Permeability and Stability of Base and Subbase Materials

State Job No. 14512(0)

Final Report No. FHWA/OH 2000/017 Appendices A-Q

by

Brian W. Randolph, Andrew G. Heydinger and Jiwan D. Gupta
with contributions by
Jiangeng Cai, Edward Steinhauser and Qinglu Xie

Department of Civil Engineering
The University of Toledo

August 2000

Prepared in cooperation with the
Ohio Department of Transportation
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Appendix A

Mathematical Tools for Design of In Situ Permeameter

- A-1 - The Confined/Phreatic Well Flow Solution Computer Program Code
- A-2 - The Convective, Dispersive Mass Transport Solution Computer Program Code
- Table A.3 - The Complimentary Error Function Table

A-1 - The Confined/Phreatic Well Flow Solution Computer Program Code (BASIC)

```
100 rem  File: cpas.bas      Written by Edward P. Steinhauser...7/20/93
110 rem  ***************************************************************
120 rem  * This is the confined/phreatic well flow solution written to
130 rem  * to calculate potential throughout the flow domain. The data
140 rem  * generated by this program is written to an output file to be
150 rem  * imported into a computer program capable of generating
160 rem  * piezometric contours.
165 rem  *
170 rem  * Input: The user inputs the distance the well is from the
180 rem  *        constant head boundary, the distance the well is
190 rem  *        the no flow boundary, the thickness of the base,
200 rem  *        the hydraulic conductivity, the potential at the
210 rem  *        well, and the potential at the constant head
215 rem  *        boundary.
220 rem  *
230 rem  * Calculations: Determine the flow rate into the well base on
240 rem  *               the potential at the well, the coordinate
250 rem  *               transformations, the x and y coordinates, and
260 rem  *               the potential at each coordinate.
270 rem  *
280 rem  * Output: Print to an output file the thickness of the base,
290 rem  *         the hydraulic conductivity, the flow rate into the
300 rem  *         well, the potential at the constant head boundary,
310 rem  *         the potential at the well on one line. Use a loop
320 rem  *         to print to the same output file in tabular form
330 rem  *         the x and y coordinates, and the corresponding
335 rem  *         potential.
340 rem  ***************************************************************
350 rem
360 rem  Ask the user for the output file name.
370 rem
380 input "Enter the output file name (Drive:\Path\Filename.Extension): ", a$
390 open "o", #1, a$
400 rem
410 rem  Constant data for the design (note: all units are meters).
420 rem  well radius
430 rw = 0.0508
440 pi = 3.141593
450 x = - 3.6
460 y = - 3.6
470 rem
480 rem  Dimensioning of Arrays
490 rem
```

```
500 dim phi(50, 50)
510 rem
520 rem  Input of Data
530 rem
540 input "Enter the distance of the well from the constant head boundary in m: ", d1
550 input "Enter the distance of the well from the no flow boundary in m:      ", d2
560 input "Enter the thickness of the base in m: ", h
570 input "Enter the hydraulic conductivity in m/s: ", k
580 input "Enter the potential at the well in m: ", phiw
590 input "Enter the potential at the constant head boundary in m: ", phio
600 rem
610 rem  Determine the flow rate in the well
620 rem
630 q = (2 * pi * (k * h * phiw - 0.5 * k * (h ^ 2 + phio ^ 2))) / LOG((4 * d1 * (d1 + d2 +
rw) + 2 * d2 * rw + rw ^ 2) / (2 * d2 * rw - rw ^ 2))
640 rem
650 rem  Output of input data
660 rem
670 print #1, h, k, q, phio, phiw
680 rem
690 rem  Loop to determine the coordinates and potential and print in
700 rem  tabular form.
710 rem
720 for i = 1 to 16
730 for ii = 1 to 16
740 rem
750 rem  Coordinate transformations
760 rem
770 r1 = ((x + d1 + 2 * d2) ^ 2 + y ^ 2) ^ 0.5
780 r2 = ((x + d1) ^ 2 + y ^ 2) ^ 0.5
790 r3 = ((x - d1) ^ 2 + y ^ 2) ^ 0.5
800 r4 = ((x - d1 - 2 * d2) ^ 2 + y ^ 2) ^ 0.5
810 z = ((q / (2 * pi)) * LOG((r3 * r4) / (r1 * r2)) + 0.5 * k * phio ^ 2 + 0.5 * k * h ^ 2) / (k
* h)
820 if z < h then 850
830 phi(i, ii) = z
840 goto 860
850 phi(i, ii) = ((((q / pi) * LOG((r3 * r4) / (r1 * r2)) + k * phio ^ 2 + k * h ^ 2) / k) - h ^ 2)
^ 0.5
860 print #1, x, y, phi(i, ii)
870 x = x + 0.24
880 z = 0
890 next ii
900 y = y + 0.48
910 x = - 3.6
920 next i
```

```
930 close #1
940 end
```

A-2 - The Convective, Dispersive Mass Transport Solution Computer Program Code (BASIC)

```
100 rem  file: cdmts.bas      Written by Edward P. Steinhauser...8/02/93
110 rem  ************************************************************
120 rem  *  This is the convective, dispersive mass transport solution
130 rem  * written to calculate the concentration of a solution at any
140 rem  * and time within a flow domain.  The output is printed
150 rem  * directly to the screen.
160 rem  *
170 rem  * Input:  The user inputs the distance the well is from the
180 rem  *        edge of the pavement, the thickness of the base, the
190 rem  *        initial concentration of the electrolytic solution,
200 rem  *        the flow rate into the well, the dispersion
210 rem  *        coefficient, the porosity of the base, and the x and
220 rem  *        y coordinates.
230 rem  *
240 rem  * Calculations:  Determine the coordinate transformations and
250 rem  *               then the concentration of the solution at a
260 rem  *               particular point and time.
270 rem  *
280 rem  * Output:  Print out the time, the x and y coordinate, and the
290 rem  *          concentration of the electrolytic solution at that
300 rem  *          coordinate point.
310 rem  ************************************************************
320 rem
330 rem  Numeric constants used in the evaluation of the complimentary error function.
340 rem
350 a1 = 0.278393
360 a2 = 0.230389
370 a3 = 0.000972
380 a4 = 0.078108
385 pi = 3.141593
390 rem
400 rem  Input of data
410 rem
420 input "Enter the distance the well is from the edge of the pavement in m:  ", d
430 input "Enter the thickness of the base in m: ", h
440 input "Enter the initial concentration of the salt solution in mg/l: ", cono
450 input "Enter the flow rate into the well in m^3/s: ",q
460 input "Enter the lateral dispersivity coefficient in m: ", alpha
470 input "Enter the porosity of the aquifer: ", n
480 input "Enter the time to evaluate the solution in seconds: ", t
490 input "Enter the x coordinate to evaluate the solution in m: ", x
500 input "Enter the y coordinate to evaluate the solution in m: ", y
```

```
510 rem
520 rem  Calculation of concentration
530 rem
540 a = q / (2 * pi * h * n)
545 rem
550 rem  Coordinate transformation
555 rem
560 r = ((x + d) ^ 2 + y ^ 2) ^ 0.5
570 xx = ((r ^ 2) / 2 - a * t) / (((4 / 3) * alpha * r ^ 3) ^ 0.5)
580 if xx < 0 then 610
590 erfc = 1 - (1 - 1 / (1 + a1 * xx + a2 * xx ^ 2 + a3 * xx ^ 3 + a4 * xx ^ 4) ^ 4)
600 goto 630
610 xx = abs(xx)
620 erfc = 1 + (1 - 1 / (1 + a1 * xx + a2 * xx ^ 2 + a3 * xx ^ 3 + a4 * xx ^ 4) ^ 4)
630 con = (cono / 2) * erfc
635 print
640 print using "The time the solution is evaluated at: #####.### seconds"; t
650 print using "The x coordinate the solution is evaluated at: #####.### meters"; x
660 print using "The y coordinate the solution is evaluated at: #####.### meters"; y
670 print using "The concentration is: #####.#### mg/l"; con
675 print
680 print "Would you like to reevaluate the solution at another time and location?"
690 input "Type y to continue or n to end the program: ", a$
695 cls
700 if a$ = "y" then 350
710 end
```

Table A.3 - The Complimentary Error Function Table

ξ	*erfc* [ξ]	ξ	*erfc* [ξ]
0.00	1.0000	0.00	1.0000
0.05	0.9441	-0.05	1.0559
0.10	0.8880	-0.10	1.1120
0.15	0.8322	-0.15	1.1678
0.20	0.7772	-0.20	1.2228
0.25	0.7234	-0.25	1.2766
0.30	0.6709	-0.30	1.3291
0.35	0.6202	-0.35	1.3798
0.40	0.5712	-0.40	1.4288
0.45	0.5242	-0.45	1.4758
0.50	0.4794	-0.50	1.5206
0.55	0.4367	-0.55	1.5633
0.60	0.3964	-0.60	1.6036
0.65	0.3583	-0.65	1.6417
0.70	0.3226	-0.70	1.6774
0.75	0.2893	-0.75	1.7107
0.80	0.2583	-0.80	1.7417
0.85	0.2297	-0.85	1.7703
0.90	0.2034	-0.90	1.7966
0.95	0.1793	-0.95	1.8207
1.00	0.1573	-1.00	1.8427
1.05	0.1374	-1.05	1.8626
1.10	0.1195	-1.10	1.8805
1.15	0.1035	-1.15	1.8965
1.20	0.0893	-1.20	1.9107
1.25	0.0766	-1.25	1.9234

1.30	0.0655	-1.30	1.9345
1.35	0.0558	-1.35	1.9442
1.40	0.0473	-1.40	1.9527
1.45	0.0400	-1.45	1.9600
1.50	0.0337	-1.50	1.9663
1.55	0.0282	-1.55	1.9718
1.60	0.0236	-1.60	1.9764
1.65	0.0197	-1.65	1.9803
1.70	0.0164	-1.70	1.9836
1.75	0.0136	-1.75	1.9864
1.80	0.0112	-1.80	1.9888
1.85	0.0092	-1.85	1.9908
1.90	0.0076	-1.90	1.9924
1.95	0.0063	-1.95	1.9937
2.00	0.0051	-2.00	1.9949
2.05	0.0042	-2.05	1.9958
2.10	0.0034	-2.10	1.9966
2.15	0.0028	-2.15	1.9972
2.20	0.0023	-2.20	1.9977
2.25	0.0019	-2.25	1.9981
2.30	0.0015	-2.30	1.9985
2.35	0.0012	-2.35	1.9988
2.40	0.0010	-2.40	1.9990
2.45	0.0008	-2.45	1.9992
2.50	0.0007	-2.50	1.9993
2.55	0.0006	-2.55	1.9994
2.60	0.0004	-2.60	1.9996
2.65	0.0004	-2.65	1.9996
2.70	0.0003	-2.70	1.9997

2.75	0.0002	-2.75	1.9998
2.80	0.0002	-2.80	1.9998
2.85	0.0002	-2.85	1.9998
2.90	0.0001	-2.90	1.9999
2.95	0.0001	-2.95	1.9999
3.00	0.0001	-3.00	1.9999
3.05	0.0001	-3.05	1.9999
3.10	0.0001	-3.10	1.9999
3.15	0.0001	-3.15	1.9999
3.20	0.0000	-3.20	2.0000
.	.	.	.
.	.	.	.
.	.	.	.
∞	0.0000	- ∞	2.0000

Appendix B

Numerical Factor Kw for Partially Loaded Simply Supported Rectangular Plate

Taken directly from Hsu, 1990

- Table B.1 - Numerical Factor Kw for b/a = 1.0 for a Partially Loaded Simply Supported Rectangular Plate (Taken from Hsu, 1990)
- Table B.2 - Numerical Factor Kw for b/a = 1.4 for a Partially Loaded Simply Supported Rectangular Plate (Taken from Hsu, 1990)
- Table B.3 - Numerical Factor Kw for b/a = 1.8 for a Partially Loaded Simply Supported Rectangular Plate (Taken from Hsu, 1990)
- Table B.4 - Numerical Factor Kw for b/a = 2.0 for a Partially Loaded Simply Supported Rectangular Plate (Taken from Hsu, 1990)

Table B.1 - Numerical Factor Kw for b/a = 1.0 for a Partially Loaded Simply Supported Rectangular Plate (Taken from Hsu, 1990)

for $\nu = 0.16$

$u/a \rightarrow$ / $v/a \downarrow$	0.0001	0.2	0.4	0.6	0.8	1.0
.... 0.0001	13.54	13.10	12.12	10.86	9.42	7.88
0.1	13.40	12.99	12.03	10.78	9.36	7.83
0.2	13.09	12.70	11.79	10.58	9.19	7.69
0.3	12.64	12.29	11.43	10.27	8.93	7.48
0.4	12.11	11.79	10.98	9.88	8.60	7.20
0.5	11.51	11.21	10.46	9.42	8.20	6.87
0.6	10.85	10.58	9.88	8.91	7.76	6.50
0.7	10.15	9.90	9.26	8.35	7.28	6.10
0.8	9.42	9.19	8.60	7.76	6.77	5.67
0.9	8.66	8.45	7.91	7.14	6.23	5.22
1.0	7.88	7.69	7.20	6.50	5.67	4.75

Table B.2 - Numerical Factor Kw for b/a = 1.4 for a Partially Loaded Simply Supported Rectangular Plate (Taken from Hsu, 1990)

for $\nu = 0.16$

$u/a \rightarrow$ / $v/a \downarrow$	0.0001	0.2	0.4	0.6	0.8	1.0
.... 0.0001	17.37	16.88	15.71	14.15	12.33	10.32
0.1	17.23	16.75	15.61	14.06	12.25	10.27
0.2	16.93	16.49	15.39	13.88	12.10	10.14
0.4	16.03	15.65	14.65	13.25	11.57	9.70
0.6	14.91	14.57	13.67	12.39	10.83	9.08
0.8	13.65	13.35	12.55	11.39	9.96	8.36
1.0	12.33	12.07	11.36	10.31	9.03	7.57
1.2	10.98	10.74	10.12	9.19	8.05	6.76
1.4	9.61	9.41	8.86	8.05	7.05	5.92

Table B.3 - Numerical Factor Kw for b/a = 1.8 for a Partially Loaded Simply Supported Rectangular Plate (Taken from Hsu, 1990)

for $\nu = 0.16$

$u/a \rightarrow$ / $v/a \downarrow$	0.0001	0.2	0.4	0.6	0.8	1.0
.... 0.0001	18.94	18.42	17.18	15.50	13.52	11.33
0.1	18.81	18.31	17.08	15.42	13.45	11.27
0.2	18.52	18.05	16.87	15.25	13.30	11.15
0.4	17.67	17.26	16.19	14.66	12.81	10.74
0.6	16.62	16.25	15.28	13.86	12.13	10.17
0.8	15.47	15.15	14.26	12.96	11.34	9.52
1.0	14.30	14.00	13.20	12.00	10.52	8.83
1.2	13.12	12.86	12.13	11.04	9.68	8.12
1.4	11.97	11.73	11.07	10.08	8.84	7.42
1.6	10.85	10.63	10.03	9.14	8.02	6.73
1.8	9.75	9.56	9.02	8.22	7.21	6.05

Table B.4 - Numerical Factor Kw for b/a = 2.0 for a Partially Loaded Simply Supported Rectangular Plate (Taken from Hsu, 1990)

for $\nu = 0.16$

$u/a \rightarrow$ / $v/a \downarrow$	0.0001	0.2	0.4	0.6	0.8	1.0
.... 0.0001	19.38	18.85	17.58	15.87	13.84	11.60
0.2	18.89	18.41	17.22	15.56	13.58	11.38
0.4	18.05	17.63	16.54	14.98	13.09	10.98
0.6	17.02	16.65	15.65	14.20	12.43	10.42
0.8	15.90	15.57	14.66	13.32	11.66	9.79
1.0	14.76	14.46	13.63	12.40	10.87	9.12
1.2	13.64	13.36	12.61	11.48	10.07	8.45
1.4	12.55	12.30	11.61	10.57	9.28	7.79
1.6	11.50	11.27	10.64	9.70	8.51	7.14
1.8	10.49	10.29	9.71	8.85	7.77	6.52
2.0	9.52	9.34	8.82	8.04	7.05	5.92

Appendix C

In Situ Hydraulic Conductivity Test Device Check List

- Table C.1 - Equipment Check List for the In Situ Hydraulic Conductivity Test Device
- Table C.2 - Accessories Check List for the In Situ Hydraulic Conductivity Test Device
- Table C.3 - Tools and Miscellaneous Parts Check List for the In Situ Hydraulic Conductivity Test Device

Table C.1 - Equipment Check List for the In Situ Hydraulic Conductivity Test Device

1. Water Control System
2. Freshwater Storage Tank
3. Standpipe
4. Standpipe Overflow Collar
5. Freshwater Tank Fitting
6. 3 - 500 g Containers of NH_4Cl
7. Two 24" Stainless Steel Probes
8. Two 20" Stainless Steel Probes w/ Leads w/ O-Rings Pusher
9. One 5/8" Garden Hose
10. One 1/2" Garden Hose
11. Closed Loop Differential Manometer
12. Gas Powered Generator
13. Salt Water Tank
14. Two Metex Digital Multimeters

Table C.2 - Accessories Check List for the In Situ Hydraulic Conductivity Test Device

1. Standpipe Tripod Stand
2. 20 – Size ‘00’ Stoppers
3. 2 - 25 Packs of 3/8" x 9/16" x 3/32" O-Rings
4. 2 - 25 Packs of 3/8" x 1/2" x 1/16" O-Rings
5. Hose Clamps Various Sizes
6. 16 Gauge Steel Wire
7. 1/2" Concrete Floor Anchors
8. 1/4" Eyelet Screws
9. 3/8" Pre-Drive Stainless Steel Rod
10. Three 1 1/2" Flexible Hoses w/ Hose Clamps
11. Three 1/2" Flexible Hoses w/ Hose Clamps
12. Two 3/4" Flexible Hoses w/ Hose Clamps

Table C.3 - Tools and Miscellaneous Parts Check List for the In Situ Hydraulic Conductivity Test Device

1. Sample Bags
2. Sample Tags
3. Orange Spray Paint
4. Liquid Wrench Lubricant
5. Wire Brush
6. Neon Tape
7. Thermometer
8. Contact Cement
9. TFE Paste (Teflon Paste)
10. Salt Measuring Container
11. Socket Set
12. PVC Pipe Cement
13. Leather Gloves
14. 30' Tape Measure
15. 30' Extension Cord w/ Adapter
16. Bicycle Tire Pump
17. Adjustable Wrench Set
18. Screw Drivers (4 Flat) (2 Phillips)
19. Two Rolls of Teflon Tape
20. Needle Nose Pliers
21. White Chalk
22. 2 meter Steel Measuring Tape

Table C.3 (cont.) - Tools and Miscellaneous Parts Check List for the In Situ Hydraulic Conductivity Test Device

23. Spatula
24. Roofing Nails
25. Carpenter Level
26. Cleaning Rags
27. 2 Lb. Table Salt
28. Six 1/2" x 20" Carbide Drill Bits
29. Four 1/2" x 24" Carbide Drill Bits
30. Two 1/2" x 30" Carbide Drill Bits
31. One Aggregate Scoop
32. Paint Stir Rod w/ Drill Attachment
33. Sledge Hammer
34. 5 Gallon Bucket
35. 1/2" inch, 7.1 amp Hammer Drill
36. Survey Measuring Wheel
37. Six Pylon Cones
38. One Lock and Key
39. Two Clipboards
40. Stop Watch

Date:

Sieve Analysis on Recovered Material

for

Weight of Pan = ___ grams

Sieve (mm)	Pan + Aggregate (grams)	Aggregate Only (grams)	Percent Retained (%)	Percent Passing (%)

Date: ______ Time: ______ AM/PM

Location:

Layer Tested: ______ **Upstream Probe**

Time	Resistance	Time	Resistance	Time	Resistance
0		75		150	
5		80		155	
10		85		160	
15		90		165	
20		95		170	
25		100		175	
30		105		180	
35		110		185	
40		115		190	
45		120		195	
50		125		200	
55		130		205	
60		135		210	
65		140		215	
70		145		220	

Time	Resistance	Time	Resistance	Time	Resistance
220		315		410	
225		320		415	
230		325		420	
235		330		425	
240		335		430	
245		340		435	
250		345		440	
255		350		445	
260		355		450	
265		360		455	
270		365		460	
275		370		465	
280		375		470	
285		380		475	
290		385		480	
295		390		485	
300		395		490	
305		400		495	
310		405		500	

Time	Resistance	Time	Resistance	Time	Resistance
505		600		695	
510		605		700	
515		610		705	
520		615		710	
525		620		715	
530		625		720	
535		630		725	
540		635		730	
545		640		735	
550		645		740	
555		650		745	
560		655		750	
565		660		755	
570		665		760	
575		670		765	
580		675		770	
585		680		775	
590		685		780	
595		690		785	

Time	Resistance	Time	Resistance	Time	Resistance
790		885		980	
795		890		985	
800		895		990	
805		900		995	
810		905		1000	
815		910		1005	
820		915		1010	
825		920		1015	
830		925		1020	
835		930		1025	
840		935		1030	
845		940		1035	
850		945		1040	
855		950		1045	
860		955		1050	
865		960		1055	
870		965		1060	
875		970		1065	
880		975		1070	

Time	Resistance	Time	Resistance	Time	Resistance
1075		1170		1265	
1080		1175		1270	
1085		1180		1275	
1090		1185		1280	
1095		1190		1285	
1100		1195		1290	
1105		1200		1295	
1110		1205		1300	
1115		1210		1305	
1120		1215		1310	
1125		1220		1315	
1130		1225		1320	
1135		1230		1325	
1140		1235		1330	
1145		1240		1335	
1150		1245		1340	
1155		1250		1345	
1160		1255		1350	
1165		1260		1355	

Time	Resistance	Time	Resistance	Time	Resistance
1360		1425		1490	
1365		1430		1495	
1370		1435		1500	
1375		1440		1505	
1380		1445		1510	
1385		1450		1515	
1390		1455		1520	
1395		1460		1525	
1400		1465		1530	
1405		1470		1535	
1410		1475		1540	
1415		1480		1545	
1420		1485		1550	

Date: ______ Time: ____AM/PM

Location:

Layer Tested: ______ **Downstream Probe**

Time	Resistance	Time	Resistance	Time	Resistance
0		75		150	
5		80		155	
10		85		160	
15		90		165	
20		95		170	
25		100		175	
30		105		180	
35		110		185	
40		115		190	
45		120		195	
50		125		200	
55		130		205	
60		135		210	
65		140		215	
70		145		220	

Time	Resistance	Time	Resistance	Time	Resistance
220		315		410	
225		320		415	
230		325		420	
235		330		425	
240		335		430	
245		340		435	
250		345		440	
255		350		445	
260		355		450	
265		360		455	
270		365		460	
275		370		465	
280		375		470	
285		380		475	
290		385		480	
295		390		485	
300		395		490	
305		400		495	
310		405		500	

Time	Resistance	Time	Resistance	Time	Resistance
505		600		695	
510		605		700	
515		610		705	
520		615		710	
525		620		715	
530		625		720	
535		630		725	
540		635		730	
545		640		735	
550		645		740	
555		650		745	
560		655		750	
565		660		755	
570		665		760	
575		670		765	
580		675		770	
585		680		775	
590		685		780	
595		690		785	

Time	Resistance	Time	Resistance	Time	Resistance
790		885		980	
795		890		985	
800		895		990	
805		900		995	
810		905		1000	
815		910		1005	
820		915		1010	
825		920		1015	
830		925		1020	
835		930		1025	
840		935		1030	
845		940		1035	
850		945		1040	
855		950		1045	
860		955		1050	
865		960		1055	
870		965		1060	
875		970		1065	
880		975		1070	

Time	Resistance	Time	Resistance	Time	Resistance
1075		1170		1265	
1080		1175		1270	
1085		1180		1275	
1090		1185		1280	
1095		1190		1285	
1100		1195		1290	
1105		1200		1295	
1110		1205		1300	
1115		1210		1305	
1120		1215		1310	
1125		1220		1315	
1130		1225		1320	
1135		1230		1325	
1140		1235		1330	
1145		1240		1335	
1150		1245		1340	
1155		1250		1345	
1160		1255		1350	
1165		1260		1355	

Time	Resistance	Time	Resistance	Time	Resistance
1360		1425		1490	
1365		1430		1495	
1370		1435		1500	
1375		1440		1505	
1380		1445		1510	
1385		1450		1515	
1390		1455		1520	
1395		1460		1525	
1400		1465		1530	
1405		1470		1535	
1410		1475		1540	
1415		1480		1545	
1420		1485		1550	

Appendix E

Test of the In Situ Hydraulic Conductivity Test Device for Ohio State Route 2 Results for Ohio DOT specification No. 310 as per plan

- E-1 - Field Test Data for ODOT No. 310 Test No. 1

Date: 09/07/94

Location: Lorain County, State Route 2, Station 4+00 48' Left of the Centerline (Center of the W.B. Driving Lane)

Material/Pavement Section: 6" No.304, 4" No. 310, 10" P.C.C.

Probe Lengths: 20" Layer Tested: 4" No. 310

Layer Thickness: 15.24 cm Water Temperature: *21°C*

Recovered Test Material Weight: 1.485 Kg

Recovered Test Material Diameter: 10.16 cm

Recovered Test Material Height: 10.16 cm

Recovered Test Material Volume: 0.000824 cubic meters

γ_{dry}: 17.69 KiloNewtons per cubic meter

$\phi_w =$ 1.041 m

Test No.: 1

	Probe Upst	Probe Dwnst	L	$\Delta\phi$	t_{up}	t_{dn}	t
begin	15	30	15	19.6			
end				19.6			
avg.	15	30	15	19.6	-	-	-

Note: All measurements are in centimeters and seconds

$K = \frac{L^2}{t\,\Delta\phi} =$ Unk

Date: 09/16/94

S.R. 2 Sieve Analysis on Recovered Material

for Ohio DOT specification No. 310

Weight of Pan = 249 grams

Sieve (mm)	Pan + Aggregate (grams)	Aggregate Only (grams)	Percent Retained (%)	Percent Passing (%)
25.400	249	0	0.00	100.00
9.525	274	25	1.68	98.32
4.750	295	46	3.10	95.22
2.360	549	300	20.20	75.02
0.425	1119	870	58.59	16.43
0.075	469	220	14.81	1.62
Pan	273	24	1.62	0.00

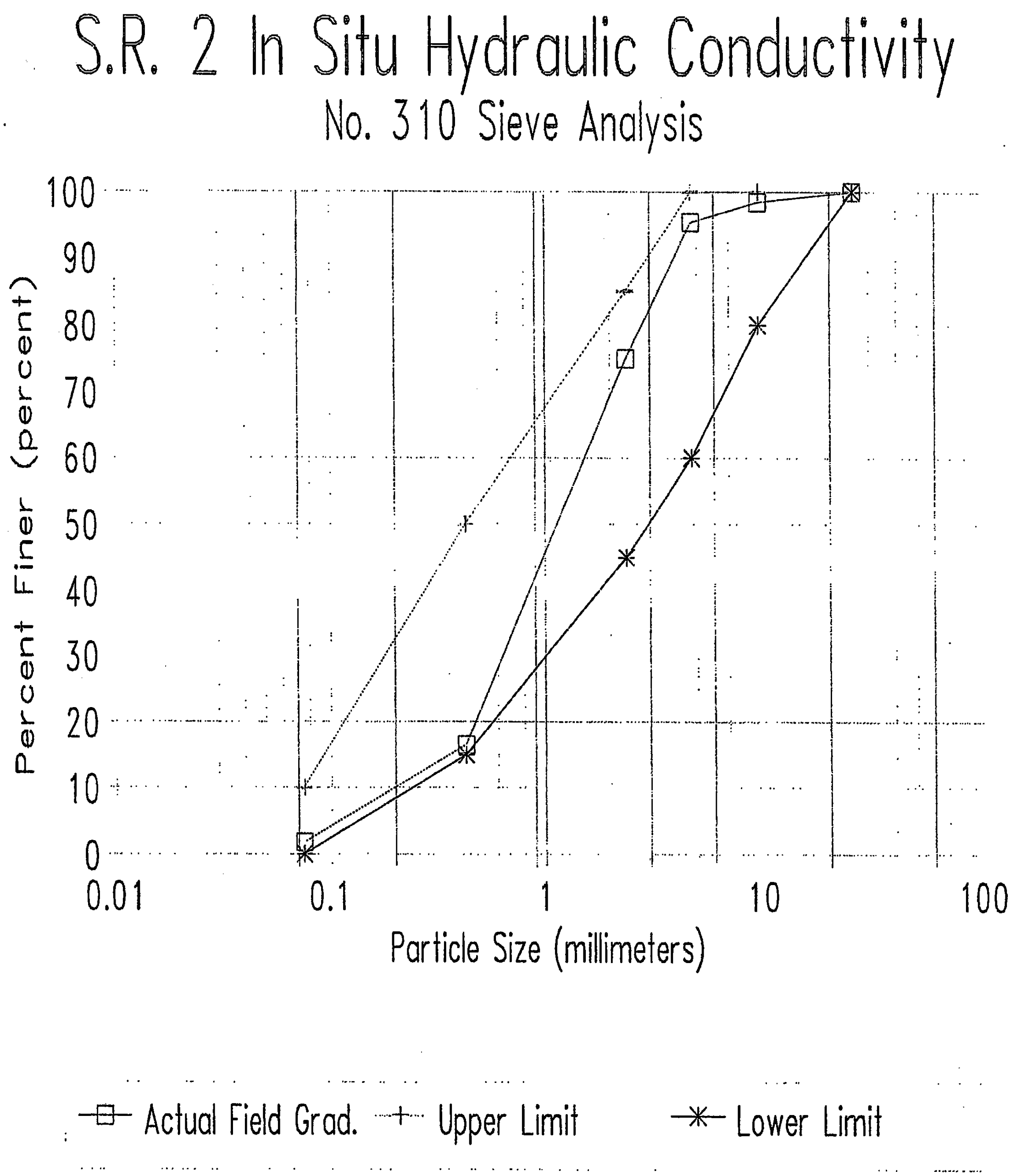


Figure E.1 - Percent Finer versus Particle Diameter for Recovered No. 310

Date: 09/07/94

Location: Lorain County, State Route 2, Station 4+00 48' Left of the Centerline (Center of the W.B. Driving Lane)

Layer Tested: 4" No. 310 **Upstream Probe**

Time	Resistance	Time	Resistance	Time	Resistance
0	32.9	470	42.7	620	51.0
60	33.5	480	43.2	630	51.3
120	33.6	490	44.0	640	51.7
180	34.0	500	44.4	650	52.1
240	34.5	510	44.6	660	52.6
270	35.1	520	45.1	670	52.9
300	36.2	530	45.6	680	53.4
330	37.1	540	46.3	690	53.9
360	38.4	550	47.3	700	54.2
390	39.6	560	47.9	710	54.6
420	41.2	570	48.2	720	55.2
430	41.5	580	48.7	730	55.6
440	41.9	590	49.4	740	55.9
450	42.3	600	50.1	750	56.1
460	42.5	610	50.7	760	56.3

Time	Resistance	Time	Resistance	Time	Resistance
770	56.5	960	56.5	1150	56.9
780	56.6	970	56.3	1160	56.5
790	56.9	980	56.0	1170	56.0
800	57.4	990	55.8	1180	55.5
810	57.9	1000	55.8	1190	55.1
820	58.1	1010	56.0	1200	54.9
830	57.9	1020	56.6	1210	54.3
840	57.9	1030	56.8	1220	53.9
850	57.6	1040	57.0	1230	53.7
860	57.4	1050	57.2	1240	53.7
870	57.3	1060	57.4	1250	53.7
880	57.4	1070	57.4	1260	53.7
890	57.6	1080	57.6	1270	53.8
900	57.9	1090	57.7	1280	54.3
910	58.0	1100	57.5	1290	54.5
920	58.1	1110	57.2	1300	54.7
930	58.0	1120	57.2	1310	55.2
940	57.6	1130	57.4	1320	55.4
950	57.0	1140	57.1	1330	55.2

Time	Resistance	Time	Resistance	Time	Resistance
1340	55.0	1530	61.2	1720	72.4
1350	54.6	1540	62.2	1730	73.0
1360	54.6	1550	63.0	1740	73.7
1370	55.7	1560	63.3	1750	74.0
1380	56.2	1570	64.1	1760	74.3
1390	56.5	1580	64.9	1770	74.5
1400	56.5	1590	65.6	1780	74.5
1410	56.5	1600	65.7	1790	74.7
1420	56.7	1610	66.0	1800	74.8
1430	56.7	1620	66.4	1810	74.9
1440	57.0	1630	67.0	1820	75.2
1450	57.7	1640	67.8	1830	75.4
1460	58.3	1650	68.3	1840	75.6
1470	59.2	1660	68.8	1850	75.6
1480	59.4	1670	69.3	1860	75.5
1490	59.5	1680	69.5	1870	75.5
1500	60.0	1690	69.7	1880	75.6
1510	60.5	1700	70.2	1890	75.7
1520	61.1	1710	71.5	1900	75.8

Time	Resistance	Time	Resistance	Time	Resistance
1920	76.2	2110	76.4	2300	80.8
1930	76.4	2120	76.4	2310	80.8
1940	76.6	2130	76.6	2320	81.0
1950	76.8	2140	77.2	2330	81.2
1960	77.0	2150	77.8	2340	81.4
1970	76.3	2160	78.4	2350	81.5
1980	75.0	2170	78.7	2360	81.7
1990	74.6	2180	79.1	2370	82.1
2000	74.5	2190	79.4	2380	82.6
2010	74.4	2200	79.7	2390	83.0
2020	74.6	2210	79.6	2400	83.3
2030	75.0	2220	79.6	2410	83.6
2040	75.3	2230	79.9	2420	83.8
2050	74.6	2240	80.2	2430	84.2
2060	74.8	2250	80.3	2440	84.6
2070	75.1	2260	80.5	2450	84.9
2080	75.3	2270	80.8	2460	85.4
2090	75.8	2280	81.1	2470	85.6
2100	76.2	2290	81.1	2480	85.6

Time	Resistance	Time	Resistance	Time	Resistance
2490	85.2	2680	88.0		
2500	84.8	2690	88.2		
2510	84.7	2700	88.5		
2520	84.6	2710	88.7		
2530	84.5	2720	88.9		
2540	84.5	2730	89.0		
2550	84.7	2740	89.1		
2560	84.9	2750	89.1		
2570	85.4	2760	89.3		
2580	85.7	2770	89.4		
2590	85.9	2780	89.5		
2600	86.2	2790	89.6		
2610	86.7	2800	89.8		
2620	87.0	2810	89.9		
2630	87.3	2820	90.1		
2640	87.4				
2650	87.7				
2660	87.6				
2670	87.9				

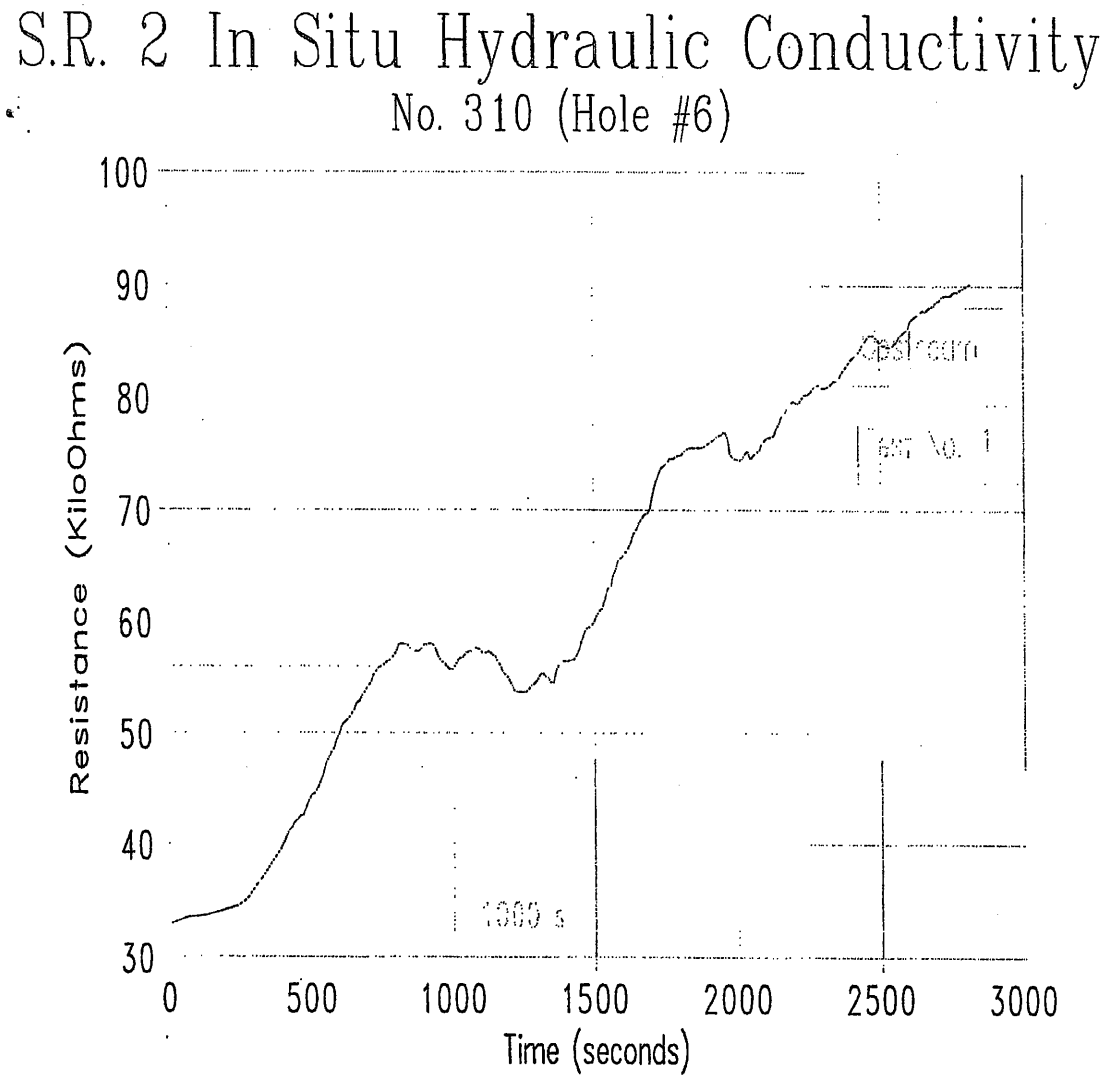


Figure E.2 - Time versus Resistance for Test No. 1, No. 310, Upstream Probe

Date: 09/07/94

Location: Lorain County, State Route 2, Station 4+00 48' Left of the Centerline (Center of the W.B. Driving Lane)

Layer Tested: 4" No. 310 **Downstream Probe**

Time	Resistance	Time	Resistance	Time	Resistance
0	46.5	470	54.0	620	55.7
60	47.3	480	54.2	630	55.8
120	48.3	490	54.4	640	55.8
180	49.5	500	54.5	650	55.9
240	50.8	510	54.6	660	56.0
270	51.4	520	54.8	670	56.1
300	51.8	530	54.8	680	56.2
330	52.2	540	54.9	690	56.3
360	52.6	550	54.9	700	56.4
390	53.0	560	55.1	710	56.5
420	53.3	570	55.2	720	56.5
430	53.4	580	55.3	730	56.6
440	53.6	590	55.4	740	56.7
450	53.7	600	55.5	750	56.8
460	53.9	610	55.6	760	56.9

Time	Resistance	Time	Resistance	Time	Resistance
770	57.0	960	58.4	1150	59.4
780	57.2	970	58.5	1160	59.5
790	57.3	980	58.5	1170	59.6
800	57.4	990	58.6	1180	59.7
810	57.5	1000	58.6	1190	59.7
820	57.6	1010	58.8	1200	59.7
830	57.7	1020	58.8	1210	59.8
840	57.7	1030	58.9	1220	59.8
850	57.8	1040	59.0	1230	59.8
860	57.8	1050	59.1	1240	59.9
870	57.9	1060	59.1	1250	59.9
880	57.9	1070	59.2	1260	60.0
890	58.0	1080	59.2	1270	60.0
900	58.0	1090	59.2	1280	60.0
910	58.0	1100	59.3	1290	60.0
920	58.1	1110	59.3	1300	60.0
930	58.3	1120	59.3	1310	60.0
940	58.4	1130	59.3	1320	60.0
950	58.4	1140	59.4	1330	60.0

Time	Resistance	Time	Resistance	Time	Resistance
1340	60.0	1530	60.2	1720	60.7
1350	60.1	1540	60.2	1730	60.8
1360	60.1	1550	60.3	1740	61.4
1370	60.1	1560	60.4	1750	61.5
1380	60.2	1570	60.3	1760	61.6
1390	60.1	1580	60.4	1770	61.6
1400	60.1	1590	60.4	1780	61.7
1410	60.1	1600	60.5	1790	61.8
1420	60.0	1610	60.5	1800	61.8
1430	60.1	1620	60.5	1810	61.9
1440	60.1	1630	60.5	1820	61.9
1450	60.1	1640	60.5	1830	62.0
1460	60.1	1650	60.6	1840	62.1
1470	60.1	1660	60.6	1850	62.2
1480	60.2	1670	60.6	1860	62.2
1490	60.2	1680	60.6	1870	62.3
1500	60.2	1690	60.6	1880	62.3
1510	60.2	1700	60.6	1890	62.4
1520	60.2	1710	60.6	1900	62.4

Time	Resistance	Time	Resistance	Time	Resistance
1920	62.4	2110	62.8	2300	62.8
1930	62.4	2120	62.8	2310	62.8
1940	62.4	2130	62.7	2320	62.9
1950	62.5	2140	62.7	2330	62.9
1960	62.5	2150	62.6	2340	62.9
1970	62.5	2160	62.6	2350	63.0
1980	62.5	2170	62.6	2360	63.0
1990	62.6	2180	62.6	2370	63.0
2000	62.6	2190	62.5	2380	63.0
2010	62.7	2200	62.5	2390	63.0
2020	62.7	2210	62.6	2400	63.0
2030	62.7	2220	62.5	2410	63.0
2040	62.8	2230	62.6	2420	63.0
2050	62.8	2240	62.5	2430	62.9
2060	62.9	2250	62.5	2440	63.0
2070	62.9	2260	62.5	2450	62.9
2080	62.9	2270	62.5	2460	63.0
2090	62.9	2280	62.6	2470	62.9
2100	62.8	2290	62.7	2480	63.0

Time	Resistance	Time	Resistance	Time	Resistance
2490	63.0	2680	62.9		
2500	63.0	2690	62.9		
2510	63.0	2700	62.9		
2520	63.0	2710	62.9		
2530	63.0	2720	62.9		
2540	63.0	2730	62.9		
2550	63.0	2740	62.9		
2560	63.0	2750	62.9		
2570	63.0	2760	62.9		
2580	63.0	2770	63.0		
2590	63.1	2780	63.1		
2600	63.1	2790	63.1		
2610	63.1	2800	63.2		
2620	63.1	2810	63.3		
2630	63.1	2820	63.4		
2640	63.1				
2650	63.0				
2660	63.0				
2670	63.0				

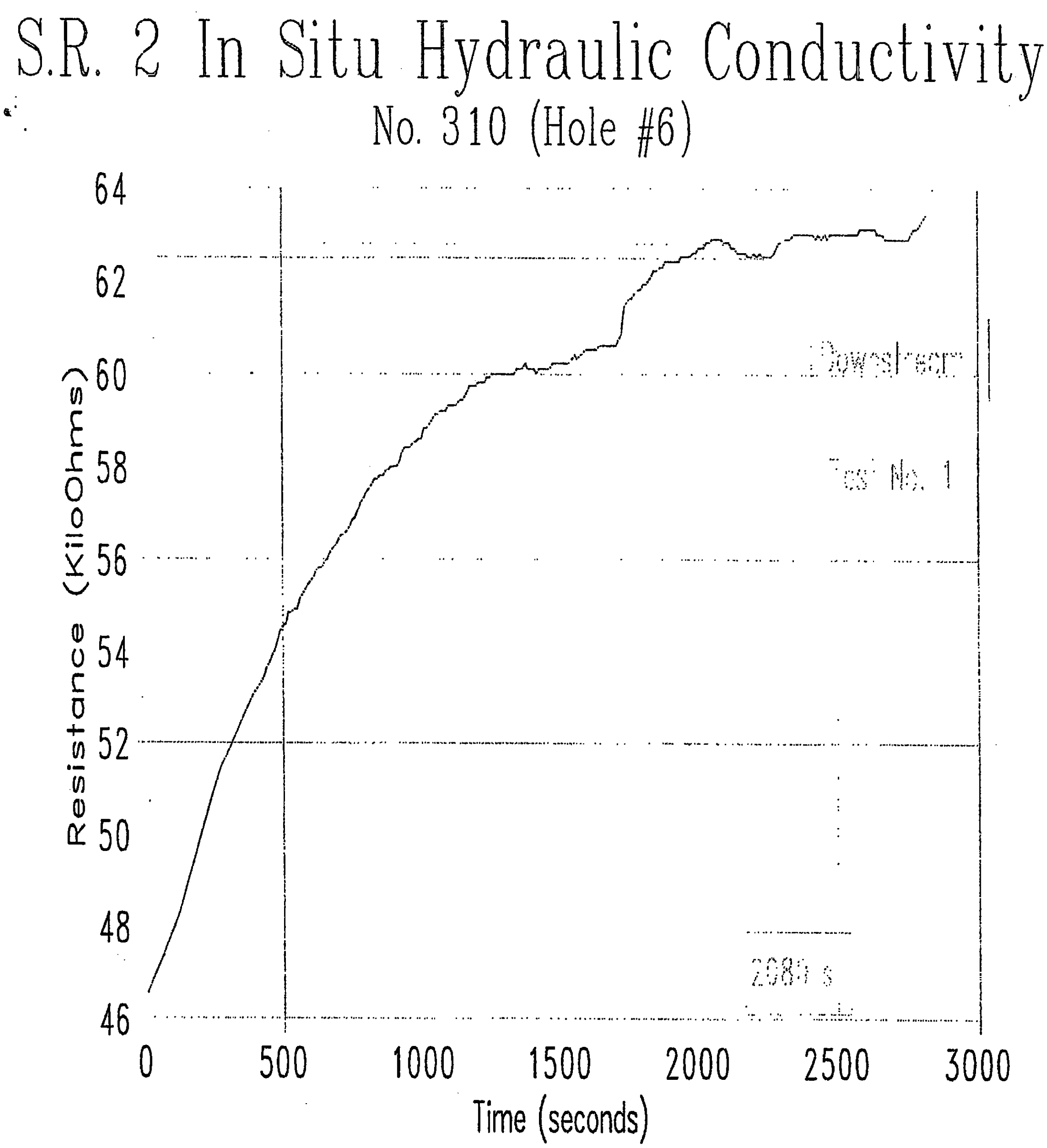


Figure E.3 - Time versus Resistance for Test No. 1, No. 310, Downstream Probe

- E-2 - Field Test Data for ODOT No. 310 Test No. 2

Date: 09/07/94

Location: Lorain County, State Route 2, Station 4+00 48' Left of the Centerline (Center of the W.B. Driving Lane)

Material/Pavement Section: 6" No.304, 4" No. 310, 10" P.C.C.

Probe Lengths: 20" Layer Tested: 4" No. 310

Layer Thickness: 15.24 cm Water Temperature: 21 °C

Recovered Test Material Weight: 1.485 Kg

Recovered Test Material Diameter: 10.16 cm

Recovered Test Material Height: 10.16 cm

Recovered Test Material Volume: 0.000824 cubic meters

γ_{dry}: 17.69 KiloNewtons per cubic meter

ϕ_w = 1.041 m

Test No.: 2

	Probe Upst	Probe Dwnst	L	$\Delta\phi$	t_{up}	t_{dn}	t
begin	15	30	15	19.1			
end				16.9			
avg.	15	30	15	18.0	435	1230	795

Note: All measurements are in centimeters and seconds

$$K = \frac{L^2}{t\,\Delta\phi} = 0.0158 \text{ cm/s}$$

Date: 09/07/94

Location: Lorain County, State Route 2, Station 4+00 48'

Left of the Centerline (Center of the W.B. Driving Lane)

Layer Tested: 4" No. 310 **Upstream Probe**

Time	Resistance	Time	Resistance	Time	Resistance
0	91.8	310	79.0	470	65.4
60	91.6	320	79.0	480	65.0
120	90.8	330	78.9	490	64.5
150	91.7	340	77.6	500	62.6
180	91.3	350	76.2	510	61.6
210	89.8	360	75.7	520	61.3
220	89.0	380	74.2	530	61.7
230	87.2	390	73.1	540	61.5
240	86.1	400	71.5	550	61.6
250	84.8	410	71.1	560	61.2
260	83.6	420	69.2	570	60.7
270	82.0	430	68.5	580	60.6
280	81.2	440	67.2	590	59.5
290	80.6	450	66.5	600	58.5
300	80.0	460	66.0	620	60.2

Time	Resistance	Time	Resistance	Time	Resistance
630	60.0	820	58.1	1010	68.7
640	59.4	830	59.0	1020	69.9
650	58.2	840	59.5	1030	71.0
660	58.2	850	60.0	1040	72.1
670	57.1	860	61.1	1050	73.2
680	56.0	870	62.2	1060	74.1
690	55.9	880	63.0	1070	74.9
700	55.3	890	63.3	1080	75.2
710	54.7	900	63.7	1090	75.9
720	54.2	910	64.0	1100	76.7
730	54.5	920	62.8	1110	77.4
740	54.8	930	62.1	1120	77.7
750	54.6	940	61.9	1130	77.4
760	54.8	950	63.2	1140	77.6
770	55.8	960	64.5	1150	77.9
780	56.4	970	65.7	1160	78.4
790	56.8	980	67.0	1170	78.8
800	56.9	990	67.9	1180	79.1
810	57.3	1000	68.3	1190	79.0

Time	Resistance	Time	Resistance	Time	Resistance
1200	79.2	1390	84.2	1580	83.6
1210	79.9	1400	84.1	1590	84.1
1220	80.6	1410	84.2	1600	84.3
1230	81.3	1420	84.6	1610	84.7
1240	82.2	1430	84.7	1620	84.7
1250	83.2	1440	85.0	1630	85.0
1260	83.6	1450	85.5	1640	85.8
1270	84.1	1460	85.8	1650	84.4
1280	83.8	1470	86.1	1660	84.4
1290	83.0	1480	86.2	1670	84.5
1300	82.7	1490	86.2	1680	84.7
1310	83.2	1500	86.3	1690	85.1
1320	83.9	1510	86.9	1700	85.5
1330	84.5	1520	87.2	1710	85.9
1340	84.9	1530	87.6	1720	86.6
1350	85.5	1540	85.1	1730	87.2
1360	84.8	1550	83.3	1740	87.6
1370	84.3	1560	82.7	1750	87.9
1380	84.5	1570	83.1	1760	88.1

Time	Resistance	Time	Resistance	Time	Resistance
1770	88.3	1970	89.8	2160	88.6
1780	88.3	1980	89.7	2190	89.4
1790	88.5	1990	89.7	2220	90.0
1800	88.6	2000	89.8	2250	91.0
1810	88.6	2010	89.8	2280	90.1
1820	88.8	2020	89.8	2310	90.8
1830	89.4	2030	89.8	2340	91.5
1840	89.7	2040	89.7	2370	92.7
1850	90.0	2050	89.6	2400	93.1
1860	90.0	2060	89.7		
1870	89.9	2070	89.6		
1880	90.0	2080	89.4		
1890	89.9	2090	89.4		
1900	89.7	2100	89.5		
1920	89.4	2110	89.6		
1930	89.6	2120	89.1		
1940	89.6	2130	88.3		
1950	89.8	2140	88.1		
1960	89.8	2150	88.4		

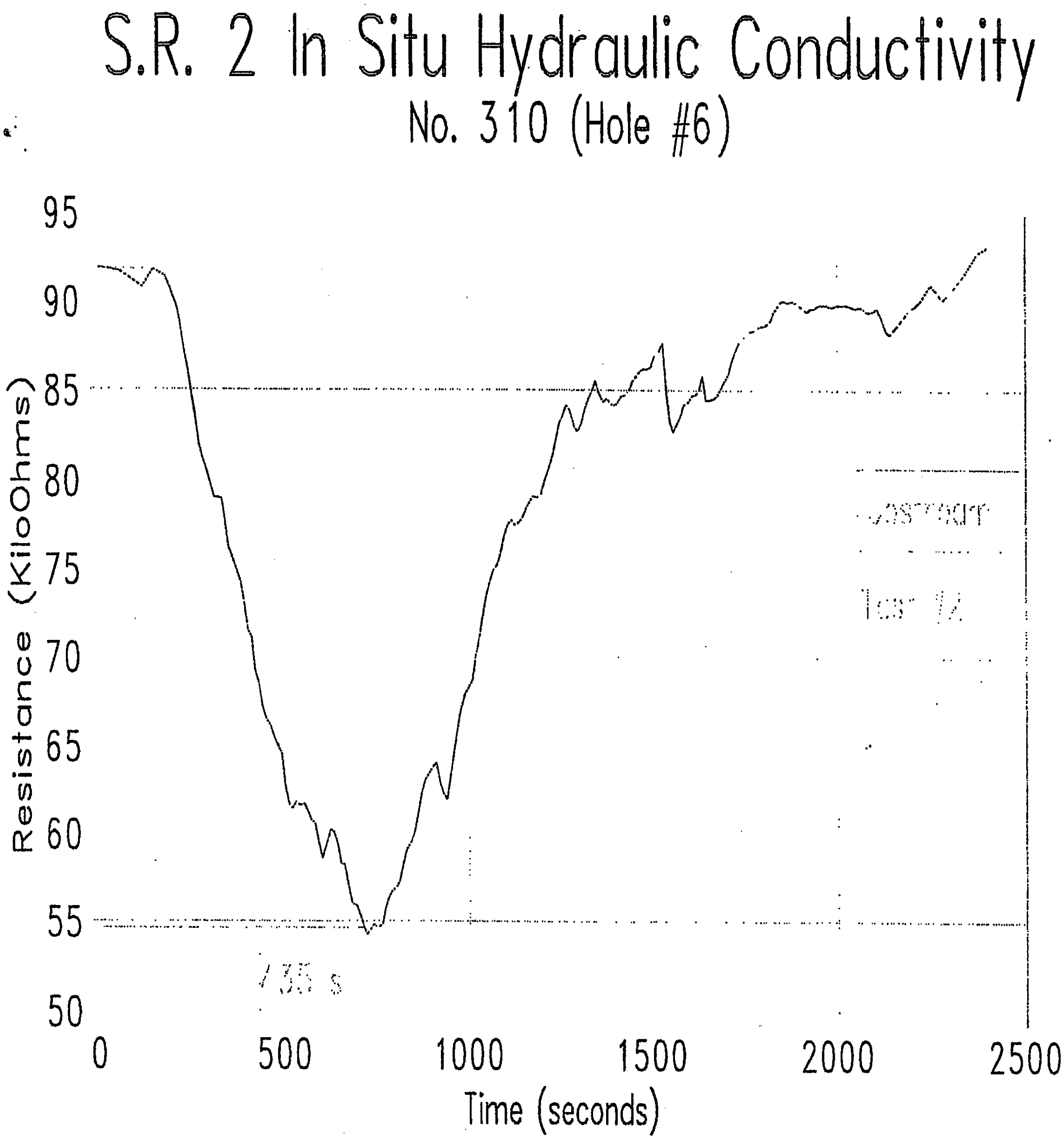


Figure E.4 - Time versus Resistance for Test No. 2, No. 310, Upstream Probe

Date: 09/07/94

Location: Lorain County, State Route 2, Station 4+00 48' Left of the Centerline (Center of the W.B. Driving Lane)

Layer Tested: 4" No. 310 **Downstream Probe**

Time	Resistance	Time	Resistance	Time	Resistance
0	76.8	310	101.9	470	117.2
60	80.1	320	103.0	480	118.0
120	81.2	330	104.0	490	118.4
150	82.2	340	107.0	500	118.8
180	85.6	350	108.0	510	119.6
210	91.9	360	108.0	520	119.8
220	93.2	380	111.2	530	120.1
230	94.8	390	112.2	540	120.4
240	96.2	400	113.3	550	120.9
250	97.1	410	113.7	560	122.0
260	97.1	420	114.1	570	122.6
270	96.6	430	114.9	580	123.0
280	96.7	440	115.4	590	123.5
290	97.3	450	115.7	600	123.6
300	99.6	460	116.5	620	124.6

Time	Resistance	Time	Resistance	Time	Resistance
630	125.3	820	134.6	1010	134.4
640	124.7	830	135.1	1020	134.0
650	124.9	840	135.3	1030	133.6
660	125.7	850	135.6	1040	133.3
670	126.4	860	135.8	1050	132.9
680	126.8	870	134.0	1060	132.5
690	127.6	880	133.9	1070	132.0
700	128.4	890	134.0	1080	131.7
710	129.1	900	134.5	1090	131.3
720	129.6	910	134.8	1100	131.3
730	130.5	920	134.8	1110	131.0
740	131.0	930	135.0	1120	130.6
750	131.7	940	134.5	1130	130.1
760	132.3	950	134.6	1140	129.7
770	132.4	960	134.9	1150	129.4
780	132.9	970	134.9	1160	129.0
790	133.3	980	134.8	1170	128.7
800	133.7	990	134.3	1180	128.3
810	134.1	1000	134.4	1190	127.9

Time	Resistance	Time	Resistance	Time	Resistance
1200	127.8	1390	122.6	1580	119.1
1210	127.3	1400	122.3	1590	118.8
1220	127.0	1410	122.3	1600	118.6
1230	126.7	1420	122.0	1610	118.7
1240	126.3	1430	121.7	1620	118.9
1250	126.0	1440	121.7	1630	118.8
1260	125.5	1450	121.8	1640	118.9
1270	125.4	1460	121.7	1650	119.1
1280	125.1	1470	121.5	1660	119.4
1290	124.5	1480	121.5	1670	119.5
1300	124.2	1490	121.1	1680	119.6
1310	124.0	1500	120.8	1690	119.5
1320	123.4	1510	120.5	1700	119.6
1330	123.3	1520	120.4	1710	119.6
1340	123.2	1530	120.2	1720	119.6
1350	122.8	1540	119.9	1730	119.5
1360	122.6	1550	119.5	1740	119.5
1370	122.5	1560	119.4	1750	119.5
1380	122.4	1570	119.2	1760	119.5

Time	Resistance	Time	Resistance	Time	Resistance
1770	119.6	1970	119.4	2160	116.5
1780	119.7	1980	119.5	2190	116.2
1790	119.5	1990	119.0	2220	115.4
1800	119.3	2000	118.7	2250	114.9
1810	119.0	2010	118.6	2280	114.7
1820	119.3	2020	118.5	2310	114.3
1830	119.3	2030	118.5	2340	113.7
1840	119.2	2040	118.2	2370	113.7
1850	119.1	2050	118.0	2400	113.4
1860	118.9	2060	118.0		
1870	118.3	2070	118.2		
1880	118.3	2080	118.1		
1890	118.4	2090	118.0		
1900	118.5	2100	118.0		
1920	118.9	2110	117.7		
1930	119.2	2120	117.3		
1940	119.4	2130	117.2		
1950	119.6	2140	117.0		
1960	119.5	2150	116.5		

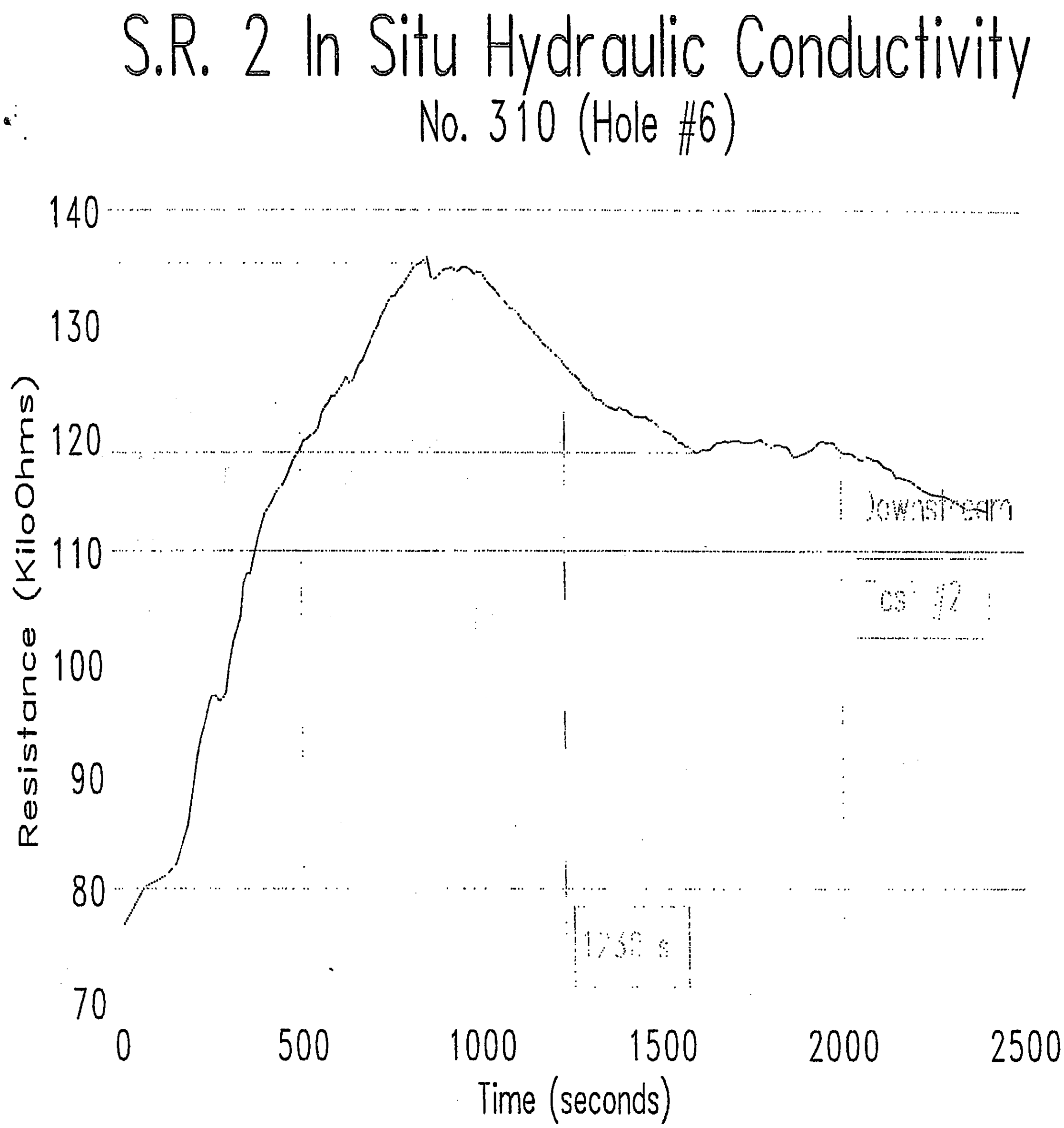


Figure E.5 - Time versus Resistance for Test No. 2, No. 310, Downstream Probe

Appendix F

Test of the In Situ Hydraulic Conductivity Test Device for Ohio State Route 2 Results for Iowa DOT specification 41-21

F-1 - Field Test Data for Iowa DOT 41-21, Test No. 1

Date: 09/08/94

Location: Lorain County, State Route 2, Station 6+00 48' Left of the Centerline (Center of the W.B. Driving Lane)

Material/Pavement Section: 6" No.304, 4" 41-21, 10" P.C.C.

Probe Lengths: 20" Layer Tested: IDOT 41-21

Layer Thickness: 15.24 cm Water Temperature: 22 °C

Recovered Test Material Weight: 1.863 Kg

Recovered Test Material Diameter: 10.16 cm

Recovered Test Material Height: 10.16 cm

Recovered Test Material Volume: 0.000824 cubic meters

γ_{dry}: 22.19 KiloNewtons per cubic meter

$\phi_w =$ 1.054 m

Test No.: 1

	Probe Upst	Probe Dwnst	L	$\Delta\phi$	t_{up}	t_{dn}	t
begin	15	30	15	1.30			
end				1.05			
avg.	15	30	15	1.18	100	496	396

Note: All measurements are in centimeters and seconds

$$K = \frac{L^2}{t\,\Delta\phi} = \text{ 0.482 cm/s}$$

Date: 09/16/94

S.R. 2 Sieve Analysis on Recovered Material

for Iowa DOT specification 41-21 Granular Base

Weight of Pan = 249 grams

Sieve (mm)	Pan + Aggregate (grams)	Aggregate Only (grams)	Percent Retained (%)	Percent Passing (%)
25.400	249	0	0.00	100.00
12.700	1218	969	52.01	47.99
2.380	874	625	33.55	14.44
0.300	362	113	6.07	8.37
0.075	389	140	7.51	0.86
Pan	265	16	0.86	0.00

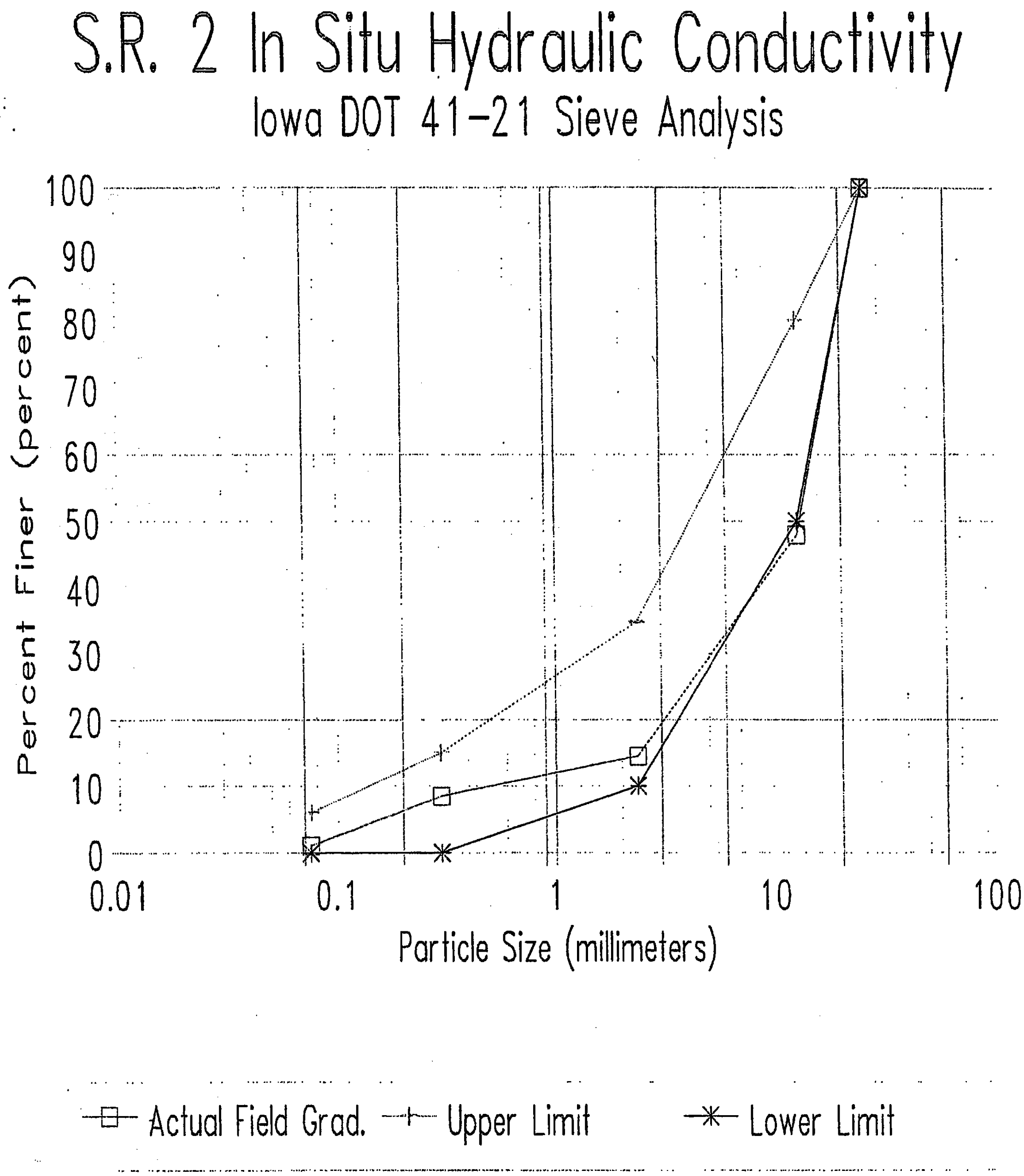


Figure F.1 - Percent Finer versus Particle Diameter for Recovered IDOT 41-21

Date: 09/08/94

Location: Lorain County, State Route 2, Station 6+00 48'

Left of the Centerline (Center of the W.B. Driving Lane)

Layer Tested: IDOT 41-21 **Upstream Probe**

Time	Resistance	Time	Resistance	Time	Resistance
0	7.24	200	6.74	350	7.19
40	7.74	210	6.77	360	7.20
60	7.81	220	6.84	370	7.21
80	7.96	230	6.90	380	7.22
90	7.98	240	6.96	390	7.23
100	7.32	250	6.99	400	7.26
110	7.02	260	7.03	410	7.26
120	6.83	270	7.06	430	7.28
130	6.68	280	7.08	440	7.10
140	6.64	290	7.11	450	6.93
150	6.64	300	7.11	460	6.83
160	6.68	310	7.13	470	6.78
170	6.72	320	7.13	480	6.75
180	6.73	330	7.14	490	6.68
190	6.73	340	7.17	500	6.61

Time	Resistance	Time	Resistance	Time	Resistance
510	6.59	700	6.06	890	6.42
520	6.42	710	6.02	900	6.47
530	6.34	720	6.03	920	6.54
540	6.29	730	6.06	940	6.66
550	6.20	740	6.08	960	6.76
560	6.16	750	6.12	980	6.88
570	6.16	760	6.15	1000	7.15
580	6.20	770	6.15	1020	7.16
590	6.27	780	6.16	1040	7.20
600	6.35	790	6.18	1060	7.18
610	6.33	800	6.32	1080	7.23
620	6.28	810	6.35		
630	6.28	820	6.35		
640	6.28	830	6.33		
650	6.26	840	6.34		
660	6.20	850	6.36		
670	6.21	860	6.35		
680	6.16	870	6.37		
690	6.09	880	6.41		

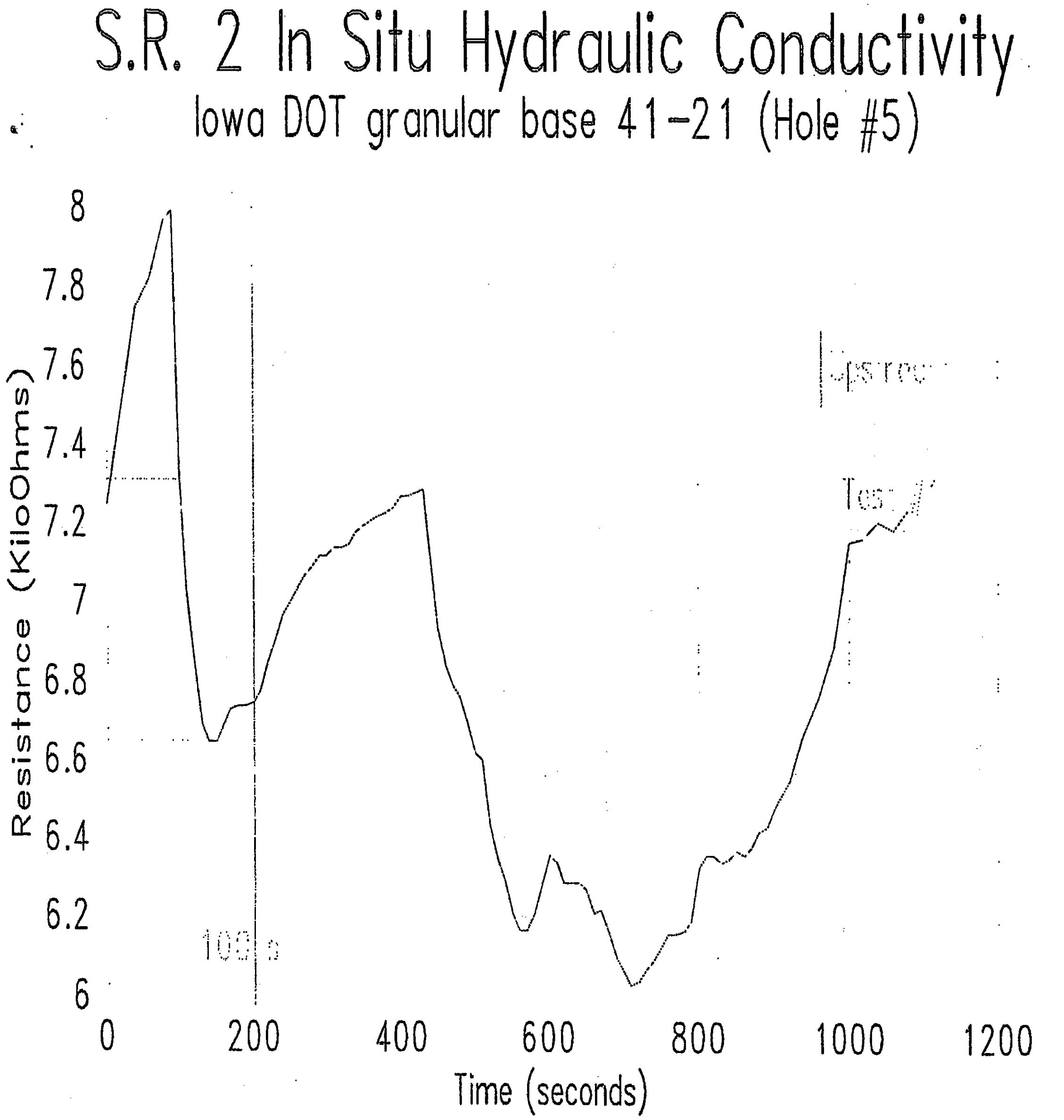


Figure F.2 - Time versus Resistance for Test No. 1, 41-21, Upstream Probe

Date: 09/08/94

Location: Lorain County, State Route 2, Station 6+00 48' Left of the Centerline (Center of the W.B. Driving Lane)

Layer Tested: IDOT 41-21 **Downstream Probe**

Time	Resistance	Time	Resistance	Time	Resistance
0	6.99	200	9.38	350	10.01
40	7.27	210	9.46	360	10.07
60	7.60	220	9.52	370	10.11
80	8.20	230	9.56	380	10.16
90	8.45	240	9.64	390	10.21
100	8.59	250	9.69	400	10.25
110	8.63	260	9.73	410	10.30
120	8.72	270	9.75	430	10.48
130	8.81	280	9.79	440	10.42
140	8.90	290	9.84	450	10.52
150	9.04	300	9.90	460	10.54
160	9.11	310	9.95	470	10.39
170	9.22	320	9.98	480	10.22
180	9.25	330	10.00	490	10.04
190	9.31	340	9.99	500	9.87

Time	Resistance	Time	Resistance	Time	Resistance
510	9.75	700	9.34	890	9.24
520	9.68	710	9.25	900	9.26
530	9.63	720	9.18	920	9.35
540	9.60	730	9.10	940	9.42
550	9.55	740	9.07	960	9.48
560	9.49	750	9.05	980	9.56
570	9.44	760	9.03	1000	9.68
580	9.41	770	9.02	1020	9.80
590	9.39	780	9.01	1040	9.91
600	9.44	790	8.99	1060	10.03
610	9.51	800	8.98	1080	10.12
620	9.55	810	8.98		
630	9.57	820	9.00		
640	9.59	830	9.03		
650	9.60	840	9.05		
660	9.61	850	9.10		
670	9.63	860	9.13		
680	9.52	870	9.16		
690	9.44	880	9.21		

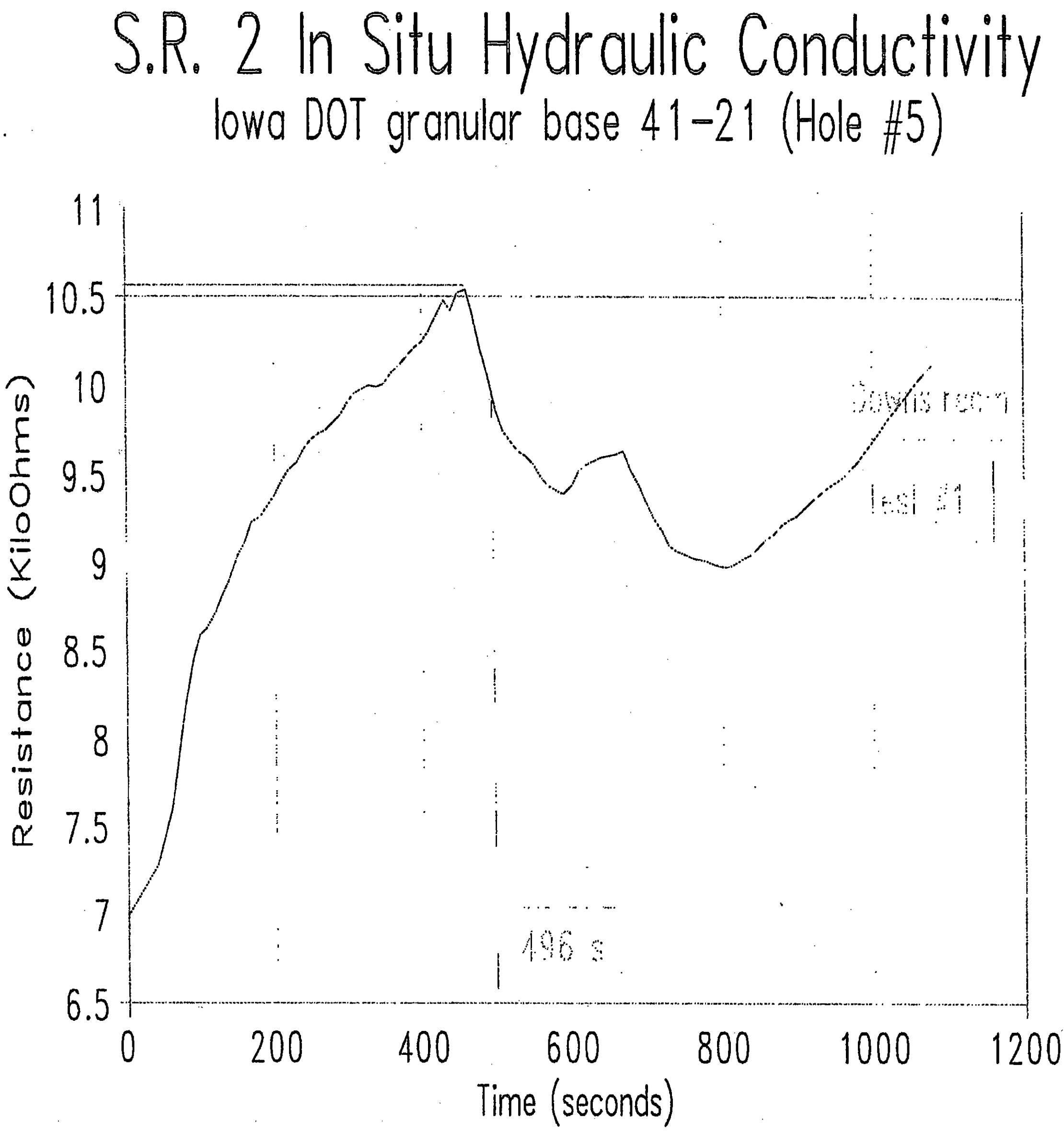


Figure F.3 - Time versus Resistance for Test No. 1, 41-21, Downstream Probe

F-2 - Field Test Data for Iowa DOT 41-21, Test No. 2

Date: 09/08/94

Location: Lorain County, State Route 2, Station 6+00 48' Left of the Centerline (Center of the W.B. Driving Lane)

Material/Pavement Section: 6" No.304, 4" 41-21, 10" P.C.C.

Probe Lengths: 20" Layer Tested: IDOT 41-21

Layer Thickness: 15.24 cm Water Temperature: 22 °C

Recovered Test Material Weight: 1.863 Kg

Recovered Test Material Diameter: 10.16 cm

Recovered Test Material Height: 10.16 cm

Recovered Test Material Volume: 0.000824 cubic meters

γ_{dry}: 22.19 KiloNewtons per cubic meter

ϕ_w = 1.054 m

Test No.: 2

	Probe Upst	Probe Dwnst	L	$\Delta\phi$	t_{up}	t_{dn}	t
begin	15	30	15	--			
end				0.80			
avg.	15	30	15	0.80	87	200	113

Note: All measurements are in centimeters and seconds

$$K = \frac{L^2}{t\,\Delta\phi} = 1\ 2.490 \text{ cm/s}$$

Date: 09/08/94

Location: Lorain County, State Route 2, Station 6+00 48' Left of the Centerline (Center of the W.B. Driving Lane)

Layer Tested: IDOT 41-21 **Upstream Probe**

Time	Resistance	Time	Resistance	Time	Resistance
0	12.03	190	12.05	340	11.97
20	12.08	200	12.02	350	11.98
40	12.10	210	12.03	360	11.96
60	12.12	220	12.05	370	11.94
70	12.13	230	12.06	380	11.93
80	12.14	240	12.06	390	11.91
90	12.13	250	12.03	400	11.91
100	12.11	260	12.05	410	11.91
110	12.11	270	12.07	420	11.92
120	12.11	280	12.08	430	11.90
130	12.11	290	12.09	440	11.90
140	12.12	300	12.09	450	11.90
160	12.07	310	12.08	460	11.89
170	12.06	320	12.04	470	11.88
180	12.06	330	12.00	480	11.88

Date: 09/08/94

Location: Lorain County, State Route 2, Station 6+00 48' Left of the Centerline (Center of the W.B. Driving Lane)

Layer Tested: IDOT 41-21 **Downstream Probe**

Time	Resistance	Time	Resistance	Time	Resistance
0	8.66	190	16.84	340	13.11
20	8.72	200	17.01	350	12.83
40	9.83	210	16.90	360	12.54
60	10.79	220	16.60	370	12.25
70	11.09	230	16.21	380	11.95
80	11.27	240	15.85	390	11.63
90	11.45	250	15.51	400	11.37
100	11.57	260	15.23	410	11.12
110	11.69	270	14.92	420	10.87
120	11.70	280	14.66	430	10.65
130	11.95	290	14.38	440	10.46
140	12.07	300	14.12	450	10.25
160	13.50	310	13.85	460	10.08
170	14.62	320	13.60	470	9.92
180	16.10	330	13.37	480	9.77

Time	Resistance	Time	Resistance	Time	Resistance
490	9.63	680	8.43	900	8.97
500	9.51	690	8.41		
510	9.41	700	8.39		
520	9.31	710	8.39		
530	9.21	720	8.41		
540	9.13	730	8.43		
550	9.06	740	8.45		
560	8.99	750	8.48		
570	8.91	760	8.51		
580	8.85	770	8.52		
590	8.78	780	8.52		
600	8.72	790	8.53		
610	8.67	800	8.56		
620	8.63	810	8.59		
630	8.59	820	8.62		
640	8.54	830	8.64		
650	8.52	840	8.64		
660	8.49	860	8.73		
670	8.45	880	8.84		

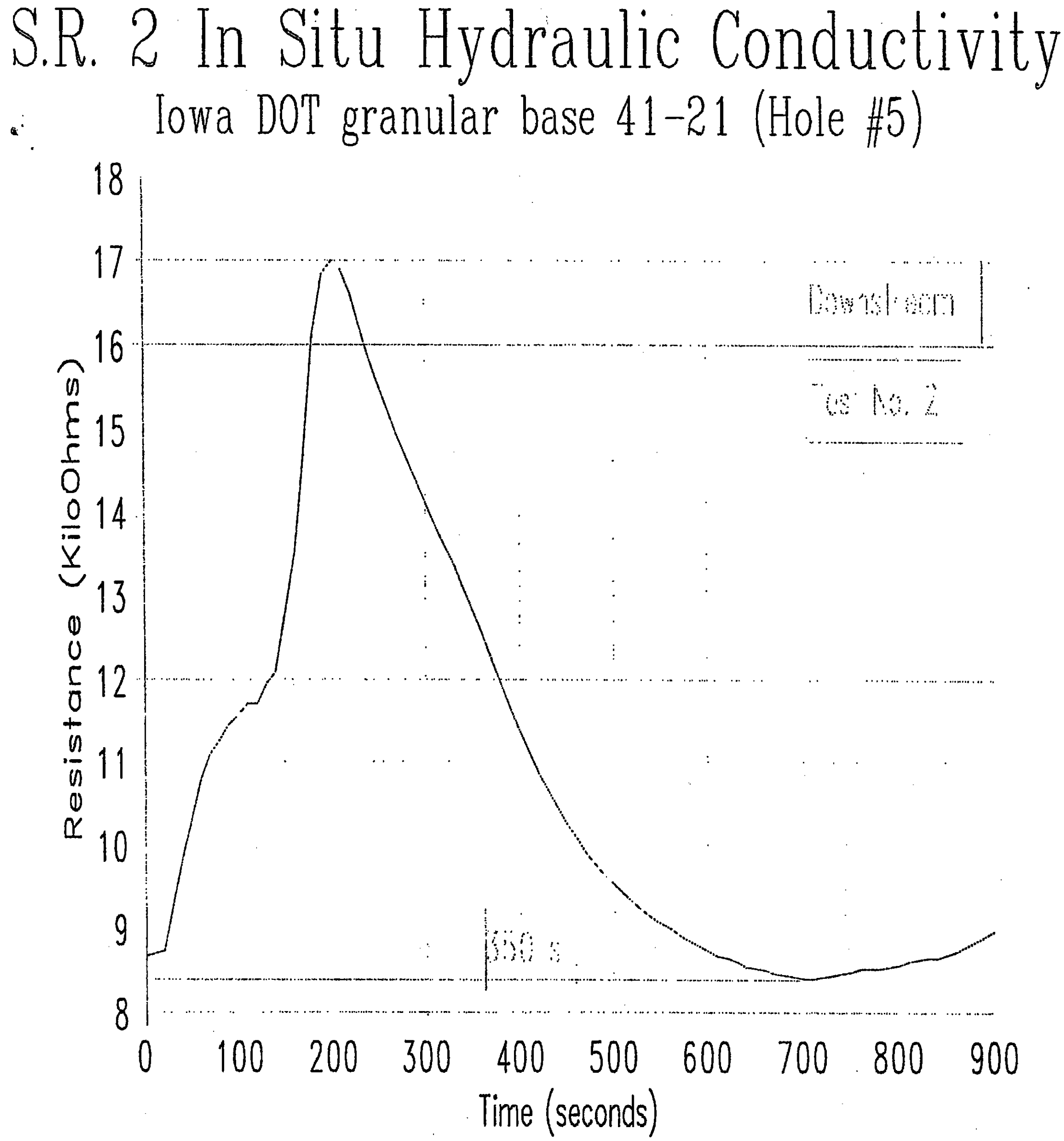


Figure F.5 - Time versus Resistance for Test No. 2, 41-21, Downstream Probe

Appendix G

Test of the In Situ Hydraulic Conductivity Test Device for Ohio State Route 2 Results for Portland Cement Stabilized AASHTO M 43 Specification No. 57

- G-1 - Field Test Data for PCC No. 57, Test No. 1
- Figure G.1 - Time versus Resistance for Test No. 1, PCC No. 57, Upstream Probe
- Figure G.2 - Time versus Resistance for Test No. 1, PCC No. 57, Downstream Probe
- G-2 - Field Test Data for PCC No. 57, Test No. 2
- Figure G.3 - Time versus Resistance for Test No. 2, PCC No. 57, Upstream Probe
- Figure G.4 - Time versus Resistance for Test No. 2, PCC No. 57, Downstream Probe
- G-3 - Field Test Data for PCC No. 57, Test No. 3
- Figure G.5 - Time versus Resistance for Test No. 3, PCC No. 57, Upstream Probe
- Figure G.6 - Time versus Resistance for Test No. 3, PCC No. 57, Downstream Probe

G-1 - Field Test Data for PCC No. 57, Test No. 1

Date: 09/12/94

Location: Lorain County, State Route 2, Station 83+00 48' Left of the Centerline (Center of the W.B. Driving Lane)

Material/Pavement Sect.: 6" No.304, 4" PCC No. 57, 10" P.C.C.

Probe Lengths: 20" Layer Tested: PCC No. 57

Layer Thickness: 15.24 cm Water Temperature: 20 °C

Recovered Test Material Weight: 1.288 Kg

Recovered Test Material Diameter: 10.16 cm

Recovered Test Material Height: 10.16 cm

Recovered Test Material Volume: 0.000824 cubic meters

γ_{dry}: 15.34 KiloNewtons per cubic meter

ϕ_w = unk.

Test No.: 1

	Probe Upst	Probe Dwnst	L	$\Delta\phi$	t_{up}	t_{dn}	t
begin	30	120	90	25.65			
end				25.65			
avg.	30	120	90	25.65	423	536	113

Note: All measurements are in centimeters and seconds

$$K = \frac{L^2}{t\,\Delta\phi} = 2.790 \text{ cm/s}$$

Date: 09/12/94

Location: Lorain County, State Route 2, Station 83+00 48' Left of the Centerline (Center of the W.B. Driving Lane)

Layer Tested: PCC No. 57 **Upstream Probe**

Time	Resistance	Time	Resistance	Time	Resistance
0	68.0	75	69.3	150	69.9
5	68.0	80	69.4	155	70.0
10	68.0	85	69.5	160	70.0
15	68.1	90	69.6	165	70.0
20	68.2	95	69.7	170	70.0
25	68.0	100	69.7	175	70.1
30	68.0	105	69.8	180	70.1
35	68.1	110	69.8	185	70.1
40	68.3	115	69.8	190	70.2
45	68.5	120	69.9	195	70.2
50	68.6	125	69.9	200	70.3
55	68.8	130	69.9	205	70.3
60	69.0	135	69.8	210	70.4
65	69.1	140	69.8	215	70.4
70	69.2	145	69.9	220	70.4

Time	Resistance	Time	Resistance	Time	Resistance
225	70.4	320	70.5	415	70.2
230	70.4	325	70.5	420	70.1
235	70.4	330	70.5	425	70.1
240	70.4	335	70.5	430	70.0
245	70.4	340	70.4	435	70.0
250	70.4	345	70.4	440	69.9
255	70.4	350	70.4	445	70.0
260	70.4	355	70.4	450	70.0
265	70.4	360	70.4	455	70.0
270	70.4	365	70.4	460	70.0
275	70.4	370	70.5	465	70.0
280	70.5	375	70.5	470	69.9
285	70.5	380	70.5	475	69.9
290	70.5	385	70.5	480	69.9
295	70.5	390	70.5	485	69.9
300	70.5	395	70.5	490	69.9
305	70.5	400	70.4	495	69.9
310	70.5	405	70.3	500	69.9
315	70.5	410	70.3	505	69.9

Time	Resistance	Time	Resistance	Time	Resistance
510	69.9	605	70.5	700	70.5
515	70.0	610	70.5	705	70.6
520	70.0	615	70.6	710	70.6
525	70.0	620	70.6	715	70.6
530	70.0	625	70.6	720	70.7
535	70.1	630	70.7	725	70.7
540	70.1	635	70.7	730	70.8
545	70.1	640	70.7	735	70.9
550	70.1	645	70.7	740	71.0
555	70.2	650	70.7	745	71.1
560	70.2	655	70.8	750	71.1
565	70.2	660	70.8	755	71.2
570	70.2	665	70.8	760	71.3
575	70.2	670	70.7	765	71.4
580	70.3	675	70.6	770	71.4
585	70.3	680	70.6	775	71.5
590	70.3	685	70.5	780	71.5
595	70.4	690	70.5	785	71.5
600	70.4	695	70.5	790	71.6

Time	Resistance	Time	Resistance	Time	Resistance
795	71.6	890	71.8	985	71.9
800	71.6	895	71.8	990	71.9
805	71.7	900	71.8	995	72.0
810	71.7	905	71.8	1000	72.0
815	71.7	910	71.8	1005	72.0
820	71.7	915	71.8	1010	72.0
825	71.8	920	71.8	1015	72.1
830	71.8	925	71.8	1020	72.1
835	71.8	930	71.8	1025	72.1
840	71.8	935	71.8	1030	72.1
845	71.8	940	71.8	1035	72.2
850	71.8	945	71.8	1040	72.3
855	71.8	950	71.8	1045	72.3
860	71.8	955	71.8	1050	72.4
865	71.8	960	71.8	1055	72.5
870	71.8	965	71.8	1060	72.5
875	71.8	970	71.8	1065	72.6
880	71.8	975	71.8	1070	72.7
885	71.8	980	71.9	1075	72.7

Time	Resistance	Time	Resistance	Time	Resistance
1080	72.7				
1085	72.8				
1090	72.8				
1095	72.8				
1100	72.8				
1105	72.9				
1110	72.9				
1115	72.9				
1120	72.9				
1125	72.9				
1130	73.0				
1135	73.0				
1140	73.0				

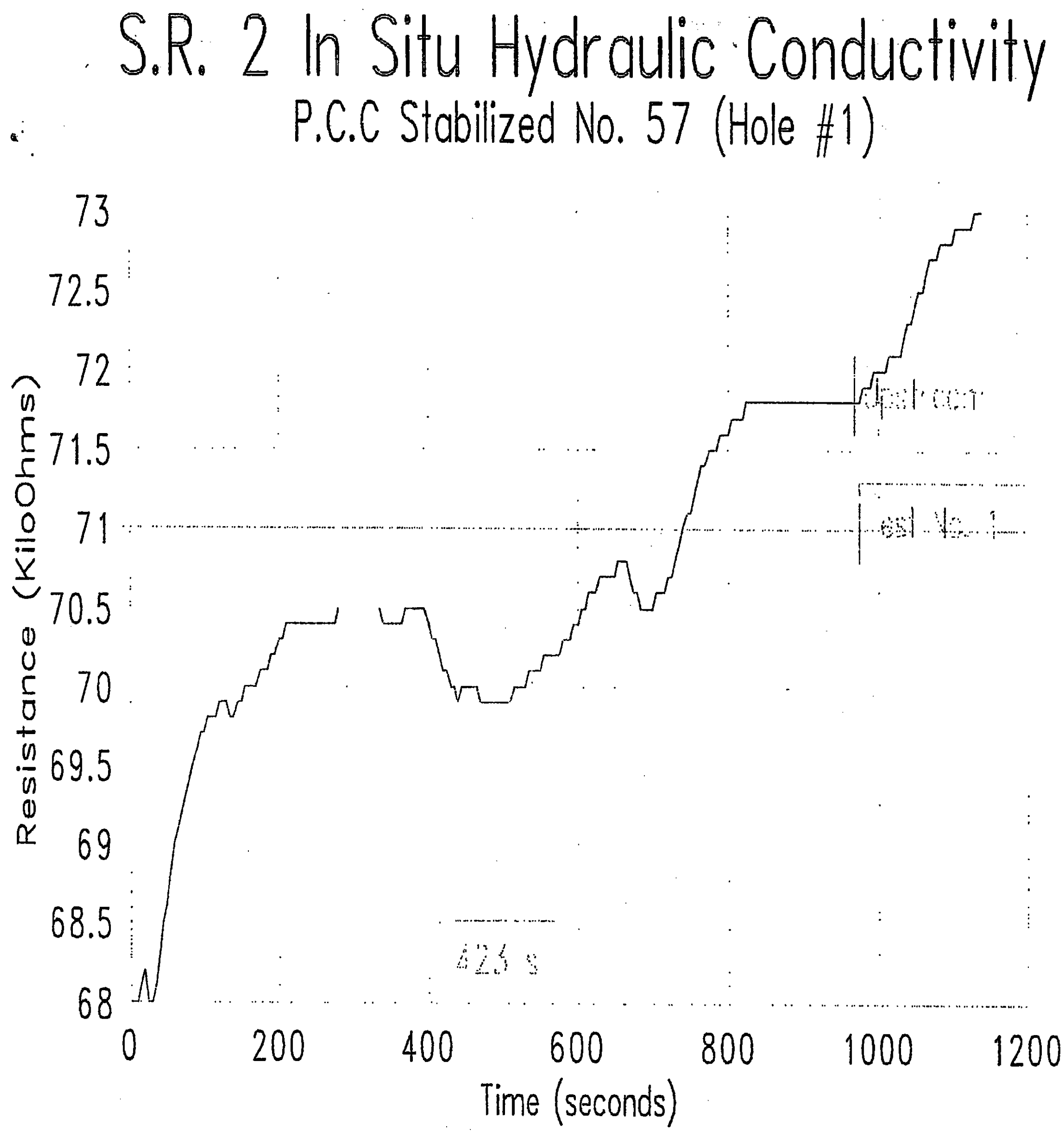


Figure G.1 - Time versus Resistance for Test No. 1, PCC No. 57, Upstream Probe

Date: 09/12/94

Location: Lorain County, State Route 2, Station 83+00 48 Left of the Centerline (Center of the W.B. Driving Lane)

Layer Tested: PCC No. 57 **Downstream Probe**

Time	Resistance	Time	Resistance	Time	Resistance
0	52.4	75	53.0	150	54.1
5	52.4	80	53.0	155	54.1
10	52.6	85	53.0	160	54.0
15	52.6	90	53.1	165	54.1
20	52.6	95	53.1	170	54.1
25	52.6	100	53.2	175	54.0
30	52.6	105	53.2	180	54.0
35	52.7	110	53.2	185	54.0
40	52.7	115	53.3	190	54.2
45	52.8	120	53.4	195	54.0
50	52.8	125	53.4	200	54.0
55	52.9	130	53.6	205	54.0
60	52.9	135	53.7	210	54.0
65	52.9	140	53.8	215	53.9
70	53.0	145	54.0	220	53.8

Time	Resistance	Time	Resistance	Time	Resistance
225	53.7	320	53.6	415	53.7
230	53.7	325	53.6	420	53.7
235	53.7	330	53.6	425	53.7
240	53.7	335	53.6	430	53.7
245	53.6	340	53.6	435	53.8
250	53.5	345	53.6	440	54.0
255	53.5	350	53.6	445	54.0
260	53.5	355	53.6	450	53.9
265	53.5	360	53.7	455	53.9
270	53.5	365	53.8	460	53.8
275	53.6	370	53.8	465	53.9
280	53.6	375	53.7	470	53.8
285	53.6	380	53.7	475	53.9
290	53.6	385	53.7	480	53.8
295	53.6	390	53.7	485	53.8
300	53.6	395	53.7	490	53.8
305	53.6	400	53.7	495	53.8
310	53.6	405	53.8	500	53.8
315	53.6	410	53.7	505	53.8

Time	Resistance	Time	Resistance	Time	Resistance
510	53.7	605	53.1	700	53.4
515	53.7	610	53.2	705	53.4
520	53.6	615	53.2	710	53.3
525	53.6	620	53.1	715	53.3
530	53.6	625	53.2	720	53.4
535	53.5	630	53.2	725	53.3
540	53.5	635	53.2	730	53.3
545	53.3	640	53.2	735	53.2
550	53.2	645	53.2	740	53.2
555	53.1	650	53.2	745	53.1
560	53.1	655	53.3	750	53.0
565	53.1	660	53.3	755	53.0
570	53.2	665	53.3	760	52.9
575	53.1	670	53.4	765	52.9
580	53.1	675	53.4	770	52.9
585	53.1	680	53.4	775	52.9
590	53.1	685	53.3	780	52.9
595	53.1	690	53.3	785	52.9
600	53.1	695	53.3	790	52.9

Time	Resistance	Time	Resistance	Time	Resistance
795	53.0	890	53.0	985	52.8
800	53.0	895	53.0	990	52.8
805	53.1	900	53.0	995	52.8
810	53.1	905	53.0	1000	52.8
815	53.2	910	53.0	1005	52.8
820	53.2	915	53.0	1010	52.8
825	53.2	920	53.0	1015	52.8
830	53.3	925	53.0	1020	52.8
835	53.3	930	52.9	1025	52.8
840	53.3	935	52.9	1030	52.8
845	53.2	940	52.9	1035	52.8
850	53.3	945	52.9	1040	52.9
855	53.2	950	52.8	1045	52.9
860	53.2	955	52.8	1050	52.9
865	53.1	960	52.8	1055	52.9
870	53.1	965	52.8	1060	52.9
875	53.1	970	52.7	1065	52.9
880	53.1	975	52.7	1070	53.0
885	53.0	980	52.8	1075	53.0

Time	Resistance	Time	Resistance	Time	Resistance
1080	53.0				
1085	52.9				
1090	52.9				
1095	52.9				
1100	52.9				
1105	53.0				
1110	53.0				
1115	53.0				
1120	53.0				
1125	53.0				
1130	53.0				
1135	53.0				
1140	53.0				

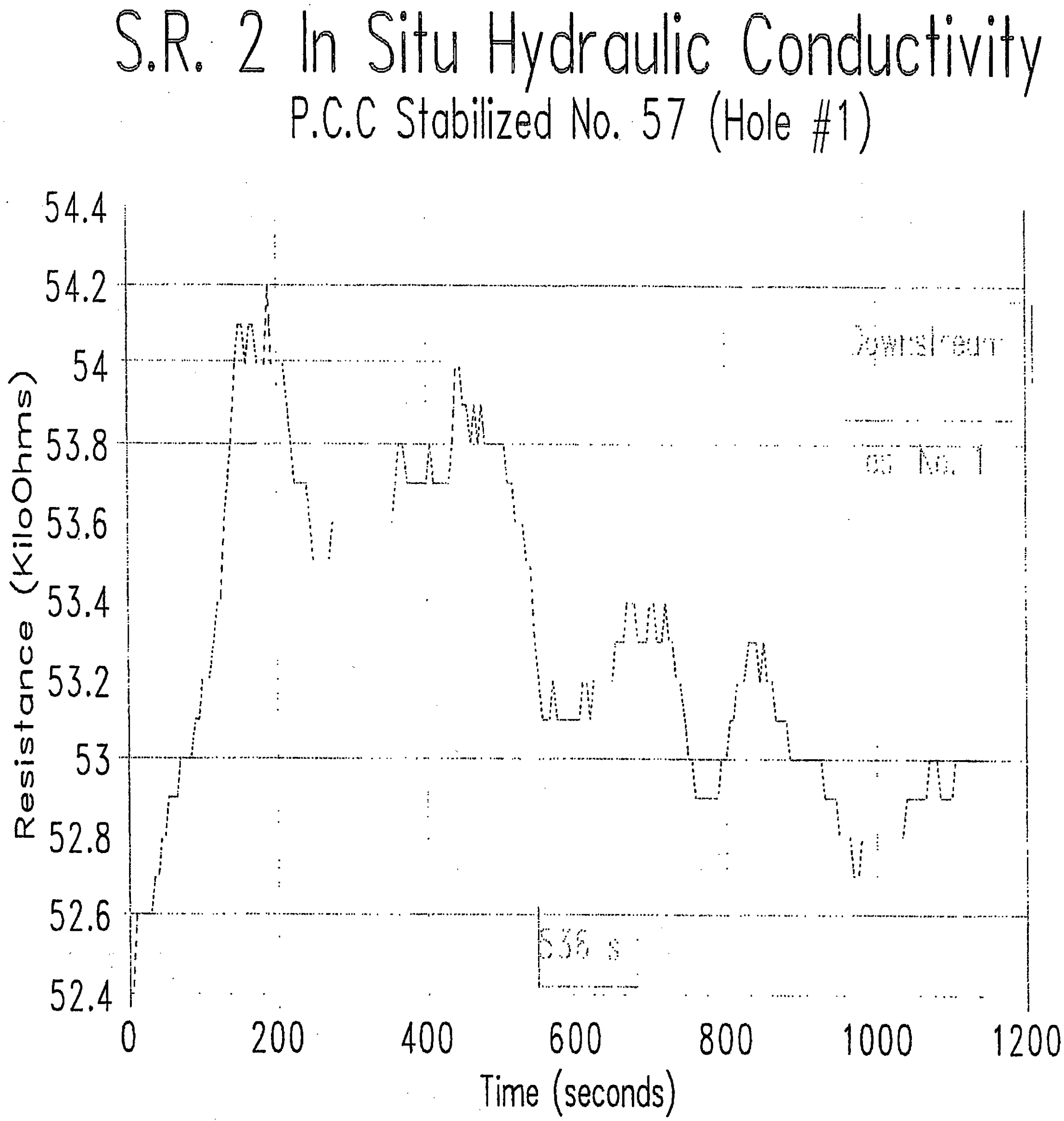


Figure G.2 - Time versus Resistance for Test No. 1, PCC No. 57, Downstream Probe

G-2 - Field Test Data for PCC No. 57, Test No. 2

Date: 09/12/94

Location: Lorain County, State Route 2, Station 83+00 48' Left of the Centerline (Center of the W.B. Driving Lane)

Material/Pavement Sect.: 6" No.304, 4" PCC No. 57, 10" P.C.C.

Probe Lengths: 20" Layer Tested: PCC No. 57

Layer Thickness: 15.24 cm Water Temperature: 22 °C

Recovered Test Material Weight: 1.288 Kg

Recovered Test Material Diameter: 10.16 cm

Recovered Test Material Height: 10.16 cm

Recovered Test Material Volume: 0.000824 cubic meters

γ_{dry}: 15.34 KiloNewtons per cubic meter

ϕ_w = unk.

Test No.: 2

	Probe Upst	Probe Dwnst	L	$\Delta\phi$	t_{up}	t_{dn}	t
begin	30	120	90	25.65			
end				33.25			
avg.	30	120	90	29.45	353	400	47

Note: All measurements are in centimeters and seconds

$$K = \frac{L^2}{t\,\Delta\phi} = \text{5.850 cm/s}$$

Date: 09/12/94

Location: Lorain County, State Route 2, Station 83+00 48' Left of the Centerline (Center of the W.B. Driving Lane)

Layer Tested: PCC No. 57 **Upstream Probe**

Time	Resistance	Time	Resistance	Time	Resistance
0	71.9	105	74.7	180	76.1
10	72.0	110	74.8	185	76.2
20	72.0	115	74.9	190	76.2
30	72.0	120	75.1	195	76.3
40	72.1	125	75.2	200	76.3
50	72.1	130	75.3	205	76.4
60	72.4	135	75.4	210	76.4
65	72.7	140	75.5	215	76.5
70	72.9	145	75.6	220	76.5
75	72.4	150	75.7	225	76.6
80	73.6	155	75.7	230	76.6
85	73.8	160	75.8	235	76.7
90	74.1	165	75.9	240	76.7
95	74.3	170	76.0	245	76.7
100	74.5	175	76.1	250	76.8

Time	Resistance	Time	Resistance	Time	Resistance
255	76.8	365	76.0	460	75.3
260	76.9	370	76.0	465	75.3
265	76.9	375	75.9	470	75.3
270	76.9	380	75.8	475	75.3
275	77.0	385	75.7	480	75.3
280	77.0	390	75.7	485	75.3
285	77.0	395	75.6	490	75.3
290	77.1	400	75.6	495	75.3
310	77.2	405	75.5	500	75.3
315	77.2	410	75.5	505	75.3
320	77.1	415	75.5	510	75.3
325	77.0	420	75.5	515	75.3
330	76.9	425	75.4	520	75.4
335	76.7	430	75.4	525	75.4
340	76.6	435	75.4	530	75.4
345	76.5	440	75.3	535	75.4
350	76.3	445	75.3	540	75.4
355	76.2	450	75.3	545	75.4
360	76.1	455	75.3	550	75.4

Time	Resistance	Time	Resistance	Time	Resistance
555	75.4	650	75.6		
560	75.4	655	75.6		
565	75.4				
570	75.4				
575	75.4				
580	75.4				
585	75.4				
590	75.4				
595	75.4				
600	75.5				
605	75.5				
610	75.5				
615	75.5				
620	75.5				
625	75.5				
630	75.6				
635	75.6				
640	75.6				
645	75.6				

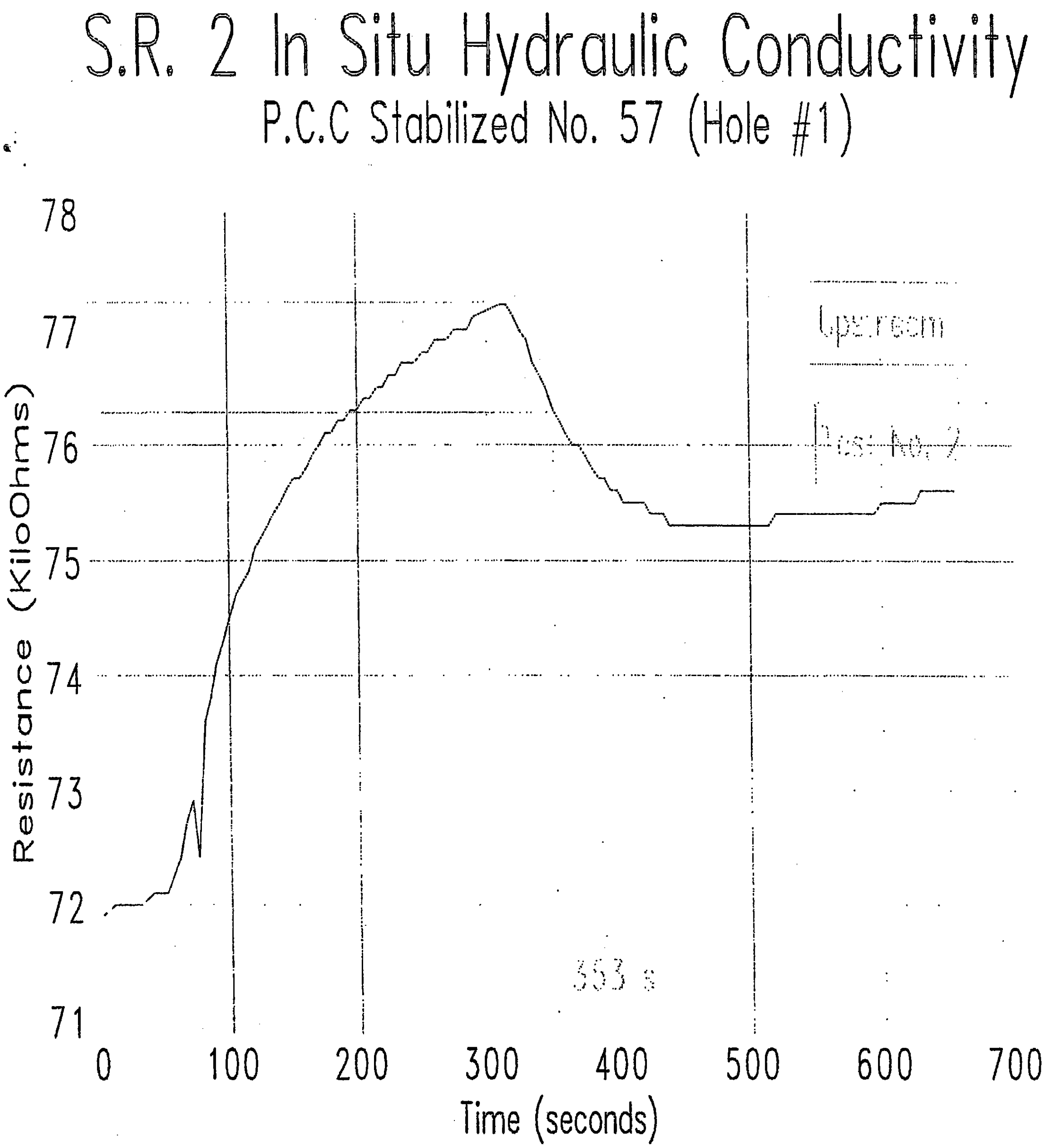


Figure G.3 - Time versus Resistance for Test No. 2, PCC No. 57, Upstream Probe

Date: 09/12/94

Location: Lorain County, State Route 2, Station 83+00 48' Left of the Centerline (Center of the W.B. Driving Lane)

Layer Tested: PCC No. 57 **Downstream Probe**

Time	Resistance	Time	Resistance	Time	Resistance
0	94.5	105	101.8	180	105.8
10	95.1	110	102.2	185	106.1
20	95.7	115	102.5	190	106.4
30	96.3	120	102.9	195	106.6
40	97.0	125	103.1	200	106.8
50	97.6	130	102.9	205	107.1
60	98.9	135	103.1	210	107.3
65	99.2	140	103.4	215	107.6
70	99.6	145	103.9	220	107.8
75	100.0	150	104.1	225	108.1
80	100.3	155	104.4	230	108.5
85	100.6	160	104.7	235	108.7
90	100.8	165	105.0	240	109.0
95	101.1	170	105.3	245	109.3
100	101.5	175	105.5	250	109.4

Time	Resistance	Time	Resistance	Time	Resistance
255	109.5	365	107.7	460	103.5
260	109.7	370	107.3	465	103.2
265	109.7	375	107.0	470	103.0
270	109.7	380	106.7	475	102.9
275	109.7	385	106.3	480	102.6
280	109.6	390	106.1	485	102.3
285	109.6	395	105.8	490	102.0
290	109.5	400	105.6	495	102.0
310	109.5	405	105.4	500	102.0
315	109.6	410	105.2	505	101.9
320	109.7	415	105.1	510	102.0
325	109.7	420	105.0	515	102.0
330	109.8	425	104.9	520	101.9
335	109.6	430	104.7	525	102.0
340	109.5	435	104.6	530	102.0
345	109.2	440	104.4	535	102.0
350	108.9	445	104.2	540	102.1
355	108.4	450	103.9	545	102.1
360	108.0	455	103.6	550	102.2

Time	Resistance	Time	Resistance	Time	Resistance
555	102.3	650	102.2		
560	102.4	655	102.2		
565	102.5				
570	102.5				
575	102.5				
580	102.5				
585	102.6				
590	102.5				
595	102.5				
600	102.5				
605	102.5				
610	102.4				
615	102.4				
620	102.4				
625	102.4				
630	102.3				
635	102.3				
640	102.3				
645	102.2				

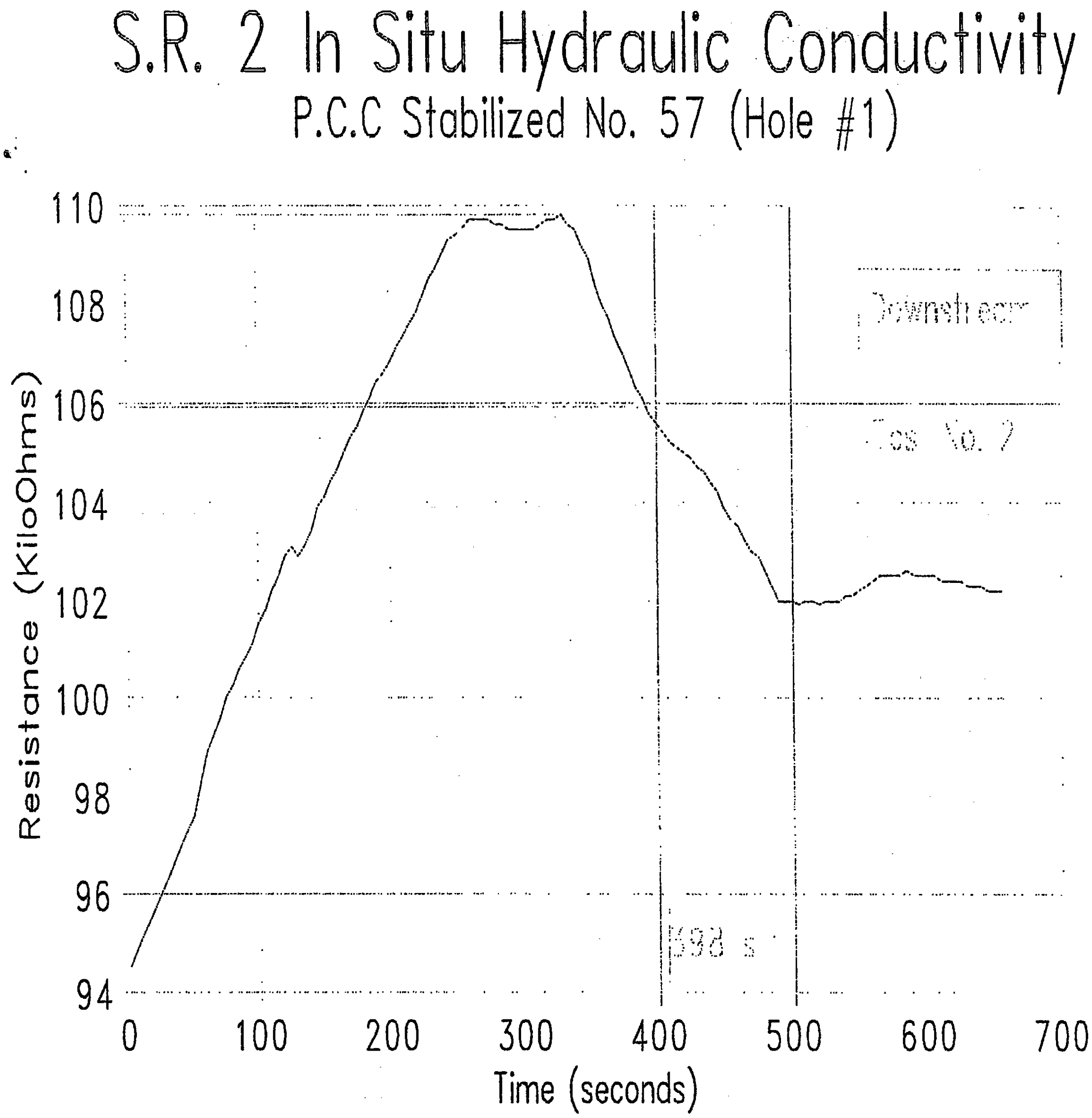


Figure G.4 - Time versus Resistance for Test No. 2, PCC No. 57, Downstream Probe

G-3 - Field Test Data for PCC No. 57, Test No. 3

Date: 09/12/94

Location: Lorain County, State Route 2, Station 83+00 48' Left of the Centerline (Center of the W.B. Driving Lane)

Material/Pavement Sect.: 6" No.304, 4" PCC No. 57, 10" P.C.C.

Probe Lengths: 20" Layer Tested: PCC No. 57

Layer Thickness: 15.24 cm Water Temperature: 22 °C

Recovered Test Material Weight: 1.288 Kg

Recovered Test Material Diameter: 10.16 cm

Recovered Test Material Height: 10.16 cm

Recovered Test Material Volume: 0.000824 cubic meters

γ_{dry}: 15.34 KiloNewtons per cubic meter

ϕ_w = unk.

Test No.: 3

	Probe Upst	Probe Dwnst	L	$\Delta\phi$	t_{up}	t_{dn}	t
begin	30	75	45	22.25			
end				31.15			
avg.	30	75	45	26.70	39	350	311

Note: All measurements are in centimeters and seconds

$$K = \frac{L^2}{t\,\Delta\phi} = \text{0.244 cm/s}$$

Date: 09/12/94

Location: Lorain County, State Route 2, Station 83+00 48'

Left of the Centerline (Center of the W.B. Driving Lane)

Layer Tested: PCC No. 57 **Upstream Probe**

Time	Resistance	Time	Resistance	Time	Resistance
0	42.7	75	32.6	150	29.6
5	42.0	80	32.3	155	29.6
10	41.2	85	32.1	160	29.6
15	40.2	90	31.8	165	29.6
20	39.6	95	31.6	170	29.6
25	38.2	100	31.3	175	29.7
30	37.4	105	31.0	180	29.8
35	36.3	110	30.8	185	30.0
40	35.6	115	30.6	190	30.3
45	34.8	120	30.3	195	32.7
50	34.2	125	30.1	200	35.8
55	33.7	130	29.9	205	37.9
60	33.4	135	29.8	210	39.8
65	33.1	140	29.7	215	41.6
70	32.9	145	29.7	220	43.0

Time	Resistance	Time	Resistance	Time	Resistance
225	44.1	320	58.0	415	69.7
230	45.1	325	58.2	420	69.9
235	46.3	330	58.4	425	70.3
240	47.4	335	59.6	430	70.5
245	48.2	340	59.8	435	70.8
250	49.2	345	61.0	440	71.2
255	50.9	350	62.1	445	71.5
260	52.6	355	63.0	450	71.8
265	52.7	360	63.7	455	72.0
270	52.6	365	64.5	460	72.2
275	52.8	370	65.3	465	72.5
280	52.3	375	65.9	470	72.7
285	53.8	380	66.4	475	73.0
290	54.4	385	67.0	480	73.2
295	55.1	390	67.5	485	73.4
300	55.8	395	68.0	490	73.6
305	56.5	400	68.4	495	73.7
310	57.2	405	68.8	500	73.8
315	57.8	410	69.1	505	74.1

Time	Resistance	Time	Resistance	Time	Resistance
510	74.3				
515	74.6				
520	74.9				
525	75.1				
530	75.3				
535	75.6				
540	75.7				
545	75.9				
550	76.1				
555	76.3				
560	76.5				
565	76.7				
570	76.8				
575	76.9				
580	77.0				
585	77.2				
590	77.3				
595	77.4				
600	77.6				

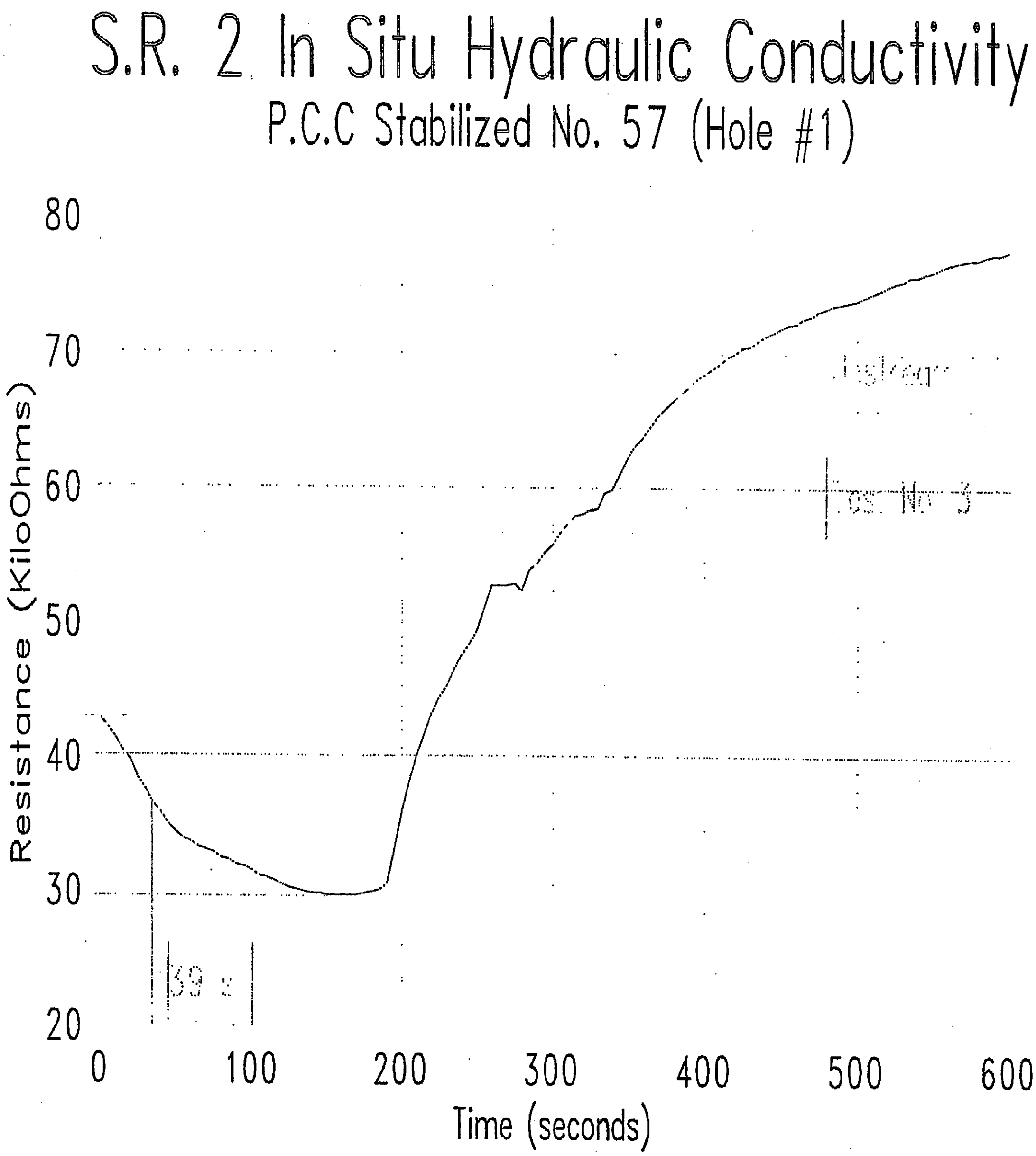


Figure G.5 - Time versus Resistance for Test No. 3, PCC No. 57, Upstream Probe

Date: 09/12/94

Location: Lorain County, State Route 2, Station 83+00 48' Left of the Centerline (Center of the W.B. Driving Lane)

Layer Tested: PCC No. 57 **Downstream Probe**

Time	Resistance	Time	Resistance	Time	Resistance
0	42.0	75	41.2	150	42.7
5		80	41.3	155	42.8
10		85	41.4	160	42.9
15		90	41.5	165	43.0
20		95	41.6	170	43.2
25		100	41.7	175	43.3
30		105	41.9	180	43.4
35		110	41.9	185	43.5
40		115	42.0	190	43.6
45		120	42.1	195	43.7
50	40.9	125	42.2	200	43.9
55	41.0	130	42.4	205	44.0
60	41.1	135	42.4	210	44.1
65	41.1	140	42.5	215	44.2
70	41.1	145	42.6	220	44.3

Time	Resistance	Time	Resistance	Time	Resistance
225	44.5	320	45.9	415	45.7
230	44.5	325	46.0	420	45.7
235	44.6	330	46.0	425	45.7
240	44.6	335	46.0	430	45.7
245	44.7	340	45.9	435	45.8
250	44.8	345	45.8	440	45.9
255	44.9	350	45.8	445	46.0
260		355	45.7	450	46.1
265		360	45.7	455	46.1
270		365	45.6	460	46.2
275		370	45.5	465	46.2
280		375	45.5	470	46.2
285		380	45.5	475	46.2
290		385	45.5	480	46.2
295		390	45.5	485	46.3
300	45.5	395	45.5	490	46.3
305	45.7	400	45.5	495	46.4
310	45.8	405	45.5	500	46.5
315	45.8	410	45.6	505	46.4

Time	Resistance	Time	Resistance	Time	Resistance
510	46.4				
515	46.4				
520	46.5				
525	46.5				
530	46.5				
535	46.5				
540	46.6				
545	46.7				
550	46.8				
555	46.9				
560	46.9				
565	47.0				
570	47.1				
575	47.2				
580	47.3				
585	47.4				
590	47.4				
595	47.5				
600	47.5				

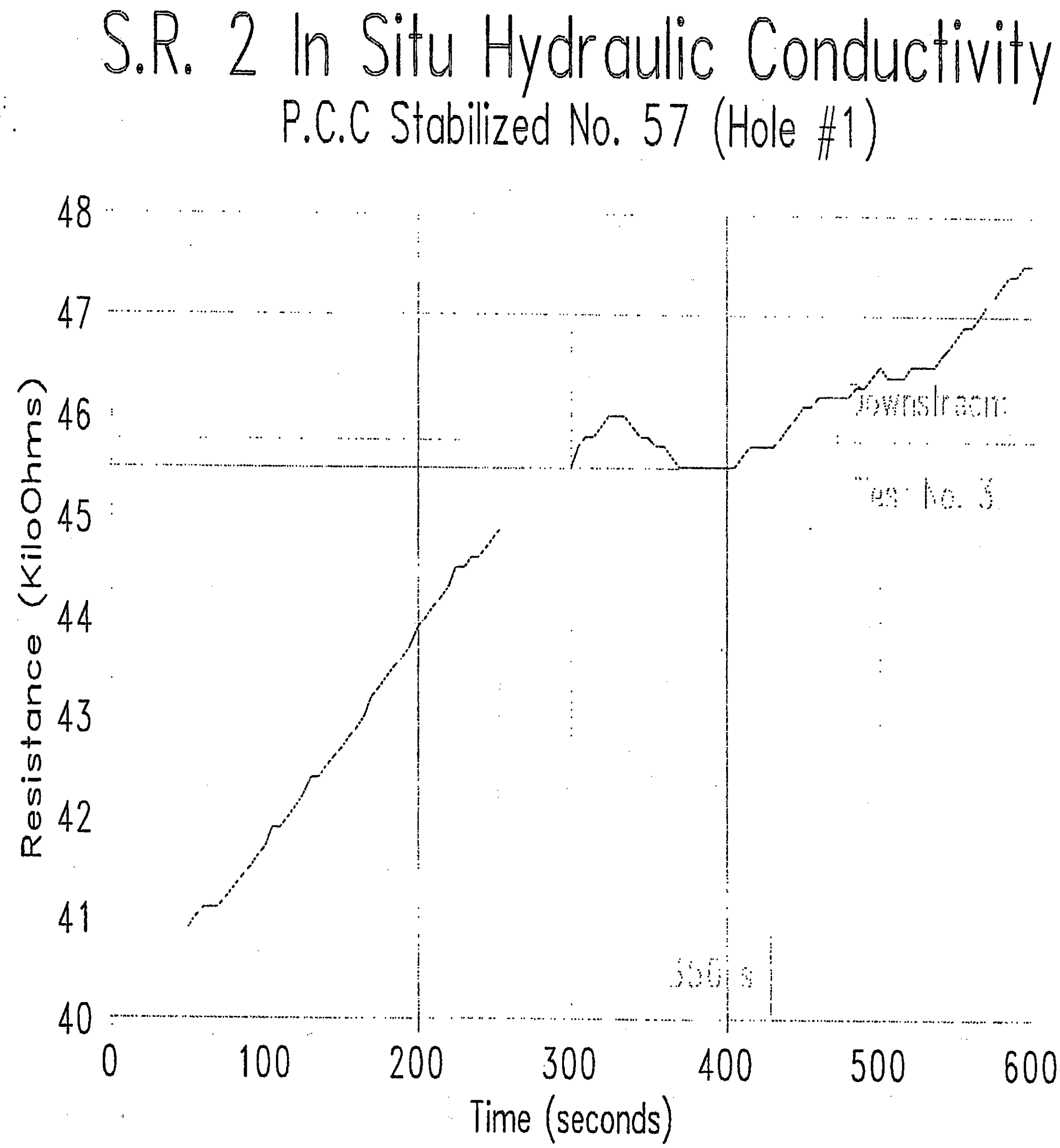


Figure G.6 - Time versus Resistance for Test No. 3, PCC No. 57, Downstream Probe

Appendix H

Test of the In Situ Hydraulic Conductivity Test Device for Ohio State Route 2
Results for Ohio DOT specification No. 304

- H-1 - Field Test Data for ODOT No. 304, Test No. 1

- Figure H.1 - Percent Finer versus Particle Diameter for Recovered No. 304

- Figure H.2 - Time versus Resistance for Test No. 1, No. 304, Upstream Probe

- Figure H.3 - Time versus Resistance for Test No. 1, No. 304, Downstream Probe

- H-2 - Field Test Data for ODOT No. 304, Test No. 2

- Figure H.4 - Time versus Resistance for Test No. 2, No. 304, Upstream Probe

- Figure H.5 - Time versus Resistance for Test No. 2, No. 304, Downstream Probe

H-1 - Field Test Data for ODOT No. 304, Test No. 1

Date: 09/13/94

Location: Lorain County, State Route 2, Station 64+00 48' Left of the Centerline (Center of the W.B. Driving Lane)

Material/Pavement Section: 10" No.304, 10" P.C.C.

Probe Lengths: 20" Layer Tested: ODOT No. 304

Layer Thickness: 25.40 cm Water Temperature: 25 °C

Recovered Test Material Weight: 1.479 Kg

Recovered Test Material Diameter: 10.16 cm

Recovered Test Material Height: 10.16 cm

Recovered Test Material Volume: 0.000824 cubic meters

γ_{dry}: 17.61 KiloNewtons per cubic meter

ϕ_w = 1.270 m

Test No.: 1

	Probe Upst	Probe Dwnst	L	$\Delta\phi$	t_{up}	t_{dn}	t
begin	20	30	10	1.50			
end				1.00			
avg.	20	30	10	1.25	2082	2352	270

Note: All measurements are in centimeters and seconds

$$K = \frac{L^2}{t\,\Delta\phi} = 0.296 \text{ cm/s}$$

Date: 09/16/94

S.R. 2 Sieve Analysis on Recovered Material

for Ohio DOT specification No. 304

Weight of Pan = 249 grams

Sieve (mm)	Pan + Aggregate (grams)	Aggregate Only (grams)	Percent Retained (%)	Percent Passing (%)
50.800	249	0	0.00	100.00
25.400	249	0	0.00	100.00
19.050	411	162	10.95	89.05
4.750	797	548	37.05	51.99
0.600	846	597	40.37	11.63
0.075	389	140	9.47	2.16
Pan	281	32	2.16	0.00

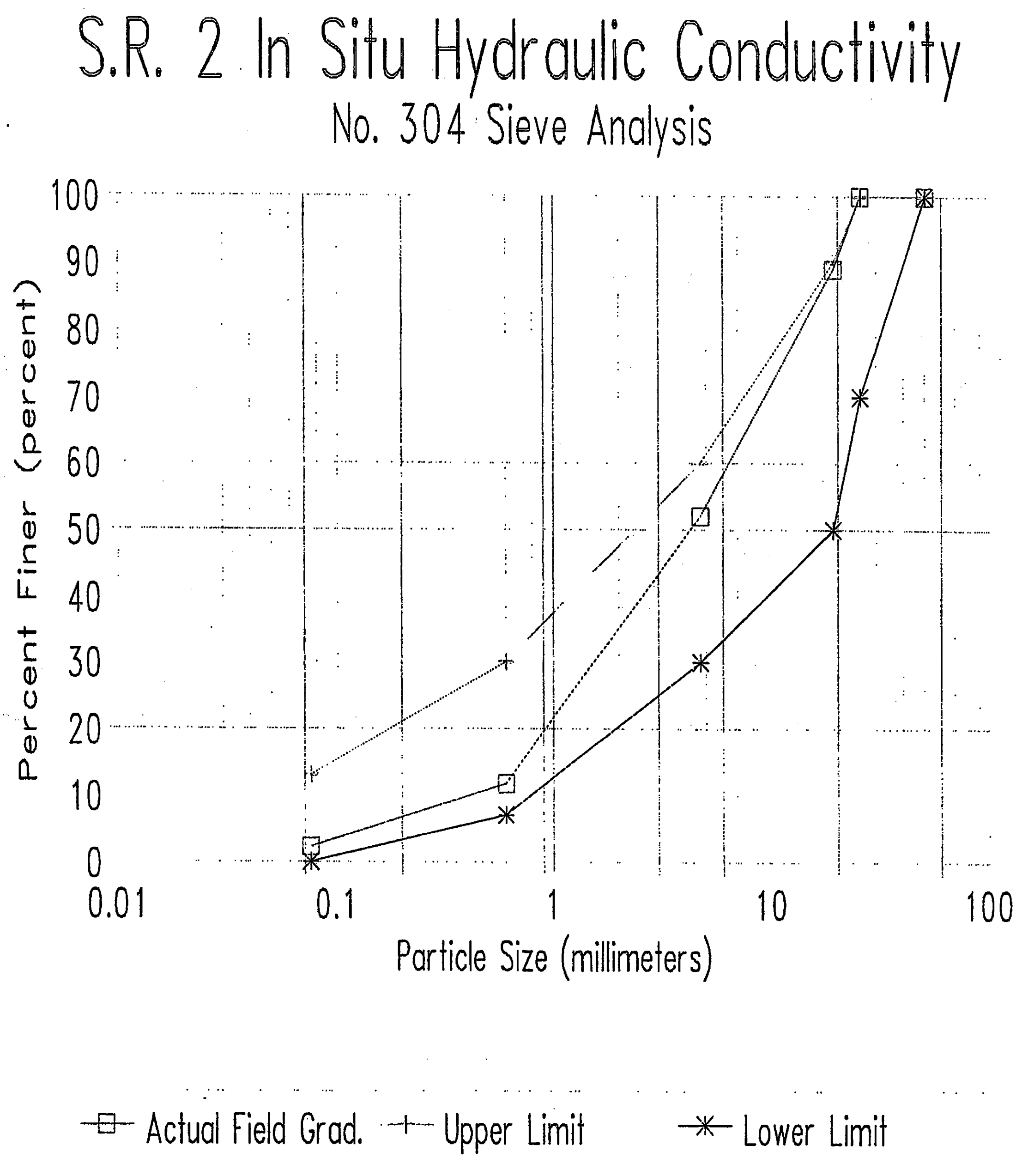


Figure H.1 - Percent Finer versus Particle Diameter for Recovered No. 304

Date: 09/13/94

Location: Lorain County, State Route 2, Station 64+00 48' Left of the Centerline (Center of the W.B. Driving Lane)

Layer Tested: ODOT No. 304 **Upstream Probe**

Time	Resistance	Time	Resistance	Time	Resistance
0	30.5	300	31.9	600	30.8
20	30.7	320	31.9	620	30.8
40	31.0	340	32.2	630	30.8
60	31.1	360	32.1	640	30.9
80	31.2	380	32.1	650	31.0
100	31.2	400	32.2	660	31.0
120	31.4	420	32.0	670	31.2
140	31.6	440	31.8	680	31.3
160	31.8	460	31.8	690	31.4
180	31.8	480	31.7	700	31.5
200	31.8	500	31.1	710	31.7
220	31.8	520	30.3	720	31.8
240	31.9	540	30.0	730	31.9
260	32.0	560	30.2	740	32.0
280	31.7	580	30.5	750	32.1

Time	Resistance	Time	Resistance	Time	Resistance
760	32.3	950	33.1	1140	32.8
770	32.2	960	33.1	1150	32.8
780	32.3	970	33.2	1160	32.8
790	32.3	980	33.2	1180	32.7
800	32.2	990	33.3	1200	32.8
810	32.3	1000	33.3	1220	33.4
820	32.3	1010	33.4	1240	33.8
830	32.4	1020	33.5	1260	34.0
840	32.5	1030	33.4	1280	34.3
850	32.6	1040	33.4	1300	34.3
860	32.6	1050	33.4	1320	34.4
870	32.6	1060	33.4	1340	34.5
880	32.6	1070	33.3	1360	34.3
890	32.7	1080	33.3	1380	34.0
900	32.7	1090	33.3	1400	34.2
910	32.9	1100	33.3	1420	34.5
920	33.0	1110	33.2	1440	34.8
930	33.0	1120	33.1	1460	35.0
940	33.2	1130	32.9	1480	35.2

Time	Resistance	Time	Resistance	Time	Resistance
1500	35.4	1880	36.0	2280	35.8
1520	35.5	1900	36.1	2300	35.8
1540	35.5	1920	36.0	2320	35.7
1560	35.5	1940	36.1	2340	35.8
1580	35.7	1960	36.0	2360	35.7
1600	35.8	1980	36.0	2380	35.7
1620	35.8	2000	35.8	2400	35.6
1640	36.1	2020	35.8	2420	35.6
1660	36.2	2040	35.8	2440	35.5
1680	35.9	2060	35.7	2460	35.5
1700	36.1	2080	35.8	2480	35.4
1720	36.1	2100	35.8	2500	35.3
1740	36.2	2120	36.0	2520	35.2
1760	36.0	2140	35.8	2540	35.3
1780	36.0	2160	35.9	2560	35.4
1800	36.3	2190	35.8	2580	35.4
1820	36.3	2220	35.9	2600	35.4
1840	36.2	2240	35.9	2620	35.5
1860	36.1	2260	35.9	2640	35.5

Time	Resistance	Time	Resistance	Time	Resistance
2660	35.6	3040	37.6		
2680	36.5	3060	37.4		
2700	35.5	3080	37.3		
2720	35.4	3100	37.2		
2740	35.3	3120	37.2		
2760	35.2	3140	37.1		
2780	35.4	3180	37.0		
2800	35.8	3200	37.0		
2820	35.9	3220	37.2		
2840	35.7				
2860	35.7				
2880	35.8				
2900	35.8				
2920	35.8				
2940	35.6				
2960	36.1				
2980	36.6				
3000	37.0				
3020	37.4				

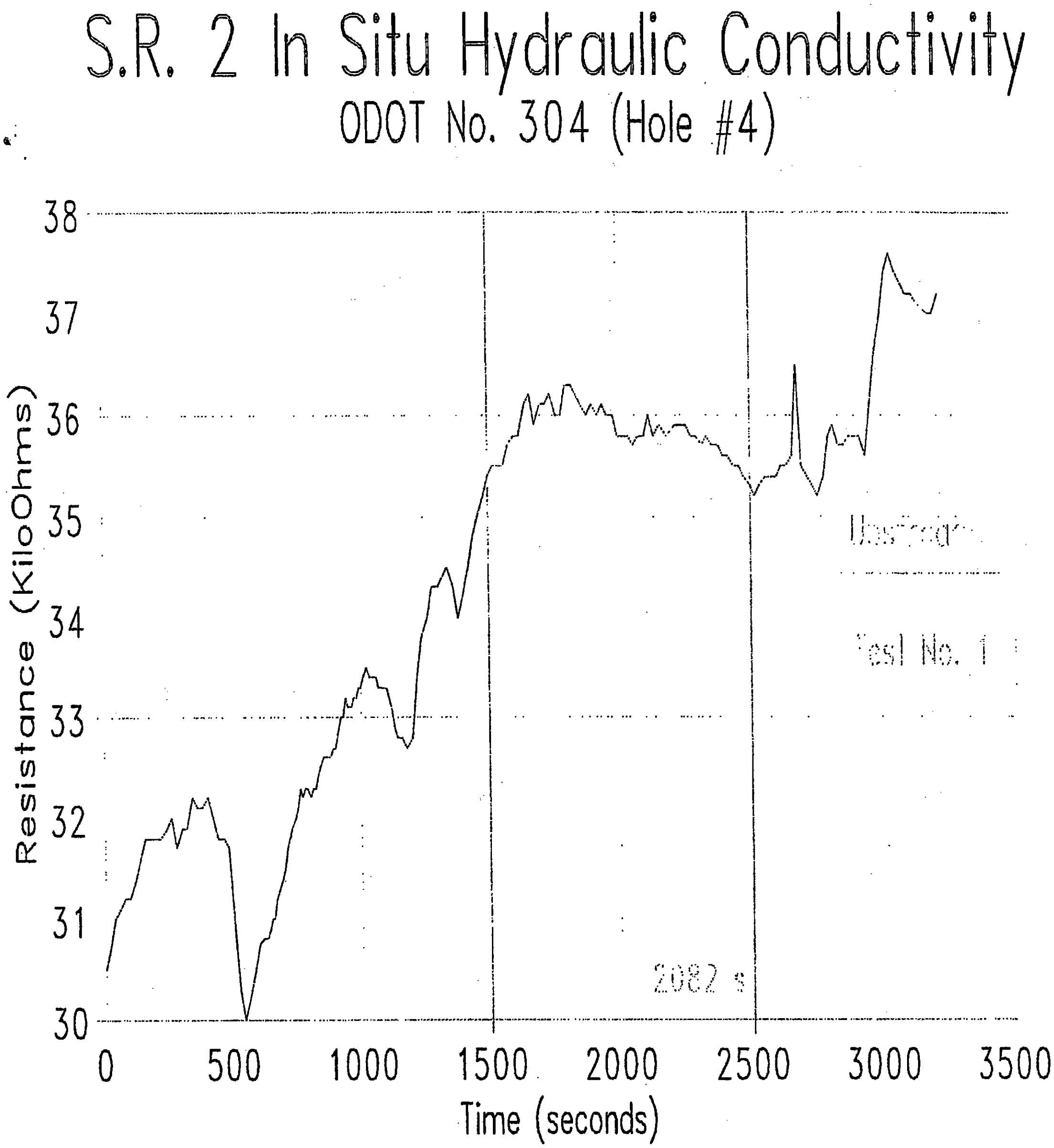


Figure H.2 - Time versus Resistance for Test No. 1, No. 304, Upstream Probe

Date: 09/13/94

Location: Lorain County, State Route 2, Station 64+00 48' Left of the Centerline (Center of the W.B. Driving Lane)

Layer Tested: ODOT No. 304 **Downstream Probe**

Time	Resistance	Time	Resistance	Time	Resistance
0	61.9	300	62.9	600	62.5
20	62.2	320	62.9	620	62.9
40	61.8	340	63.0	630	62.9
60	61.8	360	63.1	640	62.5
80	61.9	380	63.0	650	60.9
100	62.0	400	63.0	660	60.6
120	61.9	420	63.1	670	60.9
140	61.9	440	61.8	680	61.1
160	62.1	460	62.7	690	61.5
180	62.4	480	63.1	700	61.7
200	62.6	500	63.4	710	62.0
220	62.6	520	63.4	720	62.1
240	62.6	540	63.3	730	62.4
260	62.7	560	62.6	740	62.5
280	62.8	580	62.5	750	62.8

Time	Resistance	Time	Resistance	Time	Resistance
760	62.9	950	65.1	1140	66.0
770	63.0	960	65.1	1150	66.1
780	63.3	970	65.2	1160	66.4
790	63.4	980	65.2	1180	66.4
800	63.5	990	65.4	1200	66.4
810	63.6	1000	65.5	1220	66.9
820	63.7	1010	65.5	1240	67.5
830	63.8	1020	65.6	1260	67.8
840	63.9	1030	65.7	1280	68.4
850	63.9	1040	65.7	1300	68.5
860	64.0	1050	65.8	1320	68.6
870	64.1	1060	65.8	1340	69.1
880	64.2	1070	65.8	1360	68.5
890	64.3	1080	65.8	1380	68.8
900	64.4	1090	65.9	1400	69.1
910	64.6	1100	66.0	1420	69.5
920	64.8	1110	66.0	1440	69.6
930	65.0	1120	66.1	1460	70.2
940	65.1	1130	66.0	1480	70.3

Time	Resistance	Time	Resistance	Time	Resistance
1500	70.4	1880	73.0	2280	71.4
1520	70.6	1900	73.1	2300	71.1
1540	70.8	1920	73.2	2320	71.0
1560	70.9	1940	73.2	2340	70.7
1580	71.4	1960	73.2	2360	70.4
1600	71.7	1980	73.2	2380	70.3
1620	72.0	2000	73.1	2400	70.0
1640	72.2	2020	73.2	2420	70.1
1660	71.3	2040	73.1	2440	70.0
1680	71.6	2060	72.8	2460	70.1
1700	72.1	2080	72.7	2480	69.9
1720	72.4	2100	72.5	2500	69.8
1740	72.7	2120	72.6	2520	69.2
1760	72.8	2140	72.6	2540	69.3
1780	72.7	2160	72.6	2560	69.4
1800	72.9	2190	72.1	2580	69.2
1820	72.8	2220	72.0	2600	69.1
1840	72.9	2240	71.8	2620	69.1
1860	73.0	2260	71.5	2640	68.9

Time	Resistance	Time	Resistance	Time	Resistance
2660	68.7	3040	69.5		
2680	68.6	3060	69.5		
2700	68.5	3080	69.5		
2720	68.4	3100	69.4		
2740	68.2	3120	69.5		
2760	68.2	3140	69.7		
2780	67.8	3180	70.0		
2800	68.0	3200	70.0		
2820	68.2	3220	70.0		
2840	67.8				
2860	67.8				
2880	67.9				
2900	67.7				
2920	67.9				
2940	68.7				
2960	69.0				
2980	69.1				
3000	69.3				
3020	69.5				

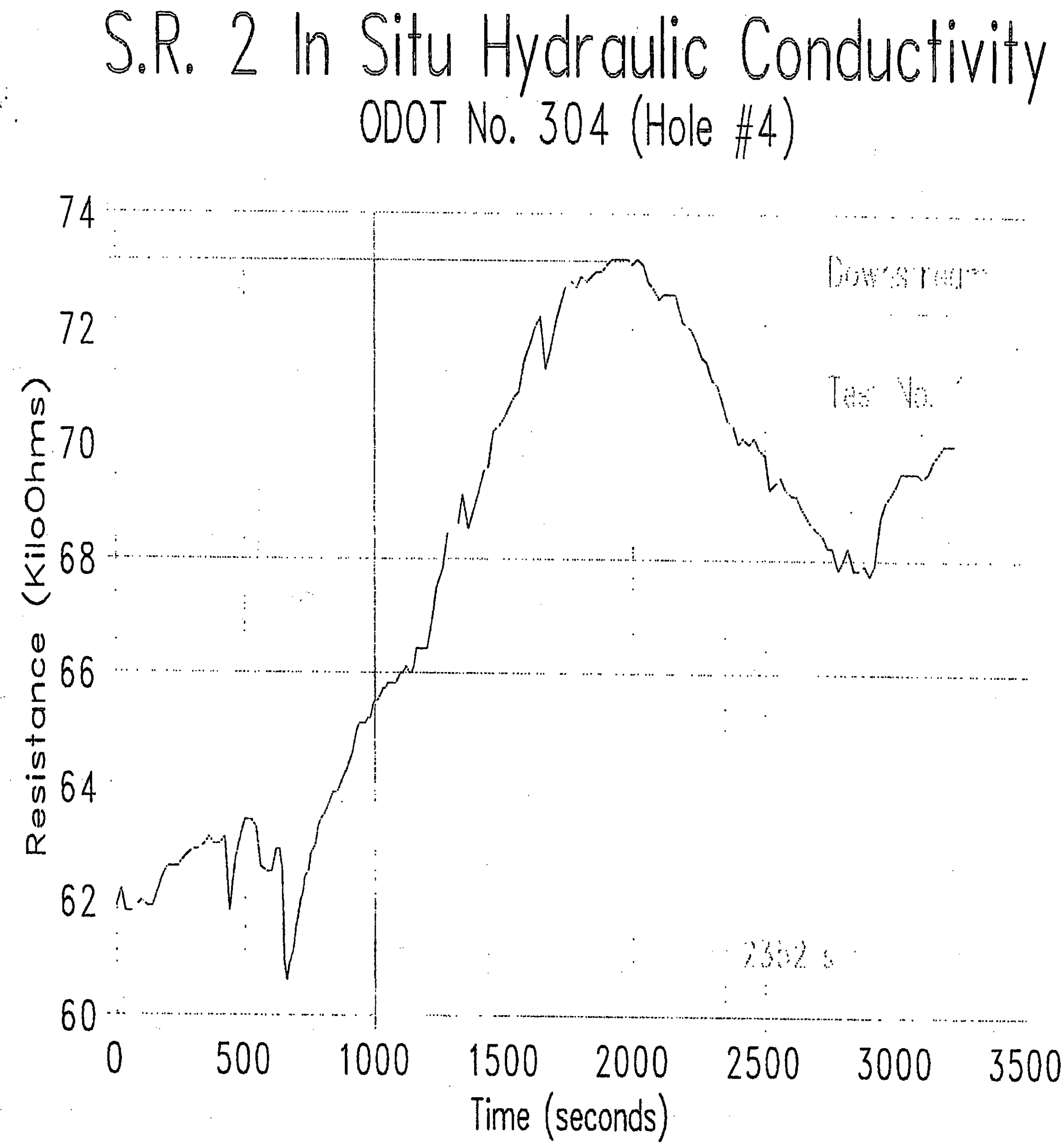


Figure H.3 - Time versus Resistance for Test No. 1, No. 304, Downstream Probe

H-2 - Field Test Data for ODOT No. 304, Test No. 2

Date: 09/15/94

Location: Lorain County, State Route 2, Station 64+00 48' Left of the Centerline (Center of the W.B. Driving Lane)

Material/Pavement Section: 10" No.304, 10" P.C.C.

Probe Lengths: 20" Layer Tested: ODOT No. 304

Layer Thickness: 25.40 cm Water Temperature: 25 °C

Recovered Test Material Weight: 1.479 Kg

Recovered Test Material Diameter: 10.16 cm

Recovered Test Material Height: 10.16 cm

Recovered Test Material Volume: 0.000824 cubic meters

γ_{dry}: 17.61 KiloNewtons per cubic meter

ϕ_w = 2.724 m

Test No.: 2

	Probe Upst	Probe Dwnst	L	$\Delta\phi$	t_{up}	t_{dn}	t
begin	20	30	10	22.05			
end				23.35			
avg.	20	30	10	22.66	1219	2000	781

Note: All measurements are in centimeters and seconds

$$K = \frac{L^2}{t\,\Delta\phi} = \text{0.00565 cm/s}$$

Date: 09/15/94

Location: Lorain County, State Route 2, Station 64+00 48' Left of the Centerline (Center of the W.B. Driving Lane)

Layer Tested: ODOT No. 304 **Upstream Probe**

Time	Resistance	Time	Resistance	Time	Resistance
0	37.6	630	39.8	1000	32.7
60	37.8	660	39.5	1020	33.0
120	37.7	690	39.2	1040	33.2
180	37.7	720	38.9	1060	33.2
240	37.4	750	38.6	1080	33.2
270	36.3	780	37.8	1100	32.8
300	36.1	810	36.8	1120	33.4
330	36.1	840	35.2	1140	33.2
360	36.3	860	33.7	1160	33.2
450	39.5	880	34.8	1180	33.3
480	40.0	900	35.2	1200	33.6
510	40.1	920	35.1	1220	29.6
540	40.1	940	34.5	1240	27.6
570	39.9	960	33.3	1260	26.3
600	39.9	980	32.9	1280	25.5

Time	Resistance	Time	Resistance	Time	Resistance
1300	24.5	1780	42.0	2160	39.2
1320	25.0	1800	41.9	2180	39.1
1340	25.1	1820	41.7	2200	38.9
1360	25.1	1840	41.7	2220	38.8
1380	25.2	1860	41.7	2240	38.7
1400	24.7	1880	41.6	2260	38.6
1420	23.5	1900	41.4	2280	38.5
1440	25.9	1920	41.3	2300	38.4
1460	26.7	1940	41.2	2320	38.2
1480	28.2	1960	41.1	2340	36.1
1600	38.3	1980	40.9	2360	36.8
1620	39.8	2000	40.6	2380	37.1
1640	40.6	2020	40.3	2400	37.3
1660	38.4	2040	40.1	2420	37.4
1680	40.4	2060	39.9	2440	37.4
1700	41.2	2080	39.7	2460	37.4
1720	41.4	2100	39.6	2480	37.4
1740	41.8	2120	39.4	2500	37.4
1760	42.0	2140	39.3	2520	37.3

Time	Resistance	Time	Resistance	Time	Resistance
2540	37.3	2920	36.1	3300	34.7
2560	37.2	2940	36.0	3320	34.7
2580	37.2	2960	35.9	3340	34.7
2600	37.1	2980	35.9	3360	34.7
2620	37.1	3000	35.8	3380	34.7
2640	37.0	3020	35.7	3400	34.7
2660	37.0	3040	35.2	3420	34.5
2680	37.0	3060	35.2	3440	34.5
2700	36.9	3080	35.3	3460	34.2
2720	36.8	3100	35.4	3480	34.3
2740	36.7	3120	35.4	3500	34.4
2760	36.7	3140	35.1	3520	34.5
2780	36.6	3160	35.2	3540	34.5
2800	36.5	3180	35.1	3560	34.4
2820	36.4	3200	35.0	3580	34.3
2840	36.3	3220	35.0	3600	34.3
2860	36.3	3240	34.9	3620	33.9
2880	36.2	3260	34.8	3640	34.0
2900	36.1	3280	34.7	3660	33.9

Time	Resistance	Time	Resistance	Time	Resistance
3680	33.9	4060	35.6	4440	28.5
3700	33.4	4080	35.7	4460	30.2
3720	33.5	4100	35.7	4480	31.1
3740	33.6	4120	35.7	4500	31.5
3760	33.7	4140	35.6	4520	31.9
3780	33.7	4160	35.5	4540	32.2
3800	33.7	4180	35.4	4560	32.4
3820	33.7	4200	35.3	4580	32.4
3840	33.7	4220	35.2	4600	32.5
3860	33.7	4240	35.0	4620	32.5
3880	33.7	4260	34.9		
3900	33.7	4280	34.8		
3920	33.7	4300	34.7		
3940	33.7	4320	34.6		
3960	33.9	4340	34.5		
3980	34.2	4360	34.4		
4000	34.9	4380	34.4		
4020	34.9	4400	16.0		
4040	35.3	4420	24.8		

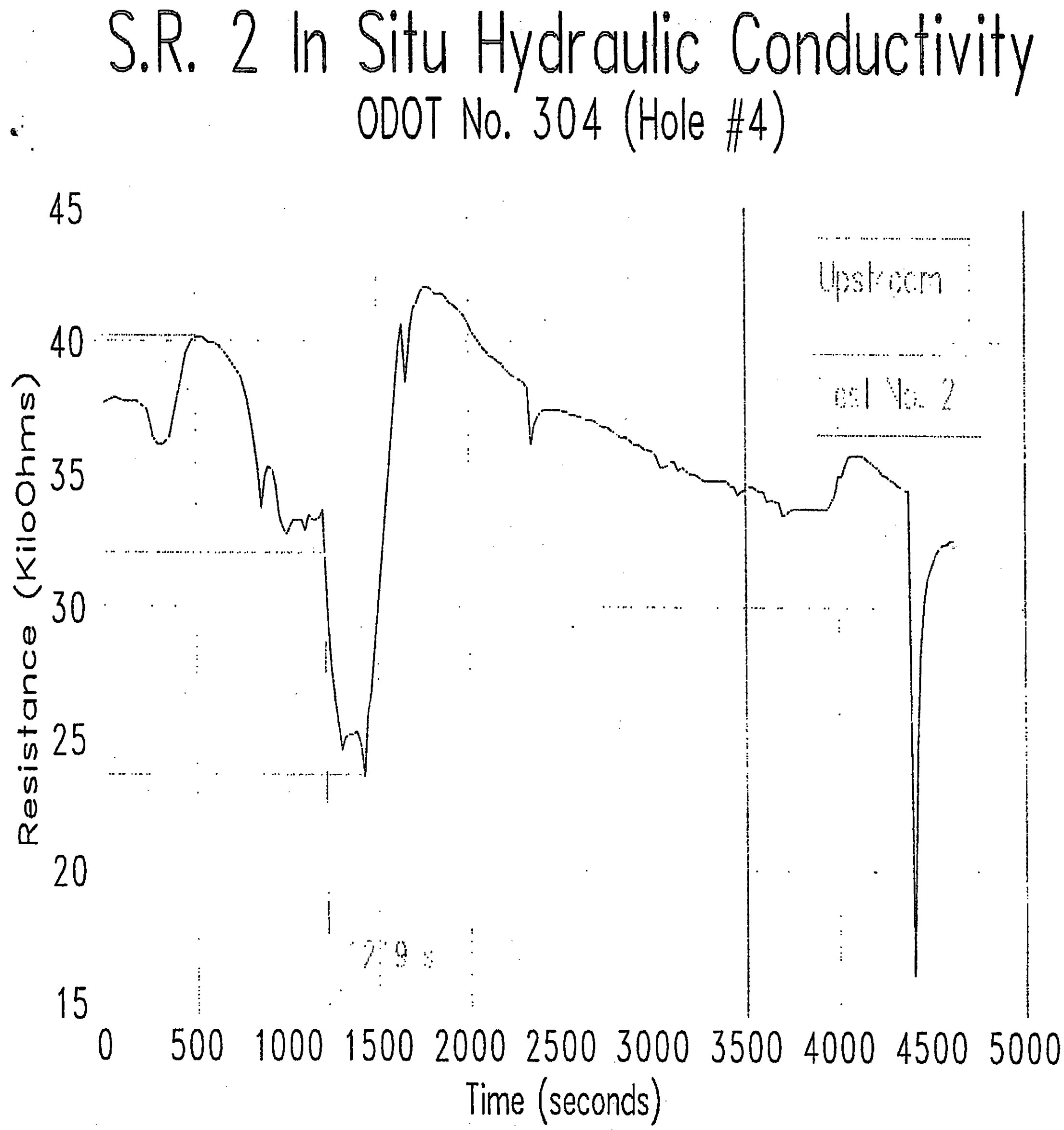


Figure H.4 - Time versus Resistance for Test No. 2, No. 304, Upstream Probe

Date: 09/15/94

Location: Lorain County, State Route 2, Station 64+00 48' Left of the Centerline (Center of the W.B. Driving Lane)

Layer Tested: ODOT No. 304 **Downstream Probe**

Time	Resistance	Time	Resistance	Time	Resistance
0	9.60	630	9.35	1000	9.05
60	9.46	660	9.33	1020	9.04
120	9.36	690	9.31	1040	9.02
180	9.30	720	9.31	1060	9.02
240	9.21	750	9.31	1080	9.02
270	9.12	780	9.26	1100	9.00
300	9.05	810	9.22	1120	9.01
330	9.06	840	9.17	1140	9.00
360	9.04	860	9.14	1160	8.96
450	9.28	880	9.15	1180	8.92
480	9.38	900	9.15	1200	8.89
510	9.35	920	9.14	1220	8.82
540	9.32	940	9.12	1240	8.78
570	9.32	960	9.10	1260	8.77
600	9.35	980	9.08	1280	8.76

Time	Resistance	Time	Resistance	Time	Resistance
1300	8.72	1780	8.17	2160	7.89
1320	8.69	1800	8.17	2180	7.79
1340	8.66	1820	8.16	2200	7.86
1360	8.61	1840	8.13	2220	7.83
1380	8.59	1860	8.09	2240	7.82
1400	8.58	1880	8.08	2260	7.75
1420	8.56	1900	8.07	2280	7.68
1440	8.57	1920	8.07	2300	7.65
1460	8.57	1940	8.06	2320	7.65
1480	8.59	1960	8.05	2340	7.59
1600	8.52	1980	8.01	2360	7.57
1620	8.57	2000	7.99	2380	7.52
1640	8.62	2020	7.98	2400	7.47
1660	8.57	2040	7.96	2420	7.41
1680	8.50	2060	7.94	2440	7.39
1700	8.41	2080	7.93	2460	7.40
1720	8.34	2100	7.92	2480	7.40
1740	8.25	2120	7.90	2500	7.38
1760	8.20	2140	7.89	2520	7.39

Time	Resistance	Time	Resistance	Time	Resistance
2540	7.40	2920	7.48	3300	7.35
2560	7.41	2940	7.47	3320	7.35
2580	7.43	2960	7.45	3340	7.33
2600	7.44	2980	7.43	3360	7.32
2620	7.43	3000	7.42	3380	7.30
2640	7.42	3020	7.40	3400	7.30
2660	7.42	3040	7.38	3420	7.29
2680	7.46	3060	7.37	3440	7.29
2700	7.49	3080	7.40	3460	7.30
2720	7.50	3100	7.41	3480	7.21
2740	7.51	3120	7.41	3500	7.19
2760	7.49	3140	7.41	3520	7.19
2780	7.49	3160	7.44	3540	7.19
2800	7.46	3180	7.46	3560	7.19
2820	7.46	3200	7.45	3580	7.18
2840	7.47	3220	7.42	3600	7.19
2860	7.46	3240	7.40	3620	7.19
2880	7.46	3260	7.38	3640	7.18
2900	7.47	3280	7.36	3660	7.15

Time	Resistance	Time	Resistance	Time	Resistance
3680	7.14				
3700	7.13				
3720	7.13				
3740	7.12				
3760	7.12				
3780	7.12				
3800	7.11				
3820	7.11				
3840	7.11				
3860	7.12				
3880	7.12				
3900	7.12				

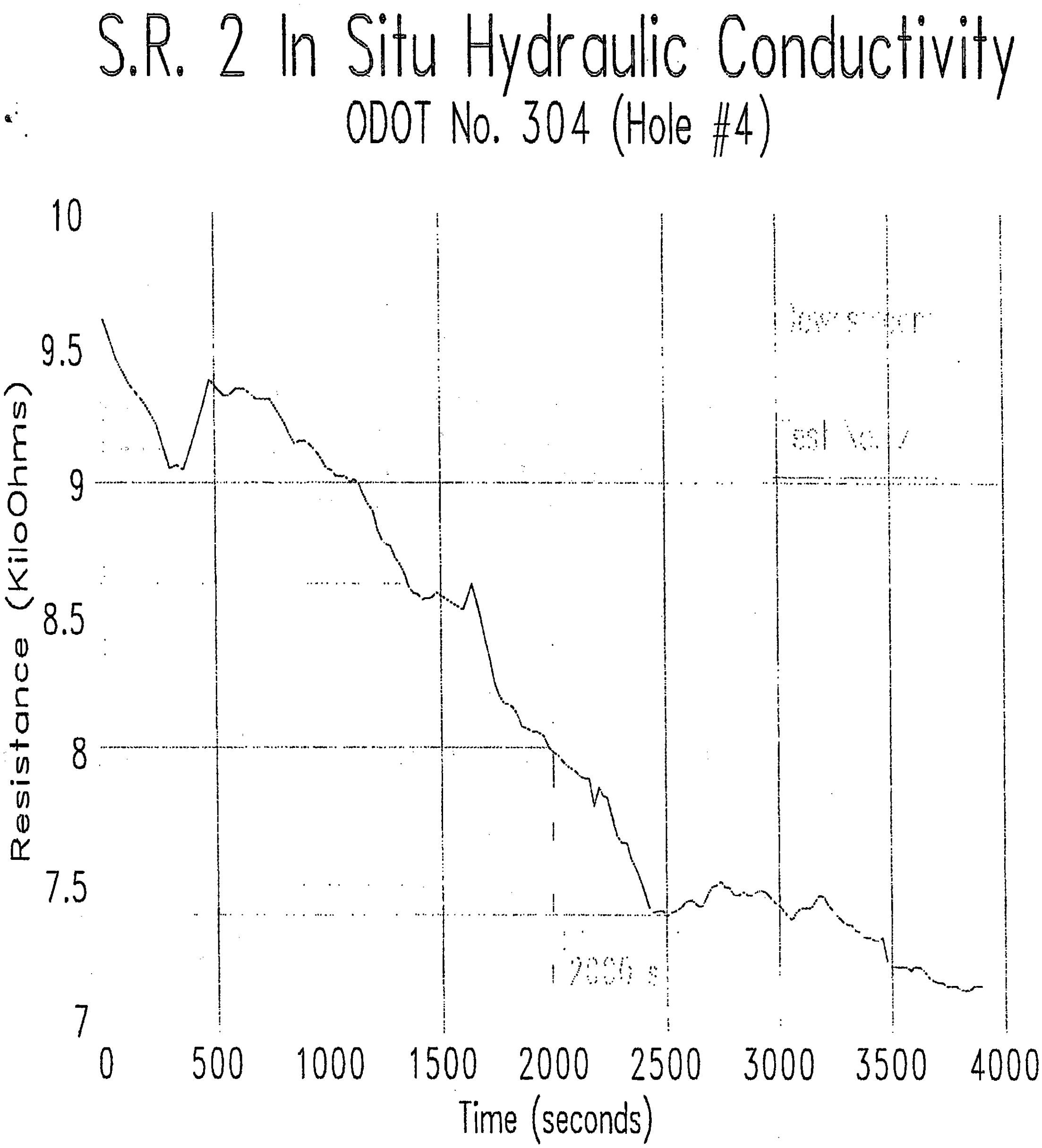


Figure H.5 - Time versus Resistance for Test No. 2, No. 304, Downstream Probe

Appendix I

Test of the In Situ Hydraulic Conductivity Test Device for Ohio State Route 2 Results for Asphalt Cement Stabilized AASHTO M 34 Specification No. 57

- I-1 - Field Test Data for Asphalt Cement No. 57, Test No. 1
- Figure I.1 - Time versus Resistance for Test No. 1, Asp. No. 57, Upstream Probe
- Figure I.2 - Time versus Resistance for Test No. 1, Asp. No. 57, Downstream Probe
- I-2 - Field Test Data for Asphalt Cement No. 57, Test No. 2
- Figure I.3 - Time versus Resistance for Test No. 2, Asp. No. 57, Upstream Probe
- Figure I.4 - Time versus Resistance for Test No. 2, Asp. No. 57, Downstream Probe

I-1 - Field Test Data for Asphalt Cement No. 57, Test No. 1

Date: 09/14/94

Location: Lorain County, State Route 2, Station 80+00 48' Left of the Centerline (Center of the W.B. Driving Lane)

Material/Pavement Sect.: 6" No.304, Asp. No. 57, 10" P.C.C.

Probe Lengths: 20" Layer Tested: Asp. No. 57

Layer Thickness: 10.16 cm Water Temperature: 25 °C

Recovered Test Material Weight: 1.361 Kg

Recovered Test Material Diameter: 10.16 cm

Recovered Test Material Height: 10.16 cm

Recovered Test Material Volume: 0.000824 cubic meters

γ_{dry}: 16.21 KiloNewtons per cubic meter

ϕ_w = unk.

Test No.: 1

	Probe Upst	Probe Dwnst	L	$\Delta\phi$	t_{up}	t_{dn}	t
begin	35	120	85	3.90			
end				4.00			
avg.	35	120	85	3.95	71	500	429

Note: All measurements are in centimeters and seconds

$$K = \frac{L^2}{t\,\Delta\phi} = \text{ 4.260 cm/s}$$

Date: 09/14/94

Location: Lorain County, State Route 2, Station 80+00 48' Left of the Centerline (Center of the W.B. Driving Lane)

Layer Tested: Asp. No. 57 **Upstream Probe**

Time	Resistance	Time	Resistance	Time	Resistance
0	47.1	75	40.8	150	38.1
5	47.1	80	40.4	155	38.0
10	47.1	85	40.0	160	37.9
15	47.0	90	39.7	165	37.9
20	46.9	95	39.5	170	37.9
25	46.9	100	39.3	175	37.9
30	46.9	105	39.1	180	37.9
35	46.9	110	38.9	185	37.9
40	46.6	115	38.6	190	38.0
45	46.0	120	38.6	195	38.0
50	45.2	125	38.6	200	38.1
55	44.4	130	38.5	205	38.2
60	43.4	135	38.4	210	38.2
65	42.8	140	38.3	215	38.0
70	41.7	145	38.1	220	38.0

Time	Resistance	Time	Resistance	Time	Resistance
225	37.9	320	38.0	415	41.7
230	37.8	325	38.0	420	41.8
235	37.8	330	38.1	425	42.1
240	37.7	335	38.1	430	42.3
245	37.7	340	38.3	435	42.5
250	37.7	345	38.3	440	42.6
255	37.8	350	38.5	445	42.8
260	37.8	355	38.8	450	43.6
265	37.7	360	39.0	455	43.4
270	37.5	365	39.3	460	43.7
275	37.5	370	39.7	465	43.9
280	37.4	375	40.0	470	44.2
285	37.5	380	40.4	475	44.4
290	37.6	385	40.7	480	44.5
295	37.6	390	41.1	485	44.6
300	37.7	395	41.4	490	44.6
305	37.8	400	41.5	495	44.9
310	37.9	405	41.6	500	45.1
315	37.9	410	41.7	505	45.4

Time	Resistance	Time	Resistance	Time	Resistance
510	45.7	605	48.3	700	49.3
515	46.0	610	48.5	705	49.4
520	46.1	615	48.5	710	49.5
525	46.2	620	48.6	715	49.6
530	46.3	625	48.7	720	49.7
535	46.5	630	48.9	725	49.9
540	46.8	635	48.9	730	50.1
545	47.1	640	48.8	735	50.2
550	47.1	645	48.8	740	50.2
555	47.2	650	48.8	745	50.2
560	47.2	655	48.7	750	50.3
565	47.2	660	48.7	755	50.2
570	47.3	665	48.7	760	50.3
575	47.6	670	48.7	765	50.3
580	47.8	675	48.6	770	50.6
585	48.0	680	48.6	775	50.7
590	48.1	685	48.7	780	50.7
595	48.2	690	48.8	785	50.8
600	48.2	695	49.0	790	50.9

Time	Resistance	Time	Resistance	Time	Resistance
795	50.9	890	51.9		
800	51.0	895	51.9		
805	51.0	900	51.8		
810	51.1				
815	51.1				
820	51.0				
825	51.0				
830	50.9				
835	50.9				
840	50.9				
845	50.9				
850	51.0				
855	51.0				
860	51.0				
865	51.0				
870	51.1				
875	51.2				
880	51.5				
885	51.6				

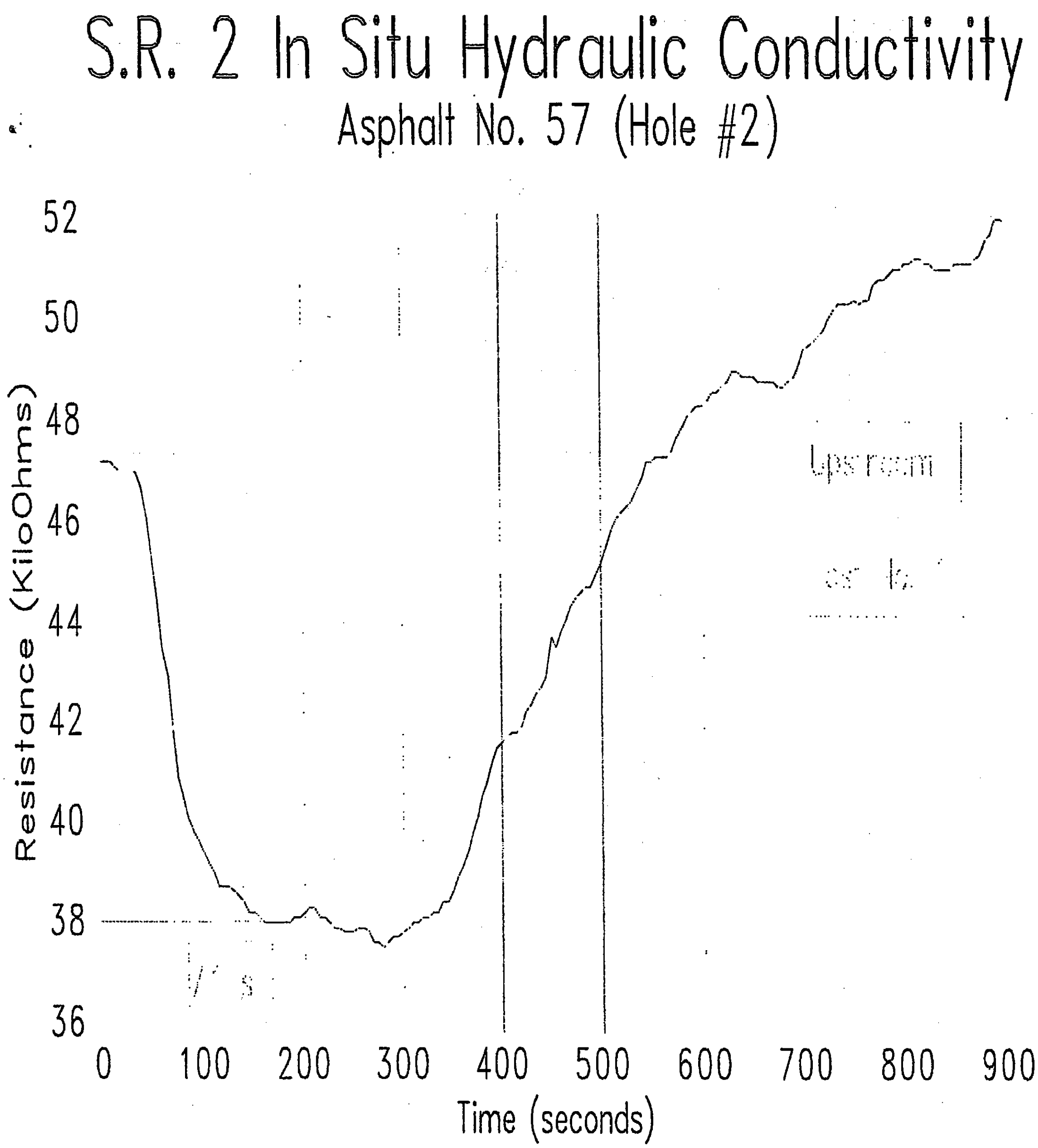


Figure I.1 - Time versus Resistance for Test No. 1, Asp. No. 57, Upstream Probe

Date: 09/14/94

Location: Lorain County, State Route 2, Station 80+00 48' Left of the Centerline (Center of the W.B. Driving Lane)

Layer Tested: Asp. No. 57 **Downstream Probe**

Time	Resistance	Time	Resistance	Time	Resistance
0	67.5	75	70.8	150	78.2
5	68.0	80	71.7	155	78.6
10	68.4	85	72.6	160	78.8
15	68.6	90	73.3	165	79.2
20	68.9	95	73.8	170	79.3
25	69.1	100	74.2	175	79.5
30	69.2	105	74.6	180	79.8
35	69.6	110	75.0	185	79.9
40	70.0	115	75.3	190	80.3
45	70.1	120	76.0	195	80.5
50	70.2	125	76.4	200	80.7
55	70.3	130	76.7	205	80.7
60	70.5	135	77.2	210	80.6
65	70.7	140	77.4	215	80.8
70	70.5	145	77.8	220	81.3

Time	Resistance	Time	Resistance	Time	Resistance
225	82.0	320	86.3	415	90.4
230	82.5	325	86.5	420	90.7
235	82.9	330	86.7	425	90.7
240	83.0	335	86.8	430	91.1
245	83.5	340	87.0	435	91.1
250	83.7	345	87.1	440	91.1
255	83.7	350	87.2	445	91.1
260	84.0	355	87.5	450	91.6
265	84.1	360	87.8	455	91.9
270	84.4	365	88.0	460	92.0
275	84.5	370	88.6	465	92.3
280	84.7	375	88.8	470	92.4
285	84.9	380	89.6	475	92.6
290	85.0	385	89.3	480	92.6
295	85.1	390	89.6	485	92.6
300	85.5	395	89.9	490	92.5
305	85.9	400	90.0	495	92.5
310	86.0	405	90.1	500	92.5
315	86.1	410	90.2	505	92.4

Time	Resistance	Time	Resistance	Time	Resistance
510	92.3	605	98.5	700	104.8
515	92.1	610	98.5	705	105.0
520	92.2	615	98.6	710	105.4
525	92.3	620	98.8	715	105.7
530	92.3	625	99.0	720	105.9
535	92.4	630	99.2	725	106.3
540	92.6	635	99.5	730	106.7
545	92.6	640	99.7	735	106.9
550	93.6	645	100.2	740	107.4
555	94.8	650	100.3	745	107.6
560	95.7	655	100.6	750	107.9
565	96.4	660	101.1	755	108.2
570	96.9	665	101.8	760	108.5
575	97.3	670	102.2	765	108.9
580	97.0	675	102.8	770	109.2
585	98.0	680	103.1	775	109.5
590	98.2	685	103.6	780	109.8
595	98.3	690	104.0	785	110.2
600	98.5	695	104.4	790	110.5

Time	Resistance	Time	Resistance	Time	Resistance
795	110.8	890	115.4		
800	111.2	895	115.7		
805	111.5	900	115.9		
810	111.7				
815	112.0				
820	112.4				
825	112.6				
830	112.8				
835	113.1				
840	113.5				
845	113.6				
850	114.0				
855	114.7				
860	114.3				
865	114.4				
870	114.6				
875	114.8				
880	114.9				
885	115.1				

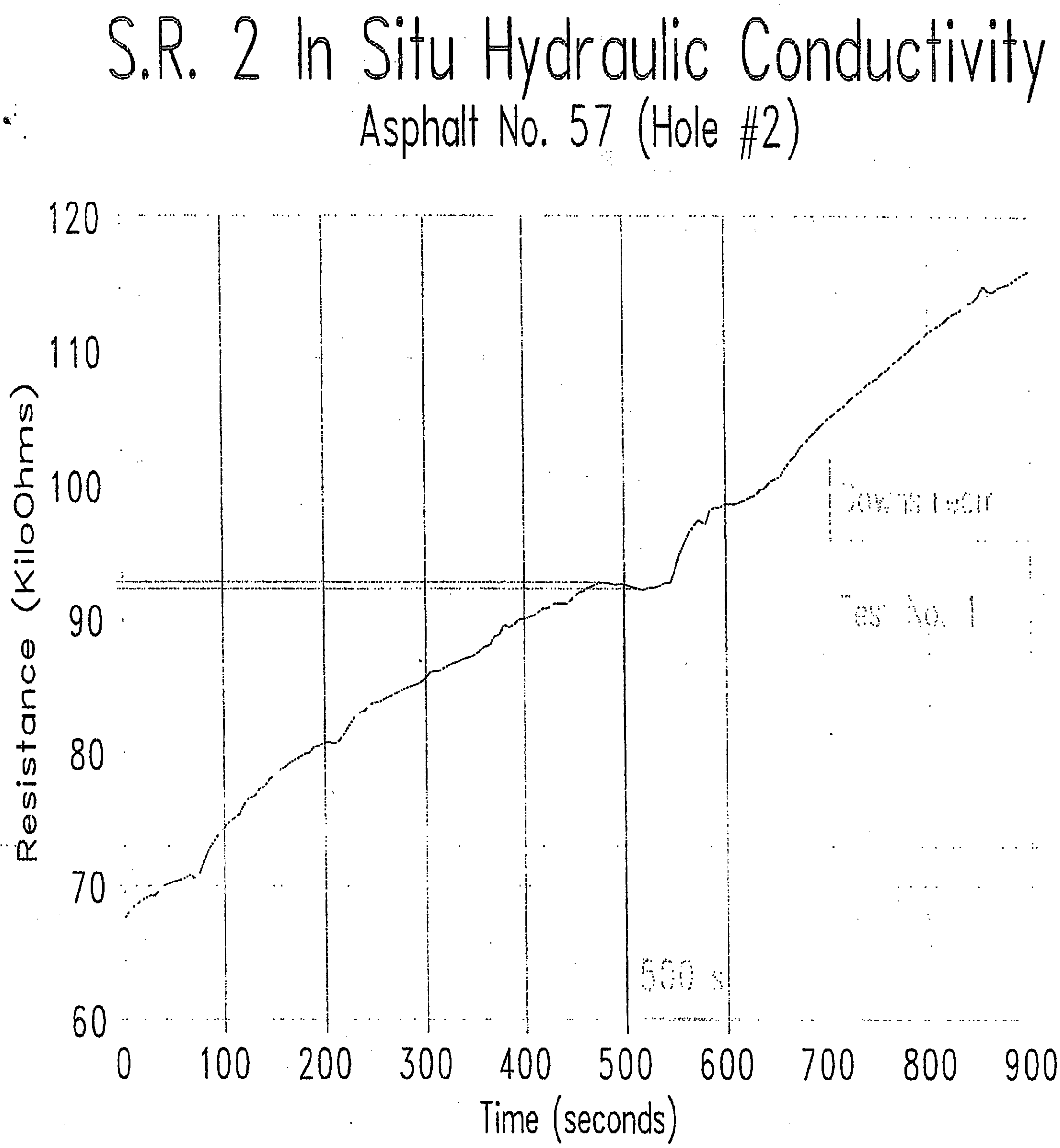


Figure I.2 - Time versus Resistance for Test No. 1, Asp. No. 57, Downstream Probe

I-2 - Field Test Data for Asphalt Cement No. 57, Test No. 2

Date: 09/14/94

Location: Lorain County, State Route 2, Station 80+00 48' Left of the Centerline (Center of the W.B. Driving Lane)

Material/Pavement Sect.: 6" No.304, 4" Asp. No. 57, 10" P.C.C.

Probe Lengths: 20" Layer Tested: Asp. No. 57

Layer Thickness: 10.16 cm Water Temperature: *23.5 °C*

Recovered Test Material Weight: 1.361 Kg

Recovered Test Material Diameter: 10.16 cm

Recovered Test Material Height: 10.16 cm

Recovered Test Material Volume: 0.000824 cubic meters

γ_{dry}: 16.21 KiloNewtons per cubic meter

ϕ_w = unk.

Test No.: 2

	Probe Upst	Probe Dwnst	L	$\Delta\phi$	t_{up}	t_{dn}	t
begin	35	120	85	4.05			
end				3.80			
avg.	35	120	85	3.93	77	600	523

Note: All measurements are in centimeters and seconds

$$K = \frac{L^2}{t\,\Delta\phi} = \text{3.520 cm/s}$$

Date: 09/14/94

Location: Lorain County, State Route 2, Station 80+00 48' Left of the Centerline (Center of the W.B. Driving Lane)

Layer Tested: Asp. No. 57 **Upstream Probe**

Time	Resistance	Time	Resistance	Time	Resistance
0	73.2	75	68.1	150	64.1
5	73.3	80	67.6	155	64.0
10	73.4	85	67.0	160	63.9
15	73.5	90	66.6	165	63.8
20	73.6	95	66.3	170	63.7
25	73.7	100	65.9	175	63.7
30	73.8	105	65.7	180	63.7
35	73.8	110	65.5	185	63.6
40	73.4	115	65.3	190	63.6
45	73.0	120	65.1	195	63.6
50	72.4	125	64.9	200	63.7
55	71.4	130	64.7	205	63.7
60	70.5	135	64.5	210	63.7
65	69.7	140	64.3	215	63.7
70	68.8	145	64.1	220	63.7

Time	Resistance	Time	Resistance	Time	Resistance
225	63.7	320	64.1	415	68.9
230	63.8	325	64.2	420	69.1
235	63.8	330	64.4	425	69.4
240	63.9	335	64.5	430	69.7
245	63.9	340	64.8	435	69.9
250	63.9	345	64.9	440	70.2
255	63.9	350	65.2	445	70.4
260	64.0	355	65.5	450	70.7
265	64.0	360	65.7	455	70.8
270	64.0	365	66.0	460	71.1
275	64.0	370	66.3	465	71.3
280	64.0	375	66.6	470	71.5
285	64.0	380	66.9	475	71.7
290	64.0	385	67.2	480	71.9
295	64.0	390	67.4	485	72.1
300	64.0	395	67.8	490	72.3
305	64.0	400	68.0	495	72.4
310	64.0	405	68.4	500	72.6
315	64.0	410	68.6	505	72.8

Time	Resistance	Time	Resistance	Time	Resistance
510	72.9	605	75.5	700	77.3
515	73.1	610	75.6	705	77.4
520	73.3	615	75.7	710	77.5
525	73.4	620	75.8	715	77.6
530	73.6	625	75.9	720	77.6
535	73.8	630	76.0	725	77.7
540	73.9	635	76.1	730	77.9
545	74.1	640	76.2	735	77.9
550	74.2	645	76.3	740	78.0
555	74.3	650	76.4	745	78.1
560	74.5	655	76.5	750	78.2
565	74.6	660	76.6	755	78.2
570	74.8	665	76.6	760	78.3
575	74.9	670	76.7	765	78.3
580	75.0	675	76.8	770	78.4
585	75.1	680	76.9	775	78.5
590	75.2	685	77.0	780	78.5
595	75.3	690	77.1	785	78.6
600	75.4	695	77.2	790	78.7

Time	Resistance	Time	Resistance	Time	Resistance
795	78.7	890	80.1	985	80.8
800	78.8	895	80.1	990	80.9
805	78.8	900	80.2	995	80.9
810	78.9	905	80.3	1000	81.0
815	79.0	910	80.3	1005	81.0
820	79.0	915	80.4	1010	81.1
825	79.0	920	80.5	1015	81.1
830	79.0	925	80.5	1020	81.2
835	79.1	930	80.6	1025	81.2
840	79.2	935	80.6	1030	81.3
845	79.3	940	80.6	1035	81.3
850	79.4	945	80.6	1040	81.3
855	79.5	950	80.6	1045	81.4
860	79.6	955	80.7	1050	81.5
865	79.7	960	80.7	1055	81.5
870	79.8	965	80.7	1060	81.6
875	79.9	970	80.7	1065	81.6
880	80.0	975	80.8	1070	81.7
885	80.0	980	80.9	1075	81.7

Time	Resistance	Time	Resistance	Time	Resistance
1080	81.8				

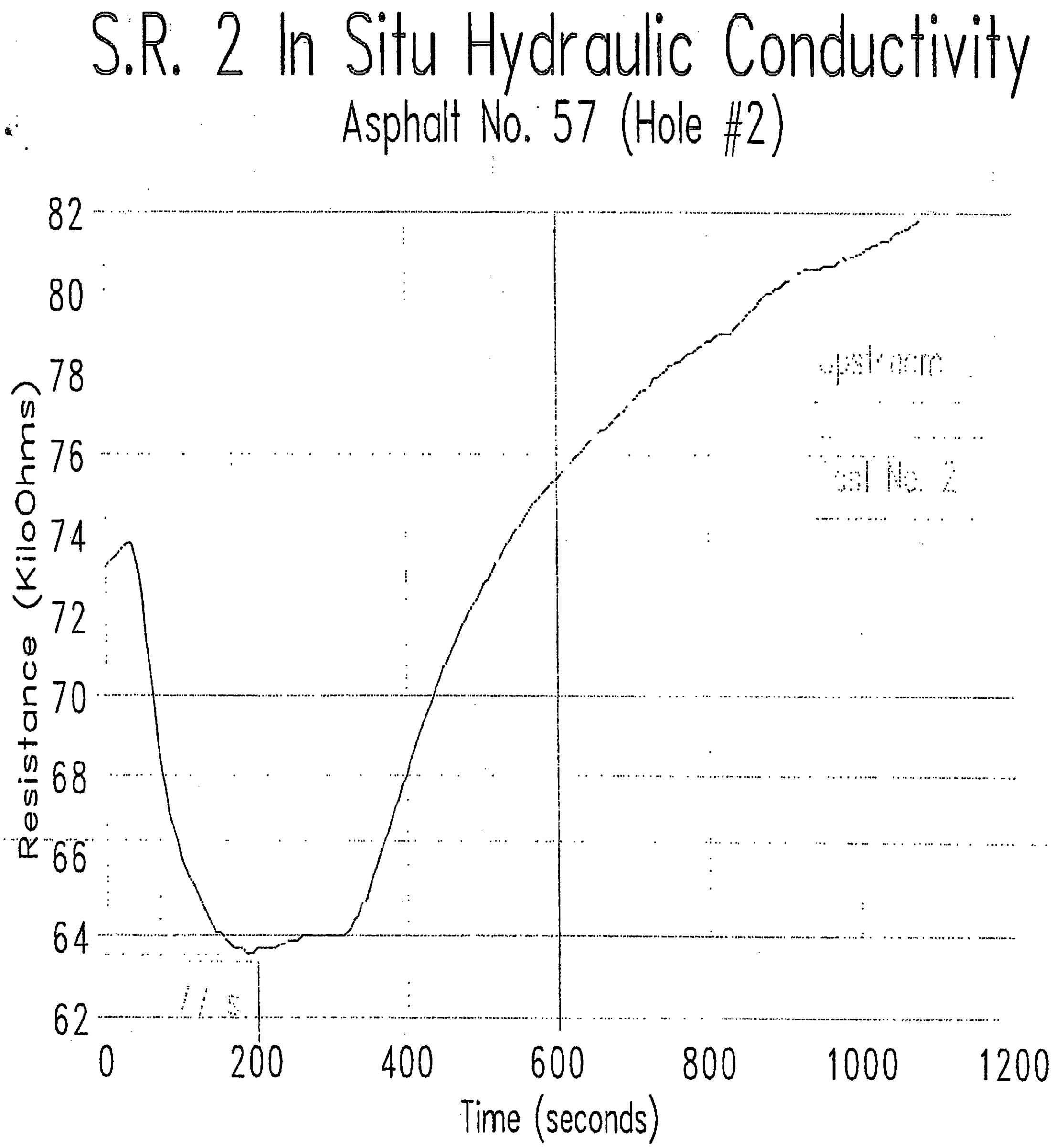


Figure I.3 - Time versus Resistance for Test No. 2, Asp. No. 57, Upstream Probe

Date: 09/14/94

Location: Lorain County, State Route 2, Station 80+00 48' Left of the Centerline (Center of the W.B. Driving Lane)

Layer Tested: Asp. No. 57 **Downstream Probe**

Time	Resistance	Time	Resistance	Time	Resistance
0	145.8	75	148.9	150	152.4
5	146.4	80	149.1	155	152.5
10	146.5	85	149.4	160	152.7
15	146.7	90	149.4	165	152.8
20	146.6	95	149.8	170	152.9
25	146.6	100	150.1	175	152.9
30	146.8	105	150.3	180	153.0
35	147.1	110	150.7	185	153.1
40	147.3	115	151.0	190	153.2
45	147.5	120	151.2	195	153.3
50	147.6	125	151.5	200	153.4
55	147.9	130	151.6	205	153.6
60	148.0	135	151.8	210	153.7
65	148.3	140	152.0	215	153.8
70	148.5	145	152.2	220	154.0

Time	Resistance	Time	Resistance	Time	Resistance
225	154.2	320	156.5	415	159.1
230	154.3	325	156.6	420	158.7
235	154.5	330	156.6	425	158.8
240	154.6	335	156.8	430	159.0
245	154.7	340	156.9	435	159.5
250	154.9	345	157.1	440	159.9
255	155.1	350	157.2	445	160.3
260	155.1	355	157.3	450	160.6
265	154.8	360	157.4	455	160.9
270	155.0	365	157.7	460	161.4
275	155.4	370	157.9	465	161.8
280	155.7	375	158.0	470	162.4
285	155.8	380	158.3	475	162.6
290	156.0	385	158.5	480	162.7
295	156.1	390	158.6	485	162.8
300	156.2	395	158.8	490	162.8
305	156.2	400	158.9	495	162.7
310	156.3	405	159.0	500	162.5
315	156.4	410	159.4	505	162.3

Time	Resistance	Time	Resistance	Time	Resistance
510	162.1	605	159.8	700	159.2
515	162.0	610	159.7	705	157.2
520	161.8	615	159.7	710	157.8
525	161.2	620	159.7	715	158.4
530	161.3	625	159.7	720	158.5
535	161.4	630	159.7	725	158.7
540	161.0	635	159.7	730	158.6
545	160.0	640	159.7	735	158.7
550	159.8	645	159.7	740	158.8
555	160.3	650	159.5	745	158.8
560	160.4	655	159.5	750	158.9
565	160.5	660	159.4	755	159.0
570	160.4	665	159.4	760	159.0
575	160.3	670	159.3	765	158.9
580	160.3	675	159.2	770	159.1
585	160.3	680	159.2	775	159.1
590	160.1	685	158.9	780	159.1
595	160.0	690	159.0	785	158.8
600	159.9	695	159.1	790	158.7

Time	Resistance	Time	Resistance	Time	Resistance
795	158.6	890	158.9	985	159.4
800	158.6	895	158.7	990	159.4
805	158.7	900	158.7	995	159.5
810	158.9	905	158.9	1000	159.5
815	157.1	910	159.0	1005	159.4
820	157.4	915	158.9	1010	159.6
825	157.5	920	158.7	1015	159.6
830	158.0	925	158.9	1020	159.8
835	158.2	930	159.1	1025	159.9
840	158.1	935	159.2	1030	160.1
845	158.5	940	159.4	1035	159.8
850	158.6	945	159.5	1040	159.9
855	158.8	950	159.7	1045	160.2
860	158.6	955	159.7	1050	160.3
865	158.8	960	159.7	1055	160.5
870	158.8	965	159.6	1060	160.6
875	158.9	970	159.6	1065	160.8
880	159.0	975	159.5	1070	160.9
885	159.0	980	159.2	1075	161.1

Time	Resistance	Time	Resistance	Time	Resistance
1080	161.3				

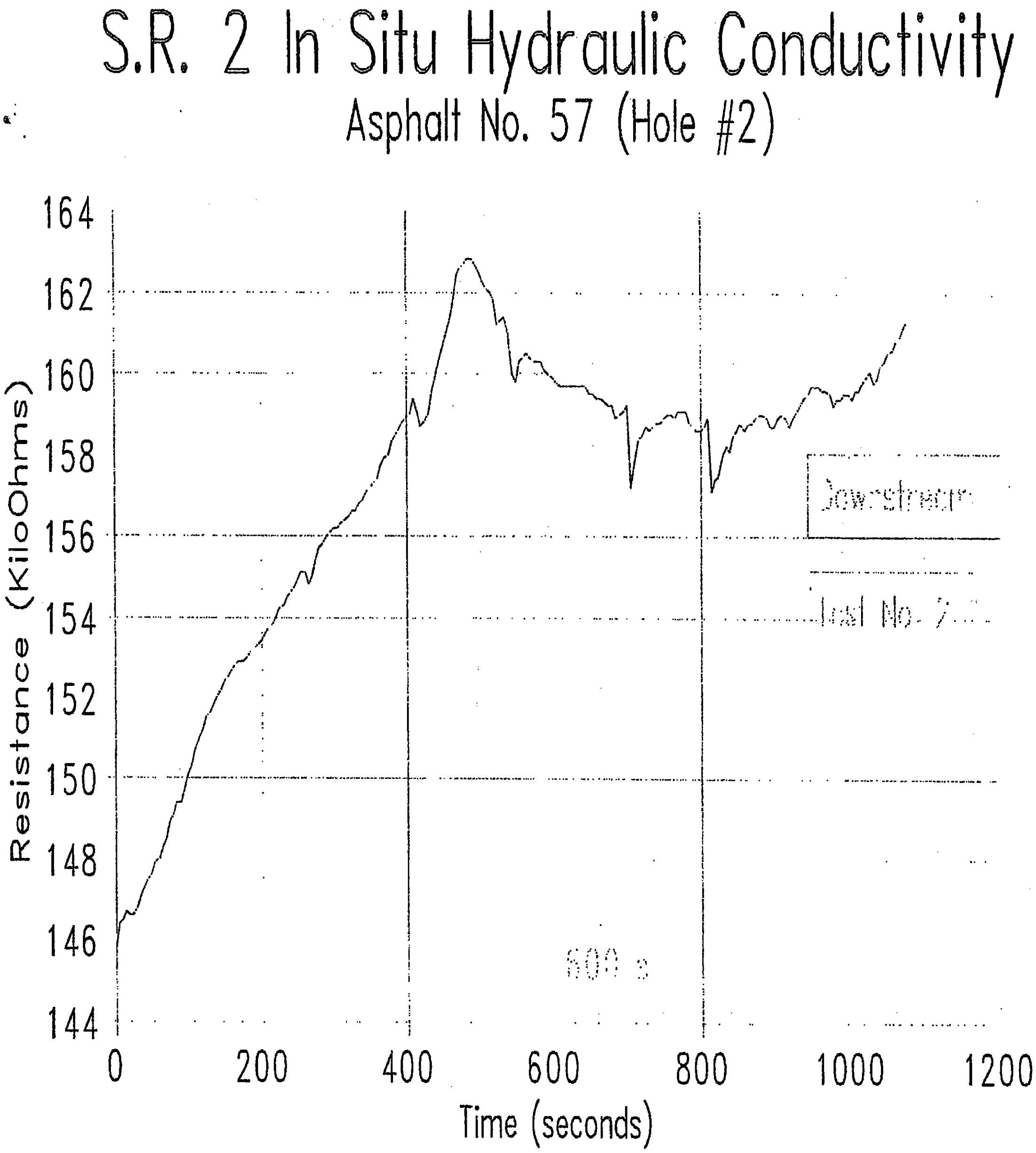


Figure I.4 - Time versus Resistance for Test No. 2, Asp. No. 57, Downstream Probe

Appendix J

Test of the In Situ Hydraulic Conductivity Test Device for Ohio State Route 2 Results for New Jersey Mix

J-1 - Field Test Data for New Jersey Mix, Test No. 1

Date: 09/14/94

Location: Lorain County, State Route 2, Station 72+00 48' Left of the Centerline (Center of the W.B. Driving Lane)

Material/Pavement Sect.: 6" No.304, 4" NJ Mix, 10" P.C.C.

Probe Lengths: 20" Layer Tested: N.J. Mix

Layer Thickness: 10.16 cm Water Temperature: $22\,°C$

Recovered Test Material Weight: 2.103 Kg

Recovered Test Material Diameter: 10.16 cm

Recovered Test Material Height: 10.16 cm

Recovered Test Material Volume: 0.000824 cubic meters

γ_{dry}: 25.09 KiloNewtons per cubic meter

$\phi_w =$ 0.743 m

Test No.: 1

	Probe Upst	Probe Dwnst	L	$\Delta\phi$	t_{up}	t_{dn}	t
begin	30	55	25	4.85			
end				3.45			
avg.	30	55	25	4.15	-	-	-

Note: All measurements are in centimeters and seconds

$K = \frac{L^2}{t\,\Delta\phi} =$ Unk.

Date: 09/16/94

S.R. 2 Sieve Analysis on Recovered Material

for the New Jersey Mix

Weight of Pan = 249 grams

Sieve (mm)	Pan + Aggregate (grams)	Aggregate Only (grams)	Percent Retained (%)	Percent Passing (%)
38.100	249	0	0.00	100.00
25.400	269	20	0.95	99.05
12.700	1068	819	38.94	60.10
4.750	795	546	25.96	34.14
2.350	688	439	20.87	13.27
1.180	384	135	6.42	6.85
0.300	317	68	3.23	3.61
0.075	305	56	2.66	0.95
Pan	269	20	0.95	0.00

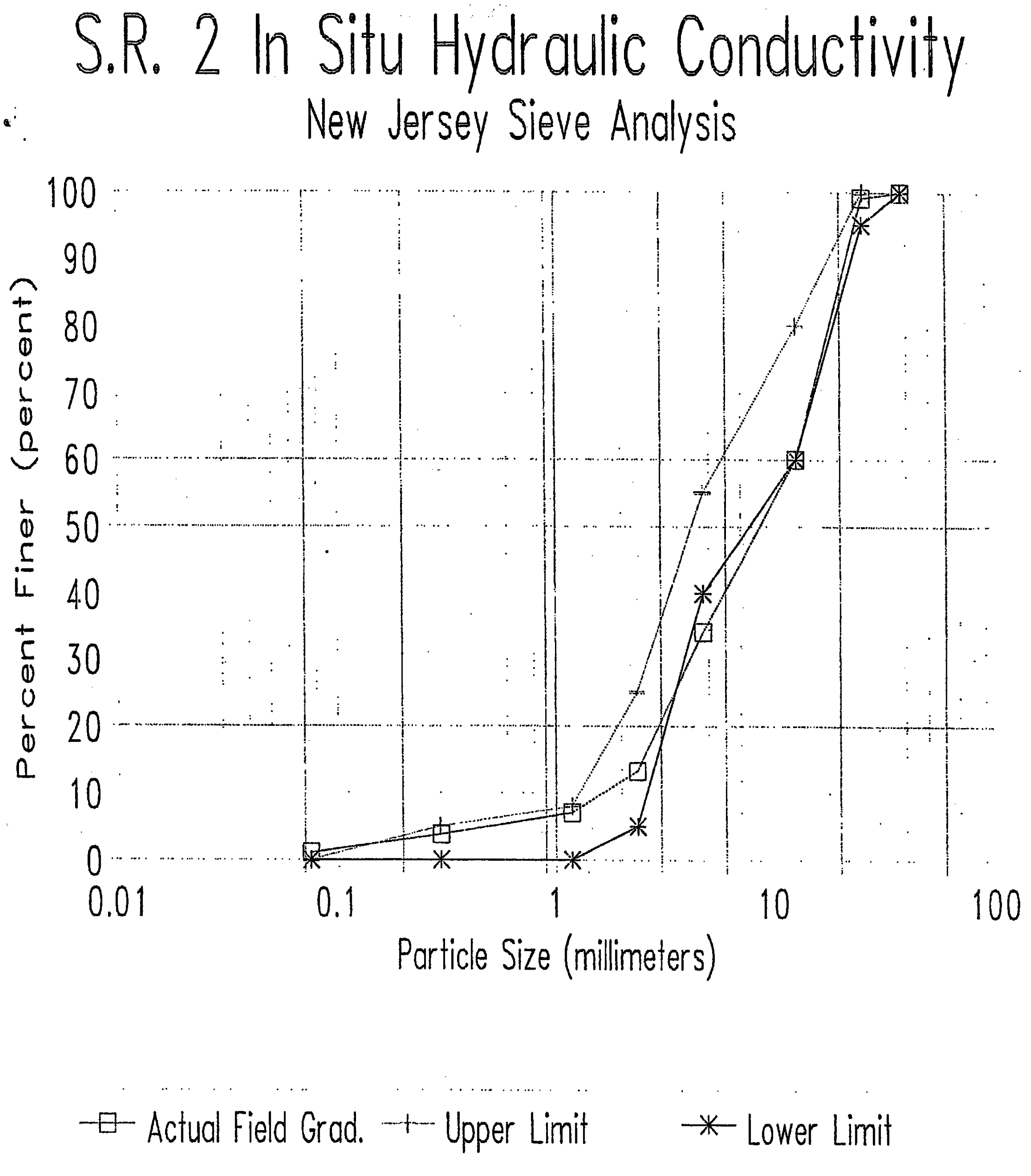


Figure J.1 - Percent Finer versus Particle Diameter for Recovered New Jersey Mix

Date: 09/14/94

Location: Lorain County, State Route 2, Station 72+00 48' Left of the Centerline (Center of the W.B. Driving Lane)

Layer Tested: N.J. Mix **Upstream Probe**

Time	Resistance	Time	Resistance	Time	Resistance
0	29.0	150	30.0	300	30.9
10	29.1	160	30.1	310	30.9
20	29.2	170	30.2	320	30.9
30	29.3	180	30.3	330	30.9
40	29.3	190	30.4	340	31.0
50	29.4	200	30.4	350	31.0
60	29.5	210	30.5	360	31.0
70	29.6	220	30.5	370	31.0
80	29.7	230	30.6	380	31.1
90	29.8	240	30.7	390	31.1
100	29.8	250	30.7	400	31.1
110	29.8	260	30.7	410	31.1
120	29.8	270	30.7	420	31.2
130	29.9	280	30.8	430	31.2
140	30.0	290	30.9	440	31.2

Time	Resistance	Time	Resistance	Time	Resistance
450	31.2	640	31.9		
460	31.2	650	31.9		
470	31.3	660	31.9		
480	31.3	670	32.0		
490	31.3	680	32.0		
500	31.4	690	32.0		
510	31.4	700	32.0		
520	31.4	710	32.0		
530	31.5	720	32.1		
540	31.5	730	32.1		
550	31.6	740	32.1		
560	31.6	750	32.1		
570	31.6	760	32.1		
580	31.7	770	32.1		
590	31.7	780	32.0		
600	31.8				
610	31.8				
620	31.8				
630	31.9				

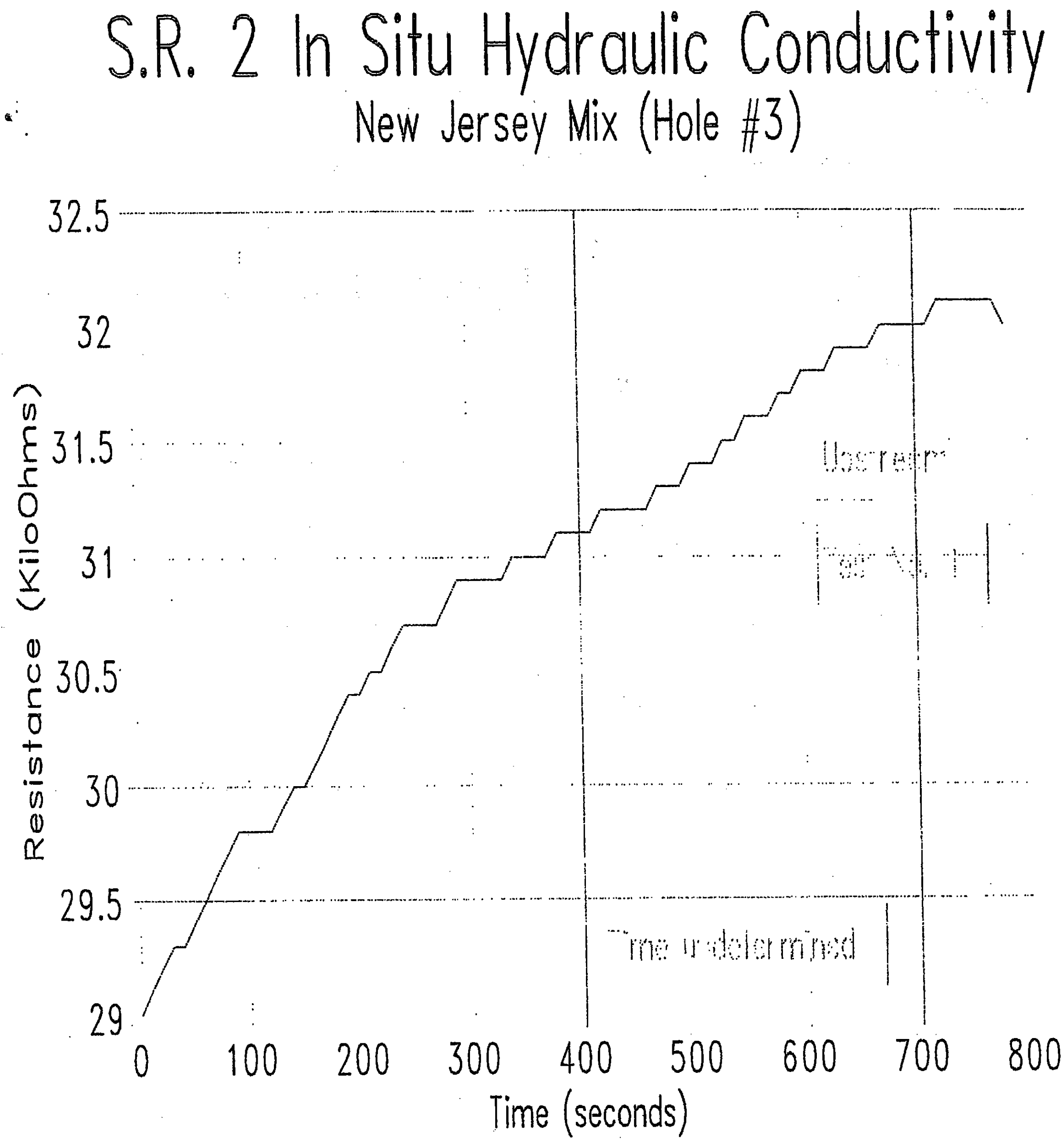


Figure J.2 - Time versus Resistance for Test No. 1, New Jersey Mix, Upstream Probe

Date: 09/14/94

Location: Lorain County, State Route 2, Station 72+00 48' Left of the Centerline (Center of the W.B. Driving Lane)

Layer Tested: New Jersey Mix **Downstream Probe**

Time	Resistance	Time	Resistance	Time	Resistance
0	69.5	150	91.9	300	119.0
10	70.5	160	94.6	310	120.8
20	71.3	170	97.1	320	121.7
30	72.1	180	99.5	330	122.2
40	73.6	190	102.3	340	122.3
50	74.6	200	104.6	350	122.6
60	75.3	210	106.3	360	123.0
70	75.0	220	108.0	370	123.1
80	75.6	230	109.2	380	123.3
90	77.2	240	110.1	390	123.9
100	80.4	250	111.0	400	124.1
110	83.6	260	112.0	410	124.5
120	85.9	270	114.3	420	125.4
130	88.4	280	116.2	430	125.9
140	89.9	290	117.6	440	126.0

Time	Resistance	Time	Resistance	Time	Resistance
450	126.4	640	55.6		
460	125.4	650	55.2		
470	123.7	660	55.0		
480	122.6	670	55.2		
490	122.8	680	55.4		
500	102.1	690	55.5		
510	88.7	700	55.8		
520	78.6	710	55.7		
530	72.7	720	55.6		
540	69.1	730	55.5		
550	65.0	740	55.3		
560	62.3	750	55.4		
570	60.5	760	55.5		
580	59.1	770	55.6		
590	57.9	780	55.7		
600	57.0				
610	56.6				
620	56.1				
630	55.8				

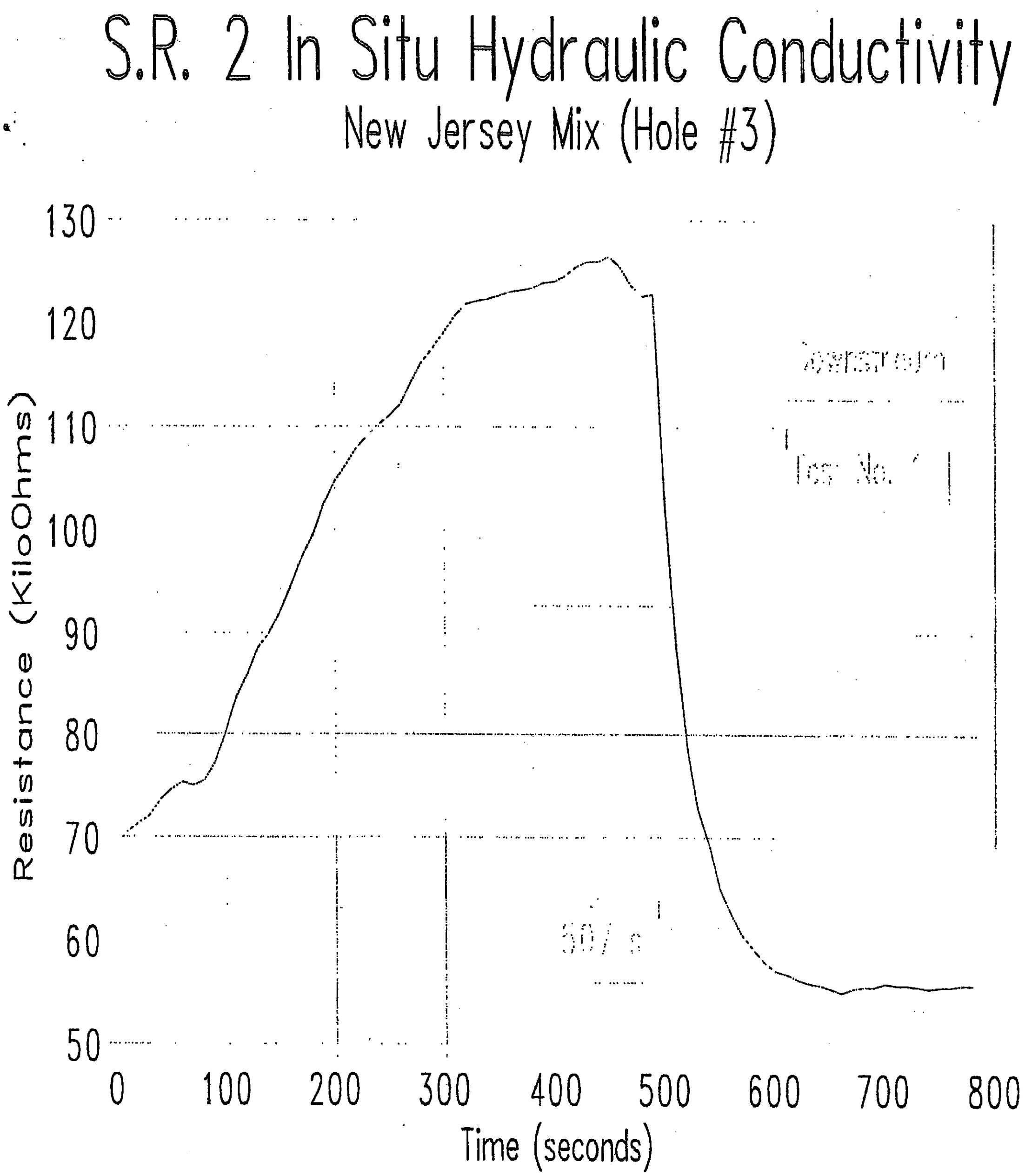


Figure J.3 - Time versus Resistance for Test No. 1, New Jersey Mix, Downstream Probe

J-2 - Field Test Data for New Jersey Mix, Test No. 2

Date: 09/14/94

Location: Lorain County, State Route 2, Station 72+00 48' Left of the Centerline (Center of the W.B. Driving Lane)

Material/Pavement Sect.: 6" No.304, 4" NJ Mix, 10" P.C.C.

Probe Lengths: 20" Layer Tested: N.J. Mix

Layer Thickness: 10.16 cm Water Temperature: 22 °C

Recovered Test Material Weight: 2.103 Kg

Recovered Test Material Diameter: 10.16 cm

Recovered Test Material Height: 10.16 cm

Recovered Test Material Volume: 0.000824 cubic meters

γ_{dry}: 25.09 KiloNewtons per cubic meter

ϕ_w = unk.

Test No.: 2

	Probe Upst	Probe Dwnst	L	$\Delta\phi$	t_{up}	t_{dn}	t
begin	30	55	25	1.40			
end				1.00			
avg.	30	55	25	1.20	200	1015	815

Note: All measurements are in centimeters and seconds

$$K = \frac{L^2}{t\,\Delta\phi} = 0.639 \text{ cm/s}$$

Date: 09/14/94

Location: Lorain County, State Route 2, Station 72+00 48' Left of the Centerline (Center of the W.B. Driving Lane)

Layer Tested: New Jersey Mix **Upstream Probe**

Time	Resistance	Time	Resistance	Time	Resistance
0	28.8	150	28.4	300	29.0
10	29.0	160	28.5	310	29.2
20	29.2	170	28.5	320	29.4
30	29.4	180	28.6	330	29.5
40	29.5	190	28.6	340	29.6
50	29.6	200	28.3	350	29.8
60	29.5	210	27.8	360	29.9
70	29.1	220	27.0	370	30.1
80	28.9	230	26.9	380	30.2
90	28.7	240	27.6	390	30.3
100	28.5	250	28.0	400	30.5
110	28.5	260	28.4	410	30.6
120	28.4	270	28.7	420	30.7
130	28.4	280	29.1	430	30.8
140	28.4	290	29.0	440	30.9

Time	Resistance	Time	Resistance	Time	Resistance
450	31.0	640	31.8	830	32.2
460	31.0	650	31.9	840	32.2
470	31.1	660	31.9	850	32.2
480	31.2	670	31.9	860	32.3
490	31.2	680	31.9	870	32.3
500	31.3	690	31.9	880	32.3
510	31.3	700	31.9	890	32.4
520	31.4	710	32.0	900	32.4
530	31.4	720	32.0	910	32.5
540	31.5	730	32.0	920	32.5
550	31.5	740	32.0	930	32.6
560	31.6	750	32.0	940	32.6
570	31.6	760	32.0	950	32.6
580	31.7	770	32.0	960	32.7
590	31.7	780	32.1	970	32.7
600	31.7	790	32.1	980	32.7
610	31.7	800	32.1	990	32.8
620	31.8	810	32.1	1000	32.8
630	31.8	820	32.1	1010	32.8

Time	Resistance	Time	Resistance	Time	Resistance
1020	32.8				
1030	32.8				
1040	32.8				
1050	32.8				
1060	32.9				
1070	32.9				
1080	32.9				
1090	32.9				
1100	33.0				
1110	33.0				
1120	33.0				
1130	33.1				
1140	33.2				
1150	33.2				
1160	33.3				
1170	33.3				
1180	33.4				
1190	33.4				
1200	33.4				

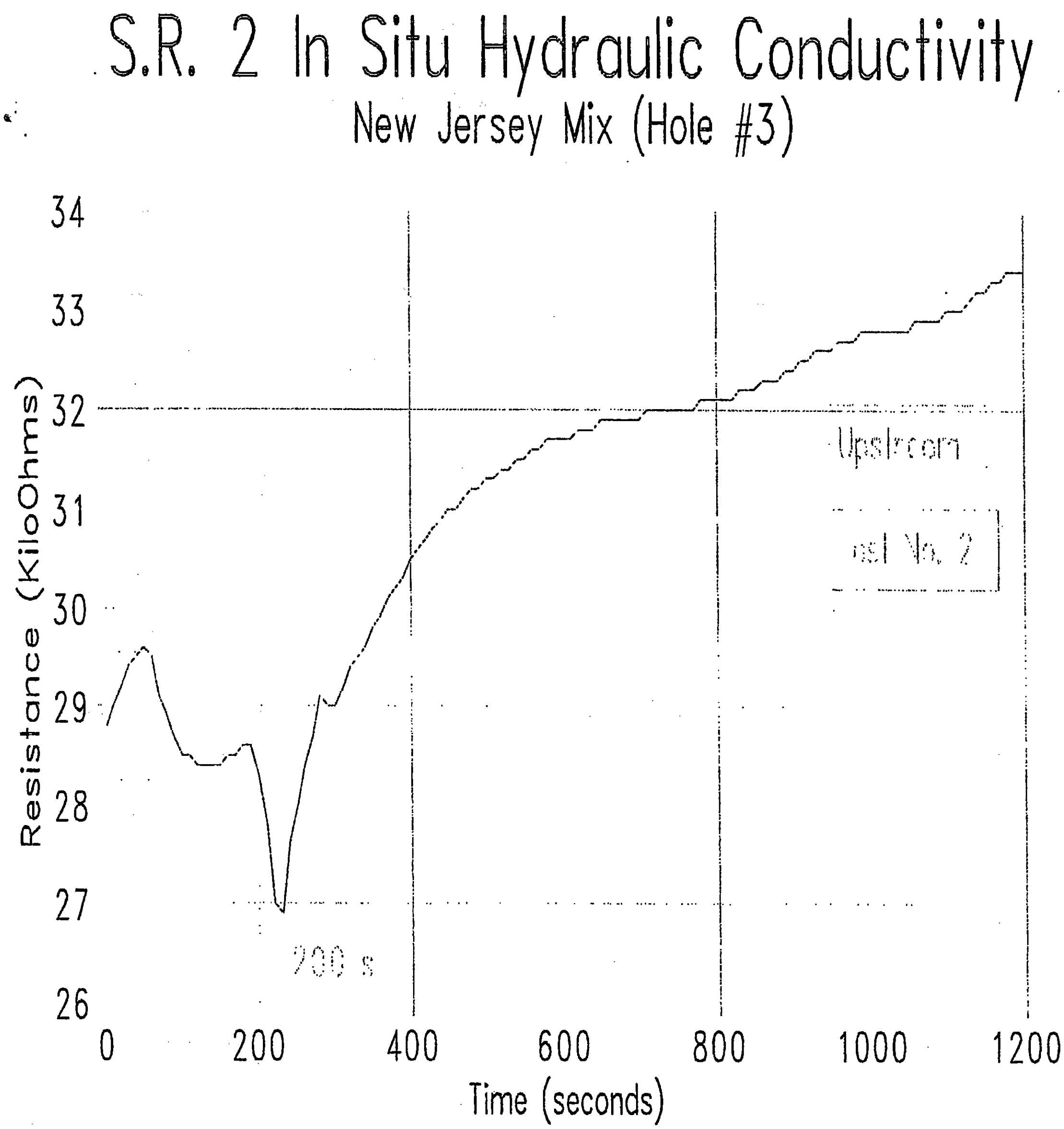


Figure J.4 - Time versus Resistance for Test No. 2, New Jersey Mix, Upstream Probe

Date: 09/14/94

Location: Lorain County, State Route 2, Station 72+00 48' Left of the Centerline (Center of the W.B. Driving Lane)

Layer Tested: New Jersey Mix **Downstream Probe**

Time	Resistance	Time	Resistance	Time	Resistance
0	27.7	150	41.8	300	52.0
10	29.1	160	42.6	310	52.3
20	30.4	170	43.4	320	52.7
30	31.6	180	44.2	330	53.1
40	32.6	190	44.9	340	53.5
50	32.5	200	45.5	350	53.8
60	32.6	210	46.2	360	54.2
70	33.5	220	46.9	370	54.6
80	34.3	230	47.5	380	54.8
90	35.4	240	48.1	390	55.2
100	36.7	250	48.5	400	55.5
110	37.9	260	48.7	410	55.8
120	38.9	270	49.4	420	56.1
130	39.9	280	50.8	430	56.3
140	40.9	290	51.8	440	56.6

Time	Resistance	Time	Resistance	Time	Resistance
450	56.8	640	60.3	830	63.5
460	57.1	650	60.5	840	63.5
470	57.3	660	60.7	850	63.6
480	57.4	670	61.0	860	63.6
490	57.5	680	61.2	870	63.7
500	57.7	690	61.5	880	63.8
510	57.9	700	61.6	890	63.9
520	58.1	710	61.7	900	64.0
530	58.3	720	61.9	910	64.1
540	58.5	730	62.2	920	64.2
550	58.7	740	62.3	930	64.3
560	58.9	750	62.6	940	64.4
570	59.2	760	62.8	950	64.6
580	59.4	770	63.0	960	64.7
590	59.7	780	62.9	970	64.8
600	59.6	790	63.1	980	64.9
610	59.6	800	63.3	990	65.1
620	59.8	810	63.4	1000	65.2
630	60.1	820	63.4	1010	65.2

Time	Resistance	Time	Resistance	Time	Resistance
1020	65.1				
1030	65.0				
1040	64.9				
1050	64.9				
1060	65.1				
1070	65.2				
1080	65.4				
1090	65.6				
1100	65.7				
1110	65.8				
1120	65.9				
1130	66.1				
1140	66.3				
1150	66.5				
1160	66.7				
1170	66.9				
1180	67.1				
1190	67.2				
1200	67.4				

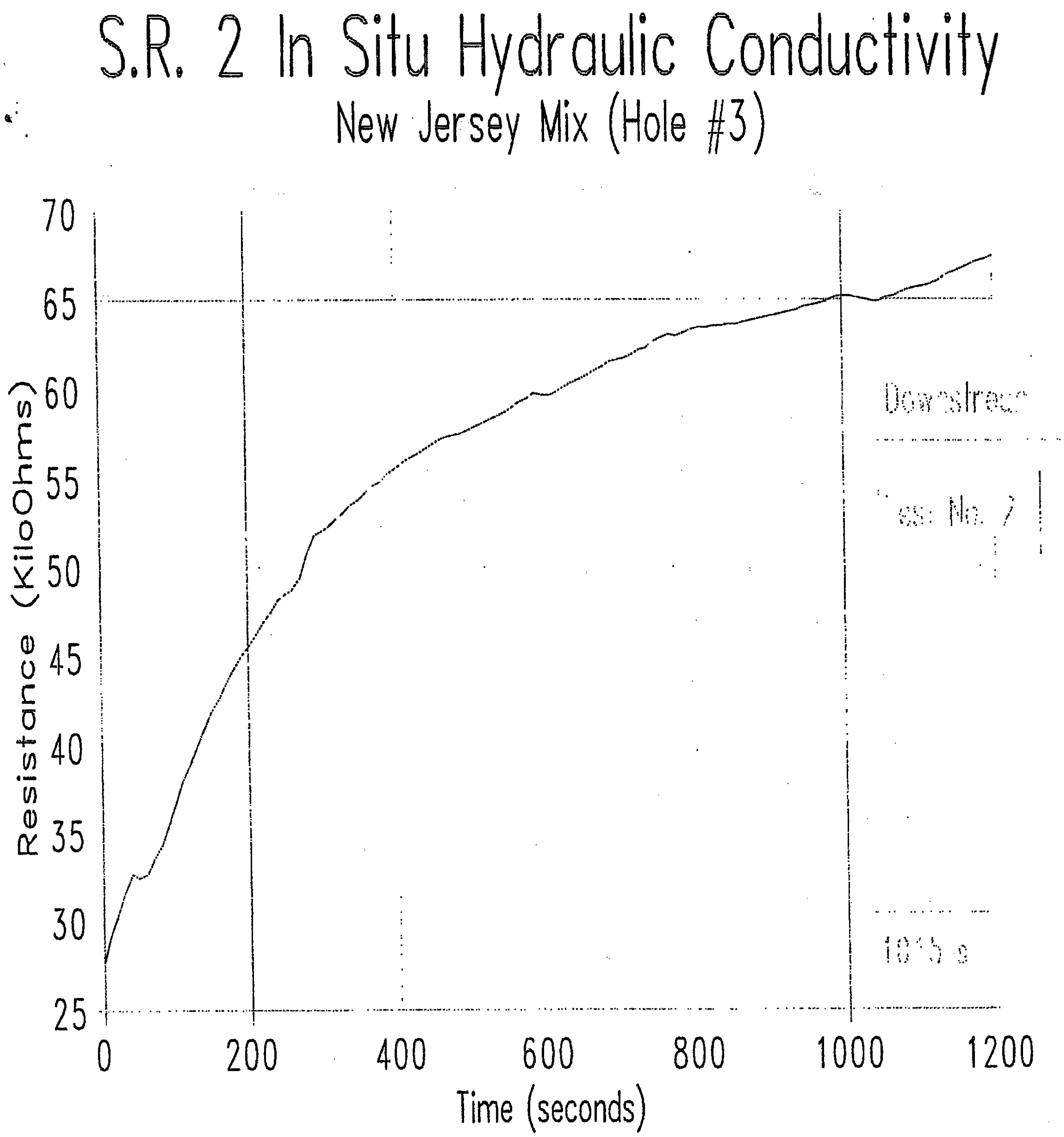


Figure J.5 - Time versus Resistance for Test No. 2, New Jersey Mix, Downstream Probe

Appendix K

Test Method for Hydraulic Conductivity of Coarse Grained Materials

Table of Contents

K.1 *Scope*

This test method covers the determination of horizontal hydraulic conductivity (coefficient of permeability) of both non-stabilized open-graded materials and stabilized open-graded base and subbase materials. The procedure is to establish representative values of hydraulic conductivity of open-graded materials that are used to construct pavement bases and subbases. This procedure was developed for the testing of ODOT 304, ODOT 310, AASHTO M-43 Specifications No. 57 (No. 57), AASHTO M-43 Specifications No. 67 (No. 67), IDOT 41-21 and NJ mix. It is limited to materials that have similar gradations.

K.2 *Apparatus*

A horizontal permeameter is presented in Figure K-1. The cross-sectional area of the permeameter cell is 12 inches by 12 inches and 18 inches long. These dimensions were chosen to reduce the effect of sample variation and sidewall leakage. It is made from polyvinyl chloride (PVC) plates. The flange around the top of the permeameter cell is 1 inch wide to attach the lid. Two perforated PVC plates separate the permeameter cell into water chambers at the two ends of the permeameter cell and a 12 inch long sample chamber in the middle. The holes in the perforated plates are 3/8 inch diameter. They are designed for those relatively coarse materials such as No. 57 and No. 67. Fine screens are used to cover the holes for relatively fine materials. Flexible, closed cell foam sheets are glued to all sides of the sample chamber, except the perforated plates. The lid is attached to the permeameter cell flange with studs and wing nuts, sealing the permeameter cell. Two aluminum bars are firmly attached to the flange across the lid surface perpendicular to the flow direction. They stiffer the lid and apply a slight vertical stress on the

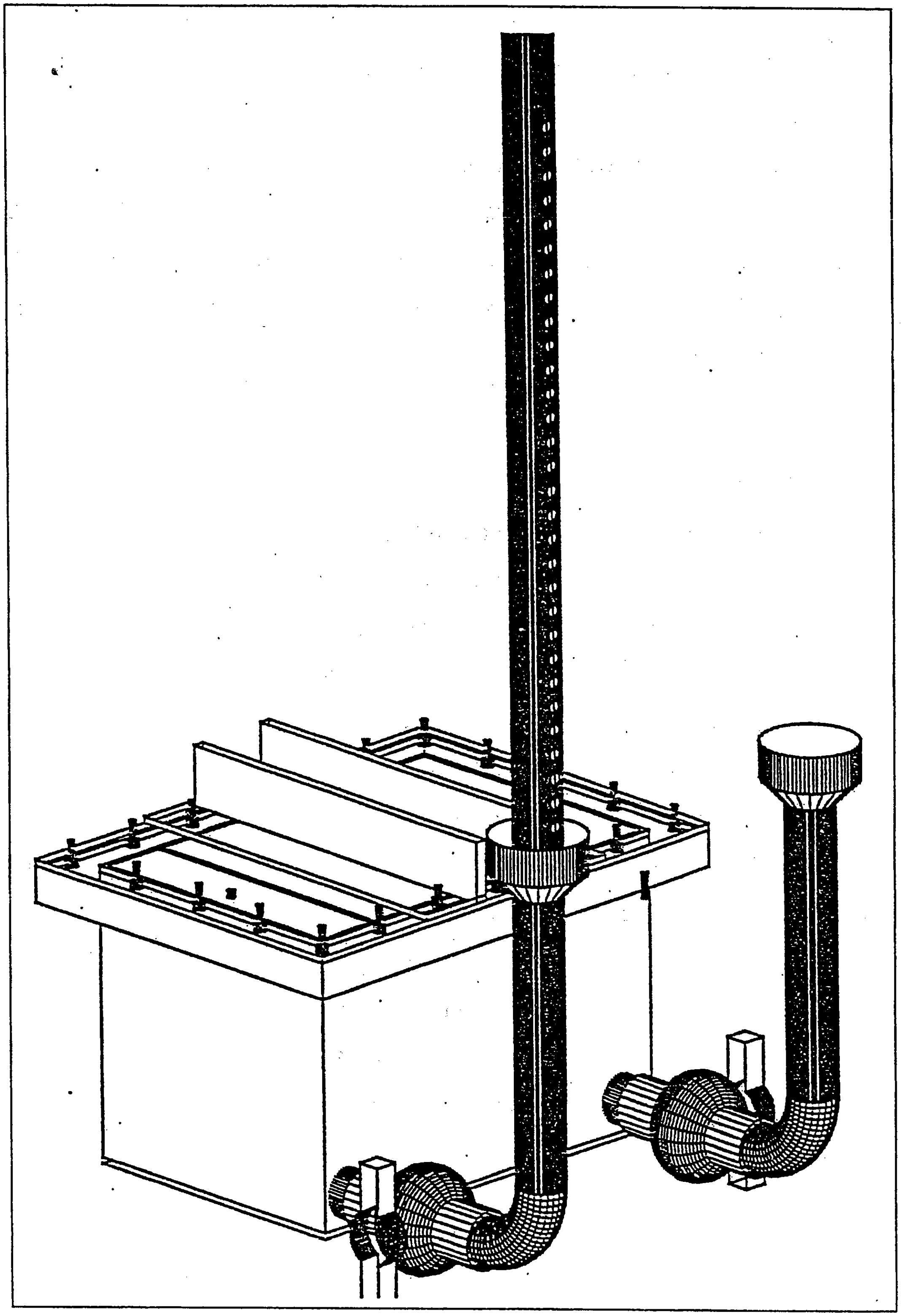


Figure K-1: Represention of a horizontal permeameter top of the sample. This prevents any volumetric change of the sample and short circuiting along the top of the sample.

Three vacuum outlets with valves are installed in the lid, with two over the water chambers, and one over the sample chamber. The valves are closed when the vacuum line is disconnected and they are open when connected. They are used to evacuate the sample under full vacuum and improve the degree of saturation at any time before making a measurement.

The standpipes are 2 inches inside diameter. A 10 foot high standpipe with a valve and elbow on the lower end can be put on or taken off from a short inlet pipe protruding from the bottom of the upstream water chamber. Double O-rings are installed on the lower end of the standpipe to provide a seal with the short inlet pipe. The inlet standpipe is fitted with an adjustable overflow cup, which can be moved up and down along the standpipe. An O-ring installed on the inside of the overflow cup provide a water-tight seal. There are a number of head level holes of 1 cm in diameter on the inlet standpipe. Used with stoppers and the adjustable overflow cup, these holes are designed to change the water level in the inlet standpipe.

A short standpipe with a valve and an elbow on its lower end can be attached to the short outlet pipe extending from the bottom of the downstream water chamber. An O-ring is fitted on the inside of the end of the standpipe so that the joint remains sealed while rotating the outlet standpipe to measure the outflow rate and alter the head difference.

A 325 gallon water tank used to settle the water and minimize dissolved air. It is equipped with a water pump and necessary connections to lead the water from the tank to the inlet standpipe of the permeameter. A valve controlling the water flow towards the permeameter is used to adjust the in-flowing water, and thereby, the applied head difference. The connections can also be connected directly to the tap if tap water is desired.

A vacuum pump is used to evacuate the sample during saturating and prior to testing. An aluminum beam with a sensitive level and a clamp is used as the datum. It is attached to the two standpipes for measuring the head difference between the inlet and the outlet water levels. A dial gauge with a precision of 0.001 inch is used to measure from the datum to calculate small head differences. This is especially important for very coarse materials such as No.57 and No. 67. A steel ruler with an accuracy of 0.01 inch is used to measure relatively large head differences. A table mounted vibrator, a steel rod and a wooded block are used as compaction equipment. A bucket_with a capacity of 40 pounds of water, a balance with a capacity of 30 pounds and precision of 0.01 pound, and a timer are used to measure the flow rates. The permeameter is placed on a balance with precision of 0.01 pound, to measure the weight of the system at different testing stages.

K.3 *Preparation of Specimen*

K.3.1 Initial Measurement

Measure the inner length, height and width of the sample chamber, the weight of the empty permeameter box without the inlet and outlet standpipes, and the lid. Record them on a data sheet. Record the following weights:

- ☐ The weight of the dry permeameter cell without the lid and the standpipes.
- ☐ The wet weight of the empty permeameter cell without the lid and the standpipes.
- ☐ The weight of the permeameter full of water with the lid, the standpipes and the connections. The water levels in the upright standpipes should be at the bottom of the hole in the overflow cup on the outlet standpipe.

K.3.2 **Preparation of sample**

K.3.2.1 *Sieving*

Set up the screens according to the gradation specification for the tested material and sieve the material. Store the separated materials in different containers with passing sieve sizes and retained sieve sizes labeled.

K.3.2.2 *Recombining*

Estimate the total amount of materials needed for a testing sample by multiplying the estimated maximum density by the sample chamber volume. The percentage by weight retained on each standard sieves can be calculated from the percentage by weight finer than each standard sieve. Take the required amount of each separated material according to the calculated percentage by weight retained on each standard sieve. Mix them thoroughly using a concrete mixer. A sheet of plastic may be used as a lid to keep the fine materials from coming out of the mixer.

For stabilized samples, wood molds of the same size as the permeameter cell are made before mixing. An allowance is made for an extra layer of closed-cell foam to wrap the sides of the specimen before placement in the permeameter cell. Add the required amount of cement and water or asphalt. Mix them thoroughly using proper equipment.

K.3.2.3 *Compaction*

Spread the aggregate from a scoop. Uniform spreading can be obtained by sliding a scoopful of soil in nearly horizontal position down along the inside surface of the device to the bottom or to the formed layer, then tilting the scoop and progressing around the inside perimeter slowly. This allows the soil to run smoothly from the scoop into a windrow without segregation and to form a uniform layer of a thickness equal to the maximum particle size. In this study, the thickness of each layer was from 1.5 inches to 2 inches.

Compact to obtain maximum density. Compact each layer of aggregate thoroughly by using a table mounted vibrator for 2 minutes and 50 falls of a light weight. Adjust the height of drop and give sufficient coverage to produce maximum density by trial and error.

At the completion of the compaction, level the upper surface of the aggregate by placing a plate in position and by rotating it gently back and forth. If the leveling reduces the density, the section shall be recompacted to eliminate the effect.

Weigh the permeameter with compacted aggregate in it but without the standpipes on both ends. Then calculate the density and check with the requirement of being equal or greater than 95% of the reference maximum density in the field. If the compacted density is less than 95% of the reference density, it shall be re-compacted until it meets the requirement.

Place the lid on the top of the permeameter and tighten it securely to the flange via wing nuts to make a water-tight seal. Place the two aluminum bars across the top of the lid and tighten them down with wing nuts.

K.3.2.4 *Saturation*

Lubricate the O rings on the lower ends of the standpipes and install the inlet standpipe and the outlet standpipe to the permeameter. Close the valves on the standpipes. After connecting one of the vacuum outlet valves on the lid to a vacuum pump, evacuate the air from the sample. Follow the evacuation by a slow saturation of the specimen from the bottom upward under a vacuum of 25 psi. This can be done by turning on the water inlet valve while the sample is still under vacuum. Saturate the sample until there are no air bubbles in the transparent vacuum line. With the outlet standpipe vertical, open the valve on the outlet standpipe with the water still flowing through the sample and with the vacuum on, until the water level reaches the overflow level.

Close all of the valves and disconnect the supply hose from the water source. Weigh the whole system. The weight is the total weight of the saturated system and can be used to calculate the degree of saturation of the sample.

Reconnect the supply hose and open all the valves except the one on the outlet standpipe. Rotate the outlet standpipe to let the water in the outlet standpipe overflow. Adjust the outlet standpipe to set the overflow level slightly lower than the lowest overflow holes on the inlet standpipe. Clamp the aluminum beam, which is used as the datum, to the inlet standpipe and rest the other end of the aluminum beam on the top of the outlet standpipe. Adjust it to make it level. Shims may be used between the beam and the top of the outlet standpipe, if necessary, when adjusting the beam. Open the valve on the outlet to allow the water to flow through the sample and overflow.

Two sources of water may be used in testing. One is settled water. Fill the 325 gallon water tank the day before testing. Let the air bubbles in the tap water escape by settling the water in the tank, the volume of which is sufficient for several tests. Another source of water is tap water. If tap water is used in the test instead of settled water, frequent resaturation is needed to keep the incoming air bubbles from desaturating the sample.

K.4 *Procedure for measurement*

K.4.1 **Applying head differences**

For relatively coarse materials, such as #57 and #67, the upper limit of hydraulic gradient for laminar flow is very low. Since the specimen length is fixed, the critical head difference in the permeameter is also very low. The precision gauge has to be used to measure the head differences within the linear flow region. The maximum head difference the available precision gauge can measure is 1 inch. Use a stopper to stop the water flowing from the inlet overflow cup to the overflow hose. The water in the inlet standpipe will be forced to flow over the overflow cup. A constant water level is kept in the overflow cup, representing the water level in the inlet standpipe. Adjust the water valve to maintain a stable water level in the overflow cup. Estimate the upper limit head difference of the tested materials for laminar flow and choose the incremental steps of head difference below the upper limit head. Adjust the inlet water valve, the position of the overflow cup or slightly rotate the outlet standpipe to get the desired head difference while maintaining the aluminum beam level. Taking the leveled aluminum bar as the datum, measure the head difference between the water levels in the two standpipes.

For relatively fine materials, such as ODOT 304 and ODOT 310, the upper limit of hydraulic gradient for laminar flow is higher than those coarser materials, such as No. 57, No. 67. The incremental steps of head difference can be greater than those for coarser materials. When the applied head differences exceed the capacity of the gauge, the steel ruler with precision of 0.01 inch can be used to measure the head difference. After the aluminum beam is set up to be level, open the value on the outlet standpipe while the one on the inlet standpipe is open. The graduated holes on the standpipe may be used as overflow outlets. Stopper the holes below the one chosen.

Taking the beam as the datum, measure the difference. The head difference must always be measured after the flow becomes stable.

K.4.2 Measuring flow rate

After the measured head difference is recorded, use a bucket to collect water flowing from the outlet overflow. Start the timer at the time the outflow water starts collecting. Sit the bucket on a balance. Stop the timer and record the elapsed time when the balance reaches a chosen weight (e.g.10 lb. or 20 lb.). Record the head difference, elapsed time and collected water weight into a data sheet.

K.4.3 Re-saturation of the sample between measurements.

This step may be skipped if settled water is used in testing. The flow rate of tap water has been found to decrease with the more flow under a constant head for relatively fine materials because the air bubbles in the tap water are easily trapped in the sample and lower the degree of saturation. As a result, the value of hydraulic conductivity obtained is lower than the value under full saturation. The effect of trapped air on the flow is insignificant within a short duration, and the flow rate is almost stable. This critical duration can be found by recording the flow rate with time under a constant head. If the flow rate decreases significantly then the sample has to be resaturated.

Close the valves on the inlet and outlet standpipes and connect the vacuum pump to the vacuum outlets of the permeameter. First, connect the vacuum line to the vacuum outlet above the upstream water chamber and vacuum it until there is no air in the vacuum line. Second, connect the vacuum line to the vacuum outlet above the sample chamber and vacuum it until there is no air in the vacuum line. Third, Connect the vacuum line to the vacuum outlet above the downstream water chamber and vacuum it until no air is present in the vacuum line. The purpose is to extract all air bubbles out of the sample.

Open the valve on the inlet standpipe and saturate the sample with the vacuum line connected to the outlet above the downstream water-chamber until there are no visible air bubbles in the vacuum line. Switch the vacuum line back to the vacuum outlet above the sample chamber. Raise the vacuum pressure and allow the water to continue flowing through the sample. Open the valve on the outlet standpipe. With the vacuum on the outlet above the sample chamber, allow water to flow through the sample for a while to make sure the sample is fully saturated. Remove the vacuum line from the permeameter cell and adjust the in-flow water rate to obtain a desirable head difference. Make the next flow measurement.

K.4.4 **Drain the sample and measure the water temperature.**

To drain the sample at the completion of the test, close the inlet water valve and the valvê on the inlet standpipe. Then rotate the outlet standpipe until the overflow outlet is below the bottom of the permeameter cell. Waiting until no water comes out from the outlet standpipe and remove the two standpipes. By tilting the permeameter cell, the rest of the water below the outlets can be drained out. Collect some water drained out from the sample and measure its temperature.

After taking the lid off, weight the wet sample with only the permeameter box. Record it in a data sheet. Empty the permeameter and clean the permeameter with fresh water. Record on the data sheet the wet weight of the empty permeameter box without the lid and the standpipes.

In summary, weigh the permeameter and the sample at different stages as follows:

1. The weight of the dry permeameter cell without the lid and the standpipes.
2. The wet weight of the empty permeameter cell without the lid and the standpipes.
3. The weight of the permeameter full of water with the lid, the standpipes and the connections.
4. The weight of the dry sample after compaction and the dry permeameter cell without the lid and the standpipes.
5. The weight of the permeameter and the saturated sample with the lid, the standpipes and the connections.
6. The weight of the sample after draining and the permeameter cell without the lid and the standpipes.

K.5 ***Report***

The report of hydraulic conductivity test shall include the following information:

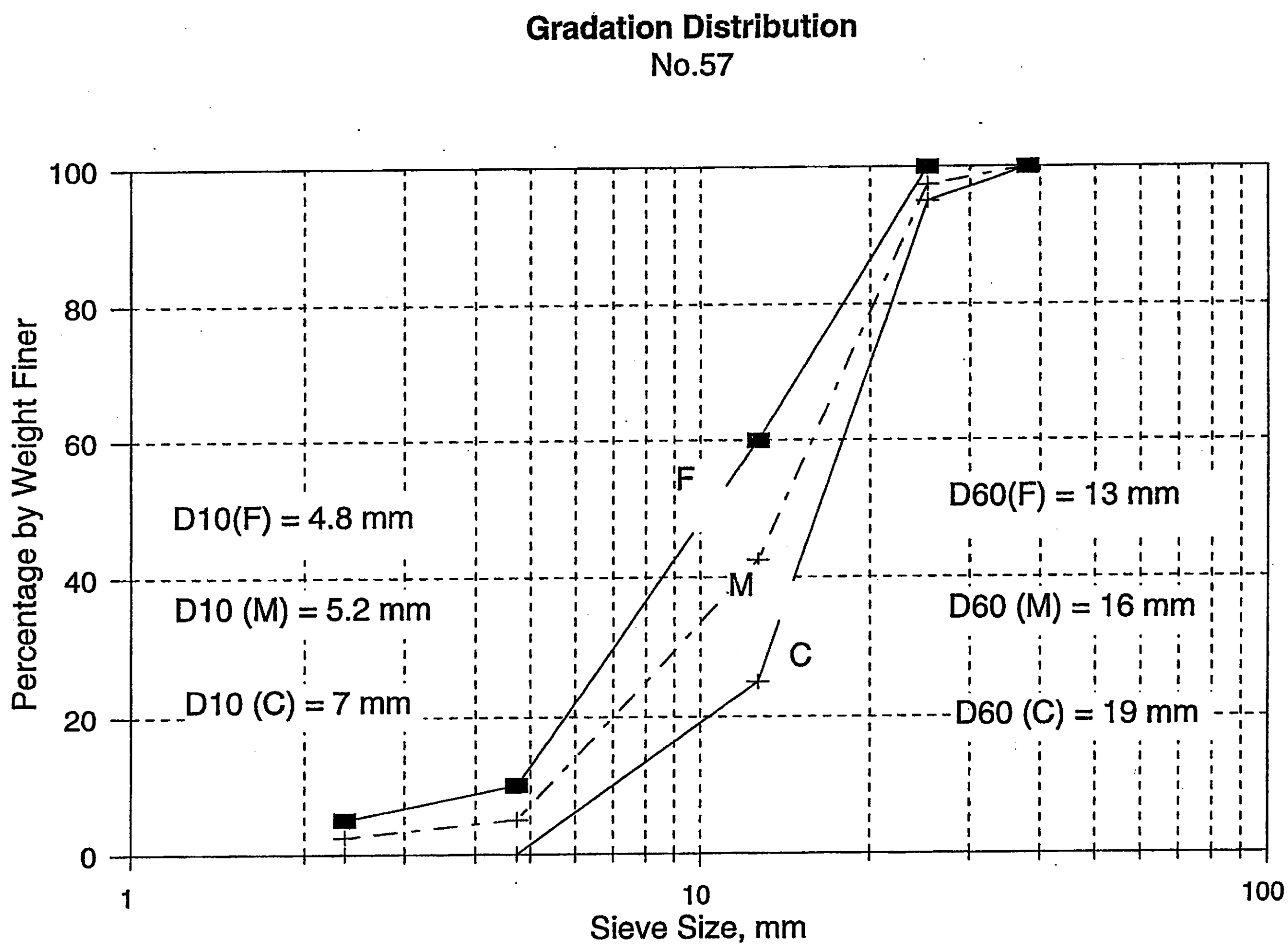
1. Test identification including gradation type, target grading, materials type, bound type.

2. Density after compacting, void ratio, effective porosity (Drained porosity based on the amount of drainable water), degree of saturation.
3. A statement of any departures from these test condition, valid materials types, so the results can be evaluated and used with caution.
4. Complete test data including head difference, volumetric water amount, time spent collection the water amount, all the weight as indicated in last section, sample dimension, etc.
5. Test curves plotting specific discharge versus hydraulic gradient, the upper limit of hydraulic gradient for linear laminar flow, if available, hydraulic conductivity at 20 degree in Celsius.

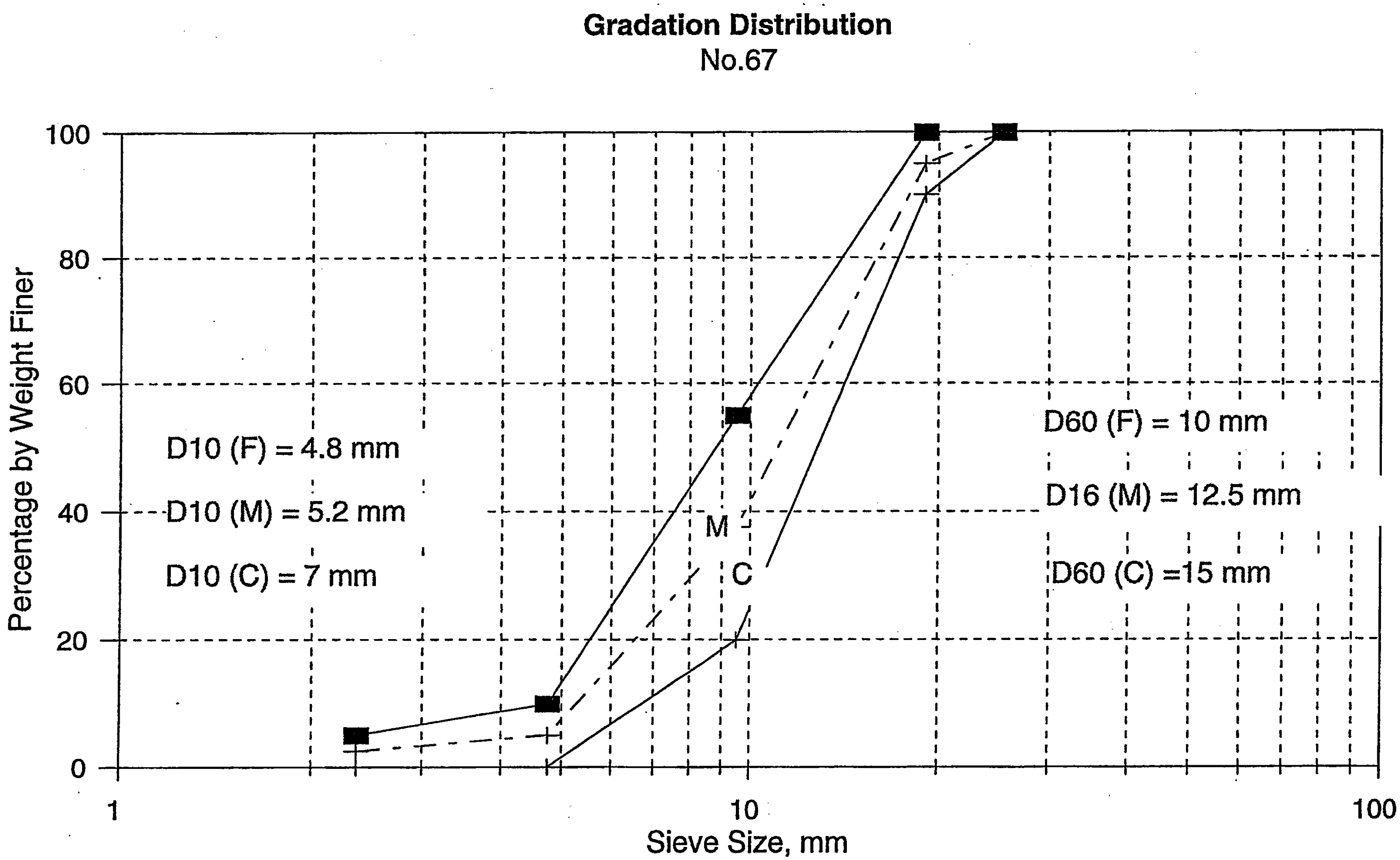
Appendix L

Miscellaneous Laboratory Test Data and Results

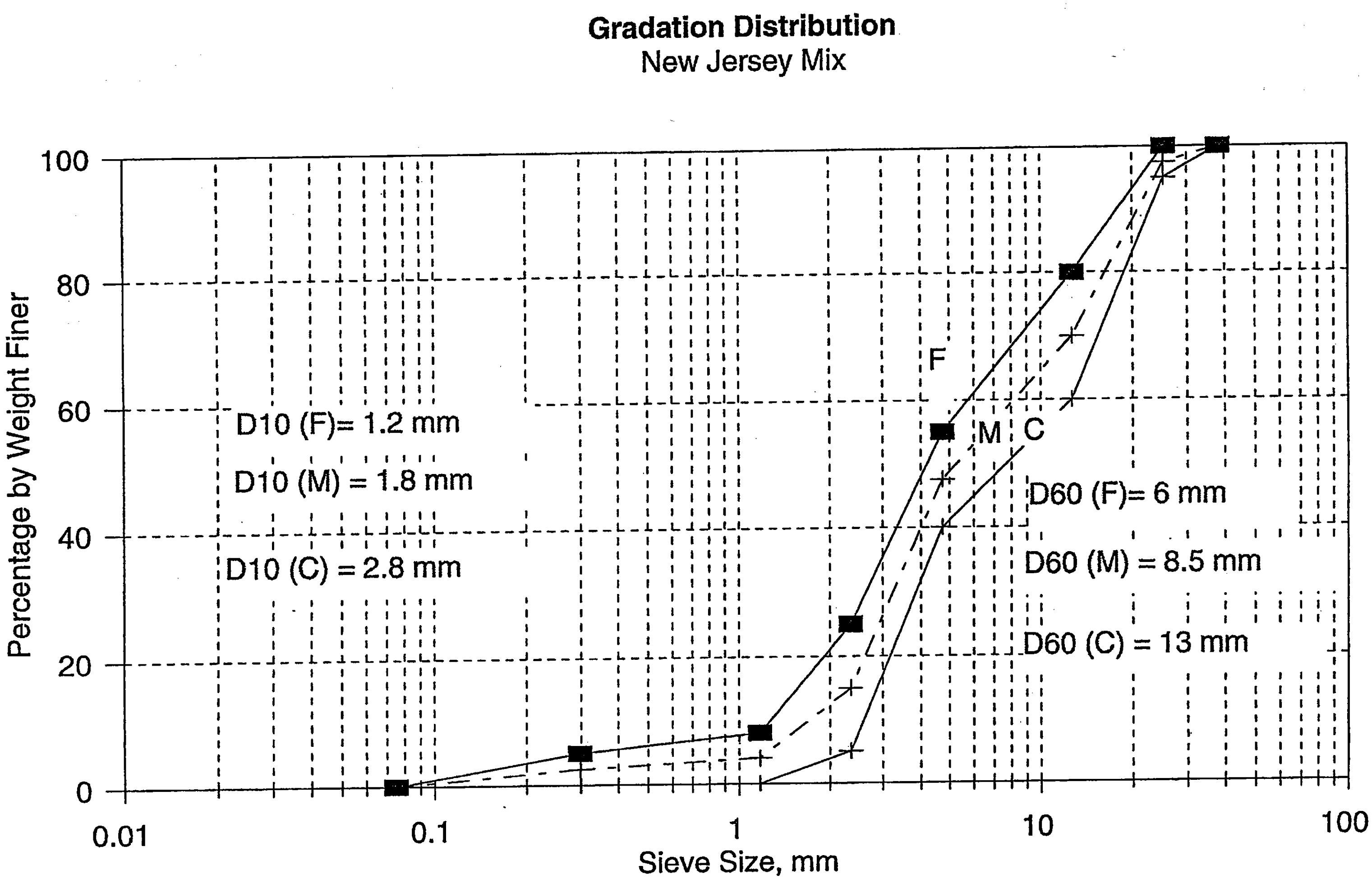
Table of Contents



Gradation Distribution
No.57
100
80
60
40
20
0
Percentage by Weight Finer
1
10
100
Sieve Size, mm
F
M
C
D10(F) = 4.8 mm
D10 (M) = 5.2 mm
D10 (C) = 7 mm
D60(F) = 13 mm
D60 (M) = 16 mm
D60 (C) = 19 mm

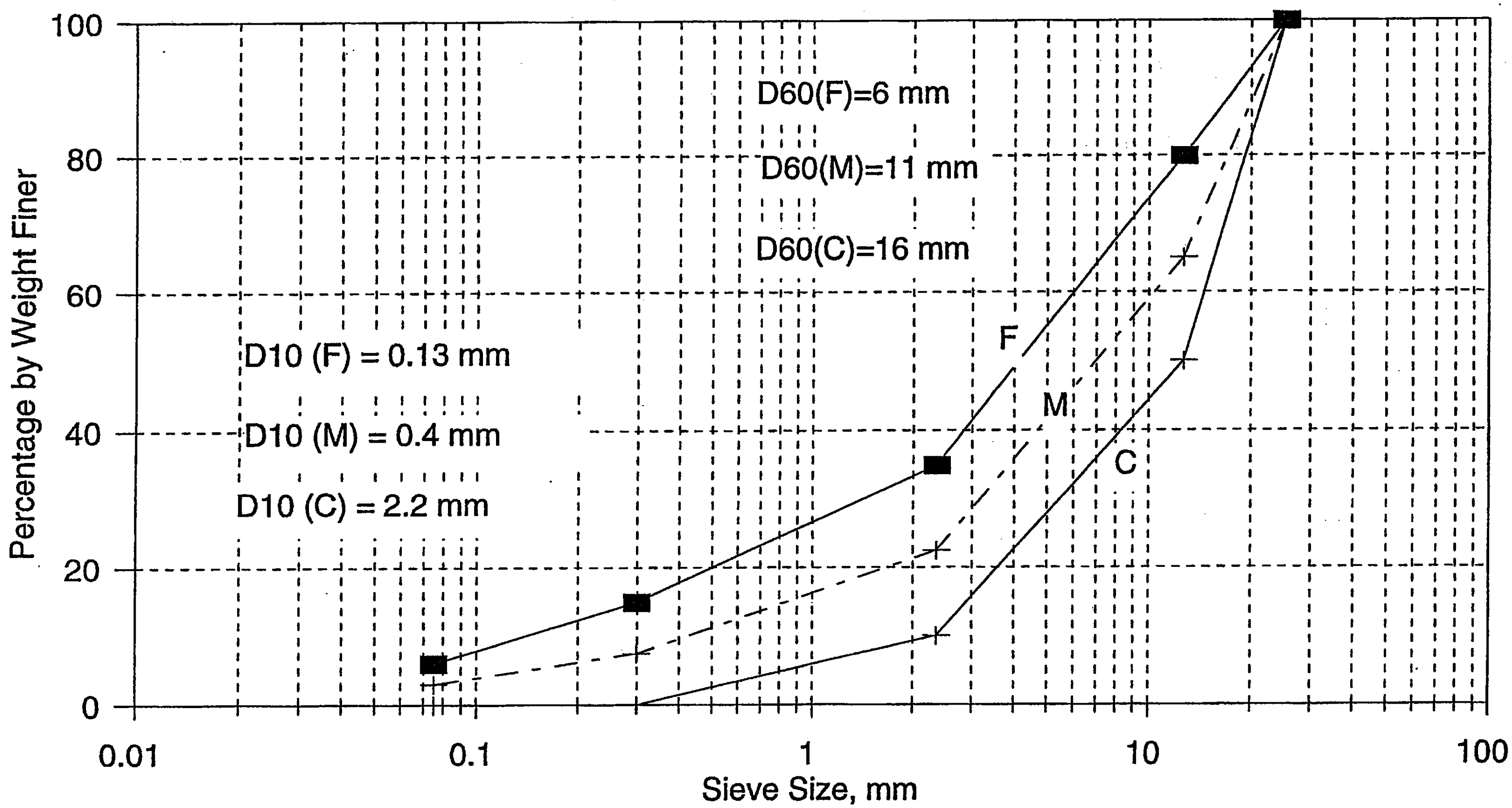


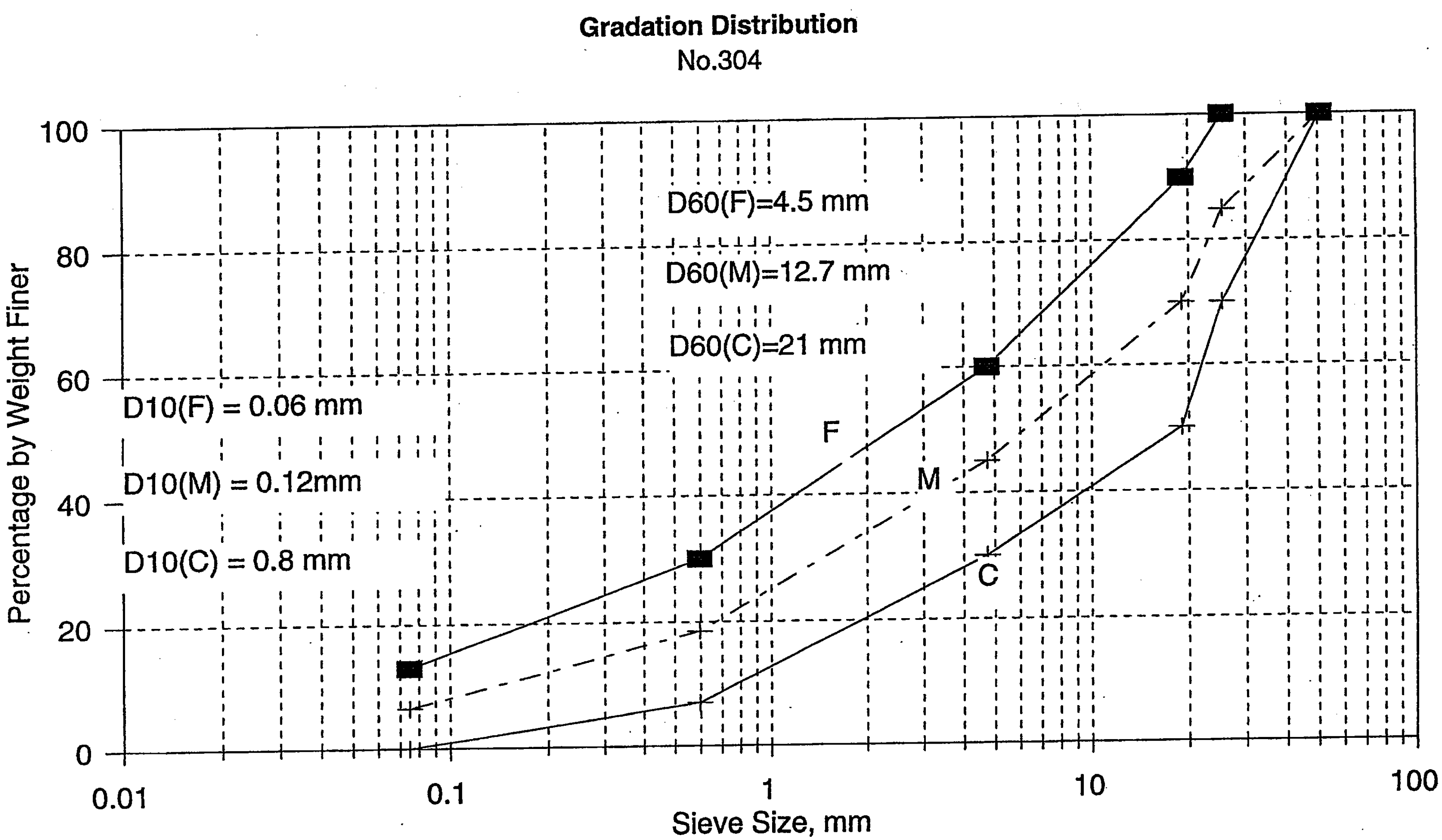
Gradation Distribution
No.67
100
80
60
40
20
0
Percentage by Weight Finer
1
10
100
Sieve Size, mm
D10 (F) = 4.8 mm
D10 (M) = 5.2 mm
D10 (C) = 7 mm
M
C
D60 (F) = 10 mm
D16 (M) = 12.5 mm
D60 (C) =15 mm



Gradation Distribution
New Jersey Mix
Percentage by Weight Finer
Sieve Size, mm
100
80
60
40
20
0
0.01
0.1
1
10
100
F
M
C
D10 (F)= 1.2 mm
D10 (M) = 1.8 mm
D10 (C) = 2.8 mm
D60 (F)= 6 mm
D60 (M) = 8.5 mm
D60 (C) = 13 mm

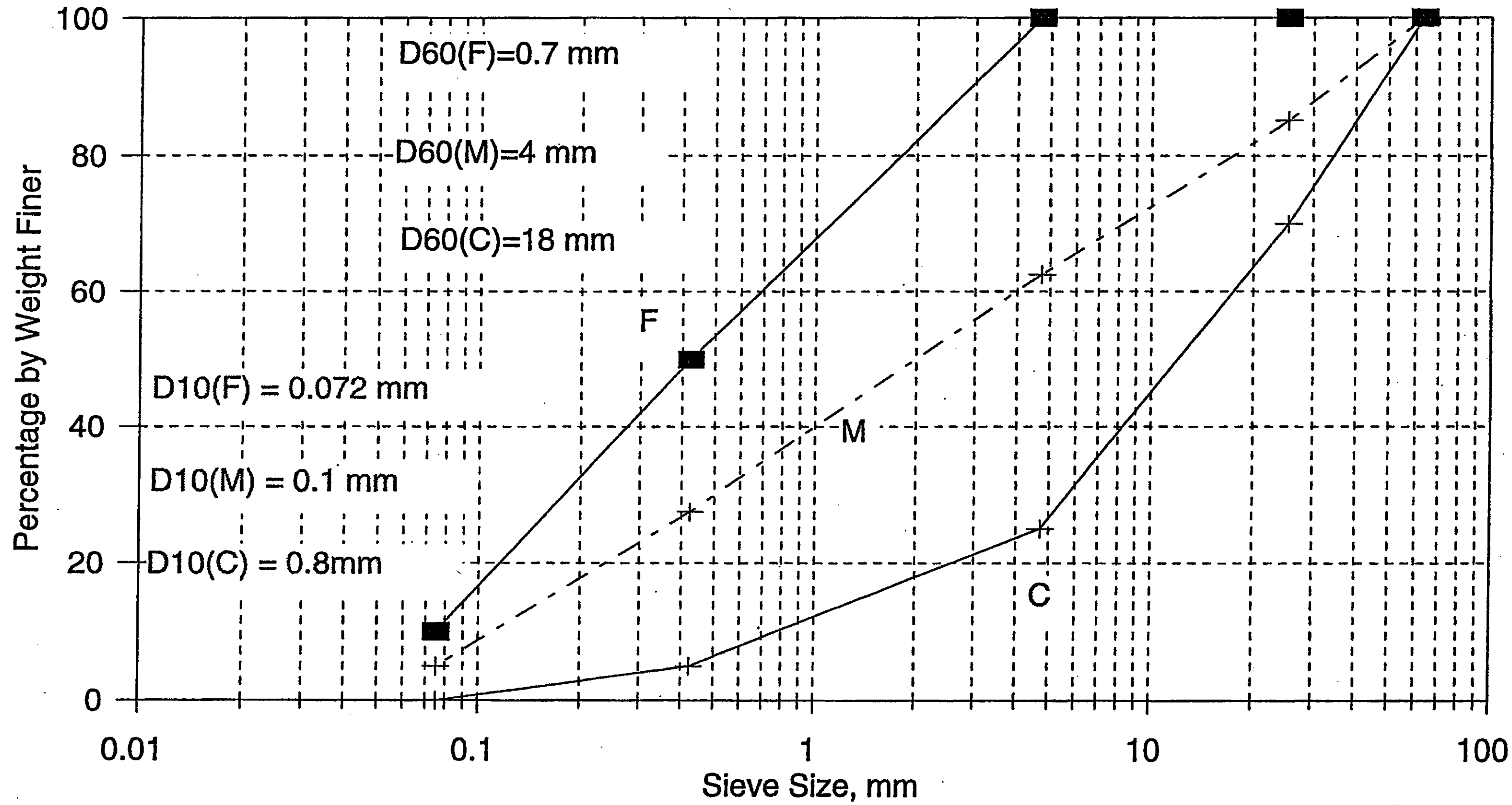
Gradation Distribution
Iowa Mix





Gradation Distribution
No.304
D60(F)=4.5 mm
D60(M)=12.7 mm
D60(C)=21 mm
D10(F) = 0.06 mm
D10(M) = 0.12mm
D10(C) = 0.8 mm
F
M
C
Percentage by Weight Finer
Sieve Size, mm
0
20
40
60
80
100
0.01
0.1
1
10
100

Gradation Distribution
No.310



Specifc Gravity Test Results

Limestone

	Grading	Percentage finer No.4	Per. Retained No.4	Bulk S.G.	Apparent S.G.	SSD_Bulk S.G.	Absorption %
No.57	F	11	89	2.665	2.799	2.713	1.79
	M	6	94	2.673	2.796	2.717	1.65
	C	1	99	2.681	2.794	2.721	1.51
No.67	F	12	88	2.664	2.800	2.712	1.82
	M	6	94	2.673	2.796	2.717	1.65
	C	1	99	2.681	2.794	2.721	1.51
No.304	F	61	39	2.589	2.825	2.673	3.22
	M	45	55	2.613	2.817	2.686	2.77
	C	30	70	2.636	2.809	2.698	2.34
No.310	F	100	0	2.533	2.846	2.643	4.34
	M	63	37	2.586	2.826	2.672	3.28
	C	26	74	2.642	2.807	2.701	2.22
Iwa	F	55	45	2.598	2.822	2.678	3.05
	M	41	59	2.619	2.815	2.689	2.65
	C	27	73	2.641	2.807	2.700	2.25
NJ	F	57	43	2.595	2.823	2.677	3.11
	M	48	52	2.609	2.818	2.684	2.85
	C	41	59	2.619	2.815	2.689	2.65

Specifc Gravity Test Results

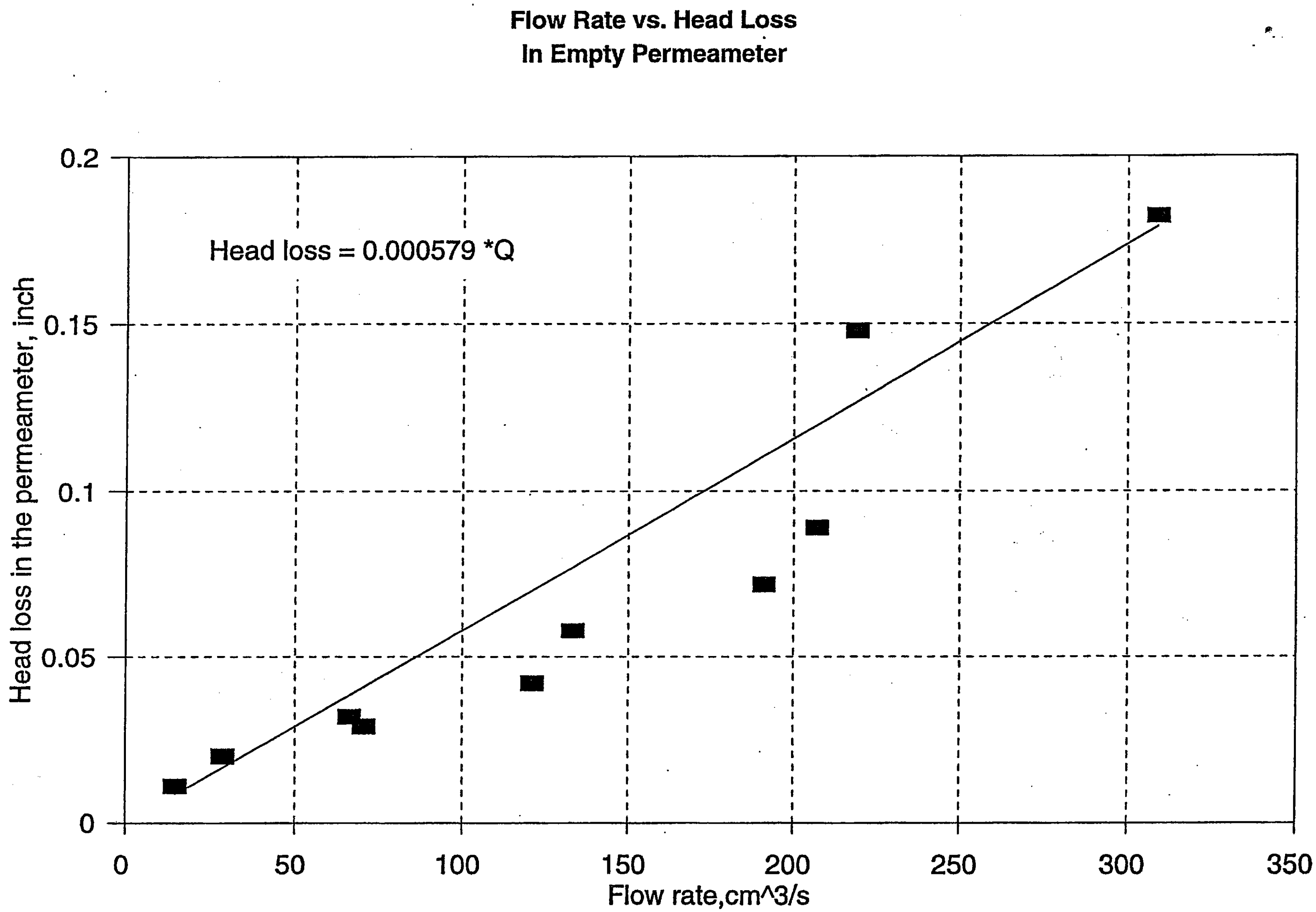
Slag

	Grading	Percentage finer No.4	Per. Retained No.4	Bulk S.G.	Apparent S.G.	SSD_Bulk S.G.	Absorption %
No.57	F	11	89	2.230	2.524	2.347	5.24
	M	6	94	2.210	2.506	2.329	5.35
	C	1	99	2.191	2.489	2.311	5.47
No.67	F	12	88	2.233	2.528	2.351	5.22
	M	6	94	2.210	2.506	2.329	5.35
	C	1	99	2.191	2.489	2.311	5.47
No.304	F	61	39	2.446	2.716	2.548	4.07
	M	45	55	2.372	2.652	2.480	4.45
	C	30	70	2.307	2.594	2.420	4.80
No.310	F	100	0	2.647	2.887	2.730	3.17
	M	63	37	2.456	2.724	2.557	4.03
	C	26	74	2.290	2.579	2.404	4.89
Iwa	F	55	45	2.418	2.692	2.522	4.21
	M	41	59	2.355	2.636	2.464	4.54
	C	27	73	2.295	2.583	2.408	4.87
NJ	F	57	43	2.427	2.700	2.531	4.17
	M	48	52	2.386	2.663	2.492	4.38
	C	41	59	2.355	2.636	2.464	4.54

Specifc Gravity Test Results

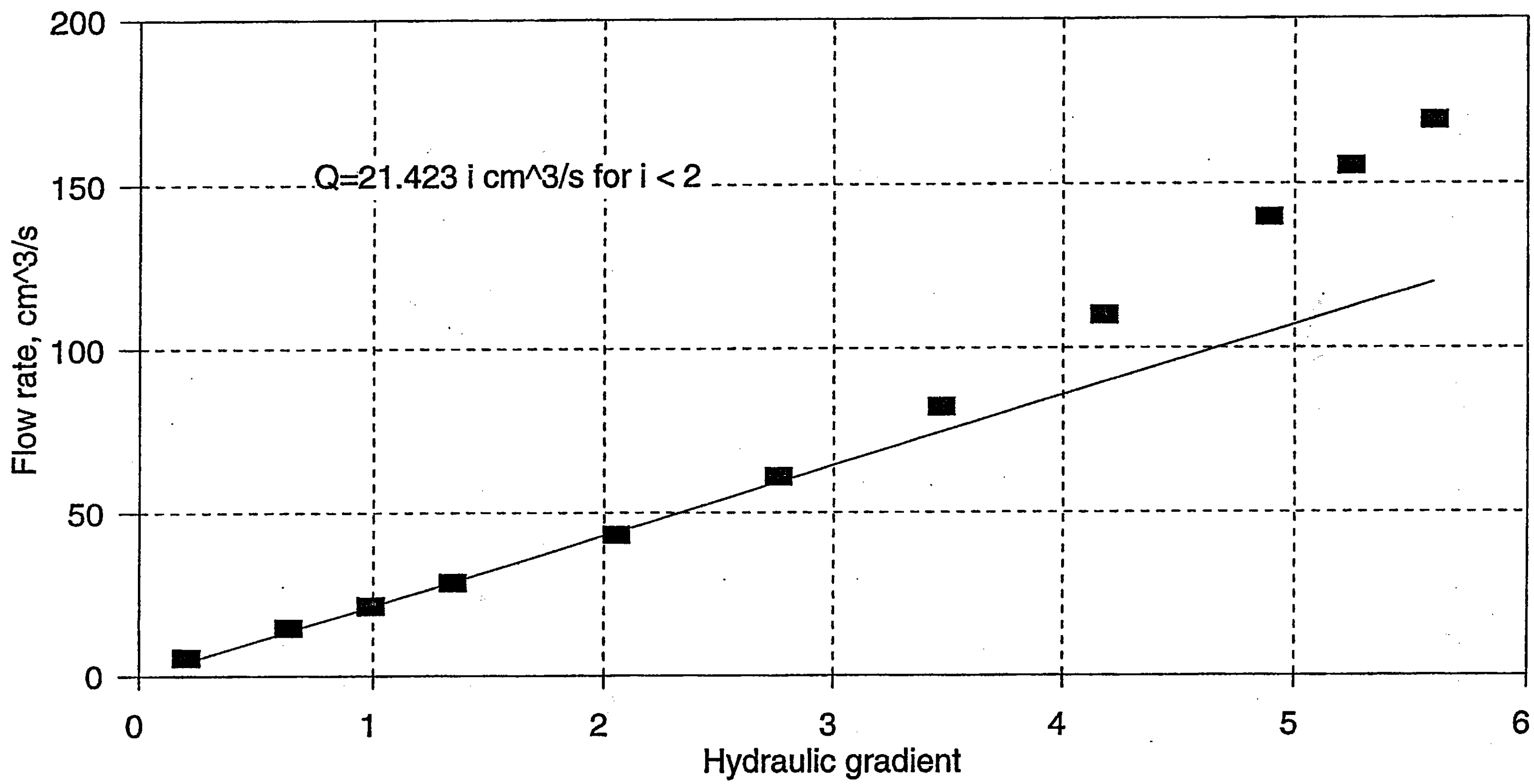
Gravel

	Grading	Percentage finer No.4	Per. Retained No.4	Bulk S.G.	Apparent S.G.	SSD_Bulk S.G.	Absorption %
No.57	F	11	89	2.596	2.775	2.660	2.48
	M	6	94	2.594	2.775	2.659	2.52
	C	1	99	2.592	2.776	2.659	2.56
No.67	F	12	88	2.596	2.774	2.660	2.48
	M	6	94	2.594	2.775	2.659	2.52
	C	1	99	2.592	2.776	2.659	2.56
No.304	F	61	39	2.613	2.766	2.669	2.11
	M	45	55	2.608	2.769	2.666	2.23
	C	30	70	2.602	2.771	2.663	2.34
No.310	F	100	0	2.627	2.759	2.675	1.82
	M	63	37	2.614	2.766	2.669	2.10
	C	26	74	2.601	2.772	2.663	2.37
Iwa	F	55	45	2.611	2.767	2.668	2.16
	M	41	59	2.606	2.769	2.665	2.26
	C	27	73	2.601	2.772	2.663	2.36
NJ	F	57	43	2.612	2.767	2.668	2.14
	M	48	52	2.609	2.768	2.666	2.21
	C	41	59	2.606	2.769	2.665	2.26



Flow Rate vs. Head Loss
In Empty Permeameter
Head loss = 0.000579 *Q
Head loss in the permeameter, inch
Flow rate,cm^3/s
0.2
0.15
0.1
0.05
0
0
50
100
150
200
250
300
350

Bypass flow rate through foam sheets
(Leakage) For stabilized samples



Appendix M

Laboratory Test Results of Hydraulic Conductivity For Limestone

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Figures

Page

Hydraulic Conductivity Testing Data & Results

Test Identification **PM57LN**

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	11.844	inch				
Sample Height	11.594	inch		0.2286	116	9090.00
Sample Width	11.813	inch		0.3175	82.63	9090.00
				0.396875	61.16	9090.00
Dry weight of permeameter box	21.2	lb		0.5842	60.91	9090.00
Wet weight of permeameter box	21.6	lb		0.714375	53.19	9090.00
Saturated weight of system w/ water	130.8	lb		0.7874	44.53	9090.00
				0.873125	48.41	9090.00
Dry soil with box	115.3	lb		1.031875	45.93	9090.00
Saturated weight of system w/ soils	191.6	lb		1.1509375	44.99	9090.00
Wet weight of soils w/box after drain	120.2	lb		1.3462	56.38	14089.50
Water temperature T	21	Degree C				

Results

Dry Density	99.2378	lb/ft^3
Degree of Saturation	1.038	
Porosity	0.432	
Effective Porosity	0.356	
Void Ratio	0.762	
Hydraulic Conductivity, K	12.526	cm/s
	35506.5	ft/day
The Upper Limit of Hydraulic Gradient	0.012	

Hydraulic Conductivity at 20 degree

K_20 =	12.227	cm/s
	34658.6	ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification PM67LN

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	11.844	inch				
Sample Height	11.594	inch		0.04572	257.7	4545.00
Sample Width	11.813	inch		0.05842	171.55	4545.00
				0.16256	102.95	5454.00
Dry weight of permeameter box	21.2	lb		0.19812	52.26	4545.00
Wet weight of permeameter box	21.6	lb		0.37846	35.02	4545.00
Saturated weight of system w/ water	130.8	lb		0.4699	40.01	4545.00
				0.70612	31.66	4545.00
Dry soil with box	115.5	lb		0.72644	31.28	5454.00
Saturated weight of system w/ soils	191.1	lb		0.7874	29.32	5454.00
Wet weight of soils w/box after drain	120.2	lb		0.85852	55.5	9090.00
Water temperature T	21	Degree C				

Results

Dry Density	99.4487	lb/ft^3
Degree of Saturation	1.013	
Porosity	0.431	
Effective Porosity	0.347	
Void Ratio	0.758	
Hydraulic Conductivity, K	17.371	cm/s
	49240.4	ft/day
The Upper Limit of Hydraulic Gradient	0.006	

Hydraulic Conductivity at 20 degree

K_20 =	16.956	cm/s
	48064.5	ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification PMNJLN

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	11.844	inch				
Sample Height	11.594	inch		0.2159	296.91	4545.00
Sample Width	11.813	inch		0.42164	133.63	4545.00
				0.44958	149.15	4545.00
Dry weight of permeameter box	21.2	lb		0.6096	101.17	4545.00
Wet weight of permeameter box	21.6	lb		0.70358	94.31	4545.00
Saturated weight of system w/ water	130.8	lb		0.70866	93.65	4545.00
				0.95504	65.96	4545.00
Dry soil with box	124	lb		1.143	45.5	4545.00
Saturated weight of system w/ soils	195	lb		1.2192	46.78	4545.00
Wet weight of soils w/box after drain	120.2	lb		1.524	38.95	4545.00
				1.7018	37.36	4545.00
Water temperature T	21	Degree C		1.8796	31.84	4545.00
				2.6162	27.93	4545.00
				3.048	46.88	9090.00
				3.6068	42.59	9090.00
				4.191	38.24	9090.00

Results

Dry Density	108.413	lb/ft^3
Degree of Saturation	0.935	
Porosity	0.385	
Effective Porosity	0.414	
Void Ratio	0.625	
Hydraulic Conductivity, K	2.694	cm/s
	7637.24	ft/day
The Upper Limit of Hydraulic Gradient	0.070	

Hydraulic Conductivity at 20 degree

K_20 =	2.630	cm/s
	7454.9	ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification **PFIWALN**

Data

Item	Data	Unit
Sample Length	11.844	inch
Sample Height	11.594	inch
Sample Width	11.813	inch
Dry weight of permeameter box	21.2	lb
Wet weight of permeameter box	21.6	lb
Saturated weight of system w/ water	130.8	lb
Dry soil with box	135.9	lb
Saturated weight of system w/ soils	202.3	lb
Wet weight of soils w/box after drain	144.5	lb
Water temperature T	21	Degree C

Delta H,cm	t, sec.	Water, V, cm^3
1.0414	282.91	4545.00
1.3716	214.52	4545.00
1.60528	181.13	4545.00
2.0574	167.34	4545.00
2.37744	131.6	4545.00
2.45364	138.46	4545.00
3.8862	122.69	6817.50
4.1148	75.84	4545.00
4.5974	75.32	4545.00
5.3086	102.02	6817.50
5.4102	64.84	4545.00
6.1214	65.04	4545.00
6.2484	58.69	4545.00
7.2898	51.64	4545.00
8.2804	47.13	4545.00
9.2456	42.55	4545.00
14.9606	32.74	4545.00

Results

Dry Density	120.963	lb/ft^3
Degree of Saturation	0.902	
Porosity	0.314	
Effective Porosity	0.124	
Void Ratio	0.459	
Hydraulic Conductivity, K	0.480	cm/s
	1361.99	ft/day
The Upper Limit of Hydraulic Gradient	0.180	

Hydraulic Conductivity at 20 degree

K_20 =	0.469	cm/s
	1329.5	ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification **PMIWALN**

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	11.844	inch				
Sample Height	11.594	inch		0.39116	394.56	4545.00
Sample Width	11.813	inch		0.7366	209.16	4545.00
				1.17094	181.77	6817.50
Dry weight of permeameter box	21.2	lb		1.19634	152.32	4545.00
Wet weight of permeameter box	21.6	lb		1.78562	98.49	4545.00
Saturated weight of system w/ water	130.8	lb		2.8702	89.93	6817.50
				3.7338	77.99	6817.50
Dry soil with box	133.2	lb		4.1656	60.49	6817.50
Saturated weight of system w/ soils	202	lb		4.2418	57.56	6817.50
Wet weight of soils w/box after drain	141.3	lb		4.4196	58.64	6817.50
				5.1054	52.24	6817.50
Water temperature T	21	Degree C		5.6896	47.51	6817.50
				7.1628	68.14	11362.50
				8.0264	88.47	15907.50
				8.9662	87.48	15907.50

Results

Dry Density	118.115	lb/ft^3
Degree of Saturation	0.985	
Porosity	0.329	
Effective Porosity	0.174	
Void Ratio	0.490	
Hydraulic Conductivity, K	0.914	cm/s
	2592.15	ft/day
The Upper Limit of Hydraulic Gradient	0.170	

Hydraulic Conductivity at 20 degree

K_20 =	0.893	cm/s
	2530.3	ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification **PCIWALN**

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	11.844	inch				
Sample Height	11.594	inch		0.14097	290.32	4545.00
Sample Width	11.813	inch		0.3048	132.77	4545.00
				0.34036	103.52	4545.00
Dry weight of permeameter box	21.2	lb		0.63246	103.6	6817.50
Wet weight of permeameter box	21.6	lb		0.70866	96.29	6817.50
Saturated weight of system w/ water	130.8	lb		0.77216	85.54	6817.50
				0.87884	82.61	6817.50
Dry soil with box	121.7	lb		0.98044	71.74	6817.50
Saturated weight of system w/ soils	193.15	lb		1.15316	62.41	6817.50
Wet weight of soils w/box after drain	127.35	lb		1.29286	100.63	11362.50
				1.32334	77.13	9090.00
Water temperature T	21	Degree C		1.64338	84.75	11362.50
				1.78562	64.86	9090.00
				2.07264	56.86	9090.00
				2.0066	51.24	9090.00
				2.5654	45.09	9090.00
				2.8702	40.56	9090.00
				3.302	37.76	9090.00

Results

Dry Density	105.987	lb/ft^3
Degree of Saturation	0.927	
Porosity	0.396	
Effective Porosity	0.261	
Void Ratio	0.656	
Hydraulic Conductivity, K	3.561	cm/s
	10094.7	ft/day
The Upper Limit of Hydraulic Gradient	0.042	

Hydraulic Conductivity at 20 degree

K_20 =	3.476	cm/s
	9853.7	ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification **PF304LN**

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	11.844	inch				
Sample Height	11.594	inch		2.69875	1542.86	4545.00
Sample Width	11.813	inch		3.4925	1175.55	4999.50
				4.048125	1441.56	4999.50
Dry weight of permeameter box	21.2	lb		4.365625	777.09	4545.00
Wet weight of permeameter box	21.6	lb		5.318125	650.38	4545.00
Saturated weight of system w/ water	130.8	lb		6.19125	623.93	4545.00
				7.540625	478.89	4545.00
Dry soil with box	146	lb		8.810625	431.62	4545.00
Saturated weight of system w/ soils	209.2	lb		10.00125	391.66	4545.00
Wet weight of soils w/box after drain	155.2	lb		11.8665625	334.38	4545.00
				13.096875	336.34	4545.00
Water temperature T	21	Degree C		14.8828125	371.67	4545.00
				16.748125	253.82	4545.00
				16.6624	379.81	6817.50
				21.7424	214.73	4545.00
				26.67	200.81	4545.00
				26.8986	205.88	4545.00
				33.8836	179.09	4545.00

Results

Dry Density	131.614	lb/ft^3
Degree of Saturation	0.905	
Porosity	0.255	
Effective Porosity	0.060	
Void Ratio	0.342	
Hydraulic Conductivity, K	0.040	cm/s
	113.963	ft/day
The Upper Limit of Hydraulic Gradient	0.075	

Hydraulic Conductivity at 20 degree

K_20 =	0.039	cm/s
	111.2	ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification PM304LN

Data

Item	Data	Unit
Sample Length	11.844	inch
Sample Height	11.594	inch
Sample Width	11.813	inch
Dry weight of permeameter box	21.2	lb
Wet weight of permeameter box	21.6	lb
Saturated weight of system w/ water	130.8	lb
Dry soil with box	145	lb
Saturated weight of system w/ soils	209.6	lb
Wet weight of soils w/box after drain	153.2	lb
Water temperature T	21	Degree C

Delta H,cm	t, sec.	Water, V, cm^3
2.54	856.14	4545.00
3.2512	707.9	4545.00
3.7338	639.29	5454.00
4.1402	662.86	5908.50
5.2324	530.31	5908.50
6.1214	571.45	7726.50
7.112	438.09	6817.50
8.5852	411.21	7272.00
10.0076	445.65	9999.00
11.6586	370.06	9090.00
11.3538	381.02	9090.00
13.335	460.09	12930.52
16.7386	196.48	6590.25
21.7424	190.24	7499.25
31.75	144.68	6817.50
41.4274	132.1	6817.50
46.2788	161.47	9594.49

Results

Dry Density	130.559	lb/ft^3
Degree of Saturation	0.983	
Porosity	0.259	
Effective Porosity	0.100	
Void Ratio	0.349	
Hydraulic Conductivity, K	0.073	cm/s
	206.031	ft/day
The Upper Limit of Hydraulic Gradient	0.520	

Hydraulic Conductivity at 20 degree

K_20 =	0.071	cm/s
	201.1	ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification **PC304LN**

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	11.844	inch				
Sample Height	11.594	inch		1.3096875	249.61	4545.00
Sample Width	11.813	inch		1.905	164.16	4545.00
				2.2225	196.2	5454.00
Dry weight of permeameter box	21.2	lb		2.69875	114.09	4545.00
Wet weight of permeameter box	21.6	lb		2.778125	139.25	4545.00
Saturated weight of system w/ water	130.8	lb		3.0559375	198.2	7726.50
				3.6909375	93.35	4545.00
Dry soil with box	140	lb		3.9290625	143.75	5454.00
Saturated weight of system w/ soils	206	lb		4.524375	96.77	5454.00
Wet weight of soils w/box after drain	148.5	lb		5.08	70.95	4545.00
				5.318125	71.63	4545.00
Water temperature T	21	Degree C		6.3103125	90.13	7272.00
				7.8184375	75.73	6363.00
				7.9248	79.74	6363.00
				9.8806	71.16	7272.00
				10.0076	62.28	7272.00
				13.6398	54.58	7272.00
				20.6248	63.65	9544.50

Results

Dry Density	125.286	lb/ft^3
Degree of Saturation	0.968	
Porosity	0.287	
Effective Porosity	0.119	
Void Ratio	0.402	
Hydraulic Conductivity, K	0.426	cm/s
	1207.2	ft/day
The Upper Limit of Hydraulic Gradient	0.230	

Hydraulic Conductivity at 20 degree

K_20 =	0.416	cm/s
	1178.4	ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification PF310LN

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	11.844	inch		11.811	233.74	909.00
Sample Height	11.594	inch		16.811	458.09	2272.50
Sample Width	11.813	inch		21.811	379.47	2272.50
Dry weight of permeameter box	21.2	lb		26.811	318.63	2272.50
Wet weight of permeameter box	21.6	lb		31.811	289.3	2272.50
Saturated weight of system w/ water	130.8	lb		36.811	265.87	2272.50
				41.811	242.07	2272.50
Dry soil with box	133.7	lb		46.811	226.77	2272.50
Saturated weight of system w/ soils	203.4	lb		51.811	208.24	2272.50
Wet weight of soils w/box after drain	146.8	lb		56.811	195.22	2272.50
				61.811	183.66	2272.50
Water temperature T	21	Degree C		66.811	170.34	2272.50
				71.811	160.41	2272.50
				76.811	148.81	2272.50
				81.811	138.25	2272.50

Results

Dry Density	118.642	lb/ft^3
Degree of Saturation	1.018	
Porosity	0.333	
Effective Porosity	0.104	
Void Ratio	0.500	
Hydraulic Conductivity, K	0.007	cm/s
	20.0821	ft/day
The Upper Limit of Hydraulic Gradient		

Hydraulic Conductivity at 20 degree

K_20 =	0.007	cm/s
	19.6	ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification **PM310LN**

Data

Item	Data	Unit
Sample Length	11.844	inch
Sample Height	11.594	inch
Sample Width	11.813	inch
Dry weight of permeameter box	21.2	lb
Wet weight of permeameter box	21.6	lb
Saturated weight of system w/ water	130.8	lb
Dry soil with box	142.8	lb
Saturated weight of system w/ soils	208.8	lb
Wet weight of soils w/box after drain	151.9	lb
Water temperature T	21	Degree C

Delta H,cm	t, sec.	Water, V, cm^3
4.191	234.72	1363.50
11.8364	126.84	1818.00
16.684	180.13	3181.50
21.684	99.06	2272.50
31.684	74.38	2272.50
41.6586	99.31	3181.50
51.6332	88.5	3181.50
61.6078	65.41	2272.50
66.6078	87.04	3181.50
71.5824	59.7	2272.50
81.557	54.04	2272.50

Results

Dry Density	128.239	lb/ft^3
Degree of Saturation	1.013	
Porosity	0.274	
Effective Porosity	0.109	
Void Ratio	0.378	
Hydraulic Conductivity, K	0.037	cm/s
	105.083	ft/day
The Upper Limit of Hydraulic Gradient	0.650	

Hydraulic Conductivity at 20 degree

K_20 =	0.036	cm/s
	102.6	ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification PC310LN

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	11.844	inch				
Sample Height	11.594	inch		0.1397	164.14	2272.50
Sample Width	11.813	inch		0.25146	73.19	2272.50
				0.2921	60.63	2272.50
Dry weight of permeameter box	21.2	lb		0.32766	74.09	3181.50
Wet weight of permeameter box	21.6	lb		0.381	90.39	4545.00
Saturated weight of system w/ water	130.8	lb		0.40386	89.69	4545.00
				0.4699	111.46	6817.50
Dry soil with box	138.8	lb		0.6223	80.69	6817.50
Saturated weight of system w/ soils	204.8	lb		0.6731	83.46	6817.50
Wet weight of soils w/box after drain	146.8	lb		0.79756	68.7	6817.50
				1.02362	75.02	9090.00
Water temperature T	21	Degree C				

Results

Dry Density	124.021	lb/ft^3
Degree of Saturation	0.945	
Porosity	0.293	
Effective Porosity	0.128	
Void Ratio	0.415	
Hydraulic Conductivity, K	4.560	cm/s
	12927	ft/day
The Upper Limit of Hydraulic Gradient		

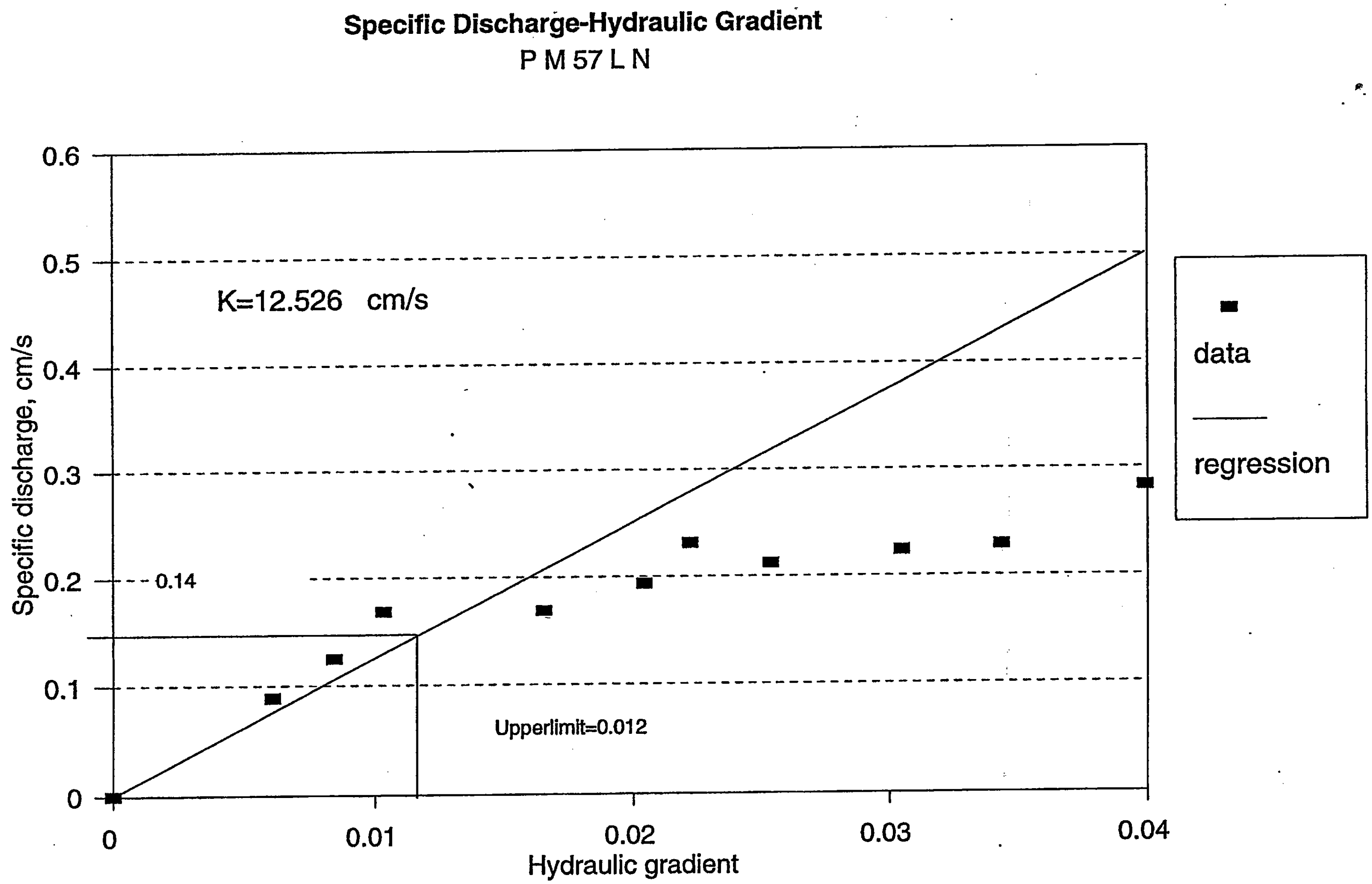
Hydraulic Conductivity at 20 degree

K_20 =	4.451	cm/s
	12618.3	ft./day

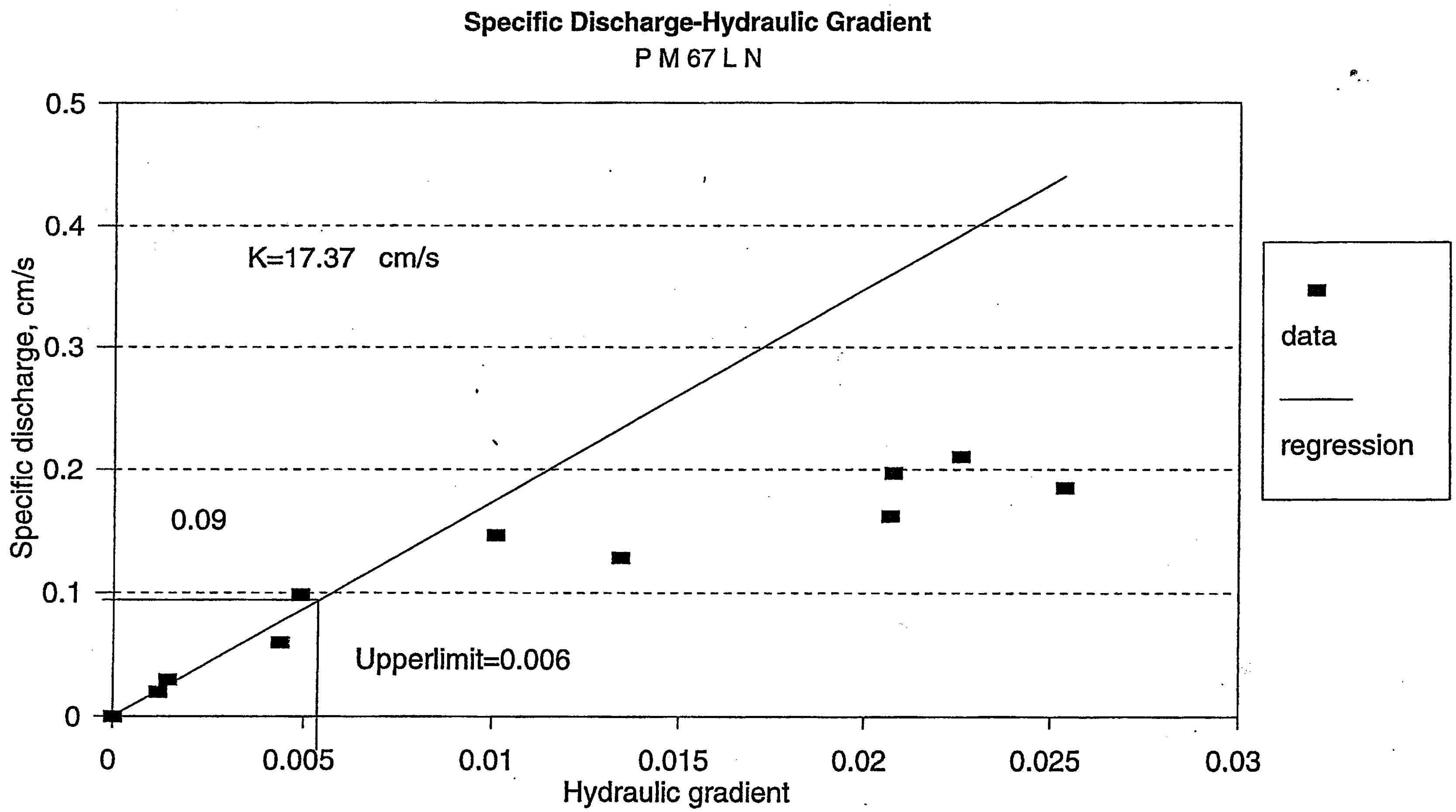
Test Result Summary of Hydraulic Conductivity

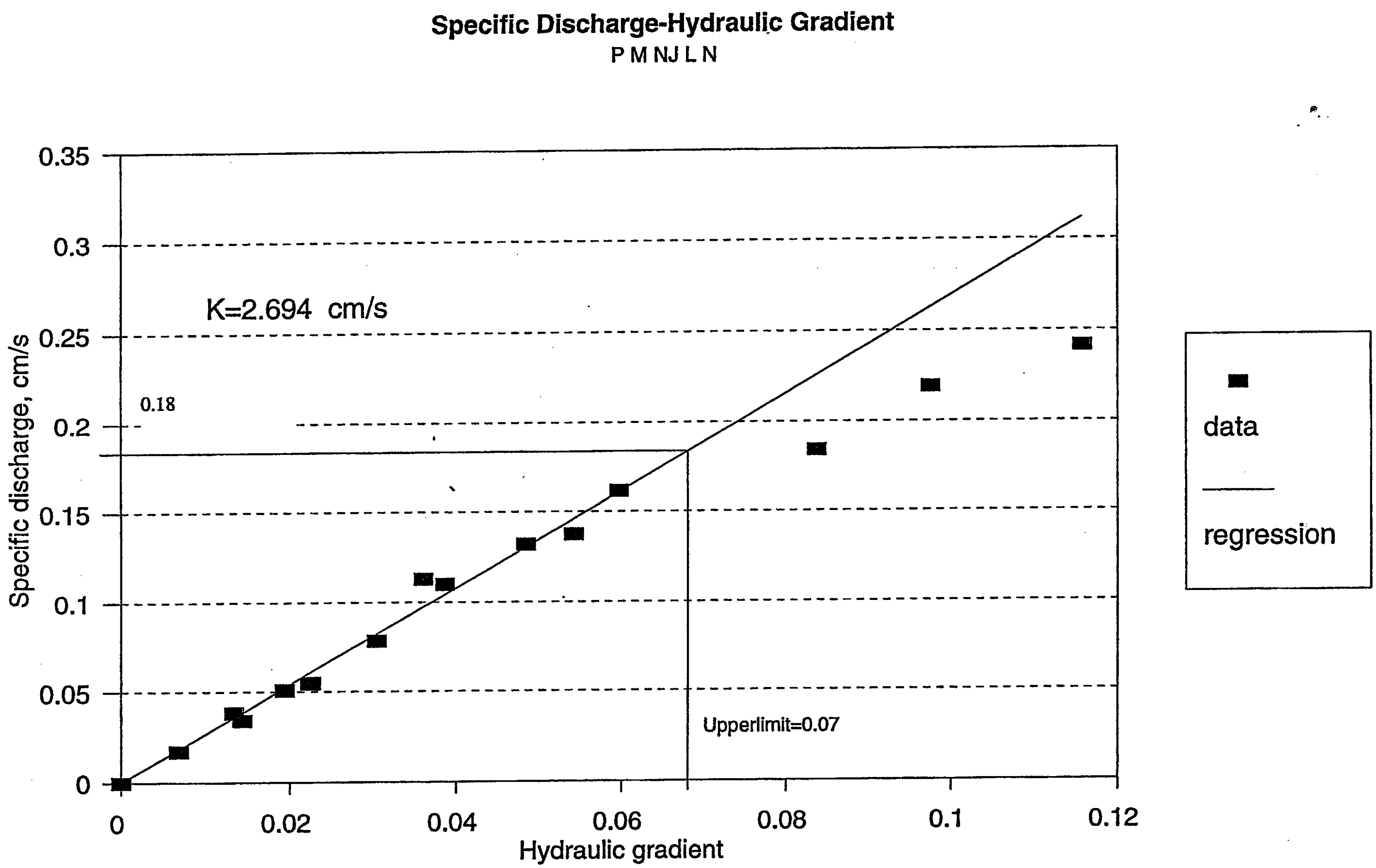
For Limestone

Type	Gradation	Dry Density lb/ft^3	Degree of Saturation	Hydraulic Conductivity At 20		i_upper
				cm/s	ft/day	
No. 57	F M C	99.2	103.8%	12.23	34,659	0.012
67	M	99.4	101.3%	16.96	48,064	0.006
N.J.Mix	M	108.4	93.5%	2.63	7,455	0.07
Iowa Mix	F	121.0	90.2%	0.47	1,329	0.25
	M	118.1	98.5%	0.89	2,531	0.17
	C	106.0	92.7%	3.48	9,853	0.042
304	F	131.6	90.5%	0.04	111	0.075
	M	130.6	98.3%	0.07	201	0.52
	C	125.3	96.8%	0.42	1,179	0.23
310	F	118.6	101.8%	0.01	20	>2.700
	M	128.2	101.3%	0.04	102	0.65
	C	124.0	94.5%	4.45	12,617	>0.032

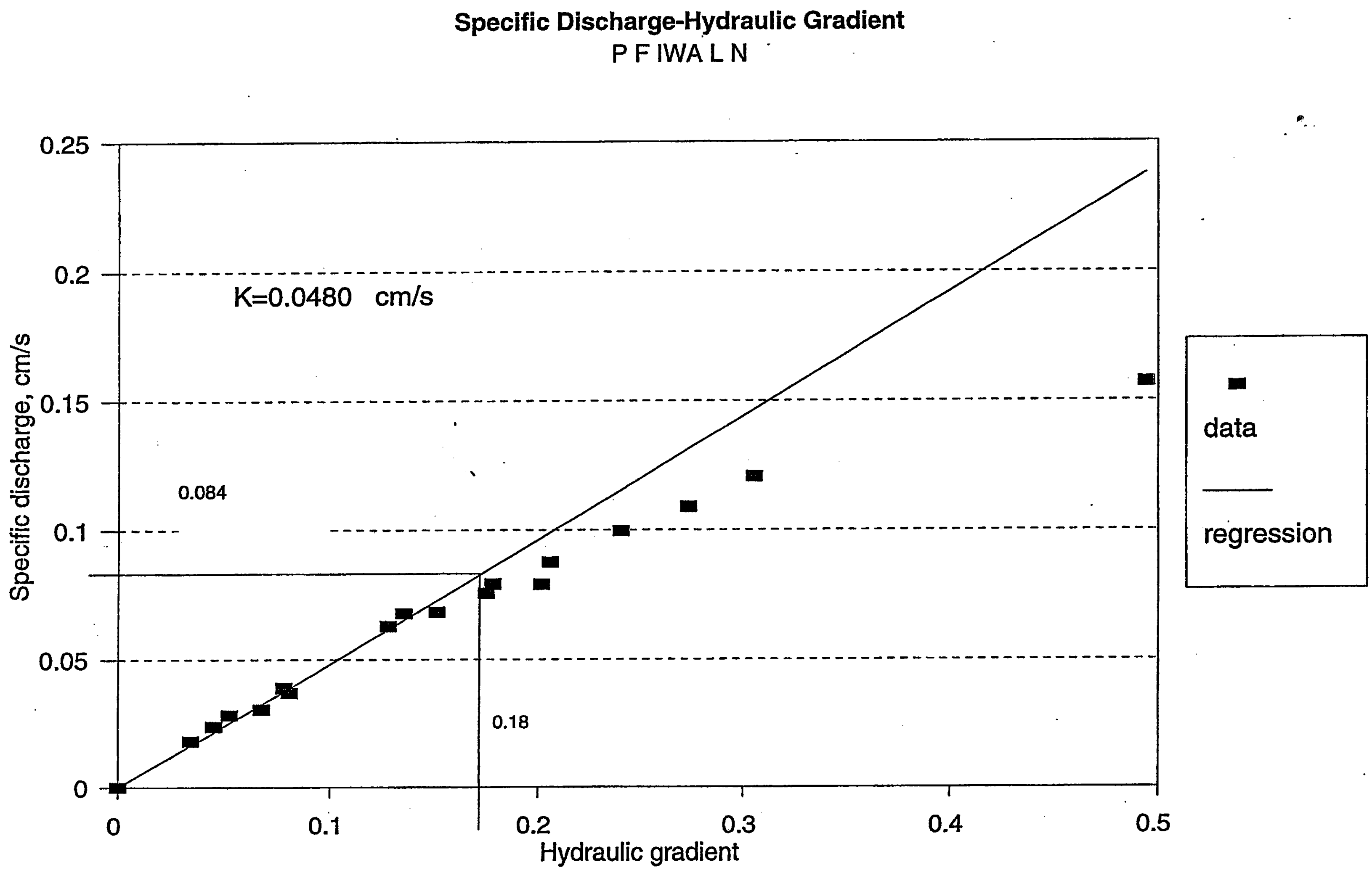


Specific Discharge-Hydraulic Gradient
P M 57 L N
K=12.526 cm/s
Specific discharge, cm/s
0.6
0.5
0.4
0.3
0.2
0.1
0
0.14
Upperlimit=0.012
0
0.01
0.02
0.03
0.04
Hydraulic gradient
data
regression


Specific Discharge-Hydraulic Gradient
P M 67 L N
Specific discharge, cm/s
0.5
0.4
0.3
0.2
0.1
0
K=17.37 cm/s
0.09
Upperlimit=0.006
0
0.005
0.01
0.015
0.02
0.025
0.03
Hydraulic gradient
data
regression

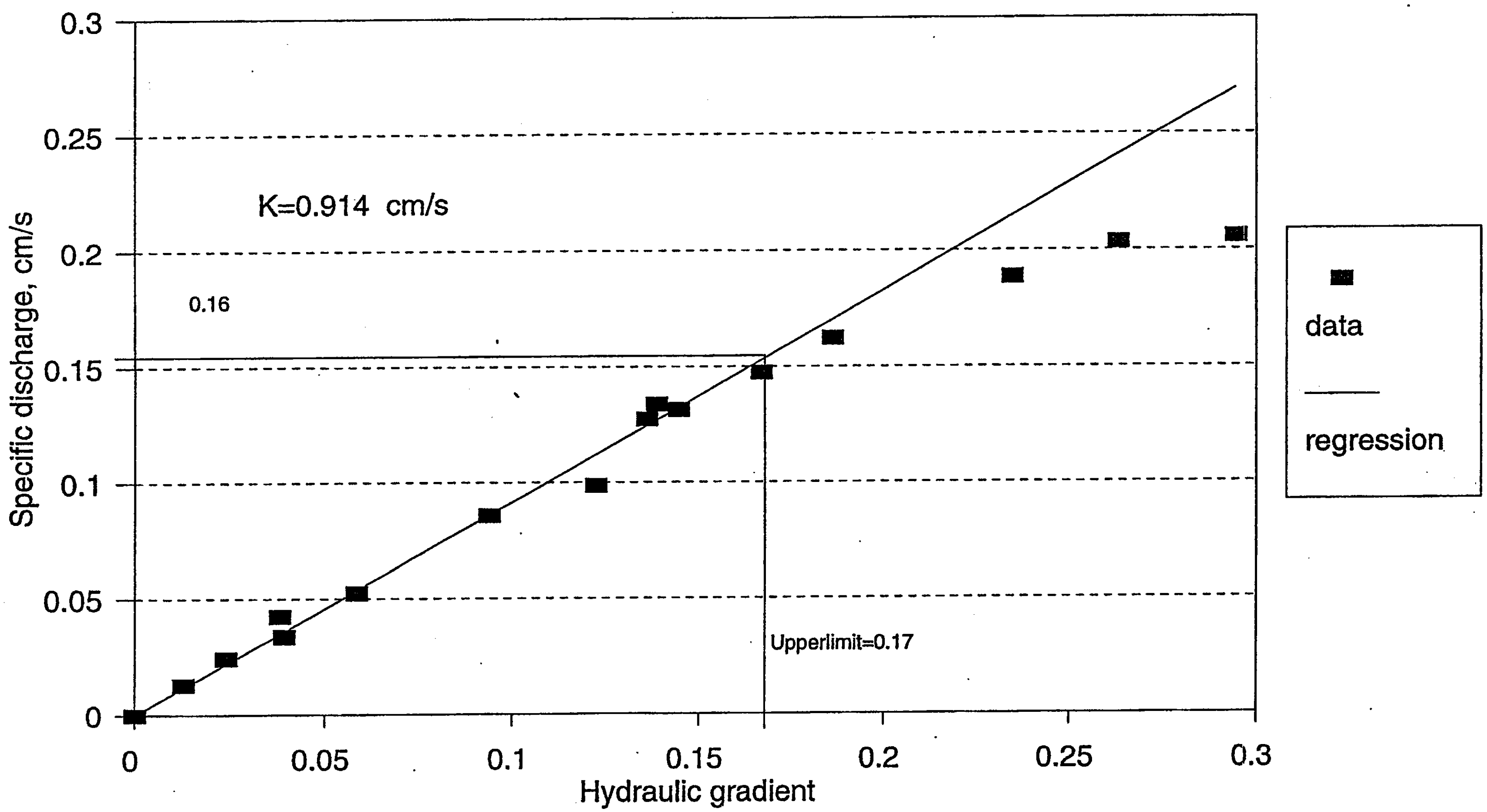


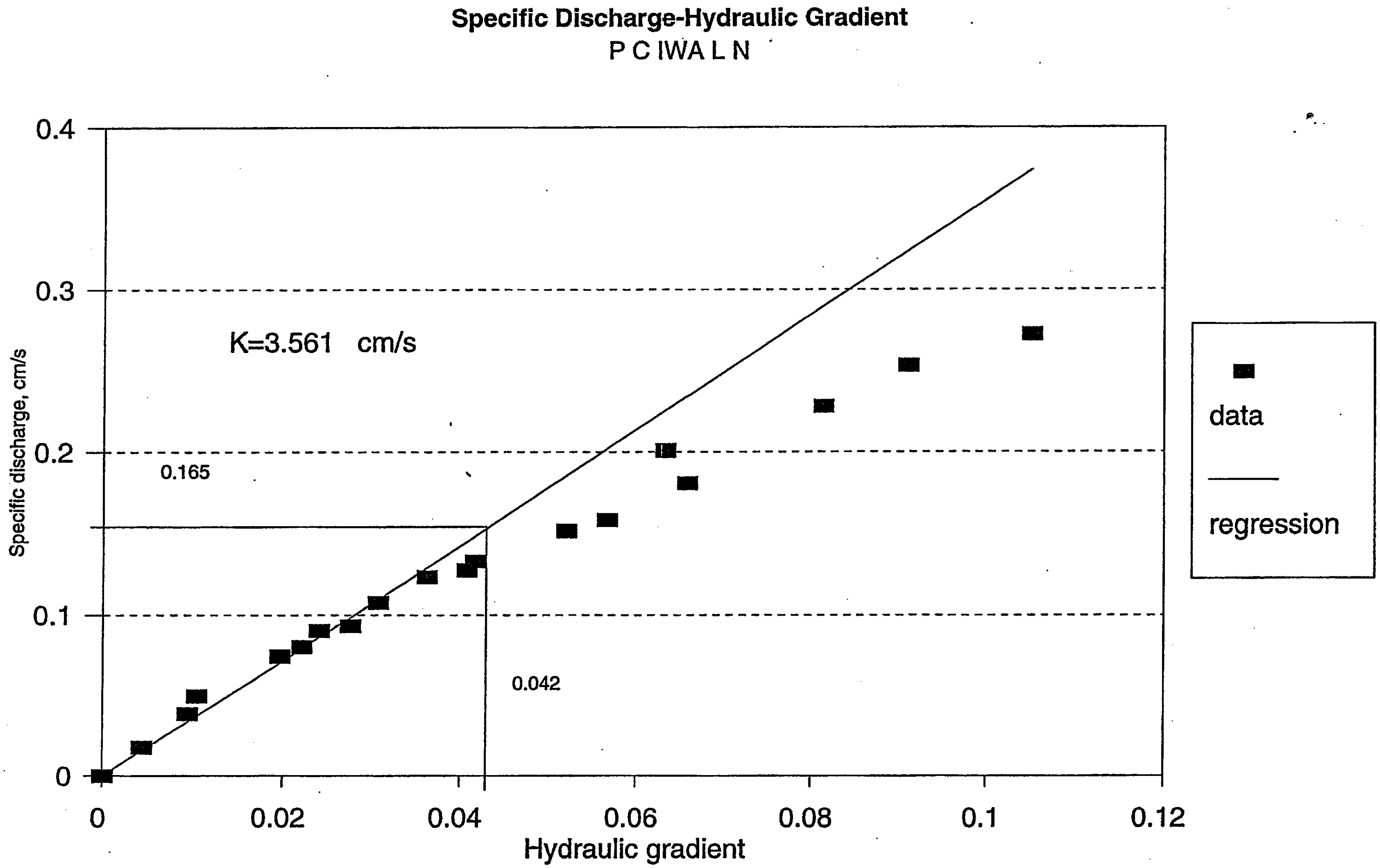
Specific Discharge-Hydraulic Gradient
P M NJ L N
K=2.694 cm/s
0.18
Upperlimit=0.07
Specific discharge, cm/s
Hydraulic gradient
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.02
0.04
0.06
0.08
0.1
0.12
data
regression



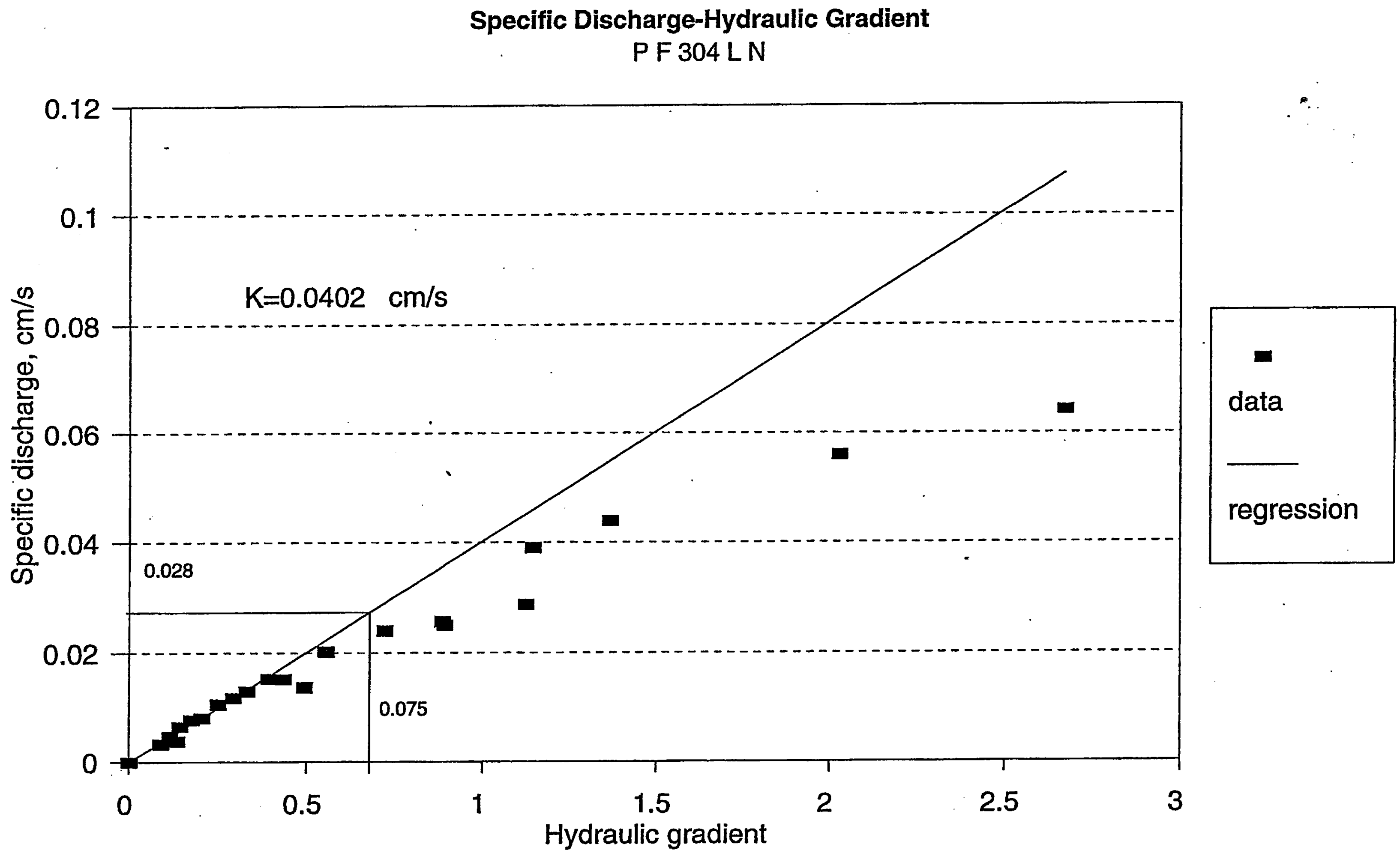
Specific Discharge-Hydraulic Gradient
P F IWA L N
K=0.0480 cm/s
0.084
0.18
Specific discharge, cm/s
Hydraulic gradient
0.25
0.2
0.15
0.1
0.05
0
0
0.1
0.2
0.3
0.4
0.5
data
regression

Specific Discharge-Hydraulic Gradient
P M IWA L N

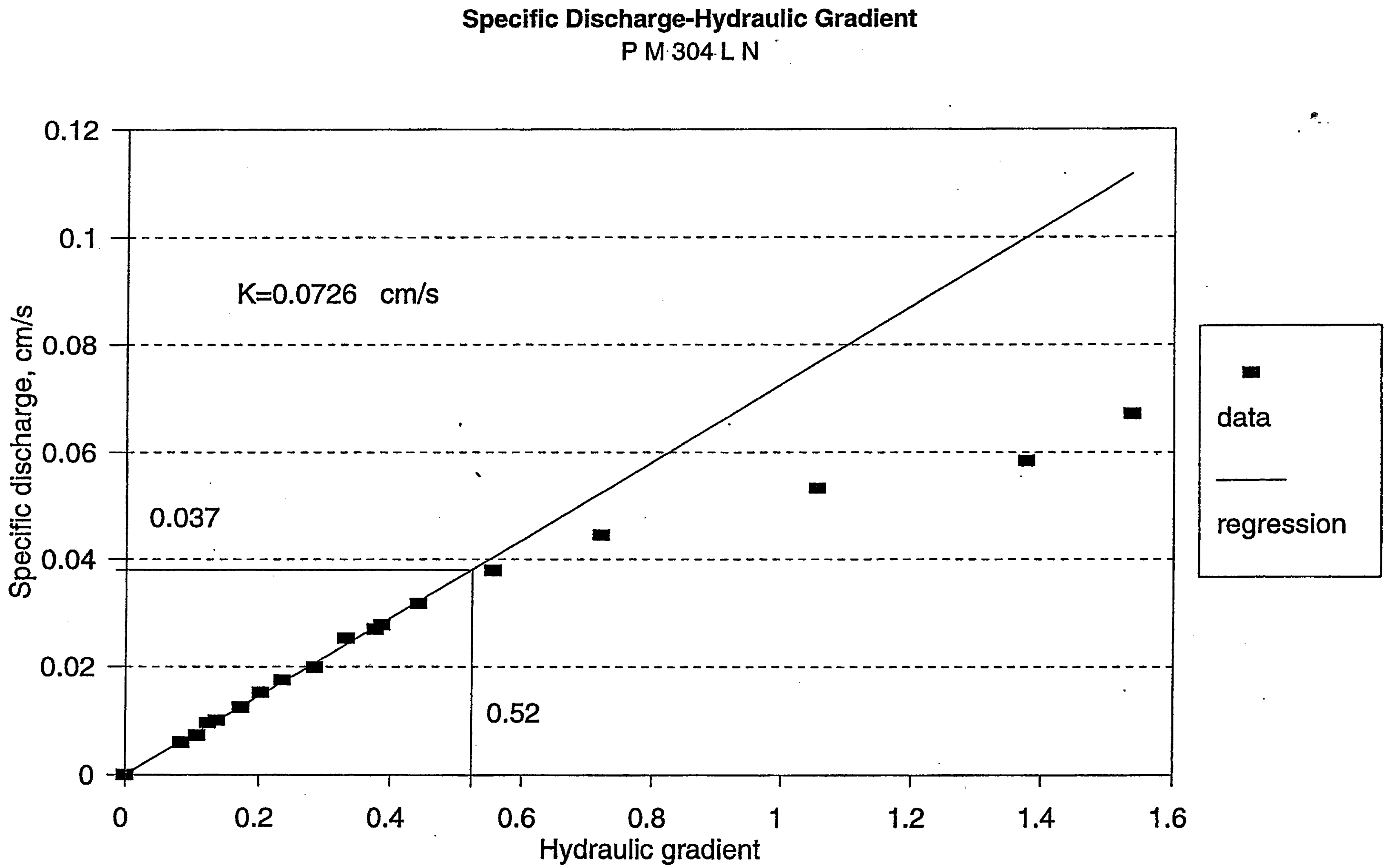




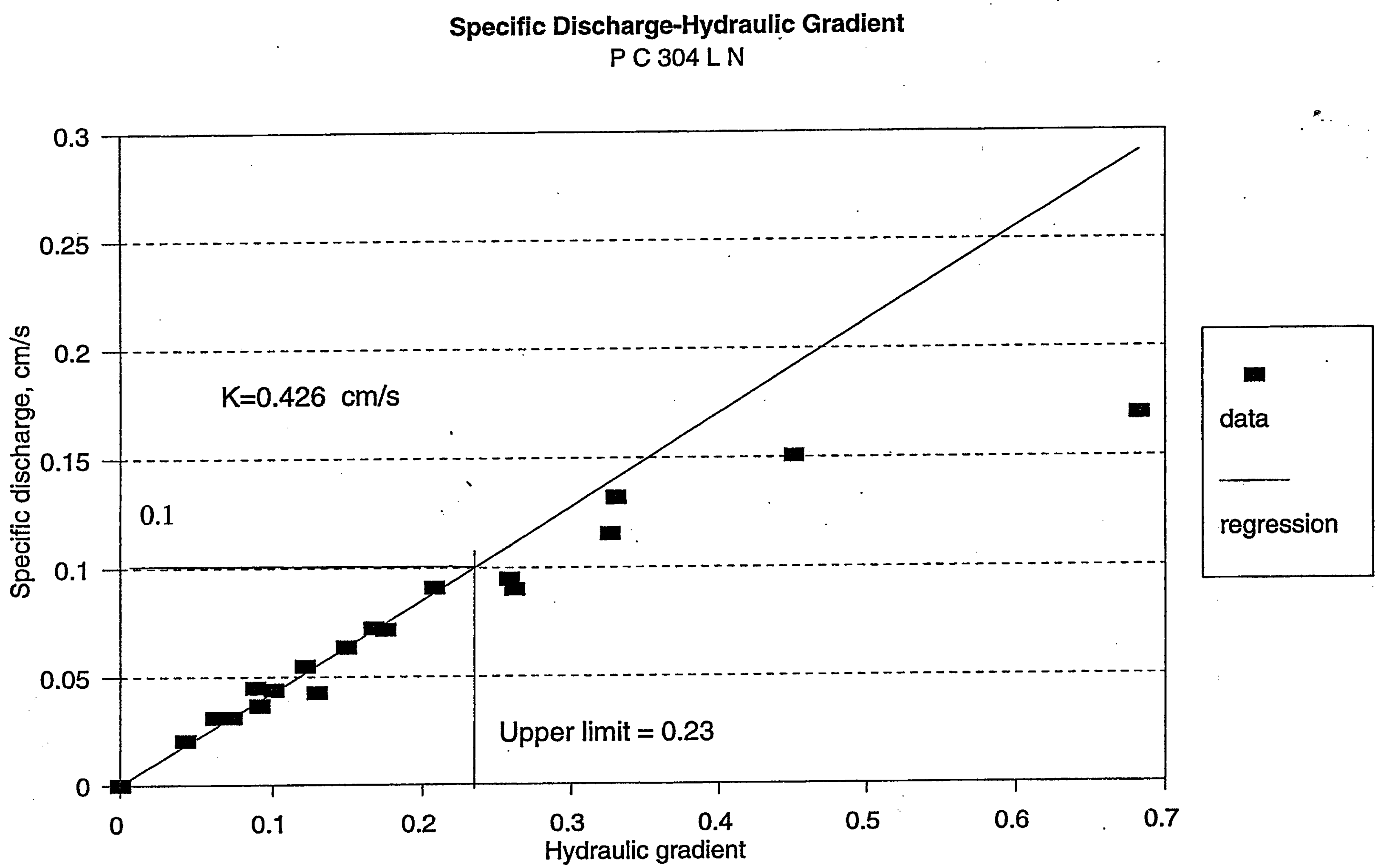
Specific Discharge-Hydraulic Gradient
P C IWA L N
K=3.561 cm/s
0.165
0.042
0.4
0.3
0.2
0.1
0
0.02
0.04
0.06
0.08
0.1
0.12
Specific discharge, cm/s
Hydraulic gradient
data
regression

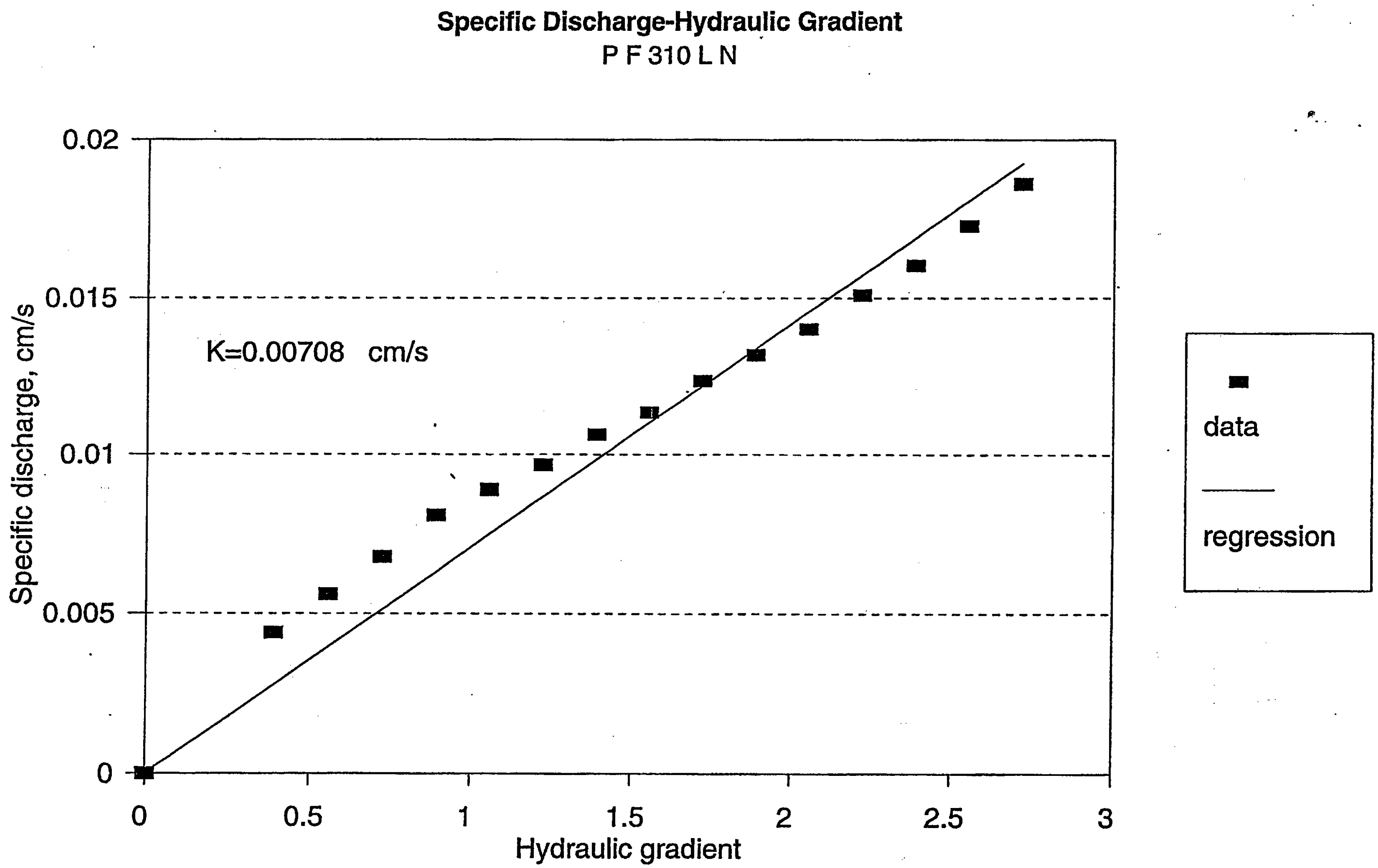


Specific Discharge-Hydraulic Gradient
P F 304 L N
K=0.0402 cm/s
0.028
0.075
Specific discharge, cm/s
Hydraulic gradient
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.5
1
1.5
2
2.5
3
data
regression

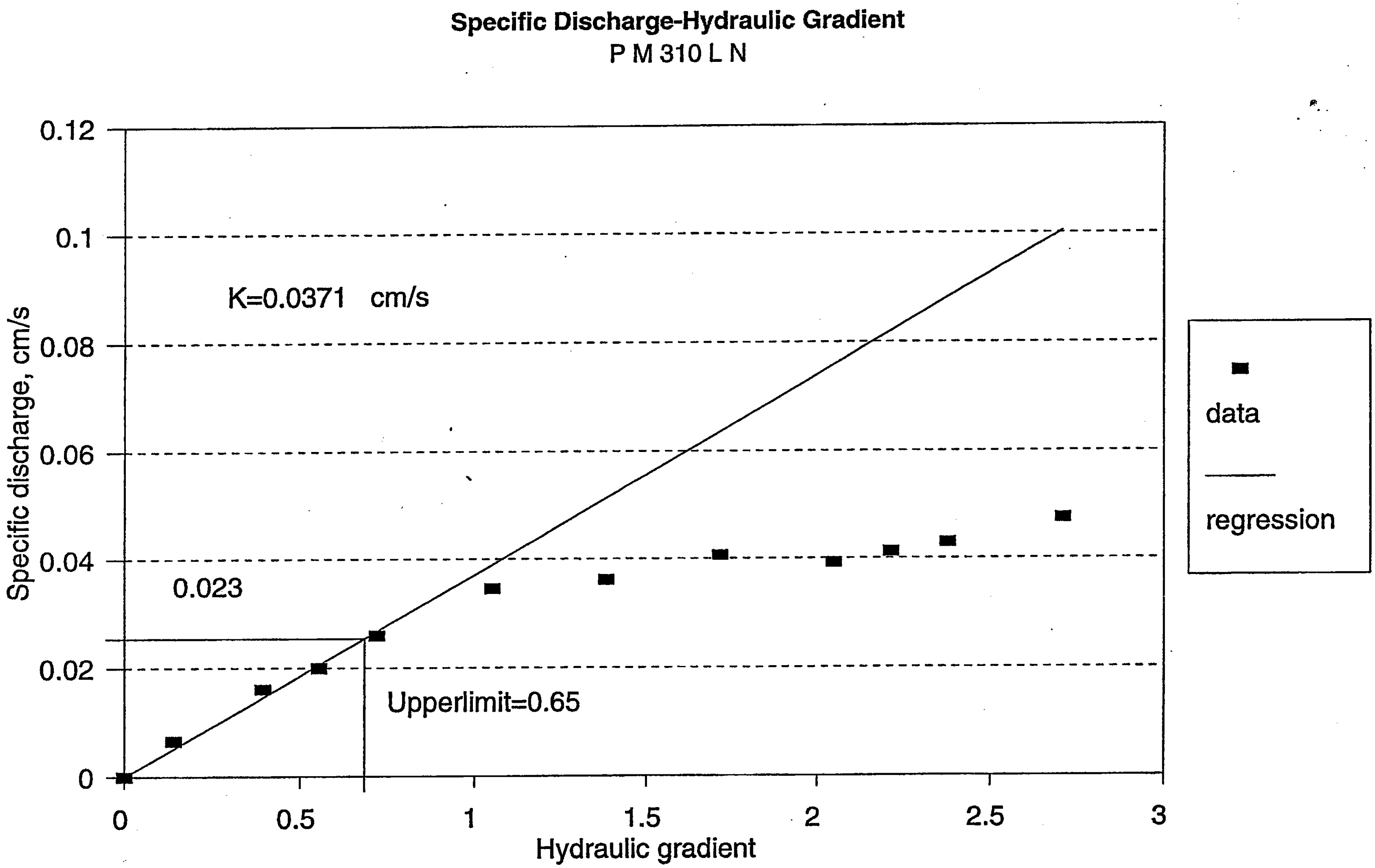


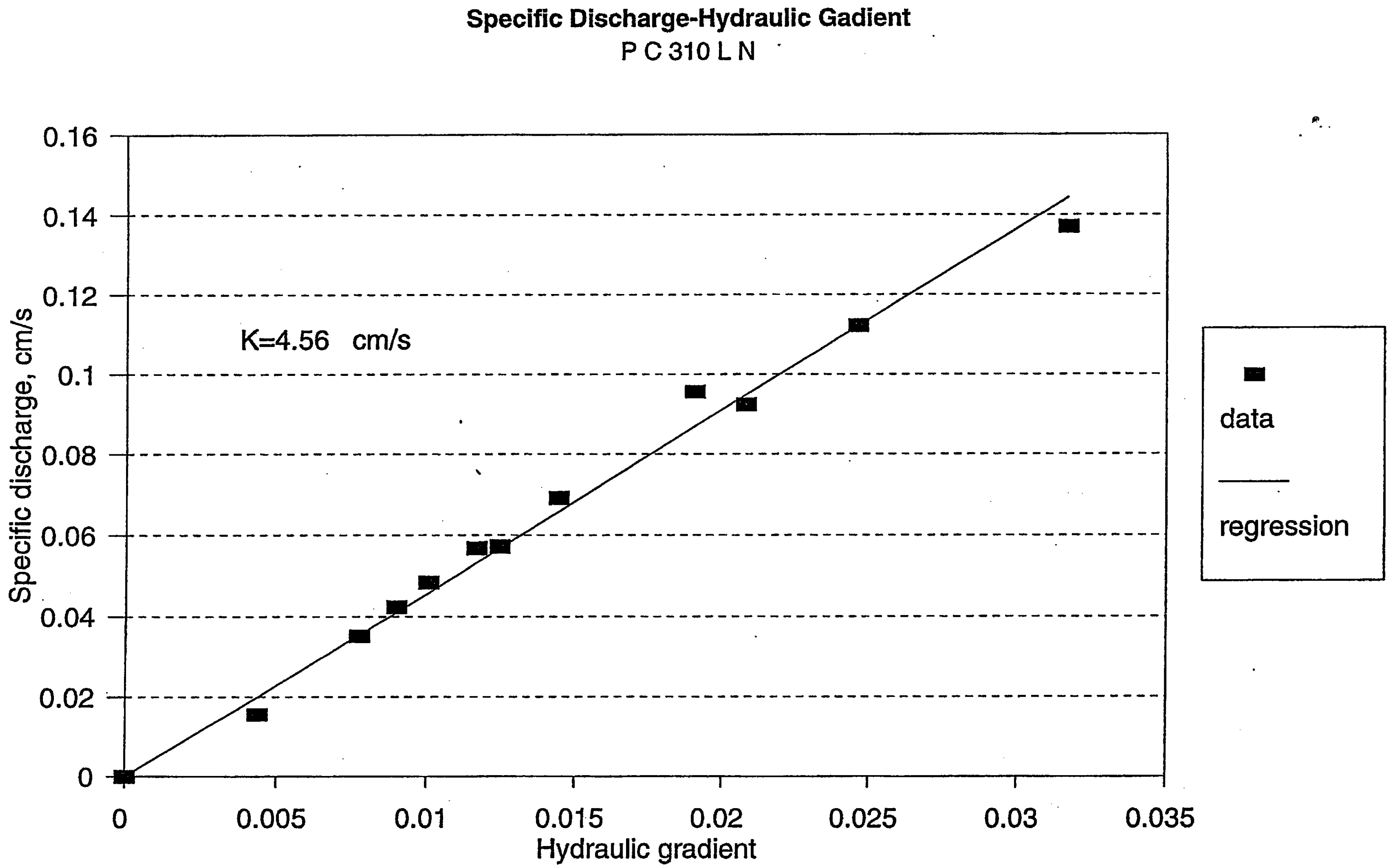
Specific Discharge-Hydraulic Gradient
P M 304 L N
K=0.0726 cm/s
0.037
0.52
Specific discharge, cm/s
Hydraulic gradient
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
data
regression


Specific Discharge-Hydraulic Gradient
P C 304 L N
Specific discharge, cm/s
0.3
0.25
0.2
0.15
0.1
0.05
0
K=0.426 cm/s
0.1
Upper limit = 0.23
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Hydraulic gradient
data
regression



Specific Discharge-Hydraulic Gradient
P F 310 L N
K=0.00708 cm/s
Specific discharge, cm/s
Hydraulic gradient
0.02
0.015
0.01
0.005
0
0
0.5
1
1.5
2
2.5
3
data
regression


Specific Discharge-Hydraulic Gradient
P M 310 L N
0.12
0.1
0.08
0.06
0.04
0.02
0
Specific discharge, cm/s
K=0.0371 cm/s
0.023
Upperlimit=0.65
0
0.5
1
1.5
2
2.5
3
Hydraulic gradient
data
regression



Specific Discharge-Hydraulic Gadient
P C 310 L N
K=4.56 cm/s
Specific discharge, cm/s
Hydraulic gradient
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.005
0.01
0.015
0.02
0.025
0.03
0.035
data
regression

Appendix N

Laboratory Test Results of Hydraulic Conductivity For Slag

Table of Contents

Figures Page

Hydraulic Conductivity Testing Data & Results

Test Identification P F 57 S N

Data

Item	Data	Unit
Sample Length	11.844	inch
Sample Height	11.594	inch
Sample Width	11.813	inch
Dry weight of permeameter box	21.2	lb
Wet weight of permeameter box	21.6	lb
Saturated weight of system w/ water	130.8	lb
Dry soil with box	99.6	lb
Saturated weight of system w/ soils	175.11	lb
Wet weight of soils w/box after drain	105.7	lb
Water temperature T	19.5	Degree, C

Delta H,cm	t, sec.	Water, V, cm^3
0.091	148.96	4543.59
0.097	118.96	4543.59
0.130	81.98	4543.59
0.226	48.74	4543.59
0.249	47.19	4543.59
0.302	45.52	4543.59
0.368	36.09	4543.59
0.450	52.65	6815.38
0.577	43.00	6815.38
0.874	49.54	11358.97
1.046	43.22	11358.97

Results

Dry Density	82.056	lb/ft^3
Degree of Saturation	0.922	
Porosity	0.480	
Effective Porosity	0.322	
Void Ratio	0.923	
Hydraulic Conductivity, K	15.467	cm/s
	43842.757	ft/day
The Upper Limit of Hydraulic Gradient	0.010	

Hydraulic Conductivity at 20 degree

K_20 = 15.574 cm/s

44148.1 ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification **P M 57 S N**

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	11.844	inch				
Sample Height	11.594	inch		0.069	171.96	4543.59
Sample Width	11.813	inch		0.086	126.68	4543.59
				0.104	139.28	6815.38
Dry weight of permeameter box	21.2	lb		0.199	85.87	6815.38
Wet weight of permeameter box	21.6	lb		0.246	62.74	6815.38
Saturated weight of system w/ water	130.8	lb		0.386	39.85	6815.38
				0.549	44.58	9087.18
Dry soil with box	99	lb		0.668	35.72	9087.18
Saturated weight of system w/ soils	174.7	lb				
Wet weight of soils w/box after drain	103.2	lb				
Water temperature T	19.5	Degree, C				

Results

Dry Density	81.428	lb/ft^3
Degree of Saturation	0.928	
Porosity	0.480	
Effective Porosity	0.357	
Void Ratio	0.924	
Hydraulic Conductivity, K	19.752	cm/s
	55991.317	ft/day
The Upper Limit of Hydraulic Gradient	0.011	

Hydraulic Conductivity at 20 degree

K_20 = 19.890 cm/s

56381.3 ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification **P C 57 S N**

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	11.844	inch				
Sample Height	11.594	inch		0.048	284.15	4543.59
Sample Width	11.813	inch		0.064	150.16	4543.59
				0.109	77.91	4543.59
Dry weight of permeameter box	21.2	lb		0.168	51.75	4543.59
Wet weight of permeameter box	21.6	lb		0.236	52.92	6815.38
Saturated weight of system w/ water	130.8	lb		0.429	33.16	6815.38
				0.572	36.91	9087.18
Dry soil with box	97	lb		0.757	34.75	9087.18
Saturated weight of system w/ soils	175	lb				
Wet weight of soils w/box after drain	100	lb				
Water temperature T	19.5	Degree, C				

Results

Dry Density	79.335	lb/ft^3
Degree of Saturation	0.988	
Porosity	0.490	
Effective Porosity	0.417	
Void Ratio	0.961	
Hydraulic Conductivity, K	23.715	cm/s
	67224.562	ft/day
The Upper Limit of Hydraulic Gradient	0.007	

Hydraulic Conductivity at 20 degree

K_20 = 23.881 cm/s

67692.8 ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification P M 67 S N

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	11.844	inch				
Sample Height	11.594	inch		0.084	147.77	4543.59
Sample Width	11.813	inch		0.165	95.24	6815.38
				0.180	57.20	4543.59
Dry weight of permeameter box	21.2	lb		0.259	61.16	6815.38
Wet weight of permeameter box	21.6	lb		0.351	53.58	6815.38
Saturated weight of system w/ water	130.8	lb		0.470	39.42	6815.38
				0.579	37.38	6815.38
Dry soil with box	100.1	lb				
Saturated weight of system w/ soils	176	lb				
Wet weight of soils w/box after drain	105.6	lb				
Water temperature T	19.5	Degree, C				

Results

Dry Density	82.579	lb/ft^3
Degree of Saturation	0.950	
Porosity	0.473	
Effective Porosity	0.339	
Void Ratio	0.897	
Hydraulic Conductivity, K	19.438	cm/s
	55098.54	ft/day
The Upper Limit of Hydraulic Gradient	0.007	

Hydraulic Conductivity at 20 degree

K_20 = 19.573 cm/s

55482.3 ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification P M NJ S N

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	11.844	inch				
Sample Height	11.594	inch		0.211	276.45	4543.59
Sample Width	11.813	inch		0.460	108.52	4543.59
				0.678	76.11	4543.59
Dry weight of permeameter box	21.2	lb		0.968	52.50	4543.59
Wet weight of permeameter box	21.6	lb		1.212	68.95	6815.38
Saturated weight of system w/ water	130.8	lb		1.306	43.04	4543.59
				1.621	52.98	6815.38
Dry soil with box	110.8	lb		1.628	54.12	6815.38
Saturated weight of system w/ soils	182.4	lb		1.920	45.71	6815.38
Wet weight of soils w/box after drain	105.6	lb		2.037	42.55	6815.38
Water temperature T	19.5	Degree, C				

Results

Dry Density	93.778	lb/ft^3
Degree of Saturation	0.868	
Porosity	0.437	
Effective Porosity	0.448	
Void Ratio	0.775	
Hydraulic Conductivity, K	2.841	cm/s
	8054.4165	ft/day
The Upper Limit of Hydraulic Gradient	>0.07	

Hydraulic Conductivity at 20 degree
K_20 = 2.861 cm/s
8110.5 ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification **P F IWA S N**

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	11.844	inch				
Sample Height	11.594	inch		0.180	275.39	1817.44
Sample Width	11.813	inch		0.594	66.25	1817.44
				0.803	142.20	4543.59
Dry weight of permeameter box	21.2	lb		1.107	108.71	4543.59
Wet weight of permeameter box	21.6	lb		1.575	86.99	4543.59
Saturated weight of system w/ water	130.8	lb		1.984	73.26	4543.59
				3.200	82.52	6815.38
Dry soil with box	123.5	lb		8.738	40.56	6815.38
Saturated weight of system w/ soils	193	lb		0.000	0.00	0.00
Wet weight of soils w/box after drain	105.7	lb		0.000	0.00	0.00
				0.000	0.00	0.00
Water temperature T	19.5	Degree, C				

Results

Dry Density	107.070	lb/ft^3
Degree of Saturation	0.954	
Porosity	0.364	
Effective Porosity	0.627	
Void Ratio	0.572	
Hydraulic Conductivity, K	1.378	cm/s
	3907.4136	ft/day
The Upper Limit of Hydraulic Gradient	0.050	

Hydraulic Conductivity at 20 degree

K_20 = 1.388 cm/s

3934.6 ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification P M IWA S N

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	11.844	inch				
Sample Height	11.594	inch		0.318	142.54	4543.59
Sample Width	11.813	inch		0.371	121.84	4543.59
				0.605	87.32	4543.59
Dry weight of permeameter box	21.2	lb		0.681	72.56	4543.59
Wet weight of permeameter box	21.6	lb		0.919	62.47	4543.59
Saturated weight of system w/ water	130.8	lb		0.942	84.23	6815.38
				1.321	66.13	6815.38
Dry soil with box	114.9	lb		1.557	43.26	4543.59
Saturated weight of system w/ soils	185.7	lb		1.748	39.85	4543.59
Wet weight of soils w/box after drain	122	lb		2.642	48.74	6815.38
				4.420	30.33	6815.38
Water temperature T	19.5	Degree, C				

Results

Dry Density	98.069	lb/ft^3
Degree of Saturation	0.906	
Porosity	0.405	
Effective Porosity	0.225	
Void Ratio	0.680	
Hydraulic Conductivity, K	3.079	cm/s
	8728.3336	ft/day
The Upper Limit of Hydraulic Gradient	0.038	

Hydraulic Conductivity at 20 degree

K_20 = 3.101 cm/s

8789.1 ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification **P C IWA S N**

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	11.844	inch				
Sample Height	11.594	inch		0.135	68.69	2271.79
Sample Width	11.813	inch		0.183	52.58	2271.79
				0.290	33.27	2271.79
Dry weight of permeameter box	21.2	lb		0.422	49.73	4543.59
Wet weight of permeameter box	21.6	lb		0.622	40.10	4543.59
Saturated weight of system w/ water	130.8	lb		0.754	32.92	4543.59
				0.940	41.43	6815.38
Dry soil with box	105.2	lb		1.217	34.31	6815.38
Saturated weight of system w/ soils	181.7	lb				
Wet weight of soils w/box after drain	106.8	lb				
Water temperature T	19.5	Degree, C				

Results

Dry Density	87.917	lb/ft^3
Degree of Saturation	1.012	
Porosity	0.455	
Effective Porosity	0.415	
Void Ratio	0.836	
Hydraulic Conductivity, K	8.830	cm/s
	25031.245	ft/day
The Upper Limit of Hydraulic Gradient	0.015	

Hydraulic Conductivity at 20 degree

K_20 = 8.892 cm/s

25205.6 ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification P F 304 S N

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	11.844	inch				
Sample Height	11.594	inch		10.643	401.65	4543.59
Sample Width	11.813	inch		15.617	316.26	4543.59
				20.566	239.03	4543.59
Dry weight of permeameter box	21.2	lb		25.516	193.38	4543.59
Wet weight of permeameter box	21.6	lb		30.541	165.85	4543.59
Saturated weight of system w/ water	130.8	lb		40.516	149.50	4543.59
				50.465	122.00	4543.59
Dry soil with box	136.6	lb		60.389	99.34	4543.59
Saturated weight of system w/ soils	197.8	lb		0.000	0.00	0.00
Wet weight of soils w/box after drain	140.4	lb		0.000	0.00	0.00
				0.000	0.00	0.00
Water temperature T	19.5	Degree, C		0.000	0.00	0
				0.000	0.00	0

Results

Dry Density	120.781	lb/ft^3
Degree of Saturation	0.726	
Porosity	0.289	
Effective Porosity	0.117	
Void Ratio	0.406	
Hydraulic Conductivity, K	0.032	cm/s
	90.083963	ft/day
The Upper Limit of Hydraulic Gradient	1.100	

Hydraulic Conductivity at 20 degree

K_20 = 0.032 cm/s

90.7 ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification **P M 304 S N**

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	11.844	inch				
Sample Height	11.594	inch		1.219	243.33	4543.59
Sample Width	11.813	inch		2.286	137.83	4543.59
				3.023	103.37	4543.59
Dry weight of permeameter box	21.2	lb		3.175	79.44	4543.59
Wet weight of permeameter box	21.6	lb		3.937	71.13	4543.59
Saturated weight of system w/ water	130.8	lb		5.918	57.37	4543.59
				8.788	43.95	4543.59
Dry soil with box	125.4	lb		13.691	32.41	4543.59
Saturated weight of system w/ soils	193.5	lb				
Wet weight of soils w/box after drain	133.6	lb				
Water temperature T	19.5	Degree, C				

Results

Dry Density	109.059	lb/ft^3
Degree of Saturation	0.946	
Porosity	0.342	
Effective Porosity	0.160	
Void Ratio	0.520	
Hydraulic Conductivity, K	0.550	cm/s
	1558.6706	ft/day
The Upper Limit of Hydraulic Gradient	0.160	

Hydraulic Conductivity at 20 degree

K_20 = 0.554 cm/s

1569.5 ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification P C 304 S N

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	11.844	inch				
Sample Height	11.594	inch		0.132	276.85	4543.59
Sample Width	11.813	inch		0.287	108.02	4543.59
				0.518	68.29	4543.59
Dry weight of permeameter box	21.2	lb		0.592	66.95	4543.59
Wet weight of permeameter box	21.6	lb		0.726	51.88	4543.59
Saturated weight of system w/ water	130.8	lb		0.983	43.86	4543.59
				1.267	38.38	4543.59
Dry soil with box	112.45	lb		1.400	69.99	9087.18
Saturated weight of system w/ soils	186.8	lb				
Wet weight of soils w/box after drain	122.3	lb				
Water temperature T	19.5	Degree, C				

Results

Dry Density	95.505	lb/ft^3
Degree of Saturation	1.038	
Porosity	0.411	
Effective Porosity	0.238	
Void Ratio	0.698	
Hydraulic Conductivity, K	4.482	cm/s
	12705.066	ft/day
The Upper Limit of Hydraulic Gradient	0.023	

Hydraulic Conductivity at 20 degree

K_20 = 4.513 cm/s

12793.6 ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification P F 310 S N

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	11.844	inch				
Sample Height	11.594	inch		52.192	435.06	4543.59
Sample Width	11.813	inch		57.168	365.98	4543.59
				62.141	321.49	4543.59
Dry weight of permeameter box	21.2	lb		67.117	288.15	4543.59
Wet weight of permeameter box	21.6	lb		72.090	255.49	4543.59
Saturated weight of system w/ water	130.8	lb		82.065	237.27	4543.59
				102.039	208.34	4543.59
Dry soil with box	130	lb				
Saturated weight of system w/ soils	200	lb				
Wet weight of soils w/box after drain	144.2	lb				
Water temperature T	19.5	Degree, C				

Results

Dry Density	113.873	lb/ft^3
Degree of Saturation	0.969	
Porosity	0.369	
Effective Porosity	0.090	
Void Ratio	0.585	
Hydraulic Conductivity, K	0.008	cm/s
	21.749306	ft/day
The Upper Limit of Hydraulic Gradient	>3.5	

Hydraulic Conductivity at 20 degree

K_20 = 0.008 cm/s

21.9 ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification **P M 310 S N**

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	11.844	inch				
Sample Height	11.594	inch		1.118	483.40	4543.59
Sample Width	11.813	inch		2.108	238.80	4543.59
				3.099	196.09	4543.59
Dry weight of permeameter box	21.2	lb		3.962	152.00	4543.59
Wet weight of permeameter box	21.6	lb		9.449	84.63	4543.59
Saturated weight of system w/ water	130.8	lb		14.627	64.23	4543.59
				19.710	51.99	4543.59
Dry soil with box	131.5	lb				
Saturated weight of system w/ soils	197.2	lb				
Wet weight of soils w/box after drain	141	lb				
Water temperature T	19.5	Degree, C				

Results

Dry Density	115.443	lb/ft^3
Degree of Saturation	0.884	
Porosity	0.322	
Effective Porosity	0.097	
Void Ratio	0.475	
Hydraulic Conductivity, K	0.265	cm/s
	752.03279	ft/day
The Upper Limit of Hydraulic Gradient	0.190	

Hydraulic Conductivity at 20 degree

K_20 = 0.267 cm/s

757.3 ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification **P C 310 S N**

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	11.844	inch				
Sample Height	11.594	inch		0.198	258.35	4543.59
Sample Width	11.813	inch		0.279	110.21	4543.59
				0.389	94.07	4543.59
Dry weight of permeameter box	21.2	lb		0.508	68.00	4543.59
Wet weight of permeameter box	21.6	lb		0.726	55.72	4543.59
Saturated weight of system w/ water	130.8	lb		0.820	41.55	4543.59
				0.935	42.38	4543.59
Dry soil with box	113	lb		1.171	33.94	4543.59
Saturated weight of system w/ soils	185.5	lb				
Wet weight of soils w/box after drain	119.1	lb				
Water temperature T	19.5	Degree, C				

Results

Dry Density	96.081	lb/ft^3
Degree of Saturation	0.978	
Porosity	0.404	
Effective Porosity	0.271	
Void Ratio	0.678	
Hydraulic Conductivity, K	4.602	cm/s
	13044.981	ft/day
The Upper Limit of Hydraulic Gradient	0.027	

Hydraulic Conductivity at 20 degree

K_20 = 4.634 cm/s

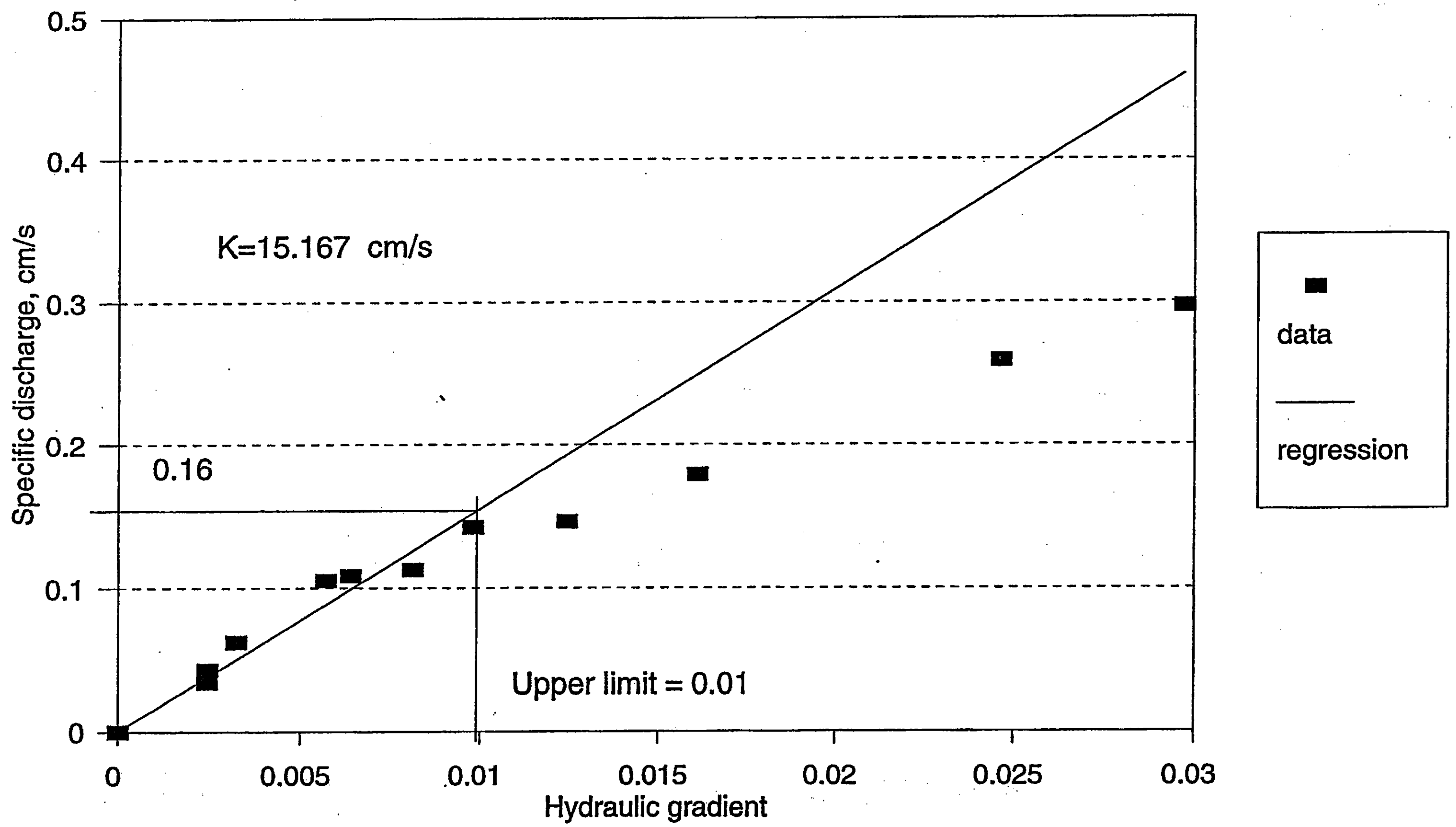
13135.8 ft./day

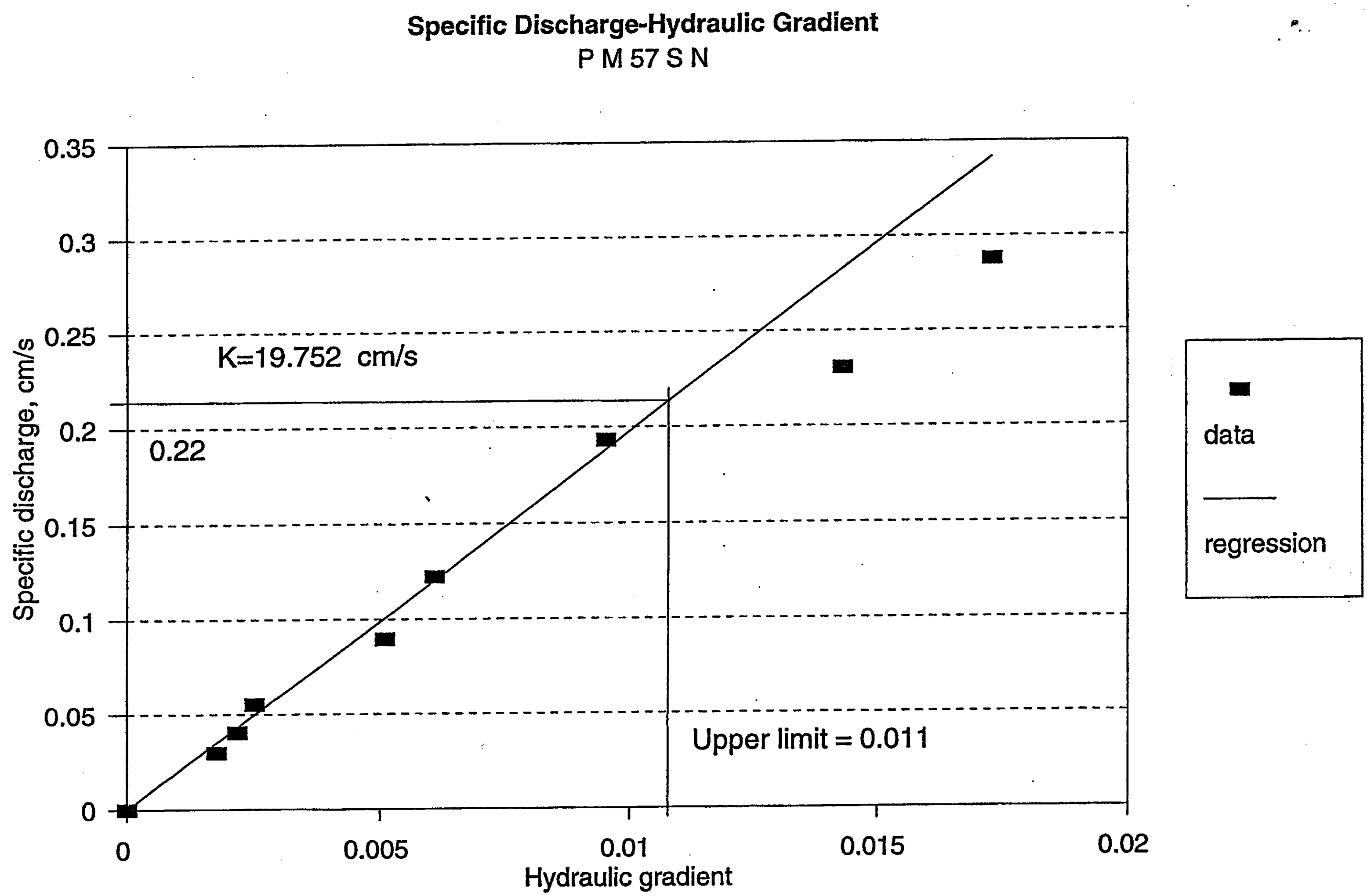
Test Result Summary of Hydraulic Conductivity

For Slags

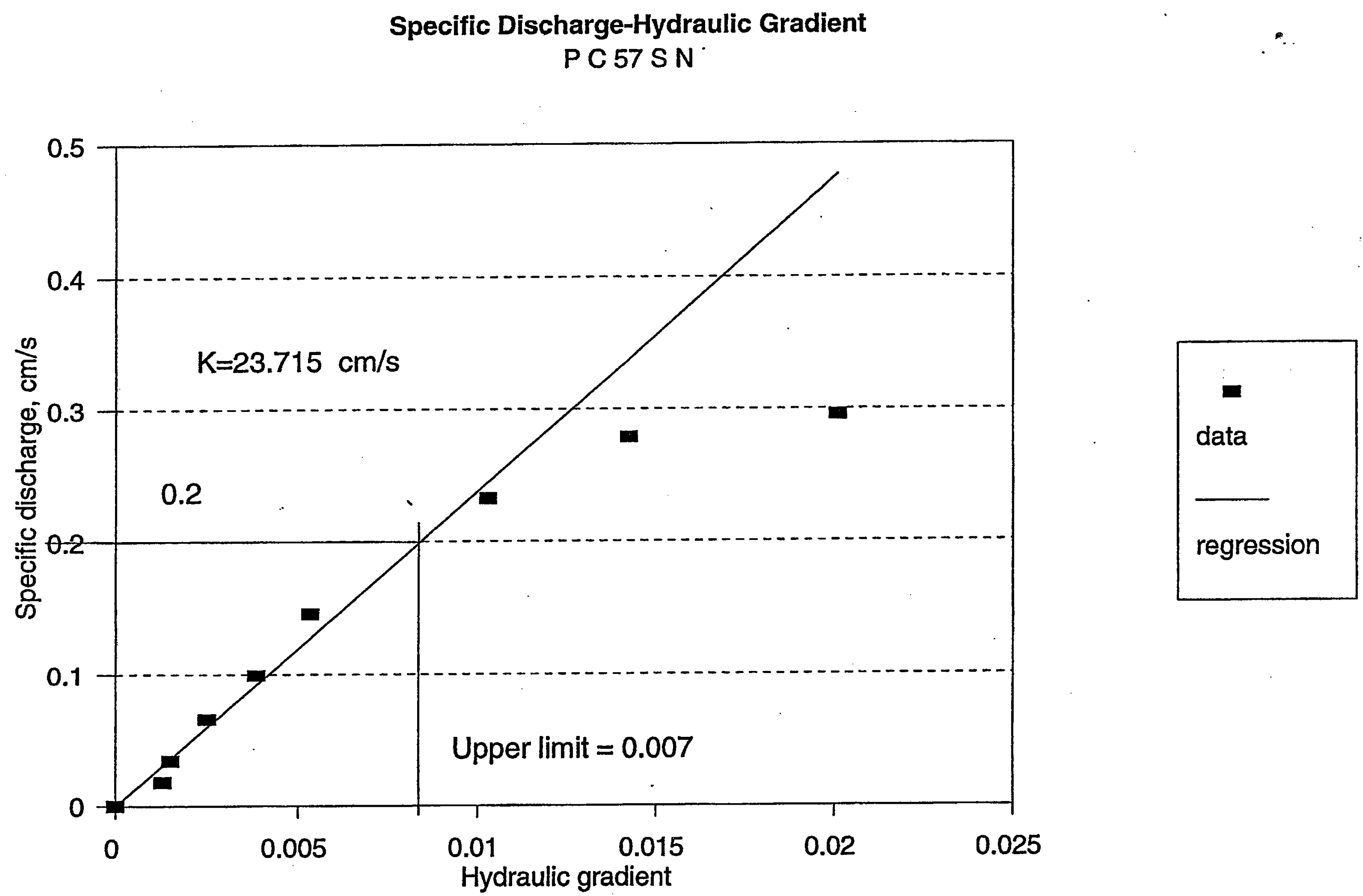
Type	Gradation	Dry Density	Degree of Saturation	Hydraulic Conductivity At 20		i_upper
		lb/ft^3		cm/s	ft/day	
No. 57	F	82.1	92.2%	15.57	44,147	0.010
	M	81.4	92.8%	19.89	56,381	0.011
	C	79.3	98.8%	23.88	67,694	0.007
No. 67	M	82.6	95.0%	19.57	55,483	0.007
N.J.Mix	M	93.8	86.8%	2.86	8,110	>0.07
Iowa Mix	F	107.1	95.4%	1.39	3,934	0.050
	M	98.1	90.6%	3.10	8,790	0.038
	C	87.9	101.2%	8.89	25,206	0.015
ODOT 304	F	120.8	72.6%	0.03	111	1.100
	M	109.1	94.6%	0.55	1,570	0.160
	C	95.5	103.8%	4.51	12,793	0.023
ODOT 310	F	113.9	96.9%	0.01	23	>3.5
	M	115.4	88.4%	0.27	757	0.190
	C	96.1	97.8%	4.63	13,136	0.027

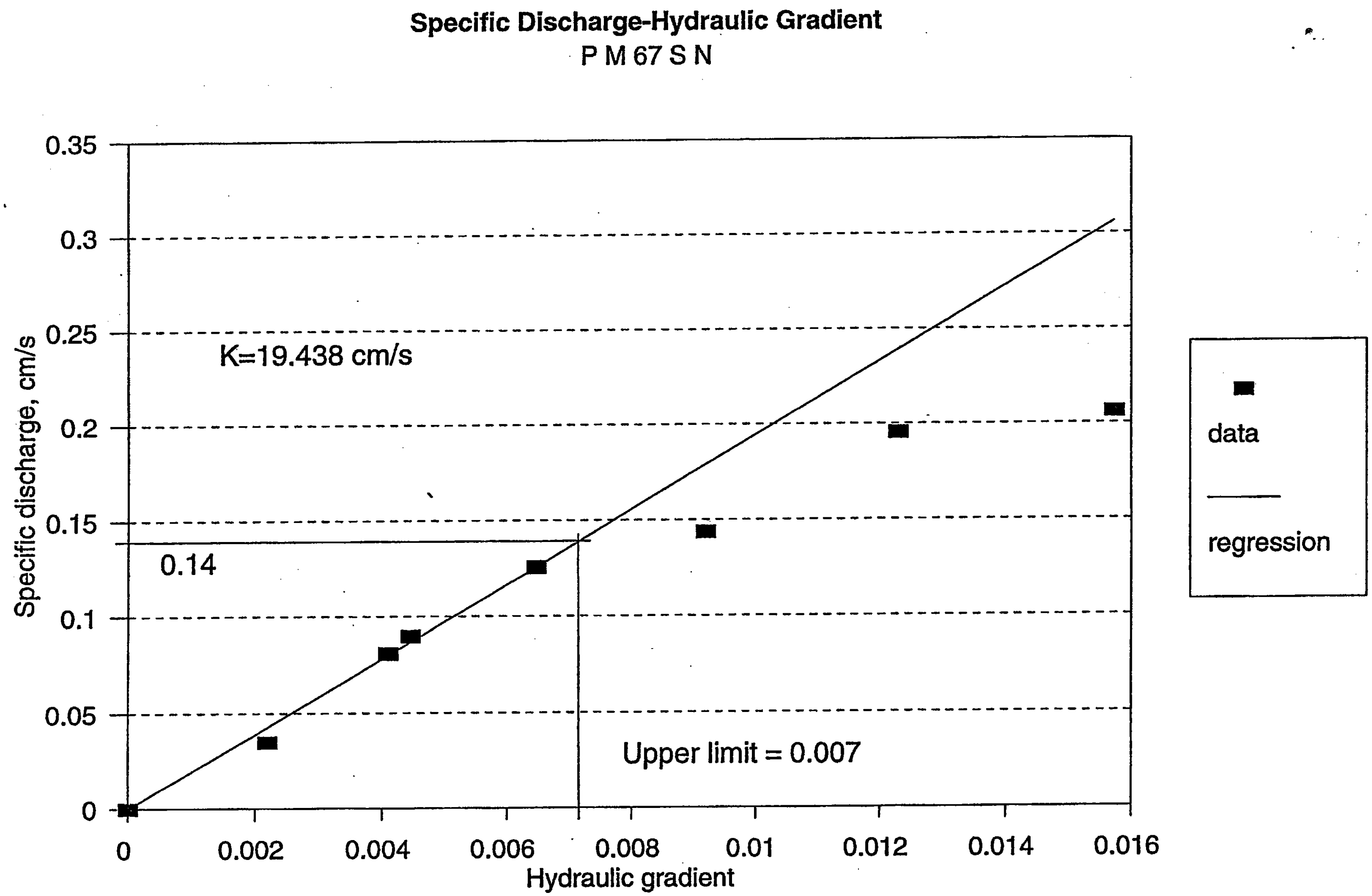
Specific Discharge-Hydraulic Gradient
P F 57 S N



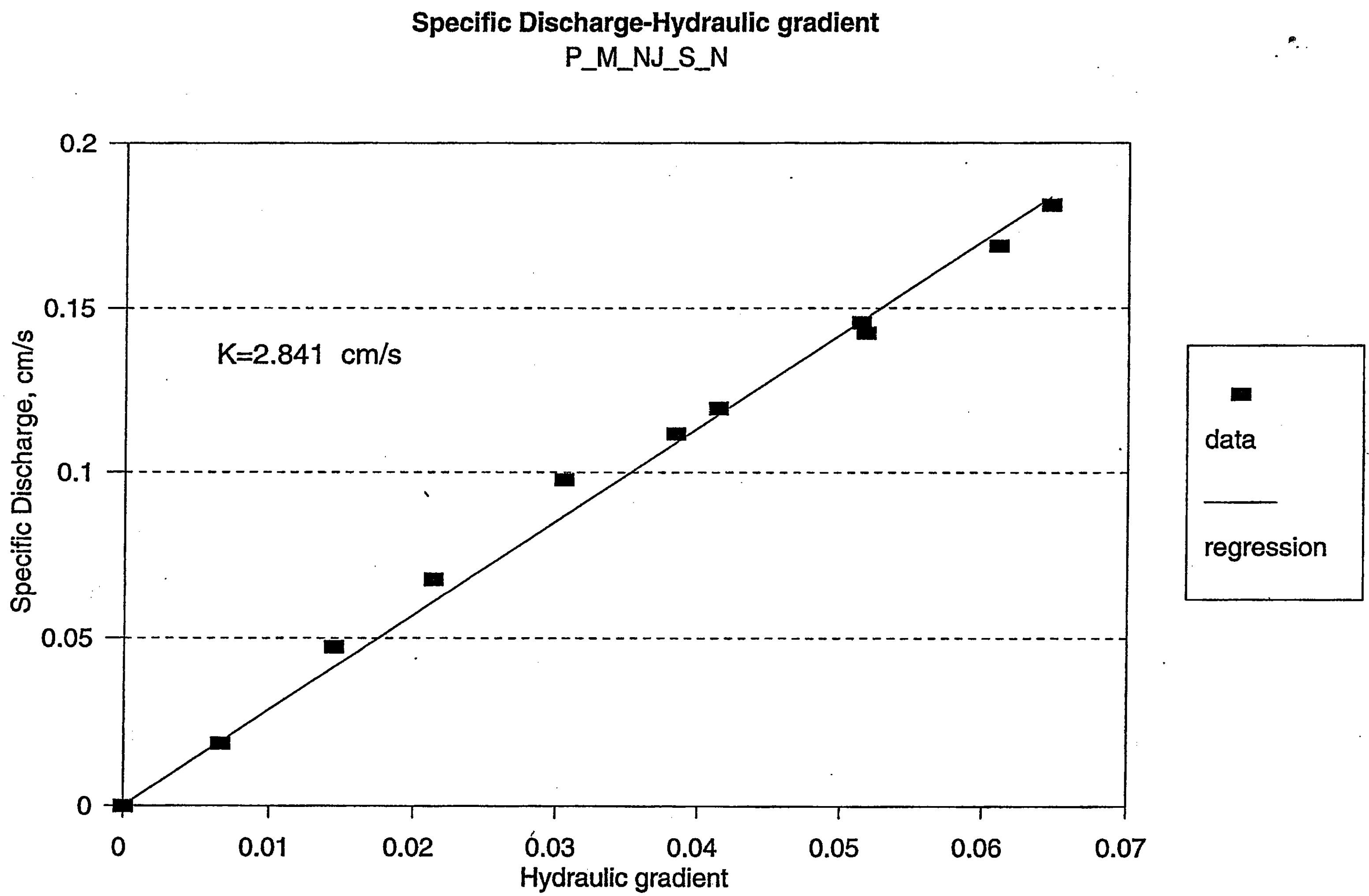


Specific Discharge-Hydraulic Gradient
P M 57 S N
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Specific discharge, cm/s
K=19.752 cm/s
0.22
Upper limit = 0.011
0
0.005
0.01
0.015
0.02
Hydraulic gradient
data
regression

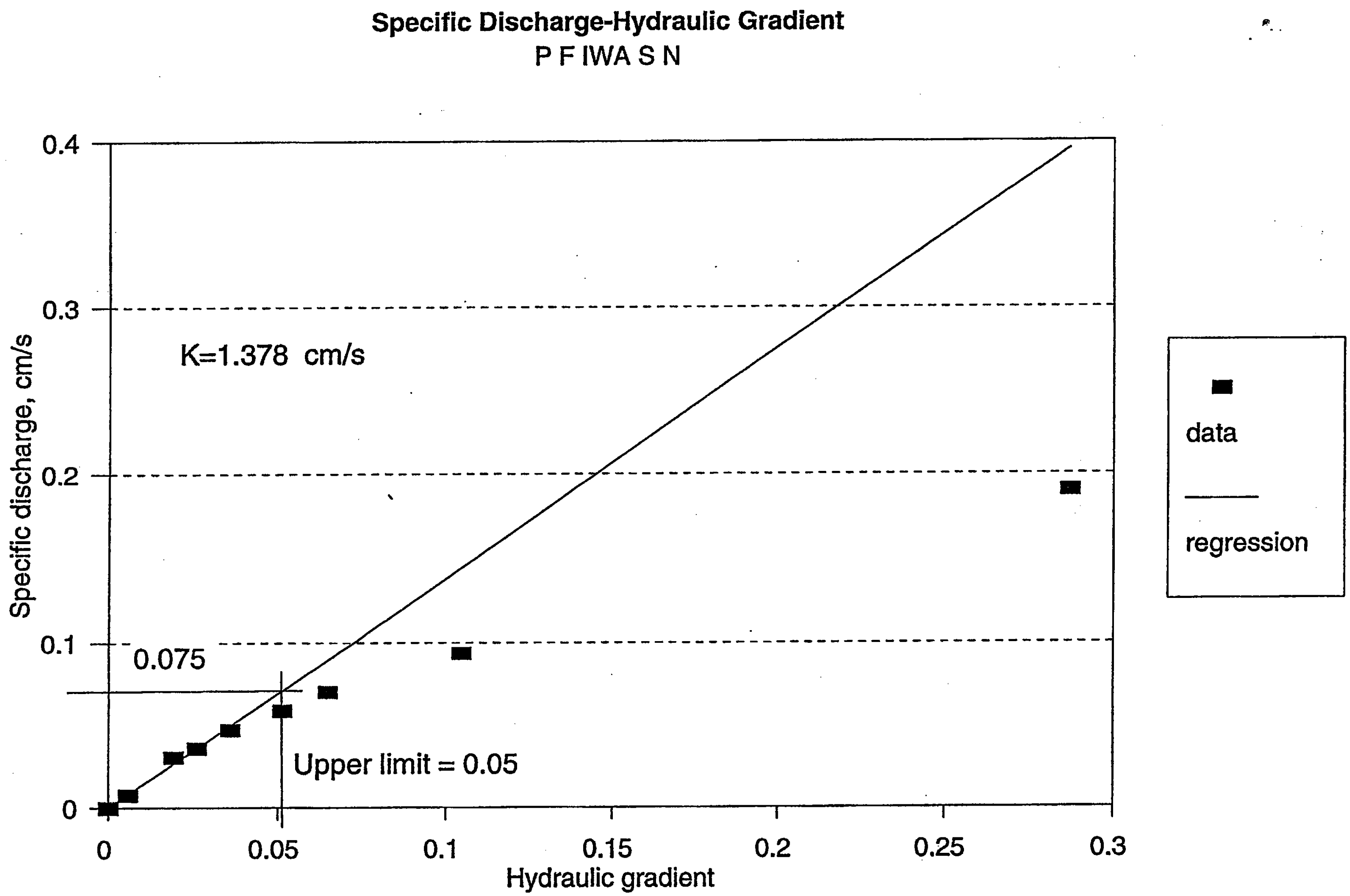

Specific Discharge-Hydraulic Gradient
P C 57 S N
0.5
0.4
0.3
0.2
0.1
0
Specific discharge, cm/s
K=23.715 cm/s
0.2
Upper limit = 0.007
0
0.005
0.01
0.015
0.02
0.025
Hydraulic gradient
data
regression



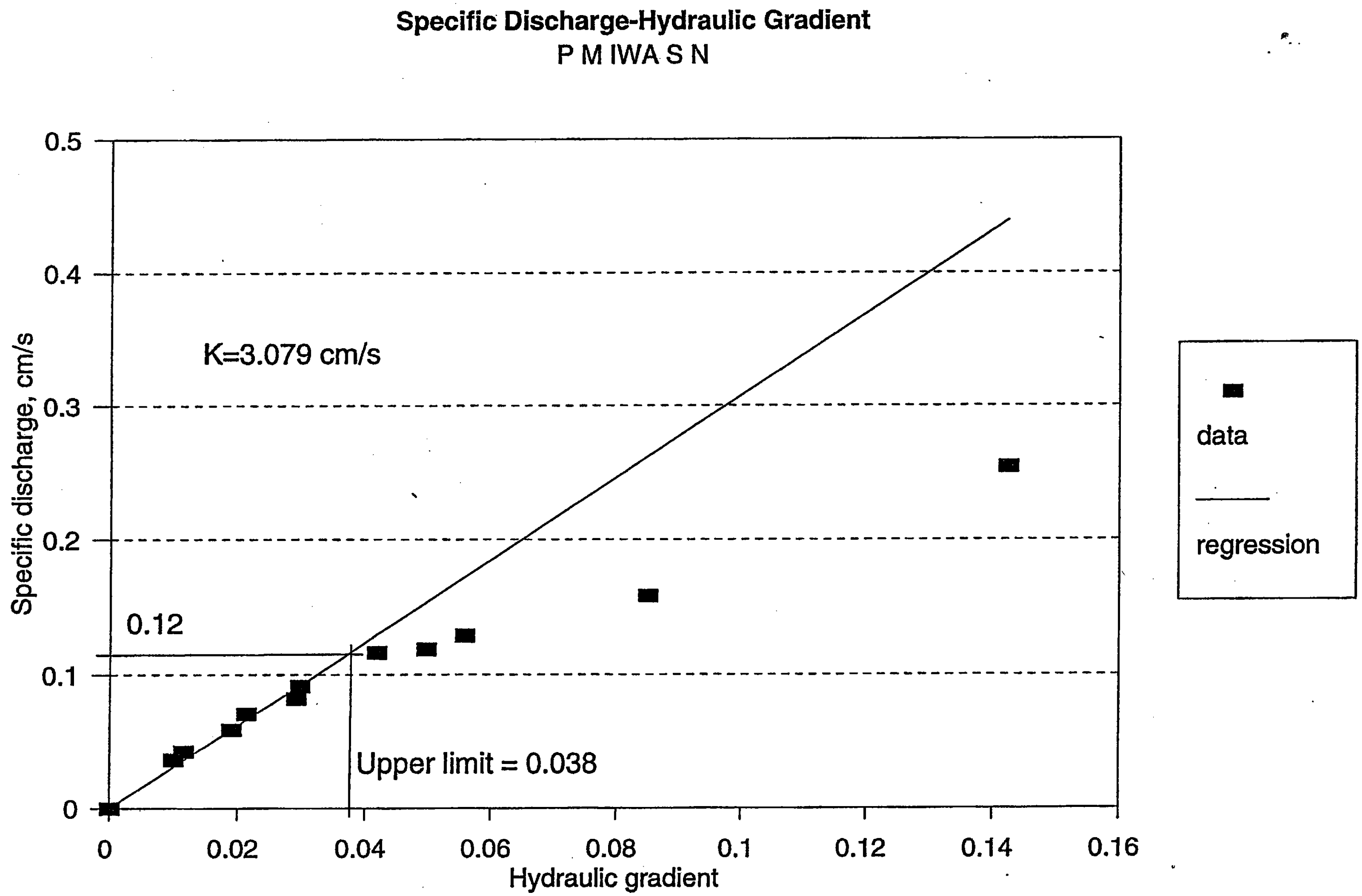
Specific Discharge-Hydraulic Gradient
P M 67 S N
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Specific discharge, cm/s
K=19.438 cm/s
0.14
Upper limit = 0.007
0
0.002
0.004
0.006
0.008
0.01
0.012
0.014
0.016
Hydraulic gradient
data
regression



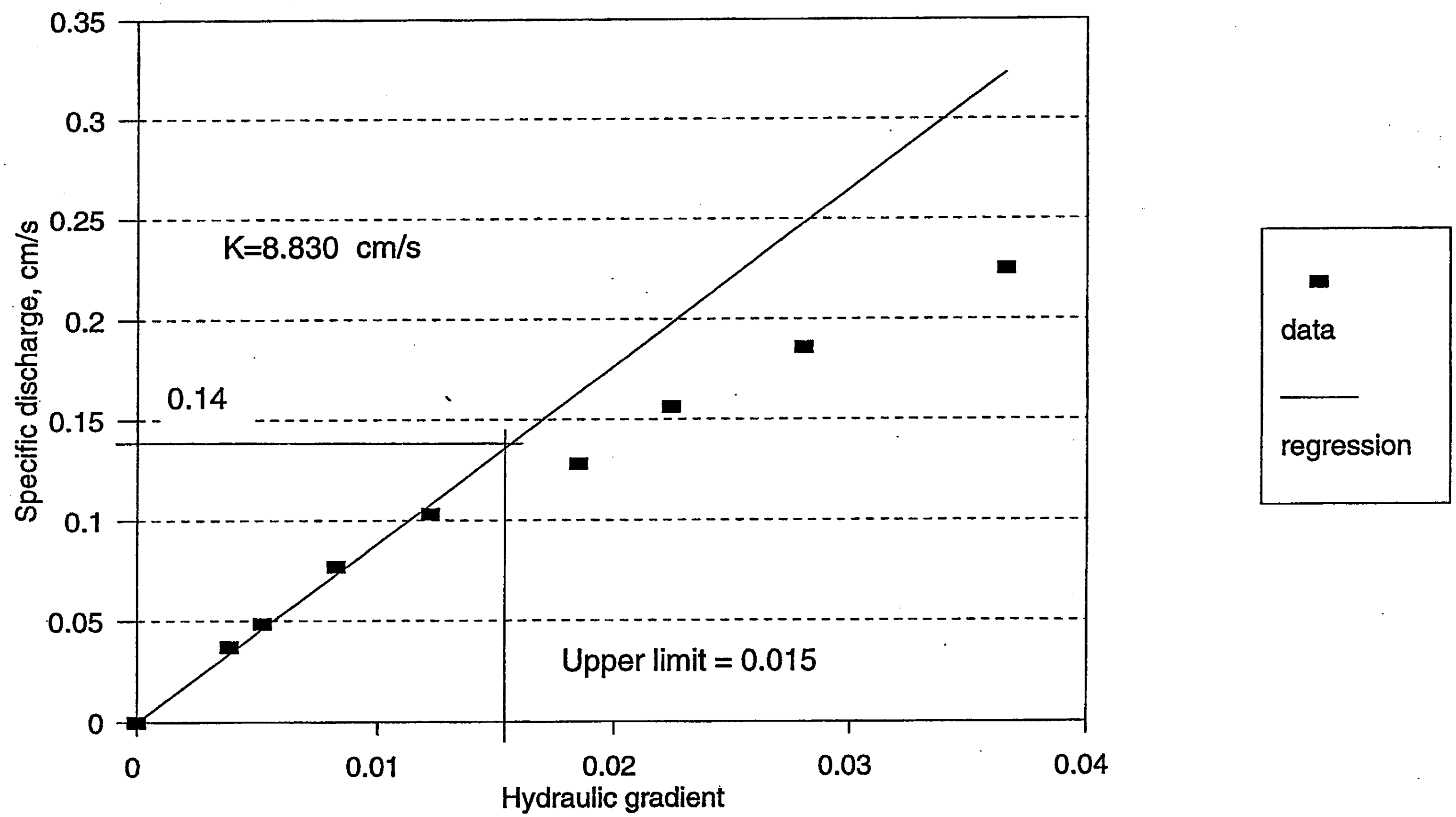
Specific Discharge-Hydraulic gradient
P_M_NJ_S_N
K=2.841 cm/s
Specific Discharge, cm/s
Hydraulic gradient
0
0.05
0.1
0.15
0.2
0.01
0.02
0.03
0.04
0.05
0.06
0.07
data
regression



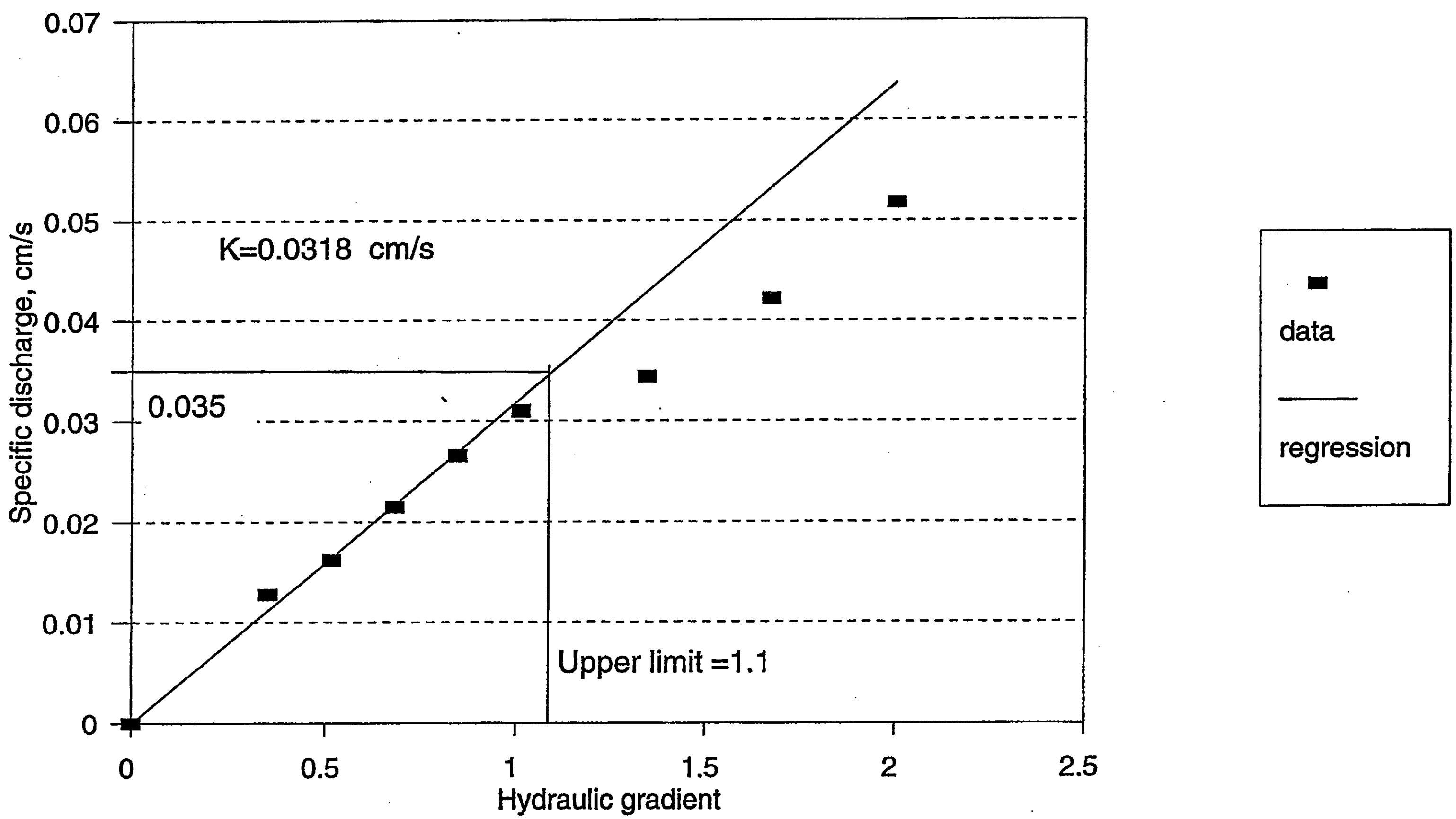
Specific Discharge-Hydraulic Gradient
P F IWA S N
Specific discharge, cm/s
0.4
0.3
0.2
0.1
0
K=1.378 cm/s
0.075
Upper limit = 0.05
0
0.05
0.1
0.15
0.2
0.25
0.3
Hydraulic gradient
data
regression

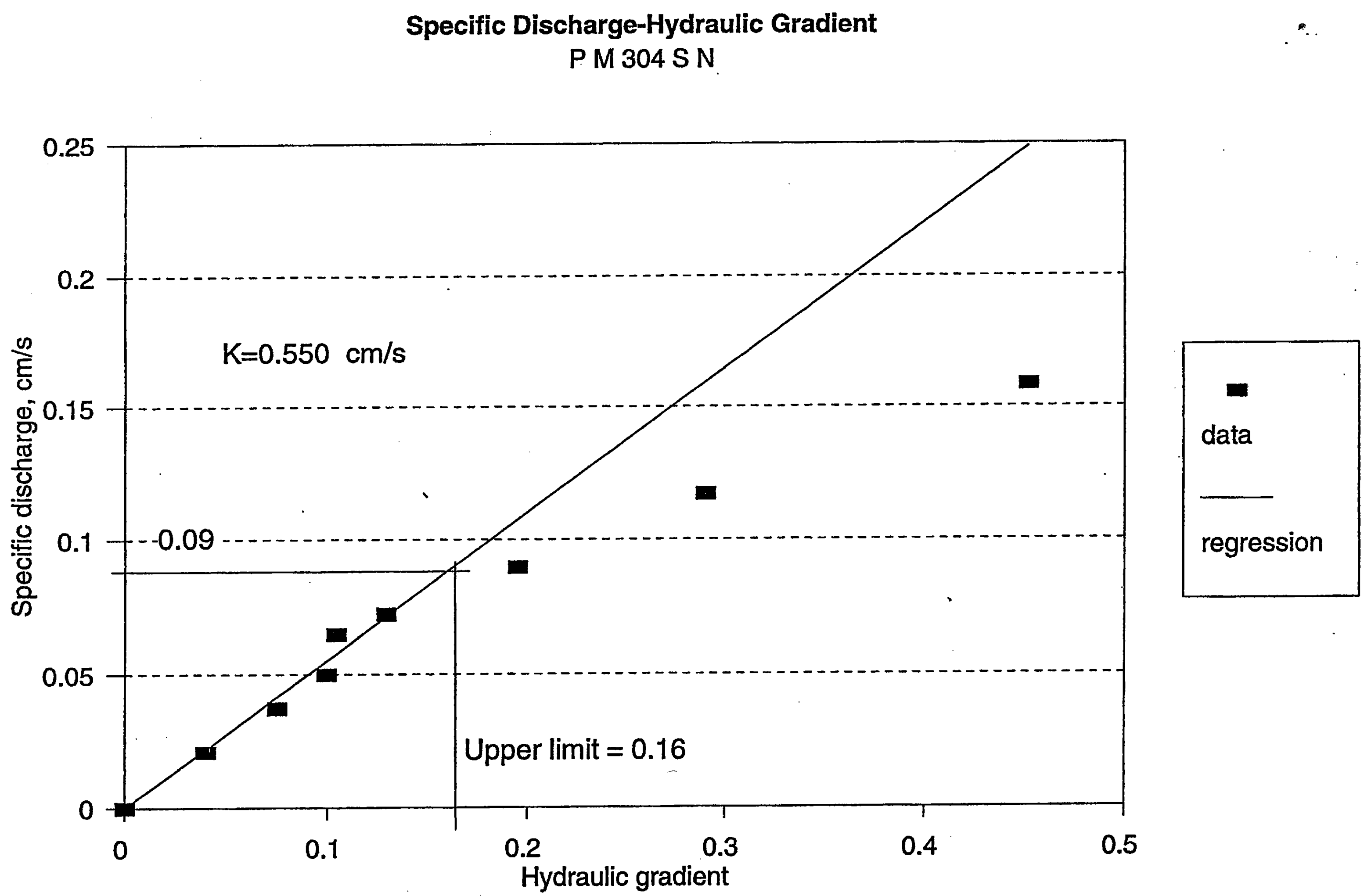

Specific Discharge-Hydraulic Gradient
P M IWA S N
Specific discharge, cm/s
Hydraulic gradient
K=3.079 cm/s
0.12
Upper limit = 0.038
data
regression
0.5
0.4
0.3
0.2
0.1
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16

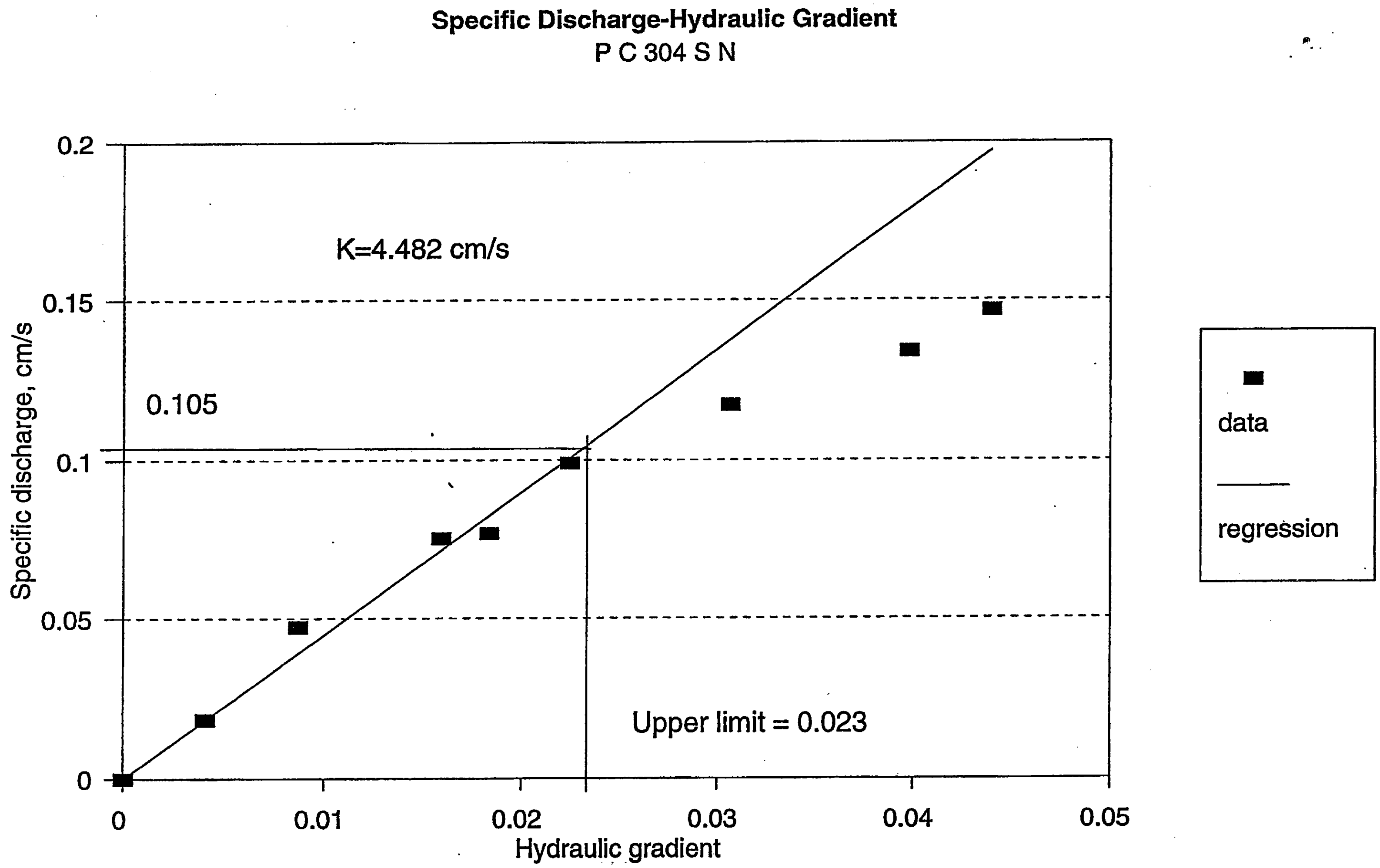
Specific Discharge-Hydraulic Gradient
P C IWA S N

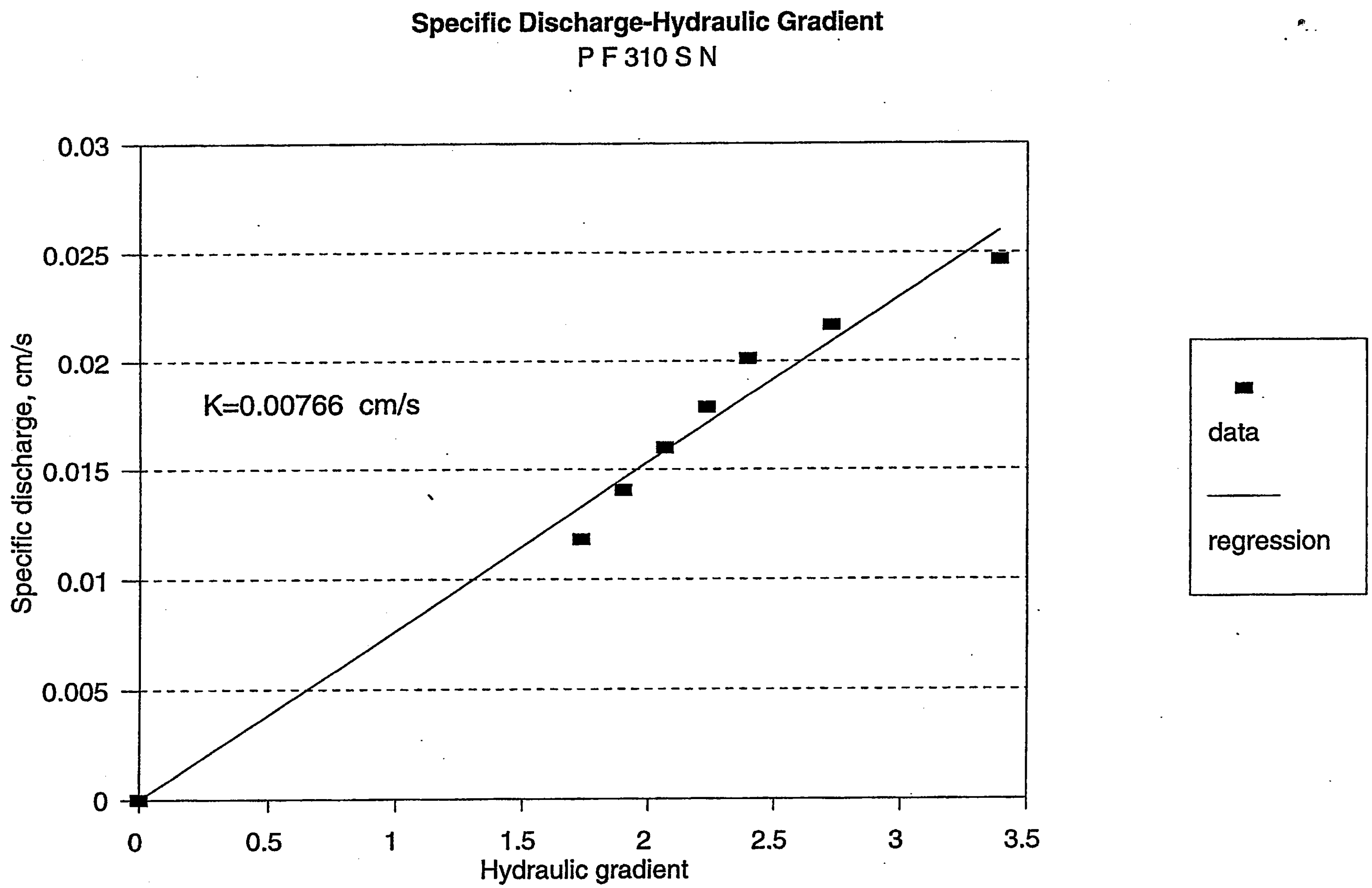


Specific Discharge-Hydraulic Gradient
P F 304 S N

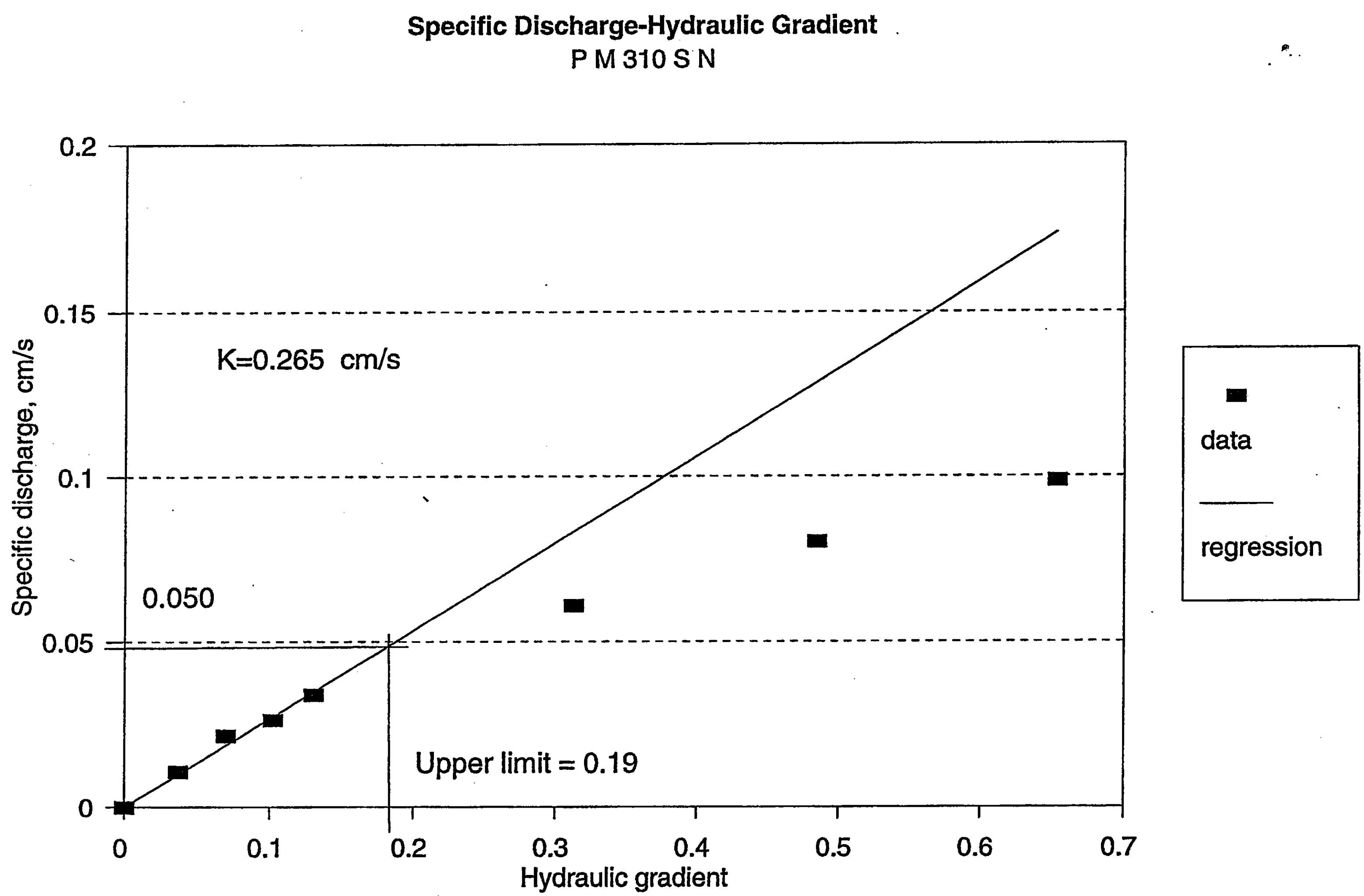


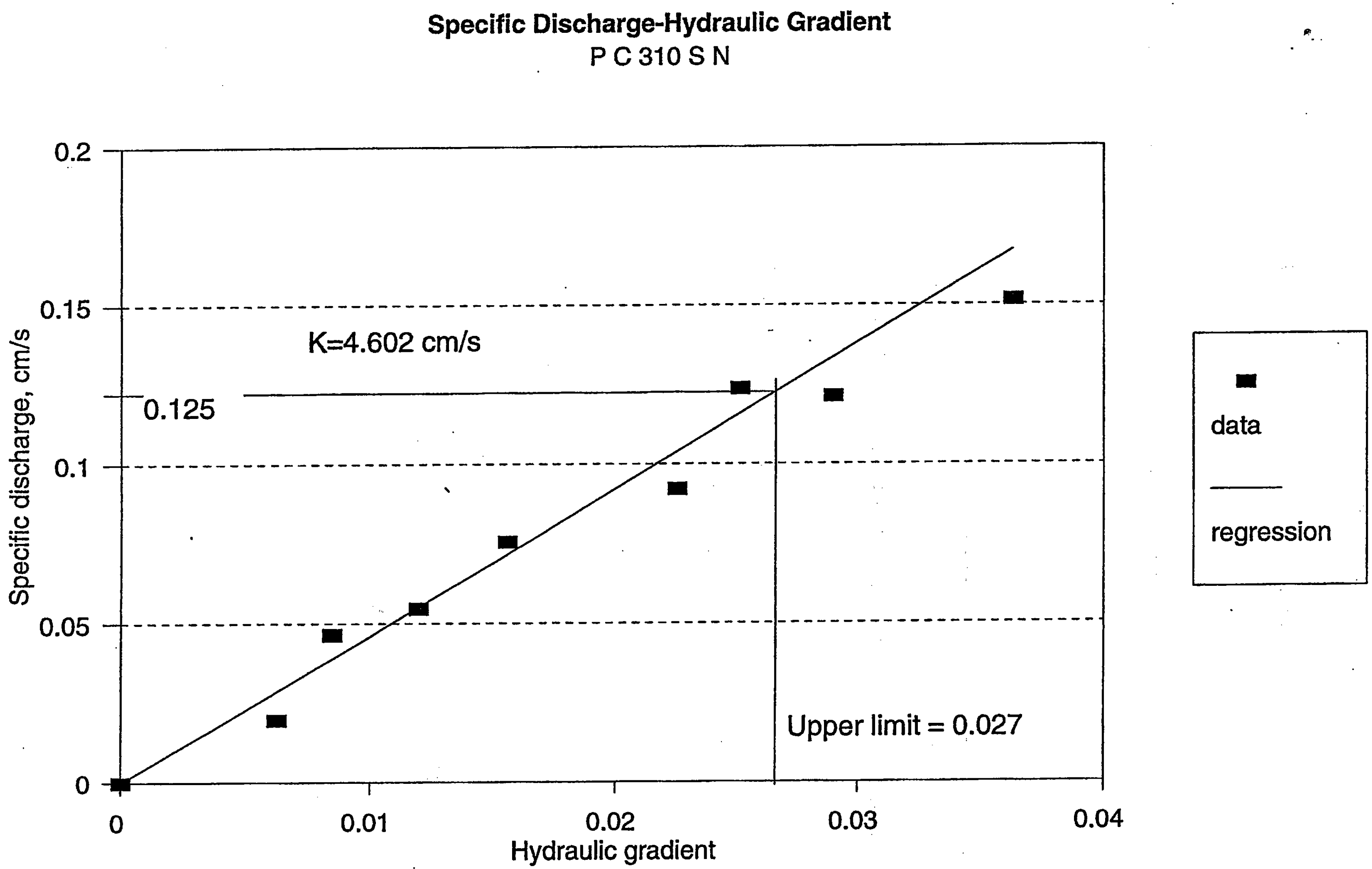

Specific Discharge-Hydraulic Gradient
P M 304 S N
K=0.550 cm/s
-0.09
Upper limit = 0.16
Specific discharge, cm/s
Hydraulic gradient
0.25
0.2
0.15
0.1
0.05
0
0
0.1
0.2
0.3
0.4
0.5
data
regression


Specific Discharge-Hydraulic Gradient
P C 304 S N
K=4.482 cm/s
0.105
Upper limit = 0.023
Specific discharge, cm/s
Hydraulic gradient
0.2
0.15
0.1
0.05
0
0.01
0.02
0.03
0.04
0.05
data
regression



Specific Discharge-Hydraulic Gradient
P F 310 S N
0.03
0.025
0.02
0.015
0.01
0.005
0
Specific discharge, cm/s
K=0.00766 cm/s
0
0.5
1
1.5
2
2.5
3
3.5
Hydraulic gradient
data
regression


Specific Discharge-Hydraulic Gradient
P M 310 S N
K=0.265 cm/s
0.050
Upper limit = 0.19
Specific discharge, cm/s
Hydraulic gradient
0
0.05
0.1
0.15
0.2
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
data
regression



Specific Discharge-Hydraulic Gradient
P C 310 S N
0.2
0.15
0.1
0.05
0
Specific discharge, cm/s
K=4.602 cm/s
0.125
Upper limit = 0.027
0
0.01
0.02
0.03
0.04
Hydraulic gradient
data
regression

Appendix O

Laboratory Test Results of Hydraulic Conductivity For Gravel

Table of Contents

Figures

Page

Hydraulic Conductivity Testing Data & Results

Test Identification **P M 57 G N**

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	11.844	inch				
Sample Height	11.594	inch		0.091	362.27	4542.68
Sample Width	11.813	inch		0.114	220.02	4542.68
				0.152	145.12	4542.68
Dry weight of permeameter box	21.2	lb		0.168	92.29	4542.68
Wet weight of permeameter box	21.6	lb		0.244	67.83	4542.68
Saturated weight of system w/ water	130.8	lb		0.262	59.86	4542.68
				0.356	44.66	4542.68
Dry soil with box	124	lb		0.373	39.05	4542.68
Saturated weight of system w/ soils	195	lb		0.610	28.81	4542.68
Wet weight of soils w/box after drain	127.1	lb		0.648	28.56	4542.68
				0.770	25.13	4542.68
Water temperature T	18.5			1.100	42.00	9085.36

Results

Dry Density	107.499	lb/ft^3
Degree of Saturation	0.984	
Porosity	0.379	
Effective Porosity	0.294	
Void Ratio	0.609	
Hydraulic Conductivity, K	11.512	cm/s
	32631.63	ft/day
The Upper Limit of Hydraulic Gradient	0.014	

Hydraulic Conductivity at 20 degree

K_20= 11.947 cm/s

33865.5 ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification **P M 67 G N**

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	11.844	inch				
Sample Height	11.594	inch		0.142	277.89	4541.86
Sample Width	11.813	inch		0.201	108.20	4541.86
				0.249	75.28	4541.86
Dry weight of permeameter box	21.2	lb		0.262	81.68	4541.86
Wet weight of permeameter box	21.6	lb		0.323	63.43	4541.86
Saturated weight of system w/ water	130.8	lb		0.376	51.62	4541.86
				0.381	46.76	4541.86
Dry soil with box	122.2	lb		0.432	41.96	4541.86
Saturated weight of system w/ soils	194.2	lb		0.569	35.41	4541.86
Wet weight of soils w/box after drain	125.8	lb		0.635	33.38	4541.86
				0.869	27.85	4541.86
Water temperature T	17.5			0.978	24.91	4541.86
				1.140	22.38	4541.86

Results

Dry Density	105.616	lb/ft^3
Degree of Saturation	0.999	
Porosity	0.390	
Effective Porosity	0.303	
Void Ratio	0.638	
Hydraulic Conductivity, K	8.895	cm/s
	25213.138	ft/day
The Upper Limit of Hydraulic Gradient	0.018	

Hydraulic Conductivity at 20 degree

K_20 = 9.470 cm/s

26843.8 ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification **P M NJ G N**

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	11.844	inch				
Sample Height	11.594	inch		0.290	342.70	4542.68
Sample Width	11.813	inch		0.503	188.88	4542.68
				0.742	132.19	4542.68
Dry weight of permeameter box	21.2	lb		0.892	112.40	4542.68
Wet weight of permeameter box	21.6	lb		0.996	104.60	4542.68
Saturated weight of system w/ water	130.8	lb		1.359	78.70	4542.68
				1.471	74.06	4542.68
Dry soil with box	125.8	lb		1.753	63.63	4542.68
Saturated weight of system w/ soils	195.3	lb		2.052	54.84	4542.68
Wet weight of soils w/box after drain	127.8	lb		2.169	52.46	4542.68
				0.000	0.00	0.00
Water temperature T	18.5	Degree C		0.000	0.00	0.00
				0.000	0.00	0

Results

Dry Density	109.381	lb/ft^3
Degree of Saturation	0.949	
Porosity	0.366	
Effective Porosity	0.287	
Void Ratio	0.577	
Hydraulic Conductivity, K at T	1.578	cm/s
	4474.3704	ft/day
The Upper Limit of Hydraulic Gradient	0.042	

Hydraulic Conductivity at 20 degree

K_20 = 1.638 cm/s

4643.6 ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification **P F IWA G N**

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	11.844	inch				
Sample Height	11.594	inch		1.369	156.48	1362.80
Sample Width	11.813	inch		2.318	339.88	5451.21
				3.267	213.82	4542.68
Dry weight of permeameter box	21.2	lb		4.191	172.50	4542.68
Wet weight of permeameter box	21.6	lb		10.019	135.16	6814.02
Saturated weight of system w/ water	130.8	lb		14.917	100.67	6814.02
				19.816	83.38	6814.02
Dry soil with box	143.8	lb		24.765	46.77	4542.68
Saturated weight of system w/ soils	206.3	lb				
Wet weight of soils w/box after drain	150.8	lb				
Water temperature T	18.5					

Results

Dry Density	128.204	lb/ft^3
Degree of Saturation	0.910	
Porosity	0.257	
Effective Porosity	0.082	
Void Ratio	0.345	
Hydraulic Conductivity, K	0.220	cm/s
	624.79318	ft/day
The Upper Limit of Hydraulic Gradient	0.240	

Hydraulic Conductivity at 20 degree

K_20 = 0.229 cm/s

649.6 ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification P M IWA G N

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	11.844	inch				
Sample Height	11.594	inch		0.216	298.84	4536.00
Sample Width	11.813	inch		0.330	170.44	4536.00
				0.574	114.43	4536.00
Dry weight of permeameter box	21.2	lb		0.813	87.00	4536.00
Wet weight of permeameter box	21.6	lb		1.019	71.75	4536.00
Saturated weight of system w/ water	130.8	lb		1.067	66.27	4536.00
				1.524	54.40	4536.00
Dry soil with box	139.8	lb		1.803	46.60	4536.00
Saturated weight of system w/ soils	204.5	lb				
Wet weight of soils w/box after drain	145.6	lb				
Water temperature T	18.5					

Results

Dry Density	124.021	lb/ft^3
Degree of Saturation	0.959	
Porosity	0.281	
Effective Porosity	0.140	
Void Ratio	0.392	
Hydraulic Conductivity, K at T	2.289	cm/s
	6487.4061	ft/day
The Upper Limit of Hydraulic Gradient	0.037	

Hydraulic Conductivity at 20 degree

K_20 = 2.375 cm/s

6732.7 ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification **P C IWA N G**

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	11.844	inch		0.135	231.47	4542.68
Sample Height	11.594	inch		0.206	120.55	4542.68
Sample Width	11.813	inch		0.325	87.41	4542.68
Dry weight of permeameter box	21.2	lb		0.343	77.87	4542.68
Wet weight of permeameter box	21.6	lb		0.442	67.39	4542.68
Saturated weight of system w/ water	130.8	lb		0.582	54.77	4542.68
				0.749	49.75	4542.68
Dry soil with box	131.1	lb		0.899	40.41	4542.68
Saturated weight of system w/ soils	199.5	lb		1.222	29.26	4542.68
Wet weight of soils w/box after drain	135.2	lb				
Water temperature T	18.5					

Results

Dry Density	114.923	lb/ft^3
Degree of Saturation	0.986	
Porosity	0.335	
Effective Porosity	0.233	
Void Ratio	0.504	
Hydraulic Conductivity, K	6.279	cm/s
	17798.09	ft/day
The Upper Limit of Hydraulic Gradient	0.015	

Hydraulic Conductivity at 20 degree

K_20 = 6.516 cm/s

18471.1 ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification **P F 304 G N**

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	11.844	inch				
Sample Height	11.594	inch		28.788	286.91	4542.68
Sample Width	11.813	inch		33.738	245.69	4542.68
				38.712	212.22	4542.68
Dry weight of permeameter box	21.2	lb		43.687	182.98	4542.68
Wet weight of permeameter box	21.6	lb		48.661	165.15	4542.68
Saturated weight of system w/ water	130.8	lb		53.636	148.95	4542.68
				58.636	65.31	2271.34
Dry soil with box	141.8	lb		63.636	63.18	2271.34
Saturated weight of system w/ soils	207.2	lb		68.611	158.63	6814.02
Wet weight of soils w/box after drain	150.2	lb				
Water temperature T	18.5					

Results

Dry Density	126.112	lb/ft^3
Degree of Saturation	1.052	
Porosity	0.269	
Effective Porosity	0.108	
Void Ratio	0.367	
Hydraulic Conductivity, K at T	0.020	cm/s
	56.031951	ft/day
The Upper Limit of Hydraulic Gradient	>2.0	

Hydraulic Conductivity at 20 degree

K_20 = 0.021 cm/s

58.2 ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification **P M 304 G N**

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	11.844	inch		1.016	193.69	2271.34
Sample Height	11.594	inch		2.794	141.38	4542.68
Sample Width	11.813	inch		4.140	122.49	4542.68
Dry weight of permeameter box	21.2	lb		5.359	103.71	4542.68
Wet weight of permeameter box	21.6	lb		6.274	96.13	4542.68
Saturated weight of system w/ water	130.8	lb		7.747	87.07	4542.68
				8.661	85.26	4542.68
Dry soil with box	141.9	lb		13.636	71.41	4542.68
Saturated weight of system w/ soils	205.8	lb		18.611	62.89	4542.68
Wet weight of soils w/box after drain	148.5	lb				
Water temperature T	18.5					

Results

Dry Density	126.217	lb/ft^3
Degree of Saturation	0.959	
Porosity	0.268	
Effective Porosity	0.113	
Void Ratio	0.366	
Hydraulic Conductivity, K at T	0.394	cm/s
	1116.1047	ft/day
The Upper Limit of Hydraulic Gradient	0.090	

Hydraulic Conductivity at 20 degree

K_20 = 0.409 cm/s

1158.3 ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification **P C 304 G N**

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	11.844	inch				
Sample Height	11.594	inch		0.163	182.37	2271.34
Sample Width	11.813	inch		0.295	123.00	2271.34
				0.432	145.22	4542.68
Dry weight of permeameter box	21.2	lb		0.536	76.64	2271.34
Wet weight of permeameter box	21.6	lb		0.706	107.18	4542.68
Saturated weight of system w/ water	130.8	lb		0.775	110.56	4542.68
				1.059	82.77	4542.68
Dry soil with box	139.5	lb		1.351	62.70	4542.68
Saturated weight of system w/ soils	204.2	lb		1.504	31.52	2271.34
Wet weight of soils w/box after drain	144.2	lb		1.793	53.29	4542.68
				2.667	40.30	4542.68
Water temperature T	18.5			2.718	59.75	6814.02
				3.378	33.34	4542.68

Results

Dry Density	123.707	lb/ft^3
Degree of Saturation	0.951	
Porosity	0.286	
Effective Porosity	0.161	
Void Ratio	0.400	
Hydraulic Conductivity, K	1.932	cm/s
	5476.7995	ft/day
The Upper Limit of Hydraulic Gradient	0.048	

Hydraulic Conductivity at 20 degree

K_20 = 2.005 cm/s

5683.9 ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification **P F 310 G N**

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	11.844	inch				
Sample Height	11.594	inch		49.042	293.51	2271.34
Sample Width	11.813	inch		59.042	253.06	2271.34
				79.042	193.63	2271.34
Dry weight of permeameter box	21.2	lb		99.017	146.67	2271.34
Wet weight of permeameter box	21.6	lb		119.017	123.52	2271.34
Saturated weight of system w/ water	130.8	lb				
Dry soil with box	133.6	lb				
Saturated weight of system w/ soils	200.2	lb				
Wet weight of soils w/box after drain	144.6	lb				
Water temperature T	18.5					

Results

Dry Density	117.537	lb/ft^3
Degree of Saturation	0.949	
Porosity	0.317	
Effective Porosity	0.084	
Void Ratio	0.463	
Hydraulic Conductivity, K	0.005	cm/s
	14.857886	ft/day
The Upper Limit of Hydraulic Gradient	>4.0	

Hydraulic Conductivity at 20 degree

K_20 = 0.005 cm/s

15.4 ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification P M 310 G N

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	11.844	inch				
Sample Height	11.594	inch		30.439	196.13	2271.34
Sample Width	11.813	inch		50.389	134.33	2271.34
				60.363	120.07	2271.34
Dry weight of permeameter box	21.2	lb		70.338	101.89	2271.34
Wet weight of permeameter box	21.6	lb		80.287	92.68	2271.34
Saturated weight of system w/ water	130.8	lb		100.236	72.84	2271.34
Dry soil with box	140.6	lb				
Saturated weight of system w/ soils	204.4	lb				
Wet weight of soils w/box after drain	149.2	lb				
Water temperature T	18.5					

Results

Dry Density	124.857	lb/ft^3
Degree of Saturation	0.924	
Porosity	0.276	
Effective Porosity	0.077	
Void Ratio	0.381	
Hydraulic Conductivity, K	0.011	cm/s
	30.454086	ft/day
The Upper Limit of Hydraulic Gradient	>3.5	

Hydraulic Conductivity at 20 degree

K_20 = 0.011 cm/s

31.6 ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification P C 310 G N

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	11.844	inch		0.213	137.31	2271.34
Sample Height	11.594	inch		0.381	75.33	2271.34
Sample Width	11.813	inch		0.485	128.62	4542.68
Dry weight of permeameter box	21.2	lb		0.704	46.74	2271.34
Wet weight of permeameter box	21.6	lb		0.742	94.52	4542.68
Saturated weight of system w/ water	130.8	lb		1.006	71.90	4542.68
				1.151	69.53	4542.68
Dry soil with box	139.2	lb		1.374	55.98	4542.68
Saturated weight of system w/ soils	203.4	lb		2.159	41.76	4542.68
Wet weight of soils w/box after drain	140.7	lb		2.946	34.52	4542.68
Water temperature T	18.5					

Results

Dry Density	123.393	lb/ft^3
Degree of Saturation	0.913	
Porosity	0.286	
Effective Porosity	0.205	
Void Ratio	0.400	
Hydraulic Conductivity, K at T	2.361	cm/s
	6691.2592	ft/day
The Upper Limit of Hydraulic Gradient	0.040	

Hydraulic Conductivity at 20 degree

K_20 = 2.450 cm/s

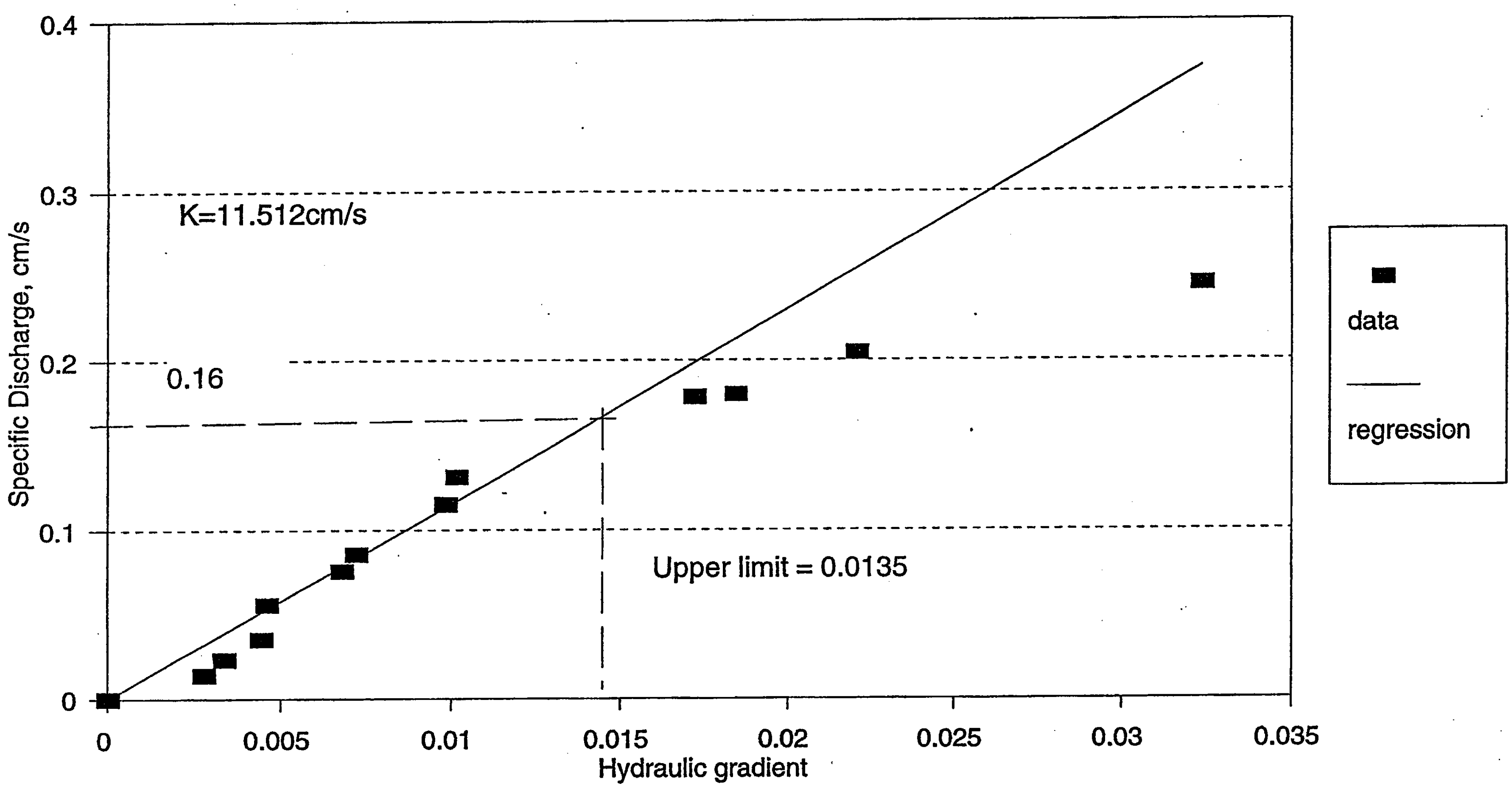
6944.3 ft./day

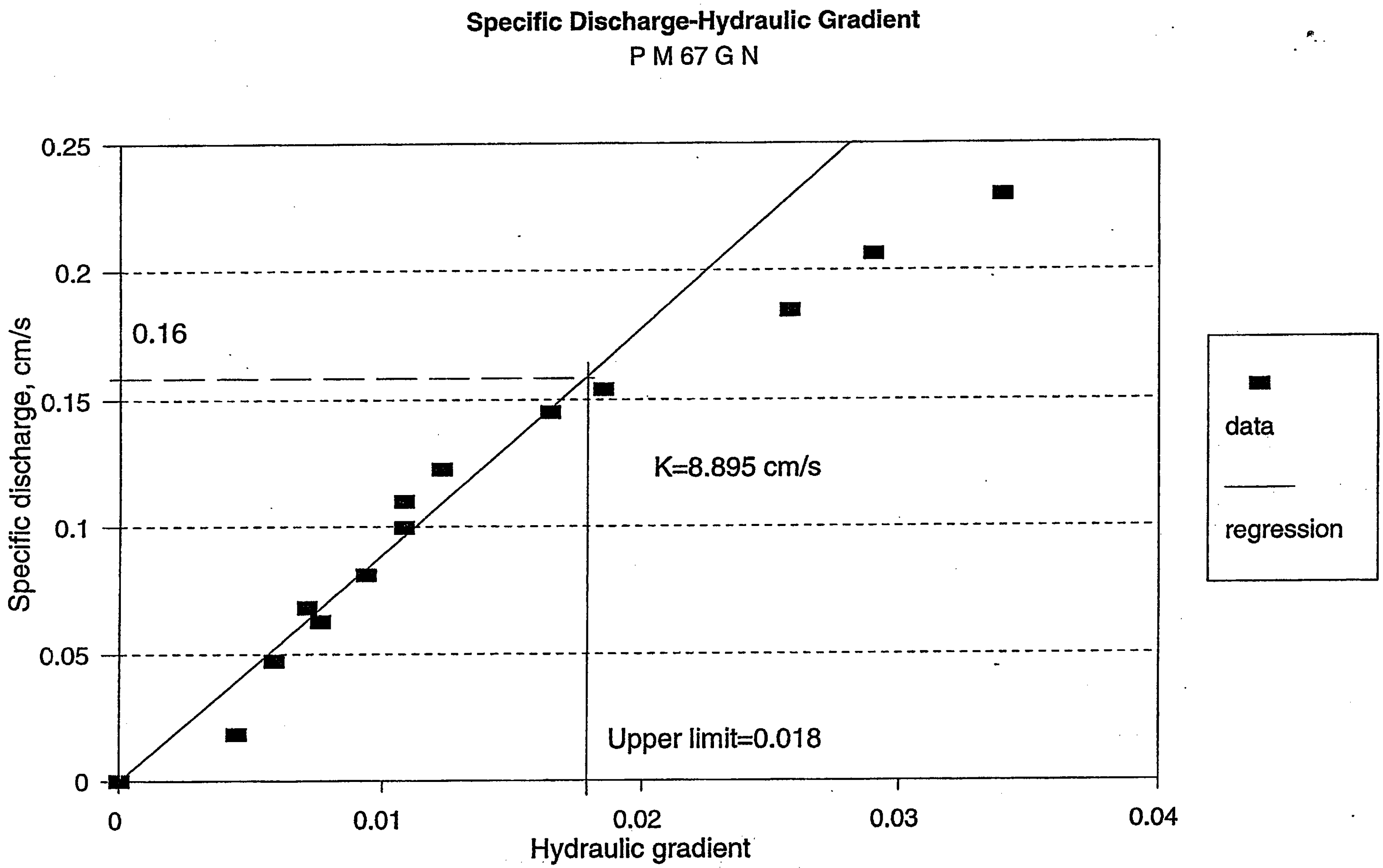
Overall Test Results of Hydraulic Conductivity

For Gravel

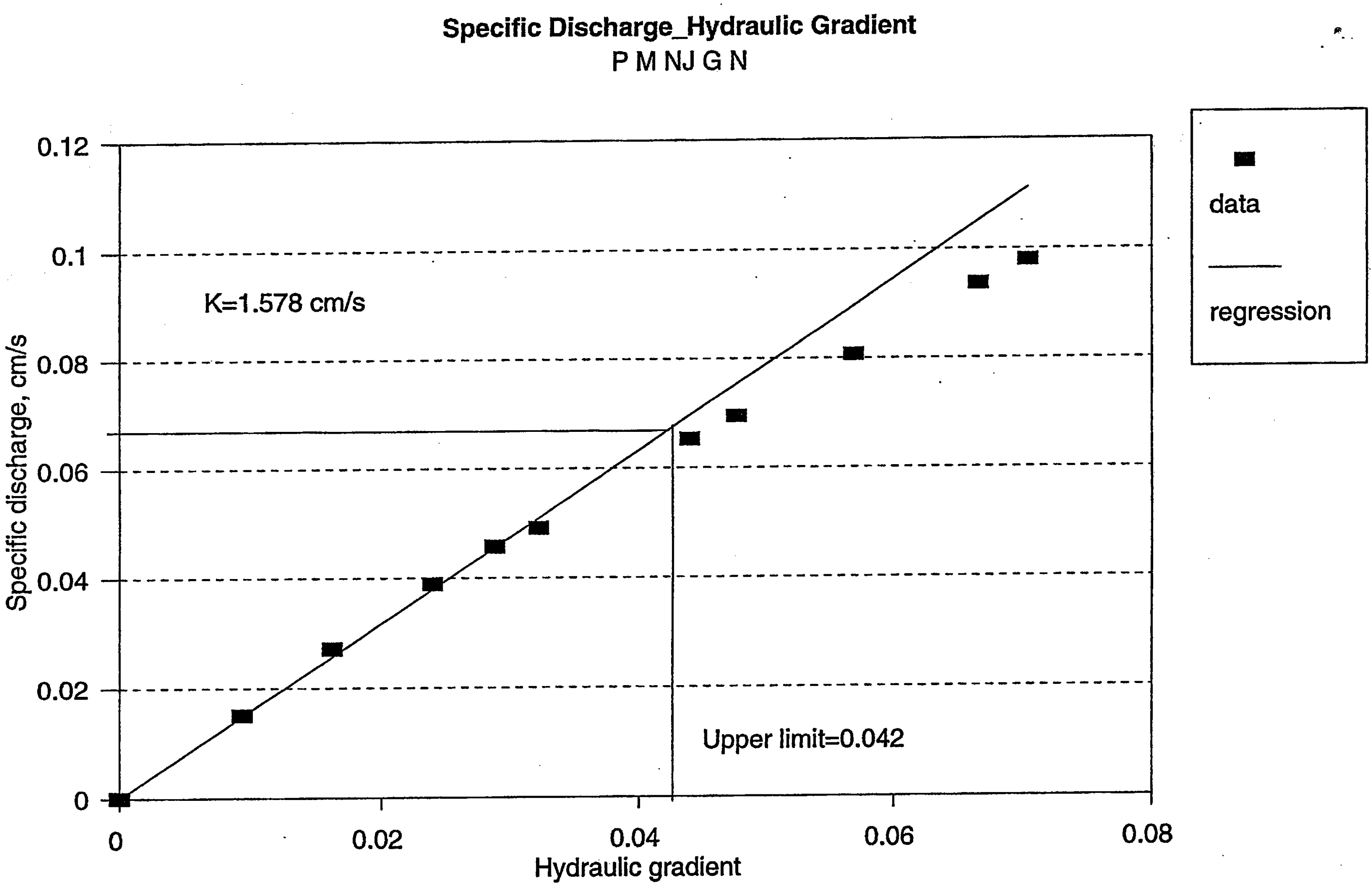
Type	Gradation	Dry Density	Degree of Saturation	Hydraulic Conductivity At 20		i_upper
		lb/ft^3		cm/s	ft/day	
No. 57	F M C	107.5	98.4%	11.95	33,800	0.014
No. 67	M	105.6	99.9%	9.47	26,800	0.018
N.J.Mix	M	109.4	94.9%	1.64	4,640	0.042
Iowa Mix	F	128.2	91.0%	0.23	649	0.240
	M	124.0	95.9%	2.38	6,730	0.037
	C	114.9	98.6%	6.52	18,400	0.015
ODOT 304	F	126.1	105.2%	0.02	111	>2.0
	M	126.2	95.9%	0.41	1,150	0.090
	C	123.7	95.1%	2.01	5,680	0.048
ODOT 310	F	117.5	94.9%	0.01	14	>4.0
	M	124.9	92.4%	0.01	31	>3.5
	C	123.4	91.3%	2.45	6,940	0.040

Specific Discharge-Hydraulic Gradient
P M 57 G N



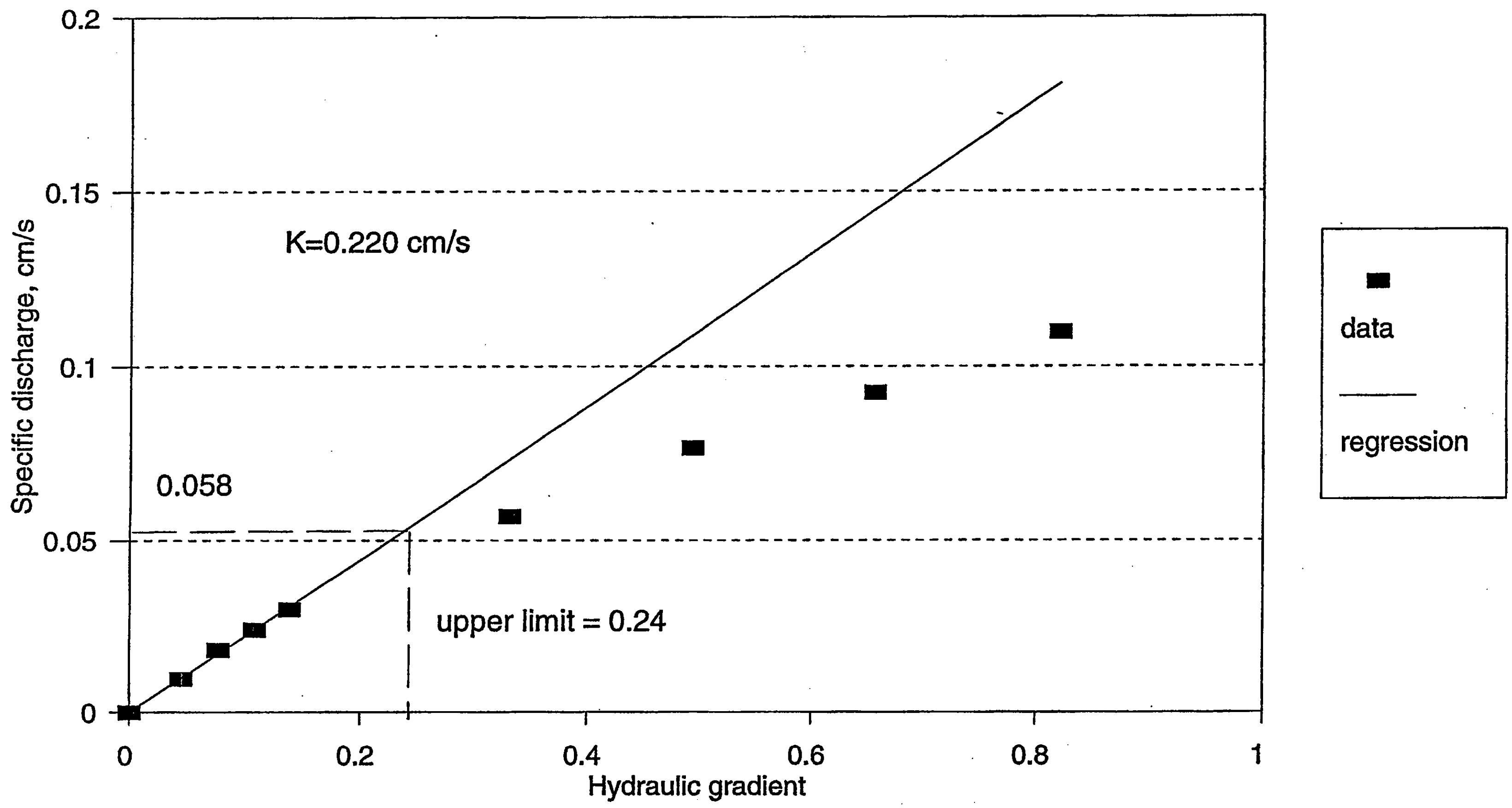


Specific Discharge-Hydraulic Gradient
P M 67 G N
0.25
0.2
0.16
0.15
0.1
0.05
0
Specific discharge, cm/s
K=8.895 cm/s
Upper limit=0.018
0
0.01
0.02
0.03
0.04
Hydraulic gradient
data
regression

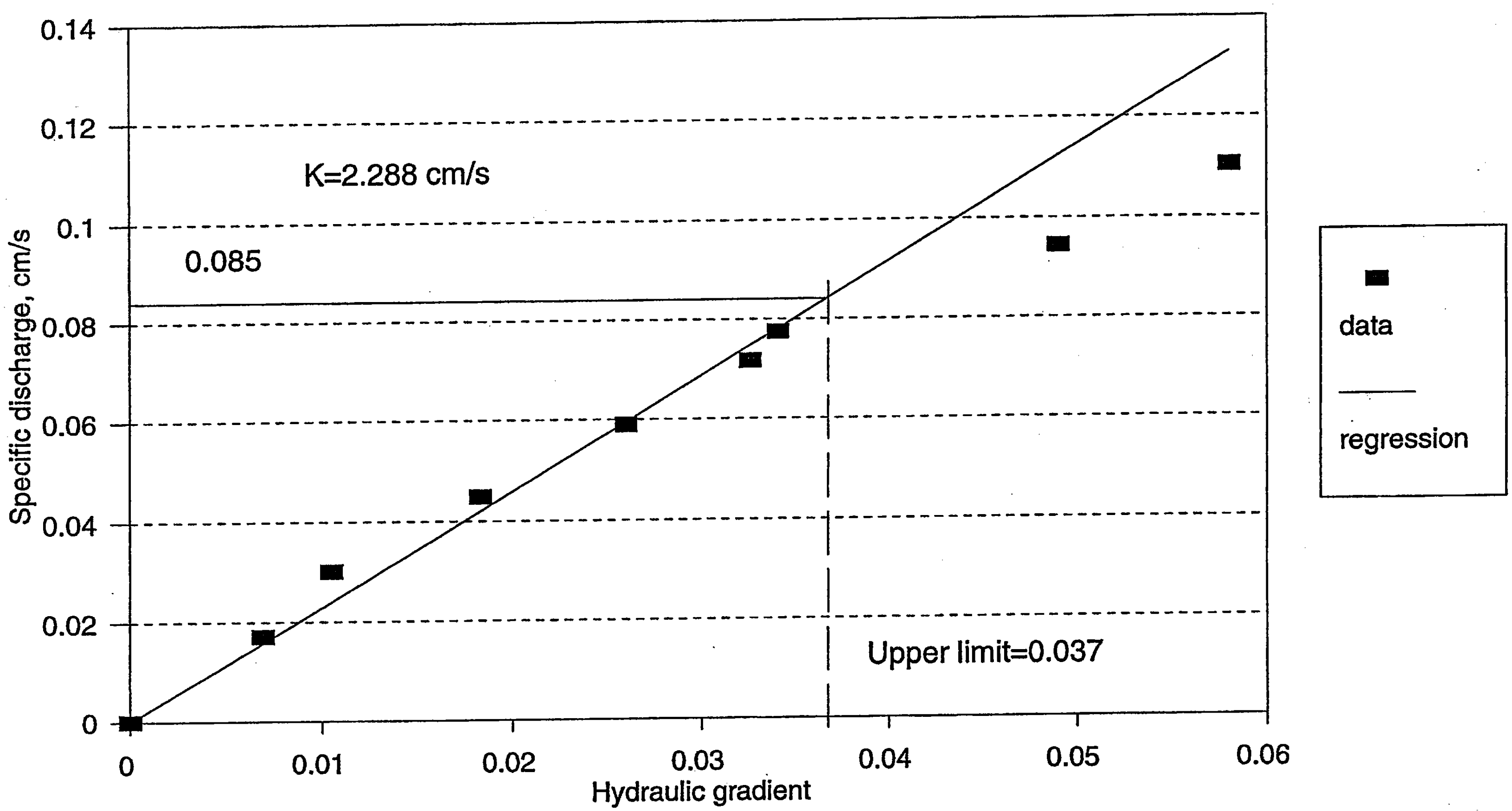


Specific Discharge_Hydraulic Gradient
P M NJ G N
0.12
0.1
0.08
0.06
0.04
0.02
0
Specific discharge, cm/s
K=1.578 cm/s
Upper limit=0.042
0
0.02
0.04
0.06
0.08
Hydraulic gradient
data
regression

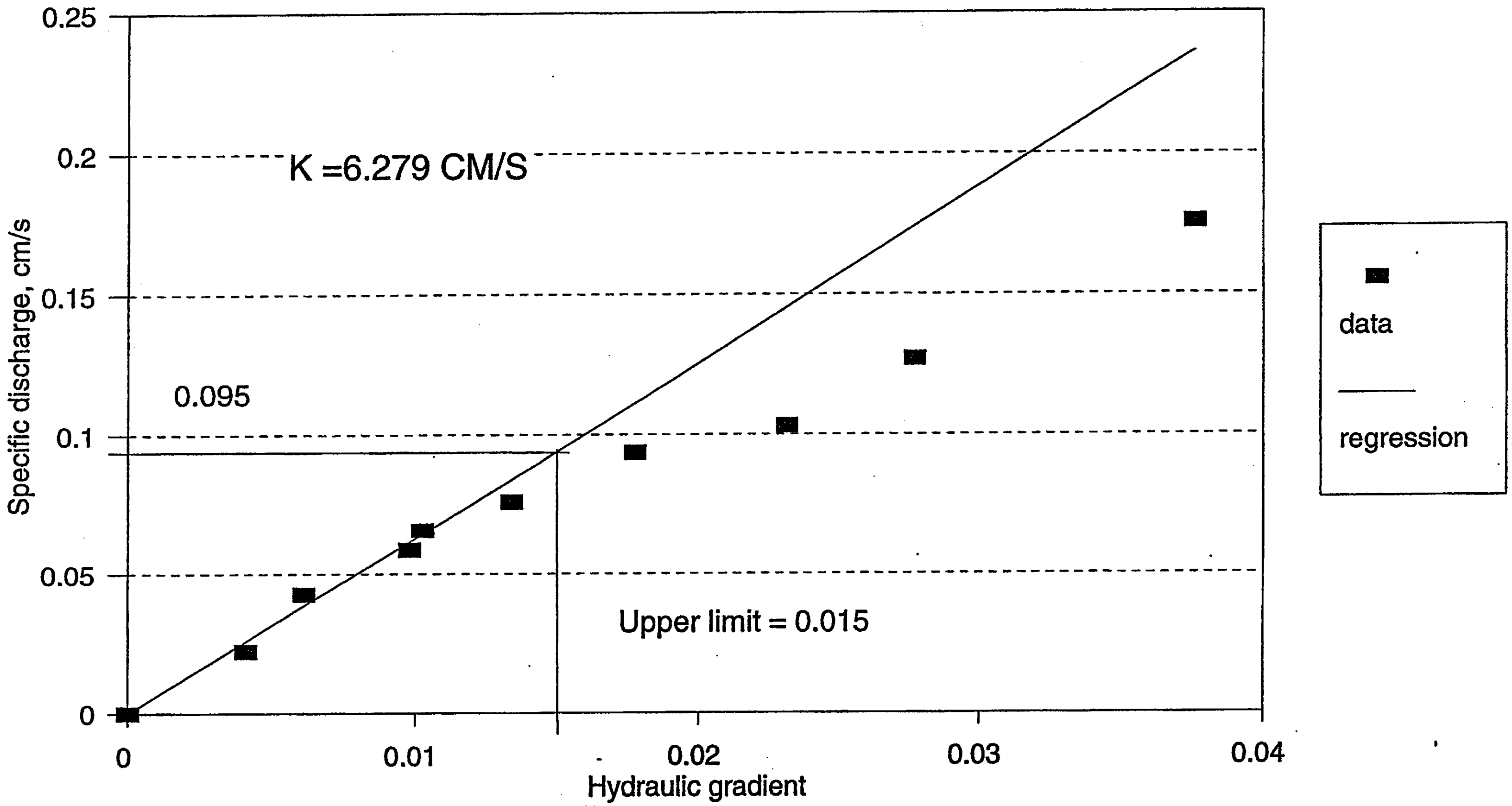
Specific Discharge-Hydraulic Gradient
P F IWA G N

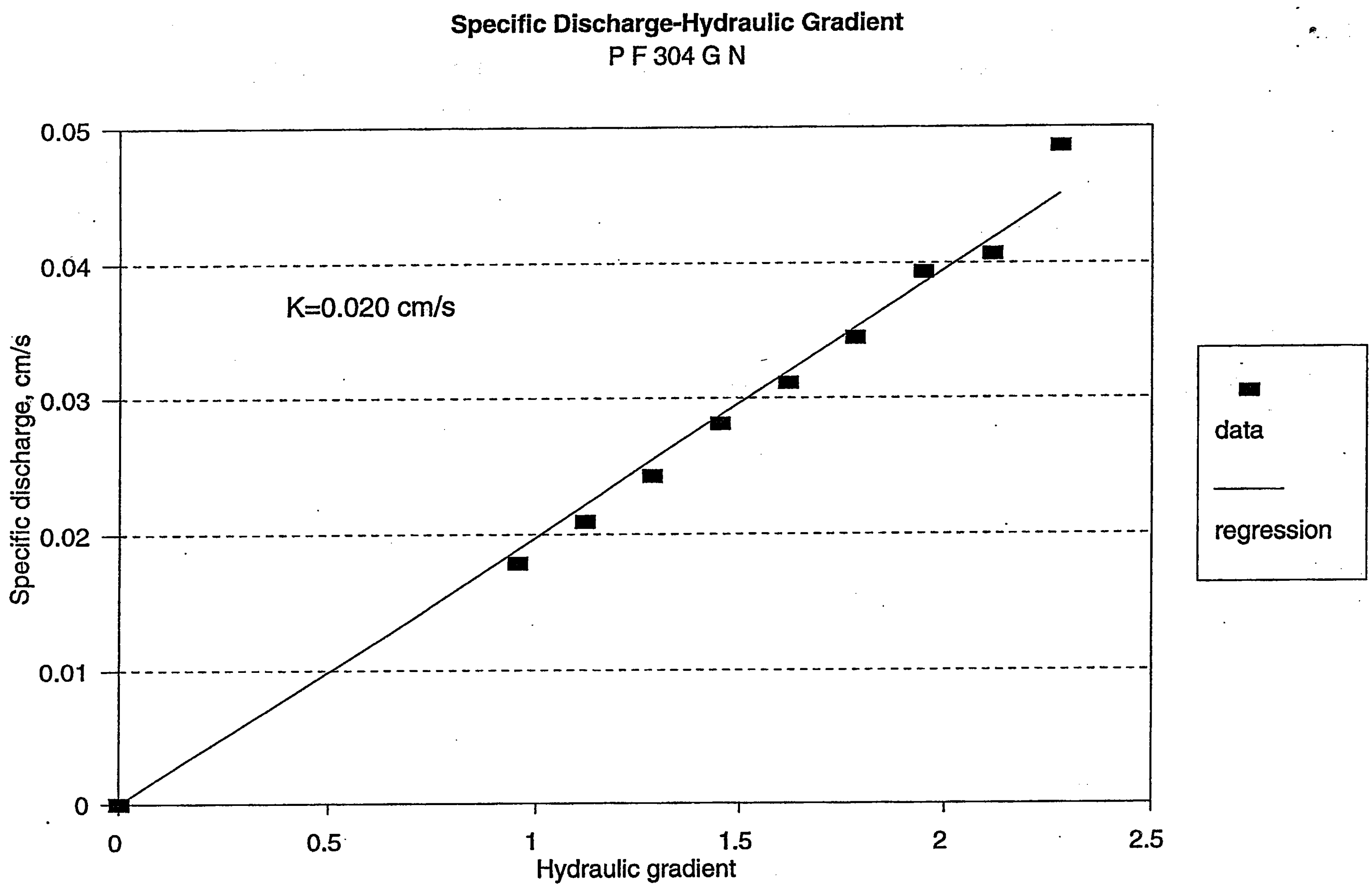


Specific Discharge-Hydraulic Gradient
P M IWA G N

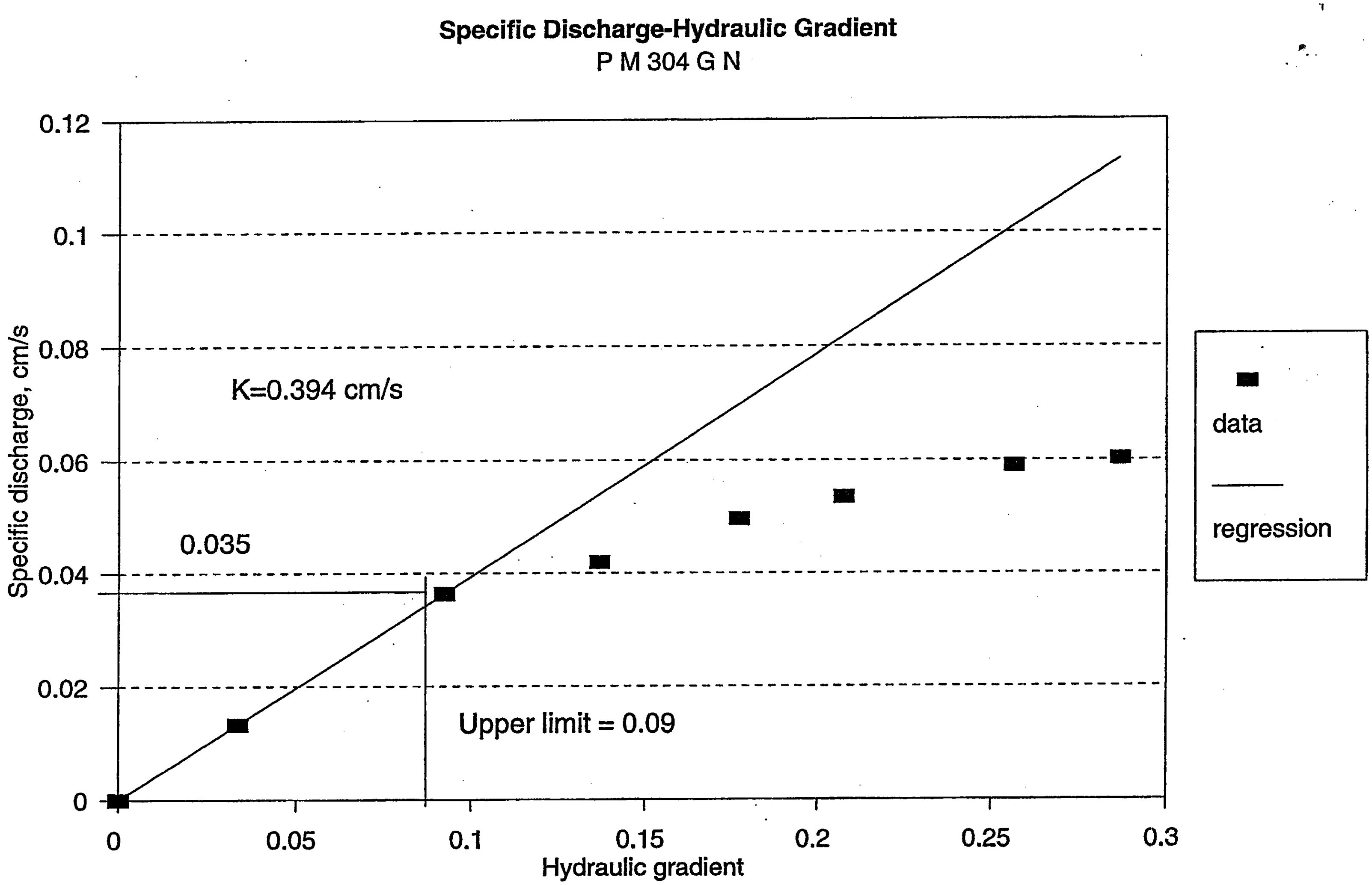


Specific Discharge-Hydraulic Gradient
P C IWA G N

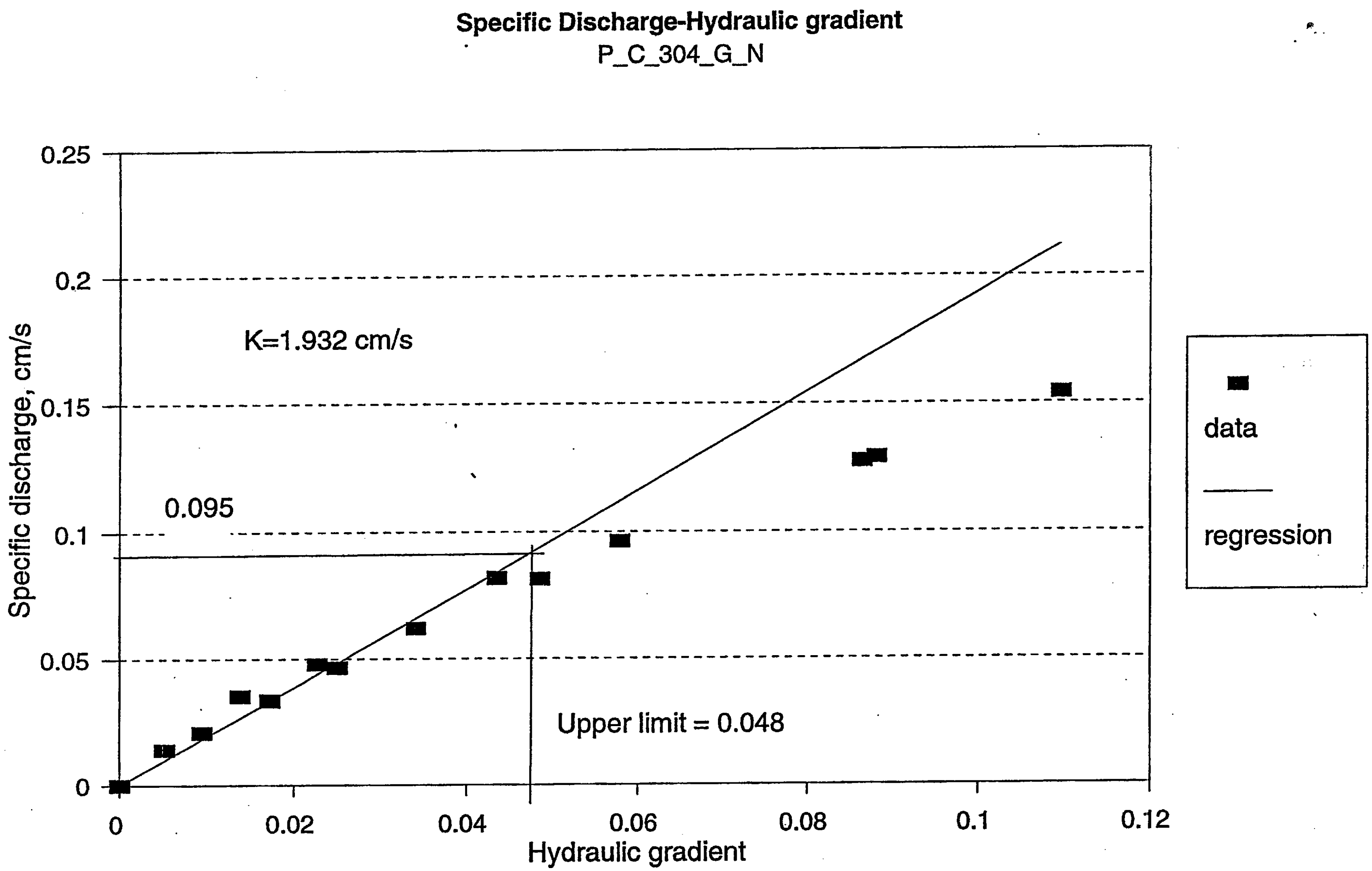




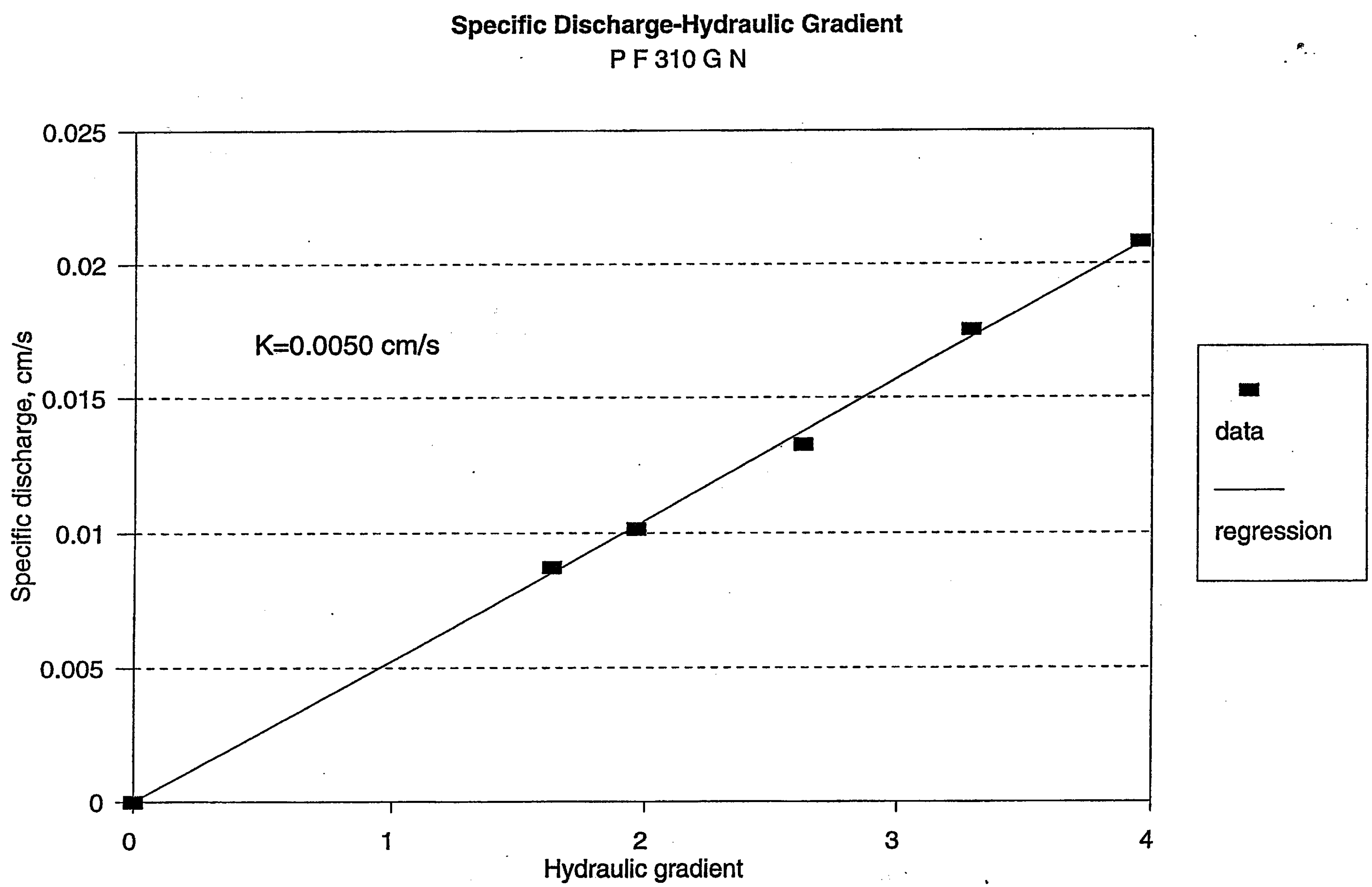
Specific Discharge-Hydraulic Gradient
P F 304 G N
K=0.020 cm/s
Specific discharge, cm/s
Hydraulic gradient
0.05
0.04
0.03
0.02
0.01
0
0
0.5
1
1.5
2
2.5
data
regression

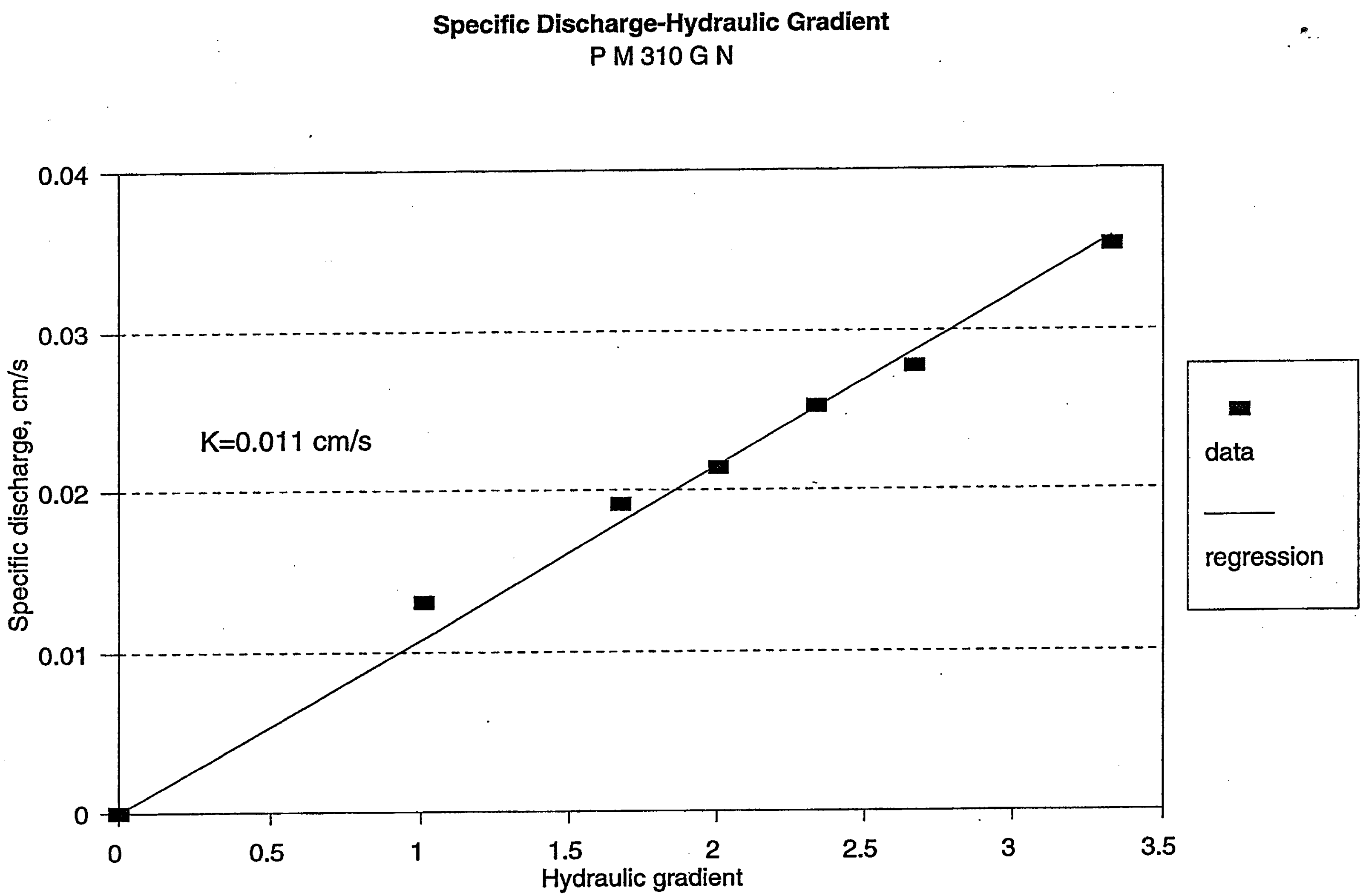


Specific Discharge-Hydraulic Gradient
P M 304 G N
Specific discharge, cm/s
0.12
0.1
0.08
0.06
0.04
0.02
0
K=0.394 cm/s
0.035
Upper limit = 0.09
0
0.05
0.1
0.15
0.2
0.25
0.3
Hydraulic gradient
data
regression

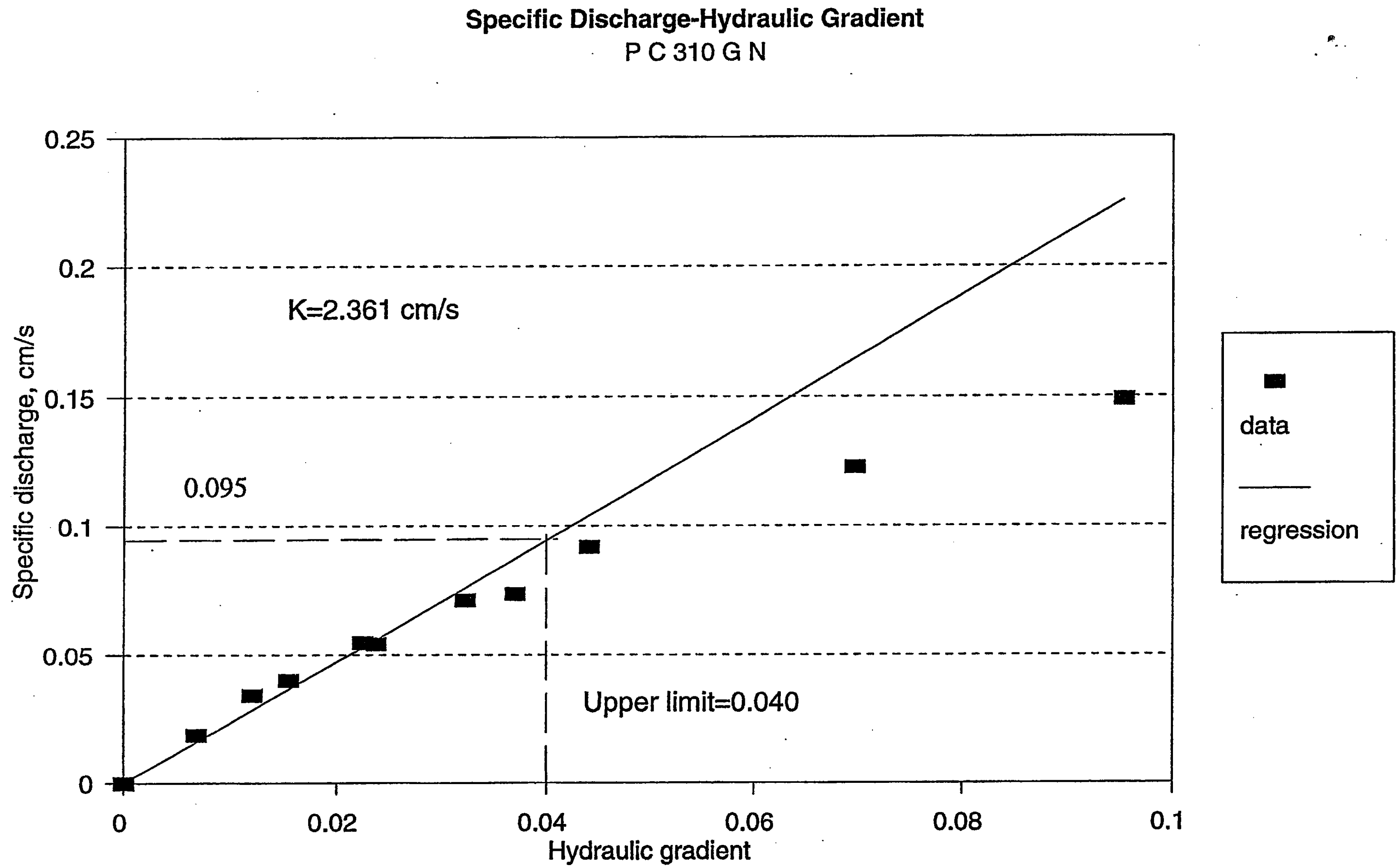


Specific Discharge-Hydraulic gradient
P_C_304_G_N
Specific discharge, cm/s
Hydraulic gradient
0.25
0.2
0.15
0.1
0.05
0
0
0.02
0.04
0.06
0.08
0.1
0.12
K=1.932 cm/s
0.095
Upper limit = 0.048
data
regression


Specific Discharge-Hydraulic Gradient
P F 310 G N
0.025
0.02
0.015
0.01
0.005
0
Specific discharge, cm/s
K=0.0050 cm/s
0
1
2
3
4
Hydraulic gradient
data
regression



Specific Discharge-Hydraulic Gradient
P M 310 G N
0.04
0.03
0.02
0.01
0
Specific discharge, cm/s
K=0.011 cm/s
0
0.5
1
1.5
2
2.5
3
3.5
Hydraulic gradient
data
regression



Specific Discharge-Hydraulic Gradient
P C 310 G N
K=2.361 cm/s
0.095
Upper limit=0.040
Specific discharge, cm/s
Hydraulic gradient
0.25
0.2
0.15
0.1
0.05
0
0
0.02
0.04
0.06
0.08
0.1
data
regression

Appendix P

Laboratory Test Results of Hydraulic Conductivity For Stabilized Materials

Table of Contents

Figures **Page**

Hydraulic Conductivity Testing Data & Results

Test Identification **P F 57 L A**

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	5.5	inch				
Sample Height	11.05	inch		0.094	93.91	4540.31
Sample Width	10.2	inch		0.112	79.86	4540.31
				0.114	80.07	4540.31
Dry weight of permeameter box	21.2	lb		0.157	69.27	4540.31
Wet weight of permeameter box	21.6	lb		0.193	64.26	4540.31
				0.292	51.80	4540.31
Sample weight after mixing	36.4	lb		0.409	43.58	4540.31
Sample weight before saturate w/box	57.6	lb				
Wet weight of soils w.box after drain	59.2	lb				
Water temperature T	15.5	Degree C				

Results

Dry Density	101.466	lb/ft^3
Hydraulic Conductivity, K	8.971	cm/s
	25428.547	ft/day
The Upper Limit of Hydraulic Gradient	0.011	

Hydraulic Conductivity at 20 degree

K_20 = 10.042 cm/s

28464.8 ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification P M 57 L A

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	5.5	inch				
Sample Height	11.05	inch		0.076	120.49	4540.31
Sample Width	10.2	inch		0.104	95.38	4540.31
				0.112	69.77	4540.31
Dry weight of permeameter box	21.2	lb		0.124	66.82	4540.31
Wet weight of permeameter box	21.6	lb		0.145	60.93	4540.31
				0.180	53.16	4540.31
Sample weight after mixing	35.7	lb		0.246	43.71	4540.31
Sample weight before saturate w/box	56.9	lb				
Wet weight of soils w.box after drain	58.4	lb				
Water temperature T	15.5	Degree C				

Results

Dry Density	99.5146	lb/ft^3
Hydraulic Conductivity, K	10.040	cm/s
	28459.789	ft/day
The Upper Limit of Hydraulic Gradient	0.011	

Hydraulic Conductivity at 20 degree

K_20 = 11.239 cm/s

31858.0 ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification **P C 57 L A**

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	5.5	inch				
Sample Height	11.05	inch		0.043	175.47	4540.31
Sample Width	10.2	inch		0.079	94.05	4540.31
				0.104	70.16	4540.31
Dry weight of permeameter box	21.2	lb		0.135	62.88	4540.31
Wet weight of permeameter box	21.6	lb		0.170	55.31	4540.31
				0.221	43.70	4540.31
Sample weight after mixing	36.5	lb		0.264	40.22	4540.31
Sample weight before saturate w/box	57.6	lb				
Wet weight of soils w.box after drain	59	lb				
Water temperature T	15.5	Degree C				

Results

Dry Density	101.745	lb/ft^3
Hydraulic Conductivity, K	11.826	cm/s
	33521.935	ft/day
The Upper Limit of Hydraulic Gradient	0.008	

Hydraulic Conductivity at 20 degree

K_20 = 13.238 cm/s

37524.6 ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification P M 67 L A

Data

Item	Data	Unit
Sample Length	5.5	inch
Sample Height	11.05	inch
Sample Width	10.2	inch
Dry weight of permeameter box	21.2	lb
Wet weight of permeameter box	21.6	lb
Sample weight after mixing	37.7	lb
Sample weight before saturate w/box	58.9	lb
Wet weight of soils w.box after drain	60.7	lb
Water temperature T	15.5	Degree C

Delta H,cm	t, sec.	Water, V, cm^3
0.056	137.23	4540.31
0.084	82.56	4540.31
0.109	67.71	4540.31
0.132	52.02	4540.31
0.173	43.62	4540.31
0.224	37.39	4540.31
0.297	32.28	4540.31

Results

Dry Density	105.09	lb/ft^3
Hydraulic Conductivity, K	11.973	cm/s
	33939.328	ft/day
The Upper Limit of Hydraulic Gradient	0.013	

Hydraulic Conductivity at 20 degree

K_20 = 13.403 cm/s

37991.8 ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification P M 57 S A

Data

Item	Data	Unit
Sample Length	5.5	inch
Sample Height	11.05	inch
Sample Width	10.2	inch
Dry weight of permeameter box	21.2	lb
Wet weight of permeameter box	21.6	lb
Sample weight after mixing	32.3	lb
Sample weight before saturate w/box	53.5	lb
Wet weight of soils w.box after drain		lb
Water temperature T	15.5	Degree C

Delta H,cm	t, sec.	Water, V, cm^3
0.081	87.68	4540.31
0.102	70.01	4540.31
0.130	60.76	4540.31
0.140	61.24	4540.31
0.155	58.23	4540.31
0.224	39.70	4540.31
0.312	34.26	4540.31

Results

Dry Density	90.037	lb/ft^3
Hydraulic Conductivity, K	11.111	cm/s
	31495.693	ft/day
The Upper Limit of Hydraulic Gradient	0.011	

Hydraulic Conductivity at 20 degree

K_20 = 12.438 cm/s

35256.4 ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification **P M 67 S A**

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	5.5	inch				
Sample Height	11.05	inch		0.084	108.30	4540.31
Sample Width	10.2	inch		0.137	75.46	4540.31
				0.165	60.54	4540.31
Dry weight of permeameter box	21.2	lb		0.178	56.00	4540.31
Wet weight of permeameter box	21.6	lb		0.218	57.04	4540.31
				0.292	43.70	4540.31
Sample weight after mixing	33.4	lb		0.000	0.00	0.00
Sample weight before saturate w/box	54.6	lb				
Wet weight of soils w.box after drain	56.5	lb				
Water temperature T	15.5	Degree C				

Results

Dry Density	93.1033 lb/ft^3
Hydraulic Conductivity, K	8.725 cm/s
	24732.316 ft/day
The Upper Limit of Hydraulic Gradient	0.012

Hydraulic Conductivity at 20 degree

K_20 = 9.767 cm/s

27685.4 ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification PM 57 G A

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	5.5	inch				
Sample Height	11.05	inch		0.076	133.42	4540.31
Sample Width	10.2	inch		0.104	103.61	4540.31
				0.140	88.81	4540.31
Dry weight of permeameter box	21.2	lb		0.152	80.87	4540.31
Wet weight of permeameter box	21.6	lb		0.183	67.49	4540.31
				0.224	58.01	4540.31
Sample weight after mixing	41.4	lb		0.302	45.58	4540.31
Sample weight before saturate w/box	62.6	lb				
Wet weight of soils w.box after drain	64.5	lb				
Water temperature T	15.5	Degree C				

Results

Dry Density	115.403	lb/ft^3
Hydraulic Conductivity, K	7.253	cm/s
	20559.417	ft/day
The Upper Limit of Hydraulic Gradient	0.015	

Hydraulic Conductivity at 20 degree

K_20 = 8.119 cm/s

23014.3 ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification P M 67 G A

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	5.5	inch				
Sample Height	11.05	inch		0.066	122.79	4540.31
Sample Width	10.2	inch		0.079	95.11	4540.31
				0.114	70.33	4540.31
Dry weight of permeameter box	21.2	lb		0.157	58.39	4540.31
Wet weight of permeameter box	21.6	lb		0.178	60.92	4540.31
				0.376	33.59	4540.31
Sample weight after mixing	39.4	lb		0.000	0.00	0.00
Sample weight before saturate w/box	60.6	lb				
Wet weight of soils w.box after drain	61.6	lb				
Water temperature T	15.5	Degree C				

Results

Dry Density	109.828	lb/ft^3
Hydraulic Conductivity, K	11.024	cm/s
	31247.884	ft/day
The Upper Limit of Hydraulic Gradient	0.008	

Hydraulic Conductivity at 20 degree

K_20 = 12.340 cm/s

34979.0 ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification **P M 57 L P**

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	5.5	inch		0.107	78.65	4540.31
Sample Height	11.05	inch		0.119	68.15	4540.31
Sample Width	10.2	inch		0.130	62.66	4540.31
Dry weight of permeameter box	21.2	lb		0.157	57.42	4540.31
Wet weight of permeameter box	21.6	lb		0.193	46.74	4540.31
				0.391	33.20	4540.31
Sample weight after mixing	40	lb		0.000	0.00	0.00
Sample weight before saturate w/box	60.7	lb				
Wet weight of soils w.box after drain	62.1	lb				
Water temperature T	15.5	Degree C				

Results

Dry Density	111.501	lb/ft^3
Hydraulic Conductivity, K	10.625	cm/s
	30117.002	ft/day
The Upper Limit of Hydraulic Gradient	0.011	

Hydraulic Conductivity at 20 degree

K_20 = 11.893 cm/s

33713.1 ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification **P M 67 L P**

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	5.5	inch				
Sample Height	11.05	inch		0.086	137.63	4540.68
Sample Width	10.2	inch		0.160	79.50	4540.68
				0.206	62.02	4540.68
Dry weight of permeameter box	21.2	lb		0.287	47.68	4540.68
Wet weight of permeameter box	21.6	lb		0.472	64.66	9081.35
				0.643	26.95	4540.68
Sample weight after mixing	39.7	lb		0.000	0.00	0.00
Sample weight before saturate w/box	60.8	lb				
Wet weight of soils w.box after drain	62.7	lb				
Water temperature T	16	Degree C				

Results

Dry Density	110.665	lb/ft^3
Hydraulic Conductivity, K	6.870	cm/s
	19475.027	ft/day
The Upper Limit of Hydraulic Gradient	0.023	

Hydraulic Conductivity at 20 degree

K_20 = 7.595 cm/s

21529.1 ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification **P M 57 S P**

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	5.5	inch				
Sample Height	11.05	inch		0.066	164.96	4540.68
Sample Width	10.2	inch		0.091	110.16	4540.68
				0.127	78.10	4540.68
Dry weight of permeameter box	21.2	lb		0.180	61.81	4540.68
Wet weight of permeameter box	21.6	lb		0.241	44.54	4540.68
				0.333	35.25	4540.68
Sample weight after mixing	36.3	lb		0.000	0.00	0.00
Sample weight before saturate w/box	57	lb				
Wet weight of soils w.box after drain	59	lb				
Water temperature T	16	Degree C				

Results

Dry Density	101.187	lb/ft^3
Hydraulic Conductivity, K	8.616	cm/s
	24422.106	ft/day
The Upper Limit of Hydraulic Gradient	0.018	

Hydraulic Conductivity at 20 degree

K_20 = 9.524 cm/s

26998.0 ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification **P M 67 S P**

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	5.5	inch				
Sample Height	11.05	inch		0.084	133.86	4540.68
Sample Width	10.2	inch		0.117	77.58	4540.68
				0.137	59.36	4540.68
Dry weight of permeameter box	21.2	lb		0.160	51.31	4540.68
Wet weight of permeameter box	21.6	lb		0.216	47.91	4540.68
				0.234	45.05	4540.68
Sample weight after mixing	36.5	lb		0.000	0.00	0.00
Sample weight before saturate w/box	57.2	lb				
Wet weight of soils w.box after drain	58.4	lb				
Water temperature T	16	Degree C				

Results

Dry Density	101.745	lb/ft^3
Hydraulic Conductivity, K	10.747	cm/s
	30464.794	ft/day
The Upper Limit of Hydraulic Gradient	0.010	

Hydraulic Conductivity at 20 degree

K_{20} = 11.881 cm/s

33678.0 ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification P F 57 G P

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	5.5	inch				
Sample Height	11.05	inch		0.071	103.28	4540.68
Sample Width	10.2	inch		0.112	72.21	4540.68
				0.137	63.02	4540.68
Dry weight of permeameter box	21.2	lb		0.152	61.37	4540.68
Wet weight of permeameter box	21.6	lb		0.191	50.41	4540.68
				0.244	42.72	4540.68
Sample weight after mixing	42.125	lb		0.305	37.46	4540.68
Sample weight before saturate w/box	62.825	lb				
Wet weight of soils w.box after drain	64.6	lb				
Water temperature T	16	Degree C				

Results

Dry Density	117.424	lb/ft^3
Hydraulic Conductivity, K	10.567	cm/s
	29954.441	ft/day
The Upper Limit of Hydraulic Gradient	0.010	

Hydraulic Conductivity at 20 degree

K_20 = 11.682 cm/s

33113.8 ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification P M 57 G P

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	5.5	inch				
Sample Height	11.05	inch		0.038	203.46	4540.68
Sample Width	10.2	inch		0.076	123.14	4540.68
				0.127	96.10	4540.68
Dry weight of permeameter box	21.2	lb		0.152	108.27	4540.68
Wet weight of permeameter box	21.6	lb		0.224	57.90	4540.68
				0.312	46.11	4540.68
Sample weight after mixing	43.44	lb		0.531	33.92	4540.68
Sample weight before saturate w/box	64.1	lb				
Wet weight of soils w.box after drain	66.7	lb				
Water temperature T	16	Degree C				

Results

Dry Density	121.09	lb/ft^3
Hydraulic Conductivity, K	7.914	cm/s
	22433.613	ft/day
The Upper Limit of Hydraulic Gradient	0.012	

Hydraulic Conductivity at 20 degree

K_20 = 8.749 cm/s

24799.7 ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification P C 57 G P

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	5.5	inch				
Sample Height	11.05	inch		0.091	111.39	4540.68
Sample Width	10.2	inch		0.114	39.34	2270.34
				0.152	65.60	4540.68
Dry weight of permeameter box	21.2	lb		0.224	113.92	9081.35
Wet weight of permeameter box	21.6	lb		0.231	53.03	4540.68
				0.455	41.69	2270.34
Sample weight after mixing	43.7	lb		0.000	0.00	0.00
Sample weight before saturate w/box	64.5	lb				
Wet weight of soils w.box after drain		lb				
Water temperature T	16	Degree C				

Results

Dry Density	121.815	lb/ft^3
Hydraulic Conductivity, K	9.585	cm/s
	27171.048	ft/day
The Upper Limit of Hydraulic Gradient	0.008	

Hydraulic Conductivity at 20 degree

K_20 = 10.596 cm/s

30036.9 ft./day

Hydraulic Conductivity Testing Data & Results

Test Identification P M 67 G P

Data

Item	Data	Unit		Delta H,cm	t, sec.	Water, V, cm^3
Sample Length	5.5	inch				
Sample Height	11.05	inch		0.084	111.94	4540.68
Sample Width	10.2	inch		0.114	75.53	4540.68
				0.155	127.51	9081.35
Dry weight of permeameter box	21.2	lb		0.188	54.74	4540.68
Wet weight of permeameter box	21.6	lb		0.241	77.35	9081.35
				0.318	70.03	9081.35
Sample weight after mixing	41.88	lb		0.384	66.29	9081.35
Sample weight before saturate w/box	64.6	lb				
Wet weight of soils w.box after drain		lb				
Water temperature T	16	Degree C				

Results

Dry Density	116.742	lb/ft^3
Hydraulic Conductivity, K	9.083	cm/s
	25746.711	ft/day
The Upper Limit of Hydraulic Gradient	0.016	

Hydraulic Conductivity at 20 degree

K_20 = 10.041 cm/s

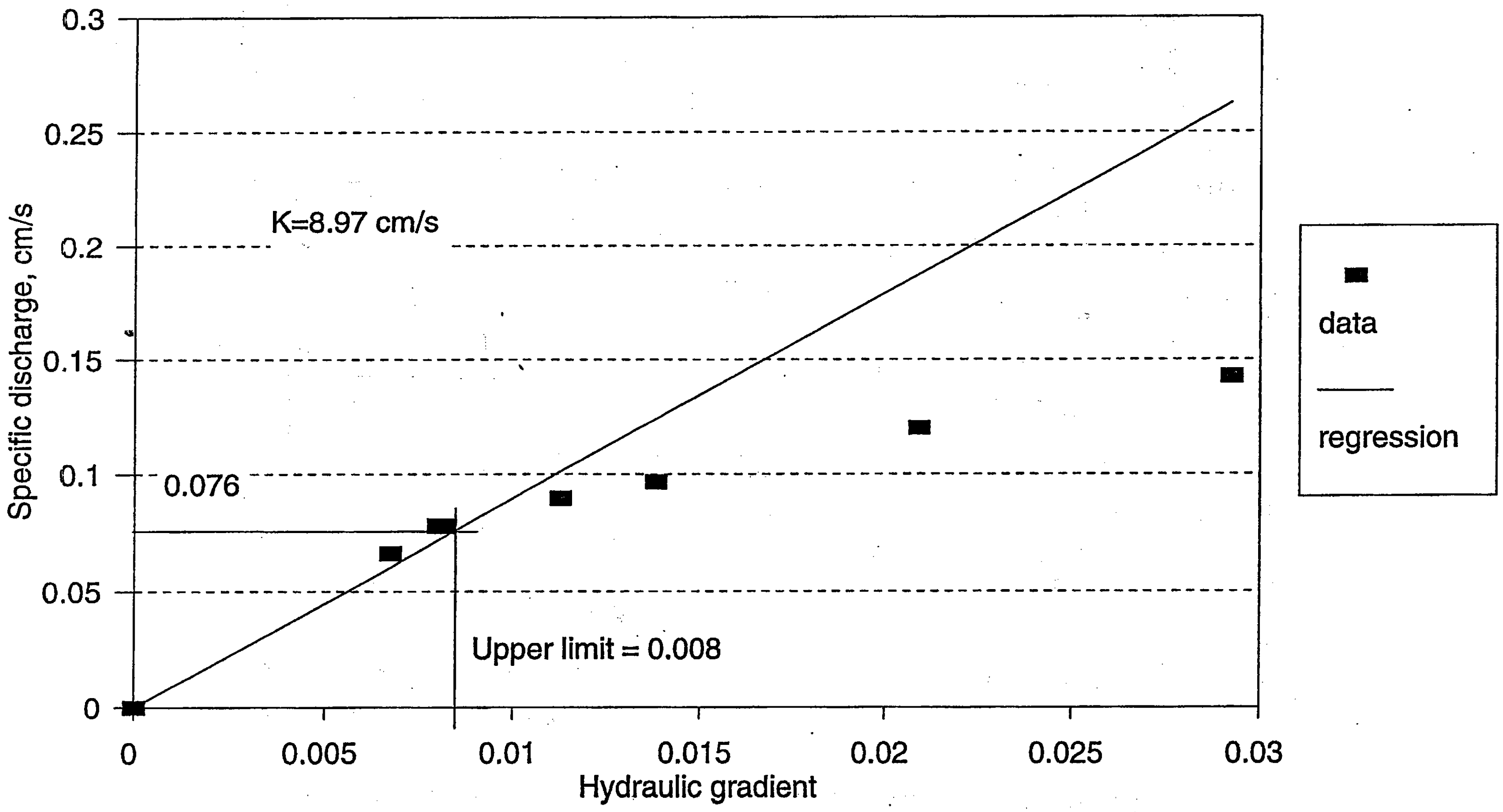
28462.3 ft./day

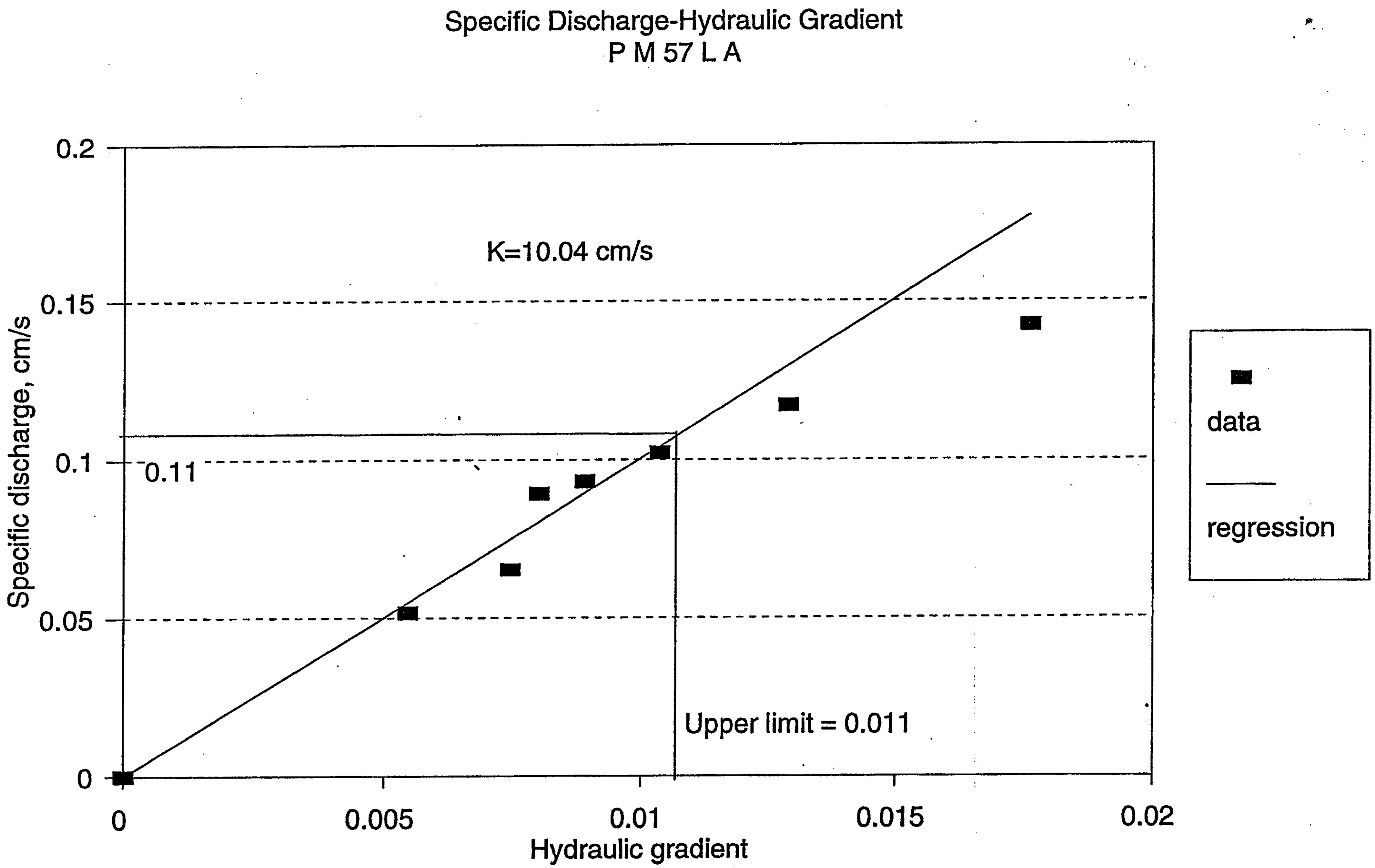
Test Result Summary of Hydraulic Conductivity

For Stabilized Samples

Test I.D.	Mix. Density	e	K at 20		i_upper
	lb/ft^3		cm/s	ft/day	
P_F_57_L_A	101.5	0.654	10.0	28,400	0.011
P_M_57_L_A	99.5	0.685	11.2	31,800	0.011
P_C_57_L_A	101.7	0.647	13.2	37,500	0.008
P_M_67_L_A	105.1	0.595	13.4	37,900	0.013
P_M_57_S_A	90.0	0.679	12.4	35,200	0.011
P_M_67_S_A	93.1	0.624	9.8	27,600	0.012
P_M_57_G_A	115.4	0.442	8.1	23,000	0.015
P_M_67_G_A	109.8	0.516	12.3	34,900	0.008
P_M_57_L_P	111.5	0.491	11.9	33,700	0.011
P_M_67_L_P	110.7	0.508	7.6	21,500	0.023
P_M_57_S_P	101.2	0.499	9.5	26,900	0.018
P_M_67_S_P	101.7	0.491	11.9	33,600	0.010
P_F_57_G_P	117.4	0.395	11.7	33,100	0.010
P_M_57_G_P	121.1	0.357	8.7	24,800	0.012
P_C_57_G_P	121.8	0.355	10.6	30,000	0.008
P_M_67_G_P	116.7	0.406	10.0	28,400	0.016

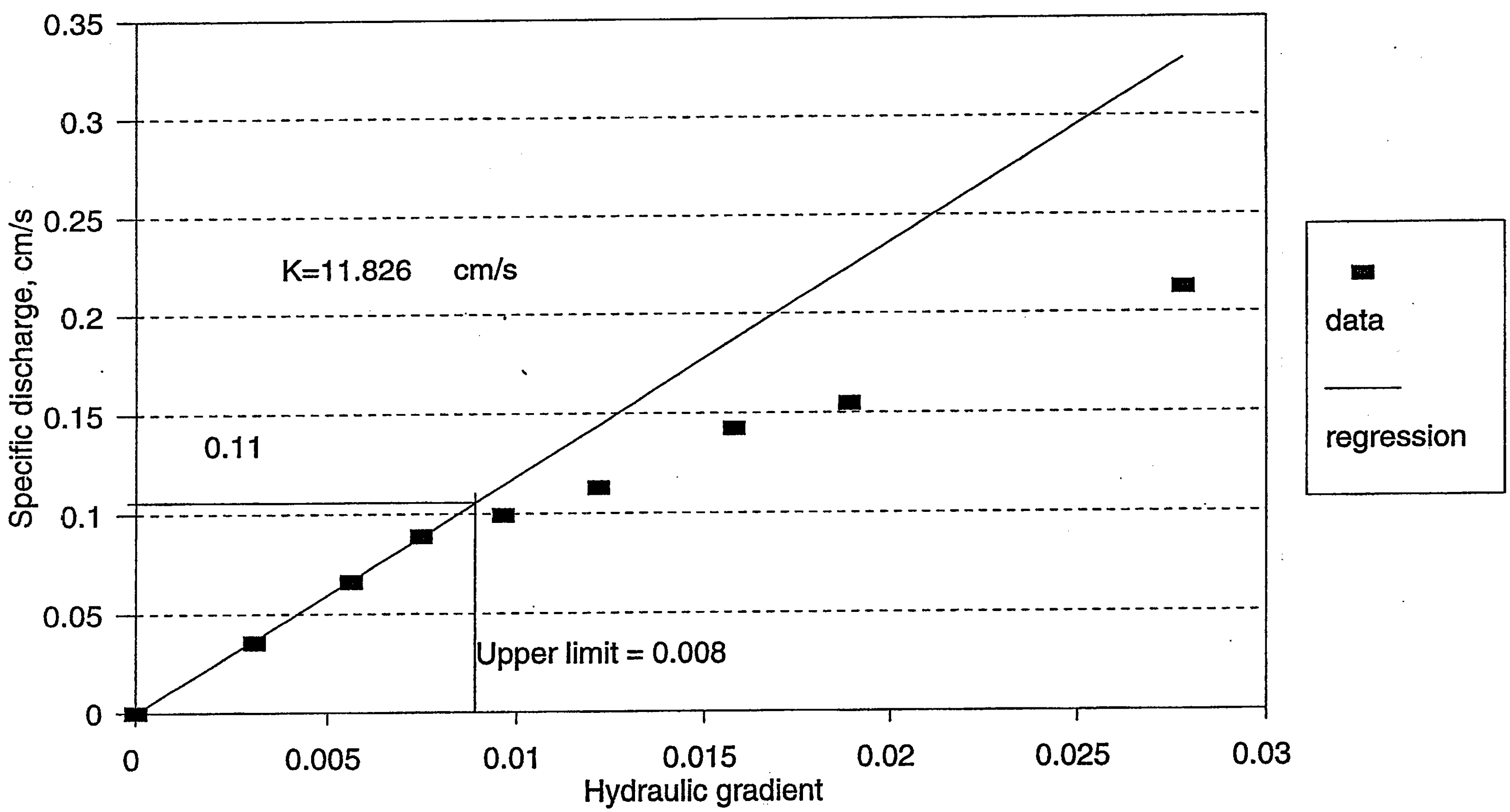
Specific Discharge-Hydraulic Gradient
P F 57 L A

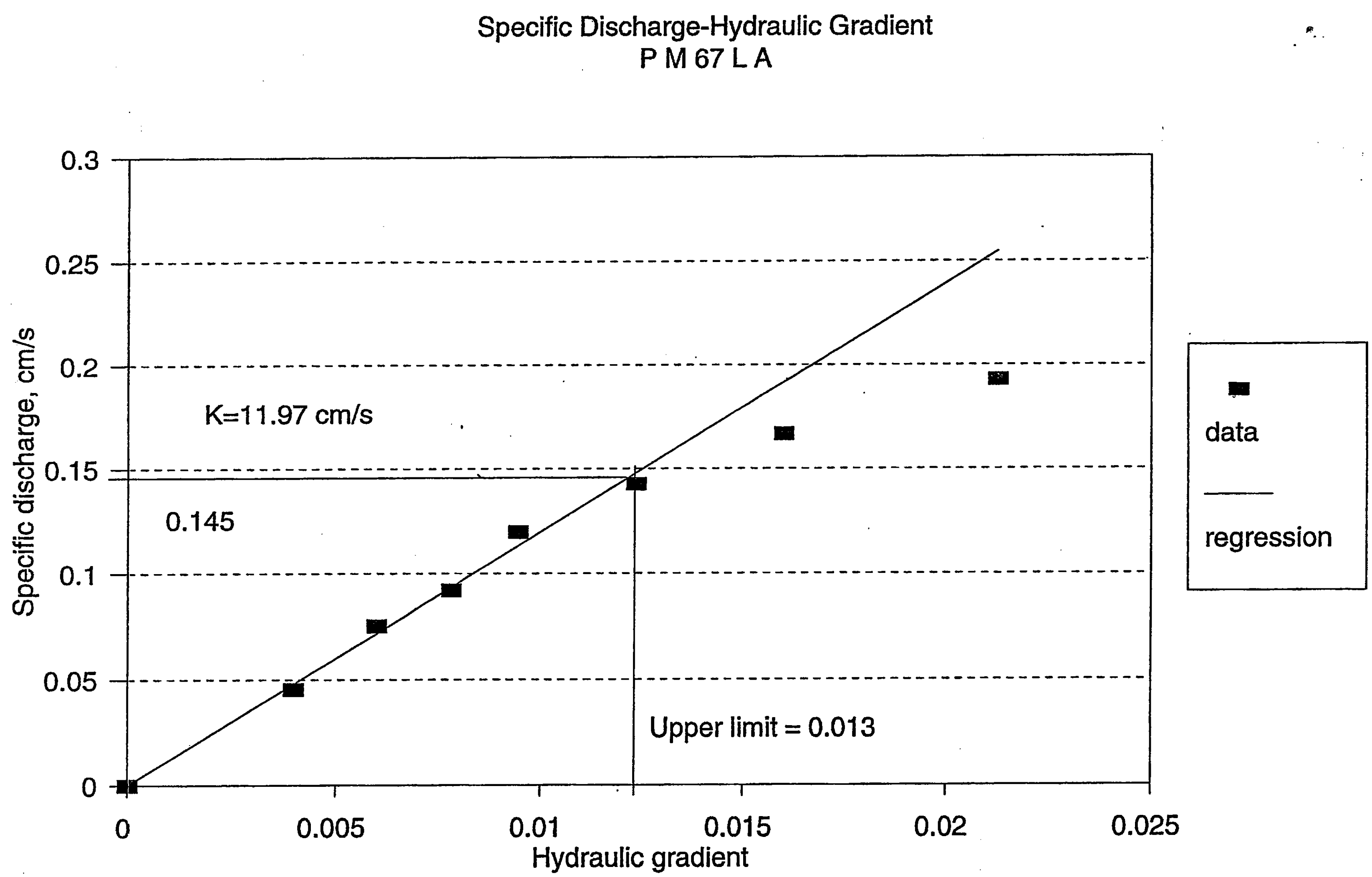




Specific Discharge-Hydraulic Gradient
P M 57 L A
K=10.04 cm/s
0.11
Upper limit = 0.011
Specific discharge, cm/s
Hydraulic gradient
0.2
0.15
0.1
0.05
0
0.005
0.01
0.015
0.02
data
regression

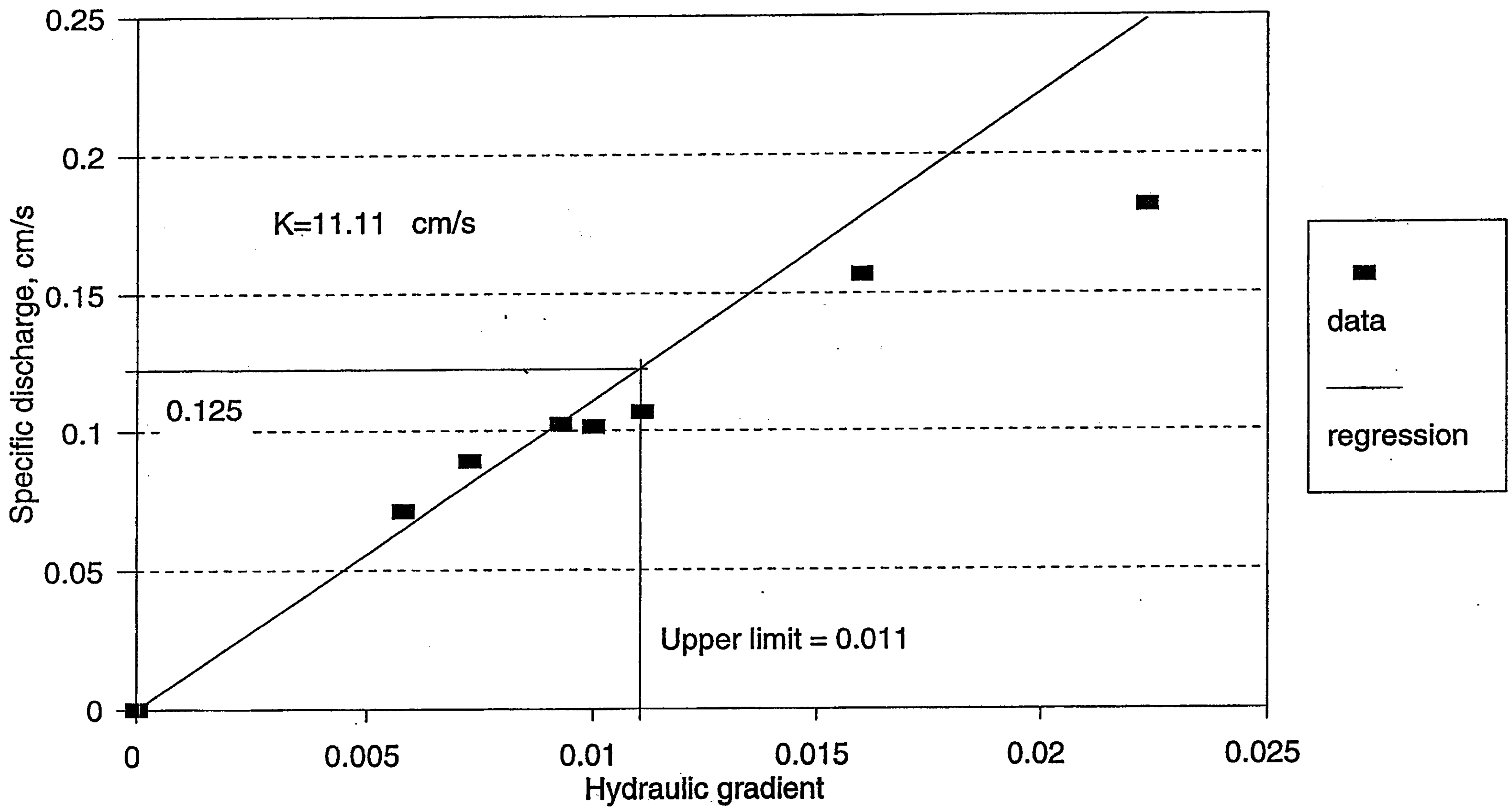
Specific Discharge-Hydraulic Gradient
P C 57 L A

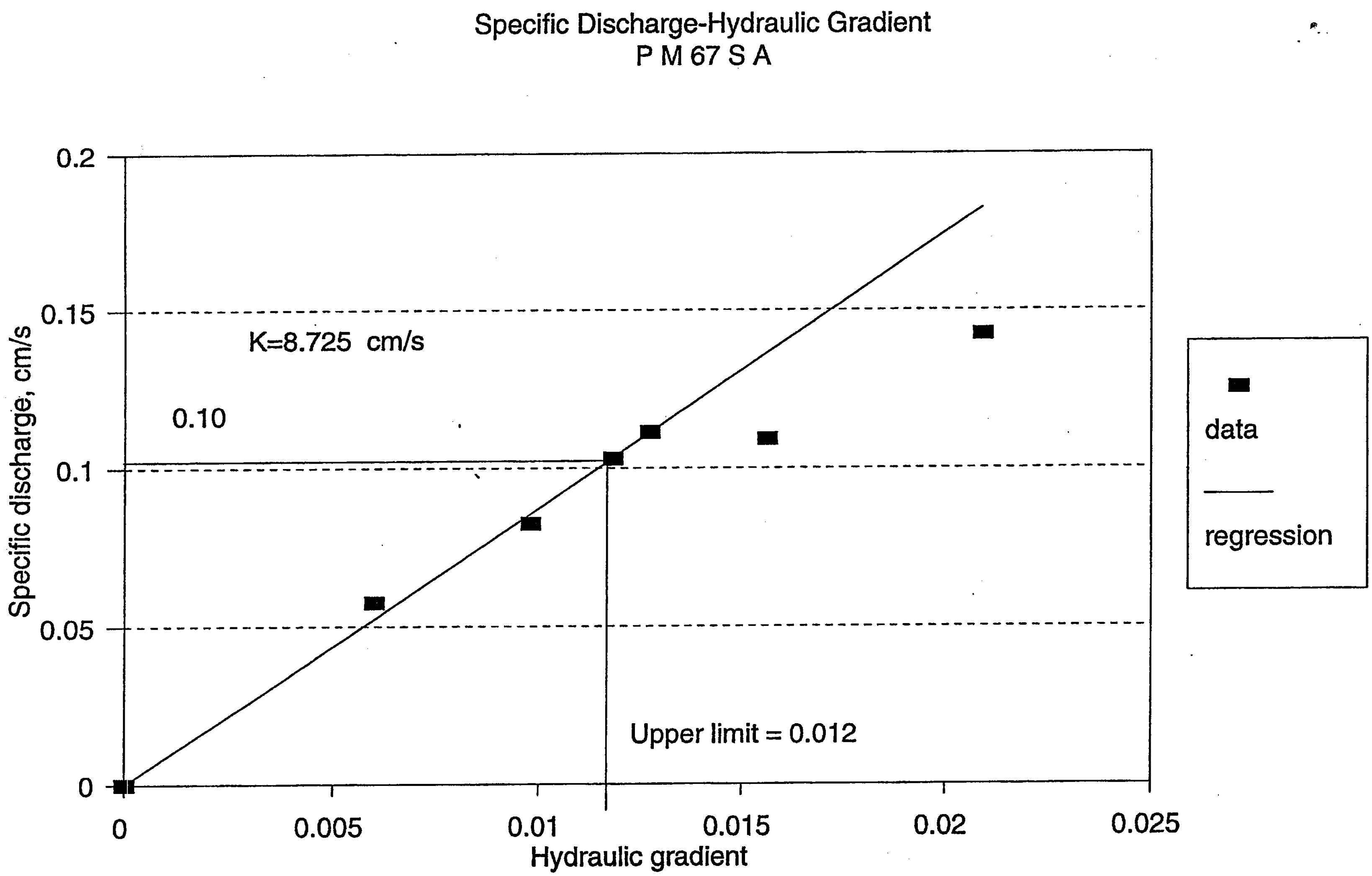




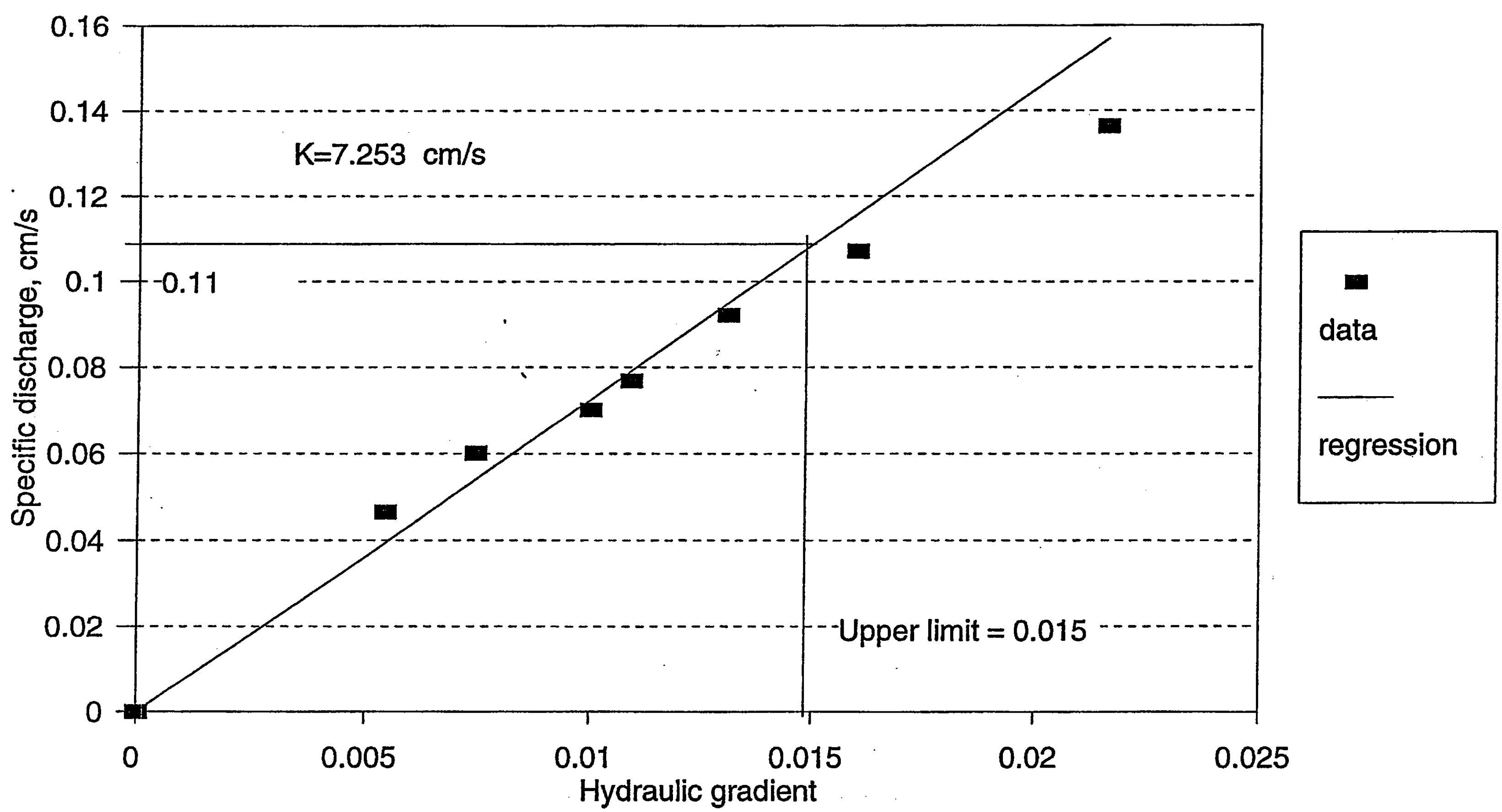
Specific Discharge-Hydraulic Gradient
P M 67 L A
0.3
0.25
0.2
0.15
0.1
0.05
0
Specific discharge, cm/s
K=11.97 cm/s
0.145
Upper limit = 0.013
0
0.005
0.01
0.015
0.02
0.025
Hydraulic gradient
data
regression

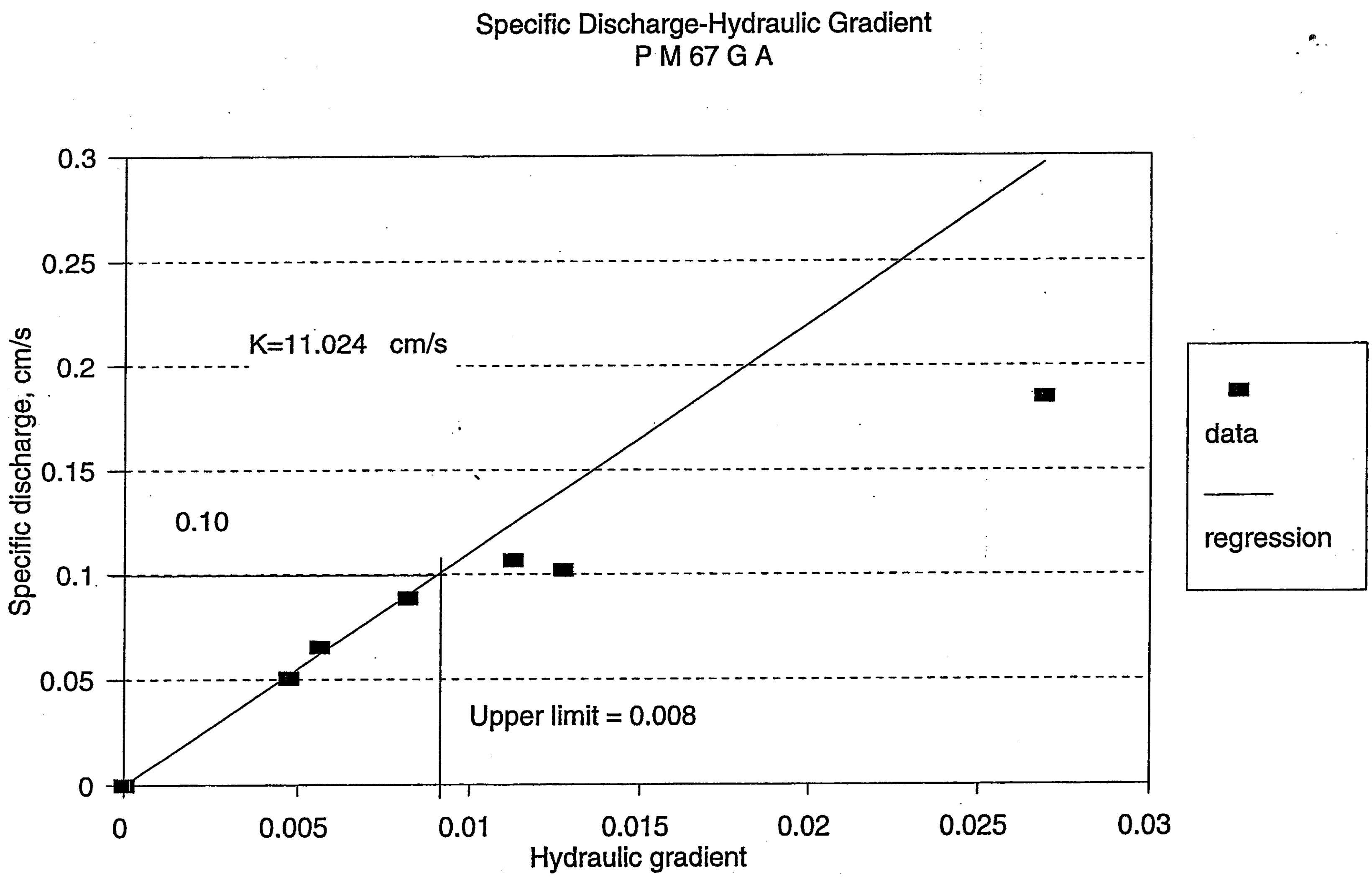
Specific Discharge-Hydraulic Gradient
P M 57 S A



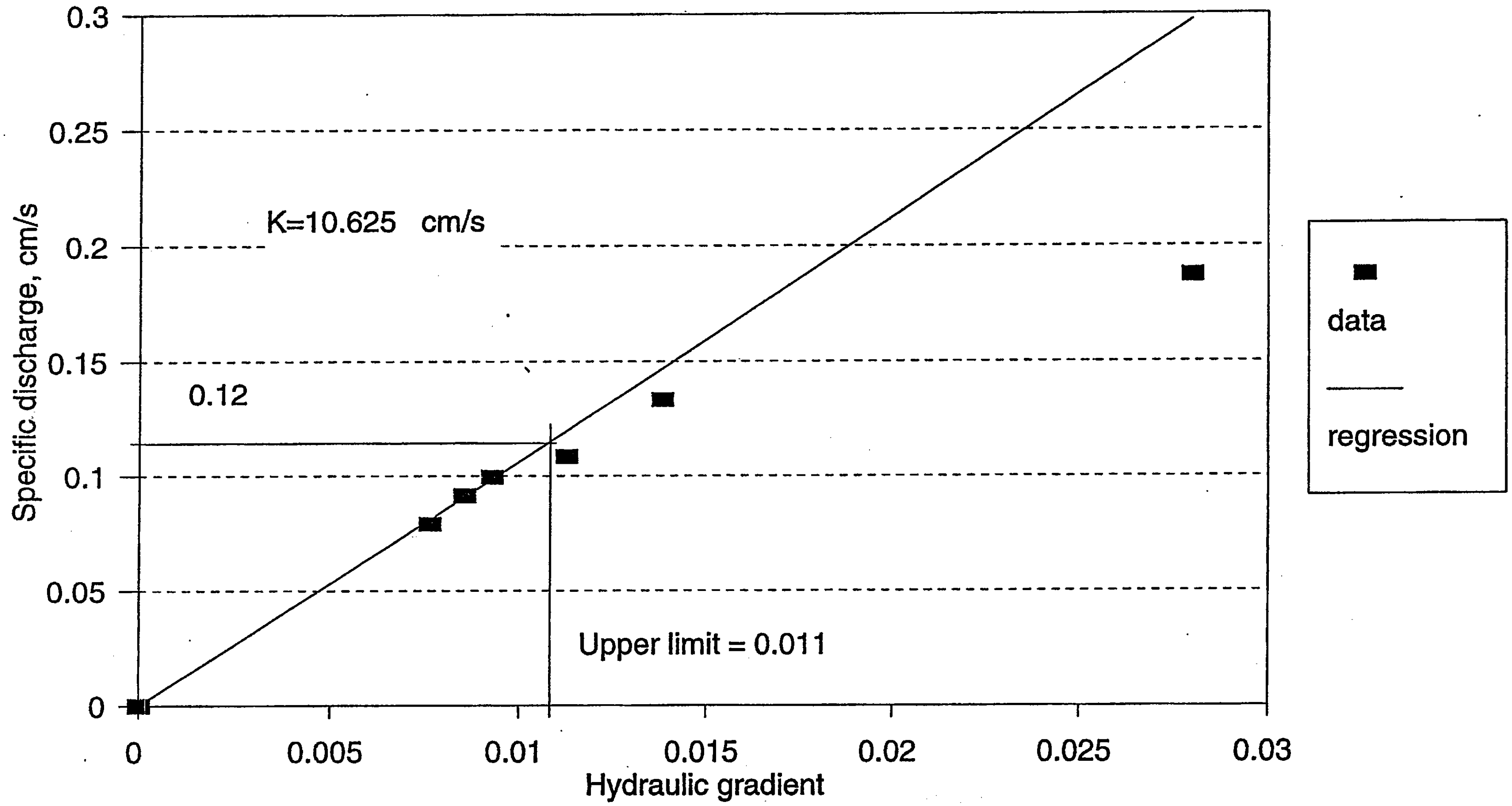

Specific Discharge-Hydraulic Gradient
P M 67 S A
K=8.725 cm/s
0.10
Upper limit = 0.012
Specific discharge, cm/s
Hydraulic gradient
0.2
0.15
0.1
0.05
0
0
0.005
0.01
0.015
0.02
0.025
data
regression

Specific Discharge-Hydraulic Gradient
P M 57 G A

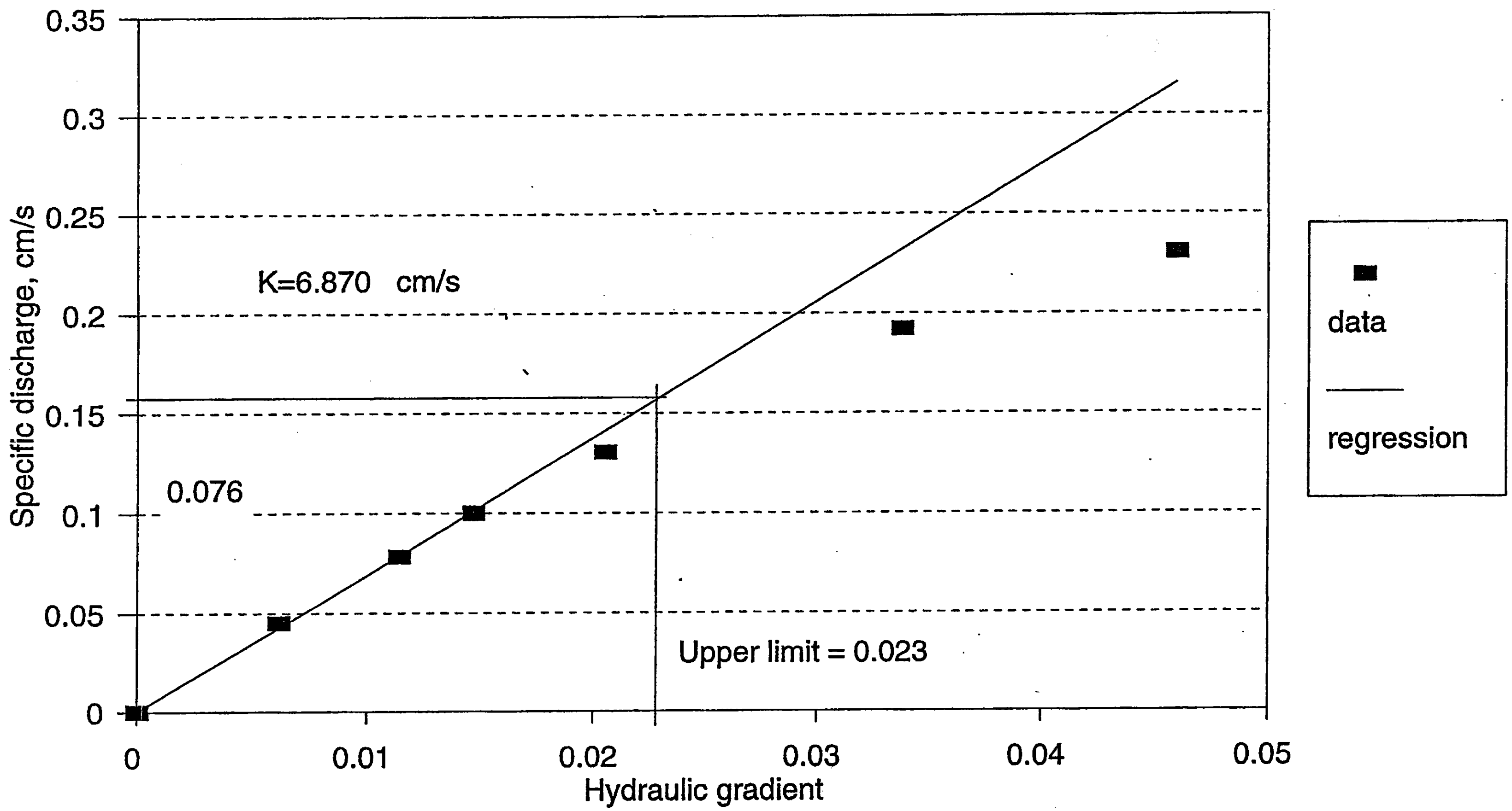


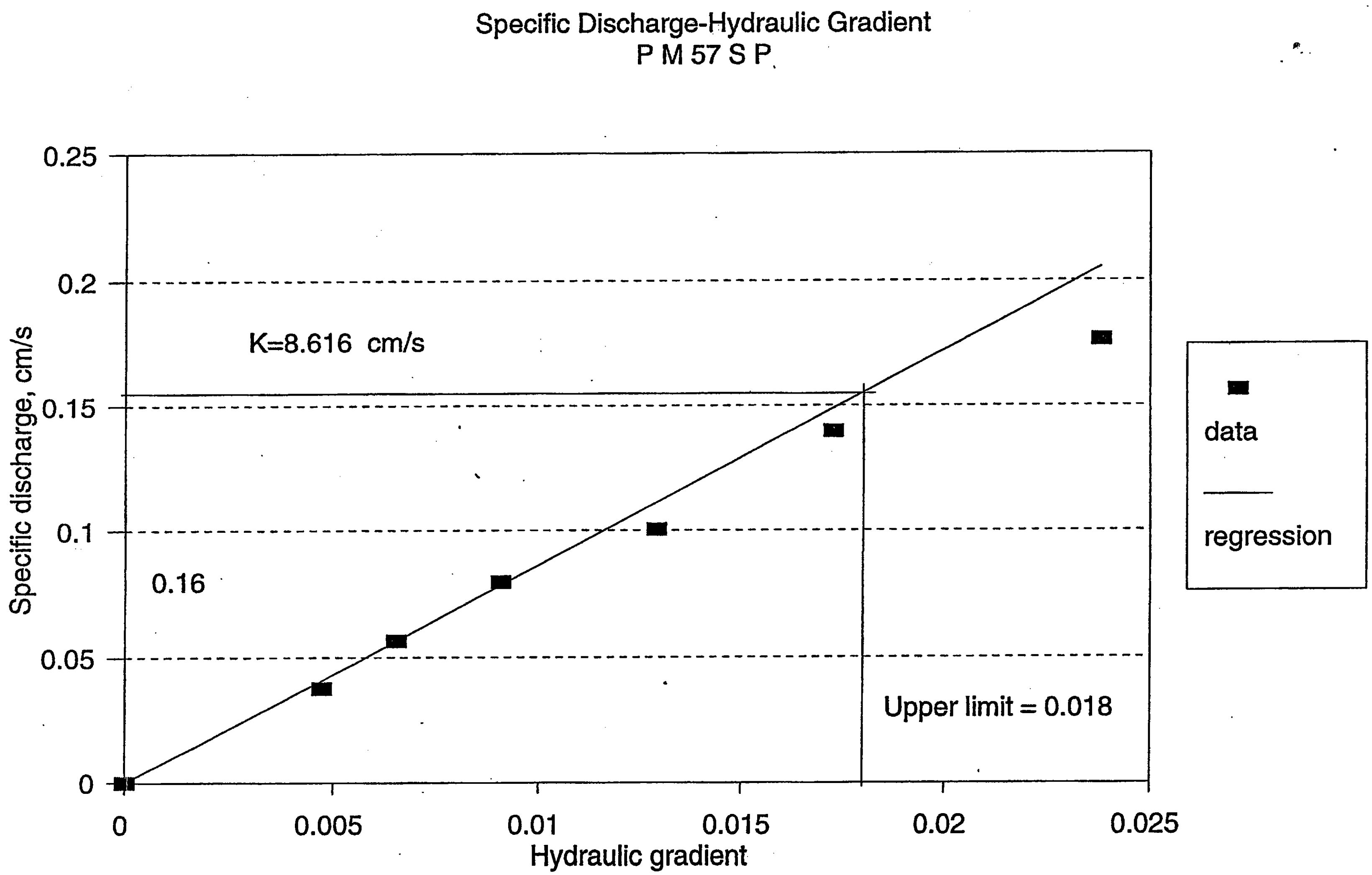

Specific Discharge-Hydraulic Gradient
P M 67 G A
K=11.024 cm/s
0.10
Upper limit = 0.008
Specific discharge, cm/s
Hydraulic gradient
0.3
0.25
0.2
0.15
0.1
0.05
0
0.005
0.01
0.015
0.02
0.025
0.03
data
regression

Specific Discharge-Hydraulic Gradient
P M 57 L P



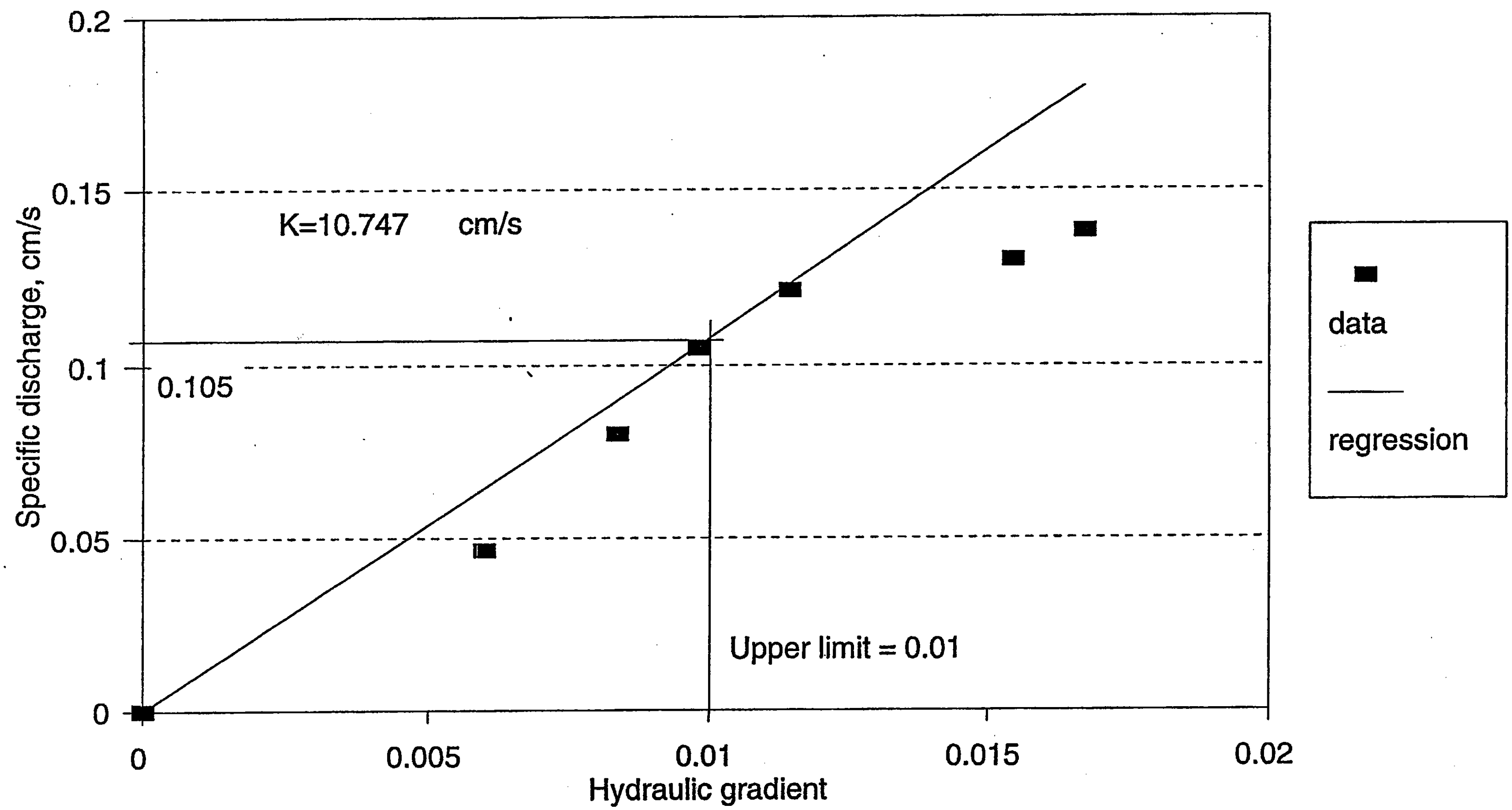
Specific Discharge-Hydraulic Gradient
P M 67 L P



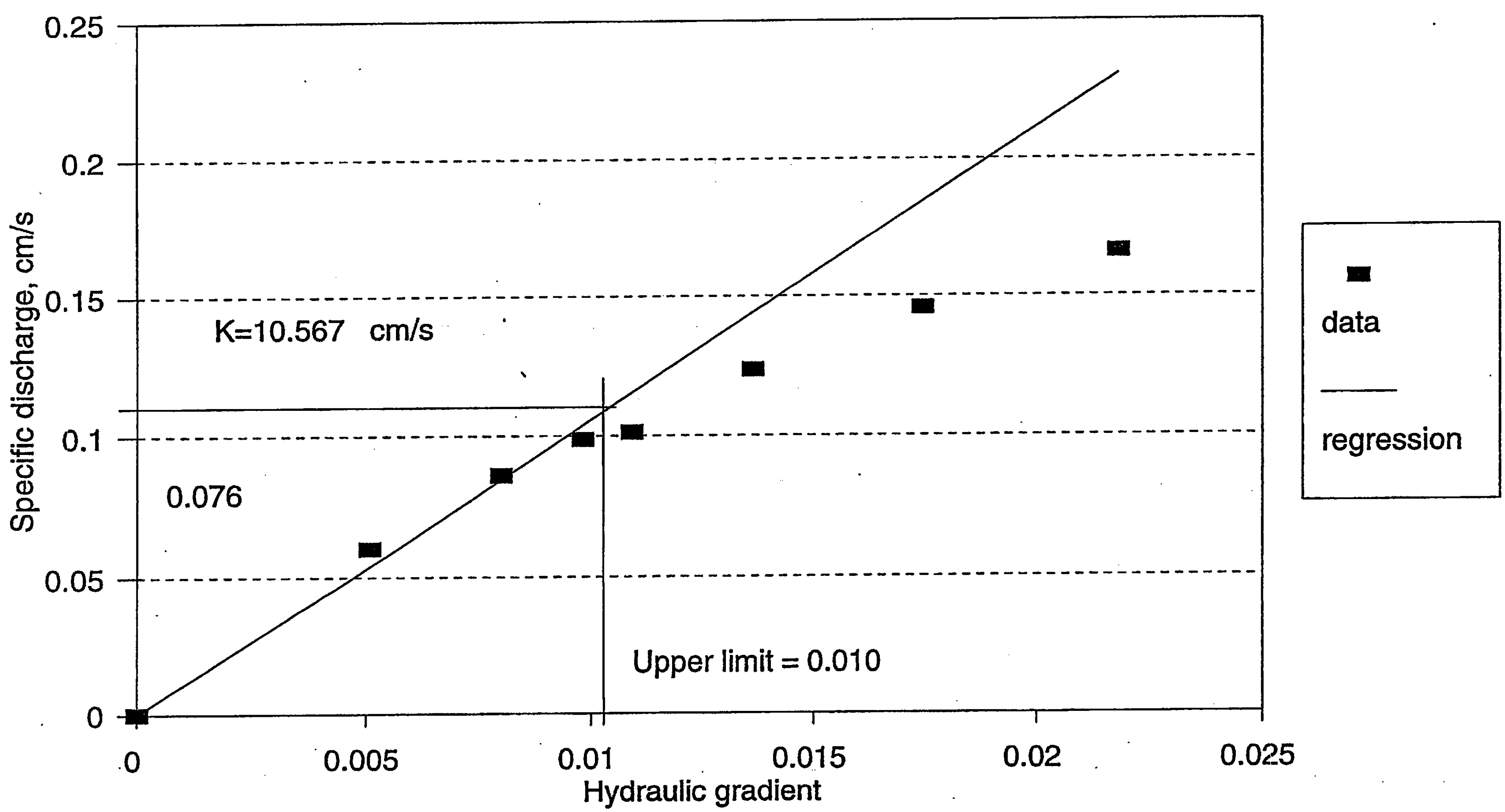


Specific Discharge-Hydraulic Gradient
P M 57 S P
0.25
0.2
0.15
0.1
0.05
0
Specific discharge, cm/s
K=8.616 cm/s
0.16
Upper limit = 0.018
0
0.005
0.01
0.015
0.02
0.025
Hydraulic gradient
data
regression

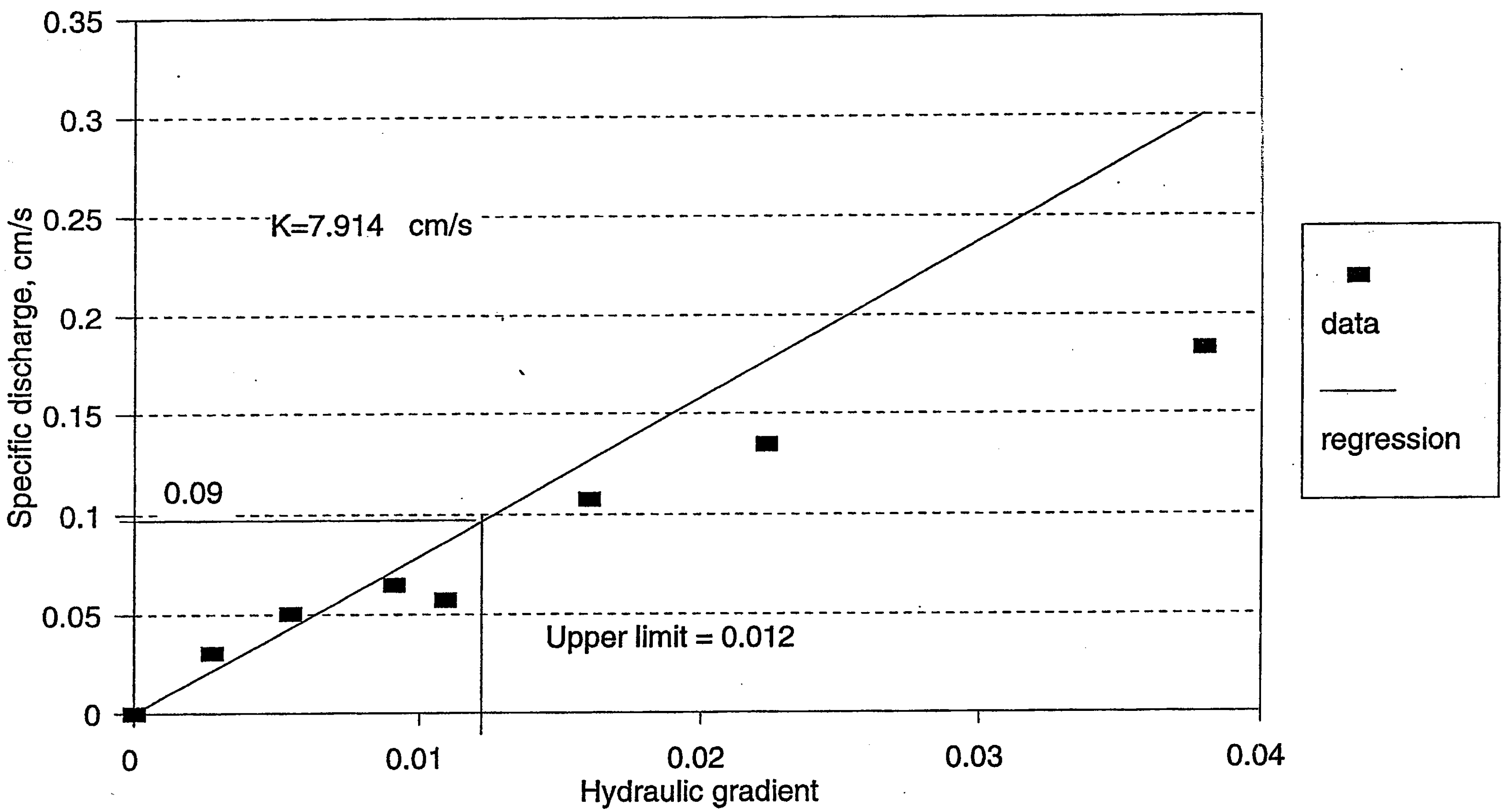
Specific Discharge-Hydraulic Gradient
P M 67 S P

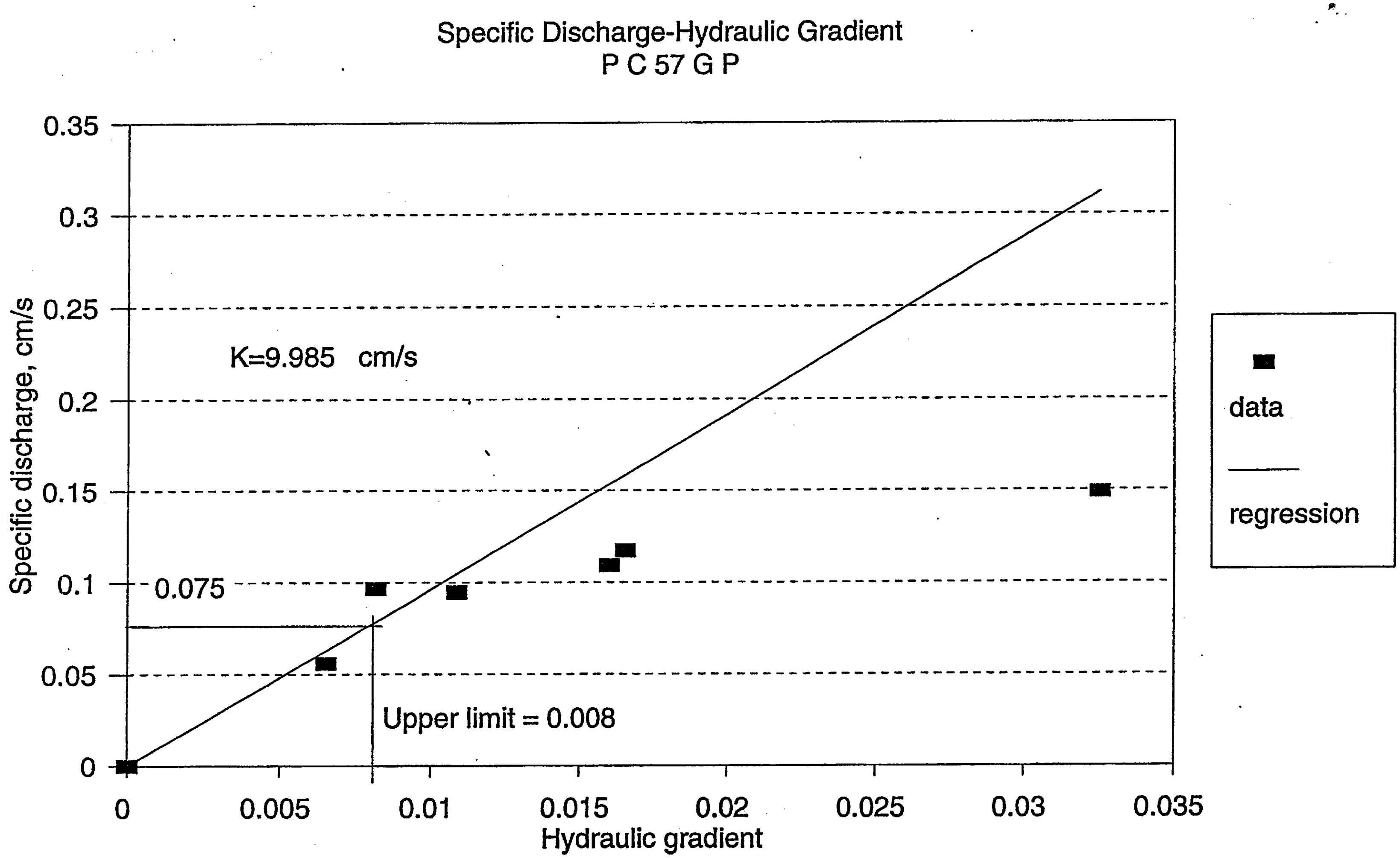


Specific Discharge-Hydraulic Gradient
P F 57 G P

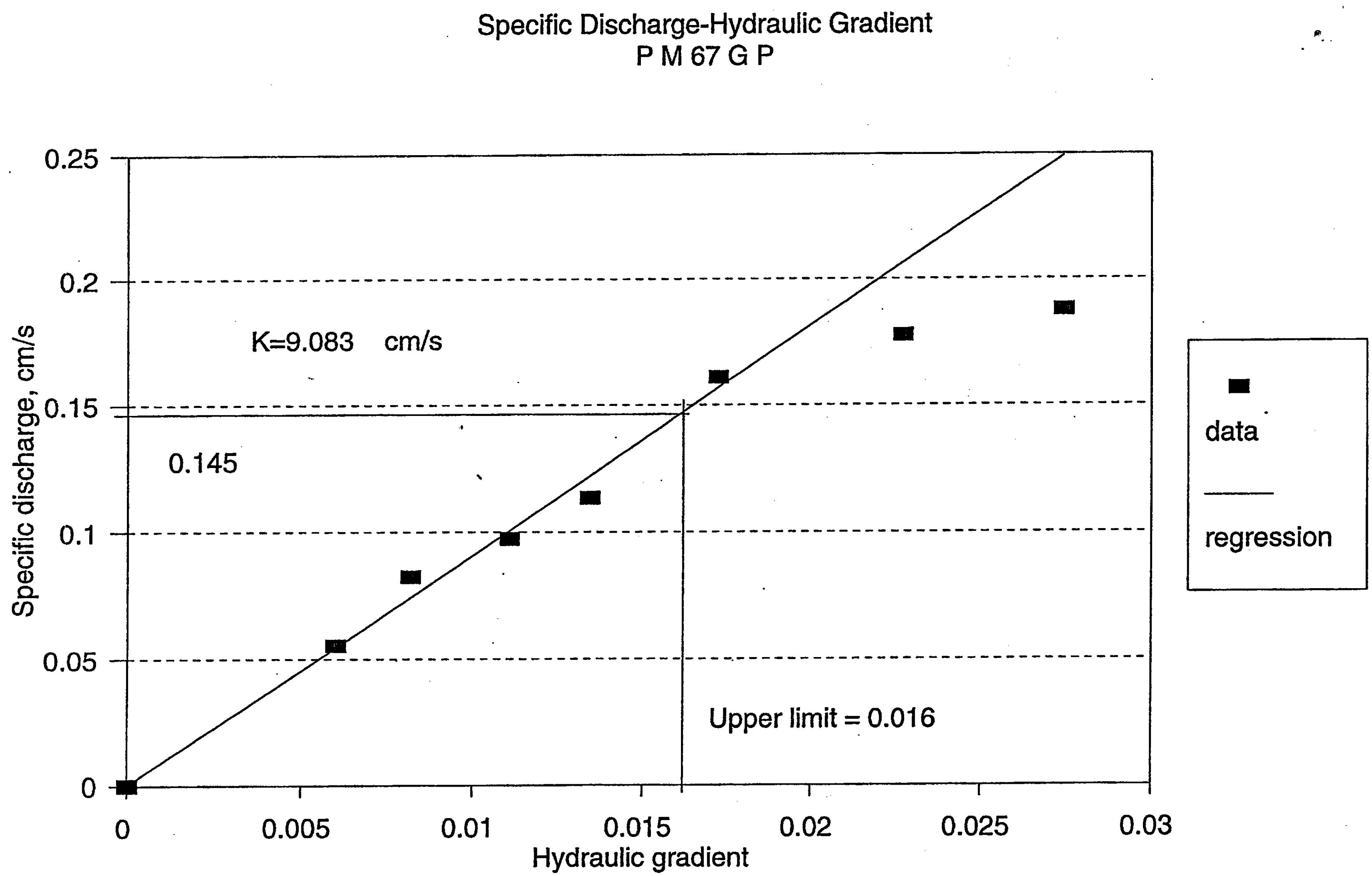


Specific Discharge-Hydraulic Gradient
P M 57 G P





Specific Discharge-Hydraulic Gradient
P C 57 G P
Specific discharge, cm/s
Hydraulic gradient
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.005
0.01
0.015
0.02
0.025
0.03
0.035
K=9.985 cm/s
0.075
Upper limit = 0.008
data
regression


Specific Discharge-Hydraulic Gradient
P M 67 G P
K=9.083 cm/s
0.145
Upper limit = 0.016
Specific discharge, cm/s
Hydraulic gradient
0
0.05
0.1
0.15
0.2
0.25
0.005
0.01
0.015
0.02
0.025
0.03
data
regression

Appendix Q

Resilient Modulus Testing of Base and Subbase Materials

Table of Contents

Q.1 Resilient Modulus Testing on AC Stabilized No. 57

Test	Limestone				Gravel				Slag			
Sequence	SM57LAD		SM57LAM		SM57GAD		SM57GAM		SM57SAD		SM57SAM	
	psi	MPa	psi	MPa	psi	MPa	psi	MPa	psi	MPa	psi	MPa
1	11300	78	10300	71			15300	105	7820	54	9330	64
2	11200	77	10800	74			14400	99	8640	60	8660	60
3	21200	146	20500	141			25900	178	12000	83	17100	118
4	9220	64	8340	58			9260	64	3750	26	5390	37
5	22500	155	22700	156			27700	191	16700	115	18700	129
6	43000	296	41400	286			48300	333	28600	197	30900	213
7	23800	164	22200	153			26000	179	14400	99	14200	98
8	49000	338	47600	328			56100	387	33900	234	35700	246
9	55900	385	59900	413			75900	524	34000	235	41600	287

Q.2 Resilient Modulus Testing on PC Stabilized No. 57

Test	Limestone				Gravel				Slag			
Sequence	SM57LPD		SM57LPM		SM57GPD		SM57GPM		SM57SPD		SM57SPM	
	psi	MPa	psi	MPa	psi	MPa	psi	MPa	psi	MPa	psi	MPa
1	13100	90	13300	92	23200	160	11200	78	8800	61	9170	63
2	13600	93	13100	90	21300	147	12500	86	9280	64	8920	62
3	24100	166	24800	171	22400	154	25800	178	15000	104	15000	104
4	9060	62	8970	62	21300	147	8100	56	5080	35	5720	39
5	27600	191	28500	196	25700	177	32400	223	17300	119	16200	112
6	49100	339	50300	347	30600	210	42100	291	27000	186	30600	211
7	25900	179	25900	179	20800	143	28000	193	16100	111	17400	120
8	52400	361	54000	373	46900	324	46900	323	35100	242	35900	248
9	71800	495	72700	501	53800	371	76300	526	47200	325	50100	345

Q.3 Resilient Modulus Testing on No. 57

Test	Limestone				Gravel				Slag			
Sequence	SM57LND		SM57LNM		SM57GND		SM57GNM		SM57SND		SM57SNM	
	psi	MPa	psi	MPa	psi	MPa	psi	MPa	psi	MPa	psi	MPa
1	7500	51	6910	48	10600	73	10200	70	4420	30	3990	28
2	15700	108	14500	100	22300	154	21500	148	9300	64	8400	58
3	20100	139	18600	128	28500	197	27500	189	11900	82	10800	74
4	14900	103	15000	103	20000	138	19900	137	9240	64	8800	61
5	22700	157	22900	158	30400	210	30300	209	14000	97	13300	92
6	26200	181	26400	182	35300	243	35200	242	16300	112	15600	107
7	29900	206	30100	208	40100	276	39900	275	18500	127	17500	121
8	39900	275	37100	256	47700	329	46600	321	21900	151	20800	144
9	42600	293	39700	274	51200	353	49900	344	23500	162	22400	154
10	33100	228	30900	213	39700	274	38800	267	18200	125	17300	120
11	43300	299	40300	278	51900	358	50700	349	23800	164	22700	156
12	50400	347	46300	319	59700	411	58800	406	22800	157	21800	150
13	49500	341	45500	313	58600	404	57800	398	22400	155	21400	147
14	50800	350	46700	322	60200	415	59300	409	23000	159	21900	151
15	62400	430	57300	395	73900	509	72800	502	28300	195	26900	186

Q.4 Resilient Modulus Testing on N.J. Mix

Test	Limestone				Gravel				Slag			
Sequence	SMNJLND		SMNJLNM		SMNJGND		SMNJGNM		SMNJSND		SMNJSNM	
	Psi	MPa	psi	MPa	psi	MPa	psi	MPa	psi	MPa	psi	MPa
1	8800	61	8520	59	11500	79	10300	71	4400	30	4900	34
2	18600	128	17900	124	24300	167	21700	149	9300	64	10300	71
3	23800	164	22900	158	31000	214	27800	192	11800	82	13100	90
4	16800	116	17500	121	20100	138	20200	139	8400	58	9240	64
5	25600	177	26700	184	30600	211	30900	213	12800	88	14100	97
6	29600	204	30900	213	35400	244	35700	246	14800	102	16300	112
7	33700	233	35200	243	40300	278	40700	281	16900	116	18600	128
8	40800	282	38500	266	50600	349	48300	333	21800	150	21800	150
9	43500	300	41100	283	55000	379	52300	361	23500	162	23200	160
10	33900	234	32000	221	42300	292	40300	278	18200	125	18100	125
11	44300	306	41800	288	55300	381	52700	363	23800	164	23700	163
12	48300	333	45300	312	54000	372	51400	355	23100	159	22600	156
13	47400	327	44500	307	53000	366	50600	349	22700	156	22200	153
14	48700	336	45700	315	54500	375	51900	358	23300	161	22800	157
15	59800	412	56100	387	66800	461	63700	439	28600	197	28000	193

Q.5 Resilient Modulus Testing on Iowa Mix, Limestone Aggregate

Test	Coarse				Middle						Fine			
Sequence	SCIWLND		SCIWLNM		SMIWLND		SMIWLNM		SMIWLNW		SFIWLND		SFIWLNM	
	psi	MPa	psi	MPa	psi	MPa	psi	MPa	psi	MPa	psi	MPa	psi	MPa
1	6040	42	6210	43	6580	45	6400	44	4300	30	7320	50	7400	51
2	12700	88	13100	90	13800	95	13500	93	9060	62	15400	106	15600	107
3	16300	112	16700	115	17700	122	17200	119	11600	80	19700	136	19900	138
4	11900	82	11500	80	13100	90	13000	90	10000	69	13900	95	15200	105
5	18200	125	17600	122	19900	137	19800	137	15200	105	21100	145	23200	160
6	21000	145	20400	140	23100	159	23000	158	17600	121	24500	169	26800	185
7	23900	165	23200	160	26200	181	26100	180	20000	138	27700	191	30600	211
8	28700	198	27500	190	28700	198	28400	196	26200	181	29200	201	29000	200
9	30800	212	29500	203	30600	211	30300	209	28000	193	31300	216	30800	213
10	23900	165	22900	158	23800	164	23600	163	21800	150	24300	167	24000	166
11	31200	215	29900	206	31200	215	30900	213	28500	196	31700	219	31400	217
12	33200	229	30700	212	32600	225	33300	229	33500	231	34700	239	36000	248
13	32600	225	3010	208	32000	221	32700	225	32900	227	34100	235	35300	244
14	33500	231	30900	213	32900	227	33500	231	33800	233	35000	241	36300	250
15	41100	283	38000	262	40400	279	41200	284	41500	286	43000	296	44600	307

Q.6 Resilient Modulus Testing on Iowa Mix, Gravel and Slag Aggregate

Test	Gravel				Slag			
Sequence	SMIWGND		SMIWGNM		SMIWSND		SMIWSNM	
	psi	MPa	psi	MPa	psi	MPa	psi	MPa
1	10100	70	8500	59	5390	37	5110	35
2	21300	147	17900	124	11300	78	10700	74
3	27300	188	22900	158	14500	100	13800	95
4	18100	125	16900	116	10900	75	10700	74
5	27500	190	25600	177	16700	115	16400	113
6	32000	220	29700	205	19300	133	18900	131
7	36200	250	33700	232	22000	152	21600	149
8	46000	317	41900	289	25100	173	25100	173
9	49300	340	44800	309	26700	184	26800	185
10	38300	264	34800	240	20800	144	20900	144
11	50100	345	45500	314	27300	188	27300	188
12	54000	372	50500	348	27200	188	27800	191
13	53000	365	49600	342	26700	184	27200	188
14	54400	375	51000	351	27500	189	28000	193
15	66800	461	62500	431	33700	232	34400	237

Q.7 Resilient Modulus Testing on No. 304, Limestone and Slag Aggregate

Test	Limestone						Slag			
Sequence	SM304LND		SM304LNM		SM304LNW		SM304SND		SM304SNM	
	psi	MPa	psi	MPa	psi	MPa	psi	MPa	psi	MPa
1	7310	50	6910	48	5300	37	4850	33	4830	33
2	15400	106	14500	100	11100	77	10200	70	10200	70
3	19700	136	18600	128	14300	98	13000	90	13000	90
4	14800	102	14700	101	12700	87	10000	69	9440	65
5	22600	156	22500	155	19400	133	15300	106	14400	100
6	26200	181	25900	179	22300	154	17700	122	16600	115
7	29800	205	29600	204	25500	176	20200	139	19000	131
8	31400	217	31700	219	29200	201	25300	175	25100	173
9	33300	229	33600	232	31200	215	27500	189	27000	186
10	26000	180	26300	181	24200	167	21200	146	20900	144
11	34000	235	34400	237	31700	219	27700	191	27300	188
12	36900	255	35200	243	34400	237	27900	192	29500	204
13	36200	250	34600	238	33800	233	27400	189	29000	200
14	37200	257	35500	245	34700	239	28100	194	29800	205
15	45700	315	43600	300	42600	293	34500	238	36600	252

Q.8 Resilient Modulus Testing on No. 304, Gravel Aggregate

Test	Coarse				Middle				Fine			
Sequence	SC304GND		SC304GNM		SM304GND		SM304GNM		SF304GND		SF304GNM	
	psi	MPa	psi	MPa	psi	MPa	psi	MPa	psi	MPa	psi	MPa
1	10400	72	10000	69	10200	70	8460	58	9820	68	9920	68
2	21800	150	21100	146	21400	148	17800	123	20700	142	20800	144
3	28000	193	26700	186	27500	189	22800	157	26400	182	26700	184
4	21200	146	21300	147	19100	132	18300	126	19500	134	18700	129
5	32300	223	32600	225	29100	201	27900	192	29600	204	28800	198
6	37300	257	37500	258	33700	232	32200	222	34500	238	33000	228
7	42600	293	43000	296	38300	264	36700	253	38900	268	38000	262
8	53700	370	47100	325	43100	297	42300	292	46200	318	47400	327
9	57900	399	49100	338	46600	321	45100	311	49900	344	50400	347
10	44800	309	38800	268	36000	248	35100	242	38500	266	39300	271
11	58600	404	50700	350	47000	324	45900	317	50400	347	51400	354
12	55100	380	52900	365	52500	362	50000	345	56500	389	53100	366
13	54200	374	51900	358	51600	356	49100	339	55400	382	52100	359
14	55600	384	53300	368	53000	365	50500	348	56900	393	53600	369
15	68300	471	65500	451	65000	448	62000	427	69900	482	65800	454

Q.9 Resilient Modulus Testing on No. 310, Limestone and Gravel Aggregate

Test	Limestone				Gravel			
Sequence	SM310LND		SM310LNM		SM310GND		SM310GNM	
	psi	MPa	psi	MPa	psi	MPa	psi	MPa
1	6880	47	7210	50	11000	76	10300	71
2	14480	100	15100	104	23100	159	21500	148
3	18500	128	19410	134	29600	204	27600	190
4	11700	81	12700	88	22800	157	21500	148
5	17900	124	19400	134	34800	240	32800	226
6	20600	142	22400	154	40200	277	37900	261
7	23700	163	25600	177	45900	317	43300	298
8	30000	207	28700	198	52400	361	51700	356
9	32000	220	30600	211	55800	385	54900	379
10	24900	172	23800	164	43500	300	42900	295
11	32600	225	31200	215	56900	392	56000	386
12	35000	241	35100	242	61700	425	58800	405
13	34300	237	34400	237	60600	418	57800	398
14	35200	243	35400	244	62200	429	59300	409
15	43300	298	43410	299	76400	527	72800	502

Q.10 Resilient Modulus Testing on No. 310, Slag Aggregate

Test	Coarse				Middle				Fine			
Sequence	SC310SND		SC310SNM		SM310SND		SM310SNM		SF310SND		SF310SNM	
	psi	MPa	psi	MPa	psi	MPa	psi	MPa	psi	MPa	psi	MPa
1	3910	27	4310	30	4260	29	4580	32	5250	36	5060	35
2	8210	57	9100	62	9000	62	9600	66	11100	76	10700	73
3	10500	73	11600	80	11500	79	12300	85	14100	97	13600	94
4	8800	61	8900	62	9710	67	9310	64	9680	67	9470	65
5	13400	92	13600	94	14800	102	14200	98	14800	102	14500	100
6	15500	107	15900	109	17100	118	16400	113	17100	118	16700	115
7	17700	122	17900	123	19400	134	18800	130	19500	135	19100	132
8	22400	155	21500	148	22700	156	22200	153	23700	163	23100	159
9	24000	166	23400	161	24300	167	23800	164	25300	174	24600	170
10	18600	129	18000	124	18900	130	18500	127	19700	136	19200	132
11	24400	168	23500	162	24700	170	24100	166	25700	177	25000	173
12	24900	172	25300	174	24800	171	25100	173	25600	176	25800	178
13	24400	169	24800	171	24400	168	24600	170	25200	173	25300	175
14	25100	173	25500	176	25100	173	25300	174	25800	178	26000	179
15	30800	213	31300	216	30800	212	31000	214	31700	218	31900	220

Q.11 Summary of Resilient Modulus Testing (MPa)

Specifi- cation	Grada- tion	Moist. Cond.	Limestone		Gravel		Slag	
			Range of M_r (MPa)	^1M_r (MPa)	Range of M_r (MPa)	^1M_r (MPa)	Range of M_r (MPa)	^1M_r (MPa)
No. 57	M	D	51 - 430	299	73 - 509	358.	30 - 195	164
	M	M	48 - 395	278	70 - 502	349	28 - 186	156
NJ Mix	M	D	61 - 412	306	79 - 461	381	30 - 197	164.
	M	M	59 - 387	288	71 - 439	363.	34 - 193	163
	C	D	42 - 283	215				
	C	M	43 - 262	206				
Iowa	M	D	45 - 279	215	70 - 461	345	37 - 232	188
Mix	M	M	44 - 284	213	59 - 431	314	35 - 237	188
	M	W	30 - 286	196				
	F	D	50 - 296	219				
	F	M	51 - 307	217				
	C	D			72 - 471	404		
	C	M			69 - 451	350		
	M	D	50 - 315	235	70 - 448	324	33 - 238	191
No. 304	M	M	48 - 300	238	58 - 427	317	33 - 252	188
	M	W	37 - 293	237				
	F	D			68 - 482	347		
	F	M			68 - 454	354		
	C	D					27 - 213	168
	C	M					30 - 216	162
No. 310	M	D	47 - 298	225	76 - 527	392	29 - 212	170
Grading	M	M	50 - 299	215	71 - 502	386	32 - 214	166
A	F	D					36 - 218	177
	F	M					35 - 220	173

^1M_r = Resilient modulus in psi for Sequence No. 11 with both confining stress and maximum deviator stress equal to 15 psi.

Q.12 Summary of Resilient Modulus Testing (psi)

Specifi- cation	Grada- tion	Moist. Cond.	Limestone		Gravel		Slag	
			Range of M_r (psi)	^1M_r (psi)	Range of M_r (psi)	^1M_r (psi)	Range of M_r (psi)	^1M_r (psi)
No. 57	M	D	7460 - 62400	43300	10600 - 73900	51900	4420 - 28300	23800
	M	M	6910 - 57300	40300	10200 - 72800	50700	3990 - 26900	22700
NJ Mix	M	D	8830 - 59800	44300	11500 - 66800	55300	4400 - 28600	23800
	M	M	8520 - 56100	41800	10300 - 63700	52700	4870 - 28000	23700
	C	D	6040 - 41100	31200				
	C	M	6210 - 38000	30000				
Iowa	M	D	6580 - 40400	31200	10100 - 66800	50100	5390 - 33700	27300
Mix	M	M	6400 - 41200	31000	8520 - 62500	45500.	5110 - 34400	27300
	M	W	4310 - 41500	28500				
	F	D	7320 - 43000	31700				
	F	M	7400 - 44600	31400				
	C	D			10400 - 68300	58600		
	C	M			10000 - 65500	50700		
	M	D	7310 - 45700	34000	10200 - 65000	47000	4840 - 34500	27700
No. 304	M	M	6910 - 43600	34400	8460 - 62000	45900	4830 - 36600	27300
	M	W	5300 - 42600	34400				
	F	D			9820 - 69900	50400		
	F	M			9920 - 65800	51400		
	C	D					3910 - 30800	24400
	C	M					4310 - 31300	23500
No. 310	M	D	6880 - 43300	32600	11000 - 76400	57000	4260 - 30800	24700
Grading	M	M	7210 - 43400	31200	10300 - 72800	56000	4580 - 31000	24100
A	F	D					5250 - 31700	25700
	F	M					5060 - 31900	25000

^1M_r = Resilient modulus in psi for Sequence No. 11 with both confining stress and maximum deviator stress equal to 15 psi.