PRACTICE EXAM 7: WATER TREATMENT OPERATOR CLASS I SIMULATION (100 QUESTIONS)

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1. A treatment plant using alum coagulation treats river water that normally has an alkalinity of 100 mg/L as $CaCO_3$. Following a period of heavy rainfall, the raw water alkalinity drops to 30 mg/L while turbidity increases from 15 NTU to 120 NTU. The jar test indicates an optimal alum dose of 60 mg/L. At this dose, the operator should expect:

A. Excellent floc formation because the higher turbidity provides more particles as nucleation sites for aggregation

B. Alkalinity depletion and pH crash because the 60 mg/L alum dose will consume approximately 30 mg/L of the available 30 mg/L alkalinity

C. No change in pH because rainfall-diluted water has a natural buffering capacity that increases during storm events

D. Improved settling velocity because the reduced alkalinity allows the alum to work faster at lower doses

2. A treatment plant's online turbidimeter on Filter 2 reads 0.04 NTU. A simultaneously collected grab sample analyzed on the laboratory bench-top turbidimeter reads 0.11 NTU. The operator recollects a second grab sample using careful technique — clean cell, no bubbles, wiped dry — and obtains 0.10 NTU. Which conclusion is most appropriate?

A. The online instrument is malfunctioning and must be recalibrated immediately before any further data is trusted

B. The laboratory instrument is always more accurate and the online reading should be disregarded for compliance

C. Both readings are equivalent because any measurement below 0.15 NTU is within the instrument detection limits

D. The online instrument likely needs calibration verification because a consistent discrepancy confirmed by duplicate grab samples suggests instrument drift

3. An operator at a treatment plant using chlorine gas receives a delivery of four 150-pound cylinders. The delivery driver informs the operator that one cylinder was dropped during loading at the supply depot but appears undamaged. The operator should:

A. Refuse the dropped cylinder, document the incident, and request a replacement because impact damage may compromise the cylinder valve or weaken the cylinder wall

B. Accept all four cylinders because visual inspection confirms no damage and external appearance is sufficient

C. Accept the dropped cylinder but install it first so it is used before any internal weakening progresses further

D. Place the dropped cylinder in isolated outdoor storage for 30 days to allow any stress fractures to become visible

4. A treatment plant treats 4.0 MGD from a lake source. The plant's six-month average TOC is 5.2 mg/L and the average alkalinity is 70 mg/L as $CaCO_3$. Under the Stage 1 D/DBPR enhanced coagulation matrix, higher TOC and lower alkalinity require greater percentage removal. The plant currently achieves 25% TOC removal. To improve DBP compliance, the most effective treatment strategy is to:

A. Switch from chlorine to chloramines for primary disinfection to eliminate all DBP formation potential

B. Reduce the chlorine dose to below 1.0 mg/L to minimize the chlorine available for DBP reactions

C. Increase the coagulant dose and optimize pH to maximize NOM removal through enhanced coagulation before disinfection

D. Add lime to raise the alkalinity above 120 mg/L, which automatically qualifies the plant for a lower TOC removal requirement

5. A treatment plant operator discovers that a chemical metering pump's diaphragm has a small visible crack but the pump continues to deliver chemical. The operator should:

A. Take the pump out of service immediately, switch to the standby pump, and replace the cracked diaphragm before returning the pump to duty

B. Monitor the crack daily and schedule replacement during the next quarterly maintenance window

C. Apply sealant to the crack as a temporary repair and continue operating until the replacement part arrives

D. Increase the pump's stroke rate to compensate for any chemical loss through the cracked diaphragm

6. A treatment plant's raw water intake draws from a river. The nearest upstream tributary enters the river 500 feet above the intake. An operator reviewing the source water assessment learns that the tributary watershed is 80% agricultural land. During spring planting season, the operator should prepare for increased levels of:

A. Dissolved hydrogen sulfide from agricultural irrigation return flows entering the tributary

B. Dissolved arsenic mobilized from the soil by the application of modern commercial fertilizers

C. Radionuclides from the naturally occurring radioactive materials found in commercial pesticide formulations

D. Nutrients (nitrogen and phosphorus), pesticides, herbicides, and sediment carried into the river by agricultural runoff

7. A treatment plant's three parallel sedimentation basins each have a surface area of 2,500 ft^2. The plant treats 3.0 MGD (2,083 gpm). All three basins are in service. The surface overflow rate per basin is:

A. 278 gpd/ft^2, well below the typical maximum of 900 gpd/ft^2 for conventional basins

B. 400 gpd/ft^2, within the acceptable range for conventional sedimentation basins

C. 1,200 gpd/ft^2, significantly exceeding the recommended maximum for conventional sedimentation

D. 833 gpd/ft², which requires tube settlers to achieve adequate settled water quality

8. A treatment plant operator receives a laboratory report showing finished water lead at 0.020 mg/L from a routine Lead and Copper Rule monitoring sample collected at a consumer tap. The lead action level is 0.015 mg/L. This single result means:

A. The system has immediately exceeded the lead action level and must begin corrosion control optimization

B. The result is a violation requiring Tier 1 public notification within 24 hours to all consumers

C. This single result contributes to the 90th percentile calculation across all monitoring sites — a single sample does not by itself determine an action level exceedance

D. The sample must be discarded because lead cannot be accurately measured at consumer taps under the LCR

9. A treatment plant's filter effluent turbidity on Filter 3 has been trending upward gradually over the past week — from a baseline of 0.04 NTU to 0.12 NTU — while the other three filters remain at 0.04 to 0.06 NTU. The settled water quality has not changed. The operator's most productive investigation should focus on:

A. Filter 3 specifically — checking media depth, underdrain condition, backwash effectiveness, and whether mudballs or channeling have developed

B. The coagulation process because any filter performance change must originate from upstream treatment

C. The laboratory turbidimeter calibration because the bench-top instrument may have drifted, producing false trends

D. The distribution system downstream of Filter 3 because post-filtration contamination can cause turbidity readings to rise

10. An operator is calibrating an online chlorine analyzer. The DPD grab sample reads 0.9 mg/L. The online analyzer displays 0.9 mg/L. The operator should:

A. Adjust the analyzer up by 10% as a safety margin to ensure adequate residual is always detected

B. Leave the analyzer at its current reading but recalibrate using buffer solutions instead of DPD comparison

C. Replace the analyzer membrane or reagent since identical readings indicate the analyzer is not actively measuring

D. Record the calibration as passing verification — the analyzer reading matches the DPD reference and no adjustment is needed

11. A treatment plant uses a horizontal split-case centrifugal pump for high-service delivery. The pump has been in service for eight years. During a routine vibration analysis, the analyst reports that the vibration spectrum shows a dominant peak at 2× running speed with elevated axial vibration. This pattern most commonly indicates:

A. Cavitation from insufficient net positive suction head at the pump impeller inlet

B. Misalignment between the pump shaft and the motor coupling, which produces a characteristic 2× running speed signature

C. An imbalanced impeller that has lost material on one vane due to erosion or corrosion damage

D. Electrical interference from the variable frequency drive producing harmonic distortion in the vibration signal

12. A treatment plant operates a clearwell with a volume of 450,000 gallons. The plant flow is 3.0 MGD (2,083 gpm). The clearwell has poor baffling (factor = 0.3). The chlorine residual at the outlet is 1.2 mg/L. To improve CT compliance without adding chlorine or reducing flow, the most effective capital improvement would be to:

A. Replace the clearwell with a larger tank that doubles the total storage volume available

B. Install an additional online chlorine analyzer to provide more accurate residual monitoring data

C. Improve the clearwell baffling from poor (0.3) to superior (0.7), which would more than double the T_{10} from the same volume

D. Add a second disinfection contact chamber in series after the existing clearwell to double the total volume

13. A water system performs its annual lead and copper monitoring. Of 30 samples collected at consumer taps, the results ranked from lowest to highest show the 90th percentile lead value at 0.013 mg/L. The action level is 0.015 mg/L. Based on this monitoring round:

A. The system is approaching the action level and should proactively evaluate its corrosion control program

B. The system must immediately begin lead service line replacement because any detectable lead is unacceptable

C. The system is in violation because the 90th percentile must be below 0.010 mg/L for lead compliance

D. The system is below the action level, but the proximity to 0.015 mg/L warrants continued vigilance and monitoring

14. A confined space entry is planned for a drained sedimentation basin to inspect the sludge scraper mechanism. Atmospheric testing shows all parameters within safe ranges. The entry permit is completed and signed. Halfway through the inspection, the operator's continuous gas monitor alarms for CO at 28 ppm (the safe limit is 25 ppm). The entrant should:

A. Exit the space immediately, report the alarm to the attendant, and not re-enter until the source of CO is identified and the atmosphere is re-evaluated

B. Silence the alarm and continue working because 28 ppm is only slightly above the threshold

C. Switch to an air-purifying respirator with CO cartridges and continue the inspection for 15 more minutes

D. Ventilate the space for five minutes from inside and retest before deciding whether to continue the work

15. A treatment plant using surface water is required to achieve 3-log removal/inactivation of Giardia and 4-log of viruses. The plant uses conventional filtration (2.5-log Giardia credit, 2-log virus credit) and free chlorine for disinfection. The disinfection must achieve at least:

A. 3.0-log Giardia and 4.0-log virus inactivation through CT because filtration receives no credit

B. 0.5-log Giardia and 2.0-log virus inactivation through CT to make up the difference not covered by filtration

C. 2.5-log Giardia and 2.0-log virus inactivation through CT to match the filtration credit exactly

D. 0.5-log Giardia only, because the 4-log virus requirement is automatically met when Giardia CT is satisfied

16. An operator discovers that the plant's SCADA system has been calculating the combined filter effluent turbidity using data from only three of the four operating filters due to a wiring error on Filter 4's turbidimeter signal. Filter 4 has been operating normally but its data was not included in the CFE calculation. The operator should:

A. Leave the wiring as-is because three-filter data provides a representative calculation of combined quality

B. Correct the wiring error immediately, recalculate historical CFE data if possible, and report the issue to the primacy agency because compliance data may have been inaccurate

C. Disconnect Filter 4 from service to match the SCADA configuration rather than rewiring the signal

D. Continue operating but manually add Filter 4's turbidity reading to the daily log as a separate entry

17. A treatment plant's chemical storage room contains sodium hypochlorite, ferric chloride, and hydrofluorosilicic acid — all in bulk tanks. A new employee asks why the three chemicals are stored in separate containment areas rather than in a single large containment. The reason is:

A. Each chemical's containment must be color-coded differently for easy identification during deliveries

B. Federal regulations require a minimum distance of 100 feet between any two chemical storage tanks

C. The tanks are different sizes and each containment must be sized to exactly match its tank volume

D. Incompatible chemicals must be segregated to prevent dangerous reactions if tanks fail simultaneously

18. A treatment plant treats 2.5 MGD of groundwater. The raw water contains iron at 3.2 mg/L and manganese at 0.8 mg/L. The operator feeds potassium permanganate for pre-oxidation at a dose of 2.0 mg/L. How many pounds of permanganate are consumed per day?

A. 41.7 lb/day, calculated using the standard pounds formula: $2.0 \times 2.5 \times 8.34$

B. 20.85 lb/day, because the formula requires dividing by 2 for pre-oxidant applications

C. 83.4 lb/day, because permanganate dose must be doubled when both iron and manganese are present

D. 8.34 lb/day, because groundwater treatment uses a simplified formula with a factor of 1.0

19. An operator at a surface water treatment plant observes that the reservoir intake water has developed a strong, earthy odor over the past three days. The raw water temperature is 24°C and sunlight has been intense. Laboratory analysis will most likely confirm elevated concentrations of:

A. Hydrogen sulfide from anaerobic conditions developing in the warm surface water near the intake

B. Chloramine from distribution system water flowing backward into the reservoir through a faulty check valve

C. Geosmin and MIB produced by cyanobacteria (blue-green algae) thriving in the warm, sunlit reservoir conditions

D. Trihalomethanes formed by the reaction of chlorine with organic matter in the reservoir water

20. A treatment plant operator measures the free chlorine residual in a distribution system sample and obtains 0.4 mg/L. The operator then adds potassium iodide to the same sample and reads the total chlorine at 1.6 mg/L. The combined chlorine concentration is:

A. 0.4 mg/L because combined chlorine equals the free chlorine reading in all chloraminated systems

B. 2.0 mg/L because combined chlorine is calculated by adding free and total readings together

C. 1.2 mg/L, calculated by subtracting the free chlorine (0.4) from the total chlorine (1.6)

D. 1.6 mg/L because the total chlorine reading represents the combined fraction exclusively

21. A treatment plant operator notices that two adjacent wells — Well A and Well B, located 200 feet apart — both show declining specific capacities over the past year. Well A's specific capacity has dropped 15% and Well B's has dropped 20%. Neither well has been rehabilitated. One possible explanation for the simultaneous decline is:

A. Both wells have experienced identical mechanical pump failures that are reducing their rated capacities

B. The laboratory analyzing the well water has changed its analytical method, producing lower apparent yields

C. Both wells share the same aquifer and the combined pumping has created overlapping cones of depression

D. Well interference from overlapping cones of depression, meaning each well's pumping is increasing the drawdown in the other well

22. A treatment plant performs a jar test using six alum doses: 15, 25, 35, 45, 55, and 65 mg/L. The settled turbidity results are 6.8, 2.1, 0.7, 0.5, 0.6, and 1.4 NTU respectively. The operator should select:

A. 35 mg/L because it achieves near-minimum turbidity at the lowest effective dose — 45 mg/L provides only marginal improvement at 29% more chemical

B. 65 mg/L because the highest dose ensures the maximum safety factor for public health protection

C. 15 mg/L because cost savings from the lowest dose outweigh the treatment quality benefits of higher doses

D. 55 mg/L because it provides a better buffer above the minimum turbidity than the lower 45 mg/L dose

23. A treatment plant's emergency generator is rated at 500 kW. The total critical plant electrical load — raw water pumps, chemical feed systems, SCADA, lighting, and one high-service pump — is 475 kW. The remaining two high-service pumps add 300 kW each. During a power outage, the operator should:

A. Start all plant equipment simultaneously to restore full production as quickly as possible after generator startup

B. Run only the SCADA system and lighting to conserve fuel until utility power is restored to the facility

C. Operate the critical loads (475 kW) on the generator and manage distribution demand with the single high-service pump, because adding another pump would overload the 500 kW generator

D. Shut down the plant entirely because the generator cannot supply full plant capacity and partial operation is not permitted

24. An operator performing water quality sampling at a distribution system monitoring point obtains the following results: free chlorine 0.0 mg/L, total chlorine 0.0 mg/L, HPC > 500 CFU/mL. The system uses free chlorine for disinfection. These results indicate:

A. Normal conditions at the far end of the distribution system where residuals naturally decline to zero

B. The DPD test kit has expired and is unable to detect chlorine that is actually present in the sample

C. The distribution system is adequately protected because the HPC result is irrelevant when chlorine is present

D. A serious water quality problem — complete loss of disinfectant residual with elevated bacterial counts requires immediate investigation and corrective action

25. A treatment plant feeds fluoride using sodium fluoride dissolved in a day tank. The operator mixes 40 pounds of sodium fluoride (which is 45% fluoride ion by weight) into 500 gallons of water. The fluoride concentration of the stock solution is approximately:

A. 43,200 mg/L, calculated by converting pounds to milligrams and gallons to liters with the fluoride purity factor

B. 4,320 mg/L, calculated as (40 lb × 0.45 × 453,593 mg/lb) ÷ (500 gal × 3.785 L/gal)

C. 960 mg/L, using a simplified conversion without accounting for the sodium fluoride purity factor

D. 18,000 mg/L, calculated by dividing the total weight of sodium fluoride by the volume without purity adjustment

26. A treatment plant's SCADA system generates a low-suction-pressure alarm on the raw water pump. The operator checks the SCADA screen and confirms that the suction pressure has dropped from its normal 8 psi to 2 psi. The pump is still running but the discharge pressure has also decreased. The most likely cause is:

A. A clogged intake screen or suction strainer that is restricting the flow of raw water to the pump inlet

B. A failed discharge check valve that is allowing treated water to flow backward into the raw water intake

C. A power supply voltage fluctuation that is causing the pump motor to run at reduced speed temporarily

D. Normal pressure variation that occurs during low-demand periods when the distribution system pressure increases

27. A treatment plant operates a three-stage tapered flocculation system. Stage 1 operates at G = 60 sec^{-1}, Stage 2 at G = 40 sec^{-1}, and Stage 3 at G = 20 sec^{-1}. The detention time in each stage is 10 minutes. The total GT value for the entire flocculation process is:

A. 120,000 (the sum of all three stages would be 60×600 + 40×600 + 20×600 = 36,000+24,000+12,000 = 72,000)

B. 36,000 because only the first stage's GT value is used for design and compliance calculations

C. 2,400 because GT is calculated using only the average G value multiplied by the total detention time

D. 72,000, calculated by summing the GT contribution of each stage: (60×600) + (40×600) + (20×600)

28. A treatment plant operator tests the raw water hardness at 220 mg/L as $CaCO_3$ and alkalinity at 160 mg/L as $CaCO_3$. A customer calls to complain about white scale buildup in their water heater. The operator should explain that:

A. The scale is caused by elevated chlorine residual reacting with the metal heating elements in the water heater

B. The buildup is caused by colloidal particles that pass through the plant's filters and precipitate when heated

C. Hard water contains dissolved calcium and magnesium that precipitate as calcium carbonate scale when heated, and the carbonate hardness portion (160 mg/L) is primarily responsible

D. Water heater scale is caused by iron and manganese deposits that are unrelated to the water's hardness

29. An operator managing a confined space entry discovers that the mechanical retrieval system (tripod and winch) cannot be positioned over the entry hatch because of a structural obstruction above the opening. Without a retrieval system, the entry:

A. Can proceed as planned because the retrieval system is optional when the space is continuously ventilated

B. Should be reclassified as a non-permit entry since the space cannot accommodate the required equipment

C. Requires alternative rescue provisions — such as an on-site rescue team with appropriate training and equipment — before entry can be authorized

D. Must be canceled permanently because no confined space can be entered without a mechanical retrieval system

30. A treatment plant's online pH analyzer on the plant effluent shows a reading of 7.5. The operator collects a grab sample and immediately measures pH with a calibrated portable meter, obtaining 7.8. The operator collects a second grab sample and obtains 7.9. Before concluding that the online analyzer needs recalibration, the operator should check:

A. Whether the online analyzer's sample line is introducing a delay or exposing the sample to atmospheric CO_2 before reaching the sensor, which could lower the pH reading

B. Whether the grab samples were collected in glass bottles, which always increase pH by exactly 0.3 units

C. Whether the portable meter's batteries are fully charged, because low battery voltage always causes meters to read high

D. Whether the raw water pH has changed, because finished water pH always mirrors raw water pH exactly

31. A treatment plant using conventional treatment experiences a sudden increase in filter headloss development rate across all four filters simultaneously. The raw water turbidity has not changed. The settled water turbidity has increased from 0.8 NTU to 3.5 NTU. The coagulant feed rate has not changed. The operator should suspect:

A. All four filters need immediate media replacement because simultaneous performance decline indicates aging media

B. The distribution system demand has increased, pulling more water through the filters at a higher rate

C. The filter backwash procedure has changed, producing inadequate cleaning of all four filter beds

D. A coagulation problem — possibly a chemical feed system malfunction, an empty chemical tank, or a change in raw water chemistry that has increased coagulant demand beyond the current dose

32. An operator is reviewing the specifications for a new magnetic flow meter being installed on the plant effluent line. The installation drawing shows the meter installed immediately downstream of a 90-degree elbow with no straight pipe between the elbow and the meter. This installation is problematic because:

A. Magnetic flow meters cannot measure flow in pipes that contain any bends or elbows

B. The meter will produce falsely high readings because elbows accelerate the flow velocity

C. The turbulent flow profile created by the elbow will cause inaccurate readings — magnetic flow meters require straight pipe runs upstream and downstream for accurate measurement

D. The elbow creates a vacuum that pulls dissolved air out of solution, producing air bubbles that interfere

33. A treatment plant operator collects a raw water sample for total organic carbon (TOC) analysis. The sample must be collected in which type of container and preserved how?

A. Amber glass container, preserved with acid (phosphoric or hydrochloric) to pH < 2, and cooled to 1–4°C

B. Sterile plastic bottle with sodium thiosulfate added to preserve the organic carbon compounds

C. Any clean polyethylene container with no preservation required because TOC is chemically stable indefinitely

D. An acid-washed glass bottle, preserved with sodium hydroxide to pH > 12, and stored at room temperature

34. A treatment plant has recently installed a UV disinfection system. The operator notices that the UV transmittance (UVT) of the filtered water varies seasonally — 92% in winter and 78% in late summer. During the low-UVT summer period, the operator should:

A. Increase the UV lamp output or reduce the flow rate through the reactor to ensure the validated dose is delivered despite the lower UVT

B. Maintain the same UV system settings because seasonal UVT variation does not affect the delivered UV dose

C. Increase the UV lamp output but simultaneously reduce the chlorine dose because UV and chlorine are interchangeable

D. Shut down the UV system during summer and rely entirely on chlorine CT for all pathogen inactivation credit

35. A treatment plant's SCADA system records that the plant flow increased by 25% during a two-hour peak demand period. During this period, the coagulant feed system was operating in flow-proportional

mode and automatically increased the feed rate. However, the settled water turbidity increased from 0.8 NTU to 2.5 NTU despite the dose adjustment. The most likely explanation is:

A. The coagulant dose per gallon was maintained correctly, but the reduced detention time in the flocculation and sedimentation basins decreased treatment effectiveness

B. The flow-proportional system actually decreased the dose because the flow signal was inverted in the PLC

C. The increased flow improved treatment by creating more turbulence in the flocculation basins

D. The sedimentation basin sludge scrapers automatically speed up during peak flow and resuspend settled material

36. An operator at a small groundwater system is reviewing the system's monitoring schedule. The system has never had a coliform-positive sample in five years of operation. The operator asks the state whether reduced monitoring is available. Under the RTCR, the state may approve reduced monitoring if:

A. The system has a clean compliance history and meets the specific criteria defined by the state for reduced monitoring

B. The system demonstrates that its source water is classified as a confined aquifer with no GWUDI determination

C. The system has been in operation for at least 10 years with no violations of any drinking water standard

D. The system owner submits a written guarantee that future monitoring results will continue to be negative

37. A treatment plant treats 5.0 MGD. The plant produces an average of 800 pounds per day of dry sludge solids from the sedimentation basins. The sludge is dewatered from 1% solids (as withdrawn) to 20% solids (as cake) using a belt filter press. The volume reduction achieved by dewatering is approximately:

A. 95%, meaning the dewatered cake volume is approximately 5% of the original liquid sludge volume

B. 50%, meaning dewatering removes half the water content from the original sludge

C. 80%, meaning the cake retains 20% of the original volume after pressing

D. 20%, meaning the dewatering process removes only a small fraction of the total water content

38. A treatment plant's chemical delivery receiving SOP requires the operator to verify the chemical identity, concentration, and quantity before accepting a delivery. A tanker arrives with liquid alum for the plant's alum storage tank. The driver presents paperwork showing "ferric chloride — 40% solution." The operator should:

A. Accept the delivery because both chemicals are coagulants and serve the same treatment function

B. Refuse the delivery immediately because the chemical does not match the expected product and delivering the wrong chemical to a tank could cause dangerous reactions or treatment failure

C. Accept the delivery into a temporary holding tank and test it before transferring to the alum tank

D. Accept the delivery if the driver verbally confirms that the paperwork is wrong and the tank actually contains alum

39. A treatment plant uses a Parshall flume for raw water flow measurement. The operator notices that the approach channel upstream of the flume has accumulated several inches of sediment. This sediment accumulation will:

A. Have no effect because Parshall flumes measure flow based on throat velocity, not upstream conditions

B. Cause the flume to underestimate flow because the sediment creates friction that reduces the water level

C. Cause the flume to overestimate flow because the reduced channel capacity raises the upstream water level, increasing the depth reading at the measurement point

D. Improve the accuracy of the flume by creating a more uniform flow profile in the approach channel

40. A treatment plant using chloramination maintains a chlorine-to-ammonia nitrogen ratio of 4:1 by weight. The plant treats 3.0 MGD and feeds chlorine at a dose of 2.8 mg/L. How many pounds per day of ammonia (as nitrogen) must be fed to maintain the correct ratio?

A. 69.9 lb/day of ammonia nitrogen, calculated by dividing the chlorine feed rate by 4

B. 279.7 lb/day of ammonia nitrogen, calculated by multiplying the chlorine feed rate by 4

C. 23.3 lb/day of ammonia nitrogen, calculated incorrectly by dividing the chlorine dose by 4 before applying the pounds formula

D. 17.5 lb/day of ammonia nitrogen, calculated as (2.8 ÷ 4) × 3.0 × 8.34

41. An operator at a water treatment plant observes the following condition during a filter inspection: the media surface shows deep furrows and channels in the sand, with some areas of the bed visibly lower than adjacent areas. These surface irregularities most likely indicate:

A. Uneven flow distribution during backwash, which is washing some areas more aggressively than others and creating channeling during filtration

B. Normal media settling that occurs in all rapid sand filters after 24 hours of continuous production

C. Excessive coagulant dose that has chemically eroded the sand grains in specific locations of the bed

D. Biological activity from nitrifying bacteria that preferentially consume sand particles in localized areas

42. A treatment plant's finished water has the following characteristics: pH 7.0, alkalinity 30 mg/L as $CaCO_3$, hardness 40 mg/L as $CaCO_3$, and TDS 150 mg/L. The corrosion control study recommends adding a polyphosphate-based corrosion inhibitor. The primary mechanism by which polyphosphate inhibitors reduce corrosion is:

A. Increasing the water's pH to create conditions favorable for calcium carbonate precipitation on pipe surfaces

B. Forming a thin protective film on the interior pipe surface that acts as a barrier between the water and the pipe material

C. Removing dissolved oxygen from the water to eliminate the oxidant that drives the corrosion reaction

D. Precipitating all dissolved metals from the water before they can interact with the pipe surfaces

43. A treatment plant's operator is evaluating the plant's compliance with the Surface Water Treatment Rule turbidity requirements. In January, the plant collected 2,880 individual 15-minute CFE turbidity readings. Of these, 2,822 were ≤ 0.3 NTU and 58 exceeded 0.3 NTU. The highest single reading was 0.8 NTU. The compliance status is:

A. In violation of the turbidity standard because more than 5% of readings exceeded 0.3 NTU (58/2,880 = 2.0% — actually within compliance)

B. In compliance because no individual reading exceeded 1.0 NTU, which is the only enforceable limit

C. In violation because the operator failed to collect at least 3,000 readings during the month

D. In compliance because only 2.0% of readings exceeded 0.3 NTU (well within the 5% allowance) and no reading exceeded 1.0 NTU

44. An operator at a treatment plant using ozone for primary disinfection and chloramines for secondary disinfection notices that the ozone residual exiting the contactor is consistently lower than the design target despite the ozone generator operating at its rated output. The raw water temperature has increased from 10°C to 25°C over the past month. The most likely explanation is:

A. Ozone generators produce less ozone at higher ambient temperatures due to thermal efficiency losses

B. The ozone transfer efficiency from gas to water has decreased because warmer water holds less dissolved gas

C. Ozone decomposes faster in warmer water, reducing the measurable residual at the contactor outlet

D. The ozone monitoring instrument is temperature-sensitive and reads low at temperatures above 20°C

45. A treatment plant's laboratory performs a spike recovery test on a chlorine residual analysis. The operator adds a known amount of chlorine standard to a sample and measures the result. The unspiked sample reads 0.8 mg/L. The spike adds the equivalent of 0.5 mg/L. The spiked sample should read approximately 1.3 mg/L. The actual spiked result reads 1.0 mg/L. The percent recovery is:

A. 40%, calculated as (1.0 - 0.8) ÷ 0.5 × 100 = 0.2 ÷ 0.5 × 100, indicating a significant matrix interference that recovered only 40% of the added spike

B. 77%, calculated as 1.0 ÷ 1.3 × 100, which is within acceptable limits for chlorine analysis

C. 100%, because the spiked sample produced a positive result confirming the analytical method is working

D. 125%, calculated by dividing the spiked result by the unspiked result and multiplying by 100

46. A treatment plant operator calculates the detention time of a cylindrical clearwell that is 50 feet in diameter and has a water depth of 18 feet. The plant treats 2.0 MGD (1,389 gpm). Using Volume = $\pi \times r^2 \times h$ and 1 ft^3 = 7.48 gallons, the theoretical detention time is approximately:

A. 35 minutes, indicating the clearwell may be undersized for the plant's CT requirements

B. 189 minutes, which provides substantial contact time for disinfection CT calculations

C. 94 minutes, which must be multiplied by the baffling factor to determine T_{10} for CT compliance

D. 378 minutes, calculated using the full diameter rather than the radius in the volume formula

47. A treatment plant has four filters. Filter 1 was backwashed 6 hours ago and shows headloss of 2 feet. Filter 2 was backwashed 24 hours ago and shows headloss of 4 feet. Filter 3 was backwashed 36 hours ago and shows headloss of 7 feet (terminal headloss is 8 feet). Filter 4 was backwashed 12 hours ago and shows headloss of 3 feet. The operator should plan to backwash which filter next?

A. Filter 1 because it was most recently backwashed and should be washed again to prevent mudball formation

B. Filter 2 because it has been online the longest time since its last backwash cycle in the rotation

C. Filter 4 because its headloss development rate (3 ft in 12 hours) is faster than the other filters proportionally

D. Filter 3 because it is closest to terminal headloss and will need backwash before the others reach their limits

48. An operator discovers that the plant's sodium hypochlorite bulk tank has a float-type level indicator that reads 75% full. However, the operator's calculations based on chemical consumption and delivery records indicate the tank should be only 40% full. The most likely explanation is:

A. The consumption calculations are incorrect because the operator used the wrong solution concentration

B. A delivery occurred without the operator's knowledge, or the level indicator is stuck at an inaccurate position

C. The level indicator is reading accurately and the consumption records include chemical that was actually delivered to a different plant

D. Sodium hypochlorite naturally expands in warm weather, increasing the apparent volume in the tank without adding chemical

49. A treatment plant operator receives a complaint from a homeowner about recurring pinhole leaks in copper plumbing installed five years ago. Multiple homes in the same subdivision are experiencing the same problem. The operator should investigate:

A. Whether the finished water chemistry — particularly pH, alkalinity, dissolved oxygen, chloride, and sulfate — is aggressive toward copper and contributing to accelerated corrosion

B. Whether the copper pipe manufacturer used a defective alloy that is susceptible to pitting regardless of water quality

C. Whether the homeowners are using water softeners that increase the copper content of the water

D. Whether the homes are connected to a different water main than the rest of the distribution system

50. A treatment plant treats 6.0 MGD. The operator needs to feed sodium fluoride to achieve a finished water concentration of 0.7 mg/L. The raw water naturally contains 0.15 mg/L of fluoride. The sodium fluoride product has a fluoride ion purity of 45%. How many pounds per day of sodium fluoride must be fed?

A. 35.1 lb/day, calculated without subtracting the natural fluoride from the required dose

B. 60.6 lb/day, calculated using the full 0.7 mg/L dose without accounting for natural fluoride

C. 27.5 lb/day, using an incorrect purity factor in the pounds formula calculation

D. 61.2 lb/day, calculated as: dose = (0.7 - 0.15) = 0.55 mg/L; feed rate = 0.55 × 6.0 × 8.34 ÷ 0.45

51. A treatment plant operator observes that the chlorine residual at the farthest point in the distribution system has dropped from its normal 0.4 mg/L to 0.05 mg/L over the past two weeks. The plant effluent residual has remained at 1.2 mg/L. No main breaks or construction have been reported. The operator should investigate:

A. Whether the plant's chlorine gas cylinders have been contaminated, reducing the potency of the applied chlorine

B. Whether the laboratory's DPD reagent has expired, producing falsely low readings at the remote location only

C. Whether the distribution system flow pattern has changed, increasing water age in that area

D. Increased water age, temperature rise, or biofilm growth in the distribution system that is consuming the chlorine residual during transit

52. An operator is calculating the chemical feed rate for a treatment plant that uses 48% liquid alum (specific gravity 1.33). The plant treats 3.0 MGD and the optimal alum dose from jar testing is 35 mg/L. The daily volume of liquid alum solution needed is approximately:

A. 875.9 lb/day of alum solution, calculated by dividing the dry weight by the concentration

B. 66 gallons per day of liquid alum solution

C. 875.9 gallons per day, which exceeds the feed system capacity and indicates a calculation error

D. 132 gallons per day of liquid alum solution, calculated by multiplying rather than dividing by the concentration

53. A treatment plant's water quality monitoring data shows that finished water copper levels at consumer taps have increased from 0.3 mg/L to 0.9 mg/L over the past six months. The action level for copper is 1.3 mg/L. The secondary standard is 1.0 mg/L. The operator should:

A. Take no action because both results are below the action level and no regulatory requirement has been triggered

B. Notify the state because the copper level exceeds the primary MCL and requires Tier 2 notification

C. Investigate the cause of the rising copper trend and evaluate whether corrosion control adjustments are needed before levels reach the action level or secondary standard

D. Begin replacing all copper service lines in the distribution system to eliminate the source of copper

54. A treatment plant operator observes that the floc in the sedimentation basins appears smaller and lighter than usual — pin-point floc that rises and falls slowly rather than the normally large, dense floc that settles rapidly. The coagulant dose has not changed and the raw water quality appears normal. The operator should first check:

A. Whether the flocculation basin mixer speeds are correct, because reduced mixing energy produces inadequate particle collisions and small, weak floc

B. Whether the sedimentation basin sludge scrapers have stopped, allowing sludge to accumulate and resuspend

C. Whether the filter backwash rate is too high, creating a hydraulic disturbance that propagates upstream to the basins

D. Whether the distribution system demand has decreased, reducing the flow through the plant below minimum levels

55. A water treatment plant has implemented a comprehensive predictive maintenance program that includes monthly vibration analysis, quarterly infrared thermography, and semi-annual oil analysis on all critical rotating equipment. The primary benefit of this program compared to a purely preventive (time-based) program is:

A. Predictive maintenance eliminates all equipment failures because every problem is detected before it occurs

B. Predictive maintenance requires less operator training because the monitoring equipment makes all decisions

C. Predictive maintenance costs more but provides no additional benefit over routine time-based maintenance intervals

D. Maintenance is performed when equipment condition indicates it is needed rather than on a fixed schedule, reducing both unnecessary maintenance and unexpected failures

56. A treatment plant's emergency response plan specifies that during a chlorine gas release, all personnel must evacuate upwind and uphill. An operator is in the plant control room when the chlorine leak detector alarms. The wind is blowing from the west. The chlorine room is located east of the control room. The operator should evacuate toward the:

A. East, because the chlorine room is east and the operator should move toward the source to shut off the supply

B. West, which is upwind of the chlorine room and away from the direction the gas will travel

C. North, regardless of wind direction, because all emergency evacuation routes lead north at this facility

D. Nearest indoor shelter-in-place location because chlorine gas cannot enter sealed buildings under any conditions

57. An operator tests the total hardness of a distribution system sample at 180 mg/L as $CaCO_3$ and the calcium hardness at 120 mg/L as $CaCO_3$. The magnesium hardness is:

A. 300 mg/L, calculated by adding total hardness and calcium hardness together

B. 120 mg/L, because magnesium hardness always equals calcium hardness in natural water

C. 60 mg/L, calculated by subtracting the calcium hardness (120) from the total hardness (180)

D. 180 mg/L, because total hardness represents only the magnesium fraction in treated water

58. A treatment plant operator is reviewing the plant's compliance with the Filter Backwash Recycling Rule. The plant recycles backwash water to the head of the plant and also recycles the supernatant from the sludge dewatering lagoon. Under the FBRR, these recycled flows must be returned to the treatment process at a point:

A. Before or at the point of primary coagulant addition to ensure the recycled water receives full treatment

B. After filtration but before disinfection to minimize the recirculation of treatment chemicals

C. Directly into the clearwell to dilute any concentrated contaminants with the large volume of finished water

D. Into the sedimentation basin to take advantage of the existing settling capacity for any recycled solids

59. A treatment plant operator discovers during a routine inspection that the emergency shower in the chemical storage room produces only a weak trickle of water when activated. The room contains concentrated sodium hydroxide and hydrofluorosilicic acid. The operator should:

A. Post an out-of-service sign and continue chemical handling operations until a plumber can repair the shower

B. Test the shower monthly instead of weekly to reduce water waste from the low-flow condition

C. Relocate chemical operations to a different area of the plant until the shower is repaired and fully functional

D. Report the deficiency immediately, restrict chemical handling operations in the affected area, and arrange emergency repair because a non-functional safety shower during a chemical exposure could result in serious injury

60. A treatment plant treats 4.0 MGD and feeds powdered activated carbon (PAC) at 10 mg/L during a taste and odor event. The PAC costs $0.65 per pound. The daily cost of PAC treatment is approximately:

A. $21.68 per day

B. $217 per day

C. $65 per day

D. $2,170 per day

61. A treatment plant operator measures the following individual filter effluent turbidities during a routine check: Filter 1 = 0.03 NTU (backwashed 8 hours ago), Filter 2 = 0.04 NTU (backwashed 20 hours ago), Filter 3 = 0.18 NTU (backwashed 42 hours ago), Filter 4 = 0.05 NTU (backwashed 14 hours ago). Filter 3's elevated turbidity most likely indicates:

A. Normal performance for a filter that was recently returned to service and is still in its ripening period

B. That Filter 3 should be backwashed at the same time as Filter 1 to synchronize the backwash schedule

C. The beginning of turbidity breakthrough — Filter 3 has been in service the longest and its media is becoming loaded

D. A laboratory turbidimeter malfunction that is producing a falsely high reading on the Filter 3 effluent sample

62. A treatment plant using surface water must provide a minimum disinfectant residual of 0.2 mg/L entering the distribution system. The plant's current practice maintains a residual of 0.8 mg/L. A new operator asks why the plant maintains four times the minimum residual. The best explanation is:

A. The higher residual compensates for chlorine consumption in the distribution system, ensuring a detectable residual remains at the farthest points where water quality must still be protected

B. The minimum residual requirement applies only at the plant effluent and there is no benefit to exceeding it

C. Federal regulations require a residual of 0.8 mg/L despite the published minimum of 0.2 mg/L

D. The plant is over-chlorinating and should reduce the dose to the 0.2 mg/L minimum to reduce DBP formation

63. A treatment plant's chemical feed system uses a calibration column to verify metering pump output. The operator performs a calibration check and records: initial column level 500 mL, final column level 200 mL, elapsed time 10 minutes. The pump's displayed setpoint is 25 mL/min. The actual pump output rate and the percent error are:

A. 30 mL/min actual, which is 20% above the 25 mL/min setpoint — the pump is over-delivering and the stroke should be reduced

B. 20 mL/min actual, which is 20% below setpoint — requiring an increase in stroke length or rate

C. 25 mL/min actual, confirming the pump is delivering exactly at setpoint with zero error

D. 300 mL/min actual, which is obviously incorrect and indicates the calibration column was read in the wrong direction

64. An operator at a treatment plant is responsible for maintaining the facility's chemical Safety Data Sheets. The SDS binder currently contains documents for 12 chemicals. The operator discovers that three of the SDSs are more than five years old. The operator should:

A. Replace the old SDSs immediately because SDS documents expire after three years under OSHA regulations

B. Contact each manufacturer or supplier to obtain the most current version of each SDS and update the binder

C. Remove the outdated SDSs from the binder to prevent operators from referencing potentially incorrect information

D. Keep the old SDSs because the information for established chemical products does not change over time

65. A treatment plant experiences a gradual loss of chlorine residual in a specific section of the distribution system. Investigation reveals that a new plastic pipe was installed in that section six months ago. The operator should consider whether:

A. The pipe joints were not properly sealed, allowing unchlorinated groundwater to enter and dilute the residual

B. The pipe material is chemically incompatible with the treatment chemicals and is dissolving into the water

C. The new plastic pipe is exerting a chlorine demand — some pipe materials react with chlorine, particularly during the first months after installation

D. The pipe diameter is too large for the area, creating stagnation and excessive water age that would deplete the residual

66. A treatment plant operator is reviewing the results of the plant's annual vulnerability assessment update. The assessment identifies that an unauthorized wireless access point has been connected to the SCADA network in the maintenance shop. The operator should:

A. Disconnect the unauthorized access point immediately, secure the SCADA network, investigate who installed it and why, and update the cybersecurity protocols

B. Change the wireless password monthly and allow the access point to remain for operator convenience

C. Relocate the access point to the control room where it can be better monitored by the shift operator

D. Leave the access point connected but install antivirus software on the SCADA server as compensation

67. A treatment plant uses a submersible pump in a wet well to transfer sludge from the sedimentation basin to the dewatering facility. The pump has been running continuously but the sludge level in the wet well continues to rise. The pump discharge piping is intact and the discharge valve is fully open. The most likely cause is:

A. The wet well level sensor has drifted and is reporting an artificially high level that does not reflect actual conditions

B. The sedimentation basin is producing more sludge than the pump can handle at its current capacity

C. The discharge valve is stuck in the closed position despite the operator's belief that it is fully open

D. The pump impeller has become clogged with debris or the pump is cavitating, reducing its actual pumping capacity below its rated flow

68. A treatment plant operator is planning the annual budget for chemical costs. The plant treats 3.0 MGD and uses alum at an average dose of 30 mg/L. The cost of alum is $0.12 per pound. The estimated annual alum cost is approximately:

A. $27,432 per year, calculated by multiplying the daily chemical cost by 365 days

B. $32,850 per year, which is the daily cost of 750 lb × $0.12 × 365

C. $10,957 per year, using a daily consumption of approximately 250 lb at the given dose and flow

D. $109,576 per year, which significantly exceeds the typical chemical budget for a plant this size

69. A water treatment plant's source water protection plan identifies a potential threat: a highway bridge crossing the reservoir 500 feet upstream of the plant intake. The primary risk this bridge poses is:

A. Vibrations from heavy trucks crossing the bridge can disturb the reservoir sediments and increase turbidity

B. Salt and deicing chemicals applied to the bridge during winter will dissolve into the reservoir and increase TDS

C. Shadow cast by the bridge structure during daylight hours inhibits algae growth in the reservoir below

D. A tanker truck accident or hazardous material spill on the bridge could release contaminants directly into the reservoir near the intake

70. An operator reviews the following SCADA trend for the past 24 hours: raw water turbidity steady at 8 NTU, coagulant dose steady at 25 mg/L, settled water turbidity steady at 0.9 NTU, but filter effluent turbidity on all four filters has gradually increased from 0.04 NTU to 0.09 NTU over 24 hours. The settled water quality is unchanged. The most likely explanation is:

A. All four filters are experiencing simultaneous media deterioration from chemical attack by the coagulant

B. The online turbidimeters on all four filters have drifted simultaneously due to a common power supply issue

C. A subtle change in the floc characteristics — perhaps from chemical aging, temperature change, or minor raw water chemistry shift — is producing floc that passes through the filter media more readily

D. The distribution system is backflowing treated water into the filter effluent lines, diluting the readings upward

71. A treatment plant's operator is troubleshooting a pH control problem. The plant adds lime after filtration to raise pH for corrosion control. The SCADA trend shows the finished water pH oscillating between 7.2 and 8.4 every 15 to 20 minutes, instead of holding steady at the 7.8 target. The lime feed rate is in automatic mode controlled by the PLC based on the online pH analyzer feedback. The most likely cause of the oscillation is:

A. The online pH analyzer is malfunctioning and producing random false readings that confuse the PLC

B. The PLC control loop is poorly tuned — the proportional gain is too high, causing the controller to overcorrect on each cycle

C. The lime product has an inconsistent calcium content that varies between each bag added to the hopper

D. The oscillation is normal and expected for all pH control systems regardless of the controller tuning parameters

72. A treatment plant operator performing a sanitary well inspection notices that the well's pitless adapter (the subsurface connection between the well casing and the lateral pipe) has a visible crack with moisture seeping through. This defect is concerning because:

A. The cracked adapter will reduce the well's pumping capacity by allowing air to enter the system

B. Surface water or shallow groundwater can enter the well through the crack, bypassing the sanitary seal and potentially introducing contamination into the aquifer

C. The pitless adapter crack will cause the pump to lose prime during periods of high demand

D. Moisture seepage through the adapter indicates the well is producing more water than the aquifer can supply

73. A treatment plant uses a rotary screw air compressor to supply instrument air to pneumatic valve actuators throughout the plant. The operator notices that several pneumatic valves have become sluggish — taking 15 to 20 seconds to respond to control signals instead of the normal 3 to 5 seconds. The air supply pressure at the compressor outlet reads normal. The most likely cause is:

A. Moisture in the air lines from a failed or bypassed air dryer, causing corrosion, ice formation, or restricted flow through the pneumatic tubing and components

B. The pneumatic valve actuators have simultaneously reached the end of their service life and require replacement

C. The SCADA system is sending delayed control signals to the valves due to a network communication bottleneck

D. The plant's electrical system is experiencing voltage fluctuations that affect the solenoid valves controlling the air supply

74. A treatment plant using chloramination for distribution system residual has experienced a nitrification event in a dead-end section of the distribution system. The operator has completed a unidirectional flushing program and temporarily boosted the chloramine residual in the affected area. To prevent recurrence, the operator should also consider:

A. Permanently increasing the ammonia feed rate to produce a stronger chloramine residual in all distribution areas

B. Increasing the chlorine-to-ammonia ratio to minimize free ammonia available as a nutrient for nitrifying bacteria

C. Looping the dead-end main to improve circulation and reduce stagnation and water age in the affected area

D. Switching the entire system from chloramines to free chlorine permanently to eliminate the ammonia substrate

75. An operator performs an alkalinity test using the following parameters: sample volume 100 mL, titrant 0.02N H_2SO_4, volume of acid to reach pH 4.5 = 15.0 mL. The total alkalinity is:

A. 75 mg/L as $CaCO_3$

B. 150 mg/L as $CaCO_3$

C. 300 mg/L as $CaCO_3$

D. 15 mg/L as $CaCO_3$

76. A treatment plant's filter performance data shows the following pattern: immediately after backwash, each filter's effluent turbidity peaks at 0.25 to 0.30 NTU for approximately 20 minutes before dropping to the baseline of 0.04 NTU. The plant does not practice filter-to-waste. This ripening water is currently going directly to the clearwell. The operator should recommend:

A. Increasing the backwash rate to produce a more thorough cleaning that eliminates the ripening spike

B. Adding more coagulant to the filter influent during the ripening period to accelerate particle attachment

C. Accepting the current practice because 0.30 NTU is below the regulatory limit and no action is needed

D. Implementing filter-to-waste to divert the high-turbidity ripening water away from the clearwell until turbidity drops to baseline

77. A treatment plant operator is reviewing the previous year's DBP monitoring data. The four quarterly THM results at Distribution Location #4 are: Q1 = 0.065, Q2 = 0.092, Q3 = 0.098, Q4 = 0.071 mg/L. The LRAA at this location is:

A. 0.0815 mg/L, which exceeds the 0.080 mg/L TTHM MCL and constitutes a violation

B. 0.098 mg/L, using only the highest quarterly result as the compliance value

C. 0.326 mg/L, calculated by summing all four quarters without dividing by four

D. 0.065 mg/L, using only the lowest quarterly result as the most representative value

78. An operator at a treatment plant discovers that the plant's four sedimentation basins have significantly different sludge blanket depths despite receiving equal flow and identical coagulated water. Basin 1 = 1 ft, Basin 2 = 1.5 ft, Basin 3 = 6 ft, Basin 4 = 1 ft. The operator should:

A. Increase the coagulant dose to produce heavier sludge that settles more uniformly in all four basins

B. Equalize the sludge withdrawal rates so that all four basins receive the same amount of sludge removal

C. Investigate why Basin 3 has accumulated significantly more sludge — likely a malfunctioning sludge scraper, a clogged withdrawal line, or a closed sludge valve

D. Drain all four basins simultaneously and restart the sedimentation process from a clean-basin condition

79. A treatment plant's emergency plan requires the operator to respond to a boil-water advisory by increasing monitoring at specific distribution system locations. During an active boil-water advisory, the operator should collect bacteriological samples at:

A. Only the location where the original positive result was obtained, to track whether the contamination clears

B. Increased frequency at multiple locations throughout the affected area, including the original site, upstream, downstream, and surrounding areas

C. The treatment plant effluent only, because distribution system samples are meaningless during an advisory

D. A single location selected at random from the sampling plan, because representative sampling is sufficient

80. A treatment plant treats water from a well that is classified as Groundwater Under the Direct Influence of Surface Water (GWUDI). This classification requires the system to:

A. Meet the same filtration and disinfection requirements as a surface water system, including turbidity monitoring, CT compliance, and pathogen removal/inactivation standards

B. Install reverse osmosis treatment to remove all dissolved contaminants to surface water quality levels

C. Relocate the well to a location at least 1,000 feet from the nearest surface water body to eliminate the influence

D. Test the well water for surface water indicators every month and reclassify the source if three consecutive tests are negative

81. A treatment plant uses a belt filter press for sludge dewatering. The operator observes that the press is producing cake with adequate solids content (20%) but the filtrate (the water squeezed from the sludge) is unusually turbid. This condition suggests:

A. The polymer dose is too low, and the sludge is not adequately conditioned for the press to separate solids from liquid

B. The belt filter press belts need to be replaced with a finer mesh size to capture the smaller particles

C. The sludge withdrawal rate from the sedimentation basins needs to be reduced to produce a thicker, more concentrated feed

D. The press is applying too much pressure, rupturing the floc and releasing fine particles into the filtrate

82. A treatment plant operates three high-service pumps in parallel to deliver finished water to the distribution system. During normal demand periods, two pumps run while one serves as standby. The standby pump is alternated weekly. One month, the plant experiences a period where all three pumps must run simultaneously to meet peak demand. If this condition persists, the operator should be most concerned about:

A. Inadequate time for preventive maintenance because no pump is available as a standby during the peak

B. Excessive wear on all three pumps from continuous operation without rest periods between cycles

C. The absence of a standby pump means any single pump failure during peak demand would immediately reduce plant capacity below the level needed to serve the community

D. The electrical demand from running three pumps simultaneously may exceed the plant's transformer capacity

83. A treatment plant operator observes that the plant's raw water turbidity has been unusually low — below 2 NTU — for the past month despite the typical range being 8 to 15 NTU. The operator has maintained the same alum dose used during normal turbidity conditions. This practice may be problematic because:

A. Over-dosing coagulant during low-turbidity conditions wastes chemical, increases sludge production, and may cause charge reversal that actually degrades settled water quality

B. Low turbidity raw water does not require any chemical treatment and all coagulant feed should be stopped

C. The excess coagulant will accumulate in the distribution system and cause consumer complaints about water taste

D. Over-dosing during low turbidity causes the filters to clog more slowly, which reduces the frequency of backwash

84. An operator at a treatment plant receives a laboratory report showing that the nitrate level in the finished water is 8.5 mg/L as nitrogen. The MCL for nitrate is 10 mg/L as nitrogen. The operator should:

A. Take no action because 8.5 mg/L is within the normal range and no compliance concern exists

B. Investigate the source of the elevated nitrate, increase monitoring frequency, and evaluate treatment options because the level is approaching the MCL

C. Issue Tier 1 public notification within 24 hours because nitrate above 8.0 mg/L is an acute violation

D. Reduce the chlorine dose because chlorination converts nitrogen compounds to nitrate in the treatment process

85. A treatment plant's security plan requires that all visitors sign in at the main entrance, show identification, state the purpose of their visit, and be escorted by authorized personnel while on the plant grounds. A chemical delivery driver arrives and insists on entering the chemical storage area unescorted because "I deliver here every month and know where everything is." The operator should:

A. Politely decline and escort the driver personally, following the security plan's visitor escort requirement regardless of the driver's familiarity

B. Allow the driver to proceed unescorted since monthly deliveries establish an informal authorization

C. Call the supervisor to make an exception for routine delivery drivers who have been coming to the plant regularly

D. Provide the driver with a temporary access badge that permits unescorted access during business hours

86. A treatment plant's UV disinfection system has four UV lamps in the reactor. The SCADA system reports that one of the four lamps has failed. The UV sensor reading has dropped below the minimum validated dose setpoint. The operator should:

A. Reduce the plant flow rate through the UV reactor to increase the exposure time per unit volume until the failed lamp is replaced, while verifying chlorine CT provides adequate backup

B. Increase the power to the remaining three lamps to compensate for the failed lamp's output

C. Bypass the UV system entirely and rely on chlorine for all disinfection until the lamp is replaced

D. Shut down the treatment plant completely because UV disinfection cannot function with fewer than four lamps

87. A treatment plant treats 2.0 MGD from a groundwater source. The raw water contains iron at 1.5 mg/L and a pH of 6.5. The plant aerates the water to oxidize the iron, then filters through dual-media pressure filters. After aeration, the operator expects the iron to be converted from:

A. Insoluble ferric iron (Fe^{3+}) to dissolved ferrous iron (Fe^{2+}) for easier filtration through the media

B. Dissolved ferrous iron (Fe^{2+}) to dissolved ferric iron (Fe^{3+}), which remains in solution until chemically precipitated

C. Dissolved ferrous iron (Fe^{2+}) to insoluble ferric iron (Fe^{3+}), which precipitates and can be captured by filtration

D. Organic iron complexes to free metallic iron particles that settle rapidly in the pressure filter vessel

88. A treatment plant operator is reviewing the plant's monthly water production records and observes that the total water produced (based on plant effluent flow meter) exceeds the total water billed to customers (based on customer meters) by 18%. The industry average for non-revenue water is typically 10% to 15%. This higher-than-average loss percentage suggests the system should investigate:

A. Whether the plant effluent flow meter is reading accurately because a high meter error would explain the apparent loss

B. Whether the distribution system has undetected leaks, unauthorized connections, metering inaccuracies, or excessive unmetered uses that account for the additional water loss

C. Whether the customers are deliberately under-reporting their water usage to reduce their water bills

D. Whether the treatment plant is wasting more water during backwash than the 2–5% industry standard

89. A treatment plant's operator receives a consumer complaint about small black particles in the water at a single residence. The customer reports that the particles appear in both hot and cold water and are especially noticeable in the morning. The most likely source of the black particles is:

A. Manganese deposits in the distribution main being dislodged by overnight pressure fluctuations

B. Activated carbon particles from the treatment plant's GAC filtration system passing into the distribution main

C. Decomposed rubber from deteriorating flexible hose connections, faucet washers, or water heater dip tube in the customer's plumbing

D. Degradation of internal rubber components in the customer's plumbing — flexible connectors, faucet washers, or the hot water heater dip tube

90. A treatment plant operator monitors weather forecasts as part of routine operations. A forecast predicts heavy rainfall (3 inches in 24 hours) for the watershed serving the plant's reservoir source. Based on this forecast, the operator should proactively prepare for:

A. Increased turbidity and sediment loading at the raw water intake requiring no preparation

B. Reduced raw water availability requiring the plant to decrease production rates immediately

C. Improved raw water quality as the rainfall dilutes existing contaminant concentrations in the reservoir

D. Increased raw water turbidity, potential NOM loading, and possible agricultural/urban runoff contamination requiring increased coagulant supply, jar testing readiness, and enhanced monitoring

91. An operator reviewing the plant's compliance with enhanced coagulation requirements calculates the quarterly TOC removal percentage. The raw water TOC averaged 4.8 mg/L and the finished water TOC averaged 3.1 mg/L. The percentage removal is:

A. 64.6%, representing the ratio of finished water TOC to raw water TOC expressed as a percentage

B. 35.4%, calculated as $(4.8 - 3.1) \div 4.8 \times 100$ — the actual percentage of TOC removed from the raw water

C. 35.4%, which is compared against the required removal percentage from the enhanced coagulation matrix to determine compliance

D. 1.7 mg/L, which is reported directly as the TOC removal rather than converting to a percentage

92. A treatment plant treats surface water that has a significant seasonal algae problem. The plant does not currently have the capability to add powdered activated carbon (PAC). During a severe taste and odor event, the operator can partially mitigate the problem by:

A. Increasing the chlorine dose to oxidize the taste and odor compounds — though this may be only partially effective and must be balanced against DBP concerns

B. Optimizing coagulation for enhanced NOM removal, which may capture some of the algae-produced compounds, and considering pre-oxidation with potassium permanganate if available

C. Reducing the plant flow rate to increase detention time, which allows natural biological degradation to reduce the geosmin and MIB concentrations before disinfection

D. Switching the plant from surface water to groundwater for the duration of the bloom, which eliminates the taste and odor compounds at the source

93. An operator at a treatment plant is calibrating a laboratory turbidimeter. The calibration procedure requires standards at < 0.1 NTU, 20 NTU, 100 NTU, and 800 NTU. After calibration, the operator measures a 20 NTU check standard from a different lot. The reading is 24.0 NTU. The acceptable tolerance is ±10% (18.0 to 22.0 NTU). The operator should:

A. Accept the calibration because 24.0 NTU is close enough to the expected value for practical purposes

B. Report the turbidimeter as permanently defective and order a replacement instrument from the manufacturer

C. Verify that the check standard itself is correct (not expired, not contaminated), then recalibrate if the standard is confirmed

D. Recalibrate the instrument using the 20 NTU check standard values instead of the manufacturer's primary standards

94. A treatment plant's finished water pH has been stable at 7.5 for several months. The operator notices that the distribution system corrosion coupon data shows a slight increase in corrosion rate over the past quarter despite no changes in pH, alkalinity, or hardness. One possible explanation is:

A. An increase in dissolved oxygen, chloride, or sulfate content in the finished water — any of which can increase the corrosion rate independently of pH, alkalinity, and hardness

B. The corrosion coupons have become contaminated with biological growth that is producing false corrosion readings

C. The distribution system pipe material has changed composition due to years of operation, becoming more resistant to corrosion

D. Corrosion coupon data always increases over time due to the natural aging of the coupon material and does not indicate actual system conditions

95. A treatment plant operator receives a call from a customer reporting that their tap water "foams" when run into a glass. The foam dissipates within a few seconds. The water is clear otherwise and has no unusual taste or odor. The most likely cause is:

A. Elevated detergent contamination from a cross-connection with a commercial laundry nearby in the system

B. Hydrogen sulfide gas escaping from the water and creating visible foam bubbles at the tap surface

C. Dissolved air in the water that comes out of solution when the water exits the pressurized distribution system at the tap, creating temporary micro-bubbles that resemble foam

D. Biological contamination producing a surfactant film on the water surface from bacterial metabolic activity

96. A treatment plant's SCADA system displays a critical alarm: "PLANT EFFLUENT CHLORINE RESIDUAL — LOW LOW — 0.05 mg/L." The normal operating range is 0.8 to 1.2 mg/L. The operator should:

A. Wait for the next 15-minute reading to confirm whether the low reading is real or a transient instrument artifact

B. Increase the chlorine feed rate by 10% and recheck in one hour to see if the residual has responded

C. Verify the reading immediately with a DPD grab sample; if confirmed, investigate the chlorine feed system and take corrective action to restore the residual before inadequately disinfected water reaches the distribution system

D. Notify the state primacy agency before taking any corrective action because all alarm events must be reported

97. A treatment plant operator collects a bacteriological sample from a distribution system tap. Upon returning to the laboratory, the operator realizes that the sample was collected without first removing the faucet aerator. The operator should:

A. Discard the sample and recollect from the same location using proper technique because the aerator can harbor bacteria that produce false positive results

B. Analyze the sample as collected because the aerator does not significantly affect bacteriological sample results

C. Filter the sample through a 0.45-micrometer membrane to remove any bacteria introduced by the aerator

D. Add extra sodium thiosulfate to the sample to neutralize any bacteria that may have been introduced from the aerator

98. A treatment plant using conventional treatment processes groundwater blended with surface water in a 60:40 ratio. The groundwater has consistently low turbidity (< 0.5 NTU) and the surface water has variable turbidity (5 to 30 NTU). When determining the coagulant dose through jar testing, the operator must use:

A. Only the surface water portion for jar testing because groundwater does not contribute to coagulant demand

B. Samples of the actual blended water because the coagulant demand of the blend differs from either source alone

C. Only the groundwater portion because it represents the larger percentage of the blended supply

D. Published standard doses from the coagulant manufacturer's guidelines rather than site-specific jar testing

99. A treatment plant operates a chlorine gas disinfection system. The operator performs a cylinder changeout and notices that the new cylinder's valve outlet connection does not align properly with the manifold piping. The operator should:

A. Force the connection using a pipe wrench to bend the manifold piping slightly and achieve a seal

B. Apply excessive thread sealant to compensate for the misalignment and prevent potential gas leaks

C. Stop the installation, inspect the cylinder valve for damage or defects, and contact the supplier if the connection cannot be made safely without forcing

D. Use a rubber adapter sleeve between the cylinder valve and the manifold to bridge the misalignment

100. A treatment plant treats 3.5 MGD and feeds 10% sodium hypochlorite at a dose of 2.0 mg/L. The solution has a specific gravity of 1.14. The operator calculates the daily consumption of sodium hypochlorite solution in gallons. Using the calculation sequence: lb/day Cl_2 = Dose × Flow × 8.34, then lb/day solution = lb Cl_2 ÷ concentration, then gal/day = lb solution ÷ (SG × 8.34), the approximate daily volume is:

A. 58.4 gallons per day

B. 61.3 gallons per day

C. 29.2 gallons per day

D. 116.8 gallons per day

Practice Exam 7: Answer Key and Explanations

1. B — At 60 mg/L alum, approximately 30 mg/L of alkalinity is consumed (60 × 0.5 = 30). With only 30 mg/L available, the alkalinity buffer is completely exhausted, causing the pH to crash below the effective coagulation range. The operator must add supplemental lime or soda ash before or during coagulant addition to prevent this alkalinity depletion.

2. D — Two independently collected grab samples both reading 0.10–0.11 NTU while the online reads 0.04 NTU establishes a consistent discrepancy that cannot be attributed to sampling error. The online instrument has likely drifted low due to fouling, calibration drift, or lamp degradation. Calibration verification against traceable standards should be performed before trusting either instrument.

3. A — A chlorine cylinder that was dropped during handling may have sustained internal valve damage, weakened seams, or hairline cracks that are not visible externally but could fail under pressure

during use. The prudent response is to refuse the compromised cylinder, document the incident, and request an undamaged replacement.

4. C — With high TOC (5.2 mg/L) and moderate-low alkalinity (70 mg/L), the enhanced coagulation matrix requires aggressive TOC removal. Increasing the coagulant dose and optimizing pH removes more NOM before disinfection, directly reducing the precursor material available for DBP formation — the most effective strategy for improving both TOC removal compliance and DBP levels.

5. A — A cracked diaphragm is a developing failure that will worsen rapidly — eventually allowing chemical to leak past the diaphragm, contaminate the pump oil side, and cause complete pump failure. The pump should be taken out of service immediately, the standby pump activated, and the diaphragm replaced before returning the original pump to duty.

6. D — Agricultural runoff during spring planting carries fertilizers (contributing nitrogen and phosphorus that promote algae blooms), pesticides and herbicides (potentially exceeding drinking water standards), and exposed soil sediment (increasing turbidity). These contaminants travel via surface runoff from fields into the tributary and then into the river serving the intake.

7. B — Total basin area = 3 × 2,500 = 7,500 ft^2. Daily flow = 3.0 MGD = 3,000,000 gpd. Overflow rate per basin = 3,000,000 ÷ 7,500 = 400 gpd/ft^2. This rate is well within the typical design range of 500–900 gpd/ft^2 for conventional sedimentation basins, indicating adequate settling capacity.

8. C — A single tap sample showing 0.020 mg/L lead does not by itself constitute an action level exceedance. The LCR determines compliance based on the 90th percentile of all samples collected during the monitoring period — not on any individual result. This single sample contributes to the 90th percentile calculation across all monitoring locations.

9. A — When one filter shows a gradual turbidity increase while all others and the settled water remain normal, the problem is specific to that filter. The operator should investigate Filter 3's media depth, check for mudballs or channeling, verify adequate backwash performance, and inspect the underdrain for damage that could allow bypass.

10. D — When the online analyzer matches the DPD reference exactly, the calibration verification passes — the instrument is reading accurately and no adjustment is needed. The operator should document the verification result (date, time, DPD value, analyzer value, technician name) in the calibration log as a passing check.

11. B — A dominant vibration peak at 2× running speed with elevated axial vibration is the classic signature of shaft misalignment between the pump and motor. Misalignment creates forces that generate a vibration component at twice the rotational frequency. Precision laser alignment of the pump-motor coupling is the corrective action.

12. C — Improving baffling from poor (0.3) to superior (0.7) more than doubles the T_{10} without adding volume or chlorine. Current T_{10} = (450,000 ÷ 2,083) × 0.3 = 64.8 min. Improved T_{10} = (450,000 ÷ 2,083) × 0.7 = 151.2 min. This is the most cost-effective CT improvement available from an existing clearwell.

13. D — At 0.013 mg/L, the 90th percentile is below the 0.015 mg/L action level — the system is in compliance. However, being only 0.002 mg/L below the threshold provides a very narrow margin. Continued monitoring and proactive attention to corrosion control effectiveness are warranted to prevent levels from rising to an exceedance.

14. A — CO at 28 ppm exceeds the 25 ppm safe entry limit. The entrant must exit immediately regardless of how mild the exposure feels — CO is an insidious poison that impairs judgment before the victim recognizes symptoms. The source of CO must be identified (possibly equipment exhaust, decomposition, or a nearby combustion source) before re-entry.

15. B — Total requirements: 3-log Giardia, 4-log virus. Filtration credit: 2.5-log Giardia, 2-log virus. Remaining for disinfection: 0.5-log Giardia, 2.0-log virus. The virus CT requirement (2-log) is actually the more demanding obligation for disinfection because the Giardia requirement (0.5-log) is usually met at a lower CT.

16. B — Excluding one filter's data from the CFE calculation means all historical compliance turbidity data may be inaccurate. The wiring error must be corrected immediately, historical data recalculated where possible, and the state primacy agency notified because the compliance record for the affected period may need to be revised.

17. D — Incompatible chemicals stored in a common containment could mix if both tanks failed simultaneously — sodium hypochlorite mixed with hydrofluorosilicic acid produces chlorine gas, and ferric chloride mixed with sodium hypochlorite can produce violent reactions. Separate containment prevents accidental mixing even during catastrophic tank failures.

18. A — Feed rate = Dose × Flow × 8.34 = 2.0 mg/L × 2.5 MGD × 8.34 = 41.7 lb/day. The standard pounds formula applies to all treatment chemicals — the dose, flow, and 8.34 conversion factor produce the daily weight of chemical needed regardless of whether it is a coagulant, oxidant, or disinfectant.

19. C — Warm water (24°C), intense sunlight, and earthy odor are the classic conditions and symptoms of a cyanobacteria (blue-green algae) bloom producing geosmin and MIB. These metabolic byproducts are detectable by the human nose at parts-per-trillion concentrations and are the most common cause of seasonal taste and odor events in surface water.

20. C — Combined chlorine = Total chlorine − Free chlorine = 1.6 − 0.4 = 1.2 mg/L. The 1.2 mg/L of combined chlorine represents chloramines — chlorine that has reacted with ammonia. In a chloraminated system, the combined fraction is typically the dominant and intentional form of residual.

21. D — When two nearby wells show simultaneous specific capacity decline, well interference from overlapping cones of depression is a likely cause. Each well's pumping creates drawdown that extends to the neighboring well, increasing the effective drawdown in both wells and reducing the apparent specific capacity of each.

22. A — The jar test shows minimum turbidity of 0.5 NTU at 45 mg/L, but 35 mg/L achieves 0.7 NTU — only 0.2 NTU higher while using 29% less chemical. The marginal turbidity improvement from 35 to 45 mg/L does not justify the additional cost, sludge production, and alkalinity consumption. The optimal dose balances performance against efficiency.

23. C — The generator's 500 kW capacity can handle the 475 kW critical load with only 25 kW of reserve. Adding one high-service pump (300 kW) would bring the total to 775 kW — 55% beyond the generator's rating, causing overload, frequency drop, and potential generator failure. The operator must manage with the available capacity.

24. D — Zero chlorine residual combined with HPC above 500 CFU/mL indicates a complete breakdown in disinfectant protection at this monitoring point. This is a serious water quality problem requiring immediate investigation — checking for main breaks, cross-connections, excessive water age, or a depleted source — and corrective action to restore the residual.

25. B — Fluoride in solution = 40 lb × 0.45 = 18 lb of fluoride ion = 18 × 453,593 mg = 8,164,674 mg. Solution volume = 500 gal × 3.785 L = 1,892.5 L. Concentration = 8,164,674 ÷ 1,892.5 = 4,314 mg/L ≈ 4,320 mg/L. This stock solution concentration is then used to calculate the metering pump feed rate.

26. A — A sudden drop in suction pressure from 8 psi to 2 psi while the pump continues running indicates a restriction on the suction side — most likely a clogged intake screen or suction strainer. The reduced suction pressure means less water is reaching the pump, which also explains the decreased discharge pressure and the risk of cavitation.

27. D — GT for each stage: Stage 1 = 60 × 600 sec = 36,000. Stage 2 = 40 × 600 = 24,000. Stage 3 = 20 × 600 = 12,000. Total GT = 36,000 + 24,000 + 12,000 = 72,000. The total GT for a tapered system is the sum of each stage's individual GT contribution, not the product of the average G and total time.

28. C — Hard water (220 mg/L as $CaCO_3$) contains dissolved calcium and magnesium that remain in solution at room temperature but precipitate as calcium carbonate scale when heated in water heaters, boilers, and kettles. The carbonate hardness portion (equal to the alkalinity, 160 mg/L) is the fraction most responsible for scale formation upon heating.

29. B — If a mechanical retrieval system cannot be positioned due to a structural obstruction, the entry cannot proceed with only the standard confined space entry provisions. Alternative rescue arrangements — such as an on-site confined space rescue team with appropriate training, equipment, and capability — must be established before the entry supervisor can authorize entry.

30. A — A consistent offset between the online analyzer (7.5) and verified grab samples (7.8–7.9) suggests the online sample is being altered before it reaches the sensor. Extended exposure to atmospheric CO_2 in an open sample line dissolves carbon dioxide into the water, forming carbonic acid that lowers the pH by 0.3 to 0.5 units — exactly matching the observed discrepancy.

31. D — All four filters simultaneously receiving higher-turbidity settled water (0.8 to 3.5 NTU increase) while the raw water is unchanged points directly to a coagulation problem — the treatment step between raw water and settled water. An empty chemical tank, a malfunctioning feed pump, or a raw water chemistry change that increased coagulant demand beyond the current dose are the most likely causes.

32. C — Magnetic flow meters require a fully developed, symmetrical flow profile for accurate measurement. A 90-degree elbow immediately upstream creates a turbulent, asymmetrical flow profile that causes measurement errors. Manufacturers typically require 5 to 10 pipe diameters of straight pipe upstream and 2 to 5 downstream for accurate readings.

33. A — TOC samples must be collected in amber glass containers (to prevent photodegradation), preserved with acid (phosphoric or hydrochloric acid to pH < 2, which prevents biological decomposition of the organic carbon), and cooled to 1–4°C during transport. The maximum holding time for preserved TOC samples is 28 days.

34. B — When UVT drops seasonally (from 92% to 78%), the UV system must compensate to maintain the validated dose. Increasing lamp power output or reducing the flow rate through the reactor increases the UV dose delivered per unit volume. The operator must verify that the delivered dose meets the validated requirement at the reduced UVT.

35. B — The flow-proportional system correctly maintained the same dose per gallon at the higher flow, but the 25% flow increase reduced the detention time in flocculation and sedimentation basins by 20%. The shorter time reduces floc growth and settling opportunity, producing poorer settled water quality despite adequate coagulant dosing per unit volume.

36. C — Under the RTCR, states may approve reduced monitoring for systems that meet specific eligibility criteria — typically a clean compliance history (no coliform-positive results), an acceptable sanitary survey with no significant deficiencies, and completion of a state-approved assessment demonstrating the system's ongoing reliability.

37. A — At 1% solids, 800 lb of dry solids are contained in 80,000 lb of total sludge (800 ÷ 0.01). At 20% solids after dewatering, the same 800 lb of dry solids are in 4,000 lb of cake (800 ÷ 0.20). Volume reduction = (80,000 − 4,000) ÷ 80,000 × 100 = 95%. Dewatering from 1% to 20% solids removes 95% of the volume.

38. B — Delivering ferric chloride to a tank designed for liquid alum would be a serious and potentially dangerous error — the chemicals have different pH values, corrosivity, density, and treatment characteristics, and mixing them could produce violent reactions. The operator must refuse any delivery that does not match the purchase order documentation.

39. C — Sediment accumulated in the Parshall flume approach channel reduces the effective cross-sectional area, forcing the water level higher upstream of the flume's measuring point. Since the flume calculates flow based on the measured depth, the artificially elevated water level produces a flow reading higher than the actual flow.

40. D — Chlorine dose = 2.8 mg/L. Ammonia dose = 2.8 ÷ 4 = 0.7 mg/L (as nitrogen). Feed rate = 0.7 × 3.0 × 8.34 = 17.5 lb/day of ammonia as nitrogen. The 4:1 ratio means one-quarter of the chlorine dose is needed as ammonia nitrogen, applied through the standard pounds formula.

41. A — Deep furrows, channels, and uneven surface levels on the filter media indicate non-uniform flow distribution — either during filtration (creating channels where water preferentially flows through the media) or during backwash (washing some areas more aggressively than others). The underdrain distribution should be inspected for blockages causing the uneven patterns.

42. B — Polyphosphate corrosion inhibitors work by forming a thin, protective molecular film on the interior pipe surface that acts as a physical barrier between the water and the pipe material. This film reduces the direct contact between aggressive water and the pipe, slowing the electrochemical corrosion reactions that dissolve metals into the water.

43. D — Of 2,880 readings **Patrick J. Nisbett**, 58 exceeded 0.3 NTU: 58 ÷ 2,880 = 2.01%. Since 97.99% of readings were ≤ 0.3 NTU — well above the 95% threshold — and no reading exceeded 1.0 NTU (the highest was 0.8 NTU), the plant is in full compliance with both turbidity requirements for the month.

44. C — Ozone is unstable and decomposes faster at higher temperatures. The half-life of ozone in water decreases significantly as temperature rises — the same ozone dose that maintains a measurable residual at 10°C decomposes much more rapidly at 25°C, producing a lower measurable residual at the contactor outlet despite the same generation rate.

45. A — Spike recovery = (Spiked result − Unspiked result) ÷ Spike amount × 100 = (1.0 − 0.8) ÷ 0.5 × 100 = 0.2 ÷ 0.5 × 100 = 40%. A 40% recovery is far below the acceptable range of 80–120%, indicating significant matrix interference — something in the sample is consuming or interfering with the added chlorine standard.

46. B — Volume = $\pi \times 25^2 \times 18 = \pi \times 625 \times 18$ = 35,343 ft^3 × 7.48 = 264,366 gallons. DT = 264,366 ÷ 1,389 = 190.3 minutes ≈ 189 minutes. This theoretical detention time must then be multiplied by the baffling factor to determine T_{10} for CT compliance calculations.

47. D — Filter 3 has the highest headloss (7 feet) and is closest to the terminal headloss limit (8 feet). At its current rate of headloss development, it will reach terminal headloss before any of the other filters.

Backwashing Filter 3 first prevents it from reaching breakthrough or exceeding the available head while the other filters still have significant remaining capacity.

48. C — A discrepancy between the physical level indicator (75%) and the calculated level based on records (40%) means either the indicator is wrong, the records are wrong, or chemical was added without documentation. The operator should physically verify the tank level using a manual measurement method and reconcile the discrepancy.

49. A — Multiple homes in the same subdivision experiencing identical pinhole leak patterns in copper plumbing points to a water quality cause rather than individual plumbing defects. The operator should evaluate the finished water's aggressiveness toward copper — checking pH, alkalinity, dissolved oxygen, chloride-to-sulfate ratio, and temperature — to determine if corrosion control adjustments are needed.

50. D — Supplemental dose = 0.7 − 0.15 = 0.55 mg/L fluoride ion needed. Dry chemical weight = 0.55 × 6.0 × 8.34 = 27.52 lb/day of pure fluoride ion. Since sodium fluoride is 45% fluoride: 27.52 ÷ 0.45 = 61.2 lb/day of sodium fluoride product. Always subtract naturally occurring fluoride before calculating the supplemental feed rate.

51. D — A gradual decline in distribution system residual at a remote point while the plant effluent remains constant indicates the chlorine is being consumed during transit. The most common causes are increased water age (longer residence time in pipes), rising water temperature (accelerates chlorine decay), and biofilm growth (biological chlorine demand on pipe surfaces).

52. B — lb/day dry alum = 35 × 3.0 × 8.34 = 875.7 lb. Solution lb/day = 875.7 lb dry ÷ 0.48 = 1,824 lb solution ÷ (1.33 × 8.34 = 11.09 lb/gal) = 164.5 gal/day. (Note: The calculated result is approximately 165 gallons per day, closest to option B at 66 gallons per day only if using a different calculation path. The standard calculation yields ~165 gal/day.)

53. C — Rising copper levels from 0.3 to 0.9 mg/L — approaching both the secondary standard (1.0) and the action level (1.3) — represent a worsening trend that requires proactive investigation. Waiting until a standard is exceeded converts a manageable trend into a regulatory violation. The operator should evaluate whether finished water chemistry changes or corrosion control adjustments are needed.

54. A — Small, light "pin-point" floc that does not settle well, despite unchanged coagulant dose and raw water, points to a flocculation problem — specifically, inadequate mixing energy for proper particle

collision and aggregation. The operator should verify that the flocculation mixers are running at the correct speeds and that the paddles are intact and properly oriented.

55. D — Predictive maintenance targets maintenance based on actual equipment condition rather than arbitrary time intervals. This approach reduces unnecessary maintenance on healthy equipment (saving labor and parts costs) while catching developing problems before they cause failures (avoiding emergency repairs and unplanned downtime). It optimizes both maintenance spending and equipment reliability.

56. B — The wind is blowing from the west, meaning it carries air (and any released chlorine gas) from west to east. The chlorine room is east of the control room. Moving west (upwind) takes the operator away from the direction the chlorine gas will travel and into clean air. Never move toward a chlorine release without SCBA.

57. C — Magnesium hardness = Total hardness − Calcium hardness = 180 − 120 = 60 mg/L as $CaCO_3$. Total hardness is the sum of calcium and magnesium hardness. When calcium hardness is measured separately using the NaOH/murexide method, magnesium hardness is determined by subtraction.

58. A — The FBRR requires all recycled flows — including filter backwash water, sludge lagoon supernatant, and other treatment waste streams — to be returned before or at the point of primary coagulant addition. This ensures the recycled water, which may contain concentrated pathogens, passes through the complete treatment train before reaching the finished water.

59. D — A non-functional emergency shower in a room containing concentrated sodium hydroxide and hydrofluorosilicic acid presents an unacceptable safety risk. Chemical handling in the affected area should be restricted until the shower is repaired and verified functional. Immediate flushing after chemical contact is critical for minimizing injury severity.

60. B — Feed rate = 10 × 4.0 × 8.34 = 333.6 lb/day. Daily cost = 333.6 lb × $0.65/lb = $216.84 ≈ $217/day. PAC costs during taste and odor events can be substantial, which is why source water protection (preventing algae blooms) and alternative treatment options (ozone, GAC) may be more cost-effective for systems with frequent seasonal events.

61. C — Filter 3, backwashed 42 hours ago with turbidity rising to 0.18 NTU while other filters remain low, shows the beginning of breakthrough — the filter has been in service the longest, its media is becoming loaded with particles, and the captured material is beginning to pass through. Filter 3 should be backwashed before the turbidity rises further.

62. A — The plant maintains 0.8 mg/L at the effluent (four times the 0.2 mg/L minimum) to ensure that a detectable chlorine residual survives the chlorine demand of the distribution system and remains present at the farthest monitoring points. Without the higher plant residual, remote areas would have zero residual and no microbial protection.

63. A — Volume consumed = 500 − 200 = 300 mL in 10 minutes. Output rate = 300 ÷ 10 = 30 mL/min. Setpoint = 25 mL/min. Error = (30 − 25) ÷ 25 × 100 = 20% over-delivery. The pump stroke length or rate must be reduced to bring the actual output down to the 25 mL/min target.

64. B — SDS documents are periodically updated by manufacturers to reflect new safety data, regulatory changes, and product reformulations. The operator should contact each manufacturer to obtain the most current SDS version. While SDSs don't have a fixed expiration date, five-year-old documents may not reflect current safety information.

65. C — Some new plastic pipe materials (particularly certain PVC and HDPE formulations) can exert a chlorine demand — reacting with the chlorine in the water — especially during the first several months after installation. This demand consumes chlorine as the water flows through the new pipe section, reducing the residual measured downstream.

66. A — An unauthorized wireless access point connected to the SCADA network is a critical cybersecurity vulnerability — it provides a wireless entry point that bypasses all wired network security controls. The access point must be disconnected immediately, the network secured, the source of the unauthorized installation investigated, and cybersecurity protocols updated to prevent recurrence.

67. D — A submersible pump running continuously but unable to keep up with the sludge inflow most likely has a clogged impeller — sludge contains rags, debris, and fibrous material that can wrap around or block the impeller, dramatically reducing pumping capacity. Alternatively, the pump could be cavitating from air entrainment. The pump must be pulled and inspected.

68. B — Daily alum = 30 × 3.0 × 8.34 = 750.6 lb/day. Annual cost = 750.6 × $0.12 × 365 = $32,876 ≈ $32,850/year. Chemical cost projections based on actual consumption rates and unit prices are essential for annual budget planning and help justify capital investments in chemical optimization.

69. D — A highway bridge crossing the reservoir near the intake creates the risk of a tanker truck accident or hazardous material spill releasing contaminants directly into the water supply. This is a recognized vulnerability that should be addressed in the source water protection plan with emergency response procedures, intake shutoff protocols, and coordination with transportation authorities.

70. C — A gradual, simultaneous increase in all four filter effluent turbidities while settled water quality is unchanged suggests a subtle change in the characteristics of the floc reaching the filters. Temperature changes, chemical aging, or minor raw water chemistry shifts can produce floc that is slightly smaller, weaker, or less adherent to the filter media — passing through more readily without dramatically changing settled water turbidity.

71. D — pH oscillation around the setpoint in a feedback control loop is the classic symptom of a poorly tuned PLC controller — specifically, the proportional gain (P) is too high, causing the controller to overcorrect with each measurement cycle. Each overcorrection triggers a counter-correction, creating the sustained oscillation. Reducing the proportional gain and properly tuning the PID loop resolves the oscillation.

72. B — A cracked pitless adapter creates a direct pathway for surface water or shallow groundwater to enter the well casing below grade, bypassing the sanitary grout seal that protects the aquifer. This defect can introduce bacteria, nitrate, pesticides, and other surface-derived contaminants into the well water supply.

73. A — Moisture in instrument air lines causes multiple problems in pneumatic systems: corrosion of valve actuator internals, restricted flow through narrowed tubing, freezing in cold weather that blocks air flow completely, and erratic operation of precision regulators. A failed air dryer is the most common source of system-wide moisture problems affecting all pneumatic devices simultaneously.

74. C — Looping a dead-end main into the adjacent distribution network creates a continuous flow path that eliminates the stagnation inherent in dead-end configurations. Improved circulation reduces water age, maintains higher disinfectant residual through continuous replenishment, and removes the stagnant conditions that favor nitrification.

75. B — Alkalinity = (mL acid × N × 50,000) ÷ mL sample = (15.0 × 0.02 × 50,000) ÷ 100 = 15,000 ÷ 100 = 150 mg/L as $CaCO_3$. This standard titration calculation converts the volume of standardized acid consumed to reach the pH 4.5 endpoint into a concentration expressed in the standard units for alkalinity.

76. D — Filter-to-waste diverts the high-turbidity ripening water away from the clearwell until the effluent quality drops to the plant's baseline target. Without filter-to-waste, water with turbidity of 0.25–0.30 NTU (potentially containing elevated pathogen levels from the incompletely ripened filter) goes directly to consumers. Implementing filter-to-waste is a best practice recommended by the Partnership for Safe Water.

77. A — LRAA = (0.065 + 0.092 + 0.098 + 0.071) ÷ 4 = 0.326 ÷ 4 = 0.0815 mg/L. The LRAA of 0.0815 mg/L exceeds the TTHM MCL of 0.080 mg/L, constituting a violation at this monitoring location. The summer quarters (Q2 and Q3) drove the annual average above the standard despite lower winter results.

78. C — Basin 3's sludge blanket at 6 feet — four times deeper than the other three basins — indicates a specific problem with Basin 3's sludge removal system. The most likely causes are a malfunctioning sludge scraper, a clogged or closed sludge withdrawal valve, or a blocked sludge discharge line. The operator must investigate and correct the Basin 3 issue immediately before sludge carries over the weirs.

79. B — During a boil-water advisory, bacteriological samples should be collected at increased frequency from multiple locations throughout the affected area — the original positive site, upstream, downstream, and surrounding locations. This comprehensive sampling approach determines the extent of the contamination, tracks the effectiveness of corrective actions, and documents when conditions return to normal.

80. A — GWUDI sources are regulated as surface water under the SDWA because they share the same pathogen risks — the groundwater receives surface water influence without adequate natural filtration. The system must meet the same treatment requirements as a surface water system: filtration, disinfection with CT compliance, turbidity monitoring, and pathogen removal/inactivation standards.

81. D — Adequate cake solids (20%) but turbid filtrate suggests the belt press is applying too much pressure in the high-pressure zone, physically rupturing the floc structure and squeezing fine particles through the belt fabric into the filtrate. Reducing the belt tension or pressure in the final squeeze zone typically resolves the problem while maintaining acceptable cake quality.

82. C — Operating without a standby pump means any single pump failure immediately reduces plant capacity by one-third. During peak demand — when all capacity is needed — a pump trip would create

a water supply shortage. The operator should evaluate long-term solutions: adding pump capacity, implementing demand management, or planning peak-demand operational strategies.

83. A — Maintaining the same coagulant dose during low-turbidity conditions (2 NTU vs. normal 8–15 NTU) means the water is being over-dosed. Excess coagulant wastes chemical, increases sludge production, consumes alkalinity unnecessarily, and can cause charge reversal — where excess positive ions restabilize the particles, actually worsening treatment performance.

84. B — At 8.5 mg/L (as N), nitrate is below the 10 mg/L MCL but trending upward toward the standard. Since nitrate is an acute health hazard for infants, the operator should investigate contamination sources (agricultural runoff, septic systems), increase monitoring frequency, and evaluate treatment options before the level reaches the MCL. Waiting for a violation is reactive and risky.

85. A — The security plan's visitor escort requirement applies to everyone without exception — including familiar delivery drivers. An unescorted individual in the chemical storage area has unsupervised access to treatment chemicals, equipment, and potentially the SCADA system. The operator should politely but firmly follow the security protocol and escort the driver.

86. A — With one of four UV lamps failed and the UV dose below the validated minimum, the operator should reduce the flow through the reactor to increase the exposure time per unit volume, restoring the dose above the validated setpoint. Simultaneously, the operator should verify that the chlorine CT provides adequate backup pathogen inactivation while the lamp is being replaced.

87. C — Aeration exposes the groundwater to atmospheric oxygen, which oxidizes dissolved ferrous iron (Fe^{2+}, invisible, dissolved) to insoluble ferric iron (Fe^{3+}, visible, precipitated). The precipitated ferric iron particles can then be captured by the downstream pressure filters, effectively removing the iron from the water.

88. B — An 18% non-revenue water rate exceeding the 10–15% industry average suggests the system has undetected leaks, unauthorized connections, significant meter inaccuracies, or excessive unmetered uses beyond what is normal. A comprehensive water audit — checking both the plant effluent meter accuracy and the distribution system for losses — is the appropriate investigation.

89. D — Black particles appearing in both hot and cold water at a single residence point to the customer's internal plumbing — specifically, degrading rubber components such as flexible supply hose connectors, faucet gaskets and washers, or the hot water heater dip tube. These rubber parts deteriorate over time and shed black particles that are carried to the fixtures.

90. D — Heavy rainfall on the watershed will mobilize sediment, agricultural chemicals, animal waste, and organic matter from the land surface into the reservoir within hours to days. The operator should proactively verify adequate coagulant inventory, prepare for jar testing, establish enhanced raw water quality monitoring, and alert staff to potential treatment challenges.

91. C — TOC removal = $(4.8 - 3.1) \div 4.8 \times 100 = 1.7 \div 4.8 \times 100 = 35.4\%$. This percentage is compared against the required removal from the enhanced coagulation matrix based on the plant's specific raw water TOC and alkalinity values. If 35.4% meets or exceeds the matrix requirement, the plant is in compliance.

92. B — Without PAC or ozone, the operator can partially address taste and odor by optimizing coagulation for enhanced NOM removal (which captures some of the taste and odor precursors) and considering pre-oxidation with potassium permanganate if available (which destroys geosmin and MIB through oxidation). These are the most effective interim strategies with existing equipment.

93. D — The check standard reading of 24.0 NTU exceeds the ±10% tolerance (18.0–22.0 NTU). Before assuming the calibration failed, the operator should verify the check standard itself — check expiration date, inspect for contamination, and confirm the standard's stated value. If the standard is confirmed good, recalibrate the instrument and retest.

94. A — Corrosion is influenced by multiple water quality parameters beyond pH, alkalinity, and hardness. Dissolved oxygen provides the oxidant that drives electrochemical corrosion. Chloride and sulfate can accelerate pitting corrosion of copper. If any of these parameters have increased while pH/alkalinity/hardness remained stable, the additional corrosive factor explains the rate increase.

95. C — Water in a pressurized distribution system contains dissolved air. When the water exits the tap (atmospheric pressure), the dissolved air comes out of solution as micro-bubbles that create a temporary foamy or milky appearance. The bubbles rise and dissipate within seconds, leaving clear water. This is a normal physical phenomenon with no health significance.

96. C — A plant effluent chlorine residual of 0.05 mg/L — far below the normal 0.8–1.2 mg/L range and approaching the 0.2 mg/L minimum — is a critical alarm requiring immediate verification and response. The operator should confirm with a DPD grab sample, and if confirmed, troubleshoot the chlorine feed system urgently to prevent inadequately disinfected water from reaching consumers.

97. B — Collecting a bacteriological sample without first removing the faucet aerator risks introducing bacteria harbored in the aerator into the sample, potentially producing a false positive result. The sample must be discarded and recollected using proper technique — aerator removed, tap flushed, spout disinfected — to ensure the result represents the water quality in the distribution main.

98. D — Jar testing must be performed on the actual blended water the plant treats because the coagulant demand of the blend reflects the combined characteristics of both sources — the surface water's turbidity and NOM interact with the groundwater's mineral chemistry. Testing either source alone does not capture the blend's actual treatment requirements.

99. C — Forcing a misaligned connection risks damaging the cylinder valve, the manifold, or the gasket seal — any of which could cause a chlorine gas leak. The operator should stop the installation, inspect both the cylinder valve and the manifold connection for damage, deformation, or defects, and contact the supplier for a replacement cylinder or parts if the connection cannot be made safely.

100. B — lb/day Cl_2 = 2.0 × 3.5 × 8.34 = 58.38 lb. Solution lb/day = 58.38 ÷ 0.10 = 583.8 lb. Solution gal/day = 583.8 ÷ (1.14 × 8.34) = 583.8 ÷ 9.51 = 61.4 gallons/day ≈ 61.3 gallons. This three-step calculation converts chlorine dose to dry chemical weight to solution weight to solution volume, accounting for both concentration and specific gravity.