

Source Water Assessment

A Hydrogeologic Susceptibility and
Vulnerability Assessment for
Bethel Community Services
Drinking Water System,
Bethel, Alaska

PWSID # 271091.001

April 2004

DRINKING WATER PROTECTION PROGRAM REPORT 1121
Alaska Department of Environmental Conservation

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The Drinking Water Protection Program (DWPP) 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. It is anticipated this assessment will be updated every five years to reflect any changes in the vulnerability and/or susceptibility of public drinking water source. 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 Bethel Community Services Source of Public Drinking Water, Bethel, Alaska

Drinking Water Protection Program Alaska Department of Environmental Conservation

EXECUTIVE SUMMARY

Bethel Community Services has one Public Water System (PWS) well. The well (PWS No. 271091.001) has been used as a drinking water source since it was drilled in 1970.

The well is a Class A (community and non-transient/non-community) water system located at 1821 State Highway in Bethel, Alaska. Available records indicate that there is water storage with a capacity of 1,200-gallons, and that the untreated drinking water is derived directly from the wellhead. This system operates year-round and serves approximately 85 residents and 6 non-residents through six service connections. The wellhead received a susceptibility rating of **Low** and the aquifer received a susceptibility rating of **Low**. Combining these two ratings produce a **Low** rating for the natural susceptibility of the well.

Identified potential and current sources of contaminants for the public drinking water source include: domestic wastewater collection systems, airports, residential heating oil tanks, and highways and roads. These identified potential and existing sources of contamination are considered as sources of bacteria and viruses, nitrates and/or nitrites, volatile organic chemicals, heavy metals, cyanide and other inorganic chemicals, synthetic organic chemicals, and other organic chemicals contaminant categories.

Overall, the water well received a vulnerability rating of **Low** for nitrates and nitrites, heavy metals, cyanide and other organic chemicals, synthetic organic chemicals, and other organic chemicals, a vulnerability rating of **Medium** for volatile organic chemicals, and a vulnerability rating of **High** for bacteria and viruses.

PUBLIC DRINKING WATER SYSTEM

The Bethel Community Services well is a Class A (community/non-transient/non-community) public water system. The system is located at 1821 State Highway in Bethel, Alaska (Sec. 18, T8N, R71W,

Seward Meridian; see Map A of Appendix A). Bethel serves as the regional center for 56 villages in the Yukon-Kuskokwim Delta. Food, fuel, transportation, medical care, and other services for the region are provided by Bethel. Bethel is located at the mouth of the Kuskokwim River, 40-miles inland from the Bering Sea, and approximately 400-air miles west of Anchorage. The community has a population of 5,736 (ADCED, 2003). Average annual precipitation for Bethel is 16 inches, including approximately 50 inches of snowfall. Temperatures range from 42 to 62°F in summer and -2 to 19°F in winter.

The community of Bethel obtains a portion of their water supply from city wells. Some households are served by the central piped water and sewage collection system; however, approximately 75% of households have water delivered and sewage hauled by truck. Several facilities have individual wells and septic tanks (ADCED, 2003). Bethel receives electrical power from the Bethel Utilities Corporation. Power generating facilities are fueled by diesel. Refuse is collected by the City of Bethel and transported to the City operated landfill (ADCED, 2003).

According to information supplied by the Alaska Department of Environmental Conservation (ADEC) for the Bethel Community Services PWS, the depth of the primary water well is 450 feet below the ground surface (bgs). Well construction details are unknown; however, it is assumed the well is screened in a confined aquifer based on available construction details for surrounding wells. The well is not located within a floodplain.

Information acquired from a December 2002 sanitary survey for the public water system indicated that the land surface was sloped away from the well. Generally, land surfaces that slope away from the wellhead promote surface water drainage, which reduces the potential of contaminant migration down the well casing annulus. The sanitary survey indicates that the well is not grouted according to ADEC regulations. Proper grouting provides added

protection against contaminants traveling along the well casing annulus and into source waters.

The Bethel area is near the southern border of the continuous permafrost zone and the City, and most of the area west of the Kuskokwim River, appear to be underlain with permafrost. The permafrost generally extends to a depth of at least 300 feet bgs, with depths of over 600 feet bgs recorded in some areas. The geology in the area consists primarily of unconsolidated floodplain alluvium, silt deposits, and reworked silt. The Bethel area consists of poorly drained wetlands that have permanently ponded water in local depressions. Sloughs, small lakes, ponds, and marshes in meander scars surround Bethel (Dames & Moore, 1996).

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. 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 protection area are most likely to impact the drinking water well, this area will serve as the focus for voluntary protection efforts. An analytical calculation was used to determine the size and shape of the DWPA for the Bethel Community Services PWS. The input parameters describing the attributes of the aquifer in this calculation were adopted from Groundwater (Freeze and Cherry, 1979). Available geology and groundwater contours were also considered to take into account any uncertainties in groundwater flow and aquifer characteristics to arrive at a meaningful protection area.

The protection areas 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 (Please refer to the Guidance Manual for Class A Public Water Systems for additional information).

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 protection area zones for wells and the calculated time-of-travel for each:

Table 1. Definition of Zones

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

The DWPA for the Bethel Community Services PWS was determined using an analytical calculation and includes Zones A, B, C, and D (See Map A 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 Bethel Community Services 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,
- Other organic chemicals.

The sources are displayed on Map C 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. Rankings include:

- Low,
- Medium,
- High, and
- Very High.

The time-of-travel for contaminants within the water varies and is dependent on the physical and chemical characteristics of each contaminant. Bacteria and Viruses are only inventoried in Zones A and B because of their short life span. Only “Very High” and “High” rankings are inventoried within the outer Zone D due to the probability of contaminant dilution by the time the contaminants get to the well. 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, volatile organic chemicals, heavy metals, cyanide and other inorganic chemicals, synthetic organic chemicals, and other organic chemicals.

VULNERABILITY OF THE DRINKING WATER SYSTEM

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

- Natural susceptibility, and
- Contaminant risks.

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. 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, cyanide and other inorganic chemicals, synthetic organic chemicals, and other organic chemicals, respectively.

A score for the Natural Susceptibility is reached by considering the properties of the well and the aquifer.

Susceptibility of the Wellhead (0 – 25 Points)
(Chart 1 of Appendix D)

+

Susceptibility of the Aquifer (0 – 25 Points)
(Chart 2 of Appendix D)

=

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

A ranking is assigned for the Natural Susceptibility according to the point score:

Natural Susceptibility Ratings	
40 to 50 pts	Very High
30 to < 40 pts	High
20 to < 30 pts	Medium
< 20 pts	Low

Bethel Community Services’ water well is in a confined aquifer. Confined aquifers are less susceptible to potential groundwater quality impacts posed by the migration of surface water contaminants downward from the surface. Table 2 shows the susceptibility scores and ratings for this PWS.

Table 2. Susceptibility

	Score	Rating
Susceptibility of the Wellhead	5	Low
Susceptibility of the Aquifer	8	Low
Natural Susceptibility	13	Low

Contaminant risks to a drinking water source depend on the type, number or density, and distribution of contaminant sources. This score 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. Flow charts are used to assign a point score, and ratings are assigned in the same way as for the natural susceptibility:

Contaminant Risk Ratings	
40 to 50 pts	Very High
30 to < 40 pts	High
20 to < 30 pts	Medium
< 20 pts	Low

Table 3 summarizes the Contaminant Risks for each category of drinking water contaminants.

Table 3. Contaminant Risks

Category	Score	Rating
Bacteria and Viruses	50	Very High
Nitrates and/or Nitrites	25	Medium
Volatile Organic Chemicals	37	High
Heavy Metals, Cyanide and		
Other Inorganic Chemicals	12	Low
Synthetic Organic Chemicals	11	Low
Other Organic Chemicals	12	Low

Finally, an overall vulnerability score is assigned for each water system by combining each of the contaminant risk scores with the natural susceptibility score:

$$\begin{array}{r}
 \text{Natural Susceptibility (0 – 50 points)} \\
 + \\
 \text{Contaminant Risks (0 – 50 points)} \\
 = \\
 \text{Vulnerability of the} \\
 \text{Drinking Water Source to Contamination (0 – 100)}.
 \end{array}$$

Again, rankings are assigned according to a point score:

Overall Vulnerability Ratings	
80 to 100 pts	Very High
60 to < 80 pts	High
40 to < 60 pts	Medium
< 40 pts	Low

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	65	High
Nitrates and Nitrites	35	Low
Volatile Organic Chemicals	50	Medium
Heavy Metals, Cyanide and		
Other Inorganic Chemicals	25	Low
Synthetic Organic Chemicals	25	Low
Other Organic Chemicals	25	Low

Bacteria and Viruses

The contaminant risk for bacteria and viruses is **Very High**. The risk is primarily attributed to the presence of contaminants in recent sampling results.

Coliforms (a bacteria) are found naturally in the environment and although they aren't necessarily a health threat, they are an indicator of other potentially harmful bacteria in the water, more specifically, fecal coliforms and E. coli, which only come from human and animal fecal waste. Harmful bacteria can cause diarrhea, cramps, nausea, headaches, or other symptoms (EPA, 2003). Positive samples increase the overall vulnerability of the drinking water source, indicating that the source is susceptible to bacteria and virus contamination.

A positive bacteria count has been reported in recent (within five years) sampling events and was further verified through immediate confirmation sampling (See Chart 3 – Contaminant Risks for Bacteria and Viruses in Appendix D). Only a small amount of bacteria and viruses are required to endanger public health.

After combining the contaminant risk for bacteria and viruses with the natural susceptibility of the well, the overall vulnerability of the well to contamination is **High**.

Nitrates and Nitrites

The contaminant risk for nitrates and nitrites is **Medium**. The risk to this source of public drinking water is primarily attributed to the presence sewer lines in Zone A (see Table 3 – Appendix B).

Nitrates are very mobile, moving at approximately the same rate as water. The sampling history for this well indicates that nitrates have not been detected in recent sampling events. Nitrate concentrations in uncontaminated groundwater are typically less than 2 mg/L; therefore, nitrate concentrations above 2 mg/L may be indicative of man-made sources (See Chart 5

- Contaminant Risks for Nitrates and/or Nitrites in Appendix D).

Nitrate levels are often derived from the decomposition of organic matter in soils. After combining the contaminant risk for nitrates and nitrites with the natural susceptibility of the well, the overall vulnerability of the well to nitrate and nitrite contamination is **Low**.

Volatile Organic Chemicals

The contaminant risk for volatile organic chemicals is **High**. The risk is primarily attributed to the presence of residential heating oil tanks and an airport in Zones A, B, C, and D. Numerous other potential contaminant sources are also found within the protection area (see Table 4 – Appendix B).

Detectable concentrations of trihalomethanes were reported in sampling events for this public water system. However, the detectable concentrations of trihalomethanes reported in 1998 were well below the MCL of 0.08 mg/L. Trihalomethanes are considered byproducts of the water treatment process and are not from the source waters. Since the reported concentration of TTHM's in recent sampling events did not exceed the applicable MCLs, risk points were not retained.

Aside from being byproducts of the drinking water treatment process, possible sources of volatile organic chemicals include facilities with automobiles, residential areas, fuel tanks, roads, and airports. See Table 4 in Appendix D for a complete listing.

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 **Medium**.

Heavy Metals, Cyanide and Other Inorganic Chemicals

The contaminant risk for heavy metals, cyanide and other inorganic chemicals is **Low**. Numerous potential contaminant sources are found within the protection area (see Table 5 – Appendix B).

Based on review of recent sampling records for this public water system, lead and copper have been detected in recent sampling history. However, each analyte did not exceed their respective MCLs (see Chart 9 – Contaminant Risks for Heavy Metals, Cyanide, and Other Inorganic Chemicals in Appendix D).

The reported concentrations of copper and lead in recent sampling events are not likely to be representative of source water conditions. These two analytes are likely attributed to either the water treatment process or water distribution network; therefore, no risk points were assigned based on the presence of these analytes.

After combining the contaminant risk for heavy metals, cyanide and other inorganic chemicals with the natural susceptibility of the well, the overall vulnerability of the well to contamination is **Low**.

Synthetic Organic Chemicals

The contaminant risk for synthetic organic chemicals is **Low**. The risk is primarily attributed to the presence of an airport in Zone D (see Table 6 – Appendix B).

No recent sampling data was available in ADEC records for Bethel Community Services (See Chart 11 – Contaminant Risks for Synthetic Organic Chemicals in Appendix D).

After combining the contaminant risk for synthetic organic chemicals with the natural susceptibility of the well, the overall vulnerability of the well to contamination is **Low**.

Other Organic Chemicals

The contaminant risk for other organic chemicals is **Low**. Numerous potential contaminant sources are found within the protection area (see Table 7 – Appendix B).

No recent sampling data was available in ADEC records for Bethel Community Services (See Chart 13 – Contaminant Risks for Other Organic Chemicals in Appendix D).

After combining the contaminant risk for other organic chemicals with the natural susceptibility of the well, the overall vulnerability of the well to contamination is **Low**.

Using the Source Water Assessment

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 Bethel Community Services and the community of Bethel 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 drinking water source.

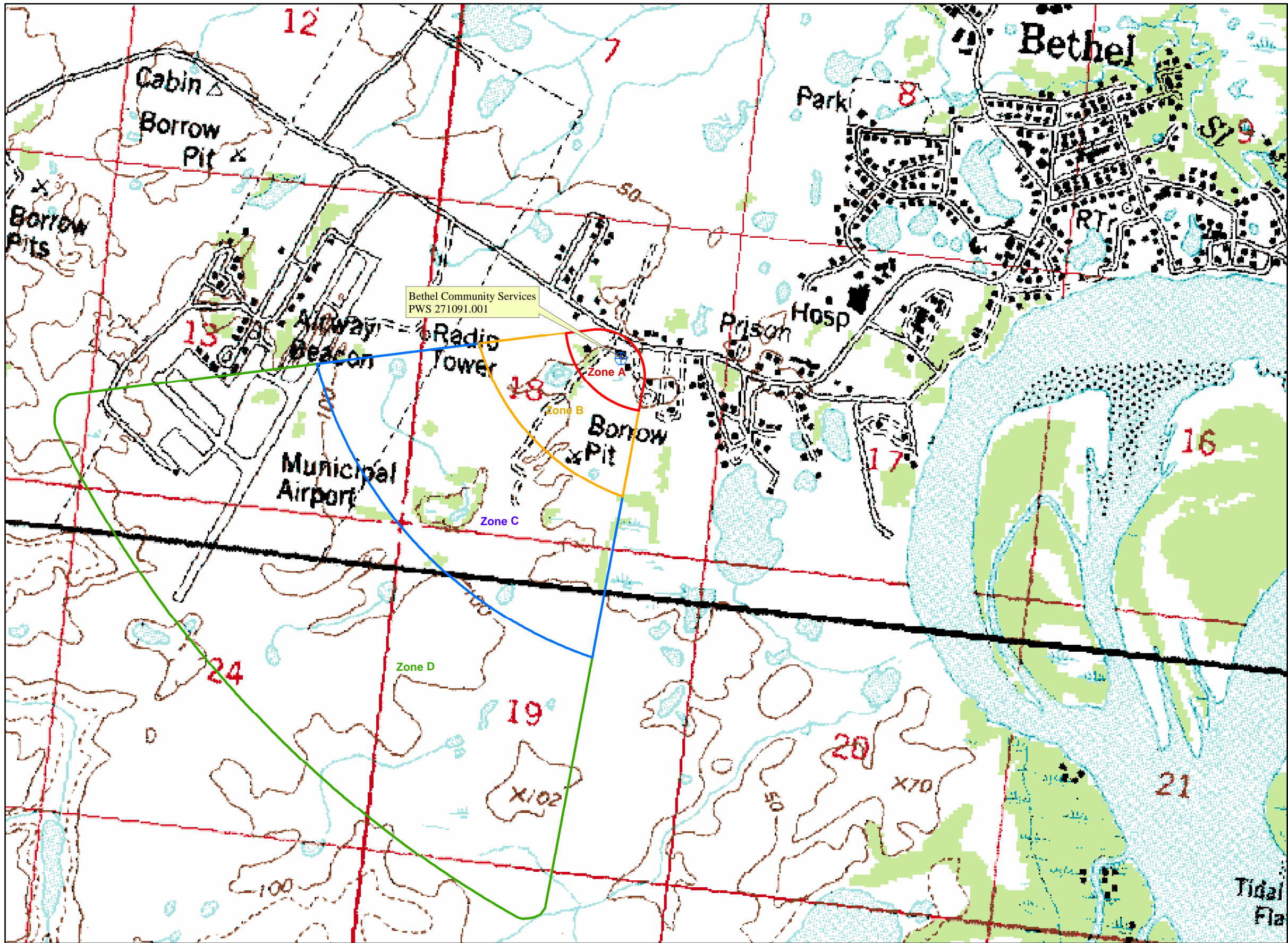
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APPENDIX A

Drinking Water Protection Area Location Map (Map A)

Public Water Well System for PWS #271091.001 Bethel Community Services



LEGEND

- Public Water System Well

Hydrography/Physical

- Parcels
- Stream
- Lake or Pond
- Contours

Transportation

- Primary Route (Class 1)
- Secondary Route (Class 2)
- Road (Class 3)
- Road (Class 4)
- Road (Class 5, Four-wheel drive)
- Road Ferry Crossing

Groundwater Protection Zones

- Zone A Protection Area- Several Months Travel Time
- Zone B Protection Area- 2 Years Travel Time
- Zone C Protection Area- 5 Years Travel Time
- Zone D Protection Area- 10 Years Travel Time

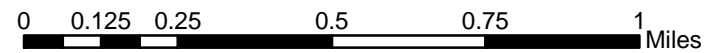
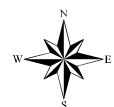
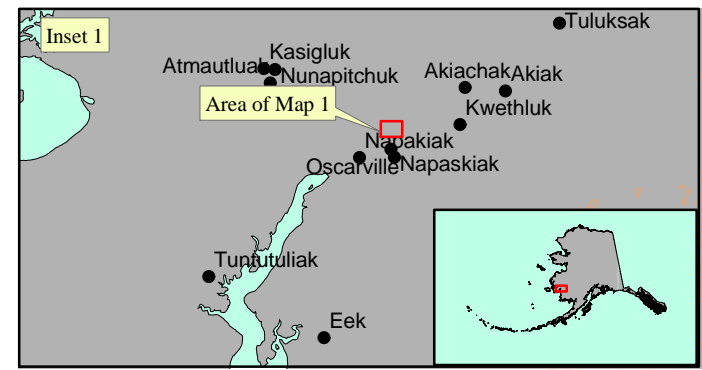
Data Sources:
 Contaminant Sources, Public Water System Wells, Contours
 Alaska Department of Environmental Conservation (ADEC)

Critical Facilities, Federal Emergency Management Agency (FEMA)

All other data:
 United States Geological Survey (USGS)

Drinking Water Protection Areas based on "Alaska Drinking Water Protection Program - Guidance Manual for Class A Public Water Systems" published by ADEC

URS Corporation does not guarantee the accuracy or validity of the data provided.



APPENDIX B

Contaminant Source Inventory and Risk Ranking (Tables 1-7)

Table 1

**Contaminant Source Inventory for
Bethel Community Services**

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Contaminant Source Type	Contaminant Source ID	CS ID tag	Zone	Map Number	Comments
Domestic wastewater collection systems (sewer lines or lift stations)	D01	D01-01	A	C	Assume area connected to municipal sewage
Tanks, heating oil, residential (above ground)	R08	R08-01	A	C	Assume 50 or less residential heating oil tanks in Zone A
Highways and roads, dirt/gravel	X24	X24-01	A	C	Assume 1-20 roads in Zone A
Highways and roads, dirt/gravel	X24	X24-02	B	C	Assume 1-20 roads in Zone B
Highways and roads, dirt/gravel	X24	X24-03	C	C	Assume 1-20 roads in Zone C
Airports	X14	X14-01	D	C	

*Contaminant Source Inventory and Risk Ranking for
Bethel Community Services
Sources of Bacteria and Viruses*

PWSID 271091.001

Table 2

<i>Contaminant Source Type</i>	<i>Contaminant Source ID</i>	<i>CS ID tag</i>	<i>Zone</i>	<i>Risk Ranking for Analysis</i>	<i>Map Number</i>	<i>Comments</i>
Domestic wastewater collection systems (sewer lines or lift stations)	D01	D01-01	A	Medium	C	Assume area connected to municipal sewage
Highways and roads, dirt/gravel	X24	X24-01	A	Low	C	Assume 1-20 roads in Zone A
Highways and roads, dirt/gravel	X24	X24-02	B	Low	C	Assume 1-20 roads in Zone B
Highways and roads, dirt/gravel	X24	X24-03	C	Low	C	Assume 1-20 roads in Zone C

*Contaminant Source Inventory and Risk Ranking for
Bethel Community Services
Sources of Nitrates/Nitrites*

PWSID 271091.001

Table 3

<i>Contaminant Source Type</i>	<i>Contaminant Source ID</i>	<i>CS ID tag</i>	<i>Zone</i>	<i>Risk Ranking for Analysis</i>	<i>Map Number</i>	<i>Comments</i>
Domestic wastewater collection systems (sewer lines or lift stations)	D01	D01-01	A	Medium	C	Assume area connected to municipal sewage
Highways and roads, dirt/gravel	X24	X24-01	A	Low	C	Assume 1-20 roads in Zone A
Highways and roads, dirt/gravel	X24	X24-02	B	Low	C	Assume 1-20 roads in Zone B
Highways and roads, dirt/gravel	X24	X24-03	C	Low	C	Assume 1-20 roads in Zone C
Airports	X14	X14-01	D	Low	C	

*Contaminant Source Inventory and Risk Ranking for
Bethel Community Services
Sources of Volatile Organic Chemicals*

PWSID 271091.001

Table 4

<i>Contaminant Source Type</i>	<i>Contaminant Source ID</i>	<i>CS ID tag</i>	<i>Zone</i>	<i>Risk Ranking for Analysis</i>	<i>Map Number</i>	<i>Comments</i>
Domestic wastewater collection systems (sewer lines or lift stations)	D01	D01-01	A	Low	C	Assume area connected to municipal sewage
Tanks, heating oil, residential (above ground)	R08	R08-01	A	Medium	C	Assume 50 or less residential heating oil tanks in Zone A
Highways and roads, dirt/gravel	X24	X24-01	A	Low	C	Assume 1-20 roads in Zone A
Highways and roads, dirt/gravel	X24	X24-02	B	Low	C	Assume 1-20 roads in Zone B
Highways and roads, dirt/gravel	X24	X24-03	C	Low	C	Assume 1-20 roads in Zone C
Airports	X14	X14-01	D	High	C	

*Contaminant Source Inventory and Risk Ranking for
Bethel Community Services*

PWSID 271091.001

Table 5

Sources of Heavy Metals, Cyanide and Other Inorganic Chemicals

<i>Contaminant Source Type</i>	<i>Contaminant Source ID</i>	<i>CS ID tag</i>	<i>Zone</i>	<i>Risk Ranking for Analysis</i>	<i>Map Number</i>	<i>Comments</i>
Domestic wastewater collection systems (sewer lines or lift stations)	D01	D01-01	A	Low	C	Assume area connected to municipal sewage
Highways and roads, dirt/gravel	X24	X24-01	A	Low	C	Assume 1-20 roads in Zone A
Highways and roads, dirt/gravel	X24	X24-02	B	Low	C	Assume 1-20 roads in Zone B
Highways and roads, dirt/gravel	X24	X24-03	C	Low	C	Assume 1-20 roads in Zone C
Airports	X14	X14-01	D	Low	C	

*Contaminant Source Inventory and Risk Ranking for
Bethel Community Services
Sources of Synthetic Organic Chemicals*

PWSID 271091.001

Table 6

<i>Contaminant Source Type</i>	<i>Contaminant Source ID</i>	<i>CS ID tag</i>	<i>Zone</i>	<i>Risk Ranking for Analysis</i>	<i>Map Number</i>	<i>Comments</i>
Domestic wastewater collection systems (sewer lines or lift stations)	D01	D01-01	A	Low	C	Assume area connected to municipal sewage
Airports	X14	X14-01	D	Medium	C	

*Contaminant Source Inventory and Risk Ranking for
Bethel Community Services
Sources of Other Organic Chemicals*

PWSID 271091.001

Table 7
















<i>Contaminant Source Type</i>	<i>Contaminant Source ID</i>	<i>CS ID tag</i>	<i>Zone</i>	<i>Risk Ranking for Analysis</i>	<i>Map Number</i>	<i>Comments</i>
Domestic wastewater collection systems (sewer lines or lift stations)	D01	D01-01	A	Low	C	Assume area connected to municipal sewage
Highways and roads, dirt/gravel	X24	X24-01	A	Low	C	Assume 1-20 roads in Zone A
Highways and roads, dirt/gravel	X24	X24-02	B	Low	C	Assume 1-20 roads in Zone B
Highways and roads, dirt/gravel	X24	X24-03	C	Low	C	Assume 1-20 roads in Zone C
Airports	X14	X14-01	D	Medium	C	

APPENDIX C

Drinking Water Protection Area and Potential and Existing Contaminant Sources (Map C)

**Public Water Well System for PWS #271091.001 Bethel Community Services
Showing Potential and Existing Sources of Contamination**

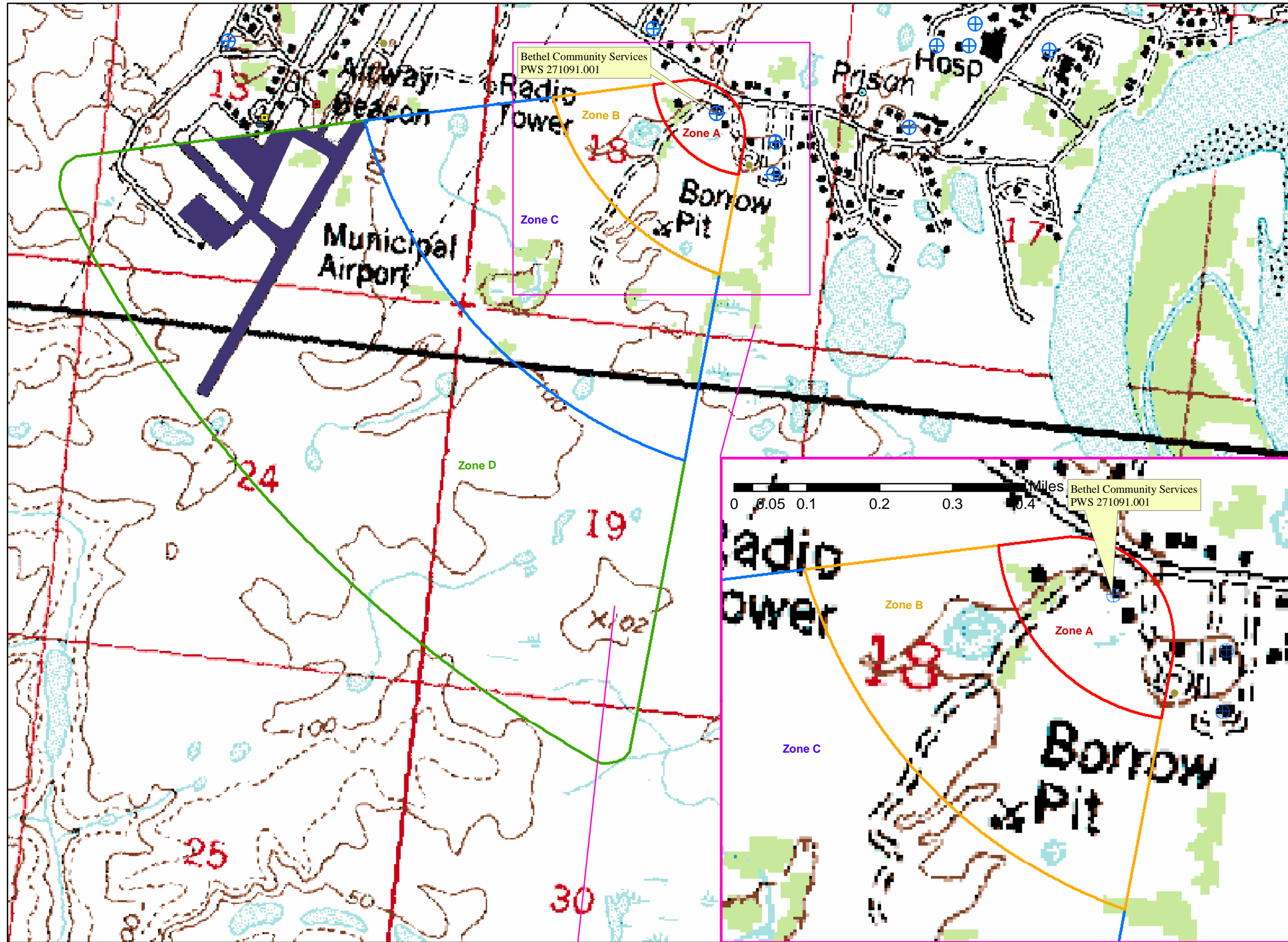
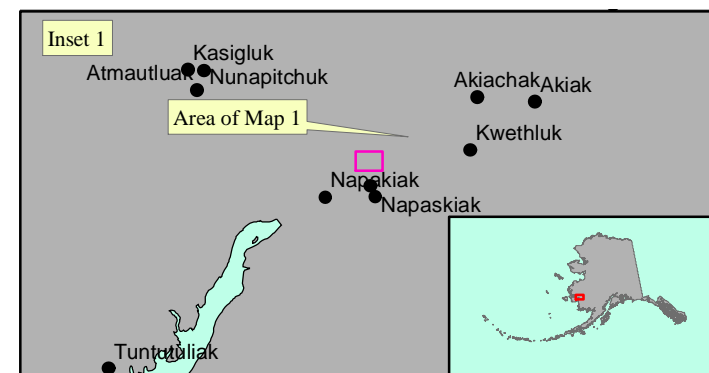
LEGEND

-  Public Water System Well
- Transportation**
-  Primary Route (Class 1)
-  Secondary Route (Class 2)
-  Road (Class 3)
-  Road (Class 4)
-  Road (Class 5, Four-wheel drive)
- Hydrography/Physical**
-  Parcels
-  Stream
-  Lake or Pond
-  Contours
- Groundwater Protection Zones**
-  Zone A Protection Area— Several Months Travel Time
-  Zone B Protection Area— 2 Years Travel Time
-  Zone C Protection Area— 5 Years Travel Time
-  Zone D Protection Area— 10 Years Travel Time
- Existing or Potential Contaminant Sources**
-  Airports/landing strips (X14)

Data Sources:
 Contaminant Sources, Public Water System Wells, Contours
 Alaska Department of Environmental Conservation (ADEC)
 Critical Facilities, Federal Emergency Management Agency (FEMA)

All other data:
 United States Geological Survey (USGS)
 Drinking Water Protection Areas based on "Alaska Drinking
 Water Protection Program - Guidance Manual for Class B
 Public Water Systems" published by ADEC

URS Corporation does not guarantee the accuracy or
 validity of the data provided.



APPENDIX D

Vulnerability Analysis for Public Drinking Water Source (Charts 1-14)

Chart 1. Susceptibility of the wellhead - Bethel Community Services (PWS No. 271091.001)

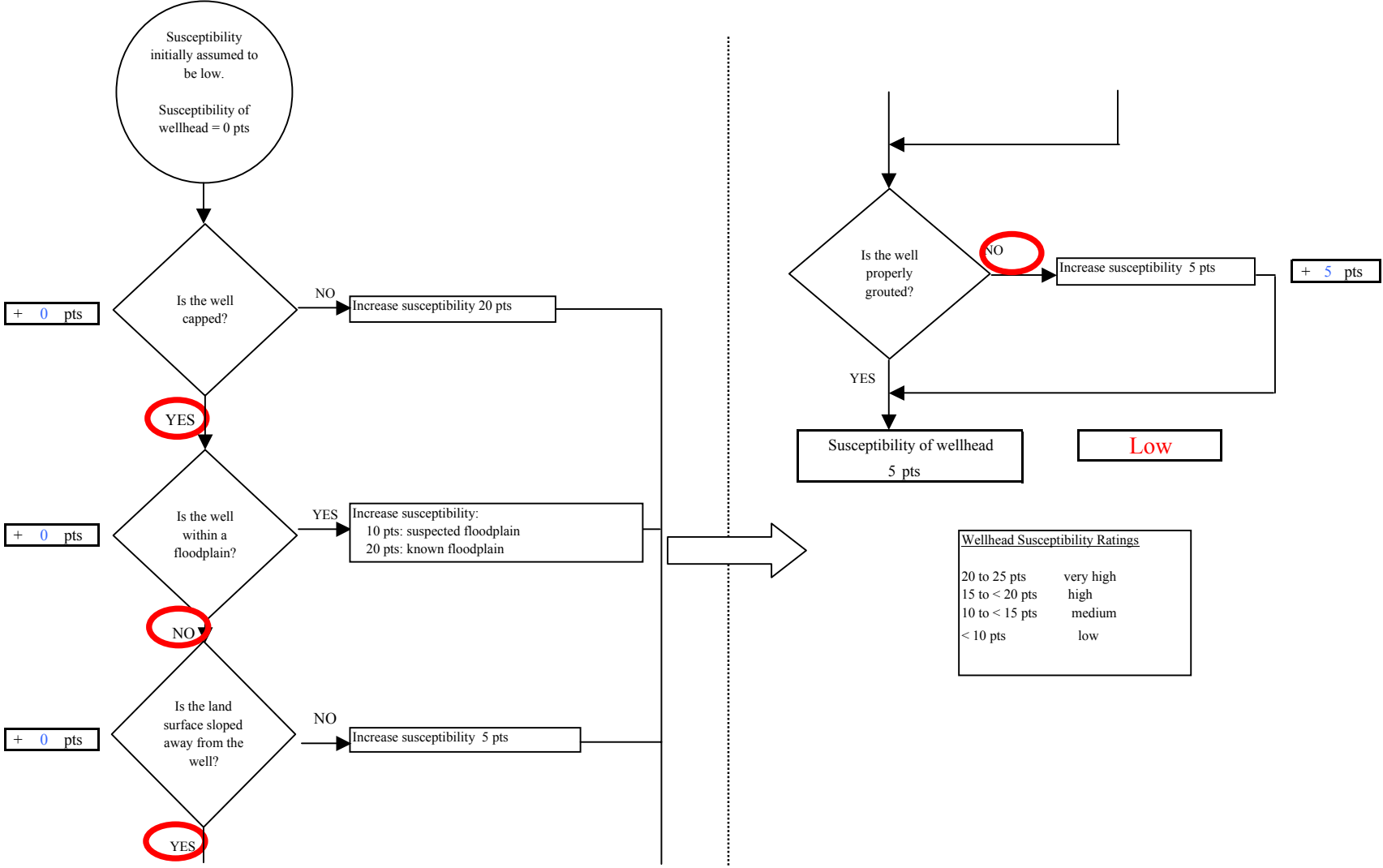


Chart 2. Susceptibility of the aquifer Bethel Community Services (PWS No. 271091.001)

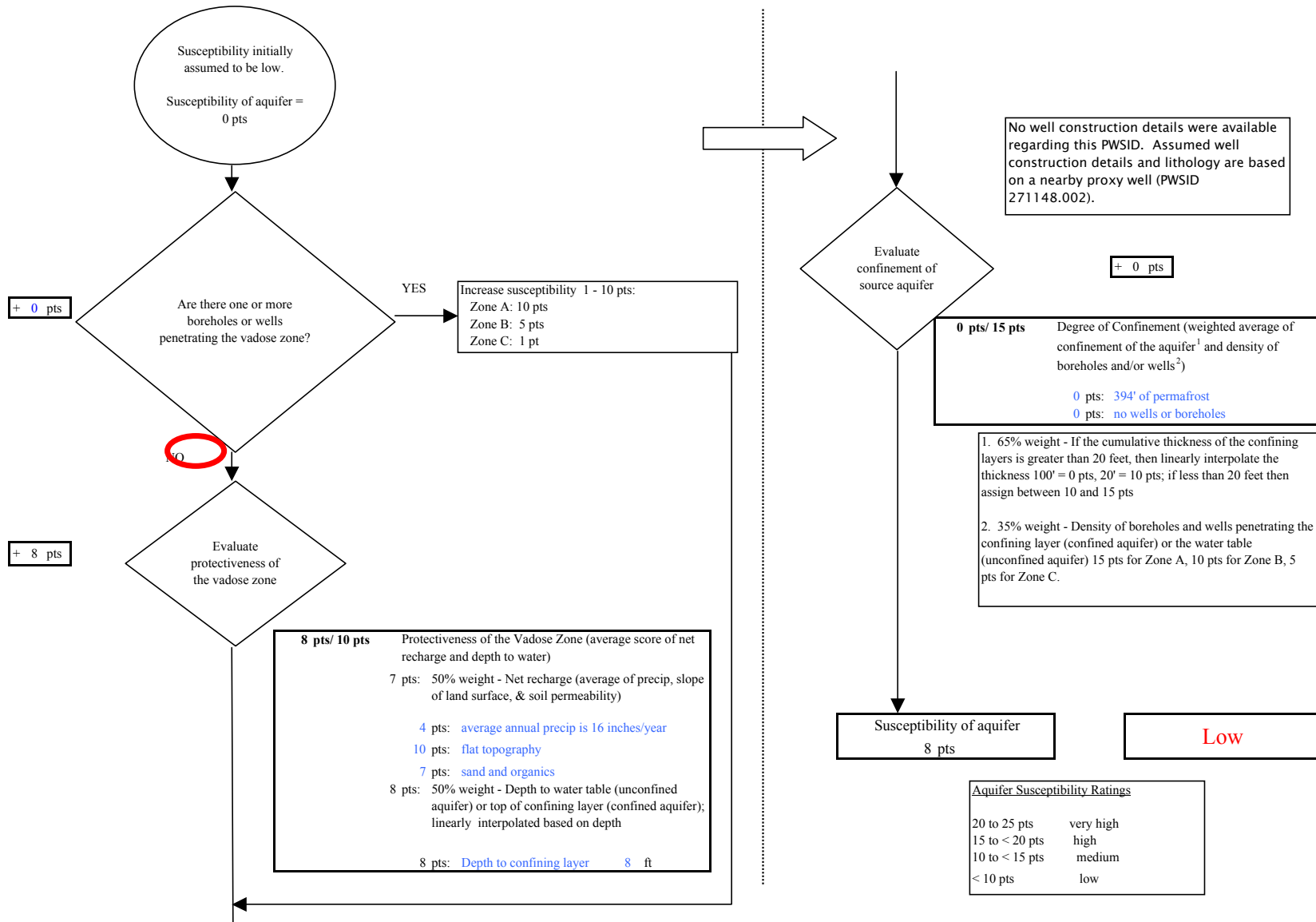


Chart 3. Contaminant risks for Bethel Community Services (PWS No. 271091.001) - Bacteria & Viruses

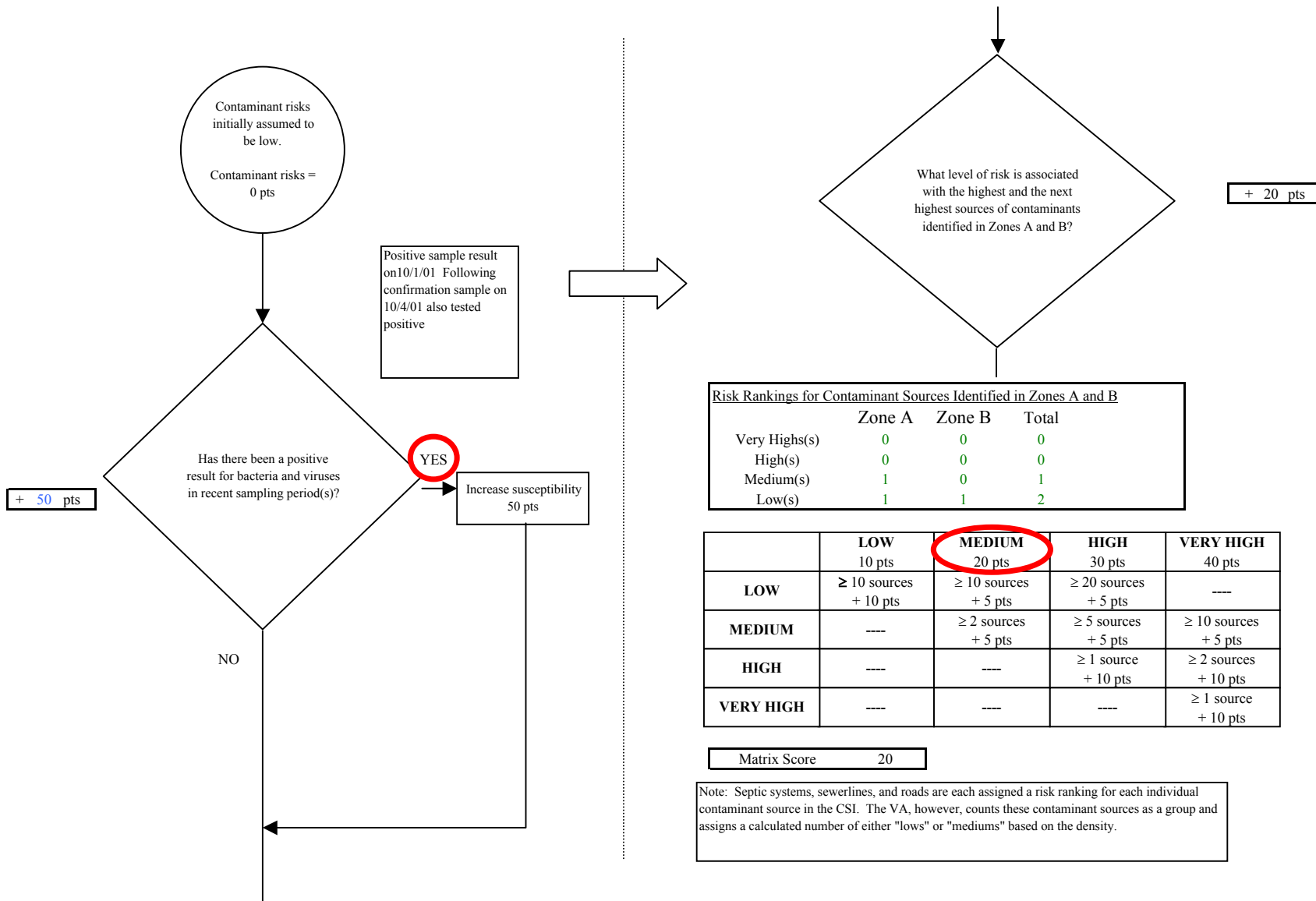
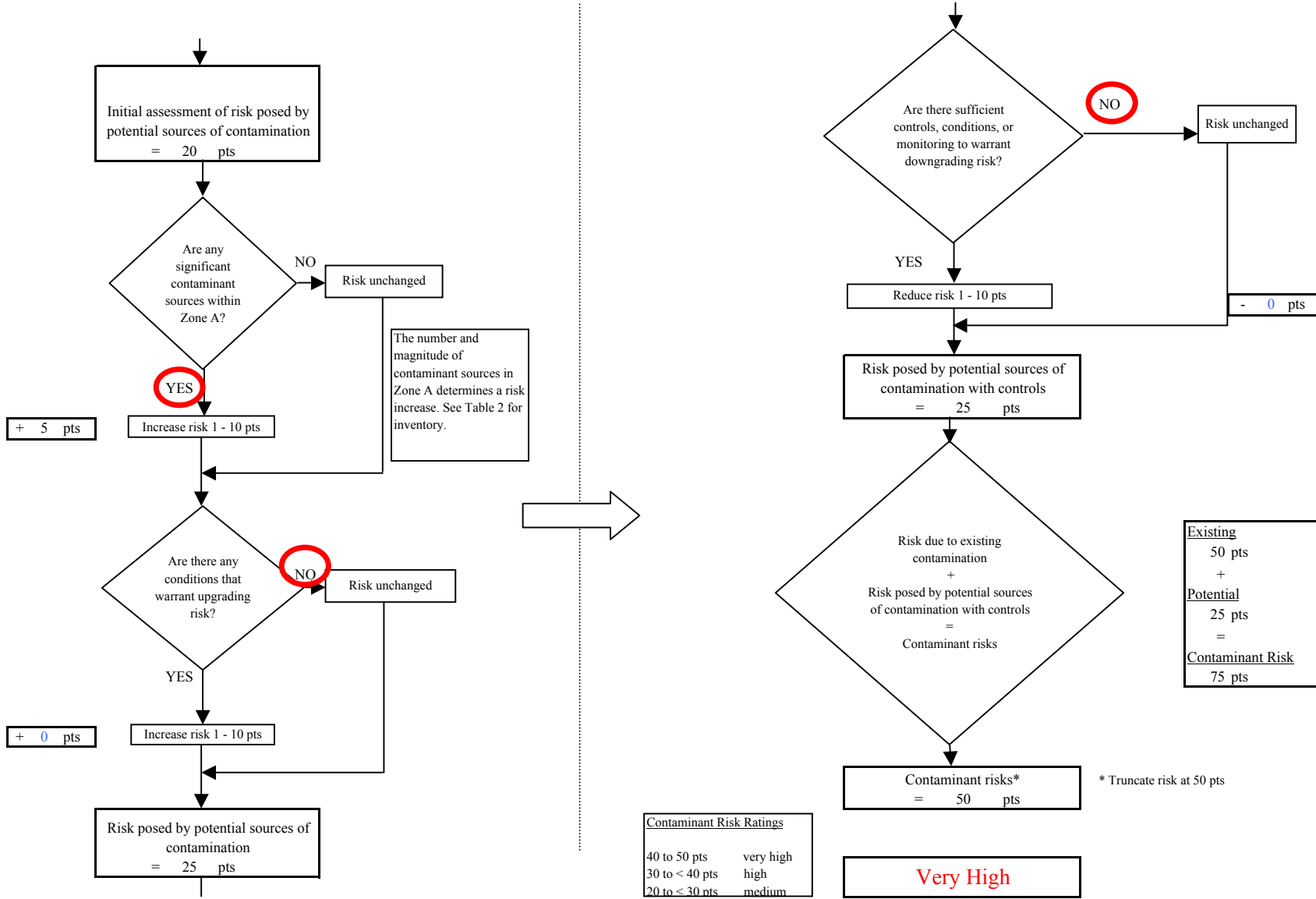


Chart 3. Contaminant risks for Bethel Community Services (PWS No. 271091.001) - Bacteria & Viruses



Contaminant Risk Ratings	
40 to 50 pts	very high
30 to < 40 pts	high
20 to < 30 pts	medium

Chart 4. Vulnerability analysis for Bethel Community Services (PWS No. 271091.001) - Bacteria & Viruses

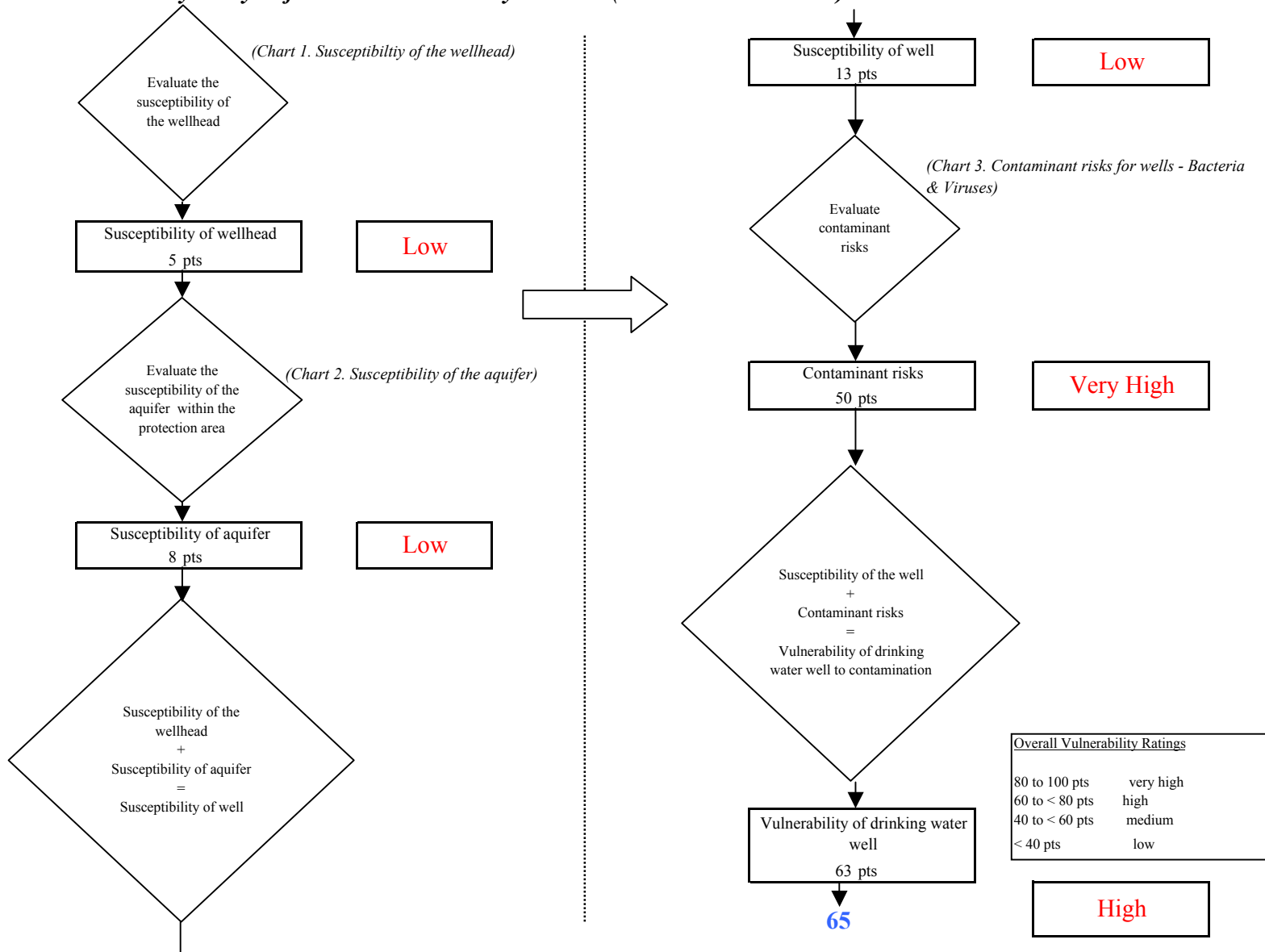


Chart 5. Contaminant risks for Bethel Community Services (PWS No. 271091.001) - Nitrates and Nitrites

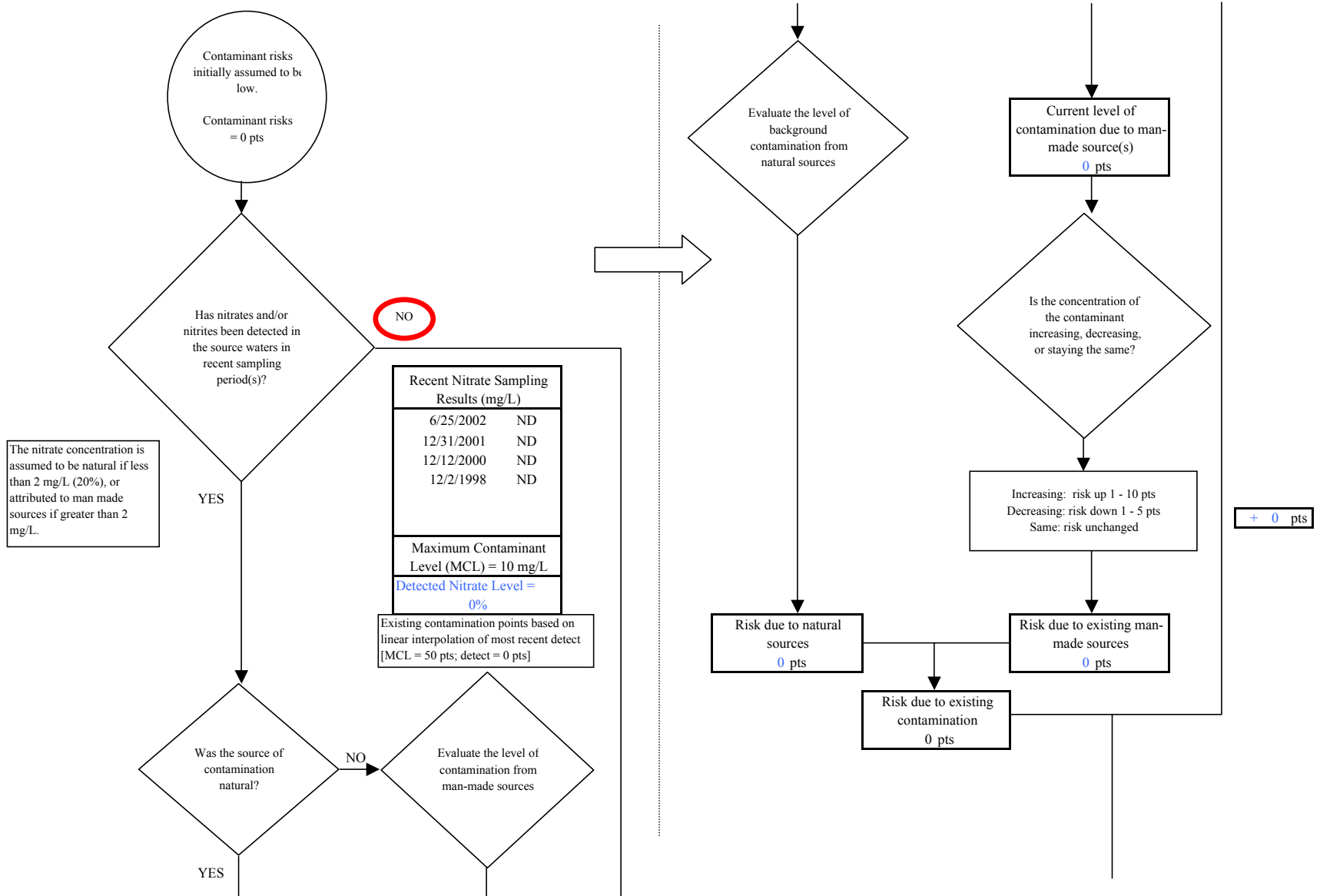


Chart 5. Contaminant risks for Bethel Community Services (PWS No. 271091.001) - Nitrates and Nitrites

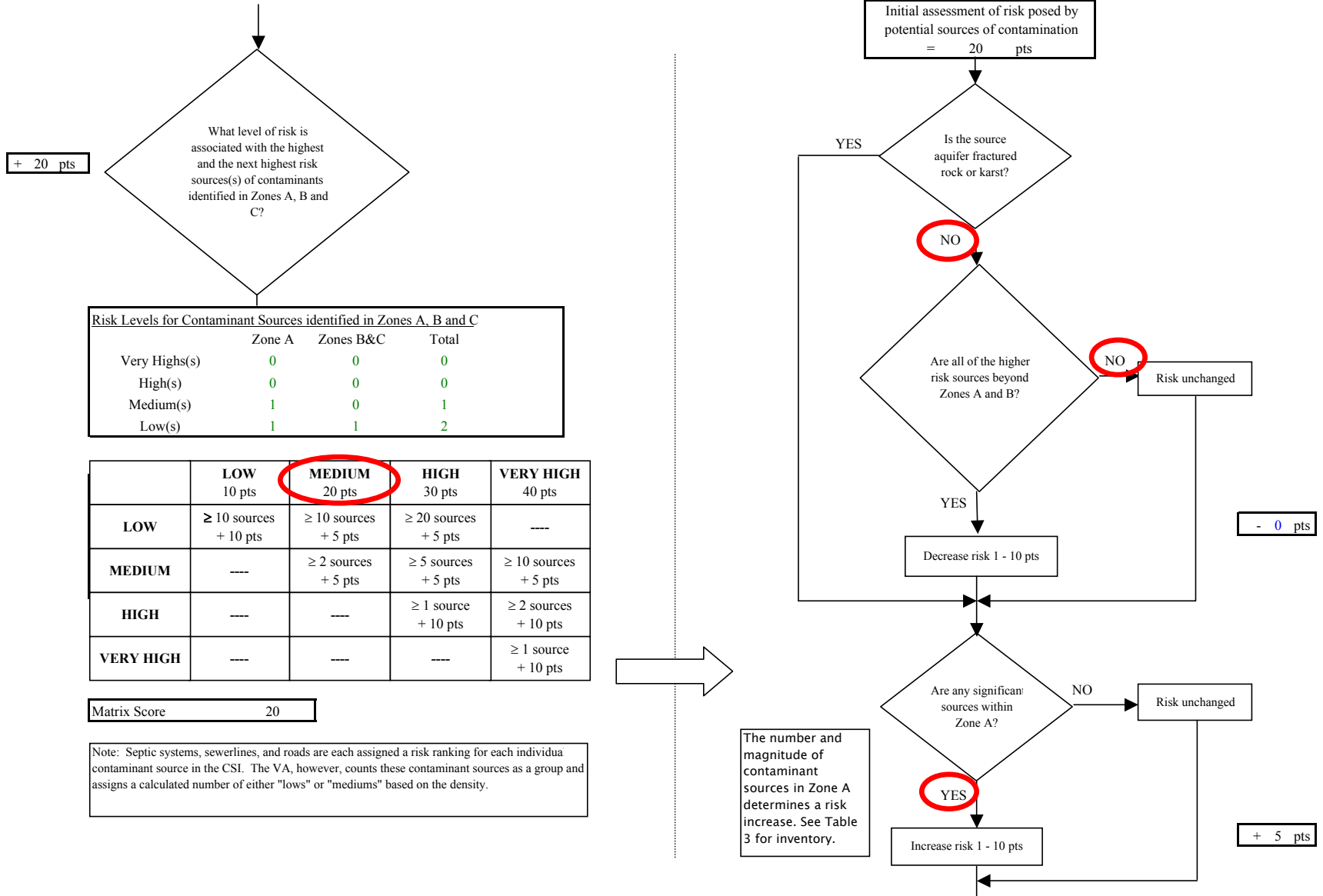


Chart 5. Contaminant risks for Bethel Community Services (PWS No. 271091.001) - Nitrates and Nitrites

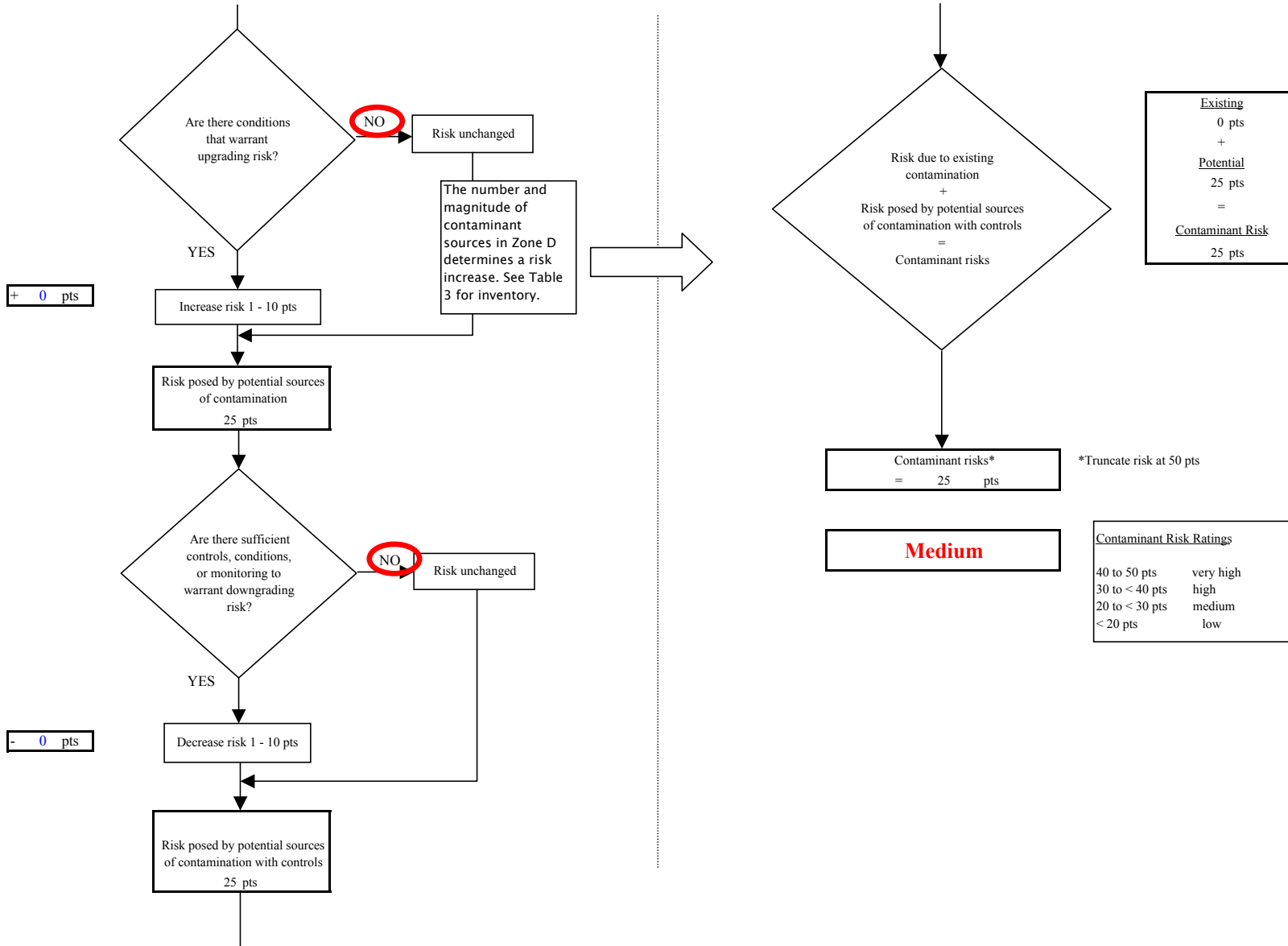


Chart 6. Vulnerability analysis for Bethel Community Services (PWS No. 271091.001) - Nitrates and Nitrites

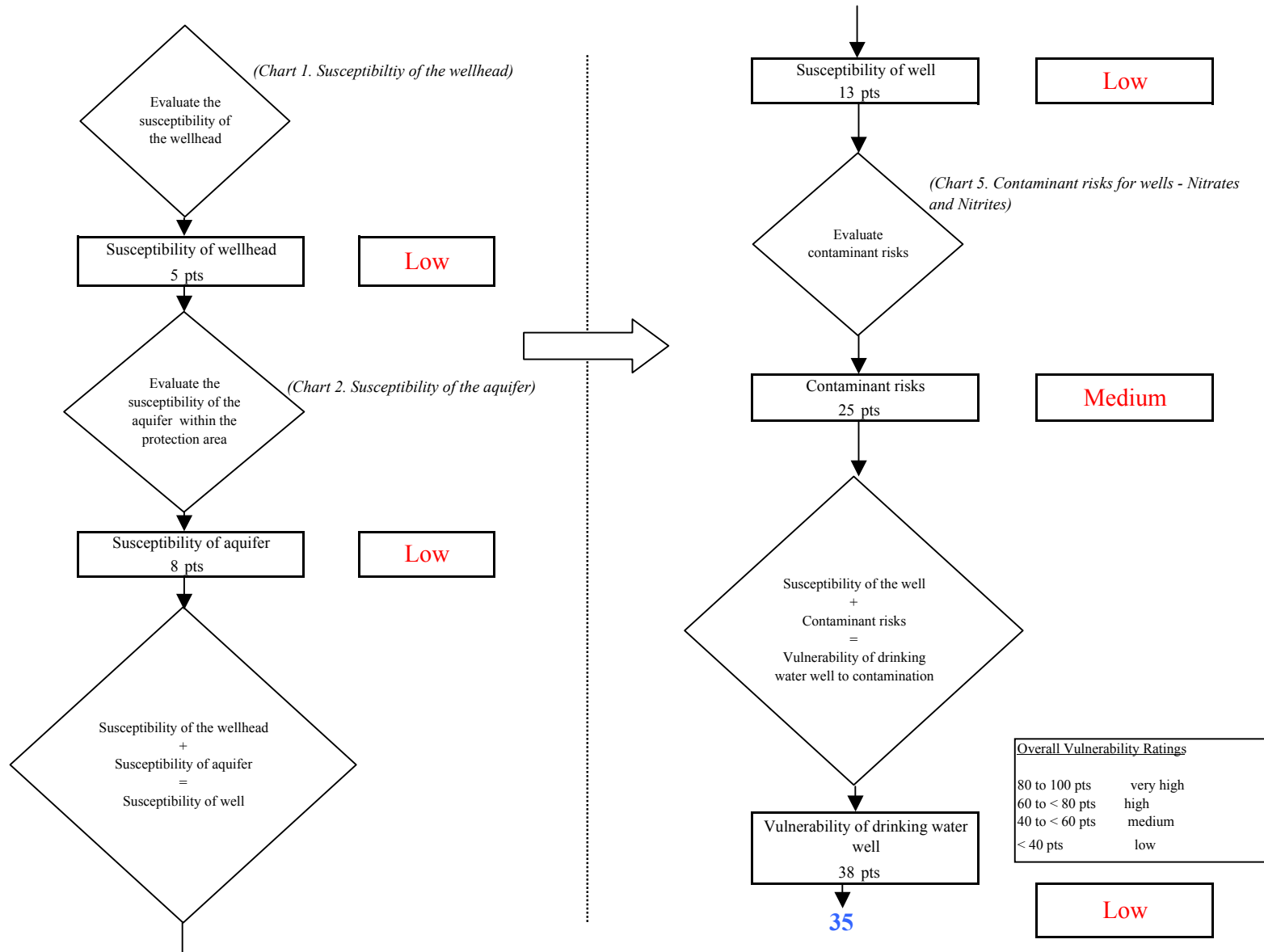


Chart 7. Contaminant risks for Bethel Community Services (PWS No. 271091.001) - Volatile Organic Chemicals

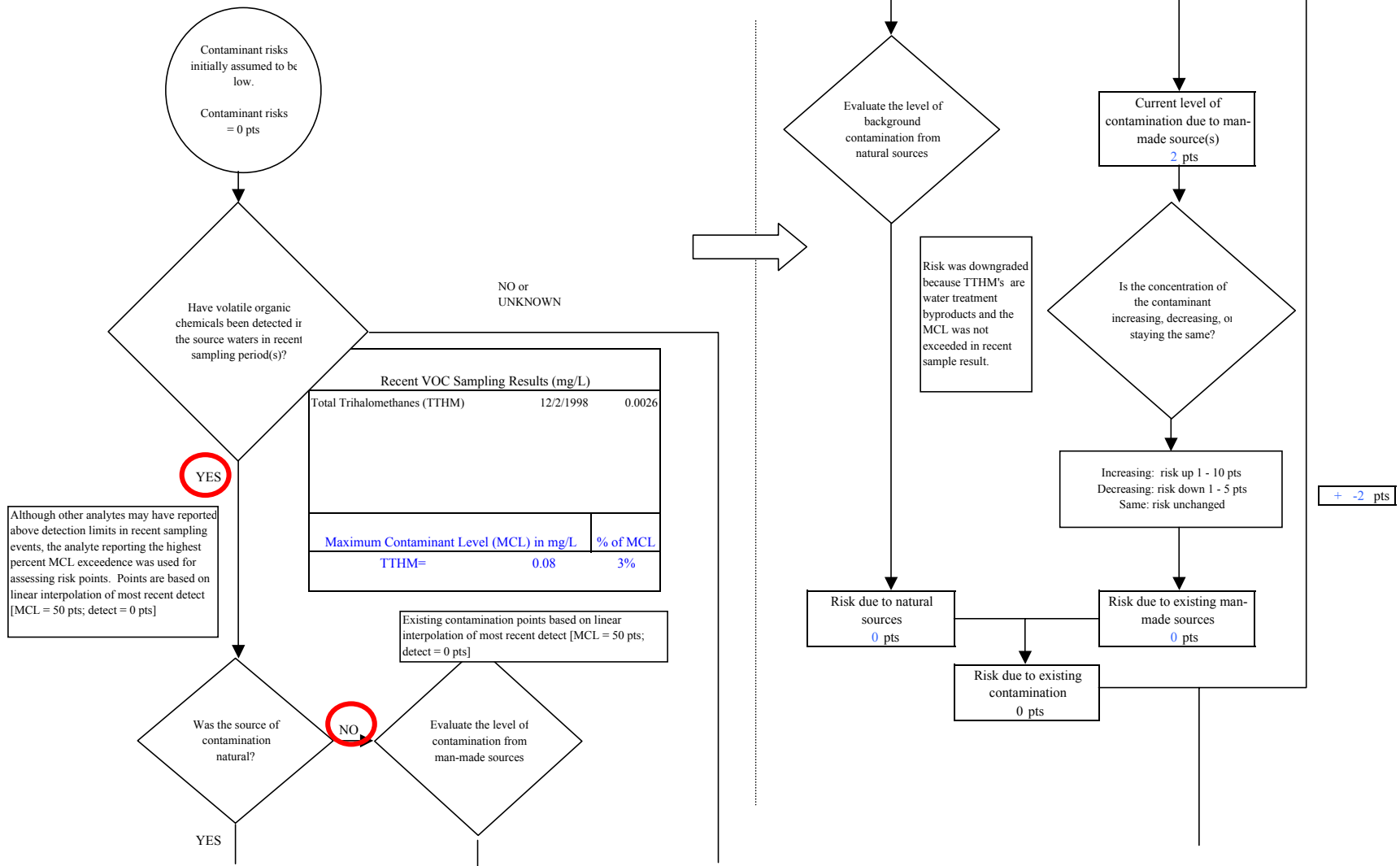


Chart 7. Contaminant risks for Bethel Community Services (PWS No. 271091.001) - Volatile Organic Chemicals

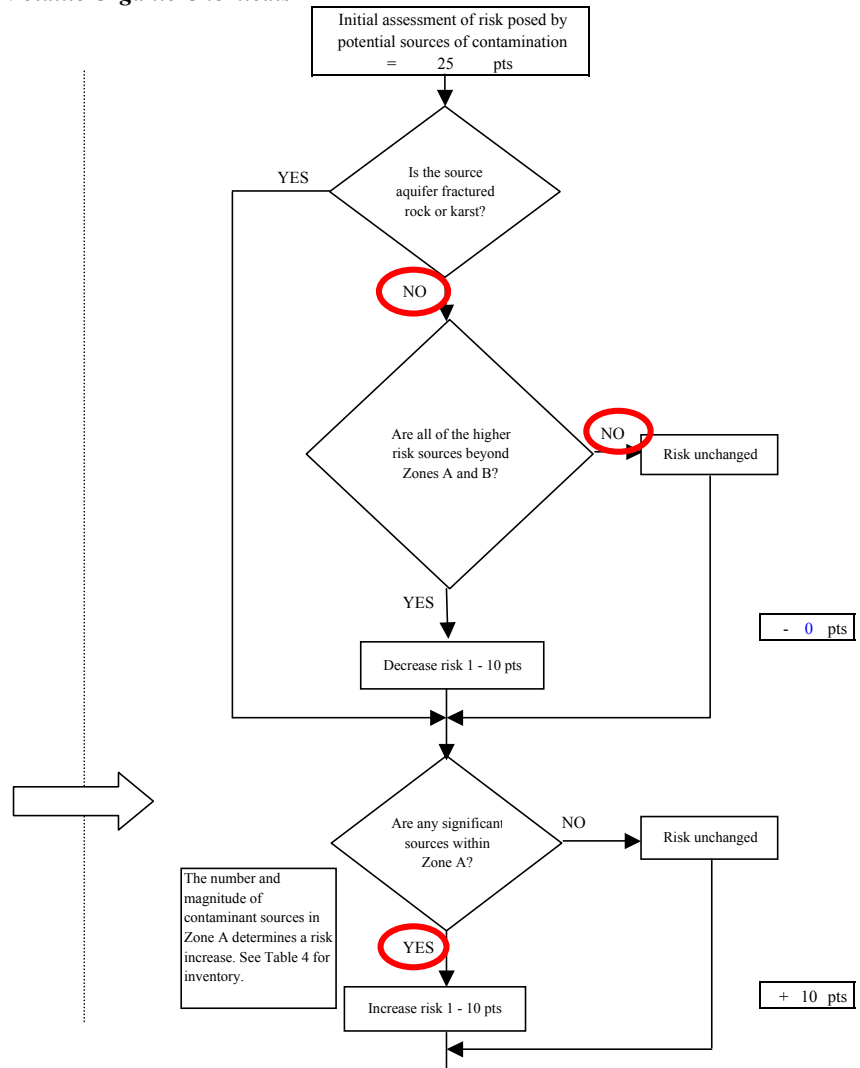
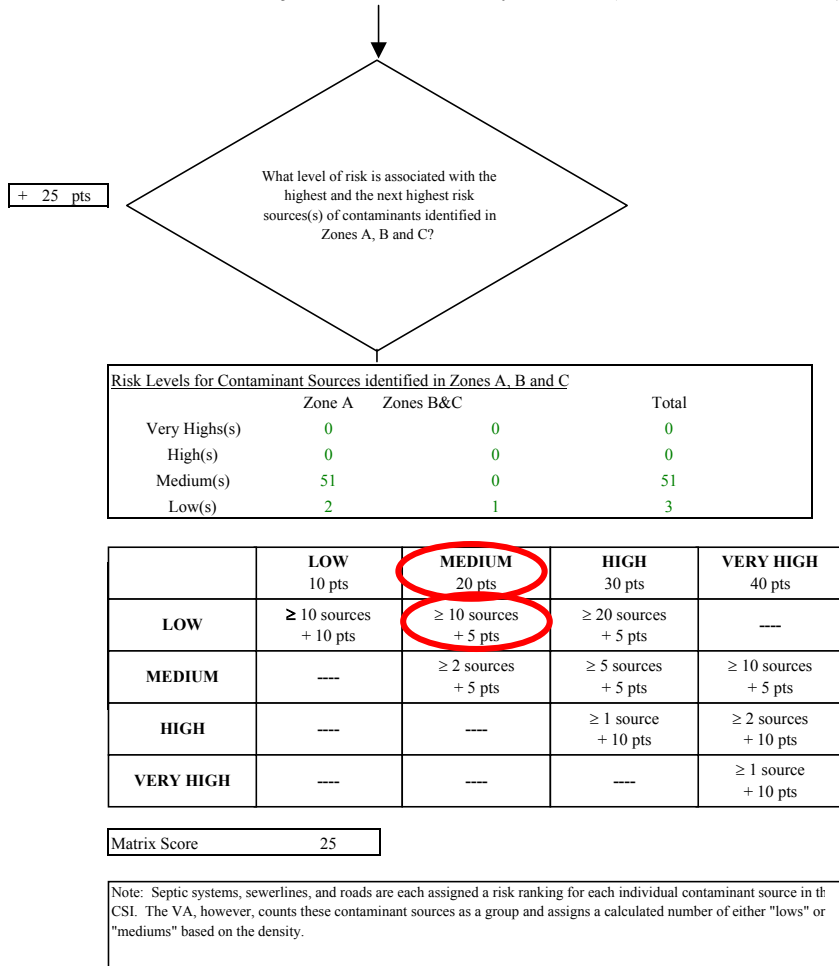


Chart 7. Contaminant risks for Bethel Community Services (PWS No. 271091.001) - Volatile Organic Chemicals

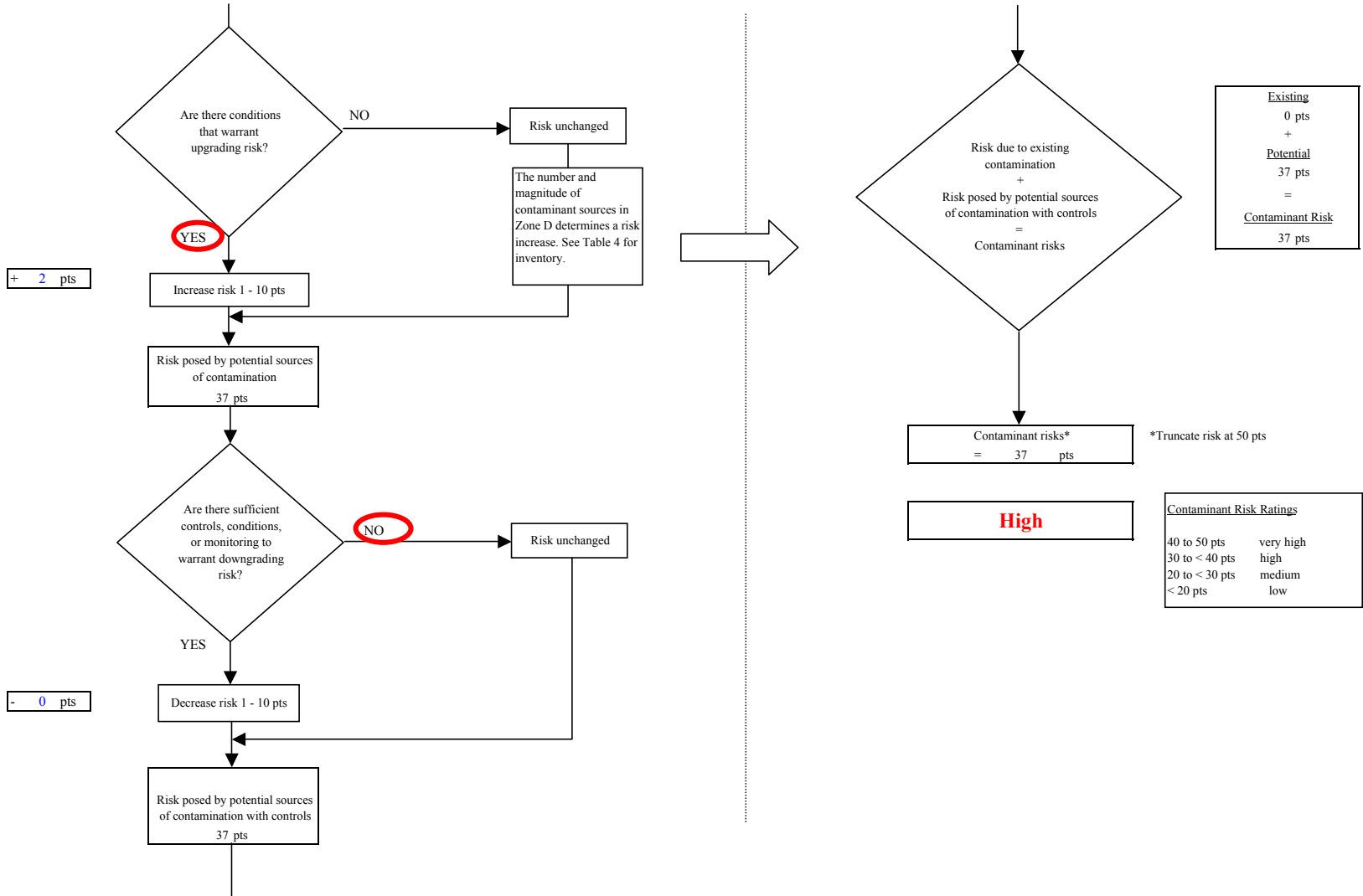


Chart 8. Vulnerability analysis for Bethel Community Services (PWS No. 271091.001) - Volatile Organic Chemicals

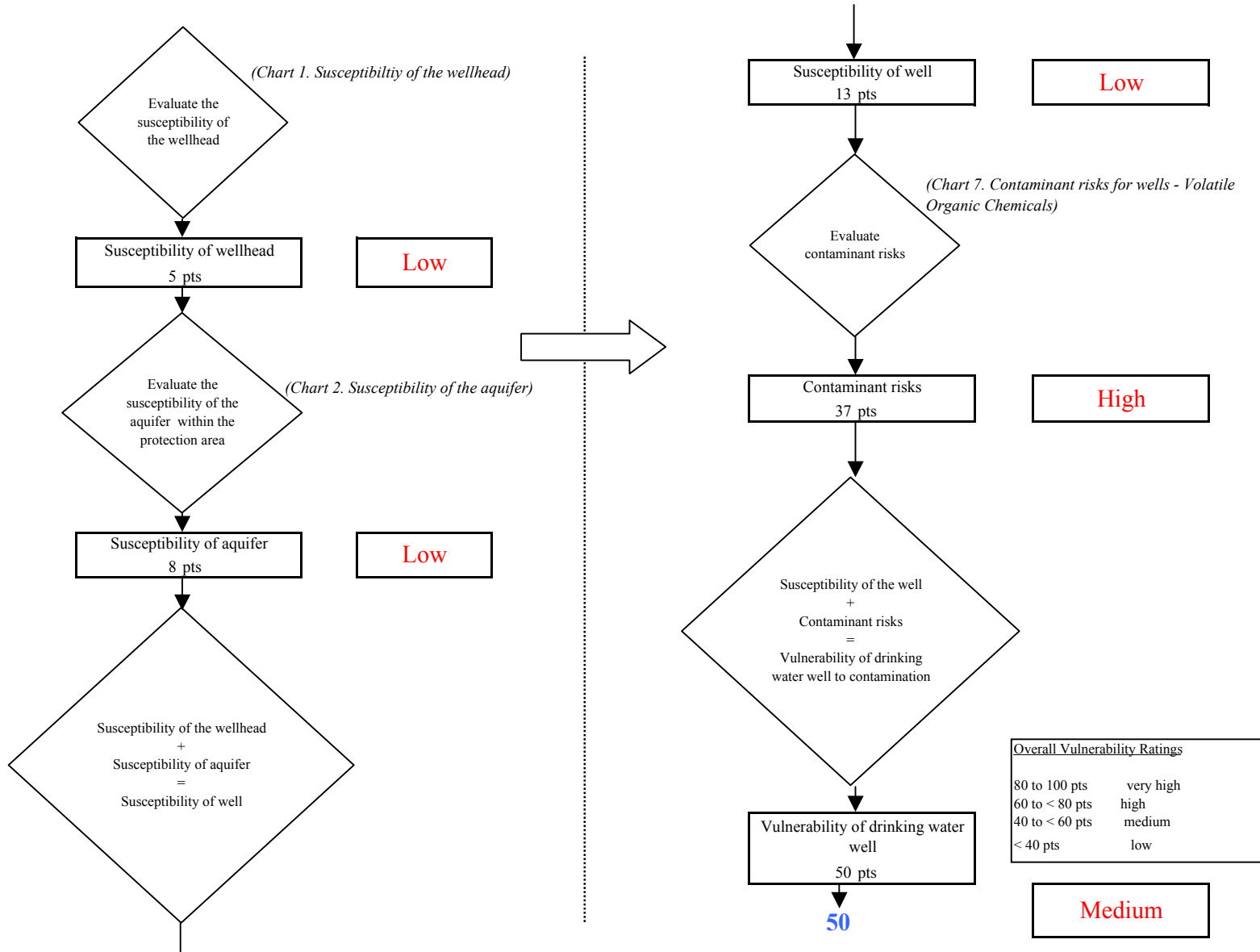


Chart 9. Contaminant risks for Bethel Community Services (PWS No. 271091.001) - Heavy Metals, Cyanide and Other Inorganic Chemicals

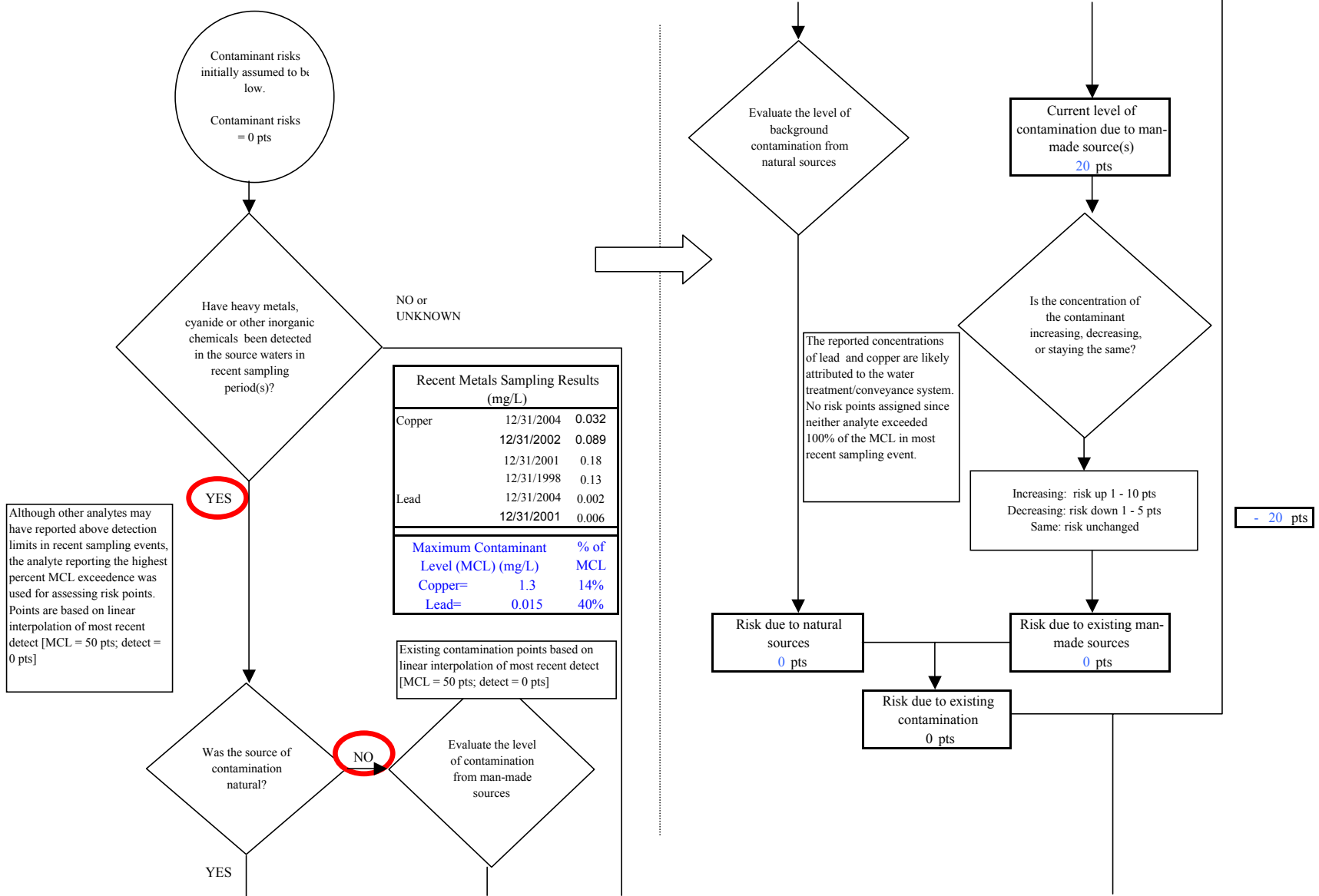


Chart 9. Contaminant risks for Bethel Community Services (PWS No. 271091.001) - Heavy Metals, Cyanide and Other Inorganic Chemicals

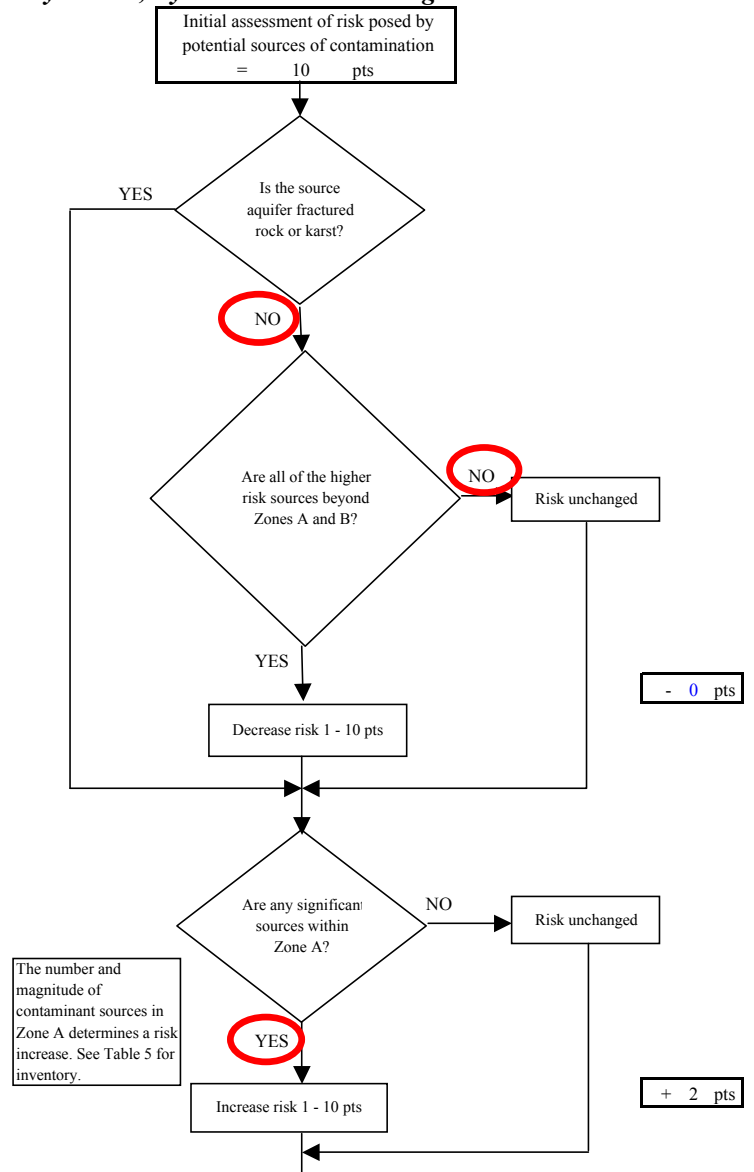
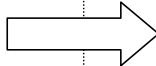
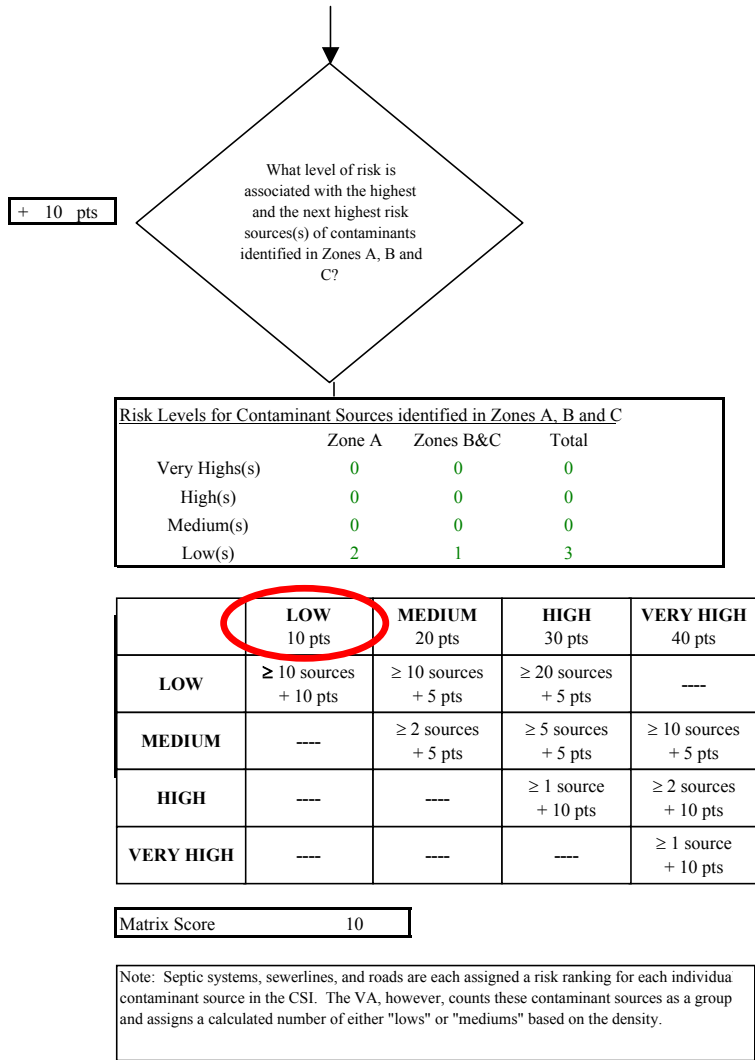


Chart 9. Contaminant risks for Bethel Community Services (PWS No. 271091.001) - Heavy Metals, Cyanide and Other Inorganic Chemicals

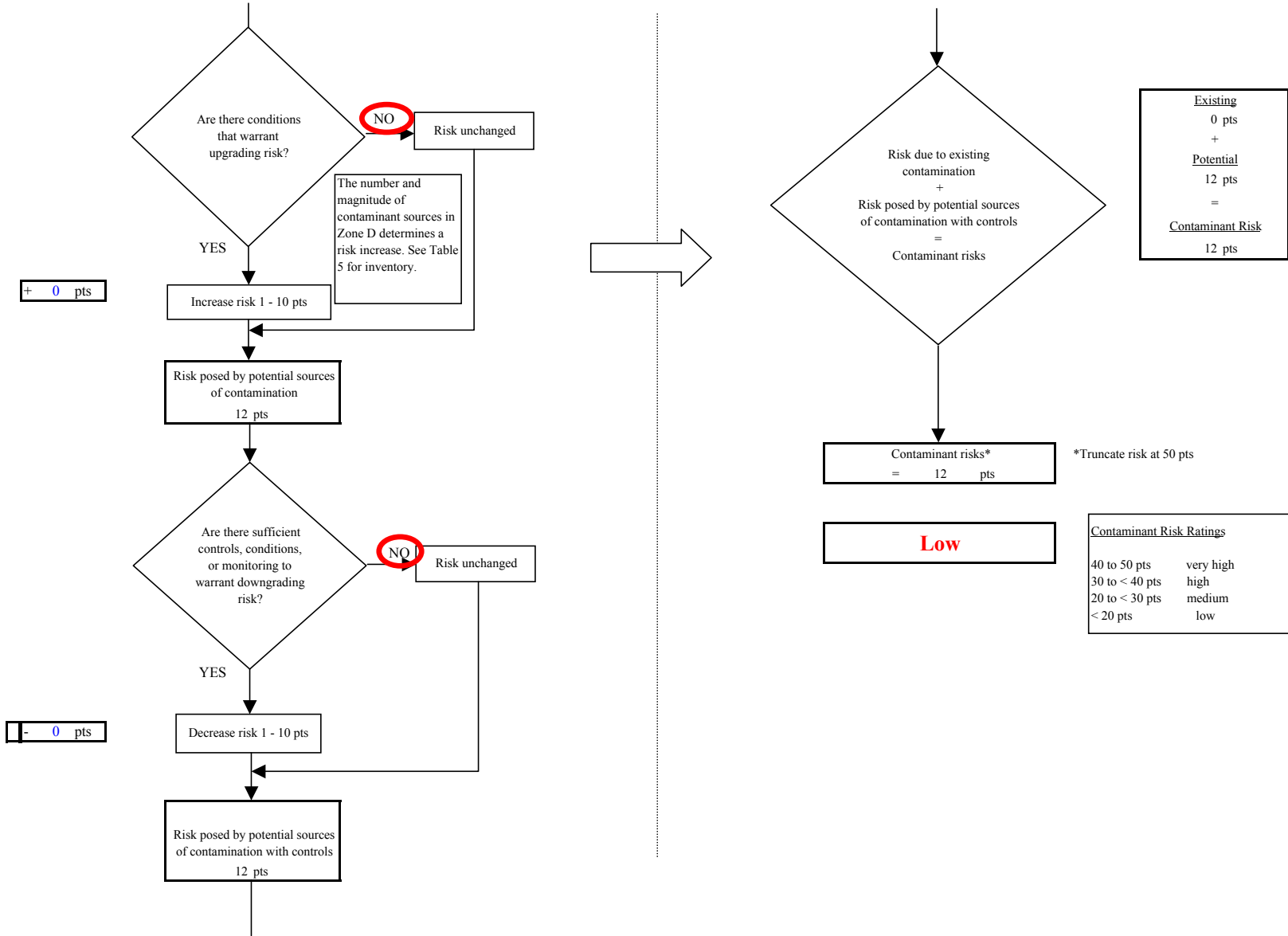


Chart 10. Vulnerability analysis for Bethel Community Services (PWS No. 271091.001) - Heavy Metals, Cyanide and Other Inorganic Chemicals

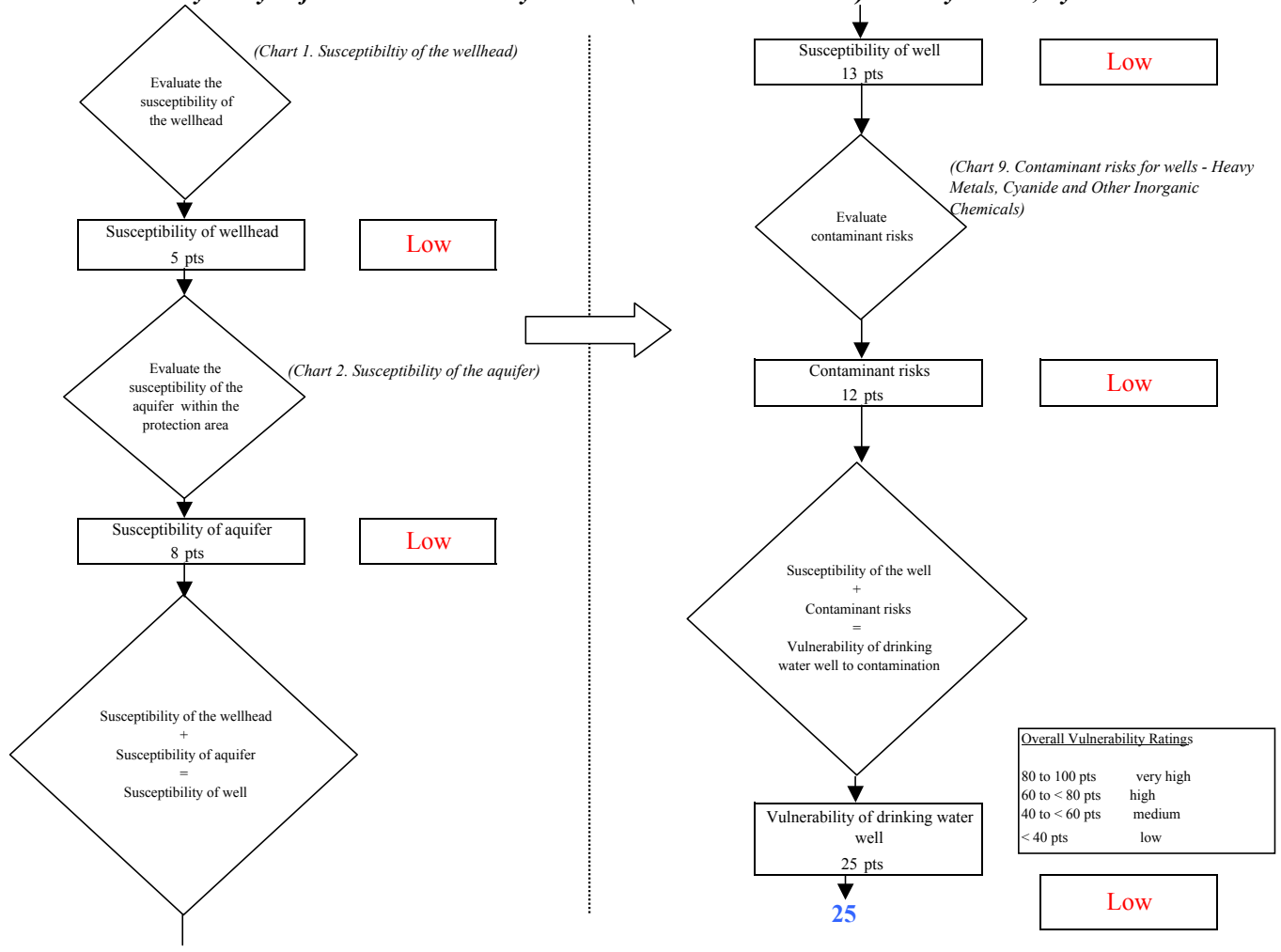


Chart 11. Contaminant risks for Bethel Community Services (PWS No. 271091.001) - Synthetic Organic Chemicals

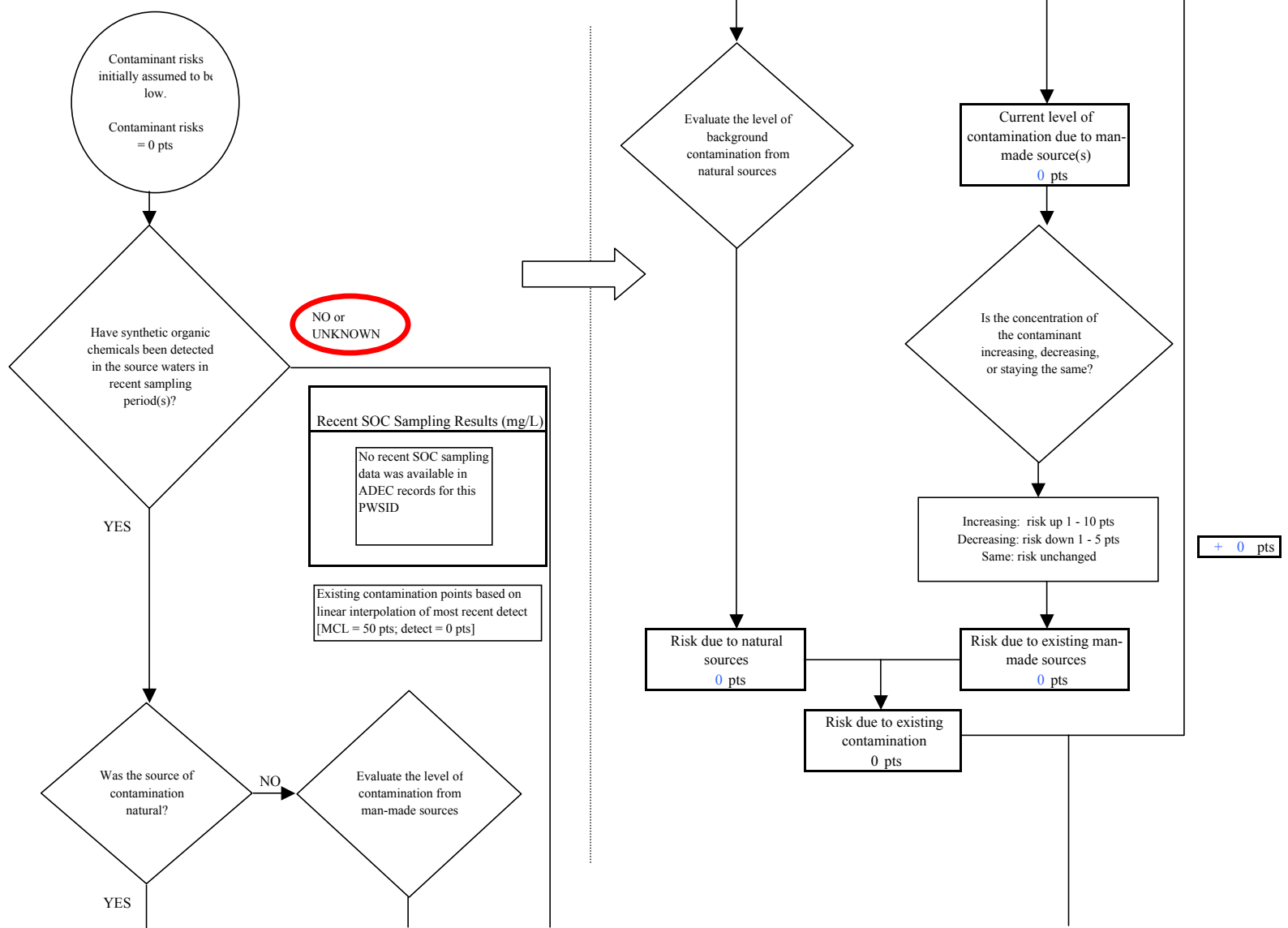


Chart 11. Contaminant risks for Bethel Community Services (PWS No. 271091.001) - Synthetic Organic Chemicals

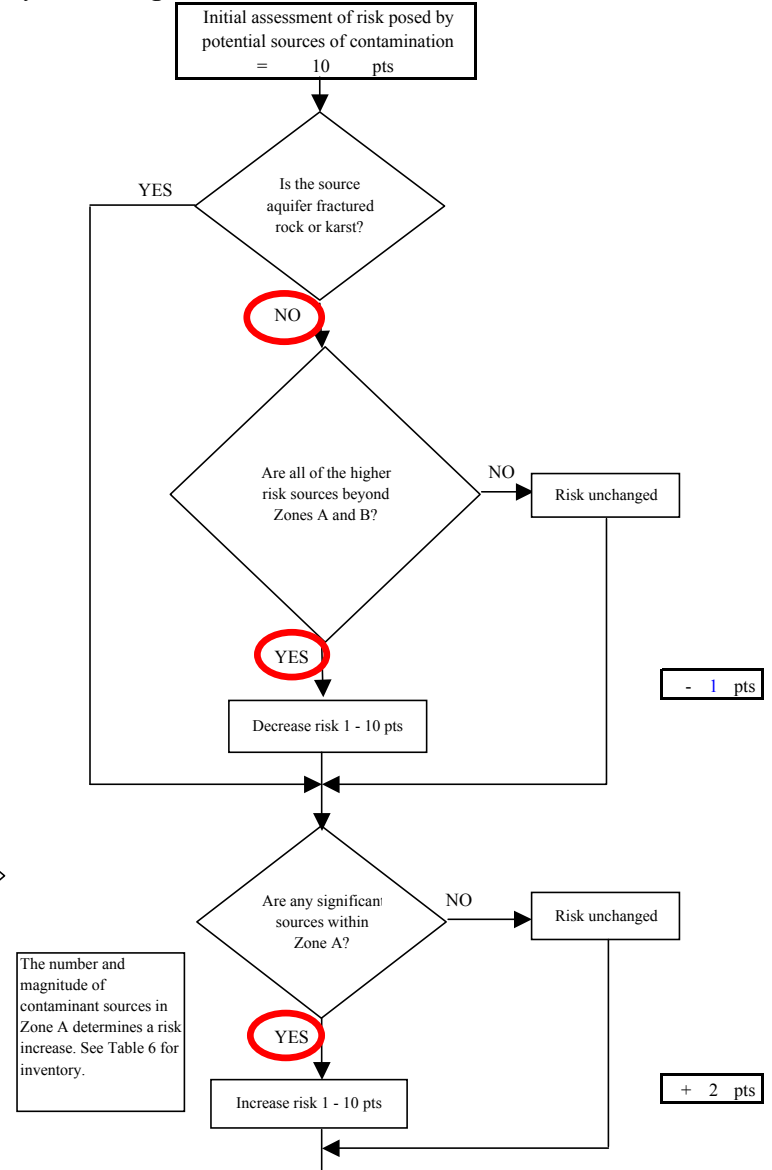
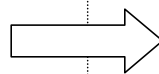
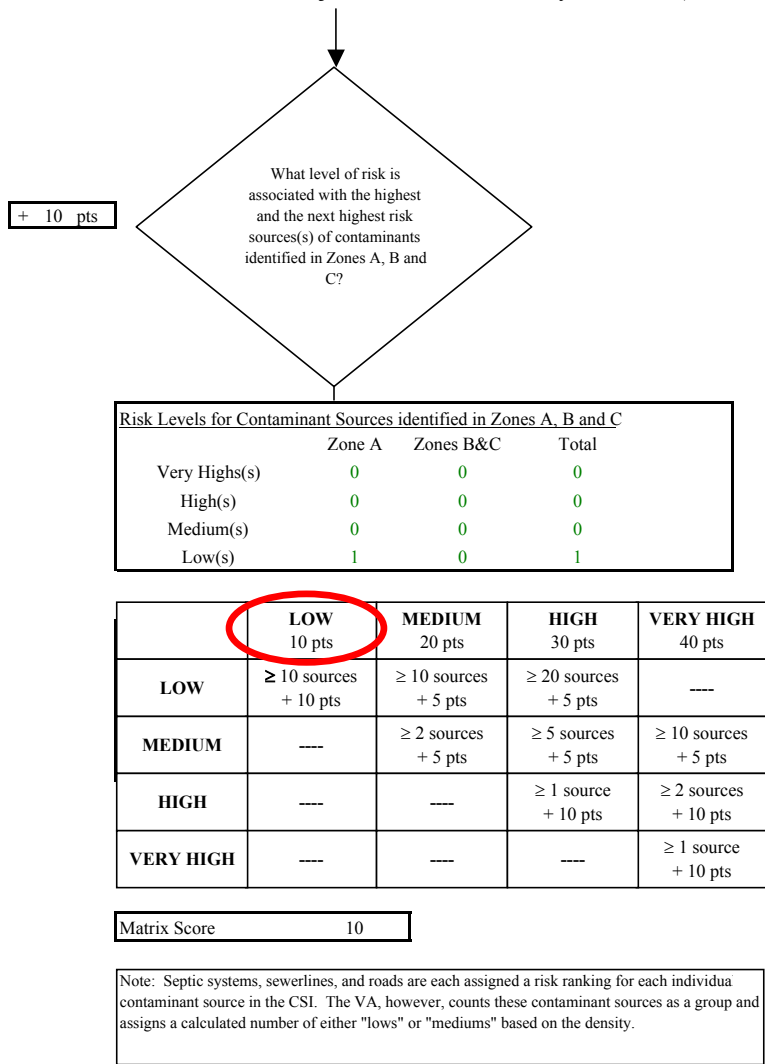


Chart 11. Contaminant risks for Bethel Community Services (PWS No. 271091.001) - Synthetic Organic Chemicals

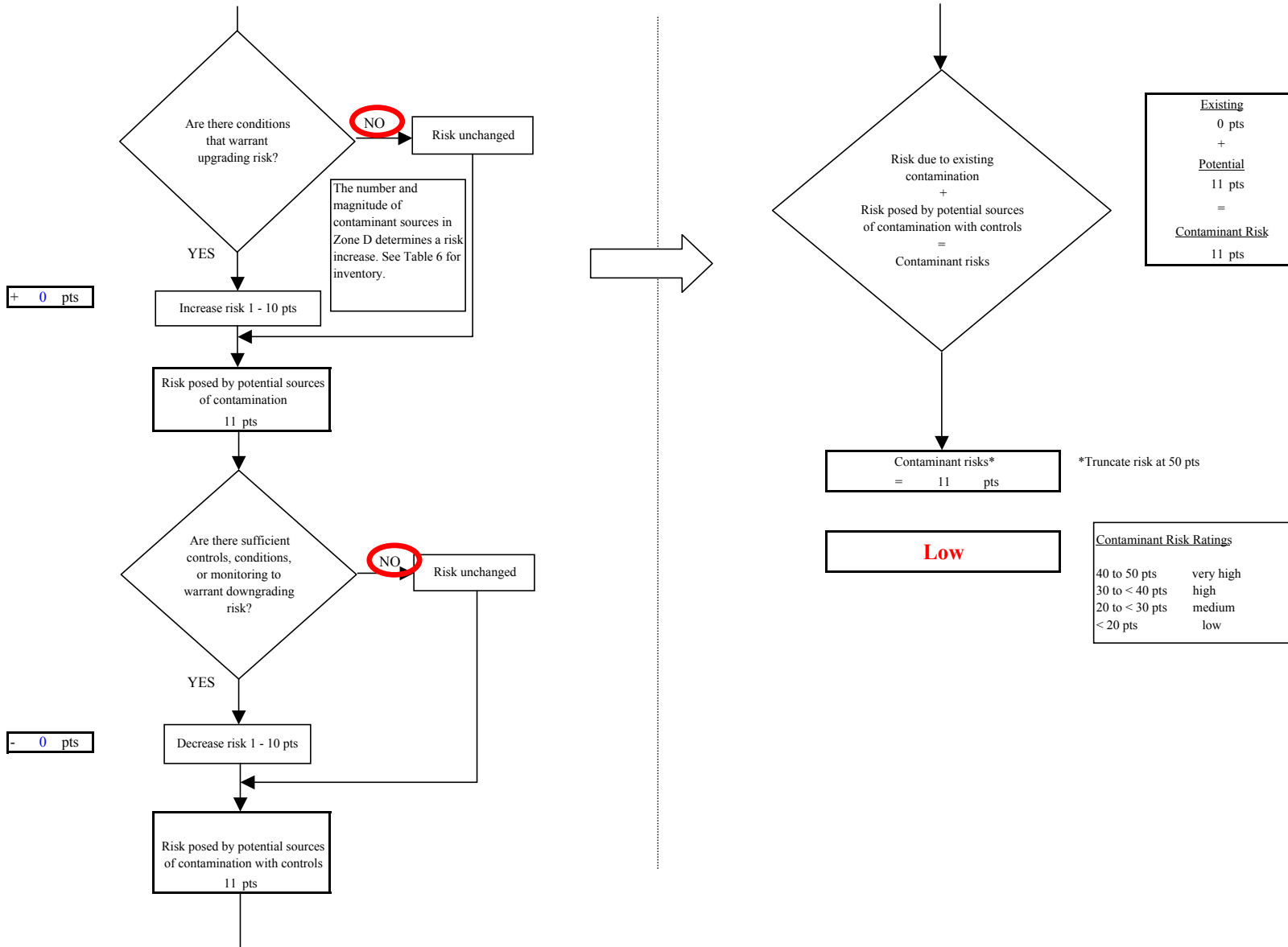


Chart 12. Vulnerability analysis for Bethel Community Services (PWS No. 271091.001) - Synthetic Organic Chemicals

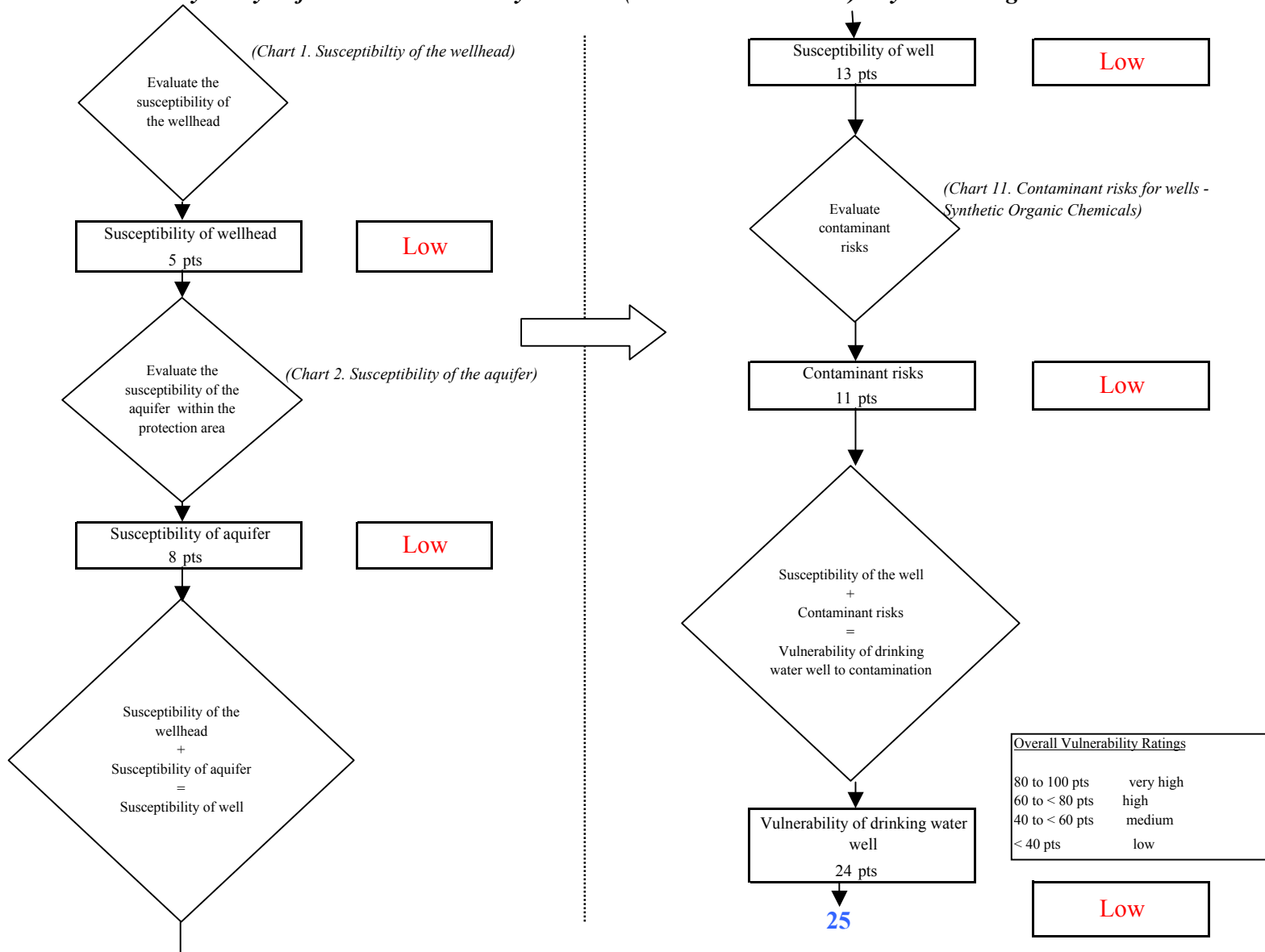


Chart 13. Contaminant risks for Bethel Community Services (PWS No. 271091.001) - Other Organic Chemicals

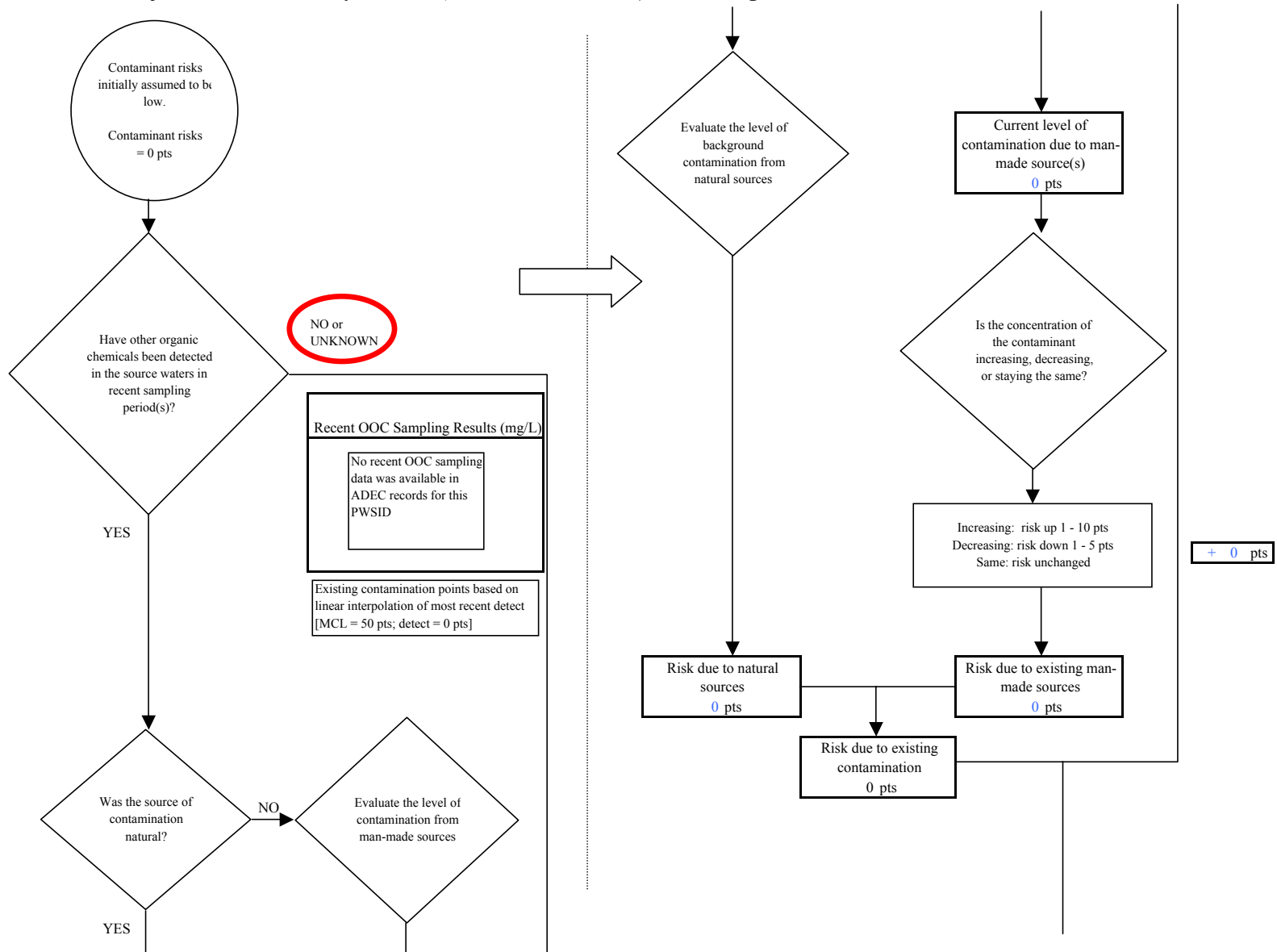


Chart 13. Contaminant risks for Bethel Community Services (PWS No. 271091.001) - Other Organic Chemicals

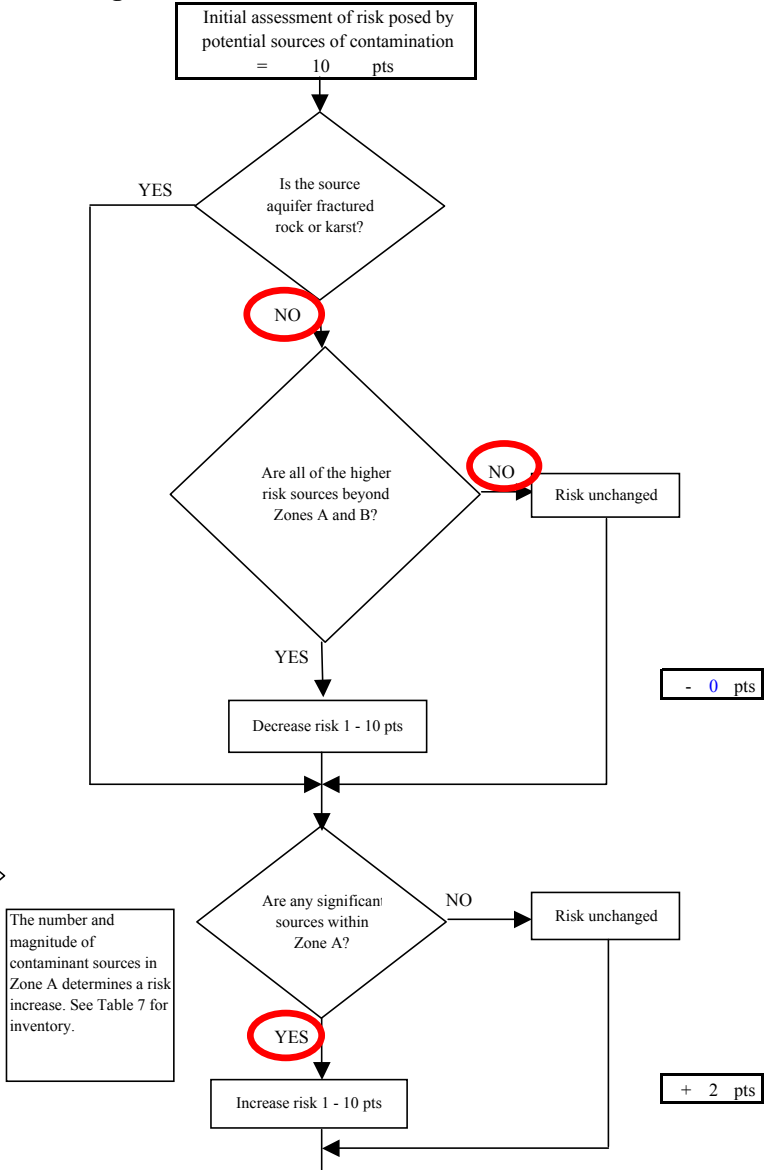
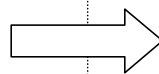
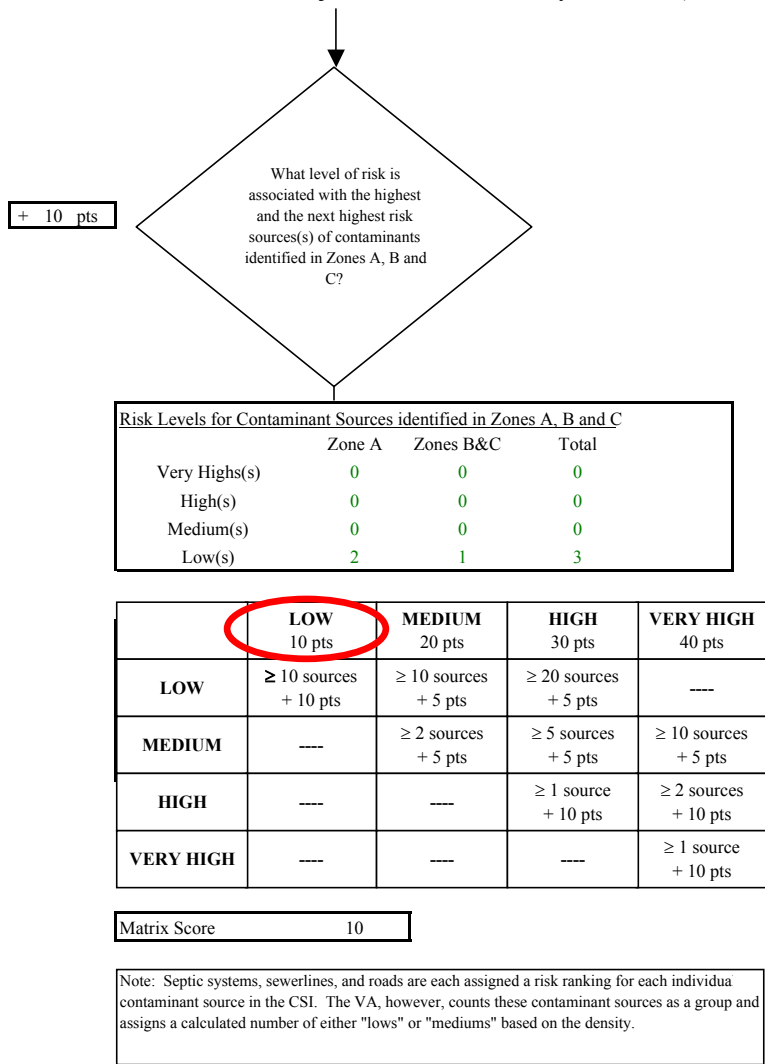


Chart 13. Contaminant risks for Bethel Community Services (PWS No. 271091.001) - Other Organic Chemicals

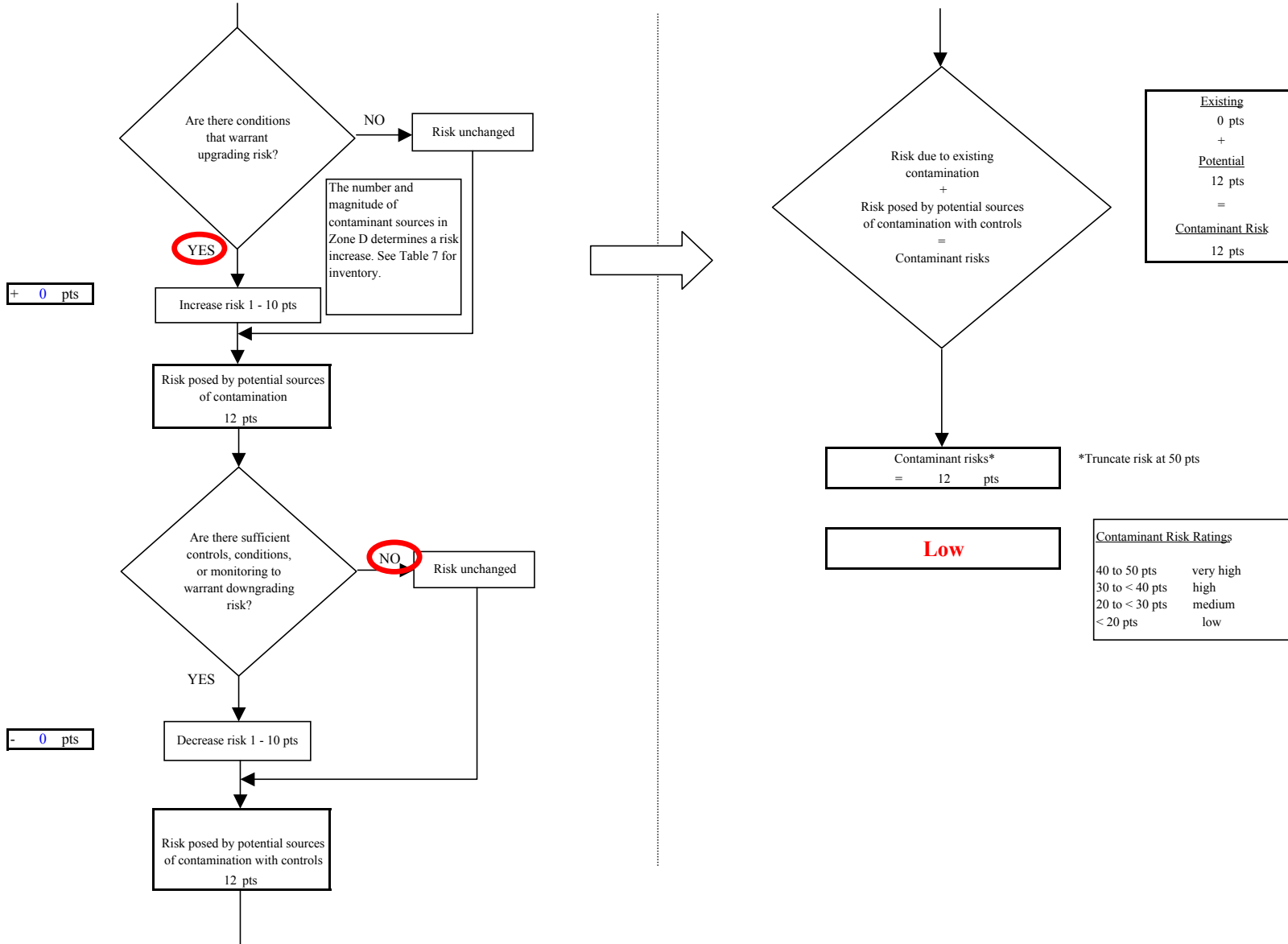


Chart 14. Vulnerability analysis for Bethel Community Services (PWS No. 271091.001) - Other Organic Chemicals

