Hydrogeologic Susceptibility and Vulnerability Assessment for U.S.F.S. Glacier Ranger District Public Drinking Water Well, Girdwood, Alaska

DRINKING WATER PROTECTION PROGRAM REPORT 2

August 2000

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By MICHAEL. J. CROTTEAU

DRINKING WATER PROTECTION PROGRAM REPORT 2

ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION: 2000

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Hydrogeologic Susceptibility and Vulnerability Assessment for U.S.F.S. Glacier Ranger District Public Drinking Water Well, Girdwood, Alaska

By Michael J. Crotteau

Drinking Water Protection Program
Alaska Department of Environmental Conservation

EXECUTIVE SUMMARY

U.S.F.S. Glacier Ranger District Public Water System is a seasonal Class B (transient/non-community) water system consisting of one well. Identified potential and current source of contaminants for the U.S.F.S. Glacier Ranger District's well include: domestic wastewater sewerlines, residential areas, a home heating fuel tank, and gravel roads and right-a-ways. These identified sources of contaminants are considered sources of bacteria and viruses, nitrates/nitrites, and volatile organic chemicals. Overall, U.S.F.S. Glacier Ranger District's public water system received a vulnerability rating of **Medium** for nitrates and nitrites, bacteria and viruses, and volatile organic chemicals.

INTRODUCTION

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

PHYSIOGRAPHY OF THE GLACIER CREEK VALLEY, ALASKA

Glacier Creek Valley, drained primarily by Glacier Creek, is located near the head of Turnagain Arm of Cook Inlet, approximately 45 miles south of Anchorage, Alaska (see Figure 1). Widened by glaciers and surrounded by steep mountain slopes, the valley is approximately six miles in length and trends northeast-southwest. The valley floor is roughly four miles wide. Elevations within the valley increase inland, from sea level at Turnagain Arm to approximately 6500 feet at the head of the valley. Development comprising the community of Girdwood is present along the lower four miles of the valley.

The floor of the Girdwood Valley is covered primarily by coniferous forests. Bedrock is exposed at the surface and wetlands occur intermittently in the valley floor. Bedrock also crops out at elevation in the mountains. Glacier Creek originates in uplands at the head of the valley, drains an area of approximately 58.2 square miles and is roughly centrally located. A mean annual discharge of 265 cubic feet per second was recorded in Glacier Creek (U.S. Geological Survey gaging station near the mouth) from 1965-78. California Creek and Alyeska Creek flow into Glacier Creek. California Creek drains an area of roughly 6.96 square miles. Virgin Creek flows directly into the Turnagain Arm and drains an area of about 3.5 square miles in the valley [*Glass and Brabets,* 1988].

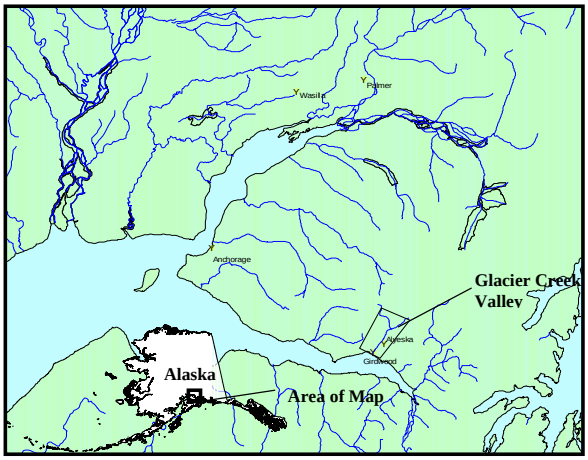


Figure 1. Index map showing the location of the Glacier Creek Valley, Alaska

Mean annual precipitation of roughly 40 inches per year was recorded near the mouth of the valley from 1955-66 and 1977-78. At the base of the Alyeska Ski Resort, annual precipitation in excess of 65 inches per year has been recorded (1985-86) [*Glass and Brabets*, 1988]. Mean daily temperature ranges from 65.1^{o} F during cool rainy summers to 13.9^{o} F in snowy winters, with average total snow depths of 197.4 inches [*Western Regional Climate Center*, 2000].

Groundwater flows from bedrock highlands, including steep valley walls, toward sediments in the center of the valley. Flow through valley sediments, or unconsolidated deposits, is generally to the southwest toward Turnagain Arm.

US.F.S. GLACIER RANGER DISTRICT PUBLIC WATER SYSTEM

U.S.F.S. Glacier Ranger District Public Water System is a Class B (transient/non-community) water system which is operated by the U.S. Department of Agriculture - U.S. Forest Service. The system consists of one well, which is located approximately 300 feet south of Monarch Mine Road and 350 west of the Alyeska Highway, northwest of the old Girdwood Townsite (see Figure 2). As per the well log, the well penetrates silt and silty gravel layers and is screened in sand and gravel from 78 to 84 feet below land surface. At the time of drilling (July 2, 1989), the well had a static water level of 61.9 feet below land surface. The well is not grouted, but is drained properly away from the site. This system operates year round and serves approximately 10 residents and 25 non-residents.

ASSESSMENT AND PROTECTION AREA FOR U.S.F.S. GLACIER RANGER DISTRICT'S DRINKING WATER SOURCE

The Drinking Water Protection and Assessment Area that has been established for U.S.F.S. Glacier Ranger District's public drinking water well is the area that is most sensitive to contamination.. This area has served as a basis for assessing the risk of the drinking water source to contamination. This zone around the drinking water source is the most critical area to the preservation of the quality of the water system's drinking water. Therefore, this area will also serve as the area of focus for voluntary protection efforts.

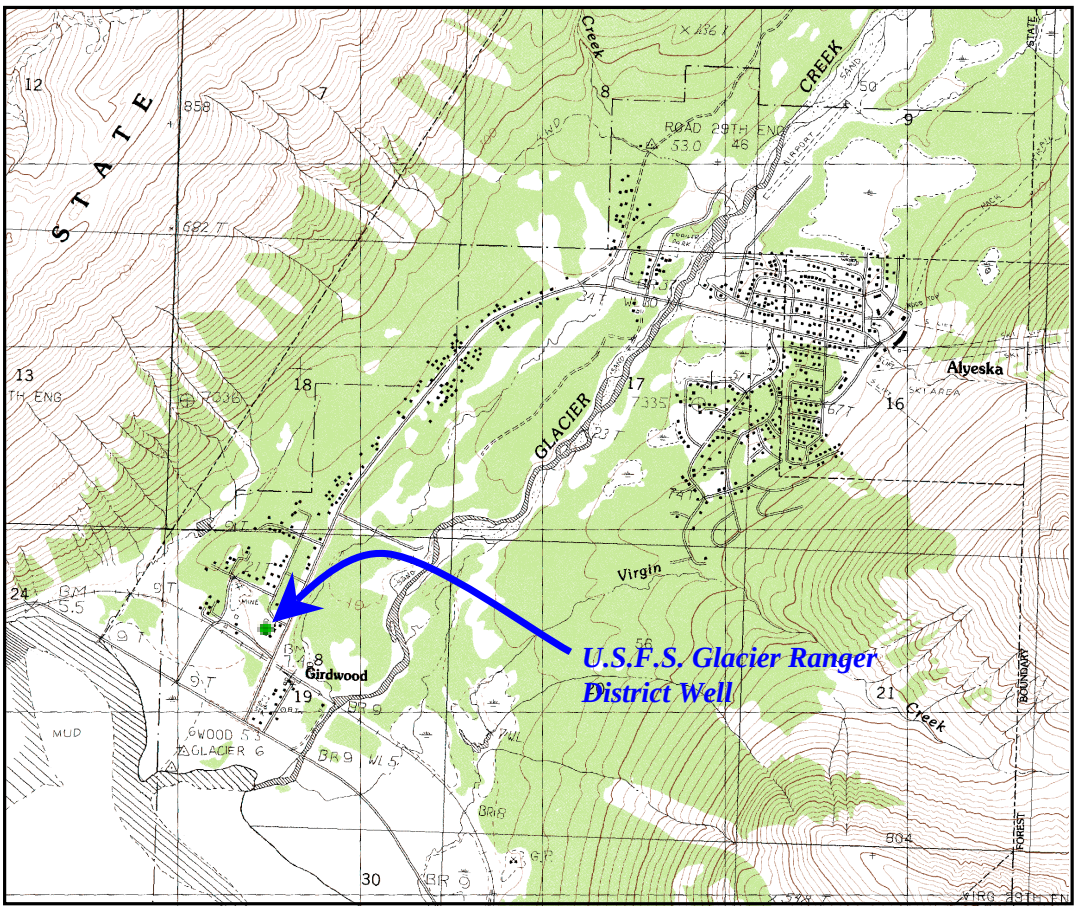


Figure 2. Map showing the location of the drinking water source for U.S.F.S Glacier Ranger District.

Conceptually, surface water and groundwater flow is downgradient from steep bedrock slopes toward the unconsolidated stream and glacial deposits in the valley (see Figure 3). A 2-dimensional groundwater flow model was built to simulate groundwater flow in the saturated valley sediments (water table aquifer). This model was used as a guide in the first step in establishing the protection and assessment areas for the U.S.F.S. Glacier Ranger District's source of public drinking water. Additional methods were further employed to take into account any uncertainties in groundwater flow and aquifer characteristics to arrive at meaningful and conservative protection and assessment areas with respect to public health (Please refer to the Guidance Manual for Class B Public Water Systems for additional information).

The Drinking Water Protection and Assessment Areas established for wells by the Alaska Department of Environmental Conservation are separated into zones. These zones correspond to a time-of-travel. Time-of-travel is the time required for water to move in the saturated zone of the ground from a specific point to the well. The Drinking Water Protection and Assessment Area for U.S.F.S. Glacier Ranger District contains two zones, Zone A and Zone B (See Map 1 - Map 3 in Appendix B). Zone A corresponds to ¼ of the distance to the 2-year time-of-travel. Depending on where a contaminant source is located, travel time for a contaminant to the well may be on the order of several days to several hours. The Zone B protection and assessment area for U.S.F.S. Glacier Ranger District corresponds to a time-of-travel of less than two years. Zone B extends up-slope to the top of the watershed divide to take into account contaminants that may flow overland and enter valley sediments.

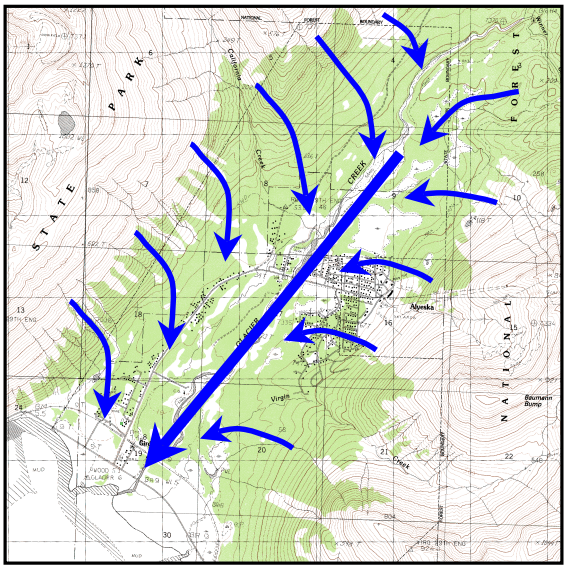


Figure 3. Map showing the conceptual groundwater flow in the Glacier Creek Valley.

INVENTORY OF PONTENTIAL AND EXISING CONTAMINANT SOURCES

The Drinking Water Protection Program has completed an inventory of potential and existing sources of contamination within U.S.F.S. Glacier Ranger District's Drinking Water Assessment and Protection Areas. This survey was completed through a search of agency records and other publicly available information. Potential sources of contamination to drinking water supplies cover a wide range of categories and types. Potential drinking water contaminants are found within agricultural, residential, commercial, and industrial areas, but can also occur within areas that have little or no development.

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

- Bacteria and viruses;
- Nitrates and nitrites; and
- Volatile organic chemicals.

Maps 4 in Appendix C depict the Contaminant Source Inventory for U.S.F.S. Glacier Ranger District. All inventoried potential sources of contamination within Zone A and Zone B were associated with residential type activities (see Table 1 in Appendix A). Below is a summary of the contaminant sources inventoried within the U.S.F.S. Glacier Ranger District's protection and assessment areas:

- Domestic wastewater sewer lines;
- An above ground home heating fuel tank;
- Gravel roads and right-of-ways; and
- Residential areas.

These potential contaminant sources present risk for all three categories of drinking water contaminants for U.S.F.S. Glacier Ranger District's drinking water source.

In October 1989, the U.S.F.S. Glacier Ranger District reported a spill containing heating oil adjacent to the warehouse on that property. Twenty-five cubic yards of contaminated soil was removed from the site in July 1990 and is currently inactive. The site is approximately 180 feet north-northeast of the well. This contaminated site (ADEC Contaminated Site 74.04) is outside the assessment and protection areas for the U.S.F.S. Glacier Ranger District.

RANKING OF CONTAMINANT RISKS

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

VULNERABILITY OF U.S.F.S. GLACIER RANGER DISTRICT'S DRIKING WATER SOURCE

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

- natural susceptibility; and
- contaminant risks.

Appendix D contains four charts, which together form the 'Vulnerability Analysis' for a source water assessment for public drinking water supply. Chart 1 contains the 'Vulnerability Analysis'. Chart 2 analyzes the 'Susceptibility of the Wellhead' to contamination by looking at the construction of the well and its surrounding area. Chart 3 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. Lastly, Chart 4 analyzes 'Contaminant Risks' for the drinking water source for bacteria and viruses. This portion of the analysis examines any existing or historical contamination that has been detected at the drinking water source through routine sampling. It also reviews contamination that has or may have occurred but has not arrived or been detected at the well. The 'Contaminant Risks' portion of the analysis also considers potential sources of contaminants. Charts 5 through 8 contain the Vulnerability Analysis for nitrstes and nitrites and volatile organic chemicals, respectively.

Each of the three categories of drinking water-regulated 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 susceptibility of the aquifer and the well to contamination is achieved by analyzing the properties of the aquifer and the well (See Chart 2 and 3 in Appendix D). The U.S.F.S. Glacier Ranger District well penetrates layers of sediment, which may inhibit the movement of contaminants. However, the well appears not to be properly grouted as indicated previously from information obtained from Department records. The absence of grouting can lead to contaminant movement along the well casing. Combining the susceptibility of the wellhead and the aquifer to contamination leads to a score (0 – 50 points) and rating of overall Susceptibility. Table 1 shows the overall Susceptibility score and rating for U.S.F.S. Glacier Ranger District.

Table 1. Susceptibility of the Wellhead and Aquifer to Contamination

	Score	Rating
Susceptibility	19	Medium

Contaminant Risks to a drinking water source depends on the type, number and density, and distribution of contaminant sources. Domestic wastewater sewer lines, an above ground home heating fuel tank, gravel roads and right-of-ways, and residential areas contribute the highest risk for potential contamination to the U.S.F.S. Glacier Ranger District's source of public drinking water. Monarch Mine Road and the domestic wasteater sewer line along this route are within 350 feet of the well in Zone A. This distance to the well corresponds to a travel time on the order of several weeks to a few months. The close proximity of these potential contaminant sources are the driving factors in the Contaminant Risks portion of the Vulnerability Analysis.

A score (0 – 50 points) and rating of Contaminant Risks is assigned based on the findings of the Contaminant Source Inventory (Appendix A - Table 1 – Table 3). Table 2 below summarizes the Contaminant Risks for the U.S.F.S. Glacier Ranger District for each category of drinking regulated contaminants.

Table 2. Contaminant Risks

Contaminant Risks	Score	Rating
Bacteria and Viruses	30	High
Nitrates and Nitrites	38	High
Volatile Organic Chemicals	28	Medium

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

Table 3. Overall Vulnerability of The U.S.F.S. Glacier Ranger District Public Drinking Water System to Contamination by Category

Category	Score	Rating
Bacteria & Viruses	45	Medium
Nitrates and Nitrites	55	Medium
Volatile Organic Chemicals	50	Medium

SUMMARY

A *Source Water Assessment* has been completed for the U.S.F.S. Glacier Ranger District's source of public drinking water. The overall vulnerability of this source to contamination by bacteria and viruses, nitrates and/or nitrites, and volatile organic chemicals is **medium**. This assessment of contaminant risks can be used as a foundation for local voluntary protection efforts as well as a basis for the continuous efforts on the part of the U.S.F.S. Glacier Ranger District 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 suceptibility of the public drinking water source.

REFERENCES CITED

Glass, Roy L. and Brabets, Timothy P., 1988, Summary of water resources data for the Girdwood-Alyeska Area, Alaska: USGS Open-File Report 87-678.

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

APPENDIX A

Contaminant Source Inventory and Risk Ranking for U.S.F.S Glacier Ranger District

Table 1

Contaminant Source Inventory for U.S.F.S Glacier Ranger District Public Water System Sources of Bacteria and Viruses

PWSID 215435

Contaminant Source Type	Contaminant Source ID	CS ID tag	Zone	Risk Ranking	Overall Rank	Location	Map Number	Notes/Comments
Domestic wastewater collection systems (sewer lines)	D1	D1-1	A	Medium	1	Monarch Mine and Sproat Road	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-2	A	Medium	2	Jewell Mine Road	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-3	B	Medium	3	Gunnysack Mine Road	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-4	B	Medium	4	Treasure Box Mine Road	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-5	B	Medium	5	Hottentot Mine Road	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-6	B	Medium	6	Agostino Mine Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-1	A	Low	7	Monarch Mine Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-2	A	Low	8	Sproat Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-3	A	Low	9	Jewell Mine Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-4	B	Low	10	Gunnysack Mine Road	Map 4	
Lawns and gardens	R1	R1-1	B	Low	11	Treasure Box to Agostino Mine Road	Map 4	
Lawns and gardens	R1	R1-2	B	Low	12	Treasure Box to Agostino Mine Road	Map 4	
Lawns and gardens	R1	R1-3	B	Low	13	Treasure Box to Agostino Mine Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-5	B	Low	14	Treasure Box Mine Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-6	B	Low	15	Hottentot Mine Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-7	B	Low	16	Agostino Mine Road	Map 4	

Table 2

Contaminant Source Inventory for U.S.F.S Glacier Ranger District Public Water System Sources of Nitrates/Nitrites

PWSID 215435

Contaminant Source Type	Contaminant Source ID	CS ID tag	Zone	Risk Ranking	Overall Rank	Location	Map Number	Notes/Comments
Domestic wastewater collection systems (sewer lines)	D1	D1-1	A	Medium	1	Monarch Mine and Sproat Road	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-2	A	Medium	2	Jewell Mine Road	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-3	B	Medium	3	Gunnysack Mine Road	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-4	B	Medium	4	Treasure Box Mine Road	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-5	B	Medium	5	Hottentot Mine Road	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-6	B	Medium	6	Agostino Mine Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-1	A	Low	7	Monarch Mine Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-2	A	Low	8	Sproat Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-3	A	Low	9	Jewell Mine Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-4	B	Low	10	Gunnysack Mine Road	Map 4	
Lawns and gardens	R1	R1-1	B	Low	11	Treasure Box to Agostino Mine Road	Map 4	
Lawns and gardens	R1	R1-2	B	Low	12	Treasure Box to Agostino Mine Road	Map 4	
Lawns and gardens	R1	R1-3	B	Low	13	Treasure Box to Agostino Mine Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-5	B	Low	14	Treasure Box Mine Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-6	B	Low	15	Hottentot Mine Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-7	B	Low	16	Agostino Mine Road	Map 4	

Table 3

Contaminant Source Inventory for U.S.F.S Glacier Ranger District Public Water System Sources of Volatile Organic Chemicals

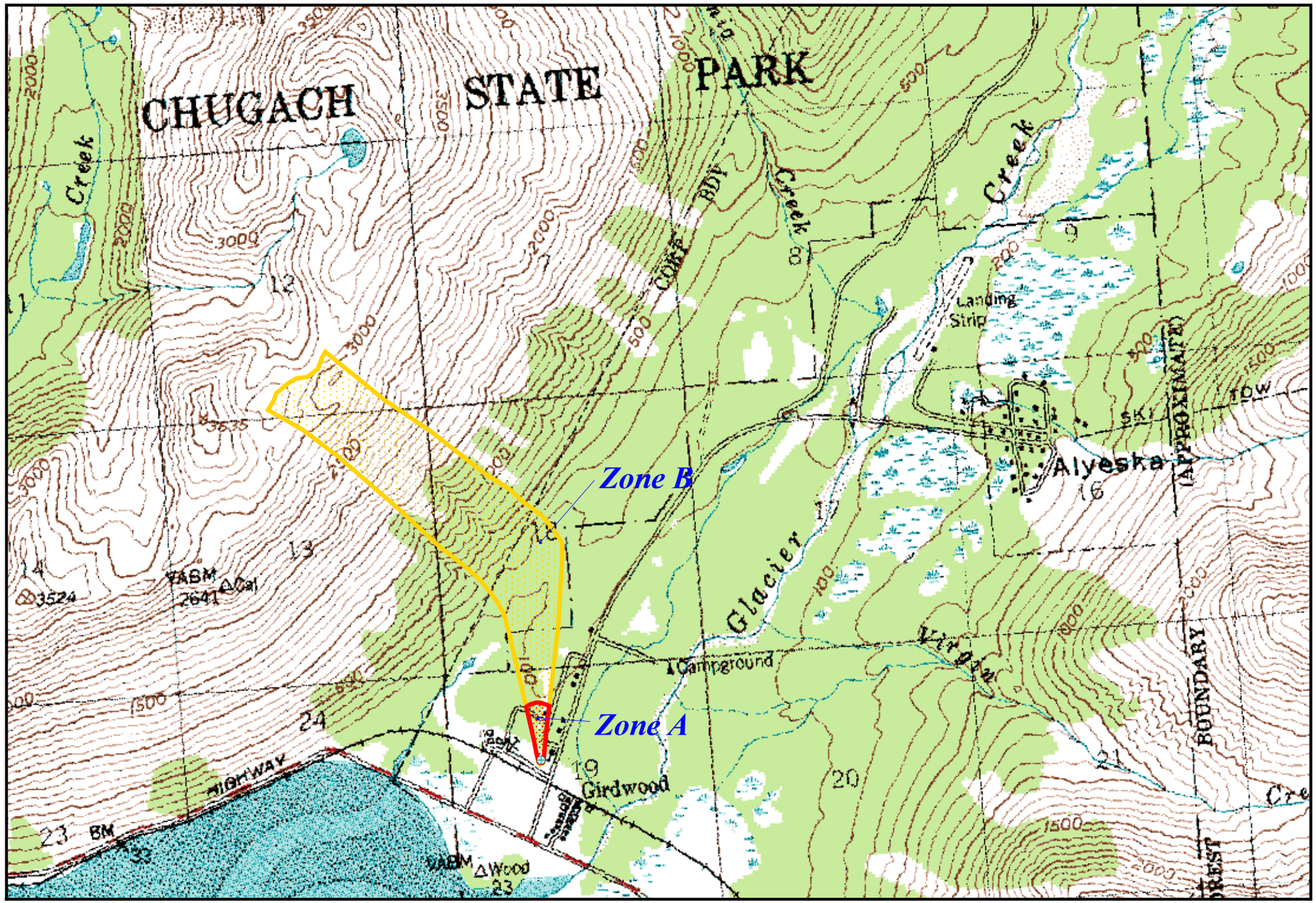
PWSID 215435

Contaminant Source Type	Contaminant Source ID	CS ID tag	Zone	Risk Ranking	Overall Rank	Location	Map Number	Notes/Comments
Highways and roads, dirt/gravel	X24	X24-1	A	Low	1	Monarch Mine Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-2	A	Low	2	Sproat Road	Map 4	
Tanks, heating oil, residential, above ground	R8	R8-1	B	Medium	3	End of Treasure Box Mine Road	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-1	A	Low	4	Monarch Mine and Sproat Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-3	A	Low	5	Jewell Mine Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-4	B	Low	6	Gunnysack Mine Road	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-2	A	Low	7	Jewell Mine Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-5	B	Low	8	Treasure Box Mine Road	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-3	B	Low	9	Gunnysack Mine Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-6	B	Low	10	Hottentot Mine Road	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-4	B	Low	11	Treasure Box Mine Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-7	B	Low	12	Agostino Mine Road	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-5	B	Low	13	Hottentot Mine Road	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-6	B	Low	14	Agostino Mine Road	Map 4	

APPENDIX B

U.S.F.S Glacier Ranger District's Drinking Water Protection Areas

U.S.F.S. Glacier Ranger District (PWSID 215435)
Drinking Water Protection Areas



- U.S.F.S. Glacier Ranger District Well

Zone A Protection Arae

- Several Months Travel Time

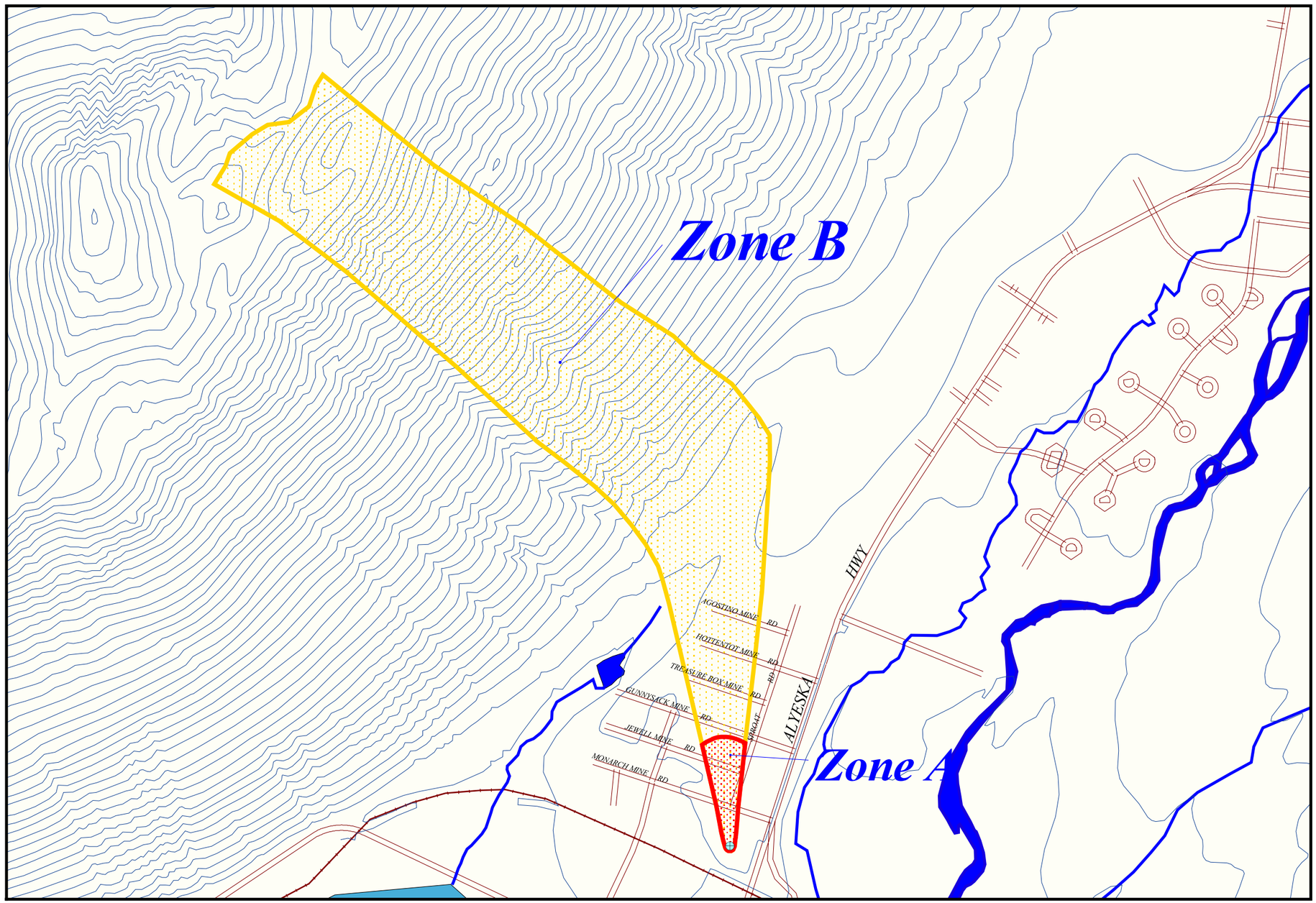
Zone B Protection Area

- Less Than 2-Years Tavel Time

N
W
E
S

Map 1

U.S.F.S. Glacier Ranger District (PWSID 215435)
Drinking Water Protection Areas



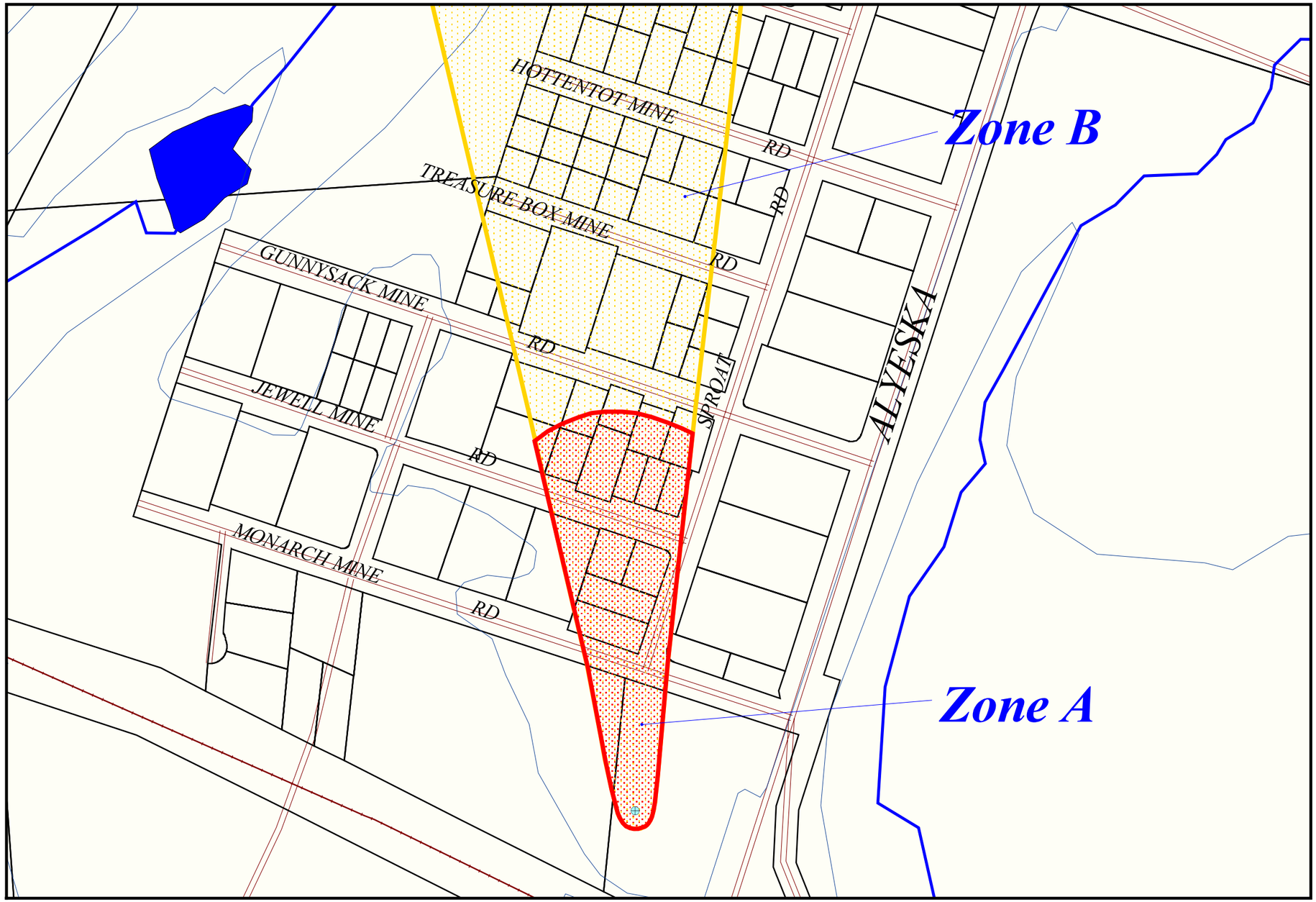
U.S.F.S. Glacier Ranger District Well
Zone A Protection Arae
Several Months Travel Time
Zone B Protection Area
Less Than 2-Years Tavel Time
Elevation Contours
2nd order streams
3rd order streams
4th order streams
Lakes and Ponds
Glacier Creek
MOA Roads
Railroads
Ocean

N
W
E
S

0.5 0 0.5 Miles

Map 2

U.S.F.S. Glacier Ranger District (PWSID 215435)
Drinking Water Protection Areas



U.S.F.S. Glacier Ranger District Well
Zone A Protection Arae
Several Months Travel Time
Zone B Protection Area
Less Than 2-Years Tavel Time
Elevation Contours
2nd order streams
3rd order streams
4th order streams
Lakes and Ponds
Glacier Creek
MOA Land Parcels
MOA Roads
Railroads

N
W
E
S

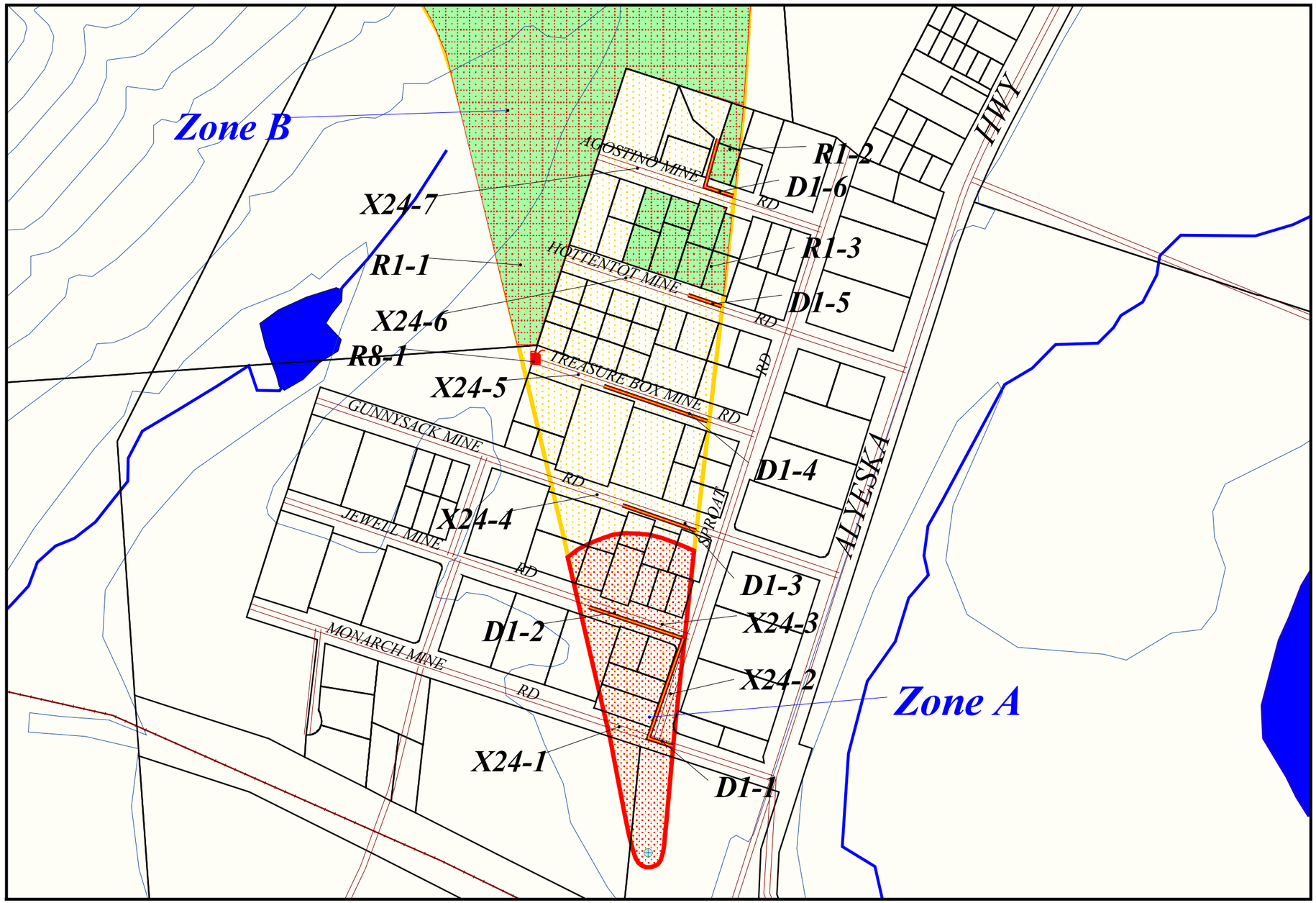
0.1 0 0.1 Miles

Map 3

APPENDIX C

U.S.F.S Glacier Ranger District's Drinking Water Protection Areas and Potential and Existing Contaminant Sources

U.S.F.S. Glacier Ranger District (PWSID 215435) Drinking Water Protection Areas and Potential and Existing Sources of Contamination



Potential and Existing Sources of Contamination
- Tanks, heating oil, residential (above ground)
- Wastewater Sewer Lines
- MOA Roads
- MOA Land Parcels
- Elevation Contours
- Residential Areas
- U.S.F.S. Glacier Ranger District Well

Zone A Protection Arae
- Several Months Travel Time

Zone B Protection Area
- Less Than 2-Years Tavel Time
- 2nd order streams
- 3rd order streams
- 4th order streams
- Lakes and Ponds
- Glacier Creek
- Railroads

N W E S

800 0 800 Feet

Map 4

APPENDIX D

Vulnerability Analysis for U.S.F.S Glacier Ranger District Public Drinking Water System

Chart 1. Vulnerability analysis for Bacteria & Viruses – U.S.F.S. Glacier Ranger District

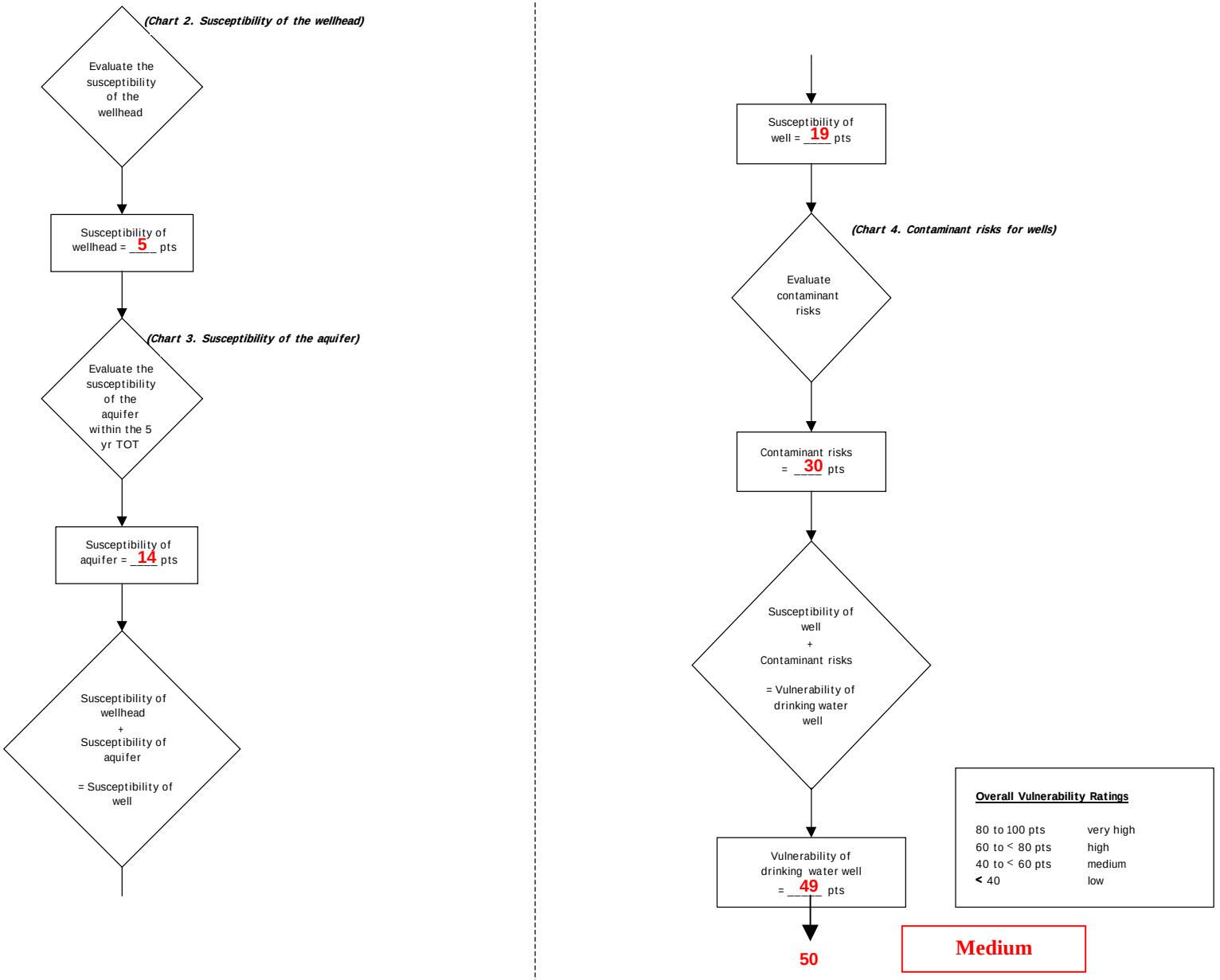
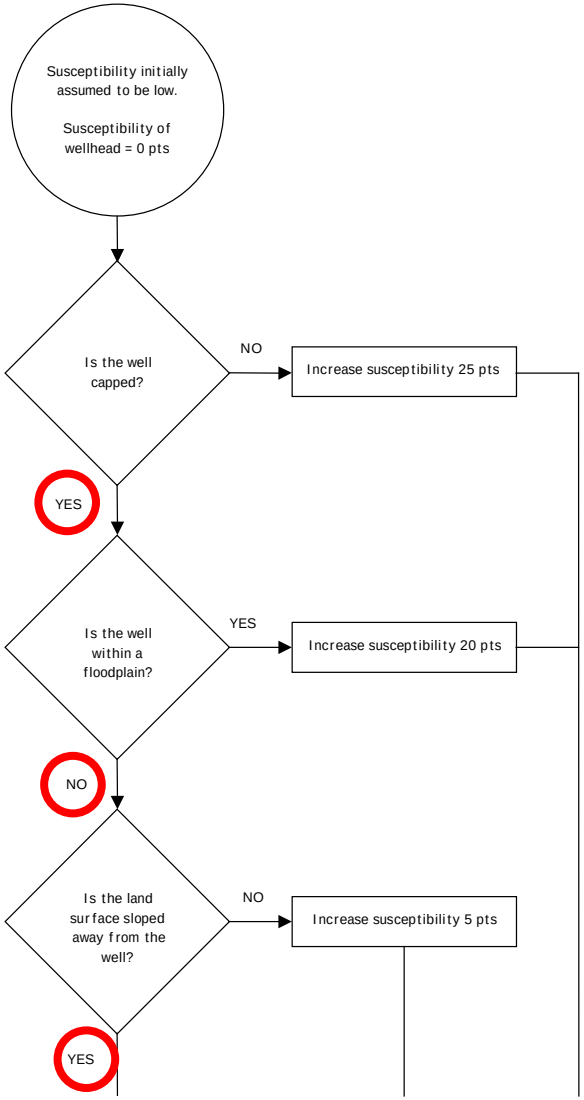
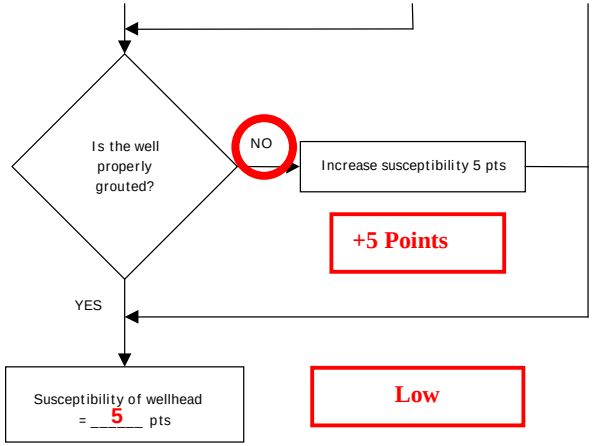


Chart 2. Susceptibility of the wellhead

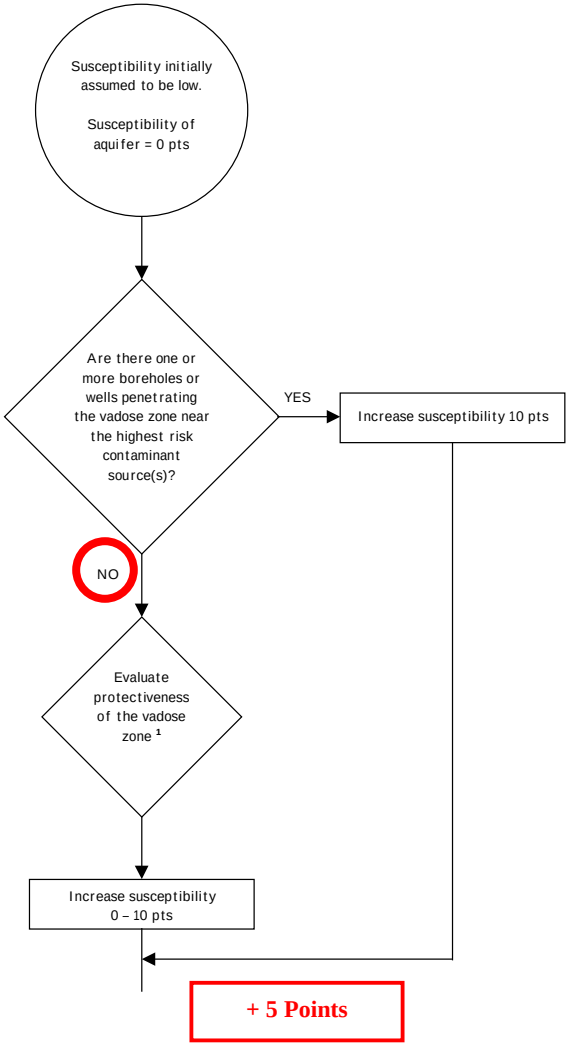


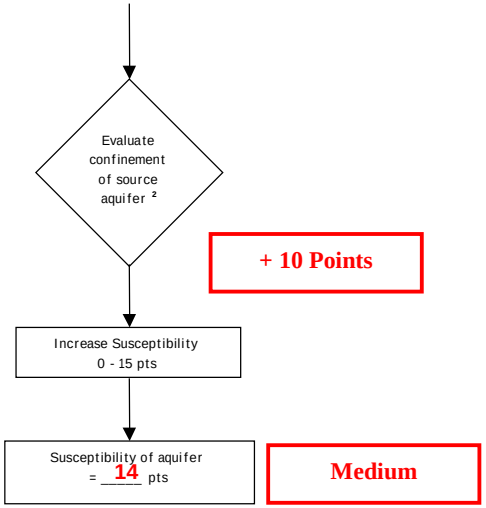


Wellhead Susceptibility Ratings

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

Chart 3. Susceptibility of the aquifer





1. Protectiveness of the Vadose Zone

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

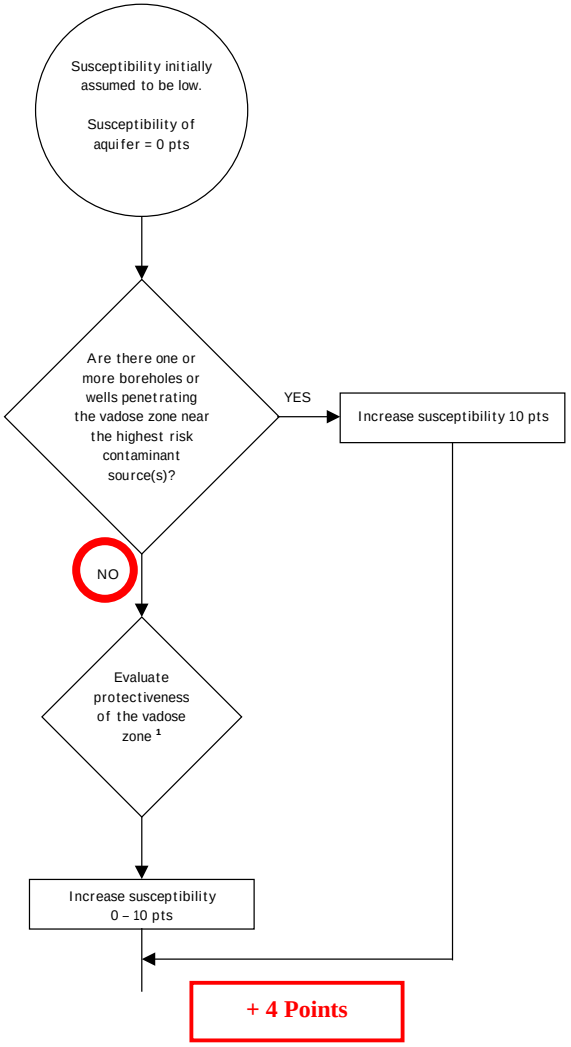
2. Degree of Confinement

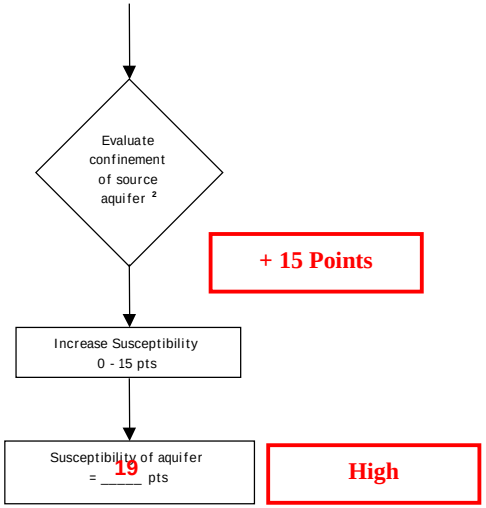
- confined verses unconfined aquifer
  [confined: K $\leq 10^{-6}$ cm/s, minimum thickness of at least one layer = 20 ft, interpolate linearly 100' – 20', 0 – 10 pts; unconfined = 15 pts; 65% weight]
- density of boreholes and wells penetrating the confining layer (confined aquifer) or the water table (unconfined aquifer)
  [confined: 0 – 15 pts; unconfined = 15 pts; 35% weight]

Aquifer Susceptibility Ratings

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

Chart 3. Susceptibility of the aquifer





1. Protectiveness of the Vadose Zone

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

2. Degree of Confinement

- confined verses unconfined aquifer
  [confined: K $\leq 10^{-6}$ cm/s, minimum thickness of at least one layer = 20 ft, interpolate linearly 100' – 20', 0 – 10 pts; unconfined = 15 pts; 65% weight]
- density of boreholes and wells penetrating the confining layer (confined aquifer) or the water table (unconfined aquifer)
  [confined: 0 – 15 pts; unconfined = 15 pts; 35% weight]

Aquifer Susceptibility Ratings

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

Chart 4. Contaminant risks for U.S.F.S. Glacier Ranger District – Bacteria & Viruses

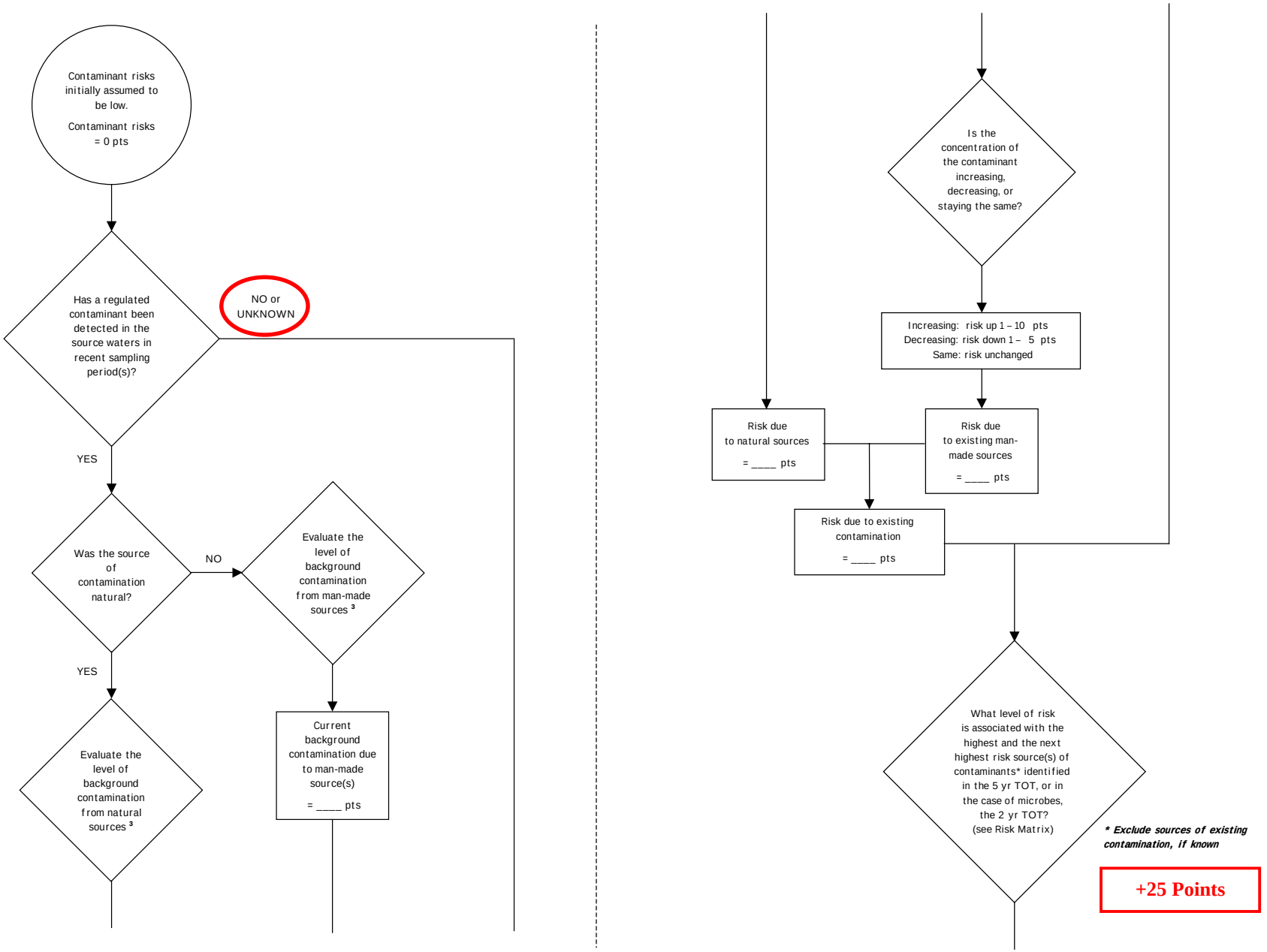
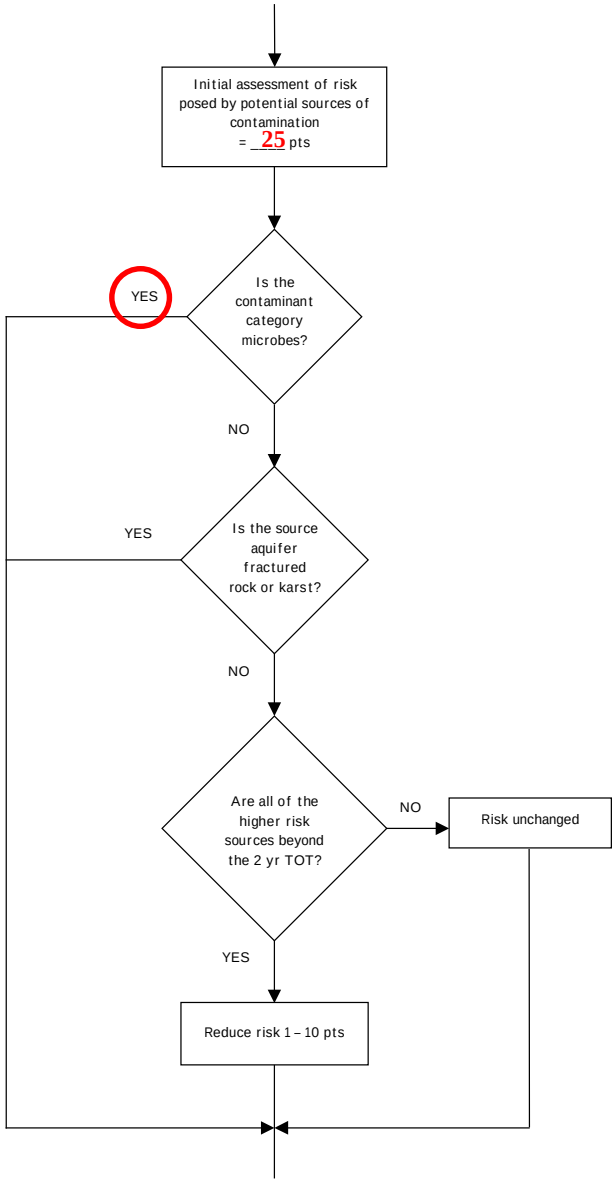


Chart 4. Contaminant risks for U.S.F.S. Glacier Ranger District – Bacteria & Viruses **(Continued)**



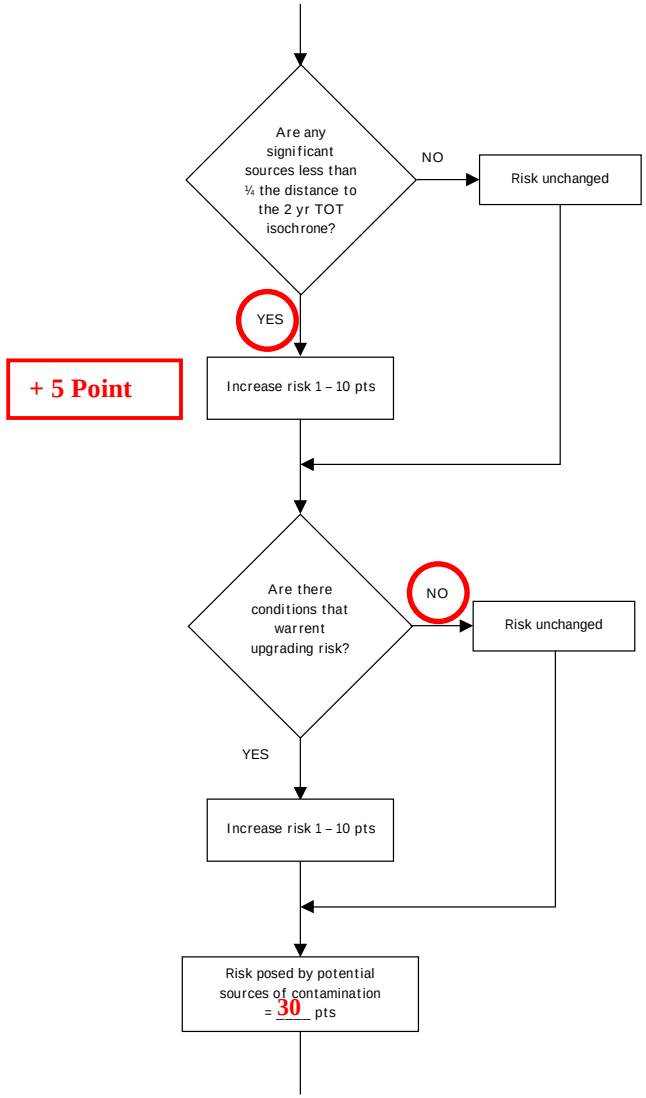
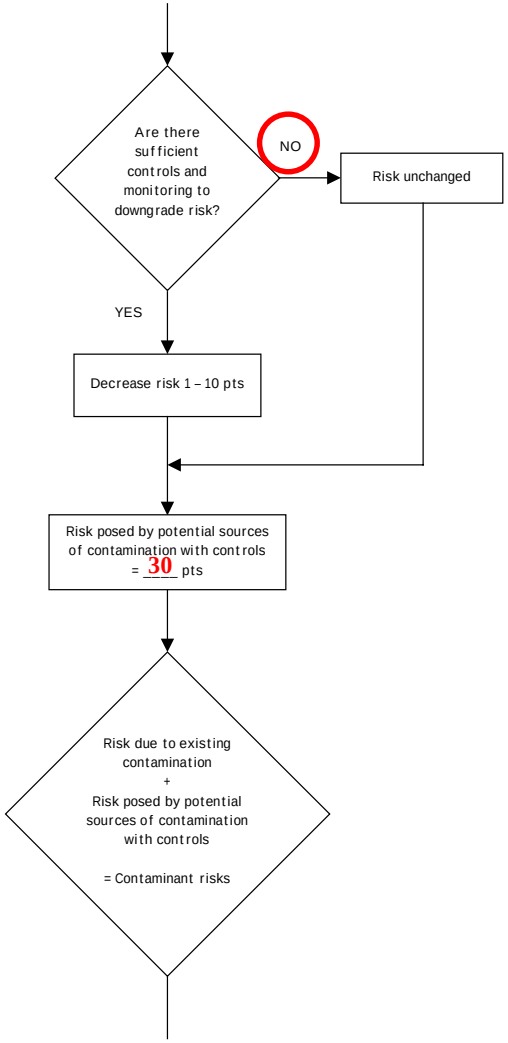
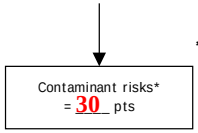


Chart 4. Contaminant risks for U.S.F.S. Glacier Ranger District – Bacteria & Viruses (Continued)





**** Truncate risk at 50 pts***

3. Level of Background Contamination

> MCL	50 pts
0.5 MCL to < MCL	20 pts
0.2 MCL to < 0.5 MCL	10 pts
'detect' to < 0.2 MCL	5 pts

Contaminant Risk Ratings

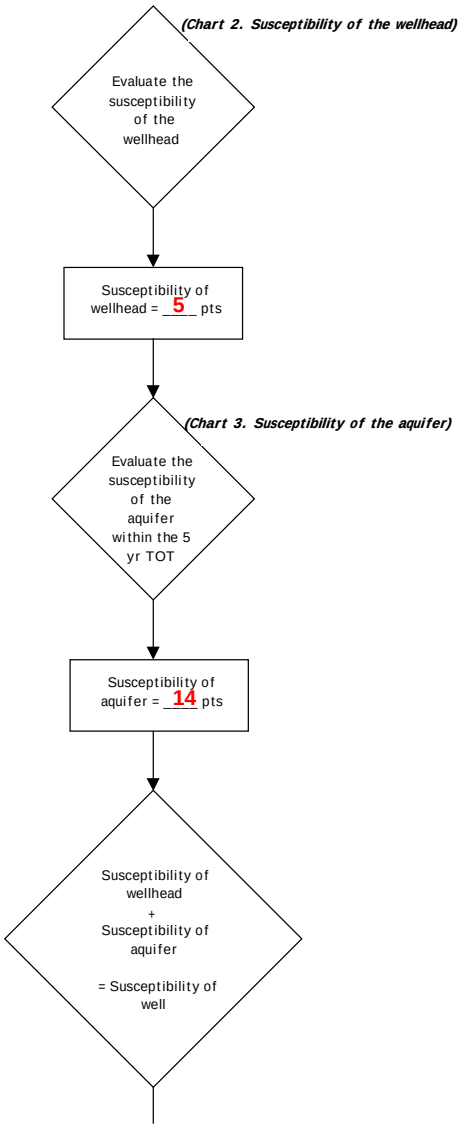
40 to 50 pts	very high
30 to < 40 pts	high
20 to < 30 pts	medium
< 20	low

Table 4. Risk Matrix for Contaminant Sources for Bacteria & Viruses – U.S.F.S. Glacier Ranger District

Level of Risk Associated with the Highest Risk Sources

Next Highest Risk Sources(s)	**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

Chart 5. Vulnerability analysis for Nitrates/Nitrites – U.S.F.S. Glacier Ranger District



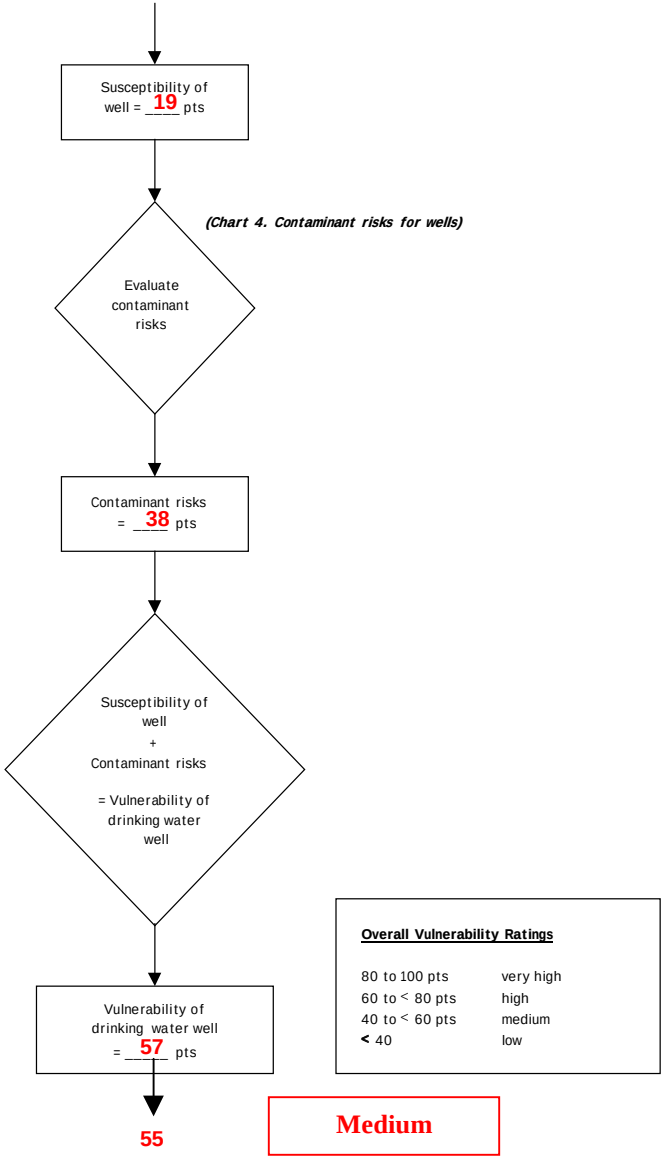


Chart 6. Contaminant risks for U.S.F.S. Glacier Ranger District – Nitrates/Nitrites

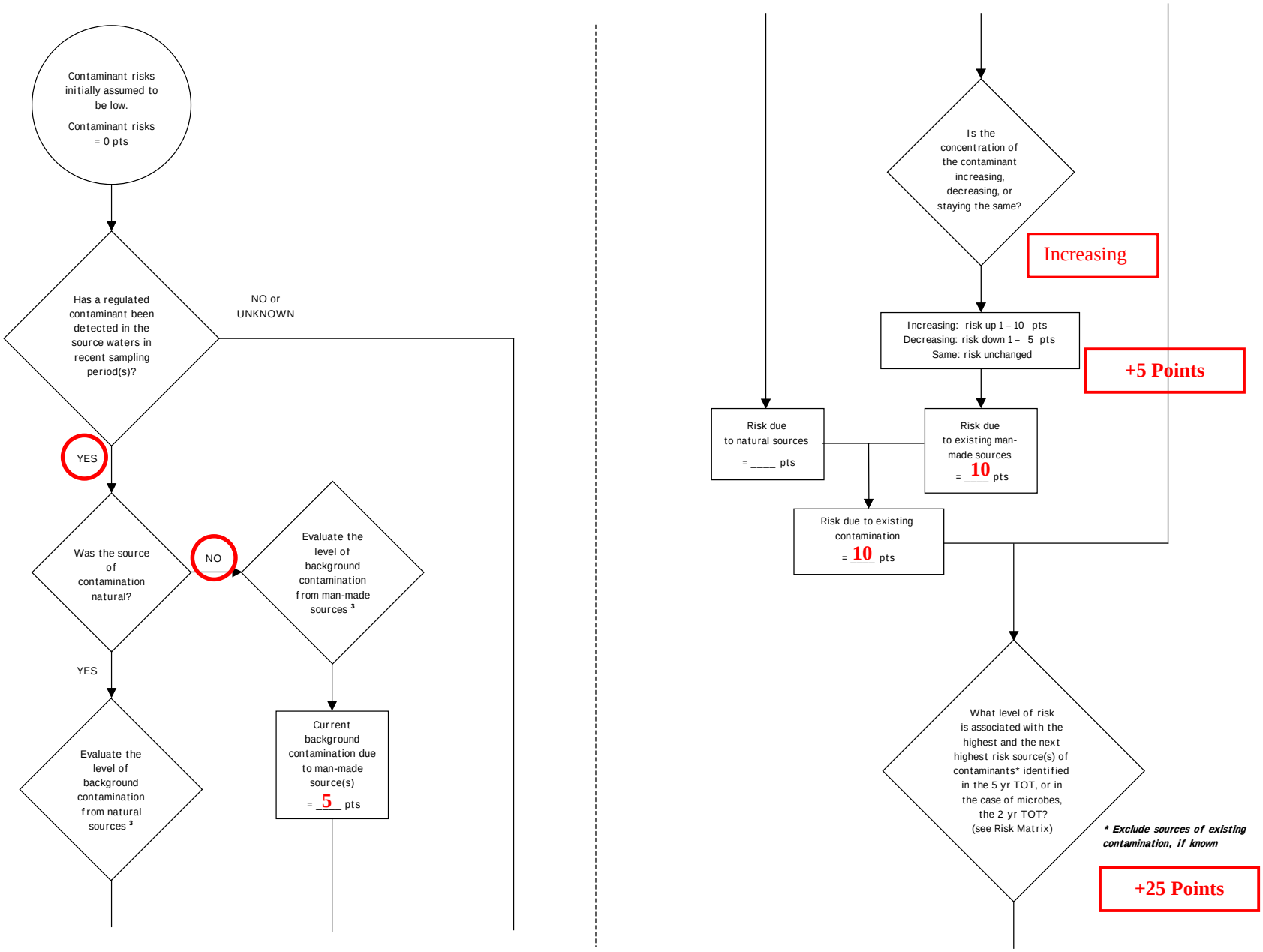
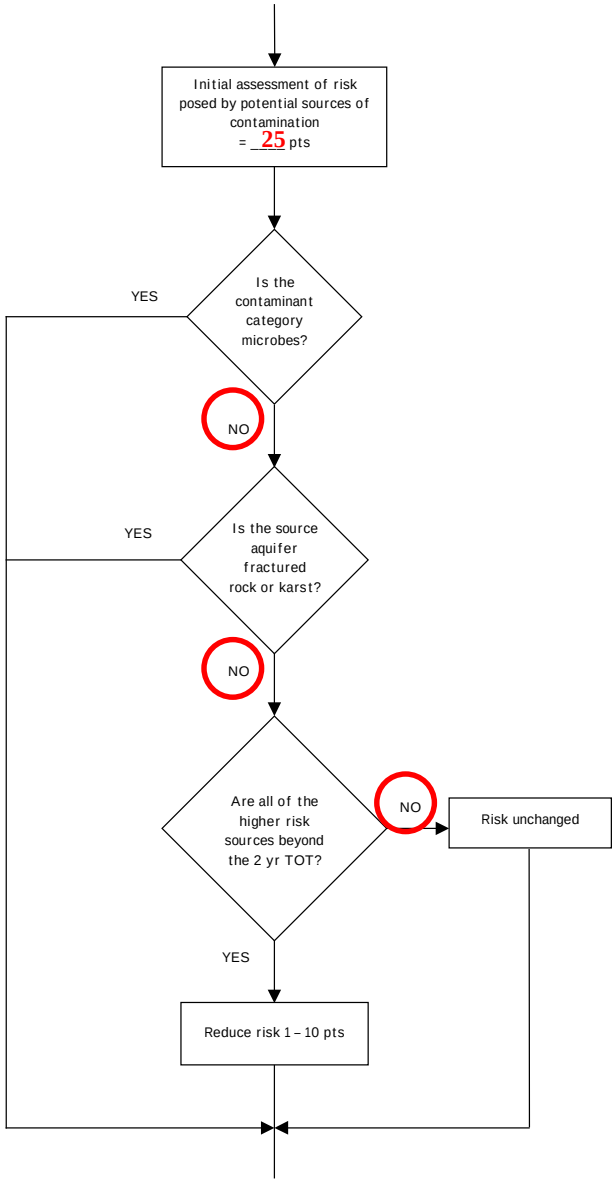


Chart 6. Contaminant risks for U.S.F.S. Glacier Ranger District – Nitrates/Nitrites (Continued)



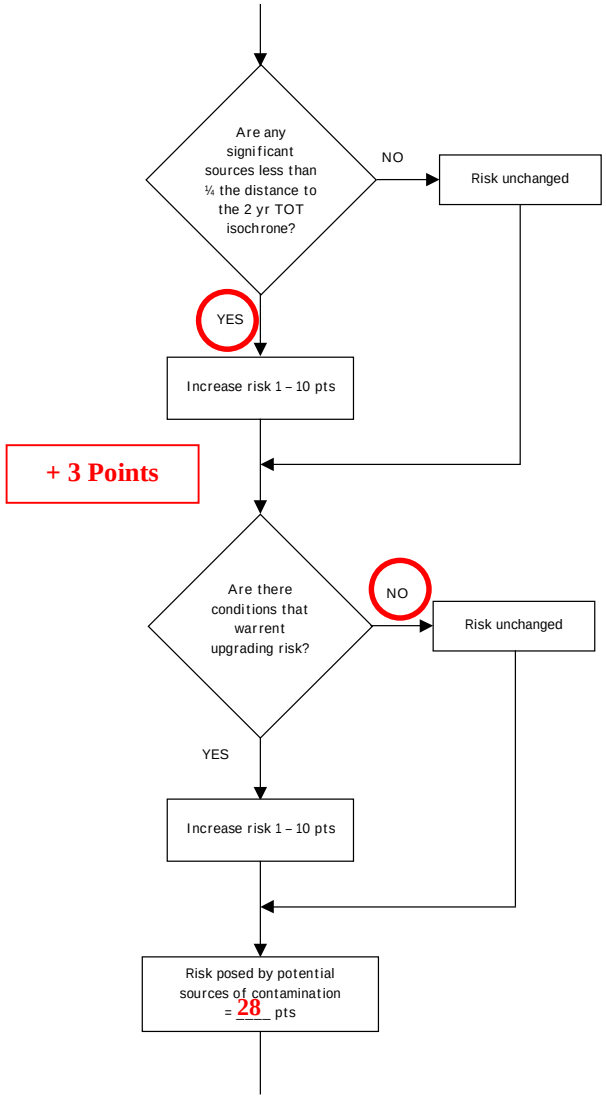
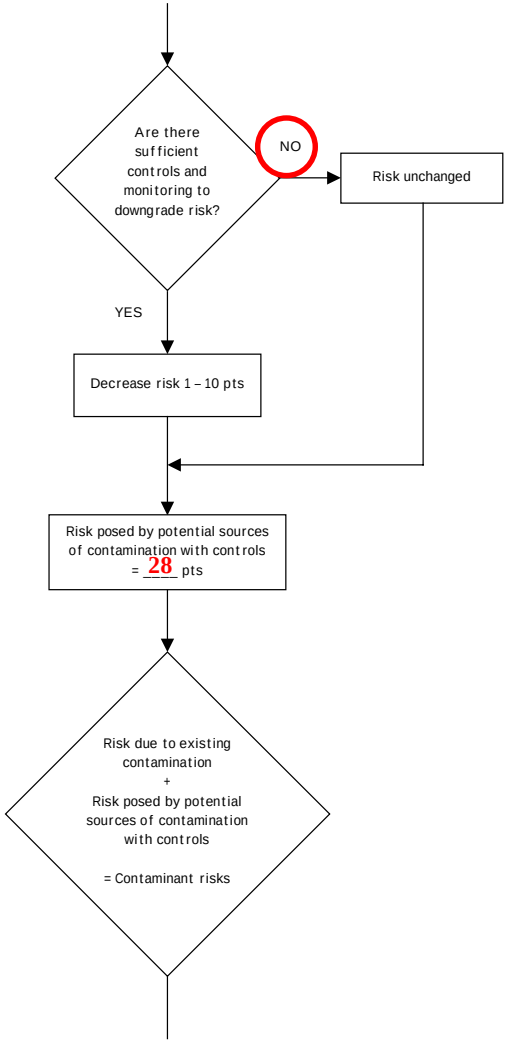


Chart 6. Contaminant risks for U.S.F.S. Glacier Ranger District – Nitrates/Nitrites (Continued)



**** Truncate risk at 50 pts***

Contaminant risks* = **38** pts

3. Level of Background Contamination

> MCL	50 pts
0.5 MCL to < MCL	20 pts
0.2 MCL to < 0.5 MCL	10 pts
'detect' to < 0.2 MCL	5 pts

Contaminant Risk Ratings

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

86 µg/L 7/20/99 Nitrate
30 µg/L 7/6/98 Nitrate
24 µg/L 12/12/97 Nitrate

High

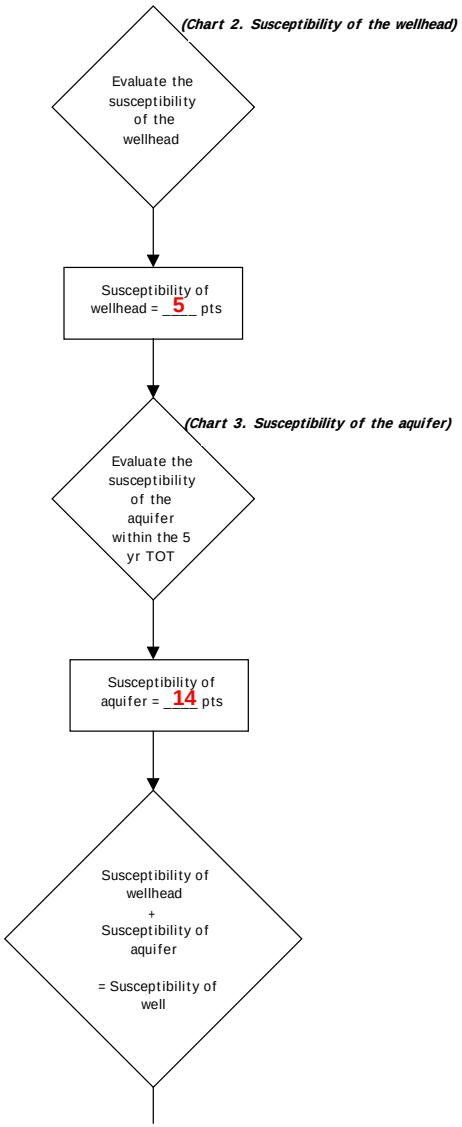
Table 5. Risk Matrix for Contaminant Sources for Nitrates/Nitrites – U.S.F.S. Glacier Ranger District

Level of Risk Associated with the Highest Risk Sources

Next Highest Risk Sources(s)

	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

Chart 7. Vulnerability analysis for Volatile Organic Chemicals – U.S.F.S. Glacier Ranger District



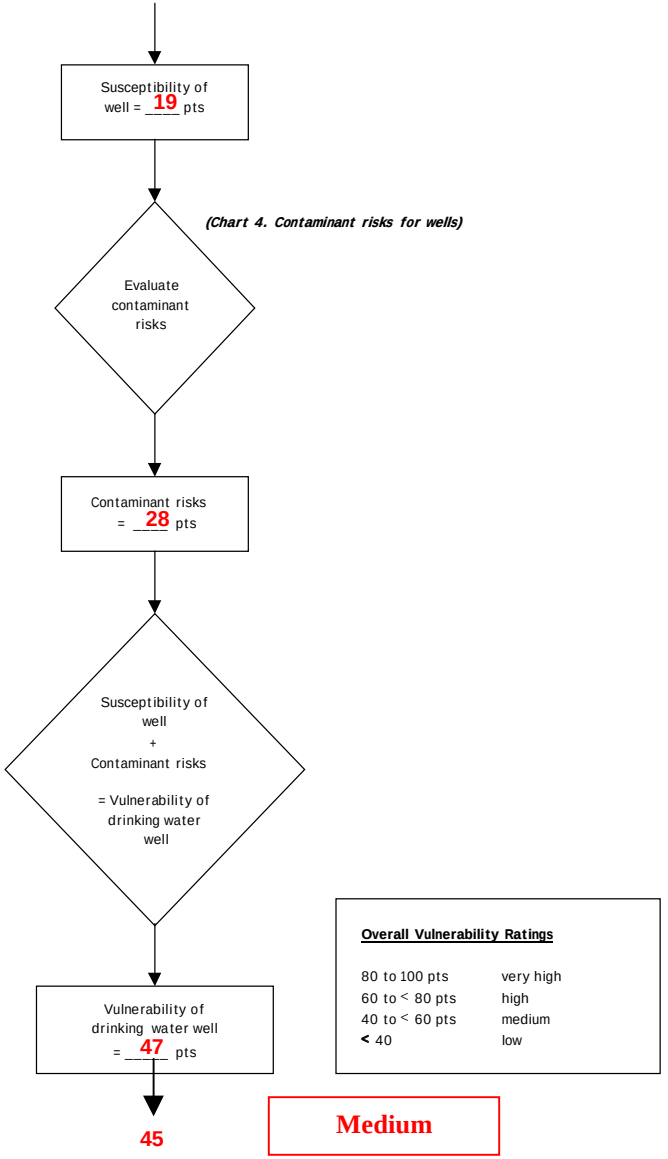


Chart 8. Contaminant risks for U.S.F.S. Glacier Ranger District - Volatile Organic Chemicals

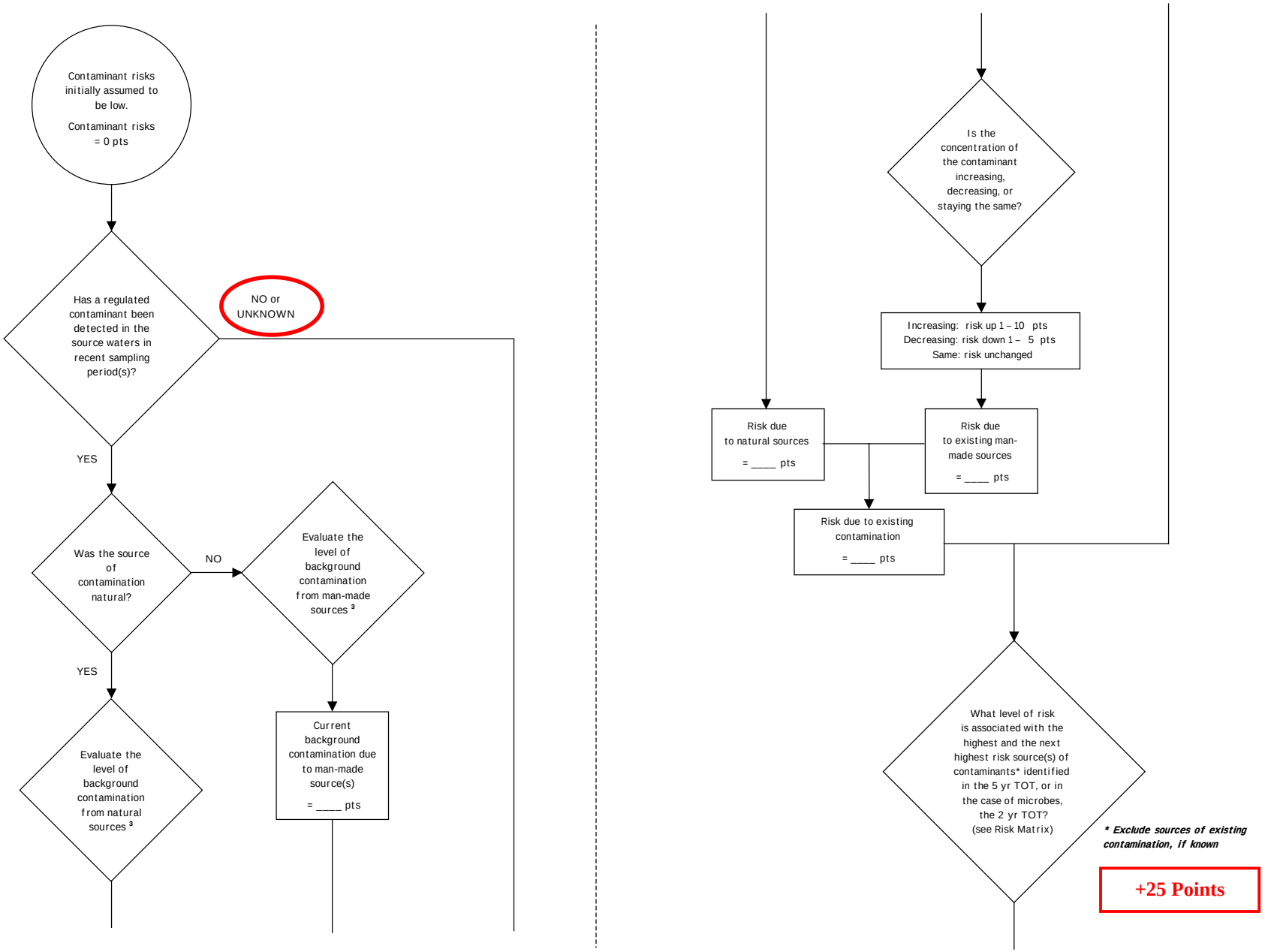
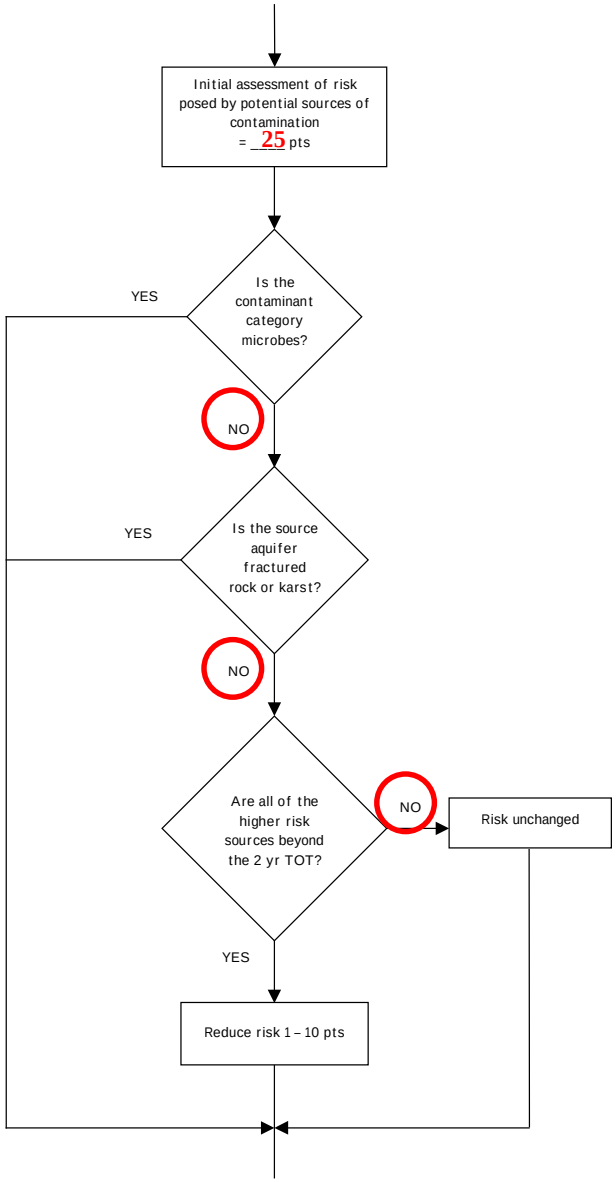


Chart 8. Contaminant risks for U.S.F.S. Glacier Ranger District (Continued)



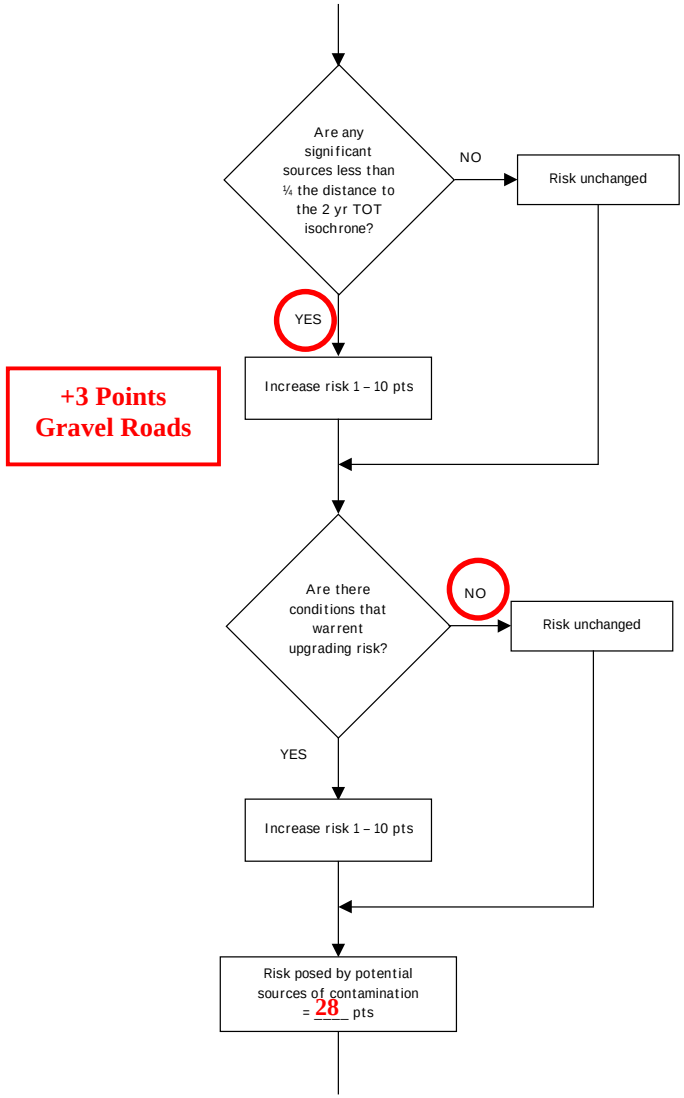
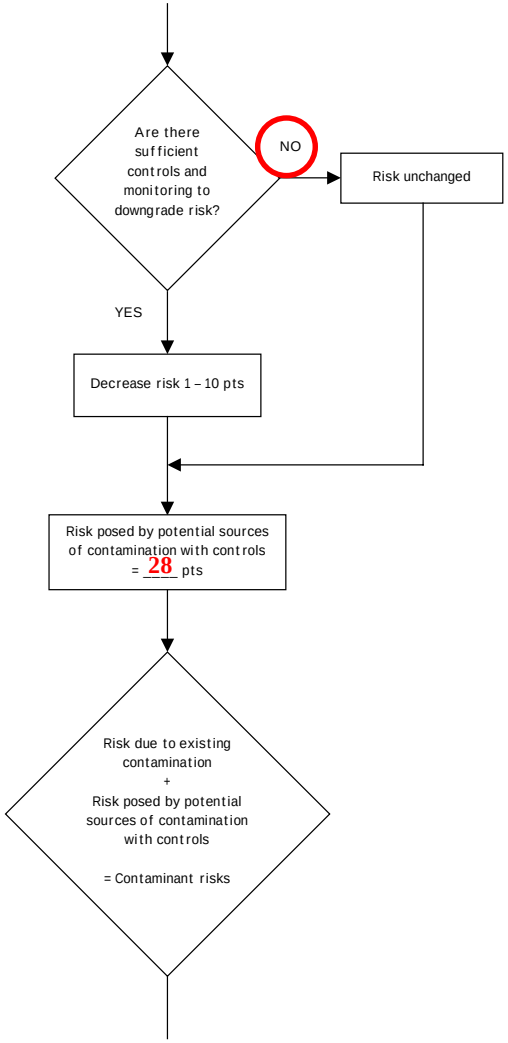


Chart 8. Contaminant risks for U.S.F.S. Glacier Ranger District (Continued)



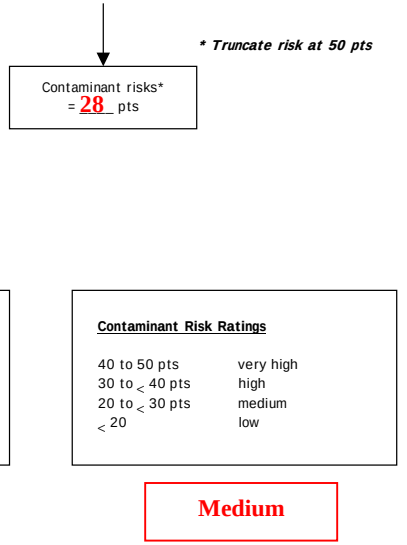


Table 6. Risk Matrix for Contaminant Sources for Volatile Organic Chemicals – U.S.F.S. Glacier Ranger District

Level of Risk Associated with the Highest Risk Sources

Next Highest Risk Sources(s)	**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