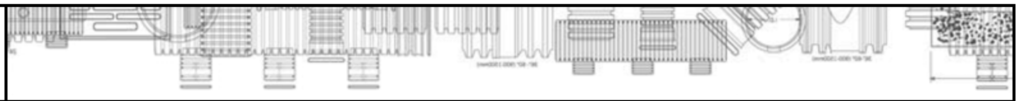

TECHNICAL NOTE

Storm Water Quality Units

TN 1.03
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Introduction

The ADS Storm Water Quality Unit (SWQU) is designed to remove pollutants from storm water during a storm event. ADS has modified its standard N-12® pipe to include weir plates at certain locations and heights to help facilitate sediment and oil removal from storm water. A bypass pipe is included in the storm water quality unit, so the system can focus on treating the “first flush”. After the “first flush” has entered the system, the bypass pipe directs high volumes of storm water around the system.

Storm Water Treatment

The ADS SWQU is designed to treat the “first flush” of a storm event or lower volume storms. First flush refers to the initial runoff generated by a storm event. Relatively high concentrations of pollutants may be flushed into storm drains during a first flush. First flush pollutant concentrations are relatively high at the beginning of storms and drop off over time. Although it may vary based on site conditions, the first flush can contain over 80% of the pollutants that will be transported off a site.

It is a widely accepted practice to provide treatment for the first flush as opposed to treating the entire design storm event. Treating the first flush provides a high level of storm water quality at a much lower cost to the developer. The storm water runoff, which follows the first flush, is generally assumed to be relatively clean in comparison. Providing treatment for this “clean water” can often double, if not triple, the cost of treatment at a minimum. By treating the first flush one can provide a great benefit to the environment at a reasonable cost.

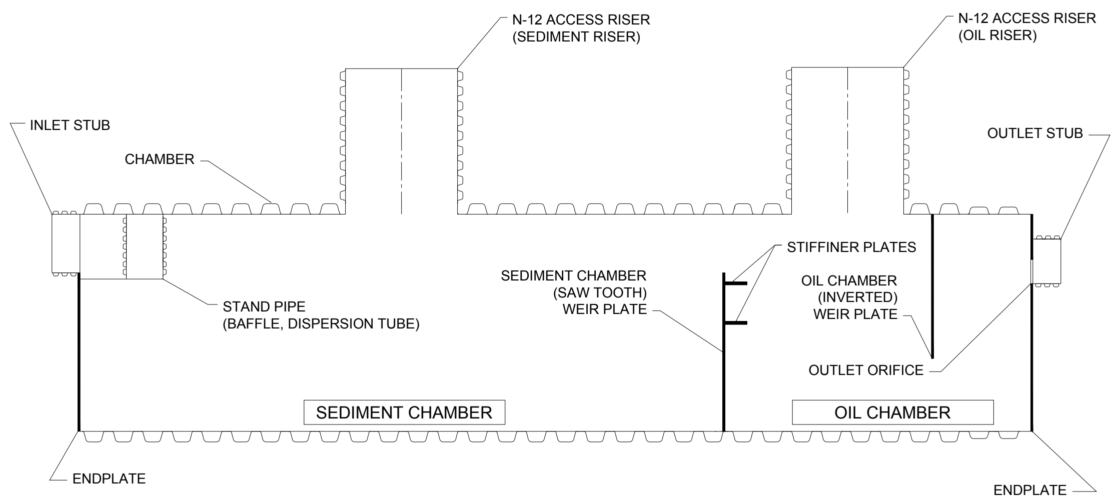
The treatment of the contaminated storm water is achieved through the use of weir plates installed at various locations within the unit. The storm water will enter the first chamber, or Sediment Chamber, which consists of an upright weir for trapping sediment. A second chamber, or Oil Chamber, uses an inverted weir to trap oils, grease, and debris. Figure 1 illustrates the typical layout of a SWQU. Field and lab testing of the unit indicate the following removal efficiencies:

- 80% Total Suspended Solids removal
- Greater than 43% Total Phosphorous removal
- 72% Heavy Metals removal
- Removal of floatable debris such as oils and greases

Testing reports and summaries are available by contacting your ADS Representative or Application Engineering. The flow through the unit is controlled at the outlet of the unit by using an orifice, thus categorizing the Storm Water Quality Unit as an outlet-controlled system. The design methodology behind outlet control is described in the entitled section Sizing a Storm Water Quality Unit.

When greater storm volumes are encountered, the addition of an external bypass allows the excess water to bypass the unit so as not to cause turbulent flow and possible resuspension of contaminants in the unit. This allows the lower volume storms and first flush events, where most contaminants are flushed off the pavement, to be trapped by the unit and remain there until the unit is cleaned.

Figure 1
Storm Water Quality Unit



Sizing a Storm Water Quality Unit

The ADS Storm Water Quality Unit is designed using the fundamental principles of Stoke's Law and a standard orifice equation. Stoke's Law is used to determine the settling velocity of a known particle size. The settling velocity can then be used to calculate the settling time, which is the time it takes a particle to fall a distance equal to the inlet pipe diameter plus 2 inches (50mm). The velocity through the chamber is found by dividing the treated flow rate by the cross sectional area of the storm water quality unit. The length of the sediment chamber can now be determined by taking the velocity through the chamber and multiplying by the settling time. After the length of the sediment chamber is established, the size of the orifice must be calculated. The orifice controls the amount of water entering the water quality unit. Once the treated flow rate is reached, excess water is diverted to the bypass. A standard orifice equation is used to find the diameter of the orifice. Example 1 provides an example calculation for sizing a Storm Water Quality Unit.

Example 1

Particle size: 140 sieve
Treated flow rate, Q_{treat} = 2.26 CFS
Assume 48 in. Water Quality Unit with 12 in. inlet pipe

<u>Stoke's Law to determine settling velocity:</u>

$$V_{settling} = 2gr^2 \frac{(\gamma_1 - \gamma_2)}{(9\mu)}$$

$V_{settling}$: Velocity of fall for a particle (ft/sec)
g : Acceleration of gravity = 32.2ft/ sec^2
r : Equivalent radius of particle
140 sieve: r = 0.000175 ft.
200 sieve: r = 0.000125 ft.

γ_1 : Density of particle (soil) = 3.69 slug/ ft^3

γ_2 : Density of medium (water) = 1.94 slug/ ft^3

μ : Viscosity of medium (water at 20^o C) = 2.09 x 10^{-5} lbf-sec/ ft^2

$$V_{settling} = 2\left(32.2\frac{ft}{\sec^2}\right)(.000175\,ft)^2\left(\frac{\left(3.69\frac{slug}{ft^3}-1.94\frac{slug}{ft^3}\right)}{\left(9\left(2.09x10^{-5}\frac{lbf-\sec}{ft^2}\right)\right)}\right)$$ = 0.018 ft/sec.

$V_{settling}$ = 0.018 ft/sec.

Settling Time:

$$T_{settling} = \frac{SD}{V_{settling}}$$

$T_{settling}$: Settling time for a particle of known size: (sec)

SD : Settling distance, inlet pipe diameter + 2 in. = (12.15 in. + 2 in.) = 1.18ft.

$V_{settling}$: Settling velocity = 0.018 ft/sec

$$T_{settling} = \frac{1.18\,ft.}{0.018\frac{ft}{\sec}} = 66\sec$$

$T_{settling}$ = 66 sec

Velocity through Sediment Chamber:

$$V_{SC} = \frac{Q_{treat}}{A_{WQU}}$$

V_{SC} : Velocity through the sediment chamber (ft/sec)

Q_{treat} : Flow at which one wants to treat for water quality = 2.26 CFS

A_{WQU} : Cross sectional area of the water quality unit = $\frac{\pi}{4}D^2 = \frac{\pi}{4}(4\,ft.)^2 = 12.57\,ft^2$

$$V_{SC} = \frac{2.26\ CFS}{12.57\ ft^2} = 0.180\ \frac{ft}{\sec}$$

V_{SC} = 0.180 ft/sec

Length of Sediment Chamber:

$$L_{\text{sediment}} = (V_{SC})(T_{settling})$$

$L_{sediment}$: Length of the sediment chamber (ft.)

V_{SC} : Velocity through the sediment chamber = 0.180 ft/sec

$T_{settling}$: Settling time for a particle of known size = 65.56 sec

$$L_{\text{sediment}} = \left(0.180 \frac{ft}{\text{sec}}\right)(66\,\text{sec}) = 12\,ft$$

L_{sediment} = 12 ft.

Orifice Equation:

$$Q_{\text{treat}} = (C_d)(A_0)\sqrt{2gh_0}$$

Q_{treat} : Treated flow rate = 2.26 CFS

Cd : Coefficient = 0.56

A_0 : Area of the orifice = $\frac{\pi}{4} d_0^{\ 2}$ (ft^2)

g : Acceleration of gravity = 32.2 ft/sec^2

h_0 : Head pressure ft = SD = 1.18 ft.

Solving the equation for the diameter of the orifice:

$$d_0 = \left[\frac{4Q_{treat}}{0.56\pi(2gh_0)^{1/2}}\right]^{1/2} = \left[\frac{4(2.26CFS)}{0.56\pi\left(2\left(32.2\frac{ft}{\sec^2}\right)1.18\,ft\right)^{\frac{1}{2}}}\right]^{\frac{1}{2}} = 0.77\,ft.$$

d_0 = 0.77ft., Use 9.24" orifice

NOTE: Although the Water Quality Unit is installed level, there is a drop across the unit to provide for proper head pressure and system performance.

Conclusion

The ADS SWQU provides a cost efficient treatment option for a variety of applications while achieving removal efficiencies that meet or exceed most local minimum requirements for storm water treatment. The treatment of both settling and floating pollutants provides a good first level management technique that offers the user the opportunity to use the device in either a stand- alone configuration or as a step in a treatment train.