2019-2020 Annual Self-Monitoring Report
Don Edwards San Francisco Bay National Wildlife Refuge
Fremont, California

Prepared for:

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Introduction

The Don Edwards San Francisco Bay National Wildlife Refuge (Refuge) 2019-2020 Annual Self-monitoring Report (Report) on Water Quality has been prepared to provide an overview of the Refuge's effects on water quality and habitat suitability of managed ponds due to management and restoration activities. This report includes:

1) A summary of the Project's progress during the 2019-2020 seasons,
2) Report on water quality data collected over 2019-2020 on Refuge ponds as well as management actions taken,
3) Update on research happening on managed ponds, and
4) Progress towards the development of a new water quality monitoring protocol for ponds managed by the U.S. Fish and Wildlife Service (Service).

This Report is designed to meet California Regional Water Quality Control Board (RWQCB) permitting requirements for a water quality self-monitoring plan as described in R2-2018-0020, Findings 9, & 111-113, as well as South Bay Salt Pond Restoration Project (SBSPRP) Phase 2 Monitoring Plan and Water Quality Self-monitoring Program for Refuge Lands (C. Strong & Underwood 2018). This Report will also be submitted to NOAA's National Marine Fisheries Service (NMFS) because we have included additional fisheries monitoring conducted as part of the Science Program's Applied Studies, which are intended to fill the most important gaps in our knowledge about South San Francisco Bay (South Bay) ecosystem.

It is anticipated that both water quality and fisheries information will help the Water Board and NMFS:

1) Understand the status of the Refuge projects,
2) Provide feedback and guidance to the Refuge Management Team on current and future applied studies and monitoring, and
3) Assist in identifying emerging key uncertainties and management decisions required to keep the South Bay Salt Pond Restoration Project (SBSPRP/Project) on track toward its restoration objectives as we implement Phase 2.

SBSPRP Progress

Phase 2 of the SBSPRP is a collaborative effort among federal, state, and local agencies working with scientists and the public to develop and implement habitat restoration, flood management, and wildlife oriented public access plans on Don Edwards National Wildlife Refuge. The former commercial salt ponds included in Phase 2 plans encompass about 2,385 acres on the Ravenswood and Alviso pond systems (Figures 1 &2) and will be restored to a mosaic of habitats, including tidal salt marsh, tidal mudflat, salt pan, subtidal flats and channels, sloughs, ponds, marsh ecotones, upland transition zones, and open water habitats (enhanced managed ponds), to support populations of wildlife, special-status species, migratory waterfowl, shorebirds, and anadromous and resident fish populations.

The amount of tidal marsh restoration approved under Order Nos. R2-2008-0078 and R2-2012-0014 was 10.5 percent of the 15,100-acre Project area. This increase remains well below the approved 50 percent endpoint analyzed for the Project. The amount of tidal marsh restoration approved under Order R2-

2018-0020 will increase tidal marsh from 10.5 percent to 17 percent (2,605 acres) of the 15,100-acre project.

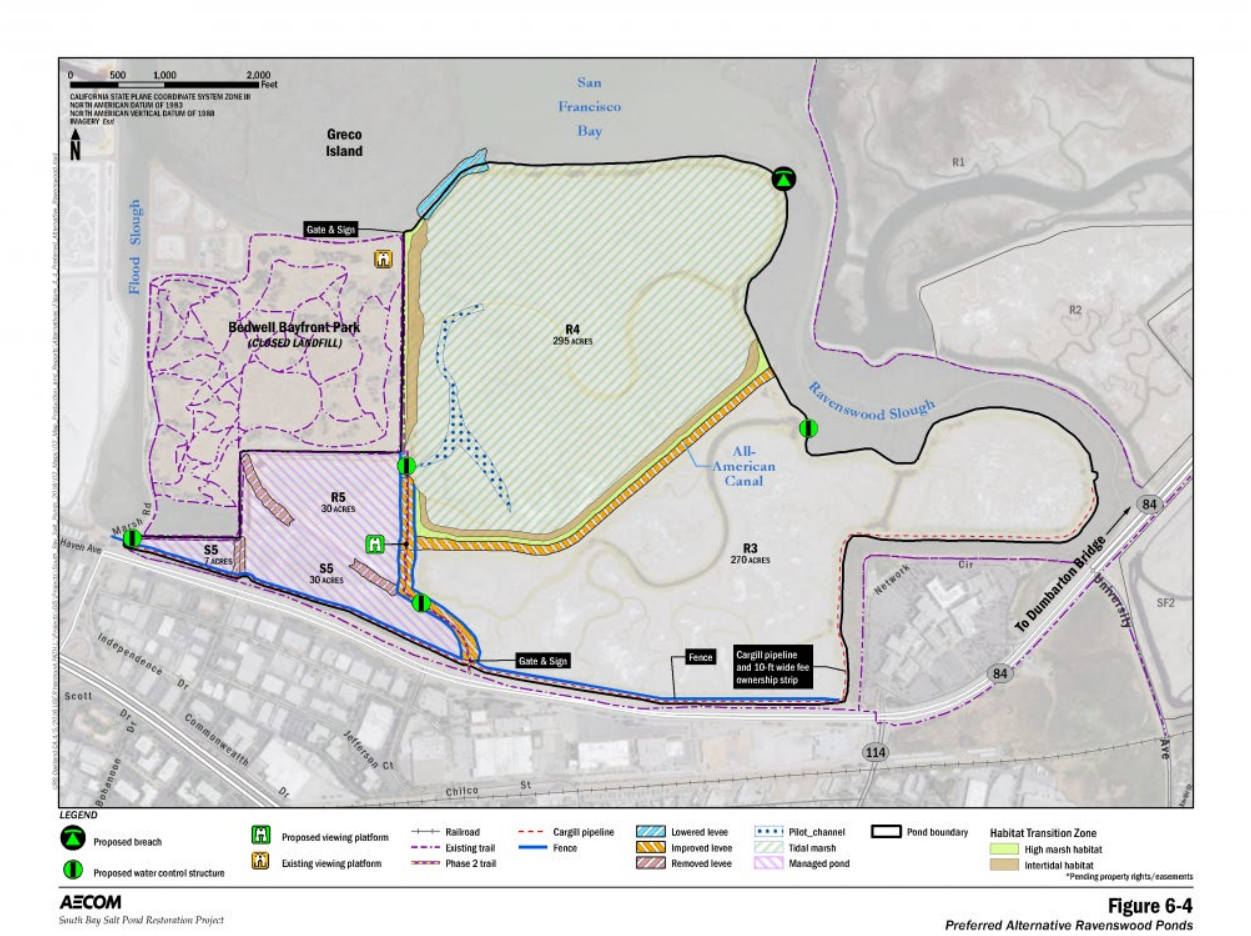

Figure 1. Map of Ravenswood Pond Complex and proposed restoration actions.

2019 & 2020

Ravenswood Unit: Ponds R3-S5

The Refuge began levee maintenance and habitat enhancement at the Ravenswood Ponds in July of 2018 as part of Phase 2 of the Project. By the end of Phase 2 actions, 294 acres of new tidal marsh will be added at Ravenswood when the levee at pond R4 is breached to the bay and 67 acres of improved pond habitat constructed by removing internal levees in ponds R5 & S5 for ducks and shorebirds. Pond R3 will be managed as dry salt flat for threatened western snowy plovers to nest. A new public access trail and viewing platforms will be added between Bayfront Expressway and the southern edge of Bedwell Bayfront Park. In 2019 and 2020, Phase 2 activities at the Ravenswood Ponds included the import of fill for the All-American Canal and habitat transition zone/ecotone at Pond R4, as well as the removal of the R5/S5 interior levee and completion of the waterbird island in R5/S5. As required by the Phase 2 RWQCB permit, Pacific States imported the soil under the guidelines of the approved Master

Quality Assurance Project Plan for Don Edwards San Francisco Bay National Wildlife Refuge (Master QAPP) (USFWS and H. T. Harvey & Associates 2018). Refer to HT Harvey Reports, Project No. 3685-01.

In 2021, Phase 2 activities will include continued material import, revegetation of the habitat transition zone, and the addition of several water control structures. In 2022, we will complete construction with the breaching of Pond R4 to the San Francisco Bay.

Alviso Unit: Pond A8

Between July and October 2020, the Santa Clara Valley Water District (Valley Water) and the Refuge imported soil to Pond A8 for Phase 2 of the SBSPRP. The fill was imported under the SBSPRP Phase 2 RWQCB Section 401 Water Quality Certification Order No. R2-2018-0020. The imported soil will be used by SBSPRP to construct a habitat transition zone (i.e., an ecotone) at Pond A8 (Figure 2). As required by the Phase 2 RWQCB permit, Valley Water imported the soil under the guidelines of the approved Master Quality Assurance Project Plan for Don Edwards San Francisco Bay National Wildlife Refuge (Master QAPP) (USFWS and H. T. Harvey & Associates 2018). Refer to HT Harvey Report, Project No. 4306-03 for details.

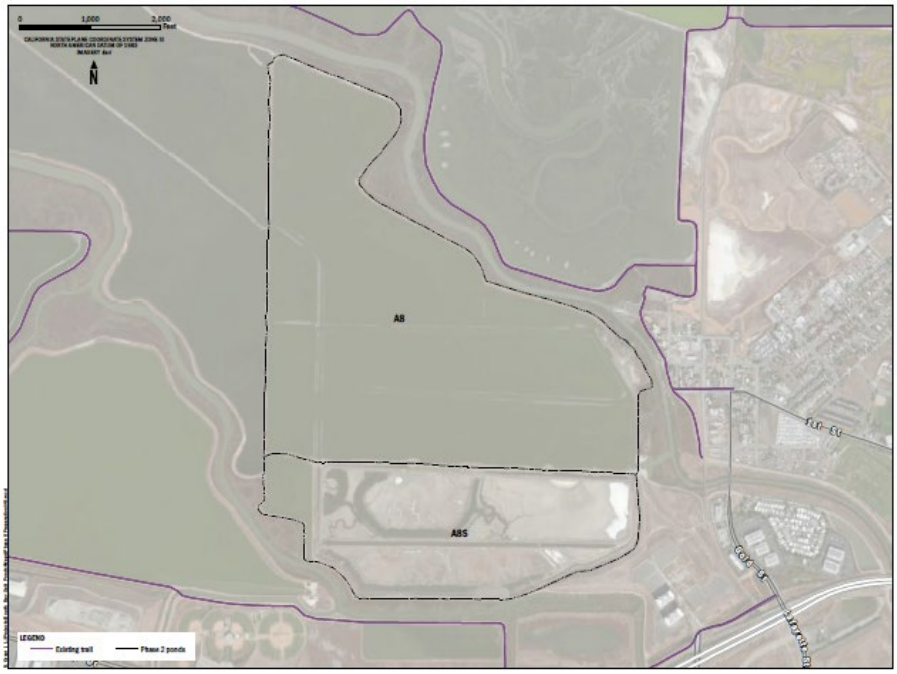

Figure 2. Site of planed Phase 2 operations, Ponds A8 & A8S highlighted.

Refuge Operations and Maintenance Progress

Ravenswood Unit: Pond R1

In 2020, the R1 levee experienced substantial erosion due to several high tide events overlapped with high wind events. As part of a USFWS Operations and Maintenance activity, which is covered under RWQCB Order R2-2018-0020 and Department of the Army Permit 2008-0001035, the outer levee of R1 was repaired with imported fill and riprap in November 2020. In addition, one of two water control

structures in Pond R1 had failed, and the decision was made to remove and fill in the levee, rather than replace the structure.

Ravenswood Unit: Pond SF2

In November 2020, the Refuge removed a plastic pipe culvert (< 4 ft diameter) from the levee of Pond SF2 and backfilled the gap with onsite material, as part of a USFWS Operations and Maintenance activity. Water management will be maintained in this location using existing weir boards.

Alviso Unit: Ponds A9-A15

In 2020 at the Alviso pond complex, two levee maintenance projects were conducted as part of a USFWS Operations and Maintenance activity. One project involved importing fill to reinforce levees eroded by wind and wave action along Ponds A12, A11, A10, and A9 (Figure 3). To prevent erosion of these levees, articulated concrete matting (brand name Flexamat) was added and then hydroseeded, along the pond side of A11 and A9. Additionally, the failing Pond A9 water control structure was replaced in the winter of 2020 and was completed in January 2021. The second levee maintenance project involved raising the levee top along A13 and A15, identified as a low spot in our Pond Infrastructure Master Plan (in progress). Fill was imported along the levee between Ponds A13 and A15. This work will continue in 2021.

Figure 3. Site of levee and trail maintenance at Alviso Ponds A9, A10, A11, A12. Red areas indicate site of 2020 levee maintenance.

Water Quality & Management Actions

2019 & 2020

Water quality data was inconsistently collected throughout the year by Refuge staff and on a six-week rotation from April 2019 to April 2020 by the San Francisco Bay Bird Observatory (SFBBO) on Refuge ponds. Data show that pond salinity at time of measurements did not exceed RWQCB effluent discharge limits of 44 parts per thousand (ppt), nor did it fall below the Basin Plan Water Quality dissolved oxygen (DO) limit (See Appendix). After an unusual event on September 9 and 10, 2021, when smoke from countless wildfires mixed with clouds and fog to block much incoming sunlight and tint the sky orange, Pond A16 experienced a fish kill involving approximately 50 striped bass. On September 14, 2021, USFWS notified the appropriate agencies that a fish kill had occurred; through adjusting water input and the improvement of ambient air, the Refuge was able to improve habitat conditions, and no further fish kills were documented. No evidence of avian botulism or above-normal amounts of algal growth were detected during the 2019-2020 seasons. Prior adjustments to pond hydrology and investment in water control structures that increased water circulation continue to work to maintain the beneficial ecological use by wildlife in Refuge pond systems. Operation of Refuge ponds as continuous flow-through systems to reduce water residence times has greatly improved water quality.

Restoration of wetland habitat continues to be the focus of the SBSPRP and the Refuge. Former salt ponds now kept as managed ponds will always represent a management challenge over a more sustainable and ecological beneficial salt marsh. Salt ponds are infrastructure that will require continual maintenance to ensure the health of the habitat they contain. Ponds will also always be an impediment to fish passage, bringing increased risks of entrainment and death, unlike a more open and fully tidal salt marsh ecosystem. Phase 2 will continue to restore wetland functions to former salt ponds, improving water quality in the South San Francisco Bay Estuary (Estuary).

Most of the current data collected on water quality in the Estuary was done as part of the Bay Regional Monitoring Program for Water Quality in San Francisco Bay (RMP) and long-term monitoring conducted by partners such as the US Geological Survey and SFBBO. Through these efforts, much is known about the physical processes that lead to water quality issues. The South Bay has extensive areas of shallow water that are susceptible to temperature increases in the summer months. Warm water impacts water quality leading to increases in phytoplankton production and declines in DO.

The physical characteristics of the South Bay cause considerable spatial and temporal variability in water quality within the Estuary. Water quality declines in the summer and early fall as phytoplankton production increases and DO levels fall (MacVean et al. 2018). The is due to a combination of higher air and water temperatures, lower suspended sediment concentrations and less freshwater entering the Estuary through runoff.

Tidal cycles are a significant contributing factor in changes to water quality in the South Bay. In a 2018 study by MacVean et al., DO was seen to decrease to below Basin Plan target levels during 1/3 of low tides but increased to above target levels during high tide. The incoming tides bring oxygen rich waters to the upper reaches of the slough, while the outgoing tides have the opposite effect by drawing hypoxic waters down the watershed to the bay. With increased tidal prism it is possible that spring tides are connecting areas with low DO resulting in lower DO levels throughout the Estuary.

While not observed in 2019 or 2020, Harmful algal blooms (HABs) have been a perennial issue for water quality in Refuge ponds. HABs typically occur when high nutrient concentrations coincide with warm water and low circulation. South Bay salt ponds contain resident population of HAB organisms (Thébault et al. 2008). In a recent survey, 98% of mussels sampled within the estuary in 2015 contained at least one of four HAB-associated toxins. Under the right conditions the bioaccumulation of these toxins in marine mussels can cause acute or chronic toxicosis in marine mammals and waterbirds (Gibble et al. 2017), potentially affecting the Refuge's ability to achieve management objectives.

Research Synthesis

Effects on Aquatic Species

In order to for the Refuge to meet its restoration goals, a thorough understanding of how tidal restoration impacts native aquatic species should be reached. Conceptual models used in the Adaptive Management Plan (AMP; Trulio et al. 2007) show benefits to native fish and aquatic species from marsh restoration. Tidal marsh habitats provide refugia from predation, increases the amount of shallow water habitat and increases food production (Herbold et al. 2014). There are also several potential negative impacts that were identified in the AMP including loss of tidal flat habitat, increased predation by non-native species, and increased levels of methylmercury due to channel scour. To assess progress toward those goals and reduce uncertainty around those potential negative impacts, the Refuge and SBSPRP identified Applied Studies that include fisheries monitoring and monitoring levels of methylmercury in response to restoration.

Assessing how habitats change in response to restoration and other management activities is an essential part of measuring success. Restoration targets of non-avian wildlife species that are affected by the Project are:

1. Increase the number of salmonids in rearing and foraging habitat relative to NEPA and CEQA baseline numbers,
2. Increase the number of native fish, and
3. Maintain or enhance numbers of harbor seals using the South Bay.

In a recent study, longfin smelt (*Spirinchus thaleichthysis)* were shown to be present in both San Pablo Bay and South SF Bay (Grimaldo et al. 2017 & Hobbs 2017). Tidal restoration is thought to benefit this state-listed threatened species by increasing shallow water refugia and decreasing prey densities. These studies point to a potentially important role that restoration in the South SF Bay plays in maintaining the Estuary's longfin smelt population. Indeed, many different species of native fish benefit from the restoration of tidal marsh ecosystem (Wood et al. 2019).

Steelhead Entrainment Studies

On December 16, 2020, FISHBIO submitted their Pond A8 Notch and Guadalupe River PIT Antenna Operation Final Report to the State Coastal Conservancy. This study is a continuation of the studies started in 2014 by Jim Hobbs, UC Davis, to assess the risk of entrainment and fate of entrained juvenile/smolt steelhead at the muted tidal connection of Pond A5, A7, A8, and A8S with the Guadalupe River/Alviso Slough. A total of 305 *O. mykiss* were tagged with Passive Integrated Transponders (PIT tags) in association with these surveys.

Antennas were deployed to detect PIT tagged steelhead in four of the past seven years (2014, 2015, 2019 and 2020; Hobbs 2015, FISBIO 2020) at Pond A8 notch, Pond A5 Water Control Structure (WCS), Pond A7 WCS and Guadalupe River. Additional antennas were deployed by Valley Water from 2018 to 2020 in the Upper Guadalupe Watershed and their results are presented in separate reports (https://www.valleywater.org/project-updates/creek-river-projects/fahce-fish-and-aquatic-habitat-collaborative-effort). In 2014, PIT antennas were installed at the Pond A5 and Pond A7 water control structures, but due to failing infrastructure, they were not continued in following years. During these surveys, six steelhead were detected in the Guadalupe River in 2014; five of those fish presumably navigated past the Pond A8 armored notch as just one was detected at the Pond A8 antenna. That single individual at the Pond A8 notch was detected by Jim Hobbs in 2014 who reported, "Given the tide level prediction, the height of notch construction and our observations of water levels and flow from the pond, the data suggest the fish was likely exiting the pond when detected as the pond would have been spilling into the starter channel at the time of detection" (Hobbs 2014).

Additional tagged fish detected at the A8 notch include one PIT tag of an unknown species was recorded at 3:30 AM on December 4, 2019 at the Pond A8 notch (FISHBIO 2020), and one tagged adult striped bass (originally tagged to access predation risk for steelhead) was detected both exiting and entering Pond A8 (Hobbs 2015). At the Guadalupe River antenna, just one steelhead (tagged in 2018) was detected in April 2019 (900_226000319368). The years between the UC Davis survey and the FISHBIO surveys included drought years when CDFW collecting permits were not awarded and additional planning time was spent in preparing and obtaining Phase 2 permits.

Mercury

The legacy of the New Almaden mercury (Hg) mine is the accumulation of the highly toxic metal in the sediments of the South Bay. From the beginning of Project planning, the mobilization of mercury from channel scour, the disturbance of sediments in the estuary, has been a concern. A 2019 study conducted by the USGS looked at the effects that restoration was having on methylmercury levels in the South Bay. The primary objective of the study was to quantify the amount of Total Hg (THg) remobilized within Alviso slough as wetland restoration progressed (A.C. Foxgrover et al. 2019) The study focused on the slough and the adjacent ponds: tidally restored Pond A6 and the muted tidal A8 pond group (Ponds A5, A7, A8 and A8S). This location was selected due to the legacy mercury contamination in the A8 pond group and Alviso Slough. This area is also expected to see a large increase in tidal prism and channel scour due to restoration activity. This mercury contamination in the A8 Ponds precluded the breaching of the dikes surrounding the ponds, and so Project planers installed a tidal control structure (A8-TCS) in the far southeastern corner of Pond A8. The TCS is approximately 12 m wide and consists of eight 5-foot wide gates that can be independently opened to allow an aperture size between 5 and 40 feet. Over the course of six years, starting in 2011, managers opened all the gates on A8-TCS. The timing and extent of gate operations were detailed in this 2019 research by A. C. Foxgrover et al.

The study used repeated bathymetric surveys competed between 2010 to 2017 to track fluctuations in sediment distributed by tidal flux in Alviso Slough and sediment core collection to analyze changes in Hg levels and determine depth & location of legacy Hg deposits. To assess the remobilization of mercury deposits in Alviso Slough, A. C. Foxgrover et al. analyzed the timing and the maximum depth of channel scour between 2010 & 2017. Sediment cores showed a large amount of spatial variability in THg deposits in the slough with higher concentrations in the mid and upper slough.

During the first 3 years of restoration, rates of THg remobilization increased modestly in the winter months to about 3 mg/mo/m^2 coinciding with increased runoff and rates of erosion from the rainy season and was comparable to mobilization rates across the slough. During the winter of 2015 and 2017 larger spikes of THg remobilization were observed in the mid and upper sloughs (9-16 mg/mo/ m^2). The greatest amount of channel scour was recorded in the lower slough were Hg levels are generally lower. From December 2010-March 2017 an estimated 52 kg (± 3) of THg was remobilized throughout the entire slough with the largest increases in THg remobilization occurring in 2012, 2015 and 2017.

Sediment remobilization within Alviso Slough is a necessary part of restoring the South Bay Salt Ponds, the ponds require deposition of sediments to allow the growth of the shallow water plants that form salt marsh ecosystem. This movement of sediments is also what leads to increases of bio-available Hg in the Estuary. This is the reality of restoration projects in this urbanized estuary with legacy contamination from past land uses. It is why special care has been taken since the Project's inception to reduce harm to the SF Bay from restoration activities.

Development of SSP for Water Quality Monitoring

The Refuge is currently developing a protocol for the monitoring of water quality. The protocol will bring the Refuge in line with USFWS guidelines for priority surveys. The protocol will also ensure Refuge compliance with RWQCB permit requirements for a water quality self-monitoring program and compliance with Basin Water Plan DO levels. The protocol will formalize the Refuge's data collection and reporting process to RWQCB and NMFS. The monitoring program is expected to begin summer 2021.

Appendices:

Table 1. Water Quality Data From Ponds Listed in Finding 9. RWQCB Permit R2-2018-0020 (Results are Average Values)

A5	DO	SALINITY		A7	DO	SALINITY
18-Jan-19	18.53	8.21		18-Feb-19	16.835	4.71
18-Apr-19				29-Apr-19	12.375	7.83
27-Sep-19	6.65	19.49		30-Sep		19.43
25-Oct-19		21.38		11-Nov-19	17.475	19.14
6-Jan-20	12.89	15.88		30-Dec-19	13.43	16.89
A2W	DO	SALINITY		A3W	DO	SALINITY
1-Feb-19	6.44	22.48		21-Jan-19	10.95	22.33
15-Mar-19	6.52	14.44		26-Feb-19	8.36	15.93
26-Apr-19	3.93	13.62		22-Apr-19	12.35	20.69
2-Oct-19		28.25		3-Oct-19		25.78
7-Nov-19	6.03	27.05		4-Nov-19		
9-Jan-20	7.77	24.39		10-Dec-19	9.07	23.17
A8	DO	SALINITY		A14	DO	SALINITY
18-Jan-19	7.8	7.08		24-Jan-19	8.93	21.41
25-Feb-19	9.98	1.69		14-Mar-19	8.33	10.83
29-Apr-19	10.98	4.48		15-Apr-19		
18-Nov-19	8.63	14.06		25-Sep-19		24.9
18-Dec-19	8.14	12.85		5-Nov-19		
				20-Dec-19		23.84
SF2	DO	SALINITY		A16	DO	SALINITY
1-Feb-19	8	40.27		19-Feb-19	9.9	5.5
19-Apr-19	8.07	35.17		21-Mar-19		
4-Sep-19	7.22	29.44		25-Sep-19		16.13
29-Oct-19	7.21	29.92		23-Oct-19		17.26
				7-Jan-20	15.41	15.14

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