Appendix D. Bathymetric Survey Results, February 2017

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Sears Point Wetland Restoration

Condition Bathymetric Survey

Field Data Collection Procedures

February 2017

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List of Acronyms

Abbreviation	Definition
AOC	Area of Concern
CORS	Continually Operating Reference Station
DEM	Digital Elevation Model
HARN	High Accuracy Reference Network
LiDAR	Light Detection and Ranging
IHO	International Hydrographic Organization
MBES	Multibeam Echo Sounder System
MLLW	Mean Lower Low Water
MRU	Motion Reference Unit
NAD83	North American Datum
NAVD88	North American Vertical Datum of 1988
NGS	National Geodetic Survey
NGS PID	National Geodetic Survey – Point Identification
NGVD29	National Geodetic Vertical Datum of 1929
OPUS	Online Positioning User Service
PPK	Post-Process Kinematic
RTK-GPS	Real-Time Kinematic GPS
SAV	Sub-Aquatic Vegetation
TIN	Triangulated Irregular Network
SSS	Sidescan Sonar
SBP	Sub-Bottom Profiler
USBL	Ultra-Short Baseline
USGS	United States Geological Survey
USACOE	United States Army Corps of Engineers
WSE	Water Surface Elevation

1. INTRODUCTION

1.1 PURPOSE AND SCOPE

CLE Engineering (Novato, CA) was contracted by Siegel Environmental (San Rafael, CA) to collect condition bathymetric survey data (USACOE Class 1 Standards) along seven elevation monitoring transects within the Sears Point Wetland Restoration Project located in southern Sonoma County, CA (Figure 1).

Singlebeam sonar-based survey data were collected along seven survey transects throughout the restoration site. The resultant survey data represent baseline elevations and will be resurveyed throughout the project monitoring period in order to track elevation changes as the marsh plain develops. This document outlines survey equipment, procedures and results of the initial monitoring effort.

1.2 DESCRIPTION OF SURVEY AREA

The 960-acre restoration site was breached in October 2015 after ten years of planning. Natural sedimentation is expected to raise the marsh plain to an elevation that will sustain tidal and subtidal habitats. The elevation surveys are part of a monitoring program designed to track the natural sedimentation, and in some areas, erosion, over the course of the evolution of the site.

2. METHODS

2.1 SURVEY CONTROL

The CLE field team tied into a control point network that was established by Ducks Unlimited (DU) and supplied to CLE by Siegel Environmental (Figure 2). CLE utilized a *Leica Geosystems System 1200* GPS base station established over DU point PT#52 with a tie-in to PT#50. The base station was programmed to collect high frequency satellite observations for processing by the National Geodetic Survey (NGS) computers in order to check the integrity of the point.

2.1.1 <u>Datums</u>

Table 1 outlines survey datums and coordinate systems.

Table 1 – Project Datums and Coordinate Systems

Horizontal Datum	Epoch	H. Coordinate System	Vertical Datum	GEOID Model	Units
NAD 83	2010.00	NAD 83 Ca State Plane Zone 2	NAVD 88	Geoid 12a	US Survey Ft.

Background Image: Google 2014

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Sears Point Wetland Restoration – 2017 Baseline Elevation Surveys
Location Map

February 2017

Figure 1

CONTROL POINT SUMMARY TABLE

Point#	Northing	Easting	Elevation (ft, NAVD88)
1	1813251.37	6428487.450	14.26
2	1813355.380	6428340.690	21.69
50	1808564.204	6425499.161	0.2
51	1805479.605	6425124.222	1.46
52	1810619.999	6429166.493	-0.27
53	1811942.595	6432016.712	8.52
54	1816182.367	6433909.419	10.45
55	1814428.429	6436930.110	-1.01
56	1808403.505	6429100.802	-0.86
57	1805565.182	6429430.584	1.15

Horizontal Datum is NAD83, California Zone 2, US Survey feet.

DUCKS UNLIMITED INC.
WESTERN REGIONAL OFFICE

SEARS POINT WETLAND RESTORATION PROJECT
SURVEY CONTROL POINT
SUMMARY MAP

Background Image: Google 2014

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Sears Point Wetland Restoration – 2017 Baseline Elevation Surveys
DU Survey Control Point Location Map

February 2017

Figure 2

2.2 SINGLEBEAM SONAR SURVEY SYSTEM

The hydrographic surveys utilized Class 1 methods and accuracies as outlined in the Army Corps of Engineers' January 2002 *Hydrographic Surveying Manual* (EM 1110-2-1003).

In order to take advantage of a high-water window at the site, the survey team utilized two shallow-water survey vessels outfitted with specially designed shoal-water sonars in order to collect singlebeam data throughout the site. Each survey system consisted of a survey-grade sonar unit, RTK-GPS rover for position, WSE data collection and vessel heave. Each survey skiff was also outfitted with a sound velocity probe, heading sensor and *Intel*-based data acquisition computer.

2.2.1 Survey Vessels

The survey crew utilized two 14 Ft. Lowe Jon Boats, each powered by a 10-horsepower jet-drive outboard specifically constructed for shallow water surveys. Each vessel was equipped with a 1,500-watt generator and acquisition computer weather housings.

2.2.2 Singlebeam Echo Sounder

Bathymetric data were collected using an *Ohmex SonarMite* survey-grade fathometer with a 4°, 200-kHz transducer. The *SonarMite* is engineered to collect sonar data in depths as shoal as ~ 1.0 Ft. The transducer was mounted on the port side of each vessel utilizing an over-the-side mount and placed with a 0.60 Ft. draft (see Appendix A for equipment specifications).

2.2.3 Positioning Equipment

Position data were measured and recorded utilizing a *Leica System 1200* RTK-GPS rover mounted directly above the fathometer sonar transducer. The RTK-GPS base station was located over the aforementioned control point established on the levee.

The rover was programmed to output position data at a rate of 20 Hertz directly to the survey acquisition program. The survey acquisition program was programmed to stop logging if the GPS mode was anything other than fixed.

2.2.4 Tides and Motion Compensation

The most common problem in accurately measuring the seafloor with any sonar-based system is the calculation of the tidal elevation offset. Commonly a tide staff or electronic gauge is deployed in one location near the survey site and is used to calculate the tides, or other types of water surface elevation changes (wind wave setup, reservoir draw-down etc.) for the entire survey area. However, it is widely understood that non-linear tidal phenomena, such as phase lags and tidal gradients can drastically influence the water surface elevation (WSE) spatially throughout the survey area and therefore the use of a single point measurement is often unreliable.

To avoid these potential WSE errors which can translate into significant departures from the true bottom depth, the survey crew utilized geodetic GPS with RTK baseline processing that is integrated within the survey data acquisition system on each vessel. The motion and Geoid 12a compensated positions and orthometric elevations of the RTK-GPS data stream are tagged with each sonar ping. In effect, the RTK-GPS mounted on the hydrographic survey vessel acts as a roving tide gauge collecting the most accurate tidal measurements throughout the survey area.

2.2.4.1 Motion Compensation

The fast update rate programmed into the GPS rover is necessary in order to utilize the GPS-generated ellipsoid heights time series for heave compensation. As the survey vessel is heaving upward or squatting downward (either due to undulations in the water surface or vessel squat resulting from the forward motion of the vessel through the water), the vertical change in the GPS antenna will be reflected in the height of the antenna above (or below) the reference ellipsoid. Post-processing computes an RTK heave correction for each sonar ping.

2.2.5 Vessel Heading

Each survey vessel utilized a *Hemisphere VS 111* heading and roll sensor. This heading reference unit is comprised of two differential GPS antennas mounted 1.5 meters apart, and an inertial-based roll sensor unit mounted in-line with the sonar transducer. The *VS 111* is accurate to 0.25 degrees.

2.2.6 Speed of Sound Measurements

Fathometers calculate water depth by using algorithms based on the speed of sound through the water column. The survey crew utilized an *Odom Digibar Pro* speed of sound probe to measure sound velocity multiple times during each survey day.

Mounted near the end of the sound velocity probe is a high frequency "sing-around" transducer and its associated reflector. This precisely spaced pair is used to measure the velocity of sound in water by transmitting and receiving a signal across their known separation distance. Speed of sound tables were loaded into the fathometers at the beginning of each survey day. Additional sound velocity casts were collected at the beginning of each ebb and flood.

The on-board data streams were collected utilizing a *Panasonic Toughbook* running *Hypack Max* (Version 2015) survey planning, data collection and reduction software.

The 4-person field crew for each survey included Mr. James Kulpa (ACSM Certified Hydrographer #288 - CLE), Mike Campagnone (Hydrographer – CLE), Kyle Berger (Hydrographic Technician – CLE) and Skylar Hurley (Hydrographic Technician – CLE).

3. RESULTS AND QUALITY ASSURANCE / QUALITY CONTROL

3.1 DATA COLLECTION TIME PERIODS

Table 2 outlines survey dates and associated survey activities.

Table 2 – Survey Diary

Date	Survey Activities	Notes
2/9/2017	Reconnoiter survey areas, verify DU control	Crew realizes Boston Whaler has too much draft, MOB both skiffs
2/10/2017	Survey	No wind, calm water surface conditions

3.2 RTK-GPS TIDES CALIBRATION

To check the accuracy of the *Hypack*-derived tidal elevation, a temporary tide staff was established at the boat ramp and surveyed into the project control network. The WSE was then checked against the *Hypack* reported values before and after each survey day for each vessel.

Table 3 – RTK Tide Calibration Results

Date	WSE As measured from tide staff	Time	Jet Boat *Hypack* Tides	Jon Boat *Hypack* Tides	Notes
2/10/17	6.55	13:30	6.50	6.52	Pre-survey cal
2/10/17	4.43	15:36	4.40	4.40	Post-survey cal

3.3 FATHOMETER BARCHECK CALIBRATIONS

There are two standard procedures used to check the accuracy of a survey fathometer whether it be a multibeam or singlebeam transducer; 1) speed of sound profiles and 2) fathometer barcheck calibrations. Fathometers calculate water depth by using algorithms based on the speed of sound through the water column. Depth-integrated sound velocity measurements were taken two times each survey day throughout the survey footprint. Sound velocity profiles were measured and recorded utilizing an *Odom Digi-Bar Pro* speed of sound probe. The sound velocity profile was then programmed directly into *Hypack.*

The second protocol is a barcheck calibration which is performed on the fathometer and consists of lowering a 36-inch diameter, weighted steel plate below the fathometer transducer and recording the actual depth of the disc (via markings on a cable) and the fathometer nadir output (output was corrected for the transducer depth offset). Table 4 shows the results of the barcheck calibrations which were measured within 0.10 Ft or less for each checked depth.

Table 4 – Barcheck Results

Date	Bar Depth	Jet Boat Fathometer Read	Jon Boat Fathometer Read	Notes
2/10/2017	2.60	2.60	2.59	Pre-survey cal
2/10/2017	3.00	3.00	3.02	Pre-survey cal
2/10/2017	5.50	5.50	5.48	Post-survey cal
2/10/2017	3.50	3.50	3.52	Post-survey cal

3.4 RTK-GPS CHECK SHOTS

In order to check the accuracy of the *Leica System 1200* RTK-GPS, and provide for a "blunder check", the *Leica* rover was checked into two of the DU survey control points. In addition, DU Points PT#50 and PT#52 was checked against the NGS Online Position User Service (OPUS - https://www.ngs.noaa.gov/OPUS/) results. The surveys were held to the OPUS result for PT#50. Figure 2 shows the location of the DU control points (map provided to CLE by Siegel).

Seven hours of static GPS data was uploaded to OPUS for processing Table 5 outlines the result of the check-in shots.

Table 5 – RTK-GPS Check-in Results

Mark	DU Reported		Reported Elevation NAVD (Ft.)	CLE Check-in Survey Results *based on OPUS results		Surveyed Elevation NAVD (Ft.)
	Northing (US ft.)	Easting (US ft.)		Northing (US ft.)	Easting (US ft.)	
PT# 50	1,808,564.204	6,425,499.161	0.20	1,808,565.5864	6,425,498.2084	0.29
PT# 52	1,810,619.999	6,429,166.493	-0.27	1,810,621.382	6,4291,65.555	-0.39

3.5 SURVEY COVERAGE

Both survey crews collected data along a total of 274 planned survey lines covering more than 78 miles of total distance. Figure 3 shows survey coverage throughout the north, central and southern lobes, as well as top of bank coverage within the main interior channel. Table 6 lists the survey bounding coordinates.

Table 6 – Bounding Coordinates

West Longitude	-122.474089
East Longitude	-122.437407
North Latitude	+38.147110
South Latitude	+38.118413

3.6 SOUNDING REDUCTION

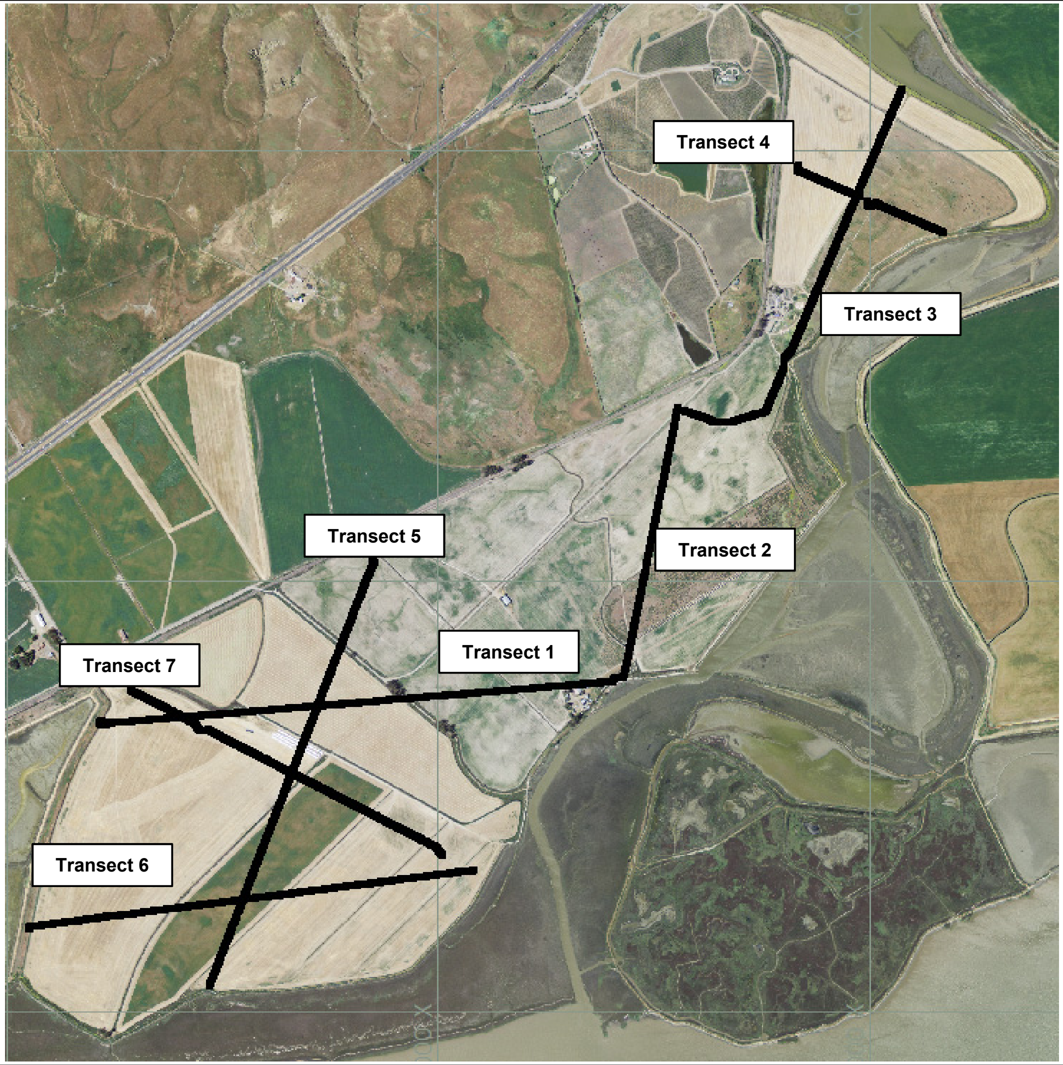
In order to reduce each raw bathymetric survey line into an XYZ dataset, the survey line was imported into the *Single Beam Editor* in *Hypac*k (Version 2013). The *Single Beam Editor* enables all of the survey variables and ancillary data sets (tides, heave, pitch and roll values and sensor offsets) to be reviewed and applied to each survey line.

The next step is extracting the *Hypack*-derived RTK-tidal time series from the raw log files, and compared against tides measured by the NOAA gage located just south of the breach on the Stinson Beach seawall in the lagoon. Hypack-derived tides are also compared to water surface elevation points that were periodically measured and recoded by the RTK-GPS topographic rover.

Each survey line is then imported and reviewed in detail and erroneous bathymetric points (spikes and other outliers) are deleted or interpolated into the survey line. RTK-GPS position and elevation quality values are also reviewed during this step. Once each line has been reviewed and edited, all of the lines for each survey day are then exported into a *Hypack Edited* file. The edited file is then reviewed in the *Hypack Shell* for position and elevation quality. Where survey lines intersect (cross lines), a review of the overlapping soundings from each line is analyzed using the *Cross Check Statistics* program in *Hypack*.

Once the *Edited Hypack* file has passed the final review, the data is then filtered using the *Sounding Selection* algorithm in *Hypack* in order to reduce the soundings to one point at three foot intervals along each survey transect. After sounding selection, the resultant dataset is then exported to an XYZ text file.

The text file is then brought into *AutoCAD Civil 3D* (Version 2014) for final review. Transects were cut and imported into Excel for graphing. The elevation transects are in Appendix B.



Background Image: Google 2014

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Sears Point Wetland Restoration – 2017 Baseline Elevation Surveys
Baseline Transect Locations

February 2017

Figure 3

4. REFERENCES

U.S. Army Corps of Engineers. 2002. *Hydrographic Survey Manual*, Engineering and Design Manual No. EM-1110-2-1003, Washington D.C.

Appendix A

Equipment Specifications

Leica GPS1200+
Technical specifications and system features

GPS1200+ receivers	GX1230+ GNSS/ ATX1230+ GNSS	GX1220+ GNSS	GX1230+	GX1220+	GX1210+
GNSS technology	SmartTrack+	SmartTrack+	SmartTrack	SmartTrack	SmartTrack
Type	Triple frequency	Triple frequency	Dual frequency	Dual frequency	Single frequency
Channels	120 channels L1/L2/L5 GPS L1/L2 GLONASS E1/E5a/ E5b/ Alt-BOC Galileo Compass[1] 4 SBAS	120 channels L1/L2/L5 GPS L1/L2 GLONASS E1/E5a/ E5b/ Alt-BOC Galileo Compass[1] 4 SBAS (with DGPS option)	16 L1 + 16 L2 GPS 4 SBAS	16 L1 + 16 L2 GPS 4 SBAS (with DGPS option)	16 L1 GPS 4 SBAS (with DGPS option)
Upgrade to GX1230+ GNSS	-	Yes	Yes	Yes	Yes
RTK	SmartCheck+	No	SmartCheck	No	No
Status indicators	3 LED indicators for GX1200+: power, tracking, memory				

GPS1200+ receivers	GX1230+ (GNSS)/ GX1220+ (GNSS)	GX1210+	ATX1230+ GNSS
Ports	1 power port, 3 serial ports, 1 controller port, 1 antenna port		1 power/controller port, *Bluetooth*® Wireless-Technology port
Supply voltage, Consumption	Nominal 12 VDC 4.6 W receiver + controller + antenna		Nominal 12 VDC 1.8 W
Event input and PPS	Optional: 1 PPS output port 2 event input ports	Optional: 1 PPS output port 2 event input ports	
Standard antenna Built-in groundplane	SmartTrack+ AX1203+ GNSS Built-in groundplane	SmartTrack AX1201 Built-in groundplane	SmartTrack+ ATX1230+ GNSS Built-in groundplane

The following apply to all receivers except where stated.

Power supply	Two Li-Ion 4.4 Ah/7.4 V plug into receiver. One Li-Ion 2.2 Ah/7.4 V plugs into ATX1230+ GNSS and RX1250.
Plug-in Li-Ion batteries Same for GNSS and TPS	Power receiver + controller + SmartTrack antenna for about 17 hours (for data logging).
	Power receiver + controller + SmartTrack antenna + low power radio modem or phone for about 11 hours (for RTK/DGPS). Power SmartAntenna + RX1250 controller for about 6 hours (for RTK/DGPS)
External power	External power input 10.5 V to 28 V.
Weights	Receiver 1.20 kg. Controller 0.48 kg (RX1210) and 0.75 kg (RX1250). SmartTrack antenna 0.44 kg. SmartAntenna 1.12 kg. Plug-in Li-Ion battery 0.11 kg (2.2 Ah) and 0.2 kg (4.4 Ah)
	Carbon fiber pole with SmartTrack antenna and RX1210 controller: 1.80 kg.
	All on pole: carbon fiber pole with SmartAntenna, RX1250 controller and plug-in batteries: 2.74 kg.

Temperature ISO9022 MIL-STD-810F	Operation:	Receiver	–40° C to +65° C
		Antennas	–40° C to +70° C
		Controllers	–30° C to +65° C
		Controller RX1250c	–30° C to +50° C
	Storage:	Receiver	–40° C to +80° C
		Antennas	–55° C to +85° C
		Controllers	–40° C to +80° C
		Controller RX1250c	–40° C to +80° C
Humidity ISO9022, MIL-STD-810F	Receiver, antennas and controllers Up to 100 % humidity.		
Protection against water, dust and sand IP67, MIL-STD-810F	Receiver, antennas and controllers: Waterpoof to 1 m temporary submersion. Dust tight		
Shock/drop onto hard surface	Receiver: withstands 1 m drop onto hard surface. Antennas: withstand 1.5 m drop onto hard surface.		
Topple over on pole	Receiver, antennas and controllers: withstand fall if pole topples over.		
Vibrations ISO9022 MIL-STD-810F	Receiver, antennas and controllers: withstand vibrations on large construction machines. No loss of lock.		

[1] The Compass signal is not finalized, although, test signals have been tracked with GPS1200+ receivers in a test environment. As changes in the signal structure may still occur, Leica Geosystems cannot guarantee full Compass compatibility.

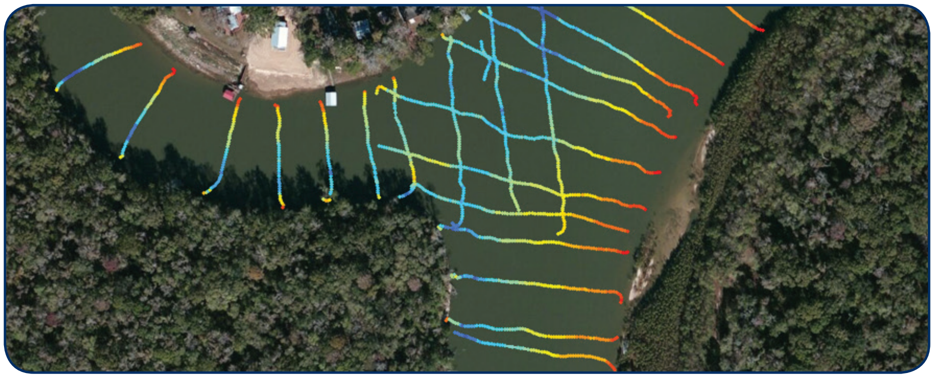
SmartTrack+ **Advanced GNSS measurement technology**	Time needed to acquire all satellites after switching on: typically about 50 seconds. Re-acquisition of satellites after loss of lock (e.g. passing through tunnel): typically within 1 second.
	Very high sensitivity: acquires more than 99 % of all possible observations above 10 degrees elevation. Very low noise. Robust tracking. Tracks weak signals to low elevations and in adverse conditions. Multipath mitigation. Jamming resistant.
	Measurement precision: Carrier phase on L1: 0.2 mm rms. On L2: 0.2 mm rms. Code (pseudorange) on L1 and L2: 20 mm rms.
SmartCheck+ **Advanced, long range RTK technology**	Initialization typically 8 seconds. Position update rate selectable up to 20 Hz. Latency < 0.03 secs. Range 40 km or more in favorable conditions. Self checking.
Accuracies	Kinematic Horizontal: 10 mm + 1 ppm Vertical: 20 mm + 1 ppm Static (ISO 17123-8) Horizontal: 5 mm + 0.5 ppm Vertical: 10 mm + 0.5 ppm
	Reliability: 99.99 % for baselines up to 40 km.
	Formats supported for transmission and reception: Leica proprietary (Leica, Leica 4G), CMR, CMR+, RTCM V2.1/2.2/2.3/3.0/3.1.
Reference station networks	RTK rover fully compatible with Leica's Spider i-MAX & MAX formats, VRS and Area Correction (FKP) reference station networks.
DGPS GX1230+ (GNSS), ATX1230+ GNSS,	DGPS, includes support of MSAS, WAAS, EGNOS and GAGAN. RTCM V2.1/2.2/2.3/3.0/3.1. formats supported for transmission and reception.
GX1220+ (GNSS) – standard GX1210+ – optional	Baseline rms: typically 25 cm rms with suitable reference station.
Position update rate and latency	Applies to RTK, DGPS and navigation positions. Update rate selectable from 0.05 sec (20 Hz) to 1 sec. Latency less than 0.03 secs.
NMEA output	NMEA 0183 V3.00 and Leica proprietary.
Post-processing with Leica Geo Office software **All GPS1200+ receivers**	Horizontal: 10 mm + 1 ppm, kinematic Vertical: 20 mm + 1 ppm, kinematic
	Horizontal: 5 mm + 0.5 ppm, static Vertical: 10 mm + 0.5 ppm, static
	For long lines with long observations Horizontal: 3 mm + 0.5 ppm, static Vertical: 6 mm + 0.5 ppm, static
Notes on performance and on accuracies	Figures quoted are for normal to favorable conditions. Performance and accuracies can vary depending on number of satellites, satellite geometry, observation time, ephemeris, ionosphere, multipath etc.

Controllers **RX1210/RX1250**	High contrast, 1/4 VGA display with colour option (RX1250) Touch screen, 11 lines x 32 characters.
	Windows CE 5.0 on RX1250.
	Full alphanumeric QWERTY keypad. Function keys and user definable keys. Illumination for screen and keys.
	Can also be used with TPS1200+ for alphanumeric input and extensive coding.
Operation with controller Same for GNSS and TPS	Via keypad and/or via touch screen. Graphical operating concept. Function keys and user definable keys. All information displayed.
Displayed information	All information displayed: status, tracking, data logging, database, RTK, DGPS, navigation, survey, stakeout, quality, timer, power, geographical, cartesian, grid coordinates etc.
Graphical display of survey Same for GNSS and TPS	Graphical display (plan) of survey. Zooming. Can access surveyed points directly via touch screen.
Stakeout display Same for GNSS and TPS	Graphical with zoom. Digital, polar and orthometric. Accuracy: 10 mm + 1 ppm at 20 Hz (0.05 sec) update rate. No degradation with high update rates.
Operation without controller GX1200+ only	Automatic on switching on. LED status indicators. For reference stations and static measurements.
Data logging Same cards used for GNSS and TPS	On CompactFlash cards: 256 MB and 1 GB Optional internal receiver memory: 256 MB.
Capacity	64 MB sufficient for (30 % less for GPS/GLONASS): About 500 hours L1 + L2 data logging at 15 sec rate. About 2 000 hours L1 + L2 data logging at 60 sec rate. About 90 000 RTK points with codes.
Data management Same for GNSS and TPS	User definable job management. Point identifiers, coordinates, codes, attributes etc.
	Search, filter and display routines. Multi point averaging. Five types of coding systems cover all requirements.
Coordinate systems Same for GNSS and TPS	Ellipsoids, projections, geoidal models, coordinate, transformations, transformation parameters, country specific coordinate systems. Fully support of RTCM 3.1 coordinate system transfer.
Application programs Same for GNSS and TPS	Standard: Full range of COGO functions. Hidden point.
	Optional: RoadRunner, Reference Line, DTM Stakeout, Reference Plane, Area Division and X-Section Survey, DXF Export, LandXML Export and Volume Calculations
Programmable Same for GNSS and TPS	User programmable in GeoC++. Users can write and upload programs for their own special requirements and applications.
Communication **Data links**	One or two of the following devices can be connected: Radio modem, GSM, GPRS, CDMA.
	Different frequencies and/or formats can be received and transmitted. Time slicing is supported.

Seafloor

datasheet

SonarMite MILSpec^{tm}



multibeam survey image

benefits

- rugged, field-proven survey grade echo sounder
- Bluetooth technology integrated with Windows Pocket PC devices
- proven “Smart” transducer design with QA output
- easily integrates with other modern software and GPS technology

about

The SonarMite MILSpec^{tm} echo sounder is the result of nearly two years’ research and development to further extend the boundaries of shallow water hydrographic survey equipment. The introduction by Ohmex in 1997 of the SonarLite, the world’s first truly portable echo sounder system has been a hard act to follow and it remains the portable instrument of choice in many survey companies around the world. The release of the SonarMite MILSPec instrument marks the next stage introducing a series of equipment designed around the WinSTRUMENT concept using the latest portable computer integrated with new measurement technologies.

specifications

frequency	200 KHz
beam width	4 degrees
ping rate	6 Hz
depth accuracy	1cm / 0.1% of depth
output formats	NMEA, ASCII
range	0.3m–75m
I/O	serial, Bluetooth
environmental	IP-65
power	rechargeable 12v battery

options

- data collection software
- heave, pitch and roll measurements
- sound velocimeter
- portable mounting bracket
- rugged shipping case
- extended warranty

SonarMite MILSpec echo sounder with cable

Seafloor Systems, Incorporated
3941 Park Drive, Suite 20-218 · El Dorado Hills, CA 95762 · USA
(530) 677–1019 · info@seafloorsystems.com · www.seafloorsystems.com

Rev 07/13/2015

VS101 and VS111 GPS Compass

Professional Heading and Positioning Receiver

VS111™

VS101™

Precise applications demand the heading and positioning performance of the VS101™ and VS111™ GPS compass. Ideal for professional machine control and navigation applications, the VS101/111 delivers reliable accuracy at significantly less cost than competitors' products or traditional methods. The Crescent® Vector™ II technology brings a series of new features to the VS101/111 including heave, pitch and roll output, and more robust performance.

The VS101/111 receiver, with its display and user interface, can be conveniently installed near the operator. The two antennas are mounted separately and with a user-determined separation to meet the desired accuracy.

Powered by Crescent

The VS101 uses SBAS (WAAS, EGNOS, MSAS, etc.) for differential GPS positioning. The VS111 includes both SBAS and radio beacon differential GPS positioning options.

Key VS101 and VS111 GPS Compass Advantages

- Affordable solution delivers 2D GPS heading accuracy better than 0.1 degree rms
- Differential positioning accuracy of less than 60 cm, 95% of the time
- Integrated gyro and tilt sensors deliver fast start-up times and provide heading updates during temporary loss of GPS
- Fast heading and positioning output rates up to 20 Hz
- SBAS compatible (WAAS, EGNOS, MSAS etc.), integrated beacon (VS111 only), and optional external differential input
- COAST™ technology maintains differentially-corrected positioning for 40 minutes or more after loss of differential signal
- The status lights and menu system make the VS101 series easy to monitor and configure

VS101 and VS111 GPS Compass

GPS Sensor Specifications

Receiver Type:	L1, C/A code, with carrier phase smoothing
Channels:	Two 12-channel, parallel tracking (Two 10-channel when tracking SBAS)
SBAS Tracking:	2-channel, parallel tracking
Update Rate:	Standard 10 Hz, optional 20 Hz (position and heading)
Horizontal Accuracy:	< 0.02 m 95% confidence (RTK[1,4]) < 0.6 m 95% confidence (DGPS[1]) < 2.5 m 95% confidence (autonomous, no SA[2])
Heading Accuracy:	< 0.30° rms @ 0.5 m antenna separation < 0.15° rms @ 1.0 m antenna separation < 0.10° rms @ 2.0 m antenna separation
Pitch / Roll Accuracy:	< 1° rms
Heave Accuracy:	30 cm
Timing (1PPS) Accuracy:	50 ns
Rate of Turn:	90°/s maximum
Cold Start:	< 60 s typical (no almanac or RTC)
Warm Start:	< 20 s typical (almanac or RTC)
Hot Start:	< 1 s typical (almanac, RTC and position)
Heading Fix:	< 10 s typical (valid position)
Antenna Input Impedance:	50 Ω
Maximum Speed:	1,850 kph (999 kts)
Maximum Altitude:	18,288 m (60,000 ft)

Beacon Sensor Specifications (VS111 version)

Channels:	2-channel, parallel tracking
Frequency Range:	283.5 to 325 kHz
Operating Modes:	Manual, automatic and database
Compliance:	IEC 61108-4 beacon standard

Communications

Serial ports:	2 full-duplex RS-232
Baud Rates:	4800 - 115200
Correction I/O Protocol:	RTCM SC-104, L-Dif™ [3], RTK[3]
Data I/O Protocol:	NMEA 0183, Crescent binary[3], L-Dif[3], RTK[3]
Timing Output:	1PPS (HCMOS, active high, rising edge sync, 10 kΩ, 10 pF load)
Event Marker Input:	HCMOS, active low, falling edge sync, 10 kΩ

Environmental

Operating Temperature:	-30°C to +70°C (-22°F to +158°F)
Storage Temperature:	-40°C to +85°C (-40°F to +185°F)
Humidity:	95% non-condensing
Shock and Vibration:	EP 455
EMC:	FCC Part 15, Subpart B, CISPR22, CE

Power

Input Voltage:	9 to 36 VDC
Power Consumption:	4.1 W nominal
Current Consumption:	340 mA @ 12 VDC nominal
Power Isolation:	Isolated power supply
Antenna Voltage:	5 VDC nominal
Antenna Short Circuit Protection:	Yes
Antenna Gain Input Range:	10 to 40 dB
Antenna Input Impedance:	50 Ω

Mechanical

Dimensions:	18.9 L x 11.4 W x 7.1 H (cm) 7.4 L x 4.5 W x 2.8 H (in)
Weight:	0.86 kg (1.9 lb)
Status Indication:	Power, primary GPS lock, secondary GPS lock, DGPS lock, and heading lock
Power Switch:	Miniature push-button
Power Connector:	2-pin, micro-Conxall
Data Connectors:	DB9-female (x2)
Antenna Connectors:	TNC-female (x2)

Aiding Devices

Gyro:	Provides smooth heading, fast heading reacquisition and reliable < 1° heading for periods up to 3 minutes when loss of GPS has occurred
Tilt Sensors:	Assists in fast start-up of heading solution

Authorized Distributor:

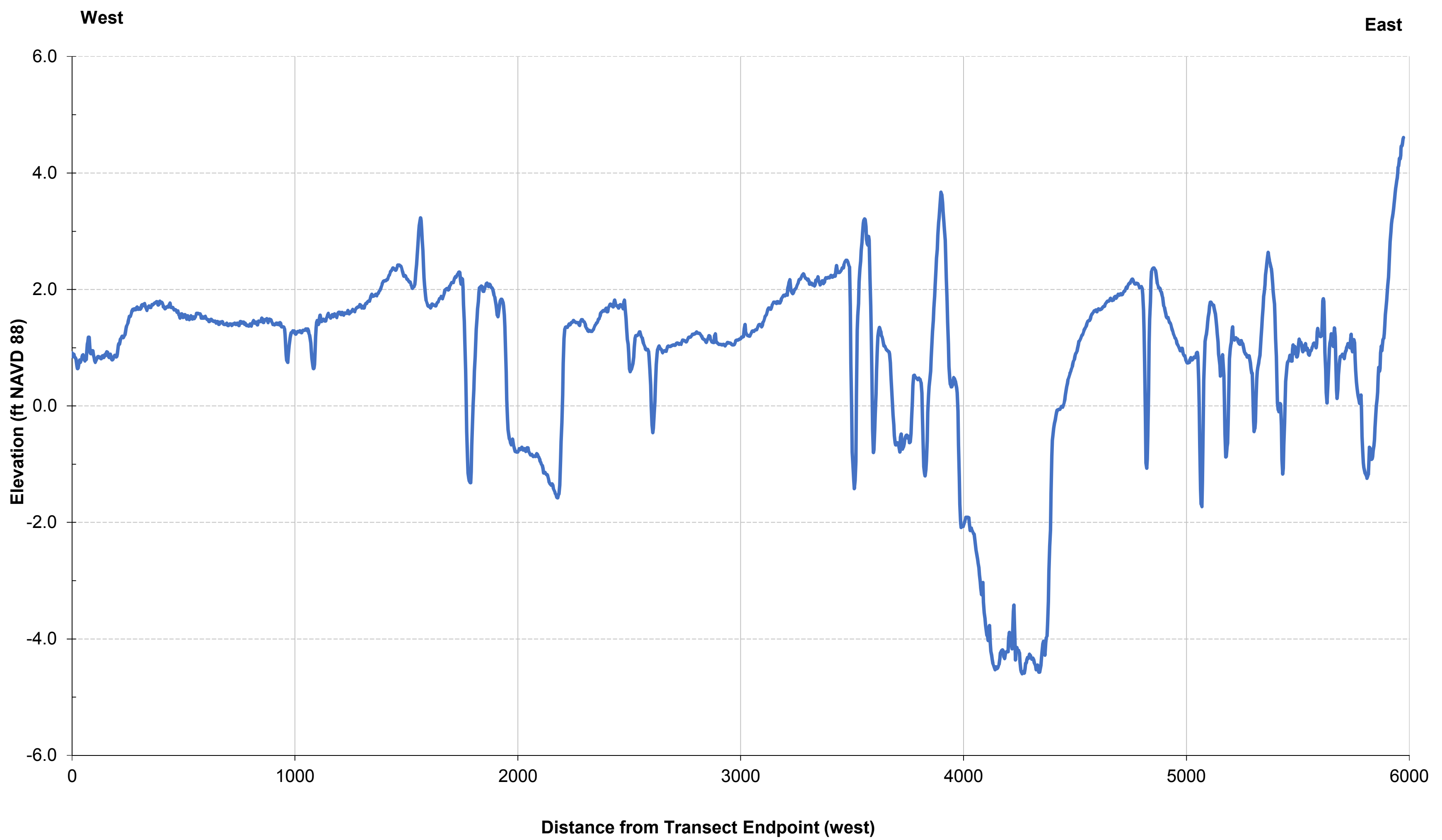
1 Depends on multipath environment, antenna selection, number of satellites in view, satellite geometry, baseline length (for local services), and ionospheric activity
2 Depends on multipath environment, number of satellites in view, and satellite geometry
3 Hemisphere GPS proprietary
4 Up to 5 km baseline length

HEMISPHERE GPS
4110 - 9th Street S.E.
Calgary, AB T2G 3C4
Canada

Phone: 403.259.3311
Fax: 403.259.8866
precision@hemispheregps.com
www.hemispheregps.com

Appendix B

Elevation Transect Graphs



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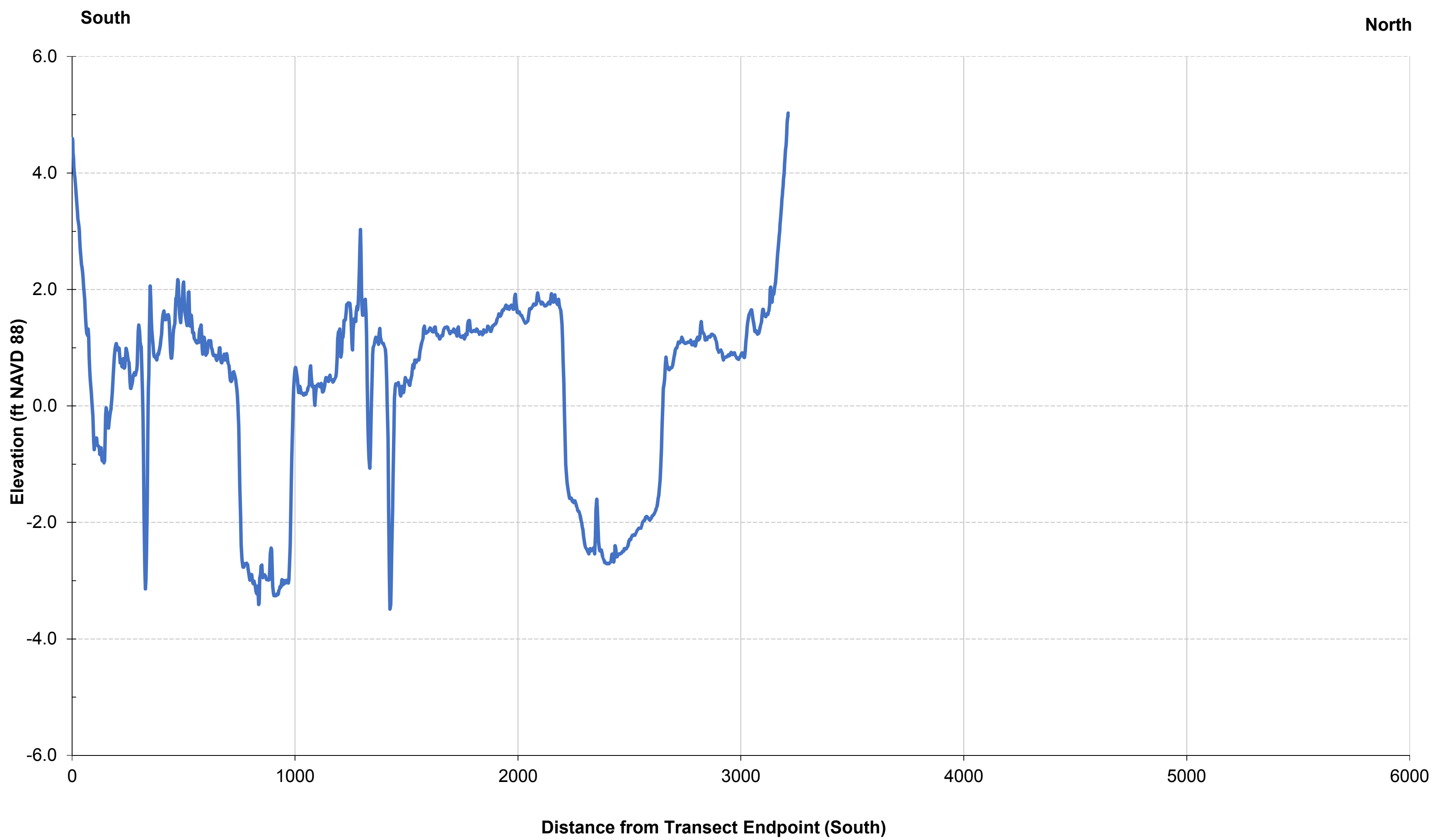
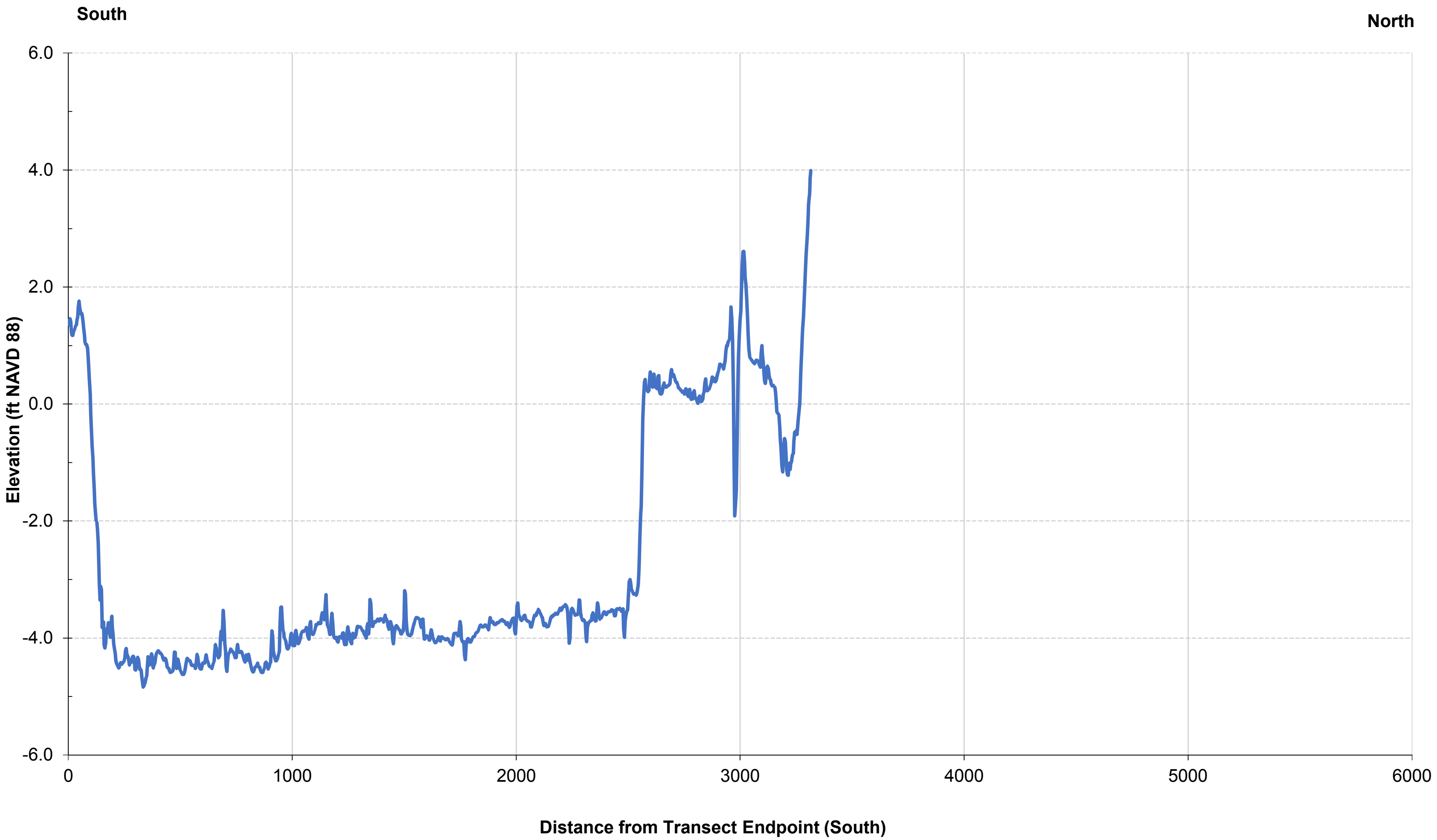
Sears Point Wetland Restoration

Elevation Transect Establishment - February 2017
Transect 1



Sears Point Wetland Restoration

Elevation Transect Establishment - February 2017
Transect 2



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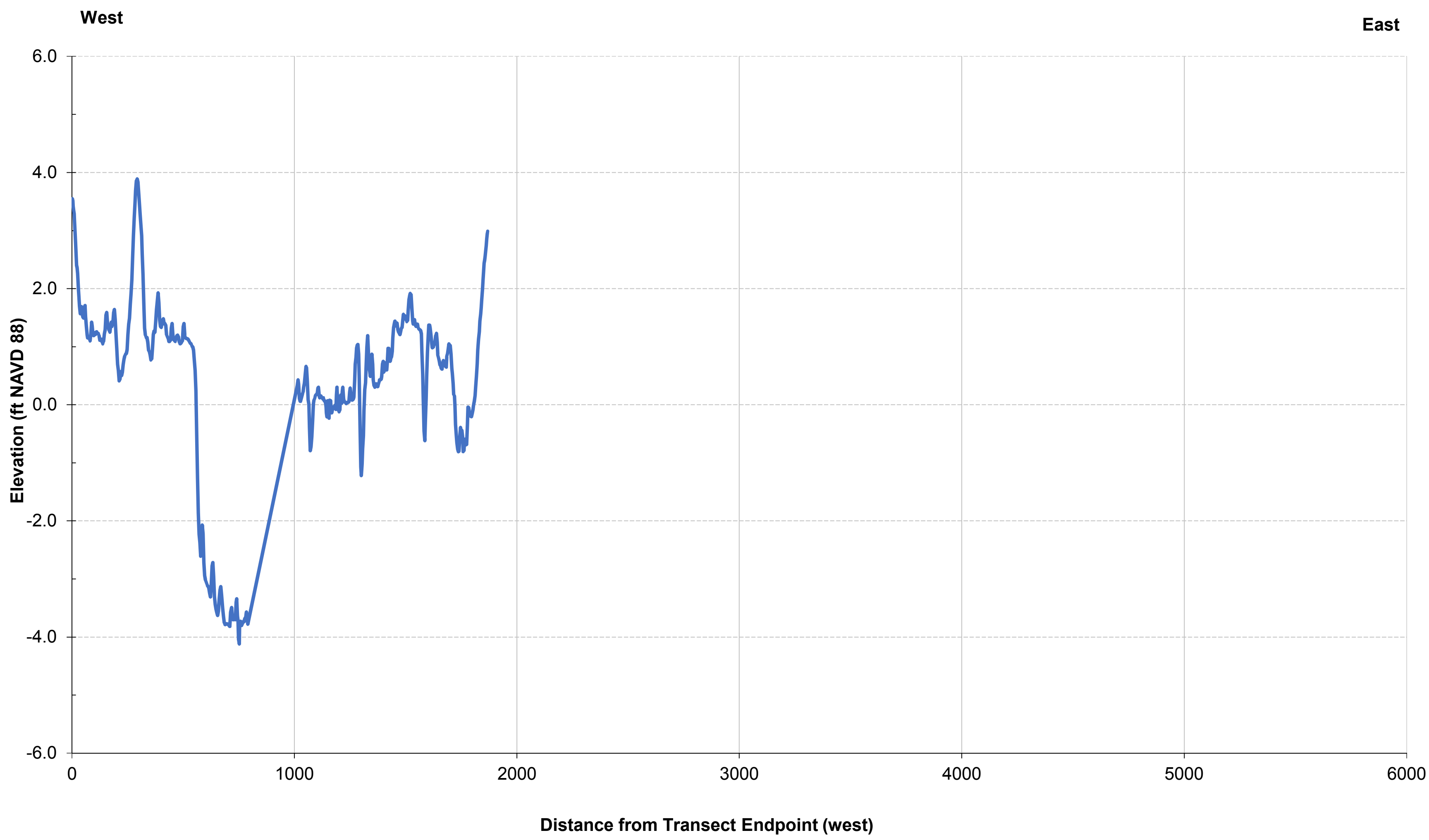
Sears Point Wetland Restoration

Elevation Transect Establishment - February 2017
Transect 3



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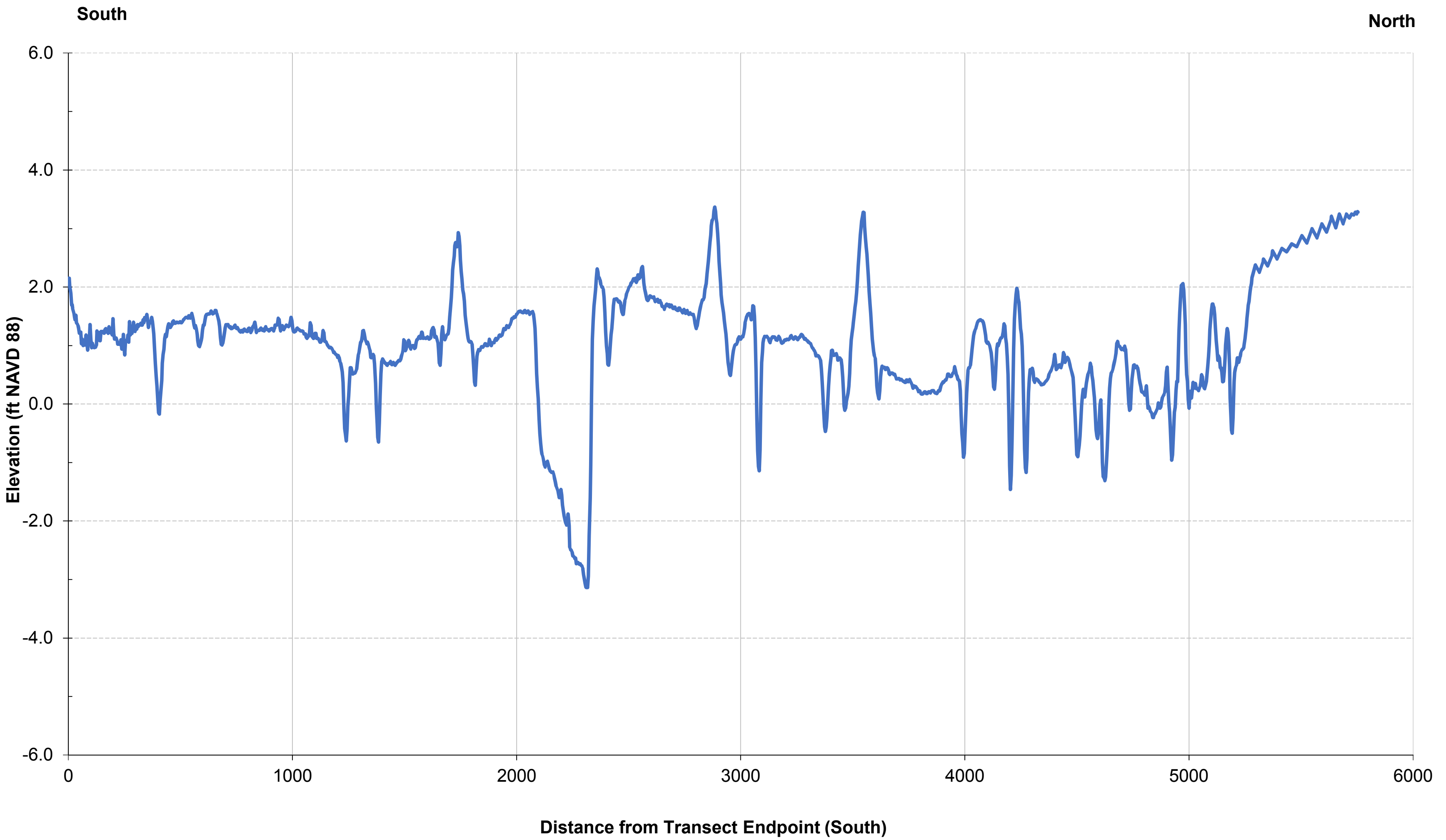
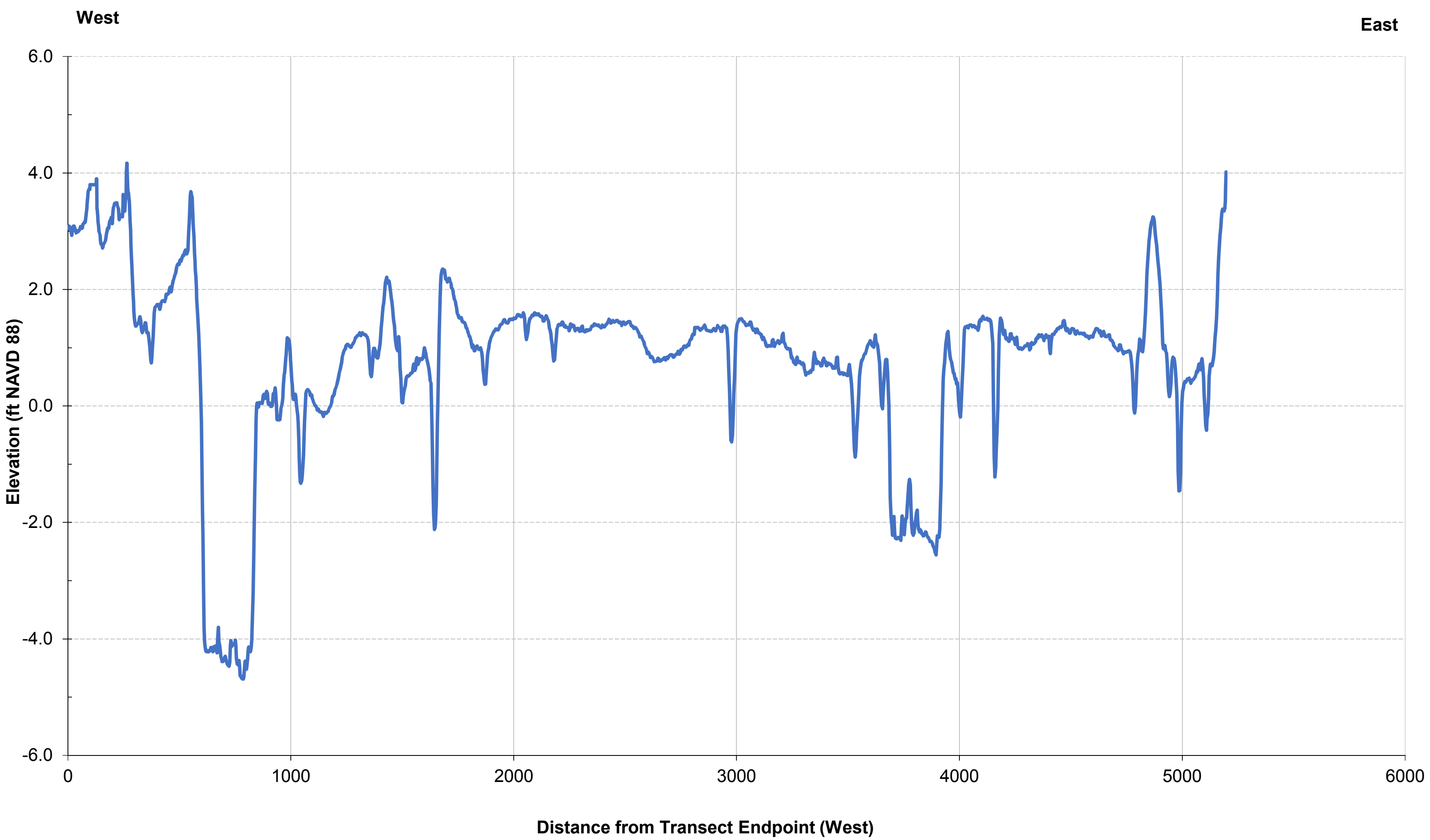
Sears Point Wetland Restoration

Elevation Transects Establishment - February 2017
Transect 4



Sears Point Wetland Restoration

Elevation Transect Establishment - February 2017
Transect 5



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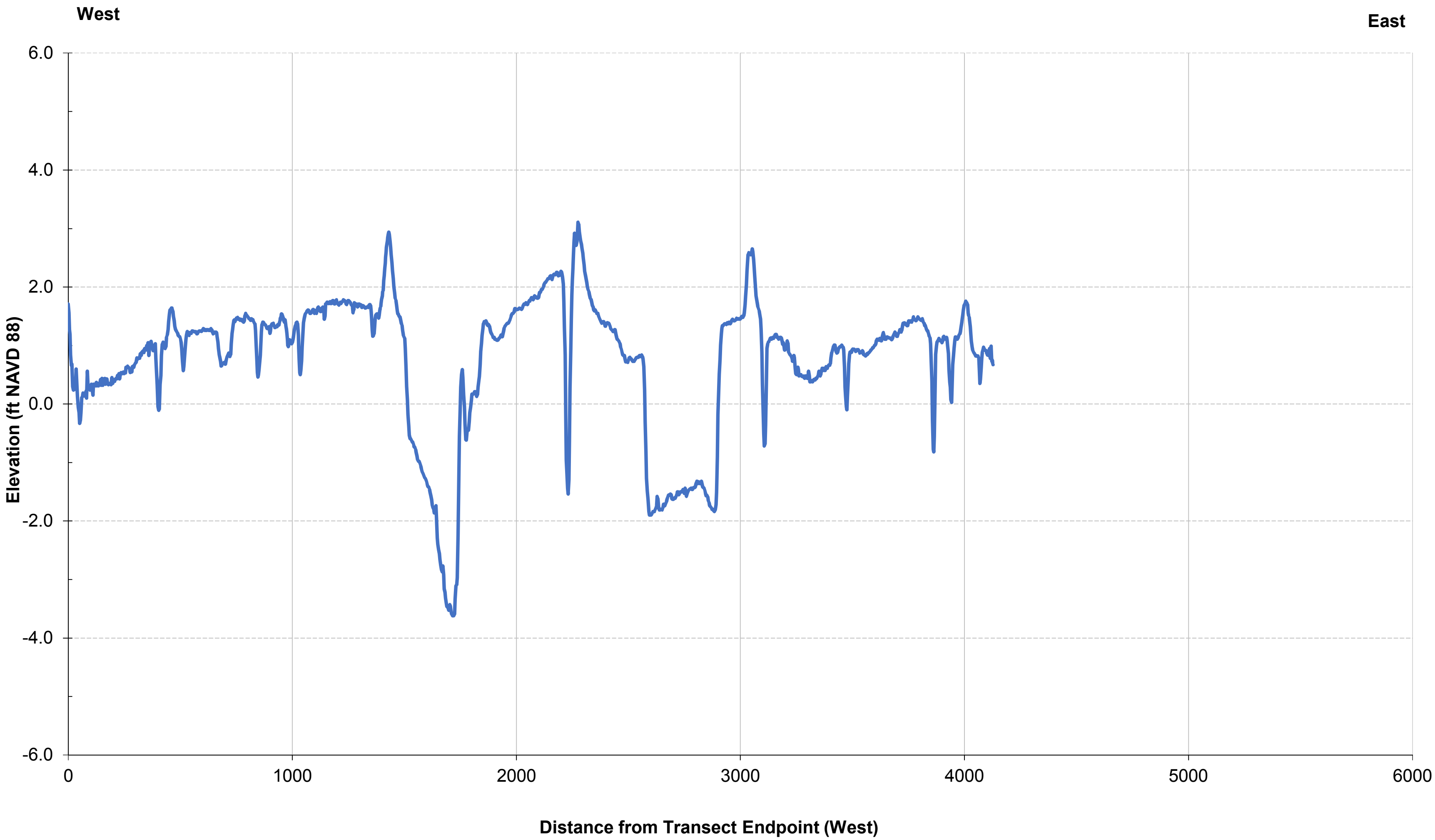
Sears Point Wetland Restoration

Elevation Transect Establishment - February 2017
Transect 6



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Sears Point Wetland Restoration

Elevation Transect Establishment - February 2017
Transect 7