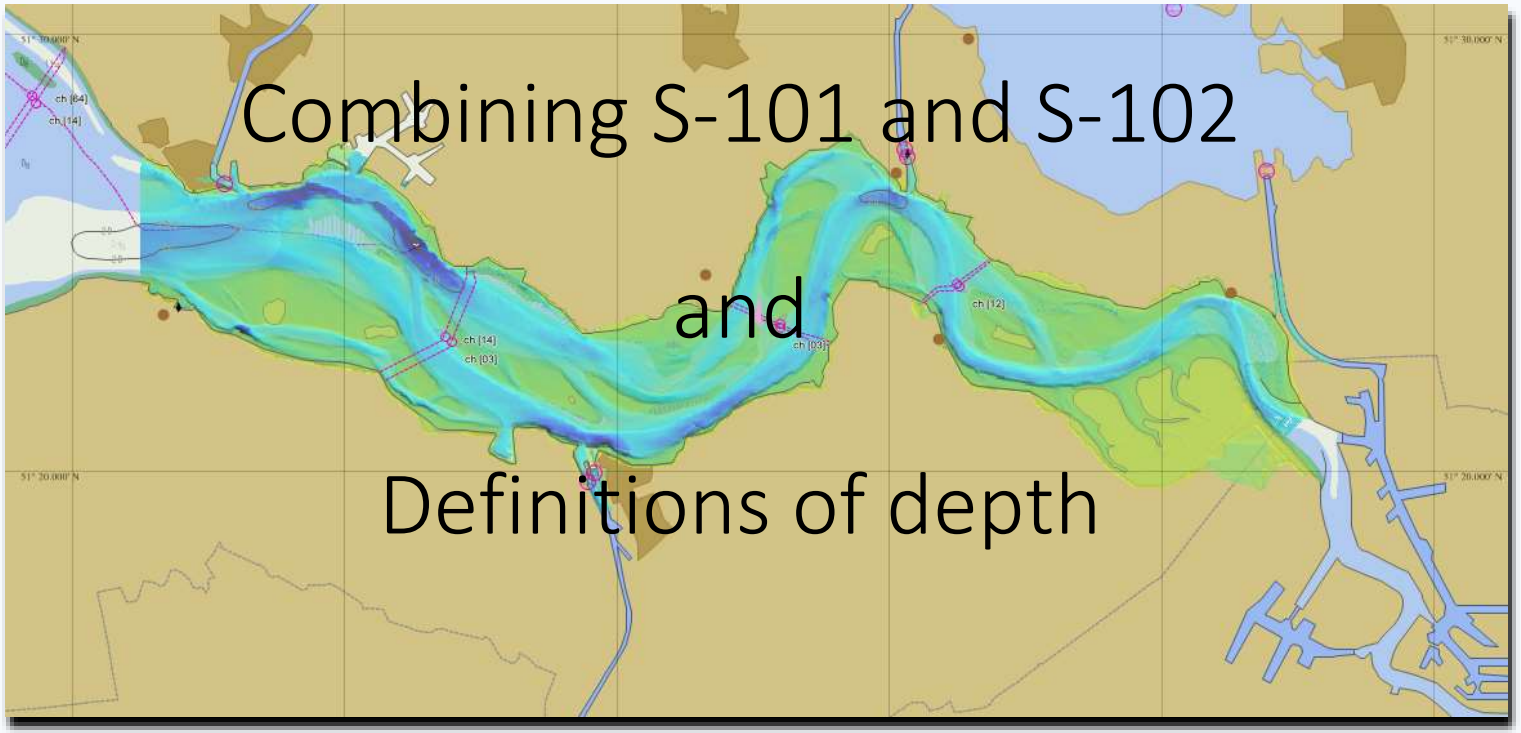
S-100 Test Strategy Meeting 7



Combining S-101 and S-102

and

Definitions of depth

IHO Data Quality Working Group

Data Quality

Good data quality does not mean
that the quality of the data has to be good.

It means that the end user is well informed
how good the Quality of the Data is.

IHO Data Quality Working Group [1]

You are here: Home ▸ HSSC ▸ DQWG

English	Français
DATA QUALITY WORKING GROUP (DQWG)	***GROUPE DE TRAVAIL SUR LA QUALITE DES DONNEES (DQWG)***
Chair: Mr. Rogier BROEKMAN (Netherlands) **Vice-Chair:** Mr. Sean LEGEER (USA) **Secretary:** Vacant	***Président :*** *M. Rogier BROEKMAN (Pays-Bas)* ***Vice-président :*** *M. Sean LEGEER (Etats-Unis d'Amérique)* ***Secrétaire :*** *Vacant*
Objectives: The primary objective of the DQWG is to develop appropriate methods of classifying and depicting the quality of digital hydrographic information. See **Terms of Reference**, for further details.	***Objectifs :*** *Développer des méthodes appropriées de classement et de description de la qualité des informations hydrographiques numériques.* Voir le **mandat** pour plus de détails.
Meetings: The WG works primarily by correspondence and aims to meet at least once every two years, normally in connection with another convenient IHO forum. See DQWG Work Plan as part of the HSSC Work Plan.	***Réunions:*** *Le GT travaille essentiellement par correspondance et a pour objectif de se réunir au moins une fois tous les deux ans, normalement en liaison avec d'autres réunions appropriées de l'OHI. Voir le programme de travail du DQWG au sein du programme de travail du HSSC.*
Members: The WG comprises representatives of IHO Member States, Expert Contributors and Observers from International Organizations. Expert Contributors principally from industry participate in the WG at the invitation of the Chair. See the list of WG Members.	***Membres:*** *Le GT est composé de représentants des Etats membres de l'OHI, d´intervenants à titre d'experts et d´observateurs d´organisations internationales. La participation des intervenants à titre d'experts, représentant principalement l'industrie, est soumise à l'approbation du président. Voir la liste des membres du GT.*

List of WG Members:

- *Australia*
- Brazil
- Canada
- Denmark
- Finland
- France
- India
- Italy
- *Indonesia*
- Japan
- *Mexico*
- Netherlands
- Norway
- *South Africa*
- Sweden
- UK
- USA

Expert Contributors:

- CSMART
- *IC-ENC*
- INTERTANKO
- PRIMAR
- *Teledyne CARIS*
- IHO Secretariat

italic = correspondence member

IHO Data Quality Working Group [2]

Next Meeting / *Prochaine réunion*	
15th meeting, Monaco (4-7 February 2020)	Documents

Past Meetings / *Réunions passées*	
14th meeting, Monaco (5-8 February 2019)	Documents
13th meeting (incl. workshop), Monaco (15-19 January 2018)	Documents
12th meeting, The Hague, Netherlands (13-15 June 2017)	Documents
11th meeting, Arlington, Virginia, USA (10-12 May 2016)	Documents
10th meeting, Brest, France (7-9 July 2015)	Documents
9th meeting, Poole, UK (3-7 November 2014)	Documents
8th meeting, Wollongong, Australia (25-27 March 2014)	Documents
7th meeting, Fredericton, New Brunswick, Canada (16-18 July 2013)	Documents
6th meeting, Silver Spring, Maryland, USA (24-26 July 2012)	Documents
5th meeting, Monaco (15-18 November 2011)	Documents
4th meeting, Helsinki, Finland (14-17 June 2011)	Documents
3rd meeting, Rostock, Germany (5 November 2010)	Documents
2nd meeting, Norfolk, Virginia, USA (10 May 2009)	Minutes
1st meeting, Bath, United Kingdom (23 September 2008)	Minutes

DQWG Reference Documents / *Documents de référence du DQWG*	
National Methodologies: from survey data to CATZOC values	Australia , **France** (eng ; fra), Netherlands, Norway, United Kingdom, USA
Quality of Bathymetric Data - Decision Tree (as designed for S-101)	Document

The principle of charting [1]

S4: Regulations of the IHO for International (INT) charts and chart specifications

A-102.1a:

Most hydrographic offices have an obligation to provide nautical chart cover of their national waters to such an extent, and on such scales, as to permit safe navigation, for all classes of vessel, from the smallest to the largest, throughout coastal waters, including major ports visited by the largest vessels, and minor arms of the sea of purely local interest. In this, the best known sense, nautical charts are navigational tools.

The principle of charting [2]

S4: Regulations of the IHO for International (INT) charts and chart specifications

A-102.1b:

National nautical chart series are usually the largest scale publications available showing the detailed configuration of the seabed offshore. In this respect, hydrographic offices have a de-facto responsibility for their national waters similar to that of topographic mapping agencies for land areas. Such information about the shape of the seabed is required by a variety of national users other than navigators: construction engineers concerned with offshore developments, dredging contractors, oceanographers, defence departments, coastal zone managers, and so on..

Maintenance of International Charts

S4: Regulations of the IHO for International (INT) charts and chart specifications

A-401.4:

Each nation, in the role of either producer or printer, will accept responsibility for the operation of a system to ensure adequate maintenance of any international chart included in its national series. The required level of maintenance is determined largely by the rate at which significant new information is received. Receipt of new data is not normally predictable so it is rarely feasible to operate on the basis of regular maintenance programs. Usually the primary factor that determines the frequency of action is rate of change of the critical data in the chart that affects safety of navigation.

Primary purpose of nautical charts

S4: Regulations of the IHO for International (INT) charts and chart specifications

B-100.4:

The primary purpose of nautical charts is to provide the information required to enable the mariner to plan and execute safe navigation. In constructing charts and selecting content it is therefore important to understand the mariner's need for appropriate, relevant, accurate and unambiguous information. Particular care must be exercised to avoid errors and the creation of situations where the mariner may be faced with too much information (chart clutter) or irrelevant information which causes confusion or distraction. (See B-102 for associated extracts from SOLAS regulations.)

Additional information

S4: Regulations of the IHO for International (INT) charts and chart specifications

B-100.4:

Additional information to suit non-navigational requirements (for example: sub-surface operations (military, research, fishing etc.); natural resource exploitation; recreation; port development; international boundaries and national limits) may be included on nautical charts if considered useful or necessary by the producing authority. On paper charts, the cartographer's expertise in design and selection, biased towards safety, is essential to achieve the required clarity. The format of electronic charts may allow detail additional to that shown on the paper chart, specific to navigation using Electronic Chart Display and Information Systems (ECDIS), to be included. However, irrespective of format, additional information must not be added at the expense of clear portrayal of navigationally significant information.

Compilation procedure [1]

S4: Regulations of the IHO for International (INT) charts and chart specifications

B-100.5:

Compilation procedure: largest scale first. The mariner requires charts to be consistent throughout the scales, at least for essential data content; this is called ‘vertical consistency’. For this reason, as far as possible, the original compilation and subsequent updating of charts, whether by Notice to Mariners or new edition (see section B-600), should proceed from the largest scale, through the series, to the smallest scale. In practice, this is best achieved by compiling from original source data into the largest scale chart and then compiling the next smaller scale using the largest scale chart as source, and so on to the smallest scale appropriate for the data type.

Compilation procedure [2]

S4: Regulations of the IHO for International (INT) charts and chart specifications

B-100.5:

Within a series of different scale charts covering the same location, chart content in terms of its cartographic detail and resolution is greatest at the largest scale. At smaller scales, detail must be generalized, with only a selection of the available source data (including soundings) being portrayed, so that the information which is selected is clearly presented. This selection is based upon the significance of the information to the mariner and the purpose of the chart (see B-300.3 and B-403). This will ensure that the charts are vertically consistent; consequently, any sounding on the smallest scale chart will also be present on the largest scale.

Assessment of incoming information (by HOs)

S4: Regulations of the IHO for International (INT) charts and chart specifications

B-610: Assessment is the process of examining incoming information against existing information in chart products and Geographic Information System (GIS) databases (see B-641.1) to:

- establish the credibility of the source, including the authority of the source provider;
- identify the differences;
- consider the significance to the chart user of the differences;
- identify the most appropriate actions to incorporate that data into 1) GIS databases, 2) chart products.

Credibility of sources (received by HOs)

S4: Regulations of the IHO for International (INT) charts and chart specifications

B-611:

Establishing the credibility of sources is a matter for professional judgement and experience. All incoming data must be checked for possible errors and inconsistencies. It is essential that the quality of all positional and depth data is established before use.

Where there are conflicting or inconsistent sources of information, or there are doubts about the accuracy or validity of the information, clarification should be sought from the appropriate authority. If no answer is forthcoming, a judgement must be made. In such instances, it is important to record the reasons for the decisions, for use when considering later information or for future research.

Source data types and guidelines

S4: Regulations of the IHO for International (INT) charts and chart specifications

B-611:

- Official (and officially sponsored) surveys prepared specifically for nautical charting.
- Unofficial surveys are undertaken for oil companies, cable laying companies or other contractors and are not specifically designed for charting purposes.
- Information from other official authorities not directly concerned with charting.
- Surveys and NM originated by local port authorities should normally be accepted, if experience has demonstrated reliability.
- Imagery derived from aerial photography and satellites is available from both official (for example land survey organizations) and commercial sources and can be a very valuable source of information. Its interpretation and application for charts requires particular expertise.

Reports from ships (guidelines) [1]

S4: Regulations of the IHO for International (INT) charts and chart specifications

B-611.9:

Reports from ships should not normally be accepted solely as the basis for permanent chart updates without corroboration unless:

- they originate from recognized survey vessels, research ships or other vessels/masters known to be reliable.
- they are reports of shoal depths, preferably accompanied by supporting evidence, for example an unambiguous echo-sounder trace, for areas where it is unlikely that corroboration can be obtained. The national or primary charting authority (see B-611.7) for the area should be consulted before NM action is taken.

Report from ships (guidelines)[2]

S4: Regulations of the IHO for International (INT) charts and chart specifications

B-611.9:

- they are the sole source of information in a remote area.
- they are of particular significance to navigation.
- the location is in an area where the level of information flow and lines of communication are poor.

Other sources

S4: Regulations of the IHO for International (INT) charts and chart specifications

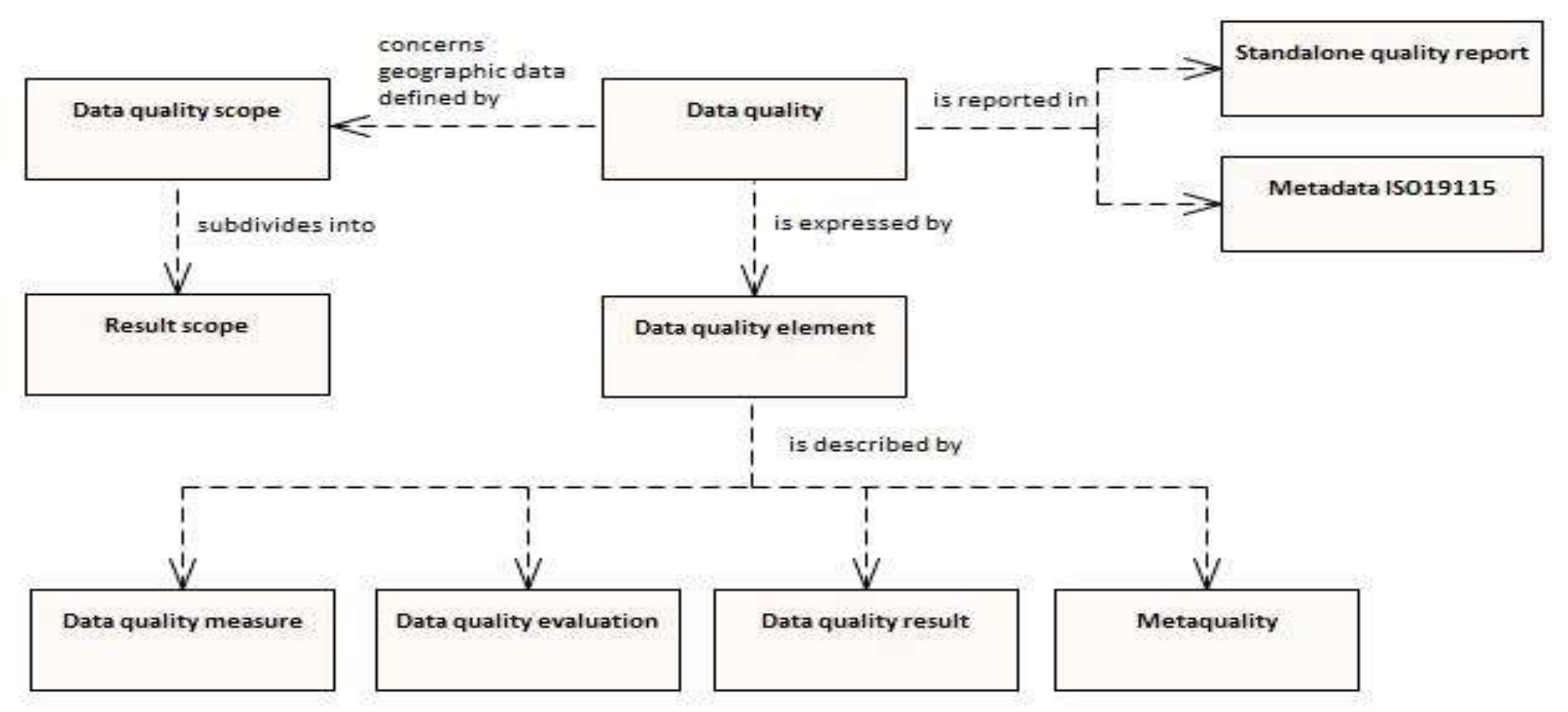
- **B-611.10**: Report from private individuals.
- **B-611.11**: Publications such as port guides, that are not produced by hydrographic offices.
- **B-611.12**: Notifications of works.
- **B-611.13**: The World Wide Web contains both official and unofficial data and is a very valuable source of information. A careful assessment of its reliability must be made if it is to be used in nautical charts.

Chart products

Paper, existing digital and future digital

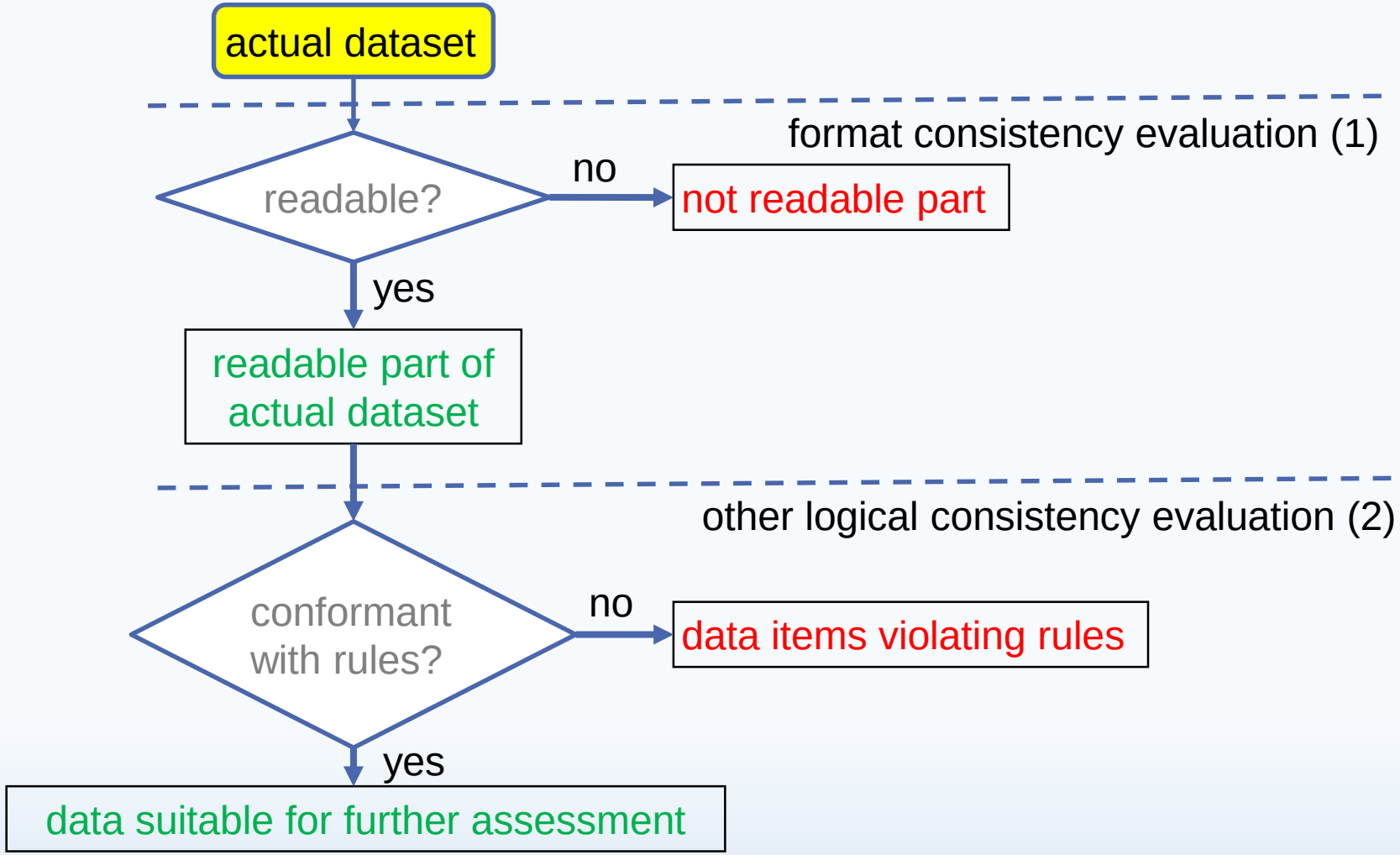
Type of chart	According to Standard	Portrayal Standard
Paper	S-4: Regulations for International Charts and Chart Specifications.	INT1: Symbols, Abbreviations, Terms used on Charts.
		INT2: INT2 Borders, Graduation, Grids and Linear Scales.
		INT3: INT3 Use of Symbols and Abbreviations.
Digital	S-57: IHO Transfer Standard for Digital Hydrographic Data.	S-52: Specifications for Chart Content and Display Aspects of ECDIS.
Digital (under development)	S-100: Universal Data model **S-101**: Electronic Navigational Chart **S-102**: Bathymetric Surface	Under development (inherits from S-52)

The concept of Data Quality -> Validation



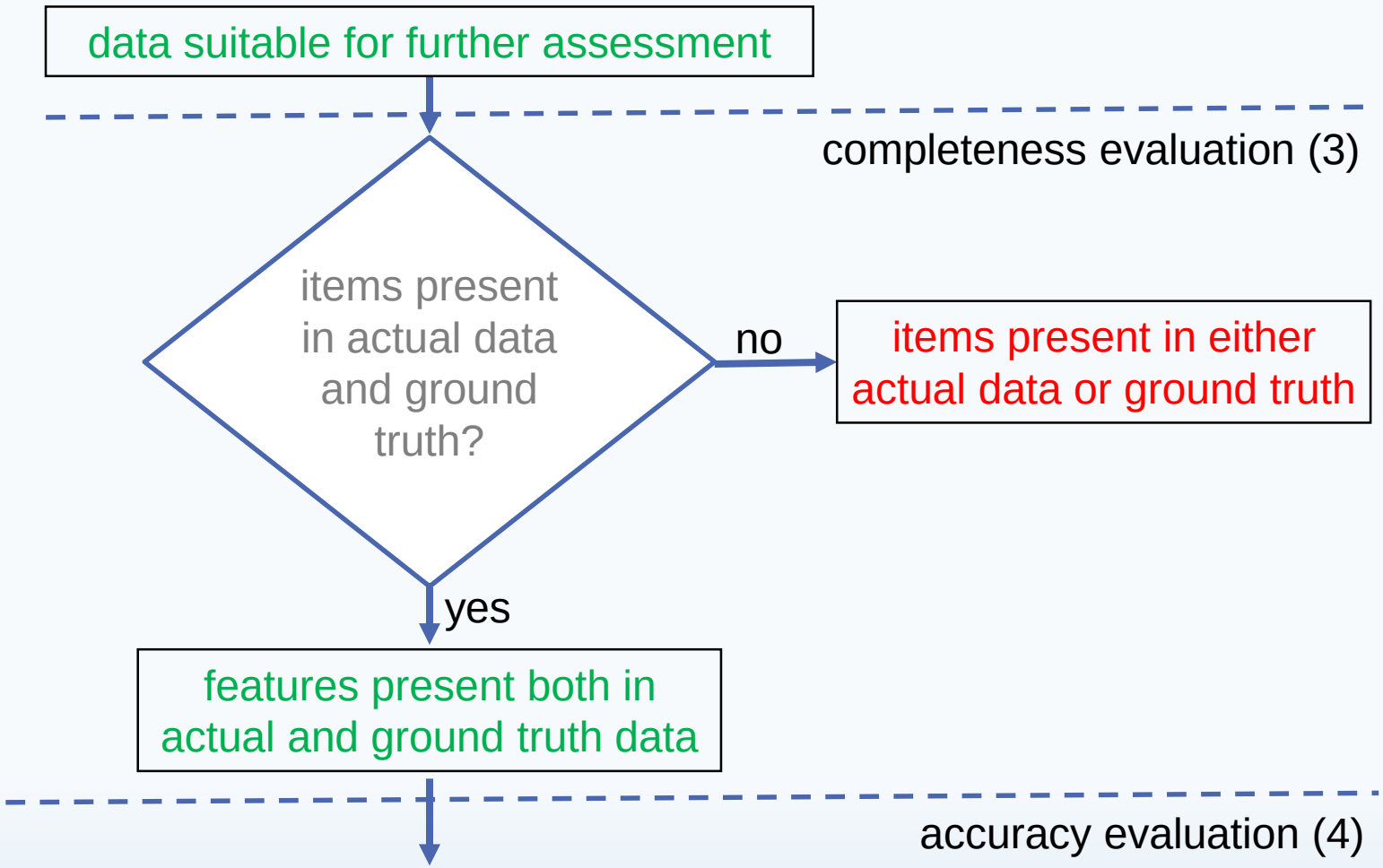
courtesy of ISO

ISO 19157 Ordering in data quality evaluation [1]



courtesy of ISO

ISO 19157 Ordering in data quality evaluation [2]



courtesy of ISO

Format consistency evaluation (1)

- Format consistency – degree to which data is stored in accordance with the physical structure of the dataset.
- Format consistency makes interoperability and portrayal of data possible.

Logical consistency evaluation (2)

- Logical Consistency is defined as the degree of adherence to logical rules of data structure, attribution, and relationships (data structure can be conceptual, logical or physical).
- Conceptual consistency – adherence to rules of the conceptual schema.
- Domain consistency – adherence of values to the value domains.
- Topological consistency – correctness of the explicitly encoded topological characteristics of a dataset (point, line, area).
- Depth area is an example of an area with a height attribute. (2.5D)

Completeness evaluation (3)

- Completeness is defined as the presence and absence of features, their attributes, and relationships. It consists of two data quality elements:

- commission, excess data present in a dataset.
- omission, data absent from a dataset.

Accuracy evaluation (4)

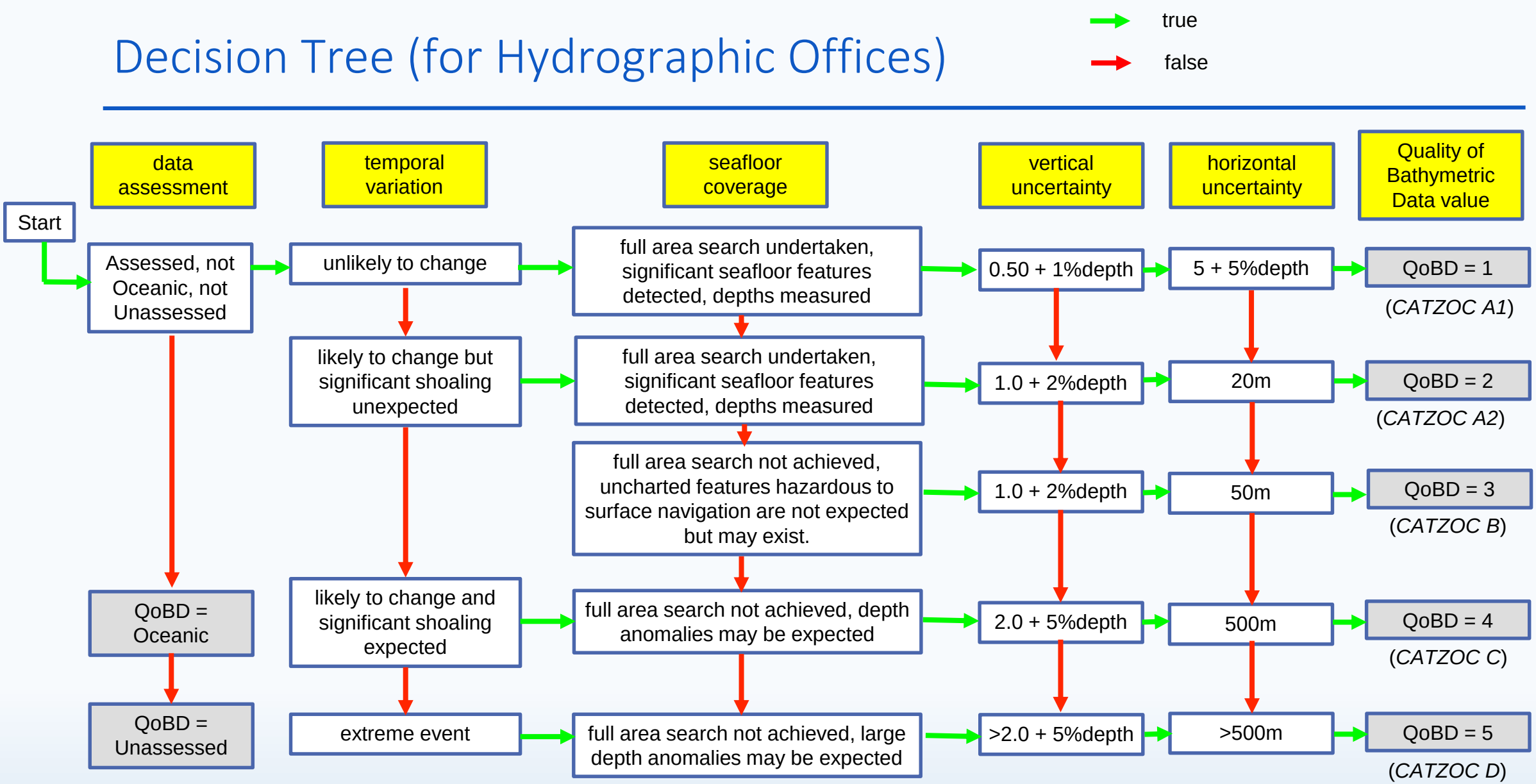
- Positional accuracy is defined as the accuracy of the position of features within a spatial reference system. It consists of three data quality elements:

- absolute or external accuracy: closeness of reported coordinate values to values accepted or as being true.
- relative or internal accuracy: closeness of the relative positions of features in a dataset to their respective relative positions accepted as or being true.
- gridded data positional accuracy: closeness of gridded data spatial position values to values accepted as or being true.

Combining S-101 (chart) and S-102 (depth data)

- S-101 Quality of Bathymetric Data: An area within which a uniform assessment of the quality of the bathymetric data exists.
- Information about quality, reliability and uncertainty of bathymetric data.
- Applies to depth areas, soundings, sub-surface objects hazardous to navigation, such as under water rocks, wrecks and obstructions.
- Provides a value for the horizontal and vertical accuracy.
- If the quality of individual soundings, under water rocks, wrecks and/or obstructions is better or worse than the aggregated value, this can be specified and labelled to the individual item.

Decision Tree (for Hydrographic Offices)



S-102 Data set

- S-102 bathymetric surface product specification. (Ed 2.0 Oct 2019)
- An S-102 bathymetric surface product is a digital elevation model which represents the seafloor in a regular grid structure.
- **Navigation surface**: A coverage representing the bathymetry and associated uncertainty with the methods by which those objects can be manipulated, combined and used for a number of tasks, certified for safety of navigation.
- **Uncertainty**: The interval (about a given value) that will contain the true value of the measurement at a specific confidence level. Note: Errors exist and are the differences between the measured value and the true value. Since the true value is never known it follows that the error itself cannot be known. Uncertainty is a statistical assessment of the likely magnitude of this error.

Hydrographer privilege

The Bathymetric Surface Product consists of a set of values organized to form a regular grid coverage, with associated metadata, for an area of the sea, river, lake or other navigable water. Final grid coverage includes a depth value and associated uncertainty estimate for each location in the matrix.

In addition, a discrete point set called a "tracking list" is included. The tracking list contains locations where a hydrographer or the data producer overrode a grid matrix value to deliberately bias the final surface for safety of navigation.

That is, the data set can carry both the corrected depth information to support the safe navigation of marine vessels as well as the original measured depth value to support scientific purposes.

Generation and display of gridded bathymetry

- Utilization of a gridded data structure eases the data management concerns of the hydrographer, providing the ability to safely decimate the total sum of collected depth estimates into a manageable quantity of representative nodal depths for processing and production.
- All gridded datasets should be exposed to rigid Quality Assurance/Control procedures to ensure the final gridded dataset accurately represents the real-world environment.
- Once a dataset passes an established Quality Assurance/Control process, modern chart production software is used to extract candidate nodal depths from the grid for consideration as final charted soundings.

Charted soundings/contours vs. gridded bathymetry

- Depth information on a nautical chart is generally displayed as depth soundings, depth contours, and depth areas. Depth contours are used to connect soundings of equal elevation referenced to a specific sounding datum.
- The introduction of a fourth depth source, S-102 gridded data, enhances navigation decision making by providing the mariner with the ability to visualize and color a pseudo three-dimensional, sun-illuminated, contiguous image of the seafloor.
- While this is a benefit, producers should understand that the selection of an improper grid resolution (that is too coarse, or too fine) may complicate the overall navigation solution when displayed with traditional depth information.

Informative grid resolution

Scale	Informative Grid Resolution
1:10,000,000	900 meters
1:3,500,000	900 meters
1:1,500,000	450 meters
1:700,000	210 meters
1:350,000	105 meters
1:180,000	54 meters
1:90,000	27 meters
1:45,000	13 meters
1:22,000	6 meters
1:12,000	3 meters
1:8,000	2 meters
1:4,000	1 meter
1:3,000	1 meter
1:2,000	1 meter
1:1,000	1 meter

Type of uncertainties (in S-102)

- "Unknown" - The uncertainty layer is an unknown type.
- "Raw Standard Deviation" - Raw standard deviation of soundings that contributed to the node.
- Dev "CUBE Standard Deviation " - Standard deviation of soundings captured by a CUBE hypothesis (that is, CUBE‘s standard output of uncertainty).
- "Product Uncertainty" - NOAA standard product uncertainty V1.0 (a blend of CUBE uncertainty and other measures).
- "Historical Standard Deviation " – Estimated standard deviation based on historical/archive data.

Gridding methods of S-102

- Basic weighted mean.
- Shoalest depth.
- Total Propagated Uncertainty weighted mean – based on remote sensing measurements.
- Combined Uncertainty and Bathymetric Estimator – using hypothesis.
- Nearest neighbor.
- Natural neighbor.
- Polynomial Tendency.
- Spline – minimize overall surface curvature.
- Kriging – estimated surface from scattered set of points

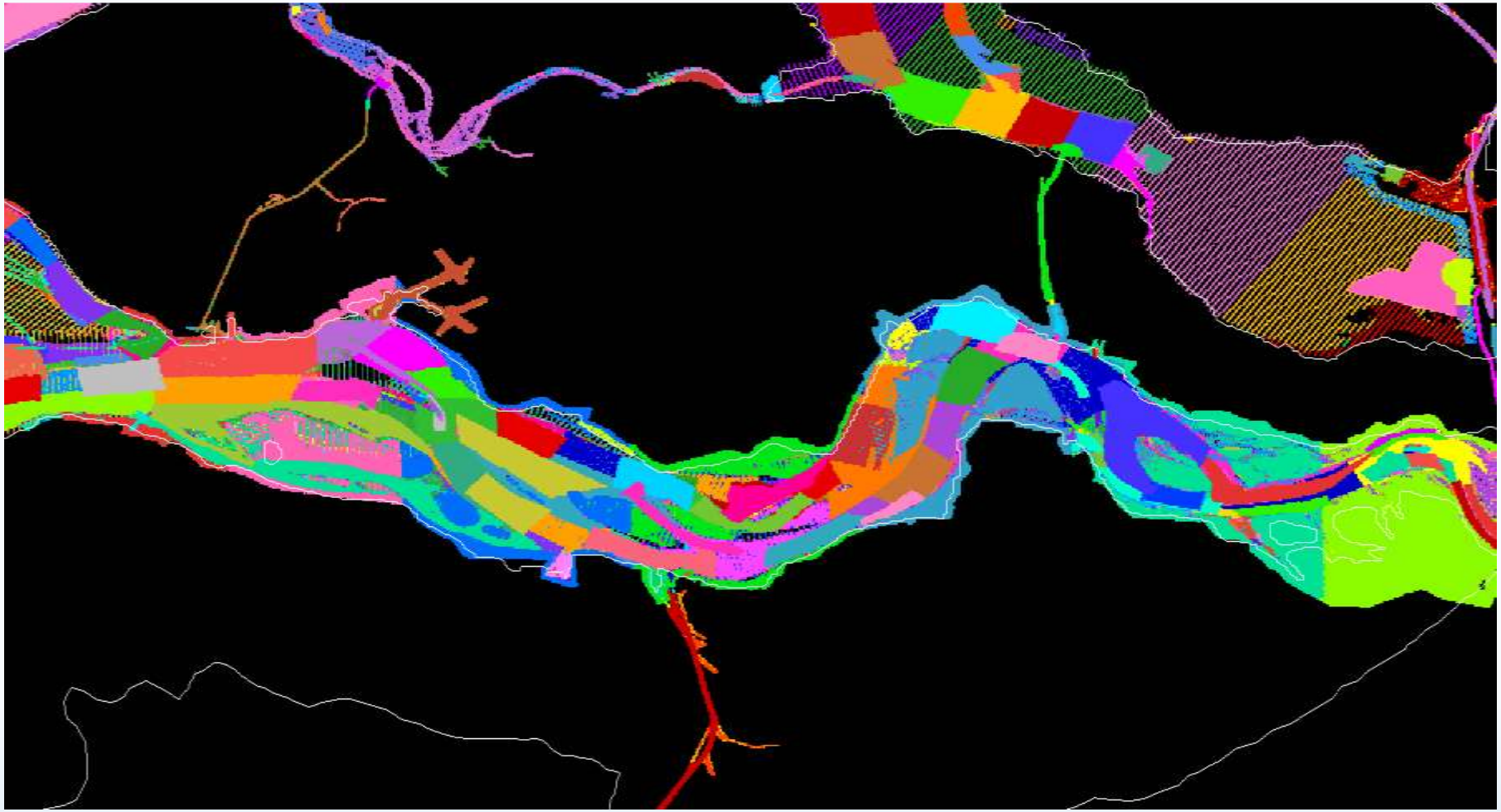
Test Case – Netherlands

Approach to Port of Antwerp goes through the Westerschelde area.

Dynamic intertidal area. Surveyed by NL and BE government. Charted by NLHO.

ENC M_NPUB field:
Depths in the main channel of the Westerschelde are maintained by dredging to 14.5m LAT.

Mosaic of hydrographic surveys over time



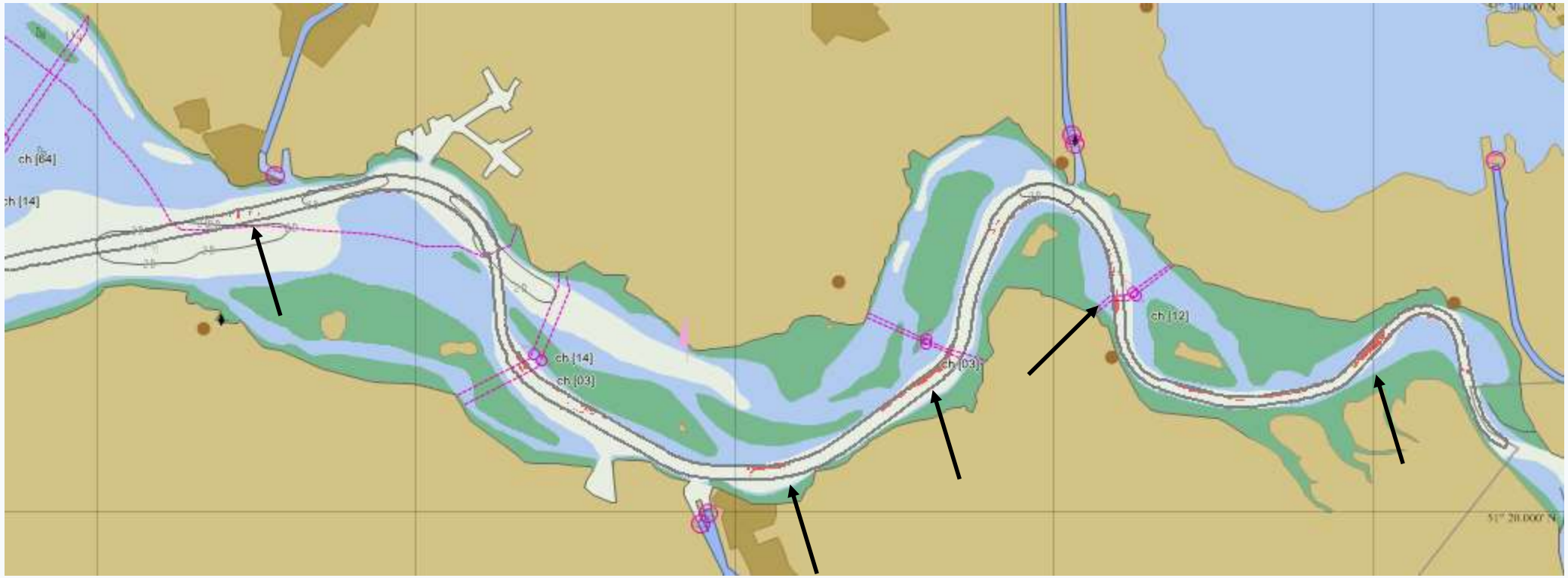
Gridding method used by NLHO (since 2003)

- Initial grid = 5x5 m at the equator.
- Grid is adjusted at latitude 52N.
- Resulting grid is 3x5m – Level of Detail value 0.
- Generalized to 6x12m – Level of Detail value 1.
- Generalized to 12x20m – Level of Detail value 2.
- At LoD (0) the average depth of the cell is taken. When generalizing to LoD (1), the 4 adjacent cells are compared and the shallowest is chosen to maintain vertical consistency. True position is maintained when producing Soundings in an ENC.
- LoD (2) is used for generating contour lines and soundings.

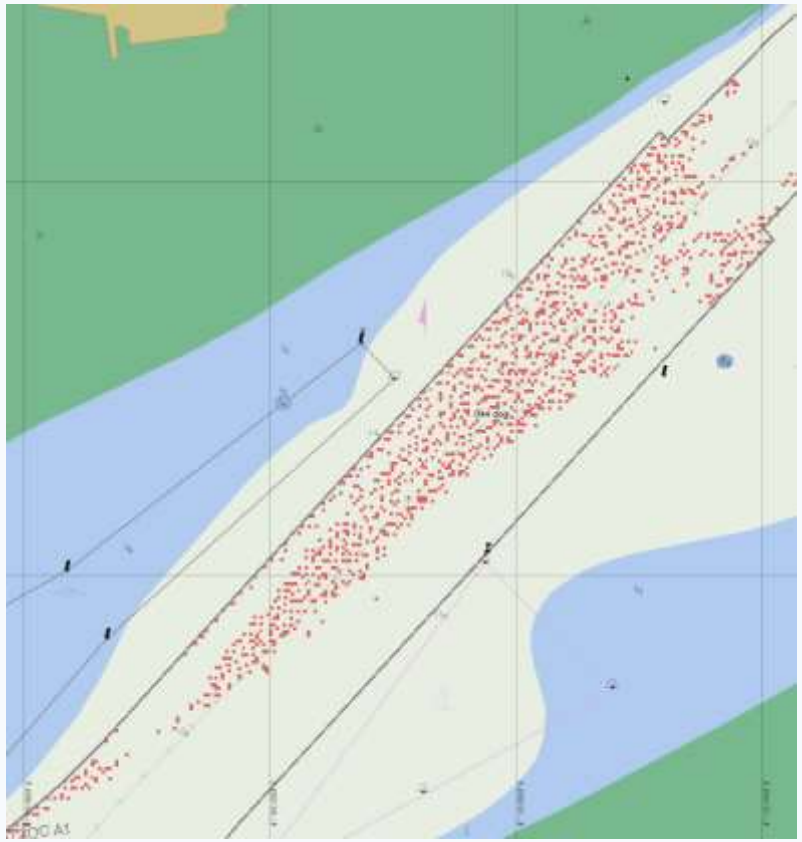
New methodology to display quality information

- DQWG presented a new methodology to display quality information in an ENC at HSSC-11 (May 2019).
- Vertical uncertainty of obstructions, soundings, wrecks and under water rocks are taken into account to determine a safe passage.
- The same principle can be applied to S-102 data, if needed.
- S-102 can be shown in “standard mode” and “worst case scenario.”
- Then the vertical uncertainty is applied to the standard depth.
- Resulted depth = standard depth – uncertainty value.
- Raises some fundamental questions if no uncertainty is available.

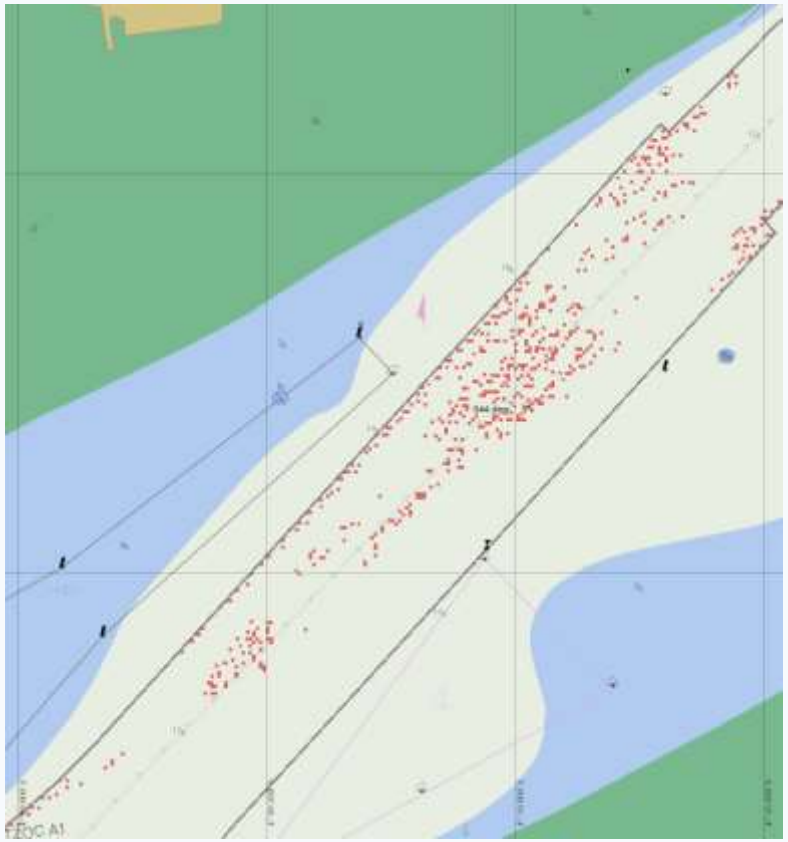
Worst case scenario of LAT -14.5 m



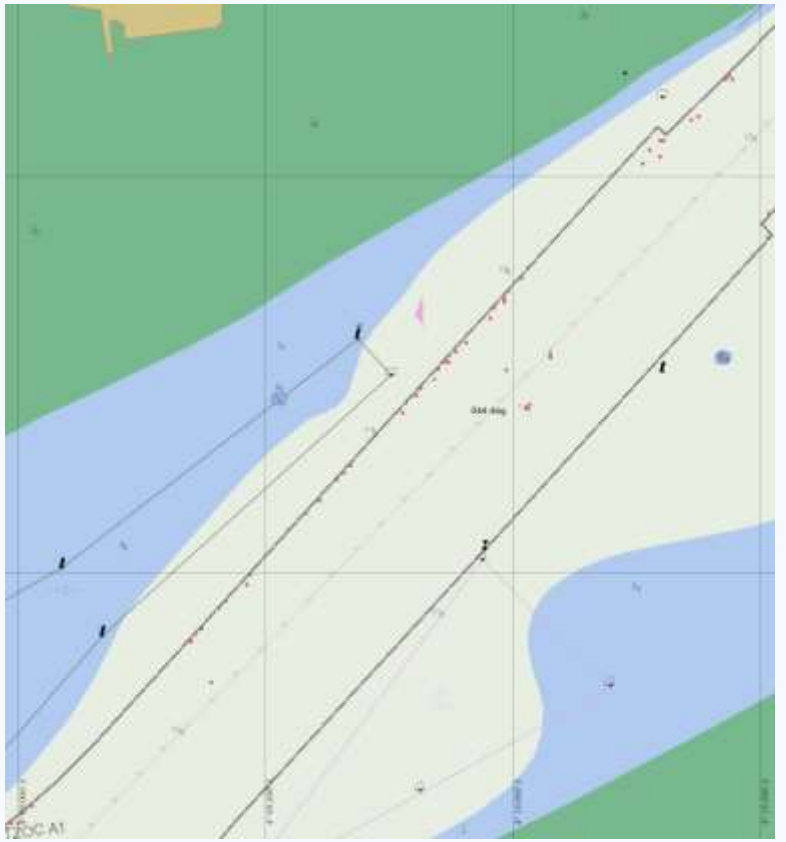
Worst case scenario of LAT -14.5 m



LAT -14.5 m



LAT -14.3 m

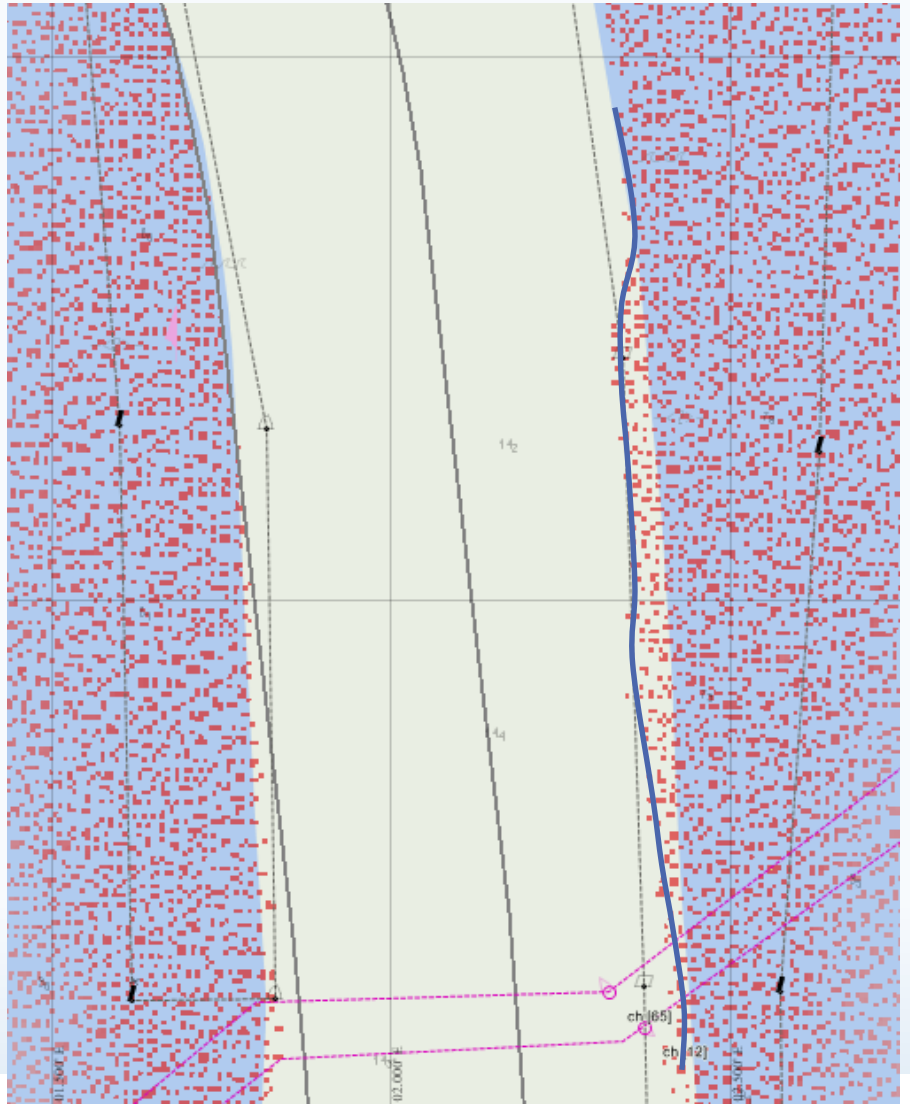


LAT -14.0 m

Difference 10m contour and worst case depth

- Standard ENC Display with two shades of color.
- Safety depth is 10m contour line.

- Safe depth based upon bathymetry including its associated uncertainty creates a depth contour that is different from the ENC.



Calculation method of worst case scenario

- Check if S-102 data contains uncertainty values?
- Yes -> apply the uncertainty values for the grid cells that have them.
- No -> compute the uncertainty values according to the Quality of Bathymetric Data parameters (see decision tree).
- QoBD = 1 -> Uncertainty = 0.5 m + 0,01* depth.
- QoBD = 2 or 3 -> Uncertainty = 1.0 m + 0,02*depth.
- QoBd = 4 or 5 -> Uncertainty = 2.0 m + 0,05*depth.

Maximum draught and minimum depth

S4: Regulations of the IHO for International (INT) charts and chart specifications

B-432.4

a. In areas where the tidal range is not appreciable, it may be useful to state the maximum draught of vessels authorized by a regulatory authority to navigate a recommended track (see B-434.3), a fairway (see B-434.5b) or within any other regulated area.

b. All other depths quoted on tracks, in deep water routes and dredged areas or channels must indicate the minimum depth of water at chart datum (and a survey year date if not maintained), for example 18,5m, as decided by a port or hydrographic authority. No statements of minimum depths must be made in changeable areas unless the critical depths are regularly examined and updated.

Safe Under Keel Clearance Passage

1. expected vessel draught in the area. (assume draught is accurate).
2. minimal under keel clearance accepted by Mariner.
3. shallowest reported depth along the route below Chart Datum.
4. applied vertical uncertainty of depth area.
5. tidal height above Chart Datum.
6. uncertainty of tidal measurement.

Note that the existence and size of under water object hazardous to the safety of navigation also needs to be taken into account.

(Quality of Bathymetric Data – former Category Zone of Confidence).

Applied vertical uncertainty of depth data

- In good quality areas, depth is reduced by 0.5 m or more.
- In medium quality areas, depth is reduced by 1.0 m or more.
- In poor quality areas, depth is reduced by 2.0 m or more.
- If S-102 uncertainties are available, they will be applied.
- If an area is a maintained or dredged depth, is uncertainty = 0 m? (100% guarantee of maintenance)
- Should we allow that a fixed value can be entered by a Hydrographic Office for historic full coverage data, where the uncertainty is no longer available, but there is no 100% guarantee that the reported depths are the shallowest?

Thank you