Emergency Response Runbook:
The Importance of Consistent Street Addressing Methods

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Abstract

The Poudre Fire Authority (PFA) and the City of Fort Collins GIS are working together to create and maintain a system that will dynamically generate a runbook to be used in emergency response vehicles. The runbooks are a very important reference for adequate emergency response.

The primary challenge encountered is to overcome different methodologies of address reporting, creating, and updating from different local government agencies. Secondary challenges included; developing a method to use feature linked annotations in runbook map pages, developing a programmatic method with ArcView 8.x and VBA for creating runbook map pages, and handling the implications of data migration from the ESRI coverage format to ESRI geodatabase format.

Introduction

The Poudre Fire Authority (PFA) and the City of Fort Collins GIS are working together to create application the will generate a map runbook to be used in emergency response vehicles. PFA currently produces very detailed map book known as a runbook for their operational boundary. Because of the great detail required for each map page within the runbook much of the work was and currently is done independently of the City of Fort Collins GIS department. The runbook is a very important reference for adequate emergency response within PFA's operational boundary and maintaining them will always be a challenge for PFA.

PFA's current method of updating their emergency response runbook is to use various spatial data layers from the GIS department and spatial data that they have created and maintain on their own, which is specific to the runbook. The city's GIS department maintains 3 key components to the runbook addressing accuracy.

1. Polygonal parcel region boundary features (ArcInfo poly region coverage)
2. Point address features. (ArcInfo point coverage)
3. Address database. (ArcInfo Table)

The parcel boundary layer is used within the runbooks to denote address boundaries and is used for the most part as separators for address number annotations. The address points which are generated from parcel region polygons and the address database are used to create labels or address annotations.
It has been for some time PFA's contention that the parcel or address data are not reliable enough for use in the emergency response runbook. Because of this PFA has invested a considerable amount of man hours in maintaining the accuracy of their emergency response runbook. This has and still requires a fulltime contractual GIS mapping technician to keep up with changes within the city.

PFA's GIS technician is responsible for quality assurance, printing, and distributing updates to over 15 facilities including emergency response vehicles for each of the stations. He also manages periodic field checks related to residential, commercial and rural addressing. The GIS technician uses field check data as one source of information to maintain the accuracy of addresses in the runbook. Another source of information is engineering drawings of platted subdivisions. These drawings are acquired directly from the City of Fort Collins engineering department by the technician and in some cases days before the drawings make it to the GIS department to be processed through a rigorous parcel updating and address numbering process. It is this span of time between when the GIS department has generated parcel and address

updates and the time that PFA is updating their runbooks based on engineering drawings. A key problem here is if PFA has made changes to their runbooks based on engineering drawings that have not be formally updated through the GIS department it is viewed as an error on the side of the GIS department. However what had not been realized by PFA, until this exercise was that the updating process performed by the GIS department maintains the highest standards possible for parcel boundary accuracy, parcel number assigning, and number address assignments. Because this process can be time intensive, and in some cases require research on the part of the GIS department when parcel boundaries and addresses are failing to pass quality control measures the time it takes to post updates is increased. Consequently PFA may have address and parcel boundary updates in their runbook days or weeks in advance of the GIS department which can be inaccurate and remain so until a field check of addresses is done.

Conversely the GIS department was not totally aware of PFA's own runbook updating process and could not offer a satisfactory solution to PFA's dilemma, which was not receiving timely parcel and address data updates.

Through many logistical and technical meetings between the Poudre Fire Authority and the City of Fort Collins GIS department a basic project was outlined to create feature linked annotation, which have some degree of positional accuracy in relation buildings within a parcel, and a way of communicating to PFA's GIS technician that updates to parcel and address data have occurred.

The goal for the project has been to create a dynamic mapping application were the emergency response map book pages change when GIS data is updated specifically addresses. Another goal has been to eliminate the necessity of hand drawing runbook map pages. This would save PFA many hours in creating, updating and producing their runbook by automating the updates for print and distribution to other fire stations throughout the city. The city and PFA also wanted to determine why discrepancies exist between the city's address database and PFA's emergency response map book. Other goals have been to integrate various datasets, reduce any amount of address mapping errors, eliminate redundant data maintenance, and address annotations that can be used by other departments.

To produce the run book 3 new data sets had to be created.

1) A feature linked annotation data set for address labeling that spatially represents where addresses are located and linked to the city's overall addressing data set.
2) A special access layer to show were the best accesses route is to large parcels.
3) A Collection of building footprints in areas where needed.

PFA maintains 1 fulltime GIS mapping technician and 1 to 2 interns at any given time in order to maintain their run book. These employees are involved in and were largely responsible for editing and quality control of run book map pages. The City of Fort Collins GIS department provides any data, technical assistance, and in house hardware support.

METHODS

Address verification process

The purpose of the address field check was to determine which addresses actually existed in the field in comparison to the City of Fort Collins GIS address data. We also used the fields check to calculate a percentage for which the city's GIS address data may be inaccurate because of real time address changes in the field, changes in the county assessors parcel and address database, and updates that may have not occurred in the city's own data.

PFA hired temporary employees to do an address field check throughout the City of Fort Collins during the winter of 2001. Volunteer field personnel used as a reference plotted parcel section maps with address labels to verify the physical address of structures. The maps were labeled using the address data from the City of Fort Collins most current address list. The field checks were limited to the extent of the current GIS

urban growth data layer. The procedure used to do the field checks was done by simply walking and driving through town and then matching addresses from the plots with those on homes and other structures. Any discrepancies in addresses were noted on the plots and then field checked a second time to confirm the physical address of the home and or structures.

The next step was to create a table of the suspected address discrepancies totaling 2437 records. This discrepancy address data produced by PFA and an outside contractor was then compared to the city's existing address table, address point and parcel polygon data layers. The expectation was that the comparison would eliminate from the 2437 addresses those that are in the address table but just overlooked by PFA. We found that 619 from the 2437 suspected discrepancies were indeed in the address table and address point data, but were viewed as discrepancies because parcels with multiple address only had a single address labeled on the printed maps used for field checks.

The 619 addresses that were thought to be errors but were just oversights were thrown out leaving only 1818 possible address discrepancies to check. Because the remaining 1818 could not geocoded when referencing the city's address point data layer we geocoded them using the city's street ArcInfo coverage. Geocoding is the process of taking a tabular address data set and generating approximate point locations using reference data. The reference data in this case was the City of Fort Collins address point data layer and street data layer, which is attributed with address ranges. The geocoding process created points along the street centerline that were then moved to their correct parcel using the cities aerial photo and parcel data as a reference.

The geocoding process done on the 1818 potential address errors produced 1677 points that needed to be checked for accuracy within both the city's address database and address point layer. Several data sources were used to confirm the 1677 geocoded address records. Table 1

Table 1. Data sources used in address verification process.

Data Source	Data Description	Data Format
City of Fort Collins	Parcel polygon regions	ESRI ArcInfo Coverage
City of Fort Collins	Address point	ESRI ArcInfo Coverage
City of Fort Collins	Address table	ESRI Info Database
City of Fort Collins	1999 – 2002 aerial photography	MrSID Raster
Larimer County	County assessors parcel polygon features	ESRI ArcSDE
Poudre Fire Authority	Emergency response map books	Hard copy books

The 1677 address that we checked, were for the most part errors related to addresses corresponding with apartment complexes, condos, mobile home parks, office complexes and other commercial areas. Many of these were in the city's address database but the records were not fully attributed with address information. These 1677 would have to be considered errors in the address database and were updated as part of the project scope. However, there were 70 point locations that could not be accurately tied to a parcel and 141 records that would not geocode. The 70 that geocoded but could not be tied to a parcel were field checked again to confirm the addresses existence. We found that 8 of them did not exist and 62 could be tied to a parcel, resulting in additional updates to the city's address table and address point data layer. These changes however were at the cost of more field checks to determine why they did not appear as they should of in the overall address data.

The 141 addresses that did not geocode were converted to a new discrepancy address table. It was determined that these 141 addresses did not geocode for several reasons such as address range errors in the street centerline and data entry errors.

We reviewed the new discrepancy address table and removed a total of 37 records from the 141 that were easily identified as errors. This left us with a total of 104 addresses to research in order to locate their corresponding parcel. After making corrections to range values on the city's street centerline data layer add address database the remaining 104 addresses produced 63 address points that could be tied to a corresponding parcel. The remaining 62 addresses were determined to human errors produced from the field checks.

Field check verification results

We used the field check data to determine an approximate margin of error that may exist at any given time in the current address data set because of address changes, updates to the address data that have not been completed and other errors. The results indicated the approximate margin of error existing between the runbook and the city's address database and parcel data layer during the time of the field checks was 3.2%. And the percentage of errors that PFA perceived to exist within the address database errors was 1.2%.

Table 2. Break down of address verification results from first round of field checks year 2001.

Address Description	Address Counts	PFA perceived GIS error	Number GIS discrepancies
Total valid addresses in the address database at time of field checks.	55413		*
Initial suspected field check 1st round of field checks discrepancies found by PFA.	2437		*
Addresses that were in the database but field checked as errors because of map labeling oversight.	*	619	*
Actual number of discrepancies. *(new discrepancy list)*	*		(2437 – 619) =1818
Number of records attempted to geocode from new discrepancy list.	1818		*
Number of records from the 1818 that geocoded after corrections to the address database were made.	1677		*
Number of remaining records from the 1677 Addresses that failed to geocode or otherwise be queried correctly from the address database.	*		78
Number of records discrepancy table that we were unable to be geocode and were identified as address errors.	*		37
Number of records from the discrepancy table which could not be geocoded and were determined to be field check errors.		62	*

The results indicated the GIS address database did contain a percentage of errors when compared to what is actually out in the field. (Total number of actual field check discrepancies) / total number of active addresses at time of field check)*100 = (1818-62)/55413)*100 = 3.4 % for year 2001. After making the necessary corrections to the address database and street centerline data layer the margin of error between address field checks and the address database yielded a 0.14 % discrepancy.

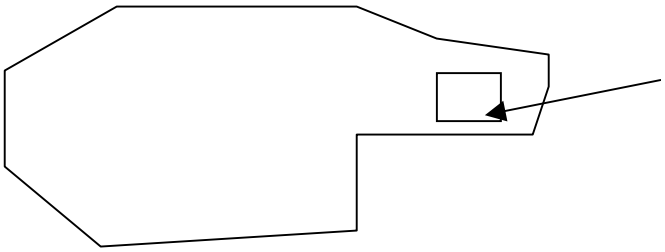
Table 3. Break down of address verification results from 2nd round of field checks year 2003.

Address Description	Address Counts	Number actual discrepancies
Number of records from the 1818 that did not geocoded after data corrections and converted to 2nd new discrepancy list.	141	*
Number of records from 2nd discrepancy list that were unable to be geocoded and identified as address errors.	*	37
Number of records from 2nd discrepancy List which geocoded and could be related to a parcel.	63	*
Number of records from 2nd discrepancy list which could not be geocoded and were determined to be field check errors.	62	*

Description of New Data Layers

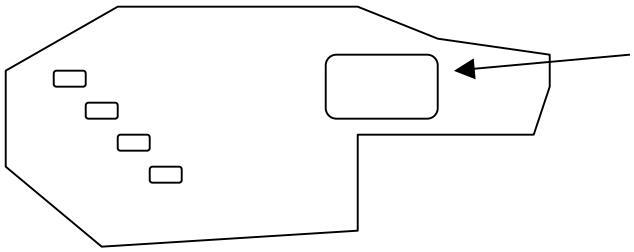
PFA Building Specific Footprint Layer

A polygon data set that will be created to display the building footprints of large structures for areas of town that have multiple addresses and buildings on large parcels. The purpose of this data would be for identifying structures that are located on large parcels and when greater detail is needed about a buildings location. (*Fig. 1and 2)*



This figure depicts a building footprint captured for location purposes on large parcels. The placement of the address annotation should be near the structure.

Figure 1: Collection of building footprint on large parcel.



This figure depicts many structures located on a parcel. The main building structure is located and the address annotation is moved to the main building or central structure.

Figure 2: Collection of building footprints to locate main structure from other existing structures.

Special Access line data

The special access line data will depict spatially where there may exist a most efficient way to access a structure on a large parcel or track of land. *(Fig. 4)*

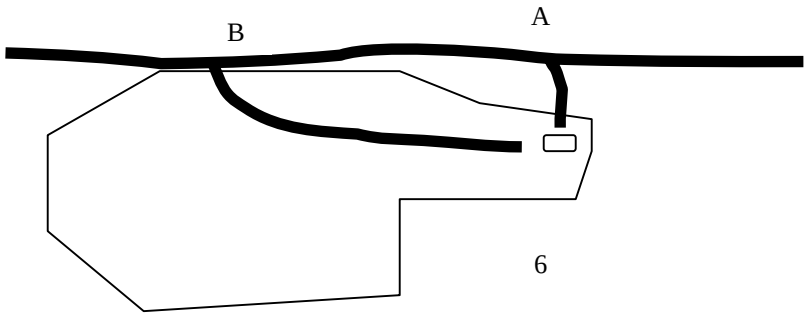


Figure 3: A parcel with two access points to the main structure. Intersection "B" representing one likely access and intersection "A" showing another access point.

Line Data to separate single parcels

A line data set will be created to add separation lines for single parcels that have multiple addresses because of building configuration. A good example of this could be found in old town where cases exist with single parcels that have more than one building and address or a single building that is subdivided and has multiple addresses. The data for cases such as these is confirmed from field checks that PFA has funded and has currently completed.

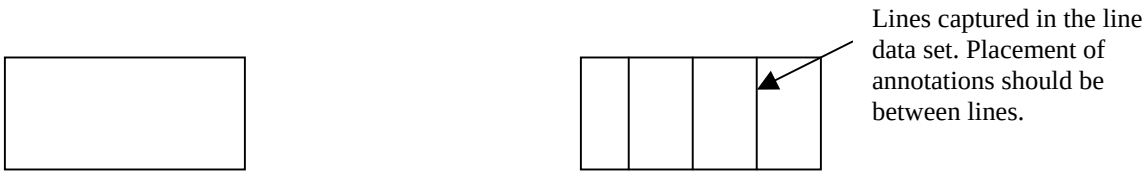


Figure 4: Parcel with single address and the same parcel with separation lines to reflect field checks.

However this would be a data set that would have to under go some level of maintenance for the most obvious reason, address and construction changes. PFA will be responsible for the updates and will be performed by their own GIS staff.

Feature Linked Annotation Layer

There were two alternatives researched for labeling addresses in the runbook maps. One was to create a data set with the address points moved to building locations so that when address labels were added they were located in the correct position in relation to buildings and polygon shape. This option was discarded because of the effects this would have on the current method for updating the address point data. Feature linked annotation was the other option looked at. This was determined to be the best option because it would utilize the existing data and not change the current procedures that are used for updating the address point data.

Data Capture Process and Quality Control

The data capture and editing will focus within the current PFA operational boundaries

(Fig 5).

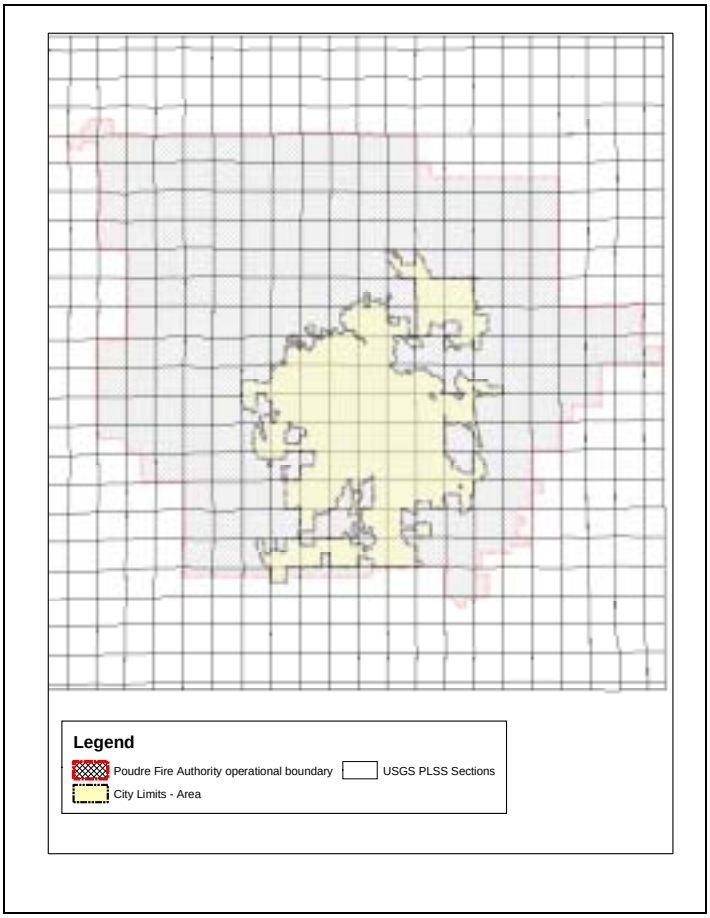


Figure 5: PFA Operational boundary.

We will initially generate each page of the map book and save the individual pages as .mxd files in a rough draft form. The .mxd files will then go through a quality control and data capture process to assure that the following criteria are met for each page

1. The page format is correct.
2. Each page displays the correct data. For example parcels, building footprints, hydrology, fire hydrants, special road access, symbology and notes if necessary. (Map layers, sources and symbology listed in appendix A.)
3. Each page has its address annotations oriented in the correct direction.

We will incorporate the data capture process into the quality control checks. As the map pages are checked for format and content the separation lines for parcels, special access routes, feature linked annotations and building footprints will be edited as needed so that each map page contains all relevant information.

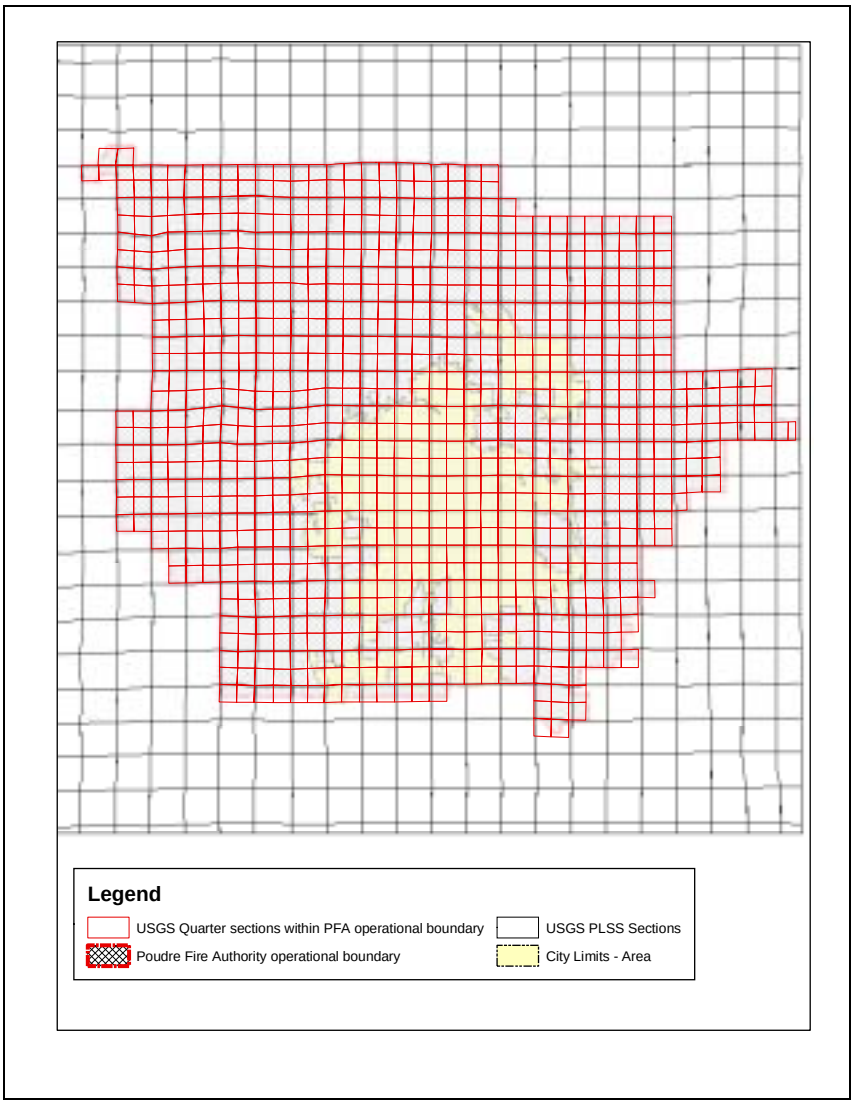


Figure 6: USGS quarter section coverage area.

The estimated time to work through each selected USGS quarter section within the PFA operational boundary varies. Figure 6 gives a general extent of the coverage area. The total number of quarter sections within PFA's boundary totals 922 of which approximately 459 quarter sections will be converted into map pages. The process of editing data and formatting a single quarter section will take approximately 2.5 hours to complete. This averages out to 1,148 working hours for editing and formatting map pages. PFA will be providing two personnel to work approximately 16 – 20 hour per week for a total of 32 – 40 working hours weekly. Table 2 gives the anticipated project schedule. A Microsoft project schedule is shown in appendix A.

Task Name	Work	Responsibility	Duration	Start	Finish
PROJECT DOCUMENTION FINAL	56 hrs	City of Fort Collins	7 days?	12/27/2001 8:00	1/4/2002 17:00
MAP PAGE GENERATION (programming task 1: create individual mxd files)	88 hrs	City of Fort Collins	11 days	1/14/2002 8:00	1/28/2002 17:00
MAP PAGE EDITING & QUALITY CONTROL	1,606.08 hrs	Poudre Fire Authority	200.76 days	2/1/2002 8:00	11/8/2002 15:05

MAP PAGE GENERATION (programming task 2: complete the programming of the runbook generator tool)	344 hrs	City of Fort Collins	43 days?	3/4/2002 8:00	5/1/2002 17:00
PRINTING	8 hrs	Poudre Fire Authority	1 day?	11/8/2002 15:05	11/11/2002 15:05

Table 2: Project schedule

The work is GIS technician level work and does not require any programming or analysis type GIS skills. The work will be fairly easy and should proceed quickly depending on the amount of data each map page contains. A technician should be able to get through several quarter sections within the course of a day. However as quarter sections fall within the urban growth area address data becomes dense and the need for greater mapping detail within each quarter section increases which will in turn slow down map production.

Run Book Application

Runbook map application criteria

PFA has designed the map page format and has asked for the following basic functionality for the runbook mapping application.

1. Display map page by query.
2. Display map page by selecting from a combo box.
3. Print entire book event.
4. Export map to PDF format event.
5. Print double sided pages, front and back.

A GIS analyst programmer using Visual Basic or Visual Basic for applications will do the programming for the mapping application. However technical assistance from Environmental Systems Research Institute (ESRI) will be used to ensure that the application is written and performs properly to avoid program crashes. A preliminary GUI interface has been designed but is subject to change as needed (Fig 7.)

The GUI will initially have only the previously stated functionality and any changes that are desired from PFA will be worked into following versions if needed.

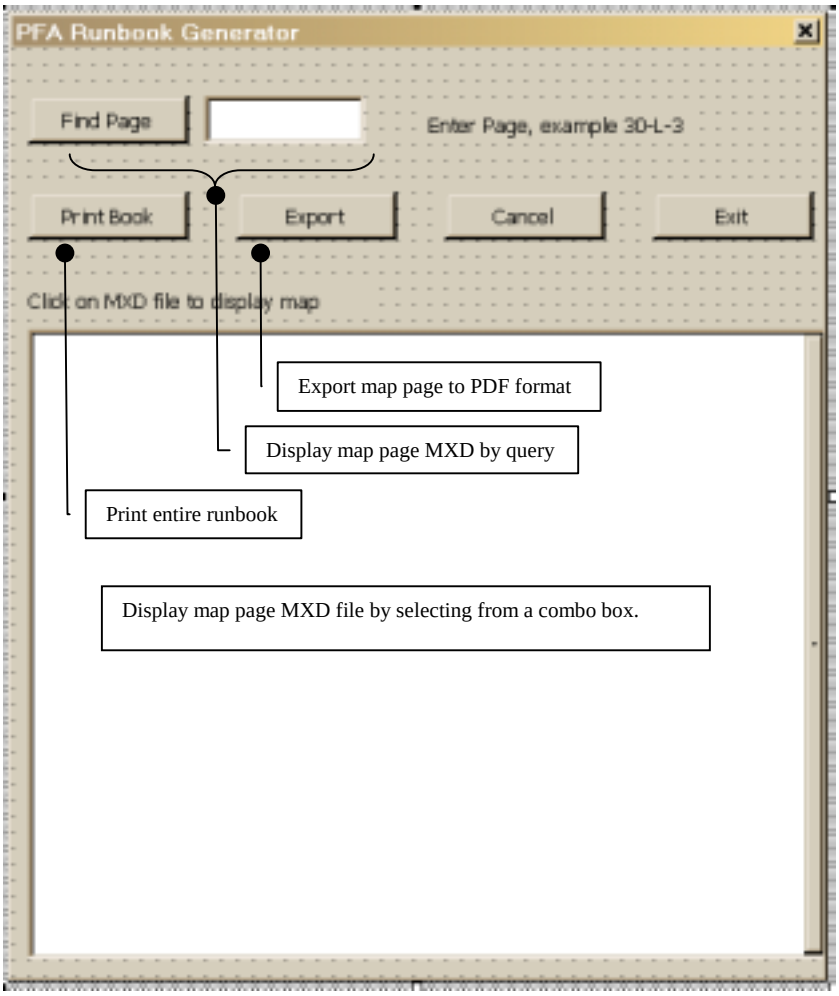


Figure 7: Runbook map generator GUI.

This will not be a standalone application but will be a tool that can be added too and used from ESRI's ArcView 8.1 standard interface. A preliminary map page format as also been designed for front and back side printing. Examples of the page formats can be seen in figures 8 and 9.

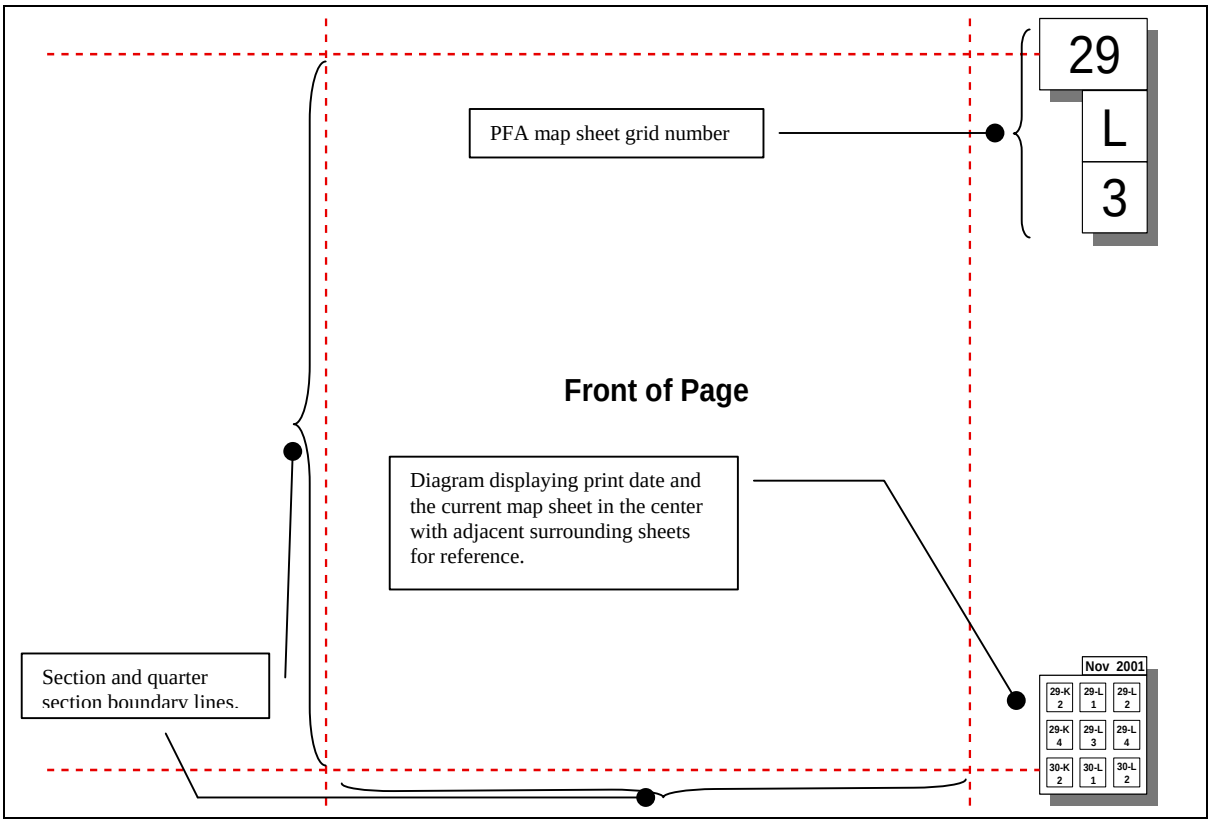


Figure 8: Front page map sheet format.

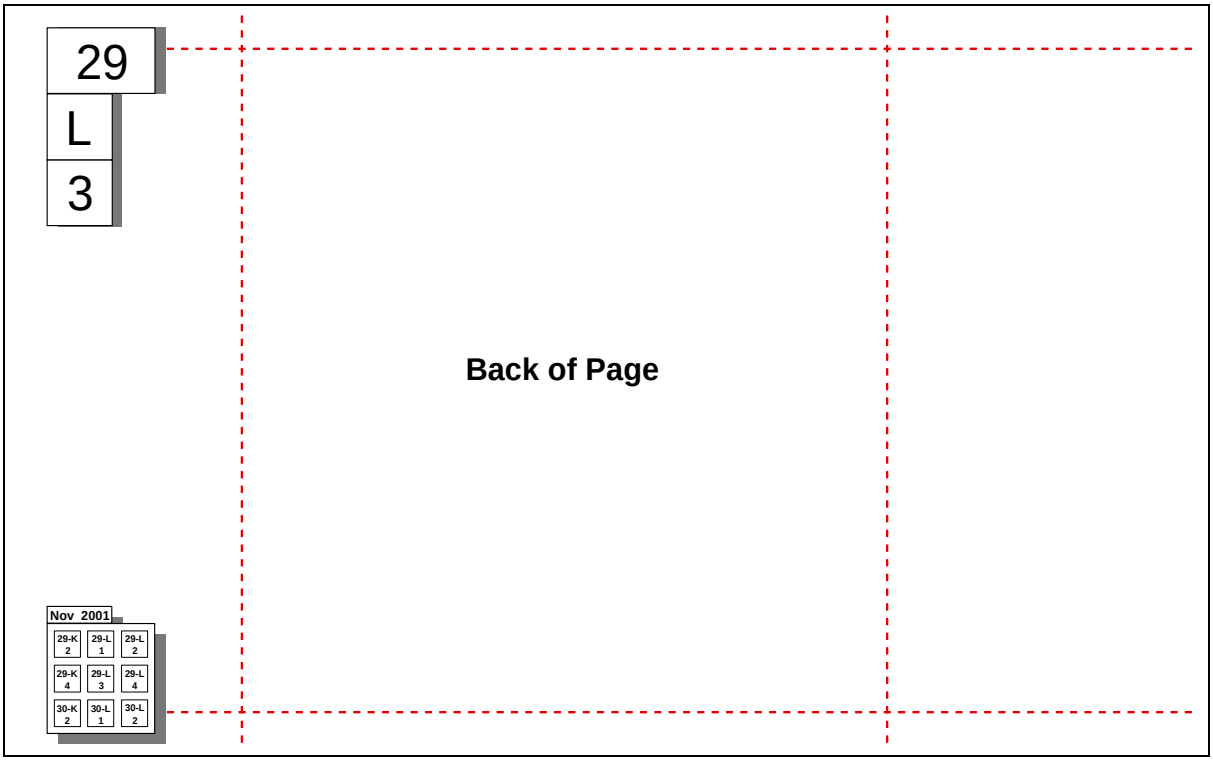


Figure 9: Back page map sheet format.

Appendix A

Approximate total addresses at time of field check	55413
Initial field check discrepancies found by PFA and GIS	2437
Addresses that were in the data base but not field checked because of map labeling oversight	619
Total number of actual discrepancies *(new discrepancy list)*	**1818**
Number of records attempted to geocode from new discrepancy list.	1818
Number of records that geocoded and were referenced back to a parcel.	1677
Number of records that geocoded but needed to be field checked again (of the 1677)	70
Number of records from the 1818 that did not geocode and converted to 2nd new discrepancy list.	**141**
Number of records from the 70 which were field checked that could not be located.	8
Number of records from 2nd discrepancy list that we were unable to be geocoded and could not be related to a parcel.	37
Number of records from the 2nd discrepancy list which geocoded and could be related to a parcel.	63

Table 3: Data layers required for producing map pages.

Feature	Source	Type	Symbol	Color
		Polygon		Yellow
		Annotation		Black
Fire Hydrants	Poudre Fire Authority	Point		Red
Hydrology	City of Fort Collins	Line, Polygon		Light Blue
Hydrology Labels	City of Fort Collins	Annotation		White
Street Labels	City of Fort Collins			Black
Parcel outlines	City of Fort Collins	Line, Polygon		Black
Rail Roads	City of Fort Collins	Line		
Pavement	City of Fort Collins	Line, Polygon		Grey
Parks	City of Fort Collins	Polygon		
Schools	City of Fort Collins	Polygon		
Oil Well	Poudre Fire Authority	Point		
Storage Tanks	Poudre Fire Authority	Point		
Bridges	Poudre Fire Authority	Point		
Bridge Rating Lables	Poudre Fire Authority	Annotation		
Dams	Poudre Fire Authority/USGS	Line		
Dam Labels	Poudre Fire Authority/USGS	Graphic		
Trails, Trail Markers	City of Fort Collins Parks/Colorado State Parks	Point, Line		Green
Trail labels	City of Fort Collins Parks/Colorado State Parks	Graphic		Green
Special access	Poudre Fire Authority	Line		
Specail access annotation	Poudre Fire Authority	Annotation		
Bike Trails *not routes	City of Fort Collins	Line		Green
County Hydrology	Poudre Fire Authority	Line, Polygon		Light Blue
County Hydrology Labels	Poudre Fire Authority	Annotation		White
Climbing Areas	Poudre Fire Authority	Polygon		Orange
911 Call Box's	Poudre Fire Authority	Point		Yellow
Heli Pads (Horsetooth and Lory State Park)	Poudre Fire Authority	Point		Blue
Water Sources (wildland area)	Poudre Fire Authority	Point		Light Blue
Mile Markers (I-25, 287, and Hwy 14)	Poudre Fire Authority	Point		Navy Blue
Pavement (Outside Urban Growth Area)	Poudre Fire Authority	Line? Polygon?		
PFA District Boundary	Poudre Fire Authority	Polygon		Red
Outlying Fire Department Boundaries	LETA	Polygon		Navy Blue
Natural Areas	City of Fort Collins	Polygon		
Section / Index	City of Fort Collins	Polygon		Red
Building Seperation Lines	Poudre Fire Authority	Line		Black

Table 1. Break down of address verification results.

Approximate total addresses at time of field check	55413
Initial suspected field check discrepancies found by PFA and GIS	2437
Addresses that were in the data base but not field checked because of map labeling oversight	619
Total number of actual discrepancies *(new discrepancy list)*	**1818**
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Number of records from the 70 which were field checked that could not be located.	8
Number of records from the 1818 that did not geocoded and converted to 2nd new discrepancy list.	**141**

Number of records from 2nd discrepancy list that we were unable to be geocoded and identified as address errors.	37
Number of records from the 2nd discrepancy list which geocoded and could be related to a parcel.	63
Number of records from the 2nd discrepancy list which could not be geocoded and were thrown out.	62

Conclusion statement. Because the City of Fort Collins has no precise way of determining the number of buildings, units, and mobile homes associated with one address