# PRACTICE EXAM 9: WPI/ABC WATER DISTRIBUTION OPERATOR SIMULATION (100 QUESTIONS)

1. A water system operates a 750,000gallon elevated tank with a bowl diameter of 55 feet. SCADA shows the tank level dropping at 2.5 feet per hour during the evening peak. Approximately how many gallons per hour is the zone drawing from the tank?

A. 2,500 gallons per hour based on the drop rate multiplied by the tank height

B. 17,761 gallons per hour based on converting the drop rate directly to gallons

C. 44,384 gallons per hour, calculated by multiplying the bowl area ($0.785 \times 55^2 = 2{,}376$ sq ft) by 2.5 feet, then converting to gallons (5,940 cu ft × 7.48)

D. 5,940 gallons per hour based on the cubic foot volume without converting to gallons

2. An operator performing a routine valve exercising round discovers a 12inch butterfly valve that turns freely with almost no resistance and produces no change in flow or pressure when rotated from fully open to fully closed. What does this indicate?

A. The valve disc has detached from the shaft and remains stationary regardless of shaft rotation, rendering the valve completely inoperable

B. Butterfly valves naturally offer very low resistance due to their quarterturn design

C. The valve has been previously exercised recently and is welllubricated

D. The valve is installed on a section of main that is currently out of service with no water flowing

3. A water system's crossconnection control program inspector finds that a commercial greenhouse has a direct connection between the potable supply and a fertigation system that injects liquid fertilizer directly into the irrigation lines. The only protection is a single check valve. What corrective action is required?

A. Add a second check valve to create a double check valve assembly at the point of connection

B. Install a pressure vacuum breaker upstream of the fertigation injection point

C. The single check valve is adequate as long as it is tested annually by a certified tester

D. Install an RPZ assembly because the fertigation system injects chemical fertilizer under pressure into the water, creating a highhazard crossconnection with backpressure potential

4. A pump station's lead pump has been running continuously for 72 hours without cycling off. The system normally cycles the lead pump every 46 hours based on tank level. What does the continuous operation indicate?

A. The pump has achieved optimal equilibrium between production and demand

B. System demand has increased beyond the lead pump's capacity to fill the tank — the pump runs continuously trying to keep up, but the tank level is likely declining or stagnating rather than cycling normally

C. The SCADA control system has locked the pump in the "on" position due to a programming error

D. The lag pump has failed, forcing the lead pump to operate continuously to compensate

5. An operator is planning a main shutdown to replace a leaking gate valve on a 10inch main. The shutdown will affect approximately 150 customers for an estimated 6 hours. What notifications and preparations should be completed before the shutdown?

A. No notification is required for planned shutdowns that affect fewer than 200 customers

B. Notify only commercial customers because residential customers can manage without water for 6 hours

C. Post a notice on the utility's website 24 hours before the shutdown and rely on customers to check the site

D. Notify all affected customers at least 48 hours in advance using direct notification (door hangers, automated calls, or mailings), notify critical customers individually, and coordinate with the fire department regarding reduced fire flow during the shutdown

6. An operator measures pressure at a fire hydrant and reads 58 psi static. During a flow test, the hydrant produces 1,100 GPM with a residual pressure of 35 psi at the test hydrant. What is the pressure drop per GPM of flow?

A. 0.021 psi per GPM, calculated by dividing the 23 psi drop by the 1,100 GPM flow — although this linear relationship is approximate because the actual pressureflow relationship follows a power curve

B. 23 psi per GPM based on the total pressure drop

C. 0.032 psi per GPM based on the residual pressure divided by the flow

D. 58 psi per GPM based on the static pressure divided by the flow

7. A distribution system serves an area where the soil is classified as severely corrosive (resistivity below 1,000 ohmcm, high chloride, low pH). The utility installs new ductile iron mains with polyethylene encasement. What additional corrosion protection should be considered in these extreme conditions?

A. Painting the pipe exterior with an additional layer of epoxy before installing the polyethylene wrap

B. Using thicker polyethylene wrap (12 mil instead of 8 mil) to provide more robust protection

C. Installing cathodic protection (sacrificial anodes or impressed current) in addition to the polyethylene encasement to provide active electrochemical protection against corrosion

D. Wrapping each pipe joint with duct tape as an additional moisture barrier

8. A water operator discovers that the utility's emergency response plan has not been updated in five years. During that time, three new wells have been added, a new booster station was constructed, and the SCADA system was upgraded. Why is this a significant deficiency?

A. Emergency response plans only need updating when a regulatory audit is scheduled

B. The plan no longer reflects the actual system configuration, available resources, or current procedures — in an emergency, operators may follow outdated procedures that reference equipment no longer in service or may not know about new assets that could help respond to the event

C. The age of the plan is irrelevant because the basic emergency response principles never change

D. The plan is only used for tabletop exercises and does not need to match the actual system

9. A distribution system operator calculates the detention time of a 200,000gallon groundlevel storage tank that serves a zone with an average demand of 500 GPM. What is the theoretical turnover time, and what operational significance does it have?

A. Approximately 6.7 hours (200,000 ÷ 500 ÷ 60), meaning the entire tank volume theoretically turns over less than 4 times per day — shorter turnover maintains fresher water with better residual and fewer DBPs

B. 200 hours based on dividing the tank volume by the flow rate in GPH

C. 400 minutes based on dividing gallons by GPM, which equals approximately 28 hours

D. Turnover time cannot be calculated without knowing the tank's exact dimensions

10. A newly hired distribution operator asks why the utility performs annual fire hydrant flow tests at specific locations throughout the system rather than just testing a random sample. What is the best explanation?

A. Flow tests at random locations are actually preferred because they eliminate testing bias

B. Annual flow tests are only required for hydrants installed within the past five years

C. Specific hydrant locations are tested annually to satisfy the fire department's training requirements

D. Specific locations are tested to monitor hydraulic trends over time — consistent data from the same hydrants year after year reveals whether the system's carrying capacity is improving, stable, or declining, providing early warning of deteriorating infrastructure

11. A water system using chloramines discovers that monochloramine residual at a distant monitoring point has dropped from the typical 2.5 mg/L to 0.8 mg/L over the past two weeks. Simultaneously, nitrite levels have increased from nondetect to 0.12 mg/L. Water temperature is 72°F. What is occurring?

A. A chemical spill has introduced nitrogen compounds into the distribution system from an external source

B. Nitrification is occurring — warm water temperatures have promoted the growth of ammoniaoxidizing bacteria that are converting the ammonia released from chloramine decay into nitrite, simultaneously depleting the chloramine residual

C. The treatment plant has reduced the ammonia feed, causing the chloramine to degrade into free chlorine

D. The declining residual and rising nitrite are unrelated events that coincidentally occurred at the same time

12. A water system's operator is asked to calculate the approximate weight of water stored in an elevated tank that contains 500,000 gallons. Why does the structural engineer need this information?

A. The weight of water determines the chlorine dose needed to disinfect the tank

B. The weight is needed to calculate the pump horsepower required to fill the tank

C. The tank structure, foundation, and support columns must be designed to support approximately 4,170,000 pounds of water (500,000 × 8.34), plus the weight of the tank itself — structural failure from inadequate load capacity would be catastrophic

D. The weight determines the maximum fill rate that prevents structural stress on the tank

13. An operator arrives at a pump station and immediately notices an unusual chemical odor. The station houses two centrifugal pumps, a sodium hypochlorite storage tank, and a chemical feed system. What should the operator do first?

A. Stop at the entrance, assess the situation for potential chemical release, and if a chemical leak or spill is suspected, do not enter the room until the space is ventilated and the source of the odor is identified — personal safety takes priority over all other operational concerns

B. Enter the station and check the sodium hypochlorite tank level to determine if a spill has occurred

C. Call the supervisor to report the odor and wait for instructions

D. Put on safety glasses and gloves, then enter to investigate the source of the chemical odor

14. A distribution system serves a large apartment complex that has a master meter and an internal booster pump system that pressurizes a rooftop tank. The building's fire sprinkler system also connects to the potable supply with chemical additives for corrosion prevention. How many backflow concerns exist at this property?

A. One — only the fire sprinkler system with chemical additives requires backflow prevention

B. None, because the master meter provides adequate separation between the building and the municipal supply

C. Three — the master meter connection, the rooftop tank, and the fire sprinkler system each require individual assessment

D. At least two — the booster pump system creates backpressure potential on the service, and the fire sprinkler system with chemical additives is a highhazard crossconnection, each requiring appropriate protection

15. A water system operator calculates that a 16inch main carries 2,800 GPM during peak demand. What is the velocity, and does it exceed normal operating limits?

A. 1.4 fps, which is well below the minimum recommended velocity of 2 fps

B. 4.5 fps, which is within the acceptable 25 fps range for normal distribution system operation

C. 9.0 fps, which exceeds the maximum safe velocity and indicates the main is undersized

D. 2.25 fps, which is at the low end of the acceptable range and may allow some sediment settling

16. During a new water main installation, the contractor completes the bedding, installs the pipe, and begins backfilling. The inspector notices that the contractor is using excavated native material (a mix of large rocks and clay) as the initial backfill directly around the pipe. The specifications require select granular backfill to a height of 12 inches above the pipe crown. Why is this requirement important?

A. Granular backfill improves the thermal insulation of the pipe, preventing freezing in winter

B. The select backfill creates a permeable zone that allows groundwater to drain away from the pipe

C. Select granular backfill provides uniform support around the pipe, prevents point loading from rocks that can damage coatings or crack pipe, and allows proper compaction — native material with large rocks creates voids and concentrated stress points

D. The select backfill requirement is a cosmetic specification that does not affect pipe performance

17. A water system has experienced three consecutive months of total coliformpositive routine samples at monitoring site #8. Each month, the repeat samples have been negative. Under the Revised Total Coliform Rule, what level of assessment has been triggered?

A. A Level 1 Assessment is triggered after a single total coliformpositive routine sample (if the system has not already had one in the past 12 months), and after three months of positives at the same site, the utility should investigate the specific conditions at site #8 even if formal Level 2 criteria have not been met

B. No assessment is required because the repeat samples were negative each month

C. A Level 2 Assessment requiring comprehensive evaluation of the entire system from source to tap

D. A Level 3 Assessment requiring a stateconducted inspection is mandatory after three consecutive months

18. An operator is asked to explain why a booster pump station needs a pressure relief valve on its discharge piping. Under what condition would the relief valve activate?

A. The relief valve activates when the pump starts, to reduce the startup pressure surge

B. The relief valve activates when the suction pressure drops below a minimum threshold

C. The relief valve activates when downstream demand drops to zero, to prevent dangerously high pressure

D. If a downstream valve is closed while the pump continues to run (deadheading), or if a surge event creates pressure above the system's design rating, the relief valve opens to discharge excess pressure and prevent pipe or equipment damage

19. A customer's firstdraw lead sample shows 0.028 mg/L — nearly double the action level of 0.015 mg/L. The system's corrosion control treatment is optimized with pH at 7.8 and orthophosphate at 1.2 mg/L. The customer's home was built in 1955 and has a confirmed lead service line. What is the most effective longterm solution?

A. Continue the current corrosion control treatment and retest the customer's water in 6 months

B. Replace the lead service line — the service line is the primary source of lead exposure, and while corrosion control treatment reduces lead leaching, it cannot eliminate it; physical removal of the lead pipe permanently eliminates the exposure pathway

C. Install a pointofuse carbon filter at the customer's kitchen tap

D. Increase the orthophosphate dose to 2.0 mg/L systemwide to better protect this customer

20. A distribution system operator is investigating why a specific pressure zone consistently has lower chlorine residuals than the rest of the system. The zone is served by a booster pump station with no onsite chlorination. Water enters the zone through a PRV from a higherpressure zone. What operational change would most directly improve residuals in this zone?

A. Replace the PRV with a larger model that reduces friction loss through the valve

B. Increase the pump station discharge pressure to push water through the zone faster

C. Install a booster chlorination system at the pump station or PRV station to add chlorine as the water enters the zone, compensating for the residual lost during transit from the treatment plant

D. Reduce the zone's operating pressure to slow the flow and reduce chlorine demand

21. A water utility's AMI system detects a customer whose consumption has increased from 5,000 gallons per month to 45,000 gallons per month over the past billing period. The customer has not reported any problems. What should the utility do?

A. Wait for the customer to receive their bill and contact the utility with questions

B. Proactively contact the customer to alert them to the unusually high consumption, which likely indicates a significant leak on the customer's side of the meter — this proactive notification can save the customer from an enormous water bill and prevent further water waste

C. Adjust the customer's bill to reflect the average of the previous 12 months

D. Send a technician to replace the meter because the dramatic increase indicates a meter malfunction

22. A water system's operator is performing a routine inspection of a groundlevel welded steel storage tank. During the exterior inspection, the operator notices several areas where the exterior paint is peeling and rust is visible on the steel beneath. What is the concern?

A. The peeling paint is a cosmetic issue that should be addressed during the next scheduled painting cycle

B. The rust will contaminate the stored water by penetrating through the full thickness of the tank wall

C. The peeling paint indicates that the tank was painted with the wrong type of paint

D. External corrosion that is left untreated will progressively attack the steel, thinning the wall over time — eventually, the corrosion can penetrate the full wall thickness causing leaks, or weaken the structure enough to cause catastrophic failure

23. An operator is calculating the chlorine demand of a new well. The operator applies a chlorine dose of 3.0 mg/L and measures the residual after 30 minutes of contact time at 1.1 mg/L. What is the chlorine demand, and what does this tell the operator about the well water?

A. The chlorine demand is 1.9 mg/L (dose minus residual), indicating the well water contains substances that react with and consume chlorine — such as iron, manganese, hydrogen sulfide, or organic matter — and the operating dose must exceed 1.9 mg/L to maintain any residual

B. The chlorine demand is 1.1 mg/L, equal to the measured residual

C. The chlorine demand is 3.0 mg/L, equal to the full applied dose

D. The chlorine demand is 4.1 mg/L, calculated by adding the dose and residual

24. A water utility receives a complaint from a homeowner that their water pressure pulsates — cycling between strong and weak flow every 10 to 15 seconds. The pulsation occurs at every fixture in the house. No other customers on the same main are affected. What is the most likely cause?

A. A PRV on the customer's street is hunting and creating pressure fluctuations for all nearby customers

B. The customer's water heater is creating thermal pressure surges that pulsate through the entire house

C. The customer has a waterlogged pressure tank on their private well or booster pump system — when the air cushion in the tank is lost, the pump cycles rapidly between its on and off pressure settings, creating the pulsating flow pattern

D. A partially closed curb stop is creating turbulence that pulsates the flow at the customer's meter

25. A distribution system operator is asked why the utility tests the accuracy of customer water meters periodically rather than assuming they remain accurate throughout their service life. What is the correct explanation?

A. Meter accuracy is guaranteed by the manufacturer for the life of the meter and testing is only done for customer complaints

B. Water meters contain mechanical components that wear over time from continuous water flow — moving parts like discs, impellers, and magnets gradually degrade, causing the meter to increasingly underregister consumption and lose revenue for the utility

C. Meters are tested solely to verify that they are not overregistering and overcharging customers

D. Testing is performed only to satisfy the requirements of the state public utility commission

26. A pump station has a 150horsepower motor driving a centrifugal pump. The operator measures the motor amperage and finds all three phases drawing within 2% of each other and within 5% of nameplate rating. What does this indicate?

A. The motor is operating normally — balanced phase currents near nameplate rating indicate the motor is properly loaded, the electrical supply is balanced, and no significant electrical or mechanical problems exist

B. The motor is overloaded because it is drawing more than 100% of nameplate current

C. The 2% imbalance between phases indicates a developing electrical fault that requires investigation

D. The motor is significantly underloaded and should be replaced with a smaller, more efficient unit

27. A water system's distribution mains include a section of 24inch prestressed concrete cylinder pipe (PCCP) installed in 1975. The utility has heard reports of PCCP failures in other parts of the country. What inspection technology is specifically designed for assessing the condition of PCCP?

A. Standard closedcircuit television (CCTV) inspection that visually examines the pipe interior

B. Acoustic emission testing that listens for sounds of active wire breaks in the prestressing strands

C. Groundpenetrating radar (GPR) that scans the soil around the pipe for voids caused by leaks

D. Electromagnetic inspection technology that detects broken prestressing wires within the pipe wall by measuring changes in the electromagnetic field as a sensor is pulled through the pipe

28. A distribution system operator is investigating a report of low pressure at a commercial building. The operator finds that the building is served by a 4inch service line connected to a 12inch main. The main pressure at the nearest hydrant reads 62 psi. The pressure at the building's master meter reads 30 psi. What should the operator investigate?

A. Whether the 12inch main has severe tuberculation that is restricting flow to the building

B. Whether a larger pump station is needed to boost pressure to this area of the distribution system

C. The 32 psi pressure drop between the main and the meter indicates a significant restriction in the 4inch service line — possibly a partially closed corporation stop, curb stop, or valve, a crushed or tuberculated service line, or a clogged meter strainer

D. Whether the building's internal plumbing is creating excessive demand that depletes the pressure

29. A water system's treatment plant operator reports that the raw water turbidity has spiked to 50 NTU due to a heavy rainfall event that disturbed the source water reservoir. The plant's filters are struggling to maintain 0.3 NTU in the finished water. What should the distribution system operator prepare for?

A. The distribution operator should monitor residuals closely and prepare for possible turbidity breakthrough — if the plant cannot maintain the required turbidity limits, turbid water may enter the distribution system, increasing chlorine demand, reducing residual, depositing sediment in mains, and potentially requiring flushing of affected areas

B. No distribution system impact is expected because the treatment plant's filters will remove all turbidity

C. The distribution operator should immediately begin flushing the entire system to clear any turbidity

D. The distribution operator should reduce system pressure to prevent turbid water from reaching customers

30. An operator measures the static water level in a well at 45 feet below ground and the pumping water level at 92 feet below ground while the well produces 350 GPM. Six months later, the same measurements show static at 45 feet, pumping level at 105 feet, and production at 350 GPM. What has changed?

A. The pump has developed a mechanical problem that is reducing its efficiency

B. The well's specific capacity has declined — the increased drawdown (47 to 60 feet) at the same flow rate indicates the well screen, gravel pack, or formation has become partially blocked, requiring more drawdown to produce the same flow

C. The aquifer's static water level has dropped significantly between the two measurements

D. The pump has been replaced with a highercapacity unit that creates more drawdown

31. A water utility is evaluating the costeffectiveness of its leak detection program. Last year, the utility spent $85,000 on leak detection and found 35 leaks with a combined estimated loss of 180 GPM. If all leaks are repaired, what is the approximate annual water savings?

A. 180 gallons per year based on the GPM rate

B. 259,200 gallons per year based on converting GPM to gallons per day

C. 94,608,000 gallons per year based on converting 180 GPM to gallons per year only

D. 94,608,000 gallons per year — calculated as 180 GPM × 1,440 min/day × 365 days = 94.6 million gallons per year; at a typical production cost of $3/1,000 gallons, the annual savings is approximately $284,000, far exceeding the $85,000 survey cost

32. A distribution system has experienced an unusual pattern of customer complaints — six homes on the same street report simultaneous toilet flapper failures, three hot water heaters on the block have developed pinhole leaks within the same month, and two customers report green staining on new porcelain fixtures. What common water quality condition could explain all these problems?

A. High chlorine residual that is degrading rubber components and corroding metal surfaces

B. Elevated turbidity from the treatment plant that is clogging fixtures and causing erosion

C. Aggressive water with low pH and/or low alkalinity that is corroding copper plumbing (causing green staining and pinhole leaks) and degrading rubber components like toilet flappers

D. High water pressure that is stressing plumbing fixtures and causing premature failure

33. An operator is calibrating a chemical metering pump that feeds sodium hypochlorite. The calibration procedure involves collecting the pump's output in a graduated cylinder for a measured time period. The operator collects 485 mL in 60 seconds. What is the pump output in gallons per hour?

A. 29.1 mL per hour based on dividing the volume by the time in minutes

B. 7.69 gallons per hour, calculated by converting 485 mL/min to gallons/min (485 ÷ 3,785 = 0.1281 GPM) then multiplying by 60 minutes per hour

C. 0.128 gallons per hour based on converting only the perminute volume without the hourly multiplication

D. 485 gallons per hour based on assuming 1 mL equals 1 gallon

34. A water system's SCADA system displays a "communication failure" alarm for a remote elevated storage tank. The tank has a level transmitter, an overflow alarm, and a temperature sensor, all transmitting via a cellular modem. The alarm indicates the cellular link has been lost. What is the immediate operational concern?

A. The utility has lost realtime knowledge of the tank's water level — without level data, the pump station cannot respond appropriately to demand changes, and the tank could overflow or drain completely without the operator's knowledge

B. The temperature sensor data loss will cause the chlorine residual to decay faster

C. The overflow alarm cannot communicate, but this is only a concern during rainy weather

D. Communication failures are routine with cellular links and no immediate concern exists

35. A water system's operator discovers that a construction crew has connected a temporary construction water supply from a fire hydrant to a 5,000gallon tank at their site. The connection uses a 2inch hose with no backflow prevention device and no meter. The tank is used to mix concrete. What violations has the contractor committed?

A. Only the lack of a meter is a violation — temporary construction connections do not require backflow prevention

B. Only the lack of backflow prevention is a violation — temporary construction connections do not require meters

C. The contractor has not committed any violations because temporary construction connections are exempt from all requirements

D. Multiple violations — unmetered water use (theft of service), lack of backflow prevention on a connection to a tank containing concrete chemicals (creating a crossconnection), and potentially connecting to a hydrant without authorization

36. An operator is troubleshooting a pump that is experiencing intermittent cavitation — the noise comes and goes throughout the day. The pump operates normally in the early morning but begins cavitating during the afternoon peak demand period. What is the most likely cause?

A. The pump motor overheats during the afternoon, causing the impeller to expand and create cavitation

B. During peak demand, increased system flow lowers the suction pressure (available NPSH) at the pump to the point where it drops below the required NPSH, triggering cavitation — when demand decreases and suction pressure recovers, the cavitation stops

C. Afternoon temperature increases cause the water to release dissolved gases that create cavitation bubbles

D. The pump's mechanical seal leaks during the afternoon when thermal expansion creates gaps

37. A distribution system has a transmission main that crosses a river using a subaqueous pipeline installed on the river bottom. During a drought, the river level drops significantly, exposing a section of the transmission main that is normally submerged. What concerns does this exposure create?

A. The exposed pipe section is more susceptible to UV degradation from direct sunlight

B. The exposed pipe is at risk of freezing in cold weather without the thermal protection of the river water

C. The exposed section is vulnerable to physical damage from boats, debris, ice, and vandalism; temperature extremes without the moderating effect of river water may cause freezethaw damage; and the pipe's weight on the exposed river bed may shift without the buoyancy effect of water

D. The exposed pipe will experience increased internal pressure due to the lack of external water pressure

38. A water utility's sampling results show that the locational running annual average (LRAA) for TTHMs at monitoring site #3 has reached 0.076 mg/L. The MCL is 0.080 mg/L. Current quarter result at this site is 0.088 mg/L. The operator knows that next quarter's sample will replace a previous quarter's result of 0.055 mg/L in the LRAA calculation. If next quarter's result is similar to this quarter's, what will happen to the LRAA?

A. The LRAA will increase because a higher value (similar to 0.088) will replace the lower value (0.055) in the fourquarter average, potentially pushing the LRAA above the 0.080 MCL

B. The LRAA will decrease because the oldest quarter always has the highest weight in the calculation

C. The LRAA will remain at 0.076 because the rolling average stabilizes over time

D. The LRAA calculation cannot be predicted without knowing all four quarterly values

39. A distribution system operator discovers that a customer has drilled a private well on their property and connected it to the home's plumbing, which is also connected to the municipal supply. The well is untested and untreated. What immediate action should the operator take?

A. Test the private well water quality before deciding on any corrective action

B. Advise the customer to install a check valve between the well and the municipal connection

C. Document the connection and add it to the utility's crossconnection inventory for annual followup

D. Require the customer to immediately disconnect the private well from the plumbing served by the municipal supply — this is a highhazard crossconnection that could allow untreated, potentially contaminated well water to enter the municipal distribution system through backflow

40. A water system treats 3.5 MGD and currently uses chlorine gas for disinfection at a dose of 2.2 mg/L. The utility is converting to 12.5% sodium hypochlorite. How many gallons per day of sodium hypochlorite will be needed to deliver the same chlorine dose?

A. 64.2 gallons per day based on dividing the chlorine dose by the solution strength

B. Approximately 61.3 gallons per day — calculated by first determining 64.2 pounds of chlorine per day (3.5 × 2.2 × 8.34), then dividing by (8.34 × 0.125) to convert to gallons of solution

C. 514 gallons per day based on multiplying the MGD by the solution concentration

D. 8.0 gallons per day based on a simplified conversion factor for 12.5% hypochlorite

41. A water system serves a food processing plant that uses municipal water to wash raw produce. The plant has an elaborate overhead spray system that uses the municipal supply mixed with a sanitizing chemical. The system operates at pressures above the municipal supply pressure. What backflow protection is appropriate?

A. An RPZ assembly on the connection to the spray system because the system contains chemical additives, operates above supply pressure (creating backpressure), and handles food processing wastewater that could contaminate the drinking water if backflow occurred

B. A DCVA is adequate because food processing facilities are classified as low hazard

C. A PVB at the service entrance provides sufficient protection for all internal connections

D. No backflow protection is needed because the spray system is designed to only discharge downward onto the produce

42. An operator notices that the SCADA trend for a well's discharge pressure shows a gradual decline of approximately 0.5 psi per month over the past year. The flow rate and motor amperage have remained constant. The pumping water level has not changed. What is the most likely cause of the pressure decline?

A. The SCADA pressure transducer has gradually drifted out of calibration over the year

B. The well pump motor is gradually losing speed due to bearing wear

C. Progressive wear on the pump's impeller and wear rings is reducing the pump's ability to develop full head, allowing more internal recirculation and less net pressure output

D. The distribution system demand has gradually increased, creating more friction loss that reduces the measured pressure at the well discharge

43. A water system operates in an area prone to earthquakes. Following a magnitude 5.2 earthquake, the operator must assess the distribution system for damage. What should the operator check first?

A. The SCADA system for loss of communication with remote sites, which may indicate power failures or structural damage

B. Storage tank levels and structural integrity — tanks are the most vulnerable aboveground structures and a tank failure creates the most widespread service impact

C. Customer complaint calls, which will indicate the locations of damage

D. Water quality samples at all monitoring points to verify that contamination has not entered the system

44. A distribution system has a section where two mains of different sizes run parallel for 2,000 feet — a 12inch main on one street and a 6inch main on the adjacent street. Both mains are connected at each end through crossconnections. During a flow test, the operator discovers that the 6inch main carries almost no flow — nearly all flow travels through the 12inch main. Why?

A. The 6inch main has a closed valve that is blocking all flow through it

B. The 6inch main has a check valve that prevents flow in the direction the water needs to travel

C. The crossconnections at each end of the parallel section have been disconnected

D. Water naturally follows the path of least resistance — the 12inch main has dramatically lower friction loss than the 6inch, so the vast majority of flow takes the easier path through the larger pipe

45. A water system's SCADA data shows that an elevated tank cycles between 75% and 95% during the week but stays nearly full (9295%) all weekend. Customers near the tank report chlorine taste and odor complaints on Monday mornings. What is the connection?

A. Water stored in the tank all weekend without significant turnover develops higher chlorine concentrations from the continuous chlorine feed at the treatment plant — the first water delivered Monday morning has an elevated residual that produces taste and odor complaints

B. The treatment plant increases the chlorine dose on weekends to compensate for lower staffing

C. The tank's interior coating reacts with chlorine during extended periods of stagnation

D. The Monday morning complaints are caused by low residual, not high residual

46. An operator is developing a scope of work for a contract leak detection survey of the entire distribution system. The system has 250 miles of main. What information should the operator provide to the leak detection contractor for the most effective survey?

A. Only the total mileage of main to be surveyed, as the contractor will determine all other parameters

B. A complete map would be helpful but is not necessary for an experienced contractor

C. System maps showing pipe location, size, material, age, and valve locations; records of previous breaks and repairs; recent water audit data identifying areas of highest loss; and information about pipe material and joint types that affect acoustic detection effectiveness

D. The contractor needs only the utility's water loss percentage to determine where to focus the survey

47. A distribution system serves a dialysis clinic that requires water meeting specific quality standards. The clinic has its own treatment system (RO, carbon, deionization) but depends on the municipal supply as its source. What is the utility's primary obligation to this critical customer?

A. Providing treated water that consistently meets all SDWA standards at the point of delivery

B. Providing treated water that meets the dialysis clinic's specific quality requirements

C. Installing and maintaining the clinic's internal water treatment equipment

D. Testing the clinic's treated water to verify it meets dialysis quality standards

48. A water main installation crosses through an area where the soil contains significant amounts of cinders and slag from a former industrial site. The pipe material specified is ductile iron. What additional protection is needed?

A. No additional protection is needed because ductile iron is resistant to all soil conditions

B. The cinders and slag can be used as bedding material since they provide excellent drainage

C. A cement mortar exterior coating should be applied to the pipe to protect against the alkaline cinders

D. Cinder and slag deposits create highly corrosive soil conditions — polyethylene encasement, cathodic protection, or both are needed to protect the ductile iron from accelerated external corrosion

49. An operator receives laboratory results showing that a routine bacteriological sample from monitoring site #14 tested positive for both total coliform AND E. coli. Under the SDWA and the RTCR, what notification tier is required?

A. Tier 2 notification within 30 days because the presence of coliform requires public education

B. Tier 3 notification through the annual consumer confidence report only

C. Tier 1 notification within 24 hours — the confirmed presence of E. coli indicates potential fecal contamination and poses an immediate public health risk requiring the fastest possible notification to affected customers

D. No notification is required until repeat samples confirm the initial positive result

50. A water operator is explaining the concept of "system head" to a trainee. The trainee asks why friction head increases as flow increases, even though the pipe doesn't change. What is the correct explanation?

A. Friction head increases because higher flow means higher velocity inside the pipe, and head loss due to friction increases approximately with the square of the velocity — doubling the flow approximately quadruples the friction loss; the pipe doesn't change, but the water's behavior inside it does

B. Friction head increases because the pipe walls expand slightly under higher flow, creating more surface area for friction

C. Friction head increases because the water temperature rises with flow, making the water more viscous

D. Friction head is actually constant regardless of flow — only static head changes with demand

51. A water system's operator discovers that a section of distribution main runs through a landfill that was closed 20 years ago. The pipe is 30yearold PVC. Recent environmental monitoring at the landfill shows elevated levels of volatile organic compounds in the soil surrounding the pipe. What is the specific concern?

A. The VOCs will chemically dissolve the PVC pipe, causing structural failure

B. The landfill gas (methane) will permeate through the PVC and create an explosion hazard in customers' homes

C. The landfill settlement will cause the PVC pipe to bend and develop joint leaks

D. VOCs in the contaminated soil can permeate through the PVC pipe wall, entering the drinking water and creating a health hazard — PVC is known to be susceptible to permeation by certain organic compounds, and this is one of the most serious known limitations of PVC in contaminated soil environments

52. A pump station operator performs a timed flow test to verify the accuracy of the station's magnetic flow meter. The operator fills a calibrated 10,000gallon tank and times the fill at exactly 16 minutes and 40 seconds. What is the pump's actual flow rate, and how does it compare to the mag meter reading of 625 GPM?

A. The actual flow rate is 600 GPM (10,000 ÷ 16.67 minutes), which is 4% below the mag meter reading of 625 GPM — indicating the meter is reading slightly high

B. The actual flow rate is 600 GPM, which matches the mag meter reading exactly

C. The actual flow rate is 625 GPM based on dividing 10,000 by 16 minutes

D. The actual flow rate is 500 GPM based on a timing calculation error

53. A distribution system operator is troubleshooting an area with chronically low pressure during morning peak demand. The area is served by a single 8inch main extending 4,000 feet from a 16inch trunk main. Pressure at the trunk main reads 65 psi during peak, but pressure at the end of the 8inch main drops to 28 psi. What infrastructure improvement would be most effective?

A. Installing a parallel 8inch (or larger) main from the trunk to the affected area, or looping the existing deadend main to an adjacent trunk main, creating a second flow path that dramatically reduces friction loss by dividing the flow between two pipes

B. Replacing all customer meters in the area with larger meters that pass more water

C. Installing a PRV at the entrance to the 8inch main to stabilize pressure during peak demand

D. Increasing the pump station output to push more pressure into the trunk main

54. A water utility's emergency response plan includes a provision for emergency interconnections with a neighboring utility. During a main break emergency, the operator attempts to open the interconnection valve and discovers it is completely seized — it will not move. The valve was last exercised seven years ago. What lesson does this failure teach?

A. Emergency interconnection valves should be replaced with actuated valves that open automatically

B. The interconnection valve should have been welded open to ensure it is always available

C. All emergency interconnection valves must be included in the utility's regular valve exercising program — a valve that has not been exercised for seven years is likely to seize, defeating the entire purpose of the emergency interconnection

D. The utility should drill a bypass around the seized valve to establish the emergency connection

55. A water system's operator is asked to estimate the cost savings from a pump rehabilitation project. The old pump operates at 58% efficiency, consuming 45 kW. After rehabilitation, the pump is expected to operate at 78% efficiency at the same duty point. What will the approximate power consumption be after rehabilitation?

A. 45 kW × (58/78) = 33.5 kW, representing a savings of about 11.5 kW

B. Approximately 33.5 kW after rehabilitation — the pump will produce the same output with less energy input because the higher efficiency means less energy is wasted as heat and internal recirculation

C. 45 kW × (78/58) = 60.5 kW, meaning the pump will actually consume more power at higher efficiency

D. 45 kW minus 20% = 36 kW based on a flat 20% efficiency improvement

56. A distribution system serves a university campus with a large indoor swimming pool and aquatic center. The pool system uses the municipal supply for makeup water. The pool water is treated with chlorine, muriatic acid, and cyanuric acid stabilizer. A booster pump pressurizes the pool's recirculation system above the municipal supply pressure. What backflow protection is required?

A. A hose bibb vacuum breaker on the makeup water fill line

B. A PVB because the pool chemicals pose only an aesthetic hazard

C. A DCVA because swimming pools are classified as lowhazard crossconnections

D. An RPZ assembly because the pool water contains multiple chemical additives (chlorine, acid, cyanuric acid), the booster pump creates backpressure, and pool water may contain biological contaminants — this is a highhazard, backpressure crossconnection

57. An operator is asked to explain the difference between "available chlorine" and "chlorine residual" to a new employee. What is the correct distinction?

A. Available chlorine refers to the percentage of actual chlorine in a chemical product (e.g., calcium hypochlorite is 65% available chlorine), while chlorine residual is the amount of chlorine remaining in the water after it has reacted with the demand — available chlorine describes the product, residual describes the treated water

B. Available chlorine and chlorine residual are the same measurement taken at different times

C. Available chlorine is the total dose applied, while chlorine residual is the dose that has been consumed

D. Available chlorine refers only to free chlorine, while residual includes both free and combined forms

58. A water system's treatment plant has converted from liquid alum to polyaluminum chloride (PACl) as its primary coagulant. Two weeks after the conversion, distribution system customers begin reporting a significant increase in white or gray scale deposits on fixtures and in appliances. What is the most likely explanation?

A. PACl has increased the water's turbidity, which deposits on fixtures as the water evaporates

B. The coagulant change is unrelated and the scale is caused by seasonal temperature changes

C. The PACl coagulant change may have altered the finished water's pH, alkalinity, or mineral balance, shifting the water's chemistry to a point where calcium carbonate precipitation (scaling) is more likely — the operator should check whether the pH or alkalinity has changed since the conversion

D. PACl contains aluminum that deposits on fixtures as aluminum scale

59. A distribution system operator is training a new hire on the proper procedure for collecting a bacteriological sample. The trainee asks why the sample bottle contains a small amount of sodium thiosulfate powder. What is its purpose?

A. The sodium thiosulfate preserves any bacteria in the sample so they survive until laboratory analysis

B. The sodium thiosulfate neutralizes the chlorine residual in the water sample, preventing the chlorine from continuing to kill bacteria after the sample is collected — without dechlorination, the chlorine would continue its disinfecting action in the bottle, potentially producing a falsenegative result

C. The sodium thiosulfate adjusts the pH of the sample to the optimal range for bacterial growth

D. The sodium thiosulfate prevents the sample bottle from absorbing contaminants from the water

60. A water main installation project requires connecting a new 8inch DI main to an existing 8inch cast iron main. The existing cast iron main has a different outside diameter than the new DI pipe. What fitting is needed to make this connection?

A. A standard mechanical joint coupling that fits both pipe types identically

B. A flanged adapter that converts between the two pipe materials

C. The two pipes have identical dimensions and can be joined with a standard pushon joint

D. A transition coupling designed to accommodate the different outside diameters of cast iron and ductile iron pipe — these couplings have differentsized gaskets or adjustable glands on each end

61. A water system has a policy of rotating the lead pump in each station monthly to equalize run hours. Despite this policy, one pump station shows Pump A with 12,000 run hours and Pump B with 6,000 run hours after three years. What should the operator investigate?

A. Whether the monthly rotation policy has been consistently followed and documented

B. Whether Pump A has a slightly higher head curve that causes the SCADA system to preferentially select it

C. Whether Pump B was out of service for extended maintenance during the threeyear period

D. All of the above — the significant run hour imbalance could be caused by inconsistent rotation, SCADA programming that preferentially selects one pump, or extended downtime for one pump; systematic investigation is needed to identify and correct the cause

62. An operator is calculating the water volume needed for a hydrant flow test that is expected to flow 1,500 GPM for 10 minutes. Approximately how many gallons will be used, and what operational consideration does this create?

A. Approximately 15,000 gallons — the operator should verify that the system can sustain this draw without significantly depleting storage or dropping pressure below acceptable levels in the surrounding area

B. Approximately 1,500 gallons — a negligible volume with no operational impact

C. Approximately 150,000 gallons — requiring advance permission from the state regulatory agency

D. The volume cannot be calculated without knowing the pipe diameter and Cfactor

63. A water system's operator discovers that the utility's GIS database contains pipe records that conflict with the actual field conditions for approximately 15% of the mains that have been verified during the valve exercising program. What should the utility do?

A. Accept the GIS records as correct and assume the field observations are wrong

B. Delete all GIS records and start over with a complete field inventory

C. Implement a systematic field verification program — using valve exercising rounds, main break responses, and other field activities to progressively verify and correct GIS records, prioritizing areas where accuracy is most critical for emergency response and system operations

D. Hire a surveying company to verify all 250 miles of main simultaneously

64. A pump station's VFD displays a "motor overtemperature" alarm and reduces the pump speed to 75% to protect the motor. The ambient temperature in the pump station is normal at 72°F. What should the operator investigate?

A. Whether the VFD's cooling fans are operating and the heat sink is free of dust and debris

B. Whether the motor's ventilation is obstructed — clogged air filters, blocked cooling fins, a failed external cooling fan, or debris around the motor housing can prevent adequate heat dissipation even at normal ambient temperatures

C. Whether the VFD's temperature sensor has malfunctioned and is reading a falsely high temperature

D. Whether the electrical supply voltage has dropped, causing the motor to draw more current and overheat

65. A water system's monthly operating report shows that daily production has been 15% higher than the same month in the previous year. Customer account records show no increase in the number of connections. What could explain this production increase?

A. Seasonal variation in demand that will selfcorrect as weather patterns change

B. An increase in authorized unmetered uses such as flushing, firefighting, or construction water

C. Meter accuracy improvements from recently installed AMI meters that are measuring more consumption

D. An increase in real losses (leaks) in the distribution system — if customer counts and consumption patterns are unchanged but production has risen, the additional water being produced is likely escaping through new or worsening leaks

66. A water utility implements a comprehensive asset management program. The program manager asks the distribution superintendent to establish a criticality rating system for all distribution mains. What factors should be used to rate criticality?

A. Only the pipe's age and material determine its criticality rating

B. Criticality should be based on the consequence of failure — considering the number of customers affected, proximity to critical facilities (hospitals, schools, fire stations), availability of alternative supply paths (looped vs. deadend), depth of cover, traffic impact of a repair, and environmental sensitivity of the area

C. All mains should receive the same criticality rating to ensure equal treatment

D. Criticality ratings should be based solely on pipe diameter, with larger pipes rated more critical

67. A customer reports that their water looks milky but clears from the bottom up when placed in a glass. This phenomenon occurs every time they turn on the cold water tap. The customer's home is at the bottom of a steep hill where the distribution main descends approximately 150 feet of elevation over a short distance. What is causing the persistent milky appearance?

A. The treatment plant is adding too much lime for pH adjustment, creating calcium carbonate cloudiness

B. A crossconnection in the customer's plumbing is introducing soap or detergent into the cold water supply

C. The high pressure at the bottom of the hill (resulting from the 150foot elevation drop) forces more air into solution; when the water exits the tap at atmospheric pressure, the dissolved air rapidly comes out of solution as microscopic bubbles that create the milky appearance

D. The milky water indicates bacterial growth in the customer's service line that produces a cloudy biofilm

68. A water system's operator is performing preventive maintenance on a chemical metering pump that feeds sodium hypochlorite. The pump has a diaphragmtype design. What is the most common failure mode for this type of pump?

A. Motor burnout from continuous operation at maximum stroke length

B. Diaphragm rupture from chemical attack, fatigue, or age — when the diaphragm fails, chemical can leak into the hydraulic oil on the drive side (internal leak) or out of the pump head (external leak), and the pump loses its ability to accurately meter chemical

C. Bearing failure from exposure to chemical fumes inside the pump head

D. Valve body erosion from highvelocity chemical flow through the pump chamber

69. A distribution system operator is reviewing a proposal to install a mixing system inside a 1milliongallon groundlevel reservoir that currently has poor water quality. The reservoir's single inlet/outlet causes shortcircuiting. What benefit does a mixing system provide?

A. The mixer oxygenates the water to improve taste and remove odor compounds

B. The mixer breaks down sediment particles so they pass through customer fixtures without clogging

C. The mixer increases the chlorine concentration by compressing dissolved chlorine gas

D. The mixer eliminates stagnation zones by continuously blending the water throughout the entire tank volume, ensuring uniform residual and temperature, reducing water age stratification, and preventing the formation of biofilm in dead zones

70. A water system's SCADA alarm history shows that a lowpressure alarm at a specific monitoring point has activated at the same time (7:15 AM) on each of the past five weekday mornings. The alarm clears by 8:00 AM. What should the operator conclude?

A. A predictable, recurring pressure drop at the same time every weekday morning indicates a demanddriven pattern — a large customer (school, factory, commercial laundry) in the area likely begins operations at 7:15 AM, creating a demand spike that temporarily drops pressure below the alarm threshold

B. The pressure monitoring point needs recalibration because it is generating false alarms at the same time daily

C. A valve downstream of the monitoring point is on a timer that closes at 7:15 AM and reopens at 8:00 AM

D. The alarm is caused by the pump station switching from night mode to day mode at 7:15 AM

71. An operator is preparing specifications for a new pump station and must select between horizontal splitcase pumps and vertical turbine pumps. The station will draw from a groundlevel clearwell with a water surface 5 feet below the pump floor. What advantage does the vertical turbine design offer in this application?

A. Vertical turbine pumps can be installed with the impeller submerged below the water surface, eliminating suction lift and the risk of losing prime — the pump draws water directly without relying on atmospheric pressure to push water up to the impeller

B. Vertical turbine pumps have higher efficiency than horizontal splitcase pumps at all flow rates

C. Vertical turbine pumps are more compact and take up less horizontal floor space than splitcase pumps, but suction characteristics are identical

D. Vertical turbine pumps cost significantly less than splitcase pumps for the same capacity

72. A distribution system operator is reviewing water quality data and notices that the HAA5 levels at a monitoring point have been steadily increasing over the past year — from 0.035 mg/L to 0.058 mg/L. The TTHM levels at the same site have remained stable at 0.045 mg/L. What could explain the divergent DBP trends?

A. The laboratory has changed its analytical method for HAA5, producing higher results

B. A change in source water quality, treatment process, or distribution system conditions has altered the DBP formation profile — HAA5 and TTHM formation are affected differently by factors such as pH, temperature, bromide concentration, and NOM characteristics, and it is possible for one to increase while the other remains stable

C. HAA5 and TTHM always increase together, so the laboratory results must contain an error

D. The monitoring site has been changed without updating the LRAA calculation

73. A water system's production well has a variable frequency drive on the pump motor. The VFD allows the operator to adjust the pump speed from 40% to 100% of full speed. During the winter when demand is low, the operator reduces the pump speed to 60% to match production to demand. What effect does the reduced speed have on the pump's performance?

A. The pump produces the same flow at reduced speed but at higher pressure

B. The pump produces more flow at reduced speed because the water moves more efficiently at lower velocities

C. The reduced speed has no effect on flow or pressure — VFDs only affect energy consumption

D. The pump produces proportionally less flow and significantly less head at reduced speed — pump affinity laws dictate that flow varies directly with speed, while head varies with the square of speed, meaning a 40% speed reduction reduces flow by 40% and head by 64%

74. A water system serves a regional medical center with 500 beds, an emergency department, surgical suites, and a dialysis unit. The medical center has a single 6inch water service connection. What vulnerability does this create?

A. A single service connection provides no redundancy — any failure, break, or planned maintenance on the 6inch service or the main it connects to will completely interrupt water supply to the hospital, potentially endangering patients

B. The 6inch service is adequately sized and a second connection would create hydraulic conflicts

C. The hospital's internal storage tanks provide adequate backup during any service interruption

D. A second connection is unnecessary because the utility will prioritize any hospital service repair above all other work

75. A distribution system operator is troubleshooting a booster pump station where the discharge pressure fluctuates between 45 and 72 psi, cycling every 2030 seconds. Both VFDcontrolled pumps are running. What is the most likely cause?

A. A failing pressure sensor is sending erratic signals to the VFD controllers

B. A leaking discharge check valve is allowing water to surge back and forth between the two pumps

C. The VFD control loop is improperly tuned — the proportional, integral, and derivative (PID) settings are causing the VFDs to overreact to pressure changes, creating an oscillating cycle where each correction overshoots in the opposite direction

D. The two pumps are fighting each other because they are set to different pressure targets

76. A water main installation requires excavation through an area where the soil investigation revealed contaminated soil from a former gas station. The contamination includes petroleum hydrocarbons at levels above environmental cleanup standards. What special considerations apply to this installation?

A. No special considerations are needed because the pipe will be protected by its standard coating

B. The contaminated soil cannot be used as backfill, workers must be protected from exposure to the contaminated soil (potentially requiring hazmatlevel PPE), the pipe material must be resistant to permeation (avoiding PVC in favor of ductile iron or HDPE with fusion joints), and the excavated contaminated soil must be handled as regulated waste

C. The installation should proceed normally, and a carbon filter installed at the nearest downstream hydrant will address any contamination

D. The contaminated area should be bypassed entirely, even if it requires a significantly longer alignment

77. A water system's emergency generator is started during a power outage. The generator runs for approximately 45 minutes, then shuts down on a high engine temperature alarm. The operator restarts the generator after a 10minute cooldown, and it runs for another 30 minutes before overheating again. What should the operator investigate?

A. Whether the fuel quality has degraded, causing the engine to run hotter than normal

B. Whether the generator is oversized for the load, causing it to run at inefficient lowload conditions

C. Whether the generator room ventilation is inadequate for extended operation

D. The cooling system — specifically the radiator for debris or corrosion blockage, coolant level, thermostat function, water pump operation, and cooling fan operation; repeated overheating under load indicates the cooling system cannot dissipate the heat generated during sustained operation

78. A distribution system has experienced a confirmed waterborne disease outbreak traced to a crossconnection at a mortuary where embalming fluids entered the municipal supply during a main break that caused negative pressure. Following the outbreak, the state mandates enhanced crossconnection control. What program improvements should the utility implement?

A. A comprehensive program including systematic hazard surveys of all commercial and industrial properties, mandatory backflow prevention device installation at all identified hazards, annual testing of all devices, public education about crossconnection dangers, and enforcement authority for noncompliance

B. Testing of all existing backflow devices but no new surveys since the mortuary was the only problem

C. Installation of RPZ assemblies at all residential service connections throughout the system

D. A single annual inspection of the mortuary to verify the backflow device is maintained

79. An operator needs to convert a well's production rate from GPM to MGD. The well produces 450 GPM and operates 18 hours per day. What is the daily production in MGD?

A. 0.450 MGD based on the GPM rate without accounting for actual operating hours

B. 0.648 MGD based on multiplying 450 GPM by 1,440 minutes per day

C. 0.486 MGD, calculated as 450 GPM × 60 min/hr × 18 hr/day = 486,000 gallons per day = 0.486 MGD

D. 0.270 MGD based on an assumed 10hour operating day

80. A water system's operator discovers that a large commercial customer has installed a private fire suppression system that connects directly to the municipal supply with no backflow prevention. The system contains stagnant water and antifreeze in some sections. During a routine inspection, the operator also notices that the sprinkler system is connected to a jockey pump that maintains pressure above the municipal supply pressure. What are the specific backflow risks?

A. The only risk is that stagnant water could produce taste and odor issues if it enters the supply

B. The jockey pump prevents any backflow because it pushes water away from the municipal supply

C. The stagnant water poses a lowhazard risk that can be managed with a DCVA

D. Multiple highhazard risks exist: the antifreeze is a chemical health hazard, the stagnant water may contain biological contaminants, and the jockey pump creates continuous backpressure that could force contaminated water into the municipal supply — an RPZ or air gap is required immediately

81. An operator is reviewing pump station energy data and discovers that Station C consumes 850 kWh/MG while Stations A and B consume 650 kWh/MG and 680 kWh/MG respectively. All three stations pump similar volumes against similar system heads. What does this comparison suggest about Station C?

A. Station C's energy consumption is within the normal range of variation and does not warrant investigation

B. Station C is significantly less efficient than the other two stations, consuming approximately 2530% more energy per million gallons — the operator should investigate pump efficiency, motor condition, and piping configuration at Station C to identify the cause of the excess energy consumption

C. Station C has a more accurate power meter that reads higher than the other stations

D. Station C pumps against a higher system head despite the operator's assessment that heads are similar

82. A water system's operator is investigating a pattern of water main breaks that cluster along a specific street. Five breaks have occurred within 800 feet over the past two years. All breaks are on a 65yearold 6inch cast iron main. Geotechnical testing of the soil reveals extremely high corrosivity. What additional investigation would help determine whether to repair individual breaks or replace the entire 800foot section?

A. A customer satisfaction survey to determine how the breaks have affected residents

B. A hydraulic model to determine if the 6inch main is adequately sized for current demand

C. A cost analysis comparing the cumulative cost of individual repairs to the onetime cost of replacement

D. A condition assessment combining soil corrosivity data, pipe wall thickness measurements (using ultrasonic testing on exposed pipe during repairs), break history analysis, and remaining useful life estimation — this comprehensive approach determines whether the pipe has enough remaining wall thickness to continue service or whether replacement is the more economical and reliable longterm solution

83. An operator is explaining to a new employee why some areas of the distribution system have higher disinfection byproduct levels than others, even though all water comes from the same treatment plant. What is the primary factor that causes this variation?

A. Water age — areas with longer residence time (dead ends, oversized mains, storage tanks with poor turnover) have more time for the ongoing chemical reaction between chlorine and organic matter, producing higher DBP concentrations than areas where water moves quickly through the system

B. Pipe material — some pipe materials catalyze DBP formation while others do not

C. Elevation — higher elevation areas have higher DBP levels due to lower pressure

D. Customer density — areas with more customers produce more DBPs because of their combined water usage

84. A water system experiences a power outage affecting all pump stations. The utility has emergency generators at all stations, and they start automatically. However, during the outage, the operator notices that one generator is consuming fuel at twice the expected rate. What should the operator investigate?

A. Whether the generator's engine has a fuel leak or a malfunctioning fuel injection system

B. Whether the fuel gauge is calibrated correctly and actually shows accurate fuel consumption

C. Whether the generator is carrying an unexpected load — equipment that is not normally powered by the generator may have automatically transferred to emergency power, increasing the load and fuel consumption

D. Whether the fuel itself has degraded and is burning less efficiently than fresh diesel

85. A distribution system serves a food manufacturing plant that produces bottled water using the municipal supply as its source. The plant operates a reverse osmosis system and ozone disinfection. What is the utility's regulatory obligation regarding the water quality the plant receives?

A. The utility must provide water that exceeds bottled water quality standards at the point of delivery

B. The utility is responsible for providing water that meets all SDWA standards at the point of delivery — the plant's internal treatment to meet bottled water standards is the plant's responsibility, not the utility's

C. The utility must certify that its water meets FDA bottled water standards before the plant can use it

D. The utility has no regulatory obligations to any customer that adds its own treatment

86. An operator is evaluating the condition of a 40yearold prestressed concrete storage tank. During the annual inspection, the operator notices a wet streak running vertically down the exterior wall from the waterline to the base. What does this wet streak indicate?

A. Condensation from temperature differential between the stored water and the outside air

B. Rainwater tracking down a surface crack in the exterior concrete

C. A normal weepage pattern common to all prestressed concrete tanks of this age

D. A potential crack, joint failure, or prestressing wire break that has created a leak path through the tank wall — prestressed concrete tank failures often begin as small leaks that progressively worsen as more wires break and should be investigated immediately by a structural engineer

87. A water utility is developing a replacement schedule for customer water meters. The utility has 15,000 meters ranging in age from 1 to 30 years. AWWA guidelines suggest testing based on throughput rather than age alone. What is the most costeffective approach to meter replacement?

A. Implement a throughputbased testing program that identifies meters most likely to be underregistering (oldest, highestvolume meters) and replaces them first — this approach targets the meters that recover the most revenue per replacement dollar and uses test data rather than arbitrary age to make replacement decisions

B. Replace all 15,000 meters at once to ensure systemwide accuracy

C. Replace all meters on a strict 15year agebased cycle regardless of throughput or tested accuracy

D. Replace meters only when customers complain about high bills

88. A distribution system operator is investigating why a newly installed 10inch DI main consistently produces higher chlorine residuals at its discharge hydrant than older mains of the same size in the same area. Both mains receive water from the same source. What characteristic of the new main explains the difference?

A. The new main's motordriven valves create less turbulence that would normally deplete chlorine

B. New DI pipe has higher internal pressure that prevents chlorine from escaping through the pipe wall

C. The new main's smooth cement mortar lining has much lower chlorine demand than the old pipe's corroded, tuberculated interior — the biofilm, iron deposits, and corrosion products on old unlined or deteriorated pipe surfaces react with and consume chlorine much faster than a clean, smooth lining

D. The new main is manufactured with a special chlorineresistant alloy that preserves the residual

89. An operator discovers that the emergency shutoff valve for the chlorine gas system at a well station cannot be reached from outside the building. The valve is located inside the chlorine room, requiring entry to close it. Why is this a serious safety deficiency?

A. The valve location makes no difference because chlorine gas shutoff is always performed inside the room

B. During a major chlorine gas leak, the room may be too dangerous to enter — the operator needs to be able to shut off the chlorine supply from outside the room without entering the toxic atmosphere; an exterioraccessible emergency shutoff valve is a critical safety requirement

C. The interior valve location only matters if the building has no ventilation system

D. The valve location is acceptable because operators are required to carry SCBA at all times

90. A water system operates two wells: Well A produces 500 GPM at pH 7.2 with iron at 0.1 mg/L, and Well B produces 400 GPM at pH 6.8 with iron at 0.5 mg/L. When both wells operate simultaneously into a common header, what water quality concern should the operator monitor?

A. The different pH values of the two waters will react and produce a precipitate at the mixing point

B. The iron levels are too low to cause any water quality concern when blended

C. The chlorine residual will be higher in the blended water because the two pH values average out

D. The blended water's iron concentration, pH, and the effect on the corrosion control program — the lower pH from Well B may increase corrosivity of the blend, and the iron from Well B may cause aesthetic complaints; the operator must monitor the blended water chemistry and adjust treatment accordingly

91. A water system is required to conduct Sanitary Surveys at a frequency determined by the state. During the most recent survey, the state inspector identifies a "significant deficiency" — a deteriorated well cap with a visible gap. What does this finding require?

A. The utility must correct the significant deficiency within a specified timeframe — typically 30 to 120 days depending on the severity and state requirements — and document the corrective action; failure to correct a significant deficiency can result in enforcement action

B. The finding is recorded in the survey report but no corrective action is required

C. The utility has five years to address significant deficiencies identified during Sanitary Surveys

D. Only "critical deficiencies" require corrective action — significant deficiencies are informational only

92. A pump station operator notices that when both pumps run simultaneously, the combined noise level in the station is significantly louder than when a single pump runs. The operator works 8hour shifts in the station. What occupational health concern does this create?

A. Noise levels in pump stations never reach dangerous levels

B. The noise level may affect the operator's concentration but does not pose a health risk

C. If the combined noise level exceeds 85 decibels (the OSHA action level for an 8hour TWA), the utility must implement a hearing conservation program including noise monitoring, audiometric testing, and providing hearing protection — pump stations with multiple large pumps frequently exceed this threshold

D. OSHA noise regulations only apply to construction sites, not to permanent pump station installations

93. A distribution system has a 20inch transmission main that supplies water to a large section of the city. The main has no redundancy — there is no parallel main or alternative supply route. A section of the main must be shut down for valve replacement. The shutdown will last 8 hours and will affect 5,000 customers. What preparations are essential?

A. Notify all affected customers and ask them to reduce water use during the shutdown

B. Coordinate with all stakeholders: notify all 5,000 customers well in advance, individually notify critical customers (hospitals, dialysis centers, schools, nursing homes), coordinate with the fire department regarding reduced fire flow, preposition emergency repair materials, arrange for alternative water supply (tanker trucks) for critical facilities, and staff the project with adequate crew for timely completion

C. Schedule the shutdown during overnight hours when demand is lowest

D. Install a temporary bypass around the valve before shutting down the main

94. A water system's operator is asked why AWWA recommends a minimum of two sources of supply for every water system. The utility currently relies on a single well. What risk does the singlesource configuration create?

A. A single source provides no backup and creates a vulnerability — if the well is contaminated, the pump fails, or the well needs rehabilitation, the utility has no water supply at all; redundancy through a second source ensures continuous service during any singlepoint failure

B. Two sources are recommended only for systems serving more than 10,000 customers

C. A single source is acceptable as long as the utility has adequate storage capacity

D. Multiple sources are recommended only for surface water systems, not groundwater systems

95. A distribution system operator is investigating a complaint from a commercial bakery about inconsistent water pressure. The bakery operates large dough mixers that require steady water flow for cooling. SCADA shows stable pressure at the main, but the bakery reports pressure drops that coincide with their peak production periods. The bakery has a 1.5inch service line. What is the most likely cause?

A. The 1.5inch service line is too small for the bakery's peak demand — when the dough mixers and other equipment draw water simultaneously, the high flow rate through the small service creates excessive friction loss that drops the pressure inside the building well below the main pressure

B. The distribution main is undersized for the commercial area

C. The bakery's internal booster pump is malfunctioning and creating pressure fluctuations

D. A PRV on the bakery's service is set too low for the equipment's pressure requirements

96. An operator performing well maintenance discovers that the well's pitless adapter connection is leaking — water is seeping around the adapter seal where it penetrates the casing. What is the primary concern with this leak?

A. The leaking water will saturate the soil around the casing and cause the well house foundation to settle

B. The water loss from the leak will reduce the well's production capacity and increase pumping costs

C. The leaking connection compromises the sanitary seal of the well casing — groundwater, surface water, and contaminants can enter the well through the defective seal, bypassing the protective casing and potentially contaminating the water supply

D. The leak will cause air to be drawn into the pump suction, reducing pumping efficiency

97. A distribution system serves a neighborhood at the highest elevation in the system. During peak demand, customers at this elevation experience pressure as low as 25 psi. The elevated tank serving this zone has an overflow elevation of 920 feet. The affected customers are at elevation 870 feet. Under static conditions, the maximum pressure at these homes is (920−870) × 0.433 = 21.65 psi. What does this reveal?

A. The tank overflow elevation is too high for this service area

B. The affected customers are receiving the maximum pressure the zone can deliver — 21.65 psi static is already below the recommended minimum of 35 psi even with zero demand; these customers cannot be adequately served by this pressure zone and need either a higher tank, a booster pump, or reassignment to a higherpressure zone

C. The tank is not filling to its overflow elevation, creating a lowerthandesigned HGL

D. The pressure gauge at the customer's home is malfunctioning and reading low

98. A water utility is evaluating whether to install a new elevated storage tank or a booster pump station to serve a growing highelevation area. What is the primary advantage of the elevated tank over the booster pump station?

A. The elevated tank is always less expensive to construct than a booster pump station

B. The elevated tank requires less maintenance because it has no mechanical equipment

C. The elevated tank provides unlimited fire flow that no booster pump station can match

D. The elevated tank provides passive, gravityfed pressure that continues working during power outages without requiring backup generators, while a booster pump station depends on continuous electrical power and active mechanical equipment to maintain pressure

99. A distribution system operator is asked to participate in a preconstruction meeting for a new residential subdivision. The developer's engineer has designed the water system for the subdivision. What specific input should the operator provide at this meeting?

A. The operator should review the plans for constructability, accessibility for future maintenance, valve placement for effective isolation, hydrant spacing and location for both fire protection and flushing, pipe

material suitability for the local soil conditions, compliance with the utility's construction standards, and any sitespecific concerns based on field knowledge of the area

B. The operator should limit input to approving the pipe material selection

C. The operator should not attend preconstruction meetings because design review is the engineer's responsibility

D. The operator should only review the plans if the development is within the utility's existing service area

100. A water system's certified operator is retiring in six months. The operator holds a Grade 2 distribution certificate and is the only certified operator on staff. What must the utility do before this operator retires?

A. Request a temporary extension of the retiring operator's certification to cover the transition period

B. Contract with a certified operator from another utility to provide parttime coverage until a replacement is found

C. The utility must hire or train a replacement operator who holds the appropriate level of certification before the current operator retires — operating a water system without a certified operator of the required grade is a violation of state drinking water regulations

D. The utility can operate without a certified operator for up to one year while recruiting a replacement

## Practice Exam 9: Answer Key and Explanations

1. C — Bowl area = 0.785 × 55² = 2,376 sq ft. Volume per foot of drop = 2,376 × 7.48 = 17,773 gallons per foot. At 2.5 feet per hour: 17,773 × 2.5 = 44,432 gallons per hour, approximately 44,384 GPH. This calculation helps operators estimate how long the tank can sustain demand before reaching its low-level setpoint or running empty.

2. A — A butterfly valve disc that has detached from the shaft allows the shaft to rotate freely with no resistance and no effect on flow. The disc remains stationary in whatever position it was in when it detached — typically open. This valve is completely inoperable and must be replaced, as it cannot provide isolation during an emergency.

3. D — A fertigation system injects chemical fertilizer under pressure into irrigation lines connected to the potable supply. This creates both a chemical hazard (fertilizer contamination) and a backpressure

condition (the injection pump pressurizes the line above supply pressure). A single check valve provides grossly inadequate protection — an RPZ assembly is required for this high-hazard, backpressure cross-connection.

4. B — A lead pump that normally cycles every 4-6 hours but has been running continuously for 72 hours indicates that demand exceeds the pump's capacity to refill the storage tank. The pump runs nonstop trying to keep up, but the tank level is likely declining or not recovering to its normal high setpoint. The operator should investigate whether the lag pump needs to be activated or whether a leak is consuming the excess production.

5. D — A 6-hour shutdown affecting 150 customers requires comprehensive advance notification — at least 48 hours — using direct methods (door hangers, automated calls) that reach every affected customer. Critical customers (nursing homes, dialysis, hospitals) need individual contact to arrange alternatives. The fire department must be informed of reduced fire flow during the shutdown.

6. A — Pressure drop = 58 − 35 = 23 psi. Drop per GPM = 23 ÷ 1,100 = 0.021 psi/GPM. While this linear approximation is useful for quick estimates, the actual pressure-flow relationship follows a power curve where head loss increases approximately with the square of flow — so doubling the flow would approximately quadruple the pressure drop, not double it.

7. C — In severely corrosive soil (below 1,000 ohm-cm), polyethylene encasement alone may not provide sufficient protection because any tear, hole, or installation damage exposes the pipe to aggressive attack. Adding cathodic protection (sacrificial anodes or impressed current) provides active electrochemical protection that continues working even if the encasement is compromised.

8. B — An emergency response plan that doesn't reflect the actual system is dangerous. Operators following an outdated plan may not know about the three new wells as potential backup supply sources, may reference a SCADA system that no longer exists, and may not know how to operate the new booster station. The plan must be a living document updated whenever the system changes.

9. A — Turnover time = 200,000 ÷ 500 = 400 minutes = 6.67 hours. This means the tank's entire volume theoretically turns over approximately 3.6 times per day. Shorter turnover keeps water fresher with higher residual and lower DBPs. Tanks with turnover times exceeding 24-48 hours are at high risk for water quality degradation.

10. D — Testing the same hydrants year after year creates a trend database that reveals whether the system's hydraulic capacity is improving (from main rehabilitation), stable, or declining (from tuberculation, demand growth). Random sampling provides no trend data. The consistent dataset enables early identification of deteriorating infrastructure before it causes service failures.

11. B — The simultaneous decline in chloramine residual and rise in nitrite is the diagnostic signature of nitrification. Ammonia-oxidizing bacteria (Nitrosomonas) thrive at water temperatures above 59°F and convert the ammonia released from chloramine decay into nitrite. The warm 72°F water temperature has promoted bacterial growth that is consuming the chloramine and producing nitrite.

12. C — Water weighs 8.34 pounds per gallon: 500,000 × 8.34 = 4,170,000 pounds — approximately 2,085 tons. The tank structure, foundation, support columns (for elevated tanks), and underlying soil must be engineered to support this enormous static load plus wind, seismic, and ice loads. Structural inadequacy could cause catastrophic failure.

13. A — An unusual chemical odor at a facility with chemical storage requires the operator to stop and assess before entering. A chemical leak or spill may have created a hazardous atmosphere. The operator should not enter until the space is ventilated and the source identified — from outside the room if possible. Personal safety always takes priority over investigating the cause.

14. D — The booster pump system creates backpressure on the service — it can push water backward into the main if it operates at higher pressure than the distribution system. The fire sprinkler system with chemical additives is a high-hazard cross-connection. Each requires appropriate protection — an RPZ at the service entrance for the booster, and an RPZ for the sprinkler system.

15. B — Q = 2,800 ÷ 448.8 = 6.24 cfs. D = 16 ÷ 12 = 1.333 ft. A = 0.785 × 1.778 = 1.396 sq ft. V = 6.24 ÷ 1.396 = 4.47 fps, approximately 4.5 fps. This falls within the acceptable 2–5 fps range for normal distribution system operation, confirming the 16-inch main is adequately sized for this peak demand.

16. C — Select granular backfill provides uniform support around the pipe circumference, fills the haunch area beneath the pipe, and allows proper compaction. Native material with large rocks creates point loads (concentrated stress from rock edges against the pipe), voids beneath the pipe, and uneven settlement. PVC is particularly vulnerable because it depends on side support to maintain its shape.

17. A — Under the RTCR, a single total coliform-positive routine sample triggers a Level 1 Assessment (if the system has not already completed one in the past 12 months). While three consecutive monthly

positives at the same site with negative repeats may not formally trigger a Level 2, the recurring pattern at site #8 strongly indicates a localized problem that demands investigation regardless of formal assessment triggers.

18. D — A pressure relief valve protects against overpressure conditions. If a downstream valve closes while the pump continues running (dead-heading), discharge pressure rises rapidly toward shutoff head and beyond. The relief valve opens at a predetermined pressure to discharge excess water and prevent the pressure from exceeding the pipe's or equipment's design rating.

19. B — The lead service line is the primary source of lead exposure in this home. While corrosion control treatment reduces lead leaching, it cannot eliminate it — lead still dissolves from the pipe at reduced rates. Physical replacement of the lead service line permanently removes the exposure pathway. This is the most effective long-term solution recommended by the EPA and public health authorities.

20. C — The zone receives water that has traveled from the treatment plant through the higher-pressure zone, losing residual along the way. Installing a booster chlorination system at the point where water enters the zone adds fresh chlorine to compensate for the transit losses, directly improving residuals throughout the zone.

21. B — A 9x increase in consumption (5,000 to 45,000 gallons/month) almost certainly indicates a significant leak — not a dramatic change in the customer's usage pattern. Proactive notification allows the customer to investigate and repair the leak before it causes catastrophic damage (if underground) or an enormous water bill. This customer service approach also reduces water waste and builds trust.

22. D — Exterior corrosion on a steel tank is progressive — it starts at paint failures and gradually consumes the steel wall. Over years of neglect, corrosion pits deepen, wall thickness decreases, and structural integrity weakens. Eventually, corrosion can penetrate the full wall, causing leaks or — in a worst case — catastrophic structural failure. The peeling paint must be addressed through surface preparation and recoating.

23. A — Chlorine demand = Dose − Residual = 3.0 − 1.1 = 1.9 mg/L. This demand tells the operator that the well water contains substances (iron, manganese, $H_2S$, organic matter) that react with and consume 1.9 mg/L of chlorine. The operating dose must exceed 1.9 mg/L to maintain any measurable residual for ongoing disinfection protection.

24. C — Pressure pulsation at every fixture, affecting only one customer, with a 10-15 second cycle is characteristic of a waterlogged pressure tank. When the air cushion is lost, the pump's on/off pressure settings are very close together, causing the pump to start and stop rapidly. Each start creates a brief pressure surge, and each stop creates a brief drop — producing the pulsating pattern.

25. B — Water meters are mechanical devices with moving parts that gradually wear from continuous exposure to flowing water. As internal components (disc, spindle, chamber walls, or impeller) wear, clearances increase and the meter increasingly under-registers — allowing water to pass without being fully measured. This under-registration represents lost revenue for the utility.

26. A — Balanced phase currents within 2% of each other indicate a healthy, balanced three-phase electrical supply. Amperage within 5% of nameplate rating indicates the motor is properly loaded — neither overloaded (which causes overheating) nor significantly underloaded (which wastes energy). These readings confirm normal motor operation with no immediate electrical or mechanical concerns.

27. D — Electromagnetic inspection technology uses sensors pulled through the pipe that detect changes in the electromagnetic field caused by broken prestressing wires. Since PCCP relies on the tensioned wires to resist internal pressure, broken wires reduce the pipe's structural capacity and can lead to catastrophic failure. This technology identifies wire breaks non-destructively while the pipe remains in service.

28. C — A 32 psi pressure drop between the main (62 psi) and the meter (30 psi) in a 4-inch service line indicates a significant restriction somewhere in the service path. Common causes include a partially closed corporation stop, curb stop, or service valve; a crushed or severely tuberculated service line; or a clogged meter strainer. The operator should systematically check each component.

29. A — The operator should prepare for potential turbidity breakthrough. If the plant's filters cannot maintain required limits, turbid water entering the distribution system will increase chlorine demand (reducing residual), deposit sediment in low-velocity areas, and potentially shield pathogens from disinfection. Close residual monitoring and readiness for targeted flushing are essential.

30. B — Static water level remained at 45 feet (aquifer level unchanged), but drawdown increased from 47 feet (92−45) to 60 feet (105−45) at the same 350 GPM flow. Specific capacity declined from 7.45 GPM/ft to 5.83 GPM/ft — a 22% reduction. This indicates the well screen or gravel pack is becoming blocked, requiring greater drawdown to force the same volume of water through increasing resistance.

31. D — Annual savings = 180 GPM × 1,440 min/day × 365 days = 94,608,000 gallons per year. At a production cost of $3/1,000 gallons, this equals $283,824 per year in savings. The $85,000 survey investment pays for itself within the first four months of recovered production. This ROI calculation is the strongest justification for proactive leak detection.

32. C — Green staining on fixtures indicates copper corrosion. Pinhole leaks in copper hot water heaters suggest aggressive water attacking copper surfaces. Premature toilet flapper failure points to degraded rubber from aggressive water chemistry. All three symptoms point to aggressive water — low pH, low alkalinity, or inadequate corrosion control — that attacks both metallic and rubber components.

33. B — 485 mL/min ÷ 3,785 mL/gal = 0.1281 GPM. Gallons per hour = 0.1281 × 60 = 7.69 GPH. Chemical metering pump calibration is a critical skill — the operator must verify that the pump delivers the intended volume per unit time to ensure accurate chemical dosing. Discrepancies between the pump setting and actual output indicate check valve problems, air leaks, or diaphragm wear.

34. A — Without real-time level data, the pump station's controls cannot respond appropriately to tank level changes. The tank could overflow (causing water waste, property damage, and potential contamination) or drain completely (leaving the zone without pressure or fire flow reserve) without the operator's knowledge. Dispatching someone to verify conditions or establishing temporary monitoring is essential.

35. D — The contractor has committed multiple violations: unmetered water use from a hydrant constitutes theft of service; connecting to a tank used for mixing concrete without backflow prevention creates a cross-connection; and using a hydrant without authorization may violate utility ordinances. The connection must be immediately disconnected and the contractor must apply for proper temporary service with metering and backflow prevention.

36. B — During peak demand, increased system flow reduces the suction pressure available to the pump. When the available NPSH drops below the pump's required NPSH, cavitation begins. During off-peak periods, reduced flow allows suction pressure to recover above the required NPSH, and cavitation stops. This intermittent pattern correlating with demand cycles confirms a marginal NPSH condition.

37. C — A subaqueous pipeline exposed by low river levels faces multiple threats: physical damage from boats, floating debris, and ice; temperature extremes without the insulating effect of water (freezing in winter, heating in summer); loss of buoyancy support that changes the loading on the pipe and its supports; and vulnerability to vandalism. Monitoring and protection measures are needed until the river level rises.

38. A — The current LRAA of 0.076 includes the 0.055 quarter that will be replaced. If next quarter's result is 0.088 (similar to this quarter), the LRAA will increase because a higher value replaces a lower value in the four-quarter average. This could push the LRAA above the 0.080 MCL, resulting in a violation. The operator must take proactive measures now to reduce TTHM formation.

39. D — A private well connected to municipal plumbing is one of the most dangerous cross-connections. The untested, untreated well water may contain bacteria, nitrates, pesticides, or other contaminants. If the well pump operates at higher pressure than the municipal supply (or if municipal pressure drops), contaminated well water will flow into the municipal system through the customer's plumbing. Immediate disconnection is required.

40. B — Pounds of chlorine per day = 3.5 × 2.2 × 8.34 = 64.2 lbs/day. Gallons of 12.5% solution = 64.2 ÷ (8.34 × 0.125) = 64.2 ÷ 1.043 = 61.6 gallons per day, approximately 61.3 GPD. This conversion is critical for utilities transitioning from gas to liquid chlorine — the operator must recalculate all feed rates using the solution strength.

41. A — The spray system operates above municipal supply pressure (backpressure), contains chemical sanitizers (health hazard), and processes food that may contaminate the recycled water with biological material. This combination of high hazard plus backpressure requires an RPZ assembly. A DCVA is inadequate for high-hazard connections regardless of the presence of backpressure.

42. C — A gradual decline in discharge pressure over 12 months at constant flow, amperage, and pumping water level points to progressive pump deterioration. Impeller erosion and wear ring deterioration allow increasing internal recirculation — the pump still draws the same power but delivers less net pressure as more energy is wasted on internal leakage. Pump rehabilitation would restore the lost pressure.

43. B — Storage tanks are the most vulnerable above-ground structures in an earthquake. A tank failure creates the most widespread impact — loss of pressure, loss of fire flow reserve, and loss of equalization storage. The operator should check SCADA for tank levels and structural integrity first, then communication status, then customer reports, and finally water quality.

44. D — When two parallel mains of different sizes connect the same two points, water follows the path of least resistance. The 12-inch main has dramatically lower friction loss (proportional to D^4.87), so the vast majority of flow naturally takes the easier path through the larger pipe. The 6-inch main carries very little flow unless the 12-inch main is shut down or restricted.

45. A — Weekend stagnation allows chlorine residual to continue reacting with organic matter and pipe surfaces. In a tank with minimal cycling, the chlorine concentration may actually increase slightly as the treatment plant's continuous feed enters a tank that isn't turning over — concentrating the residual. Monday morning's first delivery comes from this stagnant, potentially over-chlorinated water.

46. C — A comprehensive scope enables the most effective survey. System maps identify pipe locations, materials, and ages. Break history highlights problem areas. Water audit data identifies zones with the highest losses. Pipe material information affects acoustic detection methodology — PVC transmits sound differently than metal pipe, requiring different equipment settings and techniques.

47. A — The utility's obligation is to provide water that meets all SDWA standards at the point of delivery (the meter). The dialysis clinic's specific quality requirements (which exceed SDWA standards) are the clinic's responsibility to achieve through its own treatment system. The utility's consistent delivery of SDWA-compliant water provides the reliable source the clinic's treatment system depends upon.

48. D — Cinder and slag fill creates highly corrosive soil conditions due to the presence of sulfates, low pH, and high conductivity. Ductile iron pipe in these conditions will experience accelerated external corrosion without adequate protection. Polyethylene encasement provides a passive barrier, while cathodic protection provides active electrochemical defense — both may be needed in severe conditions.

49. C — Confirmed E. coli in the distribution system is a Tier 1 violation requiring notification within 24 hours. E. coli is an indicator of fecal contamination that may include pathogenic organisms capable of causing serious illness. The notification must reach affected customers as quickly as possible through broadcast media, automated calls, door-to-door notification, and social media.

50. A — Friction head loss increases approximately with the square of velocity (and flow) because faster-moving water creates more turbulent interaction with the pipe wall. The pipe itself doesn't change, but the water's behavior does — at higher velocities, more energy is lost to turbulence and wall friction. This is why doubling the flow through the same pipe approximately quadruples the head loss.

51. D — PVC pipe is known to be susceptible to permeation by VOCs and other organic compounds. In contaminated soil, these compounds dissolve into and diffuse through the PVC wall at the molecular level, entering the drinking water. This is one of the most serious known limitations of PVC in contaminated environments — the pipe may appear structurally sound while allowing chemical contamination to pass through its wall.

52. B — Actual flow = 10,000 gallons ÷ 16.67 minutes = 599.9 GPM, approximately 600 GPM. The mag meter reads 625 GPM — 4.2% higher than the actual flow. This discrepancy exceeds the typical 1-2% accuracy specification for magnetic flow meters, indicating the meter should be recalibrated. Accurate production metering is essential for water auditing and loss control.

53. A — The 37 psi pressure drop over 4,000 feet of 8-inch main during peak demand indicates severe friction loss through the single supply path. Installing a parallel main or looping the dead end creates a second flow path that divides the flow between two pipes — dramatically reducing friction loss and improving pressure. This is the most effective hydraulic improvement for this configuration.

54. C — A valve that was last exercised seven years ago and is now completely seized illustrates exactly why regular exercising is essential. Emergency interconnections are critical safety infrastructure designed to save the system during worst-case scenarios. Including all emergency valves — especially those normally closed — in the regular exercising program ensures they will operate when needed.

55. B — Power is proportional to flow × head ÷ efficiency. At the same duty point, increasing efficiency from 58% to 78% reduces power: New kW = 45 × (58/78) = 33.5 kW. The savings of 11.5 kW, operating continuously (8,760 hours/year) at $0.10/kWh, saves approximately $10,000 per year — often enough to pay for the rehabilitation within 2-3 years.

56. D — The pool contains multiple chemical additives (chlorine, muriatic acid, cyanuric acid), the booster pump creates backpressure above the municipal supply, and pool water contains biological contaminants from swimmers. This combination of chemical hazard, biological hazard, and backpressure requires an RPZ assembly — the highest level of mechanical backflow protection.

57. A — Available chlorine describes a chemical product's strength — how much actual chlorine it contains. Calcium hypochlorite at 65% available chlorine means each pound contains 0.65 pounds of actual chlorine. Chlorine residual describes the treated water — the concentration of chlorine remaining after it has reacted with the demand. One describes the product; the other describes the result.

58. C — Changing the coagulant can alter the finished water's pH, alkalinity, or mineral balance. If the new coagulant produces water with higher pH or higher calcium, the water may exceed its calcium carbonate saturation point, causing precipitation and scale formation. The operator should compare pre- and post-conversion water chemistry parameters to identify what has changed.

59. B — Sodium thiosulfate in the sample bottle is a dechlorinating agent that neutralizes the chlorine residual in the collected sample. Without dechlorination, the chlorine would continue killing bacteria in the bottle during transport to the laboratory, potentially destroying viable bacteria and producing a false-negative result. The thiosulfate preserves the sample's bacteriological condition at the moment of collection.

60. D — Cast iron and ductile iron pipe have different outside diameters for the same nominal size — a legacy of different manufacturing standards. A transition coupling accommodates both diameters with different-sized gaskets or adjustable glands, creating a watertight connection between the two dissimilar pipes. Standard couplings designed for one pipe type will not fit the other.

61. D — Multiple factors could explain the imbalance: the rotation policy may not have been consistently followed (operator forgot, documentation gap), the SCADA system may preferentially select Pump A based on performance characteristics, or Pump B may have been out of service for extended maintenance. Systematic investigation of all three possibilities is needed to identify and correct the cause.

62. A — Volume = 1,500 GPM × 10 minutes = 15,000 gallons. While 15,000 gallons may seem modest, the flow rate of 1,500 GPM is a significant draw that temporarily depletes storage and may affect pressure. The operator should verify that the tank has adequate capacity to sustain the draw without triggering low-level alarms or affecting pressure for other customers.

63. C — A 15% error rate in GIS records is significant but not unusual for older systems. A complete field inventory would be expensive and disruptive. The most practical approach integrates verification into routine field activities — every valve exercised, every main break repaired, and every construction project becomes an opportunity to verify and correct GIS records, focusing first on areas critical for emergency response.

64. B — A motor overtemperature alarm with normal ambient temperature indicates the motor cannot dissipate its heat adequately. The most common causes are obstructed ventilation — clogged air filters, dirty cooling fins, a failed cooling fan, or debris blocking airflow around the motor housing. Restoring proper ventilation should resolve the overheating without any motor repair.

65. D — A 15% production increase with no increase in customer connections or consumption patterns means the additional water is going somewhere unmetered. The most likely explanation is new or worsening leaks in the distribution system. A leak detection survey should be initiated to find and repair the sources of the increased loss.

66. B — Criticality should reflect the consequence of failure, not just physical characteristics. A 4-inch dead-end main serving 5 homes has a very low consequence of failure, while a 16-inch transmission main serving a hospital and 3,000 homes has an extremely high consequence. Factors including customers affected, critical facilities, alternate supply, repair difficulty, and environmental impact all contribute to the criticality rating.

67. C — At the bottom of a 150-foot elevation drop, the water pressure is approximately 150 × 0.433 = 65 psi. This high pressure forces significantly more air into solution (Henry's Law — gas solubility increases with pressure). When the customer opens their tap, pressure drops to atmospheric, and the dissolved air rapidly comes out of solution as microscopic bubbles that make the water appear milky. The effect is harmless and clears from the bottom up.

68. B — Diaphragm rupture is the most common failure mode in chemical metering pumps. The diaphragm is continuously flexed by the pump's reciprocating action while exposed to corrosive chemicals. Chemical attack weakens the material, and fatigue from thousands of daily flexion cycles eventually causes failure. The ruptured diaphragm allows chemical to leak and eliminates the pump's ability to accurately meter doses.

69. D — A mixing system continuously circulates the entire tank volume, eliminating the stagnation zones that develop in tanks with short-circuiting flow patterns. The mixer ensures uniform chlorine residual throughout the tank, prevents temperature stratification, and eliminates dead zones where biofilm can grow undisturbed. This directly addresses all the water quality problems caused by the single inlet/outlet configuration.

70. A — A predictable, recurring low-pressure alarm at the same time every weekday morning (but presumably not on weekends) strongly suggests a demand-driven event. A large customer in the area — a school, factory, commercial laundry, or irrigation system — begins its daily operation at 7:15 AM, creating a demand spike that temporarily draws down pressure below the alarm threshold.

71. C — A vertical turbine pump installed with its intake and impeller submerged below the water surface eliminates suction lift entirely. Water flows into the impeller by gravity and static pressure — no atmospheric pressure is needed to push water up to the pump. This eliminates the risk of losing prime (a common problem with horizontal pumps above the water surface) and provides more reliable operation.

72. B — TTHM and HAA5 formation are affected by different factors. HAA5 formation is more sensitive to chlorine dose and contact time, while TTHM formation is more sensitive to pH, temperature,

and bromide. A change in any of these parameters can cause one DBP class to increase while the other remains stable. The operator should investigate what source water or treatment condition has changed.

73. D — The pump affinity laws govern how centrifugal pump performance changes with speed: flow varies directly with speed ($Q_2/Q_1 = N_2/N_1$), head varies with the square of speed ($H_2/H_1 = (N_2/N_1)^2$), and power varies with the cube of speed. At 60% speed, flow is 60% of rated, head is 36% of rated, and power is only 21.6% of rated — producing significant energy savings.

74. A — A hospital with a single water connection has no redundancy — any interruption on the service line or the main it connects to completely eliminates water supply to a facility where water is essential for patient care, sterilization, fire suppression, and life safety. A second service connection from a different main provides the redundancy needed for a critical medical facility.

75. C — Rapid pressure oscillation (45-72 psi cycling every 20-30 seconds) with VFD-controlled pumps running indicates the PID control loop is unstable. The proportional gain is too high, causing each correction to overshoot — the VFD speeds up too much (pressure spikes), then slows too much (pressure drops), creating a continuous oscillation. Retuning the PID parameters stabilizes the output.

76. B — Contaminated soil creates multiple complications: it cannot be used as backfill (it is regulated waste), workers need hazmat-level protection from exposure, the pipe material must resist permeation (PVC is unsuitable — ductile iron or HDPE with fusion joints is preferred), and all excavated material must be handled and disposed of according to environmental regulations.

77. D — Repeated overheating under load points to a cooling system failure. The cooling system components — radiator (debris, corrosion), coolant level (low), thermostat (stuck closed), water pump (impeller failure), and cooling fan (belt broken, motor failed) — must be systematically inspected. A generator that cannot sustain load due to overheating is useless during an extended power outage.

78. A — A comprehensive program addresses the entire cross-connection problem, not just the specific incident. Systematic surveys identify hazards throughout the system, mandatory device installation eliminates identified risks, annual testing verifies ongoing protection, public education builds awareness, and enforcement authority ensures compliance. This multi-layered approach prevents future incidents.

79. C — Daily production = 450 GPM × 60 min/hr × 18 hr = 486,000 gallons = 0.486 MGD. The key is accounting for actual operating hours — using 24 hours would overstate daily production (0.648 MGD).

Wells that operate less than 24 hours must have their operating schedule factored into production calculations.

80. D — This connection has multiple high-hazard characteristics: antifreeze is a chemical health hazard, stagnant water may contain biological contaminants, and the jockey pump creates continuous backpressure that could actively push contaminated water into the municipal supply at any time. An RPZ assembly or air gap must be installed immediately to protect the public water system.

81. B — Station C's 850 kWh/MG is approximately 25-30% higher than the 650-680 kWh/MG at Stations A and B. Since all three stations pump similar volumes against similar heads, the excess energy at Station C represents wasted power — likely from worn pumps, poor efficiency, misalignment, or piping configuration issues. Investigation and correction could save significant energy costs.

82. D — A comprehensive condition assessment combines multiple data sources: soil corrosivity data quantifies the external attack environment, ultrasonic wall thickness measurements (taken during break repairs) reveal remaining pipe wall, break history identifies failure patterns, and remaining life estimation integrates all factors into a replacement decision. This evidence-based approach prevents premature replacement and avoids catastrophic failure.

83. A — Water age is the primary driver of DBP variability within a distribution system. The chemical reaction between chlorine and NOM continues as long as both are present. Areas with longer residence times (dead ends, oversized mains, tanks with poor turnover) provide more reaction time, producing higher DBP concentrations than areas where water moves quickly.

84. C — An unexpected load on the generator — equipment that automatically transferred to emergency power without the operator's knowledge — increases the generator's output and fuel consumption proportionally. HVAC systems, lighting, communication equipment, and other building loads that have automatic transfer switches may have shifted to generator power, doubling the expected fuel consumption rate.

85. B — The utility's regulatory obligation is to provide water meeting all SDWA standards at the point of delivery. The food manufacturing plant's additional treatment to meet FDA bottled water standards is the plant's own responsibility. The utility cannot guarantee water quality beyond the meter, nor is it responsible for the plant's product quality standards.

86. D — A wet streak running from the waterline to the base of a prestressed concrete tank indicates a leak path through the wall. In PCCP and prestressed concrete tanks, leaks often begin as small seepage through cracks caused by prestressing wire breaks. These breaks progressively weaken the structure, and what starts as a small leak can escalate to catastrophic failure. Immediate structural engineering evaluation is essential.

87. A — A throughput-based testing program identifies the meters that are most likely under-registering by targeting the oldest and highest-volume meters first. Testing confirms which meters need replacement, and replacing those meters first recovers the most revenue per dollar spent. This data-driven approach is more cost-effective than blanket age-based replacement.

88. C — New cement mortar lined pipe has a smooth, clean interior with very low chlorine demand. Old unlined or deteriorated pipe has a rough, corroded interior covered with biofilm, iron deposits, and corrosion products — all of which react with and consume chlorine aggressively. The dramatic difference in surface condition explains why new mains consistently show higher residuals than old mains.

89. B — During a major chlorine gas leak, the room may contain lethal concentrations of gas. Requiring entry to shut off the supply puts the operator at extreme risk. An exterior-accessible emergency shutoff valve allows the operator to stop the chlorine supply from outside the building, without entering the toxic atmosphere. This is a fundamental safety requirement for any chlorine gas installation.

90. D — Blending two waters with different pH values and iron concentrations creates a combined water whose chemistry differs from either source individually. The lower pH from Well B increases the corrosivity of the blend, potentially destabilizing corrosion control. The iron from Well B may cause aesthetic complaints. The operator must monitor and adjust treatment for the blended water chemistry.

91. A — A significant deficiency identified during a Sanitary Survey requires corrective action within a specified timeframe — typically 30 to 120 days depending on severity and state policy. A deteriorated well cap with a visible gap provides a direct pathway for surface contamination to enter the well. Failure to correct the deficiency can result in enforcement action, including compliance orders and potential penalties.

92. C — Pump stations with multiple large pumps frequently produce noise levels exceeding 85 dBA, especially when multiple pumps run simultaneously. OSHA's hearing conservation standard requires monitoring, audiometric testing, and hearing protection when 8-hour TWA noise exposure exceeds 85 dBA. Operators spending full shifts in noisy pump stations are at risk for noise-induced hearing loss.

93. B — A shutdown of a non-redundant 20-inch transmission main affecting 5,000 customers requires comprehensive preparation: extensive advance customer notification, individual contact with critical facilities, fire department coordination, alternative water supply arrangements, adequate crew for timely completion, pre-positioned repair materials, and contingency planning for delays. This is a major system event requiring project-level planning.

94. D — A single-source system has a single point of failure for its entire water supply. If the well is contaminated, the pump fails, or the well needs rehabilitation, the utility has zero production capability. Storage can sustain service temporarily, but once storage is depleted, all customers lose water. A second source — a backup well, interconnection, or purchased water — eliminates this critical vulnerability.

95. A — The 1.5-inch service line creates a bottleneck during peak bakery operations. When multiple dough mixers and cooling systems draw water simultaneously, the high flow rate through the small service generates significant friction loss that drops pressure inside the building. The main pressure is adequate (confirmed by SCADA), but the service line cannot deliver that pressure at the bakery's peak flow rate.

96. C — The pitless adapter penetration is part of the well's sanitary seal that prevents contaminants from entering the well through the casing. A leaking adapter allows surface water, shallow groundwater, insects, and contaminants to seep into the well, bypassing the protective casing. The adapter must be repaired or replaced to restore the sanitary integrity of the well.

97. B — The static pressure calculation reveals that even under zero-demand conditions (no friction losses), the maximum available pressure at elevation 870 is only 21.65 psi — well below the 35 psi recommended minimum. During any flow condition, friction losses would reduce this further. These customers cannot be adequately served from a tank with a 920-foot overflow elevation and need a higher pressure source.

98. D — An elevated tank provides passive, gravity-fed pressure that works 24/7 without electricity, pumps, or any mechanical equipment. During a power outage, the tank continues delivering water and maintaining pressure through gravity alone. A booster pump station requires continuous electrical power — and without a functioning generator, the station stops and the zone loses pressure immediately.

99. A — The distribution operator contributes practical field knowledge that engineers need: constructability concerns based on site conditions, valve placement for effective isolation and maintenance access, hydrant spacing for both fire protection and flushing programs, pipe material

selection based on soil conditions, compliance with utility standards, and any site-specific issues known from working in the area.

100. C — A water system must have a certified operator of the appropriate grade at all times. Operating without certification is a regulatory violation that can result in enforcement action against both the utility and its management. The utility must hire or train a replacement well before the retiring operator leaves, ensuring continuity of certified operation.