FINAL

INDEPENDENT EMERGENCY PERFORMANCE ASSESSMENT

Evaluation Summary

B&V PROJECT NO. 408362

Prepared for

San Antonio Water System

23 APRIL 2021

1.0 Executive Summary

The February 2021 winter event with freezing temperatures and utility power loss had significant impacts to the San Antonio Water System (SAWS) operation and ability to maintain water service to its customers. This Independent Emergency Performance Assessment was conducted to assess the planning efforts in advance of and the actions taken during and in response to this event.

While the freezing temperatures had impacts to instrumentation and communication systems, staff was largely able to maintain system operations. The loss of utility power was ultimately determined to be the primary cause of water service outages. Without utility power, SAWS could not operate wells and pump stations which had a cascading effect on the ability to maintain water service. Areas of the system not affected by utility power outages were able to maintain at least basic level of water service. It is concluded that SAWS would have likely been able to maintain water service for the majority of customers during this event had it not been for the loss of utility power.

One main observation from this evaluation was the overall dedication and experience of staff at all levels across the organization during this event. Many worked multiple days of extended hours and away from family. Field crews worked extended shifts in dangerous road and weather conditions to fix equipment and keep facilities operational. Staff's experience and institutional knowledge was evident in the timeliness of operational decisions made to address each of the complex and quickly changing priorities as the event progressed. Resourcefulness was on display in many examples such as re-purposing parts to keep systems operational, consolidating field crews to enhance coverage and expedite response times, and developing communication media to provide better customer interaction. The effects of this event could have been much worse had it not been for staff efforts throughout the organization.

Assessment of the system operations during the event did identify some key areas where improvements are recommended and should be further evaluated for implementation. Inefficiencies were identified in manual tracking of data and information that could be digitized and made accessible across all SAWS departments for improved planning and operational decision making. Communication protocol enhancements between SAWS and other City agencies could improve effectiveness in collaboration and prioritization of needs during an emergency event. Development of a web-based customer outage reporting system could alleviate the number of phone calls received while providing better feedback and transparency on outages to customers. Improvement of these items and others as highlighted throughout this assessment would both assist with current operations and potential future emergency events.

Overall, the commitment and dedication of SAWS staff through this challenging weather event lessened the impacts of the utility power outage.

2.0 Independent Emergency Performance Assessment

In February 2021, Texas experienced an extended winter storm event that resulted in freezing temperatures and utility power outages across the State. The winter event had detrimental effects on the ability of San Antonio Water System (SAWS) to produce and distribute potable water throughout its distribution system. As a result, SAWS retained Black & Veatch Corporation (Black & Veatch) to perform a comprehensive and independent evaluation of system preparations, actions, and activities before, during and after the winter storm event.

Black & Veatch's assessment is documented in the Independent Emergency Performance Assessment Report (Assessment Report), which consists of three technical memoranda:

- Technical Memorandum 1 (TM-1): Cold Weather Event Overview & Assessment;
- Technical Memorandum 2 (TM-2): Summary of Previous Risk/Resilience Reports;
- Technical Memorandum 3 (TM-3): Pressure Zone Evaluation & Confidential Critical Infrastructure Assessment.

This Executive Summary provides a summary of the Assessment Report, together with Black & Veatch's major findings and recommendations.

3.0 SAWS Overview

SAWS is a municipal water and wastewater utility serving nearly 2 million people in San Antonio and the greater Bexar County area including small portions of Comal, Medina and Atascosa counties. SAWS is a component unit of San Antonio (City), governed by the Board of Trustees including the Mayor, and consisting of an executive management team that oversees the various utility operational and business units.

The water system is primarily supplied by Edwards aquifer groundwater from wells located throughout the central and southern portions of the City. Water supply is supplemented from several external sources primarily in the northern and eastern portions of the City. SAWS also operates the H2Oaks facility in the southern portion of the system which includes a combination of supply and treatment facilities from local wells, aquifer storage and recovery, and brackish groundwater desalination. The distribution system consists of over 100 pump station and storage facilities and approximately 7,150 miles of distribution piping throughout the City which provide service to 511,300 customer connections.

The wastewater system provides service to 457,600 customer connections which flow into a collection system totaling approximately 5,700 miles of sanitary sewers and 146 lift stations. Sewer flows are collected and treated at one of three facilities (Leon Creek, Medio Creek, and Steven M. Clouse) located on the southern and western portions of the City. Some of the treated water flows are utilized for recycle purposes which includes its own network of pump stations and piping.

Additionally, SAWS operates and manages cooling water facilities at several locations in the City.

For the purposes of this assessment, the water system and the associated operation was the sole focus of evaluation. The wastewater and associated reuse systems also experienced challenges but were not assessed as part of this evaluation.

4.0 Cold Weather Event Overview

4.1 BACKGROUND

Winter Storm Uri in mid-February 2021 affected much of the central United States, bringing snow, ice, and historic low temperatures across Texas and San Antonio. The storm is responsible for numerous deaths and damages currently estimated at approximately $200 billion.

As illustrated in Figure 1, temperatures began to drop below freezing on Saturday, February 13th, and remained below freezing for the next 108 hours in combination with periods of freezing rain and snow. Historical major cold weather events were reviewed and compared to the 2021 weather event. While there was a similarly cold winter event in 1951 in terms of low temperatures and duration below freezing, the 2021 winter event also brought freezing precipitation. Therefore, the 2021 winter event could be considered the most significant winter storm in recorded history (since the late 1800s).

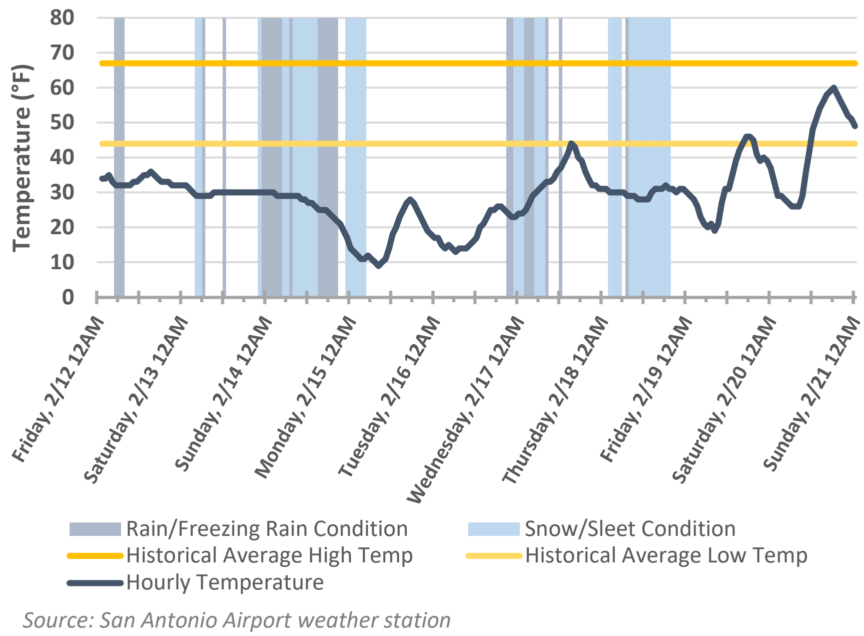

Figure 1 – Winter Weather Event Conditions

4.2 TIMELINE OF MAJOR EVENTS

The following summarizes the timeline of major events and preparation activities before, during, and after the February 2021 weather event.

- **Week Before (8th - 12th)** – SAWS field staff began preparing for the pending freeze by inspecting equipment, winterizing, filling fuel and chemical storage tanks, and staging heaters at various facilities.

- **Saturday (13th) – 2:00 PM** – Temperatures first began to drop below freezing. Minor issues were experienced with tank level instrumentation at several facilities.

- **Sunday (14th) – 6:00 AM** – SAWS began mobilizing staff to the headquarters building in anticipation of deteriorating weather conditions. Throughout the day additional staff was mobilized including field staff to various stations across the City.

- **Monday (15th) – 5:55 AM** – Utility power lost at University Pump Station with efforts to restore unsuccessful. CPS Energy implemented rolling brownouts throughout the day causing outages at other SAWS facilities.

- **Monday (15th) – Evening** – SAWS attempts to maintain service city-wide was no longer feasible and shifted to prioritizing service to critical customers.

- **Tuesday (16th) – 4:00 AM** – CPS Energy communication with SAWS prioritized increasing water pressure to support strategic power generation facilities and avoid potential major impacts to the overall statewide electrical grid. This became SAWS highest operational priority.

- **Wednesday (17th) – 2:00 PM** – Emergency City Council Meeting conducted to review system status and notified issuance of a City-wide boil water order.

- **Thursday (18th) – 9:30 AM** – CPS Energy stopped rolling brownouts and service restored to most pump station facilities. SAWS began to refill and re-pressurize the system.

- **Sunday (21st) – 3:00 PM** – Service restored to the final remaining pressure zones and service areas in the northwest portion of the City.

- **Tuesday (23rd)** – SAWS lifted the final remaining boil-water notice upon confirmation of water quality testing.

5.0 Previous Risk & Resilience Studies

5.1 PREVIOUS STUDIES

SAWS and other City and County agencies have conducted previous risk and resilience studies in response to prior events and regulatory requirements. Black & Veatch reviewed the following relevant reports for their applicability to the winter event in February 2021 and if any recommendations had been implemented or applied.

- Hazard Identification, Risk Assessment (HIRA), and Consequence Analysis for the City of San Antonio and Bexar County, City of San Antonio Office of Emergency Management, San Antonio, TX, March 1, 2014.

- Hazard Mitigation Plan for the City of San Antonio, H2O Partners, Inc., Austin, TX, December 2015.

- Risk & Resilience Assessment (RRA) for SAWS, ARCADIS, San Antonio, TX, November 2020.

- Emergency Response Plan (ERP) for SAWS, ARCADIS, San Antonio, TX, August 2020.

- Business Continuity Plan (BCP) for SAWS, ARCADIS, San Antonio, TX, December 2020

5.2 PREVIOUS RISK & RESILIENCE STUDY OBSERVATIONS

The following summarizes the primary observations and recommendations in review of these reports. While it is recognized that contingency and emergency plans cannot account for all possible events, incorporation will improve SAWS' ability to respond to future emergency events.

- Several reports did not consider the possibility of a winter storm or cold event. Of those that did, the risk assessments assigned the event a risk rating of "moderate."

- The Hazard Mitigation Plan included recommendations for adding backup power to all primary pump stations that provide water to the City's critical facilities in the event of a utility power loss. Details regarding the level of backup needed were not provided. Backup power was further evaluated in this Assessment and summarized herein. Further consideration is warranted for planning and potential incorporation of backup power facilities.

- The latest RRA conducted for SAWS did not include the impact of a winter storm or multi-day event in the risk analysis due to its perceived low likelihood of occurrence and impact. On its own this determination was reasonable, however, when coupled with a loss of utility power across one or multiple service areas, the impacts compounded significantly.

- The RRA underestimated the likelihood of a power loss, using a significant event occurrence of once every 50 years. The events that occurred during the winter events of 2011 revealed significant vulnerabilities in the power grid, and more consideration should have been given to this hazard. While credit was given to the independence of the ERCOT power grid and its protection from national level outages, impacts within and originating in the ERCOT power grid were not addressed. The most recent event further highlights the power grid vulnerabilities and the likelihood of more frequent events in the future.

- Following completion of the RRA, an implementation plan to select and prioritize risk mitigation initiatives should have been prepared. We recommend SAWS develop these next steps to determine the appropriate risk mitigation improvements which may include additional reliability, redundancy, asset resistance/hardening, and response/recovery capabilities. Focus should be on proactive improvements in system resistance, redundancy, and reliability and limit response/recovery which should be the last line of defense.

- The Emergency Response Plan's most recent update includes key components required by AWIA. We recommend SAWS develop Incident Action Plans (IAPs) and add a specific Operations Section to guide staff through emergency events with updated or new incident specific response procedures (ISRPs). Many of these can be developed from the observations and information specifically learned during this recent winter event.

- In addition to training for specific roles, we recommend SAWS practice emergency response exercises and scenarios on a regular basis. These practices should focus on the most significant emergency events such as severe weather, utility power loss, and critical main breaks. Additional enhancements to IAPs and ISRPs can be developed from these exercises that will help to better prepare for future events.

6.0 Event Review Key Findings and Recommendations

A comprehensive summary of the actions taken before, during and after the event are summarized in TM-1. Black & Veatch conducted interviews with many SAWS departments and staff to obtain direct feedback on the events that occurred, conducted site visits to assess damage, and evaluated available information provided by SAWS including production logs, internal, and external e-mail correspondence, SCADA information, and internal event reports. Upon confirmation of the event details, formal observations and recommendations were prepared.

6.1 KEY OBSERVATIONS AND RECOMMENDATIONS

6.1.1 Staff Organization & Dedication

The issues and challenges presented during this event were unique and dynamically changing. SAWS staff responded to these challenges finding successful ways to leverage existing tools and previous experience to make system improvements and communicate to customers. When inefficiencies were identified they were quickly rectified. Staff across all departments were extremely dedicated working long past standard shifts through adverse weather and challenging conditions. Many instances were identified of staff supporting other departments to assist in responding to issues.

While specific areas of communication improvement or additional cross-training of staff to assist during emergency situations are identified, the overall observation was of a well-organized, adaptable, and committed staff.

6.1.2 Utility Power Failure

Despite the initial freezing conditions that caused instrumentation issues at facilities, staff was able to operate manually to maintain the system and service to customers. The loss of utility power was ultimately determined to be the primary cause of failure which had a cascading effect on facilities and loss of water service to many customers. Without power to wells and pump stations, SAWS could not operate, and any water stored in tanks and pipelines quickly drained. It is believed that water system outages would likely have been mitigated if utility power would have been maintained.

This event in combination with the 2011 winter event highlight vulnerabilities within the ERCOT system and the electrical grid. With continued electrical demand increases the potential for extended utility power outages becomes more likely. It is recommended SAWS continue to evaluate and consider planning for backup power generation facilities at critical locations to improve service reliability during future emergency events.

6.1.3 Live Outage Tracking

The assessment highlighted specific internal challenges regarding documentation of service outage areas and communicating that information to all SAWS departments for their use in developing specific response plans. Staff was reliant on verbal communications or outage maps that were generated twice a day and were quickly outdated due to the rapidly changing conditions.

The development of a live platform for tracking outages and system status is recommended. This would allow real-time data to be available to multiple departments assisting their ability to respond in an emergency event and limiting bottlenecks in communication flow. As highlighted, this system could be connected to the customer outage system also recommended to provide additional overlapping of data to better assess system status.

6.1.4 Boil Water Notice

A City-wide boil water notice was issued on Wednesday (February 17th) due to loss of pressure in portions of the system. While portions of the system had maintained pressure, the system overall was unpredictable due to the rolling power outages. To avoid confusion with possible follow-up notifications, it was decided the boil water notice would be applied City-wide. Through coordination with TCEQ, SAWS was able to lift the boil water notices by individual pressure zones facilitated by an effective on-line mapping system that customers could access through the website.

The need for issuing a boil water notice was a regulatory requirement based on the system conditions to ensure public health. The timeliness and approach for a City-wide notice was reasonable based on the dynamic conditions.

SAWS was able to restore service with the first boil water notices lifted on Saturday (February 20th) and the final areas lifted on Tuesday (February 23rd). The duration necessary to restore service and lift the boil water notice particularly to the far north and northwest portions of the City was predicated on several factors. The external water supplies SAWS normally utilize to serve those areas had also lost service, so all water was required to be pumped from wells from the central part of the City. These northern areas are at much higher elevation and require water to be transferred through multiple pressure zone areas and booster pump stations. Many of these systems were fully drained of water due to the extended power outage and significant leaks. This required time to manually bleed air out through hydrants to refill and pressurize before moving to the next zone and repeating the process until those at the highest elevations had service restored.

6.1.5 CPS Energy Communication

Communication limitations between SAWS and CPS Energy were highlighted which hampered both utilities' ability to provide timely responses. The following primary items were identified and recommended for improvement:

- Establishing general escalation hierarchy and singular points of contact for both utilities in communicating outages, prioritization, and status updates. Too many people were included in the process from both sides which resulted in confusion.

- Developing a common platform for tracking outages and recovery status instead of reliance on e-mails and spreadsheets that were quickly outdated.

- Developing a revised prioritization of SAWS facilities most critical to restore electrical service or avoid impacting during potential brownout situations. The ERCOT based prioritization matrix was not effective in establishing hierarchy. This prioritization should be reviewed and updated on a regular basis.

- A general agreement to provide more open and transparent feedback on issue status or resolution to help each make better decisions during an emergency event.

It is recommended SAWS engage with CPS Energy to further these discussions and identify means by which both utilities can have greater synergy during future emergency events.

6.1.6 Customer Outage Reporting

The SAWS customer service and Emergency Operations Center call centers were both inundated with customer calls during the event. Call center staff were working from home with limited availability due to loss of residential power or internet which hindered the ability to respond. This resulted in customers being on hold for extended durations or some calls not being answered. The inability to process calls resulted in customers not receiving feedback and limited real time outage information SAWS staff needed to help identify where problems were occurring in the system.

It is recommended to develop an automated customer outage reporting through a web-based platform. This would also alleviate the need for all customer feedback to require human response through the call system; resulting in faster response times to those who do. Additional coordination with other water utilities is a recommended first step on how similar systems were implemented and maintained.

A public version of a formal outage map is also recommended to be further considered. While this does present challenges in its accuracy due to validity of customer reporting and water system complexities (customers in low lying areas can remain with low water pressure for some time while those on a hill will lose service quickly), a version would be helpful to customers being able to see others in their area reporting outages as well to validate the issues are system-wide and not limited to them. This could further reduce the call volume during an emergency event.

6.2 ADDITIONAL OBSERVATIONS AND RECOMMENDATIONS

Several additional observations and recommendations are summarized below. Additional detail, information and observations that provide a basis for these recommendations along with many other minor recommendations can be found in the Technical Memoranda.

ITEM	DESCRIPTION	OBSERVATION AND RECOMMENDATIONS
1.	Staffing & Provisions	Staff planning worked well, and crews were dynamic in responding to the event and putting in much longer shifts. SAWS was proactive in working with local hotels for staff lodging, traveling long distances.
2.	Issues Logging and Dispatching Field Crews	As the number of field issues increased, multiple people began contacting crews to prioritize work items leading to confusion. SAWS was dynamic in recognizing an inefficiency in dispatching crews and established single points of contact. Additional recommendation is to establish a formal work order system in lieu of manual spreadsheets to more efficiently track issues.
3.	Control Center Operations Phone Calls	More than 2200 phone calls were logged to the control center with many being straightforward communications. Recommend evaluation of a dedicated radio system for basic communications to alleviate the call volume.

ITEM	DESCRIPTION	OBSERVATION AND RECOMMENDATIONS
4.	Prioritization & Determining Alternative Solutions	Production staff was dynamic in responding to the continuously changing conditions and leveraging staff expertise in prioritizing flow to critical facilities. Staff worked well across other departments to implement field changes through valve changes to prioritize these areas.
5.	Construction Activities	Certain facilities were under construction during the event which is common for normal low demand periods. During the planning for future facility improvement projects, consideration is recommended for work sequences and limitations that could enable quick re-start of facilities in an emergency.
6.	External Water Supplies	All regional water providers experienced similar power and water delivery issues during this event. It is recommended SAWS communicate with leadership from these outside sources to discuss improvements they could make to their system to improve reliability.
7.	H2Oaks Facility	It is recommended the H2Oaks facility be further evaluated for resilience improvements including improvements to the lime system and providing backup power to well and treatment sites. Costs for this can vary significantly depending on the level of resiliency desired for implementation.
8.	Field Staff Cross-Training	While staff are trained in their specific areas of expertise, it is recommended that some basic cross-training be implemented to enable troubleshooting functions during an emergency event or to further support departments that need assistance in processing work orders or service calls.
9.	Spare Parts Management	Field staff had limited access to spare parts during the winter event due to lack of staff in service center warehouses. It is recommended SAWS allow full access to these warehouses in future emergency events and to seasonally stock items that were heavily used during this event.
10.	Work Order and Service Request Vetting	Service requests and work orders throughout the event were not always vetted and resulted in repeat responses. A more detailed approach to validating requests and streamlining documentation received through multiple media is warranted.
11.	Advanced Metering	Implementation of advanced meter infrastructure (AMI) as currently planned at strategic system locations would provide better real-time information on system status to assist operations staff on understanding system conditions and reduce field staff effort required for manual readings.
12.	Large Customer and Multi-Family Housing Coordination	Significant effort was spent by SAWS to respond to private property issues and leaks during the event. It is recommended to develop an outreach program to help educate property owners and building managers on their responsibility in understanding and maintaining their private systems.
13.	Emergency Locates	A revised emergency event protocol for accessing records for buried utility information would be helpful to allow for critical repairs to be done safely. It is recommended SAWS discuss this with the appropriate agencies.

ITEM	DESCRIPTION	OBSERVATION AND RECOMMENDATIONS
14.	Hospitals & Southwest Texas Regional Advisory Council (STRAC)	STRAC began assisting during the event and was responsible for communicating the needs of emergency medical facilities and establishing priorities. Communication with STRAC needs to be a first priority in an emergency and formally established in the emergency management plan.
15.	Water Distribution Sites Protocol	It is recommended SAWS review the protocols for the water distribution sites and establish a formal standard operating procedure (SOP) for more rapid implementation and deployment of these sites to serve the customers and community in an emergency event.
16.	Call Center and EOC Staffing	Many EOC and call center operators that had been working from home lost power and were unable to connect through VoIP to respond to calls. It is recommended SAWS consider coordinating provisions to have EOC call center staff available in person at headquarters to process the call volume and directly coordinate with other departments needing the information.
17.	Social Media	SAWS used several social media platforms, including Twitter, Facebook, NextDoor, Instagram, and YouTube to post general updates throughout the event. Most of these platforms redirected users to SAWS' website which was the primary hub for information. SAWS saw significant increases in followers on all platforms during the event, highlighting the effectiveness of this communication channel.
18.	Facility Valves & Piping	It is recommended to limit exposed sample or instrument piping in future designs. PVC and copper pipe should be avoided with use of steel or stainless steel for improved elasticity. All exposed pipe systems at pump stations should have provisions added to drain those not in service as a preventative measure with costs likely range from $2,000-$4,000 per system.
19.	Pump Station Building Enclosures	It is recommended SAWS further consider enclosing pump stations in buildings to avoid exposure and freeze damage. Priority should be given to smaller facilities with more small piping and those which may be a single supply for a pressure zone. Costs for buildings can vary significantly depending on the features included and can range from $150 to $400 per square foot. Building enclosures are less critical if backup power provisions are implemented.
20.	Heat Tracing Systems	Investigation is recommended on the reliability of existing permanent heat trace systems, particularly those observed to have failed during the event. Additional controllers may be required to improve reliability.
21.	Pressure Transmitter and Switches	Ultrasonic level transmitters could be considered as an alternative to the current standard of pressure style level transmitters. It is recommended to consider locating devices in heated cabinets instead of heat tracing for improved reliability and accessibility. Costs for such panels would likely range from $5,000-$10,000 each depending on electrical service availability.

ITEM	DESCRIPTION	OBSERVATION AND RECOMMENDATIONS
22.	Backflow Preventers	Many backflow preventers across the City and at SAWS facilities failed during the winter event. It is recommended at facilities to consider locating these indoors on future projects and to consider using insulated and heated boxes at existing outdoor locations. Costs for these would range from $10,000-$15,000.
23.	Communication System Backup Power	Further evaluation of backup power considerations is recommended as highlighted herein. Even if large scale power facilities necessary to operate pumps are not implemented, consider small units ($20,000-$30,000 per site) or quick connect provisions to provide extended communications and feedback on system status during an event.
24.	SCADA System Improvements	The operations staff in most cases disabled automation systems as instrumentation communication failed. However, several cases were identified where automation could have remained and assisted. Additionally, some modifications to SCADA screens are recommended to better schematically depict water flow in the system while navigating between screens.
25.	Fuel Service	Despite guaranteed fuel delivery contracts for the backup generators in the system, the supplier was unable to deliver requiring SAWS staff to make deliveries. It is recommended SAWS consider a larger central fuel supply at the service centers and a fuel delivery truck(s) to place SAWS in control of deliveries during emergency events.
26.	Design Standards	The current design temperatures adopted in the local building code are much higher than experienced during this event and warrant further evaluation along with other specific code deficiencies identified through this event. It is recommended SAWS discuss these potential code modifications with COSA. This recommendation has a significant impact to improving resiliency throughput the community with little to no costs to SAWS.

6.3 CUSTOMER FEEDBACK

Black & Veatch contacted several each residential, commercial and industrial customers to obtain feedback on the effectiveness of communication from SAWS regarding system status and other information during the event. The following summarizes the key items obtained from this effort.

- Many large commercial or industrial users indicated it was difficult to obtain information during the event. Calls to the main line were not successful in getting the information needed and were limited to information received on the news. This information was not specific enough for their needs. A point of contact or account manager with SAWS would be desired to provide key information so they can proactively plan for their operations.

- Consistent feedback received from customers was that information regarding the water outages should have been better explained and shared sooner. This highlights some of the recommendations noted previously of developing a more interactive platform for customers to report and observe outage areas.

- While SAWS utilized many media during the event for conveying information (website, television/radio, robo-calls, social media, etc), many customers would have preferred text message notifications. Additional evaluation is recommended on updating contact information to allow for this service to be provided for future events.

6.4 UTILITY SERVICE AGREEMENT AREAS AND OUTAGES

A question posed was whether there was a correlation between the service outage areas and new City growth areas. Based on evaluation of the available data, there was no conclusive correlation. The primary observation was water service outages were directly correlated with utility power outages. Areas in the northern portion of City, particularly outside of Loop 1604 have no groundwater supply and are at much higher elevation. These areas must be served by relaying water from wells and pump stations from further south as highlighted previously.

7.0 Critical Facilities Evaluation

During the development of TM-3, Black & Veatch evaluated the water supply and distribution system to identify the well and pump station facilities that are critical to maintain in operation during a specific emergency event. The emergency event evaluated was a widespread utility power outage such as an electric grid failure that would last for an assumed two week duration. This would require backup power provisions at facilities to maintain operations. The following summarizes the assumptions utilized in identifying the critical facilities and quantifying the backup power facilities and preliminary costs necessary for implementation.

7.1 FLOW CONDITION & DURATION

A City-wide usage of 350 million gallons per day (MGD) was established as the flow basis. This coincides with the maximum demand anticipated during a typical hot summer day when water usage is traditionally highest and when the electrical grid would be most susceptible due to peak usage as well. While this flow is less than the maximum flow experienced during the recent winter event (441 MGD), this was a single day flow skewed by the additional need to re-fill empty tanks and distribution pipes and is not considered a reasonable basis for evaluation. Even the 350 MGD flow basis could be reduced during an extended utility power outage through conservation measures and water restrictions.

Additionally, it was assumed for this evaluation that distribution water pressure would be maintained at a minimum threshold of 25 psi at high points in the distribution system. This is below the normal pressure which ranges from 60 to 80 psi. The purpose of this assumption is to ensure basic service is maintained and limit the energy demand needed to meet normal higher pressures.

7.2 SUPPLY SOURCES

For this evaluation, it was assumed that SAWS would be limited on supply sources to only the current Edwards Aquifer wells. This is the predominant supply they own and operate and thus have direct control. All external sources are not under SAWS direct control and were assumed to be unavailable as was largely experienced during the most recent winter event.

The H2Oaks facility SAWS operates was also assumed to be unavailable during this evaluation. This was primarily due to the widely distributed well and treatment infrastructure at this facility which would be difficult to provide backup power provisions. Through this evaluation it was determined it is difficult to maintain system operations without the H2Oaks facility and further evaluation is recommend on how to implement backup power provisions at the facility.

7.3 CRITICAL FACILITY DETERMINATION

SAWS distribution system is configured into approximately 50 distinct pressure zones or service sub-areas within the City. These individual pressure zones operate under a common pipe network with dedicated pumping facility(s) for each. These pressure zones are largely delineated by ground elevation necessary to maintain consistent water pressure to customers. With the wide range in ground elevation between the southern and northern ends of the City, the quantity of pressure zones areas is necessary.

Many of the pressure zones do not have wells and thus rely on water supply that is boosted from a different pressure zone or series of zones. For this evaluation, these pressure zones were consolidated into 14 primary subsystems to highlight the interdependency and to track how water flow progresses through the City.

A desktop evaluation of available information including the well and pumping facility locations, storage tanks, water main sizes, historical operational data, etc. was utilized to assign the demand and identify the individual critical facilities necessary to meet the target water usage of 350 MGD. Each facility was identified with the required pump(s) necessary to meet the demand. It is recommended that the list of critical facilities and flows be validated and further refined through formal hydraulic modeling software analysis.

7.4 BACKUP POWER REQUIREMENTS

A secondary evaluation was performed to determine the preliminary size and cost to construct backup power provisions at these critical facilities identified to maintain the target 350 MGD flow condition.

There are many alternatives for backup power considerations (diesel and natural gas generators, microgrids, third-party managed systems, etc.) that would need to be evaluated further. For this analysis, diesel fueled engine-generators were assumed as the basis due to their common usage within the industry and universal ability to be located at each site. Natural gas generators for instance could be considered but would require detailed evaluation of gas main size and pressure at each site location. Diesel fueled generators would require a large central fuel storage and ability to deliver to the many units installed. Any further consideration of backup power should evaluate all alternatives and any individual site restrictions or limitations.

The analysis determined that several critical facilities are already equipped with standby power provisions of adequate size to meet the demand. However, most are located at smaller facilities in lower demand pressure zones, typically on the outer areas of the system.

7.5 BACKUP GENERATOR COSTS

To provide backup power generators to SAWS critical facilities, two scenarios were evaluated. The first was a baseline condition to meet the target flow. The second was a more conservative basis that included increasing the facility demand to account for an adjacent facility assumed to be out of service due to a mechanical failure or construction related activity. This increased the required capacity for the primary pump stations and some of the larger booster pump stations.

For both conditions, generator sizing software was utilized to determine the preliminary capacity needed at each individual facility which when totaled for all facilities ranged from 60 megawatts (MW) for the base condition to 75 MW for the more conservative condition.

A preliminary program cost (engineering, procurement & construction) was developed for each condition with the conservative condition including additional costs for potential land acquisition necessary due to the limited space on several sites. The total preliminary program costs would range from $150 million to $200 million. These costs do not include potential backup power generation at the H2Oaks facility nor a centralized fuel storage and delivery system. Both would require additional evaluation and conceptualization.

END OF OVERVIEW SUMMARY

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1.0 Table of Contents

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2.0 Overview

The San Antonio Water System (SAWS) experienced an extended cold weather event in combination with extended utility power outages that resulted in detrimental effects in the ability to produce and distribute potable water throughout its distribution system. SAWS retained Black & Veatch to perform a comprehensive, independent evaluation of system preparations, actions and activities during and following the winter storm event. Though SAWS experienced challenges with both the water and wastewater systems, the scope of this assessment is limited primarily to the water operations. Some overlap is highlighted throughout as some staff are centralized and serve both systems.

This Technical Memorandum establishes and summarizes the key events, processes, protocols, and basic outcomes leading up to, during, and following the February 2021 Winter Storm event. The summary was developed through a compilation of records obtained in workshops with SAWS staff, review of documents provided by SAWS, field assessments, and interviews with numerous SAWS departments and staff involved in the event.

The text herein summarizes the events followed with observations including assessment and recommendation.

3.0 Summary of the Winter Weather Event

3.1 WEATHER CONDITIONS

Winter Storm Uri affected much of the central United States, including unseasonably low temperatures and freezing precipitation across Texas and specifically San Antonio. Temperatures dropped below freezing (< 32 degrees Fahrenheit [°F]) on Saturday (February 13th) and would consistently remain below freezing for approximately 108 hours. Freezing rain and snow began falling on Saturday evening, impacting driving conditions and causing road closures. Snowfall continued periodically through early Monday (15th) morning. Temperatures reached their lowest point on Monday (15th) morning as the entire region was in the single digits.

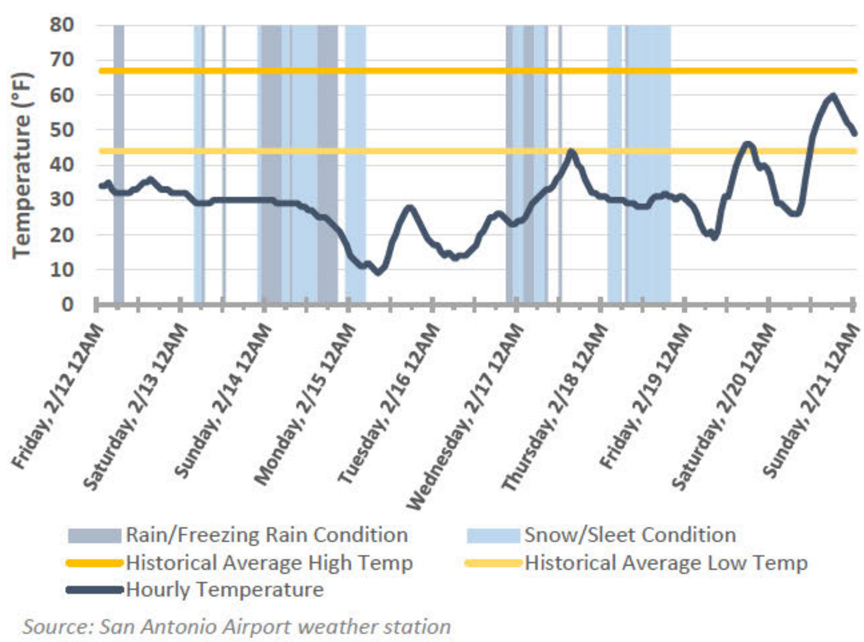


Figure 1: Winter Weather Event Conditions

Precipitation, primarily as snow started falling again early Wednesday (17th) morning and continued until mid-day. Wednesday afternoon was the first time temperatures were above freezing during the winter event. Periodic precipitation and freezing temperatures resumed Thursday (18th) and continued until Friday (19th) afternoon which served as the last time temperatures would be below freezing. A graphical summary of the event is depicted in Figure 1.

A comparison of the daily high and low temperatures during the storm with the historic average low temperature and the record day low are depicted in Figure 2. The daily high temperature during the winter event fell well below the historic average low temperature for the same days. Five out of the nine days observed broke the record for the day's low temperature.

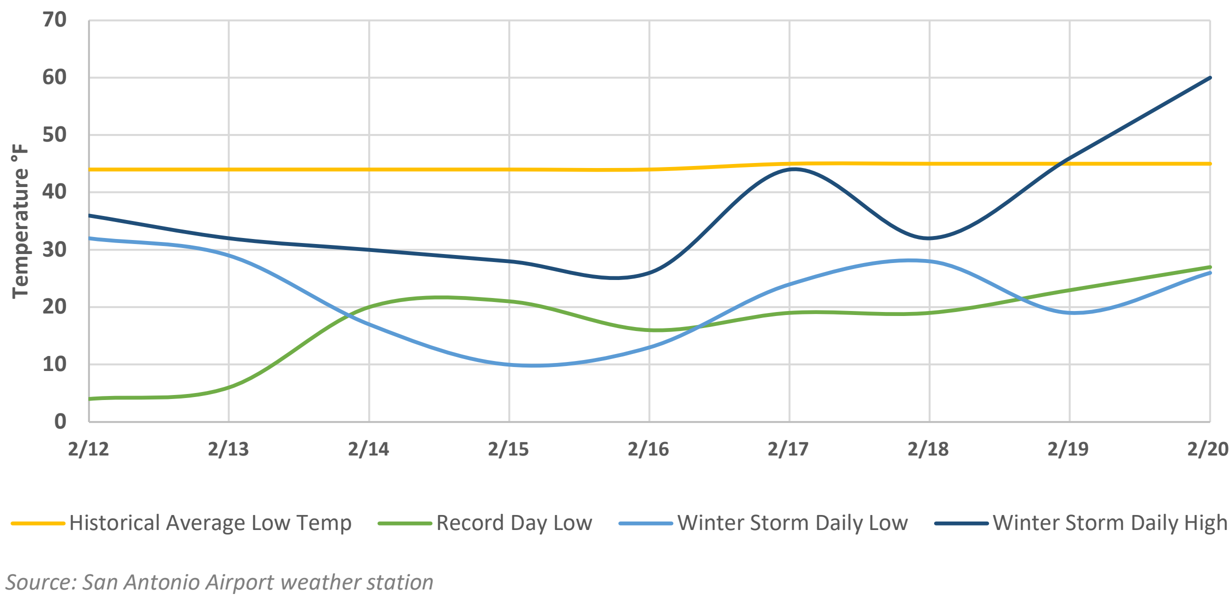


Figure 2: Historical Low and 2021 Winter Storm Temperatures Comparison

3.2 PREVIOUS MAJOR WINTER STORM EVENTS

The following summarizes previous winter storm events experienced in San Antonio, Texas[1].

- **February 1899** – An arctic event occurred on February 12th with temperatures in San Antonio reaching 4°F. This event largely set the all-time record low temperatures for many cities in Texas.
- **January 1949** – An arctic event occurred on January 31st with local temperatures reaching near zero with some snow accumulation. This event was responsible for most other all-time record low temperatures not set during the 1899 event.
- **January 1951** – An arctic front moved into the area in late January and lasted into early February. Local temperatures dropped into the single digits with total duration of temperatures below freezing lasting 108.5 hours.

[1] Weather data obtained from NOAA San Antonio Airport

- **January 1985** – One of the largest snow events occurred from January 11th to the 13th. Over 13 inches of snow fell while temperatures remained below freezing from the 10th through the 14th. The lowest temperature measured during this event was approximately 23°F.
- **December 1989** – Trace amounts of snow fell while temperatures stayed below freezing for 51 hours from December 22nd to December 24th.
- **February 2004** – Temperatures stayed above freezing while 0.6 inches of snow fell in the San Antonio area on February 14th.
- **February 2011** – Temperatures fell below freezing from February 1st to February 4th, totaling 42 hours. The lowest temperature measured during this event was approximately 20°F and 0.4 inches of snow.
- **December 2017** – About 2 inches of snow fell while temperatures hovered around freezing; temperatures increased to above the freezing point within the hour.
- **February 2021 –** An average of 6 inches of snow fell with more in the north and less in the southern portions of San Antonio. Temperatures dropped into the single digits and stayed below freezing for a total of 107.5 hours. The lowest temperature recorded during this event was 0°F.

Observations

The February 2021 winter event is one of the most significant in local and regional history. The low temperatures and duration below freezing was similar to the 1951 winter event; however, the 1951 event was largely without precipitation. In contrast, the recent winter event had significant freezing rain and snowfall. Therefore, the 2021 winter event could be considered the most significant winter storm in recorded history (since the late 1800s).

4.0 General Timeline of Activities

The following summarizes the primary critical activities that occurred prior to, during, and directly following Winter Storm Uri in February 2021. The activities are categorized as follows; Preparation, Winter Event, Power Loss & Response, and Restoration & System Recovery. It should be noted that the time periods are not discrete.

4.1 PREPARATION ACTIVITIES

- **Monday (8th)** SAWS Emergency Management began receiving notifications of the potential upcoming weather event from the National Weather Service and continued monitoring updates throughout the week.
- **Week Before (8th - 12th)** SAWS published information to customers about the upcoming storm, including information on how to winterize homes before the event and notification that payment centers would be closed on Monday the 15th.
- **Week Before (8th - 12th)** Field staff prepared sites for the pending freeze by inspecting heat trace systems, adding pipe insulation to exposed small diameter pipe and appurtenances, topped off fuel and chemical storage tanks, and staged heaters at various facilities. Focus was on sites prone to freezing based on prior events.
- **Week Before (8th - 12th)** Production Control Center along with all departments reviewed and prepared schedules to ensure staff was available and shifts covered with additional resources.
- **Saturday (13th) – 2:00 PM** Temperatures first began to drop below freezing. Minor issues experienced with tank level instrumentation at several facilities in the evening and through Sunday but able to maintain operations
- **Sunday (14th) – 6:00 AM** Production operators mobilized to the Control Center at SAWS headquarters to begin setting up.
- **Sunday (14th) – Day** SAWS Emergency Operation Center and the City Emergency Operation Center were activated.
- **Sunday (14th) – 6:00 PM** Field staff reported to their assigned locations. This was accelerated from the original target of 10 PM due to the road and weather conditions deteriorating quicker than anticipated.

4.2 WINTER EVENT, POWER LOSS & RESPONSE

- **Sunday (14th) – 7:54 AM** SAWS lost power to Winwood Pump Station (PS) temporarily and asked the Guadalupe-Blanco River Authority (GBRA) to stop sending water. Service restored and returned to operation.
- **Sunday (14th) – 4:18 PM** SAWS received first notification from CPS regarding a facility power outage.
- **Monday (15th) – 12:26 AM** SAWS received notification from CPS to conserve as much power as possible to help preserve the power grid.
- **Monday (15th) – 1:00 AM** GBRA Western Canyon stopped sending flow to Oliver Ranch.
- **Monday (15th) – 1:25 AM** Rolling brownouts begin at various locations in San Antonio.
- **Monday (15th) – 3:20 AM** Regional Carrizo through Schertz-Seguin Local Government Corporation (SSLGC) went offline due to wells tripping.
- **Monday (15th) – 4:15 AM** GBRA Western Canyon stopped sending flow to Winwood PS.
- **Monday (15th) – 4:30 AM** List of facilities critical to SAWS operation established.
- **Monday (15th) – 5:49 AM** Naco PS experienced cycling of utility power through early morning hours. Eventually returned and back in operation.
- **Monday (15th) – 5:55 AM** Utility power lost to University PS with multiple attempts to restore unsuccessful. Utility power also lost at Sunset Booster PS (10:36 AM) in combination resulted in a loss of service to much of the northwest Interstate 10 (I-10) corridor.
- **Monday (15th) – 9:00 AM** Automation of facilities through SCADA became unreliable and system moved to manual mode.
- **Monday (15th) – 11:03 AM** Vista Ridge Water Supply stopped due to power supply and freezing conditions in the well field. Agua Vista plant operators ran the plant every couple of hours to prevent pipe freezes.
- **Monday (15th) – 3:00 PM** SAWS started receiving communication from hospitals regarding low water pressure.
- **Monday (15th) – 4:20 PM** SAWS received notification from CPS Energy that rolling brownouts would occur more frequently overnight and through Tuesday due to record energy demand from the extreme low temperatures.
- **Monday (15th) – 5:50 PM** SAWS Headquarters lost utility power and began operating on generator backup.
- **Monday (15th) – Evening** H2Oaks treatment facilities, which had slowly been losing capacity through the day due to frozen equipment, was essentially fully out of service.

- **Monday (15th) – Evening** SAWS recognized restarting and restoring facilities to maintain service city-wide was no longer feasible. Focus shifted to prioritizing service to critical facilities including power generation, hospitals, military, national defense, food processing, etc. Staff began a revolving process of identification and implementation of system valve adjustments to direct available flows and boost pressure to these priority areas.
- **Tuesday (16th) – 4:00 AM** CPS Energy communication with SAWS yielded prioritization of increasing water pressure to a power generation facility to avoid further degradation of the statewide power grid.

  This became SAWS number one priority. Agua Vista staff relocated to H2Oaks to assist with restoring operation of treatment facilities. Priority was made to identify valve changes in the distribution system to direct flow to this area and to identify and isolate leaks.
- **Tuesday (16th) – 5:50 AM** SAWS Management contacted the Chief of the San Antonio Fire Department (SAFD) via phone, alerting them that system service was not reliable due to the increased power outages and tanker trucks should be used in response to any fire.
- **Tuesday (16th) – 2:02 PM** Utility Power lost to Naco PS, resulting in loss of service to much of the northeast portion of the City.
- **Tuesday (16th) – 2:57 PM** Utility Power lost to Bitters PS, resulting in loss of service to much of the U.S. Highway (HWY) 281 North and Stone Oak area.
- **Tuesday (16th) – 4:00 PM** SAWS began publicly issuing outage maps twice per day (8:00 am and 4:00 pm) through the website, social media and through press communication.

  SAWS staff filmed and published a video instructing customers how to turn off residential main water lines in English and Spanish.
- **Tuesday (16th) – 9:20 PM** South Texas Regional Advisory Council (STRAC) contacted SAWS about water direction and began assisting with coordination efforts with hospitals.
- **Wednesday (17th) – 2:00 PM** Emergency City Council Meeting held to review status of system and notify issuance of a system-wide boil water order. Customers notified via Robocall, website, media, and social media. Press conference was held immediately after meeting where SAWS and councilmembers responded to questions from the public and press.

4.3 RESTORATION & SYSTEM RECOVERY

- **Thursday (18th) – 9:30 AM** CPS Energy stopped rolling brownouts and service restored to most pump station facilities. Began to refill and re-pressurize the system.
- **Thursday (18th) – morning** SAWS created a consolidated landing webpage of SAWS.org/freeze, which included announcements, water outage maps, boil water notice information, office closures. The webpage would eventually include a feature for residents to report broken pipelines and apply for funding assistance to repair damaged property.
- **Friday (19th) – 12:00 PM** SAWS established water distribution sites with the City of San Antonio.
- **Saturday (20th)** SAWS began lifting boil-water notice by pressure zone. Interactive map prepared on SAWS website for public to confirm their location and status. Information also communicated to media and via social media and robocall.
- **Sunday (21st) – 3:00 PM** Service restored to final remaining pressure zones and service areas in the northwest portion of the City.
- **Tuesday (23rd)** Lifted the final remaining boil-water notice.
- **Wednesday (24th)** Most departments returned to regular shift schedules.
- **Ongoing** Repairing damage to pump stations and treatment plants.
- **Ongoing** Responding to customer service requests to shutoff/restart service following repairs to residential plumbing. Continuing to repair leaking curb stops or meters damaged during the event.

5.0 Executive Management

The SAWS Executive Management Team, including the President/CEO, COO, and Vice Presidents were all engaged with preparation activities leading up to the cold weather event and directly as port of the response during the event. Primary focus was on directing staff, making key external communication and coordination, and assembling the necessary feedback and information to make critical and difficult operational decisions.

Much of the Executive Management Team operated directly out of the Control Center and EOC or were managing their own department command centers. Each were in close communication with each other and the EOC. Like much of the staff, the executive team worked through all hours of the day and night to provide guidance and direction as conditions continuously were changing and priorities shifting. Multiple executive staff members spent the entirety of the event at SAWS headquarters, getting periodic sleep in cots in offices as time allotted.

As conditions deteriorated, communications with key customers or critical service providers were escalated to the executive level. Additionally, executive staff were receiving many personal calls, texts, and emails from community leaders and key customers desiring information on status. Some of these communications were necessitated by the lack of ability to receive feedback through the normal protocols or channels.

Throughout the event, other leadership including SAWS Board Members and City leadership were present at headquarters in the EOC to provide assistance where possible and to obtain information necessary to communicate to the other constituents.

6.0 Production & Treatment Operations

6.1 CONTROL CENTER OPERATIONS

6.1.1 Staffing

Production management met the week leading up to the event and established a staffing plan to include [redacted] Staff had been working from home due to COVID but was determined for efficiency and coordination that it would beneficial to have staff [redacted] (14th) to set up equipment and to make sure SCADA communications were working correctly. [redacted]. Staff shifts were planned for [redacted] Throughout the event, operations staff routinely worked longer shifts [redacted] to the number of operational challenges and to transition operational status and communications to the next shift. Shift superintendents and managers routinely stayed much longer including multiple staff who stayed at headquarters for five consecutive days.

6.1.2 Staff Provisions

The majority of operations staff were [redacted] which was complicated by dangerous road conditions from snow and ice accumulations. Many staff members live outside of the City and travel distances greater than 5 miles. To limit travel back and forth between shifts, nearby hotel rooms were purchased to [redacted] and to limit travel.

As noted, [redacted] for the entire duration of the event working many hours through the night. Sleep was limited to short periods on cots or sleeping bags [redacted] Fatigue amongst many in the management and supervisor roles was an ongoing challenge throughout the event.

Additionally, food was purchased in advance of the event and staged [redacted] for staff that would be working long hours.

Observations

SAWS was proactive in having provisions for staffing and working with local hotels for staff lodging for those who had to travel long distances. It is recommended to incorporate these procedures into a formal SOP for future events.

6.1.3 Issues Logging and Dispatching Field Crews

As described later, field crews were staged at several locations across the system and were dispatched by operators in the control center, as issues were identified. All communication to field staff was via phone call. A work order spreadsheet log was maintained within the control center to track and close issues once resolved. While this log captured much of the field repairs completed, there were some activities that were not formally captured.

As the weather conditions deteriorated and brownouts began, the number of issues increased throughout the system. At this point, a much larger team was reviewing the conditions and providing direction to field crews through various operators, supervisors, or other management staff. The field crews were receiving direction from multiple people and sometimes in conflict with others on the priorities. At times, crews were responding to issues at sites that had already been resolved by a different crew.

On Tuesday, the Control Center Supervisor was established as the single point of contact for field crews. Prioritization of field issues would be reviewed and determined by management staff and clear direction given to the field crews by the Supervisor. This improved the efficiency and direction for responding to field issues.

Observations

SAWS was dynamic in recognizing an inefficiency in dispatching crews from the initial process and making a change. It is recommended to establish a formal chain of command or communication hierarchy based on this event to establish an SOP that can be used from the outset for future events.

It is recommended to further evaluate the process for enhancing and logging work orders. As noted, work orders were maintained by spreadsheet by the control center with phone call directions to field crews. In review of the phone call logs, many times multiple calls were conducted between the control center and the field directing staff where to report, reminding them of the issue when they arrived, and additional correspondence confirming if changes resulted in resolution.

While it is recognized there is urgency during an emergency event where direct phone calls are important, some tenants of a computerized work order system could better track the issues, cut down on the number of required phone calls, free staff to investigate issues, and would provide a permanent record of repairs made.

[redacted].

6.1.4 Control Center Operations

As the number of issues increased, the amount of communication and people in the Production Control Center increased. This created confusion and became a distraction for the operators.

To help facilitate communication of ongoing status of issues, a board was established [redacted] that listed the facilities that were either out of service or limited due to issues. This provided a quick reference for anyone needing general information to visually see the status without having to ask multiple people to determine the answer needed.

Additionally, new information was being brought in from various sources. This resulted in confusion due to too many people coordinating.

An additional challenge [redacted] is that there was no practical means of social distancing due to COVID. The number of staff who occupied the space and were continuously coming and going were necessary for the required collaboration and input needed to make critical decisions. All involved sacrificed in order to work through this event.

Observations

Single points of contact and a communication hierarchy structure within the EOC would have been beneficial to assist coordination on all issues.

[redacted]*. The development and distribution of the outage map on Tuesday (16th) afternoon was also a good step but this was a single snapshot in time. A live version of this accessible through a web or internal platform could have improved the efficiency at which all parties could receive status information. Other departments were limited in their ability to respond to the event as they could not see the issues but had to rely on the verbal flow of information. While staff were scrambling to respond to the quickly changing conditions, new information wasn't getting passed on to others in a timely or streamlined fashion. An improved flow of information that is distributed throughout the organization would allow for other departments to more quickly and directly understand the issues and identify the areas to which they could provide assistance or response.*

It is recommended that SAWS develop a live GIS or similarly-based system that is linked with available field data (both remote signal and manual entry), dynamically linked with customer reported outages, and ultimately integrated with advanced meter infrastructure (AMI) information to provide real-time information on system status. This can be shared with other departments or external agencies such as SAFD, as appropriate, so that as many people as possible can react accordingly with the best information available.

Power utilities many times use a similar outage platform. Their conditions are typically much easier to track as power availability is a discrete off/on while water service is complicated depending on a customer's location within a pressure zone and the elevation. Regardless, some method to track would provide benefit.

Consideration should be given to having a condensed version of a real-time map publicly available to facilitate customer coordination on outages. This is discussed further in later sections.

It is recognized that managing the flow of information was difficult from the outset of the event. Conditions deteriorated more rapidly than anticipated and the utility power failures forced staff from a proactive to a reactive mode. In the future, having consolidated data that is available to response teams could improve the overall operational efficiency during an emergency event.

6.1.5 Internal Communications

[redacted] were the primary means for communicating with all field staff regarding issues and closures. Internal communication from production staff to other departments, such as D&C assisting with field issues, was largely done by [redacted] and a way to accurately document needs. During this weeklong event more than 2,200 calls were made or received by the Production Control Center.

Control Center operators utilize [redacted] that allows them to interact with each other, key supervisors, and management staff to obtain quick responses on specific issues.

Also, as the call center and EOC were inundated with customer calls, some calls were directed to Production Control Center operators. This posed an additional distraction to staff that were focused on maintaining operations.

Observations

A cursory review of the 2,200 calls from the Production Control Center determined that 56% lasted less than one minute and over 95% were less than five minutes. Most of the conversations were with field staff and consisted of simple communication regarding status of the current task, verification of the issue given verbally previously, and what task or location the crew was to respond next. As highlighted above, some of the conversations are necessary to facilitate troubleshooting but many of these conversations could have been communicated through a work order tracking system. This would have provided efficiencies and freed operations staff to address issues from the control center rather than being on the phone.

6.1.6 Operational Challenges – Initial Freezing Conditions

As noted, freezing conditions began Saturday (13th) afternoon and generally remained at or below freezing most of the next four days. Very soon after the temperatures dropped, some of the pressure style level transmitters on ground storage tanks began to freeze. While crews were able to thaw some devices, other devices quickly re-froze or were damaged. While this resulted in operational challenges [redacted] operators could still confirm pumps were operating and could monitor flow conditions and other instrumentation to confirm operation. Several tanks overflowed during this period simply due to "flying blind".

Additionally, portions of the distribution system that have been automated were affected by the instrumentation failures. [redacted] and operated in manual mode. The system was fully taken out of automation once utility power was lost to various stations.

SAWS had been utilizing [redacted] to provide additional operational data and feedback to validate network health that could have been beneficial during this event. However, [redacted]

While there were several minor power outages during these initial few days, these were mostly restored quickly. Despite localized challenges with instrumentation, operators were able to maintain continuous service throughout the system during the initial freeze period.

Observations

It is important to highlight that despite the issues with instrumentation freezing [redacted] *SAWS was able to manage and maintain the system at fully functional levels throughout the first several days of this event. See additional discussion and evaluation of SCADA operations later in this report.*

6.1.7 Operational Challenges – Utility Power Loss

Operations became exceedingly challenging once utility power reliability became an issue. Early on Monday (15th) morning, utility power was lost at University and periodically at Naco pump stations; [redacted] These facilities continued to have power loss issues throughout the day.

Beginning Monday night (15th) and Tuesday (16th) morning, temperatures reached their lowest points and energy demands peaked on the grid. To manage the load, CPS Energy began rolling brownouts that essentially resulted in extended blackouts, as service was not able to be restored at most locations. Utility power losses continued at various stations through Tuesday (16th) and Wednesday (17th). Power was not fully restored to all stations until Thursday (18th) morning.

Further summary of coordination with CPS Energy is summarized in Section 6.3.

Observations

Loss of utility power was the primary issue for SAWS to reliably maintain service during this event. Without power, pump stations could not operate nor could service be maintained. This was the primary driver that caused water outages and forced operations staff from a proactive and planning mode into a reactive and recovery mode. This is elaborated upon further throughout this section.

6.1.8 Prioritization & Determining Alternative Solutions

As the winter event progressed and conditions deteriorated, the Production Management Team approach also changed. Production Management established a list of facilities critical to operations early on Monday (15th). The list was distributed internally to management staff in all critical departments. The goal was to maintain water flow to and from these critical facilities.

Once the rolling power outages began, maintaining pressure to all service areas was no longer possible and staff operations switched to a tactical approach to prioritize service or pressure to critical customers. SAWS quickly began receiving calls from critical customers including [redacted] These customers became of the upmost importance and the critical facility list was updated to include facilities that were necessary to serve these locations. Hospital coordination was simplified once the STRAC became involved. As described in further detail in Section 8.1.4, STRAC functioned as a single point of contact for all the regional medical facilities and facilitated in determining the priority hierarchy for the various facilities.

The production and treatment operation challenges peaked on Tuesday (16th). In addition to the rolling blackouts, low water pressure was reported at a power generation facility, a critical requirement to operate these facilities. In addition to water, electrical power demand was also at record highs and were suffering similar facility outages at major generation stations due to the freezing temperatures. The loss of further power generation facilities at this time could have resulted in major impacts to the overall Texas power grid causing cascading effects throughout the region. Maintaining service to this power station became the highest of priorities to divert and direct flow to these areas to ensure these facilities could stay operational. SAWS diverted all Agua Vista treatment plant staff to H2Oaks to focus on repairing equipment and thawing well piping in order to place this facility back in operation and to provide a boost in flow to the southeast portion of the system.

As each new issue arose, Production Management staff strategized and developed new plans to prioritize maintaining flow and pressure to these locations. This generally consisted of [redacted] Due to [redacted] or lack of power to receive communications, staff relied on feedback from field staff taking manual pressure measurements at hydrants or customer feedback from these critical locations.

The operational plans were developed based on staff experience and knowledge of the system along with feedback received from the field pressure readings. There was not adequate time to configure, maintain and run all the unorthodox scenarios being utilized within the hydraulic model to evaluate conditions.

Observations

Staff was very dynamic in leveraging their collective knowledge to continue developing new strategies throughout this event to respond to new issues as they arose. There is no practical way to have a pre-planned approach for the specific yet quickly changing scenarios that were encountered. Given the circumstances, there is no recommendations on the approach to the specific strategies developed or operational decisions made during this event.

It is noted, however, that additional data on system status would have been beneficial in making informed decisions throughout the event and is recommended for additional development.

Additional consideration should be given to establishing practice scenarios for specific emergency conditions to help staff consider alternatives in advance of an event.

6.1.9 Construction Activities

Winter is the low water demand period for SAWS and thus many of the major facility improvement projects are targeted for this period when the ability to reliably meet demands can be accomplished through other facilities. Multiple facilities had major construction activities underway, including [redacted] and [redacted] among others. These facilities under construction had limited or no capacity during the winter storm event, further limiting SAWS' ability to meet record demands.

Observations

A winter event resulting in the significant demand experienced is largely an outlier event. Construction activities should continue to be implemented during winter months and overall low demand periods. Considerations should be given during the planning of facility improvement projects to the shutdown sequences to determine if provisions or limitations on work areas can be in place to re-start the system quickly in case of an emergency event.

6.1.10 Boil Water Notice

Due to the loss of pressure to portions of the system, a system-wide boil water notice was issued to the public on Wednesday (17th) to comply with the Texas Commission on Environmental Quality (TCEQ) regulations. While there were portions of the system that maintained pressure and did not formally require a boil-water notice, maintaining operation and water pressure throughout the system was unpredictable due to the rolling power outages and the record demand. Therefore, it was decided to proactively include the entire City in the boil water notice rather than risk multiple follow-up notifications if other areas became affected.

SAWS coordinated with TCEQ to lift the boil water notices by individual pressure zone once pressure was restored and water quality results were determined to be acceptable. This was facilitated by an on-line mapping system that is described in Section 9.4.2.2.

Observations

The need for issuing a boil water notice was a regulatory requirement based on the system conditions. The timeliness and approach for a City-wide boil water notice was reasonable based on the uncertainty of maintaining operations. Further complicating was that customers in low elevation areas within a pressure zone were likely to maintain service (albeit low pressure) for some time whereas higher elevation areas drained quickly. Therefore, issuance of multiple notices would have likely created more confusion for customers.

Feedback received questioned why it took several days to recover from the boil water notice, particularly in the far north and northwest portions of the system. [redacted] *Water had to be transferred through multiple other pressure zones and pumping stations to reach these areas. With many of the pipelines drained and full of air, this required a labor-intensive process of bleeding air through hydrants to re-fill one pressure zone at a time. Once one zone was re-pressurized, staff could move to the next and continue the same process until those at the highest elevations within the City had restored service.*

The on-line mapping system used during the lifting of boil water notices was a creative and effective approach and highlights how a dynamic tool can help convey information to customers.

6.1.11 Historic Water Demands

An additional challenge of the event was the historic water demands experienced by the system. As noted in Figure 3, daily water demands leading up to the winter event were approximately 200 MGD. Starting on Monday (15th) and progressing through the week, the overall demand progressively increased by 220% to a record demand of 441 MGD on Thursday (18th). The previous record of 378 MGD was set on June 20, 2004, an expected summer event. The daily water demands remained above 400 MGD for two consecutive days (Thursday the 18th and Friday the 19th).

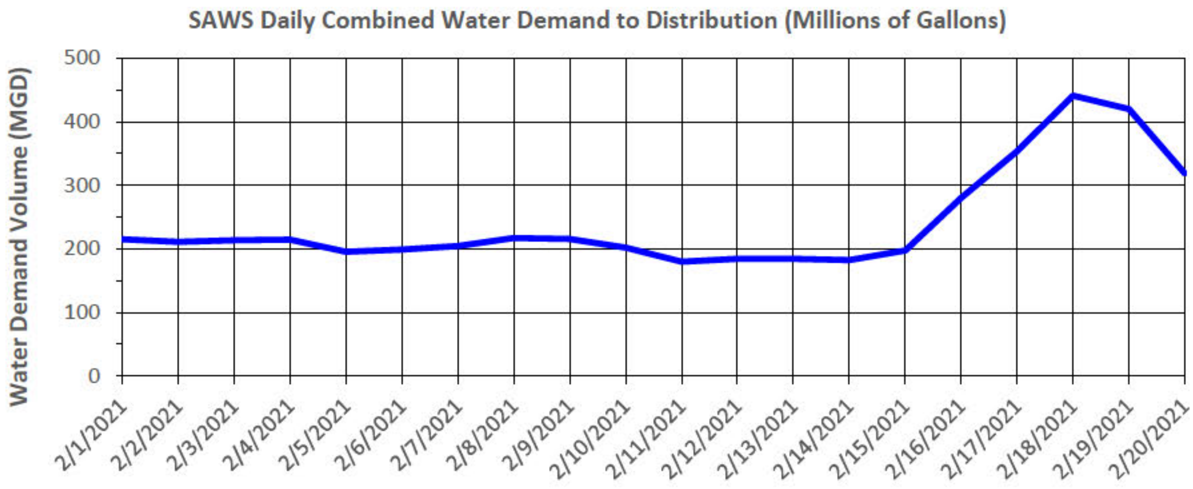


Figure 3: Daily Water Demands Prior to and During Winter Event

This record demand can likely be attributed to several factors:

- Customers running faucets to prevent residential plumbing from freezing. This was demonstrated by an above normal increase in flow with a corresponding increase at wastewater treatment plants.
- Leaks occurring in residential, commercial and industrial plumbing systems due to frozen and broken piping.
- Panic filling of bathtubs and buckets by customers who did have service as a preparation measure in case they lost service.
- As power was restored, service zones that had drained all storage tanks and portions of the transmission and distribution piping needed to be refilled and thus some of the demand was likely attributed to restoring storage.

Observations

One advantage for SAWS is the extensive distributed Edwards well supply and standby capacity that allowed them to operate at much higher capacities than normal and were not restricted or limited by centralized treatment plants. Many other utilities were limited by this and could not physically treat enough water to meet demand. SAWS was able to restore service faster than other utilities under similar circumstances. Considerations should be given to potentially adding additional wells at key locations that could further assist response during a future event or serve critical customers.

The record 441 MGD water demands exceeds the previous record demand by 17%. Furthermore, the previous record-setting demand of 378 MGD was established during the summer months, when peak demands would be expected. This was an extreme event and an outlier and is not recommended to be used for establishing a baseline for future design conditions.

6.1.12 System Restart Challenges

As power was restored, facilities coming back on-line faced challenges with restarting due to little or no pressure in the system. Pumps are designed to operate under normal system pressure conditions, which allows them to operate efficiently and without damaging equipment. With no back pressure, the pumps ran at very high flow but low head conditions or on the extreme right side of the performance curve. This led to overdraw of the electrical current above the motor's rating, resulting in some protective relays tripping and shutting the unit down. Other units experienced significant cavitation and vibration due to operating outside the normal parameters, which can have detrimental effects on the life of the pump.

Field staff were dispatched to sites to throttle the discharge ball or butterfly control valves to artificially create backpressure to get the pumps back operating within their performance curves. This limited the ability to refill the system as quickly as possible and to re-gain storage, which was coupled with the historic water demands at the time. This also required field staff to periodically adjust the valves, as pressure within the system was developed.

Observations

The system restart challenges are considered an outlier event and is not recommended to be addressed through design condition modifications to current or future facilities. It is recommended to note the specific procedures implemented in an SOP for reference in future events.

6.1.13 Headquarters Power & Water

The SAWS headquarters was not immune to utility outages experienced during the winter event. Power was lost at the main building and required [redacted] Additionally, the pump station serving the area was also without power which resulted in no water to headquarters and the surrounding area. Portable toilets were brought in for the many staff who were having to continue to work through this event.

6.2 WATER SUPPLY SOURCES

6.2.1 Edwards Aquifer

The majority of water supply is sourced from wells in the Edwards Aquifer, which are distributed throughout the City. One advantage for SAWS is the extensive distributed Edwards well supply and standby capacity that allowed them to operate at much higher capacities than normal and were not restricted or limited by centralized treatment plants.

6.2.2 External Supplies

In addition to the Edwards Aquifer, SAWS sources groundwater from the Carrizo-Wilcox and Trinity Aquifers, and surface water from Lake Dunlap and Canyon Lake. The following summarizes the providers and water sources for non-Edwards Aquifer supplies:

- Carrizo-Wilcox Aquifer
    a. Schertz-Seguin Local Government Corporation (SSLGC) Regional Carrizo
    b. SAWS Vista Ridge

c. SAWS Local Carrizo

d. SAWS Brackish Groundwater Desalination (BGD)

e. SAWS Aquifer Storage and Recovery (ASR) of Edwards Aquifer Water in the Lower Wilcox formation

- Lake Dunlap:

  a. Canyon Regional Water Authority (CRWA)

- Canyon Lake:

  a. Guadalupe-Blanco River Authority (GBRA)

- Trinity Aquifer Wells:

  a. Water Exploration Company (WECo) Texas Water Supply

  b. Stein Ranch

  c. Oliver Ranch

For purposes of this memorandum, the following supply sources were categorized as "external" sources since they involve some degree of coordination or agreements with external entities:

1. SSLGC Regional Carrizo
2. Vista Ridge
3. CRWA Lake Dunlap
4. GBRA Canyon Lake
5. WECo Texas Water Supply
6. Stein Ranch
7. Oliver Ranch

The first four sources lost full service for at least several days during this event, as they experienced similar issues with loss of utility power and freezing conditions.

Texas Water Supply source was off prior to the event due to low groundwater level but a force majeure event clause went into to effect to provide up to 10 MGD (7 MGD average) during the event.

The Oliver Ranch supply remained available during the event but is a small contribution at 2.5 MGD.

Observations

All regional utilities experienced similar issues with power failures and frozen equipment during this event, which had a cascading effect on SAWS' ability to deliver water. It is recommended that SAWS engage in resilience efforts with these regional partners and external providers of water to discuss operational enhancements or infrastructure improvements to improve system reliability.

6.2.3 H2Oaks Facility

Additionally, SAWS operates the H2Oaks facility at the south end of their system which includes the ASR facility, the BGD facility, and the Local Carrizo Wellfield. This facility had maintained power throughout the winter event but experienced significant reductions in capacity due to the freezing conditions. Most of the effects were due to production wells and the lime system. On Monday (15th) the entire BGD facility was offline due to the wells being inoperable.

During the winter event, it was determined that [redacted] Plant operations staff were relocated from Agua Vista to H2Oaks to assist with operations and getting equipment back in service. Staff were able to thaw well equipment and maximize production of the facility. By Thursday (18th) the facility was able to operate above its rated capacity and still meet water quality parameters [redacted].

Additional description of specific issues at the H2Oaks facility is summarized in Section 10.4 of this report.

Observations

Restoring service to H2Oaks [redacted] *This facility is recommended to be further evaluated for resilience improvements. Specific observations and recommendations for the H2Oaks facility are highlighted in Section 10.4 of this report.*

6.3 CPS ENERGY COORDINATION

The following summarizes the basic coordination and protocols working with CPS Energy through the event.

6.3.1 Preliminary Outage Notification Protocols

These automated message from CPS Energy were generic in nature, simply indicating there was a power outage, the situation was being assessed, and there was not an estimated time to have power restored.

Additionally, control center operators would contact CPS directly through a specific contact list that is maintained for the various sites as they observed power issues. Many times, CPS indicated power had been restored but field crews would travel to site to reset equipment and determine that power had not been restored. This led to repeated messages back and forth on power status and efforts. For example, University PS lost power 14 times during the event, based on power monitoring records. Many other facilities experienced similar issues.

Numerous other automated messages from CPS Energy were issued for various outages, requests for energy conservation, and ultimately the rolling brownouts.

6.3.2 CPS Energy Communications During the Event

CPS Energy has standard points of contact for power outages. However, due to the volume of issues and the challenges they were facing in maintaining their system, the person contacted would likely not respond and resulted in many different people on both sides having conversations on the issues. This created difficulty in tracking the issues, status, and establishing an understanding of the priorities.

As conditions worsened and the criticality to maintain system operations increased, communications elevated to management level staff from both organizations. SAWS reiterated the need for specific facilities to be kept in service and to avoid rolling outages in these areas. However, this was not implemented, as highlighted by the number of critical facilities that were without service. Multiple discussions were held about operating facilities during short periods while power was temporarily restored but this was not feasible due to the record demands in the system.

SAWS began providing an email list of critical stations that needed power to CPS Energy on Monday (15th). This quickly was updated to a list of facilities without service that needed restoration. The list was updated through multiple rounds of email correspondence amongst a large network of people from both SAWS and CPS. Since conditions were changing rapidly, it was difficult to keep the facilities restoration list current and to ensure staff were working from the most current version.

One of the biggest challenges noted was the lack of direct feedback on the status of power and when service could be restored at various facilities. Since the water system function is dependent largely on power supply, it became difficult to make decisions on alternative operating scenarios as well as being able to communicate to critical customers and the community on the status of when water service could be restored.

Another challenge was the difficulty SAWS had in getting CPS to understand that some stations needed to have power continuously and could not be on the rolling brownout list. Following the email from SAWS containing the list of facilities that needed power restoration, CPS asked if providing power to the station for [redacted] would be acceptable. SAWS emphasized they needed [redacted] Following the exchange, CPS Energy sent a list of the pump stations to SAWS with details on the power status of each but noted the list was subject to change. Mixed messaging received of attempting to restore power to certain facilities while simultaneously shutting off power to others through rolling brownouts created confusion on the priorities and what actions were to be anticipated moving forward.

Observations

This section will be prefaced with an acknowledgement that both utilities were operating under tremendous and unprecedented challenges that were rapidly evolving. Each utility had the same goal to restore service to all customers while prioritizing critical infrastructure needs. Reaching full restoration of service was made more difficult by the interdependence of power and water services; some critical infrastructure needed both and water to function. However, it was clear that improvements in communication could have streamlined the response of this event and ultimately led to better decision making and more efficient improvements in maintaining service.

The first improvement recommended is to establish a better coordination protocol and system between SAWS and CPS Energy. This coordination protocol would include two specific points of contact for SAWS *at CPS Energy. Review of some of the phone and email records highlights multiple different staff at multiple levels from each organization providing notices, requesting status updates, responding to issues, etc. Many times, the chain of questions would get routed and answered by someone not originally directed and became difficult to maintain consistent flow from both sides. Once the outages escalated beyond the first several, an escalation hierarchy and formal point person or two from each side was needed for all communications.*

The second improvement recommended is to develop a better system for tracking outages and status of resolution. The spreadsheet distributed back and forth through email was updated so frequently it was quickly outdated or would be followed up with direct emails requesting status on specific items. Different people would then respond on the chain and the spreadsheet was no longer used, resulting in unclear status or prioritization of critical issues. Further, all parties were inundated with emails throughout this event and multiple emails regarding status updates exacerbated communication inefficiencies. It is recommended to develop a common platform or SharePoint for future emergency events where outages can be logged in a common location and each utility can update status in real-time for staff to see.

Additionally, establishing communication through [redacted] *was used between SAWS and other agencies throughout this event and something similar could have been developed and utilized to communicate between the utilities as well. This would have eliminated email traffic for basic questions that* [redacted] *could have seen.*

More straightforward answers between each group would have also been helpful in making decisions and planning next steps. While nobody could exactly predict some of the outcomes that did occur, more honest dialogue could have allowed for better decisions to be made in strategizing alternative plans. Feedback that certain stations were attempting to have power restored while yet taking other locations out of service did not bode well in confidence to the reliability of the information being provided.

Ultimately a lot of feedback was observed on SAWS inability to provide updates to their customers on status of service, but this was impossible to provide without reliable feedback on utility power status.

6.3.3 [redacted]

SAWS had previously developed a [redacted] The [redacted] designates sites by a priority number that is established and defined by the Electric Reliability Council of Texas (ERCOT). However, nearly all SAWS facilities fall into the same generic ERCOT prioritization ranking (*Priority 4 – Law Enforcement and facilities affecting public health, safety and welfare*) and thus does not provide any further breakdown of the individual facilities that would have higher priority than others.

Additionally, [redacted] lists the primary and secondary contact information for both SAWS and CPS Energy for each facility. [redacted] was last submitted in 2017 and did not include the facilities constructed in the last few years. The [redacted] is not intended to be used in an emergency event like the one discussed herein but it was the only comprehensive list discussed and exchanged between SAWS and CPS Energy until this event.

Observations

The ERCOT prioritization ranking is not adequate in communicating the priority of facilities necessary to be restarted following a major failure event such as this. With everything having the same scoring the prioritization is neutralized. It is recommended SAWS work with CPS Energy to establish a detailed prioritization based on a revised facility criticality hierarchy. This should be prioritized on several factors including the capacity, the number of pressure zones served, the area or number of customers the facility can serve, critical customers, etc. This list should be reviewed and updated on at least an annual basis.

Further, a reversal of this list is important to establish those facilities which can be taken offline first if needed to curtail overall power usage in a pending rolling brownout situation. It would have been helpful in this recent event for SAWS to have input as several of the facilities affected by the rolling brownouts/blackouts were critical to maintaining service to large areas of the system and thus had a cascading effect on loss of service. Additional coordination could have directed the brownouts to less critical facilities or where greater redundancy exists.

6.4 FIELD OPERATIONS

Field operations consist of the Mechanical, Electrical & Instrumentation teams that support Production Operations. Similar groups separately support the Treatment Operations.

6.4.1 Preparations & Staging

As highlighted, the week prior the freeze the field crews from each group went to the facilities throughout the system to check heat trace systems and insulate as much exposed piping and valves as possible. Buildings with heaters were verified for operation and standby generators were checked. Additional details on some specific winterization measures are described later.

Additionally, a plan was developed to pre-stage field crews from each group at central locations throughout the system [redacted] Each group would cover an area of the system to more quickly respond to issues and limit unnecessary travel. In general, the plan was to assign more experienced staff to the areas that have historically had more issues during prior freeze events.

Figure 4: Temporarily Insulated Valves at Shields PS

Observations

Staff prepared as well as could be expected. Numerous valves, piping, etc. were temporarily insulated and covered where possible. Most of the issues experienced are not associated with a lack of preparation.

6.4.2 Staffing

All crews established an initial schedule that covered a full 24-hour period. After the first couple of days, the schedules were changed to accommodate the increasing number of repairs and new group structure. All crews were scheduled for [redacted] shifts but many worked significantly more to accommodate the number of issues. Most of all staff crews were available during the event, but each group was short several staff that were dealing with issues at their own homes or could not travel due to road conditions in their area. Some staff that was on-call ended up stranded or stuck in several instances due to icy or snow packed road conditions.

Observations

Staff responded as well as could be expected during the event. Many staff went well above and beyond their shift durations, working in the conditions, traveling risks, etc; highlighting their dedication to the organization and fulfilling their role to restoring and maintaining service.

6.4.3 Dispatching

The field crews were directed to site issues [redacted] As noted earlier, work orders were logged and maintained by spreadsheet in the control center. As issues were addressed, field crew staff would call back to the control center to confirm the issue was resolved, close the issue in the spreadsheet log, and receive direction on the next issue to address.

As the number of issues increased throughout the system, various operators, supervisors, or other management staff would contact the crews directly on what the priority issue they needed to respond to next. This resulted in multiple direction being provided and confusion on where to respond. As noted previously, on Tuesday the Operations Supervisor was established as the single point of contact for field crews. Prioritization would be determined by management staff and clear direction given to the field crews. This provided a much more efficient process and direction for responding to issues.

Observations

See recommendations in previous report section(s) regarding this subject.

6.4.4 Teaming

Over the course of Sunday (14th) and Monday (15th) it was observed that an individual from each of the three departments would respond to an issue at a site only to determine a different trade needed to be involved to address the problem encountered. Additionally, many times the issues would only be temporarily resolved and would re-occur.

By Tuesday (16th) the crews were changed into working teams of three including an electrician, mechanic and instrumentation technician to ensure all trades were present. These crews would travel together and remain on a single site until everything was fully operational before moving onto another site for repairs. There were a few specific instances where this approach was changed to send specific staff to individual issues but overall was the approach used for the remainder of the week and was deemed much more efficient.

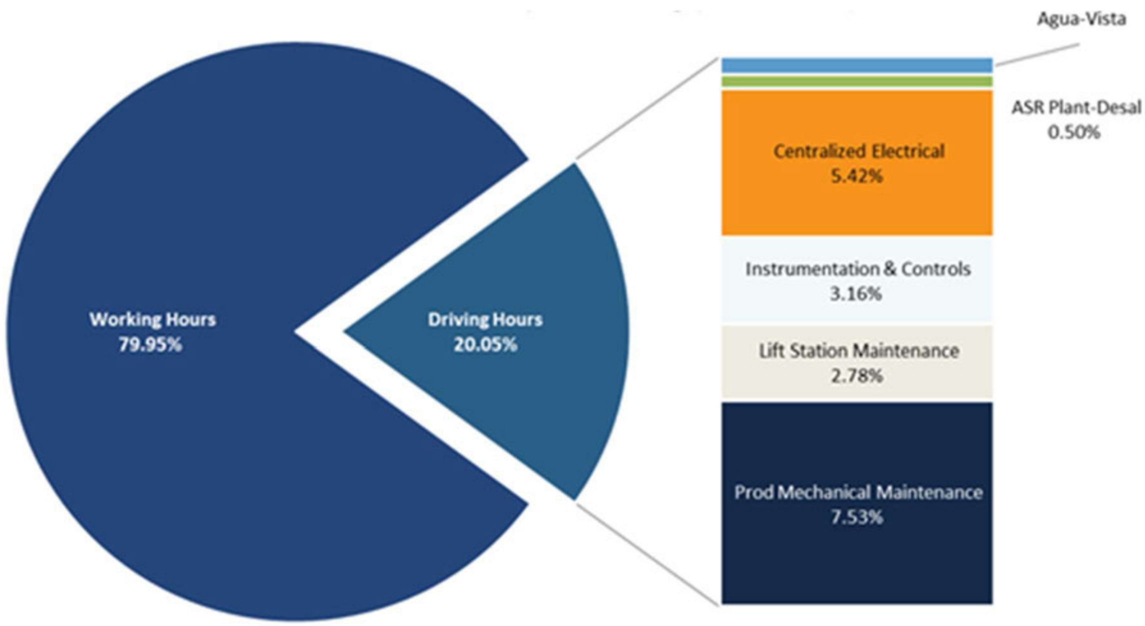
Observations

Teaming was another instance of an inefficiency realized during the event and adapting the response protocol to be more effective. This should be established as an SOP for future events.

While each of the trades are specifically trained in their specific areas of expertise, it is recommended that some basic cross-training be considered which could allow basic troubleshooting functions to be completed by any group to maximize effectiveness of limited staff during an emergency event.

An evaluation was conducted to compare the time field staff spent driving based on the tracking of service vehicles in comparison to the total hours worked over the course of the event. The analysis is summarized graphically in Figure 5 is highlighted by an overall average of about 80% of field staff time was spent working at a facility with all departments above 73%. This seems appropriate considering how widespread the facilities are across the City and the number of issues that were experienced.

The staging of staff to regional areas of the City was an effective approach and reduced some of the risk of staff on the roads in the weather conditions. Note there were several outlier cases of specific individuals driving excessive mileage (nearly 1,000 miles for the event) which could warrant further analysis for optimization.



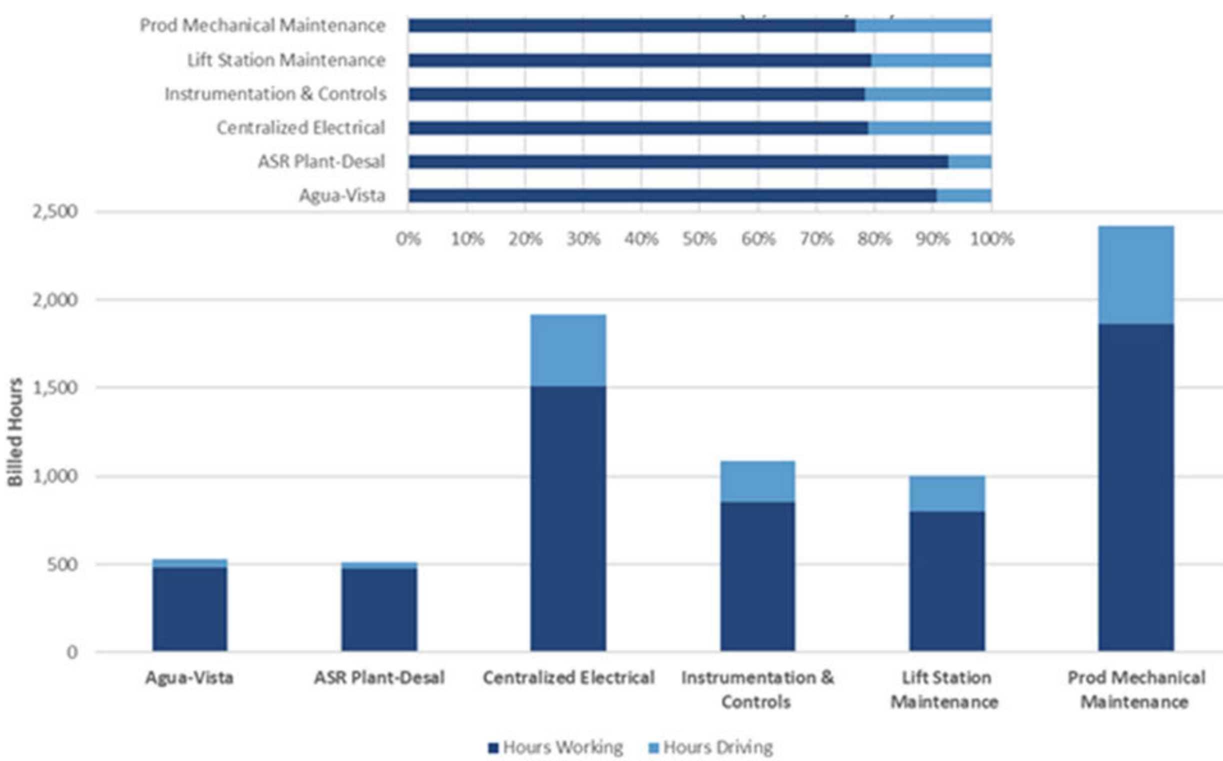


Figure 5: Summary of Production Field Staff Hours Working vs Driving

6.4.5 Spare Parts

A lot of materials were needed to make repairs to damaged equipment and instrumentation. For most instances crews were able to use readily available spare parts, salvaged materials from another site, leverage supplies from local vendors, or develop a temporary fix to get systems back in operation.

Spare parts located in warehouse storage were at times difficult to obtain due to the facilities being closed or being able to locate which facility they were available.

PVC fittings in particular were noted as a challenging item to keep in stock with field crews.

Permanent replacement of damaged equipment and fittings has resulted in long lead times due to the demand from the regional damage caused by the event.

Observations

Spare parts limitations are referenced throughout this report for each department but will be summarized collectively herein. SAWS normally utilizes [redacted] *for field crews to obtain spare parts from* [redacted] *However, during much of this event,* [redacted] *A SAWS acknowledged improvement to implement is to allow full access to* [redacted] *An additional recommendation is to review those items most frequently used during this winter event and seasonally stock these items each fall.*

7.0 Distribution & Collection

7.1 CONTROL CENTER OPERATIONS

7.1.1 Command Center Setup

The Distribution and Collection team (D&C) established their own Command Center or "war room" [redacted] While not directly connected with the Production control center, having [redacted] was beneficial in coordination with the rest of the team on issues.

An early step taken was to establish management structure and primary points of contact within the group. [redacted] were assigned as the primary gatekeepers for information coming in and direction going out.

Since this set-up was [redacted]

Observations

[redacted] *worked well. Future events should plan to establish a* [redacted] *or other items that could further streamline the process.*

7.1.2 Staffing

Command center staff were [redacted] providing [redacted] for the event. Similar to many other groups, the volume of issues resulted in many staff working much past their planned shift.

7.1.3 Data Compilation

The normal and primary process for D&C to respond to field issues is from service requests generated by calls received in the EOC with priority assigned based on the severity. As noted previously, [redacted] resulted in many of the issues not being identified. Despite [redacted] the number or service requests generated for D&C were significantly less than even a normal period. Because of this focus was primarily directed to Production related issues.

Additionally, requests and information from multiple sources throughout the event were coming into the D&C Control Center including from Production, EOC, call center, direct discussion, etc. These work requests were primarily received [redacted] The D&C team established a streamlined approach to tracking issues, prioritizing, and developing formal work orders for crews to address.

The first activity was to consolidate the information received from the various sources into a common spreadsheet log. This allowed items to be reviewed to remove duplicate requests that were received from alternative sources or to confirm if an issue had been already addressed. Some of the [redacted] were brought in to assist with this activity. Additionally, some of the calls or issues that were directed from the EOC were not fully vetted of the issue and thus needed follow up.

Additionally, priority was established to these items based on their impact to operations. Primary focus was to ensure [redacted]

It was noted, particularly early in the event, that it was difficult to understand or get clear direction on the specific challenges that Production staff was facing. Additional clarity and understanding of the concerns could have led to better assistance being provided. This improved as the event progressed.

Observations

[redacted] *was a clear bottleneck in the process and potential missed opportunity to understand and quickly respond to field issues. Despite a significant increase in call volume, the number of Service Requests to D&C actually decreased from normal during the event. With the large volume of leaks in the system, it is clear these issues were not making their way to D&C. This communication gap is recommended for further evaluation.*

Further discussion is held in a later section on revising protocols such that issues can be identified without the need for [redacted]

As highlighted previously, the recommended development of a dynamic system to document outages would be beneficial to multiple departments to assist in understanding, tracking and resolving issues.

7.1.4 Assigning & Tracking Work Orders

Once the issue was clearly defined, a work order was generated [redacted] and distributed to the field crews to resolve or execute. This was important to accurately track all actions taken, specifically for [redacted] as these all needed to be [redacted]

[redacted] rather than having to find the correct person to ask. As repairs were completed the team would [redacted] This gave all people access to the information on work orders, valve movement, and other pending items to help avoid a duplication of efforts.

7.2 FIELD CREWS

7.2.1 Staging and Staffing

Work crews were staged from [redacted] Operations quickly went to [redacted] and staff that were primarily scheduled [redacted] worked much longer to address the volume of issues.

7.2.2 Preparations

Work crews prepped for the pending freeze event based on standard protocols from previous events. Activities primarily consisted of ensuring vehicles and equipment were prepped and stocked with materials and drained exposed piping in several locations that was prone to freezing.

7.2.3 Critical Customer Coordination

Coordination with large users during the event [redacted] was handled [redacted] Most times when one of these customers reached out to SAWS with a low-pressure issue or a leak issue, SAWS would typically send a crew to perform an inspection and assist.

It was noted that this was particularly difficult and time-consuming activity when the customer was not willing to investigate the issue with their own staff before contacting SAWS, sometimes repeatedly. Many of these critical customer campuses have multiple buildings and structures distributed throughout and thus have their own piping network they operate and manage, all which is not part of the SAWS system. In some cases, they still had service but a major leak in one building was causing the loss of pressure to the rest of their system. SAWS staff assisted to locate and isolate these leaks but this did divert focus from addressing other issues.

Observations

This event highlighted deficiencies some of these critical customers had in understanding the systems they own and operate and to check/troubleshoot first prior to contacting SAWS. While the assistance provided to these customers was beneficial in stopping large leaks that were affecting the system as a whole, this was not SAWS responsibility and diverted staff's attention away from other issues. It is recommended to have some follow up conversations with the specific large customers and highlight the importance for them to review and understand their system.

7.2.4 Commercial and Multi-Family Housing Coordination

Throughout the event, field crews responded to multiple commercial buildings, apartment complexes and other non-residential service locations due to reports of leaks. Similarly, many of these were locations that had experienced failure on the customer side of the system including backflow preventers, freezing of fire risers within unheated building chases, or general leaks that had developed due to frozen plumbing lines.

Similarly, the property managers or staff at many of these locations were not familiar with the systems on their side of the meter. Field crews routinely had to assist in isolating service to so that repairs could be made by the owners.

There were also communication issues identified between property managers and the employees or residents of the facilities they served. Sometimes they did recognize an issue and shut off service from their side but failed to notify the employees or residents and these customers began contacting SAWS about not having service, further inundating the call center.

In several instances, field crews had to [redacted] to major leaks [redacted] reduce the demand on the system.

Observations

Similar to the previous item, there was multiple instances of private services not addressing their own issues. Some type of outreach is recommended to help educate these property owners and building managers on their responsibility in understanding and maintaining their private systems. Potentially this could be a SAWS sponsored event to educate basic functions of valve operations, backflow preventers, service shutoffs, etc.

7.2.5 Production Assistance

The primary operation of the field crews was [redacted] throughout the distribution system to help [redacted]

Additionally, Production mechanics were overwhelmed by the number of facility issues experienced during the event. D&C field crews assisted throughout the event to help respond to and repair leaks within stations, locating spare parts and fittings they had available in storage, salvaging fittings and materials from various stations to reuse elsewhere, and other general assistance.

Observations

This was another example of crews working across department lines to help out in a crisis for the good of the organization.

7.2.6 Hydrant Pressure Readings

Another item D&C field staff assisted the Production team with was to o[redacted] Since most [redacted] was critical to obtain point readings at various locations to confirm status or to validate if [redacted] However, this was a labor-intensive process to obtain a [redacted]

Observations

Several [redacted] provide better opportunity for additional data over a wider area to help off-set [redacted]

The implementation of the AMI system, specifically [redacted] would be the ultimate step in having the most real-time information readily available. However, this is *also dependent on the need for reliable power for data transmission which should be investigated further.*

7.2.7 Emergency Locates

At times emergency excavations were necessary to expose a pipe or valve for repair or emergency operation. In these critical times, the 811 service was not available or couldn't respond as quickly as needed. Some of the critical underground gas and electrical systems are not a shared GIS dataset across utilities due to proprietary considerations. SAWS had to rely on available as-built drawings in their files to locate nearby utilities to the best of their abilities during these times.

Observations

While there is an understanding some services are proprietary across other utilities, allowing SAWS and other utilities access to this type of information is a critical in all emergency events. It is recommended to have further discussions with the 811 system and subscribing utilities on having [redacted]

7.2.8 System Refilling

Since large portions of the system were fully drained due to the extended service outage, much of the distribution piping was filled with air. Production began re-filling but had difficulty moving water through the system. D&C field crews spent much time opening hydrants in a systemic approach throughout the system to bleed trapped air out. This was especially challenging in the north and northwest portions of the system due to the hilly terrain and numerous high points in the distribution piping where air collects.

Observations

The challenges associated with system refilling is largely to be expected during an extended outage. The challenge of a having a fully networked system with multiple and high and low points as opposed to a typical main replacement made air removal more difficult. Any specific noteworthy methods or protocols learned during the event should be documented in an SOP for future reference.

8.0 Emergency Management

8.1.1 SAWS Emergency Manager

The SAWS Emergency Manager serves as the primary point of contact and coordinator with various other emergency response roles from other governmental or agencies throughout the City of San Antonio and Bexar County. This is a [redacted] but works in close coordination to relay necessary information. The following summarizes several of the major areas of coordination during the event. Emergency management communication through this event was primarily [redacted]

Observations

A major emergency event such as this freeze event required frequent communication with numerous agencies. Consideration is recommended to establish deputy staff who can be assigned during such events to support communications to specific agencies.

8.1.2 City of San Antonio & Bexar County Emergency Operations Center

The COSA/Bexar County Emergency Operations Center (EOC) is comprised of various City and County entities including COSA, CPS Energy, TxDOT, Bexar County, Police, Fire, SAWS, amongst others. In the week prior to the freeze, daily virtual meetings were held by members of the EOC along with the National Weather Service to get updates on projections and preparation activities taking place. Meeting notes would be prepared and distributed to SAWS management.

COSA officially activated their EOC on Sunday (14th). They began contacting SAWS shortly thereafter to report issues regarding residential and commercial facilities with broken pipes that were causing a hazard. Many of these were quickly determined to be on the customer side of the service.

As the event progressed, SAWS Emergency Management was in regular contact with the COSA EOC. Starting Monday (15th), SAWS provided regular formal updates through virtual meetings to provide updates on the status of the system.

SAWS is offered space to operate within the COSA/Bexar County EOC to be in more direct contact with the other agencies. However, during this event this was not utilized. It was determined that remote operation would lose the connectivity to the direct issues the system was facing, and the more effective approach was to provide updates from the SAWS EOC where information could be obtained in real time. Utilizing what was effectively a "virtual EOC" through regular video conferencing and chat was deemed a more time and staff efficient strategy.

Observations

Maintaining the [redacted] *and operating in a de facto "virtual EOC" with the other agencies was the most efficient and best use of SAWS staff. It is recommended to have additional follow-up with the COSA and other City and County agencies on how they viewed the efficiency of this and potentially find improvements to this process or streamlining communications in the future.*

8.1.3 SAWS Emergency Operations Center

SAWS has established their own Emergency Operations Center [redacted] This is normally staffed [redacted] The phone calls handled are typically from customers reporting outages or issues which are then directed to the applicable department as a service request.

The EOC call center was inundated by customer calls during the event. This is covered in more detail in a later section.

[redacted]

8.1.4 Hospitals & Southwest Texas Regional Advisory Council (STRAC)

Initially calls were received from various hospitals and medical facilities that began experiencing low pressure conditions and requesting feedback on the timing of return to service. This presented challenges in providing responses to all the requests for feedback as there was limited knowledge on the duration of the power outages. The number of calls and requests for status exceeded the staff's ability to adequately respond and prioritize.

A helpful step was the involvement and coordination provided by STRAC. They serve as a liaison between the regional hospitals, dialysis facilities and the public utilities and served as the primary point of contact for all the regional medical facilities to call instead of SAWS. They coordinated with the hospitals on their priorities and then would give consolidated priority list to SAWS.

Starting Wednesday (17th) morning, STRAC facilitated meetings and phone calls between hospitals and SAWS during this emergency event. A daily 4 PM call was established to provide updates and coordination activities that were being implemented by the various facilities. [redacted]

Through these efforts it was determined that some hospitals had alternative water supplies with local wells to serve as an emergency backup. Other hospitals developed innovative ways to receive bulk water that could at least provide some basic levels of operation to some of their priority systems to remain functional.

STRAC helped prioritize the most critical medical facilities based on the water availability and ultimately made the critical decisions on relocating patients, as was determined necessary for at least one facility. Coordination with them was key in helping prioritize where water restoration efforts needed to be directed.

Observations

The integration of STRAC into the coordination efforts with the medical facilities was very beneficial to establish a single point of contact for prioritizing needs across all facilities and allowed SAWS to focus their efforts on the locations STRAC determined to be most critical. Initial coordination and *communication with STRAC needs to be one of the first things steps taken in an emergency event and incorporated into the formal Emergency Management Plan.*

The establishment of [redacted] *helped facilitate the flow of information between STRAC and SAWS. A* [redacted] *is recommended to be established with other agencies to provide a more streamlined flow of information.*

Further follow-up is recommended with the hospitals and medical facilities to better understand those that have backup water supply systems and to validate if those can be functional during a future emergency event.

8.1.5 San Antonio Fire Department

The San Antonio Fire Department (SAFD) experienced challenges through this event as well. The cold temperatures froze pump trucks and snow-covered roads hindered travel particularly in hilly areas. The loss of water service at various locations throughout the system also hindered response efforts.

SAFD is also part of the COSA EOC and needed access to information regarding water service and their ability to respond to a fire and thus stayed in frequent contact with SAWS on status. As noted in the sequence of events, SAWS contacted the Chief of SAFD on Tuesday (16th) morning to alert them that pressure could not be guaranteed throughout the system due to the utility power outages and that they should utilize tankers in responding to any fire issues. SAFD eventually stationed one of the department chiefs at the SAWS EOC so they observe the emergency operations throughout the day to get the most current information on system outages and limitations in supply and provide feedback to SAFD.

The biggest piece of information the fire department was needing was the pressures at each fire hydrant to determine if they would have water pressure to fight a fire in that location. With large portions of the system without communication, that was not information not readily available and any measuring would have to be done manually at a hydrant.

Two total loss fires occurred during the winter event. In one case, the fire crews were unable to draw water from the nearby fire hydrant due to no available water pressure.

Observations

Having a SAFD department chief in the SAWS EOC was likely the most efficient way in this event to receive timely information and to see the issues first-hand. Further follow up discussions with SAFD is recommended to discuss their observations on the feedback.

As noted previously, the development of a better tracking system status for system outages and areas of low pressure would be beneficial. A streamlined version of this could be developed and accessible to SAFD so they could better understand local issues in responding to fires.

8.1.6 Texas Utilities Call

A call was assembled on Wednesday (17th) evening with other major water utilities in Texas. This was beneficial in understanding how widespread the issues were and to discuss the specific challenges each utility was facing. It also served as an opportunity to share ideas on what each was doing to manage the event and any sources for materials or other resources.

It was also discussed how it would be beneficial to develop consistent messaging to the general public on measures to take during an emergency event. For instance, there was mixed messaging across the utilities to customers on whether they should be dripping their faucets to prevent freezing. Future collaboration on such items would be beneficial.

Observations

The utilities call was beneficial and gained an appreciation for how widespread the issues were through the region. It is recommended for further utility coordination through AWWA or a similar platform to continue these discussions on successful strategies implemented by other utilities and to develop unified messaging for customer on specific responses during these of events.

8.1.7 Water Distribution Sites

The Emergency Management department also facilitated the setup of the water distribution sites for the public working through the logistics of staffing these locations, having the necessary legal and human resources protocols in place, and working with communications so the public was aware these locations had been setup. This entire program was conceived and implemented in just over 24 hours.

SAWS worked with COSA to establish the location of these water distribution sites at several locations around the City. This was an opportunity for customers to bring their own bottles or buckets and SAWS staff would fill them. The first of the sites opened Friday (19th) and were operated through the following week until only a couple stations remained in a self-service mode.

The operation of these stations was largely by volunteer SAWS staff from across multiple departments.

Observations

The use of water distribution sites was a beneficial option for the public and customers who were without service due to frozen pipes or general service outages. Unfortunately, this didn't start until Friday afternoon, more than five days after some customers had lost service. While travel was restricted earlier in the week, having this service available earlier would have been beneficial for those customers in need of water. It is recommended to review the plans for these sites and establish a formal SOP for implementation such that these could be more rapidly deployed in a future event.

9.0 Customer Service & Communications

9.1 CALL CENTER

9.1.1 Call Center & EOC Typical Operations

The call center is normally staffed with phone operators from 7:30 AM to 6 PM on weekdays. The EOC is staffed [redacted] As customer calls come in, they can be directed by the IVR system specifically to the EOC in case of an emergency or to the general call center for further direction.

Calls to the EOC are clarified with the type of issue and a priority established and then directed to the appropriate department (Meter Technicians, D&C, etc.) as a service request.

9.1.2 Call Center and EOC Staffing

Because of COVID, all EOC and call center operators had been working remotely from home for the past year. Unfortunately, once utility power was lost to their residence, they were unable to connect through VoIP system and respond to issues. With slick road conditions the ability to commute to headquarters would have been difficult.

This coincided with the highest volume of calls as customers were requesting outages, leaks, or general status updates. At the worst point of the event only 20% of call center staff was able to reliably be on-line, 40% had intermittent power or internet and were available when possible and the remaining 40% were unavailable due to lost power.

EOC staff had better availability during the event but did require several backup staff to assist for those unable to connect. Available EOC staff was typically [redacted] to try and keep up with the volume of calls.

Other departments assisted in handling the volume of calls during the event [redacted]

Observations

The inability of staff to answer calls was a major setback during this event that had ripple effects through other areas of the organization. Many of the critical leaks identified by customers were not being reported as calls couldn't be answered. It also impacted the ability to receive feedback from customers on areas of low pressure to provide more data points to Production on impacted areas that they could not see due to instrumentation out of service or no utility power.

COVID and travel adversely impacted the ability to respond during this event. For future events it is recommended to consider coordinating provisions necessary to have [redacted] *and to facilitate coordination with the other teams also in person to provide the most streamlined feedback between groups as possible. Service vehicles could escort staff from their homes in poor road conditions and provide local lodging to limit travel like was implemented with the Production operators.*

An additional recommendation is to have staff from other departments cross-trained to help process and respond to calls during emergency events.

9.1.3 Call Center and EOC Operations During Event

As noted, the call volume increased significantly due to the event. Total number of responded to calls quadrupled from the same period weekly period a year ago.

The call system has a queue size limitation for callers on hold ([redacted] Due to the volume of calls, the queues for the EOC and call center were full for most of the winter storm event. Once the queue hits its maximum capacity, customer are directed through automatic message to call back later. Additionally, customers in the queues experienced long wait times to speak to a representative. Consideration was given to expanding the queues but due to concerns over the long wait times, no changes were made to the queue limits.

A high volume of customers were calling due to "no water". Normally, a service request would be created to investigate the cause. On Monday, once it became clear that water outages were widespread, service requests for no water investigations were no longer created. As customers reported low pressure concerns, EOC conveyed this information to Production in order to identify affected areas.

Only service requests for meter leaks or service turnoffs were created and prioritized based on whether internal property damage was occurring. If internal property damage was occurring, a Priority 1 was assigned and the service request was dispatched. All other service request were assigned a Priority 2 and worked as resources were available. Mid-week, the water waste web form was modified to allow customers to report water leaks at their property. These were forwarded to the EOC to create a service request and prioritize.

One of the biggest challenges was not having good feedback to customers on when service would be restored as this was one of the primary calls customers were making.

The decision on Thursday (18th) to utilize the revised billing format for the lowest use monthly period between January and February was helpful as there was an anticipation of numerous customer calls regarding their water bills based on the large usage volume due to running faucets or residential leaks due to frozen pipes.

Observations

As noted, the inability to answer calls hampered multiple aspects of operations. First, customers could not make reliable communication with SAWS to report issues and obtain assistance. Secondly, Production and D&C were not receiving valuable information on system status to help fill information gaps on areas where instrumentation was not valid or where major leaks were occurring.

Obtaining information limited primarily to phone calls placed a bottleneck on information in both directions. It is recommended to develop an on-line portal for customers to report outages or issues that can be populated on a map. Many customers would much prefer to report an issue on-line rather than to wait on hold to talk with someone. This on-line reporting system could be a series of questions similar to the IVR recordings used to help classify or clarify the issue and linked directly to the account. Capabilities *could be included to upload a picture of a leak or the impact to assist with classifying and understanding the issue. This could provide more accurate information to all areas of the operation on issues that are developing in much more real time than waiting for calls to come in and be logged. This would presumably take at least some load off the call center during these events while still receiving information from the public.*

While the validity of all on-line reporting can be questioned, the likelihood is most cases will be legitimate. Follow-up calls could always occur to validate issues, particularly those that may be identified as critical. This would likely be preferred by customers to avoid waiting on hold to talk to someone. Even calls aren't always legitimate as highlighted during the event of customers saying whatever they needed to in order to get in communication with someone on the status of their issue.

Consideration should also be given to make outage information in some fashion available for customers to see. First it provides transparency that the issue has been received when they can see their outage on a publicly available map. Second, it could show the total outages in an area and would provide additional feedback to customers that an issue is widespread and thus may not be worth calling. This developed largely organically through social media like Next Door as customers were communicating with each other on status. Similar functions are available and utilized by other utilities.

9.1.4 Interactive Voice Response (IVR)

When customers call the main SAWS number, an automated recording (English and Spanish) helps direct calls to the appropriate department. The IVR was updated multiple times through the event to help reduce the call volume (such as indicating to customers that they would not respond to notifications of not having water service) and to direct people to the website if possible to review outage maps or boil notices.

9.1.5 Communication between Call Center & EOC Staff

As noted with call center staff largely working from home and not in a common area, it was challenging to update all on the current status and messaging for responding to customer calls. The use of [redacted] was helpful to provide staff the current messaging to discuss with customers. It was also helpful in that customers are many times the first to see any issue and thus provided some indication or validation of how issues were progressing through the system.

9.1.6 Live Chat & Email

The Call Center utilizes a live chat feature on the website as an alternative means for customers to communicate. This function was disabled on Tuesday (16th) to allow all staff to focus on answering calls.

Additionally, customers can email the call center with issues. Due to the high volume of emails, additional staff including customer service management were assigned to respond to emails.

Observations

Further evaluation is recommended to determine the efficiency or time required in responding for calls, emails, live chat, etc. Chat is function some customers prefer as opposed to a call. This may be a function that should be maintained during a future event.

9.1.7 Repeat Contacts

It was observed that many customers were contacting the call center and other departments multiple times through all available contact options, regardless if their issue aligned with that group. This led to diverting focus from staff in those departments along with duplication of efforts.

9.2 WATER METERING

9.2.1 Meter Reading

Once the forecast showed pending weather, the meter reading staff began accelerating reads for the week leading up to the event including the weekend before. Most of the crews drive light weight vehicles so would not be conducive for travelling in slick conditions along with the safety challenges for walking and avoid slips and trips. Additionally, meter boxes are difficult to locate under snow.

Meter reading was paused early in the week but resumed in full force and crews by Wednesday. Meter reading was fully caught up and back to the normal read cycle within a week following the freeze event.

9.2.2 Emergency Shutoffs

As temperatures dropped, residential piping within the customer's homes began to freeze and break causing leaks and damage within the homes. Many times, the customer does not have an isolation valve on their side of the meter, particularly with older homes, and thus the only way to isolate is to contact SAWS to request an emergency shutoff at the curb stop.

These calls started on Monday and quickly became inundated with the quantity of requests. The normal process is a service request is created and a meter technician responds to the address to determine the leak location. Meter technician crews got a late start on this activity due to the road conditions on Monday. By mid-week nearly all available staff within the department (other than meter readers) was assigned to emergency shutoffs along with support from several other departments to try and keep up with the incoming requests. Shutoffs were being completed on a 24-hour schedule to try and contain the leaks and reduce the overall demand on the system.

To assist in reducing the volume of calls, SAWS developed a video and posted on their website that showed customers how to shut off their own water if they were experiencing a leak. This video was viewed over 30,000 times and was generally considered positive but there were several hundred cases of the customer damaging the valve or service connection by turning the wrong way or just due to the age, thus causing additional issues.

Even nearly a month after the initial freeze event, a backlog of service requests are still in queue due to the number of leaks that continue to be found by customers that require shutoff or valve repair.

Observations

Training customers to shut their own service was a practical and necessary approach in reducing the number of staff needed to respond to issues and to more quickly slow the leaks in the system.

Support from other departments in assisting in performing emergency shut-offs was another good example of staff working across department lines. Further consideration should be given to cross-training other staff to be ready earlier and in standby to assist in performing shut-offs during emergency events.

9.2.3 Service Re-Start

A lingering challenge for the group is that all the shutoffs that were conducted eventually must be re-opened once the plumbing repairs were completed by the homeowner. This is anticipated to continue for some time while repairs are conducted.

9.2.4 Material & Parts Availability

The record number of repairs required a lot of materials to be used. Fortunately, SAWS does keep stock of spare parts in supply [redacted] around the City and generally did not impact anything during this event.

9.2.5 Advanced Metering Infrastructure (AMI)

SAWS is currently piloting new AMI systems (ConnectH2O) at select locations within the distribution system that can provide real time data on usage and local pressure. This technology will be useful in evaluating system conditions in similar situations in the future. However, the network utilizes [redacted] so with an extensive outage as experienced in this event could lend to issues in receiving this real-time data.

Observations

As highlighted previously, the implementation of an AMI system, even just on a limited but widely distributed rollout or at critical customer locations could greatly enhance real-time data on system status that was either unavailable during this event or required significant manpower to obtain readings (hydrant pressure readings). Further evaluation on the reliability of data feedback during an extensive outage is warranted.

9.3 GENERAL COMMUNICATIONS

The Communications department was responsible for developing and conveying updates to customers and the general public on the status of the emergency events. Standard messaging has been established for typical emergency situations including a freeze event. However, the uniqueness of this situation with how quickly the situation deteriorated and widespread the issues became presented a challenging situation to provide accurate and current updates to the public on the status of issues. This required multiple revisions and updating of the message to provide the most current information available.

One initial challenge was obtaining information from Production staff on the status of the system as they were focused on resolving the onslaught of continuous new issues that it was difficult to obtain or understand the gravity of the situation. On Tuesday (16th) morning regular meetings were established with production leads which helped the public relations team provide a consistent stream of information they could use in messaging to the customers.

Observations

As highlighted previously, a [redacted] to depict the outage areas would have been beneficial for all to understand the magnitude of the issues and in developing responses.

A noted issue was how to provide customer feedback with the uncertainty of events and how quickly the situation was changing. The recommended approach is to provide as much accurate information as possible, even if it is not good news. Customers can usually tolerate honest feedback much better than vague answers or no information at all.

9.4 OUTREACH MEDIUMS UTILIZED

9.4.1 Television and Radio

Public relations staff and executive management began appearances on local radio and television news which quickly resulted in multiple times per day and even hour to catch all the major news cycles and to provide updates as new information became available. More than 30 interviews in both English and Spanish were conducted for the local news stations.

9.4.2 Website

The SAWS website served as a primary hub for distributing information over the course of the freeze event. This was especially critical as many customers were without power but could still access information via cellular phones. Traffic to the website increased tenfold, from typically about 10,000 hits per day to more than 100,000 hits per day during the event. Normal distribution of site traffic is about 50% between mobile phone and desktop computers. During this event phone traffic increased to more than 80%, likely due to residential power outages.

In the week leading up to the event, a notification ribbon was added to the website alerting customers to the pending event and basic precautions to take. By Friday (12th), site developers created a page dedicated to the freeze event. This page provided customers a central location for information that had been released and was updated throughout the week.

Throughout the event, new site tools were developed to help collect and distribute information. Much of it was adapted by repurposing and reformatting other existing tools to address new challenges.

Several of the specific items developed for the website include the following.

9.4.2.1 Outage Maps

SAWS began preparing system outage maps on Tuesday (16th) to help educate staff across all departments on which areas of the system were out of service. These outage maps were updated twice per day at 8:00 AM and 4:00 PM. Due to changes happening so rapidly it was not effective to update them more frequently. These began to be posted on the website as well to help the public understand and to ultimately reduce the number of calls.

9.4.2.2 Boil Water Maps

A boil water notice was issued on Wednesday (17th) due to lack of pressure in large parts of the system. While portions of the system had been sustained, it was determined to be too difficult to accurately convey which areas should be on boil notice and which were not due to the unique pressure zone boundaries and randomness of the outage areas.

SAWS coordinated with TCEQ to lift the boil water notice by pressure zone once pressure was restored to an area and satisfactory water quality results were attained. To avoid confusion on areas that were clear and those still with boil water in effect, SAWS team utilized an existing tool used for main breaks and construction to quickly develop a live map for the website where a customer could input their address to determine the status of the boil water notice.

This feature was posted on Saturday (20th) as the boil water notices began to be rescinded and received thousands of hits within the first hour it was posted. Additional tracking metrics showed most customers who used the tool viewed the map multiple times through the event to obtain status updates.

9.4.2.3 Residential Shutoff Video

As mentioned earlier, the volume of calls received for emergency shutoff service for homes was inundating the call center and EOC. Staff developed a quick video explaining and showing customers how to isolate their service from the curb stop to more quickly isolate leaks within their homes and to alleviate the demand on field crews responding to the requests. This video was viewed more than 30,000 times.

9.4.3 Social Media

SAWS used several social media platforms including Twitter, Facebook, Next Door and Instagram to post general updates throughout the events. and direct customers to the SAWS website for further information. The number of followers SAWS has on each social media platform grew substantially during the winter event as customers desired updates on status. Facebook grew by about 9,000 followers; Twitter grew by more than 5,000; and Instagram grew by more than 1,000. Social media was used to quickly update the public about changes. Social media was also used to share a video instructing homeowner connected to the SAWS system on how to turn off their main water valve if they had a leak. Across all platforms, SAWS made over 200 posts in both English and Spanish.

In the month of February, the SAWS Twitter account had 4.16 million impressions on its posts. The specific tweet on the announcement of the initial boil water notice had 746,000 impressions alone, indicating the minimum number of times people saw the tweet.

On Facebook, SAWS averaged more than 122,000 daily reach (the number of times posts were seen) from February 16-23 with a high of more than 337,000 reach on February 20th alone.

On NextDoor, more than 139,000 people viewed SAWS' 16 posts regarding the winter storm.

9.4.4 Robo Calls

SAWS did implement several robo calls during the event to provide updates and to direct customers to the website for information. The challenge with robo calls was determining many phone numbers were no longer correct and that many people have switched from landlines to cellular phones. SAWS is currently in a program requesting customers to update their contact information as part of the billing process.

COSA and Bexar County do have the capability to provide cellular notifications through a reverse notification system as part of emergency alerts. However, this system was not discussed or used during this event. An additional challenge is the COSA and Bexar County areas have many other service providers than just SAWS.

9.4.5 Email

Another innovative tool implemented was the conservation group had established a database of customer emails over the years through the events and programs they had sponsored along with waste reporting through their website. This database totaled more than 325,000 customers. Emails were sent out to these to provide status updates and to direct customers to the website to obtain the most current information. In addition to status notification, the staff monitored and responded to questions received in these emails throughout the event.

Observations

Staff was dynamic in using all available platforms and used ingenuity in modifying or repurposing components on the fly to be able to push information out to customers. A key modification the team made was changing the Water Waste reporting tool to allow customers to report leaks.

The website served as the hub for all information and critical information like the outage maps and boil water notices. As stated throughout, the development of a live on-line portal, possibly built from the basis of the Water Waste reporting tool, could be a great asset for customers experiencing outages to be able to report. The boil-water notice maps highlighted how successful an on-line tool could be for allowing the public to obtain information on their own.

9.5 CUSTOMER FEEDBACK

Black & Veatch reached out to multiple customers that had been in contact with SAWS during the winter storm event. These customers included Homeowner Associations, school districts, businesses, and residential customers. The following summarizes the primary feedback received so far. Note limited feedback has been provided to date.

Observations

Feedback from some of the large customers indicated it was very difficult to get information during the event and contact through the main line was not successful. They would like to establish a specific point of contact or account manager with SAWS to identify critical customer needs and proactively plan for emergency type events to get direct feedback on service status. The majority of the information received was from watching the news but was not specific to their needs

Large customers also noted the need for additional guidance regarding measures to take after the boil-water notice was lifted was needed for water fountains, cafeteria equipment, etc.

Of the residential customers providing feedback, they noted the best way to receive information is through text message and they feel SAWS should implement such a system.

Consistent customer feedback was received that information regarding water outages should have been better explained and shared with the public sooner.

10.0 Facilities Assessment

The following summarizes the major field system components at the various production and treatment facilities. Documentation of the issues is a compilation of interviews conducted with the various field staffs along with direct assessment during physical site visits.

10.1 PROCESS MECHANICAL

10.1.1 Winterizations

Since the number of freeze events is typically limited, most SAWS sites are outdoors and not designed for extended freeze events. SAWS generally starts their winterization process in October. There is not a set protocol, but the heat tracing and heaters are checked and then insulation is confirmed to be in place on small diameter pipes and appurtenances. Before a pending freeze event, the field staff re-checks the winterization measures to validate functionality.

Figure 6: Broken Instrument, Pipe Leak & Insulated Valve

10.1.2 High Service Pumps

Most high service pumps including vertical turbine and horizontal split case units [redacted] Heat trace and insulation are applied as part of the winterization efforts to bearing or casing seal lube lines and miscellaneous gauges. There were not any noted cases of damage to pump casings due to freezing. Some of the pumps were not operable due to ice in the suction or discharge piping.

10.1.3 Valves & Piping

Some of the exposed small diameter piping 2-inch and less were heat traced and insulated or at least insulated and taped. Exposed valves and piping up to 12-inches were insulated in some areas with carpet padding and poly-wrap. In many cases piping that was protected still froze and broke. PVC and small diameter copper piping were most susceptible to breaking. Most steel and stainless steel tubing fared well with some isolated issues of some compression fittings that pulled apart.

Figure 7: Heat Traced Control Pipe on PRV at Montana Pass PS

Further complicating matters was when lines froze or broke, the insulation, jacketing and heat trace all had to be removed to make the repair or thaw the lines. This is not easily reinstalled and thus many times had to be crudely re-insulated or left exposed.

Any exposed piping on medium sized piping systems (4-inch to 24-inch) was susceptible to freezing and damage if the lines were stagnant. This was most prevalent in the northern portions of the system. Typically, any piping remaining in service operated without issue. Cast or ductile iron bodied valves, fittings, pump housing, etc. were susceptible to freezing and splitting. This was experienced at several facilities that lost power.

Figure 8: Cracked Valve Body at Winwood Pump Station

Observations

- *Small diameter PVC and copper systems are the most susceptible to freeze damage. Steel or stainless steel while not immune to freeze damage are more elastic and recommended for any exterior small diameter instrument or analyzer piping. Costs for materials on new work is negligible in comparison to the remainder of the work.*
- *It is recommended for future facility design to review the amount of exposed sample or instrument piping. Many cases were noted where an excessive amount of sample piping was*

required to connect the device to the source. This results in additional exposure of stagnant pipe, heat trace, etc. Device placement should be located as close as practical to the source.

- *For all medium and larger exposed pipe systems, it is recommended that a tapped connection and valve be added to drain pipe systems that are not in service as a preventative measure before an event or as a protective measure during a loss of utility power. Some areas could have avoided damage if the piping would have been isolated and drained. These connections can be added with costs on the order of several thousand dollars each.*
- *A more detailed evaluation is recommended on whether certain existing and new facilities should be located inside of a building structure. A building requires initial capital investment and associated maintenance cost but does eliminate the need for heat trace or cabinet provision and prolongs the life of coating systems or other devices exposed to the elements. Even during a power loss, a building structure will retain heat for an extended duration and keeps wind off pipe systems that expedite the freezing process. Recent facilities projects have located or re-located electrical equipment into a conditioned building and thus would be some scale factor savings in extending the size of the structure to include the pump and piping systems. Buildings would be more justifiable at pump stations that have medium to smaller diameter pipe systems as these are more susceptible to freezing.*

  Building costs can vary significantly based on many factors including location, size, architecture theme, materials, amenities, etc. Pricing can range from around $150 per square foot for large basic structures to more than $400 per square foot for smaller or architecturally complex facilities. If a building structure is already included as part of new work for say an electrical building, a major economy of scale can be realized by enlarging to enclosing pump facilities. Building costs would need to be evaluated on a case-by-case basis.
- *Alternatively, the need for a building structure is less prudent if the facility can be equipped with backup power. While this doesn't prevent water freezing in stagnant pipe systems, it does allow for systems to remain in service. Generator costs are discussed in Technical Memorandum No. 3.*

10.1.4 Production Wells

Wells use [redacted] Most have [redacted] Some of these were heat traced. Overall, there were limited issues with production wells losing operation or being damaged due to freezing conditions.

10.1.5 Chemical Areas

Heaters were placed inside some of the [redacted] and to ensure the vaporization process is maintained and to prevent any feed lines from freezing. Overall, there was not any significant issues noted with this system.

Some sites utilize [redacted] Some of these sites experienced damage to small diameter PVC softened water piping that ran to outdoor brine tanks. Most of these lines were heat traced and insulated but the lines remain stagnant most of the time and thus likely led to the freezing. [redacted]

Observation

[redacted] *While the brine solution itself will not freeze, the softened water piping to the tanks and fill connections require heat tracing. In most instances the building would not require to be substantially larger to house the tank and the incremental cost of the structure would not be significant. All piping could then be exposed and better facilitate future maintenance or repair.*

10.1.6 Spare Parts

The mechanical group had some parts in stock to make repairs to facilities that sustained damage during the winter event. As noted many parts or fittings were salvaged from other facilities or stockpiles. The group was also able to acquire additional parts from local vendors which helped. There are still several parts that will take weeks to come in with high demands after the storm.

10.2 ELECTRICAL

10.2.1 Standby Generators

Many facilities have standby generators to serve as backup for communications, chemical feed, and in some cases a limited number of the high service pumps. All were fueled before the freeze and they all operated as intended at the facilities that experienced power failures. The primary issue as noted previously was keeping the units fueled while operating.

10.2.2 Heat Tracing Systems

The heat tracing systems are checked annually prior to the winter season starting in October and then again before a predicted freeze event. This is done primarily to verify that they are functioning and that any burned out fuses or tripped breakers are replaced or reset.

Most of the heat trace systems operated as intended during the event. Some locations experienced controllers tripping or burning fuses because of the load and thus had to be bypassed or regularly monitored. In locations that lost power, the heat trace systems were of no operational value and resulted in pipes freezing and being damaged. Even some locations where the heat tracing was believed to be active, the temperatures were so cold or the insulation not adequate that the lines being protected still froze or were damaged.

Observation

Further investigation is warranted on the reliability of existing permanent heat trace systems; particularly those observed to have failures during the event. Locations that experienced tripping or fuse issues are likely caused by a specific problem such as a shorted cable or the heat trace cable length exceeded the load capacity of the controller. Additional controllers may be necessary to distribute the load.

Those locations where it was believed the heat tracing was active and still froze should be further investigated. It is unlikely the heat trace couldn't keep up with the temperatures and is more plausible the heat trace was periodically down due to power loss or there were exposed portions of the pipe. Additional or thicker insulation (say 2" vs 1") would provide a marginal benefit but not likely to change the outcome with or without heat trace.

10.2.3 Motor Protection Relays

Due to poor incoming electrical quality, several of the protective relays within the electrical switchgear would trip. Most of these were due to phase or current imbalances likely due to the extreme load the overall electrical system was experiencing. [redacted] Following the event, all setpoints were re-established to the original conditions.

10.3 INSTRUMENTATION

10.3.1 Winterization

Like the other groups, basic winterization for field instruments included checking the heat tracing systems and adding insulation where necessary. Primary focus was on the pressure and level devices.

10.3.2 Level Transmitters

The pressure style level transmitters used for monitoring levels in storage tanks were among some of the first instruments in the field to freeze. [redacted] These pipe connections are generally heat traced and insulated but in several cases the lines still froze. Since these lines are stagnant and small, even if they were thawed, they would typically re-freeze again within 15-20 minutes if unprotected.

Sometimes when the line froze the diaphragm for the device was damaged and thus required replacement. Approximately 20 of these units were lost across the system. [redacted]

Figure 9: Pressure Style Level Transmitters Heat Traced and Insulated at Winwood GST

10.3.3 Pressure Transmitters and Switches

Pressure transmitters and switches have the same configuration as the level transmitters and similar issues with freezing and diaphragms being damaged occurred. Pumps are equipped with low and high pressure switches and in some cases when they froze, [redacted] These had to be thawed out to read correctly again or had to be overridden to allow equipment to continue operating.

Observation

Pressure and pressure style level transmitters and switches are combined for evaluation herein.

[redacted] *be considered as an alternative to the current standard of pressure style level transmitters as they do not require* [redacted] *susceptible to freezing. However, these devices would need to be* [redacted]

Consideration could also be given where possible to [redacted] *Further this wouldn't address most pump applications which have* [redacted]

At a minimum it is recommended to [redacted] *Further consideration should be given to* [redacted] *This provides a more reliable means of protection than heat tracing and allows the device to be fully exposed if piping leaked or needed replacement. As observed throughout the system, removal of the insulation and jacketing on standard heat trace application creates a secondary issue of having to re-install later.*

The costs of a heated enclosure on an existing system would be dependent on the local availability of electrical service to power the panel heater. It is assumed most can be installed for between $5,000-$10,000 per device. On a new facility the costs would be offset by eliminating heat tracing and insulation.

10.3.4 Flowmeters

Several magnetic flowmeters experienced damage where the pump discharge piping froze and damaged the units.

10.3.5 UPS Systems

The UPS Systems [redacted] generally performed without any failures. The systems are set up [redacted]

Observation

The UPS systems are sized appropriately with [redacted] *It is not feasible to design UPS systems for outage durations experienced with this freeze event.*

The addition of [redacted] *Even if large-scale generators necessary to maintain pump operations* *are not provided, small generators necessary to maintain basic operations could be considered. A small (10kW) permanent generator installed would be on the order of $20,000 to $30,000.*

At a minimum, it is recommended to at least have quick-connect provisions for future facilities to where a portable generator could be implemented in short order. Costs for quick connect provisions are negligible if included in the original design.

10.3.6 SCADA communications

Most of the radio and the broadband communication systems operated throughout the event without issues. [redacted]

[redacted]

Observation

Additional discussion on SCADA related items are discussed in a later section.

10.4 TREATMENT PLANTS (AGUA VISTA AND H2OAKS)

10.4.1 Winterization

The treatment plant operations, mechanics, electrical and instrumentation techs all performed similar preparation activities as the other groups in verifying heat trace systems were functional, adding insulation to exposed small diameter piping, and draining certain portions of the process systems that were not being used.

Additionally, chemical storage was reviewed, and additional deliveries were received in the week leading up to the event.

Observation

Winterization preparations in advance of the event were largely adequate. The specific issues encountered were more a limitation of the equipment. It is recommended to document the specific measures taken into formal SOPs for use during future events.

10.4.2 Production Wells

Production wells for ASR, Local Carrizo and Brackish Groundwater Desalination (BGD) began experiencing freezing issues. Copper tubing froze and split causing the units to be shut down. Some of the exposed valves were frozen in the closed position and could not be open to run the well.

Observation

The BGD wells experienced more issues with the well flush system highlighted below. The other wells fared better provided they remained in operation. Wells that were offline and then started had more challenges in thawing out to make valves operational. It is recommended for future operations to *consider increasing production and running most wells to avoid stagnation and increase likelihood of riding through a freeze event.*

10.4.3 Well Flush Systems

The BGD wells use a flush system [redacted] placed in operation to remove initial turbidity in the supply. The [redacted] As the temperatures dropped the control tubing on the PRVs began to freeze causing the valves to open and discharge thus losing flow to the plant. While crews could thaw them temporarily, they would freeze again and go back to wasting. Additionally, the air releases would freeze open and exhaust. This caused a full outage of the BGD plant at one point.

Observation

The PRVs serving as the flush system have been problematic even without the freeze event and are being considered for replacement [redacted]*. This proposed change would eliminate the exposed control tubing and failure potential. Costs for replacing* [redacted] *would likely range in the $20,000 to $30,000 range and would depend largely on the availability power necessary for the valve actuator. A more detailed analysis of site conditions would be warranted to validate the costs.*

10.4.4 Lime Systems

Water service to the lime systems at both facilities experienced issues with lines freezing and breaking. The systems that were not in service were primarily affected as there was no flow in the pipes. Some of the lime slurry lines to the feedpoints also froze and had to be thawed or replaced with temporary piping to keep in operation.

Observation

At Agua Vista, the standby silo experienced the most issues. Consideration for future events would be to establish an SOP to drain the interior piping systems that are not being used or provide supplemental space heaters to prevent freezing. The lime slurry loop lines could also be drained by disconnecting at the various quick couplers.

At ASR, much of the lime system is exposed outdoors and thus consideration should be given to enclosing the entire lime feed area and heating. This type of structure would be fully customized and would like be several hundred thousand dollars. Consideration may be worth revising the entire lime system layout.

For both facilities, the portions of lime slurry piping that is PVC is most susceptible to freezing and consideration could be given to replacing with continuous spiral tubing that is common in lime slurry applications and is more elastic.

10.4.5 Backflow Preventers

Backflow preventers serving process or chemical areas experienced damaged or exhausted flow. Many of these were heat traced and insulated but still failed.

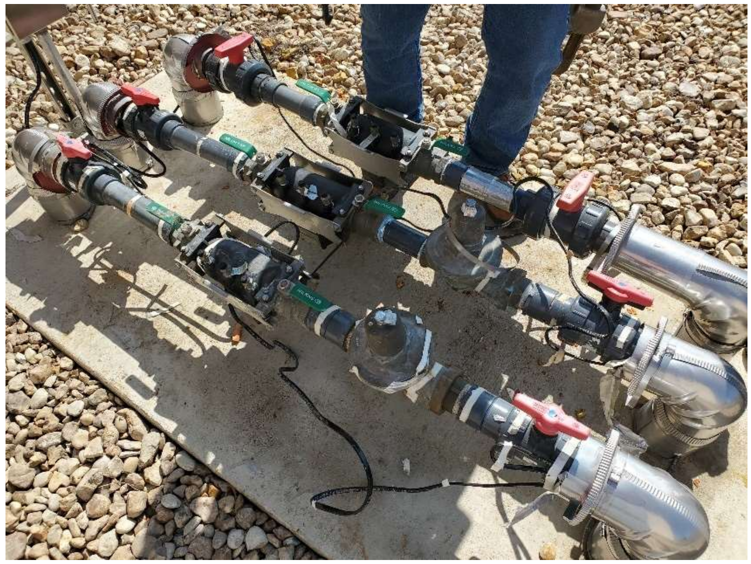


Figure 10: Heat Traced Backflow Preventers at Agua Vista

Observation

Backflow preventers are difficult to heat trace and insulate due the test connections and valves. Further, once the insulation is removed to expose the device it is difficult to reassemble. Future consideration should be given to using heated enclosures instead of heat tracing and insulation for backflow devices. Alternatively, backflow preventers should be considered for location in a process building instead of outdoors as long as adequate drain provisions are in place should a device exhaust. Most enclosures with heaters could be provided for $10,000 - $15,000 depending on the size of enclosure required and the availability of electrical power for heaters.

11.0 SCADA Operations

[redacted]

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12.0 Miscellaneous

12.1 FUEL AND ENERGY MANAGEMENT

12.1.1 CPS Electrical Contracts

SAWS contracts electrical service for each facility individually through CPS Energy. Currently there are no contracts terms or premium service options that would allow guaranteed power delivery to SAWS. The contracts are structured with an agreed upon rate for electricity usage and an additional fee for redundant services.

Observations

It may be worth exploring if a guaranteed power option with CPS Energy is possible to ensure any electable outages avoid critical facilities. However, this still does not help during events when transmission is affected.

12.1.2 Redundant Services

Some pump stations and treatment facilities are [redacted] This second option is not feasible or cost prohibitive at many locations as there is not a second substation in close proximity or transmission capabilities from that location. SAWS pays an additional tariff as part of their monthly utility bill where there is full redundancy with a second feed from a separate substation.

These redundant services were not beneficial during this winter event at the stations that did lose power.

Observations

Further evaluation of true redundant service is warranted. As observed, this was not helpful at locations that lost both utility services. The likelihood of benefit would be more useful during a potential ice storm or severe thunderstorm event in which tree limbs took down overhead power lines. Regardless, a life cycle analysis should be conducted to evaluate the tariff paid for this service in comparison to local standby generators. Generators would offer more direct control to SAWS in improving reliability.

12.1.3 Fuel Service

SAWS manages [redacted] fuel service contracts for operations. [redacted]

Before the storm event, all generators and the service centers received fuel deliveries to fill storage as much as possible. As the brownouts began, standby generators had to operate throughout the system. [redacted]

While fuel delivery to the service centers was not interrupted during the event, the supplier for the generators was unable to provide deliveries [redacted] contractual delivery obligation. This required SAWS to dedicate various staff to use fuel tanks in the back of service trucks to deliver small batches to various generators to keep them operational. [redacted] This was especially challenging [redacted] and required numerous deliveries to maintain operations.

Since this service was contracted, [redacted] to deliver large volumes of fuel to make this process more efficient.

The [redacted] However, this facility is currently planned for an upgrade which will include [redacted] to alleviate this issue in future events.

Observations

Despite having guaranteed delivery within 24 hours in the fuel contract, this was not honored and required SAWS staff to make emergency deliveries to maintain operations. Consideration should be given to maintaining a larger central fuel supply [redacted] *along* [redacted] *of fuel deliveries during an emergency event. This would also offer the ability to make larger volume deliveries to sites and requiring less manpower. This would be further warranted if additional diesel generators are added to the system to further support the SAWS system during an emergency event.*

12.2 CURRENT DESIGN STANDARDS

Facilities in San Antonio are not designed for the low and extended temperatures experienced during this recent event. Currently the facilities are designed based on the 2018 International Plumbing Code, adopted by the City of San Antonio. Facilities are to be designed to withstand a 97.5% Winter Design Temperature. In San Antonio, TX this temperature is 30 degrees Fahrenheit, more than 20 degrees above temperatures experienced during this most recent event. As noted, numerous homes, buildings and structures experienced damage due to loss of utility power and freezing.

Observations

It is recommended to have conversations with COSA regarding the current design standards and whether adoption of lower temperature design conditions should be considered. Having this incorporated into the building code could improve design conditions and alleviate some of the issues of residential and commercial customer lines freezing and breaking, and the subsequent impacts on maintaining system operations. Additional design conditions could be considered including hot box enclosures for PRVs or backflow preventers; installing pipe in unheated building chases, etc.

12.3 UTILITY SERVICE AGREEMENT AREA CORRELATION WITH OUTAGES

The City continues to grow outward through new developments. These developments obtain utility service from SAWS through a Utility Service Agreement (USA). These are primarily water service but can also include wastewater. A question that was posed was whether there as a correlation between the recent USAs and the outages during this event. Figure 11 below shows the correlation between the service outages and the USAs for the past 5 years.

Observations

As shown in the graph, USAs are widely distributed throughout the City. While some do fall within the service outage areas, it is difficult to conclusively draw any direct correlation.

It should be noted the far northern areas of the system, primarily north of Loop 410 but especially north of Loop 1604 have little to no groundwater supply. These areas rely on wells from the central portion of the system or from external sources in the north. When these external sources were unavailable during the event and with utility power outages, these were the most difficult to maintain service. Further, these areas are much higher in elevation and rely on several levels of pumping stations to relay water to those areas. Additionally, the pressure zones in these areas are typically much smaller due to the variation in elevation and thus are not as widely networked as the central portions of the system.

Another key observation is the water outage areas are directly correlated to those that lost utility power to the facilities that serves them. As noted, there are locations in established areas inside of Loop 410 that lost utility power and did not have service.

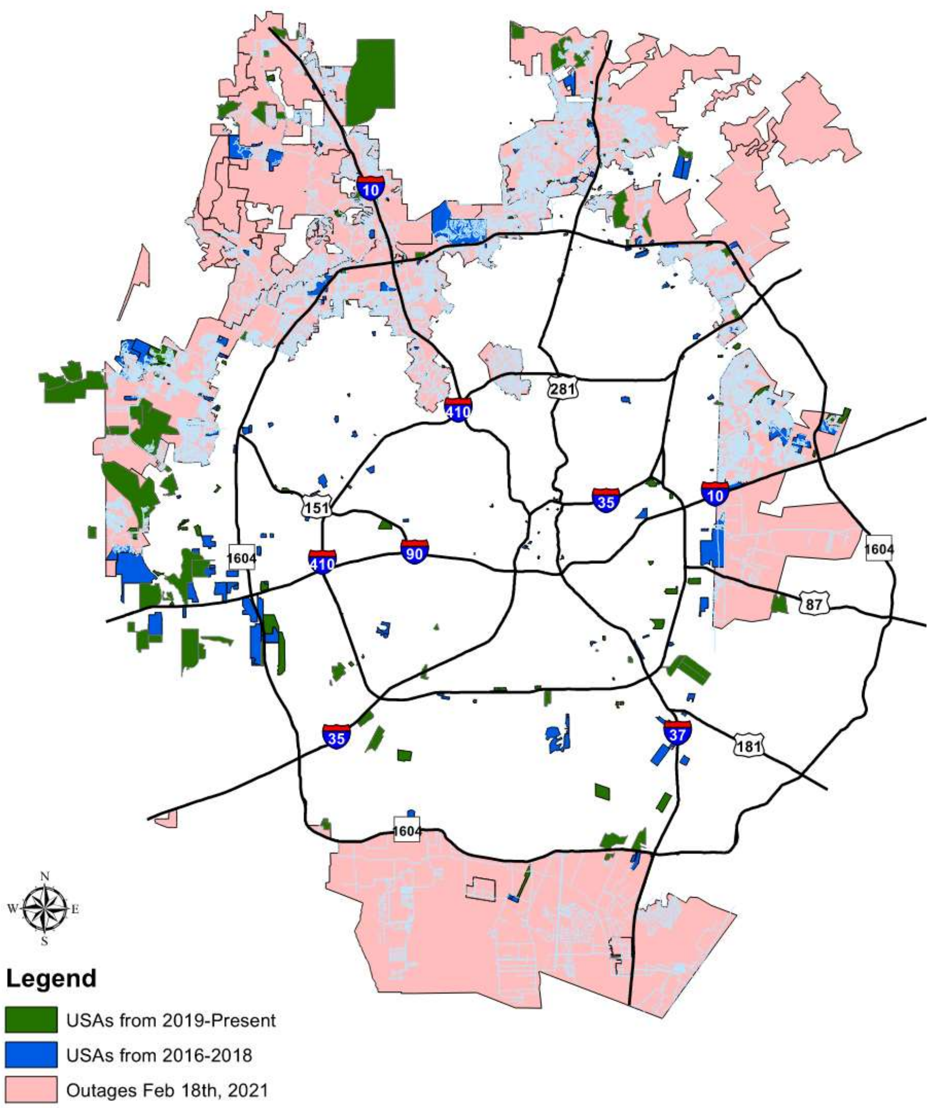

Figure 11: Recent Utility Service Agreements & Water Outage Map

FINAL

INDEPENDENT EMERGENCY PERFORMANCE ASSESSMENT

Technical Memorandum No. 2

Previous Risk & Resilience Reports Summary and Assessment

B&V PROJECT NO. 408362

Prepared for

San Antonio Water System

23 APRIL 2021

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Building a world of difference.

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1.0 Background

The San Antonio Water System (SAWS) experienced an extended winter storm event in combination with utility power outages in February 2021 that resulted in detrimental effects in the ability to produce and distribute potable water throughout its distribution system. SAWS retained Black & Veatch to perform a comprehensive, independent evaluation of system preparations, actions and activities during and following the winter storm event. The purpose of this technical memorandum (TM) is to review previously prepared system evaluations for risk and resiliency and summarize the prior recommendations as they relate to the nature of this recent event.

1.1 SUMMARY OF EVENT

The winter storm event and its effects occurred primarily between February 13th and 21st, 2021. Preparation for the event began one week before its occurrence. This included reviewing schedules to ensure operators were available for the event; checking sites prone to freezing; inspecting heat tracing, pipe insulation, fuel levels, and heaters at various facilities; monitoring National Weather Service updates throughout the week; and activating the SAWS Emergency Operation Center and the City Emergency Operation Center.

Impacts of cold weather began on February 13th, 2021, with tank level sensors and instrumentation, discharge pressure sensors, access roads, various well and high service pumps, and treatment components experiencing damage our outages due to sub-freezing temperatures. Inconsistent or complete loss of utility power at facilities began shortly thereafter, resulting in extended service outages for portions of the system ultimately resulting in boil-water notices. Operations staff managed the system as much as possible to maintain service to critical customers and locations while attempting restoration activities when power was available. As power was restored the system was ultimately brought fully back on-line and began lifting boil-water notices by pressure zone.

A detailed description of this winter event and the specific challenges encountered can be found in Technical Memorandum No. 1 – Cold Weather Event Overview.

1.2 OVERVIEW OF AWIA REQUIREMENTS

In October 2018, the America's Water Infrastructure Act of 2018 (AWIA) was signed into law and included several amendments to the Safe Drinking Water Act (SDWA). Section 2013 of this act requires community water systems serving more than 3,300 people to conduct a Risk and Resilience Assessment (RRA), prepare or revise an Emergency Response Plan (ERP), and to certify completion of these documents to the U.S. Environmental Protection Agency (EPA). These documents need to be updated every five years. The following subsections provide an overview of AWIA requirements.

1.2.1 Risk & Resilience Assessment

AWIA Section 2013 entitled "Community water system risk and resilience" broadened the risk assessment focus from "terrorism and intentional attacks" to "malevolent acts and natural hazards". AWIA Section 2013 requires the RRA to cover the following key aspects:

- Risks to the system from malevolent acts and natural hazards;

- Resilience of all physical assets from source water to distribution system and (security of) electronic, computer and automated systems:
  - pipes and constructed conveyances,
  - physical barriers,
  - source water,
  - raw water collection and intake,
  - pretreatment,
  - treatment,
  - storage and distribution facilities, and
  - electronic, computer, or other automated systems (including the security of such systems);
- Monitoring practices;
- Financial infrastructure of the system (security of business systems, billing, accounting);
- The operation and maintenance of the system;
- The use, storage, or handling of various chemicals by the system; and
- Evaluation of capital and operational needs (if needed).

The EPA does not require use of specific standards, methods or tools for completing RRAs; however, it has recommended the use of available standards including the American Water Works Association (AWWA) Risk Analysis and Management for Critical Asset Protection (RAMCAP©) Standard for Risk and Resilience Management of Water and Wastewater Systems (J100-10). The J100 standard includes a seven-step process for data collection, analysis, and decision-making to understand and manage critical assets. The J100 seven-step process for Risk Analysis and Management for Critical Asset Protection is shown in Figure 1.

Figure 1 AWWA J100 Seven-Step Process for Risk Analysis and Management for Critical Asset Protection

1.2.2 Emergency Response Planning

Emergency preparedness planning is made up of a variety of plans that work together to guide the utility through extraordinary events. AWIA Section 2013 requires development or update of an ERP that incorporates findings of the RRA to include the following components:

- Strategies and resources to improve the resilience of the system, including the physical security and cybersecurity of the system.
- Plans and procedures that can be implemented, and identification of equipment that can be utilized, in the event of a malevolent act or natural hazard that threatens the ability of the community water system to deliver safe drinking water.
- Actions, procedures, and equipment which can obviate or significantly lessen the impact of a malevolent act or natural hazard on the public health and the safety and supply of drinking water provided to communities and individuals, including the development of alternative source water options, relocation of water intakes, and construction of flood protection barriers.
- Strategies that can be used to aid in the detection of malevolent acts or natural hazards that threaten the security or resilience of the system.

The community water system is also required "to the extent possible coordinate with local emergency planning committees (established under the Emergency Planning and Community Right-To-Know Act of 1986) when preparing or revising an assessment or emergency response plan under the AWIA. Further, systems must maintain a copy of the assessment and emergency response plan for five years after certifying the plan to the EPA."

The AWWA G440-27 Emergency Preparedness Practices Standard and M19 Emergency Planning for Water and Wastewater Utilities Manual provides an all-hazards approach for principles, practices, and guidelines in water utility emergency planning. M19 approach is aimed to assist utilities with responding to emergencies, restoring normal operations, and minimizing disruption of critical lifeline services. Figure 2 below illustrates the emergency planning process per AWWA Manual for Emergency Planning for Water and Wastewater Utilities (M19).

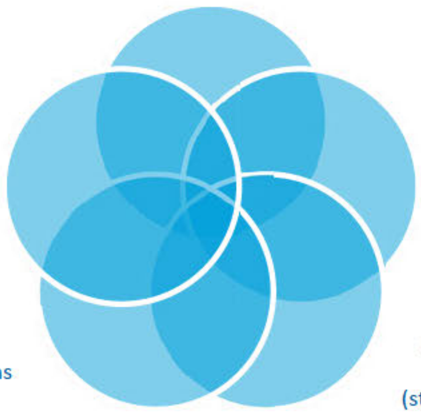

Figure 2 AWWA M19 Emergency Planning Approach for Water and Wastewater Utilities

1.2.3 Guidance and References

The following are the relevant guidance and references for the completion of AWIA community water system risk and resilience requirements:

- America's Water Infrastructure Act of 2018, Section 2013
- EPA Community Water System Emergency Response Plan template and Instructions EPA 816-B-19-003, EPA Office of Water (4608T), July 2018
- Drinking Water Advisory Communication Toolbox, EPA and CDC, July 6, 2020, https://www.cdc.gov/healthywater/emergency/dwa-comm-toolbox/index.html
- AWWA, American National Standards Institute (ANSI), AWWA Management Standard, ANSI/AWWA G 440-17, Emergency Preparedness Practices G440 -17G440-17, August 2017
- FEMA, National Response Framework, https://www.fema.gov/national-planning-frameworks
- AWWA Emergency Planning for Water and Wastewater Utilities, 5th Edition. Manual for Water Supply Practices M19, 2018

- EPA Response Protocol Toolbox: Planning for and Responding to Drinking Water Contamination Threats and Incidents, August 2004
- Emergency Management Planner's Guide and Project Plan, the Planner's Toolkit, Texas Division of Emergency Management Preparedness Section, February 2015, Updated December 2017
- Texas Administrative Code 30 TAC §290.47(g)
- Business Continuity Planning for Water Utilities: Guidance Document, jointly sponsored by: Water Research Foundation; U.S. Environmental Protection Agency, and American Water Works Association
- EPA Incident Action Checklist-Extreme Cold and Winter Cold, Office of Water (4608-T) EPA 817-F-15-003 January 2015
- Homeland Security Presidential Directive 5, Department of Homeland Security, https://www.dhs.gov/publication/homeland-security-presidential-directive-5: Created Date: February 28, 2003, Last Published Date: April 29, 2019,

2.0 Prior Studies

B&V reviewed the following documents by as part of this evaluation:

- Hazard Identification, Risk Assessment (HIRA), and Consequence Analysis for the City of San Antonio and Bexar County, Office of Emergency Management, March 1, 2014.
- Hazard Mitigation Plan for the City of San Antonio, H2O Partners, Inc, Austin, TX, December 2015.
- Risk & Resilience Assessment (RRA) for SAWS, ARCADIS, San Antonio, TX, November 2020.
- Emergency Response Plan (ERP) for SAWS, ARCADIS, San Antonio, TX, August 2020.
- Business Continuity Plan (BCP) for SAWS, ARCADIS, San Antonio, TX, December 2020.

Summaries of these documents are provided in subsequent sections.

2.1 HIRA AND CONSEQUENCE ANALYSIS

This analysis was developed for the City of San Antonio and Bexar County in 2014. HIRA and Consequence Analysis was considered the first step in evaluating natural and technological hazards. HIRA was intended to serve as the basis for the development of plans, public education programs, and responder training and exercises. It was also developed to support mitigation efforts to minimize 13 identified potential threats. These 13 threats are listed in Figure 3.

The HIRA and Consequence Analysis considered winter storm and extreme cold events as significant as they are included in the State Plan and the Alamo Area Council of Government's (AACOG) Regional Multi-Hazard Mitigation Plan, signifying a substantial threat. Section 3.13 of the report covers winter storm and extreme cold events. The analysis predicted winter storm events could last between a few hours to several days. Expected potential consequences included immobilization of a region, closing of transportation routes, disruption of emergency services and supplies, loss of power, and structural damage.

The analysis relied on historical winter storm events from 1996 to 2011 gathered from the National Oceanic and Atmospheric Administration's (NOAA) National Climate Data Center (NCDC) to determine the risks from this hazard. In this time frame, there were eight total events with two causing property and crop damage (1996 and 1997). Descriptions were given on the 2000, 2001, 2007, and 2011 occurrences. In 2000, there were downed power lines and overpass and bridge closures. In 2001, there were traffic accidents. In 2007, there were flight cancellations, highway closures, and scattered power outages. In 2011, there were road closures and traffic accidents.

The analysis of this hazard considered the reoccurrence rate to be moderate; the population of the County to be vulnerable; the overhead circuits (approximately 57% of total circuits) to be vulnerable; the possibility of water mains and water pipes freezing; trees and agricultural crops to be vulnerable; and City and County operations to be vulnerable due to road closures and loss of power and/or communications. The analysis prioritized this hazard as a moderate risk. Figure 3 below shows the results of risk ranking from this analysis.

Table 4.1 Hazard Risk Ranking, San Antonio/Bexar County

Hazard	Risk
Flood	High
Wildfire	High
Drought	High
Extreme Heat	Moderate
Extreme Wind	Moderate
Hail	Moderate
Hazardous Materials	Moderate
Infectious Disease	Moderate
Pipeline Failure	Moderate
Terrorism	Moderate
Tornado	Moderate
Winter Storm and Extreme Cold	Moderate
Dam Failure	Low

(Source: *San Antonio Office of Emergency Management*)

Figure 3 HIRA Hazard Risk Ranking

Observations

While this assessment identified the potential of a winter storm and extreme cold event, the selected risk level of moderate, at least associated with the most recent event was underestimated.

2.2 HAZARD MITIGATION PLAN

This plan was developed in 2015 for the City of San Antonio by H2O Partners, Inc. The plan was created to allow the planning team members to evaluate successful mitigation actions and explore opportunities to avoid future disaster loss. The 13 hazards described in the HIRA and Consequence Analysis were considered to develop mitigation projects with the goal of minimizing or eliminating long-term risk to human life and property, and identifying and implementing cost-effective mitigation actions.

Section 13 of the Hazard Mitigation Plan covers winter storm events. It predicts winter storms to occur every two years and that past records show that extreme cold events could last between 1 and 10 days. The plan recommends, *"Based on historical data for the City of San Antonio area, the average event to mitigate would be a mild to moderate winter storm. The City can expect anywhere between 0.1 to 3.0 inches of ice and snow during a winter storm event and temperatures between 30°F and 50°F with winds ranging from zero to 15 mph."* Expected consequences include power outages, rolling blackouts, utility outages due to ice and freezing temperatures, loss of access or damage to files hindering business capabilities, hindered access due to icy or snow covered roads, structure damage, and personnel safety risk.

The plan relied on historical winter storm events from 1996 to 2014 gathered from NOAA's NCDC to determine the ranking of this hazard. In this time frame, there were 12 events with one causing a fatality (2007) and two causing property and crop damage (1996 and 1997). The plan considered winter storm hazard to have a highly likely frequency of occurrence (once every two years) with a minor potential severity (approximate annual loss of $213,510), giving it an overall moderate ranking. Figure 4 below shows the results of hazard rankings from this plan.

HAZARD	FREQUENCY OF OCCURENCE	POTENTIAL SEVERITY	RANKING
Hail	Highly Likely	Minor	Moderate
Hazardous Materials	Highly Likely	Major	Moderate
Infectious Disease	Likely	Major	Moderate
Pipeline Failure	Likely	Major	Moderate
Terrorism	Unlikely	Major	Moderate
Tornado	Highly Likely	Major	Moderate
Winter Storm	Highly Likely	Minor	Moderate
Dam Failure	Unlikely	Substantial	Low

Figure 4 Hazard Mitigation Plan Hazard Ranking

The plan offers several mitigation actions to reduce the risk associated with winter storms. Most relevant actions with respect to water supply are listed below, along, with their proposed implementation schedules:

- Purchase generators for secondary emergency backup power with enough power to enable full use of the primary pump stations that provide water to the City's critical facilities i.e., fire departments, fire hydrants, hospitals, medical offices, schools, universities, numerous high value commercial customers, large residential apartment complexes and homeowners.
  - 2015 – 2020
- Install quick connect systems at all primary pump stations identified as essential to provide water to the city's critical facilities.
  - 2015 – 2016

Observations

While this report identified the likelihood of a winter storm event, it underestimated the impact severity, at least associated with the most recent event. The cost impacts are associated with all City services, not just potable water delivery and thus are much more significant than projected.

This report did recommend the addition of backup power to enable full use of all primary pump stations. A separate analysis is being conducted as part of this current assessment to better conceptualize the required backup power capacity and preliminary costs necessary to incorporate this recommendation. It *is not recommended to have backup power to enable full use of the facility but rather just the backup power required to meet the target demand conditions.*

Further discussions between the City, CPS and SAWS, are recommended to discuss the reliability of the electrical system and delivery during potential future events to determine if the costs associated with backup power is the optimal solution or if other improvements to the electrical system would be more cost effective.

2.3 RISK & RESILIENCE ASSESSMENT

The following sections review the organization and components of SAWS' RRA completed in 2020.

2.3.1 Methodology Used

The RRA was developed in November 2020 by Arcadis US, Inc., to satisfy AWIA requirements. It uses the J100 7-step process described earlier in this TM. The 7-step process was supported by four workshops to present and review results. The RRA concluded with five high-risk level threats, which led to 14 proposed mitigation initiatives. These are described in more detail in subsequent sections.

2.3.2 Threat Characterization

This step included consideration of malevolent threats; natural hazards (potential surrounding threats to a given asset); and dependency hazards (supply chain or service interruptions). Threats were identified in workshops based on subject matter expertise, emergency management hazard mitigation planning efforts, Planning Team historical and emerging threat data, and institutional knowledge. Appendix C provides a complete list of threat considered.

2.3.2.1 Natural Hazard Threats

The assessment provided a list of potential hazards which were vetted by SAWS based on historical experience, J100-10 methodology, and information provided in the HIRA and Hazard Mitigation Action Plan, described above. Regional hazards were considered with respect to potential utility and water system impacts historically and situationally. It was noted that system redundancy and asset locations were such that significant water system impacts were not associated with two high-risk hazards: flood and wildfire. The following natural hazards were identified for analysis:

- Drought,
- Pandemic,
- Accidental Contamination (finished water),
- Accidental Contamination (source water), and
- Accidental Break (pipes).

Winter storm events/ice storms were not included in the list of identified hazards for analysis. The report indicated that SAWS *"is not prepared for winter storms and ice can prevent employees from accessing critical facilities. However, the issue is expected to persist for a couple of days and should not impact the mission."* This conclusion contributed to winter storms being excluded from detailed assessment. This issue and available information on winter storms are further discussed in the Threat Likelihood Analysis Section below.

The accidental pipe break hazard included accidental breaks due to construction excavation activities and aging infrastructure, but not breaks associated with cold weather and freezing.

Observations

Due to the assessed low likelihood and determination that a multi-day event would not impact the utility mission, winter storm events were not included in the risk analysis portion of the RRA. On its own, this assessment is reasonable demonstrated by the utility's ability to operate through the initial days of the event. However, coupled with a parallel hazard in loss of utility power, the affects were exacerbated.

2.3.2.2 Dependency Hazard Threats

Three dependency hazards were considered based on SAWS supply chain, including services, products, equipment, spare parts, and key employees. The following hazards were identified for analysis:

- Loss of Power,
- Loss of Salt, and
- Loss of Employees.

It categorized a power loss event as, "*an isolated incident impacting a single facility, a localized incident impacting two or more facilities in the same area, or a widespread event impacting significant portions of the water system service area.*" Power outages were attributed to rain, wind, lightning, broken tree limbs, vehicle accidents, and wildlife, with more significant power outages being caused by extreme flood events. The RRA did not consider winter storm events to be associated with power outages, although it was stated icing can contribute to broken tree limbs and loss of power.

The assessment indicated that due to an independent and redundant state-wide power grid managed by the Electric Reliability Council of Texas (ERCOT), widespread power outages associated with the North American power grid would not impact the State of Texas power reliability. However, impacts within and originating in the ERCOT power grid were not discussed.

The anticipated worst reasonable case scenario was considered to be a power loss event lasting multiple days, five days longer than current system storage capacity, that impacted two or more pump stations. The report indicated that the water storage system capacity is sufficient to supply water for up to two days and groundwater well production is power dependent.

The assessment categorized a 'loss of employees' threat as the loss of employees due to retirement. Loss of staff due to transportation or access limitations was not considered.

Observations

Power loss likelihood was underestimated, with a significant event to occur only once every 50 years. This may be due to an overstatement of the reliability and resilience offered by the power grid and CPS. Although it is outside the responsibility of SAWS, the cold weather events in 2011 revealed significant vulnerabilities in the power grid, which should have been considered more thoroughly in the RRA. It is recommended that power loss considerations be re-assessed jointly between the City, CPS and SAWS, to better define the risk moving forward and to establish mitigation strategies.

2.3.3 Threat Likelihood Analysis

Because winter storm events were not chosen for analysis, a formal threat likelihood analysis was not completed. A preliminary likelihood was determined using the NOAA Storm Event Database. It was indicated that the latest winter storm event available was in 1996, despite NOAA NCDC containing nine winter storm events between 1997 and 2018, the majority of which were included in the HIRA and Hazard Mitigation Plan. There were also 11 winter weather events listed on NOAA NCDC between 2008 and February 2020.

According to NOAA, a winter storm *"has more than one significant hazard (i.e., heavy snow and blowing snow; snow and ice; snow and sleet; sleet and ice; or snow, sleet and ice) and meets or exceeds locally/regionally defined 12 and/or 24-hour warning criteria for at least one of the precipitation elements. Normally, a Winter Storm would pose a threat to life or property."* Winter weather is an *"event that causes a death, injury, or a significant impact to commerce or transportation, but does not meet locally/regionally defined warning criteria. A Winter Weather event could result from one or more winter precipitation types (snow, or blowing/drifting snow, or freezing rain/drizzle). The Winter Weather event can also be used to document out-of-season and other unusual or rare occurrences of snow, or blowing/drifting snow, or freezing rain/drizzle."*

The assessment used the following formula to calculate likelihood:

$F=E/Y$

where:

F = frequency,
E = number of events, and
Y = years.

Relying on a single event from 24 years ago (1996), the calculation used was F = 0 / 24, or a frequency of 0.00. This calculation did not consider the frequency of events prior to 1996, nor the events that the NOAA NCDC database indicated occurred after 1996. This low frequency estimate further reinforced this hazard's removal from the assessment.

For dependency threats, likelihood was estimated based on GIS database information, historic events, Planning Team institutional knowledge, and best professional judgement. For loss of power, a significant event was estimated to occur once every 50 years, or a 0.02 probability. A justification of this likelihood estimate was not provided.

2.3.4 Risk and Resilience Analysis

The analysis concluded with a total of six threat-asset pairs resulting in a total risk greater than $1,000,000, ranging from $2,000,000 to $7,000,000. Five of the top risks included physical outsider sabotage of chlorine cylinders. Risk and resilience analysis details and results were provided in Appendix H of the RRA report. The top five threats were the following:

1. Physical outsider sabotage (1-ton chlorine gas cylinders);
2. Physical insider assault (active shooter incident);
3. Accidental break of critical pipelines;

4. Drought impacting Edwards aquifer; and
5. Widespread loss of power affecting pump stations.

The loss of power threats accounted for the 10th through 13th, 20th, and 23rd highest threats by total risk ($ Millions). The risks calculated for power loss at a single critical facility were highest (above $500,000) at [redacted]:

[redacted]

[redacted]

[redacted]

[redacted]

- [redacted]
    - [redacted]
    - [redacted]
    - [redacted]
- [redacted]
    - [redacted]
    - [redacted]
    - [redacted]
    - [redacted]

Observations

[redacted]

[redacted]

[redacted]

2.3.5 Risk and Resilience Management

Several mitigation initiatives were recommended to reduce the risk associated with loss of power. This included an existing mitigation initiative of coordinating with CPS Energy to prioritize SAWS operations in a power loss event. The others are listed below with their financial investment level and magnitude of benefit.

- Develop an [redacted] with accessible/ formally documented procedures, policies, plans, and asset information. This would include procedures that are known but not formally captured.
  - Financial Investment: Low
  - Magnitude of Benefit: High
- Coordination with CPS Energy on distributed power (cogeneration / natural gas).
  - Financial Investment: Very High
  - Magnitude of Benefit: High

An implementation plan to select and prioritize the mitigation initiatives was not completed. The AWIA requirements make a reference to the evaluation of capital and operational needs for risk and resilience management, however this is not stated as a strict requirement. It is left to each water system to determine the appropriate risk mitigation through improvements which may be in additional redundancy, asset resistance/hardening, asset reliability and response/recovery capabilities.

Observations

An implementation plan to select and prioritize risk mitigation initiatives was not completed. The AWIA requirements make a reference to the evaluation of capital and operational needs for risk and resilience management, however this is not stated as a strict requirement. It is left to each water system to *determine the appropriate risk mitigation through improvements which may be in additional redundancy, asset resistance/hardening, asset reliability and response/recovery capabilities. In our experience many water systems focus on response/recovery capabilities which should be the last line of defense relative to improvements in system resistance, redundancy and reliability.*

SAWS should define its target level of resilience for disruptive events and emergency conditions, such as being able to meet maximum day demand. This should be used as the basis for consequence criteria and risk analysis, considering all hazards that have the potential to impact the delivery of the target level of service. This approach would set the stage for identifying and prioritizing potential risk mitigation improvements such as emergency backup power in critical facilities, asset hardening, additional redundancy and contingency planning.

SAWS should ensure that all threats identified in the RRA should be reflected in the Emergency Response Plan, with appropriate detection strategies, incident specific response procedures and recovery plans.

Regarding the recommendation to implement [redacted] *with documented procedures, policies, etc; this would have been a useful tool during the most recent event and is recommended to be formally adopted moving forward.*

Regarding the recommendation about distributed power, this is recommended to be considered as part of a comprehensive evaluation between the City, CPS and SAWS, regarding the overall reliability of the electrical system and where the best value can be obtained for all stakeholders.

2.4 EMERGENCY RESPONSE PLAN

The following sections summarize the organization and incident specific response procedures of the SAWS ERP.

2.4.1 Organization of the ERP

The ERP contains the information management needs to guide SAWS through an emergency event at multiple levels. The content of the document includes the following sections:

0. Document Information describes how the plan was developed and update information.
1. Introduction includes the purpose, scope, assumptions and document management.
2. Overview of Facilities includes an overview of the system
3. Concept of Operations describes organizational and control.
4. Internal and External Communications and Reporting this includes communication protocols.
5. Emergency Resources includes internal and external resources.
6. Administration, Finance, and Procurement describes procurement, fund management, tracking and reimbursement.
7. Recovery section supports recovery activities and resources, and after-action reviews.
8. Detection Strategies includes strategies to detect emergency situations.

9. Mitigation Actions describes the activities and resources SAWS has available to reduce the impact of an incident.
10. Training and Exercise Program outlines the training and exercises to be conducted to provide participant competency.
11. Appendices contain details needed for response and include contact lists and notification procedures, facility information and maps and diagrams, equipment and resources, ICS position guides, ICS and SAWS forms, and Incident Specific Response Procedures.

Section 4.0 Concept of Operations describes SAWS's organizational structure during an emergency and defines the roles, responsibilities, emergency operations center, and direction and control. SAWS uses Federal Emergency Management Agency's (FEMA) incident command system (ICS) as the organizational structure for emergency response. Additionally, the utility uses the forms provided by FEMA for planning and recordkeeping. The ICS structure is recommended by AWWA G440 and Homeland Security Presidential Directive 5. ICS aligns the utility organization with other government agencies and provides flexibility to expand and retract as needed to meet the requirements of the emergency. It is required to receive federal emergency response and preparedness funding. Roles and responsibilities are described for each position. The person who fills the role of Incident Commander depending on the complexity of the event is defined in Table 3-1. The training required for each role is listed in Section 10.2. The Emergency Action Levels for ERP Activation is outlined in Table 3-2. Extreme weather is a listed criterion for an Emergency Action Level 2- Major Emergency. A Major Emergency suggests:

- Full SAWS ICC activation
- Water Quality Advisory Plan implemented
- Implement SAWS ICS Incident Management Team (IMT) and Coordinate /Notify City and Bexar County Office of Emergency Management
- Notify affected customers Issue Do Not Use, Do Not Drink, or Boil Water Notice
- Restore system operations

However, the plan does allow for the IC to determine the Emergency Action Level.

As the incident develops and expands to a significant disruption of service, the emergency action level action level would rise to Level 1 and require additional activities:

- SAWS ICC activation and manned; use Planning "P" model
- Implement SAWS ICS IMT
- Notify City and Bexar County Office of Emergency Management
- Coordinate with Metro Health
- Coordinate with City Public Information Office
- Activate mutual aid and/or private contracts

Full implementations of the IMT would include the Incident Commander, the Safety Officer, the Liaison Officer, and the Public Information Officer. This group is Command Management. The IC may activate the following Sections as needed: Operations Section Chief, the Planning Section Chief, the Logistics Section Chief, and the Finance/Admin Section Chief. Command Management is responsible for the overall operations, information dissemination, external agency contact, and safety of the responders. Operations Section Chief is responsible for field activities. Logistics Section Chief provides the resources for the response. Planning Section Chief collects data documentation and plans future activities and needs. Finance/Admin Section Chief tracks costs including personnel, accounting, procurement and cost analysis. During large scale responses, resources can be requested from the IMT starting at the City level and progressing up to the State level.

Sustained operations in the ERP is defined as lasting more than 12 hours in the ERP (an operational period). The Incident Commander (IC) determines staffing levels required and recalls the personnel needed. In such event, the IC Commander is to activate the Planning Section, who should work with the Operations Section to develop an Incident Action Plan (IAP) (Section 3.6.2). The IAP consists of multiple FEMA forms.

This incident action plan should be revised as needed through the response. The IAP must be prepared for each operational period and distributed prior to each operations shift briefing according to the ERP. The regular updates address the variety of type, complexity, size and requirements of the response. The level of detail included in the IAP should correspond to the size and complexity of the incident.

Following the ERP, this plan should be prepared and distributed for each operational period. Only if the initial response is readily controlled may an IAP not be necessary. The IAP should be developed to encompass the four major phases of an incident: response, recovery, damage assessment and incident investigation, and termination (including demobilization). The forms are found in Appendix E and on FEMA's website with the link included in the ERP. The forms include instruction for how to complete the forms. Forms are available for operational planning, safety analysis, status summary, resource requests, organization assignments, incident objectives, and others to plan for all phases of the event.

Internal and external communication procedures and resources are outlined in Section 4.0. This includes the use of Dispatch, Incident Management Team (IMT), Public Information Officer (PIO), Media Relations, Liaison Officer, Human Resources, CEO, and Legal. SAWS coordinates with the City EOC (Emergency Operations Center) if the communication systems are not operational. Dispatch can be used for internal communications and can push emergency notification to appropriate personnel. The Liaison Officer is responsible for coordination with external agencies (Section 3.5.3) Section 4 gives coordination of external agency notifications to the Logistics Section Chief. The Senior Operator is responsible for communication with local and state regulatory agencies about drinking water quality issues. Coordination with Local Emergency Planning Committees about hazard chemical response is also discussed. Contact information is included in the Appendices to the ERP.

The Communications Office can establish a Crises Communications Team as needed. The Team is led by the PIO. This teams make notifications and sends out advisories to customers throughout the phases of the response. Pathways the Team can use are listed in Section 4.3.1. Critical customers are to be notified by Customer Services and Plant staff.

The ERP includes emergency resources in Section 6.0. This includes a statement that generators are maintained and tested under regular inspection schedules. An inventory of the generators is included in the appendices. Section 8.6 Power Outage states "*SAWS is considered a critical customer of CPS and receives high priority service in the event of a major power outage*."

Power resilience is discussed in Section 9.4 and as a mitigation strategy, SAWS maintains [redacted] In 2018, an internal memo discusses [redacted]

Observations

This ERP includes documents, including systems maps to guide the planners in developing IAPs for emergency response. Some of those IAPs could be developed in advance focusing on an all hazards approach. For example, how to reroute pressure if it is lost in a particular zone.

Additional coordination between SAWS and various priority vendors is recommended. This would include reviewing the contracts and establishing contingency plans or working with the vendors on strategic service plan. This would include services for power, chemicals, fuel, etc. Some of these items are addressed directly in other chapters of this report.

SAWS ERP should consider a Section for the Operations Section. This should include appendices that guide the maintenance, plant operations, and distribution and collections teams through emergencies.

The Planning Section Chief should have developed incident action plans for each operational period, long range plans, and plans for demobilization. These developed IAPs should be part of the Incident After Action Review process described in Section 7.8.

It is recommended that the after-action review described in Section 7.8 is conducted after every emergency response event, not only those involving chemical releases or large events. This will help to refine the ERP to create a stronger plan. The Section Chiefs should be included in these reviews.

2.4.2 Incident Specific Response Procedures

To aid in preidentified responses, incident specific response procedures (ISRPs) are included in ERP Appendix F. These procedures have been developed for:

- Malevolent Act
- SCADA/Cyber Intrusion
- Water Contamination
- Power Outage
- Transmission Line Break
- Hazardous Material
- Severe Weather
- Tornado
- Flooding

Each of the ISRPs describe the response procedure following the following format:

Figure 5 ISRP Format

Each ISRP contains a flow chart that provides an outline for each response. This categorizes the response and describes the activities that belong to each category. These are still high-level plans. The categories include:

- discovery,
- procedural,
- personnel,
- system operations,
- damage assessment,
- documentation and reporting,
- power, energy, and fuel,
- communication and coordination,
- and continuous assessment or after-action report.

Specific activities would be outlined in the IAP as it is developed. There should be SOPs that are retained in each operational group's programs. The severe weather ISRP includes thunderstorms, hurricanes and tropical storms, high winds, gusts and squalls, and severe winter weather. The activities described are written to include all the severe weather events. Other parts of the ERP apply to the ISRP as well. For example, where the ISRP directs to issue water advisories, Section 4.0 of the ERP describes internal and external communication processes, Section 5.2 contains processes for engaging mutual aid, and Appendix A contains contact lists. Detection strategies and mitigation strategies that apply to a severe weather can be found in Sections 9.0 and 10.0. Having the response pieces for an ISRP in the ERP allows for an all hazards response where procedures are in place to tackle an emergency, even when a full plan has not been developed or as the emergency evolves. This allows the planner to develop the Incident Action Plan quickly as the pieces have been developed in advance.

Observations

The ERP generator lists should include operating capacity for how long a generator can run on a tank of fuel so the Planner can pass the information to Logistics for timely scheduling of fuel delivery.

SAWS should consider breaking the Severe Weather ISRP up into separate events-winter storms, hurricanes, etc. Creating these plans will provide the utility a chance to evaluate whether they have the resources to adequately respond to the different attributes of the types of storms.

Department or team specific incident specific plans for mitigation and response to events can help them focus on quickly responding to an event. For example, many ERPs include department specific plans for hurricanes include pre-storm activities, assembly areas, response activities and damage checksheets, and addresses other department specific needs. These tie back to the utility's ERPs, maintaining communications and organizational structures as required by the ERP. This will help the Planning Section build better plans and receive more timely information since the field staff will already be deployed.

This plan is dated 2020 as a response to 2018 AWIA and meets those requirements. Training on this plan for all levels of staff should occur annually and a review after every major event. Specific roles, such as Logistics Section Chief, should receive training that applies to their position, including the use of the ICS forms. Familiarity with the plan and the forms will ensure a much smoother response during an actual event.

In addition to training for specific roles, it is recommended that SAWS practice emergency scenarios annually. These practices should focus on the most significant emergency events such as severe winter weather, power loss and critical main breaks.

2.5 BUSINESS CONTINUITY PLAN

A BCP is developed so that the utility can continue to deliver essential functions during disruptions to normal operations. SAWS's BCP structure includes:

- Purpose
- Scope
- Water system Description and Emergency Organizational Structure
- Planning Assumptions
- Objectives
- Concept of Operations
- Organization and Assignment of Responsibilities
- Direction, Control, and Coordination
- Disaster Intelligence
- Budgeting and Acquisition of Resources

The BCP is not written for the direction of wastewater or water treatment, distribution, collections, or centralized cooling operations. It assumes that the disaster is recoverable. The BCP considers all levels of preparedness from the organization level to professional planning, to the employees' families. Staff are encouraged to have family plans and provides education related to it. Preparedness activities include training, contact information is updated and available, and exercising employee notification systems. Activation of the BCP includes the decision process, alert and notification procedures, and the relocation process if needed. Professionals are asked to keep a go kit ready to supply their physical needs during extended stays onsite.

The Business Continuity Coordinator is a role that is included in SAWS's ICS structure as part of the Incident Management Team when the BCP is activated by the SAWS CEO or designee. Reporting, recordkeeping, and budgeting are all outlined in the BCP. The essential functions for continuity of operations to focus on are the water source, water treatment operations, and water distribution.

Emergency procurement is in the Procurement Policy (separate from the BCP). Contracts that are vital to support of agency essential functions "*SAWS has ensured contractor statements of work include the provision to provide staffing, services, and resources during emergency conditions*."

Observations

The Business Continuity Plan was generally successful through the event. Most critical operations and field staff were able to respond to the work locations. Additional provisions were put into place including local lodging and food to ensure staff could most effectively serve their roles. There were specific limitations with [redacted]*. Some of this function had been previously defined as non-essential but some of the specific challenges of this event highlighted the need for flow of information on real time activities. It is recommended the BCP is reviewed and updated based on the specific insights gained through this event.*

Emergency procurement limitations specifically related to fuel delivery to engine-generators was a noted failure during the event. It is recommended this contract be reviewed for enforceability on this clause or research alternatives to ensure operation in a separate event [redacted] *local central storage location.*

FINAL

INDEPENDENT EMERGENCY PERFORMANCE ASSESSMENT

Technical Memorandum No. 3

Pressure Zone Evaluation & Confidential Critical Infrastructure Assessment

B&V PROJECT NO. 408362

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San Antonio Water System

23 APRIL 2021

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