

# Source Water Assessment:

Hydrogeologic Susceptibility and Vulnerability Assessment for  
Meadowood Shopping Center Drinking Water Well, Big Lake, Alaska

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DRINKING WATER PROTECTION PROGRAM REPORT 72

October 2001

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By Shannon & Wilson, Inc.

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# Hydrogeologic Susceptibility and Vulnerability Assessment for Meadowood Shopping Center Public Drinking Water Source, Big Lake, Alaska

By Shannon & Wilson, Inc.

## Drinking Water Protection Program Alaska Department of Environmental Conservation

### EXECUTIVE SUMMARY

The Meadowood Shopping Center well is a Class B drinking water source consisting of one well. The well is located in the Meadow Creek watershed, in Big Lake, Alaska. Identified potential and current sources of contaminants for Meadowood Shopping Center include: high-capacity septic systems, lumber storage/processing, hardware store, auto parts store, highways and roads, fireworks sales and distribution stands, residential septic systems, and approximately 29 acres of residential area. These identified potential and existing sources of contamination are considered sources of bacteria and viruses, nitrates and/or nitrites, and volatile organic chemicals. Overall, Meadowood Shopping Center public water source received vulnerability ratings of **High** for bacteria and viruses and **Medium** for nitrates and/or nitrites and for volatile organic chemicals.

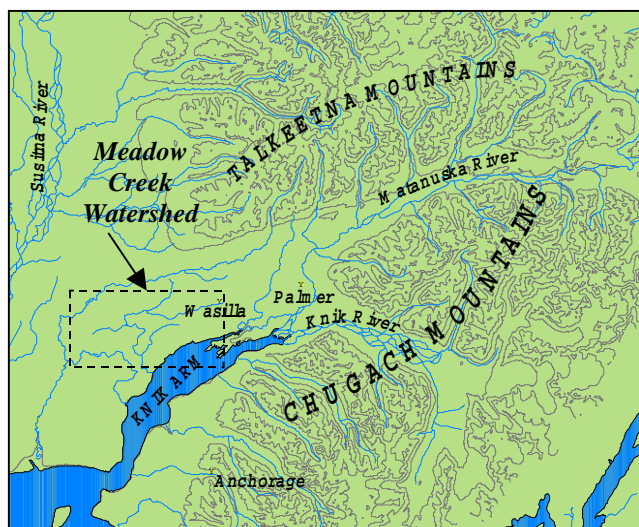


Figure 1. Index Map showing the location of the Matanuska-Susitna Valley and the Meadow Creek Watershed.

### INTRODUCTION

The purpose of this environmental assessment is to provide public water system owners/operators, communities, and local governments with information they can use to preserve the quality of Alaska's public drinking water supplies. This assessment was completed for the Meadowood Shopping Center source of public drinking water. This source consists of one well in the Meadow Creek Watershed (see Figure 1). This assessment, known under the Alaska Drinking Water Protection Program as the *Source Water Assessment*, has combined a review of the natural hydrogeologic sensitivity with potential and existing contaminant risks to arrive at an overall vulnerability of the drinking water source to contamination. This assessment has been completed as a basis for local voluntary protection efforts and to assist agencies in their efforts to reduce risk to this public drinking water supply.

### DESCRIPTION OF THE MEADOW CREEK - AREA, ALASKA

#### Location

The Meadow Creek watershed, located in southcentral Alaska, lies within the Matanuska-Susitna Borough. The Borough encompasses 24,694 square miles and supports a population in 2000 of 59,322. The Borough is contained within the watersheds of the Matanuska and Susitna Rivers which flow from the glacier melt waters in the Alaska Range, Talkeetna Mountains, and the Chugach Mountains to tidewater in the Knik Arm of Upper Cook Inlet (Jokela, Munter and Evans, 1991) (Figure 1). The area between the Matanuska and Susitna Valley is commonly referred to as the Mat-Su Valley. The Meadow Creek watershed contains 115 lakes, including Big Lake, and extends from an area northwest of Wasilla to the west end of Big Lake (Jokela, Munter and Evans, 1991), as shown in Figure 1.

The Borough's close proximity to Anchorage and its abundance of surface-water resources has helped contribute to rapid growth over the last two decades. The population has tripled since 1980. As of 1998, approximately 9% of the state's population resided in the Matanuska-Susitna Borough. The projected growth rate is expected to be 3.3% per year, three times higher than the state rate. At this rate, the Borough will have approximately 13% of the states population by 2018 (ADOL, 1999).

## Climate

The Meadow Creek-area climate is somewhat transitional in that it does not experience large daily and annual temperature fluctuations like those experienced in the interior of Alaska nor does it experience high amounts of precipitation typified by gulf coast regions.

The mean daily temperature ranges from 69.4 degrees Fahrenheit during the summer months to 13.8 degrees Fahrenheit during the winter months. The annual precipitation in the Meadow Creek-area is approximately 20 inches per year and total snow is around 59 inches per year. The average snow depth during snowy months is 6.4 inches (Western Regional Climate Center, 2000). Precipitation generally increases inland toward the Talkeetna Mountains where annual precipitation may exceed 60 inches per year (Brabets, 1997).

## Physiography and Groundwater Conditions

Surface elevations in the Matanuska-Susitna Borough range from sea level where the Knik River and Matanuska River enter the Cook Inlet to well over 6,000 feet in the peaks that bound the area. Glacial moraine and outwash deposits primarily mantle the surface of the Mat-Su Valley.

The regional geology and ground water conditions of the Mat-Su Valley vary greatly depending on location. The terrain is dominated by distinctive landforms created by repeated glacial advances and retreats during the Pleistocene epoch (2 million to 10,000 years before present). The unconsolidated layers, layers of sediment that are not cemented together, are comprised of various mixtures of fine- to coarse-grained particles (clay to boulders). The majority of wells in the Mat-Su Valley are located in unconsolidated layers consisting of relatively well sorted sands and gravels. These unconsolidated layers vary substantially in size and distribution throughout the Valley. In general, the unconsolidated layers increase in thickness as you move towards Cook Inlet. (Jokela, Munter, Evans, 1991). Throughout the area numerous confining layers ranging from less than 1- to 60-feet thick separate the unconsolidated layers.



Figure 2. Map showing regional ground-water flow in Matanuska-Susitna Valley. (Jokela, Munter and Evan, 1991)

In the Mat-Su Valley, the groundwater is primarily recharged by snowmelt and precipitation infiltrating into the foothill slopes of the Talkeetna or Chugach Mountains and by direct precipitation and snowmelt throughout the study area.

Groundwater flow in the confined aquifer is generally, north to south in the central region of the valley, toward the Matanuska River in the eastern region and the slope is predominantly northeast to northwest in the western region. The direction of groundwater flow in the upper unconfined aquifer's are more variable due to the influence from surficial topography as well as its close connection with surface water bodies. (*Jokela, Munter and Evans, 1991*) (Figure 2).

## **MEADOWOOD SHOPPING CENTER PUBLIC WATER SOURCE**

Meadowood Shopping Center public water source is located in the Meadow Creek watershed. The system is a Class B public drinking water source and is owned and operated by the Trood Family Investors, Ltd. The source consists of one well near the south corner of the parcel near Big Lake Road. It is located at an elevation of approximately 200 feet above sea level. The well is inferred to tap the underlying, unconfined aquifer. According to the well log, the Meadowood Shopping Center well does not appear to be grouted and penetrates sand and gravel to a total depth of 60 feet below land surface. The well is assumed to be cased to a depth of 60 feet below land surface in sand and gravel. Based on engineer's reports of the local water table, the static water level is about 18 feet below land surface.

This water source operates year round. The Meadowood Shopping Center drinking water source is assumed to serve no residents and approximately 50 non-residents through one service connection.

## **ASSESSMENT AND PROTECTION AREA FOR MEADOWOOD SHOPPING CENTER DRINKING WATER SOURCE**

The Drinking Water Protection and Assessment Area that has been established for Meadowood Shopping Center is the area that is most sensitive to contamination. This area has served as a basis for assessing the risk of the drinking water source to contamination. This zone around the drinking water source is the most critical area for the preservation of the quality of the drinking water for this source. For simplicity, this area will be known as your Drinking Water Protection Area and will serve as the area of focus for voluntary protection efforts.

Groundwater recharge for the Meadowood Shopping Center water system enters the aquifer system through infiltration of direct precipitation within the area. An

analytical calculation was used to calculate the size and shape of the area that contributes water to the well. The input parameters describing the attributes of the aquifer in this calculation were adopted from well logs from the surrounding area and from past studies (*Jokela, Munter and Evans, 1991*). This analytical calculation was used as a guide as the first step in establishing the protection area for Meadowood Shopping Center. Additional methods were further employed to take into account any uncertainties in groundwater flow and aquifer characteristics in an attempt to arrive at a meaningful and conservative protection area with respect to public health (please refer to the Guidance Manual for Class B Public Water Systems for additional information).

The Drinking Water Protection Areas established for wells by the Alaska Department of Environmental Conservation are separated into zones. These zones correspond to a time-of-travel. Time-of-travel is the time required for water to move in the saturated zone of the ground from a specific point to the well. The Drinking Water Protection Areas for Meadowood Shopping Center contain four zones, Zone A, Zone B, Zone C and Zone D (See Map 1 in Appendix A). Zone A corresponds to the area between the well and the distance equal to  $\frac{1}{4}$  of the distance of the 2-year time-of-travel. Depending on where a contaminant source is located within Zone A, travel time for a contaminant to the well may be on the order of several days to several hours. Zone A also extends downgradient from the well to take into account the area of the aquifer that is influenced by pumping of the well.

The Zone B protection area for Meadowood Shopping Center corresponds to a time-of-travel of less than two years and extends eastward. The Zone C protection area extends from the 2-year time of travel to the 5-year time of travel. Lastly, Zone D extends from Zone C to the end of the protection area, roughly 1.2 miles from the Meadowood Shopping Center well.

## **INVENTORY OF POTENTIAL AND EXISTING CONTAMINANT SOURCES**

The Drinking Water Protection Program has completed an inventory of potential and existing sources of contamination within Meadowood Shopping Center's Drinking Water Protection Area. This survey was completed through a search of agency records and other publicly available information, as well as a reconnaissance of the area surrounding the well.

Potential sources of contamination to drinking water supplies cover a wide range of categories and types. Potential drinking water contaminants are found within agricultural, residential, commercial, and industrial areas, but can also occur within areas that have little or no development.

For the basis of this assessment and all Class B public water system assessments, three categories of drinking water contaminants were inventoried. They include:

- Bacteria and viruses;
- Nitrates and/or nitrites;
- Volatile organic chemicals;

Map 2 and Map 3 in Appendix C depict the Contaminant Source Inventory for Meadowood Shopping Center. Inventoried potential sources of contamination within Zones A through Zone B were associated with residential and commercial type activities (See Table 1 in Appendix B). Zone C contains only roads, residential, and minimal commercial activity. Only high and very high potential and existing sources of contamination were inventoried within Zone D. None were identified in Zone D. Below is a summary of the contaminant sources inventoried within the Meadowood Shopping Center protection area:

- Large Capacity Septic Systems;
- Approximately 29 acres of residential area;
- Activities associated with highways and roads;
- Fireworks Sales and Distribution
- Hardware Store and Auto Parts Store
- Lumber Storage/Processing
- Single family Septic Systems

These potential contaminant sources present risk for all three categories of drinking water contaminants for Meadowood Shopping Center drinking water source.

## RANKING OF CONTAMINANT RISKS

Potential and existing sources of contamination have been identified, sorted, and ranked according to what type and level of risk they represent. Ranking of contaminant risks for a “potential” or “existing” source of contamination is a function of toxicity and volumes of specific contaminants associated with that source. Contaminant risks are further a function of the number and density of those types of contaminant sources as well as the proximity of those sources to the well.

## VULNERABILITY OF MEADOWOOD SHOPPING CENTER DRINKING WATER SOURCES

Vulnerability of a drinking water source to contamination is a combination of two factors:

- Natural susceptibility; and
- Contaminant risks.

Each of the three categories of drinking water contaminants has been analyzed and an overall vulnerability score of 0 to 100 is ultimately assigned:

Natural Susceptibility (0 – 50 points)

+

Contaminant Risks (0 – 50 points)

=

Vulnerability of the  
Drinking Water Source to Contamination (0 – 100).

A score for the Natural Susceptibility is achieved by analyzing the properties of the well and the aquifer.

Susceptibility of the Wellhead (0 – 25 Points)

+

Susceptibility of the Aquifer (0 – 25 Points)

= Natural Susceptibility (Susceptibility of the Well)  
(0 – 50 Points)

Meadowood Shopping Center’s well is completed in an unconfined aquifer setting. Therefore, contaminants that enter the subsurface within the vicinity of the well and Drinking Water Protection Area may enter the aquifer uninhibited by the absence of any protective layer. It is unclear whether the well is grouted. For purposes of this study, it is assumed that the well is not grouted. The absence of grouting can allow the transport of contaminants from the surface along the well casing. Combining the susceptibility of the wellhead and the aquifer to contamination leads to a score (0 – 50 points) and rating of overall Susceptibility (See Appendix D). Table 1 shows the overall Susceptibility score and rating for Meadowood Shopping Center.

**Table 1. Natural Susceptibility - Susceptibility of the Wellhead and Aquifer to Contamination**

	Score	Rating
Susceptibility of the Wellhead	5	Low
Susceptibility of the Aquifer	17	High
Natural Susceptibility	22	Medium

Contaminant risks to a drinking water source depend on the type, number or density, and distribution of contaminant sources. Large capacity septic systems, approximately 29 acres of residential area, residential septic systems, lumber storage, a hardware store, an auto parts store, fireworks sales and distribution, and highways and roads contribute the highest risk for potential contamination to the Meadowood Shopping Center source of public drinking water.

A score (0 – 50 points) and rating of Contaminant Risks (See Appendix D) is assigned based on the findings of the Contaminant Source Inventory (Appendix B - Table 1 – Table 4). This portion of the analysis examines any existing or historical contamination that has been detected at the drinking water source through routine sampling. It also reviews contamination that has or may have occurred but has not arrived or been detected at the well. Table 2 summarizes the Contaminant Risks for each category of drinking water contaminants.

**Table 2. Contaminant Risks**

Contaminant Risks	Score	Rating
Bacteria and Viruses	42	Very High
Nitrates and/or Nitrites	35	High
Volatile Organic Chemicals	30	High

Appendix D contains eight charts, which together form the ‘Vulnerability Analysis’ for a source water assessment for a public drinking water source. Chart 1 analyzes the ‘Susceptibility of the Wellhead’ to contamination by looking at the construction of the well and its surrounding area. Chart 2 analyzes the ‘Susceptibility of the Aquifer’ to contamination by looking at the naturally occurring attributes of the water source and influences on the groundwater system that might lead to contamination. Chart 3 analyzes ‘Contaminant Risks’ for the drinking water source with respect to bacteria and viruses. The ‘Contaminant Risks’ portion of the analysis considers potential sources of contaminants as well as a review of contamination that has or may have occurred but has not arrived or been detected at the well. Lastly, Chart 4 contains the ‘Vulnerability Analysis for Bacteria and Viruses’. Charts 5 through 8 contain the Contaminant Risks and Vulnerability Analysis for nitrates and nitrites and volatile organic chemicals, respectively.

Vulnerability of the drinking water source to contamination is the combination of susceptibility of the aquifer and the well with contaminant risks. Table 3 contains the overall vulnerability scores (0 – 100) and ratings for each of the three categories of drinking water contaminants (See Appendix D). Note: scores are rounded off to the nearest five.

**Table 3. Overall Vulnerability of Meadowood Shopping Center Public Drinking Water Source to Contamination by Category**

Category	Score	Rating
Bacteria and Viruses	65	High
Nitrates and Nitrites	55	Medium
Volatile Organic Chemicals	50	Medium

Tables 2 through 4 in Appendix B contain the ranking of potential and existing sources of contamination with respect to bacteria and viruses, nitrates and/or nitrites, and volatile organic chemicals.

Overall, the contaminant risks for bacteria and viruses and nitrate/nitrites category are very high and high, respectively, with large capacity septic systems driving the scores. Combining the potential contamination risk for each category with the susceptibility of the well, yields an overall vulnerability to bacteria/viruses and nitrates/nitrites of high and medium, respectively, for this source of public drinking water.

Nitrates and/or nitrites are found in natural background concentrations at the site, as elsewhere in Alaska. The sampling history of the Meadowood Shopping Center source water indicates low concentrations of nitrate were reported in August 1999. (See Chart 6-Contaminant Risks for Nitrates/Nitrites in Appendix D). The reported nitrate contamination was less than 10% of the allowable limit (MCL) for this contaminant. Due to high solubility and weak retention by soil, nitrates are very mobile in soil, moving approximately the same rate as water. Nevertheless, the current nitrate concentration in the Meadowood Shopping Center water source remains at safe levels, with respect to human health.

Lumber storage/processing is performed in close proximity to the well, which drives the risk of volatile organic chemicals (VOC) contamination for the well. Additionally, auto parts stores and hardware stores store and sell materials containing VOCs. The public water system is not required to sample for VOCs, thus it is unknown if any VOCs from these types of sources are reaching the source.

## SUMMARY

A *Source Water Assessment* has been completed for the Meadowood Shopping Center source of public drinking water. The overall vulnerability of this source to contamination is **High** for bacteria and viruses and **Medium** for nitrates and/or nitrites and for volatile organic chemicals. This assessment of contaminant risks can be used as a foundation for local voluntary protection efforts as well as a basis for the continuous efforts on the part of the Alaska Department of Environmental Conservation to protect public health. It is anticipated that *Source Water Assessments* will be updated every five years to reflect any changes in the vulnerability and/or susceptibility of the public drinking water source.



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## **APPENDIX A**

### **Meadowood Shopping Center Drinking Water Protection Area**

## **APPENDIX B**

### **Contaminant Source Inventory and Risk Ranking for Meadowood Shopping Center**

## **APPENDIX C**

### **Meadowood Shopping Center Drinking Water Protection Area and Potential & Existing Contaminant Sources**

## **APPENDIX D**

### **Vulnerability Analysis for Meadowood Shopping Center Public Drinking Water Source**

Table 1

## Contaminant Source Inventory for Meadowood Shopping Center

PWSID 222343.001

<b>Contaminant Source Category</b>	<b>Contaminant Source ID</b>	<b>CS ID Tag</b>	<b>Zone</b>	<b>Location</b>	<b>Map</b>	<b>Comments</b>
<i>Highways and roads, paved (cement or asphalt)</i>	<i>X20</i>	<i>X20-1</i>	<i>A</i>	<i>Big Lake Road</i>	<i>2</i>	
<i>Highways and roads, dirt/gravel</i>	<i>X24</i>	<i>X24-1</i>	<i>A</i>	<i>Brittany Dr</i>	<i>2</i>	
<i>Lumber Storage/ Processing</i>	<i>N4</i>	<i>N4-1</i>	<i>A</i>	<i>~100 Ft North of Well</i>	<i>2</i>	
<i>Fireworks sales and distribution</i>	<i>C11</i>	<i>C11-1</i>	<i>B</i>	<i>In Meadowood Shopping Center</i>	<i>3</i>	
<i>Fireworks sales and distribution</i>	<i>C11</i>	<i>C11-2</i>	<i>B</i>	<i>North of Meadowood Shopping Center</i>	<i>3</i>	
<i>Hardware stores</i>	<i>C17</i>	<i>C17-1</i>	<i>B</i>	<i>In Meadowood Shopping Center</i>	<i>3</i>	
<i>Motor/motor vehicle supplies stores</i>	<i>C28</i>	<i>C28-1</i>	<i>B</i>	<i>Outside of Meadowood Shopping Center</i>	<i>3</i>	
<i>Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal Method)</i>	<i>D10</i>	<i>D10-1</i>	<i>B</i>	<i>Southwest of Meadowood Shopping Center Well</i>	<i>3</i>	
<i>Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal Method)</i>	<i>D10</i>	<i>D10-2</i>	<i>B</i>	<i>Across Big Lake Rd</i>	<i>3</i>	
<i>Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal Method)</i>	<i>D10</i>	<i>D10-3</i>	<i>B</i>	<i>North of Meadowood Shopping Center</i>	<i>3</i>	
<i>Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal Method)</i>	<i>D10</i>	<i>D10-4</i>	<i>B</i>	<i>Northeast of Parks Hwy</i>	<i>3</i>	
<i>Septic systems (serves one single-family home)</i>	<i>R2</i>	<i>R2-1</i>	<i>B</i>	<i>West of Meadowood Shopping Center</i>	<i>3</i>	
<i>Septic systems (serves one single-family home)</i>	<i>R2</i>	<i>R2-2</i>	<i>B</i>	<i>North of Forest Lake Rd</i>	<i>3</i>	
<i>Highways and roads, paved (cement or asphalt)</i>	<i>X20</i>	<i>X20-2</i>	<i>B</i>	<i>Parks Hwy</i>	<i>2</i>	
<i>Highways and roads, dirt/gravel</i>	<i>X24</i>	<i>X24-2</i>	<i>B</i>	<i>Forest Lake Dr</i>	<i>2</i>	

Table 1

## Contaminant Source Inventory for Meadowood Shopping Center

PWSID 222343.001

<b>Contaminant Source Category</b>	<b>Contaminant Source ID</b>	<b>CS ID Tag</b>	<b>Zone</b>	<b>Location</b>	<b>Map</b>	<b>Comments</b>
<i>Highways and roads, dirt/gravel</i>	<i>X24</i>	<i>X24-3</i>	<i>B</i>	<i>Rosewell Rd</i>	<i>2</i>	
<i>Residential Areas</i>	<i>R1</i>	<i>R1-1</i>	<i>C</i>	<i>North of Forest Lake Drive</i>	<i>2</i>	<i>29 acres</i>
<i>Septic systems (serves one single-family home)</i>	<i>R2</i>	<i>R2-3-- R2-16</i>	<i>C</i>	<i>13 Septics Northwest of Forest Lake</i>	<i>3</i>	
<i>Highways and roads, dirt/gravel</i>	<i>X24</i>	<i>X24-4</i>	<i>C</i>	<i>Forest Park Dr</i>	<i>2</i>	
<i>Highways and roads, dirt/gravel</i>	<i>X24</i>	<i>X24-5</i>	<i>C</i>	<i>Lakeshore Dr</i>	<i>2</i>	
<i>Highways and roads, dirt/gravel</i>	<i>X24</i>	<i>X24-6</i>	<i>C</i>	<i>Forest Park Ct</i>	<i>2</i>	
<i>Highways and roads, dirt/gravel</i>	<i>X24</i>	<i>X24-7</i>	<i>C</i>	<i>O'Daniel Circle</i>	<i>2</i>	
<i>Highways and roads, dirt/gravel</i>	<i>X24</i>	<i>X24-8</i>	<i>C</i>	<i>Wandering Way</i>	<i>2</i>	

Table 2

Potential and Existing Sources of Contamination for Meadowood Shopping Center  
Bacteria and Viruses

PWSID 222343.001

<b>Contaminant Source Category</b>	<b>Contaminant Source ID</b>	<b>CS ID Tag</b>	<b>Zone</b>	<b>Risk Ranking for Analysis</b>	<b>Overall Rank After Analysis</b>	<b>Location</b>	<b>Map</b>	<b>Comments</b>
Highways and roads, paved (cement or asphalt)	X20	X20-1	A	Very Low		Big Lake Road	2	
Highways and roads, dirt/gravel	X24	X24-1	A	Very Low		Brittany Dr	2	
Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal Method)	D10	D10-1	B	High	1	Southwest of Meadowood Shopping Center Well	3	
Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal Method)	D10	D10-2	B	High	2	Across Big Lake Rd	3	
Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal Method)	D10	D10-3	B	High	3	North of Meadowood Shopping Center	3	
Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal Method)	D10	D10-4	B	High	4	Northeast of Parks Hwy	3	
Septic systems (serves one single-family home)	R2	R2-1	B	Very Low		West of Meadowood Shopping Center	3	
Septic systems (serves one single-family home)	R2	R2-2	B	Very Low		North of Forest Lake Rd	3	
Highways and roads, paved (cement or asphalt)	X20	X20-2	B	Very Low		Parks Hwy	2	
Highways and roads, dirt/gravel	X24	X24-2	B	Very Low		Forest Lake Dr	2	
Highways and roads, dirt/gravel	X24	X24-3	B	Very Low		Rosewell Rd	2	
Residential Areas	R1	R1-1	C	Low	5	North of Forest Lake Drive	2	29 acres
Septic systems (serves one single-family home)	R2	R2-3-- R2-16	C	Very Low		13 Septics Northwest of Forest Lake	3	
Highways and roads, dirt/gravel	X24	X24-4	C	Very Low		Forest Park Dr	2	
Highways and roads, dirt/gravel	X24	X24-5	C	Very Low		Lakeshore Dr	2	
Highways and roads, dirt/gravel	X24	X24-6	C	Very Low		Forest Park Ct	2	



Table 2

Potential and Existing Sources of Contamination for Meadowood Shopping Center  
Bacteria and Viruses

PWSID 222343.001

<b><i>Contaminant Source Category</i></b>	<b><i>Contaminant Source ID</i></b>	<b><i>CS ID Tag</i></b>	<b><i>Zone</i></b>	<b><i>Risk Ranking for Analysis</i></b>	<b><i>Overall Rank After Analysis</i></b>	<b><i>Location</i></b>	<b><i>Map</i></b>	<b><i>Comments</i></b>
<i>Highways and roads, dirt/gravel</i>	<i>X24</i>	<i>X24-7</i>	<i>C</i>	<i>Very Low</i>		<i>O'Daniel Circle</i>	<i>2</i>	
<i>Highways and roads, dirt/gravel</i>	<i>X24</i>	<i>X24-8</i>	<i>C</i>	<i>Very Low</i>		<i>Wandering Way</i>	<i>2</i>	

Table 3

Potential and Existing Sources of Contamination for Meadowood Shopping Center  
Nitrates and Nitrites

PWSID 222343.001

<i>Contaminant Source Category</i>	<i>Contaminant Source ID</i>	<i>CS ID Tag</i>	<i>Zone</i>	<i>Risk Ranking for Analysis</i>	<i>Overall Rank After Analysis</i>	<i>Location</i>	<i>Map</i>	<i>Comments</i>
Highways and roads, paved (cement or asphalt)	X20	X20-1	A	Very Low		Big Lake Road	2	
Highways and roads, dirt/gravel	X24	X24-1	A	Very Low		Brittany Dr	2	
Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal Method)	D10	D10-1	B	High	1	Southwest of Meadowood Shopping Center Well	3	
Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal Method)	D10	D10-2	B	High	2	Across Big Lake Rd	3	
Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal Method)	D10	D10-3	B	High	3	North of Meadowood Shopping Center	3	
Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal Method)	D10	D10-4	B	High	3	Northeast of Parks Hwy	3	
Fireworks sales and distribution	C11	C11-1	B	Low	4	In Meadowood Shopping Center	3	
Fireworks sales and distribution	C11	C11-2	B	Low	5	North of Meadowood Shopping Center	3	
Hardware stores	C17	C17-1	B	Low		In Meadowood Shopping Center	3	
Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal Method)	D10	D10-1	B	Very Low		Southwest of Meadowood Shopping Center Well	3	
Septic systems (serves one single-family home)	R2	R2-1	B	Very Low		West of Meadowood Shopping Center	3	
Septic systems (serves one single-family home)	R2	R2-2	B	Very Low		North of Forest Lake Rd	3	
Highways and roads, paved (cement or asphalt)	X20	X20-2	B	Very Low		Parks Hwy	2	
Highways and roads, dirt/gravel	X24	X24-2	B	Very Low		Forest Lake Dr	2	
Highways and roads, dirt/gravel	X24	X24-3	B	Very Low		Rosewell Rd	2	

Table 3

Potential and Existing Sources of Contamination for Meadowood Shopping Center  
Nitrates and Nitrites

PWSID 222343.001

<i>Contaminant Source Category</i>	<i>Contaminant Source ID</i>	<i>CS ID Tag</i>	<i>Zone</i>	<i>Risk Ranking for Analysis</i>	<i>Overall Rank After Analysis</i>	<i>Location</i>	<i>Map</i>	<i>Comments</i>
<i>Residential Areas</i>	<i>R1</i>	<i>R1-1</i>	<i>C</i>	<i>Low</i>		<i>North of Forest Lake Drive</i>	<i>2</i>	<i>29 acres</i>
<i>Septic systems (serves one single-family home)</i>	<i>R2</i>	<i>R2-3-- R2-16</i>	<i>C</i>	<i>Very Low</i>		<i>13 Septics Northwest of Forest Lake</i>	<i>3</i>	
<i>Highways and roads, dirt/gravel</i>	<i>X24</i>	<i>X24-4</i>	<i>C</i>	<i>Very Low</i>		<i>Forest Park Dr</i>	<i>2</i>	
<i>Highways and roads, dirt/gravel</i>	<i>X24</i>	<i>X24-5</i>	<i>C</i>	<i>Very Low</i>		<i>Lakeshore Dr</i>	<i>2</i>	
<i>Highways and roads, dirt/gravel</i>	<i>X24</i>	<i>X24-6</i>	<i>C</i>	<i>Very Low</i>		<i>Forest Park Ct</i>	<i>2</i>	
<i>Highways and roads, dirt/gravel</i>	<i>X24</i>	<i>X24-7</i>	<i>C</i>	<i>Very Low</i>		<i>O'Daniel Circle</i>	<i>2</i>	
<i>Highways and roads, dirt/gravel</i>	<i>X24</i>	<i>X24-8</i>	<i>C</i>	<i>Very Low</i>		<i>Wandering Way</i>	<i>2</i>	

Table 4

Potential and Existing Sources of Contamination for Meadowood Shopping Center  
Volatile Organic Chemicals (VOCs)

PWSID 222343.001

<b>Contaminant Source Category</b>	<b>Contaminant Source ID</b>	<b>CS ID Tag</b>	<b>Zone</b>	<b>Risk Ranking for Analysis</b>	<b>Overall Rank After Analysis</b>	<b>Location</b>	<b>Map</b>	<b>Comments</b>
Highways and roads, paved (cement or asphalt)	X20	X20-1	A	Very Low		Big Lake Road	2	
Highways and roads, dirt/gravel	X24	X24-1	A	Very Low		Brittany Dr	2	
Lumber Storage/ Processing	N4	N4-1	A	Medium	1	~100 Ft North of Well	2	
Hardware stores	C17	C17-1	B	Low	2	In Meadowood Shopping Center	3	
Motor/motor vehicle supplies stores	C28	C28-1	B	Low	3	Outside of Meadowood Shopping Center	3	
Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal Method)	D10	D10-1	B	Low	4	Southwest of Meadowood Shopping Center Well	3	
Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal Method)	D10	D10-2	B	Low	5	Across Big Lake Rd	3	
Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal Method)	D10	D10-3	B	Low	5	North of Meadowood Shopping Center	3	
Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal Method)	D10	D10-4	B	Low		Northeast of Parks Hwy	3	
Septic systems (serves one single-family home)	R2	R2-1	B	Very Low		West of Meadowood Shopping Center	3	
Septic systems (serves one single-family home)	R2	R2-2	B	Very Low		North of Forest Lake Rd	3	
Highways and roads, paved (cement or asphalt)	X20	X20-2	B	Very Low		Parks Hwy	2	
Highways and roads, dirt/gravel	X24	X24-2	B	Very Low		Forest Lake Dr	2	
Highways and roads, dirt/gravel	X24	X24-3	B	Very Low		Rosewell Rd	2	
Residential Areas	R1	R1-1	C	Low		North of Forest Lake Drive	2	29 acres
Septic systems (serves one single-family home)	R2	R2-3-- R2-16	C	Very Low		13 Septics Northwest of Forest Lake	3	

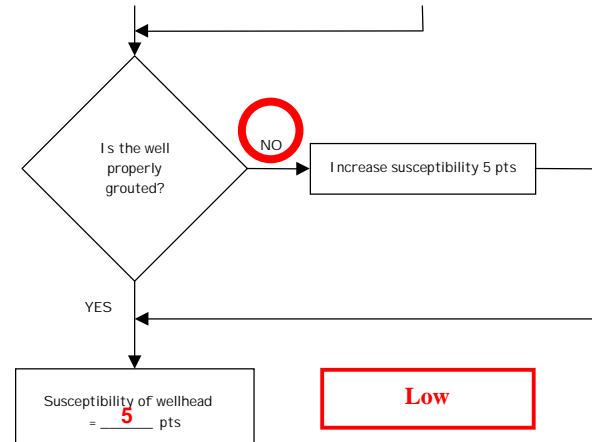
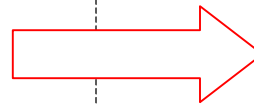
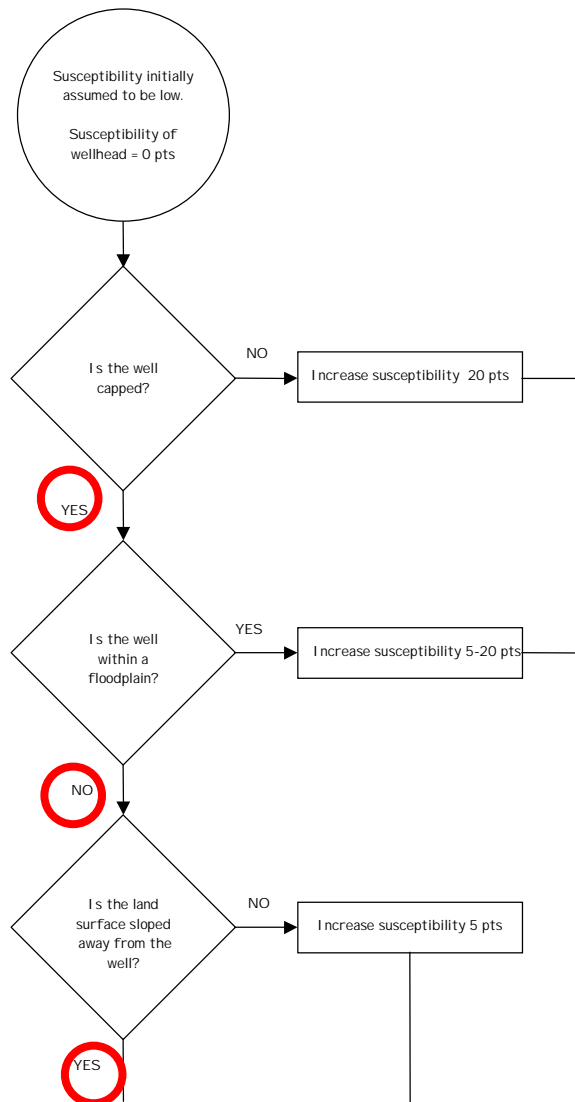
Table 4

Potential and Existing Sources of Contamination for Meadowood Shopping Center  
Volatile Organic Chemicals (VOCs)

PWSID 222343.001

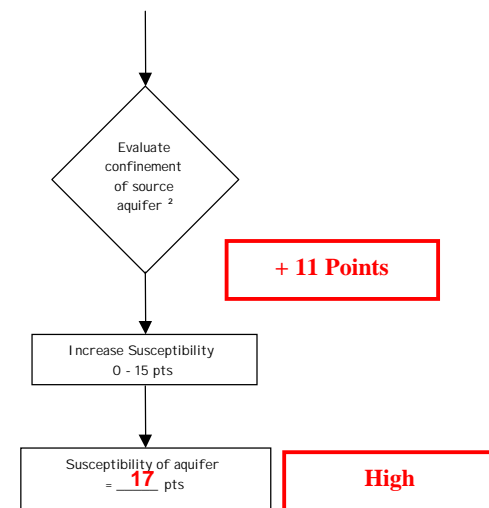
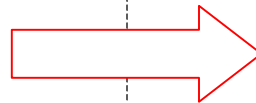
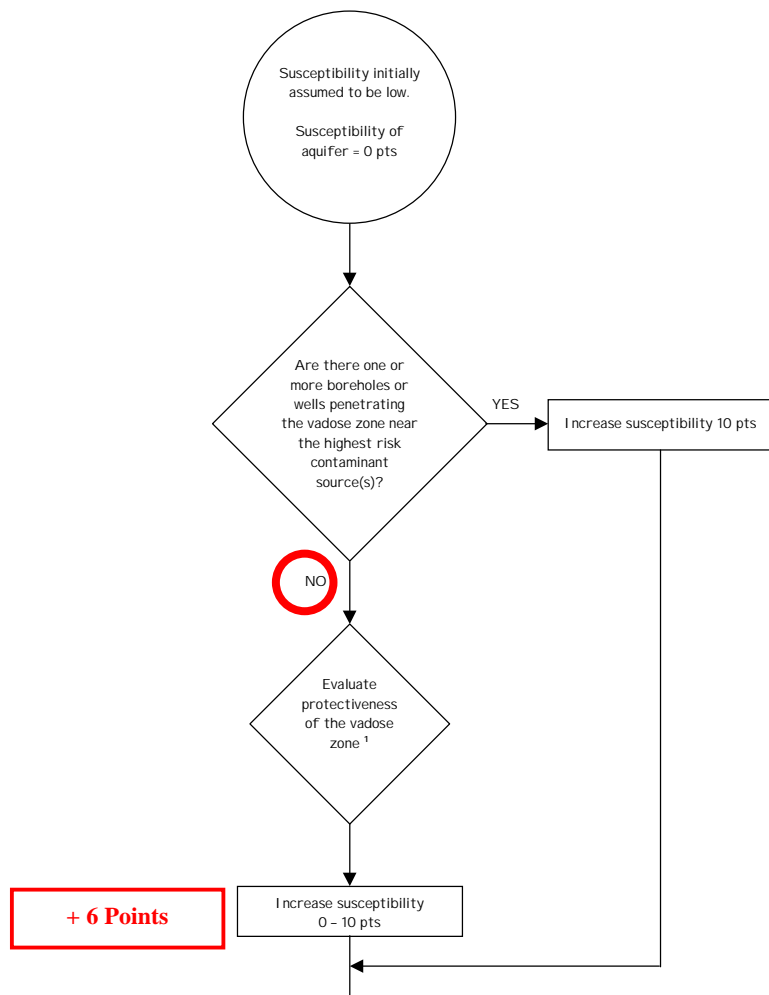
<b>Contaminant Source Category</b>	<b>Contaminant Source ID</b>	<b>CS ID Tag</b>	<b>Zone</b>	<b>Risk Ranking for Analysis</b>	<b>Overall Rank After Analysis</b>	<b>Location</b>	<b>Map</b>	<b>Comments</b>
<i>Highways and roads, dirt/gravel</i>	<i>X24</i>	<i>X24-4</i>	<i>C</i>	<i>Very Low</i>		<i>Forest Park Dr</i>	<i>2</i>	
<i>Highways and roads, dirt/gravel</i>	<i>X24</i>	<i>X24-5</i>	<i>C</i>	<i>Very Low</i>		<i>Lakeshore Dr</i>	<i>2</i>	
<i>Highways and roads, dirt/gravel</i>	<i>X24</i>	<i>X24-6</i>	<i>C</i>	<i>Very Low</i>		<i>Forest Park Ct</i>	<i>2</i>	
<i>Highways and roads, dirt/gravel</i>	<i>X24</i>	<i>X24-7</i>	<i>C</i>	<i>Very Low</i>		<i>O'Daniel Circle</i>	<i>2</i>	
<i>Highways and roads, dirt/gravel</i>	<i>X24</i>	<i>X24-8</i>	<i>C</i>	<i>Very Low</i>		<i>Wandering Way</i>	<i>2</i>	

**Chart 1. Susceptibility of the Wellhead – Meadowood Shopping Center**



Wellhead Susceptibility Ratings	
20 to 25 pts	very high
15 to < 20 pts	high
10 to < 15 pts	medium
< 10	low

**Chart 2. Susceptibility of the aquifer – Meadowood Shopping Center**



**1. Protectiveness of the Vadose Zone**

- net recharge (function of precipitation, slope of land surface, & permeability of soils)  
[0 - 10 pts; 50% weight]
- depth to water table (unconfined aquifer) or top of confining layer (confined aquifer)  
[interpolate linearly: 100' - 20', 0 - 5 pts; 20' - 0', 5 - 10 pts; 50% weight]

Precipitation=20"/Yr.= 4 pts.  
Soil = Silt/Loam = 4 pts.  
Slope = 0-5% = 10 pts.  
18 pts./3 = 6 pts.  
6 pts. X 50% = **3 pts.**

Depth to water table = 18 feet  
Interpolate linearly = 6 pts.  
6 pts. X 50% = **3 pts.**

**Total = 6 of 10 Points**

**2. Degree of Confinement**

- confined verses unconfined aquifer  
[confined:  $K \leq 10^{-8}$  cm/s, minimum thickness of at least one layer = 20 ft, interpolate linearly 100' - 20', 0 - 10 pts; unconfined = 10 - 15 pts; 65% weight]
- density of boreholes and wells penetrating the confining layer (confined aquifer) or the water table (unconfined aquifer)  
[confined: 0 - 15 pts; unconfined = 10-15 pts; 35% weight]

**Unconfined Aquifer**

Well depth 61 feet = 11 pts.  
Few wells/boreholes in proximity = 10 pts.

11(65%) + 10(35%) = **11 pts.**

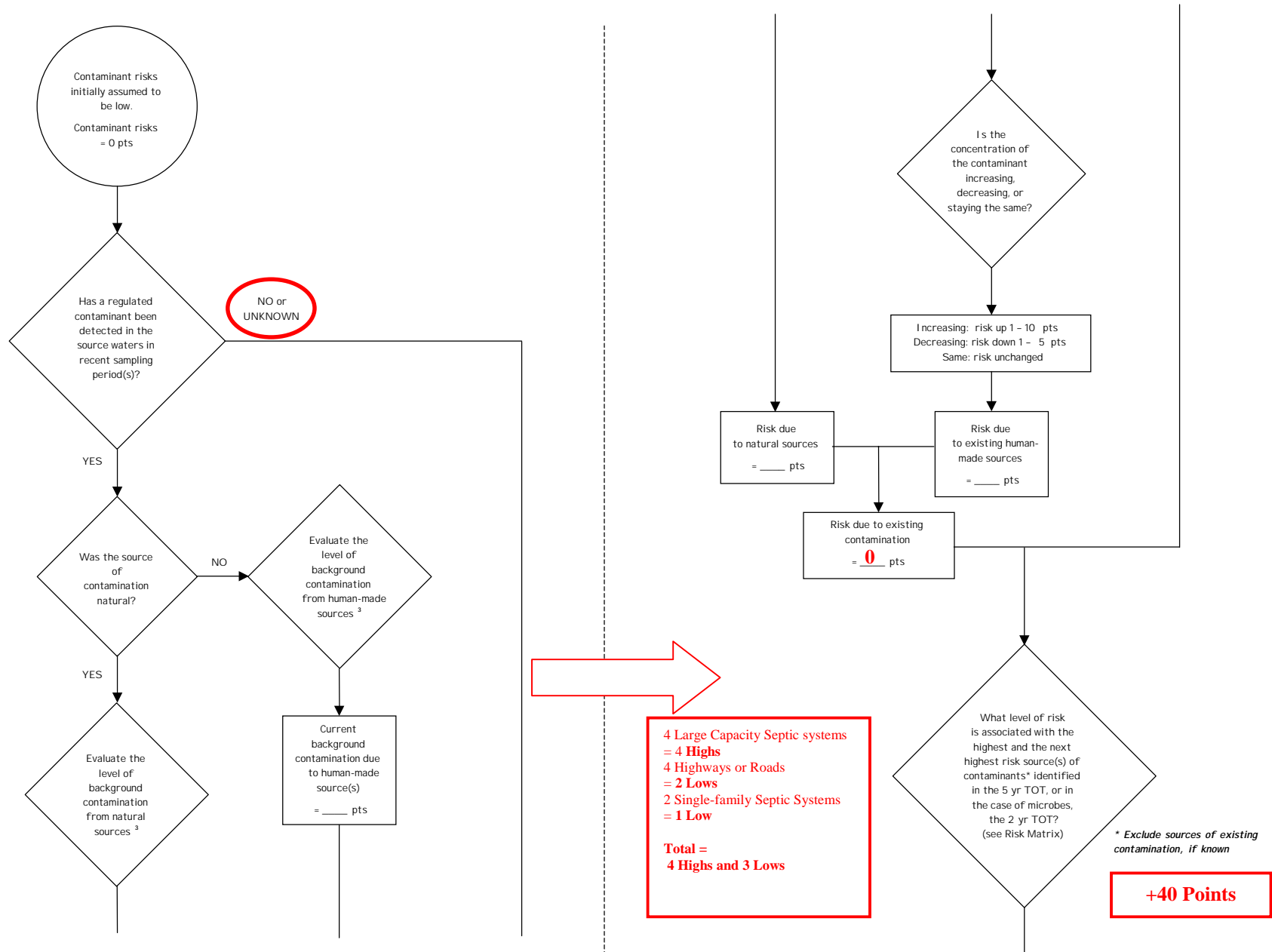
**Total = 11 of 15 Points**

**Aquifer Susceptibility Ratings**

20 to 25 pts	very high
15 to < 20 pts	high
10 to < 15 pts	medium
< 10	low

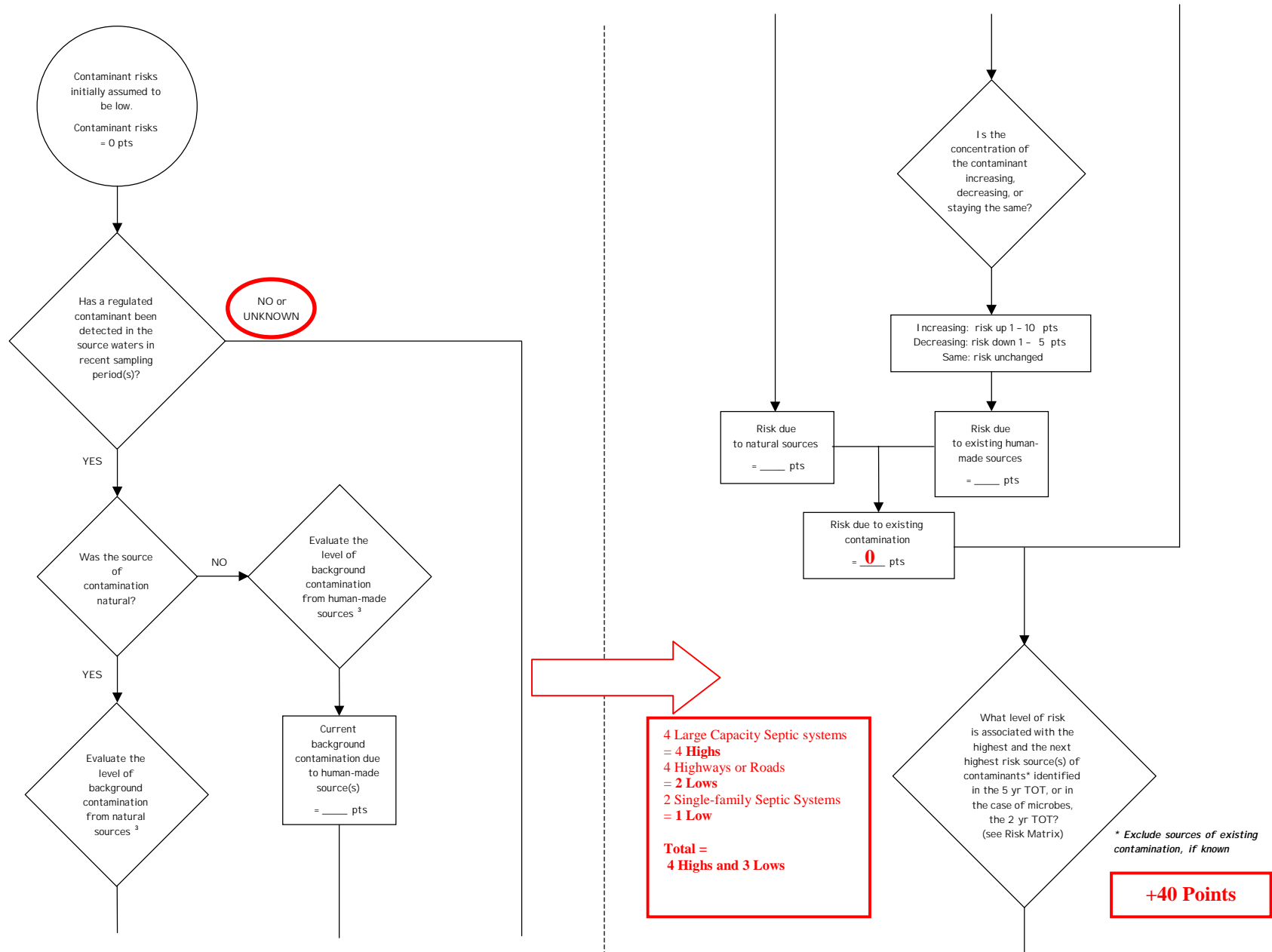
**High**

**Chart 3. Contaminant risks for Meadowood Shopping Center – Bacteria & Viruses**





**Chart 3. Contaminant risks for Meadowood Shopping Center – Bacteria & Viruses**



**Chart 3. Contaminant risks for Meadowood Shopping Center– Bacteria & Viruses (Continued)**

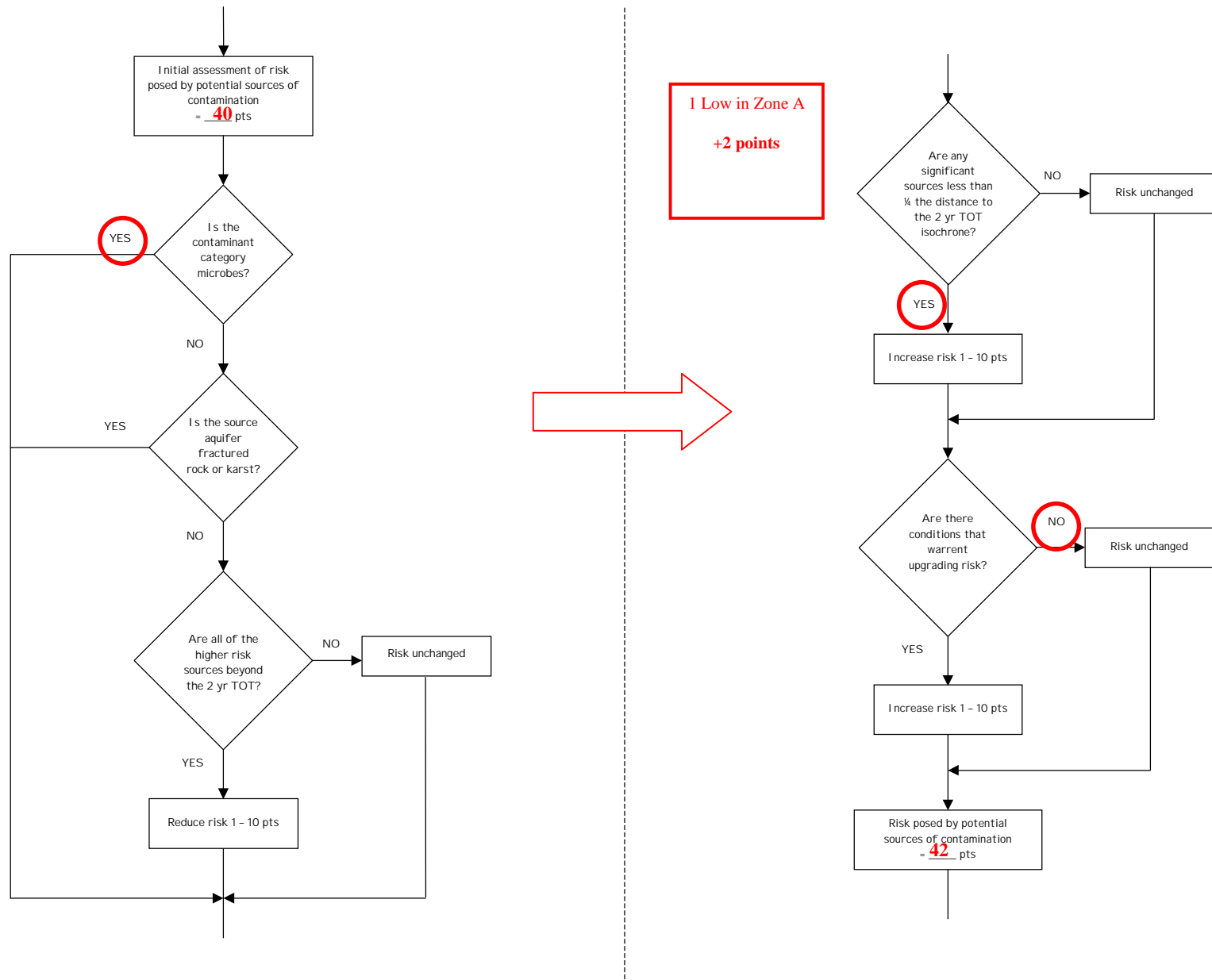
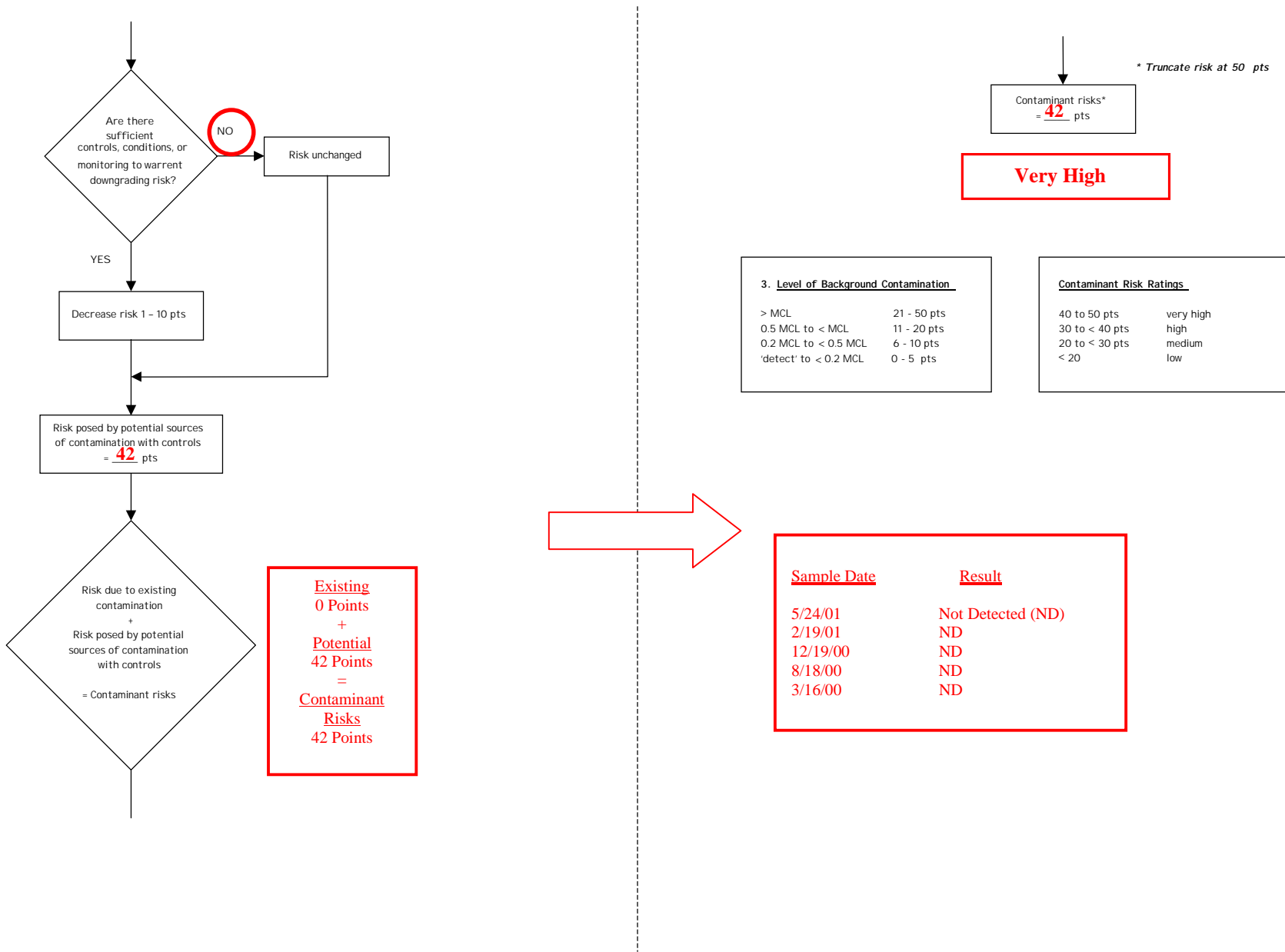


Chart 3. Contaminant risks for Meadowood Shopping Center– Bacteria & Viruses (Continued)

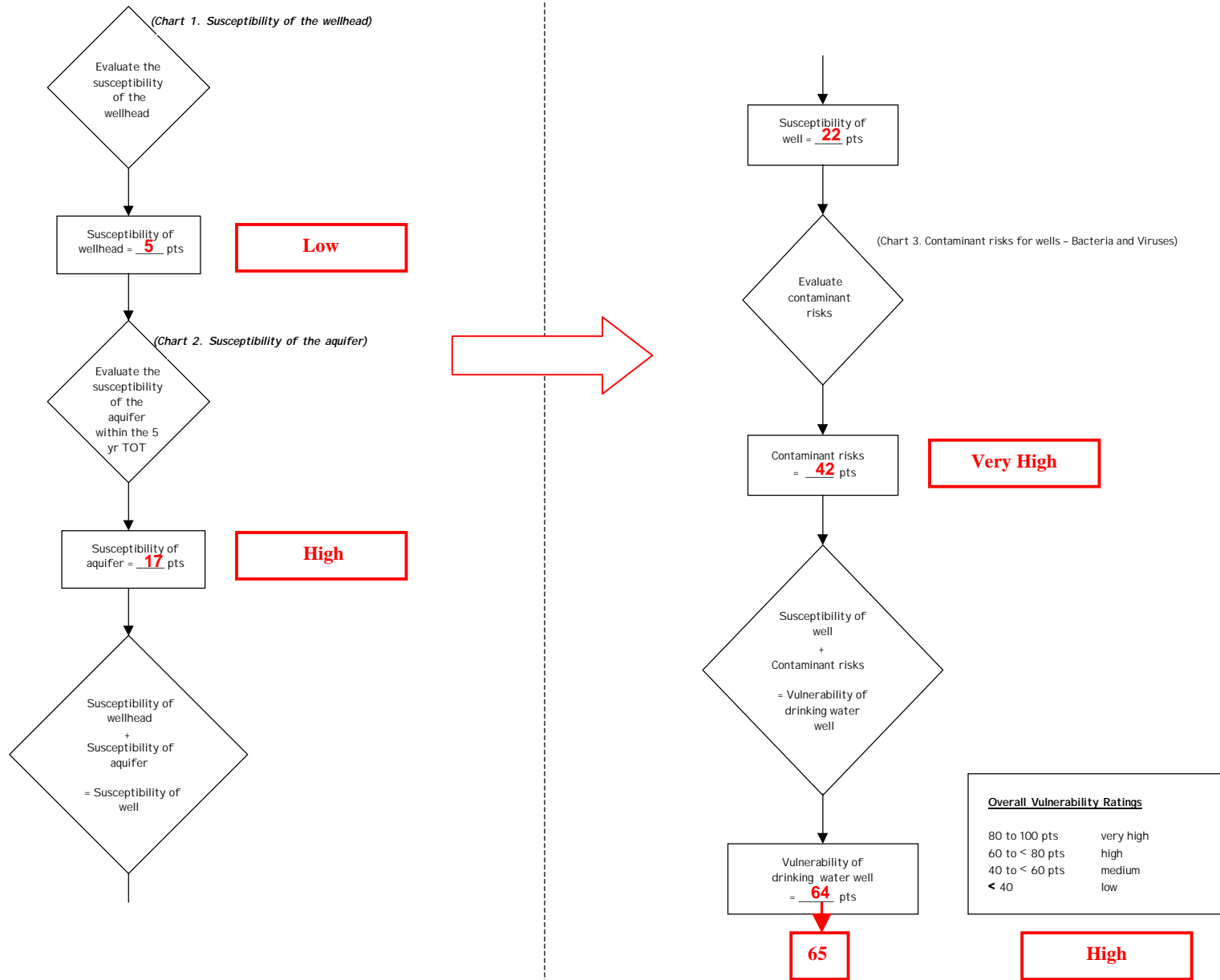


**Table 1. Risk Matrix for Contaminant Sources for Meadowood Shopping Center– Bacteria & Viruses**

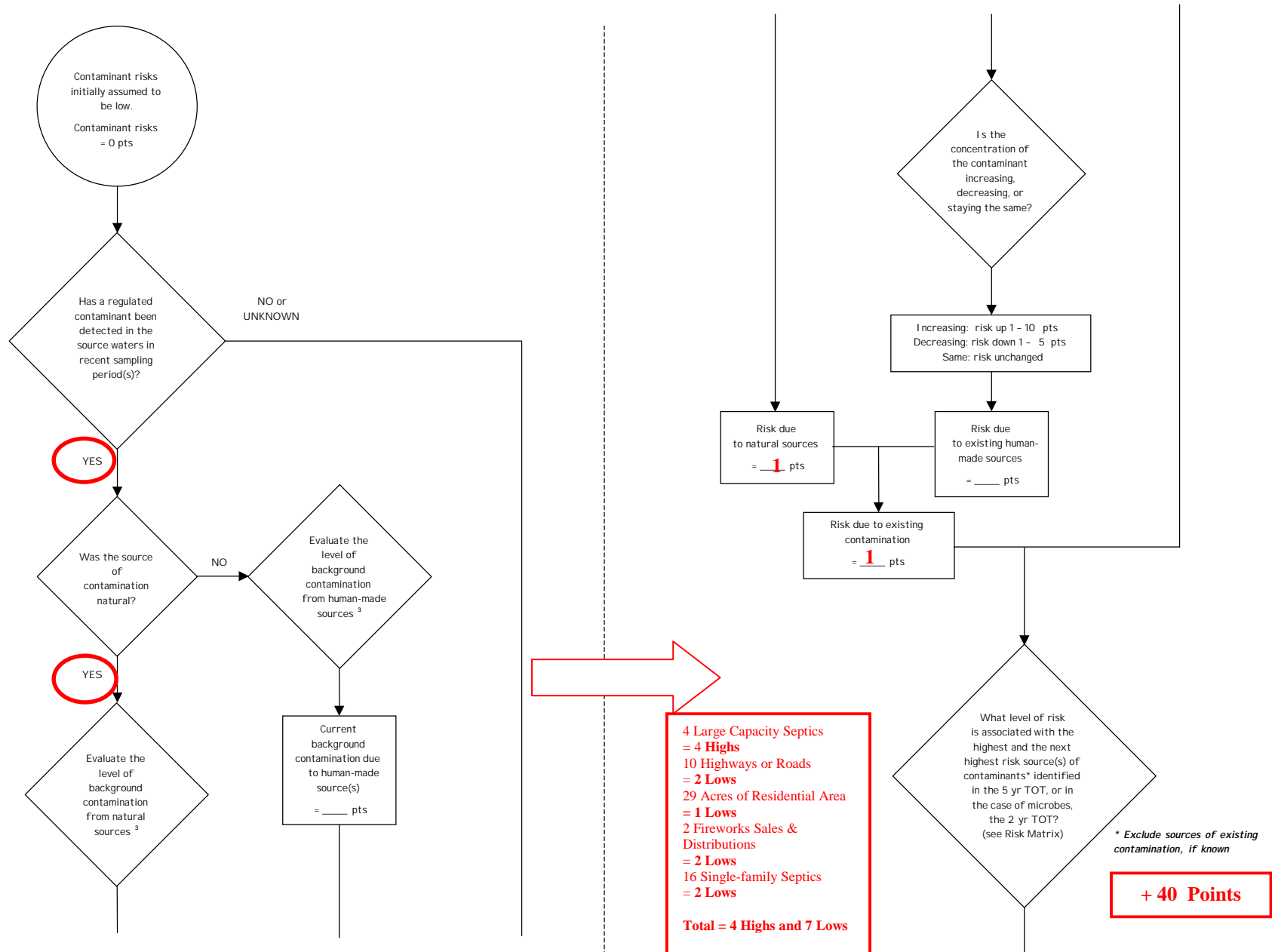
**Level of Risk Associated with the Highest Risk Sources**

<b>Next Highest Risk Source(s)</b>	<b>Total</b> 4 Highs 3 Lows	<b>LOW</b> 10 pts	<b>MEDIUM</b> 20 pts	<b>HIGH</b> 30 pts	<b>VERY HIGH</b> 40 pts
	<b>Low</b>	≥ 10 sources + 10 pts	≥ 10 sources + 5 pts	≥ 20 sources + 5 pts	—
	<b>Medium</b>	—	≥ 2 sources + 5 pts	≥ 5 sources + 5 pts	≥ 10 sources + 5 pts
	<b>High</b>	—	—	1 source + 10 pts	≥ 2 sources + 10 pts
	<b>Very High</b>	—	—	—	1 source + 10 pts

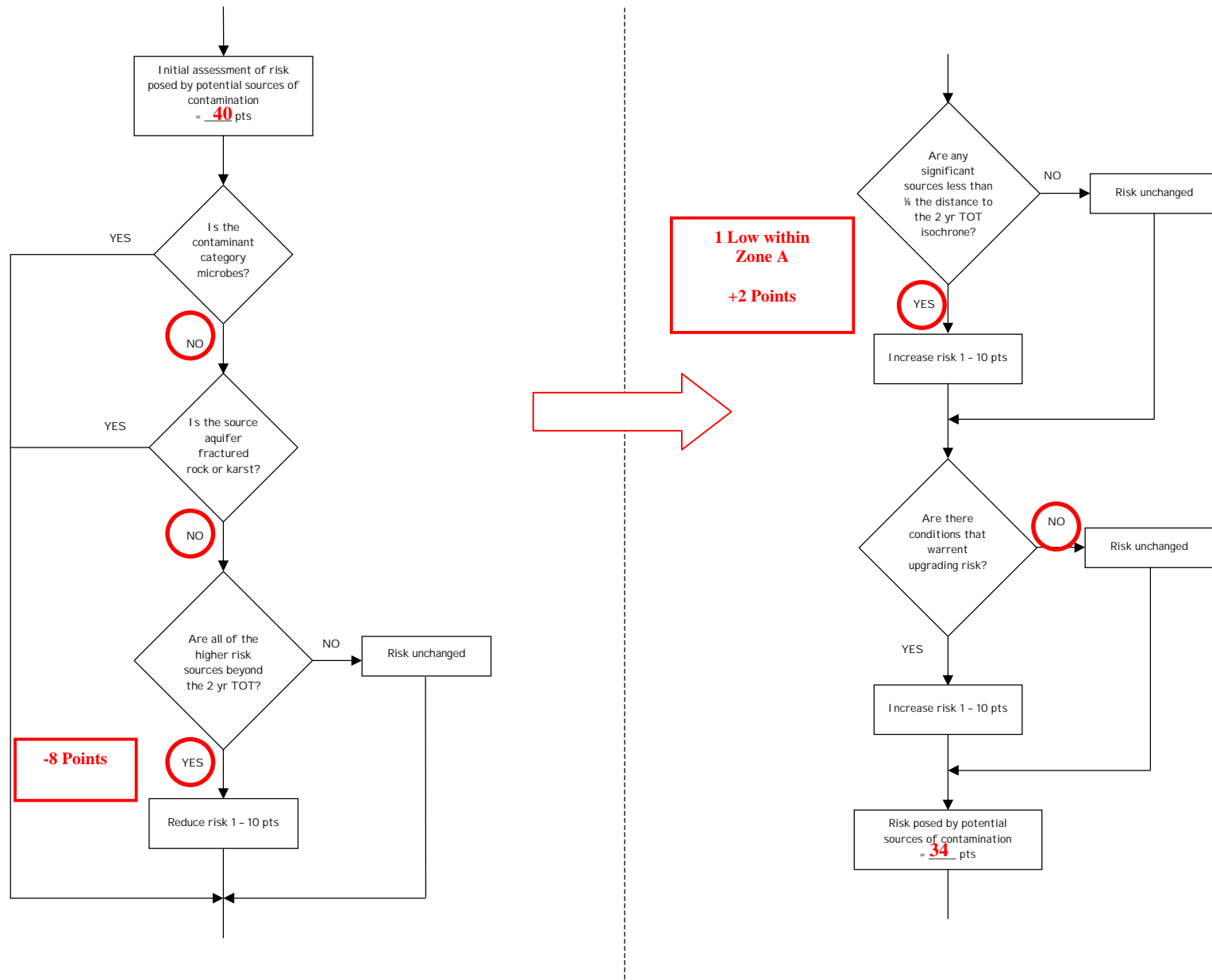
**Chart 4. Vulnerability analysis for Meadowood Shopping Center – Bacteria & Viruses**



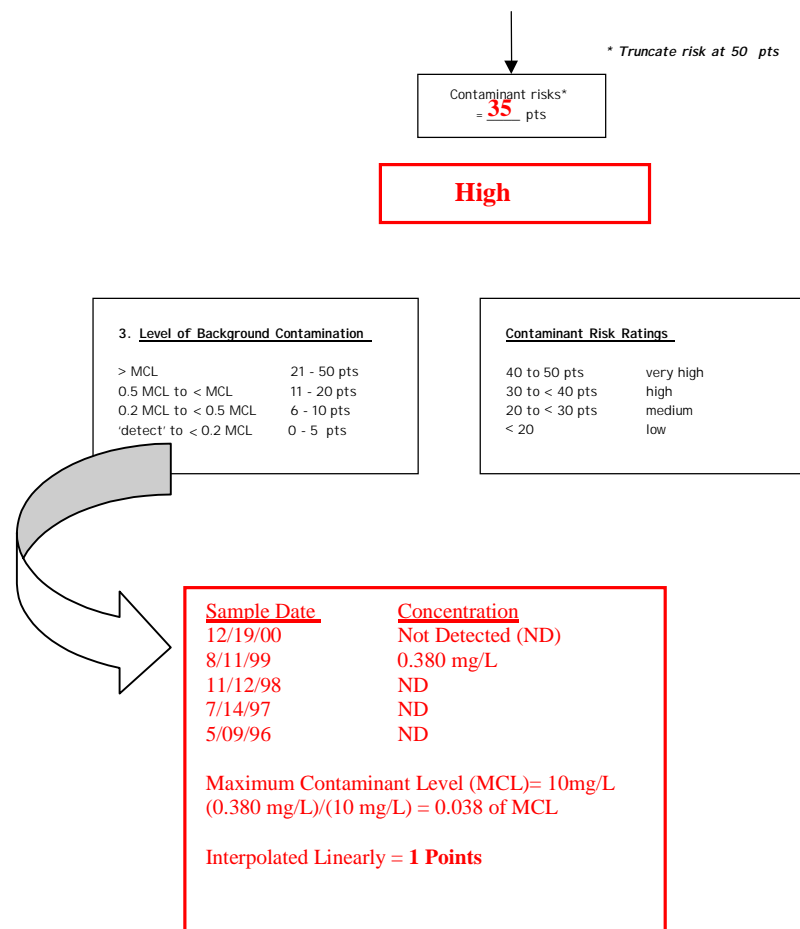
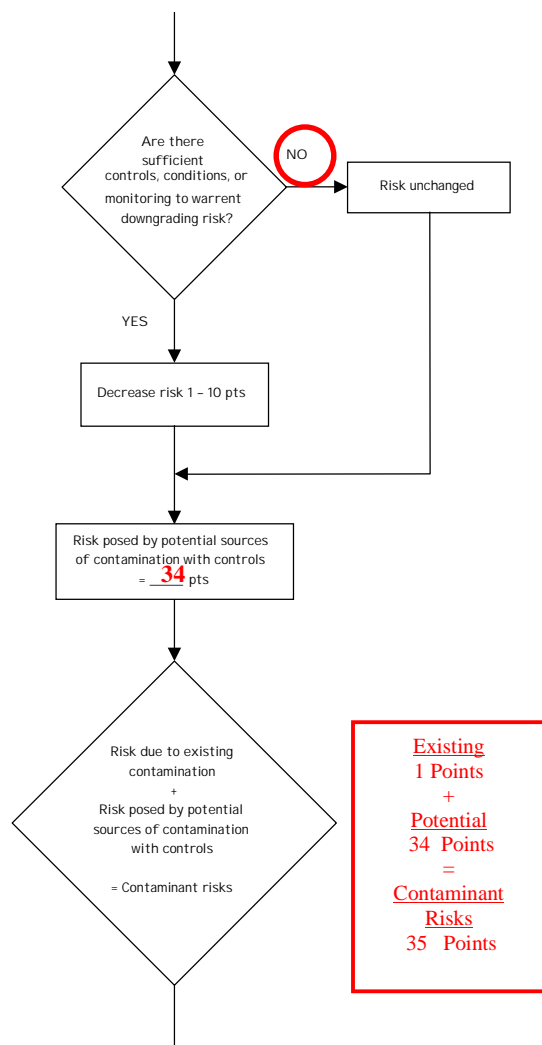
**Chart 5. Contaminant risks for Meadowood Shopping Center – Nitrates and Nitrites**



**Chart 5. Contaminant risks for Meadowood Shopping Center– Nitrates and Nitrites (Continued)**



**Chart 5. Contaminant risks for Meadowood Shopping Center– Nitrates and Nitrites (Continued)**



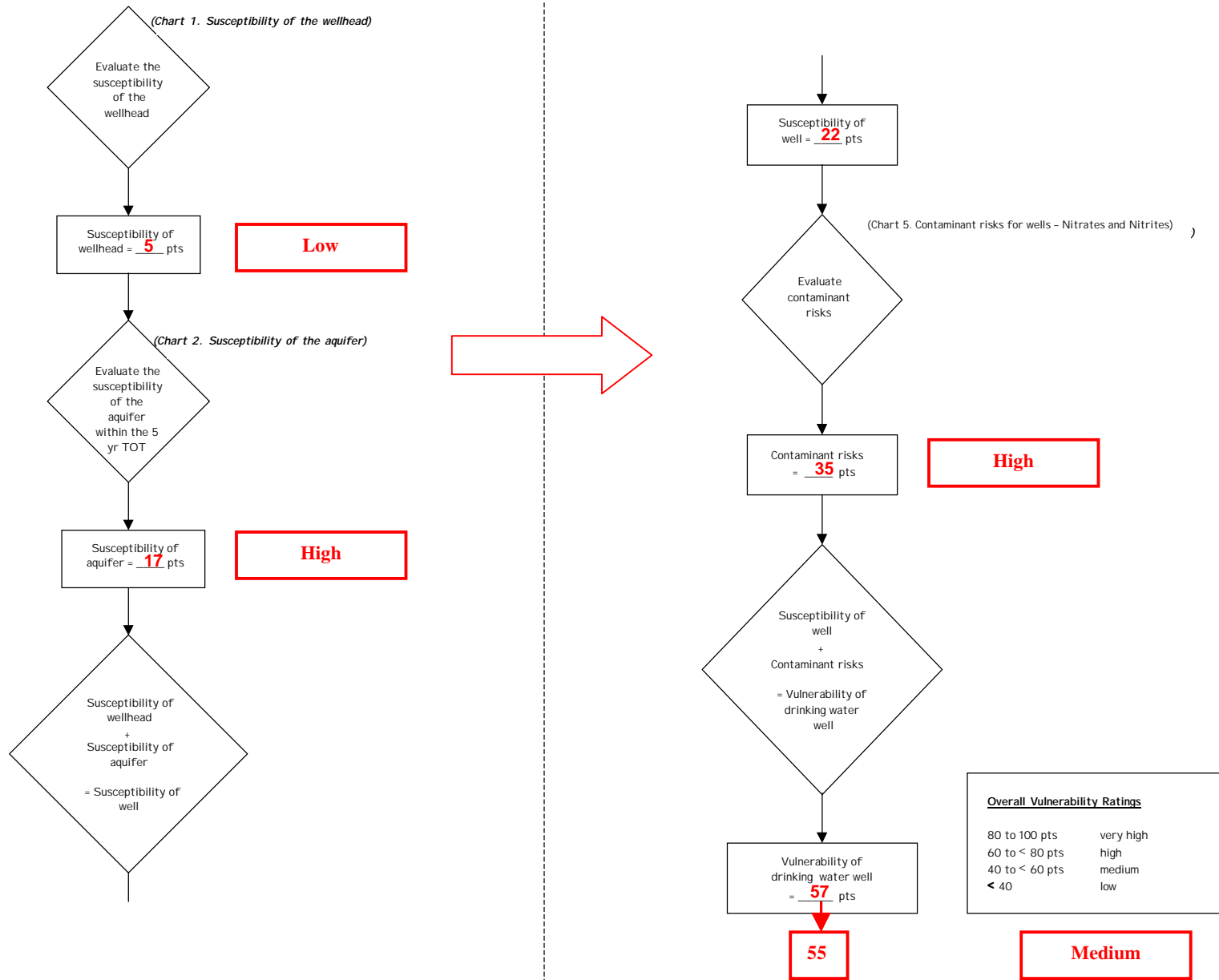


**Table 2. Risk Matrix for Contaminant Sources for Meadowood Shopping Center– Nitrates and Nitrites**

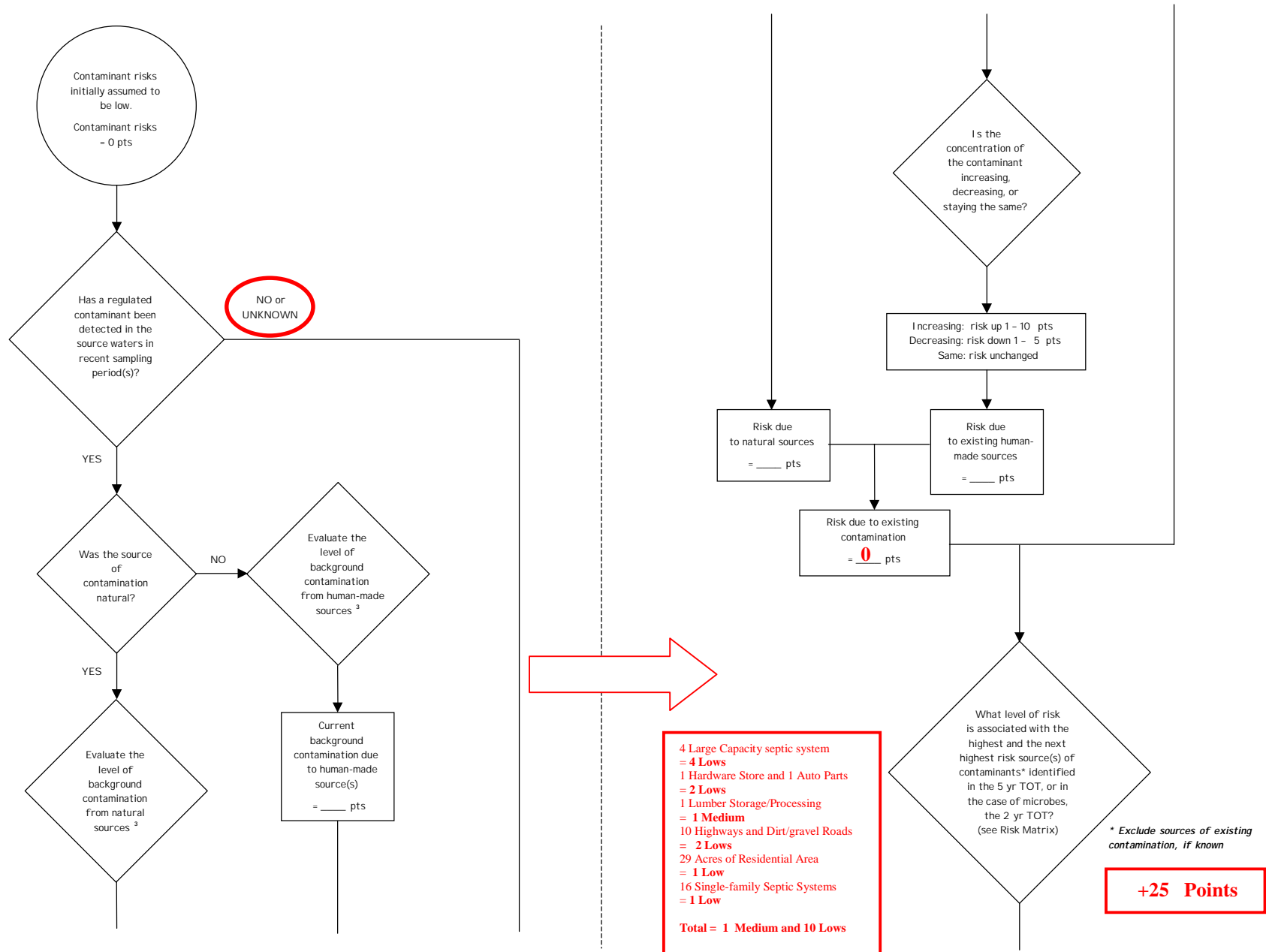
**Level of Risk Associated with the Highest Risk Sources**

Total 4 Highs 7 Lows	<b>LOW</b> 10 pts	<b>MEDIUM</b> 20 pts	<b>HIGH</b> 30 pts	<b>VERY HIGH</b> 40 pts
<b>Low</b>	≥ 10 sources + 10 pts	≥ 10 sources + 5 pts	≥ 20 sources + 5 pts	—
<b>Medium</b>	—	≥ 2 sources + 5 pts	≥ 5 sources + 5 pts	≥ 10 sources + 5 pts
<b>High</b>	—	—	1 source + 10 pts	≥ 2 sources + 10 pts
<b>Very High</b>	—	—	—	1 source + 10 pts

**Chart 6. Vulnerability analysis for Meadowood Shopping Center – Nitrates and Nitrites**



**Chart 7. Contaminant risks for Meadowood Shopping Center – Volatile Organic Chemicals**



**Chart 7. Contaminant risks for Meadowood Shopping Center– Volatile Organic Chemicals (Continued)**

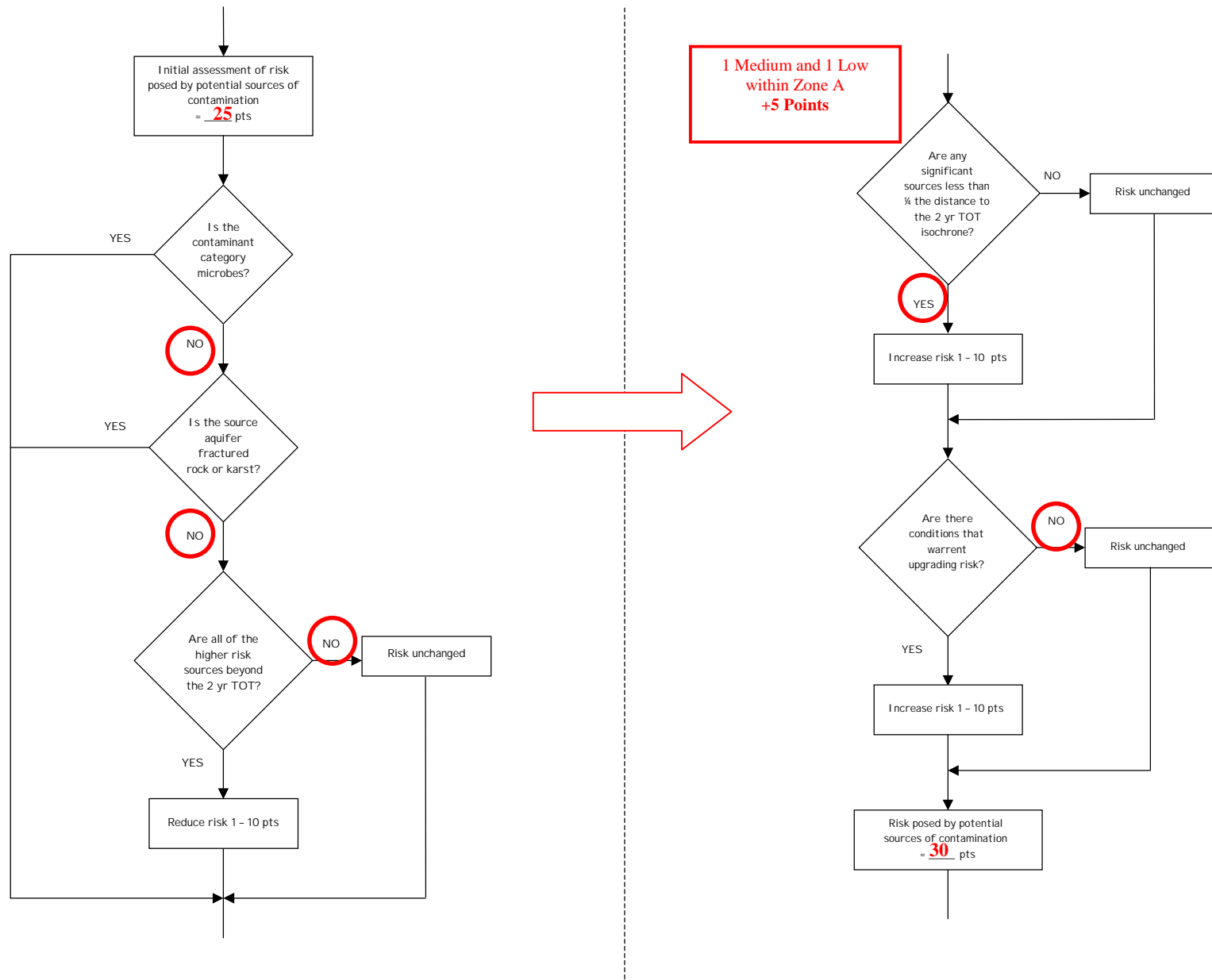
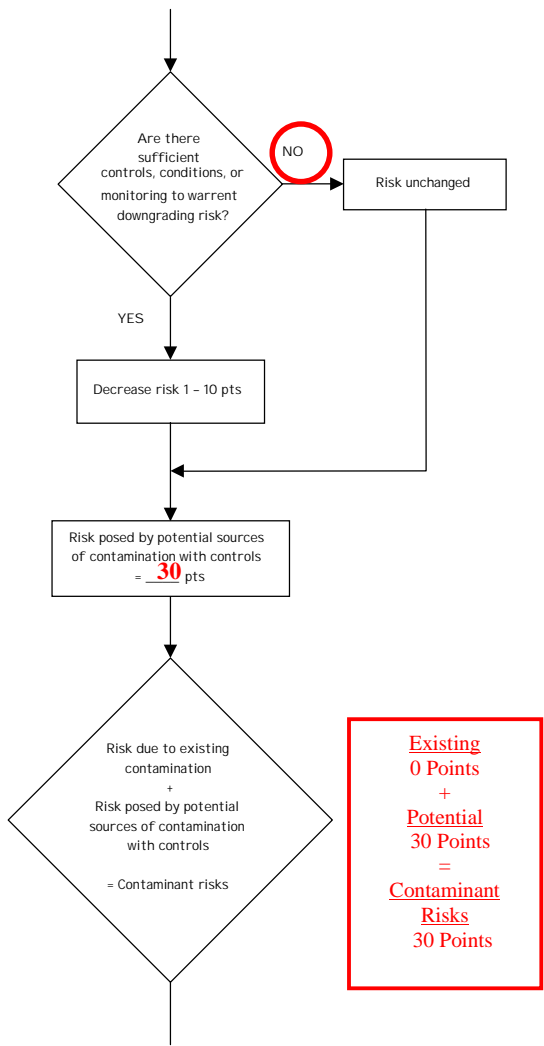


Chart 7. Contaminant risks for Meadowood Shopping Center– Volatile Organic Chemicals (Continued)



Contaminant risks\* = **30** pts

\* Truncate risk at 50 pts

**High**

3. Level of Background Contamination

> MCL	21 - 50 pts
0.5 MCL to < MCL	11 - 20 pts
0.2 MCL to < 0.5 MCL	6 - 10 pts
'detect' to < 0.2 MCL	0 - 5 pts

Contaminant Risk Ratings

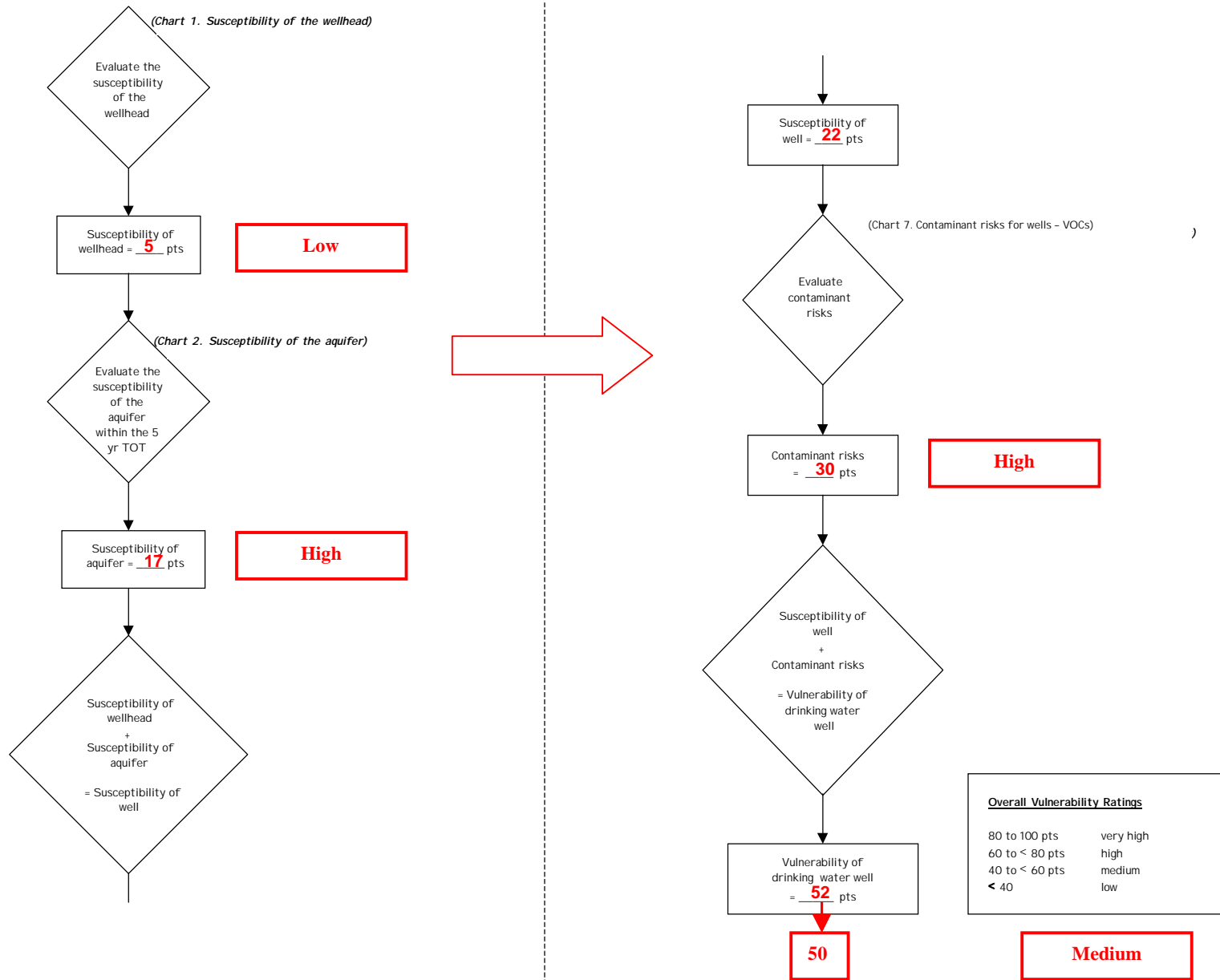
40 to 50 pts	very high
30 to < 40 pts	high
20 to < 30 pts	medium
< 20	low

**Table 3. Risk Matrix for Contaminant Sources for Meadowood Shopping Center– Volatile Organic Chemicals**

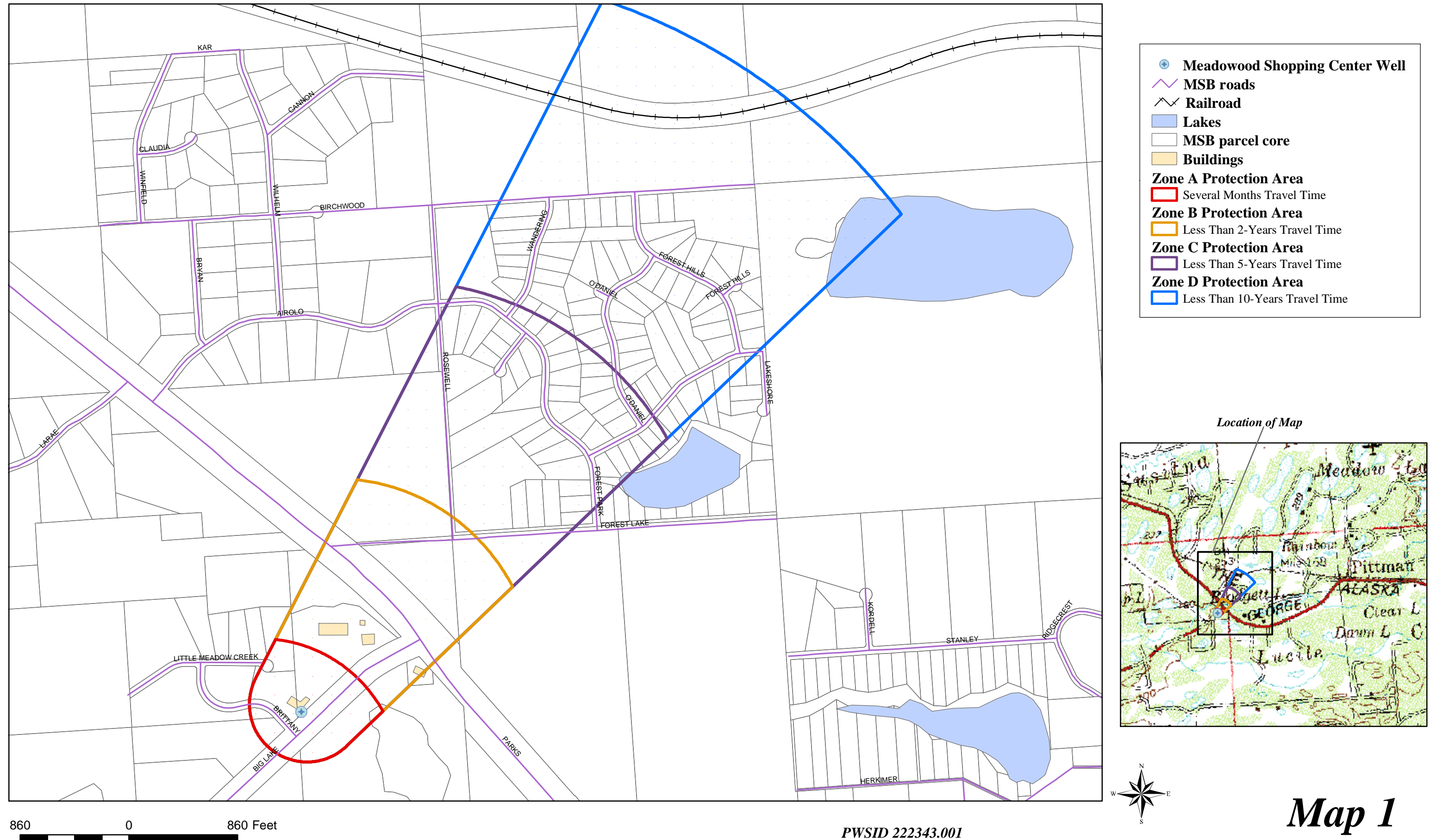
**Level of Risk Associated with the Highest Risk Sources**

<b>Total</b> <b>1 Medium</b> <b>10 Lows</b>	<b>LOW</b> <b>10 pts</b>	<b>MEDIUM</b> <b>20 pts</b>	<b>HIGH</b> <b>30 pts</b>	<b>VERY HIGH</b> <b>40 pts</b>
<b>Low</b>	≥ 10 sources + 10 pts	≥ 10 sources + 5 pts	≥ 20 sources + 5 pts	—
<b>Medium</b>	—	≥ 2 sources + 5 pts	≥ 5 sources + 5 pts	≥ 10 sources + 5 pts
<b>High</b>	—	—	1 source + 10 pts	≥ 2 sources + 10 pts
<b>Very High</b>	—	—	—	1 source + 10 pts

**Chart 8. Vulnerability analysis for Meadowood Shopping Center – Volatile Organic Chemicals**

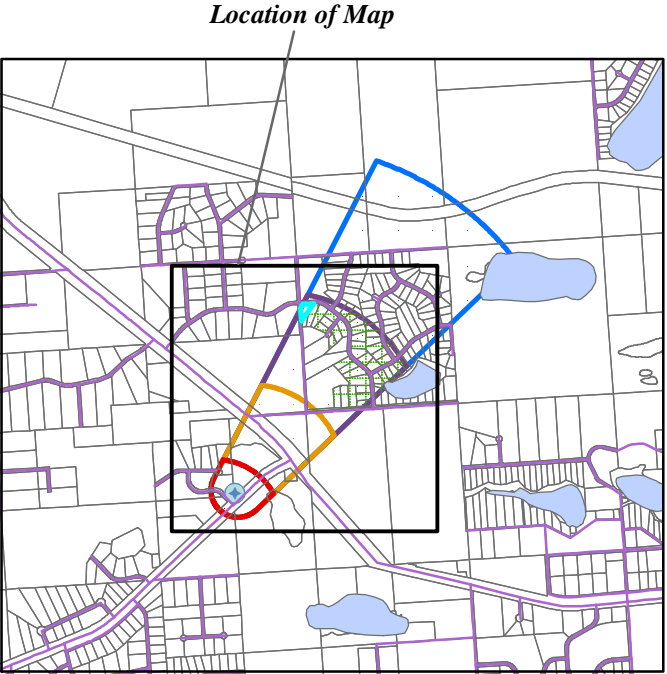
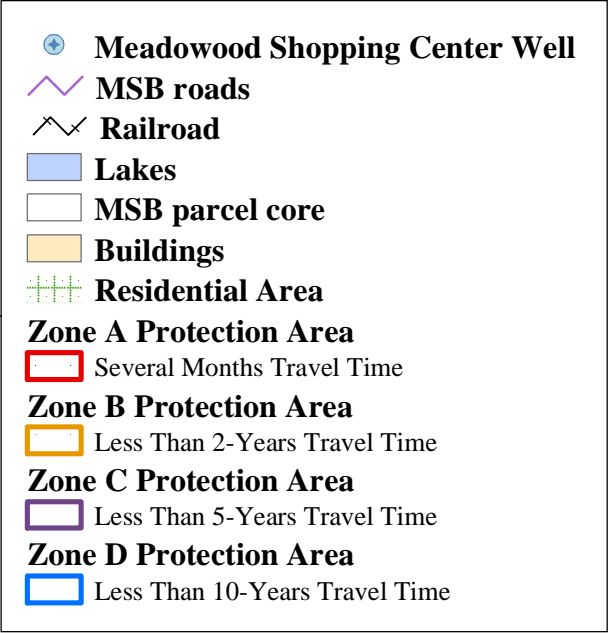
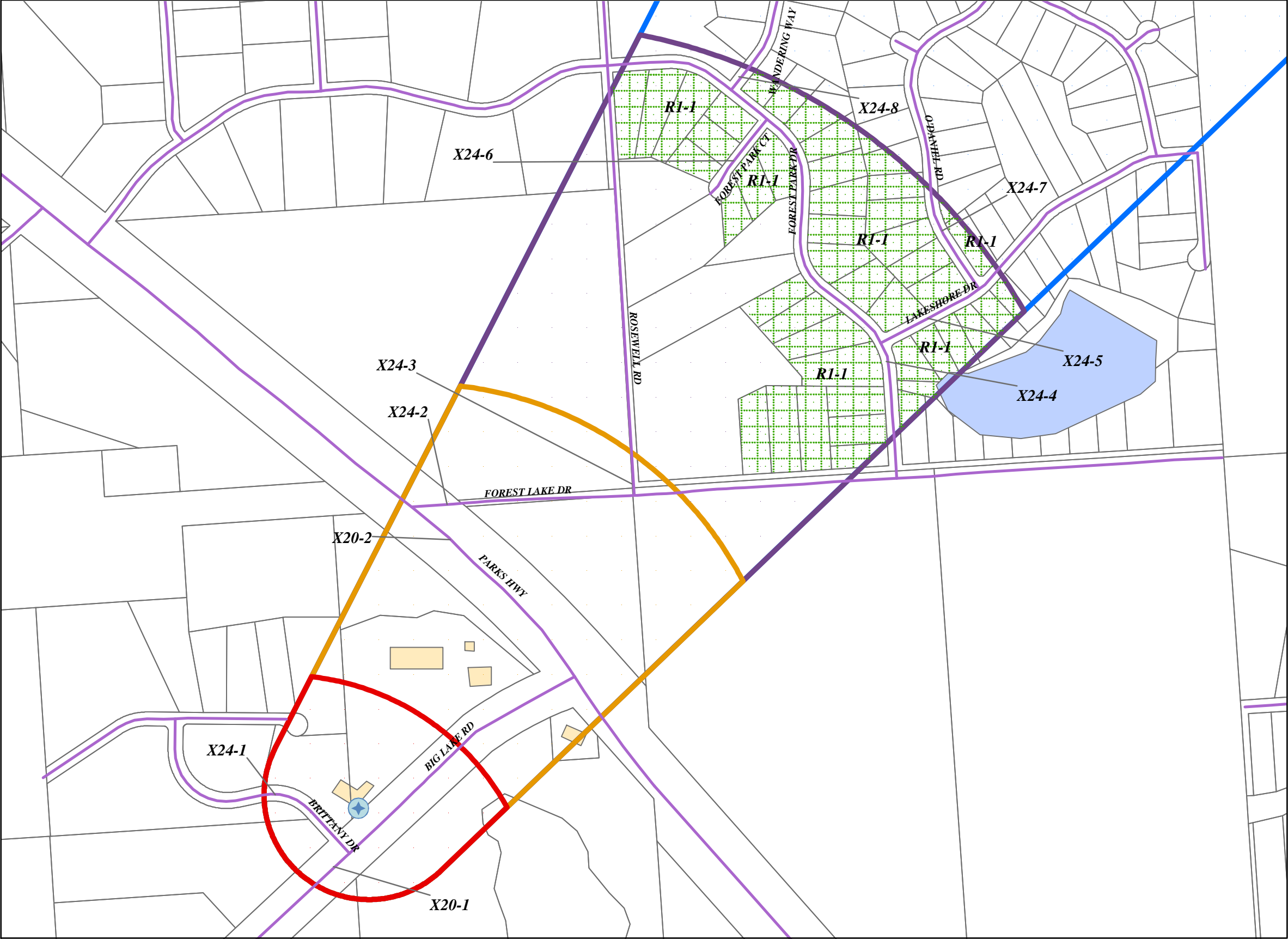


## *Drinking Water Protection Areas for Meadowood Shopping Center*





# Drinking Water Protection Areas for Meadowood Shopping Center and Potential and Existing Sources of Contamination



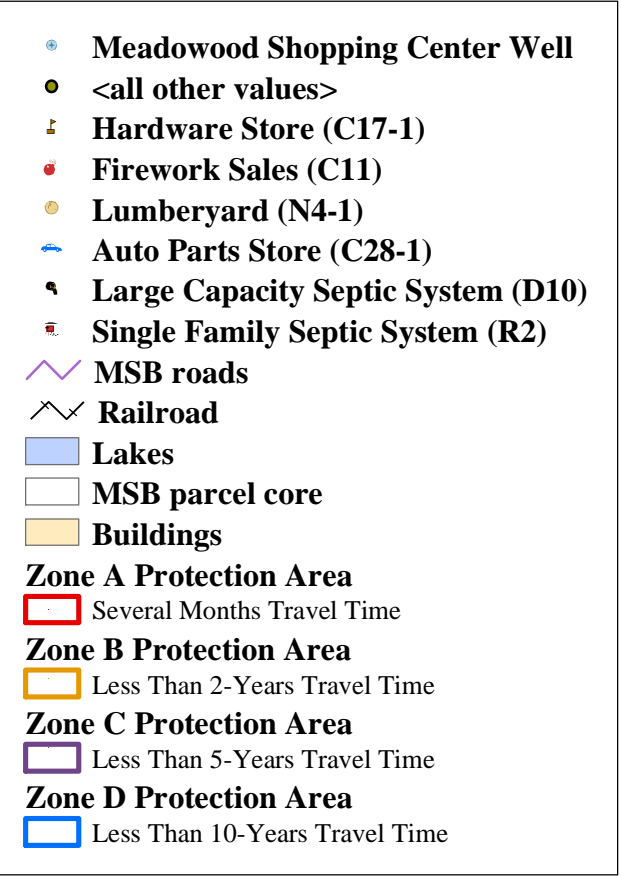
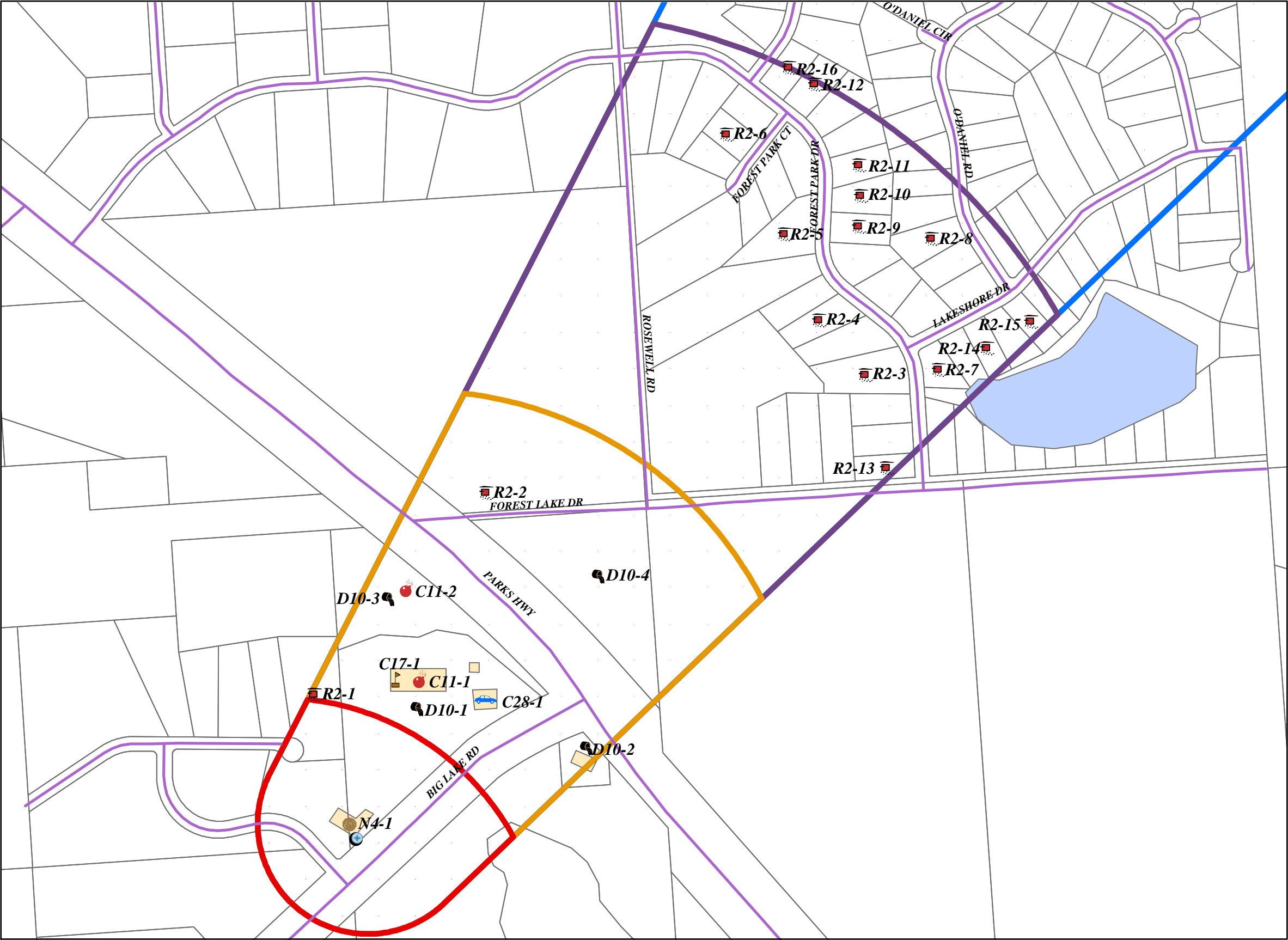
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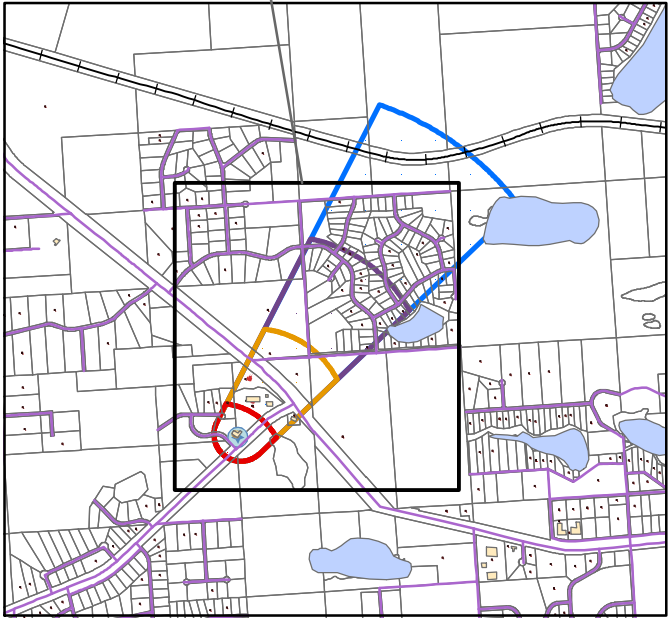


Map 2

# Drinking Water Protection Areas for Meadowood Shopping Center and Potential and Existing Sources of Contamination



Location of Map



520 0 520 Feet

PWSID 222343.001



Map 3