FINAL REPORT

UNIVERSITY OF MINNESOTA - SWROC CWL PROJECT

PROJECT INVESTIGATOR
Dr. Jeff Strock

PROJECT ADMINISTRATION
Mark Dittrich

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Evaluation of Nutrient Retention Basins for Treating Drainage from Agricultural Landscapes

Summary ***– The goals of this project included 1) design and instrument a series of water and nutrient storage basins for the treatment of agricultural drainage water, 2) collect water and nutrient date in order to assess the capacity of the designed systems to improve edge-of-field water quality, and 3) educate stakeholders on the potential benefits of these systems. Despite dry conditions in 2009 and wet conditions in 2010 and the first half of 2011 and design challenges we observed nutrient load reductions in water after treatment in the systems.***

INTRODUCTION

There is growing interest in off-site methods for treating agricultural runoff. This is evidenced by a recent report from the USEPA's Science Advisory Board's Integrated Nitrogen Committee. One of the committee's recommendations to reduce excess flows of reactive nitrogen (Nr) to surface waters is through improved landscape management using *wetland management*, improved tile-drainage systems, and riparian buffers on cropland. Wetland restorations in Minnesota have been shown to be effective in improving agricultural water quality. One disadvantage of wetland restoration is that the wetlands often disrupt the continuity of farming practices because of their location. Constructed nutrient retention basins have been successfully used in agricultural livestock production as an effective method of treating animal waste. It is unknown how effective and efficient constructed nutrient retention basins may be at removing agricultural contaminants from combined surface and subsurface drainage runoff under Minnesota conditions. Constructed nutrient retention basins could also be strategically located to optimize water quality benefits and farming practices.

Objective – This ongoing project seeks to better understand and measure the effectiveness and efficiency of agricultural contaminant removal from three types of constructed nutrient retention basins designed to improve agricultural water quality.

Site Development and Data Collection

Replicated constructed nutrient retention basins were designed and constructed appropriately in fall 2007 at the University of Minnesota, SW ROC, Lamberton to meet water quality objectives. The area consisted of undrained Canisteo poorly drained soil. The contributing watershed is annually planted to corn and soybean.

Replicated constructed nutrient retention basin designs included pairs of surface-flow (SF) basins, subsurface-flow (HF) basins, and vertical-flow (VF) basins. The surface-flow basins were designed so that incoming water principally flows above the ground surface, as shallow sheetflow, through a dense growth of terrestrial and emergent aquatic plants. Subsurface-flow basins treat water by passing it horizontally through a permeable media planted with terrestrial and aquatic plants. Vertical flow basins are similar to subsurface-flow basins except that these systems are designed to treat water by passing it vertically through soil planted with terrestrial and aquatic plants. Each basin occupied an area equal to approximately one-half acre. Nitrogen and phosphorus were the main nutrients of concern from agricultural runoff.

Water Quantity and Quality instrumentation

Each pair of SF and VF nutrient retention basins shared an equalization basin for distributing water into the individual basins through H-flumes. The HF nutrient retention basins also share an equalization basin however; water is distributed to the individual basins through two Hickenbottom inlets. Water level and outflow from each basin were controlled by an in-line water level control structure. Instrument shelters located near the inlet H-flumes and the outlet water level control structures contain equipment for measuring water level and for water sample collection. Each shelter contains an ISCO water sampler and a Campbell Scientific Inc. CR1000 data logger used to collect and store stage height (water level) data. Each H-flume and water level control structure is equipped with an INW, Inc. pressure transducer to record changes in stage height. The INW pressure transducer also measures water temperature.

The constructed basin site received a combination of surface and subsurface agricultural drainage runoff water. An H-flume and accompanying wing-walls for measuring snowmelt runoff and surface water runoff from a 71 acre contributing watershed were installed in a grassed waterway leading to the site in late autumn 2010. In March 2011, the flume was equipped with a data logger, pressure transducer, and ISCO sampler. A water level control structure was installed at the end of a subsurface drainage system that collected water from a 114 acre contributing area. The water level control structure was instrumented in the same manner as the surface runoff H-flume.

A combination of grab and storm activated discrete samples were be collected for each nutrient retention basin cell. Water inflow to and outflow from the basins was monitored in order to quantify sediment, nutrient, and hydrologic budgets for each of the three basin types. Water samples were analyzed at the University of Minnesota SW ROC analytical lab for total nitrogen, nitrate-nitrogen, ammonium-nitrogen, total phosphorus, ortho-phosphorus, and total suspended solids.

Soil sampling

A grid of six sampling locations was established in each basin with locations distributed at roughly equal intervals throughout a basin. The locations were georeferenced and permanently marked with a 1 m PVC pipe driven 0.5 m into the substrate.

A composite soil sample was obtained from each location with a 1 cm diameter coring device. Each composite sample consisted of eight individual soil samples. Cores were collected to a depth of 30 cm. Soil samples were separated into three to five depth increments (0-2.5, 2.5-5, 5-10, 10-20 and 20-30 cm). Approximately 5 kg of diatomaceous earth (a fine powder of marine diatoms) was dispersed in the vicinity of each coring location so as to provide a stratigraphic marker to assess sediment/nutrient accumulation over time. Diatomaceous earth was distributed within a circular area (3558 cm^2; radius of 33.655 cm) with the PVC marker at the center. Composite soil samples will be analyzed for phosphorus content and major element chemistry. The upper sample represents the material at the sediment/water interface and the initial condition within the basin. The deeper samples provide the composition of the underlying soil/sediment.

Soils were analyzed for trace metals by inductively coupled plasma atomic spectrometry (ICP-AES) following a microwave digestion with nitric acid (P, K, Na, Ca, Mg, Al, B, Fe, Mn, Cu, Zn, Cd, Ca, Ni, Pb, Co, Mo, Si, S, As, Ti, Be, Sr, Rb, Li, V, and Ba). Soil was analyzed for total P by microwave digestion, water soluble P, Bray and Kurtz P1, and Olsen P test. Soil pH was measured in water (1:1). Organic matter was determined by loss on ignition and total nitrogen was measured by combustion using the Dumas method. Total carbon and inorganic carbon were determined by dry combustion at 2500°F and subsequent measurement of CO_2 evolution by IR spectrum absorption using a Skalar Primacs carbon furnace. Inorganic carbon was determined by addition of phosphoric acid in a closed, purged, system and measurement of CO_2 evolution by IR spectrum absorption. Organic carbon was determined by difference.

RESULTS

Precipitation

Overall 2008 was below normal precipitation, 402 mm, compared to the 30 yr- normal of 470 mm. During the growing season precipitation was below normal during July and August (Table 1). Above normal precipitation in October contributed to soil moisture recharge and no surface runoff or tile drainage was observed. Below normal precipitation, 214 mm, compared to the 30 yr- normal of 340 mm, occurred during the first six months of 2009 (Table 1). Between March and June precipitation was 22% to 52% below normal (Table 1). Two snowmelt runoff events dominated site hydrology during the first six months of 2009. The first event occurred over four days between February 9 and 12. The second event occurred over a three day period between March 5 and 7. Unfortunately, neither of these events was captured because the monitoring and sampling equipment was not installed in the field. Above normal precipitation in October contributed to soil moisture recharge however no surface runoff or tile drainage was observed. Dry conditions coupled with nominal soil moisture recharge in fall 2008 resulted in intermittent subsurface tile drain flow during 2009.

Overall precipitation during 2010 was 34% above the 30-year average of 721 mm. Significant snow in late December 2009 and no mid-winter thaw event, and above normal precipitation, 369 mm, compared to the 30 yr- normal of 340 mm, occurred during the first six months of 2010 (Table 1). Snow melt beginning the second week of March and excess rain in June contributed to an active drainage season during the first half of 2010. March and April precipitation was 16% to 21% below normal, while June precipitation was 70% greater than normal (Table 1). The snowmelt event was slow and dominated site hydrology during March. The second half of 2010 was dominated by a wet September. An extreme precipitation event occurred between September 23 and 24 that resulted in 148 mm of precipitation that caused significant flooding. Above normal precipitation, 508 mm, compared to the 30 yr- normal of 340 mm, occurred during the first six months of 2011 (Table 1). Two snowmelt runoff events occurred in 2011. The first snowmelt event took place on February 16 however monitoring equipment was only operational at the basin outlets. The main snowmelt event was slow and occurred between March 14 and 25. All monitoring equipment was in place during the main snowmelt event. June precipitation was more than twice the 30-yr average; between June 15 and 22, 187 mm was recorded.

Vegetation Management

Between 2008 and 2010, terrestrial and aquatic vegetation was managed as prescribed by the management plan for noxious weed control. The terrestrial and aquatic vegetation in the HF and VF basins became well established, flourishing and becoming densely populated. The vegetation in the SF basins in the shallow zone is somewhat weedy and sparse. Cattails and small trees began to invade the SF basins in 2010. Ongoing vegetation management is necessary. The vegetation in the uplands, which were seeded with the prescribed seed mix along with annual rye grass in fall 2008, is generally dense except for traffic areas. Weeds are prevalent in some areas. The entire site was subject to a controlled burn in spring 2011 as prescribed (Figure 2).

Soil

Results from pre-flooding soil property analysis are expected to provide several benefits to the experiment. First, results will provide baseline data for soil chemical properties before the basins are subjected to periodic inundations by agricultural drainage water. Second, data will aid in the calculation of mass balances for certain elements, for example phosphorus. Third, the data will provide some indication of future observations with respect to basin inflow and outflow water quality. For example, a basin with high soil test phosphorus values may act as a source of phosphorus under certain conditions and contribute to a greater flux of phosphorus exported from the basin. Finally, these data will be beneficial for making post-flooding comparisons of soil chemical properties and water quality results by aiding in the understanding process and mechanisms controlling translocation and transformation of important elements.

Soil test results show a high degree of variability in soil properties with depth and by location (Tables 3-5). Results of pH analysis indicate that the soil is slightly alkaline. Soil organic matter content ranges from 1.2 to 6.0% and in general decreases with depth with the exception of surface flow basin two, location C. It is speculated that this could be an artifact of historic upland erosion and subsequent deposition of lower organic matter subsoil at this location. Both Olsen and Bray soil test phosphorus extractants were used to test for available soil phosphorus. Based on pH, the Olsen test is most appropriate for these soils. The surface soils of both surface flow basins at location A, to a depth of 10 cm, were in the high to very-high range (Table 3). With a few exceptions, the soil test phosphorus values for the rest of the basins and locations are in the very-low to medium range (Tables 3-5).

Results from ICP analysis of pre-flooding soil properties, which were not available at the time of the last report, are provided below. Pre-flooding analyses are expected to provide several benefits to the experiment. First, results will provide baseline data for soil chemical properties before the basins are subjected to periodic inundations by agricultural drainage water. Second, data will aid in the calculation of mass balances for certain elements, for example phosphorus. Third, the data will provide some indication of future observations with respect to basin inflow and outflow water quality. For example, a basin with high soil test phosphorus values may act as a source of phosphorus under certain conditions and contribute to a greater flux of phosphorus exported from the basin. Finally, these data will be beneficial for making post-flooding comparisons of soil chemical properties and water quality results by aiding in the understanding process and mechanisms controlling translocation and transformation of important elements.

Soil test results show a high degree of variability in soil properties with depth and by location (Tables 6-8). Important trace metals measured in the basins that merit further consideration include aluminum, manganese, and iron. Aluminum in soil is often associated with the mineral gibbsite $Al(OH)_3$. The phosphorus adsorption capacity of saturated soils is associated aluminum (Al) and iron (Fe). Soils subject to fluctuations in water content are under the influence of the reduction-oxidation potential (*pe*). Under conditions of water saturation, the lack of molecular oxygen can result in a sequence of redox reactions. Redox reactions influence metal ion solubility and the chemical form of ions and molecules dissolved in soil-water systems.

In systems like the nutrient retention basins that contain organic material, the sequence of microbially mediated redox reactions would theoretically begin with the oxidation of organic matter which is observed to occur first by the reduction of oxygen, O_2 by respiration. This reaction is followed by denitrification or the reduction of nitrate (V), NO_3^-, to dinitrogen gas (0), N_2. Estimating denitrification by measuring N_2 gas emissions is difficult because of problems associated with sampling and stripping. Atmospheric contamination in gas sampling and analysis is a major concern because 78% of dry air is composed of N_2. Denitrification is closely followed by reduction of manganese (hydr)oxides (IV), for example, MnO_2, to soluble manganese (II), Mn^{2+}. Changes in Mn concentration in soils/sediments could indicate that conditions were favorable for the reduction of solid forms of Mn and the formation of soluble Mn^{2+}. Next in the sequence of redox processes is the reduction of nitrate (V), NO_3^-, to nitrite (III), NO_2^-. In the oxidized mineral form in soils, ferric iron occurs mainly as goethite, FeOOH, and ferrihydrite $(Fe(OH)_3$, Fe^{3+} (III). to soluble iron (II), Fe^{2+}. As a consequence, phosphate bound to iron (hydr)oxides is released due to reductive dissolution of the solid phases of iron. Prolonged anoxic conditions cause sulfate (VI), SO_4^{2-}, to be reduced to hydrogen sulfide (-II), H_2S. In reducing environments there is a strong association of mercury (Hg) with sulfide that results in low mobility although volatile forms (e.g. methylmercury) can lead to some mobilization. Future measurements of trace metals in the inflow/outflow water as well as in the soil/sediment will help aid in the calculation of mass balances for elements like nitrogen, carbon, phosphorus, manganese, and iron.

Drainage

Unfortunately, during spring 2010 excess snow in the HF and SF inlet large approach sections prevented installation of monitoring and sampling equipment which consequently limited early season data collection for these locations. Another complicating factor involved in missing early season flow measurements was a departure from the planned elevation (1109.50 ft) of the large concrete approach sections (Table 9). It was necessary to raise the HF and VF approaches sections by 1.8 and 2.28 inches, respectively. The HF and VF large concrete approach sections were raised to the elevation of the SF approach section by laminating together strips of sheet PVC to the proper height and then securing them in place at the inlet of the appropriate approach section. We subsequently also discovered that the small concrete approach sections for the VF and SF 1.5-ft H-flumes were not at the same planned elevation. This resulted in variability in flow through the VF and SF inlet H-flumes. It was necessary to raise the VF and SF approaches sections between 0.36 and 1.32 inches in order to achieve uniform flow through the approach sections. The technique that was used on the large approach sections was used on the small approach sections on April 12, 2011. There is an unexplainable data gap for all the inlets and outlets between May 7 and May 20, 2010.

The data collected from the outlets of the basins consists of a longer record than the inlets because they are equipped with stilling-wells and water level control structures which help to minimize early season complications due to freeze-thaw conditions. One issue that was immediately apparent during the March thaw in 2010 was that snow, which had drifted across the outlet pipes of the VF basins and the south HF basin caused drainage water to back up in the control structure. Some discrepancies in outflow data between the basins are attributed to preferential flow of water between inlets. For instance, in 2010 significant flow was directed to the south HF basin at the inlet and almost no water flowing to the north HF inlet. This was mainly due to uneven grading of the soil and rock at the inlet which was subsequently corrected.

The flume for quantifying surface runoff and "day lighting" a portion of the subsurface was completed in autumn 2010, thus there is no data reported for 2010. The data show two significant surface runoff events during 2011, one related to snowmelt and the other to an intense storm before the crop canopy closed in June. The consequence of a lack of crop canopy closure is a lack of interception of precipitation which is then available for runoff. Subsurface drainage accounted for

30% of the inflow to the system. Some of the apparent discrepancy between flow into the system and flow through the basins can be accounted for due to runoff that enters the system but which is not quantified. Snow accumulation and snow melt in the basins and the equalization basin also account for some of the inflow disparity. In the future there should be an attempt to quantify the flow contributed due to snow in the systems.

As previously noted, there were some disparities in water flow through the system during 2010 until engineering solutions remedied some of the flow problems. The flow measured entering the HF system is likely greater than what actually entered the system because the H-flume where stage height is measure was frequently submerged during 2010 and 2011. This is due to a design flaw that will be corrected once dry conditions permit lowering the collection basin and associated piping in autumn 2011.

There are four noticeable increases in flow through the basins, two in 2010 and two in 2011. The early increase in both years is due to snowmelt runoff. The second increase in 2010 occurred in response to the extreme event in September 2010. The second increase in 2011 also occurred due to an extreme event in June 2011. The least amount of outflow was observed from the HF systems. The VF systems were intermediate although the VFS outlet was similar in outflow to the SFN outlet by mid June 2011. The most outflow was observed from the SFS system followed by the SFN system. This occurred in part due to snow melt that occurred for a short period in February 2011.

Nutrient Loads

Nutrient loads are presented by year but only reflect loads during the period generally between March and November during frost free periods. Loads for 2011 are only for the period January through June when surface runoff, subsurface drainage, or snowmelt occurred. The lack of nutrient load data for SFSin and HFNout were the result of a programming problem and in the case of SFSin a rodent infestation that has since has been taken care of.

Phosphorus

Reductions in P were observed for TP and DMRP for both years. Reductions in P were generally greater than 50% when comparing the inlet load to the outlet load for 2010 and similar for the first half of 2011. Although the data is not shown, there were several events that sediment was observed in the runoff. We make no attempt here to infer the process or mechanism or P removal from drainage waters, however, it is likely that vegetative uptake and deposition of some P associated with sediment occurred.

Nitrogen

There were relatively high loads of N during 2010 and 2011. These can be attributed to subsurface drainage that lasted well into the summer of 2010 due to excess precipitation during June through September. For the first half of 2011, we observed 7 cm of subsurface drainage. Subsurface drainage is generally the main source of dissolved N entering surface waters. During a typical year, subsurface drainage begins in mid-March and ends by mid July. In general, the basins were effective in removing NO_3-N from drainage water. In 2011, the VFS inflow and outflow loads were similar. At this point we have no reasonable explanation for this phenomenon. During both years the VF basins were effective in removing dissolved $NH_{-4}N$ from the drainage water. This was likely do to sorption onto the surface of soil particles as the water filtered through the soil.

Ecosystem Services

The entire complex of basins is providing multiple ecosystem services. Regulation functions and related services include: water supply regulation, soil retention, nutrient cycling, and pollination. The site has so far created water storage and apparent soil and nutrient retention/cycling. Various forbs and grasses at the site also provide natural pollination. Habitat functions and related services include: living space for plants and animals and breeding and nursery areas. This spring various frogs, toads, shorebirds, and waterfowl have used the site. There have been several nesting pairs of waterfowl at the site. Production functions and related services include: production of raw materials in the form of native grasses. Although there are no plans at this time to harvest and use these raw materials the capacity exists. Information functions and related services include: aesthetic, recreational, scientific and educational information. Anyone who has visited the site can attest to the aesthetic nature of the site. Several events at the SWROC have included this site as a tour stop for educational purposes. The complex also has intrinsic value as a research and demonstration site.

OUTREACH

A brochure was created based on the design and construction of these basins and has been widely distributed. The brochure can be downloaded or printed from
http://swroc.cfans.umn.edu/prod/groups/cfans/@pub/@cfans/@swroc/documents/asset/cfans_asset_279118.pdf.
Twenty-five presentations were given to stakeholder groups during the past year in which the project was highlighted or the focus of the presentation. Over 1000 people participated in the events.

- Wetlands Go Underground: Susburface Nutrient-Retention Basins can Purify Farm Field Drainage Water Cost-Effectively, by Liz Morrison, Corn & Soybean Digest. Nov. 2008.
- University of Minnesota SWROC 50th Anniversary – 19 January, 2009. Lamberton, MN. Number of participants: 125.
- MN Land Improvement Contractors Association – 19 January, 2009. Owatonna, MN. Number of participants: 35.
- Agricultural Drainage Workshop – 18 February, 2009. Mankato, MN. Number of participants: 50.
- NCR207: Drainage design and management practices to improve water quality meeting – 31 March - April 1, 2009. Columbus, OH. Number of participants: 25.
- RCRCA and Area II Legislative Update and Year-in-Review – 12 December, 2009. Wabasso, MN. Number of participants: 55.
- MN Ag. Expo – 11 January, 2010. Presenter. Morton, MN.
- Conservation Drainage Focus Group – 14 January, 2010. Montevideo, MN. Number of participants: 8.
- Conservation Drainage Focus Group – 21 January, 2010. Montevideo, MN. Number of participants: 6.
- Drainage Water Management: Benefits, Conflicts, and Resolutions. 18 March, 2010. Hayti, SD. Number of participants: 130.
- 3rd Crop Producer Meeting – 22 March, 2010. Fairmont, MN. Invited presenter. Number of participant: 33.
- 9th International Drainage Symposium – 13-15 June, 2010. Presenter. Quebec City, Quebec Canada. Number of participants: 31.
- NCERA217: Drainage design and management practices to improve water quality meeting – 15 June, 2010. Presenter, participant. Quebec City, Quebec Canada. Number of participants: 15.
- Special Seminar: Drainage Water Management – 16 June, 2010. Invited presenter. Agriculture and Agrifood Canada, Harrow, Ontario Canada. Number of participants: 11.
- Drainage Water Management to meet Agronomic and Environmental Goals. 17 June, 2010. Harrow, ON, Canada. Number of participants: 14.

- Improving Teacher Quality Workshop. 29 June, 2010. Lamberton, MN. Number of participants: 33.
- Farm Fest. 3-5 August, 2010.
- Wisconsin Annual Soil and Water Conservation Society Conference – 8 February, 2011. Stevens Point, WI. Invited presenter. Number of participant: 151.
- Area V Southwest Minnesota Association of Soil and Water Conservation Districts – 17 February, 2011. Marshall, MN. Invited presenter. Number of participant: 43.
- Corn and Soybean Day – 24 February, 2011. Invited presenter. Slayton, MN. Number of participants: 42.
- 3rd Crop Producer Meeting – 28 March, 2011. Fairmont, MN. Invited presenter. Number of participants: 33.
- SW AMC Task Force Meeting – 13 April, 2011. Slayton, MN. Invited presenter. Number fo participants: 15.
- MN Ag. Expo, 17 January, 2011. Presenter. Morton, MN.
- CP39 Workshop – 21 March, 2011. Invited presenter. Number of participants: 13.
- Driven to Discover Water Solutions Workshop – 6 May, 2011. Invited presenter. St. Paul, MN. Number of participants: 135.

ACKNOWLEDGEMENTS
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Table 1. Monthly precipitation at Lamberton, MN.					
Month	Precipitation (mm)				
	2008	2009	2010	2011	30-yr Normal
January	3	8	22	26	15
February	2	16	19	40	14
March	32	29	34	40	43
April	75	38	64	65	76
May	82	41	51	123	87
June	91	82	179	214	105
July	85	51	96	-	99
August	15	79	122	-	102
September	54	85	269	-	77
October	107	125	51	-	51
November	25	10	25	-	36
December	21	47	36	-	16

Table 3. Pre-flooding soil sample test results for location **A**.

	Soil Property																	
Depth	pH		Total P		WEP		Bray P1		Olsen P		OM		Total C		Total N		Sulfate-S	
cm			mg/kg								%						mg/kg	
	Surface flow basin																	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
0-2.5	7.4	7.4	582	614	0.06	0.04	29	13	26	19	4.0	4.2	2.4	3.4	0.26	0.28	8	132
2.5-5	7.4	7.4	552	609	0.03	0.02	20	29	15	22	4.2	4.0	2.4	3.2	0.24	0.25	4	106
5-10	7.4	7.4	615	631	0.03	0.03	18	27	14	22	4.4	3.7	2.4	3.4	0.25	0.29	8	161
10-20	7.3	7.4	664	735	0.03	0.02	13	19	10	14	5.1	2.4	3.0	4.4	0.29	0.35	63	156
20-30	7.5	7.5	719	722	0.02	0.02	7	14	8	10	5.2	1.8	3.1	4.5	0.30	0.34	26	356
	Vertical flow basin																	
0-2.5	7.4	7.4	653	637	0.02	0.03	5	3	9	17	4.4	4.7	3.0	2.9	0.26	0.25	185	190
2.5-5	7.5	7.4	709	586	0.02	0.01	4	2	6	8	5.4	4.0	3.4	2.7	0.30	0.17	131	172
5-10	7.5	7.4	687	608	0.01	0.01	3	2	7	10	5.2	4.4	3.4	2.9	0.30	0.25	128	169
10-20	7.3	7.4	682	635	0.01	0.01	3	2	5	9	5.3	4.7	3.4	2.9	0.30	0.24	259	264
20-30	7.4	7.4	523	700	0.01	0.02	2	7	3	11	4.7	5.1	2.7	3.1	0.22	0.29	432	300
	Horizontal flow basin																	
0-2.5	7.4	7.5	697	642	0.04	0.03	16	11	20	15	4.4	4.4	2.6	2.6	0.27	0.26	54	96
2.5-5	7.5	7.5	587	582	0.03	0.03	17	9	15	15	4.3	4.3	2.8	2.9	0.25	0.28	73	202
5-10	7.4	7.4	559	631	0.02	0.03	18	10	14	15	4.1	4.7	2.5	3.0	0.24	0.27	124	243

Table 4. Pre-flooding soil sample test results for location **B**.																		
	Soil Property																	
Depth	pH		Total P		WEP		Bray P1		Olsen P		OM		Total C		Total N		Sulfate-S	
			mg/kg								%						mg/kg	
	Surface flow basin																	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
0-2.5	7.4	7.5	428	556	0.01	0.03	2	5	5	10	2.3	3.6	3.0	2.9	0.30	0.21	264	354
2.5-5	7.6	7.5	436	526	0.01	0.05	2	3	5	7	2.3	2.8	1.6	2.3	0.11	0.15	92	121
5-10	7.5	7.3	426	504	0.01	0.05	2	2	4	3	2.1	1.8	1.6	2.1	0.12	0.09	72	73
10-20	7.6	7.6	438	516	0.01	0.02	2	2	4	3	1.8	1.5	1.5	2.4	0.10	0.07	54	59
20-30	7.7	7.6	450	577	0.01	0.02	2	1	2	2	1.5	1.2	1.4	2.8	0.08	0.05	39	56
	Vertical flow basin																	
0-2.5	7.5	7.5	530	463	0.01	0.01	2	6	7	8	3.1	3.2	2.8	2.0	0.15	0.17	146	131
2.5-5	7.6	7.5	504	473	0.01	0.01	1	3	4	6	2.8	3.0	2.7	1.9	0.15	0.18	122	113
5-10	7.6	7.4	485	530	0.01	0.01	1	5	3	7	2.8	3.9	2.4	2.3	0.15	0.25	100	161
10-20	7.6	7.3	490	397	0.01	0.01	1	5	3	5	2.7	3.2	2.5	2.0	0.14	0.17	97	149
20-30	7.6	7.5	488	366	0.01	0.01	1	3	3	3	2.5	2.2	2.7	1.3	0.12	0.12	91	85
	Horizontal flow basin																	
0-2.5	7.5	7.5	601	587	0.04	0.02	14	8	18	14	4.4	4.6	2.7	2.9	0.27	0.29	110	116
2.5-5	7.4	7.5	611	577	0.03	0.02	20	10	15	14	4.3	4.6	2.5	2.7	0.27	0.26	100	165
5-10	7.8	7.5	561	563	0.03	0.03	10	12	16	14	4.2	4.6	2.5	2.9	0.25	0.28	192	177

Table 5. Pre-flooding soil sample test results for location **C**.																		
	Soil Property																	
Depth	pH		Total P		WEP		Bray P1		Olsen P		OM		Total C		Total N		Sulfate-S	
			mg/kg								%						mg/kg	
	Surface flow basin																	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
0-2.5	7.4	7.4	475	647	0.01	0.03	5	10	8	15	2.9	4.6	2.2	3.0	0.17	0.21	190	264
2.5-5	7.2	7.5	427	600	0.01	0.03	8	6	8	10	2.6	4.5	1.8	2.6	0.15	0.22	78	72
5-10	7.4	7.4	394	522	0.01	0.05	7	9	7	10	2.7	4.9	1.7	2.5	0.14	0.21	36	56
10-20	7.5	7.4	456	348	0.01	0.05	2	7	6	9	2.7	5.7	2.3	1.4	0.14	0.13	56	34
20-30	7.5	7.4	465	263	0.01	0.02	5	2	8	7	2.6	6.0	1.9	0.8	0.14	0.09	50	31
	Vertical flow basin																	
0-2.5	7.7	7.3	530	583	0.01	0.02	3	8	11	10	3.7	3.9	2.6	2.5	0.21	0.22	81	439
2.5-5	7.8	7.4	467	648	0.01	0.01	2	6	6	7	3.2	3.8	2.2	2.3	0.15	0.22	73	310
5-10	7.6	7.4	444	413	0.01	0.01	1	6	4	7	2.4	3.3	2.0	2.0	0.12	0.17	64	284
10-20	7.7	7.3	406	499	0.01	0.02	1	6	3	5	1.8	2.0	1.8	1.1	0.07	0.10	36	182
20-30	7.5	7.4	491	428	0.01	0.01	1	5	3	5	1.6	1.2	1.9	0.6	0.07	0.07	47	72
	Horizontal flow basin																	
0-2.5	7.8	7.7	604	526	0.03	0.01	20	4	16	10	4.2	3.6	2.5	2.5	0.24	0.21	10	72
2.5-5	7.6	7.6	593	520	0.02	0.01	10	3	16	8	3.9	3.5	2.5	2.5	0.22	0.20	27	68
5-10	7.5	7.6	549	537	0.03	0.01	15	2	16	6	3.9	3.4	2.5	2.5	0.25	0.21	65	59

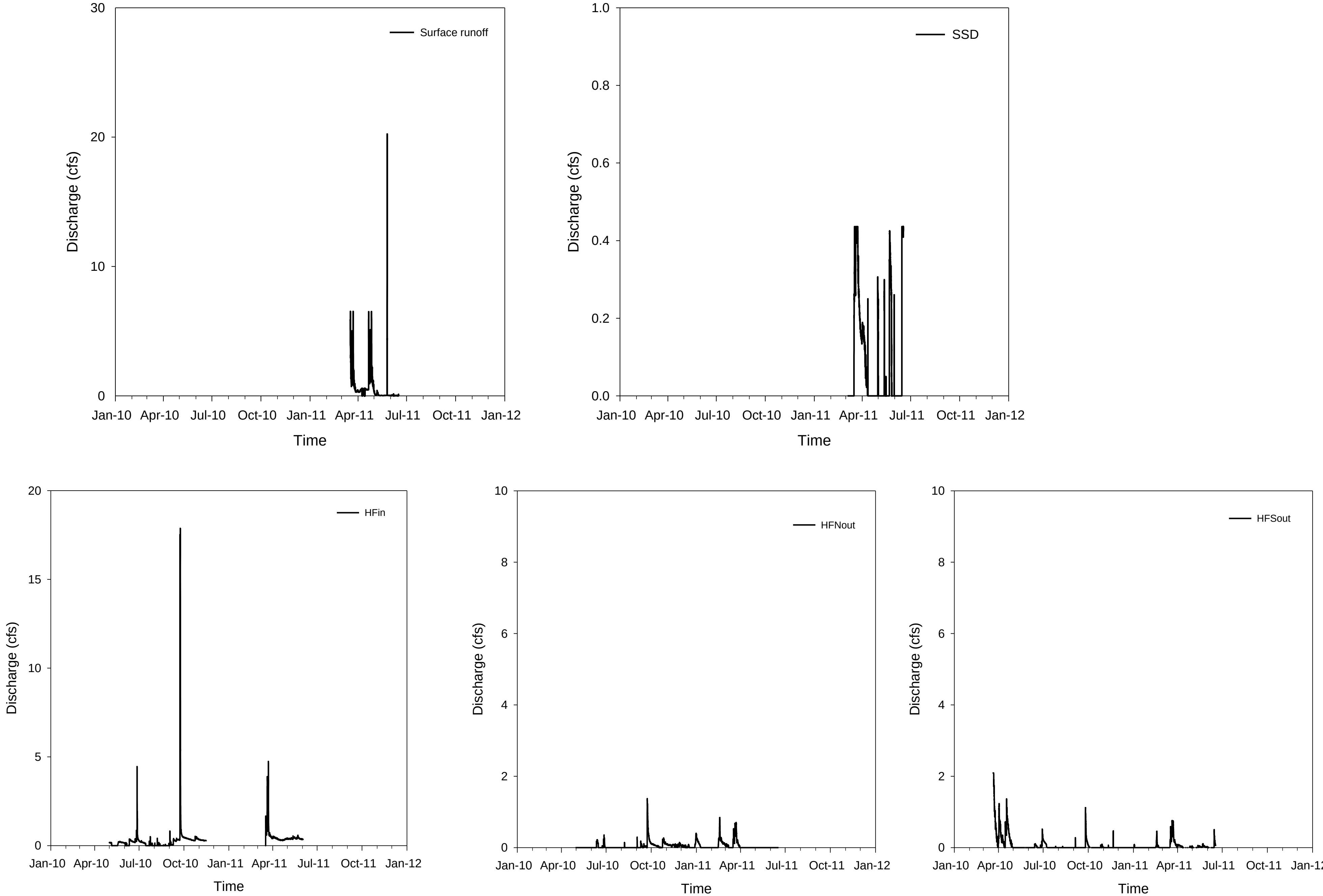
Table 6.	Pre-flooding ICP soil sample test results for location **A**.									
Chemical	Depth (cm)									
Property	0-2.5		2.5-5		5-10		10-20		20-30	
	Surface flow basin									
	1	2	1	2	1	2	1	2	1	2
Al (g kg^{-1})	12.3	14.0	12.5	19.3	10.9	20.5	14.6	14.3	15.8	13.7
B (mg kg^{-1})	12.1	18.6	12.1	24.1	11.4	26.1	17.1	21.8	20.4	25.4
Ca (g kg^{-1})	13.3	25.6	11.9	21.7	14.1	21.0	16.8	26.9	20.1	52.5
Cd (mg kg^{-1})	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Cr (mg kg^{-1})	19.1	22.1	19.0	27.9	16.6	29.6	21.7	20.7	24.0	19.8
Cu (mg kg^{-1})	11.6	11.2	11.4	11.5	11.8	11.9	12.5	11.9	12.2	10.4
Fe (g kg^{-1})	17.6	17.5	17.6	18.9	17.4	19.1	18.1	17.4	18.3	15.5
K (g kg^{-1})	2.0	2.3	1.4	2.3	1.2	2.5	1.7	1.8	1.9	1.8
Mg (g kg^{-1})	4.1	1.5	3.8	4.8	3.9	4.9	4.4	4.6	4.6	4.8
Mn (mg kg^{-1})	598	530	627	551	693	537	592	567	625	505
Na (mg kg^{-1})	212	221	240	349	131	594	266	208	521	176
Ni (mg kg^{-1})	22.5	23.4	21.6	21.9	22.6	24.4	21.6	21.3	21.8	19.8
P (mg kg^{-1})	576	614	552	609	615	631	664	735	719	722
Pb (mg kg^{-1})	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1
Zn (mg kg^{-1})	50.2	50.6	48.1	51.9	47.8	53.4	51.8	51.7	51.6	45.2
	Vertical flow basin									
Al (g kg^{-1})	14.2	9.06	8.8	11.2	9.06	11.7	12.8	17.8	8.3	18.1
B (mg kg^{-1})	24.2	16.7	18.5	19.6	18.6	20.6	23.4	28.6	16.5	30.0
Ca (g kg^{-1})	35.5	41.4	30.5	42.0	30.2	45.3	37.4	38.3	57.8	31.3
Cd (mg kg^{-1})	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Cr (mg kg^{-1})	21.8	14.2	13.3	18.3	13.3	18.9	18.9	26.3	12.5	27.1
Cu (mg kg^{-1})	13.4	11.2	11.9	11.3	11.6	10.5	11.2	11.9	9.4	12.4
Fe (g kg^{-1})	17.7	14.4	14.0	16.0	14.6	16.1	16.5	19.0	13.9	18.9
K (g kg^{-1})	2.5	1.8	1.8	4.6	1.9	4.3	2.6	4.7	2.6	4.9
Mg (g kg^{-1})	6.1	4.9	4.6	5.6	4.3	6.1	4.7	5.7	4.9	4.8
Mn (mg kg^{-1})	543	568	694	514	608	531	712	580	574	550
Na (mg kg^{-1})	600	147	198	177	206	180	316	367	229	368
Ni (mg kg^{-1})	21.8	22.1	23.1	21.3	20.7	22.5	23.2	23.5	19.0	22.1
P (mg kg^{-1})	653	637	709	586	687	608	682	635	523	700
Pb (mg kg^{-1})	22.8	14.1	16	14.1	14.1	14.1	14.1	14.1	14.1	14.1
Zn (mg kg^{-1})	147.4	45.3	44.8	44.3	43.8	45.3	49.0	53.0	39.7	55.4
	Horizontal flow basin									
Al (g kg^{-1})	11.0	9.4	12.6	10.3	11.0	15.3	-	-	-	-
B (mg kg^{-1})	12.6	10.2	14.5	11.6	11.4	18.1	-	-	-	-
Ca (g kg^{-1})	17.8	22.6	15.7	28.7	16.7	26.4	-	-	-	-
Cd (mg kg^{-1})	0.88	0.88	0.88	0.88	0.88	0.88	-	-	-	-
Cr (mg kg^{-1})	17.7	14.4	19.7	15.4	17.1	22.8	-	-	-	-
Cu (mg kg^{-1})	12.0	10.7	12.1	10.5	12.1	11.1	-	-	-	-
Fe (g kg^{-1})	18.0	15.0	17.6	15.0	17.2	17.3	-	-	-	-
K (g kg^{-1})	1.6	1.4	1.7	1.5	1.5	2.1	-	-	-	-
Mg (g kg^{-1})	3.6	3.4	3.7	3.5	3.5	4.1	-	-	-	-
Mn (mg kg^{-1})	562	558	629	496	626	520	-	-	-	-
Na (mg kg^{-1})	199	152	231	225	206	212	-	-	-	-
Ni (mg kg^{-1})	20.9	19.0	23.4	17.7	21.2	20.0	-	-	-	-
P (g kg^{-1})	697	642	587	582	559	631	-	-	-	-
Pb (mg kg^{-1})	14.1	14.1	14.1	14.1	14.5	14.1	-	-	-	-
Zn (mg kg^{-1})	49.4	45.0	50.5	43.9	48.8	47.1	-	-	-	-

Table 7. Pre-flooding ICP soil sample test results for location **B**.										
Chemical	Depth (cm)									
Property	0-2.5		2.5-5		5-10		10-20		20-30	
	Surface flow basin									
	1	2	1	2	1	2	1	2	1	2
Al (g kg^{-1})	9.1	16.0	11.8	12.1	11.6	18.0	10.7	9.9	7.6	6.8
B (mg kg^{-1})	10.1	20.0	11.3	14.2	12.3	20.6	11.6	14.4	10.0	12.6
Ca (g kg^{-1})	22.9	29.5	18.3	27.2	22.6	34.9	29.6	48.2	30.3	68.0
Cd (mg kg^{-1})	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Cr (mg kg^{-1})	14.8	24.5	19.0	18.7	18.4	27.9	18.0	17.3	12.9	13.8
Cu (mg kg^{-1})	9.0	12.0	9.6	10.8	9.4	11.1	9.4	10.1	9.0	30.4
Fe (g kg^{-1})	16.6	19.5	17.6	17.7	17.4	19.2	16.6	17.5	18.3	17.2
K (g kg^{-1})	0.9	1.8	1.3	4.2	1.9	4.3	1.0	4.9	0.8	0.6
Mg (g kg^{-1})	5.2	5.4	4.2	5.3	4.3	7.7	4.9	9.0	5.5	12.4
Mn (mg kg^{-1})	596	592	547	681	730	554	758	927	507	593
Na (mg kg^{-1})	213	374	361	233	405	908	422	251	193	364
Ni (mg kg^{-1})	23.8	26.5	22.5	26.2	26.6	26.6	27.5	26.1	24.4	31.1
P (mg kg^{-1})	428	556	436	526	426	504	438	516	450	577
Pb (mg kg^{-1})	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	175.6
Zn (mg kg^{-1})	41.7	59.4	45.6	48.1	45.4	49.2	42.7	38.7	39.8	460.3
	Vertical flow basin									
Al (g kg^{-1})	7.3	16.1	8.3	9.1	9.5	9.8	9.4	11.9	11.8	14.5
B (mg kg^{-1})	13.3	22.5	14.7	12.8	15.2	14.8	15.4	10.4	19.4	3.4
Ca (g kg^{-1})	40.2	19.2	41.9	22.4	43.1	24.4	45.7	15.2	59.3	18.2
Cd (mg kg^{-1})	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Cr (mg kg^{-1})	12.0	25.0	12.9	15.1	14.8	15.5	15.4	18.0	19.2	24.0
Cu (mg kg^{-1})	8.8	11.7	8.8	11.5	8.9	11.1	8.3	12.0	8.3	13.1
Fe (g kg^{-1})	12.2	20.6	13.1	16.5	13.8	18.8	13.8	18.9	14.3	31.1
K (g kg^{-1})	1.1	2.2	1.0	1.2	1.1	1.3	1.1	1.4	1.5	9.2
Mg (g kg^{-1})	5.9	5.2	6.1	4.9	5.8	4.7	5.7	3.8	6.7	4.8
Mn (mg kg^{-1})	345	681	350	437	388	773	276	500	314	815
Na (mg kg^{-1})	160	335	183	206	248	197	227	207	228	659
Ni (mg kg^{-1})	16.8	26.9	18.0	22.4	19.5	25.9	17.3	23.5	19.7	32.8
P (mg kg^{-1})	530	463	504	473	485	530	490	397	488	366
Pb (mg kg^{-1})	14.1	14.1	14.1	14.1	14.1	15.9	14.1	15.3	14.1	19.1
Zn (mg kg^{-1})	35.5	54.4	36.8	45.6	37.6	44.9	36.3	51.8	35.9	80.7
	Horizontal flow basin									
Al (g kg^{-1})	14.3	15.1	13.7	12.9	9.9	11.6	-	-	-	-
B (mg kg^{-1})	15.7	18.5	14.4	14.5	10.4	12.4	-	-	-	-
Ca (g kg^{-1})	15.3	22.8	16.7	25.1	15.8	22.9	-	-	-	-
Cd (mg kg^{-1})	0.88	0.88	0.88	0.88	0.88	0.88	-	-	-	-
Cr (mg kg^{-1})	21.8	22.1	20.3	19.8	15.1	18.1	-	-	-	-
Cu (mg kg^{-1})	12.5	10.7	11.9	10.6	11.3	10.5	-	-	-	-
Fe (g kg^{-1})	19.0	17.3	18.5	16.5	16.3	15.7	-	-	-	-
K (g kg^{-1})	2.0	2.1	1.8	1.8	1.3	1.6	-	-	-	-
Mg (g kg^{-1})	3.8	3.9	3.7	3.8	3.2	3.6	-	-	-	-
Mn (mg kg^{-1})	600	480	573	516	534	517	-	-	-	-
Na (mg kg^{-1})	279	216	205	323	198	231	-	-	-	-
Ni (mg kg^{-1})	21.6	18.6	21.5	19.0	19.4	17.2	-	-	-	-
P (g kg^{-1})	601	587	611	577	561	563	-	-	-	-
Pb (mg kg^{-1})	14.1	14.1	14.1	14.9	14.1	14.1	-	-	-	-
Zn (mg kg^{-1})	53.4	46.6	49.9	44.7	44.4	44.0	-	-	-	-

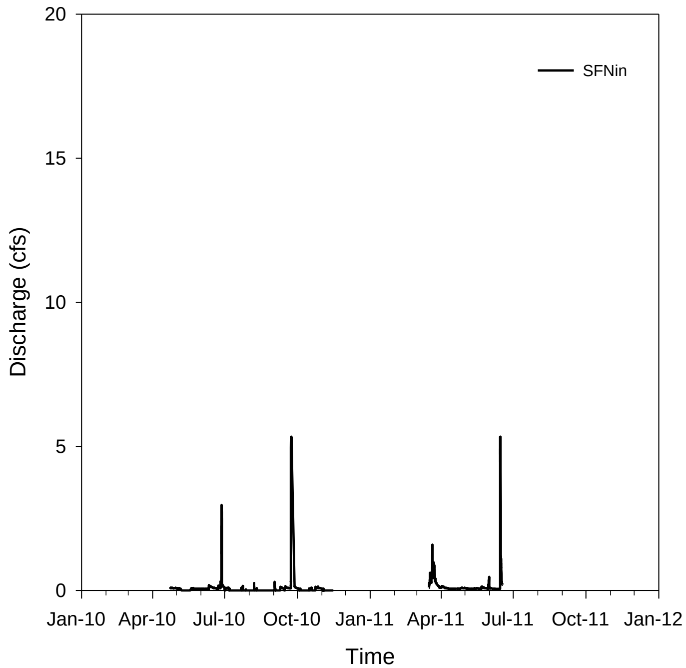
Table 8. Pre-flooding ICP soil sample test results for location **C**.										
Chemical	Depth (cm)									
Property	0-2.5		2.5-5		5-10		10-20		20-30	
	Surface flow basin									
	1	2	1	2	1	2	1	2	1	2
Al (g kg^{-1})	10.9	15.6	9.4	13.0	9.2	9.7	13.7	16.7	16.5	10.6
B (mg kg^{-1})	11.2	16.7	8.0	11.9	8.0	8.6	13.8	12.1	15.4	8.0
Ca (g kg^{-1})	19.7	21.2	15.3	12.0	14.0	11.6	23.0	8.2	35.8	11.4
Cd (mg kg^{-1})	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Cr (mg kg^{-1})	16.8	25.5	14.5	19.9	13.9	14.1	21.5	24.1	23.5	14.8
Cu (mg kg^{-1})	12.4	16.1	10.2	12.9	9.4	18.2	10.1	11.2	9.9	11.2
Fe (g kg^{-1})	19.7	23.2	17.5	19.3	17.3	16.0	17.8	17.3	18.3	14.4
K (g kg^{-1})	1.2	2.0	0.93	1.5	0.87	1.1	1.5	2.0	2.0	1.6
Mg (g kg^{-1})	4.7	6.2	3.9	4.5	3.5	3.8	4.9	3.6	5.3	3.0
Mn (mg kg^{-1})	751	589	574	581	697	533	597	305	532	189
Na (mg kg^{-1})	217	263	131	168	123	124	349	925	368	212
Ni (mg kg^{-1})	26.9	26.1	25.1	23.3	23.9	22.3	23.5	18.3	25.1	17.4
P (mg kg^{-1})	475	647	427	600	394	522	456	348	465	263
Pb (mg kg^{-1})	14.1	14.1	14.1	14.1	14.1	29.1	14.1	17.6	14.1	110.3
Zn (mg kg^{-1})	50.6	65.2	44.4	53.4	43.6	215.9	46.2	68.6	46.2	82.6
	Vertical flow basin									
Al (g kg^{-1})	10.5	8.4	12.9	8.1	15.1	6.7	7.7	10.2	7.3	11.6
B (mg kg^{-1})	15.4	11.6	17.9	11.5	20.4	5.5	11.6	12.6	13.5	14.3
Ca (g kg^{-1})	21.1	29.0	23.3	28.0	31.6	10.3	30.0	21.7	45.6	7.8
Cd (mg kg^{-1})	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Cr (mg kg^{-1})	17.1	13.4	20.4	13.0	23.3	11.8	12.9	16.9	12.9	21.8
Cu (mg kg^{-1})	10.8	11.6	9.9	11.7	9.2	9.9	8.0	10.8	8.3	9.8
Fe (g kg^{-1})	16.7	14.9	17.9	14.3	17.2	17.9	14.7	16.6	14.0	22.3
K (g kg^{-1})	1.5	1.3	1.6	1.3	1.8	0.80	0.88	1.4	9.5	1.5
Mg (g kg^{-1})	4.5	4.5	4.8	4.2	6.6	3.3	5.5	4.0	7.9	3.8
Mn (mg kg^{-1})	521	375	1059	431	920	1029	627	645	1045	603
Na (mg kg^{-1})	194	272	232	253	434	154	205	315	200	444
Ni (mg kg^{-1})	20.4	20.6	28.3	21.5	26.6	27.2	19.7	23.3	23.0	23.1
P (mg kg^{-1})	530	583	467	648	444	413	406	499	491	428
Pb (mg kg^{-1})	14.1	15.1	14.1	14.1	14.1	14.1	14.1	15.4	14.1	14.1
Zn (mg kg^{-1})	43.5	42.5	43.8	41.1	40.9	37.8	34.9	43.7	33.3	40.6
	Horizontal flow basin									
Al (g kg^{-1})	13.3	11.5	13.0	11.4	11.0	16.3	-	-	-	-
B (mg kg^{-1})	14.5	12.1	12.7	11.2	9.0	18.0	-	-	-	-
Ca (g kg^{-1})	20.4	26.5	15.2	27.6	14.0	29.0	-	-	-	-
Cd (mg kg^{-1})	0.88	0.88	0.88	0.88	0.88	0.88	-	-	-	-
Cr (mg kg^{-1})	20.9	17.5	20.5	18.0	16.9	25.0	-	-	-	-
Cu (mg kg^{-1})	11.9	10.6	12.2	10.5	10.9	11.0	-	-	-	-
Fe (g kg^{-1})	18.7	16.3	19.1	16.4	17.0	19.2	-	-	-	-
K (g kg^{-1})	`1.8	15.2	17.0	14.8	14.1	21.4	-	-	-	-
Mg (g kg^{-1})	4.3	4.8	3.8	4.8	3.3	5.8	-	-	-	-
Mn (mg kg^{-1})	548	509	602	465	527	629	-	-	-	-
Na (mg kg^{-1})	286	206	176	295	108	333	-	-	-	-
Ni (mg kg^{-1})	21.7	20.5	22.2	19.5	19.8	22.9	-	-	-	-
P (g kg^{-1})	604	526	593	520	549	537	-	-	-	-
Pb (mg kg^{-1})	14.1	14.1	14.1	14.1	14.1	17.1	-	-	-	-
Zn (mg kg^{-1})	50.8	47.2	51.0	45.3	46.5	49.3	-	-	-	-

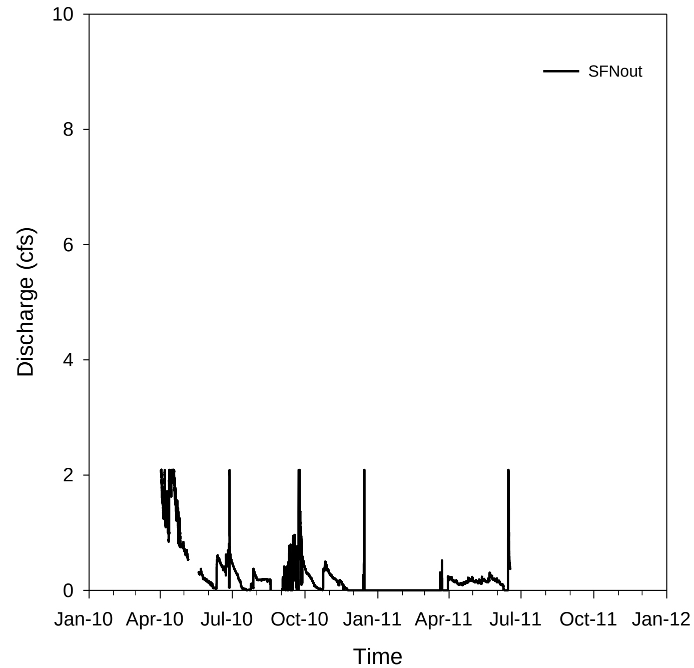
Table 9. Departure of inlet flume approach sections from planned elevation.			
Design	Actual elevation (ft)	†Difference (ft)	Final elevation
Large approach sections			
Horizontal	1109.44	-0.06 (-0.72)	1109.63
Vertical	1109.48	-0.02 (-0.24)	1109.63
Surface	1109.63	+0.12 (+1.44)	1109.63
Small approach sections			
Vertical			
North	1009.13	-0.09 (-1.08)	1109.22
South	1109.11	-0.11 (-1.32)	1109.22
Surface			
North	1109.22	baseline	1109.22
South	1109.19	-0.03 (-0.36)	1109.22
† Quantity in parenthesis is the difference in inches.			

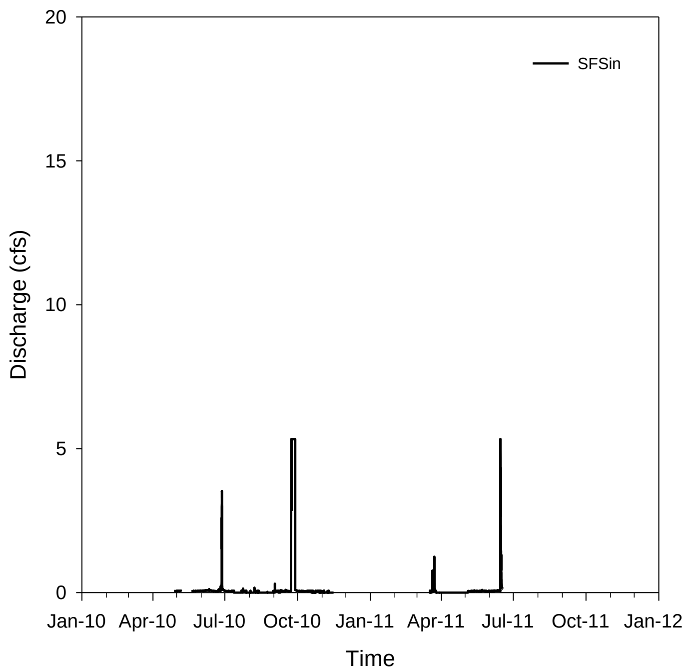
Table 10. Flow and preliminary nutrient load summary.						
Location	Flow	Total P	DMRP	Total N	Ammonium	Nitrate
	cm	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha
				2010		
Inlets						
HFin	27	0.21	0.16	69	0.6	30
VFNin	7	0.15	0.10	56	0.4	38
VFSin	2	0.81	0.39	48	0.6	27
SFNin	9	0.41	0.23	41	0.6	25
SFSin	6	0.67	0.36	42	0.5	31
Outlets						
HFNout	5	0.09	0.08	13	0.05	8
HFSout	2	0.11	0.08	10	0.1	5
VFNout	37	0.08	0.05	26	0.05	17
VFSout	17	0.30	0.18	21	0.08	14
SFNout	26	0.26	0.09	18	<0.01	11
SFSout	11	0.41	0.17	16	0.01	13
				2011		
Inlets						
SRO	21	0.25	0.13	31	0.22	15
SSD	7	0.01	0.01	9	0.13	14
HFin	20	0.08	0.1	74	0.5	41
VFNin	21	0.04	0.06	74	0.5	52
VFSin	10	0.2	1.02	38	2.6	18
SFNin	9	0.01	0.4	23	1.6	16
SFSin	4	-	-	-	-	-
Outlets						
HFNout	2	-	-	-	-	-
HFSout	3	0.03	<0.01	11	0.06	6
VFNout	9	0.01	0.01	28	0.3	20
VFSout	17	0.12	0.27	32	1.0	18
SFNout	8	0.02	0.02	15	0.2	13
SFSout	8	0.04	0.03	17	0.1	10

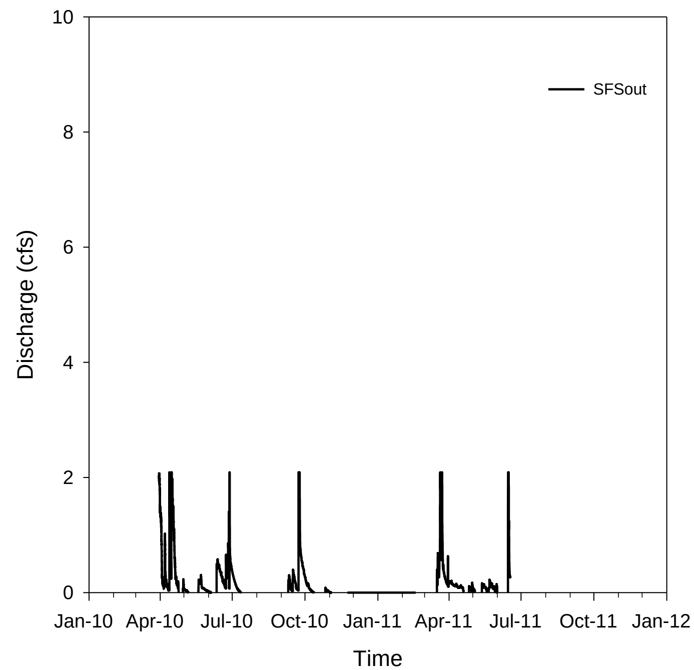


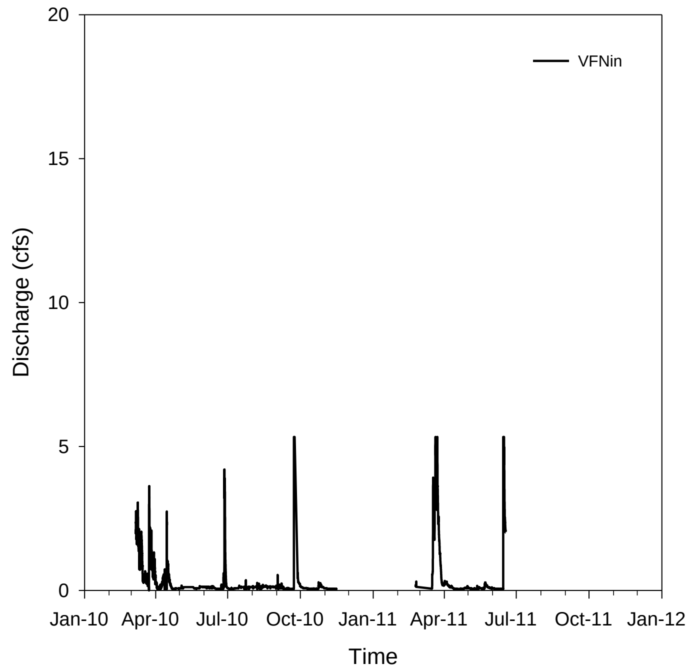
Surface runoff
SSD
HFin
HFNout
HFSout
Discharge (cfs)
Time
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12


SFNin
Discharge (cfs)
20
15
10
5
0
Jan-10 Apr-10 Jul-10 Oct-10 Jan-11 Apr-11 Jul-11 Oct-11 Jan-12
Time

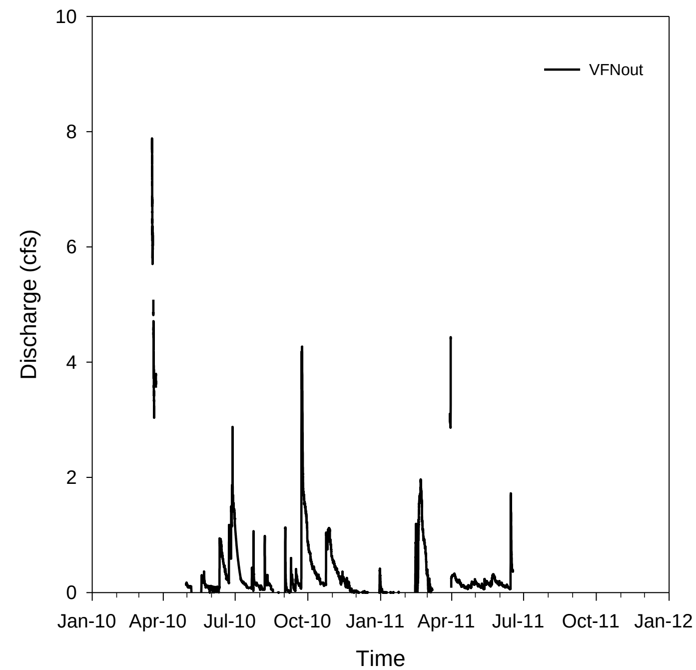

SFNout
Discharge (cfs)
10
8
6
4
2
0
Jan-10 Apr-10 Jul-10 Oct-10 Jan-11 Apr-11 Jul-11 Oct-11 Jan-12
Time


SFSin
Discharge (cfs)
20
15
10
5
0
Jan-10 Apr-10 Jul-10 Oct-10 Jan-11 Apr-11 Jul-11 Oct-11 Jan-12
Time

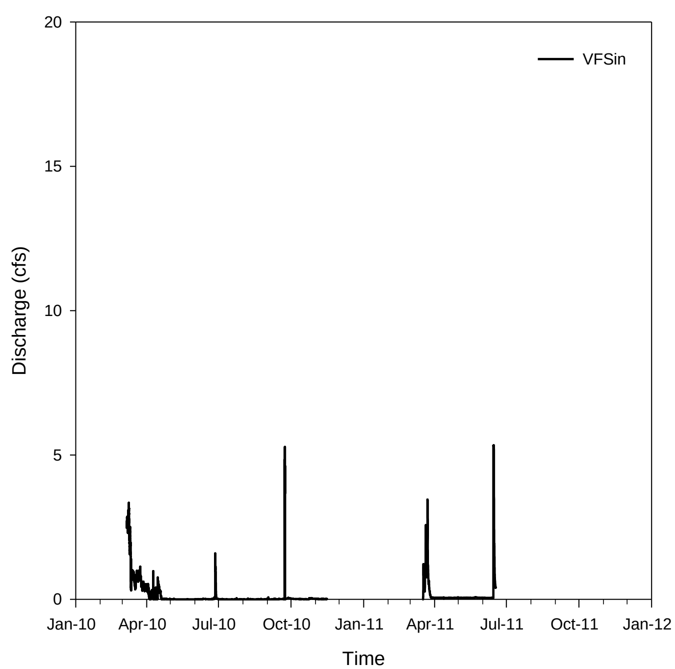

SFSout
Discharge (cfs)
10
8
6
4
2
0
Jan-10 Apr-10 Jul-10 Oct-10 Jan-11 Apr-11 Jul-11 Oct-11 Jan-12
Time



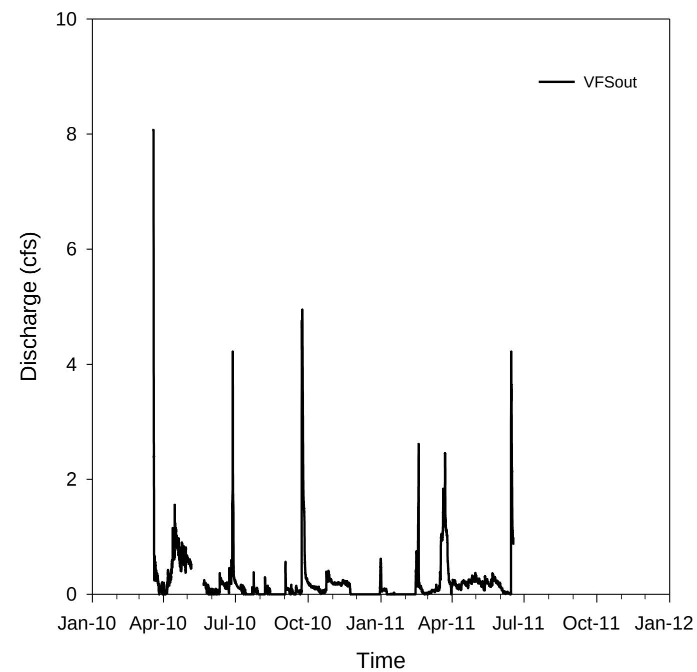
VFNin
Discharge (cfs)
Time
20
15
10
5
0
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12



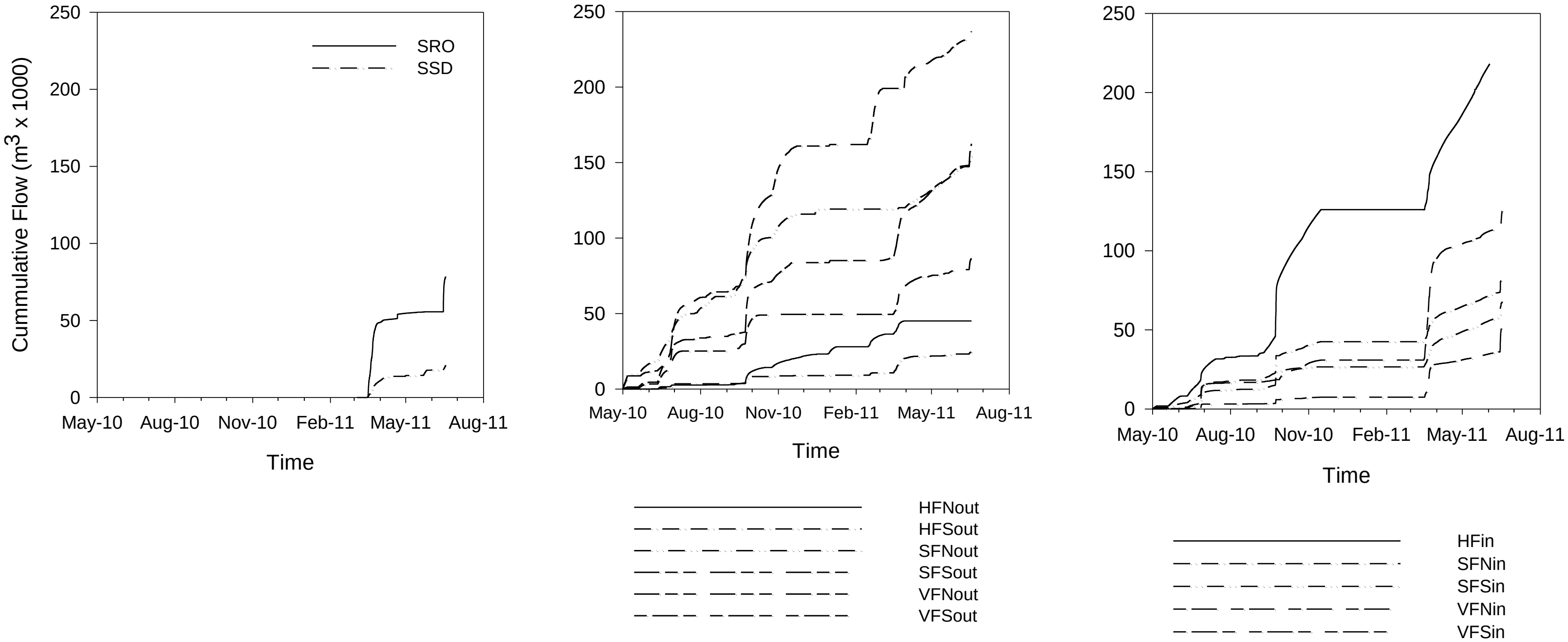
VFNout
Discharge (cfs)
Time
10
8
6
4
2
0
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12



VFSin
Discharge (cfs)
Time
20
15
10
5
0
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12



VFSout
Discharge (cfs)
Time
10
8
6
4
2
0
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12



Cummulative Flow (m3 x 1000)
250
200
150
100
50
0
May-10
Aug-10
Nov-10
Feb-11
May-11
Aug-11
Time
SRO
SSD
HFNout
HFSout
SFNout
SFSout
VFNout
VFSout
HFin
SFNin
SFSin
VFNin
VFSin