# Creating a Sewer Geodatabase Model for the City of Torrance.

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## Introduction

The City of Torrance is located in Los Angeles County, California approximately 20 miles south east of the city of Los Angeles. The City covers about 21 square miles with a population approaching 140,000 people. Torrance is a full service City reflected in around 300 GIS layers, including parcel, water, storm drain and sewer layers.

In 2002 – 2003, the City of Torrance, CA worked with consultant DCSE to update the sewer GIS. The update included many new features, such as sewer laterals, that were not in the previous sewer GIS coverages. The sewer model design was offered by DCSE as an additional bonus after the start of theGIS sewer updating project . A decision was made to bite the bullet and create a sewer geodatabase. Water and stormdrain conversion and model design were not within the scope and budget of the project.

The first section of this paper explains how the ESRI Water/Sewer Stormwater data model was adapted to a simpler model. As updated data were entered into the geodatabase, some advantages of using a model became apparent. The City of Torrance also opted to use a sewer atlas creation tool that was adapted from the Map Book Developer Sample. The second section of the paper briefly describes the tool, discusses advantages for map production and shows tips and tricks that were used to overcome issues during map series creation.

## Torrance Sewer Data Model

### Goals

In developing the City of Torrance Sewer data Model, the ESRI Water/Sewer Stormdrain Data model was modified to reflect the City's current and future requirements. The ArcGIS Water/Sewer Stormdrain UML (Unified Modeling Language – version 2000) model was used as a template for the system. The existing GIS coverages from the City provided a starting point for the database definition. Additional feature classes and associated attributes were identified using the existing Sewer Atlas maps from the City. The list was refined with some additional changes appropriate for the City's future needs. The Sewer Geodatabase was designed to accommodate the list of identified attributes and features in addition to the ArcGIS Water/Sewer Storm UML model. The model was designed from the project outset to be scalable.

The City of Torrance sewer system is simpler than the ESRI model since the City of Torrance system does not incorporate all features. For example, there is no sewer treatment plant at the City. City sewer pipes connect to Los Angeles County sewer pipes to carry waste to County treatment plants. There are two treatment plants used by Torrance, Carson and Hyperion, and this is reflected by the two outfall areas.

One distinguishing feature of the Torrance Sewer Data Model is that it is very specific in terms of capturing the data shown on the Atlas Sheets. There are no general comments fields where unsorted source data can be entered and accommodated in the database. When exceptions to the existing model design were discovered, the team endeavored to find, or introduce, specific solutions to the model rather than use general solutions. The more specific solutions would lend themselves to more precise mapping and analysis capability in the future. The data model was very carefully designed such that it meets the following goals:

1. The model is simple.
2. No duplication of data.
3. Specific.
4. Scalable.

### Methodology

In order to meet all of the above goals, the development of the model began before the start of Sewer GIS updating and was completed only at final delivery of the Sewer Geodatabase. The development of the model can be broken into 3 phases:

1. Customization of the ESRI Water/Sewer Stormdrain data model to the City's requirements.
2. Review of the pilot area source material for sewer system updates – add any new attributes, feature classes, and domain values, as necessary.

3. Adding attributes and domain values as new ones are discovered in the production area of the sewer system GIS updates.

## Customization

There were many changes between the models for the Sewer Network feature dataset. The following figure illustrates the major changes made to the ESRI model. The figure uses levels 0 – 3 to represent the heirarchy of database for better explanation. In addition to the changes illustrated in the figure, there were modifications in the attributes and subtypes that were within the typical expectations for a database design of this nature.

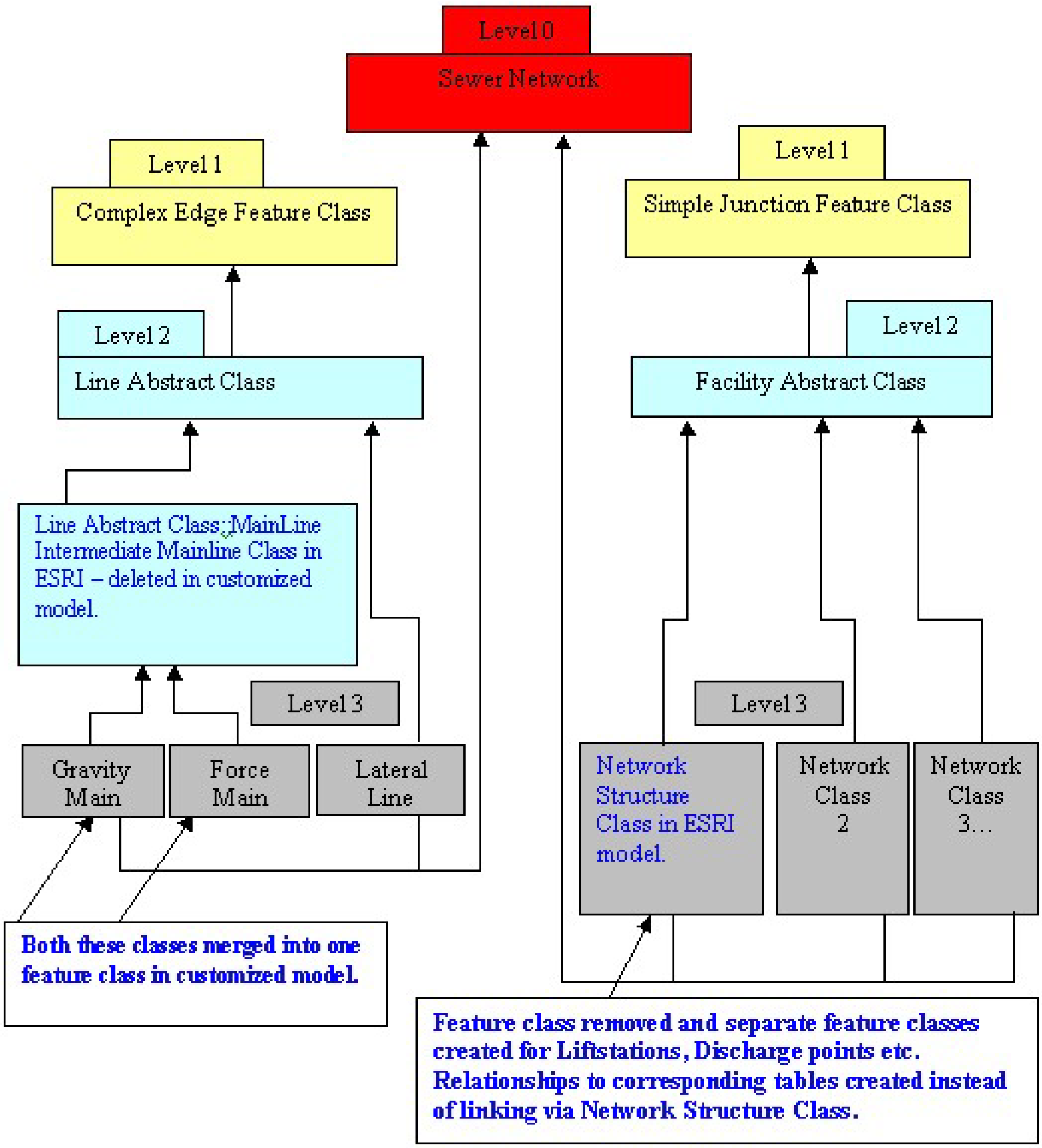
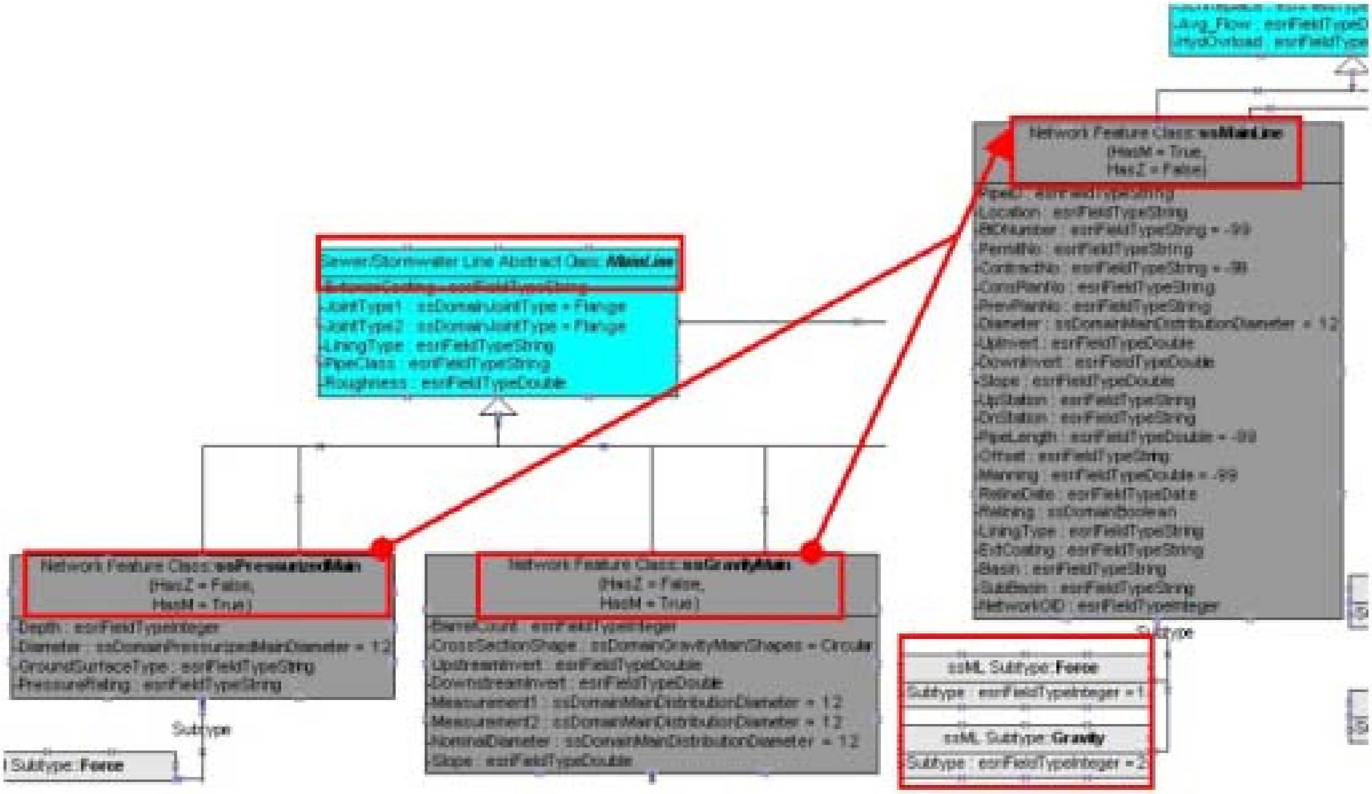



**Diagram showing Customization of the ESRI Model**

The changes that were made to the ESRI database model were all at levels 2 and 3. Level 2 contains the attributes that are common to all the features. This level needed some changes, since some of the attributes in the ESRI data model were found to be either extraneous in the data model, or they needed a change in name or data type definition .
Level 3 underwent major changes. The following is a listing of the major changes that were made at level three:

- Sewer Network Changes

1. ESRI model has Pressurized Main, Gravity Main & Lateral Line as their Complex Edge Features. The City had a simpler definition of mainlines as compared to the ESRI model. The model was customized to have Main Line and Lateral Line and with Main Line having two subtypes, Pressurized and Gravity.

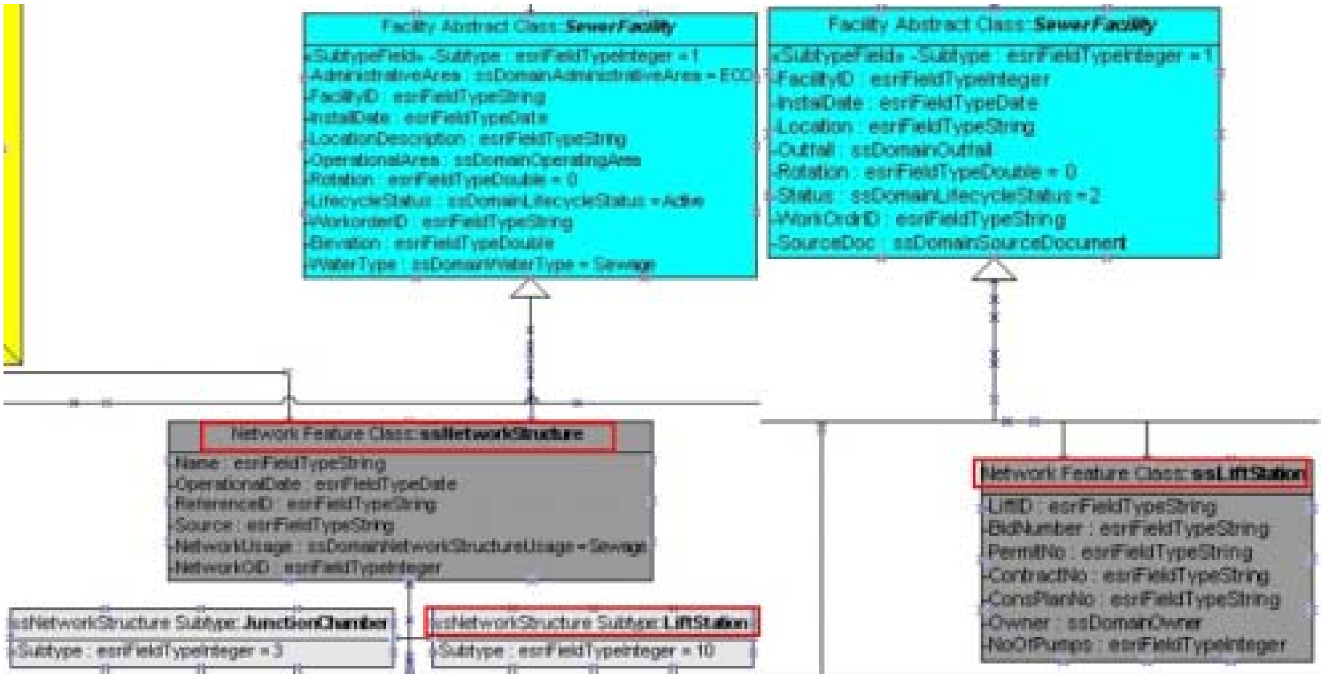



**ESRI Model – Mainline** **Customized Torrance Model – Mainline**

**Diagram Showing Differences Between ESRI Mainline Model and Torrance Mainline Model**

2. In order to simplify the model the ssNetworkStructure (part of Sewer Network, Sewer Facility Abstract Class) was substituted with the specific multiple feature classes. The City's model has the Liftstation as feature classes in the network instead of as a subtype in the ESRI model for the ssNetworkStructure class.

When the feature class was removed there were problems due to existing dependencies on this class. These were handled by changing the structure of the model slightly. For example, pumps became a table related to lift stations, rather than separate feature class. Any tables, like motors, that were relevant to liftstations related to the ssNetwork Structure feature class were retained and the relationship was mapped to the liftstation via pumps instead.




**ESRI Model** **Customized Torrance Model**

**Diagram Showing Differences between ESR Sewer Facility Model and Torrance Sewer Facility Model**

- Other Changes to the Sewer Network:
  The Sewer line abstract class added new attributes like **PipeID**, **Outfall** and **Source Document**.
  Attributes like administrative area, operational area and water type were removed, since they were not found to be relevant for the City's design.
  - Feature Classes
    1. New Feature class **Lateral Chimney** was added to capture chimney structures on sewer laterals.
    2. ***Cleanout, Fitting,*** and ***Meter*** classes were removed from the model. Cleanout was added to the list of manhole subtypes. Fittings were a surprise, since initially it was not expected to find them. After the feature class was deleted, fittings were found in a couple of locations, and accommodated as manhole subtype. Since pipes are broken for fittings, manhole is appropriate to the topological model.
  - SubTypes
    1. Several subtypes were added to **Manhole**. These included, **Standard**, **Junction**, **Chimney**, **Shallow**, **Lamp**, **Cleanout**, **Plug**, **Dummy**, **Fitting**, and **Interceptor Vault**.
    2. System Valve added a new subtype called **SwingCheck**.
  - Attributes
    1. MainLine added new attributes such as **Bid #, Permit number, Contract Number, Construction Number and Previous plan number**.
       Mainline also gained **Basin ID** related to Sub Basin.
       Mainline added **Relining** and **Relining date** to differentiate lined and unlined pipes
    2. Lateral Line incorporated **AddressID**, and several **Permit numbers**.

- Sewer Feature Class Changes:
  - Feature Classes
    1. New Feature class **SepticTank** was added.
    2. **Anode** and **Underground Enclosure** classes were removed from the customized model.
    3. Repair data was implemented as two separate feature classes **– Repair Points** and **Repair Lines**. These feature classes are linked to the spatial operations records table in the database.
  - SubTypes
    1. Casing gained a new subtype **Sleeve**. **Conduit Bridge**, **Protective Tunnel**, and **Access Tunnel** subtypes were eliminated.
    2. SpatialOperationsRecord added subtypes, **Break, Retrofit, and Overflow**. **Leak** was removed.
  - Attributes
    1. Casing incorporated **Start Stationing** and **End Stationing** as new attributes.
    2. SpatialOpertionsRecord added **History**, **FileName**, and **URL** as new attributes.

- Sewer Domains
  All Integer attributes used **'-99',** and all String attributes used "**Unknown**" as their Domains to capture unknown data. These values will also serve as flags for making corrections to such data in the future.

- New Feature Dataset
  A new feature dataset, **Landbase** was created to store the features that do not participate in the geometric network, but are necessary for other purposes - such as Easements and Basins.

- Tables
  A new table, **Plate**, was introduced to reduce data redundancy. The plate table is linked to the manhole attributes – via the manhole ID. Los Angeles County sewers within the City of Torrance use plate features to divert flow from one outfall to a different outfall.

- Equipment Modules:
  The Storm Sewer Equipment module and the Warehouse equipment module of the ESRI model were modified to create a single module as per the City's requirement. Extraneous tables like Warehouse Meter, and Standby Power were deleted. The City has separate SCADA and Work Management Systems.

- Relationship
  Created new relationship classes to improve database efficiency.
  1. **Plate** has a one to one relationship to **Manhole**.
  2. **Pumps** and **WetWells** have one to many relationships with **LiftStation**. And **Motor** has one to one relationship with **Pump.**
  3. **SubBasins** to **Mainline** relationship (1 to many).

## Project Outcomes

As this was City of Torrance's first experience with a geodatabase design, Torrance members of the design team were climbing a steep learning curve while the design was taking place. The City's input was important and DCSE were helpful in explaining the consequences of design decisions that Torrance were taking. The ESRI book on the ARCGIS Water Utilities Data Model was a useful learning resource for useful background information and explanation of newly encountered terminology.

The City welcomed the opportunity to be involved in a geodatabase design and staff set some time aside to learn about the model and to respond to the questions from DCSE as they arose. The City recognized that time spent on the database design in researching questions and issues that arose would pay dividends in a tighter model design that was more able to support future mapping and analysis needs. As model anomalies occurred during conversion work, research for a solution not only included map searches to reveal the extent of exceptions, but also included questioning of field operations staff who have extensive knowledge of the sewer facilities.

On order to track the resolution the many questions that occurred during design, DCSE implemented an Internet anomaly system. Each technical question was assigned an anomaly tracking number and status and retained in a database. As anomalies were resolved, the solutions were entered into the system and the anomaly was assigned a completed status. The knowledgebase was maintained on-line throughout the project so that reference could be made to the resolution database, as necessary.

Since the installation of the updated sewer data the City has seen some benefits from the adoption of the geodatabase and attention to detail on the design. Incorporation of domain values that were encountered on the maps has facilitated more accurate attribute data entry by City staff. A request has been received from operations staff to see relined sewers on the atlas maps. This will be possible due to the inclusion of relining information in the sewer mainline attributes. Use of the geodatabase gives the City good compatibility between data and ArcGIS mapping tools. For creation of the sewer atlas map series, the City can leverage such functionality as feature linked annotation with confidence that attribute value changes in the geodatabase will be displayed on newly printed map sets.

This exercise of implementing a personal geodatabase for the sewer system has the City has been very encouraging towards the next step. The City is looking towards implementing an enterprise geodatabase in the future.

# City of Torrance Sanitary Sewer GIS Atlas Tool for ArcGIS

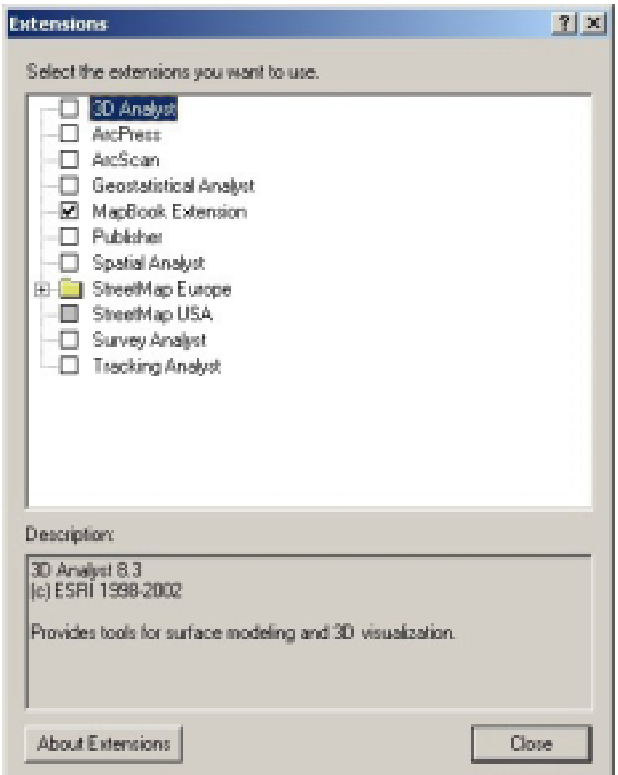
## Overview

The City of Torrance Sanitary Sewer GIS Atlas Tool is a customized version of the DSMapBook sample available through the ESRI website. The sample code was modified by DCSE specifically for the City so that users can quickly and easily to create updated sanitary sewer atlas maps using ArcMap. DCSE improved error handling to make the application more stable, and added some necessary components for generating sewer atlas maps. DCSE also packaged the sample into an ArcMap extension, and created simplified installation and loading.

Additionally, a user guide was prepared to include instructions for installing the Map Book extension, to describe features that have been added/customized for the City, and to include snapshots from the layout developed for the new sanitary sewer atlas maps.

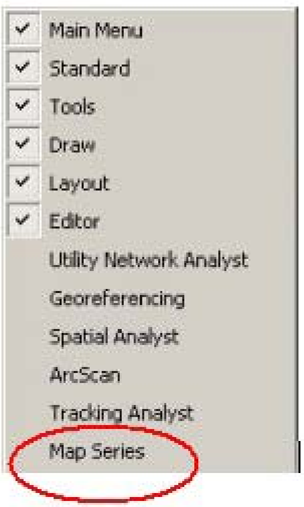
## Installation

During installation of the application under ArcMap environment, the Map Book Extension is loaded (see below).




**Snapshot of Extensions Dialog Box (Tools > Extensions)**

Following the loading of the extension, Map Series is added to the list of toolbars. Using standard methods, the Map Series toolbar can be displayed or hidden from view.

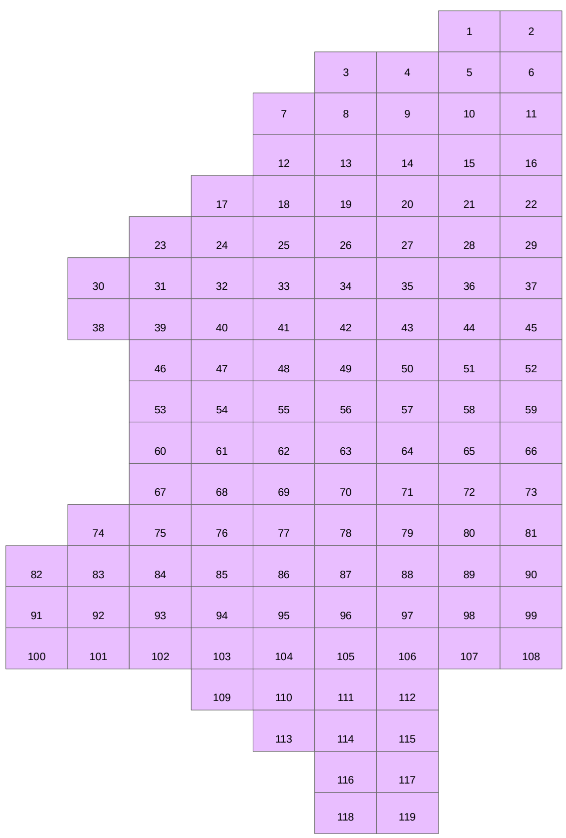



**Snapshot of Toolbars Available (Right-click on any Toolbar in ArcMap to look at Available Toolbars)**

## Requirements

Before creating a Map Series, a polygon Index Grid is required as a basis for map pages. The grids do not have to be of any particular size and shape, nor do they need to be interconnected. The grid features just need to be polygon shapes. The Index Grid must contain a field with string values representing the name of each page (tile). If a predefined Index Grid is not available, the Grid Generator wizard can be used to create one.

The City of Torrance has a standard pre-defined 119-tile grid numbered from north to south and west to east.



**The above illustration shows the standard City of Torrance 119 tile grid.**

In addition to an Index Grid, a page layout is necessary to generate a Map Series. If a page layout is not available, standard ArcMap tools can be used to create one.

## Map Sheet Wizard

Once an Index grid is available and a layout is loaded into the ArcMap session, the Map Series can be created. The wizard for creating a Map Series can be accessed by either selecting the "Create Series" tool on the Map Series toolbar, or by right clicking on "Map Series" on the top of the Map Book tab and selecting "Add Map Series".

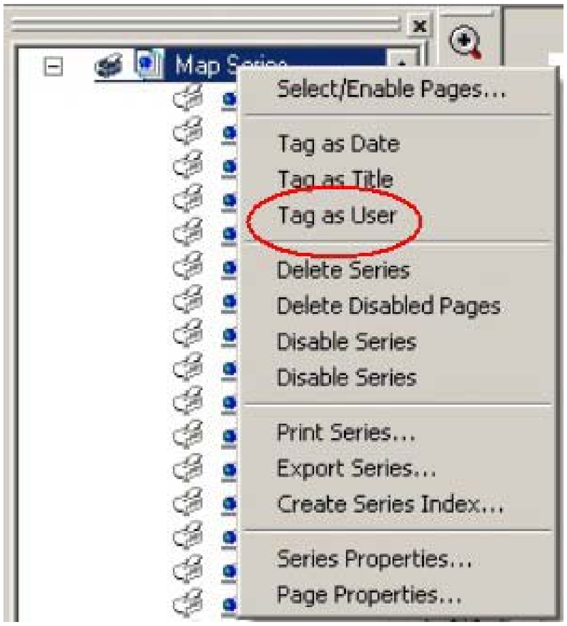
By using the wizard and the map layouts, it was possible to generate many mapsheet features automatically, such as page and grid numbering, index map, title block and other marginalia.

An additional tab was created to specify a user name or initials to help identify who created/updated the Map Series. This value can also be changed, to identify the editor, once the Map Series has been created.

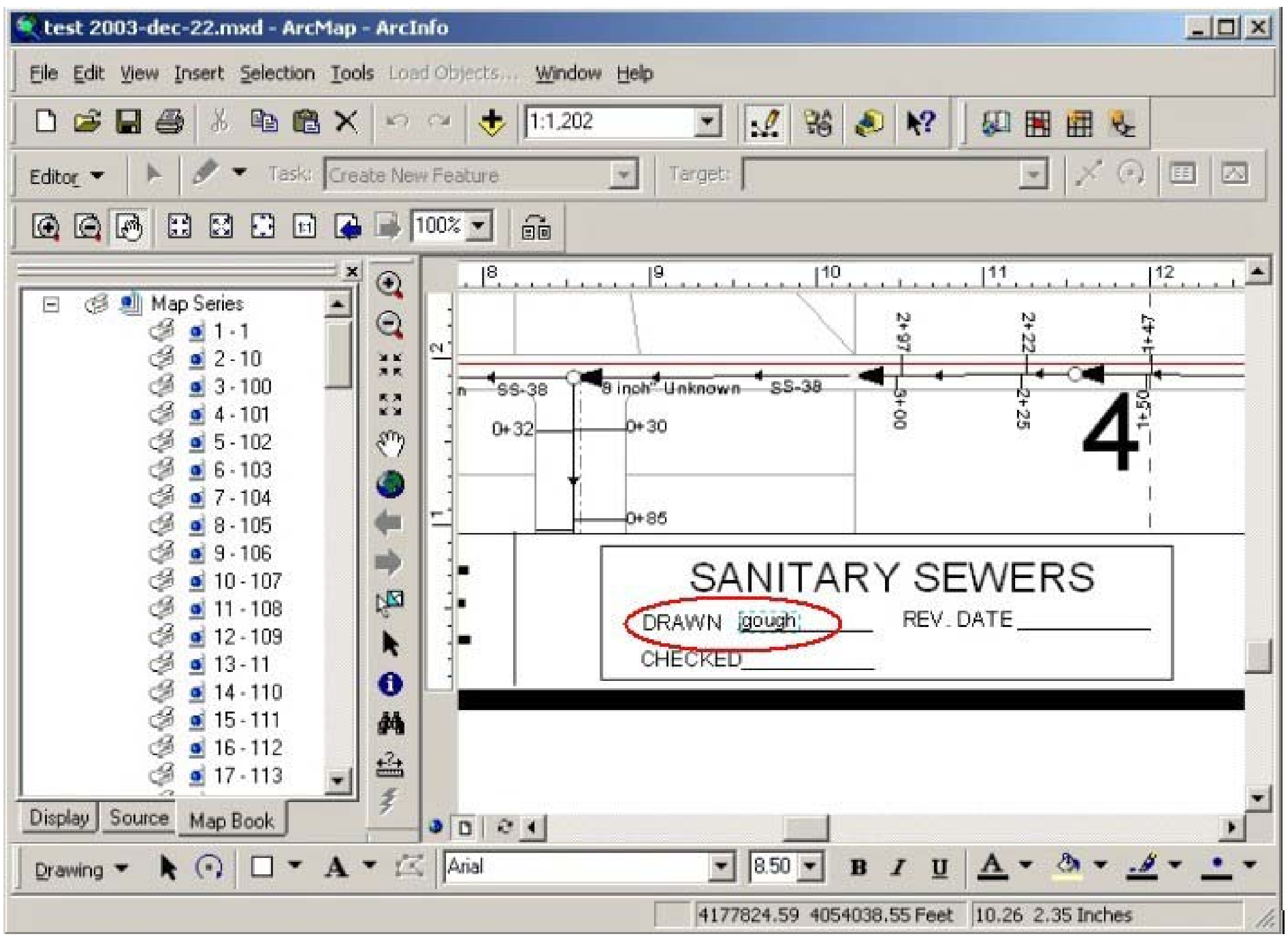

**Snapshot Showing Map Sheet Wizard - Tag for User Name**

### *Adding a User Name*

Adding a User (Drawn By) item is similar to adding a title. To create a User item, begin by adding a Text Element to your map at the appropriate position, size, color, etc. An additional menu item, 'Tag as user' was added. The user name will be updated with the user name each time a page is generated.




**Additional Menu Item – Tag as User**




**Snapshot of the Assigned User Name in the Map Layout**

## *Flow Arrows*

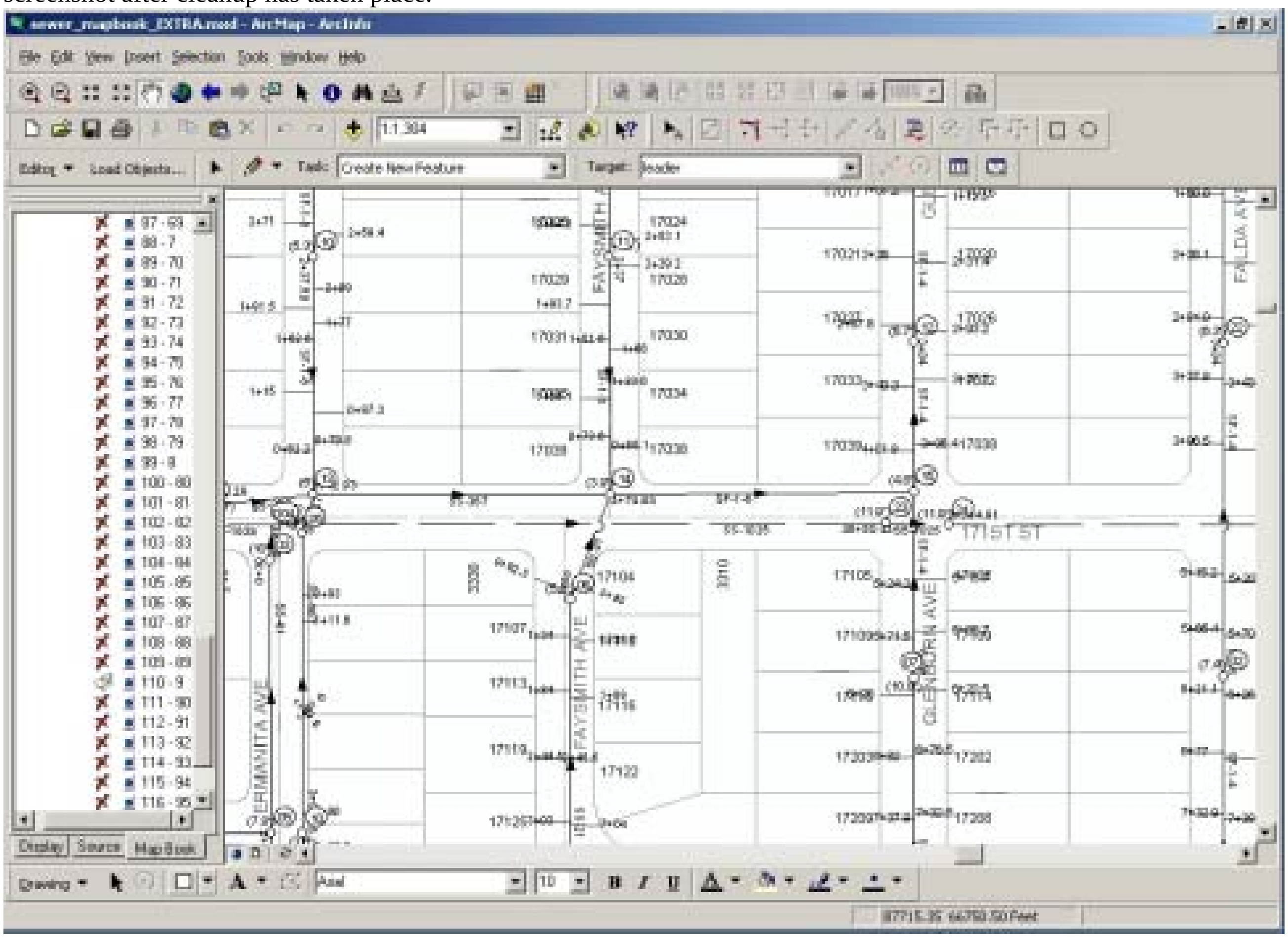
The pipe arrows that show the direction of flow needed to be customized for use on the sewer atlas maps. Although some arrow symbols were available in the ESRI symbol sets, they would display at the pipe end, as shown in the illustration above. DCSE were able to provide a customized symbol that placed the flow arrows in the center of the pipe segment.

## *Labels and Annotation*

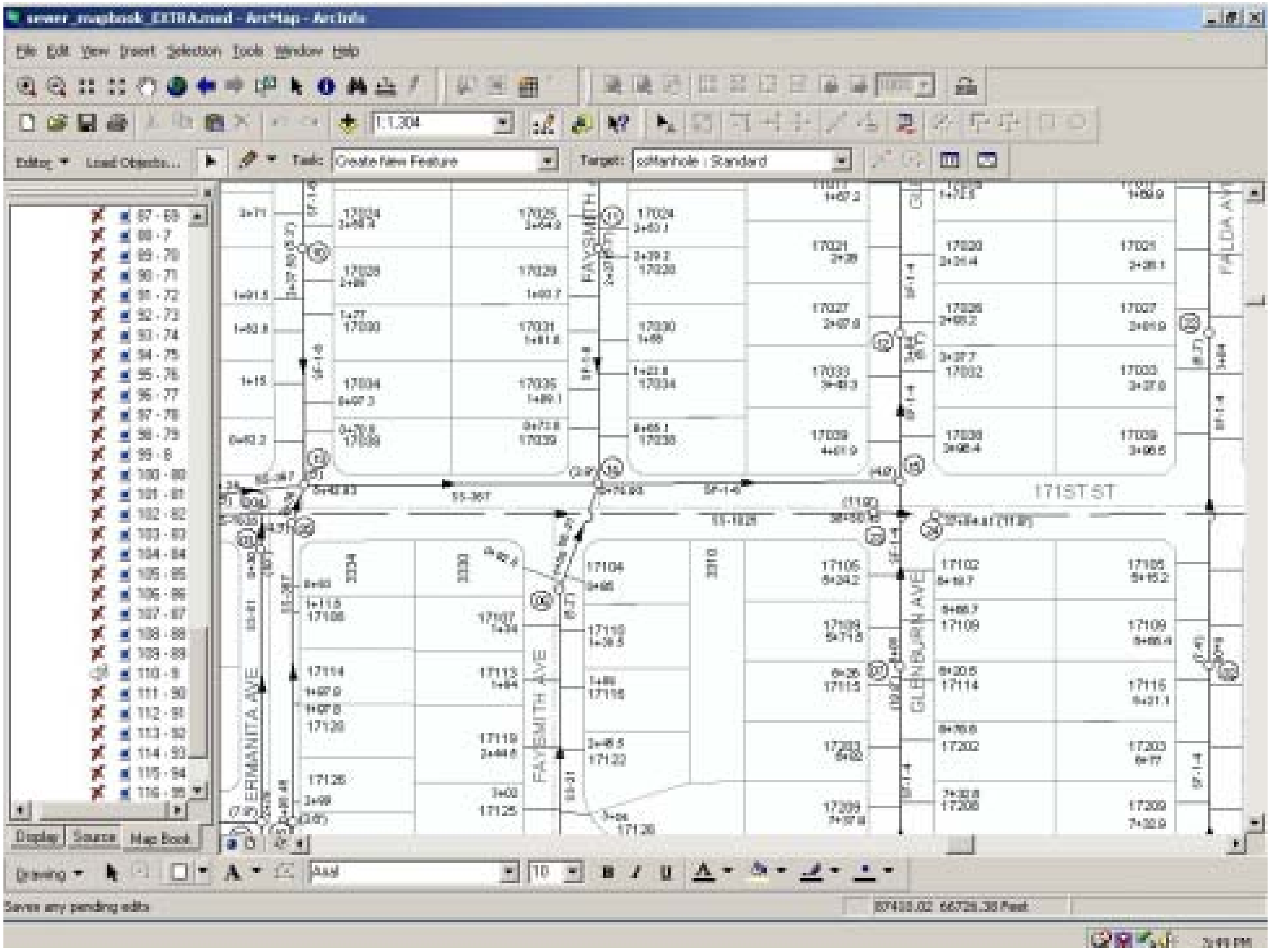
Label properties are selected to give the best possible automated label placement for sewer features. The label placement tools create many overlapping labels, the City does not have Maplex that would probably produce more refined solution and save some cleanup time.

Visual Basic expressions are used within the labeling tool to concatenate and filter label fields. For example, a filter is used so that -99 values do not display on the map. Also expressions such as Right([[ManholeID],2) to place only the last two digits of a page- grid-manhole number combination.

Once the labels are optimally placed, they are converted to feature linked annotation. At this point most of the overflow labels are not placed on the map, since there is sufficient clutter to resolve. The first illustration below shows a screenshot showing the "raw" annotation after conversion from labels. At this stage an operator cleans the annotation, checking all overlapping annotation to place it in a more suitable location. When there are several parallel pipes and manholes in close proximity, placing all annotation can quite an art. The operator checks that all of the necessary annotation is present for a feature. If not, copy parallel, or a similar command, to an uncluttered area will reveal all annotation and the missing annotation can be copied back into position. The second illustration below shows a screenshot after cleanup has taken place.




**Screenshot showing "Raw" annotation after conversion from labels**




**Screenshot Showing Cleaned up Annotation**

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***References:***

- ArcGIS Sewer Stormwater Model – ESRI
- DSMapBook sample - ESRI