# Source Water Assessment

A Hydrogeologic Susceptibility and Vulnerability Assessment for Twin Birch, Anchorage, Alaska Twin Birch PWSID # 210590

DRINKING WATER PROTECTION PROGRAM REPORT Report 465

Alaska Department of Environmental Conservation

# Source Water Assessment for Twin Birch
# Anchorage, Alaska
# Twin Birch PWSID# 210590

By Heather A. Hammond

DRINKING WATER PROTECTION PROGRAM REPORT 465

The Drinking Water Protection Program is producing Source Water Assessments in compliance with the Safe Drinking Water Act Amendments of 1996. Each assessment includes a delineation of the source water area, an inventory of potential and existing contaminant sources that may impact the water, a risk ranking for each of these contaminants, and an evaluation of the potential vulnerability of these drinking water sources.

These assessments are intended to provide public water systems owners/operators, communities, and local governments with the best available information that may be used to protect the quality of their drinking water. The assessments combine information obtained from various sources, including the U.S. Environmental Protection Agency, Alaska Department of Environmental Conservation (ADEC), public water system owners/operators, and other public information sources. The results of this assessment are subject to change if additional data becomes available. If you have any additional information that may affect the results of this assessment, please contact the Program Coordinator of DWPP, (907) 269-7521.

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# Source Water Assessment for Twin Birch Sources of Public Drinking Water, Anchorage, Alaska

By Heather A. Hammond

**Drinking Water Protection Program**
**Alaska Department of Environmental Conservation**

## EXECUTIVE SUMMARY

The public water system for Twin Birch is a Class A (community) water system consisting of one well in the Anchorage area. Identified potential and current sources of contaminants for Twin Birch's public drinking water source include: approximately 15 acres of residential area, sewer lines, roads, a construction trade area, and parks and recreation trails. These identified potential and existing sources of contamination are considered sources of bacteria and viruses, nitrates and/or nitrites, volatile organic chemicals, heavy metals, synthetic organic chemicals and other organic chemicals. Overall, the public drinking water source for Twin Birch received a vulnerability rating of **Medium** for bacteria and viruses, nitrates and/or nitrites, heavy metals, cyanide and other inorganic chemicals, and **Low** for volatile organic chemicals, synthetic organic chemicals, and other organic chemicals.

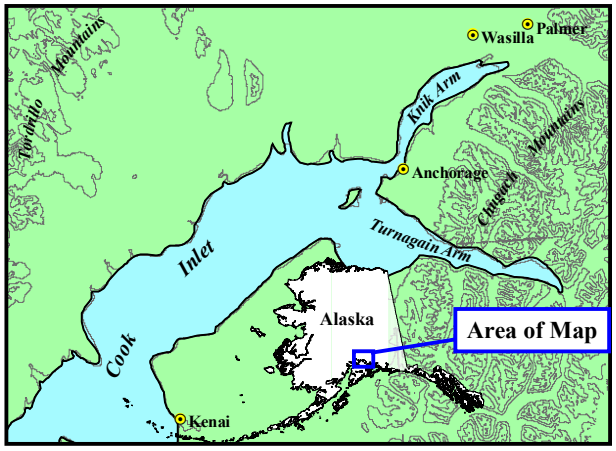



**Figure 1. Index map showing the location of Anchorage, Alaska**

## INTRODUCTION

The Alaska Department of Environmental Conservation (ADEC) is completing source water assessments for all public drinking water sources in the State of Alaska. The purpose of this assessment is to provide public water system owners and/or operators, communities, and local governments with information they can use to preserve the quality of Alaska's public drinking water supplies. The results of this source water assessment can be used to decide where voluntary protection efforts are needed and feasible, and also what efforts will be most effective in reducing contaminant risks to your water system.

This source water assessment combines a review of the natural conditions at the site and the potential and existing contaminant risks. These are combined to determine the overall vulnerability of the drinking water source to contamination.

## DESCRIPTION OF THE ANCHORAGE AREA, ALASKA

### Location

Anchorage, located in south-central Alaska, encompasses 1,698 square miles of land and 264 square miles of water. The area containing a majority of the urban development, commonly referred to as the Anchorage Bowl, encompasses approximately 180 square miles [*Partick, Brabets, and Glass, 1989*] and envelopes the low lands of the area. This area is bounded on the east by the Chugach Mountains and the north, west, and south by the Knik and Turnagain Arm of Cook Inlet (Figure 1). In recent times, urban development has extended eastward along the flanks of the Chugach Mountains. This area, known locally as the Anchorage Hillside, contains development at elevations exceeding 3,700 feet in elevation above sea level.

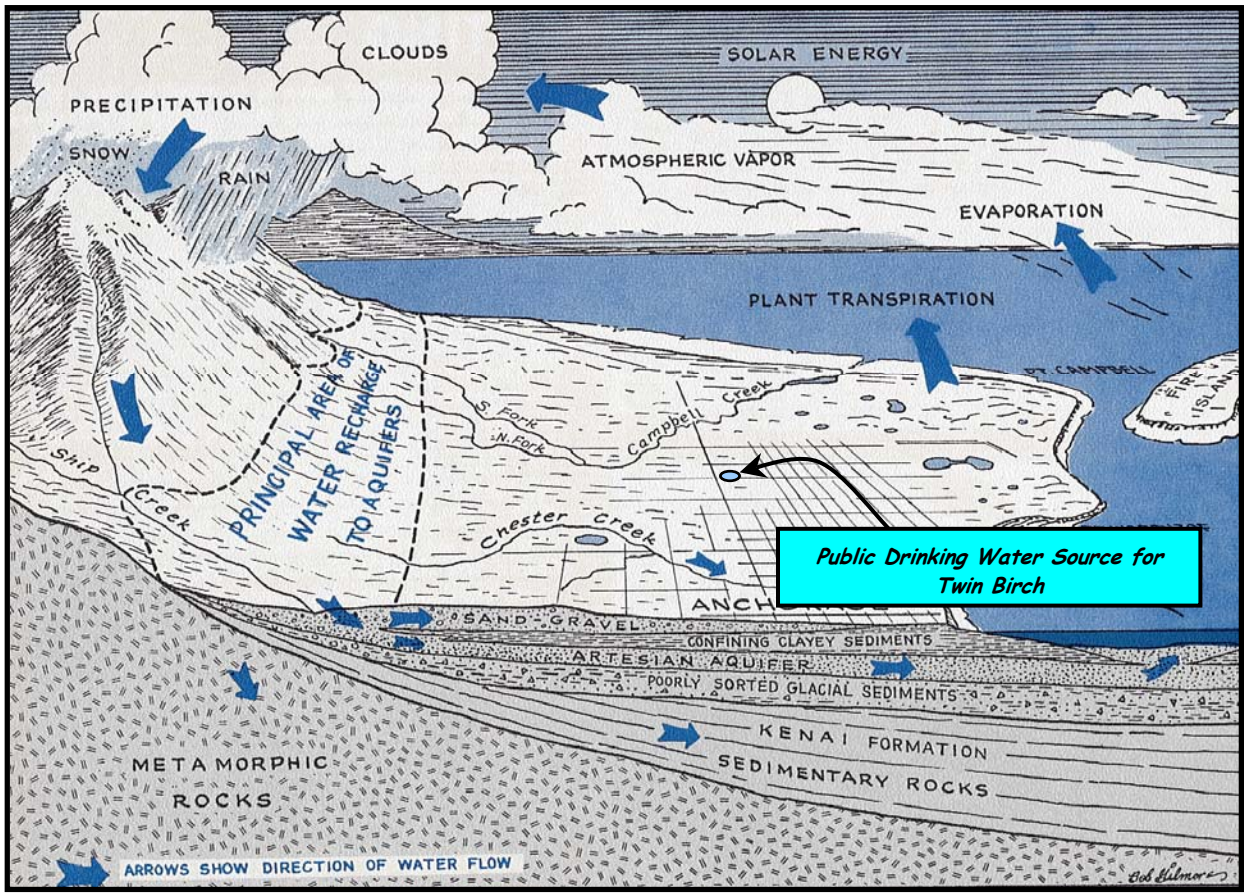



**Figure 2. Generalized hydrologic cycle in the Anchorage area [*Barnwell, George, Dearborn,Weeks, and Zenone*, 1972].**

## Climate

The Anchorage 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. Mean annual precipitation at the Anchorage International Airport is approximately 16 inches per year. On average, Anchorage receives a total snow accumulation of 69 inches per year. Precipitation generally increases inland toward the Chugach Mountains where annual precipitation may exceed 160 inches per year [*Barnwell, George, Dearborn, Weeks, and Zenone*, 1972]. Mean daily temperature ranges from 65° F during July to 8° F in January [*Western Regional Climate Center*, 2000].

## Physiography and Groundwater Conditions

Surface elevations in the Anchorage area range from sea level at Knik and Turnagain Arms to well over 5,000 feet in the peaks that bound the area. Glacial moraine and outwash deposits primarily mantle the surface of the Anchorage Bowl.

The backbone of the Chugach Mountains is composed primarily of metamorphic marine and volcanic rocks (bedrock). These high peaks that bound Anchorage's east side are flanked with colluvium or slope deposits. These slope deposits eventually grade into the glacial and stream deposits at lower elevations in the Anchorage Bowl.

In the Anchorage area, two principal groundwater flow systems or aquifers exist (see Figure 2). The upper unconfined aquifer or water-table aquifer is separated from a lower confined aquifer system by layers of silty, clayey glacially derived sediments (confining layer) [*Ulery and Updike*, 1983]. The lower confined aquifer system consists of a series of hydrologically interconnected layers and lenses of gravel, sand and silt that, collectively, form the confined aquifer. The confining layer ranges from 0 to 270 feet thick throughout the Anchorage area and generally thins with increasing distance from Cook Inlet, thus pinching out at the mountain front [*Patrick, Brabets, and Glass*, 1989].

Water enters or recharges these two aquifer systems in several different ways. Along the front of the Chugach Mountains, groundwater seeps from fractures in

bedrock into the sediments. At these higher elevations, rain and snowmelt also enters the sediments. This area along the mountain front is considered the principal recharge area for wells in the Anchorage area. Precipitation in the low lands may also percolate directly into the ground. Lastly, aquifers may also be recharged by streams where surface water percolates into surrounding permeable sediments (losing reaches of streams). Groundwater flow in the confined aquifer is generally east to west from the mountain front toward Cook Inlet and Turnagain Arm, except in areas where the direction of flow is influenced by large municipal or industrial production wells. The direction of groundwater flow in the upper unconfined aquifer is more variable due to the influence from surfacial topography as well as its close connection with surface water bodies.

## TWIN BIRCH'S PUBLIC DRINKING WATER SYSTEM

Twin Birch is a Class A (community) water system. The system consists of one well located near the intersection of Forty-sixth Avenue and Write Street (See Map 1 of Appendix A). This area is at an elevation of approximately 150 feet above sea level.

According to the well log the depth of the well is 160 feet and was completed in a 6-inch casing. The well penetrates layers of sand, clay and gravel. There is a confining layer, consisting of clay and gravel from 100 to 109 feet below the land surface. However, near the base of the Chugach Mountains, these clay layers tend to thin out toward the mountains. Therefore, contaminants that enter the subsurface near the base of the mountains may enter the confined aquifer uninhibited by the absence of any protective layer.

The most recent Sanitary Survey (09/25/01) indicates that the well was installed with a cap providing a sanitary seal. A properly installed sanitary seal may provide protection against contaminants from entering the source waters at the well casing. The Sanitary Survey also indicates that the land surface is appropriately sloped away from the well providing adequate surface water drainage. Both wells are grouted according to ADEC regulations. Proper grouting provides added protection against contaminants travelling along the well casing and into source waters.

This system operates year-round and serves 40 residents through 21 service connections.

## TWIN BIRCH'S DRINKING WATER PROTECTION AREA

In order to evaluate whether a drinking water source is at risk, we must first evaluate what are the most likely pathways for surface contamination to reach the groundwater. Some areas are more likely to allow contamination to reach the well than others. These areas are determined by looking at the characteristics of the soil, groundwater, aquifer, and well.

The most probable area for contamination to reach the drinking water well is the area that contributes water to the well, the groundwater recharge area. This area is designated as the Drinking Water Protection Area (DWPA). Because releases of contaminants within the DWPA are most likely to impact the drinking water well, this area will serve as the focus for voluntary protection efforts.

An outline of the immediate watershed was used to determine the size and shape of the DWPA for Twin Birch. Available geology was also considered to take into account any uncertainties in groundwater flow and aquifer characteristics to arrive at a meaningful DWPA (Please refer to the Guidance Manual for Class A Public Water Systems for additional information).

The DWPAs established for wells by the ADEC are usually separated into four zones, limited by the watershed. These zones correspond to differences in the time-of-travel (TOT) of the water moving through the aquifer to the well. An analytical calculation was used to determine the size and shape of the DWPA. The input parameters describing the attributes of the aquifer in this calculation were adopted from the U.S. Geological Survey (*Patrick, Brabets, and Glass, 1989*), and State of Alaska Department of Water Resources (*Jokela et. al., 1991*).

The time of travel for contaminants within the water varies and is dependent on the physical and chemical characteristics of each contaminant. The following is a summary of the four DWPA zones and the calculated time-of-travel for each:

**Table 1. Definition of Zones**

| Zone | Definition |
|---|---|
| A | ¼ the distance for the 2-yr. TOT |
| B | Less than the 2 year TOT |
| C | Less Than the 5 year TOT |
| D | Less than the 10 year TOT |

As an example, water moving through the aquifer in Zone B will reach the well in less than 2 years from the time it crosses the outer limit of Zone B.

Zone A also incorporates the area downgradient from the well to take into account the area of the aquifer that is influenced by pumping of the well. Water within the aquifer in Zone A will reach the well in several hours to several months (See Map 1 of Appendix A).

**INVENTORY OF POTENTIAL AND EXISTING CONTAMINANT SOURCES**

The Drinking Water Protection Program has completed an inventory of potential and existing sources of contamination within the Twin Birch DWPA. This inventory was completed through a search of agency records and other publicly available information. Potential sources of contamination to the drinking water aquifer include 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 all Class A public water system assessments, six categories of drinking water contaminants were inventoried. They include:

- Bacteria and viruses;
- Nitrates and/or nitrites;
- Volatile organic chemicals
- Heavy metals, cyanide, and other inorganic chemicals,
- Synthetic organic chemicals, and
- Other organic chemicals.

The sources are displayed on Maps 2 through 4 of Appendix C and summarized in Table 1 of Appendix B.

**RANKING OF CONTAMINANT RISKS**

Once the potential and existing sources of contamination have been identified, they are assigned a ranking 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.

Tables 2 through 7 in Appendix B contain the ranking of potential and existing sources of contamination with respect to bacteria and viruses, nitrates and/or nitrites, volatile organic chemicals, heavy metals, synthetic organic chemicals, and other organic chemicals.

**VULNERABILITY OF TWIN BIRCH'S DRINKING WATER SOURCE**

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

- Natural susceptibility; and
- Contaminant risks.

Each of the six 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)

Table 2 shows the Susceptibility scores and ratings for the wells serving Twin Birch.

**Table 2. Susceptibility**

| | Score | Rating |
|---|---|---|
| Susceptibility of the Wellhead | 5 | Low |
| Susceptibility of the Aquifer | 9 | Low |
| Natural Susceptibility | 14 | Low |

Contaminant risks to a drinking water source depend on the type, number or density, and distribution of contaminant sources. This data has been derived from an examination of existing and historical contamination that has been detected at the drinking water source through routine sampling. It also evaluates potential sources of contamination. Table 3 summarizes the

Contaminant Risks for each category of drinking water contaminants.

**Table 3. Contaminant Risks**

| Category | Score | Rating |
|---|---|---|
| Bacteria and Viruses | 25 | Medium |
| Nitrates and/or Nitrites | 28 | Medium |
| Volatile Organic Chemicals | 15 | Low |
| Heavy Metals, Cyanide, and Other Inorganic Chemicals | 37 | High |
| Synthetic Organic Chemicals | 12 | Low |
| Other Organic Chemicals | 18 | Low |

Appendix D contains fourteen 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 14 contain the Contaminant Risks and Vulnerability Analyses for nitrates and nitrites, volatile organic chemicals, heavy metals, synthetic organic chemicals, and other organic chemicals, respectively.

Table 4 contains the overall vulnerability scores (0 – 100) and ratings for each of the six categories of drinking water contaminants. Note: scores are rounded off to the nearest five.

**Table 4. Overall Vulnerability**

| Category | Score | Rating |
|---|---|---|
| Bacteria and Viruses | 40 | Medium |
| Nitrates and Nitrites | 40 | Medium |
| Volatile Organic Chemicals | 30 | Low |
| Heavy Metals, Cyanide and Other Inorganic Chemicals | 50 | Medium |
| Synthetic Organic Chemicals | 30 | Low |
| Other Organic Chemicals | 30 | Low |

**Bacteria and Viruses**
The contaminant risk for bacteria and viruses is medium with residential areas and sewer lines presenting the most significant risk to the drinking water well (See Chart 3 – Contaminant Risks for Bacteria and Viruses in Appendix D).

After combining the contaminant risk for bacteria and viruses with the natural susceptibility of each well, the overall vulnerability is medium.

**Nitrates and Nitrites**
The contaminant risk for nitrates and nitrites is medium with residential areas, sewer lines and parks and recreation trails presenting the most significant risk to the drinking water well.

It is unknown how much of the existing nitrate concentration can be attributed to natural or human-made sources. Nitrate concentrations in uncontaminated groundwater are typically less than 2 milligrams per liter (mg/L) and are derived primarily from the decomposition of organic matter in soils [Wang, Strelakos, Jokela, 2000].

Sampling history for Twin Birch indicates that low concentrations of nitrates have been detected. Existing nitrate concentration is approximately 0.598 mg/L or 6% of the Maximum Contaminant Level (MCL) of 10mg/L. The MCL is the maximum level of contaminant that is allowed to exist in drinking water and still be consumed by humans without harmful health effects. Throughout the past 5 years nitrate and/or nitrite concentrations have shown decrease and have not been detected in the source waters since 1999 (See Chart 5 - Contaminant Risks for Nitrates and/or Nitrites in Appendix D).

After combining the contaminant risk for nitrates and nitrites with the natural susceptibility of the well, the overall vulnerability of the well to contamination is medium.

**Volatile Organic Chemicals**
The contaminant risk for volatile organic chemicals is low with roads, residential area, a construction trade area, and sewer lines presenting the most significant risk for volatile organic chemicals (See Chart 7 – Contaminant Risks for Volatile Organic Chemicals in Appendix D).

Recent sampling history of Twin Birch's well indicates that a low level of one of the contaminants within the Volatile Organic Chemicals category was detected in the water. Total Trihalomethanes (TTHM) were detected on 2/8/96 at a concentration of 0.0018 mg/L, or 1% of the MCL (0.08 mg/L). TTHM are usually

found in drinking water as a byproduct of drinking water disinfection. In higher concentrations, TTHM has the potential to cause liver, kidney, and central nervous system disorders, and to increase the risk of cancer. After combining the contaminant risk for volatile organic chemicals with the natural susceptibility of the well, the overall vulnerability of the well to contamination is low.

**Heavy Metals, Cyanide, and Other Inorganic Chemicals**
The contaminant risk for heavy metals is high with residential areas, roads, and the construction trade area presenting the most significant risk to the drinking water wells (See Chart 9 – Contaminant Risks for Heavy Metals, Cyanide, and Other Inorganic Chemicals in Appendix D.

The high contaminant risk for heavy metals resulted from a monitoring sample that was analyzed for chemicals within the Heavy Metals, Cyanide and Other Inorganic Chemicals. The sample was collected October 25, 2001 and showed detectable levels of Arsenic at approximately 0.005 mg/L or 50% of the MCL of 0.01mg/L. The same sample showed Barium as approximately 0.017 mg/L or less than 1% of the MCL of 2mg/L (See Chart 9 – Contaminant Risks for Heavy Metals, Cyanide, and Other Inorganic Chemicals in Appeidix D).

According to a study conducted by the United States Geological Survey (USGS), arsenic in ground water is largely the result of minerals dissolving from weathered rocks and soils. Several types of cancer have been linked to arsenic in water. In 2001 the US Environmental Protection Agency (EPA) lowered the maximum level of arsenic permitted in drinking water from 50 micrograms per liter (ug/L) to 10 ug/L. The health effects of Arsenic depend on the concentration of arsenic in drinking water and the amount of water consumed.

Barium can come from the discharge of drilling wastes; discharge from metal refineries; or the erosion of natural deposits. There are no mining activities occurring near the protection area for Twin Birch. It is suspected that the detected levels of barium are a result of the erosion of natural deposits. The (EPA) has found barium to potentially cause the following health effects when people are exposed to it at levels above the MCL for relatively short periods of time: gastrointestinal disturbances and muscular weakness. Long-term health effects include high blood pressure.

After combining the contaminant risk for heavy metals, cyanide and other inorganic chemicals with the natural susceptibility of the wells, the overall vulnerability is medium.

**Synthetic Organic Chemicals**
The contaminant risk for synthetic organic chemicals is low with sewer lines representing the most significant risk. After combining the contaminant risk with the natural susceptibility of the well, the overall vulnerability to synthetic organic chemicals for is low.

**Other Organic Chemicals**
The contaminant risk for other organic chemicals is low with the sewer lines, roads, and a construction trade area representing the most significant risk. After combining the contaminant risk with the natural susceptibility of the well, the overall vulnerability to other organic chemicals for both wells is low.

Review of the historical sampling data indicates that no synthetic organic chemicals or other organic chemicals have been detected in Twin Birch drinking water within the past 5 years (See Charts 11 and 13 – Contaminant Risks for Synthetic Organic Chemicals and Other Organic Chemicals in Appendix D, respectively).

**SUMMARY**

A *Source Water Assessment* has been completed for the source of public drinking water serving Twin Birch. The overall vulnerability of well to contamination is **Medium** for bacteria and viruses, nitrates and/or nitrites, heavy metals cyanide and other inorganic chemicals, and **Low** for volatile organic chemicals, other organic chemicals, and synthetic 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 Twin Birch 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 Twin Birch's public drinking water source.

# REFERENCES


Barnwell, W.W., George, R.S., Dearborn, L.L., Weeks, J.B., and Zenone, C., 1972, Water for Anchorage: an atlas of the water resources of the Anchorage area, Alaska: U.S. Geological Survey Open-File Report, 76 p.

Patrick, L.D., Brabets, T.P., and Glass, R.L., 1989, Simulation of ground-water flow at Anchorage, Alaska: U.S. Geological Survey Water-Resources Investigations Report 88-4139, 41p.

Ulery, C.A. and Updike, R.G, 1983, Subsurface structure of the cohesive facies of the Bootlegger Cove Formation, Southwest Anchorage, Alaska: Alaska Division of Geological and Geophysical Surveys Professional Report 84, 5 p.

United States Geological Survey., 2002, Arsenic in Groundwater of the United States. Retrieved July 5, 2002. [www.document]. URL http://co.water.usgs.gov/trace/arsenic/

United States Environmental Protection Agency, 2001, Office of Water, National Primary Drinking Water Regulations, Consumer Factsheet on Arsenic. Retrieved February 2002. [WWW document]. URL http://www.epa.gov/safewater/dwh/c-ioc/arsenic.html

United States Environmental Protection Agency (EPA, Office of Water). 2001, July 23.Retrieved February 2002 [WWW document]. URL http://www.epa.gov/safewater/ars/ars_rule_factsheet.html

United States Environmental Protection Agency (EPA, Office of Water). 2002, May 22. Retrieved July 12, 2002 [WWW document]. URL http://www.epa.gov/safewater/dwh/c-ioc/barium.html

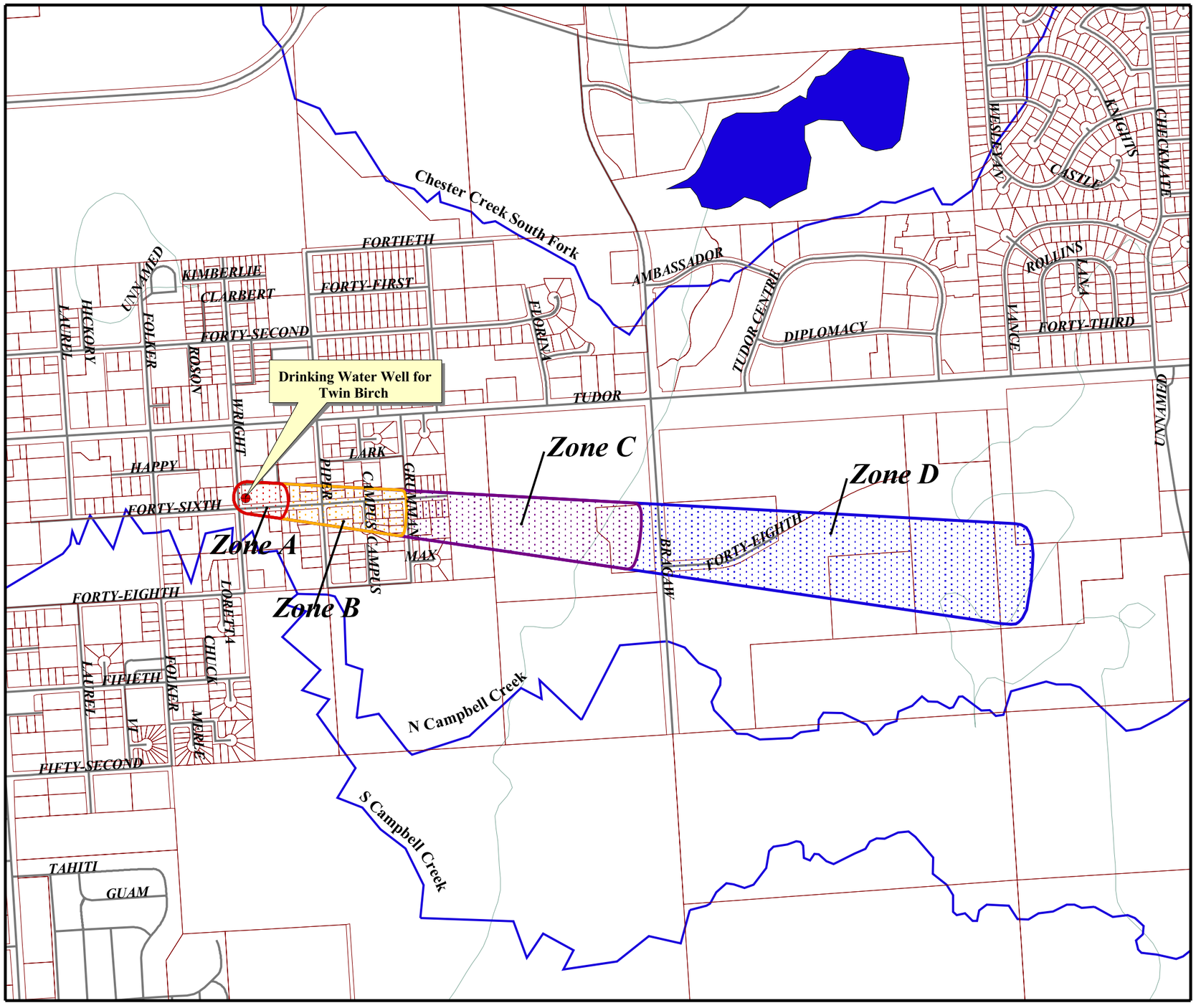
Wang, B., Strelakos, P.M., and Jokela, B., 2000, Nitrate Source Indicators In Groundwater of the Scimitar Subdivision, Peters Creek Area, Anchorage Alaska: U.S. Geological Survey Water-Resources Investigations Report 00-4137, 25p.

Western Regional Climate Center, 2000, August 24, Web extension to the *Western Regional Climate Center* [WWW document]. URL http://www.wrcc.dri.edu/index.html

# APPENDIX A

## Twin Birch
## Drinking Water Protection Area Location Map
## (Map 1)

# Drinking Water Protection Area and
# Potential & Existing Contaminant Sources for Twin Birch




- Twin Birch Drinking Water Well

**Zone A Protection Area**
- Several Months Travel Time

**Zone B Protection Area**
- Less That 2 Years Travel Time

**Zone C Protection Area**
- Less Than 5 Years Travel Time

**Zone D Protection Area**
- Less Than 10 Years Travel Time

- Land Parcels
- Anchorage Roads
- Anchorage Lakes
- Anchorage Streams
- Elevation Contours

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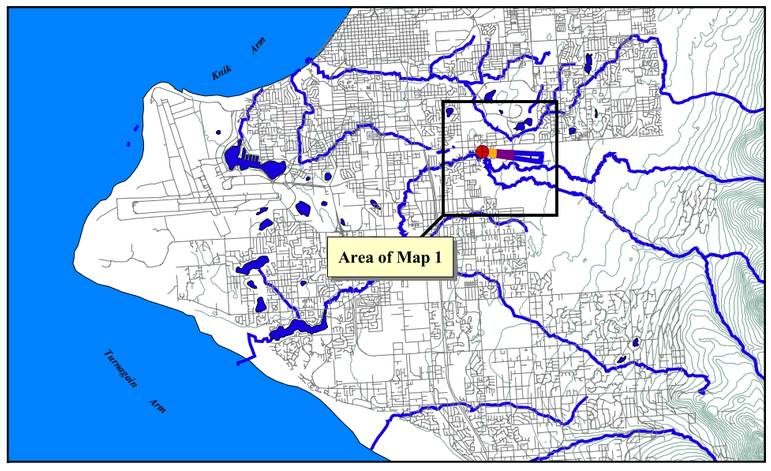


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# Map 1

# APPENDIX B

## Contaminant Source Inventory and Risk Ranking for Twin Birch (Tables 1-7)

***Table 1***

# *Contaminant Source Inventory for* ***Twin Birch***

***PWSID 210590.001***

| *Contaminant Source Type* | *Contaminant Source ID* | *CS ID tag* | *Zone* | *Location* | *Map Number* | *Comments* |
|---|---|---|---|---|---|---|
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-1 | A | Along Wright Street | 3 | |
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-2 | A | Along Forty-sixth Street | 3 | |
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-3 | A | Perpindicular to Forty-sixth Ave. within Zone A | 3 | |
| Residential Areas | R01 | R1-1 | A | Residential areas located within Zone A | 3 | Approximately 2.5 acres in Zone A. |
| Highways and roads, paved (cement or asphalt) | X20 | X20-1 | A | Wright Street | 2 | |
| Highways and roads, paved (cement or asphalt) | X20 | X20-2 | A | Forty-sixth Street | 2 | |
| Highways and roads, paved (cement or asphalt) | X20 | X20-3 | A | Unnamed Road | 2 | |
| Highways and roads, paved (cement or asphalt) | X20 | X20-4 | A | Piper Street | 2 | |
| Highways and roads, paved (cement or asphalt) | X20 | X20-5 | A | Campus Circle | 2 | |
| Municipal or city parks (with green areas) | X04 | X4-1 | A | Anchorage municipal or city park located within Zone A | 2 | |
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-4 | B | Along Piper Street | 3 | |
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-5 | B | Along Campus Circle | 3 | |
| Residential Areas | R01 | R1-2 | B | Residential areas located within Zone B | 3 | Approximately 6.5 acres in Zone B. |
| Construction trade areas and materials | C09 | C9-1 | C | Within Zone C | 4 | |
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-6-13 | C | Sewer lines 6 through 13 located within Zone C | 4 | |
| Residential Areas | R01 | R1-3 | C | Residential areas located within Zone C | 4 | Approximately 6 acres in Zone C. |
| Highways and roads, paved (cement or asphalt) | X20 | X20-6 | C | Grummin Street | 4 | |

**Table 2**

# *Contaminant Source Inventory and Risk Ranking for Twin Birch*
## *Sources of Bacteria and Viruses*

**PWSID 210590.001**

| *Contaminant Source Type* | *Contaminant Source ID* | *CS ID tag* | *Zone* | *Risk Ranking for Analysis* | *Location* | *Map Number* | *Comments* |
|---|---|---|---|---|---|---|---|
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-1 | A | Medium | Along Wright Street | 3 | |
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-2 | A | Medium | Along Forty-sixth Street | 3 | |
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-3 | A | Medium | Perpindicular to Forty-sixth Ave. within Zone A | 3 | |
| Residential Areas | R01 | R1-1 | A | Low | Residential areas located within Zone A | 3 | Approximately 2.5 acres in Zone A. |
| Highways and roads, paved (cement or asphalt) | X20 | X20-1 | A | Low | Wright Street | 2 | |
| Highways and roads, paved (cement or asphalt) | X20 | X20-2 | A | Low | Forty-sixth Street | 2 | |
| Highways and roads, paved (cement or asphalt) | X20 | X20-3 | A | Low | Unnamed Road | 2 | |
| Highways and roads, paved (cement or asphalt) | X20 | X20-4 | A | Low | Piper Street | 2 | |
| Highways and roads, paved (cement or asphalt) | X20 | X20-5 | A | Low | Campus Circle | 2 | |
| Municipal or city parks (with green areas) | X04 | X4-1 | A | Medium | Anchorage municipal or city park located within Zone A | 2 | |
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-4 | B | Medium | Along Piper Street | 3 | |
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-5 | B | Medium | Along Campus Circle | 3 | |
| Residential Areas | R01 | R1-2 | B | Low | Residential areas located within Zone B | 3 | Approximately 6.5 acres in Zone B. |
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-6-13 | C | Medium | Sewer lines 6 through 13 located within Zone C | 4 | |
| Residential Areas | R01 | R1-3 | C | Low | Residential areas located within Zone C | 4 | Approximately 6 acres in Zone C. |
| Highways and roads, paved (cement or asphalt) | X20 | X20-6 | C | Low | Grummin Street | 4 | |

**Table 3**

# *Contaminant Source Inventory and Risk Ranking for Twin Birch*
## *Sources of Nitrates/Nitrites*

**PWSID 210590.001**

| *Contaminant Source Type* | *Contaminant Source ID* | *CS ID tag* | *Zone* | *Risk Ranking for Analysis* | *Location* | *Map Number* | *Comments* |
|---|---|---|---|---|---|---|---|
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-1 | A | Medium | Along Wright Street | 3 | |
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-2 | A | Medium | Along Forty-sixth Street | 3 | |
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-3 | A | Medium | Perpindicular to Forty-sixth Ave. within Zone A | 3 | |
| Residential Areas | R01 | R1-1 | A | Low | Residential areas located within Zone A | 3 | Approximately 2.5 acres in Zone A. |
| Highways and roads, paved (cement or asphalt) | X20 | X20-1 | A | Low | Wright Street | 2 | |
| Highways and roads, paved (cement or asphalt) | X20 | X20-2 | A | Low | Forty-sixth Street | 2 | |
| Highways and roads, paved (cement or asphalt) | X20 | X20-3 | A | Low | Unnamed Road | 2 | |
| Highways and roads, paved (cement or asphalt) | X20 | X20-4 | A | Low | Piper Street | 2 | |
| Highways and roads, paved (cement or asphalt) | X20 | X20-5 | A | Low | Campus Circle | 2 | |
| Municipal or city parks (with green areas) | X04 | X4-1 | A | Medium | Anchorage municipal or city park located within Zone A | 2 | |
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-4 | B | Medium | Along Piper Street | 3 | |
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-5 | B | Medium | Along Campus Circle | 3 | |
| Residential Areas | R01 | R1-2 | B | Low | Residential areas located within Zone B | 3 | Approximately 6.5 acres in Zone B. |
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-6-13 | C | Medium | Sewer lines 6 through 13 located within Zone C | 4 | |
| Residential Areas | R01 | R1-3 | C | Low | Residential areas located within Zone C | 4 | Approximately 6 acres in Zone C. |
| Highways and roads, paved (cement or asphalt) | X20 | X20-6 | C | Low | Grummin Street | 4 | |

**Table 4**

# *Contaminant Source Inventory and Risk Ranking for Twin Birch*
## *Sources of Volatile Organic Chemicals*

**PWSID 210590.001**

| *Contaminant Source Type* | *Contaminant Source ID* | *CS ID tag* | *Zone* | *Risk Ranking for Analysis* | *Location* | *Map Number* | *Comments* |
|---|---|---|---|---|---|---|---|
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-1 | A | Low | Along Wright Street | 3 | |
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-2 | A | Low | Along Forty-sixth Street | 3 | |
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-3 | A | Low | Perpindicular to Forty-sixth Ave. within Zone A | 3 | |
| Residential Areas | R01 | R1-1 | A | Low | Residential areas located within Zone A | 3 | Approximately 2.5 acres in Zone A. |
| Highways and roads, paved (cement or asphalt) | X20 | X20-1 | A | Low | Wright Street | 2 | |
| Highways and roads, paved (cement or asphalt) | X20 | X20-2 | A | Low | Forty-sixth Street | 2 | |
| Highways and roads, paved (cement or asphalt) | X20 | X20-3 | A | Low | Unnamed Road | 2 | |
| Highways and roads, paved (cement or asphalt) | X20 | X20-4 | A | Low | Piper Street | 2 | |
| Highways and roads, paved (cement or asphalt) | X20 | X20-5 | A | Low | Campus Circle | 2 | |
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-4 | B | Low | Along Piper Street | 3 | |
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-5 | B | Low | Along Campus Circle | 3 | |
| Residential Areas | R01 | R1-2 | B | Low | Residential areas located within Zone B | 3 | Approximately 6.5 acres in Zone B. |
| Construction trade areas and materials | C09 | C9-1 | C | Low | Within Zone C | 4 | |
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-6-13 | C | Low | Sewer lines 6 through 13 located within Zone C | 4 | |
| Residential Areas | R01 | R1-3 | C | Low | Residential areas located within Zone C | 4 | Approximately 6 acres in Zone C. |
| Highways and roads, paved (cement or asphalt) | X20 | X20-6 | C | Low | Grummin Street | 4 | |

**Table 5**

# *Contaminant Source Inventory and Risk Ranking for Twin Birch*

## *Sources of Heavy Metals, Cyanide and Other Inorganic Chemicals*

**PWSID 210590.001**

| *Contaminant Source Type* | *Contaminant Source ID* | *CS ID tag* | *Zone* | *Risk Ranking for Analysis* | *Location* | *Map Number* | *Comments* |
|---|---|---|---|---|---|---|---|
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-1 | A | Low | Along Wright Street | 3 | |
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-2 | A | Low | Along Forty-sixth Street | 3 | |
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-3 | A | Low | Perpindicular to Forty-sixth Ave. within Zone A | 3 | |
| Residential Areas | R01 | R1-1 | A | Low | Residential areas located within Zone A | 3 | Approximately 2.5 acres in Zone A. |
| Highways and roads, paved (cement or asphalt) | X20 | X20-1 | A | Low | Wright Street | 2 | |
| Highways and roads, paved (cement or asphalt) | X20 | X20-2 | A | Low | Forty-sixth Street | 2 | |
| Highways and roads, paved (cement or asphalt) | X20 | X20-3 | A | Low | Unnamed Road | 2 | |
| Highways and roads, paved (cement or asphalt) | X20 | X20-4 | A | Low | Piper Street | 2 | |
| Highways and roads, paved (cement or asphalt) | X20 | X20-5 | A | Low | Campus Circle | 2 | |
| Municipal or city parks (with green areas) | X04 | X4-1 | A | Low | Anchorage municipal or city park located within Zone A | 2 | |
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-4 | B | Low | Along Piper Street | 3 | |
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-5 | B | Low | Along Campus Circle | 3 | |
| Residential Areas | R01 | R1-2 | B | Low | Residential areas located within Zone B | 3 | Approximately 6.5 acres in Zone B. |
| Construction trade areas and materials | C09 | C9-1 | C | Low | Within Zone C | 4 | |
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-6-13 | C | Low | Sewer lines 6 through 13 located within Zone C | 4 | |
| Residential Areas | R01 | R1-3 | C | Low | Residential areas located within Zone C | 4 | Approximately 6 acres in Zone C. |
| Highways and roads, paved (cement or asphalt) | X20 | X20-6 | C | Low | Grummin Street | 4 | |

***Table 6***

# *Contaminant Source Inventory and Risk Ranking for Twin Birch*
## *Sources of Synthetic Organic Chemicals*

***PWSID 210590.001***

| *Contaminant Source Type* | *Contaminant Source ID* | *CS ID tag* | *Zone* | *Risk Ranking for Analysis* | *Location* | *Map Number* | *Comments* |
|---|---|---|---|---|---|---|---|
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-1 | A | Low | Along Wright Street | 3 | |
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-2 | A | Low | Along Forty-sixth Street | 3 | |
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-3 | A | Low | Perpindicular to Forty-sixth Ave. within Zone A | 3 | |
| Residential Areas | R01 | R1-1 | A | Low | Residential areas located within Zone A | 3 | Approximately 2.5 acres in Zone A. |
| Municipal or city parks (with green areas) | X04 | X4-1 | A | Low | Anchorage municipal or city park located within Zone A | 2 | |
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-4 | B | Low | Along Piper Street | 3 | |
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-5 | B | Low | Along Campus Circle | 3 | |
| Residential Areas | R01 | R1-2 | B | Low | Residential areas located within Zone B | 3 | Approximately 6.5 acres in Zone B. |
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-6-13 | C | Low | Sewer lines 6 through 13 located within Zone C | 4 | |
| Residential Areas | R01 | R1-3 | C | Low | Residential areas located within Zone C | 4 | Approximately 6 acres in Zone C. |

**Table 7**

# *Contaminant Source Inventory and Risk Ranking for Twin Birch*
## *Sources of Other Organic Chemicals*

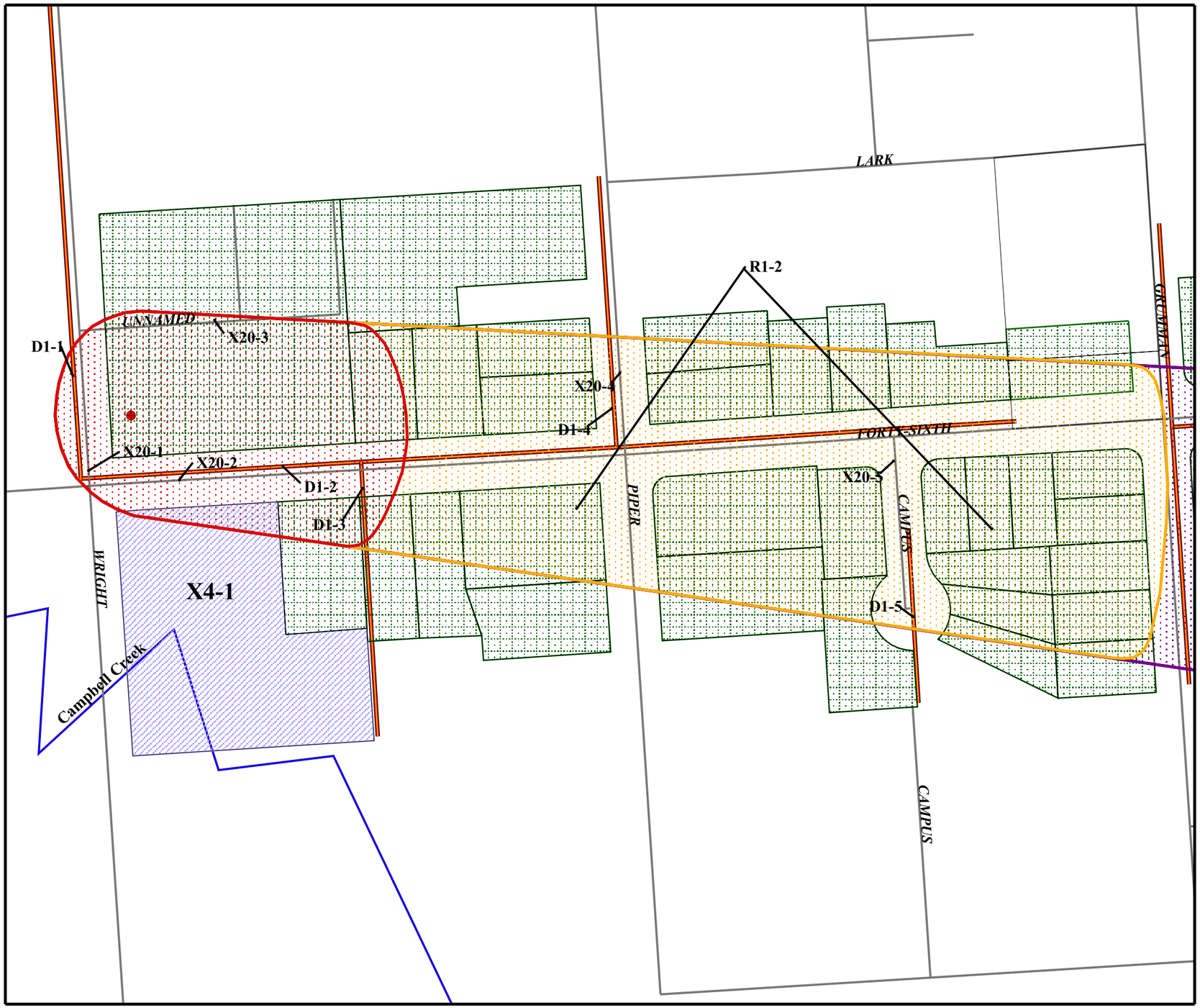
**PWSID 210590.001**

| *Contaminant Source Type* | *Contaminant Source ID* | *CS ID tag* | *Zone* | *Risk Ranking for Analysis* | *Location* | *Map Number* | *Comments* |
|---|---|---|---|---|---|---|---|
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-1 | A | Low | Along Wright Street | 3 | |
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-2 | A | Low | Along Forty-sixth Street | 3 | |
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-3 | A | Low | Perpindicular to Forty-sixth Ave. within Zone A | 3 | |
| Residential Areas | R01 | R1-1 | A | Low | Residential areas located within Zone A | 3 | Approximately 2.5 acres in Zone A. |
| Highways and roads, paved (cement or asphalt) | X20 | X20-1 | A | Low | Wright Street | 2 | |
| Highways and roads, paved (cement or asphalt) | X20 | X20-2 | A | Low | Forty-sixth Street | 2 | |
| Highways and roads, paved (cement or asphalt) | X20 | X20-3 | A | Low | Unnamed Road | 2 | |
| Highways and roads, paved (cement or asphalt) | X20 | X20-4 | A | Low | Piper Street | 2 | |
| Highways and roads, paved (cement or asphalt) | X20 | X20-5 | A | Low | Campus Circle | 2 | |
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-4 | B | Low | Along Piper Street | 3 | |
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-5 | B | Low | Along Campus Circle | 3 | |
| Residential Areas | R01 | R1-2 | B | Low | Residential areas located within Zone B | 3 | Approximately 6.5 acres in Zone B. |
| Construction trade areas and materials | C09 | C9-1 | C | Low | Within Zone C | 4 | |
| Domestic wastewater collection systems (sewer lines or lift stations) | D01 | D1-6-13 | C | Low | Sewer lines 6 through 13 located within Zone C | 4 | |
| Residential Areas | R01 | R1-3 | C | Low | Residential areas located within Zone C | 4 | Approximately 6 acres in Zone C. |
| Highways and roads, paved (cement or asphalt) | X20 | X20-6 | C | Low | Grummin Street | 4 | |

# APPENDIX C

## Twin Birch
## Drinking Water Protection Area
## and Potential and Existing Contaminant Sources
## (Maps 2-4)

# Drinking Water Protection Area and
# Potential & Existing Contaminant Sources for Twin Birch




- Twin Birch Drinking Water Well

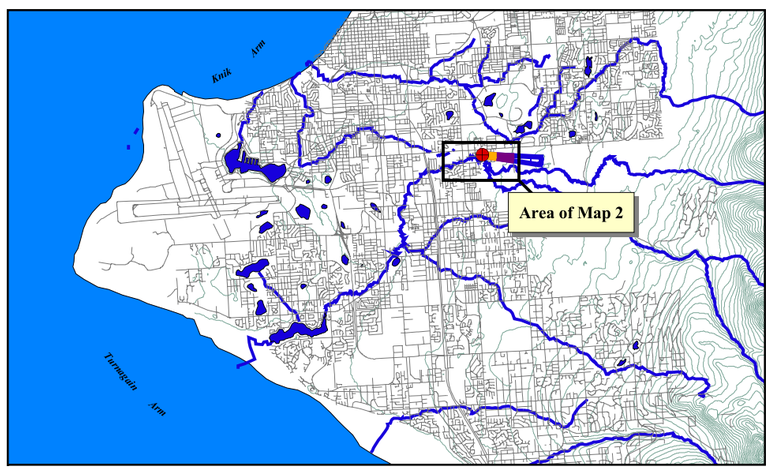
**Zone A Protection Area**
- Several Months Travel Time

**Zone B Protection Area**
- Less That 2 Years Travel Time

**Zone C Protection Area**
- Less Than 5 Years Travel Time

**Zone D Protection Area**
- Less Than 10 Years Travel Time
- Anchorage Land Parcels
- Anchorage Parks (X4)
- Lawns and Gardens (R1)
- Anchorage Roads (X20)
- Sewer Lines (D1)
- Anchorage Streams
- Elevation Contours

N
W E
S

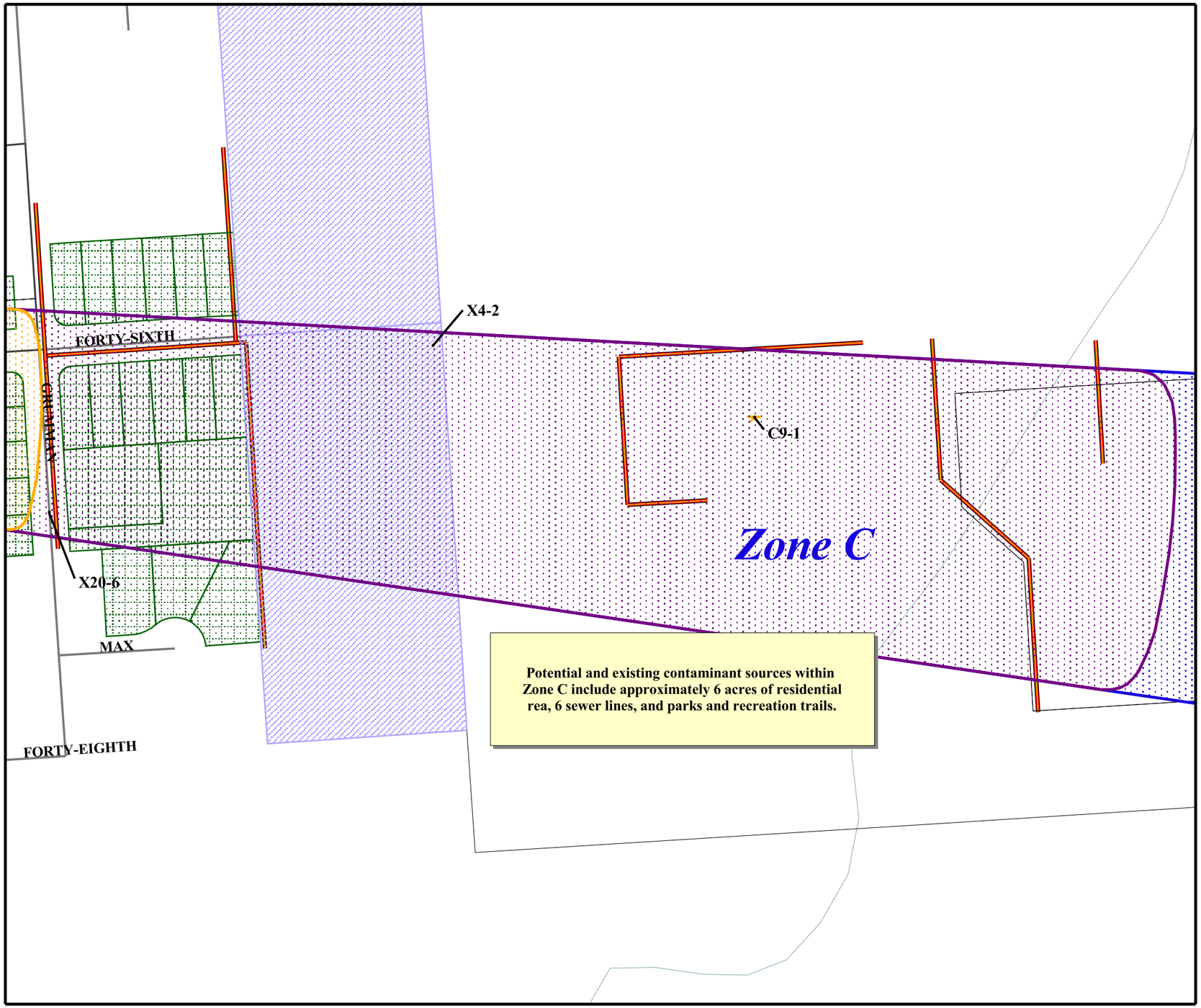



300 0 300 600 Feet

PWSID 210590.001

# *Map 2*

# Drinking Water Protection Area and Potential & Existing Contaminant Sources for Twin Birch




- Twin Birch Drinking Water Well

**Zone A Protection Area**
- Several Months Travel Time

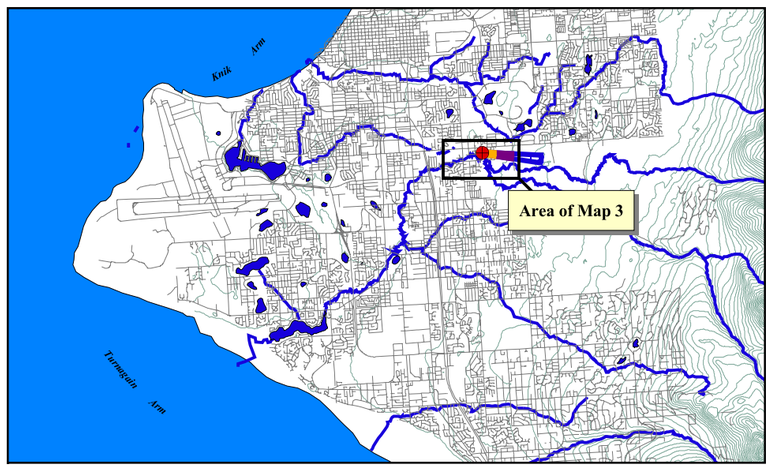
**Zone B Protection Area**
- Less That 2 Years Travel Time

**Zone C Protection Area**
- Less Than 5 Years Travel Time

**Zone D Protection Area**
- Less Than 10 Years Travel Time

**Potential Contaminant Sources**
- Construction Trade Areas and Materials (C9)
- Anchorage Parks (X4)
- Lawns and Gardens (R1)
- Anchorage Land Parcels
- Sewer Lines (D1)
- Anchorage Roads (X20)
- Anchorage Streams
- Elevation Contours

N W E S

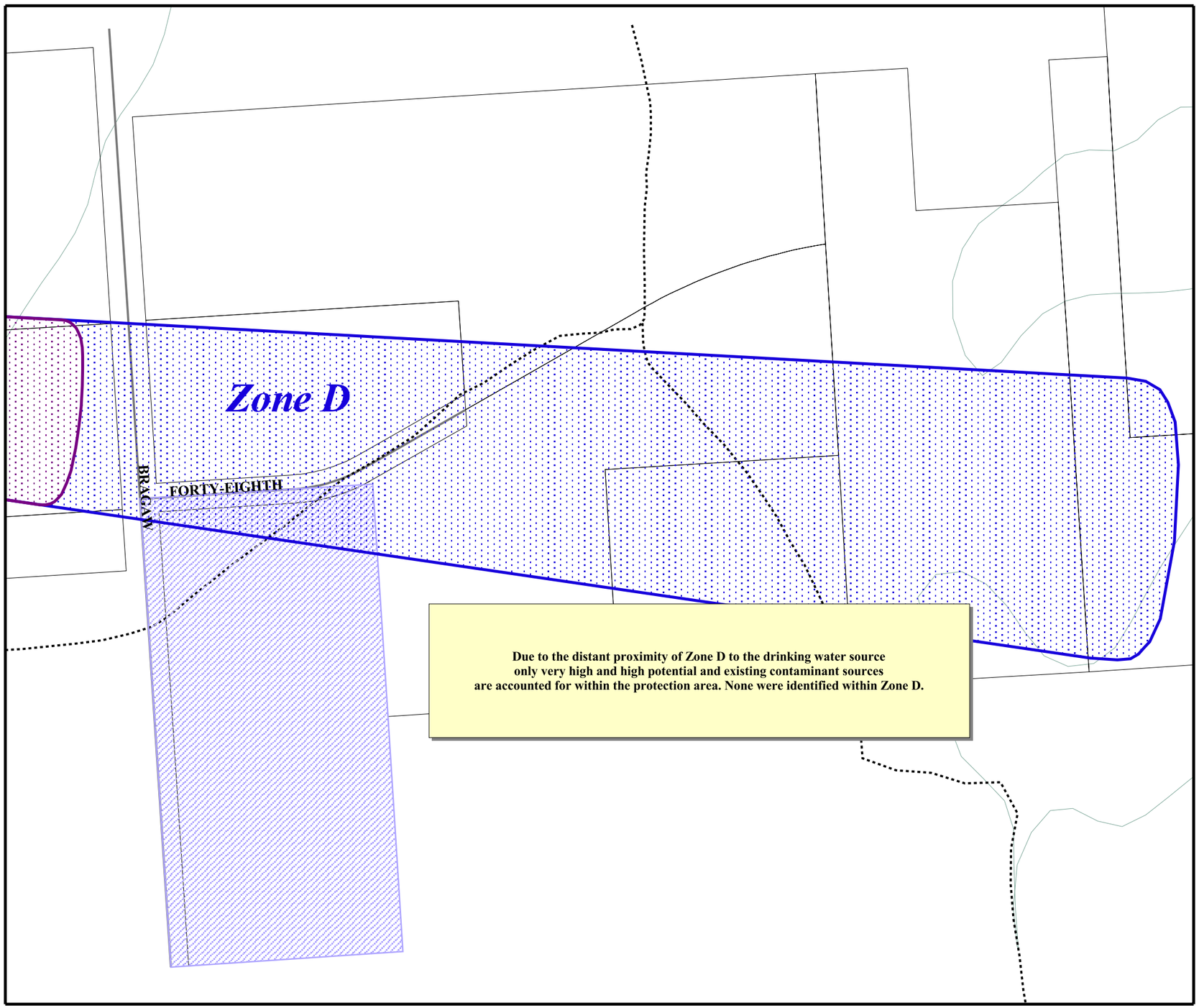



400 0 400 800 Feet

PWSID 210590.001

# Map 3

# Drinking Water Protection Area and
# Potential & Existing Contaminant Sources for Twin Birch




- Twin Birch Drinking Water Well

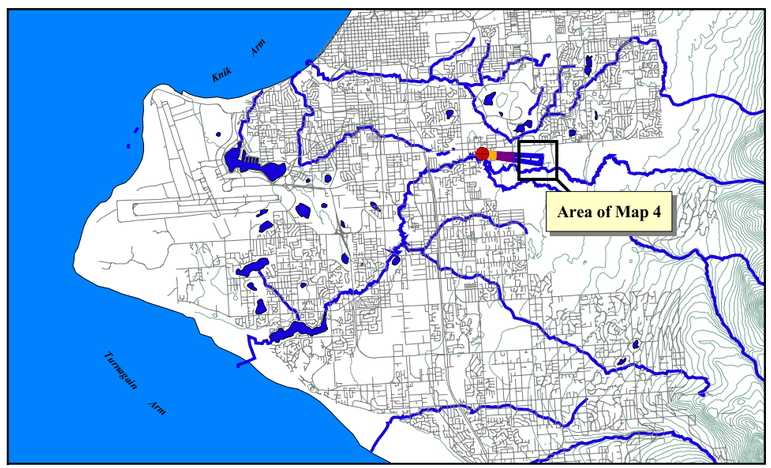
Zone A Protection Area
- Several Months Travel Time

Zone B Protection Area
- Less That 2 Years Travel Time

Zone C Protection Area
- Less Than 5 Years Travel Time

Zone D Protection Area
- Less Than 10 Years Travel Time
- Anchorage Parks (X4)
- Anchorage Land Parcels
- Trails (X46)
- Anchorage Roads (X20)
- Elevation Contours

N
W E
S




700 0 700 1400 Feet

PWSID 210590.001

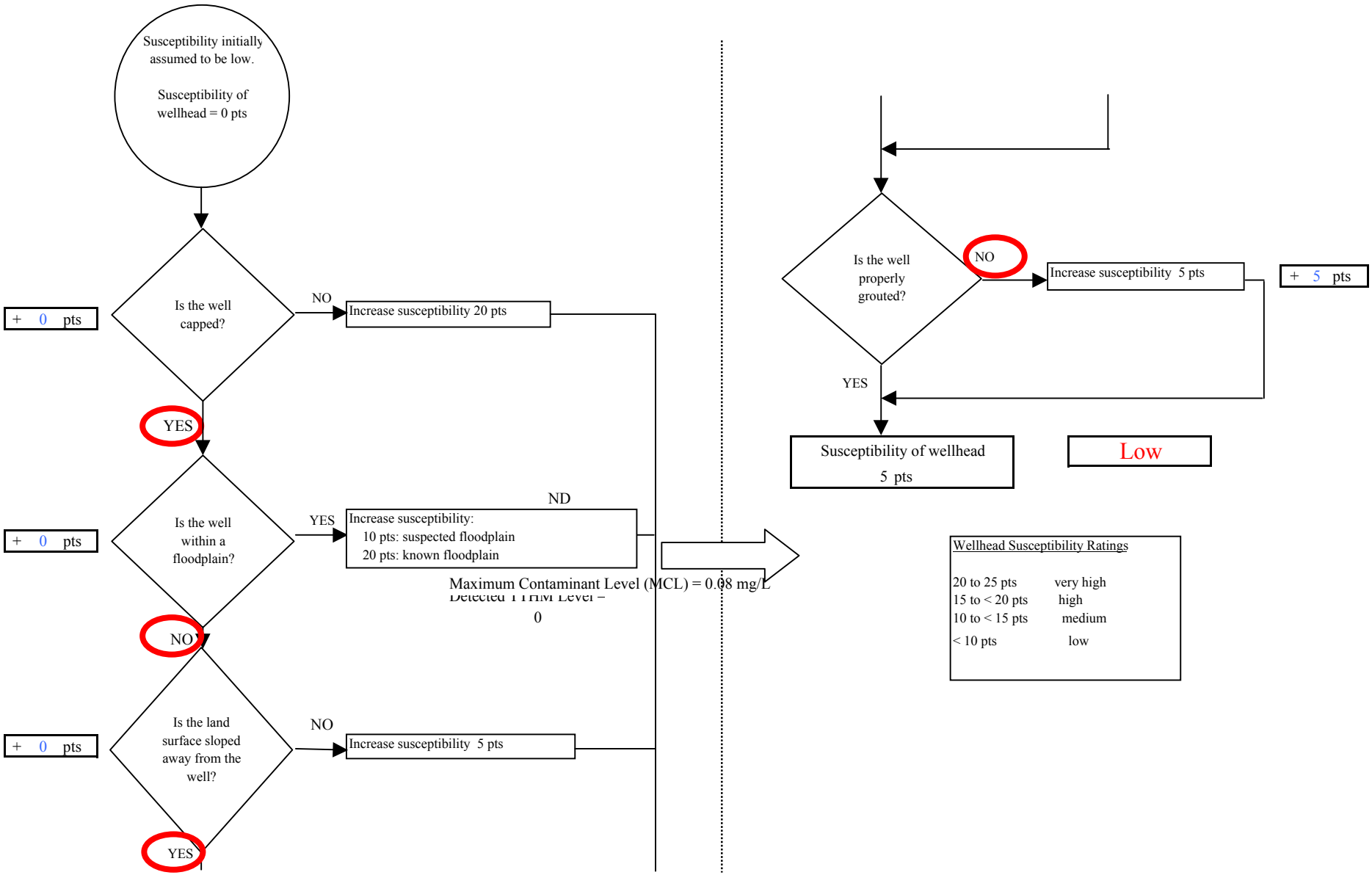
# *Map 4*

# APPENDIX D

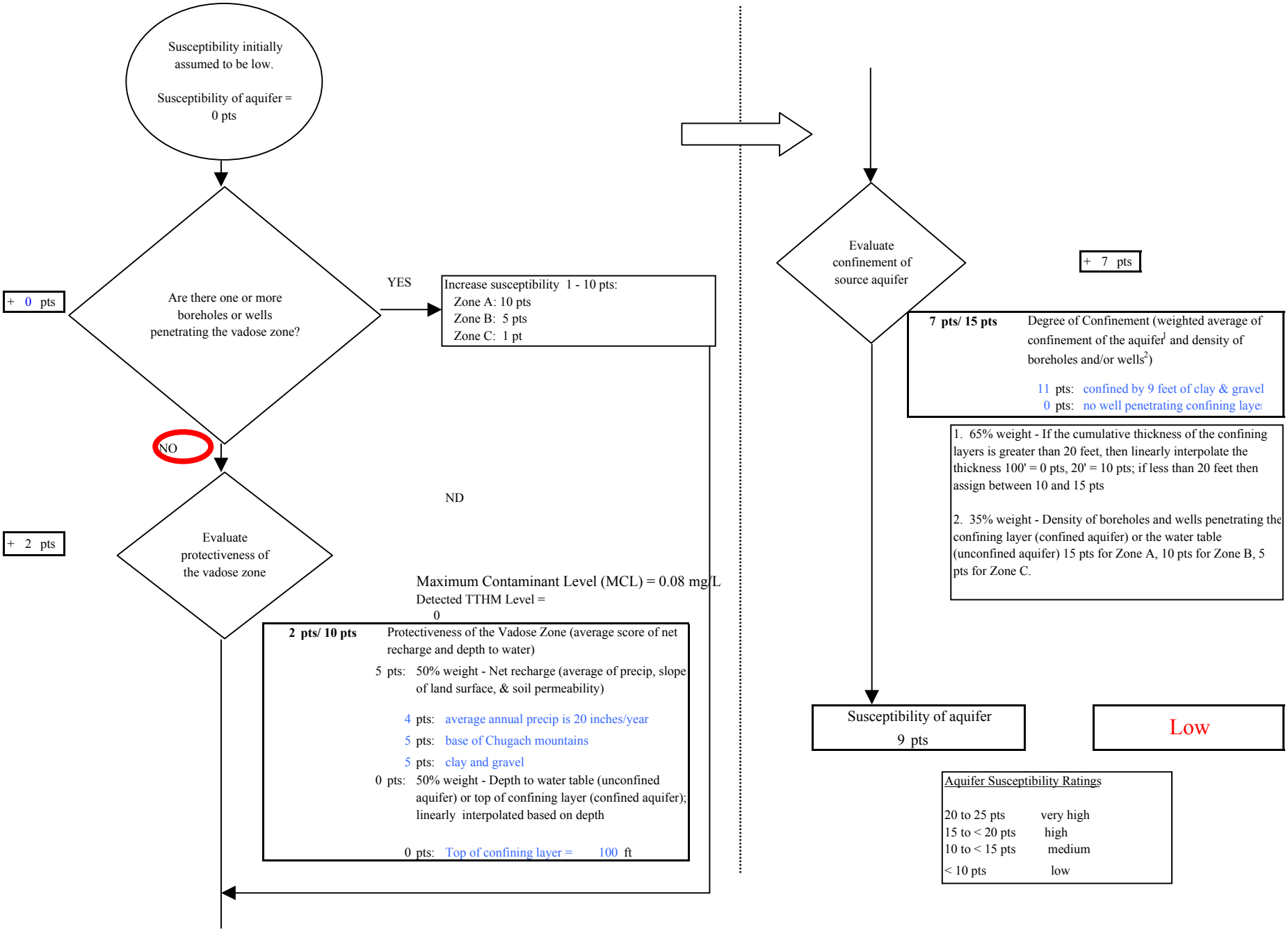
## Vulnerability Analysis for Twin Birch Well #1

**(Charts 1-14)**

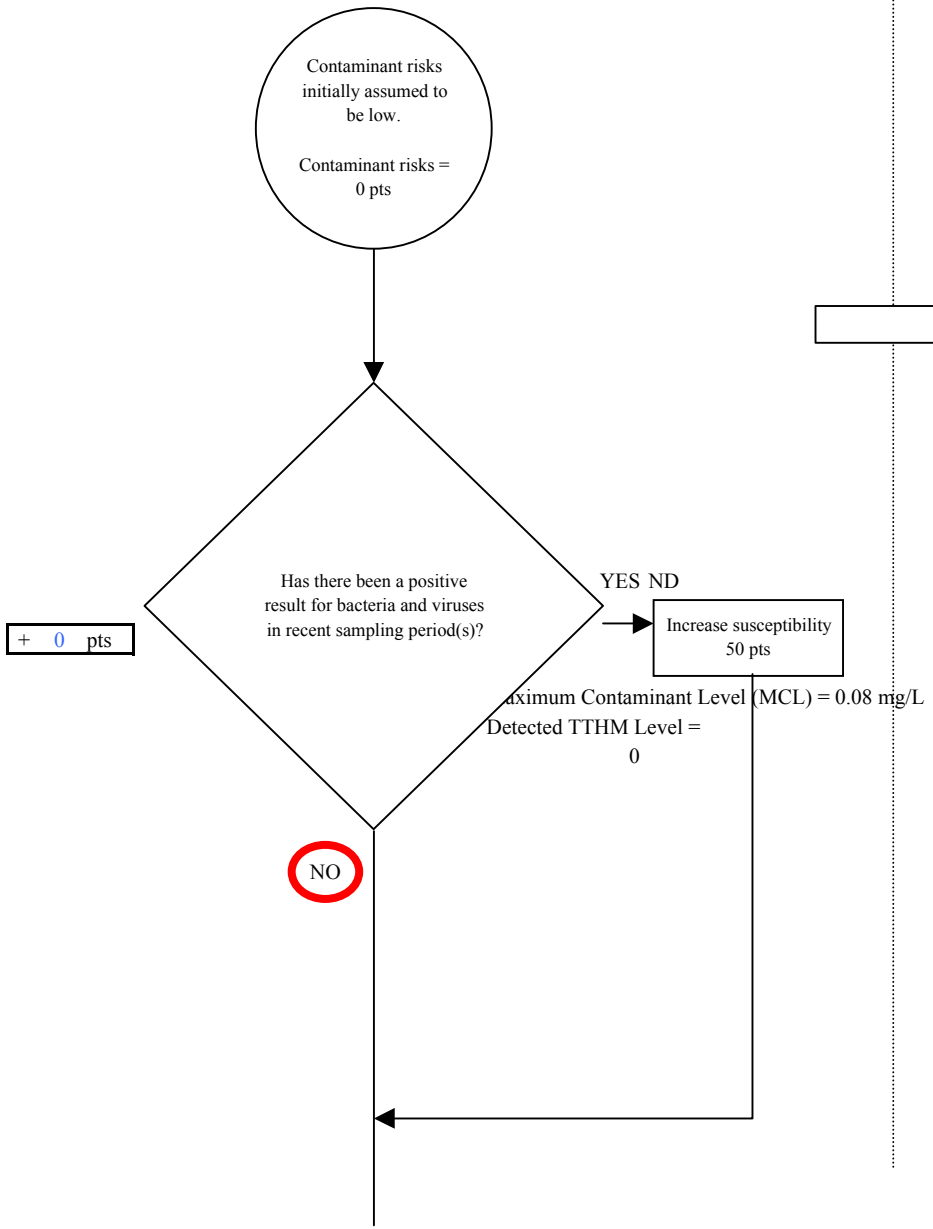
## *Chart 1. Susceptibility of the wellhead - Twin Birch*

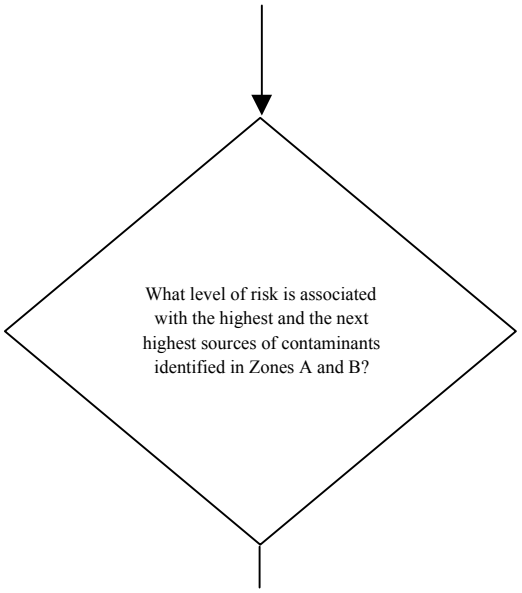


## *Chart 2. Susceptibility of the aquifer - Twin Birch*



## *Chart 3. Contaminant risks for Twin Birch - Bacteria & Viruses*




+ 20 pts

Risk Rankings for Contaminant Sources Identified in Zones A and B

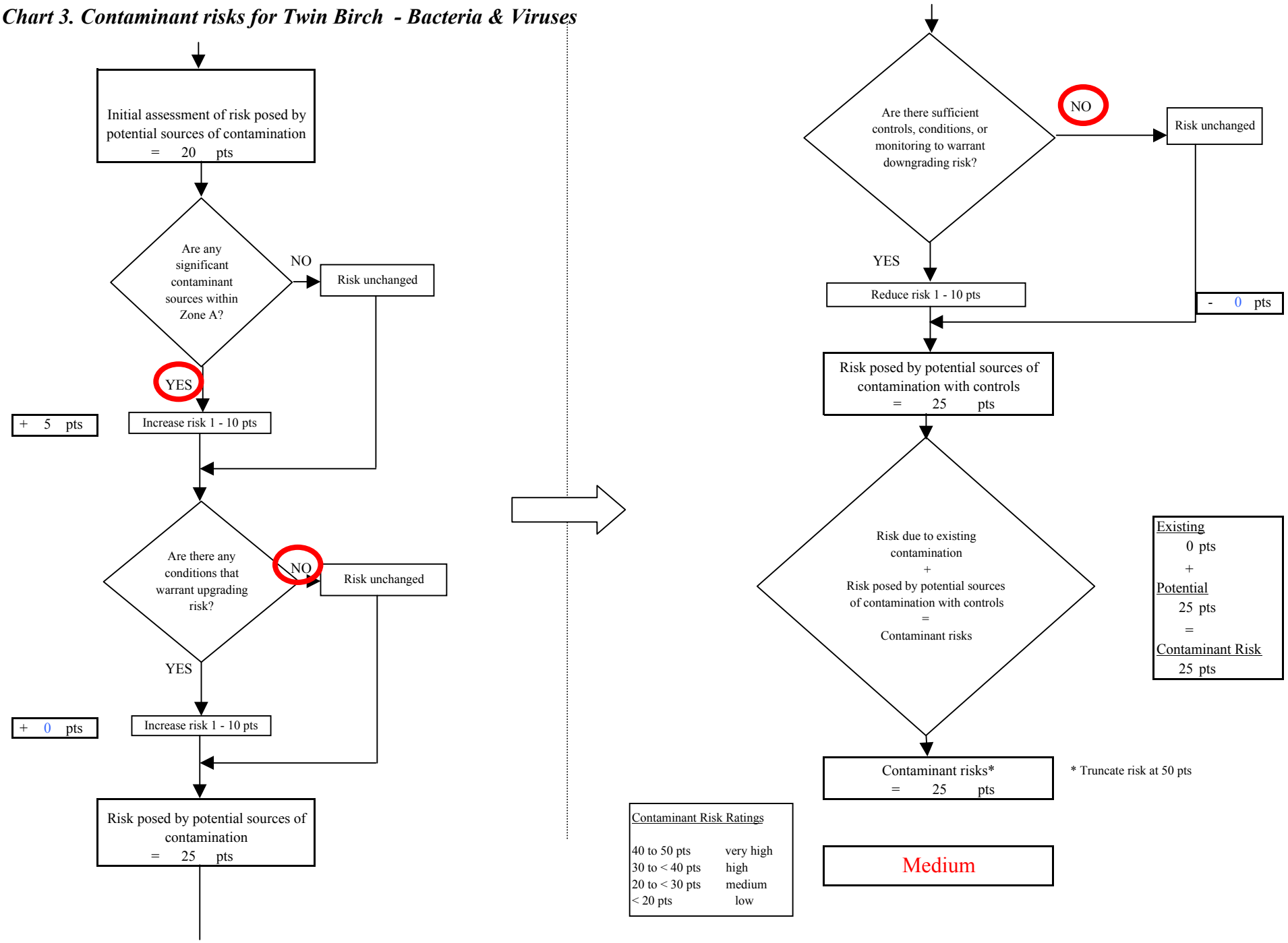
| | Zone A | Zone B | Total |
|---|---|---|---|
| Very Highs(s) | 0 | 0 | 0 |
| High(s) | 0 | 0 | 0 |
| Medium(s) | 2 | 0 | 2 |
| Low(s) | 2 | 2 | 4 |

| | **LOW** 10 pts | **MEDIUM** 20 pts | **HIGH** 30 pts | **VERY HIGH** 40 pts |
|---|---|---|---|---|
| **LOW** | ≥ 10 sources + 10 pts | ≥ 10 sources + 5 pts | ≥ 20 sources + 5 pts | ---- |
| **MEDIUM** | ---- | ≥ 2 sources + 5 pts | ≥ 5 sources + 5 pts | ≥ 10 sources + 5 pts |
| **HIGH** | ---- | ---- | ≥ 1 source + 10 pts | ≥ 2 sources + 10 pts |
| **VERY HIGH** | ---- | ---- | ---- | ≥ 1 source + 10 pts |

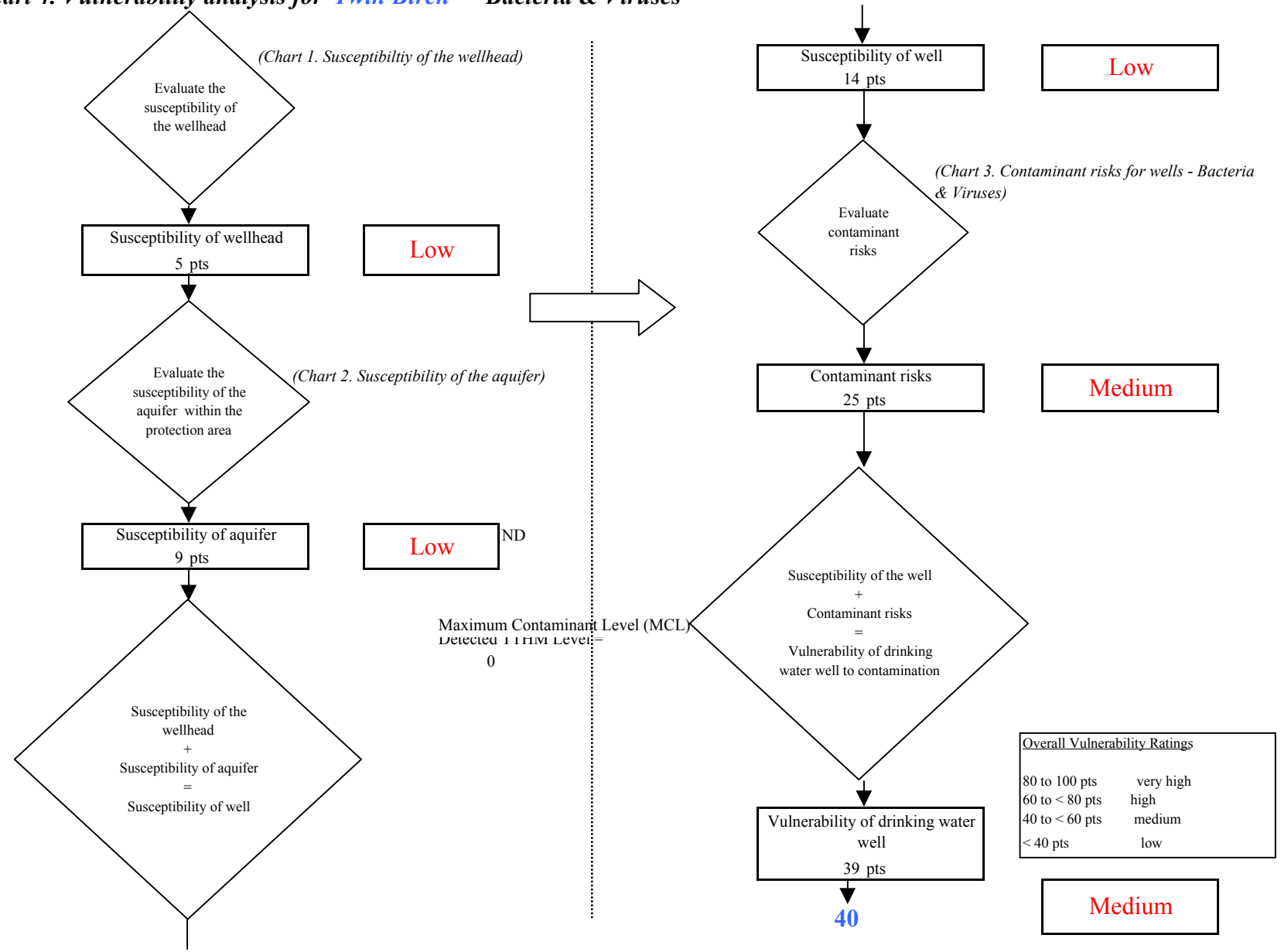
Matrix Score 20

Note: Septic systems, sewerlines, and roads are each assigned a risk ranking for each individual contaminant source in the CSI. The VA, however, counts these contaminant sources as a group and assigns a calculated number of either "lows" or "mediums" based on the density.

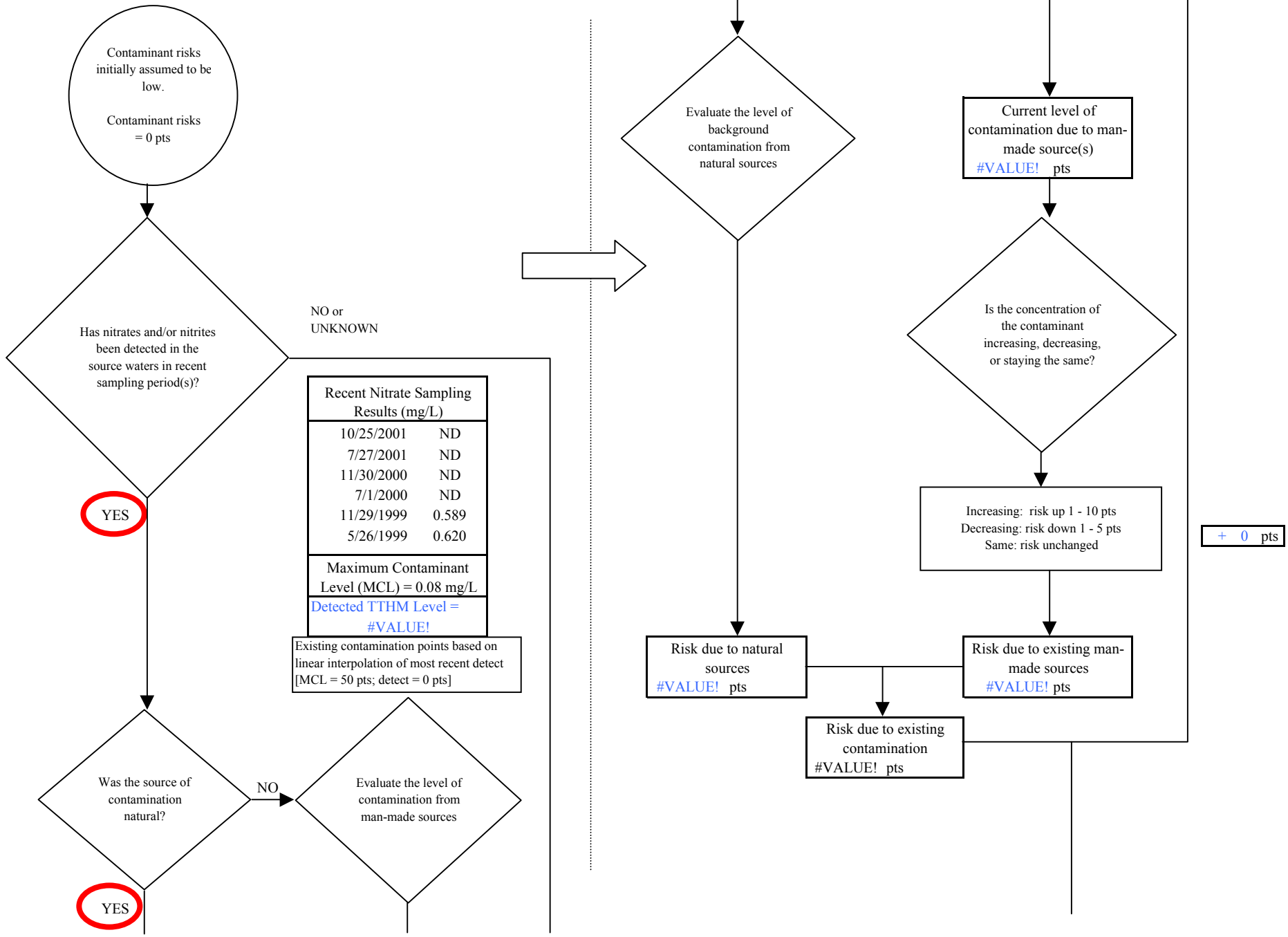
## *Chart 3. Contaminant risks for Twin Birch - Bacteria & Viruses*



## *Chart 4. Vulnerability analysis for Twin Birch - Bacteria & Viruses*



## *Chart 5. Contaminant risks for Twin Birch - Nitrates and Nitrites*



## *Chart 5. Contaminant risks for Twin Birch - Nitrates and Nitrites*

+ 20 pts

What level of risk is associated with the highest and the next highest risk sources(s) of contaminants identified in Zones A, B and C?

Risk Levels for Contaminant Sources identified in Zones A, B and C

| | Zone A | Zones B&C | Total |
|---|---|---|---|
| Very Highs(s) | 0 | 0 | 0 |
| High(s) | 0 | 0 | 0 |
| Medium(s) | 2 | 0 | 2 |
| Low(s) | 2 | 4 | 6 |

| | LOW 10 pts | MEDIUM 20 pts | HIGH 30 pts | VERY HIGH 40 pts |
|---|---|---|---|---|
| **LOW** | ≥ 10 sources + 10 pts | ≥ 10 sources + 5 pts | ≥ 20 sources + 5 pts | ---- |
| **MEDIUM** | ---- | ≥ 2 sources + 5 pts | ≥ 5 sources + 5 pts | ≥ 10 sources + 5 pts |
| **HIGH** | ---- | ---- | ≥ 1 source + 10 pts | ≥ 2 sources + 10 pts |
| **VERY HIGH** | ---- | ---- | ---- | ≥ 1 source + 10 pts |

Matrix Score 20

Note: Septic systems, sewerlines, and roads are each assigned a risk ranking for each individual contaminant source in the CSI. The VA, however, counts these contaminant sources as a group and assigns a calculated number of either "lows" or "mediums" based on the density.

Initial assessment of risk posed by potential sources of contamination = 20 pts

Is the source aquifer fractured rock or karst?

YES

NO

Are all of the higher risk sources beyond Zones A and B?

NO

Risk unchanged

YES

- 0 pts

Decrease risk 1 - 10 pts

Calculated by matrix shown in blue to the right.

Are any significant sources within Zone A?

NO

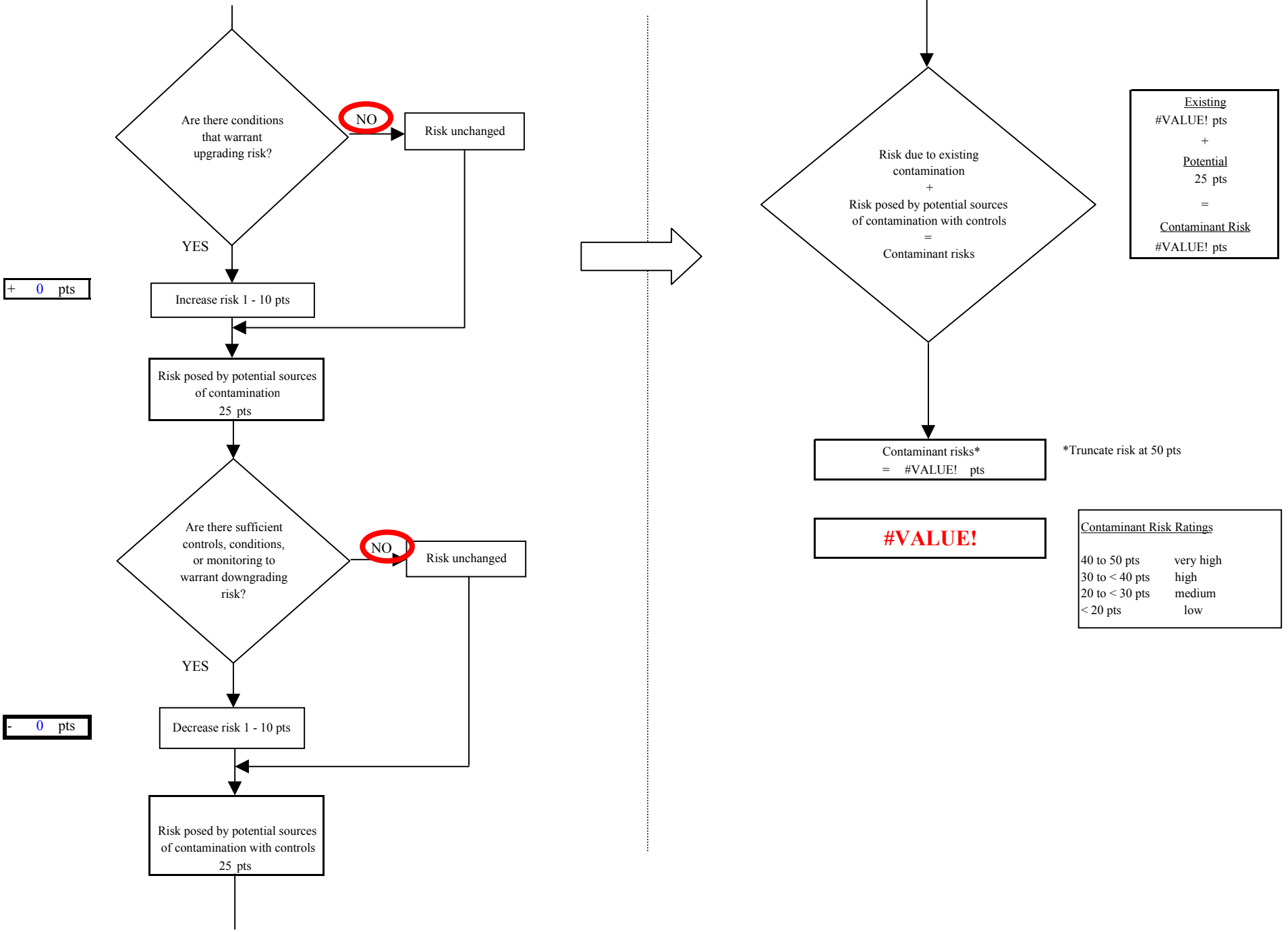
Risk unchanged

YES

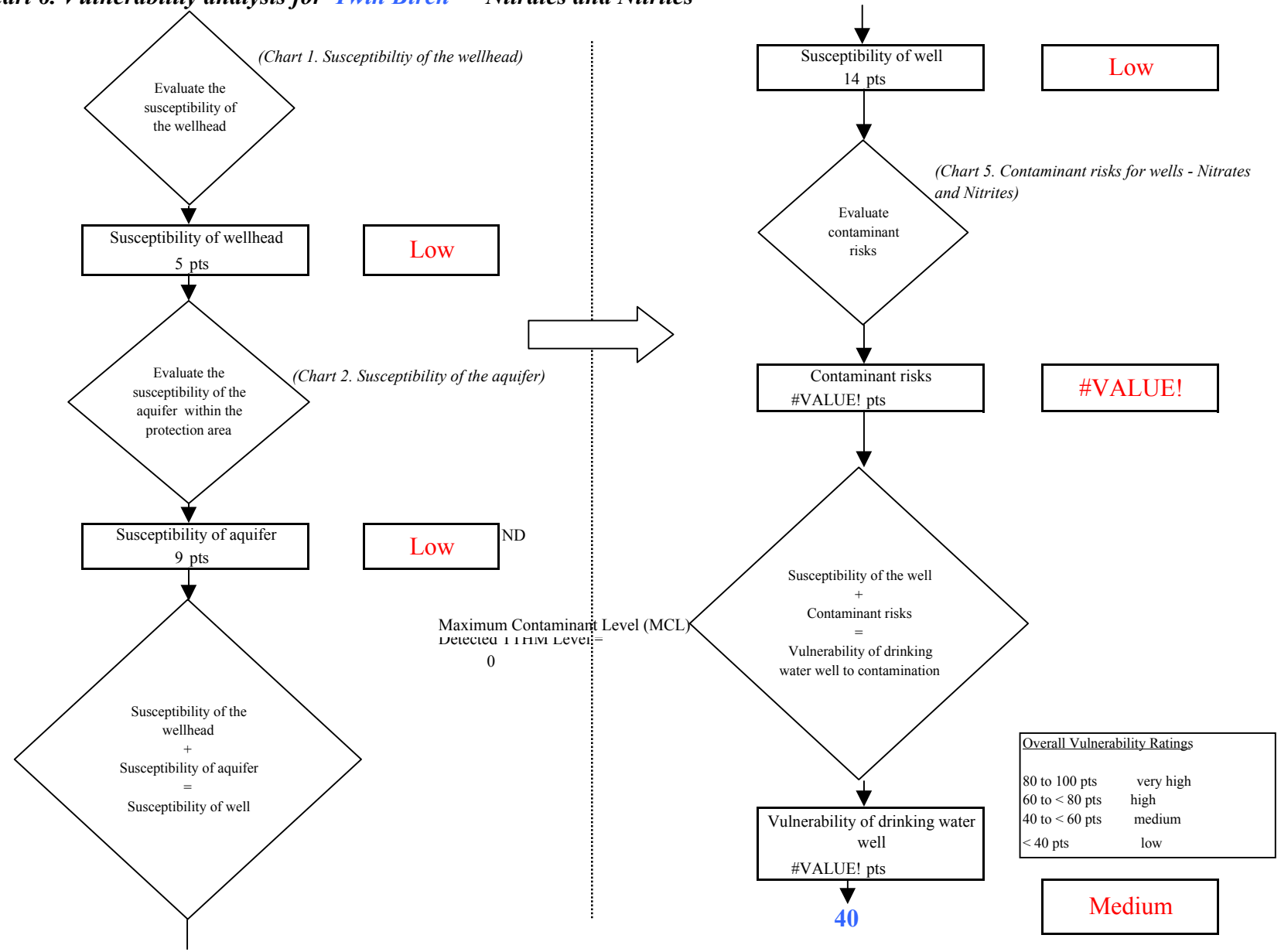
+ 5 pts

Increase risk 1 - 10 pts

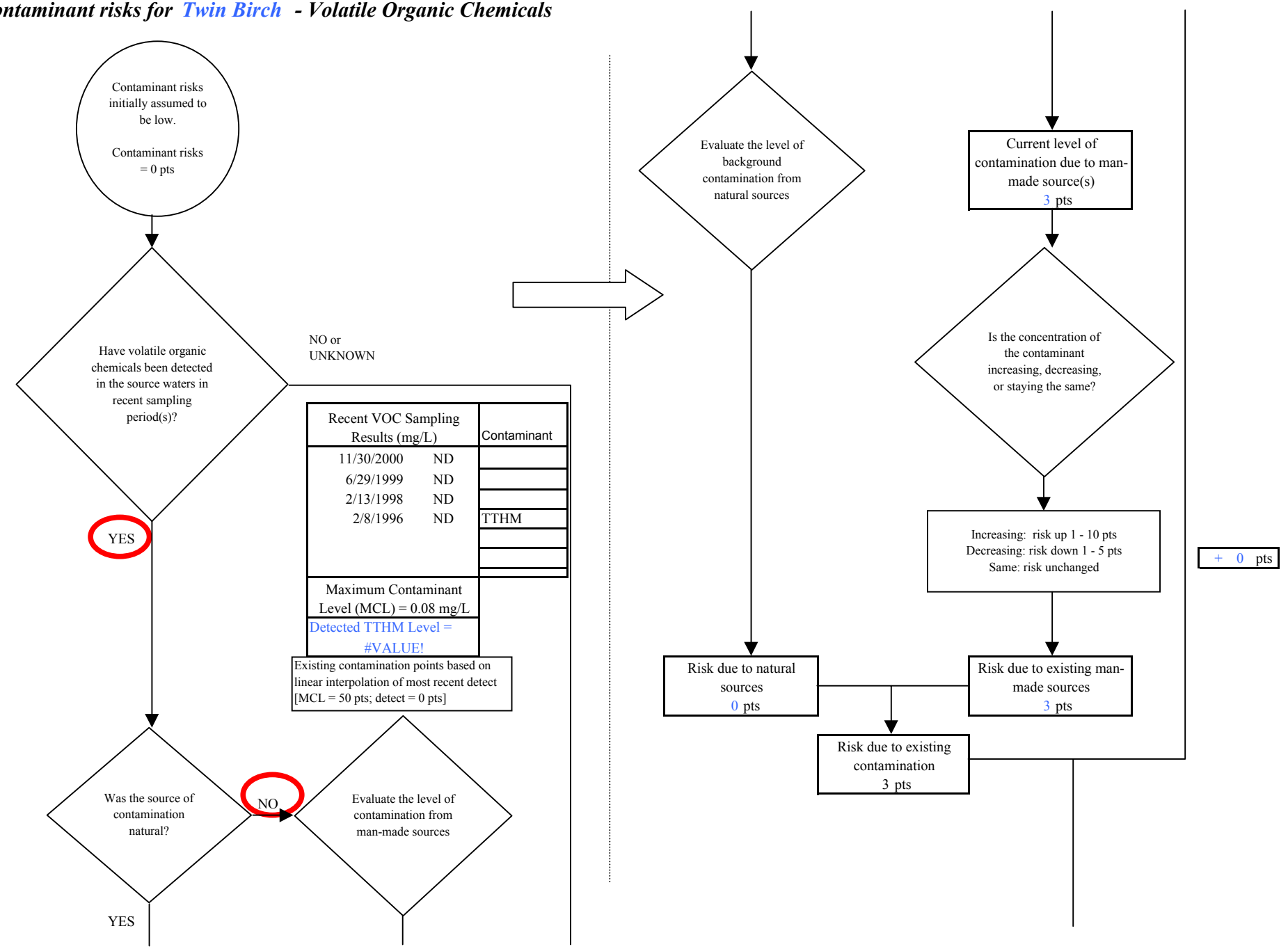
## *Chart 5. Contaminant risks for Twin Birch - Nitrates and Nitrites*



## *Chart 6. Vulnerability analysis for Twin Birch - Nitrates and Nitrites*



## *Chart 7. Contaminant risks for Twin Birch - Volatile Organic Chemicals*



## *Chart 7. Contaminant risks for Twin Birch - Volatile Organic Chemicals*

+ 10 pts

What level of risk is associated with the highest and the next highest risk sources(s) of contaminants identified in Zones A, B and C?

| Risk Levels for Contaminant Sources identified in Zones A, B and C | | | |
|---|---|---|---|
| | Zone A | Zones B&C | Total |
| Very Highs(s) | 0 | 0 | 0 |
| High(s) | 0 | 0 | 0 |
| Medium(s) | 0 | 0 | 0 |
| Low(s) | 3 | 5 | 8 |

| | **LOW** 10 pts | **MEDIUM** 20 pts | **HIGH** 30 pts | **VERY HIGH** 40 pts |
|---|---|---|---|---|
| **LOW** | ≥ 10 sources + 10 pts | ≥ 10 sources + 5 pts | ≥ 20 sources + 5 pts | ---- |
| **MEDIUM** | ---- | ≥ 2 sources + 5 pts | ≥ 5 sources + 5 pts | ≥ 10 sources + 5 pts |
| **HIGH** | ---- | ---- | ≥ 1 source + 10 pts | ≥ 2 sources + 10 pts |
| **VERY HIGH** | ---- | ---- | ---- | ≥ 1 source + 10 pts |

| Matrix Score | 10 |
|---|---|

Note: Septic systems, sewerlines, and roads are each assigned a risk ranking for each individual contaminant source in the CSI. The VA, however, counts these contaminant sources as a group and assigns a calculated number of either "lows" or "mediums" based on the density.

Initial assessment of risk posed by potential sources of contamination = 10 pts

Is the source aquifer fractured rock or karst?

YES

NO

Are all of the higher risk sources beyond Zones A and B?

NO

Risk unchanged

YES

Decrease risk 1 - 10 pts

- 0 pts

Are any significant sources within Zone A?

NO

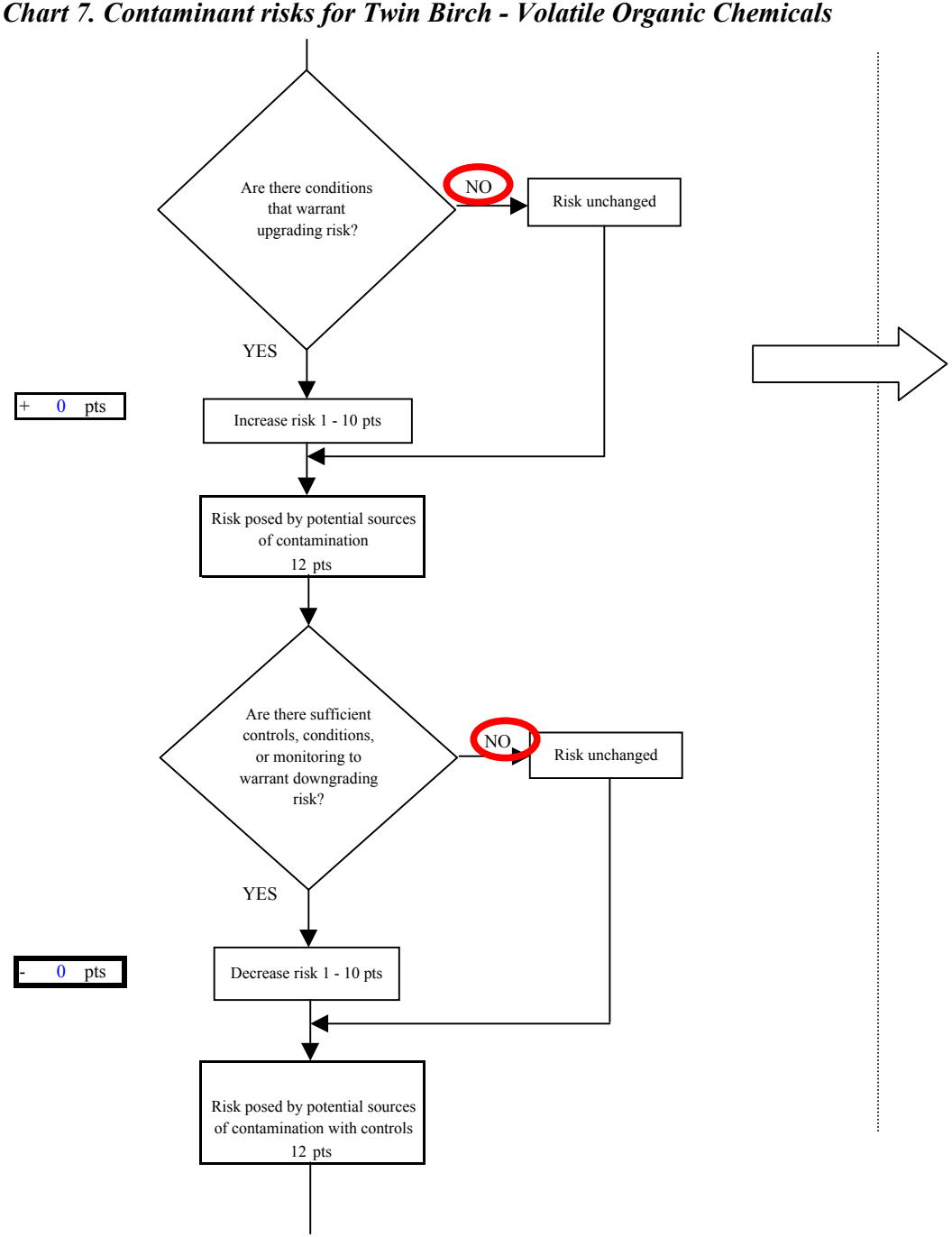
Risk unchanged

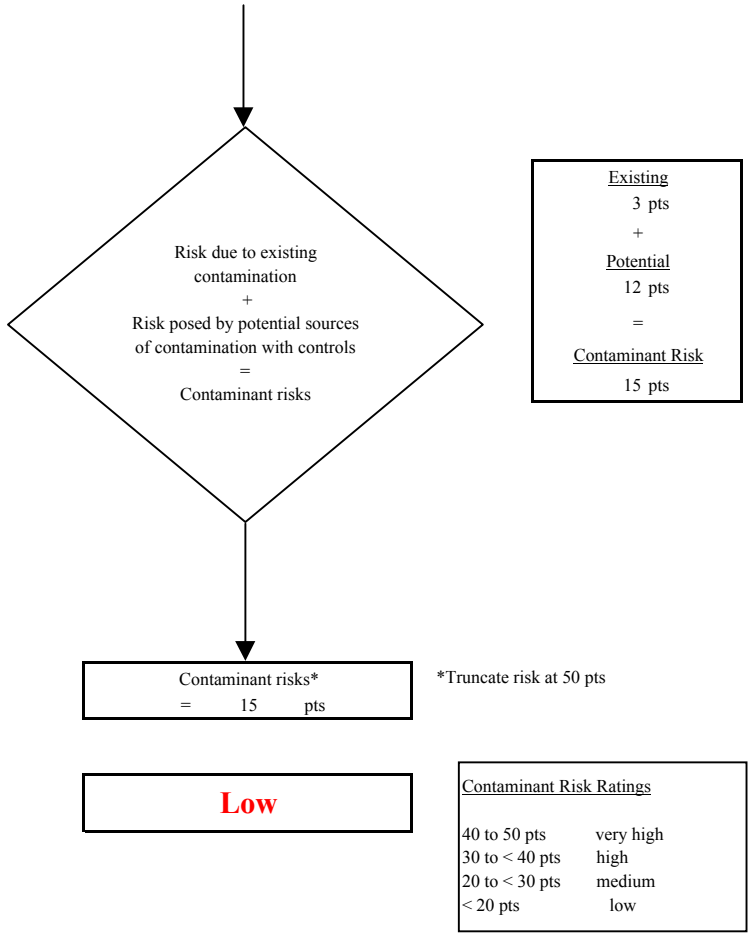
YES

Increase risk 1 - 10 pts

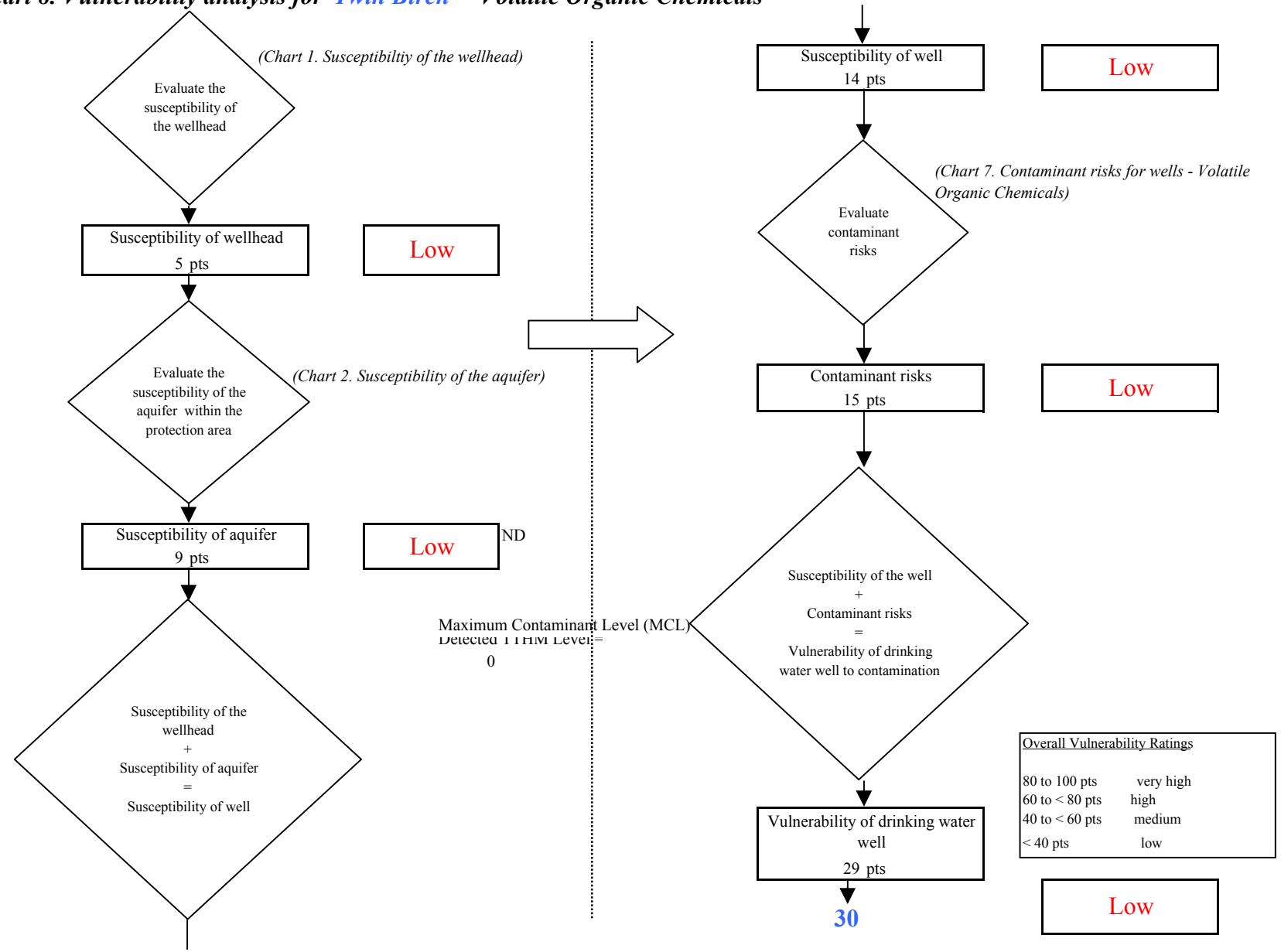
+ 2 pts

## *Chart 7. Contaminant risks for Twin Birch - Volatile Organic Chemicals*

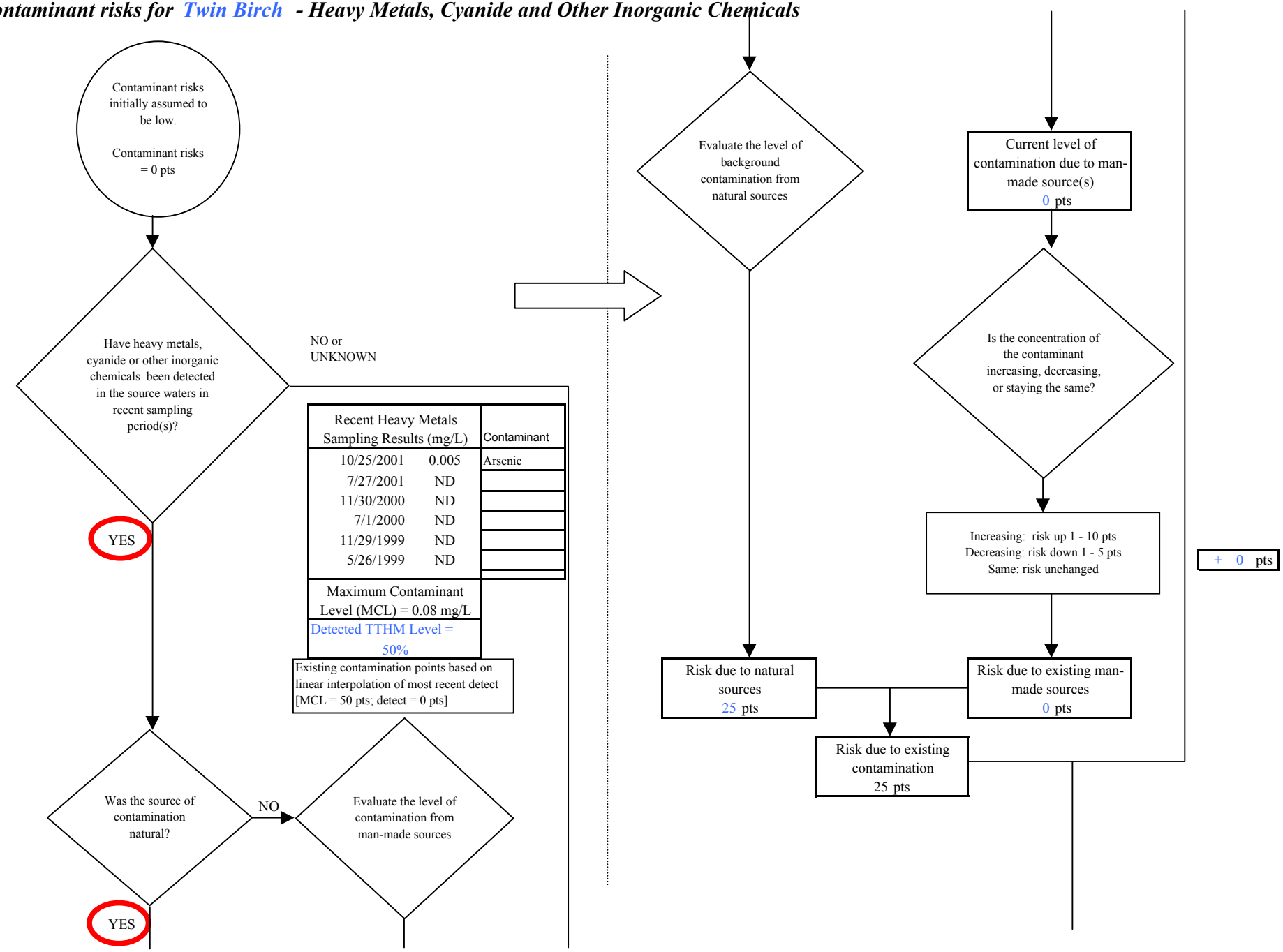


## *Chart 8. Vulnerability analysis for Twin Birch - Volatile Organic Chemicals*



## *Chart 9. Contaminant risks for Twin Birch - Heavy Metals, Cyanide and Other Inorganic Chemicals*



## *Chart 9. Contaminant risks for Twin Birch - Heavy Metals, Cyanide and Other Inorganic Chemicals*

+ 10 pts

What level of risk is associated with the highest and the next highest risk sources(s) of contaminants identified in Zones A, B and C?

| Risk Levels for Contaminant Sources identified in Zones A, B and C | | | |
|---|---|---|---|
| | Zone A | Zones B&C | Total |
| Very Highs(s) | 0 | 0 | 0 |
| High(s) | 0 | 0 | 0 |
| Medium(s) | 0 | 0 | 0 |
| Low(s) | 4 | 5 | 9 |

| | **LOW** 10 pts | **MEDIUM** 20 pts | **HIGH** 30 pts | **VERY HIGH** 40 pts |
|---|---|---|---|---|
| **LOW** | ≥ 10 sources + 10 pts | ≥ 10 sources + 5 pts | ≥ 20 sources + 5 pts | ---- |
| **MEDIUM** | ---- | ≥ 2 sources + 5 pts | ≥ 5 sources + 5 pts | ≥ 10 sources + 5 pts |
| **HIGH** | ---- | ---- | ≥ 1 source + 10 pts | ≥ 2 sources + 10 pts |
| **VERY HIGH** | ---- | ---- | ---- | ≥ 1 source + 10 pts |

Matrix Score 10

Note: Septic systems, sewerlines, and roads are each assigned a risk ranking for each individual contaminant source in the CSI. The VA, however, counts these contaminant sources as a group and assigns a calculated number of either "lows" or "mediums" based on the density.

Initial assessment of risk posed by potential sources of contamination = 10 pts

Is the source aquifer fractured rock or karst?

YES

NO

Are all of the higher risk sources beyond Zones A and B?

NO → Risk unchanged

YES → Decrease risk 1 - 10 pts

- 0 pts

Calculated by matrix shown in blue to the right.

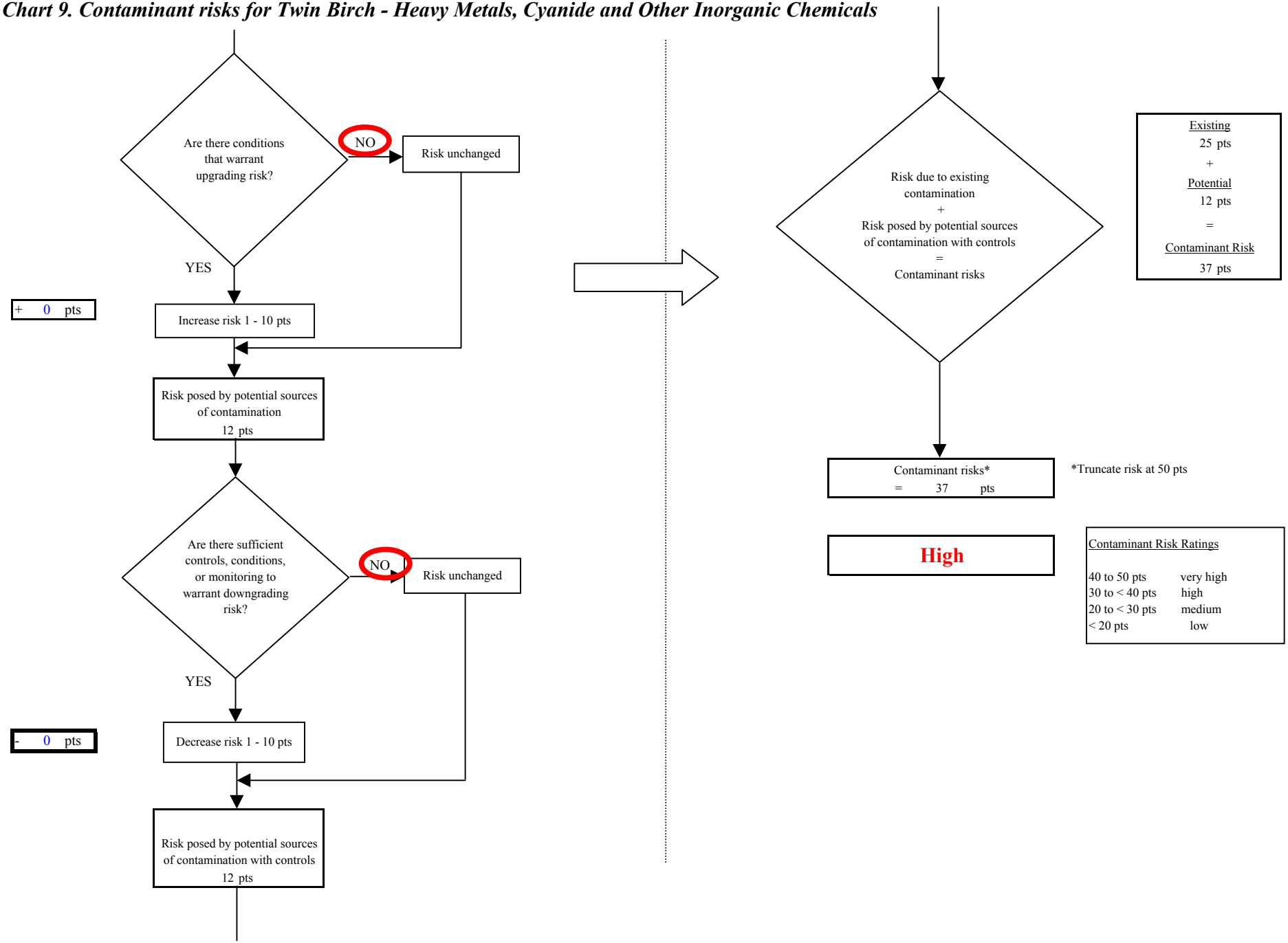
Are any significant sources within Zone A?

NO → Risk unchanged

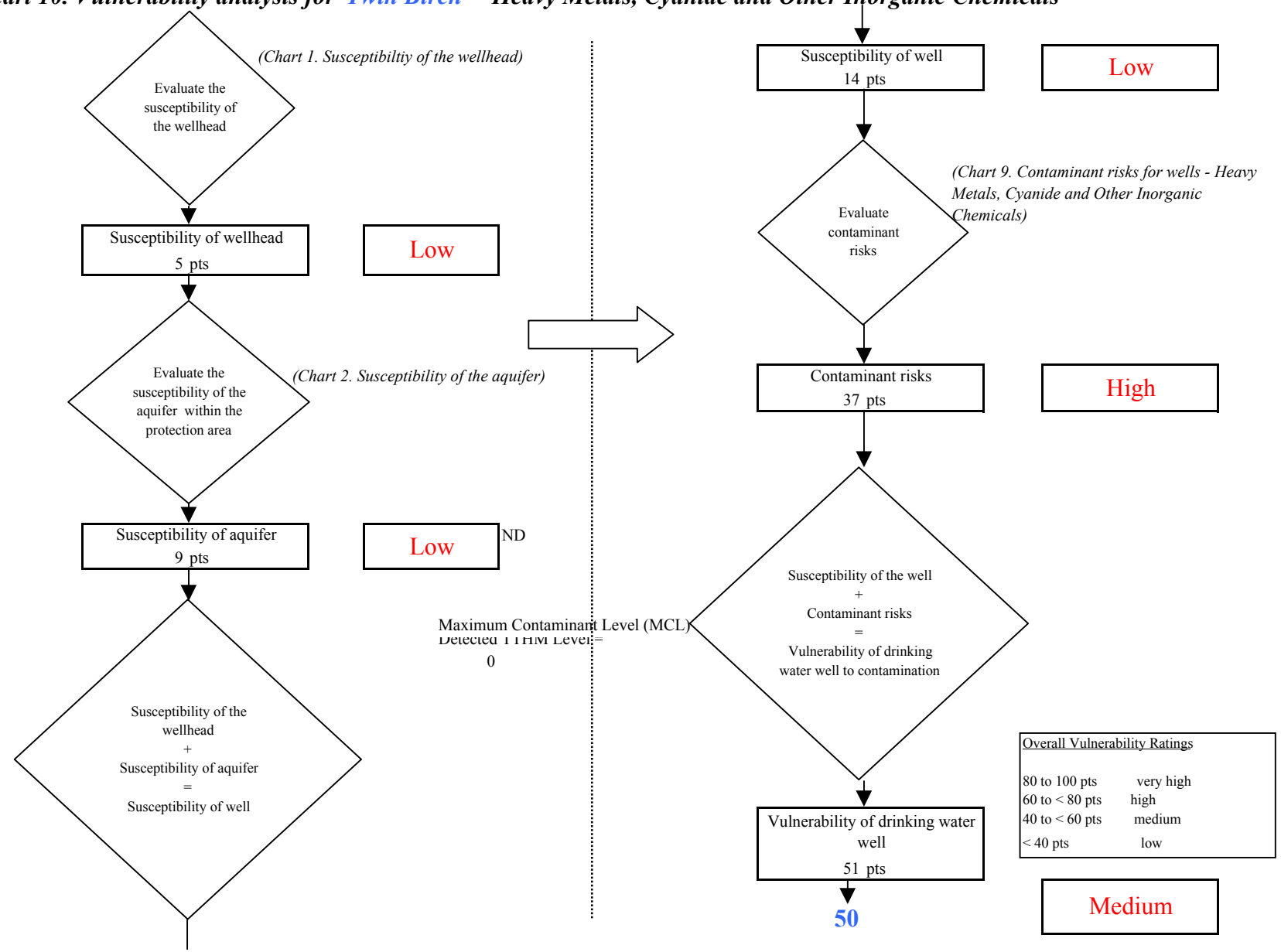
YES → Increase risk 1 - 10 pts

+ 2 pts

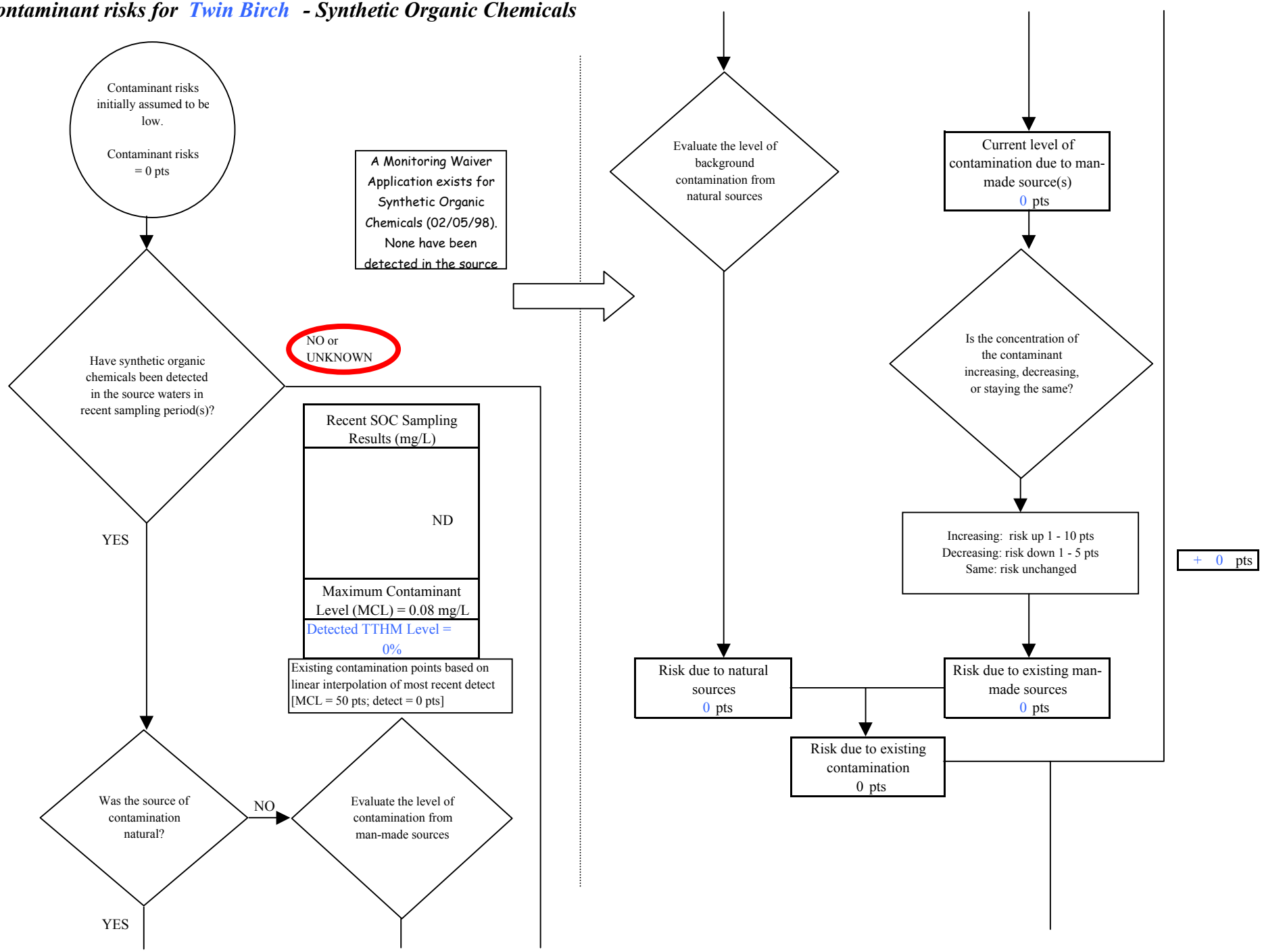
## *Chart 9. Contaminant risks for Twin Birch - Heavy Metals, Cyanide and Other Inorganic Chemicals*



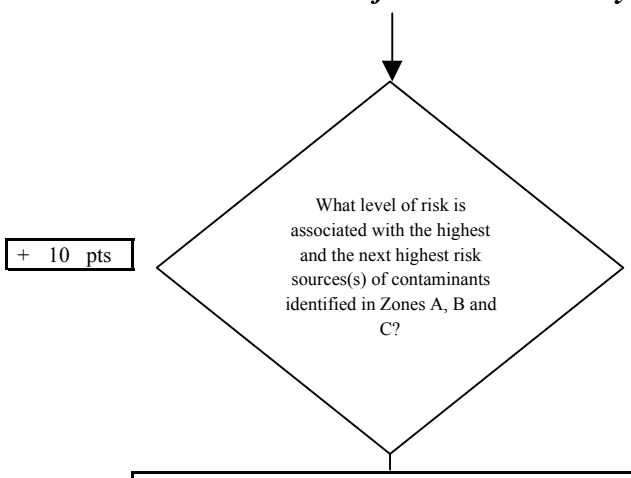
## *Chart 10. Vulnerability analysis for Twin Birch - Heavy Metals, Cyanide and Other Inorganic Chemicals*



## *Chart 11. Contaminant risks for Twin Birch - Synthetic Organic Chemicals*



## *Chart 11. Contaminant risks for Twin Birch - Synthetic Organic Chemicals*




+ 10 pts

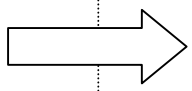
Risk Levels for Contaminant Sources identified in Zones A, B and C

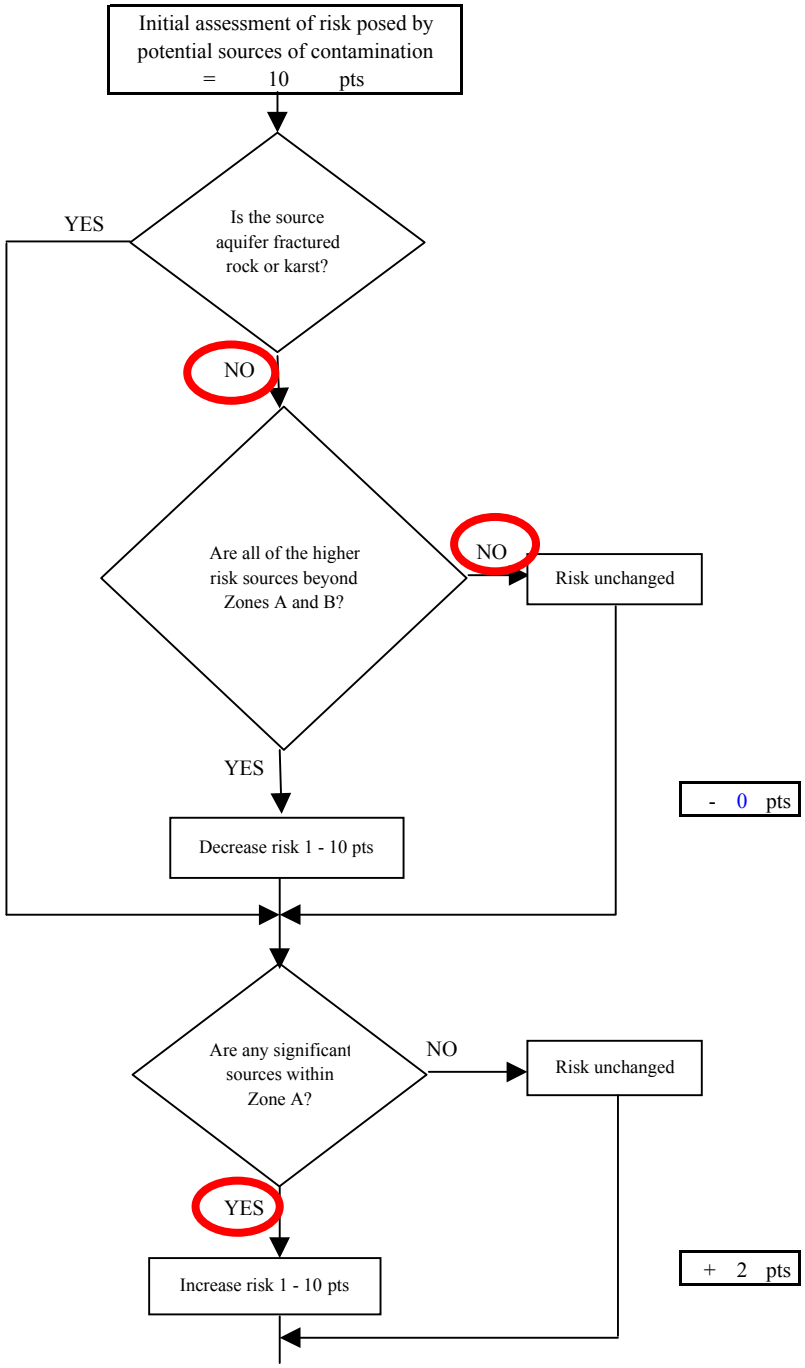
| | Zone A | Zones B&C | Total |
|---|---|---|---|
| Very Highs(s) | 0 | 0 | 0 |
| High(s) | 0 | 0 | 0 |
| Medium(s) | 0 | 0 | 0 |
| Low(s) | 3 | 3 | 6 |

| | **LOW** 10 pts | **MEDIUM** 20 pts | **HIGH** 30 pts | **VERY HIGH** 40 pts |
|---|---|---|---|---|
| **LOW** | ≥ 10 sources + 10 pts | ≥ 10 sources + 5 pts | ≥ 20 sources + 5 pts | ---- |
| **MEDIUM** | ---- | ≥ 2 sources + 5 pts | ≥ 5 sources + 5 pts | ≥ 10 sources + 5 pts |
| **HIGH** | ---- | ---- | ≥ 1 source + 10 pts | ≥ 2 sources + 10 pts |
| **VERY HIGH** | ---- | ---- | ---- | ≥ 1 source + 10 pts |

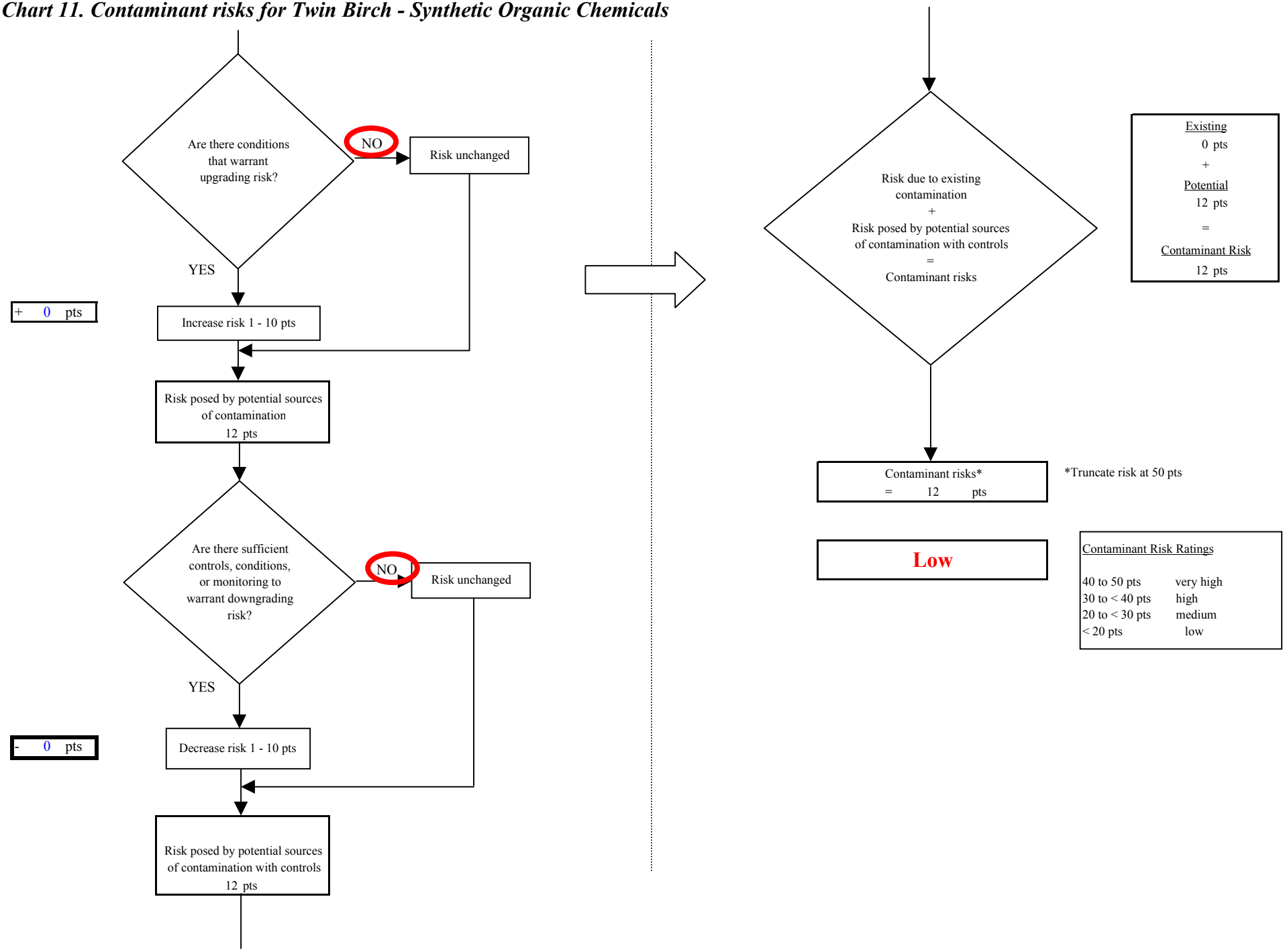
Matrix Score 10

Note: Septic systems, sewerlines, and roads are each assigned a risk ranking for each individual contaminant source in the CSI. The VA, however, counts these contaminant sources as a group and assigns a calculated number of either "lows" or "mediums" based on the density.

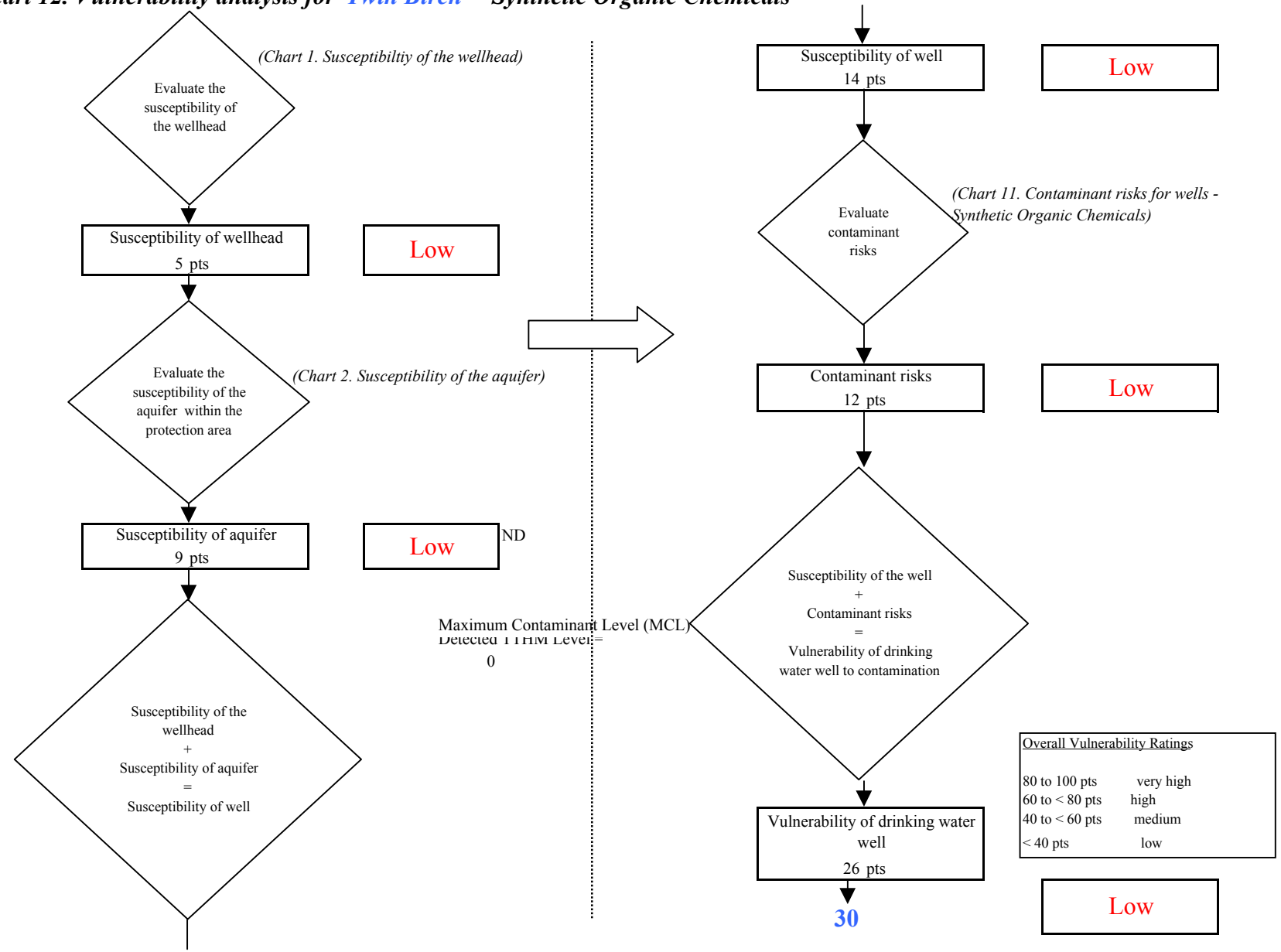




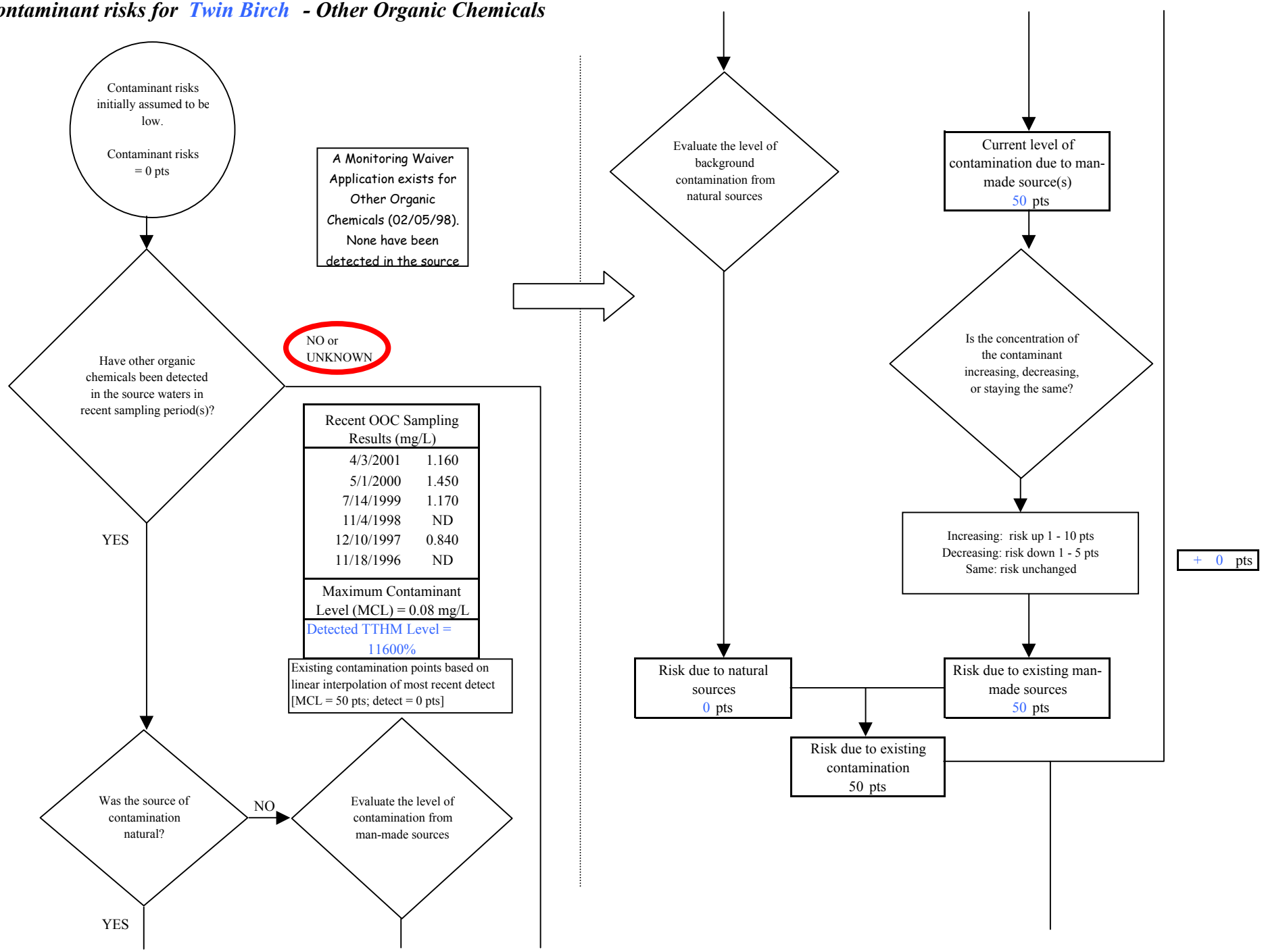
## *Chart 11. Contaminant risks for Twin Birch - Synthetic Organic Chemicals*



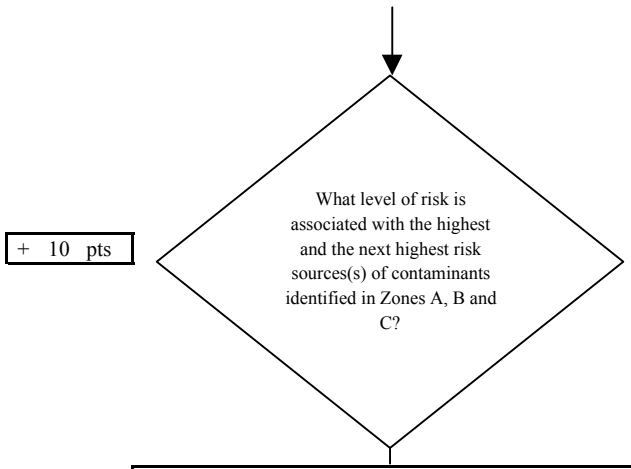
## *Chart 12. Vulnerability analysis for Twin Birch - Synthetic Organic Chemicals*



## *Chart 13. Contaminant risks for Twin Birch - Other Organic Chemicals*



## *Chart 13. Contaminant risks for Twin Birch - Other Organic Chemicals*



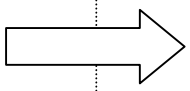

+ 10 pts

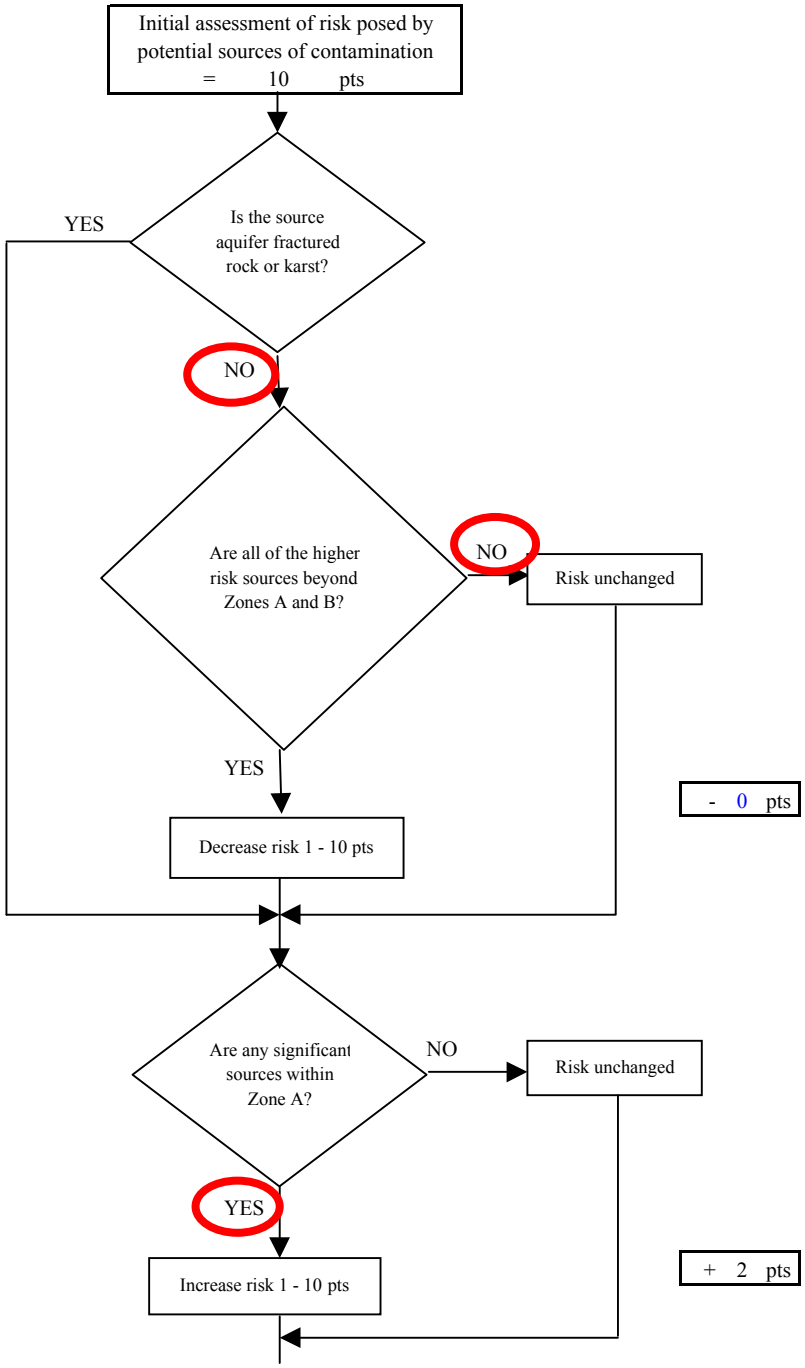
| Risk Levels for Contaminant Sources identified in Zones A, B and C | | | |
|---|---|---|---|
| | Zone A | Zones B&C | Total |
| Very Highs(s) | 0 | 0 | 0 |
| High(s) | 0 | 0 | 0 |
| Medium(s) | 0 | 0 | 0 |
| Low(s) | 3 | 4 | 7 |

| | **LOW** 10 pts | **MEDIUM** 20 pts | **HIGH** 30 pts | **VERY HIGH** 40 pts |
|---|---|---|---|---|
| **LOW** | ≥ 10 sources + 10 pts | ≥ 10 sources + 5 pts | ≥ 20 sources + 5 pts | ---- |
| **MEDIUM** | ---- | ≥ 2 sources + 5 pts | ≥ 5 sources + 5 pts | ≥ 10 sources + 5 pts |
| **HIGH** | ---- | ---- | ≥ 1 source + 10 pts | ≥ 2 sources + 10 pts |
| **VERY HIGH** | ---- | ---- | ---- | ≥ 1 source + 10 pts |

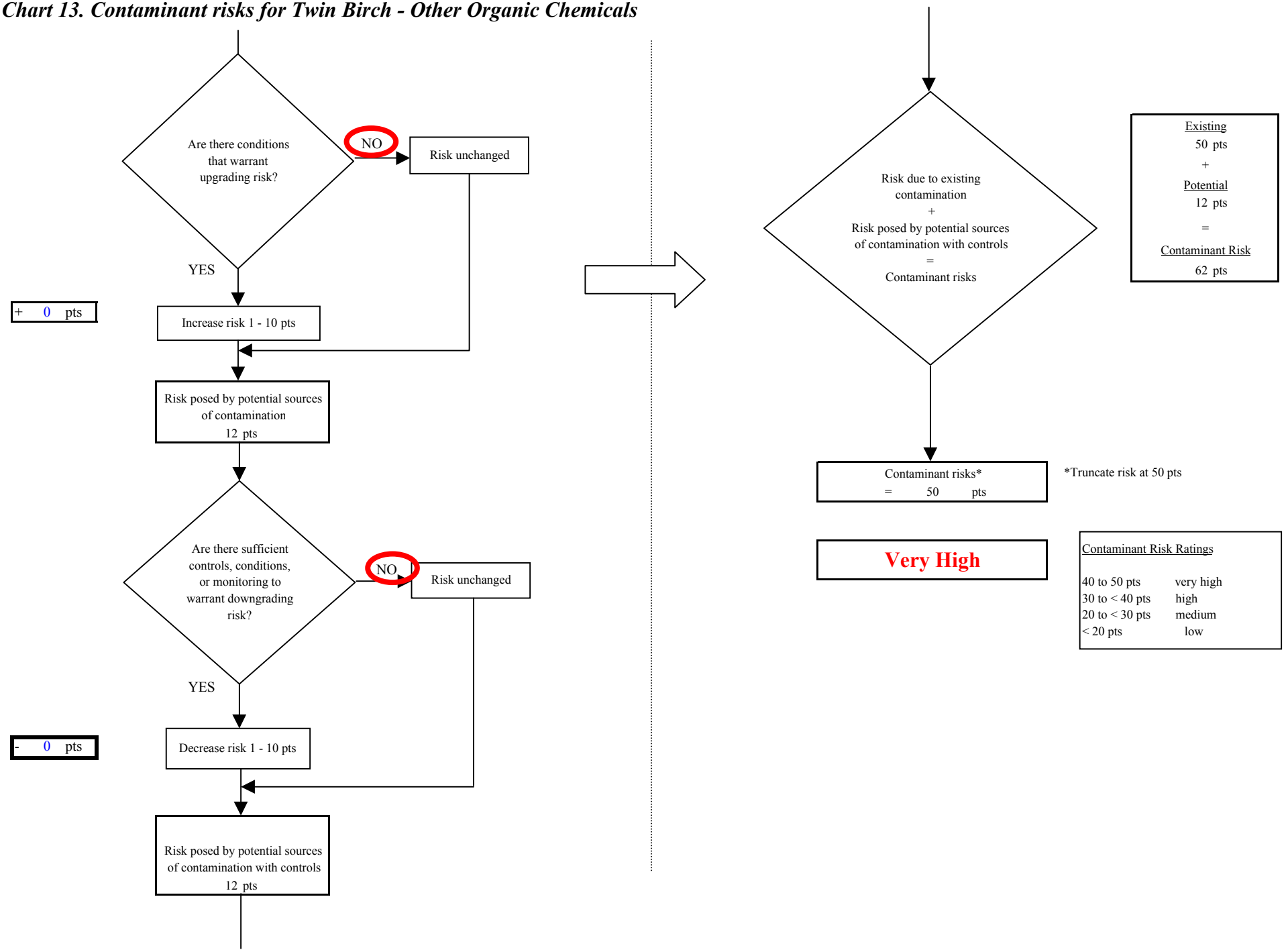
Matrix Score 10

Note: Septic systems, sewerlines, and roads are each assigned a risk ranking for each individual contaminant source in the CSI. The VA, however, counts these contaminant sources as a group and assigns a calculated number of either "lows" or "mediums" based on the density.





## *Chart 13. Contaminant risks for Twin Birch - Other Organic Chemicals*



## *Chart 14. Vulnerability analysis for Twin Birch - Other Organic Chemicals*