Source Water Assessment

A Hydrogeologic Susceptibility and Vulnerability Assessment for the TeckCominco Red Dog Mining Facility

Kotzebue (region), Alaska

PWSID # 340670.001

October 2004

Drinking Water Protection Program Report #1489

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 the TeckCominco Red Dog Mining Facility Water System

Drinking Water Protection Program
Alaska Department of Environmental Conservation

EXECUTIVE SUMMARY

The TeckCominco Red Dog Mining Facility water system is a Class A (community) water system that obtains water from a reservoir created by a small dam on Bons Creek. Water is collected via an infiltration gallery located below the dam. The overall protection area is approximately 3.8-square miles in size and received a susceptibility rating of "**very high**". *A rating of high to very high is typical for all systems with surface water intakes*. Potential and existing sources of the following contaminants were evaluated for the Source Water Assessment: bacteria and viruses, nitrates and/or nitrites, heavy metals, cyanide, and other inorganic chemicals, synthetic organic chemicals, volatile organic chemicals, and other organic chemicals. A road, above ground fuel tanks, an airstrip, a large capacity septic system, and a mine tailings pile were identified as potential sources of contaminants for the drinking water source. This evaluation included all available water sampling data submitted to ADEC by the system operator. The samples may have been collected from either raw water or post-treated water. Combining the susceptibility of the surface water source with the contaminant risks, this water system has received a vulnerability rating of **"high"** for volatile organic chemicals, synthetic organic chemicals, and other organic chemicals; and **"very high"** for bacteria and viruses, nitrates/nitrites, and heavy metals. This assessment can be used as a foundation for local voluntary protection efforts as well as a basis for the continuous efforts on the part of TeckComino to protect public health.

DRINKING WATER SYSTEM AND AREA OVERVIEW

The TeckCominco Red Dog mining facility (Sec. 31, T031N, R018W, Kateel River Meridian) is located 90 miles north of Kotzebue in the DeLong Mountains of the Brooks Range (Please see the inset of Map 1 in Appendix A for location). The current working population of the facility is approximately 365 (TeckCominco, 2004).

The Red Dog water system is a Class A (community) water system that serves the working population of the mine. Water is collected from a reservoir created by a small dam on Bons Creek. Water is collected via an infiltration gallery located below the dam (See Map 1 of Appendix A). Water from this source is used at the mining facility and also at the construction camp (when the camp is in use). Both the camp and the mining facility utilize separate treatment systems. As a backup water source, water may also be collected directly from the reservoir instead of from the infiltration gallery.

The 2002 sanitary survey indicates that the water intake is screened, maintained, inspected regularly, and protected from ice buildup and siltation. The survey also states that the system's pumping capacity is approximately 2,250 gallons per minute. System operators indicate that the volume of the reservoir is 210 million gallons.

RED DOG MINING FACILITY DRINKING WATER PROTECTION AREA

Identifying the pathways most likely for surface contamination to reach water intake areas is the first step in determining the water system's risk. These are initially determined by looking at the drainage area contributing overland water flow to a surface water source intake. The entire drainage area is also known as the "drinking water protection area". Please refer to pages 10-11of the "Guidance Manual for Class A Public Water Systems" for additional information.

The protection area established for surface water sources by the ADEC is usually separated into three zones, limited by the watershed boundary. These zones correspond to the overland-flow distance that water travels to get to the source. The ADEC Drinking Water Protection Program's Technical Advisory Committee developed guidelines for derivation of these zones in 1998. The following is a summary of the three protection area zones:

Table 1. Definition of Zones

Zone	Definition
A	Areas within 1000-ft of lakes or streams
B	Areas within 1-mile of lakes or streams
C	The watershed boundary

The protection area for the Red Dog mining facility water intake includes each of these Zones, although due to the small size of the watershed, Zones B and C cover the same area (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 Red Dog mining facility protection area. This inventory was completed through a search of agency records and other publicly available information. There is a wide array of potential contamination sources to surface water. These contaminants are found within agricultural, residential, commercial, and industrial areas, but *can also occur within areas that have little or no development*.

For 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.

Sources identified in the protection area are displayed on Map 2 of Appendix C and summarized in Table 1 of Appendix B.

RANKING OF CONTAMINANT RISKS

Once potential and existing sources of contamination have been identified, they are assigned a ranking according to what category and level of risk they represent. Ranking of contaminant risks for "potential" or "existing" sources of contamination is a function of the toxicity and the volume of specific contaminants associated with that source. Rankings include:

- Low;
- Medium;
- High; and
- Very High.

The time-of-travel for contaminants within the water is dependent on the physical and chemical characteristics of each contaminant. Bacteria and Viruses are only inventoried in Zone A because of their short life span. Only "Very High" and "High" rankings are inventoried within Zones B and C due to the probability of contaminant dilution by the time the contaminants reach the water intake.

The remaining tables in Appendix B (if necessary) 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:

- Surface Water Susceptibility; and
- Contaminant risks.

Appendix D contains 13 charts, which together form the 'Vulnerability Analysis' for the public drinking water Source Water Assessment. Chart 1 analyzes the 'Susceptibility of the Surface Water Source' to contamination by looking at the climate, terrain, and intake location. Chart 2 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 intake area. Chart 3 contains the 'Vulnerability Analysis for Bacteria and Viruses', which is a composite score of the Vulnerability Analysis and the overall Susceptibility. Charts 4 through 13 repeat 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 Surface Water Susceptibility of the source is reached by considering the properties of the water intake and the surrounding area. The derivation of this information is presented below and the data for this source is shown in Chart 1 of Appendix D.

Susceptibility of the Surface Water Source – always considered to be "high" (30 points)

+

Adequate Construction of the Intake (0 – 5 Points)

+

Runoff Potential Within Zone B (0 – 5 Points)

+

Dilution Capacity of the Surface Water (0 – 10 Points)

=

Natural Susceptibility
(0 – 50 Points)

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

Surface Water Source Susceptibility Ratings	
40 to 50 pts	Very High
30 to < 40 pts	High

Table 2. Susceptibility of the Water Source

	Score	Rating
Minimum Allowable Susceptibility	30	
Intake Construction Adequate	0	
Runoff Potential	5	
Dilution Capacity	5	
Overall Susceptibility	**40**	**Very High**

For contaminants, risks to a drinking water source depend on the type, number or density, and distribution of the contaminant sources. The Contaminant Risk score has been derived from an examination of existing, and historical contamination sources that have been detected in the protection area 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 the 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. Red Dog Mining Facility Contaminant Risks

Category	Score	Rating
Bacteria and Viruses	40	Very High
Nitrates and/or Nitrites	40	Very High
Volatile Organic Chemicals	25	Medium
Heavy Metals, Cyanide, and Other Inorganic Chemicals	40	Very High
Synthetic Organic Chemicals	25	Medium
Other Organic Chemicals	25	Medium

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

Susceptibility of the Surface Water Source

(0 – 50 points)

+

Contaminant Risks (0 – 50 points)

=

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

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 and ratings for each of the six categories of drinking water contaminants. Note: scores are rounded off to the nearest five.

Table 4. Red Dog Mining Facility Overall Vulnerability

Category	Score	Rating
Bacteria and Viruses	80	Very High
Nitrates and Nitrites	80	Very High
Volatile Organic Chemicals	65	High
Heavy Metals, Cyanide, and Other Inorganic Chemicals	80	Very High
Synthetic Organic Chemicals	65	High
Other Organic Chemicals	65	High

Bacteria and Viruses

The contaminant risk for bacteria and viruses is "very high". Typically, coliform detection in raw water samples collected from surface water sources is normal. (See Chart 2 – Contaminant Risks for Bacteria and Viruses in Appendix D).

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.

No bacteria have been detected in samples collected from 2000-2004.

After combining the contaminant risk for bacteria and viruses with the natural susceptibility of the source, the overall vulnerability of the source to bacteria and virus contamination is "very high".

Nitrates and Nitrites

The contaminant risk for nitrates and nitrites is "very high" (See Chart 4 - 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 water source indicates that no nitrates detected in samples collected in 2000 through 2003. The Maximum Contaminant Level (MCL) for nitrates is 10 milligrams per liter (mg/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 (EPA, 2003).

Possible sources of nitrates/nitrites could be from human/animal activity along roads, airfields, or large capacity septic systems located within the protection area.

After combining the contaminant risk for nitrates and nitrites with the natural susceptibility of the source, the overall vulnerability of the source to contamination is "very high".

Volatile Organic Chemicals

The contaminant risk for volatile organic chemicals is "medium" (See Chart 6 – Contaminant Risks for Volatile Organic Chemicals in Appendix D).

Trihalomethanes and chloroform were detected at levels below the MCL during sampling in 2003, although these chemicals typically originate during the process of water treatment and not from the source waters. The MCL for chloroform is 0.2 milligrams per liter (mg/L) and the MCL for total trihalomethanes is 0.1 mg/L.

Possible sources of volatile organic chemicals could be from activity along roads, airfields, above ground fuel tanks, or large capacity septic systems located within the protection area.

After combining the contaminant risk for volatile organic chemicals with the natural susceptibility of the source, the overall vulnerability of the source to contamination is "high".

Heavy Metals, Cyanide, and Other Inorganic Chemicals

The contaminant risk for heavy metals is "very high". Copper and lead have been detected in samples collected during 1999-2002, but at levels below the MCL (See Chart 8 – Contaminant Risks for Heavy Metals, Cyanide, and Other Inorganic Chemicals in Appendix D). The MCL for copper is 1.3 mg/l. and the MCL for lead is 0.015 mg/l.

The most common source of these chemicals is the infrastructure of the distribution system following the treatment process and not from the source waters. Additional sources of heavy metals could be from activity along roads, airfields, large capacity septic systems, or from mine tailings located within the protection area.

After combining the contaminant risk for heavy metals with the natural susceptibility of the source, the overall vulnerability of the well to contamination is "very high".

Synthetic Organic Chemicals

The contaminant risk for synthetic organic chemicals is "medium".

Review of the historical sampling data indicates that test results for ethylene dibromide and bromodichloromethane in 2002-2003 were negative.

Sources of synthetic organic chemicals could be from airfields or large capacity septic systems located within the protection area.

After combining the contaminant risk with the natural susceptibility of the source, the overall vulnerability to synthetic organic chemicals of the source is "high" (See Chart 11 – Contaminant Risks for Synthetic Organic Chemicals in Appendix D).

Other Organic Chemicals

The contaminant risk for other organic chemicals is "medium".

Review of the historical sampling data indicates that no other organic chemicals have been sampled recently.

Sources of other organic chemicals could be from activity along roads, airfields, or from large capacity septic systems located within the protection area.

After combining the contaminant risk with the natural susceptibility of the source, the overall vulnerability to other organic chemicals of the source is "high" (See Chart 13 – Contaminant Risks for Other Organic Chemicals in Appendix D).

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 TeckCominco 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.

REFERENCES

Alaska Department of Community and Economic Development (ADCED), 2003 [WWW document]. URL http://www.dced.state.ak.us/cbd/commdb/CF_COMDB.htm

TeckCominco, 2004. [WWW document]. URL http://www.teckcominco.com/operations/reddog/review.htm

United States Environmental Protection Agency (EPA), 2003 [WWW document]. URL http://www.epa.gov/safewater/mcl.html.

APPENDIX A

Red Dog Mining Facility
Drinking Water Protection Area Location Map
(Map 1)

TeckCominco (Red Dog Mine)
Drinking Water Protection Area

Map 1: TeckCominco (Red Dog Mine) Drinking Water Protection Area

PWSID: 340670.001

Alaska Department of Environmental Conservation

Alaska Drinking Water Protection Program

0 2,000 4,000 8,000 12,000 Feet

1:50,191

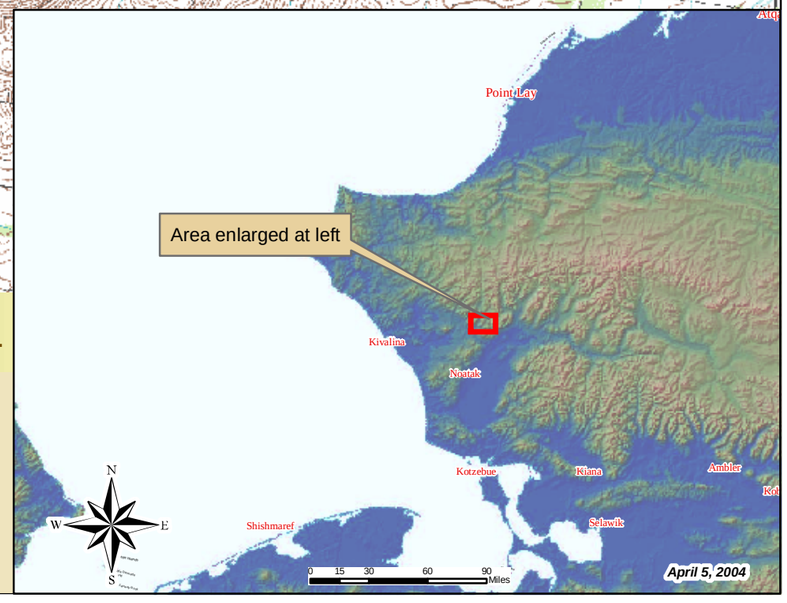
Data Sources:

Background image
- USGS 1:63,000 mapping

Protection zones were delineated based upon streams noted on USGS 1:63,000 mapping.

Legend

- RedDog Water Intake
- Stream
- Zone A Protection Area
- Zone B Protection Area
- Zone C Protection Area



APPENDIX B

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

Table 1

Contaminant Source Inventory for ***TeckCominco Red Dog Mine***

PWSID 340670.001

Contaminant Source Type	*Contaminant Source ID*	*CS ID tag*	*Zone*	*Map Number*	*Comments*
Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal Method)	D10	D10-1	A	2	Assumed septic system for ConPac facility.
Mine tailings (active piles or ponds)	E07	E07-1	A	2	Information taken from Aerial map provided by operator.
Tanks, diesel (above ground)	T06	T06-1	A	2	Information taken from Aerial map provided by operator.
Airports	X14	X14-1	A	2	Information provided by system operator.
Highways and roads, dirt/gravel (Paved with Arctic Asphalt)	X24	X24-1	A	2	Information provided by system operator.

Table 2

Contaminant Source Inventory and Risk Ranking for TeckCominco Red Dog Mine Sources of Bacteria and Viruses

PWSID 340670.001

Contaminant Source Type	***Contaminant Source ID***	***CS ID tag***	***Zone***	***Risk Ranking for Analysis***	***Map Number***	***Comments***
Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal Method)	D10	D10-1	A	High	2	Assumed septic system for ConPac facility.
Highways and roads, dirt/gravel (Paved with Arctic Asphalt)	X24	X24-1	A	Low	2	Information provided by system operator.

Table 3

Contaminant Source Inventory and Risk Ranking for TeckCominco Red Dog Mine Sources of Nitrates/Nitrites

PWSID 340670.001

Contaminant Source Type	***Contaminant Source ID***	***CS ID tag***	***Zone***	***Risk Ranking for Analysis***	***Map Number***	***Comments***
Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal Method)	D10	D10-1	A	High	2	Assumed septic system for ConPac facility.
Airports	X14	X14-1	A	Low	2	Information provided by system operator.
Highways and roads, dirt/gravel (Paved with Arctic Asphalt)	X24	X24-1	A	Low	2	Information provided by system operator.

Table 4

Contaminant Source Inventory and Risk Ranking for TeckCominco Red Dog Mine Sources of Volatile Organic Chemicals

PWSID 340670.001

Contaminant Source Type	***Contaminant Source ID***	***CS ID tag***	***Zone***	***Risk Ranking for Analysis***	***Map Number***	***Comments***
Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal Method)	D10	D10-1	A	Low	2	Assumed septic system for ConPac facility.
Tanks, diesel (above ground)	T06	T06-1	A	Medium	2	Information taken from Aerial map provided by operator.
Airports	X14	X14-1	A	Medium	2	Information provided by system operator.
Highways and roads, dirt/gravel (Paved with Arctic Asphalt)	X24	X24-1	A	Low	2	Information provided by system operator.

Table 5

Contaminant Source Inventory and Risk Ranking for TeckCominco Red Dog Mine

Sources of Heavy Metals, Cyanide and Other Inorganic Chemicals

PWSID 340670.001

Contaminant Source Type	*Contaminant Source ID*	*CS ID tag*	*Zone*	*Risk Ranking for Analysis*	*Map Number*	*Comments*
Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal Method)	D10	D10-1	A	Low	2	Assumed septic system for ConPac facility.
Mine tailings (active piles or ponds)	E07	E07-1	A	Very High	2	Information taken from Aerial map provided by operator.
Airports	X14	X14-1	A	Low	2	Information provided by system operator.
Highways and roads, dirt/gravel (Paved with Arctic Asphalt)	X24	X24-1	A	Low	2	Information provided by system operator.

Table 6

Contaminant Source Inventory and Risk Ranking for TeckCominco Red Dog Mine Sources of Synthetic Organic Chemicals

PWSID 340670.001

Contaminant Source Type	*Contaminant Source ID*	*CS ID tag*	*Zone*	*Risk Ranking for Analysis*	*Map Number*	*Comments*
Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal Method)	D10	D10-1	A	Low	2	Assumed septic system for ConPac facility.
Airports	X14	X14-1	A	Medium	2	Information provided by system operator.

Table 7

Contaminant Source Inventory and Risk Ranking for TeckCominco Red Dog Mine
Sources of Other Organic Chemicals

PWSID 340670.001

Contaminant Source Type	***Contaminant Source ID***	***CS ID tag***	***Zone***	***Risk Ranking for Analysis***	***Map Number***	***Comments***
Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal Method)	D10	D10-1	A	Low	2	Assumed septic system for ConPac facility.
Airports	X14	X14-1	A	Medium	2	Information provided by system operator.
Highways and roads, dirt/gravel (Paved with Arctic Asphalt)	X24	X24-1	A	Low	2	Information provided by system operator.

APPENDIX C

Red Dog Mining Facility
Drinking Water Protection Area
and Potential and Existing Contaminant Sources
(Map 2)

Red Dog Camp

E7
Mining Tailings
(active piles or ponds)

X24-1
Dirt/Gravel Roads

X14-1
Airport / AirStrip

Water System Intake

T6
Construction Camp
Tanks, diesel (above ground)

D10
Construction Camp
Large capacity septic system

Area enlarged at left

Map 2: Potential and Existing Contaminant Sources

PWSID: 340670.001

Alaska Department of Environmental Conservation

Alaska Drinking Water Protection Program

0 1,000 2,000 4,000 Feet

1:20,973

Data Sources:

Background image
- USGS 1:63,000 mapping

Protection zones were delineated based upon streams noted on USGS 1:63,000 mapping.

For this PWS, Zone C (the entire watershed) covers the same area as Zone B (areas within 1-mile of the stream).

Legend

- TeckCominco / ConPAC - Red Dog
- Zone A Protection Area
- Zone B Protection Area
- Zone C Protection Area
- Transportation

N W E S

0 1 2 Miles

April 5, 2004

APPENDIX D

Vulnerability Analysis and Contaminant Risks
(Charts 1-13)

Chart 1. Susceptibility of the Surface Water Source - TeckCominco - Red Dog Mine

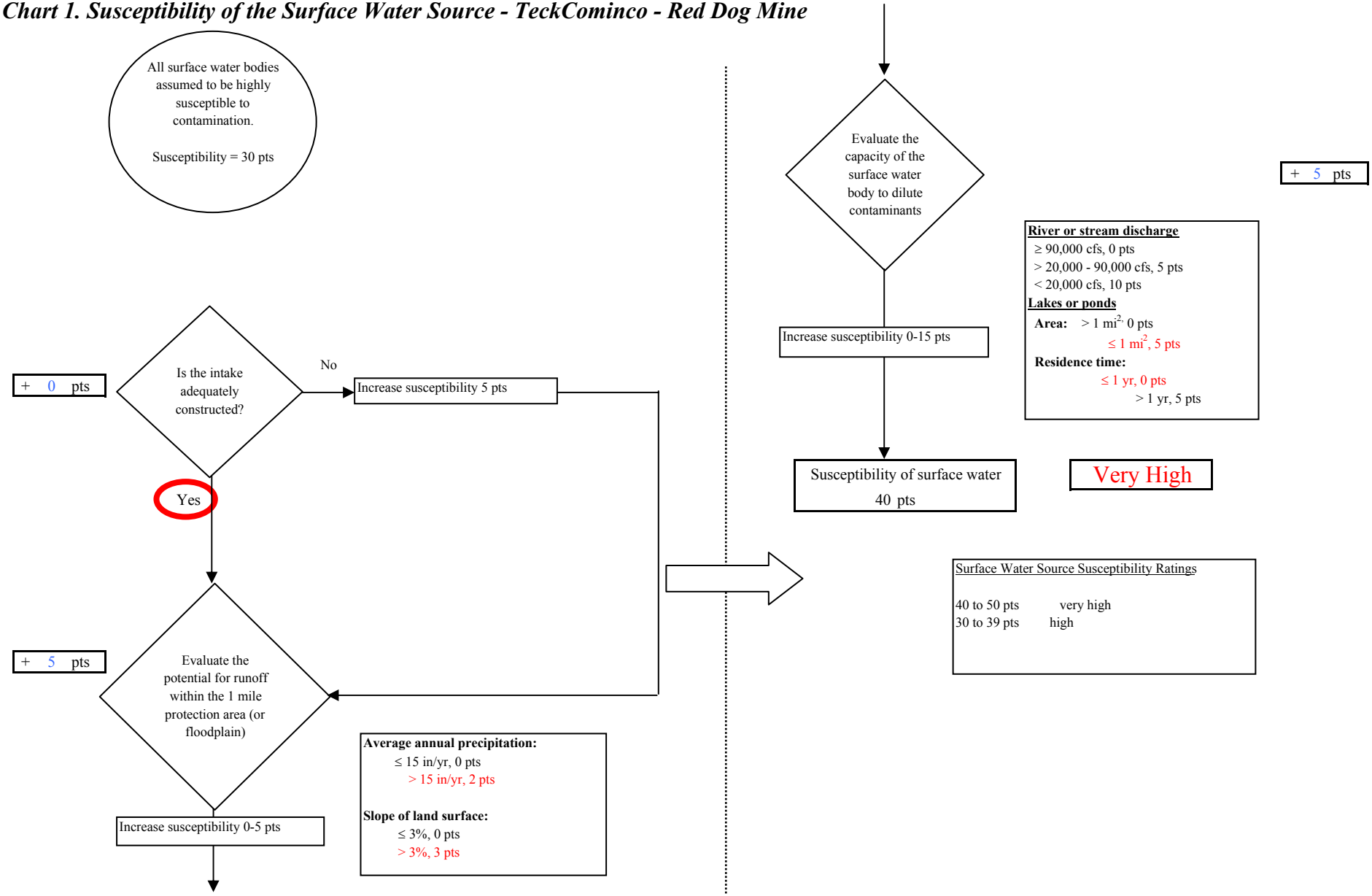
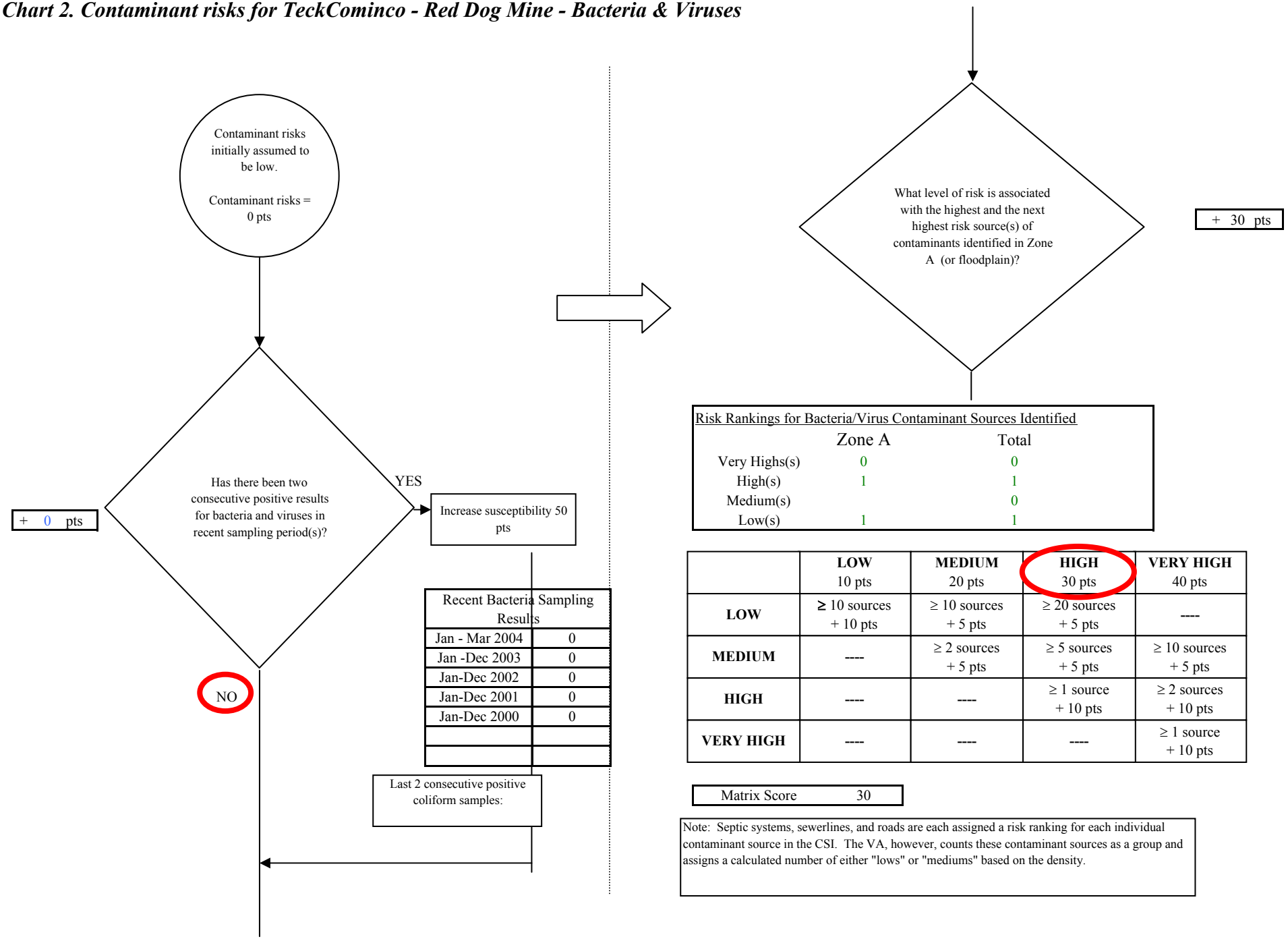


Chart 2. Contaminant risks for TeckCominco - Red Dog Mine - Bacteria & Viruses



Risk Rankings for Bacteria/Virus Contaminant Sources Identified

	Zone A	Total
Very Highs(s)	0	0
High(s)	1	1
Medium(s)		0
Low(s)	1	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 2. Contaminant risks for TeckCominco - Red Dog Mine - Bacteria & Viruses

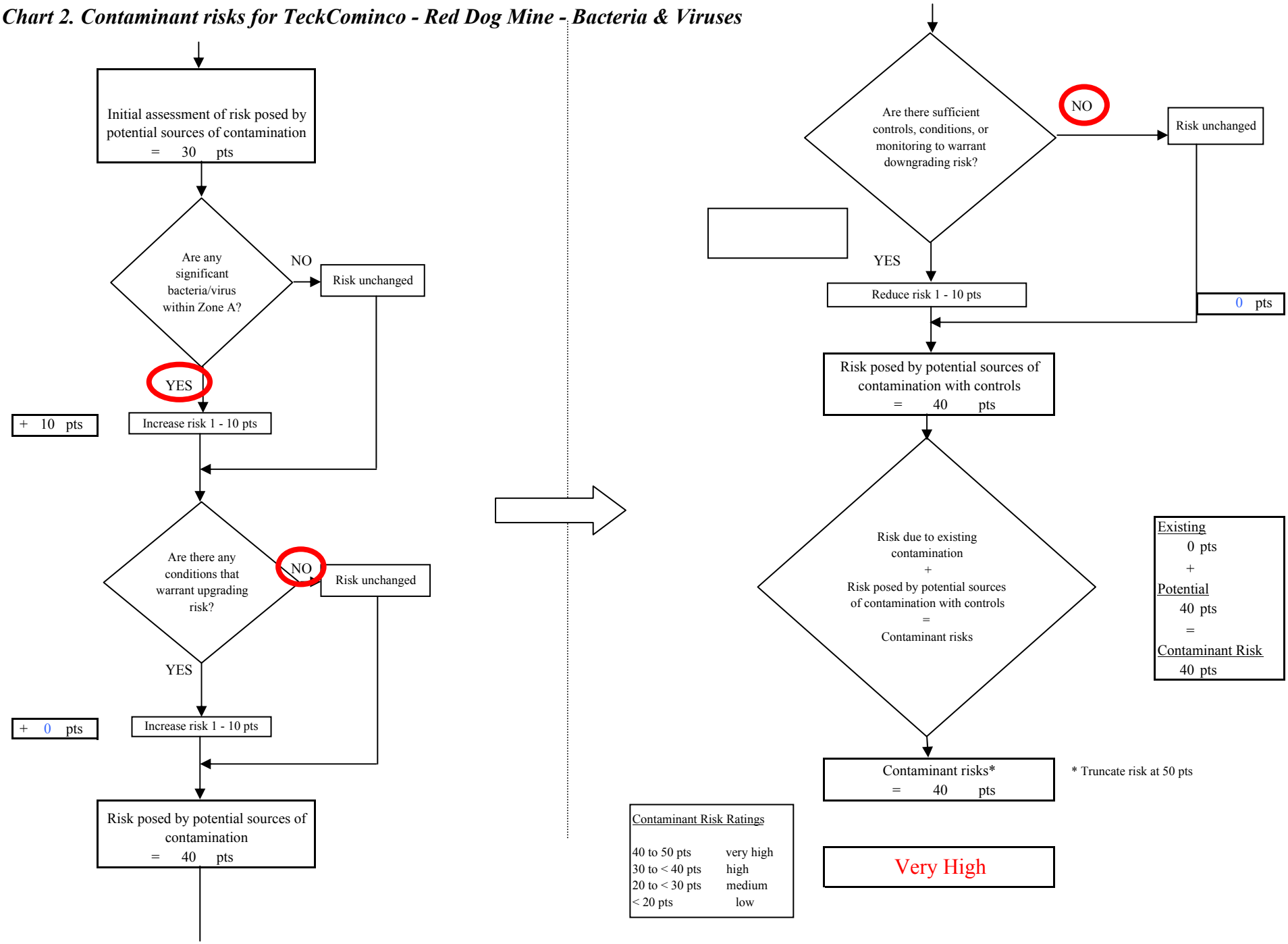


Chart 3. Vulnerability analysis for TeckCominco - Red Dog Mine - Bacteria & Viruses

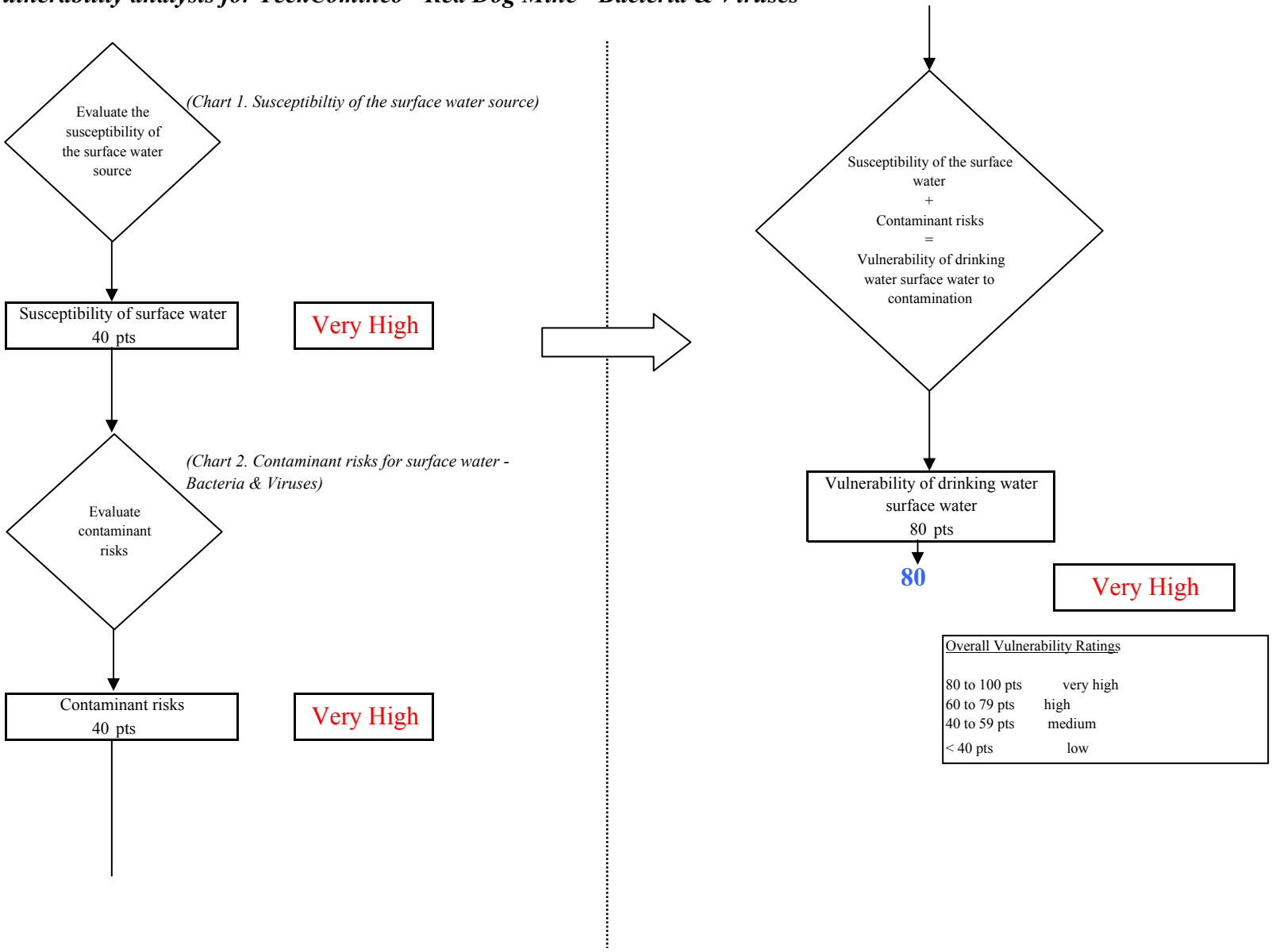


Chart 4. Contaminant risks for TeckCominco - Red Dog Mine - Nitrates and Nitrites

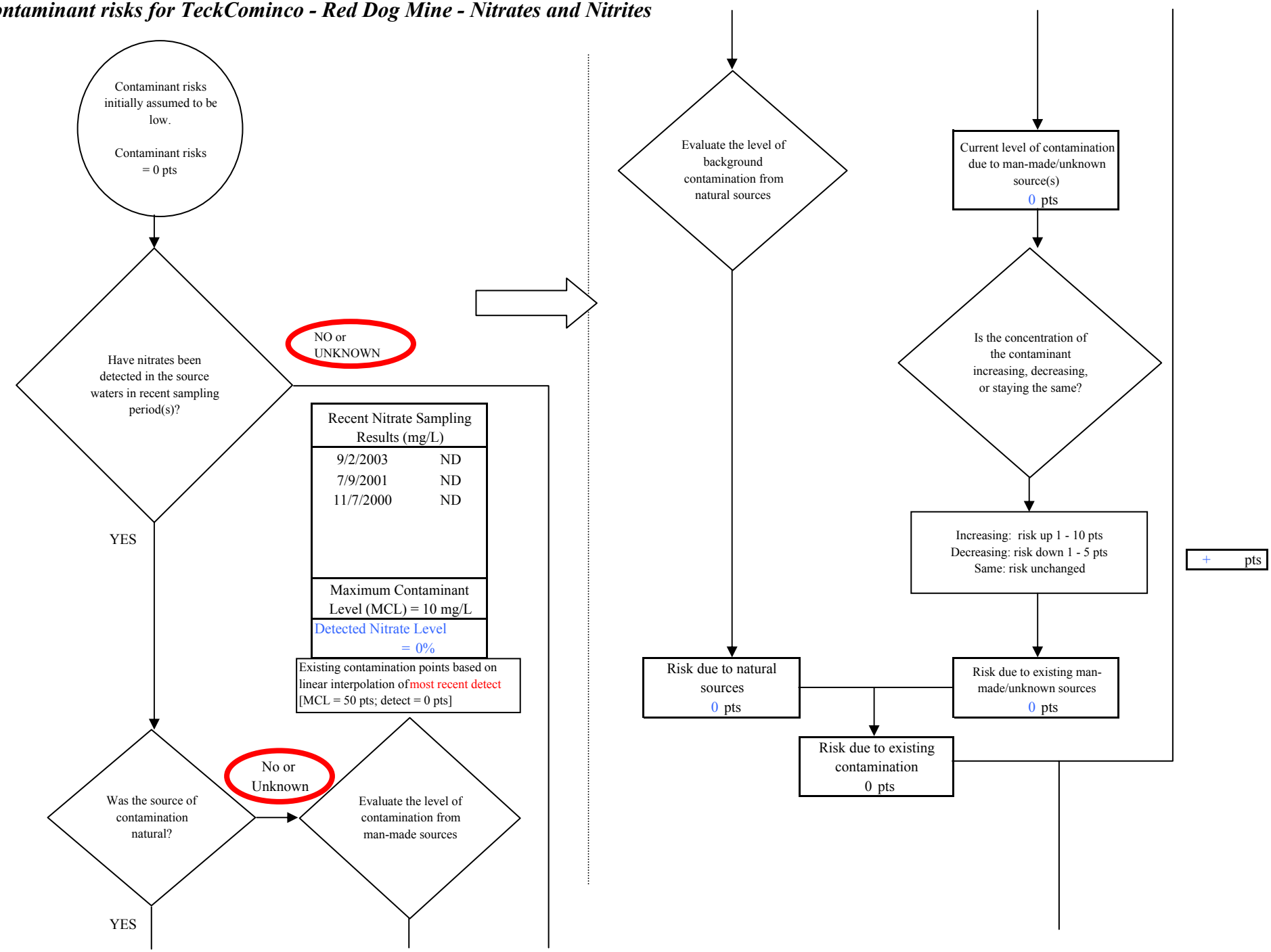
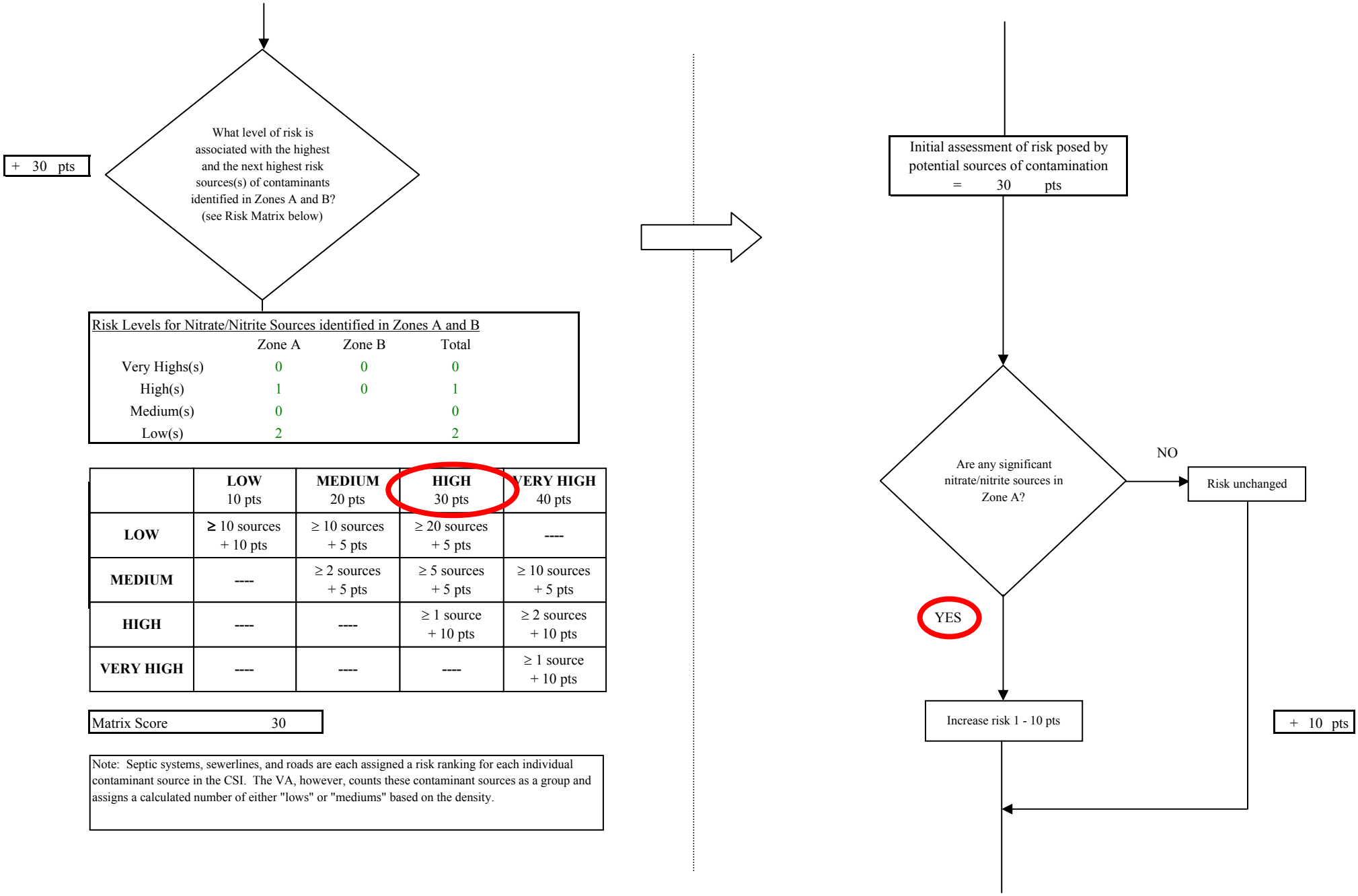


Chart 4. Contaminant risks for TeckCominco - Red Dog Mine - Nitrates and Nitrites



Risk Levels for Nitrate/Nitrite Sources identified in Zones A and B

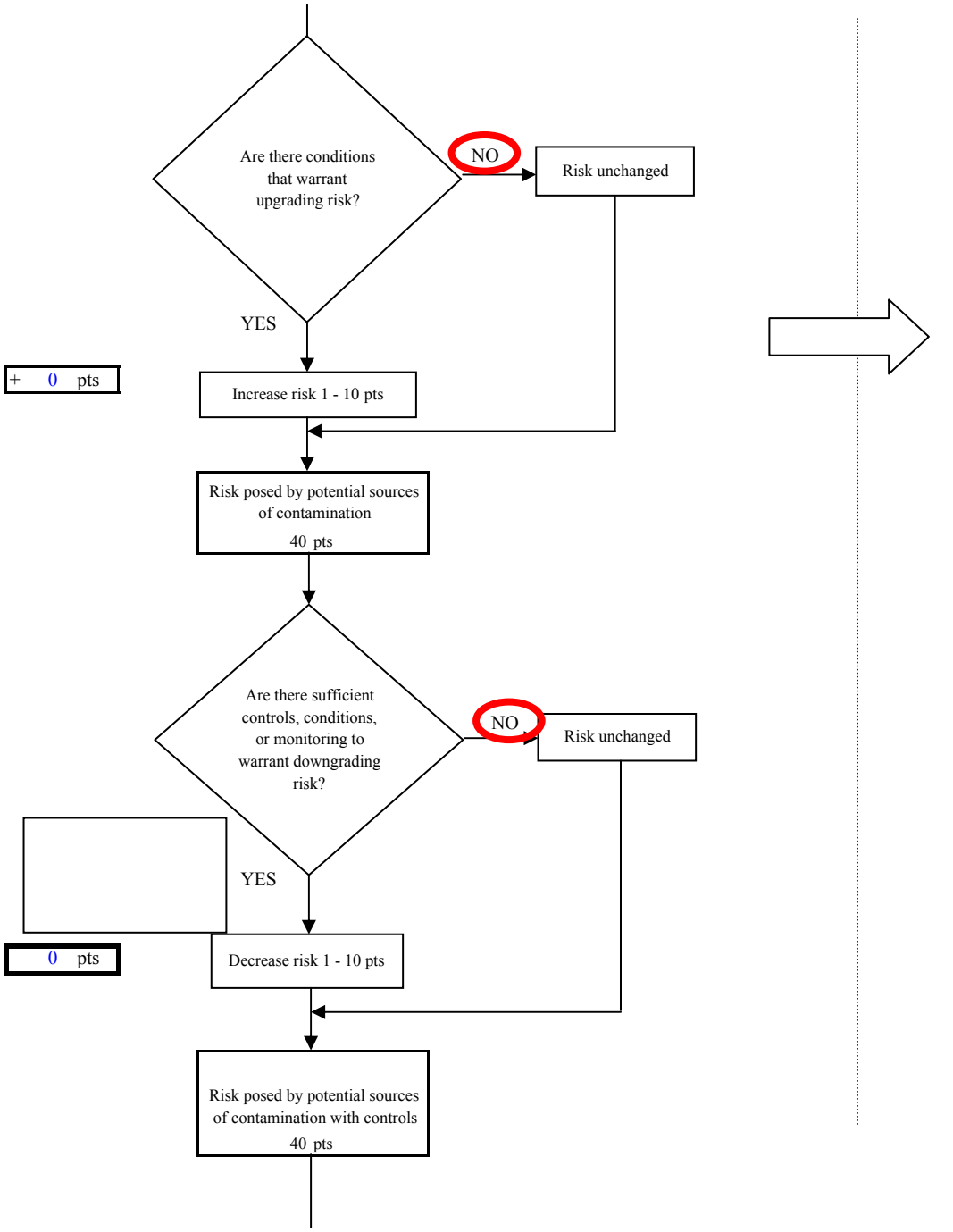
	Zone A	Zone B	Total
Very Highs(s)	0	0	0
High(s)	1	0	1
Medium(s)	0		0
Low(s)	2		2

	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 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 4. Contaminant risks for TeckCominco - Red Dog Mine - Nitrates and Nitrites



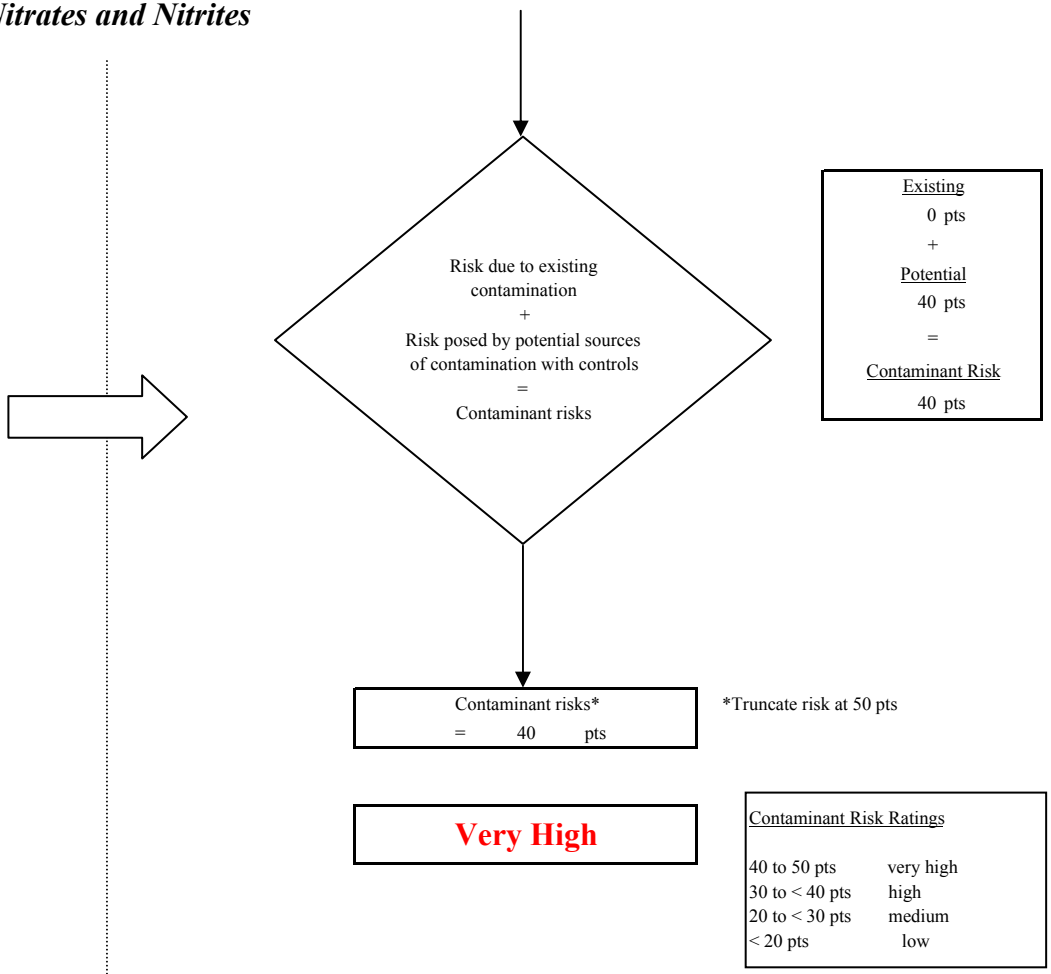


Chart 5. Vulnerability analysis for TeckCominco - Red Dog Mine - Nitrates and Nitrites

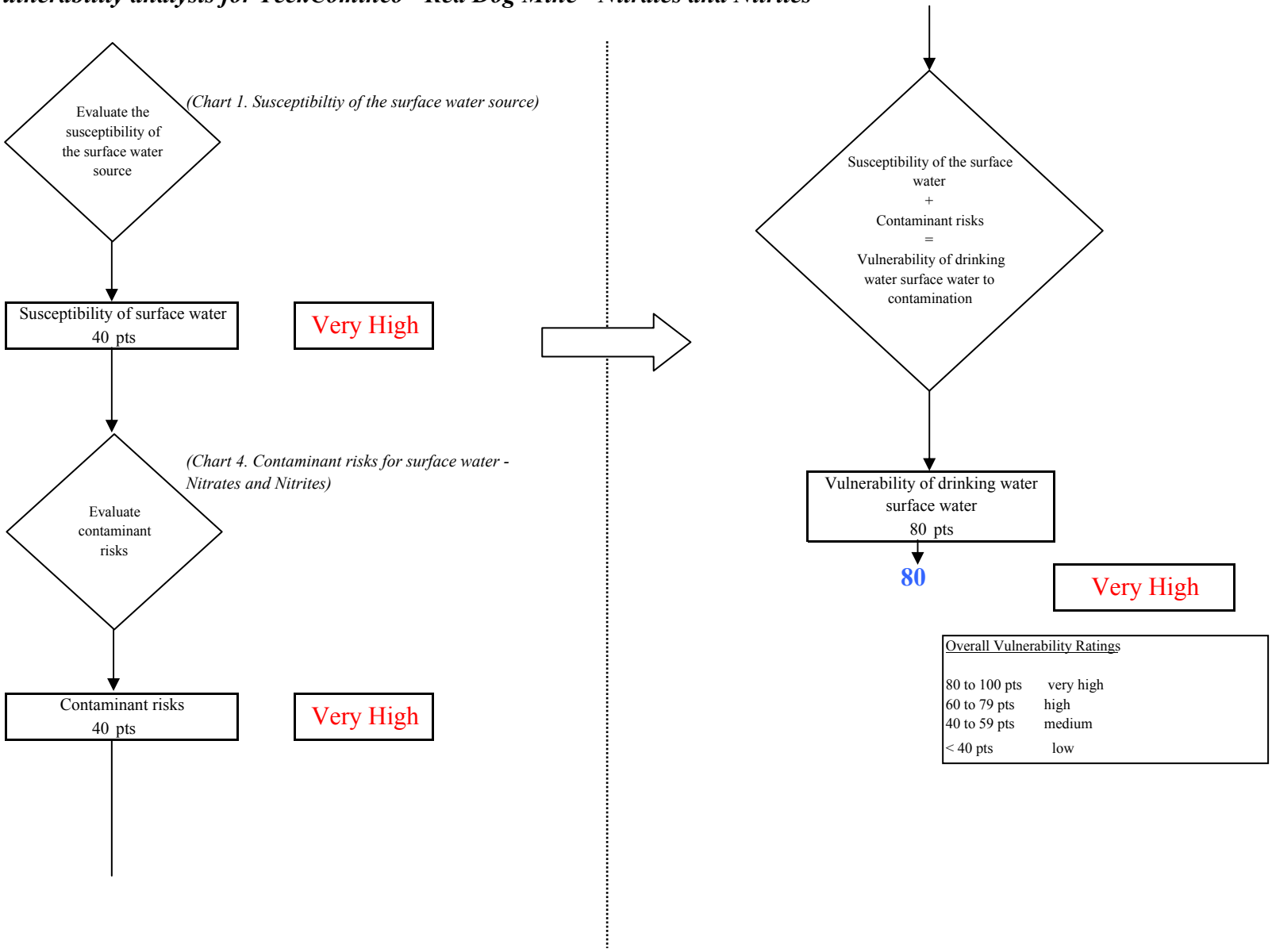


Chart 6. Contaminant risks for TeckCominco - Red Dog Mine - Volatile Organic Chemicals

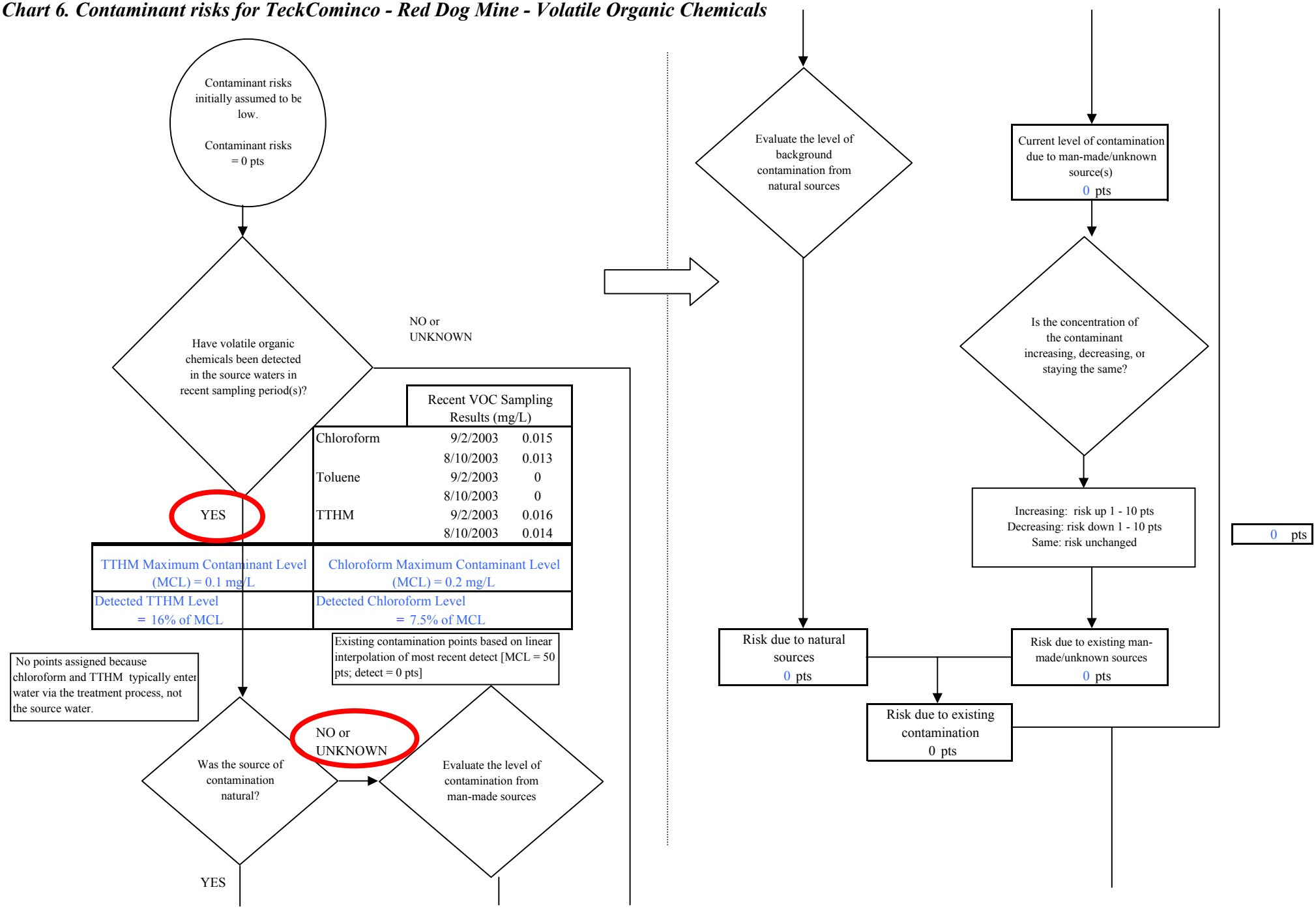
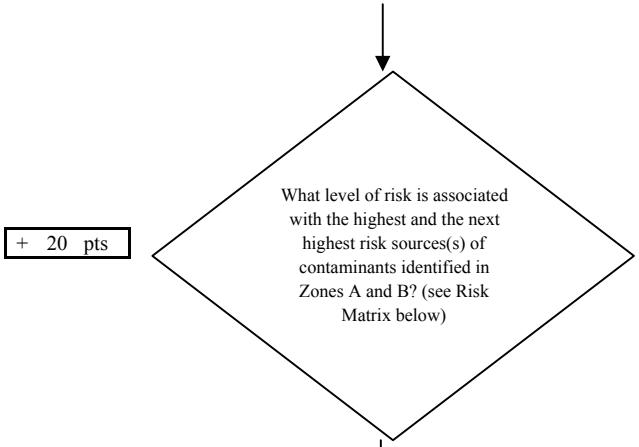


Chart 6. Contaminant risks for TeckCominco - Red Dog Mine - Volatile Organic Chemicals



+ 20 pts

Risk Levels for VOC 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		2
Low(s)	2		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.

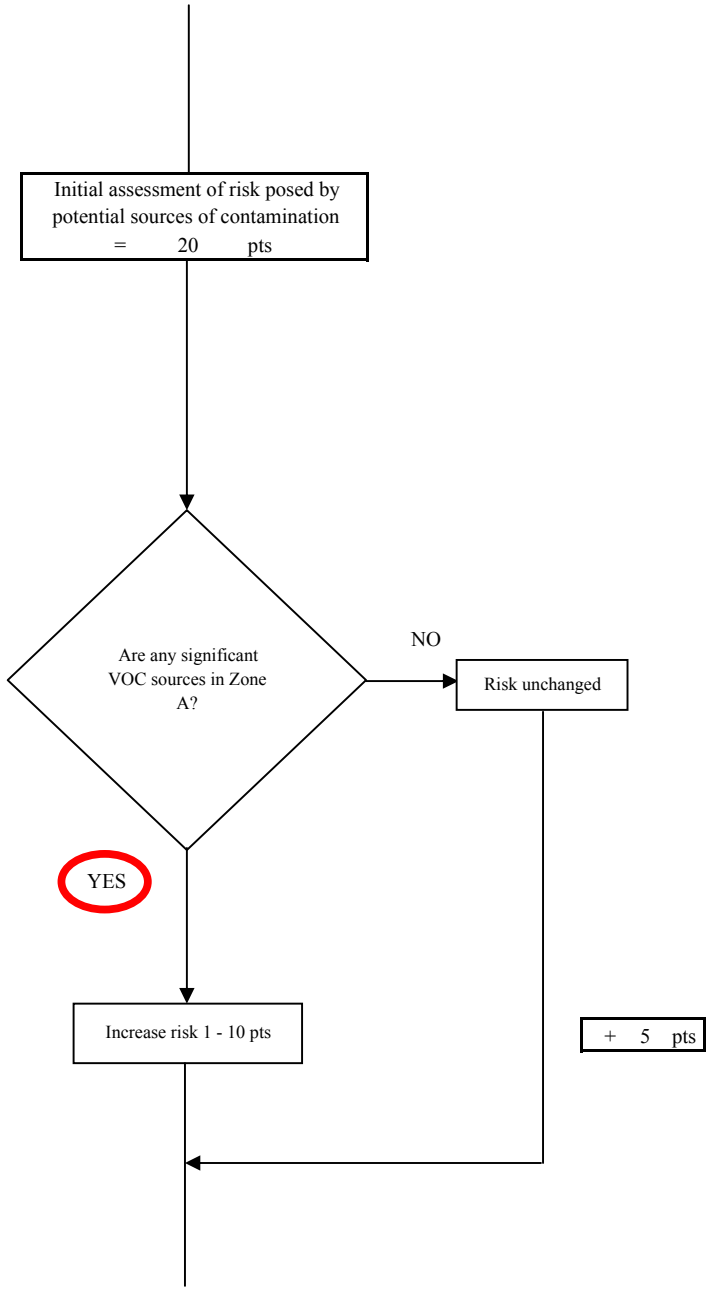


Chart 6. Contaminant risks for TeckCominco - Red Dog Mine - Volatile Organic Chemicals

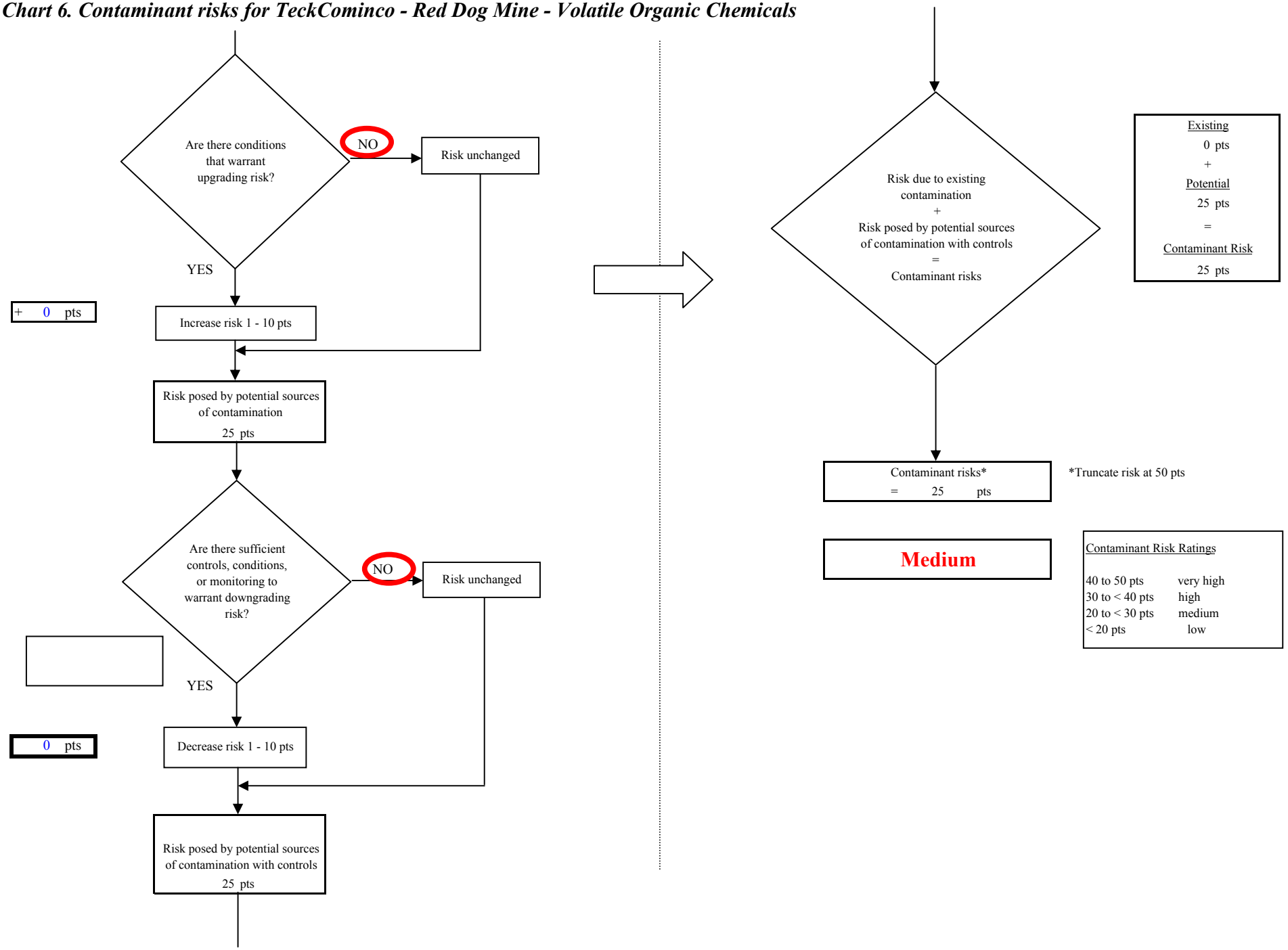


Chart 7. Vulnerability analysis for TeckCominco - Red Dog Mine - Volatile Organic Chemicals

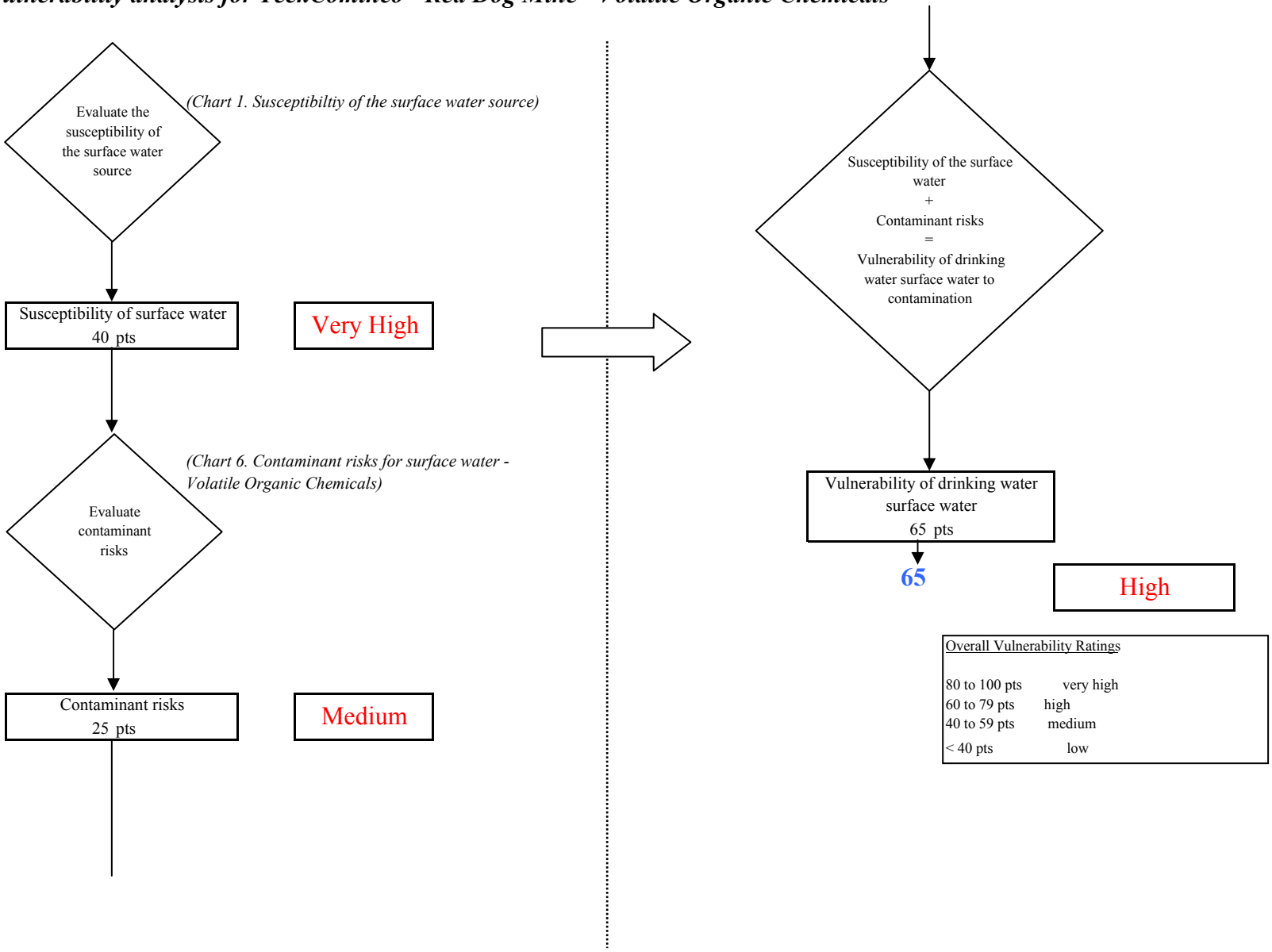


Chart 8. Contaminant risks for TeckCominco - Red Dog Mine - Heavy Metals, Cyanide and Other Inorganic Chemicals

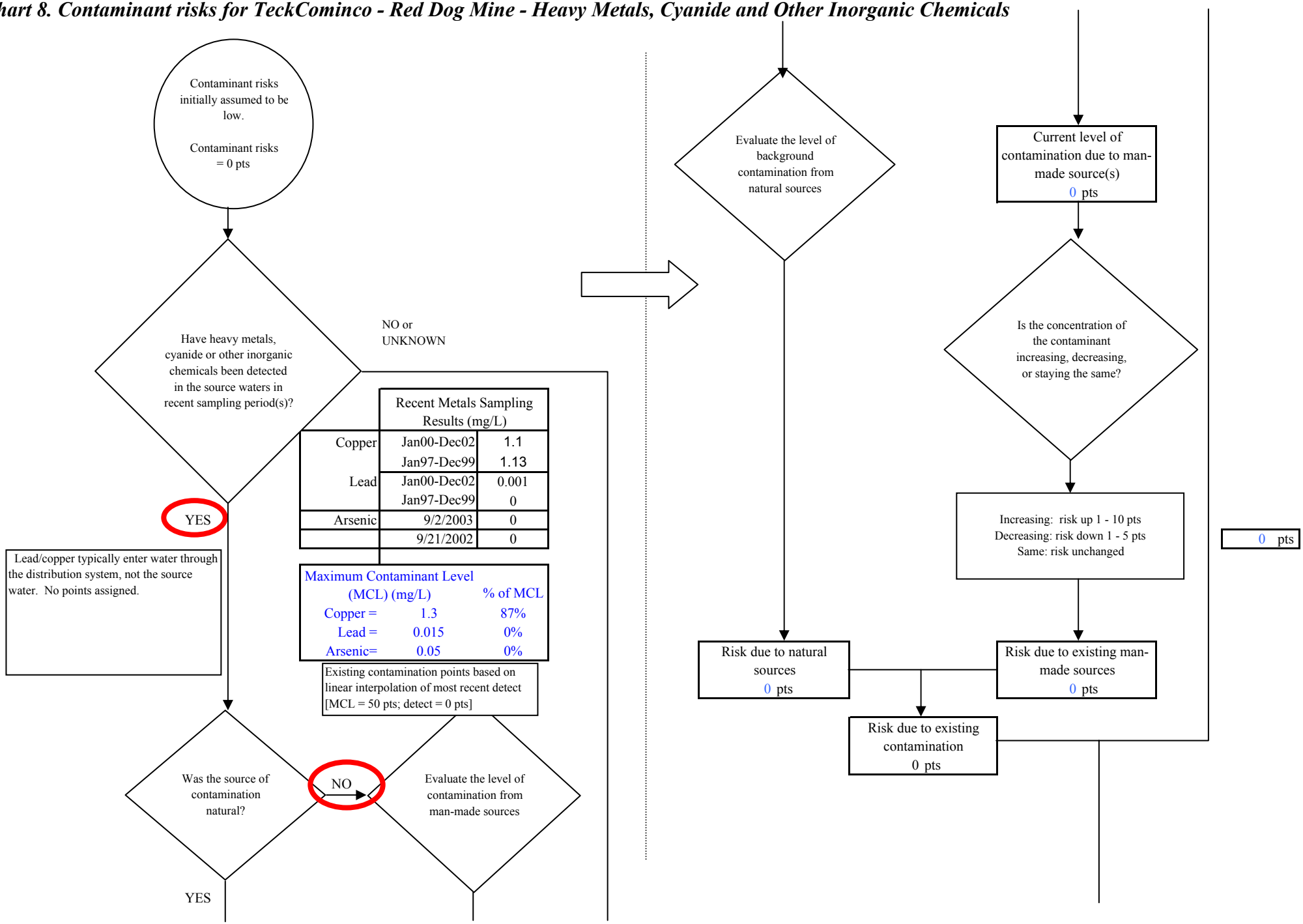
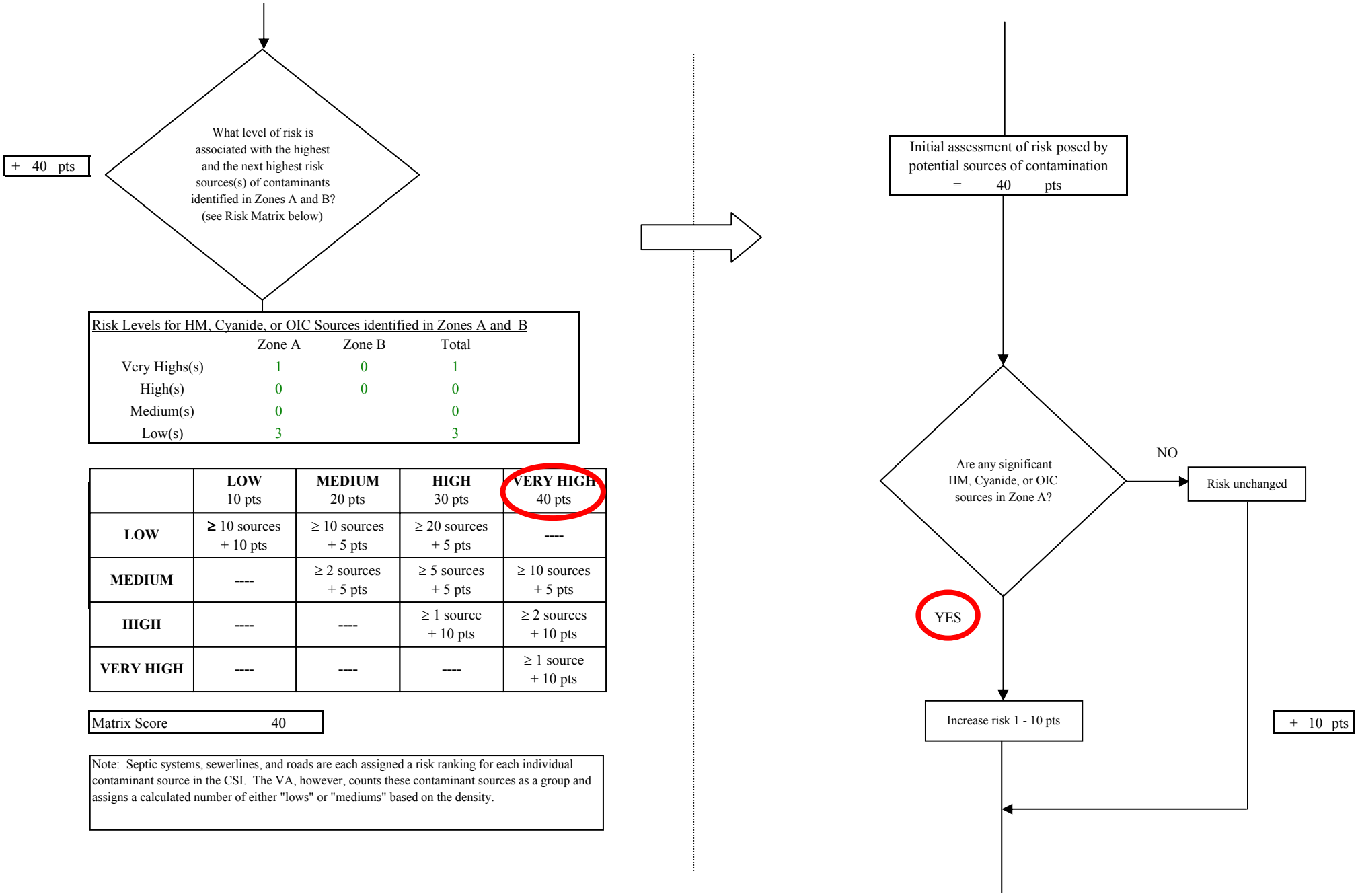


Chart 8. Contaminant risks for TeckCominco - Red Dog Mine - Heavy Metals, Cyanide and Other Inorganic Chemicals



Risk Levels for HM, Cyanide, or OIC Sources identified in Zones A and B

	Zone A	Zone B	Total
Very Highs(s)	1	0	1
High(s)	0	0	0
Medium(s)	0		0
Low(s)	3		3

	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 40

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 8. Contaminant risks for TeckCominco - Red Dog Mine - Heavy Metals, Cyanide and Other Inorganic Chemicals

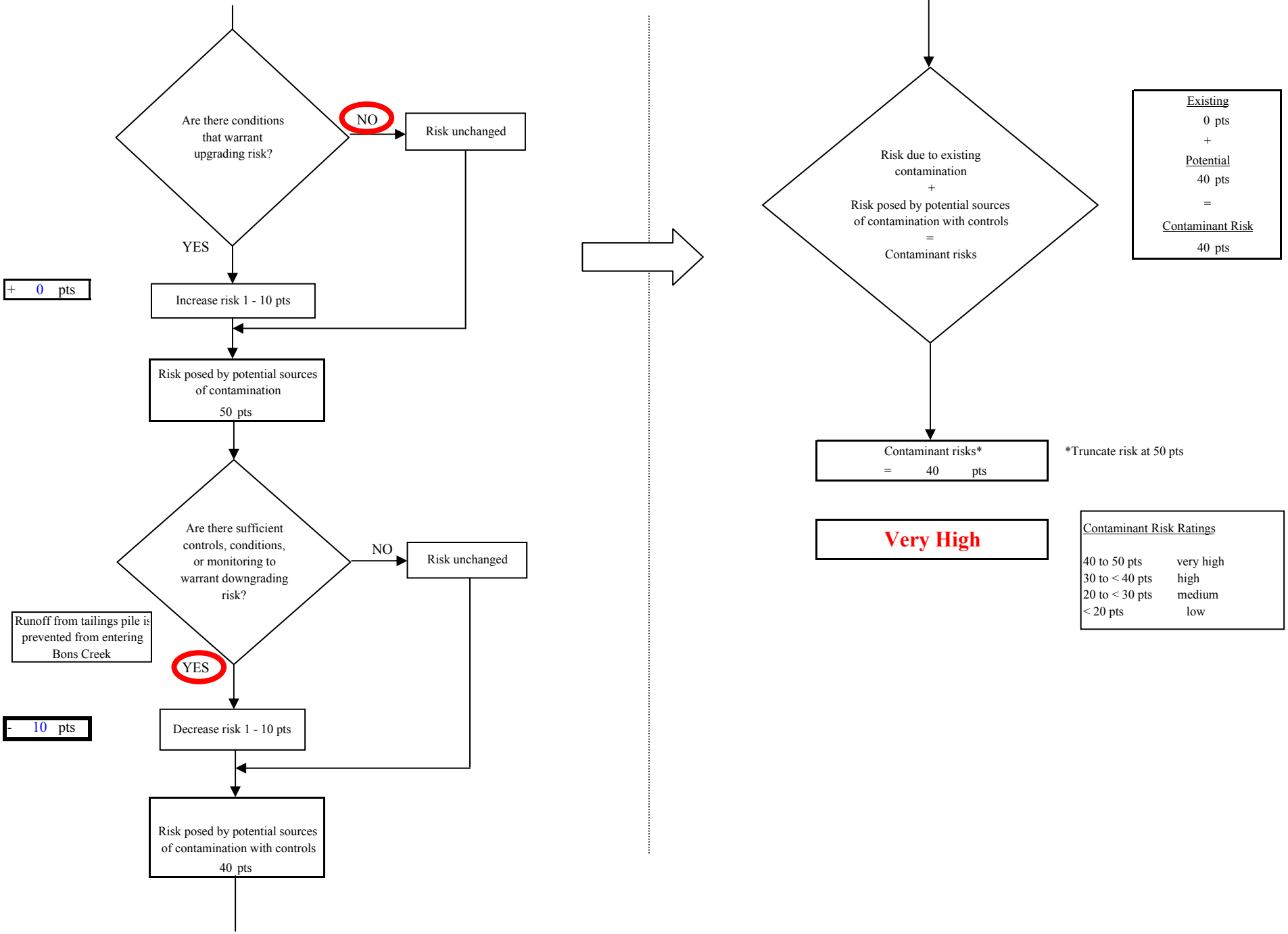


Chart 9. Vulnerability analysis for TeckCominco - Red Dog Mine - Heavy Metals, Cyanide and Other Inorganic Chemicals

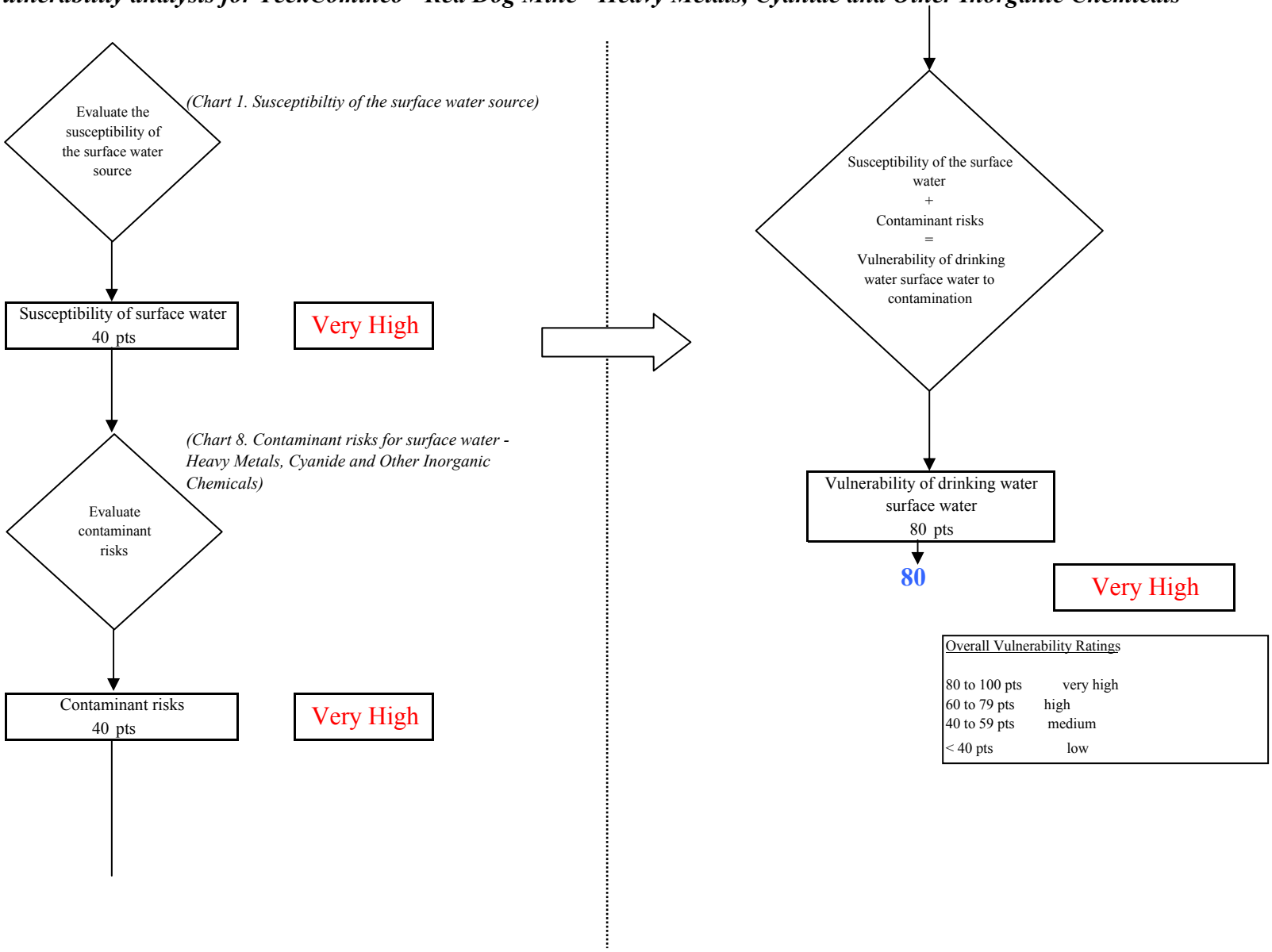


Chart 10. Contaminant risks for TeckCominco - Red Dog Mine - Synthetic Organic Chemicals

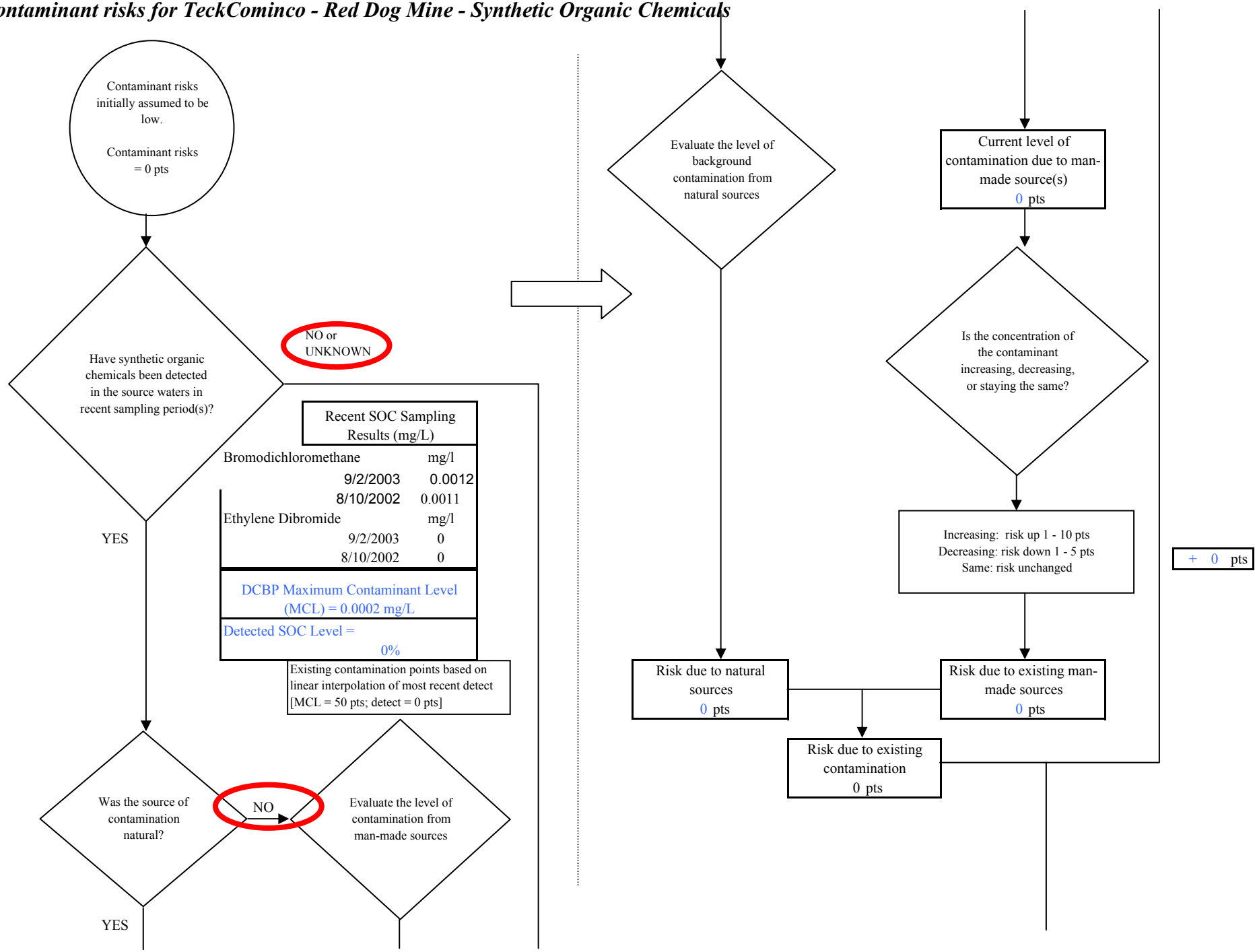
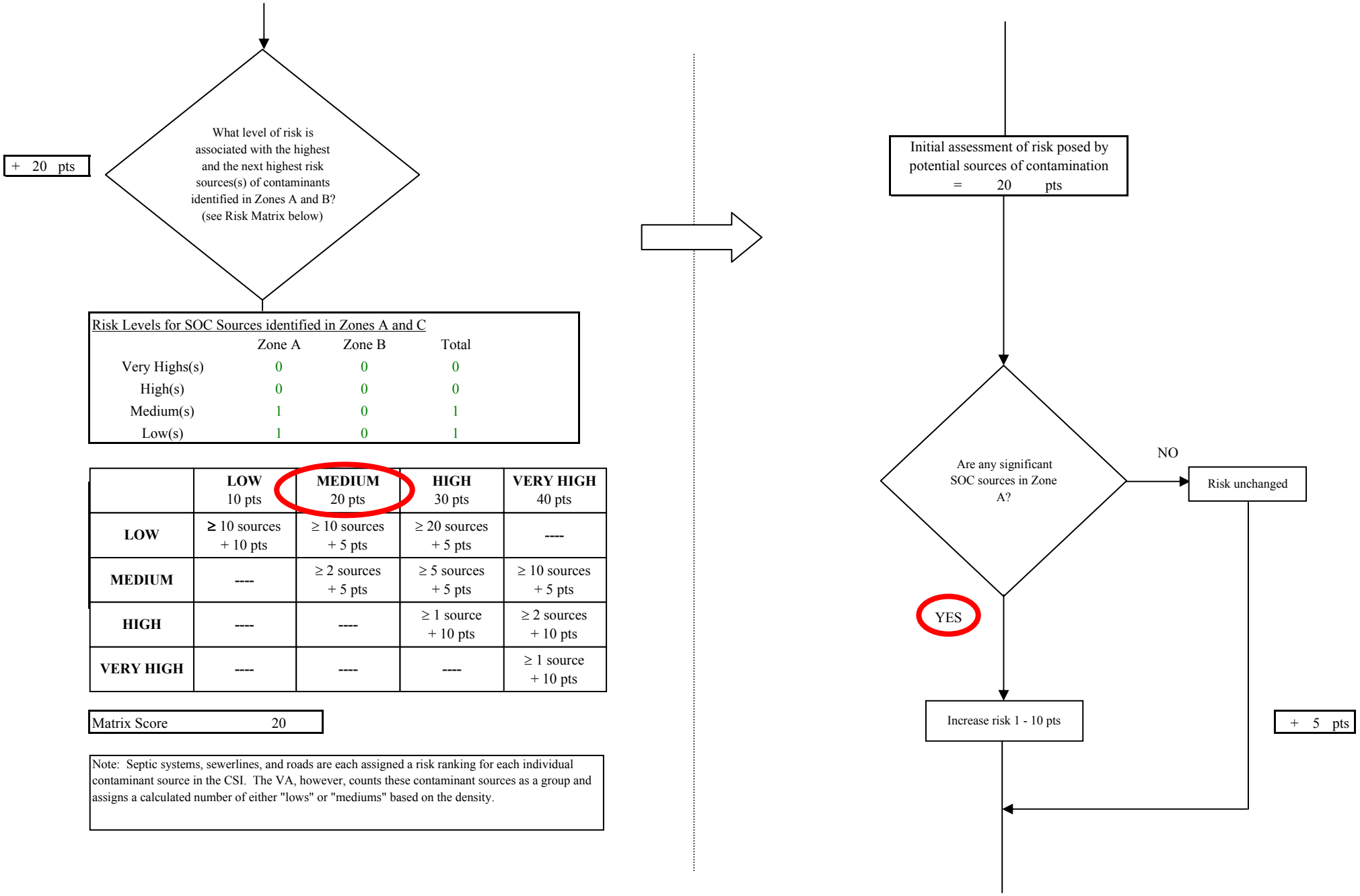


Chart 10. Contaminant risks for TeckCominco - Red Dog Mine - Synthetic Organic Chemicals



Risk Levels for SOC Sources identified in Zones A and C

	Zone A	Zone B	Total
Very Highs(s)	0	0	0
High(s)	0	0	0
Medium(s)	1	0	1
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 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 10. Contaminant risks for TeckCominco - Red Dog Mine - Synthetic Organic Chemicals

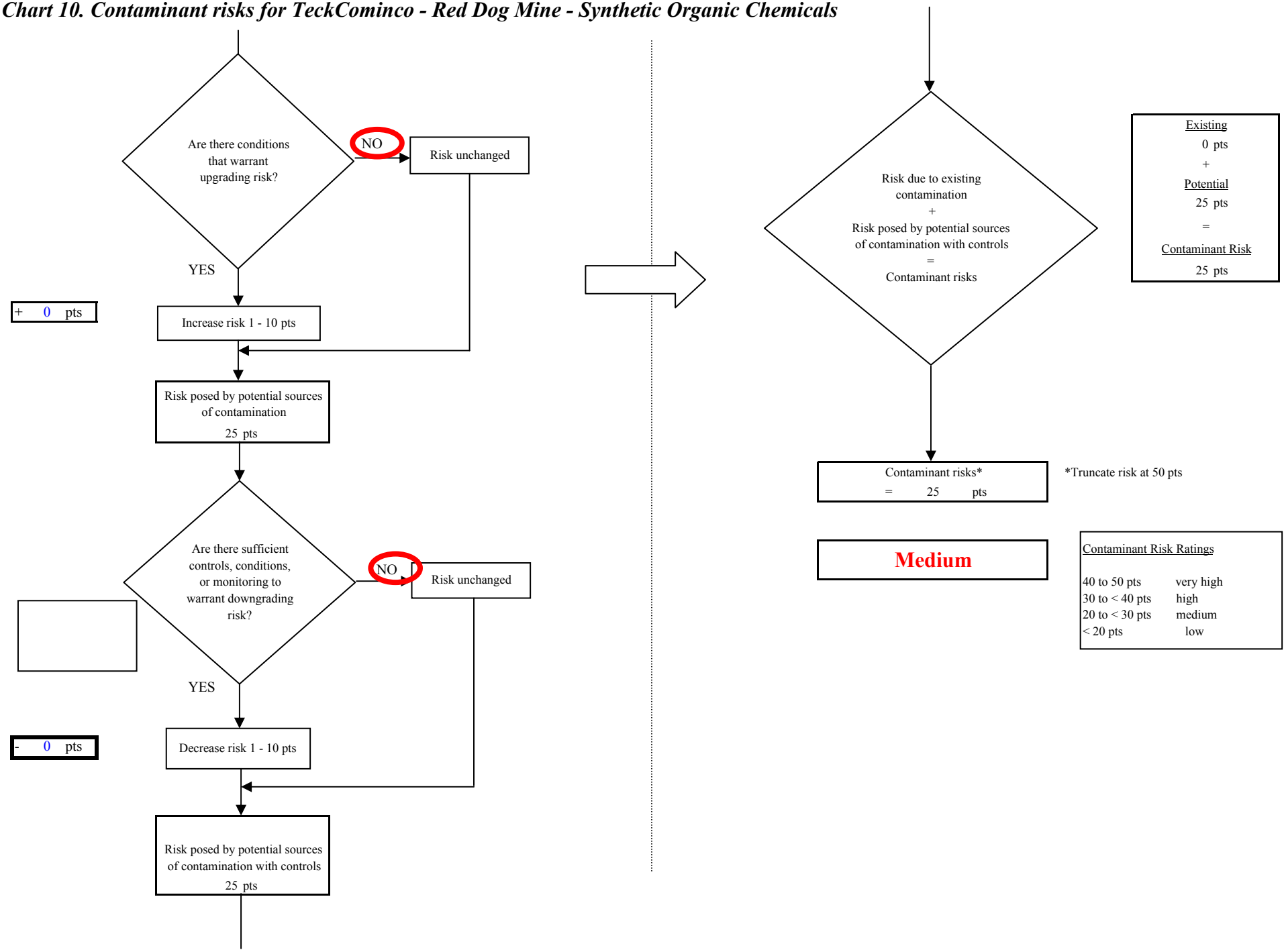


Chart 11. Vulnerability analysis for TeckCominco - Red Dog Mine - Synthetic Organic Chemicals

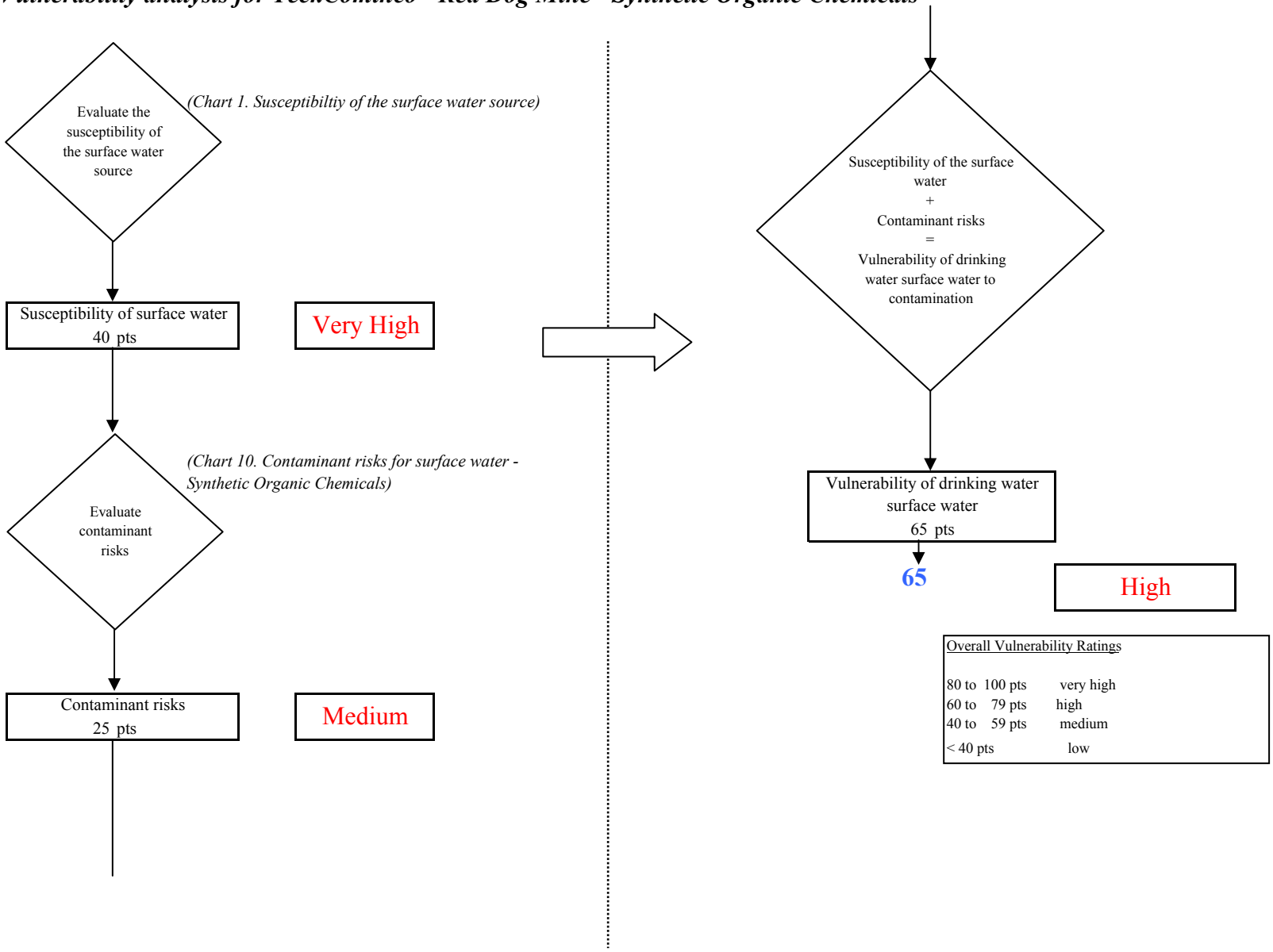


Chart 12. Contaminant risks for TeckCominco - Red Dog Mine - Other Organic Chemicals

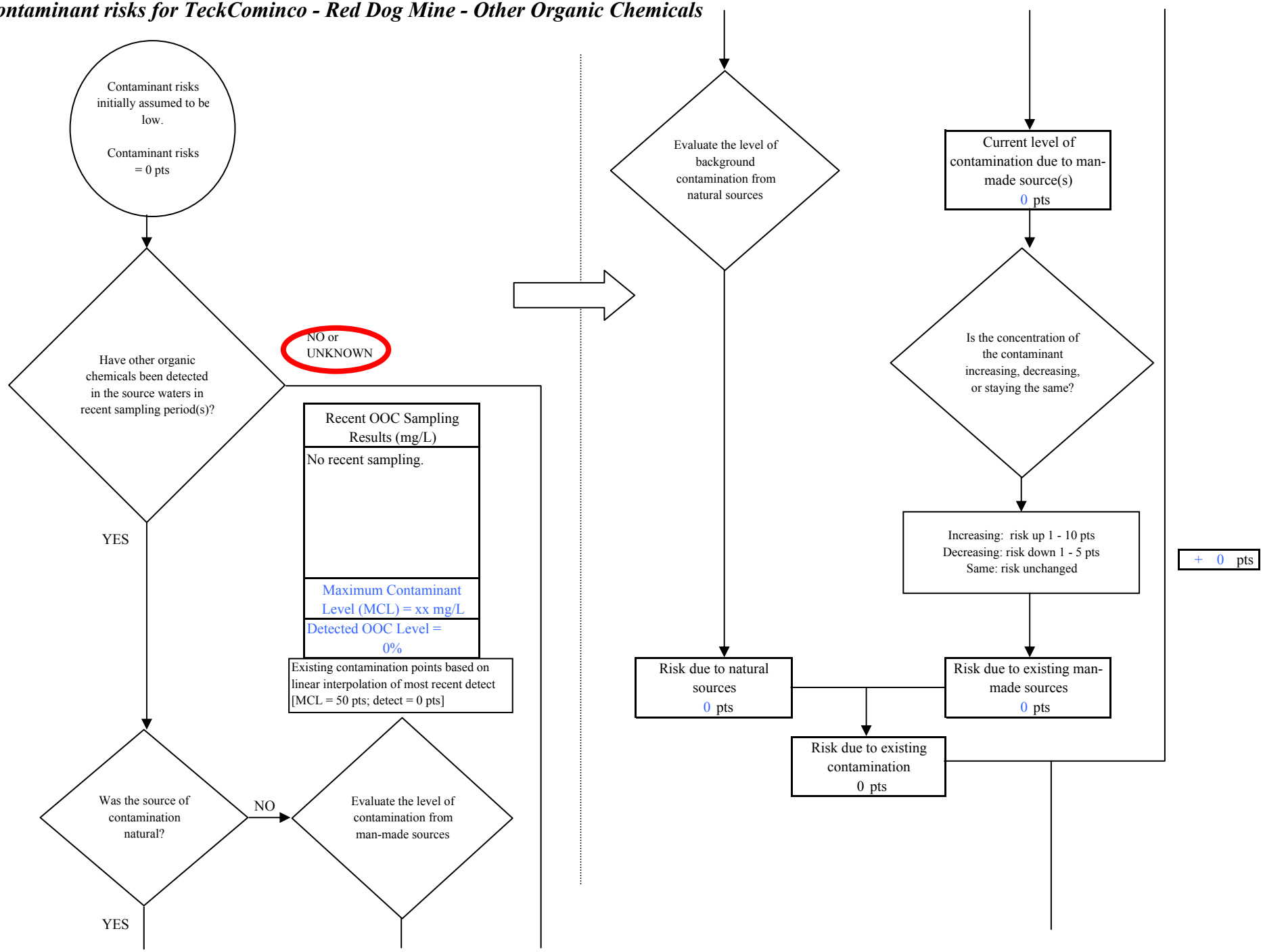
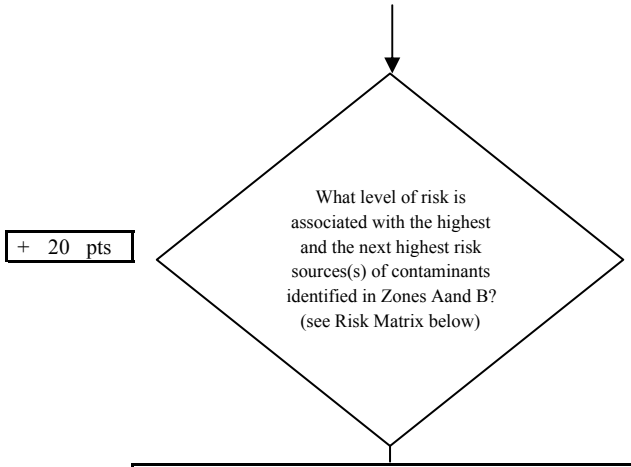


Chart 12. Contaminant risks for TeckCominco - Red Dog Mine - Other Organic Chemicals



+ 20 pts

Risk Levels for OOC 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)	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.

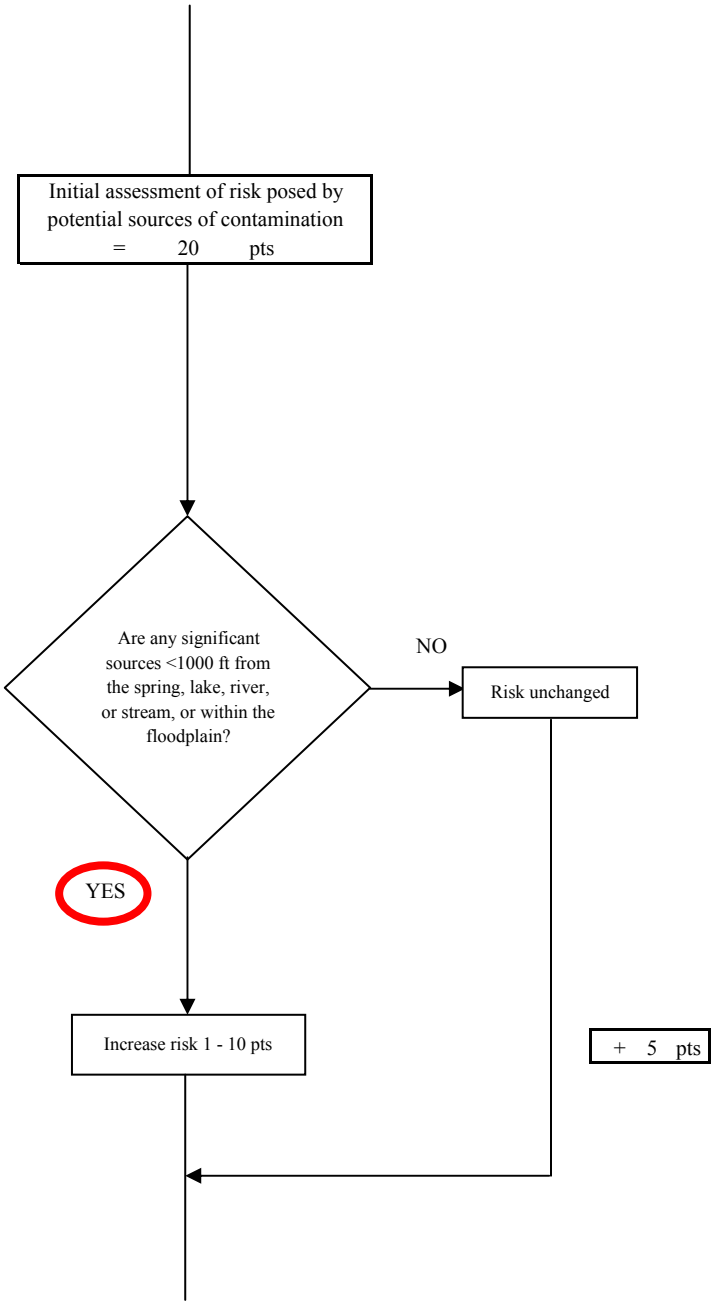


Chart 12. Contaminant risks for TeckCominco - Red Dog Mine - Other Organic Chemicals

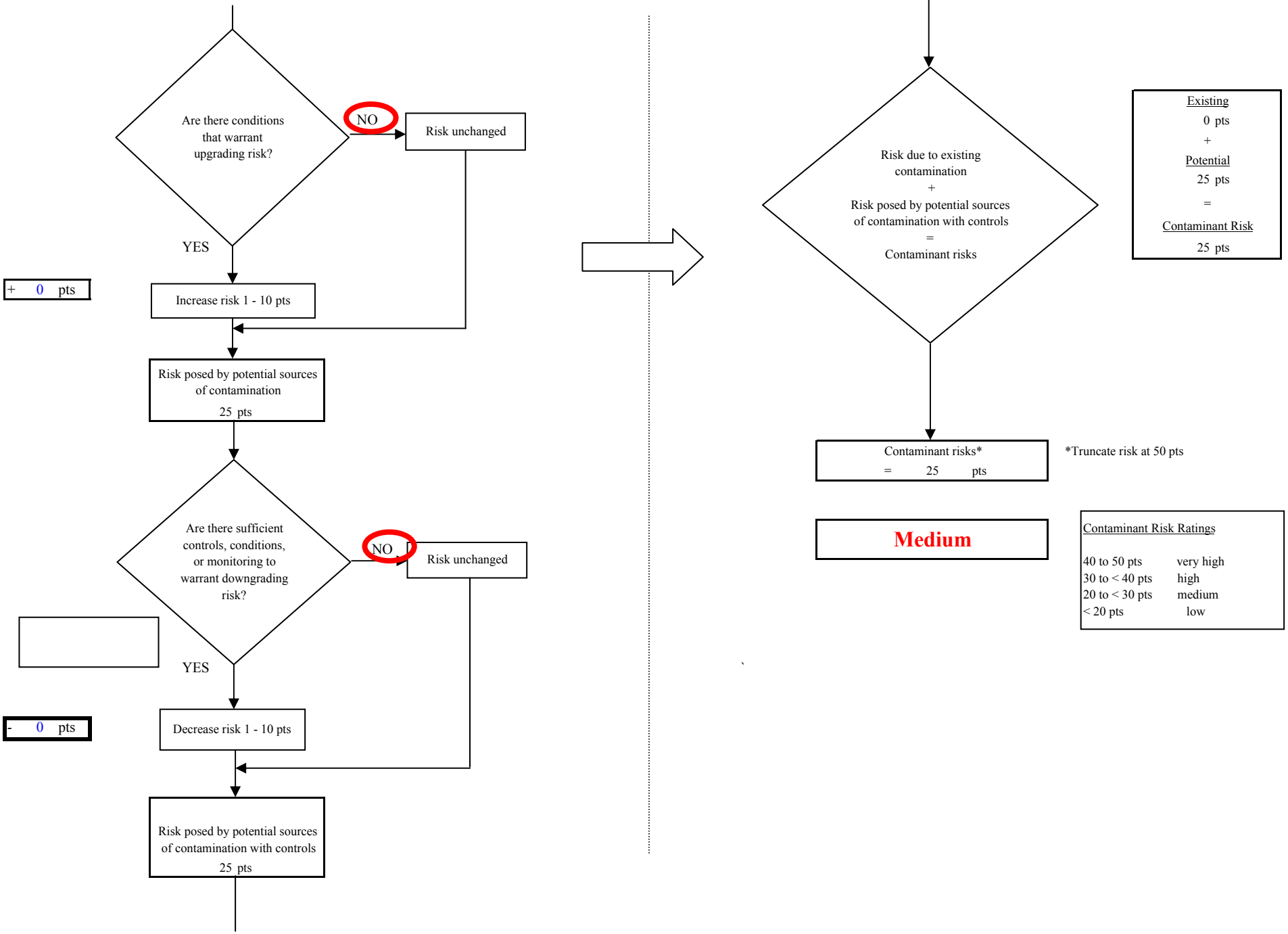


Chart 13. Vulnerability analysis for TeckCominco - Red Dog Mine - Other Organic Chemicals