

The Power of GIS:

Applications for Monitoring Curbside Recycling Activities

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Trying to figure out where you are and where you are going is probably one of man's oldest dilemmas. It was no different with Metro Waste Authority's Curb It! residential curbside recycling program.

By Matt Nieswender

The Curb It! program was put in place in 1994, and seeing some leveling off in participation rates and tonnages collected, Metro Waste Authority (MWA) looked for ways to analyze where the program had been, where it was now, and how to energize recycling for the future.

Beginning in early 1998, MWA and Barker Lemar Engineering Consultants (Des Moines, IA) had been working together to create a landfill management system using Internet-based geographic information systems (GIS) and global positioning systems (GPS). In 2000, as MWA staff became more familiar with the technology, it became apparent that this technology could be used as a tool to better understand and manage the Curb It! residential recycling program.

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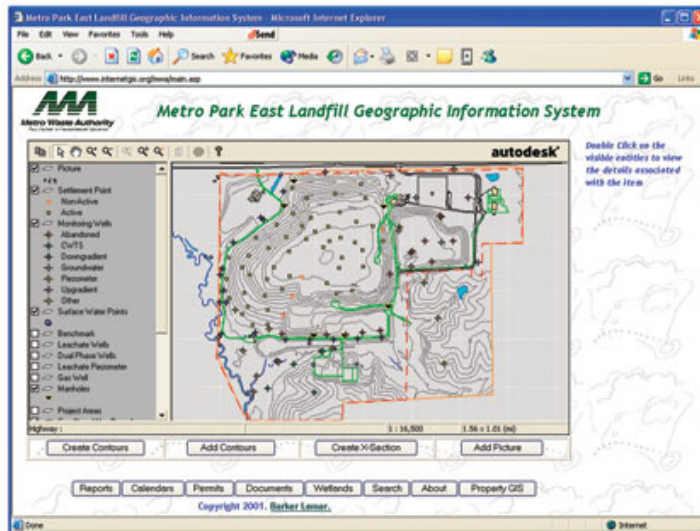
In this same time frame, GPS manufacturers were beginning to create smaller, more-economical units. In addition, the first generations of touch-screen tablet computers were becoming available with enough capacity to store and retrieve large volumes of data. Based on these synergies, MWA felt it was time to explore and invest in a technology that held the possibility of managing geographically distinct curbside recycling data.

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GPS-based landfill management system as seen on the Internet

In 1994, MWA began Curb It! to serve MWA's 17 member communities in central Iowa, including Polk County. These communities ranged from 100-household towns to the capital city of Des Moines with more than 62,000 households. About 115,000 households were eligible for Curb It! at the start. The program is a curbside five-sort system using 18-gallon plastic bins for mixed paper, HDPE and PET plastic containers, tin and aluminum cans, newspaper, and clear glass. The Des Moines Public Works Department maintains a city-operated program that collects recyclables biweekly from its residents. MWA contracts with a private firm for weekly collection for the remaining communities.

A Need for Information

Once the curbside recycling program was established, community leaders, residents, and program managers needed continuous data on the effectiveness of the program. However, gathering accurate data was always problematic.



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Drivers tracked participating house counts while they serviced their route, which sometimes ran across community lines. The contractor, using the driver's route reports, reported the figures to MWA. MWA in turn calculated a monthly participation figure for each community. These methods had their limitations and could not provide the increasingly specific, accurate information that MWA wanted to give the public and its city leaders about progress of the program. Nor did the reporting system allow the analysis of advertising, education programs, and communications that MWA needed. Furthermore, the total number of residential units was not in an electronic format and was often out of date for the growing metropolitan area.

Initiating a Dream

In 2001, Matt Nieswender, an environmental planner with Barker Lemar, and Beth Shonts, MWA's Curb It! program manager, set

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out to collect accurate information including number of households, monthly participation, weekly setout, commodities recycled, effectiveness of education programs, and effectiveness of its communications. The data summaries had to provide the information necessary to judge the effects of educational and outreach efforts as well as provide the community leaders with a recycling report card. Nieswender and Shonts envisioned a system that could capture, store, process, and present tabular and geographically accurate data. The team began to design the foundation for an Internet-based GIS information system using GPS and tablet-sized computers for data collection. Barker Lemar had the experience working on similar GIS-based programs for MWA and other clients. As a result, some of the programming experience was used to develop the new Curb It! tracking system.

MWA combined \$40,000 from its own budget with \$60,000 (a \$20,000 forgivable loan and a \$40,000 zero-interest loan) from an Iowa Department of Natural Resources grant program for the initial phases of a GIS/GPS Curbside Recycling Evaluation Program. The three-year project began on January 2, 2002, and will end on July 15, 2005.

From the beginning, the vision was to equip drivers with touch-screen tablet computers to gather data from each household while completing the routes. In practice, these data were to be collected daily, from several routes as opposed to the traditional way of paying additional staff to follow trucks, manually recording information and then transferring it to an electronic spreadsheet.

Selecting Hardware and Software

Staff reviewed two computers for this trial: the ViewSonic ViewPad Super PDA and the Hitachi ePlate 360-ETR, selecting the former as it has 128 megabytes of memory, a 10-inch screen, and a 206-megahertz processor. The ViewSonic uses Windows CE as the operating system and is compatible with ESRI's ArcPad software. This software is a mobile GIS mapping program designed for handheld and mobile devices. The consultant programmed the tablets using ArcPad scripting language, and staff performed initial testing and determined that this first-generation system of computer and software was able to store and process the large databases quickly enough for use on a collection route.

Initiating GIS

MWA's Curb It! curbside recycling program serves approximately 340,000 people in 122,000 residential units (single-family through four-plex). As mentioned, MWA developed the program as a five-sort system using 18-gallon plastic bins. Since the initiation of curbside recycling in the Des Moines metropolitan area, the ability to count the number of homes participating and, consequently, the participation levels within each community has been difficult. The data providing the total number of available residential units had to be gathered from several public agencies. These data were generally not available in an electronic format and were often out of date due to the rapid growth occurring in the metropolitan area.

Beginning in early 2000, MWA and Barker Lemar began working together to create an Internet-based, GIS-based Landfill Management Program. Barker Lemar was also developing similar Internet-based GIS work for other clients, including Keep Iowa Beautiful.

The team began to explore the vast potential for a GIS database designed to meet the criteria previously mentioned. From the beginning, it envisioned touchscreen tablet computers operated by drivers while they were on their route. By efficiently using the drivers, data could be collected daily from several routes, without paying additional staff to follow several trucks per day manually and then manually inputting recorded data.

Critical GIS Components

The initial phase of the project involved securing the necessary databases that were critical to providing MWA with accurate house counts.

MWA and the Polk County Assessor's Office signed a Digital Mapping Product Licensing Agreement allowing MWA and Barker Lemar, as MWA's contractor, access to Polk County Assessor's countywide GIS. This database includes both geospatial and tabular data. At the time, the software used by the contractor and the assessor's office to view, analyze, and query the data was ESRI's GIS software, ArcView GIS 3.2.

Digital parcel-level data had the potential to solve many data collection problems at once. Parcel-level data are regularly updated via the Internet directly from the Assessor's Office. Regular monthly downloads and filtering of the database provide accurate house counts for Polk County and any geographic subset within the county.

Additionally, the geospatial data include building outlines and parcel outlines for each property. This allows the drivers to visualize where they are, using GIS-generated maps. The ability of GIS to layer levels of detail allows programmers to turn various layers on for managers and then limit display of any layers that may clutter the screen for drivers. This same ability to limit layers of data is used when portraying GIS data over the Internet.

Other electronic databases and geographically distinct boundaries used as layers for this project included US Census block data, individual school attendance boundaries, county supervisor boundaries, and city council boundaries.

Initial Testing and Lessons Learned

Initial testing went very well. Although the tablets were not the "ruggedized" models on the market today, they held up well when mounted in the collection trucks and performed reliably in most weather conditions, although a few modifications were required to prevent overheating. The tablets were mounted in wood pedestals custom-designed for the trucks and the tablet computers.

Artistic Waste Services (Artistic) is the Curb It! contractor providing collection services in MWA's suburban communities. Artistic's drivers and managers provided invaluable feedback to Barker Lemar programmers regarding ease of use, visibility, color contrast, "zoom-in" percent, training/training manual, cold-weather/hot-weather performance, and numerous other operational details. The team understood the need for the program to be intuitive and easy to use and that it could not significantly slow the driver.

Barker Lemar designed the program with drivers in mind. The limitations of programming in Windows CE and scripting language did not allow programmers to make every recommendation provided by the drivers.

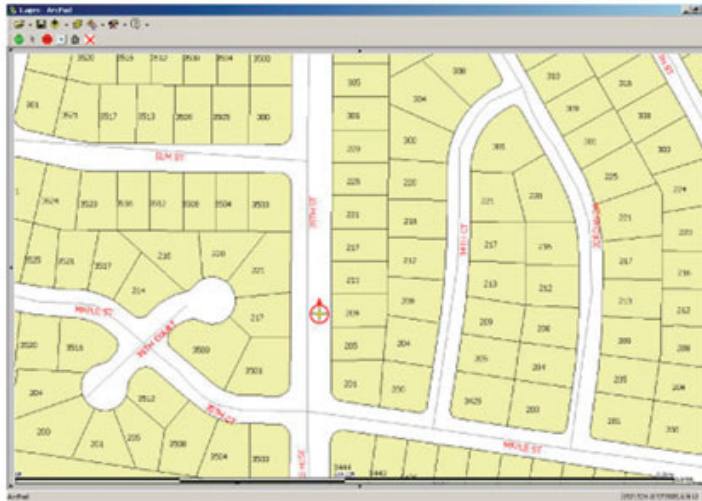
After opening the program, the drivers viewed a GPS-generated icon representing the truck and truck direction, road name, lot (parcel) and house outline, and address of each visible parcel. The GPS units use the Federal Aviation Administration Wide Area Augmentation System to differentially correct the GPS location. This allows the system to provide locations to a horizontal accuracy of plus or minus 8 feet. This is generally enough precision to determine the side of the road the vehicle is on and to provide the driver with a visual cue as to which parcel he is collecting. The screen and icon scrolled with the driver as the truck moved. Once stopped, the driver simply tapped the parcel or parcels that had set out a bin. Within a few seconds, the computer saved that/those record(s) and was ready for another entry. After each entry, the program saved data to a flash memory card in case the computer lost power. Programming controls prohibited drivers from selecting a parcel more than one time each day.

When the driver completed the day's route(s), the computer was unplugged from the truck and taken inside Artistic's operation system where the data were downloaded to project servers via the Internet. The program updated and refreshed new parcel information at that time so the computer was ready for the next day's route.

As the GIS and GPS programs were being developed and field trials were being performed showing the accuracy of the data, MWA initiated other Curb It! GIS applications.

Easter Lake Area Study

During the field trials for the ViewSonic tablets, the City of Des Moines and MWA requested assistance tracking curbside information within the city of Des Moines. The Des Moines Public Works Department wanted to improve curbside collection (provided biweekly). In an effort to improve curbside recycling service to Des Moines residents, the department wanted to collect data regarding participation, commodity weights, and the types of commodities collected from each home.



Roads and GPS-generated truck icon

The Des Moines Public Works Department selected an area of Des Moines, commonly referred to as Easter Lake, to participate in the study. Investigators used the routes provided by the Des Moines Public Works Department to examine the recycling habits of 1,410 homes in the area. The first run for the Easter Lake Baseline Data Collection Program was June 19, 2002, and the data were gathered over five collection cycles (10 weeks) using three trucks. To capture commodity weights, the Des Moines Public Works Department asked drivers to weigh each commodity separately at the recycling facility. To capture the number of homes recycling each commodity, the contractor developed a "drop-down" screen that drivers had to select before the parcel participation data were saved. The compilation of information showed that

- setout rates were just more than 46% for each collection cycle;
- 85% of the homes recycled plastic containers (HDPE/PET), averaging 0.9 lb./house/two-week cycle;
- 77% recycled mixed paper, averaging 8.0 pounds per house per two-week cycle;
- 75% recycled newspaper, averaging 13.1 pounds per house per two-week cycle;
- 50% recycled metals, averaging 1.8 pounds per house per two-week cycle;
- 35% recycled glass, averaging 4.2 pounds per house per two-week cycle; and
- 35% recycled glass, averaging 4.2 pounds per house per two-week cycle.

GIS Determines Focus Group Selection

Using the parcel data collected from Easter Lake, MWA worked with another consultant to arrange two focus groups that were held in September 2002. The groups were based on the residents' activity in Curb It!. Crawford, Johnson & Northcott Inc. facilitated the focus groups; one was comprised of residents who recycled every collection cycle during the pilot (14 individuals),

and the other was with those who had never recycled during the trial period (nine individuals). The focus groups revealed that both groups were aware of the benefits of recycling. The difference was their commitment to the process. Nonrecyclers appeared unwilling to make the effort to recycle, such as packing the bins, sorting the material, or asking for a bin.

Audit of Rural Polk County Recycling Routes

In the spring of 2002, Polk County shifted the costs for Curb It! collection to residents, selecting the areas of highest population density for participation. A recycling service area map and an accurate billing list had to be developed. The Polk County Planning and Development Office had developed an electronic route map for the selected service area. This map was an unprojected Microstation file.

Based on driver feedback and the service area map, County staff thought initial house counts were 9,343. MWA asked the contractor to use the County's service area map and the existing parcel data to develop an accurate house count. Additionally, a mailing list was to be developed of the participating and nonparticipating households so a customized letter could be used to inform Polk County residents of the new Curb It! changes.

Barker Lemar staff converted the Microstation file to an ESRI shape file for use with the Polk County parcel data and then redrew the entire route to match the centerline of roads. During this process, staff programmed the GIS/parcel data to select parcels that were adjacent to the route. After this selection process, staff reviewed the route to hand-select parcels that were not selected by the computer. These included parcels with long driveways, unusually shaped parcels, and so on. The final process was to validate the exact starting and stopping point of the routes. This was necessary in cases where homes on acreages were not included in the program as the route was stopped before the long drive to their home.

Periodically validating homes on collection routes presents significant potential benefits. Using GIS software to quickly review the routes, the final Curb It! participating house count was established at 7,036, considerably less than the initial 9,343 that planners had been estimating. This tool allowed the County to accurately bill only those homes on the route.

Generating Mailing Lists From GIS Databases

To generate the mailing list of rural Polk County Curb It! customers, the parcels were sorted according to four occupancy descriptions selected by MWA: biattached, single-family, duplex, and townhouse. These categories along with individual

addresses were transferred to an Access 2000 database, and mailing labels were printed. MWA used the labels to send a direct-mail survey to the 7,036 program participants, with the goals of determining satisfaction levels with the frequency of collection, customer service, why they recycle, and how strongly they supported the program. The results provided valuable information to MWA program managers and Polk County supervisors. Of the 6,833 responses received, rural residents stated the following:

- 83% recycle at home with the Curb It! bins.
- 74% are very satisfied with curbside recycling .
- 63% place a green bin at the curb every week.
- 51% would not participate in recycling if they had to take materials to a drop-off location.
- 58% recycle because it is good for the environment.
- 12% would recycle more if they had a bigger bin.
- 66% recycle mixed paper, 81% recycle newspaper, 73% recycle cardboard, 70% recycle clear glass, 65% recycle tin/aluminum, and 77% recycle plastic.



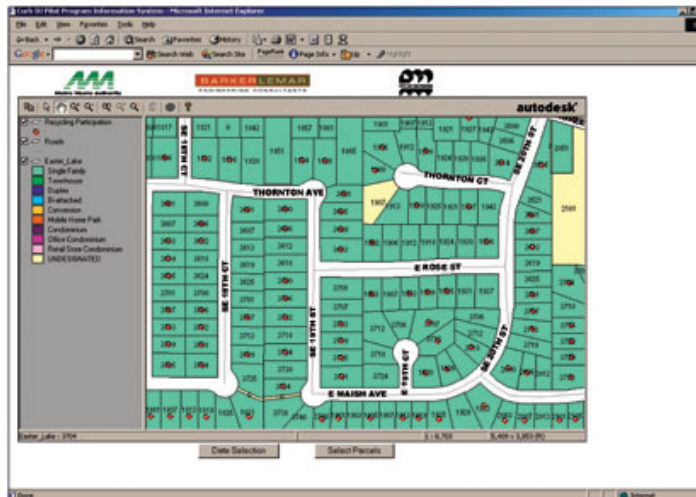
Selected parcels (red dots) participating in the Easter Lake Participation and Commodity Study as seen on the Internet



Computer mounted on pedestal inside recycling truck

Tracking the Effect of Direct Mail on Participation in Rural Polk County

MWA, much like many other solid-waste planning agencies, invests much time and effort in attempts to increase program participation rates. In the past, it was difficult—if not impossible—to track the effectiveness of these marketing/educational efforts. It appeared that the new tracking program would provide a method to examine the effectiveness of such efforts. MWA set out to design a marketing program and to use the system to track the results.

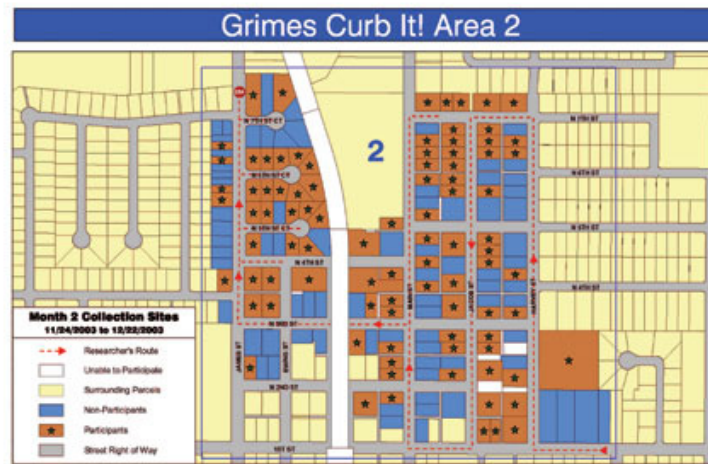


Selected parcels (red dots) participating in the Easter Lake study

The first step was to develop a baseline for participation in the target area. For baseline data collection, Barker Lemar, Artistic, and MWA staff selected five neighborhoods in rural Polk County as a sample to represent all of unincorporated Polk County. The rural participation figures were developed using data collected from Artistic drivers while operating their routes. This calculation of monthly participation figures represented three weeks from March 1 through March 22, 2003.

The five neighborhoods comprised 562 potential Curb It! participating parcels. Participation ranged from 24.6% to 67.7% during the three weeks. Of the 562 homes (parcels), 294 did not set out a Curb It! bin during the test dates. The average monthly participation figure for these five neighborhoods in unincorporated Polk County was 49%.

MWA wanted to see if a direct-mail piece could change recycling behavior. The names and addresses corresponding to the 294 homes that did not set out a bin during the test date were transferred to a database to generate mailing labels. The direct-mail piece with a headline "Bin Out Lately" was designed to remind residents how to get a bin, how to load it, and how to get it picked up. Geo parcel codes are unique parcel identifiers used by the Polk County Assessor's Office and are unique to each parcel. Geo parcel codes allowed programmers to map specific survey questions and develop a visual display of negative and positive results overlaid with County Supervisor jurisdictions.



Map of participating households in Area 2 of Grimes, IA

After one month, data were again collected. The number of homes that participated in recycling increased by 28%. Based on these results, MWA plans to design a further scientific study of the effect of multiple direct-mail prompts to nonrecyclers. The use of the GIS system allows MWA to target specific users (such as nonrecyclers) with customized marketing efforts. This was not possible before implementation of the system.

The Impact of Educational Outreach on Setout Rates

The purpose of this test was to calculate any changes in curbside participation after an MWA-sponsored school education program. Mary Gillaspey, education specialist for MWA, presented information regarding curbside recycling to all the sixth-graders at the Dallas Center Grimes (Iowa) Middle School.

The team selected three neighborhoods within Grimes from which to perform this test. MWA staff collected baseline information from October 13 through November 3, 2003. Gillaspey made the school presentations the week of November 10, and data collection resumed November 24.

Before the presentation, the weekly setout rate ranged from 41.51% to 43.66% with an average monthly setout rate of 42.85%. After the school presentation, the weekly setout rate ranged from 43.23% to 46.88% with an average monthly setout rate of 45.06%. While this cannot prove a causal relationship, it does open up possibilities for MWA for future testing and tracking.

Operating Multiple Computers on Multiple Trucks During Multiple Routes

One of the goals of this project was to have a computer in every curbside collection vehicle collecting data on a daily basis. The data would be used to



Panasonic Toughbook 18 with GIS parcel-level data

calculate a metrowide weekly setout rate and monthly participation figures. Although the project placed 14 computers in the Artistic trucks, managing this many computers became impractical.

Program speed was not an issue; nor was operating the actual program. The problem arose when the tablet computers would reformat if they lost power. Although the tablet power source was hard-wired to the trucks, the computers had to be removed at night and downloaded, and many times they would reformat during this stage and lose the GIS programming. Additionally, peripheral equipment, such as GPS antennae, were cut inside truck doors, and GPS cards had to be reinforced as the pins were too fragile for the daily rigors of life in a recycling truck. At times, the loss of the GPS signal and/or slow acquisition of the GPS frustrated drivers and managers. Artistic staff provided an exceptional amount of support; however, limitations of the operating language, processor speed, and "toughness" of the peripheral equipment made collecting data throughout the entire planning area at one time too difficult.

Barker Lemar and MWA are applying the lessons learned during this experience to the next generation of tablet computers.

Tracking Yardwaste Participation

MWA and the City of Urbandale will be adapting the programs used for curbside recycling to collect yardwaste participation information during the 2004 spring yardwaste season.

MWA offers its residents Compost It!, a yardwaste collection system using kraft bags. The City of Urbandale is evaluating the feasibility of offering an automated yardwaste system using toters.

In late March 2004, the City of Urbandale drivers began operating one computer four days a week, covering approximately 50% of the Urbandale households.

This test allows Urbandale and MWA to determine how many bags are set out per house, how many houses participate, and how frequently homes set out yardwaste. MWA maintains databases of all households participating and not participating for potential survey work. Ultimately the data will assist Urbandale planners in determining an economical and efficient pricing strategy.

Upgrade of Hardware and Software

The Urbandale Yard Waste Project will be the first to utilize a new generation of ruggedized touchscreen tablet computers:

Panasonic's Toughbook 18. The Toughbook 18 is a fully ruggedized touch-screen tablet computer with a Windows XP operating system. It has an 82-key keyboard, 512 megabytes of SDRAM, a 40-gigabyte hard drive, a 10.4-inch color touchscreen, and a 900-megahertz Intel processor. This ruggedized tablet computer will not have the same reformatting issues of the previous computers.

Programming and operating within Windows XP provides additional flexibility to the programmers and to MWA as new applications are identified. In addition, the upgraded hardware allows additional features to be added to the software. The increased speed and storage capacity is also beneficial. It allows parcel-level data for the entire county to be uploaded on each machine.

The Future

Residents within the MWA service area are asked every day to take responsibility for improving their communities and their environment. MWA's recycling programs give them opportunities to do just that. GIS/GPS provides the tools to report successes by solid-waste planning area, political jurisdictions, cities, school attendance boundary, and even neighborhood association. GIS and GPS provide a flexible system that can track changes in household behavior for a given variable in a geographically defined area. Additionally, the data can be presented using maps that represent the target area, helping improve communication, identify localized trends, and, hopefully, increase the participation in curbside recycling and other MSW systems.

The multiple benefits MWA and its member communities have identified in the short time the system has been tested continue to spur new applications.

In these times of ever-tightening budgets, it becomes imperative for collection agencies to maximize the benefit of their education and marketing spending. The system implemented by MWA has provided the data to allow the evaluation and modification of these programs to maximize their results.

The technology of tablet computers is moving quickly, and new hardware and software applications are developing rapidly. GIS and GPS can serve as one additional tool helping waste reduction and recycling managers track the effect of various outreach tools used to improve the integrated solid-waste systems they manage.

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MSW - September/October 2004

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