Source Water Assessment

A Hydrogeologic Susceptibility and Vulnerability Assessment for Moose Mountain Drinking Water System, Ester, Alaska

Moose Mountain PWSID # 313869

DRINKING WATER PROTECTION PROGRAM REPORT Report 449

Alaska Department of Environmental Conservation

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By Sarah A. Bendewald

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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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By Sarah A. Bendewald

Drinking Water Protection Program
Alaska Department of Environmental Conservation

EXECUTIVE SUMMARY

The public water system for Moose Mountain is a Class B (transient/non-community) water system consisting of one well along Moose Mountain road north of Ester, Alaska. Identified potential and current sources of contaminants for Moose Mountain public drinking water source include: a large capacity septic system, an underground mine, and a gravel road. These identified potential and existing sources of contamination are considered sources of bacteria and viruses, nitrates and/or nitrites, and volatile organic chemicals. Overall, the public water sources for Moose Mountain received a vulnerability rating of **Very High** for bacteria and viruses, and **High** for nitrates and nitrites, and **Medium** for volatile organic chemicals.

INTRODUCTION

The Alaska Department of Environmental Conservation (ADEC) is completing source water assessments for all Class A and Class B 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 FAIRBANKS AREA, ALASKA

Fairbanks Area

The Fairbanks area is located in the Fairbanks North Star Borough which is near the center of Alaska (Please see the inset of Map 1 in Appendix A for location). The Borough's current population is 82,840 making it the second-largest population center in the state (ADCED, 2002). Communities located within the Borough include : College, Eielson Air Force Base, Ester, Fairbanks, Fox, Harding Lake, Moose Creek, North Pole, Pleasant Valley, Salcha, and Two Rivers.

The Koyukon Athabascans are native to the Fairbanks area. Non-native population of the area began as a trading post on the Chena River. The discovery of gold in the early 1900s brought more than 6,000 prospectors during the Pedor Dome gold rush (ADCED, 2002). Construction of the Alcan Highway in the 1940s and the Trans-Alaska oil pipeline in the 1970s helped to continue the growth and development of the Fairbanks area.

Ester

Ester is located 8.5 miles west of Fairbanks along the George Parks Highway. Ester originally began as a mining camp established before 1905 and officially became a community in 1936 (ADCED, 2002).

The majority of Ester residents have individual wells and septic systems, and the remainder haul water from a central water point in Ester (ADCED, 2002). Heating oil (stored in both above and below ground 275 to 500-gallon tanks) is used for heating homes and buildings. Electricity is provided by Golden Valley Electric Association. Refuse is transported to the Fairbanks North Star Borough landfill.

Climate

The Fairbanks area experiences extreme weather variations according to season. Temperatures in January vary from –22 to –2 degrees Farenheight and from 50 to 72 degrees in July (ADCED, 2002). Average annual precipitation in the area is 11.3 inches (ADCED, 2002). Ice fog is common during the winter.

Topography and Drainage

The Fairbanks area includes two distinct topographic areas: the floodplain of the Tanana River and the Chena River, and the uplands north of this floodplain. Ester is located in the uplands. Elevation in the uplands varies from about 500 feet to 2500 feet.

The uplands are drained by many small creeks that flow into the Chena, Tanana, and Chatanika Rivers. The hydrology of these streams is greatly affected by the distribution of permafrost. Streams in the upper areas are dry most of the summer with runoff occurring during spring snowmelt and after heavy summer rains.

Geology and Soils

Bedrock under the Fairbanks area is predominanty a metamorphosed marine mud deposit, called a pelitic schist. Calc-mica schist, marble, and quartzite are also found in the area. The schist is locally intruded by granitic rocks – granite and quartz diorite.

Permafrost is common on the lower part of the north-facing slopes and valley bottoms (Nelson, 1978).

Groundwater

Groundwater is principally contained in fractured bedrock of the Yukon-Tanana complex (King, 1969). Groundwater flows through bedrock primarily within the fractures. The capacity of the rocks to yield water to wells depends in part on their ability to hold fractures open against the pressure of overlying rocks. The water wells in the Ester area with the greatest well recharge appear to be in quartz veins, quartzite, and siliceous schist (Nelson, 1978).

Groundwater in the uplands is recharged by local precipitation. Outflow of ground water in the uplands primarily occurs two ways. In areas under artesian pressure (pressure caused by overlying permafrost), water can flow to the surface through thawed conduits within the permafrost. Otherwise groundwater will flow under the permafrost (if present) and out to the groundwater beneath the adjacent flood plain or creek valley (Nelson, 1978).

MOOSE MOUNTAIN PUBLIC DRINKING WATER SYSTEM

Moose Mountain public water system is a Class B (transient/non-community) water system. The system consists of one well along Moose Mountain Road six and a half miles north of Ester, Alaska (T1N, R2W, Section 5) (See Map 1 of Appendix A). This area is at an elevation of approximately 700 feet above sea level.

According to the well log, the depth of the well is 95 feet and the static water level is at 11 feet below the ground surface. The well casing is perforated for 20 feet in bedrock. The Sanitary Survey (7/23/01) indicates the sanitary seal on the well casing is loose and not sealed correctly. A properly installed sanitary seal may provide protection against contaminants from entering the source waters at the well casing. The land surface is appropriately sloped away from the well providing adequate surface water drainage. The well casing is grouted according to ADEC regulations. Proper grouting provides added protection against contaminants travelling along the well casing and into source waters.

This system operates from November to April 15 and serves approximately 25 non-residents through one service connection.

MOOSE MOUNTAIN 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 are. 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 Moose Mountain. 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 B 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.

The DWPA for Moose Mountain is limited by its immediate watershed and includes only Zones A (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 Moose Mountain 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 B public water system assessments, three categories of drinking water contaminants were inventoried. They include:

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

The sources are displayed on Map 2 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 sorted and ranked according to what type and level of risk they represent. Ranking of contaminant risks for a "potential" or "existing" source of contamination is a function of toxicity and volumes of specific contaminants associated with that source. Further, contaminant risks are a function of the number and density of those types of contaminant sources as well as the proximity of those sources 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, and volatile organic chemicals.

VULNERABILITY OF MOOSE MOUNTAIN 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 three categories of drinking water contaminants has been analyzed and an overall vulnerability score of 0 to 100 is ultimately assigned:

Natural Susceptibility (0 – 50 points)

\+

Contaminant Risks (0 – 50 points)

=

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

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

Susceptibility of the Wellhead (0 – 25 Points)

\+

Susceptibility of the Aquifer (0 – 25 Points)

=

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

The well for Moose Mountain is completed in an unconfined aquifer. Because an unconfined aquifer is recharged by surface water and precipitation that migrate downward from the surface, contaminants at the surface have the potential to negatively impact this aquifer. The Sanitary Survey (7/23/01) indicates the well is located in an area of permafrost. Permafrost can act as a barrier between surface contaminants and the aquifer because of its impermeability. Permafrost does not occur consistently throughout this area and therefore provides only minimal protection. Table 2 shows the Susceptibility scores and ratings for Moose Mountain.

Table 2. Susceptibility

	Score	Rating
Susceptibility of the Wellhead	20	Very High
Susceptibility of the Aquifer	14	Medium
Natural Susceptibility	34	High

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	50	High
Nitrates and/or Nitrites	36	High
Volatile Organic Chemicals	25	Medium

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

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

Table 4. Overall Vulnerability

Category	Score	Rating
Bacteria and Viruses	85	Very High
Nitrates and Nitrites	70	High
Volatile Organic Chemicals	55	Medium

Bacteria and Viruses

The contaminant risk for bacteria and viruses is very high with the large capacity septic system at the Moose Mountain Lodge presenting the most significant risk to the drinking water well (See Chart 3 – Contaminant Risks for Bacteria and Viruses in Appendix D).

Monitoring samples analyzed in November 1996 were positive for bacteria and viruses. The positive samples increase the overall vulnerability of the drinking water souce, indicating that the source is susceptable to bacteria and viruses contamination. The source of the bacteria and viruses is unknown. All samples since the positive result in 1996 have had negative results for bacteria and viruses. 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 very high.

Nitrates and/or Nitrites

The contaminant risk for nitrates and nitrites is high with the large capacity septic system, because of its effluent discharge, posing the most significant contaminant risk to this source of public drinking water

(See Chart 5 - Contaminant Risks for Nitrates and/or Nitrites in Appendix D). Nitrates are very mobile, moving at approximately the same rate as water.

Sampling history for the Moose Mountain well indicates that very low concentrations of nitrate have been detected in the drinking water. Existing nitrate concentration is approximately 0.1 mg/L or 1% 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. Nitrate concentrations have remained consistent with concentrations varying from not detected to 0.17 mg/L within the past 5 years.

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].

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 high.

Volatile Organic Chemicals

The contaminant risk for volatile organic chemicals is medium with the underground mine creating the most significant risk for volatile organic chemicals (See Chart 7 – Contaminant Risks for Volatile Organic Chemicals in Appendix D).

The drinking water at Moose Mountain has not been sampled for Volatile Organic Chemicals recently. 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.

SUMMARY

A *Source Water Assessment* has been completed for the sources of public drinking water serving Moose Mountain. The overall vulnerability of this source to contamination is **Very High** for bacteria and viruses, **High** for nitrates and nitrites, and **Medium** for volatile organic chemicals. This assessment of contaminant risks can be used as a foundation for local voluntary protection efforts as well as a basis for the continuous efforts on the part of Moose Mountain 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 Moose Mountain public drinking water source.

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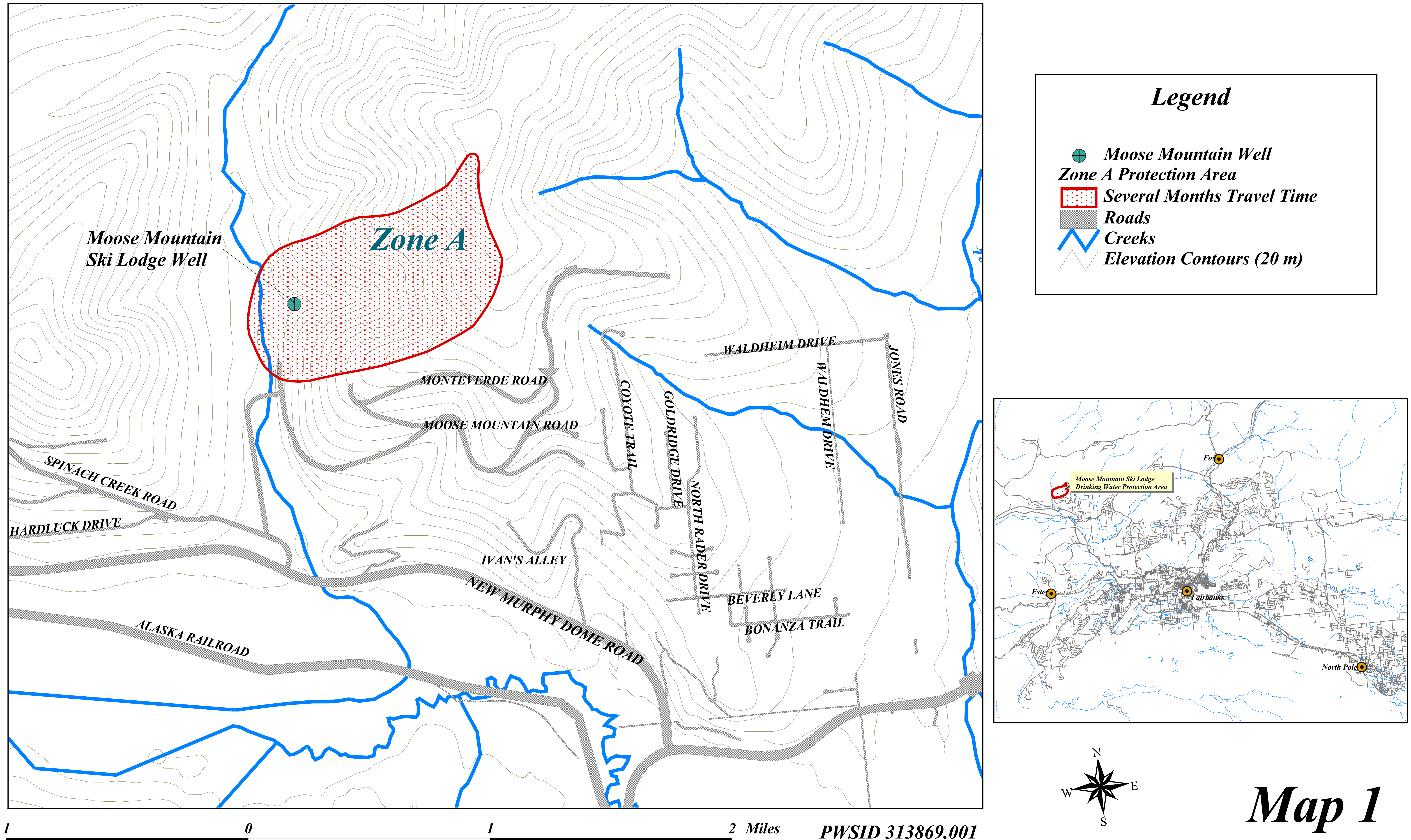
Patrick, L.D., Brabets, T.P., and Glass, R.L., 1989, Simulation of ground-water flow at Anchorage, Alaska: US Geological Survey Water-Resources Investigations Report 88-4139, 41p.

United States Environmental Protection Agency (EPA), 2002 [WWW document]. URL http://www.epa.gov/safewater/mcl.html.

APPENDIX A

Moose Mountain
Drinking Water Protection Area Location Map
(Map 1)

Moose Mountain Ski Lodge Drinking Water Protection Area



PWSID 313869.001

Map 1

APPENDIX B

Contaminant Source Inventory and Risk Ranking for Moose Mountain (Tables 1-4)

Table 1 *Contaminant Source Inventory for* ***PWSID 313869.001***

Moose Mountain

Contaminant Source Type	*Contaminant Source ID*	*CS ID tag*	*Zone*	*Location*	*Map Number*	*Comments*
Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal Method)	D10	D10-1	A	Moose Mountain Ski Lodge, Moose Mountain Road	2	
Metals mining, underground (active or inactive?)	E05	E05-1	A	Moose Mountain	2	Francody Mine
Highways and roads, dirt/gravel	X24	X24-1	A	Moose Mountain Rd	2	

Table 2

Contaminant Source Inventory and Risk Ranking for Moose Mountain Sources of Bacteria and Viruses

PWSID 313869.001

Contaminant Source Type	Contaminant Source ID	CS ID tag	Zone	Risk Ranking for Analysis	Location	Map Number	Comments
Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal Method)	D10	D10-1	A	High	Moose Mountain Ski Lodge, Moose Mountain Road	2	
Highways and roads, dirt/gravel	X24	X24-1	A	Low	Moose Mountain Rd	2	

Table 3

Contaminant Source Inventory and Risk Ranking for Moose Mountain Sources of Nitrates/Nitrites

PWSID 313869.001

Contaminant Source Type	*Contaminant Source ID*	*CS ID tag*	*Zone*	*Risk Ranking for Analysis*	*Location*	*Map Number*	*Comments*
Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal Method)	D10	D10-1	A	High	Moose Mountain Ski Lodge, Moose Mountain Road	2	
Highways and roads, dirt/gravel	X24	X24-1	A	Low	Moose Mountain Rd	2	

Table 4

Contaminant Source Inventory and Risk Ranking for Moose Mountain
Sources of Volatile Organic Chemicals

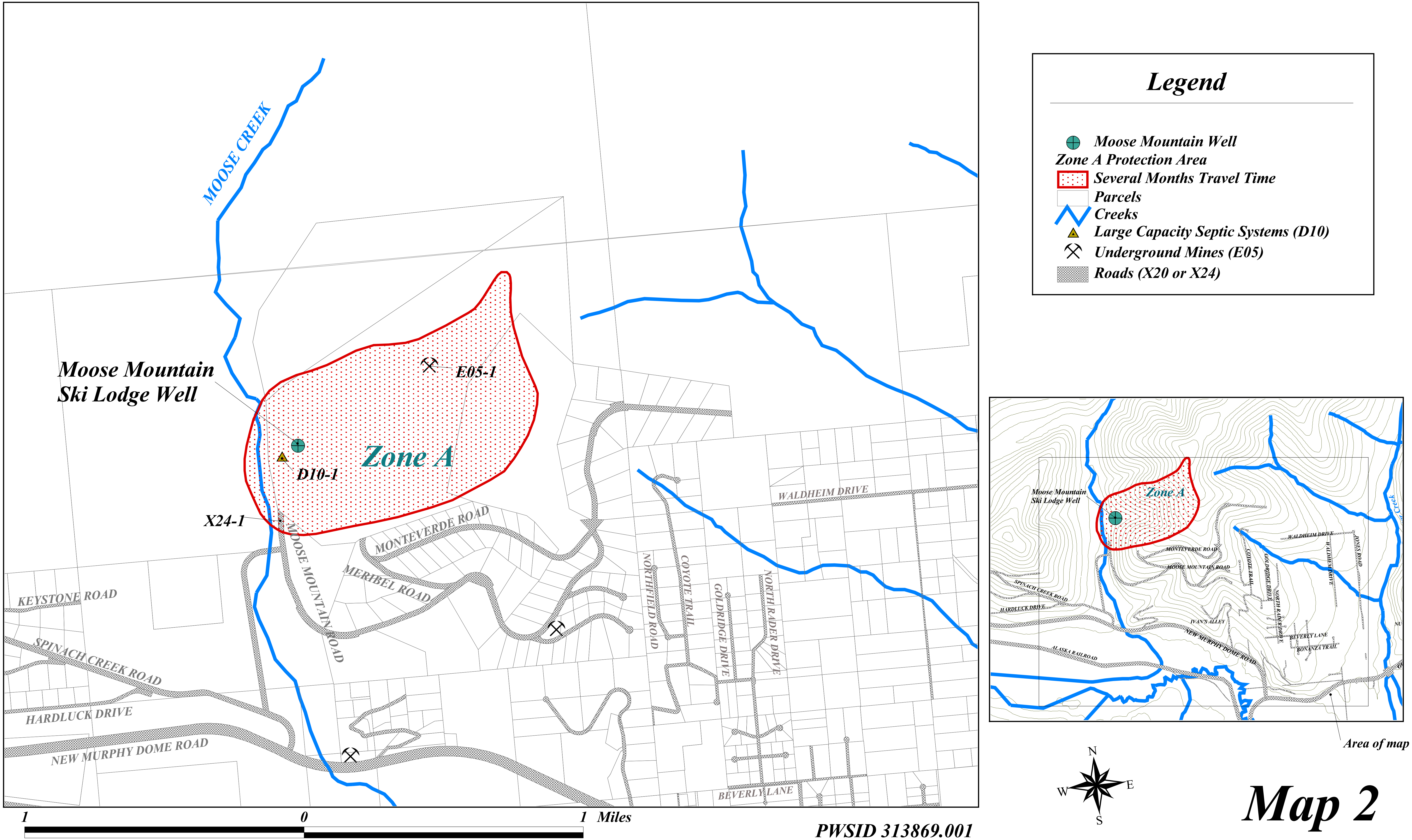
PWSID 313869.001

Contaminant Source Type	*Contaminant Source ID*	*CS ID tag*	*Zone*	*Risk Ranking for Analysis*	*Location*	*Map Number*	*Comments*
Metals mining, underground (active or inactive?)	E05	E05-1	A	Medium	Moose Mountain	2	Francody Mine
Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal Method)	D10	D10-1	A	Low	Moose Mountain Ski Lodge, Moose Mountain Road	2	
Highways and roads, dirt/gravel	X24	X24-1	A	Low	Moose Mountain Rd	2	

APPENDIX C

Moose Mountain
Drinking Water Protection Area
and Potential and Existing Contaminant Sources
(Map 2)

Moose Mountain Drinking Water Protection Area with Potential & Existing Contaminant Sources



Map 2

APPENDIX D

Vulnerability Analysis for Moose Mountain Public Drinking Water Source

(Charts 1-8)

Chart 1. Susceptibility of the wellhead - Moose Mountain

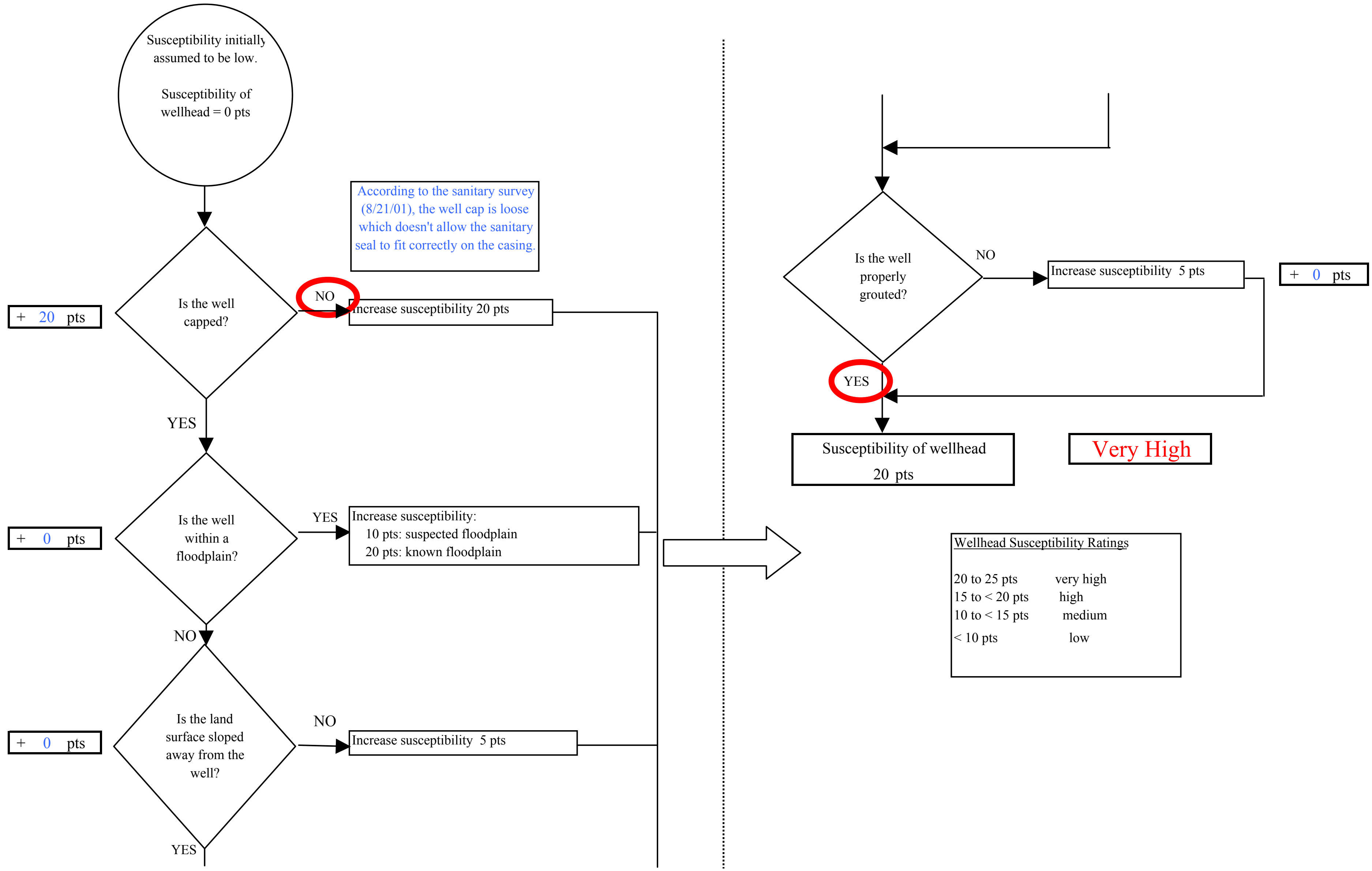


Chart 2. Susceptibility of the aquifer - Moose Mountain

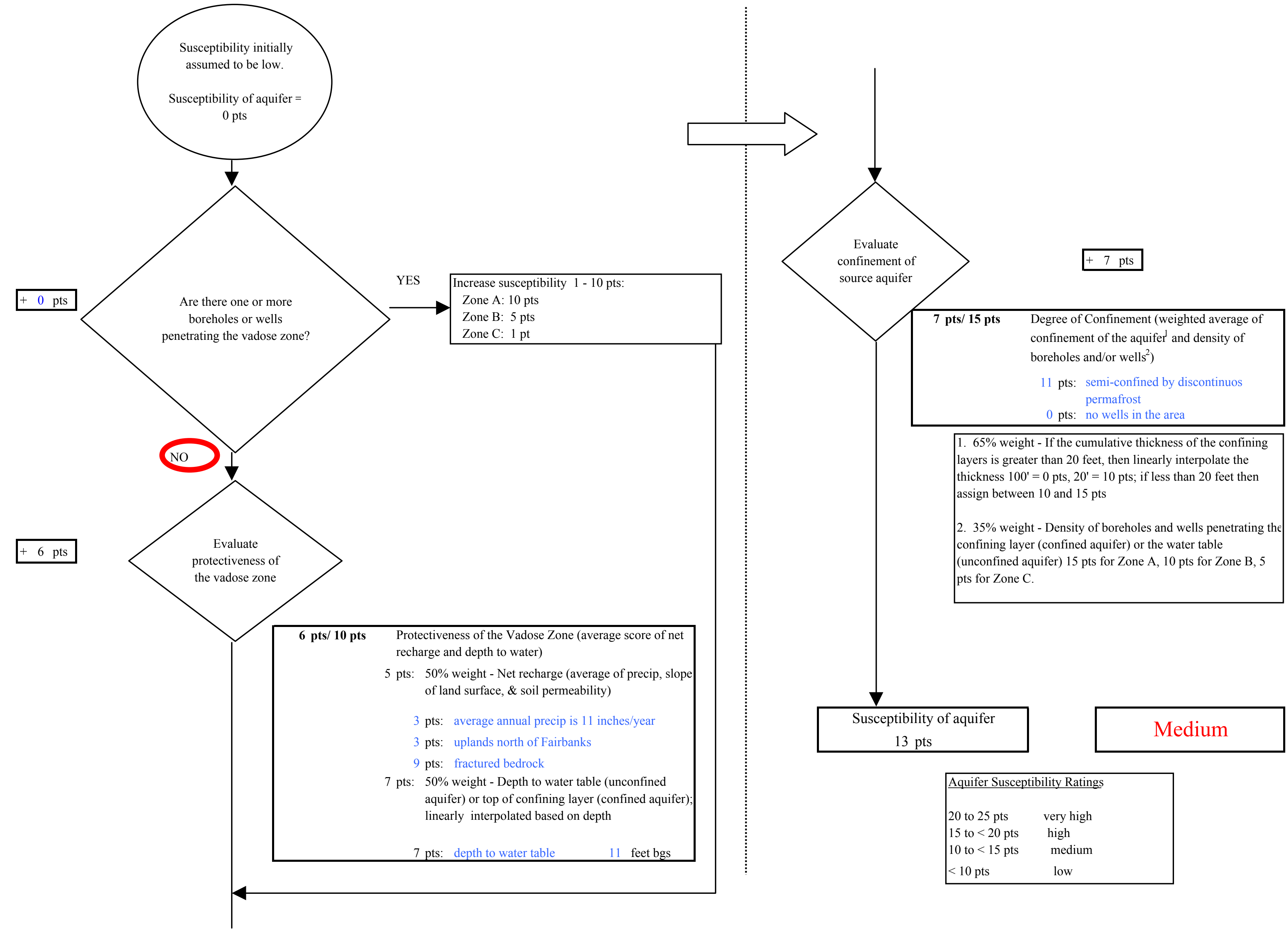
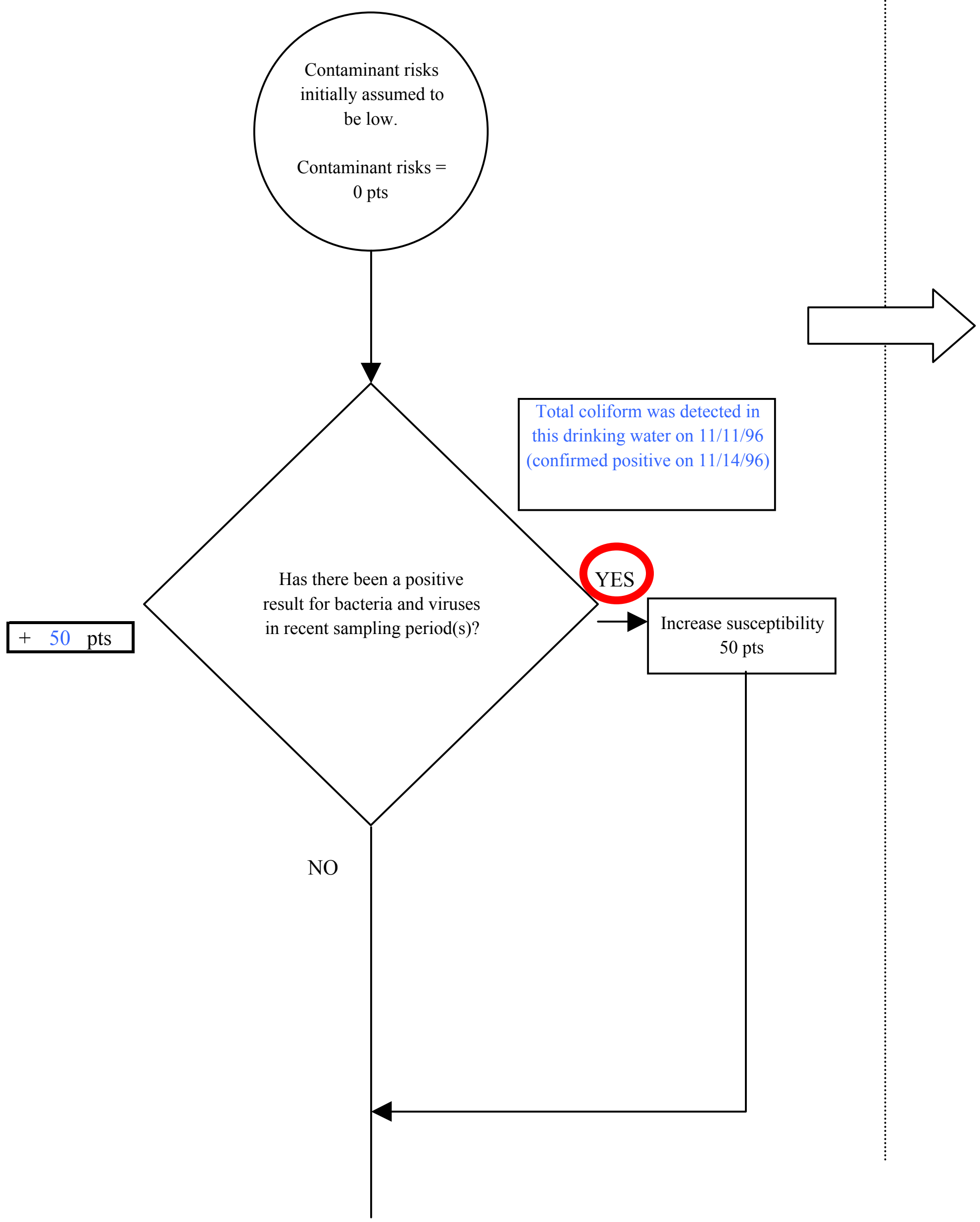
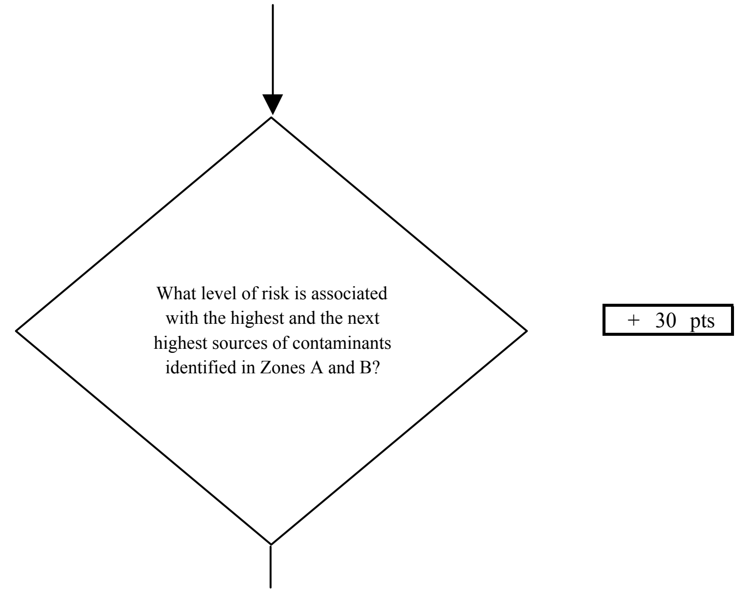


Chart 3. Contaminant risks for Moose Mountain - Bacteria & Viruses





Risk Rankings for Contaminant Sources Identified in Zones A and B

	Zone A	Zone B	Total
Very Highs(s)	0	0	0
High(s)	1	0	1
Medium(s)	0	0	0
Low(s)	1	0	1

	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	30

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 Moose Mountain - Bacteria & Viruses

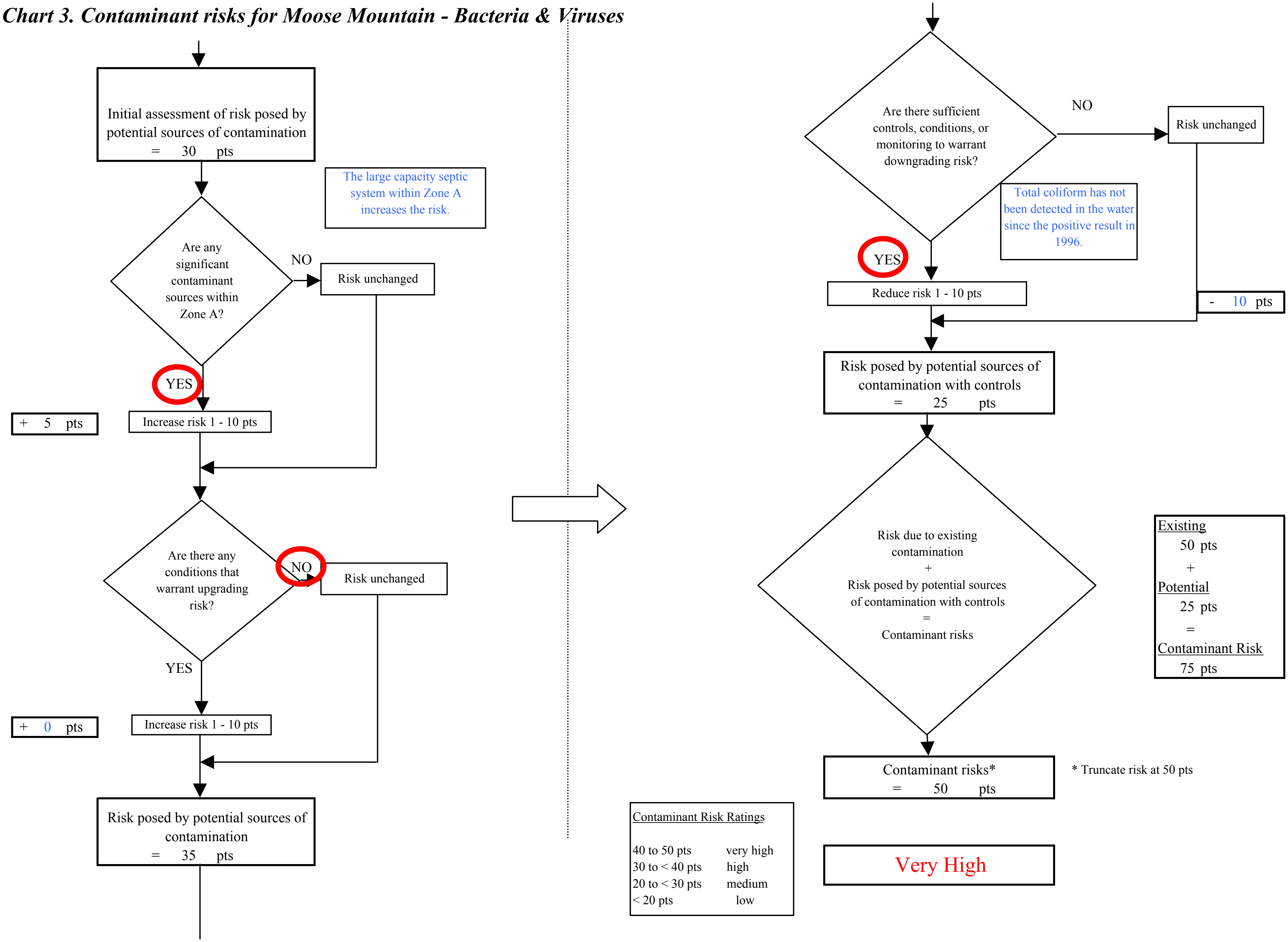


Chart 4. Vulnerability analysis for ***Moose Mountain*** ***- Bacteria & Viruses***

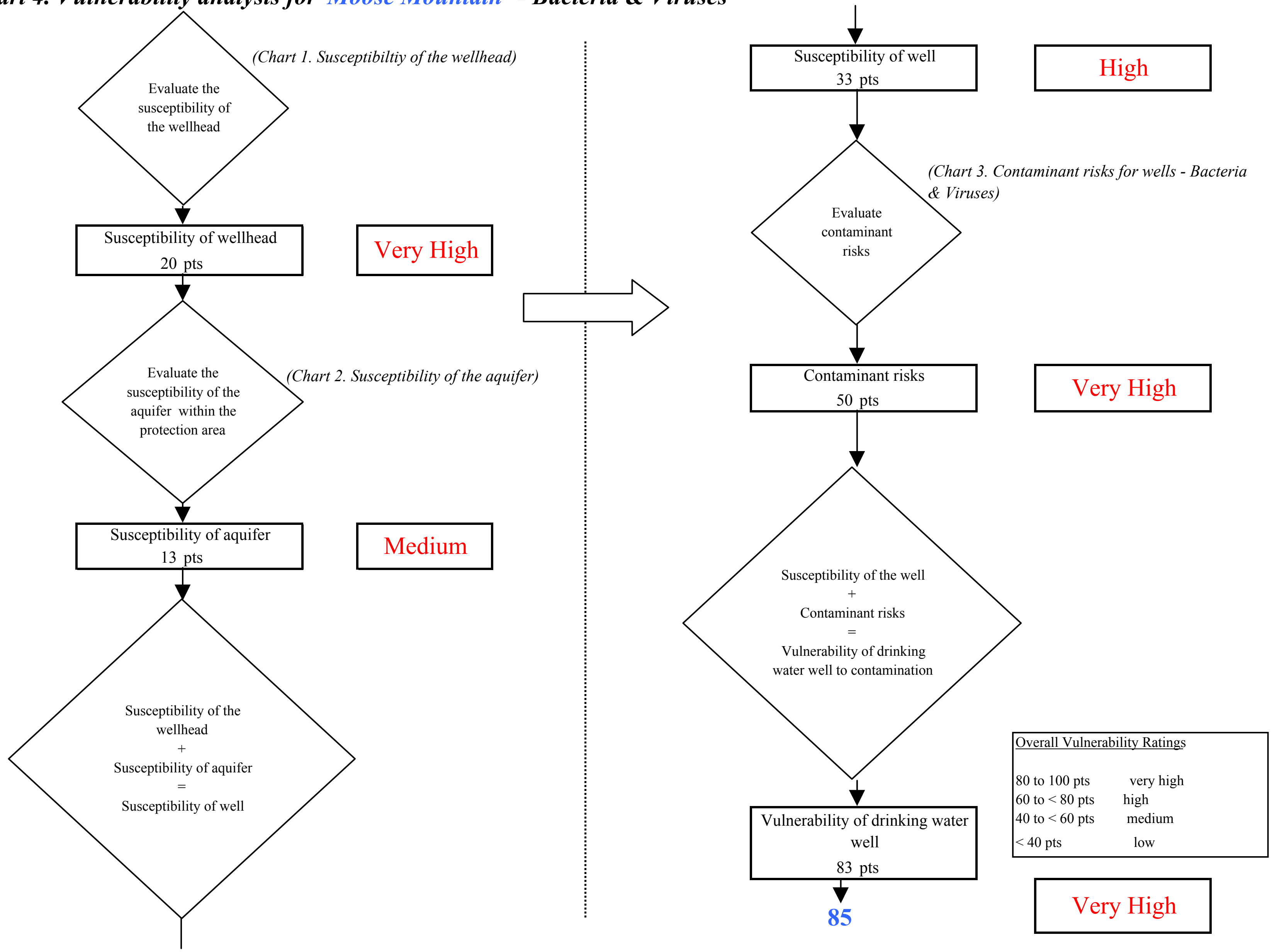
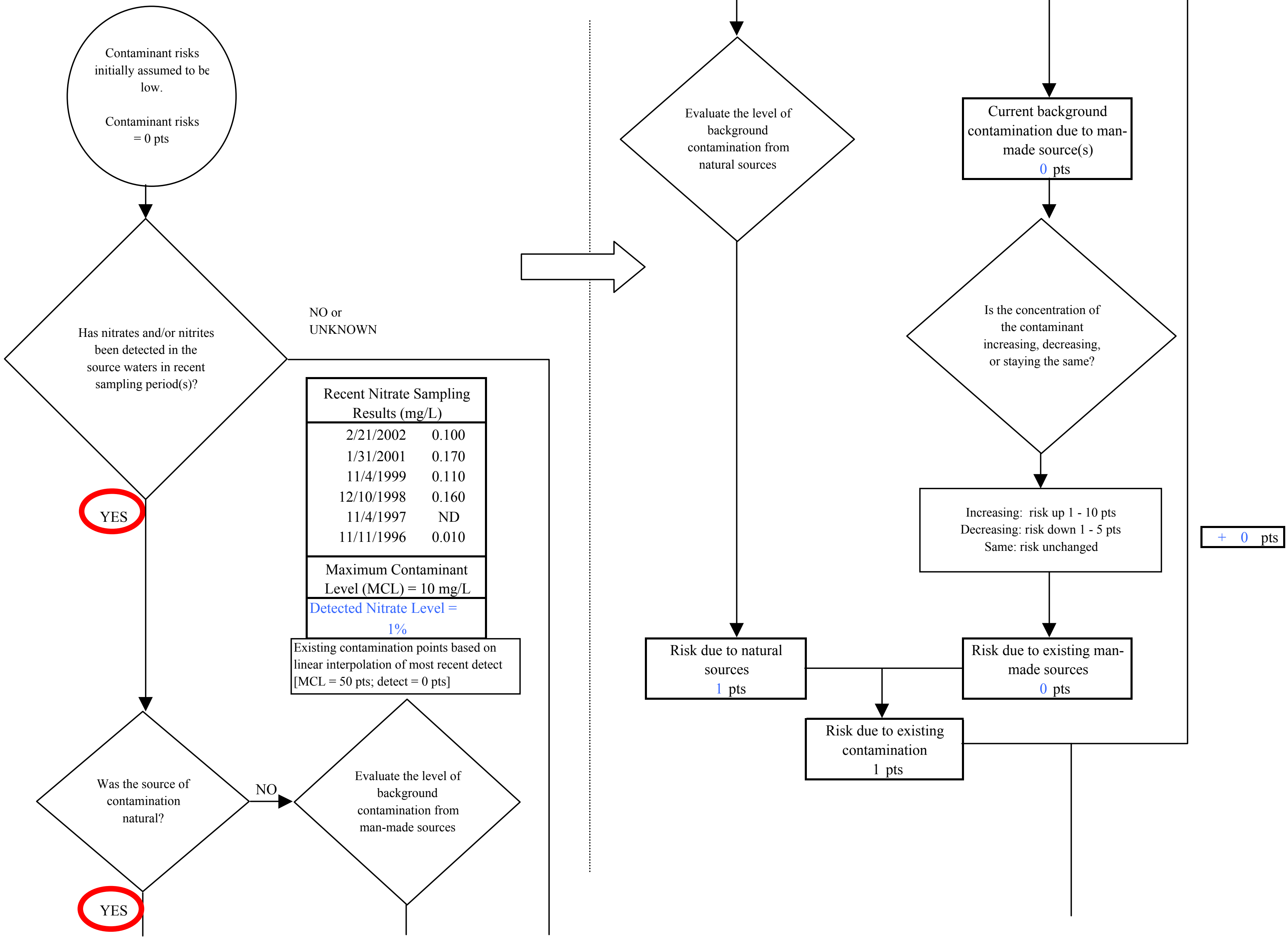
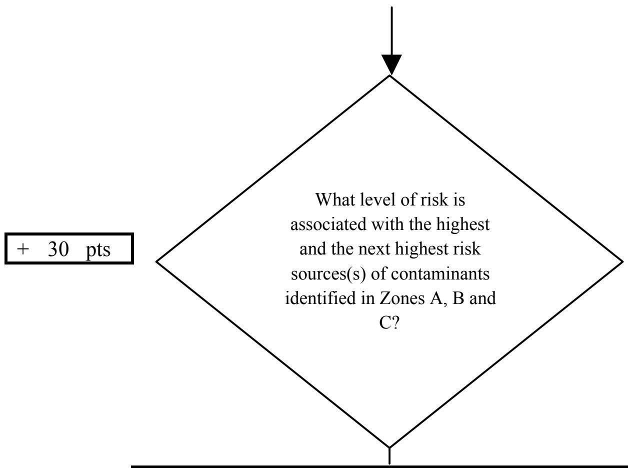


Chart 5. Contaminant risks for Moose Mountain - Nitrates and Nitrites



Recent Nitrate Sampling Results (mg/L)	
2/21/2002	0.100
1/31/2001	0.170
11/4/1999	0.110
12/10/1998	0.160
11/4/1997	ND
11/11/1996	0.010
Maximum Contaminant Level (MCL) = 10 mg/L	
Detected Nitrate Level = 1%	

Chart 5. Contaminant risks for Moose Mountain - Nitrates and Nitrites



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)	1	0	1
Medium(s)	0	0	0
Low(s)	1	0	1

	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 30

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.

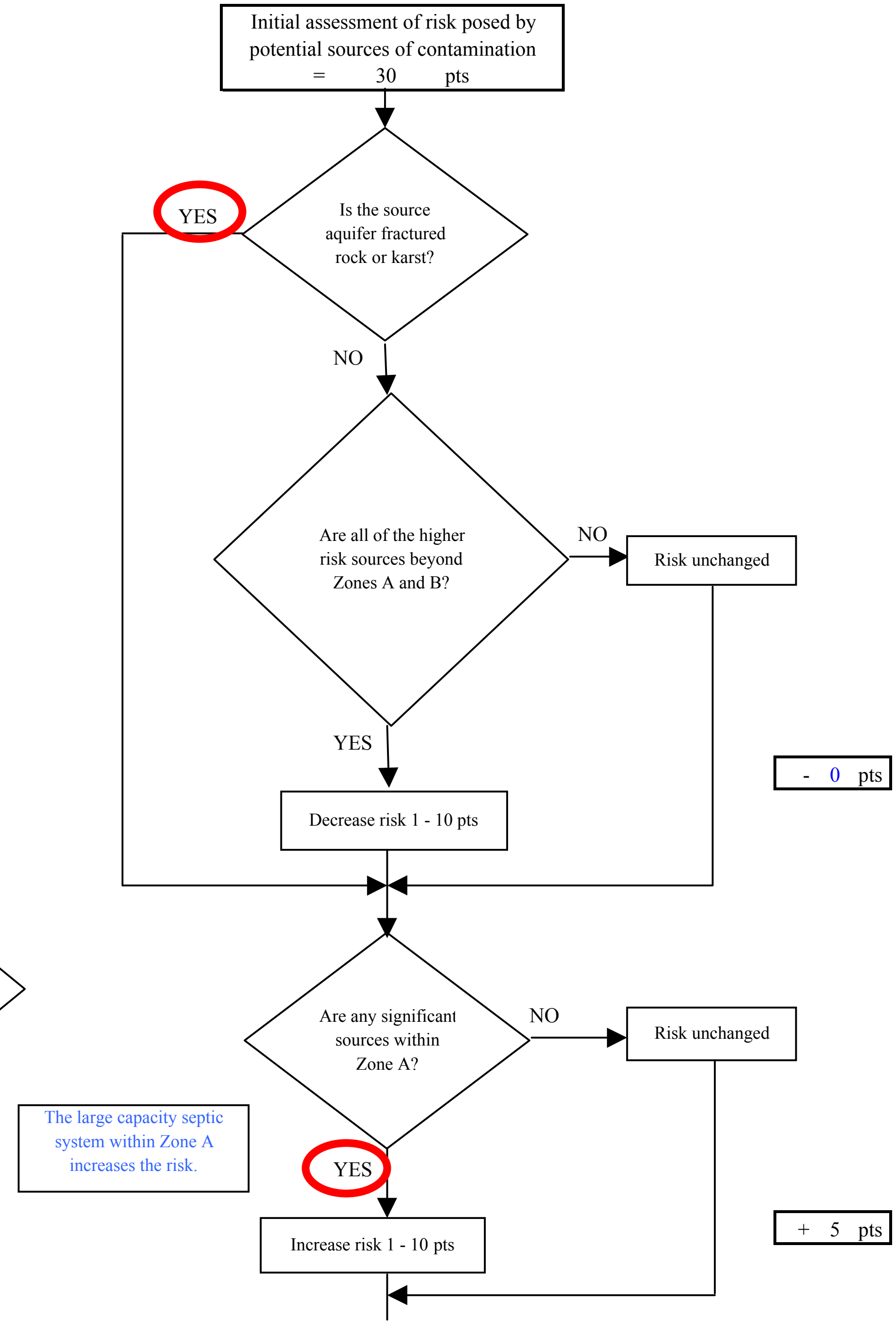


Chart 5. Contaminant risks for Moose Mountain - Nitrates and Nitrites

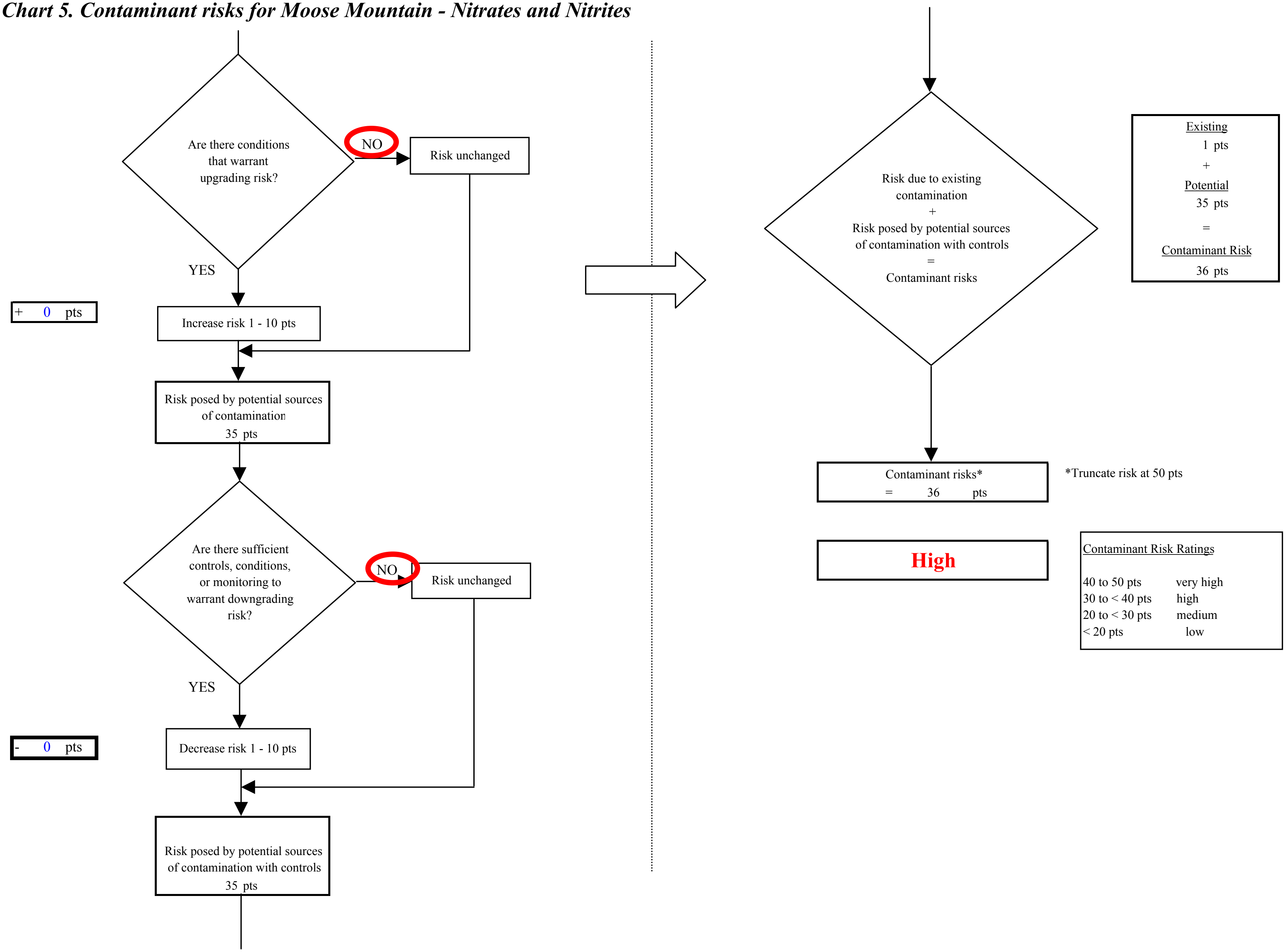


Chart 6. Vulnerability analysis for Moose Mountain - Nitrates and Nitrites

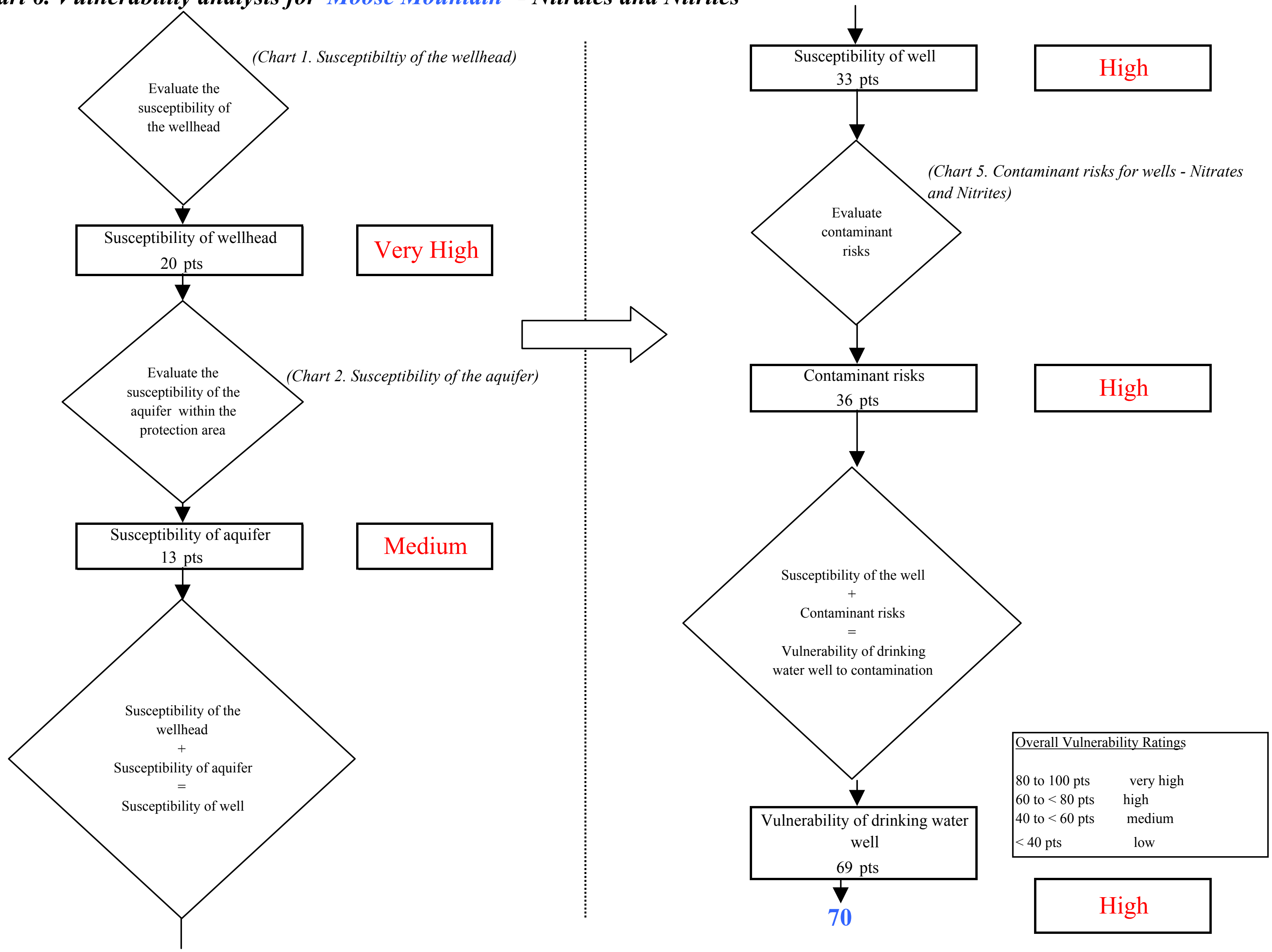


Chart 7. Contaminant risks for Moose Mountain - Volatile Organic Chemicals

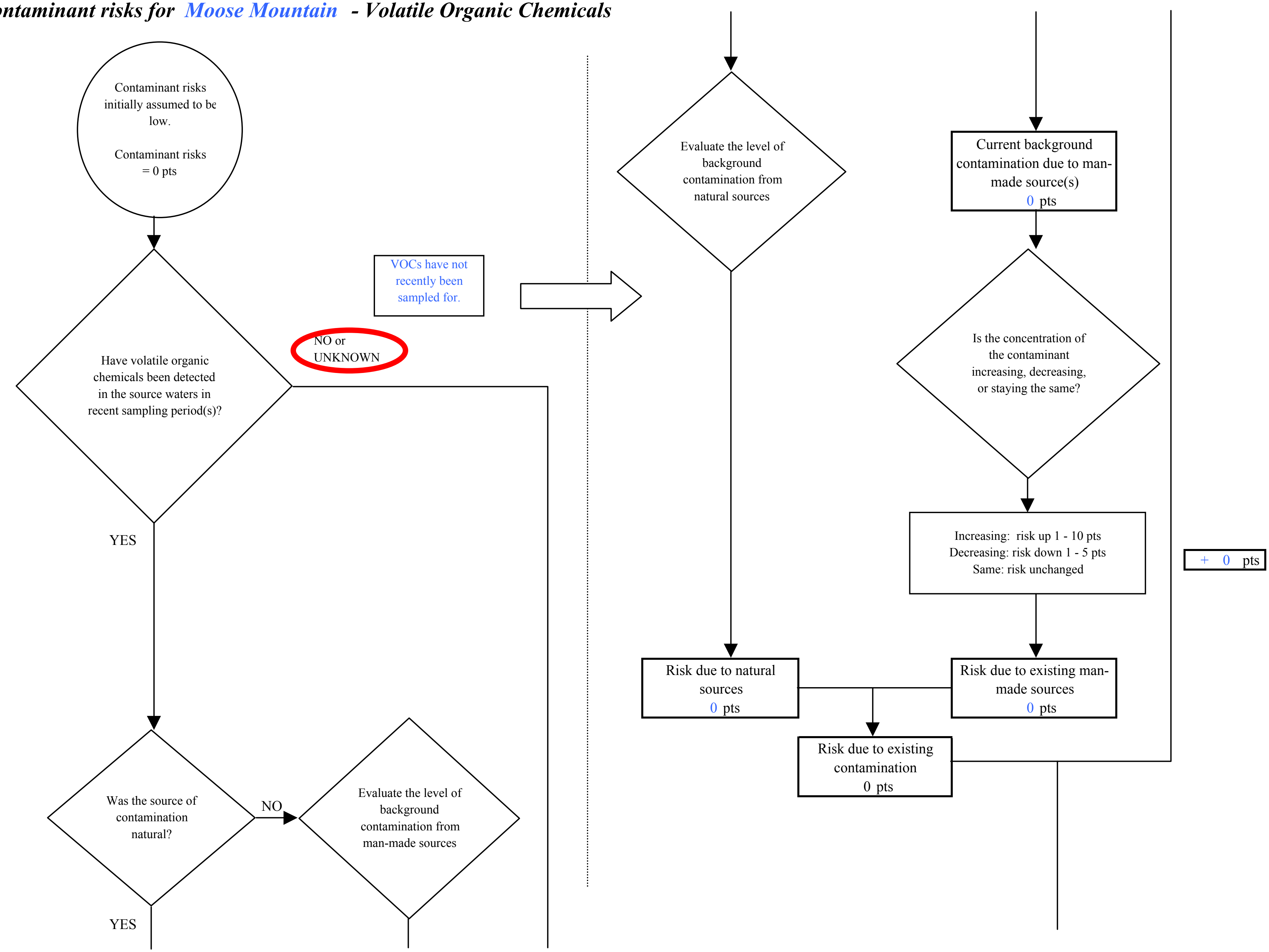
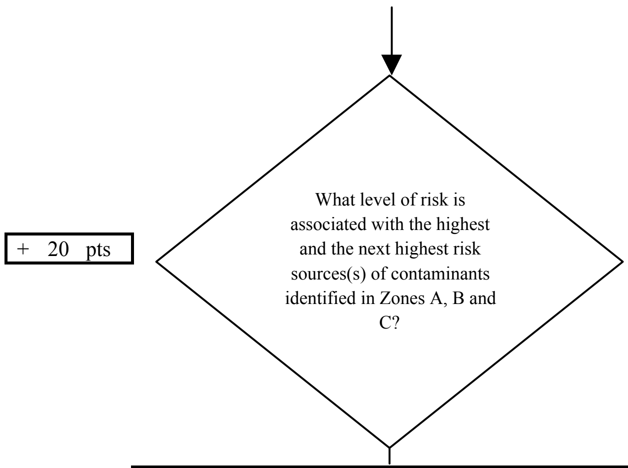


Chart 7. Contaminant risks for Moose Mountain - Volatile Organic Chemicals



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)	1	0	1
Low(s)	2	0	2

	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.

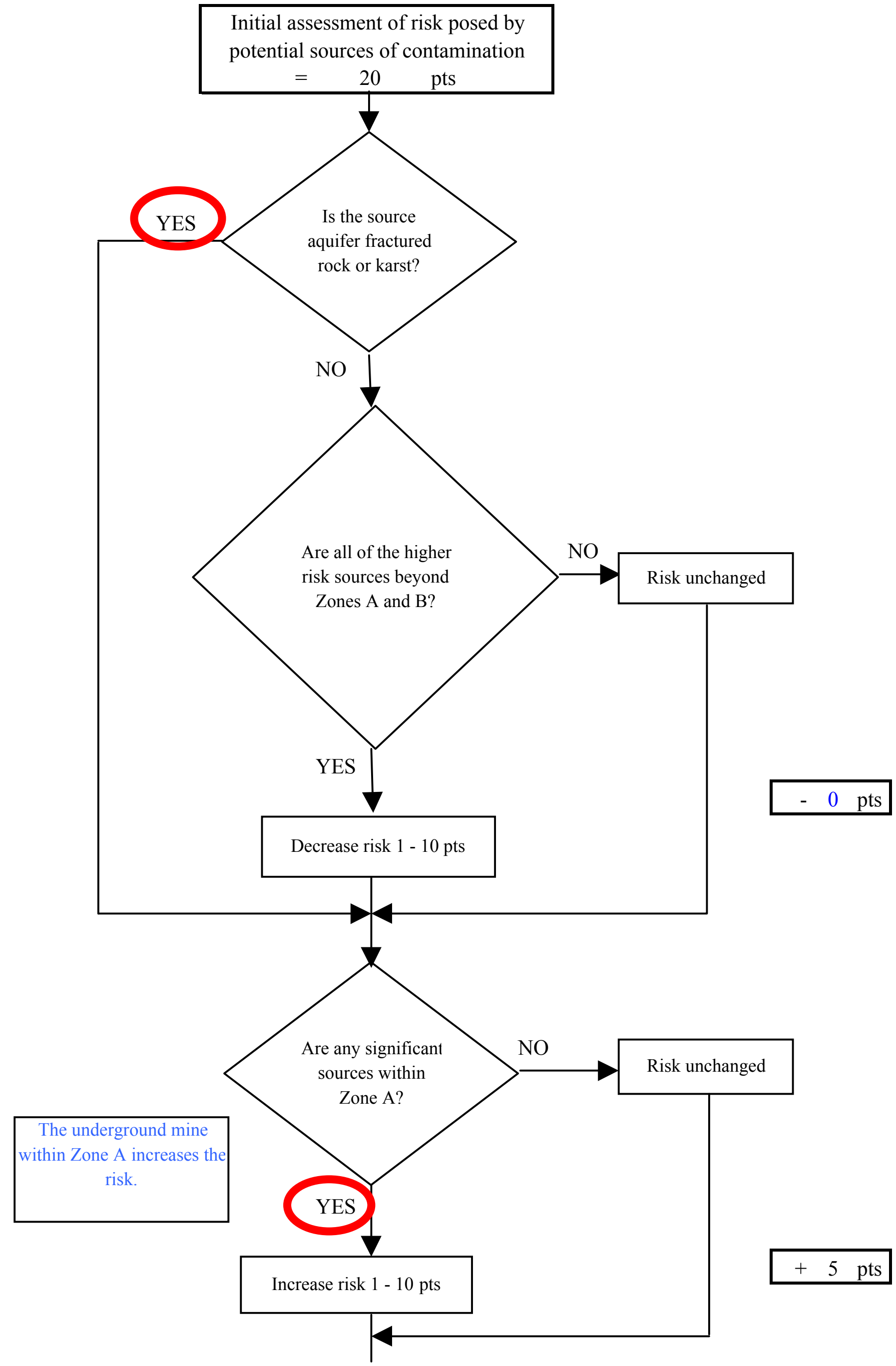


Chart 7. Contaminant risks for Moose Mountain - Volatile Organic Chemicals

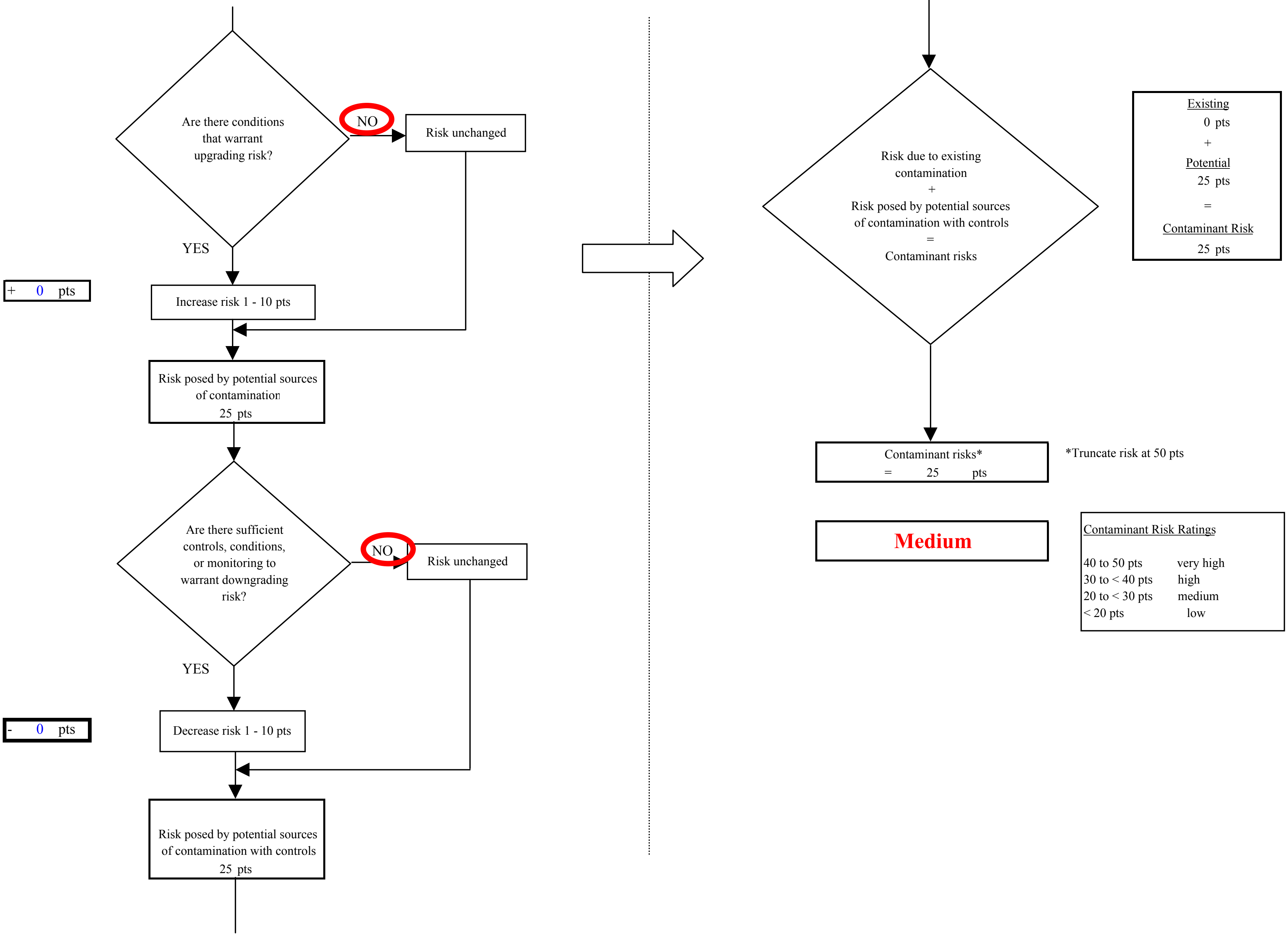


Chart 8. Vulnerability analysis for Moose Mountain - Volatile Organic Chemicals