# Technical Note

**TN 6.37_C** Modeling Aquabox Modules in Hydroflow Hydrographs

## Introduction

The following steps provide instructions for modeling Aquabox modules as a pond in the Hydraflow Hydrographs modeling software. This document does not address setting up a hydrograph or connecting inlet and outlet devices. This document is for the sole purpose of modeling the stage storage volume of the modules.

Aquabox modules are modeled in Hydraflow Hydrographs using either the “Manual” input option or the “Chambers” input option. The manual input option requires the use of the Aquabox Cumulative Storages spreadsheet to calculate the stage storage data. Data points are then copied from the Cumulative Storage spreadsheet into the manual inputs options menu when creating a pond in Hydraflow Hydrographs. The second option of using the “Chambers” input in Hydraflow is recommended as it makes it easier for the user to modify pond size when designing the outlet controls.

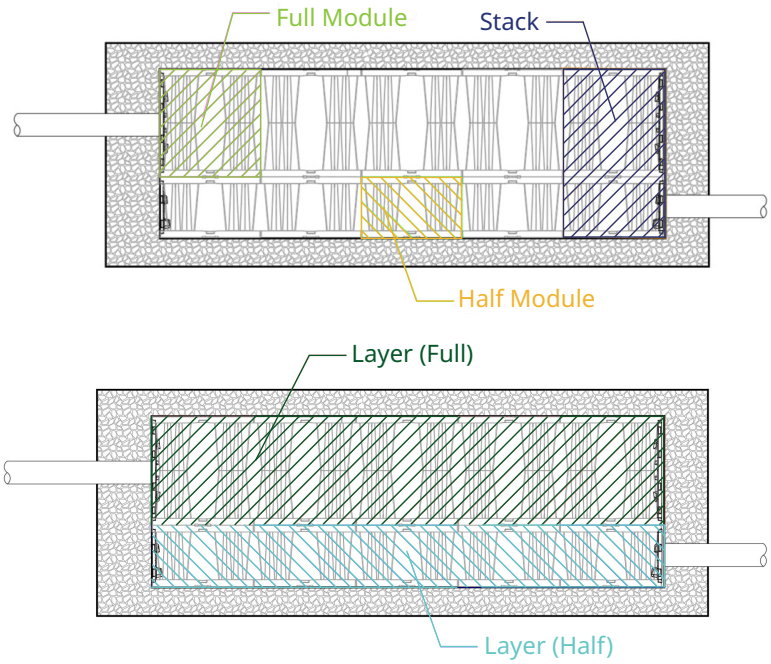
## Terminology

**Aquabox Module:** A module used to comprise one unit in a single layer

**Aquabox Half Module:** A module used to comprise one unit in a half layer.

**Layer:** All modules across the full area of the bed at a given depth. e.g; a 1.5-layer system is comprised of one half layer and one full layer.

**Stack:** All modules in the area of a single module, across the entire depth of the system. e.g; a 1.5-layer system with 400 stacks has 400 full modules placed on 400 half modules.



## Data Inputs

Under the Stage/Storage/Discharge setup screen select the “Chambers” option. Set the parameters for this screen as follows:

1. Invert Elev. Dn → Set to bottom of module
2. Shape → “Box”
3. Rise, Span, & Barrel Length should follow the values in Table 1

**Table 1**

| Configuration | Rise m (ft) | Span m (ft) | Length m (ft) |
|---|---|---|---|
| 0.5 - Layer | 0.45 (1.48) | 0.71 (2.32) | 0.75 (2.46) |
| 1.0 - Layer | 0.80 (2.62) | 0.73 (2.38) | 0.75 (2.46) |
| 1.5 - Layer | 1.25 (4.10) | 0.72 (2.35) | 0.75 (2.46) |
| 2.0 - Layer | 1.60 (5.25) | 0.72 (2.36) | 0.75 (2.46) |
| 2.5 - Layer | 2.05 (6.73) | 0.72 (2.35) | 0.75 (2.46) |
| 3.0 - Layer | 2.40 (7.87) | 0.72 (2.36) | 0.75 (2.46) |

Note: Minimum width values are equal to span values and will always need to be increased to represent the true volume. Actual width can be closely estimated using the formula below and may need further refinement to most closely match the true volume.

4. No. Barrels → Set to desired number of stacks
   - Hydraflow has a maximum barrel count of 500. If you have more than 500 Aquabox stacks in a system, divide the number of stacks by any variable *X* such that the result is less than 500. Next, modify the barrel length by multiplying the length value in the above table by the selected value of *X*.
   - Example: 2400 Aquabox Stacks

$$\frac{2400}{X} = \frac{2400}{6} = 400\ Barrels\ \rightarrow 0.75\ m * X = 0.75\ m * 6 = 4.50\ m\ Barrel\ Length$$

5. Slope → 0.0%
6. Headers → “No”
7. Stone Encasment → “Yes”
8. Bottom Elev. → Set to bottom of stone foundation
9. Width & Depth (minimum values) should follow the values in Table 2

**Table 2**

| Configuration | Width m (ft) | Depth m (ft) |
|---|---|---|
| 0.5 - Layer | 0.71 (2.32) | 0.75 (2.48) |
| 1.0 - Layer | 0.73 (2.38) | 1.10 (3.62) |
| 1.5 - Layer | 0.72 (2.35) | 1.55 (5.10) |
| 2.0 - Layer | 0.72 (2.36) | 1.90 (6.25) |
| 2.5 - Layer | 0.72 (2.35) | 2.35 (7.73) |
| 3.0 - Layer | 0.72 (2.36) | 2.70 (8.87) |

Note: Minimum width values are equal to span values and will always need to be increased to represent the true volume. Actual width can be closely estimated using the formula below and may need further refinement to most closely match the true volume.

$$Width = \frac{Area\ of\ Bed}{(\#\ of\ Barrels) * 0.75m} = \frac{Area\ of\ Bed}{(\#\ of\ Barrels) * 2.46ft}$$

10. Voids → 40.0%

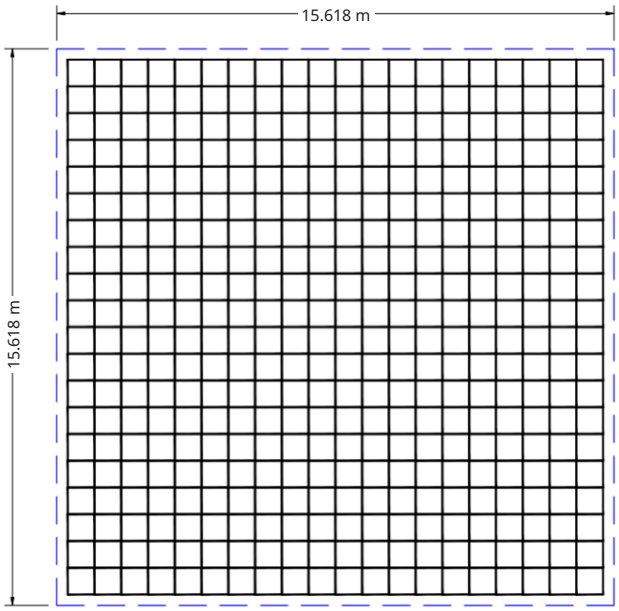
# Examples

The two examples below each contain 400 Aquabox-1.0 Modules. The first set of drawings show the dimensions assuming minimum stone perimeter offset (300 mm [12”]) for Aquabox modules. The second set of drawings account for the addition of an underdrain, manifolds, & an irregular shape, all of which alter the amount of stone required for the system.

## Example 1

### Layout using standard Aquabox perimeter stone

| PROPOSED LAYOUT | | | |
|---|---|---|---|
| 400 | AQUABOX-1 (1 LAYER) | 0 | MODULE INSPECTION PORTS |
| 400 | AQUABOX FULL MODULE | | |
| 0 | AQUABOX CUBE MODULE | | |
| 152 | STONE ABOVE (mm) | | |
| 152 | STONE BELOW (mm) | | |
| 40 | % STONE VOID | | |
| **208.6** | **INSTALLED SYSTEM VOLUME (m³) (PERIMETER STONE INCLUDED)** | | |
| 243.9 | EXCAVATION AREA (m²) | | |
| 62.5 | EXCAVATION PERIMETER (m) | | |
| 225.3 | MODULE AREA (m²) | | |
| 60.0 | MODULE PERIMETER (m) | | |
| **PROPOSED ELEVATIONS** | | | |
| 989.933 | MAXIMUM ALLOWABLE GRADE (TOP OF PAVEMENT/UNPAVED) | | |
| 988.562 | MINIMUM ALLOWABLE GRADE (UNPAVED WITH TRAFFIC) | | |
| 988.409 | MINIMUM ALLOWABLE GRADE (UNPAVED NO TRAFFIC) | | |
| 988.409 | MINIMUM ALLOWABLE GRADE (BASE OF FLEXIBLE PAVEMENT) | | |
| 988.409 | MINIMUM ALLOWABLE GRADE (TOP OF RIGID PAVEMENT) | | |
| 988.104 | TOP OF STONE | | |
| 987.952 | TOP OF MODULE | | |
| 987.152 | BOTTOM OF MODULE | | |
| 987.000 | BOTTOM OF STONE | | |




Note: Inspection Ports require Aquabox Cube modules for that specific stack. Cube module stacks have a slightly lower volume than full modules but can be modeled as such for the purposes of this exercise.

### Aquabox Stage Storage Spreadsheet Output

**Project:** Example 1

| | | |
|---|---|---|
| Layers - | 1 | Layers |
| Number of Full Modules - | 400 | Modules |
| Number of Cube Modules - | 0 | Modules |
| Number of Stacks - | 400 | Stacks |
| Amount of Stone Above Modules - | 152 | mm |
| Amount of Stone Below Modules - | 152 | mm |
| Voids in stone (porosity) - | 40% | |
| Base of Stone Elevation - | 987 | |
| Area of system - | 243.9 | m2 - Minimum Area 225m2 |

| Height of System (mm) | Incremental Single Module (cubic meters) | Incremental Module Total (cubic meters) | Incremental Stone (cubic meters) | Incremental Module & Stone (cubic meters) | Cumulative Volume (cubic meters) | Elevation (meters) |
|---|---|---|---|---|---|---|
| 1104.9 | 0.0000 | 0.0000 | 1.24 | 1.24 | 208.61 | 988.105 |
| 1092.2 | 0.0000 | 0.0000 | 2.48 | 2.48 | 207.37 | 988.092 |
| 1066.8 | 0.0000 | 0.0000 | 2.48 | 2.48 | 204.89 | 988.067 |
| 1041.4 | 0.0000 | 0.0000 | 2.48 | 2.48 | 202.41 | 988.041 |

## Calculating Width

$$Width = \frac{Area\ of\ Bed}{(\#\ of\ Barrels) * 0.75\ m} = \frac{243.9\ m^2}{400\ Barrels * 0.75\ m} = 0.813\ m$$

## Hydraflow Inputs

| Item | Input |
|---|---|
| Storage Type = | UG Chambers |
| Invert Elev. Dn (m) = | 987.152 |
| Rise (m) = | 0.800 |
| Shape = | Box |
| Span (m) = | 0.730 |
| Barrel Length (m) = | 0.750 |
| No. Barrels = | 400 |
| Slope (%) = | 0.000 |
| Headers = | No |
| Stone Encasement = | Yes |
| Bottom Elev. (m) = | 987.000 |
| Width (m) = | 0.784 |
| Depth (m) = | 1.100 |
| Voids (%) = | 40.000 |

Note: Calculated width of 0.813 m (2.67') overestimates the volume. Width has to be reduced to 0.784 m (2.57') to most accurately represent the true storage volume.

## Hydraflow Stage Storage Results

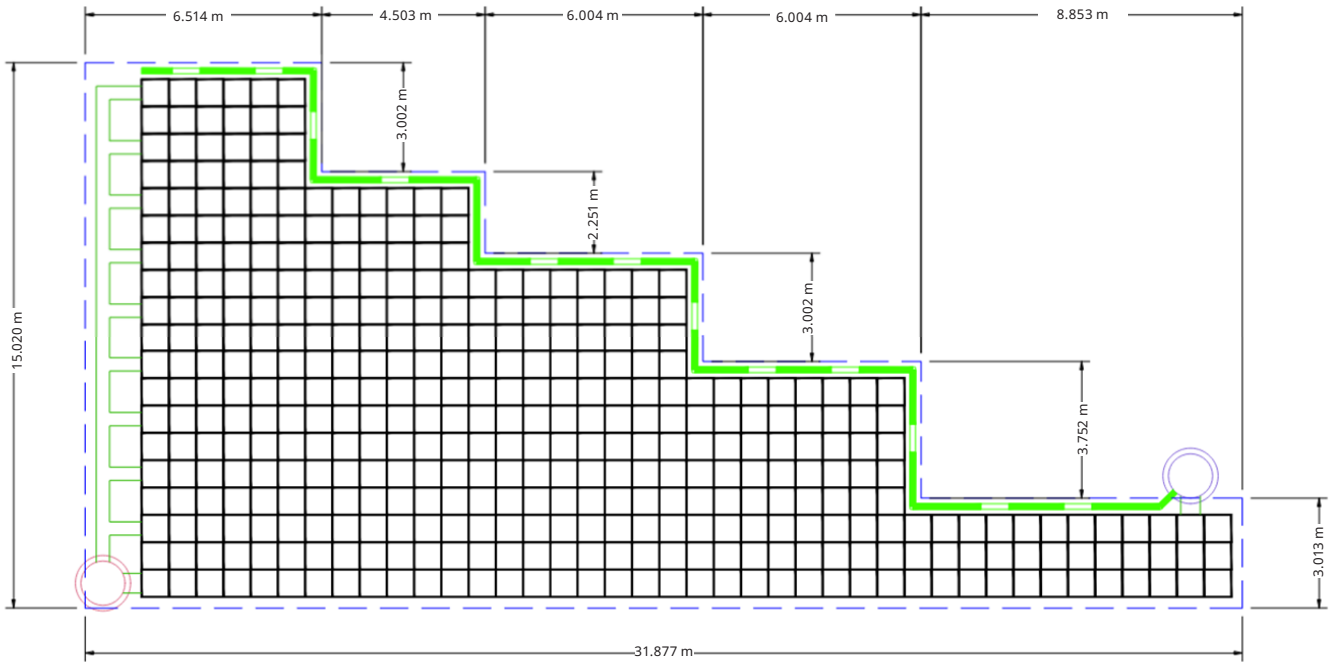
| Row | Stage | Elevation | Contour Area | Incremental Storage | Total Storage | Total Discharge |
|---|---|---|---|---|---|---|
| | (m) | (m) | (sqm) | (cum) | (cum) | (cms) |
| 0 | 0.000 | 987.000 | n/a | 0.000 | 0.000 | 0.000 |
| 1 | 0.110 | 987.110 | n/a | 10.351 | 10.351 | 0.000 |
| 2 | 0.220 | 987.220 | n/a | 19.290 | 29.641 | 0.000 |
| 3 | 0.330 | 987.330 | n/a | 24.815 | 54.456 | 0.000 |
| 4 | 0.440 | 987.440 | n/a | 24.806 | 79.262 | 0.000 |
| 5 | 0.550 | 987.550 | n/a | 24.806 | 104.067 | 0.000 |
| 6 | 0.660 | 987.660 | n/a | 24.806 | 128.873 | 0.000 |
| 7 | 0.770 | 987.770 | n/a | 24.806 | 153.679 | 0.000 |
| 8 | 0.880 | 987.880 | n/a | 24.815 | 178.494 | 0.000 |
| 9 | 0.990 | 987.990 | n/a | 19.805 | 198.299 | 0.000 |
| 10 | 1.100 | 988.100 | n/a | 10.351 | 208.650 | 0.000 |

Note: It can be observed that there is a discrepancy between the Aquabox Stage Storage spreadsheet and the Hydraflow ouput, however, the Hydraflow output produced via this method is usually within 1% of the actual value. In this example the difference is less than 0.1%.

# Example 2

## Layout including additional perimeter stone for manifolds & underdrain

| PROPOSED LAYOUT | | | |
|---|---|---|---|
| 400 | AQUABOX-1 (1 LAYER) | 0 | MODULE INSPECTION PORTS |
| 400 | AQUABOX FULL MODULE | | |
| 0 | AQUABOX CUBE MODULE | | |
| 152 | STONE ABOVE (mm) | | |
| 152 | STONE BELOW (mm) | | |
| 40 | % STONE VOID | | |
| **223.6** | **INSTALLED SYSTEM VOLUME (m³) (PERIMETER STONE INCLUDED)** | | |
| 277.9 | EXCAVATION AREA (m²) | | |
| 93.8 | EXCAVATION PERIMETER (m) | | |
| 225.3 | MODULE AREA (m²) | | |
| 88.6 | MODULE PERIMETER (m) | | |
| **PROPOSED ELEVATIONS** | | | |
| 989.933 | MAXIMUM ALLOWABLE GRADE (TOP OF PAVEMENT/UNPAVED) | | |
| 988.562 | MINIMUM ALLOWABLE GRADE (UNPAVED WITH TRAFFIC) | | |
| 988.409 | MINIMUM ALLOWABLE GRADE (UNPAVED NO TRAFFIC) | | |
| 988.409 | MINIMUM ALLOWABLE GRADE (BASE OF FLEXIBLE PAVEMENT) | | |
| 988.409 | MINIMUM ALLOWABLE GRADE (TOP OF RIGID PAVEMENT) | | |
| 988.104 | TOP OF STONE | | |
| 987.952 | TOP OF MODULE | | |
| 987.375 | 300 mm CONCENTRIC CONNECTION | | |
| 987.299 | 450 mm CONCENTRIC CONNECTION | | |
| 987.152 | BOTTOM OF MODULE | | |
| 987.000 | UNDERDRAIN INVERT | | |
| 987.000 | BOTTOM OF STONE | | |



## Aquabox Stage Storage Spreadsheet Output

**Project:** Example 2

| | | |
|---|---|---|
| Layers - | 1 | Layers |
| Number of Full Modules - | 400 | Modules |
| Number of Cube Modules - | 0 | Modules |
| Number of Stacks - | 400 | Stacks |
| Amount of Stone Above Modules - | 152 | mm |
| Amount of Stone Below Modules - | 152 | mm |
| Voids in stone (porosity) - | 40% | |
| Base of Stone Elevation - | 987 | |
| Area of system - | 277.9 | m2 - Minimum Area 225m2 |

| Height of System (mm) | Incremental Single Module (cubic meters) | Incremental Module Total (cubic meters) | Incremental Stone (cubic meters) | Incremental Module & Stone (cubic meters) | Cumulative Volume (cubic meters) | Elevation (meters) |
|---|---|---|---|---|---|---|
| 1104.9 | 0.0000 | 0.0000 | 1.41 | 1.41 | 223.63 | 988.105 |
| 1092.2 | 0.0000 | 0.0000 | 2.82 | 2.82 | 222.22 | 988.092 |
| 1066.8 | 0.0000 | 0.0000 | 2.82 | 2.82 | 219.40 | 988.067 |
| 1041.4 | 0.0000 | 0.0000 | 2.82 | 2.82 | 216.57 | 988.041 |

## Calculating Approximate Width

$$Width = \frac{Area\ of\ Bed}{(\#\ of\ Barrels) * 0.75\ m} = \frac{277.9\ m^2}{400\ Barrels * 0.75\ m} = 0.926\ m$$

## Hydraflow Inputs

| Item | Input |
|---|---|
| Storage Type = | UG Chambers |
| Invert Elev. Dn (m) = | 987.152 |
| Rise (m) = | 0.800 |
| Shape = | Box |
| Span (m) = | 0.730 |
| Barrel Length (m) = | 0.750 |
| No. Barrels = | 400 |
| Slope (%) = | 0.000 |
| Headers = | No |
| Stone Encasement = | Yes |
| Bottom Elev. (m) = | 987.000 |
| Width (m) = | 0.897 |
| Depth (m) = | 1.100 |
| Voids (%) = | 40.000 |

Note: Calculated width of 0.926 m (3.04') overestimates the volume. Width has to be reduced to 0.897 m (2.94') to most accurately represent the true storage volume.

## Hydraflow Stage Storage Results

| Row | Stage | Elevation | Contour Area | Incremental Storage | Total Storage | Total Discharge |
|---|---|---|---|---|---|---|
| | (m) | (m) | (sqm) | (cum) | (cum) | (cms) |
| 0 | 0.000 | 987.000 | n/a | 0.000 | 0.000 | 0.000 |
| 1 | 0.110 | 987.110 | n/a | 10.351 | 10.351 | 0.000 |
| 2 | 0.220 | 987.220 | n/a | 19.290 | 29.641 | 0.000 |
| 3 | 0.330 | 987.330 | n/a | 24.815 | 54.456 | 0.000 |
| 4 | 0.440 | 987.440 | n/a | 24.806 | 79.262 | 0.000 |
| 5 | 0.550 | 987.550 | n/a | 24.806 | 104.067 | 0.000 |
| 6 | 0.660 | 987.660 | n/a | 24.806 | 128.873 | 0.000 |
| 7 | 0.770 | 987.770 | n/a | 24.806 | 153.679 | 0.000 |
| 8 | 0.880 | 987.880 | n/a | 24.815 | 178.494 | 0.000 |
| 9 | 0.990 | 987.990 | n/a | 19.805 | 198.299 | 0.000 |
| 10 | 1.100 | 988.100 | n/a | 10.351 | 208.650 | 0.000 |

Note: The added complexity of irregular shapes & additional components may increase the variance in true volume vs presented volume, however rarely exceeds 1.0%. This example has less than 0.1% variance.