2013 Floodplain Management Conference
September 3-6, Anaheim, California

Creating a Safer Tomorrow

Building Resilience through Integrated Flood Risk Management

Creating a Safer Tomorrow
FLOODPLAIN MANAGEMENT CONFERENCE
September 3-6, 2013 • Anaheim, California

CONTENTS

Friday, September 6, 2013

Room/ Time	Workshop / Event
7:30 – 8:30	CONTINENTAL BREAKFAST
8:00 – 9:00	FORUM: What are Your National and State Floodplain Management Policy Priorities? Mapping, climate change, land development practices, stormwater regulations, building codes, levee certification, floodways, funding, etc.: What's on your mind? Join FMA, ASFPM and NAFSMA in a fun, lively and interactive dialogue on your priorities for state and national policies in floodplain management. Moderator: Iovanka Todt, Executive Director, Floodplain Management Association • Pal Hegedus, PE, FMA Past Chair, RBF Consulting – A Baker Company • Chad Berginnis, CFM, Executive Director, Association of State Floodplain Managers • Dusty Williams, PE, CFM, Chair, National Association of Flood and Stormwater Agencies & General Manager/ Chief Engineer, Riverside County Flood Control & Water Conservation District
8:30 – 12:00	CFM Exam. Advance registration with ASFPM required at www.floods.org.
CONCURRENT MORNING SESSIONS	
9:00 – 10:30	Integrated Approaches to Flood Management Moderator: David H. Pohl, PhD, PE, Senior Program Manager, ESA PWA Panelists: • Eileen Takata, Watershed Program Manager, U.S. Army Corps of Engineers, Los Angeles District • Cid Tesoro, PE, Program Manager, County of San Diego Public Works • Terri Grant, PE, Assistant Division Engineer, Watershed Management Division, Los Angeles County Public Works
9:00 – 10:30	TOPICS IN 2D MODEL VALIDATION Session Chair: Andrew Trelease, PE, Principal Civil Engineer, Clark County Regional Flood Control District • 2D Model Calibration of 1998 El Niño Storm. Hassan Kasraie, Kasraie Consulting, Ventura, CA • The Effect of Orientation of Square 2D Grid Elements on Possible Hydraulic Bias in Multiple-Direction Flow Hydraulic Models. Neil M. Jordan, PE, D.WRE, Hromadka & Associates and Theodore Hromadka, Department of Mathematical Science, United States Military Academy, West Point, NY • Benchmarking SWMM5/ PCSWMM 2D Model Performance. Rob James, Computational Hydraulics International
9:00 – 10:30	SPECIAL AGENCY MEETING: Southern California Silver Jackets Kick-Off Summit
10:30 – 12:00	2-D Modeling Roundtable: What have we learned? Moderator: Pal Hegedus, PE, FMA Past Chair, RBF/ Baker. Join the 2D Modeling "Geeks" in this interactive forum to examine conference findings and develop recommendations for improving the use of 2D modeling in floodplain analysis.
10:45 – 12:00	Regulatory Challenges In Managing Flood Risk Moderator: David H. Pohl, PhD, PE, Senior Program Manager, ESA PWA Panelists: • Greg Gearhart, Senior Water Resources Engineer, California State Water Resources Control Board • Corice Farrar, Chief, Orange and Riverside Counties Section, Regulatory Division, U.S. Army Corps of Engineers, Los Angeles District • Nardy Khan, PE, Engineering Supervisor, Projects and Regulatory Permits Unit, Orange County Public Works • Jason Uhley, Chief of Watershed Protection Program, Riverside County Flood Control & Water Conservation District

FLOODPLAIN MANAGEMENT ANNUAL CONFERENCE & 2-D MODELING SYMPOSIUM
September 3-6, Marriott Hotel, Anaheim, California

September 3rd 2-D Modeling Symposium
Exploring "Best Practices" for 2-D Flood Modeling and Mapping

- **Engineering Method Selection and Application**

The Effect of Orientation of Square 2D Grid Elements on Possible Hydraulic Bias in Multiple-Direction Flow Hydraulic Models

N. Jordan (1), Presenter; and T.V. Hromadka II (2)

Abstract:

Multiple directional flow models, such as occasionally used and developed for modeling of unsteady flow in two dimensions, are governed by the well-known flow equations of continuity and momentum. Some of these models use quasi one-dimensional flow rate estimates of flows as applied in the four principal directions along Cartesian coordinate axes and then budget the source and receiving modeling control volumes or cells in order to track mass balance or mass conservation. In this paper is presented the results of research into this topic that are presented in detail and published in the Journal of Hydrology. This paper concludes that mis-alignment of an array of square grid elements in a steady uniform flow results in the greatest error (slight underestimation of flow depth) when the misalignment angle is about 13 degrees, not 45 degrees as previously thought. The bias is about the same as or less than the magnitude of other uncertainties in hydraulic models, and would be compensated for during customary model calibration. Because of the near-uniformity of the slight bias from about 5 degrees to 85 degrees mis-alignment, it is concluded that the array of square elements can be applied over a complex drainage system without respect to topographic flow directions.

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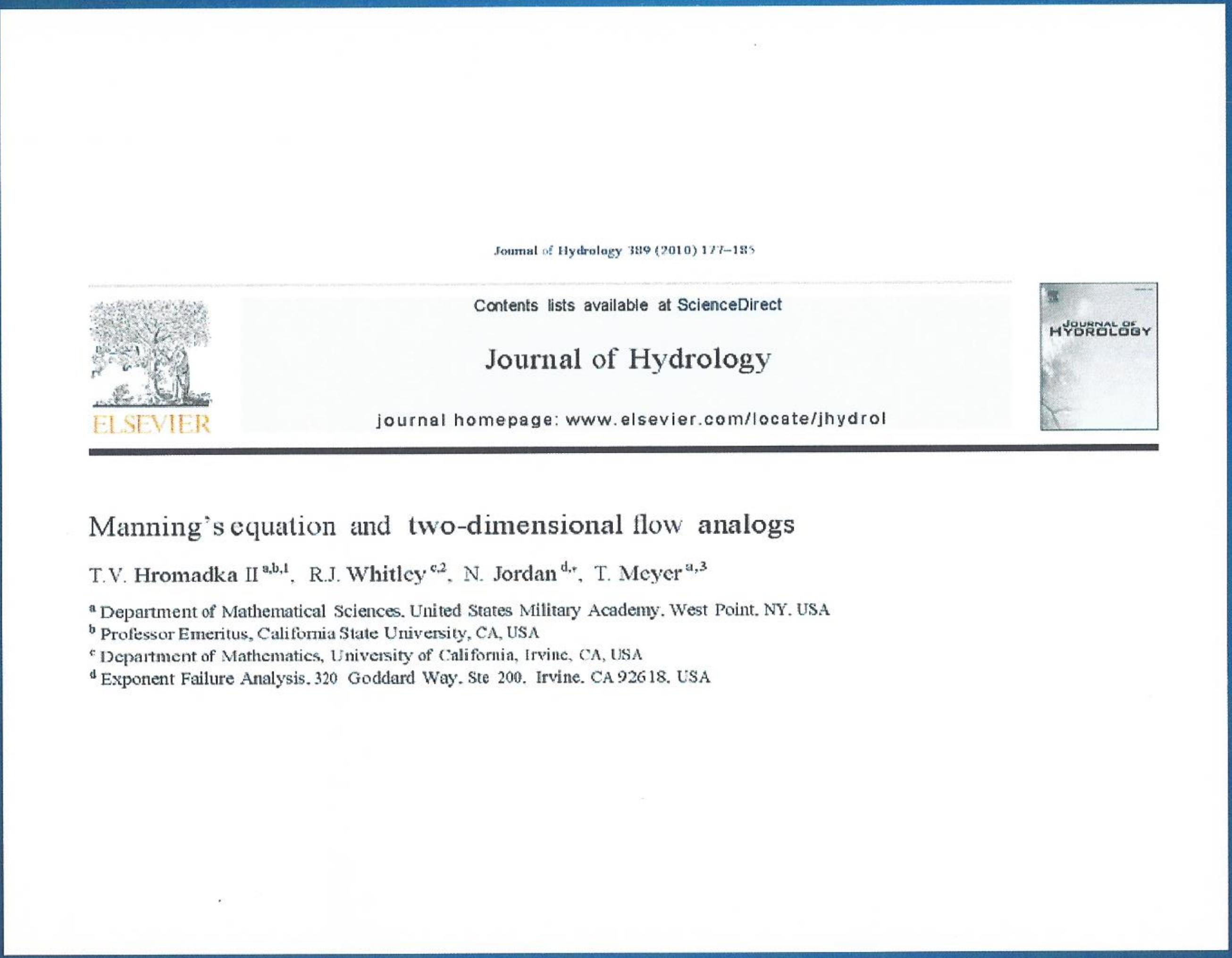
THE EFFECT OF ORIENTATION OF SQUARE 2D GRID ELEMENTS ON POSSIBLE HYDRAULIC BIAS IN MULTIPLE-DIRECTION FLOW HYDRAULIC MODELS

N.M. JORDAN and T.V. HROMADKA

FLOODPLAIN MANAGEMENT
ANNUAL CONFERENCE & 2-D
MODELING SYMPOSIUM

SEPTEMBER 6, 2013

A REPORT OF FINDINGS FROM RESEARCH PUBLISHED IN THE JOURNAL OF HYDROLOGY



Journal of Hydrology 389 (2010) 177–185

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Journal of Hydrology

journal homepage: www.elsevier.com/locate/jhydrol

Manning's equation and two-dimensional flow analogs

T.V. **Hromadka** II[a,b,1], R.J. **Whitley**[c,2], N. **Jordan**[d,*], T. **Meyer**[a,3]

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[b] Professor Emeritus, California State University, CA, USA
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JULY 2010

RESEARCH TO ANSWER SECOND OF TWO QUESTIONS RAISED IN APPLICATION OF US GEOLOGICAL SURVEY 2-D MODEL DEVELOPED BY HROMADKA & YEN IN 1987, WHICH USED MANUAL GRIDDING OF SQUARE GRID ELEMENTS OVER TOPOGRAPHIC SURFACE, ALIGNED APPROXIMATELY TO FLOW STREAMLINES.

WHAT IF SQUARE GRID ELEMENTS ARE NOT ALIGNED WITH FLOW STREAMLINES?

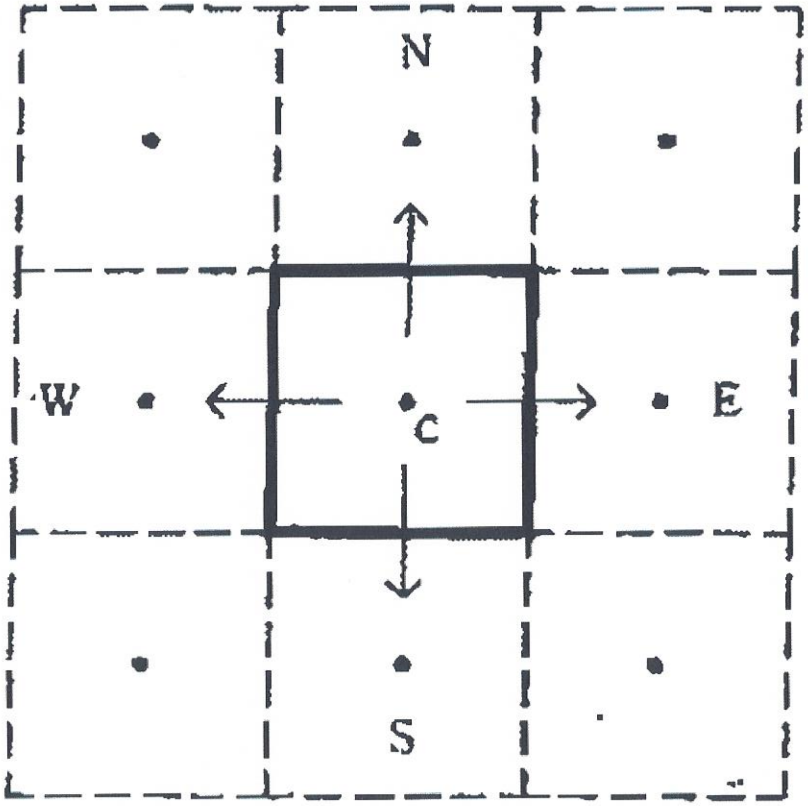
PAPER REPRINT AND SUPPORT DOCUMENTS AVAILABLE AT
http://www.diffusionhydrodynamicmodel.com/index2.html

DHM

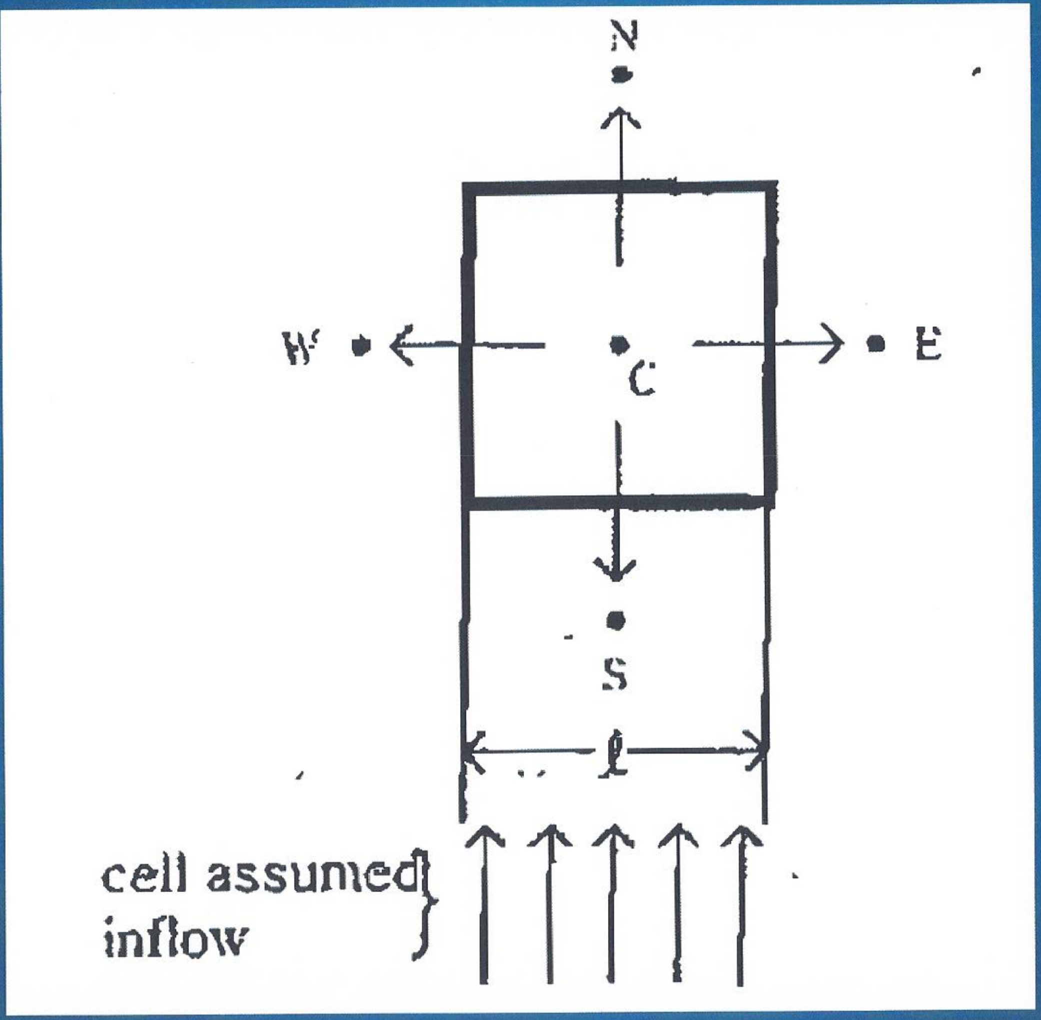
Diffusion Hydrodynamic Model

USGS Water Resources Division Special Report 87-4137

USGS DIFFUSION HYDRODYNAMIC MODEL TILES A TOPOGRAPHIC SURFACE WITH SQUARE GRID ELEMENTS



INTENT IN 1987 WAS TO ALIGN THE GRID ELEMENTS WITH FLOW STREAMLINES



HROMADKA & YEN (1987) USED TILING ALIGNED WITH COMPASS DIRECTION . . .

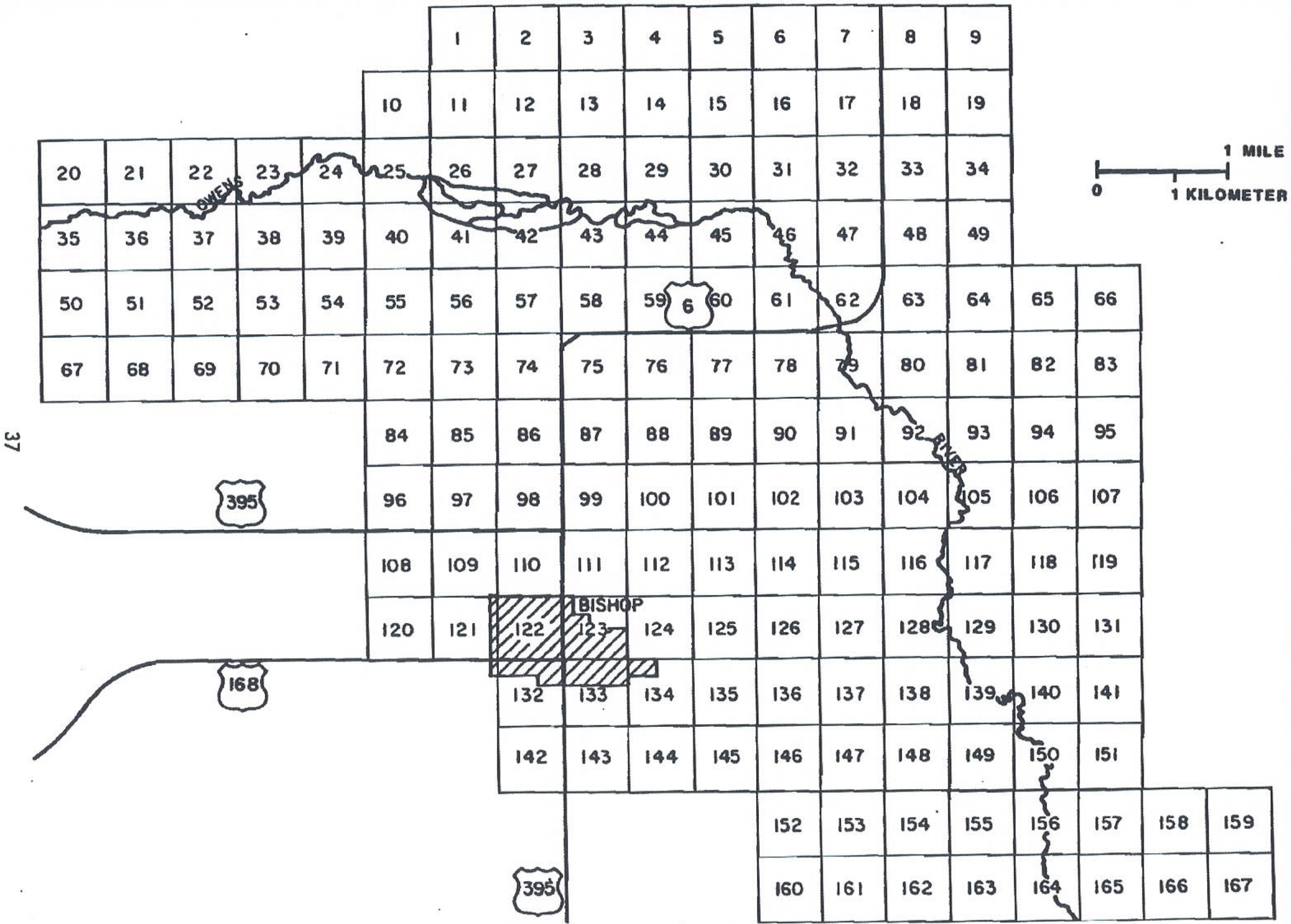
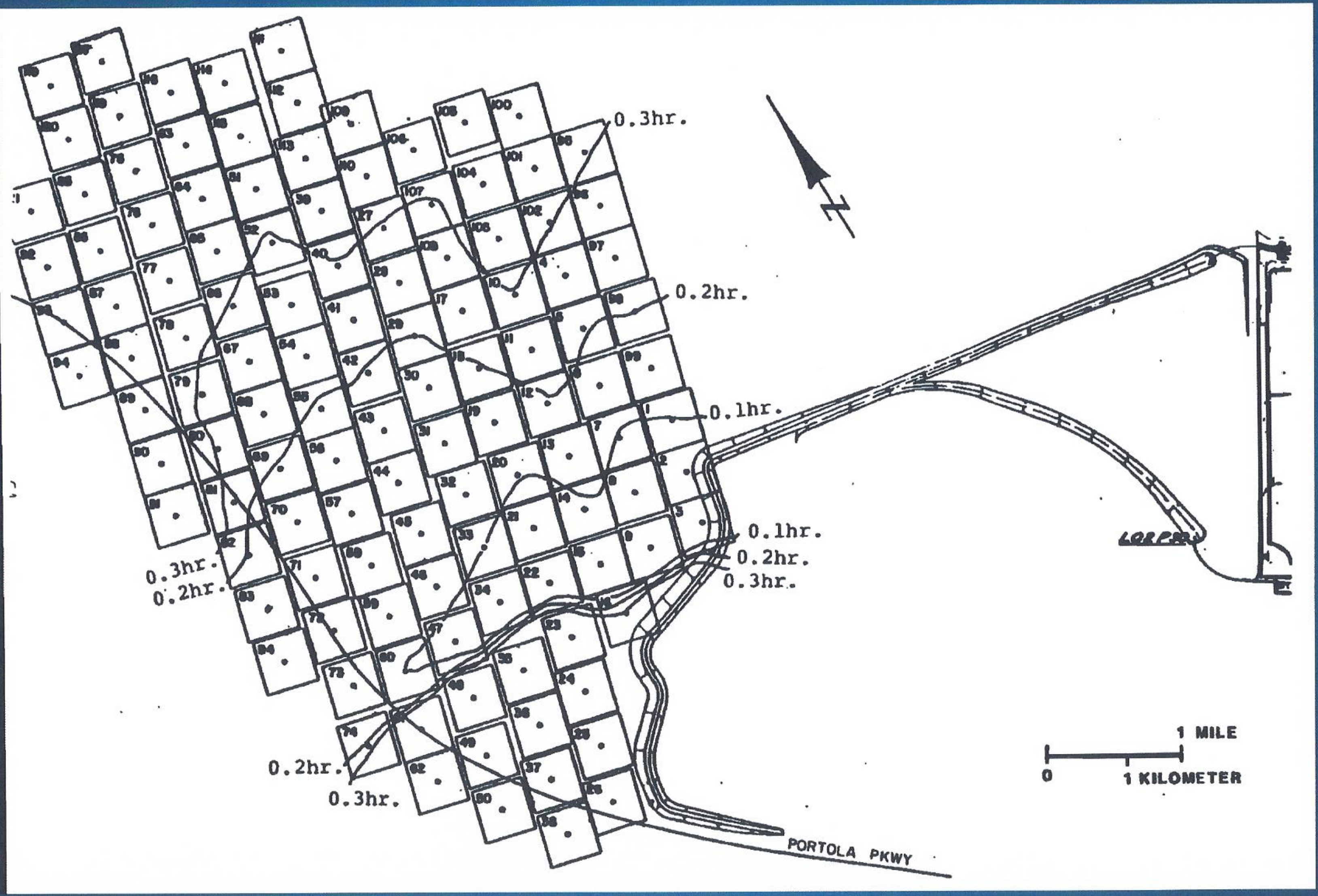


Figure 10.--Floodplain discretization for two-dimensional diffusion hydrodynamic model.

AND ALSO WITH APPROXIMATE FLOW STREAMLINES.



SQUARES ROTATED AND APPROXIMATELY OVERLAPPED

WORST CASE WAS ORIGINALLY CONSIDERED TO BE 45 DEGREES OUT OF ALIGNMENT . . .

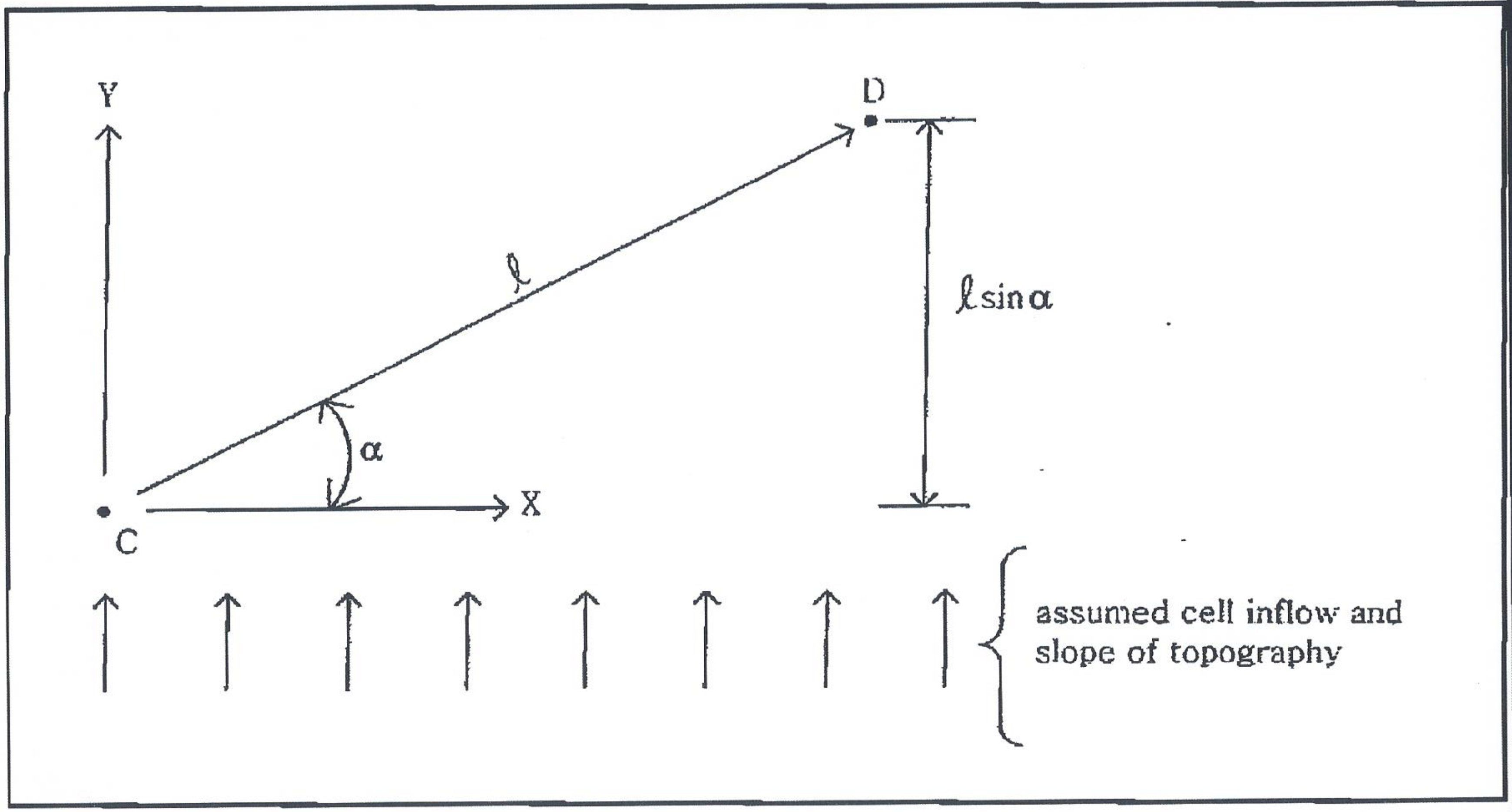


Figure 7. Calculations of Topographic Slope Along Flow Vector Between Nodes C and D.

BUT . . .

MIS-ALIGNMENT EFFECT NOTED BY HORRITT & BATES (2001)

HYDROLOGICAL PROCESSES

Hydrol. Process. **15**, 825–842 (2001)

DOI: 10.1002/hyp.188

Predicting floodplain inundation: raster-based modelling versus the finite-element approach

M. S. Horritt* and P. D. Bates

School of Geographical Sciences, University of Bristol, University Road, Bristol BS8 1SS, UK

Abstract:

"A possible criticism of the cellular approach is that it fails to reproduce some (intuitively correct) features of floodplain flows. **For example, flow may not be parallel to the free surface gradient, depending on the orientation of the free surface slope and the model grid**, but the two approaches agree when the slope is parallel to one of the grid axes. The differences between the two models can be derived analytically for a free surface slope of unit magnitude as a function of direction. **The flow vectors differ in magnitude by a mean value of c. 20% and in angle by c. 10°.** Although these deviations may be compensated for partially in the friction calibration process (the cellular approximation predicts larger flows than the diffusive approximation), the effect on the bulk flow behaviour of the model is unclear, and so both approximations are tested in this study."

MAXIMUM EFFECT WAS AT ABOUT 10 DEGREES MISALIGNMENT.

ALIGNMENT QUANDARY WAS APPROACHED ANALYTICALLY AND EMPIRICALLY FOR A SQUARE GRID ELEMENT IN STEADY UNIFORM FLOW FIELD.

THE ANALYTICAL APPROACH , STARTING WITH:

"For the considered four-direction flow analog, flow directions are in the x, y directions only, whereas in an unaligned flow, streamlines are at an angle h with the positive x-axis. For 2D grid size W, flow velocities in the projected x- and y-directions are obtained from the streamline flow velocity, vs, by. . .[Eq. 11]"

$$\left.\begin{aligned} v_y &= v_s \sin\theta \\ v_x &= v_s \cos\theta \\ v_s^2 &= v_x^2 + v_y^2 \end{aligned}\right\} \qquad (11)$$

THE ANALYTICAL APPROACH , SOLUTION FOR THE TERM BETA, THE RATIO OF STEADY UNIFORM FLOW NORMAL DEPTH TO COMPUTED DEPTH:

"Therefore, the factor, beta, for any angle, can be expressed as a ratio of normal depth to computed depth [Eq. 31]."

$$\beta(\theta) = y_n \,/\, h_4 \qquad \textbf{(31)}$$

"for theta values between 0 and pi/2. Because qx and qy are known by the flow analog application, Eq. (31) is readily applied."

INTRODUCTION OF MANNING'S N SOLUTION FOR THE TERM GAMMA, THE FACTOR APPLIED TO MANNING'S N SO THAT COMPUTED DEPTH EQUALS NORMAL DEPTH FOR A SQUARE GRID ELEMENT IN STEADY UNIFORM FLOW FIELD.

"3. Extension of Manning's equation

"From the previous section, use of a similar application of Manning's equation to flow vectors that are not in alignment with the considered SSUF problem streamlines may introduce a bias in the estimation of hydraulic properties. In this section, the identified possible bias is addressed by redefining the application of the flow vector friction factor. For the considered SSUF problem, equating inflow into the grid to grid outflow by the four-direction flow analog gives [Eq. 32],

$$\frac{1}{n} y_n^{5/3} s_o^{1/2} W(\cos\theta + \sin\theta) = \frac{1}{\gamma n} y_n^{5/3} W(s_{oy}^{1/2} + s_{ox}^{1/2})$$

"where gamma is a factor applied to Manning's n value as applied in the four-direction flow analog such that h4-way = yn [normal depth]."

EQUATION 33, GAMMA AS A FUNCTION OF ANGLE THETA

“From Eq. (16) and combining with Eq. (32) gives gamma as a function of angle theta [Eq. 33]:”

$$\gamma(\theta) = \frac{\sqrt{\cos\theta} + \sqrt{\sin\theta}}{\cos\theta + \sin\theta}$$

GAMMA AS A FUNCTION OF ANGLE THETA

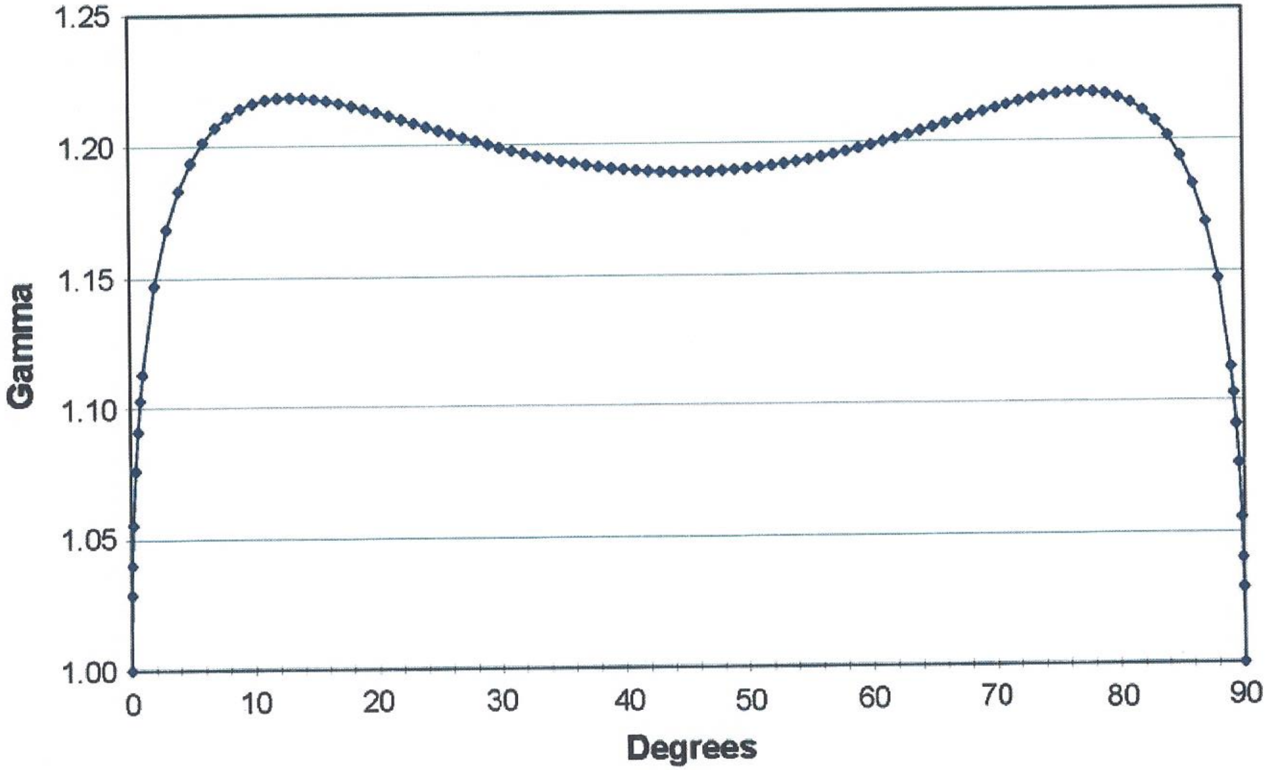


Fig. 2. **Plot of** $C(h) = [({}^{p}\cos h) + ({}^{p}\sin h)]/(\cos h + \sin h)$.

SUMMARY:

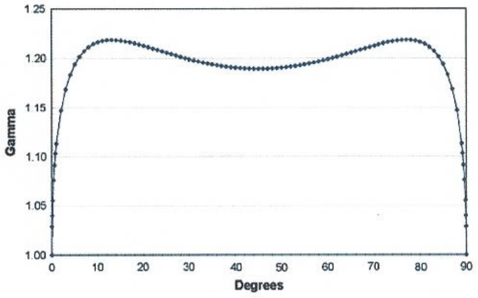


Fig. 2 Plot of $\Gamma(h) = [(^P\cos h) - (^P\sin h)]/(\cos h - \sin h)$

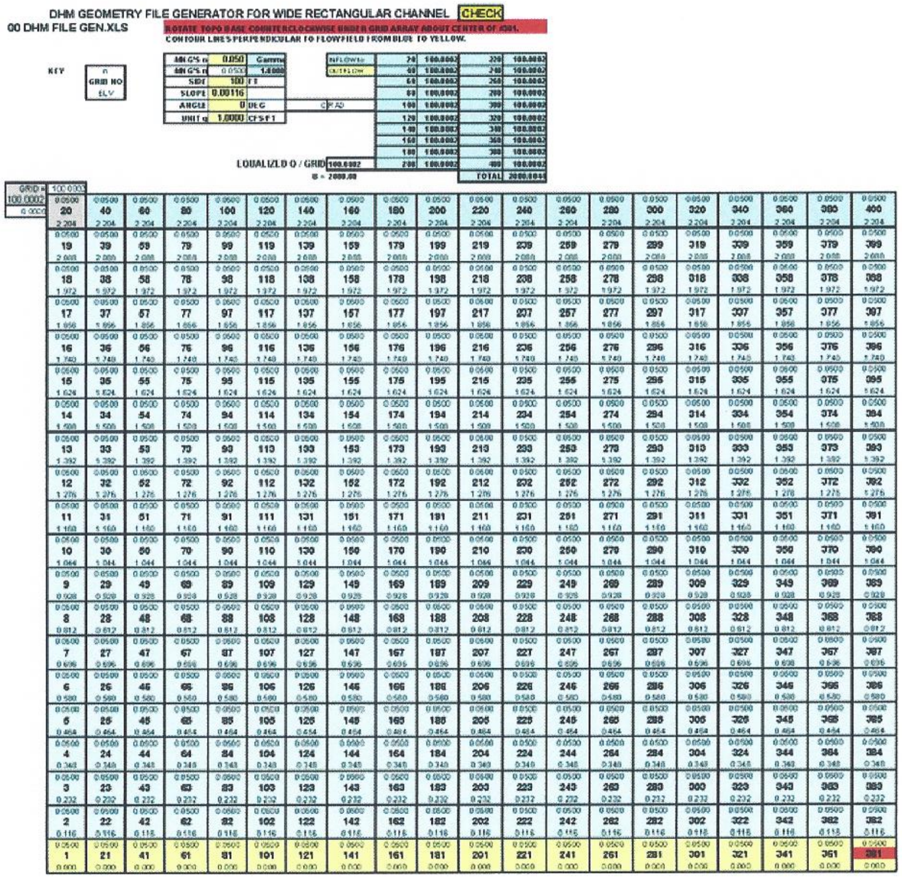
- MIS-ALIGNMENT ANGLE THAT RESULTS IN THE HIGHEST VALUE OF GAMMA (1.22) IS ABOUT 13 DEGREES.
- AVERAGE VALUE OF GAMMA TAKEN AT 1 DEGREE INCREMENTS FROM 0 TO 90 DEGREES IS 1.19.
- AVERAGE VALUE OF GAMMA TAKEN AT 1 DEGREE INCREMENTS FROM 5 TO 85 DEGREES IS 1.20.
- VALUE OF GAMMA AT 45 DEG IS EXACTLY 2^(1/4) OR 1.19.

NOW THE HARD PART –

SET UP ARRAYS OF SQUARE GRID ELEMENTS AT INCREMENTAL ANGLES TO TEST THE EFFECT OF MISALIGNMENT.

- USGS DIFFUSION HYDRODYNAMIC MODEL.
- USE ARRAY OF 20 X 20 GRID ELEMENTS (400 TOTAL).
- USE SLOPE AND ROUGHNESS TO CREATE SHALLOW STEADY UNIFORM SUBCRITICAL FLOW 1 FT DEEP. SUBCRITICAL DRAWDOWN M2 CURVE.
- ROTATE ARRAY IN INCREMENTS OF 1:10 (6 deg), 1:5 (11 deg), 1:4 (14 deg), 1:3 (18 deg), 1:2 (27 deg) AND 1:1 (45 deg).
- NOTE THAT COMPUTED FLOW DEPTHS IN ALL ROTATED (MIS-ALIGNED) MODELS WERE SLIGHTLY LESS THAN ACTUAL NORMAL DEPTH.
- INCREMENTALLY INCREASE MANNING'S N UNTIL COMPUTED FLOW DEPTHS EQUALED ACTUAL NORMAL DEPTH.

ALIGNED MODEL



DHM GEOMETRY FILE GENERATOR FOR WIDE RECTANGULAR CHANNEL **CHECK**

00 DHM FILE GEN.XLS

ROTATE TOPO BASE COUNTERCLOCKWISE UNDER GRID ARRAY ABOUT CENTER OF #381.

CONTOUR LINES PERPENDICULAR TO FLOWFIELD FROM BLUE TO YELLOW.

KEY

n
GRID NO
ELV

MNG'S n	0.050	Gamma	
MNG'S n	0.0500	1.0000	
SIDE	100	FT	
SLOPE	0.00116		
ANGLE	0	DEG	0 RAD
UNIT q	1.0000	CFS/FT	

INFLOW	20	100.0002	220	100.0002
OUTFLOW	40	100.0002	240	100.0002
	60	100.0002	260	100.0002
	80	100.0002	280	100.0002
	100	100.0002	300	100.0002
	120	100.0002	320	100.0002
	140	100.0002	340	100.0002
	160	100.0002	360	100.0002
	180	100.0002	380	100.0002
	200	100.0002	400	100.0002
			TOTAL	2000.004

EQUALIZED Q / GRID 100.0002

Q = 2000.00

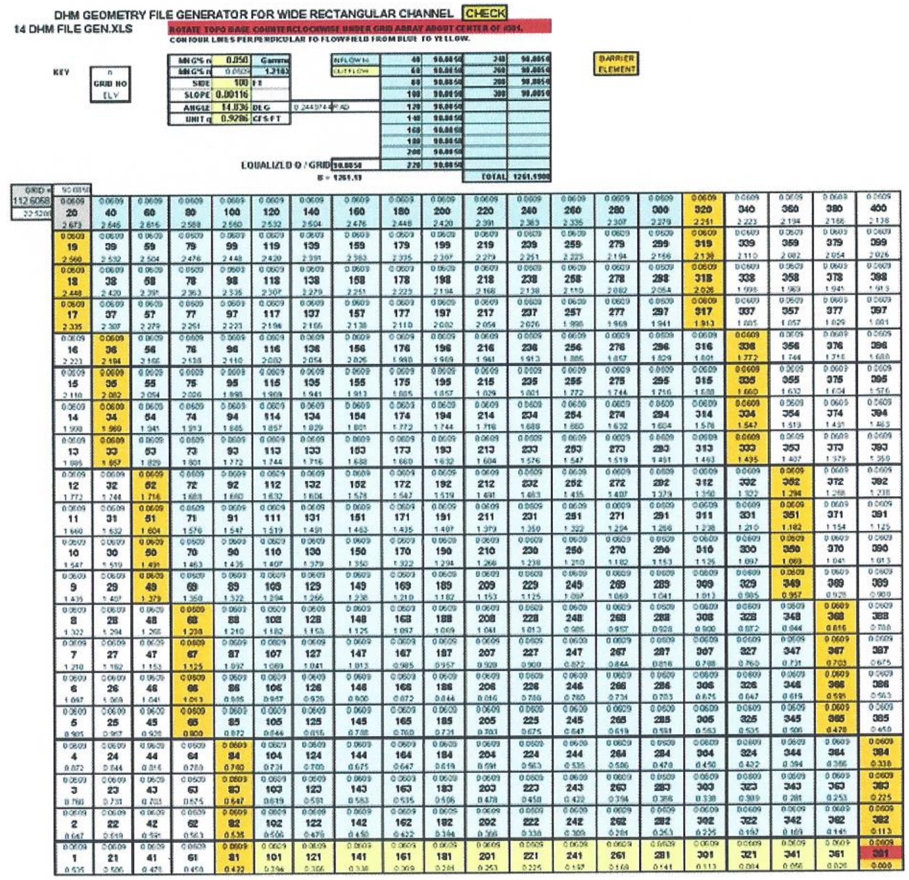
GRID = 100.0002

100.0002

0.0000

0.0500 20 2.204	0.0500 40 2.204	0.0500 60 2.204	0.0500 80 2.204	0.0500 100 2.204	0.0500 120 2.204	0.0500 140 2.204	0.0500 160 2.204	0.0500 180 2.204	0.0500 200 2.204	0.0500 220 2.204	0.0500 240 2.204	0.0500 260 2.204	0.0500 280 2.204	0.0500 300 2.204	0.0500 320 2.204	0.0500 340 2.204	0.0500 360 2.204	0.0500 380 2.204	0.0500 400 2.204
0.0500 19 2.088	0.0500 39 2.088	0.0500 59 2.088	0.0500 79 2.088	0.0500 99 2.088	0.0500 119 2.088	0.0500 139 2.088	0.0500 159 2.088	0.0500 179 2.088	0.0500 199 2.088	0.0500 219 2.088	0.0500 239 2.088	0.0500 259 2.088	0.0500 279 2.088	0.0500 299 2.088	0.0500 319 2.088	0.0500 339 2.088	0.0500 359 2.088	0.0500 379 2.088	0.0500 399 2.088
0.0500 18 1.972	0.0500 38 1.972	0.0500 58 1.972	0.0500 78 1.972	0.0500 98 1.972	0.0500 118 1.972	0.0500 138 1.972	0.0500 158 1.972	0.0500 178 1.972	0.0500 198 1.972	0.0500 218 1.972	0.0500 238 1.972	0.0500 258 1.972	0.0500 278 1.972	0.0500 298 1.972	0.0500 318 1.972	0.0500 338 1.972	0.0500 358 1.972	0.0500 378 1.972	0.0500 398 1.972
0.0500 17 1.856	0.0500 37 1.856	0.0500 57 1.856	0.0500 77 1.856	0.0500 97 1.856	0.0500 117 1.856	0.0500 137 1.856	0.0500 157 1.856	0.0500 177 1.856	0.0500 197 1.856	0.0500 217 1.856	0.0500 237 1.856	0.0500 257 1.856	0.0500 277 1.856	0.0500 297 1.856	0.0500 317 1.856	0.0500 337 1.856	0.0500 357 1.856	0.0500 377 1.856	0.0500 397 1.856
0.0500 16 1.740	0.0500 36 1.740	0.0500 56 1.740	0.0500 76 1.740	0.0500 96 1.740	0.0500 116 1.740	0.0500 136 1.740	0.0500 156 1.740	0.0500 176 1.740	0.0500 196 1.740	0.0500 216 1.740	0.0500 236 1.740	0.0500 256 1.740	0.0500 276 1.740	0.0500 296 1.740	0.0500 316 1.740	0.0500 336 1.740	0.0500 356 1.740	0.0500 376 1.740	0.0500 396 1.740
0.0500 15 1.624	0.0500 35 1.624	0.0500 55 1.624	0.0500 75 1.624	0.0500 95 1.624	0.0500 115 1.624	0.0500 135 1.624	0.0500 155 1.624	0.0500 175 1.624	0.0500 195 1.624	0.0500 215 1.624	0.0500 235 1.624	0.0500 255 1.624	0.0500 275 1.624	0.0500 295 1.624	0.0500 315 1.624	0.0500 335 1.624	0.0500 355 1.624	0.0500 375 1.624	0.0500 395 1.624
0.0500 14 1.508	0.0500 34 1.508	0.0500 54 1.508	0.0500 74 1.508	0.0500 94 1.508	0.0500 114 1.508	0.0500 134 1.508	0.0500 154 1.508	0.0500 174 1.508	0.0500 194 1.508	0.0500 214 1.508	0.0500 234 1.508	0.0500 254 1.508	0.0500 274 1.508	0.0500 294 1.508	0.0500 314 1.508	0.0500 334 1.508	0.0500 354 1.508	0.0500 374 1.508	0.0500 394 1.508
0.0500 13 1.392	0.0500 33 1.392	0.0500 53 1.392	0.0500 73 1.392	0.0500 93 1.392	0.0500 113 1.392	0.0500 133 1.392	0.0500 153 1.392	0.0500 173 1.392	0.0500 193 1.392	0.0500 213 1.392	0.0500 233 1.392	0.0500 253 1.392	0.0500 273 1.392	0.0500 293 1.392	0.0500 313 1.392	0.0500 333 1.392	0.0500 353 1.392	0.0500 373 1.392	0.0500 393 1.392
0.0500 12 1.276	0.0500 32 1.276	0.0500 52 1.276	0.0500 72 1.276	0.0500 92 1.276	0.0500 112 1.276	0.0500 132 1.276	0.0500 152 1.276	0.0500 172 1.276	0.0500 192 1.276	0.0500 212 1.276	0.0500 232 1.276	0.0500 252 1.276	0.0500 272 1.276	0.0500 292 1.276	0.0500 312 1.276	0.0500 332 1.276	0.0500 352 1.276	0.0500 372 1.276	0.0500 392 1.276
0.0500 11 1.160	0.0500 31 1.160	0.0500 51 1.160	0.0500 71 1.160	0.0500 91 1.160	0.0500 111 1.160	0.0500 131 1.160	0.0500 151 1.160	0.0500 171 1.160	0.0500 191 1.160	0.0500 211 1.160	0.0500 231 1.160	0.0500 251 1.160	0.0500 271 1.160	0.0500 291 1.160	0.0500 311 1.160	0.0500 331 1.160	0.0500 351 1.160	0.0500 371 1.160	0.0500 391 1.160
0.0500 10 1.044	0.0500 30 1.044	0.0500 50 1.044	0.0500 70 1.044	0.0500 90 1.044	0.0500 110 1.044	0.0500 130 1.044	0.0500 150 1.044	0.0500 170 1.044	0.0500 190 1.044	0.0500 210 1.044	0.0500 230 1.044	0.0500 250 1.044	0.0500 270 1.044	0.0500 290 1.044	0.0500 310 1.044	0.0500 330 1.044	0.0500 350 1.044	0.0500 370 1.044	0.0500 390 1.044
0.0500 9 0.928	0.0500 29 0.928	0.0500 49 0.928	0.0500 69 0.928	0.0500 89 0.928	0.0500 109 0.928	0.0500 129 0.928	0.0500 149 0.928	0.0500 169 0.928	0.0500 189 0.928	0.0500 209 0.928	0.0500 229 0.928	0.0500 249 0.928	0.0500 269 0.928	0.0500 289 0.928	0.0500 309 0.928	0.0500 329 0.928	0.0500 349 0.928	0.0500 369 0.928	0.0500 389 0.928
0.0500 8 0.812	0.0500 28 0.812	0.0500 48 0.812	0.0500 68 0.812	0.0500 88 0.812	0.0500 108 0.812	0.0500 128 0.812	0.0500 148 0.812	0.0500 168 0.812	0.0500 188 0.812	0.0500 208 0.812	0.0500 228 0.812	0.0500 248 0.812	0.0500 268 0.812	0.0500 288 0.812	0.0500 308 0.812	0.0500 328 0.812	0.0500 348 0.812	0.0500 368 0.812	0.0500 388 0.812
0.0500 7 0.696	0.0500 27 0.696	0.0500 47 0.696	0.0500 67 0.696	0.0500 87 0.696	0.0500 107 0.696	0.0500 127 0.696	0.0500 147 0.696	0.0500 167 0.696	0.0500 187 0.696	0.0500 207 0.696	0.0500 227 0.696	0.0500 247 0.696	0.0500 267 0.696	0.0500 287 0.696	0.0500 307 0.696	0.0500 327 0.696	0.0500 347 0.696	0.0500 367 0.696	0.0500 387 0.696
0.0500 6 0.580	0.0500 26 0.580	0.0500 46 0.580	0.0500 66 0.580	0.0500 86 0.580	0.0500 106 0.580	0.0500 126 0.580	0.0500 146 0.580	0.0500 166 0.580	0.0500 186 0.580	0.0500 206 0.580	0.0500 226 0.580	0.0500 246 0.580	0.0500 266 0.580	0.0500 286 0.580	0.0500 306 0.580	0.0500 326 0.580	0.0500 346 0.580	0.0500 366 0.580	0.0500 386 0.580
0.0500 5 0.464	0.0500 25 0.464	0.0500 45 0.464	0.0500 65 0.464	0.0500 85 0.464	0.0500 105 0.464	0.0500 125 0.464	0.0500 145 0.464	0.0500 165 0.464	0.0500 185 0.464	0.0500 205 0.464	0.0500 225 0.464	0.0500 245 0.464	0.0500 265 0.464	0.0500 285 0.464	0.0500 305 0.464	0.0500 325 0.464	0.0500 345 0.464	0.0500 365 0.464	0.0500 385 0.464
0.0500 4 0.348	0.0500 24 0.348	0.0500 44 0.348	0.0500 64 0.348	0.0500 84 0.348	0.0500 104 0.348	0.0500 124 0.348	0.0500 144 0.348	0.0500 164 0.348	0.0500 184 0.348	0.0500 204 0.348	0.0500 224 0.348	0.0500 244 0.348	0.0500 264 0.348	0.0500 284 0.348	0.0500 304 0.348	0.0500 324 0.348	0.0500 344 0.348	0.0500 364 0.348	0.0500 384 0.348
0.0500 3 0.232	0.0500 23 0.232	0.0500 43 0.232	0.0500 63 0.232	0.0500 83 0.232	0.0500 103 0.232	0.0500 123 0.232	0.0500 143 0.232	0.0500 163 0.232	0.0500 183 0.232	0.0500 203 0.232	0.0500 223 0.232	0.0500 243 0.232	0.0500 263 0.232	0.0500 283 0.232	0.0500 303 0.232	0.0500 323 0.232	0.0500 343 0.232	0.0500 363 0.232	0.0500 383 0.232
0.0500 2 0.116	0.0500 22 0.116	0.0500 42 0.116	0.0500 62 0.116	0.0500 82 0.116	0.0500 102 0.116	0.0500 122 0.116	0.0500 142 0.116	0.0500 162 0.116	0.0500 182 0.116	0.0500 202 0.116	0.0500 222 0.116	0.0500 242 0.116	0.0500 262 0.116	0.0500 282 0.116	0.0500 302 0.116	0.0500 322 0.116	0.0500 342 0.116	0.0500 362 0.116	0.0500 382 0.116
0.0500 1 0.000	0.0500 21 0.000	0.0500 41 0.000	0.0500 61 0.000	0.0500 81 0.000	0.0500 101 0.000	0.0500 121 0.000	0.0500 141 0.000	0.0500 161 0.000	0.0500 181 0.000	0.0500 201 0.000	0.0500 221 0.000	0.0500 241 0.000	0.0500 261 0.000	0.0500 281 0.000	0.0500 301 0.000	0.0500 321 0.000	0.0500 341 0.000	0.0500 361 0.000	0.0500 381 0.000

MIS-ALIGNED MODEL
14 DEGREES



DHM GEOMETRY FILE GENERATOR FOR WIDE RECTANGULAR CHANNEL **CHECK**

14 DHM FILE GEN.XLS

ROTATE TOPO BASE COUNTERCLOCKWISE UNDER GRID ARRAY ABOUT CENTER OF #381.

CONTOUR LINES PERPENDICULAR TO FLOWFIELD FROM BLUE TO YELLOW.

KEY

n
GRID NO
ELV

BARRIER ELEMENT

MEG'S n	0.050	Gamma	
MEG'S n	0.0609	1.2183	
SIDE	100	FT	
SLOPE	0.00116		
ANGLE	14.036	DEG	0.244974 RAD
UNIT q	0.9286	CFS/FT	

INFLOW Is	40	90.0850	240	90.0850
OUTFLOW	60	90.0850	260	90.0850
	80	90.0850	280	90.0850
	100	90.0850	300	90.0850
	120	90.0850		
	140	90.0850		
	160	90.0850		
	180	90.0850		
	200	90.0850		
EQUALIZED Q / GRID 90.0850	220	90.0850		
			TOTAL	1261.1900

B = 1261.19

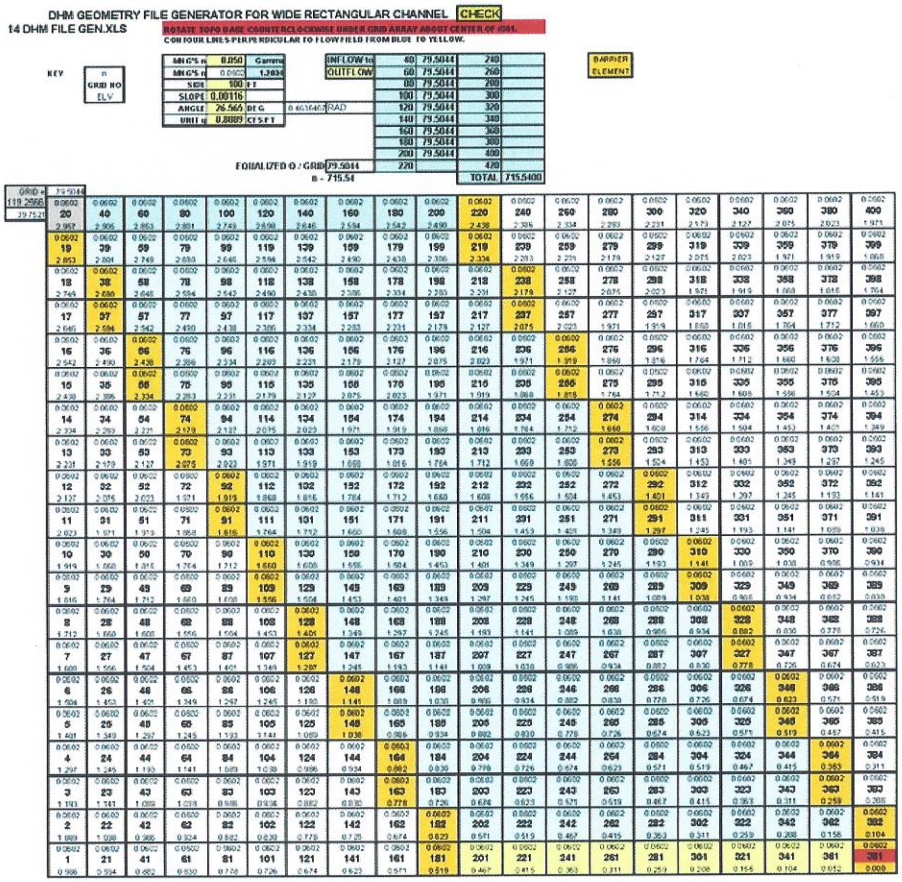
GRID = 90.0850

112.6068

22.5200

0.0609 20 2.673	0.0609 40 2.646	0.0609 60 2.616	0.0609 80 2.588	0.0609 100 2.560	0.0609 120 2.532	0.0609 140 2.504	0.0609 160 2.476	0.0609 180 2.448	0.0609 200 2.420	0.0609 220 2.391	0.0609 240 2.363	0.0609 260 2.335	0.0609 280 2.307	0.0609 300 2.279	0.0609 320 2.251	0.0609 340 2.223	0.0609 360 2.194	0.0609 380 2.166	0.0609 400 2.138
0.0609 19 2.560	0.0609 39 2.532	0.0609 59 2.504	0.0609 79 2.476	0.0609 99 2.448	0.0609 119 2.420	0.0609 139 2.391	0.0609 159 2.363	0.0609 179 2.335	0.0609 199 2.307	0.0609 219 2.279	0.0609 239 2.251	0.0609 259 2.223	0.0609 279 2.194	0.0609 299 2.166	0.0609 319 2.138	0.0609 339 2.110	0.0609 359 2.082	0.0609 379 2.054	0.0609 399 2.026
0.0609 18 2.448	0.0609 38 2.420	0.0609 58 2.391	0.0609 78 2.363	0.0609 98 2.335	0.0609 118 2.307	0.0609 138 2.279	0.0609 158 2.251	0.0609 178 2.223	0.0609 198 2.194	0.0609 218 2.166	0.0609 238 2.138	0.0609 258 2.110	0.0609 278 2.082	0.0609 298 2.054	0.0609 318 2.026	0.0609 338 1.998	0.0609 358 1.969	0.0609 378 1.941	0.0609 398 1.913
0.0609 17 2.335	0.0609 37 2.307	0.0609 57 2.279	0.0609 77 2.251	0.0609 97 2.223	0.0609 117 2.194	0.0609 137 2.166	0.0609 157 2.138	0.0609 177 2.110	0.0609 197 2.082	0.0609 217 2.054	0.0609 237 2.026	0.0609 257 1.998	0.0609 277 1.969	0.0609 297 1.941	0.0609 317 1.913	0.0609 337 1.885	0.0609 357 1.857	0.0609 377 1.829	0.0609 397 1.801
0.0609 16 2.223	0.0609 36 2.194	0.0609 56 2.166	0.0609 76 2.138	0.0609 96 2.110	0.0609 116 2.082	0.0609 136 2.054	0.0609 156 2.026	0.0609 176 1.998	0.0609 196 1.969	0.0609 216 1.941	0.0609 236 1.913	0.0609 256 1.885	0.0609 276 1.857	0.0609 296 1.829	0.0609 316 1.801	0.0609 336 1.772	0.0609 356 1.744	0.0609 376 1.716	0.0609 396 1.688
0.0609 15 2.110	0.0609 35 2.082	0.0609 55 2.054	0.0609 75 2.026	0.0609 95 1.998	0.0609 115 1.969	0.0609 135 1.941	0.0609 155 1.913	0.0609 175 1.885	0.0609 195 1.857	0.0609 215 1.829	0.0609 235 1.801	0.0609 255 1.772	0.0609 275 1.744	0.0609 295 1.716	0.0609 315 1.688	0.0609 335 1.660	0.0609 355 1.632	0.0609 375 1.604	0.0609 395 1.576
0.0609 14 1.998	0.0609 34 1.969	0.0609 54 1.941	0.0609 74 1.913	0.0609 94 1.885	0.0609 114 1.857	0.0609 134 1.829	0.0609 154 1.801	0.0609 174 1.772	0.0609 194 1.744	0.0609 214 1.716	0.0609 234 1.688	0.0609 254 1.660	0.0609 274 1.632	0.0609 294 1.604	0.0609 314 1.576	0.0609 334 1.547	0.0609 354 1.519	0.0609 374 1.491	0.0609 394 1.463
0.0609 13 1.885	0.0609 33 1.857	0.0609 53 1.829	0.0609 73 1.801	0.0609 93 1.772	0.0609 113 1.744	0.0609 133 1.716	0.0609 153 1.688	0.0609 173 1.660	0.0609 193 1.632	0.0609 213 1.604	0.0609 233 1.576	0.0609 253 1.547	0.0609 273 1.519	0.0609 293 1.491	0.0609 313 1.463	0.0609 333 1.435	0.0609 353 1.407	0.0609 373 1.379	0.0609 393 1.350
0.0609 12 1.772	0.0609 32 1.744	0.0609 52 1.716	0.0609 72 1.688	0.0609 92 1.660	0.0609 112 1.632	0.0609 132 1.604	0.0609 152 1.576	0.0609 172 1.547	0.0609 192 1.519	0.0609 212 1.491	0.0609 232 1.463	0.0609 252 1.435	0.0609 272 1.407	0.0609 292 1.379	0.0609 312 1.350	0.0609 332 1.322	0.0609 352 1.294	0.0609 372 1.266	0.0609 392 1.238
0.0609 11 1.660	0.0609 31 1.632	0.0609 51 1.604	0.0609 71 1.576	0.0609 91 1.547	0.0609 111 1.519	0.0609 131 1.491	0.0609 151 1.463	0.0609 171 1.435	0.0609 191 1.407	0.0609 211 1.379	0.0609 231 1.350	0.0609 251 1.322	0.0609 271 1.294	0.0609 291 1.266	0.0609 311 1.238	0.0609 331 1.210	0.0609 351 1.182	0.0609 371 1.153	0.0609 391 1.125
0.0609 10 1.547	0.0609 30 1.519	0.0609 50 1.491	0.0609 70 1.463	0.0609 90 1.435	0.0609 110 1.407	0.0609 130 1.379	0.0609 150 1.350	0.0609 170 1.322	0.0609 190 1.294	0.0609 210 1.266	0.0609 230 1.238	0.0609 250 1.210	0.0609 270 1.182	0.0609 290 1.153	0.0609 310 1.125	0.0609 330 1.097	0.0609 350 1.069	0.0609 370 1.041	0.0609 390 1.013
0.0609 9 1.435	0.0609 29 1.407	0.0609 49 1.379	0.0609 69 1.350	0.0609 89 1.322	0.0609 109 1.294	0.0609 129 1.266	0.0609 149 1.238	0.0609 169 1.210	0.0609 189 1.182	0.0609 209 1.153	0.0609 229 1.125	0.0609 249 1.097	0.0609 269 1.069	0.0609 289 1.041	0.0609 309 1.013	0.0609 329 0.985	0.0609 349 0.957	0.0609 369 0.928	0.0609 389 0.900
0.0609 8 1.322	0.0609 28 1.294	0.0609 48 1.266	0.0609 68 1.238	0.0609 88 1.210	0.0609 108 1.182	0.0609 128 1.153	0.0609 148 1.125	0.0609 168 1.097	0.0609 188 1.069	0.0609 208 1.041	0.0609 228 1.013	0.0609 248 0.985	0.0609 268 0.957	0.0609 288 0.928	0.0609 308 0.900	0.0609 328 0.872	0.0609 348 0.844	0.0609 368 0.816	0.0609 388 0.788
0.0609 7 1.210	0.0609 27 1.182	0.0609 47 1.153	0.0609 67 1.125	0.0609 87 1.097	0.0609 107 1.069	0.0609 127 1.041	0.0609 147 1.013	0.0609 167 0.985	0.0609 187 0.957	0.0609 207 0.928	0.0609 227 0.900	0.0609 247 0.872	0.0609 267 0.844	0.0609 287 0.816	0.0609 307 0.788	0.0609 327 0.760	0.0609 347 0.731	0.0609 367 0.703	0.0609 387 0.675
0.0609 6 1.097	0.0609 26 1.069	0.0609 46 1.041	0.0609 66 1.013	0.0609 86 0.985	0.0609 106 0.957	0.0609 126 0.928	0.0609 146 0.900	0.0609 166 0.872	0.0609 186 0.844	0.0609 206 0.816	0.0609 226 0.788	0.0609 246 0.760	0.0609 266 0.731	0.0609 286 0.703	0.0609 306 0.675	0.0609 326 0.647	0.0609 346 0.619	0.0609 366 0.591	0.0609 386 0.563
0.0609 5 0.985	0.0609 25 0.957	0.0609 45 0.928	0.0609 65 0.900	0.0609 85 0.872	0.0609 105 0.844	0.0609 125 0.816	0.0609 145 0.788	0.0609 165 0.760	0.0609 185 0.731	0.0609 205 0.703	0.0609 225 0.675	0.0609 245 0.647	0.0609 265 0.619	0.0609 285 0.591	0.0609 305 0.563	0.0609 325 0.535	0.0609 345 0.506	0.0609 365 0.478	0.0609 385 0.450
0.0609 4 0.872	0.0609 24 0.844	0.0609 44 0.816	0.0609 64 0.788	0.0609 84 0.760	0.0609 104 0.731	0.0609 124 0.703	0.0609 144 0.675	0.0609 164 0.647	0.0609 184 0.619	0.0609 204 0.591	0.0609 224 0.563	0.0609 244 0.535	0.0609 264 0.506	0.0609 284 0.478	0.0609 304 0.450	0.0609 324 0.422	0.0609 344 0.394	0.0609 364 0.366	0.0609 384 0.338
0.0609 3 0.760	0.0609 23 0.731	0.0609 43 0.703	0.0609 63 0.675	0.0609 83 0.647	0.0609 103 0.619	0.0609 123 0.591	0.0609 143 0.563	0.0609 163 0.535	0.0609 183 0.506	0.0609 203 0.478	0.0609 223 0.450	0.0609 243 0.422	0.0609 263 0.394	0.0609 283 0.366	0.0609 303 0.338	0.0609 323 0.309	0.0609 343 0.281	0.0609 363 0.253	0.0609 383 0.225
0.0609 2 0.647	0.0609 22 0.619	0.0609 42 0.591	0.0609 62 0.563	0.0609 82 0.535	0.0609 102 0.506	0.0609 122 0.478	0.0609 142 0.450	0.0609 162 0.422	0.0609 182 0.394	0.0609 202 0.366	0.0609 222 0.338	0.0609 242 0.309	0.0609 262 0.281	0.0609 282 0.253	0.0609 302 0.225	0.0609 322 0.197	0.0609 342 0.169	0.0609 362 0.141	0.0609 382 0.113
0.0609 1 0.535	0.0609 21 0.506	0.0609 41 0.478	0.0609 61 0.450	0.0609 81 0.422	0.0609 101 0.394	0.0609 121 0.366	0.0609 141 0.338	0.0609 161 0.309	0.0609 181 0.281	0.0609 201 0.253	0.0609 221 0.225	0.0609 241 0.197	0.0609 261 0.169	0.0609 281 0.141	0.0609 301 0.113	0.0609 321 0.084	0.0609 341 0.056	0.0609 361 0.028	0.0609 381 0.000

MIS-ALIGNED MODEL
27 DEGREES



DHM GEOMETRY FILE GENERATOR FOR WIDE RECTANGULAR CHANNEL CHECK

14 DHM FILE GEN.XLS

ROTATE TOPO BASE COUNTERCLOCKWISE UNDER GRID ARRAY ABOUT CENTER OF #381.

CONTOUR LINES PERPENDICULAR TO FLOWFIELD FROM BLUE TO YELLOW.

KEY

n
GRID NO
ELV

MNG'S n	0.050	Gamma	
MNG'S n	0.0602	1.2036	
SIDE	100	FT	
SLOPE	0.00116		
ANGLE	26.565	DEG	0.4636476 RAD
UNIT q	0.8889	CFS/FT	

INFLOW to	40	79.5044	240	
OUTFLOW	60	79.5044	260	
	80	79.5044	280	
	100	79.5044	300	
	120	79.5044	320	
	140	79.5044	340	
	160	79.5044	360	
	180	79.5044	380	
	200	79.5044	400	
	220		420	
			TOTAL	715.5400

EQUALIZED Q / GRID 79.5044

Q = 715.54

BARRIER ELEMENT

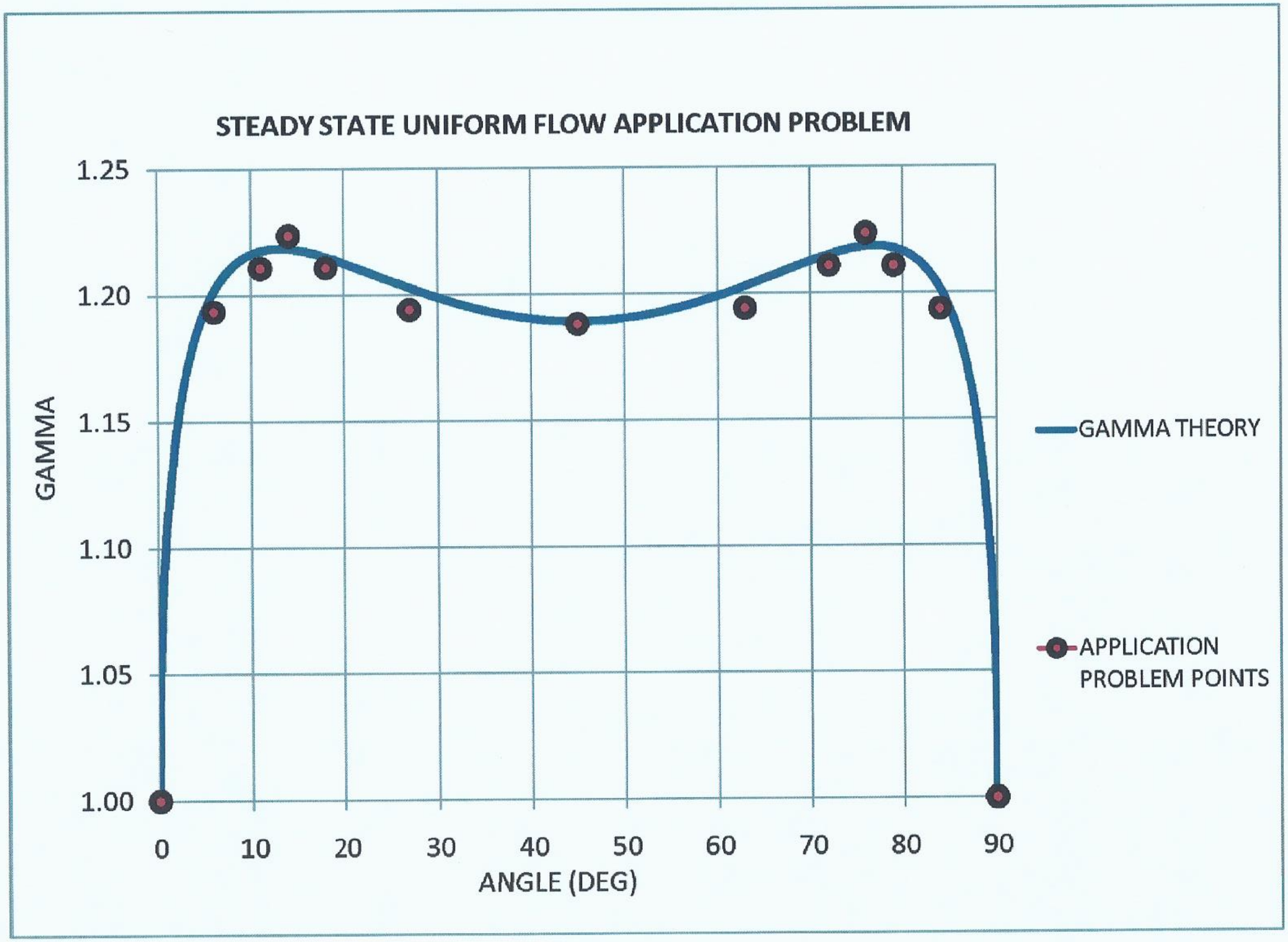
GRID = 119.2966

39.7521

79.5044

0.0602 20 2.957	0.0602 40 2.905	0.0602 60 2.853	0.0602 80 2.801	0.0602 100 2.749	0.0602 120 2.698	0.0602 140 2.646	0.0602 160 2.594	0.0602 180 2.542	0.0602 200 2.490	0.0602 220 2.438	0.0602 240 2.386	0.0602 260 2.334	0.0602 280 2.283	0.0602 300 2.231	0.0602 320 2.179	0.0602 340 2.127	0.0602 360 2.075	0.0602 380 2.023	0.0602 400 1.971
0.0602 19 2.853	0.0602 39 2.801	0.0602 59 2.749	0.0602 79 2.698	0.0602 99 2.646	0.0602 119 2.594	0.0602 139 2.542	0.0602 159 2.490	0.0602 179 2.438	0.0602 199 2.386	0.0602 219 2.334	0.0602 239 2.283	0.0602 259 2.231	0.0602 279 2.179	0.0602 299 2.127	0.0602 319 2.075	0.0602 339 2.023	0.0602 359 1.971	0.0602 379 1.919	0.0602 399 1.868
0.0602 18 2.749	0.0602 38 2.698	0.0602 58 2.646	0.0602 78 2.594	0.0602 98 2.542	0.0602 118 2.490	0.0602 138 2.438	0.0602 158 2.386	0.0602 178 2.334	0.0602 198 2.283	0.0602 218 2.231	0.0602 238 2.179	0.0602 258 2.127	0.0602 278 2.075	0.0602 298 2.023	0.0602 318 1.971	0.0602 338 1.919	0.0602 358 1.868	0.0602 378 1.816	0.0602 398 1.764
0.0602 17 2.646	0.0602 37 2.594	0.0602 57 2.542	0.0602 77 2.490	0.0602 97 2.438	0.0602 117 2.386	0.0602 137 2.334	0.0602 157 2.283	0.0602 177 2.231	0.0602 197 2.179	0.0602 217 2.127	0.0602 237 2.075	0.0602 257 2.023	0.0602 277 1.971	0.0602 297 1.919	0.0602 317 1.868	0.0602 337 1.816	0.0602 357 1.764	0.0602 377 1.712	0.0602 397 1.660
0.0602 16 2.542	0.0602 36 2.490	0.0602 56 2.438	0.0602 76 2.386	0.0602 96 2.334	0.0602 116 2.283	0.0602 136 2.231	0.0602 156 2.179	0.0602 176 2.127	0.0602 196 2.075	0.0602 216 2.023	0.0602 236 1.971	0.0602 256 1.919	0.0602 276 1.868	0.0602 296 1.816	0.0602 316 1.764	0.0602 336 1.712	0.0602 356 1.660	0.0602 376 1.608	0.0602 396 1.556
0.0602 15 2.438	0.0602 35 2.386	0.0602 55 2.334	0.0602 75 2.283	0.0602 95 2.231	0.0602 115 2.179	0.0602 135 2.127	0.0602 155 2.075	0.0602 175 2.023	0.0602 195 1.971	0.0602 215 1.919	0.0602 235 1.868	0.0602 255 1.816	0.0602 275 1.764	0.0602 295 1.712	0.0602 315 1.660	0.0602 335 1.608	0.0602 355 1.556	0.0602 375 1.504	0.0602 395 1.453
0.0602 14 2.334	0.0602 34 2.283	0.0602 54 2.231	0.0602 74 2.179	0.0602 94 2.127	0.0602 114 2.075	0.0602 134 2.023	0.0602 154 1.971	0.0602 174 1.919	0.0602 194 1.868	0.0602 214 1.816	0.0602 234 1.764	0.0602 254 1.712	0.0602 274 1.660	0.0602 294 1.608	0.0602 314 1.556	0.0602 334 1.504	0.0602 354 1.453	0.0602 374 1.401	0.0602 394 1.349
0.0602 13 2.231	0.0602 33 2.179	0.0602 53 2.127	0.0602 73 2.075	0.0602 93 2.023	0.0602 113 1.971	0.0602 133 1.919	0.0602 153 1.868	0.0602 173 1.816	0.0602 193 1.764	0.0602 213 1.712	0.0602 233 1.660	0.0602 253 1.608	0.0602 273 1.556	0.0602 293 1.504	0.0602 313 1.453	0.0602 333 1.401	0.0602 353 1.349	0.0602 373 1.297	0.0602 393 1.245
0.0602 12 2.127	0.0602 32 2.075	0.0602 52 2.023	0.0602 72 1.971	0.0602 92 1.919	0.0602 112 1.868	0.0602 132 1.816	0.0602 152 1.764	0.0602 172 1.712	0.0602 192 1.660	0.0602 212 1.608	0.0602 232 1.556	0.0602 252 1.504	0.0602 272 1.453	0.0602 292 1.401	0.0602 312 1.349	0.0602 332 1.297	0.0602 352 1.245	0.0602 372 1.193	0.0602 392 1.141
0.0602 11 2.023	0.0602 31 1.971	0.0602 51 1.919	0.0602 71 1.868	0.0602 91 1.816	0.0602 111 1.764	0.0602 131 1.712	0.0602 151 1.660	0.0602 171 1.608	0.0602 191 1.556	0.0602 211 1.504	0.0602 231 1.453	0.0602 251 1.401	0.0602 271 1.349	0.0602 291 1.297	0.0602 311 1.245	0.0602 331 1.193	0.0602 351 1.141	0.0602 371 1.089	0.0602 391 1.038
0.0602 10 1.919	0.0602 30 1.868	0.0602 50 1.816	0.0602 70 1.764	0.0602 90 1.712	0.0602 110 1.660	0.0602 130 1.608	0.0602 150 1.556	0.0602 170 1.504	0.0602 190 1.453	0.0602 210 1.401	0.0602 230 1.349	0.0602 250 1.297	0.0602 270 1.245	0.0602 290 1.193	0.0602 310 1.141	0.0602 330 1.089	0.0602 350 1.038	0.0602 370 0.986	0.0602 390 0.934
0.0602 9 1.816	0.0602 29 1.764	0.0602 49 1.712	0.0602 69 1.660	0.0602 89 1.608	0.0602 109 1.556	0.0602 129 1.504	0.0602 149 1.453	0.0602 169 1.401	0.0602 189 1.349	0.0602 209 1.297	0.0602 229 1.245	0.0602 249 1.193	0.0602 269 1.141	0.0602 289 1.089	0.0602 309 1.038	0.0602 329 0.986	0.0602 349 0.934	0.0602 369 0.882	0.0602 389 0.830
0.0602 8 1.712	0.0602 28 1.660	0.0602 48 1.608	0.0602 68 1.556	0.0602 88 1.504	0.0602 108 1.453	0.0602 128 1.401	0.0602 148 1.349	0.0602 168 1.297	0.0602 188 1.245	0.0602 208 1.193	0.0602 228 1.141	0.0602 248 1.089	0.0602 268 1.038	0.0602 288 0.986	0.0602 308 0.934	0.0602 328 0.882	0.0602 348 0.830	0.0602 368 0.778	0.0602 388 0.726
0.0602 7 1.608	0.0602 27 1.556	0.0602 47 1.504	0.0602 67 1.453	0.0602 87 1.401	0.0602 107 1.349	0.0602 127 1.297	0.0602 147 1.245	0.0602 167 1.193	0.0602 187 1.141	0.0602 207 1.089	0.0602 227 1.038	0.0602 247 0.986	0.0602 267 0.934	0.0602 287 0.882	0.0602 307 0.830	0.0602 327 0.778	0.0602 347 0.726	0.0602 367 0.674	0.0602 387 0.623
0.0602 6 1.504	0.0602 26 1.453	0.0602 46 1.401	0.0602 66 1.349	0.0602 86 1.297	0.0602 106 1.245	0.0602 126 1.193	0.0602 146 1.141	0.0602 166 1.089	0.0602 186 1.038	0.0602 206 0.986	0.0602 226 0.934	0.0602 246 0.882	0.0602 266 0.830	0.0602 286 0.778	0.0602 306 0.726	0.0602 326 0.674	0.0602 346 0.623	0.0602 366 0.571	0.0602 386 0.519
0.0602 5 1.401	0.0602 25 1.349	0.0602 45 1.297	0.0602 65 1.245	0.0602 85 1.193	0.0602 105 1.141	0.0602 125 1.089	0.0602 145 1.038	0.0602 165 0.986	0.0602 185 0.934	0.0602 205 0.882	0.0602 225 0.830	0.0602 245 0.778	0.0602 265 0.726	0.0602 285 0.674	0.0602 305 0.623	0.0602 325 0.571	0.0602 345 0.519	0.0602 365 0.467	0.0602 385 0.415
0.0602 4 1.297	0.0602 24 1.245	0.0602 44 1.193	0.0602 64 1.141	0.0602 84 1.089	0.0602 104 1.038	0.0602 124 0.986	0.0602 144 0.934	0.0602 164 0.882	0.0602 184 0.830	0.0602 204 0.778	0.0602 224 0.726	0.0602 244 0.674	0.0602 264 0.623	0.0602 284 0.571	0.0602 304 0.519	0.0602 324 0.467	0.0602 344 0.415	0.0602 364 0.363	0.0602 384 0.311
0.0602 3 1.193	0.0602 23 1.141	0.0602 43 1.089	0.0602 63 1.038	0.0602 83 0.986	0.0602 103 0.934	0.0602 123 0.882	0.0602 143 0.830	0.0602 163 0.778	0.0602 183 0.726	0.0602 203 0.674	0.0602 223 0.623	0.0602 243 0.571	0.0602 263 0.519	0.0602 283 0.467	0.0602 303 0.415	0.0602 323 0.363	0.0602 343 0.311	0.0602 363 0.259	0.0602 383 0.208
0.0602 2 1.089	0.0602 22 1.038	0.0602 42 0.986	0.0602 62 0.934	0.0602 82 0.882	0.0602 102 0.830	0.0602 122 0.778	0.0602 142 0.726	0.0602 162 0.674	0.0602 182 0.623	0.0602 202 0.571	0.0602 222 0.519	0.0602 242 0.467	0.0602 262 0.415	0.0602 282 0.363	0.0602 302 0.311	0.0602 322 0.259	0.0602 342 0.208	0.0602 362 0.156	0.0602 382 0.104
0.0602 1 0.986	0.0602 21 0.934	0.0602 41 0.882	0.0602 61 0.830	0.0602 81 0.778	0.0602 101 0.726	0.0602 121 0.674	0.0602 141 0.623	0.0602 161 0.571	0.0602 181 0.519	0.0602 201 0.467	0.0602 221 0.415	0.0602 241 0.363	0.0602 261 0.311	0.0602 281 0.259	0.0602 301 0.208	0.0602 321 0.156	0.0602 341 0.104	0.0602 361 0.052	0.0602 381 0.000

APPLICATION PROBLEM MODEL RESULTS



APPLICATION PROBLEM MODEL RESULTS –

- SEVEN TEST MISALIGNMENTS (AND SIX MORE BY SYMMETRY) AGREE WITH THEORETICAL VALUES OF GAMMA.
- ZERO DEGREE (AND 90 DEGREE) ALIGNMENT, AND 45 DEGREE MISALIGNMENT AGREE EXACTLY WITH THEORETICAL VALUES.

IS THIS BIAS A PROBLEM?

"Investigation of a ratio with respect to Manning's n, as opposed to introducing a new factor into Manning's equation, is justified for the typical application of USGS DHM to analyze shallow overland flow in floodplains. Engman (1989) has shown that the governing flow equations can be solved with proper boundary conditions and the selection of only one parameter, Manning's n."

IS THIS BIAS A PROBLEM?

"It might be concluded that Manning's n could be adjusted for each element so that computed depths match actual depths. However, the small variation in Manning's n across the wide range of streamline flow angles with respect to the element alignments makes this an ineffective process that might indeed be superfluous. For usual cases where random streamline trajectory variability within the floodplain flow is greater than a few degrees from perfect alignment, the ratio $\gamma(\Theta)$ appears to be implicitly included in the Manning's n values."

"IT CAN BE CONCLUDED THAT THE ARRAY OF SQUARE ELEMENTS MAY BE APPLIED OVER THE DIGITAL TERRAIN MODEL WITHOUT RESPECT TO TOPOGRAPHIC FLOW DIRECTIONS."

ANOTHER TEST – FOR ANOTHER DAY.

ROTATE AN ARRAY OVER A GAGED WATERSHED WITH VERY COMPLEX TOPOGRAPHY.

IS THERE ANY EFFECT ON USGS DHM RAINFALL-RUNOFF CALCULATION?

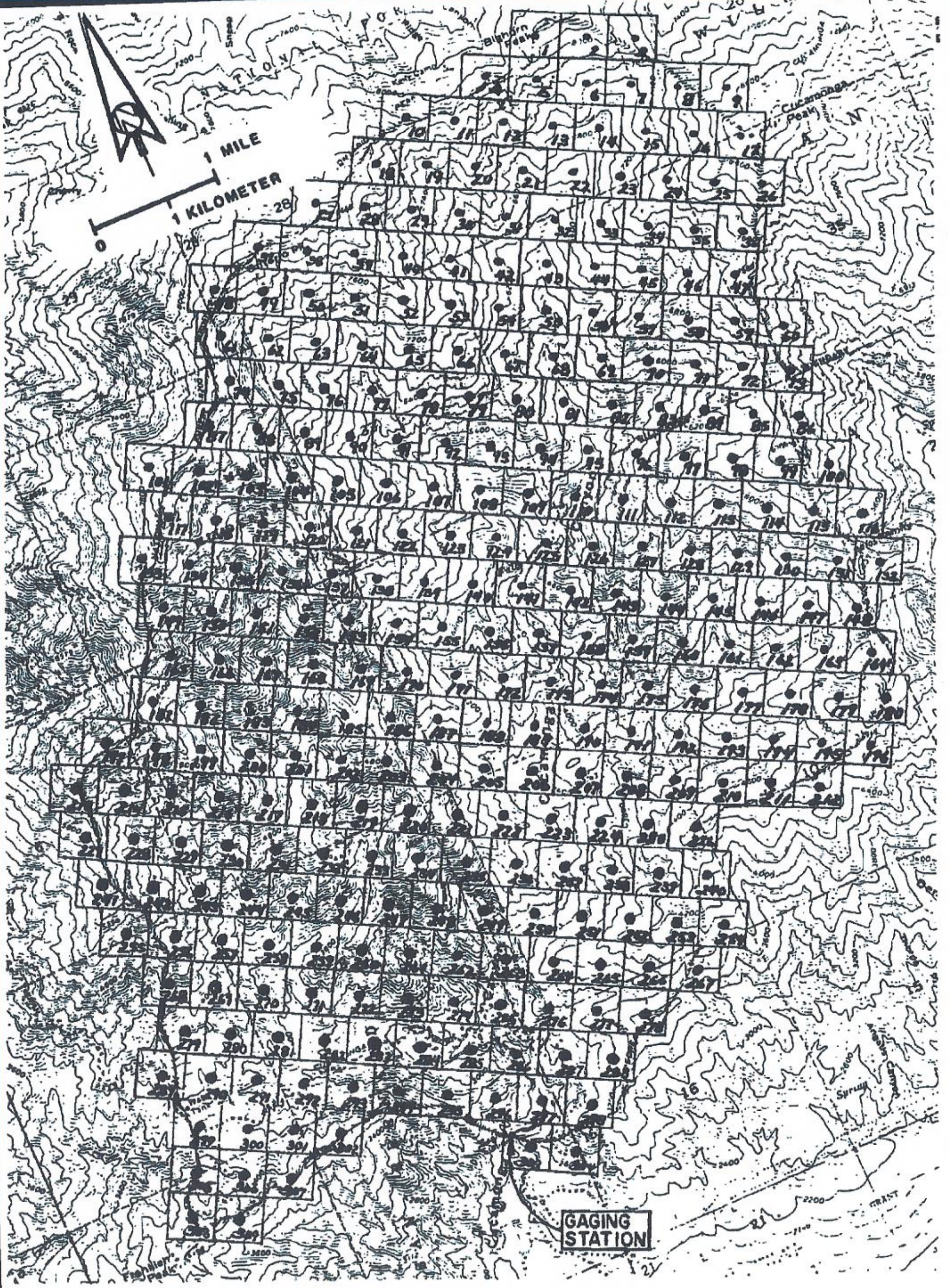


Figure 17.--Cucamonga Creek Discretization

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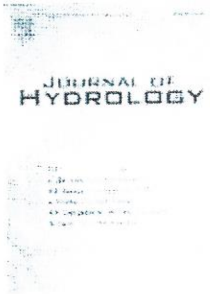

Title: Manning's equation and two-dimensional flow analogs

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