STORMWATER MONITORING PROGRAM
Brevard County, Florida

Final Report,
Sediment Control Project Assessment,
For
Indialantic basin IR30 contract 92W221
and
Micco basin M17, contract 92W219
Brevard County Florida

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Executive Summary

Evaluation of this treatment method focused primarily on the Indialantic installation with additional monitoring and analysis of the Micco site for comparison. As discussed in the Indialantic Master Plan, it was anticipated that 40 to 70 percent of suspended particles would settle out depending on the flow rate and velocities of stormwater moving through the box. Suspended solids (SS) were measured at the inlet and outlet of the box in order to assess the actual removal efficiency. Evaluation of the sample results indicated an overall 70.6 percent SS removal rate on average (mean).

During the period August 21, 1992 to September 22, 199.2, approximately 4500 pounds of sediment were removed from the box. This period would correspond to the summer season of higher intensity, shorter duration storms with higher resulting flow rates. Between September 22, 1992 and February 4, 1993, an estimated additional 4,000 pounds of sediment were removed over a four month period during the winter season with lower intensity, longer duration storms. This would indicate from the estimated quantities removed that the basin has a much greater suspended solids loading than originally anticipated. This probably results from a greater removal rate under low flow conditions and some error in estimating the volumes of sediment removed during cleaning of the boxes.

In addition, the composition of the suspended solids was analyzed. Approximately 50 percent of the nutrient phosphorus is in particle form. Consequently an overall estimated 20 to 35 percent removal rate for phosphorus was expected. Total phosphorus was analyzed from samples collected at the inlet and outlet of the box to determine the actual removal efficiency. Sample results for this parameter showed a 38 percent average (median) reduction.

Approximately 25 percent of the suspended solids is organic in nature, the decomposition of which creates an oxygen demand; therefore BOD was measured. A 10 to 17 percent reduction in BOD was anticipated. Sample results indicated an average 39 percent BOD reduction for two dates and one date showed a 25 percent increase between inlet and outlet.

The removal efficiency and quantities.of pollutants removed is dependent on many factors, including land use, drainage basin area, soil types, stormwater velocities through the box, and the frequency and thoroughness of box cleanings. Staff of the Surface Water Improvement Division (SWID) learned a great deal from the installation of the boxes, water and sediment sampling, and maintenance of this project that will make future installations (and evaluating those installations) more effective. The importance of regular cleaning to prevent resuspension of sediment and associated pollutants is evident from the data collected. A maintenance schedule is being developed for each baffle box by scheduling frequent inspections to document sediment accumulation and account for differences in basin loadings and seasonal variations in weather. Changes in equipment and/or manhole placement and number will be incorporated in future baffle boxes to make cleaning easier and more efficient.

SWID will **continued** to monitor the Indialantic baffle box in order to further assess its-effectiveness under various conditions. Future manual storm event sampling will require anticipating storm events and arriving on site prior to the event, or use of automated sampling equipment. It is clear from the data collected to date that the pollutants which were expected to be removed by the baffle box are being removed when the efficiency of the box is maintained by frequent cleaning thereby reducing resuspension.

In order to supplement data collected in the field, hydraulic scale modeling is being considered to collect data under more controlled laboratory conditions. Size and shape of the boxes and baffles as well as baffle placement can be evaluated under various controlled sediment loadings, velocities and flow rates. This information can then be incorporated into future designs. A proposal for such analysis is currently under consideration, provided partial funding can be obtained.

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I. Introduction/Background

The Indialantic Master Plan documents the drainage characteristics in this 1800-acre basin, estimates pollutant loadings from sub-basins, and presents recommendations for corrective action. Sampling conducted in the Indialantic basin documented sediment accumulation in residential canals receiving stormwater as well as elevated levels of metals, nutrients (including phosphorus), and organic materials. The Indian River Lagoon Surface Water Improvement and Management (SWIM) Plan (St. Johns River Water Management District, September 1989) identifies suspended material loadings and contaminants carried by stormwater runoff as a major issue in the Lagoon basin. One of the treatment methods proposed involves the installation of a sediment removal or entrapment system, commonly called a baffle box (Figure 1), to remove the sediment before it reaches surface waters.

Brevard County entered into a cost share agreement with St. Johns River Water Management District for installation and monitoring of two such baffle boxes. Funding for these projects is shared by the District's SWIM program, the EPA's Indian River Lagoon National Estuary Program (NEP) and the Brevard County Surface Water Improvement Division. Monitoring was required in accordance with contract Exhibit A, Item II.B, which states, "As a follow-up the county will provide water quality monitoring to measure the efficiency of the treatment device. Monitoring results and a maintenance record will be provided to the St. Johns River Water Management District." Exhibit A, Item IV.7, called for quarterly storm event monitoring. Evaluation of this treatment method focused primarily on the simpler Indialantic basin (Figure 2) with additional monitoring and analysis of the Micco site (Figure 3) for comparison. Sampling was conducted in two phases; a summary of this sampling follows.

II. Phase 1. Preliminary Monitoring

Between August 21, 1992 and March 16, 1993 the SWID collected preliminary water quality data at the Indialantic sediment control project (baffle box) on one occasion during a storm event and three occasions during dry weather. Water samples were also collected from the Micco box on one occasion. This data was collected primarily to allow county staff (who collected the samples) and laboratory personnel (who conducted the analysis) to develop the procedures and refine the techniques required. This sampling was considered preliminary screening only. No attempt was made to determine removal efficiencies based on the preliminary data collected. However, this data did give preliminary indication that those parameters expected to be removed were indeed being removed

A. Water Quality Parameters

Initial water column sampling included several parameters which are not reduced by the baffle box (allowing sedimentation) but were collected to provide information on the contributing watersheds. These parameters included total suspended solids (TSS) , nitrates (NOD , nitrites (N02) , total Kj eldahl nitrogen (TKN) , ammonia. (NH4) , total phosphorus (TP) , biochemical oxygen demand (BOD), chemical oxygen demand (COD), fecal coliform bacteria (FC), and oil and grease. A metals scan was initially performed to help evaluate which metals were present. Additional more detailed analysis was then confined to mercury, lead, zinc, cadmium, chromium, selenium, copper, nickel, and iron.

Nutrients can contribute to algae blooms. Except for phosphorus, most nutrients are in dissolved form and not removed by sediment collection methods. Therefore, the nutrients analyzed in Phase 2 were limited to total phosphorus (TP).

certain organic compounds require oxygen to decompose. These processes reduce the oxygen available to organisms in surface waters and contribute to fish kills. One indicator of this demand is the biochemical oxygen demand (BOD), which was also evaluated.

Metals may be toxic to various aquatic organisms and a health concern to humans. Because metals concentrations in the water column were low, evaluation of metals concentrated on sediment analysis. There are three chambers in the box with the larger, heavier particles having the tendency to settle first, resulting in differences in the sediment accumulating in each chamber. A sample was therefore collected from each chamber and analyzed. Metals analyzed include aluminum (Al), chromium (Cr), nickel (Ni), copper (Cu), zinc (Zn), arsenic (As), selenium (Se), cadmium (Cd), mercury (Hg), and lead (Pb).

B. Methods Developed

For the Indialantic box, dedicated water sampling ports were provided consisting of threaded and capped 3 inch PVC pipe grouted into the inlet pipe and outlet pipe immediately before and after the baffle box. No sample ports were provided for sampling the Micco baffle box, with sampling access provided through the manholes.

During the period of preliminary sampling, several different types of pumps were evaluated. A small hand-held siphon plunger pump with tubing connected to the inlet proved awkward and its use was abandoned. A second diaphragm pump of suitable materials, with the inlet attached to a 6-foot length of 2-inch PVC pipe, was more successful and used for all subsequent sampling. The pump and associated piping were field-cleaned with laboratory soap and flushed with distilled water between each sample collected. The PVC pipe attached to the pump was lowered through the sample port to the bottom of the inlet or outlet pipe to be sampled, raised off the bottom to avoid any sediment that may have been deposited in the bottom of the pipe, and then pumped several times until a uniform sample could be collected. Samples were placed in container-s (supplied and cleaned by the laboratory) constructed of appropriate material for the parameters to be analyzed. Samples were field preserved if required and immediately placed in an ice-filled cooler for transport to the laboratory within allowable holding times. To collect water samples from the Micco box, the suction end of the PVC pipe was placed in the inlet or outlet pipe accessed through the manholes. All other procedures at the Micco site were as followed at the Indialantic site. Laboratory analysis was conducted in accordance with Standard Methods for the Examination of Water and Wastewater, 17th Edition, or Environmental Protection Agency approved methods.

Sediment depth in each baffle box chamber was also measured, and samples were collected once from each chamber of the Indialantic box to assess the nature and quantity of the accumulations. Due to the often unconsolidated, soupy nature of the sediment, various methods for collection were evaluated. A core sampling device was fabricated from 2 inch PVC pipe with a check valve to hold the sediment in place. Similar devices have been used to collect samples from residential canals and the Lagoon bottom.

The baffle boxes in this study have three chambers. The first and second chambers collect the heavier particles consisting mostly of coarse, large-grain sand. Because of the sediment's weight and coarseness and the length of pipe required to reach the sediment, there was insufficient vacuum and seal for lifting; therefore it was necessary to place two valves near the bottom of the PVC pipe in order to retain the sample. This allowed sampling of the first two chambers. The last chamber generally contained an unconsolidated slurry of fine organic and metals-rich sediment and water with the consistency of pudding. The PVC core sampler was unable to hold such an unconsolidated sample long enough to allow retrieval. A syringe-type muck sampler was consequently purchased and used for sampling this chamber. The sediment sampling equipment was constructed of suitable material, field-cleaned with laboratory soap and flushed with distilled water between collection of samples. The sample containers used were of materials appropriate to the parameters to be analyzed, and supplied and cleaned by the laboratory. Samples were immediately placed in an ice-filled cooler for transport to the laboratory for analysis within allowable holding times. Laboratory analysis was conducted in accordance with Standard Methods for the Examination of Water and Wastewater, 17th Edition, or Environmental Protection Agency approved methods.

In order to assess the quantity of sediment accumulating behind each baffle, multiple depth measurements were taken in each chamber. It should be noted that no chambers had a uniform depth of sediment. Directly under the inlet pipe in the first chamber, where velocities were highest, much less sediment accumulated than in the corners. Also sediment accumulation was greatest against and on the up stream side of each baffle and the downstream end of the box and tapered off toward the inlet. Using multiple measurements from each chamber, an average depth was derived. Because most of the sediment consisted of heavier coarse to medium sand, a sample was collected from the center chamber and a known volume was dried and weighed. Based on this weight per unit volume the weight of the removed sediment was estimated.

C. Sediment Analysis and Results

In order to determine the nature and quantity of accumulated sediment, volumes (discussed above) were measured and sediment samples collected. Because there are three chambers in the box and the heavier particles tend to settle first, a sample was collected from each chamber (Indialantic box only) and analyzed for metals commonly found in the suspend portion of stormwater. These metals include mercury, lead, zinc, cadmium, chromium, aluminum, copper, nickel, and iron. Sediment analysis results (Table 1) are compared against regulatory thresholds, and data collected from canals and the Lagoon in the Indialantic area.

Prior to sediment removal by pump-out (Table 2) the sediment level in the first chamber, comprised mostly of coarse sand, often exceeds two feet in depth (Table 3). The sediment in the second chamber, a mixture of finer sand and organic matter, often approaches depths of between one and two feet. The third chamber, consisting of the very fine sediment that contains higher concentrations of metals and organic material, usually remained below one foot in depth.

Table 1. Water sample analysis results from the baffle box inlet prior to treatment, and outlet of the baffle box following treatment.

INDIALANTIC		TOTAL SUSPENDED SOLIDS mg/L		TOTAL PHOSPHORUS mg/L		BIOCHEMICAL OXYGEN DEMAND mg/L	
DATE	TIME	INLET	OUTLET	INLET	OUTLET	INLET	OUTLET
10-06-93	1045	35.2	03.6	3.40	0.42	2.24	1.21
11-23-93	0935	66.2	13.8	1.81	0.59	2.20	1.50
01-12-94	1055	22.4	09.6	0.30	0.31	X	X
02-17-94	1045	07.8	03.4	0.46	0.46	1.20	1.50

MICCO		TOTAL SUSPENDED SOLIDS mg/L		TOTAL PHOSPHORUS mg/L		BIOCHEMICAL OXYGEN DEMAND mg/L	
DATE	TIME	INLET	OUTLET	INLET	OUTLET	INLET	OUTLET
10-06-93	1140	34.0	09.6	0.04	0.03	1.59	1.90
11-23-93	1035	08.6	09.2	0.02	0.02	2.00	1.80
01-12-94	1137	04.4	12.5	0.03	0.03	X	X
02-17-94	1210	19.2	03.2	0.13	0.09	1.20	1.40

Table 2. Dates of sediment removal (cleaning)

	Indialantic	Micco
Date constructed	8-21-92	9-04-92
1st cleaning	9-22-92	12-03-93
2nd cleaning	2-04-93	
3rd cleaning	8-3-93	
4th cleaning	9-29-93	
5th cleaning	1-26-94	

Table 3. Sediment depths (inches) in each chamber of the baffle boxes at Indialantic and Micco, for the period November 18, 1993, through March 29, 1994.

DATE:	11/18/93	12/20/93	01/20/94	02/22/94	03/29/94
<u>INDIATLANTIC</u>					
1st Chamber:	18	28	26	26	22
2nd Chamber:	21	31	30	18	20
3rd Chamber:	12	12	14	14	16
<u>MICCO</u>					
1st Chamber:	4	2	4	2	2
2nd Chamber:	16	15	14	0	2
3rd Chamber:	9	6	6	0	0

In addition to chemical analysis of the sediments, a sieve analysis (Table 4) was conducted by Florida Institute of Technology (Dr. Pandit) to evaluate the particle sizes being removed from each chamber. As with the other analysis, samples were collected and evaluated from each of the three baffle box chambers. The sediment was strained through seven different sieve sizes with openings varying from 2.0 mm. down to .075 mm. The material retained on the sieves was oven dried, weighed, and percentages of each size range were determined.

Pollutants in sediments accumulate in the Lagoon over time, with high concentrations possible in areas that are subject to heavy loadings. When sediment in the baffle boxes is removed on a regular basis, a reduction in sediment depositor and accumulation is expected in the vicinity of the downstream outfalls. The nutrients, metals, and organic materials present in the sediments are not in concentrations that would be considered hazardous or toxic. Table 1 lists the concentrations found along with those values considered acceptable in clean soils. Concentrations found during previous studies in the canals and the Lagoon are provided for comparison purposes.

III. Phase 2. Monitoring to Determine Removal Efficiency

The actual efficiency and quantities of pollutants removed is dependent on many factors, including land use, drainage basin area, soil types, stormwater velocities through the box, and the frequency and thoroughness of box cleanings. Because the Micco installation actually receives drainage from four subbasins containing a sand ridge, different soils, paved and unpaved roads, a wetland, a borrow pit, a park, dense woods, a residential area, and an artisan well, the monitoring focused primarily on the simpler Indialantic sub-basin. Both Indialantic and Micco have constant background flow due to groundwater infiltration.

According to the Indialantic Stormwater Master Plan, this 24.1 acre sub-basin consists of 23.8 acres of medium density residential land use and 0.3 acres of paved highway. Soils in this basin are predominantly Galveston-Urban Land Complex, which is a well-drained sandy soil containing shell fragments.

The amount of sediment and other pollutants carried by stormwater varies during and after a storm and reaches a maximum at some point in between. It is difficult to predict the exact time that this maximum, worst-case discharge will occur. Despite the constant monitoring of frontal activity, radar reports, and localized rainfall variations, catching and

Table 4. Sieve analysis results, percent by weight of each size in each chamber

Particle Sizes (mm)	>0.425	0.425to 0.15	<0.15
1st Chamber	41.72	55.29	3.14
2nd Chamber	33.42	61.21	4.94
3rd Chamber	19.81	48.84	30.88

sampling the "first flush" proved difficult. SWID staff sampled following three storm events during the period September 29, 1993, through November 23, 1993. From November 23, 1993, to the final sample excursion date of February 17, 1994, a dry period was experienced with only one 24-hour rainfall total exceeding 0.50 inches (0.59 inches on Saturday, January 2, 1994). The rainfall events during this typical winter period were primarily scattered low-intensity, longer duration storms (Table 5). Several hours were required after the initial rainfall before any indication of increased flow from the watershed was observed. The increase in flow during and shortly after the showers was so small that determining when or if a "first flush" had occurred was impossible.

Manually sampling a storm event is as much art as science. Significant, high-intensity rain events in east central Florida are difficult to predict and "capture" due to the often isolated, spotty occurrence of rainfall. Over 75 percent of the rain events occurring over a five-year period for 13 Florida locations totaled 0.50 inches or less (Wanielista, 1981). During the summer, slow-moving, isolated thunderstorms often dump over an inch of rain in less than an hour over a relatively localized area before dissipating. While annual and historic rainfall totals are fairly uniform throughout the region, daily, weekly, and even monthly totals may vary greatly over a short distance. While Doppler radar is a useful tool for estimating rainfall intensities and totals for rain events, access to the system is limited to the National Weather Service and selected users. Automated samplers, which are automatically triggered by pre-determined rainfall intensities, totals, and/or flow rates, more efficiently monitor a storm event.

A. Parameters

For this phase of the sampling, parameters were reduced to those expected to be removed by this treatment method, and also found in preliminary sampling in significant quantities. No oil or grease was found and metals were only present in minute quantities in the water samples. Other parameters such as FC nitrite, nitrate, ammonia, dissolved solids, conductivity, pH, and TKN were collected to provide information on the sub-basin pollutant loading and are not removed by this treatment method. Due to the low metals concentrations encountered in the water, COD was eliminated also. The baffle box is primarily intended to remove suspended particles. This material, consists of large quantities of inert sand, and lesser quantities of nutrients, metals, and organic materials. In order to evaluate removal efficiencies of this treatment system, total suspended

Table 5. Rainfall (hourly, in inches) at Indiatlantic and Micco project sites prior to sampling.

DATE:	10/06/93	11/23/93	01/12/94	02/17/94
INDIATLANTIC				
1 hour:	0.00	0.00	0.01	0.09
3 hour:	0.04	0.00	0.02	0.12
6 hour:	0.06	0.00	0.05	0.25
12 hour:	0.14	0.13	0.07	0.25
24 hour:	0.66	0.16	0.07	0.25
48 hour:	0.77	0.26	0.07	0.25
72 hour:	0.77	0.26	0.07	0.25

DATE:	10/06/93'	11/23/931	01/12/94'	02/17/94 2
MICCO				
1 hour:	0.04	0.00		
3 hour:	0.09	0.20		
6 hour:	0.11	0.27		
12 hour:	0.35	0.65		
24 hour:	0.35	1.10	0.18	0.01
48 hour:	0.35	1.29	0.35	0.01
72 hour:	0.35	1.31	0.35	0.01

Notes:

1 Hourly rainfall readings from Micco project site

2 not available - gauge inoperative, Daily (24 hour) rainfall reading from Barefoot Bay Waste Water Treatment Plant substituted these dates.

solids (TSS), total phosphorus (TP), and biochemical oxygen demand (BOD) were analyzed.

B. Methods

In an attempt to obtain maximum loadings, water samples were collected on four excursions during or shortly after storm events. Results are compared against expected removal efficiencies, and estimated sediment volumes and weights removed. The methods employed for actual sample collection are those found to be most appropriate and described under preliminary sampling.

C. Results

The following sections attempted to recognize possible relationships and explain possible causes or contributing factors in order to evaluate the results of the data collected. These statements must be qualified by recognizing that it is difficult to draw definitive conclusions based on four sample excursions, especially when a wide range of environmental variables affect results.

C.1 Indialantic

As discussed in the Indialantic Master Plan, it was anticipated that 40 to 70 percent of suspended particles would settle out depending on the flow rate and velocities of stormwater moving through the box. Based on area occupied within the basin by each land use, suspended solids loading for this basin was estimated to be 2,651 pounds per year. A 40 to 70 percent removal rate would result in 1060 to 1856 pounds per year of suspended solids removal. As previously stated, during the period August 21, 1992 to September 22, 1992 approximately 4500 pounds of sediment were removed from the box. This period would correspond to the summer season of higher intensity, shorter duration storms with greater resulting flow rates. Between September 22, 1992 and February 4, 1993, an estimated additional 4,000 pounds of sediment was removed over a four month period during the lower intensity, longer duration winter season. It appears from the estimated quantities removed that the basin has a much greater suspended solids loading than originally anticipated.

Suspended solids (SS) were also measured at the inlet and outlet of the box in order to assess the actual removal efficiency. Evaluation of the sample results (Table 6) indicated an overall 70.62 percent SS reduction on average (mean). This was expected, but it is much lower than the estimated weight of the sediment removed from the box based on

Table 6. Sediment analysis results

Indialantic Baffle Box

Parameters (ppb)

	Al	As	Cd	Cr	Cu	Hg	Pb	Ni	Zn
1St chamber	32.1	1.13	bdl	.04	.63	bdl	5.26	2.1	3.23
2nd chamber	X	6.70	.28	10.05	.84	X	5.61	16.79 -	11.04
3rd chamber	X	64.80	.28	8.22	30.6	X	29.76	130.6	202.4

Parameters (ppm)

Location	Al	As	Cd	Cr	Cu	Hg	Pb	Ni	Zn
Canal 11	34000	bdl	bdl	265	62	.056	54	76	125
Canal 21	33500	bdl	bdl	111	80	.074	56	31	165
Canal 31	43000	bdl	bdl	295	81	.076	75	91	175
Background'	21000	bdl	bdl	41	3.2	<.005	<2	17	2.2
Regulatory Threshold		10	37	50		23	108		

1 Indialantic Master Plan 1993 2 FDER November 1992 Maximum **concentrations for clean soil.** bdl = below detection limit

Notes: Sediment analysis results, values from Indialantic canals, background lagoon sediment, and regulatory thresholds provided for comparison purposes. To compare canal and background values (in ppm) with Indialantic Baffle Box data (in PPB), multiply ppm values by 1,000.

Table 6. Sediment analysis results

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	Parameters (ppb)								
	Al	As	Cd	Cr	Cu	Hg	Pb	Ni	Zn
1st chamber	32.1	1.13	bdl	.04	.63	bdl	5.26	2.1	3.23
2nd chamber	X	6.70	.28	10.05	.84	X	5.61	16.79 -	11.04
3rd chamber	X	64.80	.28	8.22	30.6	X	29.76	130.6	202.4

	Parameters (ppm)								
Location	Al	As	Cd	Cr	Cu	Hg	Pb	Ni	Zn
Canal 1[1]	34000	bdl	bdl	265	62	.056	54	76	125
Canal 2[1]	33500	bdl	bdl	111	80	.074	56	31	165
Canal 3[1]	43000	bdl	bdl	295	81	.076	75	91	175
Background[1]	21000	bdl	bdl	41	3.2	<.005	<2	17	2.2
Regulatory[2] Threshold		10	37	50	-	23	108		

1 Indialantic Master Plan 1993 2 FDER November 1992 Maximum concentrations for clean soil. bdl = below detection limit

Notes: Sediment analysis results, values from Indialantic canals, background lagoon sediment, and regulatory thresholds provided for comparison purposes. To compare canal and background values (in ppm) with Indialantic Baffle Box data (in PPB), multiply ppm values by 1,000.

sediment depths before cleaning. This may be due to a greater removal rate under low flow conditions and some error in estimating the volumes of sediment removed in cleaning the boxes. In addition, the composition of the suspended solids (SS) was analyzed. Approximately 50 percent of the nutrient phosphorus is in particle form. Based on an estimate of 33.5 pounds of phosphorus loading and an expected 20 to 35 percent removal rate, 6.7 to 11.7 pounds per year of phosphorus was expected to be removed. Total phosphorus was also analyzed from samples collected at the inlet and outlet of the box to determine the actual removal efficiency. Sample results for this parameter showed a 38 percent average (median) reduction.

Approximately 25 percent of the suspended solids are (organic in nature, the decomposition of which creates an oxygen demand; therefore BOD was measured. Assuming a 10 to 17 percent removal rate and an estimated loading of 828.4 pounds BOD/year, an estimated 82.84 to 140.82 pounds BOD/year reduction was anticipated. Sample results indicated an average 39 percent BOD reduction for two dates with one date showing a 25 percent increase between inlet and outlet. The greater than expected BOD reduction may be due to greater than expected organic loading.

Relationships between individual sample excursions, parameters, and dates that the boxes were cleaned were evaluated. The Indialantic data presented in Table 6 indicates an overall reduction of SS by 70.62 percent, with the last two dates showing less reduction (56.78 percent). For TP the first two dates showed 77.5 percent removal, which may indicate that greater than 50 percent of the TP from this basin is in particle form. For the first two dates BOD went down 38.9 percent on average. On one date BOD went up slightly, and for one date laboratory problems prevented analysis. The September 29, 1993 cleaning appears to have been effective as indicated by the October 6, 1993 and November 23, 1993 higher removal efficiencies for all parameters. It is also suspected that the January 26, 1994 cleaning between the last two sample excursions was only a partial cleaning, with significant sediment remaining afterwards. This is also indicated by the similarity of the depths measured on January 20, 1994 and February 22, 1994 (Table 3), with little rainfall in this period. Because the TSS went down on all sample dates, it appears that the heavier sand particles which make up most of the sediment volume continued to be removed. TP and BOD either remained the same or went up slightly on the last two dates, which may indicate that the lighter sediment containing these constituents was not removed or was re-suspended due to excessive buildup between cleanings.

C. 2 Micco

When evaluating the Micco box data there appears to be little consistency between parameters, cleaning dates and removal effectiveness expected. On October 6, 1993 the TSS (Table 6) was reduced by the expected 70 percent, but TP remained the same and BOD went up slightly. Similar results occurred on February 17, 1994, with TSS reduced, TP remaining the same, and BOD going up. This may, as with the Indialantic data, indicate that the lighter particles containing TP and BOD were not effectively removed. On November 23, 1993 and January 12, 1994 TSS went up slightly, with TP and BOD essentially remaining the same. These results were obtained despite a sediment removal between the two dates on December 3, 1993. This inconsistency may be partially attributed to incomplete cleaning on December 3, 1993 as may be indicated by the similar depths measured (Table 3) on November 18, 1993, before cleaning, and on December 20, 1993, after cleaning, with little rain in between. Unlike the Indialantic box, dedicated sample ports were not provided at the inlet and outlet of the Micco box. Access for sampling was through the manholes, which proved awkward and made it difficult to obtain consistent samples. These results may have also been affected by the complexity of the four subbasins contributing to this outfall. There is also an artisian well controlled ' by a valve upstream from the box that was opened after the box was installed. Discharge from this well contributed to higher velocities and flow rates above background.

IV. Maintenance (Pump-out) of Baffle Boxes

As stated above, the effectiveness of the boxes in removing sediment is greatly influenced by the regular removal, or pumping out, of accumulated sediment and debris. If the chambers in the boxes are allowed to fill up, stormwater transporting sediment and debris is not treated properly, and pollutants which would settle out in the chambers of a maintained baffle box remain suspended, rapidly entering the receiving water body. In addition, the pollutants stored near capacity during relatively dry periods may be readily resuspended and flushed out of the box during turbulent flow conditions caused by high-intensity storm events.

Noxious gases may be generated when organic material is allowed to build up over extended periods of time in the chambers of the baffle boxes, with decomposition resulting in significant amounts of methane, carbon dioxide, and hydrogen sulfide being produced. During the period August 21, 1992, to September 22, 1992, approximately 4500 pounds of sediment were removed from the box. Between September 22, 1992, and February 4, 1993, an estimated additional 4,000 pounds of sediment were removed.

Sediment and muck levels in the Indialantic baffle box over the three month period of November 18, 1993, through January 20, 1994, ranged from 12 to 31 inches (Table 3) in each chamber due to an extended period without cleaning. Large bubbles of noxious gas were often released when the chambers were probed during the measurements, requiring caution by field personnel to avoid inhaling the emissions. Table 2 lists the dates that, the accumulated sediment was removed from each of the boxes.

SWID environmental staff supervised the first two cleanings of the Indialantic box September 22, 1992 and February 4, 1993, and checked the box following the cleanings to measure the remaining sediment. The amount remaining following cleaning was deducted from the estimated amount removed. As a-result the initial estimations of amount of sediment removed is still considered a reasonable estimation. Subsequent cleanings were scheduled by SWID engineering staff and not supervised. The field crew responsible for cleaning the boxes later reported difficulty in reaching the sediment with the suction nozzle through the manholes provided for this purpose. This resulted in infrequent cleanings and significant sediment remaining after the cleanings which made determination of removal efficiency difficult to assess. Evaluation of the sampling results on the four excursions showed the values for some parameters actually went up between the inlet and outlet of the box, indicating likely re-suspension of sediment. As a result of the problems encountered in maintaining the box, future baffle box designs will include provisions for better access to avoid this situation.

V. Final Conclusions

SWID learned a great deal from the installation of the boxes, water and sediment sampling, and maintenance of this project that will make future installations (and evaluating those installations) more efficient. Field and laboratory procedures have been refined based on the lessons learned.

The importance of regular cleaning is documented, and changes in equipment and/or manhole placement and number will be incorporated in future design, to make cleaning easier and more efficient. A maintenance schedule is being developed for each baffle box by scheduling frequent inspections to document sediment accumulation and account for differences in basin loadings and seasonal variations in weather.

The amount of sediment and other pollutants carried by stormwater vary during and after a storm, reaching a maximum at some point in between. It is extremely difficult to predict when during the storm this will occur. By comparing when the samples were taken with respect to when the initial rainfall was received over the watershed, it is clear that most samples collected did not occur (despite a conscientious effort) under worst case loading conditions (first flush). SWID will continued to monitor the Indialantic baffle box in order to further assess its effectiveness under various conditions. Future manual storm event sampling will require anticipating storm events and arriving on site prior to the beginning of an event, or use of automated sample equipment. In order to supplement data collected in the field, hydraulic scale modeling is being considered to collect data under more controlled laboratory conditions. Size and shape of the boxes and baffles can be evaluated under various controlled sediment loadings, velocities and flow rates and then incorporated in future designs. A proposal for such analysis is currently under consideration provided partial funding can be obtained. It is clear from the data collected to date that the pollutants which were expected to be removed by the baffle box are being removed when the efficiency of the box is maintained by frequent cleaning thereby reducing resuspension.

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