

**NOAA's Ocean Service**  
**Center for Operational Oceanographic Products and Services (CO-OPS)**  
**Environmental Measurement Systems**  
**Sensor Specifications and Measurement Algorithms**

Measurement Parameter	Sensor Manufacturer	Estimated Accuracy	Resolution	Sample Interval	Transmittal Interval	Measurement Algorithm
Water Level (Primary)	Aquatrak®(Air Acoustic sensor in protective well)	<b>Relative to Datum</b> ± 0.02 m (Individual measurement) ± 0.005 m (monthly means)	0.001 m	6 minutes	6 minutes (Satellite-GOES or IP Modem)	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) <b>Note - Tsunami Ready stations also send 6 - 1 minute average water level measurements per Tx.</b>
Water Level (Primary)	Dual Orifice Bubbler Paroscientific Digiquartz® sensor Model # 6000-30G (Pressure)	<b>Relative to Datum</b> ± 0.02 m (Individual measurement) ± 0.005 m (monthly means)	0.001 m	6 minutes	6 minutes (Satellite-GOES or IP Modem)	37 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. <b>Note - Tsunami Ready stations also send 6 - 1 minute average water level measurements per Tx.</b>
Water Level (Primary)	Xylem WaterLOG® H-3611i Microwave Radar Water Level Sensor	<b>Relative to Datum</b> ± 0.02 m (Individual measurement) ± 0.005 m (monthly means)	0.001 m	6 minutes	6 minutes (Satellite-GOES or IP Modem)	300 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. <b>Note - Tsunami Ready stations also send 6 - 1 minute average water level measurements per Tx.</b>

Measurement Parameter	Sensor Manufacturer	Estimated Accuracy	Resolution	Sample Interval	Transmittal Interval	Measurement Algorithm
Storm Surge Water Level	Xylem WaterLOG® H-3611i Microwave Radar Water Level Sensor	<b>Relative to Datum</b> ± 0.02 m (Individual measurement) ± 0.005 m (monthly means)	0.001 m	6 minutes	6 minutes (Satellite-GOES or IP Modem)	300 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.
Water Level Stations Great Lakes (Primary)	BEI Absolute Shaft Angle Encoder Model # MT-40D (Float and Counter-weight)	<b>Relative to Datum</b> ± 0.006 m (Individual measurement) ± 0.003 m (monthly means)	0.001 m	6 minutes	6 minutes (Satellite-GOES, IP Modem, or Telephone Modem)	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.
Water Level (Primary)	Single Orifice Bubbler Paroscientific Digiquartz® sensor Model # 6000-30G (Pressure)	<b>Relative to Datum</b> ± 0.02 m (Individual measurement) ± 0.005 m (monthly means)	0.001 m	6 minutes	6 minutes (Satellite-GOES)	37 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.
Water Level (Backup)  <b>Generally used to fill data gaps</b>	Single Orifice Bubbler Strain Gauge Sensor (Pressure) GE Druck PDCR 4010, KPSI™ 500T	<b>Relative to Datum</b> ± 0.05 m (Individual measurement)	0.001 m	6 minutes	6 minutes (Satellite-GOES or IP Modem)	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. Tsunami

Measurement Parameter	Sensor Manufacturer	Estimated Accuracy	Resolution	Sample Interval	Transmittal Interval	Measurement Algorithm
Water Level Stations Great Lakes (Redundant)	Xylem WaterLOG® Shaft Angle Encoder Model # H-344-2N (Float and Counter-weight)	<b>Relative to Datum</b> ± 0.006 m (Individual measurement) ± 0.003 m (monthly means)	0.001 m	6 minutes	6 minutes (Satellite-GOES, IP Modem, or Telephone Modem)	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.
Water Level (Backup)	Single Orifice Bubbler Paroscientific Digiquartz sensor Model # 6000-30G (Pressure)	<b>Relative to Datum</b> ± 0.02 m (Individual measurement) ± 0.005 m (monthly means)	0.001 m	6 minutes	6 minutes (Satellite-GOES)	37 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.
<i>Primary WL sensor data gaps.</i>		± 0.02 m (monthly means)				(3 minute water level average )
Water Level (Short Term)	Aquatrak® (Air Acoustic sensor in protective well)	<b>Relative to Datum</b> ± 0.02 m (Individual measurement) ± 0.005 m (monthly means)	0.001 m	6 minutes	1 hourly (Satellite-GOES)	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 )

Measurement Parameter	Sensor Manufacturer	Estimated Accuracy	Resolution	Sample Interval	Transmittal Interval	Measurement Algorithm
Water Level (Short Term)	Single Orifice Bubbler Paroscientific Digiquartz sensor Model # 6000-30G (Pressure)	<b>Relative to Datum</b> $\pm 0.02$ m (Individual measurement) $\pm 0.005$ m (monthly means)	0.001 m	6 minutes	6 Hourly Satellite-GOES	37 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.
Water Level (Short Term)	Xylem WaterLOG® H-3611i Microwave Radar Water Level Sensor	<b>Relative to Datum</b> $\pm 0.02$ m (Individual measurement) $\pm 0.005$ m (monthly means)	0.001 m	6 minutes	1 Hourly (Satellite-GOES, IP Modem, or Iridium SBD)	300 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.
Air Temp	YSI	$\pm 0.2$ Deg.C	0.1 Deg.C	6 minutes	6 minutes (Satellite-GOES, IP Modem, or Iridium SBD)	21 six-second samples collected over a 2 minute period are averaged for each measurement. The samples are collected starting one minute prior to each tenth hour at PORTS® sites
Water Temp	YSI	$\pm 0.2$ Deg.C	0.1 Deg.C	6 minutes	6 minutes (Satellite-GOES, IP Modem, or Iridium SBD)	21 six-second samples collected over a 2 minute period are averaged for each measurement. The samples are collected starting one minute prior to each tenth hour at PORTS® sites

Measurement Parameter	Sensor Manufacturer	Estimated Accuracy	Resolution	Sample Interval	Transmittal Interval	Measurement Algorithm
Wind S/D/G (Typically installed approx 10m above sea level)	R.M. Young Wind Monitor (Models 05103, 05103-45)	Speed ± 0.3 m/sec.  Direction ± 3 Deg.  (Speed Threshold 1 m/sec)	Speed 0.1 m/sec.  Direction 1.0 Deg.	6 minutes	6 minutes (Satellite-GOES or IP Modem)	Wind Speed - 2 minute scalar average of 1 second wind speed measurements collected prior to each tenth hour.  Wind Direction - 2 minute unit vector average of wind direction collected prior to each tenth hour.  Wind Gust - The maximum 5 second moving scalar average of wind speed that occurred during the previous 6 minutes for PORTS® stations.
Backup Wind S/D/G (Typically installed approx 10m above sea level)	Vaisala WS425 Ultrasonic (Heated Transducers)	Speed ± 0.135 m/sec.  Direction ± 2 Deg.  (Speed Threshold 1 m/sec)	Speed 0.1 m/sec.  Direction 1.0 Deg.	6 minutes	6 minutes (Satellite-GOES or IP Modem)	Wind Speed - 2 minute scalar average of 1 second wind speed measurements collected prior to each tenth hour.  Wind Direction - 2 minute unit vector average of wind direction collected prior to each tenth hour.  Wind Gust - The maximum 5 second moving scalar average of wind speed that occurred during the previous 6 minutes.
Barometric Pressure (at mean sea level)	Sutron Accubar® Gauge Pressure Sensor	± 0.5 mbar	0.1 mbar	6 minutes	6 minutes (Satellite-GOES or IP Modem)	21 six-second samples collected over a 2 minute period are averaged for each measurement. The samples are collected starting one minute prior to each tenth hour at PORTS® sites
Conductivity	Falmouth Sci. or Greenspan	Conductivity ± 0.1 mS/cm Temperature ± 0.05 Deg C		6 minutes	6 minutes (Satellite-GOES or IP Modem)	21 six-second 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 hour at PORTS® sites

Measurement Parameter	Sensor Manufacturer	Estimated Accuracy	Resolution	Sample Interval	Transmittal Interval	Measurement Algorithm
Density	Derived from Conductivity and Water Temp.					
Water Current Profiler (Vertical - Bottom Mount)	RD Instruments Workhorse (4 beam configuration with 20° beam angle) Frequency 600 or 1200 KHz depending on water depth.	Speed $\pm 0.25$ cm/sec. (1200 & 600 kHz) $\pm 0.5$ cm/s (300 kHz) Tilts $\pm 0.5^\circ$ Compass $\pm 2^\circ$ Max Tilts $\pm 15^\circ$	Velocity 0.1 cm/s Heading $0.01^\circ$ Tilts $0.01^\circ$	6 minutes	6 minutes (IP Modem)	6 minute average comprised of 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 temperature.  Specs ref – <a href="http://www.rdinstruments.com/pdfs/datasheets/workhorse_sentinel_ds_lr.pdf">http://www.rdinstruments.com/pdfs/datasheets/workhorse_sentinel_ds_lr.pdf</a>
Water Current Profiler (Vertical - Bottom Mount)	SonTek ADP (3 beam configuration with 25° beam angle). Frequency 500 or 1500 KHz depending on water depth.	Speed $\pm 0.5$ cm/sec ( $\pm 1\%$ measured velocity) Heading $\pm 2^\circ$ Pitch, Roll $\pm 1^\circ$ Profiling range 15-25 meter (1500 kHz) pressure sensor 0.1%	Velocity 0.1 cm/s Heading $0.1^\circ$ Tilts $0.1^\circ$	6 minutes	6 minutes (IP Modem)	6 minute average comprised of 2000 profiles (pings) per measurement. Data includes east, north, and vertical 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 pressure and temperature.  Specs ref – <a href="http://www.sontek.com/download/brochure/adp.pdf">http://www.sontek.com/download/brochure/adp.pdf</a>

Measurement Parameter	Sensor Manufacturer	Estimated Accuracy	Resolution	Sample Interval	Transmittal Interval	Measurement Algorithm
Water Current Profiler (Horizontal)	Nortek AWAC (2 beam, frequency 400 kHz)	Maximum profiling range is 100 meters (400 kHz) ± 0.5 cm/sec (± 1% measured velocity)	Velocity 0.1 cm/s Heading, 0.1° Tilts 0.1°	6 minutes	6 minutes (IP Modem)	6 minute average comprised of 500 profiles (pings) per measurement . 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 pressure if ADP is equipped with appropriate sensors. <b>Specs ref -</b> <b><a href="http://www.nortek-as.com/en/products/current-profilers/continental">http://www.nortek-as.com/en/products/current-profilers/continental</a></b>
Water Current Profiler (Horizontal)	SonTek ADP (2 beam configuration with 25° beam angle ). Frequency 500 kHz and 250 kHz depending on range	Maximum profiling range is 70-120 meters (500 kHz) and 120-180 meters (250 kHz) Speed ± 0.5 cm/sec (± 1% measured velocity)	Velocity 0.1 cm/s Heading, 0.1° Tilts 0.1°	6 minutes	6 minutes (IP Modem)	6 minute average comprised of 500 / 700 profiles (pings) per measurement (250kHz / 500kHz). 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 pressure if ADP is equipped with appropriate sensors. <b>Specs ref –</b> <b><a href="http://www.sontek.com/download/brochure/adp.pdf">http://www.sontek.com/download/brochure/adp.pdf</a></b>

Measurement Parameter	Sensor Manufacturer	Estimated Accuracy	Resolution	Sample Interval	Transmittal Interval	Measurement Algorithm
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 depending on range)	Maximum profiling range is 85meters (600 kHz) Speed $\pm 0.25$ cm/sec ( $\pm 1\%$ measured velocity) And 250 meters (300kHz) $\pm 0.5$ cm/sec ( $\pm 1\%$ measured velocity)	Velocity 0.1 cm/s Heading, 0.1° Tilts 0.1°	6 minutes	6 minutes (IP Modem)	6 minute average comprised of 300 profiles (pings) per measurement (300kHz / 600kHz). 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 pressure sensor.  <b>Specs ref – Workhorse H-ADCP</b> <b><a href="http://www.rdinstruments.com">http://www.rdinstruments.com</a></b>
Water Current Profiler (Vertical - Buoy Mount)	Nortek Aquadopp Profiler (3 beam configuration with 25° beam angle ). Frequency 1 MHz.	Profiling range 15-25 meters Speed $\pm 0.5$ cm/sec ( $\pm 1\%$ of measured velocity) Horizontal vel range $\pm 10$ m/s Max tilts $\pm 30^\circ$	1 mm/s (Velocity) Heading, 0.1° Tilts 0.1° Pressure sensor 1mm Water Temp 0.01 Deg C	6 minutes	6 minutes (IP Modem)	6 minute average comprised of 300 – 1 Hz 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.  <b>Specs ref -</b> <b><a href="http://nortekusa.com/hardware/AquadoppProfiler.html">http://nortekusa.com/hardware/AquadoppProfiler.html</a></b>



Measurement Parameter	Sensor Manufacturer	Estimated Accuracy	Resolution	Sample Interval	Transmittal Interval	Measurement Algorithm
Visibility	Vaisala FS11	Accuracy: ±10% range at 5 – 10,000 m  ±20% range at 10,000 m – 75,000 m  Scatter measurement accuracy: ±3%	Range: 5 – 75,000 m with 1, 3 and 10-minute averaging	6 minutes	6 minutes (Satellite-GOES or IP Modem)	3-minute average w/ 15-second samples centered on each tenth of an hour. Measurements also include 1-minute and 10-minute averages. Data includes meteorological optical range in units of meters (m).
Visibility <i>(Limited acceptance for PORTS use)</i>	Vaisala PWD22	Accuracy: ±10%, range 10 ... 10,000 m  ±15%, range 10 ... 20 km	Range: 10 – 20,000 m	6 minutes	6 minutes (Satellite-GOES or IP Modem)	3-minute average w/ 15-second samples centered on each tenth of an hour. Measurements also include 1-minute and 10-minute averages. Data includes meteorological optical range in units of meters (m).
Air Gap (Bridge Clearance)	Miros SM094 Microwave Radar Water Level Sensor	±0.15 m (individual measurement)	0.01 m	6 minutes	6 minutes (Satellite-GOES or IP Modem)	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.
Air Gap (Bridge Clearance)	Xylem WaterLOG® H- 3612 Microwave Radar Water Level Sensor	±0.15 m (individual measurement)	0.01 m	6 minutes	6 minutes (Satellite-GOES or IP Modem)	300 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.