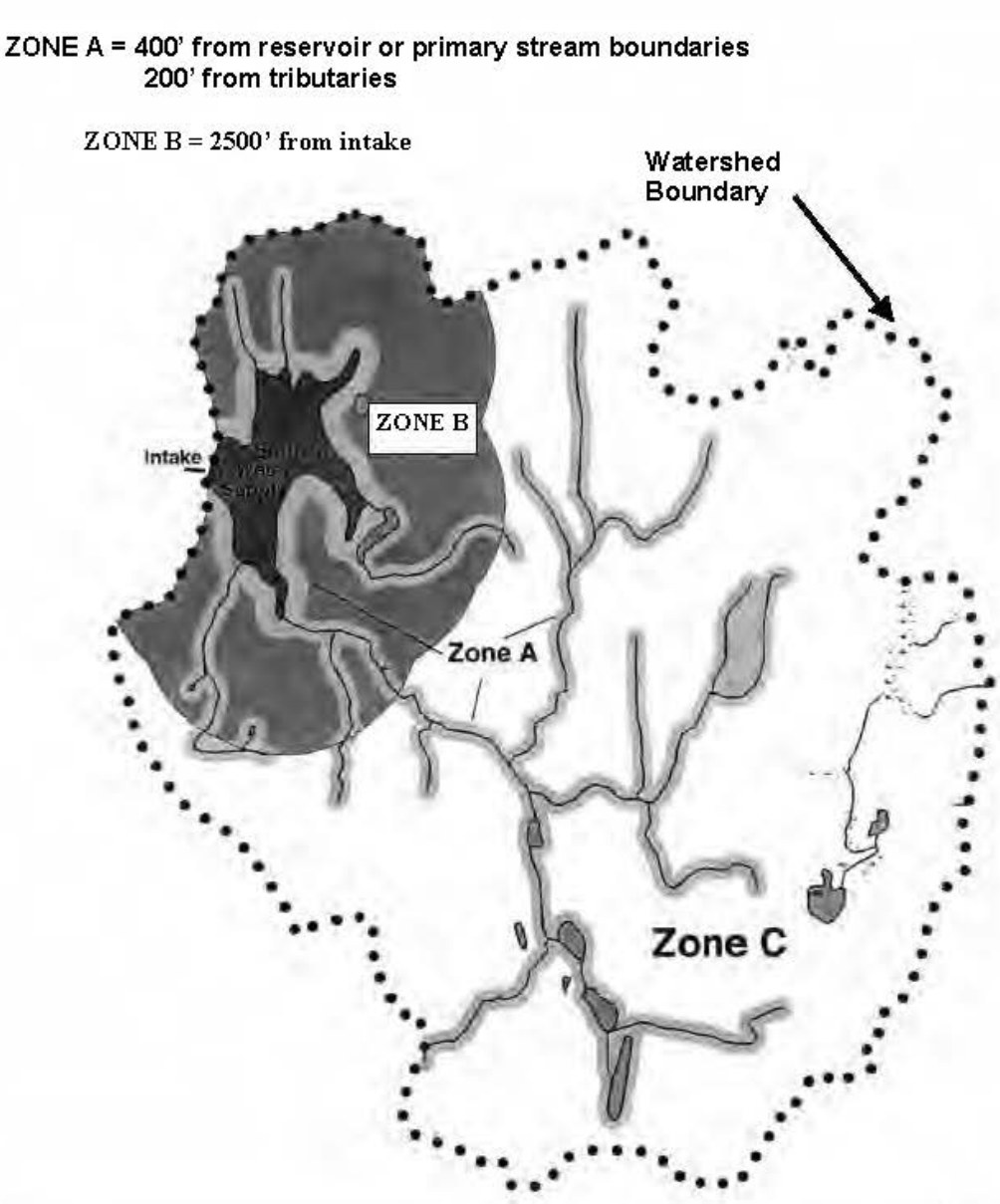

Figure 6-1. Surface water supply protection areas showing suggested zones (Adapted from Massachusetts DEP "Developing a Local Surface Water Supply Protection Plan," 1996)

Auguscik-25 (Cont.)

January 1999 – with April 1999 and January 2000 revisions

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(Cont.)

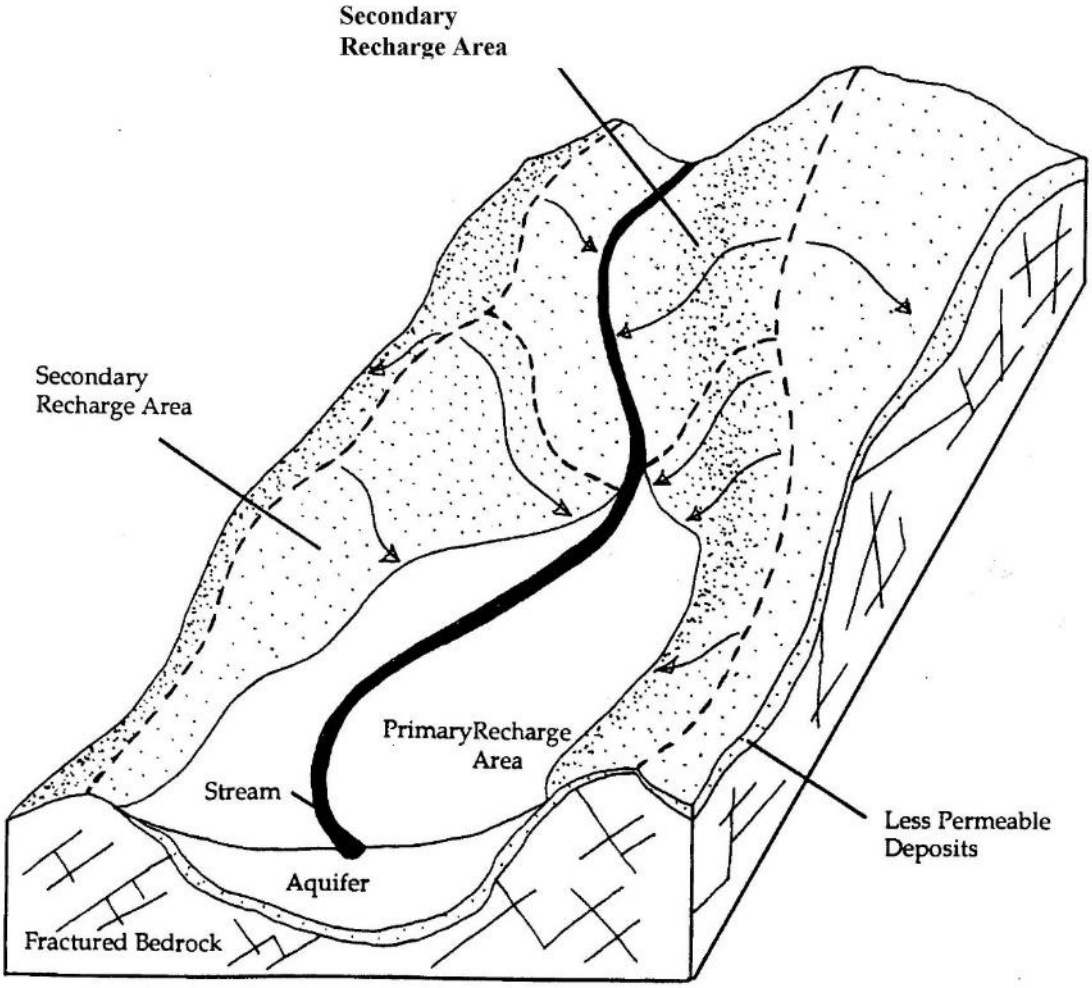

Figure 6-2. Illustration of recharge areas (Adapted from Witten and Horsley, 1995)

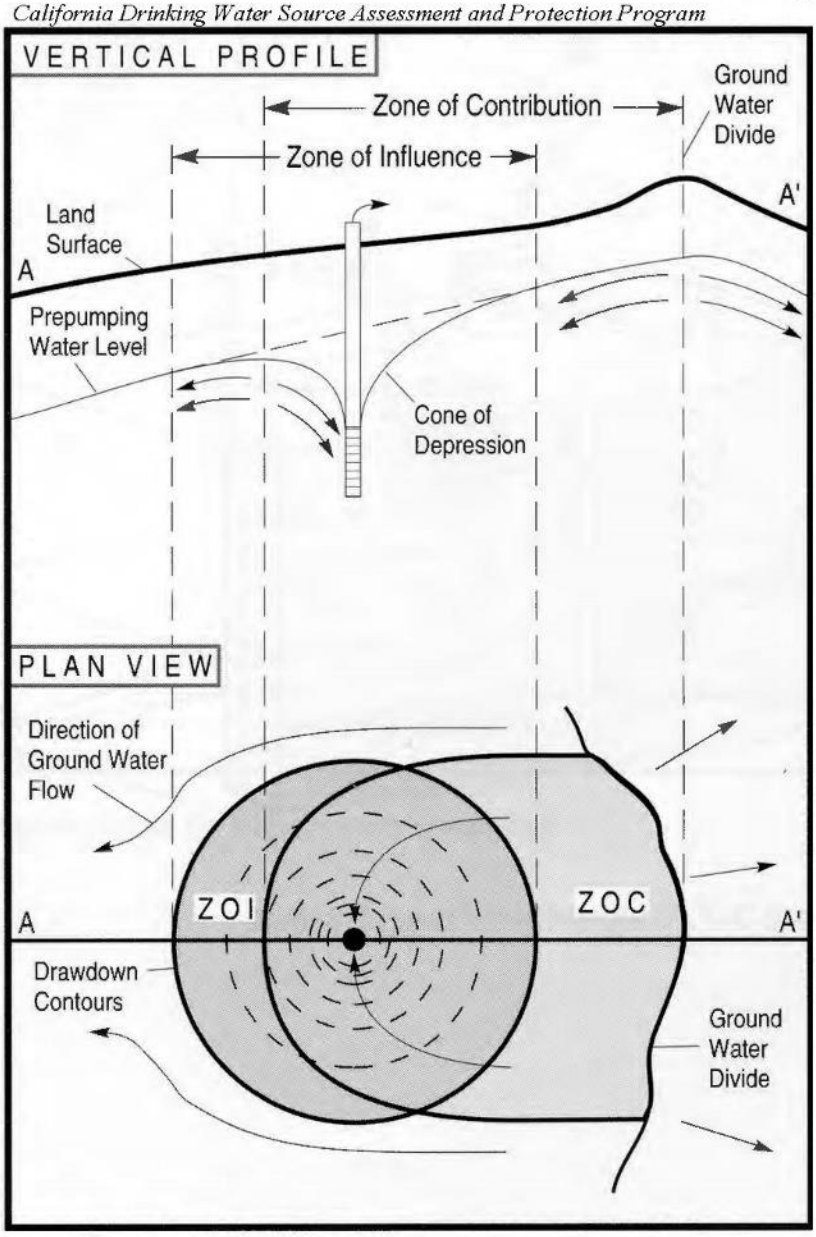

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Fig. 6-3. Changes to the ground water system due to a pumping well (From Witten, Horsley, 1995)

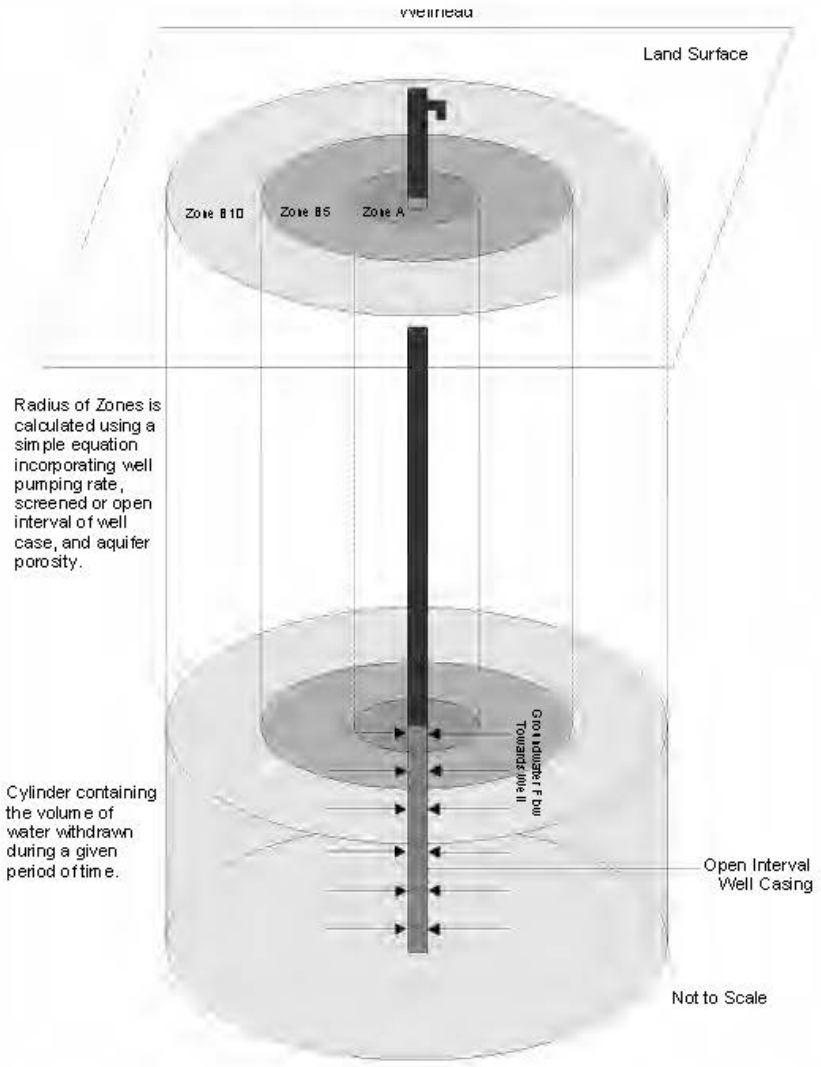

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Figure 6-4. Calculated fixed radius delineation method (Adapted from Washington State, "Wellhead Protection Program Guidance Document," 1995)

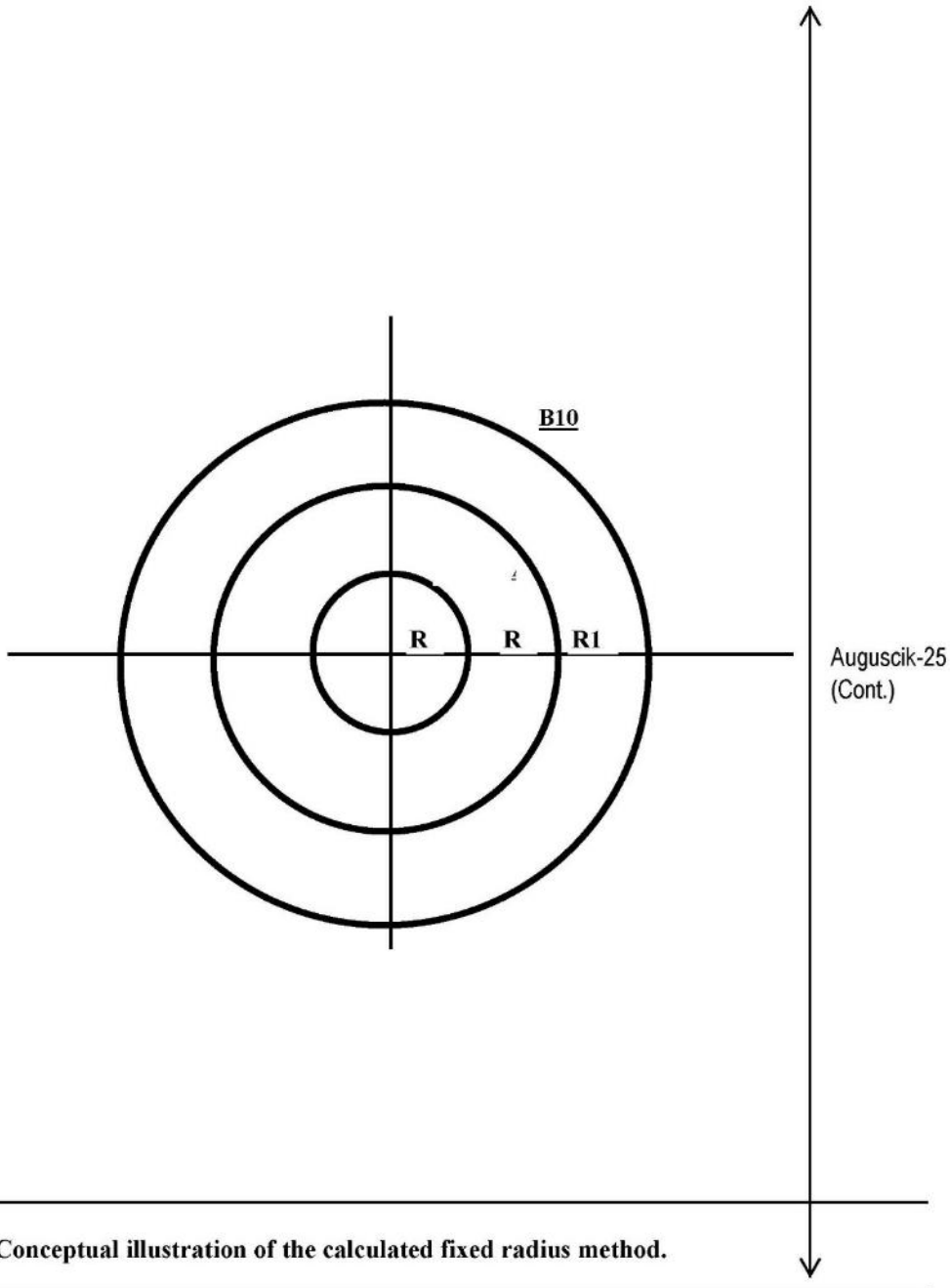


Figure 6-5. Conceptual illustration of the calculated fixed radius method.

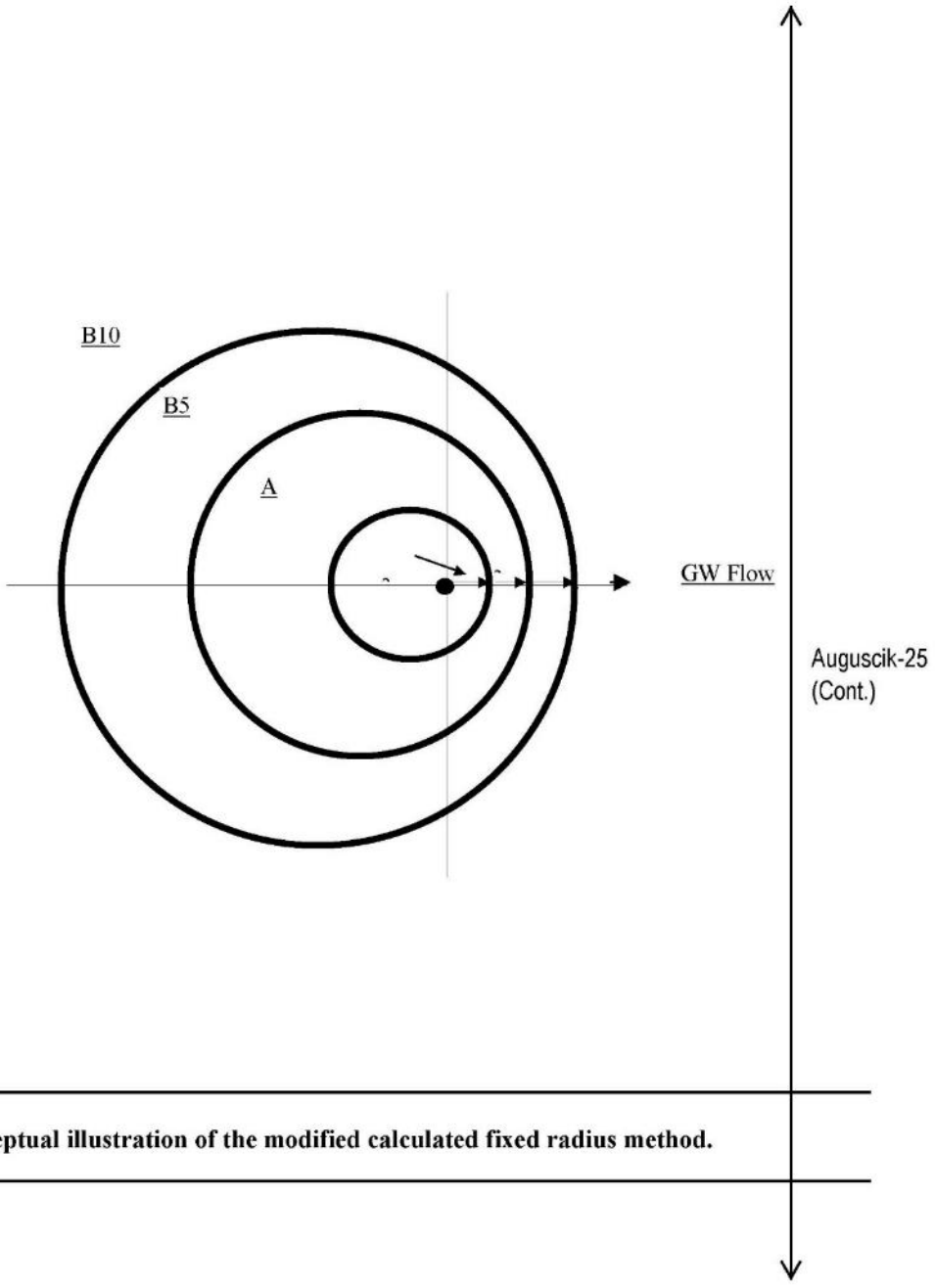
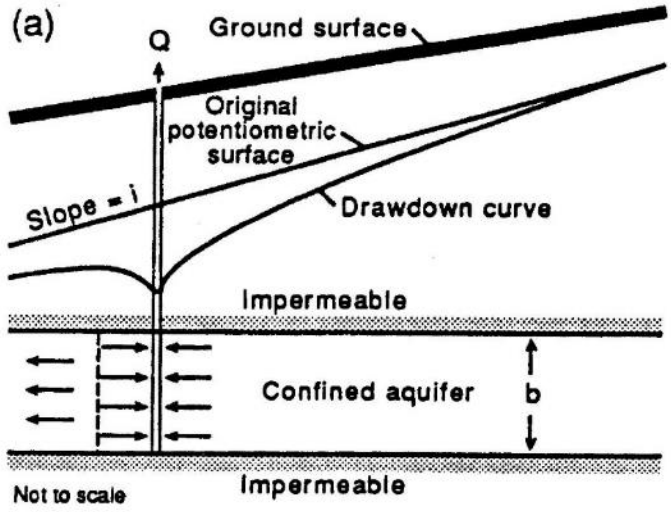
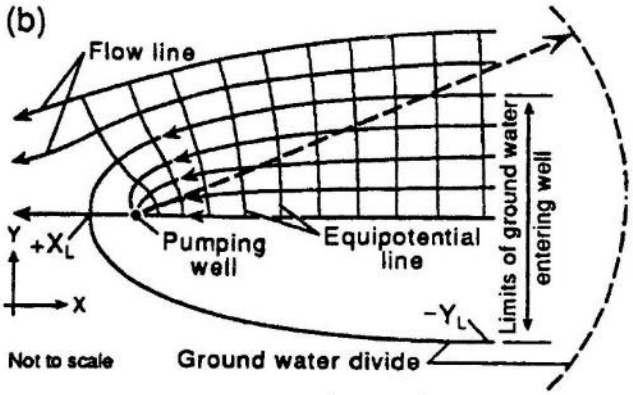


Figure 6-6. Conceptual illustration of the modified calculated fixed radius method.

January 1999 – with April 1999 and January 2000 revisions





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Uniform flow equation: $-\frac{Y}{X} = \tan\left(\frac{2\pi Kbi}{Q} Y\right)$

Distance to down-gradient null point: $X_L = -\frac{Q}{2\pi Kbi}$

Boundary limit: $Y_L = \pm\frac{Q}{2Kbi}$

Where: Q = Well pumping rate
K = Hydraulic conductivity
b = saturated thickness

Figure 6-7. Uniform flow equations for determining area of contribution to a pumping well (adapted from Todd, 1980)

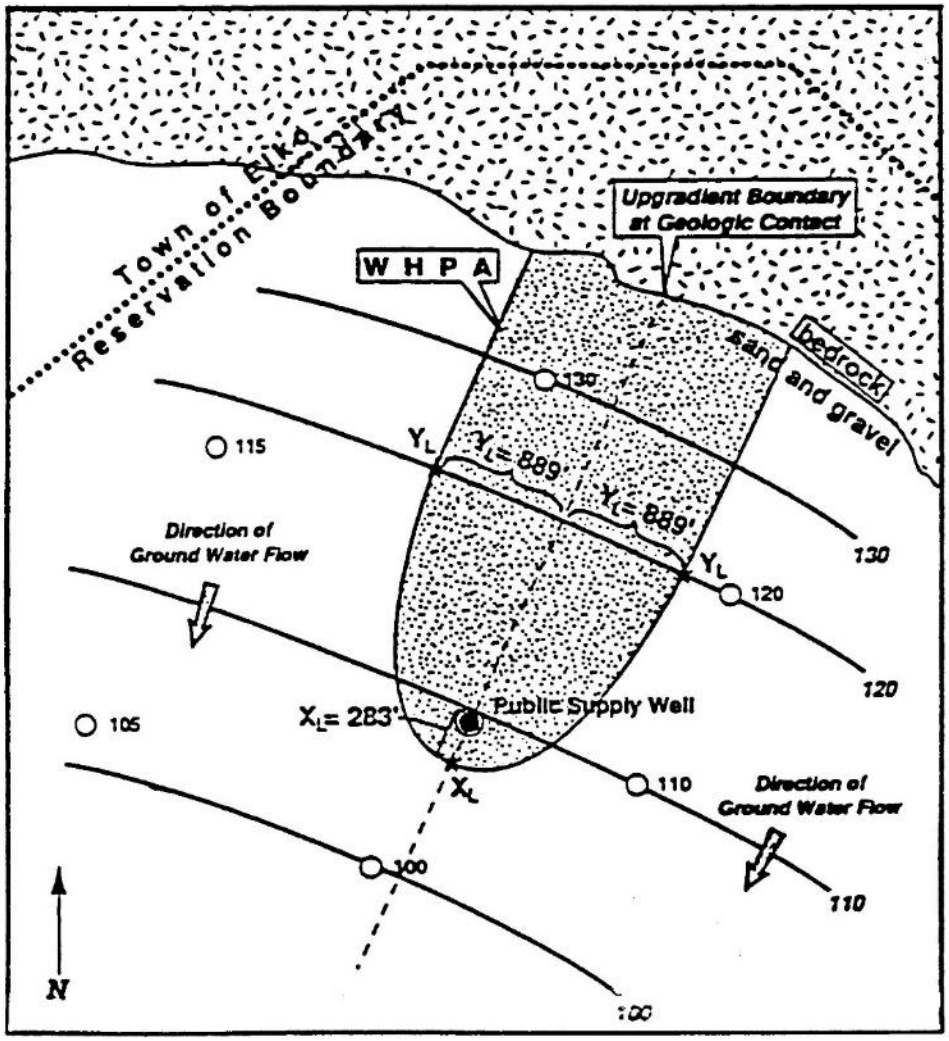

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Figure 6-8. Delineation of a drinking water source protection area by analytical methods.

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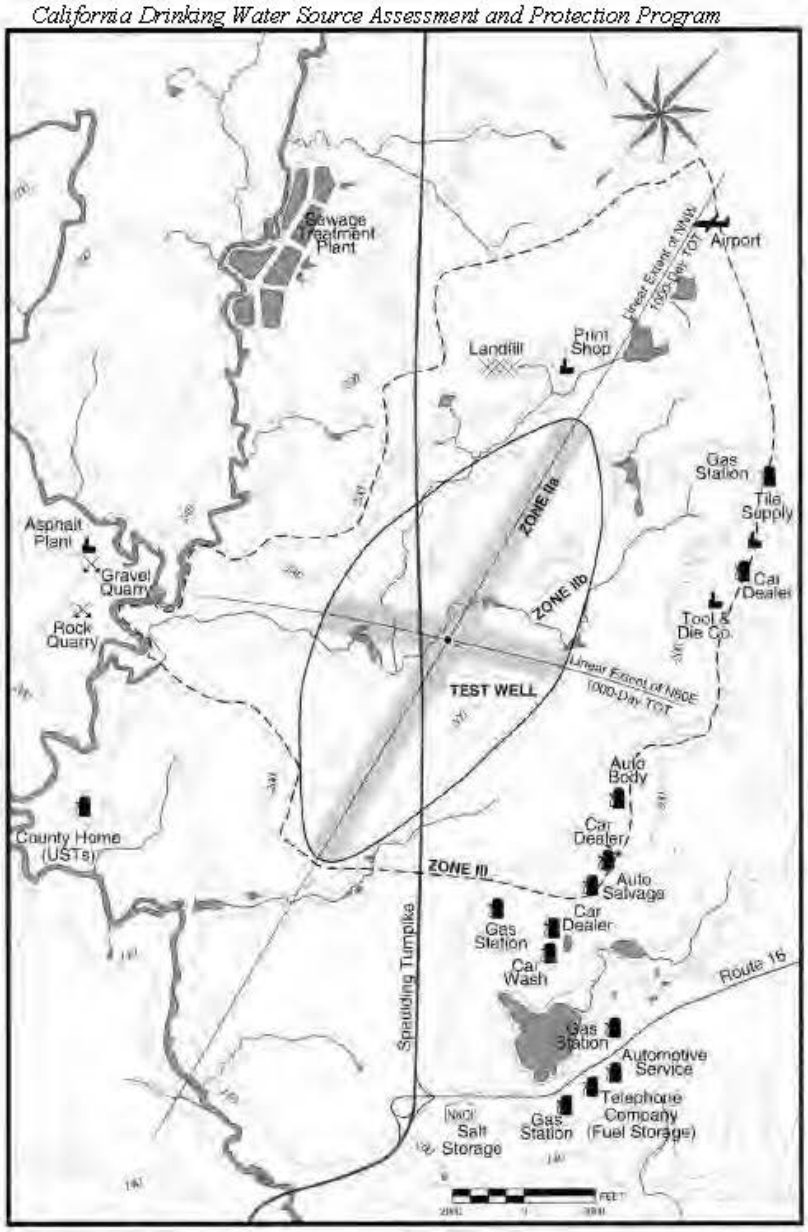

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Figure 6-9. Conceptual example of source area and zones using hydrogeologic mapping (From Witten and Horsley, 1995)

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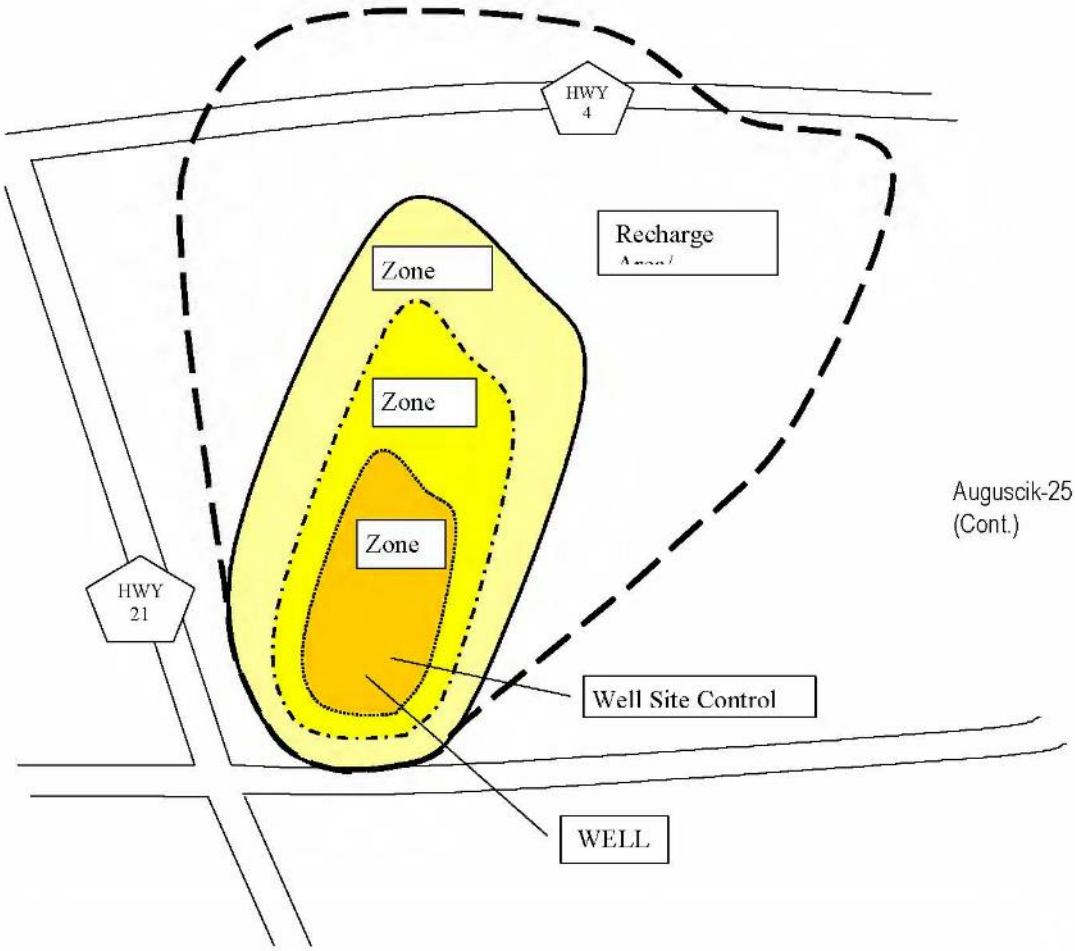

Figure 6-10. Illustration of conceptual ground water source area and protection zones (Adapted from Witten and Horsley, 1995)

January 1999 – with April 1999 and January 2000 revisions

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(Cont.)

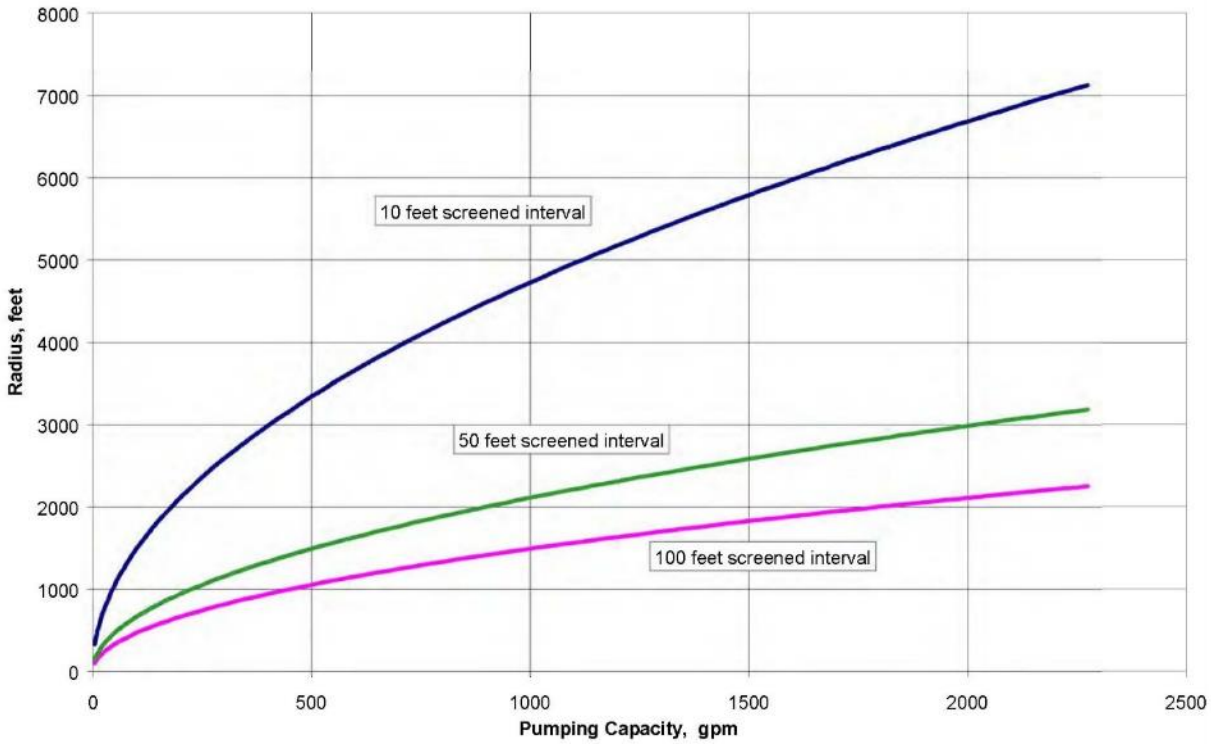

Figure 6-11. Radius of microbiological Zone A (2-year time of travel), using calculated fixed radius method (assumes porosity = 0.2)

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(Cont.)

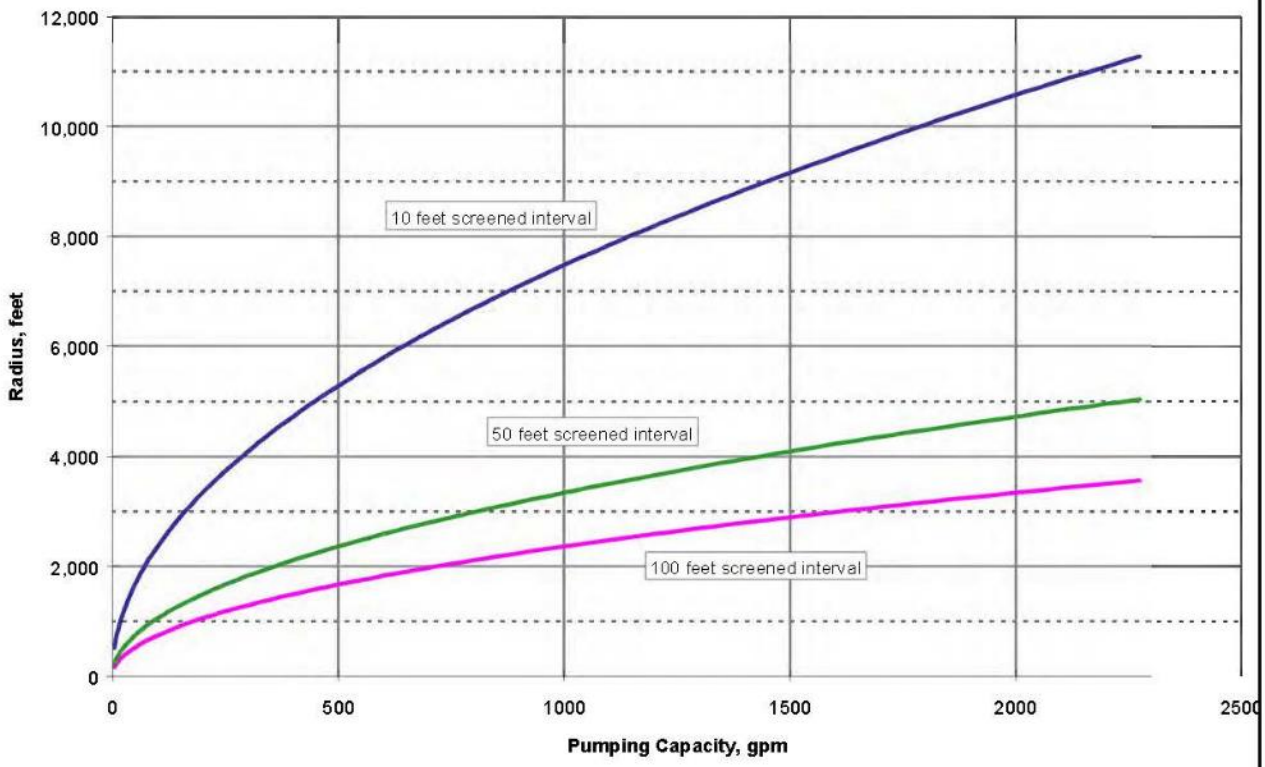

Figure 6-12. Radius of Zone B5 (5-year time of travel), using calculated fixed radius method (assumes porosity =0.2)

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(Cont.)

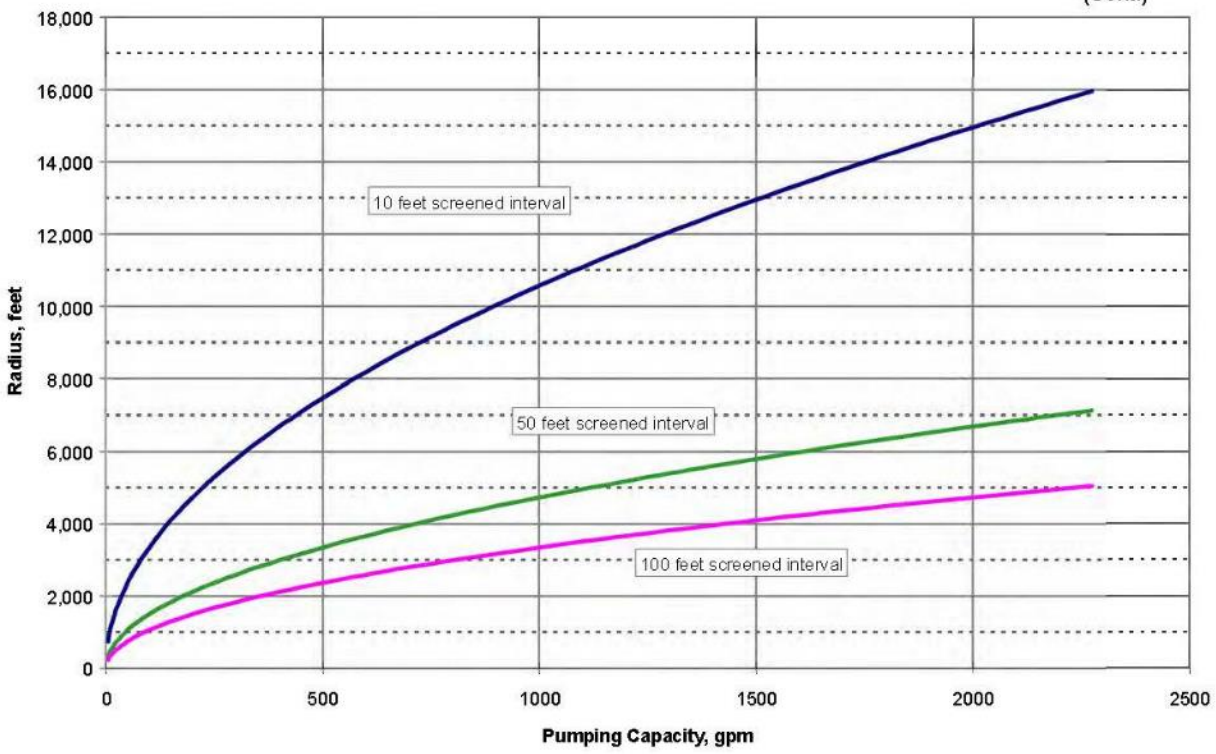

Figure 6-13. Radius of Zone B10 (10-year time of travel), using calculated fixed radius method (assumes porosity =0.2)

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7.0 Inventory of Possible Contaminating Activities (PCAs) within Source Areas and Protection Zones

An essential element of the drinking water source assessment program is an inventory of possible contaminating activities, industries, or land use. PCAs are considered to be potential origins of contamination in drinking water source areas and protection zones.

An inventory of PCAs can serve at least three important functions:

- Identify past and present activities -- and others that are proposed (to the extent feasible) -- that may pose a threat to the drinking water supply, based on their potential for contamination of ground water or surface water. These activities may include transporting, storing, manufacturing, producing, using, or disposing of potential contaminants. Historic activities are also important to include, as are activities that may contribute to a cumulative impact by a potential contaminant that may otherwise be considered somewhat innocuous.

- Provide information on the existence of PCAs and their proximity to the drinking water source, especially those that present the greatest risks to the water supply.

- Provide an effective means of educating the local public about potential problems.

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Although there are various steps in developing the PCA inventory, the process should be viewed as an iterative one. If a type of activity occurs within a zone, then there is a potential origin of contamination, and this would be indicated in the initial phases of the source assessment. Additional review may provide site-specific information that indicates that the activity is not a potential origin of significant contamination. For example, a septic system that is far away from a well may be of less importance than one nearby, in terms of its microbiological significance. A PCA may be important even though it is a great distance away from the source because of the particular contaminant(s) associated with it, other characteristics of the PCA, or characteristics of the drinking water source.

The information obtained in the PCA inventory may be helpful in refining the delineation process described in Section 6.0. In addition, iterations of the PCA inventory and delineations of the source area and protection zones are important in voluntary protection programs.

Contaminants of concern. If any of the following contaminants of concern are associated with an activity, then that activity needs to be in the PCA inventory.

- Microorganisms of drinking water importance, including fecal coliform bacteria, *Escherichia coli*, viruses, *Giardia lambia*, and *Cryptospordium*.

- Chemicals for which maximum contaminant levels (MCLs) or California drinking water action levels have been established, and unregulated chemicals in drinking water for which monitoring is required (Table 7-1).

- Turbidity and total organic carbon (TOC). Turbidity can affect treatment and monitoring for microbiological contaminants, while TOC can influence the presence of disinfection byproducts, which have an attendant carcinogenic concern.

7.1 Alternative Approaches for Conducting a PCA Inventory

For the minimum program, a PCA inventory focuses on identifying whether a type of activity (PCA) exists within a source area or protection zone. Neither the exact location nor the number of sites of that type of PCA need be determined for the minimum assessment. For a more detailed assessment specific PCA locations and the density (number of facilities) for a PCA type can be included in the inventory. This is particularly useful if a source protection program is anticipated.

7.2 Information for PCA Inventories

PCA inventories should be coordinated with work done to comply with requirements of various state, local and federal agencies. Information may be obtained from permitting agencies, such as the state Department of Toxic Substances Control, the Regional Water Quality Control Boards, the Integrated Waste Management Board, the Department of Pesticide Regulation, the Department of Food and Agriculture, the local air pollution control districts, or other local agencies.

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To assist in the PCA inventory process, DHS is preparing a list of agencies that have data available, some of it electronically accessible. This list will include agencies with data on topography, soils, watersheds, drinking water sources, permitted waste dischargers, hazardous waste and other waste sites, leaking underground fuel tanks, pesticide use, and others (see Section 5.0).

DHS will include on its Internet site a list of agencies and other locations that have or may have pertinent data, and DHS will have Internet links to them when possible. DHS will update and maintain the listing, but will not be responsible for the quality of, or for updating the data of, other agencies. Accessing this listing and the data other agencies have available could be an initial step in conducting a PCA inventory.

Information from the state-wide data sources will need to be supplemented with local information: septic systems, land application of biosolids (sewage sludge), livestock operations, wildlife refuges, storm water runoff, recreational bathing beaches, and various hazardous substances data bases maintained by local fire departments, county environmental health departments, and county agricultural commissioners.

7.3 Steps in Developing an Inventory of PCAs

The purpose of the PCA inventory is to identify the existence and proximity to the water source of past, present and proposed activities that might be a potential threat to the water supply.

The steps involved in a PCA inventory are detailed below.

7.3.1 Develop an Initial List of Types of PCAs of Concern that May Exist Within or Near the Source Area or Protection Zone

The initial list of types of PCAs should include known sources of contamination, significantly high risk activities within or near the recharge area or watershed, and other activities that should not be overlooked in the inventory process. Table 7-2 is a list of activities that may possibly release contaminants.

Before proceeding with the inventory, resources should be assembled that will assist in locating activities; the DHS Internet site data directory, land use maps, files, and contacts for people that may have current and historical knowledge of the area.

7.3.2 Prepare a PCA Inventory Form

DHS has developed PCA Inventory Forms for surface water sources (Appendix D) and for ground water sources (Appendix K). The PCA inventory forms presented in the appendices should not be considered complete lists of all potential origins of contamination. If a type of PCA of concern from the initial list (Section 7.2.1) is not on an inventory form, it should be added to the appropriate inventory form. Other forms may be acceptable for the PCA inventory; this should be determined in consultation with DHS.

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Tables 7-3, 7-4, 7-5 and 7-6 list activities differentiated by potential risk to a water supply (very high, high, moderate, and low). The lists in those tables provide a means of ranking types of PCAs for the vulnerability analysis (Section 8.0). The inventory forms (Appendix D for surface water sources and Appendix K for ground water sources) incorporate the information from Tables 7-3, 7-4, 7-5 and 7-6.

The list of PCAs and the associated risk rankings were developed based on EPA guidance materials, other state programs, input from advisory committees and comments on the program. The risk ranking for a type of PCA is based on the relative risk of a drinking water supply to the contaminants associated with that PCA. The risk ranking may change based on the zone in which the PCA occurs. For example, PCAs associated with microbiological contamination (septic systems, animal facilities, sewer lines) are a very high risk if located within Zone A. Outside of this area they are considered less of a risk because the bacteria and viruses die off over time.

7.3.3 Conduct the PCA Inventory within the Source Area and/or Protection Zones

The initial review of the PCA inventory may be best performed by an individual or group with knowledge of activities around the drinking water source. The initial review could be done with

the Assessment Map (showing drinking water source, source area and zones) and additional maps that may be available.

The initial review allows those doing the assessment to narrow the PCA inventory lists, eliminating types of PCAs that do not occur, and noting the proximity (zone) of types of PCAs whose existence is known.

After the initial review, the PCA inventory should be completed using readily available resources. This may include consultation with various government agency or water system staff (especially for historical information), review of maps and files, access to electronic data sources, and field visits.

Again, it is not the intent of the assessment program to identify the exact location of each and every PCA within the source area and protection zones. The assessments are intended as a first step in an on-going iterative process. The initial PCA inventory should be considered an identification of the types of PCAs that exist within the delineated area(s). A water purveyor may desire to do a more detailed PCA inventory for purposes of a protection program (see Section 11.0). When more detailed information is available it is useful to include this in the assessment.

7.3.4 Attach a List of PCAs to the Assessment Map

As a minimum, a list of the types of PCAs and the area or zone(s) in which they occur should be attached to the assessment map. If the information is available, the locations of some PCAs may be shown as points or symbols on the assessment map. If a water system has a map that more clearly indicates the location of PCAs (e.g., parcel, land use, or service area maps) this may be submitted in addition to the Assessment Map.

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It should be noted that the assessment map may be based on general information and approximations. It should not be used as an endpoint for targeting source protection efforts and resources but as a starting point for further investigation. It should never be assumed that an assessment map and the attached list contains all possible contaminating activities or activity types, nor should it be assumed that all possible contaminating activities on the list are actual contamination sources.

7.4 Names and Addresses Associated with PCAs

During the development of the DWSAP, DHS received a number of comments on whether or not specific names and addresses of PCAs should be identified in the PCA inventory.

Considerable concern was expressed about labeling a specific business as a "polluter," when in fact, inclusion of a PCA only refers to an activity that is "possibly contaminating."

Concern was also expressed about lumping together all facilities of an activity as one PCA without taking into account whether an individual facility is small or large, or whether it poses an

actual risk (based on historical contamination), or a potential risk, based on its specific business operations.

DHS determined that specific identification of a PCA in terms of name and address is not needed for the minimum assessment. For example, if one or more gas stations are located within Zone A, B5 or B10 of a well, for purposes of the DWSAP, the presence of the facilities and the general proximity to the water source are the most significant.

Information about ownership and other specifics about any property site or business activity can be readily accessed from other public agencies, if it is needed for local protection programs or other reasons.

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Table 7-1. California Drinking Water Primary and Secondary Maximum Contaminant Levels, Action Levels, and Unregulated Chemicals Requiring Monitoring.

Maximum Contaminant Levels. MCLs are primary and secondary drinking water standards. They are enforceable regulatory levels, under the Safe Drinking Water Act, and must be met by all public drinking water systems to which they apply.

Primary MCLs are established for a number of chemical and radioactive contaminants. Primary MCLs can be found in Title 22 California Code of Regulations (CCR) for inorganic chemicals (§64431), trihalomethanes (§64439), radioactivity (§64441 and §64443) and organic chemicals (§64444).

Lead and copper have specific regulations in 22 CCR, Chapter 17.5 §64670 *et seq*. The lead and copper regulations use the term "action level" for each substance, for purposes of regulatory compliance.

Secondary MCLS, which are set for taste, odor, or appearance of drinking water, are presented in 22 CCR §64449. Secondary MCLs exist for more than a dozen chemicals/characteristics.

Action Levels (ALs). Except for lead and copper, as described above, ALs are advisory levels for unregulated chemicals, and are not enforceable standards. The ALs are listed below. DHS recommends that drinking water utilities provide public notification if ALs are exceeded. If sources exceeding ALs are taken out of service, notification is not needed.

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Unregulated chemicals requiring monitoring. Some chemicals, (e.g., MtBE) are "unregulated" but have certain monitoring requirements, as set forth in 22 CCR §64450. There are a number of unregulated chemicals that are or may be required to be monitored, depending on the vulnerability of drinking water systems.

PRIMARY MAXIMUM CONTAMINANT LEVELS
[All values in milligrams per liter (mg/L), unless otherwise noted.]

Constituent	Primary MCL
22 CCR §64431, Table 64431-A--Inorganic Chemicals	
Aluminum	1
Antimony	0.006
Arsenic	0.05
Asbestos	7 MFL[a]
Barium	1
Beryllium	0.004
Cadmium	0.005
Chromium	0.05
Cyanide	0.2
Fluoride	2.0
Mercury	0.002
Nickel	0.1
Nitrate (as NO_3)	45
Nitrate + Nitrite (sum as nitrogen)	10

January 1999 – with April 1999 and January 2000 revisions

Nitrite (as nitrogen)	1
Selenium	0.05
Thallium	0.002

22 CCR §64433.2, Table 64433.2-A—Optimal Fluoride Levels
See also the Fluoride MCL, 22 CCR §64431, Table 64431-A

Annual average of maximum daily air temperature	Optimal Level (Range)
50.0 to 53.7 degrees Fahrenheit (°F)	1.2 (1.1–1.7)
53.8 to 58.3 °F	1.1 (1.0–1.6)
58.4 to 63.8 °F	1.0 (0.9–1.5)
63.9 to 70.6 °F	0.9 (0.8–1.4)
70.7 to 79.2 °F	0.8 (0.7–1.3)
79.3 to 90.5 °F	0.7 (0.6–1.2)

22 CCR §64441 and §64443--Radioactivity

Gross alpha particle activity[b]	15 pCi/L[c]
Gross beta particle activity	50 pCi/L
Combined Radium-226 and Radium-228	5 pCi/L
Strontium-90	8 pCi/L
Tritium	20,000 pCi/L
Uranium	20 pCi/L

22 CCR §64439--Total Trihalomethanes

Sum of bromodichloromethane, dibromochloromethane, bromoform, and chloroform	0.1

22 CCR §64444--Organic Chemicals

Alachlor (Alanex)	0.002
Atrazine (Aatrex)	0.003
Bentazon (Basagran)	0.018
Benzene	0.001
Benzo(a)pyrene	0.0002
Carbofuran (Furadan)	0.018
Carbon tetrachloride	0.0005
Chlordane	0.0001
2,4-D	0.07
Dalapon	0.2
1,2-Dibromo-3-chloropropane (DBCP)	0.0002
1,2-Dichlorobenzene (o-Dichlorobenzene)	0.6
1,4-Dichlorobenzene (p-DCB)	0.005
1,1-Dichloroethane (1,1-DCA)	0.005
1,2-Dichloroethane (1,2-DCA)	0.0005
1,1-Dichloroethylene (1,1-DCE)	0.006
cis-1,2-Dichloroethylene	0.006
trans-1,2-Dichloroethylene	0.01
Dichloromethane (Methylene chloride)	0.005
1,2-Dichloropropane (Propylene dichloride)	0.005
Di(2-ethylhexyl)adipate	0.4
1,3-Dichloropropene	0.0005
Di(2-ethylhexylphthalate (DEHP)	0.004
Dinoseb	0.007
Diquat	0.02
Endrin	0.002
Endothal	0.1
Ethylbenzene (Phenylethane)	0.7

Auguscik-25 (Cont.)

January 1999 – with April 1999 and January 2000 revisions

Ethylene dibromide (EDB)	0.00005
Glyphosate	0.7
Heptachlor	0.00001
Heptachlor epoxide	0.00001
Hexachlorobenzene	0.001
Hexachlorocyclopentadiene	0.05
Lindane (gamma-BHC)	0.0002
Methoxychlor	0.04
Molinate (Ordam)	0.02
Monochlorobenzene (Chlorobenzene)	0.07
Oxamyl	0.2
Pentachlorophenol	0.001
Picloram	0.5
Polychlorinated biphenyls (PCBs)	0.0005
Simazine (Princep)	0.004
Styrene (Vinylbenzene)	0.1
2,4,5-TP (Silvex)	0.05
2,3,7,8-TCDD (Dioxin)	0.00000003
1,1,2,2-Tetrachloroethane	0.001
Tetrachloroethylene (PCE)	0.005
Thiobencarb (Bolero)[d]	0.07
Toluene (Methylbenzene)	0.15
Toxaphene	0.003
1,2,4-Trichlorobenzene (Unsym-Trichlorobenzene)	0.07
1,1,1-Trichloroethane (1,1,1-TCA)	0.200
1,1,2-Trichloroethane (1,1,2-TCA)	0.005
Trichloroethylene (TCE)	0.005
Trichlorofluoromethane (Freon 11)	0.15
1,1,2-Trichloro-1,2,2-Trifluoroethane (Freon 113)	1.2
Vinyl chloride	0.0005
Xylenes (single isomer or sum of isomers)	1.750

[a] MFL = million fibers per liter, MCL is for fibers exceeding 10 microns in length.
[b] Including radium-226 but excluding radon and uranium.
[c] pCi/L = picocuries per liter.
[d] Also listed with a Secondary MCL of 0.001 mg/L.

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LEAD AND COPPER, 22 CCR §64672.3
[All values in milligrams per liter (mg/L).]

Constituent	Action Level
Copper (Level to be met at customer tap)	1.3[e]
Lead (Level to be met at customer tap)	0.015[e]

[e] The action levels for copper and lead are used to determine the treatment requirements that a water system is required to complete. The action level for copper is exceeded if the concentration of copper in more than 10 percent of tap water samples collected during any monitoring period conducted in accordance with 22 CCR §64682-§64685 is greater than 1.3 mg/L. Similarly, the action level for lead is exceeded if the concentration of lead in more than 10 percent of tap water samples collected in accordance with 22 CCR §64682-§64685 is greater than 0.015 mg/L. Failure to comply with the applicable requirements for lead and copper (22 CCR Chapter 17.5) is a violation of primary drinking water standards for these substances.

SECONDARY MAXIMUM CONTAMINANT LEVELS, 22 CCR §64449
[All values in milligrams per liter (mg/L), unless otherwise noted.]

CONSUMER ACCEPTANCE LIMITS

Constituent	Secondary MCL
Aluminum	0.2
Color	15 units
Copper	1.0
Corrosivity	Non-corrosive
Foaming agents (MBAS)	0.5
Iron	0.3
Manganese	0.05
Methyl tertiary Butyl Ether (MTBE)[f]	0.005
Odor-Threshold	3 units
Silver	0.1
Thiobencarb (Bolero)[g]	0.001
Turbidity	5 units
Zinc	5.0

[f] Also listed with an Action Level of 0.035 mg/L.
[g] Also listed with a Primary MCL of 0.07 mg/L.

Constituent	Secondary MCL Ranges		
	Recommended	Upper	Short Term
Total Dissolved Solids or	500	1,000	1,500
Specific Conductance, micromhos	900	1,600	2,200
Chloride	250	500	600
Sulfate	250	500	600

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ACTION LEVELS
[All values in milligrams per liter (mg/L).]

Constituent	Action Level
Inorganic Chemicals	
Boron	1
Perchlorate	0.018
Organic Chemicals	
Aldicarb (Temik) [h]	0.01
Aldrin [h]	0.00005
Baygon	0.090
a-Benzene Hexachloride (a-BHC)	0.0007
b-Benzene Hexachloride (b-BHC)	0.0003
n-Butylbenzene (1-Butylpropane) [h]	0.045
Captan	0.350
Carbaryl (Sevin) [g]	0.060
Chloropicrin	0.050(0.037)[j]
2-Chlorotoluene (o-Chlorotoluene) [g]	0.045
4-Chlorotoluene (p-chlorotoluene) [g]	0.045
Diazinon (Basudin, Neocidol)	0.014
1,2-Dichlorobenzene (o-Dichlorobenzene)	0.130(0.010)[k]
1,3-Dichlorobenzene (m-Dichlorobenzene)	0.130(0.020)[k]
Dichlorodifluoromethane (Difluorodichloromethane) [g]	1.0
Dieldrin [h]	0.00005
1,4-Dioxane	0.003
Dimethoate (Cygon) [h]	0.140
2,4-Dimethylphenol	0.40
Diphenamide	0.040
Ethion	0.035
Formaldehyde	0.030
Isopropyl N (3-Chlorophenyl) Carbamate (CIPC)	0.350
Malathion	0.160
Methyl Isobutyl Ketone (MIBK)	0.040
Methyl Parathion	0.030
Methyl-tert-butyl ether (MTBE) [h,i]	0.035
N-Nitrosodimethylamine (NDMA)	0.000002
Parathion	0.030
Pentachloronitrobenzene (Terrachlor)	0.0009
Phenol	0.0050[j]
Trithion	0.0070

[h] Chemical is identified as "unregulated" for purposes of monitoring.
[i] Chemical also has secondary MCL
[j] Taste and odor threshold.
[k] Taste and odor threshold either for a single isomer or the sum of the two isomers.
[j] Taste and odor threshold for chlorinated systems.

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UNREGULATED CHEMICALS REQUIRING MONITORING, 22 CCR §64450

Monitoring is required for chemicals designated "a". If a system is determined to be vulnerable, monitoring is required for chemicals designated "b,"c," and "d."

Constituent	Unregulated category
Inorganic Chemicals	
Perchlorate	d
Organic Chemicals	
Aldicarb (Temik) [1]	c
Aldicarb sulfone	c
Aldicarb sulfoxide	c
Aldrin [1]	c
Bromacil (Hyvar X, Hyvar XL)	b
Bromobenzene (Monobromobenzene)	a
Bromochloromethane (Chlorobromomethane)	b
Bromodichloromethane (Dichlorobromomethane)	a
Bromoform (Tribromomethane)	a
Bromomethane (Methyl bromide)	a
Butachlor (Butanex, Lambast, Machete)	c
n-Butylbenzene (1-Butylpropane) [1]	b
sec-Butylbenzene (2-Phenylbutane)	b
tert-Butylbenzene (2-Methyl-2-phenylpropane)	b
Carbaryl (Sevin) [1]	c
Chlorodibromomethane (Dibromochloromethane)	a
Chloroethane (Ethyl chloride)	a
Chloroform (Trichloromethane)	a
Chloromethane (Methyl chloride)	a
Chlorothalonil (Bravo)	b
2-Chlorotoluene (o-Chlorotoluene) [1]	a
4-Chlorotoluene (p-chlorotoluene) [1]	a
Dibromochloromethane (Chlorodibromomethane)	a
Dibromomethane (Methylene bromide)	a
Dicamba (Banax, Banvel, Dianat)	c
1,3-Dichlorobenzene (m-Dichlorobenzene) [1]	a
Dichlorodifluoromethane (Difluorodichloromethane)	a
1,3-Dichloropropane	a
2,2-Dichloropropane	a
1,1-Dichloropropene	a
Dieldrin [1]	c
Dimethoate (Cygon) [1]	b
Diuron (Karmex, Krovar)	b
Ethyl tertiary butyl ether (ETBE)	b
Hexachlorobutadiene (Perchlorobutadiene)	b
3-Hydroxycarbofuran	c
Isopropylbenzene (Cumene)	b
p-Isopropyltoluene (p-Cymene)	b
Methoxychlor (Lannate)	c
Methyl-tert-butyl ether (MTBE) [m]	b
Metolachlor (Metelilachlor)	c
Metribuzin (Lexone, Sencor, Sencoral)	c
Naphthalene (Naphthalin)	b

Auguscik-25 (Cont.)

January 1999 – with April 1999 and January 2000 revisions

1-Phenylpropane (n-Propylbenzene)	b
Prometryn (Caparol)	b
Propachlor (Albrass, Ramrod)	c
Tertiary amyl methyl ether (TAME)	b
1,1,1,2-Tetrachloroethane	a
1,2,3-Trichlorobenzene (vic-Trichlorobenzene)	b
1,2,3-Trichloropropane (Allyl Trichloride)	a
1,2,4-Trimethylbenzene (Pseudocumene)	b
1,3,5-Trimethylbenzene (Mesitylene)	b

[l] Chemical also has a California drinking water action level.
[m] Chemical also has a California secondary MCL and a drinking water action level.

Auguscik-25
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Auguscik-25 (Cont.)

Table 7-2. Potential sources of surface water and ground water contaminants.

Potential Sources of Surface Water and Ground Water Contaminants	
Source	*Groundwater Contaminants* [1,2,3]
Commercial / Industrial	
Automobile Body shops/repair shops	Waste oils; solvents; acids; paints; automotive wastes;[4] miscellaneous cutting oils
Car washes	Soaps; detergents, waxes; miscellaneous chemicals, hydrocarbons
Gas stations/sumps	Oils; solvents; miscellaneous wastes
Boat Services/repair/refinishing	Diesel fuels; oil; septage from boat waste disposal area; wood preservative and treatment chemicals; paints; waxes; varnishes; automotive wastes[4]
Cement/concrete plants	Diesel fuels; solvents; oils; miscellaneous wastes; salts, high pH
Chemical/petroleum processing/storage	Hazardous chemicals; solvents; hydrocarbons; heavy metals; asphalt
Dry cleaners	Solvents (perchloroethylene, petroleum solvents, Freon); spotting chemicals (trichloroethane, methylchloroform, ammonia, peroxides, hydrochloric acid, rust removers, amyl acetate)
Electrical/electronic manufacturing	Cyanides; metal sludges; caustic (chromic acid); solvents; oils; alkalis; acids; paints and paint sludges; calcium fluoride sludges; methylene chloride; perchloroethylene; trichloroethane; acetone; methanol; toluene; PCBs
Fleet/trucking/bus terminals	Waste oil; solvents; gasoline and diesel fuel from vehicles and storage tanks; fuel oil; other automotive wastes[4]
Food processing	Nitrates; salts; phosphorus; miscellaneous food wastes; chlorine; ammonia; ethylene glycol
Funeral services/graveyards	Formaldehyde; wetting agents; fumigants; solvents; leachate; lawn and garden maintenance chemicals[5]
Furniture repair/manufacturing	Paints; solvents; degreasing and solvent recovery sludges; lacquers; sealants
Hardware/lumber/parts stores	Hazardous chemical products in inventories; heating oil and fork lift fuel from storage tanks; wood-staining and treating products such as creosote; paints; thinners; lacquers; varnishes
Home manufacturing	Solvents; paints; glues and other adhesives; waste insulation; lacquers; tars; sealants; epoxy wastes; miscellaneous chemical wastes
Junk/scrap/salvage yards	Automotive wastes [4]; PCB contaminated wastes; any wastes from businesses[6] and households[7]; oils; lead
Machine shops	Solvents; metals; miscellaneous organics; sludges; oily metal shavings; lubricant and cutting oils; degreasers (tetrachloroethylene); metal marking fluids; mold-release agents
Medical/vet offices	X-ray developers and fixers[8]; infectious wastes; radiological wastes; biological wastes; disinfectants; asbestos; beryllium; dental acids; miscellaneous chemicals
Metal plating/finishing/ fabricating	Sodium and hydrogen cyanide; metallic salts; hydrochloric acid; sulfuric acid; chromic acid; boric acid; paint wastes; heavy metals; plating wastes; oils; solvents

January 1999 – with April 1999 and January 2000 revisions

Auguscik-25 (Cont.)

Mines/gravel pits	Mine spills or tailings that often contain metals; acids; highly corrosive mineralized waters; metal sulfides; metals; acids; minerals sulfides; other hazardous and nonhazardous chemicals[9]
Office buildings/complexes	Building wastes[5]; lawn and garden maintenance chemicals[5]; gasoline; motor oil
Parking lots/malls (> 50 spaces)	Hydrocarbons; heavy metals; building wastes[6]
Photo processing/printing	Biosludges; silver sludges; cyanides; miscellaneous sludges; solvents; inks; dyes; oils; photographic chemicals
Plastics/synthetics producers	Solvents; oils; miscellaneous organic and inorganics (phenols, resins); paint wastes; cyanides; acids; alkalis; wastewater treatment sludges; cellulose esters; surfacant; glycols; phenols; formaldehyde; peroxides; etc.
Research laboratories	X-ray developers and fixers[8]; infectious wastes; radiological wastes; biological wastes, disinfectants; asbestos; beryllium; solvents; infectious materials; drugs; disinfectants; (quaternary ammonia, hexachlorophene, peroxides, chlornexade, bleach); miscellaneous chemicals
Recreational vehicle (RV)/mini storage	Automobile wastes[4]; gasoline and diesel fuel from vehicles and storage tanks
Sewer lines	Sewage
Wood preserving/treating	Wood preservatives; creosote, pentachlorophenol, arsenic
Wood/pulp/paper processing and mills	Metals; acids; minerals; sulfides; other hazardous and nonhazardous chemicals[9]; organic sludges; sodium hydroxide; chlorine; hypochlorite; chlorine dioxide; hydrogen peroxide; treated wood residue (copper quinolate, mercury, sodium bazide); tanner gas; paint sludges; solvents; creosote; coating and gluing wastes
Agricultural/Rural	
Confined animal feeding operations	Livestock sewage wastes; nitrates; phosphates; chloride; chemical sprays and dips for controlling insect, bacterial, viral and fungal pests on livestocks; coliform[10] and noncoliform bacteria; viruses; protozoa; total dissolved solids
Grazing animals, other animal operations	Livestock sewage wastes; nitrates; phosphates; coliform and noncoliform bacteria; protozoa, viruses; total dissolved solids;
Dairies	Livestock sewage wastes; nitrates; total dissolved solids; salts; phosphates; potassium.
Farm chemical distributor/application service	Pesticides[11]; fertilizers[12]; hydrocarbons from motor vehicles and storage tanks
Farm machinery repair	Automotive wastes[4]; welding wastes
Irrigated crops	Pesticides[11]; fertilizers[12]; nitrates; phosphates; potassium (can be worsened by over-watering)
Lagoons	Nitrates; Livestock sewage wastes; salts; pesticides[11]; fertilizers[17]; bacteria
Nonirrigated crops	Pesticides[11]; fertilizers[12]; nitrates; phosphates; potassium
Pesticide/fertilizer/petroleum storage & transfer areas	Pesticides[11]; fertilizers[12]; petroleum residues
Rural homesteads	*Machine shops:* Automotive wastes[4]; welding wastes; solvents; metals; lubricants; sludges *Septic systems:* Septage; coliform[10] and noncoliform bacteria; viruses; nitrates; heavy metals; synthetic detergents; cooking

January 1999 – with April 1999 and January 2000 revisions

Auguscik-25 (Cont.)

	and motor oils; bleach; pesticides;[5,13] paints; paint thinner; photographic chemicals; swimming pool chemicals;[14] septic tank/cesspool cleaner chemicals;[15] elevated levels of chloride, sulfate, calcium, magnesium, potassium, and phosphate
Sludge application to land	Organic and inorganic chemicals, coliform and noncoliform bacteria, viruses, protozoa[16]
Agricultural Drainage	Pesticides[11]; fertilizers[12]; total dissolved solids; total organic carbon; nitrates
Residential / Municipal	
Airports (maintenance/fueling areas)	Jet fuels; deicers; diesel fuel; chlorinated solvents; automotive wastes;[4] heating oil; building wastes[6]
Apartments and condominiums	Swimming pool maintenance chemicals[14]; pesticides for lawn and garden maintenance and cockroach, termite, ant, rodent, and other pest control[5,13], wastes from on-site sewage treatment plants; household hazardous wastes[7]
Camp grounds/RV parks	Septage; gasoline; diesel fuel from boats; pesticides for controlling mosquitoes, ants, ticks, gypsy moths, and other pests[11,13]; household hazardous wastes from RVs[7]
Drinking water treatment plants	Treatment chemicals; pesticides[11]
Fire stations	General building wastes[6]; hydrocarbons from test burn areas
Golf courses	Fertilizers[12]; herbicides[11]; pesticides for controlling mosquitoes, ticks, ants, gypsy moths, and other pests[5]
Housing	*Household hazardous wastes[7]:* Household cleaners; oven cleaners; drain cleaners; toilet cleaners; disinfectants; metal polishes; jewelry cleaners; shoe polishes; synthetic detergents; bleach; laundry soil and stain removers; spot removers and dry cleaning fluid; solvents; lye or caustic soda; household pesticides;[13] photo chemical; printing ink, paints; varnishes; stains; dyes; wood preservatives (creosote); paint and lacquer thinners; paint and varnish removers and deglossers; paint brush cleaners; floor and furniture strippers *Mechanical Repair and Other Maintenance Products:* Automotive wastes;[4] waste oils; diesel fuel; kerosene; #2 heating oil; grease; degreasers for driveways and garages; metal degreasers; asphalt and roofing tar; tar removers; lubricants; rustproofers; car wash detergents; car waxes and polishes; rock salt; refrigerants *Lawn/garden care:* Fertilizers;[11] herbicides and other pesticides used for lawn and garden maintenance[5] (can be worsened by over-watering) *Swimming pools:* Swimming pool maintenance chemicals[14] *Urban runoff/stormwater[3]:* Gasoline; oil; other petroleum products; microbiological contaminants
Landfills/dumps	Leachate; organic and inorganic chemical contaminants; waste from households[7] and businesses[6]; nitrates; oils; metals; solvents; sludge

Auguscik-25 (Cont.)

Motor pools	Automotive wastes[4]: solvents; waste oils; hydrocarbons from storage tanks
Parks	Fertilizers[12]; herbicides[5]; insecticides[11,13]; (can be worsened by over-watering)
Railroad yards/maintenance/fueling areas	Diesel fuel; herbicides for rights-of-way [11]; creosote for preserving wood ties; solvents; paints; waste oils
Recreational use of surface water sources (body contact)	Microbiological contamination from swimmers
Recreational use of surface water sources (motorized watercraft)	Gasoline fuel from watercraft; marinas.

Schools	Machinery/vehicle serving wastes; gasoline and heating oil from storage tanks; general building wastes[6]; pesticides[11,13].
Septic systems	Septage; coliform[10] and noncoliform bacteria; viruses; nitrates; heavy metals; synthetic detergents; cooking and motor oils; bleach; pesticides;[5,13] paints; paint thinner; photographic chemicals; swimming pool chemicals;[14] septic tank/cesspool cleaner chemicals[15]; elevated levels of chloride, sulfate, calcium, magnesium, potassium, and phosphate; other household hazardous wastes[7];
Sewer lines	Sewage
Utility stations/maintenance areas	PCBs from transformers and capacitors; oils; solvents; sludges; acid solution; metal plating solutions (chromium, nickel, cadmium); herbicides from utility rights-of-way
Waste transfer/recycling stations	Residential and commercial solid waste residues
Wastewater	Municipal wastewater; sludge[16]; treatment chemicals[17]; nitrates; heavy metals; coliform[10] and noncoliform bacteria; nonhazardous wastes[16]
Other	
Above ground storage tanks	Heating oil; diesel fuel; gasoline; other chemicals
Construction/demolition areas (plumbing, heating, and air conditioning, painting, paper hanging, decorating, drywall and plastering, acoustical insulation, carpentry, flooring, roofing, and sheet metal etc.)	Solvents; asbestos; paints; glues and other adhesives; waste insulation; lacquers; tars; sealants; epoxy waste; miscellaneous chemical wastes
Historic gas stations	Diesel fuel; gasoline; kerosene
Historic waste dumps/landfills	Leachate; organic and inorganic chemicals; waste from households [7]; and businesses [6]; nitrates; oils; heavy metals; solvents
Hospitals	Various chemical and radiological substances, and microorganisms.
Injection wells/drywells/sumps	Stormwater runoff [3]; spilled liquids; used oils; antifreeze; gasoline; solvents; other petroleum products; pesticides[11]; and a wide variety of other substances
Managed forests	Pesticides; fertilizers; total dissolved solids
Medical/dental offices and clinics	Various chemical substances.
Military installations	Wide variety of hazardous and nonhazardous wastes depending on the nature of the facility and operation[3,9]; diesel fuels; jet fuels; solvents; paints; waste oils; heavy metals; radioactive wastes
Seawater intrusion	Salinity, disinfection byproducts
Silviculture	Pesticides, fertilizers, total dissolved solids
Surface water - stream/lakes/rivers	(Directly related to surface water quality in the stream, lake, or river which is recharging groundwater)
Transportation corridors	Herbicides in highway right-of-way[11,5]; road salt (sodium and calcium chloride); road salt, anticaking additives (ferric ferrocyanide, sodium ferrocyanide); road salt anticorrosives (phosphate and chromate); automotive wastes[4]

Auguscik-25 (Cont.)

Underground storage tanks	Diesel fuel; gasoline; heating oil; other chemical and petroleum products
Veterinary offices/clinics	Various chemical and radiological substances and microorganisms.
Wells, agricultural (such as irrigation wells, abandoned wells)	Storm water runoff, irrigation water runoff, nitrates, pesticides, and other substances
Wells, gas, oil, geothermal	Various petroleum-related substances, inorganics
Wells (such as water supply wells, monitoring wells, unsealed or abandoned wells, and test holes)	Storm water runoff [3]; solvents; nitrates; septic tanks; hydrocarbons; and other substances

SOURCE: Adapted from EPA (1993), and from the Oregon Wellhead Protection Program

[1]In general, source water contamination stems from the *misuse and improper disposal* of liquid and solid wastes; the *illegal dumping or abandonment* of household, commercial, or industrial chemicals; the *accidental spilling* of chemicals from trucks, railways, aircraft, handling facilities, and storage tanks; or the *improper siting, design, construction, operation, or maintenance* of agricultural, residential, municipal, commercial, and industrial drinking water wells and liquid and solid waste disposal facilities. Contaminants also can stem from *atmospheric pollutants*, such as airborne sulfur and nitrogen compounds, which are created by smoke, flue dust, aerosols, and automobile emissions, and which are removed from the atmosphere by wet or dry deposition, and runoff from or percolate through the soil. ***When the sources listed in this table are used and managed properly, contamination is not likely to occur, or is likely to occur at low levels.***

[2]Contaminants can reach groundwater from activities occurring on the land surface, such as industrial waste storage; from sources below the land surface but above the water table, such as septic systems; from structures beneath the water table, such as wells; or from contaminated recharge water.

[3]This table lists the most common wastes, but not all potential wastes. For example, it is not possible to list all potential contaminants contained in stormwater runoff or from military installations.

[4]Automobile wastes can include gasoline; antifreeze; automatic transmission fluid; battery acid; engine and radiator flushes; engine and metal degreasers; hydraulic (brake) fluid; and motor oils.

[5]Common pesticides used for lawn and garden maintenance (i.e., weed killers, and mite, grub, and aphid controls) include such chemicals as 2,4-D; chlorpyrifos; diazinon; benomyl; captan; dicofol; and methoxychlor.

[6]Common wastes from public and commercial buildings include automotive wastes; and residues from cleaning products that may contain chemicals such a xylenols, glycol esters, isopropanol, 1,1,1,-trichloroethane, sulfonates, chlorinated phenols, and cresols.

[7]Household hazardous wastes are common household products that contain a variety of toxic or hazardous components.

[8]X-ray developers and fixers may contain reclaimable silver, glutaldehyde, hydroquinone, potassium bromide, sodium sulfite, sodium carbonate, thiosulfates, and potassium alum.

[9]The Resource Conservation and Recovery Act (RCRA) defines a hazardous waste as a solid waste that may cause an increase in mortality or serious illness or pose a substantial threat to human health and the environment when improperly treated, stored, transported, disposed of, or otherwise managed. A waste is hazardous if it exhibits characteristics of ignitability, corrosivity, reactivity, and/or toxicity. Not covered by RCRA regulations are domestic sewage; irrigation waters or industrial discharges allowed by the Clean Water

Act; certain nuclear and mining wastes; household wastes; agricultural wastes (excluding some pesticides); and small quantity hazardous wastes (i.e., less than 220 pounds per month) generated by businesses.

[10]Coliform bacteria can indicate the presence of pathogenic (disease-causing) microorganisms that may be transmitted in human feces. Diseases such as typhoid fever, hepatitis, diarrhea, and dysentery can result from sewage contamination of water supplies.

[11]Pesticides include herbicides, insecticides, rodenticides, fungicides and avicides. EPA has registered approximately 50,000 different pesticide products for use in the United States. Many are highly toxic and quite mobile in the subsurface. An EPA survey found that the most common pesticides found in drinking water wells were DCPA (dacthal) and atrazine, which EPA classifies as *moderately toxic* (class 3) and *slightly toxic* (class 4) materials, respectively

[12]The EPA National Pesticides Survey found that the use of fertilizers correlates to nitrate contamination of groundwater supplies.

[13]Common household pesticides for controlling pests such as ants, termites, bees, wasps, flies, cockroaches, silverfish, mites, ticks, fleas, worm, rates, and mice can contain active ingredients include naphthalene, phosphorus, xylene, chloroform, heavy metals, chlorinated hydrocarbons, arsenic, strychnine, kerosene, nitrosamines, and dioxin.

[14]Swimming pool chemicals can contain free and combined chlorine; bromine; iodine; mercury-based, copper-based, and quaternary algaecides; cyanuric acid; calcium or sodium hypochlorite; muriatic acid; sodium carbonate.

[15]Septic tank/cesspool cleaners include synthetic organic chemicals such as 1,1,1 trichloroethane, tetrachloroethylene, carbon tetrachloride, and methylene chloride.

[16]Municipal wastewater treatment sludge can contain organic matter, nitrates; inorganic salts, heavy metals; coliform and noncoliform bacteria; protozoa (giardia and cryptosporidium) and viruses.

[17]Municipal wastewater treatment chemicals include calcium oxide; alum; activated alum, carbon, and silica; polymers; ion exchange resins; sodium hydroxide; chlorine; ozone; and corrosion inhibitors.

Table 7-3. Possible Contaminating Activities (PCAs) associated with Very High potential risks. Very High risk PCAs are considered to have the highest potential for drinking water contamination, greater than those designated High risk (Table 7-4), Moderate risk (Table 7-5), or Low risk (Table 7-6). The risk rankings are based on the general nature of activities and the contaminants associated with them (refer to Table 7-2), not on facility-specific management practices. Instead, such management practices may be considered in the vulnerability analysis, and should be considered in a protection program. (An asterisk [*] indicates PCAs that may be associated with microbiological contamination.)

COMMERCIAL/INDUSTRIAL
Automobile-related activities
Gas stations
Chemical/petroleum processing/storage
Dry cleaners
Metal plating/ finishing/fabricating
Plastics/synthetics producers

RESIDENTIAL/MUNICIPAL
Airports - maintenance/fueling areas
Landfills/dumps
*Septic systems - High density (>1/acre) (VH if in Zone A, otherwise M)
*Wastewater Treatment Plants (VH in Zone A, otherwise H)

AGRICULTURAL/RURAL
* Animal Feeding Operations (VH in Zone A, otherwise H)
* Concentrated Aquatic Animal Production Facilities (VH for surface water in Zone A, otherwise H)
* Managed Forests (VH for surface water in Zone A, otherwise H)

OTHER
Underground injection of commercial/ industrial discharges
Historic gas stations
Historic waste dumps/landfills
Injection wells/dry wells/sumps
Known contaminant plumes
Military installations
Mining operations
- Historic
- Active

Underground storage tanks
- Confirmed leaking tanks

Auguscik-25 (Cont.)

Table 7-4. Possible Contaminating Activities (PCAs) associated with High potential risks. High risk PCAs are considered to have less potential for drinking water contamination than those designated Very High risk (Table 7-3), but greater potential for contamination than those designated Moderate risk (Table 7-5), or Low risk (Table 7-6). The risk rankings are based on the general nature of activities and the contaminants associated with them (refer to Table 7-2), not on facility-specific management practices. (An asterisk [*] indicates PCAs that may be associated with microbiological contamination.)

COMMERCIAL/INDUSTRIAL

Automobile related Activities
- Body shops
- Repair shops

Boat services/repair/refinishing
Chemical/petroleum pipelines
Electrical/electronic manufacturing
Fleet/trucking/bus terminals
Furniture repair/manufacturing
Home manufacturing
Junk/scrap/salvage yards
Machine shops
Photo processing/printing
Research laboratories
Wood preserving/treating
Lumber processing and manufacturing
Wood/pulp/paper processing and mills
*Sewer collection systems (H, if in Zone A, otherwise L)

RESIDENTIAL/MUNICIPAL

Railroad yards/maintenance/fueling areas
*Sewer collection systems (H, if in Zone A, otherwise L)
Utility stations - maintenance areas
*Wastewater Treatment Plants (VH in Zone A, otherwise H)

AGRICULTURAL/RURAL

* Grazing (> 5 animals/acre) (H in Zone A, otherwise M)
* Animal Feeding Operations (VH in Zone A, otherwise H)
* Other animal operations (H in Zone A, otherwise M)
Concentrated Aquatic Animal Production Facilities (VH in Zones for surface water, otherwise H)
Other aquatic animal operations (H in Zones for surface water, otherwise M)
Farm chemical distributor/ application service
Farm machinery repair
*Septic systems- low density (<1/acre) (H if in Zone A, otherwise L)
*Lagoons/liquid wastes
Machine shops
Pesticide/fertilizer/petroleum storage and transfer areas
Managed Forests (VH in Zones for surface water, otherwise H)
Agricultural Drainage (H in Zone A, otherwise M)
Wells- Agricultural, Irrigation

OTHER

NPDES/WDR permitted discharges
Illegal activities/unauthorized dumping
Mining – Sand/Gravel
Wells- Oil, Gas, Geothermal
Salt water intrusion
*Recreational area - surface water source
Underground storage tanks:
Non-regulated tanks (tanks smaller than regulatory limit)
Not yet upgraded or registered tanks
Snow Ski Areas (H in Zones for surface water, otherwise M)
Recent (< 10 years) Burn Areas (H in Zones for surface water, otherwise M)
Dredging (H in Zones for surface water, otherwise M)

Auguscik-25 (Cont.)

Table 7-5. Possible Contaminating Activities (PCAs) associated with Moderate potential risks. Moderate risk PCAs are considered to have a lower potential for drinking water contamination than those designated Very High risk (Table 7-3) and High risk (Table 7-4), and a greater potential for drinking water contamination than activities designated Low risk (Table 7-6). The risk rankings are based on the general nature of activities and the contaminants associated with them (refer to Table 7-2), not on facility-specific management practices. (An asterisk [*] indicates activities that may be associated with microbiological contamination.)

COMMERCIAL/INDUSTRIAL
Car washes
Parking lots/malls (>50 spaces)
Cement/concrete plants
*Food processing
Funeral services/graveyards
Hardware/lumber/parts stores

RESIDENTIAL/MUNICIPAL
*Septic systems - High density (>1/acre) (VH if in Zone A, otherwise M)
Drinking water treatment plants
Golf courses
Housing - High density (>1 house/0.5 acres)
Motor pools
Parks
Waste transfer/recycling stations

AGRICULTURAL/RURAL
* Grazing (> 5 animals/acre) (H in Zone A, otherwise M)
* Other animal operations (H in Zone A, otherwise M)
Other aquatic animal operations (H in Zones for surface water, otherwise M)
Crops, irrigated (berries, hops, mint, orchards, sod, greenhouses, vineyards, nurseries, vegetables)
NOTE: Drip-irrigated crops are considered Low risks.
*Sewage sludge (biosolids) land application
Fertilizer, pesticide/herbicide application
Managed Forests (M for ground water)
Agricultural Drainage (H in Zone A, otherwise M)

OTHER
Above ground storage tanks
Wells – water supply
Construction/demolition staging areas
Contractor or government agency equipment storage yards
Managed forests
Transportation corridors
Freeways/state highways
Railroads
Historic railroad right-of-ways
Road right-of-ways (herbicide use areas)
Hospitals
Storm drain discharge points
Storm water detention facilities
Artificial recharge projects – non-potable water (includes recycled, storm, and untreated imported water)
Injection wells
Spreading basins
Snow Ski Areas (H in Zones for surface water, otherwise M)
Recent (< 10 years) Burn Areas (H in Zones for surface water, otherwise M)
Dredging (H in Zones for surface water, otherwise M)

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Table 7-6. Possible Contaminating Activities (PCAs) associated with Low potential risks. Low risk PCAs are considered to have a lower potential for drinking water contamination than those designated Very High risk (Table 7-3), High risk (Table 7-4) or Moderate risk (Table 7-5). The risk rankings are based on the general nature of activities and the contaminants associated with them (refer to Table 7-2), not on facility-specific management practices. Instead, such management practices may be considered in the vulnerability analysis, and should be considered in a protection program. (An asterisk [*] indicates PCAs that may be associated with microbiological contamination.)

COMMERCIAL/INDUSTRIAL

*Sewer collection systems (H, if in Zone A, otherwise L)
Appliance/Electronic repair
Office buildings/complexes
Rental yards
RV/mini storage

RESIDENTIAL/MUNICIPAL

*Sewer collection systems (H, if in Zone A, otherwise L)
Apartments and condominiums
Campgrounds/Recreational areas
Fire stations
RV parks
Schools
Hotels, Motels

AGRICULTURAL/RURAL

Crops, non-irrigated (e.g. Christmas trees, grains, grass seeds, hay) (or drip-irrigated crops)
* Septic systems – low density (<1/acre) (H if in Zone A, otherwise L)

OTHER

Underground storage tanks
- Decommissioned - inactive
- Upgraded and/or registered – active

Roads/Streets
Artificial recharge projects - potable water
- Injection wells
- Spreading basins

Medical/dental offices/clinics
Veterinary offices/clinics
*Surface water - streams/lakes/rivers
Wells – Monitoring, test holes, borings

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8.0 Vulnerability of Drinking Water Sources to Contamination

After the initial inventory of Possible Contaminating Activities (PCAs) has been completed (Section 7), a vulnerability analysis is conducted to determine the types of PCAs to which the drinking water source is most vulnerable by prioritizing the list of activities identified in the inventory. The analysis factors in the source and/or site characteristics that may affect the vulnerability of the source to contamination from the types of PCAs identified in the inventory.

8.1 Definition

Vulnerability: A determination of the most significant threats to the quality of the water supply that takes into account the physical barrier effectiveness of the drinking water source. The vulnerability determination also considers the type and proximity to the water supply of activities that could release contaminants.

Vulnerability, as defined in the DWSAP Program, is consistent with existing California regulations (see Section 8.4).

Auguscik-25 (Cont.)

8.2 Vulnerability Analysis Procedures

The vulnerability analysis evaluates the types of PCAs identified in the inventory within the context of the characteristics of the source and its site. The first step in the analysis is to determine the Physical Barrier Effectiveness (PBE) for the drinking water source. The PBE can be determined using site-specific information on hydrogeology, hydrology and soils. Additional information is required depending upon whether the source is ground water or surface water.

8.2.1 Drinking Water Source and Site Characteristics

8.2.1.1 Drinking Water Source Information

The information needed to determine the Physical Barrier Effectiveness should be compiled using readily available data and reports. A minimum level of information is necessary to make the initial determination, but additional information may be useful in refining the determination.

For surface water sources, Appendix C shows the minimum water body and watershed information necessary to determine Physical Barrier Effectiveness. Most of this information can be found in the Watershed Sanitary Survey for the source.

For ground water sources, the minimum information necessary to determine Physical Barrier Effectiveness is shown in Appendix J. The information to be collected should be available from well logs, soil survey maps, some general knowledge of the hydrogeology of the area, and well operation information.

8.2.1.2 Determination of Physical Barrier Effectiveness

The Physical Barrier Effectiveness is essentially an estimate of the ability of the natural geologic materials, hydraulic conditions, and construction features of the well or intake to prevent the movement of contaminants to the drinking water source.

A qualitative rating of low, moderate or high Physical Barrier Effectiveness (PBE), based on the drinking water source and site characteristics, is determined for each source. A simple approach to determining PBE for surface water is shown in Appendix C, and for ground water in Appendix J. In the DWSAP approach, the reviewer collects some basic information on the water body and watershed for surface water, and on the drinking water source and aquifer for ground water. This information is then evaluated with parameters that indicate the relative effectiveness of the source and site in preventing the migration of contaminants to the water supply.

Auguscik-25 (Cont.)

In general, the intent of the Physical Barrier Effectiveness determination is to highlight the sources that have "high" or "low" effectiveness. Most sources will have "moderate" PBE. A more detailed review of the Physical Barrier Effectiveness at a site can be done during the development of a local source water protection program (see Section 11.0).

Surface Water

For surface water, the PBE evaluation considers several parameters including the size of, and detention time in, the reservoir, topography, geology, soils, vegetation, precipitation and ground water recharge. The size of the watershed is also important to consider, in terms of its potential for dilution or retardation of contaminants.

As shown in Appendix C, in order to get a high PBE ranking, all the parameters for a source must have values that indicate an effective barrier. For example, a source with a high PBE would be in flat terrain, with low precipitation and non-erosive soils covered by grassland.

A source is considered to have low PBE (i.e. high potential for contamination), if any of the parameters have values that do not indicate an effective barrier. For example, a source would be considered to have a low PBE if the watershed has steep slopes or if the soils are erodible or have high runoff potential.

For surface water, all sources that do not clearly have a low or high PBE are considered to have a moderate PBE. To be conservative (i.e., health protective), if any of the parameters is unknown, the drinking water source is considered to have low physical barrier effectiveness.

Ground Water

For ground water, the evaluation of Physical Barrier Effectiveness first considers the degree of confinement of the aquifer. An aquifer is classified as confined or unconfined (which includes semi-confined, leaky, and unknown). Detailed review is necessary to determine that an aquifer is confined. Table 6-1 lists indicators to consider in determining the presence or degree of confinement of an aquifer. In general, DHS will assume that an aquifer is unconfined unless detailed hydrogeologic information is available that clearly indicates that the aquifer is confined. Fractured rock aquifers, for purposes of the PBE analysis, are included in the unconfined aquifers, due to the complexity of their flow patterns.

PBE of Confined Aquifers

Confined aquifers generally are considered highly effective in preventing the migration of contaminants. However, the PBE may be diminished if abandoned or improperly destroyed wells are present that corrupt the integrity of the confining layer. The PBE may be improved if the hydraulic head in the confined aquifer is higher than the hydraulic head of aquifers above (i.e., the well exists under artesian conditions). The construction of the well can impact the effectiveness in retarding contaminants, particularly the presence of a properly constructed sanitary seal.

Auguscik-25 (Cont.)

PBE of Unconfined Aquifers

For aquifers that are unconfined, semi-confined or of unknown confinement, the PBE evaluation next considers the soil materials in the aquifer. Wells in fractured rock are always considered to have low PBE due to the high transport velocities that can occur within fractures. Sources in porous media that have a thick continuous layer of clay above the water table have more effective barriers, similar to confined aquifers.

Abandoned or improperly destroyed wells within the protection zones for a source can decrease the effectiveness of the barrier. Because of the prevalence of abandoned and improperly destroyed wells, and the difficulty of locating them, they are considered to decrease the effectiveness of all ground water sources unless their absence can be assured.

In unconfined aquifers, water level conditions of a well can impact the likelihood that contaminants may be drawn to the well. Greater depths to ground water are more effective at preventing contamination. Wells with high production rates, short screened

intervals and perforations located close to the top of the water table are more likely to pull contaminants towards the well.

As with unconfined aquifers, the construction of the well in a confined aquifer can impact its effectiveness in retarding contaminants, particularly the presence of a properly constructed sanitary seal.

The procedures for determining PBE for ground water use the checklist in Appendix J. A ground water source is assigned points for each parameter on the Physical Barrier Effectiveness checklist. The points are totaled to arrive at a PBE score for the source, ranging from a low of 0 points to a high of 100 points. The PBE points in themselves are not a quantitative value; rather they are used to determine the overall PBE rating for the source: low, moderate or high.

Physical Barrier Effectiveness
Score Interpretation

Point Total	PBE
0 to 35	Low (includes all sources in fractured rock)
36 to 69	Moderate
70 to 100	High

Auguscik-25 (Cont.)

Notes on Physical Barrier Effectiveness checklist for ground water:

- **The highest score a source in a confined aquifer can get is 100 (High PBE). The lowest score a source in a confined aquifer can get is 40 (Moderate PBE).**
  - The highest score a source in an unconfined aquifer can get is 70 (High PBE). Without having a clay layer 25' thick, the highest score for a source in an unconfined aquifer is 60 (Moderate PBE).
- The only sources that can get High PBE are those in confined aquifers, and those in unconfined aquifers with a clay layer, with no abandoned or improperly destroyed wells in the protection zones.
- All sources in fractured rock are considered to have Low PBE.

8.2.2 Modifying the Risk Ranking for a PCA

As described in Section 7.0, the PCA inventory includes a ranking of the potential risk or threat of contamination to a drinking water source for each type of PCA. In the inventory, activities that are considered to have a high potential for pollution of drinking

water sources are designated "very high" or 'high" risk. Other activities having lower potential for drinking water pollution are designated "moderate" or "low" risk.

The risk ranking provides a simple approach to comparing the relative risk of types of PCAs. The risk rankings are based on the general nature of the activities and the contaminants associated with them (refer to Table 7-2), not on the density (number of facilities) or facility-specific information, such as management practices.

Comments were received regarding the ability to modify the risk ranking for an individual facility for a type of PCA. The DWSAP program is intended to be a simple, first-cut screening tool. Further detail, such as modifying the risk ranking of types of PCAs (Appendix E or L), is an optional part of the minimum drinking water source assessment. Evaluation of site-specific information may best be performed during the development of a local protection program (see Section 11.0).

8.2.3 Determination of Vulnerability

DHS has developed a simple approach to substitute for a detailed vulnerability determination. The vulnerability analysis uses the PCA inventory and the Physical Barrier Effectiveness determination to prioritize the list of types of PCAs in order to determine to which the drinking water source is most vulnerable.

Auguscik-25 (Cont.)

The vulnerability ranking process is shown in Appendix F for surface water sources and Appendix K for ground water sources. The process involves reviewing each type of PCA identified in the inventory (and those types of PCAs whose presence is unknown) and assigning points based on the risk ranking of the type of PCA, the zone in which it occurs, and the Physical Barrier Effectiveness of the drinking water source. The points are added together, and the types of PCAs are prioritized according to points from highest to lowest, with the highest points representing the types of PCAs to which the source is most vulnerable. Finally, a cutoff point is identified, and the source is not considered vulnerable to types of PCAs with points below the cutoff.

As with the PBE scores, the vulnerability points in and of themselves do not have a quantitative value. Rather, the points are used to relatively rank the types of PCAs for an individual source. The ranking is intended as a preliminary tool to facilitate local source water protection programs that are site-specific.

The steps in the vulnerability ranking are listed below. The points for each element and the process for adding the points and assessing the relative vulnerability can be found following the steps.

1. Determine if any contaminants have been detected in the water supply (the information collected for use in the Consumer Confidence Report may be used for this purpose).

2. Determine, to the extent practical, the types of PCAs associated with detected contaminants.

3. For each type of PCA identified as existing in the protection zone(s), or as unknown, determine the number of points for the associated risk ranking.

4. For each type of PCA, determine the zone in which it occurs and add the points associated with that zone. If that type of PCA exists within more than one zone, repeat the process for each zone.

5. For each drinking water source, determine the Physical Barrier Effectiveness (PBE) and add the points associated with that PBE (these points are for Low, Moderate and High PBE as shown below).

6. Prioritize the types of PCAs by the vulnerability points, from the most points to the least.

7. The drinking water source is vulnerable to all types of PCAs with vulnerability points above the cutoff. Refer to the appropriate Vulnerability Matrix below.

8. The drinking water source is most vulnerable to PCA types with the highest vulnerability points, and to those PCA types associated with a contaminant detected in the water source, regardless of the vulnerability points.

9. The drinking water source is considered vulnerable to types of PCAs whose existence is Unknown, if the vulnerability points are equal to or greater than the cutoff.

Auguscik-25 (Cont.)

Points for Vulnerability Analysis

PCA Risk Ranking Points:

Very High	7
High	5
Moderate	3
Low	1

Zone Points:

Surface Water (Zones defined)		Surface Water (Zones not defined)		Ground Water	
Zone A	= 5	Watershed	= 5	Zone A	= 5
Zone B	= 3			Zone B5	= 3
Remainder of Watershed	= 1			Zone B10	= 1
Unknown	= 0	Unknown	= 0	Unknown	= 0

Physical Barrier Effectiveness points:

Low	5
Moderate	3
High	1

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Vulnerability Matrix for SURFACE WATER SOURCES

The cutoff point for vulnerability is **11**. The drinking water source is considered Vulnerable to all PCA's with Vulnerability Score greater than or equal to **11** (shaded boxes).

PCA points	**Zone points**		**PCA + Zone points**	PBE Points			**Vulnerability Score PCA + Zone + PBE points**		
Risk Ranking	Zones Defined	Zones Not Defined		Low	Med	High	PBE Low	PBE Med	PBE High
VH (7)	A (5)	Watershed (5)	12	5	3	1	17	15	13
VH (7)	B (3)		10	5	3	1	15	13	11
VH (7)	Watershed (1)		8	5	3	1	13	11	9
VH (7)	Unknown (0)*	Unknown (0)*	7	5	3	1	12	10	8
H (5)	A (5)	Watershed (5)	10	5	3	1	15	13	11
H (5)	B (3)		8	5	3	1	13	11	9
H (5)	Watershed (1)		6	5	3	1	11	9	7
H (5)	Unknown (0)*	Unknown (0)*	5	5	3	1	10	8	6
M (3)	A (5)	Watershed (5)	8	5	3	1	13	11	9
M (3)	B (3)		6	5	3	1	11	9	7
M (3)	Watershed (1)		4	5	3	1	9	7	5
M (3)	Unknown (0)*	Unknown (0)*	3	5	3	1	8	6	4
L (1)	A (5)	Watershed (5)	6	5	3	1	11	9	7
L (1)	B (3)		4	5	3	1	9	7	5
L (1)	Watershed (1)		2	5	3	1	7	5	1
L (1)	Unknown (0)*	Unknown (0)*	1	5	3	1	6	4	2

* Source is considered vulnerable to types of PCAs that are Unknown, if the Vulnerability Score is 11 or higher.

Auguscik-25
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Vulnerability Matrix for GROUND WATER SOURCES

The cutoff point for vulnerability is **8**. The drinking water source is considered Vulnerable to all PCA's with Vulnerability Score greater than or equal to **8** (shaded boxes).

PCA points	**Zone points**	**PCA + Zone points**	PBE Points			**Vulnerability Score PCA + Zone + PBE points**		
Risk Ranking	A, B5, B10		Low	Med	High	PBE Low	PBE Med	PBE High
VH (7)	A (5)	12	5	3	1	17	15	13
VH (7)	B5 (3)	10	5	3	1	15	13	11
VH (7)	B10 (1)	8	5	3	1	13	11	9
VH (7)	Unknown (0) *	7	5	3	1	12	10	8
H (5)	A (5)	10	5	3	1	15	13	11
H (5)	B5 (3)	8	5	3	1	13	11	9
H (5)	B10 (1)	6	5	3	1	11	9	7
H (5)	Unknown (0) *	5	5	3	1	10	8	6
M (3)	A (5)	8	5	3	1	13	11	9
M (3)	B5 (3)	6	5	3	1	11	9	7
M (3)	B10 (1)	4	5	3	1	9	7	5
M (3)	Unknown (0) *	3	5	3	1	8	6	4
L (1)	A (5)	6	5	3	1	11	9	7
L (1)	B5 (3)	4	5	3	1	9	7	5
L (1)	B10 (1)	2	5	3	1	7	5	1
L (1)	Unknown (0) *	1	5	3	1	6	4	2

* Source is considered vulnerable to types of PCAs that are Unknown, if the Vulnerability Score is 8 or higher.

January 1999 – with April 1999 and January 2000 revisions

8.3 Uses of Vulnerability Analyses

The prioritized list from the vulnerability analysis may be used by a water system in developing protection measures to address activities that are most significant to the water supply.

In addition, the prioritized list will be useful to DHS to determine drinking water sources that may be eligible for chemical monitoring relief.

The prioritized list may also be useful on a statewide basis in determining the types of activities that represent the greatest threats to drinking water supplies, their proximity to drinking water sources, and an estimate of their prevalence.

The PBE determination may be useful for a water system in comparing water sources to each other, and identifying the ones that are at greater risk. The PBE determination may be useful on a state-wide basis in determining areas where sources with high or low effectiveness may be concentrated.

Auguscik-25 (Cont.)

8.4. Vulnerability Assessment Procedures in California Regulations

Existing California regulations detail the vulnerability assessment procedures required to obtain a waiver for monitoring certain organic and inorganic chemicals in drinking water supplies.

California Code of Regulations (CCR), Title 22, Chapter 15, Section 64432(l) addresses vulnerability waivers for cyanide:

> (l) A water system may be eligible for a waiver from the monitoring frequencies for cyanide specified in paragraph (b)(1) of this section without any prior monitoring if it is able to document that it is not vulnerable to cyanide contamination pursuant to the requirements in section 64445(d)(1) or (d)(2). *(See below).*

CCR, Title 22, Chapter 15, Section 64432.2 addresses vulnerability waivers for asbestos for ground water systems:

> The Department will determine the vulnerability of ground water sources on the basis of historical monitoring data and possible influence of serpentine formations.

CCR, Title 22, Chapter 15, Section 64445(d)(1) and (2) addresses waivers for organic chemicals based on use and susceptibility:

(d) A water system may apply to the Department for a monitoring waiver for one or more of the organic chemicals on Table 64444-A in accordance with the following:

(1) A source may be eligible for a waiver if it can be documented that the chemical has not been previously used, manufactured, transported, stored, or disposed of within the watershed or zone of influence and therefore, that the source can be designated non-vulnerable.

(2) If previous use of the chemical locally is unknown or the chemical is known to have been used previously and the source cannot be designated non-vulnerable pursuant to Paragraph (d)(1), it may still be eligible for a waiver based on a review related to susceptibility to contamination. The application to the Department for a waiver based on susceptibility shall include the following:

(A) Previous monitoring results;
(B) user population characteristics;
(C) proximity to sources of contamination;
(D) surrounding land uses;
(E) degree of protection of the water source;
(F) environmental persistence and transport of the chemical in water, soil and air;
(G) elevated nitrate levels at the water supply source; and
(H) historical system operation and maintenance data including previous Departmental inspection results.

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9.0 Implementation of the Drinking Water Source Assessment Program

California is mandated by federal law to conduct the assessment portion of DWSAP Program. However, time and financial resources are not sufficient to enable DHS to perform comprehensive, detailed assessments, though the state will provide guidance, recommendations and technical assistance to water systems that choose to do more detailed assessments on their own.

A completed drinking water source assessment will likely be a future requirement for water systems to obtain or continue chemical monitoring waivers. Existing regulations require a vulnerability analysis for waivers (see Section 8.4). The assessment procedures will fulfill the vulnerability analysis requirements.

DHS encourages large systems to do their own source water assessments. Large public water systems with surface water sources should make use of their watershed sanitary surveys to satisfy the requirement for a drinking water source assessment. DHS considers a watershed sanitary survey completed in accordance with existing watershed sanitary survey guidance to satisfy most of the assessment components of the Program.

Auguscik-25 (Cont.)

Systems that have performed evaluations for their ground water sources (e.g., work done for Assembly Bill 3030 Groundwater Management Plans) may find that, depending on the extent of those evaluations, they may satisfy all or portions of the components of the DWSAP Program.

DHS plans to conduct source water assessments for those sources not voluntarily assessed by public water systems or by local primacy agency (LPA) counties. The methods herein describe DHS' approach to conducting the assessments; this defines the minimum components of a source water assessment.

9.1 Source Location

In the course of routine inspection and permitting activities, DHS will determine locations (latitude and longitude) of wells and surface water intakes as accurately as possible, via Global Position System (GPS), using GPS units with a sensitivity (accuracy) of 25 meters or less. The 25-meter accuracy goal is based on US EPA's Locational Data Policy.

Each drinking water source may not receive a site visit during EPA's time frame for source water assessments (1999 – May 2003). For purposes of completing the assessments, DHS will determine interim locations through the use of USGS quadrangle maps (7.5 minute series), and make use of locational data from other sources (i.e., public water systems). The method for determining locations and the associated accuracy of the method will be recorded.

9.2 Source Area and Protection Zone Delineation

Because of limited resources and time constraints, DHS does not anticipate using the more sophisticated models described in Section 6.0, and instead will use simplified methods. However, drinking water systems that choose to do their own assessments may utilize more complex models, with DHS concurrence.

For surface water sources, DHS will delineate the entire watershed as a source area, and will define protection zones if warranted.

For ground water sources, the source area will be comprised of the recharge area and delineated protection zones. DHS will generally delineate protection zones by using the calculated fixed radius method.

For noncommunity water systems with ground water sources, DHS may use the arbitrary fixed radius method. For transient-noncommunity water systems, DHS may establish only one protection zone for acute contaminants (bacteriological and nitrate) at the minimum distance for Zone A (600' in porous media, 900' in fractured rock).

Recharge areas will be identified to the extent that they can be determined from readily available information.

Auguscik-25 (Cont.)

9.3 Inventory of PCAs

Details of the PCA inventory are presented in Section 7.0.

DHS will use readily available information from state and local programs. As part of the DWSAP program, DHS will collaborate in improving the accessibility of data from state agencies. Some of this data may currently be accessible electronically, as mentioned in Section 7.1.

For transient-noncommunity water systems, DHS may limit the inventory to activities associated with bacteriological and nitrate contamination. Readily available state-wide databases may also be reviewed.

9.4 Vulnerability Analyses

Details of the vulnerability analysis procedures are presented in Section 8.0.

DHS will use information in water system files to evaluate Physical Barrier Effectiveness (PBE), and will rank types of PCAs based on risk rankings and proximity to the source. DHS will not include the density of facilities or facility-specific information in the vulnerability analysis.

For transient-noncommunity water systems, DHS may use a default PBE of Low, and the source will be considered most vulnerable to all activities identified in the reduced inventory.

9.5 Completion of Assessments and Summary

A checklist for a completed source water assessment is presented in Appendix G for a surface water source and Appendix K for a ground water source.

DHS will prepare a summary of each assessment that includes the assessment map and the prioritized list of the types of PCAs identified in the inventory, noting the ones to which the source is most vulnerable.

DHS will prepare vulnerability summary for assessments using standardized language. Specific information for each source, or a group of sources if appropriate, will be inserted in the summary. The language is not yet developed, but it will probably be similar to the following:

> *"An assessment of the drinking water source(s) for XYZ water system was completed in month and year. The source(s) are considered most vulnerable to the following activities associated with contaminants detected in the water supply: _____, _____, _____. In addition, the source is considered most vulnerable to these activities: _____, _____, _____.*
>
> *"A copy of the complete assessment is available at DHS District Office address or Water System Address. You may request a summary of the assessment be sent to you by contacting DHS district engineer or Water System Representative at phone number."*

Auguscik-25 (Cont.)

9.6 Availability of Assessment Results to the Public

Copies of completed assessment results (including inventory forms, maps, and other information described in Appendices G and K) will be available for public review in DHS district field offices and are recommended to be available for public review at the office of the public water system. The means of providing results of assessments at other locations will be dictated by the size and complexity of the assessments, and by local interest.

DHS will send out the summary of an assessment upon request.

If DHS conducts the assessment, DHS will send the vulnerability summary for the assessment to the water system for inclusion in the annual consumer confidence report.

9.7 Updating Information

DHS recommends that assessments be reviewed and updated every five years. DHS will update assessments, to the extent possible, in the course of routine activities.

Water systems, as part of an assessment update, may solicit comments from local agencies and the public, or others who may have suggestions of additional information that should be included or other possible improvements. Where a local drinking water source protection program has been put in place, DHS anticipates that information from that program would be included in any assessment updates.

9.8 Anticipated Schedule for Drinking Water Source Assessments

Auguscik-25 (Cont.)

As mentioned above, a number of activities required under existing law (e.g., watershed sanitary surveys for surface water sources) are related to surface water and ground water assessment and protection. These activities will proceed and can be incorporated easily into the DWSAP Program.

There are approximately 16,000 active drinking water sources in California (Table 9.1), and several thousand standby and inactive sources. Given the resource limitations (approximately $7.5 million from the federal Drinking Water State Revolving Fund, or roughly a few hundred dollars per source), DHS envisions scheduling its assessments according to its normal three- to five-year cycle for water system inspections. Further, since public water systems with surface water sources need to update watershed sanitary surveys on a five-year cycle, that requirement will dictate the schedule for surface water sources. To the extent that public water systems elect to conduct their own assessments, the schedule will be modified (See Section 9.9).

DHS intends to expeditiously conduct assessments throughout the time period 1999 - May 2003 generally according to the following priortized list:

1. Community water systems with more than 1,000 and up to 10,000 service connections, approximately 660 ground water sources (100 systems) and 50 surface water sources (30 systems) per year.

2. Community water systems with 200 to 1,000 service connections, approximately 280 ground water sources (90 systems) and 30 surface water sources (25 systems) per year.

3. Community water systems with fewer than 200 service connections, approximately 670 ground water sources (540 systems) and 60 surface water sources (50 systems) per year.

4. Nontransient-noncommunity water systems, approximately 280 ground water sources (240 systems) and 10 surface water sources (10 systems) per year.

5. Transient-noncommunity water systems: approximately 980 ground water sources (approximately 940 systems) and 80 surface water sources (80 systems) per year.

6. Community water systems with more than 10,000 service connections, approximately 840 ground water sources (40 systems) and 50 surface water sources (20 systems) per year.

Standby and inactive sources will not be scheduled for a source water assessment during this period, unless they are activated. If activated after April 1, 2003, public water systems will need to complete a source water assessment for standby and inactive sources before they can be used.

Auguscik-25 (Cont.)

New sources will be assessed by the public water systems that intend to bring them on line (see Section 10.0).

DHS intends assessments to be completed by May 2003, in order to meet the federally-required completion deadline.

The overall order for conducting drinking water source assessments will change if some public water systems complete their own assessments, as discussed in the next section.

9.9 Assessments Done Voluntarily by Drinking Water Systems

As mentioned previously, conducting drinking water source assessments is the responsibility of DHS. However, drinking water systems are not precluded from conducting their own, upon notification to DHS, and they may voluntarily choose to do so.

A number of public water systems have already performed evaluations that may satisfy many of the components of the drinking water assessment. A watershed sanitary survey, for example, has been mentioned throughout this document as an example of previously conducted work for surface water sources that will largely satisfy the assessment components of the DWSAP program. Some public water systems may have already conducted similar kinds of evaluations for their ground water sources of drinking water.

Those systems should contact the DHS district office to determine whether their prior work or portions of it are sufficient to satisfy the needs of the DWSAP Program.

There are a number of benefits to a drinking water system that has a complete comprehensive assessment of its sources. These include:

- DHS will incorporate the DWSAP approach for assessing vulnerability into its determination for monitoring waivers (see Section 8.4). A deadline will likely be established beyond which any waiver renewals will be subject to the new approach.
- Source water assessments will be a prerequisite for gaining access to State Revolving Fund monies for local source water protection projects and programs (see Section 11.0).
- DHS will incorporate assessment procedures into the permit requirements for new sources (see Section 10.0).
- A drinking water system may be qualified for some relief of regulatory requirements under the anticipated Ground Water Rule if it has completed a comprehensive source water assessment.
- A comprehensive assessment can serve as a document to share with land use planning agencies.
- For communities interested in source water protection activities, the DWSAP assessments provide the basic information to begin those activities.
- A comprehensive assessment will contribute to the institutional memory of a drinking water system.
- A comprehensive assessment brings a variety of information together in a single place.
- A comprehensive assessment can provide a drinking water system with a useful public relations and public information tool.

Based on the history of implementing other drinking water-related programs in California, DHS believes that some systems will proceed with conducting their own source water assessments. Those water systems that plan to conduct their own assessments will need to notify DHS by December 31, 2000, submit a progress report to DHS no later than February 2002, and submit the final assessment to DHS no later than

Auguscik-25 (Cont.)

January 1, 2003, to enable departmental review. Those systems intending to incorporate the drinking water source assessment into their scheduled watershed sanitary survey update cycle should inform DHS and indicate when the update will be available (no later than January 1, 2003).

An estimate of the possible implementation is as follows:

Large water systems (>10,000 service connections). DHS expects that these systems will voluntarily conduct all the elements of a source water assessment, with some data tools provided by DHS and other agencies.

Medium water systems (>1,000 to 10,000 service connections). DHS expects that most of these systems will voluntarily conduct some of the elements of a source water assessment (location of drinking water sources, delineation of source areas and protection zones, PCA inventory, dissemination of assessment results to the public). Roughly half of these systems are expected to conduct their vulnerability analyses with technical support by DHS and other agencies. The remainder will be performed by DHS.

Auguscik-25 (Cont.)

Small water systems (<1,000 service connections). DHS and LPA counties are expected to conduct all of the source water assessments for these systems, using State Revolving Fund monies. Some may be able to conduct their own PCA inventories.

For drinking water systems or communities that want to immediately embark on voluntary source water protection programs (see Section 11.0), incorporation of the source water assessment steps into those programs is appropriate, and is encouraged by DHS.

DHS will have to conduct the assessments if they are not completed by public water systems.

Table 9-1. Distribution of California's 15,984 active drinking water sources by public drinking water system size and source type.

System Size, by Service Connections (SCs)	Ground Water		Surface Water	
	Systems	Sources	Systems	Sources
>10,000 SCs	152	3,362	74	165
1,000–10,000 SCs	394	2,656	130	192
200–1,000 SCs	359	1,130	102	134
<200 SCs	2,151	2,689	209	226
Non-Transient	964	1,135	47	48
Transient	3,773	3,929	313	318
Total	7,793*	14,901	875*	1,083

* Some systems have both ground water and surface water sources, and are included in each column. Therefore, the total of 8,668 ground water and surface water systems presented in this table exceeds the actual number of systems.

Auguscik-25 (Cont.)

10.0 New Drinking Water Sources

New water systems, or existing water systems that add a source of supply, are required to submit a permit application to DHS (California Health and Safety Code, Section 116525, et seq.). As part of the permit application, the water system is required to submit a technical report. DHS will incorporate the DWSAP assessment procedures into the permit requirements for new drinking water sources. The assessment will be considered in the permitting of the source.

Assessment work that has been done for existing drinking water sources may be useful in fulfilling these requirements.

As part of the permit application the water system will be required to submit the minimum components for an assessment as described in Section 3.0 and listed here (pertinent sections of this document are noted):

✓**Location of the Drinking Water Source.** Section 9.1 and Appendix A or H.

✓**Delineation of Source Areas and Protection Zones.** Section 6.0, and Appendix B or I.

✓**Inventory of Possible Contaminating Activities (PCAs).** Section 7.0 and Appendix D or K.

✓**Physical Barrier Effectiveness Checklist.** Section 8.0 and Appendix C or J.

✓**Vulnerability Ranking – Prioritized Listing of PCAs.** Section 8.0 and Appendix F or M.

✓**Assessment Map.** Section 6.3 and Appendix G or N.

✓**Drinking Water Source Assessment Checklist.** Appendix G or N.

Auguscik-25 (Cont.)

Water systems are encouraged to conduct a preliminary assessment before constructing new drinking water sources.

Voluntary protection activities for new sources would be similar to those for existing sources, as discussed in Section 11.0.

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PART FOUR

Voluntary Drinking Water Source Protection Programs

A description of the approach public water systems and communities may wish to use in developing source water protection programs

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Section 11—Implementation of a voluntary source water protection program

Section 12—Management approaches within source areas and protection zones

Section 13—Contingency planning for drinking water supplies

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11.0 Implementation of A Voluntary Source Water Protection Program

A voluntary drinking water source water protection plan offers a public water system or community an opportunity to build on work done for drinking water source assessments.

The goal of a local source protection program is to identify, develop and implement local measures that advance the protection of the drinking water supply. A local program should maximize use of existing data and develop more detailed information, drawing on local knowledge.

The following steps are recommended for drinking water systems or communities that choose to implement a voluntary source water protection program.

- Review the State's DWSAP Program
- Establish a local advisory committee
- Review the initial drinking water source assessment and determine if and where to expand and refine it. Activities that may be appropriate include:
    - Gathering additional information
    - Revising delineations of the source area and protection zones, if necessary
    - Refining and updating the inventory of possible contaminating activities (PCAs)
    - Reviewing the vulnerability analysis and vulnerability ranking
    - Prioritizing the contaminant activities that need to be studied more closely based on vulnerability of the drinking water source
- Prepare reports and maps
- Develop a protection program based on revised assessment
- Submit the protection program (and revised assessment) to DHS, other agencies, and the public
- Implement the protection program and its management approaches
- Conduct contingency planning

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The sharing of information is encouraged, especially among drinking water systems or communities with common delineated source areas or protection zones, or those that share aquifers or watersheds. DHS recommends that communities and systems with common interests work together on protection programs. The DHS' local offices can provide examples of groups of water systems that have joined together to work on similar projects (e.g., watershed surveys).

Smaller systems, whose source areas and protection zones lie within the source areas and/or protection zones of a larger system, may be able to make use of the information developed by the larger system, as well as provide information to the larger system.

More detail about some of the steps is provided below.

11.1 Involve the Public during Development of a Source Water Protection Program

A successful source water protection program requires that drinking water systems or communities involve the public. Such involvement may be through local public advisory groups or the use of volunteers for information collection, to name two examples. Representatives from a variety of stakeholder groups (See Table 4-1) may be appropriate to include in forming local advisory groups.

11.2 Review initial source water assessment and determine whether revisions are appropriate

The source water assessment for the drinking water source should be reviewed to determine whether it should be updated or revised. Revisions of the assessment, if appropriate, could be made on the delineation, the PCA inventory, the vulnerability analysis or a combination of these elements.

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Delineation

Local drinking water systems or communities may revise the source areas or protection zones that were used in the initial assessment, based on more detailed or more accurate data. Various methods for delineating source areas and protection zones are described in Section 6.0.

PCA Inventory

As with the original assessment, gathering supplemental information should be coordinated with the work of various state, local and federal agencies. It should also make use of the permits issued and the enforcement actions taken. Some examples of these are presented in Sections 5.0 and Sections 7.0 of this document. Some communities have inventoried PCAs on a parcel-by-parcel basis, sometimes by using volunteers from the community.

As part of a local protection program, other potential contaminants associated with particular activities could be considered besides those subject to drinking water

regulation (see Section 7.0). Those could include the following: US EPA's priority pollutants; chemicals that are subject to the Toxic Release Inventory; California's list of hazardous substances; chemicals identified as causing cancer or birth defects or other reproductive harm for purposes of California's Safe Drinking Water and Toxic Enforcement Act of 1986 ("Proposition 65"); or chemicals for which permits are issued by the Regional Water Quality Control Board.

Supplemental inventories could include research of written documents, review of land use data, conducting surveys, and field reconnaissance. Each of these methods is described in more detail below.

Written documents include those maintained by federal, state, and local agencies, such as lists, inventories, records and other items that would identify the following: underground or above ground storage tanks, federal Superfund sites, contamination sites, landfill locations, septic systems, and other state and locally regulated activities. Other documents include telephone directories, business records, property tax records, news articles, and historical or archival information.

Land use data can help identify possible contaminant activities or sources of pollution. These can often be identified from information that may be available from the local planning or building departments. These may include aerial photographs, topographic maps, zoning maps, and building permits.

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Surveys may also be done to confirm or supplement information collected by other means. The surveys can be prioritized by type of PCA or by zone. Types of surveys include mail questionnaires, telephone surveys, personal interviews, and automobile windshield surveys.

A field review may be done to identify land uses and to look for potential sources of contamination not clearly identified by the previous methods. Items to document could include: abandoned or improperly destroyed wells, closely spaced septic systems, point source and non-point source contaminants, unauthorized activities and changes in business use.

Vulnerability Analysis

The objective of the vulnerability analysis in a protection program is to more accurately determine which of the types of PCAs pose the greatest threat to the water supply. Procedures for the minimum assessment are described in Section 8.0.

The physical barrier effectiveness determination could be modified based upon more detailed information on the hydrology or hydrogeology of the watershed or aquifer, and the source. Water systems may choose to use a different method to evaluate physical barrier effectiveness, provided that it considers the same factors as the DWSAP method.

The vulnerability ranking could be modified by considering additional information on some or all of the PCAs. The density (number of facilities) and the quantity and/or extent of the area that the type of PCA occupies in the protection zone could be included in determining potential risk.

In addition, facility-specific information (compliance, construction, operation, etc.) could be considered. Appendix E or L may be useful for this purpose.

Update of assessment maps

Results of the revised assessment could be illustrated on an updated map that identifies the drinking water source, source areas and protection zones, and PCAs to which the source is most vulnerable. Such a map is helpful in the development of a protection program and in describing the program to the public.

Follow-Up Iterations

Iterations are important in this process, particularly since, for many drinking water systems, a simple approach will be used for the initial assessment. A simple delineation and inventory may suggest that a drinking water source is at risk of contamination, while a more detailed approach may show that the "risk" initially identified reflected the assumptions used and not the actual situation.

11.3 Initiate Protection Measures, If Appropriate

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If the drinking water source is vulnerable to contamination, protection measures may be taken. These might include increased monitoring, abatement or remediation of the contaminant source, planning for an alternative source of supply, or other management activities, as described in Sections 12.0 and 13.0.

11.4 Provide Information to the Public

When the drinking water system or community decides to make the findings of its protection efforts available to the public, the following methods are examples of those that may be used.

- Provide documents for review in public libraries
- Provide documents for review at county health/environmental health department
- Issue press releases that refer public to locations of documents for public review
- Mail notice to organizations identifying locations of documents for public review
- Mail notice to customers of locations of documents for public review

- Hold a public meeting that describes the findings of the protection program and refers to locations of documents for public review
- Mail assessment map and summary to customers/public
- Provide results or a summary in annual consumer confidence report to customers/public
- Make results available by electronic access (e.g., Internet)

In all cases, copies of source water assessment and protection reports should be provided to DHS.

11.5 Update Source Water Assessment and Protection Information

The public water system or community should develop a schedule for updating its protection program. To be consistent with source water assessments, the protection program should be reviewed for possible update every five years.

Information for the public should be updated based on revised assessment maps and follow-up iterations as described in Section 11.2. This will ensure that the public receives the most up-to-date and accurate information.

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12.0 Management Approaches within Source Areas and Protection Zones

Source water protection is not a mandated element of the EPA's Source Water Assessment Program requirements. However, protection is required for a complete wellhead protection program. EPA and DHS encourage development of protection programs for all sources, recognizing that prevention of contamination is of greater benefit to the public and to drinking water utilities than dealing with it after the fact, through expensive drinking water monitoring and treatment and other expensive environmental cleanup activities.

A drinking water system with a completed source water assessment and a protection program may be eligible for waivers from monitoring. As mentioned previously for the assessment program, the State could require protection programs to be in place for permitting and waivers, particularly for water systems with sources that have detected levels of a regulated or unregulated chemical.

Drinking water systems and communities are encouraged to develop management strategies to mitigate the impact and risk of contamination of the drinking water supply. Another activity related to the DWSAP is contingency planning, which is discussed in Section 13.0

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Management within source water protection areas is primarily the responsibility of local governments and public drinking water systems, supported and guided by State policies and programs. Source water protection activities in California can be divided into three categories. Each category is described below:

1. State programs related to drinking water source protection
2. Recommended guidelines for management in protection areas
3. Local management activities

12.1 State Programs Related to Drinking Water Source Protection

Existing state programs to protect water supplies and to inventory, regulate, and clean up contaminant sources are described in Section 5.0, Roles and Responsibilities of Government Agencies.

DHS will actively promote the development of local drinking water source protection programs. DHS' activities to promote protection of drinking water supplies include technical assistance, financial assistance, training, education, and demonstration projects.

As each assessment performed by DHS is completed, the information will be shared with the public water system along with guidance for local protection programs.

Technical Assistance

The DHS Drinking Water Program has a source water (wellhead) protection coordinator available to assist local agencies with protection programs. In addition, staff at Drinking Water Program district offices are available for assistance, if requested. These DHS personnel can make presentations to water suppliers and community groups about source water protection, and can review technical elements of proposed programs.

Financial Assistance

California is establishing a State Revolving Fund (SRF) for drinking water. These funds will be primarily targeted to water system infrastructure improvements. However, some portion of the funding will be available for source water protection activities. The state is currently developing guidelines for the SRF program.

Training

DHS, in conjunction with EPA, is preparing a training program in source water protection for utility operators, managers and board members. This training will be offered for the first time in 1999, and on a repeating basis thereafter throughout the state. Other organizations may offer training as well.

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Education

DHS will be preparing educational materials for use by water utilities, community groups, and other interested parties. These materials may include additional guidance documents for implementation of the DWSAP Program.

Demonstration Projects

DHS is participating in several demonstration projects. The first community demonstration project is focused on ground water sources of the City of Sebastopol in Sonoma County. The project is funded by the City of Sebastopol, with DHS providing project coordination and technical assistance. Another demonstration project is a drinking water source protection program for Yosemite National Park, funded by the US EPA and DHS. Additional ground water (wellhead) demonstration projects may develop, including some in conjunction with the California Rural Water Association.

Directory of Source Water Protection-Related Activities

DHS has prepared a directory of agency programs (see Section 5.0) to enable drinking water systems and communities to access pertinent information for drinking water source protection activities. The data directory will be available through the Internet.

12.2 Recommended Guidelines for Management in Source Areas and Protection Zones

The protection areas and zones mentioned in the following subsections refer to those identified in Section 6.0 for surface water and ground water sources.

12.2.1 Surface Water Sources

Surface water intakes, and land areas near surface water sources should be managed to reduce the possibility of contamination. Potential origins of contamination such as septic systems should be designed and used with appropriate precautions to ensure protection of surface water from microbial organisms. Chemicals capable of contaminating surface water should not be stored or used near surface water intakes or near surface water sources of drinking water, or should be stored and used with appropriate precautions to eliminate the possibility of spills or discharges.

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If zones are established within a surface water source area (i.e., watershed), the zones that are farther from the source, yet still within the watershed, allow the community to appropriately plan and site future high risk and medium risk PCAs. These zones also serve as an educational tool for industry, the general public, and others to understand the source of their drinking water and the significance of their actions within a watershed or surface water source area.

12.2.2 Ground Water Sources

Recharge Areas

Where ground water recharge areas can be identified, they should be managed in a manner generally similar to that described above for surface water sources, using primary and secondary recharge areas (Section 6.3) to represent source areas and protection zones.

Protection Zones

Protection zones within the source area of a ground water source allow the community to appropriately plan and site future high risk and medium risk PCAs. These zones also serve as an educational tool for industry, the general public, and others to understand the

source of their drinking water and the significance of their actions upgradient or within the protection zones of their drinking water wells, and for the entire aquifer and recharge area, too.

Well Site Control Zone

The well site control zone should be managed to reduce the possibility of surface flows reaching the wellhead and traveling down the casing. It is recommended that the water purveyor own this area, or have a permanent easement. Within this zone, the immediate vicinity of the well should be fenced and locked, or may include a well house or other building. It is not necessary for the entire zone to be fenced.

Zone A - Microbial/Direct Chemical Contamination Protection Zone

Within Zone A, the protection zone established on the basis of the two-year time of travel, activities that could be potential sources of microbial or direct chemical contamination should be strictly managed to eliminate or reduce the risk of contamination of the water supply.

Potential sources of contamination such as septic systems and animal facilities should be designed and used with appropriate precautions to ensure appreciable reduction in nitrates and microbial organisms before reaching ground water or surface water.

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Activities should be managed so that chemicals capable of contaminating ground water would not be stored or used, or would be stored and used with appropriate precautions to eliminate the possibility of spills or discharges.

Zones B5 and B10 - Chemical Contamination Protection Zones

Zone B5, the area within the five-year time-of-travel, should be actively managed for control of potential chemical contaminants. Within Zone B5, chemicals capable of contaminating ground water should be stored and used with appropriate precautions to eliminate the possibility of spills or discharges.

Zone B10, the area between the five- and ten-year time-of-travel, allows the community to plan and site future high risk and medium risk sources of ground water contamination at a distance from the source where they are less likely to contaminate the water supply.

Buffer Zone - Additional Chemical Contamination Zone

A buffer zone enables additional planning for particular activities that may affect the community's ground water supplies.

12.3 Local Management Measures

After identifying source areas, protection zones, and types of PCAs, and developing a vulnerability ranking, the local community or water supplier may choose to develop a management strategy for protecting the water supply. The strategy could identify measures to be accomplished at the local level, and may affect agencies, districts or other communities besides the community served by the water supply. The cooperation of the entire community is vital for source water protection management measures to work.

A source water protection management strategy could include measures that are already undertaken, and ones to implement in the future.

There are both non-regulatory and regulatory management measures that can be effective as part of a source water protection program. The easiest ones to implement are non-regulatory, such as public education, and they may be very successful. If, however, as a result of the PCA inventory and vulnerability analysis, a local community determines that the water supply is at high risk of contamination, then land use planning, permitting, and possibly more restrictive regulatory methods may be necessary to ensure protection of the water supply. Potential local management measures are listed in Table 12-1.

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In assessing the merits of protection measures, consideration should be given to the costs to parties of implementing the measures, the probable effects of implementing the measures, and the benefits associated with those effects. Source water protection is a valuable tool in water quality management, but not all source water protection measures will be cost effective.

There have been a number of documents published that can assist water systems and communities in developing local protection programs. Several organizations assist with source water protection efforts. Water systems and communities are encouraged to review the resource documents listed in Table 12-2 and to contact the organizations listed in Table 12-3. In addition, DHS intends to develop state-specific guidance for local protection programs.

Table 12-1. Potential management measures for local source water protection programs.

Regulatory

Zoning

Overlay Source Water Protection Districts
Prohibition of Various Land Uses
Special Permitting
Large-Lot Zoning
Transfer of Development Rights
Cluster/PUD Design
Growth Controls/Timing
Performance Standards

Land Use Permit Conditions

New Uses – Review for ground or surface water contamination potential
Existing Uses – Require review for change in chemical type/quantity/handling
Underground Storage Tank requirements

Subdivision Control

Drainage Requirements
Impact Fees

Other

Septic System Upgrades
Toxic and Hazardous Materials Handling Regulations
Private Well Protection
Sewer system hookups

Non-Regulatory

Land Transfer and Voluntary Restrictions

Sale/Donation
Conservation Easements
Limited Development

Other

Watershed Restoration Efforts
Storm Water Monitoring
Ground Water Monitoring
- Review existing monitoring wells
- Install new monitoring wells
- Conduct sampling of existing private wells

Contingency Plans
Hazardous Waste/Used Oil Collection
Public Education
Identify Underground Injection Sources or Abandoned Wells
Notify Other Agencies with Land Use or Regulatory Authority
Groundwater Guardian *(contact Groundwater Foundation)*
Storm Drain Labeling
Fencing/ Access Restriction

Legislative

Regional Wellhead Protection Area Districts
Land Banking

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Table 12-2. Documents related to source water protection and wellhead protection

January 1999 – with April 1999 and January 2000 revisions

California Well Standards, DWR Bulletin 74-90 and DWR Bulletin 74-81

A Guide to Wellhead Protection, Witten, J. and Horsley, S., American Planning Association, Planning Advisory Service, Report #457/458, August, 1995,

Basic Ground-Water Hydrology, USGS Publication #2220

California Groundwater Management, Groundwater Resources Association of California

Delineation of Wellhead Protection Areas in Fracture Rocks, EPA Publication EPA570991009

Ground Water and Wellhead Protection, EPA Handbook EPA625/R94001

Guide to Groundwater Supply Contingency Planning for Local and State Government, EPA Technical Assistance Document EPA4404690003

Guidelines for Delineation of Wellhead Protection Areas, EPA Publication EPA440593001

Protecting Local Ground-water Supplies through Wellhead Protection, EPA Publication EPA570991007

Wellhead Protection : A Guide for Small Communities, EPA Seminar Publication EPA625R93002

Wellhead Protection in Confined, Semi-Confined, Fractured, Aquifer Settings, EPA Publication ERIC: G-127, EPA813K93001, NTIS:PB94-109402

Wellhead Protection Programs: Tools for Local Governments, EPA Publication EPA440/6-89/002

Wellhead Protection Strategies for Confined Aquifer Settings, EPA Publication EPA570991008

Why Do Wellhead Protection? Issues and Answers in Protecting Public Drinking Water Supply Systems, EPA Publication EPA813K95001

GroundWater and Surface Water – A Single Resource, USGS Circular 1139

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Table 12-3. Organizations that may assist with source water protection efforts

California Groundwater Association
P.O. Box 14369
Santa Rosa, California 95402-6369
(707) 578-4408

California Rural Water Association
8300 Fair Oaks Boulevard, Suite 302
Carmichael, California 95608
1-800-833-0322

Groundwater Resources Association of California
601 Villanova Drive
Davis, California 95616
(530) 758-3656

Water Education Foundation
717 K Street, Suite 517
Sacramento, California 95814
(916) 444-6240

The GroundWater Foundation
P.O. Box 22558
Lincoln, Nebraska 68542-2558
(402) 434-2740

National Rural Water Association
2915 South 13th Street
Duncan, Oklahoma 73533
(405) 252-0629

Farm*A*Syst / Home*A*Syst
(assessment procedures for farms and homes)
B142 Steenbock Library
550 Babcock Drive
Madison, WI 53706-1293
(608)262-0024

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13.0 Contingency Planning for Drinking Water Supplies

Contingency planning to protect drinking water supplies is an essential element of a complete source water protection program. It is also required by the Safe Drinking Water Act (SDWA) and the Emergency Planning and Community Right-to-Know Act of 1986, enacted as Title III of the Superfund Amendments and Re-authorization Act (SARA).

Local governments are typically given responsibility for implementing components of a drinking water source protection program. While program requirements may vary, a public water supplier should develop a contingency plan to locate and provide alternate drinking water supplies in the event of contamination. A contingency plan should not be limited to planning for alternative supplies; it should be used to identify and to prevent both physical and operational threats from contaminating or closing a public water supply.

The following are minimum components for local contingency plans. These will ensure adequate planning, encourage reliability and consistency, and create uniform response protocols. Any local plan should be consistent with Urban Water Plans.

A contingency plan could be made a condition of a public water system's water supply permit. Such a plan is required for a complete wellhead protection program.

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13.1 Contingency Planning at the State Level

Contingency planning at the state level is also an important component of the State Drinking Water Source Assessment and Protection Program. A state plan would identify state roles, responsibilities, and resources.

A State Contingency Plan could include the following activities: Analysis of the characteristics of water systems statewide; analysis of the vulnerability of surface and ground water supplies statewide; review of existing State emergency response plans; analysis of water supply replacement options statewide; evaluation of the State's technical, logistical, and financial resources to support local response activities; development of guidance and standards to direct local plan development; identification of future steps that should be taken to prevent or mitigate future disruptions; improvement of the State's ability to respond to major supply disruptions; and organization of a process for reviewing and updating the plan.

A State Contingency Plan would provide the overall framework for state and local responses and integrate other state and federal programs, and provide direction for local plans. A State

Contingency Plan could be developed after EPA approval of the State Drinking Water Source Assessment and Protection Program.

13.2 Minimum Components of Local Contingency Plans

A local contingency plan should include an assessment of the water system's ability to function with a loss of major supply, and it should address alternate supplies in case they are needed. Specific steps are identified in this section.

13.2.1 Assessment of the Ability of the Water System to Function with the Loss of the Largest Source of Supply

In order to assess the ability to function with the loss of the largest source of supply, the water supplier should do the following: (1) Identify the water system's maximum capacity considering the source, distribution system, and water rights or other restrictions; and (2) re-evaluate this capacity if the largest supply source were to be lost.

13.2.2 Development of a Plan for Alternate Water Supplies

To develop a plan for alternate water supplies, the water supplier should determine both short-term and long-term supplies, the additional capacity that would be provided from the alternate supplies, and the associated costs. The plan should consider such alternatives as: increasing production from existing sources, identifying existing and potential inter-ties with other public water systems, and installing treatment on sources not currently used because of water quality problems.

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13.2.3 Development of a Spill/Incident Response Plan

Using the results of the PCA inventory, a response plan for spills and emergencies should be developed with local emergency responders. Emergency response actions to be taken should consider protection of the water supply. For example, chemical spills within the protection area should be soaked up with absorbent materials rather than being washed away to drainage systems. Similarly, in the event of a fire it may be best to allow certain facilities to burn rather than have contaminated runoff that could pollute the community water supply.

References

American Water Works Association, California-Nevada Section, 1993. *Watershed Sanitary Survey Guidance Manual*. Source Water Quality Committee, December.

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Massachusetts Department of Environmental Protection, 1996. *Developing a Local Surface Water Supply Protection Plan.*

Todd, D.K. 1980. *Groundwater Hydrology*. 2nd Ed. New York: John Wiley & Sons.

Washington State Department of Health, Environmental Health Programs. 1995. *Washington State Wellhead Protection Program Guidance Document*. Olympia, Washington. DOH Publication 331-018, April.

US Environmental Protection Agency, 1997. *State Methods for Delineating Source Water Protection Areas for Surface Water Supplied Sources of Drinking Water*, EPA 816-R-97-008, August.

US Environmental Protection Agency, 1997. *State Source Water Assessment and Protection Programs Guidance*, Final Guidance, Office of Water, EPA 816-R-97-009, August.

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Appendices

Drinking water systems and communities that choose to perform their own source water assessments as part of a drinking water source assessment and protection program should contact their regional DHS drinking water office to make sure they are using the up-to-date version of the forms and checklists contained in the Appendices.

APPENDICES TO BE USED FOR A SURFACE WATER SOURCE

Appendix A — Drinking Water Source Location – Surface Water

Appendix B — Delineation of Surface Water Protection Zones

Appendix C — Physical Barrier Effectiveness Checklist – Surface Water Source

Appendix D — Possible Contaminating Activity (PCA) Inventory Form – Surface Water Source

Appendix E — Possible Contaminating Activities Evaluation – Surface Water Source

Appendix F — Vulnerability Analysis Procedures – Surface Water Source

Appendix G — Checklist for Drinking Water Source Assessment – Surface Water Source

APPENDICES TO BE USED FOR A GROUND WATER SOURCE

Appendix H — Drinking Water Source Location – Ground Water

Appendix I — Delineation of Ground Water Protection Zones

Appendix J — Physical Barrier Effectiveness Checklist and Well Data Sheet – Ground Water Source

Appendix K— Possible Contaminating Activity (PCA) Inventory Form – Ground Water Source

Appendix L — Possible Contaminating Activities Evaluation – Ground Water Source

Appendix M — Vulnerability Analysis Procedures – Ground Water Source

Appendix N — Checklist for Drinking Water Source Assessment – Ground Water Source

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APPENDICES TO BE USED FOR A SURFACE WATER SOURCE

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Appendix A

Drinking Water Source Location – Surface Water

Public water system: _____ ID No.: _____

Name of source: _____ ID No.: _____

Location date: _____ Source located by (name of person): _____

Method of determining location:

_____ USGS quad map (7.5 minute series, 1:24,000 scale), hand calculated

_____ USGS quad map (7.5 minute series, 1:24,000 scale), computer calculated

_____ Global Positioning System (GPS)

Unit (manufacturer/model): _____

Accuracy of GPS unit (+/- _____ ft.)

_____ Other Method _____

Accuracy of method (+/- _____ ft.)

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Location of intake (decimal degrees): Latitude: _____

Longitude: _____

Physical description of location [Name of surface water body, pertinent landmarks, address, or approximate address (cross streets, etc.)]:

NOTE: Indicate location of the surface water intake on the drinking water source assessment map. Map should also indicate the source area (watershed) and protection zones, if established (See other Appendices).

January 1999 – with April 1999 and January 2000 revisions

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Appendix B

Delineation of Surface Water Protection Zones

Public water system: _____ ID No.: _____

Name of source: _____ ID No.: _____

Delineation date: _____ Delineation conducted by _____

The delineation of protection zones for a surface water source is optional. The source area for a surface water source is the watershed.

If protection zones are established, the recommended distances are as follows:

Zone A: 400 feet from reservoir banks or primary stream boundaries
200 feet from tributaries
Zone B: 2,500 feet from intakes

Protection zones established for this source are:

Zone A: _____ feet from reservoir banks or primary stream boundaries

_____ feet from tributaries

Zone B: _____ feet from intakes

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Appendix C

Physical Barrier Effectiveness Checklist -- Surface Water Source

Public water system: _____ ID No.:_____

Name of source:_____ ID No.:_____

Assessment date:_____ Assessment conducted by _____

Drinking Water Source/ Watershed Information

Note: Other methods of determine Physical Barrier Effectiveness may be acceptable. Consult with DHS.

Note: Most of the following information should be available from the Watershed Sanitary Survey of the water source.

1. Is the source an impounded reservoir or a direct stream intake?
    a. Reservoir
    b. Stream intake
    c. Other, describe: _____

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2. Source Characteristics
    a. Area of tributary watershed:_____acres or square miles
    b. Area of water body within watershed:_____acres or square miles
    c. Volume of water body: _____acre-feet
    d. Maximum rate of withdrawal through intake:_____gallons per day
    e. Are the primary tributaries seasonal, perennial or both? _____

3. What is the approximate travel time to the intake for water at farthest reaches of the impounded water body?
    a. Source is direct intake, no impounded water body
    b. Less than 30 days, or unknown
    c. More than 30 days and less than 1 year
    d. More than 1 year

4. What is the general topography of the watershed?
    a. Flat terrain (<10% slopes)
    b. Hilly (10 to 30% slopes)
    c. Mountainous (> 30% slopes)
    d. Not sure

January 1999 – with April 1999 and January 2000 revisions

5. What is the general geology of the watershed?
    a. Materials prone to landslides
    b. Materials not prone to landslides
    c. Not sure

6. What general soil types are on the watershed?
    a. Rock
    b. Loams, sands
    c. Clay
    d. Not sure

7. What type of vegetation covers most of the watershed?
    a. Grasses
    b. Low growing plants and shrubs
    c. Trees
    d. Not sure

8. What is the mean seasonal precipitation on the watershed?
    a. More than 40 inches/year
    b. 10 to 40 inches/year
    c. Less than 10 inches/year
    d. Not sure

9. Is there significant ground water recharge to the water body?
    a. Yes
    b. No
    c. Not sure

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Physical Barrier Effectiveness Determination

Parameters indicating **Low Physical Barrier Effectiveness** (LE)
(A source with any of the parameters listed below would be considered to have less effective physical barrier properties)

3a
4c or 4d
5a or 5c
7c or 7d
8a or 8d
9a

Parameters indicating **High Physical Barrier Effectiveness** (HE)
(A source would need to have all of the parameters listed below to be considered to have highly effective physical barrier properties)

3d and
4a and
5b and
7a and
8c and
9b

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All other sources are considered to have **Moderate Physical Barrier Effectiveness**

Determination for this source:

Low (LE)

Moderate (ME)

High (HE)

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Appendix D

Possible Contaminating Activities (PCA) Inventory Form

Surface Water Source

Public water system name:_____ID No. _____

Name of drinking water source:_____ID No._____

Inventory date:_____ Inventory conducted by:_____

Name of Surface Water Body :_____

Indicate PCAs pertinent to the drinking water source, its source area (watershed) and protection zones (if established), from the following tables, as applicable:

Commercial/Industrial (Table D-1) _____

Residential/Municipal (Table D-2) _____

Agricultural/Rural (Table D-3) _____

Other (required for all) (Table D-4) _____

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Are zones established? YES or NO

Attach map of Drinking Water Source with watershed boundaries and zones (if established) indicated.

Proceed to appropriate checklist or checklists. Place a mark in the appropriate boxes. Example:

		X

Risk Ranking of PCAs (see Tables 7-2, 7-3, 7-4 and 7-5 for separate category lists), where VH = Very High Risk, H = High Risk, M = Moderate Risk, L = Low Risk

Note: If zones are not established use higher risk ranking. If zones are established, use higher risk ranking in zones, lower risk ranking for remainder of watershed.

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Auguscik-25
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Auguscik-25 (Cont.)

PCA Checklist Table D-1, page 1 of 2						
COMMERCIAL/INDUSTRIAL						
	IF ZONES ESTABLISHED					
PCA (Risk Ranking)	No PCA in zones	PCA in Zone A?	PCA in Zone B?	PCA in Watershed	Unknown	Comments
Automobile-related activities						
Body shops (H)						
Car washes (M)						
Gas stations (VH)						
Repair shops (H)						
Boat services/repair/ refinishing (H)						
Chemical/petroleum processing/storage (VH)						
Chemical/petroleum pipelines (H)						
Dry cleaners (VH)						
Electrical/electronic manufacturing (H)						
Fleet/truck/bus terminals (H)						
Furniture repair/ manufacturing (H)						
Home manufacturing (H)						
Junk/scrap/salvage yards (H)						
Machine shops (H)						
Metal plating/ finishing/fabricating (VH)						
Photo processing/printing (H)						
Plastics/synthetics producers (VH)						
Research laboratories (H)						

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PCA Checklist Table D-1, page 2 of 2						
COMMERCIAL/INDUSTRIAL						
	IF ZONES ESTABLISHED					
PCA (Risk Ranking)	No PCA in zones	PCA in Zone A?	PCA in Zone B?	PCA in Watershed	Unknown	Comments
Wood preserving/treating (H)						
Wood/pulp/paper processing and mills (H)						
Lumber processing and manufacturing (H)						
Sewer collection systems (H, if in Zones, otherwise L)						
Parking lots/malls (>50 spaces) (M)						
Cement/concrete plants (M)						
Food processing (M)						
Funeral services/graveyards (M)						
Hardware/lumber/parts stores (M)						
Appliance/Electronic Repair (L)						
Office buildings/complexes (L)						
Rental Yards (L)						
RV/mini storage (L)						
Other (list)						

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PCA Checklist Table D-2, page 1 of 2						
RESIDENTIAL/MUNICIPAL						
	IF ZONES ESTABLISHED					
PCA (Risk Ranking)	No PCA in zones	PCA in Zone A?	PCA in Zone B?	PCA in Watershed	Unknown	Comments
Airports - Maintenance/ fueling areas (VH)						
Landfills/dumps (VH)						
Railroad yards/ maintenance/ fueling areas (H)						
Septic systems - high density (>1/acre) (VH if in Zones, otherwise M)						
Sewer collection systems (H, if in Zones, otherwise L)						
Utility stations - maintenance areas (H)						
Wastewater treatment and disposal facilities (VH in Zones, otherwise H)						
Drinking water treatment plants (M)						
Golf courses (M)						
Housing - high density (>1 house/0.5 acres) (M)						
Motor pools (M)						
Parks (M)						
Waste transfer/recycling stations (M)						

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PCA Checklist
Table D-2, page 2 of 2

RESIDENTIAL/MUNICIPAL						
	IF ZONES ESTABLISHED					
PCA (Risk Ranking)	No PCA in zones	PCA in Zone A?	PCA in Zone B?	PCA in Watershed	Unknown	Comments
Apartments and condominiums (L)						
Campgrounds/ Recreational areas (L)						
Fire stations (L)						
RV Parks (L)						
Schools (L)						
Hotels, Motels (L)						
Other (list)						

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PCA Checklist Table D-3, page 1 of 3						
AGRICULTURAL/RURAL						
	IF ZONES ESTABLISHED					
PCA (Risk Ranking)	No PCA in zones	PCA in Zone A?	PCA in Zone B?	PCA in Watershed	Unknown	Comments
Grazing (> 5 large animals or equivalent per acre) (H in Zones, otherwise M)						
Concentrated Animal Feeding Operations (CAFOs) as defined in federal regulation[1] (VH in Zones, otherwise H)						
Animal Feeding Operations as defined in federal regulation[2] (VH in Zones, otherwise H)						
Other Animal operations (H in Zones, otherwise M)						
Concentrated Aquatic Animal Production Facilities, as defined in federal regulation (VH in Zones, otherwise H)						
Other Aquatic Animal production operations (H in Zones, otherwise M)						
Managed Forests (VH in Zones, otherwise H) (unless additional detail provided*)						
Farm chemical distributor/ application service (H)						
Farm machinery repair (H)						

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PCA Checklist Table D-3, page 2 of 3						
AGRICULTURAL/RURAL						
	IF ZONES ESTABLISHED					
PCA (Risk Ranking)	No PCA in zones	PCA in Zone A?	PCA in Zone B?	PCA in Watershed	Unknown	Comments
Septic systems – Low density (<1/acre) (H in Zones, otherwise L)						
Lagoons / liquid wastes (H)						
Machine shops (H)						
Pesticide/fertilizer/ petroleum storage & transfer areas (H)						
Agricultural Drainage (H in Zones, otherwise M)						
Wells - Agricultural/ Irrigation (H)						
Crops, irrigated (Berries, hops, mint, orchards, sod, greenhouses, vineyards, nurseries, vegetable) (M)						
Sewage sludge/biosolids application (M)						
Fertilizer, Pesticide/ Herbicide Application (M)						
Crops, nonirrigated (e.g., Christmas trees, grains, grass seeds, hay, pasture) (L) (includes drip-irrigated crops)						
Other (list)						

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PCA Checklist Table D-3, page 3 of 3						
AGRICULTURAL/RURAL						
	IF ZONES ESTABLISHED					
PCA (Risk Ranking)	No PCA in zones	PCA in Zone A?	PCA in Zone B?	PCA in Watershed	Unknown	Comments
* Additional Detail for Managed Forests The following categories can be used in lieu of the default risk ranking for Managed Forests:						
* Managed Forests - Broadcast fertilized areas (M in Zones, otherwise L)						
* Managed Forests - Clearcut harvested <30 years (VH in Zones, otherwise H)						
* Managed Forests - Partial harvested <10 years (H in Zones, otherwise M)						
* Managed Forests - Road density > 2 mi/sq. mi) (H in Zones, otherwise M)						

1. Concentrated Animal Feeding Operation: Animal Feeding Operation (requires NPDES permit) with greater than:

If pollutants discharged (directly or indirectly) to navigable waters	**If pollutants not discharged**
300 slaughter or feeder cattle	1,000 slaughter or feeder cattle
200 mature dairy cows	700 mature dairy cows
750 swine	2500 swine
150 horses	500 horses
3000 sheep or lambs	10,000 sheep or lambs
16,500 turkeys	55,000 turkeys
9,000 laying hens or broilers (liquid manure system)	30,000 laying hens or broilers (liquid manure system)
1500 ducks	5000 ducks
300 animal units	1000 animal units

2. Animal Feeding Operation: lot or facility where animals (other than aquatic) have been or will be stabled or confined and fed or maintained for total of 45 days or more in any 12 month period.

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PCA Checklist Table D-4, page 1 of 3						
OTHER ACTIVITIES						
	IF ZONES ESTABLISHED					
PCA (Risk Ranking)	No PCA in zones	PCA in Zone A?	PCA in Zone B?	PCA in Watershed	Unknown	Comments
NPDES/WDR permitted discharges (H)						
Underground Injection of Commercial/Industrial Discharges (VH)						
Historic gas stations (VH)						
Historic waste dumps/ landfills (VH)						
Illegal activities/ unauthorized dumping (H)						
Injection wells/ dry wells/ sumps (VH)						
Known contaminant plumes (VH)						
Military installations (VH)						
Mining operations - Historic (VH)						
Mining operations – Active (VH)						
Mining - Sand/Gravel (H)						
Wells – Oil, Gas, Geothermal (H)						
Salt Water Intrusion (H)						
Recreational area – surface water source (H)						
Snow Ski Areas (H in Zones, otherwise M)						
Recent (< 10 years) Burn Areas (H in Zones, otherwise M)						

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PCA Checklist Table D-4, page 2 of 3						
OTHER ACTIVITIES						
	IF ZONES ESTABLISHED					
PCA (Risk Ranking)	No PCA in zones	PCA in Zone A?	PCA in Zone B?	PCA in Watershed	Unknown	Comments
Dredging (H in Zones, otherwise M)						
Underground storage tanks						
Confirmed leaking tanks (VH)						
Decommissioned - inactive tanks (L)						
Non-regulated tanks (tanks < than regulatory limit) (H)						
Not yet upgraded or registered tanks (H)						
Upgraded and/or registered - active tanks (L)						
Above ground storage tanks (M)						
Wells – Water supply (M)						
Construction/demolition staging areas (M)						
Contractor or government agency equipment storage yards (M)						
Transportation corridors						
Freeways/state highways (M)						
Railroads (M)						
Historic railroad right-of-ways (M)						
Road Right-of-ways (herbicide use areas) (M)						
Roads/ Streets (L)						

Auguscik-25 (Cont.)

PCA Checklist Table D-4, page 3 of 3						
OTHER ACTIVITIES						
	IF ZONES ESTABLISHED					
PCA (Risk Ranking)	No PCA in zones	PCA in Zone A?	PCA in Zone B?	PCA in Watershed	Unknown	Comments
Hospitals (M)						
Storm Drain Discharge Points (M)						
Storm Water Detention Facilities (M)						
Artificial Recharge Projects						
Injection wells (potable water) (L)						
Injection wells (non-potable water) (M)						
Spreading Basins (potable water) (L)						
Spreading Basins (non-potable water) (M)						
Medical/dental offices/clinics (L)						
Veterinary offices/clinics (L)						
Surface water - streams/ lakes/rivers (L)						
Other (list)						

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Auguscik-25
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Appendix E

Possible Contaminating Activities Evaluation – Surface Water Source

(Note: This form is OPTIONAL. It should be completed if a modification of the risk ranking for a type of PCA is desired)

Public water system: _____ ID No.: _____

Name of source: _____ ID No.: _____

Assessment date: _____ Assessment conducted by _____

PCA/Potential Contaminant Information

1. Type of Activity (from contaminant inventory checklist):

2. Type of potential contaminant associated with this activity (refer to Table 7-2):
   a. Microbiological
   b. Chemical
   c. Both or Other

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3. Potential Risk (from PCA contaminant inventory checklist):
   a. Low
   b. Medium
   c. High
   d. Very High

4. Location:
   a. Within a zone (if defined) or within DHS minimum setback distances
   b. On the watershed outside of zones (if defined) or outside DHS minimum setback distances
   c. On the watershed (if no zones defined)

5. Spatial Area occupied by activity as percentage of watershed area:
   a. Small (<1% of area)
   b. Moderate (1% to 10% of area)
   c. High (>10% of area)
   d. Unknown

6. Volume of potential contaminant *(not applicable for microbiological contaminants)*:
   If the maximum quantity of potential contaminant stored at the facility were discharged into

the quantity of water produced by the drinking water supply in a day would the concentration be:

a. Small (less than one part per billion)
b. Moderate (between one part per thousand and one part per billion)
c. High (more than one part per thousand)
d. Unknown

7. Magnitude of potential acute or chronic health effects associated with the contaminant:
   a. Low
   b. High
   c. Unknown

8. Likelihood of potential contaminant to migrate to drinking water supply:
a. Low
b. High
c. Unknown

9. Has the potential contaminant been detected in the drinking water supply or near-by monitoring wells?
   a. Yes
   b. No
   c. Unknown

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10. Compliance of facility (demonstrated performance to keep potential contaminant from being discharged)
    a. Good
    b. Poor
    c. Unknown

Determination of revised risk ranking for PCAs

Microbiological Contamination

If the PCA is categorized as **2a or 2c**, the risk ranking would be LOW if the PCA meets all of the parameters in the table below for **Low.** The risk ranking would be HIGH if the PCA meets all of the parameters in the table for **High**. Otherwise the risk ranking is MODERATE.

Microbiological Contamination
PCA Risk Ranking

Parameter	Low	High
3	**a**	**c or d**
4	**b**	**a or c**
5	**a**	**c or d**
7	**a**	**b or c**
8	**a**	**b or c**
9	**b**	**a or c**
10	**a**	**b or c**

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Chemical Contamination

If the PCA is categorized as **2b or 2c**, the risk ranking would be LOW if the PCA meets all of the parameters in the table below for **Low.** The risk ranking would be HIGH if the PCA meets all of the parameters in the table for **High**. Otherwise the risk ranking is MODERATE.

Chemical Contamination
PCA Risk Ranking

Parameter	Low	High
3	**a**	**c or d**
4	**b**	**a or c**
5	**a**	**c or d**
6	**a**	**c or d**
7	**a**	**b or c**
8	**a**	**b or c**
9	**b**	**a or c**
10	**a**	**b or c**

Auguscik-25
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Appendix F

Vulnerability Analysis Procedures – Surface Water Source

The Vulnerability analysis incorporates the types of Possible Contaminating Activities (PCAs) identified in the inventory, their respective Risk Rankings, the Zone and the Physical Barrier Effectiveness determination. These factors are used to develop a prioritized listing of types of PCAs and to determine the types of PCAs to which the drinking water source is most vulnerable.

Public water system: _____ ID No.:_____

Name of source:_____ ID No.:_____

Assessment date:_____ Assessment conducted by _____

Vulnerability analysis steps:

1. For each type of PCA identified as existing in the watershed and/or zones, or unknown, determine the number of PCA risk ranking points for that type of PCA. (If the risk ranking for a type of PCA has been modified, Appendix E should be attached). (*For example, Very High (VH) risk activities are 7 points.)*

2. For each type of PCA determine the zone in which it occurs (if zones are defined, or within the watershed if zones are not defined). Add the points associated with that zone to the PCA risk ranking points. If the type of PCA exists within more than one zone, repeat the process for each zone. (*For example, if a type of PCA exists in Zone A add 5 points. For a VH risk PCA in Zone A, the PCA Risk Ranking points + Zone points = 7 + 5 = 12 points.*)

3. Determine the Physical Barrier Effectiveness (PBE) for the drinking water source (from Appendix C). Add the points associated with that PBE to the PCA risk ranking and zone points. The total is the Vulnerability Score. (*For example, if the PBE is Low add 5 points. For a VH risk PCA in Zone A, the Vulnerability Score = PCA Risk Ranking points + Zone points + PBE points = 7 + 5 + 5 = 17 points.)*

4. Prioritize all types of PCAs by the Vulnerability Score, from the most points to the least. A sample form is shown below.

5. The drinking water source is vulnerable to all types of PCAs with a Vulnerability Score of **11** or greater. Refer to the Vulnerability Matrix below. The source is <u>most</u> vulnerable to the types of PCAs with the highest score.

6. **In addition, the Drinking Water Source is <u>most</u> vulnerable to all types of PCAs associated with a contaminant detected in the water source, regardless of Vulnerability Score.**

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Vulnerability Matrix for SURFACE WATER SOURCES

INDICATE WHICH APPLIES:
WITHIN ZONES (if defined) OR
WITHIN ENTIRE WATERSHED (if zones are not defined)

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The cutoff point for surface water vulnerability is **11**. The drinking water source is considered Vulnerable to all types of PCAs with Vulnerability Score greater than or equal to **11** (shaded boxes).

PCA points	Zone points		PCA + Zone points	PBE Points			Vulnerability Score PCA + Zone + PBE points		
Risk Ranking	Zones Defined	Zones Not Defined		Low	Mod	High	PBE Low	PBE Mod	PBE High
VH (7)	A (5)	Watershed (5)	12	5	3	1	17	15	13
VH (7)	B (3)		10	5	3	1	15	13	11
VH (7)	Watershed (1)		8	5	3	1	13	11	9
VH (7)	Unknown (0)*	Unknown (0)*	7	5	3	1	12	10	8
H (5)	A (5)	Watershed (5)	10	5	3	1	15	13	11
H (5)	B (3)		8	5	3	1	13	11	9
H (5)	Watershed (1)		6	5	3	1	11	9	7
H (5)	Unknown (0)*	Unknown (0)*	5	5	3	1	10	8	6
M (3)	A (5)	Watershed (5)	8	5	3	1	13	11	9
M (3)	B (3)		6	5	3	1	11	9	7
M (3)	Watershed (1)		4	5	3	1	9	7	5
M (3)	Unknown (0)*	Unknown (0)*	3	5	3	1	8	6	4
L (1)	A (5)	Watershed (5)	6	5	3	1	11	9	7
L (1)	B (3)		4	5	3	1	9	7	5
L (1)	Watershed (1)		2	5	3	1	7	5	1
L (1)	Unknown (0)*	Unknown (0)*	1	5	3	1	6	4	2

* Source is considered vulnerable to type of PCAs that are Unknown, if the Vulnerability Score is 11 or higher.

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Format for Prioritized Listing of type of PCAs

List type of PCAs in order by Vulnerability Score from highest to lowest.

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Zone	Type of PCA	PCA Points VH = 7 H = 5 M = 3 L = 1	Zone Points Watershed = 5 *(or A = 5, B = 3, Watershed = 1 See vulnerability matrix)* Unknown = 0	PBE Points L= 5 M = 3 H = 1	Vulnerability Score PCA points + Zone points + PBE points

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Auguscik-25
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