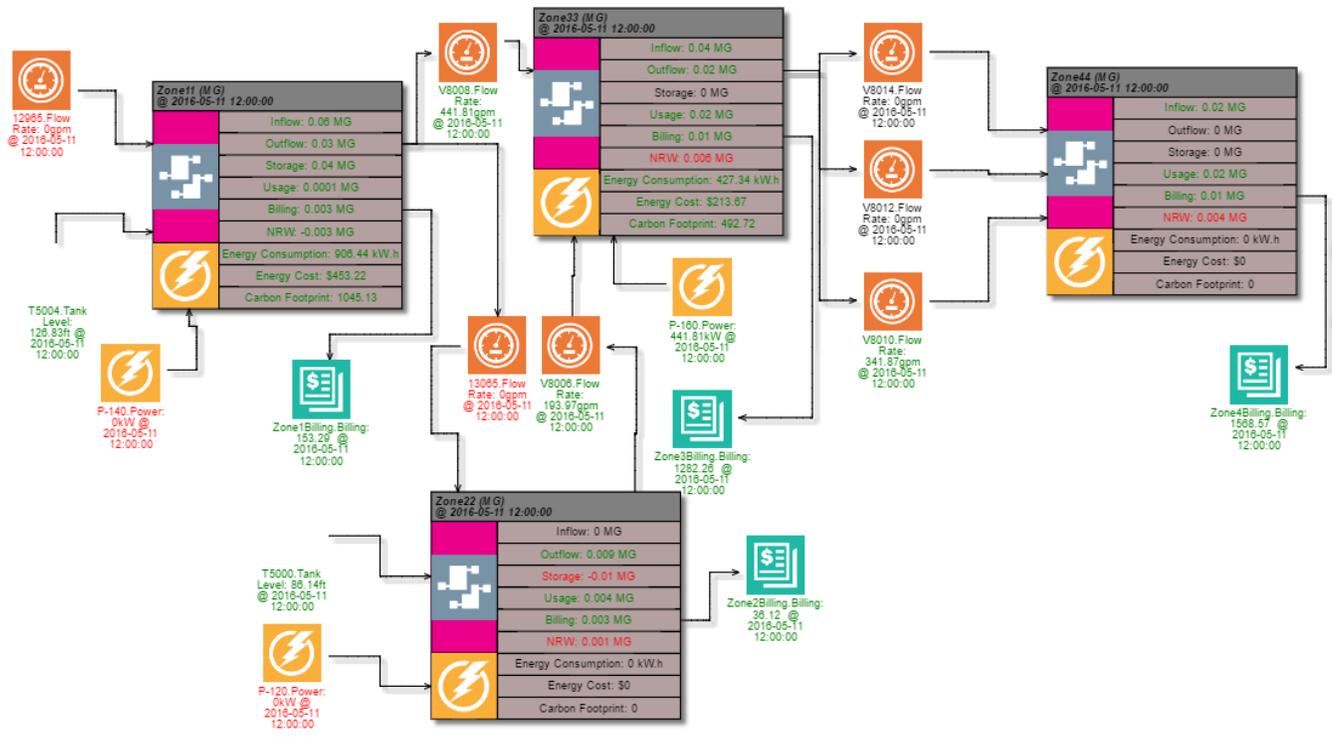
**Connect Elements**

Click and drag from one component to another to create connection arrows between components and their Zone.



<b>Set Element Properties</b>	<p>Double click on an component to open and edit its properties:</p> <table border="1"> <thead> <tr> <th data-bbox="272 184 483 233">Object</th> <th data-bbox="483 184 1490 233">Description</th> </tr> </thead> <tbody> <tr> <td data-bbox="280 247 475 443">  </td> <td data-bbox="492 247 1482 443"> <p>Flow objects define measured water flow in and out of each zone at the boundaries.</p> <p>To define a flow object, specify the associated sensor with a type of Flow Rate.</p> </td> </tr> <tr> <td data-bbox="280 464 475 659">  </td> <td data-bbox="492 464 1482 659"> <p>Storage objects track changes in volumetric storage within each zone which is an important part of mass balance calculations.</p> <p>To define a storage object, specify the associated sensor with a type of Tank Level.</p> <p>Note: ensure that the associated <a href="#">Tank Curve</a> data for the sensor is accurate; this is used in the calculation of volume from tank level.</p> </td> </tr> <tr> <td data-bbox="280 680 475 875">  </td> <td data-bbox="492 680 1482 875"> <p>Billing objects allow Info360 to compare the calculated water usage with the actual billed water that reached customers in order to calculate Non Revenue Water automatically. 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<b>Resize and Relocate Elements</b>	<p>Clicking on an object on the Mass Balance canvas will show node points. Click and drag points to move and re-size any object.</p> <p>Any object or arrow can be removed by selecting it and hitting the Delete key on the keyboard.</p>												
	<p>Saves changes to Mass Balance</p>												

Snapshot mode displays the results of the Mass Balance. Simply check the Real-time Snapshot box or select a snapshot time to calculate and display results.



Once results have been calculated, double click on the Zone or any object to open a Chart of the data in the current Workspace. This allows historic charts of multiple useful results including water usage, non revenue water over time, energy usage over time, etc.

