GOVERNMENT OF THE DISTRICT OF COLUMBIA
OFFICE OF THE INSPECTOR GENERAL

AUDIT OF THE ACCURACY OF THE D.C. WATER AND SEWER AUTHORITY'S RESIDENTIAL WATER METERS

CHARLES C. MADDOX, ESQ.
Inspector General

OIG NO. 03-2-13LA(a) **December 23, 2003**

GOVERNMENT OF THE DISTRICT OF COLUMBIA
Office of the Inspector General

Inspector General

December 23, 2003

Jerry N. Johnson
General Manager
D. C. Water and Sewer Authority
5000 Overlook Avenue, S.W.
Washington, D. C. 20032

Dear Mr. Johnson:

This is the final report on the *Audit of the Accuracy of the D.C. Water and Sewer Authority's (WASA) Residential Water Meters* (OIG No. 03-2-13LA(a)). The audit was performed in response to requests from you and Councilmember Adrian M. Fenty to review the accuracy of residential water meters and the efficacy of the billing and customer complaint processes. This report addresses the first issue of water meter accuracy. A second report, *Audit of WASA's Billing and Customer Complaint Processes* (OIG No. 03-2-13LA(b)), will be issued at a later date.

In order to address the first concern of residential water meter accuracy, we engaged a firm, Hydrotech Mechanical Services, Inc. (Hydrotech), to conduct the necessary tests of water meters to answer our audit objective, i.e., whether WASA water meters for residential users accurately record water usage. In response to our statement of work requirements, Hydrotech identified a universe of 92,598 residential water meters, which it tested by using statistical sampling methodologies.[1] Hydrotech selected a sample of 383 residential water meters to test and as a basis to project the results to the universe. Hydrotech advised WASA of the meters it had selected. WASA personnel, in turn, extracted from its respective location each of the serially-numbered residential water meters in the randomly selected sample and sent the meters to Hydrotech for meter flow testing and a test of the accuracy of the electronic meter transmission units (MTUs).

Hydrotech bench-tested the sampled water meters for low, medium, and high water flow. The results of testing 383 water meters indicated 374 water meters were within standard, 9 water meters were below standard (recorded water flow at a slower rate) and 0 water meters were above standard (recorded water flow at a faster rate). In projecting these results to the universe of 92,598 water meters, we estimate that 97.6 percent (90,376 water meters) would operate within industry standards, 2.4 percent (2,222 water meters) would register slow or under registered the water flow, and that none of the water meters would run fast or otherwise over register water flow. Hydrotech noted that having a few water meters that under register water flow is normal when one considers variances in wear, construction, installation, and conditions of use. We note that metered usage may vary slightly from exact usage but still operate within acceptable tolerances.

[1] The sample size and projections were based upon a 95 percent confidence level and a +/-5 percent error rate.

In addition to water flow tests, the sampled meters were tested to assess the accuracy of the MTU transmissions to WASA's Hexagram System. The Hexagram System receives data from the MTU for usage recording and for subsequent billing purposes. The results of that test showed that all 383 MTUs transmitted accurately.

Our conclusion, based on the independent tests conducted by Hydrotech, is that the results provide strong evidence that residential reports of higher than normal water meter usage reflects anomalies or unique circumstances and that there is no causal relationship between any reported residential high water usage and water meters registering faster than the norm. When these results are extended to the residential population of water meters, our conclusion is that the District's residential water meters are generally accurately recording water flow and accurately transmitting water meter readings to WASA's receiving units. Our second report will complete the billing cycle by examining the billing process from the point of WASA's receipt of the electronically transmitted water usage to the actual billing sent to the customer and will include a review of the customer complaint process.

The complete text of Hydrotech's report is incorporated as Enclosure 1 to this report. We relied on Hydrotech's expertise in the field of meter testing and evaluated and monitored Hydrotech's progress and application of the statistical sample. We assured ourselves that Hydrotech's technical review was performed in a manner consistent with generally accepted government auditing standards and guidelines for use of a specialist's services. While this report contains no recommendations, we invite comments on the tests and conclusions presented in this final report.

The General Manager of WASA also provided his response to the report, which is incorporated in its entirety as Enclosure 2. The response indicated that WASA was pleased that the Inspector General found that the new meters were registering accurately and that there was no relationship between reported high bills and meters registering too fast. Moreover, he stated that, "Customers should take comfort that all of the meters' transmitting units tested sent accurate reads. . . ."

Should you have any questions about this report, please call William J. DiVello, Assistant Inspector General for Audits, or me at (202) 727-2540.

Sincerely,

Charles C. Maddox, Esq.
Inspector General

CCM/ws

Enclosures

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HYDROTECH
Mechanical Services, Inc.

December 11, 2003

Charles C. Maddox
Inspector General
Government of the District of Columbia
717 Fourteenth Street, N.W., Fifth Floor
Washington, D.C. 20005

Re: OIG No. 03-2-13LA(a)

Dear Mr. Maddox:

This report provides the results of our tests of residential water meters (meters) resulting from a representative sampling of recently installed DCWASA residential meters and related reading/transmitting system. The tests were performed in accordance with a purchase order, initiated by the Office of the Inspector General, which authorized Hydrotech Mechanical Services, Inc. (Hydrotech) to perform these tests. This report discusses the results of our work, including meter selection, meter transportation, meter accuracy testing, spread sheet report definitions, additional meters, testing parameters, and meter transmission unit (MTU) reading verification.

Objectives:

Our objective was to determine whether the residential water meters for residential users accurately report water usage at low, medium, and high rate-of-flow. Our objective included determining whether water meter usage was accurately transmitted or otherwise entered into DCWASA's Hexagram System. Information in the Hexagram System is ultimately used to bill customers.

Water Meter Selection:

We selected the number of water meters (sample) to be tested based on the following criteria: A random number generation was completed based on the entire population (92,598 meters). Based upon a 95% confidence level requirement, we determined the correct sample size to be 383 meters. Two completely separate random generations were made. Having two completely separate lists (a yellow and a red list), would allow for any non-billable or inaccessible meters that may have been selected on the first list (yellow) to be chosen from the second list (red), which would ensure that the correct size of the sample (383) would be attained randomly. Once the random generations were made, they were partnered with a listing of all the meters in the entire population (92,598). We listed the meters listed by

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number 1, 2, 3, etc., that is, sequentially by serial number. Each number generated by the random number generation was matched up with its partner in the entire population listing. Each meter selected was highlighted in yellow or red, depending on the origin of its number generation. Of the meters selected by either random number generation, there were two instances where identical meter selection occurred in both the first and second random number generation. Once we identified the water meters for the sample by serial number, a DCWASA work order was initiated to have those particular meters removed from their installed location and returned to the meter shop for transportation and testing. The MTUs were shut off so that they would not continue to transmit readings, and the meters were sealed in boxes.

Water Meter Transportation:

The meters were placed into boxes and sealed by DCWASA employees. Hydrotech employees then loaded the boxes into a truck, which were than transported to Hydrotech for testing. After testing, the meters were loaded back into the same cartons used by DCWASA for packaging, sealed, and transported back to the DCWASA meter shop. Once at the shop, DCWASA employees unpacked the meters and then turned on the MTUs, which were programmed with a generic premise number for identification purposes.

Water Meter Testing:

The meters were tested on a Ford Ackron style test bench. Three tests were conducted on each meter, i.e., to test at low, intermediate, and high water flow. The serial number and test results for each meter were recorded on a work sheet, the results of which were transferred to an amended yellow/red file in the Microsoft Excel program. A separate "test tag" was also affixed to each meter listing the individual serial number and test results at the various flows. Of the 383 meters tested, 374 were within standard, 9 were below standard, and 0 were above standard. Based on this representative sampling at the 95% confidence level, of the 92,598 meters installed, we can make a statistical projection that 2.4% (2,222 meters) of the meters are slow (under registration), 97.6% (90,376 meters) of the meters are within standard, and 0% (0 meters) of the meters will register fast (over registration).

Definitions of the Column Headings Used on the Spreadsheets:

Yellow/Red Set: Denotes the random sample title. There were two random samples drawn to select the 383 meters chosen. One sample was labeled the "Yellow" set, and the other was labeled the "Red" set.

Meter No.: Denotes the physical serial number stamped into the actual meter. That number was used as the sole means of positive meter identification and for work order generation, meter removal, and testing.

Meter ID: Denotes the random number generation "number" associated with a particular meter. For example, meter 79 was the first number generated randomly on the Yellow list.

Size: Denotes the size of the selected water meter – 5/8", 3/4", 1".

Meter In-read: Denotes the physical reading viewed on the meter register as received from DCWASA for testing by Hydrotech.

Low flow % Accuracy: Denotes the accuracy achieved and recorded for that meter at the low flow test.

Intermediate flow % Accuracy: Denotes the accuracy achieved and recorded for that meter at the intermediate flow test.

Max flow % Accuracy: Denotes the accuracy achieved and recorded for that meter at the max flow test.

Meter Out-read: Denotes the physical reading viewed on the meter register at the completion of testing, and as returned to DCWASA.

Test Results: Denotes a pass or fail status for that particular meter based on the testing parameters. Meters that failed the accuracy test have a Bold "Fail" denotation in the appropriate column, and the failing accuracy is also in bold type. There were nine (9) failed tests in the sample. The failed meters are meter #s: 50, 53, 59, 111, 173, 184, 186, 247, & 366.

Meter Batch: Denotes in which "batch" that particular meter arrived. Various amounts of meters were picked up from DCWASA at different intervals for testing. Identifying the meters associated with a particular batch allowed all the parties involved to keep an accounting of the number of meters tested as well as the physical location of a particular meter at any given time.

MTU Out-read: Denotes the meter reading, which the associated MTU transmitted to the DCWASA Hexagram System.

MTU Matches Register?: Denotes whether the meter reading transmitted by a particular MTU matches the actual reading found on the physical register of the associated meter, as described in terms of Yes or No.

Additional Meters Tested:

Of the 383 meters on the Yellow list, 32 were not tested due to several possible reasons. The meter may not have been removed because it was determined that it was non-billable, or inaccessible during the time of the meter-testing program. To make up for the meters not tested on the Yellow list, meters were selected from a block on the Red list.

During the time DCWASA was removing meters on the Red list to make up for the shortage on the Yellow list, a greater portion of meters than what was needed was actually removed. Doing so ensured the minimum amount of meters, 32 meters, was available to make up for the shortfall on the Yellow list. To explain further, although the requirement called for the removal of 32 Red list meters, DCWASA anticipated potential difficulties in field technicians being able to remove the precise amount by the intended deadline. Therefore, to avoid delaying the project by continually producing a few more work orders to ensure the correct amount of meters was removed, DCWASA removed 38 Red list meters to ensure a complete sample in the allotted time frame.

The six (6) additional meters removed and tested are shown on the Red list, but are NOT included in any of the mathematical or statistical calculations regarding accuracy in registration or MTU transmission into the Hexagram System. Since all 38 of the meters selected from the Red list passed both the accuracy test, and their associated MTU transmitted correctly, any of the 38 can be exchanged with any one of the remaining 37 meters tested without making any mathematical or statistical difference. The block of 38 Red list meters removed and tested begins at line 342. Like the Yellow list, the Red list contained several meters that were non-billable or inaccessible.

Due to clerical errors, there were several other meters which DCWASA removed and packaged for testing that were not a member of either the Red or Yellow list. Although those meters were tested, the results of those tests were not introduced into the survey, nor were they a part of any of the associated calculations. The meters were identified as not being part of the survey in any way, and returned to DCWASA.

Meter Testing Parameters:

Each meter was tested with other same size meters, at the same time, and in the same fashion. The size of the meter is a description of the inlet and outlet threads, as well as the measuring section of the meter. All meter testing was conducted by performing the low flow first, the intermediate flow second, and the high flow last. Testing in this fashion ensured the most accurate depiction of a particular meter's operation in its installed setting. By evaluating the low flow first, there is less chance of dislodging some debris, or changing some other anomaly in the meter, which would provide an inaccurate description of particular meters' true operating characteristics.

The "flow GPM/Amount" describes the speed at which, and the volume of, water that was passed through the meter-measuring element during a particular test. For example, .5 GPM/ 1 Cubic Foot, means that ½ gallon of water was passed through the meter evenly every 60 seconds until the calibrated tank measured 1 cubic foot (1 cubic foot = 7.48 gallons). The high flows were limited to "at or below" the maximum flow threshold for each meter size to minimize meter damage and accurately depict normal operational conditions. Table 1 depicts the flow testing parameters for each meter size:

Table 1 - Flow Testing Parameters by Meter Size

Size: 5/8"		
Low flow GPM/Amount	.5 GPM	1 Cubic Foot
Intermediate flow GPM/Amount	5 GPM	5 Cubic Foot
High flow GPM/Amount	20 GPM	10 Cubic Foot
Size: 3/4"		
Low flow GPM/Amount	.5 GPM	1 Cubic Foot
Intermediate flow GPM/Amount	5 GPM	5 Cubic Foot
High flow GPM/Amount	<30 GPM	10 Cubic Foot
Size: 1"		
Low flow GPM/Amount	1 GPM	1 Cubic Foot
Intermediate flow GPM/Amount	7 GPM	5 Cubic Foot
High flow GPM/Amount	<40 GPM	10 Cubic Foot

For the sake of simplicity and the most conservative approach, accuracy testing (Pass/Fail) was based upon 100% accuracy, plus 2.0% and minus 3%. Therefore, meters had to perform within our stringent range of 97%-102.0% to obtain a Pass result. Although the American Water Works Association allows for as low as 95% acceptable low flow accuracy and as much as 103% (fast) accuracy on various meters depending on the meter size, type and the conditions of the test, the selected parameters ensured a most conservative standard in culling out of poor performing meters on both ends of the spectrum. And, although meters are allowed to run slightly fast and still be considered acceptably accurate, the 102.0% accuracy threshold requirement ensures all generally accepted industry standards were easily maintained, and thus would be in the best interest of DCWASA customers.

Example: Any flow accuracy below 97% (slow) would be considered a failed test. Therefore, 96.9% and below = accuracy test failure. There were nine (9) failures from the sample that fell into this category. To put those percentages into terms that can be more easily understood by individuals not associated with meter testing, the following is an example. Assuming the customer's water meter has an average accuracy of 97% and the customer used 1,000 cubic feet in a billing cycle, that customer would be invoiced for 970 cubic feet of water consumption.

Any flow accuracy above 102.0% (fast) would be considered a failed test. Therefore, 102.1 and above = accuracy test failure. There were no (0) failures in the sample that fell into this category. A customer's water meter with an average accuracy of 101.0%, where a customer used 1,000 cubic feet, would result in an invoice for 1,010 cubit feet of water consumption. This slight overage is defined as an acceptable accuracy error. Even so, like any other mechanical device, most meters register slower over time as moving parts wear and deteriorate.

MTU Reading Verification:

Once the selected meters were transported to the DCWASA meter shop, they were unpacked and the MTU for each associated meter turned on. DCWASA provided Hydrotech with limited access to the Hexagram System. Hydrotech accessed the Hexagram System to verify the readings being transmitted by each MTU and entered the results of those findings for each meter on the yellow/red list. This took longer than anticipated due to our desire to obtain a reading from each tested meter, coupled with the fact that initially we were not able to verify some of the MTU reads. As it turns out, the problem appeared to have been incorrect or incomplete programming of the MTUs for reading. Eventually, we were able to receive a reading transmission from all of the MTUs and the meters associated with each. Since all of the MTUs transmitted accurately, once programmed with the correct address and billing information, we can project, based on sample results, that of the total population of meters (92,598), 0 meters MTUs will fail to transmit based on same average age, use, wear, etc. In addition, based on those findings, we can conclude that all the MTUs that do transmit a reading will do so accurately, and will mirror the physical reading registered by the meter itself.

Conclusion:

Any desired information required from this meter testing and certification process, can be gleaned from the data as depicted in the attached spreadsheet. The data and associated results are self evident, and in no small way relay as much, if not more, information than can be found in this brief report.

Generally speaking, the recently installed meters read accurately from a physical accuracy-testing standpoint. Having tested personally for 10 years, in my opinion, the few (9) meters that tested slow (under-registration) is normal considering variances in wear, construction, installation, and use conditions. None of the meters that we tested ran fast (over-registration), and therefore, based on the confidence level of the survey, it is safe to assume that a corresponding percentage of the entire population would perform in the same manner. We reasonably concluded that no DCWASA customers are being over-charged for water based on meter accuracy. Of the MTUs that transmitted, all mirrored the results of the physical register, and the correct reading was accurately transmitted to the Hexagram

System. Therefore, it is also safe to assume that all the operational MTUs installed during the same period, are performing at the same level as the ones selected for the survey.

Based on the results of this sample and related projections, conducted under the stated parameters and confidence levels, it is our opinion that no DCWASA customers are being subjected to an over-registration situation for water consumption based on water meter accuracy or data transmission into the Hexagram System.

Sincerely,

Scott G. Perry
General Manger

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:1003-7