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EVALUATING FLOATING SURFACE SKIMMERS

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Biography

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Benton Ruzowicz, Technical Specialist – Mr. Ruzowicz provides technical assistance to land disturbers, local governments, and erosion and sediment control professionals around the State on erosion and sedimentation control issues and the appropriate use of urban BMP's. He also provides technical plan reviews on behalf of the Districts in the Metro Atlanta area as well as technical support to all plan reviewers throughout the State. Ben also helps oversee the State's education and certification program for people involved in land disturbing activities in which there have been over 75.000 people certified.

Jay Sprague, Lab Director – Mr. Sprague is the Laboratory Director of TRI Environmental's Denver Downs Research Facility in Anderson, SC. Mr. Sprague directs all site operations and testing, supervises a staff of technicians, and is responsible for the implementation of TRI's Quality Systems throughout all lab operations. Mr. Sprague's background includes developing markets and technologies associated with agricultural and erosion and sediment control products.

Abstract

In 2010, the Georgia Soil and Water Conservation Commission (GSWCC) received funding to revise the Manual for Erosion and Sediment Control in Georgia. One of the parameters was to incorporate new BMP's into the Manual. This was done by characterizing full-scale, installed performance of commonly used best management practices (BMPs) for sediment control. Some of the specific BMPs tested included what the GSWCC refers to as floating surface skimmers.

A floating surface skimmer, or floating pond skimmer, is a buoyant device that releases/drains water from the surface of sediment ponds, traps or basins at a controlled rate of flow. It "skims", or dewaters, from the water surface where sediment concentrations are at a minimum in the water column instead of draining from the bottom where sediment concentrations are their highest. The skimmer and associated piping drains to a riser or the backside of a dam.

Critical elements of performance are the ability of the floating surface skimmers to:

- To discharge cleaner, less turbid water from the surface of a sediment pond, trap or basin at a relatively uniform rate. This practice is in contrast to a traditional perforated riser which discharges more turbid and sediment-laden water from lower depths of a sediment pond, trap, or basin.

- To reduce the retention time associated with meeting a desired water quality standard for discharge from a sediment pond, trap or basin.

Each skimmer product (and each product size) has a unique performance, including the associated hydraulics, which is affected by the floatation, inlet, and drain design chosen. The discharge rate is dependent on the specific product design and can only be determined through product-specific testing. This paper describes the testing of several sizes of each of 4 unique designs of floating pond skimmers and presents the associated results. The wide range of results is discussed and a straight forward process to choose the skimmer that best matches the required "time-to-drain" specified for a project is proposed. The required volume (or dimensions) of the sediment pond, trap, or basin must be known, as well as, the number of hours/days to drain the basin. With this information, a drawdown rate calculation is made for each product and size using product-specific flow rates.

Keywords: floating pond skimmer, floating surface skimmer, BMP, pond outlet, GSWCC, flow rate

1 Background

In 2010, the Georgia Soil and Water Conservation Commission (GSWCC) received funding to revise the Manual for Erosion and Sediment Control in Georgia. One of the goals was to incorporate new BMP's into the Manual. This was done by characterizing full-scale, installed performance of commonly used best management practices (BMPs) for sediment control. Some of the specific BMPs tested included what the GSWCC refers to as floating surface skimmers.

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2 Introduction to Floating Surface Skimmers

2.1 Purpose

Floating surface skimmers are designed to serve two principal functions; facilitate drainage of a sediment pond, basin, or trap, and reduce turbidity and sediment concentration of the effluent discharge. Traditionally, the principal spillway of most sediment basins is a vertical riser pipe. The bottom half of the riser is typically perforated with ½" holes, and covered with 2 feet of ½- to ¾-inch gravel, which filters the outflow as it passes through the perforations. Even with the gravel filter, the perforations in the lower elevations of the vertical riser allow discharge to pass which has a relatively high level of turbidity. Over time, the gravel filter surrounding the riser is coated with sediment that traps and detains water in the basin. This reduces the storage capacity for incoming runoff. Sediment in the trapped water is re-suspended with each new inflow, and never has the opportunity to settle to the bottom.

In contrast, floating surface skimmers release a lower rate of flow, drawing water from the surface of the basin slowly at a relatively constant rate. The combination of low flow coupled with surface dewatering allows for soil particles to settle to the bottom of the sediment pond, thus reducing turbidity and sediment concentration of the discharged effluent, as well as reducing the retention time to obtain similarly clear discharge using traditional outlets. The inlet of the skimmer device is sized according to the basin volume and designed to drain the basin in a predetermined amount of time. Thus, a well designed floating surface skimmer can improve the performance of a sediment pond or basin by reducing retention time associated with meeting a desired water quality standard, discharging cleaner water, and providing more consistent, predictable draw down times.

In this way, a floating surface skimmer replaces the riser pipe as the principal spillway, but DOES NOT REPLACE THE EMERCENCY OVERFLOW SPILLWAY. The skimmer only drains the basin from the crest of the emergency overflow spillway down to the bottom of the sediment pond. Its flow capacity is too small to accommodate extreme storm events that exceed the available storage capacity, so an emergency spillway is still required.

2.3 Design Criteria

As discussed above, a well designed floating surface skimmer can improve the performance of a sediment pond or basin by reducing retention time associated with meeting a desired water quality standard, discharging cleaner water, and providing more consistent, predictable draw down times. To accomplish this, the following design criteria must be considered to accomplish the principal purposes of a floating surface skimmer:

- The inlet of the floating surface skimmer must float at or near the surface of the impounded water in a sediment pond, trap, or basin.
- The inlet of the floating surface skimmer must connect to the outlet of the sediment pond, trap, or basin, whether through a vertical riser or dam embankment.
- The connection between the inlet of the floating surface skimmer and the outlet of the sediment pond must be able to articulate so as to maintain surface dewatering as the elevation of the pond rises and falls.
- The inlet must dewater through gravity forced flow, as opposed to siphoning, as siphoning will greatly increase the amount of soil particles that are “sucked” into the inlet.
- The volume of the sediment pond, trap, or basin must be known, as well as the required number of hours/days to drain the basin.

With the above criteria, a floating surface skimmer can be designed that will provide the required flow rate to adequately dewater a sediment pond, trap, or basin in the specified time frame.

2.4 Product Designs

A typical floating surface skimmer consists of three main components; a flexible coupling, a rigid tube that serves as the inlet, and a floating headworks that serves to support the inlet at or near the surface of the impounded water. (See Figure 1) One end of a rigid tube is connected to the barrel of the discharge system via a flexible coupling. The other end of the rigid tube is connected to the floating headworks and floats at or near the water surface. The flexible coupling allows the rigid tube to articulate as the water level changes.

A floating skimmer may be constructed from any material approved by the associated regulatory body, but is commonly constructed from Schedule 40 PVC. In addition to the three main components listed above, a floating surface skimmer typically includes a trash guard or screen covering the inlet to prevent floating debris from entering the rigid tube, as well as a maintenance rope tied to the floating headworks. The maintenance rope allows for the floating surface skimmer to be accessed and maintained from the edge of a sediment pond, even when the pond is partially filled with water. In addition, it is important to excavate a shallow pit filled with riprap under the floating surface skimmer to account for sediment that accumulates on the floor of the sediment basin around the skimmer. The pit allows the skimmer to completely drain the basin.

Each product (and each product size) has a unique design, including the associated hydraulics that are affected by the floatation, inlet, and connecting tube/coupling designs chosen. The discharge rate is dependent on the specific product design and can only be determined through product-specific, full scale, “as installed” testing.

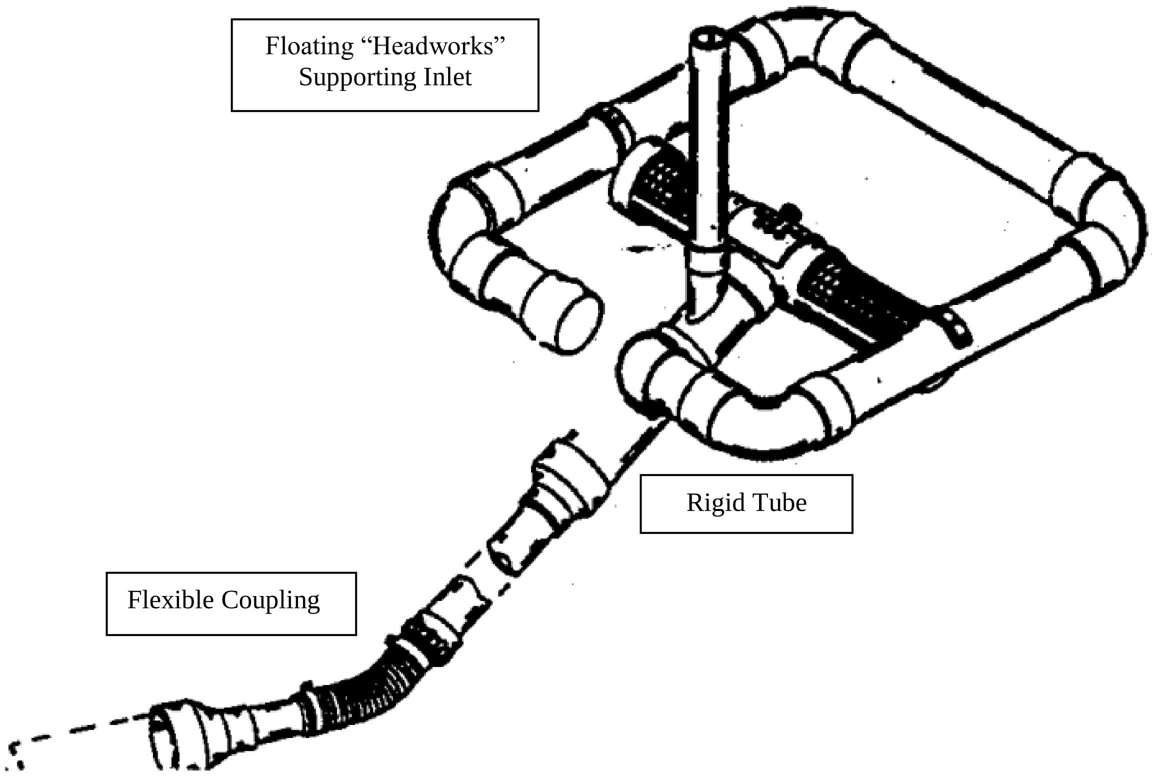

Figure 1. Skimmer Components

3 Testing of Floating Surface Skimmers

3.1 Full-scale Performance Testing of Floating Surface Skimmers

As noted earlier, the actual performance of floating surface skimmers is system and water depth dependent. Therefore a large-scale test that can incorporate full-scale "as installed" conditions is the ideal evaluation procedure. To this end, a protocol was developed for evaluating floating surface skimmers, including details for setting up a performance test that can be used for design characterization as well as quality assurance to determine product conformance to project specifications. The protocol has been compiled into a draft "Standard of Practice" and submitted to ASTM for consideration as a national standard.

The proposed practice covers the guidelines, requirements and procedures for evaluating the flow rate of a floating pond skimmer vs. pond depth under full-scale testing procedures, and is patterned after conditions typically found on construction sites within a sediment basin. The practice outlines test preparation, test execution, data collection, data analysis and reporting procedures for any size calibrated basin.

4 Floating Surface Skimmer Testing Program

4.1 Products/Systems Tested

Figures 2 through 5 show the skimmers tested. As this program was intended to demonstrate testing methodology and use of test results, not to promote certain skimmer designs over others, each of the tested skimmers were given generic designations for testing and reporting purposes to remove commercial considerations from the program.

Figure 2. E-Type Floating Skimmer

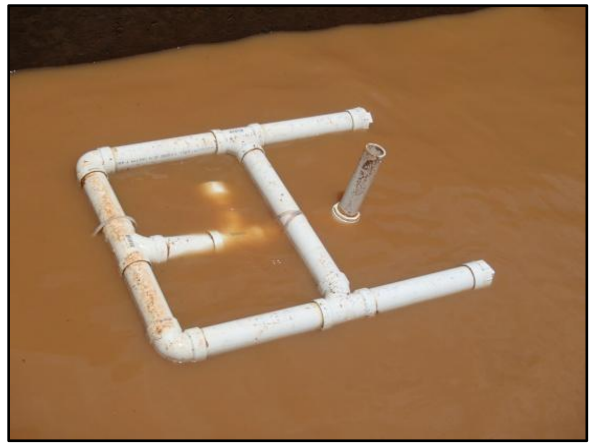

Figure 3. B-Type Floating Skimmer

Figure 4. S-Type Floating Skimmer

Figure 5. F-Type Floating Skimmer

4.2 Testing Protocol

4.2.1 Apparatus / Facility

Testing of the floating surface skimmer was performed in a calibrated basin (i.e. it has a known surface area at any known depth). The basin dimensions were 40-ft long x 6-ft wide x 4-ft deep. The basin was outfitted with an 8" discharge pipe. The discharge pipe was fitted with a valve that could be controlled from the outside of the basin to initiate and stop flow through the skimmer. In addition, the test basin was outfitted with a second valved discharge pipe to enable lowering of the water surface within the basin if desired to take flow rate measurements at various depths without waiting for drainage exclusively through the skimmer. A calibrated ruler was mounted on the side of the test basin to allow depth to be read at pre-determined intervals. To facilitate filling of the 7000 gallon basin, a PTO driven Crisafulli pump was used to draw water from an adjacent pond, quickly filling the test basin and allowing for multiple test replicates per day.

4.2.2 Test Setup

The skimmer to be tested was attached to the discharge pipe prior to pond filling using reducers/connectors depending on the size of the flexible coupling. The connection between the discharge pipe and the flexible coupling was watertight to ensure that the only outflow from the test basin was through the skimmer inlet. Figures 6-11 depict the typical test setup, filling, draining, and measuring of the tested floating surface skimmer.

Figure 6. View of Test Pool during Fill Test

Figure 7. Outlet is Controlled with 8-inch Valve

Figure 8. Skimmer Connected to Outlet Pipe via Flex Hose

Figure 9. Skimmer Floats to Top during Filling

Figure 10. Air Allowed to Escape Start of Test

Figure 11. Depth Recorded During Test

4.2.4 Test Operation and Data Collection

With the valve on the discharge pipe closed, and the skimmer to be tested in place, the test basin was filled with water to the maximum desired depth using the PTO driven pump and piping. Filling proceeded at a pace which allowed all of the air within the skimmer assembly to bleed completely during filling. This slow bleeding of the air trapped inside the skimmer system ensured that all tested skimmers were not influenced by trapped "air pockets" and that gravity flow was occurring. Once the basin was filled to the desired depth, the surface of the water was allowed to become still and the initial depth reading was recorded on the calibrated ruler mounted on the sidewall. After the initial reading was taken, the skimmer discharge valve was opened and the clock on the test was simultaneously started. As the water discharged from the test basin through the floating skimmer, periodic depth and time readings were recorded. By converting change in depth to change in water volume, an average flow rate at different water elevations was calculated for each individual skimmer design and size.

4.3 Test Results

Measurements of water surface elevation over time were the principle data used to determine the performance of the product tested. This data is entered into a spreadsheet that transforms the measurements of water surface elevation over time into a curve that fits average flow rate, in gallons per minute, to a given depth, in feet. The data for the various skimmer designs and sizes tested in the program described herein are summarized in Figure 12 and 13. The data shows that each skimmer type exhibits a unique flow rate at various depths. This is true across all sizes and all unique skimmer designs. The data clearly show that some designs provide for significantly higher flow rates at associated depths than others.

5 Discussion

While unique skimmer types are often given the same nominal categorization based on the diameter of the rigid tube, or inlet, used in construction of the skimmer, the performance of the unique skimmer types can be vastly different. As seen in Figures 12 & 13 a "Type 3" 3-inch skimmer has a flow rate (gallons/minute) 60% higher than a "Type 1" 3-inch skimmer at the maximum tested depth. If a skimmer specification referred only to inlet size, both of these skimmers could be used interchangeably to draw down a sediment pond of a certain size at a certain required rate. Clearly, the performance curves from product-specific testing show this would be a mistake as one skimmer type of a certain size would dewater at a significantly different rate than another type of the same size. This performance difference between different skimmer types of the same size demonstrates the importance of product-specific testing

Further, once a product specific flow rate as a function of depth has been determined from testing, one may construct a table similar to Table 1 to determine the skimmer type and size necessary to meet the required draw down time for a specific sediment pond, basin, or trap. Table 1 uses the equations for the product-specific flow vs. depth curves from testing, such as those shown in Figures 12 and 13, along with the project-specific pond size.

6 Conclusions and Recommendations

Floating pond skimmers are a useful tool for improving the performance of a sediment pond or basin by reducing retention time associated with meeting a desired water quality standard, discharging cleaner water, and providing more consistent, predictable draw down times, especially when compared with a traditional perforated riser. However, the unique design of a skimmer and its associated hydraulics can greatly affect the rate at which it is able to dewater a sediment pond, trap, or basin. Thus, determining product specific flow rates based on each unique design through full-scale, "as installed" testing is of the utmost importance.

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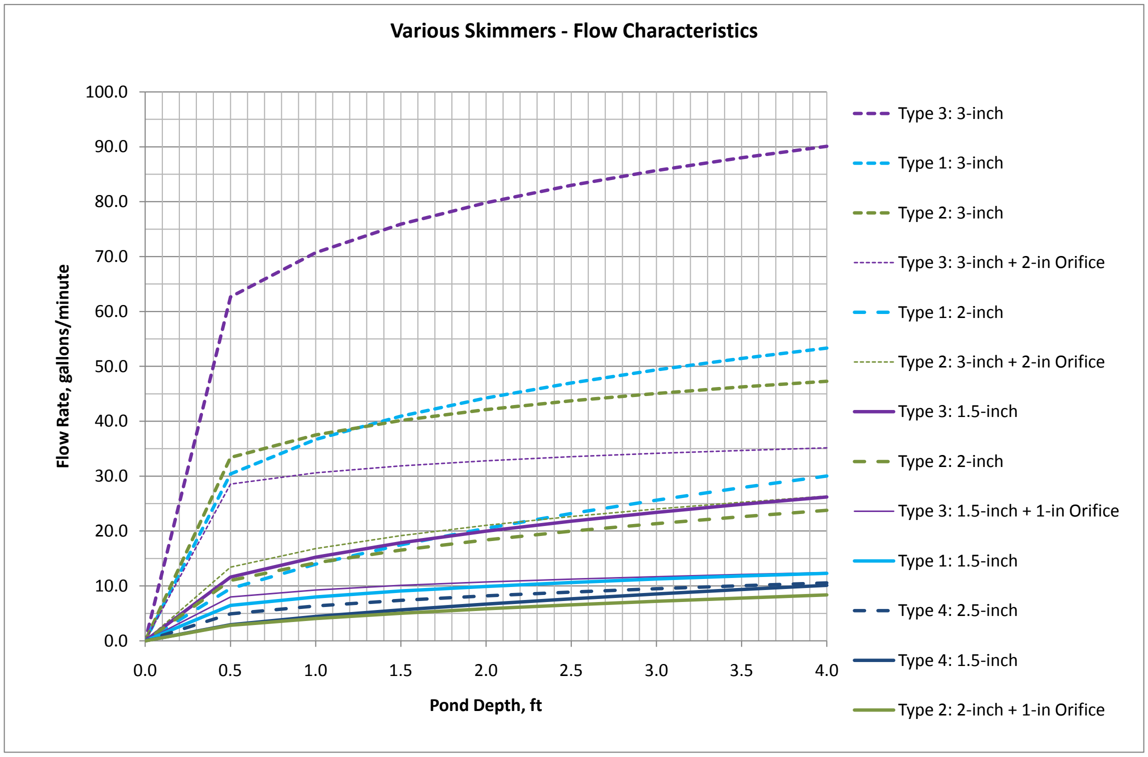

Figure 12. Summary Data Table – Skimmer Flow Rate, gal/min

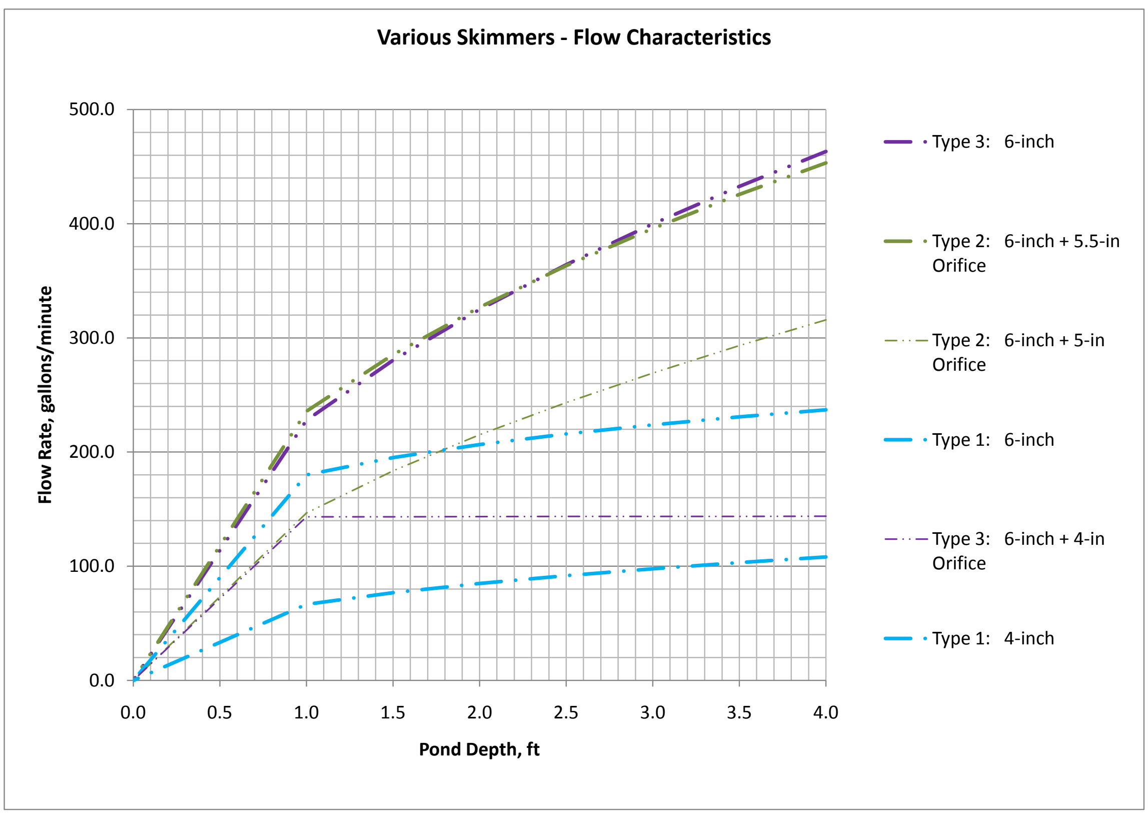

Figure 13. Summary Data Table – Skimmer Flow Rate, gal/min

Skimmer Sizing Table

Example Shown: 125 ft x 125 ft x 4 ft deep pond; Drainage Time < 72 hours

Inputs		Calculations	
Time to Drain, hrs =	72	Calculated Pond Volume, ft^3 =	40833
Pond Depth, ft =	4	Calculated Pond Volume, gal =	3E+05
Pond Top Length, ft =	125	No. of Increments for Calcs, in. =	20
Pond Top Width, ft =	125	Depth Increments for Calcs, in. =	2.4
Pond Bottom Length, ft =	75	Note: Flow rate equations are from product testing →	
Pond Bottom Width, ft =	75		

Skimmer Size Selection Optimization

Skimmer Size, in / Orifice Size, in

Type 1: 1.5 / 0.00	Type 1: 2.0 / 0.00	Type 1: 3.0 / 0.00	Type 3: 3.0 / 0.00	Type 1: 4.0 / 0.00	Type 1: 6.0 / 0.00	Type 3: 6.0 / 0.00
Flow Rate: $7.9914*d^{0.3116}$	Flow Rate: $13.985*d^{0.5514}$	Flow Rate: $36.676*d^{0.2702}$	Flow Rate: $70.714*d^{0.1747}$	Flow Rate: $66.588*d^{0.3494}$	Flow Rate: $180.07*d^{0.1981}$	Flow Rate: $227.83*d^{0.5118}$

Water Level Depth (d), in.	Avg. Water Level Depth, in.	Incr. Depth, in	L	W	Incr. Dis-charge, ft3	Cumm. Dis-charge, ft3	Cumm. Dis-charge, gal	% of Total Volume Dis-charged	Skimmer Flow Rate, gal/min	Cumm. Drain Time, hrs.	Skimmer Flow Rate, gal/min	Cumm. Drain Time, hrs.	Skimmer Flow Rate, gal/min	Cumm. Drain Time, hrs.	Skimmer Flow Rate, gal/min	Cumm. Drain Time, hrs.	Skimmer Flow Rate, gal/min	Cumm. Drain Time, hrs.	Skimmer Flow Rate, gal/min	Cumm. Drain Time, hrs.	Skimmer Flow Rate, gal/min	Cumm. Drain Time, hrs.
48			125	125																		
45.6	46.8	2.4	123	123	3063	3063	22911	7.5%	12	31	30	13	53	7	90	4	107	4	236	2	457	1
43.2	44.4	2.4	120	120	2940	6003	44905	14.7%	12	62	29	26	52	14	89	8	105	7	233	3	445	2
40.8	42	2.4	118	118	2820	8824	66002	21.6%	12	92	28	38	51	21	88	12	103	10	231	5	433	2
38.4	39.6	2.4	115	115	2703	11527	86219	28.2%	12	121	27	51	51	28	87	16	101	14	228	6	420	3
36	37.2	2.4	113	113	2588	14115	105577	34.6%	11	149	26	63	50	34	86	20	99	17	225	8	407	4
33.6	34.8	2.4	110	110	2475	16590	124093	40.6%	11	177	25	75	49	41	85	24	97	20	222	9	393	5
31.2	32.4	2.4	108	108	2365	18955	141787	46.4%	11	204	24	88	48	47	84	27	94	23	219	10	379	6
28.8	30	2.4	105	105	2258	21213	158676	52.0%	11	230	23	100	47	53	83	31	92	26	216	12	364	6
26.4	27.6	2.4	103	103	2153	23366	174780	57.2%	10	256	22	112	46	58	82	34	89	29	212	13	349	7
24	25.2	2.4	100	100	2050	25417	190117	62.2%	10	282	21	124	45	64	81	37	86	32	209	14	333	8
21.6	22.8	2.4	98	98	1950	27367	204706	67.0%	10	306	20	136	44	70	79	40	83	35	204	15	316	9
19.2	20.4	2.4	95	95	1853	29220	218566	71.6%	9	331	19	148	42	75	78	43	80	38	200	16	299	9
16.8	18	2.4	93	93	1758	30978	231715	75.9%	9	355	17	161	41	81	76	46	77	41	195	18	280	10
14.4	15.6	2.4	90	90	1665	32643	244172	79.9%	9	379	16	174	39	86	74	49	73	44	190	19	261	11
12	13.2	2.4	88	88	1575	34219	255956	83.8%	8	403	15	187	38	91	72	51	69	47	184	20	239	12
9.6	10.8	2.4	85	85	1488	35707	267086	87.4%	8	427	13	201	36	96	69	54	64	50	176	21	216	13
7.2	8.4	2.4	83	83	1403	37110	277580	90.9%	7	451	11	216	33	102	66	57	59	53	168	22	190	14
4.8	6	2.4	80	80	1320	38430	287456	94.1%	6	477	10	234	30	107	63	59	52	56	157	23	160	15
2.4	3.6	2.4	78	78	1240	39670	296735	97.2%	5	505	7	255	26	113	57	62	44	59	142	24	123	16
0	1.2	2.4	75	75	1163	40833	305433	100.0%	4	542	4	292	20	120	47	65	30	64	114	25	70	18
Lowest depth that can still drain through skimmer.			Skimmer / Orifice Combinations with Sufficient Flow:						**no**		**no**		**no**		**Type 3: 3.0 / 0.00**		**Type 1: 4.0 / 0.00**		**Type 1: 6.0 / 0.00**		**Type 3: 6.0 / 0.00**	

Table 1 – Typical Floating Surface Skimmer Sizing Table