Wastewater System Capacity Tool
Evaluates Potential Development Impacts
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

Legend
- PipesBefore1900
- Pipes1900to1920
- Pipes1920to1940
- Pipes1940to1960
- Pipes1960to1980
- Pipes1980to2000
- Pipes2000-Today
- SanFinal

Scale: 0 Feet, 6,500, 13,000, 26,000 Feet
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 = \( \frac{(\text{peak factor} \times \text{avg. flow}) + \text{I&I}}{0.86} \)
  - Peaking factor = 2.6 \times (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

Uniform Flow Model Switchboard

Upstream Propagation of Outfall ID

1. Create Feature Classes Based On Selection
2. Calculate Pipe Capacity
3. Propagate Terminal Junction ID Upstream

Downstream Accumulation of Flow

4. Assign Flow from Parcels to Pipe
5. Accumulate Flow Downstream
6. Calculate Peaked Design Flow

Peaking Factor Equation:

$2.6 \times (ADF)^{0.16}$: Capped at 4

Citywide Modeling
Metro Outfalls
Model Planned Pipes
Turn Off Annotated Prompts
Run Scenario
Run Modeled Selection Set

About
User Guide

Matrix Design Group, Inc.

ArcUFM Version: 4.0
Author: Matrix Design Group, Inc.
Date Released: 03/09/2009
Sanitary Sewer Capacity Model

FEATURE CLASS INPUT
- Outfalls
- Planned Manholes
- Gravity Mains
- Cleanouts
- Manholes
- Pressure Mains
- Fittings
- Pretreatment Facilities

MODEL PROCESSES
- Parcels

FEATURE CLASS OUTPUT
- Network Pipes
- Network Junctions
- Trans Basin Flow
- Metro Outfalls
- Outfalls From Metro

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
Development Impact Tools

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

<table>
<thead>
<tr>
<th></th>
<th>Current</th>
<th>Year 2020</th>
</tr>
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<tbody>
<tr>
<td>Total Average Daily Flow</td>
<td>1.039467 cfs</td>
<td>2.016197 cfs</td>
</tr>
<tr>
<td>Maximum Accumulated Average Daily Flow</td>
<td>1.039467 cfs</td>
<td>2.016197 cfs</td>
</tr>
<tr>
<td>Maximum Peak Flow</td>
<td>2.862301 cfs</td>
<td>4.862144 cfs</td>
</tr>
<tr>
<td>Average Loading</td>
<td>0.004559 cfs/ac</td>
<td>0.008844 cfs/ac</td>
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<tr>
<td>Average Loading</td>
<td>2,946.8 gpd/ac</td>
<td>5,715.7 gpd/ac</td>
</tr>
</tbody>
</table>

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%*

<table>
<thead>
<tr>
<th>Maximum Peak Flow/Capacity</th>
<th>Count</th>
<th>Cumulative Length</th>
<th>% by Length</th>
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<tbody>
<tr>
<td>Not Modeled</td>
<td>16</td>
<td>1,702.5 ft</td>
<td>4.4</td>
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<tr>
<td>&lt;=0.87</td>
<td>159</td>
<td>37,275.4 ft</td>
<td>95.6</td>
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<tr>
<td>&gt;0.87 &amp; &lt;=1</td>
<td>0</td>
<td>0.0 ft</td>
<td>0.0</td>
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<tr>
<td>&gt; 1</td>
<td>0</td>
<td>0.0 ft</td>
<td>0.0</td>
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</table>
Downstream Trace

- Model downstream effects of additional loading
Alameda Station – Proposed Pipe Length

Length of Proposed Pipe by Flow Scenario

<table>
<thead>
<tr>
<th>Additional Flow (cfs)</th>
<th>Proposed Pipe Length (ft)</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>600</td>
</tr>
<tr>
<td>1</td>
<td>1,500</td>
</tr>
<tr>
<td>2</td>
<td>2,500</td>
</tr>
<tr>
<td>3</td>
<td>3,500</td>
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</table>
Alameda Station – Replacement Cost

Cost of Sanitary Sewer Replacement by Flow Scenario

<table>
<thead>
<tr>
<th>Additional Flow (cfs)</th>
<th>Replacement Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>500,000</td>
</tr>
<tr>
<td>1</td>
<td>700,000</td>
</tr>
<tr>
<td>2</td>
<td>800,000</td>
</tr>
<tr>
<td>3</td>
<td>1,000,000</td>
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</table>
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

<table>
<thead>
<tr>
<th>ITEM DESCRIPTION</th>
<th>QUANTITY</th>
<th>UNITS</th>
<th>UNIT COST</th>
<th>TOTAL COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>10&quot; DIAMETER PVC PIPE</td>
<td>1484</td>
<td>LF</td>
<td>$63</td>
<td>$93,492</td>
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<tr>
<td>12&quot; DIAMETER PVC PIPE</td>
<td>1748</td>
<td>LF</td>
<td>$66</td>
<td>$115,368</td>
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<tr>
<td>15&quot; DIAMETER PVC PIPE</td>
<td>1304</td>
<td>LF</td>
<td>$71</td>
<td>$92,584</td>
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<tr>
<td>18&quot; DIAMETER PVC PIPE</td>
<td>186</td>
<td>LF</td>
<td>$76</td>
<td>$14,136</td>
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<tr>
<td>21&quot; DIAMETER PVC PIPE</td>
<td>56</td>
<td>LF</td>
<td>$86</td>
<td>$4,816</td>
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<tr>
<td>8&quot; DIAMETER PVC PIPE</td>
<td>369</td>
<td>LF</td>
<td>$60</td>
<td>$22,140</td>
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<tr>
<td>4 FT. DIA. MANHOLE TYPE A CONCENTRIC CONE</td>
<td>28</td>
<td>EA</td>
<td>$2,840</td>
<td>$79,520</td>
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</tbody>
</table>

### OTHER ITEMS

<table>
<thead>
<tr>
<th>ITEM DESCRIPTION</th>
<th>QUANTITY</th>
<th>UNITS</th>
<th>UNIT COST</th>
<th>TOTAL COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASPHALT PATCH (ASSUME 9 IN. THICKNESS)</td>
<td>46414</td>
<td>SY-IN</td>
<td>$4</td>
<td>$185,655</td>
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<td>WET UTILITY RELOCATE</td>
<td>1</td>
<td>EA</td>
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<td>$47,000</td>
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<tr>
<td>DRY UTILITY RELOCATE</td>
<td></td>
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<td>5%</td>
<td>$32,736</td>
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</tbody>
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**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