Water Level Information on S-100 ECDIS

Submitted by:	TWCWG Chair Team, S-104 Project Team
Executive Summary:	Describes the TWCWG position on the role of S-104 water level information data on an S-100 ECDIS.
Related Documents:	--
Related Projects:	S-104; S-100; S-98; S-100 validation checks; S-164

Introduction

The S-104 (Water Level Information) Product Specification includes different coverage types for water level information. S-98 Edition 1.0.0 Annex C describes "water level adjustment" (WLA) as new functionality planned for S-100 ECDIS. Draft "validation checks" circulated recently propose that S-100 ECDIS accept only the "regular grid" coverage type and reject all others, in addition to imposing other requirements on all S-104 (as well as S-102 - Bathymetry).

Use of S-104 datasets on ECDIS should be anticipated for ECDIS installed on or after 1 January 2026, in accordance with MSC.530(106). S-104 is a Phase 1 product in the S-100 Roadmap.

References

IMO MSC.530(106), Performance Standards for Electronic Chart Display and Information Systems (ECDIS), 2022.

S-104 - Water Level Information for Surface Navigation, Edition 1.1.0, March 2023.

S-98 Ed. 1.0.0, Annex C: Harmonised User Experience for ECDIS and INS. May 2022.

Input on proposed checks relating to HDF5-format products, https://github.com/iho-ohi/S-100-Validation-Checks/issues/13

Input on validation checks, https://github.com/iho-ohi/S-102-Product-Specification/issues/50

S100WG8-21: Portrayal of complex data structure and pick reports

S100WG8-30: S-100 Validation Tests and Cross-Product Validation

NIPWG10-08.2A: Complex Portrayals and Pick Reports

Background

Draft "S-100 level" validation checks are to be proposed to the S-100 WG, reported on GitHub:

> *In the S-164 group a breakout meeting on implementing water level adjustment with the OEMs specifically requested that IHO puts validation tests in place to ensure compatibility between S-101 and S-102/S-104 data. The requested tests were*
>
> - *identical vertical (sounding) datums*
> - *no holes in the S-102/S-104 coverage unless over land and no coverage on land*
> - *use of only regular grids*
> - *coincident coverage of S-102/S-104*
>
> *from the OEM perspective, all S-102/S-104 data destined for ECDIS (and this is only for data for use on an ECDIS) should meet these requirements - the OEM will filter out anything not meeting them and tests have been requested for S-164 so they can develop that functionality.*

As written – noting that this is not phrased in terms of "*what can be used for water level adjustment as described in S-98 Annex C*" but in terms of "*what is allowed for use on an ECDIS*" – it means that any S-104 datasets that are not in the "regular grid" format and conformant to the other requirements will be rejected.

Completeness of information on ECDIS

The new IMO performance standard MSC.530(106) applies to ECDIS installed on or after 1 January 2026. MSC.530(106) requires that –

> ***1.3*** *ECDIS should be capable of displaying all nautical information necessary for safe and efficient navigation, originated and distributed by or on the authority of a government, authorized hydrographic office or other relevant government institution, as required by SOLAS regulations V/19 and V/27.*

MSC.530(106) also defines the concept of ENDS (Electronic navigational data service):

> ***3.3*** *Electronic navigational data service (ENDS) means a special-purpose database compiled from nautical chart and nautical publication data, standardized as to content, structure and format, issued for use with ECDIS by or on the authority of a government, authorized hydrographic office or other relevant government institution, and conforming to IHO standards; and, which is designed to meet the requirement of marine navigation and the nautical charts and nautical publications carriage requirements in SOLAS regulations V/19 and V/27. The navigational base layer of ENDS is the electronic navigational chart (ENC).*

The above implies that ECDIS should be capable of displaying tide tables. However –

- The proposed checks would prohibit tide tables on ECDIS since they would be point-based data, with the geographic coordinates being the location of the tide station.
- Some hydrodynamic models generate water level data, including forecast information, using grids whose cells are not rectangles. This can be encoded and distributed as georeferenced grids or TIN (Triangulated Irregular Network) data. However, the proposed checks would also preclude georeferenced grid and TIN format.
- Hydrodynamic models whose cells are rectangles or not can also be encoded and distributed as point-based data, i.e., sampling of the model at a tide station location for model evaluation comparison to astronomical tidal predictions and/or total water level observations (which would also be point-based data). All of this point-based information would be blocked.
- Plans for the future include the distribution of water level information via AIS Application Specific Messages. This too would not be regular gridded data, and therefore blocked.

In summary - the proposed validation requirements, especially the regular grid requirement, would block a great deal of water level information from ECDIS even though it is necessary for safe and efficient navigation.

Production considerations

When S-100 ECDIS becomes an operational reality in 2026 it is necessary that data be available for operational use even though complete coverage is not initially required. The following factors affect the availability of this data:

- Conversion of existing water level information from tide gauge stations to regular grid format requires a substantial investment of time, effort and know-how. Smaller hydrographic offices in particular may not have the resources and expertise to complete this by 2026 or shortly after; furthermore, they are often dependent on commercial tools to produce data.
- Hydrographic Offices need to validate their water level models and be sure they are confident of the reported accuracy of the data they distribute. This requires significant development even for well-resourced Hydrographic Offices.
- The matter of distribution, including technical, infrastructure, licensing, and management aspects, needs to be addressed, especially since some Hydrographic Offices plan to distribute S-104 datasets multiple times a day.

The TWCWG expects that only a few hydrographic offices will be ready to distribute S-104 datasets **in the regular grid format** at the time S-100 ECDIS become operational. Tide tables, on the other hand, are widely produced and can be converted to S-104 datasets (as “fixed station format” datasets) relatively easily compared to regularly gridded data, and do not need to be updated daily or weekly.

Any rule that ECDIS allow only regular grid data means that S-104 datasets on ECDIS will initially be very scarce. Tide and water level data will be completely absent from ECDIS for many of the world’s ports and marine waterways. As a result, important nautical publications (i.e., tide tables or a substitute thereof) will be missing from the “ENDS” defined in MSC.530(106) for many ports and marine waterways.

Use on ECDIS

There remains the question of what ECDIS can do with S-104 water level information other than use it for water level adjustment, given that S-100 5.1.0 portrayal apparently does not include the necessary functionality for time series plots and complex structured portrayals. To address this, the following developments are required:

- define interim portrayal compatible with S-100 5.1.0,
- make it available to the end user via pick reports,
- use it in other types of interoperability – that is, other than Annex C water level adjustment – specifically, interoperability as described in S-98 “Main” and S-100 Part 16.

The next section goes into more detail about the first two points.

Portrayal and pick reports

Solution approaches

A comprehensive description of portrayal and pick reports is beyond the scope of this paper, and solutions are under development as this paper is being written and will be in Edition 2.0.0 of S-104. However, the following points should be noted:

- "Portrayal" for tide tables, in the sense of displaying a symbol on the chart graphic, consists only of displaying the existing TIDHT01 symbol at the locations of the tide stations. This should be already possible with S-100 5.1.0 portrayal. The content of water level information contained in tide tables is actually in the "pick report" generated when the location of the tide station is clicked.
- "Complex pick reports" are currently the subject of NIPWG work and related papers have been submitted to this S-100WG meeting. Some TWCWG members suggest support for development of the Rule or Template complex portrayal approaches described in those papers.
    - TWCWG will monitor developments in the area of complex pick reports for potential use with both S-104 and S-111 data.
    - The greatest flexibility is desirable to allow for effective use of data including comparative display in graphical fashion and would allow best for future evolution. It would also achieve appropriate comparative display between model forecast, predicted and observed data. Otherwise, the mariner will not have the capability to exercise appropriate judgement based on their own comparative evaluation.
- There is already a proposed interim solution, to pre-generate the displayed material (e.g., as HTML) and store them in a "system attribute" when the dataset is being compiled. This approach can work for S-104 point data too either by adding similar “system attributes” in the HDF5 dataset or making the said “system attributes” references to support files provided in the exchange set. These support files could be either graphics or “text” (e.g., HTML) format. The modeling details are expected to be developed by NIPWG in connection and potentially specified in S-98 Annex C.
- The “interoperabilityIdentifier” tactic described in another paper at this meeting provides another method of linking information in S-104 datasets to features in other data products.
- Another possible solution is to provide only the most basic portrayal for S-104 data other than point data (such as a polygon with a centered TIDHT01 symbol or a complex linestyle boundary including that symbol), to indicate areas where water level information is available, then a cursor pick on any point within that polygon would bring up an ordinary pick report or hover box reporting the local water level and trend at the applicable time, or range of time points around the applicable time.

Examples

Examples of display are shown in the figure below.

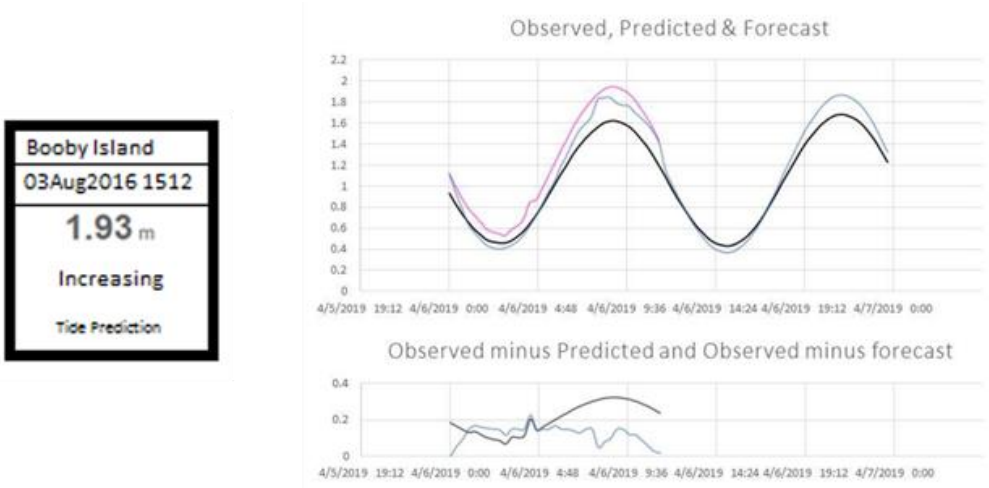

Figure 1. Water level at a station (L) and graphic showing time series of water level data (R).

Use cases

Please also refer to S-104 ANNEX G – Use Cases for more information.

Case 1 - Display of tide table extract (simple) – textual pick report on discrete point coverage

Data: Tide table (dataCodingFormat, DCF, 8) with pre-generated formatted text support files showing high and low water for all calendar weeks for an entire year. (Assumes a WLA-compatible regular grid S-104 dataset is not available for this location.)

Description: ECDIS displays the TIDHT01 symbol at the location of the tide station. When the user clicks on the symbol, the system takes the date setting from the ECDIS and displays the high and low water times for the current calendar week as a table in a formatted text file as shown in the figure below. The formatted text files for all weeks of the year are included in the exchange set as support files.

Usage: The mariner can use the tide tables on ECDIS to more safely and efficiently perform route planning, especially in areas with strong or large tides. For example, tide tables provide information for when and to what extent a high tide or low tide will occur in shallow harbours, enabling the mariner to know in advance when it is safe to manoeuvre into the harbour and avoid grounding hazards.

While preparing the route plan, the user selects the tide stations that are known to represent water levels along different segments of the route (in the absence of “zones of influence” encoded in the water level product, this requires local knowledge). On the route plan, annotations are added indicating the waypoints and/or segments traversed at the times of high and low tide at the user-selected tide station. Waypoints or route segments are annotated with the water level height from that tide station.

NOAA/NOS/CO-OPS
Disclaimer: These data are based upon the latest information available as of the date of your request, and may differ from the published tide tables.
Daily Tide Predictions
StationName: Los Angeles
State: CA
Stationid: 9410660
Prediction Type: Harmonic
From: 20231022 06:31 - 20231028 22:01
Units: Metric
Time Zone: LST_LDT
Datum: MLLW
Interval Type: High/Low

Date	Day	Time	Pred	High/Low
2023/10/22	Sun	06:31 AM	1.20	H
2023/10/22	Sun	10:18 AM	1.06	L
2023/10/22	Sun	04:04 PM	1.53	H
2023/10/22	Sun	11:45 PM	0.00	L
2023/10/23	Mon	06:50 AM	1.33	H
2023/10/23	Mon	11:48 AM	0.86	L
2023/10/23	Mon	05:29 PM	1.58	H
2023/10/24	Tue	12:32 AM	-0.04	L
2023/10/24	Tue	07:14 AM	1.48	H
2023/10/24	Tue	12:46 PM	0.61	L
2023/10/24	Tue	06:34 PM	1.64	H
2023/10/25	Wed	01:11 AM	-0.04	L
2023/10/25	Wed	07:40 AM	1.65	H
2023/10/25	Wed	01:35 PM	0.36	L
2023/10/25	Wed	07:30 PM	1.66	H
2023/10/26	Thu	01:47 AM	0.01	L
2023/10/26	Thu	08:08 AM	1.81	H
2023/10/26	Thu	02:21 PM	0.12	L
2023/10/26	Thu	08:22 PM	1.64	H
2023/10/27	Fri	02:21 AM	0.10	L
2023/10/27	Fri	08:37 AM	1.94	H
2023/10/27	Fri	03:05 PM	-0.06	L
2023/10/27	Fri	09:12 PM	1.57	H
2023/10/28	Sat	02:53 AM	0.23	L
2023/10/28	Sat	09:07 AM	2.03	H
2023/10/28	Sat	03:49 PM	-0.18	L
2023/10/28	Sat	10:01 PM	1.47	H

Figure 2. Tide table extract for calendar week

Notes: This is one of the simplest concepts for data production as well as display on ECDIS. More sophisticated displays can obviously be generated with the use of HTML, CSS and/or a scripting language such as JavaScript. For example, a table of water levels at hourly intervals from the current date/time.

Case 2 – Pick report on continuous coverage

Data: Regular grid (DCF 2), ungeorectified data (DCF 3) or TIN data (DCF 7) from hydrodynamic forecast model

Description: ECDIS displays the water levels from the model as a coverage fill. User can click where there is coverage from the model to get either a graphic time series plot or pick report (water level height, trend, etc.) from the model. Note that the cursor pick is not at the location of a tide station.

ECDIS route planning software uses water level information to determine “windows of opportunity” using the ship’s draft with the water level predictions (time series as grid).

Usage: The mariner can use the pick report from the hydrodynamic model forecast on ECDIS again to more safely and efficiently perform route planning. Whereas the tide tables provide information only regarding astronomical tides, hydrodynamic model forecasts can include tidal information as well as future changes in water levels based on variations in riverine, wind, atmospheric pressure, and wave effects. With this additional information, a more accurate hourly forecast of water levels can be used by the mariner to plan in more detail and more effectively transit into a port and harbor across narrow shipping channels and areas with high traffic density, as well as planning for more efficient loading of ships while at berth.

As for Use Case 1, annotations giving water level height and trend can be automatically added to waypoints on the route plan by route planning software, since the location and arrival time at the waypoint can be calculated. If the actual time varies from the route plan schedule, the height and trend can be automatically adjusted by the ECDIS during route monitoring (using S-104 data for the same locations but updated time points). Further, an alarm or indication can be raised if variation from schedule causes underkeel clearance or safe distance from hazards to fall below pre-set thresholds.

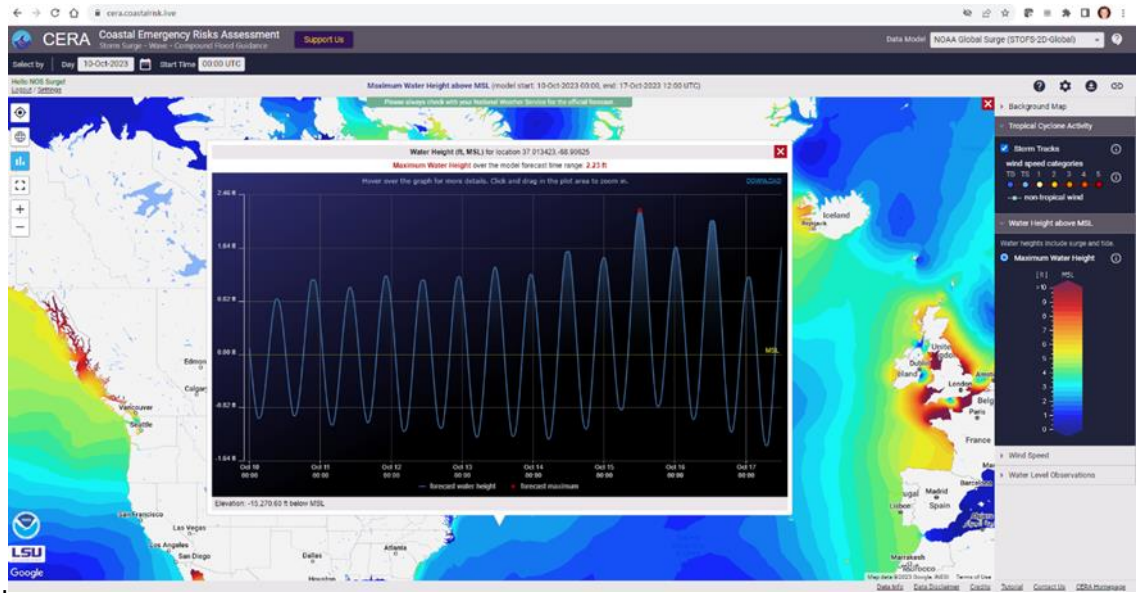

Figure 3. Pick report on continuous coverage

Notes: In this case portrayal on the chart graphic consists of an overlay of color shades corresponding to water level height in a gridded or TIN S-104 product.

Case 3 – Pick report on continuous coverage (water level station)

Data: Regular grid (DCF 2), ungeorectified data (DCF 3) or TIN data (DCF 7) from hydrodynamic forecast model; time series at fixed stations (DCF 1 or 8) from hydrodynamic forecast model, astronomical tidal predictions, and/or observations

Description: ECDIS displays the water levels from the model as a coverage fill. User can click a location of a water level station to get either a graphic time series plot or pick report (water level height, trend, etc.) from the model, observation, and/or astronomical tidal prediction. All water level data will be on chart datum. Uncertainty information could also be portrayed.

ECDIS route planning software uses water level information to determine “windows of opportunity” using the ship’s draft with the water level predictions (time series as single points).

Usage: The pick report at a water level station enables the mariner to view the hydrodynamic model forecast at that location, as well as evaluate the model’s forecast accuracy and bias by comparing to the near-real time recent observation at that same location (i.e., observed minus forecast). Further, by comparing the model forecast to the astronomical tidal prediction (i.e., residual: forecast minus predicted) or observation to prediction (i.e. observed minus predicted) at that location, the mariner can better understand the separate contribution to water levels from tides and non-tides (e.g., river, atmosphere, waves). This provides the mariner with a more complete situational awareness for better decision making in route planning and also route monitoring based on observations.

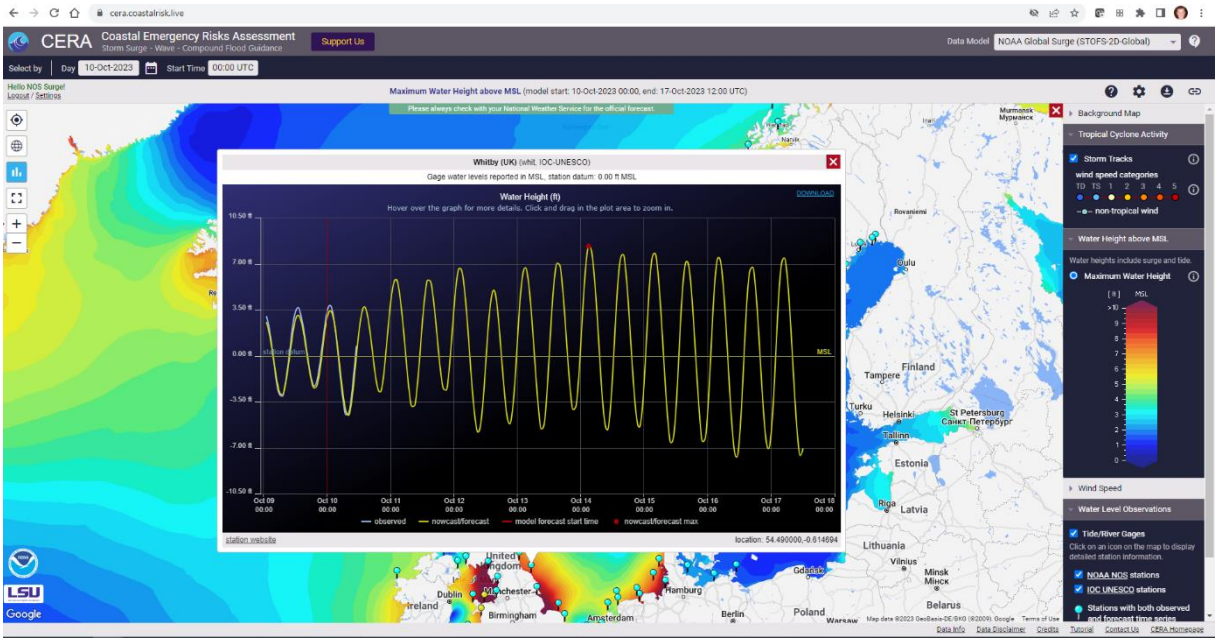

Figure 4. Pick report on continuous coverage (water level station)

ECDIS Application Detection of Water Level Adjustment (WLA)-compatible datasets

If both WLA-compatible and non-WLA compatible datasets are available, ECDIS applications can, without an extension to S-100 Edition 5.1.0 Part 17 discovery metadata, detect WLA-compatible datasets by opening the HDF5 dataset and checking the embedded metadata encoded within it, which includes vertical and horizontal datum, geographic extent, type of grid (dataCodingFormat), and type of data (forecast, prediction, observation, etc.). These metadata are documented in the S-104 Product Specification.

Encoding this in discovery metadata would simplify the task even further by avoiding the need to open the HDF5 dataset and check attributes. Options:

1) Extension – add a new code to the S100_CompliancyCategory enumeration in Part 17 and explain it in Part 4a where the compliancy categories are described.
   - category5: IHO-S-100 and IMO harmonized display compliant and designed for S-98 water level adjustment algorithms.
   - Clause 4a-5.6 (new) – describe code 5: “As for category 4 and containing only features that meet the requirements for water level adjustment.”
2) Clarification – use the currently unused *specificUsage* attribute of S100_DatasetDiscoveryMetadata in S-100. As its type is MD_Usage which allows gco:characterString values, the attribute can take any string value.
   - In S-100, add a remark in that row constraining the value: Datasets compatible with S-98 Ed. 1.1.0 water level adjustment must encode “WLA” as the content of this attribute.

Being a clarification, the second option can be effected without any change to the S-100 model or schemas.

Conclusions

It is important not to over-restrict the types of water level information accepted on ECDIS. S-104 information in the following formats should be accepted on ECDIS:

dataCodingFormat	Type of Data
1	Time series data at one or more fixed stations
2	Regularly-gridded data at one or more times
3	Ungeorectified gridded data or point set data at one or more times
7	TIN data
8	Stationwise time series at one or more fixed stations

Ref: S-104 Table 10.1, derived from S-100 Table 10c-23

Recommendations

1. S-100 level validation should be such that S-100 ECDIS accepts S-104 data formats into regular grids complying with the proposed requirements for water level adjustment.
2. S-104 Edition 2.0 should define portrayal and pick report formats compatible with S-100 Edition 5.1.0 or the interim solution for complex pick reports described above and in NIPWG papers.
3. The following checks should be in S-98 as compatibility checks for WLA purposes instead of S-100-level validation checks:
    a. Any checks pertaining to compatibility between S-101, S-102, and S-104 for the purposes of water level adjustment, including the proposed validation checks described in the Background section above.
    b. A check corresponding to whichever option (new compliancy category or *specificUsage* content) is selected for detection of WLA-compatible information.
4. Appropriate amendments should be made in one or both of S-100 and S-98 pertaining to the new compliancy category code or the restriction on specific usage.

Actions Requested

The S-100 WG is invited to:

- Endorse the use on ECDIS of S-104 data types in addition to regular grid data.
- Advise on preferred interim solutions for pick reports.
- Update S-100 and/or S-98 according to the recommendations in this paper.