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Through its approach to reducing real water losses, a small Texas utility demonstrates how it uses technology, innovation, and smart planning to benefit itself and its customers.

BY JESSICA GREEN AND PAUL GAGLIARDO

SATELLITE DATA COMPLEMENT TRADITIONAL LEAK DETECTION AND REPAIR PROGRAMS

NEW BRAUNFELS, TEXAS, is located in the greater San Antonio area. When the city's water utility, New Braunfels Utilities (NBU), decided to cut its nonrevenue water (NRW) losses in 2014, it embarked on a five-year zone-leak monitoring program using various technologies to conduct a full-system, traditional boots-on-the-ground zone monitoring survey between 2014 and 2018.

In 2018, NBU served a population of 84,200 through 39,060 service connections. An average of 13.3 mgd was supplied to the system, with a net sales volume of 10.9 mgd. This equated to an NRW volume of 2.4 mgd, or 18 percent. As detailed in AWWA's Manual of Water Supply Practices M36, *Water Audits and Loss Control Programs* (www.awwa.org/M36), NRW is defined as the total of real losses, or system leakage; apparent losses, such as meter inaccuracies and unauthorized consumption; and unbilled authorized consumption, such as system flushing and firefighting flows. Total NRW loss is modest, but the cost of producing water is high. Thus, reducing real water losses significantly helps the utility's bottom line.

In 2019, NBU tested a new program using satellite radar remote survey technology to pre-locate likely leaks to determine the technical efficacy and value of this option. To monitor its entire network on an ongoing basis, NBU contracted with Utilis, a San Diego–based company that uses synthetic aperture radar satellite data and a proprietary algorithm to specifically identify areas with soil moisture at a depth underground that often signifies drinking water leaks from pipes. This information was provided to the utility to complement its existing leak detection and repair program.

PHOTOGRAPHS: UTILIS

NBU's planning team (top) reviewed the satellite data and selected pre-localized areas for physical inspection by the leak team (bottom).

TRADITIONAL ZONE MONITORING SURVEY

As shown in Figure 1, NBU's water system consists of 573 miles of water mains and has a service territory of 88 mi^2, located in Comal and Guadalupe counties. As part of its traditional zone monitoring survey, 20 percent of the system mileage was systematically and manually inspected each year. Acoustic loggers were installed in various locations for a week to search for background leaks, acoustic signals were analyzed at each location, and NBU staff was dispatched to find the leaks. The acoustic loggers were then moved to another location, and the process was repeated. This five-year effort yielded 178 leaks, or about 35 leaks per year. One leak was found for every 3.2 miles inspected. Over the course of the program, it was able to identify 0.14 leaks per crew day. A dedicated staff of three full-time line technicians, plus supervisory oversight and planning support, was assigned to this effort.

To use these results to determine the technology's value, a cost-per-leak-found metric was calculated. NBU provided cost and resource information for the 2018 traditional leak detection effort. Sixteen leaks were found in 249 days of inspection. The crew, supervisor, and equipment costs were calculated to be $910 per day on the basis of actual budget figures. NBU had purchased 120 moveable loggers at $1,000 each, for a total logger cost of $120,000. During the five-year program, the annual cost of logger equipment was $24,000. Additionally, the cost of a truck roll and crew, ground microphones, and correlators was budgeted at $28,600 per year. The cost to NBU of finding one leak during 2018 was $14,160 (Table 1).

Table 1. NBU Fiscal Year 2018 Zone Monitoring Analysis

The cost to NBU of finding one leak during 2018 was $14,160.

Parameter	Value
Annual equipment cost	$28,600
Annual logger capital cost	$24,000
Cost per crew day	$910
Crew days per year	249
Annual labor cost	$173,350
Total annual cost	$225,950
Leaks found	16
Cost per leak found	$14,160

SATELLITE PRE-LOCATING PROGRAM

Before executing the satellite pre-locating program, NBU organized and tested the workflow so the utility could analyze the results from a technical and value perspective. The following process was used for four service events:

- Contract to provide four satellite images of the NBU service area, spread throughout the year.
- Inspect all location points of interest provided by the satellite imagery for leaks using NBU staff and traditional handheld acoustic monitoring and correlating equipment within a two-month period (Figure 2).
- Follow best practices of field leak inspection methods.
- Identify and repair all leaks found, calculate leakage rate during repair, and estimate the historical duration of the leak.
- Collect and codify all leak information.

As a result of this rigorous process, data were available to determine the satellite imagery's effectiveness in identifying likely leak locations from space. It was also

Figure 1. NBU's Service Area

NBU's service area covers 88 mi^2, making a satellite-based leak detection program an appealing addition to the utility's traditional leak detection efforts.

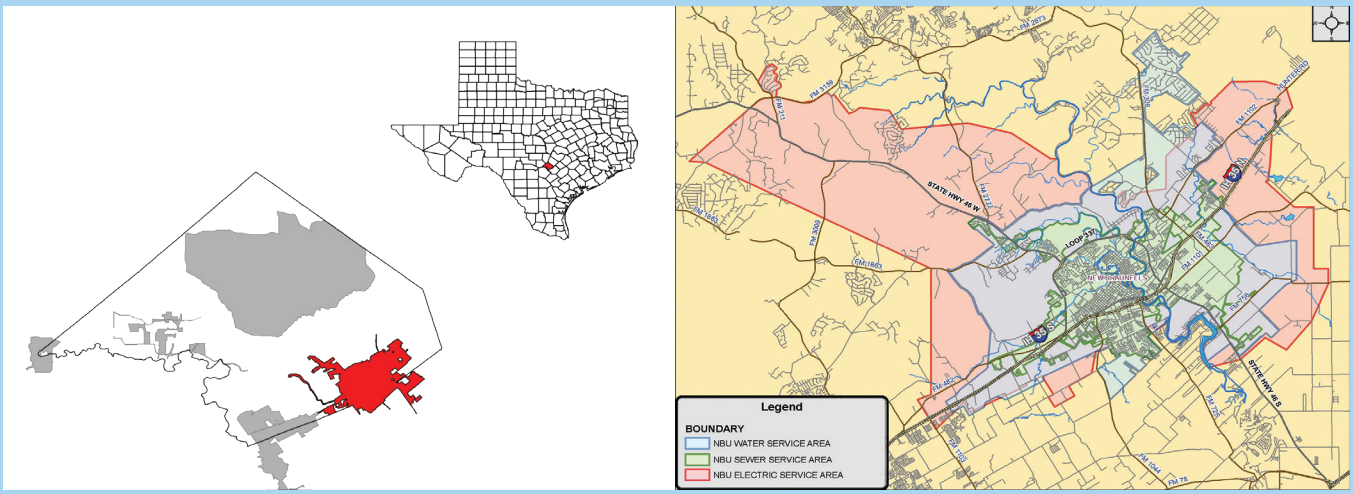

FIGURE 1: WIKIMEDIA COMMONS, NEW BRAUNFELS UTILITIES

Overall, the satellite program in 2019 found 14 times the leaks (229) the traditional program did in 2018 (16).

Table 2. Satellite Imagery Performance Results, Fiscal Year 2019

Data were available to determine satellite imagery's effectiveness in identifying likely leak locations from space.

	Points of Interest	Number of Leaks	Number of Days	Points of Interest Inspected Per Day	Total Miles Inspected	Leaks Per Day	Leaks Per Mile	Miles Inspected Per Day
Total	816	229	56	14.6	176	4.1	1.3	3.1

possible to assess the value and return on investment when using the process to find leaks and reduce NRW. Table 2 shows the performance metrics from the four satellite images and subsequent field leak inspection activities. After collecting and analyzing each of the four satellite images, the maintenance planner directed the leak crew to inspect certain areas identified as likely leak locations. A total of 14 crew days were allocated to conduct field inspection for each of the four images. Crew days are defined as nominal eight-hour work days for the three line technicians.

The primary value performance metric is leaks per crew day found. The more leaks found per day in the field, the better the return on investment of physical and fiscal resources. As can be seen from Table 2, the cumulative service program achieved more than four leaks per day found.

A secondary metric is leaks per mile physically inspected. This shows the technical ability of the satellite imagery to identify likely leak locations and the ability of the field crew to correlate the actual leak location. As shown in Table 2, 1.3 leaks per mile inspected were found during the program.

NBU's cost to find one leak during the satellite program was calculated to be $678. The total cost of service was $155,400, and 229 leaks were found. This assumes the cost for a crew day was $990. Crew costs were calculated on the basis of actual NBU budget allocation of labor and equipment costs. All of the other variables were defined by the actual costs and results. Table 3 contains the key parameters used in these calculations.

Table 4 compares the performance of the legacy program with the satellite pre-location program.

A return-on-investment calculation can be performed to determine the overall value of finding and repairing leaks. The accuracy of this metric relies on calculating the cost to find a leak, the marginal cost of water purchase and production, and the estimation of the size and duration of the leak. The cost of water purchase and production is calculated to be $4.52 per 1,000 gallons.

LEAK ASSESSMENT

There are two main components in determining the value of lost water because of a leak: leak flow rate and leak duration. Both are difficult to accurately define. NBU solved this challenge by determining the leak type when it's uncovered and estimating the leak flow rate when it's repaired. The leaks are classified as customer side or NBU side.

In this study of the satellite pre-location program, the customer-side leaks were estimated to average 0.17 gpm on the basis of the typical size of break and local system pressure. The calculated leak volumes from NBU-side leaks averaged 8.7 gpm. Some of the leaks were easily fixed during the field inspection by tightening fittings on meters or valves. These leaks were set at a zero leak rate.

The NBU-side leaks are either identifiable or unidentifiable. NBU created these definitions to localize the added value of the satellite program to the utility's particular system setting. Unidentifiable leaks are those that are determined impossible to find with traditional methods. These types might be leaks in rural areas, with no connections, that aren't typically visited or leaks occurring in rocky soil, where they're never expected to surface.

Figure 2. Project Dashboard

A dashboard shows points of interest (POI) and field inspection results.

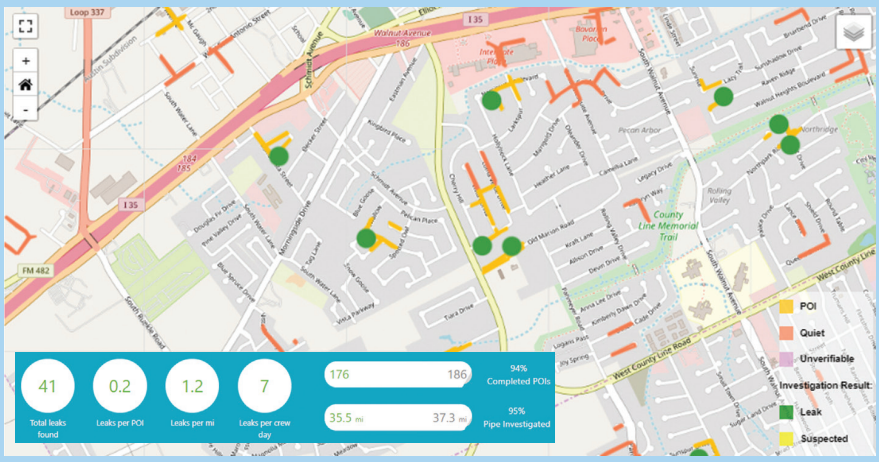

FIGURE 2: UTILIS

Table 3. Satellite Cost Per Leak Found

NBU's cost to find one leak during the satellite program was calculated to be $678.

Parameter	Value
Cost of satellite service	$100,000
Cost of leak crew	$155,400 (56 days at $990)
Number of leaks found	229

Table 4. Performance Comparison

A return-on-investment calculation can be performed to determine the overall value of finding and repairing leaks.

Program Type	Leaks Per Day Found	Leaks Per Mile Inspected	Miles Per Day Inspected
Fiscal Year 2018 NBU traditional	0.06	0.14	0.5
Satellite NBU average	4.1	1.3	3.1

In this study, the leak duration for identifiable leaks was set at 45 days, or 1.5 months, because the satellite surveys and subsequent field inspections were performed quarterly. Therefore, a leak's average duration, if evenly distributed during the three-month period, was half that time. For the unidentifiable leaks, the duration was pegged at 2.5 years, or 30 months. NBU historically could survey and inspect only 20 percent of the full system per year, thus taking five years to inspect the entire system. Therefore, the leak duration was set at half the five years.

To estimate the volume of water loss and thus the value of fixing the leak, the leak flow rate was multiplied by the duration defined by its designation. Of the 229 leaks identified, 128 were customer-side and 101 were NBU-side, with 36 of those deemed unidentifiable. Of the 229 leaks, 143 were deemed to have a quantifiable leak flow rate. Altogether, it was calculated that total water loss from these leaks was 50.1 million gallons. Of this total, 1.4 million gallons was due to customer-side leaks, leaving a total of 48.7 million gallons of NBU-side real water losses. This equates to a lost value to NBU of $220,120. The simple payback period is six months, as the cost of the full service (four images) is $100,000.

Another way to analyze the value of the satellite program is to calculate a benefit–cost ratio. The water value savings was calculated to be $220,100. The operating budget savings was calculated to be $146,400 on the basis of the reduction in labor and cost of a truck roll from 249 crew days to 56 crew days. Therefore, total benefit was $366,500. This equates to a 3.7 benefit–cost ratio.

COMPARING THE TWO METHODS

On the basis of the flow rate of the leaks identified in the full-service program, it was calculated that current NRW loss reduction was 225,500 gpd. The satellite program reduced the NBU NRW from 18 to 16.6 percent during the period of the work.

The satellite program was shown to be able to identify 4.1 leaks per crew day as compared with the traditional method of 0.06 leaks per day in 2018. This is a 70-times improvement in the program's efficiency. The satellite program was shown to have a 95 percent lower cost per leak found, at $678 versus $14,130 for the traditional program.

Overall, the satellite program in 2019 found 14 times the leaks (229) the traditional program did in 2018 (16). The satellite program achieved that goal using less than 25 percent of the crew labor—56 versus 249 crew days. Total labor costs were reduced from $173,350 for the traditional program to $42,900 for the satellite program. The overall operating budget impact was reduced from the traditional program in 2018 of $201,900 to $155,500 for the satellite program in 2019 (Table 5).

NBU was able to significantly reduce its nonrevenue water loss because of this program. All leaks identified were repaired according to their priority level; emergencies were fixed immediately, and the others were scheduled for repair within a week. The satellite service was a great success in terms of water conservation and an increased level of customer service. The program will be continued in this fiscal year.

Table 5. Performance and Value Metrics Comparison

NBU was able to significantly reduce its nonrevenue water loss because of the program.

Parameter	Fiscal Year 2018 Traditional Program	Fiscal Year 2019 Satellite Pre-locating Program
Leaks per day found	0.06	4.1
Number of leaks found	16	229
Cost per leak found	$14,130	$678
Crew labor days	249	56
Crew labor costs	$173,350	$42,900
Overall operating budget	$201,900	$155,500
Capital costs	$24,000	$0