ENVIRONMENT CANADA

CONSERVATION AND PROTECTION

ENVIRONMENTAL PROTECTION

PACIFIC AND YUKON REGION

DATA REPORT

COMPUTER SIMULATIONS OF THE USE OF DIFFUSERS TO REDUCE THE TOXICITY OF CONTAMINATED STORM WATER RUNOFF FROM TREATED LUMBER STORAGE YARDS.

REGIONAL DATA REPORT DR-88-02

BY

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APPENDICEES

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1.0 SUMMARY OF THE USE OF DIFFUSERS TO REDUCE THE TOXICITY OF CONTAMINATED STORM WATER EFFLUENT.

There are several benefits and costs from using diffusers to reduce the acute toxicity of stormwater runoff from surface treated lumber storage yards. This data report will outline the general criteria based on average but realistic conditions which can be experienced at sawmill and lumber storage yards (terminals) in British Columbia. (It will not attempt to highlight any other topics such as source control) The conditions outlined are to serve as a guide to the discussion of stormwater control mechanisms.

Benefits

- Chlorophenols are slow to biodegrade/photodegrade in the natural aquatic environment, can bioaccumulate and contain trace contamination of dioxins and furans. These chemicals are scheduled for phase out and diffuser systems which are installed to reduce the acute toxicity of chlorophenols will also work for chemicals which will be replacing them.

- The dispersion through a diffuser system will likely increase the opportunities for photo degradation and possibly biodegradation.

- The diffusers would reduce the acutely toxic zones of the effluent plume by dispersion of effluent into the receiving water column.

Costs

- Diffusion will not satisfy the intent of section 33.2 of the Federal Fisheris Act which prohibits the discharge of a substance deliterious to fish.

- The diffusion of contaminated runoff will not reduce the total loading of chemical to the receiving environment.

- There is limited knowledge at present as the long term effects of the replacement chemicals and there breakdown products. The large scale discharge of these chemicals may pose an unacceptable risk to the environment.

- Most mills/terminals cannot afford to dedicate any yard surface area to the construction of holding ponds to regulate flow. A diffuser system would require the installation of a storm sewer collection system which directs storm water from a paved yard surface to a pumping station. The pumping station(s) would require a minimum 10 year and possibly a 20-25 year storm design.

- Pump stations will require a level activated system and a pump capable of discharging the effluent under pressure during high runoff and high tide conditions.

- In river systems such as the Fraser where siltation is a problem a second flushing line feeding river water through the pump/diffuser system will be required. This flushing will be required on a daily interval during periods of dry weather. The flushing is necessary to keep the lines and diffuser ports clear of silt.

- In tidal influenced rivers such as the lower Fraser the tides will have negative affects on plume dispersion and concentration. During the initial and final periods of a storm event when runoff concentrations peak several orders of magnitude there will be shock loads to a stagnant flow regieme that occurs at high tide. Extended acutely toxic zones are likely to occur under these conditions. Addition of river water to the discharge effluent may be required to achieve dilution.

- Under certain tidal conditions and rain events the plumes of previous discharges may wash back and forth with the tide producing additive effects to the new discharges.

- In areas where there are adjacent mills and/or pump stations the plumes may impinge on each other and produce additive effects.

2.0 STORM DESIGN CRITERIA

A "10 Year Storm" was the minimum design criteria for estimating the affects of using diffusers to dilute runoff from treated lumber storage yards. This criteria states that "there is a 100% probability that a storm of this magnitude (or greater) will occur at least once every 10 years. The volume of runoff to be treated/diffused was assumed to be from 116 mm of rainfall per 24 hour period. This is a rounded average of the 10 year storm values of Vancouver Harbour and Squamish B.C. (1)

2.1 Lumber Storage Yard Design Criteria.

The lumber storage yard was assumed to be 22,370 square meters surfaced with blacktop paving and serviced by an underground storm sewer system capable of handling a 10 year storm flow. (See Figure 1) This is the average yard size of sawmill storage yards in the B.C. Lower mainland area. (2) A 10 year storm of 116 mm/day will generate an average flow of 30 L/s which is directed to a pump station capable of delivering this flow through a diffuser system. A minimum flow velocity of 0.75 m/s is required to prevent deposition and clogging of the pipe system. (3) The discharge pipe diameter required is 0.226m and the diffuser pipe will lie at the bottom of the river at a depth of 5.1m at low tide and 7.0 m at high tide. (4) The diffuser system will lie at 90 degrees to the current flow and will consist of three diffuser ports spaced three meters apart. Each diffuser port will angle 20 degrees from the horizontal and point in the normal downstream direction. The diffuser ports will be circular in shape and 0.130 m in diameter. (Assuming the discharge is to the lower Fraser River at Mitchell Island the diffuser ports will point downstream to produce maximum diffusion during the lower river velocity that occurs when tidal action reverses river flow.)

The high sediment load of the Fraser River is likely to cause siltation and clogging of the diffusers which would be inactive during prolonged periods of dry weather. An intake line which draws river water and pumps it through the diffusers at regular intervals may be required to overcome this problem.

2.2 River Flow Criteria

The lower 90 to 110 km of the Fraser River is affected by tidal action. The river level will vary 2.0 m or greater during a tidal cycle depending on weather conditions, river flow volume and distance upstream. During a high tide the river will reverse flow in all areas of the lower reaches from Steveston upstream to New Westminster. A salt water wedge up to 2.0 meters deep may intrude as far up river as the Annacis Island Sewage treatment plant. (5) The range of flow velocities in the various arms of the lower delta is from 0.0 - 3.6 m/s. (5) (See Table 1)

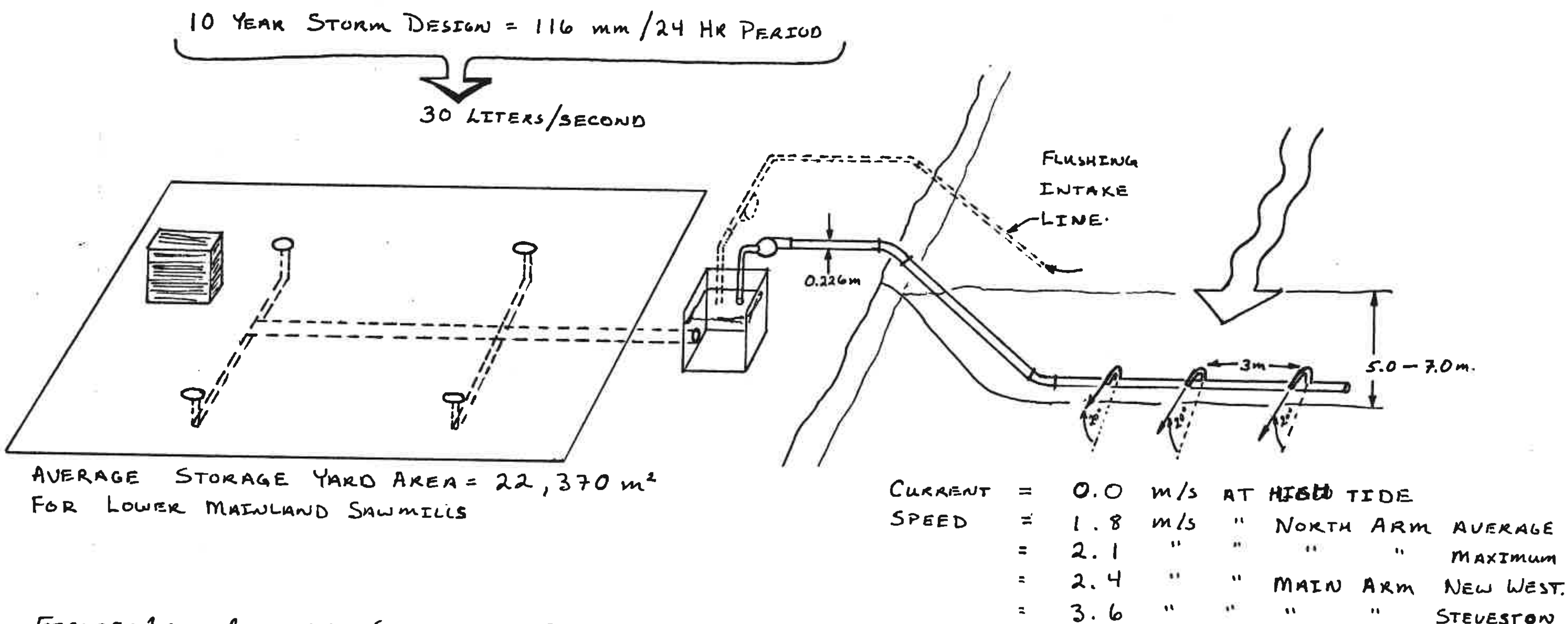


FIGURE: 1: AVERAGE SAWMILL, RAINFALL AND RIVER CONDITIONS

Table 1: Average River Velocities in the Fraser River from New Westminster to Steveston.

Current Speed	Location
0.0 m/s	All areas at slack high/low tide
1.8 m/s	North Arm average velocity
2.1 m/s	North Arm maximum velocity
2.4 m/s	Main Arm, New Westminster
3.6 m/s	Main Arm, Steveston

3.0 Discharge Simulations

All discharge simulations were made using the United States Environmental protection Agency (USEPA) plume dispersion model called "UMERGE". (9) The model "analyzes a positively bouyant discharge by tracing a plume element through its trajectory and dilution. Conditional controls rather than conceptual limitations, prevent analysis of negatively bouyant discharges. UMERGE is a two-dimensional model which accounts for adjacent plume interference and which accepts arbitrary current speed variations with depth" (9) Further criteria and assumptions are detailed in reference #9 and Appendix I.

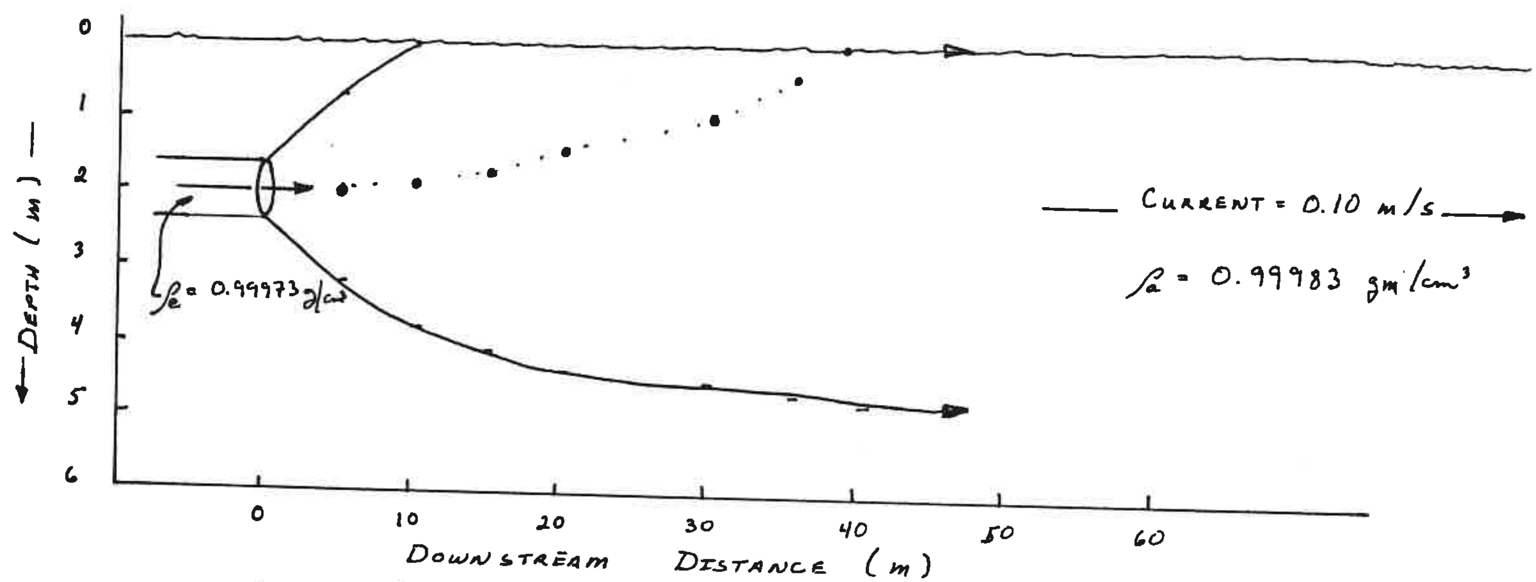
3.1 Stormwater Discharged from a Single, Open Sewer Pipe to a Near Surface Flow Regieme.

The effect of a single storm sewer pipe under tidal influence was simulated to contrast the flow regiemes produced by a diffuser system. An open sewer pipe or a pipe with a tide gate will not produce any flow during a storm event when the river level is above the head (elevation) of the pipe. When the tide ebbs enough to allow the airlock to release in the pipe, or , the head upstream of the pipe is sufficiently above the river level flow through the pipe will occur in the form of a large flush. (10) Figure 2 shows the affect of 0.340 $m3/s$ flow from a round pipe into a slow river velocity of 0.10 m/s at the start of an ebb tide. The runoff is assumed to have a temperature of 2 C higher than the river water which gives the plume bouyancy to rise to the surface. Colder plumes may trap below the surface or sink depending on the temperature differential. Appendix II details the simulation data.

Current operating practices at sawmills which apply all the requirements of the report "Chlorophenate Wood Protection, Recommendations for Design and Operation" (the Code) will produce a minimum effluent concentration of 500 parts per billion (ppb) of chlorophenols (6) or 2-(thiocyanomethylthio)-benzothiazole (TCMTB). (7) The 96 Hr Lethal Concentration of chlorophenols is 30 ppb (8) and 20 ppb for TCMTB.

Figure 2 shows that a dilution of 24X the original effluent concentration is reached within 40 meters of the discharge. The discharge will produce a plume of water 30-40 m long and up to 8 m in diameter which contains 670 m3 of habitat from which fish would be excluded during a storm event. If the drainage were to originate from a storage yard that contains rough lumber discharging at 1000-1200 ppb the plume would be acutely toxic at 20 - 30 m downstream.

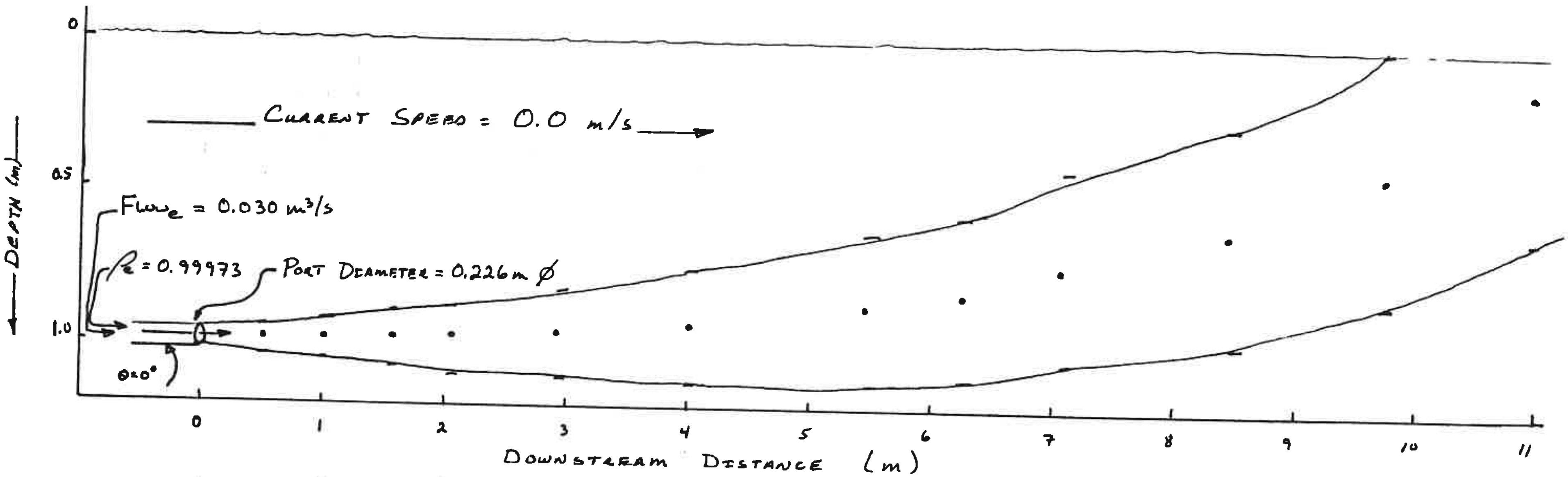
3.2 Stormwater Discharged from a Single Diffuser to a Near Surface, Stagnant Flow Regime.



DILUTION	1 X	6 X	12 X	16X	18X	24 X
CONCENTRATION (PARTS PER BILLION)	500 **15**	83 **2.5**	42 **1.25**	31 **0.94**	28 **0.83**	21 **0.625**
	1000	166	84	62	56	42
	1200	200	100	75	67	50
	10000	1660	840	640	560	420
PLUME VOLUME (CUBIC METERS)	0		112		670	

FIGURE #2: PLUME OF STORMWATER DISCHARGED FROM A SINGLE OPEN SEWER PIPE TO A NEAR SURFACE FLOW REGIEME.

A single diffuser port of 0.226m diameter is required to deliver 0.030 L/s of flow from the average sawmill storage yard to a receiving river system under 10 year storm conditions. Figure 3 shows the simulation of such a discharge to the 1.0 m surface zone of the Fraser River at slack tide. The plume was found to surface within 11m of the discharge and achieve a 21X dilution of the original effluent. Appendix III details the simulation data.



Dilution	1.0X	1.7X	4.5X	6.0X	8.0X	10.6X	12X	14X	16X	18X	21X
Concentration (Parts Per Billion)	100	59	22	17	13	9	8	7	6	6	5
	500	294	111	83	63	47	42	36	31	28	24
	1000	588	222	166	126	94	84	72	62	56	48
	10,000	5880	2220	1660	1260	940	840	720	620	560	480
Plume Volume (Cubic Meters)	0			1.5				18			64

Figure 2: Plume of Stormwater Discharged from a Single Port Under Pressure To a Near Surface Flow Regime.

4.0 Stormwater Discharged from a Multiple Port Diffuser

Three diffuser ports of 0.13m diameter are required to deliver a 30 L/s flow generated by 10 year storm conditions. All of the following simulations will use this diffuser design.

4.1 Stormwater Discharged from a Multiple Port Diffuser Through a 2m Salt Water Wedge.

At locations downstream of the north end of Annacis Island the diffuser plumes must rise through a (semi-diluted) 2 m layer of saltwater. For the purposes of a simulation the salt water wedge is assumed to be partially diluted with fresh river water and has a density of 1.01500 gm/cm3. A 5.7 m layer of freshwater will lie above the saltwater at high slack tide. Figure 4 shows that the low density effluent plume will rise rapidly within the first two meters of downstream distance and then trap at the salt water/freshwater interface with a 12 X dilution. The trapping is believed to result from the entrainment of heavier saltwater in the effluent plume. Dilution of the effluent is rapid during the plume rise and then minimal after the trapping level is reached. This would likely result in the formation of a poorly diluted cloud around the diffuser. Appendix III details the simulated data.

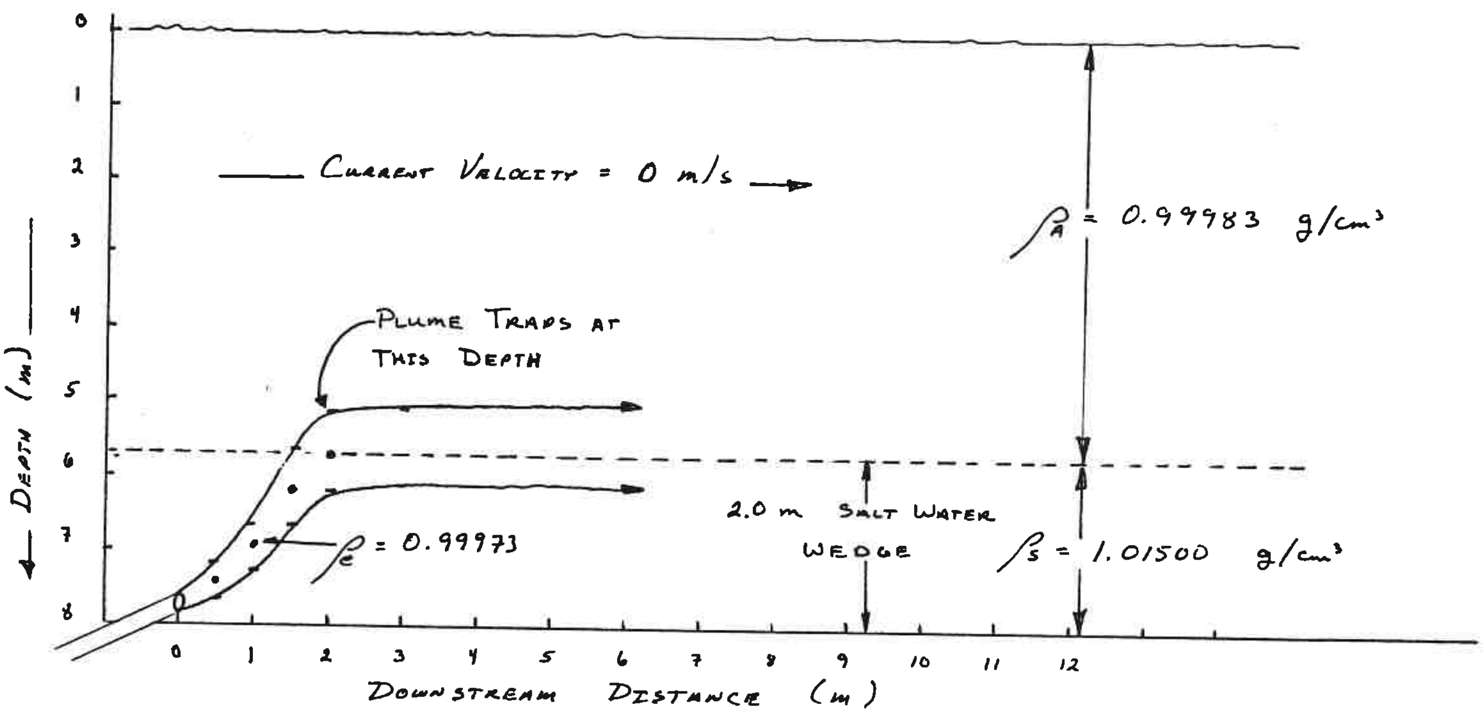
Figure 5 shows that when the diffuser is located above the salt water wedge that trapping is avoided and that dilution reaches 33 X before the system stabilizes. Appendix V details the simulated data.

4.2 Stormwater Discharged from a Multiple Port Diffuser through 7.7m of River Water.

In the absence of a saltwater wedge the average depth of fresh water in the North Arm of the Fraser River at high slack tide will be 7.7m. Figure 6 shows the effluent plume discharging from the design configuration through 7.7m of water. The extra 2m depth over that in Figure 5 allows the plume to surface 2m further downstream (ie. 13-14 m from the discharge pipe) and achieve a dilution of 39.5 X. This will result in reducing a 500 ppb and 1000 ppb initial effluent concentration to 30 ppb within 5 - 6m and 11 - 12m respectively of the discharge. Appendix VI details the simulated data.

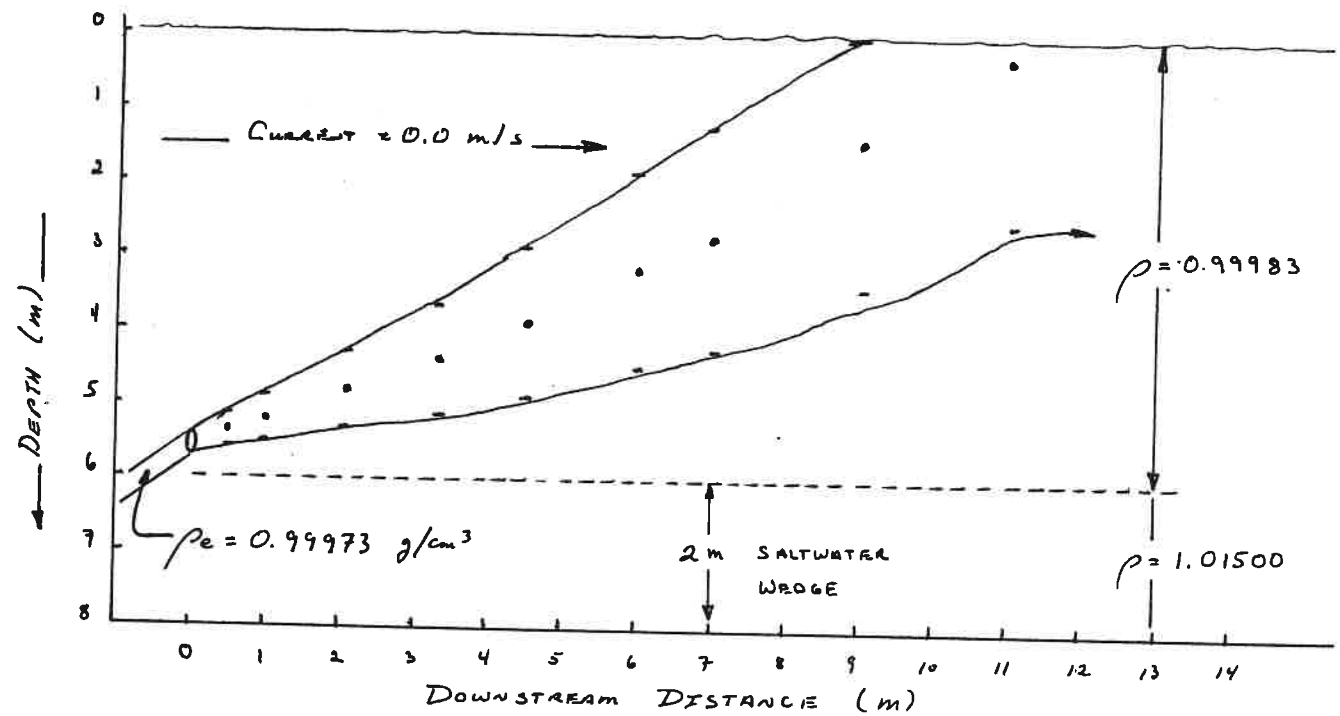
~~3.5~~ 4.3 Stormwater discharged from a Multiple Port Diffuser through 5.1m of Water Flowing at 1.8 m/s.

The average river velocity of 1.8 m/s in the North Arm of the Fraser River will occur at low tide when the water depth has reached 5.1m. There will be no salt water wedge to influence the plume density. Figure 7 shows that the plume will experience a



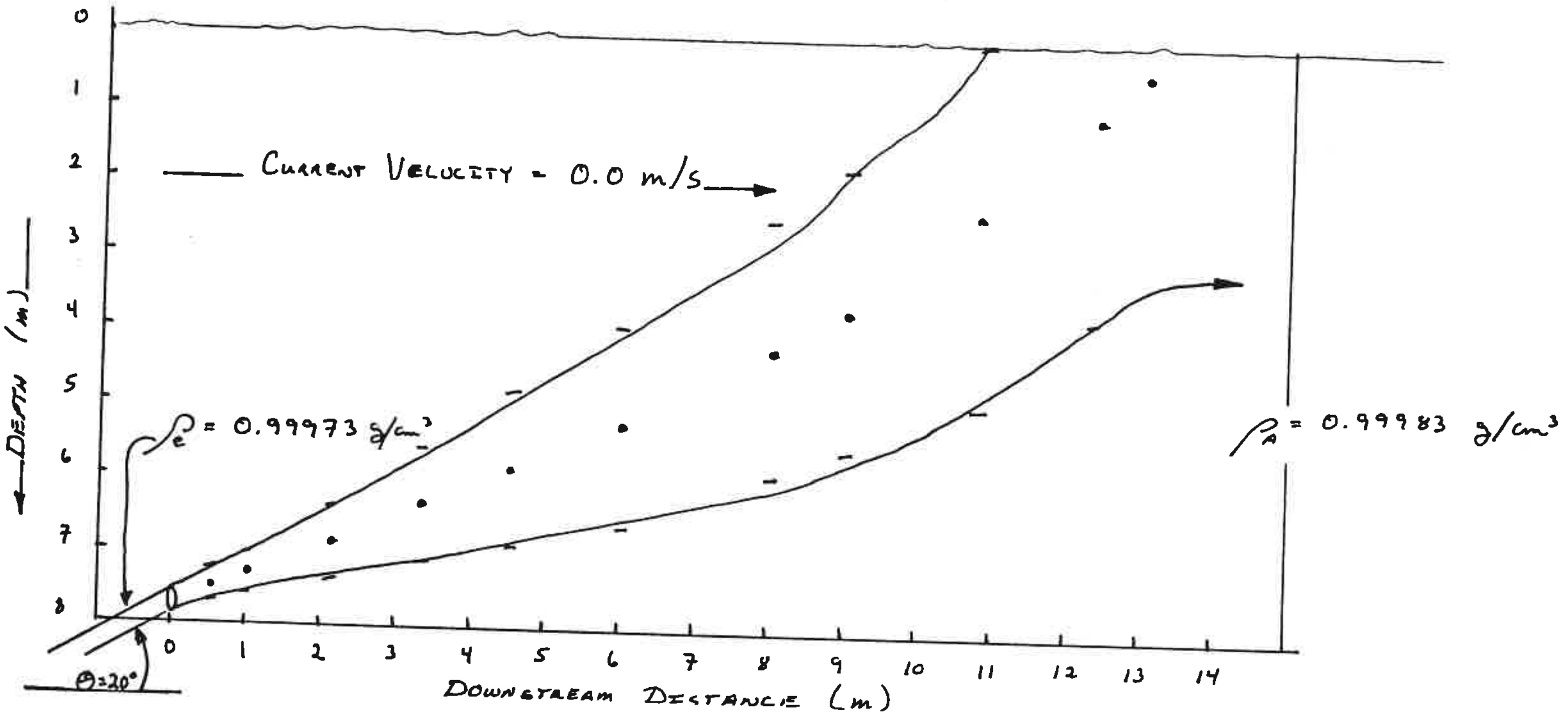
DILUTION	1X	5X	12X →
CONCENTRATION (PARTS PER BILLION)	500	96	42 → NO SIGNIFICANT
	1000	192	83 → DILUTION
	10,000	1920	833 → OCCURS.
PLUME VOLUME (CUBIC METERS)	0		3.1

FIGURE 4 : PLUME OF STORM WATER DISCHARGED FROM 3 PORTS (ONE PORT SHOWN) THROUGH A 2.0 m SALTWATER LAYER TO A FRESH WATER LAYER AT HIGH SLACK TIDE.



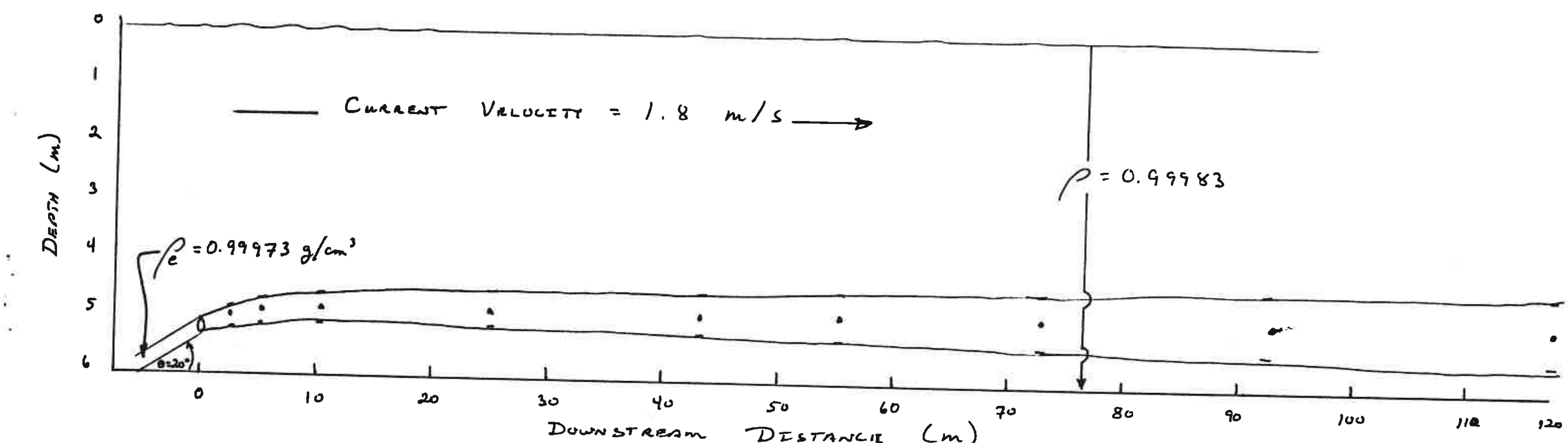
Dilution	1	4X	7X	11X	14X	21X	24X	30	33
Concentration (Parts Per Billion)	500	125	71	47	36	24	21	16	15
	1000	250	142	94	72	48	42	32	30
	10,000	2500	1420	940	720	96	420	320	300
Plume Volume (m^3)	0 (x 3 ports)				4.7 (14.1)		16.5 (49.5)		61 (183)

Figure 95 Plume of Stormwater Discharges from 3 Ports (One Port Shown) Above a 2.0 m Saltwater Wedge



Dilution	1X	4.5X	8X	12X	16X	21X	27X	34X	39.5X
Concentration Parts Per Billion	500	111	62.5	42	31	24	19	15	13
	1000	222	126	84	62	48	38	30	26
	10000	2220	1260	840	620	480	380	300	260
Plume Volume (m³)	0 (x 3 ports)			2.0 (6.3)			25.6 (77)		103 (309)

Figure 6: Plume of Storm Water Discharges From 3 Ports



Dilution	1	22	38	64	76	91	108	127
Concentration (Parts Per Billion)	500	23	13	8	7	6	5	4
	1000	46	26	16	14	11	10	8
	10,000	460	260	160	140	110	100	80
Plume Volume (m³)	0 (x 3 ports)		1.3 (3.9)		2.2 (6.6)	19 (56)		25 (75)

Figure 7: Plume of Storm Water Discharges from 3 Ports (One Port Shown) at Low Tide and River Current Velocity at 1.8 m/s

very slow rise to the surface as it is washed downstream by the current. A dilution of 22 X will be reached within 10m of the outfall which will reduce the 500 ppb and 1000 ppb initial concentrations to 23 ppb, and 46 ppb respectively. Appendix VII details the simulated data

REFERENCES

1) Environment Canada, Atmospheric and Environmental Services, Vancouver Airport Weather Station, 1986

2) Krahn, P.K., Unpublished data, Environmental Protection, Environment Canada, Pacific and Yukon Region, 1988

3) Grace, R. A., " Marine Outfall Systems, Planning, Design and Construction", Prentice - Hall Inc., Englewood Cliffs, New Jersey 07632, ____

4) Marine Charts

5) Al Ages, Personal Conversation, Institute of Ocean Sciences, Sidney B.C., 1988

6) Krahn, P.K., Shrimpton, J.A., Glue, R.D., "Assessment of Storm Water Related Chlorophenol Releases from Wood Protection Facilities in British Columbia." Environmental Protection - Conservation and Protection, Regional Program Report 87-14, 1987

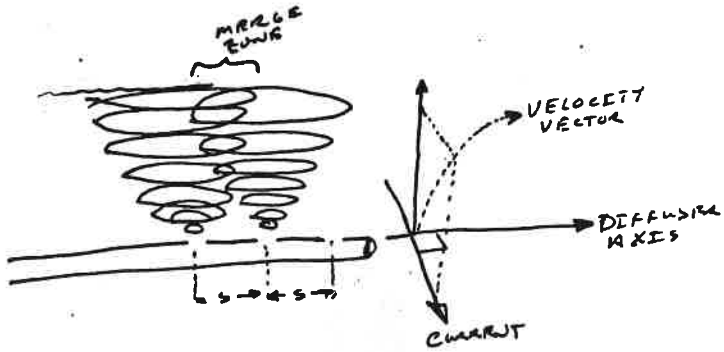
7) MacMillan Bloedell, Unpublished

8) Code of Practice

9) USEPA - Plume Model Programs.

APPENDIX I

UMERGE : THERØRETICAL DEVELOPMENT



UMERGE

Theoretical Development

The model UMERGE analyzes a positively buoyant discharge by tracing a plume element through the course of its trajectory and dilution. Conditional controls, rather than conceptual limitations, prevent analysis of negatively buoyant discharges. UMERGE is a two-dimensional model which accounts for adjacent plume interference and which accepts arbitrary current speed variations with depth. Diffuser ports are assumed to be equally spaced and may be oriented at any common elevation angle. The current is assumed to be normal to the diffuser axis and the discharge velocity vector is assumed to be in the plane formed by the current direction and the vertical axis.

The basic plume equations are summarized as follows

$$dm/dt = \text{entrainment (Taylor hypothesis + forced continuity)} \quad (60)$$
$$d(mu)/dt = u_o(dm/dt) \text{ (conservation of horizontal momentum)} \quad (61)$$
$$d(mv)/dt = (\Delta\rho/\rho)mg \text{ (vertical momentum)} \quad (62)$$
$$d(mT)/dt = T_o(dm/dt) \text{ (conservation of temperature)} \quad (63)$$
$$d(mS)/dt = S_o(dm/dt) \text{ (conservation of salinity)} \quad (64)$$

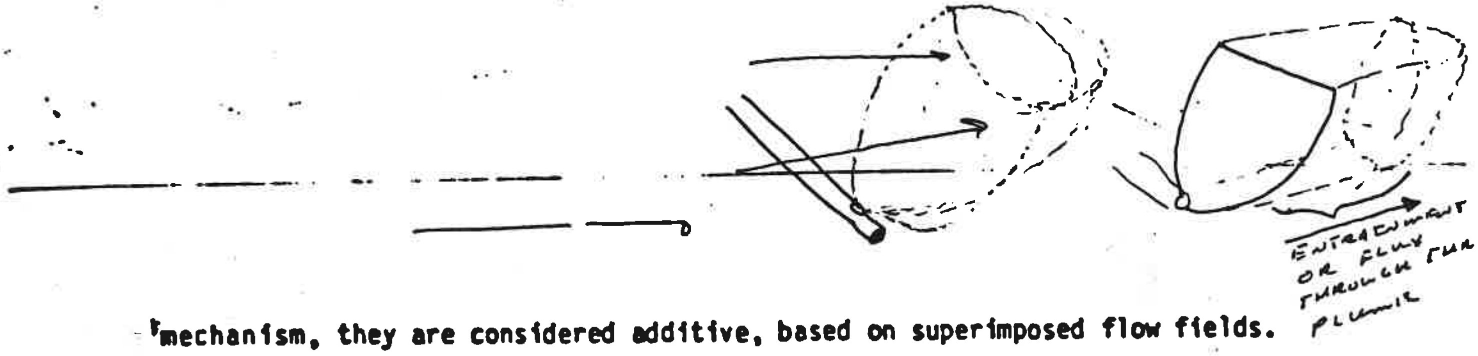
$$\Delta h/(u^2+v^2)^{1/2} = \Delta h_i/(u_i^2+v_i^2)^{1/2} = \text{constant} \quad (65)$$

where

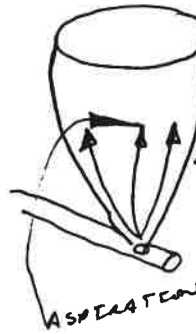
i = initial conditions
o = ambient conditions.

Equation (65) transforms the integral flux plume equations to their Lagrangian counterparts. Also required is an equation for density (subroutine SIGMAT) as a function of temperature and salinity (U.S. Navy Hydrographic Office 1952). The equations are integrated with respect to time.

Forced and aspiration entrainment (Taylor hypothesis, see Morton et al. 1956) are handled in much the same way as in UOUTPLM. However, rather than considering the larger of the two components as being the operative



mechanism, they are considered additive, based on superimposed flow fields. In the absence of a current, entrainment is due solely to aspiration. At moderate current levels, entrainment is from both mechanisms but aspiration is somewhat reduced in the lee of the plume. In the presence of higher currents, entrainment is largely forced (Frick 1981, 1984).



The merging equations are based on purely geometric considerations. The mass of overlapping portions of adjacent plumes is redistributed by increasing the normal dimensions of the plumes, and entrainment is adjusted accordingly.

Assumptions inherent in the model formulation include

- Exchange between adjacent plumes does not change the average properties of a plume element (mirror imaging) but does affect the plume radius
- The model calculates average plume properties
- The ambient fluid is largely undisturbed by the presence of the plume
- No net pressure forces are exerted on the plume by the ambient and adjacent plume elements exert no net force on each other
- Energy and salinity are conserved
- Specific heat is considered to be constant over the range of temperatures observed in the system
- In addition to entrainment by aspiration, all fluid impinging on the projected area of the plume is entrained

- Current direction is assumed to be normal to the diffuser axis

- The plume boundary encloses all the plume mass.

Model Description

Entrainment is considered as the mass flowing through the projected plume area plus the aspirated quantity. While the concept is simple, the computation for the projected plume area is complex and the reader is referred to Frick (1984) for further development. The changes in mass (Δm) and time (Δt) are scaled internally by the model, allowing for a variable time step. This feature shortens execution time, important when using microcomputers or when using the program to optimize a design. The new plume element average horizontal velocity, temperature, and salinity are calculated using weighted averages of both the element and entrained masses. In calculating the vertical velocity, the effect of buoyancy is taken into account.

The subsequent position of the plume element is found by multiplying the new element velocity by the time increment and adding to the previous coordinates. The length of the plume element changes during each time increment due to the velocity gradient between the two faces of the element. Elongation, or contraction, can be estimated by comparing the element velocities between iterations. The effect of merging is estimated by distributing the overlapping mass to other portions of the plume, calculating the resulting changes in the element radius, and by adjusting entrainment terms.

Once all plume properties have been calculated for a given time step, the iteration process begins anew until the vertical velocity becomes negative (maximum rise), the surface is reached, or the maximum number of specified iterations is exceeded.

ULINE

The model ULINE is based on Roberts' (1977) uniform density flume experiments and is a generalization of Roberts' (1979b) discussion of dilution

APPENDIX II

SIMULATION DATA OF STORMWATER DISCHARGED FROM A SINGLE OPEN SEWER PIPE TO A NEAR SURFACE FLOW REGI~~E~~ME

```
TI' LE :        STRM PLUME 0.34 CU/S 1 PRT 1M
1.   TOTAL DISCHARGE FLOW (CU.M/S)              :              .34
2.   NUMBER OF PORTS                            :              1
3.   PORT DIAMETER (M)                          :              .76
4.   PORT VERTICAL ANGLE (DEG.)                 :              0
5.   PORT DEPTH (M)                             :              2
6.   HOR.CURRENT SPEED (M/S)(UOUTPLM ONLY):                    0
7.   ANGLE OF CURRENT TO DIFFUSER (DEG.)        :              90
8.   DISTANCE BETWEEN ADJACENT PORTS (M)        :              5
9.   MAXIMUM NUMBER OF ITERATIONS               :              5000
10   ITERATION PRINTOUT FREQUENCY               :              20
11.  NO MORE CHANGES

AC EPTABLE (Y/N) ?

1

 UNIVERSAL DATA FILE: PETER1

 *********************************************************
      NOTE, THIS IS THE ORIGINAL FILE.                   *
 *    IT DOES NOT REFLECT CHANGES MADE INTERACTIVELY.    *
      THOSE CHANGES ARE SHOWN IN THE OUTPUT HEADING.     *
 *********************************************************

STRM PLUME 0.34 CU/S 1 PRT 1M
: 1,1,0,0,0,0,0,
.34,1,.76,0,2,
0,90,5,
( 5000,20,0,0,0,0,0,0,0,0,0,0,0,
: .99973,0,
0,.99983,0,.1,
: .99983,0,.1,
1 JMERGE VERSION 1.0 AUGUST 1985.
 ................. ................. ................. .................
 UNIVERSAL DATA FILE: PETER1
 CASE I.D. STRM PLUME 0.34 CU/S 1 PRT 1M
 RUN TITLE:  RUNONE

 ASPIRATION ENTRAINMENT COEFFICIENT    =        .10    (DEFAULT)
 NUMBER OF STEPS ALLOWED               =   5000
 ITERATION PRINTOUT FREQUENCY          =     20
 PRINT ARRAY AA (O=NO, 1=YES)          =      0        (DEFAULT)
 PRINT ARRAY AB (O=NO, 1=YES)          =      0        (DEFAULT)
 PRINT ARRAY AC (O=NO, 1=YES)          =      0        (DEFAULT)
```

INITIAL DENSITY OF THE PLUME = -.2700 SIGMAT UNITS
FROUDE NUMBER = 27.4

DEPTH (M)	SIGMAT	U (M/S)
.00	-.17	.100
2.00	-.17	.100

TOTAL EFFLUENT FLOW = .3400 CMS
NUMBER OF PORTS = 1
PORT DIAMETER = .7600 M
PORT SPACING = 1000.0 M(DEFAULT)
VERTICAL PORT ANGLE FROM HORIZONTAL = .0 DEGREES
PORT DEPTH = 2.00 M

FIRST LINE OF OUTPUT ARE INITIAL CONDITIONS

X (M)	Z (M)	PLUME DIAMETER (M)	DILU- TION	DENDIFF (SIGMAT)	HORIZ VEL (M/S)	VERT VEL (M/S)	TOTAL VEL (M/S)	AMBIENT CURRENT (M/S)
.00	2.00	.760	1.00	.10	.75	.00	.75	.100
.02	2.00	.763	1.01	.10	.74	.00	.74	.100
.29	2.00	.862	1.15	.09	.67	.00	.67	.100
.61	2.00	.979	1.32	.08	.59	.00	.59	.100
.98	2.00	1.111	1.52	.07	.53	.00	.53	.100
1.40	2.00	1.259	1.74	.06	.47	.00	.47	.100
1.88	2.00	1.424	2.00	.05	.42	.00	.42	.100
2.42	1.99	1.608	2.30	.04	.38	.00	.38	.100
3.05	1.99	1.812	2.64	.04	.35	.00	.35	.100
3.76	1.98	2.039	3.03	.03	.31	.00	.31	.100
4.57	1.98	2.288	3.48	.03	.29	.00	.29	.100
5.50	1.96	2.563	4.00	.03	.26	.00	.26	.100
6.56	1.95	2.865	4.59	.02	.24	.00	.24	.100
7.78	1.92	3.194	5.28	.02	.22	.00	.22	.100
9.18	1.89	3.553	6.06	.02	.21	.01	.21	.100
10.80	1.85	3.942	6.96	.01	.19	.01	.19	.100
12.68	1.79	4.364	8.00	.01	.18	.01	.18	.100
14.86	1.71	4.819	9.19	.01	.17	.01	.17	.100
17.41	1.61	5.309	10.55	.01	.16	.01	.16	.100
20.40	1.47	5.836	12.12	.01	.15	.01	.15	.100
23.89	1.28	6.400	13.93	.01	.15	.01	.15	.100
27.84	1.04	7.004	16.00	.01	.14	.01	.14	.100
32.19	.74	7.651	18.38	.01	.14	.01	.14	.100
36.90	.40	8.341	21.11	.00	.13	.01	.13	.100

COMPUTATIONS CEASE: PLUMES SURFACE

PLUMES DID NOT MERGE OR TRAP
DILUTION = 24.21

APPENDIX III

SIMULATION DATA OF STORMWATER DISCHARGED FROM A SINGLE PORT UNDER PRESSURE TO A NEAR SURFACE FLOW REGIEME

```
TI LE :        STRME PLUME 1 PRT 1 M
1.  TOTAL DISCHARGE FLOW (CU.M/S)              :          .03
2.  NUMBER OF PORTS                            :          1
3.  PORT DIAMETER (M)                          :          .226
4.  PORT VERTICAL ANGLE (DEG.)                 :          0
5.  PORT DEPTH (M)                             :          1
6.  HOR.CURRENT SPEED (M/S)(UOUTPLM ONLY):                0
7.  ANGLE OF CURRENT TO DIFFUSER (DEG.)        :          90
8.  DISTANCE BETWEEN ADJACENT PORTS (M)        :          5
9.  MAXIMUM NUMBER OF ITERATIONS               :          5000
1C  ITERATION PRINTOUT FREQUENCY               :          20
11. NO MORE CHANGES

AC EPTABLE (Y/N) ?
```

PC NT	DEPTH(M)	DENSITY(G/CM3)	CURRENT(M/S)
1	0	.99983	0
2	1	.99983	0

```
AC EPTABLE (Y/N) ?

1

 JNIVERSAL DATA FILE: PETER1

 ***********************************************************
 *    NOTE, THIS IS THE ORIGINAL FILE.                     *
 *    IT DOES NOT REFLECT CHANGES MADE INTERACTIVELY.      *
 *    THOSE CHANGES ARE SHOWN IN THE OUTPUT HEADING.       *
 ***********************************************************
```

```
1,1,1,0,0,0,0,0,
.03,1,.226,0,1,
C 90,5,
0,5000,20,0,0,0,0,0,0,0,0,0,0,0,
2..99973,0,
C .99983,0,0,
1,.99983,0,0,
```

1 UMERGE VERSION 1.0 AUGUST 1985.

NIVERSAL DATA FILE: PETER1
CASE I.D. STRME PLUME 1 PRT 1 M
PUN TITLE: RUNONE

ASPIRATION ENTRAINMENT COEFFICIENT	=	.10	(DEFAULT)
NUMBER OF STEPS ALLOWED	=	5000	
TERATION PRINTOUT FREQUENCY	=	20	
RINT ARRAY AA (0=NO, 1=YES)	=	0	(DEFAULT)
PRINT ARRAY AB (0=NO, 1=YES)	=	0	(DEFAULT)
PRINT ARRAY AC (0=NO, 1=YES)	=	0	(DEFAULT)

INITIAL DENSITY OF THE PLUME	=	-.2700	SIGMAT UNITS
FROUDE NUMBER	=	50.2	

DEPTH (M)	SIGMAT	U (M/S)
.00	-.17	.000
1.00	-.17	.000

OTAL EFFLUENT FLOW	=	.0300	CMS
NUMBER OF PORTS	=	1	
PORT DIAMETER	=	.2260	M
ORT SPACING	=	1000.0	M(DEFAULT)
VERTICAL PORT ANGLE FROM HORIZONTAL	=	.0	DEGREES
PORT DEPTH	=	1.00	M

FIRST LINE OF OUTPUT ARE INITIAL CONDITIONS

X (M)	Z (M)	PLUME DIAMETER (M)	DILU- TION	DENDIFF (SIGMAT)	HORIZ VEL (M/S)	VERT VEL (M/S)	TOTAL VEL (M/S)	AMBIENT CURRENT (M/S)
.00	1.00	.226	1.00	.10	.75	.00	.75	.000
.00	1.00	.227	1.01	.10	.74	.00	.74	.000
.08	1.00	.259	1.15	.09	.65	.00	.65	.000
.18	1.00	.297	1.32	.08	.57	.00	.57	.000
.29	1.00	.341	1.52	.07	.49	.00	.49	.000
.42	1.00	.392	1.74	.06	.43	.00	.43	.000
.56	1.00	.450	2.00	.05	.37	.00	.37	.000
.73	1.00	.517	2.30	.04	.33	.00	.33	.000
.92	1.00	.594	2.64	.04	.28	.00	.28	.000
1.14	1.00	.683	3.03	.03	.25	.00	.25	.000
1.40	1.00	.784	3.48	.03	.21	.00	.21	.000
1.69	.99	.901	4.00	.03	.19	.00	.19	.000
2.02	.99	1.035	4.59	.02	.16	.00	.16	.000
2.41	.99	1.189	5.28	.02	.14	.00	.14	.000
2.85	.98	1.365	6.06	.02	.12	.00	.12	.000
3.36	.97	1.568	6.96	.01	.11	.00	.11	.000
3.94	.95	1.801	8.00	.01	.09	.00	.09	.000
4.61	.93	2.069	9.19	.01	.08	.00	.08	.000
5.38	.89	2.376	10.55	.01	.07	.00	.07	.000
6.26	.84	2.727	12.12	.01	.06	.00	.06	.000
7.27	.75	3.130	13.93	.01	.05	.01	.05	.000
8.42	.62	3.589	16.00	.01	.05	.01	.05	.000
9.74	.43	4.112	18.38	.01	.04	.01	.04	.000
11.20	.15	4.687	21.04	.00	.04	[illegible]	[illegible]	[illegible]

COMPUTATIONS CEASE: PLUMES SURFACE

PLUMES DID NOT MERGE OR TRAP
DILUTION = 22.24

APPENDIX IV

SIMULATION DATA OF STORMWATER DISCHARGED FROM 3 PORTS THROUGH A 2.0 M SALTWATER LAYER.

```
TI LE :        STRMPLUME 3 PORTS 0 M/S 7.7M
1.  TOTAL DISCHARGE FLOW (CU.M/S)              :          .03
2.  NUMBER OF PORTS                            :          3
3.  PORT DIAMETER (M)                          :          .13
4.  PORT VERTICAL ANGLE (DEG.)                 :          20
5.  PORT DEPTH (M)                             :          7.7
6.  HOR.CURRENT SPEED (M/S)(UOUTPLM ONLY):                0
7.  ANGLE OF CURRENT TO DIFFUSER (DEG.)        :          90
8.  DISTANCE BETWEEN ADJACENT PORTS (M)        :          3
9.  MAXIMUM NUMBER OF ITERATIONS               :          5000
10  ITERATION PRINTOUT FREQUENCY               :          20
11. NO MORE CHANGES

AC EPTABLE (Y/N) ? Y
```

```
PC NT    DEPTH(M)   DENSITY(G/CM3)  CURRENT(M/S)
 1        0           .99983           0
 2        5.699       .99983           0
 3        5.7         1.015            0
 4        7.7         1.015            0

ACCEPTABLE (Y/N) ?
```

1

```
 NIVERSAL DATA FILE: PETER1

 ***********************************************************
      NOTE, THIS IS THE ORIGINAL FILE.                     *
      IT DOES NOT REFLECT CHANGES MADE INTERACTIVELY.      *
 *    THOSE CHANGES ARE SHOWN IN THE OUTPUT HEADING.       *
 ***********************************************************

STRMPLUME 3 PORTS 0 M/S 7.7M
1 1,1,0,0,0,0,0,
. 3,3,.13,20,7.7,
0,90,3,
0.5000,20,0,0,0,0,0,0,0,0,0,0,0,
4 .99973,0,
C,.99983,0,0,
5.699,.99983,0,0,
5 7,1.015,0,0,
7 7,1.015,0,0,
 UMERGE VERSION 1.0 AUGUST 1985.
 ................. ................. ................. .................
 NIVERSAL DATA FILE: PETER1
 CASE I.D. STRMPLUME 3 PORTS 0 M/S 7.7M
 RUN TITLE:  RUNONE

 SPIRATION ENTRAINMENT COEFFICIENT   =        .10     (DEFAULT)
 NUMBER OF STEPS ALLOWED             =     5000
```

PRINT ARRAY AA (0=NO, 1=YES) = 0 (DEFAULT)
PRINT ARRAY AB (0=NO, 1=YES) = 0 (DEFAULT)
PRINT ARRAY AC (0=NO, 1=YES) = 0 (DEFAULT)

INITIAL DENSITY OF THE PLUME = -.2700 SIGMAT UNITS
FROUDE NUMBER = 5.4

DEPTH (M)	SIGMAT	U (M/S)
.00	-.17	.000
5.70	-.17	.000
5.70	15.00	.000
7.70	15.00	.000

TOTAL EFFLUENT FLOW = .0300 CMS
NUMBER OF PORTS = 3
PORT DIAMETER = .1300 M
PORT SPACING = 3.00 M
VERTICAL PORT ANGLE FROM HORIZONTAL = 20.0 DEGREES
PORT DEPTH = 7.70 M

FIRST LINE OF OUTPUT ARE INITIAL CONDITIONS

X (M)	Z (M)	PLUME DIAMETER (M)	DILU-TION	DENDIFF (SIGMAT)	HORIZ VEL (M/S)	VERT VEL (M/S)	TOTAL VEL (M/S)	AMBIENT CURRENT (M/S)
.00	7.70	.130	1.00	15.27	.71	.26	.75	.000
.00	7.70	.130	1.01	15.16	.70	.26	.75	.000
.04	7.68	.148	1.15	13.29	.62	.23	.66	.000
.10	7.66	.170	1.31	11.57	.54	.21	.58	.000
.15	7.64	.194	1.51	10.07	.47	.20	.51	.000
.22	7.61	.221	1.73	8.77	.41	.18	.45	.000
.29	7.58	.252	1.98	7.64	.35	.17	.39	.000
.37	7.53	.287	2.28	6.65	.31	.17	.35	.000
.46	7.48	.324	2.61	5.79	.27	.16	.31	.000
.56	7.42	.365	3.00	5.04	.23	.16	.28	.000
.67	7.34	.410	3.44	4.39	.20	.16	.26	.000
.78	7.24	.456	3.95	3.82	.18	.16	.24	.000
.90	7.12	.505	4.54	3.32	.15	.17	.23	.000
1.02	6.98	.555	5.21	2.89	.13	.17	.21	.000
1.14	6.82	.608	5.99	2.52	.12	.17	.21	.000
1.26	6.63	.663	6.87	2.19	.10	.17	.20	.000
1.37	6.42	.722	7.89	1.91	.09	.17	.19	.000
1.49	6.19	.784	9.07	1.66	.08	.17	.19	.000
1.60	5.93	.851	10.41	1.45	.07	.17	.18	.000
*****NOMINAL TRAPPING LEVEL REACHED								
1.69	5.67	.915	11.79	-13.79	.06	.16	.17	.000
1.71	5.64	.998	11.96	-13.60	.06	.12	.14	.000

COMPUTATIONS CEASE: VERTICAL PLUME VELOCITY IS LESS THAN 0

PLUMES DID NOT MERGE
TRAPPING LEVEL= 5.68M BELOW SURFACE; DILUTION= 11.72

APPENDIX V

SIMULATION DATA OF STORMWATER DISCHARGED

FROM 3 PORTS ABOVE A 2.0 M SALT WATER WEDGE.

```
TITLE :         STRM PLUME 3 PRTS/5.6M 7.7M 0 M/S
1.   TOTAL DISCHARGE FLOW (CU.M/S)              :                      .03
2.   NUMBER OF PORTS                            :                      3
3.   PORT DIAMETER (M)                          :                      .13
4.   PORT VERTICAL ANGLE (DEG.)                 :                      20
5.   PORT DEPTH (M)                             :                      5.699
6.   HOR.CURRENT SPEED (M/S)(UOUTPLM ONLY):                            0
7.   ANGLE OF CURRENT TO DIFFUSER (DEG.)        :                      90
8.   DISTANCE BETWEEN ADJACENT PORTS (M)        :                      3
9.   MAXIMUM NUMBER OF ITERATIONS               :                      5000
10   ITERATION PRINTOUT FREQUENCY               :                      20
11   NO MORE CHANGES


ACCEPTABLE (Y/N) ? Y


POINT     DEPTH(M)   DENSITY(G/CM3) CURRENT(M/S)
 1         0           .99983          0
 2         5.699       .99983          0
 3         5.7         1.015           0
 4         7.7         1.015           0

ACCEPTABLE (Y/N) ? Y



1

   UNIVERSAL DATA FILE: PETER1

  ***********************************************************
  *     NOTE, THIS IS THE ORIGINAL FILE.                     *
  *     IT DOES NOT REFLECT CHANGES MADE INTERACTIVELY.      *
  *     THOSE CHANGES ARE SHOWN IN THE OUTPUT HEADING.       *
  ***********************************************************

 STRM PLUME 3 PRTS/5.6M 7.7M 0 M/S
 1 1,1,0,0,0,0,0,
 .03,3,.13,20,5.699,
 0,90,3,
 0 5000,20,0,0,0,0,0,0,0,0,0,0,0,
 4 .99973,0,
 0,.99983,0,0,
 5.699,.99983,0,0,
 5.7,1.015,0,0,
 7.7,1.015,0,0,
1 UMERGE VERSION 1.0 AUGUST 1985.
  ................  ................  ................  ................
  UNIVERSAL DATA FILE: PETER1
  CASE I.D. STRM PLUME 3 PRTS/5.6M 7.7M 0 M/S
  RUN TITLE:  RUNONE

  ASPIRATION ENTRAINMENT COEFFICIENT      =       .10     (DEFAULT)
  NUMBER OF STEPS ALLOWED                 =    5000
  ITERATION PRINTOUT FREQUENCY            =      20
  PRINT ARRAY AA (0=NO, 1=YES)            =       0       (DEFAULT)
  PRINT ARRAY AB (0=NO, 1=YES)            =       0       (DEFAULT)
  PRINT ARRAY AC (0=NO, 1=YES)            =       0       (DEFAULT)

  INITIAL DENSITY OF THE PLUME            =     -.2700   SIGMAT UNITS
  FROUDE NUMBER                           =     66.7

   DEPTH    SIGMAT       U
    (M)                (M/S)
```

.00	-.17	.000
5.70	-.17	.000
5.70	15.00	.000
7.70	15.00	.000

OTAL EFFLUENT FLOW = .0300 CMS
NUMBER OF PORTS = 3
PORT DIAMETER = .1300 M
ORT SPACING = 3.00 M
ERTICAL PORT ANGLE FROM HORIZONTAL = 20.0 DEGREES
PORT DEPTH = 5.70 M

IRST LINE OF OUTPUT ARE INITIAL CONDITIONS

X (M)	Z (M)	PLUME DIAMETER (M)	DILU-TION	DENDIFF (SIGMAT)	HORIZ VEL (M/S)	VERT VEL (M/S)	TOTAL VEL (M/S)	AMBIENT CURRENT (M/S)
.00	5.70	.130	1.00	.10	.71	.26	.75	.000
.00	5.70	.130	1.01	.10	.70	.26	.75	.000
.05	5.68	.149	1.15	.09	.62	.22	.66	.000
.10	5.66	.171	1.32	.08	.54	.20	.57	.000
.16	5.64	.196	1.52	.07	.47	.17	.50	.000
.23	5.62	.226	1.74	.06	.41	.15	.43	.000
.30	5.59	.259	2.00	.05	.35	.13	.38	.000
.39	5.56	.298	2.30	.04	.31	.11	.33	.000
.50	5.52	.342	2.64	.04	.27	.10	.29	.000
.62	5.47	.393	3.03	.03	.23	.09	.25	.000
.75	5.42	.451	3.48	.03	.20	.07	.22	.000
.91	5.37	.518	4.00	.03	.18	.07	.19	.000
1.09	5.30	.595	4.59	.02	.15	.06	.16	.000
1.30	5.22	.683	5.28	.02	.13	.05	.14	.000
1.54	5.13	.784	6.06	.02	.12	.04	.12	.000
1.81	5.03	.900	6.96	.01	.10	.04	.11	.000
2.12	4.91	1.033	8.00	.01	.09	.03	.09	.000
2.48	4.77	1.186	9.19	.01	.08	.03	.08	.000
2.89	4.61	1.360	10.55	.01	.07	.03	.07	.000
3.36	4.42	1.560	12.12	.01	.06	.02	.06	.000
3.89	4.20	1.787	13.93	.01	.05	.02	.06	.000
4.50	3.94	2.046	16.00	.01	.04	.02	.05	.000
5.20	3.63	2.341	18.38	.01	.04	.02	.04	.000
5.98	3.25	2.673	21.11	.00	.03	.02	.04	.000
****MERGING BEGINS								
6.82	2.83	3.027	24.08	.00	.03	.02	.03	.000
6.87	2.80	3.048	24.25	.00	.03	.02	.03	.000
7.95	2.19	3.497	27.28	.00	.03	.02	.03	.000
8.94	1.58	3.897	29.68	.00	.02	.02	.03	.000
9.86	.96	4.259	31.76	.00	.02	.02	.03	.000
10.73	.33	4.591	33.65	.00	.02	.02	.03	.000

COMPUTATIONS CEASE: PLUMES SURFACE

PLUMES MERGED, DID NOT TRAP; DILUTION = 34.58

APPENDIX VI

SIMULATION DATA OF A PLUME OF STORM WATER

DISCHARGING FROM THREE PORTS THROUGH 7.7 M OF WATER.

```
TI LE :        STRM PLUME 3 PRTS 7.7 M 0 M/S
1.   TOTAL DISCHARGE FLOW (CU.M/S)              :          .03
2.   NUMBER OF PORTS                            :          3
3.   PORT DIAMETER (M)                          :          .13
4.   PORT VERTICAL ANGLE (DEG.)                 :          20
5.   PORT DEPTH (M)                             :          7.7
6.   HOR.CURRENT SPEED (M/S)(UOUTPLM ONLY):                0
7.   ANGLE OF CURRENT TO DIFFUSER (DEG.)        :          90
8.   DISTANCE BETWEEN ADJACENT PORTS (M)        :          3
9.   MAXIMUM NUMBER OF ITERATIONS               :          5000
1C   ITERATION PRINTOUT FREQUENCY               :          20
11.  NO MORE CHANGES


AC EPTABLE (Y/N) ? Y









PC  NT     DEPTH(M)   DENSITY(G/CM3)  CURRENT(M/S)
 1          0            .99983             0
 2          7.7          .99983             0

AC EPTABLE (Y/N) ?

ST M PLUME 3 PRTS 7.7 M 0 M/S
1,.,1,0,0,0,0,0,
.03,3,.13,20,7.7,
0, 0,3,
0, 000,20,0,0,0,0,0,0,0,0,0,0,0,
2,.99973,0,
0, 99983,0,0,
7. ,.99983,0,0,
1

  NIVERSAL DATA FILE: PETER1

 **********************************************************
 *    NOTE, THIS IS THE ORIGINAL FILE.                     *
 *    IT DOES NOT REFLECT CHANGES MADE INTERACTIVELY.      *
 *    THOSE CHANGES ARE SHOWN IN THE OUTPUT HEADING.       *
 **********************************************************

 S RM PLUME 3 PRTS 7.7 M 0 M/S
 1,1,1,0,0,0,0,0,
 . 3,3,.13,20,7.7,
 ( 90,3,
 0,5000,20,0,0,0,0,0,0,0,0,0,0,0,
   .99973,0,
 ( .99983,0,0,
 7.7,.99983,0,0,
1 UMERGE VERSION 1.0 AUGUST 1985.
```

UNIVERSAL DATA FILE: PETER1
CASE I.D. STRM PLUME 3 PRTS 7.7 M 0 M/S
RUN TITLE: RUNONE

ASPIRATION ENTRAINMENT COEFFICIENT = .10 (DEFAULT)
NUMBER OF STEPS ALLOWED = 5000
ITERATION PRINTOUT FREQUENCY = 20
PRINT ARRAY AA (0=NO, 1=YES) = 0 (DEFAULT)
PRINT ARRAY AB (0=NO, 1=YES) = 0 (DEFAULT)
PRINT ARRAY AC (0=NO, 1=YES) = 0 (DEFAULT)

INITIAL DENSITY OF THE PLUME = -.2700 SIGMAT UNITS
FROUDE NUMBER = 66.7

DEPTH (M)	SIGMAT	U (M/S)
.00	-.17	.000
7.70	-.17	.000

TOTAL EFFLUENT FLOW = .0300 CMS
NUMBER OF PORTS = 3
PORT DIAMETER = .1300 M
PORT SPACING = 3.00 M
VERTICAL PORT ANGLE FROM HORIZONTAL = 20.0 DEGREES
PORT DEPTH = 7.70 M

FIRST LINE OF OUTPUT ARE INITIAL CONDITIONS

X (M)	Z (M)	PLUME DIAMETER (M)	DILUTION	DENDIFF (SIGMAT)	HORIZ VEL (M/S)	VERT VEL (M/S)	TOTAL VEL (M/S)	AMBIENT CURRENT (M/S)
.00	7.70	.130	1.00	.10	.71	.26	.75	.000
.00	7.70	.130	1.01	.10	.70	.26	.75	.000
.05	7.68	.149	1.15	.09	.62	.22	.66	.000
.10	7.66	.171	1.32	.08	.54	.20	.57	.000
.16	7.64	.196	1.52	.07	.47	.17	.50	.000
.23	7.62	.226	1.74	.06	.41	.15	.43	.000
.30	7.59	.259	2.00	.05	.35	.13	.38	.000
.39	7.56	.298	2.30	.04	.31	.11	.33	.000
.50	7.52	.342	2.64	.04	.27	.10	.29	.000
.62	7.47	.393	3.03	.03	.23	.09	.25	.000
.75	7.42	.451	3.48	.03	.20	.07	.22	.000
.91	7.37	.518	4.00	.03	.18	.07	.19	.000
1.09	7.30	.595	4.59	.02	.15	.06	.16	.000
1.30	7.22	.683	5.28	.02	.13	.05	.14	.000
1.54	7.13	.784	6.06	.02	.12	.04	.12	.000
1.81	7.03	.900	6.96	.01	.10	.04	.11	.000
2.12	6.91	1.033	8.00	.01	.09	.03	.09	.000
2.48	6.77	1.186	9.19	.01	.08	.03	.08	.000
2.89	6.61	1.360	10.55	.01	.07	.03	.07	.000
3.36	6.42	1.560	12.12	.01	.06	.02	.06	.000
3.89	6.20	1.787	13.93	.01	.05	.02	.06	.000
4.50	5.94	2.046	16.00	.01	.04	.02	.05	.000
5.20	5.63	2.341	18.38	.01	.04	.02	.04	.000
5.98	5.25	2.673	21.11	.00	.03	.02	.04	.000
*****MERGING BEGINS								
6.82	4.83	3.027	24.08	.00	.03	.02	.03	.000
6.87	4.80	3.048	24.25	.00	.03	.02	.03	.000
7.95	4.19	3.497	27.28	.00	.03	.02	.03	.000
8.94	3.58	3.897	29.68	.00	.02	.02	.03	.000
9.86	2.96	4.259	31.76	.00	.02	.02	.03	.000
10.73	2.33	4.591	33.65	.00	.02	.02	.03	.000
11.55	1.69	4.899	35.41	.00	.02	.02	.03	.000

12.33	1.04	5.166	37.08	.00	.02	.02	.03	.000
13.07	.37	5.458	38.68	.00	.02	.02	.02	.000

OMPUTATIONS CEASE: PLUMES SURFACE

PLUMES MERGED, DID NOT TRAP; DILUTION = 39.54

APPENDIX VII

SIMULATION DATA OF STORM WATER DISCHARGED FROM THREE PORTS INTO RIVER CURRENT MOVING AT 1.8 M/S.

```
TI LE :         STRM PLUME 3 PORTS 1.8 M/S 5.1M
1.  TOTAL DISCHARGE FLOW (CU.M/S)              :              .03
2.  NUMBER OF PORTS                            :              3
3.  PORT DIAMETER (M)                          :              .13
4.  PORT VERTICAL ANGLE (DEG.)                 :              20
5.  PORT DEPTH (M)                             :              5.1
6.  HOR.CURRENT SPEED (M/S)(UOUTPLM ONLY):                    0
7.  ANGLE OF CURRENT TO DIFFUSER (DEG.)        :              90
8.  DISTANCE BETWEEN ADJACENT PORTS (M)        :              3
9.  MAXIMUM NUMBER OF ITERATIONS               :              5000
10  ITERATION PRINTOUT FREQUENCY               :              25
11  NO MORE CHANGES


AC EPTABLE (Y/N) ? Y


PO NT     DEPTH(M)   DENSITY(G/CM3)  CURRENT(M/S)
 1         0            .99983           1.8
 2         5.1          .99983           1.8

AC EPTABLE (Y/N) ? Y


1

  UNIVERSAL DATA FILE: PETER1

   *********************************************************
   *   NOTE, THIS IS THE ORIGINAL FILE.                    *
   *   IT DOES NOT REFLECT CHANGES MADE INTERACTIVELY.     *
       THOSE CHANGES ARE SHOWN IN THE OUTPUT HEADING.      *
   *********************************************************

 STRM PLUME 3 PORTS 1.8 M/S 5.1M
 1 1,1,0,0,0,0,0,
 .03,3,.13,20,5.1,
 0.90,3,
 C 5000,25,0,0,0,0,0,0,0,0,0,0,0,
 2,.99973,0,
 0,.99983,0,1.8,
 5 1,.99983,0,1.8,
1  MERGE VERSION 1.0 AUGUST 1985.
 ..................  .................  .................  .................
  UNIVERSAL DATA FILE: PETER1
  CASE I.D. STRM PLUME 3 PORTS 1.8 M/S 5.1M
  RUN TITLE:  RUNONE

  ASPIRATION ENTRAINMENT COEFFICIENT    =       .10    (DEFAULT)
  NUMBER OF STEPS ALLOWED               =   5000
  ITERATION PRINTOUT FREQUENCY          =     25
  PRINT ARRAY AA (0=NO, 1=YES)          =      0       (DEFAULT)
  PRINT ARRAY AB (0=NO, 1=YES)          =      0       (DEFAULT)
  PRINT ARRAY AC (0=NO, 1=YES)          =      0       (DEFAULT)

  INITIAL DENSITY OF THE PLUME          =      -.2700  SIGMAT UNITS
  FROUDE NUMBER                         =     66.7

   DEPTH    SIGMAT      U
    (M)               (M/S)

     .00     -.17     1.800
    5.10     -.17     1.800
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  TOTAL EFFLUENT FLOW                   =       .0300  CMS
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NUMBER OF PORTS = 3
PORT DIAMETER = .1300 M
PORT SPACING = 3.00 M
VERTICAL PORT ANGLE FROM HORIZONTAL = 20.0 DEGREES
PORT DEPTH = 5.10 M

FIRST LINE OF OUTPUT ARE INITIAL CONDITIONS

X (M)	Z (M)	PLUME DIAMETER (M)	DILU- TION	DENDIFF (SIGMAT)	HORIZ VEL (M/S)	VERT VEL (M/S)	TOTAL VEL (M/S)	AMBIENT CURRENT (M/S)
.00	5.10	.130	1.00	.10	.71	.26	.75	1.800
.00	5.10	.130	1.01	.10	.72	.26	.76	1.800
.02	5.09	.130	1.19	.08	.88	.22	.91	1.800
.05	5.09	.132	1.41	.07	1.03	.18	1.04	1.800
.08	5.08	.136	1.68	.06	1.15	.15	1.16	1.800
.13	5.08	.142	2.00	.05	1.25	.13	1.26	1.800
.19	5.07	.150	2.38	.04	1.34	.11	1.35	1.800
.27	5.07	.160	2.83	.04	1.41	.09	1.42	1.800
.37	5.06	.170	3.36	.03	1.48	.08	1.48	1.800
.51	5.05	.183	4.00	.03	1.53	.06	1.53	1.800
.70	5.05	.196	4.76	.02	1.57	.05	1.57	1.800
.94	5.04	.212	5.66	.02	1.61	.05	1.61	1.800
1.27	5.03	.229	6.73	.01	1.64	.04	1.64	1.800
1.69	5.02	.247	8.00	.01	1.66	.03	1.66	1.800
2.25	5.01	.268	9.51	.01	1.69	.03	1.69	1.800
2.97	5.00	.291	11.31	.01	1.70	.02	1.70	1.800
3.92	4.99	.316	13.45	.01	1.72	.02	1.72	1.800
5.16	4.98	.343	16.00	.01	1.73	.02	1.73	1.800
6.78	4.96	.373	19.03	.01	1.74	.01	1.74	1.800
8.88	4.95	.406	22.62	.00	1.75	.01	1.75	1.800
1.61	4.93	.441	26.91	.00	1.76	.01	1.76	1.800
15.16	4.91	.480	32.00	.00	1.77	.01	1.77	1.800
19.75	4.89	.523	38.05	.00	1.77	.01	1.77	1.800
25.68	4.87	.570	45.25	.00	1.78	.01	1.78	1.800
33.34	4.85	.620	53.81	.00	1.78	.01	1.78	1.800
43.20	4.82	.676	63.99	.00	1.78	.00	1.78	1.800
55.87	4.79	.737	76.10	.00	1.79	.00	1.79	1.800
72.07	4.76	.803	90.50	.00	1.79	.00	1.79	1.800
92.72	4.73	.875	107.62	.00	1.79	.00	1.79	1.800
118.90	4.69	.954	127.98	.00	1.79	.00	1.79	1.800
151.91	4.64	1.040	152.20	.00	1.79	.00	1.79	1.800
193.25	4.59	1.133	180.99	.00	1.79	.00	1.79	1.800
244.62	4.54	1.236	215.24	.00	1.79	.00	1.79	1.800
307.91	4.48	1.347	255.96	.00	1.80	.00	1.80	1.800
385.17	4.41	1.469	304.39	.00	1.80	.00	1.80	1.800
474.27	4.34	1.596	359.32	.00	1.80	.00	1.80	1.800
574.13	4.26	1.713	414.32	.00	1.80	.00	1.80	1.800
664.01	4.20	1.823	469.23	.00	1.80	.00	1.80	1.800
743.90	4.13	1.927	524.50	.00	1.80	.00	1.80	1.800
833.80	4.07	2.026	579.91	.00	1.80	.00	1.80	1.800
923.71	4.01	2.122	635.82	.00	1.80	.00	1.80	1.800
******	3.94	2.214	692.55	.00	1.80	.00	1.80	1.800
******	3.88	2.304	749.97	.00	1.80	.00	1.80	1.800
******	3.83	2.391	807.60	.00	1.80	.00	1.80	1.800
******	3.77	2.475	865.68	.00	1.80	.00	1.80	1.800
******	3.71	2.558	924.40	.00	1.80	.00	1.80	1.800
******	3.66	2.639	983.94	.00	1.80	.00	1.80	1.800
******	3.60	2.719	1044.43	.00	1.80	.00	1.80	1.800
******	3.55	2.798	1106.02	.00	1.80	.00	1.80	1.800
******	3.49	2.876	1168.84	.00	1.80	.00	1.80	1.800
******	3.44	2.954	1232.94	.00	1.80	.00	1.80	1.800
******MERGING BEGINS								
******	3.40	3.006	1276.74	.00	1.80	.00	1.80	1.800