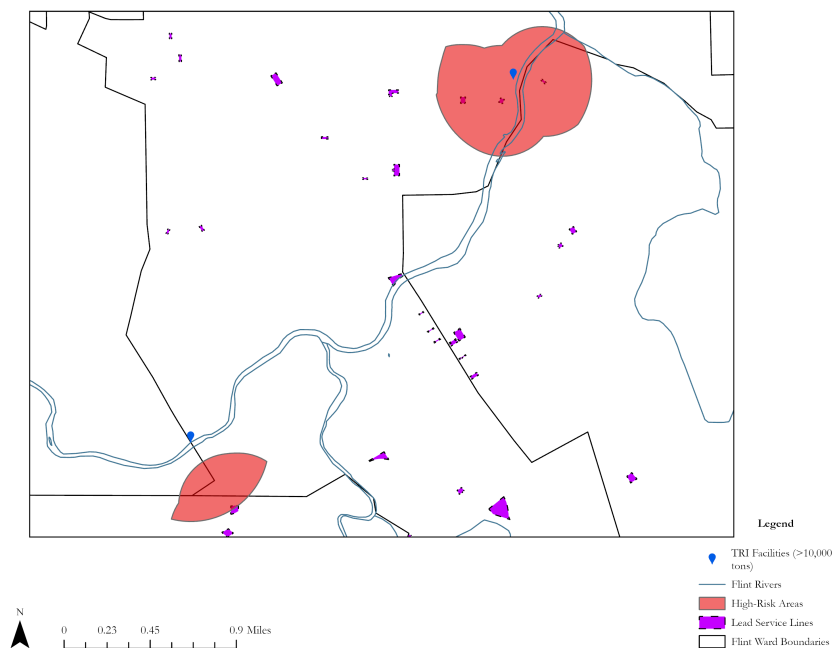


# Fundamentals of GIS: Mastery Assignment 3

## Identifying High-Risk Areas for Water Contamination in Flint, Michigan

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High-Risk Areas for Water Contamination in Flint, Michigan - Detail View



## 1 Objective

In this mastery assignment, we were asked to examine areas in Flint, Michigan that were most at risk for drinking poisonous/contaminated tap water. High Risk Areas were based on based on the combination of three criteria:

1. Areas within 0.3 miles of TRI (Toxic Release Inventory) facilities with water pollution exceeding 10,000 tons
2. Areas within 0.3 miles of a river
3. Areas within 0.2 miles of water service lines made of lead

The analysis employed multi-criteria site suitability techniques to determine areas where all three risk factors overlap, identifying the most vulnerable populations in Flint.

## 2 Data Used

Dataset	Type	Description
Michigan_river	Line feature	Rivers in Michigan
Michigan_TRI_Facilities	Point data (table)	TRI facilities with coordinates
Servicelinedata	Polygon feature	Water service line materials in Flint
TRI-Water_Pollution	Data table	TRI IDs and water emissions (tons)
Ward_Boundaries	Polygon feature	Flint city limits

Table 1: Datasets Used in Analysis

### 3 Maps

#### 3.1 Map 1: Overview of High-Risk Areas

High-Risk Areas for Water Contamination in Flint, Michigan

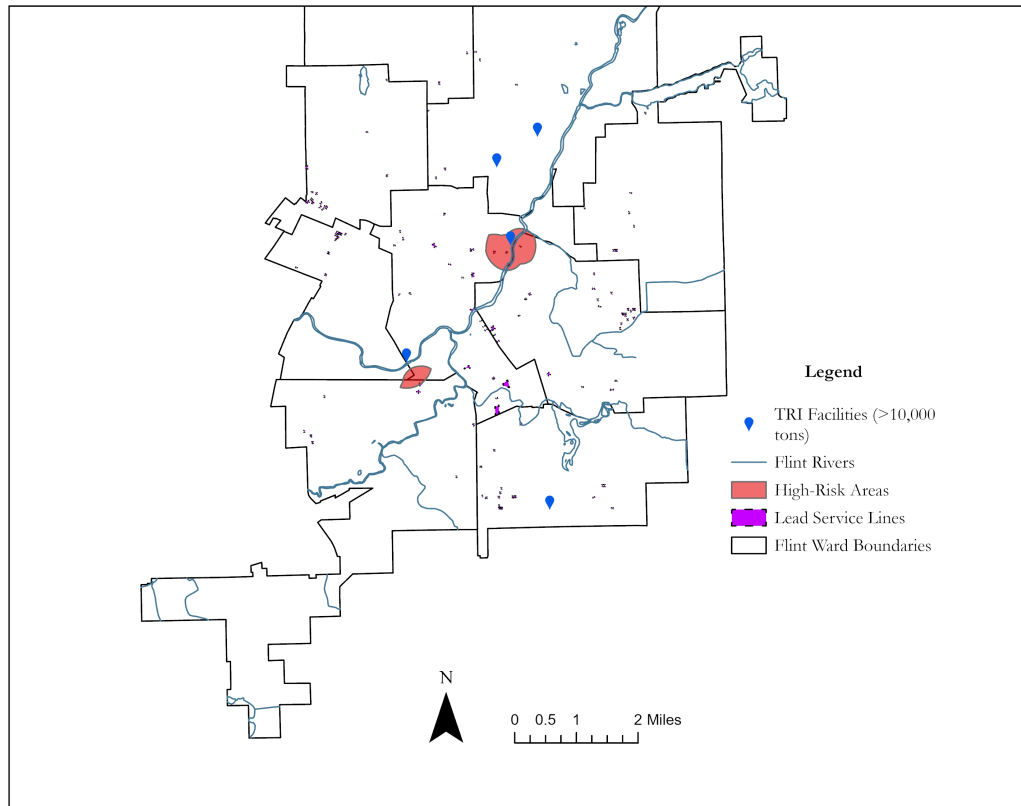


Figure 1: High-Risk Areas for Water Contamination in Flint, Michigan - Overview

### 3.2 Map 2: Detail View of High-Risk Areas

High-Risk Areas for Water Contamination in Flint, Michigan - Detail View

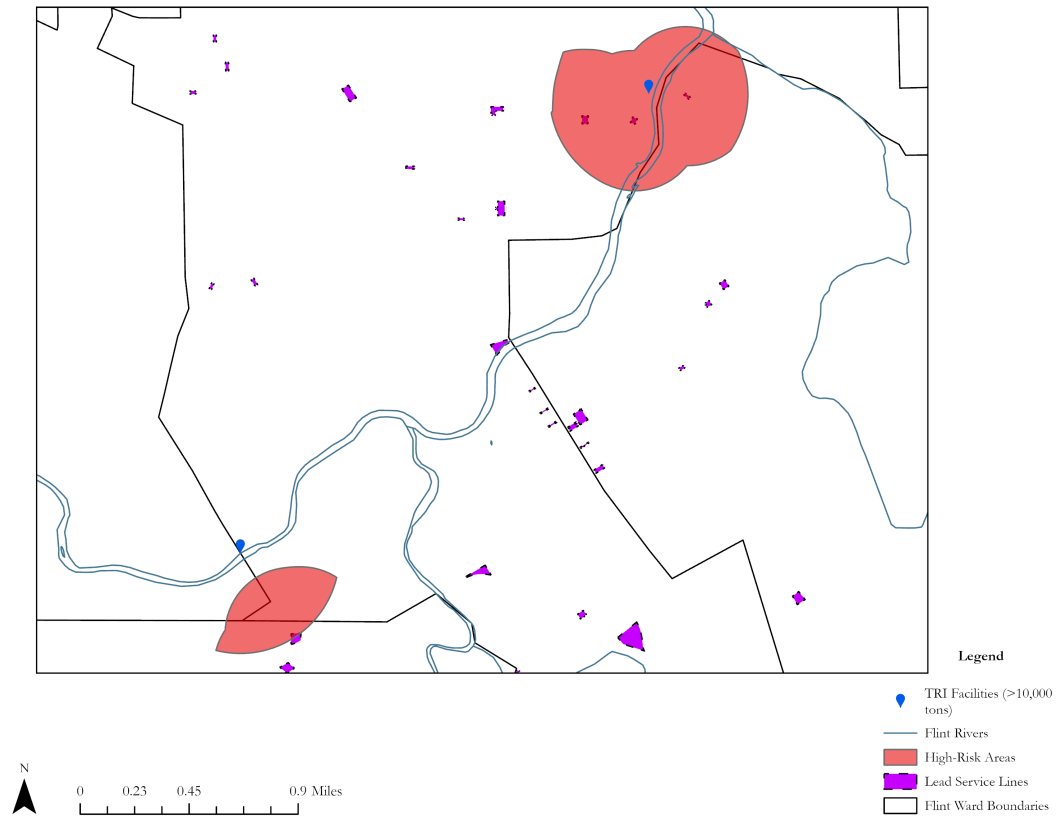


Figure 2: High-Risk Areas for Water Contamination in Flint, Michigan - Detail View

## 4 Process and Methodology

### 4.1 Workflow Diagram

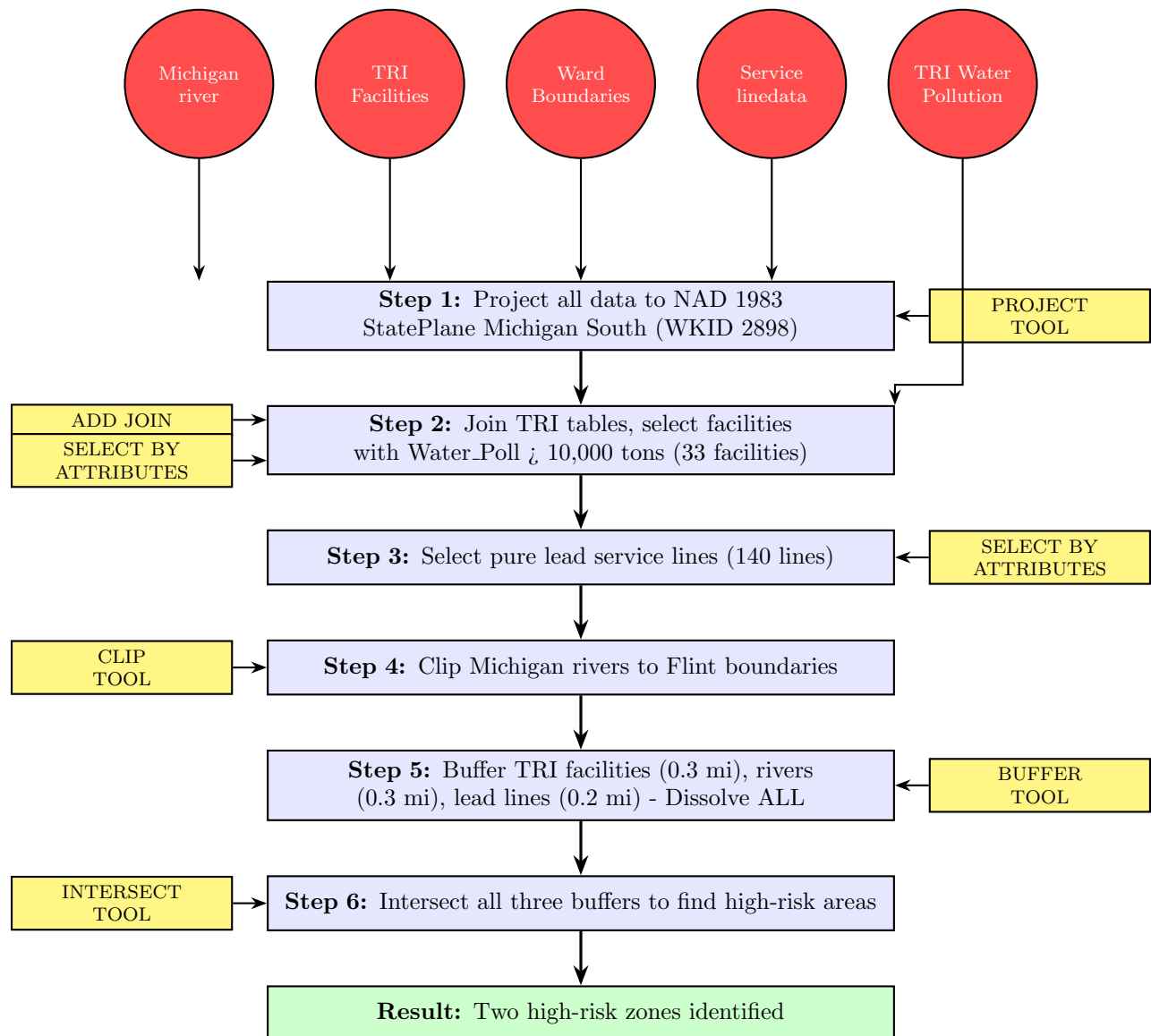


Figure 3: Workflow Diagram - Simple Process Flow

## 5 Results and Analysis

The analysis identified **two primary high-risk zones** in Flint:

1. **Northern high-risk area:** Located in north-central Flint
2. **Southern high-risk area:** Located in south-central Flint

The high-risk areas follow the river corridors through Flint, which is expected given that one criterion explicitly requires proximity to rivers. However, the limited extent of these zones (only two distinct areas) demonstrates that not all river-adjacent locations with lead pipes are near high-pollution facilities. The 33 TRI facilities with >10,000 tons of water pollution are the constraining factor that limits the geographic extent of high-risk zones.

Residents living in these two high-risk zones face water contamination threats from:

- **Lead exposure** from aging service line infrastructure
- **Industrial pollutant exposure** from nearby TRI facilities
- **Surface water contamination risk** from river proximity

## 6 Challenges and Lessons Learned

### 6.1 Field Name Syntax Issues

When joining the TRI tables, I encountered an issue with a space before the word “Lead” in the service line material field. This caused the initial export to fail with Error 999999. This highlighted the importance of exact string matching in SQL queries and careful attention to data quality issues like leading/trailing spaces.

### 6.2 Processing Performance with Large Datasets

The Michigan\_Rivers dataset initially caused significant processing delays when creating the 0.3-mile buffer (5+ minutes at 0% progress). I added a step of clipping rivers to Flint boundaries (using the ward\_boundaries data) first reduced processing time to under 30 seconds. This made the process more manageable.

## 7 Conclusion

This spatial analysis successfully identified two distinct geographic areas in Flint, Michigan where residents face elevated water contamination risk due to the convergence of three factors: proximity to high-pollution industrial facilities, proximity to river systems, and proximity to lead service line infrastructure.

## A Detailed Process Steps

### A.1 Step 1: Data Preparation and Coordinate System Standardization

**Objective:**

Ensure all datasets use the same coordinate system for accurate distance measurements. (Hint 1 used.)

**Target Coordinate System:** NAD\_1983\_HARN\_StatePlane\_Michigan\_South\_FIPS\_2113\_Feet\_Intl (WKID 2898)

**Steps:**

1. Verified coordinate systems for all datasets
  - Servicelinedata: Already in WKID 2898
  - Michigan\_river: WGS 1984 (WKID 4326) - needed projection
  - Michigan\_TRI\_Facilities: Web Mercator (WKID 3857) - needed projection
  - Ward\_Boundaries: Web Mercator (WKID 3857) - needed projection
2. Used **Project** tool (Data Management Tools) to project three datasets

### A.2 Step 2: Identify High-Pollution TRI Facilities

**Objective:**

Determine which Toxic Release Inventory facilities released more than 10,000 tons of water pollution. (Hint 2 Used.)

**Steps:**

1. Joined TRI facility locations with pollution data
  - Tool: **Add Join** (right-click layer → Joins and Relates)
  - Input: Michigan\_TRI\_Facilit\_Project
  - Join field: TRI\_FACILI
  - Join table: TRI-Water\_Pollution
  - Result: Combined spatial locations with pollution tonnage
2. Selected high-pollution facilities
  - Tool: **Select By Attributes**
  - Query: `Water_Poll > 10000`
  - Result: **33 facilities selected** out of 895 total
3. Exported selected facilities
  - Tool: **Export Features**
  - Output: TRI\_HighPollution

**Rationale:** The 10,000-ton threshold identifies facilities with the most significant water pollution impact, representing the greatest environmental hazard to nearby water sources.

### A.3 Step 3: Identify Pure Lead Service Lines

**Objective:** Select water service lines made exclusively of lead material. (Hint 3 Used)

**Steps:**

1. Explored service line material types
  - Tool: **Summary Statistics** on Servicelinedata
  - Field: SL\_DetFull
  - Result: Identified “Lead”
2. Selected pure lead service lines only
  - Tool: **Select By Attributes**
  - Query: SL\_DetFull = ‘Lead’
  - Result: **140 features selected**
3. Exported selected lines
  - Tool: **Export Features**
  - Output: Lead\_ServiceLines

### A.4 Step 4: Optimize River Data for Flint Study Area

**Objective:** Limit river data to the Flint area only. (Rivers data was quite large)

**Steps:**

1. Clipped rivers to Flint boundaries
  - Tool: **Clip**
  - Input features: Michigan\_Rivers\_Project
  - Clip features: ward\_boundaries\_Project
  - Output: Flint\_Rivers

**Rationale:** The original Michigan\_Rivers\_Project contained statewide data, which significantly slowed buffer processing. Clipping to Flint reduced processing time from 5+ minutes to under 30 seconds while maintaining analytical accuracy.

### A.5 Step 5: Create Risk Zone Buffers

**Objective:** Generate buffer zones around each of the three risk factors.

**Steps:**

1. Buffer high-pollution TRI facilities (0.3 miles)
  - Tool: **Buffer**
  - Input: TRI\_HighPollution



- Distance: 0.3 Miles
  - Dissolve type: **ALL**
  - Output: TRI\_Buffer\_03mi
2. Buffer rivers (0.3 miles)
- Tool: **Buffer**
  - Input: Flint\_Rivers
  - Distance: 0.3 Miles
  - Dissolve type: **ALL**
  - Output: River\_Buffer\_03mi
3. Buffer lead service lines (0.2 miles)
- Tool: **Buffer**
  - Input: Lead\_ServiceLines
  - Distance: 0.2 Miles
  - Dissolve type: **ALL**
  - Output: Lead\_Buffer\_02mi

## A.6 Step 6: Identify High-Risk Areas (Multi-Criteria Analysis)

**Objective:** Find areas meeting ALL THREE risk criteria simultaneously.

### Steps:

1. Intersected all three buffer zones
  - Tool: **Intersect** (Analysis Tools → Overlay)
  - Input features: TRI\_Buffer\_03mi, River\_Buffer\_03mi, Lead\_Buffer\_02mi
  - Output: HighRisk\_Areas

**Result:** The intersect operation identified **two distinct high-risk zones** in Flint where all three buffer zones overlap. These areas represent locations where residents face:

- Proximity to major industrial polluters (>10,000 tons water emissions)
- Proximity to rivers that can carry contaminants
- Proximity to lead service line infrastructure