PRACTICE EXAM 15: WPI/ABC WATER DISTRIBUTION OPERATOR SIMULATION (100 QUESTIONS)

1. A water system operator reviews SCADA data and discovers that daily production has risen from 4.0 MGD to 4.6 MGD over a 120day period. Customer connections have not changed, and seasonal demand should be decreasing. The treatment plant's production meter was recently calibrated and confirmed accurate. What is the most likely explanation for the 15% production increase?

A. Customers have collectively increased consumption by 15% due to an undetected billing rate change

B. The elevated storage tank has developed a leak that consumes the additional 0.6 MGD through seepage

C. The treatment plant is producing extra water to build emergency reserves in the storage tanks

D. A developing or worsening leak in the distribution system is progressively consuming the additional 0.6 MGD — the gradual, sustained increase with a confirmed accurate production meter and no new connections is the classic signature of a growing distribution system leak

2. A pump station has two identical centrifugal pumps rated at 700 GPM each in a lead lag configuration. The station also has a standby pump. During normal operations, the lead pump runs at variable speed to maintain 60 psi. When peak demand exceeds the lead pump's capacity at 100% speed, the lag pump starts. What is the station's firm capacity?

A. 2,100 GPM because firm capacity equals the total output of all three installed pumps

B. Approximately 1,300 GPM — the output of two pumps operating in parallel (slightly less than 1,400 due to increased system head), representing the capacity with the largest single pump out of service

C. 700 GPM because firm capacity equals the output of a single pump

D. 1,400 GPM because firm capacity equals the sum of two individual pump ratings

3. A distribution system serves a commercial building that has a cooling tower with chromium based corrosion inhibitors, a fire sprinkler system with glycol based antifreeze, and a landscape irrigation

system with no chemical injection. The building has a single master meter at the service entrance. What is the minimum number of backflow prevention assessments needed for this building?

A. One assessment covers the entire building because the RPZ at the service entrance protects against all internal hazards

B. Two assessments — one for the combined cooling tower and sprinkler system, and one for the irrigation

C. Three — each connection (cooling tower, sprinkler, irrigation) represents a different hazard level requiring individual assessment and protection appropriate to its specific risk

D. No assessments are needed because the building's maintenance staff monitors all internal systems

4. An operator measures the chlorine residual at two monitoring points on the same main during the same hour. Point A (1 mile from the treatment plant) reads 1.8 mg/L. Point B (6 miles from the plant, at a dead-end terminus) reads 0.15 mg/L. The treatment plant dose has not changed. What principle does this data illustrate, and what action should the operator consider?

A. Chlorine residual decays with distance and water age — the 6mile journey to Point B consumed nearly all the residual; the operator should consider installing a booster chlorination station between Points A and B to replenish the residual before it drops to an unacceptable level

B. The treatment plant is overdosing at Point A and underdosing at Point B simultaneously

C. The low reading at Point B indicates a cross connection that is diluting the residual with unchlorinated water

D. Point B's residual is within the acceptable range and no action is needed

5. A water system's elevated tank has a bowl diameter of 60 feet and a water depth varying between a low of 18 feet and a high of 28 feet. What is the usable storage volume between these two operating levels?

A. 750,000 gallons based on the total tank volume from floor to high water level

B. 105,600 gallons based on using the tank radius instead of diameter in the calculation

C. 1,688,990 gallons based on the total tank volume without subtracting the low water volume

D. Approximately 211,321 gallons — calculated as $0.785 \times 60^2 \times (28 - 18) = 0.785 \times 3{,}600 \times 10 = 28{,}260$ cu ft $\times 7.48 = 211{,}385$ gallons

6. A distribution system operator receives a customer complaint about persistent brown water from every tap in their home. The customer's home is at the end of a 500foot dead-end 4inch main. The operator opens the nearest hydrant and flushes for 15 minutes until the water clears. Four days later, the customer calls again with the same complaint. What does the recurrence indicate?

A. The customer's internal galvanized steel plumbing is the source of the iron discoloration

B. The dead-end main has severe internal tuberculation that continuously generates iron particles — flushing temporarily removes discolored water, but the corroded pipe surfaces immediately begin shedding particles again; the permanent solution is cleaning and lining or replacing the dead-end main

C. The treatment plant is sending water with elevated iron content to this area of the system

D. A cross connection at a nearby property is introducing contaminated water into the dead-end main

7. A confined space entry team is preparing to enter a drained underground water reservoir for interior inspection. Initial atmospheric testing at the access hatch shows: O_2 = 20.9%, LEL = 0%, CO = 0, H_2S = 0. The reservoir normally stores chloramine treated water. What additional atmospheric hazard must be evaluated before entry?

A. Carbon dioxide accumulation from concrete carbonation reactions inside the reservoir

B. Methane generated by decomposing organic matter in the residual sediment at the bottom

C. Residual chloramine on wet surfaces can off gas ammonia and chlorine compounds as the reservoir dries — the standard four gas monitor does not detect these chemicals; a chlorine specific and/or ammonia specific detector is needed to evaluate this site specific hazard

D. Radon gas emanating from the concrete structure and underlying soil

8. An operator calculates the weight of water in a 20inch diameter, 400foot long transmission main that crosses a bridge. The bridge engineer needs this information for structural loading. What is the approximate weight of the water?

A. Approximately 26,176 pounds — calculated as: D = 20/12 = 1.667 ft; A = 0.785 × 2.778 = 2.182 sq ft; Volume = 2.182 × 400 = 872.7 cu ft; Weight = 872.7 × 62.4 = 54,456... wait, let me recalculate: Volume = 2.182 × 400 = 872.7 cu ft × 7.48 = 6,528 gal × 8.34 = 54,443 lbs. Actually the answer is approximately 54,456 lbs

B. 6,528 pounds based on the volume in gallons without converting to weight

C. 872 pounds based on the volume in cubic feet without converting to weight

D. 108,912 pounds based on doubling the correct calculation for a safety factor

9. A water system's cross connection control inspector discovers that a veterinary clinic has a direct connection between the potable supply and a euthanasia chemical injection system. The chemicals include pentobarbital (a controlled substance) and embalming fluid. The only backflow protection is a single check valve. What level of protection is required?

A. A DCVA because veterinary clinics are classified as moderate hazard facilities

B. The single check valve is adequate because the chemical injection system operates at lower pressure than the supply

C. A PVB at the chemical injection point because the system involves back siphonage risk only

D. An air gap or RPZ assembly — euthanasia chemicals and embalming fluids represent the highest possible health hazard; a single check valve provides negligible protection; the connection requires either physical separation (air gap) or the maximum level of mechanical protection (RPZ)

10. A distribution system has a PRV station reducing pressure from Zone 1 (88 psi) to Zone 2 (target 52 psi). During a fire in Zone 2, the fire department draws 2,500 GPM. Zone 2 pressure drops to 8 psi. After the fire, the fire chief requests that the utility improve fire flow capacity in Zone 2. What design modification would most directly address the fire flow limitation?

A. Increase the PRV setpoint from 52 to 65 psi to provide more baseline pressure for fire flow events

B. Install a fire flow bypass line around the PRV station — the bypass has a normally closed valve that opens automatically (or manually by the fire department) during high demand events, allowing Zone 1's full 88 psi to supplement Zone 2 and deliver the additional fire flow capacity

C. Replace all 6inch mains in Zone 2 with 12inch mains to increase carrying capacity

D. Install a dedicated fire pump in Zone 2 that activates only during fire flow events

11. An operator performs a DPD chlorine test at a monitoring point in a system using chloramines for secondary disinfection. The results show: free chlorine = 0.1 mg/L, total chlorine = 2.8 mg/L. What is the combined chlorine concentration, and what do the results indicate about the chloramine program?

A. Combined chlorine = 2.9 mg/L, calculated by adding the free and total readings together

B. The test is invalid because free chlorine should always equal total chlorine in a chloramine system

C. Combined chlorine = 2.7 mg/L (total minus free), indicating the chloramine program is functioning normally — the vast majority of the residual is combined chlorine (monochloramine), with only a trace of free chlorine, which is typical for a properly controlled chloramine system

D. Combined chlorine = 0.1 mg/L because free chlorine represents the combined fraction in chloramine systems

12. A water system operator calculates that a well produces 550 GPM and operates 18 hours per day. The system's average daily demand is 520,000 gallons. Is this single well adequate as the sole source of supply?

A. The well produces 594,000 gallons per day (550 × 60 × 18), which exceeds the 520,000gallon average demand by only 14% — while technically meeting average demand, this minimal surplus provides no margin for peak demand (typically 1.52.0× average), fire flow, or equipment downtime; a single source system this close to capacity is critically vulnerable

B. The well is grossly inadequate because 550 GPM cannot meet any residential system's demand

C. The well provides more than adequate supply with a 100% surplus above average daily demand

D. The adequacy cannot be determined without knowing the maximum day demand and fire flow requirements

13. A distribution system serves a large apartment complex with 200 units. The complex has a master meter, a domestic water booster pump, a fire sprinkler system with chemical corrosion inhibitors, and a swimming pool with chemical treatment. A cross connection control survey identifies multiple potential backflow hazards. What is the minimum protection needed at the building's service entrance?

A. A DCVA at the master meter because the building's internal systems are monitored by maintenance staff

B. No protection at the service entrance because each internal hazard will have its own dedicated device

C. A PVB at the service entrance because the primary risk is back siphonage from the pool chemical system

D. An RPZ assembly at the service entrance — the booster pump creates backpressure, the sprinkler chemicals and pool chemicals represent health hazards; premises isolation with an RPZ protects the municipal supply from all internal hazards simultaneously, while individual internal devices provide defenseindepth

14. A water main break occurs at 2:00 AM on a 20inch transmission main. The operator arrives and finds a massive longitudinal crack gushing an estimated 5,000+ GPM. SCADA shows the elevated tank dropping at 6 feet per hour. The operator locates the two nearest isolation valves. Valve 1 closes normally. Valve 2 requires extreme effort and eventually closes after 15 minutes of work with a 6foot cheater bar. What does Valve 2's difficulty indicate?

A. Valve 2 is a butterfly valve and naturally requires more torque than a gate valve

B. Valve 2 has not been exercised recently and has developed internal corrosion that resists operation — this near failure demonstrates why all valves, including those on transmission mains, must be included in the regular exercising program; had Valve 2 been fully seized, the operator would have needed the next available valve, dramatically expanding the outage

C. Valve 2 is larger than Valve 1 and all larger valves require more effort to operate

D. Valve 2's difficulty is normal for a valve under high pressure, high flow conditions

15. A water system's operator calculates the head loss in 4,000 feet of 8inch cement mortar lined ductile iron pipe (C=140) carrying 800 GPM. The Hazen Williams calculation yields approximately 22 feet. What is this equivalent to in psi?

A. Approximately 9.5 psi, calculated as 22 feet × 0.433 psi/foot — this means the 4,000foot section produces a 9.5 psi pressure drop due to friction at this flow rate

B. 50.8 psi based on multiplying 22 feet by 2.31

C. 22 psi based on feet of head equaling psi directly

D. 2.9 psi based on dividing the head loss by the pipe length in thousands of feet

16. A distribution system's SCADA alarm log shows 1,500 alarms in the past 30 days. An alarm management audit reveals that 1,350 (90%) were acknowledged without investigation. The utility's alarm management policy requires investigation of all alarms within 30 minutes. What does this data indicate?

A. The operators are efficiently managing the alarm load by quickly acknowledging and clearing alarms

B. The SCADA system software has a bug that generates excessive false alarms

C. Severe alarm fatigue — operators have been conditioned by the high alarm volume to acknowledge without investigating, creating the dangerous possibility that critical alarms (low residual, tank overflow,

pump failure) will be dismissed along with nuisance alarms; alarm rationalization must eliminate nuisance alarms and establish clear priorities for the remainder

D. The alarm management policy is unrealistic and the investigation requirement should be extended to 4 hours

17. A water system's treatment plant switches its secondary disinfectant from free chlorine to chloramines. Which customer groups must receive specific advance notification before the conversion?

A. Only commercial customers with industrial water treatment systems must be notified

B. Only customers within one mile of the treatment plant must be notified because they receive the highest residual

C. No specific notification is required beyond the annual consumer confidence report

D. Dialysis patients and facilities (chloramines are toxic to blood and not removed by standard dialysis carbon), fish and aquarium owners (chloramines are lethal to aquatic life and not removed by standard carbon or aeration), and businesses that depend on free chlorine for their processes — all must be notified with adequate lead time to modify their systems

18. A water operator discovers that a customer has connected a private well to their home's plumbing, which is also connected to the municipal supply. The private well is untested and untreated. The customer states the well provides irrigation water only and is not connected to any drinking water fixtures. Why is this still a cross connection concern?

A. Even though the customer claims the well feeds only irrigation, the two systems are physically connected through the home's plumbing network — a single valve left open or a plumbing modification could allow untreated well water to flow to any fixture; moreover, the well pump can create backpressure that forces contaminated water into the municipal supply through the shared plumbing

B. Regardless of the customer's stated intent, the physical connection between the two sources creates the cross connection — human error, plumbing modifications, or pressure changes can cause untreated well water to enter the municipal system at any time

C. Private well connections are only a concern if the well is deeper than 100 feet

D. The connection is acceptable as long as the customer signs an annual certification that the well is used only for irrigation

19. A distribution system has a section where a 14inch main transitions to an 8inch main through a reducer. Customers downstream of the reducer consistently report low pressure during peak demand. An operator measures flow at 1,800 GPM through both pipe sections. What are the velocities in each pipe, and what do they reveal?

A. The 14inch main carries the flow at approximately 3.8 fps while the 8inch carries it at approximately 11.5 fps — the dramatic velocity increase through the smaller pipe creates enormous friction losses downstream of the reducer, directly explaining the pressure complaints; the 8inch section is severely undersized for this flow rate

B. Both pipes carry the same velocity because the flow rate is identical through both sections

C. The 14inch pipe has higher velocity because its larger diameter creates less resistance

D. The 8inch pipe has lower velocity because the reducer slows the water before it enters the smaller pipe

20. An operator is asked to explain the purpose of the annual consumer confidence report (CCR) to a customer who received it in the mail. What is the correct explanation?

A. The CCR is a marketing document designed to encourage customers to use more municipal water

B. The CCR is an invoice supplement that explains the utility's rate structure and billing procedures

C. The CCR is a federally required transparency document that informs customers about the source of their water, any contaminants detected during the past year, compliance status, and health significance of any detections — it empowers customers with knowledge about their drinking water quality

D. The CCR is an internal document that was accidentally mailed to customers and should be disregarded

21. A water system has two elevated tanks serving the same pressure zone. Tank A (overflow = 920 feet) consistently cycles between 70% and 92%. Tank B (overflow = 920 feet, same elevation) barely cycles — staying between 87% and 93%. Both tanks are hydraulically connected through the open distribution network. What is the most likely cause of Tank B's poor cycling?

A. The distribution piping between the pump station and Tank B has higher friction than the path to Tank A — during fill cycles, more water flows to Tank A through lower resistance piping; during drawdown, Tank A supplies more demand because water flows more easily from Tank A through its lower friction supply path

B. Tank B's altitude valve has failed in a partially closed position, restricting flow in and out

C. Tank B is structurally different from Tank A and has a smaller inlet/outlet pipe

D. Tank B's SCADA level sensor has drifted and is not accurately reporting the actual cycling range

22. A water system's emergency generator at a critical pump station has a 800gallon diesel fuel tank. The generator consumes 22 gallons per hour at full load. A major ice storm causes a power outage expected to last 96 hours. How many hours of operation does the fuel provide, and what is the operator's most critical logistical challenge?

A. 36.4 hours of operation, and the challenge is preventing the fuel from gelling in the extreme cold

B. 80 hours of operation, which is nearly adequate for the 96hour outage with minimal management

C. 36.4 hours (800 ÷ 22), which is only 38% of the 96hour outage — the operator must arrange multiple fuel deliveries during an ice storm when roads may be impassable and fuel suppliers overwhelmed; prestorm fuel topping, multiple supplier contacts, and emergency management coordination are essential

D. 96 hours of operation at reduced load if the operator shuts down all but one pump

23. An operator is performing a valve exercising round and encounters a 12inch gate valve that requires 34 turns to close instead of the recorded 26 turns. After closing, the operator reopens and counts 26 turns to fully open — matching the record. What does the 8turn discrepancy during closure indicate?

A. The valve stem has stretched from corrosion, requiring more turns on the closing stroke only

B. Debris or sediment accumulated on the valve seat prevented the gate from fully seating during the normal 26 turns — the additional 8 turns compressed through or displaced the material; the 26turn reopening confirms the correct mechanical travel once the seat was clear

C. The valve record is incorrect and should be updated to 34 turns

D. The valve body has expanded from internal pressure, increasing the gate's travel distance

24. A water system's operator receives laboratory results showing the LRAA for TTHMs at monitoring site #5 has reached 0.079 mg/L — just below the MCL of 0.080. The most recent quarterly result was 0.094 mg/L. Next quarter, the oldest result in the LRAA (0.062 mg/L) will be replaced by the new quarterly result. What is the operational urgency?

A. No urgency exists because the LRAA is currently below the MCL and compliance is based solely on the LRAA

B. The operator should move the monitoring site to a location with lower TTHM levels

C. The operator should request the laboratory to retest the 0.094 sample for possible analytical error

D. Extreme urgency — if next quarter's result is anything above 0.065 mg/L, the LRAA will exceed 0.080 and trigger a violation; the operator must immediately implement measures to reduce water age at this site (flushing, storage optimization, checking for closed valves) and evaluate treatment plant options for reducing THM precursors

25. A distribution system serves a school district that has requested lead testing at all school drinking water taps. Testing reveals that 5 of 85 taps exceed 0.015 mg/L — all are old brass drinking fountains installed before 1990. The remaining 80 taps show lead below 0.005 mg/L. What does this pattern indicate?

A. The corrosion control program is effective systemwide (80 of 85 taps show very low lead), but the 5 old brass fountains contain leadbearing components that leach despite treatment — the fountains' internal materials are the lead source, and remediation should focus on replacing or filtering these specific fixtures

B. The corrosion control program has failed because any tap above 0.015 mg/L proves the treatment is inadequate

C. All 85 taps should be taken out of service until every fountain is replaced

D. The 5 elevated results are laboratory errors because the other 80 taps prove the water is safe

26. An operator discovers that the utility's wellhead protection plan has not been updated in three years. During that period, a gas station, an auto body shop, and a dry cleaner have all opened within the outer protection zone. What risk does the outdated plan create?

A. The plan is still adequate because the outer protection zone is far enough from the well to prevent contamination

B. The wellhead protection plan is informational only and has no regulatory significance

C. The three new businesses represent potential contamination sources that are not documented, monitored, or regulated under the outdated plan — a gasoline leak, solvent spill, or chemical release from any of these unmonitored facilities could contaminate the well's source water without the utility's knowledge

D. The businesses will be covered automatically by the state's environmental regulations without any action from the utility

27. A water system's operator is asked to calculate the daily chlorine requirement for a system treating 4.2 MGD at a dose of 2.6 mg/L using 12.5% sodium hypochlorite. How many gallons per day of the solution are needed?

A. 91.1 gallons per day based on the pounds formula result equaling the gallons needed

B. Approximately 87.3 gallons per day — calculated as: pounds of chlorine = 4.2 × 2.6 × 8.34 = 91.1 lbs/day; gallons of 12.5% solution = 91.1 ÷ (8.34 × 0.125) = 91.1 ÷ 1.043 = 87.4 gallons/day

C. 728 gallons per day based on multiplying the pounds of chlorine by 8.0

D. 10.9 gallons per day based on dividing the MGD by the dose concentration

28. A distribution system has a section of 6inch PVC main installed 12 years ago through an area where environmental testing now reveals petroleum contamination in the soil from a leaking underground storage tank at a nearby gas station. The contamination includes benzene at levels above the MCL in the groundwater surrounding the pipe. What is the specific concern?

A. Benzene will corrode the PVC pipe, causing structural failure within months

B. The benzene contamination will increase chlorine demand inside the pipe, depleting the residual

C. Benzene vapors will enter the distribution system through the main's air release valves

D. Benzene and other petroleum compounds can permeate through PVC pipe walls at the molecular level, entering the drinking water and potentially exposing customers to a carcinogen at concentrations above the MCL — PVC is known to be susceptible to permeation by petroleum products

29. A water system's operator is investigating why the fire flow test results at a specific hydrant have declined from 1,600 GPM to 800 GPM at 20 psi residual over the past six years. The mains are 50yearold unlined cast iron. Cfactor testing shows C = 42. What is the most cost-effective rehabilitation option if the pipe structure is still sound?

A. Clean and cement mortar line the existing mains — this removes the interior tuberculation (restoring the full bore diameter), applies a smooth surface (C ≈ 140), and dramatically reduces friction losses; if

the pipe wall is structurally sound, this restores fire flow capacity to near original levels at approximately 4060% of the cost of full replacement

B. Replace all mains in the area with new 12inch ductile iron pipe

C. Install booster pumps to push more water through the corroded mains

D. Reduce the fire flow requirement for this area through a variance from the fire marshal

30. A distribution system operator measures pressure at a hydrant (elevation 550 feet) and reads 62 psi. The elevated tank serving this zone has an overflow elevation of 700 feet. If the system were truly static (zero flow, zero friction), what would the theoretical maximum pressure be at this hydrant, and what does the difference between theoretical and measured tell the operator?

A. Theoretical = 150 psi based on the elevation difference alone without converting to psi

B. Theoretical = 28.6 psi based on dividing the elevation difference by 2.31 instead of multiplying by 0.433

C. Theoretical = (700 − 550) × 0.433 = 65.0 psi; the measured 62 psi is 3.0 psi (6.9 feet) below theoretical, indicating either the tank is not completely full or there is a small amount of residual flow creating friction loss — the 3 psi difference is within normal operating tolerance

D. Theoretical = 150 psi, and the 88 psi difference from measured indicates a severe restriction between the tank and the hydrant

31. A water system's emergency response plan is activated when a tornado damages the treatment plant's chemical storage area, ruptures a chlorine gas cylinder, causes power outages at three pump stations, and topples trees onto distribution mains in two neighborhoods. The operator must triage these concurrent emergencies. What is the correct prioritization?

A. Main breaks first because they cause immediate customer disruption and visible property damage

B. Power restoration first because all pump stations need electricity to function

C. All four emergencies should be addressed simultaneously by dividing available staff equally

D. Chlorine gas leak first (immediate life safety for plant personnel and nearby residents), then treatment plant stabilization (to ensure safe water production when power is restored), then pump station power (to restore system pressure and supply), then main breaks (which can be temporarily managed with valve isolation)

32. A water operator is calibrating a chemical metering pump that feeds sodium hypochlorite. The pump is set to 80% stroke at 110 strokes per minute. During a 5minute timed calibration test, the operator collects 2,100 mL. What is the pump's output in gallons per hour?

A. 420 mL per minute, which converts to approximately 26.5 gallons per hour

B. Approximately 6.65 gallons per hour — calculated as 2,100 mL ÷ 5 min = 420 mL/min; converting to GPM: 420 ÷ 3,785 = 0.1110 GPM; converting to GPH: 0.1110 × 60 = 6.66 GPH

C. 0.111 gallons per hour based on the per minute conversion without multiplying by 60

D. 2,100 gallons per hour based on assuming 1 mL equals 1 gallon

33. A pump station operator discovers that Pump 2's discharge pressure has declined from 92 psi to 83 psi over the past eight months. Flow rate (850 GPM), motor amperage (44 amps), and suction conditions have remained constant. What is the most likely cause?

A. Progressive wear on the pump's impeller and wear rings is allowing increasing internal recirculation — the pump does the same total work (constant amperage) but delivers less net pressure as more water leaks internally from the high pressure discharge side back to the low-pressure suction; rehabilitation (wear ring and impeller replacement) would restore the lost 9 psi

B. The discharge piping has developed increasing scale buildup that consumes the additional 9 psi

C. The SCADA discharge pressure transducer has drifted 9 psi low over the eight month period

D. The motor is gradually losing speed due to bearing wear, reducing energy transfer to the water

34. A water system serves a commercial district where a new restaurant has opened with a commercial dishwasher that injects chemical sanitizer, a carbonated beverage system with CO_2 injection at pressures above supply, and an exterior grease interceptor with a potable water flush connection. How many cross connection hazards exist?

A. One — only the carbonated beverage system poses a backflow risk because of its high pressure CO_2

B. Two — the dishwasher and the beverage system, because the grease interceptor connection is standard plumbing

C. Three — the dishwasher with chemical injection (chemical hazard), the carbonated beverage system with CO_2 above supply pressure (backpressure + chemical hazard), and the grease interceptor flush

connection (high hazard connection to a sewage containing vessel) each require individual assessment and protection

D. None — restaurants are inspected by the health department and exempt from cross connection requirements

35. A water system's SCADA data shows that an elevated tank dropped from 85% to 20% overnight — consuming approximately 390,000 gallons from a 600,000gallon tank. Average overnight demand for the zone is approximately 60,000 gallons. No main breaks were reported. What should the operator investigate?

A. Whether the SCADA level sensor malfunctioned and the actual tank level did not change

B. Whether seasonal demand increases account for the additional 330,000 gallons consumed overnight

C. Whether the treatment plant reduced output overnight, limiting supply to the zone

D. Approximately 330,000 gallons of unaccounted-for water was consumed overnight — this could be a large unreported main break, an unauthorized hydrant opening, a previously undetected large leak that is masked by daytime production, or a stuck open altitude valve draining the tank to a lower zone; immediate investigation is required

36. A distribution system has a section where two 10inch mains run parallel for 2,500 feet between the same two junction points. Main A (installed 1965, unlined cast iron, C=50) and Main B (installed 2015, cement mortar lined DI, C=140). During a flow test, Main B carries approximately 56 times more flow than Main A. What explains this dramatic flow imbalance?

A. Main A has a partially closed valve that restricts its flow contribution

B. Water follows the path of least resistance — Main B's Cfactor of 140 produces dramatically lower friction than Main A's Cfactor of 50; the ratio of head losses is approximately $(140/50)^{1.85} \approx 6$, meaning Main A has about 6 times the friction of Main B for any given flow; the vast majority of water takes the easier path through Main B

C. Main B's ductile iron material is inherently smoother than cast iron regardless of lining condition

D. Main A has been abandoned and carries no flow at all

37. A confined space entry team is working inside a large underground concrete water reservoir. The continuous atmospheric monitor at the entry point reads normally. After 90 minutes of work, the entrant, who is 80 feet from the hatch, reports a strong chemical odor and mild dizziness. What should happen?

A. The entrant must exit immediately through the retrieval system — symptoms of dizziness and chemical odor indicate a hazardous condition that the monitor at the entry point may not detect because it is 80 feet away; atmospheric conditions can vary significantly within large confined spaces, and the entrant's symptoms take absolute priority over instrument readings at a distant location

B. The attendant should reposition the atmospheric monitor closer to the entrant's location before deciding on evacuation

C. The entrant should move to the side of the reservoir opposite the odor source and continue working

D. The strong odor is likely residual disinfectant and will dissipate if the ventilation blower output is increased

38. A water system serves a hospital that reports water pressure dropping to 28 psi during peak morning demand. The hospital requires minimum 40 psi for medical equipment. System pressure at the 16inch trunk main reads 65 psi during the same period. The hospital is served by a 4inch service line. What is causing the 37 psi pressure loss between the main and the hospital?

A. A PRV on the hospital's service has malfunctioned and is restricting flow

B. The 16inch trunk main has severe tuberculation that restricts flow to the hospital area

C. The hospital's peak morning demand creates high flow through the undersized 4inch service line, generating 37 psi of friction loss — the service line cannot deliver the hospital's peak demand without enormous friction loss; upsizing to a 6inch or 8inch service would dramatically reduce the pressure drop

D. The treatment plant reduces its output during morning hours for routine maintenance

39. A water system's operator is asked to calculate the specific capacity of a well with the following test results: static water level = 48 feet below ground, pumping water level = 96 feet below ground at 500 GPM. What is the specific capacity, and what does it tell the operator?

A. 500 GPM per foot based on dividing flow by the pumping level

B. 5.2 GPM per foot based on dividing flow by the static level

C. 10.4 GPM per foot based on dividing flow by the drawdown (pumping level minus static level)

D. Specific capacity = 500 ÷ (96 − 48) = 500 ÷ 48 = 10.4 GPM per foot of drawdown — this metric tells the operator how efficiently the well produces water relative to the effort required; tracking it over time reveals declining productivity from screen fouling or gravel pack deterioration

40. A water system's annual water audit reveals: production = 5.5 MGD, billed metered consumption = 4.2 MGD, authorized unmetered use = 0.2 MGD, apparent losses = 0.4 MGD, real losses = 0.7 MGD. What is the nonrevenue water percentage?

A. 23.6%, calculated as (5.5 − 4.2) ÷ 5.5 × 100 = 1.3 ÷ 5.5 × 100 — this 1.3 MGD includes authorized unmetered (0.2), apparent losses (0.4), and real losses (0.7)

B. 12.7% based on real losses only as a percentage of production

C. 7.3% based on apparent losses only as a percentage of production

D. 20.0% based on subtracting billed consumption from production and dividing by billed consumption

41. A distribution system experiences a water main break on a 10inch main at a busy intersection at 5:00 PM on a Friday during heavy traffic. The operator arrives at 5:25 PM. What are the first three actions in order?

A. Close isolation valves first to stop water loss, then set up traffic control, then assess the break for repair

B. Establish traffic control first to protect the public and the operator from vehicle strikes, close isolation valves to stop the water loss, then assess the break for repair planning — traffic control comes first because the heavy Friday rushhour traffic at the intersection poses an immediate lifesafety risk to the operator and bystanders

C. Begin excavation immediately at the break location while a second crew sets up traffic control

D. Contact the media to prepare a public notification, then close valves, then set up traffic control

42. A water system's operator discovers that a construction contractor has stockpiled 25 tons of material directly over a 24inch prestressed concrete transmission main buried at 5 feet of cover. What is the concern?

A. The stockpiled material will prevent the pipe from being located electronically for future maintenance

B. The concentrated surface load creates vibration that will gradually loosen the pipe joints

C. The stockpile will compress the soil above the pipe, reducing the depth of cover for future excavation

D. The 25ton concentrated load may exceed the maximum allowable external loading for the PCCP at 5 feet of burial — PCCP relies on the prestressing wires to resist both internal pressure and external loads;

excessive surface loading could cause cracking that leads to wire corrosion and eventual structural failure

43. An operator is asked to explain why the utility invests $95,000 annually in its cross connection control program (one inspector, annual device testing, public education). A council member argues this is an unnecessary expense because no contamination events have occurred. What is the strongest counterargument?

A. The program's $95,000 annual cost prevents contamination events whose consequences — widespread illness, litigation costs, regulatory enforcement, and devastating loss of public trust — would cost the utility millions; the absence of contamination events is proof the program works, not evidence it is unnecessary

B. The cross connection control program generates revenue through inspection and testing fees that offset its cost

C. Federal regulations mandate the program and the utility will be fined if it is eliminated

D. The program provides employment for the inspector and eliminating it would require a layoff

44. A water system's operator measures the velocity of water flowing through a 12inch main at 1,800 GPM. What is the approximate velocity?

A. 2.0 fps, which is at the minimum recommended velocity and may allow some sediment settling

B. 7.3 fps, which exceeds the normal 25 fps range and is only acceptable for short duration conditions

C. Approximately 5.1 fps — calculated as $(1{,}800 \div 448.8) \div (0.785 \times 1.0^2) = 4.01 \div 0.785 = 5.11$ fps; this is slightly above the normal 25 fps range but may be acceptable during moderate peak demand periods

D. 10.2 fps, which exceeds the maximum safe velocity for any operating condition

45. A water system serves a community where the sole production well has a naturally occurring arsenic concentration of 0.009 mg/L. The MCL for arsenic is 0.010 mg/L. The utility does not currently blend with any other source. What is the operational concern?

A. The arsenic level exceeds the MCL and the well must be shut down immediately

B. The 0.009 mg/L level is so far below the MCL that no monitoring or concern is warranted

C. Arsenic is only regulated in surface water systems and does not apply to groundwater wells

D. The arsenic level is only 0.001 mg/L below the MCL — any change in well conditions (pumping rate, aquifer chemistry, seasonal variation) could push the concentration above the MCL; the operator must monitor closely, evaluate blending options or treatment, and maintain records that demonstrate ongoing compliance

46. A distribution system has a 400,000gallon elevated tank that serves a residential zone. SCADA shows the tank cycling between 82% and 96% daily — only 14% turnover. Customers near the tank report taste and odor issues that are worst on Monday mornings. What is the connection between the minimal cycling and the Monday complaints?

A. The tank's exterior paint is contaminating the stored water through the roof hatches

B. The 86% of the tank volume that never cycles contains stagnant water that ages for days or weeks — chlorine residual decays, biological activity develops, and taste/odor compounds accumulate; the minimal weekend demand worsens the stagnation, and Monday morning customers receive the most degraded water first

C. The tank's altitude valve is malfunctioning and restricting flow, causing water quality to deteriorate

D. The taste issues are caused by the treatment plant reducing its chlorine dose on weekends

47. A distribution system operator is troubleshooting an area where multiple customers report that their water pressure pulsates rhythmically. SCADA shows stable pressures at the pump station and storage tank. The affected customers are all served by the same booster pump station with a VFDcontrolled pump. What is the most likely cause?

A. The VFD's PID control loop is improperly tuned — the proportional gain is too high, causing the controller to overreact to pressure changes; each correction overshoots, creating a sustained oscillation that produces the rhythmic pressure pulsation experienced by customers

B. The booster pump's impeller is damaged and produces pulsating flow with each rotation

C. A partially closed valve downstream of the booster station is creating turbulence that pulsates the flow

D. The pressure transducer feeding the VFD has a loose electrical connection that creates intermittent signal drops

48. A water system's operator is asked to explain the concept of "water age" and its significance to a new board member who questions why it matters if the water was treated at the plant. What is the correct explanation?

A. Water age is irrelevant because properly treated water maintains its quality indefinitely in the distribution system

B. Water age is important only for aesthetic reasons — older water tastes worse but is still perfectly safe

C. Water age is the time water spends in the distribution system from treatment to consumption — it matters because chlorine residual decays over time (reducing protection), disinfection byproducts continue forming (increasing health risk), biological activity can develop as residual disappears, and temperature changes affect all these processes; managing water age through operational strategies is one of the most important aspects of distribution system management

D. Water age only affects systems using surface water because groundwater does not change in the distribution system

49. A water system's operator discovers that the annual inspection of a ground level welded steel storage tank has revealed multiple areas where the interior coating has failed and active corrosion pitting is occurring. The deepest pit measures 3/16 inch on a tank wall that is 3/8 inch (0.375 inch) thick. What percentage of the wall has been consumed, and what is the significance?

A. 25% of the wall has been consumed, which is within acceptable limits for a tank of this age

B. The pit depth cannot be compared to wall thickness because corrosion affects only the coating, not the steel

C. 75% of the wall has been consumed, requiring immediate tank replacement

D. 50% of the wall has been consumed (0.1875 ÷ 0.375 = 50%) — this is a critical structural concern; the pit creates a stress concentration that weakens the wall beyond what the remaining thickness alone would suggest; the tank needs emergency structural evaluation, immediate recoating to halt further corrosion, and possible reinforcement or replacement

50. A water main installation requires connecting a new 10inch ductile iron main to an existing 10inch cast iron main. The operator knows that CI and DI pipe have different outside diameters for the same nominal size. What fitting resolves this dimensional difference?

A. A standard pushon coupling designed for ductile iron that also fits cast iron without modification

B. A transition coupling with different sized gaskets or adjustable glands on each end that accommodates the dimensional difference between the two pipe materials

C. A flanged adapter that requires field drilling bolt holes to match the existing pipe

D. No special fitting is needed because 10inch CI and 10inch DI have identical outside diameters

51. A distribution system serves a large university campus with research laboratories using radioactive isotopes. The campus has a single master meter connection to the municipal supply. What is the minimum backflow protection required at the campus's service entrance?

A. An air gap or RPZ assembly — the presence of radioactive materials on campus represents the highest possible hazard level; the protection at the premises isolation point must match the highest internal hazard, regardless of how many other low hazard connections exist on campus

B. A DCVA because the campus's primary function is educational and classified as low hazard

C. A PVB because the primary backflow risk at the campus is back siphonage, not backpressure

D. No premises isolation is needed as long as the laboratory has its own dedicated backflow device

52. An operator performs a pump efficiency test and determines: flow = 1,000 GPM, TDH = 140 feet, motor input = 55 kW. Using the wire to water efficiency formula, what is the approximate pump efficiency?

A. Approximately 95% efficiency, indicating the pump is operating above design specifications

B. Approximately 45% efficiency, indicating the pump is critically degraded and needs immediate replacement

C. Approximately 64% — this is below the typical design efficiency of 7585%, indicating moderate degradation from wear that warrants investigation and likely rehabilitation

D. The efficiency cannot be calculated without knowing the motor's rated horsepower

53. A distribution system serves a neighborhood where six customers on the same dead-end street report water that tastes "stale" and has an earthy odor. The chlorine residual at the hydrant at the end of the dead-end main measures 0.08 mg/L — essentially zero. The normal residual at the trunk main connection point is 1.2 mg/L. What combination of factors explains the poor water quality?

A. The treatment plant is sending inadequate chlorine to this specific area of the system

B. The dead-end configuration creates stagnation (no throughflow), the low demand from only six customers means minimal water movement, and the extended residence time depletes the chlorine residual through reactions with pipe surfaces and biofilm — together these factors produce the worst water quality conditions in the system

C. A cross connection on the dead-end street is introducing contaminated water that depletes the residual

D. The trunk main's residual of 1.2 mg/L is too low to sustain a residual through the entire dead-end length

54. A water system's operator is reviewing the utility's emergency interconnection with a neighboring system. The interconnection valve was last exercised three years ago. The operator attempts to open it during a drought emergency and finds it completely seized. What lesson does this demonstrate?

A. The interconnection valve should be replaced with an automated, motor operated valve

B. Emergency interconnection valves should be removed and replaced with permanent open connections

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

D. All emergency interconnection valves must be included in the regular valve exercising program — a valve that has not been operated in three years is virtually guaranteed to seize, rendering the emergency interconnection useless precisely when it is needed most

55. A water system operates a well that produces water with a pH of 6.5 and total dissolved solids of 45 mg/L. This water is classified as "aggressive." Without corrosion control treatment, what distribution system problems will this aggressive water cause?

A. Low pH, low mineral content water actively dissolves metals from pipe surfaces — leaching lead from service lines and solder joints, copper from plumbing, iron from mains, and zinc from galvanized pipe; elevated metal levels in customers' water create health hazards (lead, copper) and aesthetic complaints (iron discoloration, zinc taste), and the pipe deterioration accelerates infrastructure failure

B. Aggressive water causes excessive scale buildup on pipe interiors, reducing carrying capacity

C. Aggressive water promotes algae growth in storage tanks due to its low mineral content

D. Aggressive water has no significant impact on metallic distribution system components

56. An operator is investigating a complaint from a customer who reports that their water has a strong "swimming pool" chlorine smell from the hot water tap only. Cold water has minimal chlorine taste. The system uses free chlorine, and the residual at the customer's tap is 1.0 mg/L. What explains the difference?

A. The water heater is generating additional chlorine through a chemical reaction with the anode rod

B. The hot water plumbing has a cross connection with a pool chlorination system

C. Heating water increases the volatility of chlorine compounds — warm air above the hot water carries more chlorine vapor to the customer's nose; additionally, hot water releases dissolved chlorine gas from solution more readily than cold water, making the smell more noticeable even though both hot and cold contain the same chlorine concentration

D. The water heater concentrates chlorine through evaporation, increasing the residual in the hot water

57. A water system's SCADA trend data shows that daily production has been exactly 3.200 MGD for 21 consecutive days — the same reading to three decimal places every single day. What should the operator suspect?

A. The pump station has achieved perfect operational balance between production and demand

B. The system has reached equilibrium at the same flow rate due to stable weather and constant demand

C. The production flow measurement is incredibly precise and is recording actual daily production accurately

D. The production flow meter or totalizer has malfunctioned and is reporting a fixed value — real water production varies daily with demand fluctuations, weather, day of the week, and customer behavior; identical readings to three decimal places for 21 days is statistically impossible under normal conditions

58. A distribution system has a 16inch transmission main that crosses beneath a navigable river through a subaqueous pipeline. The river crossing is 500 feet long and 15 feet below the riverbed. What is the most significant maintenance concern specific to this installation?

A. The river's current creates vibration that gradually loosens the pipe joints over time

B. Access for inspection and repair is extremely limited — a leak or break at this location requires specialized diving operations, cofferdams, or long duration bypass that may take days to mobilize; during mobilization, the supply through this main is completely lost, potentially affecting thousands of customers

C. Fish can enter the pipe through submerged joints and contaminate the water supply

D. The water temperature changes caused by the river affect the treatment plant's chemical dosing

59. A water system's operator is developing a list of critical spare parts for emergency main break response. The system has mains ranging from 4inch to 20inch in diameter, made of cast iron, ductile iron, and PVC. What categories of parts should be stocked?

A. Full circle repair clamps in sizes covering the most common main diameters, repair sleeves and couplings for each pipe material and size, transition couplings for connecting different materials, valve box lids, hydrant repair kits, service line repair fittings, and gaskets for each pipe type — the parts must be immediately available because a main break at 2 AM cannot wait for next day parts delivery

B. Only repair clamps for the three most common pipe sizes, since other sizes can be ordered overnight

C. A complete inventory of all pipe sizes in all materials to enable full section replacement of any main

D. Only PVC repair materials because PVC mains break more frequently than metallic mains

60. A water system's operator is asked to explain the single most important reason the utility maintains positive pressure (minimum 20 psi) throughout the distribution system at all times. What is the primary public health justification?

A. Positive pressure prevents pipe collapse from external soil loading that would restrict water flow

B. Positive pressure ensures adequate flow rate at customer fixtures for comfortable daily use

C. Positive pressure prevents back siphonage — when internal pressure exceeds external pressure, any leak or imperfection pushes water outward rather than allowing contaminated external water to be drawn into the pipe; loss of positive pressure turns every cross connection, every flooded meter pit, and every pipe joint into a potential contamination entry point

D. Positive pressure is required to maintain adequate fire flow at hydrants for firefighting operations

61. An operator discovers that the utility's consumer confidence report was distributed to only 85% of customers by the July 1 deadline due to a printing error. The remaining 15% (approximately 2,000 customers) did not receive copies. What must the utility do?

A. Wait until next year's CCR to reach the remaining 2,000 customers

B. Post the CCR on the utility's website and consider the requirement fulfilled

C. Redistribute the CCR to the 2,000 affected customers as soon as possible, notify the state regulatory agency of the distribution shortfall, and document the corrective action — failure to distribute the CCR to all customers by July 1 is a SDWA violation

D. The 85% distribution rate exceeds the minimum 75% threshold and no further action is needed

62. A pump station has three identical centrifugal pumps rated at 500 GPM each. During a peak demand event, all three pumps are running simultaneously. SCADA shows the total station output is 1,350 GPM — not 1,500 GPM. What explains the 150 GPM shortfall from the combined theoretical output?

A. When three pumps operate in parallel, the combined flow increases friction in the common discharge piping — this higher system head forces all three pumps to operate at higher head, lower flow operating points on their curves; the shortfall increases as more pumps are added because friction losses increase approximately with the square of flow

B. One of the three pumps has a worn impeller that is producing less than its rated 500 GPM

C. The SCADA flow meter is inaccurate at high flow rates and reads approximately 10% low

D. The third pump's check valve is partially restricting its contribution to the combined flow

63. A water system's operator is investigating an area where a new housing development at the highest elevation in the system experiences pressure as low as 22 psi during peak demand. The elevated tank overflow is at 910 feet and the highest home is at elevation 878 feet. Under static conditions, pressure = $(910 - 878) \times 0.433 = 13.9$ psi. What does this reveal?

A. The customer's pressure gauge is malfunctioning because the measured 22 psi exceeds the theoretical static pressure of 13.9 psi

B. The static pressure is higher during peak demand because the pumps add additional pressure beyond the tank's gravity head

C. The measured 22 psi during peak demand seems to exceed the 13.9 psi static calculation, which is impossible unless the pumps are running and adding head above the tank's HGL — this indicates the pump station is supplementing the tank's gravity head during peak periods, but even with pump assist, the pressure is far below the 35 psi minimum

D. Even under static conditions (zero demand), the maximum available pressure at this elevation is only 13.9 psi — far below the 35 psi minimum; these homes cannot be adequately served by this pressure zone regardless of pump operation

64. A confined space rescue drill is being conducted at a water storage tank. During the drill, the "victim" (entrant playing an unconscious role) is located 60 feet from the access hatch inside the tank. The nonentry retrieval system's line reaches only 40 feet. What does this limitation reveal about the rescue plan?

A. The nonentry retrieval system is adequate because the "victim" can be dragged the remaining 20 feet

B. The rescue plan must include provisions for entry rescue in this tank — the large interior distance exceeds the nonentry retrieval system's reach, meaning a trained rescue team wearing SCBA must be prepared to enter the space to reach an incapacitated entrant far from the hatch

C. The tank should be divided into zones with a maximum 40foot working distance from the hatch

D. A longer retrieval line should be purchased to extend the nonentry system's reach to 80 feet

65. A water system serves a food processing plant that uses municipal water to wash raw produce. The plant's wash system adds a sanitizing chemical to the municipal water and operates through a booster pump at pressures above the municipal supply. What backflow protection is required?

A. A DCVA because the plant uses only potable water with added food grade sanitizer

B. A PVB because the wash system involves primarily back siphonage risk from the produce wash water

C. An RPZ assembly — the booster pump creates backpressure above supply, and the wash water contains sanitizing chemicals plus agricultural contaminants (pesticides, bacteria, organic matter) from the produce; this combination of backpressure and health hazard requires an RPZ or air gap

D. No protection is needed because food processing plants are regulated by the FDA, not the utility

66. A water system's operator is reviewing pump station energy performance. Station A pumps 2.8 MGD and consumes 1,960 kWh per day (700 kWh/MG). Station B pumps 3.5 MGD and consumes 3,150 kWh per day (900 kWh/MG). Both stations pump against similar system heads with similar equipment. What does this comparison suggest?

A. Station B is more efficient because it produces more total water per day

B. Station A's lower energy cost is due to having newer pumps that are inherently more efficient

C. The 200 kWh/MG difference is within normal variation and does not warrant investigation

D. Station B's pumps are significantly less efficient — consuming 29% more energy per million gallons than Station A; the cause is likely pump wear (deteriorated wear rings, eroded impellers), and pump efficiency testing would confirm the diagnosis and justify rehabilitation

67. An operator calculates the volume of a cylindrical storage tank that is 45 feet in diameter and has a water depth of 30 feet. What is the approximate volume in gallons?

A. 47,713 gallons based on using the tank radius instead of diameter

B. Approximately 357,077 gallons — calculated as $0.785 \times 45^2 \times 30 = 0.785 \times 2{,}025 \times 30 = 47{,}689$ cu ft $\times 7.48 = 356{,}714$ gallons

C. 714,154 gallons based on doubling the correct answer for a two compartment tank

D. 47,689 gallons based on the cubic foot volume without converting to gallons

68. A water system's operator discovers that the utility's GIS database shows a valve at a specific intersection, but thorough field investigation (metal detection, excavation) confirms no valve exists at that location. What should the operator do?

A. Update the GIS to remove the nonexistent valve record, document the investigation findings, and flag any emergency isolation plans that relied on this valve — operators expecting to use this valve during a main break emergency would discover it doesn't exist only after the crisis is underway, potentially expanding the outage area

B. Leave the GIS record unchanged because the original installation records must be the authoritative source

C. Mark the location for future valve installation to match the GIS record

D. Assume the valve was removed during a previous construction project and archive the record without updating

69. A water system experiences a confirmed E. coli positive result from a routine monitoring sample at site #8. The operator issues Tier 1 notification within 24 hours. Repeat samples from site #8 and adjacent sites all return negative. However, the operator discovers that a main break occurred near site #8 two days before the positive sample was collected. What is the most likely source of the E. coli?

A. The laboratory contaminated the original sample during analysis and the result is a false positive

B. A customer near site #8 has a cross connection that introduced contamination during the low-pressure event

C. The main break caused a pressure drop in the area, allowing contaminated water to enter the distribution system through back siphonage at a nearby cross connection, flooded meter pit, or imperfect pipe joint — the negative repeat samples indicate the contamination was transient, corresponding to the pressure recovery after the break was repaired

D. Site #8's sampling tap is contaminated and should be permanently relocated to a different address

70. An operator is asked to calculate the approximate pump horsepower needed to pump 800 GPM against 160 feet of total dynamic head. Using WHP = (Q × TDH) / 3,960, what is the water horsepower, and what motor size is needed assuming 72% pump efficiency and 91% motor efficiency?

A. WHP = 32.3 hp, requiring approximately 32 hp motor based on the WHP alone

B. WHP = 32.3 hp, but the motor must be larger to account for efficiency losses

C. WHP = 128,000 hp based on multiplying flow by head without dividing

D. WHP = (800 × 160) / 3,960 = 32.3 hp; at 72% pump efficiency and 91% motor efficiency, motor HP = 32.3 / (0.72 × 0.91) = 32.3 / 0.655 = 49.3 hp — a standard 50 or 60 hp motor would be specified

71. A distribution system serves a hospital with a single 6inch water service connection. The hospital has 300 beds, surgical suites, a dialysis unit, and an emergency department. What is the most critical vulnerability this configuration creates?

A. The 6inch service may not deliver adequate flow during peak hospital demand

B. A single service connection provides no redundancy — any failure on the 6inch service line, the main it connects to, or any valve in the supply path completely eliminates water for patient care, sterilization, fire suppression, and dialysis; a second independent service from a different main is essential for this critical facility

C. The fire sprinkler system may not receive adequate flow through a single 6inch connection

D. The dialysis unit requires higher water quality than a single service can provide

72. An operator measures pressure at two hydrants on the same main during steady flow. Hydrant A (elevation 580 feet) reads 56 psi. Hydrant B (elevation 610 feet, 3,000 feet downstream) reads 43 psi. What is the friction head loss between the two points?

A. Approximately 0.7 feet — calculated as: HGL_A = 580 + (56 × 2.31) = 709.4 ft; HGL_B = 610 + (43 × 2.31) = 709.3 ft; head loss = 709.4 − 709.3 = 0.1 feet... rechecking: HGL_A = 580 + 129.4 = 709.4; HGL_B = 610 + 99.3 = 709.3; HL = 0.1 ft. This minimal head loss over 3,000 feet indicates the main has very low friction

B. 13 psi based on the simple pressure difference, which would be 30 feet of head loss

C. 30 feet based on the elevation difference between the two hydrants

D. The head loss cannot be calculated without knowing the pipe diameter and flow rate

73. A distribution system's SCADA alarm management audit reveals that 95% of all alarms are acknowledged without investigation. The most frequent alarm is "low tank level" at Tank C, which activates 812 times daily. Investigation reveals the alarm setpoint was set at 85% — far too high for normal operations. What should be done?

A. Disable the Tank C lowlevel alarm entirely because it generates too many nuisance activations

B. Reassign all alarm acknowledgment duties to the supervisor to ensure proper investigation

C. Rationalize the alarm system — adjust Tank C's lowlevel alarm to a meaningful setpoint (such as 4050%) that indicates an actual operational concern rather than normal cycling; review all alarms systemwide to eliminate nuisance alarms, prioritize the remaining alarms by severity, and establish clear investigation requirements for each priority level

D. Install a second SCADA system to provide redundant alarm monitoring

74. A water system serves a community where the average water main age is 70 years. AWWA data indicates exponentially increasing break rates after age 50 for cast iron pipe. The utility's break rate has tripled over the past decade. What does this data support in terms of capital planning?

A. The utility should wait for the break rate to stabilize before investing in replacement

B. The utility has adequate capacity to manage the current break rate through reactive repair

C. All mains should be replaced simultaneously in a single, large capital project

D. The utility is in the acceleration phase of infrastructure deterioration — capital investment in main replacement must increase significantly and immediately; a risk based prioritization program should target the highest risk mains first while developing a long-term replacement schedule that prevents the system from reaching a catastrophic failure threshold

75. A water operator is investigating a section of the distribution system where Cfactor testing on 55yearold unlined cast iron mains shows C = 38. The original Cfactor when new was approximately 130. Fire flow tests produce only 500 GPM at 20 psi residual — far below the required 1,000 GPM. What are the two most effective rehabilitation options?

A. Install additional fire hydrants to distribute the available flow across more outlets

B. Clean and cement mortar line the existing mains (restoring C to approximately 140 if the pipe structure is sound) or replace the mains with new larger ductile iron pipe — both options dramatically improve carrying capacity and fire flow; the choice between rehabilitation and replacement depends on the structural condition of the existing pipe

C. Install booster pumps to force more water through the corroded mains at higher pressure

D. Reduce the fire flow requirement through a variance from the fire marshal

76. A water system operates a well that has shown declining specific capacity over the past five years — from 14.0 GPM/ft to 7.5 GPM/ft. The utility schedules well rehabilitation. What is the first step in the rehabilitation process?

A. Video inspection of the well bore to assess the condition of the casing, screen, and gravel pack before selecting the appropriate cleaning method — without knowing the specific cause of the decline (mineral encrustation, biofouling, sand bridging, screen corrosion), the correct rehabilitation technique cannot be selected

B. Chemical treatment with hydrochloric acid to dissolve mineral deposits on the well screen

C. Mechanical surging and redevelopment to dislodge material blocking the screen openings

D. Install a new, larger pump to overcome the reduced well efficiency

77. A distribution system has a section where a new 10inch main was installed three months ago to replace a severely tuberculated 8inch main. Since the replacement, nearby customers have reported intermittent brown water during demand changes. What is causing the discoloration?

A. The new main's cement mortar lining is leaching calcium into the water, creating a brown precipitate

B. The new pipe has manufacturing residue on its interior surface that has not been fully flushed

C. The improved hydraulics of the new larger pipe have changed the flow patterns in the adjacent old mains — higher velocities in the connected older pipes disturb sediment that was previously stable under the old, lower velocity flow regime; the brown water comes from the old mains, not the new one

D. The disinfection chemicals used during the new main installation reacted with the old pipe to produce iron precipitates

78. A water system's emergency generator at a critical pump station successfully starts during a power outage and runs for 8 hours. The generator then shuts down on a low coolant temperature alarm. Investigation reveals the thermostat is stuck open, causing coolant to circulate through the radiator continuously and overcool the engine. What maintenance practice would have detected this?

A. Monthly full load testing that runs long enough to bring the engine to normal operating temperature would have revealed the overcooling condition

B. Weekly visual inspection of the generator's exterior for leaks and damage

C. Annual replacement of all generator cooling system components regardless of condition

D. Including thermostat function testing and coolant temperature verification as part of the regular generator maintenance program — checking that the engine reaches and maintains normal operating temperature during load tests would identify a stuck open thermostat before it causes an emergency shutdown

79. A distribution system serves a community where the utility's water audit shows real losses of 20% of production. The utility produces 6.0 MGD at an allin cost of $3.25 per 1,000 gallons. What is the annual cost of these real losses?

A. $7,800 per year based on the daily cost of real losses multiplied by 30 days

B. Approximately $1,423,500 per year — calculated as 6.0 MGD × 0.20 = 1.2 MGD of real losses; annual volume = 1.2 × 365 = 438 MG; cost = 438,000 × $3.25/1,000 = $1,423,500; this enormous annual loss provides compelling justification for aggressive leak detection and infrastructure investment

C. $142,350 per year based on using only 10% of the actual loss volume

D. $3,900 per year based on the daily production cost without accounting for the loss volume

80. A distribution system operator is asked to identify the single most important piece of information needed when responding to a main break emergency at 3:00 AM. What is the correct answer?

A. The age and material of the broken pipe to determine appropriate repair materials

B. The depth of the pipe to select the correct excavation equipment

C. The manufacturer of the pipe to order the correct replacement section

D. The location and operability of the nearest isolation valves — without knowing which valves to close and where they are, the operator cannot stop the water loss; every minute of delay means more water wasted, more storage depleted, and more property damaged; valve location knowledge determines the speed and effectiveness of every main break response

81. A water system's operator is reviewing the utility's chemical storage configuration. Sodium hypochlorite (oxidizer) and hydrofluosilicic acid (corrosive acid) are stored in the same room without physical separation or individual secondary containment. What safety hazard does this arrangement create?

A. An accidental spill that mixes the two chemicals could produce toxic chlorine gas — these chemicals are incompatible and must be stored separately with physical barriers and individual secondary containment to prevent contact from spills, delivery errors, or container failures

B. The two chemicals will react through their storage tank walls even without direct contact

C. The arrangement is safe because both chemicals are used in water treatment and are compatible

D. The only concern is that both chemicals have similar looking storage tanks, creating delivery confusion risk

82. A water system serves an area where a new housing development has been built at the highest elevation in the pressure zone. The elevated tank overflow is at 930 feet and the highest homes are at elevation 900 feet. Under static conditions, the maximum pressure = (930 − 900) × 0.433 = 13.0 psi. What must the utility do?

A. Accept the 13 psi as adequate for this development since the homes were built knowing the elevation limitation

B. Increase the pump station discharge pressure to push more water uphill to these customers

C. These homes cannot be adequately served by this pressure zone — even under ideal static conditions, the maximum pressure of 13 psi is far below the 35 psi minimum; the utility must either raise the tank overflow (affecting all customers in the zone), install a dedicated booster pump system for the high elevation area, or reassign these homes to a higher pressure zone

D. Install larger water meters at these homes to reduce the pressure loss through the meter

83. An operator is performing a fire hydrant flow test. The static pressure at the residual hydrant is 64 psi. After opening two flow hydrants, the residual drops to 46 psi while the combined pitot measured flow is 1,200 GPM. Using the standard formula, what is the approximate available fire flow at 20 psi residual?

A. 2,400 GPM based on doubling the tested flow for the lower residual target

B. Approximately 1,724 GPM — calculated as 1,200 × [(64−20)/(64−46)]^0.54 = 1,200 × (44/18)^0.54 = 1,200 × 2.444^0.54 = 1,200 × 1.437 ≈ 1,724 GPM

C. 1,200 GPM because the available flow always equals the tested flow regardless of target pressure

D. 600 GPM because the available flow is half the tested flow at any lower residual target

84. A water system's operator discovers that the utility has been operating for 12 months with an uncalibrated production flow meter. The meter was reading 5% high — reporting 5.25 MGD when actual production was 5.0 MGD. What operational impacts has this inaccuracy caused?

A. The inaccurate meter has had no significant operational impact because customer meters track actual consumption

B. The meter error only affects the utility's billing for wholesale water sales

C. The inaccurate meter caused cosmetic data errors but no operational problems

D. For 12 months, the utility has been overdosing chemicals by 5% (because the pounds formula used the inflated 5.25 MGD), and the water audit has underestimated real losses by 0.25 MGD (because the artificially high production masked the true loss volume) — both errors affect public health protection and financial analysis

85. A water main repair crew completes an emergency repair on a 16inch transmission main. The repair involved cutting out a section and installing a replacement piece with couplings. The utility's SOP for repairs of this size requires AWWA C651 spray application of 200 mg/L chlorine on all exposed surfaces, followed by flushing until residual matches the system. After flushing, the residual reads 1.1 mg/L — matching the system. Can the main be returned to service?

A. Yes — the repair disinfection SOP has been followed correctly: spray application disinfected exposed surfaces, flushing removed construction debris and excess chlorine, and the 1.1 mg/L residual matching the system confirms fresh, properly disinfected water has reached the repair site

B. No, the main must be held at 25 mg/L for 24 hours per AWWA C651 Method 1

C. No, bacteriological samples must be collected and cleared by the laboratory before the main can return to service

D. Yes, but only if the repair is photographed and documented in the maintenance management system before service restoration

86. A distribution system serves a community where a water quality event has occurred — a chemical spill near a distribution main has contaminated the soil with an industrial solvent. The main is 12inch ductile iron with mechanical joints. Under what conditions could the solvent enter the drinking water through this pipe?

A. Solvents cannot enter ductile iron pipe under any conditions because the metal is impervious to permeation

B. The solvent will corrode through the ductile iron wall within days, creating an entry point

C. If the distribution main experiences a pressure drop below the external pressure of the contaminated groundwater, the solvent could infiltrate through mechanical joint gaskets — standard SBR rubber gaskets can be degraded by chlorinated solvents, and under negative pressure conditions, contaminated water can enter through any imperfect seal

D. The solvent can only enter through air release valves at nearby high points in the distribution main

87. An operator is asked to explain the most important operational lesson from the utility's experience managing its distribution system over the past decade. What single principle has proven most fundamental to effective water distribution operations?

A. Mastering the hydraulic formulas and calculations required for system design and analysis

B. Knowing the physical system — every pipe, valve, hydrant, tank, and pump — is the foundation that makes every other skill effective; an operator who knows the system responds faster to emergencies, plans better maintenance, makes smarter capital decisions, and provides better daily service than one who relies solely on GIS, SCADA, and classroom knowledge

C. Maintaining the SCADA system as the primary tool for all operational decisions

D. Building relationships with regulatory agencies to facilitate compliance

88. A water system's operator is developing a comprehensive training program for newly hired distribution operators. What topic must be covered FIRST — before the new operator performs any field work?

A. Hydraulic calculations and the Hazen Williams formula for system analysis

B. SCADA system operation and data management procedures

C. Water quality sampling techniques and DPD chlorine testing methods

D. Safety training — confined space entry, excavation safety, traffic control, lockout/tagout, chemical handling, and emergency response; these life safety topics must precede all field work because the hazards distribution operators face daily (trench cave-ins, confined space atmospheres, traffic, electricity, chemicals) can be lethal for untrained workers

89. A water system's retiring distribution superintendent with 35 years of experience is asked to leave one final piece of advice for the utility. Based on decades of managing water distribution infrastructure, what would the superintendent most likely recommend?

A. Invest in your people and your infrastructure — train operators continuously because their knowledge and skills protect public health every day; maintain your system proactively because deferred maintenance always costs more in emergencies than it would have cost in prevention; and never forget that every decision you make affects the water that families drink, cook with, and bathe in

B. Focus on keeping the SCADA system updated because technology drives all modern water operations

C. Prioritize customer relations above all other operational concerns

D. Maintain the lowest possible operating budget to maximize the utility's financial reserves

90. A distribution system operator is asked to perform one final comprehensive review of the utility's emergency response plan before it is submitted for state approval. What single element is MOST critical to verify in the plan?

A. That the plan's formatting meets the state's submission requirements and page limits

B. That the plan includes a glossary of all technical terms used throughout the document

C. That every resource listed in the plan — emergency contacts, mutual aid agreements, interconnection valves, generator locations, chemical suppliers, and contractor phone numbers — is current, verified,

and actually available; a plan filled with disconnected phone numbers, expired agreements, seized valves, and outdated contact information provides a false sense of preparedness that fails exactly when it matters most

D. That the plan has been reviewed by the utility's legal counsel for liability protection

91. A water system has been asked by the state regulatory agency to develop and submit a comprehensive asset management plan within 12 months. The utility has 200 miles of water main, 4 pump stations, 3 elevated tanks, 2 ground level reservoirs, 6 production wells, and 15,000 service connections. What is the FIRST step in developing this plan?

A. Calculate the replacement cost of all 200 miles of water main at current construction prices

B. Hire a consulting engineer to perform a hydraulic model of the entire distribution system

C. Establish a 20year capital improvement budget based on replacing 5% of the system per year

D. Complete a comprehensive asset inventory documenting the location, material, size, age, condition, and criticality of every asset in the system — you cannot manage what you have not inventoried; the inventory forms the foundation for all subsequent analysis including risk assessment, condition evaluation, lifecycle cost analysis, and capital improvement prioritization

92. A water system's operator is reviewing the utility's overall performance and is asked to identify the single most important metric that indicates whether the distribution system is protecting public health. What metric best serves as the overall indicator of distribution system performance?

A. The total number of main breaks per year per mile of pipe

B. The percentage of the distribution system that maintains adequate chlorine residual at all times — residual presence confirms the disinfection barrier is intact throughout the network; areas with depleted residual are unprotected against microbial contamination; this single metric captures water age, system hydraulics, chemical feed effectiveness, and infrastructure condition simultaneously

C. The total volume of nonrevenue water as a percentage of production

D. The average customer satisfaction rating from the annual survey

93. A distribution system operator is performing the final quality check on this study guide's content. The operator reviews all 15 practice exams (1,500 total questions) and identifies that the exams collectively cover every domain of the WPI/ABC Water Distribution Operator certification exam. What is the most effective way to use these practice exams for exam preparation?

A. Take all 15 exams in sequence, review every answer explanation, identify weak content areas from questions answered incorrectly, revisit the corresponding chapters in Part One for those weak areas, and retake the exams focusing on previously missed questions — this iterative study approach builds both knowledge depth and test taking confidence

B. Take only the final 3 exams because they are the most difficult and most representative of the actual exam

C. Read only the answer explanations without attempting to answer the questions first

D. Take one exam per week and skip any exam where you score above 80%

94. A water system's operator is asked to summarize the single most important principle of water distribution system operation — the foundational concept that underlies every operational decision, every maintenance activity, and every emergency response. What is that principle?

A. Minimize operational costs while maintaining regulatory compliance

B. Maximize water production to ensure adequate supply under all conditions

C. Protect public health by maintaining the quality and safety of drinking water from the treatment plant to the customer's tap — every operational decision, every valve exercised, every main repaired, every residual tested, every cross connection eliminated, and every emergency response serves this single overriding purpose

D. Maintain system pressure above 60 psi at all points in the distribution network

95. A water distribution operator has completed all 15 practice examinations in this study guide and is preparing for the WPI/ABC certification exam. Based on the comprehensive content covered across all exams, what final study strategy would be most effective in the days before the exam?

A. Memorize all mathematical formulas without understanding the concepts behind them

B. Read the entire study guide from cover to cover one more time without stopping

C. Focus on reviewing any material that was unclear during the selfstudy process

D. Review the answer explanations for every question answered incorrectly across all 15 exams — these explanations identify specific knowledge gaps; then revisit the corresponding Part One chapters that address those gaps; focus the final study sessions on weak areas rather than reviewing material already mastered; and get adequate rest before the exam

96. A newly certified water distribution operator begins their first day of work. They have passed the WPI/ABC Grades 1 & 2 exam and hold their certification. Their supervisor assigns them to shadow an experienced operator for the first month. What is the most important thing the new operator should do during this shadowing period?

A. Study for the next certification level to advance their career as quickly as possible

B. Learn the physical system — walk every street, locate every valve, understand every pipe connection, identify every pump station, memorize tank locations, and absorb the experienced operator's institutional knowledge about where problems recur, where vulnerabilities exist, and how the system behaves under different conditions; this firsthand knowledge will serve them throughout their entire career

C. Focus exclusively on mastering the SCADA system interface and data management

D. Begin developing a capital improvement plan based on the knowledge gained during certification study

97. The WPI/ABC Water Distribution Operator certification exam tests knowledge across four primary domains. This study guide was structured to address all four domains through both learning content (Part One chapters) and assessment content (Part Two practice exams). What is the single most effective study approach for mastering all four domains?

A. Integrate reading Part One chapters with taking Part Two practice exams — read a chapter, then take the related practice exam questions; use incorrect answers to identify knowledge gaps; revisit the chapter content for those gaps; and repeat the cycle until consistently scoring above 90% across all domains

B. Study only the practice exams because they contain all the information needed to pass

C. Focus exclusively on the domain with the highest question weight and skip the others

D. Memorize the answer keys for all 15 practice exams

98. A water distribution operator who has thoroughly studied this guide and completed all practice exams arrives at the WPI/ABC testing center on exam day. What final piece of advice applies to taking the actual certification exam?

A. Rush through the exam as quickly as possible to minimize test anxiety

B. Skip all calculation questions and return to them at the end because they take too long

C. Read each question carefully, eliminate obviously wrong answers first, apply the knowledge gained from studying, manage time wisely across all 100 questions, and remember that approximately 35% of questions test recall while 65% test application — the practice exams have prepared you for both question types

D. Focus only on questions that seem familiar from the practice exams and guess on all others

99. This study guide concludes with a comprehensive final review question. A water distribution operator is asked to identify the THREE most critical responsibilities of a certified water distribution operator — the responsibilities that, if neglected, would most directly endanger public health. What are they?

A. Maintaining accurate billing records, responding to customer complaints promptly, and keeping the SCADA system updated

B. Maintaining operator certification, attending board meetings, and preparing budget documents

C. Installing new water meters, reading existing meters accurately, and maintaining the AMI system

D. Maintaining adequate disinfectant residual throughout the distribution system (protecting against microbial contamination), maintaining positive pressure at all times (preventing back siphonage contamination), and maintaining an effective cross connection control program (eliminating backflow pathways) — these three responsibilities form the core of distribution system public health protection

100. The final question of the final practice exam in this study guide asks: What is the ultimate purpose of water distribution operator certification?

A. To restrict entry into the water distribution profession and limit the number of qualified operators

B. Certification ensures that every person responsible for operating a public water distribution system possesses the knowledge, skills, and commitment to protect the health of every customer who drinks the water — certification is not just a credential; it is a public trust that the operator will maintain the safety of the community's most essential resource

C. To satisfy a regulatory requirement imposed by the state drinking water program

D. To provide operators with a pathway to higher salaries and career advancement

Practice Exam 15: Answer Key and Explanations

1. D — A gradual 15% production increase over 120 days with no new connections, declining seasonal demand, and a confirmed-accurate meter is the classic signature of a developing distribution system leak. The leak is progressively enlarging — likely from soil erosion around the opening — consuming an additional 0.6 MGD that the system must produce to maintain pressure and storage levels.

2. B — Firm capacity equals the system output with the largest single pump out of service. With three identical 700 GPM pumps, removing one leaves two operating in parallel producing approximately 1,300 GPM (slightly less than 1,400 due to increased system head from higher combined flow). This ensures demand can be met during a single-pump failure.

3. C — Each connection represents a different hazard: the cooling tower with chromium (high hazard, chemical), the sprinkler with glycol antifreeze (high hazard, chemical + backpressure from jockey pump), and the irrigation system (low hazard, backsiphonage). Each requires assessment and protection matched to its specific hazard level and backflow mechanism.

4. A — Chlorine residual decays with distance and time in the distribution system. Point B's near-zero residual after traveling 6 miles demonstrates that the treatment plant dose, while adequate near the plant, cannot sustain protection to the system's extremities. A booster chlorination station between the two points replenishes residual before it reaches dangerously low levels.

5. D — Usable volume = $0.785 \times 60^2 \times (28 - 18) = 0.785 \times 3{,}600 \times 10 = 28{,}260$ cu ft $\times$ 7.48 = 211,385 gallons. This volume between the low and high operating levels is what the system draws upon during peak demand, fire flow, and equalization — the volume below the low level serves as reserve.

6. B — A dead-end main with severe internal tuberculation continuously generates iron particles from the corroded pipe surface. Flushing temporarily clears the discolored water, but the corroded interior immediately begins shedding again. The recurrence within four days confirms the pipe itself is the source. Cleaning/lining or replacement is the only permanent solution.

7. C — Standard four-gas monitors detect O_2, LEL, CO, and H_2S but not chloramine, ammonia, or chlorine. A reservoir that stored chloramine-treated water will have residual chloramine on wet surfaces that can off-gas as the chamber dries. Chlorine-specific and ammonia-specific detectors are needed to evaluate this known, site-specific hazard.

8. A — D = 20/12 = 1.667 ft. A = 0.785 × 2.778 = 2.182 sq ft. Volume = 2.182 × 400 = 872.7 cu ft. Weight = 872.7 × 62.4 = 54,456 lbs (approximately 27 tons). This weight, plus the pipe's empty weight, must be supported by the bridge structure. Engineers require this calculation for structural load analysis.

9. D — Euthanasia chemicals (pentobarbital) and embalming fluids represent the highest possible health hazard — lethal substances that cannot be tolerated at any concentration in drinking water. A single check valve provides essentially no reliable protection for this extreme hazard level. An air gap provides absolute protection; an RPZ is the minimum mechanical alternative.

10. B — A fire flow bypass line around the PRV station has a normally closed valve that opens during high-demand events. This allows Zone 1's full 88 psi to supplement Zone 2, dramatically increasing available fire flow without permanently changing Zone 2's normal operating pressure. This directly addresses the hydraulic bottleneck that the PRV creates during fire flow events.

11. C — Combined chlorine = Total − Free = 2.8 − 0.1 = 2.7 mg/L. In a properly controlled chloramine system, the vast majority of residual should be combined chlorine (monochloramine), with minimal free chlorine. The 0.1 mg/L free chlorine is a trace amount typical of a well-controlled chloramine program operating near the optimal chlorine-to-ammonia ratio.

12. A — Daily production = 550 × 60 × 18 = 594,000 gallons. This exceeds the 520,000 average demand by only 74,000 gallons (14%). However, peak day demand typically reaches 1.5-2.0 times average, and fire flow requirements add further demand. A single source with only 14% surplus above average demand is critically vulnerable to any disruption.

13. D — The building contains multiple high-hazard connections: the booster pump creates backpressure, the sprinkler chemicals and pool chemicals create health hazards. An RPZ at the service entrance provides premises isolation protecting the municipal supply. Individual devices on internal connections provide defense-in-depth. Both levels of protection are needed.

14. B — A valve requiring extreme effort and a cheater bar to operate has not been exercised recently and has developed internal corrosion. Had this valve been completely seized, the operator would have needed the next available valve — potentially hundreds of feet or blocks away, dramatically expanding the outage area. This near-failure demonstrates why transmission main valves must be regularly exercised.

15. A — To convert feet of head to psi: 22 × 0.433 = 9.5 psi. This means the 4,000-foot section of 8-inch main carrying 800 GPM produces a 9.5 psi friction loss. This is a significant pressure drop that must be accounted for in system design and operation.

16. C — With 90% of alarms acknowledged without investigation, operators have been conditioned to dismiss all alarms rather than evaluate each one. Critical alarms — low residual, pump failure, tank overflow — may be buried in the noise and dismissed alongside nuisance alarms. Alarm rationalization must eliminate the nuisance alarms and establish clear priority levels for the remaining actionable ones.

17. D — Chloramines are toxic to blood (dialysis patients), lethal to fish (aquarium owners), and behave differently than free chlorine in industrial processes. Each group must be notified with adequate lead time to modify their systems before chloraminated water arrives. Failing to notify these groups could result in patient harm, fish kills, and process failures.

18. B — The physical connection between the untreated well and the municipal supply creates the cross-connection regardless of the customer's intended use. Human error (leaving a valve open), plumbing modifications, or pressure changes can allow untreated well water to enter the municipal system at any time. The well pump can also create backpressure that forces contamination into the supply.

19. A — In the 14-inch: V = (1,800/448.8) / (0.785 × 1.167^2) = 4.01 / 1.069 = 3.75 fps. In the 8-inch: V = 4.01 / (0.785 × 0.667^2) = 4.01 / 0.349 = 11.5 fps. The velocity triples through the smaller pipe, and since friction varies approximately with V^1.85, the head loss increases dramatically — directly explaining the downstream pressure complaints.

20. C — The CCR is a federally mandated transparency document that empowers customers with knowledge about their drinking water. It discloses the source water, all detected contaminants and their levels versus MCLs, any violations, and health significance of detections. This information allows customers to make informed decisions about their water quality.

21. A — The distribution piping between the pump station and Tank B has higher friction than the path to Tank A. During fill cycles, more water takes the easier path to Tank A. During drawdown, Tank A supplies more demand through its lower-resistance path. Tank B receives and discharges less water, resulting in poor cycling and associated water quality problems.

22. C — 800 ÷ 22 = 36.4 hours at full load — only 38% of the 96-hour outage. The operator needs at least two additional fuel deliveries during the ice storm. Roads may be impassable, fuel suppliers

overwhelmed, and delivery trucks unable to reach remote stations. Pre-storm fuel topping, multiple supplier contacts, and emergency management coordination are essential.

23. B — The 8 extra turns during closure indicate debris on the valve seat preventing the gate from seating during the normal 26 turns. The additional turns compressed through or displaced the material. The 26-turn reopening confirms the correct mechanical travel once the seat was clear. The valve should be flagged for potential cleaning.

24. D — When the oldest LRAA result (0.062) drops out and is replaced by any new result above 0.065, the LRAA will exceed 0.080 — triggering a violation. The operator has one quarter to reduce TTHM formation at this site through operational measures: flushing, storage optimization, valve position checks, and treatment plant precursor removal.

25. A — The 80 taps showing very low lead (below 0.005) confirm the corrosion control program works system-wide. The 5 elevated fountains contain lead-bearing brass components that leach despite treatment. The fixtures — not the system — are the lead source. Remediation must target these specific fixtures through replacement or point-of-use filtration.

26. C — Three new potential contamination sources within the wellhead protection area are undocumented, unmonitored, and unregulated under the outdated plan. A gasoline leak, solvent spill, or chemical release from any of these facilities could contaminate the well without the utility's knowledge. The plan must be updated to include these sources.

27. B — Pounds of chlorine = $4.2 \times 2.6 \times 8.34 = 91.1$ lbs/day. Gallons of 12.5% solution = $91.1 \div (8.34 \times 0.125) = 91.1 \div 1.043 = 87.4$ gallons/day. Always calculate pure chlorine first using the pounds formula, then divide by the product strength to determine the volume of chemical solution needed.

28. D — PVC is well-documented to be susceptible to permeation by petroleum compounds including benzene. The contaminated soil surrounding the pipe provides a continuous source of hydrocarbons that slowly diffuse through the PVC wall at the molecular level, entering the drinking water. With benzene above the MCL in the groundwater, customers face exposure to a known carcinogen.

29. A — Cleaning and cement mortar lining removes the interior tuberculation, restores the full bore diameter, and applies a smooth surface ($C \approx 140$). If the pipe wall is structurally sound, this restores carrying capacity and fire flow to near-original levels at 40-60% of the cost of full replacement. C-factor testing and/or wall thickness measurement confirms structural adequacy.

30. C — Theoretical static pressure = (700 − 550) × 0.433 = 65.0 psi. The measured 62 psi is 3.0 psi below theoretical — indicating either the tank isn't completely full or a small residual flow creates minor friction loss. This 3 psi difference is within normal operating tolerance and does not indicate a significant system problem.

31. D — Chlorine gas leak is the immediate life-safety priority — it can kill plant personnel and nearby residents within minutes. Treatment plant stabilization ensures safe water when power returns. Pump station power restoration restores supply and pressure. Main breaks can be temporarily managed with valve isolation while higher-priority emergencies are addressed.

32. B — Per-minute rate = 2,100 ÷ 5 = 420 mL/min. Converting: 420 ÷ 3,785 = 0.1110 GPM. Converting to GPH: 0.1110 × 60 = 6.66 gallons per hour. Accurate calibration ensures the intended chemical dose reaches the water — under-delivery means inadequate treatment, over-delivery wastes chemical and may affect taste.

33. A — A 9 psi decline at constant flow, constant amperage, and stable suction conditions is the classic signature of progressive wear ring and impeller deterioration. The widening internal clearances allow increasing recirculation from discharge to suction. The pump does the same total work but delivers less net pressure. Wear ring and impeller replacement restores the lost performance.

34. C — All three connections represent cross-connection hazards: the dishwasher injects chemical sanitizer (chemical hazard), the CO_2 beverage system operates above supply pressure (backpressure + chemical), and the grease interceptor flush connection links potable water to a sewage-containing vessel (high hazard). Each requires individual assessment and appropriate protection.

35. D — Approximately 330,000 gallons of unaccounted-for water disappeared overnight beyond normal demand. Possible causes include a large unreported main break, unauthorized hydrant use, a large hidden leak masked by daytime production, or a control valve malfunction draining the tank to another zone. The magnitude demands immediate field investigation.

36. B — Water follows the path of least resistance. The C-factor ratio (140/50 = 2.8) raised to the 1.85 power ≈ 6.1 means Main A produces approximately 6 times the friction of Main B for any given flow. The vast majority of water takes the easier path through Main B, leaving Main A with minimal flow contribution.

37. A — Symptoms of dizziness and chemical odor 80 feet from the monitoring point indicate a hazardous condition that the distant monitor cannot detect. Large confined spaces have atmospheric gradients — conditions near the entrant may differ dramatically from conditions at the hatch. The entrant's symptoms take absolute priority over any instrument reading taken at a different location.

38. C — System pressure at the 16-inch main is 65 psi — adequate. The 37 psi drop occurs in the 4-inch service line during peak morning hospital operations. High flow through the undersized service creates enormous friction loss. Upsizing to 6-inch or 8-inch dramatically reduces the pressure drop, delivering adequate pressure for medical equipment operation.

39. D — Specific capacity = Flow ÷ Drawdown = 500 ÷ (96 − 48) = 500 ÷ 48 = 10.4 GPM per foot. This metric quantifies well productivity — higher values indicate a more productive well. Tracking specific capacity over time reveals declining performance from screen fouling or gravel pack deterioration, enabling proactive rehabilitation before the well fails.

40. A — NRW = Production − Billed = 5.5 − 4.2 = 1.3 MGD. Percentage = 1.3 ÷ 5.5 × 100 = 23.6%. This includes authorized unmetered use (0.2), apparent losses (0.4), and real losses (0.7). Understanding the composition guides corrective priorities — leak detection for real losses and meter programs for apparent losses.

41. B — Traffic control comes first because the heavy Friday rush-hour traffic at the intersection creates an immediate life-safety hazard for the operator and bystanders. Once the work zone is protected, closing isolation valves stops the water loss. Then the operator assesses the break to determine repair requirements. Safety always precedes operational response.

42. D — PCCP relies on prestressing wires under tension to resist both internal pressure and external loads. The 25-ton concentrated surface load may exceed the pipe's design loading at 5 feet of cover, potentially causing cracking. Cracks in PCCP allow water to reach the prestressing wires, initiating corrosion that can lead to catastrophic failure. The load must be redistributed.

43. A — The program's $95,000 annual cost prevents contamination events whose consequences — emergency response, widespread illness, litigation, regulatory enforcement, and loss of public trust — routinely cost millions. The absence of contamination proves the program works. Eliminating it is analogous to canceling insurance because no claims have been filed.

44. C — Q = 1,800 ÷ 448.8 = 4.01 cfs. D = 12/12 = 1.0 ft. A = 0.785 × 1.0 = 0.785 sq ft. V = 4.01 ÷ 0.785 = 5.11 fps. This slightly exceeds the normal 2-5 fps range but may be acceptable during moderate peak conditions. Sustained velocities above 5 fps increase erosion of pipe surfaces and fittings.

45. D — At 0.009 mg/L — only 0.001 below the 0.010 MCL — any natural variation in well conditions could push arsenic above the MCL. Seasonal aquifer chemistry changes, increased pumping rates, or drought conditions can all increase arsenic concentration. Close monitoring, blending evaluation, and treatment planning are essential proactive measures.

46. B — The 86% of tank volume that never turns over contains water aging for days or weeks. Chlorine decays, biological activity develops, and taste/odor compounds accumulate in this stagnant volume. Weekend demand is even lower than weekday, worsening the stagnation. Monday morning customers receive the most degraded water — the oldest, most stagnant volume.

47. A — A VFD with excessive proportional gain overreacts to each pressure deviation. Each correction overshoots the setpoint, triggering a correction in the opposite direction. This sustained oscillation produces the rhythmic pressure pulsation customers experience. Reducing the proportional gain and retuning the PID parameters stabilizes the output at the target pressure.

48. C — Water age is the single most important water quality parameter in the distribution system. Chlorine decays, DBPs continue forming, biological activity develops, and temperature changes accelerate all processes. Water that left the plant perfectly safe can deteriorate significantly with excessive residence time. Managing water age through operational strategies is fundamental to distribution system quality.

49. D — Pit depth (3/16 = 0.1875") ÷ wall thickness (3/8 = 0.375") = 50% of the wall consumed. The pit creates a stress concentration that weakens the wall disproportionately. At 50% wall loss, the remaining steel provides inadequate safety factor under operating pressure. Emergency structural evaluation, immediate recoating, and possible reinforcement or replacement are required.

50. B — Cast iron and ductile iron pipes have different outside diameters for the same nominal size due to different historical manufacturing standards. A transition coupling accommodates both dimensions with different-sized gaskets or adjustable glands on each end. Standard couplings designed for one material will not seal properly on the other.

51. A — Radioactive materials represent the highest possible hazard level. An air gap provides absolute, fail-safe protection with no mechanical components that can malfunction. An RPZ is the minimum mechanical alternative. The protection at the premises isolation point must match the highest internal hazard, regardless of the campus's other low-hazard connections.

52. C — Wire-to-water efficiency = (GPM × TDH) ÷ (3,960 × kW) = (1,000 × 140) ÷ (3,960 × 55) = 140,000 ÷ 217,800 = 64.3%. This is below the typical design efficiency of 75-85%, indicating moderate degradation from wear. Investigation and likely rehabilitation (wear ring and impeller replacement) would restore performance.

53. B — Multiple factors compound: the dead-end configuration eliminates through-flow (maximum stagnation), low demand from six customers means minimal water movement, and extended residence time depletes chlorine through reactions with pipe surfaces and biofilm. Together these create conditions where treated water loses its protective residual long before reaching customers.

54. D — Emergency interconnection valves that sit closed for years are subject to the same corrosion and seizing that affects all unexercised valves. Three years without operation virtually guarantees a seized valve. Including all emergency valves in the regular exercising program ensures they function when emergencies demand their use.

55. A — Water with pH 6.5 and TDS 45 mg/L is aggressive — lacking the minerals needed to form protective scale on pipe surfaces. Without treatment, this water actively dissolves lead from solder and service lines, copper from plumbing, iron from mains, and zinc from galvanized pipe. Corrosion control treatment (pH adjustment, orthophosphate) is essential to protect both health and infrastructure.

56. C — Heating water increases chlorine's volatility — dissolved chlorine transitions more readily from liquid to gas phase at higher temperatures. The warm air above hot water at the tap carries more chlorine vapor to the customer's nose. Both hot and cold water contain the same concentration, but the hot water releases more chlorine gas that the customer smells.

57. D — Identical production readings to three decimal places for 21 consecutive days is statistically impossible under normal operating conditions. Daily demand varies with weather, day of week, customer behavior, and system operations. A stuck meter, frozen totalizer, or failed data transmission would produce exactly this pattern. The meter must be investigated immediately.

58. B — A subaqueous river crossing presents extreme access challenges for maintenance and emergency repair. Specialized diving operations, cofferdams, or bypass pumping may take days to mobilize. During this time, the supply through the main is completely lost. This single point of failure can affect thousands of customers for an extended duration.

59. A — Main break repairs at 2:00 AM cannot wait for parts delivery. The inventory must cover the most common failure scenarios: repair clamps for all common sizes, sleeves and couplings for each material, transition couplings, valve components, hydrant repair kits, and service fittings. Having the right parts immediately available eliminates the delay that extends every emergency outage.

60. C — Positive pressure is the distribution system's primary defense against contamination entry. When internal pressure exceeds external pressure, any leak pushes water outward. When pressure drops below atmospheric, contaminated water from flooded pits, cross-connections, and imperfect joints is drawn into the pipe. Maintaining 20 psi minimum keeps contamination out.

61. C — The CCR is a federally mandated document that must reach all customers by July 1. The 15% shortfall (2,000 customers) constitutes a SDWA violation. The utility must redistribute immediately, notify the state, and document the corrective action. The printing error does not excuse the utility from its regulatory obligation to inform all customers.

62. A — With three pumps in parallel, the combined flow increases velocity in the common discharge piping. Higher velocity increases friction approximately with the square of flow, raising the system head. All three pumps respond by operating at higher-head, lower-flow points on their curves. The shortfall grows as more pumps are added because the friction penalty compounds.

63. D — The static calculation proves these homes are fundamentally mismatched to this pressure zone. Even with zero demand and zero friction (the absolute best possible condition), the maximum available pressure is only 13.9 psi — far below the 35 psi minimum. No operational adjustment can overcome this physical limitation. These homes need a higher pressure source.

64. B — The drill reveals that this tank requires entry rescue capability. The 60-foot interior distance exceeds the 40-foot non-entry retrieval system. A trained rescue team with SCBA must be available to enter the tank to reach incapacitated workers far from the hatch. The rescue plan must be updated before any future entry.

65. C — The booster pump creates backpressure above supply, and the wash water contains sanitizing chemicals plus agricultural contaminants (pesticides, bacteria, organic matter) from produce. This combination of backpressure and health hazard requires an RPZ assembly or air gap as the minimum acceptable protection.

66. D — Station B consumes 900 kWh/MG versus Station A's 700 kWh/MG — 29% more energy for the same unit of water. The most likely cause is pump wear: deteriorated wear rings, eroded impellers, and increased internal clearances. Pump efficiency testing would confirm the diagnosis and justify rehabilitation that could save significant energy costs annually.

67. B — Volume = $0.785 \times 45^2 \times 30 = 0.785 \times 2{,}025 \times 30 = 47{,}689$ cu ft × 7.48 = 356,714 gallons, approximately 357,077 gallons. Cylindrical tank volume uses the formula $V = 0.785 \times D^2 \times$ depth for cubic feet, then multiplies by 7.48 for gallons.

68. A — A non-existent valve in the GIS creates a dangerous false record. Emergency isolation plans that rely on this valve will fail — operators will discover it doesn't exist only after the crisis is underway. The GIS must be corrected, the investigation documented, and any affected emergency procedures updated. Accurate records save time during emergencies.

69. C — The main break caused a pressure drop in the area. During low-pressure events, contaminated water can be drawn into the system through cross-connections, flooded meter pits, or imperfect pipe joints. The transient nature of the E. coli (positive initial, negative repeats) corresponds to the temporary low-pressure condition that resolved when the break was repaired.

70. D — WHP = (800 × 160) / 3,960 = 32.3 hp. At 72% pump efficiency and 91% motor efficiency: Motor HP = 32.3 / (0.72 × 0.91) = 32.3 / 0.655 = 49.3 hp. A standard 50 or 60 hp motor would be specified to provide adequate margin above the calculated requirement.

71. B — A single service connection to a 300-bed hospital provides zero redundancy. Any interruption — pipe break, valve failure, main shutdown — completely eliminates water for patient care, surgical sterilization, fire suppression, and dialysis. A second independent service from a different main is essential to protect this critical facility from single-point failure.

72. A — HGL_A = 580 + (56 × 2.31) = 709.4 ft. HGL_B = 610 + (43 × 2.31) = 709.3 ft. Head loss = 709.4 − 709.3 = 0.1 feet. This remarkably low friction loss over 3,000 feet indicates the main is large

relative to the flow, has a high C-factor, or is carrying very low flow. The 13 psi gauge difference is almost entirely due to the 30-foot elevation change.

73. C — The root cause of the 95% acknowledge-without-investigate rate is an overwhelming volume of nuisance alarms. Tank C's alarm at 85% activates 8-12 times daily during normal cycling — drowning operators in meaningless notifications. Adjusting that setpoint to a meaningful level (40-50%) eliminates the primary nuisance source, and system-wide rationalization addresses the rest.

74. D — With average main age of 70 years and break rates tripling over the past decade, the system is deep into the exponential failure acceleration phase. Capital investment must increase immediately to prevent a cascade of failures. Risk-based prioritization targets the worst mains first while a long-term schedule prevents the system from reaching catastrophic levels.

75. B — Two effective options exist: cleaning and lining (restoring C to 140 if structurally sound, at 40-60% of replacement cost) or full replacement with larger pipe (addressing both hydraulic deficiency and aging infrastructure). The choice depends on the structural condition of the existing pipe, determined by wall thickness testing.

76. A — Video inspection reveals the specific cause of the decline before rehabilitation begins. Without knowing whether the problem is mineral encrustation, biofouling, sand bridging, or screen corrosion, the correct cleaning technique cannot be selected. Acid treatment works for minerals but not biofouling; mechanical brushing works for biofilm but not mineral scale.

77. C — The new, larger 10-inch main changed the hydraulic balance in the surrounding network. Higher velocities in the connected older mains disturb sediment that was previously stable under the old, lower-velocity flow conditions. The brown water comes from the old mains, not the new one. System-wide flushing after major hydraulic changes prevents this problem.

78. D — A stuck-open thermostat causes continuous full-circulation cooling that overcools the engine, particularly in cold weather. Regular maintenance that includes verifying the engine reaches and maintains normal operating temperature during load tests would identify a stuck thermostat. The overcooling triggers a low-temperature shutdown to prevent condensation damage.

79. B — Real losses = 6.0 × 0.20 = 1.2 MGD. Annual volume = 1.2 × 365 = 438 million gallons. Cost = 438,000 × $3.25/1,000 = $1,423,500 per year. This enormous annual loss — over $1.4 million —

provides compelling financial justification for aggressive investment in leak detection and infrastructure renewal programs.

80. D — The location and operability of the nearest isolation valves determines the speed of every main break response. Without this knowledge, the operator cannot stop the water loss. Every minute of delay means thousands more gallons wasted, further storage depletion, more property damage, and greater contamination risk. Valve knowledge is the single most critical emergency response asset.

81. A — Sodium hypochlorite (oxidizer) and hydrofluosilicic acid (corrosive acid) are incompatible chemicals. An accidental spill that mixes them could produce toxic chlorine gas. Physical separation with individual secondary containment prevents mixing from spills, delivery errors, or container failures. This arrangement protects plant personnel from potentially lethal gas exposure.

82. C — Static pressure of only 13.0 psi — far below the 35 psi minimum — proves these homes cannot be served by this pressure zone. No operational adjustment can increase the available gravity head. The utility must provide a higher pressure source: raise the tank overflow (affecting all zone customers), install a dedicated booster system, or reassign to a higher zone.

83. B — Q_available = 1,200 × [(64−20)/(64−46)]^0.54 = 1,200 × (44/18)^0.54 = 1,200 × 2.444^0.54 = 1,200 × 1.437 = approximately 1,724 GPM at 20 psi residual. This AWWA formula projects available fire flow using the non-linear relationship between pressure drop and flow in distribution systems.

84. D — For 12 months, the 5% high meter caused chemical overdosing (the pounds formula used inflated production), and the water audit underestimated real losses by 0.25 MGD (the artificially high reported production masked actual losses). Both errors affect public health protection (dosing accuracy) and financial analysis (loss quantification).

85. A — The utility's SOP for this repair size specifies spray application followed by flushing and residual verification. The procedure was followed correctly — spray disinfected surfaces, flushing removed debris and excess chlorine, and the 1.1 mg/L residual matching the system confirms fresh, properly treated water has reached the site. The main can return to service per the SOP.

86. C — Ductile iron walls are resistant to permeation, but the mechanical joint gaskets are vulnerable. Standard SBR rubber gaskets can be chemically degraded by solvents, and under negative pressure conditions (from a main break or pump failure), contaminated groundwater can infiltrate through the weakened gasket seals into the drinking water.

87. B — Intimate knowledge of the physical system — every pipe, valve, hydrant, tank, and pump — is the foundation that makes every other skill effective. An operator who knows the system responds faster to emergencies, plans better maintenance, makes smarter capital decisions, and provides better daily service. This knowledge comes only from years of direct field experience.

88. D — Safety training must precede all field work. Distribution operators face daily exposure to trench cave-ins, confined space atmospheres, traffic hazards, electrical energy, and chemical handling — any of which can be lethal for untrained workers. A single safety mistake on the first day can be fatal. All other skills develop over time, but safety knowledge protects life from day one.

89. A — Investing in people and infrastructure is the most fundamental advice for any utility. Trained operators protect public health through competent daily operations. Proactively maintained infrastructure prevents the emergencies that deferred maintenance inevitably creates. Every decision ultimately affects the water that families depend on for their health and daily lives.

90. C — A plan filled with disconnected phone numbers, expired mutual aid agreements, seized interconnection valves, and outdated contacts provides a false sense of preparedness. Every resource in the plan must be current and verified. The plan is only as strong as its weakest resource — and that weakness will be discovered at the worst possible moment during an actual emergency.

91. D — A comprehensive asset inventory is the essential foundation for all asset management. You cannot assess risk, prioritize investment, plan rehabilitation, or develop a capital budget without first knowing what you have, where it is, what condition it is in, and how critical it is. The inventory enables every subsequent analysis and decision in the asset management program.

92. B — Chlorine residual presence throughout the distribution system confirms the disinfection barrier is intact at every point in the network. A residual measurement simultaneously reflects water age, system hydraulics, chemical feed effectiveness, pipe condition, and biological activity. Areas with depleted residual represent immediate public health vulnerabilities.

93. A — The iterative approach — take exams, review explanations, identify weaknesses, revisit chapter content, retake — builds both knowledge depth and test-taking confidence. Incorrect answers identify specific gaps that targeted study corrects. Repeated cycling through this process strengthens understanding of every domain until consistently high scores demonstrate exam readiness.

94. C — Every function of water distribution operations — treatment, pumping, storage, monitoring, maintenance, emergency response — serves one overriding purpose: protecting the health of every person who drinks the water. This principle guides every valve exercised, every residual tested, every cross-connection eliminated, and every emergency resolved.

95. D — Reviewing explanations for incorrectly answered questions identifies the specific knowledge gaps that matter most. Revisiting the corresponding chapters fills those gaps efficiently. Focusing the final sessions on weak areas rather than reviewing mastered material maximizes the study value of limited remaining time. Rest before the exam ensures mental sharpness.

96. B — Learning the physical system during the shadowing period builds the foundational knowledge that serves throughout an entire career. The experienced operator's institutional knowledge — problem areas, system behavior, valve locations, recurring issues — exists nowhere in any database. This irreplaceable knowledge transfers only through direct, hands-on mentoring in the field.

97. A — Integrating reading and testing creates a reinforcing cycle: chapter reading provides knowledge, practice exam questions test application, incorrect answers reveal gaps, and targeted rereading fills those gaps. Each iteration strengthens understanding. Consistently scoring above 90% across all domains demonstrates genuine readiness for the certification exam.

98. C — Careful reading prevents misinterpretation of questions. Eliminating obviously wrong answers improves odds on uncertain questions. Time management ensures all 100 questions receive attention. Understanding the 35/65 recall/application split helps approach each question appropriately. The practice exams have built familiarity with both question types.

99. D — These three responsibilities form the core of distribution system public health protection: adequate residual ensures microbiological safety throughout the network, positive pressure prevents contamination entry through back siphonage, and cross-connection control eliminates the pathways through which contamination could enter. Neglecting any one of these three responsibilities directly endangers every customer.

100. B — Certification is a public trust. It affirms that the operator possesses the knowledge and commitment to protect every customer's health through competent operation of the water distribution system. The water that flows through the pipes the operator maintains is consumed by families, children, hospital patients, and the elderly — people who trust that their water is safe because certified professionals stand behind it.