GIS as a Tool for Water Distribution System Planning

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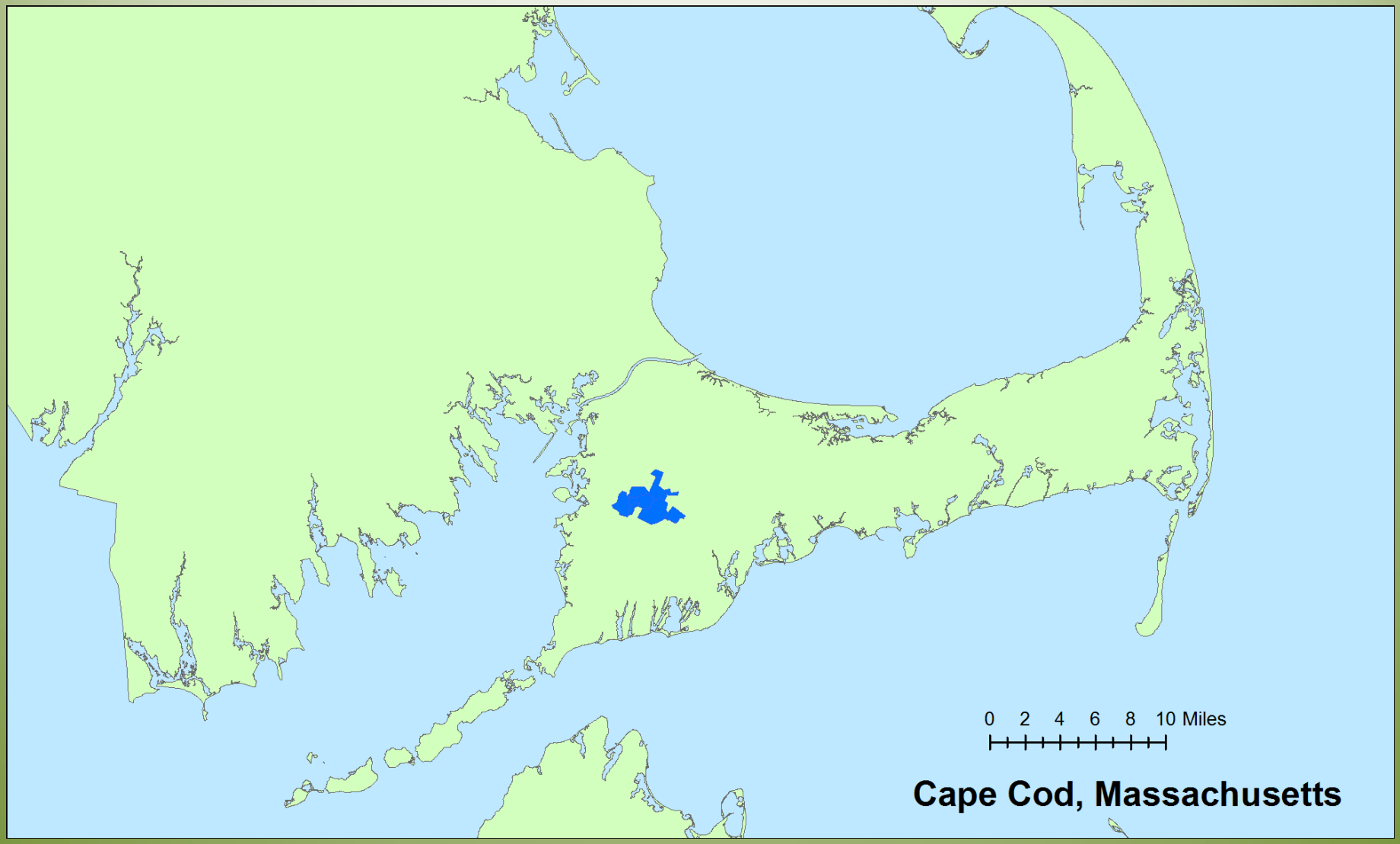
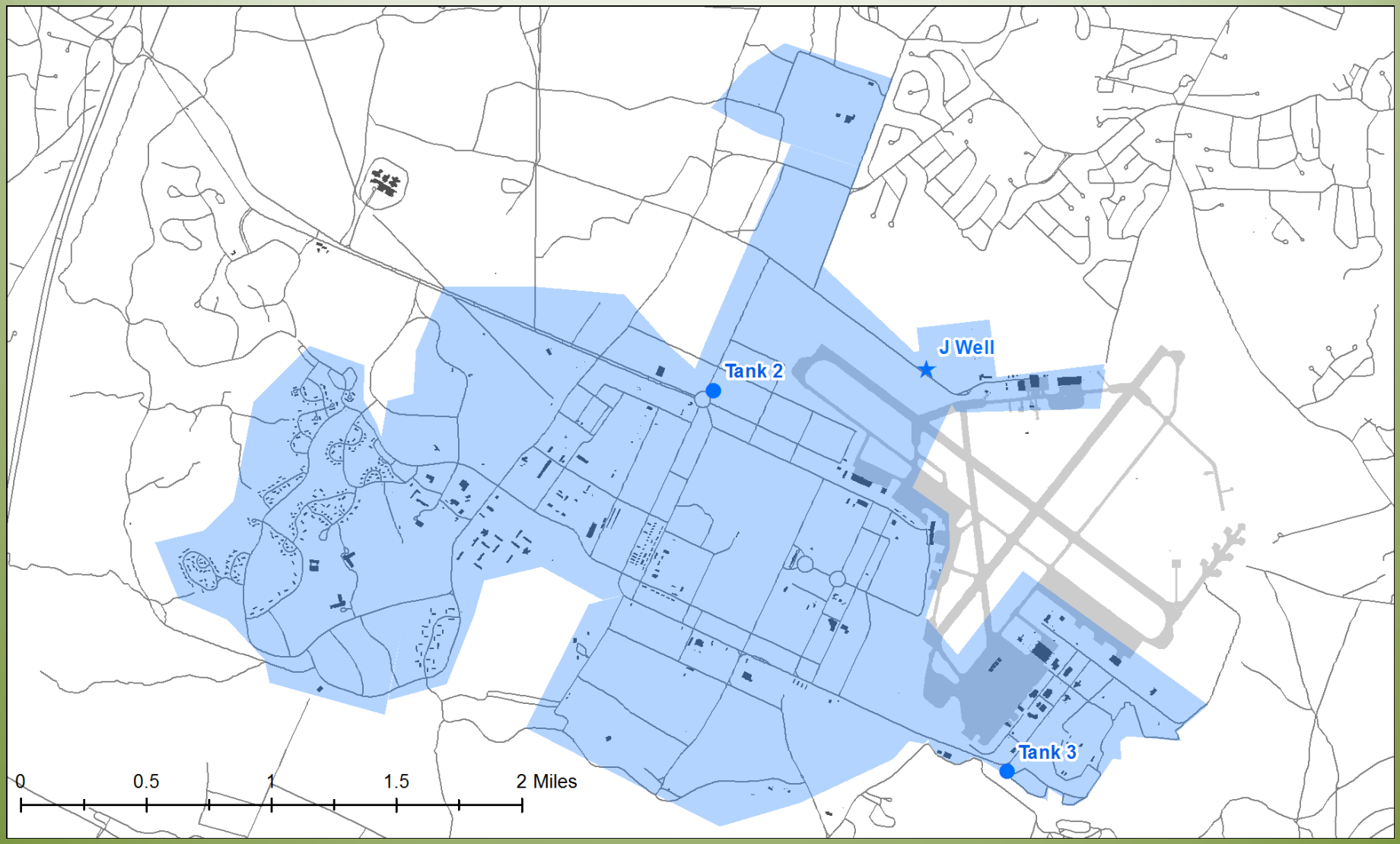
Contents

- Introduction
- The History of the Otis Public Water Supply
- Development of a Utility Infrastructure GIS
- Some GIS Answers to Simple Questions
- Looking at some Non-Spatial Data
- A Spatial Analysis for a Complex Question

Location – Otis ANGB Water System



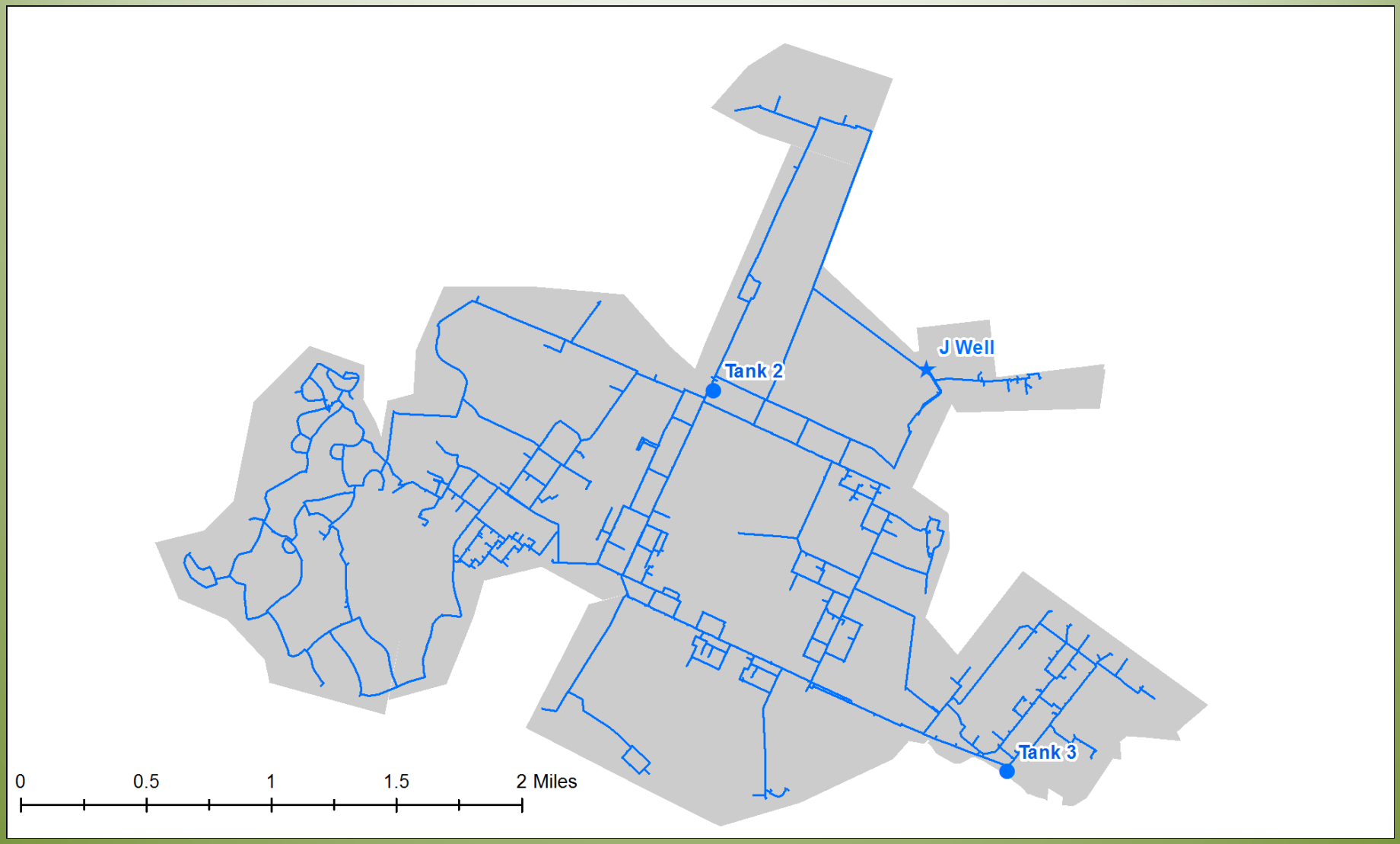
Current Infrastructure



Water Utility GIS Inventory

- (1) Public Water Supply Well
- (2) Water Distribution Tanks
- (8) Water Use Zones
- (45 miles) Water Mains
- (7 miles) Water Service Pipes
- (460) Service Connections
- (1006) Gate Valves
- (275) Fire Hydrants
- (1335) Various Fittings

Service Area



History of the Water System

1940 Before Construction – 6” Pipe

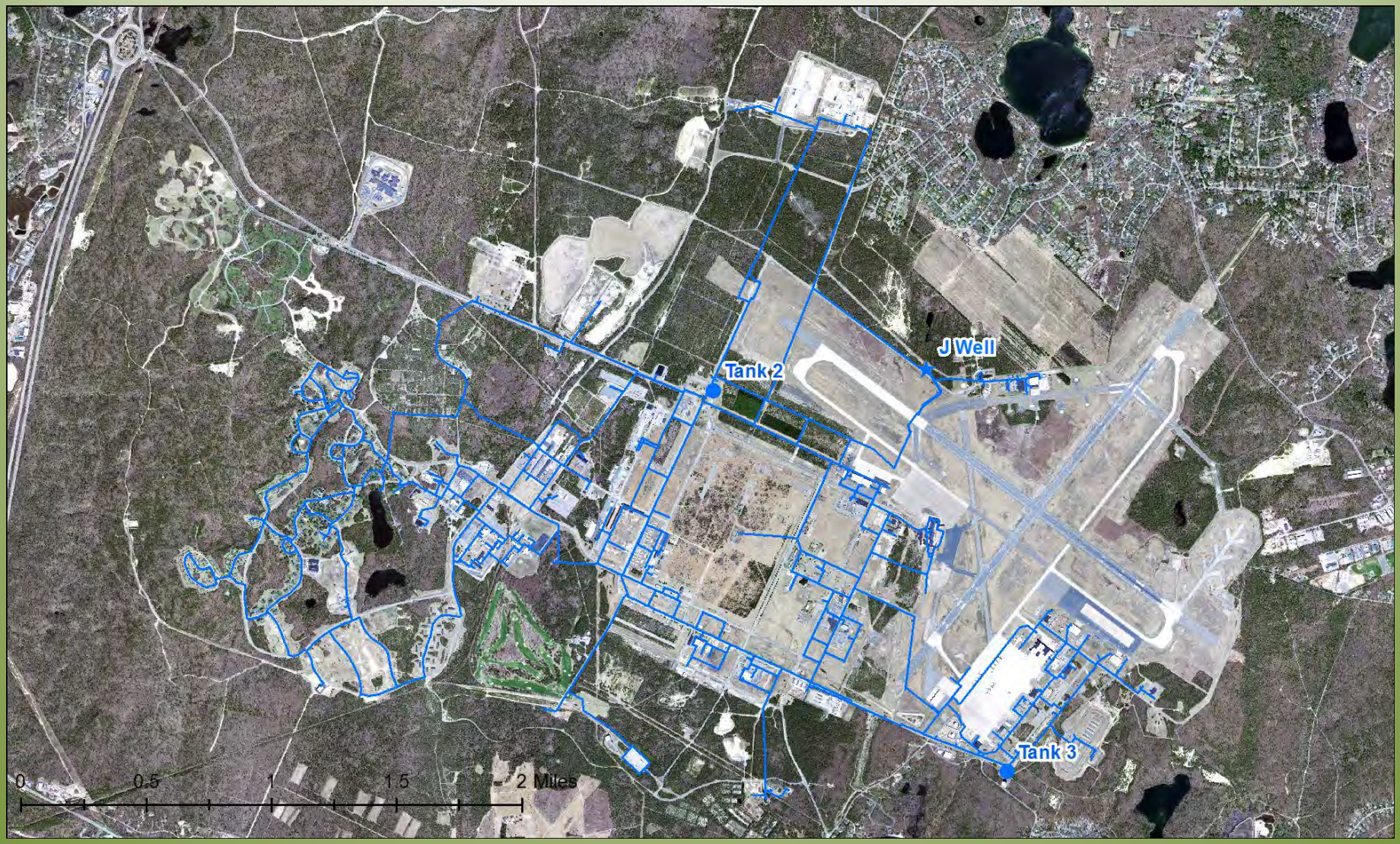
1940/1941 – Original Construction

System Designed for 70,000

Second Build-up 1955-1959

1966 – Maximum Buildup

2007 – Current Day



Water System Description

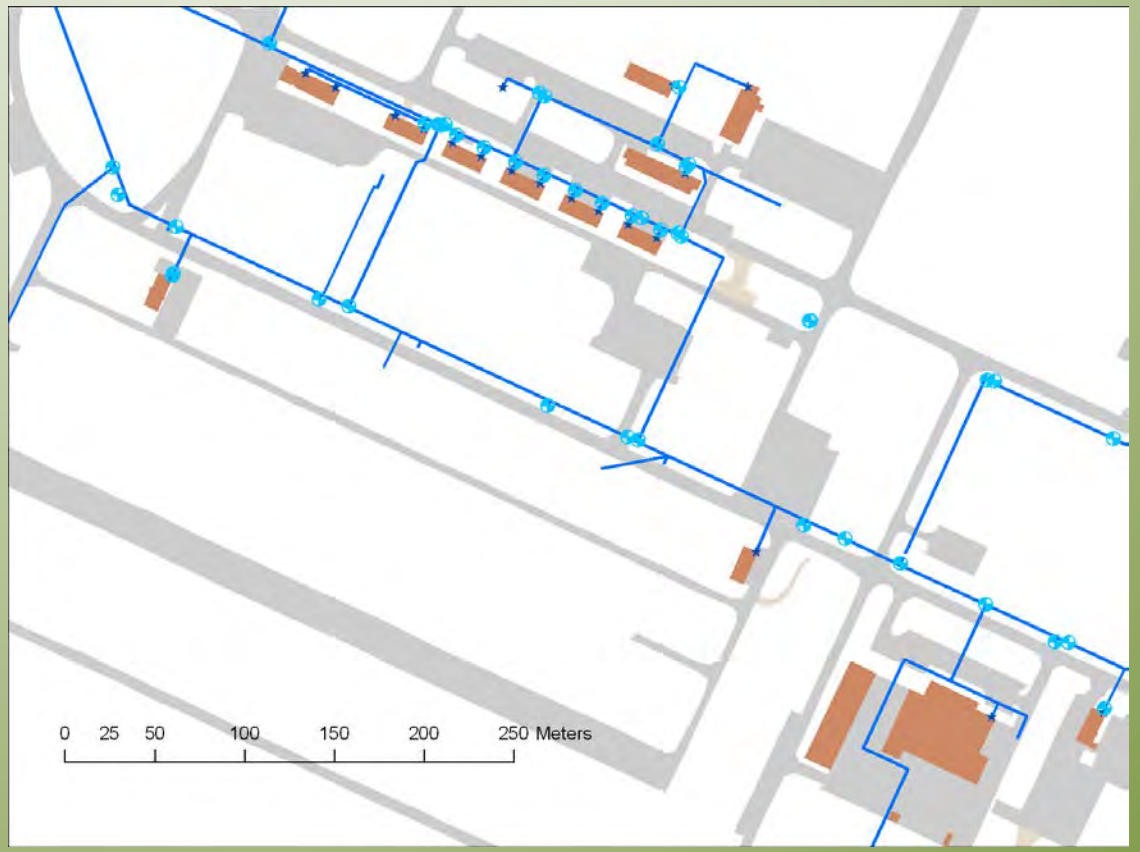
- 1600 Residents, 2000 Day Time, Transients
- Average Daily Usage is 152,000 gallons
- Tank Capacity is 700,000 gallons
- Over 1000 Active Gate Valves
- Over 52 miles of Active Pipeline
- Abandoned Infrastructure

Attributes from Construction History

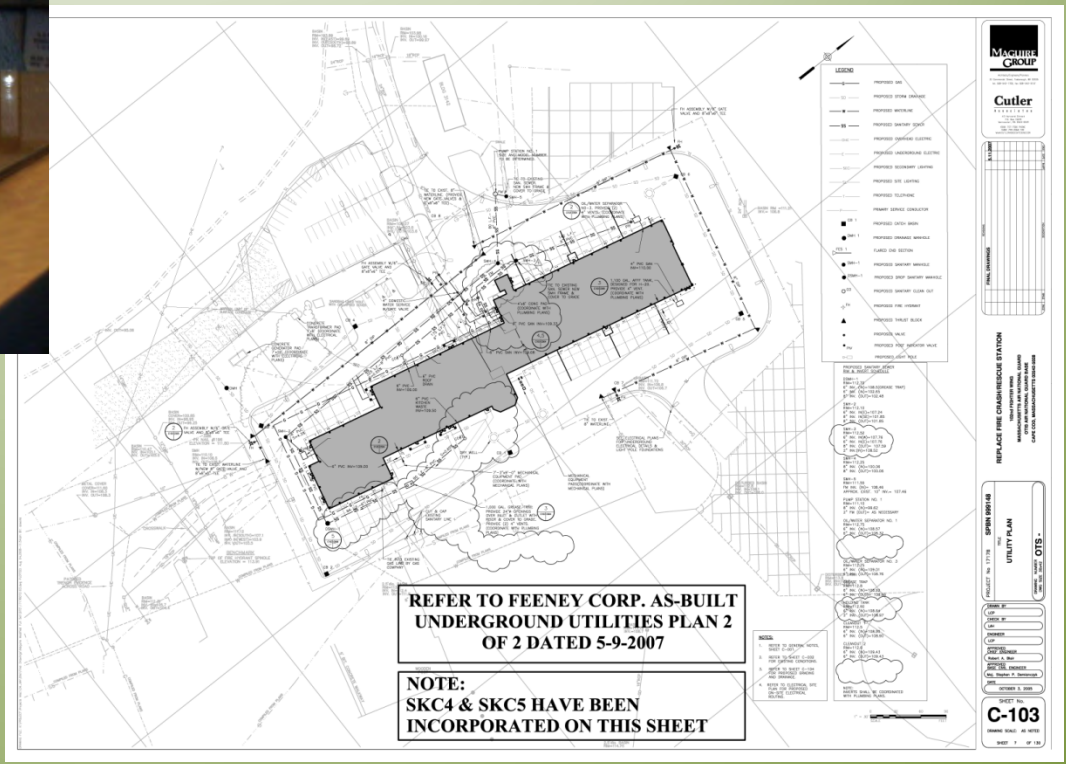
- Cast-iron Pipe: 1936-1946
- Asbestos-cement Pipe: 1955-1960
- Ductile-iron Pipe: 1970-2010
- PVC Pipe: 2010-present

Data Development

GPS above ground Features



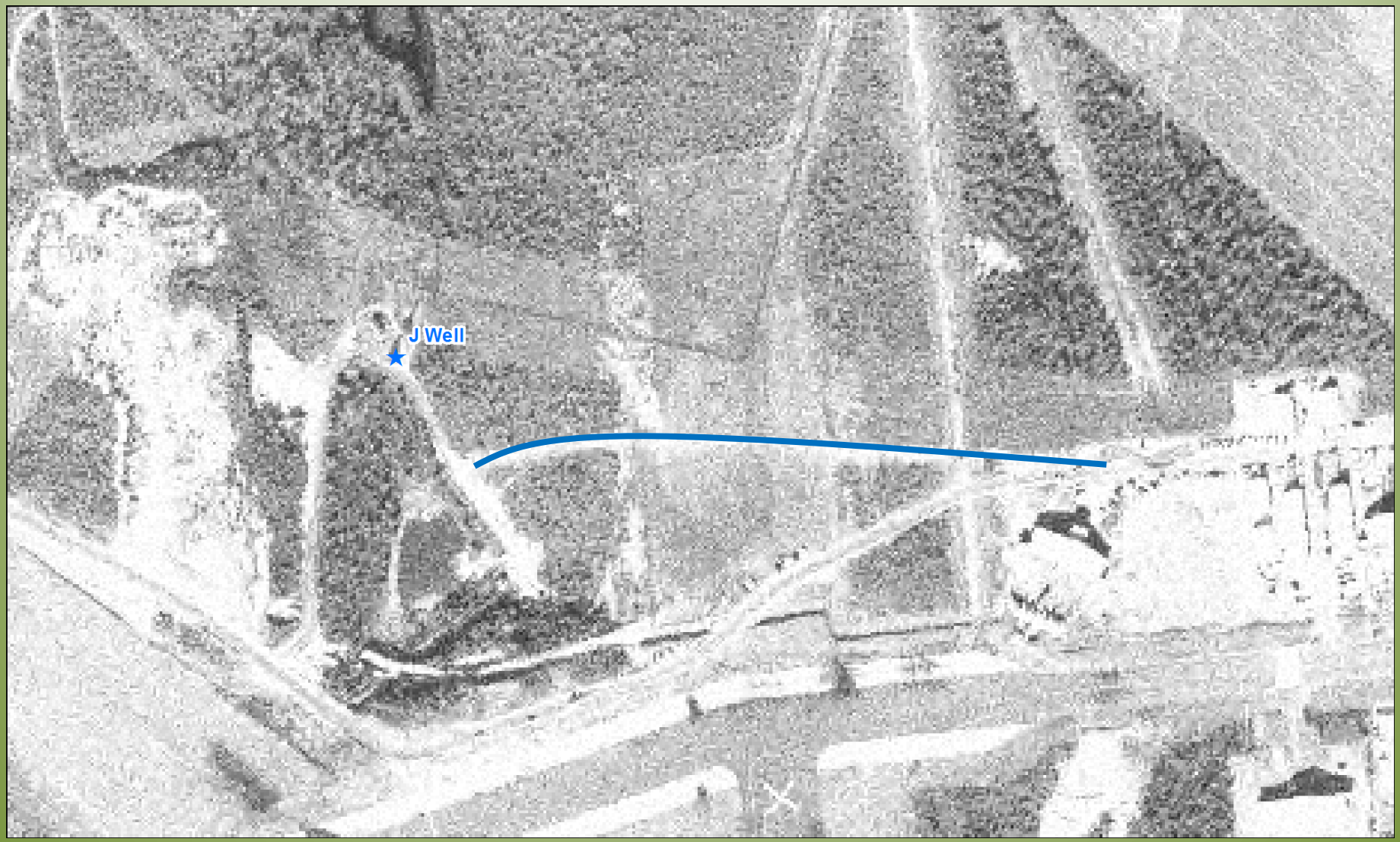
CAD Site Plans



Paper Site Plans

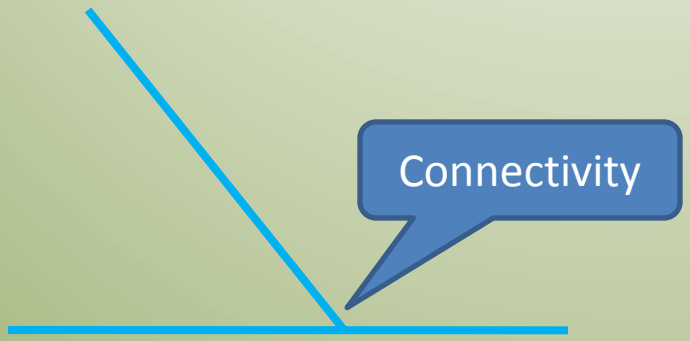
Some Plans are better than others.

1955 Photo used to locate waterline

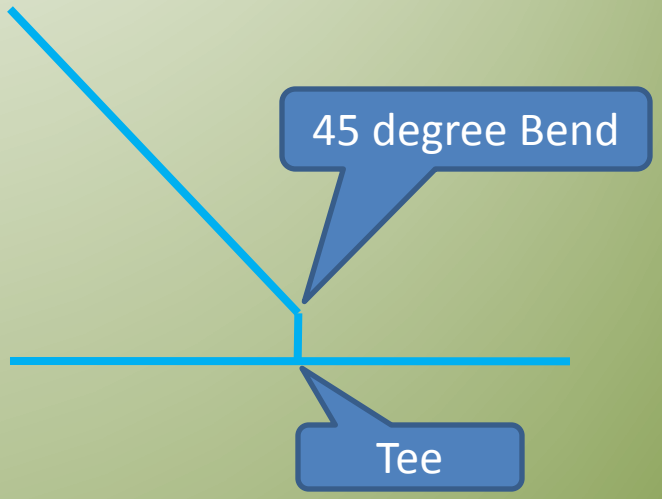


Pipe Connectivity

Less Work versus Better Inventory



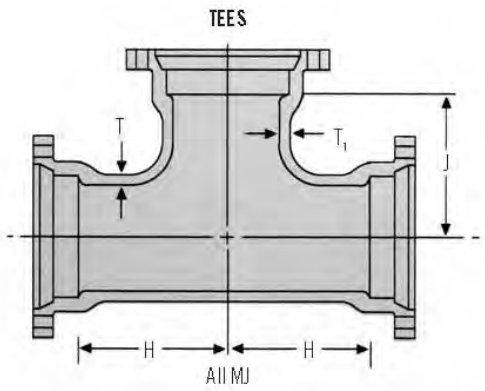
Schematic

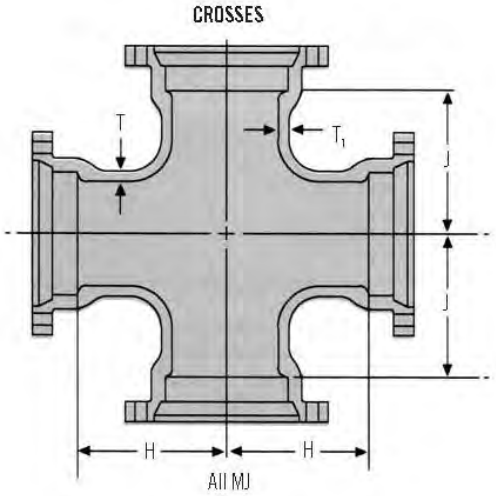


Spatial

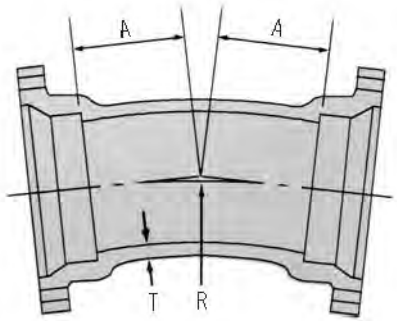
Pipe Geometry

Tees and Crosses

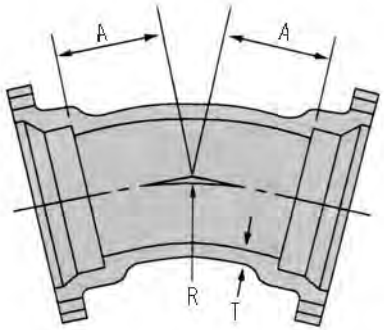




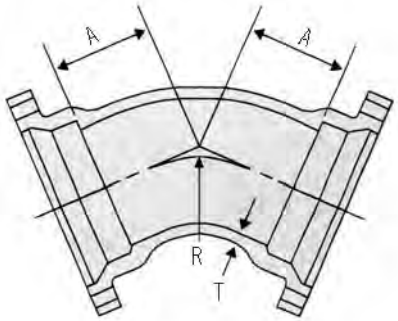
11.25° Bends



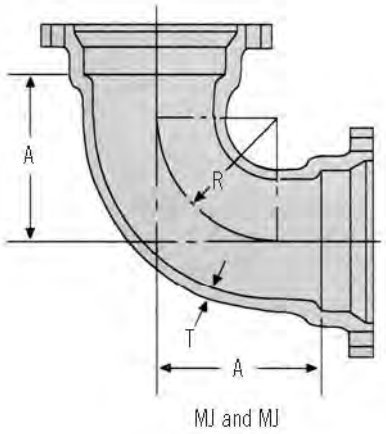
22.5° Bends



45° Bends



90° Bends



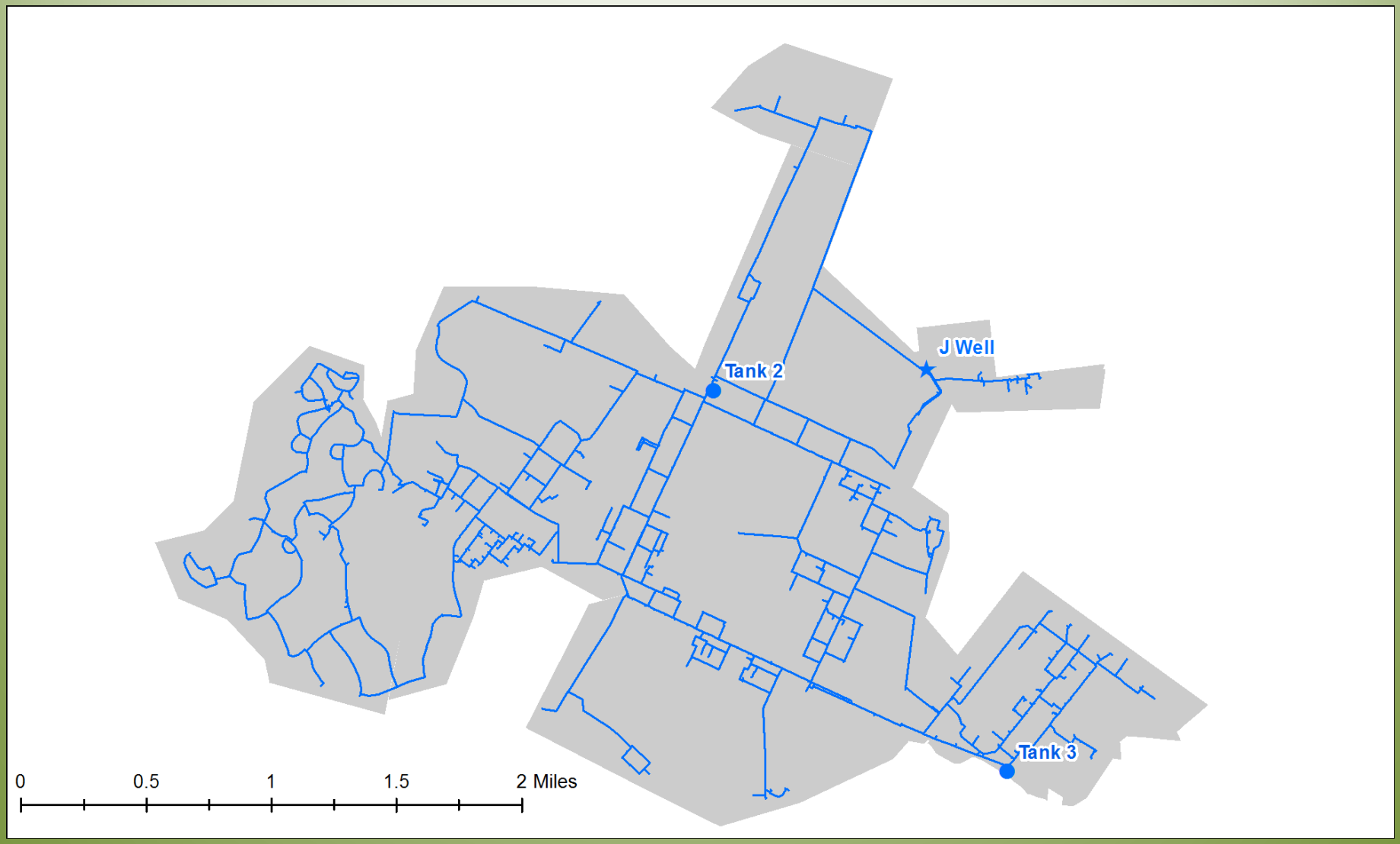
Rigid Pipe Geometry

GIS for Utility Infrastructure

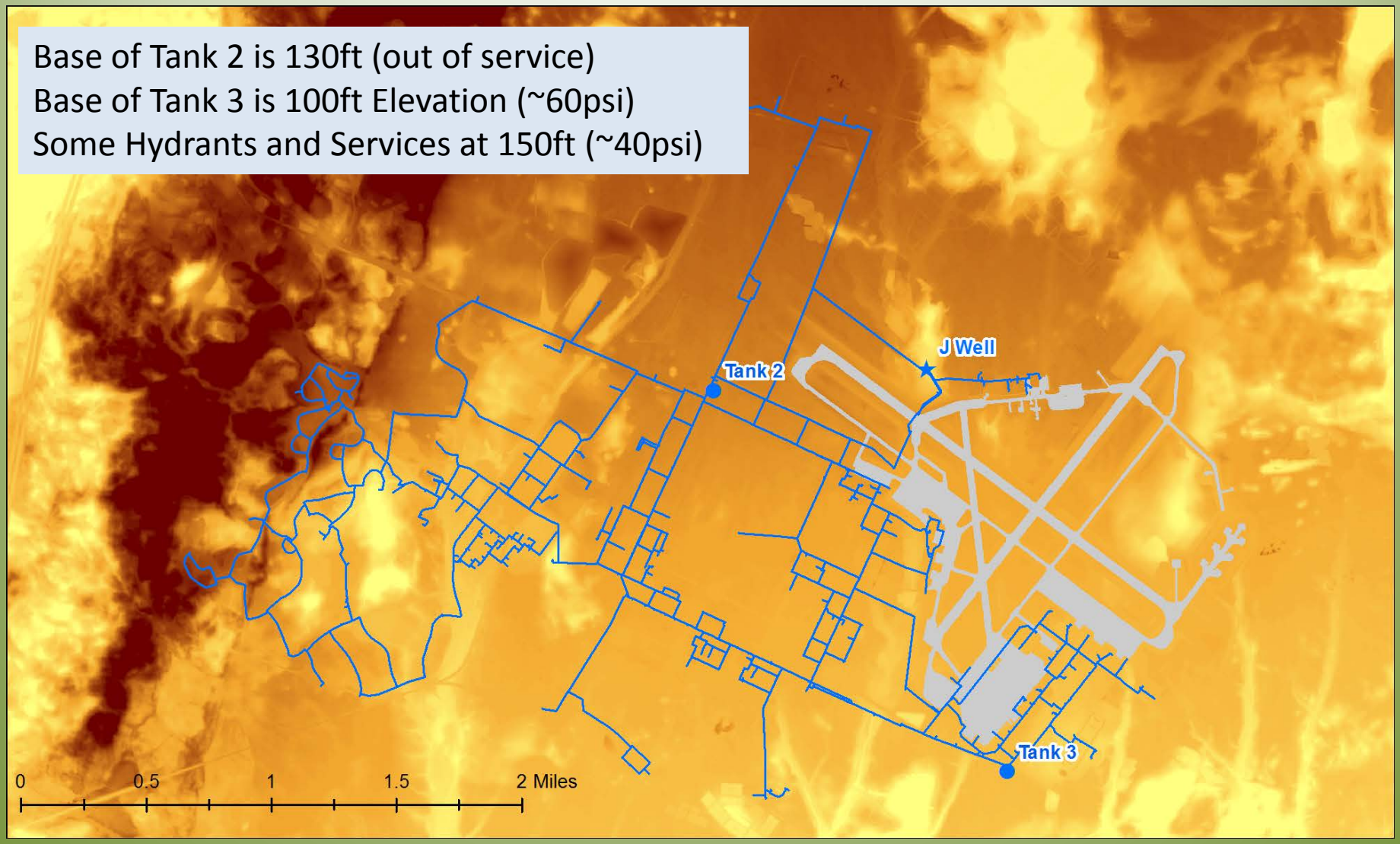
- Design Database
- Collect Information - D…
- GPS Feat…
- …
- …
- …
- …
- …
- Perform Field Checks and Updates

Create the GIS Database then you can do the Spatial Analysis

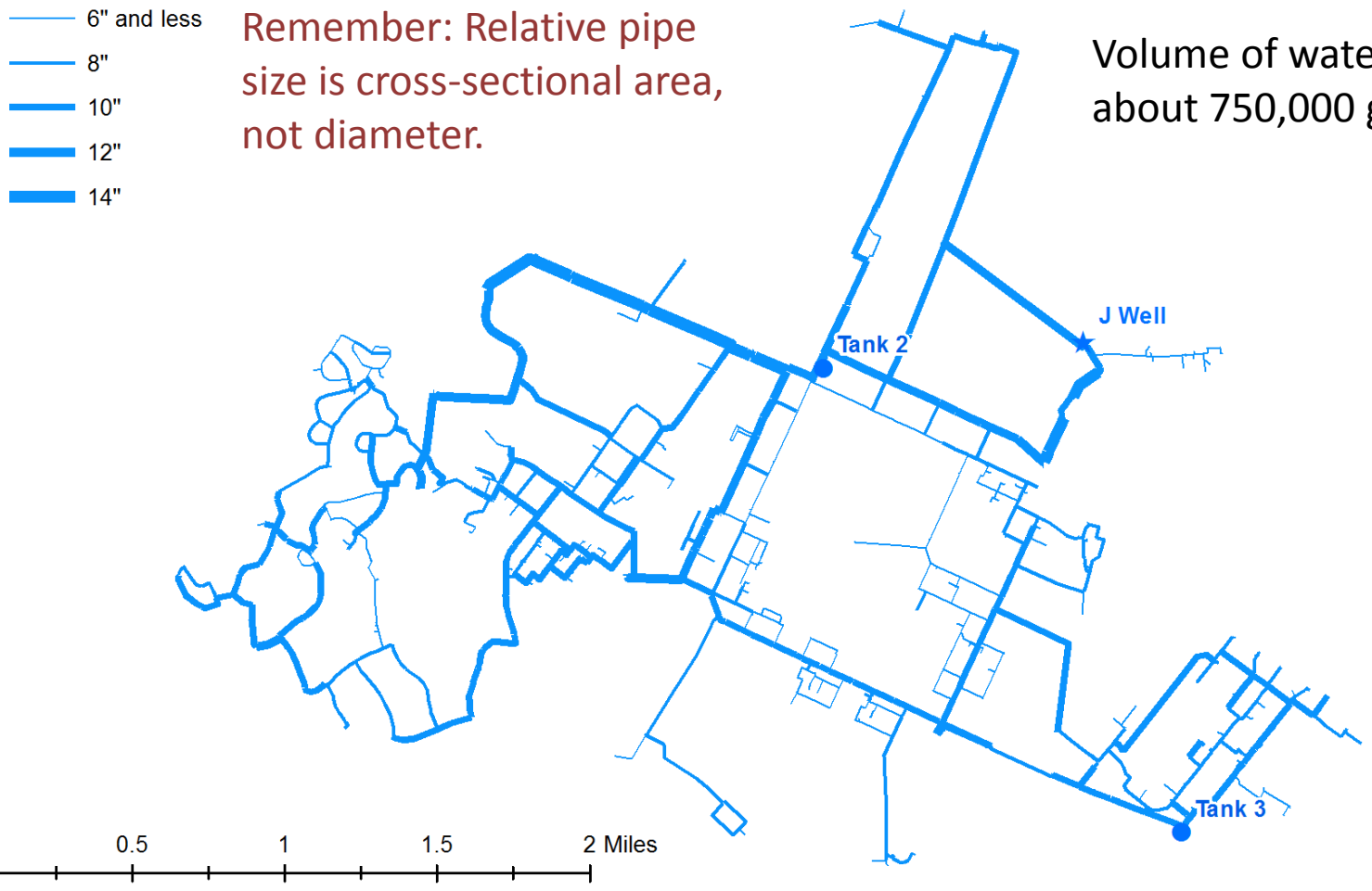
Water System GIS – Some Answers



Elevation

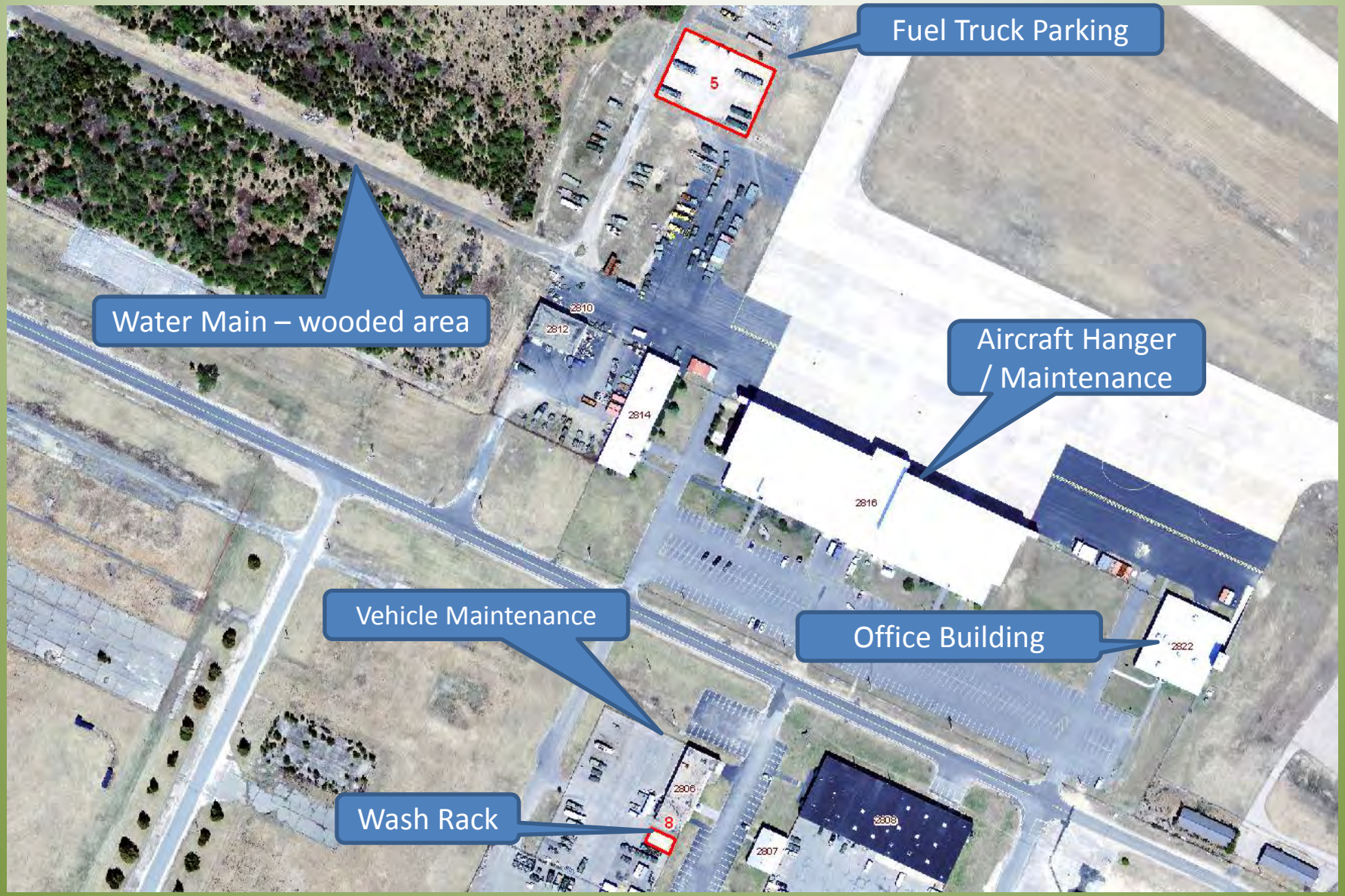

Base of Tank 2 is 130ft (out of service)
Base of Tank 3 is 100ft Elevation (~60psi)
Some Hydrants and Services at 150ft (~40psi)
Tank 2
J Well
Tank 3
0
0.5
1
1.5
2 Miles

Water Pipe Sizes

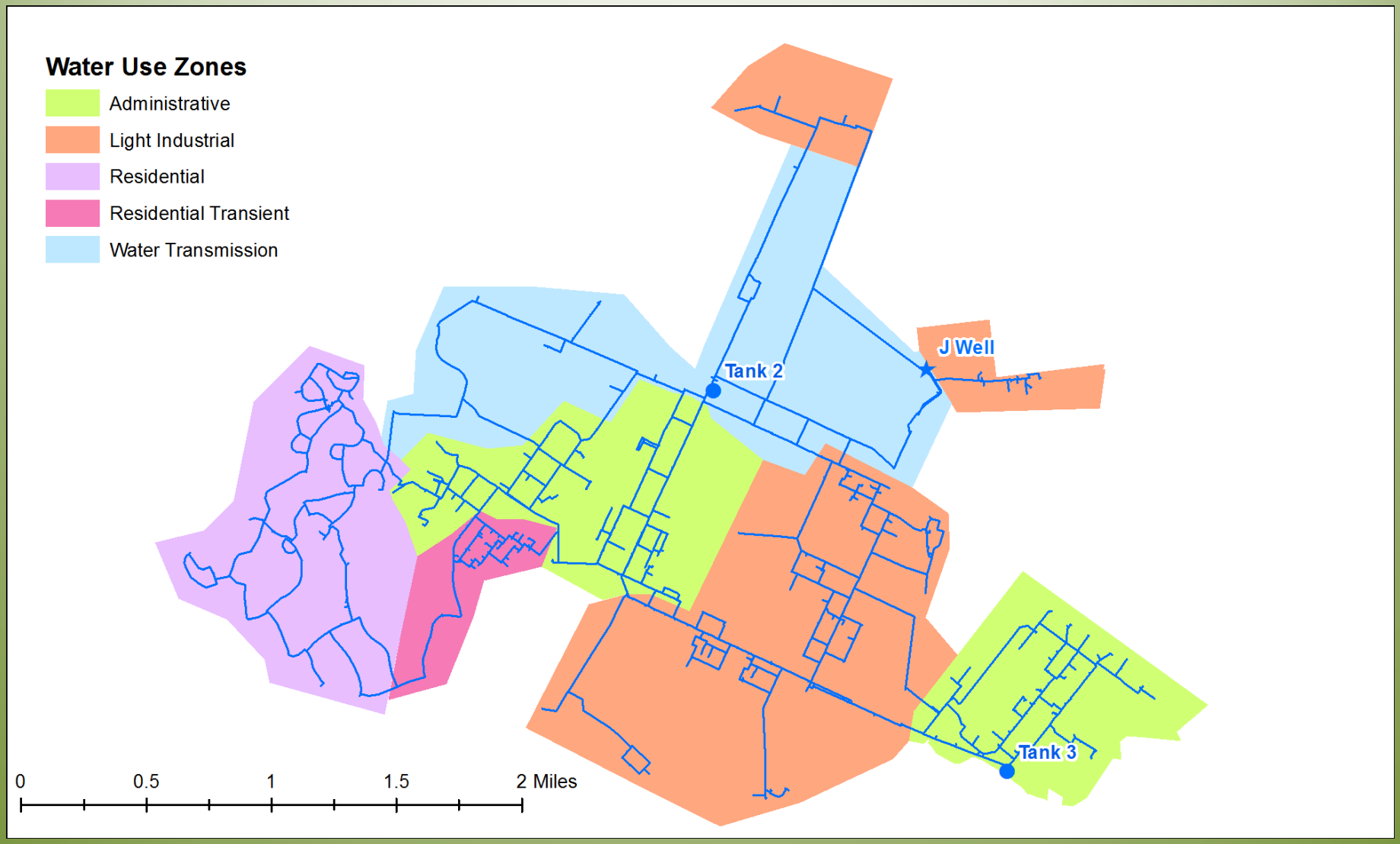


Water System in Residential Area

Water System in Industrial Area



Water Use – Landuse



Non-Spatial Data

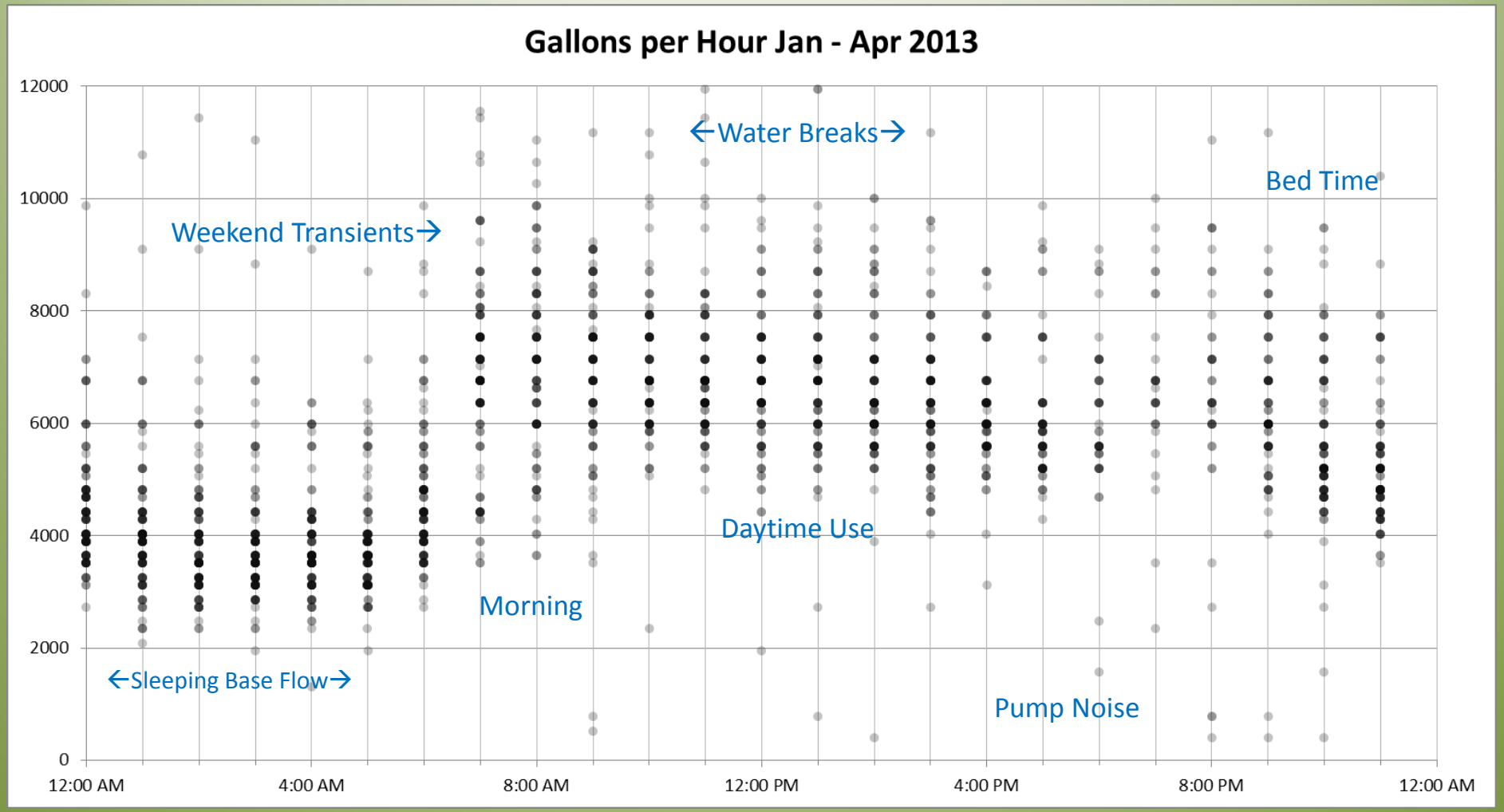
- SCADA – Supervisory Control And Data Acquisition
  - Tracks all equipment
  - Has sensors throughout the system
  - Time stamps everything
  - Creates flat files
- Example: Water Tank Level in two minute increments

Water Tank 2 – Out of Service

Statistical Test

t-Test: Two-Sample Assuming Unequal Variances (Tank 2 Service)		
Daily Use		
	w/ Tank 2	*w/out Tank 2*
Mean	210034.543	152180.109
Variance	4837502658	2100827311
Observations	178	269
Hypothesized Mean Difference	0	
df	278	
t Stat	9.78103594	
P(T<=t) one-tail	6.5545E-20	
t Critical one-tail	1.65035323	
P(T<=t) two-tail	1.3109E-19	
t Critical two-tail	1.96853397	

Water Usage

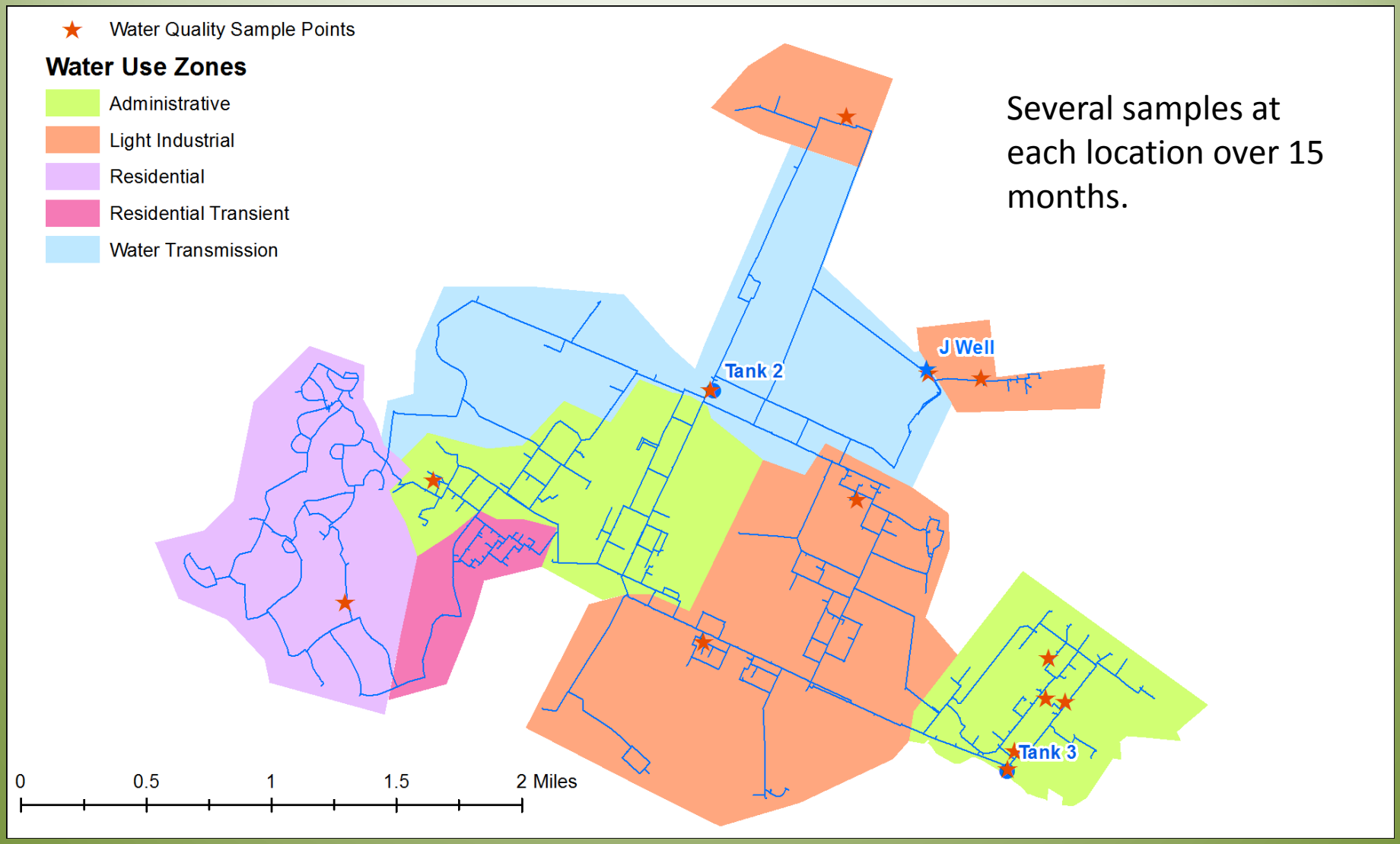

Gallons per Hour Jan - Apr 2013
12000
10000
8000
6000
4000
2000
0
12:00 AM
4:00 AM
8:00 AM
12:00 PM
4:00 PM
8:00 PM
12:00 AM
←Water Breaks→
Bed Time
Weekend Transients→
Daytime Use
Morning
←Sleeping Base Flow→
Pump Noise

Spatial Analysis

What can we do about low free chlorine levels in some locations?

Note: No significant difference between free chlorine concentration when ‘Tank 2’ is out of service

Water Quality Test Points

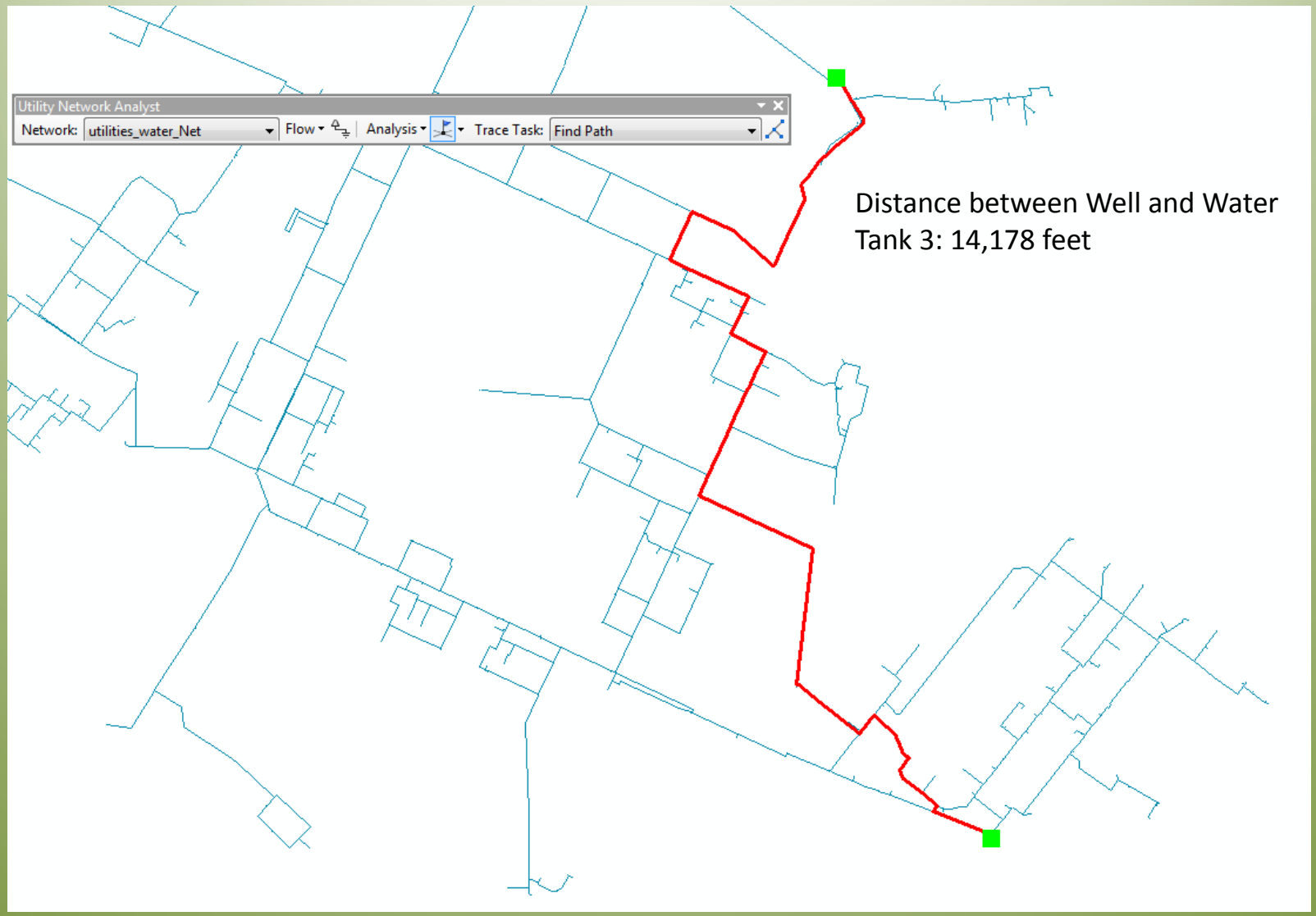


Chlorine Concentration Factors

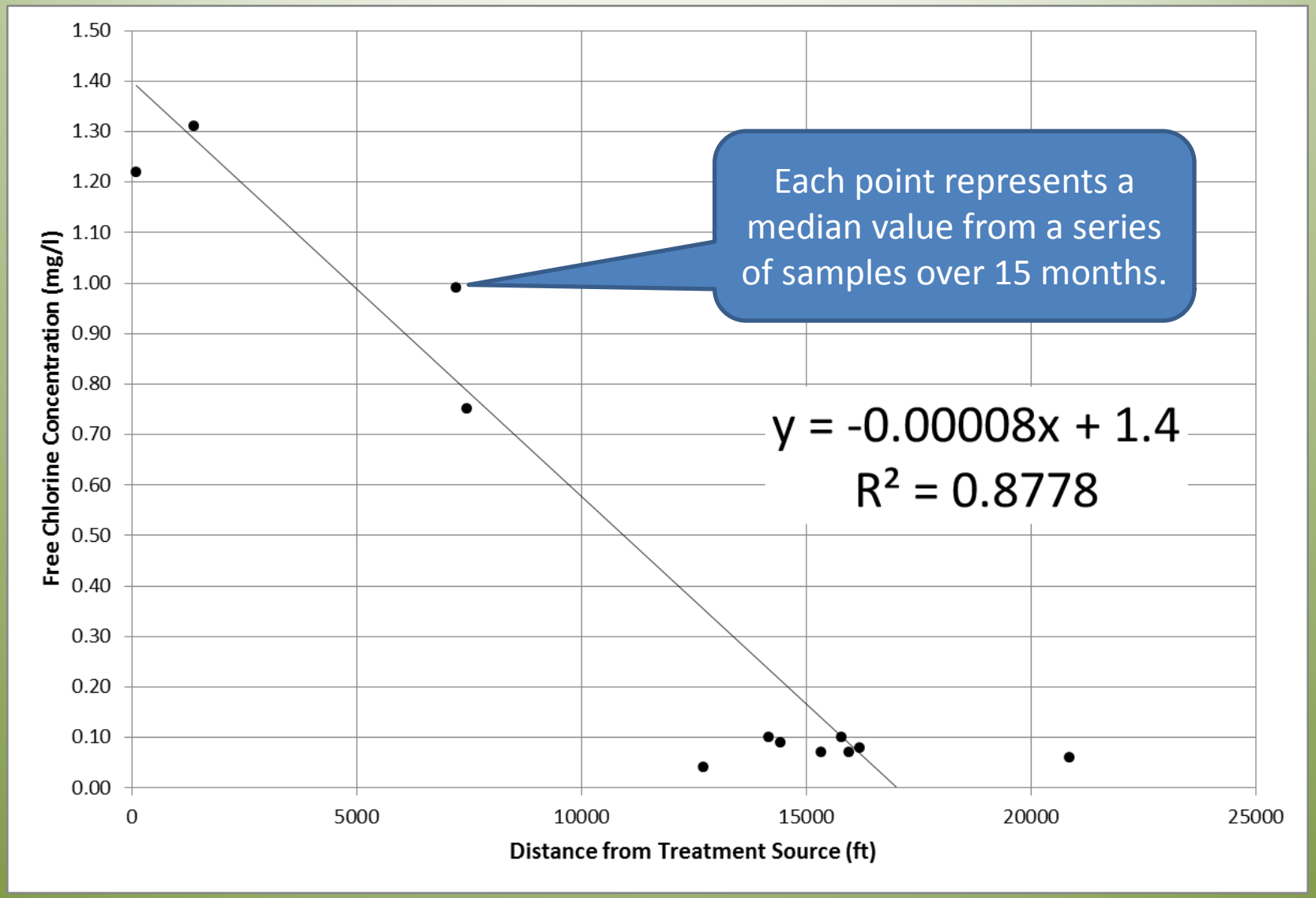
- Initial Concentration (Treatment Concentration)
- Time since application
- Size and Material of Pipe
- Bioreactivity of Pipe
- Amount of Water Use
- Flow Character (Branched vs. Looped)
- Distance from source of application

Water Pipe Network

Water Pipe Network



Free Chlorine Observations

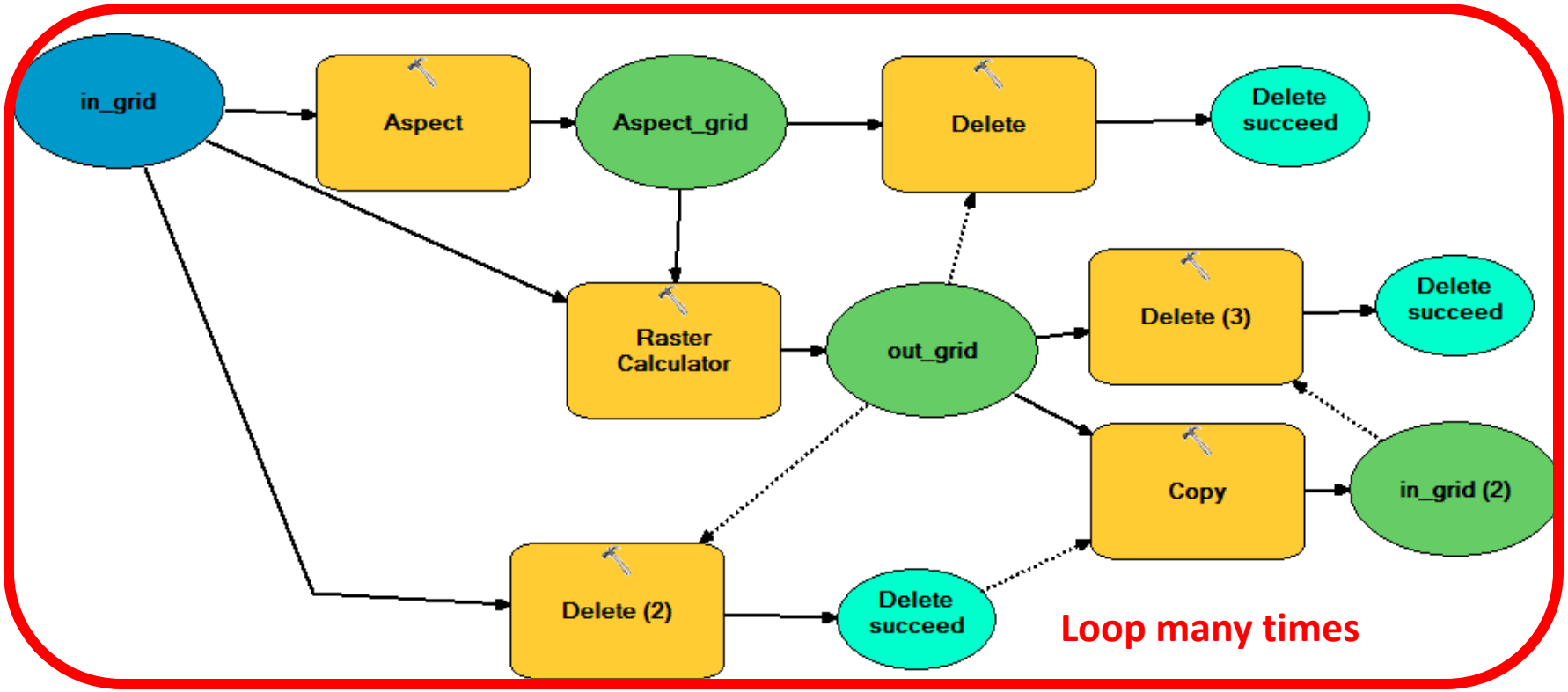


Modeling Chlorine Distribution

- Convert Pipeline Vectors to a 5 meter Grid with a Value of 0 for each Cell
- Choose Source Location and Set Cell to 1
- Create Count Raster from Source
- Convert Count Grid to Distance Grid
- Use Equation: (Distance Grid * -0.00008) + 1.4

Treatment Concentration

Model For Count Grid

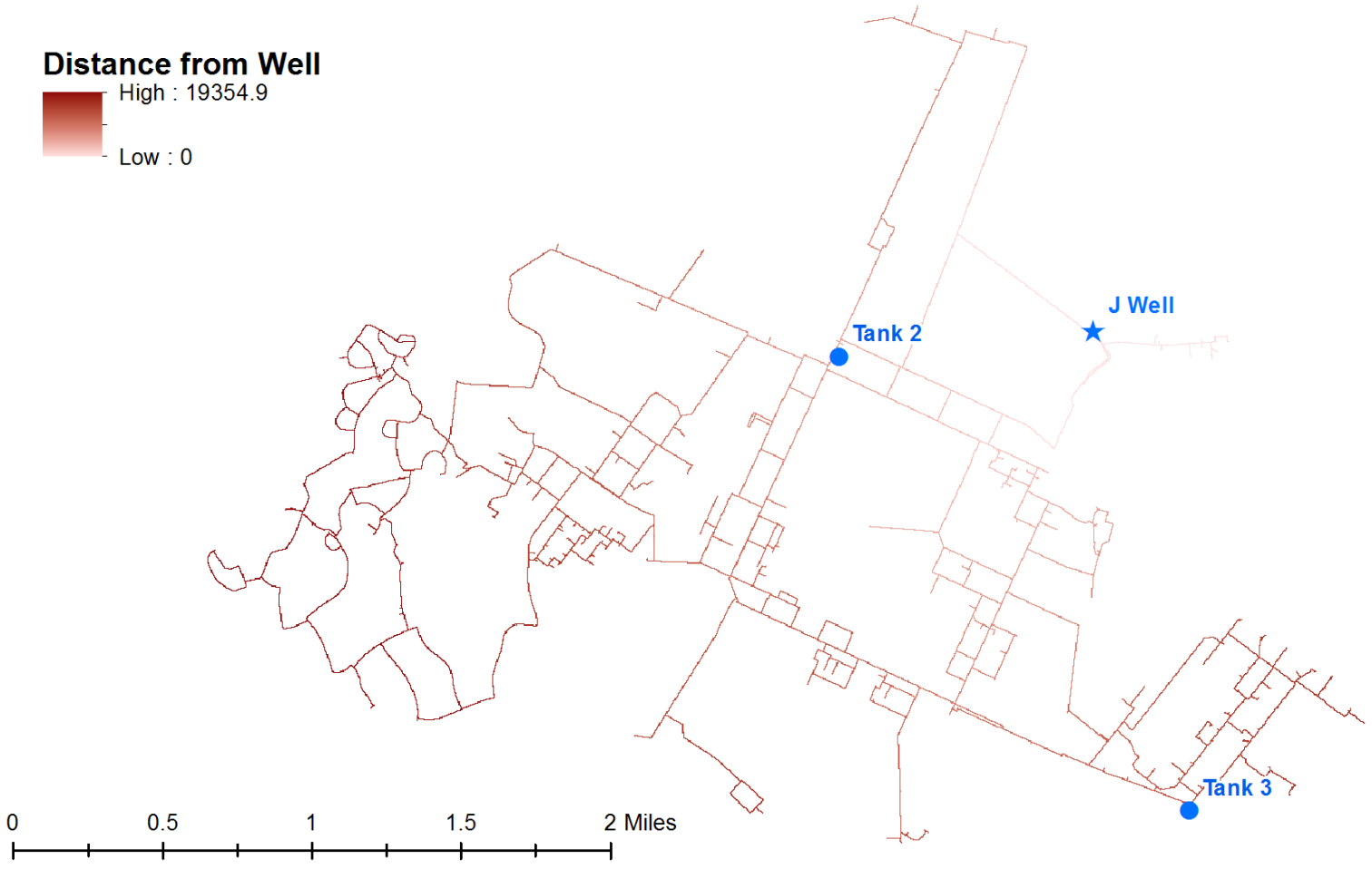


Count Grid


Count from Well
High : 1001
Low : 0
J Well
Tank 2
Tank 3
0
0.5
1
1.5
2 Miles

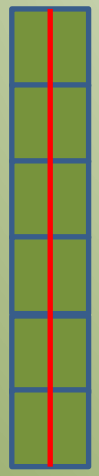
Distance Grid

Count Grid * -1 + Number of Loop Iterations * Cell Size Factor * 3.28



Cell Size Factor

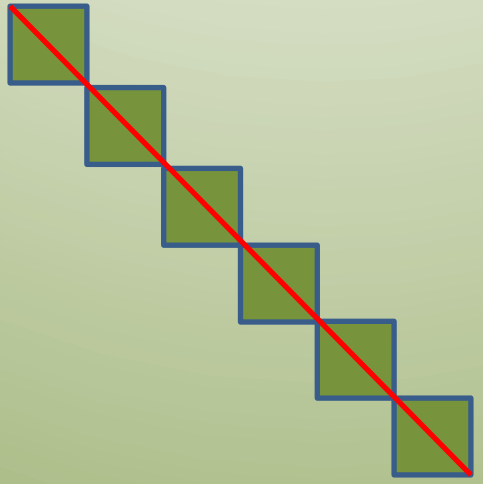
Example 5 meter Cell Size



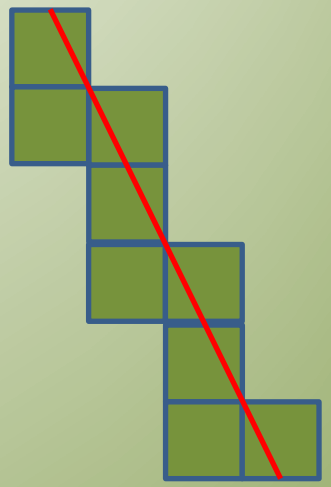
Number of Cells * Cell Size
6 * 5m = 30m

Some Data

Number of Cells * Diagonal of Cell Size
6 * 7.071m = 42.43m



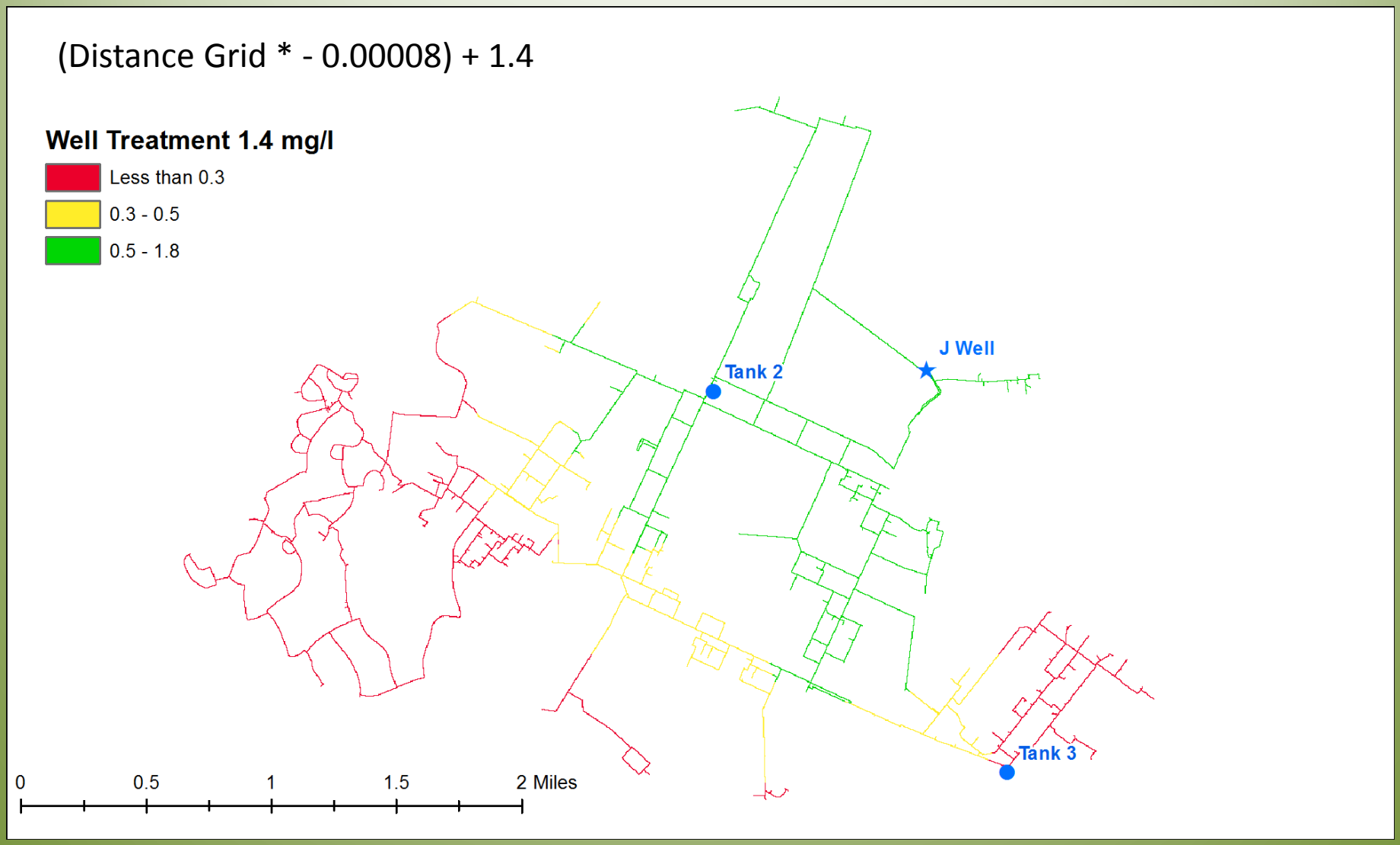
Most Data



Number of Cells * Variable Factor
6 * 5.895m = 35.37m

MS Excel Solver
to determine factor

Modeled Chlorine Distribution



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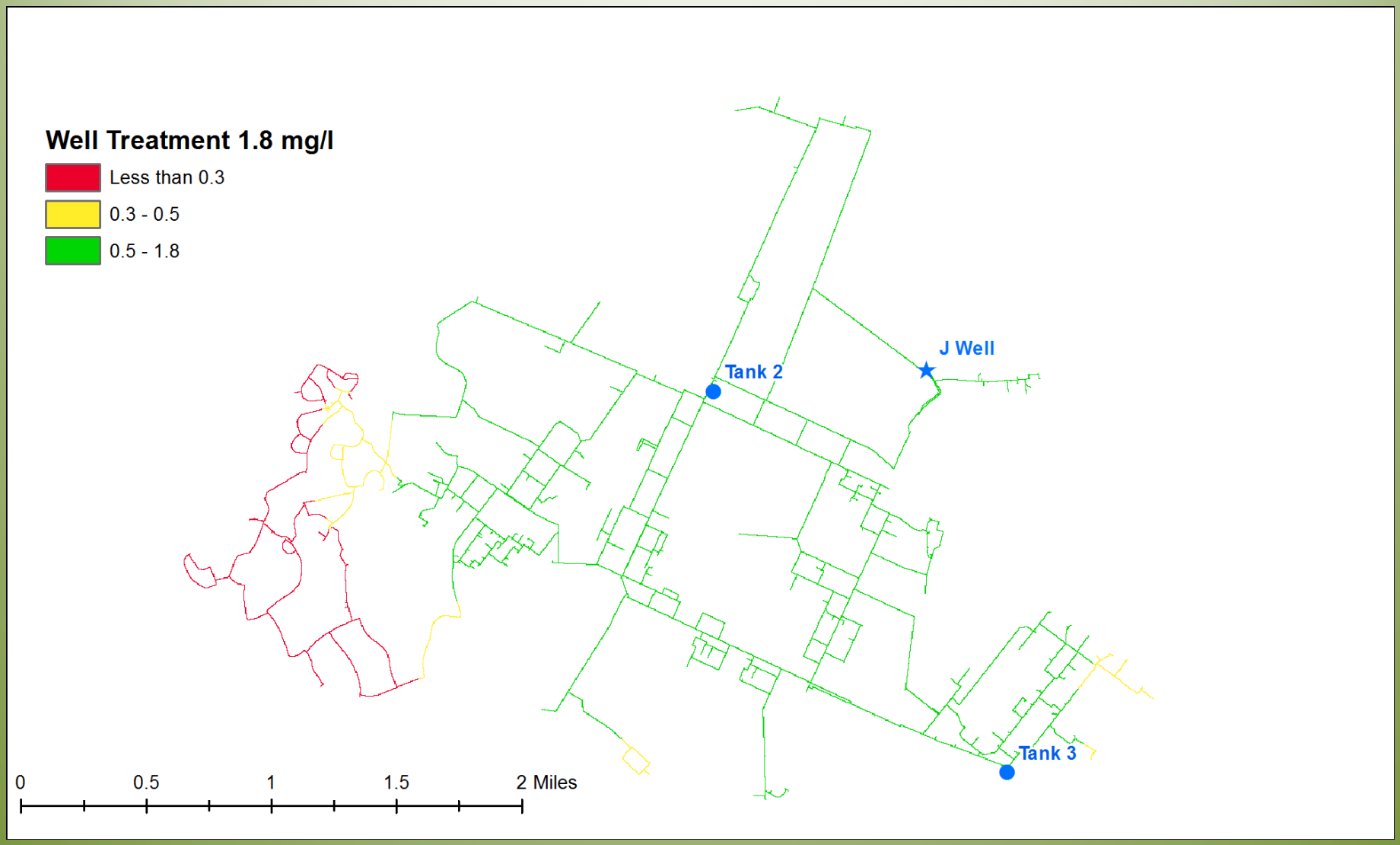

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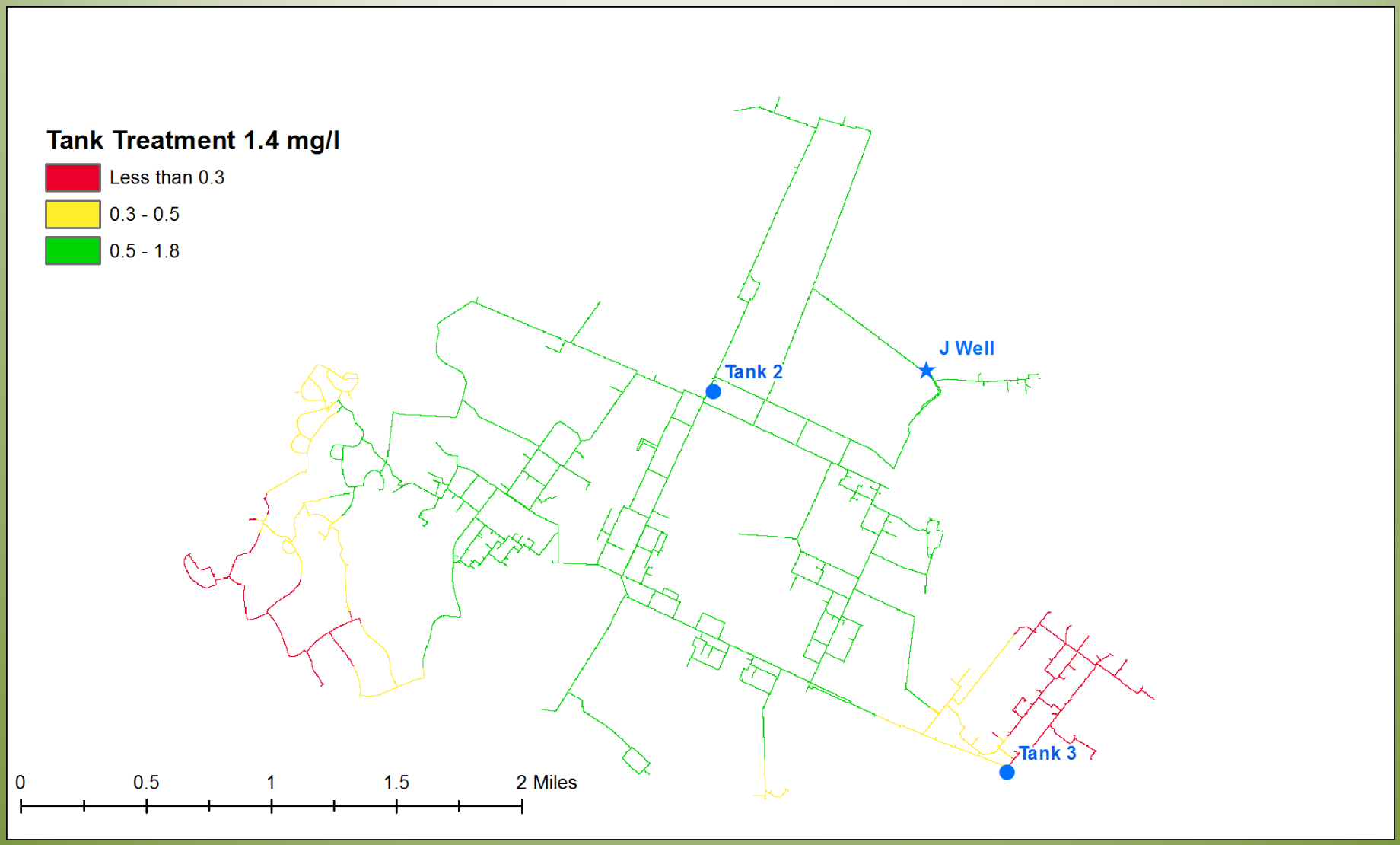

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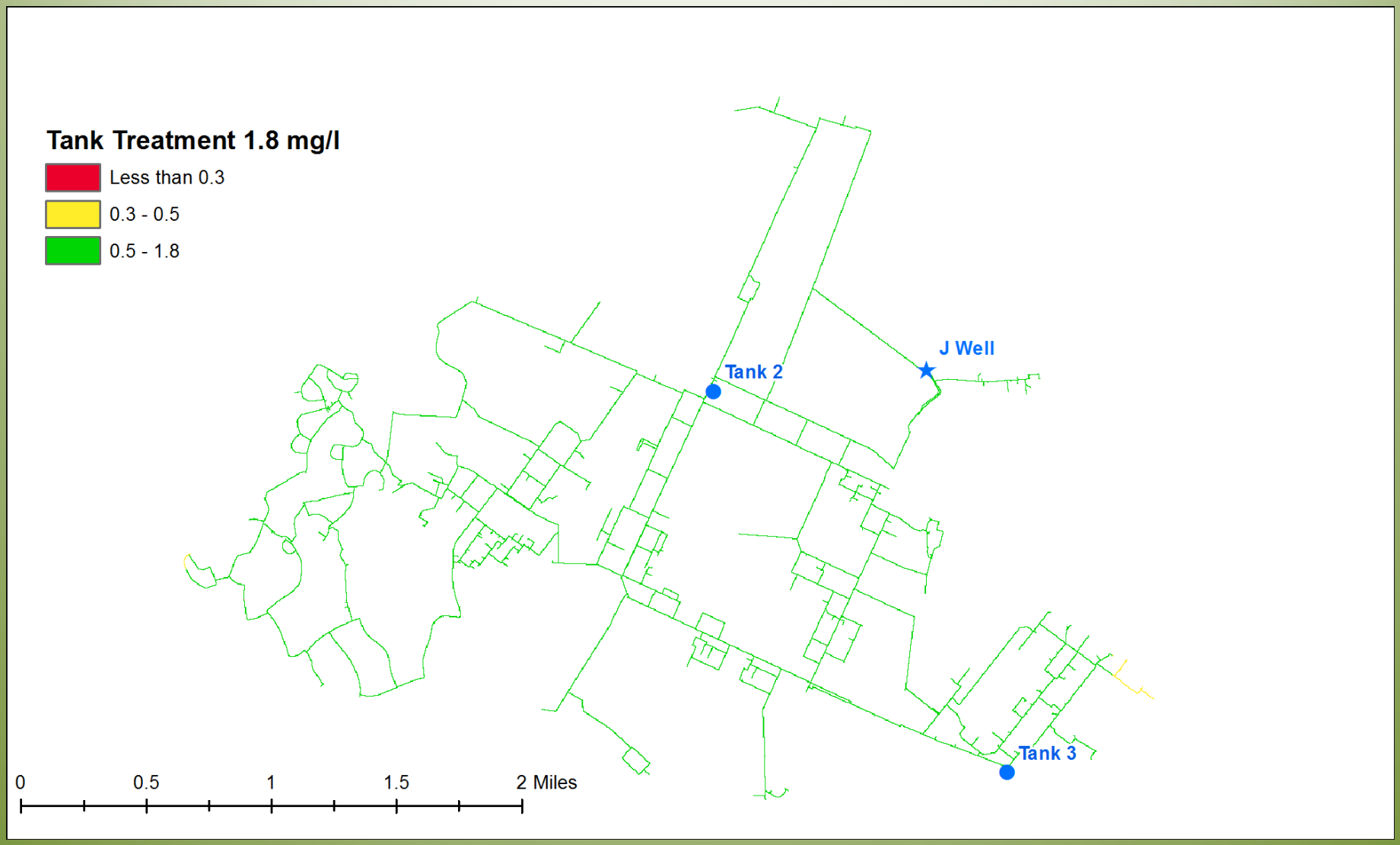

Questions