Wastewater Management with a Digital Twist

Conquering the deficiencies of field data collection.

Abstract

Nested within the typical scope of wastewater infrastructure management lies the hurdle of data transfer. We increasingly rely on the various crews of our authority to collect specific system data, and deliver it to administrative personnel. Due to escalating regulatory requirements, our authority has begun a venture to create a seamless transition between field data acquisition and end user format. Utilizing ArcPad and ArcPad Studio 6.0, we are creating custom forms, which allow field personnel to record their findings in great detail. This information is then updated daily into our ArcGIS database for immediate use by internal decision-makers.

Introduction

Over the past several years wastewater treatment facilities have come under increased scrutiny in Western Pennsylvania. Tighter regulations, increased inflow and infiltration (I/I) abatement, and the need to understand system capacity and hydraulics have all led to a greater demand for more accurate and efficient field data. The major cause for the heightened study comes from the limiting factor of system capacity routinely stretched during every rainfall, mainly due to I/I and illegal drainage connections. The Authorities of these facilities bear the responsibility to provide this system understanding in order to meet both the state regulations and the federal mandates.

The McCandless Township Sanitary Authority (MTSA), located in Western Pennsylvania, is one of these authorities who have come to grips with their responsibilities. Working closely with their consulting engineer, Buchart-Horn, Inc. (BH), MTSA has worked to develop and employ several innovative and cutting edge GIS tools that enable them to more accurately inspect and define their system characteristics. The purpose of this paper is to highlight the development of one of those creative solutions for handheld field data collection. This project is a cost and time efficient solution for testing illegal drain connections entering the Authority's system. The paper showcases the progress of one Authority's innovations in complying with strict regulations and their incorporation of GIS technologies to achieve this goal.

Background

The McCandless Township Sanitary Authority was incorporated on December 30, 1955 for the purpose of providing sewage service for the Town of McCandless. In the early 1970's Franklin Park Borough, Bradford Woods Borough, Pine Township, Marshall Township and minor portions of Ross and Hampton Townships agreed to have properties in the Pine Creek watershed, within the aforementioned municipalities, served by the Authority. Currently the Authority services approximately 15,000 accounts consisting of approximately 52,000 customers. Our customers include residential, commercial, schools, colleges and hospitals. The Authority owns and operates a comprehensive sanitary sewer divided into five collection systems with four treatment plants, sixteen pumping stations and 350 miles of 8" to 42" gravity sewer.

A Sanitary Authority Defined in Respect to Technological Innovation

The operations of many sanitary authorities encompass the following functions and obligations:

- Conveyance: The infrastructure of an authority is where most of the problems and conflict with regulatory agencies arise. The extreme recent push has been to eliminate inflow and infiltration from systems through a variety of methods. The solutions in this paper deal with 2 methods of elimination in an automated fashion, I/I elimination from manholes and I/I elimination from illegally connected building rain leaders.
- Treatment: Most sanitary operations have at least one sewage treatment plant to handle the areas it serves. Treatment plants tend to be controlled environments that are equipped to deal with changing biological influent. As the conditions within the plant change with the weather, adjustments can be made within the plant to accommodate the chemical/biological demands. One thing the plants can't control is excessive contribution.
- Administration: To maintain both the physical operations, a solid proactive management team must lead the way. The ideal team must be positioned to deal with regulatory changes on the horizon. The team must embrace the latest technologies available to efficiently manage increasing demands with a thinning financial support base.
- Financial Responsibility: The administration of any authority must ensure all capital expenditures are justifiable. Funds spent must not only provide for present solvency, but should also allow for efficiency of future operations, anticipated sustainability, and regulatory compliance. One of the best ways to accomplish this is through the implementation of sound technological advancements.
- Regulatory Compliance: Required regulatory compliance of an authority drives all the above functions. The steering hand of regulatory agencies will define the future of the wastewater industry. Acknowledging this fact allows authorities to proactively plan for future operations in an efficient manor that includes sound financial investments, stable growth with increased service area acquisition, and compliance with the letter and the spirit of the law. All of this and much more can be accomplished through the implementation of a multifaceted GIS program.

GIS System

MTSA currently has two ArcGIS 8.x workstations. The GIS system houses all necessary spatial information for the entire service area. Information includes manholes, sewer lines, houses, property parcel lines, streets, hydrology, boundaries of service areas, and contours. An active push is in progress to populate the GIS database with property parcel lot and block numbers. These IDs are the common unifying language for Allegheny County. In anticipation of a future watershed approach the lot and block numbers will be the common language to all communities, and prove most beneficial to linking an effective GIS program.

The Authority also has a licensed stand alone differential correction GPS base-station, allowing for precise plotting of all structure points within our service area. The development department employs a pack worn GPS unit and captures the manhole point structures as new housing developments are constructed. The combination of an in-house base-station with GPS capabilities provides a powerful and cost effective tool for continually updating the Authority's GIS system.

Some current GIS uses include; daily maintenance direction maps, generated every morning for the various work crews, maps with specifically queried attributes used for field inspections, one-call system acknowledgments, system upgrades, line replacements, flow studies, hydrologic studies, capacity evaluation, CCTV scheduling, cleaning operations, dye testing, and manhole inspections.

Dye Testing Defined

A large amount of water is contributed to a sanitary sewer system through downspouts and area drains connected to the Authority's collection system. During initial sewer installation in the late 50's, a common practice to eliminate rain run-off was to tie in house gutters with the sanitary sewer. The sanitary sewer system would inevitably overflow during a significant rain event, dumping large quantities of untreated sewage into the areas streams and rivers.

Direct elimination of precipitation run-off contribution to a sanitary system can be achieved through an aggressive dye-testing program. Through this program the Authority employs two crews equipped with dye test spraying outfit and two 500 gallon water tanks. The water carried in these tanks will dye test approximately five houses. Arrangements have been made with a local fire company to refill the tanks during the day, as needed. MTSA has installed a water meter at the refill facility to aid in monetary reimbursement. The trucks were purchased through the Federal Surplus Program, and fitted in-house with flatbed bodies. All in-house work was completed during the winter months to defer employee layoff and provided a cost efficient means of conducting necessary field inspections.

MTSA has performed in excess of 3,600 dye tests since starting in 1998. Most of the compiled data over the past five years has been entered manually into the GIS system and scanned in JPEG format into a standalone database. Gaining access to these records is both time consuming and highly unreliable.

Purpose

In March 2003, BH was retained by MTSA to create an automated field data management system. The system would associate some of the Authority's field operations directly with tasks performed in their offices. There are a number of cases where the Authority could be more efficient and save time and money by eliminating the transfer of paper work and the redundant entering of information. The historical trail of dye test information and manhole inspection forms has been plagued with data entry inaccuracies and increased data management. The entire process was contingent upon personnel efficiency and individual interpretation of inspection data. MTSA was interested in employing the use of handheld computers in the field to collect inspection data and then deploy that information into their existing GIS. BH's role was to develop an effective means of capturing the interested field information, minimize error in data duplication, and automate the transfer of data across the GIS system. Accomplishing these tasks would enable the Authority to efficiently store, query, and report their field investigations with confidence.

Key Project Goals

- Design a Dye Test Data Management System incorporating a handheld CE device to link data acquisition in the field to the automated entry of information into a master database for use in letter notification and report generation.
- Select Hardware and Software compatible with the current Data Management System that would utilize current GIS and database software.
- Develop a database that will function as the master database for dye testing data, eliminating stand-alone storage.
- Develop a customized GIS project for the handheld and desktop computers to be used for data collection and analysis.

Methodology

Initially the management structure for the Authority's Dye Test inspections was centered on the Senior Inspector creating paper map books and forms for the field crews to use. Once the field inspections were complete, the paper information was transferred through several internal channels and eventually stored as scanned JPEGs in a stand alone database. As you can see in Figure 1, the structure allowed for redundancy, duplication of tasks, and inefficient production.

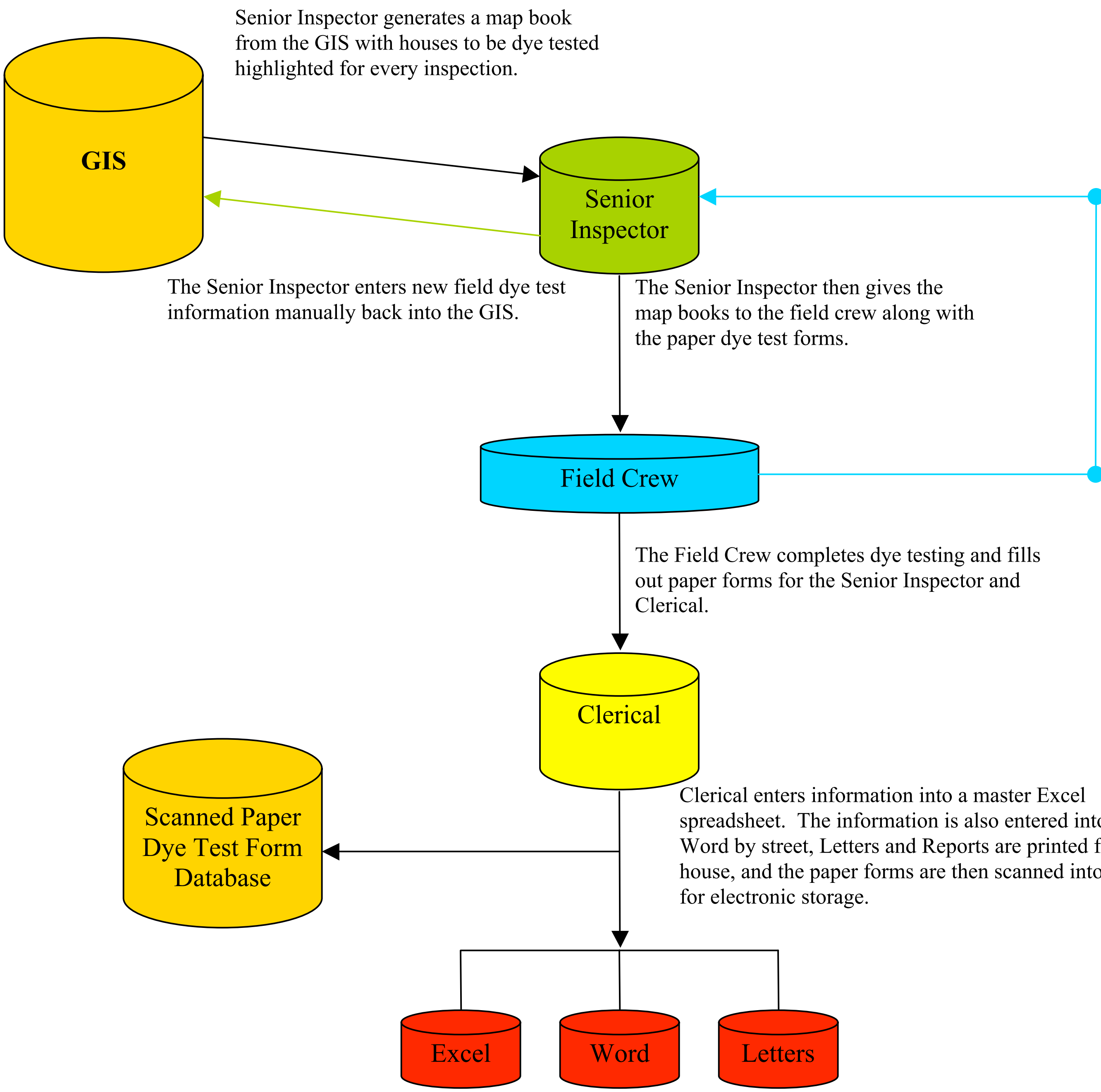
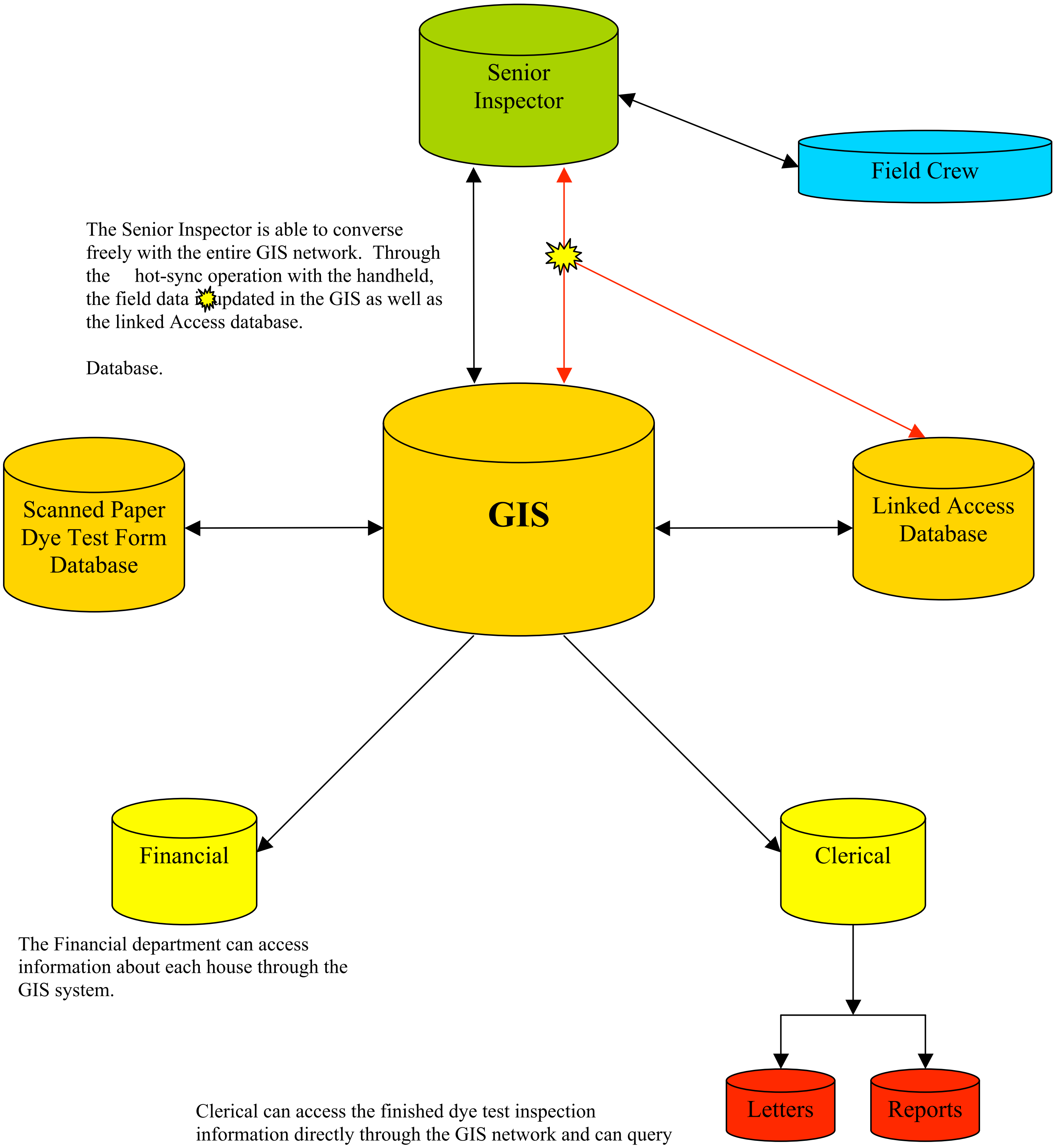


Figure 1: Original MTSA Dye Test management structure

After reviewing the current field management system, BH was able to develop a more efficient solution utilizing the power and flexibility of the GIS system as the management focal point. The success of the Dye Test Data Management System relies on a structured tree of information and data transfer beginning with the GIS system, as modeled in Figure 2 below.

The Senior Inspector creates customized



The Senior Inspector is able to converse freely with the entire GIS network. Through the hot-sync operation with the handheld, the field data updated in the GIS as well as the linked Access database.

Database.

The Financial department can access information about each house through the GIS system.

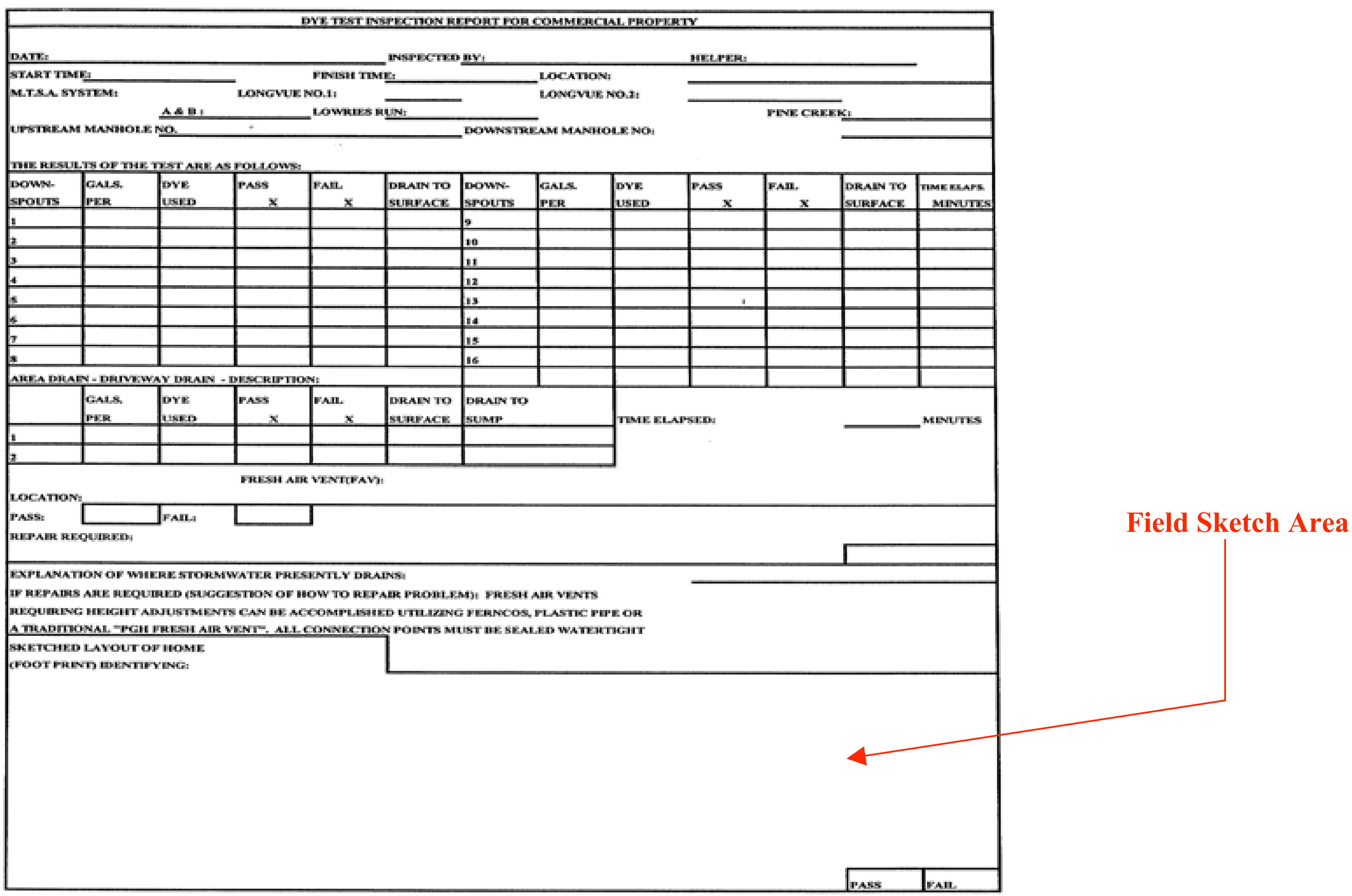
Clerical can access the finished dye test inspection information directly through the GIS network and can query the database, print reports, and print letters to homeowners.

Figure 2: **New Dye Test Management System developed by BH**

The new system is entirely GIS driven, relying heavily on querying, editing, and spatial representation. The overall system dynamics have shifted from using paper entry forms to utilizing a central GIS network for creation and deployment of field activities.

Original Dye Test Inspection Program

The initial methodology for the Authority's Dye Test inspections relied on entering information onto a paper dye test inspection report.



DYE TEST INSPECTION REPORT FOR COMMERCIAL PROPERTY

DATE: ______ INSPECTED BY: ______ HELPER: ______
START TIME: ______ FINISH TIME: ______ LOCATION: ______
M.T.S.A. SYSTEM: LONGVUE NO.1: ______ LONGVUE NO.2: ______
A & B : ______ LOWRIES RUN: ______ PINE CREEK: ______
UPSTREAM MANHOLE NO. ______ DOWNSTREAM MANHOLE NO: ______

THE RESULTS OF THE TEST ARE AS FOLLOWS:

DOWN-SPOUTS	GALS. PER	DYE USED	PASS X	FAIL X	DRAIN TO SURFACE	DOWN-SPOUTS	GALS. PER	DYE USED	PASS X	FAIL X	DRAIN TO SURFACE	TIME ELAPS. MINUTES
1						9						
2						10						
3						11						
4						12						
5						13						
6						14						
7						15						
8						16						

AREA DRAIN - DRIVEWAY DRAIN - DESCRIPTION:

	GALS. PER	DYE USED	PASS X	FAIL X	DRAIN TO SURFACE	DRAIN TO SUMP
1						
2						

TIME ELAPSED: ______ MINUTES

FRESH AIR VENT(FAV):

LOCATION: ______

PASS: ☐ FAIL: ☐

REPAIR REQUIRED:

EXPLANATION OF WHERE STORMWATER PRESENTLY DRAINS:

IF REPAIRS ARE REQUIRED (SUGGESTION OF HOW TO REPAIR PROBLEM): FRESH AIR VENTS REQUIRING HEIGHT ADJUSTMENTS CAN BE ACCOMPLISHED UTILIZING FERNCOS, PLASTIC PIPE OR A TRADITIONAL "PGH FRESH AIR VENT". ALL CONNECTION POINTS MUST BE SEALED WATERTIGHT

SKETCHED LAYOUT OF HOME (FOOT PRINT) IDENTIFYING:

PASS FAIL

Figure 3: **Paper form for Dye Test inspection**

This report contained all the necessary variables needed for each inspection, along with an area for a field sketch. The field sketch provides a detailed location map showing where the downspout(s), area drain(s), and fresh air vent is located. The sketch plays an integral part in the inspection and analysis of the Authority's system by displaying where certain connections are and what part of the system they connect to. Providing for a sketch in the new Dye

Test Management System was critical and ultimately shaped the design through a GIS solution as opposed to a stand-alone form based platform with a supplemental drawing tool for the sketch.

New Dye Test Management System - Handheld Application

The new Dye Test inspection program begins in ArcPad with five customized ArcPad projects, representative of each collection system within the MTSA service area as seen in Figure 4.

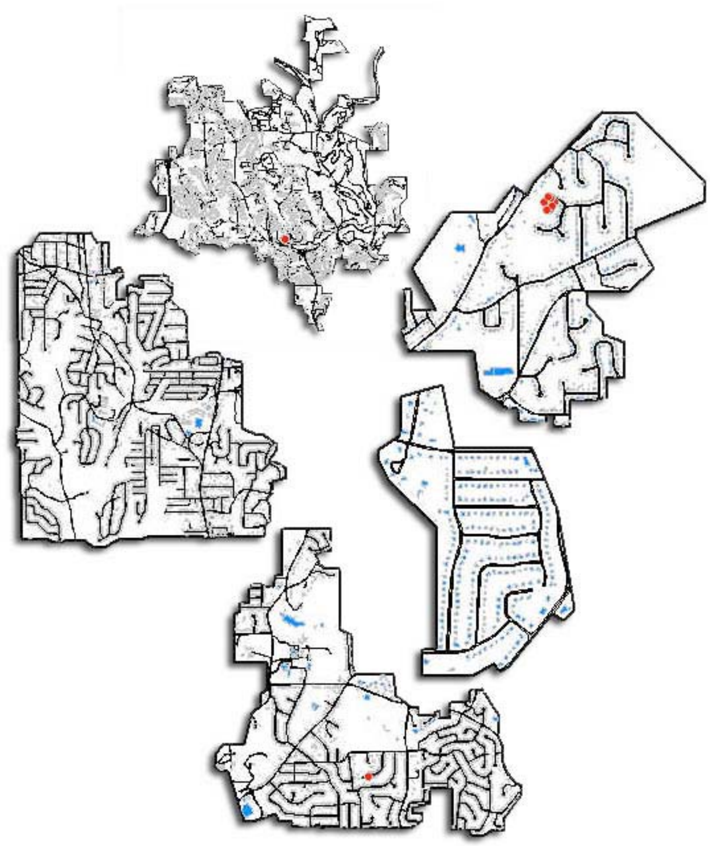


Figure 4: 5 Collection Systems within MTSA Service Area

The inspection process starts in ArcPad on the desktop with the Senior Inspector selecting those houses to be dye tested and creating bookmarks at each dye test location. These bookmarks are stored automatically with each specialized project and are hot-synced through the desktop onto the handheld when inspections are to begin.

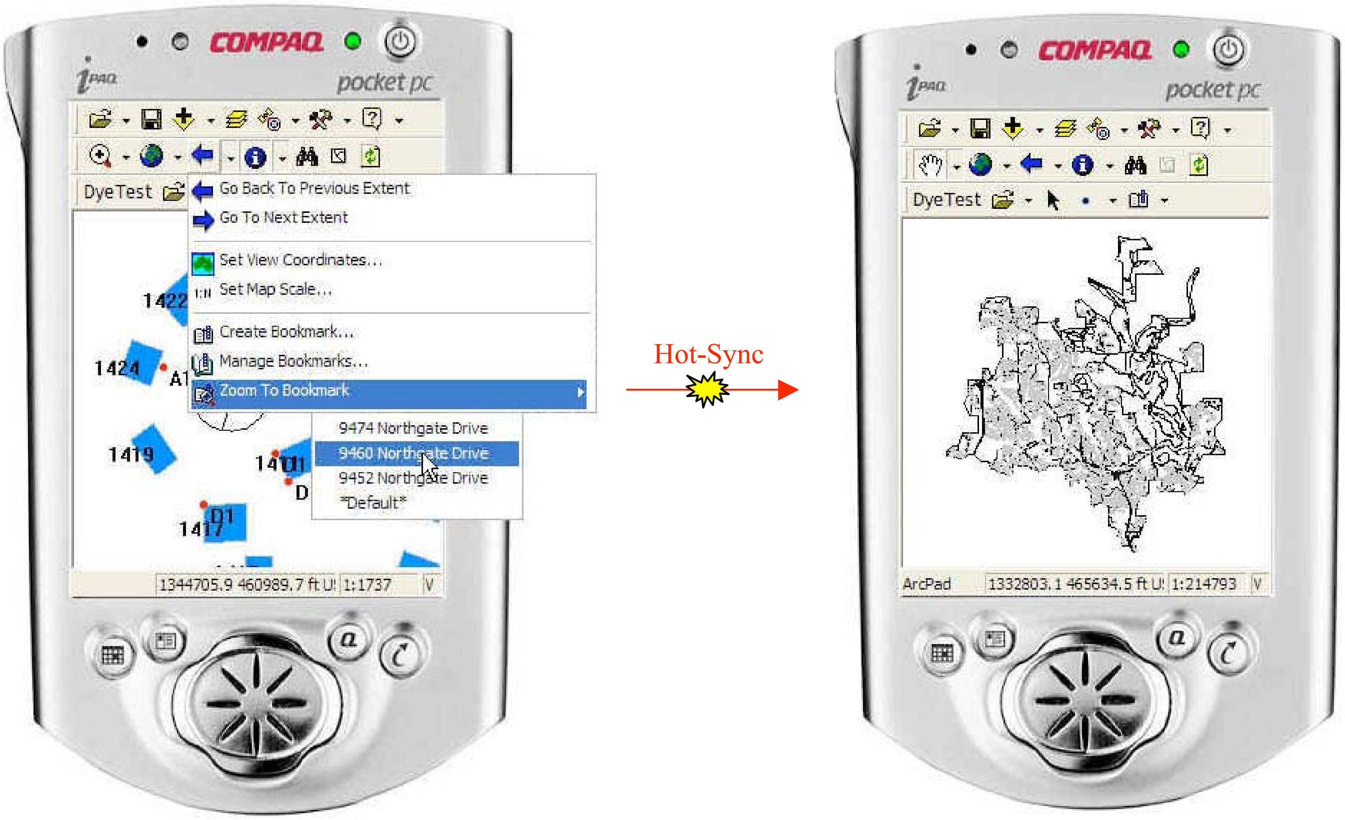


Figure 5: ArcPad project with Dye Test Bookmarks Hot-Synced into the Handheld

While in the field the inspection crews can move from house to house via the bookmarks within each project. Once the crew arrives at the house, the inspection begins by locating the fresh air vent, the downspout(s), and finally the area drain(s). Each is tested with colored dye and water to demonstrate where a connection may be. The crew marks each of these locations by creating a point shapefile "on the fly." These features are added into a system specific point shapefile every time a variable is located. When the location is entered a unique EDIT form appears with specific drop-down menus for data entry. Being able to harness the flexibility of data capture in the field through the use of customized forms with unique drop-down menus significantly reduces inspection error and provides a higher confidence in the Authority's quantitative data.

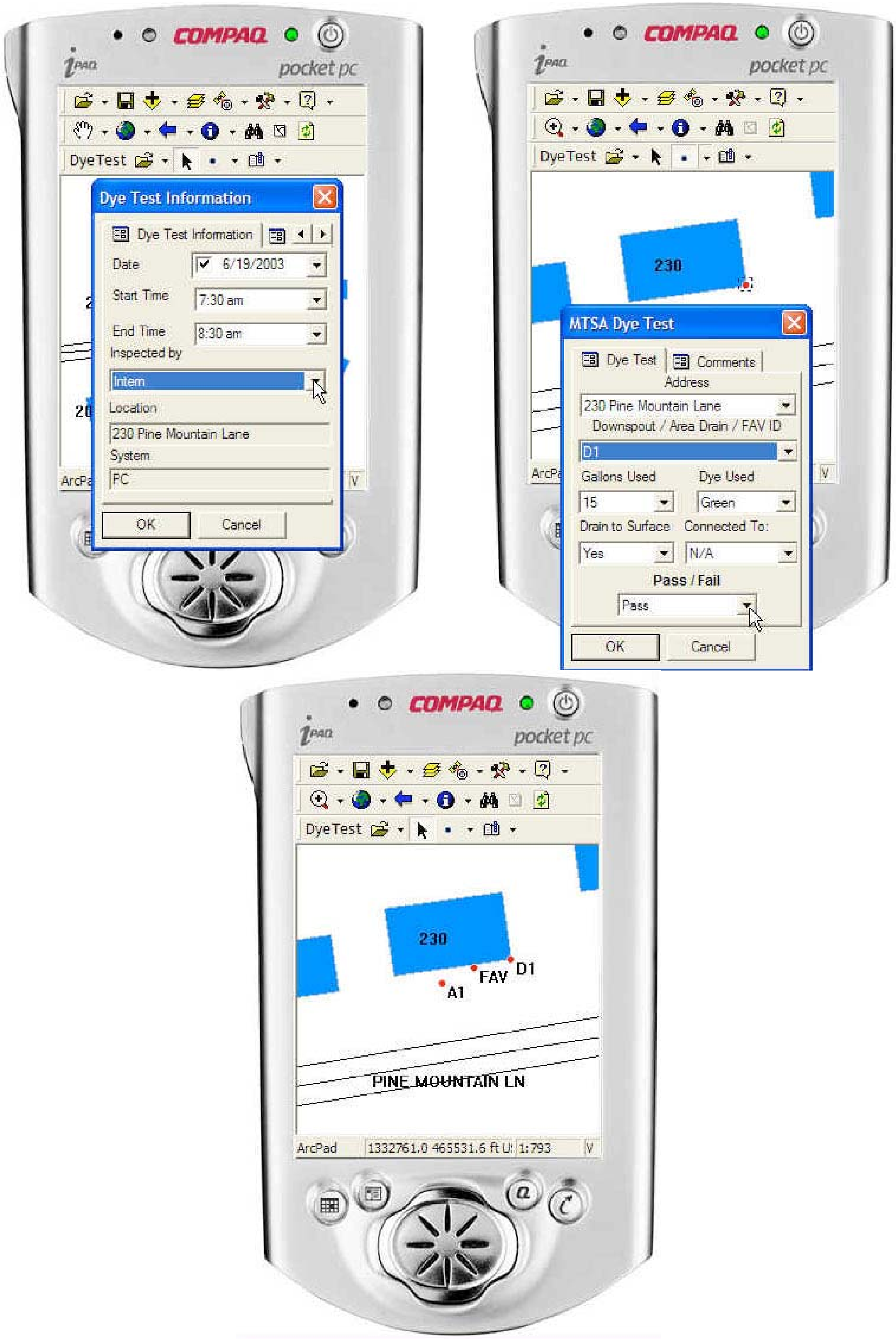


Figure 6: **Customized Project EDIT forms with Specific Drop-Down Menus**

After all the field data is collected, the handheld is brought back into the office where it is again synced with the desktop. At this point the data is automatically updated in both the GIS and Access database systems. It is important to remember that the point locations and the houses are tied not only spatially but also by address in the attribute table. This is a crucial link which enables querying and printing of reports specific to each house. The final step for the Senior Inspector involves the creation of the field sketches, or sketch maps, for use in the Dye Test Inspection Report. This is accomplished by using the Find utility in ArcMap to zoom to the inspected houses, by way of their addresses, and exporting a JPEG into a standard folder location on the desktop. The export utility is accomplished through a customized export toolbar. Once this operation is complete, the inspection is concluded and the GIS and Access database is fully functional. From here the databases can be queried, reports can be printed, and the letters of notification for those houses that pass or fail the inspection can be automatically generated from an entry screen in Access.

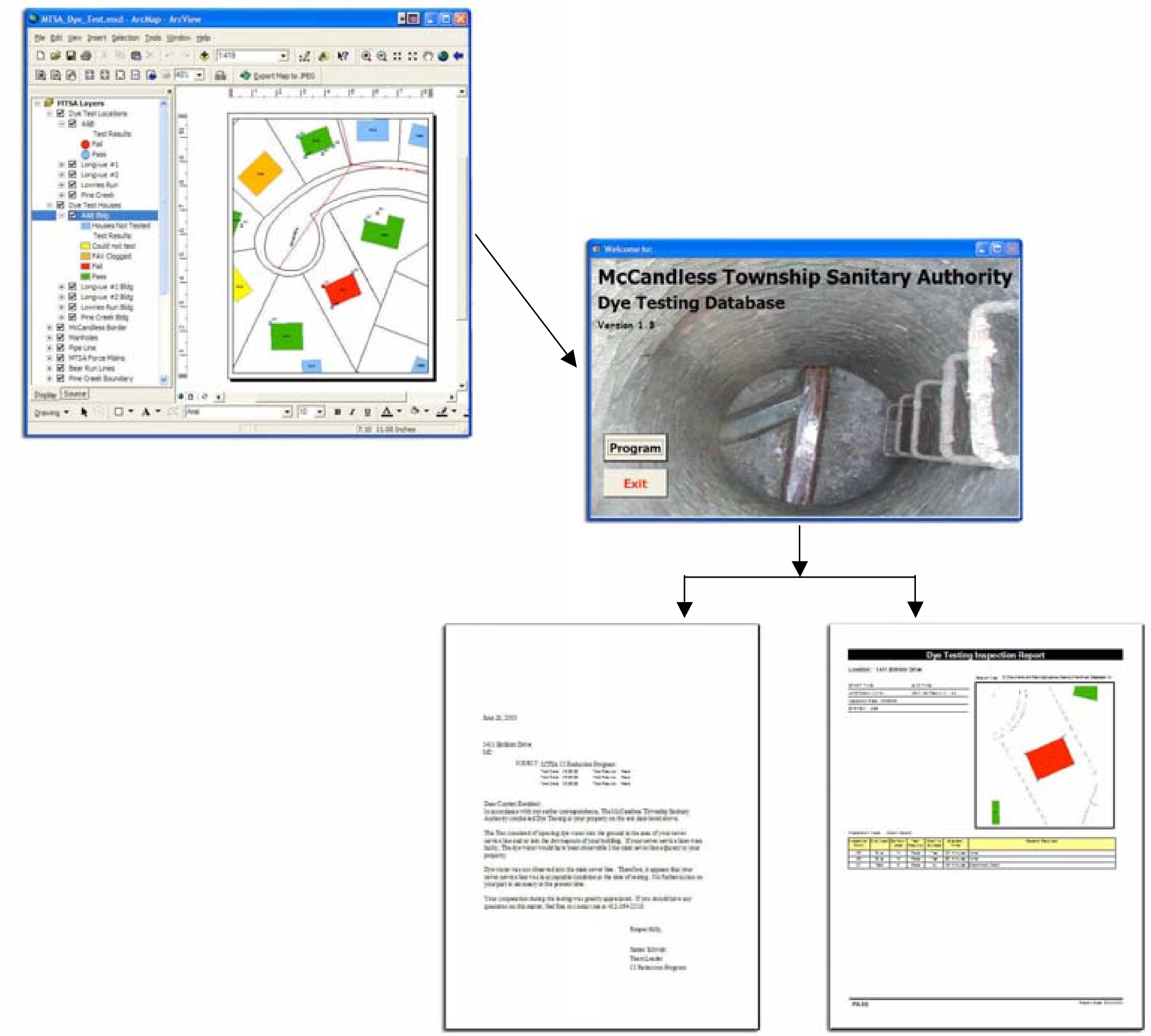


Figure 7: ArcMap Project with customized Access database showing report and letter writing

Conclusion

The newly created Dye Test Management System will serve as a model for how future GIS applications are designed and utilized within the MTSA system. During an era of increasing regulatory mandates and tighter system controls, wastewater management authorities will continually rely on cost effective solutions for complying with each new regulation and mandate. MTSA has plans already to increase their effectiveness even more, by moving to a central server geodatabase network. By doing so they would be able to readily handle any service area expansion and incorporate new systems and customers timely and efficiently. The Authority's utilization of best management practices and current GIS technologies push them continually further along the cutting edge of wastewater management.

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