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DESIGN CRITERIA FOR GRAVITY OIL/WATER SEPARATORS

Department of Ecology

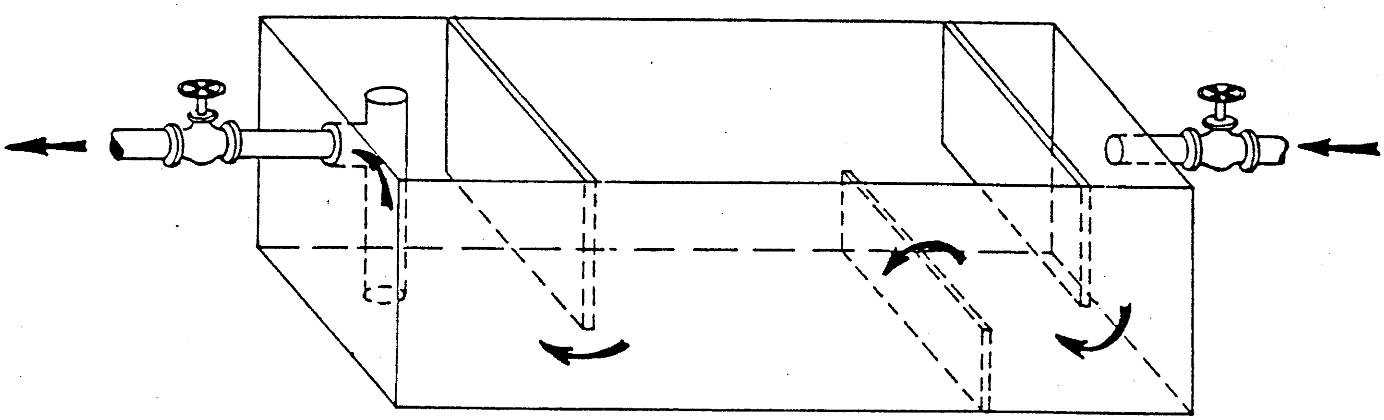
WDOE 82-1

JANUARY 1982

DESIGN CRITERIA

FOR

GRAVITY OIL/WATER SEPARATORS



Water Quality Planning
Office of Water Programs
Washington State Department of Ecology
Olympia, Washington 98504

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Introduction

These guidelines set forth the design criteria for gravity oil/water separators. These units are required by the Washington Department of Ecology (WDOE) for each facility where there is a potential for the discharge of oily contaminated waters. These units are not to be used in lieu of spill prevention measures or for control and treatment of toxic chemicals.

Oil separator discharges require plan approval from WDOE under RCW 90.48.343. For further information contact the nearest WDOE regional office as shown on the map below.

Approval by the Department does not obviate the requirements imposed by law from any federal, state, or local government for any phase of planning or construction of the project.

Design Criteria

Due to variabilities in effluents, each installation should be specifically designed to consider the uniqueness of the site and the wastewater.

The primary objective is to separate free oil from water. It is not to separate settleable solids or to handle emulsified oils.

These criteria do not pertain to wastewater containing either detergents, solvents or mixtures of oil and detergents or oil and solvents. Do not discharge process waste oils or solvents to the separator. A specialized design is required in these situations.

Also, these criteria do not pertain to uncontaminated waste and storm waters. These should be routed around the separator to minimize hydraulic loading.

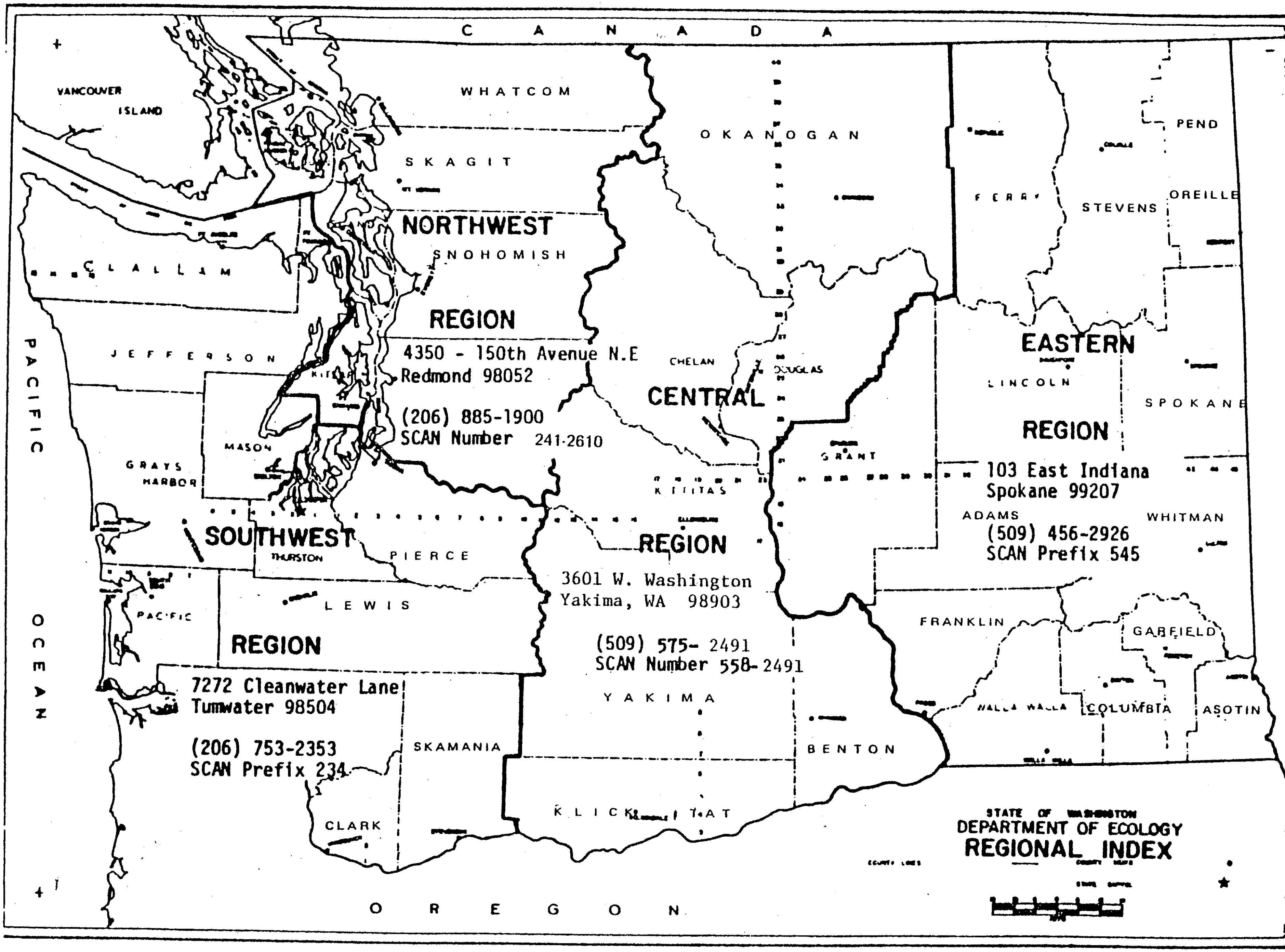
The unit's efficiency depends on the design, the size, and the rate of rise of oil globules. The effectiveness of the unit depends on:

(1) Type or state of oil;
(2) Waste stream characteristics e.g., acid/caustic, high temperature; and
(3) Routine maintenance.

In designing the unit, the important wastewater characteristics to consider are:

(1) Presence or absence of emulsion;
(2) Coldest ambient temperature;
(3) Specific gravity of the oil and wastewater;
(4) Absolute viscosity; and,
(5) Amount of settleable solids.

For gravity separation, the rate of rise of oil globules is 0.1 fpm at the coldest ambient temperature expected. This rate varies according to the physical properties of the wastewater. A different rate can be used if the appropriate calculations are made. The API Manual (Reference No. 1) is the source document for these calculations.


STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
REGIONAL INDEX
CANADA
OREGON
PACIFIC OCEAN
VANCOUVER ISLAND
NORTHWEST REGION
4350 - 150th Avenue N.E
Redmond 98052
(206) 885-1900
SCAN Number 241-2610
CENTRAL REGION
3601 W. Washington
Yakima, WA 98903
(509) 575- 2491
SCAN Number 558-2491
EASTERN REGION
103 East Indiana
Spokane 99207
(509) 456-2926
SCAN Prefix 545
SOUTHWEST REGION
7272 Cleanwater Lane
Tumwater 98504
(206) 753-2353
SCAN Prefix 234
WHATCOM
SKAGIT
SNOHOMISH
CLALLAM
JEFFERSON
KITSAP
MASON
GRAYS HARBOR
THURSTON
PIERCE
PACIFIC
LEWIS
SKAMANIA
CLARK
OKANOGAN
CHELAN
DOUGLAS
KITTITAS
GRANT
YAKIMA
KLICKITAT
BENTON
FERRY
STEVENS
PEND OREILLE
LINCOLN
SPOKANE
ADAMS
WHITMAN
FRANKLIN
GARFIELD
WALLA WALLA
COLUMBIA
ASOTIN

The design criteria should normally be within the following limits:

(1) Horizontal velocity - 3 fpm or 15 times the rate of rise of the oil globules (whichever is smaller);
(2) Depth - 3 to 8 ft.;
(3) Depth to width ratio - 0.3 to 0.5;
(4) Width - 6 to 16 ft.;
(5) Baffle height to depth ratio - 0.85 for the top baffles and 0.2 for the bottom baffle.

If settleable solids are present, the design should include a settling basin upstream of the separator.

If the unit has been approved to receive storm waters, the rainfall frequency, intensity, and duration should be considered when designing the unit. The facilities should normally be designed to retain and effectively treat the storm waters from a 25-year storm. See Appendix II for rainfall intensity, duration and frequency curves.

Wastewater must enter through an inlet pipe. Wastewater entering the separator should be a laminar flow (not turbulent) to minimize emulsion of the oil. Pumps in the wastewater stream shall be installed downstream of the separator to prevent emulsification of the oil.

Do not use plastic pipe in association with steam cleaning operations or with high temperature wastewater. Plastic pipe, when used in these conditions, has been known to collapse.

Sealants used to seal the baffles should be compatible with the wastewater. The unit's effectiveness is destroyed if the oil or gas component of the wastewater breaks down the seals.

Access to the separator shall be unhindered at all times. Access and inspection covers should not weigh more than 30 lbs. They should have suitable hand holds. And, they should be located directly above the inspection "tee" and oil/grit collection compartment.

A schematic drawing of a gravity oil/water separator is shown in Exhibit A-I.

Example design calculations for a gravity oil/water separator are shown in Exhibit A-II.

Construction Materials

Tank - concrete, steel plate, or fiberglass

Baffles - concrete, steel plate, wood, or fiberglass

Piping - cast iron, steel, or plastic

Sealant - oil/solvent resistant

Operation and Maintenance

The owner/operator assumes full responsibility and liability for the proper and periodic maintenance and operation of the separator.

In the event of a spill, a separate holding tank should be provided to hold the spilled product.

Oil accumulation in the separator shall be checked at least once a week or more frequently as needed. If it exceeds three inches, the unit must be cleaned.

Close the effluent shut-off valve before removing waste oils or grit and before refilling the separator with clean water.

Following a cleanup of the separator, back-fill the separator with clean water to prevent oil carry-over to the clean well.

A maintenance log shall be kept, and shall be signed and dated when the separator is inspected or cleaned.

Oil residuals shall be recycled or disposed at an approved site. They shall be disposed in a manner that prevents them from reaching surface and ground waters.

Optional Features

Depending on site conditions and wastewater characteristics, the following features may be incorporated into the design of the oil/water separator to increase its operating efficiency and effectiveness.

- Bar screen
- Flow diffuser ports in distribution baffle
- Oil removal mechanism can be:
  - skimmer
  - slotted pipe
  - float-valves outlet
- Waste oil storage tank
- Electronic/conductivity oil sensing probe
- Automatic shut-off valves
- Warning light alarm
- Polishing filters - "absorbent sandwich" - in clear well
- Grit sump

Manufacturers/Suppliers of Ready-made Units

Locally Available

ATECO
1124 Elliott West
P.O. Box 9039
Seattle, WA 98119
206/281-5000

D. R. Shannon Co.
13130 - 44th Ave. So.
Seattle, WA 98168
206/246-4074

Evans Products
933 Westlake Ave. North
Seattle, WA 98109
206/283-1919

HARCO Manufacturing Co.
7700 S.W. 69th Avenue
P.O. Box 2344
Portland, OR 97223
503/244-7571

MARCO Pollution Control
2300 West Commodore Way
Seattle, WA 98199
206/285-3200

NALCO Chemical Co.
One Lake, Suite 108
Bellevue, WA 98004
206/453-8284

Utility Vault Company
P.O. Box 588
Auburn, WA 98002
206/839-3500

Northwest Power & Plant Equipment Co.
2366 Eastlake E. Suite 215
P.O. Box 12128
Seattle, WA 98102-0128
206/324-6880

Out-of-State

Aerodyne Development Corporation
24340 Miles Road
Cleveland, OH 44128
216/292-2828

AFL Industries, Inc.
3661 West Blue Heron Rd.
Riveria Beach, FL 33404
303/844-5200

Envirotech
WEMCO
P.O. Box 15619
Sacramento, CA 95813
206/444-7160

HYDE Products, Inc.
810 Sharon Drive
Cleveland, OH 44145
216/871-4885

Inland Environmental
2541 West Chicago Ave.
Chicago, IL 60622
312/342-0552

Lockheed Missiles & Space Co., Inc.
Organization 1554, Bldg. 150L
P.O. Box 504
Sunnyvale, CA 94088
408/742-8855

Oil Mop Inc.
P.O. Drawer P
Belle Chasse, LA 70037
504/394-6110

Oil Skimmers, Inc.
1803 W. Royalton Rd.
Cleveland, OH 44147
216/237-6181 & 6183

Pielkenroad Separator Co
P.O. Box 9637
Corpus Christi, TX 78408
512/882-3615 Telex: 767509

ROMICON, Inc.
100 Cummings Park
Woburn, MA 01801
617/935-7840

REFERENCES

1. "Oil-Water Process Design," API Manual on Disposal of Refinery Wastes, see volume on Liquid Wastes, Am. Petrol. Inc., New York. WDOE Library No. C-345-1.

2. "Construction Details of Gravity-Type Separators," API Manual on Disposal of Refinery Wastes, see volume on Liquid Wastes, Am. Petrol. Inst., New York. WDOE Library No. C-345-1.

3. "Effectiveness of Oil Separators," P. C. Blokker (1968), CONCAWE, Van Hogenhouklan 60, 2596 TE, Den Haag.

4. "Lagoons for Livestock and Poultry Wastes," Washington State University, Extension Bulletin 655, February 1975. WDOE Library No. C-696.

5. "Highway Hydraulic Manual," Washington State Department of Transportation, N23.01(HB). WDOE Library No. F-289.

EXHIBIT A-1

SCHEMATIC DRAWING OF GRAVITY OIL / WATER SEPARATOR

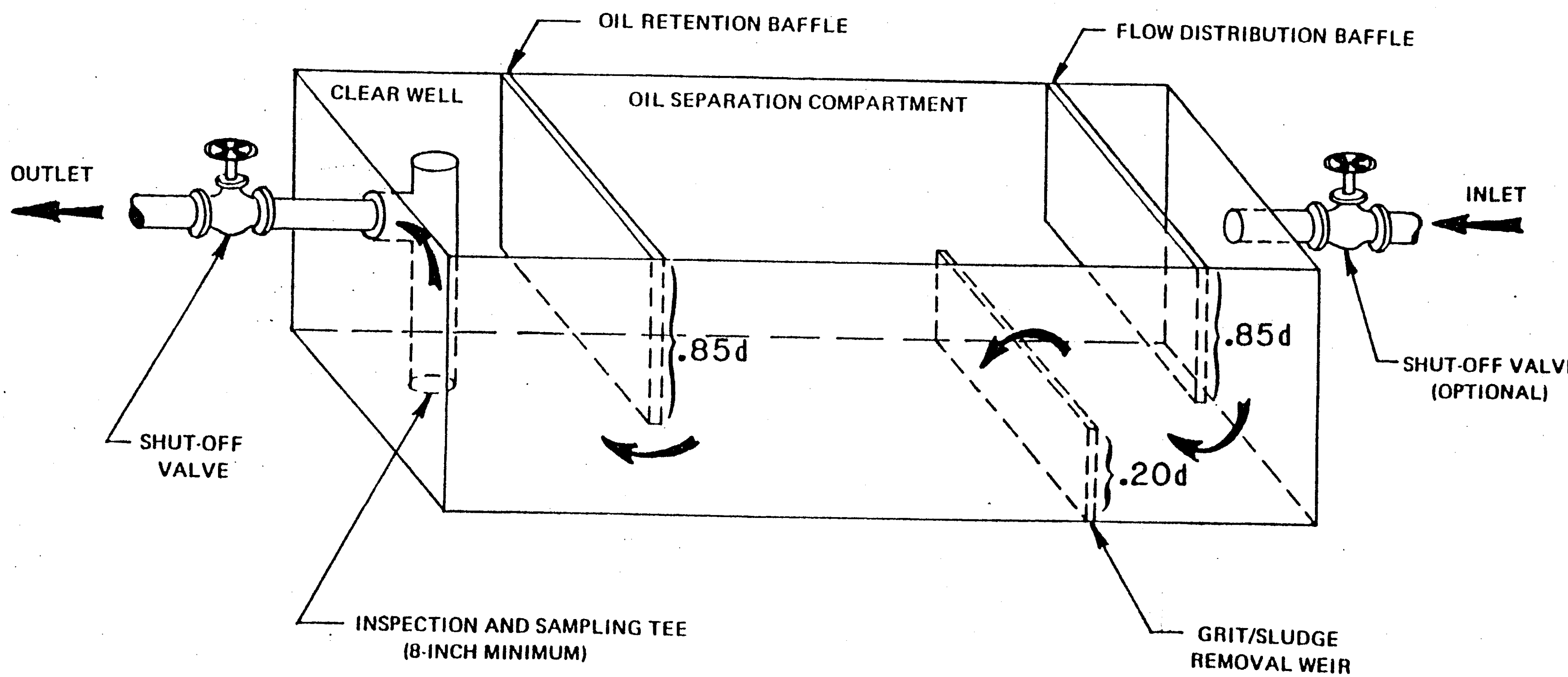


Exhibit A-II
Example Design Calculations
for an Oil/Water Separator

Calculate the size of separator needed to separate the oily residues in the storm water runoff from a paved, flat, one acre square collection area in Forks, WA.

First, determine the runoff in cubic feet per second (cfs) through the following equation: Q = CIA.

Explanation of Symbols

Q = runoff in cubic feet per second

Qm = runoff in cubic feet per minute

C = a rainfall runoff factor representing a ratio of runoff to rainfall - see Appendix I.

I = Average rainfall in inches per hour for a duration equal to the time of concentration - see Appendix II.

A = area in acres

Assumptions

Time of concentration is 14 minutes because of slope and shape of parking lot. See Appendix I.
Slope is .25%
Longest distance of travel is 295 ft.
(the hypotenuse of a square).

Rainfall frequency is 25 years.
Depth to width ratio is 0.5.
Horizontal velocity is 1.5 fpm (15 x 0.1 fpm).

Calculations

C = 0.9 (the runoff factor for a flat paved surface)

I = 2.65 (the 25-year rainfall intensity for 14 minute duration in Forks)

A = 1.0 (the size of the parking lot in acres)

Q = CIA

$$= \underset{C}{(0.9)}\ \underset{I}{(2.65)}\ \underset{A}{(1.0)}$$

= 2.39 cfs = 2.4 cfs

Qm = (2.4cfs) (60 sec/min) = 144 cfm

Then, calculate retention time of the separator through the following equation:
Rt = d/rate of rise

Explanation of Symbols

Rt = retention time

d = depth of separator minus "freeboard"

Calculations

$$Rt = d/\text{rate of rise} = \frac{7.0 \text{ ft.}}{0.1 \text{ ft./min}} = 70 \text{ min.}$$

Then calculate the length of the separator through the following equation:

$l = V_H\ Rt$

Explanation of Symbols

l = length in feet

Rt = retention time

V_H = Horizontal Velocity

Calculations

$$l = V_H\ Rt = (1.5)(70) = 105 \text{ ft.}$$

The dimensions of the separator are:

l = 105 feet
w = 14.0 feet
d = 8.0 feet (7.0 feet plus 1.0 feet of freeboard)

The top baffles should extend down 82 inches (.85d) from the top of the separator. The bottom baffle should rise 19 inches (.20d) from the bottom of the separator.

Note: The dimensions for a similar separator located in Port Angeles are:

l = 78 feet; w = 10.5 feet; and d = 6.2 feet

Then, calculate the depth of the separator through the following equation:
$d = (Qm/2V_H)^{1/2}$

Explanation of Symbols

w = width

d = depth in feet

Qm = volume in cubic feet per minute (cfm)

V_H = horizontal velocity through separator

Ac = cross-sectional area of the separator

Derivation of Equation

$Ac = Qm/V_H$

$Ac = wd = (2d)(d) = 2d^2$

Substituting into equation:

$2d^2 = Qm/V_H$

$d^2 = Qm/2V_H$

$d = (Qm/2V_H)^{1/2}$

Calculations

$d = (Qm/2V_H)^{1/2}$

$V_H = 15 \times \text{rate of rise}$

$= 15 \times 0.1$

$= 1.5$

$d = [144/(2)(1.5)]^{1/2}$

$= (144/3.0)^{1/2}$

$= 6.93 = 7.0$ ft.

$w = 2d$

$= 14.0$ ft

APPENDIX I

Runoff Factors

	Flat	Rolling 2% - 10%	Hilly Over 10%
Asphalt Pavement	0.90	0.90	0.90
Compact Gravel	0.50	0.55	0.90

Time of Concentration Tables

For asphalt paved collection areas:

Length (ft.)*	% Slope .25	.5	1.0	1.5	2.0	5.0
100	7	6	5	4	4	3
250	13	10	8	7	7	5
500	19	16	13	11	10	8
750	24	20	16	14	13	10
1,000	29	24	19	17	16	12
1,500	37	30	24	22	20	15

For compact gravel collection areas:

Length (ft.)*	% Slope .25	.5	1.0	1.5	2.0	5.0
100	13	11	9	8	8	6
250	24	20	16	14	13	10
500	37	30	24	22	20	15
750	47	38	31	28	25	19
1,000	56	45	37	33	30	23
1,500	71	58	47	43	38	29

*Length is measured as the longest distance in the collection area.

APPENDIX II

RAINFALL INTENSITY

DURATION - FREQUENCY

CURVES

INDEX TO RAINFALL CHARTS

	CHART NO.
-A-	
ieen	1
:	2
ra	37
ia Park	3
ortes	15
ngton	18
ord	2
-B-	
ngham	16
ne	15
erton	6
ster	29
geport	29
ley	2
ington	16
-C-	
ere	29
met	19
se Pass	31
erville	27
ralia	15
ialis	15
an	29
ey	34
ook Pass	31
llam Bay	2
kston	29
Elum	29
fax	29
lege Place	35
ville	30
crete	18
mos	18
lee City	28
lee Dam	29
-D-	
rington	22
enport	28
Deming	18
Diablo Dam	19
-E-	
Elbe	2
Ellensburg	24
Elma	2
Ephrata	27
Everett	18
Everson	17
-F-	
Ferndale	16
Forks	4
-G-	
Glacier	18
Gold Bar	18
Goldendale	27
Granite Falls	18
-H-	
Hamilton	18
Harts Pass	31
Hoquiam	1
Humptulips	5
-I-	
Ione	29
-K-	
Kelso	17
Kennewick	24
Kettle Falls	30
Kittitas	24
-L-	
LaConner	15
Lacrosse	27
Leavenworth	30
Lind	26
Long Beach	23
Longview	17
Lyman	18
Lynden	17
-M-	
Marblemount	18
Maryhill	29
Marysville	18
Mayfield	6
McCleary	2
Medical Lake	34
Morton	18
Moses Lake	26
Mossy Rock	18
Mount Baker	19
Mount Vernon	16
-N-	
Neah Bay	2
Newport	29
Nooksack	17
North Bend	18
North Bonneville	32
North Head	23
Northport	30
-O-	
Oak Harbor	15
Odessa	27
Okanogan	29
Olympia	7
Omak	29
Oroville	29
Othello	25
-P-	
Packwood	18
Palouse	29
Pasco	24
Pateros	29

INDEX TO RAINFALL CHARTS (cont.)

	CHART NO.
Patterson	25
Plymouth	25
Pomeroy	29
Port Angeles	8
Port Orchard	6
Port Townsend	9
Prosser	25
Pullman	29

-Q-

Quinault	3
Quincy	27

-R-

Raymond	20
Reardon	34
Renton	10
Republic	30
Ritzville	27
Rockford	34
Roosevelt	25
Rosalia	28
Roslyn	29
Ross Dam	19

-S-

Seattle	10
Seaview	23
Sedro Wooley	16
Sekiu	2
Sequim	11
Shelton	2
Shuksan	19
Skykomish	21
Snohomish	18
Snoqualmie	18
Snoqualmie Pass	33
Soap Lake	27
South Bend	20
Spokane	34

	CHART NO.
Sprague	27
Stanwood	18
Stevens Pass	31
Stevenson	32
Sultan	18
Sumas	17
Sumner	6

-T-

Tacoma	12
Tatoosh Island	13
Toledo	15
Tonasket	29
Toppenish	36
Twisp	29

-V-

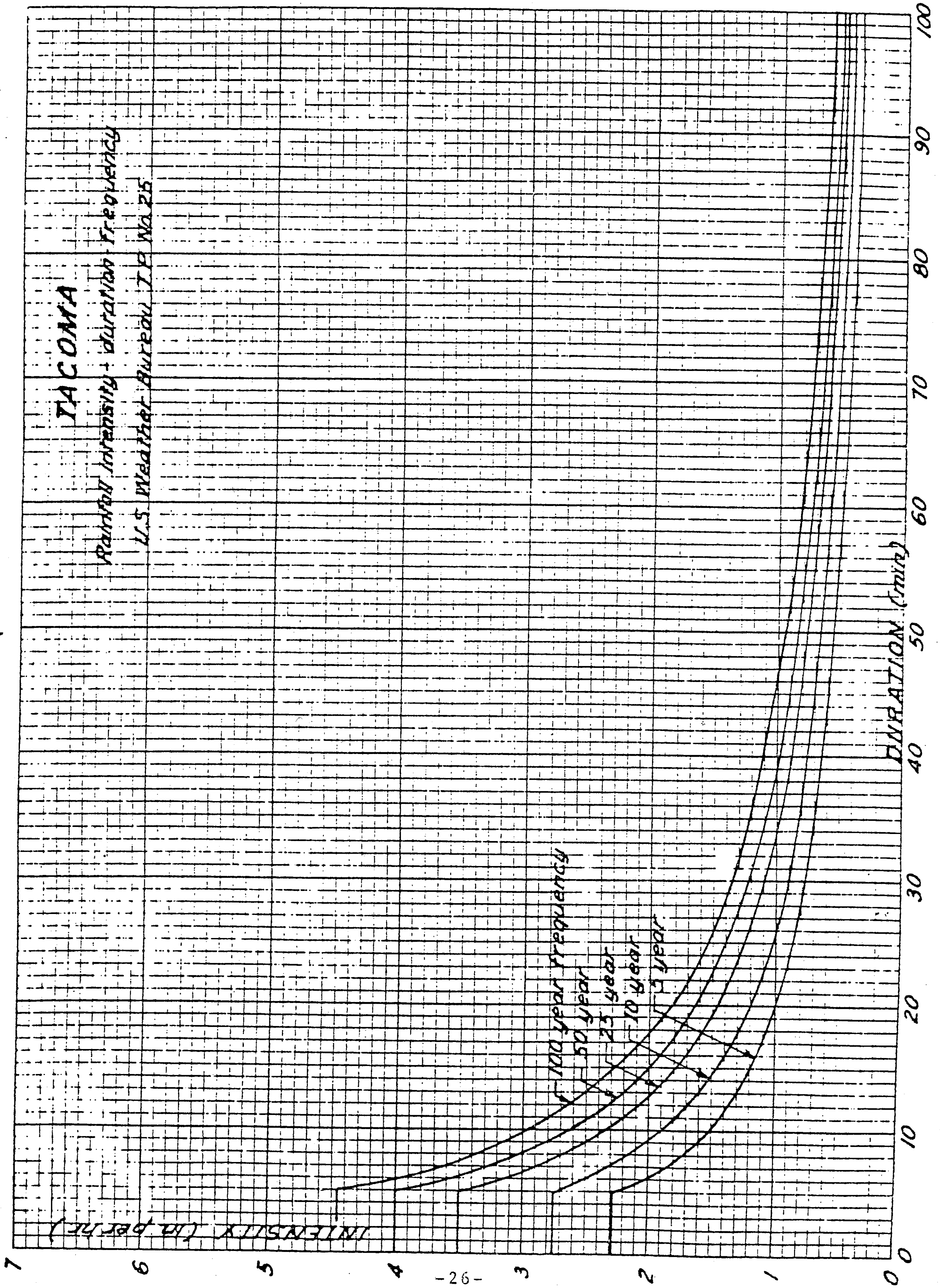
Vancouver	14
Vantage	25

-W-

Walla Walla	35
Warnick	18
Washtucna	26
Wenatchee	29
Westlake	26
White Pass	31
White Salmon	29
Wilbur	37
Winthrop	29
Woodland	18

-Y-

Yakima	36


TACOMA
Rainfall intensity-duration-frequency
U.S. Weather Bureau T.P. No. 25
100 year frequency
50 year
25 year
10 year
5 year
DURATION (min)
INTENSITY (in. per hr)
0
10
20
30
40
50
60
70
80
90
100
0
1
2
3
4
5
6
7