

Attachment 15– Devereux Slough and North Campus
Open Space Hydrology Report (ESA, 2016)

Devereux Slough and North Campus Open Space:
Hydrology Report, Fall 2015 – Winter 2016



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INTRODUCTION

As part of the upcoming restoration of the North Campus Open Space (NCOS), the Cheadle Center for Biodiversity and Ecological Restoration (CCBER) has been monitoring the hydrology of the Devereux Slough and its inputs from the NCOS area. The monitoring includes the collection of data on the water level of the slough, and of the creeks and groundwater piezometer wells in NCOS. This report summarizes the hydrology data collected for the period of September 2015 to April 2016, and accompanies a separate report on flow rate data collected at locations in NCOS where leveloggers are deployed.

DATA COLLECTION METHODS

DEVEREUX SLOUGH

CCBER has been monitoring the water level, as well as the salinity and other water quality parameters of Devereux Slough by collecting data continuously using a YSI EXO1 Sonde. The Sonde is deployed in the main channel of the slough, at the location of the “pier” (what used to be a bridge). It is secured to the pier deck with a stainless steel cable, and is housed in an open-bottom perforated PVC pipe that is anchored to a pile on the south side of the pier (Figure 1). The total length of the sonde is 2.11 feet (including the protective sleeve over the external sensors), and the integrated pressure transducer (“depth sensor”) is approximately in the middle, about 1.16 feet from the bottom. At the deployment site, the bottom of the sonde is estimated to rest at approximately one foot above the floor of the slough.

The sonde records the pressure, and calculates the water level (to the nearest 0.001 meter) and all other parameters every 15 minutes. To download the data, replace the batteries, and clean and calibrate the sonde, it is removed from the slough every 8 weeks, which usually results in a 3 to 12-hour gap in the data. This is scheduled to occur when there is no forecast of rainfall or other events that would affect the water level or other data. The sonde’s water level data are adjusted to water surface elevation (WSE) in feet (based on the North American Vertical Datum, NAVD) by determining the difference of the sonde’s data (converted to feet) from the WSE recorded manually at an elevation benchmark surveyed by Environmental Science Associates (ESA) atop a concrete wall near the deployment site (Figure 1). The manually recorded WSE is obtained by measuring the distance (in inches) to the slough water surface from the top of the concrete wall (above a staff gauge), and subtracting that measurement from the surveyed elevation of the top of the wall (9.21 ft NAVD). This manual WSE measurement is obtained, at a minimum, before removing the sonde for routine maintenance, and after re-deployment.

NORTH CAMPUS OPEN SPACE CREEKS

To monitor the water level of the streams in the North Campus Open Space (NCOS), CCBER has installed Solinst Leveloggers (Model 3001 – Levellogger Junior Edge) at four locations: in Phelps Creek under Marymount Bridge, by the Whittier Drive stormdrain outflow, in Devereux Creek at the outflow of a culvert near the western edge of NCOS, and above the sill that separates Devereux Creek from the slough (Figure 2). The leveloggers at the Phelps Creek and Devereux Creek sill sites have been installed since July 2013 and June 2015, respectively, while the loggers at the other two sites have been installed since late December 2015. At each site, the levellogger is housed in a pvc tube that is attached to a metal stake driven into the bottom sediment of the stream, and located as near as practical to a low point in the stream.



Figure 1. Map showing the location where the YSI EXO-1 data sonde is installed on the “pier” in the main channel of Devereux Slough, and the location of the elevation benchmark atop the concrete wall with staff gauge (also in photo), where the reference water surface elevation (WSE) is manually measured in order to adjust the sonde water level data to WSE in feet (NAVD).



Figure 2. Map of the North Campus Open Space, with labeled yellow points indicating the four locations where Leveloggers are installed to record water level and temperature every 15 minutes.

The levelloggers record the water level (to the nearest 0.001 meter), and temperature (in Celsius) every 15 minutes. The data are downloaded periodically (at least once every 6 months) and are compensated using barometric pressure data recorded every 15 minutes with a Solinst Barologger. The compensation calculation is done automatically using software provided by Solinst. The resulting data are converted to feet, and then adjusted to WSE (in feet NAVD) using one of two methods depending on the site (Table 1). For the Phelps Creek and Devereux Creek sill sites, the water level recorded by the logger was subtracted from the WSE measured at the site by ESA at a particular date and time, and this difference was then added to all of the level data for that site (see Table 1 for details). For the Whittier Stormdrain and West NCOS culvert sites, the logger data is adjusted to WSE by adding the elevations of the top of the logger housings surveyed by ESA, and then subtracting the approximate length from the top of the housing to the zero line of the logger (0.5 ft). The reason for this method is that we had a malfunctioning logger at the Whittier Stormdrain site, and there was no water present at the West NCOS culvert site at the time ESA surveyed the elevations of the logger housings.

Table 1. Surveyed elevation of the four Solinst Levellogger housings and water surface (WSE) compared with the water level recorded by each logger, and the difference added to the logger water level to obtain WSE in feet (NAVD).

| Levellogger Site | Date and Time | Logger Water Level (ft) | Surveyed logger housing elevation (ft NAVD) | Surveyed WSE (ft. NAVD) | Difference added to Logger Water Level |
|------------------------------------|-----------------------|--------------------------------|--|--------------------------------|---|
| Phelps Creek – Marymount Bridge | 12/11/2015 2:30pm | 0.61 | 11.15 | 10.6 | 9.99 |
| Whittier Drive Stormdrain Outflow | 12/11/2015 4:30pm | NA | 10.91 | 9.81 | 10.41 |
| Devereux Creek - west NCOS culvert | 12/11/2015 | NA | 9.915 | NA | 9.415 |
| Devereux Creek - above sill | 12/10/2015 11:45am | 1.56 | 8.17 | 6.37 | 4.81 |

NORTH CAMPUS OPEN SPACE GROUNDWATER

CCBER monitors the level and salinity of groundwater in NCOS using 19 piezometer wells distributed across the upper (South Parcel) and lower (previously Ocean Meadows Golf Course) areas of the site (Figure 3). The wells consist of a pvc tube that is open at the bottom and capped on top. Most of the tubes are more than 10 feet in length, with between 8 to 9 feet of the well beneath the ground surface.

The wells are normally checked every two weeks. However, we checked the wells on a weekly basis from January 8 to March 25, 2016 (the “rainy” season). The water level in the well is measured by drawing a wet erase marker line onto a standard measuring tape, and lowering the tape to the bottom of the well. The total depth of the well is recorded, and the height, or “thickness” of water in the well is determined by the point on the measuring tape (to the nearest 1/32 of an inch) at which the wet erase line is removed by the water.

HYDROLOGY MONITORING DATA, AUGUST 2015 TO APRIL 2016

WATER LEVELS IN DEVEREUX SLOUGH AND NCOS CREEKS

From late summer through autumn of 2015 (from 08/01 to 11/30), the water level in Devereux Slough gradually declined by nearly two feet, with the WSE dropping from about seven to five feet (Figure 4). The water level above the Devereux Creek sill also declined, from a WSE close to six down to below five feet, until a rainfall event on 9/15/2015 that raised the level by more than two feet (Figure 4). In contrast, the water level at the Phelps Creek site under Marymount Bridge remained stable, with a WSE above 10 feet, briefly rising to over 12 feet following rainfall events on 9/15 and 10/14/2015 (Figure 4).

With little to no precipitation, water levels continued to remain stable through December. Near the end of the month, CCBER installed the Levelloggers at the Whittier Drive stormdrain outflow and the in Devereux Creek at the outflow of the culvert in the western part of NCOS. In the first week of January, 2016, a significant amount of rainfall from two consecutive storms caused water levels to rise and fall rapidly. The greatest change in water level occurred on January 6 at the Phelps Creek site, where the water level increased by nearly seven feet in less than three hours, and then decreased by five feet three to four hours later (Figure 5). Beginning at 6:00 am on January 5, the water level in Devereux Slough increased by more than 3.5 feet in 36 hours. This rise coincided with high tides and surf that washed over the beach berm into the slough and collectively resulted in the slough breaching into the sea at approximately 7:00 pm, and the water level dropping by more than four feet in just over two hours on January 6 (Figure 5). Following the breach, the slough was tidally connected with the ocean for seven days.

From mid-January to March, 2016, water levels in the NCOS creeks briefly rose and then dropped back to baseline levels following a few relatively small rainfall events. Since the NCOS creeks drain into the slough, its water level gradually increased by more than two feet during

this period (Figure 6). Rainfall on March 6 caused the water level in the slough to rise by more than one foot, which was enough for a second breach event to occur. This time, however, the slough was tidally connected with the ocean for only about a day and a half (Figure 6).

WATER LEVELS IN NCOS GROUNDWATER WELLS

Here we report on the water levels in the NCOS groundwater piezometer wells located in the former Ocean Meadows Golf Course (wells 12 through 20 in Figure 3). The water level in these wells generally remained steady at baseline (or “dry season”) levels, or gradually decreased from mid-September through December 2015 (Figure 7). The elevation of water in wells 14 and 17 remained consistently above the water elevation in all other wells, indicating a higher elevation of the water table in these areas. The water elevation in wells 13, 15, 16, 18 and 20 was most heavily influenced by rainfall, as indicated by the significant increases in water level following heavy rainfall in the first week of January, 2016 (e.g. the level in well 20 rose by nearly six feet; Figure 7). This most likely reflects the position of these wells being close to the creeks and drainages in NCOS. Groundwater elevations in all wells have been gradually declining since the last significant rainfall in mid-March (Figure 7).

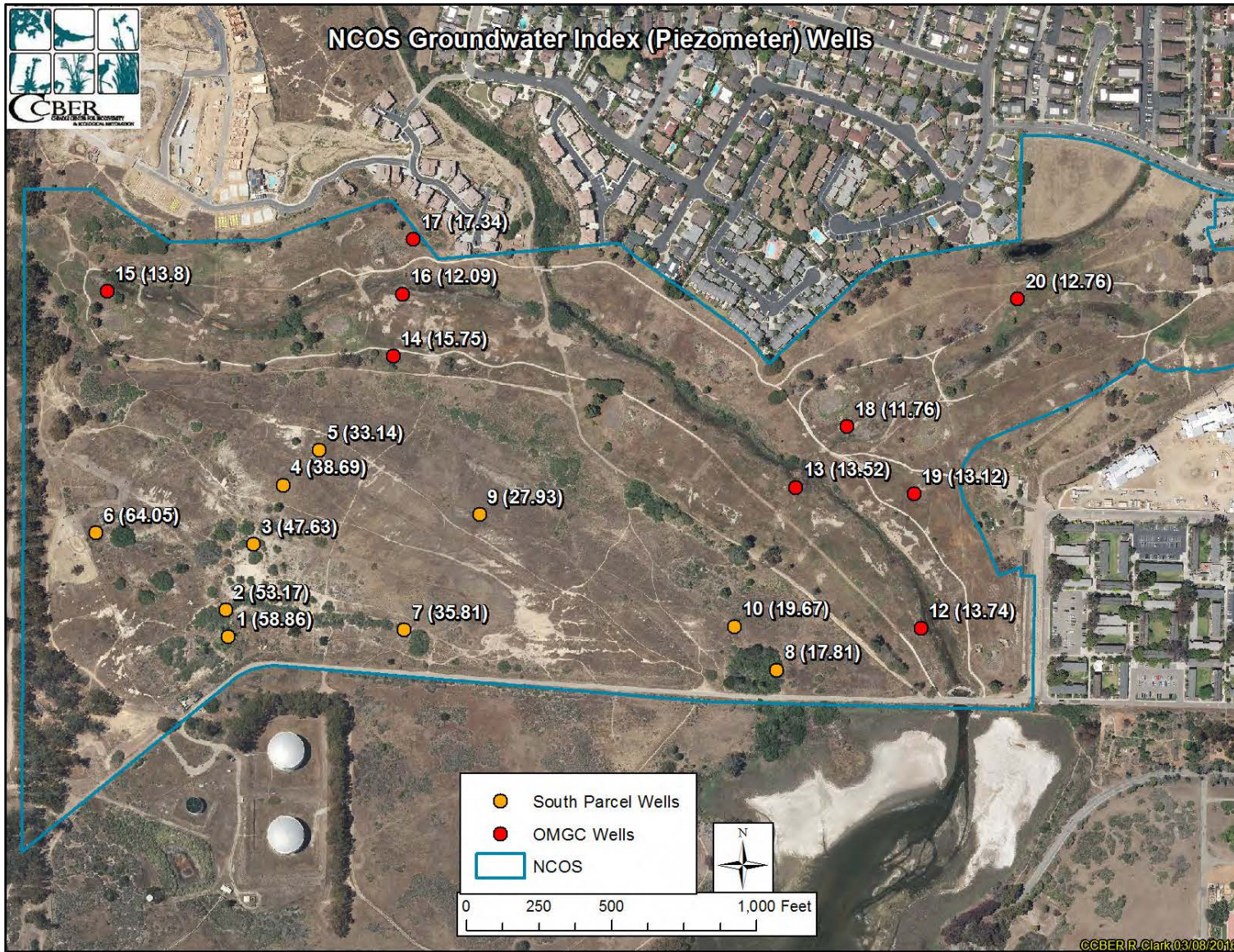


Figure 3. Map of the North Campus Open Space, with the locations of groundwater piezometer wells indicated with points labeled with the well number and surveyed elevation (in feet NAVD) of the top of the well.

**NCOS Creeks & Devereux Slough WSE (feet NAVD) derived from Levellogger & YSI data:
August 1 to November 30, 2015**

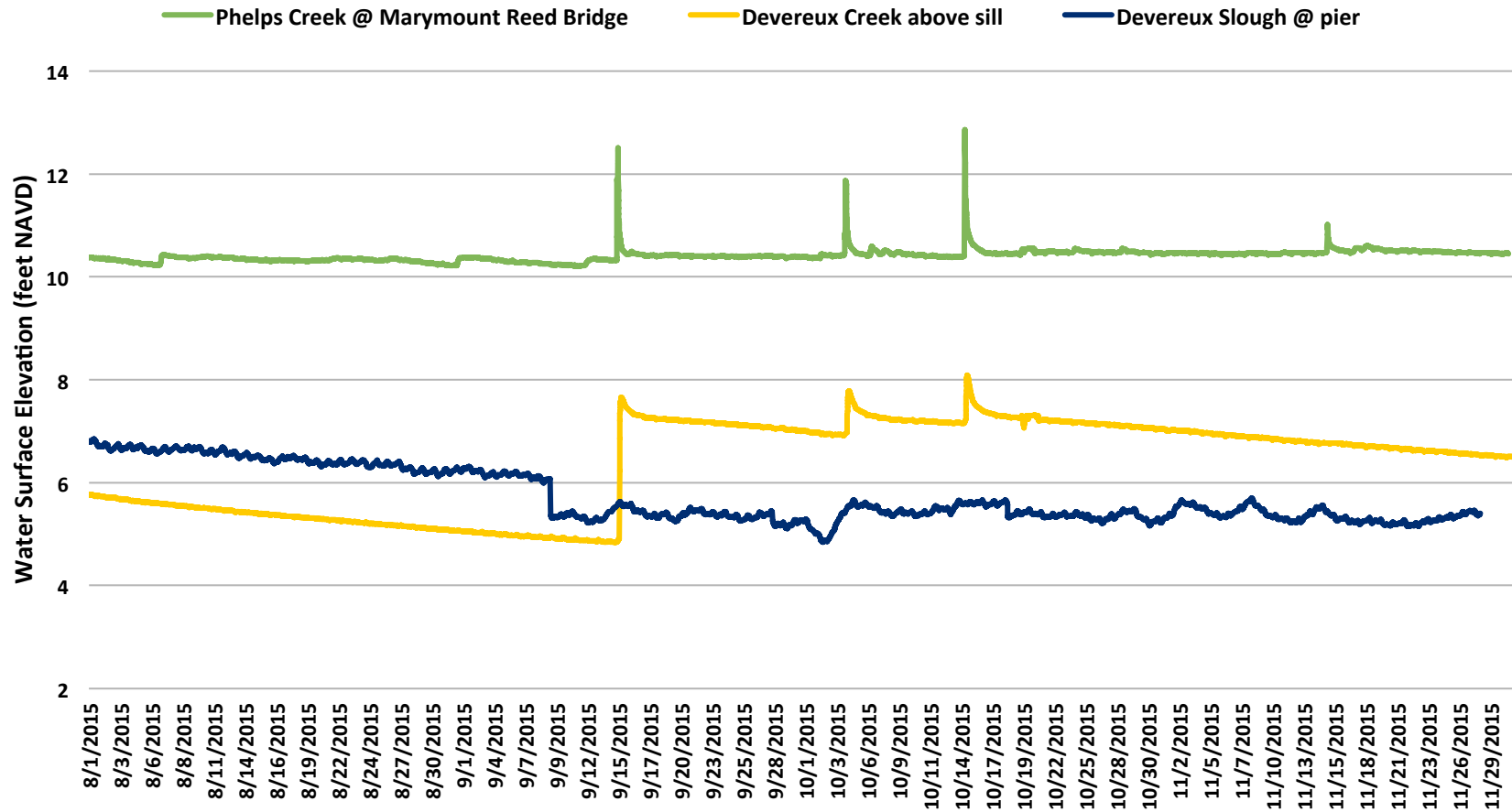


Figure 4. Water surface elevation (WSE) in feet (North American Vertical Datum – NAVD) from August 1 to November 30, 2015 at two locations North Campus Open Space (NCOS) creeks and in the main channel of Devereux Slough. The data were recorded every 15 minutes by Solinst Levelloggers in the NCOS creeks locations, and by a YSI EXO-1 sonde in Devereux Slough.

**NCOS Creeks & Devereux Slough WSE (feet NAVD) derived from Levelogger & YSI Data:
December 30, 2015 to January 15, 2016 - highlighting slough breach event**

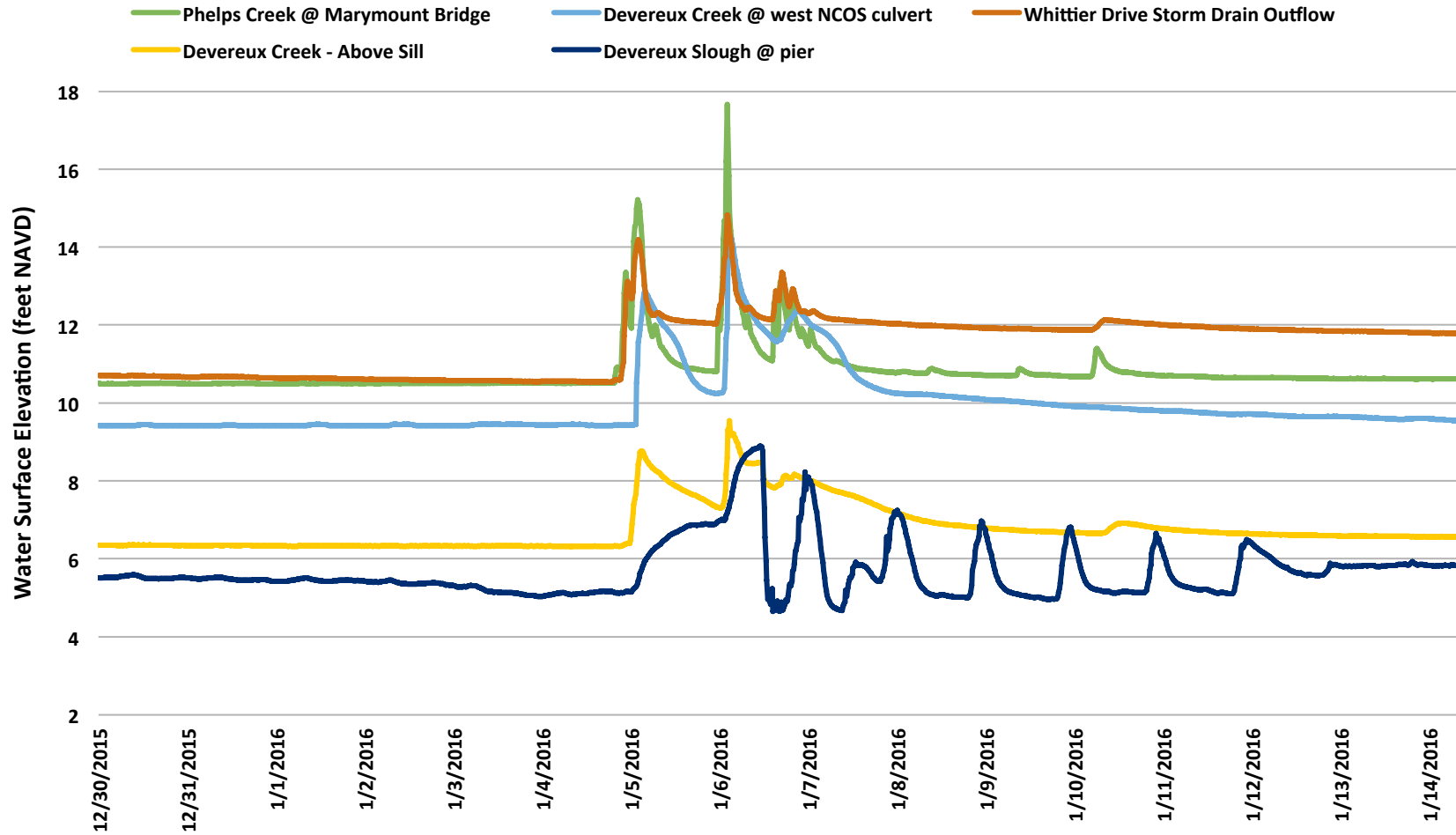


Figure 5. Water surface elevation (WSE) in feet (North American Vertical Datum – NAVD) from December 30, 2015 to January 15, 2016 at four locations in North Campus Open Space (NCOS) creeks, and in the main channel of Devereux Slough. The data were recorded every 15 minutes by Solinst Leveloggers in the NCOS creeks locations, and by a YSI EXO-1 sonde in Devereux Slough. The figure highlights an event where Devereux Slough breached and was tidally connected with the ocean for about a week.

**NCOS Creeks & Devereux Slough WSE (feet NAVD) derived from Levelogger & YSI Data:
January 16 to March 17, 2016**

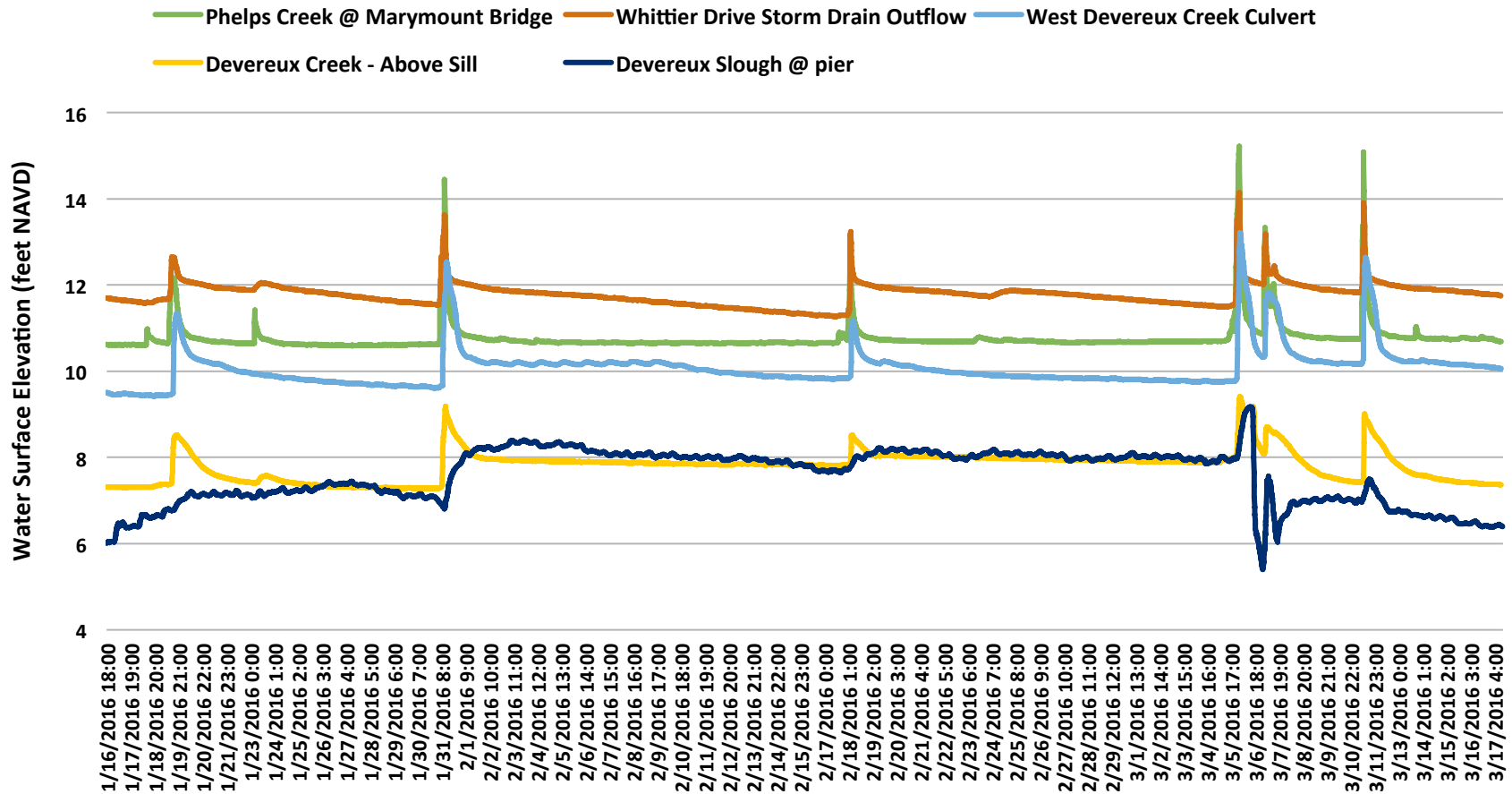


Figure 6. Water surface elevation (WSE) in feet (North American Vertical Datum – NAVD) from January 16 to March 17, 2016 at four locations in North Campus Open Space (NCOS) creeks, and in the main channel of Devereux Slough. The data were recorded every 15 minutes by Solinst Leveloggers in the NCOS creeks locations, and by a YSI EXO-1 sonde in Devereux Slough.

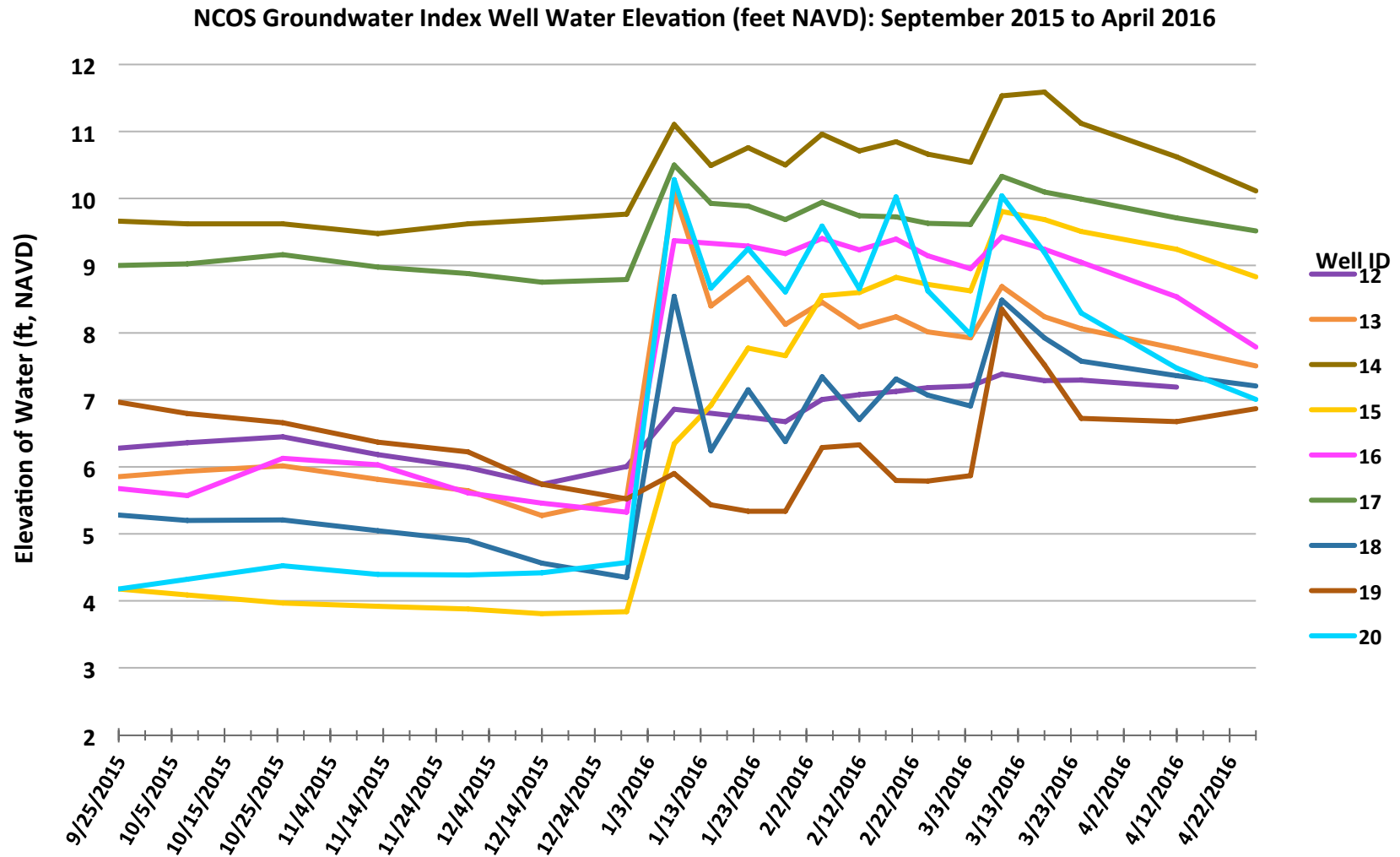


Figure 7. Groundwater elevation in feet (North American Vertical Datum – NAVD) from September 2015 to April 2016 in nine piezometer wells distributed across the lower portion of the North Campus Open Space (NCOS), formerly Ocean Meadows Golf Course. Water levels were manually measured every two weeks, except between January 8 to March 25, when levels were measured weekly.