

# STANDARD OPERATING PROCEDURE

For

SM 2130 B

(SM 22<sup>nd</sup> Edition)

## Determination of Turbidity by the Nephelometric Method

SOP #: SM 2130 B

SOP REVISION #: 3.0

DATE: October 2022

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# MassDEP

### Massachusetts Department of Environmental Protection Division of Environmental Laboratory Sciences

Senator William X. Wall Experiment Station  
37 Shattuck Street, Lawrence, MA 01843

Originally  
Prepared by: James H. Sullivan

*James H. Sullivan, Laboratory Supervisor*

Date: April 26, 1999

Revised by: Elsy P. Naveo

*Elsy P. Naveo, Environmental Analyst*

Date: October 1, 2022

Approved by: Peter Piro

*Peter Piro, Acting Laboratory Supervisor, Inorganic Chemistry*

Date: November 17, 2022

Approved by:

Beth McDonough

*Beth McDonough, Laboratory QA and Data Manager*

Date: November 17, 2022

Approved by:

Oscar C. Pancorbo

*Oscar Pancorbo, Ph.D., DELS/WES Director*

Date: December 30, 2022



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## LIST OF REVISIONS

Rev. #	Date	Description of Revision	Page #
0	March 1999	None	
1.0	December 2000	Section 14.0 and 15.0 changed Assorted minor typos etc. corrected	Throughout document
1.1	November 2001	Section 13.0 through 17.0 renumbered to 14.0 through 18.0 New Section 13.0	
1.2	December 2001	Section 13.2 – 1.0 NTU changed to 1.8 Section 13.10 – Changed Section 13.15 – Deleted Section 13.16 – Changed from 1.0 NTU to 1.8 NTU Section 13.16 – Section 13.18 renumbered to 13.15 – 13.17 Table 1, 3 and 4 – Deleted (Section 18) New Table 1 (Section 18) Table 5 renumbered to Table 3 (Section 18)	
1.3	November 2003	Section 1.2 – 0.1 NTU changed to 0.13 NTU Several minor changes/corrections to Sections 7.1, 7.3, 9.1, 9.5, 9.6, 10.1, 10.2.1, 13.2, 13.4, 13.5, 13.10, 13.11, 13.15, 13.17, and 14.1 Table 1 and Table 3 values (MDL) updated (Section 18)	
1.4	April 2004	Section 6.1.1 added – Nephelometer Maintenance Section 7.4 added – Preparation of QCS standard Section 9.1 – CCS standard specified Section 9.2 – Acceptance criteria specified Section 9.3 – Acceptance criteria specified Section 9.5 – Changed procedure for reporting low-level results Section 9.6 – Added reference standard prep book Section 13.2 – Changed/specified QCS and IPC Section 13.4 – Specified CCS Section 13.11 – Changed value of IPC and QCS Section 13.14 – Added duplicate to protocol	



Rev. #	Date	Description of Revision	Page #
		Section 13.15 – Changed value of CCS Table 1 – Clarified duplicate frequency (Section 18)	
1.5	October 2006	Replaced old DEP Logo with state seal + MassDEP  Section 6.1 – Turbidimeter Model changed from 18900 to 2100AN  Section 7.2 - Added Calibration Standards  Sections 9.4, 13.2 & 13.9 - Changed Calibration Standards  Section 10.0 - Changed Calibration Procedure  Section 13.15 - Changed LFB Standard  Table 3 - Updated MDL (Section 18)	Title page & header
1.6	February 2010	Changed calibration standards  Sections 3.10, 3.11, and 3.12 – Added definitions  Deleted previous Section 10.2.6 - i.e., calibration with 7500 NTU standard  Table 3 – Updated MDL Data (Section 18)	Throughout document
1.7	November 2012	Sections 1.2, 7.3, 9.5, 13.9, and Table 3 (Section 18): Updated MDL and MRL.  Sections 7.4, 9.1, 9.2, 9.6, 13.2, 13.4, and 13.9: Changed concentrations of QCS, LFB, IPC, and CCS.  Sections 11.5, 11.6, 11.7, and 11.8: Added instructions for standard preparation and disposal.  Table 3: Updated MDL data (Section 18)  Table 4: New table added (Section 18)	
1.8	February 2016	Changed division name from Division of Environmental Analysis (DEA) to Division of Environmental Laboratory Sciences (DELS), and made other minor clarifications to update document  Table 3 – MDL/MRL Updated (Section 18)	Throughout document



Rev. #	Date	Description of Revision	Page #
2.0	March 2016	Section 1 - Updated. Section 2 - Clarified. Section 4 - Clarified. Section 5 – Updated and expanded. Section 6 - Updated and expanded. Section 7 - Clarified and expanded. Section 8 - Updated and expanded. Section 9 - Updated and clarified. Section 10 - Clarified. Section 11 - Updated and clarified. Section 12 - Deleted; Section 14 became Section 12. Section 14 - Updated. Table 3 (MDLs/MRLs) – Removed (Section 18). Table 4 (QC elements results) – Removed (Section 18)	
2.1	March 2020	U.S. EPA 2019 Audit Corrective Actions: Section 6.2 – Description of Indexed Sample Cells clarified Section 9.8 – LFB concentration changed from 10.0 to 1.0 NTU Section 11.4 – Calibration Check procedure clarified Sections 12.1 and 12.2 – Data Analysis and Calculations Sections clarified	



Rev. #	Date	Description of Revision	Page #
3.0	October 2022	Section 1.3 – Updated calibration range. Section 3 – Reformatted section and updated definitions. Section 6 – Added new turbidimeter model, HACH TL2300. Section 9 – Updated entire section. Section 10 – Added calibration instructions for TL2300. Section 11 – Added sample analysis instructions for TL2300. Section 12 – Added instructions for data export on TL2300. Section 12.2 – Added method-specific rounding explanation. Section 12.2.1 – Added new section. Section 13 – Added new section and discussed results of 2022 IDC/MDL study. Section 14 – Added new section detailing maintenance procedures and renumbered subsequent sections accordingly.	



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## 1.0 SCOPE AND APPLICATION

- 1.1 This method describes the procedure used to determine the turbidity of potable and non-potable waters. For samples falling under the Safe Drinking Water Act, this method is used to determine if digestion (samples > 1 NTU) is required prior to further analysis.
- 1.2 This method is applicable to the determination of turbidity in drinking, surface and saline waters, and domestic and industrial wastewater.
- 1.3 The applicable range of this method is from 0.10 up to 4,000 NTU. The range may be extended with sample dilution, but dilutions should be avoided whenever possible.

## 2.0 SUMMARY OF METHOD

- 2.1 A volume of sample is poured into a glass sample cell and placed in a turbidimeter. The turbidimeter consists of a nephelometer with a light source for illuminating the sample and a photoelectric detector to indicate intensity of light scattered at 90° to the path of incident light. The method is based on a comparison of the intensity of light scattered by the suspended particles and/or microscopic organisms in the sample under defined conditions with the intensity of light scattered by a standard reference suspension under the same conditions. The higher the intensity of the scattered light, the higher the turbidity. The intensity of light scattered by the sample is given in nephelometric turbidity units (NTU).

## 3.0 DEFINITIONS

- 3.1 Calibration Standard (CAL): Commercially prepared, stabilized sealed liquid turbidity standards. The CAL solutions are used to calibrate the meter response with respect to analyte concentration.
- 3.2 Calibration Blank (CB) [Equivalent to an LRB in this method]: A volume of reagent water fortified with the same matrix as the calibration standards, but without the analyte. The calibration blank is a < 0.1 NTU standard and is used to calibrate the turbidimeter. Depending on when it is run following instrument calibration, it may also be called an Initial Calibration Blank (ICB) or Continuing Calibration Blank (CCB). The ICB is analyzed immediately after ICV standard and before the analysis of samples. The CCB is analyzed immediately after every CCV.
- 3.3 Continuing Calibration Verification (CCV) Standard: An IPC analyzed after every 10 samples and at the end of the sample run just before the last CCB.
- 3.4 Instrument Performance Check (IPC) Standard: A solution of method analytes, used to evaluate the performance of the instrument system with respect to a defined set of method criteria. Depending on when it is run following instrument calibration, it may also be called an Initial Calibration Verification (ICV) or Continuing Calibration Verification (CCV). The ICV is analyzed immediately following calibration and the CCV is analyzed after every tenth sample and at the end of the analytical run.
- 3.5 Laboratory Duplicates (Sample and Sample Duplicate): Two aliquots of the same sample taken in the laboratory and analyzed separately with identical procedures.
- 3.6 Laboratory Fortified Blank (LFB): An aliquot of reagent water or other blank matrices to which known quantities of the method analytes are added. The LFB can be prepared in the laboratory or purchased commercially.





- 3.7 Linear Calibration Range (LCR): The concentration range over which the instrument response is linear.
- 3.8 Method Detection Limit (MDL): The minimum concentration of an analyte that can be identified, measured, and reported with 99% confidence that the analyte concentration is greater than zero.
- 3.9 Minimum Reporting Level (MRL): The lowest analyte concentration that can be quantitated with acceptable accuracy and precision under stated analytical conditions.
- 3.10 Quality Control Standard (QCS): A solution of method analytes of known concentrations. The QCS is obtained from a source external to the laboratory and different from the source of calibration standards.
- 3.11 Safety Data Sheet (SDS): Written information provided by vendors concerning a chemical's toxicity, health hazards, physical properties, fire, and reactivity data including storage, spill, and handling precautions.

#### **4.0 INTERFERENCES**

- 4.1 Samples containing light absorbing floating debris or coarse sediments, which settle out rapidly, will give low readings.
- 4.2 Dirty and/or scratched sample cells, air bubbles, vibrations, or any other disturbance to the path of light going through the sample cell will give false results.
- 4.3 True color (i.e., water color due to dissolved substances that absorb light) may cause measured turbidities to be low.
- 4.4 Do not use any standards containing co-polymer styrene divinylbenzene beads or any other polymer suspensions other than formazin. Use aqueous standards as opposed to gel standards.

#### **5.0 SAFETY**

- 5.1 Standard laboratory protective clothing is required.
- 5.2 Standards for this method contain formazin which is a highly toxic substance. Handle standards with care and dispose of waste as instructed in Section 13.2

#### **6.0 EQUIPMENT AND SUPPLIES**

- 6.1 Hach Turbidimeter: Model 2100AN or Model TL2300
- 6.2 Indexed Sample Cells: Use clean, clear, colorless glass cells, free of scratches and wiped with silicone oil prior to analysis. Only manufacturer indexed cells are used. Indexed cells are marked for proper orientation in the turbidimeter.
- 6.3 Wide-Mouth Glass Bottle with Cap: 500 mL or larger, used for waste.
- 6.4 Oiling cloth: Soft and lint-free, preferably purchased from turbidimeter manufacturer.
- 6.5 Kimwipes: Used to clean EPA filter module located inside the turbidimeter and to wipe the outside of sample cells.



## 7.0 REAGENTS AND STANDARDS

- 7.1 Hach StablCal® Formazin Turbidity Standards Calibration Kit: Containing < 0.1, 20, 200, 1,000, and 4,000 NTU standards in sealed vials.
- 7.2 < 0.1 NTU Turbidity Standard
- 7.3 0.3 (nominal) NTU Turbidity Standard
- 7.4 0.5 (nominal) NTU Turbidity Standard
- 7.5 1.0 (nominal) NTU Turbidity Standard
- 7.6 2.0 (nominal) NTU Turbidity Standard: Purchased from a different manufacturer than all other standards.
- 7.7 Silicone Oil and Sample Cell Oiling Cloth: Oil must have the same refractive index as glass.
- 7.8 Lens Cleaner: Used to clean the EPA filter module.
- 7.9 Reagent water: ASTM Type I
- 7.10 1:1 Hydrochloric acid (HCl): Add 500 mL concentrated HCl to 400 mL reagent water and dilute to 1 L with reagent water.

## 8.0 SAMPLE COLLECTION, PRESERVATION AND STORAGE

- 8.1 Plastic or glass sample bottles rinsed with turbidity free water. A minimum of 100 mL must be collected for testing.
- 8.2 Determine turbidity on the day the sample is collected if possible. Best results are obtained if the sample conditions, such as temperature and pH, are not altered. If samples cannot be analyzed upon receipt, samples may be stored at 4°C until the next day. Maximum hold time is 48 hours.
- 8.3 For metal samples falling under the Safe Drinking Water Act, adjust pH to < 2 with concentrated nitric acid. Store at 4°C.

## 9.0 QUALITY CONTROL

- 9.1 The quality control (QC) requirements of this method include initial and ongoing elements: instrument calibration and verification (ICV, CCV & QCS), evaluating analyst and method accuracy/precision (LFB/QCS recovery/RSD, sample duplicate % RPD), MDL/MRL determination for sensitivity/reporting levels, method and instrument contamination (ICB, CCB, & LRB), participation in annual proficiency testing, and contribution of sample bias (LFM not applicable to turbidity) on data quality results. This section details the specific requirements for each of these QC elements. The laboratory is required to maintain performance records that define the quality of the data that are generated.



## 9.2 Initial Demonstration of Capability

9.2.1 Operational Range – Verify that the intended range of use is within the operational range of the instrument. Use standard concentrations that provide increasing instrument response.

9.2.2 MDL Determination – USEPA MDL Procedure, Revision 2

9.2.2.1 To determine an MDL, analyze at least seven aliquots of both LRB replicates (MDL<sub>b</sub>) and low-level LFB replicates (MDL<sub>s</sub>). The replicate aliquots should be processed through the entire analytical method over at least three separate days. The low-level LFB should be at a concentration of 2 to 10 times the estimated instrument detection limit (IDL) or previously established MDL using a similar linear calibration range (LCR). The spike recovery of the low-level LFB determinations must be within 80 to 120%. If this criterion is not met, the spiking level is too low and the determinations must be repeated at a higher concentration.

9.2.2.2 Calculate the MDL<sub>s</sub> (the MDL based on low-level LFB samples) as follows:

$$\text{MDL}_s = (t) \times S_s$$

where,

t = Student's t value for a 99% confidence level and a standard deviation estimate with n-1 degrees of freedom [t = 3.14 for seven replicates]

S<sub>s</sub> = standard deviation of the replicate spiked sample analyses

9.2.2.3 Calculate the MDL<sub>b</sub> (the MDL based on LRB samples) as follows:

$$\text{MDL}_b = X_b + (t) \times S_b$$

where,

X<sub>b</sub> = mean of method blank results

t = Student's t value for a 99% confidence level and a standard deviation estimate with n-1 degrees of freedom [t = 3.14 for seven replicates]

S<sub>b</sub> = standard deviation of replicate method blank sample analyses

9.2.2.4 The MDL then equals whichever is greater: MDL<sub>s</sub> or MDL<sub>b</sub>.

9.2.3 Accuracy and Precision – Analyze at least seven aliquots of both QCS (Section 9.3.3) and LFB (Section 9.3.5) in three separate batches on three separate days. The purpose of these replicates is to show whether the laboratory is capable of making accurate and precise measurements for this method.

## 9.3 Ongoing Demonstration of Capability

9.3.1 Instrument Calibration – Performed every 3 months using StablCal® Turbidity Standards Calibration Kit following the manufacturer's operating instructions as described in Section 10.

9.3.2 Calibration Verification – For all determinations, the user must analyze an Instrument Performance Check (IPC) immediately followed by a Calibration Blank (CB). For this method, the LRB is the same as the CB and the LFB and the IPC are the same standard. The IPC immediately after calibration, also called Initial Calibration Verification (ICV)



is analyzed to verify that the instrument is providing accurate results throughout the reportable range. Subsequent analyses of the IPC solution, also called Continuing Calibration Verification (CCV), must be analyzed after every ten or fewer samples and at the end of the analytical run.

9.3.2.1 The 1.0 NTU turbidity standard is used for the ICV, CCV, and LFB and results must be within 10% of the true value. The < 0.1 NTU turbidity standard is used for the CB and LRB and results must be less than ½ MRL.

9.3.2.2 If a calibration verification fails, immediately cease analyzing samples and initiate corrective action. The first step should be to ensure standards are within the allowed time window for measurements after inverting, then check that sample cells are properly oiled, and make certain indexed cells are correctly aligned in the turbidimeter. If after following these steps, the calibration verification passes, continue the analysis, repeating all samples after the last acceptable CCV. However, if the calibration verification continues to fail, abort the run and recalibrate the instrument.

9.3.3 Quality Control Standard (QCS) – A second source laboratory control sample used to verify the calibration standards used to create the calibration curve. The QCS must be prepared from a different vendor's stock standard than that used to create the calibration curve.

9.3.3.1 The 2.0 NTU turbidity standard is used for the QCS, and results must be within 10% of the true value. The QCS is usually analyzed right after the LRB and before any samples are analyzed.

9.3.3.2 If the calibration standards are not verified, performance is unacceptable, and sample turbidity measurements are not taken. The source of the problem is identified and corrected before proceeding on with any analyses.

9.3.4 Method Reporting Level (MRL) Check – Low-level standard with concentration at least 3 to 5 times the MDL value. The check standard is analyzed at the beginning of each analytical run following the QCS and before the samples are analyzed.

9.3.4.1 The 0.3-NTU turbidity standard is used for the MRL check standard and results must be within 20% of the true value. The acceptable range must be met before reporting data. If unacceptable, then repeat the analysis. If the problem persists, suspect the MDL and MRL are too low for the analysis conditions. The MRL may be raised to the next highest level if the end users' data quality objectives are still met.

9.3.5 Laboratory Fortified Blank (LFB) – A laboratory sample used to evaluate laboratory performance and analyte recovery in a blank matrix. Process the LFB through all sample preparation and analysis steps (i.e., LFB counts as a sample). For this method, the LFB is purchased commercially from the same source as the calibration standards. Additionally, the LFB and the IPC are the same standard.

9.3.5.1 The 1.0-NTU turbidity standard is used for the LFB and results must be within 10% of the true value. If LFB results are out of control, take corrective action, including re-analysis of the opening QC and/or recalibration of the instrument.

9.3.6 Sample and Sample Duplicate – A randomly selected sample that is analyzed in duplicate with every 10 or fewer samples. The sample/sample duplicate assesses the laboratory's



ability to produce reproducible results but also assess sample homogeneity. The duplicate samples are to be independently prepared and analyzed. The relative percent difference (RPD) must be less than 20%. If duplicate results are out of control, re-prepare and re-analyze the sample and take additional corrective action, as needed.

#### 9.4 Ongoing Annual Verification

9.4.1 MDL Determination – At least once every thirteen months, re-calculate MDL<sub>s</sub> and MDL<sub>b</sub> from the collected spiked samples and method blank results using the equations in Sections 9.3.2 and 9.3.3. The verified MDL is the greater of the MDL<sub>s</sub> or MDL<sub>b</sub>.

9.4.1.1 Include data generated within the last twenty-four months, but only data with the same spiking level. If the laboratory believes the sensitivity of the method has changed significantly, then the most recent data available may be used, maintaining compliance with the requirement for at least seven replicates in three separate batches on three separate days.

9.4.1.2 Only use data associated with acceptable calibrations and batch QC. Include all routine data, with the exception of batches that are rejected, and the associated samples reanalyzed. If the method has been altered in a way that can be reasonably expected to change its sensitivity, then use only data collected after the change.

9.4.2 Proficiency Testing – Analyze an externally-generated, single-blind quality control sample (QCS of unknown concentration) annually. Obtain this sample from a source external to the laboratory and compare results to the PT provider's acceptance range. If results are not within acceptance limits, investigate why, take corrective action, and analyze a new PT. Repeat this process until results meet the acceptance criteria.

### 10.0 CALIBRATION

#### 10.1 Primary Calibration (quarterly) for HACH Model TL2300

10.1.1 The turbidimeter is ready for calibration 60 minutes after start-up. Keep the instrument on 24 hours a day if used regularly.

10.1.2 Calibrate the turbidimeter at least every 3 months and clean the USEPA filter assembly before doing a primary calibration. The manufacturer recommended calibration points (<0.1, 20, 200, 1,000 and 4,000 NTU) provide the best calibration accuracy.

10.1.3 Turn on turbidimeter by pressing on the power button and let the instrument warm and stabilize for at least 1 hour. Make sure the StablCal® standards are at room temperature before use.

10.1.4 While the turbidimeter is warming, lift lid and carefully remove EPA filter assembly by pulling up (refer to the Basic User Manual if further instruction is required). Clean the glass filter by spraying a cotton-tipped swap with lens cleaner and gently wiping both sides of the filter. Be careful not to push the lens out of the filter assembly. Gently dry with a Kim wipe. Replace and close lid.

10.1.4.1 Inspect the filter glass for scratches or other damage. If a cloudy circle is seen around the edge of the filter, the filter material is delaminating. Replace the filter assembly.



- 10.1.5 After the instrument has warmed up, open the standards case and carefully remove the < 0.1 NTU standard. Replace the case cover and invert remaining standards for 2-3 minutes. Let the standards stand for 3-5 minutes.

**Note: Never shake or invert the < 0.1 NTU standard. If standard should become mixed or shaken, allow to settle for at least 15 minutes. Also, never handle any of the standards below the index mark.**

- 10.1.6 Push **Login** and select the applicable Operator ID. Push **Login** again and enter the password. Push **OK**.

- 10.1.7 Push **Calibration**. Get the < 0.1 NTU and clean the vial with a Kimwipe to remove water spots and fingerprints. Apply a thin coat of oil to the < 0.1 NTU vial by placing a drop of oil on the oiling cloth and wiping up and down to spread evenly around the cell. Wipe off any excess oil. Carefully insert the < 0.1 NTU standard in the cell holder so that the index mark (white triangle) on the standard aligns with the referenced mark on the cell holder. Push the lid closed until a click is heard. Push **Read**. Wait 1 minute for the instrument to complete the measurement. Remove the standard and place back in case. Apply a thin coat of oil (as above) to the next standard (20 NTU) and press **Read**. Repeat procedure for remaining standards (200, 1,000, and 4,000 NTU). When complete, the measured values are shown.

- 10.1.8 Push **Store** to save the new calibration data.

## 10.2 Primary Calibration (quarterly) for HACH Model 2100AN

- 10.2.1 Turn on turbidimeter (switch located in the back) and let warm and stabilize for at least 1 hour. Remove calibration standards from refrigerator and warm to room temperature.

- 10.2.2 While the turbidimeter is warming, lift lid and carefully remove EPA filter module by pulling up (refer to the *Basic User Manual* if further instruction is required). Clean the glass filter by spraying a cotton-tipped swap with lens cleaner and gently wiping both sides of the filter. Gently dry with a Kimwipe. Replace and close lid.

- 10.2.3 After instrument and standards have warmed, open the standards case and carefully remove the < 0.1 NTU standard. Replace cover and invert remaining standards for 2-3 minutes. Let stand for 3-5 minutes

**Note: Never shake or invert the < 0.1 NTU standard. If standard should become mixed or shaken, allow to settle for at least 15 minutes. Also, never handle standard below the index mark.**

- 10.2.4 Press the CAL/Zero key on the turbidimeter. The LED display will flash "00". Apply a thin coat of oil to the < 0.1 NTU cell by placing a drop of oil on the oiling cloth and wiping up and down to spread evenly around the cell. Wipe off any excess oil. Carefully insert the < 0.1 NTU standard in the cell holder so that the index mark (white triangle) on the standard aligns with the referenced mark on the cell holder. Close cover and press ENTER key. The turbidimeter will count down from 60 seconds. After 60 seconds, remove standard and place back in case. Apply a thin coat of oil (as above) to the next standard (20 NTU) and press ENTER key. Repeat procedure for remaining standards (200, 1,000, and 4,000 NTU).

**Note: Press Cal/Zero after the 4,000 NTU calibration.**

- 10.2.5 Press the PRINT key to print the calibration coefficients.





10.2.6 Press the CAL/Zero key to return to measurement mode.

**Note: Do not press EXIT key. All calibration data will be lost and primary calibration will need to be repeated.**

## 11.0 PROCEDURE

- 11.1 Turn on turbidimeter and let stabilize for at least 1 hour. While turbidimeter is stabilizing, clean the internal and external surfaces of the sample cell and cap with 1:1 hydrochloric acid. Then fully rinse sample cells at least 3 times with reagent water. Take out any refrigerated standards and/or samples from the refrigerator and allow to come to room temperature.
- 11.2 If the samples are being analyzed for Post-Acid Turbidity as a prerequisite for analysis by EPA 200.7 or EPA 200.8, the pH of the samples must be checked prior to turbidity analysis. The pH of the post-acid samples must be < 2. If the pH is outside this range, more acid must be added, and the sample held for 16 hours until verified to be pH < 2.
- 11.3 It is strongly recommended for first time analyst to read the turbidimeter *Basic User Manual*. If using the TL2300 model, follow the instructions below to create an operator ID and sample IDs:
  - 11.3.1 Add operator ID by pushing **Login**. Push **Options>New**. Enter a new operator ID (20 characters maximum), then push **OK**. Push the **LEFT** and **RIGHT** arrows to select the icon for the operator ID (e.g., fish, butterfly, or soccer ball). Push **Operator Password**, then enter a password for the operator ID. Push **Security Level**, then select the security level for the operator ID. Push **OK>Close**.
  - 11.3.2 Add a unique sample ID for each sample (1,000 maximum). Push **Sample ID**. Push **Options>New**. Enter a new sample ID (20 characters maximum). Push **OK**. Select **Add Date/Time** option. Push **OK>Close**.
- 11.4 Calibrate instrument according to procedure given in Section 10.1 or 10.2, depending on the turbidimeter model being used. If turbidimeter has been calibrated within the last 3 months, proceed to Section 11.5.
- 11.5 Prepare quality control (QC) standards (IPC, QCS, MRL Check) and samples by gently and slowly inverting for 2-3 minutes. Be careful not to add air bubbles. Let sample cells sit for 10 minutes before testing but no longer than 30 minutes. If samples sit more than 30 minutes, invert the samples for 2-3 minutes and let sit for 10 minutes. **Do not shake or invert the < 0.1 NTU standard.**
  - 11.5.1 Turbidity standards manufactured by Hach can be stored at room temperature but expire one month after opening or on the expiration date listed on the Certificate of Analysis (CoA), whichever comes first.
  - 11.5.2 If the QCS is purchased from Sigma (Cat # TURB2), the standard must be refrigerated when not in use and it expires on the date given in the CoA.
- 11.6 Individually prepare all the sample cells to be analyzed with the appropriate solutions (standards or samples) by rinsing a clean, empty sample cell two times with approximately 10 mL of the solution. After pouring each 10 mL aliquot, cap the cell tightly, invert 3-4 times then empty cell contents to waste. Fill sample cell to fill line (approximately 30 mL, minimum 20 mL) with the solution. Clean the exterior of the sample cell with a soft, lint-free cloth and apply a thin coat of oil as described in Section 10.1.4. Analyze the first QC element (IPC) by inserting the sample cell into sample holder with the cell index mark and cell holder reference mark aligned.



- 11.6.1 For the TL2300 model, Push **Login** and select the applicable Operator ID. Push **Login** and enter the password. Push **OK**. Push **Sample ID**. Select the applicable sample ID, then push **Select**. The selected sample ID shows on the display. Push **Read** and wait for the instrument to read the sample. Record the result on the bench sheet. Repeat process with remaining QC standards in the sequence outlined on the bench sheet (bench sheet located in SharePoint in: \DELS\EICL\Forms\Standard & Reagent Prep Forms\Active Forms\Turbidity)
- 11.6.2 For the 2100AN model, ensure that the turbidimeter is in measurement mode (green LED light next to SAMPLE key is lit; if not lit, press SAMPLE key). Close lid and wait for result to stabilize. Record the result on the bench sheet. Repeat process with remaining QC standards in the sequence outlined on the bench sheet (bench sheet located in: SharePoint in: \DELS\EICL\Forms\Standard & Reagent Prep Forms\Active Forms\Turbidity)
- 11.7 Analyze 9 samples as described in Section 11.6.1 or 11.6.2, depending on meter model being used. Randomly select a sample from each batch of 10 samples to run in duplicate.
- 11.8 After analyzing 10 or fewer samples, analyze a CCV (LFB) followed immediately by a CCB (LRB). If 30 minutes have lapsed from initial inversion, re-invert the CCV standard for approximately 2-3 minutes and let sit for 10 minutes prior to analysis.
- 11.9 After analysis, empty cell contents to waste and thoroughly rinse the cell with 1:1 HCl and reagent water. Store sample cells filled with reagent water and capped tightly.

## 12.0 DATA ANALYSIS AND CALCULATIONS

- 12.1 For the TL2300 model, all the recorded data are kept in the data log. There are three types of data logs:
- Reading log - Shows the recorded measurements.
  - Calibration log - Shows the calibration history.
  - Verification log - Shows the verification history. This feature is not used because the raw data for the verification is not given, only recovery results.
- 12.1.1 Push **Data Log** and select the applicable data log. To show the details of a log entry, select the log entry and then push **View Details**. For the calibration log, the details view shows a graph and coefficient of determination ( $r^2$ ) for the calibration curves.
- 12.1.2 Send data to USB by connecting the USB memory device to the USB port on the instrument. Push **Data Log** and select the applicable log. To send only some of the data, use the filter settings or select a single data point. Push **Options>Send Data Log**. Select single data point, filtered data or all data. Push **OK**. The instrument sends the selected data to the connected devices. The Filter Settings allows data to be refined by **Time Interval**, **Operator ID** or **Sample ID**.
- 12.2 Enter results into WinLIMS: WinLIMS is programmed to round turbidity raw results as described in Table 2. Where the turbidity specific rounding is ambiguous, WinLIMS uses the 5-up-rounding rule to determine the last digit of the rounded result. Due to a technology limitation, 5-even rounding cannot be run at the same time as method specific rounding.
- 12.2.1 Check that WinLIMS is rounding properly to the nearest NTU as outlined in Table 2, using 5-up rounding where applicable.





- 12.3 Enter results into WinLIMS below the MRL of 0.3 as the actual concentration measured by the meter. Check that WinLIMS is correctly reporting these results as < MRL.
- 12.4 The WinLIMS dilution factor (DF) column can contain no more than 3 decimal figures. If a dilution is necessary to perform the analysis, note that the DFs entered into WinLIMS may be rounded.

### **13.0 METHOD PERFORMANCE**

- 13.1 See the Initial Demonstration of Capability (IDC) for accuracy and precision data, along with results from the yearly Method Detection Limit (MDL) study, for method performance. All data are kept on file by the Quality Assurance & Data Manager. Precision and accuracy quality control charts are generated automatically by the LIMS and reviewed monthly.

### **14.0 MAINTENANCE**

- 14.1 Clean spills – obey all facility safety protocols for spill control and discard the waste according to applicable regulations.
- 14.2 Clean the instrument – clean the exterior of the instrument with a moist cloth, and then wipe the instrument dry.
- 14.3 Clean the filter assembly – follow instructions listed in Section 10.1.4.

### **15.0 POLLUTION PREVENTION**

- 15.1 Refer to the WES Environmental Management System (EMS) policy and SOPs regarding pollution prevention.
- 15.2 The quantity of chemicals purchased should be based on expected usage during its shelf life. Actual reagent preparation volumes should reflect anticipated usage and reagent stability.

### **16.0 WASTE MANAGEMENT**

- 16.1 WES laboratories fully comply with all applicable federal, state, and local environmental regulations. WES is also committed to protecting the air, water, and land by minimizing and controlling all chemical releases from fume hoods, biological safety cabinets, and bench operations. Refer to the WES EMS policy and SOPs regarding waste management.
- 16.2 All waste chemicals are collected in sealed waste containers. Once the waste containers reach capacity, they are transferred to the WES hazardous waste storage room where they are emptied into a waste drum (organic or inorganic). Within 180-days of waste accumulation, the waste drum is transported off the premises by a licensed hazardous waste management contractor. Under the WES EMS, a chemical inventory database has been developed to track purchases and use of chemicals and other hazardous materials, and the waste generated by the use of these chemicals.

### **17.0 REFERENCES**

- 17.1 *Standard Methods for the Examination of Water and Wastewater*, 22<sup>nd</sup> Edition, 2012. American Public Health Association, American Water Works Association, and Water Environment Federation, Washington, DC



- 17.2 U.S. Environmental Protection Agency. 1993. Method 180.1 – *Determination of Turbidity by Nephelometry*, Revision 2.0, August 1993.
- 17.3 2100AN *Basic User Manual*, Edition 4. 2012. Hach Company, Loveland, Colorado.
- 17.4 TL2300 *Basic User Manual*, Edition 3. 2018. Hach Company, Loveland, Colorado.



## 18.0 TABLES

**TABLE 1. Quality Control Elements and Acceptance Limits for SM 2130B - Determination of Turbidity by the Nephelometric Method**

QC Elements	Frequency	Acceptance Criteria	Corrective Action
CCB (LRB)	After calibration, at end of run, and after every 10 or fewer samples.	< ½ MRL	Repeat analysis.
Duplicates	Every 10 or fewer samples.	RPD < 20%	Repeat analysis.
IPC (LFB)/CCV	After calibration, at end of run, and after every 10 or fewer samples.	± 10%	Repeat analysis.
QCS	Every analytical run.	± 10%	Repeat analysis.
MDL Determination	Annually, when there is a new operator or when there is a significant change in the instrument.	Target analyte concentration spiked into the blank matrix must not exceed 10 times (1 to 5x) the experimentally determined MDL.	Repeat MDL study spiking the blank matrix with lower concentration of the target analyte.
MRL Check	Every analytical run.	± 20%	Repeat analysis.

**TABLE 2. Significant Figures for Turbidity Measurements**

Turbidity Range NTU	Report to the nearest NTU
< 1.0	0.05
1.0 to < 10	0.1
10 to < 40	1
40 to < 100	5
100 to < 400	10
400 to < 1000	50
> 1000	100