Wastewater System Capacity Tool Evaluates Potential Development Impacts

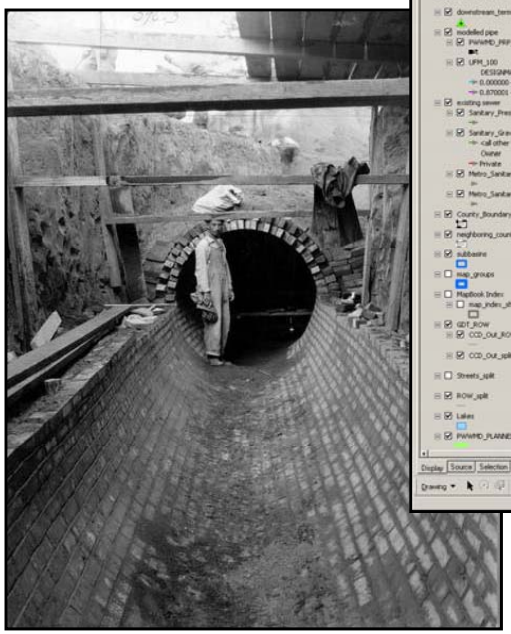
DENVER
THE MILE HIGH CITY

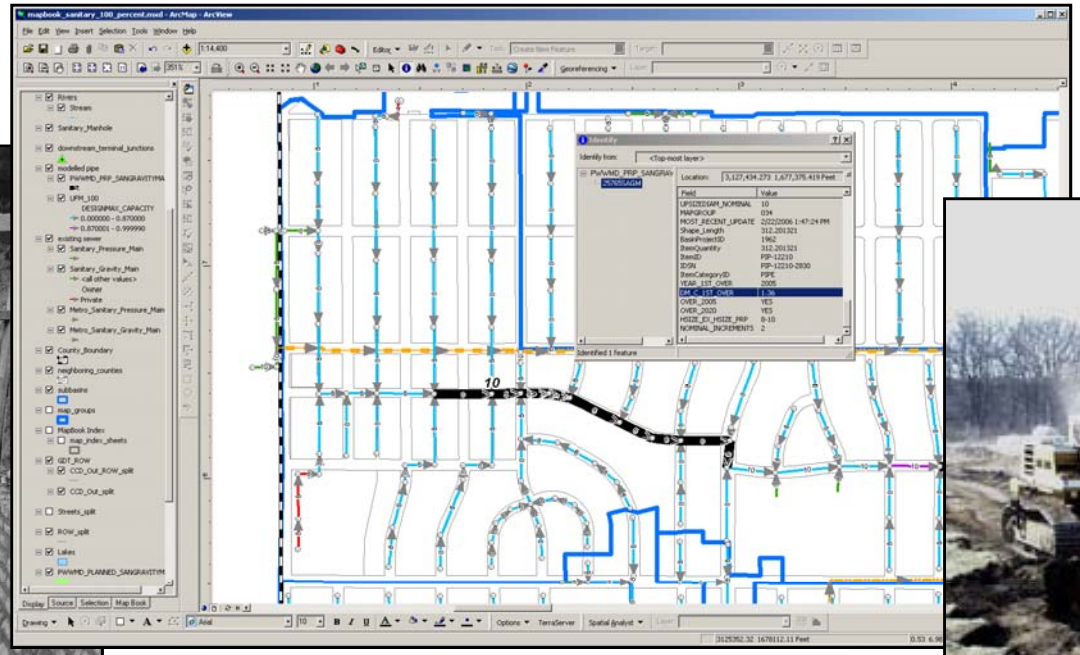
ESRI International User Conference
2009

Celebrating 10 Years
Matrix Design Group, Inc.
An Employee Owned Company

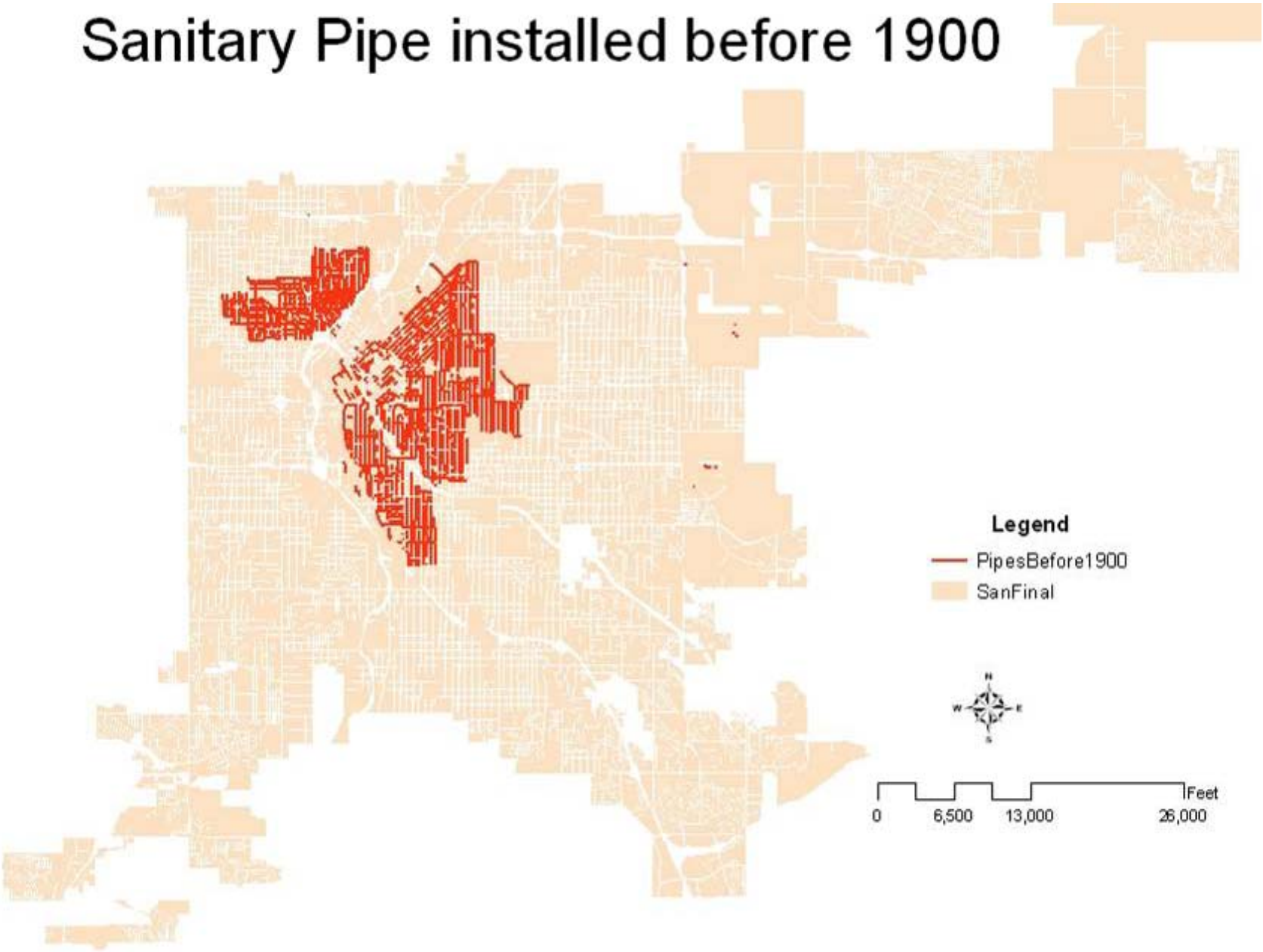
Denver Sanitary Sewer System

- GIS Master Plan Modeling effort begun in 2005
- Service Area: 113 square miles of 155 citywide
- 8 million lineal feet of public sanitary sewer mains
- 570,000 population -149,266 customer count in 2005

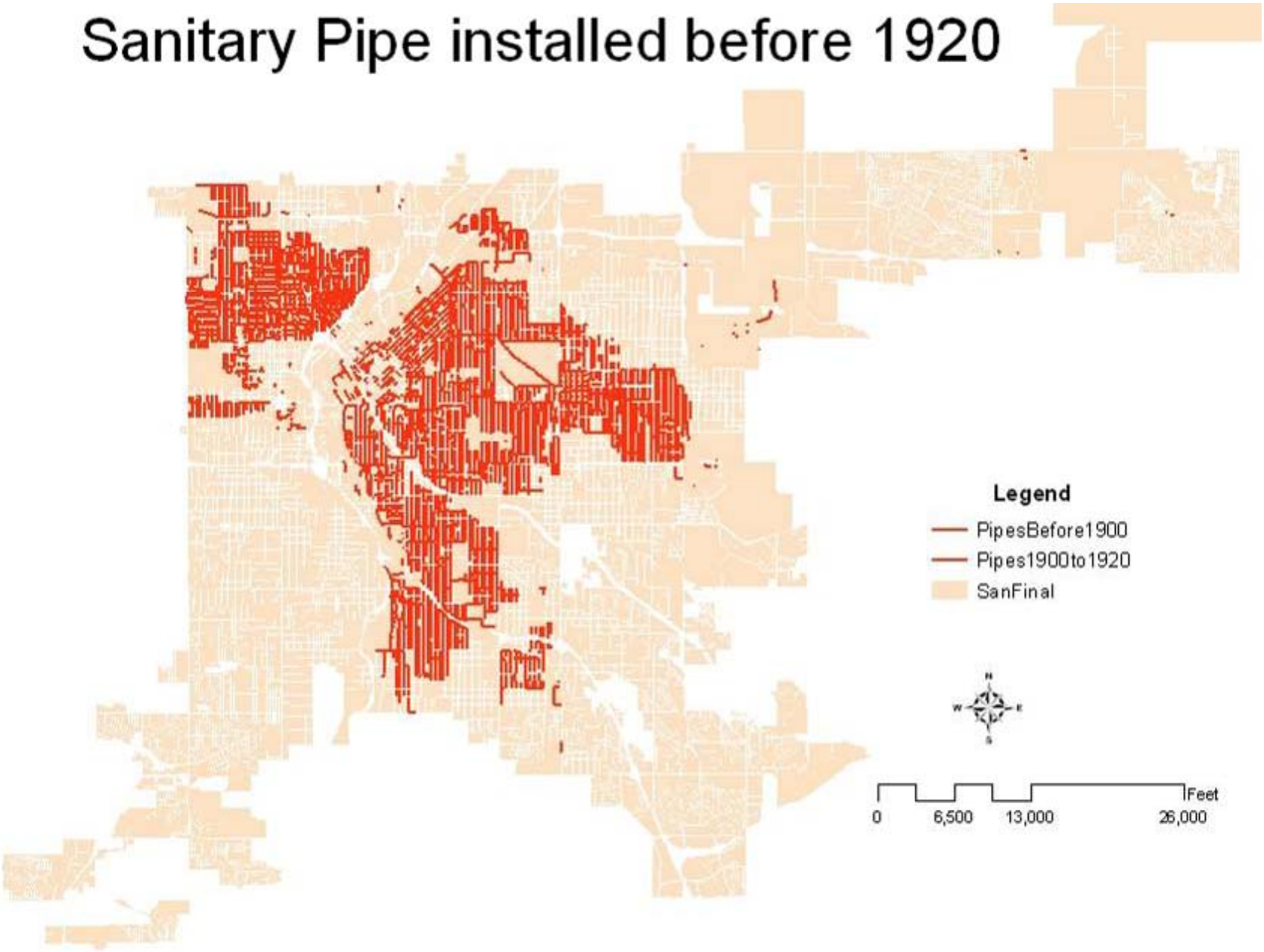




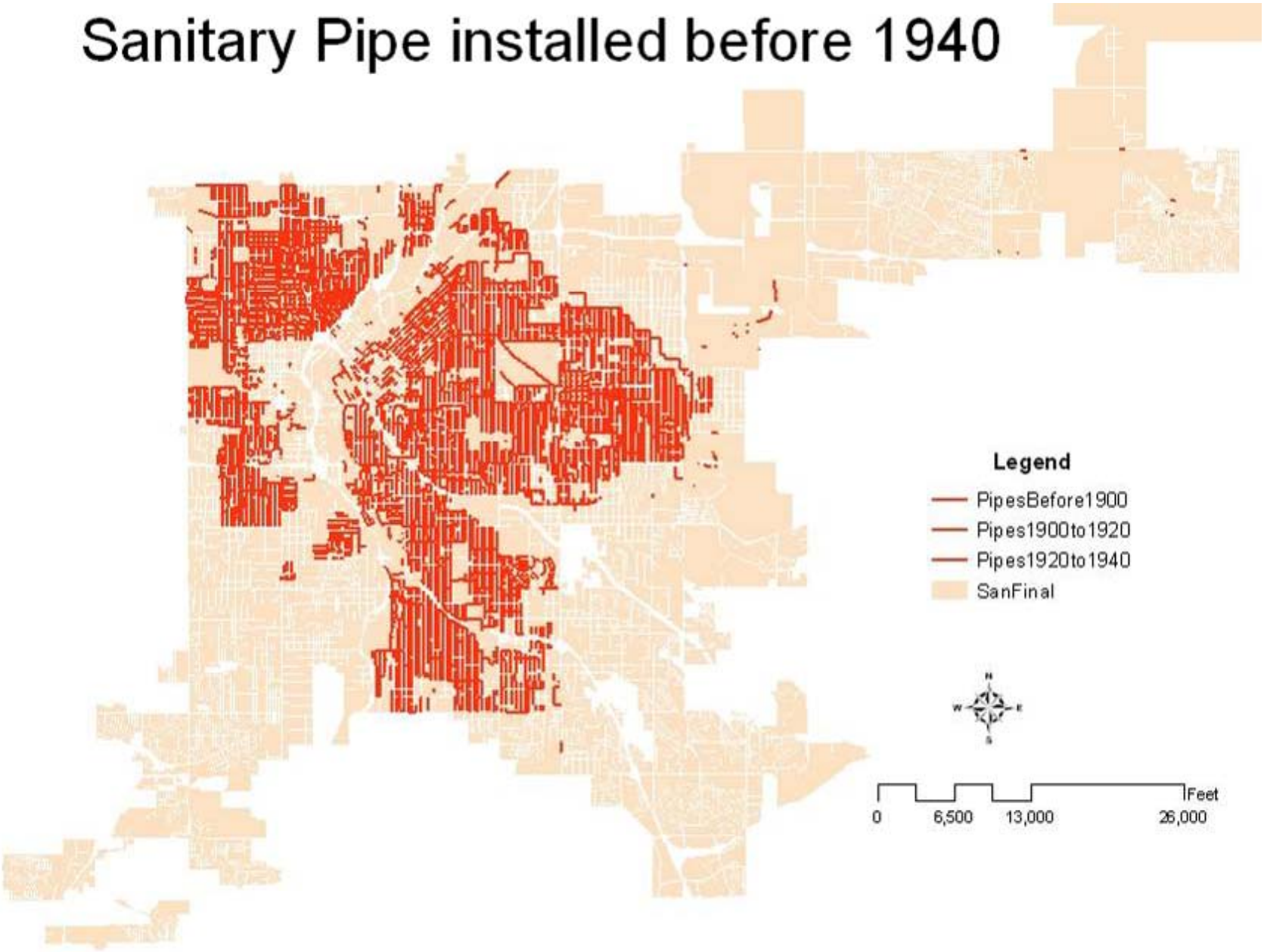
Sanitary Pipe installed before 1900



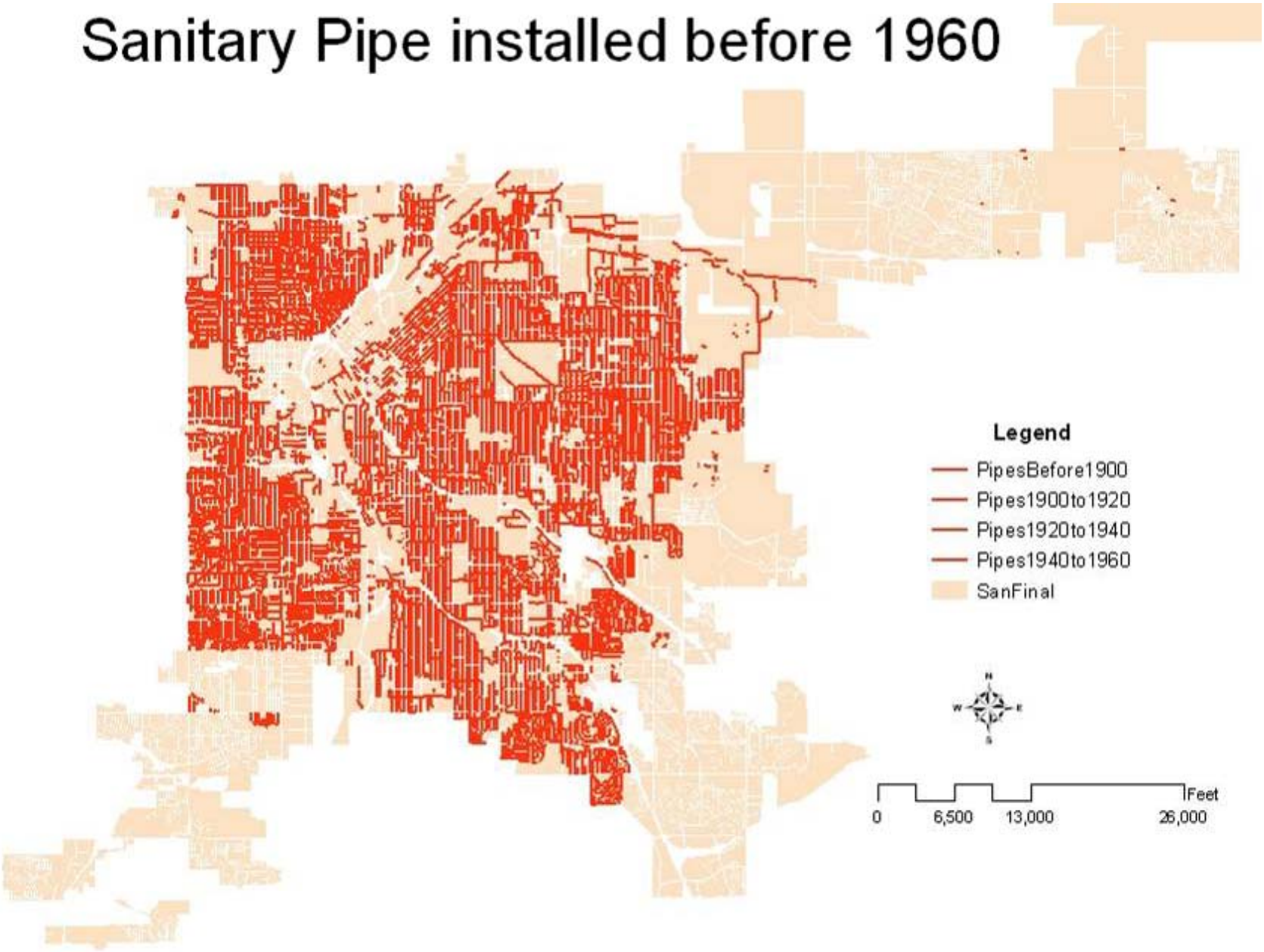
Sanitary Pipe installed before 1920



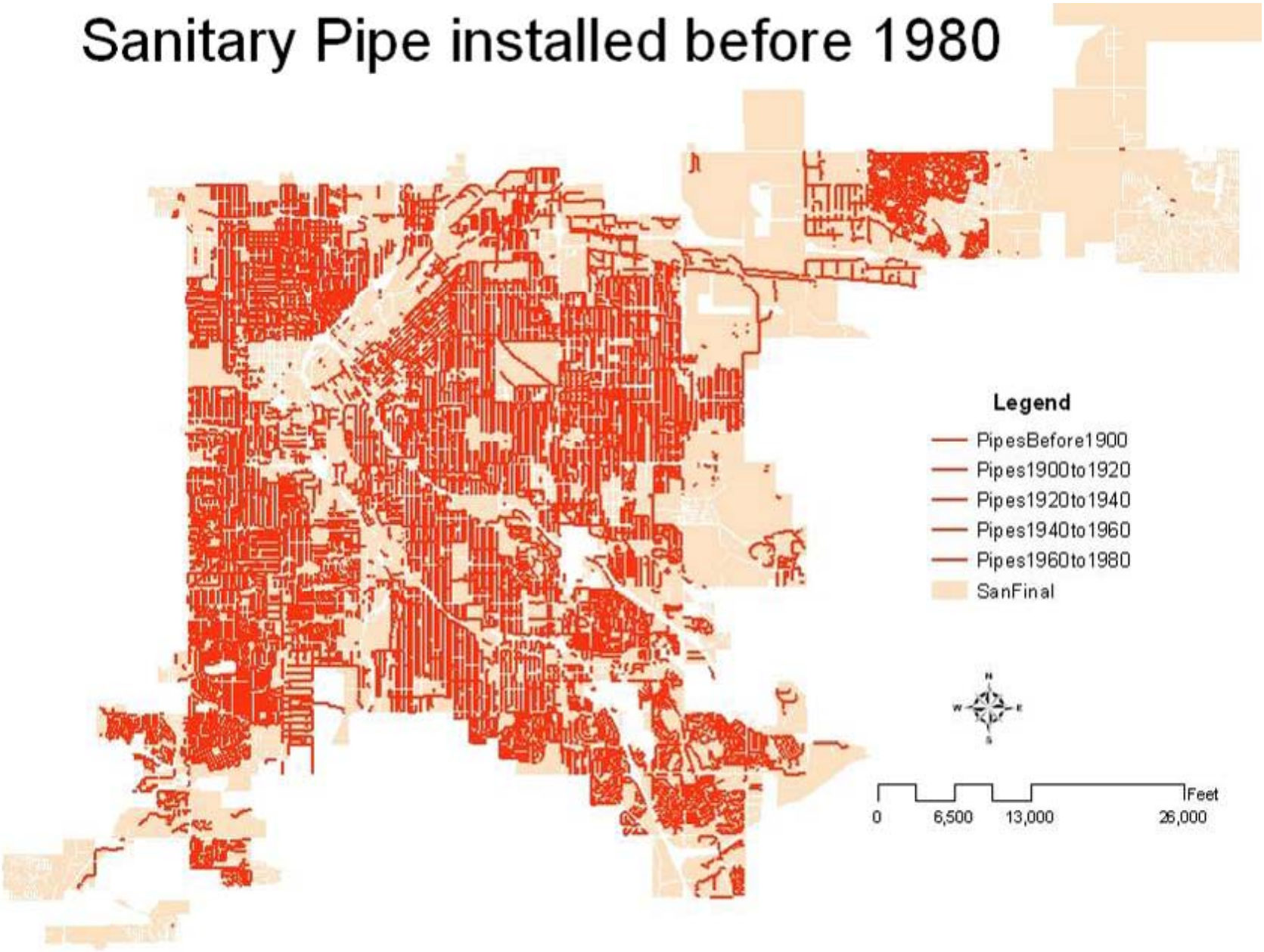
Sanitary Pipe installed before 1940



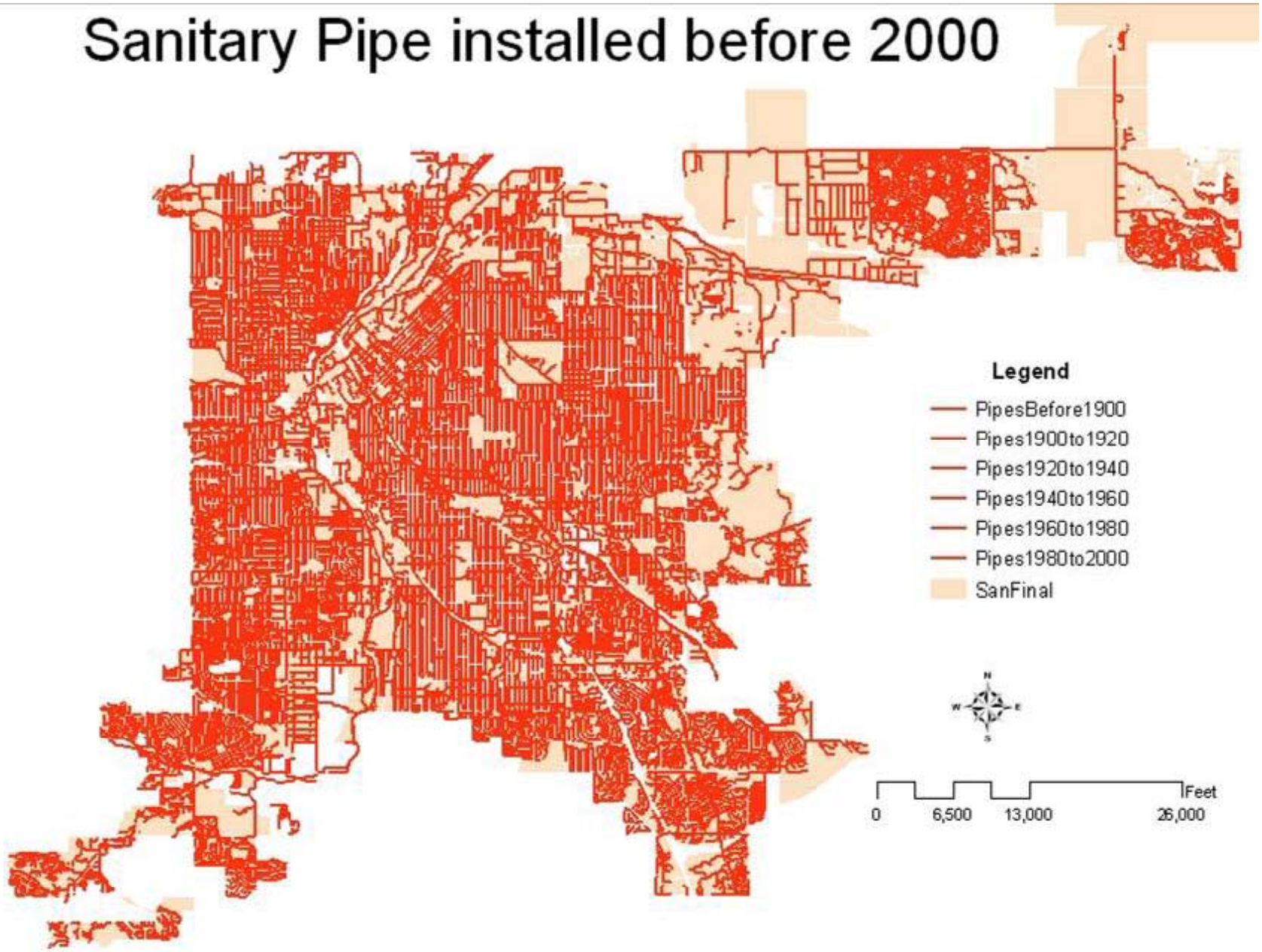
Sanitary Pipe installed before 1960



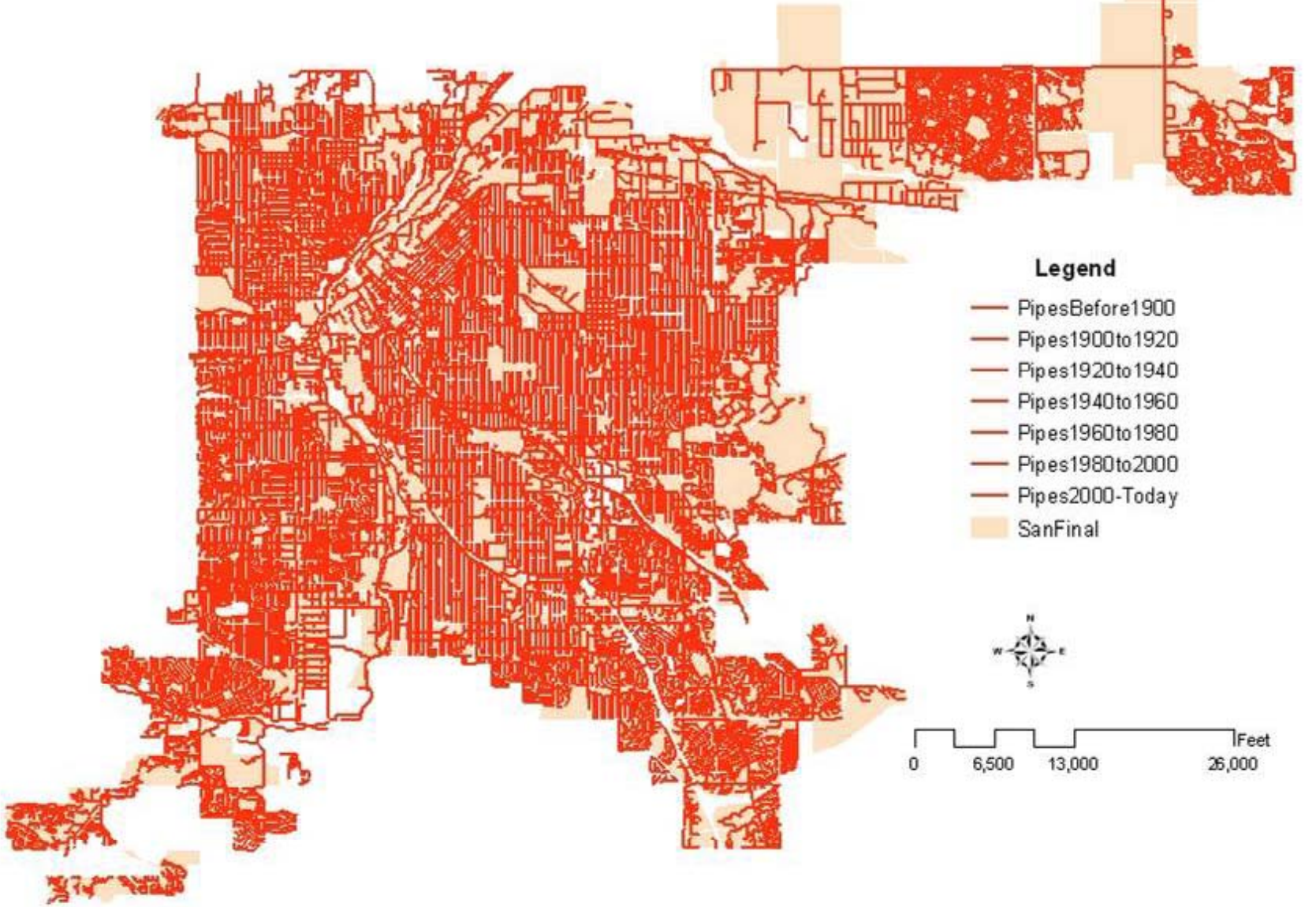
Sanitary Pipe installed before 1980



Sanitary Pipe installed before 2000

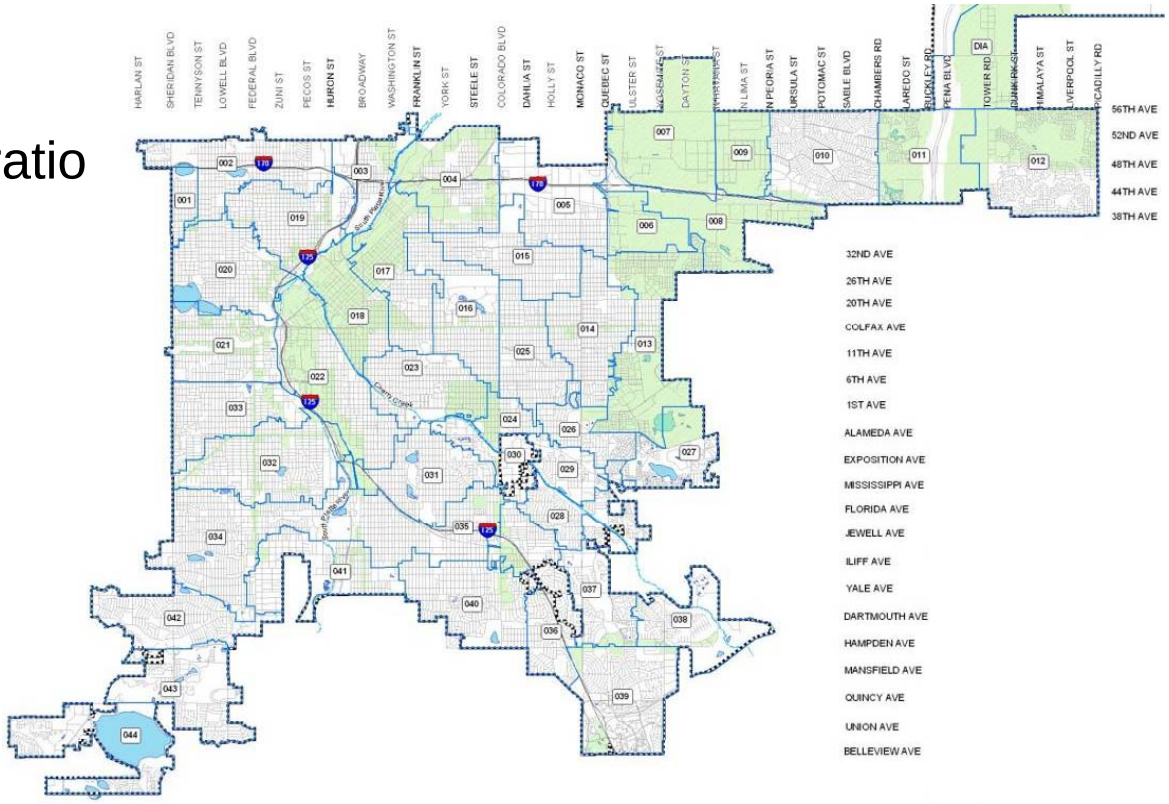


Sanitary Pipe installed before 2006



Overview

- Sanitary sewer capacity model based on database method
  - Geometric network of wastewater system
  - Loading based on parcel-based land use
  - Pipe Capacity Model
- Depicting results
  - Map Pipe flow to capacity ratio
  - Customized map book
- Development impact tools
  - Upstream trace summary
  - Downstream accumulation
  - Summary statistics



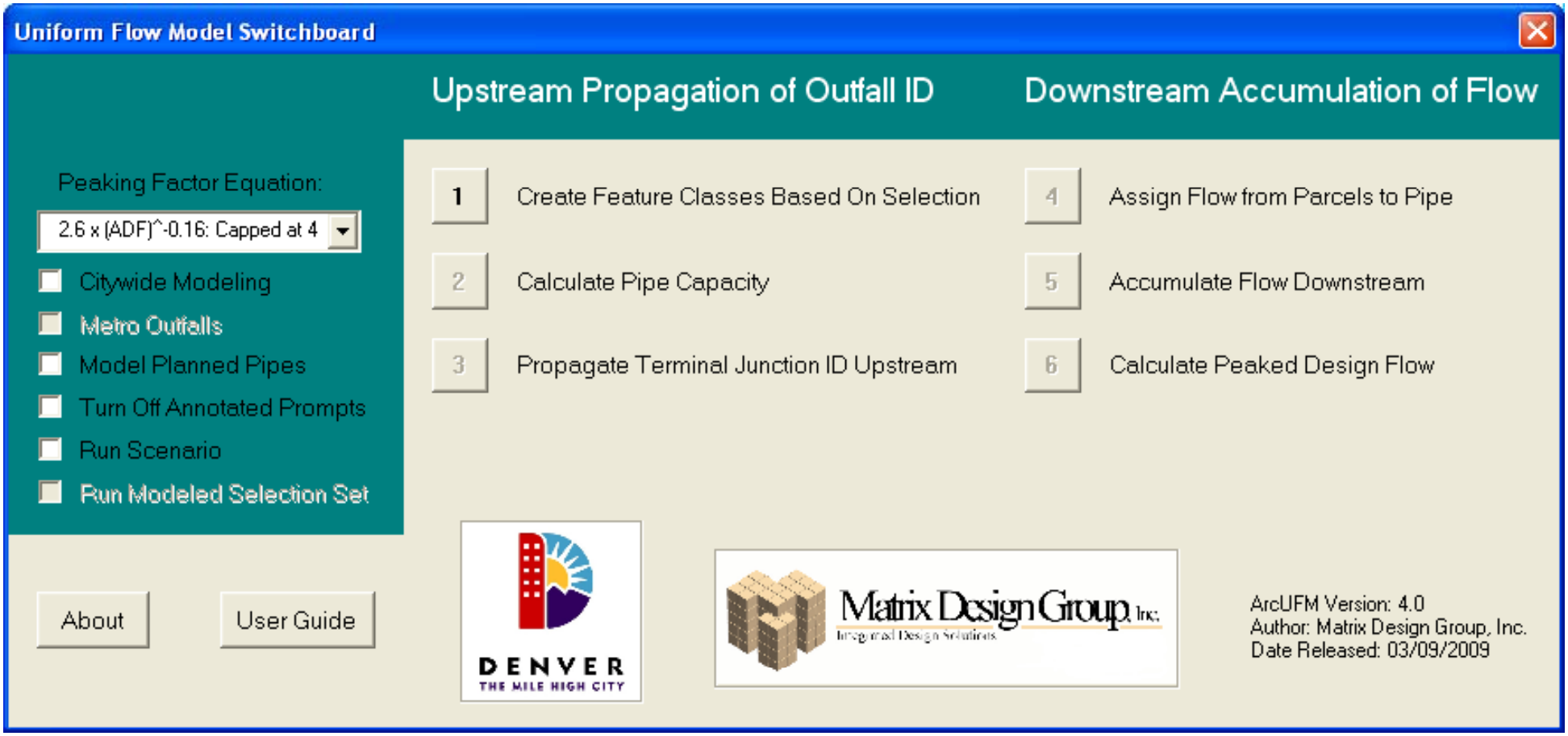
Pipe Capacity Model

- Uniform flow modeling approach (UFM)
  - ArcMap interface
  - Runs on ESRI personal geodatabase
  - Flow accumulation via geometric network
- Manning's Equation used for capacity
- Land use-based loading at the parcel level
  - Loading per Denver's criteria manual
  - Infiltration & inflow (I&I) is calculated using parcel area
- Sewershed delineation by network trace

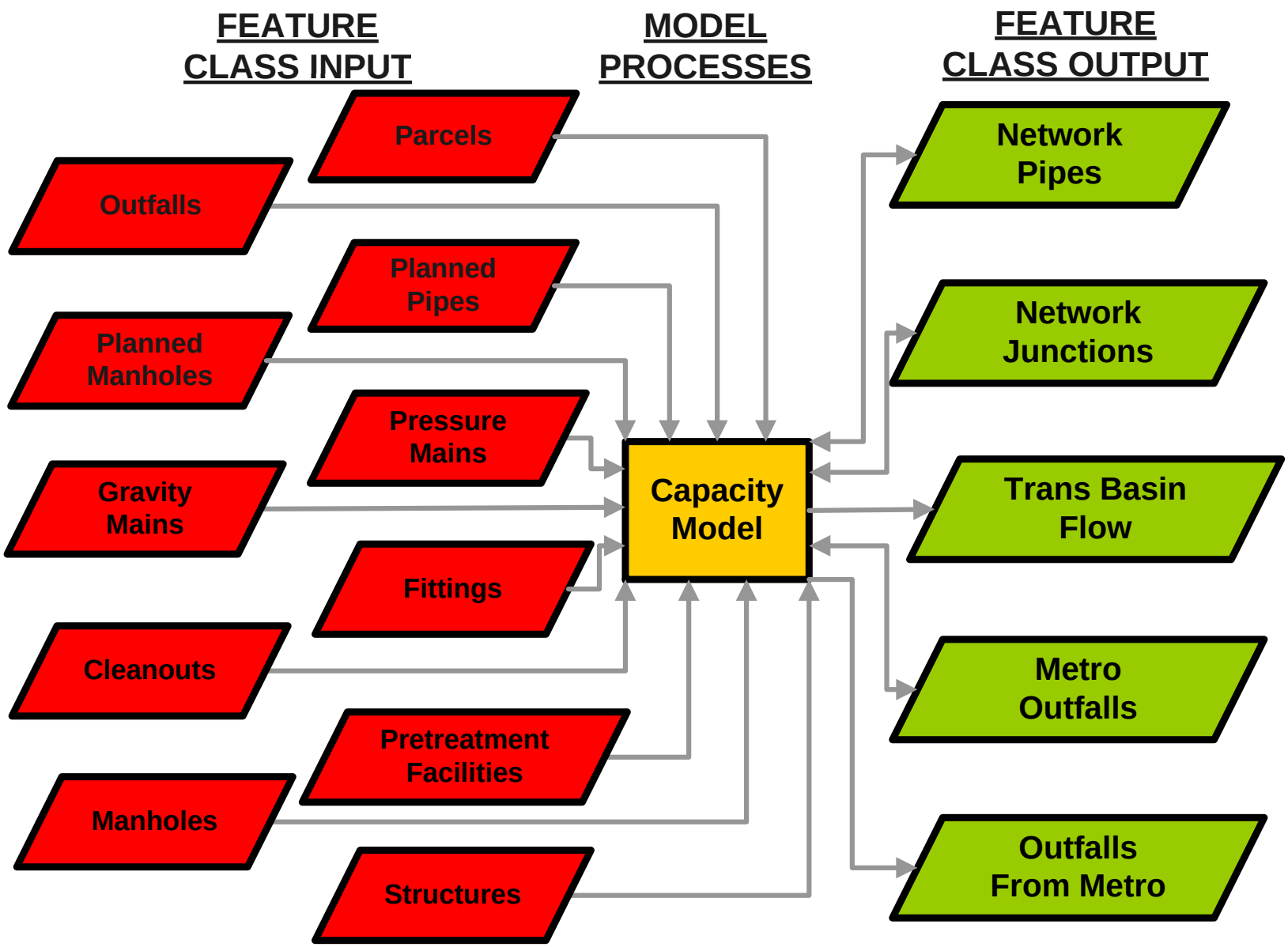
Capacity Analysis

- **Required sewer capacity = ((peak factor x avg. flow) + I&I) /0.86**
  - Peaking factor = 2.6 x (ADF)-0.16
    - ADF = average daily flow (cfs)
    - Peaking factor is capped at 4
  - I & I = 500 gallons/gross acre/day
  - Pipe considered full at 86% of full flow capacity

ArcGIS Interface

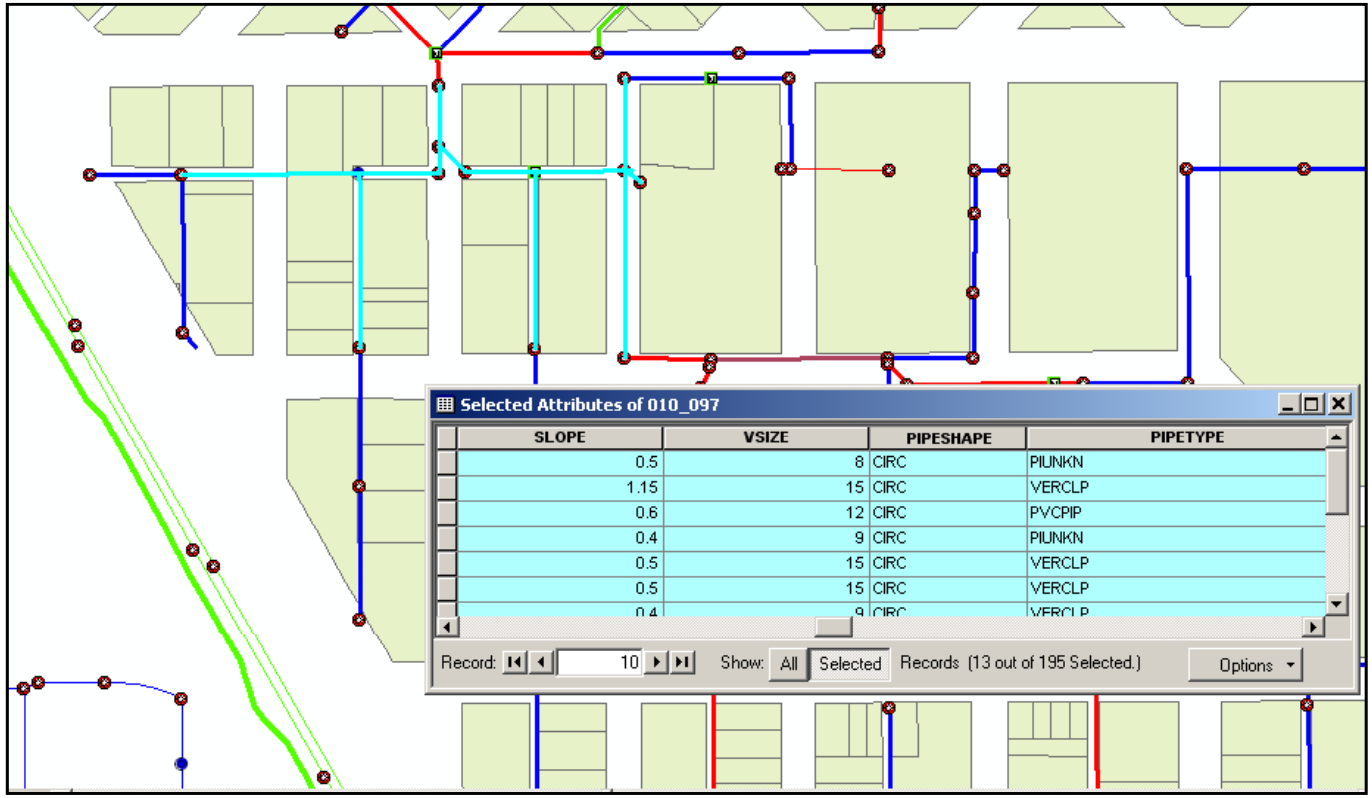


Sanitary Sewer Capacity Model



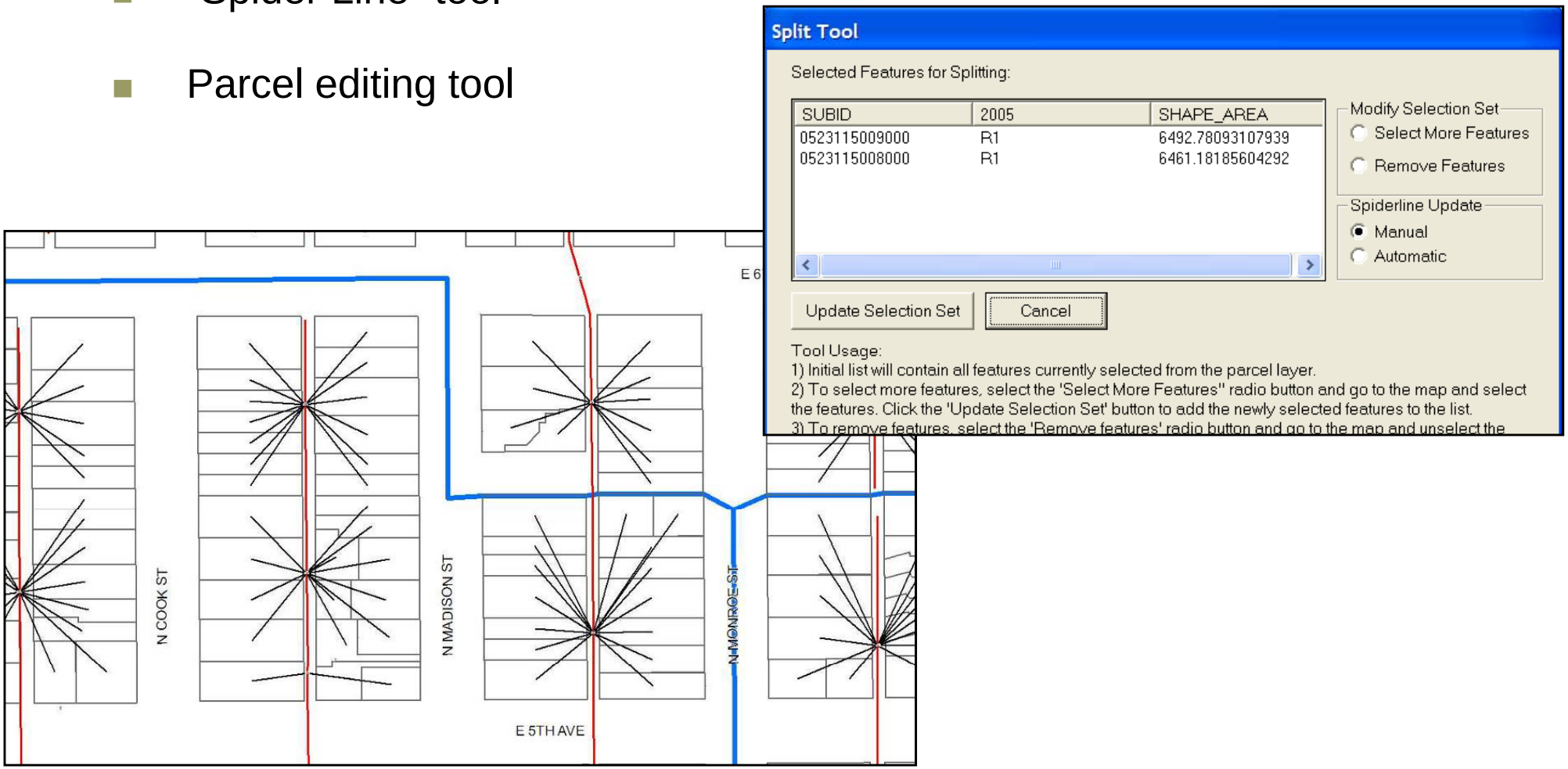
Sanitary Sewer Capacity Model Input

- Wastewater collection system (pipe, manholes & fittings)
- Geometric network
- Parcel-based land use for daily sewer loading
- Map groups



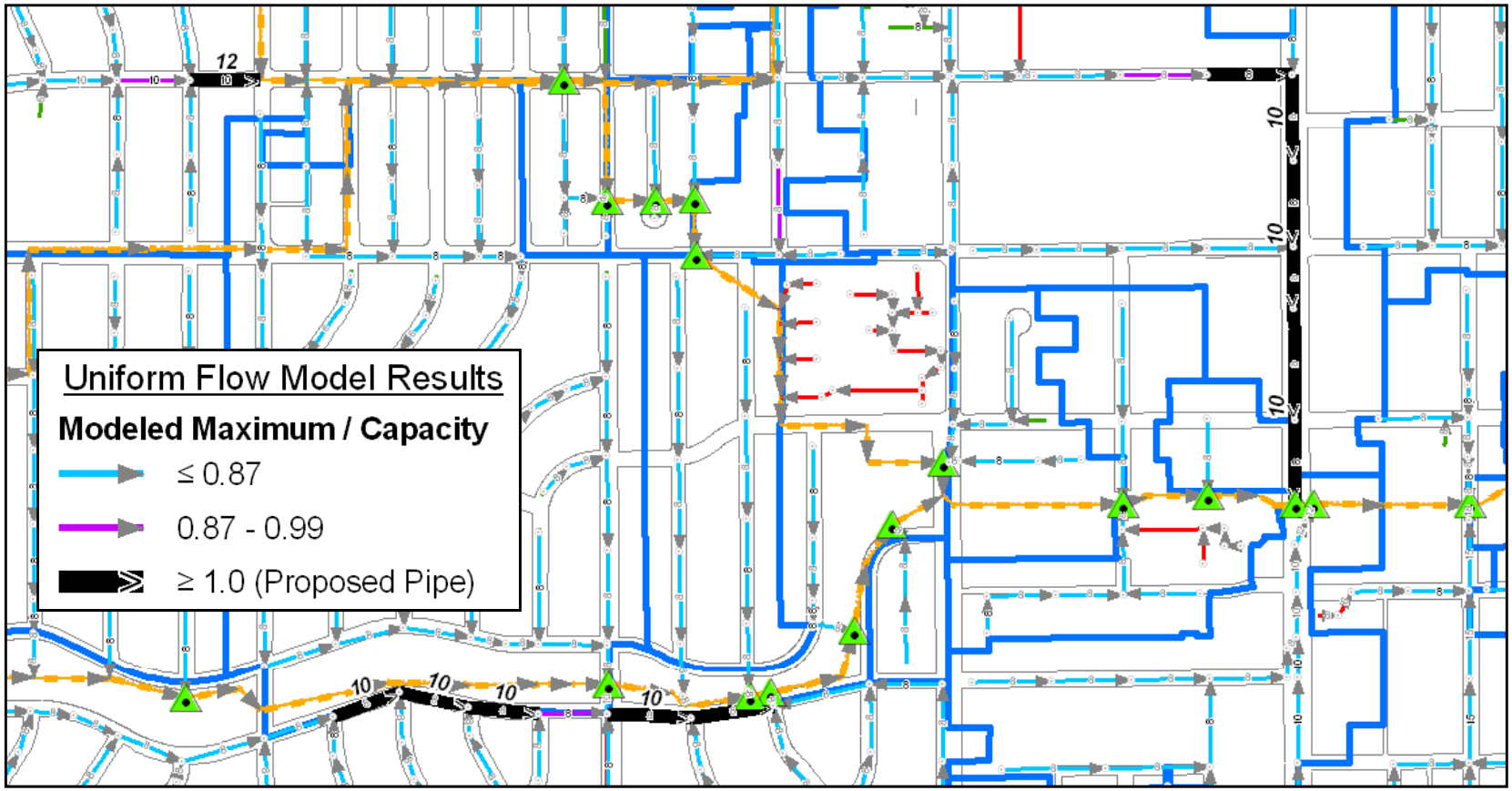
Wastewater Collection System Loading

- Flow allocated from parcels to pipe using GIS tools
  - “Spider Line” tool
  - Parcel editing tool



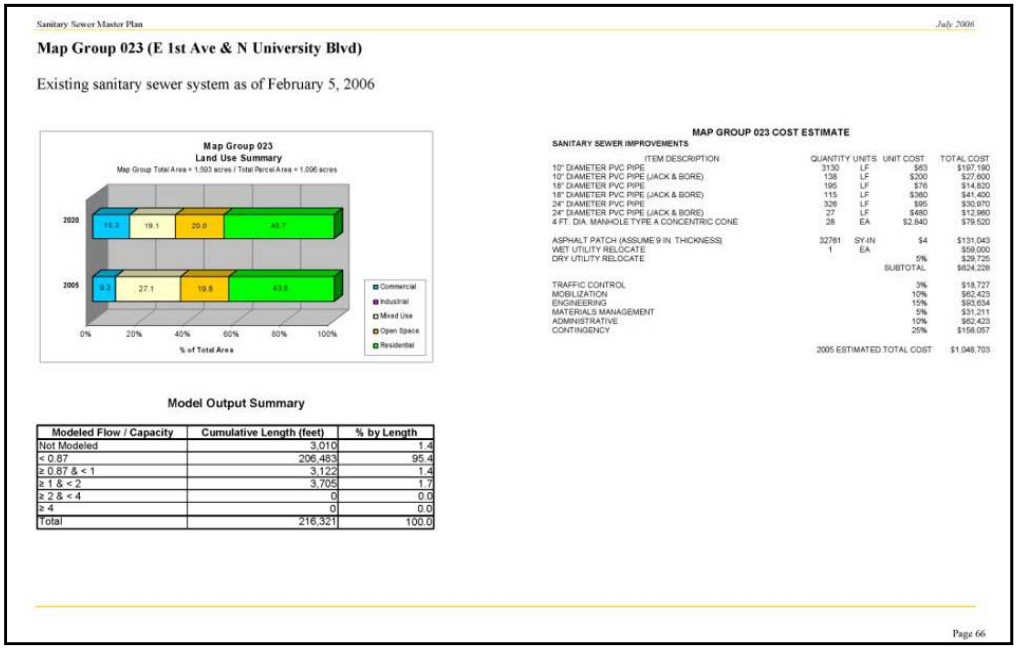
Mapping Capacity Deficient Pipe

- Pipe symbolized by: modeled maximum flow / pipe capacity
- Manning's Equation used to calculate nominal pipe diameters for proposed pipe



11x17 Map Book

- Cost estimate by map group
- Land use analysis
- Model output summary table
- Existing conditions
- Symbolized model output
- Proposed improvements



Sanitary Sewer Master Plan — July 2006

Map Group 023 (E 1st Ave & N University Blvd)

Existing sanitary sewer system as of February 5, 2006

Model Output Summary

Modeled Flow / Capacity	Cumulative Length (feet)	% by Length
Not Modeled	3,010	1.4
< 0.87	206,483	95.4
≥ 0.87 & < 1	3,122	1.4
≥ 1 & < 2	3,705	1.7
≥ 2 & < 4	0	0.0
≥ 4	0	0.0
Total	216,321	100.0

MAP GROUP 023 COST ESTIMATE

SANITARY SEWER IMPROVEMENTS

ITEM DESCRIPTION	QUANTITY	UNITS	UNIT COST	TOTAL COST
10" DIAMETER PVC PIPE	3130	LF	$63	$197,190
10" DIAMETER PVC PIPE (JACK & BORE)	136	LF	$200	$27,600
18" DIAMETER PVC PIPE	195	LF	$76	$14,820
18" DIAMETER PVC PIPE (JACK & BORE)	115	LF	$360	$41,400
24" DIAMETER PVC PIPE	326	LF	$95	$30,970
24" DIAMETER PVC PIPE (JACK & BORE)	27	LF	$480	$12,960
4 FT. DIA. MANHOLE TYPE A CONCENTRIC CONE	28	EA	$2,840	$79,520
ASPHALT PATCH (ASSUME 9 IN. THICKNESS)	32781	SY-IN	$4	$131,043
WET UTILITY RELOCATE	1	EA		$59,000
DRY UTILITY RELOCATE			5%	$29,725
			SUBTOTAL	$624,228
TRAFFIC CONTROL			3%	$18,727
MOBILIZATION			10%	$62,423
ENGINEERING			15%	$93,634
MATERIALS MANAGEMENT			5%	$31,211
ADMINISTRATIVE			10%	$62,423
CONTINGENCY			25%	$156,057
2005 ESTIMATED TOTAL COST				$1,048,703

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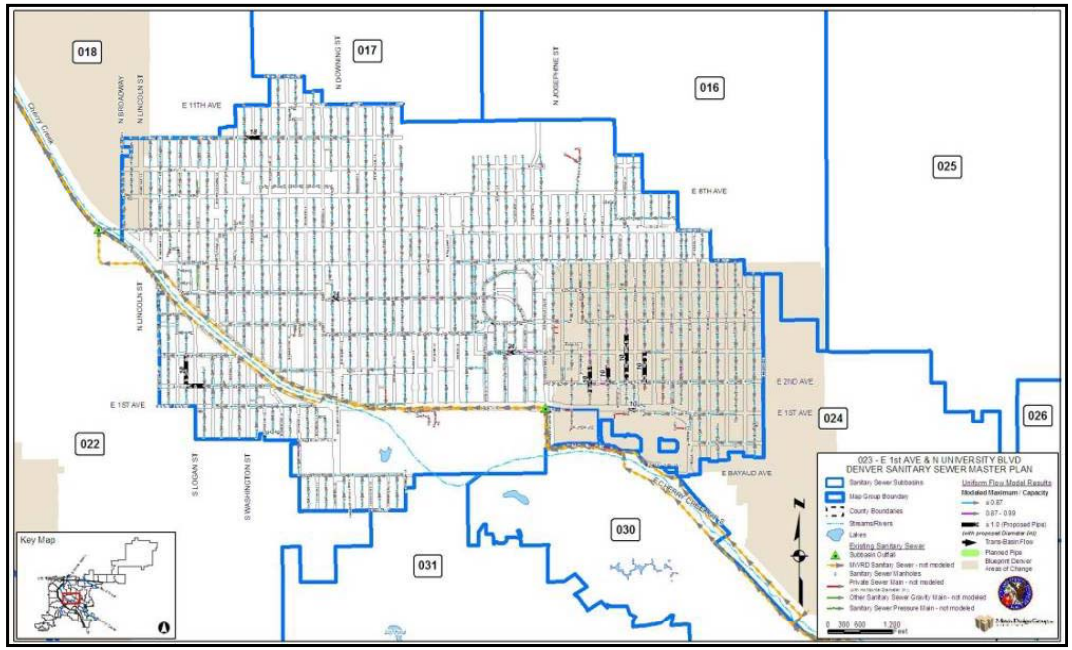
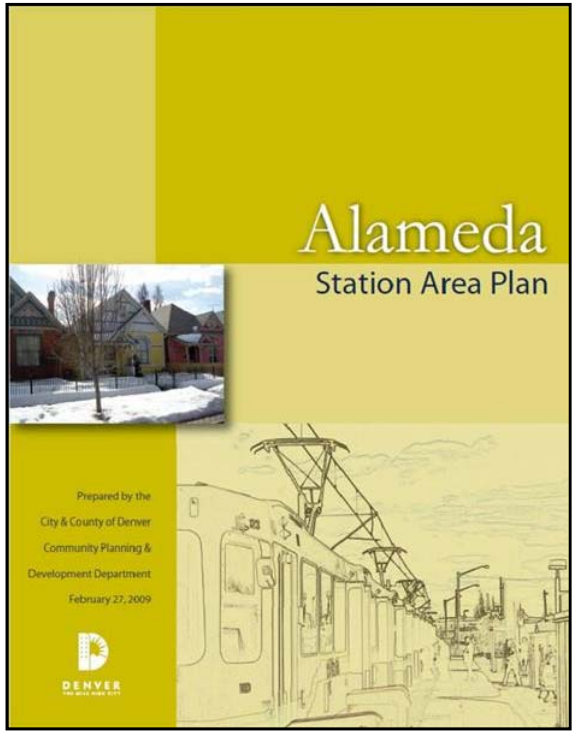
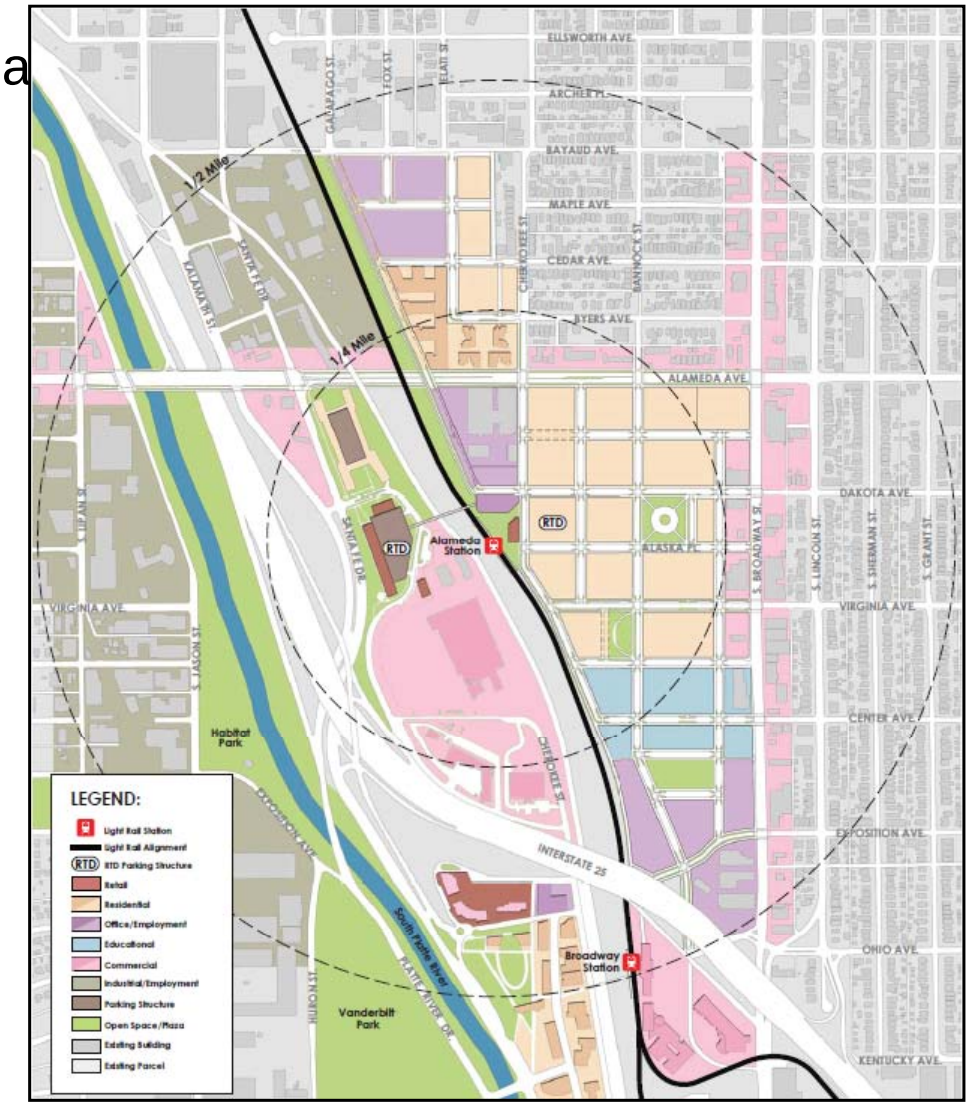


Development Impact Tools

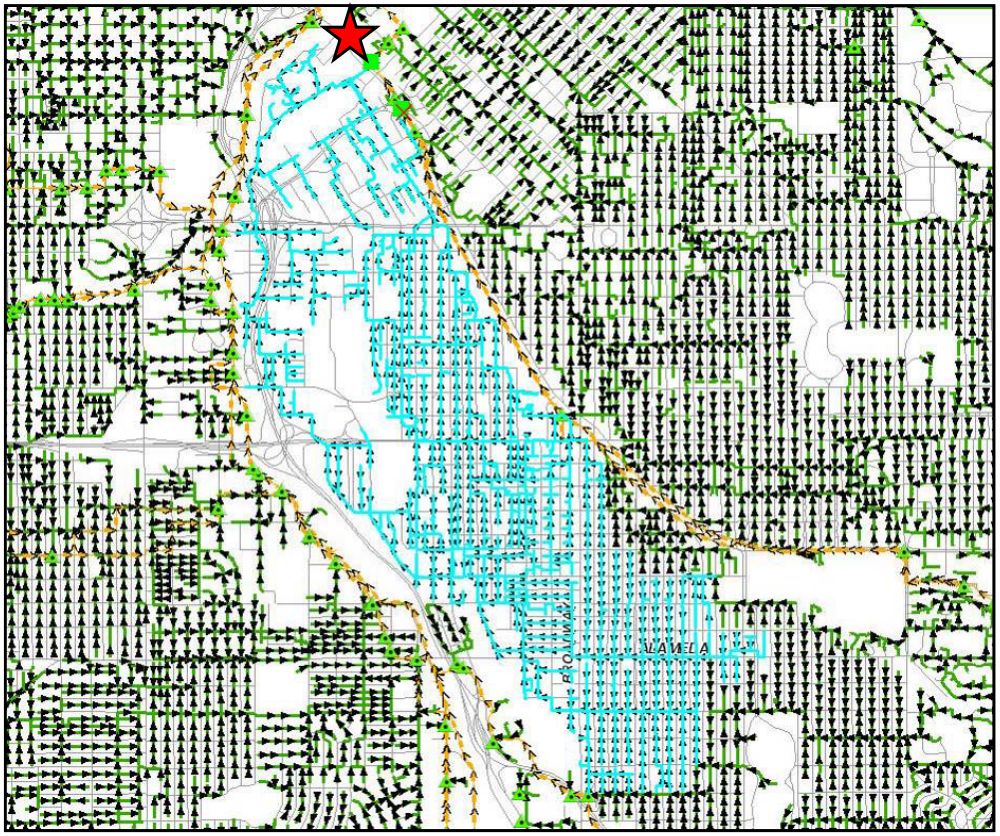
- Conceptual flow modeling using a geometric network
  - Alameda Station
  - Transit hub for Regional Light Ra



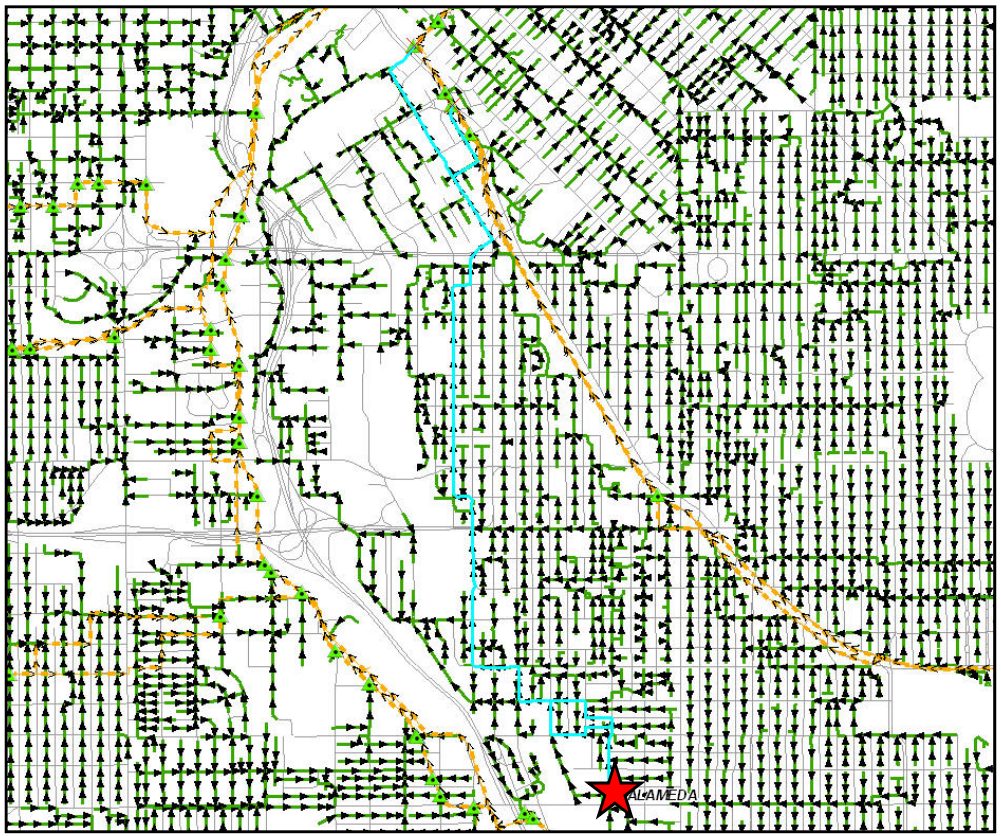


Development Impact Tools

- Upstream summary and downstream flow push tools



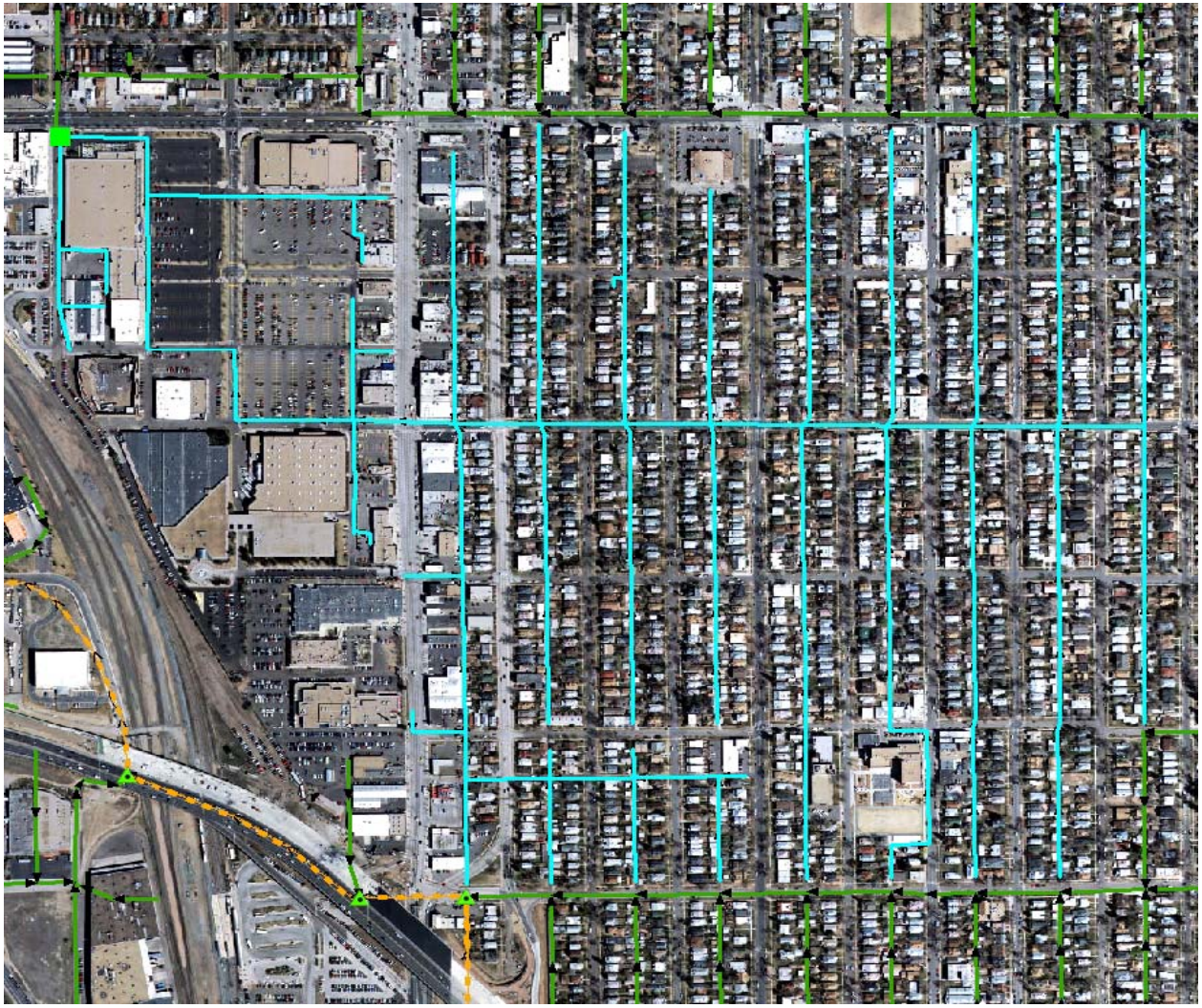
Upstream trace from outfall



Downstream trace from site

Upstream Trace

- Summarize current conditions and loading



Upstream trace from site

Upstream Trace Statistics

Selection Set Summary Statistics

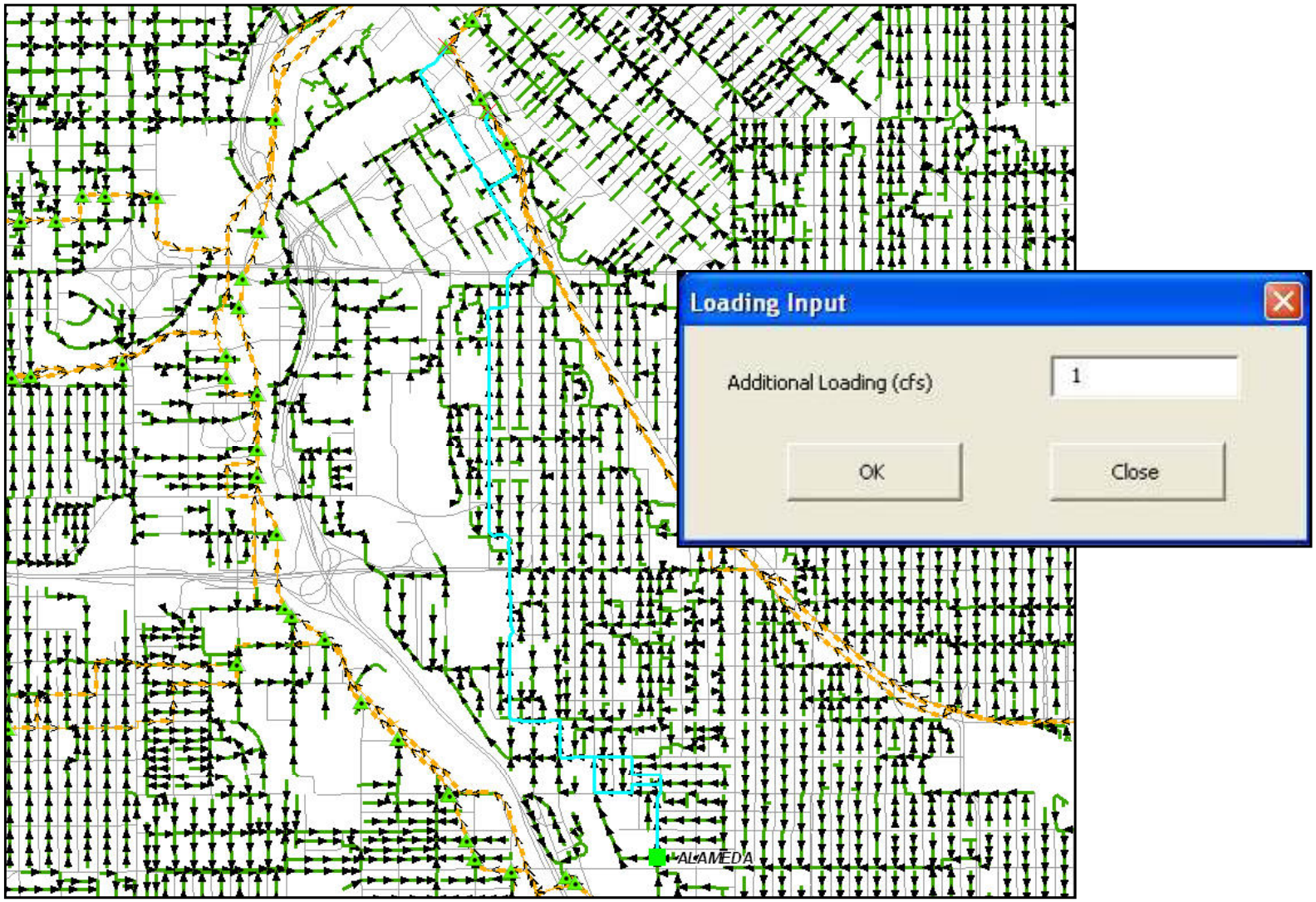
Selection Set Summary Statistics

Export Stats | Export Map | Export Flags & Barriers | Export Features

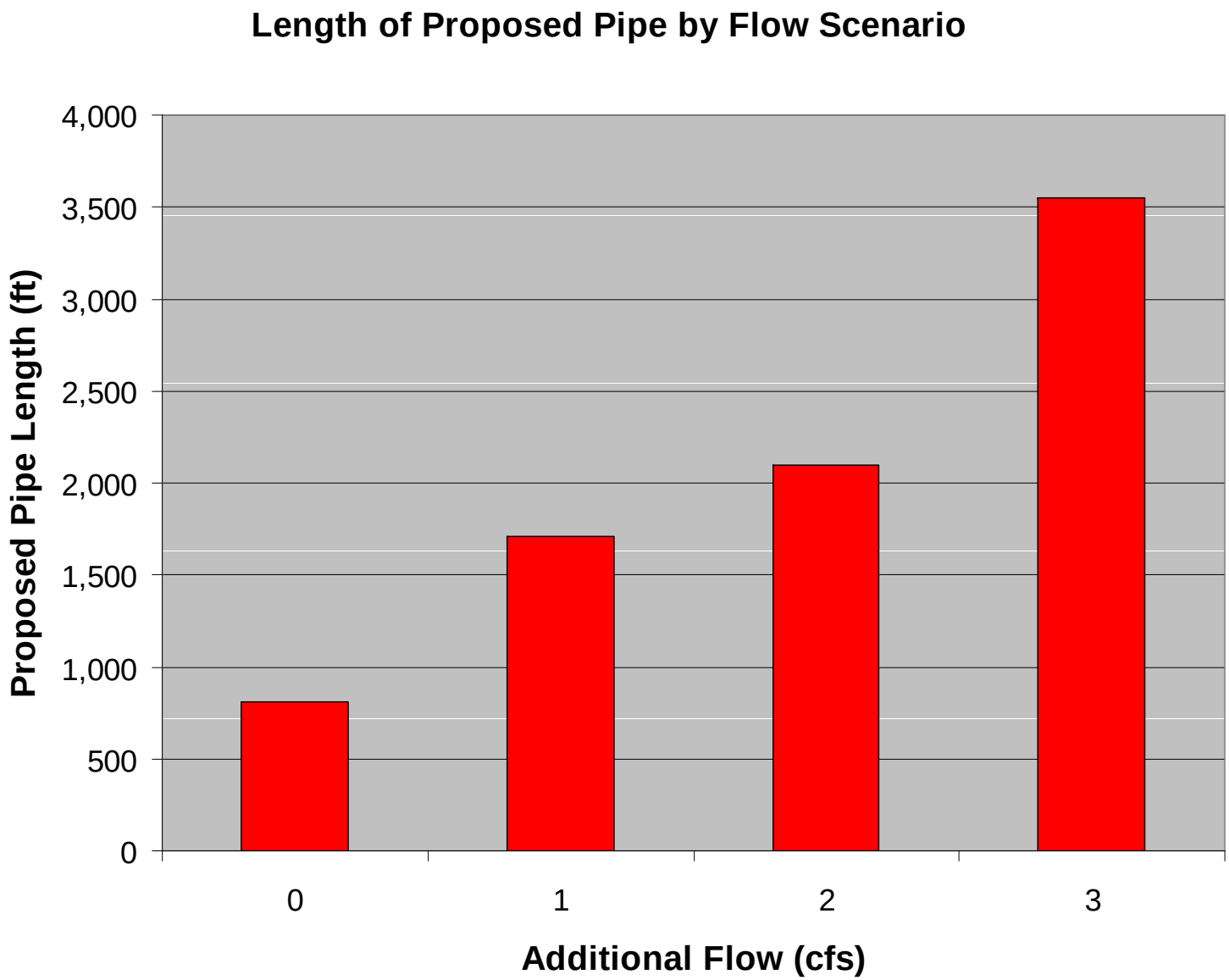
```
Upstream trace started from the junction with FacilityID: 24202SAMH
Number of Pipe Features = 175
Number of Junction Features = 178
Actual Contributing Area = 227.99 acres
Effective Contributing Area = 227.99 acres
Total length of pipe = 38,978.0 feet

                                          Current          Year 2020
Total Average Daily Flow                  1.039467 cfs     2.016197 cfs
Maximum Accumulated Average Daily Flow    1.039467 cfs     2.016197 cfs
Maximum Peak Flow                         2.862301 cfs     4.862144 cfs
Average Loading                           0.004559 cfs/ac  0.008844 cfs/ac
Average Loading                           2,946.8 gpd/ac   5,715.7 gpd/ac

Total Maximum Peak Flow = 66.2228 cfs
Total Capacity = 252.9996 cfs*
% Capacity Used (Total Maximum Peak Flow / Total Capacity) = 26.2%*
% Remaining Capacity ((Total Capacity - Total Max. Peak Flow) / Total Capacity) = 73.8%*

Maximum Peak Flow/Capacity      Count     Cumulative Length    % by Length
Not Modeled                     16        1,702.5 ft           4.4
<=0.87                          159       37,275.4 ft          95.6
>0.87 & <=1                     0         0.0 ft               0.0
> 1                             0         0.0 ft               0.0
```

Downstream Trace

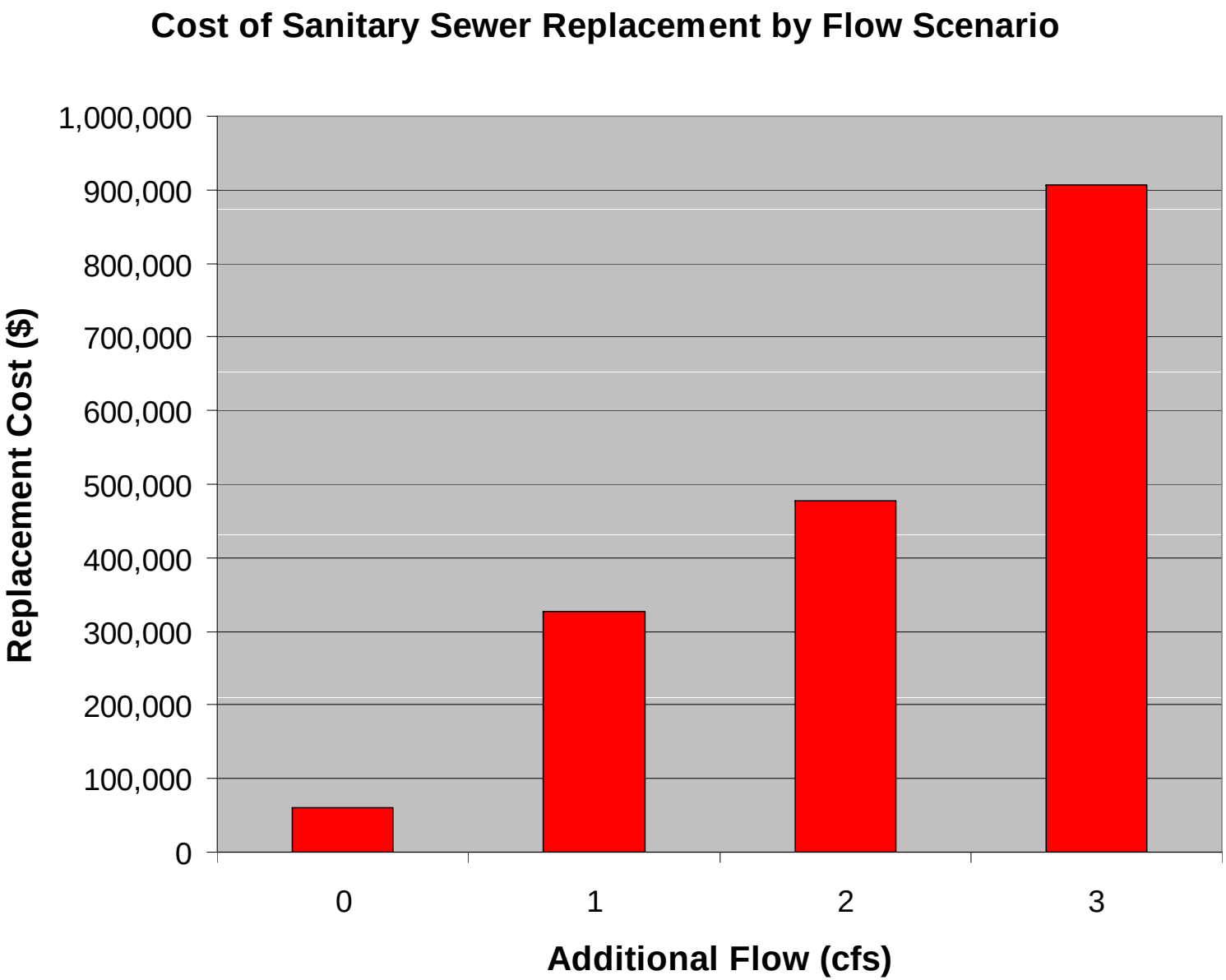
- Model downstream effects of additional loading



Alameda Station – Proposed Pipe Length

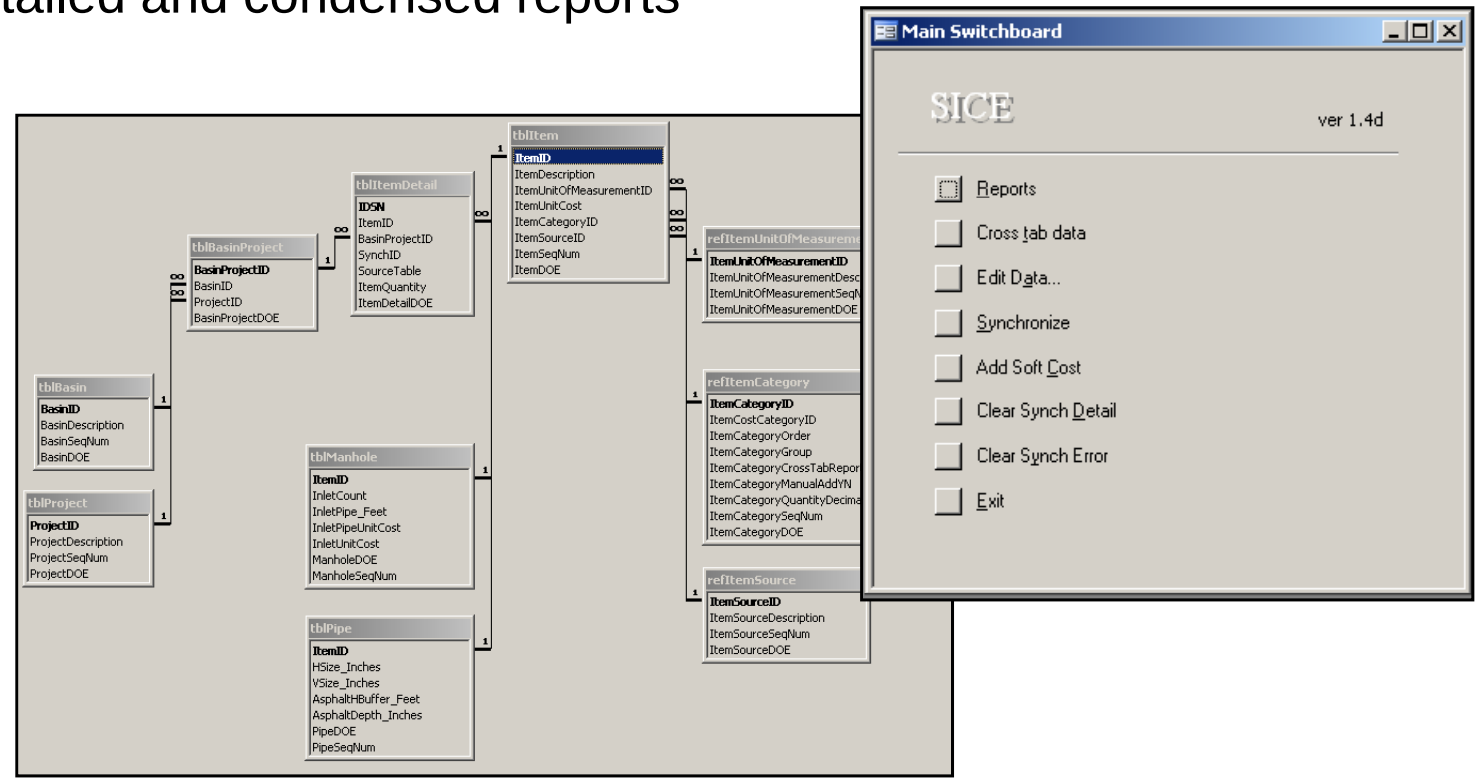


Alameda Station – Replacement Cost



Depicting Results – Cost Model

- GIS linked budget tool
  - Cost estimating tool for proposed infrastructure improvements
  - Microsoft Access based application
  - Linked to proposed Improvements in GIS data
  - Costs can be automatically updated to reflect changes to GIS data
  - Detailed and condensed reports



Depicting Results – Cost Report

MAP GROUP 002 COST ESTIMATE

SANITARY SEWER IMPROVEMENTS

ITEM DESCRIPTION	QUANTITY	UNITS	UNIT COST	TOTAL COST
10" DIAMETER PVC PIPE	1484	LF	$63	$93,492
12" DIAMETER PVC PIPE	1748	LF	$66	$115,368
15" DIAMETER PVC PIPE	1304	LF	$71	$92,584
18" DIAMETER PVC PIPE	186	LF	$76	$14,136
21" DIAMETER PVC PIPE	56	LF	$86	$4,816
8" DIAMETER PVC PIPE	369	LF	$60	$22,140
4 FT. DIA. MANHOLE TYPE A CONCENTRIC CONE	28	EA	$2,840	$79,520
ASPHALT PATCH (ASSUME 9 IN. THICKNESS)	46414	SY-IN	$4	$185,655
WET UTILITY RELOCATE	1	EA		$47,000
DRY UTILITY RELOCATE			5%	$32,736
			SUBTOTAL	$687,447
TRAFFIC CONTROL			3%	$20,623
MOBILIZATION			10%	$68,745
ENGINEERING			15%	$103,117
MATERIALS MANAGEMENT			5%	$34,372
ADMINISTRATIVE			10%	$68,745
CONTINGENCY			25%	$171,862

2005 ESTIMATED TOTAL COST $1,154,911

Conclusions

- Powerful tool for evaluating potential development impacts
- Quickly Respond to Requests with Added Confidence
- Every Pipe Modeled – Flow can be added at any manhole
- Model Requires Initial and Continued GIS Data Maintenance
- More Efficient Capital and Maintenance Activities