NOAA's National Ocean Service
Center for Operational Oceanographic Products and Services (CO-OPS)

Environmental Measurement Systems
Sensor Specifications and Measurement Algorithms

Section 1: NWLON, PORTS and Short-Term Water Level Sensors

- All water level sensors shall have a minimum resolution of 0.001 m
- All water level sensors shall sample and be configured to support the transmission of data at a six-minute interval

CO-OPS Sensor Specifications – NWLON and PORTS Water Level Sensors				
Measurement Parameter	**Sensor Type**	**Sensor Manufacturer & Model**	**Estimated Accuracy**	**Measurement Specifications**
Water Level (Primary)	Air Acoustic Sensor Mounted in Protective Well	Aquatrak 3003-XCR-4 Model 3000 Transducer with Model 4110 Controller	***Relative to Datum*** ± 0.02 m (Individual measurement) ± 0.005 m (monthly means)	181 one-second water level samples centered on each tenth of an hour are averaged, a three standard deviation outlier rejection test applied, the mean and standard deviation are recalculated and reported along with the number of outliers. *(3-minute water level average)* Note - For each 6-minute Tx, Tsunami Ready stations will also send 6 - 1-minute averages composed of 60 one-second samples measured from 0 – 59 seconds.
Water Level (Primary)	Pressure - Dual Orifice Bubbler	Two (2) Paroscientific Digiquartz® Intelligent Transmitters - Model # 6000-30G	***Relative to Datum*** ± 0.02 m (Individual measurement) ± 0.005 m (monthly means)	36 five-second water level samples centered on each tenth of an hour are averaged, a three standard deviation outlier rejection test applied, the mean and standard deviation are recalculated and reported along with the number of outliers. *(3-minute water level average)* Note - For each 6-minute Tx, Tsunami Ready stations will also send 6 - 1-minute averages composed of 6 five-second samples measured from 0 – 59 seconds. .

Water Level (Primary)	Pressure - Single Orifice Bubbler *(With Approved Waiver Request)*	One (1) Paroscientific Digiquartz® Intelligent Transmitter - Model # 6000-30G	***Relative to Datum*** ± 0.02 m (Individual measurement) ± 0.005 m (monthly means)	36 five-second water level samples centered on each tenth of an hour are averaged, a three standard deviation outlier rejection test applied, the mean and standard deviation are recalculated and reported along with the number of outliers. *(3-minute water level average)* Note - For each 6-minute Tx, Tsunami Ready stations will also send 6 - 1-minute averages composed of 6 five-second samples measured from 0 – 59 seconds.
Water Level (Primary)	Microwave Radar	• YSI WaterLog® H-3611 • YSI Nile 502 • YSI NOAA Nile (item # 203360)	***Relative to Datum*** ± 0.02 m (Individual measurement) ± 0.005 m (monthly means)	360 one-second water level samples centered on each tenth of an hour are averaged, a three standard deviation outlier rejection test applied, the mean and standard deviation are recalculated and reported along with the number of outliers. *(6-minute water level average)* Note - For each 6-minute Tx, Tsunami Ready stations will also send 6 - 1-minute averages composed of 60 one-second samples measured from 0 – 59 seconds.
Water Level (Backup)	Pressure - Single Orifice Bubbler	SUTRON Compact Constant Flow Bubbler with built-in Accubar® Pressure Sensor	***Relative to Datum*** ± 0.02 m (Individual measurement) ± 0.005 m (monthly means)	72 five-second water level samples centered on each tenth of an hour are averaged, a three standard deviation outlier rejection test applied, the mean and standard deviation are recalculated and reported along with the number of outliers. *(6-minute water level average)*

Water Level (Backup)	Pressure – Single Orifice Bubbler Strain Gauge Sensor	GE Druck UNIK PDCR 5031 Pressure Transducer, P/N PDCR5 031-TB-A3-CC-H1-PE-30PSIG-7	***Relative to Datum*** ± 0.05 m (Individual measurement) ± 0.02 m (monthly means)	181 one-second water level samples centered on each tenth of an hour are averaged, a three standard deviation outlier rejection test applied, the mean and standard deviation are recalculated and reported along with the number of outliers. *(3-minute water level average)*
Water Level (Backup)	Pressure - Single Orifice Bubbler	Paroscientific Digiquartz® Intelligent Transmitter - Model # 6000-30G	***Relative to Datum*** ± 0.02 m (Individual measurement) ± 0.005 m (monthly means)	36 five-second water level samples centered on each tenth of an hour are averaged, a three standard deviation outlier rejection test applied, the mean and standard deviation are recalculated and reported along with the number of outliers. *(3-minute water level average)*
Water Level (Backup)	Microwave Radar *(With Approved Waiver Request if Primary Sensor is also a Microwave Radar)*	● YSI WaterLog® H-3611 ● YSI Nile 502 ● YSI NOAA Nile (item # 203360)	***Relative to Datum*** ± 0.02 m (Individual measurement) ± 0.005 m (monthly means)	360 one-second water level samples centered on each tenth of an hour are averaged, a three standard deviation outlier rejection test applied, the mean and standard deviation are recalculated and reported along with the number of outliers. *(6-minute water level average)*
Great Lakes Water Level (Primary)	Absolute Shaft Angle Encoder (Float)	BEI Model # MT-40D (Float) Part No. 802-05-0143, MT40D-X-HSS1024N-64T-XD13-X-SC14-X-12, Multi-turn Absolute-Position Encoder	***Relative to Datum*** ± 0.006 m (Individual measurement) ± 0.003 m (monthly means)	181 one-second water level samples centered on each tenth of an hour are averaged, a three standard deviation outlier rejection test applied, the mean and standard deviation are recalculated and reported along with the number of outliers. *(3-minute water level average)*

Great Lakes Water Level (Backup)	Shaft Angle Encoder (Float)	WaterLOG Shaft Angle Encoder H-344-2N	***Relative to Datum*** ± 0.006 m (Individual measurement) ± 0.003 m (monthly means)	181 one-second water level samples centered on each tenth of an hour are averaged, a three standard deviation outlier rejection test applied, the mean and standard deviation are recalculated and reported along with the number of outliers. *(3-minute water level average)*
Great Lakes Water Level (Backup)	Pressure - Submersible Hydrostatic Level Transducer	KPSI 500T 500T1CA0A-0021	***Relative to Datum*** ± 0.05 m (Individual measurement) ± 0.02 m (monthly means)	31 six-second water level samples centered on each tenth of an hour are averaged, a three standard deviation outlier rejection test applied, the mean and standard deviation are recalculated and reported along with the number of outliers. *(3-minute water level average)*
Water Level (Short-Term)	Air Acoustic Sensor Mounted in Protective Well	Aquatrak 3003-XCR-4 Model 3000 Transducer with Model 4110 Controller	***Relative to Datum*** ± 0.02 m (Individual measurement) ± 0.005 m (monthly means)	181 one-second water level samples centered on each tenth of an hour are averaged, a three standard deviation outlier rejection test applied, the mean and standard deviation are recalculated and reported along with the number of outliers. *(3-minute water level average)*
Water Level (Short-Term)	Pressure - Single Orifice Bubbler	Paroscientific Digiquartz® Intelligent Transmitter - Model # 6000-30G	***Relative to Datum*** ± 0.02 m (Individual measurement) ± 0.005 m (monthly means)	36 five-second water level samples centered on each tenth of an hour are averaged, a three standard deviation outlier rejection test applied, the mean and standard deviation are recalculated and reported along with the number of outliers. *(3-minute water level average)*

Water Level (Short-Term)	Microwave Radar	• YSI WaterLog® H-3611 • YSI Nile 502 • YSI NOAA Nile (item # 203360)	***Relative to Datum*** ± 0.02 m (Individual measurement) ± 0.005 m (monthly means)	360 one-second water level samples centered on each tenth of an hour are averaged, a three standard deviation outlier rejection test applied, the mean and standard deviation are recalculated and reported along with the number of outliers. *(6-minute water level average)* Note - Tsunami Ready stations also send 6 - 1 minute average water level measurements per 6-minute Tx. (Primary only)

Section 2: PORTS Air Gap Sensors

- All Air Gap sensors shall sample and be configured to support the transmission of data at a six minute interval

CO-OPS Sensor Specifications – PORTS Air Gap Sensors				
Measurement Parameter	**Sensor Manufacturer & Model**	**Estimated Accuracy**	**Resolution**	**Measurement Algorithm**
Air Gap (Bridge Clearance)	● Miros SM094 ● YSI WaterLog® H-3612 ● YSI Nile 517	±0.15 m (individual measurement)	0.01 m	181 one-second water level samples centered on each tenth of an hour are averaged, a three standard deviation outlier rejection test applied, the mean and standard deviation is recalculated and reported along with the number of outliers.

Section 3: Auxiliary Meteorological & Oceanographic Sensors

- All Met/Ocean sensors shall sample and be configured to support the transmission of data at a six minute interval

CO-OPS Sensor Specifications -- Auxiliary Meteorological & Oceanographic Sensors				
Measurement Parameter	**Sensor Manufacturer & Model**	**Estimated Accuracy**	**Resolution**	**Measurement Algorithm**
Air Temperature	YSI (Yellow Springs Instruments) 44032 Thermistor with Carol Brand C1202 Cable (or equivalent cable)	± 0.2 Deg. C	0.1 Deg. C	20 equally spaced samples collected over a 2-minute period are averaged for each measurement. The samples are collected starting one minute prior to each tenth of an hour.
Water Temperature	YSI (Yellow Springs Instruments) 44032 Thermistor with Carol Brand C1202 Cable (or equivalent cable)	± 0.2 Deg. C	0.1 Deg. C	20 equally spaced samples collected over a 2-minute period are averaged for each measurement. The samples are collected starting one minute prior to each tenth of an hour.
Wind (Speed, direction, and gusts)[1]	● R.M. Young Wind Monitor 05103 ● R.M Young Heavy Duty Wind Monitor-HD-Alpine 05103-45 ● Vaisala WINDCAP® Ultrasonic Wind Sensor WS425 ● Vaisala WINDCAP® Ultrasonic Wind Sensor WMT700	Speed: ± 0.3 m/sec. Direction: ± 3 Deg. Speed Threshold: 1 m/sec	Speed: 0.1 m/sec. Direction: 1 Deg.	Wind Speed - 2-minute scalar average of 1 second wind speed measurements collected prior to each tenth of an hour. Wind Direction - 2-minute unit vector average of wind direction collected prior to each tenth of an hour. Wind Gust - The maximum 5 second moving scalar average of wind speed that occurred during the previous 6 minutes.

[1] Ideally installed at least 10m above sea level and 10m above and away from any obstacles

Barometric Pressure	Sutron Accubar® Barometric Pressure Sensor 5600-0120	± 0.5 mbar	0.1 mbar	20 equally spaced samples collected over a 2-minute period are averaged for each measurement. The samples are collected starting one minute prior to each tenth of an hour.
Relative Humidity (RH)	Rotronic Hygroclip S3 Humidity Temperature Probe	± 0.8 %rh, ± 0.1 K, at 23 °C (10...30 °C)	1% rh	20 equally spaced samples collected over a 2-minute period are averaged for each measurement. The samples are collected starting one minute prior to each tenth of an hour.
Water Conductivity	● Falmouth Scientific, Inc. (FSI) NXIC CTD (legacy only) ● Greenspan MP47-3000 (formerly EC3000) Electrical Conductivity and Temperature Sensors, part number 50091 ● SeaBird SBE 37SMP MicroCAT C & T Recorder ● Aqua TROLL 200 Level Sensor P/N: 0056020	Conductivity: ± 0.1 mS/cm Temperature: ± 0.05 Deg C		20 equally spaced samples collected over a 2-minute period are averaged for each measurement. The samples are collected starting one minute prior to each tenth of an hour.
Water Density	Derived from Conductivity and Water Temp.			
Visibility	● Vaisala FS11 ● Vaisala PWD22	±10 % at (10-10,000 m) [2] (32-32,800 ft)	1.0 m	13 equally spaced samples collected over a 3-minute period are averaged for each measurement using the internal sensor processing. The samples are collected starting 90 seconds prior to each tenth of an hour. (3-minute visibility range average)

[2] CO-OPS limits the maximum reported visibility sensor range to 10,000 m (5.4NM). Sensor operational ranges are generally much greater.

Section 4: PORTS and Survey Current Sensors

- Current sensors used for the support of the National Current Observation Program, tides and currents tables, and mapping and charting activities normally use internal data storage and have no real-time data telemetry capability.
- Current sensors used for the real-time support of maritime navigation and port activities installed for real-time data telemetry shall sample and be configured to support the transmission of data at a six minute interval.

CO-OPS Sensor Specifications – PORTS and Survey Current Sensors			
Measurement Parameter	**Sensor Manufacturer & Model**	**Estimated Accuracy**	**Measurement Algorithm**
Water Current (Vertical)	RD Instruments (4 beam Configuration with 20° beam angle) 600 or 1200 kHz *(Frequency chosen based on water depth and/or specific range requirements)*	Maximum profiling range is 12 - 20 m (1200 kHz) and 30 - 66 m (600 kHz Speed ± 5% ± 0.25 cm/sec (1200 & 600 kHz) ± 5% ± 0.5 cm/sec (300 kHz) Tilts: ± 0.5° Compass: ± 2° Max Tilts: ± 15°	6-minute average comprised of up to approximately 345 profiles (pings) per measurement. Data includes east, north, and vertical velocities, echo amplitude, correlation magnitude, percent good pings for each beam and each bin. Included with each measurement are compass, pitch, and roll as well as water pressure and water temperature.
Water Current Profiler (Horizontal)	Nortek Continental 470 kHz, 2 beam profiler	Maximum profiling range is 100 meters (470 kHz) Speed ± 0.5 cm/sec (± 1% measured velocity)	6-minute average comprised of approximately 300 profiles (pings) per measurement (470 kHz) and Data includes east and north velocity, standard deviation, and echo amplitude for each beam and each bin. Included with each measurement are compass, pitch, and roll as well as water temperature and water pressure per project or application specifications. *** This sensor has been replaced by the Nortek 2D 400kHz profiler

Water Current Profiler (Horizontal)	Sontek (2 beam configuration with 25° beam angle). 250 or 500 kHz *(Frequency chosen based on water depth and/or specific range requirements)*	Maximum profiling range is 70-120 meters (500 kHz) and 120-180 meters (250 kHz) Speed ± 0.5 cm/sec (± 1% Measured velocity)	6-minute average comprised of approximately 300 profiles (pings) per measurement (250 kHz) and 300 profiles (pings) per ensemble (500 kHz). Data includes east and north velocity, standard deviation, and echo amplitude for each beam and each bin. Included with each measurement are compass, pitch, and roll as well as water temperature and occasionally water pressure per project or application specifications.
Water Current Profiler (Horizontal)	RDI (3 beam configuration with 25° beam angle for a 600 kHz system and 20° beam angle for a 300 kHz system *(Frequency chosen based on water depth and/or specific range requirements)*	Maximum profiling range is 85 meters (600 kHz) Speed ± 0.25 cm/sec (± 1% Measured velocity) and 250 meters (300kHz) ± 0.5 cm/sec (± 1% measured velocity)	6-minute average comprised of approximately 300 profiles (pings) per measurement (300 kHz) and 300 profiles (pings) per ensemble (600 kHz). Data includes east and north velocity, standard deviation, and echo amplitude for each beam and each bin. Included with each measurement are compass, pitch, and roll as well as water temperature and occasionally water pressure if ADP is equipped with one.
Water Current Profiler (Horizontal)	Nortek 400 kHz 2D Horizontal Profiler, 2 beam	Maximum profiling range is 100 – 130 meters (400 kHz ± 0.5 cm/sec (± 1% measured velocity)	6-minute average comprised of approximately 300 profiles (pings) per measurement (400kHz) and Data includes east and north velocity, standard deviation, and echo amplitude for each beam and each bin. Included with each measurement are compass, pitch, and roll as well as water temperature and water pressure per project or application specifications.
Water Current Profiler (Vertical - 3D)	Nortek 600 kHz or 1 MHz Aquadopp Profiler (3 beam configuration with 25° beam angle). *(Frequency chosen based on water depth and/or specific range requirements)*	Profiling range 15-25 meters for 1 mHz, 30-40 m for 600 kHz). Speed ± 0.5 cm/sec (± 1% of measured velocity) Horizontal vel range ± 10 m/s Max tilts ± 30°	6-minute sampling interval, each six-minute average is comprised of approximately 300, one second profiles (pings) per measurement. Data includes east, north, and vertical velocity, and echo amplitude for each beam and each bin. Included with each measurement are compass, pitch, and roll, water temperature, and water pressure.

Section 5: VDatum GNSS Buoy Water Level Systems

- The GNSS buoy water level systems are used for the support of Hydrographic Surveys and NOAA's vertical datum transformation (VDatum) efforts. These systems use internal data storage and may be equipped with Iridium short-burst data (SBD) modems for real-time data telemetry and system monitoring.
- Systems should incorporate the latest GNSS and inertial measurement systems, with sensor specifications that meet or exceed the accuracy / resolution of firmware integration to Trimble BX940 GNSS receiver, Honeywell HG1120CA50 inertial measurement unit (IMU), and industry standard water intrusion sensor.

CO-OPS Sensor Specifications – VDatum GPS / GNSS Water Elevation Buoy Systems			
Measurement Parameter	**Sensor Manufacturer & Model**	**Estimated Accuracy Resolution**	**System Specifications**
Water level as measured on the absolute three-dimensional International Terrestrial Reference Frame (ITRF) using RTK or global Precise Point Position (PPP) techniques	System based on the AXYS Technologies HydroLevel buoy using the latest global differential standards and motion sensing technologies and incorporating the WatchMan500™ controller to integrate sensor systems and provide onboard data processing, data logging, telemetry and diagnostic/set up routines. Buoy / float platforms must be approved by the CO-OPS Director or her delegate.	Relative to Datum: ± 0.09 - 0.16 m (instantaneous measurement) ± 0.03 – 0.101 m (six-minute mean)	Average 600 seconds of the instantaneous 1-Hz measurements centered on each epoch. Data must first be filtered for outliers of ± 3x the standard deviation (per computation using the "raw" 600-sec binned data).