Martin Slough Enhancement Project
2020 Monitoring Report

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TABLE OF CONTENTS

INTRODUCTION

This report summarizes the 2020 monitoring efforts for the Martin Slough Enhancement Project. This report was prepared by the Natural Resources Services division of the Redwood Community Action Agency (RCAA) in fulfillment of permit and agency requirements, and in accordance with the Martin Slough Monitoring Plan. This report focuses on *post-construction* monitoring for phase 2 (year 2) and phase 3 (year 1) of the Project (see Table 1).

Background

Martin Slough is part of the Elk River watershed, which is part of the larger Humboldt Bay ecosystem. Martin Slough has been identified by the California Department of Fish and Wildlife as playing a key role in the life cycle of coho salmon (*Oncorhynchus kisutch*), providing ideal rearing habitat for juvenile coho; it also provides critical habitat for the endangered tidewater goby (*Eucyclogobius newberryi*). In 2006 the Elk River watershed, including Martin Slough, was listed under the Clean Water Act as impaired for sediment and siltation, citing impaired water quality, impaired spawning habitat, and increased depth of flooding due to sediment. The Martin Slough project site is diked-former-tideland that has been degraded by past management practices, including draining the former tidal wetland by excavating straight-line channels, removing the riparian vegetation, and installing dikes and tide gates at the confluence of Martin Slough and Swain Slough. The exclusion of the tide resulted in losing the sediment transport benefits and natural fluvial geomorphic process that maintained the tidal wetlands and the channel capacity. In response to these stressors, the Martin Slough Enhancement Project was developed with the goal of enhancing fish habitat for endangered coho salmon and reducing the extent and duration of flooding.

The project area encompasses two properties – 40 acres of pasture owned by the Northcoast Regional Land Trust (NRLT) and 120 acres upstream of the NRLT property owned by the City of Eureka and operated as the Eureka Municipal Golf Course. The project was initiated in 2001 when RCAA and partners began preparing a feasibility study, which was completed in 2006. Between 2007 and 2014, RCAA contracted with Michael Love & Associates (MLA) and GHD, Inc., to develop designs for a new tide gate at the confluence of Martin Slough and Swain Slough, along with enhancements to the slough channel, new tidal marshes, and off-channel brackish and freshwater ponds. The tide gate replacement was completed in 2014, and enhancement work on the NRLT property was completed in 2019. Enhancement on the Golf Course began in 2019, and is estimated to be completed in 2021 (see Table 1).

Project Purpose

The purpose of the Martin Slough Enhancement Project is to improve aquatic and riparian habitat and reduce flooding of pasture and golf course greens throughout the project area. Specific goals of the project include the following:

1. Improve fish access from Swain Slough into Martin Slough,
2. Reduce flood impacts to current land use,
3. Improve sediment transport,
4. Increase the amount of riparian corridor and riparian canopy,

5. Improve water quality (increased circulation, decrease nutrient inputs, decrease sedimentation),
6. Increase the extent of the estuarine ecotone in Martin Slough, providing a gradual transition from brackish water to freshwater habitats, and
7. Enhance and create low-velocity off-channel/backwater habitats.

Project Phasing

The Martin Slough Enhancement Project was developed to be implemented in five phases. Table 1 outlines each phase, along with the completion status. Monitoring begins for each phase once construction has been completed, and continues for five years post-construction, depending on availability of funding.

Table 1. Project Phasing

	Action	**Status**
Phase 1	Replace 3 outdated tides gates on Martin Slough at the confluence with Swain Slough with two 6'x6' side hinged gates, one 6'x6' top hinged gate, and a 2'x2' auxiliary gate – fitted with muted tide regulators that allow for a muted tide into Martin Slough	Completed 2014
Phase 2	Enlarge Martin Slough channel throughout NRLT property, build Marshplains A and B and Pond C, realign SE tributary and construct a freshwater pond, replace two culvert crossings and install an agriculture bridge	Completed 2018
Phase 3	Enlarge Martin Slough channel on the lower Eureka golf course up to the east tributary, enhance Pond D, remove undersize culvert, and install new access bridge	Completed 2019
Phase 4	Enlarge Martin Slough channel up to the North Fork confluence, enhance Pond E and construct Pond F, and replace bridges	Completed 2020
Phase 5	Enlarge remainder of the upper Martin Slough channel and the north fork, construct Pond G, install temporary salinity barrier	Anticipated completion 2021

MONITORING OVERVIEW

Purpose

The essential purpose of monitoring activities is to raise a warning flag if the project's enhancement components or the current course of management actions are not working so that corrective actions and adaptive management may be applied while cost-effective and time sensitive solutions are still available. Conversely, good monitoring can also demonstrate that the current design and management approaches are working and provide evidence for the continuation of current management. In addition, implementation of the Monitoring Plan will demonstrate ongoing permit compliance and, it is anticipated, a trajectory of incremental project

success as the project meets various annual performance criteria described in the Plan, which cumulatively lead to attaining final success criteria. Finally, the results of thorough project evaluation through implementation of this Plan will help this project to provide information about sound design or flaws, effective or ineffective management techniques to other projects, land managers, restoration designers, and practitioners conducting similar estuarine restoration efforts in and around Humboldt Bay.

Parameters

Five general post-construction parameters (topography, hydrology, water quality, vegetation, and fisheries) are outlined in the Martin Slough Monitoring Plan. These parameters are directly linked to individual long-term objectives established for the project and will provide a multi-parameter basis for evaluating the final success of the project. These five parameters were selected to ensure that overlapping structural and functional components assessing both physical and biological characteristics of the site will be measured to evaluate project success.

This report covers post-construction monitoring for Phases 2 and 3, and addresses all five parameters: fisheries, topography, hydrology, water quality, and vegetation. While there is a brief update on topography, no topographic monitoring took place in 2020. Post-construction monitoring was conducted according to the Martin Slough Monitoring Plan and to all project permits.

Performance and Success Criteria

Performance criteria are annual qualitative and quantitative benchmarks against which project progress will be tracked. The final success criteria will be used to determine if the project has substantially met its individual and overall objectives within the five (5) year monitoring period. Attainment of the final success criteria will indicate that the project is trending toward meeting the long-term habitat goals with little chance of failure. While overall monitoring will continue for a five-year period, if final success criteria are reached for a particular parameter in less than five years, monitoring of that parameter may be discontinued or reduced in scope and frequency.

There are separate annual performance and final success criteria for each parameter and a correlating monitoring method and schedule. Specific performance and final success criteria are listed for each parameter in Table 2.

Table 2. Topographic, hydrologic, water quality, fisheries and vegetation monitoring parameters, schedule, performance and success criteria.

Parameters	Type of Monitoring	Frequency	Schedule	Performance Criteria	Success Criteria	Remedial Actions
Topographic	Repeat surveys longitudinal channel profiles of mainstem Martin Slough and cross section of slough channels, marshplains, and ponds	Collected in Years 1, 3 and 5	Once during the year	- No high points in mainstem thalweg profile that restrict drainage of ebb tides - Less than 10 percent net change in cross sectional area below design MHHW of 5.5 feet (NAVD88) at all cross sections	- No high points in mainstem thalweg profile that restrict drainage of ebb tides - Less than 20 percent net change in cross sectional areas below design MHHW of 5.5 feet (NAVD88) at all cross sections within project after 5 years.	- Evaluate causes of excess aggradation or scour (i..e. tidal prism) and address root causes. - Identify cause of high points. Actions may include channel excavation or changes to tidal prism.
Hydrologic	Data logger used for continuous recording of water levels in Swain Slough and Martin Slough	Download approx. every six weeks	Continuous through period where MTR is being adjusted, or if funding is available, through the end of Year 5 after last phase completed	Muted high tides sufficient during growing season to inundate constructed marshplains		Adjust 6'x6' MTR gate and Auxiliary MTR gate to increase time gate is open
				Tide gate duration open ≥ 35% (not including aux. door), assumes muted tide is only through auxiliary MTR gate	Tide gate duration open ≥ 50% (not including aux. door)	
				Summer MLLW in Martin Slough > 2.0 ft (NAVD88)		Identify potential high points or channel aggradation. Actions may include channel excavation or changes to tidal prism.

Parameters	Type of Monitoring	Frequency	Schedule	Performance Criteria	Success Criteria	Remedial Actions
Water Quality	Surface and bottom salinity and temp. meters placed at the 3 Martin Slough water level monitoring stations. Spot meas. Of DO, salinity and temp. during downloads. Additional spot meas. w/fisheries monitoring.	Continuous, download approx. every six weeks	Year round through Year 5 following final phase of implementation, as funding allows	- Avg. daily water temperature $\leq$ 18ºC during expected salmonid period of usage - Max. daily water temp $\leq$ 21 ºC during expected salmonid period of usage - Pond G and SE Trib Pond during expected salmonid period of usage: DO $\geq$ 4 ppm, and salinity $\leq$ 4 ppt		- Adaptive management: meet and discuss water quality data with fisheries biologists and agency staff. Depending on these discussion, some possible actions could include: - Increase circulation through MTR gate adjustments - Increase riparian vegetation for shading to cool water and reduce aquatic vegetation growth - Modify inlet/outlet of ponds to increase circulation.
Fisheries	**Salmonids**: Seining and deployment of baited minnow traps at selected locations consisting of varying habitat types (pond vs channel) and longitudinal locations with the project	Approximately once per month during expected salmonid period of usage, as funding allows	Post-construction for 3 years, or up to 8 years as funding allows	Annual average net increase of 50% over pre-project coho salmon numbers (combined total for juvenile young-of-the-year and one-year old fish) monitored by CDFW	Annual average net increase of 50% over pre-project coho salmon numbers (combined total for juvenile young-of-the-year and one-year old fish) monitored by CDFW	None – uncontrollable variables (ocean conditions, run size) can affect numbers; this is a continuation of CDFW's monitoring
	Tidewater goby: Seining	In conjunction with salmonid sampling	Post-construction for 5 years, as funding allows	Presence in new terminal ponds at upper end of new slough channels	Presence in new terminal ponds at upper end of new slough channels	None – uncontrollable variables affect tidewater goby distribution including predation by birds and fish.
Vegetation	Plant survival and species composition	Years 2 and 5. Contingency Years 3 and 4	Spring/summer	Success criteria shown in Table 4 of Monitoring Plan	Success criteria shown in Table 4 of Monitoring Plan	Replant, re-seed until criteria met; mechanically or manually remove invasive plants within revegetated areas of the Project

MONITORING RESULTS

Fisheries

Overview

The objective of fisheries monitoring in Martin Slough is to document the presence/absence of target fish species in different habitats; specifically, the presence/absence of target fish species in aquatic habitat re-established or enhanced as part of the project.

In 2020, monitoring occurred in eleven locations throughout the project area (Figure 1). On the NRLT property, monitoring took place at Pond C, Pond C Terminal Channel, Southeast (SE) Tributary, Southeast (SE) Tributary Pond, and the Oxbow. On the Eureka Golf Course property, monitoring took place at Pond D, East Tributary Step Pools, Pond E, Pond E Channel (this monitoring site discontinued after 2020 construction), Pond F and Upper Fairway Drive Pool. Monitoring occurred in January, February, March, April, May, October, and December, although not all sites were monitored each month. For example, monitoring in Pond F (which was constructed over the 2020 construction season) began in October (see Table 5 for details on monitoring locations and dates). Water quality monitoring occurred during each monitoring event (Appendix C).

Monitoring was conducted by fisheries biologist Ross Taylor & Associates (RTA) and HSU fisheries department graduate student Josh Cahill. Due to the Covid-19 pandemic, shelter-in-place protocols and social distancing guidelines, Cahill was only able to monitor in January, February and October.

Methods

Fisheries monitoring was conducted primarily with baited minnow traps and a variety of seine nets (including 10-foot, 30-foot, 80-foot and 100-foot nets). Seine nets were set by 1-3 crew members, with 1-3 consecutive seine hauls conducted at each location. The method varied slightly depending on the site (e.g. to accommodate very narrow channels). Fish from each haul were kept separated and placed in aerated 5-gallon buckets prior to processing.

The minnow traps were fished at each site on the bottom of the channel next to habitat structures where possible. Soak time of individual traps ranged from 30 to 180 minutes.

Salmonids captured by seine or minnow traps were anesthetized using Alka Seltzer Gold in order to safely handle them. The lowest concentration of sodium bicarbonate that permitted safe handling was used and ranged from 1 to 2 tablets per gallon of fresh river water depending on fish size and water temperature. The bicarbonate material was allowed to completely dissolve before fish were added to the anesthetic bath. Salmonids were usually able to be handled after 1-2 minutes in the anesthetic bath and were processed immediately following loss of equilibrium. Fish were then allowed to recover in 5-gallon buckets of aerated fresh river water until normal behavior was observed. Water temperature in the recovery bucket was monitored and maintained to be within 2°C of the ambient river temperature. Fish were released to slow water habitat in the location in which they were originally found.

Figure 1. Monitoring Locations in Martin Slough

All of the fish were measured for fork length and weighed. While anesthetized, juveniles were individually placed onto a wetted Plexiglas measuring board and measured to the nearest mm fork length, then transferred to a wetted container on an electronic scale and individually weighed to the nearest 0.01 g.

All fish were scanned for passive integrated transponder (PIT) tags. Anesthetized fish greater than or equal to 70-mm fork length were implanted with 12-mm PIT tags or smaller, fish 60-mm FL to 69-mm FL were implanted with 9-mm PIT tags or smaller, and fish <60-mm were not tagged. A full duplex PIT tag was surgically implanted into the body cavity of the fish; a small

incision was made with a sterile scalpel anterior to the pectoral fin and the tag was inserted by hand.

Water quality measurements were taken with YSI handheld meters. Water quality parameters measured include dissolved oxygen, temperature, and salinity (see Appendix C).

Results

Fisheries monitoring in 2020 resulted in the catch of 217 coho and 3,666 tidewater goby. Table 4 shows the total salmonid and goby catch by month for the 2020 monitoring season. The majority of salmonids were found in Pond D and Pond E, from January through April (Tables 4 and 5). No salmonids were injured or killed during monitoring in 2020.

Table 3. Salmonid and Goby Catch by Month in 2020 in Martin Slough

MONTH	Tidewater Goby	Juvenile Coho Salmon	Coastal Cutthroat Trout	Steelhead
January	372	59	0	0
February	531	111	1	0
March	10	4	0	0
April	595	41	0	0
May	114	2	0	0
October	1760	0	0	0
December	284	0	0	0
TOTALS FOR 2020 MONITORING	**3666**	**217**	**1**	**0**

Other species caught during monitoring include three-spine stickleback, staghorn sculpin, juvenile smelt, California roach, red-legged frog tadpoles, Pacific Giant Salamander, rough skinned newt and jack smelt. Table 4 shows the total for each species caught during the 2020 monitoring season by month. Table 5 shows the total for each species caught during the 2020 monitoring season by day and by monitoring location. Appendix B shows the number and species of fish PIT-tagged during monitoring.

Water quality spot sampling occurred alongside each fisheries monitoring event. Monitors used a handheld YSI meter to measure for temperature, salinity and dissolved oxygen at increasing depths from the surface to the bottom of the sampling site. All water quality data from fisheries monitoring can be found in Appendix C (note: for additional water quality measurements and analysis see the Water Quality parameter section below).

Over the seven month fisheries sampling period, water temperatures ranged between a maximum of 25.7 degrees C (May) in the Pond C terminal channel and a minimum of 7.3 degrees C (February) in the SE tributary Pond. Salinity ranged from 27.2 ppt in the lower portion of the project area and 0.1 ppt in the upstream areas. Dissolved oxygen ranged from 15.9 mg/L (Pond D) to 0.8 mg/L (SE Tributary Pond) (see Appendix C).

Select photos from the 2020 fisheries monitoring effort can be found in Appendix A.

Table 4. Fisheries Monitoring Results by Month in 2020 in Martin Slough

MONTH	Tidewater Goby	Juvenile Coho Salmon	Staghorn Sculpin	Three-spine Stickleback	Sculpin *sp.*	Juvenile Smelt (sp)	Coastal Cutthroat Trout
January	372	59	5	1367	6	0	0
February	531	111	25	288	1	0	1
March	10	4	0	625	1	0	0
April	595	41	4	530	0	0	0
May	114	2	5	500	0	0	0
October	1760	0	1	1065	1	0	0
December	284	0	17	141	0	46	0
TOTALS FOR 2020 MONITORING	**3666**	**217**	**57**	**4516**	**9**	**46**	**1**

MONTH	California Roach	Surf Smelt	Red Legged Frog tadpoles	Rough skinned Newt	Pacific Giant Salamander	Fathead Minnow	Jack Smelt
January	5	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	2	0	0	0	0	0	0
April	10	0	39	11	0	0	0
May	15	0	79	0	6	0	0
October	0	0	0	0	0	1	80
December	2	0	2	0	7	0	0
TOTALS FOR 2020 MONITORING	**34**	**0**	**120**	**11**	**13**	**1**	**80**

Table 5. Fisheries Monitoring Results by Day and Location in 2020 in Martin Slough

Date	Site Name	Tidewater Goby	Juvenile Coho Salmon	Staghorn Sculpin	Three-spine Stickleback	Sculpin *sp.*	Juvenile Smelt (sp)	Coastal Cutthroat Trout
1/6/2020	Tidegate	0	0	0	2	1	0	0
1/6/2020	Pond C	38	0	0	30	3	0	0
1/6/2020	Pond C Term. Ch.	161	0	3	800	1	0	0
1/6/2020	SE Tributary	1	0	0	65	0	0	0
1/6/2020	SE Trib Pond	0	1	0	25	0	0	0
1/6/2020	Oxbow	125	0	0	300	0	0	0
1/26/2020	Upper Fairway Dr.	0	1	0	3	1	0	0
1/26/2020	Pond E	25	11	2	30	0	0	0
1/26/2020	Pond E Channel	0	0	0	0	0	0	0
1/26/2020	Pond D	0	46	0	62	0	0	0
1/26/2020	East Trib Step Pools	22	0	0	50	0	0	0
2/21/2020	Pond C	512	0	7	40	0	0	0
2/17/2020	SE Tributary	8	0	0	110	0	0	0
2/17/2020	SE Trib Pond	0	8	0	20	0	0	0
2/21/2020	Oxbow	5	0	0	5	0	0	0
2/23/2020	Upper Fairway Dr.	0	0	0	2	1	0	0
2/23/2020	Pond E	6	42	18	45	0	0	0
2/23/2020	Pond E Channel	0	0	0	0	0	0	0
2/23/2020	Pond D	0	56	0	31	0	0	1
2/23/2020	East Trib Step Pools	0	5	0	35	0	0	0
3/26/2020	Pond C	0	0	0	0	0	0	0
3/26/2020	Pond C Term. Ch.	0	0	0	0	0	0	0
3/26/2020	SE Tributary	7	2	0	550	1	0	0
3/26/2020	SE Trib Pond	0	2	0	25	0	0	0
3/26/2020	Oxbow	3	0	0	50	0	0	0

4/23/2020	Pond C	152	0	0	100	0	0	0
4/23/2020	Pond C Term. Ch.	362	0	0	20	0	0	0
4/23/2020	SE Tributary	78	0	0	150	0	0	0
4/23/2020	SE Trib Pond	0	1	0	10	0	0	0
4/23/2020	Pond D	0	28	0	150	0	0	0
4/23/2020	Pond E	3	12	4	100	0	0	0
5/26/2020	SE Tributary	0	0	0	55	0	0	0
5/26/2020	SE Trib Pond	0	0	0	10	0	0	0
5/26/2020	Oxbow	11	0	0	50	0	0	0
5/26/2020	Pond C Term. Ch.	46	0	0	10	0	0	0
5/26/2020	Pond C	57	0	1	100	0	0	0
5/26/2020	Pond D	0	1	0	75	0	0	0
5/26/2020	Pond E	0	1	4	200	0	0	0
10/26/2020	Pond D	385	0	0	113	0	0	0
10/26/2020	East Trib Step Pools	0	0	0	69	0	0	0
10/26/2020	Pond E	425	0	1	55	1	0	0
10/26/2020	Pond F	950	0	0	828	0	0	0
12/1/2020	SE Tributary	2	0	0	65	0	0	0
12/1/2020	SE Trib Pond	0	0	0	10	0	0	0
12/1/2020	Pond C Term. Ch.	74	0	0	1	0	18	0
12/1/2020	Pond C	38	0	14	10	0	28	0
12/28/2020	SE Tributary	54	0	0	52	0	0	0
12/28/2020	SE Trib Pond	0	0	0	1	0	0	0
12/28/2020	Pond C Term. Ch.	72	0	2	0	0	0	0
12/28/2020	Pond C	44	0	1	2	0	0	0
TOTALS FOR 2020 MONITORING		**3666**	**217**	**57**	**4516**	**9**	**46**	**1**

Table continued on next page…

Date	Site Name	California Roach	Surf Smelt	Red Legged Frog tadpoles	Rough skinned Newt	Pacific Giant Salamander	Fathead Minnow	Jack Smelt
1/6/2020	Tidegate	0	0	0	0	0	0	0
1/6/2020	Pond C	0	0	0	0	0	0	0
1/6/2020	Pond C Term. Ch.	0	0	0	0	0	0	0
1/6/2020	SE Tributary	0	0	0	0	0	0	0
1/6/2020	SE Trib Pond	5	0	0	0	0	0	0
1/6/2020	Oxbow	0	0	0	0	0	0	0
1/26/2020	Upper Fairway Dr.	0	0	0	0	0	0	0
1/26/2020	Pond E	0	0	0	0	0	0	0
1/26/2020	Pond E Channel	0	0	0	0	0	0	0
1/26/2020	Pond D	0	0	0	0	0	0	0
1/26/2020	East Trib Step Pools	0	0	0	0	0	0	0
2/21/2020	Pond C	0	0	0	0	0	0	0
2/17/2020	SE Tributary	0	0	0	0	0	0	0
2/17/2020	SE Trib Pond	0	0	0	0	0	0	0
2/21/2020	Oxbow	0	0	0	0	0	0	0
2/23/2020	Upper Fairway Dr.	0	0	0	0	0	0	0
2/23/2020	Pond E	0	0	0	0	0	0	0
2/23/2020	Pond E Channel	0	0	0	0	0	0	0
2/23/2020	Pond D	0	0	0	0	0	0	0
2/23/2020	East Trib Step Pools	0	0	0	0	0	0	0
3/26/2020	Pond C	0	0	0	0	0	0	0
3/26/2020	Pond C Term. Ch.	0	0	0	0	0	0	0
3/26/2020	SE Tributary	0	0	0	0	0	0	0
3/26/2020	SE Trib Pond	2	0	0	0	0	0	0
3/26/2020	Oxbow	0	0	0	0	0	0	0
4/23/2020	Pond C	0	0	0	0	0	0	0

4/23/2020	Pond C Term. Ch.	0	0	0	0	0	0	0
4/23/2020	SE Tributary	0	0	3	0	0	0	0
4/23/2020	SE Trib Pond	10	0	12	2	0	0	0
4/23/2020	Pond D	0	0	17	6	0	0	0
4/23/2020	Pond E	0	0	7	3	0	0	0
5/26/2020	SE Tributary	0	0	20	0	0	0	0
5/26/2020	SE Trib Pond	15	0	3	0	6	0	0
5/26/2020	Oxbow	0	0	6	0	0	0	0
5/26/2020	Pond C Term. Ch.	0	0	0	0	0	0	0
5/26/2020	Pond C	0	0	0	0	0	0	0
5/26/2020	Pond D	0	0	50	0	0	0	0
5/26/2020	Pond E	0	0	0	0	0	0	0
10/26/2020	Pond D	0	0	0	0	0	1	5
10/26/2020	East Trib Step Pools	0	0	0	0	0	0	0
10/26/2020	Pond E	0	0	0	0	0	0	50
10/26/2020	Pond F	0	0	0	0	0	0	25
12/1/2020	SE Tributary	0	0	0	0	0	0	0
12/1/2020	SE Trib Pond	1	0	0	0	6	0	0
12/1/2020	Pond C Term. Ch.	0	0	0	0	0	0	0
12/1/2020	Pond C	0	0	0	0	0	0	0
12/28/2020	SE Tributary	0	0	2	0	0	0	0
12/28/2020	SE Trib Pond	1	0	0	0	1	0	0
12/28/2020	Pond C Term. Ch.	0	0	0	0	0	0	0
12/28/2020	Pond C	0	0	0	0	0	0	0
TOTALS FOR 2020 MONITORING		**34**	**0**	**120**	**11**	**13**	**1**	**80**

Topography

Overview

Topographic monitoring is focused on assessing geomorphic adjustments with regards to potential sediment aggradation and/or scour in channels and channel bank stability. Additionally, topographic monitoring identifies geomorphic changes to critical aquatic areas and key revegetation areas, including sedimentation within ponds and sediment accretion within vegetated habitats.

Annual surveys are planned for years 1, 3 and 5 of each phase of construction. Year 1 topographic monitoring was conducted in 2019 for Phase 2. No topographic monitoring was conducted in 2020. Year 1 topographic monitoring for Phases 3-5 and Year 3 for Phase 2 are planned for 2021. This will make all the topographic monitoring of the various phases occur on odd years.

Please see Appendix D: Martin Slough Enhancement Project 2020 Physical Monitoring Report, sections 2.1 and 3.1 for more information about Topography monitoring in 2020, including observations of channel condition and inspections of large wood structures.

Hydrology

Overview

Hydrologic monitoring consists of monitoring water levels throughout the length of the project to verify the amplitude and longitudinal extent of the muted tide influence. Results are then used to adaptively manage the muted tide through adjustments of the muted tide regulator (MTR) on the tide gate and auxiliary gate. Results are also used to assess frequency and duration of tide gate openness for aquatic organism passage and will aid in interpretation of the water quality monitoring data.

Below is a brief summary of the 2020 hydrologic monitoring efforts. For a full description and analysis of hydrologic monitoring, see Appendix D: Martin Slough Enhancement Project 2020 Physical Monitoring Report, sections 2.2 and 3.2.

Methods

Water Level Monitoring

Project hydrology was monitored by installing submersible water level loggers in four locations throughout the project reaches on the mainstem of Martin Slough. The loggers measure the hydrostatic pressure above the sensor and is corrected using recorded atmospheric pressure to calculate the stage, or water level, in 15-minute intervals. Each monitoring station consists of a perforated PVC stand pipe secured to a T-post or other stable feature. The data logger is placed at the bottom of the stand pipe and connected with a cable or cord to the cap for retrieval. A reference benchmark was established at each site and surveyed to determine water surface

elevations in North America Vertical Datum 1988 (NAVD88). The data loggers were downloaded approximately every two months and serviced or repaired as needed. At least one water level observation was made during each download period to calibrate the recoded data to the reference benchmark, placing all water level data into the NAVD88 vertical datum.

The following hydrologic monitoring stations were maintained and regularly monitored during water year 2020: Swain Slough, MS-Pond C (NRLT), MS-18 (golf course), MS-NF (golf course) (see Appendix D, Figure 2). For more information on installation dates, and removal for construction or repair, see Appendix D, section 2.2.1 Water Level Monitoring.

Tidal Datums

Humboldt Bay experiences semidiurnal tides: two high tides and two low tides per day. A key metric in sizing and maintaining tidal channel geometry is the average tidal prism, which is defined as the volume of water that drains between MHHW and MLLW.

The North Spit, on Humboldt Bay, tidal datums (converted to NAVD88) were used as a reference for unmuted tidal conditions. Tidal datums for each monitoring station were calculated on a per-month basis and seasonally using the measured water levels. A spreadsheet algorithm was used to identify the daily MHHW, MLHW, MLLW, and MHLW and calculate the monthly averages (Appendix D, sections 2.2.2 and 2.2.3).

Results

Water Level Observations

Water level data for each monitoring station was plotted for each month of the 2020 water year (Appendix D). In Swain Slough, water levels fluctuated similar to those recorded at the NOAA North Spit tidal station (No. 9418767), except that the water level never dropped below 1.0 feet. The plots of Martin Slough water levels at the Pond C gage show water level fluctuating as expected, with the distinct signature of a muted tide that peaks just below elevation 5 feet (NAVD88) and does not drop below an elevation of 1 foot. The highest water level recorded at Gage MS-18 was 7.1 feet on December 22, 2019 and followed a similar pattern as recorded at Pond C. During the dry weather monitoring period (June through September) the Hole 18 monitoring station is tidally influenced with a muted tide pattern fluctuating between a low level of 1 foot and a high of 5 feet, closely corresponding to the water levels recorded at the Pond C gage. The North Fork Tributary Confluence gage was installed and operational between November 5, 2019 and September 9, 2020. The baseflow water level is consistently between elevation 4 and 5 feet, with noticeable rises in response to rainfall events. The two highest water level peaks were recorded on December 22, 2019 and January 16, 2020.

For a full discussion and analysis of MTR settings and water level observations, including data plots, see Appendix D, section 3.2.1 and 3.2.2.

Tidal Datums

Stage data for the Phase 3 monitoring was analyzed and tidal datums were calculated relative to the NAVD88 vertical datum. The Swain slough data collected during this monitoring period appears similar to North Spit, but slightly higher. At the Pond C gage, when compared to the water year 2019 datums, the MLLW, MTL and MHHW all increased. At the Hole 18 gage, the MLLW is 3.18 feet lower than the previous year.

For a full discussion and analysis of tidal datums, including data tables, see Appendix D, section 3.2.3.

Water Quality

Overview

The objectives of water quality monitoring are to measure salinity, dissolved oxygen and water temperature to assess sufficiency of water quality for target habitat and species and ensure that salinity does not extend upstream to the golf course pump intake used for irrigation. These parameters directly influence suitability of aquatic habitat for salmonids, tide water goby, and other aquatic organisms. Surface salinity also influences vegetation communities on marshplains and along the margins of the channels and ponds.

Below is a brief summary of the 2020 water quality monitoring efforts. For a full description and analysis of water quality monitoring, see Appendix D: Martin Slough Enhancement Project 2020 Physical Monitoring Report, sections 2.3 and 3.3.

Methods

Water quality parameters were measured by installing temperature and salinity data loggers at the same locations as the water level loggers (no salinity logger was installed at the Swain Slough station).

Two salinity data loggers, which also record water temperature, were installed in each perforated stand pipe; one at the bottom coupled to the water level logger and one attached to a float that travels the height of the stand pipe and measures conditions approximately 10 inches below the surface. The salinity data loggers' period of record matches the water level loggers. Salinity and temperature were recorded continuously on the same 15-minute interval as the stage data loggers. Salinity data loggers were not installed at the Swain Slough station, but Swain Slough water temperatures were recorded by the water level logger placed at the bottom of the water column. Spot measurements of salinity, temperature and dissolved oxygen were also taken using a YSI handheld meter and recorded on data sheets when the data loggers were downloaded. Additional water quality measurements were taken as part of the fisheries monitoring (Appendix C). For more information on installation dates of all monitoring stations, and removal for construction or repair, see Appendix D, section 2.2.1 Water Level Monitoring.

Results

Water quality data (surface and bottom salinity and water temperature) for each monitoring station was plotted for each month of the 2020 water year (Appendix D). The plots also include

daily rainfall totals measured at the NWS office on Woodley Island for reference. In addition, water quality spot measurements were recorded during each data download. These include water temperature, salinity and dissolved oxygen concentrations.

Salinity was not recorded in Swain Slough. Water temperatures in Swain Slough during the fall of 2019 and early winter of 2020 were similar to those measured in the freshwater reach of Martin Slough near Hole 18 and upstream at MS-NF, with small diurnal temperature fluctuations. However, by mid-April 2020, water temperatures in Swain Slough become more elevated compared to near Hole 18 and both diurnal and tidal influenced temperature fluctuations become more apparent.

In Martin Slough, near Pond C, the salinity was highly correlated to precipitation, and stratification was present during periods not dominated by freshwater inflows. During periods between rainfall events the bottom salinity would fluctuate dramatically with incoming verses outgoing tides, while the surface salinity generally fluctuated less and was less brackish. During periods with precipitation, salinity concentrations became close to zero for days at a time. Water temperatures in Martin Slough near Pond C remained low throughout the fall and early winter months. Surface and bottom temperatures were nearly identical much of the time, with periods where the surface water temperature was colder and fluctuated much more with tidal cycles than along the bottom. As early as February 2020, temperatures at this location began to rise, as did salinity, due to the minimal rainfall for the entire month. During the summer months water temperatures remained above 20o C and were consistently warmer than Swain Slough.

Salinity measurements in Martin Slough near Hole 18 show that for nearly the entire monitoring period the bottom had salinity concentrations between 9 ppt and 12 ppt with the exception of during rainfall events, while the surface fluctuated between saline and fresh with the tides. Water temperatures in Martin Slough near Hole 18 fluctuated with tides, and showed diurnal fluctuation with changes associated with precipitation and ambient air temperature.

Salinity measurements for the gage located on the mainstem downstream of the confluence with the North Fork Tributary show that no brackish water is reaching the upper reach of Martin Slough in the project area. Temperature values show normal diurnal fluctuations, with warming during the summer months.

For a full discussion and analysis of water quality data, including data plots and data tables, see Appendix D, section 3.3.1 and 3.3.2.

Vegetation

Overview

The principal revegetation goal of the project is to establish, rehabilitate, or re-establish vegetative habitats within the project area, including tidal marsh, brackish marsh, freshwater marsh, riparian, and coastal prairie plant associations through both passive and active revegetation. The monitoring goal is to estimate the absolute vegetative cover of native and non-native vascular plants species and document species richness once construction activities are complete.

Quantitative vegetation sampling will occur post-construction, at a minimum in years two and five, with contingencies for monitoring in years three and four if year two success criteria have not been met. Qualitative monitoring will occur in conjunction with quantitative monitoring. Annual inspections and maintenance efforts will be conducted as needed.

Methods

The visual inspection of plants was conducted on foot and weeding and plant protection fence repairs were done by hand. In addition, photo monitoring was conducted (Appendix E).

Results

Quantitative vegetation sampling was not scheduled to occur in 2020. Year two quantitative sampling will occur on the revegetated areas on the NRLT property (Phase 2) in summer 2021. RCAA inspected the revegetated areas in the summer of 2020 and conducted hand-pulling of weeds around plant bases, as well as repairs to the plant protection fencing. There was evidence of minor deer browse on some plants. It was also noted that a small percentage of the plant species in the riparian areas on the golf course (Phase 3) were in poor condition and may have found the soil to be too wet during the winter months. The condition of these plants will be observed in 2021 inspections and replaced with a wet tolerant species if needed. These observations were noted for plant species selection in future upstream revegetation activities in 2021. Photo monitoring is part of the vegetation parameter, and is conducted post-construction along with vegetation monitoring. See Appendix E for the 2020 photo monitoring report.

APPENDICES

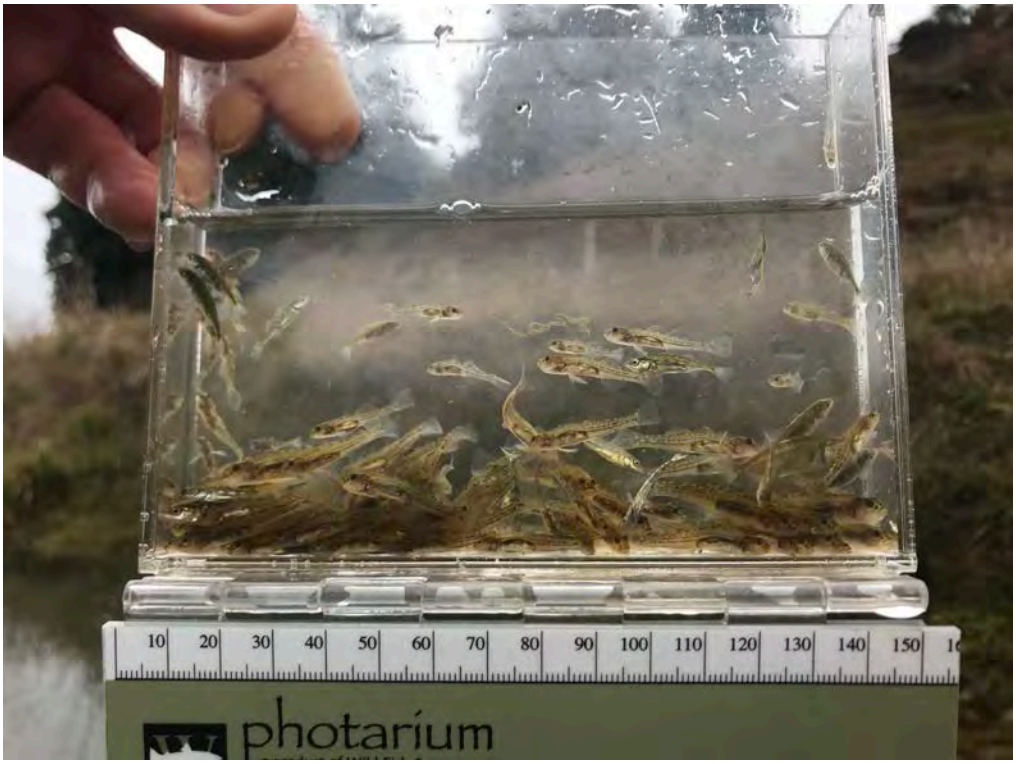
Appendix A

Photos from Fisheries Monitoring 2020
Courtesy of Ross Taylor and Associates

Coho salmon, Pond D – April 23, 2020

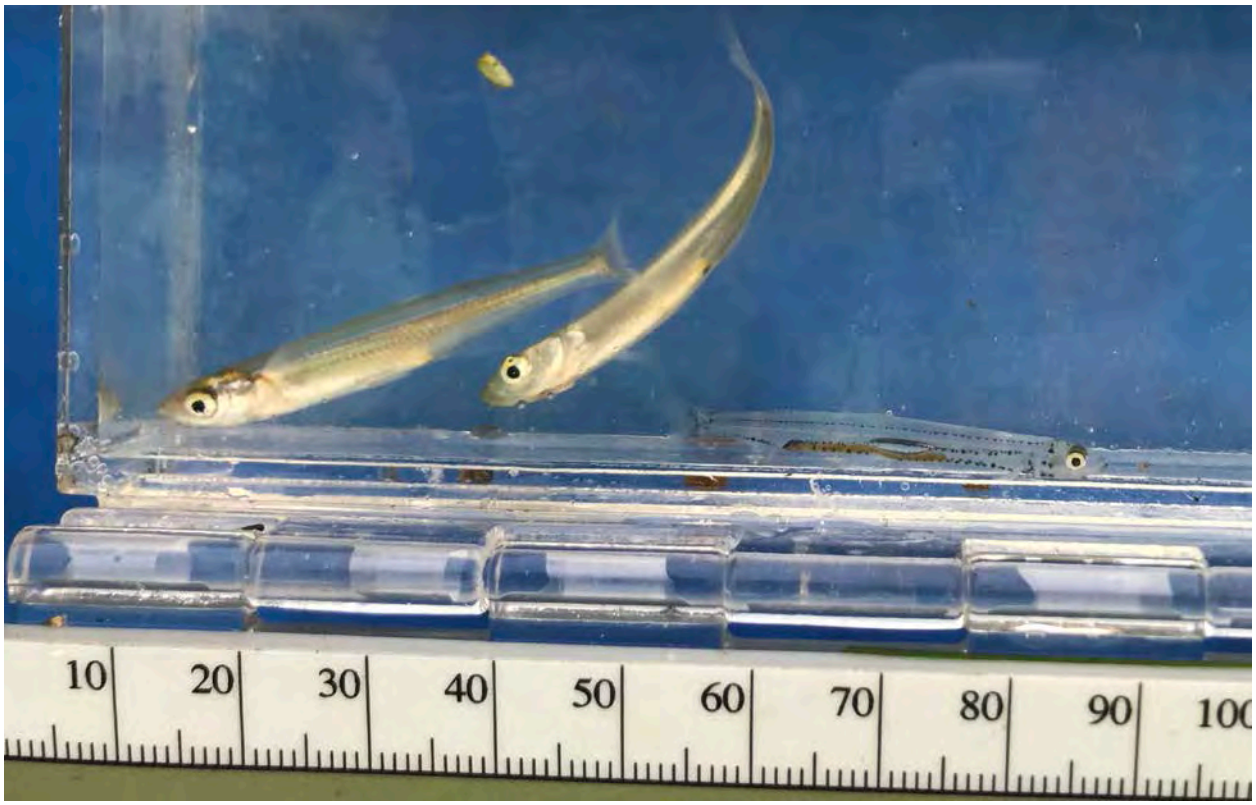
Coho salmon, Pond D – April 23, 2020

Coho salmon, Pond D – April 23, 2020



Tidewater Goby and Stickleback, Pond C Terminal Channel – November 14, 2019

Juvenile Smelt, Pond C – December 11, 2019



Juvenile Smelt, Pond C – December 11, 2019

Appendix B

Pit Tag Data for 2020 Fisheries Monitoring in Martin Slough

Date	Location	Fork Length (mm)	Weight (g)	Pit Tag Number	Black Spot	Comments
1/6/2020	SE TRIB POND	70	3.7	982.126056334067		
1/26/2020	POND E	64	2.8	999088994510187	0	
1/26/2020	POND E	75	4.6	982126058454324	4	
1/26/2020	POND E	80	5.5	982126058454447	3	
1/26/2020	POND E	75	4.9	982126058454351	1	
1/26/2020	POND E	72	4.0	982126058454404	2	
1/26/2020	POND E	69	3.6	999088994510074	2	
1/26/2020	POND E	86	6.3	982126058454513	1	
1/26/2020	POND E	87	7.5	982126058454361	1	
1/26/2020	POND E	82	5.7	982126058454428	1	
1/26/2020	POND E	71	3.6	982126058454396	3	
1/26/2020	POND D	78	4.9	982126058454382	1	
1/26/2020	POND D	80	6.9	982126058454373	3	
1/26/2020	POND D	78	5.9	999088994610196	2	RECAPTURE
1/26/2020	POND D	83	6.6	982126058454371	3	
1/26/2020	POND D	85	7.7	982126058454322	1	
1/26/2020	POND D	70	4.9	982126058454316	1	
1/26/2020	POND D	82	6.1	982126058454510	0	
1/26/2020	POND D	97	11.0	982126058454386	1	
1/26/2020	POND D	79	5.1	982126058454552	1	
1/26/2020	POND D	101	11.1	982126058454412	1	
1/26/2020	POND D	91	9.2	982126058454274	2	
1/26/2020	POND D	92	9.3	982126058454374	1	
1/26/2020	POND D	91	9.1	982126058454439	0	
1/26/2020	POND D	90	9.0	900226000340997	0	
1/26/2020	POND D	84	6.5	982126058454353	2	
1/26/2020	POND D	79	Failed	982126058454501	3	
1/26/2020	POND D	75	Failed	982126058454282	2	
1/26/2020	POND D	79	Failed	982126058454483	1	
1/26/2020	POND D	91	Failed	982126058454293	1	
1/26/2020	POND D	89	Failed	982126058454343	0	
1/26/2020	POND D	95	Failed	982126058454366	1	
1/26/2020	POND D	84	Failed	982126058454370	1	
1/26/2020	POND D	87	Failed	982126058454413	0	

1/26/2020	POND D	64	Failed	999088994510102	2	
1/26/2020	POND D	85	Failed	982126058454426	1	
1/26/2020	POND D	93	Failed	982126058454335	2	
1/26/2020	POND D	75	Failed	982126058454336	0	
1/26/2020	POND D	94	Failed	982126058454495	2	RECAPTURE
1/26/2020	POND D	85	Failed	982126058454273	2	
1/26/2020	POND D	80	Failed	982126058454459	1	
1/26/2020	POND D	90	Failed	982126058454469	1	RECAPTURE
1/26/2020	POND D	84	Failed	982126058454306	1	
1/26/2020	POND D	76	Failed	982126058454315	0	
1/26/2020	POND D	85	Failed	982126058454504	1	
1/26/2020	POND D	87	Failed	982126058454356	2	
1/26/2020	POND D	93	Failed	982126058454279	1	
1/26/2020	POND D	71	Failed	982126058454487	1	
1/26/2020	POND D	73	Failed	982126058454342	0	
1/26/2020	POND D	80	Failed	982126058454411	0	
1/26/2020	POND D	85	Failed	982126058454402	0	
1/26/2020	POND D	99	Failed	982126058454507	1	
1/26/2020	POND D	75	Failed	982126058454329	0	
1/26/2020	POND D	89	Failed	982126058454392	0	
1/26/2020	POND D	81	Failed	982126058454285	1	
1/26/2020	POND D	85	Failed	982126058454550	0	
1/26/2020	POND D	78	Failed	982126058454503	1	
2/21/2020	SE TRIB POND	86	7.0	982.126056334067		RECAPTURE
2/21/2020	SE TRIB POND	79	4.6	989.001029145279		
2/21/2020	SE TRIB POND	81	5.7	989.001029145251		
2/21/2020	SE TRIB POND	80	4.8	989.001029145239		
2/21/2020	SE TRIB POND	83	6.5	989.001029145313		
2/21/2020	SE TRIB POND	107	13.4	989.001029145252	light	
2/21/2020	SE TRIB POND	79	5.1	989.001029145255		
2/21/2020	SE TRIB POND	89	6.9	989.001029145271	light	
2/23/2020	POND E	127	21.4	982126058454838	2	injured left eye
2/23/2020	POND E	81	5.9	982126058454960	0	
2/23/2020	POND E	98	10.3	982126058454872	2	
2/23/2020	POND E	100	11	982126058454963	2	
2/23/2020	POND E	84	6.2	982126058454773	1	
2/23/2020	POND E	97	10	982126058454877	0	
2/23/2020	POND E	93	8.4	982126058428675	0	
2/23/2020	POND E	83	6.3	982126058454890	2	
2/23/2020	POND E	101	11	982126058454842	2	anal fin torn
2/23/2020	POND E	89	7	982126058454803	0	

2/23/2020	POND E	103	10.9	982126058454790	2	
2/23/2020	POND E	72	4.1	982126058428709	0	
2/23/2020	POND E	80	5.4	982126058454396	3	RECAPTURE
2/23/2020	POND E	95	8.5	982126058454361	1	RECAPTURE
2/23/2020	POND E	87	6.7	982126058428690	1	
2/23/2020	POND E	97	10	982126058428737	1	
2/23/2020	POND E	100	10.3	982126058428684	0	
2/23/2020	POND E	80	5.6	982126058454949	1	
2/23/2020	POND E	94	9.5	982126058454780	1	
2/23/2020	POND E	99	9.5	982126058454919	2	
2/23/2020	POND E	87	7	982126058454937	1	
2/23/2020	POND E	96	9.5	982126058454912	1	
2/23/2020	POND E	89	7.7	982126058454924	2	
2/23/2020	POND E	90	7.7	982126058454791	1	
2/23/2020	POND E	91	7.9	982126058454961	1	
2/23/2020	POND E	93	8.4	982126058454573	1	
2/23/2020	POND E	90	7.2	982126058454801	2	
2/23/2020	POND E	101	11.4	982126058454920	4	
2/23/2020	POND E	82	6	982126058454866	1	
2/23/2020	POND E	106	12.8	982126058454744	1	
2/23/2020	POND E	106	12	982126058454889	3	dorsal cut/scar
2/23/2020	POND E	88	7.4	982126058428678	0	
2/23/2020	POND E	76	4.7	982126058454907	2	
2/23/2020	POND E	95	8.9	982126058428753	1	
2/23/2020	POND E	90	8.1	982126058454854	1	
2/23/2020	POND E	78	5.6	982126058454747	1	
2/23/2020	POND E	79	5.6	982126058454775	0	
2/23/2020	POND E	94	9.4	982126058454859	1	
2/23/2020	POND E	109	15.9	982126058454783	2	
2/23/2020	POND E	89	8.6	900226000340963	1	
2/23/2020	POND E	99	11.3	982126058428712	1	
2/23/2020	POND E	87	6.5	982126058454923	2	
2/23/2020	STEP POOLS	97	8.4	982126058454834	2	
2/23/2020	STEP POOLS	85	7	982126058454770	1	
2/23/2020	STEP POOLS	101	11.2	982126058454274	1	RECAPTURE
2/23/2020	STEP POOLS	100	10.3	982126058454684	3	
2/23/2020	STEP POOLS	76	5.3	982126058454947	0	
2/23/2020	POND D	88	7.3	982126058454336		RECAPTURE
2/23/2020	POND D	87	6	982126058454863	1	
2/23/2020	POND D	97	9.9	982126058454959	0	
2/23/2020	POND D	88	7.3	982126058428689	1	

2/23/2020	POND D	80	5.2	982126058454662	1	
2/23/2020	POND D	92	8.2	982126058454552	1	RECAPTURE
2/23/2020	POND D	100	11.2	982126058454772	0	
2/23/2020	POND D	92	8.1	982126058454922	2	
2/23/2020	POND D	110	14.3	982126058454941	2	
2/23/2020	POND D	110	14	982126058454481	1	RECAPTURE
2/23/2020	POND D	87	7.8	982126058454888	1	
2/23/2020	POND D	98	10.8	982126058428706	0	
2/23/2020	POND D	105	13.4	982126058454374	1	RECAPTURE
2/23/2020	POND D	105	12.5	982126058454439	0	RECAPTURE
2/23/2020	POND D	99	11.4	982126058454578	2	
2/23/2020	POND D	125	22.4	982126058454797	1	
2/23/2020	POND D	98	10.6	982126058454535	2	RECAPTURE
2/23/2020	POND D	102	11.9	982126058454836	2	
2/23/2020	POND D	109	14	982126058454967	0	
2/23/2020	POND D	91	8.5	982126058428752	0	
2/23/2020	POND D	103	12.1	982126058454495	2	RECAPTURE
2/23/2020	POND D	98	10	982126058454402	0	RECAPTURE
2/23/2020	POND D	106	13.8	982126058454560	2	RECAPTURE
2/23/2020	POND D	94	7.9	982126058454723	0	
2/23/2020	POND D	92	8.7	982126058454745	0	
2/23/2020	POND D	85	7.2	982126058428719	0	
2/23/2020	POND D	91	9.1	982126058454516	1	RECAPTURE
2/23/2020	POND D	95	10	982126058454796	0	
2/23/2020	POND D	85	7.4	982126058454882	1	
2/23/2020	POND D	88	7.2	982126058454769	1	
2/23/2020	POND D	83	6.6	982126058454382	1	RECAPTURE
2/23/2020	POND D	103	12.1	982126058454382	1	
2/23/2020	POND D	100	10.8	982126058454375	1	
2/23/2020	POND D	93	8.5	982126058454724	0	
2/23/2020	POND D	105	13.6	982126058454335	2	RECAPTURE
2/23/2020	POND D	81	7.1	982126058454810	2	
2/23/2020	POND D	113	15.7	982126058428754	1	
2/23/2020	POND D	105	12.9	982126058454910	1	
2/23/2020	POND D	84	7.3	982126058454597	0	
2/23/2020	POND D	100	10.9	982126058454903	2	
2/23/2020	POND D	91	7.8	982126058454914	1	
2/23/2020	POND D	104	12	982126058428696	2	
2/23/2020	POND D	95	9.2	982126058454426	1	RECAPTURE
2/23/2020	POND D	85	6.3	982126058454845	2	
2/23/2020	POND D	96	10	982126058428694	1	

2/23/2020	POND D	85	7.2	982126058454282	2	RECAPTURE
2/23/2020	POND D	92	8.8	982126058454852	0	
2/23/2020	POND D	98	10.3	982126058454550	0	RECAPTURE
2/23/2020	POND D	98	9.7	982126058454874	1	
2/23/2020	POND D	82	5.7	982126058454815	3	
2/23/2020	POND D	112	16	982126058454412	1	RECAPTURE
2/23/2020	POND D	91	8.2	982126058454774	1	
2/23/2020	POND D	77	5.1	982126058454813	1	
2/23/2020	POND D	91	8.8	982126058454916	1	
2/23/2020	POND D	105	12.7	982126058454293	1	RECAPTURE
3/26/2020	SE TRIB	75	4.1	989.001029145236		
3/26/2020	SE TRIB	107	13.9	989.001029145295		
3/26/2020	SE TRIB POND	82	5.7	989.001029145240		
3/26/2020	SE TRIB POND	84	6.6	989.001029145238		
4/23/2020	SE TRIB POND	93	9.7	NO TAG		
4/23/2020	POND D	122	18.3	982.126058454774		Recapture – HSU tag #
4/23/2020	POND D	125	23.1	982.126058454535		Recapture – HSU tag #
4/23/2020	POND D	129	22.7	982.126058428696		Recapture – HSU tag #
4/23/2020	POND D	111	16.0	982.126058454723		Recapture – HSU tag #
4/23/2020	POND D	122	19.2	NO TAG		
4/23/2020	POND D	130	21.3	NO TAG		
4/23/2020	POND D	126	21.1	NO TAG	light	
4/23/2020	POND D	96	9.9	NO TAG		
4/23/2020	POND D	106	12.4	NO TAG		
4/23/2020	POND D	120	18.0	NO TAG		
4/23/2020	POND D	132	26.3	982.126058454411		Recapture – HSU tag #
4/23/2020	POND D	118	17.8	NO TAG		
4/23/2020	POND D	120	17.0	982.126058454459		Recapture – HSU tag #
4/23/2020	POND D	108	12.4	NO TAG		
4/23/2020	POND D	140	26.1	982.126058454967		Recapture – HSU tag #
4/23/2020	POND D	121	15.2	NO TAG		
4/23/2020	POND D	121	19.3	NO TAG		
4/23/2020	POND D	119	17.0	982.126058454342		Recapture – HSU tag #
4/23/2020	POND D	133	24.3	NO TAG	light	
4/23/2020	POND D	117	16.4	NO TAG		
4/23/2020	POND D	103	12.7	NO TAG	light	
4/23/2020	POND D	125	20.6	NO TAG		
4/23/2020	POND D	139	26.9	NO TAG		
4/23/2020	POND D	119	20.8	NO TAG		
4/23/2020	POND D	118	17.2	NO TAG		
4/23/2020	POND D	122	19.6	NO TAG		

4/23/2020	POND D	121	24.0	NO TAG		
4/23/2020	POND D	118	17.3	982.126058454516		Recapture – HSU tag #
4/23/2020	POND E	111	15.5	NO TAG		
4/23/2020	POND E	94	10.1	NO TAG		
4/23/2020	POND E	112	16	NO TAG		
4/23/2020	POND E	109	14.7	NO TAG		
4/23/2020	POND E	101	12.6	NO TAG		
4/23/2020	POND E	118	17.7	NO TAG	light	
4/23/2020	POND E	102	11.8	NO TAG		
4/23/2020	POND E	107	12.9	NO TAG	light	
4/23/2020	POND E	104	12.9	NO TAG		
4/23/2020	POND E	108	13.1	NO TAG		
4/23/2020	POND E	106	12.2	NO TAG	light	
4/23/2020	POND E	118	17.9	NO TAG	light	
5/26/2020	POND D	105	12.9	NO TAG		
5/26/2020	POND E	103	12.6	NO TAG		

Appendix C

Water Quality Spot Measurements at Fish Monitoring Locations in 2020 in Martin Slough

Date	Time	Location	Depth (ft)	DO (mg/L)	Temp. (C)	Salinity (ppt)
1/6/2020	13:50	SE Trib Pond	0.5	6.9	8.9	0.2
1/6/2020	13:50	SE Trib Pond	1.0	6.6	8.6	0.2
1/6/2020	13:50	SE Trib Pond	2.0	6.5	8.2	0.2
1/6/2020	13:50	SE Trib Pond	3.0	6.5	8.2	0.2
1/6/2020	13:50	SE Trib Pond	3.5	6.3	8.2	0.2
1/6/2020	14:15	SE Trib	0.5	8.6	8.3	0.2
1/6/2020	14:15	SE Trib	1.0	8.4	8.1	0.3
1/6/2020	14:35	SE Trib	0.5	9.7	8.9	0.4
1/6/2020	14:35	SE Trib	1.0	9.3	8.8	0.8
1/6/2020	15:50	Pond C	0.5	8.3	10.7	0.8
1/6/2020	15:50	Pond C	1.0	7.8	10.6	2.5
1/6/2020	15:50	Pond C	1.5	7.5	10.4	7.8
1/6/2020	15:55	Pond C Term. Ch.	0.5	8.6	10.4	0.6
1/6/2020	15:55	Pond C Term. Ch.	1.0	7.8	10.4	2.7
1/6/2020	15:55	Pond C Term. Ch.	1.5	7.2	10.4	4.6
1/6/2020	16:40	Marin Slough	0.5	8.1	9.4	0.2
1/6/2020	16:40	Marin Slough	1.0	8.1	9.3	0.2
1/6/2020	16:40	Marin Slough	2.0	8.0	9.2	0.4
1/26/2020	0:00	Upper Fairway Dr.	0.0	9.8	10.8	0.1
1/26/2020	0:00	Upper Fairway Dr.	3.0	9.7	10.8	0.1
1/26/2020	0:00	Pond D	0.0	10.4	11.0	0.1
1/26/2020	0:00	Pond D	4.5	9.3	10.9	0.1
1/26/2020	0:00	East Trib Step Pools	0.0	10.3	11.5	0.1
1/26/2020	0:00	East Trib Step Pools	4.0	10.5	11.5	0.1
1/26/2020	0:00	Pond E Channel	0.0	7.7	11.6	0.1
1/26/2020	0:00	Pond E Channel	6.0	7.5	11.5	0.1
1/26/2020	0:00	Pond E	0.0	7.5	11.4	0.1
1/26/2020	0:00	Pond E	5.0	6.6	11.3	0.2
2/21/2020	9:45	Pond C	0.5	9.9	8.0	6.9
2/21/2020	9:45	Pond C	1.0	10.2	9.7	9.8
2/21/2020	9:45	Pond C	2.0	10.1	9.9	14.2
2/21/2020	9:45	Pond C	3.0	10.1	10.2	15.5
2/21/2020	9:45	Pond C	4.0	9.8	11.1	19.5
2/21/2020	10:45	SE Trib Pond	0.5	4.1	8.4	0.2
2/21/2020	10:45	SE Trib Pond	1.0	3.6	7.8	0.2

2/21/2020	10:45	SE Trib Pond	2.0	3.4	7.4	0.2
2/21/2020	10:45	SE Trib Pond	3.0	3.3	7.3	0.2
2/21/2020	10:45	SE Trib Pond	4.0	3.3	7.3	0.2
2/21/2020	11:30	SE Trib	0.5	10.2	9.6	5.7
2/21/2020	11:30	SE Trib	1.0	10.5	9.6	11.5
2/21/2020	11:30	SE Trib	2.0	10.2	9.7	16.0
2/23/2020	0:00	Upper Fairway Dr.	0.0	8.6	9.3	0.1
2/23/2020	0:00	Upper Fairway Dr.	2.5	8.4	9.7	0.1
2/23/2020	0:00	Pond D	0.0	10.3	11.8	0.1
2/23/2020	0:00	Pond D	4.5	9.7	9.5	0.1
2/23/2020	0:00	East Trib Step Pools	0.0	10.4	12	0.1
2/23/2020	0:00	East Trib Step Pools	3.0	10.1	12	7.6
2/23/2020	0:00	Pond E Channel	0.0	8.5	10.8	1.5
2/23/2020	0:00	Pond E Channel	4.0	8.6	10.4	14.5
2/23/2020	0:00	Pond E	0.0	9.33	10	0.7
2/23/2020	0:00	Pond E	4.5	4.11	11.4	17.8
3/26/2020	12:20	SE Trib Pond	0.5	6.6	11.1	0.2
3/26/2020	12:20	SE Trib Pond	1.0	5.6	8.4	0.2
3/26/2020	12:20	SE Trib Pond	2.0	5.2	7.9	0.2
3/26/2020	12:20	SE Trib Pond	3.0	5.0	7.7	0.2
3/26/2020	12:20	SE Trib Pond	4.0	3.8	7.5	0.2
3/26/2020	12:30	SE Trib	0.5	9.7	10.4	0.2
3/26/2020	12:30	SE Trib	1.0	9.6	10.4	0.2
3/26/2020	12:40	SE Trib	0.5	10.4	10.9	0.2
3/26/2020	12:40	SE Trib	1.0	10.3	10.8	0.2
3/26/2020	12:40	SE Trib	2.0	8.9	10.7	0.2
3/26/2020	12:50	SE Trib	0.5	9.8	11.3	0.5
3/26/2020	12:50	SE Trib	1.0	9.4	10.9	3.6
3/26/2020	13:30	Pond C	0.5	9.3	11.5	5.4
3/26/2020	13:30	Pond C	1.0	8.9	11.6	7.8
3/26/2020	13:30	Pond C	2.0	8.6	11.7	12.3
3/26/2020	13:30	Pond C	3.0	7.9	12.2	17.4
4/23/2020	11:20	Pond C	0.5	5.6	15.8	7.5
4/23/2020	11:20	Pond C	1.0	4.4	15.3	17.7
4/23/2020	12:25	SE Trib Pond	0.5	2.7	12.4	0.2
4/23/2020	12:25	SE Trib Pond	1.0	2.2	12.2	0.2
4/23/2020	12:25	SE Trib Pond	2.0	1.9	12.1	0.2
4/23/2020	12:25	SE Trib Pond	3.0	1.8	12.1	0.2
4/23/2020	12:25	SE Trib Pond	4.0	1.6	11.9	0.2
4/23/2020	12:25	SE Trib Pond	5.0	1.4	11.9	0.2
4/23/2020	12:50	SE Trib	0.5	7.8	14.8	0.9

4/23/2020	12:50	SE Trib	1.0	6.2	14.5	10.6
4/23/2020	13:45	Pond E	0.5	8.4	15.4	0.2
4/23/2020	13:45	Pond E	1.0	8.3	15.4	0.2
4/23/2020	13:45	Pond E	2.0	7.7	15.3	0.2
4/23/2020	13:45	Pond E	2.5	7.4	15.2	0.2
4/23/2020	16:00	Pond D	0.5	10.6	17.4	0.2
4/23/2020	16:00	Pond D	1.0	10.5	16.7	0.2
4/23/2020	16:00	Pond D	2.0	9.1	15.1	0.2
4/23/2020	16:00	Pond D	3.0	7.1	13.8	0.2
4/23/2020	16:00	Pond D	3.5	5.6	13.4	0.2
5/26/2020	13:00	SE Trib Pond	0.5	3.4	15.6	0.2
5/26/2020	13:00	SE Trib Pond	1.0	2.1	14.7	0.2
5/26/2020	13:00	SE Trib Pond	2.0	1.6	14.0	0.2
5/26/2020	13:00	SE Trib Pond	3.0	1.2	13.7	0.2
5/26/2020	13:15	SE Trib	0.5	5.7	19.2	1.7
5/26/2020	13:15	SE Trib	1.0	5.2	19.1	9.5
5/26/2020	14:05	Pond C	0.5	7.8	25.1	5.5
5/26/2020	14:05	Pond C	1.0	6.2	24.3	12.4
5/26/2020	14:10	Pond C Term. Ch.	0.5	7.2	25.7	8.0
5/26/2020	14:10	Pond C Term. Ch.	1.0	5.6	24.3	11.2
5/26/2020	15:10	Pond E	0.5	9.6	21.0	0.2
5/26/2020	15:10	Pond E	1.0	7.3	20.2	0.2
5/26/2020	15:10	Pond E	2.0	5.1	18.4	0.2
5/26/2020	16:20	Pond D	0.5	10.4	22.5	0.2
5/26/2020	16:20	Pond D	1.0	10.4	21.2	0.2
5/26/2020	16:20	Pond D	2.0	9.7	17.9	0.2
5/26/2020	16:20	Pond D	3.0	6.4	15.6	0.2
5/26/2020	16:20	Pond D	3.5	4.8	14.6	0.2
10/26/2020	10:40	East Trib Step Pools	0	7.3	11.2	3.5
10/26/2020	10:50	East Trib Step Pools	1.5	7.3	11.3	6.9
10/26/2020	11:00	Pond D	0	9.3	12.3	7.1
10/26/2020	11:10	Pond D	3	15.9	12	10.9
10/26/2020	12:44	Pond E	0	10.5	13.1	10.6
10/26/2020	12:52	Pond E	4	8.9	13.2	11.6
10/26/2020	13:30	Pond F	0	5.7	13.5	10.8
10/26/2020	13:40	Pond F		5.7	13.8	11.1
12/1/2020	13:20	SE Trib Pond	0.5	10.2	8.8	0.3
12/1/2020	13:20	SE Trib Pond	1.0	9.3	7.8	0.3
12/1/2020	13:20	SE Trib Pond	2.0	7.1	7.3	0.3
12/1/2020	13:20	SE Trib Pond	3.0	1.2	7.6	0.3
12/1/2020	13:20	SE Trib Pond	4.0	0.8	7.8	0.3

12/1/2020	13:30	SE Trib	0.5	6.7	9.8	20.1
12/1/2020	13:30	SE Trib	1.0	6.1	9.6	21.5
12/1/2020	13:30	SE Trib	2.0	5.7	9.3	24.1
12/1/2020	13:50	SE Trib	0.5	9.3	9.6	24.4
12/1/2020	13:50	SE Trib	1.0	9.2	9.5	25.8
12/1/2020	13:50	SE Trib	2.0	8.9	9.4	26.3
12/1/2020	15:10	Pond C	0.5	10.1	9.7	22.6
12/1/2020	15:10	Pond C	1.0	10.1	9.6	25.0
12/1/2020	15:10	Pond C	2.0	9.8	9.5	26.3
12/1/2020	15:10	Pond C	3.0	9.6	9.4	27.2
12/28/2020	13:00	SE Trib Pond	0.5	5.7	10.4	10.4
12/28/2020	13:00	SE Trib Pond	1.0	5.6	9.4	9.4
12/28/2020	13:00	SE Trib Pond	2.0	5.1	9.3	9.3
12/28/2020	13:00	SE Trib Pond	3.0	4.3	9.2	9.2
12/28/2020	13:10	SE Trib	0.5	-	10.1	0.3
12/28/2020	13:10	SE Trib	1.0	-	9.8	0.3
12/28/2020	13:10	SE Trib	2.0	-	9.6	7.5
12/28/2020	13:10	SE Trib	2.5	-	9.3	14.1
12/28/2020	13:15	SE Trib	0.5	-	10.2	0.3
12/28/2020	13:15	SE Trib	1.0	-	9.9	12.6
12/28/2020	13:15	SE Trib	2.0	-	9.7	15.7
12/28/2020	13:15	SE Trib	2.5	-	9.4	15.7
12/28/2020	13:25	SE Trib	0.5	-	10.6	3.8
12/28/2020	13:25	SE Trib	1.0	-	10.1	16.4
12/28/2020	13:25	SE Trib	2.0	-	9.7	19.5
12/28/2020	13:25	SE Trib	3.0	-	9.5	20.1
12/28/2020	14:50	Pond C	0.5	-	9.4	10.5
12/28/2020	14:50	Pond C	1.0	-	9.3	15.9
12/28/2020	14:50	Pond C	2.0	-	9.2	20.5
12/28/2020	14:50	Pond C	3.0	-	8.9	22.9
12/28/2020	15:00	Pond C	0.5	-	10.2	9.4
12/28/2020	15:00	Pond C	1.0	-	9.8	17.1
12/28/2020	15:00	POND C	2.0	-	8.8	21.4
12/28/2020	15:00	POND C	3.0	-	8.7	22.7
12/28/2020	15:00	POND C	3.5	-	9.0	23.1

Appendix D

Martin Slough Enhancement Project
2020 Physical Monitoring Report

Martin Slough Enhancement Project
2020 Physical Monitoring Report

Eureka, California

December 2020

Prepared for:

Redwood Community Action Agency

Prepared by:

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2020 Physical Monitoring Report
Martin Slough Enhancement Project

Eureka, California

Prepared for:

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December 2020

Table of Contents

Appendices

1 INTRODUCTION

1.1 Purpose of Report

This report summarizes water year 2020 results from performance monitoring of hydrology and water quality conditions within the Martin Slough project area. It also includes field observations and recommendations.

1.2 Background

Martin Slough is part of the Elk River watershed, which is part of the larger Humboldt Bay ecosystem. Martin Slough has been identified by the California Department of Fish and Wildlife as playing a key role in the life cycle of Coho Salmon, providing ideal rearing habitat for juvenile coho. In 2006 the Elk River watershed, including Martin Slough, was listed under the Clean Water Act as impaired for sediment and siltation, citing impaired water quality, impaired spawning habitat, and increased depth of flooding due to sediment. In response to these stressors, the Martin Slough Enhancement Project was developed with the goal of enhancing fish habitat for endangered Coho Salmon and reducing the extent and duration of flooding.

The project area encompasses two properties – 40 acres of pasture owned by the Northcoast Regional Land Trust (NRLT) and 120 acres upstream of the NRLT property owned by the City of Eureka and operated as the Eureka Municipal Golf Course. The project was initiated in 2001 when RCAA and partners began preparing a feasibility study, which was completed in 2006. Between 2007 and 2014, MLA and GHD developed designs for new tide gates, enhanced slough channel, new tidal marshes, and off-channel brackish and freshwater ponds. Construction of the project has been phased, with the first phase implemented in 2014 and the last phase of implementation planned for 2021.

1.3 Project Purpose

While not much is known relative to the historical composition of the lower portions of Martin Slough prior to construction of the existing dikes, it is apparent from its elevation relative to tidewater and its geomorphic features that the lower portions of Martin Slough consisted of estuarine habitat, likely composed of some salt marsh and slough channels along with other more brackish and freshwater habitats. Existing limiting factors that have been identified in Martin Slough include obstructed fish access, poor fish habitat, poor sediment routing, lack of riparian habitat, and frequent prolonged flooding that has a negative economic impact on current land uses.

The purpose of the Martin Slough Enhancement Project is to improve aquatic and riparian habitat and reduce flooding of pasture and golf course greens throughout the project area. Specific goals of the project include the following:

1. Improve fish access from Swain Slough into Martin Slough,
2. Reduce flood impacts to current land use,
3. Improve sediment transport,
4. Increase the amount of riparian corridor and riparian canopy,
5. Improve water quality (increased circulation, decrease nutrient inputs, decrease sedimentation),

6. Increase the extent of the estuarine ecotone in Martin Slough, providing a gradual transition from brackish water to freshwater habitats, and
7. Enhance and create low-velocity off-channel/backwater habitats.

1.4 Project Phasing

Following completion of the project planning elements, implementation of the project occurred in phases due to funding constraints and the logistics associated with implementing the entire project. The project components and phases are shown in Figure 1.

1.4.1 Phase 1 – Tide Gate Replacement

Replacement of the Martin Slough tide gates was accelerated due to the dilapidated state of the existing gates. In 2014, the dilapidated tide gates at the confluence at Swain Sloughs were replaced with a new tide gate system that includes two Muted Tide Regulators (MTRs) designed to allow a limited amount of tidal water into the project area. This is considered Phase 1 of the project. Since construction, only the smaller MTR gate (auxiliary door) has been in operation, and only during limited portions of the year. The MTR system cannot be fully operational until all project phases are complete.

1.4.2 Phase 2- NRLT Property

Over the summer and fall of 2018 channel and off-channel enhancements were constructed on the NRLT property (Phase 2). The work included: enlarging approximately 3,000 feet of the Martin Slough channel to accommodate the design muted tidal prism (volume), constructing 3.05 acres of tidal marsh plains (Marsh Plain A and B), 1.7 acres of brackish marsh (Pond C), a new Southeast Tributary channel and terminal freshwater pond, replacing two undersized culverts to improve fish passage through the historical channel meander, installation of log weirs on the Southeast Tributary and woody instream habitat structures, and installation of an access bridge over the mainstem Martin Slough. Revegetation of native wetland and salt marsh plants in restored areas occurred over the winter/spring of 2019. The 2019 Physical Monitoring Report detailed the post project conditions.

1.4.3 Phase 3 – Downstream of Fairway Drive

Phase 3 of the project was constructed during the summer and fall of 2019 on the Eureka Municipal Golf Course downstream of Fairway Drive. Phase 3 consisted of enlarging approximately 1,000 feet of Martin Slough mainstem channel (Reach 4 and 5), enlarging an existing tributary pond (Pond D), installation of 8 log weirs on the tributary downstream of Pond D, installation of 7 woody instream habitat structures and a rock grade control structure in Pond D, and construction of one vehicle bridges across Martin Slough.

1.4.4 Phase 4 – Extending upstream to North Fork Tributary Confluence

Phase 4 of the project was constructed in summer and fall of 2020 and included 1,800 feet of new slough channel from just downstream of Fairway drive to the North Fork Tributary confluence (Reach 6 and lower portions of Reach 7) and included construction of Pond E and Pond F. A temporary rock grade control was installed immediately downstream of the North Fork confluence.

1.4.5 Phase 5 – Pond G and Upstream Limits of Project

The remaining project elements are anticipated to be constructed in 2021. This includes Pond G on the North Fork and final grading of the North Fork and upstream-most portion of Reach 7 along the mainstem of Martin Slough.

1.5 Physical Monitoring Goals

The goal of project monitoring is to ensure the project is functioning as intended and to provide a means of identifying any shortcomings in project performance to allow for adaptive management as needed.

Description of Phasing and Restoration Activities

Phase 1 (2014): Installed new tide gate to restore estuarine ecosystem funotion, inorease conveyanoe and partially restore muted tidal influenoe.

Phase 2 (2018): Construction of mainstem Reaches 1, 2, and 3, Marsh Plains A, B1 and B2, Pond C and Southeast Tributary and Pond.

Phase 3 (2019): Construction of mainstem Reach 4 and partial Reach 5, and Pond D.

Future Phases: Construction of mainstem Reach 5, 6 and 7, and Ponds E, F, and G.

Project Elements

A & B (2.75 acres) - salt marsh plain 50 ft wide paralleling slough channel and 70 ft wide along abandoned meander.

C (1.72 acres) - Salt marsh with low elevation pond connected to springs.

D & E (0.64 acres & 1.17 acres) - Expanded brackish wetlands, containing deep open water, littoral benches and elevated outlet sill that minimizes salinity intrusion during wet season.

F (1.04 acres) - Backwater slough with island and deep open water and littoral bench on inside of bend.

G (0.5 acres) - Predominantly freshwater alcove pond. Deep open water with emergent vegetation along banks.

North Fork (0.74 acres) - Restored channel with marsh plan and side channel.

South East Tributary (0.3 acres) - Restored channel with small freshwater pond connected to existing tributary.

New channel dimensions - Trapezoidal shape with 1.5:1 (H:V) side slopes and bottom elevation ranges from -1.0 to 2.8 ft. Stable tidal channel geometry based on published relationships of diurnal tidal prism and slough channel dimensions.

MARTIN SLOUGH ENHANCEMENT PROJECT

Figure 1. Overview of Martin Slough Enhancement Project. Phase 1 (2014) comprised of tide gate replacement, Phase 2 (2018) comprised of Reach 1, 2, 3, Marsh plain A, B, Pond C, and the Southeast tributary, and Phase 3 (2019) included Reach 4, 5 and Pond D, and Phase 4 (2020) included Reach 6, 7 and Ponds E and F.

2 MATERIALS AND METHODS

The following parameters, as defined by NOAA Restoration Center (NOAA, 2003), are being monitored as part of the Martin Slough Enhancement Project: (1) hydrology, (2) water quality, and (3) topography. Vegetation and fisheries-use are also parameters being monitored for the project and are reported on in separate reports. The hydrologic and water quality results are generally organized by water years, which start October 1st and end September 30th. This report is providing monitoring results and findings for water year 2020.

The Martin Slough Enhancement Project Monitoring Plan (RCAA 2018) provides performance and success criteria to evaluate whether the project is performing as intended. Once the project is fully completed, allowing for the intended tidal amplitude, hydrologic circulation, and water quality conditions, the monitoring results will be compared to the project performance and success criteria. Prior to project completion, monitoring of the three parameters (topography, hydrology, and water quality) will be used to manage interim water quality conditions, evaluate inundation of revegetated wetland areas, and identify areas experiencing topographic changes and determine the causes of those changes.

2.1 Topographical Parameter

The objectives of the topography parameter are to monitor persistence of, and identify changes in, post-construction topographic conditions. As scheduled in the Martin Slough Enhancement Project Monitoring Plan (RCAA 2018), topographic monitoring occurs at the end of years 1, 3 and 5 as funding is available. Topographic monitoring was completed for water year 2020 for the portions of the project constructed on the NRLT (Phase 2). During water year 2021 the project will complete Year 3 monitoring for Phase 2 and Year 1 monitoring for Phases 3-5.

Large wood features placed in Phase 3 (2019) were visually inspected at the conclusion of water year 2019. These included large wood cover structures throughout the constructed project and log weirs installed at Pond D. The inspection focused on determining if any of the wood had moved, if any steel anchors were loose or corroded, and if any undesirable scour induced by the structure had occurred.

2.2 Hydrology Parameter

The objectives of monitoring hydrology of the project are to measure water level fluctuations relative to tidal influence within the project area to:

- Evaluate the extent to which the project muted tides match the design muted tidal ranges
- Assess flow conveyance (in both directions) through the project reaches, and
- Assess whether the higher muted tides (spring tides) during the dry season are remaining within acceptable ranges and not inundating adjacent pasture (NRLT) and greens (Eureka Municipal Golf Course).

Results from the monitoring can be used to guide adjustments to the tide gate MTRs (Muted Tide Regulators) and identify if any flow constrictions are affecting project performance.

2.2.1 Water Level Monitoring

The methods used to monitor project hydrology consisted of installation of submersible water level loggers in four locations throughout the project reaches on the mainstem of Martin Slough. The loggers measure the hydrostatic pressure above the sensor and is corrected using recorded atmospheric pressure to calculate the stage, or water level, in 15-minute intervals. Each monitoring station consists of a perforated PVC stand pipe secured to a T-post or other stable feature. The data logger is placed at the bottom of the stand pipe and connected with a cable or cord to the cap for retrieval. A reference benchmark was established at each site and surveyed to determine water surface elevations in North America Vertical Datum 1988 (NAVD88). The data loggers were downloaded approximately every two months and serviced or repaired as needed. At least one water level observation was made during each download period to calibrate the recoded data to the reference benchmark, placing all water level data into the NAVD88 vertical datum.

Stage data was recorded after Phase 1 completion starting in March 2017, expanded after Phase 2 completion and expanded further following implementation of Phase 3. The following monitoring stations/locations were maintained during water year 2020 (Figure 2). Dates of gage installations and periods when data loggers were removed for servicing are provided in Table 1.

Phase 1

Property Line: Middle Reach of Martin Slough on NRLT property, near the property line with the Eureka Municipal Golf Course, a water level gage was installed in Martin Slough on March 14, 2017 and was in operation through July 11, 2018, when it was removed for construction of Phase 2. This gage has been discontinued and was replaced by the MS-18 gage after construction in 2018.

Swain Slough: In Swain Slough near the tide gate a water level logger was installed on February 11, 2018 and remains operational.

Phase 2

MS-Pond C: Lower Martin Slough on NRLT property, a water level logger was installed in Martin Slough, upstream of the confluence with Pond C on December 17, 2018 and remains operational.

MS-18: Middle reach of Martin Slough on the Golf Course property, a water level logger was installed in Martin Slough between Hole 17 and 18 (downstream of Pond E) on the golf course on November 19, 2018 and removed on October 22, 2019 for Phase 3 construction. Following Phase 3 construction this water level logger was reinstalled on November 5, 2019 to the newly constructed vehicle bridge and remains operational.

Phase 3

MS-NF: Upper reach of Martin Slough, a water level logger was installed in Martin Slough downstream of the North Fork Tributary confluence on the golf course on November 5, 2019 and removed on September 9, 2020 for Phase 4 construction. They were reinstalled in December 2020, moving the station to a bridge on the North Fork Tributary just downstream of the existing irrigation pond and future Pond G.

Table 1. Water year 2020 dates of water level logger installations and periods data loggers were out for servicing

Gaging Station	Data Type	New Installation	Removed for Construction
MS-NF	All	11/5/2019	9/9/2020
MS-18	All	11/5/2019	N/A

Gaging Station	Logger Maintenance	Removed	Reinstalled
Swain	Stage	9/25/2020	10/2/2020
MS-18	Stage	9/25/2020	10/2/2020
MS-18	Salinity Surface	1/1/2020	2/25/2020
MS-18	Salinity Bottom	6/18/20	9/9/2020
MS-Pond C	Stage	9/25/2020	10/2/2020
MS-Pond C	Salinity Surface	9/18/2020	12/14/2020
MS-Pond C	Salinity Bottom	9/25/2020	10/2/2020

2.2.2 Tidal Datums

Humboldt Bay experiences semidiurnal tides: two high tides and two low tides per day. The tidal datums of Mean Higher High Water (MHHW), Mean Lower High Water (MLHW), Mean Higher Low Water (MHLW), Mean Lower Low Water (MLLW), and sometimes Mean Tide Level (MTL) are used for designing and evaluating performance of tidal restoration projects. A key metric in sizing and maintaining tidal channel geometry is the average tidal prism, which is defined as the volume of water that drains between MHHW and MLLW.

The North Spit, on Humboldt Bay, tidal datums (converted to NAVD88) were used as a reference for unmuted tidal conditions. Tidal datums for each monitoring station were calculated on a per-month basis and seasonally using the measured water levels. A spreadsheet algorithm was used to identify the daily MHHW, MLHW, MLLW, and MHLW and calculate the monthly averages.

2.2.3 Tidal Prism

The volume of tidal water exchanged between MHHW and MLLW defines the tidal prism. It is a key parameter in the design and self-sustainability of the project. Though Martin Slough receives freshwater inflows, the hydraulic geometry of the tidal channel of Martin Slough will be governed by the daily tidal flux created by the muted tide rather than less frequent high flow events from upstream. The daily tidal prism is a governing factor in the dimensions of the channel, and a significant reduction in the tidal prism could cause sedimentation and a decrease in the channel cross-sectional area. Changes in MHHW or MLLW during the dry season would suggest a change in tidal prism, and may require changes in tide gate settings to restore the intended tidal prism and maintain geomorphic stability of the tidal channels.

2.3 Water Quality Parameter

The objectives of monitoring water quality parameters are to measure salinity, dissolved oxygen and water temperature to assess sufficiency of water quality for target habitat and species and ensure that salinity does not extend upstream to the golf course pump intake used for irrigation. The methods used to measure water quality parameters consisted of installation of temperature and salinity data loggers at the same locations as the water level loggers (salinity loggers were not installed at Swain Slough).

Two salinity data loggers, which also record water temperature, were installed in each perforated stand pipe; one at the bottom coupled to the water level logger and one attached to a float that travels the height of the stand pipe and measures conditions approximately 10 inches below the surface. The salinity data loggers' period of record matches the water level loggers. Salinity and temperature were recorded continuously on the same 15-minute interval as the stage data loggers. Salinity data loggers were not installed at the Swain Slough station, but Swain Slough water temperatures were recorded by the water level logger placed at the bottom of the water column. Spot measurements of salinity, temperature and dissolved oxygen were also taken using a YSI handheld meter and recorded on data sheets when the data loggers were downloaded. Additional water quality measurements were taken as part of the fisheries monitoring, as covered in a separate monitoring report.

Dates of installation of water quality instruments and periods when data loggers were removed for servicing are provided in Table 1.

Figure 2. Overview of Phases 1, 2, and 3, and location of stage and water quality monitoring stations (image from Google Earth, Oct. 2019).

3 RESULTS AND DISCUSSION

3.1 Topography

To quantify any changes to the channel shape and assess potential sedimentation or scour, annual surveys are planned for years 1, 3 and 5 of each phase of construction. Year 1 topographic monitoring was conducted in 2019 for Phase 2. No topographic monitoring was conducted in 2020. Year 1 topographic monitoring for Phases 3-5 and Year 3 for Phase 2 are planned for 2021. This will make all the topographic monitoring of the various phases occur on odd years.

3.1.1 Channel Condition

A high spot in the channel caused by a slumping bank was identified during the Year 1 survey of Phase 2. This is located immediately upstream of the new bridge and sheet pile retaining wall at the NRLT barn. A section of the right bank appears to be slumping into the channel when observed at low tide, and there are numerous seeps emerging from the adjacent hillside (Figure 3). High groundwater along the base of the adjoining hillslope appears to be driving the instability.

Observations made during low tide on December 10, 2020, confirm that the instability is still present although the extents of the slump appear to be relatively unchanged when compared to observations in 2019.

3.1.2 Inspection of Large Wood Structures

The large wood structures were inspected on December 10, 2020 to ensure they were stable and functioning as intended. All structures (Log Cover Structures, Rood Wad Deflectors, and Root Wad Habitat Structures, Log Constrictors, Log Weirs) appeared stable and show no signs of shifting since constructed. Wood features located in the middle of Pond D were observed from the shore. All anchor points looked sound. The only item of note was erosion visible against pile logs associated with the log weirs between Pond D and the mainstem Marin Slough channel (Figure 4). The erosion is along the back (downstream) side of the training logs that sit on top of the weir logs. This occurred during high flows on December 22, 2019, when water flanked the training logs and eroded the relatively loose and unvegetated bank material. This is a common location for erosion to develop during the first year following construction due to difficulty compacting the soils in this area and the lack of well-established vegetation. The voids can be filled and compacted with soil or rock. Brush baffles combined live stake and other plantings could within the placed fill to slow water velocities at these vulnerable locations.

(a)

(b)

Figure 3. Bank slumping along the right side of the channel immediately upstream of the new bridge and sheet pile retaining wall, as seen (a) in December 2019 and (b) in December 2020 at low tide.

(a)

(b)

Figure 4. On December 22, 2019 (a) high flows overtopped the banks at Pond D and the channel draining the pond into Martin Slough, causing flow to flank the log weirs and (b) causing scour pockets behind the training logs located on top of the weir logs.

3.2 Hydrology

3.2.1 Muted Tide Regulator (MTR) Settings and Target Water Levels

During water year 2020 the muted tide in Martin Slough was controlled solely using the 2-foot by 2-foot auxiliary door (slide gate) connected to its MTR float-switch located on the upstream side of the tide gate. The MTR float was set to close the auxiliary gate when the inside Martin Slough water levels approached elevation 5.0 feet. This is an interim water level setting.

With completion of Phase 4 at the end of water year 2020, the MTR float for the 6-foot by 6-foot was activated and the muted tidal setting was raised to peak at approximately 5.5 feet. The design peak muted tide is 5.7 feet, which will be implemented once the project is completed.

3.2.2 Water Level Observations

Water level data, combined with salinity and water temperature data, was plotted for each month during the period following Phase 1, 2, and 3 implementations. Water level plots for water year 2020 are provided in Appendix A.

Swain Slough Water Levels

Swain Slough water levels fluctuated similar to those recorded at the NOAA North Spit tidal station (No. 9418767), except that the water level never dropped below 1.0 feet. Two conditions affect this; 1) The gage is located in an outlet scour pool below a drainage flap gate, and the pool becomes disconnected from Swain Slough at the lowest tides in Swain Slough, and 2) A tidal sill located on Elk River downstream of the confluence with Swain Slough results in the lowest tide levels being between elevation 0.5 to 1 foot (NAVD88). This tidal sill was noted in NOAA's historical Elk River tidal station.

Martin Slough near Pond C Water Levels

The plots of Martin Slough water levels at the Pond C gage show water level fluctuating as expected, with the distinct signature of a muted tide that peaks just below elevation 5 feet (NAVD88) and does not drop below an elevation of 1 foot. Occasional peaks above 5 feet occur, typically only occurring over one or two days associated with elevated streamflows due to rainfall events. The two highest peaks recorded at the Pond C Gage were 7.4 feet on December 22, 2019 and 7.1 feet on January 16, 2020. Occasionally debris becomes lodged in one of the tide gates, forcing it to remain partially open during one or more tide cycles and causing water levels to rise higher than the MTR setting.

Starting on December 15, 2020 it appears the MTR auxiliary gate was closed, resulting in a muted tide with a maximum high tide level of elevation 3.0 feet, mostly associated with freshwater inflows backing up during high tides. In early January it was discovered that the MTR habitat gate had been vandalized by someone disengaging the float. Between January and early February, the float switch was tampered with two more times and reset by RCAA staff each time. Subsequently, on February 14, 2020 RCAA removed the cable that allowed the MTR to be disengaged and no more tampering of the float occurred. The cable was reinstalled on September 14, 2020 and the crank handles were taken off for storage at RCAA offices.

Martin Slough near Hole 18 Water Levels
The Hole 18 monitoring station is located in Martin Slough, on the golf course vehicle bridge located approximately 500 feet downstream of Fairway drive. The station is a short distance upstream of the confluence of Pond D with Martin Slough and immediately downstream of the temporary rock grade control installed at the end of 2019 construction. The Hole 18 water level logger was removed for maintenance for approximately 3 weeks during October and November 2020.

Following construction of Phase 3 in 2019, the tidal influence extended to the Hole 18 gage and is reflected in the water level observations in water year 2020. The highest water level recorded at Gage MS-18 was 7.1 feet on December 22, 2019 and followed a similar pattern as recorded at Pond C. During the dry weather monitoring period (June through September) the Hole 18 monitoring station is tidally influenced with a muted tide pattern fluctuating between a low level of 1 foot and a high of 5 feet, closely corresponding to the water levels recorded at the Pond C gage.

Martin Slough at North Fork Confluence Water Levels
The North Fork Tributary Confluence gage was installed and operational between November 5, 2019 and September 9, 2020. The baseflow water level is consistently between elevation 4 and 5 feet, with noticeable rises in response to rainfall events. The two highest water level peaks were recorded on December 22, 2019 and January 16, 2020. On those two days water level peaked at 7.9 and 7.8 ft respectively, presumably this is when water flows out of bank and onto the golf course. During the dry months small drops in water level are visible daily in response to pumping. This could be associated with irrigation pumping from upstream and/or pumping water around the temporary coffer dam that was in place just upstream of the Hole 18 gage during summer 2020 construction. Beginning August 31, 2020, the temporary coffer dam was relocated further upstream and water levels began to rise and fall daily associated with ponding upstream of the dam and pumping bypass flows around the work area.

3.2.3 Tidal Datums

Stage data for the Phase 3 monitoring was analyzed and tidal datums were calculated relative to the NAVD88 vertical datum. Monthly values are provided at the end of Appendix D, and averages for the dry season of July through October, when freshwater inputs were minimal, are provided in Table 2, below. For reference, the yearly tidal datums calculated at the North Spit for the Epoch encompassing 1983 to 2001 and the design muted tidal datums are also included in Table 2. Tidal Datums for the MS-NF Gage were not computed because it was located upstream of tidal influence.

With the exception of MLLW, which is influenced by a tidal sill in the Elk River Slough that limits draining of the tide, the Swain slough data collected during this monitoring period appears similar to North Spit, but slightly higher. This is likely due to periods of elevated flows in the Elk River that raise water levels in Swain Slough.

At the Pond C gage, when compared to the water year 2019 datums, the MLLW, MTL and MHHW all increased. The most significant increase was for the MHHW (+1.82 ft). This is due to adjustments in the MTR setting to increase the muted peak tide to around 5.0 feet at the beginning of water year 2020.

At the Hole 18 gage, the MLLW is 3.18 feet lower than the previous year. This is due to the channel excavation completed as part of the Phase 3 (2019) construction, which allows the tidal influence to extend through this reach. As such, the tidal datums for MHHW are much closer to the design values than the previous year.

The design tidal range will be provided once the project is completed and the golf course establishes an alternative water supply for irrigation. In the interim, the tidal datums can be used to determine the inundation frequency of different areas that have been revegetated with brackish-tolerant plant species. With completion of Phase 4 in 2020, the interim peak muted tide level was raised to 5.5 feet.

Table 2. Tidal Datums for dry period of July through October, 2020 at each gage station.

	Water Level (NAVD88)			
Location	**MLLW**	**MTL**	**MHHW**	**Ave. Diurnal Range**
North Spit (for epoch 1983-2001)	-0.34 ft	3.36 ft	6.51 ft	6.85 ft
Swain Slough	1.52 ft	4.09 ft	6.91 ft	5.39 ft
Martin Slough				
MS Design	1.50 ft	Not Provided	5.50 ft	4.00 ft
MS at Pond C	1.37 ft	3.11 ft	4.86 ft	3.50 ft
MS at Hole 18	1.24 ft	2.98 ft	4.73 ft	3.50 ft

3.3 Water Quality

Surface and bottom salinity concentrations and water temperatures recorded at each gaging location in water year 2020 are plotted with water level, and provided in Appendix A and Appendix B, respectively. The plots also include daily rainfall totals measured at the NWS office on Woodley Island for reference. Also included in Appendix C is a table of water quality spot measurements recorded during each data download. These include water temperature, salinity and dissolved oxygen concentrations.

3.3.1 Water Quality Performance Criteria

The project monitoring plan defines performance criteria for salinity, water temperature, and dissolved oxygen (DO). The performance criteria for each of these parameters is applied during periods when salmonids are expected to be present. This is applied primarily to Pond G and the North Fork Tributary, which are intended to provide over-summering habitat for rearing salmonids. For salinity, the threshold is 4 ppt, and is generally applied to the surface salinity concentrations due to higher DO concentrations near the surface.

Water temperature performance criteria are based on daily values. Water temperature should maintain a daily average at or below 18° C and daily maximum at or below 21°C during periods when salmonids are expected to be present. Plots of daily average and daily maximum water temperatures are provided in Figure 5.

The project monitoring plan defines performance criteria for DO concentrations as being no lower than 4 mg/l during periods when salmonids are anticipated to be present. This is generally applied to surface DO concentrations, as bottom concentrations can be substantially lower when fish are present.

3.3.2 Salinity and Temperature

The project, when completed, is intended to create a longitudinal gradient of salinity, with highest salinity near the tide gate transitioning to freshwater conditions at the upstream end, with each pond having different concentrations of brackish water. Additionally, stratification is expected to provide a vertical gradient from more saline waters at the bottom to less brackish water near the surface. During rainfall-runoff events the entire project channel length and all the ponds are anticipated to be predominately freshwater. The water year 2020 salinity data show these conditions are partially provided, as expected. With completion of future project phases, the longitudinal salinity gradient will extend further upstream.

Water temperatures within the project area are dependent on air temperature, temperature of freshwater inflow from upstream, and temperatures of inflow from Swain Slough. During winter months temperatures are anticipated to be similar to freshwater streams around Humboldt Bay. During the dry season, areas with brackish water should experience higher water temperatures due to influences from water temperatures in Humboldt Bay and Swain Slough. These can well exceed 20 degrees Celsius due to shallow inundation of mudflats during rising tides in the day time. Water temperature data from water year 2019 and 2020 show these expected trends.

Swain Slough Salinity and Temperature

Salinity was not recorded in Swain Slough. Water temperatures in Swain Slough during the fall of 2019 and early winter of 2020 were similar to those measured in the freshwater reach of Martin Slough near Hole 18 and upstream at MS-NF, with small diurnal temperature fluctuations. However, by mid-April 2020, water temperatures in Swain Slough become more elevated compared to near Hole 18 and both diurnal and tidal influenced temperature fluctuations become more apparent.

Martin Slough near Pond C Salinity and Temperature

In Martin Slough, near Pond C, the salinity was highly correlated to precipitation, and stratification was present during periods not dominated by freshwater inflows. During periods between rainfall events the bottom salinity would fluctuate dramatically with incoming verses outgoing tides, while the surface salinity generally fluctuated less and was less brackish. During periods with precipitation, salinity concentrations became close to zero for days at a time. Several days following the cessation of rainfall, the bottom salinity would increase relatively rapidly, while the surface salinity slowly increased with each tide cycle. This pattern was most pronounced in January 2020.

Water temperatures in Martin Slough near Pond C remained low throughout the fall and early winter months. Surface and bottom temperatures were nearly identical much of the time, with periods where the surface water temperature was colder and fluctuated much more with tidal cycles than along the bottom. This is assumed to be associated with stratification during flood tide and then mixing during ebb tide. As early as February 2020, temperatures at this location began to rise, as did

salinity, due to the minimal rainfall for the entire month. During the summer months water temperatures remained above 20° C and were consistently warmer than Swain Slough.

Martin Slough near Hole 18 Salinity and Temperature
Salinity measurements in Martin Slough near Hole 18 show that for nearly the entire monitoring period the bottom had salinity concentrations between 9 ppt and 12 ppt with the exception of during rainfall events, while the surface fluctuated between saline and fresh with the tides. Water temperatures in Martin Slough near Hole 18 fluctuated with tides, and showed diurnal fluctuation with changes associated with precipitation and ambient air temperature.

The bottom salinity (and temperature) logger was removed for repairs in May and sent to the manufacturer for data recovery and was reinstalled in September just before the end of the monitoring period.

Martin Slough at the North Fork Confluence Salinity and Temperature
Salinity measurements for the gage located on the mainstem downstream of the confluence with the North Fork Tributary show that no brackish water is reaching the upper reach of martin slough in the project area. This was expected because of the temporary grade control that was downstream of the gaging station.

Temperature values show normal diurnal fluctuations, with warming during the summer months. This is the area of the project that the performance criteria for water temperature is applied year-round, due to the desire to provide year-round conditions suitable for rearing salmonids. In general, water temperatures remained below thresholds throughout water year 2020 (Figure 5), except for the surface temperatures on a couple occasions. Two days the daily average surface water temperature exceeded 18°C, and on three days the daily maximum surface water temperature exceeded 21°C. These increased water temperatures may be due to the locations of coffer dams in Martin Slough during construction, which were installed below and above the NF gage station at varying times during the summer as part of construction sequencing. In particular, the coffer dam was moved to just downstream of the NF gage in late August. The water temperatures recorded during summer of 2020 may be higher than will occur in the future due to warming of the increased surface area from backwatering by the coffer dams.

3.3.3 Dissolved Oxygen Spot Measurements

Spot measurements of dissolved oxygen (DO) by RCAA staff during each download are provided in Appendix D. The measured DO levels at the four sites were generally above the minimum performance criteria of 4 mg/l on the surface, and were often substantially higher. These DO levels are considered acceptable for rearing salmonids and other aquatic organisms.

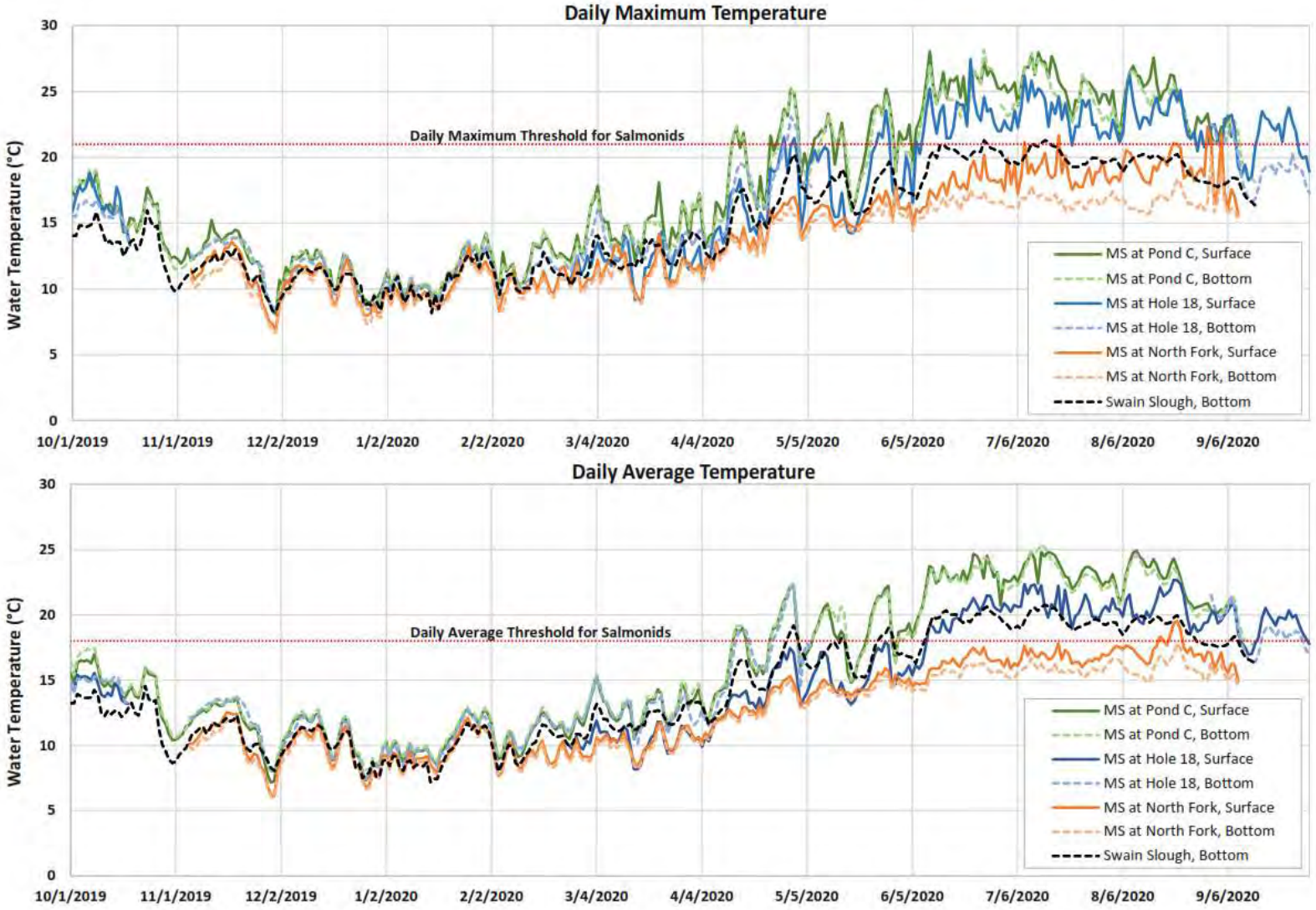


Figure 5. Daily maximum and daily average water temperatures for water year 2020 recorded at the Swain Slough, Martin Slough at Pond C, Martin Slough at Hole 18 and Martin Slough at the North Fork Confluence gaging stations. Summer salmonid usage assumed to be in the vicinity of the MS at North Fork station.

4 RECOMMENDATIONS

The Martin Slough Enhancement Project is being implemented in phases. The intended project hydrology, including the introduction of the design muted tidal prism, will not be fully functional until all of the project phases are completed. As such, the findings from the first year of monitoring following completion of Phase 3 (second year of monitoring following Phase 2) show that the tidal amplitude and prism has increased for the first year but is still less than the design range. However, the estuary environment created with Phase 2 and Phase 3 completed is already present, with brackish water extending up the mainstem, and salinity concentrations fluctuating with rainfall events and with tidal fluctuations.

The water level data and associated tidal datums show that Reach 4 and Pond D are receiving the intended tidal inundation and associated brackish water. With the completion of Phase 4 and bringing on-line Ponds E and F in the fall of 2020, the tidal range was increased and the 6-foot by 6-foot MTR was activated to increase conveyance capacity during flood tides given the increased tidal prism.

An area of potential concern arising out of the water year 2019 monitoring is associated with the high point identified along the thalweg profile around Station 14+00 due to a slumping bank associated with high groundwater and saturated soils close to the base of the adjoining hillslope. Material may be continuing to slump at this location, but currently is not significantly constricting the channel or influencing the tidal amplitude. Additional channel constriction could cause upstream flooding and channel sedimentation, and would limit upstream tidal influences. The project manager and project engineer should inspect this site after high flow events to detect if any additional slumping occurs, and if material is being transported. This reach is slated to be resurveyed as part of next topographic monitoring activities in summer of 2021.

The log weirs at Pond D have shown some scouring behind the training logs and around the log posts due to flanking at high flows. Next summer, when this section of channel is dry, the areas of scour around the training logs should be reinforced with rock or compacted earth combined with use of live stakes and other plantings to slow the water velocities in this area and add root strength to the banks. Brush baffles could also be installed with live stakes to provide additional hydraulic roughness. The training logs were installed according to plan; however, the overhang of the logs may be causing some flow constriction that forces flow into the areas of source. Therefore, it would be beneficial to cut these logs to reduce the overhang distance. Cutting them so the end of the log is aligned with the outside of edge of the adjoining log post would likely suffice.

5 REFERENCES

NOAA, 2003. Science-based restoration monitoring of coastal habitats, Volume 1: A framework for monitoring plans under the Estuaries and Clean Water Act of 2000.

RCAA, 2018. Martin Sough Enhancement Project Monitoring Plan. August 2013, Revised July 2018. By Redwood Community Action Agency Natural Resources Services Division.

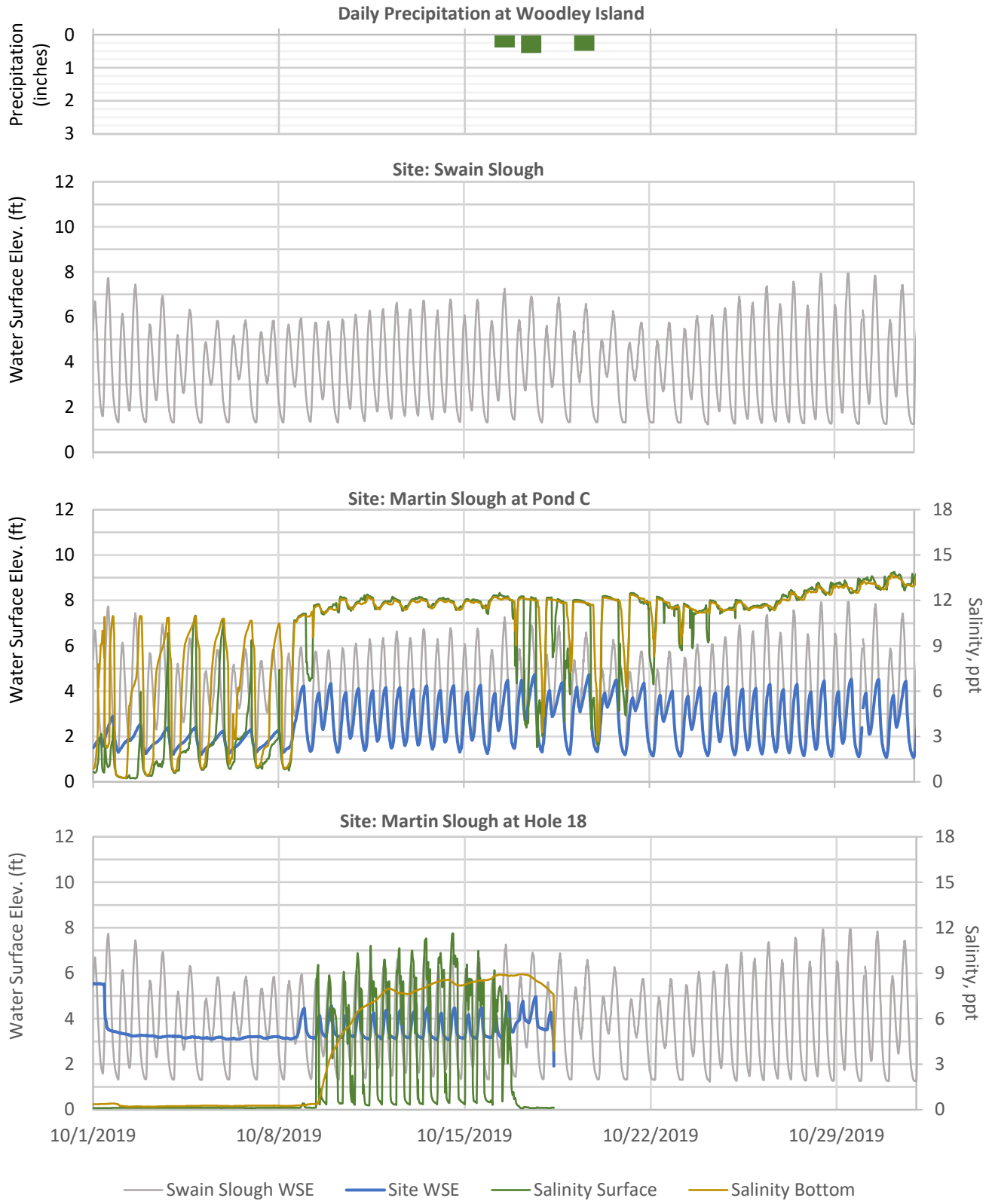
Appendix A

Martin Slough Water Level and Water Quality Data

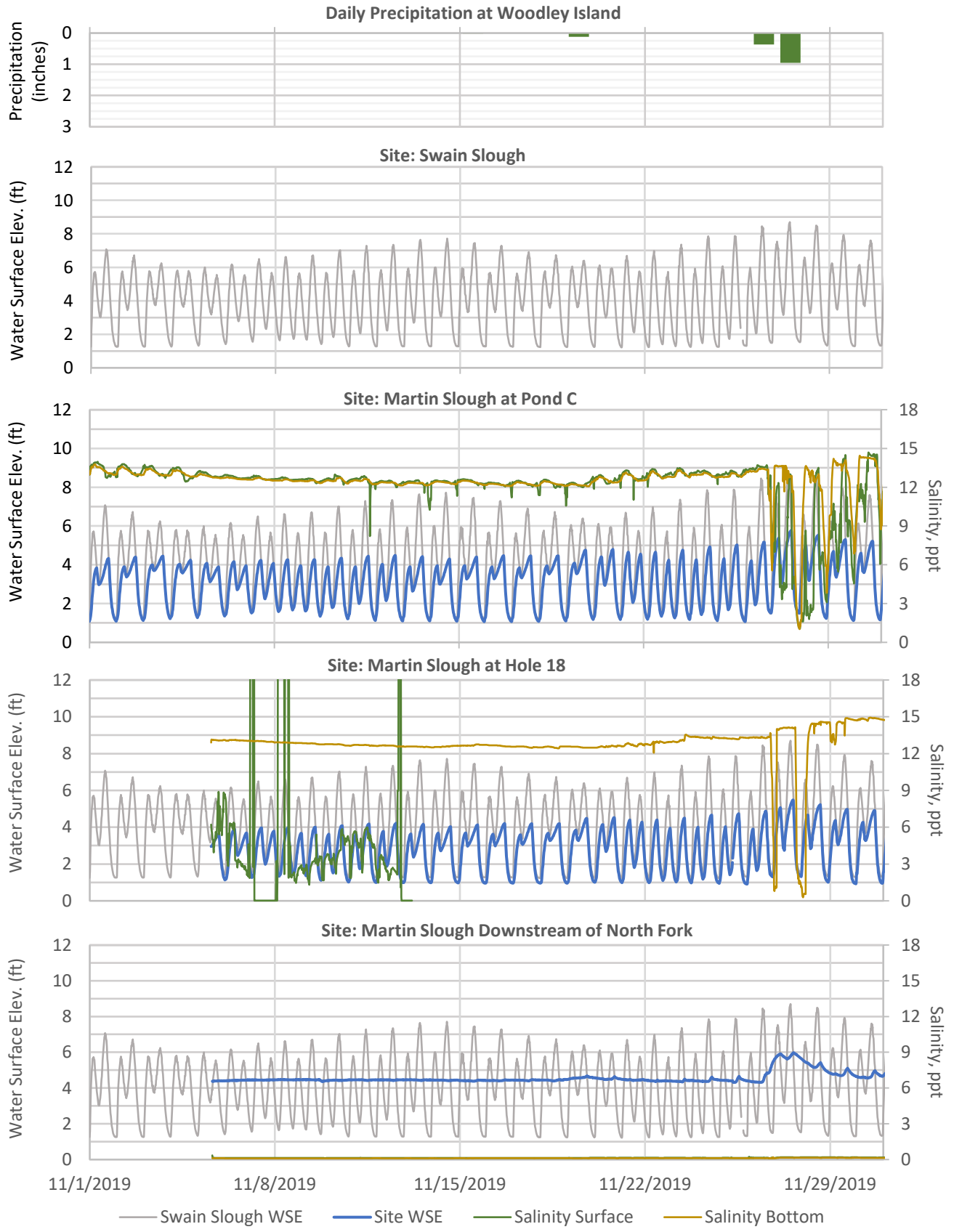
Water Year 2020:

Stage and Salinity Plots

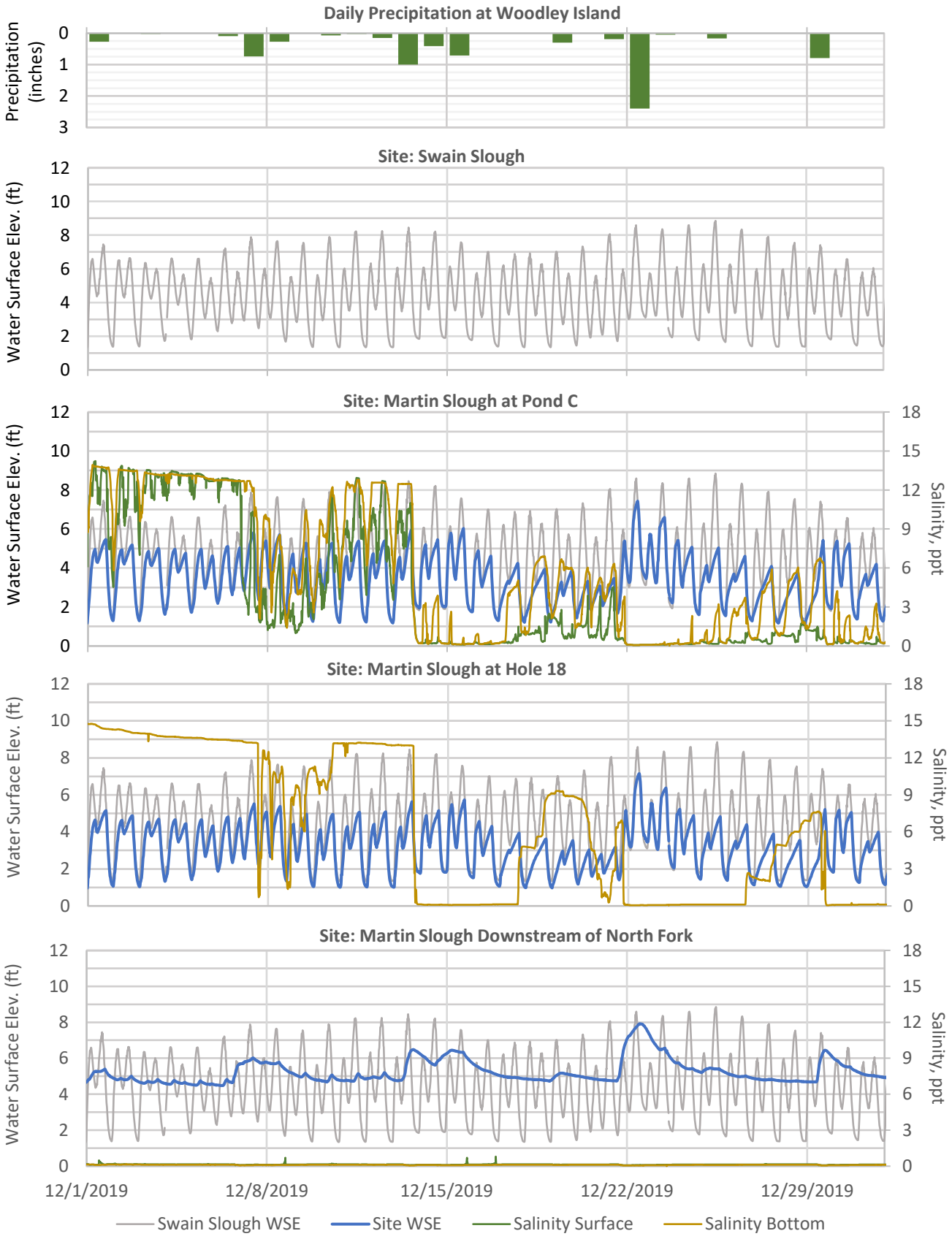
Martin Slough **October 2019**



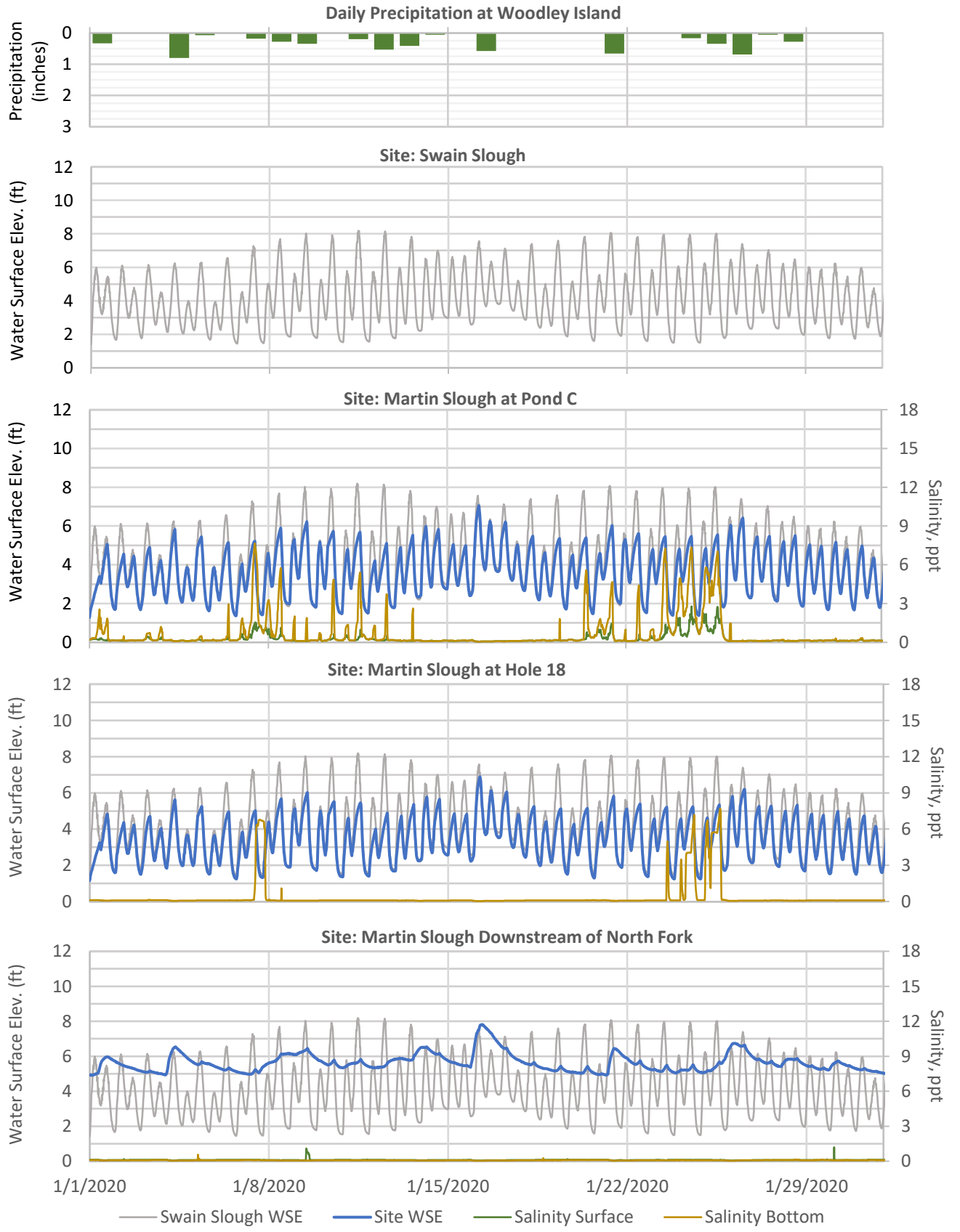
Martin Slough **November 2019**



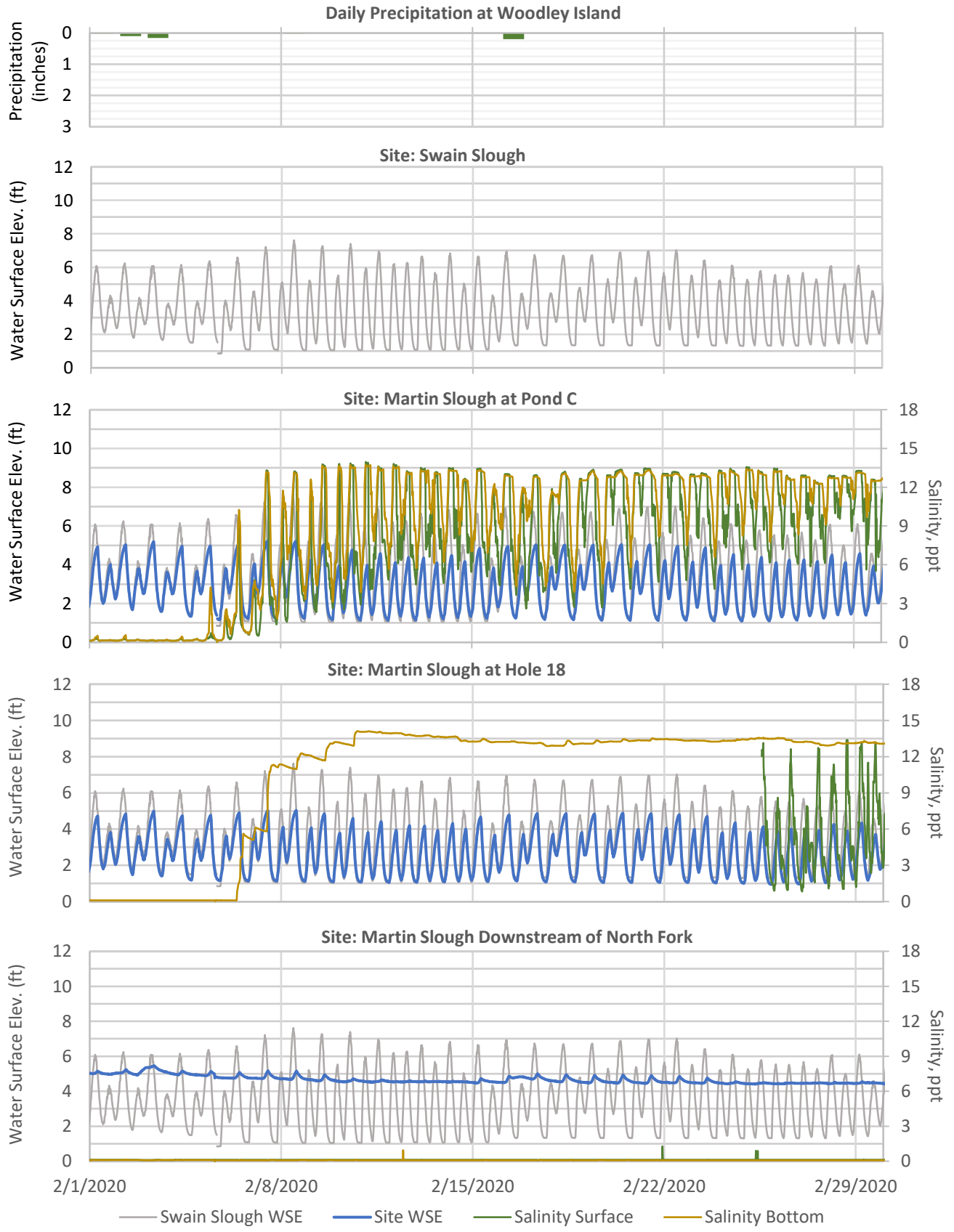
Martin Slough **December 2019**



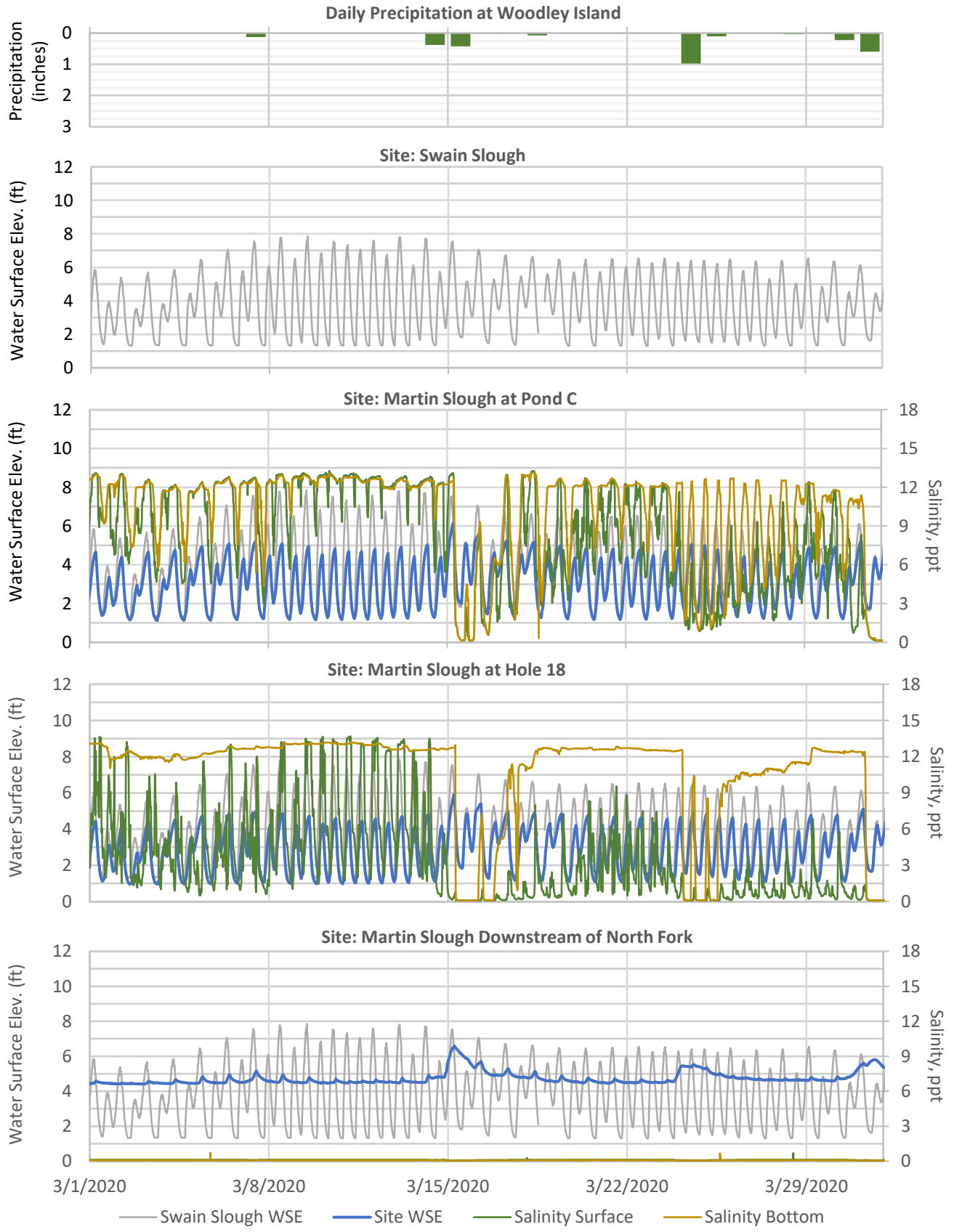
Martin Slough **January 2020**



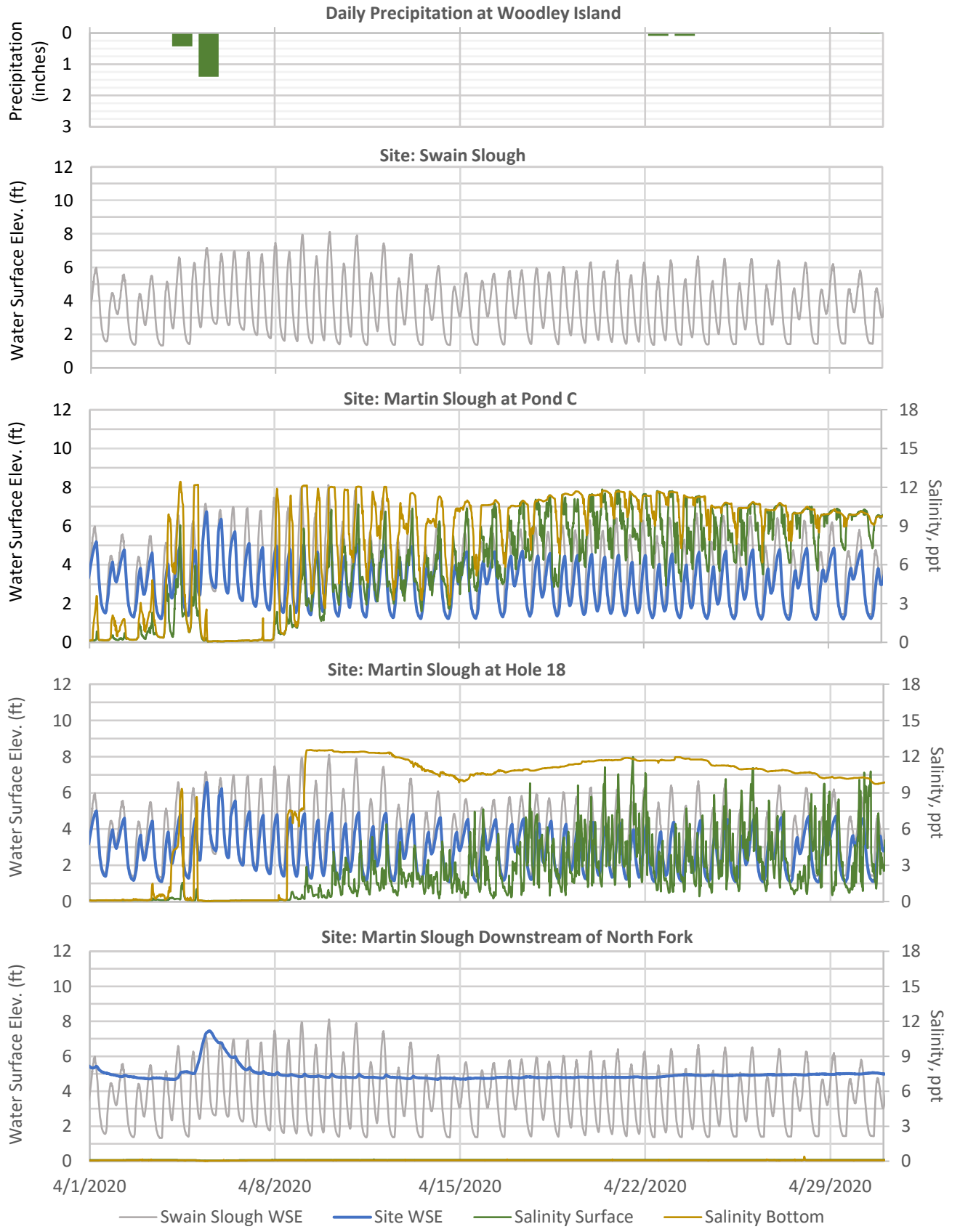
Martin Slough **February 2020**



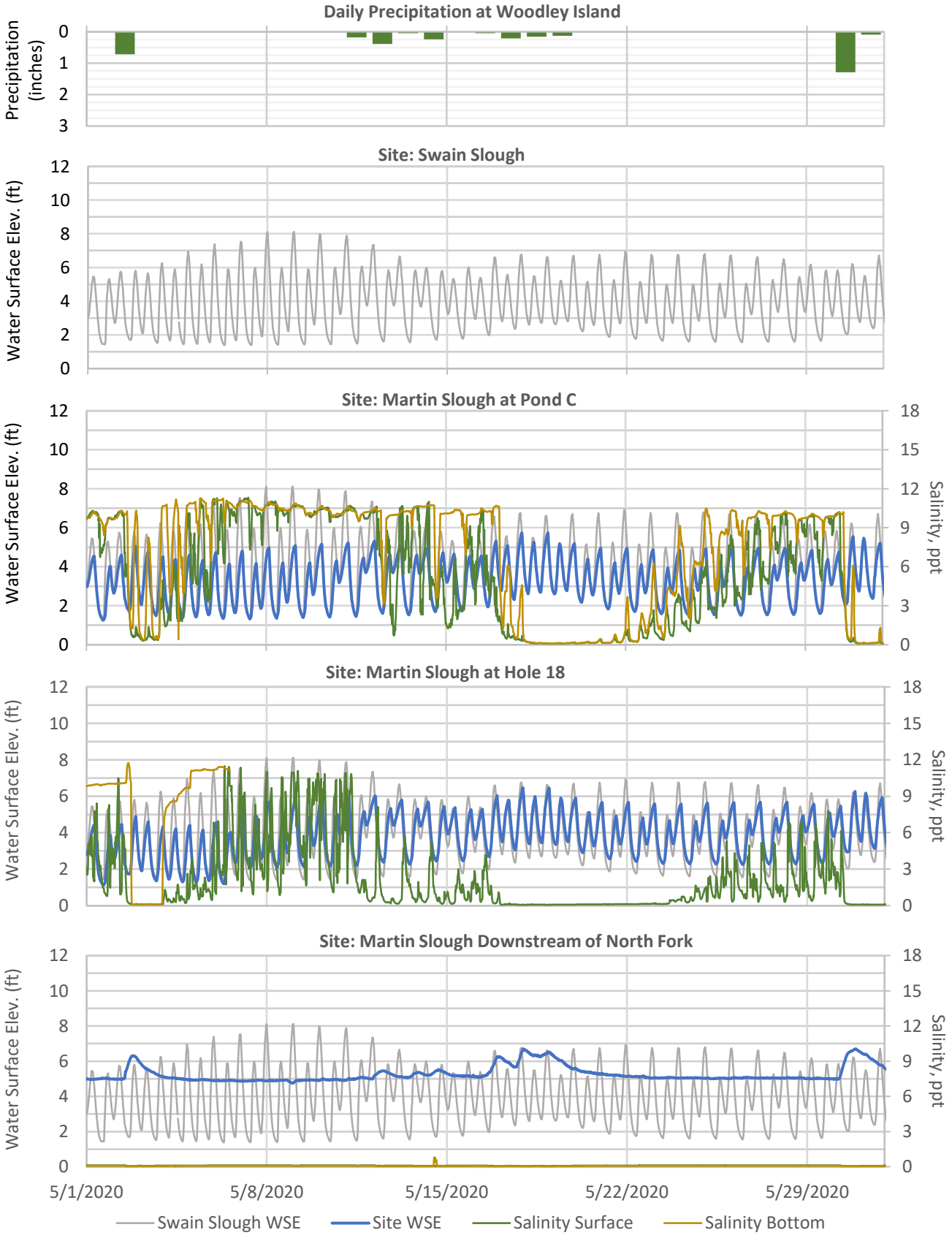
Martin Slough **March 2020**



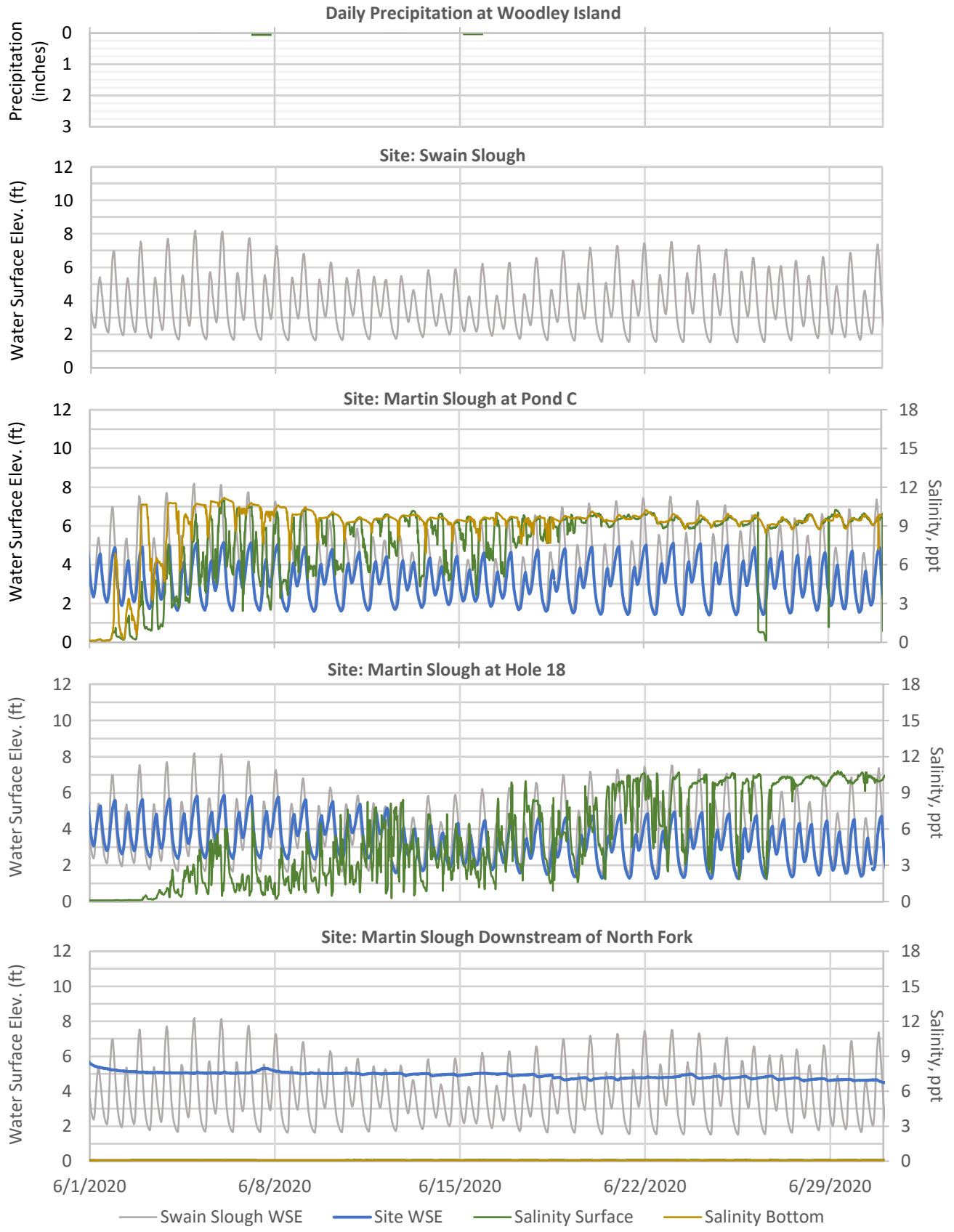
Martin Slough **April 2020**



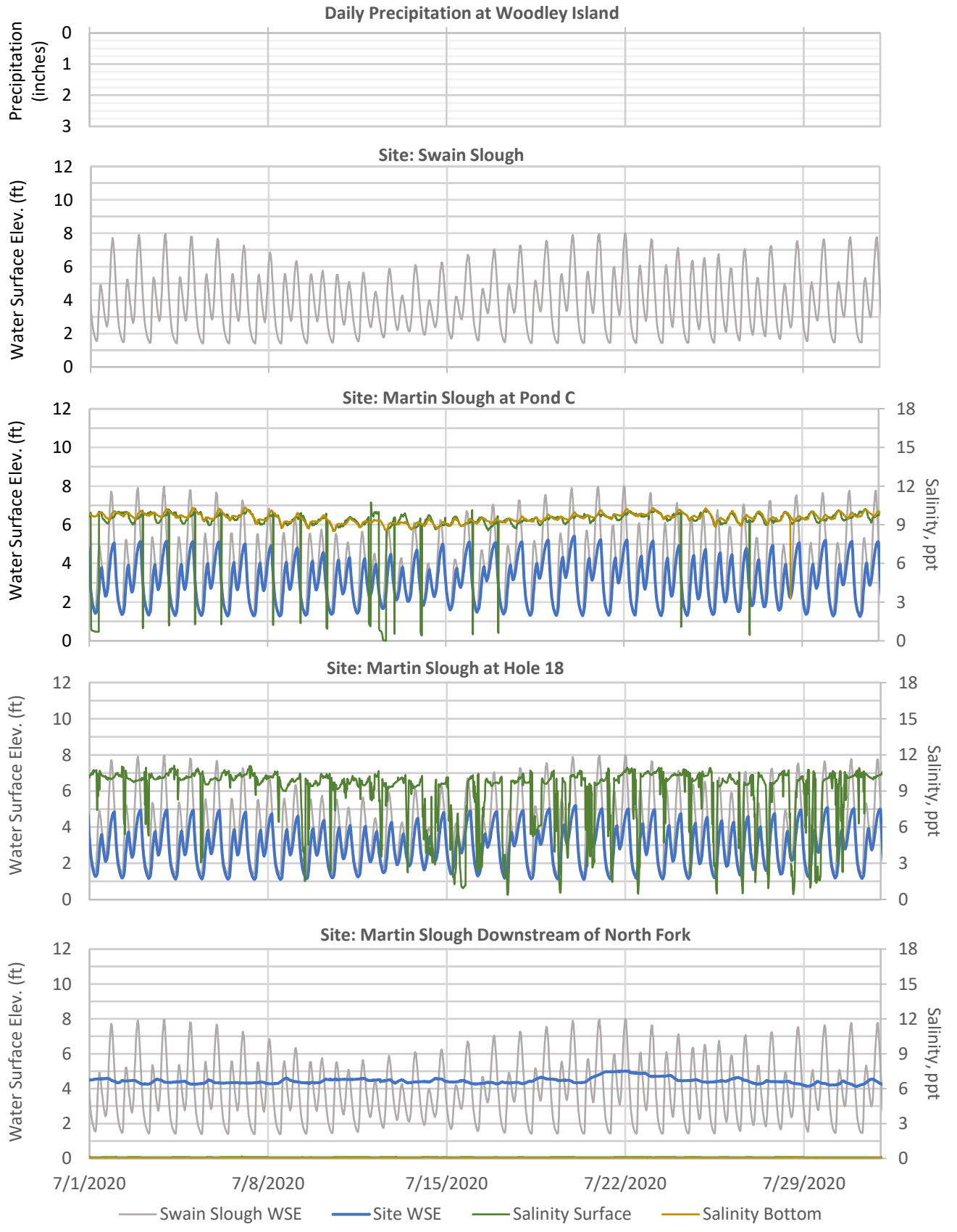
Martin Slough **May 2020**



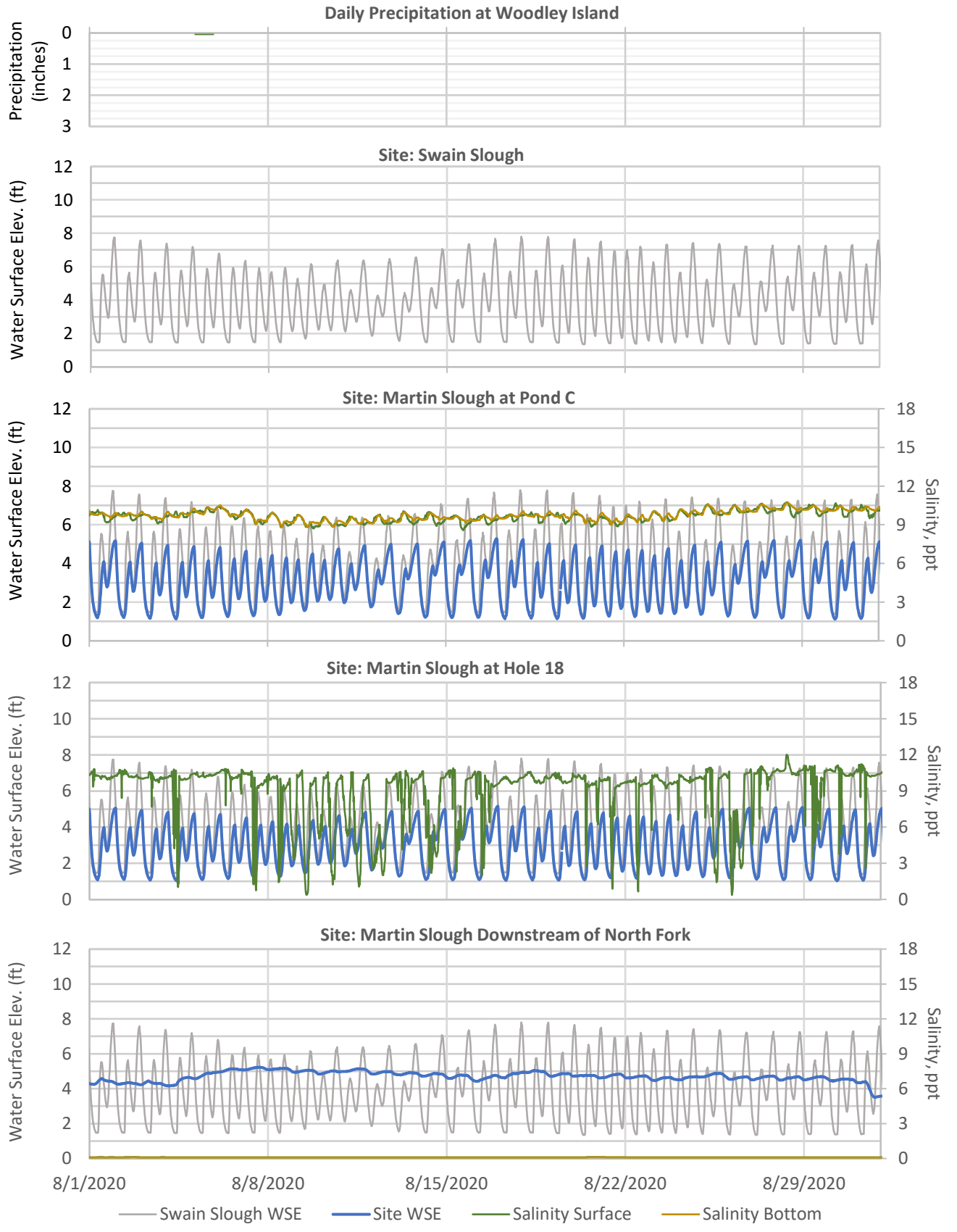
Martin Slough **June 2020**



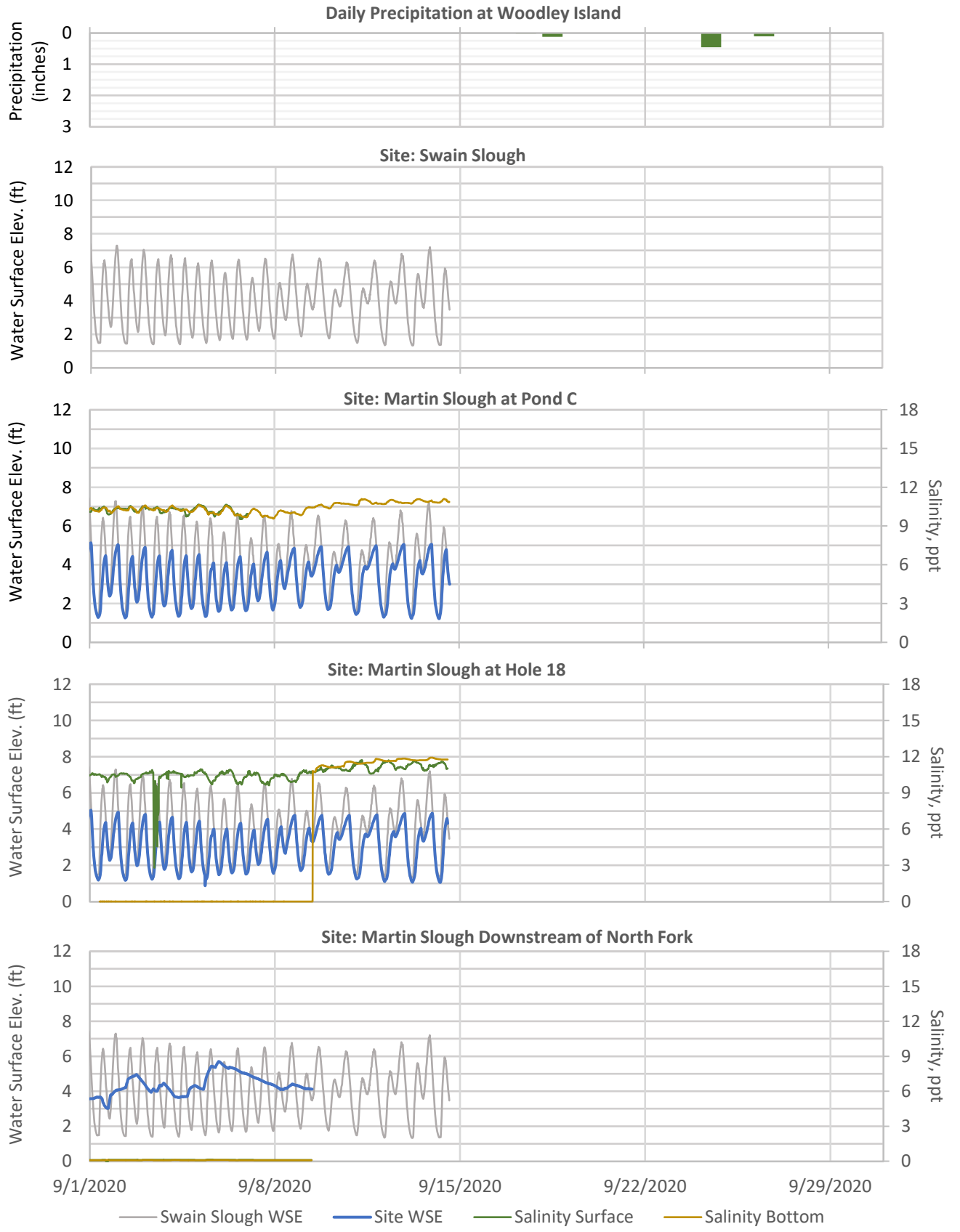
Martin Slough **July 2020**



Martin Slough **August 2020**



Martin Slough **September 2020**



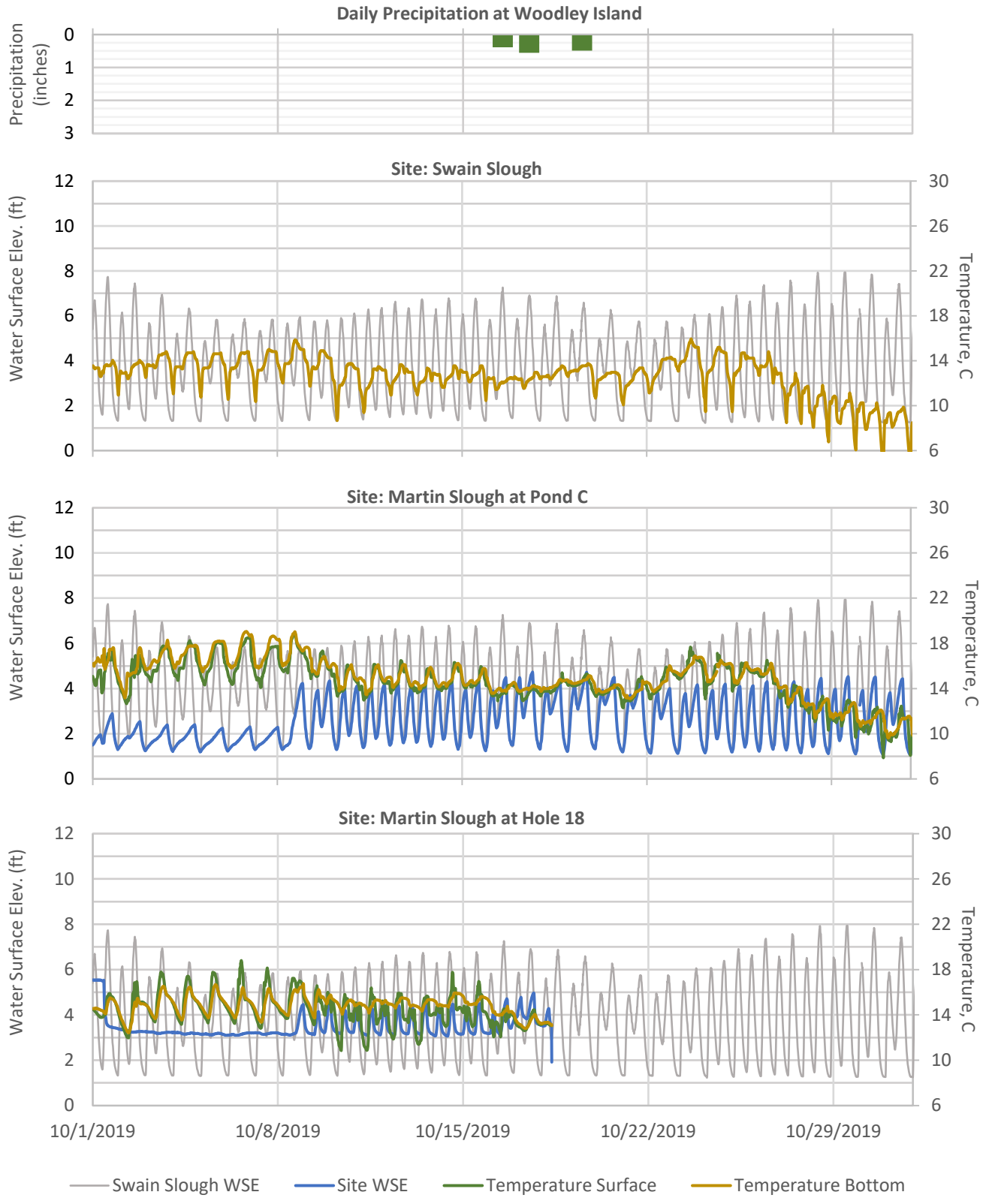
Appendix B

Martin Slough Water Level and Water Quality Data

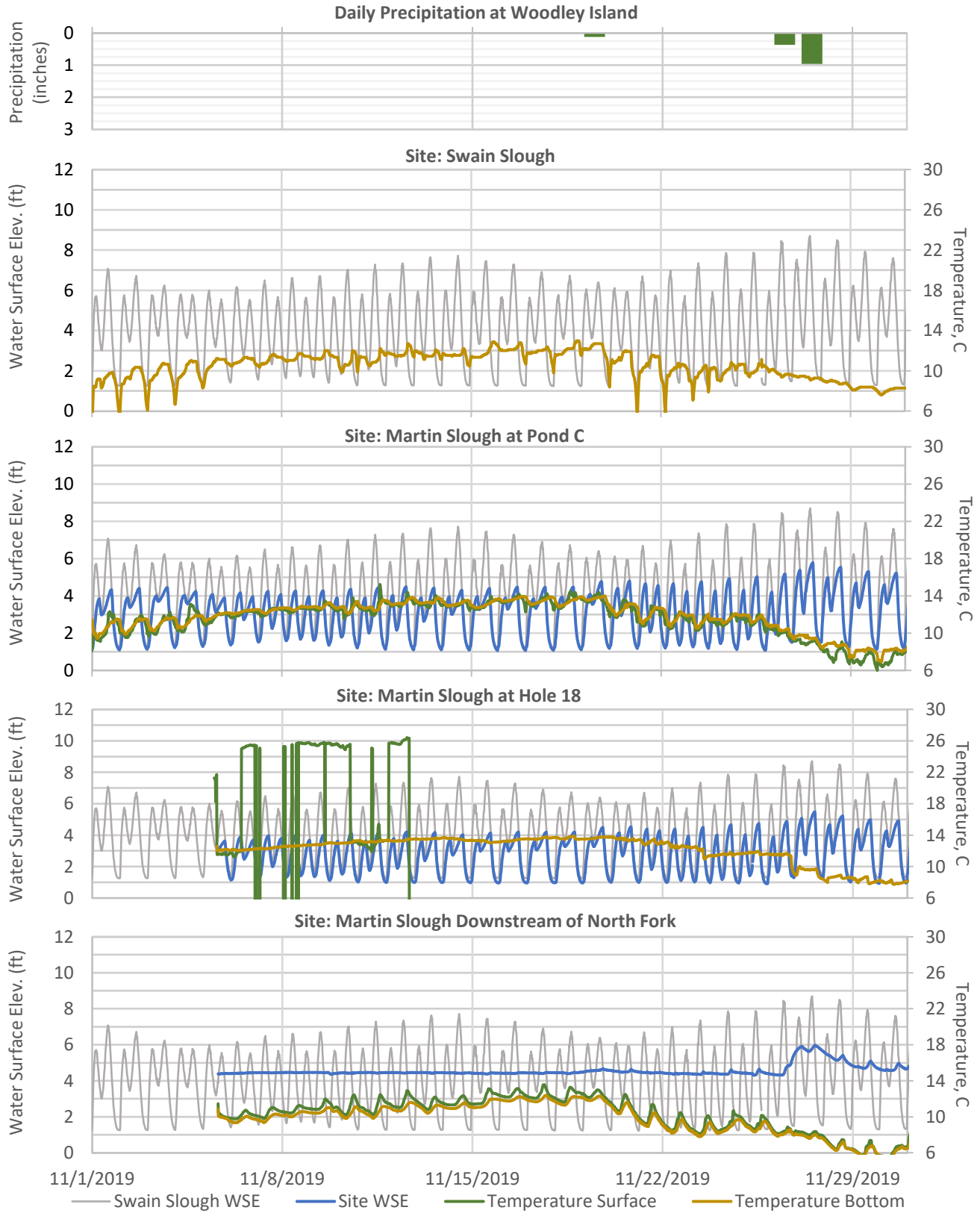
Water Year 2020:

Stage and Temperature Plots

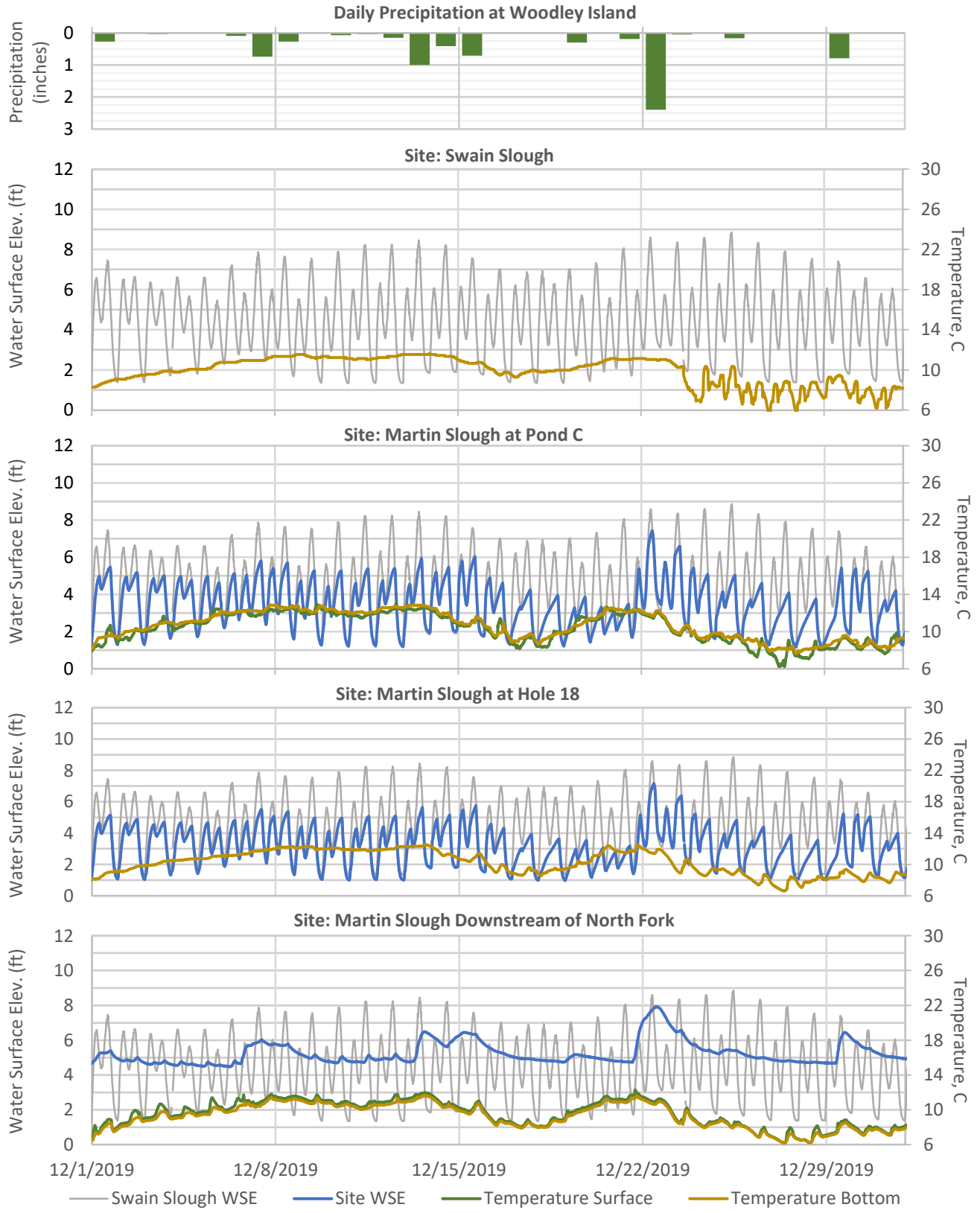
Martin Slough **October 2019**



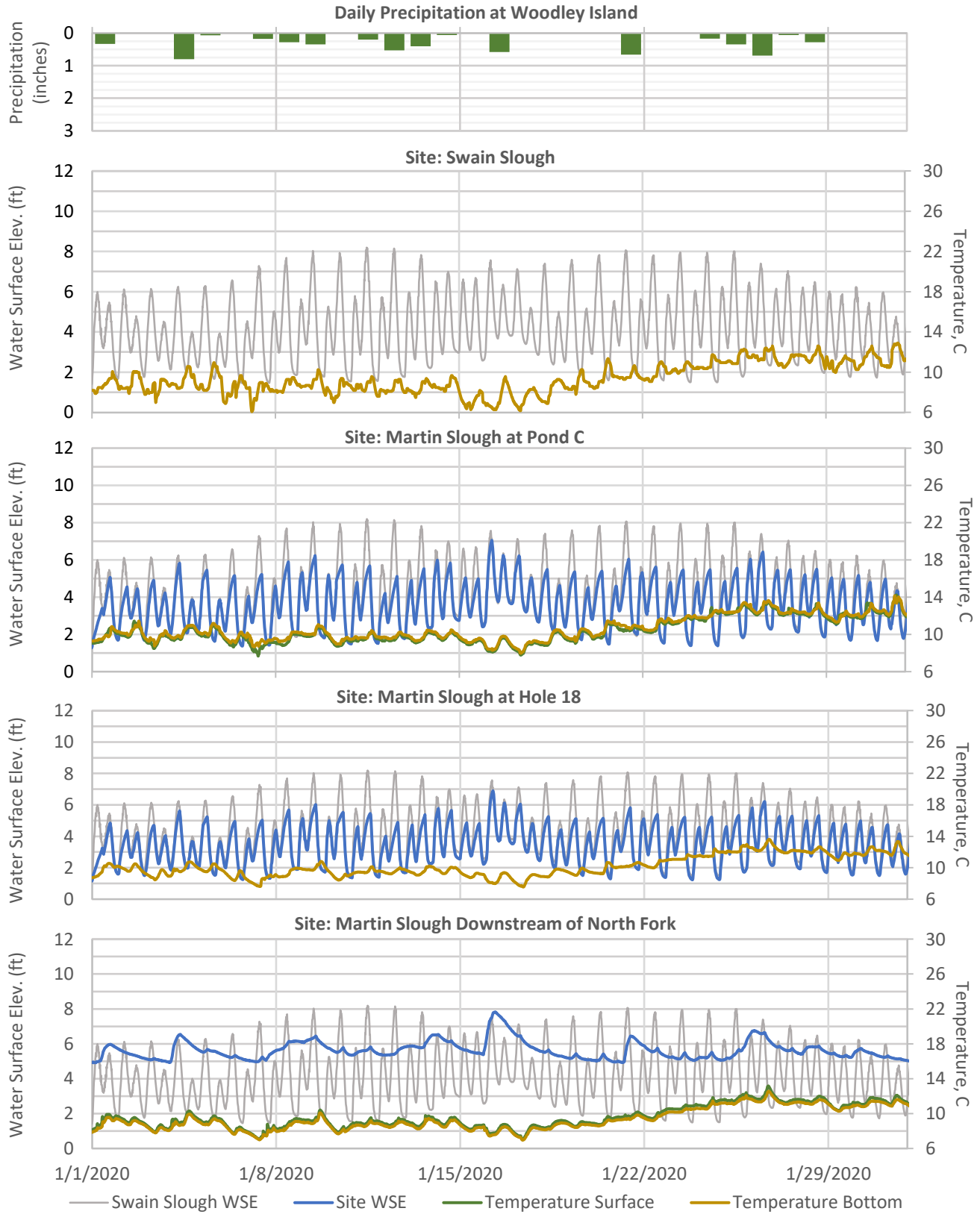
Martin Slough **November 2019**



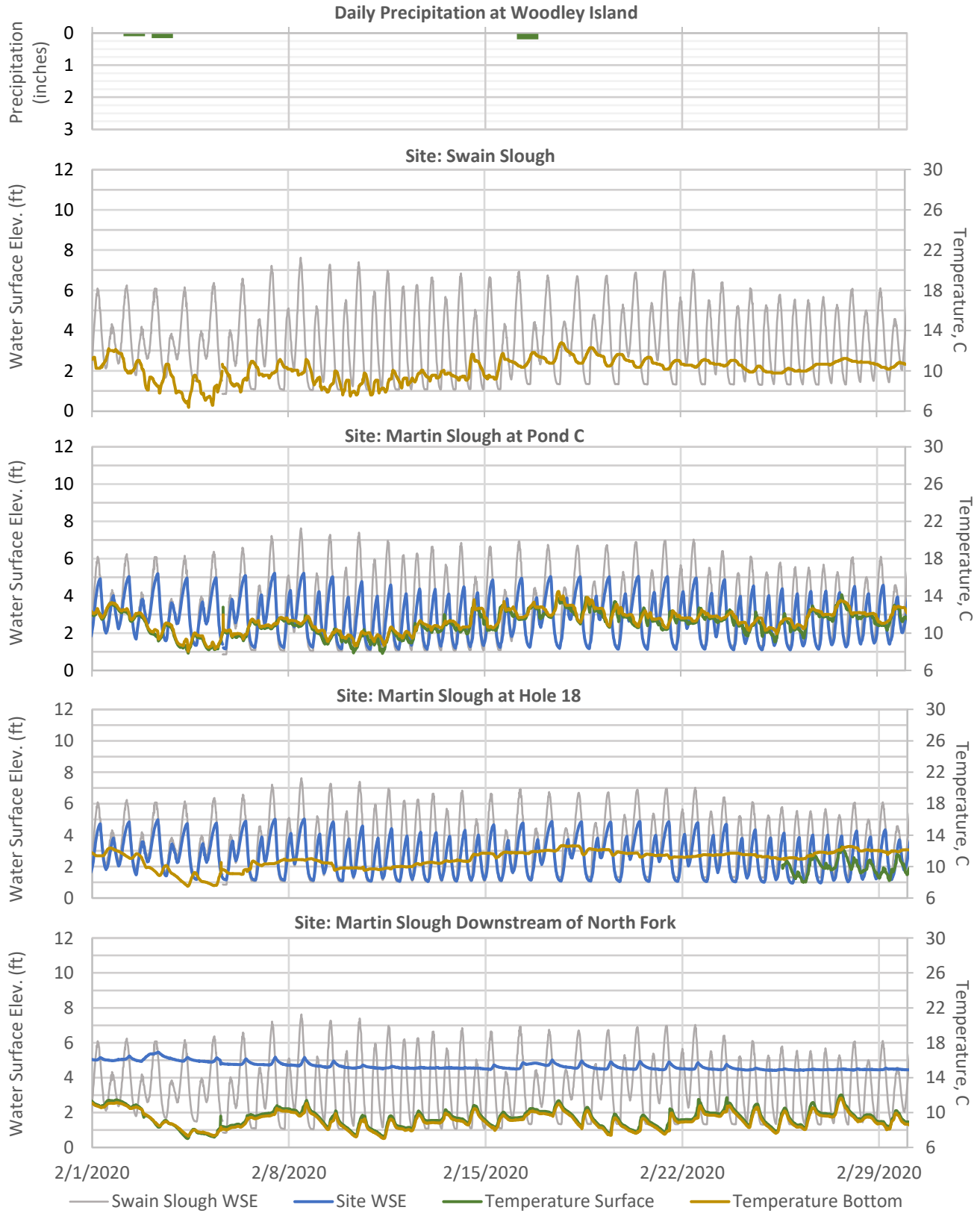
Martin Slough **December 2019**



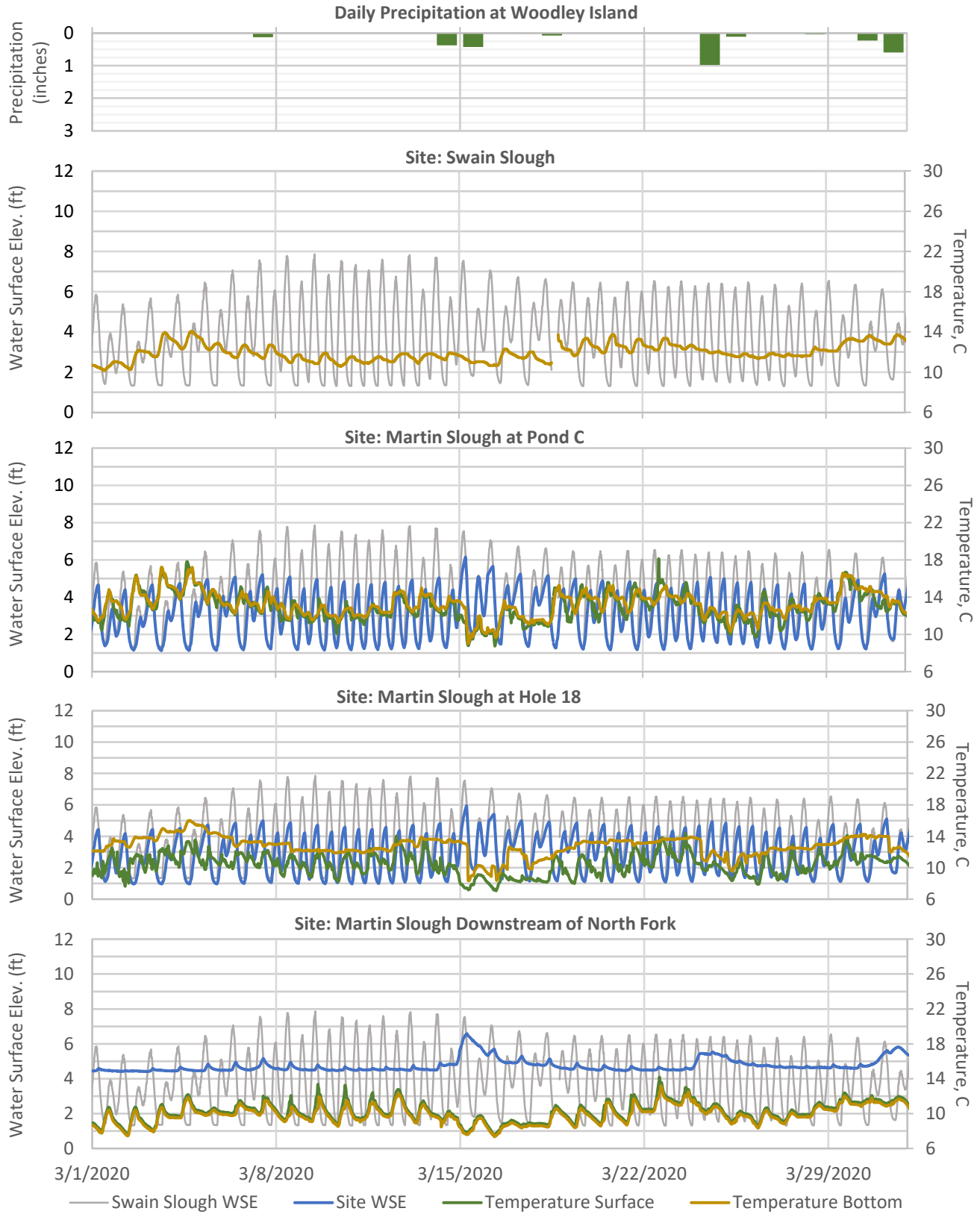
Martin Slough **January 2020**



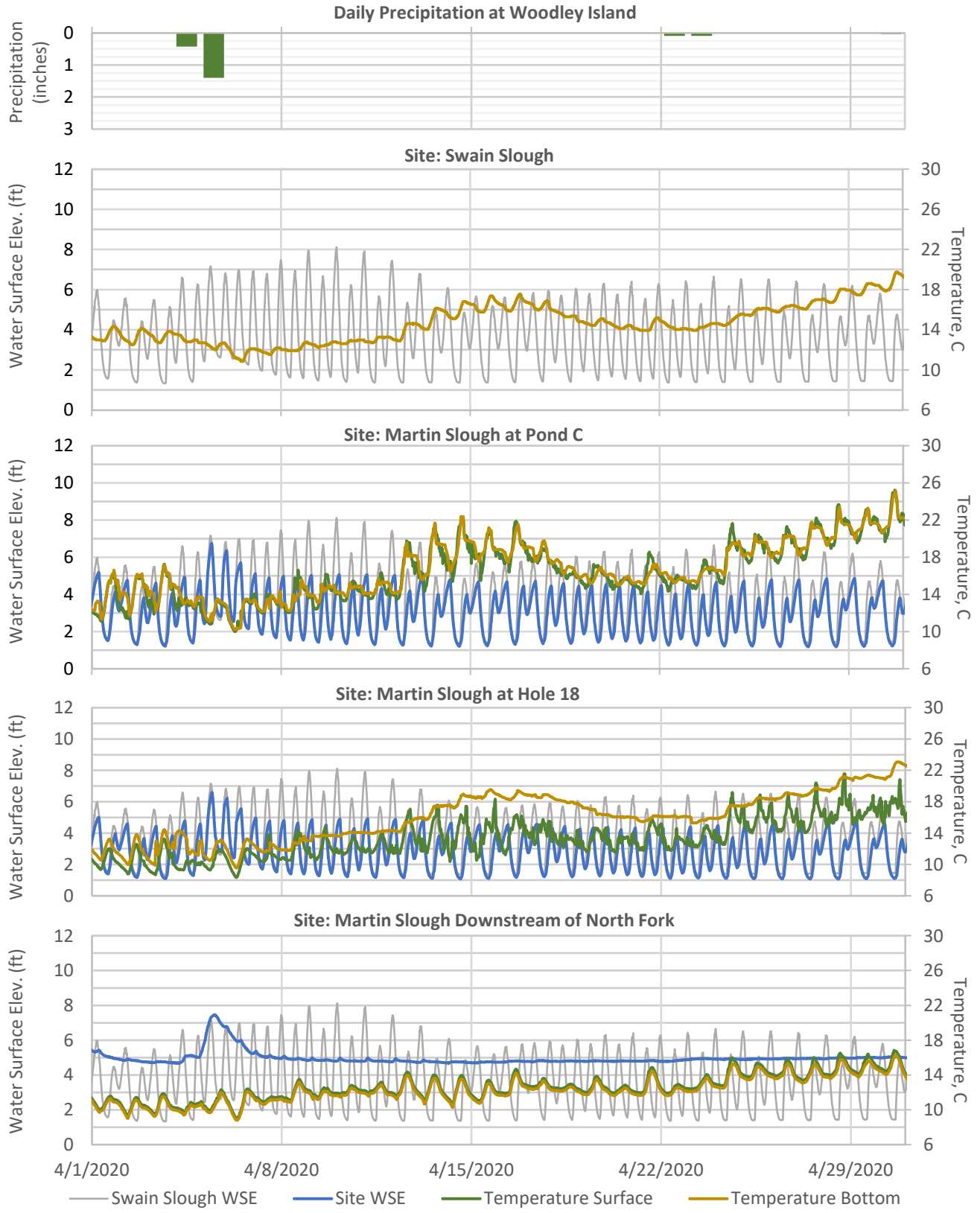
Martin Slough **February 2020**



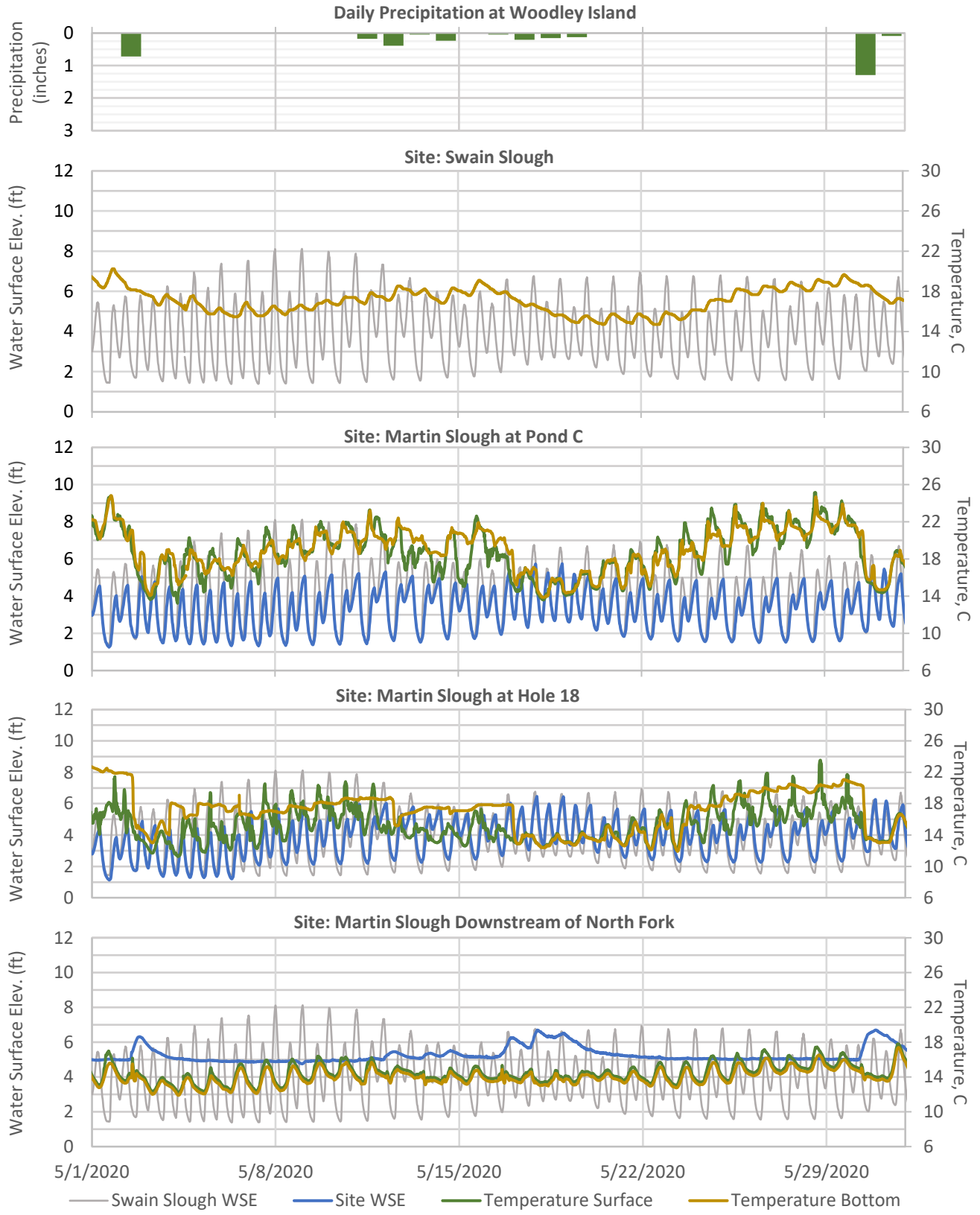
Martin Slough **March 2020**



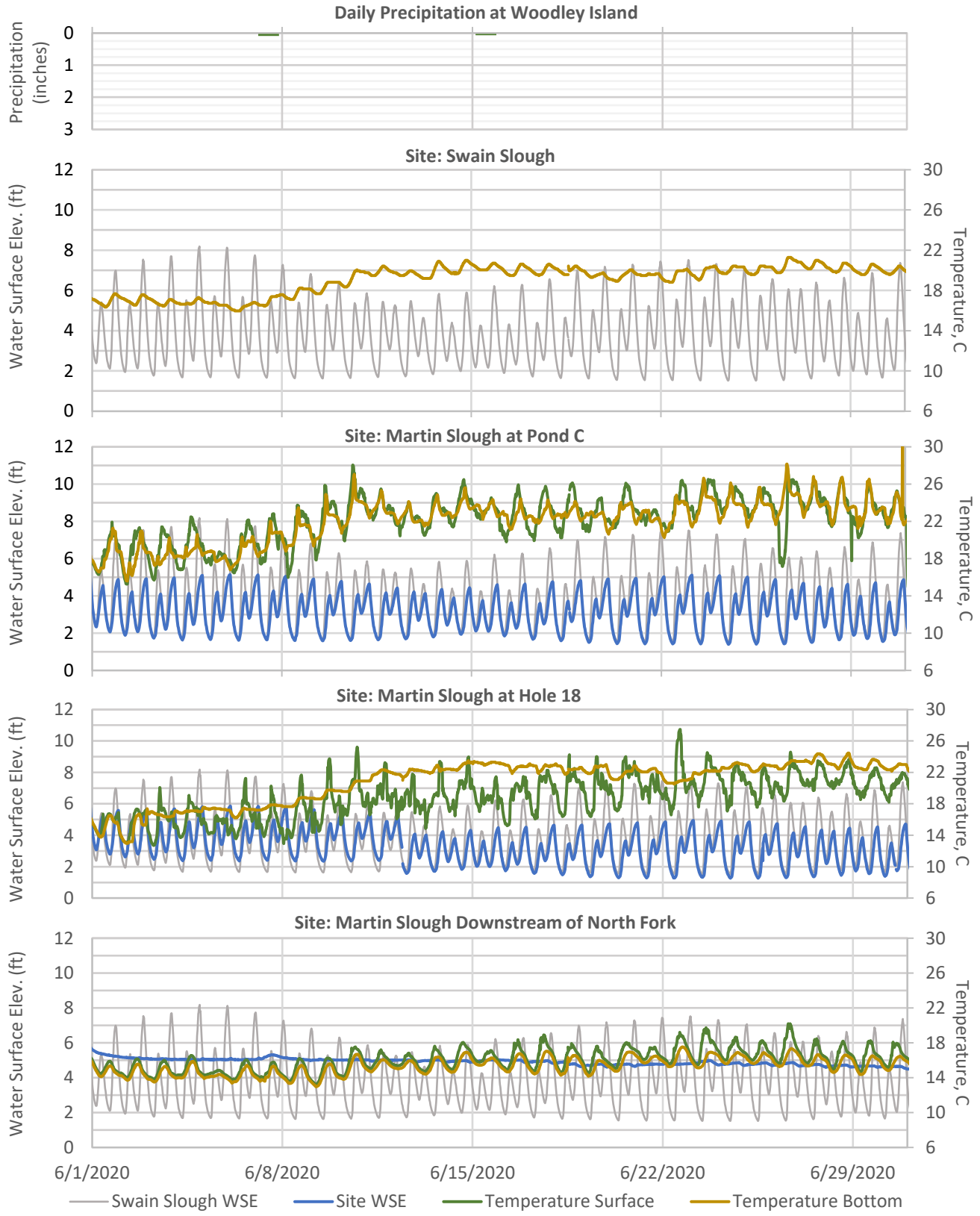
Martin Slough **April 2020**



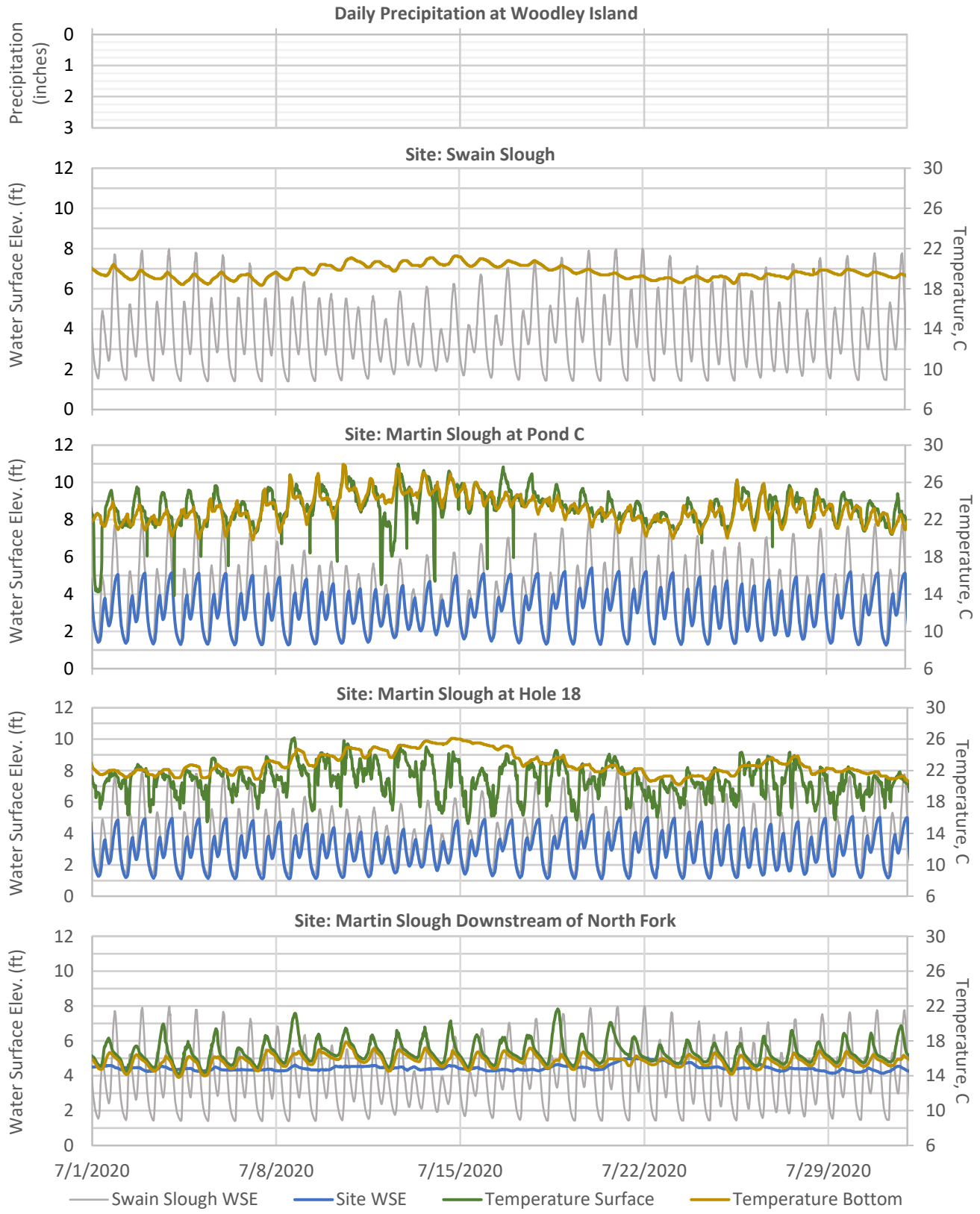
Martin Slough **May 2020**



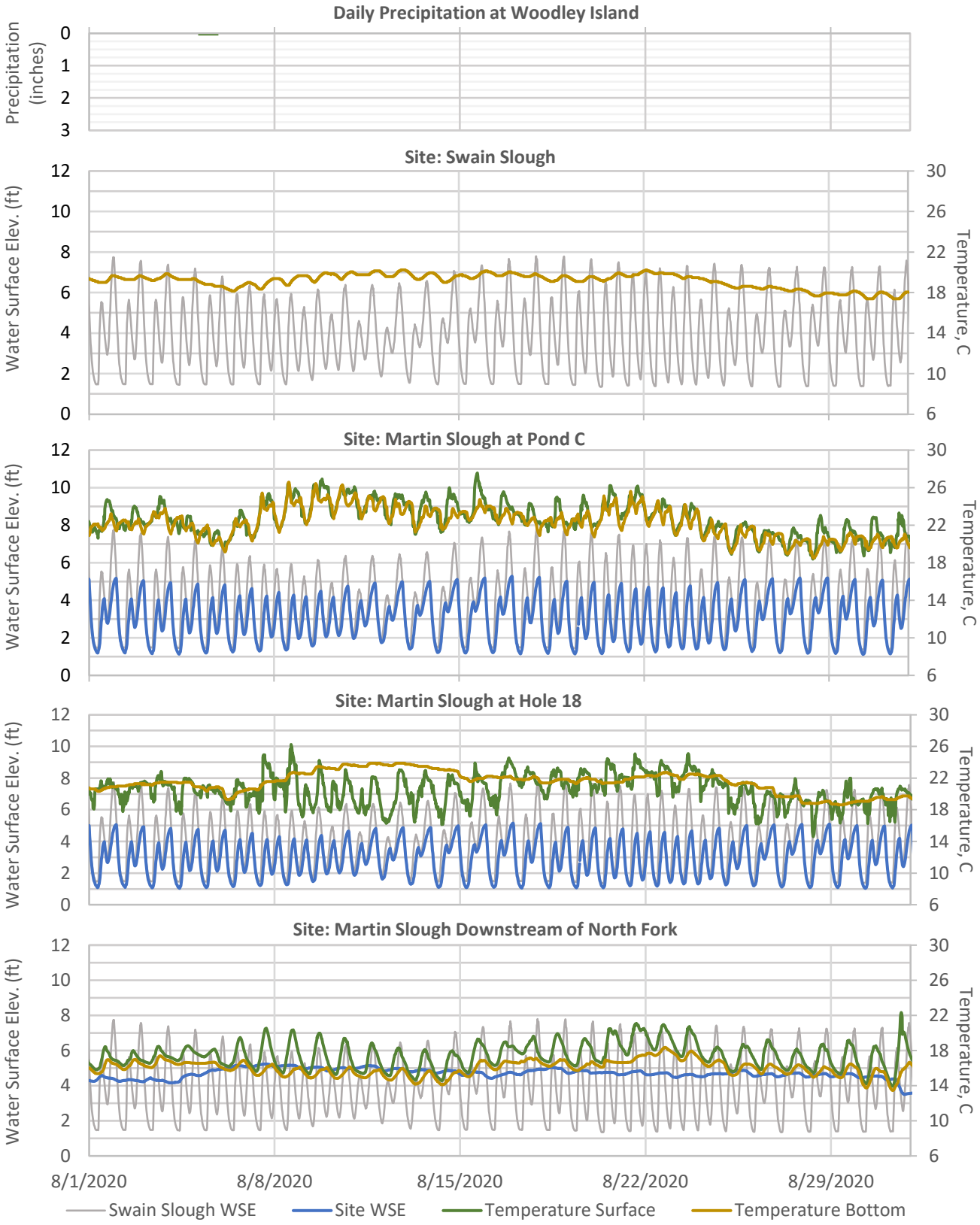
Martin Slough **June 2020**



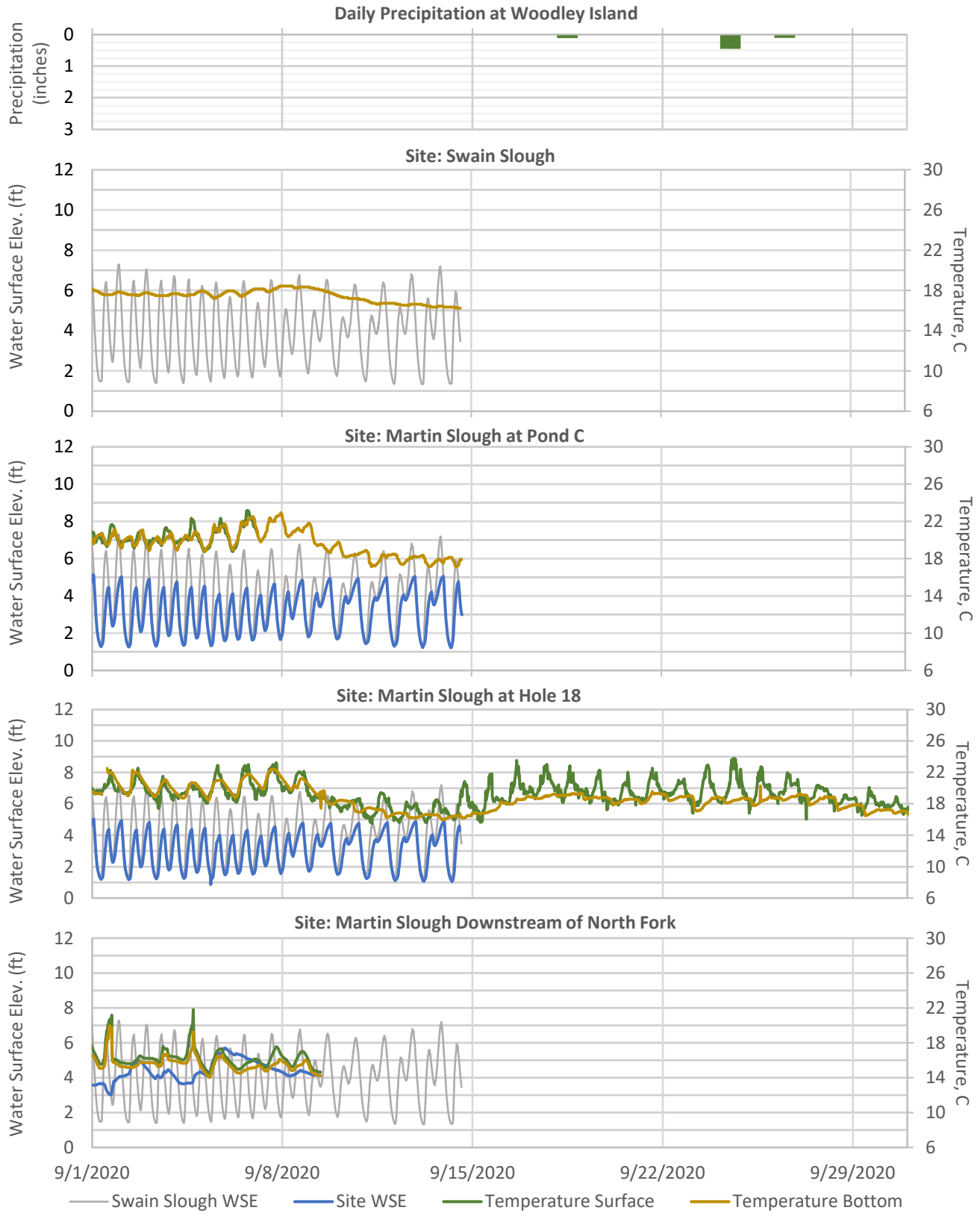
Martin Slough **July 2020**



Martin Slough **August 2020**



Martin Slough **September 2020**



Appendix C

Martin Slough Water Quality Spot Measurements

Martin Slough Channel Enhancement

Discrete Measurements of Water Surface Elevations (WSE) and Water Quality Parameters

Date: October 24, 2019			Period: Post Project						
			Surface			Bottom			
Gage Location	Time (PST)	WSE NAVD88 (ft)	D.O. (mg/L)	Salinity (ppt)	Temp (°C)	D.O. (mg/L)	Salinity (ppt)	Temp (°C)	Tide at Gage
Swain Slough	3:15 PM	2.30	6.0	20.0	15.2	6.0	12.7	14.4	
MS POND C	4:45 PM	1.78	7.3	16.0	14.7	10.5	26.4	14.1	

Date: December 23, 2019			Period: Post Project						
			Surface			Bottom			
Gage Location	Time (PST)	WSE NAVD88 (ft)	D.O. (mg/L)	Salinity (ppt)	Temp (°C)	D.O. (mg/L)	Salinity (ppt)	Temp (°C)	Tide at Gage
Swain Slough	2:45 PM	2.95	12.8	0.2	8.8	11.0	0.2	8.8	Ebb
MS POND C	3:45 PM	2.58	12.0	0.1	9.0	9.5	0.1	9.0	
MS-18	1:45 PM	3.51	10.1	0.1	8.7	7.1	0.1	8.7	Ebb
MS-NF	1:00 PM	6.32	11.0	0.1	8.2	9.1	0.1	8.2	Ebb

Date: February 5, 2020			Period: Post Project						
			Surface			Bottom			
Gage Location	Time (PST)	WSE NAVD88 (ft)	D.O. (mg/L)	Salinity (ppt)	Temp (°C)	D.O. (mg/L)	Salinity (ppt)	Temp (°C)	Tide at Gage
Swain Slough	3:30 PM	1.51				7.7	20.2	9.7	Ebb
MS POND C	4:00 PM	1.39	9.5	0.1	8.7	7.5	3.2	8.0	
MS-18	2:15 PM	1.51	8.9	0.1	8.2	8.8	0.1	8.2	
MS-NF	1:45 PM	4.76	9.5	0.1	7.4	8.5	0.1	7.5	Ebb

Date: March 18, 2020			Period: Post Project						
			Surface			Bottom			
Gage Location	Time (PST)	WSE NAVD88 (ft)	D.O. (mg/L)	Salinity (ppt)	Temp (°C)	D.O. (mg/L)	Salinity (ppt)	Temp (°C)	Tide at Gage
Swain Slough	12:45 PM	2.11	10.7	17.2	13.1	10.3	28.8	11.5	
MS POND C	2:05 PM	1.64	7.7	5.9	12.0	7.1	15.8	10.9	Ebb
MS-18	11:30 AM	2.81	8.3	4.7	9.7	7.0	15.6	10.0	
MS-NF	11:00 AM	4.94	7.6	0.1	9.0	7.9	0.1	8.9	Ebb

Date: May 4, 2020			Period: Post Project						
			Surface			Bottom			
Gage Location	Time (PST)	WSE NAVD88 (ft)	D.O. (mg/L)	Salinity (ppt)	Temp (°C)	D.O. (mg/L)	Salinity (ppt)	Temp (°C)	Tide at Gage
Swain Slough	1:00 PM	2.98	9.1	16.2	15.2	7.4	21.7	14.5	
MS POND C	2:05 PM	2.27	7.0	6.3	14.5	4.0	16.3	15.3	Ebb
MS-18	11:30 AM	2.81	8.3	4.7	9.7	7.0	15.6	10.0	
MS-NF	11:15 AM	5.02	6.1	0.1	12.5	5.8	0.1	12.5	Ebb

Date: June 18, 2020			Period: Post Project						
			Surface			Bottom			
Gage Location	Time (PST)	WSE NAVD88 (ft)	D.O. (mg/L)	Salinity (ppt)	Temp (°C)	D.O. (mg/L)	Salinity (ppt)	Temp (°C)	Tide at Gage
Swain Slough	1:45 PM	3.65	6.3	16.8	20.4	5.3	19.3	21.3	
MS POND C	2:30 PM	3.28	6.5	12.9	23.8	6.3	18.9	21.8	
MS-18	12:30 PM	3.41	6.9	8.8	22.5	4.3	15.6	22.1	
MS-NF	12:00 PM	4.92	4.0	0.1	15.5	3.3	0.1	14.9	

Date: July 28, 2020			Period: Post Project						
			Surface			Bottom			
Gage Location	Time (PST)	WSE NAVD88 (ft)	D.O. (mg/L)	Salinity (ppt)	Temp (°C)	D.O. (mg/L)	Salinity (ppt)	Temp (°C)	Tide at Gage
Swain Slough	12:15 PM	2.35	6.8	26.0	22.2	5.1	28.1	21.3	
MS POND C	1:05 PM	2.29	8.5	26.1	22.0	8.6	27.9	20.7	
MS-18	11:30 AM	2.31	11.1	12.1	21.3	5.8	26.8	21.4	
MS-NF	11:00 AM	4.41	4.8	0.1	15.0	3.8	0.1	14.8	

Date: September 14, 2020			Period: Post Project						
			Surface			Bottom			
Gage Location	Time (PST)	WSE NAVD88 (ft)	D.O. (mg/L)	Salinity (ppt)	Temp (°C)	D.O. (mg/L)	Salinity (ppt)	Temp (°C)	Tide at Gage
Swain Slough	3:15 PM	3.47	4.6	28.0	17.4	3.2	30.9	16.0	
MS POND C	4:30 PM	2.45	4.6	28.0	17.4	3.2	30.9	16.0	
MS-18	1:45 PM	4.31	6.9	23.7	17.4	3.5	28.0	16.1	
MS-NF	10:45 AM	4.80	6.7	0.1	13.4	5.7	0.1	13.4	

Appendix D

Martin Slough Calculated Tidal Datums

Martin Slough Tidal Datums

Gage: Swain Slough

Year	Month	MLLW	MLW	MW	MHW	MHHW	MTL	DIURNAL RANGE	MINIMUM STAGE	MAXIMUM STAGE
2019	10	1.33	1.80	3.79	6.27	6.62	3.95	5.29	1.23	7.93
2019	11	1.33	1.94	4.06	6.54	7.12	4.18	5.79	1.22	8.70
2019	12	1.67	2.42	4.42	6.79	7.55	4.54	5.88	1.34	8.85
2020	1	1.90	2.41	4.17	6.37	7.13	4.32	5.23	1.43	8.19
2020	2	1.28	1.57	3.46	5.79	6.54	3.61	5.27	0.85	7.62
2020	3	1.39	1.81	3.79	6.16	6.72	3.92	5.33	1.30	7.86
2020	4	1.54	1.90	3.70	6.01	6.50	3.87	4.96	1.33	8.11
2020	5	1.71	2.23	3.93	6.16	6.67	4.11	4.96	1.38	8.12
2020	6	1.74	2.18	3.85	6.03	6.76	4.02	5.02	1.52	8.19
2020	7	1.54	2.09	3.92	6.22	7.03	4.08	5.49	1.40	8.00
2020	8	1.50	2.02	3.95	6.33	7.05	4.10	5.55	1.34	7.80
2020	9	1.52	2.10	3.99	6.15	6.65	4.08	5.13	1.33	7.29
	Yearly	1.53	2.04	3.92	6.24	6.87	4.07	5.33	0.85	8.85
2020	**July to Sept**	1.52	2.07	3.95	6.24	6.91	4.09	5.39	1.36	7.70

Martin Slough Tidal Datums

Gage: MS-Pond C

Year	Month	MLLW	MLW	MW	MHW	MHHW	MTL	DIURNAL RANGE	MINIMUM STAGE	MAXIMUM STAGE
2019	10	1.25	1.56	2.55	3.93	3.91	2.68	2.66	1.07	4.73
2019	11	1.22	1.61	3.02	4.40	4.62	3.01	3.40	1.06	5.78
2019	12	1.59	2.09	3.45	4.92	5.10	3.49	3.52	1.12	7.43
2020	1	1.89	2.32	3.65	5.21	5.52	3.72	3.63	1.28	7.05
2020	2	1.24	1.56	2.83	4.41	4.74	2.94	3.50	1.09	5.21
2020	3	1.29	1.62	3.01	4.64	4.88	3.09	3.59	1.13	6.15
2020	4	1.44	1.70	2.99	4.56	4.84	3.08	3.40	1.17	6.74
2020	5	1.70	1.98	3.26	4.72	4.94	3.32	3.25	1.25	5.75
2020	6	1.66	1.99	3.10	4.44	4.79	3.17	3.13	1.40	5.15
2020	7	1.41	1.77	3.07	4.52	4.96	3.12	3.55	1.26	5.41
2020	8	1.28	1.62	3.02	4.53	4.89	3.06	3.61	1.12	5.28
2020	9	1.42	1.71	3.14	4.58	4.75	3.14	3.33	1.22	5.13
	Yearly	1.45	1.80	3.09	4.58	4.83	3.16	3.38	1.06	7.43
2020	**July to Sept**	1.37	1.70	3.08	4.54	4.86	3.11	3.50	1.20	5.27

Martin Slough Tidal Datums

Gage: MS-18

Year	Month	MLLW	MLW	MW	MHW	MHHW	MTL	DIURNAL RANGE	MINIMUM STAGE	MAXIMUM STAGE
2019	10	3.13	3.18	3.50	4.02	4.19	3.57	1.06	3.06	5.55
2019	11	1.05	1.38	2.76	4.21	4.41	2.79	3.36	0.91	5.48
2019	12	1.33	1.96	3.19	4.67	4.81	3.28	3.48	0.97	7.15
2020	1	1.76	2.16	3.46	5.02	5.33	3.55	3.56	1.16	6.89
2020	2	1.14	1.41	2.65	4.24	4.55	2.76	3.41	0.94	5.03
2020	3	1.16	1.43	2.83	4.44	4.70	2.90	3.54	0.97	5.93
2020	4	1.30	1.60	2.84	4.42	4.68	2.95	3.38	1.07	6.59
2020	5	2.28	2.55	3.83	5.27	5.49	3.88	3.21	1.12	6.47
2020	6	1.86	2.17	3.29	4.62	4.97	3.36	3.11	1.26	5.86
2020	7	1.26	1.56	2.90	4.36	4.78	2.94	3.53	1.11	5.20
2020	8	1.18	1.53	2.92	4.44	4.80	2.96	3.62	1.03	5.16
2020	9	1.27	1.60	3.01	4.47	4.61	3.02	3.34	0.88	5.04
	Yearly	1.52	1.85	3.09	4.54	4.81	3.16	3.29	0.88	7.15
2020	**July to Sept**	1.24	1.57	2.94	4.42	4.73	2.98	3.50	1.01	5.13

Appendix E

MARTIN SLOUGH PHOTO MONITORING

Photo Points 1-9

Note – Photo Points 1-9 taken using a tripod; Magnetic declination = 19^{o}; Ht is from ground to center of lens. Photo Point numbering is sequential from downstream (NRLT) to upstream (Eureka Golf Course).

Photo Point 1

Location: On Tide Gate

GPS (NAD 83): 0400671 (northing); 4511753 (easting)

Camera: Canon Rebel EOS; 50 mm lens

Photo #	Bearing in ^{o}	ShutterSpd	F Stop	Date	Time	Ht
MS_PP1_23_1_29_19	23	1/200	8.0	1/29/19	2:55 PM	4’10”
MS_PP1_113_1_29_19	113	1/200	8.0	1/29/19	2:50 PM	4’10”
MS_PP1_203_1_29_19	203	1/250	9.0	1/29/19	2:52 PM	4’10”
MS_PP1_293_1_29_19	293	1/250	9.0	1/29/19	2:54 PM	4’10”

Photo Point 2

Location: Marsh Plain A at ~ sta 4+50

GPS (NAD 83): 0400298 (northing); 4511921 (easting)

Camera: Canon Rebel EOS; 50 mm lens

Photo #	Bearing in ^{o}	ShutterSpd	F Stop	Date	Time	Ht
MS_PP2_66_1_29_19	66	1/250	9.0	1/29/19	3:11 PM	4’0”
MS_PP2_156_1_29_19	156	1/320	10.0	1/29/19	3:15 PM	4’0”
MS_PP2_246_1_29_19	246	1/320	10.0	1/29/19	3:18 PM	4’0”
MS_PP2_293_1_29_19	336	1/125	6.3	1/29/19	3:20 PM	4’0”

Photo Point 3

Location: Marsh Plain B1 at ~ sta MS 4+00

GPS (NAD 83): 0400534 (northing); 4511822 (easting)

Camera: Canon Rebel EOS; 50 mm lens

Photo #	Bearing in ^{o}.	ShutterSpd	F Stop	Date	Time	Ht
MS_PP3_275_1_30_19	275	1/125	7.1	1/30/19	1:50 PM	4’0”
MS_PP3_05_1_30_19	05	1/125	7.1	1/30/19	1:51 PM	4’0”
MS_PP3_095_1_30_19	95	1/125	7.1	1/30/19	1:53 PM	4’0”
MS_PP3_185_1_30_19	185	1/125	6.3	1/30/19	1:55 PM	4’0”

Photo Point 4

Location: March Plain B2 at ~ sta MS 10+00; near southern apex of meander
GPS (NAD 83): 0400671 (northing); 4511753 (easting)
Camera: Canon Rebel EOS; 50 mm lens

Photo #	Bearing in °.	ShutterSpd	F Stop	Date	Time	Ht
MS_PP4_130_1_30_19	130	1/100	5.6	1/30/19	2:07 PM	4'6"
MS_PP4_220_1_30_19	220	1/125	7.1	1/30/19	2:09 PM	4'6"
MS_PP4_310_1_30_19	310	1/125	7.1	1/30/19	2:12 PM	4'6"
MS_PP4_40_1_30_19	40	1/125	6.3	1/30/19	2:14 PM	4'6"

Photo Point 5

Location: South Side Main Channel at ~ sta MS 19+20; at upstream confluence with
GPS (NAD 83): 0400741 (northing); 4511937 (easting)
Camera: Canon Rebel EOS; 50 mm lens

Photo #	Bearing in °.	ShutterSpd	F Stop	Date	Time	Ht
MS_PP5_275_1_30_19	275	1/160	7.1	1/30/19	2:23 PM	4'5"
MS_PP5_05_1_30_19	005	1/125	6.3	1/30/19	2:25 PM	4'5"
MS_PP5_95_1_30_19	095	1/125	7.1	1/30/19	2:27 PM	4'5"
MS_PP5_185_1_30_19	185	1/125	7.1	1/30/19	2:28 PM	4'5"

Photo Point 6

Location: North Side Southeast Fork at ~ sta 6+75; adjacent to SE pond
GPS (NAD 83): 0400940 (northing); 4511868 (easting)
Camera: Canon Rebel EOS; 50 mm lens

Photo #	Bearing in °.	ShutterSpd	F Stop	Date	Time	Ht
MS_PP6_270_1_30_19	270	1/100	5.6	1/30/19	2:38 PM	4'7"
MS_PP6_360_1_30_19	360	1/100	5.5	1/30/19	2:39 PM	4'7"
MS_PP6_90_1_30_19	090	1/80	5.0	1/30/19	2:40 PM	4'7"
MS_PP6_180_1_30_19	180	1/80	5.0	1/30/19	2:28 PM	4'7"

Photo Point 7

Location: Northeast Side of Pond C adjacent to ~ sta MS 24+00
GPS (NAD 83): 0400842 (northing); 4512037 (easting)
Camera: Canon Rebel EOS; 50 mm lens

Photo #	Bearing in °.	ShutterSpd	F Stop	Date	Time	Ht frm grd to ctr lens
MS_PP7_250_1_30_19	250	1/160	7.1	1/30/19	2:59 PM	4'5"
MS_PP7_340_1_30_19	340	1/100	5.6	1/30/19	3:00 PM	4'5"
MS_PP7_70_1_30_19	070	1/100	5.6	1/30/19	3:02 PM	4'5"
MS_PP7_160_1_30_19	160	1/125	6.3	1/30/19	3:03 PM	4'5"

Photo Point 8
Location: left bank of main channel at ~ sta. 32+20; 20 ft. from channel
GPS (NAD 83): 0400298 (northing); 4511927 (easting)
Camera: Canon Rebel EOS; 50 mm lens; using automatic settings

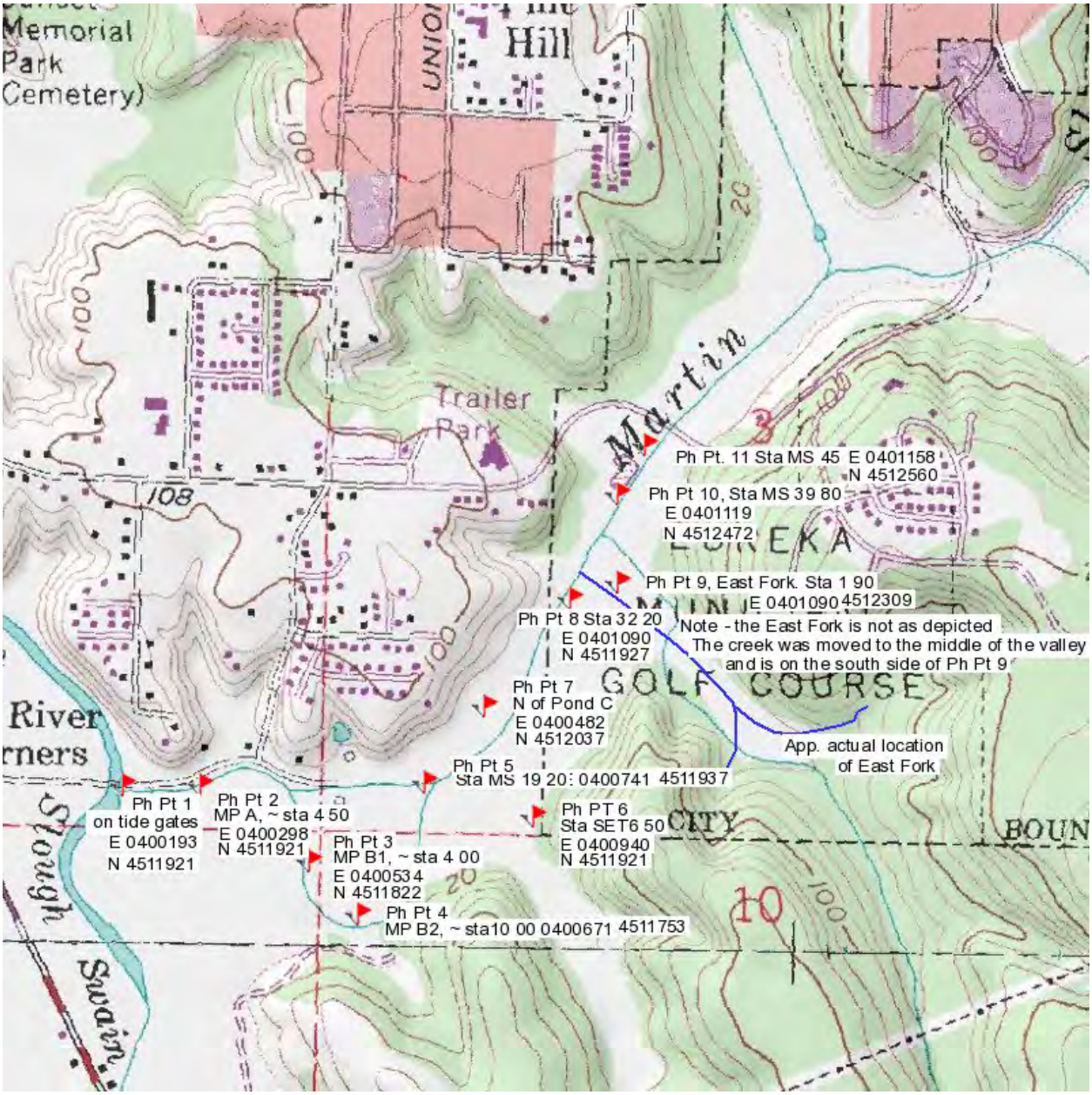
Photo #	Bearing in °	ShutterSpd	F Stop	Date	Time	Ht
MS_PP8_20_6_4_19	20	1/200	9.0	6/4/19	10:07AM	4'9"
MS_PP8_110_6_4_19	110	1/200	9.0	6/4/19	10:10AM	4'9"
MS_PP8_200_6_4_19	200	1/200	8.0	6/4/19	10:12AM	4'9"
MS_PP8_290_6_4_19	290	1/80	5.6	6/4/19	10:14AM	4'9"

Photo Point 9
Location: right bank of East Fork at ~sta. 1+90; 10 ft. north of channel; 10 ft west of pedestrian bridge
GPS (NAD 83): 0401090 (northing); 4512309 (easting)
Camera: Canon Rebel EOS; 50 mm lens; using automatic settings

Photo #	Bearing in °	ShutterSpd	F Stop	Date	Time	Ht
MS_PP9_140_6_4_19	140	1/200	9.0	6/4/19	10:30AM	4'9"
MS_PP9_230_6_4_19	230	1/200	9.0	6/4/19	10:33AM	4'9"
MS_PP9_320_6_4_19	320	1/200	9.0	6/4/19	10:35AM	4'9"
MS_PP9_50_6_4_19	50	1/160	8.0	6/4/19	10:44AM	4'9"

Photo Point Location Map

Photo Points 1-11



This monitoring report includes photo points 1-9. Photo points 10 and 11 will be included in the 2021 monitoring report.

Photo Point 1 – 2019

Photo Point 1 – 2020

Photo Point 2 – 2019

Photo Point 2 – 2020

Photo Point 3 – 2019

Photo Point 3 – 2020

Photo Point 4 – 2019

Photo Point 4 – 2020

Photo Point 5 – 2019

Photo Point 5 – 2020

Photo Point 6 – 2019

Photo Point 6 – 2020

Photo Point 7 – 2019

Photo Point 7 – 2020

Photo Point 8 – 2019

Photo Point 8 – 2020

Photo Point 9 – 2019

Photo Point 9 – 2020