Drinking Water Instrumentation Data Integrity Checklists

Version 1.0

Background/Disclaimer

United States Environmental Protection Agency (EPA) drinking water regulations, including the analytical methods incorporated into those regulations by reference, establish legally binding requirements for public water systems (PWSs). In contrast, use of the checklists described in this document is not required; rather, the purpose of the checklists is to serve as a resource to help ensure the accuracy and reliability (i.e., the "integrity") of data generated using various instruments that measure water quality parameters. The intended audiences are PWSs that wish to optimize their operations and primacy agencies that oversee PWSs. The checklist content was developed based on EPA and state experiences during implementation of the "Area-Wide Optimization Program (AWOP)."

While EPA has made every effort to ensure the accuracy of the discussion in this document, the obligations of the regulated community are determined by statutes, regulations, or other legally binding requirements. In the event of a conflict between the discussion in this document and any statute or regulation, this document would not be controlling.

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Office of Water (MS-140)
EPA 815-B-22-002
January 2022
Version 1.0

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Online DPD Colorimetric Chlorine Analyzer

	Sample tap is a sufficient distance downstream of chemical feed points to ensure adequate mixing and sufficient reaction time (in turbulent flow conditions 10 x pipe diameters is suggested, in laminar flow conditions more than 100 × pipe diameters is suggested) and representative of process performance
	Sample tap orientation is "good" or "ideal" per Table 1 in Appendix A to ensure sample is representative of process performance
	Sample tap location is appropriate for measuring desired parameters (e.g., not measuring free chlorine after the addition of ammonia)
	If using a sample conditioning kit, ensure that it is installed correctly (see Figure 1 in Appendix A; per manufacturer's recommendation the drain tee should be installed 24" above the instrument cabinet to ensure the needed sample pressure in the analyzer)
	Sample line length is not excessive (i.e., less than one-minute residence time)
	Sample flow rate to sample conditioning is between 200 to 500 mL/min
	Sensor cables or wiring are not damaged (i.e., properly shielded and insulated) and not installed near other electronic devices that may result in potential signal interference
	Correct reagents are installed (i.e., free chlorine indicator is installed when free chlorine is intended to be measured)
	Reagents are not expired
	Reagents bottles are connected to correct delivery tubes labeled "buffer" or "reagent" inside the instrument
	Indicator reagent is prepared as specified by the manufacturer (indicator powder is mixed and fully dissolved in the indicator solution)
	Stir bar is installed in the colorimeter cell (remove plug on the colorimeter and insert paper clip to remove)
	Pressure plate on peristaltic pump is securely attached (to avoid backflow of the sample into the reagents)
	Signal Averaging (SIGAVG) feature, which is used to average reading and prevent erratic recorder output, is disabled (default is SIGAVG = 1, which disables this feature)
	Calibration settings are at factory default (OFFSET = 0.00), the analyzer is factory calibrated and does not require recalibration unless specified by regulatory agency
	Record output span brackets the expected range of chlorine residual (i.e., factory default RECMIN = 0.00 mg/L @ 4 mA and RECMAX = 5.00 mg/L @ 20 mA)
	Verify that the reading on the display of the online analyzer is the same as what is being shown on SCADA
	Alarm settings are configured at desired trip points, if this feature is activated (i.e., toggle to ALARM menu and then RECALL WARNINGS to display active alarms)
	Colorimeter cell is cleaned monthly when temperatures are less than 80 F and biweekly when temperatures are more than 80°F with 19.2 N sulfuric acid solution and cotton swabs
	Pump tubing is replaced per manufacturers recommendation (i.e., if ambient temperature is <80° F, replace at six-month intervals; if >80°F, replace at three-month intervals)
	Remaining analyzer tubing is replaced annually, per manufacturers recommendation
	Routine calibration check of the online chlorine analyzer is performed in accordance with EPA Method 334 at least once per week (within ±0.10 mg/L or ±15% of expected value [whichever is larger], by comparison with an EPA approved grab sample method (e.g., DPD colorimetric method) that has also been verified with a routine calibration check at least once per quarter with a primary calibration check standard [±15% of expected value]. See EPA Method 334 for additional details.

Online Amperometric Chlorine Analyzer

	Sample tap is a sufficient distance downstream of chemical feed points to ensure adequate mixing and sufficient reaction time (in turbulent flow conditions 10 x pipe diameters is suggested, in laminar flow conditions more than 100 × pipe diameters is suggested) and representative of process performance
	Sample tap orientation is "good" or "ideal" per Table 1 in Appendix A to ensure sample is representative of process performance
	Sample tap location is appropriate for measuring desired parameters (e.g., not measuring free chlorine after the addition of ammonia)
	Sample line length is not excessive (i.e., as close and direct as reasonably possible)
	Sample flow rate is maintained in the desired range of 500 to 833 mL/min, which can be confirmed if the LED light on the flow sensor is on (the exact flow rate is not important as long as flow is constantly maintained in that range)
	Pressure regulator (PRV or sample conditioning; see Figure 1 in Appendix A) is installed if analyzer is under the influence of pressure/flow variations (e.g., under the influence of a storage tank or pumps)
	Sensor cables or wiring are not damaged (i.e., properly shielded and insulated) and not installed near other electronic devices that may result in potential signal interference
	Analyzer is not under the influence of a heat source or in direct sunlight
	Analyzer is configured to measure the desired parameters (toggle to sensor setup menu), such as chlorine (total or free), pH (optional), and temperature (optional)
	Tubing (Teflon or PVDF) is replaced annually, per manufacturers recommendation
	Sensor flow cells are clean (i.e., free of sediment deposits and film, not discolored)
	Membrane cap on the chlorine sensor is replaced at least once per year (during replacement the electrode should be polished and electrolyte solution should be replaced)
	Electrolyte solution in the chlorine sensor is replaced every 3 to 6 months
	Electrolyte solution is not expired
	Chlorine sensor is replaced every three years
	Measurement span settings are at desired range (toggle to sensor setup menu)
	Alarm settings are configured at desired trip points, if this feature is activated (i.e., toggle to Sensor Setup menu and then Cal Watch to display active alarms)
	Routine calibration check of the online chlorine analyzer is performed in accordance with EPA Method 334 at least once per week (within ±0.10 mg/L or ±15% of expected value [whichever is larger], by comparison with an EPA approved grab sample method (e.g., DPD colorimetric method) that has also been verified with a routine calibration check at least once per quarter with a primary calibration check standard [±15% of expected value]. See EPA Method 334 for additional details.
	pH sensor is calibrated (see Chlorine Sensor User Manual for details) at least weekly per EPA Method 150.3
	pH sensor calibration is verified daily by comparing a grab sample using a portable or bench-top meter (calibrated daily), if results deviate by more than ±0.2 pH units recalibrate the online pH sensor per EPA Method 150.3
	pH sensor is cleaned and inspected at least once every 90 days (see pH Sensor User Manual for details)
	pH sensor is "rebuilt" (standard cell solution and salt bridge is replaced) at least once every 6 months

Online Nephelometric Turbidimeter w/90° Detector

	Sample tap location is representative of treatment process and not immediately downstream of a chemical feed location that may result in positive bias
	Sample tap orientation is "good" or "ideal" per Table 1 in Appendix A to ensure sample is representative of process performance
	Sample tap location is appropriate for measuring desired parameters (e.g., filter-to-waste sample location is representative of filter-to-waste sample).
	Sample line length is not excessive (i.e., as close and direct as reasonably possible)
	Sample line does not have excessive elevation changes
	Sample pumping is to be avoided, if possible
	Sample flow rate to turbidimeter is between 200 and 750 mL/min and is verified quarterly (samples with high turbidity should operate at as high as flow rate as possible and without a bubble trap, while samples with low turbidity should operate at as low as flow rate as possible); consider targeting a 500 mL/min flow rate to ensure that flow remains in the optimal range in the event of pressure fluctuations
	Turbidimeter is installed indoors or in a location isolated from vibration, heat, and direct sunlight
	Sensor cables or wiring are not damaged (i.e., properly shielded and insulated) and not installed near other electronic devices that may result in potential signal interference
	Turbidimeter head is securely seated on the turbidimeter body
	Turbidimeter lamp and assembly is replaced once per year, per manufacturers recommendation
	Turbidimeter is calibrated per manufacturer's specifications at least once every three months during normal operation and after any significant maintenance or repair (check calibration/verification history)
	Turbidimeter body, bubble trap, and photocell window (do not disassemble or scratch) is thoroughly cleaned and rinsed as needed, or prior to calibration (see user's manual for details)
	Verify that the reading on the display of the online analyzer is the same as what is being shown on SCADA
	Turbidimeter photocell contains oil and any air bubble is not visible when in the upright position
	Turbidimeter output mode is set to "HOLD" during calibration and maintenance activities
	Turbidimeter error mode is set to "TRANSFER" during normal operation and transfer value is set to 0.00 or 20.00 NTU
	Turbidimeter calibration is verified at least once weekly, and results should be within ±10% of calibration standard per EPA Method 180.1
	Turbidimeter date and time stamp is verified during calibration and after power outages
	Turbidimeter sample line is inspected during calibration and replaced as needed (raw water sample lines will need to be replaced more frequently that filtered water sample lines); utilities with elevated iron and/or manganese may also need to replace lines more frequently
	Turbidimeter data log interval (DATALOG INTRVL) is at desired setting (≤ 1 minute is recommended)
	Turbidimeter output signal span is set to 0.00 to 5.10 NTU for filtered water samples
	Turbidimeter bubble reject (BUBBLE REJECT) setting is at desired setting (enabled, or yes, is recommended)
	Turbidimeter signal averaging setting (SIGNAL AVG) is at desired interval (30 second interval is recommended)
	Turbidimeter offset value (OFFSET) is at desired setting (0.00 NTU is factory default)

Online Laser Turbidimeter

	Sample tap location is representative of treatment process and not immediately downstream of a chemical feed location that may result in positive bias
	Sample tap orientation is "good" or "ideal" per Table 1 in Appendix A to ensure sample is representative of process performance
	Sample line length is not excessive (i.e., as close and direct as reasonably possible)
	Sample flow rate to turbidimeter is between 100 and 750 mL/min and is verified quarterly (samples with high turbidity should operate at as high as flow rate as possible, while samples with low turbidity should operate at as low as flow rate as possible); consider targeting a 425 mL/min flow rate to ensure that flow remains in the optimal range in the event of pressure fluctuations
	Turbidimeter is installed indoors in location that is isolated from vibration, heat, and direct sunlight
	Sensor cables or wiring are not damaged (i.e., properly shielded and insulated) and not installed near other electronic devices that may result in potential signal interference
	Turbidimeter head is securely seated on the turbidimeter body
	Turbidimeter is calibrated per manufacturer's specifications at least once every three months during normal operation and after any significant maintenance or repair (check calibration/verification history)
	Turbidimeter is cleaned at least once per month and prior to calibration verification (see user's manual for details)
	Turbidimeter sample line is inspected during calibration and replaced as needed (utilities with elevated iron and/or manganese may will need to replace sample lines more frequently)
	Turbidimeter output mode is set to "hold" during calibration and maintenance activities
	Turbidimeter calibration is verified at least once every month (check calibration/verification history)
	Turbidimeter data log interval (DATALOG INTRVL) is at desired setting (≤ 1 minute is recommended)
	Turbidimeter bubble reject (BUBBLE REJECT) setting is at desired setting (enabled, or yes, is recommended)
	Turbidimeter signal averaging setting (SIGNAL AVG) is at desired interval (30 second interval is recommended)
	Turbidimeter offset value (OFFSET) is at desired setting based on calibration (0 mNTU is factory default)

Online Nephelometric Laser Turbidimeter w/360° x 90° Detector

	Sample tap location is representative of treatment process and not immediately downstream of a chemical feed location that may result in positive bias
	Sample tap orientation is "good" or "ideal" per Table 1 in Appendix A to ensure sample is representative of process performance
	Sample tap location is appropriate for measuring desired parameters (e.g., filter-to-waste sample location is representative of filter-to-waste sample).
	Sample line length is not excessive (i.e., as close and direct as reasonably possible)
	Sample line does not have excessive elevation changes
	Sample pumping is to be avoided, if possible
	Sample flow rate to turbidimeter is between 100 and 1000 mL/min and is verified quarterly (samples with high turbidity should operate at as high as flow rate as possible and without a bubble trap, while samples with low turbidity should operate at as low as flow rate as possible); if equipped, confirm flow rate on flow sensor; consider targeting a flow rate of 550 mL/min to ensure that flow remains in the optimal range in the event of pressure fluctuations
	Turbidimeter is installed indoors or in a location that is isolated from vibration, heat, and direct sunlight
	Turbidimeter is not installed in immediate proximity of televisions, radios, computers, or other electronic equipment. This instrument is sensitive to electromagnetic and electromechanical interference.
	Sensor cables or wiring are not damaged (i.e., properly shielded and insulated) and not installed near other electronic devices that may result in potential signal interference
	Turbidimeter is installed in a vertical position and is level
	Vial is cleaned at least once every three months
	Vial is replaced at least every two years
	Desiccant cartridge is replaced at least every two years or as identified by instrument notification
	Turbidimeter is calibrated per manufacturer's specifications at least once every three months during normal operation and after any significant maintenance or repair (check calibration/verification history)
	Verify that the reading on the display of the online analyzer is the same as what is being shown on SCADA
	Turbidimeter output mode is set to "HOLD" during calibration and maintenance activities
	Turbidimeter error mode is set to "TRANSFER" during normal operation and transfer value is set to 0.00 or 20.00 NTU
	Turbidimeter calibration is verified at least once every week
	Turbidimeter date and time stamp is verified during calibration and after power outages
	Turbidimeter sample line is inspected during calibration and replaced as needed (raw water sample lines will need to be replaced more frequently that filtered water sample lines) ; utilities with elevated iron and/or manganese may also need to replace lines more frequently.
	Turbidimeter data log interval (DATALOG INTRVL) is at desired setting (≤ 1 minute is recommended). The default setting for this instrument is 10 minutes, which is greater than desired.
	Turbidimeter output signal span is set to 0.00 to 5.10 NTU for filtered water samples
	Turbidimeter bubble reject (BUBBLE REJECT) setting is at desired setting (enabled, or yes, is recommended)
	Turbidimeter signal averaging setting (SIGNAL AVG) is at desired interval (30 second interval is recommended)
	Turbidimeter offset value (OFFSET) is at desired setting (0.00 NTU is factory default)

Portable Colorimeter

	Appropriate method (or program number) is used for anticipated sample concentration (LR, MR, HR)
	Appropriate sample volume is used (10 or 25 mL)
	Appropriate sample cell is used (plastic or glass)
	Appropriate sample reaction time is used (may be temperature dependent; see user's manual)
	Sample cells are clean and not scratched
	Sample cells are consistently oriented in the appropriate position in the colorimeter (i.e., white diamond consistently faces towards the front of the instrument)
	Sample cells are consistent material and condition (e.g., visually identical)
	Ensure that sample cells are firmly held in place in the cell holder in the instrument (i.e., plastic clips are not broken that secure the sample cell and prevent movement)
	Instrument cap is securely placed on top of instrument prior to analysis
	Excess liquid (e.g., condensation) and fingerprints are wiped from sample cells prior to analysis with a lint-free cloth
	Appropriate reagent is used (free or total chlorine; for 10- or 25-mL samples)
	If a reagent dispenser is used, confirm that humidity is not causing reagent to clog in the dispenser
	If a reagent dispenser is used, confirm that the reagent cartridge is used within 6 months after opening
	Reagents are not expired
	Reagent blank value is determined for each new lot of reagents (i.e., replace the sample in the test procedure with deionized water to determine reagent blank value, which will be subtracted from all sample results to account for "baseline" color development). It is recommended that the reagent blank value is written on the package of reagent, including date and operator initials.
	Separate sample cells are labeled and used for free and total chlorine analysis
	Colorimeter performance is verified (e.g., Spec Check Secondary Gel Standards, primary standards) at least weekly during routine use or before each use during infrequent use
	Instrument is using the most current software/firmware (check manufacturer's website)
	Instrument is re-zeroed at each sample location (if used for distribution system sampling)
	Instrument is displaying the desired test results (concentration, Abs, %T)
	Instrument is displaying the desired units (e.g., mg/L as NH_3-N vs. NH_3)
	Sample cells are rinsed well between samples using deionized water or fresh sample
	Sample cells are capped and gently inverted prior to analysis (after the reaction time is complete) to remove any bubbles that may have accumulated on the sample cell wall (common issue with plastic sample cells)
	Samples are not left in direct sunlight (both before and after the addition of reagent)
	Factory default calibration is not adjusted (unless asked to do so by regulatory agency)
	Samples are analyzed immediately and are not preserved for later analysis
	Sample locations are adequately flushed, so that the sample is representative water quality at the desired location (i.e., calculated flush time concept)
	Plastic containers are not used to collect samples (plastic can have chlorine demand)
	Operator is following the most recent version of the method procedure (method procedures are updated periodically to improve performance; check manufacturer's website)
	Operator is aware of potential interferences with reagents (e.g., Mn^{4+} interferes with DPD reagent)
	Instrument batteries have adequate charge (i.e., low battery icon is not flashing on display)
	If equipped, turn off the Bluetooth dongle when not in use to extend battery life and minimize unintended data communication with other devices

Portable Parallel Analyzer

	Instrument is using the most current software/firmware (check manufacturer's website)
	Date and time are current, and battery is sufficiently charged
	Analyzer performance is verified with a primary or secondary standard (e.g., System Verification Chemkey) at least once per week during routine use or before each use during infrequent use
	Probes (e.g., pH, conductivity) are properly stored in buffer/storage solution between use
	Probes (e.g., pH, conductivity) are not damaged and calibrated before each use
	Reagents (Chemkeys and buffer solutions) are not expired
	Operator is following the most recent version of the method procedure (method procedures are updated periodically to improve performance; check manufacturer's website)
	Operator is aware of potential interferences with reagents (e.g., manganese can interfere with DPD reagent)
	Sample locations are adequately flushed, so that the sample is representative water quality at the desired location (i.e., calculated flush time concept)
	Appropriate Chemkey is used for desired method; the analyzer automatically identifies the parameter(s) being analyzed when Chemkey(s) are installed and/or probe(s) are connected
	Chemkeys are installed and recognized by the analyzer without receiving an error message (e.g., expired reagent, Chemkey leaked, barcode error) prior to placing in sample tray
	Sample tray is rinsed well between samples using deionized water or fresh sample
	Appropriate sample volume is added to sample tray (i.e., filled to line)
	Samples are analyzed immediately and are not preserved for later analysis

Benchtop Nephelometric Turbidimeter w/90° Detector

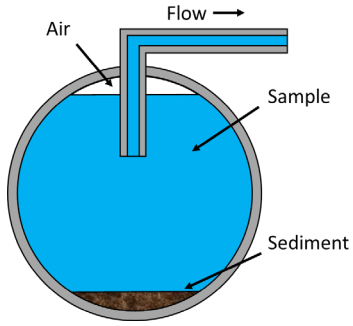
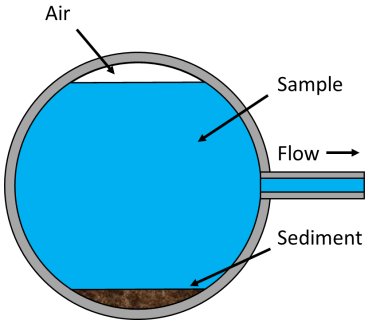
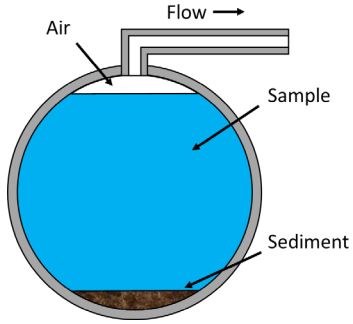
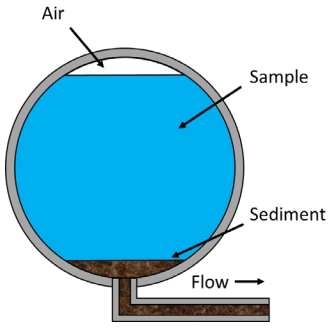
	Turbidimeter is located on stable, level surface that is free of vibration
	Turbidimeter is not located in direct sunlight or near a heat source
	Turbidimeter is calibrated at least every three months or as specified by regulatory agency
	Turbidimeter is calibrated per manufacturers recommendations (e.g., at 20, 100, and 800 NTU and then verified at 10 NTU)
	Turbidimeter is calibrated using formazin or other approved standards. Consult safety data sheet to determine appropriate handling and disposal.
	Turbidimeter and standards are both at ambient temperature during calibration
	Sealed vial standards (e.g., StablCal) standards are stored at approximately 5°C (40°F), if used less than once per month
	Turbidimeter is left "on" 24 hours a day if it used regularly (per manufacturer's recommendation)
	Turbidimeter is "on" at least 30 minutes (ratio on) and 60 minutes (ratio off) prior to analysis
	Silicone oil is used on sealed vial standards and sample vials prior to calibration/analysis (see user's manual for procedure)
	Vials are placed in the cell holder with the triangle on the vial aligned with the reference mark on the sample cell holder
	Turbidimeter calibration is verified at least once per week using secondary standards (e.g., Gelex), which should be ±5% of the value recorded on the secondary standard vial
	Sample cells are not dirty, scratched, or damaged (see user's manual for cleaning procedure)
	Sample cells are free of condensation (common when water temperature is cooler; see user's manual)
	Sample cells are indexed and matched (see user's manual for procedure)
	Samples are mixed by gentle inversion prior to analysis
	Air bubbles are removed, if present (see user's manual for various techniques)
	Samples are analyzed immediately after they are collected (changes in temperature and settling can occur)
	Turbidimeter ranging setting (RANGE) is set to "automatic" (recommended by manufacturer)
	Turbidimeter signal averaging setting (SIGNAL AVG) is "on" (recommended by manufacturer)
	Turbidimeter ratio setting (RATIO) is "on" (recommended by manufacturer)

Benchtop Nephelometric Laser Turbidimeter w/360° x 90° Detector

	Turbidimeter is located on stable, level surface that is free of vibration
	Turbidimeter is not located in direct sunlight or in extreme temperatures (<50°F or >104°F)
	Turbidimeter is calibrated at least every three months or as specified by regulatory agency
	Turbidimeter is calibrated per manufacturers recommendations (e.g., at 20, 600 NTU and dilution water (with Formazin))
	Turbidimeter is calibrated using formazin or other approved standards. Consult safety data sheet to determine appropriate handling and disposal.
	Turbidimeter and standards are both at ambient temperature during calibration
	Sealed vial standards (e.g., StablCal) standards are stored at approximately 5°C (40°F), if used less than once per month
	Turbidimeter software has been updated to most current version
	Turbidimeter reading setting is set to "single" with 10-second average
	Turbidimeter bubble reject setting is "on"
	Turbidimeter verify after calibration setting is "on"
	Turbidimeter *calibration* reminder setting is set to "90 days" or less
	Turbidimeter *calibration verification* reminder setting is set to "7 days" or less
	Turbidimeter calibration is verified at least once per week using secondary standards (e.g., StablCal or glass rod secondary turbidity standard), which should be ±5% of the value recorded on the secondary standard vial
	Sample cells are not dirty, scratched, or damaged (see user's manual for cleaning procedure)
	Sample cells are free of condensation (common when water temperature is cooler; see user's manual)
	Sample cells are filled with distilled or deionized water during storage
	Sample cells are not handled on the measurement surface (i.e., side and bottom)
	Sample cells are filled to the 10-mL sight line with sample during analysis
	Samples are mixed by gentle inversion prior to analysis
	Sample cells are stored in the vial stand to prevent contamination on the bottom of the vial
	Air bubbles are removed, if present (see user's manual for various techniques)
	Samples are analyzed immediately after they are collected (changes in temperature and settling can occur)

Appendix A: Supplemental Information

Table 1: Sample Tap Configuration

Cross-Sectional View of Sample Tap Configuration	Description
	*Ideal* sample tap configuration: • Sample tap *includes a quill* that enters the top *or* side of the pipe and extends into the center of the pipe • Configuration minimizes air bubbles and sediment from entering the sample line • Ensures most representative sample from center of process stream • Assume that a sample tap does not include a quill unless physically verified
	*Good* sample tap configuration: • Sample tap *does not include a quill*, but enters the side of the pipe • Configuration minimizes air bubbles and sediment from entering the sample line • Ensures representative sample of process stream • Assume that a sample tap does not include a quill unless physically verified
	*Poor* sample tap configuration: • Sample tap *does not include a quill* and enters the top of the pipe • Configuration can result in air bubbles entering the sample line, which may not be representative of the treatment process • Assume that a sample tap does not include a quill unless physically verified
	*Poor* sample tap configuration: • Sample tap *does not include a quill* and enters the bottom of the pipe • Configuration can result in accumulated sediment entering the sample line, which may not be representative of the treatment process • Assume that a sample tap does not include a quill unless physically verified

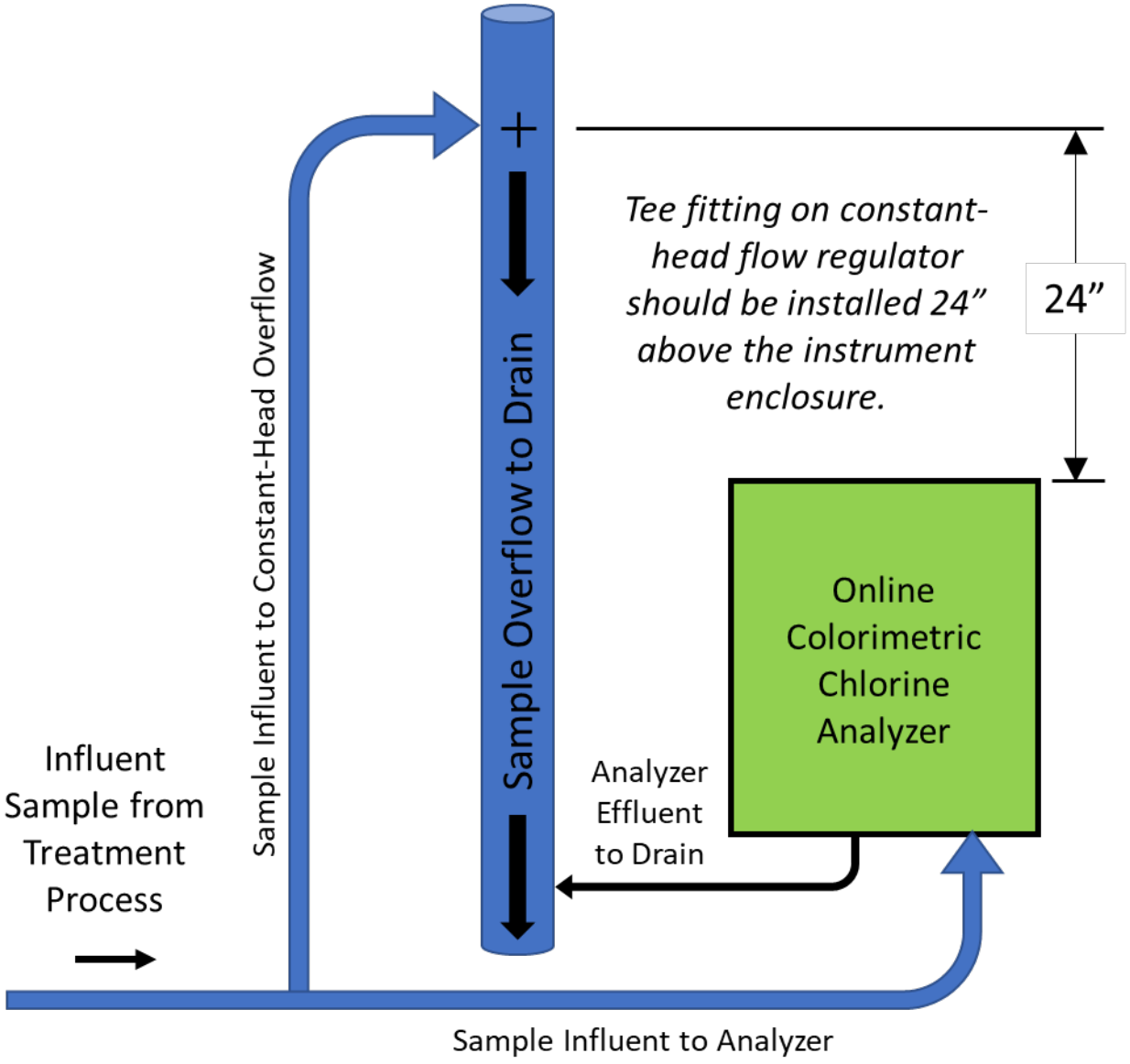


Figure 1: Sample Conditioning Kit Configuration