Cleveland Water's Data Creation and Maintenance Application

Background

The City of Cleveland's Division of Water is a municipally owned and managed water utility. We are a full service utility. We treat raw water from Lake Erie, the smallest of the Great Lakes and pump it to our 1.5 million customers within 65 different communities covering 630 square miles. Furthermore, we provide maintenance of the water infrastructure such as repairs to water mains, valves, hydrants, service lines, and regulators. All our billing is done in-house with support from our IT staff.

Our distribution system contains:

- 54,000 miles of Pipe 16" in diameter and smaller of various materials but primarily cast and ductile iron.
- 422 miles of Pipe between 20" – 54" in diameter of various materials but primarily cast, ductile iron, concrete pipe (pre-stressed and reinforced), and steel
- 71,000 Hydrants:
- 56,000 System valves

Cleveland's Distribution System is fed by 4 treatment plants with over 100 Pumps with the capacity treat 800 MGD. In actuality, we pump roughly 200 MGD, or one quarter of our total capacity in our distribution system each day.

Over the past 5 years, the Cleveland Division of Water has been converting all the hard copies of our record as-built construction drawings and other system information into an enterprise geodatabase.

A fundamental premise of a Water GIS model is that it must provide enough information in a user friendly manner to gain buy in from your organization. If your staff continues to use hardcopies of original drawings, you must question the usefulness of your GIS. Keeping field and office staff engages in decisions through your implementation is essential for success.

The History of Cleveland's Water Distribution System is a story told by our records. Records that have been lost over the one and one-half centuries of our existence end up as holes in our history. Inaccurate records lead to increased cost as mistakes are made in the field based on the inability to pre-plan work or assess logical improvements. From written logs of materials used to build our first mains to electronic AutoCAD data files, Cleveland Division of Water has seen a many formats of records. The majority of our records are hardcopies of maps that have been hand drafted and even those that have been done in AutoCAD have been simply printed out as hardcopies and sit side by side with all the hand drafted records. A complete cataloging of hardcopies is essential prior to beginning your data conversion. The records used for our conversion are summarized as follows.

Original Map Sources
"Records Research"

There were many different types of as-builts in our collection of records. These records are as follows:

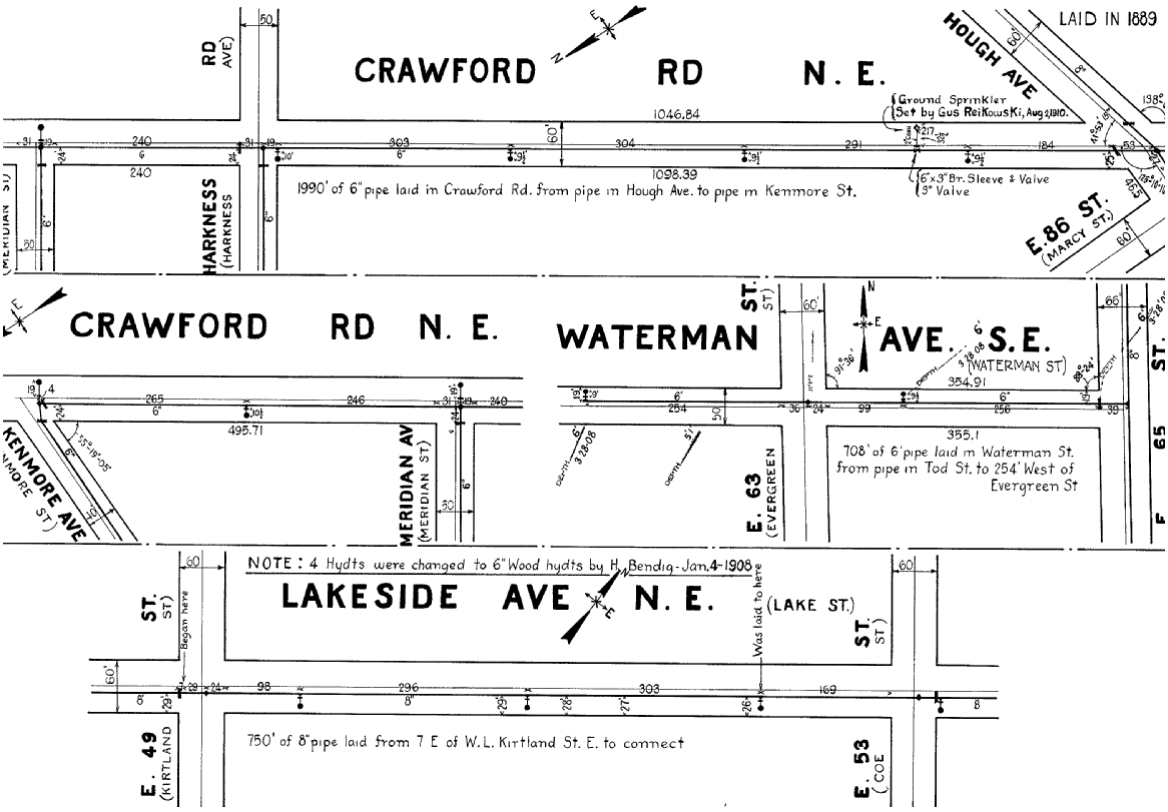
- Volume and Page Books
- City Maps (CMs)
- Village Maps (VMs),
- Record Prints (RPs)
- Hydrant sketches
- Repair/field sketches

Primary features of each record type along with quantity of records and an example of each is provided below.

Volume & Pages Books –

Key features of the Volume and page books area as follows:

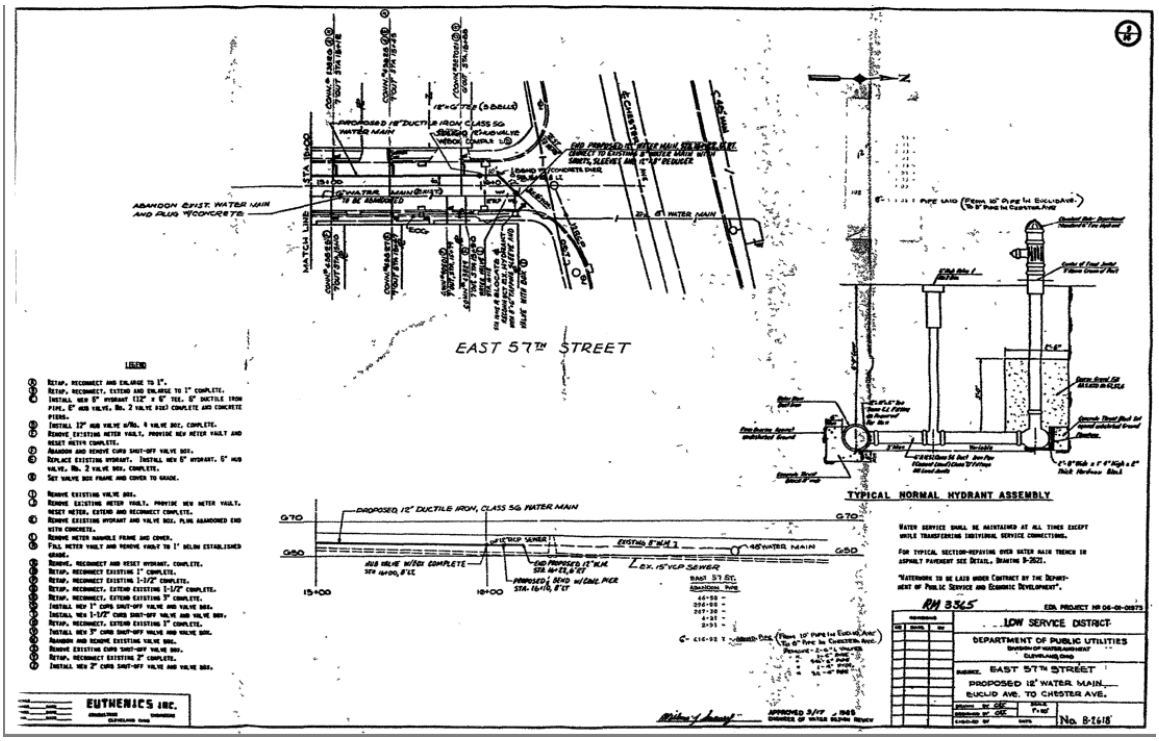
- They are the earliest mapped drawings.
- In total there are 40 volumes, each with approximately 60 pages. Each page contains multiple projects. (approximately 2400 sheets depicting approximately 10,000 projects)
- These maps were hand drafted and where color coded to express the status of the main as either abandoned, existing, or new/proposed.
- The City stopped using these in the 1950's, when they switched to the designation of CM's (City Maps), but some edits were made up to the 1980's.
- Index books exist by street name to look up these records.
- All are scanned in and available in an electronic format.



Volume and Page maps were essentially plan drawings. Any reference to depth or elevation was done by use of noting spot elevations.

CMs – "City Maps" – As-builts in the City of Cleveland Proper

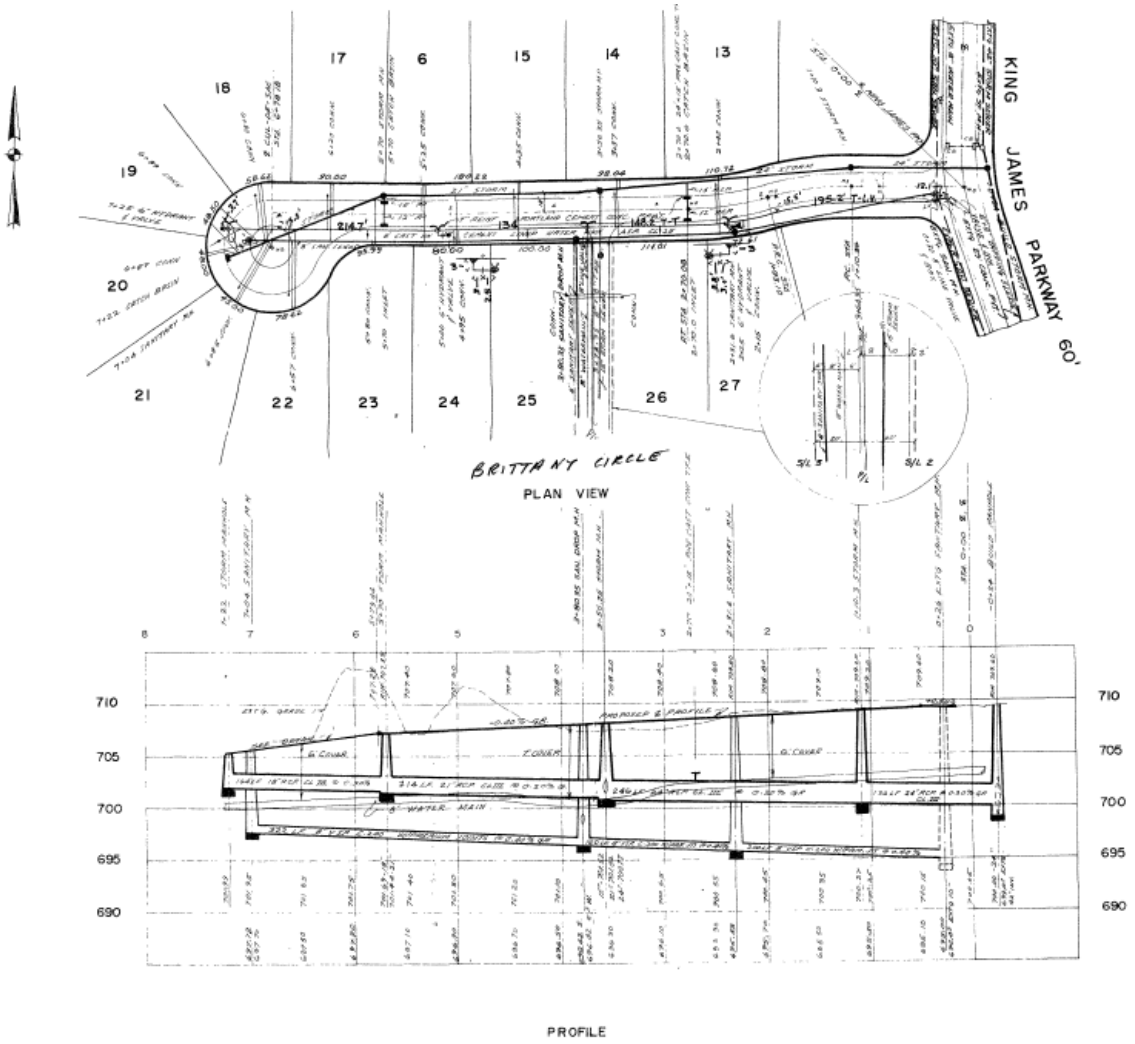
- City Maps introduced profiles to our piping records.
- There are about 1000 CM records, each containing multiple pages (approximately 3000 projects)
- They do not contain connections information.
- They are Indexed on cards filed by street name
- All are scanned in and available in an electronic format.



VM – "Village Maps" – Suburban As-builts

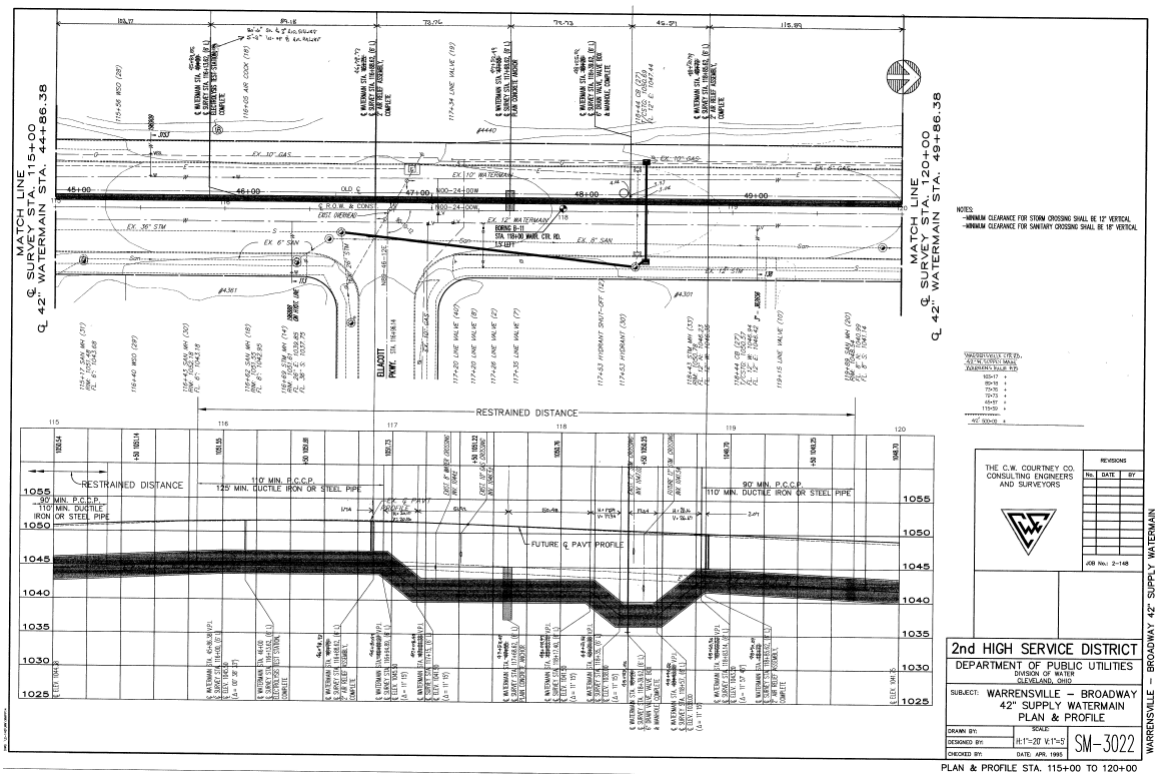
Prior to the expansion of the distribution system, all projects were in the City of Cleveland however as the system expanded to provide service to surrounding communities, another era of as-builts was born.

- VMs show the plan and profile data for as-builts outside City of Cleveland (in the suburbs)
- There are about 84,000 drawing sheets covering roughly 12,000 projects
- They do not contain connections information.
- They are indexed by street name.
- All are scanned in and available in an electronic format.



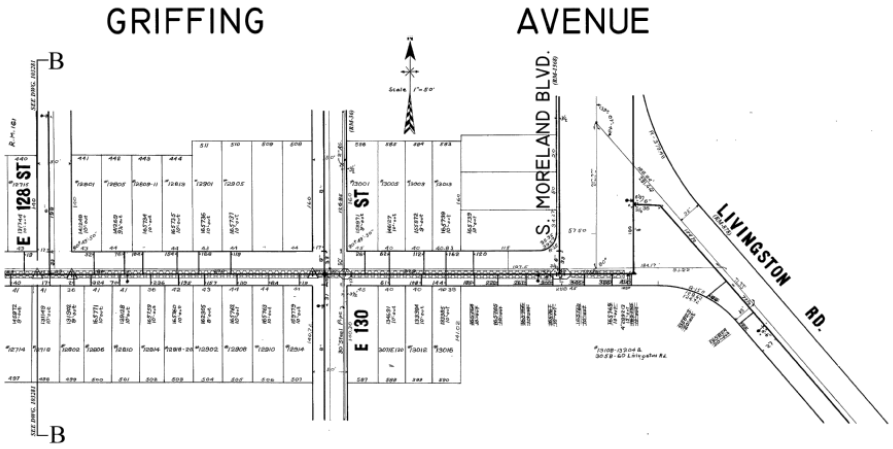
RPs – "Record Prints" – As-builts of large Transmission mains (aka trunk mains or supply mains) within the piping network

- Approximately 3000 drawings spanning 105 major projects.
- As-builts for 20" or larger trunk mains that date back to the 1950's. Access manholes, drains, air cocks will only be found here.
- SM (Supply Main) number is the reference to the original design drawing.
- Transmission mains prior to the concept of RPs are shown on the Volume and Page records.
- All RPs have been scanned.



CR – Cleaning and Lining Record (aka Cleaning and Lining) – The vast majority of the water mains installed early in the history of Cleveland's Water System were cast iron pipes. In the mid-1950s pipe manufacturers began the process of factory lining the interior of cast iron pipes with a cement mortar lining. Cleveland transitioned to using Ductile Iron mains in 1973 that are also factory lined. Older mains that pre-date the factory lining react adversely with the water chemistry forming tubercles in a process known as tuberculation. The cement mortar lining provides an area of high ph near the pipe wall and provides a barrier between the pipe which is more susceptible to corrosion. The Division of Water uses in-situ cleaning and lining to rehabilitate water main that are otherwise in stable structural condition by cleaning or scraping our all the tuberculation and cement lining the pipe.

- Define limits of rehabilitation by Cleaning and Lining Process of both Distribution Pipes (16" and less) and Transmission Main (20" and larger). Valves and hydrants that were replaced with these projects are also defined.
- Occasionally there is other water work defined on these projects such as water main replacements and abandonment.
- In the year 2000, the Division of Water completed the final Cleaning and Lining of a Transmission main. All our transmissions mains are not cleaned and lined.
- The Division of Water has had approximately 100 contracts over the past 50 years which has resulted in the cleaning and lining of 2500 miles of pipe.



GRIFFING AVENUE CLEAN & LINE 6" WATER MAIN	
	From 12" pipe in East 116th Street to 8" pipe in East 125th Street
38.00'	Remove & Replace 2 - 6" Valves w/ Valve Boxes
344.00'	
301.00'	CUT-IN VALVES 2-12" Valves w/ Valve Boxes North & South R/W of Giffing Ave. in East 116th Street
35.00'	
341.00'	
236.50'	CUT-IN VALVE 2 - 6" Valves w/ Valve Boxes West & East R/W of East 125th Street
7.50'	
23.50'	
13.50'	
84.50'	
56.00'	
82.00'	
17.00'	
53.00'	
114.00'	
86.00'	
17.00'	
Total: 1,821.50'	

GRIFFING AVENUE CLEAN & LINE 6" WATER MAIN	
	From 8" pipe in East 125th Street to 6" pipe in Moreland Avenue
33.00'	Remove & Replace 4 - 6" Valves w/ Valve Boxes
158.50'	CUT-IN VALVE 2 - 6" Valves w/ Valve Box East R/W of East 125th Street
176.50'	
17.00'	CUT-IN VALVE 2 - 6" Valves w/ Valve Box West R/W of East 126th Street
33.00'	
156.00'	
194.00'	CUT-IN VALVE 2 - 6" Valves w/ Valve Box West & East R/W of East 128th Street
17.00'	
33.00'	CUT-IN VALVE 2 - 6" Valves w/ Valve Box West R/W of East 130th Street
80.00'	
270.00'	
17.00'	
52.00'	
270.00'	
27.00'	
3.50'	
6.00'	
180.50'	
Total: 1,837.00'	

NOTES:

1) THE CITY DOES NOT GUARANTEE THE NATURE OF BENDS SHOWN (I.E. SHORT OR LONG RADIUS, ETC.) ADDITIONAL ACCESS EXCAVATION DUE TO BENDS SHOWN MAY BE NECESSARY DURING CONSTRUCTION. COST OF ALL EXCAVATIONS DUE TO BENDS SHOWN SHALL BE INCLUDED IN THE BID PER LINEAR FOOT IN THE CLEANING AND LINING CONTRACT.

2) THE CONTRACTOR SHALL SUBMIT FOR THE CITY'S APPROVAL A PLAN OF THE PROPOSED BYPASS SYSTEM AT LEAST (2) TWO WEEKS BEFORE PLANNED WORK. THE DIAGRAM SHALL SHOW WHERE THE TEMPORARY VALVES AND FIRE HYDRANTS WILL BE PLACED. NO WORK IN ANY SPECIFIC AREA SHALL COMMENCE UNTIL A BYPASS PLAN HAS BEEN APPROVED BY THE CITY.

3) THE CLOSING OF ALL SMALL VALVES (16" AND SMALLER) ON EXISTING MAINS FOR MAKING CONNECTIONS, TESTS, OR FOR ANY OTHER CAUSE SHALL BE DONE BY THE CONTRACTOR AND WITNESSED BY THE CITY. SUFFICIENT NOTICE SHALL BE GIVEN TO THE CITY BY THE CONTRACTOR SO THAT THE WORK MAY BE DONE WITH MINIMUM OF INCONVENIENCE TO THE PUBLIC AND DELAY TO THE CONTRACTOR. ALL LARGE VALVES (20" OR LARGER) SHALL ONLY BE OPERATED BY THE CITY.

LEGEND

- WATER MAIN(S) TO BE CLEANED AND LINED
- EXISTING LINE VALVE TO BE REMOVED AND REPLACED
- NEW CUT IN VALVE TO BE INSTALLED
- REFER TO NOTE OR DETAIL

REVISIONS:		
NO.	DATE	BY

2004 CLEANING AND LINING PROGRAM
AREA A-3

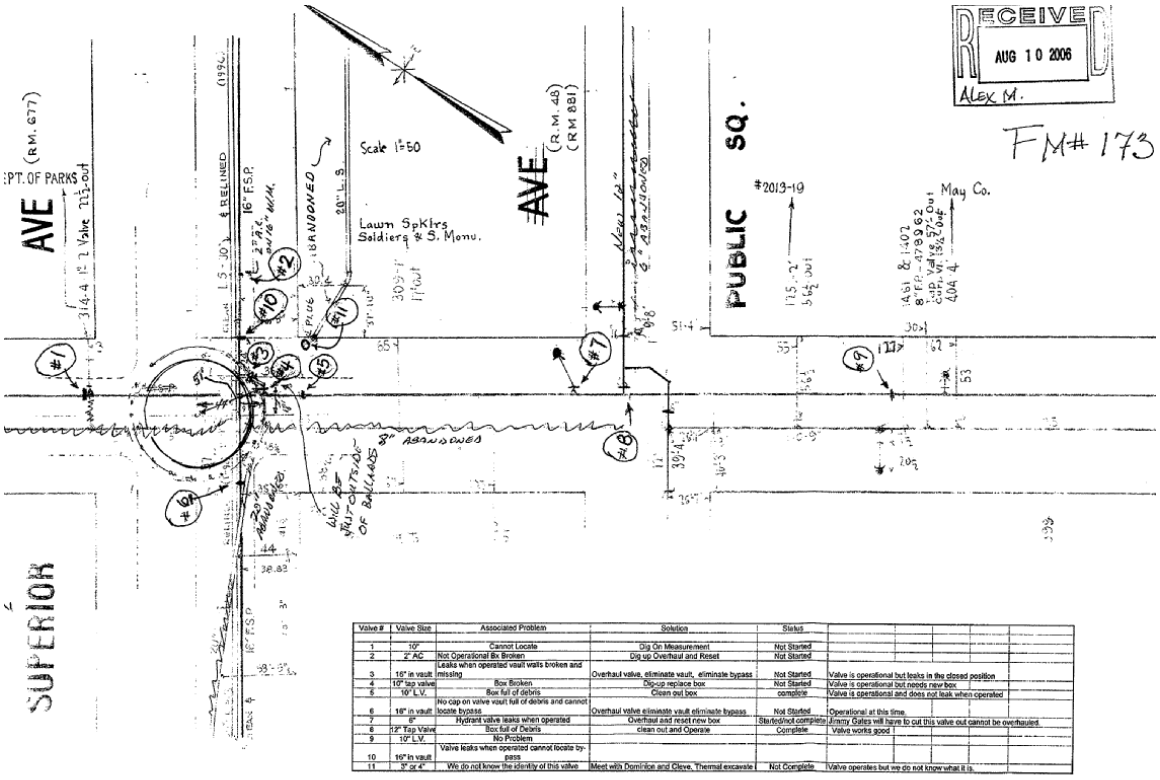
DEPARTMENT OF PUBLIC UTILITIES
DIVISION OF WATER
CLEVELAND, OH.

SUBJECT: GRIFFING AVENUE - 6" & 8" Water Mains
Fr. 12" pipe in East 116th Street to 8" pipe in East 125th Street
Fr. 8" pipe in East 125th Street to 8" pipe in Moreland Avenue
RM# 125 S.S. # 56

DRAWN BY: M.A. SCALE:
DESIGNED BY: M.A. 1" = 50'-0"
CHECKED BY: N.S. DATE: 12/2004

No. 103282

FM – "Field Maps"



Valve #	Valve Size	Associated Problem	Solution	Status	
1	10"	Cannot Locate	Dig On Measurement	Not Started	
2	2" AC	Not Operational Bx Broken	Dig up Overhaul and Reset	Not Started	
3	16" in vault	Leaks when operated vault walls broken and missing	Overhaul valve, eliminate vault, eliminate bypass	Not Started	Valve is operational but leaks in the closed position
4	10" tap valve	Box Broken	Dig-up replace box	Not Started	Valve is operational but needs new box
5	10" L.V.	Box full of debris	Clean out box	complete	Valve is operational and does not leak when operated
6	16" in vault	No cap on valve vault full of debris and cannot locate bypass	Overhaul valve eliminate vault eliminate bypass	Not Started	Operational at this time.
7	6"	Hydrant valve leaks when operated	Overhaul and reset new box	Started/not complete	Jimmy Gates will have to cut this valve out cannot be overhauled
8	12" Tap Valve	Box full of Debris	clean out and Operate	Complete	Valve works good
9	10" L.V.	No Problem			
10	16" in vault	Valve leaks when operated cannot locate by-pass			
11	3" or 4"	We do not know the identity of this valve	Meet with Dominice and Cleve, Thermal excavate	Not Complete	Valve operates but we do not know what it is.

- These are sketches of water main lowering and relocations.
- There were 600 backlogged jobs at the time data conversion began. All other FMs have been previously incorporated into our current record format. (rollmaps and sections sheets)

JCs – "Job Cards"

- These are general repair sketches detailing repairs, connection pluggings, connection relocation or new connections.
- They indicate the connection size, street name, and date and time work took place.
- There were 300 backlogged jobs at the time data conversion began. All other FMs have been previously incorporated into our current record format. (rollmaps and sections sheets)

Blue Cards/ Connection Cards

- These cards give a reference measurement to their respective service connection.
- This data provided from this source was redundantly stored in our billing database and was not found to be extremely useful. This is the original description of the service that was then entered into AS-400 and then the cards are given to our mapping to update the roll maps.

AS-400/Billing System Databases

- The AS-400 is our Billing database. It contains information on our accounts, connections, meters, etc… Specific information that is taken from this source includes:
  - Connection Size
  - Connection location (referenced from an above ground feature.)
  - Meter Location
  - Meter Size
  - Etc…

Design Drawings

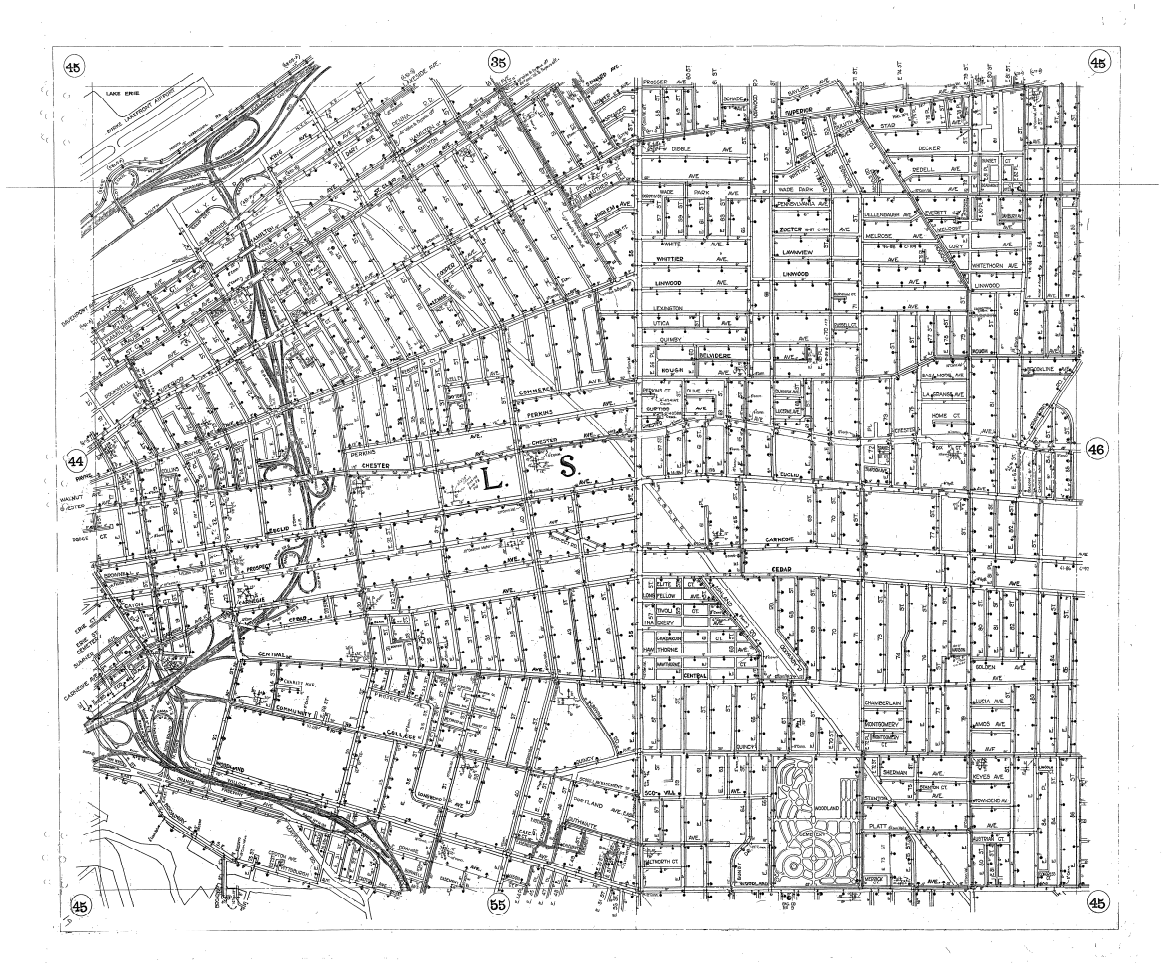
- These are the original design drawings.
- They were only used for data conversion when no as-built existed.

Pre-GIS Method for updating records

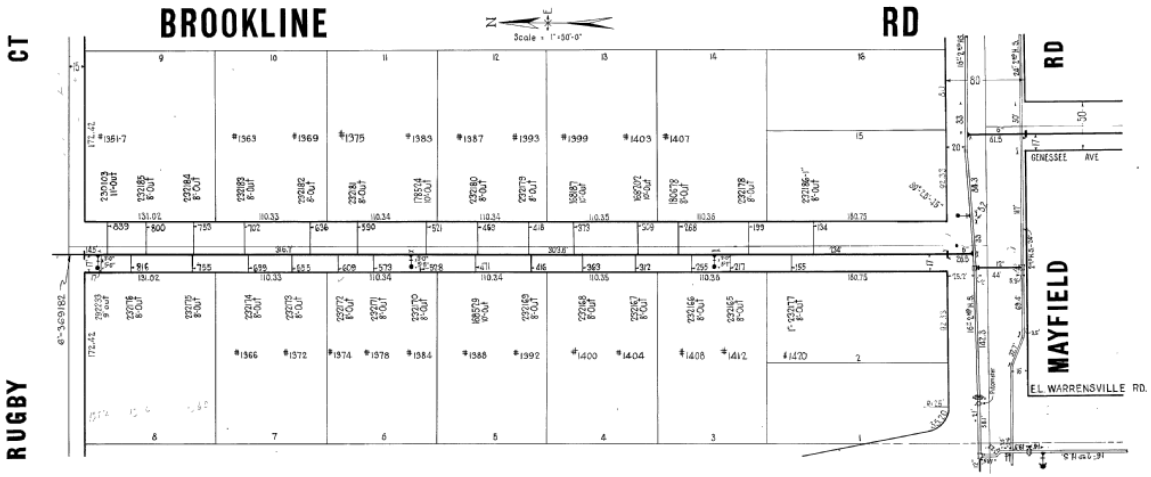
Traditionally, the aforementioned records were all compiled into two primary types of working records that have historically been used by our staff on a daily basis. These are:

- **Sections Sheets and**
- **Roll Maps**

Section Sheets were developed to show us the big picture. They consist of 126 sheets that created a picture of our entire distributing system. There are various versions of these maps but the most commonly utilized maps were 30" by 40", covering six square mile at a scale of 1" = 400'. Many copies of half size maps at 1" to 800' also exist. These maps show hydrants, valves, pipes (with diameters), and key facilities. These maps also show topological information such as contour lines and key elevations. It was the intent to compile all the edits to this map prior to the concept of the GIS, however, there were many copies of these and each owner (department) inevitably edited specific items without consideration of the long term implications.



Roll Maps show us detailed information regarding specific mains on specific streets. Roll Maps are at a Scale of 1" = 50'. They are called Roll Maps because they are rolled up and stored that way like a scroll with no folds. They have been used to compile all the detailed modifications in the distribution system based on as-built records. Roll Maps have been cataloged by map number as well as alphabetically by street name and have been scanned in and attached to a database for easy reference. They have been and still are used by both in-house and field staff for day-to-day operation. They contain dimensions between almost all relevant features. They include the location of each service lateral with dimensional reference to visible features such as hydrants and valves (valves boxes).



As with section sheets, there were many copies of roll maps throughout our organization. Each set includes approximately 11,000 maps varying in length from 2 feet to 25 feet. The Mapping Unit is the department responsible for making updates but since not all updates got to them, not all edits where compiled. However, different sections such as the maintenance department, out of necessity, made edits on their copy but selfishly, did not necessarily share this with the mapping unit. Another example unorthodox edits was in the case of our permitting section. When they sold a service lines, receipt information was jotted down on the map. This often at least gave the indication of the existence of connections while the primary copy showed nothing. Although, the intent was to have every edit centralized by our mapping unit, maps started to become less accurate. The following is a summarizing list of loopholes in our mapping process that lead to mapping discrepancies and inaccuracies.

- Maintenance crews' focus was on fixing water mains and often did not follow through with a sketch for the mapping unit. Furthermore,

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- For budgeting reasons, the mapping unit decreased in staff size through the years.

- On new main installations, CLEVELAND DIVISION OF WATER requires as-builts before we will chlorinate a water main. Often we did not strictly enforce this.

- Other water work projects did not require disinfection, thus CLEVELAND DIVISION OF WATER had no leverage in requiring as-builts.

- Major changes would become very laborious and pull drafters away from other, more routine edits.

A very important key feature of Roll Maps is the concept of the **service connections**. In general, service connections are the link between the distribution pipes and individual houses and buildings. Our Permitting section sells eight to ten services lines per day. Of course this fluctuates greatly over the course of the year and year by year but on average this leads to 8 – 10 maps/day being changed. These changes require making edits to hundreds of maps each year. It is by far the most dynamic component of the distribution system.

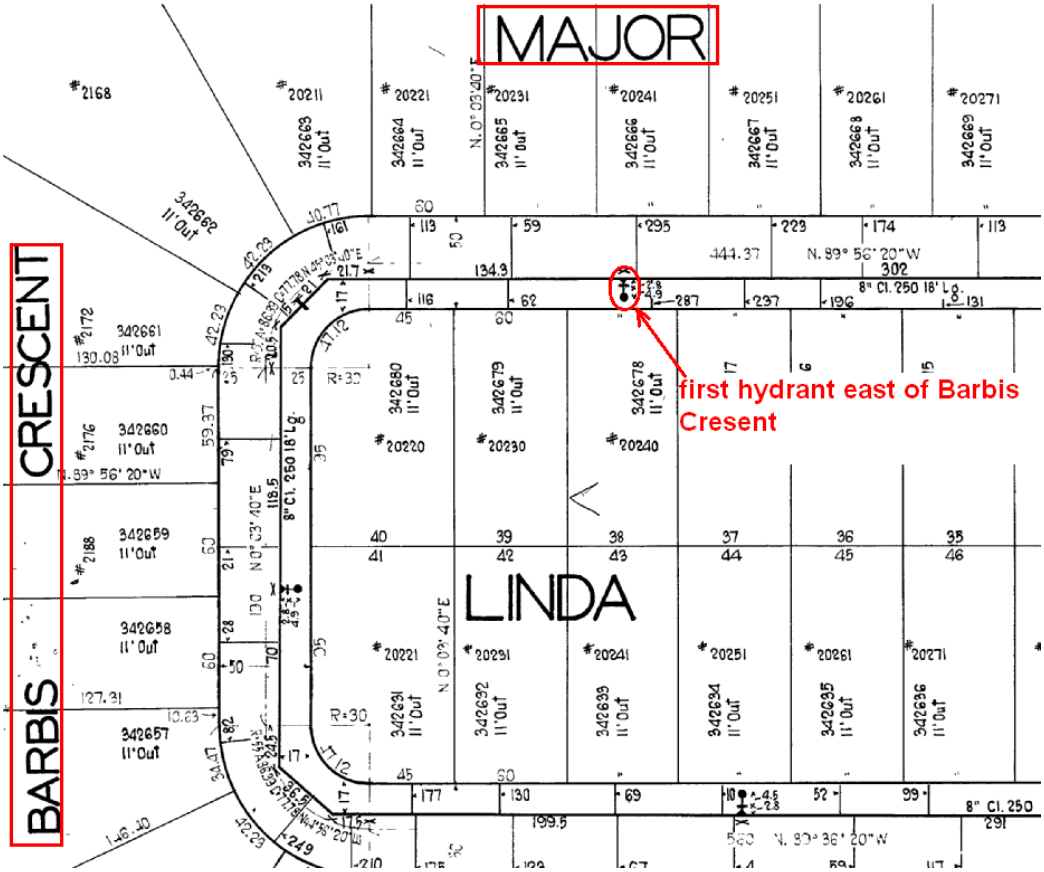
Historically, services lines were available in the following sources:

a. The connection cards.
b. The AS-400 (Billing system)
c. Rollmaps

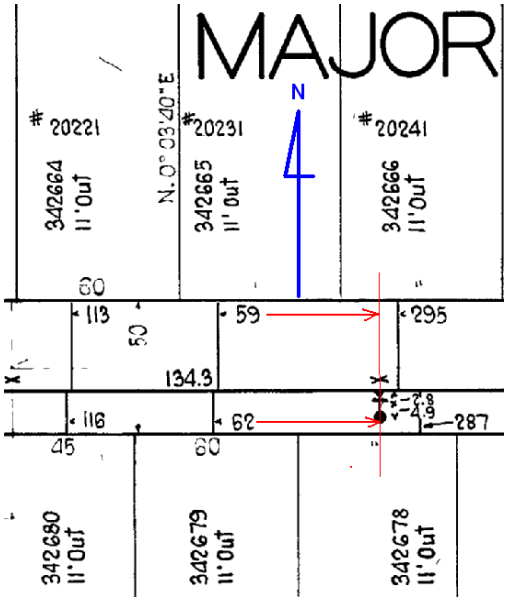
Connections Cards have been used by the Division of Water as a work management tool. Our organization charges a fee for new services which requires work to be performed jointly by our tapping crews and by private contractors. One of the traditional duties of our tap crews is to provide a measurement which is typically referenced form a hydrant but is sometimes referenced from less visible items such as valve boxes or a right-of-way line. An example of these descriptions is: ***On the North Side of Major Drive, 59 feet west of the first hydrant east of Barbis Cresent.***

But to make matters worse a common but not standard way of expressing this same information is: ***NS of Major Dr 59' WO 1st Hyd EO Barbis Cresent.***

The 2 images below correspond to the above textual descriptions.



The textual description refers to the connection on the North Side of Major Drive.



Connections cards are returned to the office where they are entered into the AS-400 billing system and then given to the mapping unit to update the roll map. This process was not properly managed for many years and consequentially our records became out of date.

A couple of issues to note are:

- Connection Cards did continue to get filled out and logged on to the billing system, even though many did not get onto maps.
- There is a fundamental problem with the method of referencing service lines from features that may move. If a hydrant is relocated or abandoned, all the connections referenced from that hydrant become inaccurate. Abandoning a hydrant can cause all the connections on a street to be come inaccurate because the "3rd" hydrant from an intersection may now become the "2nd" hydrant and so on. It takes very sharp field employees to figure out what happened in the past that make our records erroneous.

Given this information and knowledge of what potential levels of accuracy risk where associated with each source, a method was put in place to partially automate the process of drawing service connections during the data conversion process.

Over the last decade, the Division of Water began tracking all our plan reviews in a database designed internally by our staff. It links items such as projects, streets in which the projects are constructed, and contacts such as the designers, contractors, developers, and contract administrators. It has always been desirous to GIS enable this database so that we are capable of seeing the location of each of these projects to aid in coordination, conflict detections, and overall awareness of the impact of a project to our organization and the community. This same database provided useful information regarding newer projects where permanent as-built records were unavailable.

DATA CONVERSION

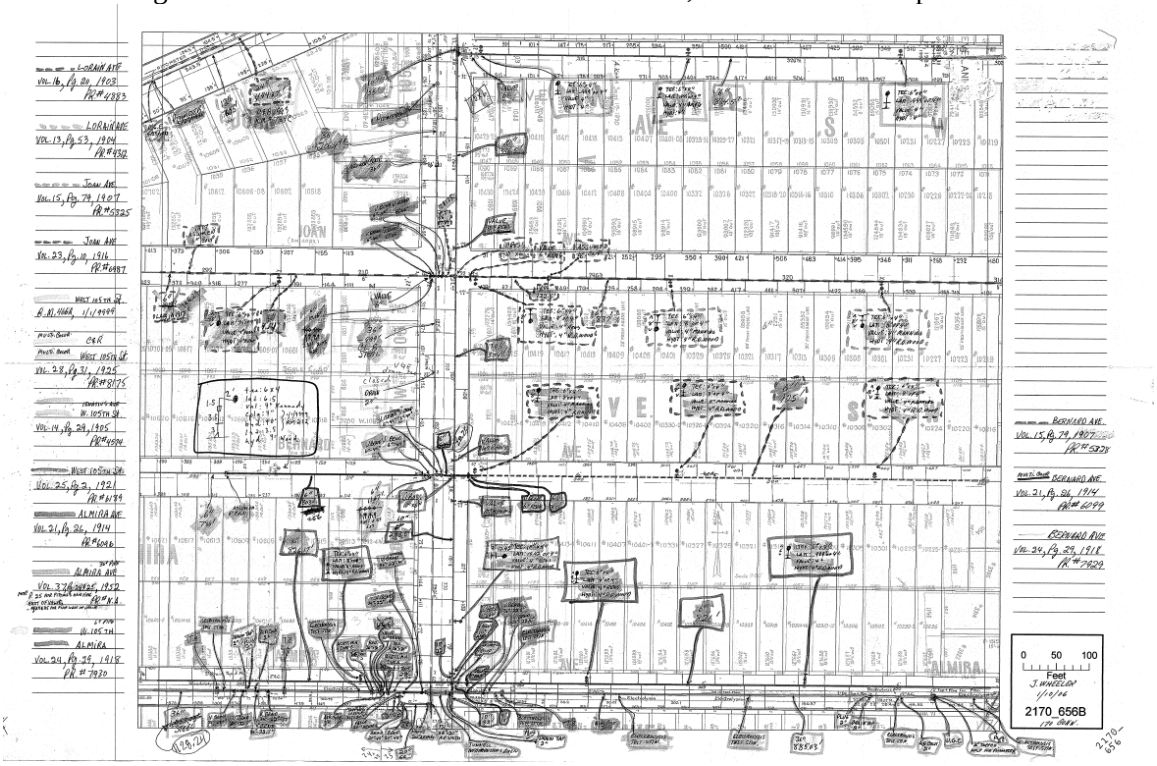
A fundamental and prevailing concept our Engineering department had regarding the GIS data is that it had to be:

- Accurate
- Dependable/reliable
- User friendly
- A system to keep the data up-to-date after initial data conversion.

To gain buy-in from both office and field staff, it was and is important that there is not a tendency to continue to use old records instead of using the GIS data. Providing access to our old records within the GIS is a good option as it introduces users to the easy of using the GIS and allows users to look at both the converted GIS data and the original record if there is a discrepancy. This concept was kept in mind throughout the data conversation process.

Data Scrubbing

After locating, cataloging and scanning in all the original source material it was necessary to bring all the relevant data into a common geographic location. Our service area was divided up into 319 equal grids known as Orthogrids. Each Orthogrid was further broken down into 9 "sub areas" and each sub area into 4 equal scrub plots. Thus, each orthogrid contained a total of 36 scrub plots such as the image below. The process of compiling all our records onto the scrub plots is known as the Scrubbing Process. Roll Maps were pieced together and used as the base map for putting together the "scrub plots". The Scrubbing Process entailed taking all the source documents and hand writing all the associated records information to prepare a document that can be used to digitize all the data. In total there were over 11,000 of these scrub plots.



These scrub plots contain the most comprehensive information related to our entire library of records and are the unified source of information for the digitizing technicians. A key concept is that every piece of pipe, valve, and hydrant has a project number associated with them that is a reference to the original project that installed them.

Each section of main was highlighted with it's corresponding record that impacted it. The technician needed to be mindful of the location of the main while collected the necessary attribute data. For example, a section of pipe has many attributes such as:

- Diameter
- Material Type
- Year of Installation
- Was the main rehabilitated/Cleaned and Lined?
- What year was it cleaned and lined, who was the contractor that installed it?
- Who was the contractor that cleaned and lined it?

All this and more was collected for every valve, hydrant, water main, and all other water appurtenances in our distribution system

Since these drawings are all scanned, the original source documents can be hyperlinked to the source ID of the features' attribute data. This is a valuable tool as it doubles as a document management system that is geographically searchable.

The scanned Roll Maps were all geo-referenced prior to creating the scrub plots. Georeferncing the roll maps created a seamless backdrop; a raster image of all 11,000 roll maps.

Digitizing

The next phase of the conversion process was to digitize the GIS data based on the pain staking record research. By this time, all aspects of the process have been converted to an electronic format so that any piece of information needed could be seen on a computer screen. The scrub plots were available as backdrops and heads up digitizing could be used to draw the pipes and place valves, hydrants, and all other water appurtenances. Some features were added by virtue of rules imposed upon the geographic data. For example, a 12" pipe could not connect to an 8" pipe without a 12" x 8" tee, a 12" by 8" tapping sleeve, or a 12" to 8" reducer/increaser if the connections were end to end.

The scrub plots had sections of pipe highlighted in colors to match the project source information on the plot ledger such that associating the pipe to the project that build it or rehabilitated it was obvious and easily accessible. When necessary to call up the actual as-built source for more detailed information or to clear up any inconsistencies the digitizers would do so.

Service lines where digitized last and since there are a half a million of them, we looked at options to automate the process. Service lines exist in a specific geographic locations and it is important that our organization knows exactly where each connections is. We shut off water service for non-payment, property side leaks, or when a customer requiring a backflow prevention device is not compliant with their annual testing requirements. The curb valves are the actual point that our staff must locate to make the shut.. Furthermore, the meters and backflow prevention devices, when applicable, are also located along the service line. Essentially the bulk

of the customer information is associated with the service connection and the items attached to the service connection.

There are no as-builts for service connections. As previously mentioned service line information was on our Roll Maps, original connection cards, and in our Billing System Database. The most accessible source of course was the data base. Data was extracted from our billing system into a file which was used to connect account information to a geographic location. Information used to make this connection include:

- Parcel number
- Address and zip code
- Location Description Field
- Connection Numbers

Parcel numbers are a good method of matching up account information with a geographic location since parcel numbers are unique. However, since parcel number was not a mandatory field carried by the billing system, not all accounts had one associated. Were a parcel number existed; account point was placed in the centroid of the parcel.

When a parcel number was not available the address and zip code was used to geocode the account point. Lastly, parsing of the textual description was another method used to locate account points. In theory this would be the most accurate placement, but this round of population was simply done to place an account point in a location in close proximity to the connection location. Not necessarily in it's geographically correct location.

Using custom tools, many of which persist in our maintenance application, digitizers, would use the Roll Map images as backdrops and pre-loaded data to enter distances referenced from features as shown on the Roll Maps. Data in the account points would then get associated with the connection. Each connection has a unique connection number. Connection numbers were also a primary data field in our billing system making the data joins between these two features a rather straightforward process.

Data Maintenance

Water Infrastructure is dynamic. New water mains are constructed every day. Water mains are lowered or relocated as other utilities come into conflict with them or when roads are relocated. Water mains are replaced as they approach the end of their useful life. Other water infrastructure such as hydrants and valves are repaired or replaced daily. New service lines are installed as new homes and buildings are constructed. The investment to convert data to a geographic information system will be for not if data is not maintained.

It was identified early in the project that we had a need for a user friendly but robust data editing and maintenance application that will enforce rules but be flexible enough to mirror actual field practices. The following section describes our methodology in selecting our data maintenance solution as well as the benefits we believe it will provide to the integrity of our data.

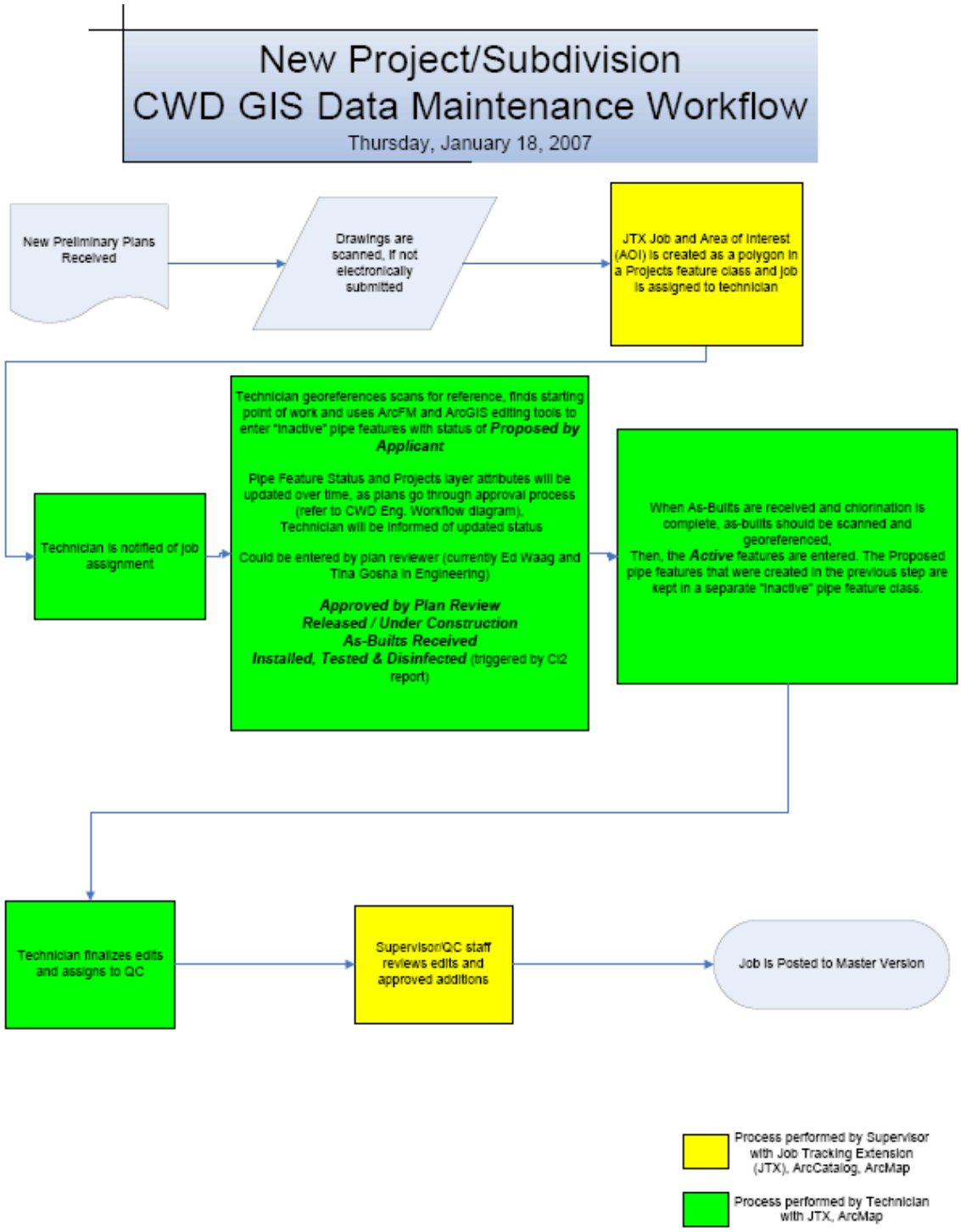


Figure XXXX- Data Maintenance Workflow For New Water Main Installation

Project Type --->	Dist. Main New Installation	TM New Installation	WM Replacement	Cleaning and Lining	Road Widening	Road Reconstruction	Sewer Projects	WM Lowerings	Add Connection	Install Master Meter
Cut-In Tee Tool	X		X	X	X	X	X			
Hydrant Install Tool	X		X	X			X	X		
Reducer/Increaser Tool	X	X	X	X				X		
Spool Piece Tool	X		X	X			X			
Cut-In Valve Tool	X	X	X	X			X	X		
Regulator Assembly Tool	X		X							
Flush Pipe Assembly Tool	X		X				X			
Hydrant Extend Tool					X	X				
Connection Extend Tool					X	X				
Connection Replacement/ Re-Tap/ Re-Connect Tool			X	X	X	X		X		
Lowering Tool		X			X	X	X	X		
New Connection Tool	X								X	
New Supply Main Toolset	X									
New Trunk Main Toolset		X								
Install Horizontal Bend Tool	X	X	X	X			X			
Install Meter Tool	X								X	
Install Master Meter Tool										X
Relocate Meter Tool (move vaults or meters in houses)					X	X				
Install Thrust Block Tool (automated with user options)	X	X	X	X				X		

X - This Tool will most likely be used for entering GIS data for this type of work
X - This Tool may occasionally be used for entering GIS data for this type of work

Figure XXXX- Matrix of Functionality Needs

Data Maintenance Solution for the Division of Water

Several pieces of software make up the data maintenance solution for the Division of Water. They include Telvent Miner & Miner's ArcFM extension and the ESRI Job Tracking Extension (JTX) on top of ArcInfo, as well as some custom coded tools. Typical edits can be made efficiently by technicians using ESRI's editing tools in ArcInfo with the added capabilities of ArcFM. JTX provides a framework for the maintenance process and a method for tracking job progress. The exchange of data between the GIS and other CWD information systems is also key to the solution.

ArcFM

There are many efficiency gains available to a technician digitizing a water main project with ArcFM. ArcFM's attribute editor allows the user to store attribute information for features so that they may be reused without re-keying them in. This occurs frequently on water distribution projects where size, material and manufacturer is the same for many pipes in the project. If the size, material and manufacturer may occur again on another project, the technician can save that pipe and it's characteristics as an ArcFM favorite, so that it can be used again. When a technician

uses a favorite, the attributes for size, material and manufacturer will already be entered, so the only task for the user is to place the pipe.

Two other related features of the software are ArcFM composite favorites and template favorites. The composite favorite is a group of features that all get placed with one click. Each of the features can have attributes pre-loaded so that the technician does not have to key them in. A good example is a pressure regulator. Each pressure reducing valve is placed in the distribution system with a bypass valve, strainer, and other line valves and fittings. All of these appurtenances have standardized sizes. The pipe dimensions are also standardized. Since this is the case, the technician can make a single click on the end of a pipe and place an entire regulator assembly with all of its components and their attributes rather than having to enter each component one-by-one.

Template favorites work well for assemblies that have the same components in each case, but may have different dimensions between components. Hydrant assemblies are entered using an ArcFM template favorite. A technician will click on the pipe where the hydrant tee is cut-in, then click where the hydrant branch valve is located, click where there is a bend in the hydrant branch pipe, and finally where the hydrant barrel is located. Again, all attributes for each component can be pre-loaded or the user can key them in during placement if necessary. Since hydrants are regularly placed on nearly every water main project, this is a time saver.

ArcFM auto-updaters apply for every feature created in the CWD GIS. With ArcFM auto-updaters, the user does not have to enter unique ID values, or attributes such as CREATED_DATE or CREATED_BY. With some configuration, ArcFM automatically updates these values when a feature is created. The ID values can come from an Oracle Sequence, the date and user name can be taken from the operating system.

ESRI Job Tracking Extension (JTX)

The ESRI Job Tracking Extension (JTX) is a workflow management tool that simplifies production for managers and technicians. For each type of project that results in changes in the water distribution system, a GIS data maintenance workflow can be set up in JTX. JTX uses a straight-forward flowchart view to display process steps. The workflow for a typical data maintenance activity is (a) manager assigns job to technician, (b) source drawing is georeferenced by technician, (c) technician uses ArcInfo, ArcFM and custom tools to digitize work, (d) work is checked, (e) new data is posted to Default version and available to all users reading the GIS data.

JTX is highly customizable. Users can configure different status values for projects, setup automatic e-mail notification when a project step is complete, automatically create versions for editing, and set an area-of-interest polygon for the project which is saved in the geodatabase. JTX can timestamp essentially every action that is taken by a user on a data maintenance project. This detailed reporting allows managers to monitor productivity and provide information to executives or clients regarding work tasks and their durations.

The data maintenance workflows were developed in JTX 3.0.1 and have been tested in a development environment, but are not in production currently. JTX 4.0 is due to be released at the same time as ArcGIS 9.3, so the implementation of JTX has been put on hold until then.

Other CWD Information Systems

An obvious benefit to having a GIS is the ability to relate the features in the map space to data in other systems with associated information.

In each system at CWD, there is a key field which ties a feature in the GIS to a record or group of records in the non-spatial database. For customer information, the key field is the service connection ID. In work management and permitting, the key field is the a parcel number.

Using database joins, much of the information stored in these systems becomes accessible to the GIS user. Questions about customer accounts or recent repair work in an area can be quickly determined straight from the user's desktop without opening multiple programs.

Since the address is so important to many of these systems, CWD is working with a consultant to develop an address verification web service that can be used to validate addresses and intersections that are entered in the customer information database, work management system, and permit system. Better addresses lead to better matches to the address point and parcel data in the GIS. By verifying the entry, the web service will essentially eliminate multiple names being entered for the same street (for example: East 9th, E 9th, E. 9, E. 9th).

Current Status of CWD Data Maintenance Solution

The GIS staff is currently updating water data using ArcFM and ArcGIS. As of June 1, 2008, there is a backlog of approximately 100 water main installation projects which occurred after the beginning of the data conversion project, which started in 2003. Three technicians are digitizing the mains and all of their appurtenances using ArcFM and ArcGIS. ArcFM auto-updaters are populating unique identifiers and user and timestamp data. Hydrant assemblies and pressure regulators are being placed using ArcFM favorites. As mentioned above, the ESRI Job Tracking Extension (JTX) will be implemented upon the release of ArcGIS 9.3. For now, maintenance jobs are assigned by the manager and checked and posted after digitizing is complete.

Custom tools are under development for more complex editing. The service connection assembly includes components like meter, curb valve, and others. Data from a separate database table is used to determine component placement and attribute population. This is a case that could not easily be implemented with ArcFM favorites. Another such case is viewing and editing information about makes and models of pipes, valves, and other infrastructure which reside in multiple related tables. While the user could join tables or open several attribute table windows at once to view the related data, a custom tool which shows all the information the user needs in one form will simplify the process.

The CWD Engineering Department and CeGIS have been working with a consultant to develop a CAD standard for as-built drawings which are submitted by contractors after installation is complete. The standard was designed with CAD to GIS conversion in mind. The standard has not yet been finalized, but test drawings have been converted to GIS to verify that the layer properties and block attributes from CAD could be translated to attributes on the feature classes appropriately.

Finally, the process for getting field work edits needs to be streamlined. Currently, significant in-house field work and repairs are drawn up on a field sketch which is sent to the Mapping Unit so that maps can be updated. Field sketches will be also be sent to the GIS group. Many times, a

field sketch is not developed for emergency situations or smaller jobs like valve or leak repairs. In the coming months, CeGIS and CWD departments will be working on developing a process for determining which types of field work should be identified for updates in the GIS. The result will be a method to pass sufficient information from work management system, supplemented by additional notes from crew foremen, on to the GIS group for making the data as current as possible.

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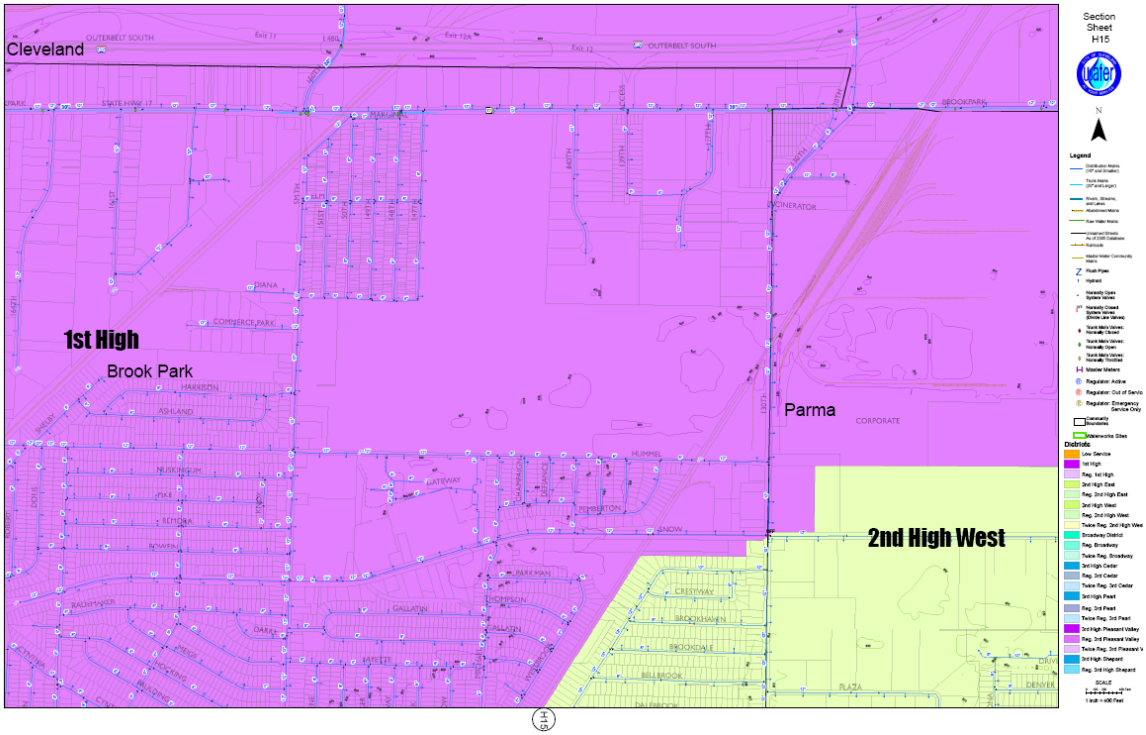
Through our history, we installed or oversaw the installation of thousands of miles of pipes to the point were now our system contains over 50,000 miles (a quarter of a billion feet) of pipe. In addition to the new mains installed, many mains were replaced, upsized, cleaned and lined, relocated, lowered, raised, repaired or abandoned. It is of extreme importance to track and all these changes and edit your records accordingly. Some aspects of water maps are very static and others are very dynamic. Although buried pipe doesn't change often, our maps do change every time we make a new service tap. This happens on the average of about 5 to 6 times a day!


Cleveland
1st High
Brook Park
Parma
2nd High West
Section
Sheet
H15
H15