

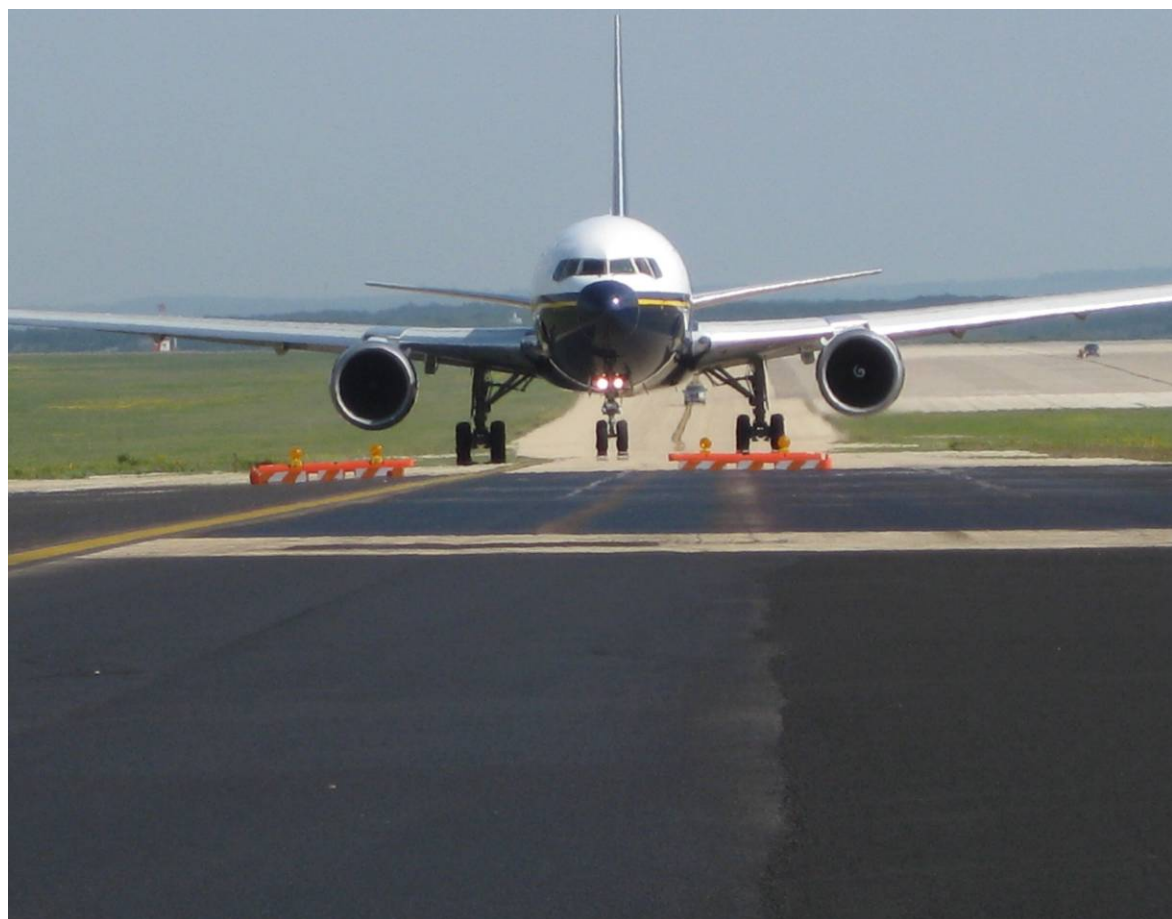


**US Army Corps
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Engineer Research and
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Long-Term Performance Evaluation of Asphalt Surface Treatments: Product Placement

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Long-Term Performance Evaluation of Asphalt Surface Treatments: Product Placement

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Final report

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Abstract: The U.S. Army Engineer Research and Development Center recently began a research project to evaluate pavement preservation techniques for asphalt pavements on Army airfields. Three field sites were selected for testing. Field sites represented the following climatic regions: hot and wet, hot and dry, and cold. Each of the test sites was on a taxiway or parking apron pavement on an Army airfield. Commercially available products marketed for pavement preservation were placed at each site. Existing pavements were in good condition, and all exhibited only minor longitudinal or transverse cracking and limited weathering. Preliminary data were collected by evaluating pavement surface properties and by extracting pavement cores prior to placement of the surface treatment. Additional tests were performed after product placement. Annual evaluations will provide comparable data to quantify the benefit of the treatment based on its ability to reduce environmental distresses. This report provides information on the products placed at each site as well as pavement conditions before product placement.

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Contents

Figures and Tables	iv
Preface	xii
Unit Conversion Factors	xiii
1 Introduction	1
Background	1
Objective	3
Scope	3
2 Test Methods	4
Surface texture	4
Skid resistance	4
<i>Grip Tester</i>	4
<i>Dynamic Friction Tester</i>	5
Pavement condition	7
3 Field Sites	8
Lawson Army Airfield, Fort Benning, Georgia	9
Robert Gray Army Airfield, Fort Hood, Texas	20
Wheeler-Sack Army Airfield, Fort Drum, New York	28
4 Preliminary Data	32
Surface texture	32
Skid resistance	32
Pavement distresses	33
5 Conclusions and Recommendations	34
Conclusions	34
Recommendations	34
References	35
Report Documentation Page	

Figures and Tables

Figures

Figure 1. Sand patch test and materials.....	5
Figure 2. Findlay-Irvine Grip Tester underside view	6
Figure 3. Rotating disc of Dynamic Friction Tester (DFT).....	6
Figure 4. Dynamic Friction Tester (DFT) during operation.	7
Figure 5. Lawson AAF Yellow Ramp test section layout.....	10
Figure 6. Lawson AAF White Ramp test section layout.....	10
Figure 7. Lawson AAF Blue Ramp test section layout.	11
Figure 8. Application of Gem Seal Polytar.....	13
Figure 9. Application of Grip Flex primer.	14
Figure 10. Application of Grip Flex slurry.....	14
Figure 11. Grip Flex slurry box.....	15
Figure 12. Application of Gem Seal CBRTSO asphalt rejuvenator.....	16
Figure 13. Application of Gem Seal Federal Coal Tar Sealer.....	17
Figure 14. Application of RejuvaSeal.....	17
Figure 15. Shot blaster during operation.	18
Figure 16. Shot blasted asphalt pavement.....	19
Figure 17. Application of Pavement Dressing Conditioner (PDC).....	19
Figure 18. Application of Reclamite.....	21
Figure 19. Joint Bond application.	21
Figure 20. Robert Gray AAF test section location.....	22
Figure 21. Side view of Viking Construction slurry box.	24
Figure 22. Application of Viking Construction Type II slurry seal.	24
Figure 23. Application of SealMaster Polymer Modified MasterSeal (PMM).	27
Figure 24. Application of Pass QB.	27
Figure 25. Application of PaverX asphalt rejuvenator.....	28
Figure 26. Aerial view of test site at Robert Gray AAF.	29
Figure 27. Aerial view of test site at Wheeler-Sack AAF.....	31
Figure 28. Lawson AAF Section 2 (Station 0-50 ft).....	36
Figure 29. Lawson AAF Section 2 (Station 50-100 ft).	37
Figure 30. Lawson AAF Section 2 (Station 100-150 ft).....	38
Figure 31. Lawson AAF Section 2 (Station 150-200 ft).....	39
Figure 32. Lawson AAF Section 2 (Station 200-250 ft).	40
Figure 33. Lawson AAF Section 2 (Station 250-300 ft).	41
Figure 34. Lawson AAF Section 3 (Station 0-50 ft).....	42

Figure 35. Lawson AAF Section 3 (Station 50-100 ft).....	43
Figure 36. Lawson AAF Section 3 (Station 100-150 ft).....	44
Figure 37. Lawson AAF Section 3 (Station 150-200 ft).....	45
Figure 38. Lawson AAF Section 3 (Station 200-250 ft).....	46
Figure 39. Lawson AAF Section 3 (Station 250-300 ft).....	47
Figure 40. Lawson AAF Section 4 (Station 0-50 ft).....	48
Figure 41. Lawson AAF Section 4 (Station 50-100 ft).....	49
Figure 42. Lawson AAF Section 4 (Station 100-150 ft).....	50
Figure 43. Lawson AAF Section 4 (Station 150-200 ft).....	51
Figure 44. Lawson AAF Section 4 (Station 200-250 ft).....	52
Figure 45. Lawson AAF Section 4 (Station 250-300 ft).....	53
Figure 46. Lawson AAF Section 5 (Station 0-50 ft).....	54
Figure 47. Lawson AAF Section 5 (Station 50-100 ft).....	55
Figure 48. Lawson AAF Section 5 (Station 100-150 ft).....	56
Figure 49. Lawson AAF Section 5 (Station 150-200 ft).....	57
Figure 50. Lawson AAF Section 5 (Station 200-250 ft).....	58
Figure 51. Lawson AAF Section 5 (Station 250-300 ft).....	59
Figure 52. Lawson AAF Section 6 (Station 0-50 ft).....	60
Figure 53. Lawson AAF Section 6 (Station 50-100 ft).....	61
Figure 54. Lawson AAF Section 6 (Station 100-150 ft).....	62
Figure 55. Lawson AAF Section 6 (Station 150-200 ft).....	63
Figure 56. Lawson AAF Section 6 (Station 200-250 ft).....	64
Figure 57. Lawson AAF Section 6 (Station 250-300 ft).....	65
Figure 58. Lawson AAF Section 7 (Station 0-50 ft).....	66
Figure 59. Lawson AAF Section 7 (Station 50-100 ft).....	67
Figure 60. Lawson AAF Section 7 (Station 100-150 ft).....	68
Figure 61. Lawson AAF Section 7 (Station 150-200 ft).....	69
Figure 62. Lawson AAF Section 7 (Station 200-250 ft).....	70
Figure 63. Lawson AAF Section 7 (Station 250-300 ft).....	71
Figure 64. Lawson AAF Section 8 (Station 0-50 ft).....	72
Figure 65. Lawson AAF Section 8 (Station 50-100 ft).....	73
Figure 66. Lawson AAF Section 8 (Station 100-150 ft).....	74
Figure 67. Lawson AAF Section 8 (Station 150-200 ft).....	75
Figure 68. Lawson AAF Section 8 (Station 200-250 ft).....	76
Figure 69. Lawson AAF Section 8 (Station 250-300 ft).....	77
Figure 70. Lawson AAF Section 9 (Station 0-50 ft).....	78
Figure 71. Lawson AAF Section 9 (Station 50-100 ft).....	79
Figure 72. Lawson AAF Section 9 (Station 100-150 ft).....	80
Figure 73. Lawson AAF Section 9 (Station 150-200 ft).....	81
Figure 74. Lawson AAF Section 9 (Station 200-250 ft).....	82

Figure 75. Lawson AAF Section 9 (Station 250-300 ft).	83
Figure 76. Lawson AAF Section 10 (Station 0-50 ft).	84
Figure 77. Lawson AAF Section 10 (Station 50-100 ft).	85
Figure 78. Lawson AAF Section 10 (Station 100-150 ft).	86
Figure 79. Lawson AAF Section 10 (Station 150-200 ft).	87
Figure 80. Lawson AAF Section 10 (Station 200-250 ft).	88
Figure 81. Lawson AAF Section 10 (Station 250-300 ft).	89
Figure 82. Lawson AAF Section 11 (Station 0-50 ft).	90
Figure 83. Lawson AAF Section 11 (Station 50-100 ft).	91
Figure 84. Lawson AAF Section 11 (Station 100-150 ft).	92
Figure 85. Lawson AAF Section 11 (Station 150-200 ft).	93
Figure 86. Lawson AAF Section 11 (Station 200-250 ft).	94
Figure 87. Lawson AAF Section 11 (Station 250-300 ft).	95
Figure 88. Lawson AAF Section 12 (Station 0-50 ft).	96
Figure 89. Lawson AAF Section 12 (Station 50-100 ft).	97
Figure 90. Lawson AAF Section 12 (Station 100-150 ft).	98
Figure 91. Lawson AAF Section 12 (Station 150-200 ft).	99
Figure 92. Lawson AAF Section 12 (Station 200-250 ft).	100
Figure 93. Lawson AAF Section 12 (Station 250-300 ft).	101
Figure 94. Lawson AAF Section 13 (Station 0-50 ft).	102
Figure 95. Lawson AAF Section 13 (Station 50-100 ft).	103
Figure 96. Lawson AAF Section 13 (Station 100-150 ft).	104
Figure 97. Lawson AAF Section 13 (Station 150-200 ft).	105
Figure 98. Lawson AAF Section 13 (Station 200-250 ft).	106
Figure 99. Lawson AAF Section 13 (Station 250-300 ft).	107
Figure 100. Lawson AAF Section 14 (Station 0-50 ft).	108
Figure 101. Lawson AAF Section 14 (Station 50-100 ft).	109
Figure 102. Lawson AAF Section 14 (Station 100-150 ft).	110
Figure 103. Lawson AAF Section 14 (Station 150-200 ft).	111
Figure 104. Lawson AAF Section 14 (Station 200-250 ft).	112
Figure 105. Lawson AAF Section 14 (Station 250-300 ft).	113
Figure 106. Robert Gray AAF Section 1 (Station 0-50 ft).	114
Figure 107. Robert Gray AAF Section 1 (Station 50-100 ft).	115
Figure 108. Robert Gray AAF Section 1 (Station 100-150 ft).	116
Figure 109. Robert Gray AAF Section 1 (Station 150-200 ft).	117
Figure 110. Robert Gray AAF Section 1 (Station 200-250 ft).	118
Figure 111. Robert Gray AAF Section 1 (Station 250-300 ft).	119
Figure 112. Robert Gray AAF Section 2 (Station 0-50 ft).	120
Figure 113. Robert Gray AAF Section 2 (Station 50-100 ft).	121
Figure 114. Robert Gray AAF Section 2 (Station 100-150 ft).	122

Figure 115. Robert Gray AAF Section 2 (Station 150-200 ft).....	123
Figure 116. Robert Gray AAF Section 2 (Station 200-250 ft).....	124
Figure 117. Robert Gray AAF Section 2 (Station 250-300 ft).....	125
Figure 118. Robert Gray AAF Section 3 (Station 0-50 ft).	126
Figure 119. Robert Gray AAF Section 3 (Station 50-100 ft).	127
Figure 120. Robert Gray AAF Section 3 (Station 100-150 ft).....	128
Figure 121. Robert Gray AAF Section 3 (Station 150-200 ft).....	129
Figure 122. Robert Gray AAF Section 3 (Station 200-250 ft).....	130
Figure 123. Robert Gray AAF Section 3 (Station 250-300 ft).....	131
Figure 124. Robert Gray AAF Section 4 (Station 0-50 ft).	132
Figure 125. Robert Gray AAF Section 4 (Station 50-100 ft).	133
Figure 126. Robert Gray AAF Section 4 (Station 100-150 ft).....	134
Figure 127. Robert Gray AAF Section 4 (Station 150-200 ft).....	135
Figure 128. Robert Gray AAF Section 4 (Station 200-250 ft).....	136
Figure 129. Robert Gray AAF Section 4 (Station 250-300 ft).....	137
Figure 130. Robert Gray AAF Section 5 (Station 0-50 ft).	138
Figure 131. Robert Gray AAF Section 5 (Station 50-100 ft).....	139
Figure 132. Robert Gray AAF Section 5 (Station 100-150 ft).....	140
Figure 133. Robert Gray AAF Section 5 (Station 150-200 ft).....	141
Figure 134. Robert Gray AAF Section 5 (Station 200-250 ft).....	142
Figure 135. Robert Gray AAF Section 5 (Station 250-300 ft).....	143
Figure 136. Robert Gray AAF Section 6 (Station 0-50 ft).	144
Figure 137. Robert Gray AAF Section 6 (Station 50-100 ft).	145
Figure 138. Robert Gray AAF Section 6 (Station 100-150 ft).....	146
Figure 139. Robert Gray AAF Section 6 (Station 150-200 ft).....	147
Figure 140. Robert Gray AAF Section 6 (Station 200-250 ft).....	148
Figure 141. Robert Gray AAF Section 6 (Station 250-300 ft).	149
Figure 142. Robert Gray AAF Section 7 (Station 0-50 ft).	150
Figure 143. Robert Gray AAF Section 7 (Station 50-100 ft).	151
Figure 144. Robert Gray AAF Section 7 (Station 100-150 ft).....	152
Figure 145. Robert Gray AAF Section 7 (Station 150-200 ft).....	153
Figure 146. Robert Gray AAF Section 7 (Station 200-250 ft).....	154
Figure 147. Robert Gray AAF Section 7 (Station 250-300 ft).....	155
Figure 148. Robert Gray AAF Section 8 (Station 0-50 ft).	156
Figure 149. Robert Gray AAF Section 8 (Station 50-100 ft).	157
Figure 150. Robert Gray AAF Section 8 (Station 100-150 ft).....	158
Figure 151. Robert Gray AAF Section 8 (Station 150-200 ft).	159
Figure 152. Robert Gray AAF Section 8 (Station 200-250 ft).....	160
Figure 153. Robert Gray AAF Section 8 (Station 250-300 ft).....	161
Figure 154. Robert Gray AAF Section 9 (Station 0-50 ft).	162

Figure 155. Robert Gray AAF Section 9 (Station 50-100 ft).	163
Figure 156. Robert Gray AAF Section 9 (Station 100-150 ft).	164
Figure 157. Robert Gray AAF Section 9 (Station 150-200 ft).	165
Figure 158. Robert Gray AAF Section 9 (Station 200-250 ft).	166
Figure 159. Robert Gray AAF Section 9 (Station 250-300 ft).	167
Figure 160. Robert Gray AAF Section 10 (Station 0-50 ft).	168
Figure 161. Robert Gray AAF Section 10 (Station 50-100 ft)	169
Figure 162. Robert Gray AAF Section 10 (Station 100-150 ft).	170
Figure 163. Robert Gray AAF Section 10 (Station 150-200 ft).	171
Figure 164. Robert Gray AAF Section 10 (Station 200-250 ft).	172
Figure 165. Robert Gray AAF Section 10 (Station 250-300 ft).	173
Figure 166. Robert Gray AAF Section 11 (Station 0-50 ft).	174
Figure 167. Robert Gray AAF Section 11 (Station 50-100 ft).	175
Figure 168. Robert Gray AAF Section 11 (Station 100-150 ft).	176
Figure 169. Robert Gray AAF Section 11 (Station 150-200 ft).	177
Figure 170. Robert Gray AAF Section 11 (Station 200-250 ft).	178
Figure 171. Robert Gray AAF Section 11 (Station 250-300 ft).	179
Figure 172. Robert Gray AAF Section 12 (Station 0-50 ft).	180
Figure 173. Robert Gray AAF Section 12 (Station 50-100 ft).	181
Figure 174. Robert Gray AAF Section 12 (Station 100-150 ft).	182
Figure 175. Robert Gray AAF Section 12 (Station 150-200 ft).	183
Figure 176. Robert Gray AAF Section 12 (Station 200-250 ft).	184
Figure 177. Robert Gray AAF Section 12 (Station 250-300 ft).	185
Figure 178. Robert Gray AAF Section 13 (Station 0-50 ft).	186
Figure 179. Robert Gray AAF Section 13 (Station 50-100 ft).	187
Figure 180. Robert Gray AAF Section 13 (Station 100-150 ft).	188
Figure 181. Robert Gray AAF Section 13 (Station 150-200 ft).	189
Figure 182. Robert Gray AAF Section 13 (Station 200-250 ft).	190
Figure 183. Robert Gray AAF Section 13 (Station 250-300 ft).	191
Figure 184. Robert Gray AAF Section 14 (Station 0-50 ft).	192
Figure 185. Robert Gray AAF Section 14 (Station 50-100 ft).	193
Figure 186. Robert Gray AAF Section 14 (Station 100-150 ft).	194
Figure 187. Robert Gray AAF Section 14 (Station 150-200 ft).	195
Figure 188. Robert Gray AAF Section 14 (Station 200-250 ft).	196
Figure 189. Robert Gray AAF Section 14 (Station 250-300 ft).	197
Figure 190. Robert Gray AAF Section 15 (Station 0-50 ft).	198
Figure 191. Robert Gray AAF Section 15 (Station 50-100 ft).	199
Figure 192. Robert Gray AAF Section 15 (Station 100-150 ft).	200
Figure 193. Robert Gray AAF Section 15 (Station 150-200 ft).	201
Figure 194. Robert Gray AAF Section 15 (Station 200-250 ft).	202

Figure 195. Robert Gray AAF Section 15 (Station 250-300 ft).	203
Figure 196. Robert Gray AAF Section 16 (Station 0-50 ft).	204
Figure 197. Robert Gray AAF Section 16 (Station 50-100 ft).	205
Figure 198. Robert Gray AAF Section 16 (Station 100-150 ft).	206
Figure 199. Robert Gray AAF Section 16 (Station 150-200 ft).	207
Figure 200. Robert Gray AAF Section 16 (Station 200-250 ft).	208
Figure 201. Robert Gray AAF Section 16 (Station 250-300 ft).	209
Figure 202. Robert Gray AAF Section 17 (Station 0-50 ft).	210
Figure 203. Robert Gray AAF Section 17 (Station 50-100 ft).	211
Figure 204. Robert Gray AAF Section 17 (Station 100-150 ft).	212
Figure 205. Robert Gray AAF Section 17 (Station 150-200 ft).	213
Figure 206. Robert Gray AAF Section 17 (Station 200-250 ft).	214
Figure 207. Robert Gray AAF Section 17 (Station 250-300 ft).	215
Figure 208. Robert Gray AAF Section 18 (Station 0-50 ft).	216
Figure 209. Robert Gray AAF Section 18 (Station 50-100 ft).	217
Figure 210. Robert Gray AAF Section 18 (Station 100-150 ft).	218
Figure 211. Robert Gray AAF Section 18 (Station 150-200 ft).	219
Figure 212. Robert Gray AAF Section 18 (Station 200-250 ft).	220
Figure 213. Robert Gray AAF Section 18 (Station 250-300 ft).	221
Figure 214. Wheeler-Sack AAF Section 1 (Station 0-50 ft).	222
Figure 215. Wheeler-Sack AAF Section 1 (Station 50-100 ft).	223
Figure 216. Wheeler-Sack AAF Section 1 (Station 100-150 ft).	224
Figure 217. Wheeler-Sack AAF Section 1 (Station 150-200 ft).	225
Figure 218. Wheeler-Sack AAF Section 1 (Station 200-250 ft).	226
Figure 219. Wheeler-Sack AAF Section 1 (Station 250-300 ft).	227
Figure 220. Wheeler-Sack AAF Section 2 (Station 0-50 ft).	228
Figure 221. Wheeler-Sack AAF Section 2 (Station 50-100 ft).	229
Figure 222. Wheeler-Sack AAF Section 2 (Station 100-150 ft).	230
Figure 223. Wheeler-Sack AAF Section 2 (Station 150-200 ft).	231
Figure 224. Wheeler-Sack AAF Section 2 (Station 200-250 ft).	232
Figure 225. Wheeler-Sack AAF Section 2 (Station 250-300 ft).	233
Figure 226. Wheeler-Sack AAF Section 3 (Station 0-50 ft).	234
Figure 227. Wheeler-Sack AAF Section 3 (Station 50-100 ft).	235
Figure 228. Wheeler-Sack AAF Section 3 (Station 100-150 ft).	236
Figure 229. Wheeler-Sack AAF Section 3 (Station 150-200 ft).	237
Figure 230. Wheeler-Sack AAF Section 3 (Station 200-250 ft).	238
Figure 231. Wheeler-Sack AAF Section 3 (Station 250-300 ft).	239
Figure 232. Wheeler-Sack AAF Section 4 (Station 0-50 ft).	240
Figure 233. Wheeler-Sack AAF Section 4 (Station 50-100 ft).	241
Figure 234. Wheeler-Sack AAF Section 4 (Station 100-150 ft).	242

Figure 235. Wheeler-Sack AAF Section 4 (Station 150-200 ft).....	243
Figure 236. Wheeler-Sack AAF Section 4 (Station 200-250 ft).....	244
Figure 237. Wheeler-Sack AAF Section 4 (Station 250-300 ft).	245
Figure 238. Wheeler-Sack AAF Section 5 (Station 0-50 ft).....	246
Figure 239. Wheeler-Sack AAF Section 5 (Station 50-100 ft).	247
Figure 240. Wheeler-Sack AAF Section 5 (Station 100-150 ft).....	248
Figure 241. Wheeler-Sack AAF Section 5 (Station 150-200 ft).	249
Figure 242. Wheeler-Sack AAF Section 5 (Station 200-250 ft).....	250
Figure 243. Wheeler-Sack AAF Section 5 (Station 250-300 ft).....	251
Figure 244. Wheeler-Sack AAF Section 6 (Station 0-50 ft).....	252
Figure 245. Wheeler-Sack AAF Section 6 (Station 50-100 ft).	253
Figure 246. Wheeler-Sack AAF Section 6 (Station 100-150 ft).....	254
Figure 247. Wheeler-Sack AAF Section 6 (Station 150-200 ft).....	255
Figure 248. Wheeler-Sack AAF Section 6 (Station 200-250 ft).....	256
Figure 249. Wheeler-Sack AAF Section 6 (Station 250-300 ft).....	257
Figure 250. Wheeler-Sack AAF Section 7 (Station 0-50 ft).....	258
Figure 251. Wheeler-Sack AAF Section 7 (Station 50-100 ft).	259
Figure 252. Wheeler-Sack AAF Section 7 (Station 100-150 ft).....	260
Figure 253. Wheeler-Sack AAF Section 7 (Station 150-200 ft).....	261
Figure 254. Wheeler-Sack AAF Section 7 (Station 200-250 ft).....	262
Figure 255. Wheeler-Sack AAF Section 7 (Station 250-300 ft).....	263
Figure 256. Wheeler-Sack AAF Section 8 (Station 0-50 ft).....	264
Figure 257. Wheeler-Sack AAF Section 8 (Station 50-100 ft).....	265
Figure 258. Wheeler-Sack AAF Section 8 (Station 100-150 ft).....	266
Figure 259. Wheeler-Sack AAF Section 8 (Station 150-200 ft).....	267
Figure 260. Wheeler-Sack AAF Section 8 (Station 200-250 ft).....	268
Figure 261. Wheeler-Sack AAF Section 8 (Station 250-300 ft).....	269
Figure 262. Wheeler-Sack AAF Section 9 (Station 0-50 ft).....	270
Figure 263. Wheeler-Sack AAF Section 9 (Station 50-100 ft).	271
Figure 264. Wheeler-Sack AAF Section 9 (Station 100-150 ft).....	272
Figure 265. Wheeler-Sack AAF Section 9 (Station 150-200 ft).....	273
Figure 266. Wheeler-Sack AAF Section 9 (Station 200-250 ft).....	274
Figure 267. Wheeler-Sack AAF Section 9 (Station 250-300 ft).....	275
Figure 268. Wheeler-Sack AAF Section 10 (Station 0-50 ft).....	276
Figure 269. Wheeler-Sack AAF Section 10 (Station 50-100 ft).....	277
Figure 270. Wheeler-Sack AAF Section 10 (Station 100-150 ft).....	278
Figure 271. Wheeler-Sack AAF Section 10 (Station 150-200 ft).....	279
Figure 272. Wheeler-Sack AAF Section 10 (Station 200-250 ft).	280
Figure 273. Wheeler-Sack AAF Section 10 (Station 250-300 ft).	281
Figure 274. Wheeler-Sack AAF Section 11 (Station 0-50 ft).	282

Figure 275. Wheeler-Sack AAF Section 11 (Station 50-100 ft).....	283
Figure 276. Wheeler-Sack AAF Section 11 (Station 100-150 ft).....	284
Figure 277. Wheeler-Sack AAF Section 11 (Station 150-200 ft).....	285
Figure 278. Wheeler-Sack AAF Section 11 (Station 200-250 ft).	286
Figure 279. Wheeler-Sack AAF Section 11 (Station 250-300 ft).	287
Figure 280. Wheeler-Sack AAF Section 12 (Station 0-50 ft).	288
Figure 281. Wheeler-Sack AAF Section 12 (Station 50-100 ft).....	289
Figure 282. Wheeler-Sack AAF Section 12 (Station 100-150 ft).	290
Figure 283. Wheeler-Sack AAF Section 12 (Station 150-200 ft).	291
Figure 284. Wheeler-Sack AAF Section 12 (Station 200-250 ft).	292
Figure 285. Wheeler-Sack AAF Section 12 (Station 250-300 ft).	293

Tables

Table 1. Lawson AAF Product Placement Summary	12
Table 2. Robert Gray AAF Product Placement Summary.....	23
Table 3. Wheeler-Sack AAF Product Placement Summary	29
Table 4. Summary of sand patch test results prior to product placement.	32
Table 5. Summary of selected DFT data prior to product placement.	33

Preface

The project described in this report was sponsored by the U.S. Army Headquarters Installation Management Command (IMCOM) under the Army Transportation Infrastructure Program (ATIP). The HQ IMCOM ATIP program manager is Ali Achmar.

This publication was prepared by personnel from the U.S. Army Engineer Research and Development Center (ERDC), Geotechnical and Structures Laboratory (GSL), Vicksburg, MS. John F. Rushing and Anthony J. Falls, Airfield and Pavements Branch (APB), GSL, prepared this publication under the supervision of Dr. Gary L. Anderton, Chief, APB; Dr. Larry N. Lynch, Chief, Engineering Systems and Materials Division; Dr. William P. Grogan, Deputy Director, GSL; and Dr. David W. Pittman, Director, GSL.

COL Gary E. Johnston was Commander and Executive Director of ERDC. Dr. Jeffery P. Holland was Director.

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Unit Conversion Factors

Multiply	By	To Obtain
degrees Fahrenheit	$(F-32)/1.8$	degrees Celsius
feet	0.3048	meters
gallons (U.S. liquid)	3.785412 E-03	cubic meters
inches	0.0254	meters
miles per hour	0.44704	kilometers per second
pounds (mass)	0.45359237	kilograms
square feet	0.09290304	square meters
square yards	0.8361274	square meters
yards	0.9144	meters

1 Introduction

Background

Environmental degradation of asphalt concrete is a common phenomenon on airfield pavements. Army airfields are especially prone to environmental failures, because traffic is relatively infrequent compared to commercial airport or highway pavements. Examples of environmental failures include raveling (aggregate loss) due to ultraviolet and oxidative degradation of the asphalt binder on the pavement surface, and surface cracking due to oxidative aging and subsequent embrittlement of the asphalt binder. These conditions can result in foreign object debris (FOD) on the airfield which, if ingested by jet engines, can result in significant damage.

Techniques for maintaining asphalt concrete airfield pavements are typically performed in response to the formation of environmental-related distresses. One of the most common maintenance techniques is sealing medium and high-severity thermal cracks. Severely deteriorated cracks may require additional measures such as placement of asphalt overlays.

Preventative maintenance techniques have not been commonly utilized on military airfields. These procedures aim to prolong the initial period before rehabilitating techniques are required. Preventative maintenance techniques for asphalt concrete pavements include the application of sealing or rejuvenating products to the surface to prevent additional oxidative damage to the asphalt binder.

Asphalt rejuvenators are considered to be materials that rehabilitate aged asphalt. Rejuvenators are often low viscosity fluids that are able to penetrate into a small portion, 1/4 to 1/2 in., of the pavement surface. Moreover, rejuvenators have been shown to reduce the stiffness of asphalt binders resulting in reduced brittleness and cracking in the penetrated pavement over time (Brown 1998). Although application of an asphalt rejuvenator can increase the flexibility of a portion of the pavement, administration of rejuvenator substances in excess of prescribed amounts can lead to increased rutting susceptibility in the pavement and result in a loss of friction (Shen et al. 2006).

The use of surface coverings is another technique used as preventative maintenance on asphalt pavements. Surface coverings are relatively thin (0.25- to 1-in.) layers of sealant substances, often asphalt emulsions containing fine aggregates, placed on top of existing pavements. Coverings may include slurry seals, fog seals, micro-surfacing treatments, and thin surface overlays. The coverings are used to protect the pavement from environmental hazards, restore friction, and preserve the structural integrity of the pavement. Environmental hazards include the penetration of oxygen and ultraviolet light, both of which contribute at varying degrees to the oxidation and aging of the asphalt, and penetration of water into the pavement. Furthermore, coverings prevent damaged portions of the underlying asphalt from degrading further and separating from the pavement, possibly causing FOD to aircraft using the airfield.

Preventative maintenance techniques are not commonly used on airfield asphalt concrete pavements for two primary reasons. First, spray applications of liquid agents on the pavement surface have the potential to reduce the frictional characteristics of the pavement surface (Brown and Johnson 1976; Shoenberger 2003). Friction is vital to providing skid resistance for high-speed aircraft. Second, some surface treatments create a thin layer of binding product and fine aggregate on the pavement surface that is prone to delamination and subsequent FOD generation. Potential danger to aircraft engines has precluded the use of these types of systems.

As the price of petroleum products, particularly asphalt cement, increases, efforts to reduce consumption will continue to grow. For asphalt cement, limiting its use can be attained by extending the usable life of existing asphalt concrete pavements. Techniques for achieving this goal are particularly attractive for pavements prone to environmental degradation such as airfield pavements. Multiple products marketed as being capable of providing these results are currently available. However, little information exists about performance and safety of these systems on airfield asphalt concrete pavements.

This report contains information about a project initiated to evaluate the performance of asphalt concrete surface treatments on Army airfields. Results and conclusions will be based on a 5-year observation of the performance of materials placed in small test areas.

Objective

The objective of this study was to document the performance of asphalt surface treatments on Army airfields in different climatic regions. The overall objective of this work is to identify methods and materials for pavement preservation that can be utilized on Army airfields.

Scope

The scope of the study included placement of small test areas of commercially available asphalt surface treatment products on three Army airfields. The three airfields were located in different climatic regions. Installations in a hot and wet, hot and dry, and cold climate were included. Vendors applied their respective products in predetermined test areas at each of the installations according to commonly used procedures. Researchers observed and documented product placement. Annual evaluations of the test areas will be conducted to provide data for the study. Final recommendations using asphalt surface treatments on Army airfields will be made after products have been in service for 5 years.

2 Test Methods

Several procedures for evaluating the surface treatments were selected. These procedures included measurements of the changes in pavement surface characteristics, including changes in friction, caused by the surface treatments. Other procedures included documentation of initial pavement condition to monitor the progression of distresses in the pavement. Some laboratory characterization of the asphalt binder was conducted to quantify changes caused by the surface treatments. The following paragraphs describe the procedures used for this study.

Surface texture

The sand patch method was used to measure the surface texture of the pavement. The surface texture affects the skid resistance of the pavement (Shoenberger 2003). The sand patch method (ASTM E965) uses silica sand between the sizes of the 300- μm (No. 50) and 150- μm (No. 100) sieve. A known volume of sand is placed onto the pavement surface and spread in a circular fashion with a rubber tool until the sand forms a level pavement profile, shown in Figure 1. The diameter of the area filled with sand is recorded. The diameter is used to calculate the mean texture depth (MTD) of the pavement.

Skid resistance

Grip Tester

Some friction data was collected using a Findlay-Irvine Grip Tester. This device is used by the U.S. Air Force to conduct skid measurements on airfields. The device is also included in the list of approved measurement systems for friction testing on FAA airports. The Grip Tester is a three-wheeled trailer that measures pavement friction using the braked-wheel, fixed-slip principle. Two wheels support the Grip Tester on a drive axle, while a measuring wheel with a smooth-tread tire is used for friction measurements. The measuring wheel is mounted on an instrumented axle that measures the horizontal drag force and vertical load force. A transmission system routinely brakes the measuring wheel, causing it to slip.

This action provides the responses that enable it to measure friction values. The Grip Tester uses a self-wetting system to produce a stream of



Figure 1. Sand patch test and materials.

water in front of the measuring wheel that leaves a 0.04-in. (1-mm) film of water on the pavement surface. The flow rate of the self-wetting system is automatically adjusted to achieve the desired film thickness for the desired testing speeds of 40 and 60 miles per hour (mph). The value of water film thickness and testing speeds were adopted from the FAA AC 150/5320-12C. The underside of the Grip Tester is shown in Figure 2.

Dynamic Friction Tester

An evaluation of skid resistance was conducted on each surface treatment using a Nippo Dynamic Friction Tester (DFT) in accordance with ASTM E303. This test method uses a disk, shown in Figure 3, which spins with its plane parallel to the test surface. Three rubber sliders are mounted on the lower surface of the disk. The disk has a diameter of 13.75 in. (350 mm) and a maximum tangential speed of 55 mph (90 km/hr). The device also contains a water dispersion system that supplies a continuous film of water in front of the rubber sliders. During operation, the spinning disk is lowered to the pavement, and a transducer measures the friction force. Friction measurements can be made from 0 to 56 mph (0 to 90 km/hr). The measurements at 37 mph (60 km/hr) were selected in this study to correlate more closely with the 40 mph (64 km/hr) speed used by the Department of Defense (DoD) in friction criteria for tow-behind measurement systems. Figure 4 shows the DFT setup while testing.

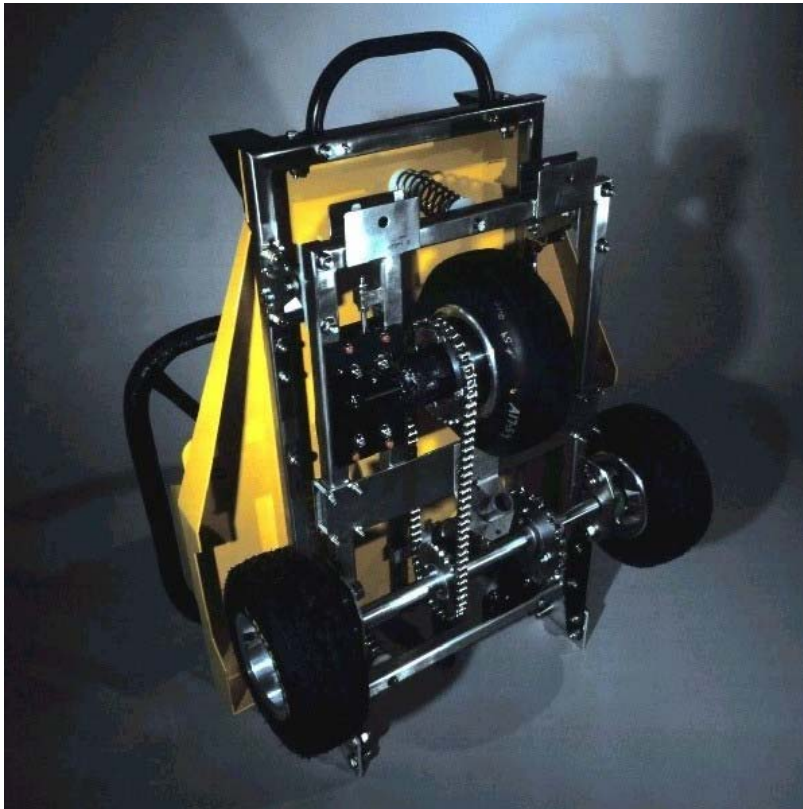


Figure 2. Findlay-Irvine Grip Tester underside view (source: Tradewind Scientific, <http://www.tradewindscientific.com/griptester.htm>).



Figure 3. Rotating disc of Dynamic Friction Tester (DFT).



Figure 4. Dynamic Friction Tester (DFT) during operation.

Pavement condition

Pavement condition at the time of treatment was documented by drawing a scaled map of all of the existing cracks in the test area pavement. Crack length was measured using a small measuring wheel. The precise location was documented on graph paper. The general pavement condition was also noted. The change in condition will be monitored by measuring crack initiation and propagation over the 5-year evaluation period.

3 Field Sites

A survey was sent to all Army airfield managers on 29 January 2009. The survey contained questions about any previous experience using asphalt surface treatments and about potential sites to conduct the field tests. Several Army installations had sites that met the following criteria:

- Pavement age: 5 to 15 years old
- Pavement surface type: asphalt concrete
- Pavement feature type: apron or taxiway
- No planned maintenance for 5 years

The range for pavement age was selected to correspond with expected distress levels. Pavements older than 15 years were considered near the end of their life. They were expected to show distress levels too high for pavement preservation. New pavements (less than 5 years) were not targeted, because they were expected to show too little distress at the end of the 5-year evaluation period. The pavement at the end of the test period needed to show some difference in distress level to differentiate product performance.

The pavement surface type was required to be asphalt concrete for the scope of the study. The feature type was required to be an apron or taxiway. Runway pavements were not considered because of concerns that the treatments could potentially reduce the pavement friction. Additionally, FOD potential of the products was unknown.

The final requirement for the study was that no maintenance or reconstruction was to be performed on the pavement area during the 5-year evaluation timeframe. This requirement was established so the full length of the study could be achieved.

Final site selections were made by identifying potential candidate sites in each desired climatic region (hot and wet, hot and dry, and cold). Airfield evaluation reports were used to compare potential candidate sites in each climatic region to determine the pavement condition, traffic, and logistical feasibility. The sites selected for airfields in hot and wet, hot and dry, and

cold climates were Lawson Army Airfield (AAF), Robert Gray AAF, and Wheeler-Sack AAF, respectively.

Lawson Army Airfield, Fort Benning, Georgia

A site visit was conducted at Lawson AAF on 18 February 2009 to inspect potential sites for placing test areas of asphalt surface treatments. As a result of the inspection, the Yellow, White, and Blue ramps were selected. Researchers returned to Lawson AAF on 19 March 2009 to coordinate placement of asphalt surface treatments and to collect data from the test areas.

Features A8B and A10B were selected for use on the Yellow ramp. These pavements were originally constructed between 1941 and 1943 (Engineer Research and Development Center (ERDC) 2006a). The original pavement surface consisted of 6 in. of Portland cement concrete (PCC). In 1970, 1.5 in. of asphalt concrete was placed over the PCC. Another asphalt concrete overlay was placed in 1981. The latest construction consisted of a 1-in. asphalt concrete overlay in 2003. In 2005, a pavement condition index survey indicated that these areas were in good condition but contained low-severity joint reflective cracking. The current condition of the ramp is good. The joint reflective cracking continues to emerge and is expected to intensify in the future. Test sections were placed on the north side of the ramp. Three test sections were marked on both sides of the access road located at gate 30. Figure 5 shows the location of the test sections on the ramp.

Feature A22B of the White ramp was used in the study. This pavement was originally constructed in 1959 (ERDC 2006a). The total thickness of the pavement was 9 in., and the surface was asphalt concrete. A 1.25-in. overlay was placed in 1981. In 2003, this section was milled at a depth of 2 in. and overlaid with a 1.5-in. layer of asphalt concrete. A 2005 pavement condition index survey indicated the pavement had a PCI of 94 and was in excellent condition. Some minor cracking was noted. The current condition of this pavement is similar but additional cracking has emerged. The cracking appears to be reflective cracking from the original block-cracked pavement. Four test areas were marked on this ramp. Two test sections were located on both sides of the centerline stripe. The sections were placed near the center of the ramp with a 50-ft transition area for separation. A minimum of 350 ft remained at the ends of the ramp to facilitate

vehicle movements for friction testing. Figure 6 shows the layout of the test sections on the White ramp.



Figure 5. Lawson AAF Yellow Ramp test section layout.



Figure 6. Lawson AAF White Ramp test section layout.

Feature A26B of the Blue ramp was used in the study. This pavement was originally constructed in 1964 (ERDC 2006a). The total thickness of the pavement was 8 in., and the surface was asphalt concrete. A 1.25-in. overlay was placed in 1981. In 2003, this section was milled at a depth of 2 in. and overlaid with a 1.5-in. layer of asphalt concrete. A 2005 pavement condition index survey indicated the pavement had a PCI of 94 and was in excellent condition. Some minor cracking was noted. The current condition of this pavement is similar, but additional cracking has emerged. The cracking appears to be reflective cracking from the original block-cracked pavement. Four test areas were marked on this ramp. Two test sections were located on both sides of the centerline stripe. The sections were placed near the center of the ramp with a 100-ft transition area for separation. A minimum of 350 ft remained at the ends of the ramp to facilitate vehicle movements for friction testing. Figure 7 shows the layout of the test sections on the Blue ramp.



Figure 7. Lawson AAF Blue Ramp test section layout.

Prior to product placement, eight 6-in. cores were taken from each test section. The cores were collected and transported to the ERDC for laboratory testing. Pavement surface texture was measured using the sand patch method. Five measurements were taken on each test section. Pavement

friction was collected using two devices, the Findlay Irvine Grip Tester and the Nippo Sanyo Dynamic Friction Tester. The pavement condition was documented by measuring and mapping all existing cracks in the pavement for each section.

Some test sections were placed during the same week as preliminary testing. Friction measurements on these sections were performed at various intervals following application. The testing intervals were dictated by the ability to conduct testing between periods of inclement weather following their placement. Additionally, eight 6-in. cores were taken from each treated section on 29 March for transportation to ERDC for subsequent testing.

Further treatments on other sections were delayed due to the inclement weather. Product applications resumed on 8 April 2009. The remaining treatments were applied during a 2-day period. Post-placement testing was not conducted due to time constraints from other scheduled project activities. A summary of the products is given in Table 1. The following paragraphs describe the product placement at Lawson AAF.

Table 1. Lawson AAF Product Placement Summary

Section Number	Product	Product Type	Application Rate (gsy)	Application Rate (Sand)	Date Applied
1	Gem Seal PolyTar	Sealer	0.240	0.75	4/9/2009
2	Grip Flex	Sealer	0.330	None	4/8/2009
3	Grip Flex Primer	Slurry	n/a	None	4/8/2009
4	GemSeal CBRTSO	Rejuvenator/Sealer	0.070	0.75 ¹	4/9/2009
5	GemSeal CBRTSO	Rejuvenator/Sealer	0.060	None	4/9/2009
6	GemSeal Federal Coal Tar	Sealer	0.250	1.0	4/9/2009
7	Gem Seal Polymer-Modified Asphalt	Sealer	0.270	None	4/9/2009
8	RejuvaSeal	Rejuvenator/Sealer	0.065	None	3/25/2009
9	RejuvaSeal	Rejuvenator/Sealer	0.065	0.5 ¹	3/25/2009
10	RejuvaSeal	Rejuvenator/Sealer	0.065	Surface Textured	3/25/2009
11	PDC	Rejuvenator/Sealer	0.055	None	3/24/2009
12	PDC	Rejuvenator/Sealer	0.065	None	3/24/2009
13	Reclamite	Rejuvenator	0.090	None	4/8/2009
14	Joint Bond	Rejuvenator/Sealer	0.090	None	4/8/2009

¹ Black Beauty aggregate applied topically after spraying product.

Section 1 was treated with Gem Seal Polytar on 9 April 2009. The material contained the 100 gal Polytar sealer, 10 gal water, and 300 lb sand. Product placement began at approximately 1500 hr. The air temperature was 68°F. The pavement temperature was 103°F. Polytar was placed on Section 1 in two coats. The first coat was applied at a rate of 0.14 gallon per square yard (gsy). After the first coat was dry (approximately 1 hr), the second coat was applied at a rate of 0.1 gsy.

Figure 8 illustrates the application technique.

Sections 2 and 3 were treated with Grip Flex on 8 April 2009. Product placement began at approximately 1400 hr. The air temperature was 65°F. The pavement temperature was 99°F. First, a primer was sprayed onto both sections. The primer was applied using a hand wand, which is shown in Figure 9. Using the hand wand caused some uneven coverage. A total of 87 gal were applied to 667 sq yd of pavement. The average application rate was 0.13 gsy. After the primer dried (approximately 1 hr), the Grip Flex slurry with type B aggregate was placed using a specialized truck with a slurry box, shown in Figure 10 and Figure 11. Type B aggregate is one of three gradations available from the manufacturer. Type A is a coarser gradation with a more open surface texture. Type C is a finer gradation containing natural sand. Type B was selected as an intermediate blend. Two strips, each 10 ft wide, were placed on Section 3 and a portion of Section 2. The remaining area on Section 2 was sprayed with a second coat of primer at an application rate of 0.2 gsy.



Figure 8. Application of Gem Seal Polytar.



Figure 9. Application of Grip Flex primer.



Figure 10. Application of Grip Flex slurry.



Figure 11. Grip Flex slurry box.

Section 4 was treated with Gem Seal CBRTSO asphalt rejuvenator (Figure 12) on 9 April 2009. Product placement began at approximately 1230 hr. The air temperature was 60°F. The pavement temperature was 90°F. The rejuvenator was applied at a rate of 0.07 gsy. After applying the rejuvenator, approximately 300 lb of Black Beauty aggregate was spread over the section using a garden fertilizer spreader. The aggregate was applied to increase the friction of the treated area. A Ford F550 truck was used to seat the aggregate by traversing the section for approximately 40 passes. The excess aggregate was blown off using a gas-powered fan.

Section 5 was also treated with Gem Seal CBRTSO asphalt rejuvenator on 9 April 2009. Product placement began at approximately 1200 hr. The air temperature was 60°F. The pavement temperature was 90°F. The rejuvenator was applied at a rate of 0.06 gsy.

Section 6 was treated with Gem Seal Federal Coal Tar Sealer on 9 April 2009. The material contained the 100 gal coal tar sealer, 50 gal water, 4 gal of a latex additive, and 400 lb sand. Product placement began at approximately 1100 hr. The air temperature was 56°F. The pavement temperature was 76°F. The coal tar sealer was placed on Section 6 in two



Figure 12. Application of Gem Seal CBRTSO asphalt rejuvenator.

coats (Figure 13). The first coat was applied at a rate of 0.15 gsy. After the first coat was dry (approximately 1 hr), the second coat was applied at a rate of 0.1 gsy. At the time of the second application the air temperature was 60°F, and the pavement temperature was 90°F.

Section 7 was treated with Gem Seal Polymer-Modified Asphalt Emulsion on 9 April 2009. Product placement began at approximately 1630 hr. The air temperature was 79°F. The pavement temperature was 120°F. The polymer-modified asphalt emulsion was placed on Section 7 in two coats and was applied using the same technique illustrated in Figure 13. The first coat was applied at a rate of 0.175 gsy. After the first coat was dry (approximately 1 hr), the second coat was applied at a rate of 0.09 gsy.

Sections 8 through 10 were treated with RejuvaSeal on 25 March 2009. Product placement began at approximately 1200 hr. The application technique is shown in Figure 14. The air temperature was 67°F. The three test sections were treated using various techniques of addressing pavement friction concerns. Section 8 was placed using a topical spray on the pavement of 0.065 gsy. Section 9 was placed using the topical spray of 0.065 gsy followed by the application of 0.5 lb/yd² of Black Beauty



Figure 13. Application of Gem Seal Federal Coal Tar Sealer.



Figure 14. Application of RejuvaSeal.

aggregate. The aggregate was added to attempt to increase the friction of the treated pavement. Section 10 was placed using a topical spray of 0.065 gsy after the pavement had been subjected to shot blasting (Figure 15). Shot blasting is a procedure intended to increase the rough texture of the asphalt concrete pavement.

Shot blasting is performed by striking the pavement surface with small-diameter steel media at high velocities. The pavement contact area is sealed, and the steel media are vacuumed back through the shot blaster to be recycled and cleaned for repetitive use. Once the process is completed, the area subjected to shot blasting is further cleaned with a magnetic sweeper. Figure 16 shows the pavement surface condition with and without shot blasting.

Sections 11 and 12 were treated with PDC (Figure 17) on 24 March 2009. Product placement began at approximately 1200 hr. The air temperature was 69°F. PDC was placed on Section 11 at a rate of 0.055 gsy.



Figure 15. Shot blaster during operation.



Figure 16. Shot blasted asphalt pavement.



Figure 17. Application of Pavement Dressing Conditioner (PDC).

It was placed on Section 12 at a rate of 0.065 gsy. Test sections were 300 ft long and approximately 7.5 ft wide.

The width of the section was dictated by the maximum application width of the distribution equipment (Figure 17). The product absorbed into the

pavement within several minutes on each section. The heavier application rate was perceived to absorb more slowly than the lower application rate as expected

Section 13 was treated with Reclamite on 8 April 2009. Product placement began at approximately 1100 hr. The air temperature was 52°F. The pavement temperature was 90°F. Reclamite was placed on Section 13 at a rate of 0.09 gsy. The product absorbed into the pavement within several minutes. The application of Reclamite is shown in Figure 18.

Joint Bond was placed on a portion of Taxiway H (Figure 19) on 8 April 2009. The two outer longitudinal construction joints were treated. The spray width was approximately 2 ft. Only half of the length of the taxiway was treated. The other half was left untreated as a control for comparison. The treatment was placed on the end of the taxiway nearest Taxiway K. The treatment began at the hold line and proceeded 192 ft. The end of the taxiway nearest the runway was untreated. Product placement began at approximately 1200 hr. The air temperature was 57°F. The pavement temperature was 103°F. Joint Bond was placed at a rate of 0.12 gsy. The product absorbed into the pavement within several minutes.

After product placement eight additional 6-in. cores were taken from each test section. The cores were collected and transported to the ERDC for laboratory testing. Pavement surface texture was again measured using the sand patch method. Five measurements were taken on each test section. Pavement friction was collected using the Nippo Sanyo Dynamic Friction Tester. Data was not collected for all sections due to time conflicts with planned product placement at Robert Gray AAF.

Robert Gray Army Airfield, Fort Hood, Texas

A site visit was conducted at Robert Gray AAF on 4 February 2009 to inspect potential sites for placing test areas of asphalt surface treatments. As a result of the inspection, a portion of Taxiway Alpha (Feature T3A) was selected. Researchers returned to Robert Gray AAF on 15 April 2009 to coordinate placement of asphalt surface treatments and to collect data from the test areas.



Figure 18. Application of Reclamite.



Figure 19. Joint Bond application.

A portion of Feature T3A was selected for use on Taxiway Alpha. This pavement was originally constructed between 1944 and 1947 (ERDC 2006b). The original pavement surface consisted of 4 in. of asphalt concrete. In 1986, an asphalt concrete overlay 1.5 in. thick was placed over the existing pavement. The latest construction consisted of milling 1 in. of asphalt followed by a 1-in. asphalt concrete overlay. In 2005, a pavement

condition index survey indicated that these areas were in good condition, but they contained low-severity longitudinal and transverse cracking and low-severity weathering. The current condition of the ramp is good. Test sections were placed on the north end of Feature T3A on Taxiway Alpha. A total of 18 test sections were used at this site. Figure 20 shows the location of the test sections on the ramp. A list of products placed at Robert Gray AAF is given in Table 2.

Prior to product placement, thirty-six 6-in. cores were taken from the test area. Twelve cores were taken from three different paving lanes. The paving lanes near the edges of the taxiway and the paving lane near the center of the taxiway were selected for extracting cores. The cores were collected and transported to ERDC for laboratory testing. Additionally, DFT and sand patch measurements were taken on each section before products were applied. Six measurements were taken with the DFT on each section; two sand patch tests were performed on each section. The test section areas were also examined to map all of the existing visible cracks in the pavement surface.

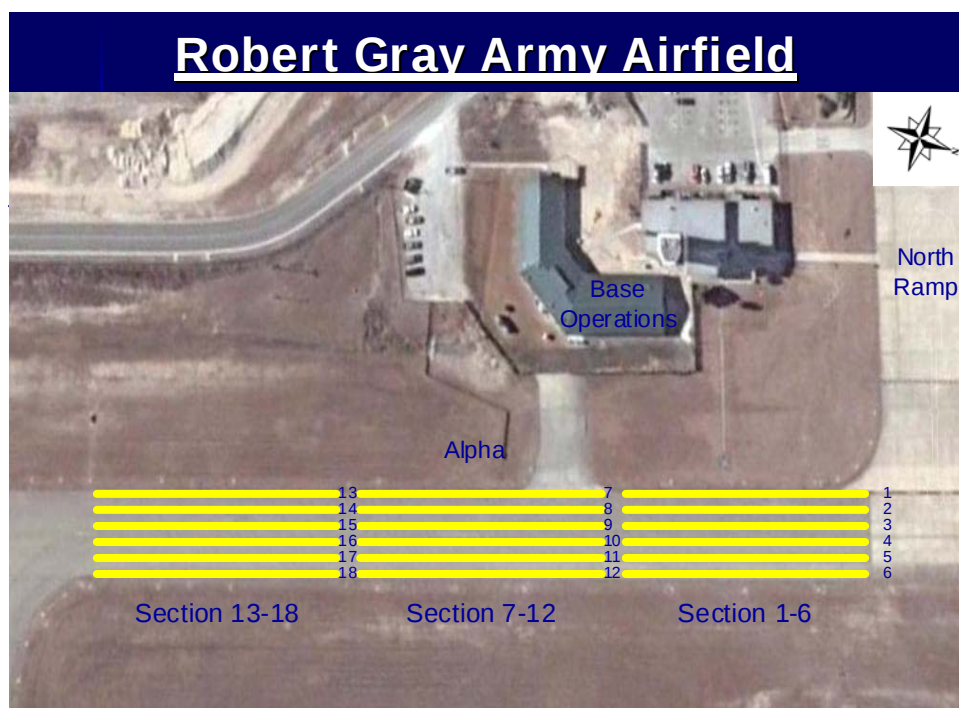


Figure 20. Robert Gray AAF test section location.

Table 2. Robert Gray AAF Product Placement Summary

Section Number	Product	Product Type	Application Rate (gsy)	Sand (lb/yd ²)	Date Applied
1	Reclamite	Rejuvenator	0.070	None	4/30/2009
2 and 3	Viking Construction	Type II Slurry Seal	n/a	None	4/24/2009
4	GemSeal CBRTSO	Rejuvenator/Sealer	0.065	None	4/22/2009
5	Gem Seal PolyTar	Sealer	0.290	1.13	4/22/2009
6	Gem Seal Polymer-Modified Asphalt	Sealer	0.280	None	4/22/2009
7	Grip Flex	Sealer	0.120	None	4/23/2009
8	Grip Flex Primer	Slurry	n/a	None	4/23/2009
9	GemSeal Federal Coal Tar	Sealer	0.250	1.0	4/22/2009
10	GemSeal CBRTSO	Rejuvenator/Sealer	0.065	0.7 ¹	4/22/2009
11	PDC	Rejuvenator/Sealer	0.055	None	4/22/2009
13	SealMaster PMM	Sealer	0.320	1.0	4/23/2009
14	Pass QB	Rejuvenator	0.120	None	4/23/2009
15E	PaverX	Rejuvenator/Sealer	0.060	None	4/23/2009
15W	PaverX	Rejuvenator/Sealer	0.065	None	4/23/2009
16	RejuvaSeal	Rejuvenator/Sealer	0.065	0.5 ¹	4/20/2009
17	RejuvaSeal	Rejuvenator/Sealer	0.065	Surface Textured	4/20/2009
18	RejuvaSeal	Rejuvenator/Sealer	0.065	None	4/20/2009

¹ Black Beauty aggregate applied topically after spraying product.

Section 1 was treated with Reclamite asphalt rejuvenator on 30 April 2009. Product placement began at approximately 1400 hr. The air temperature was 80°F. The pavement temperature was 88°F. The Reclamite was placed on Section 1 using a tanker truck with a 12-ft-wide distribution bar at a rate of 0.07 gsy. The spray rate was controlled by a calibrated computer system in the cab of the truck.

Sections 2 and 3 were treated with a Type II slurry seal on 24 April 2009. The slurry was placed by Viking Construction. Product placement began at approximately 1230 hr. The air temperature was 77°F. The pavement temperature was 81°F. The Type II slurry was placed using a specialized truck with a slurry box, which is shown in Figure 21. Two strips, each 10 ft wide, were placed on Section 3 and a portion of Section 2. The product stiffened in approximately 15 min. The application of the slurry seal is shown in Figure 22.



Figure 21. Side view of Viking Construction slurry box.



Figure 22. Application of Viking Construction Type II slurry seal.

Section 4 was treated with Gem Seal CBRTSO asphalt rejuvenator 22 April 2009. Product placement began at approximately 1715 hr. The air temperature was 87°F. The pavement temperature was 105°F. The rejuvenator was applied at a rate of 0.065 gsy.

Section 5 was treated with Gem Seal Polytar on 22 April 2009. The material contained the 100 gal Polytar sealer, 10 gal water, and 450 lb sand. Product placement began at approximately 1500 hr. The air temperature was 93°F. The pavement temperature was 116°F. Polytar was placed on Section 5 in two coats. The first coat was applied at a rate of 0.15 gsy. After the first coat was dry (approximately 0.5 hr), the second coat was applied at a rate of 0.14 gsy.

Section 6 was treated with Gem Seal Polymer-Modified Asphalt Emulsion on 22 April 2009. Product placement began at approximately 1600 hr. The air temperature was 93°F. The pavement temperature was approximately 116°F. The polymer-modified asphalt emulsion was placed on Section 6 in two coats. The first coat was applied at a rate of 0.15 gsy. After the first coat was dry (approximately 1 hr), the second coat was applied at a rate of 0.13 gsy.

Sections 7 and 8 were treated with Grip Flex on 23 April 2009. Product placement began at approximately 1330 hr. The air temperature was 80°F. The pavement temperature was 108°F. First, a primer was sprayed onto both sections. The primer was applied using a hand wand. A total of 90 gal were applied to 766 sq yd of pavement. The average application rate was 0.12 gsy. After the primer dried (approximately 0.5 hr), the Grip Flex slurry with type B aggregate was placed using a specialized truck with a slurry box. Two strips, each 10 ft wide, were placed on Section 8 and a portion of Section 7.

Section 9 was treated with Gem Seal Federal Coal Tar Sealer on 22 April 2009. The material contained the 100 gal coal tar sealer, 50 gal dilution water, 4 gal of a latex additive, and 400 lb sand. Product placement began at approximately 0930 hr. The air temperature was 73°F. The pavement temperature was 82°F. The coal tar sealer was placed on Section 9 in two coats. The first coat was applied at a rate of 0.13 gsy. After the first coat was dry (approximately 1 hr), the second coat was applied at a rate of 0.12 gsy. At the time of the second application the air temperature was 74°F, and the pavement temperature was 90°F.

Section 10 was also treated with Gem Seal CBRTSO asphalt rejuvenator on 22 April 2009. Product placement began at approximately 1700 hr. The air temperature was 87°F. The pavement temperature was 107°F. The rejuvenator was applied at a rate of 0.065 gsy. After applying the rejuvenator, approximately 0.7 lb/yd² of Black Beauty aggregate was spread over the section using a garden fertilizer spreader. The aggregate was applied to increase the friction of the treated area.

Section 11 was treated with PDC on 22 April 2009. Product placement began at approximately 1000 hr. The air temperature was 74°F. The pavement temperature was 90°F. PDC was placed on Section 11 at a rate of 0.055 gsy. Test sections were 300 ft long and approximately 7.5 ft wide. The width of the section was dictated by the maximum application width of the distribution equipment. The product absorbed into the pavement within several minutes.

Section 13 was treated with SealMaster Polymer Modified MasterSeal (PMM) on 23 April 2009. Product placement began at approximately 1030 hr. The air temperature was 70°F. The pavement temperature was 80°F. The polymer-modified asphalt emulsion was placed on Section 13 using a hand wand (Figure 23) at an average rate of 0.32 gsy. The product contained the emulsion and 400 lb sand.

Section 14 was treated with Pass QB on 23 April 2009. Product placement began at approximately 1400 hr. The air temperature was 80°F. The pavement temperature was 108°F. The polymer-modified asphalt emulsion was placed on Section 14 using a tanker truck (Figure 24) with a 12-ft-wide distribution bar at a rate of 0.12 gsy. The spray rate was controlled by a calibrated computer system in the cab of the truck. Prior to spraying, the product was heated to 140°F using the truck's heating system.

Section 15 was treated with PaverX asphalt rejuvenator (Figure 25) on 23 April 2009. Product placement began at approximately 0900 hr. The air temperature was 64°F. The pavement temperature was 67°F. Two different application rates were used on Section 15. The east side was treated at a rate of 0.06 gsy; the west side was treated at a rate of 0.065 gsy. The 0.06 gsy application on the east side of the section was placed 7.5 ft wide. The 0.065 gsy application on the west side was placed 3 ft wide.



Figure 23. Application of SealMaster Polymer Modified MasterSeal (PMM).



Figure 24. Application of Pass QB.

Sections 16, 17, and 18 were treated with RejuvaSeal on 20 April 2009. Product placement began at approximately 1200 hr. The air temperature was 75°F. The pavement temperature was 93°F. The three test sections



Figure 25. Application of PaverX asphalt rejuvenator.

were treated using various techniques of addressing pavement friction concerns. Section 16 was placed using the topical spray of 0.065 gsy followed by the application of 0.5 lb/yd² of Black Beauty aggregate. The aggregate was added to attempt to increase the friction of the treated pavement. Section 17 was placed using a topical spray of 0.065 gsy after the pavement had been subjected to the shot blasting procedure described in the previous section. Section 18 was placed using a topical spray on the pavement of 0.065 gsy.

After product placement, eight 6-in. cores were taken from each test section. The cores were collected and transported to the ERDC for laboratory testing. Pavement friction was collected using the Nippo Sanyo Dynamic Friction Tester. Figure 26 shows an aerial view of the entire test site.

Wheeler-Sack Army Airfield, Fort Drum, New York

A site visit was conducted at Wheeler-Sack AAF on 7 May 2009 to inspect potential sites for placing test areas of asphalt surface treatments. As a result of the inspection, the east side of the North Ramp (Feature T20B) was selected.



Figure 26. Aerial view of test site at Robert Gray AAF.

Products were placed at Wheeler-Sack AAF on the North Ramp Taxiway (Feature T20B) from 8 to 9 June 2009. The North Ramp Taxiway was originally constructed in 1992 (ERDC 2009). The pavement surface consisted of 6-in. asphalt concrete. In 2008, a PCI survey indicated the taxiway was in satisfactory condition and contained low and medium-severity longitudinal and transverse cracking.

Test sections were placed on the south end of the North Ramp Taxiway near the fixed-wing hangars. A total of eight test sections were used at this site. No pavement cores were taken from the test area, because airfield personnel reported a history of patch failures due to climatic influences.

DFT and sand patch measurements were taken on each section before and after products were applied. Six measurements were taken with the DFT on each section; two sand patch tests were performed on each section. The test section areas were also examined to map all of the existing visible cracks in the surface. A summary of the products placed at Wheeler-Sack AAF is given in Table 3.

Table 3. Wheeler-Sack AAF Product Placement Summary

Section Number	Product	Product Type	Application Rate (gsy)	Application Rate (Sand)	Date Applied
1	PaverX	Rejuvenator/Sealer	0.060	None	6/9/2009
2	PaverX	Rejuvenator/Sealer	0.050	None	6/9/2009
5	Grip Flex	Slurry	n/a	None	6/9/2009
6	Reclamite	Rejuvenator	0.050	None	6/9/2009
7	Reclamite	Rejuvenator	0.060	None	6/9/2009
9	RejuvaSeal	Rejuvenator/Sealer	0.065	Surface Textured	6/8/2009
10	RejuvaSeal	Rejuvenator/Sealer	0.065	0.4 ¹	6/8/2009
11	RejuvaSeal	Rejuvenator/Sealer	0.065	None	6/8/2009

¹ Black Beauty aggregate applied topically after spraying product

Sections 1 and 2 were treated with PaverX on 9 June 2009. Product placement began at 1145 hr. Section 1 was treated at a rate of 0.06 gsy; Section 2 was treated at a rate of 0.05 gsy. At the time of treatment, the air temperature was 70°F; the pavement surface temperature was 81°F.

Section 5 was treated with Grip-Flex on 9 June 2009. Product placement began at 1100 hr. The air temperature was 70°F; the pavement surface temperature was 80°F. The placement included hand-applying a modified coal tar emulsion primer using paint rollers. The primer was placed at approximately 0.08 gsy. The primer was allowed to dry for 1 hr. Next, the Grip-Flex slurry was hand-applied using a squeegee at a rate of 0.33 gsy. This application rate included 25 gal emulsion and 500 lb type B aggregate. The section length was reduced to accommodate available shipping options. No slurry truck was available to place the product, and the material was transported by pickup truck.

Sections 6 and 7 were treated with Reclamite on 9 June 2009. Product placement began at 1220 hr. Section 6 was treated at a rate of 0.05 gsy. Section 7 was treated at a rate of 0.06 gsy. The air temperature was 70°F; the pavement surface temperature was 92°F. The product soaked into the pavement surface within 30 min.

Sections 9, 10, and 11 were treated with RejuvaSeal on 8 June 2009. Product placement began at 1200 hr. At the time of treatment, the air temperature was 63°F, and the pavement surface temperature was 91°F. All three sections were treated at a rate of 0.065 gsy. Prior to the product application, Section 9 was shot blasted to increase the texture and friction of the test section. Following product application, Section 10 was covered

with 175 lb of Black Beauty aggregate using a walk-behind fertilizer spreader.

After product placement, pavement friction was collected using the Nippo Sanyo Dynamic Friction Tester. Pavement surface texture was again measured using the sand patch method. Figure 27 shows an aerial view of the entire test site at Wheeler-Sack AAF.



Figure 27. Aerial view of test site at Wheeler-Sack AAF.

4 Preliminary Data

Data was collected from the test sections prior to placing asphalt surface treatments. This section of the report contains pre-treatment data. Data collected after product placement is not included in this report.

Surface texture

Data from the sand patch test were used to calculate a value of MTD for the pavement surface. The MTD was calculated according to ASTM E 965. A summary of the data collected from each location is shown in Table 4. The MTD data will be used to compare the pavement texture after product placement. Sealants are expected to fill surface voids in the pavement. The reduction in voids may promote friction loss.

Table 4. Summary of sand patch test results prior to product placement.

Value	Mean Texture Depth (mm)				
	Lawson AAF			Robert Gray AAF	Wheeler-Sack AAF
	Yellow Ramp	White Ramp	Blue Ramp	Taxiway Alpha	North Ramp Taxiway
Average	1.1	0.85	0.91	1.2	1.2
Standard deviation ¹	0.3	0.05	0.04	0.18	0.11

¹ Values are calculated using a 95 percent confidence interval.

Skid resistance

A summary of the DFT data collected on each test section prior to product placement is shown in Table 5. The friction coefficient, μ , is reported only at 35 mph (60 km/hr). Friction data for all three locations prior to product placement were similar. μ values ranged from 0.59 to 0.72. These values would be considered acceptable for aircraft operations. The DoD requires a minimum μ value of 0.53 and 0.43 for planning and action conditions, respectively, when measured by the Findlay Irvine Grip Tester. No correlation between the Grip Tester and the DFT is currently known.

Table 5. Summary of selected DFT data prior to product placement.

Section No.	Friction Coefficient @ 36 mph (60 km/hr)					
	Lawson AAF		Robert Gray AAF		Wheeler-Sack AAF	
	Average	Standard Deviation	Average	Standard Deviation	Average	Standard Deviation
1	-	-	0.669	0.015	0.617	0.051
2	-	-	0.656	0.027	0.644	0.025
3	-	-	0.586	0.045	0.652	0.017
4	-	-	0.673	0.019	0.709	0.012
5	-	-	0.658	0.022	0.643	0.012
6	-	-	0.714	0.006	0.655	0.010
7	0.683	0.006	0.676	0.009	0.636	0.024
8	0.716	0.003	0.647	0.012	0.665	0.031
9	0.675	0.006	0.634	0.015	0.680	0.011
10	0.703	0.007	0.662	0.014	0.644	0.008
11	0.639	0.020	0.645	0.005	0.676	0.038
12	0.683	0.004	0.715	0.016	0.666	0.017
13	0.687	0.027	0.686	0.038	-	-
14	0.695	0.000	0.678	0.039	-	-
15	-	-	0.653	0.023	-	-
16	-	-	0.656	0.013	-	-
17	-	-	0.694	0.008	-	-
18	-	-	0.728	0.006	-	-
Range of values	0.64–0.72	0–0.03	0.59–0.73	0–0.04	0.62–0.71	0.01–0.05

Pavement distresses

All cracks from each individual test section were mapped on graphing paper to monitor the change of crack initiation and propagation over the 5-year evaluation period. The maps were further superimposed onto corresponding graphs shown in Figures 28–105 (Lawson AAF), Figures 106–213 (Robert Gray AAF), and Figures 214–285 (Wheeler-Sack AAF).

5 Conclusions and Recommendations

Conclusions

As a result of this study, the following conclusions can be made:

1. Asphalt surface treatments can be effectively placed using a range of distribution equipment. The size of the equipment and the application rate of the product will determine the efficiency of the procedure.
2. Test sections measuring 12 ft wide and 300 ft long provided ample pavement surface for conducting the required tests. The size of the test sections was convenient for application using the vendor equipment. Transition areas of at least 1,000 ft at the end of the test section are needed if skid testing is performed using a tow-behind system.
3. Well-trained equipment operators are needed to ensure uniform product coverage. Variations in equipment speed and/or direction can cause insufficient coverage or excess product buildup.
4. Unprotected spray bars on distribution trucks are subject to excessive overspray during windy conditions. These types of distributors should be used only during reasonable weather conditions.

Recommendations

Based on the information obtained from the placement of asphalt surface treatments on Army airfields, researchers recommend that the pavement test sections continue to be monitored for the duration of the planned study. Annual inspections should include documenting changes in pavement surface characteristics, pavement distresses, and changes compared with untreated areas. Future results should be compiled into a report that documents any decreases in friction or the potential for FOD caused by the surface treatments. Final results should include guidance for selecting asphalt surface treatments for extending the life of asphalt concrete pavements on airfields.

References

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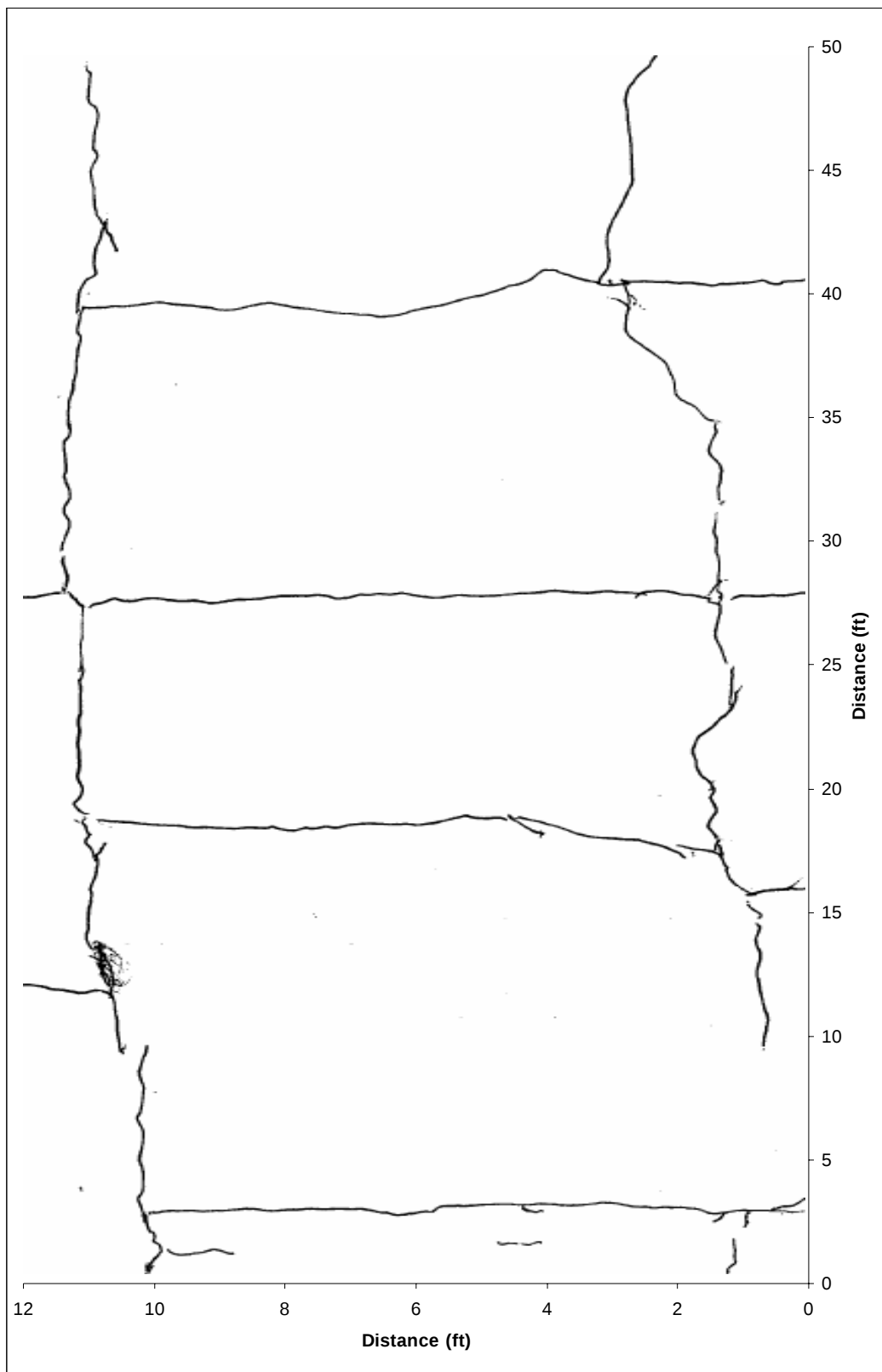


Figure 28. Lawson AAF Section 2 (Station 0-50 ft).

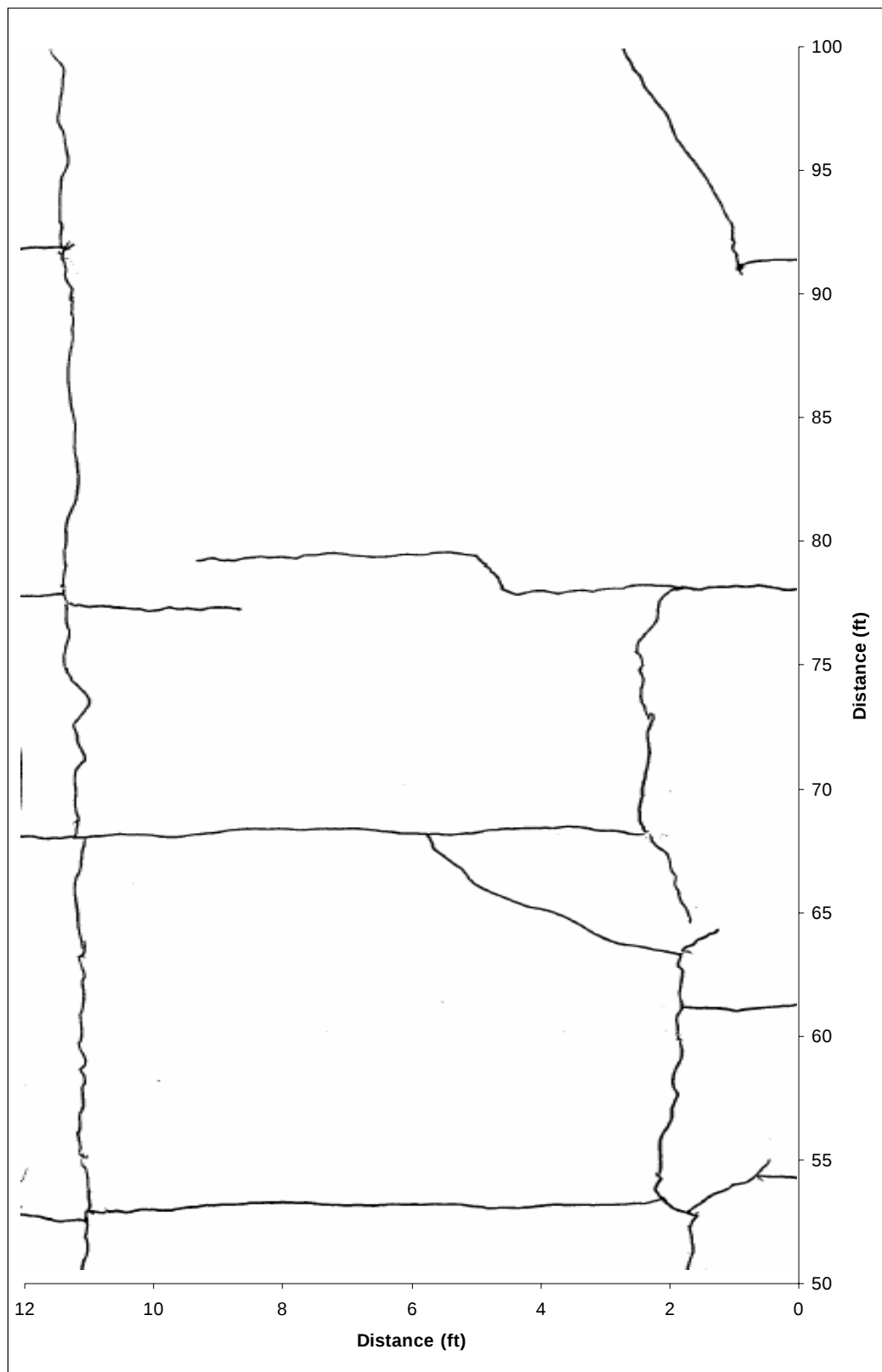


Figure 29. Lawson AAF Section 2 (Station 50-100 ft).

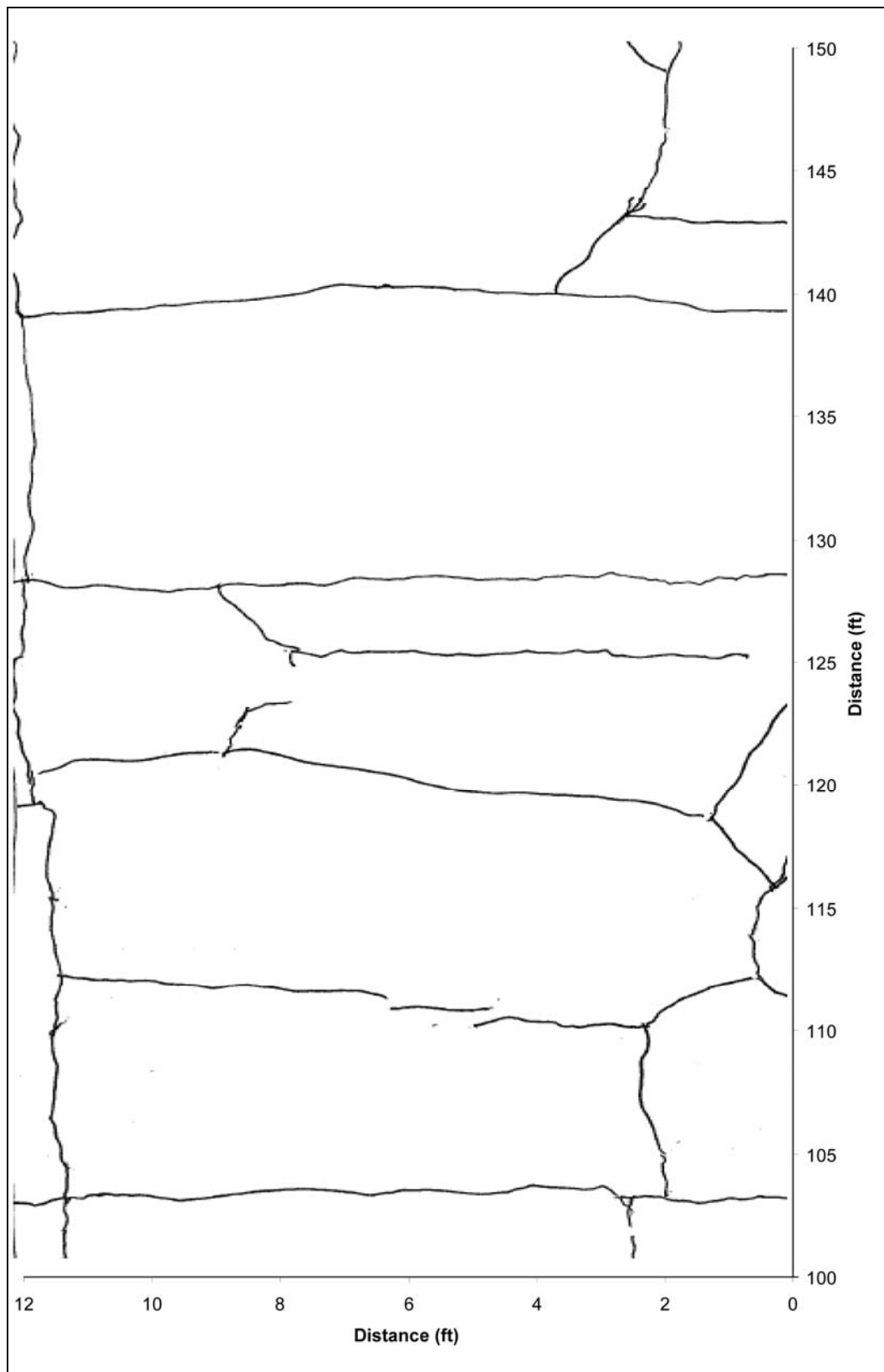


Figure 30. Lawson AAF Section 2 (Station 100-150 ft).

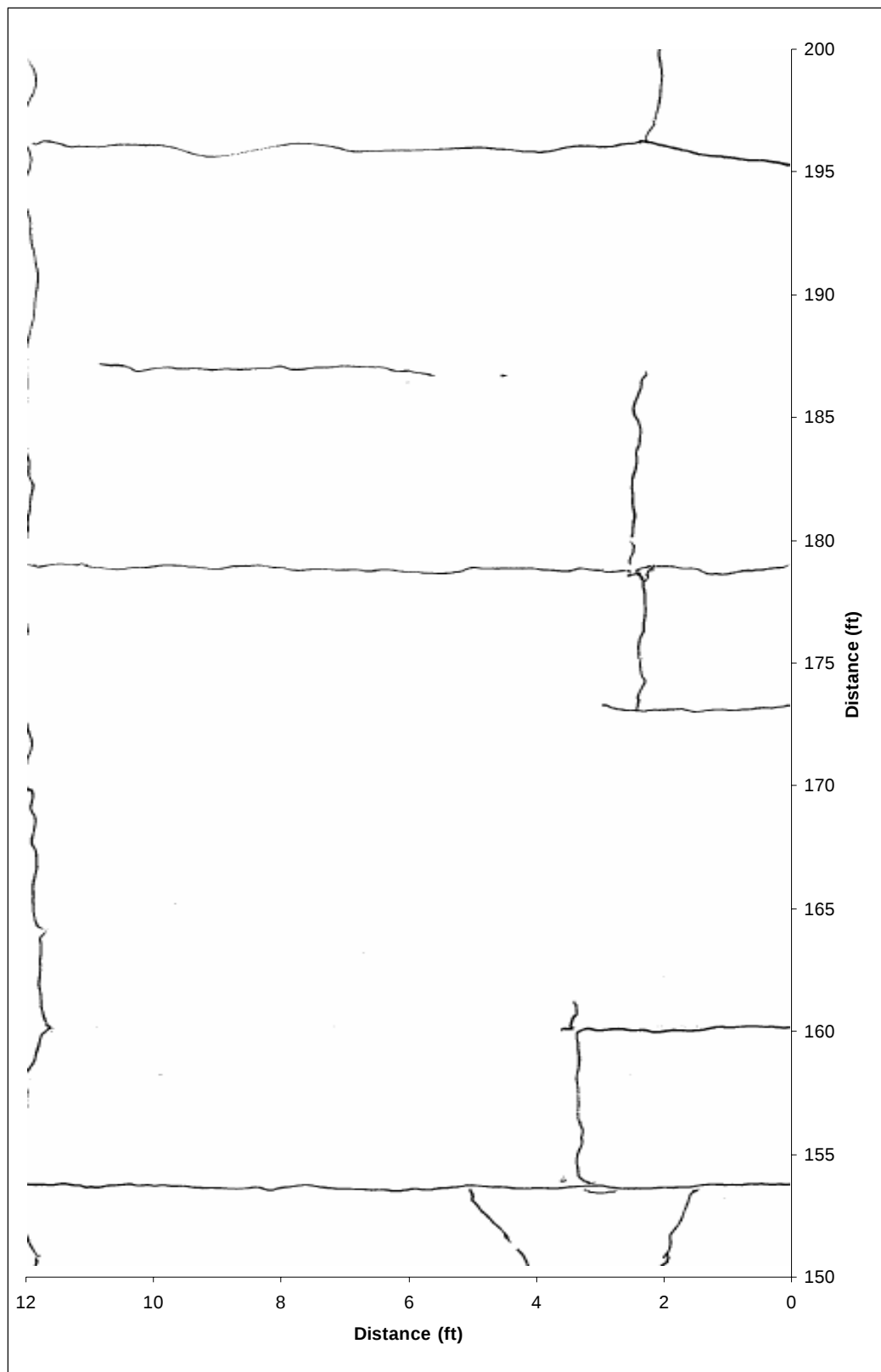
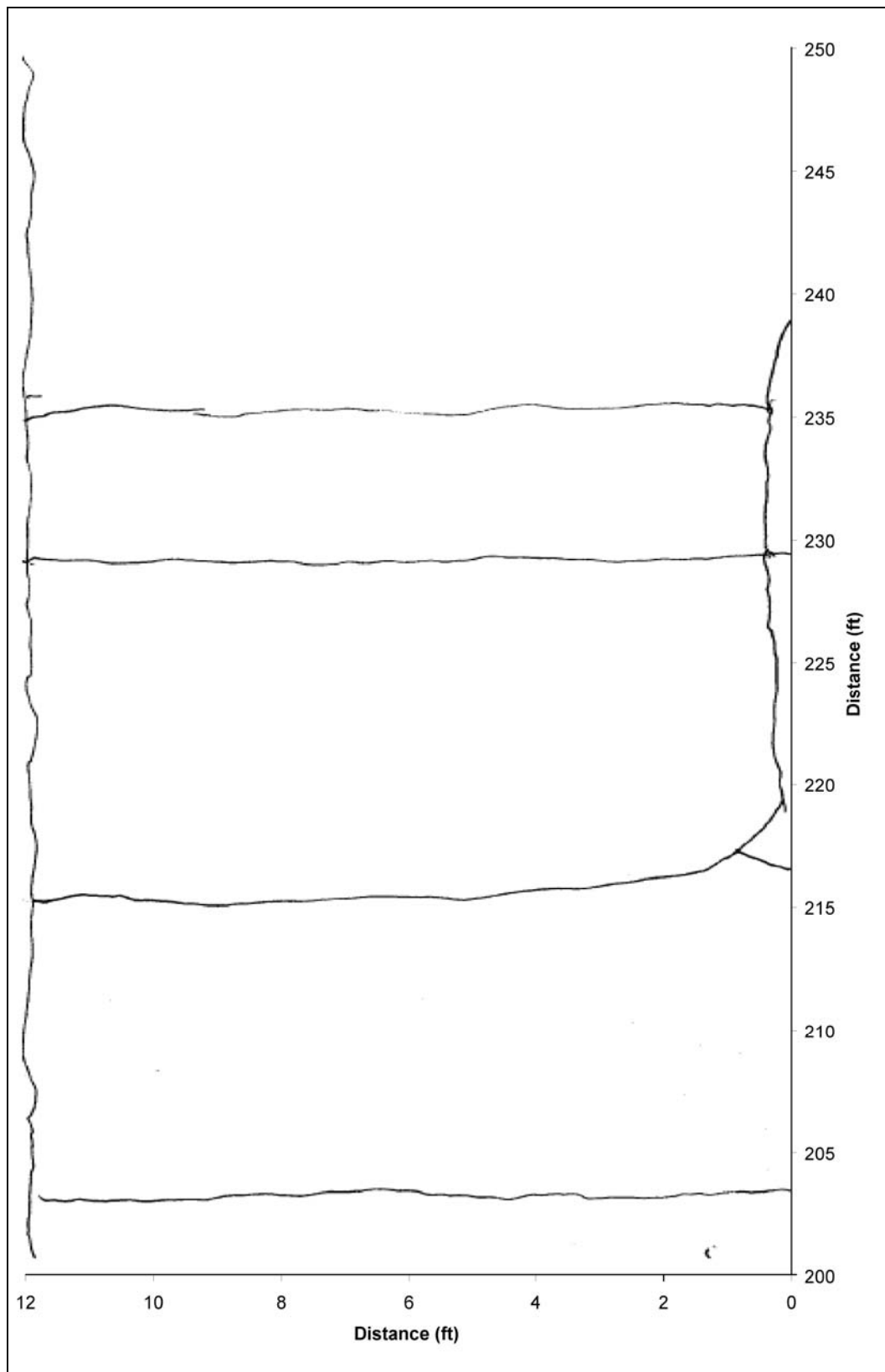


Figure 31. Lawson AAF Section 2 (Station 150-200 ft).



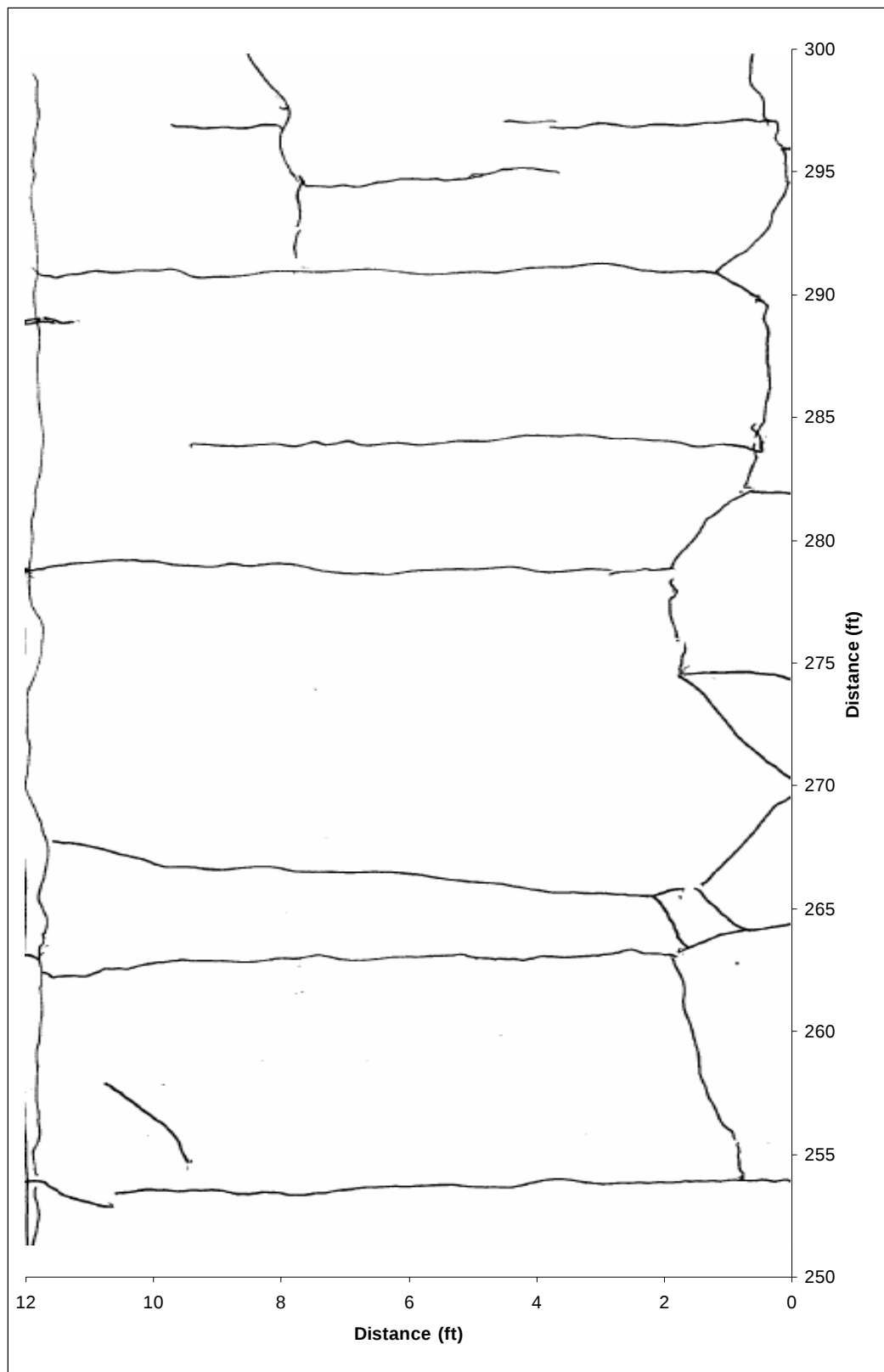


Figure 33. Lawson AAF Section 2 (Station 250-300 ft).

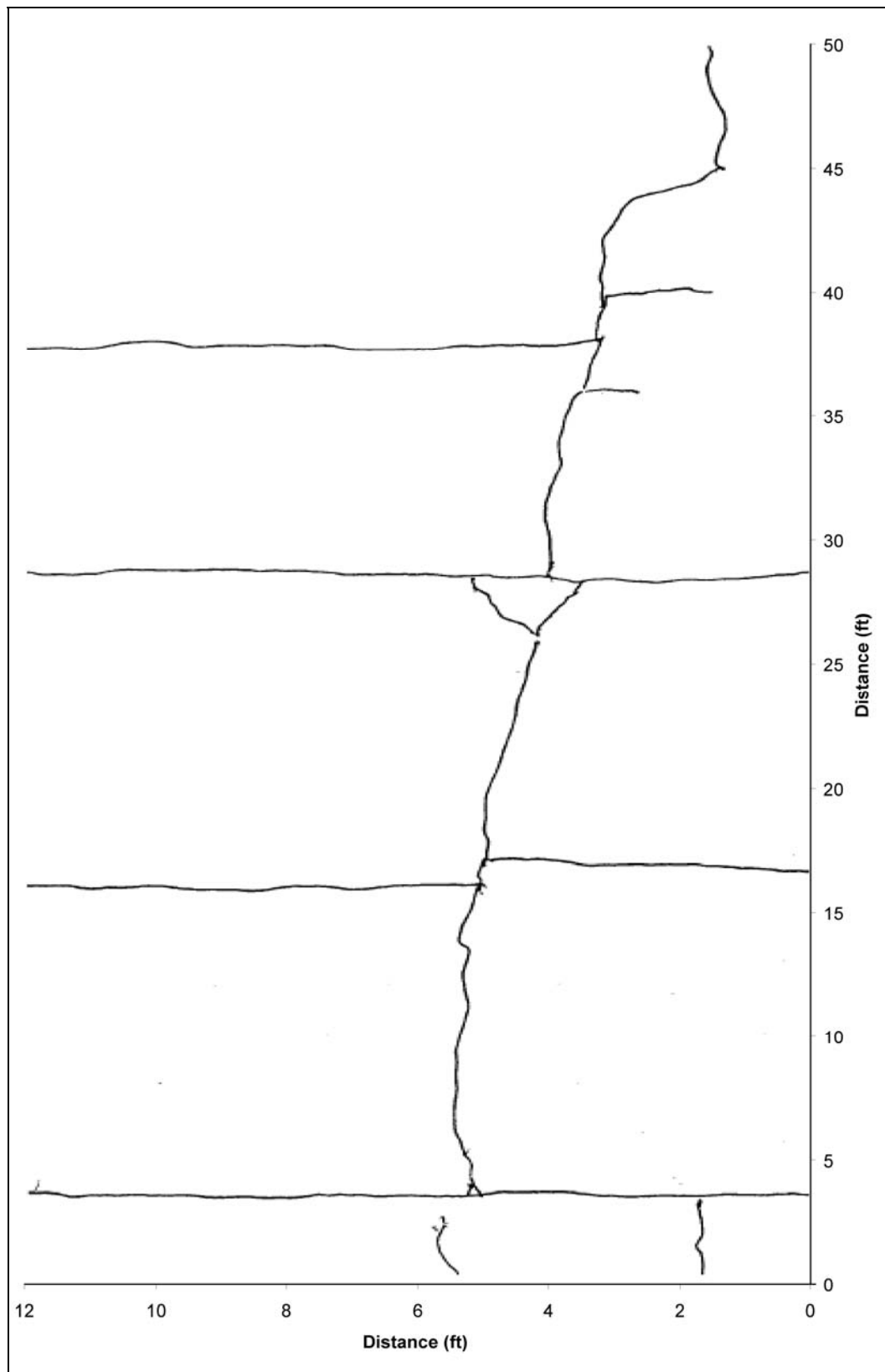


Figure 34. Lawson AAF Section 3 (Station 0-50 ft).

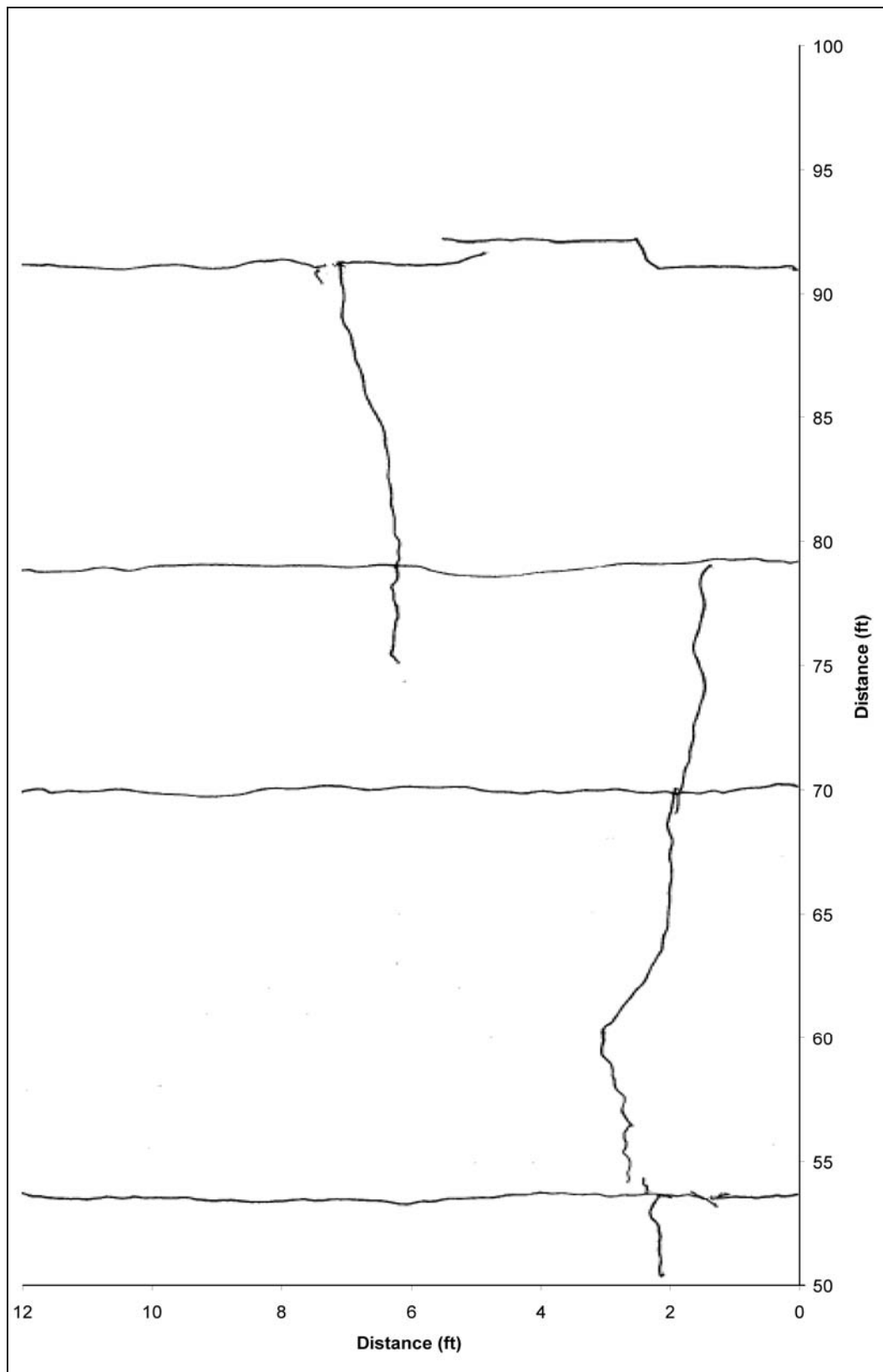


Figure 35. Lawson AAF Section 3 (Station 50-100 ft).

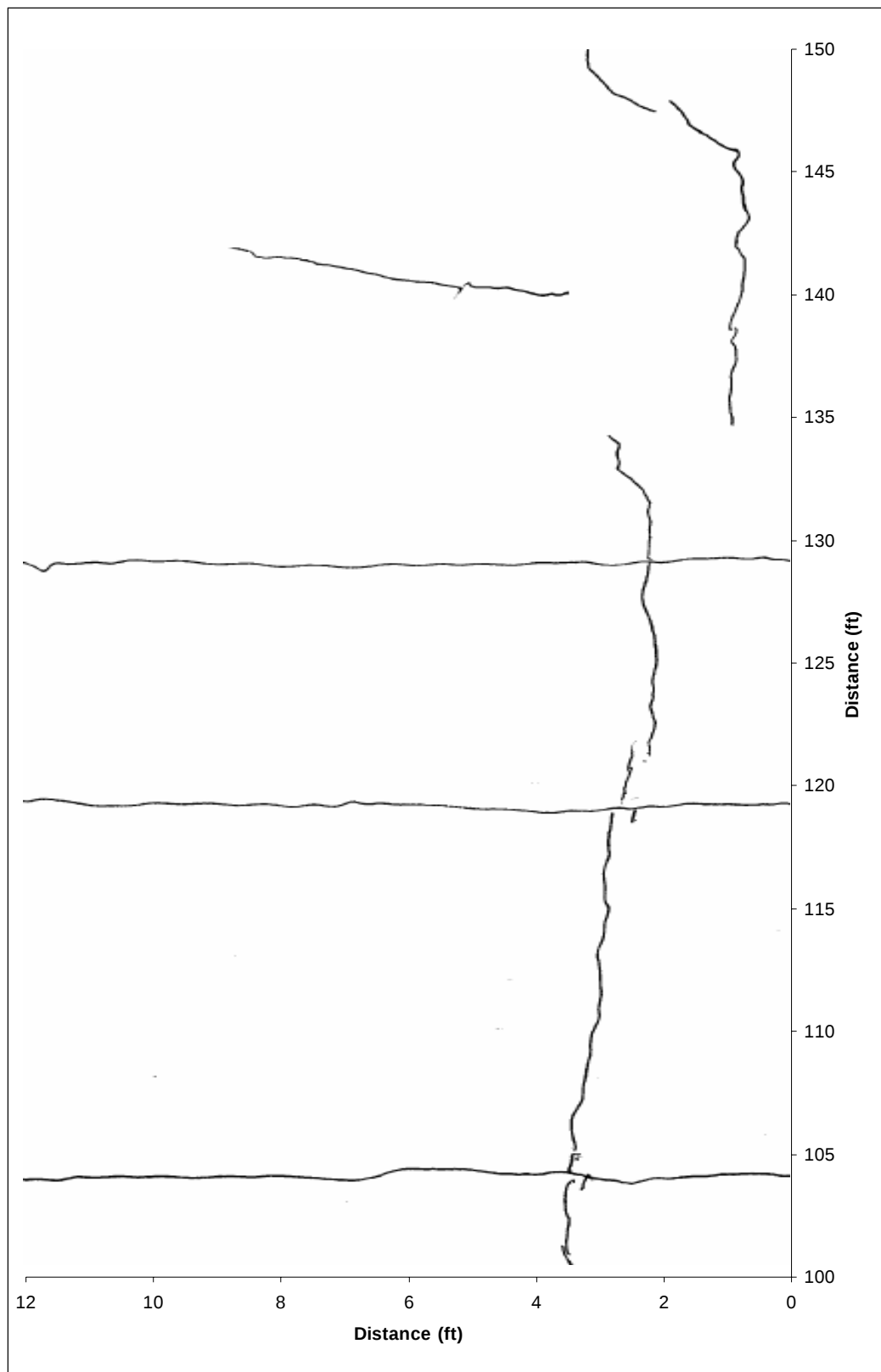


Figure 36. Lawson AAF Section 3 (Station 100-150 ft).

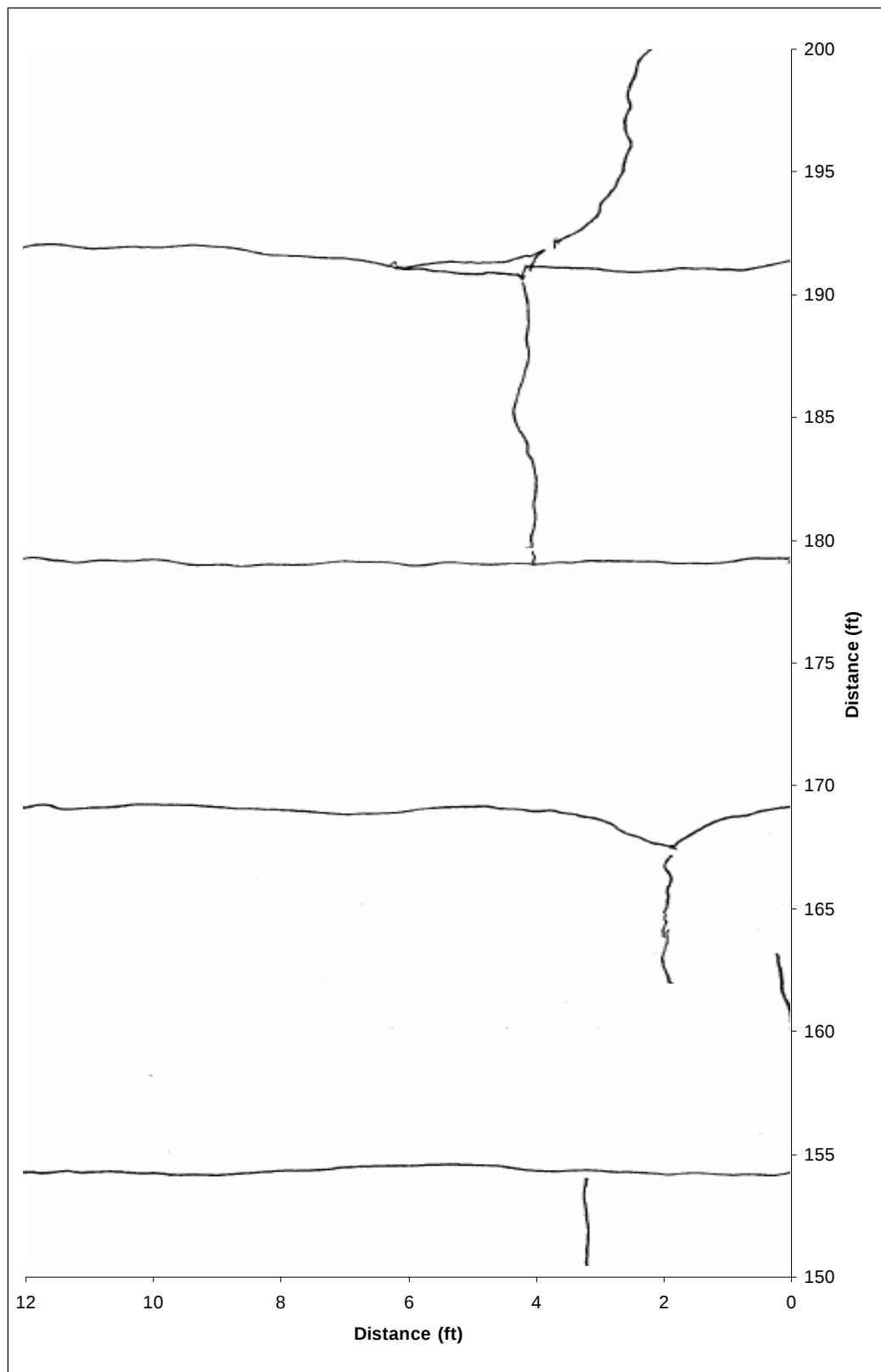


Figure 37. Lawson AAF Section 3 (Station 150-200 ft).

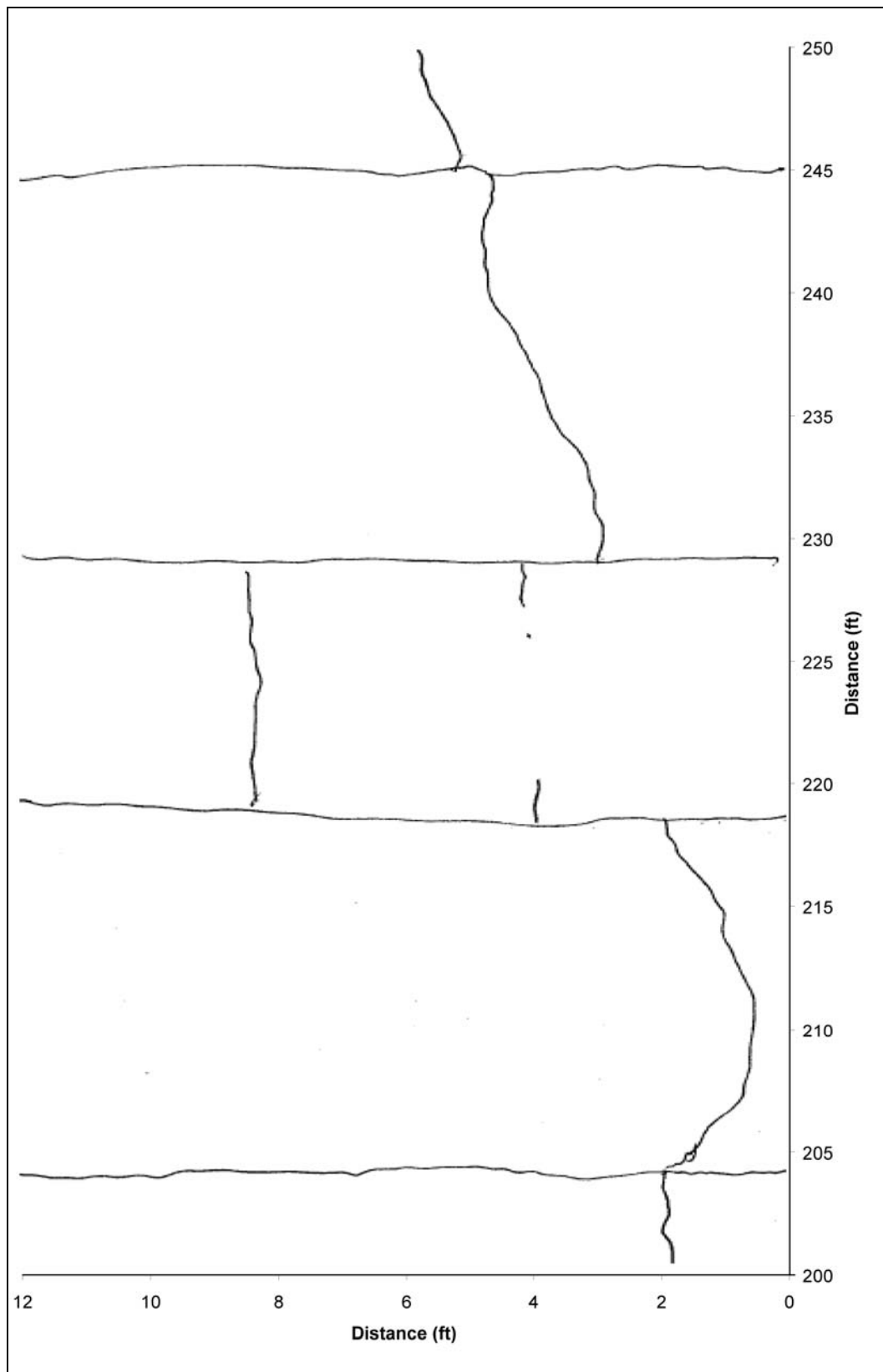


Figure 38. Lawson AAF Section 3 (Station 200-250 ft).

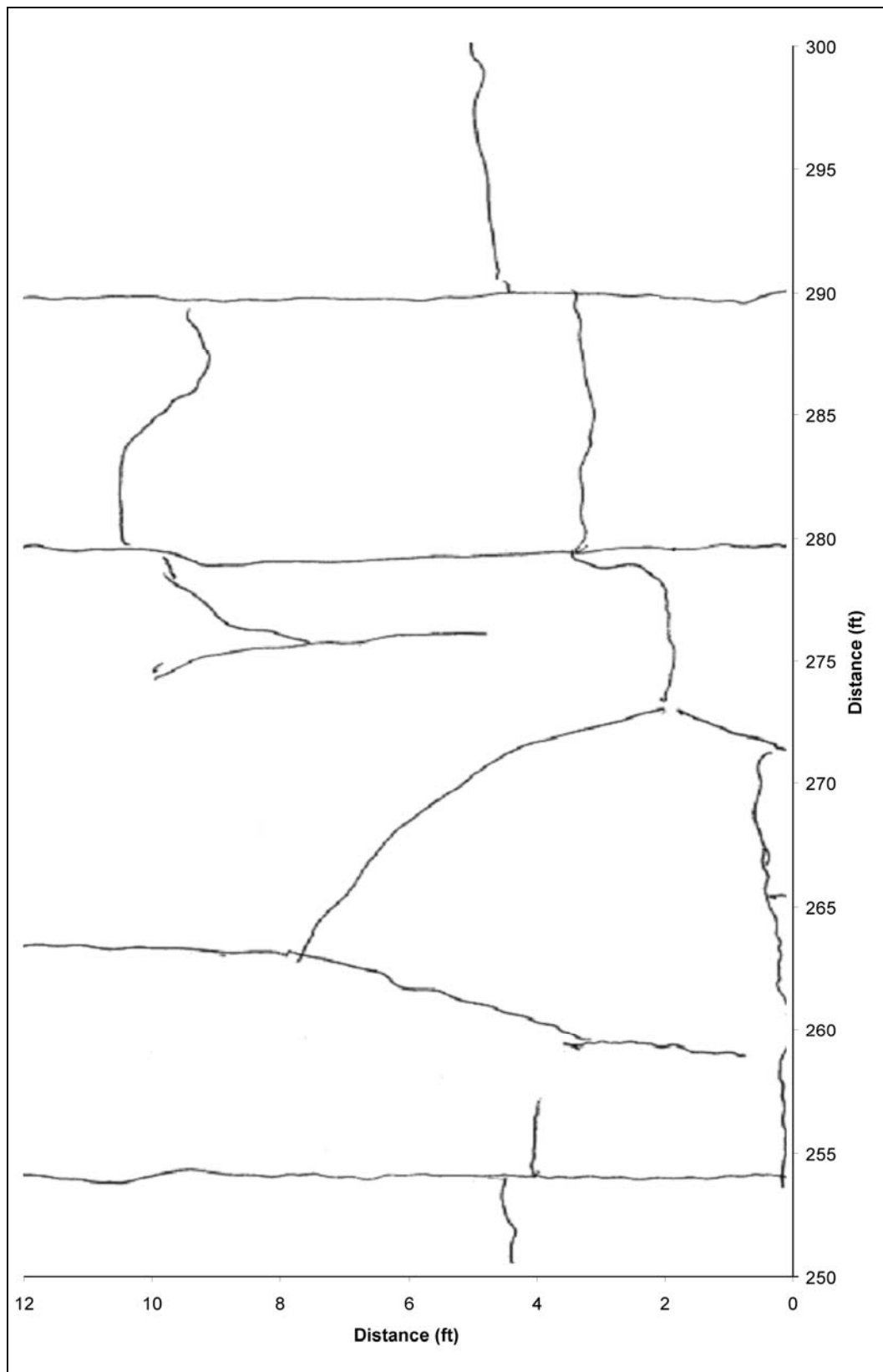


Figure 39. Lawson AAF Section 3 (Station 250-300 ft).

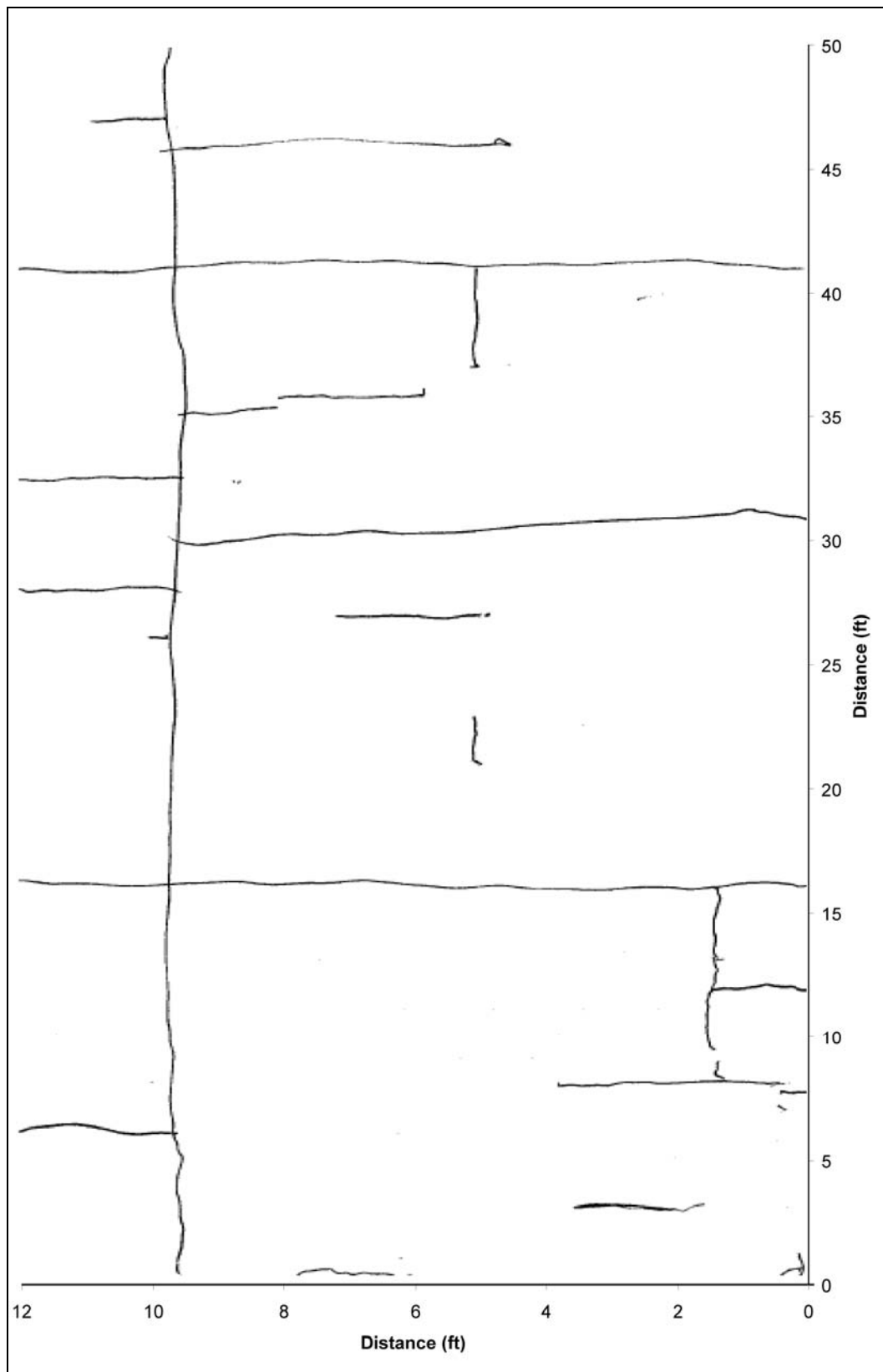


Figure 40. Lawson AAF Section 4 (Station 0-50 ft).

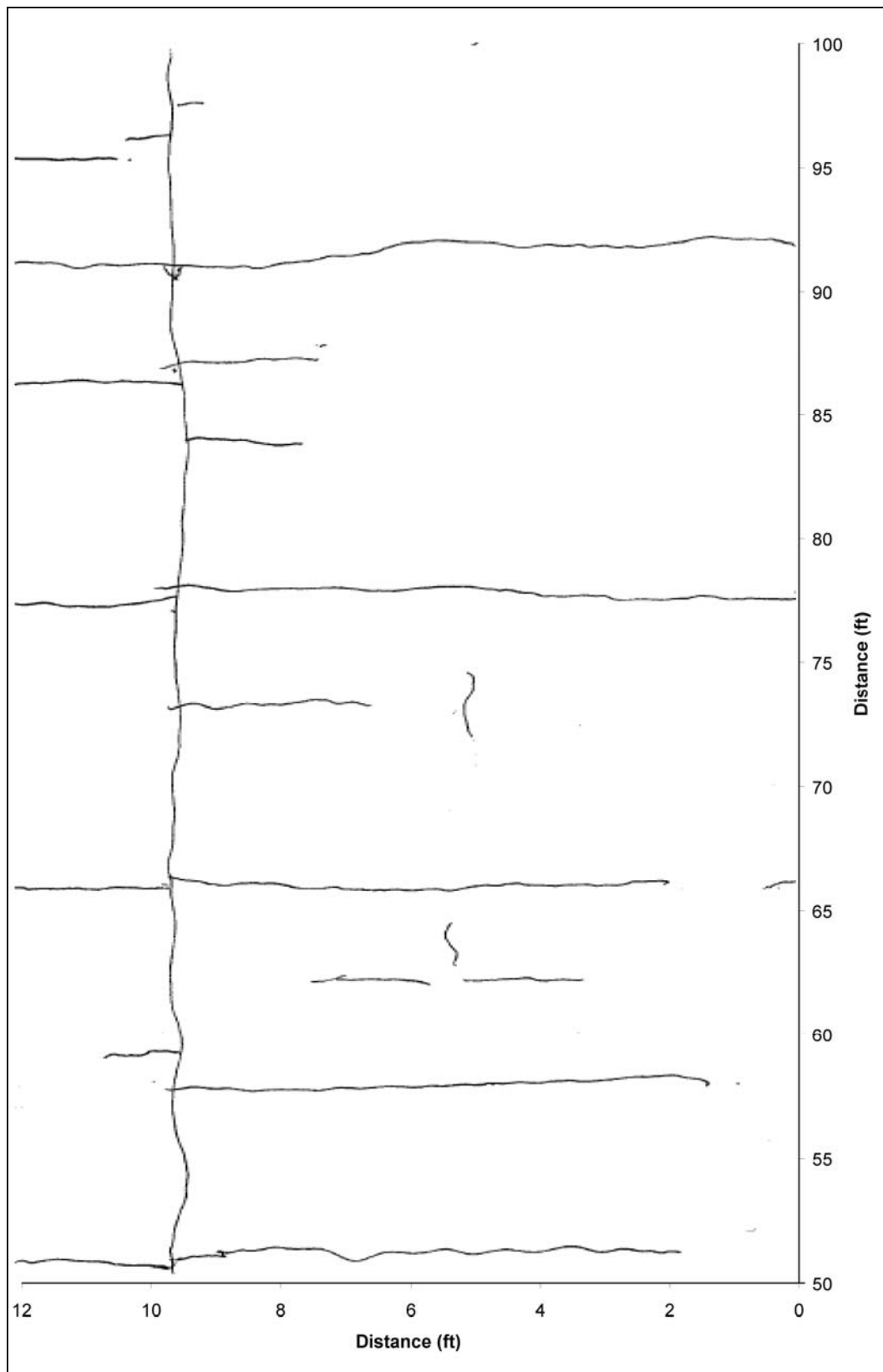


Figure 41. Lawson AAF Section 4 (Station 50-100 ft).

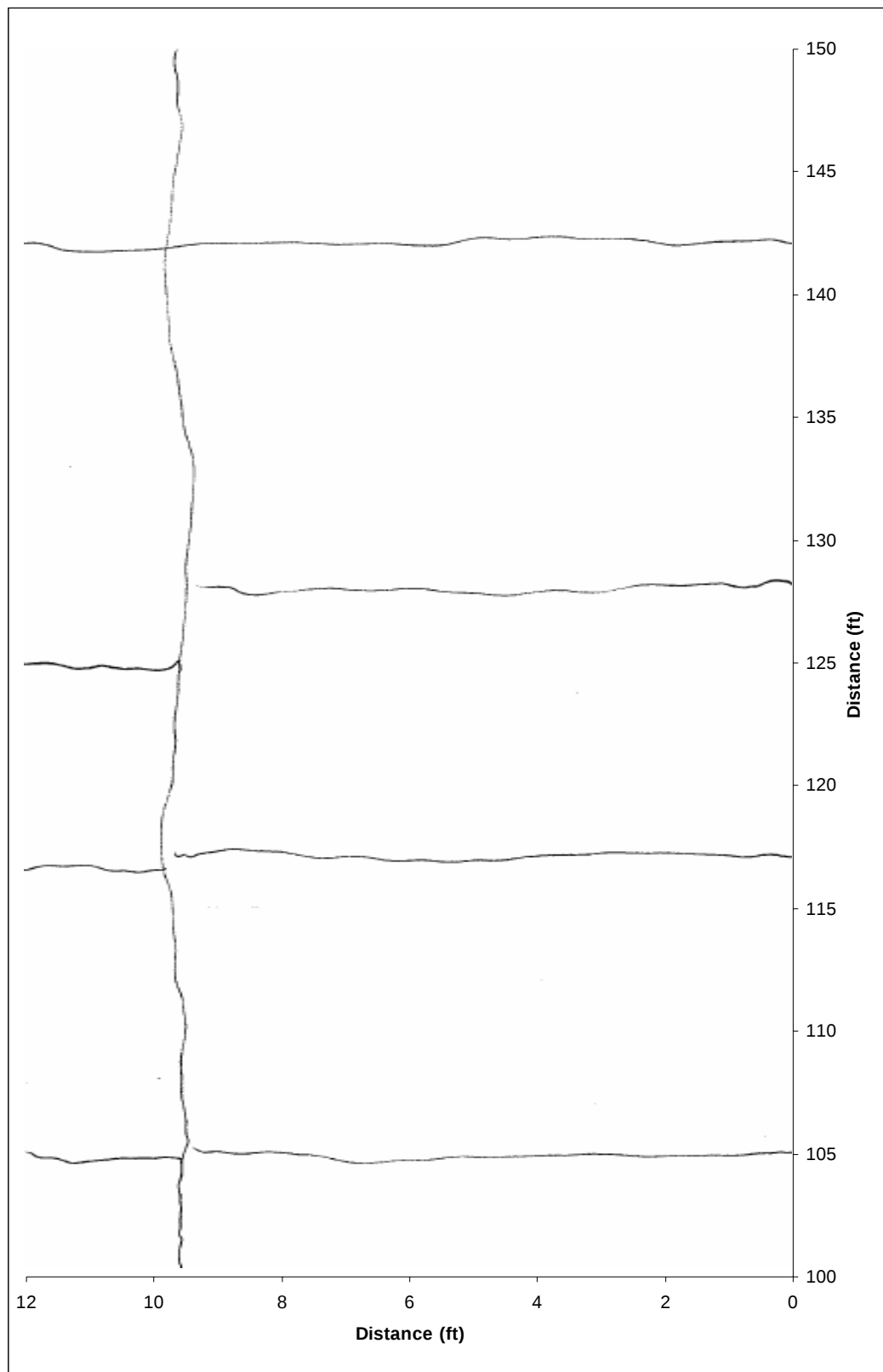


Figure 42. Lawson AAF Section 4 (Station 100-150 ft).

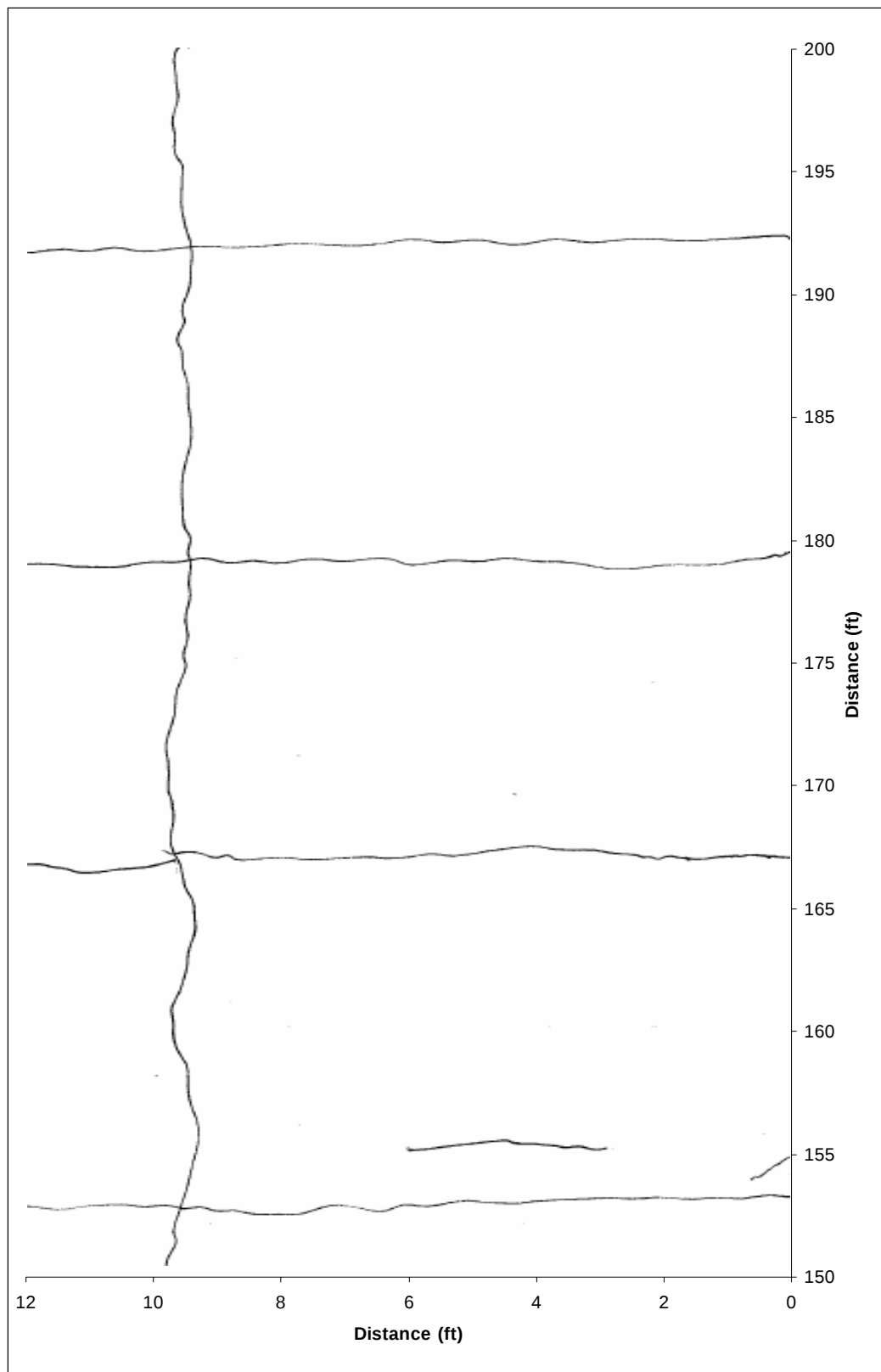


Figure 43. Lawson AAF Section 4 (Station 150-200 ft).

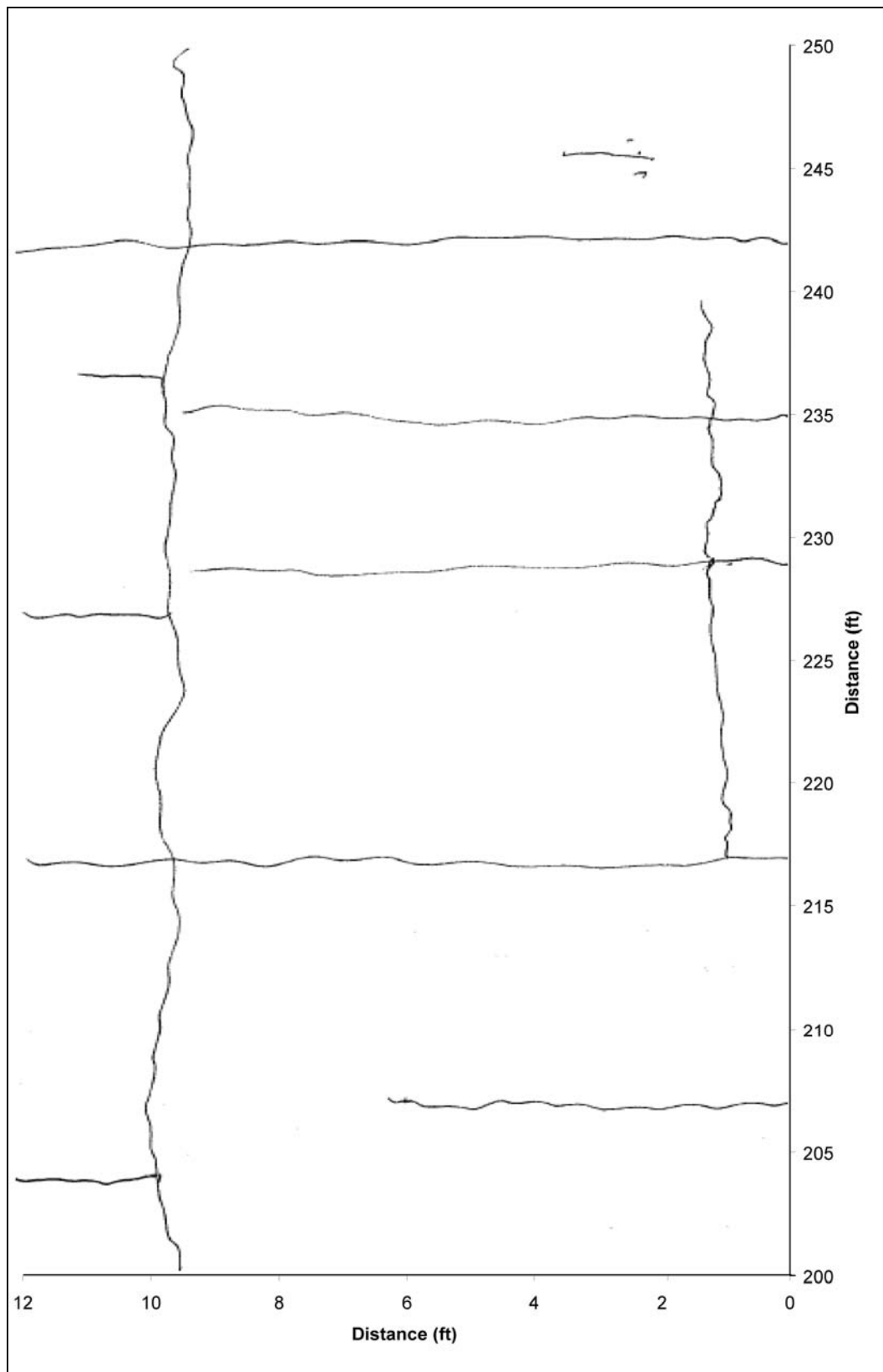


Figure 44. Lawson AAF Section 4 (Station 200-250 ft).

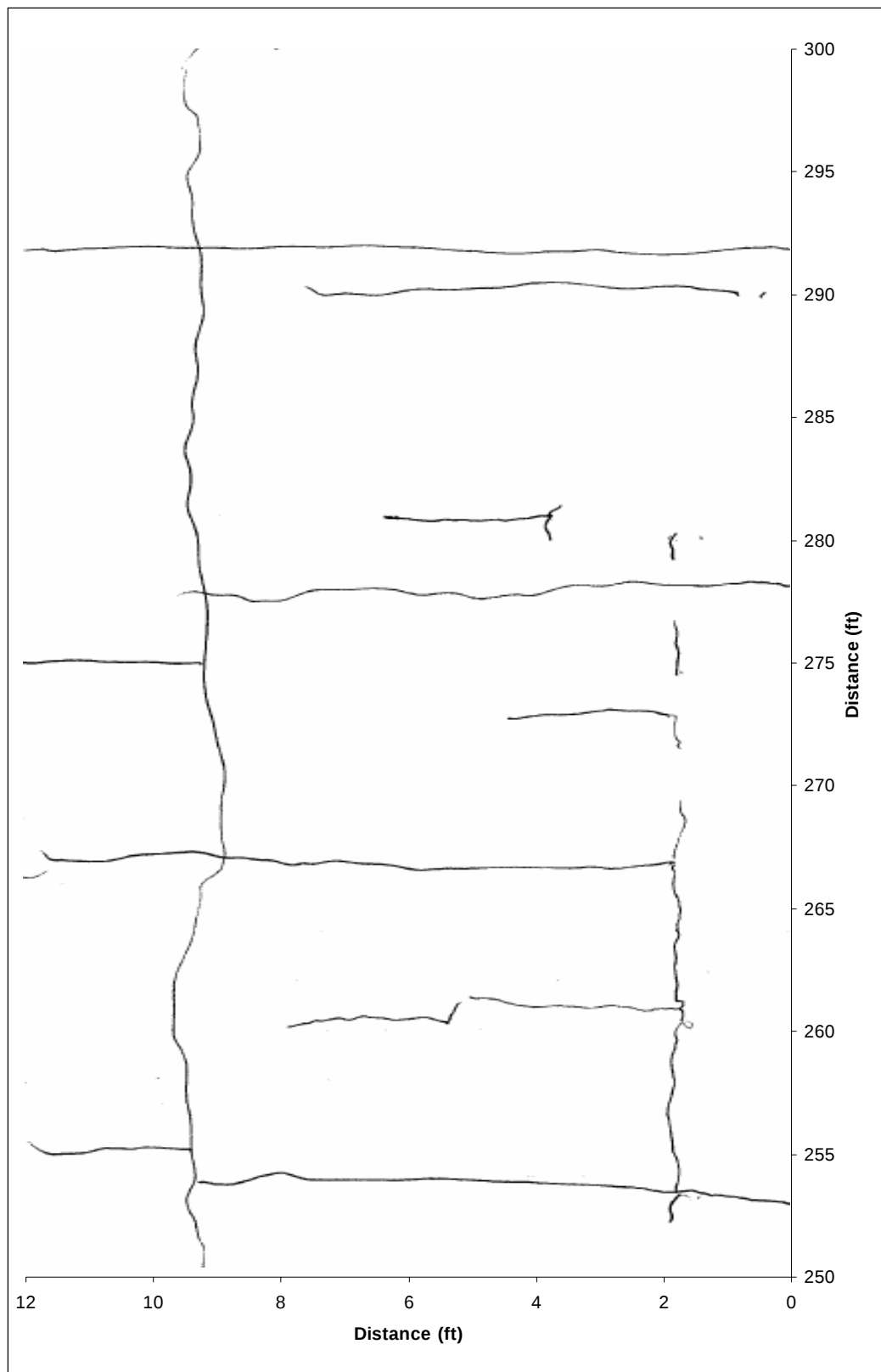


Figure 45. Lawson AAF Section 4 (Station 250-300 ft).

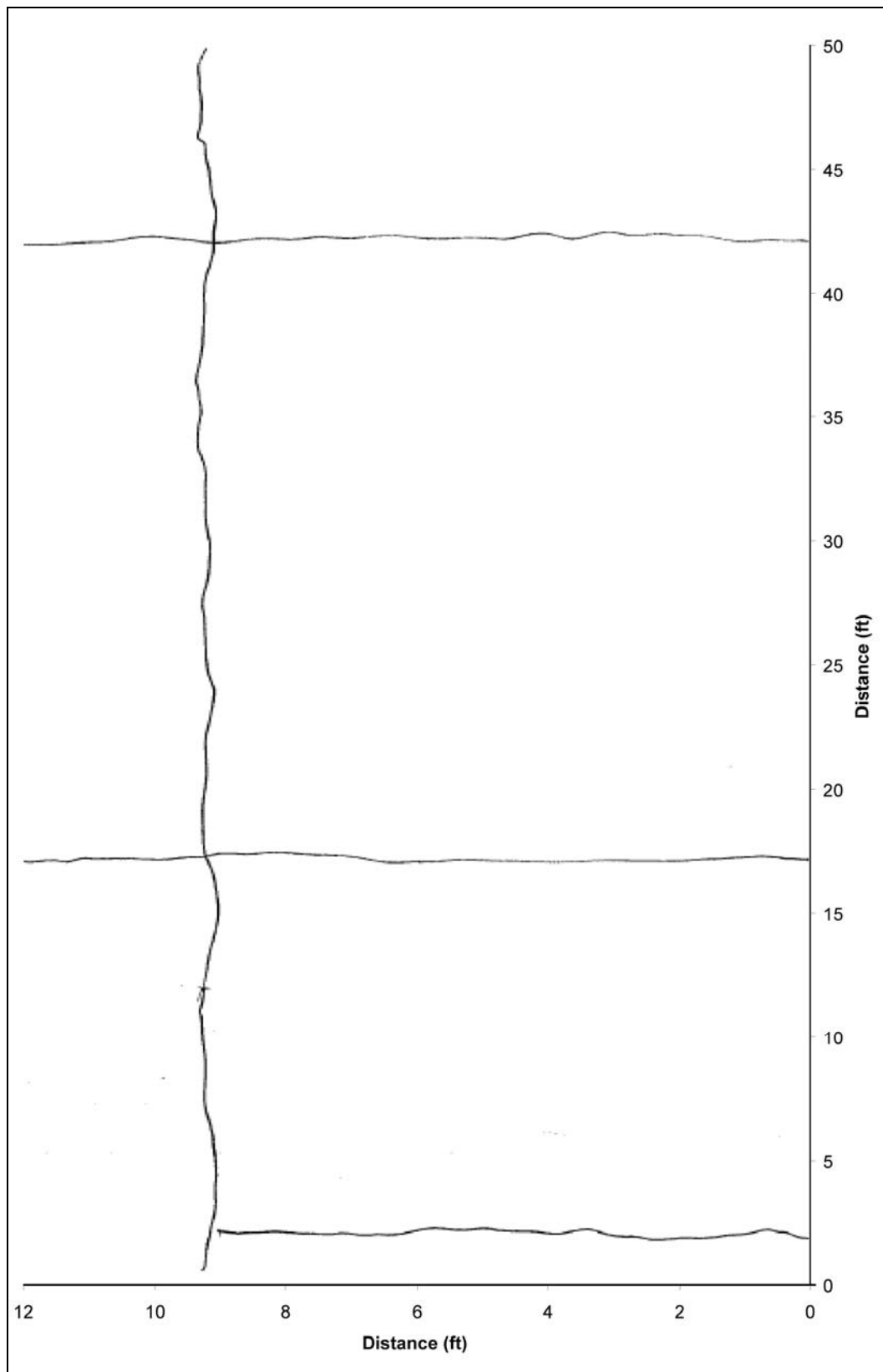


Figure 46. Lawson AAF Section 5 (Station 0-50 ft).

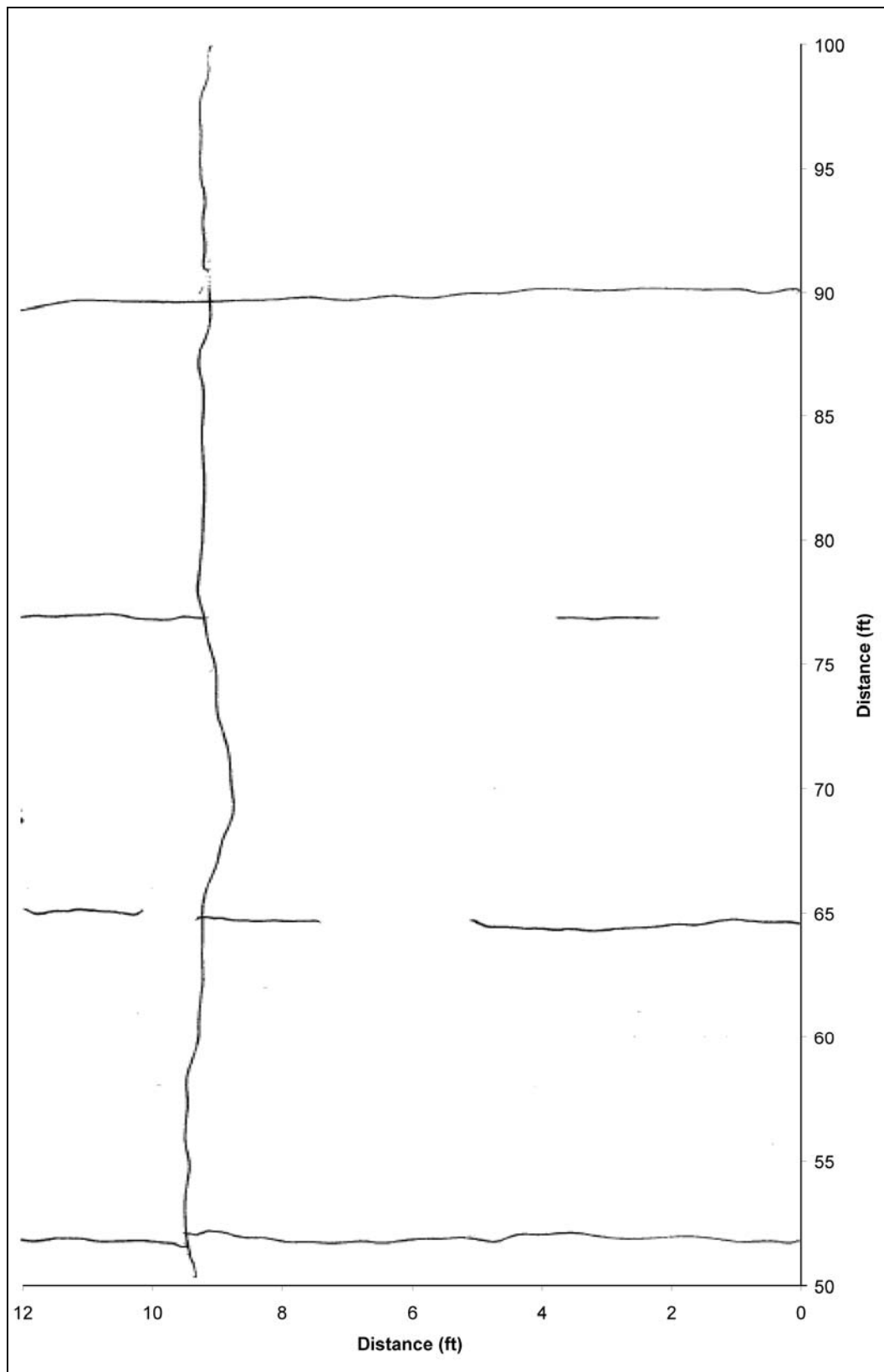


Figure 47. Lawson AAF Section 5 (Station 50-100 ft).

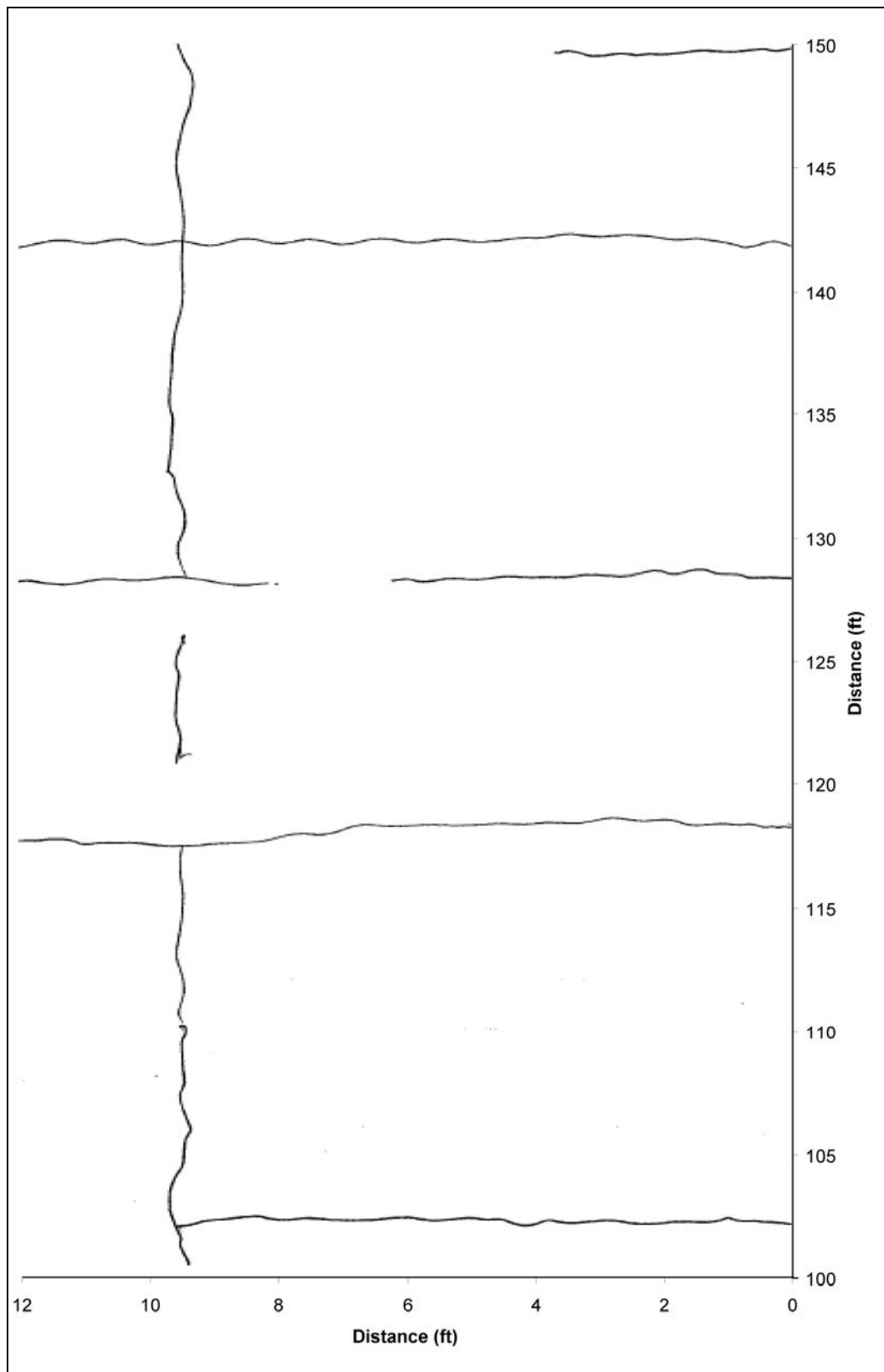


Figure 48. Lawson AAF Section 5 (Station 100-150 ft).

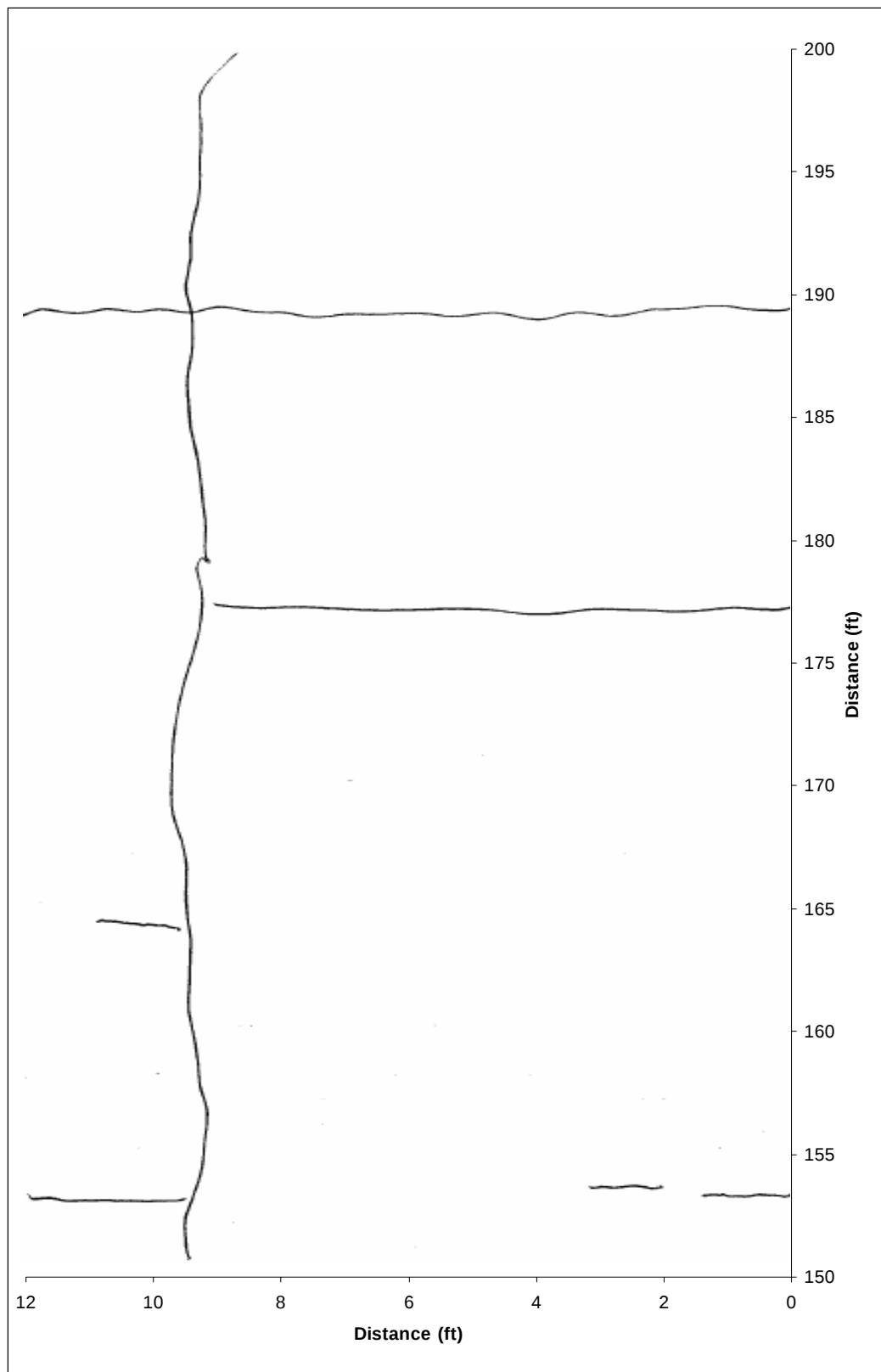


Figure 49. Lawson AAF Section 5 (Station 150-200 ft).

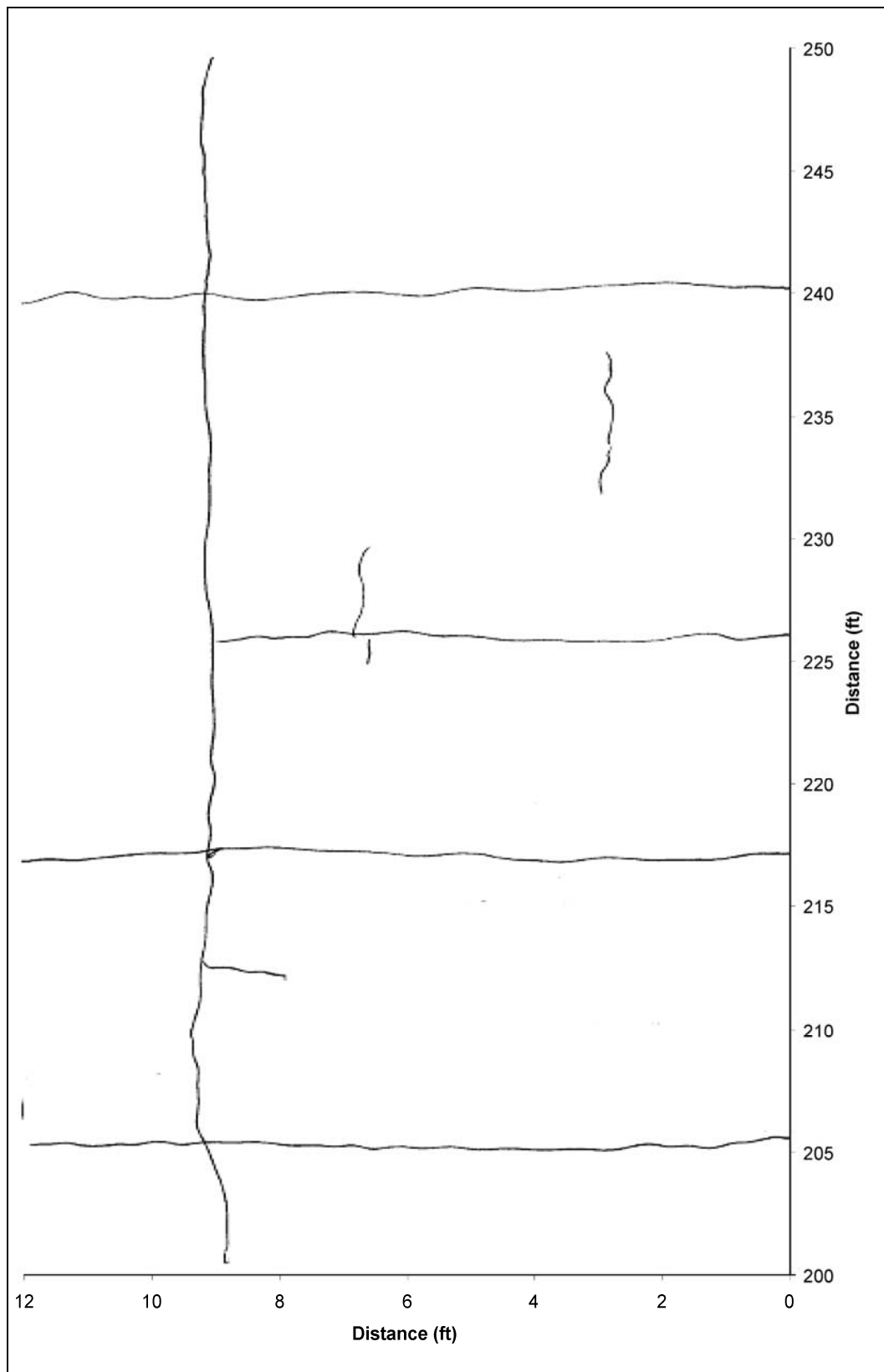


Figure 50. Lawson AAF Section 5 (Station 200-250 ft).

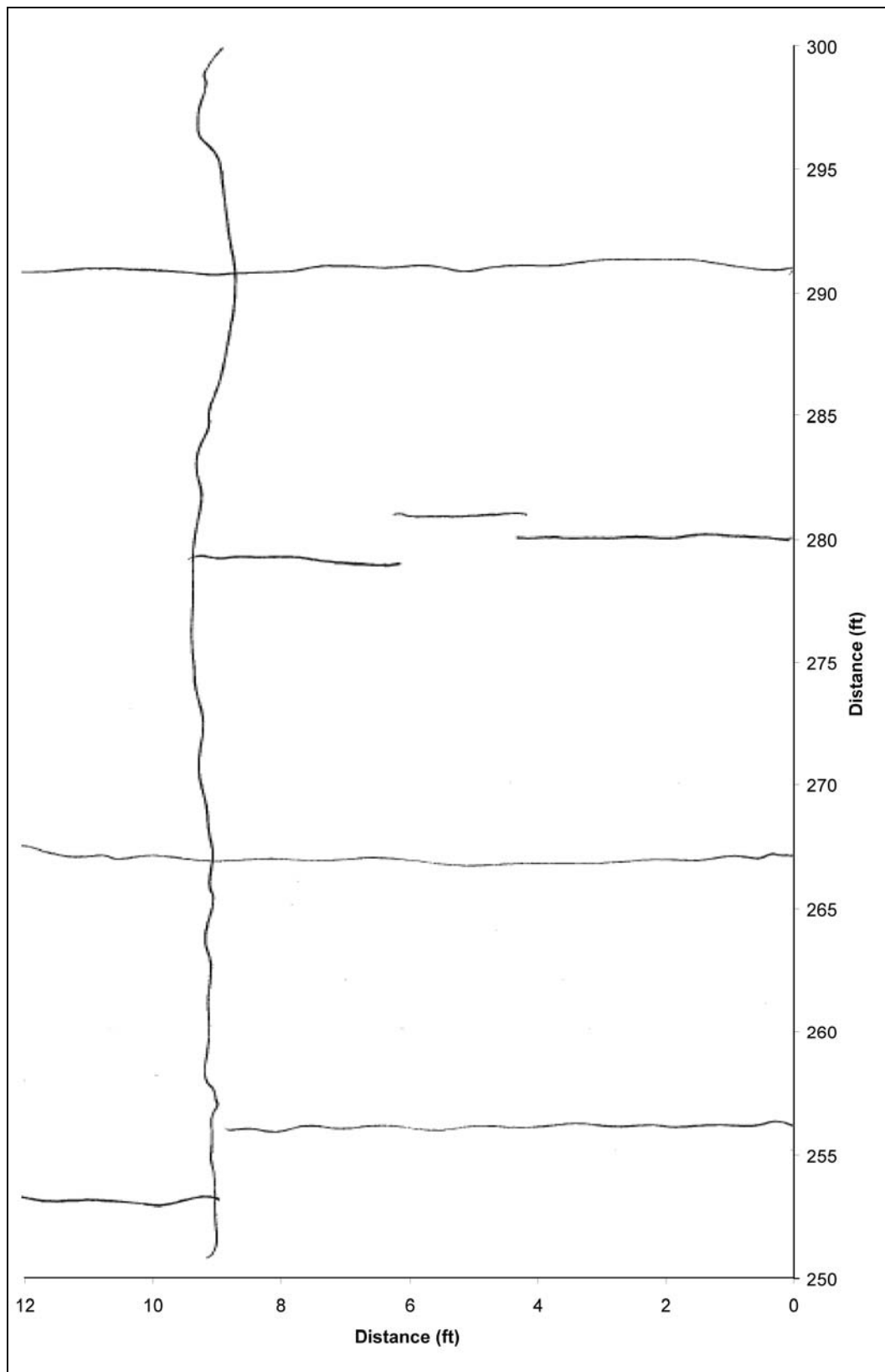
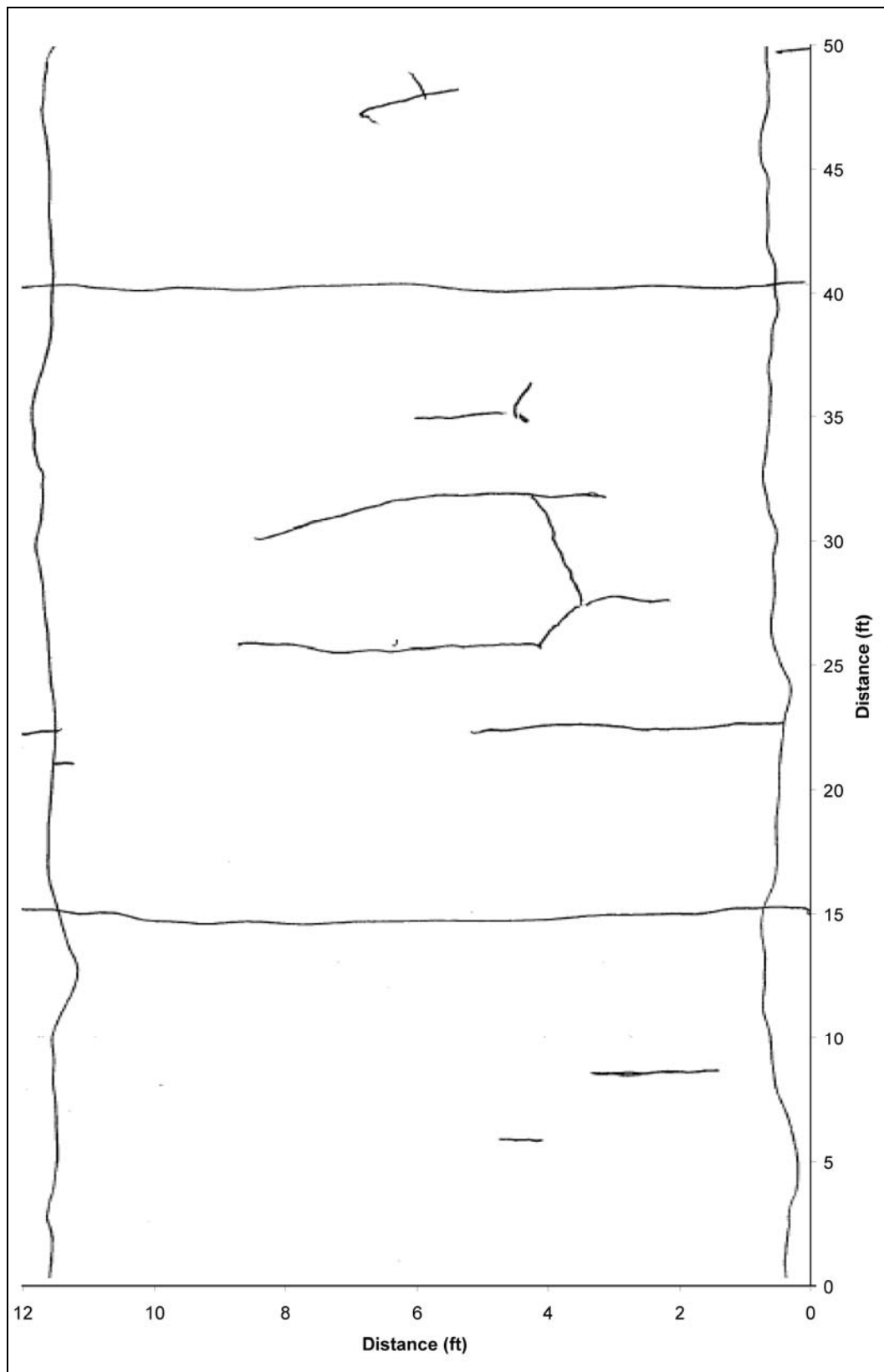


Figure 51. Lawson AAF Section 5 (Station 250-300 ft).



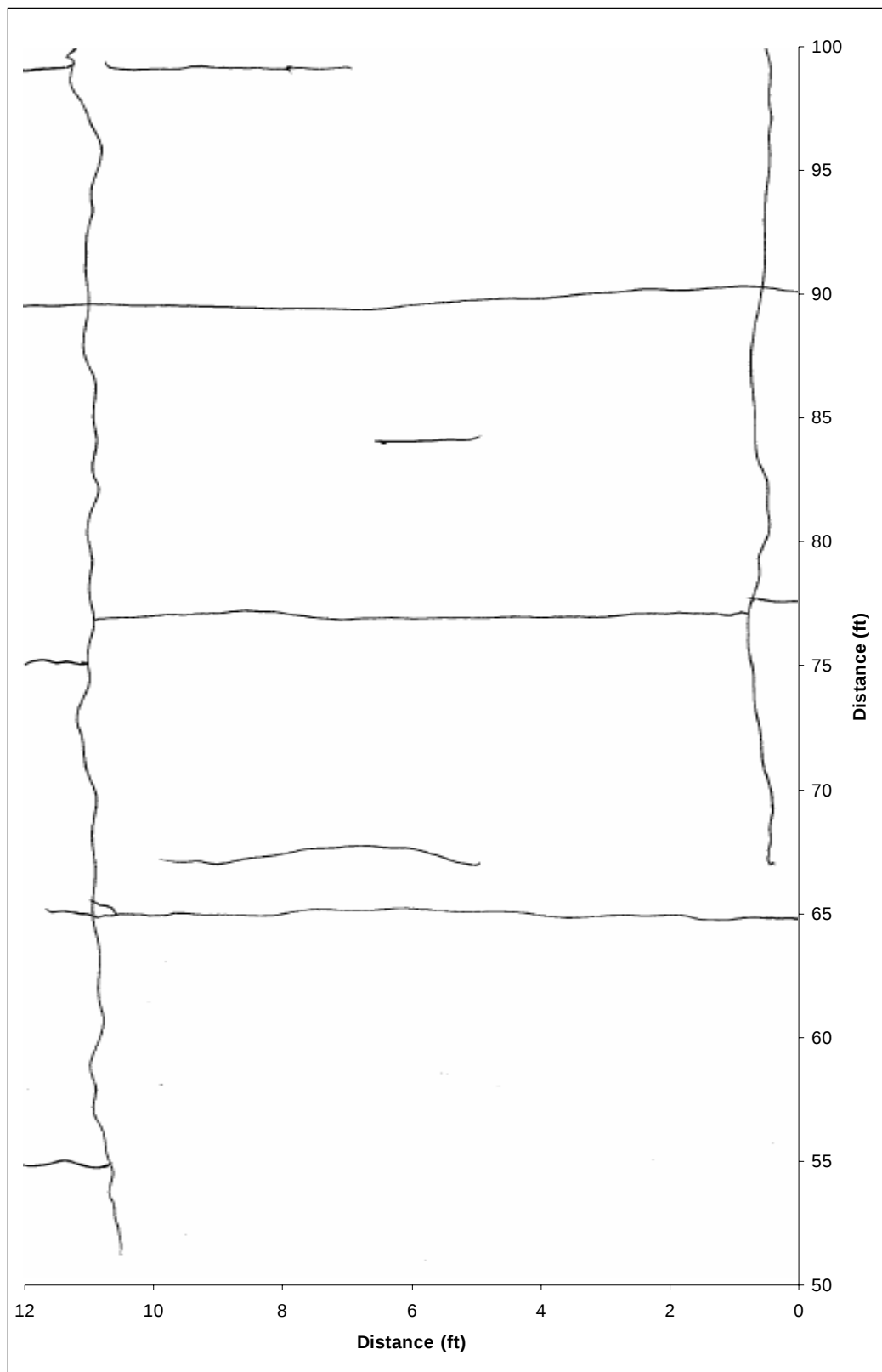


Figure 53. Lawson AAF Section 6 (Station 50-100 ft).

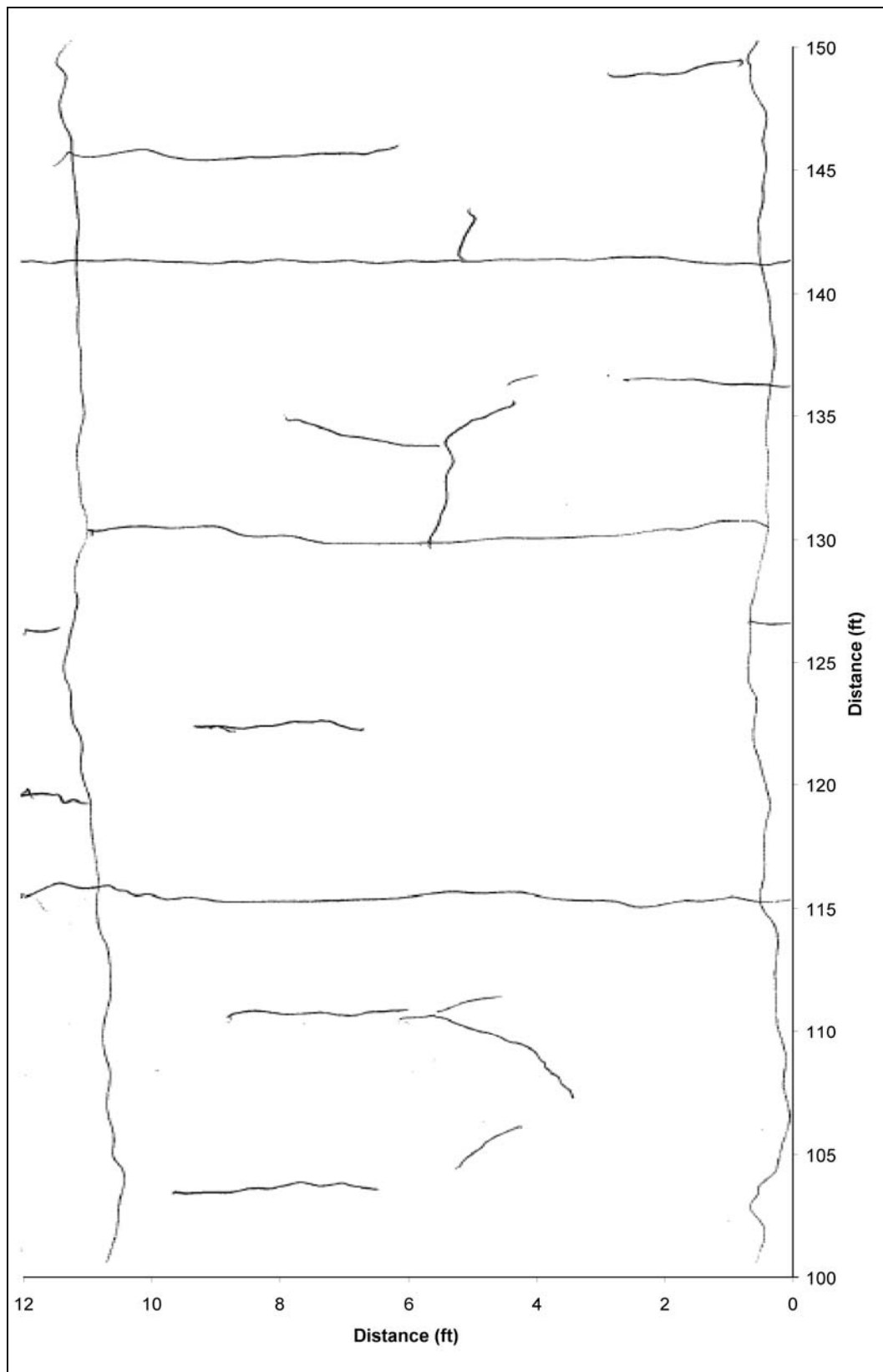


Figure 54. Lawson AAF Section 6 (Station 100-150 ft).

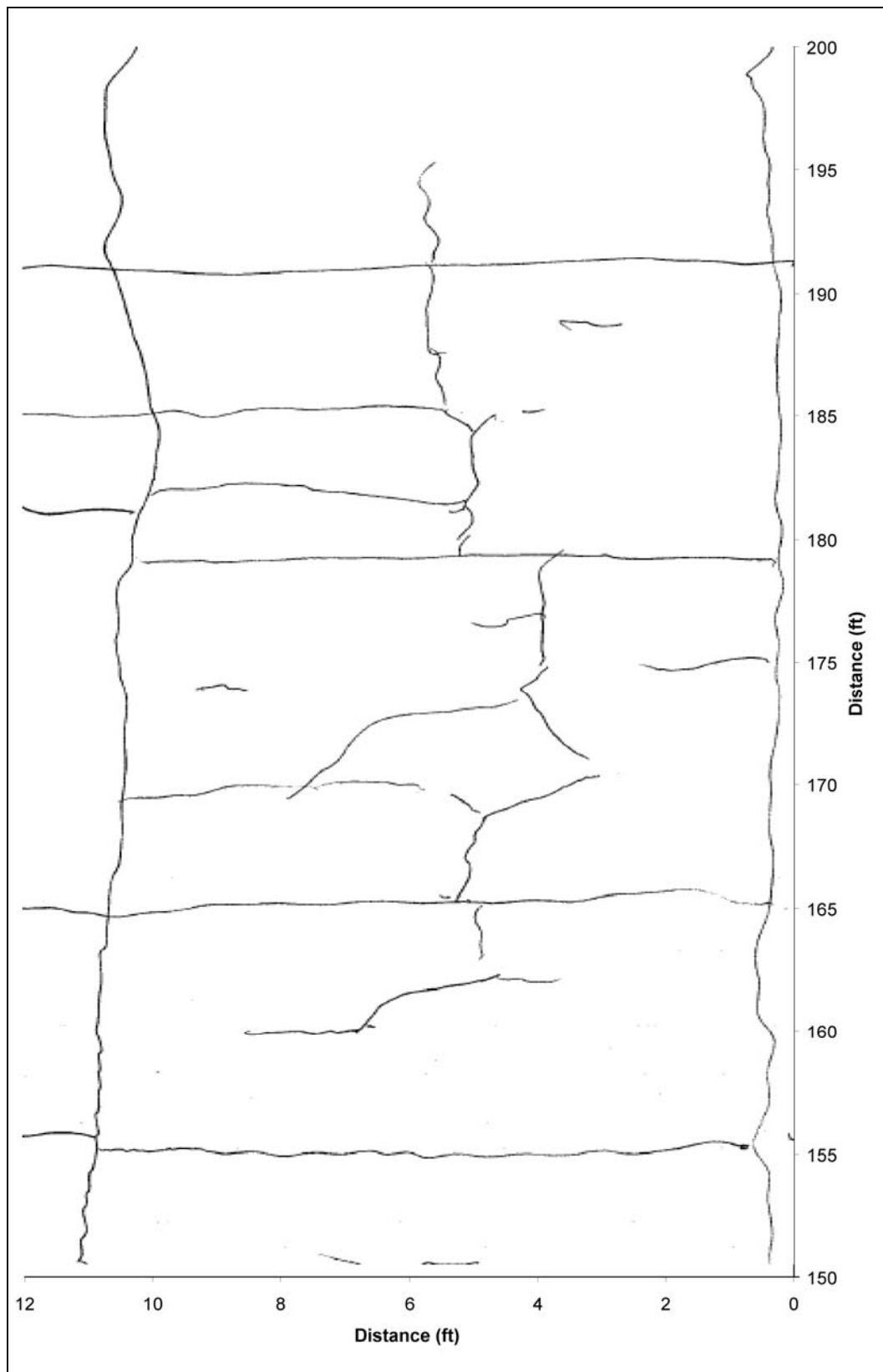


Figure 55. Lawson AAF Section 6 (Station 150-200 ft).

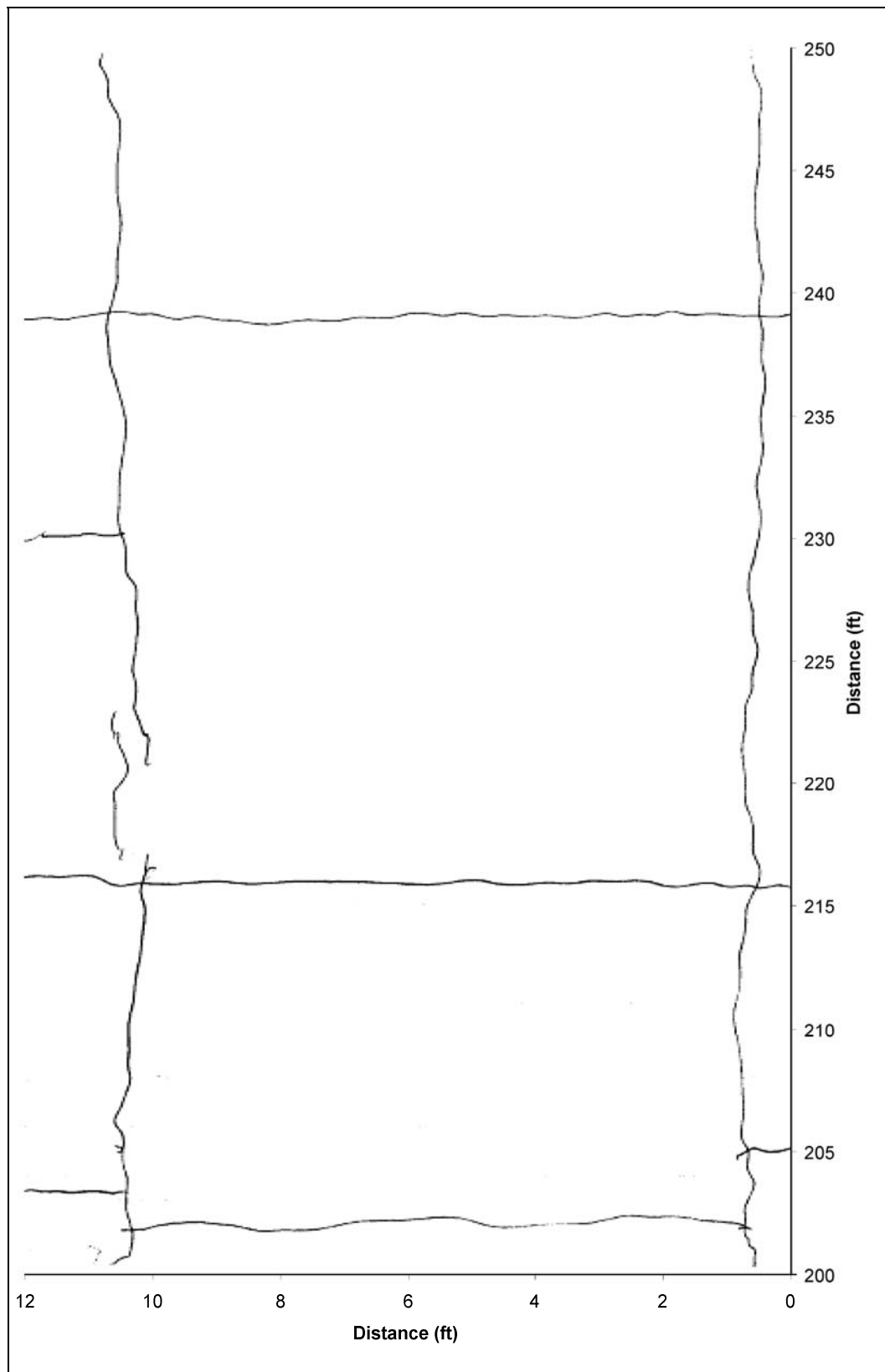


Figure 56. Lawson AAF Section 6 (Station 200-250 ft).

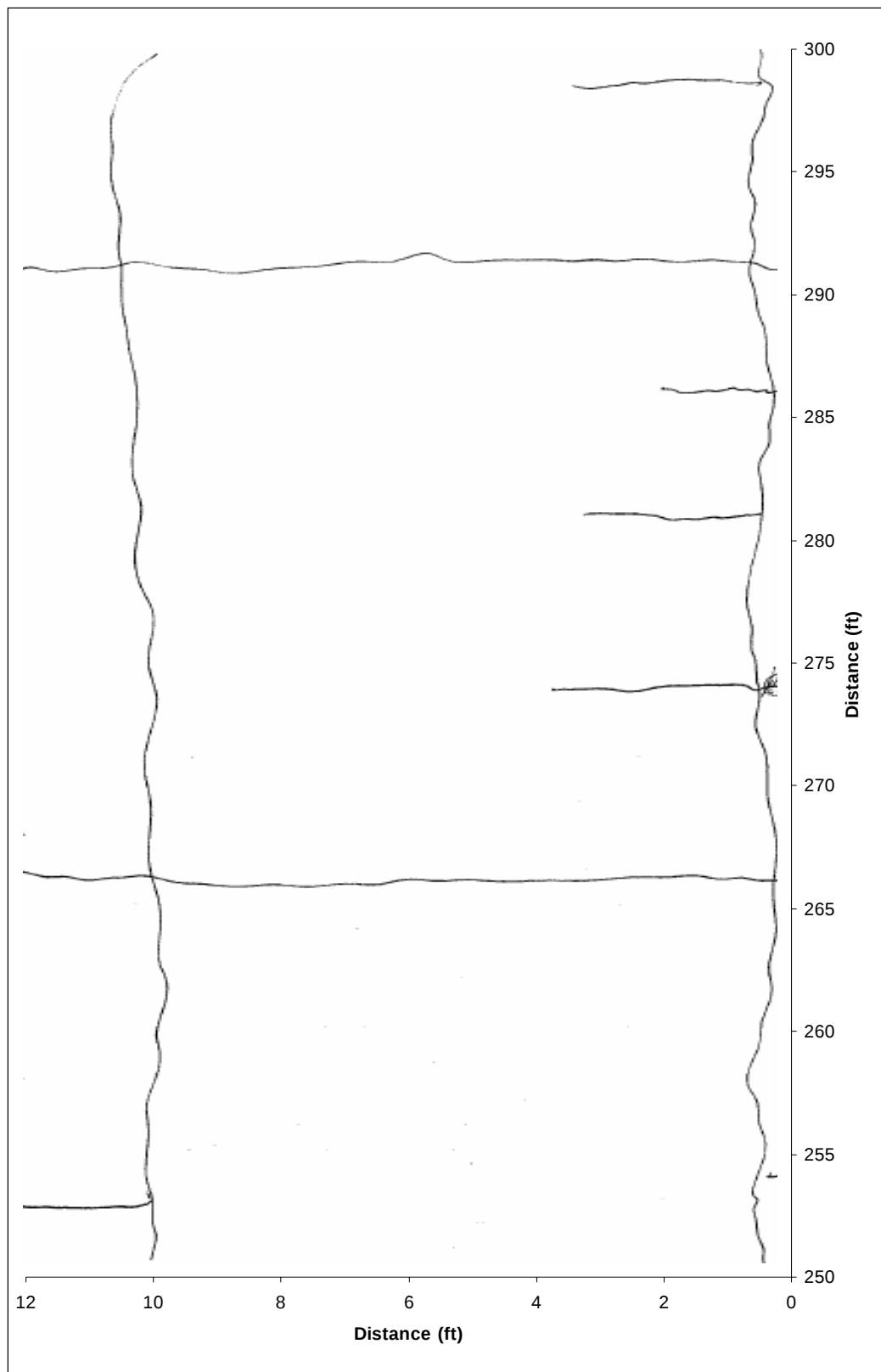


Figure 57. Lawson AAF Section 6 (Station 250-300 ft).

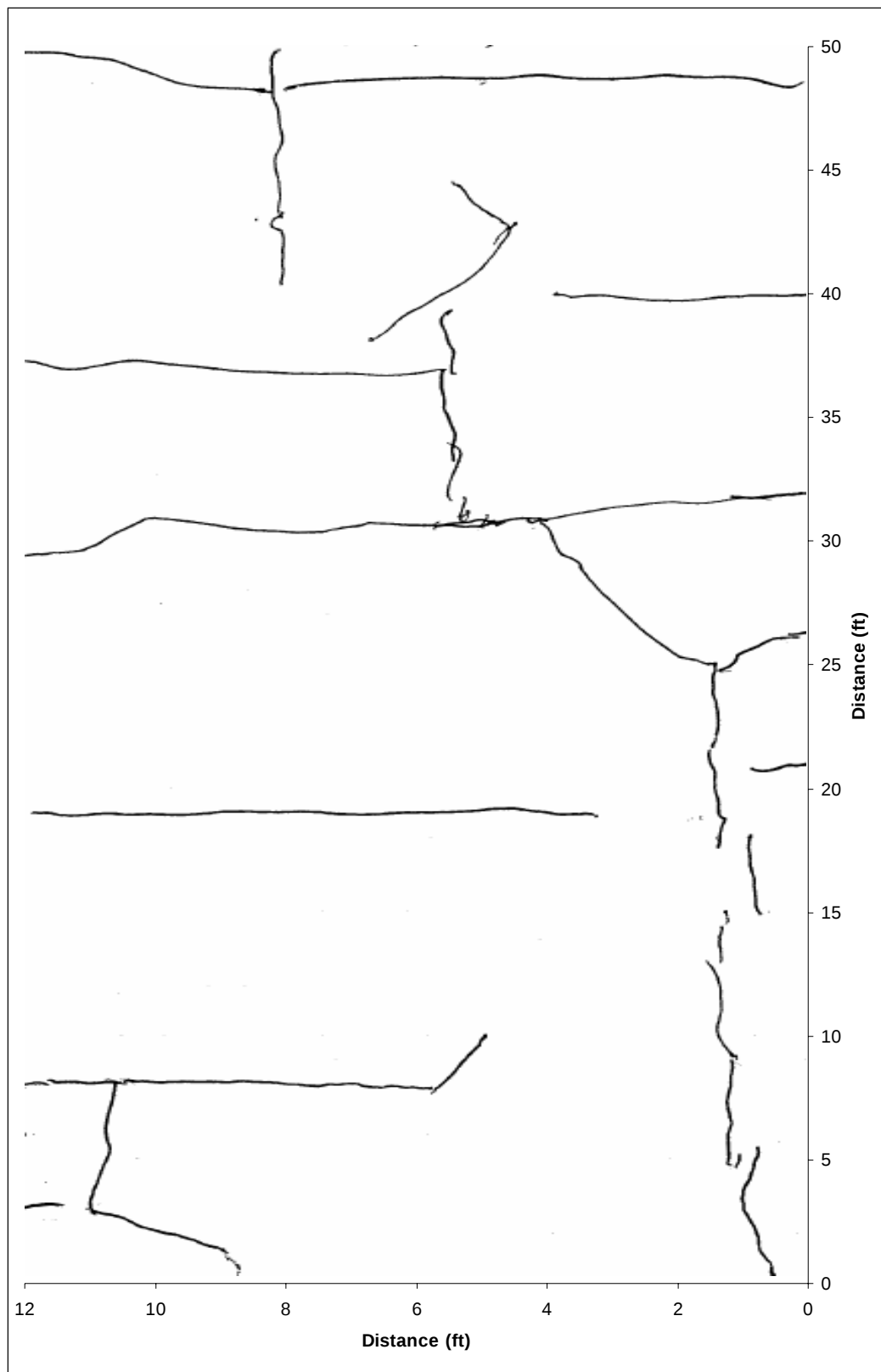


Figure 58. Lawson AAF Section 7 (Station 0-50 ft).

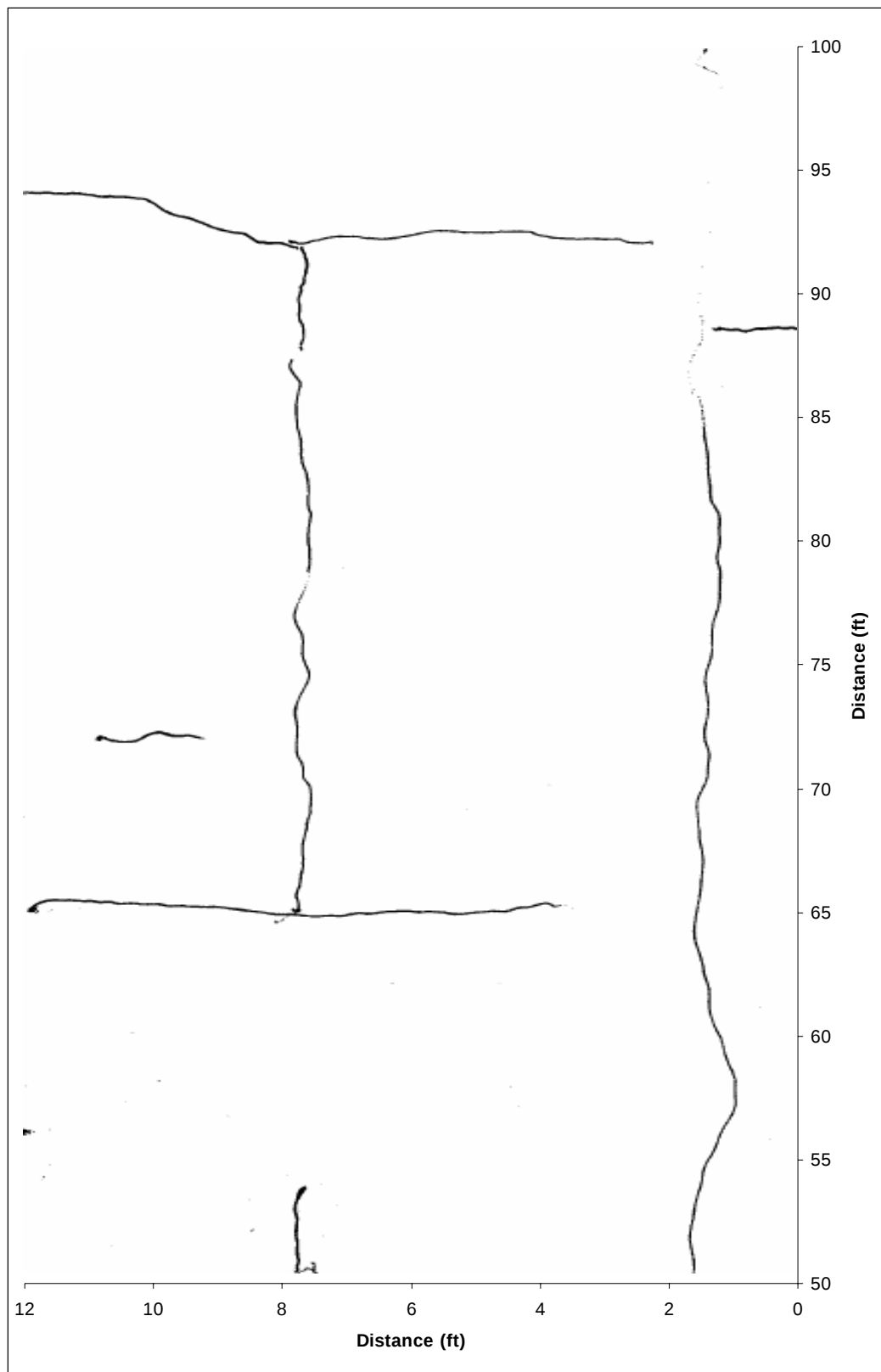


Figure 59. Lawson AAF Section 7 (Station 50-100 ft).

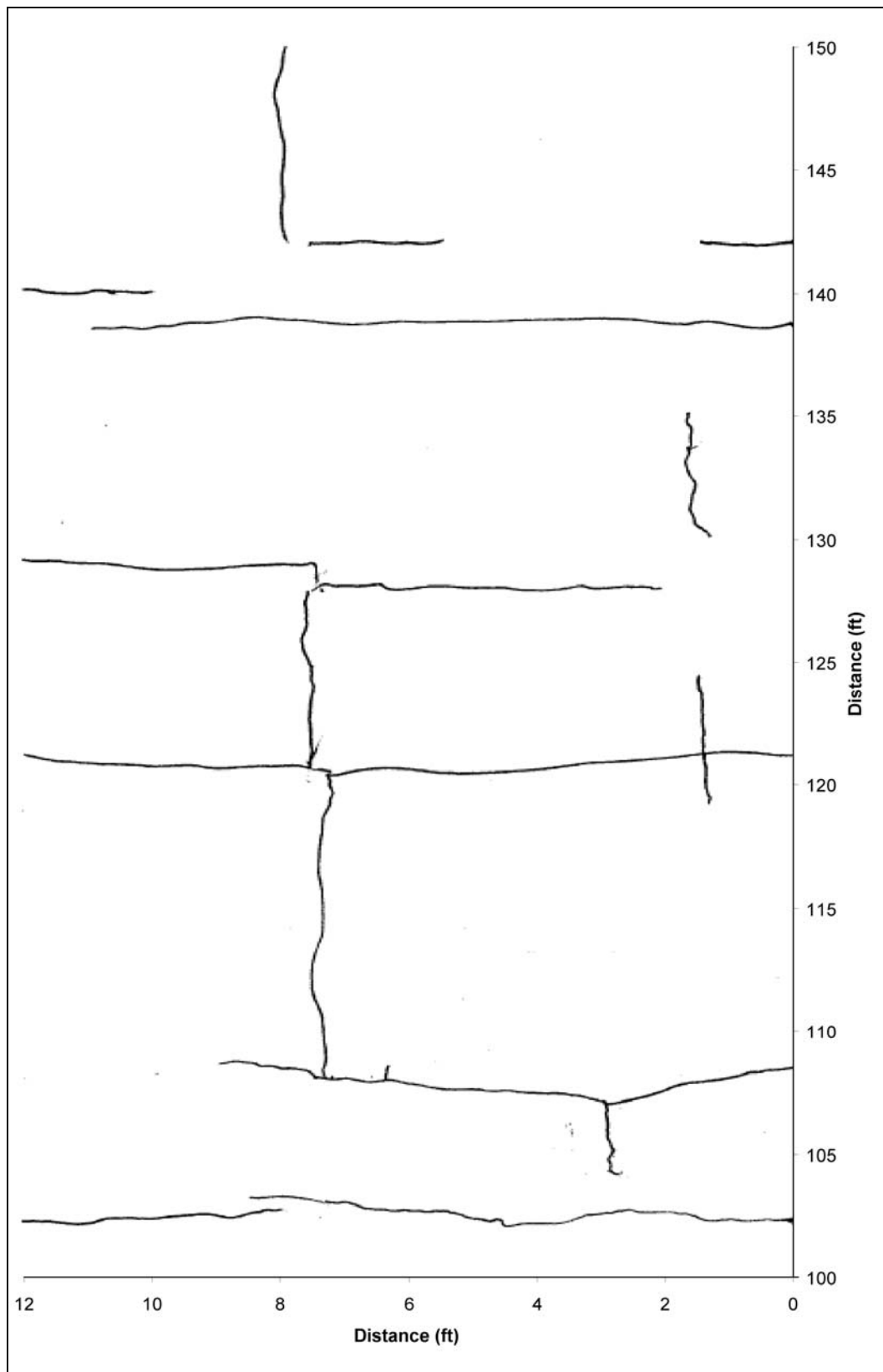


Figure 60. Lawson AAF Section 7 (Station 100-150 ft).

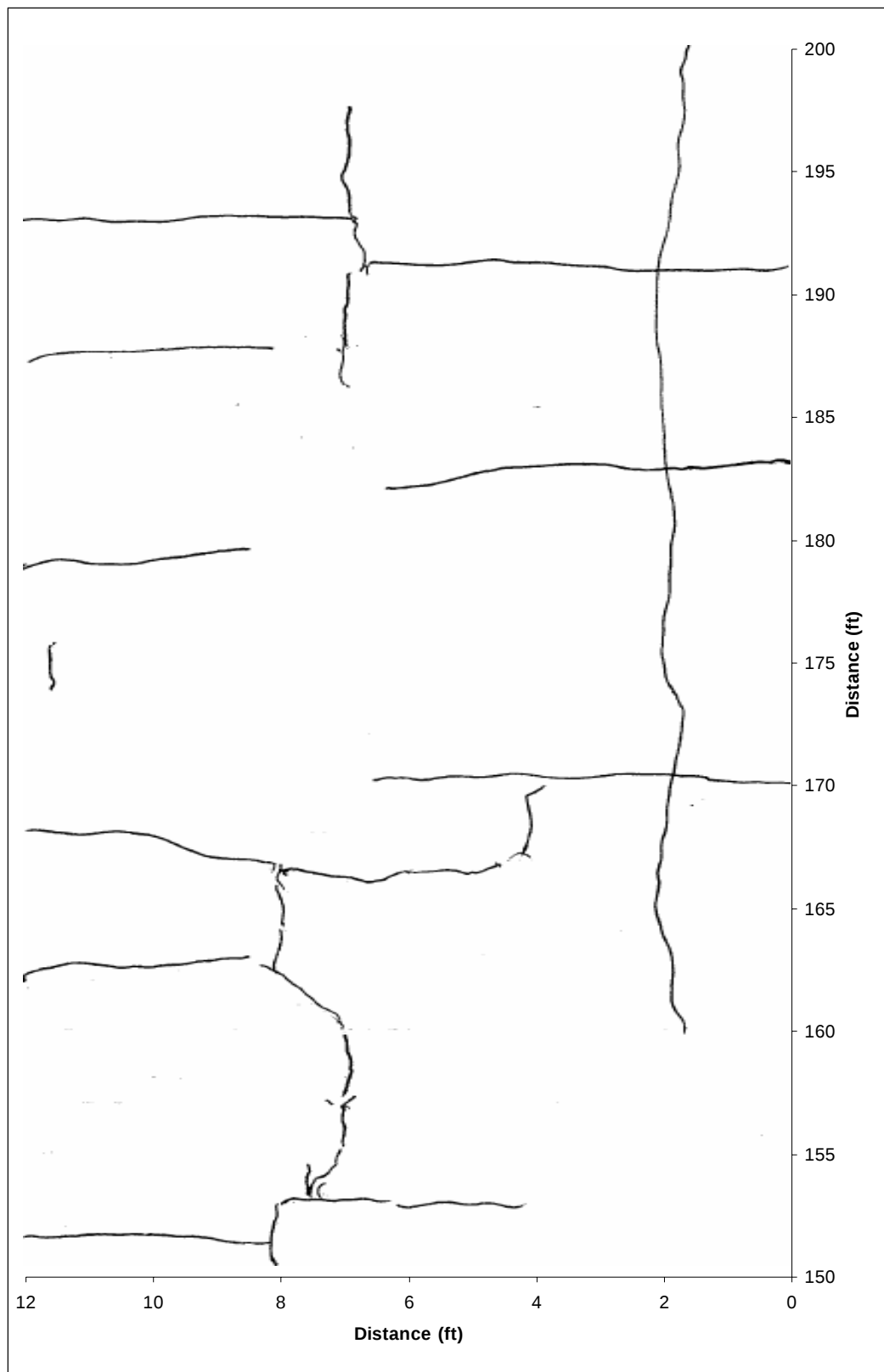


Figure 61. Lawson AAF Section 7 (Station 150-200 ft).

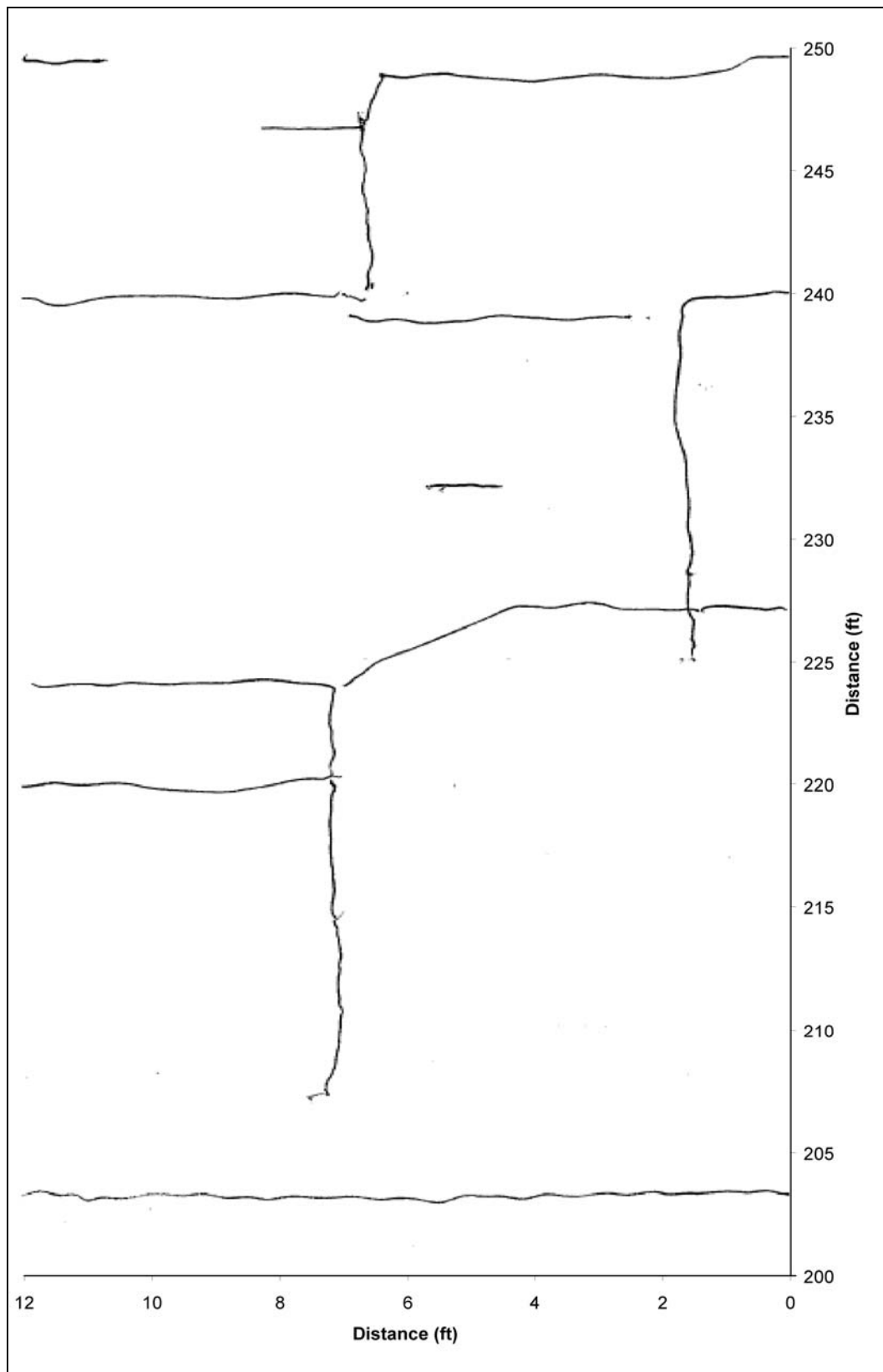


Figure 62. Lawson AAF Section 7 (Station 200-250 ft).

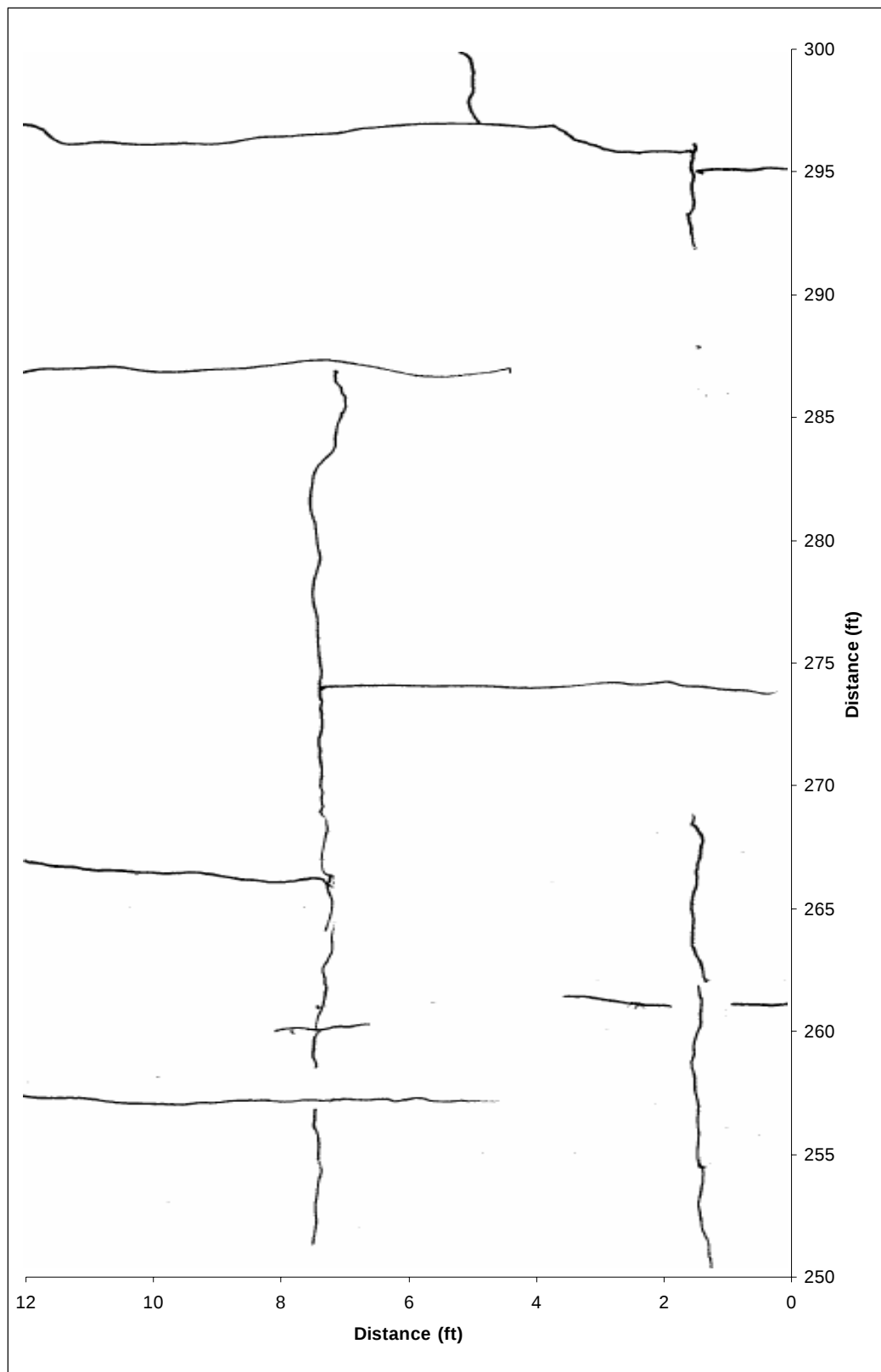


Figure 63. Lawson AAF Section 7 (Station 250-300 ft).

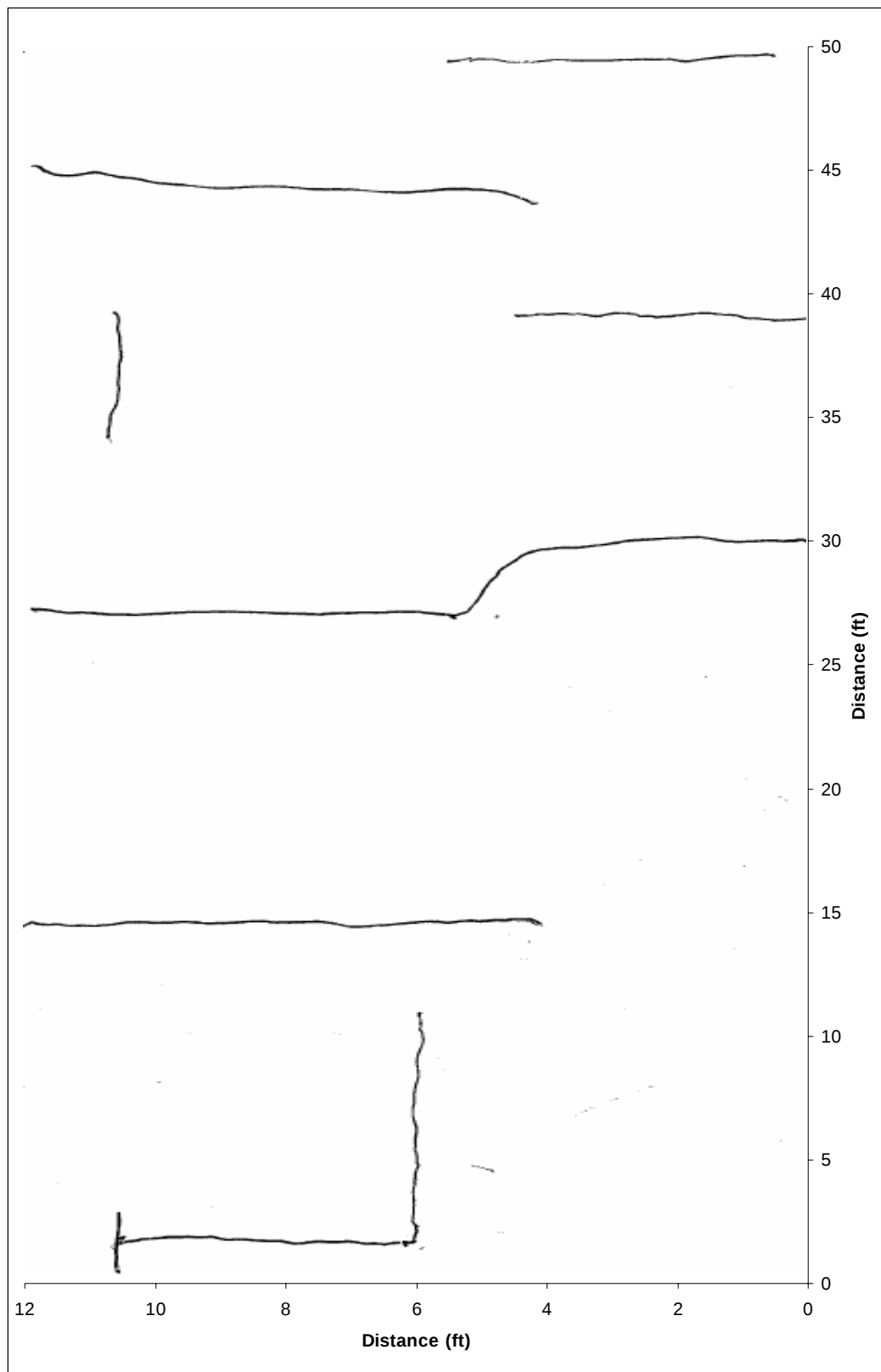


Figure 64. Lawson AAF Section 8 (Station 0-50 ft).

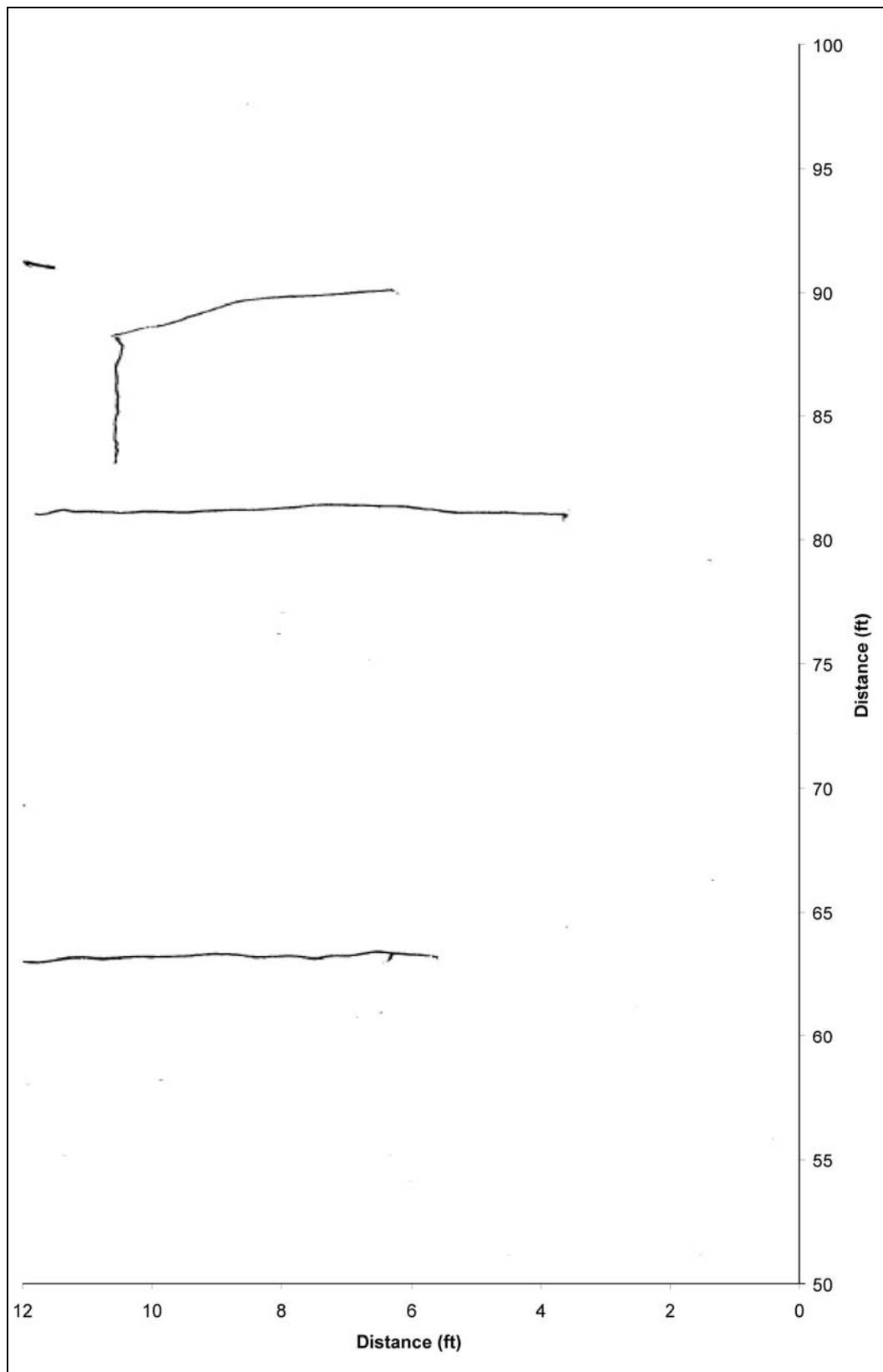


Figure 65. Lawson AAF Section 8 (Station 50-100 ft).

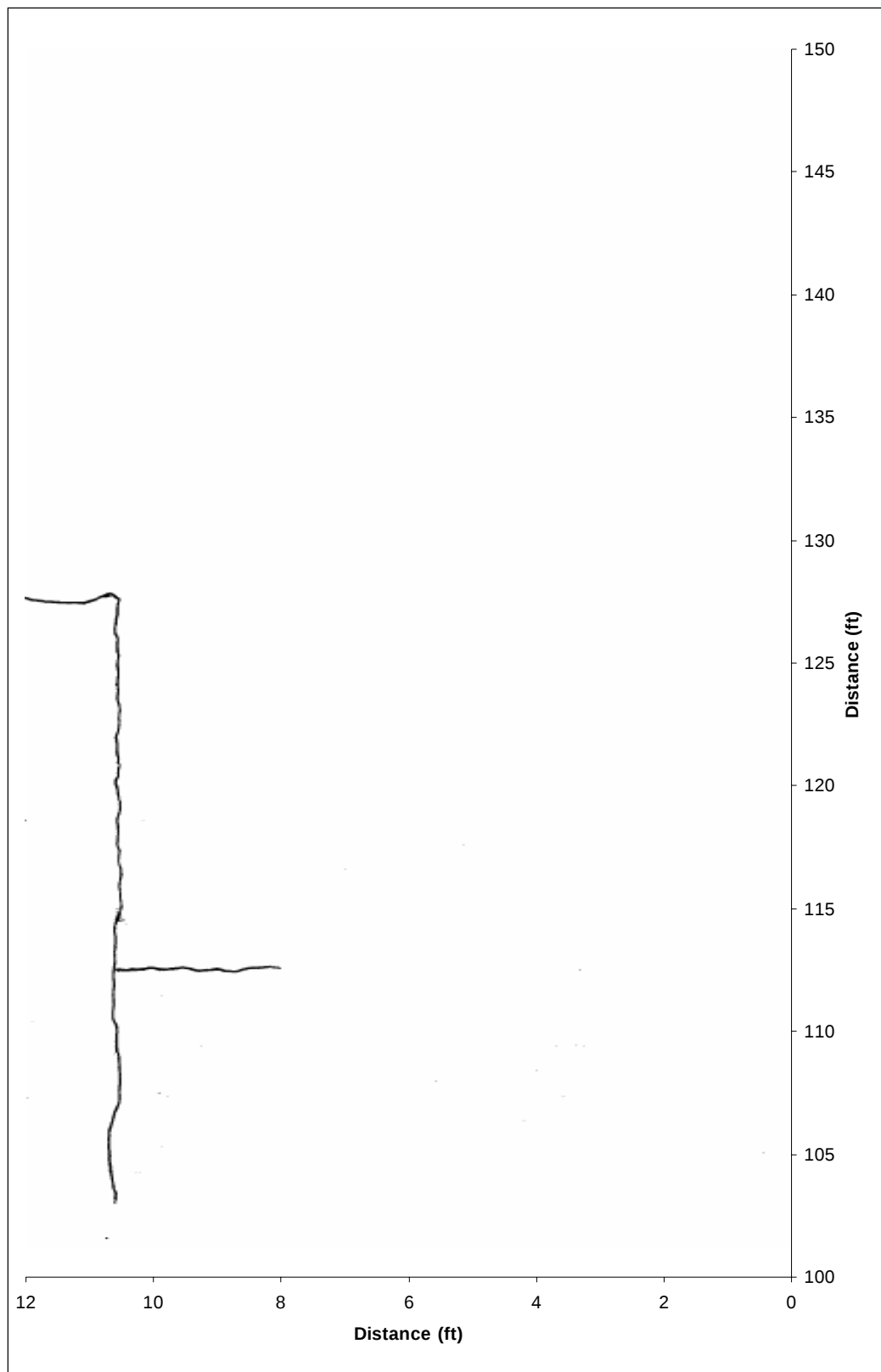


Figure 66. Lawson AAF Section 8 (Station 100-150 ft).

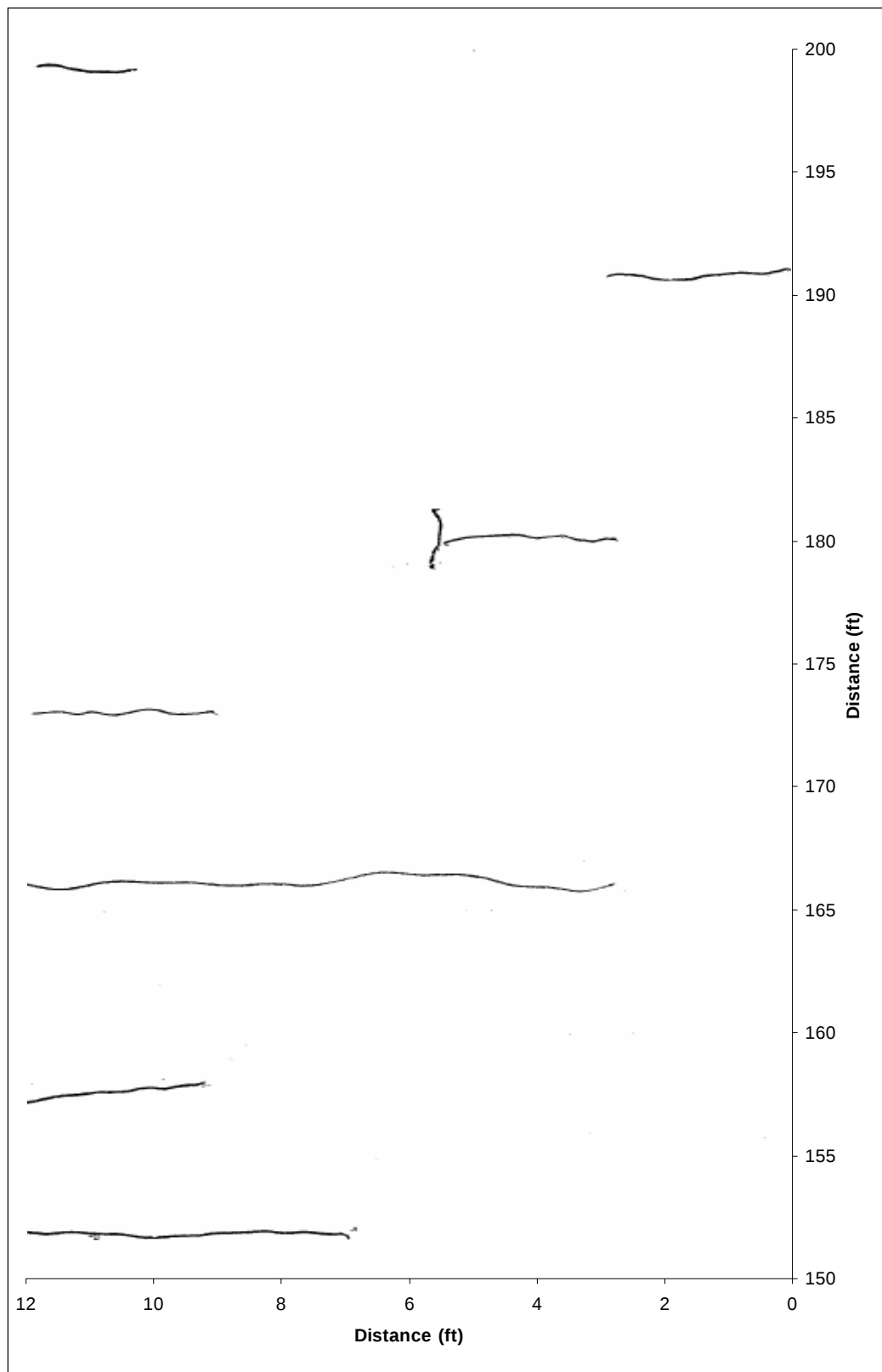


Figure 67. Lawson AAF Section 8 (Station 150-200 ft).

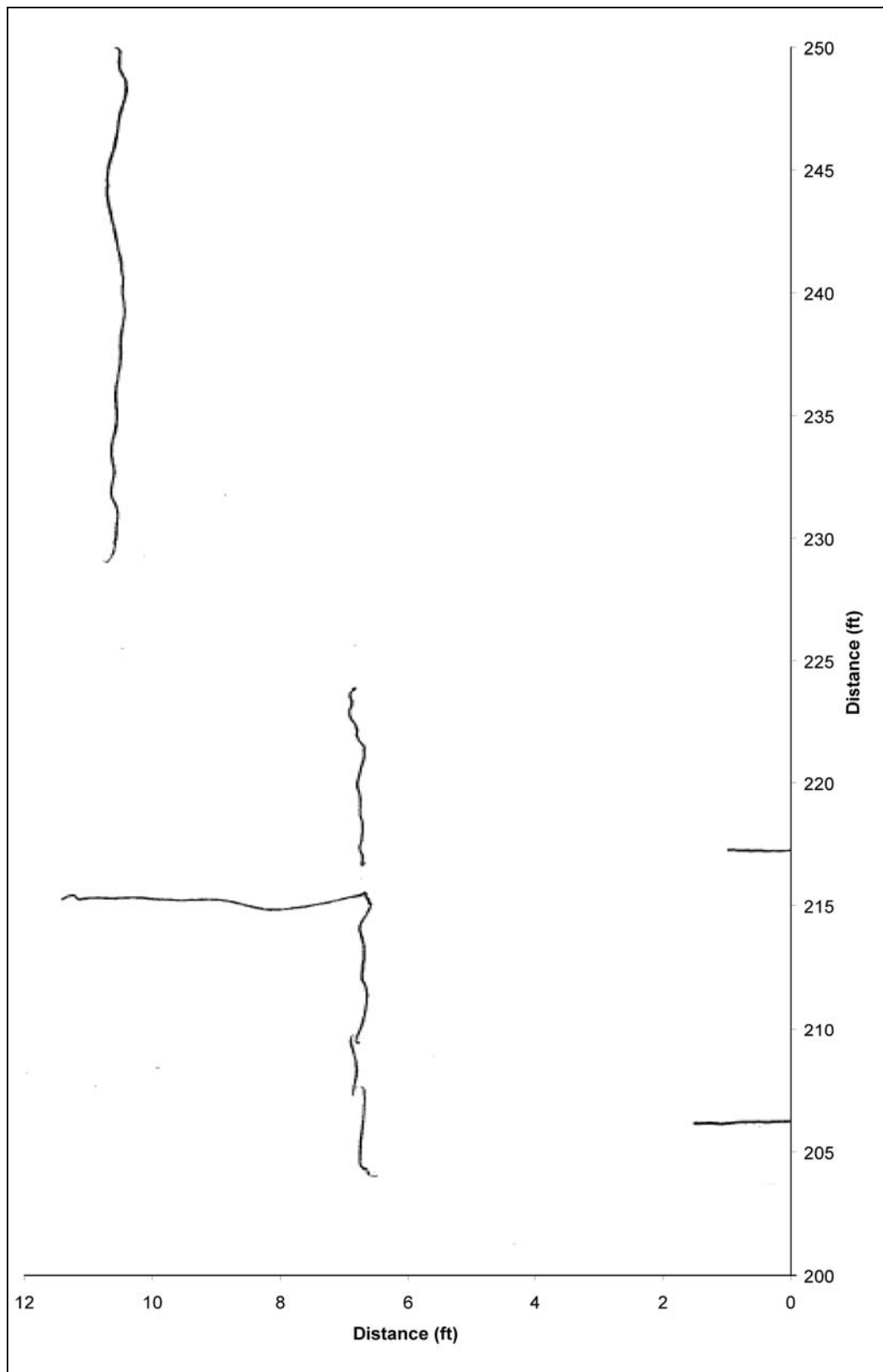


Figure 68. Lawson AAF Section 8 (Station 200-250 ft).

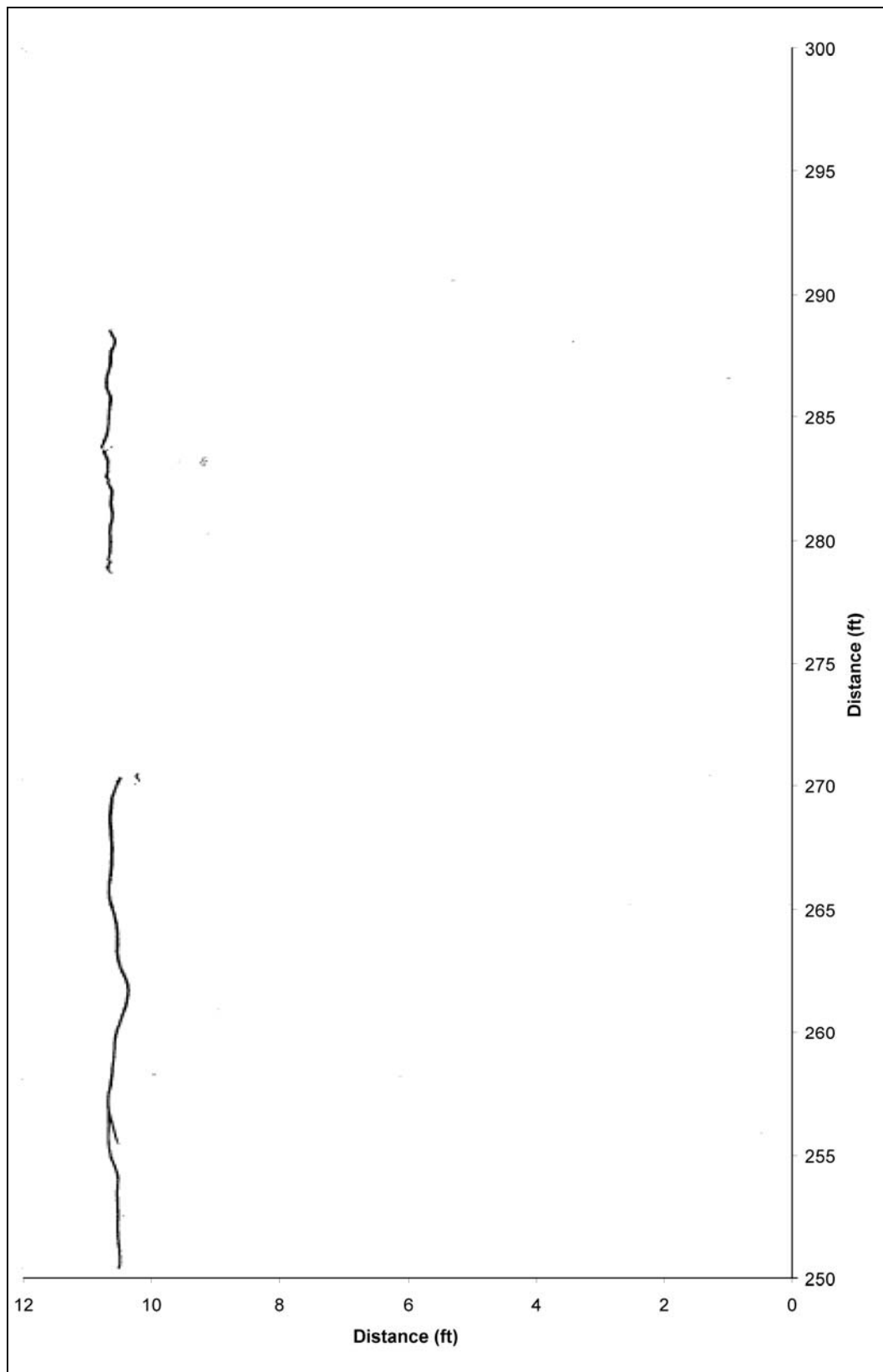


Figure 69. Lawson AAF Section 8 (Station 250-300 ft).

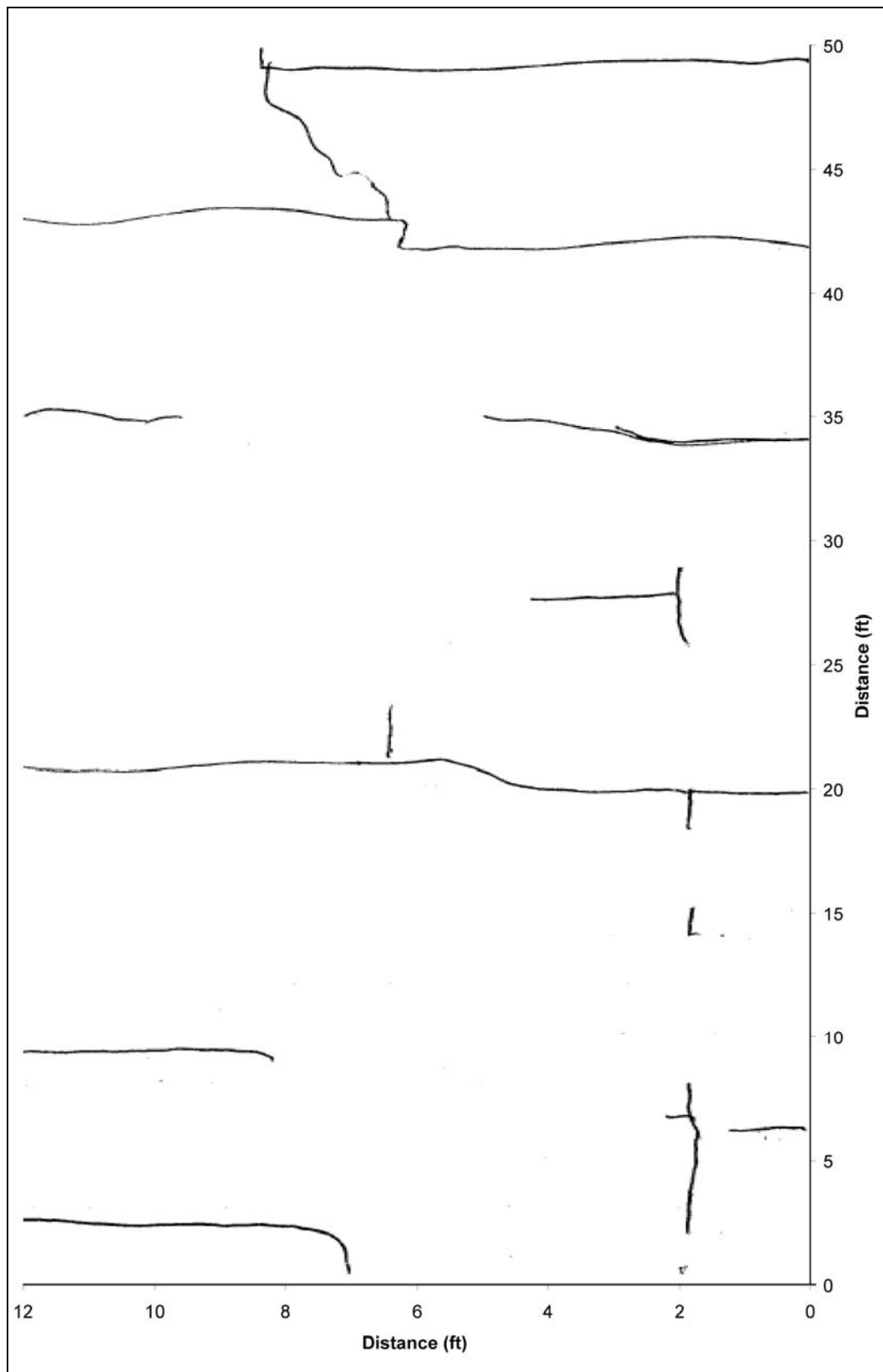


Figure 70. Lawson AAF Section 9 (Station 0-50 ft).

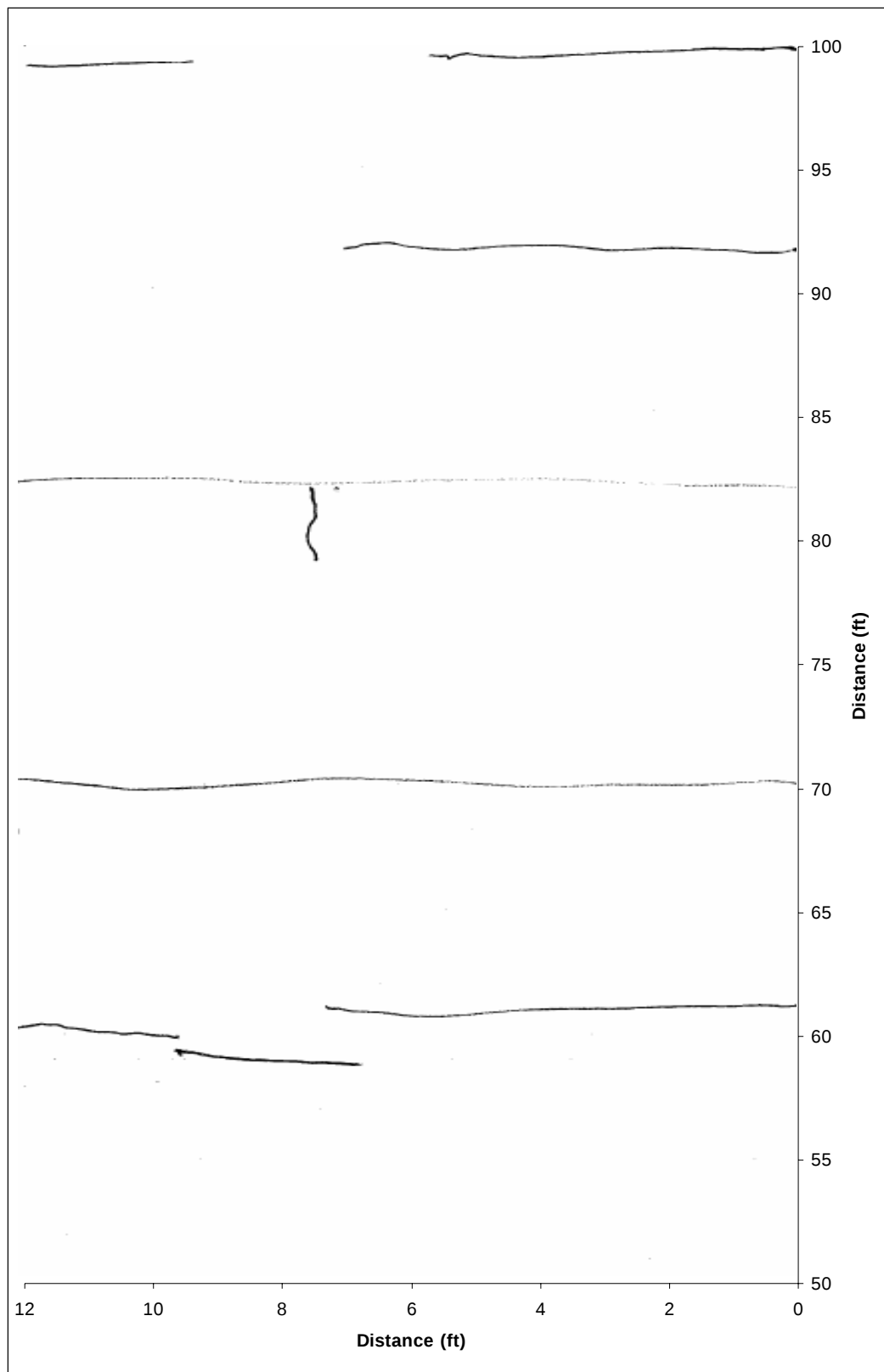


Figure 71. Lawson AAF Section 9 (Station 50-100 ft).

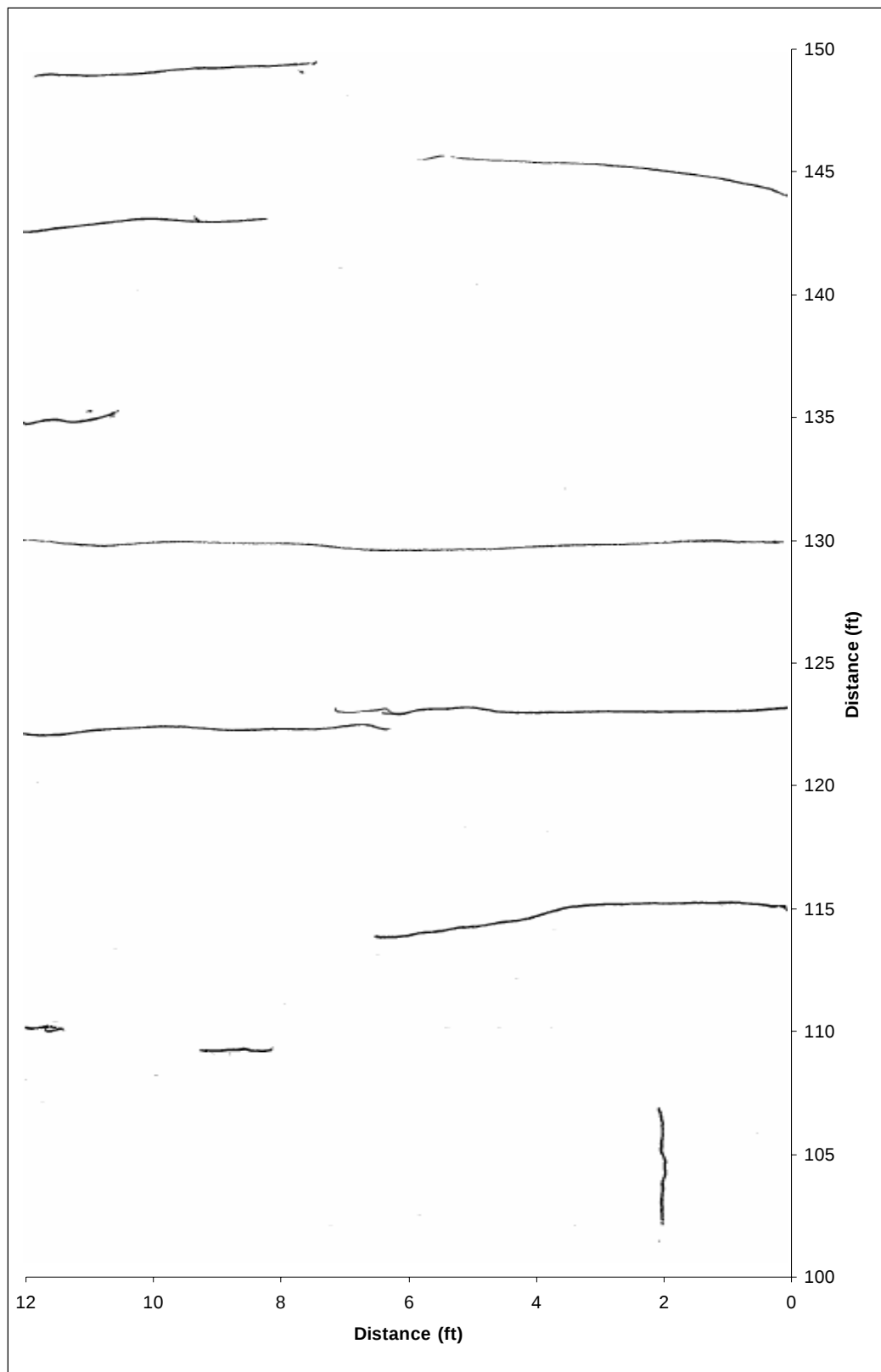


Figure 72. Lawson AAF Section 9 (Station 100-150 ft).

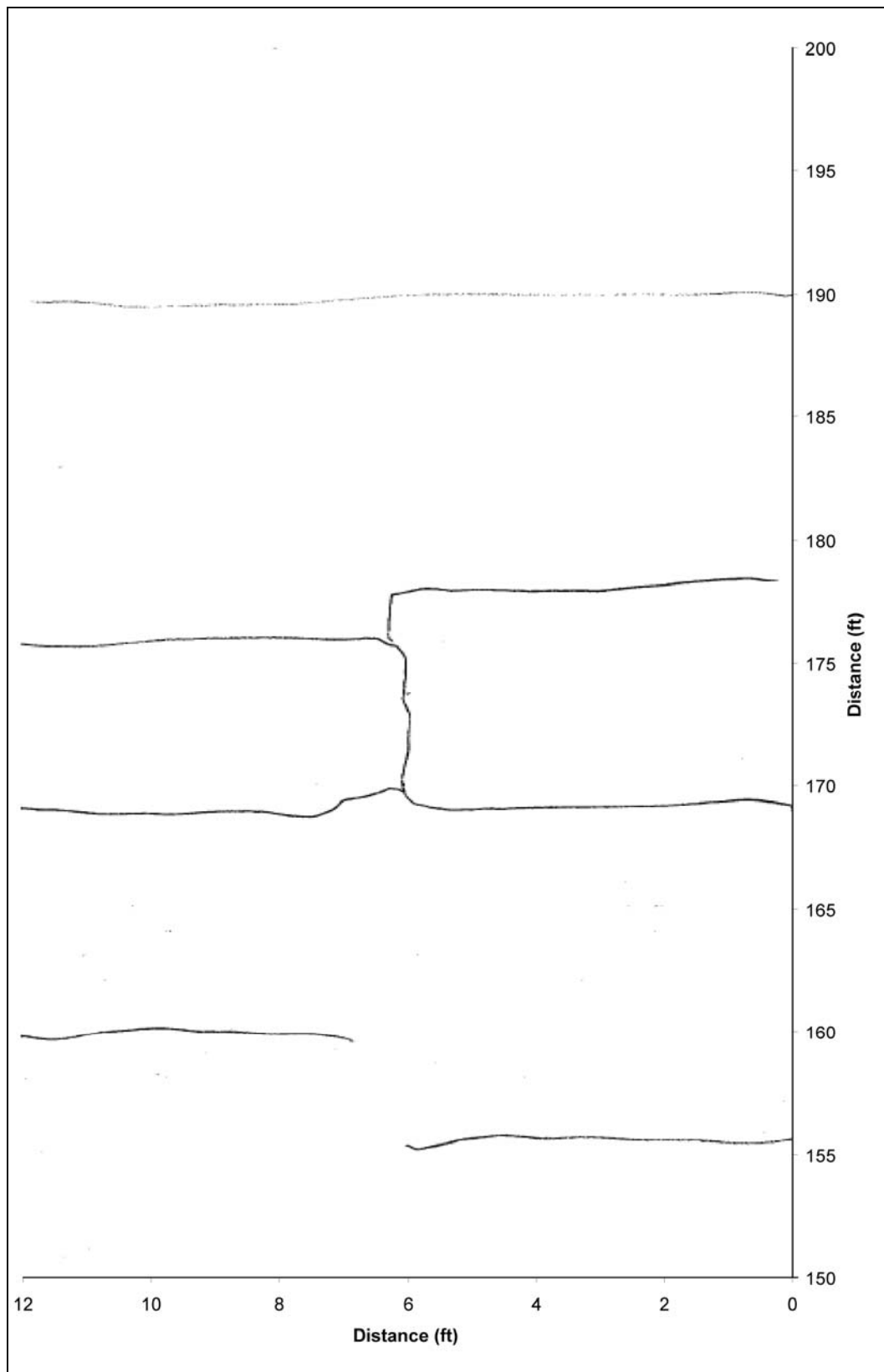


Figure 73. Lawson AAF Section 9 (Station 150-200 ft).

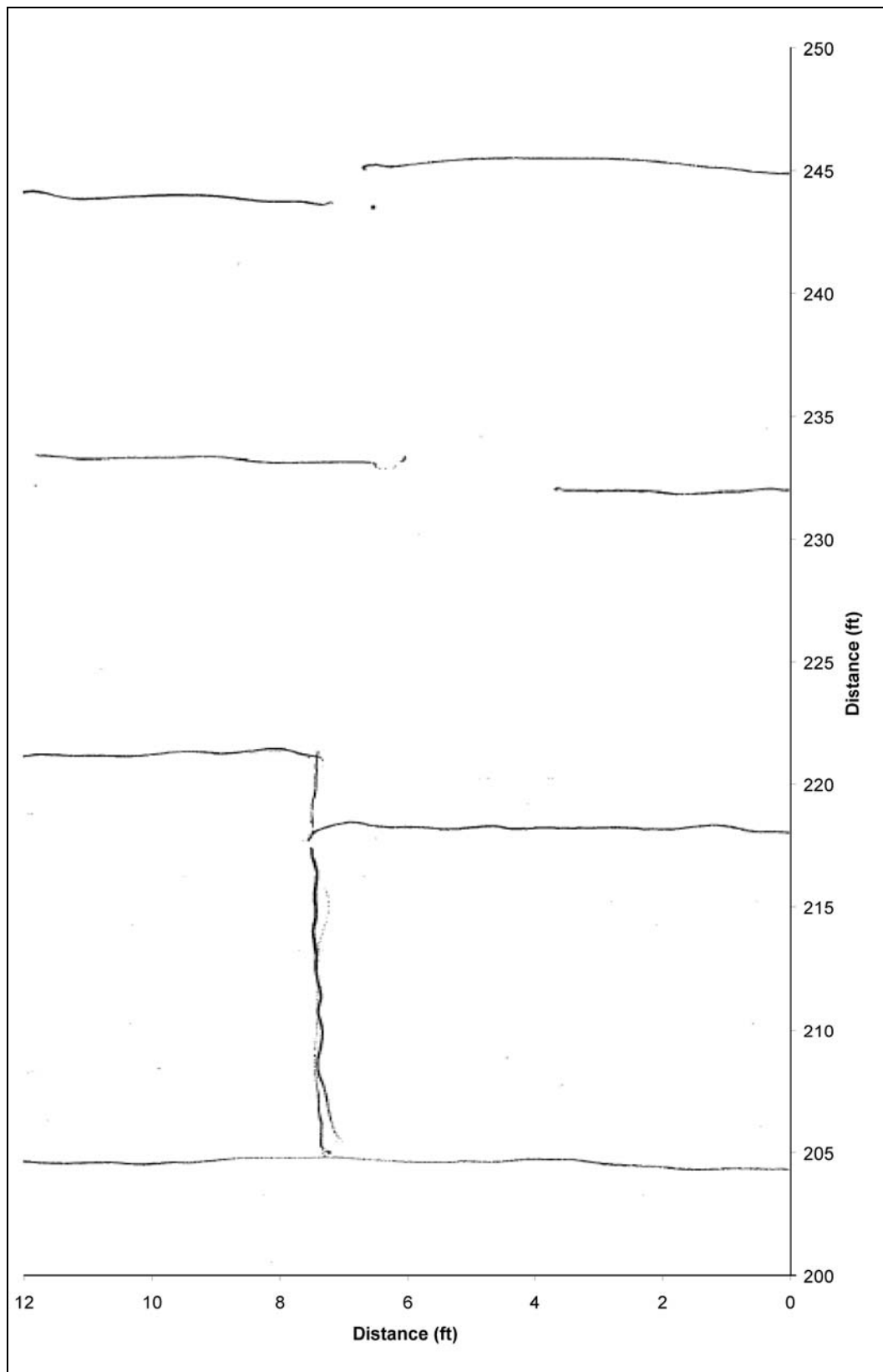


Figure 74. Lawson AAF Section 9 (Station 200-250 ft).

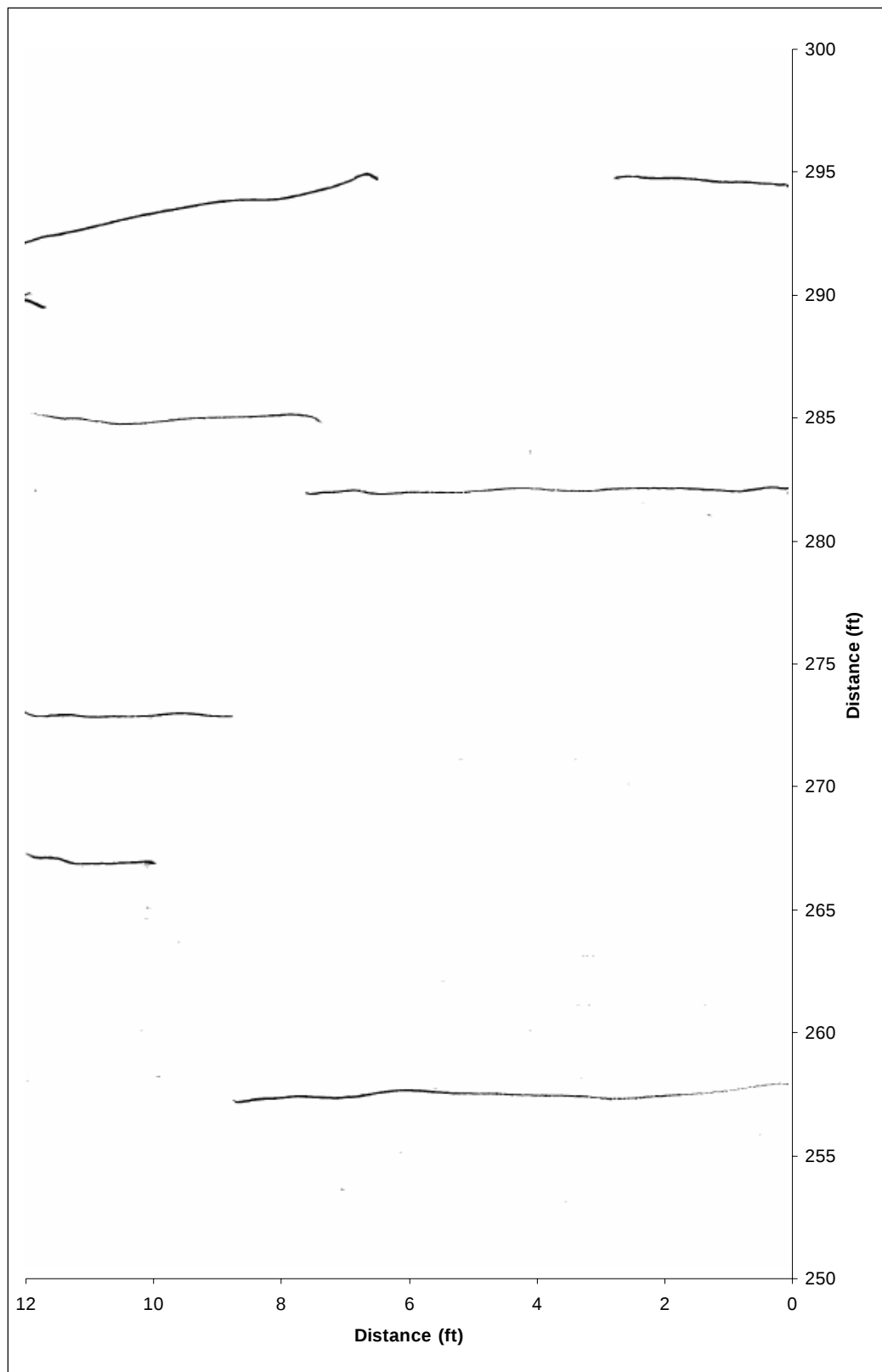


Figure 75. Lawson AAF Section 9 (Station 250-300 ft).

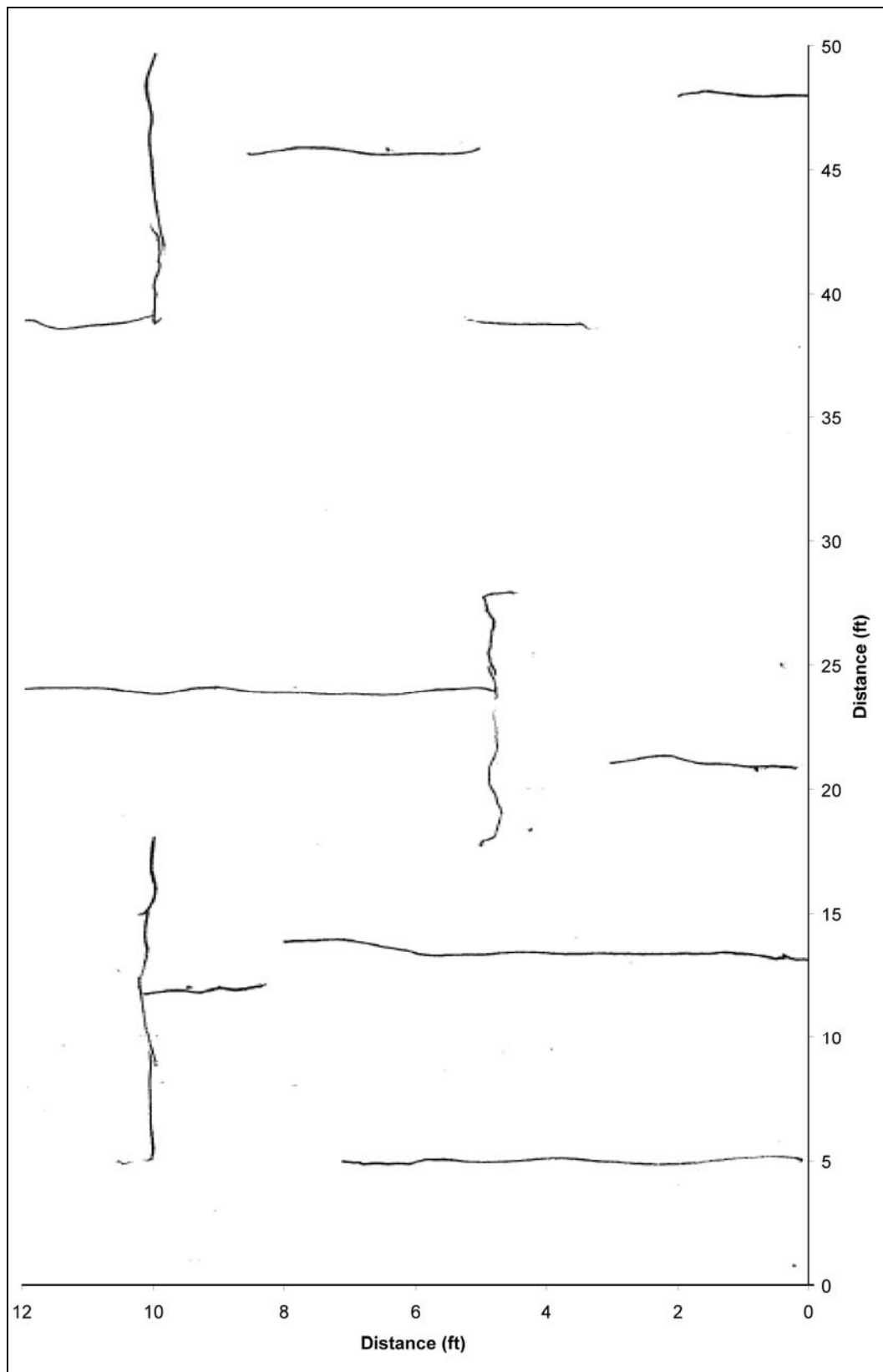


Figure 76. Lawson AAF Section 10 (Station 0-50 ft).

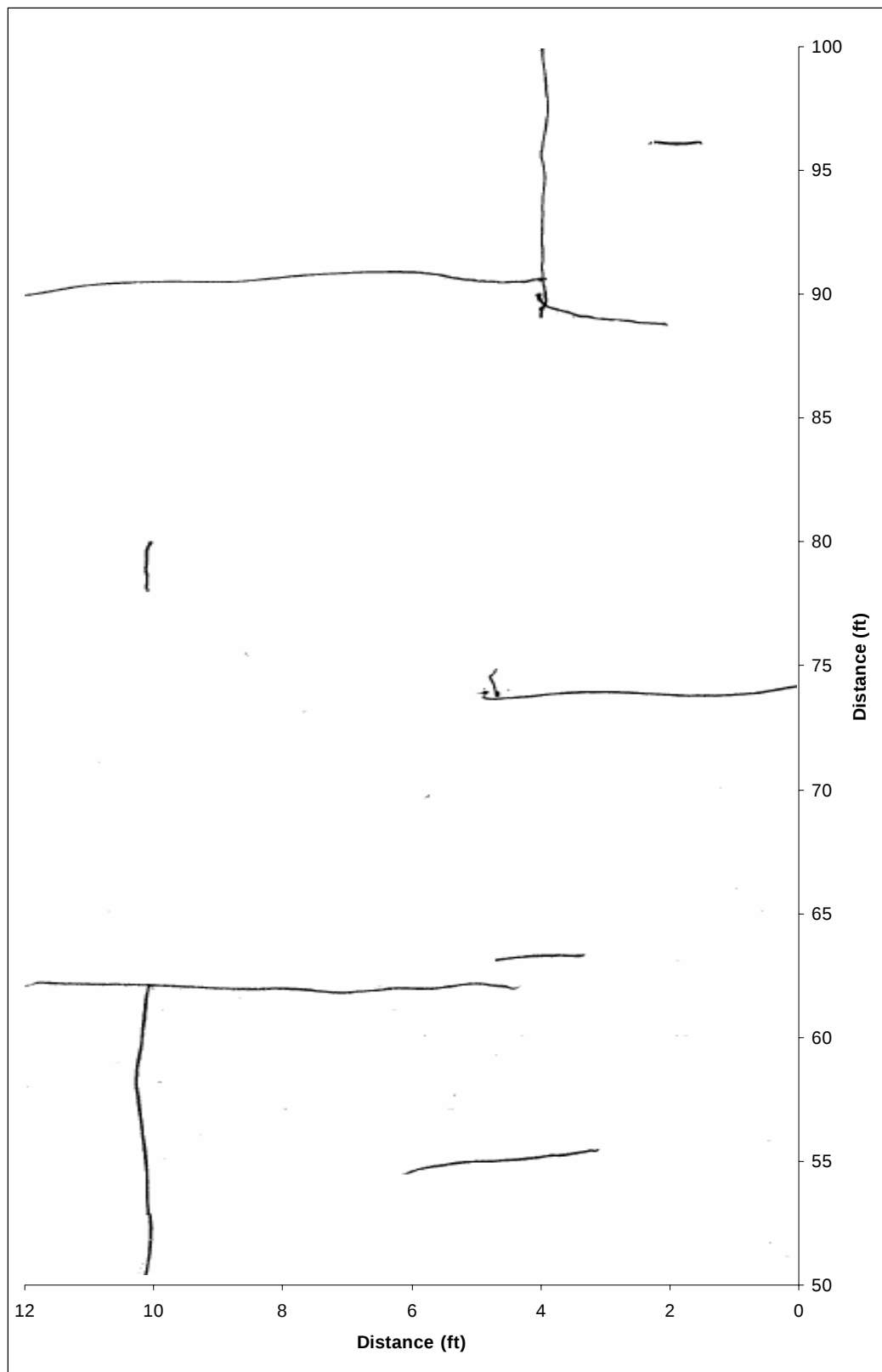


Figure 77. Lawson AAF Section 10 (Station 50-100 ft).

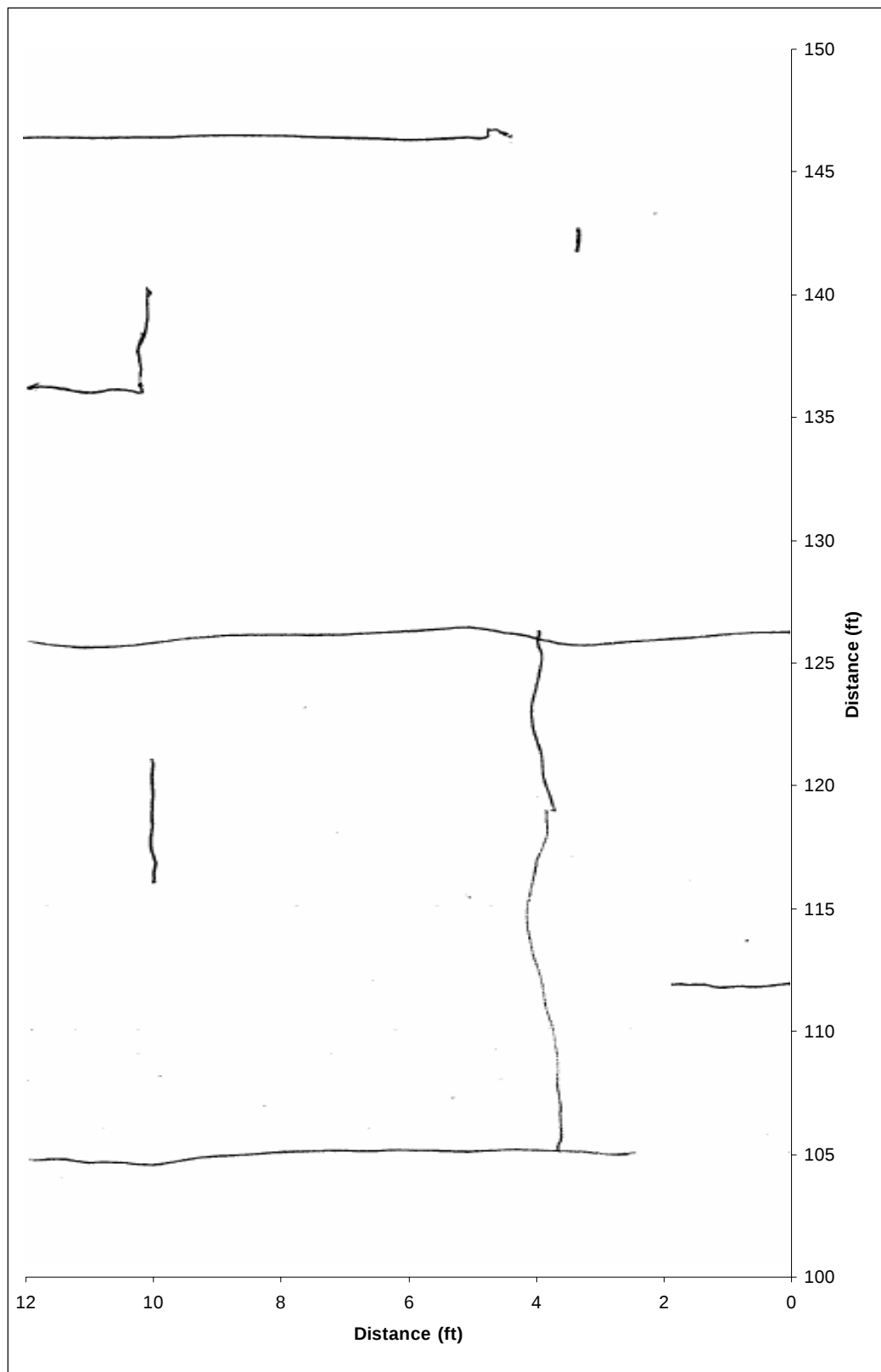


Figure 78. Lawson AAF Section 10 (Station 100-150 ft).

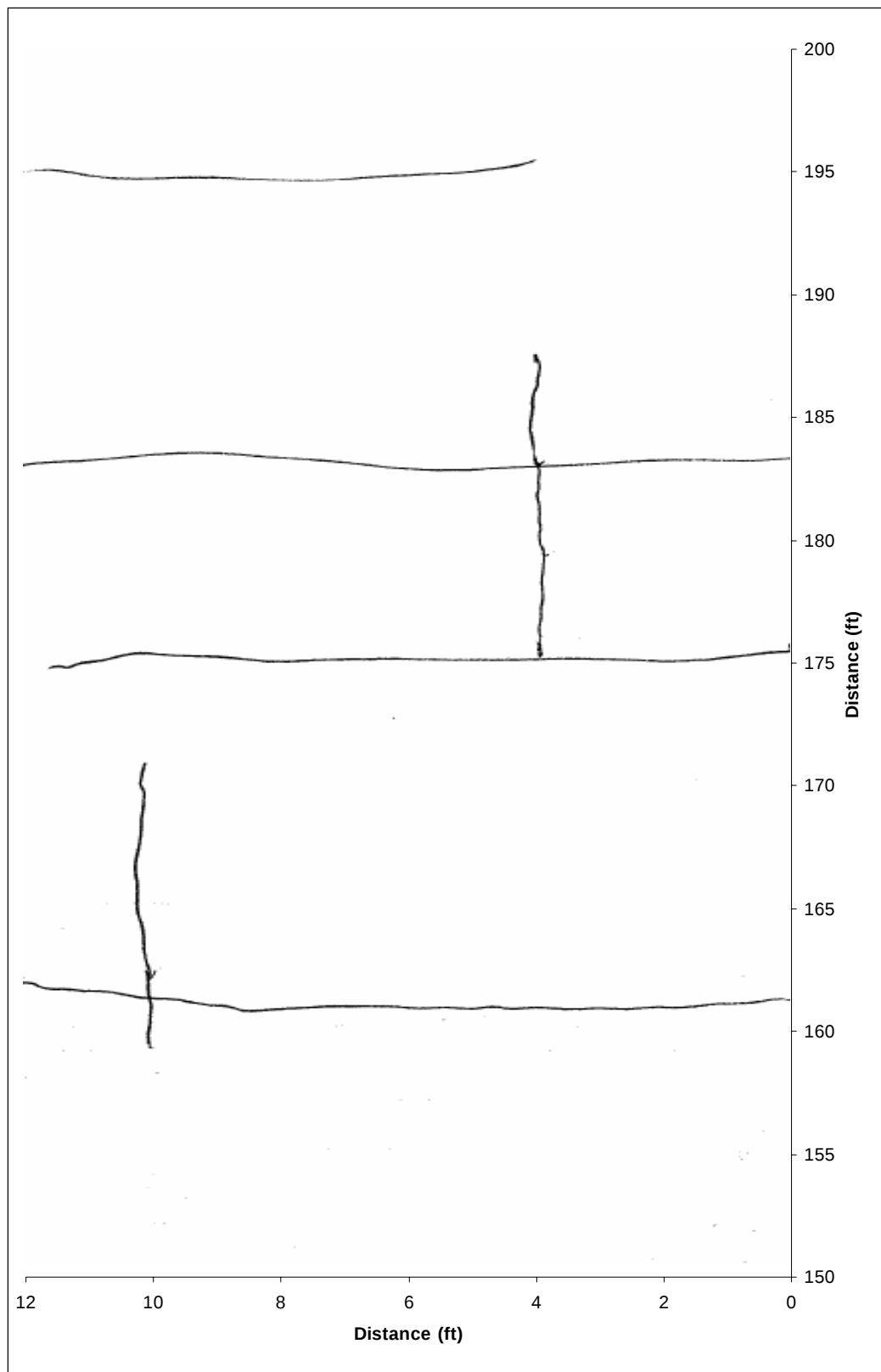


Figure 79. Lawson AAF Section 10 (Station 150-200 ft).

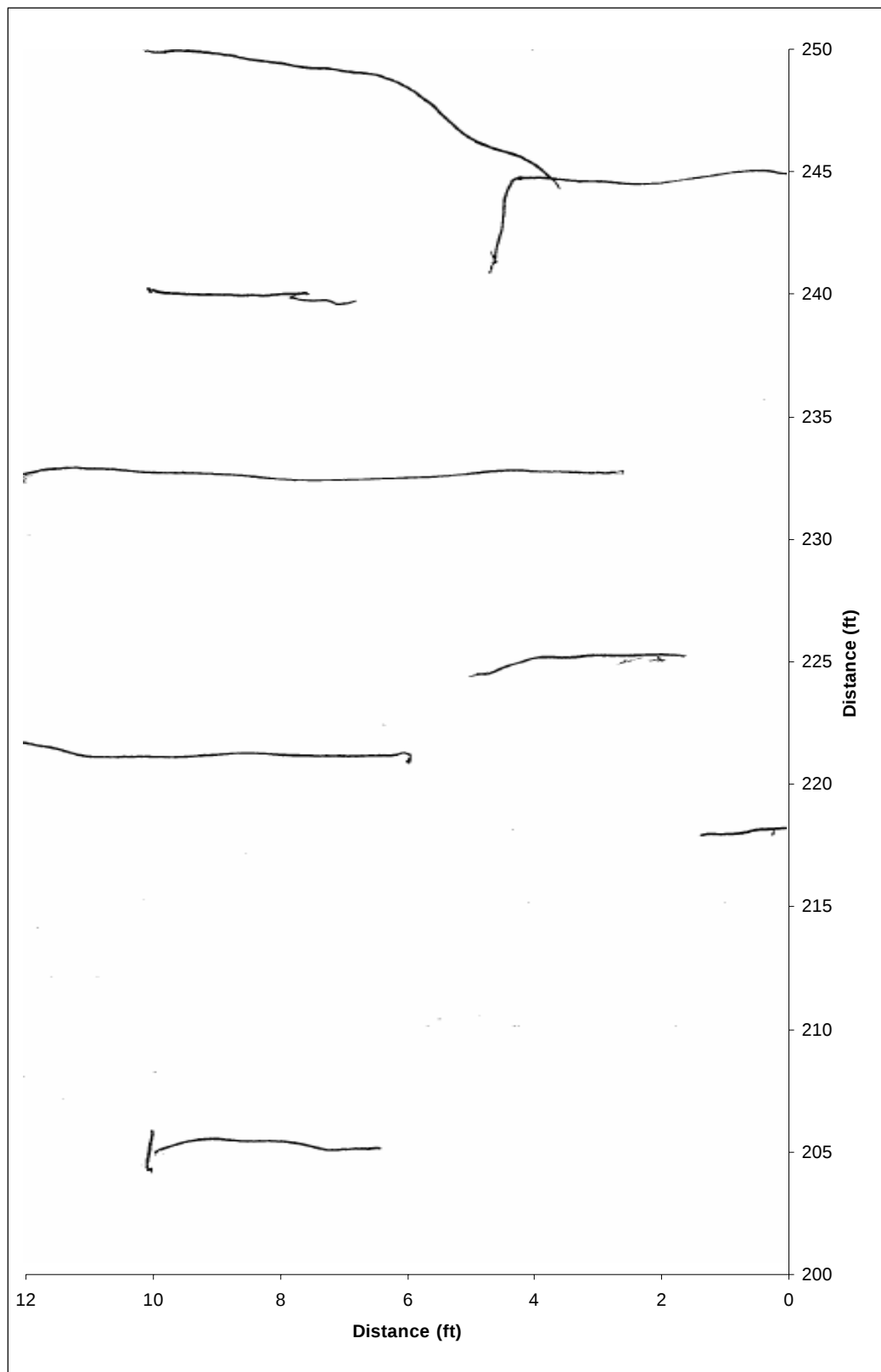


Figure 80. Lawson AAF Section 10 (Station 200-250 ft).



Figure 81. Lawson AAF Section 10 (Station 250-300 ft).

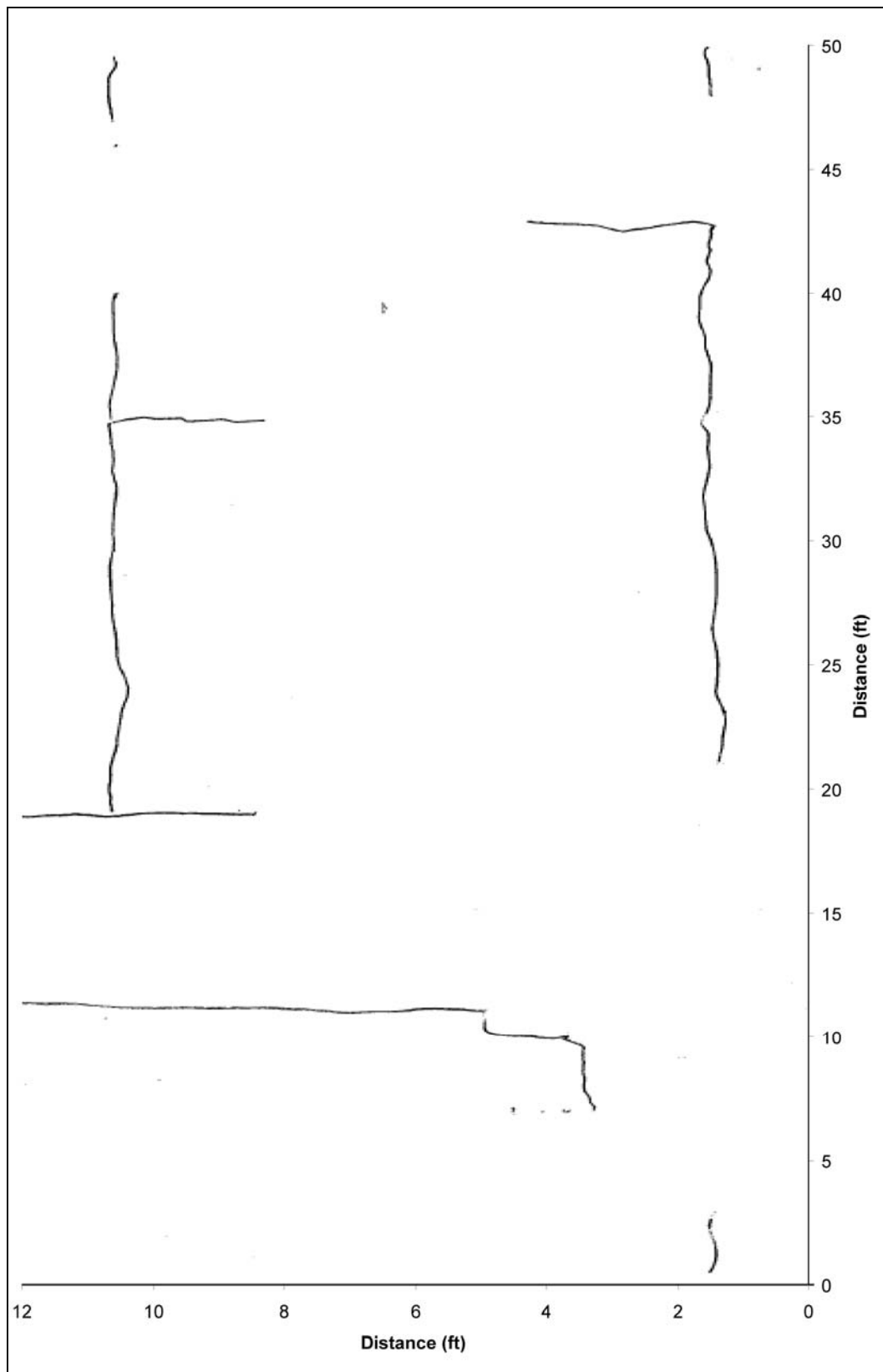


Figure 82. Lawson AAF Section 11 (Station 0-50 ft).

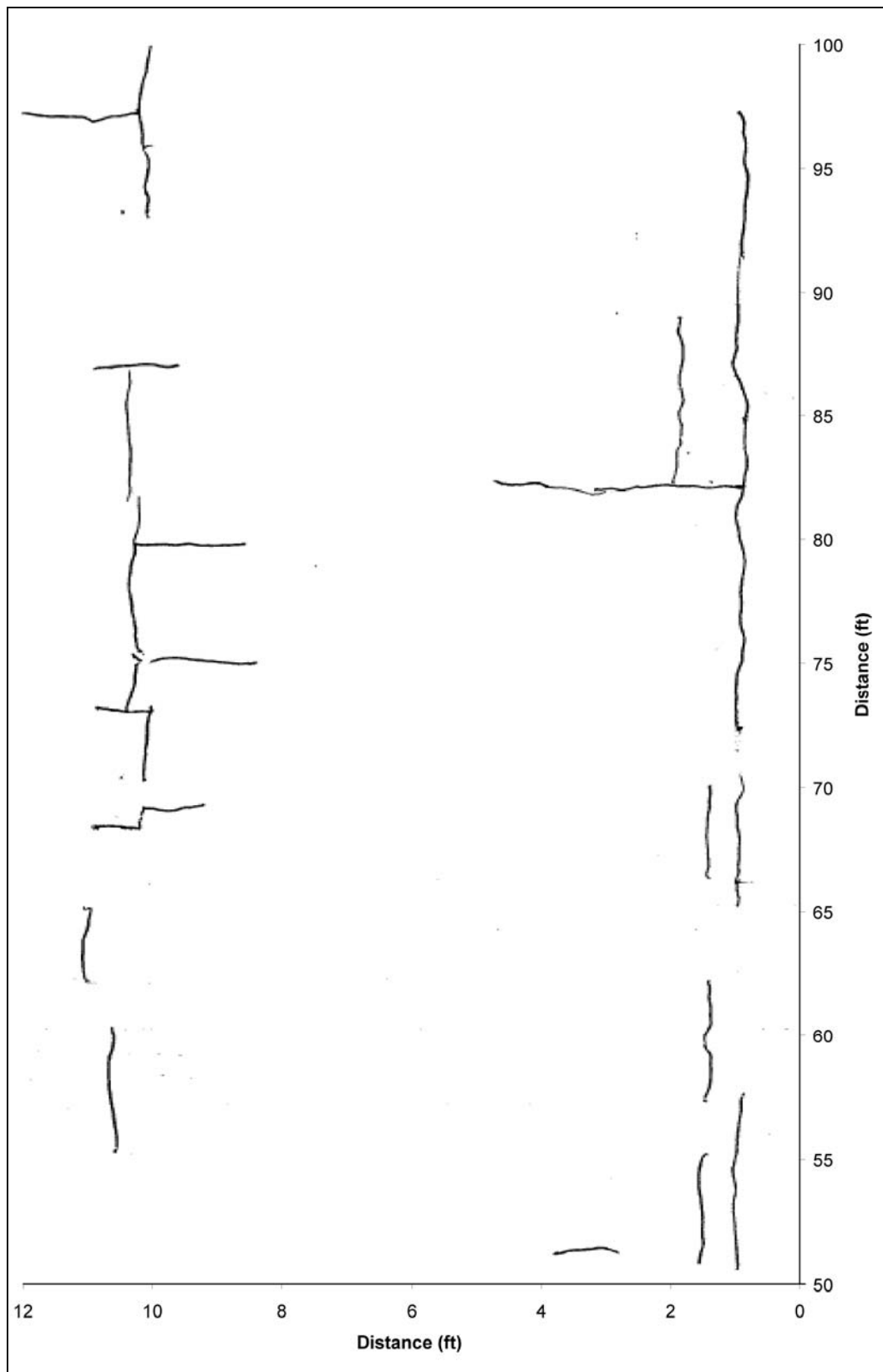


Figure 83. Lawson AAF Section 11 (Station 50-100 ft).

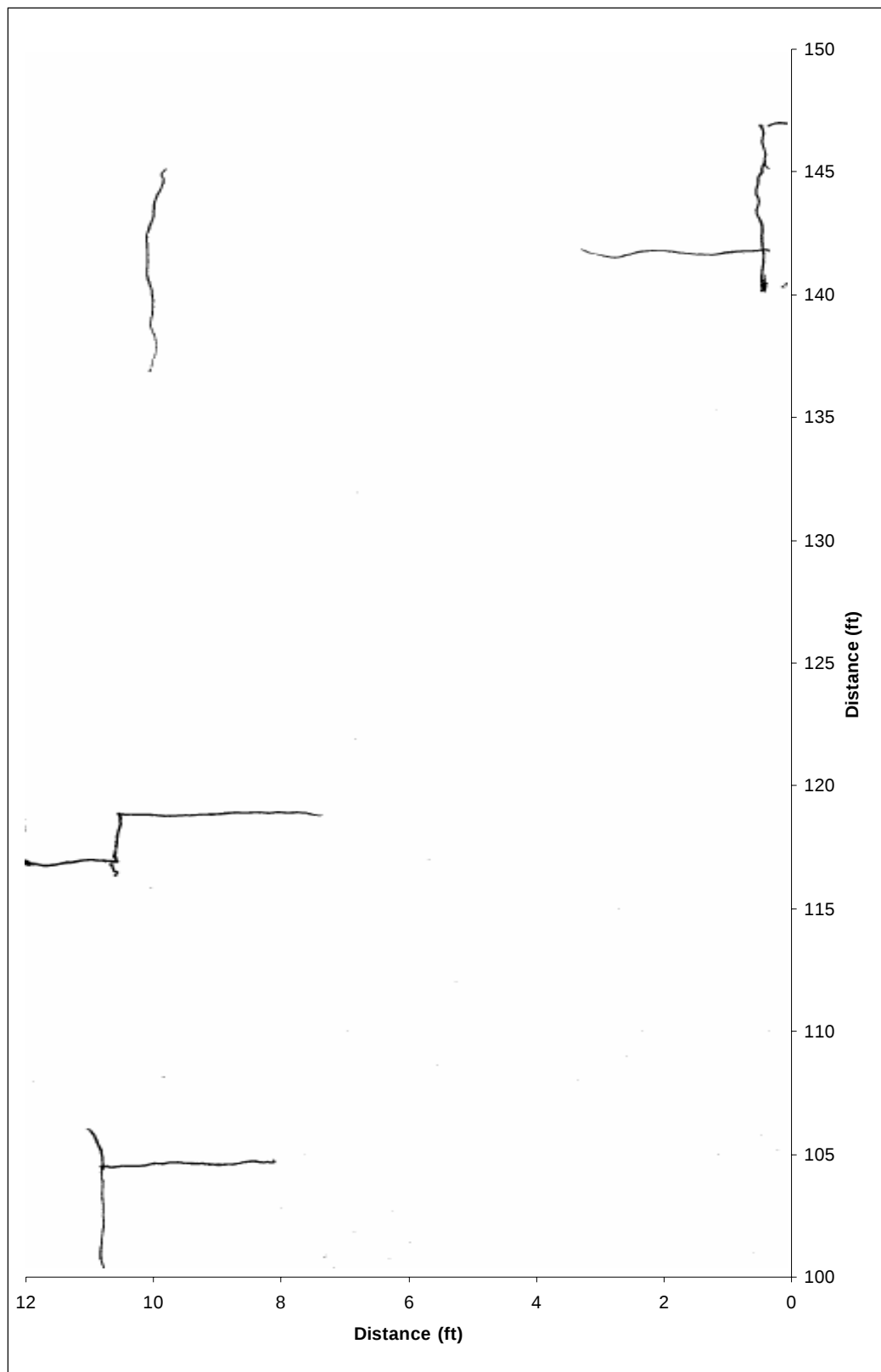


Figure 84. Lawson AAF Section 11 (Station 100-150 ft).

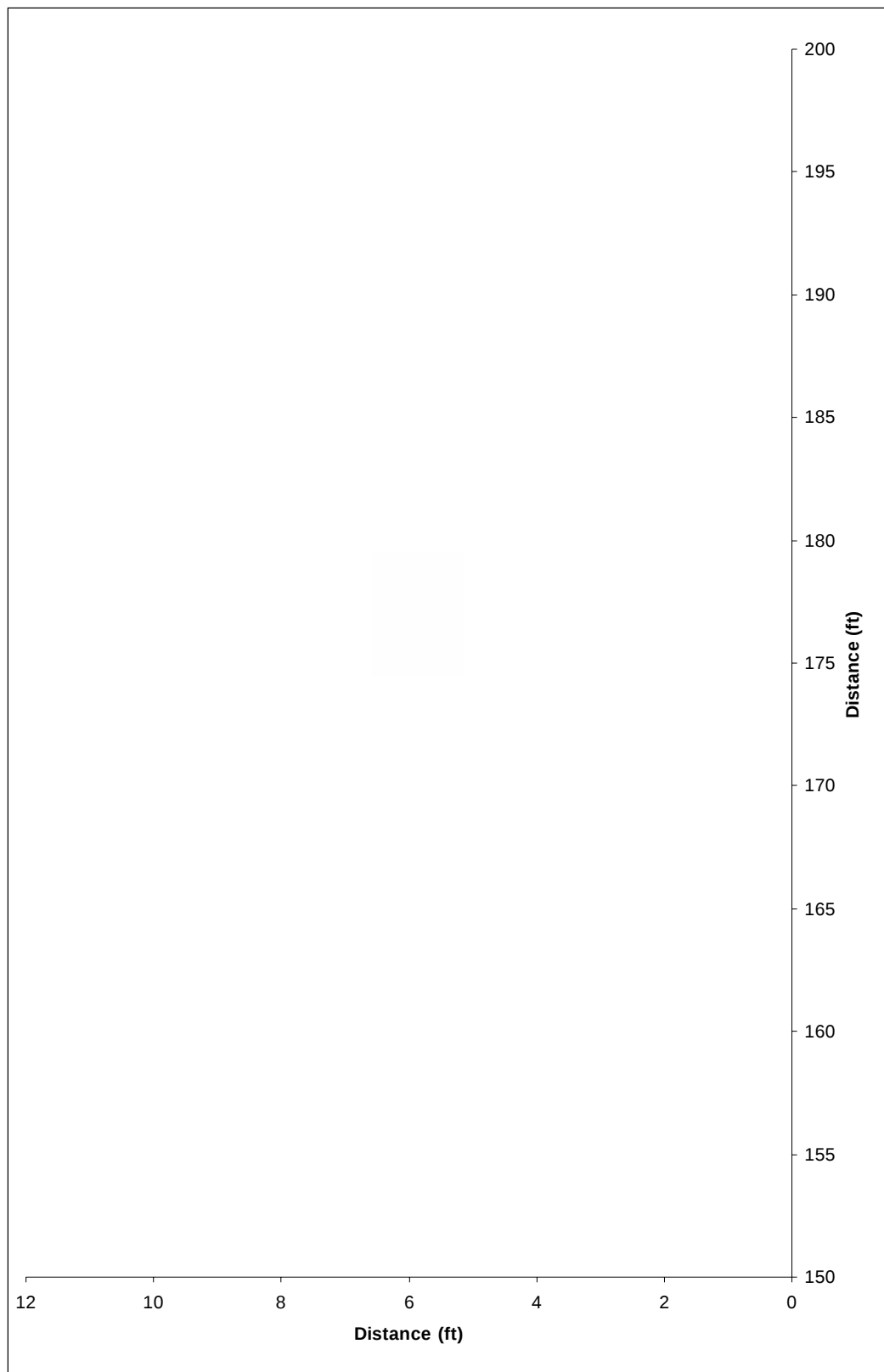


Figure 85. Lawson AAF Section 11 (Station 150-200 ft).

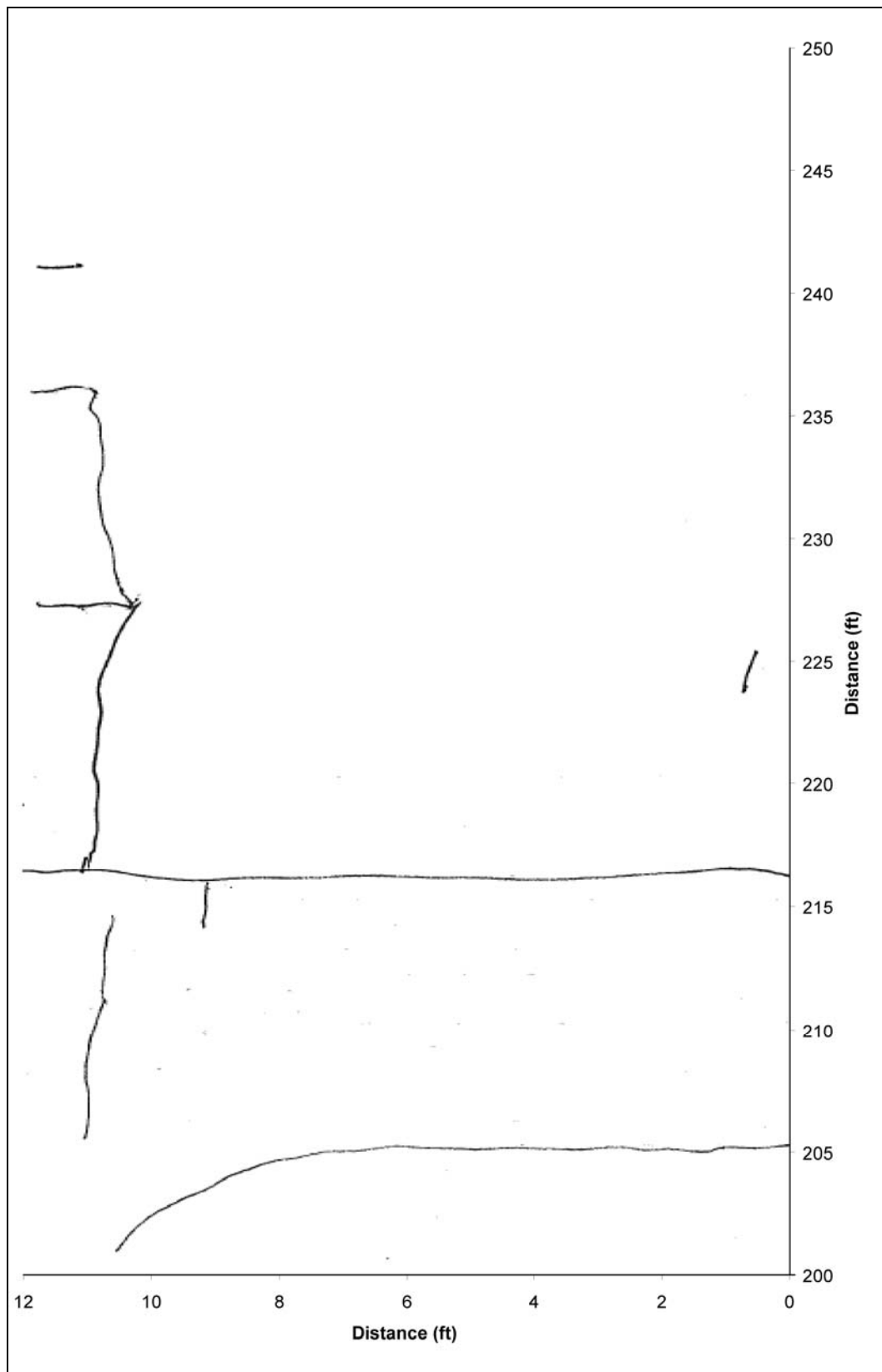


Figure 86. Lawson AAF Section 11 (Station 200-250 ft).

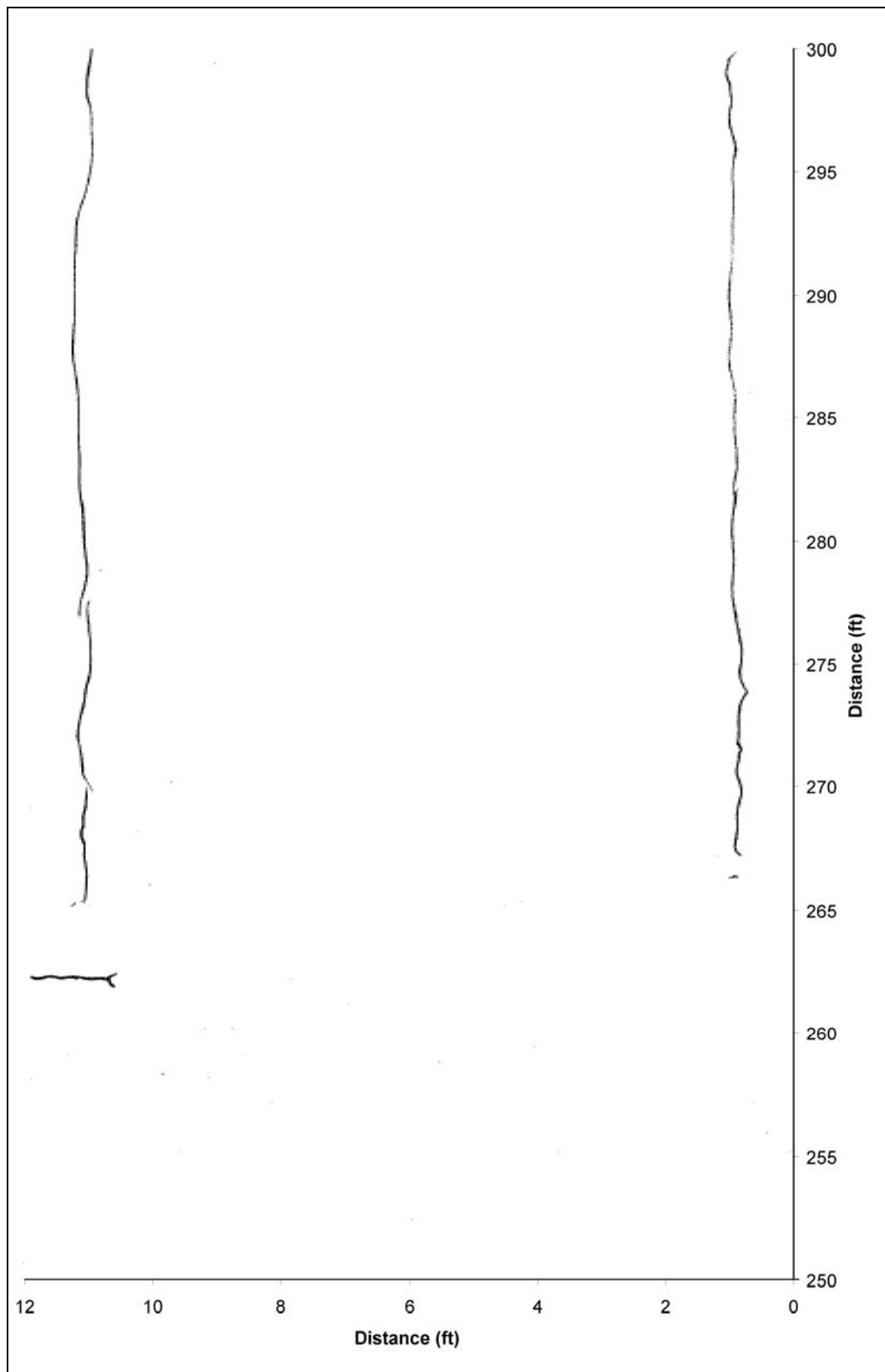


Figure 87. Lawson AAF Section 11 (Station 250-300 ft).

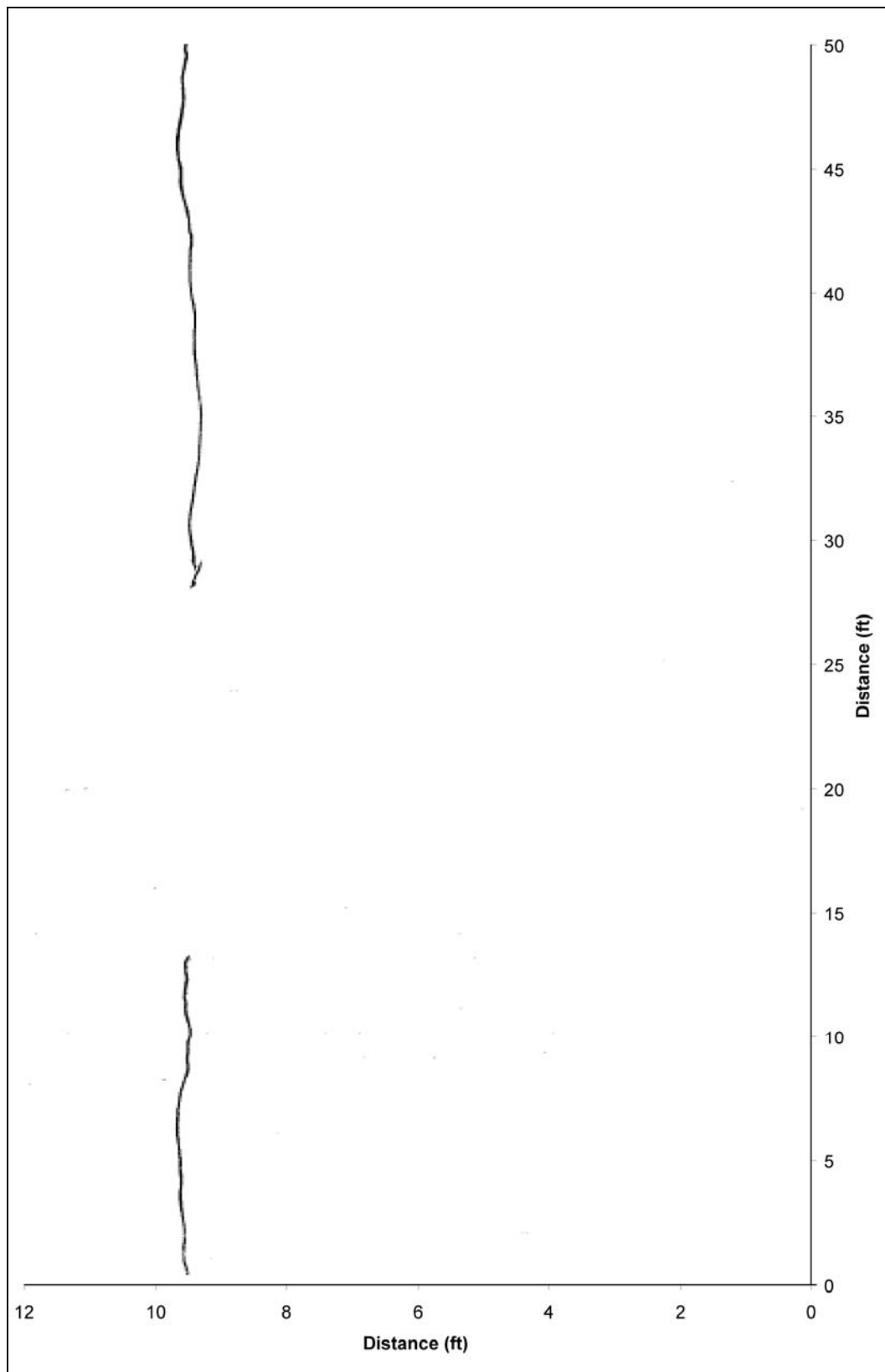


Figure 88. Lawson AAF Section 12 (Station 0-50 ft).

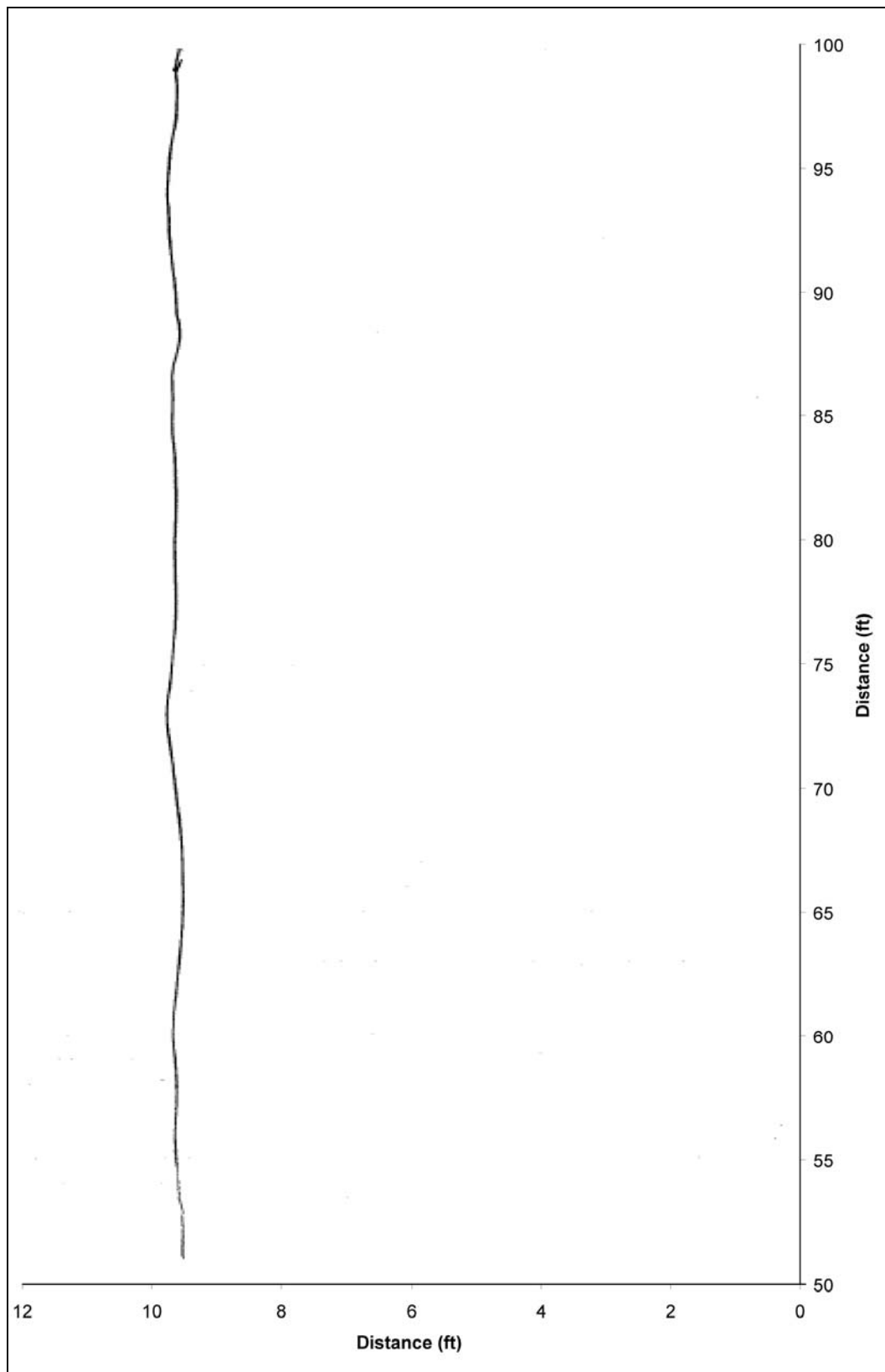


Figure 89. Lawson AAF Section 12 (Station 50-100 ft).

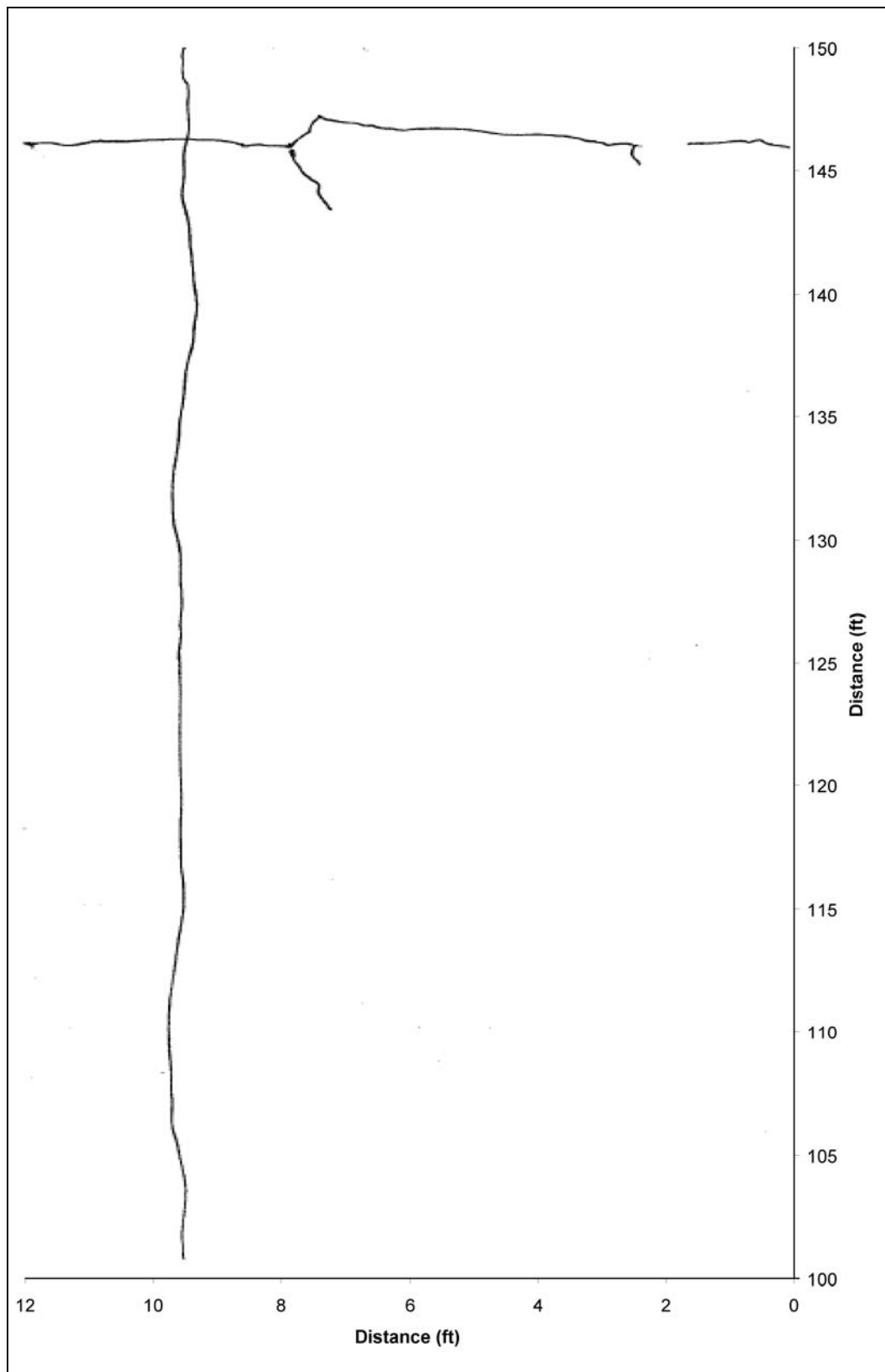


Figure 90. Lawson AAF Section 12 (Station 100-150 ft).

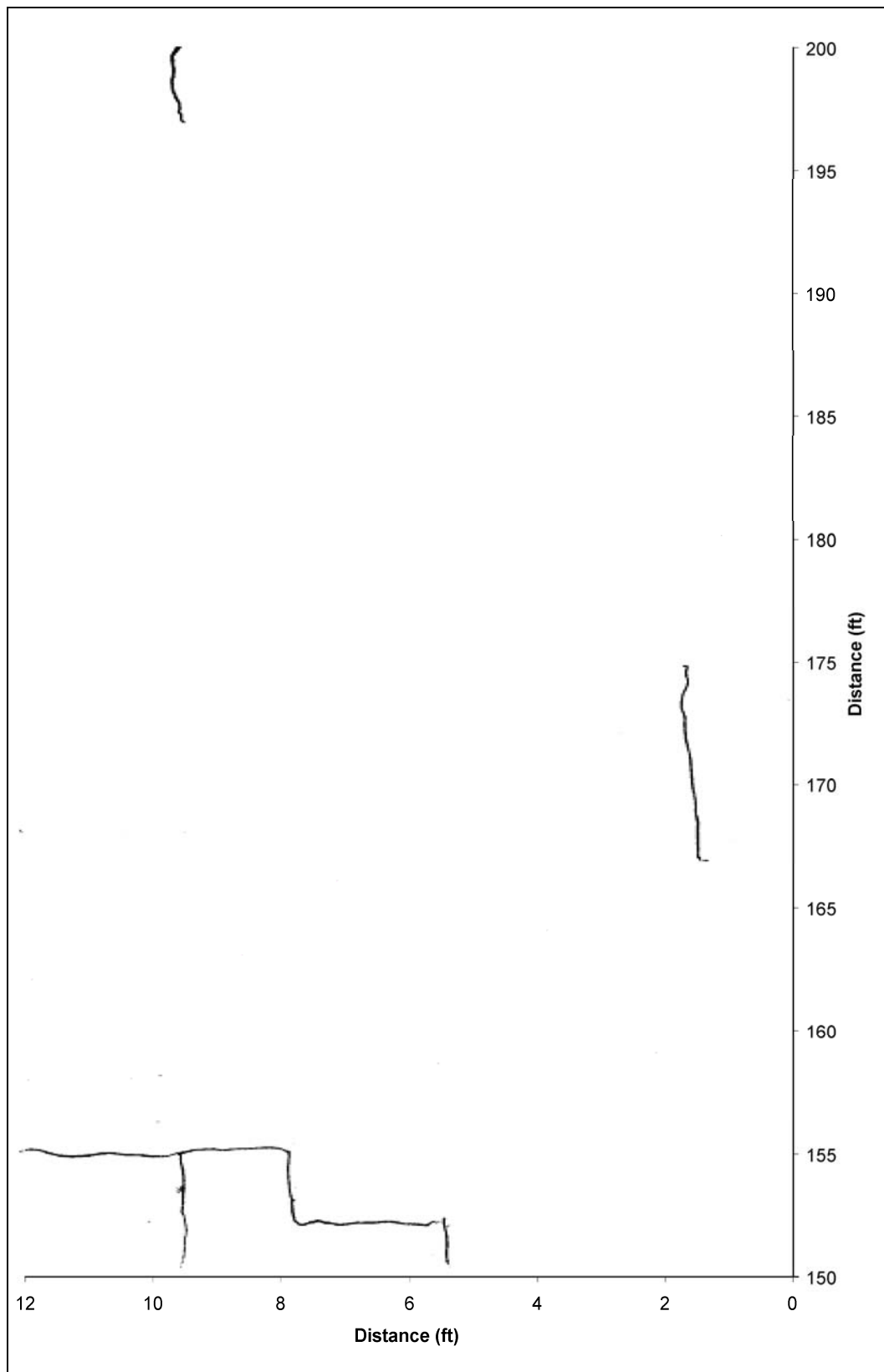


Figure 91. Lawson AAF Section 12 (Station 150-200 ft).

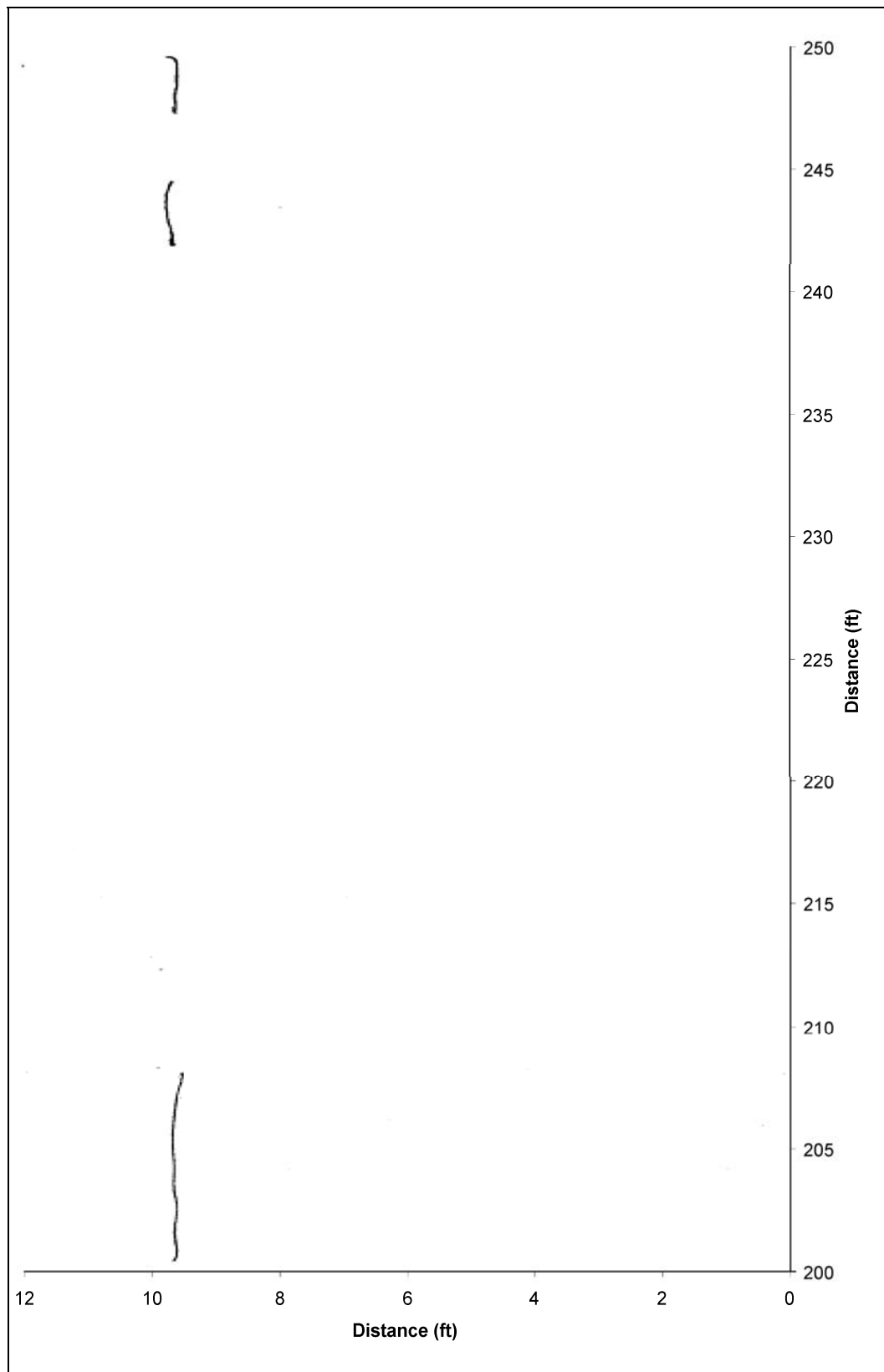


Figure 92. Lawson AAF Section 12 (Station 200-250 ft).

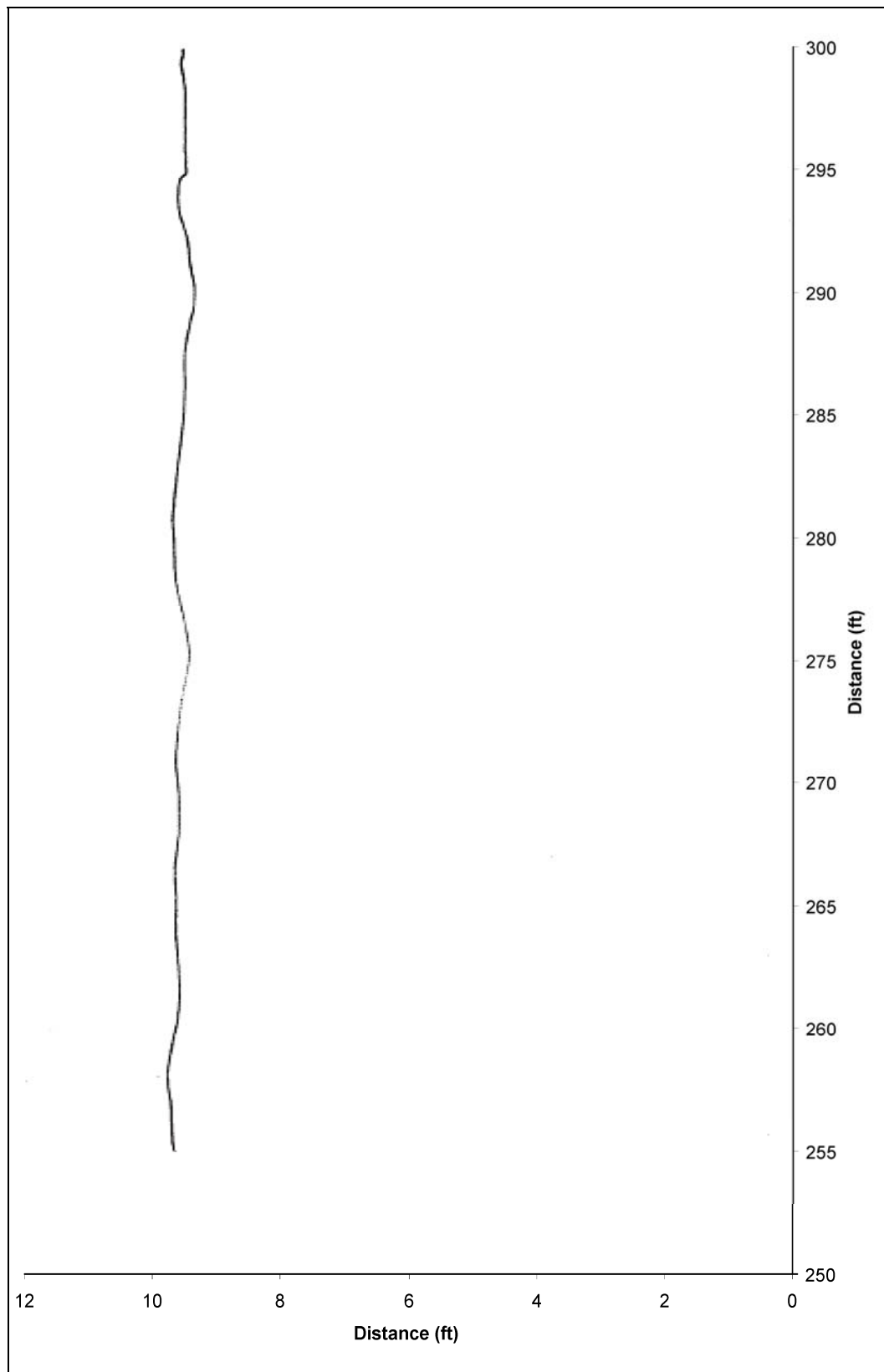


Figure 93. Lawson AAF Section 12 (Station 250-300 ft).

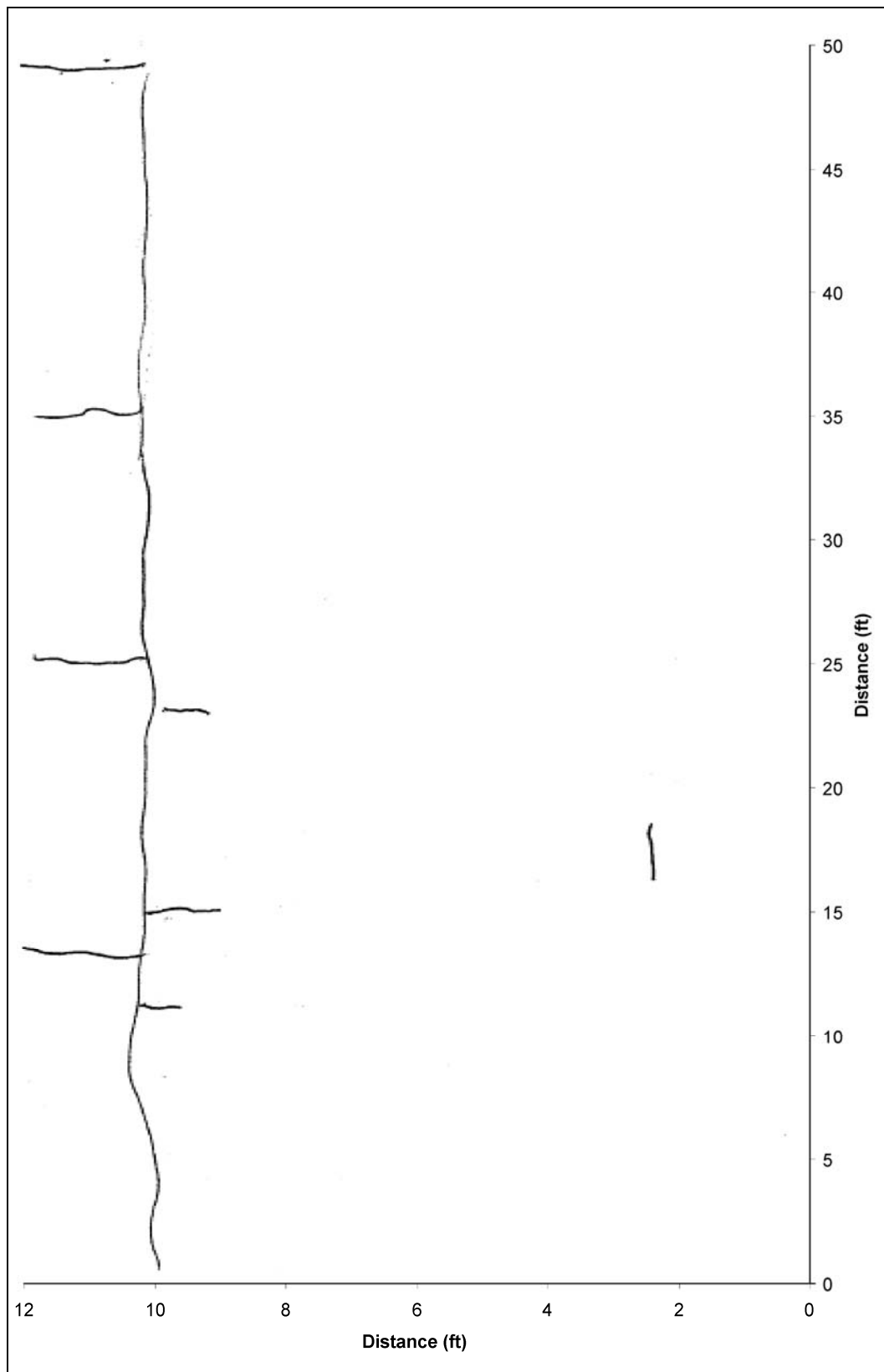


Figure 94. Lawson AAF Section 13 (Station 0-50 ft).

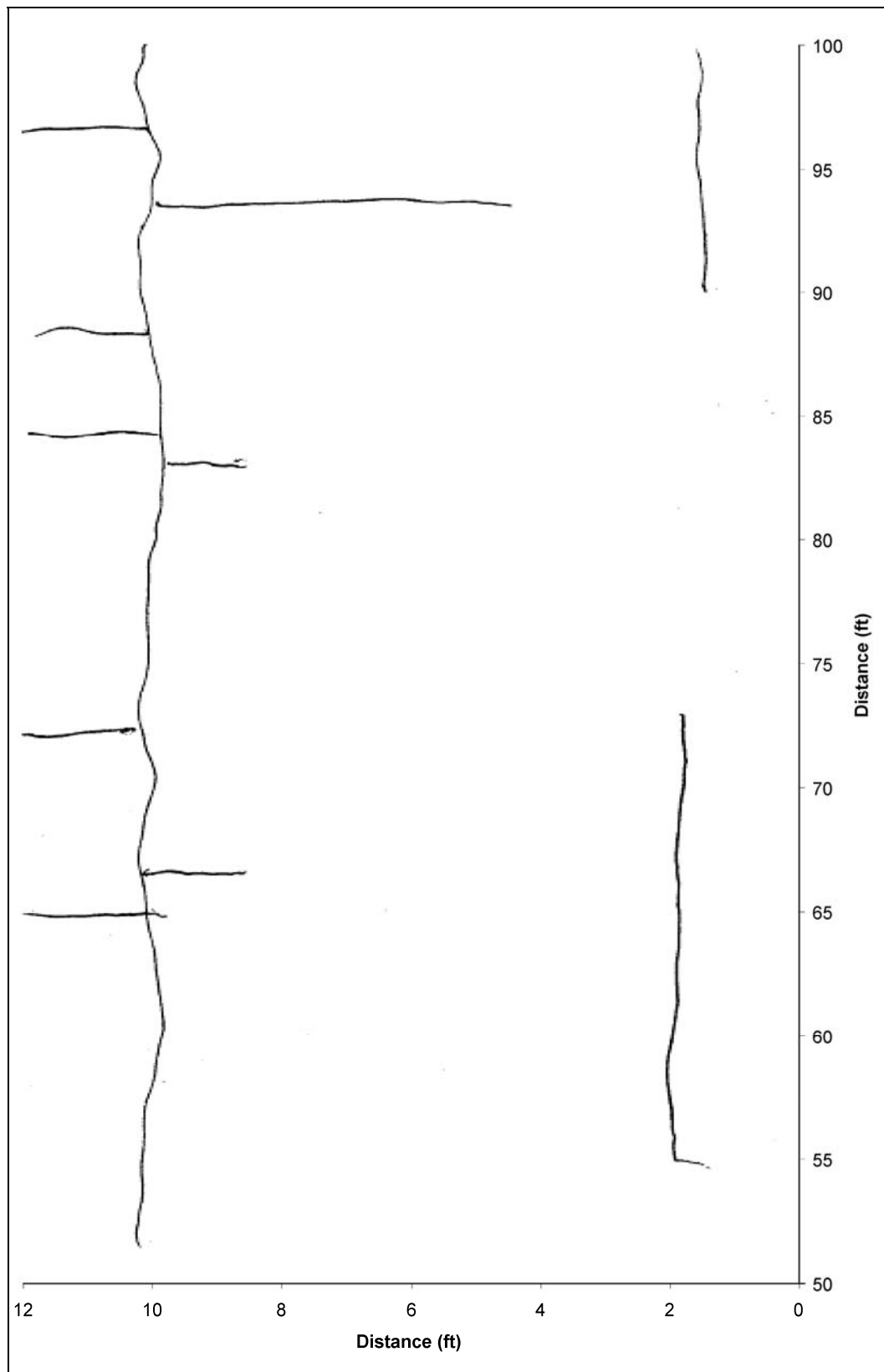


Figure 95. Lawson AAF Section 13 (Station 50-100 ft).

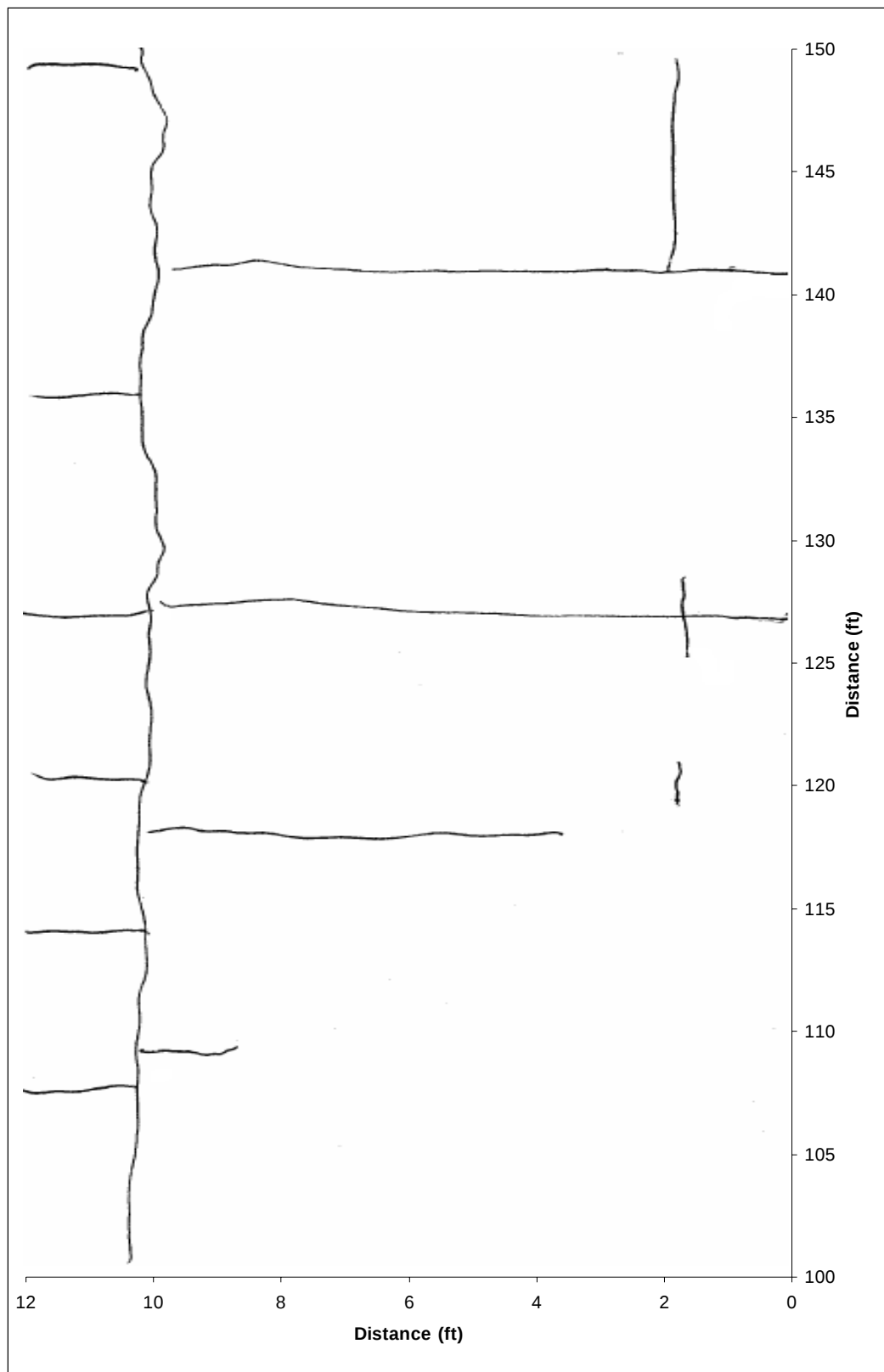


Figure 96. Lawson AAF Section 13 (Station 100-150 ft).

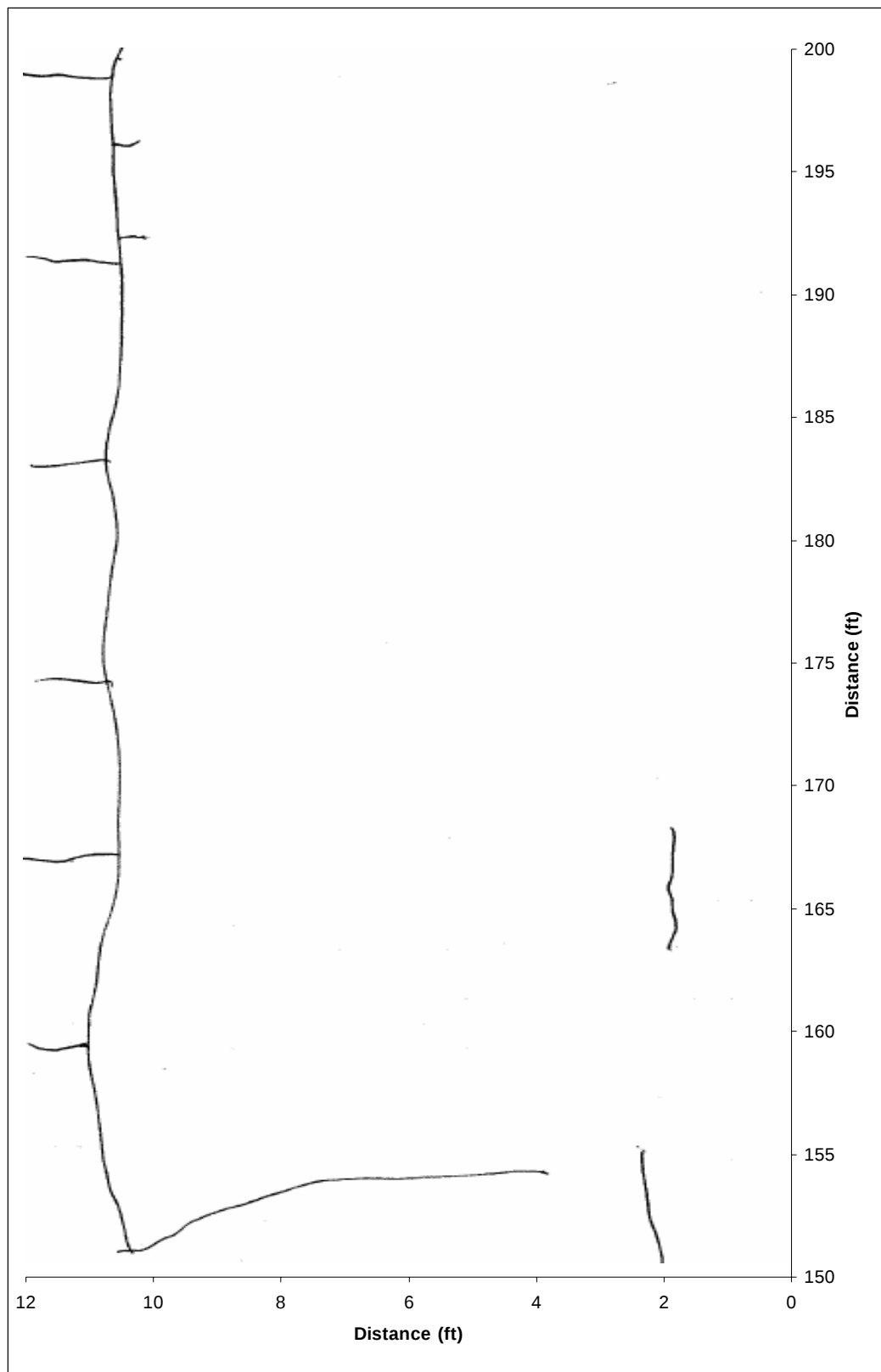


Figure 97. Lawson AAF Section 13 (Station 150-200 ft).

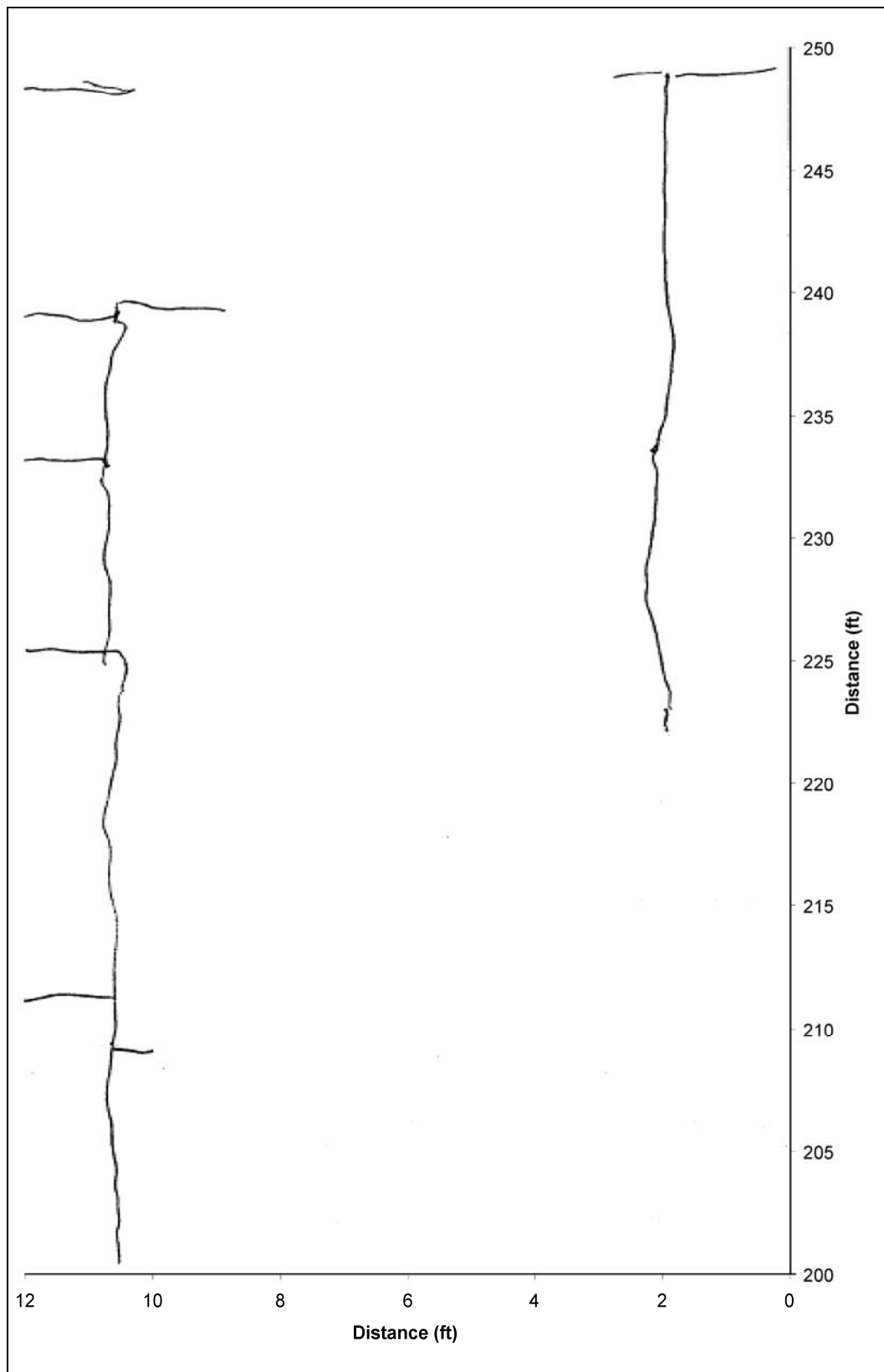


Figure 98. Lawson AAF Section 13 (Station 200-250 ft).

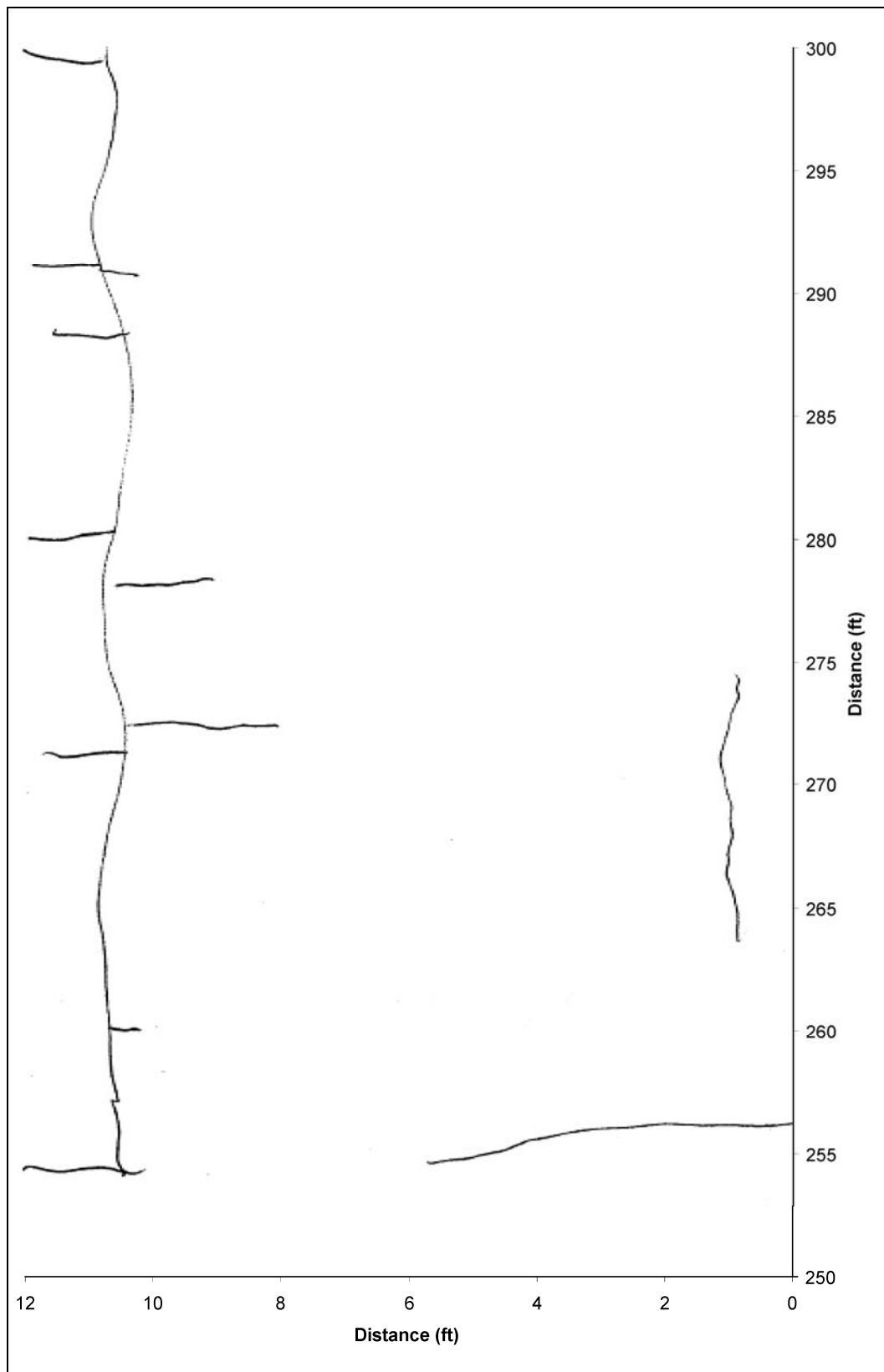


Figure 99. Lawson AAF Section 13 (Station 250-300 ft).

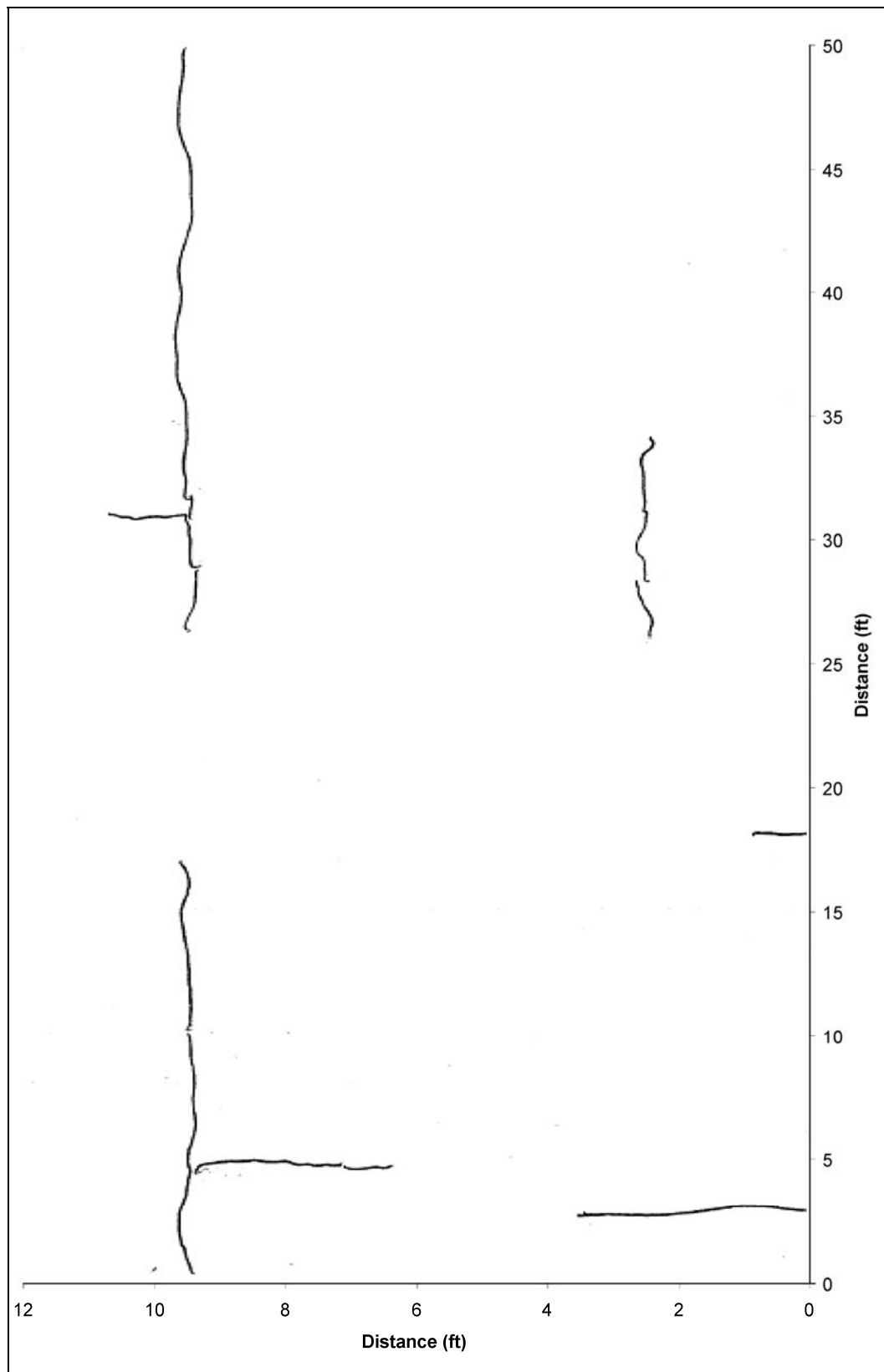


Figure 100. Lawson AAF Section 14 (Station 0-50 ft).

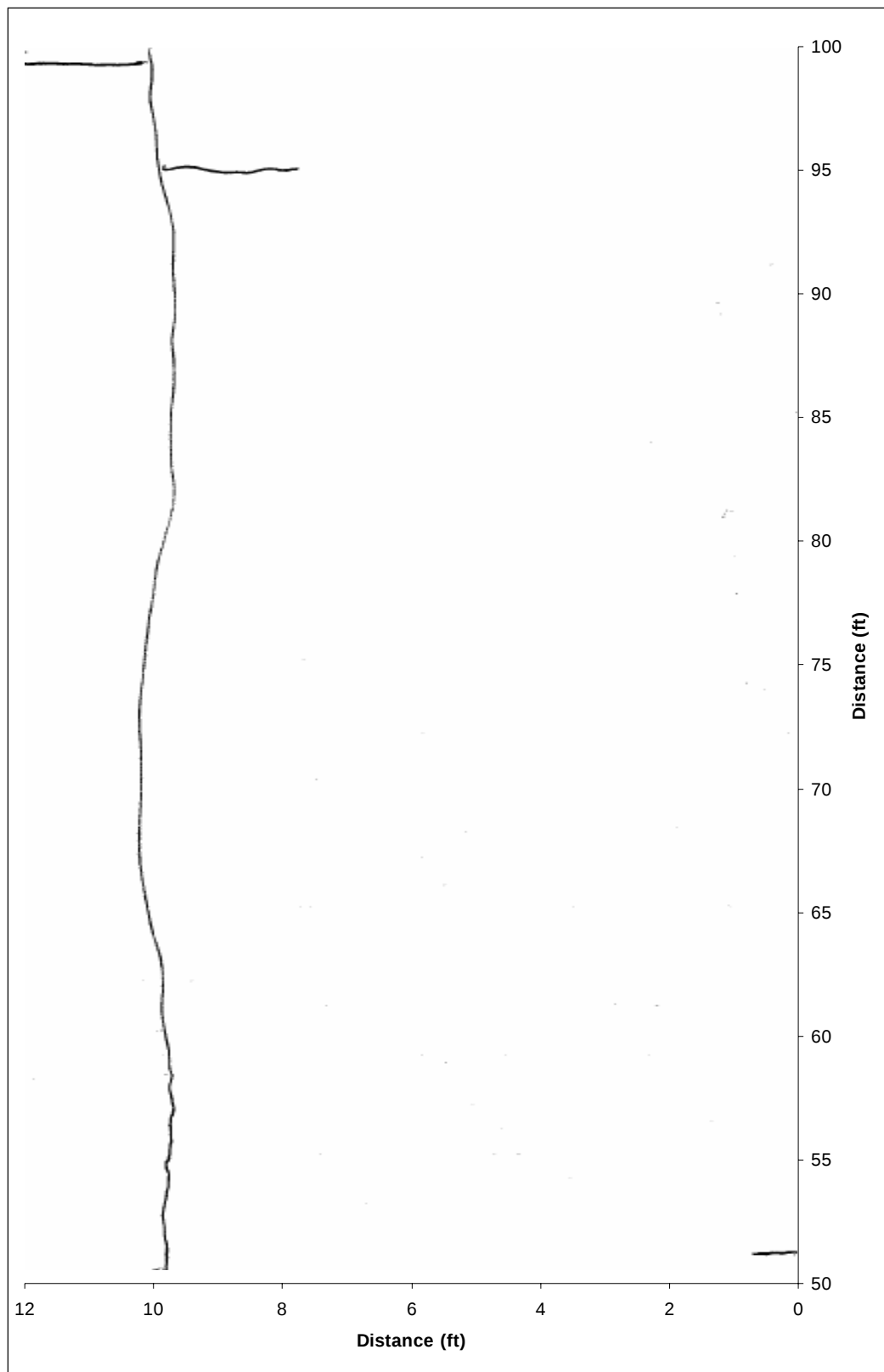


Figure 101. Lawson AAF Section 14 (Station 50-100 ft).

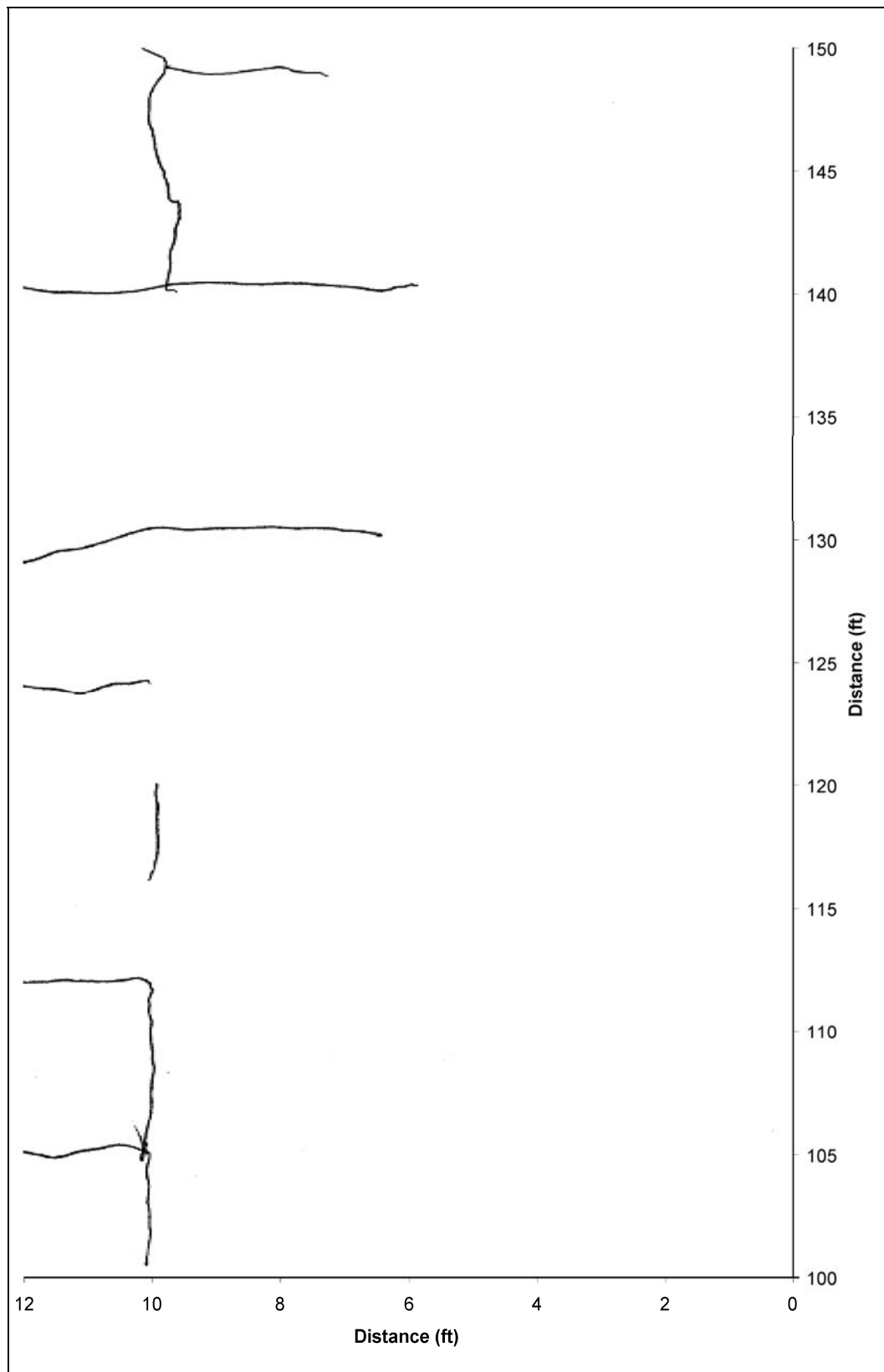


Figure 102. Lawson AAF Section 14 (Station 100-150 ft).

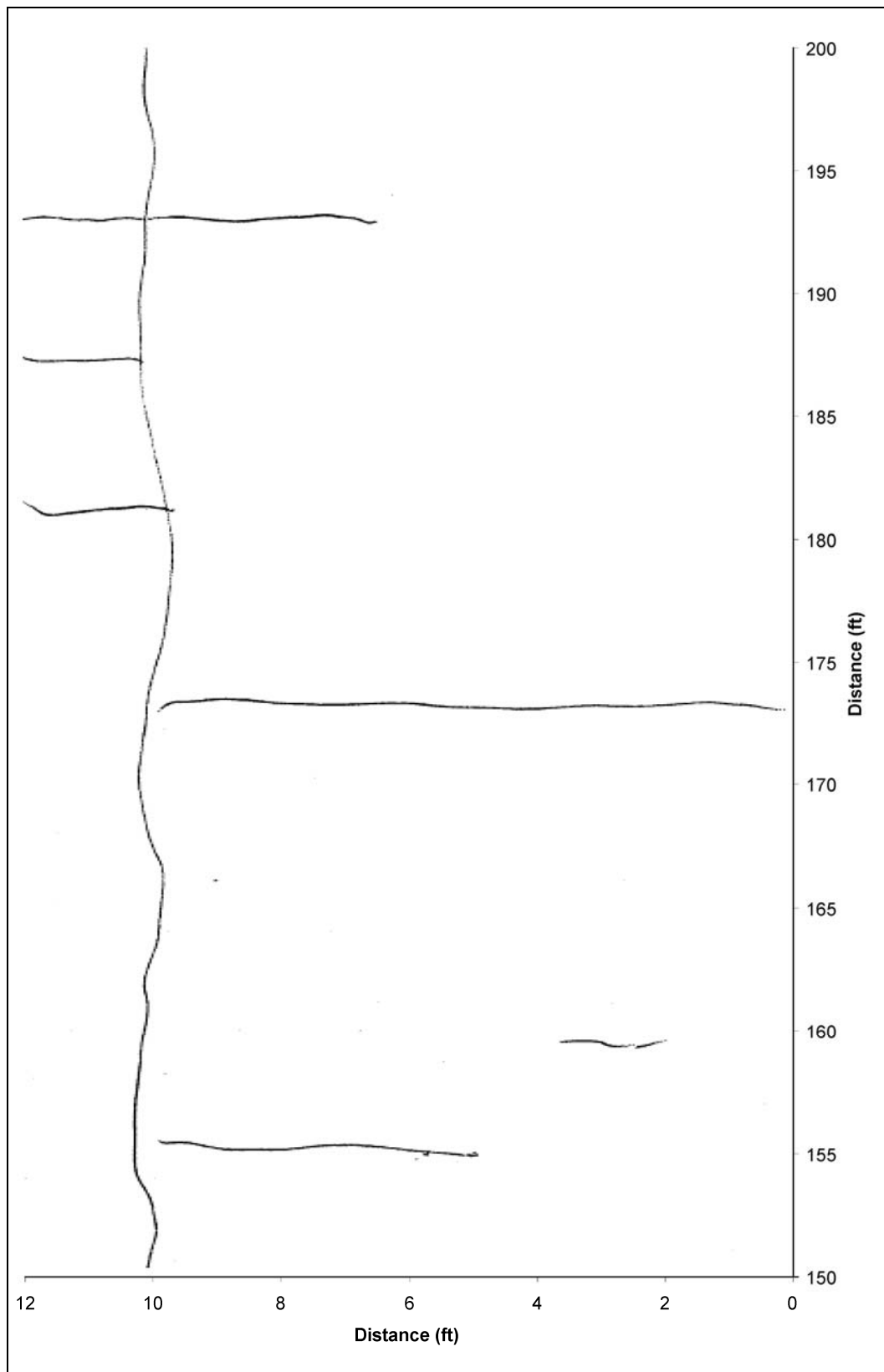


Figure 103. Lawson AAF Section 14 (Station 150-200 ft).

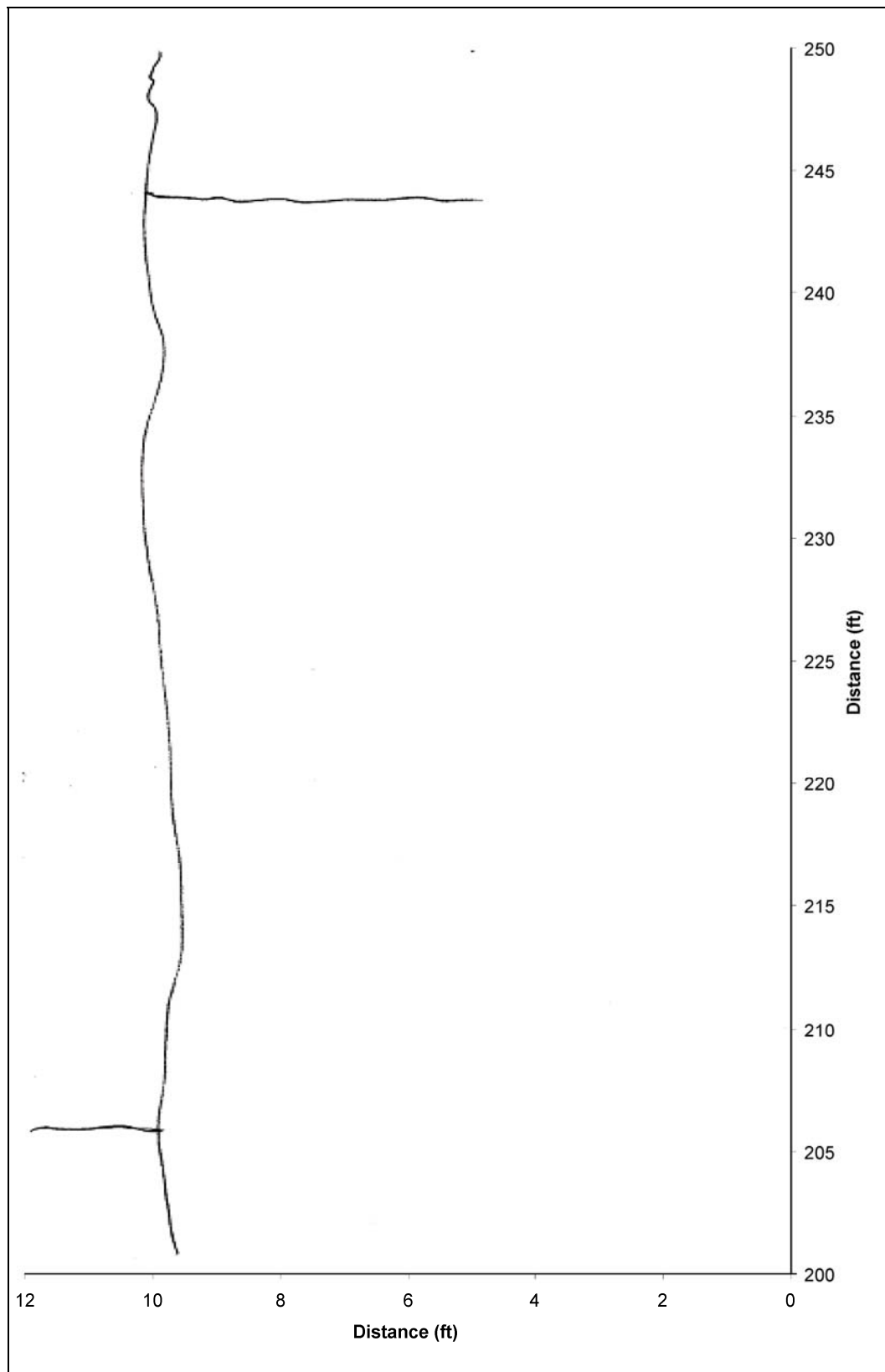


Figure 104. Lawson AAF Section 14 (Station 200-250 ft).

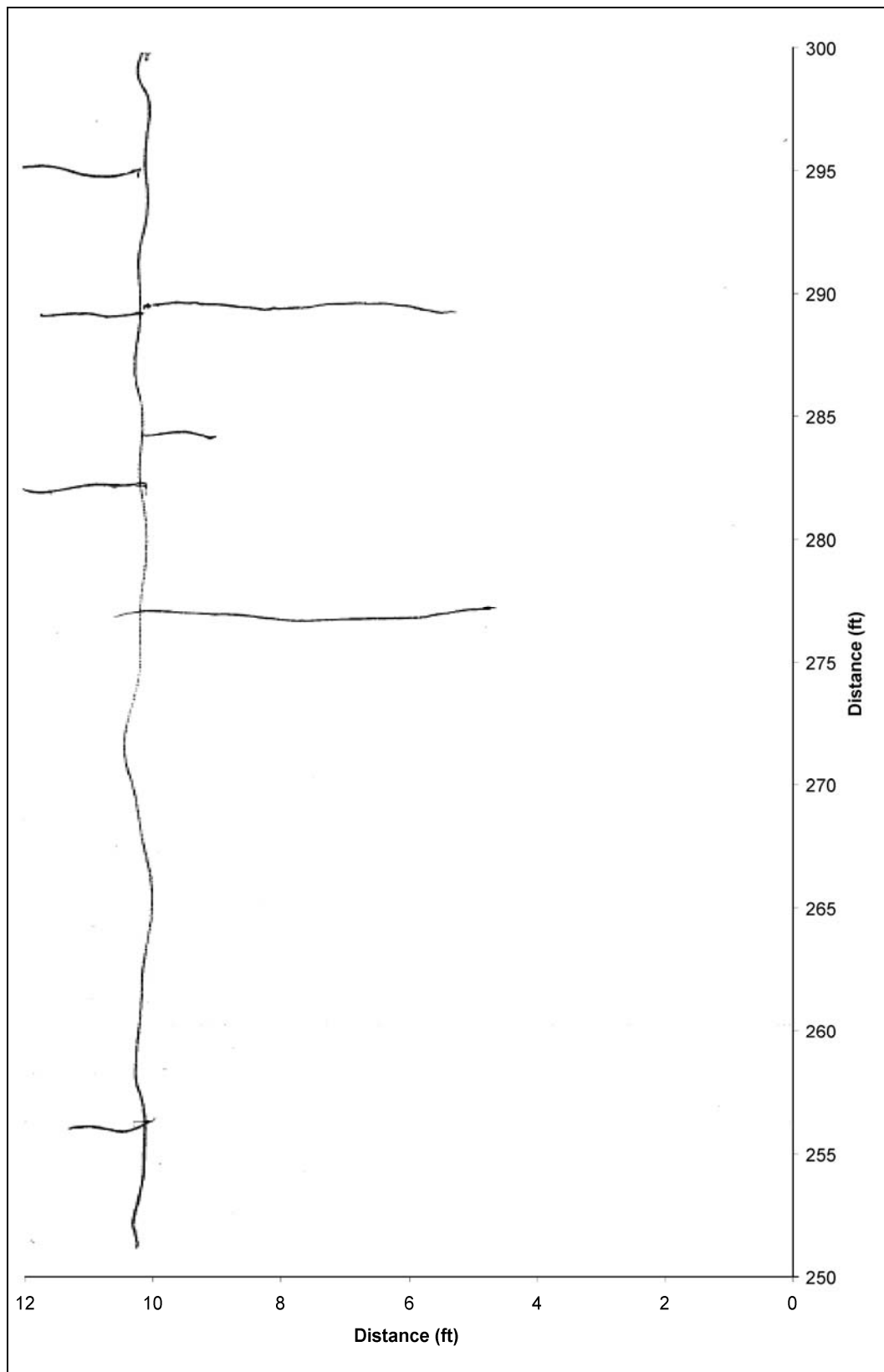


Figure 105. Lawson AAF Section 14 (Station 250-300 ft).

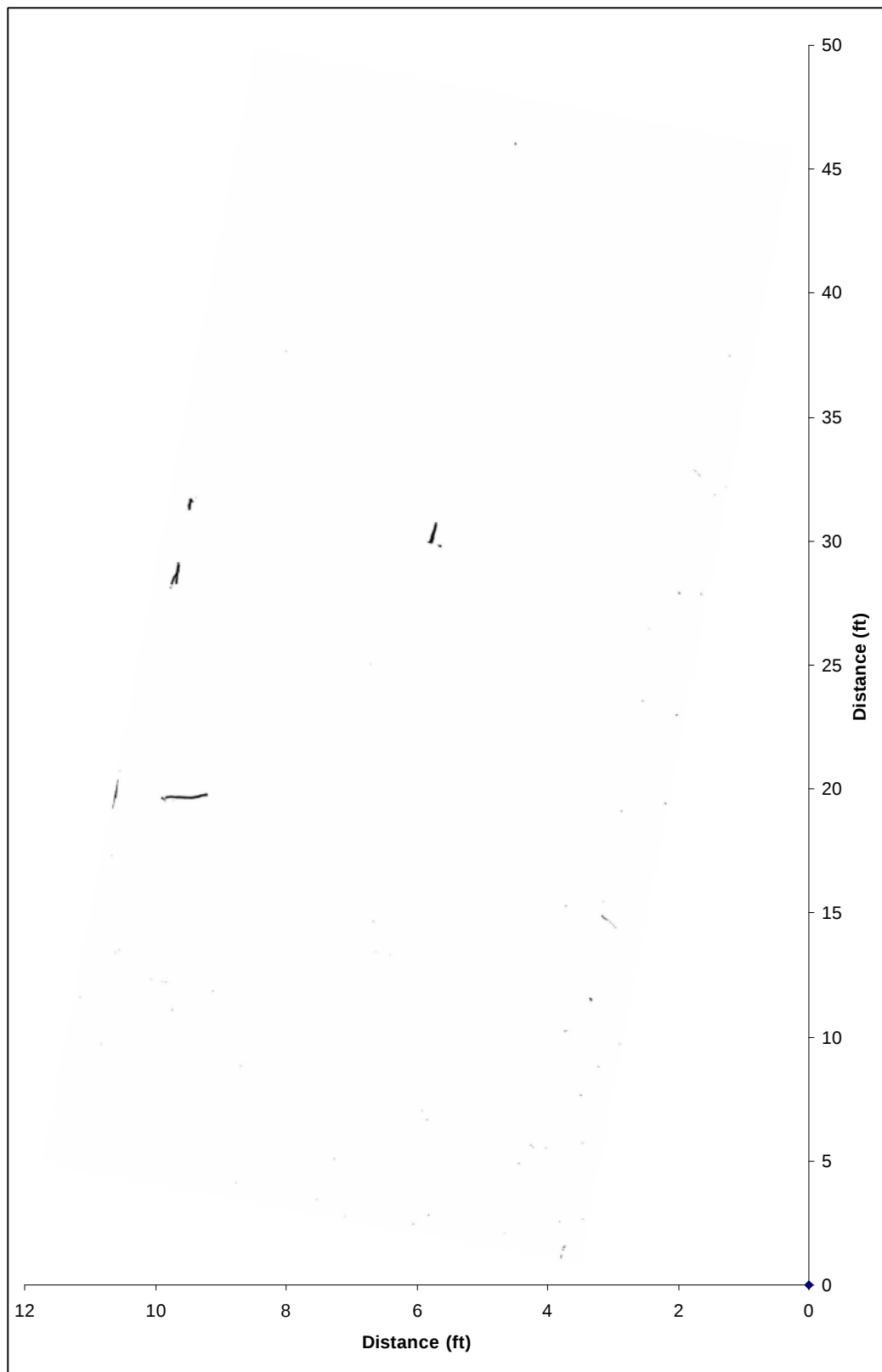


Figure 106. Robert Gray AAF Section 1 (Station 0-50 ft).

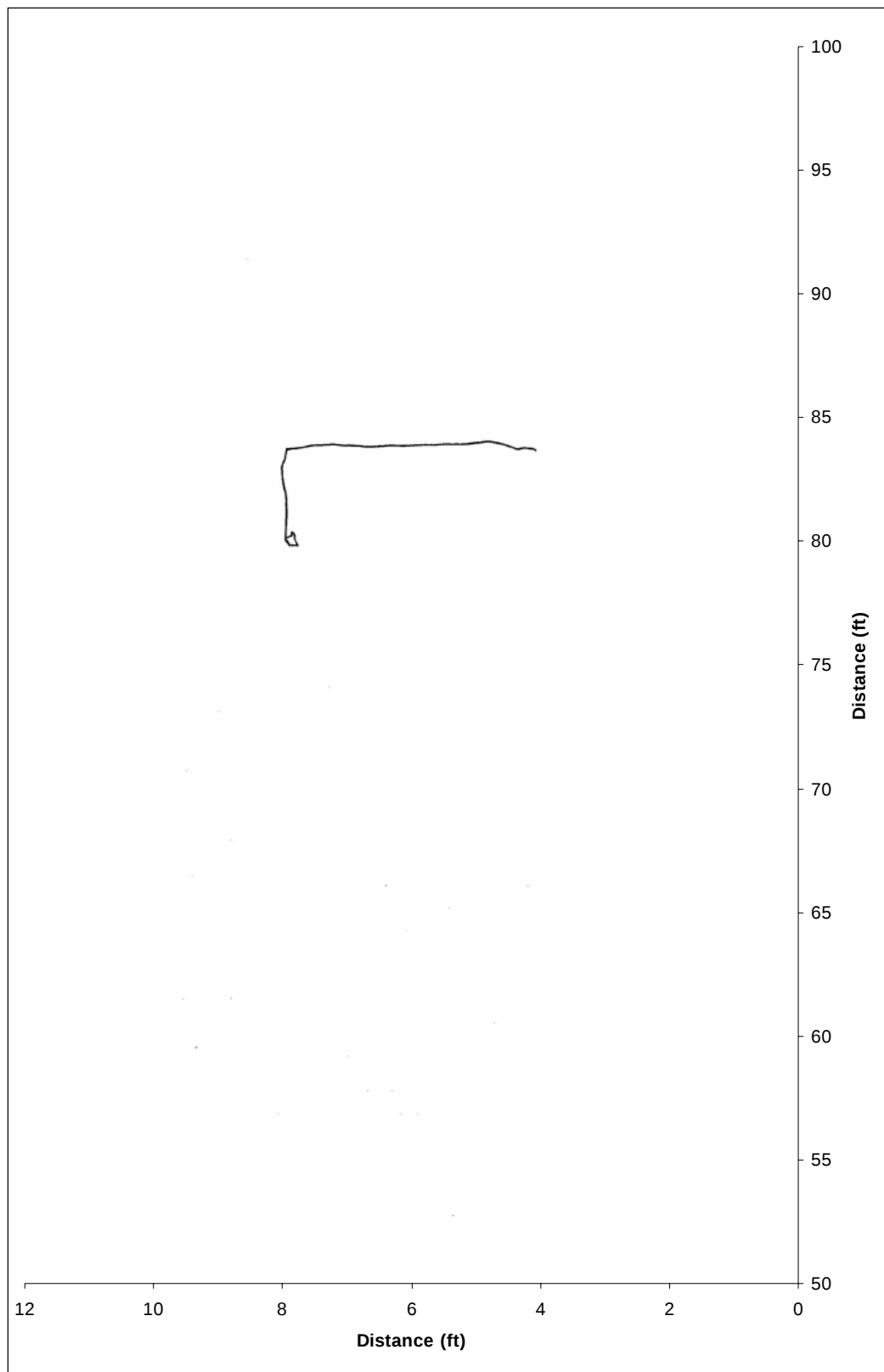


Figure 107. Robert Gray AAF Section 1 (Station 50-100 ft).

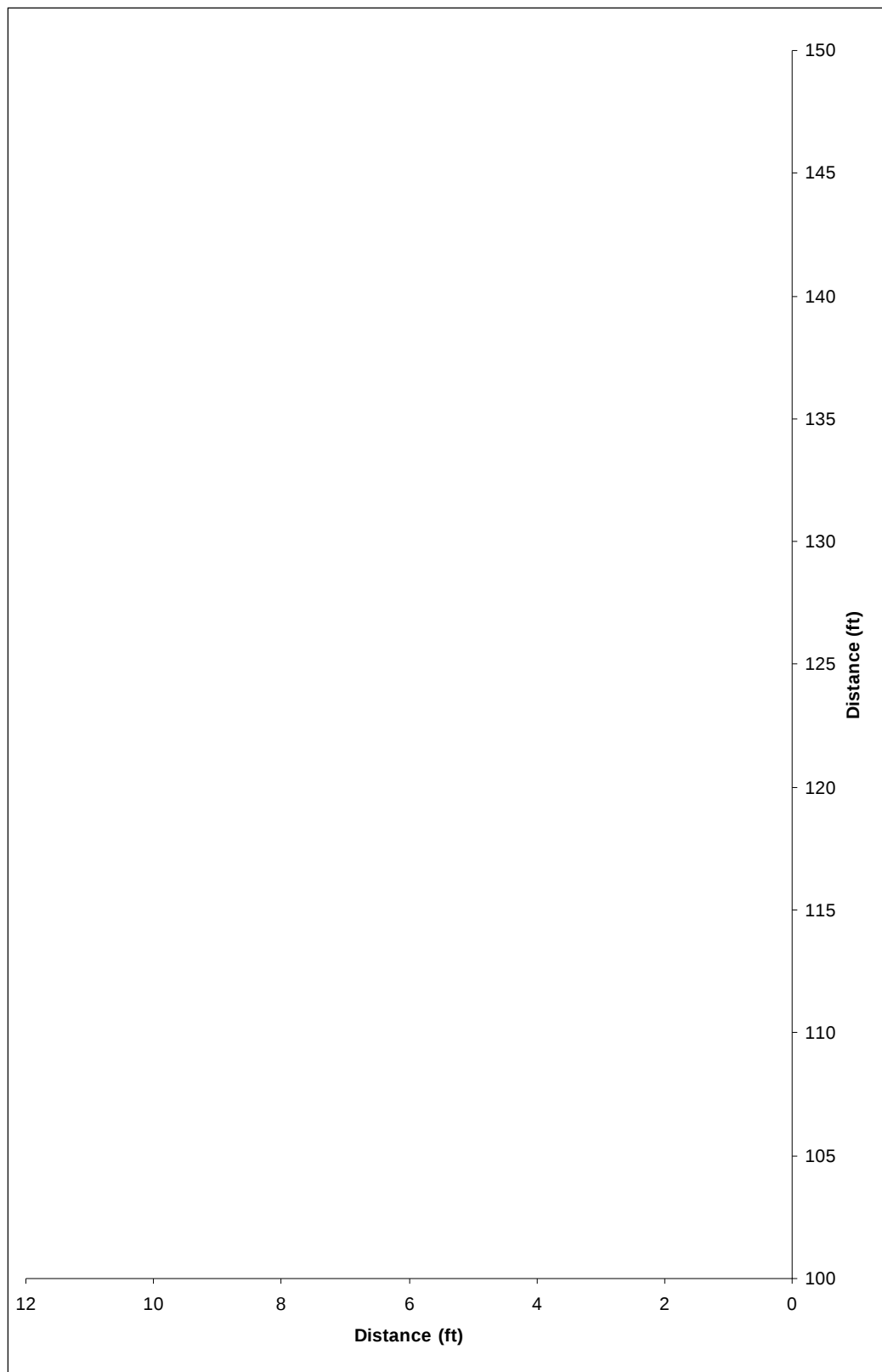


Figure 108. Robert Gray AAF Section 1 (Station 100-150 ft).

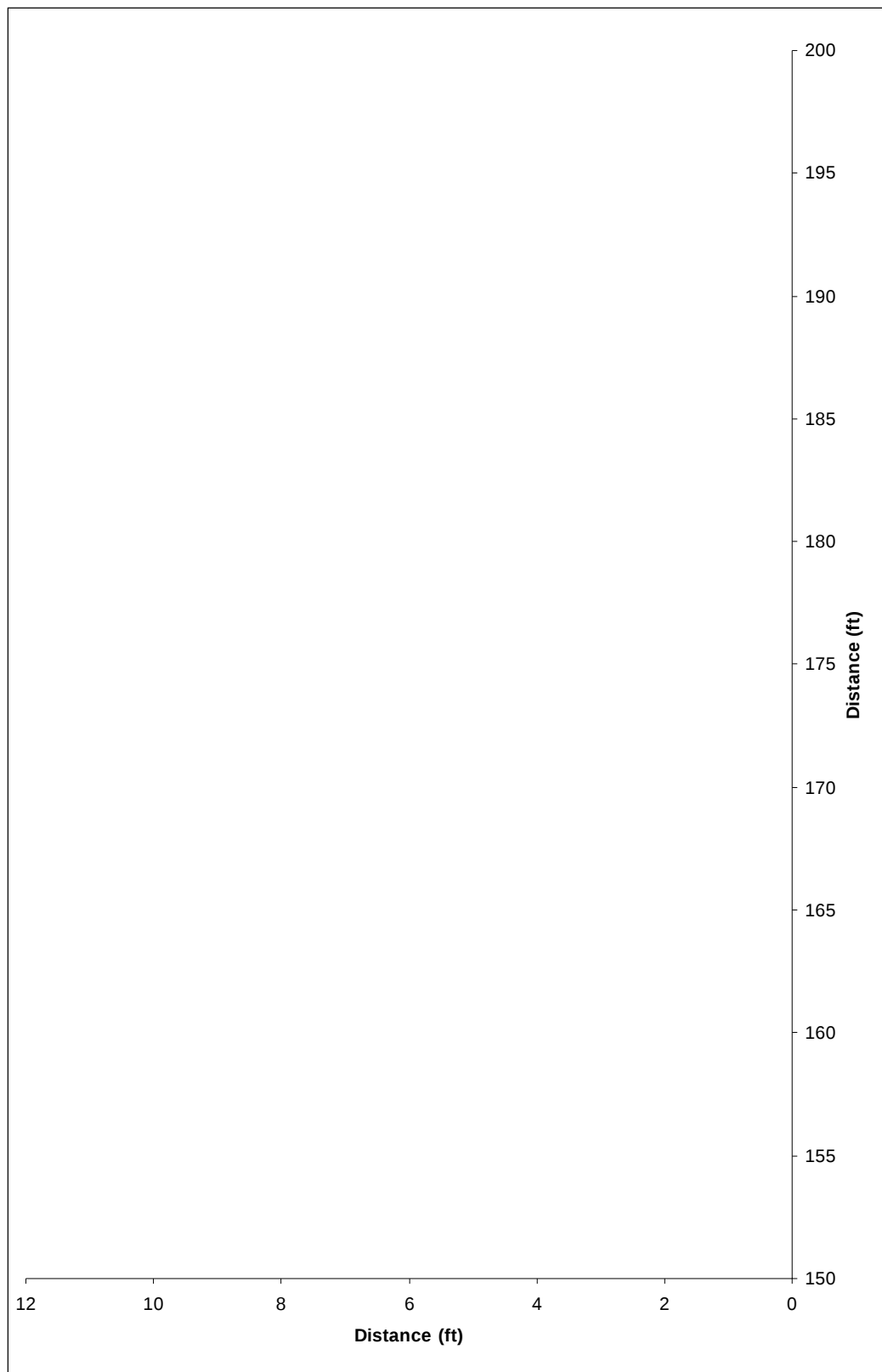


Figure 109. Robert Gray AAF Section 1 (Station 150-200 ft).

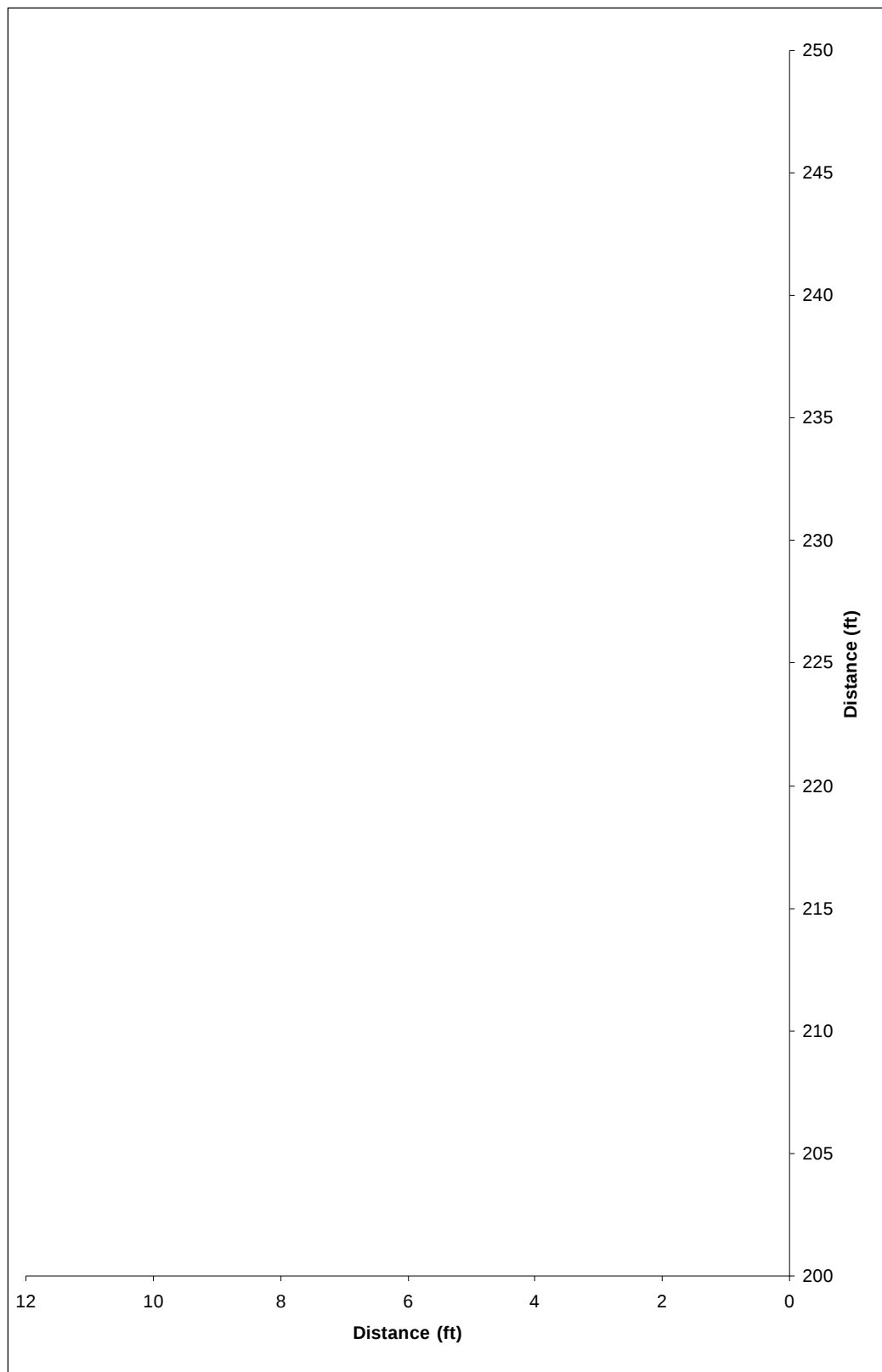


Figure 110. Robert Gray AAF Section 1 (Station 200-250 ft).

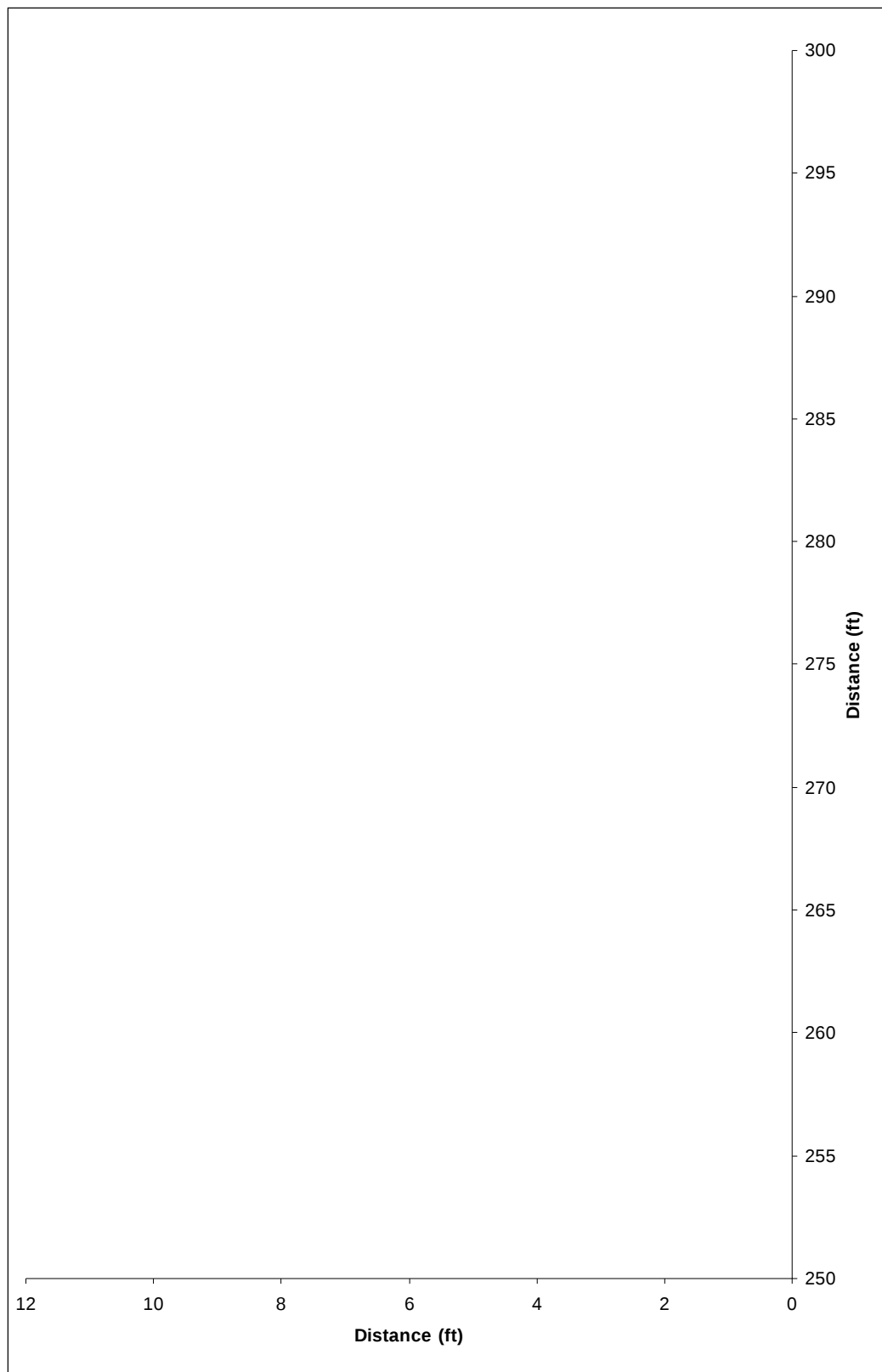


Figure 111. Robert Gray AAF Section 1 (Station 250-300 ft).

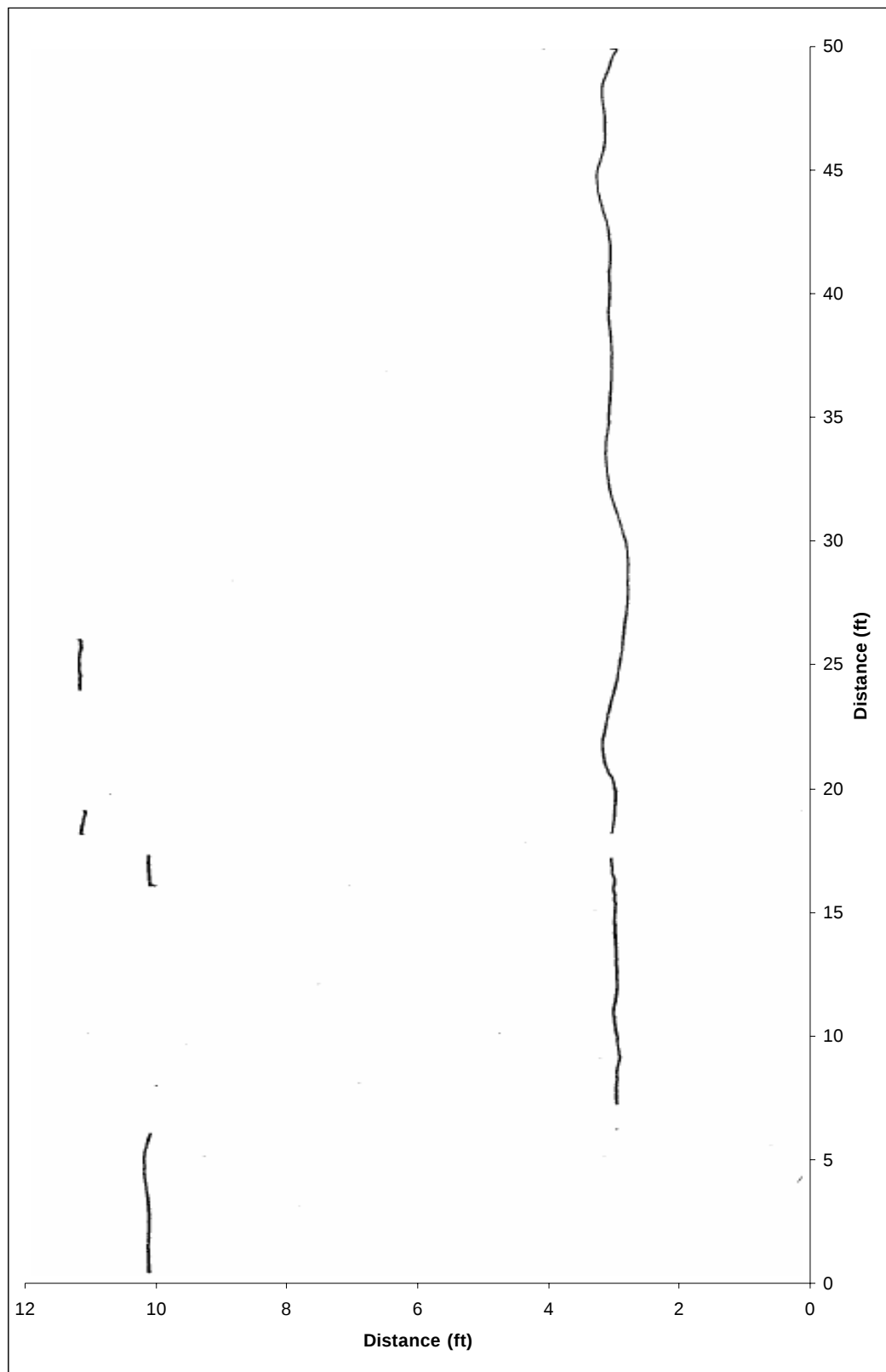


Figure 112. Robert Gray AAF Section 2 (Station 0-50 ft).

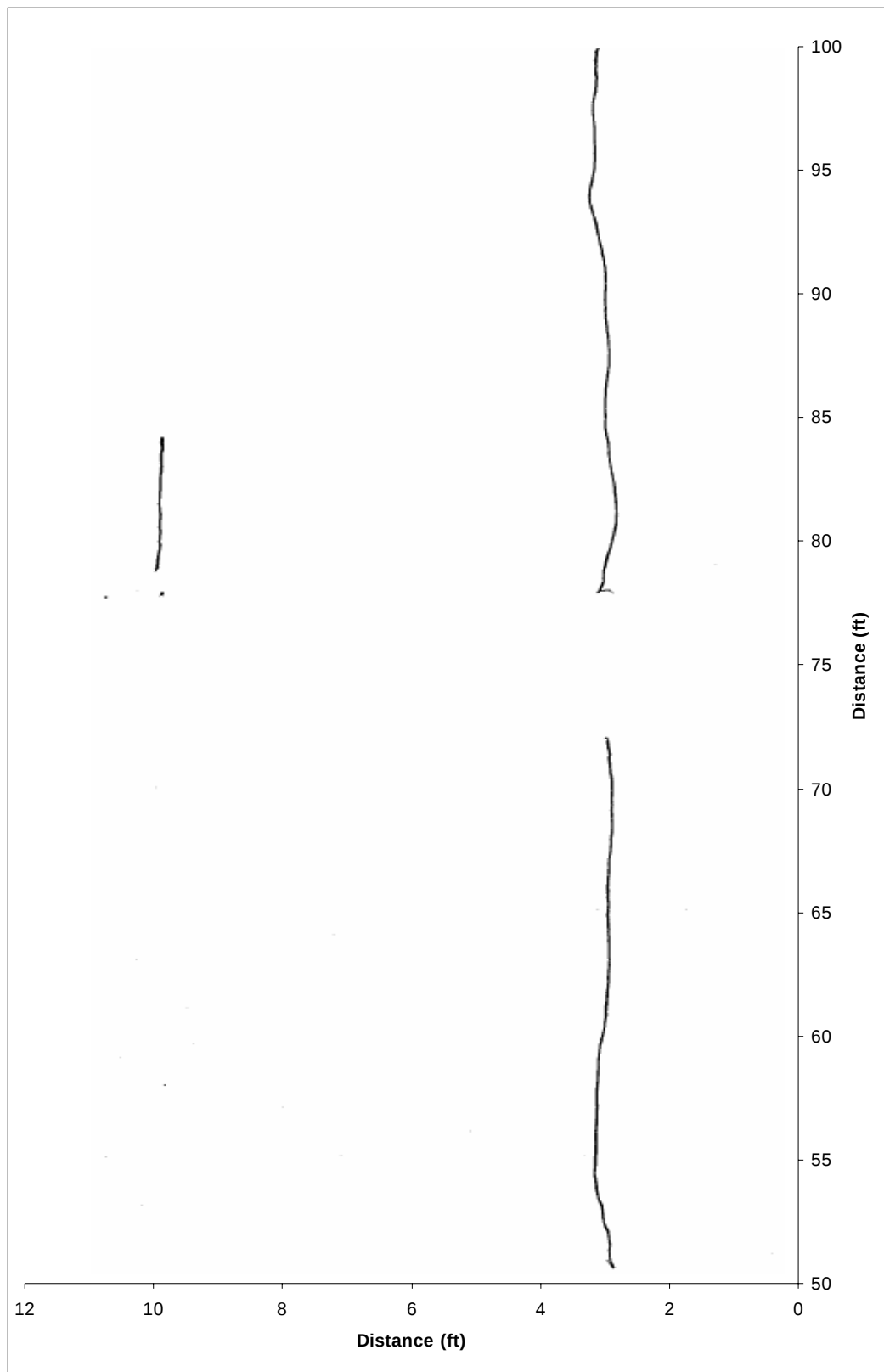


Figure 113. Robert Gray AAF Section 2 (Station 50-100 ft).

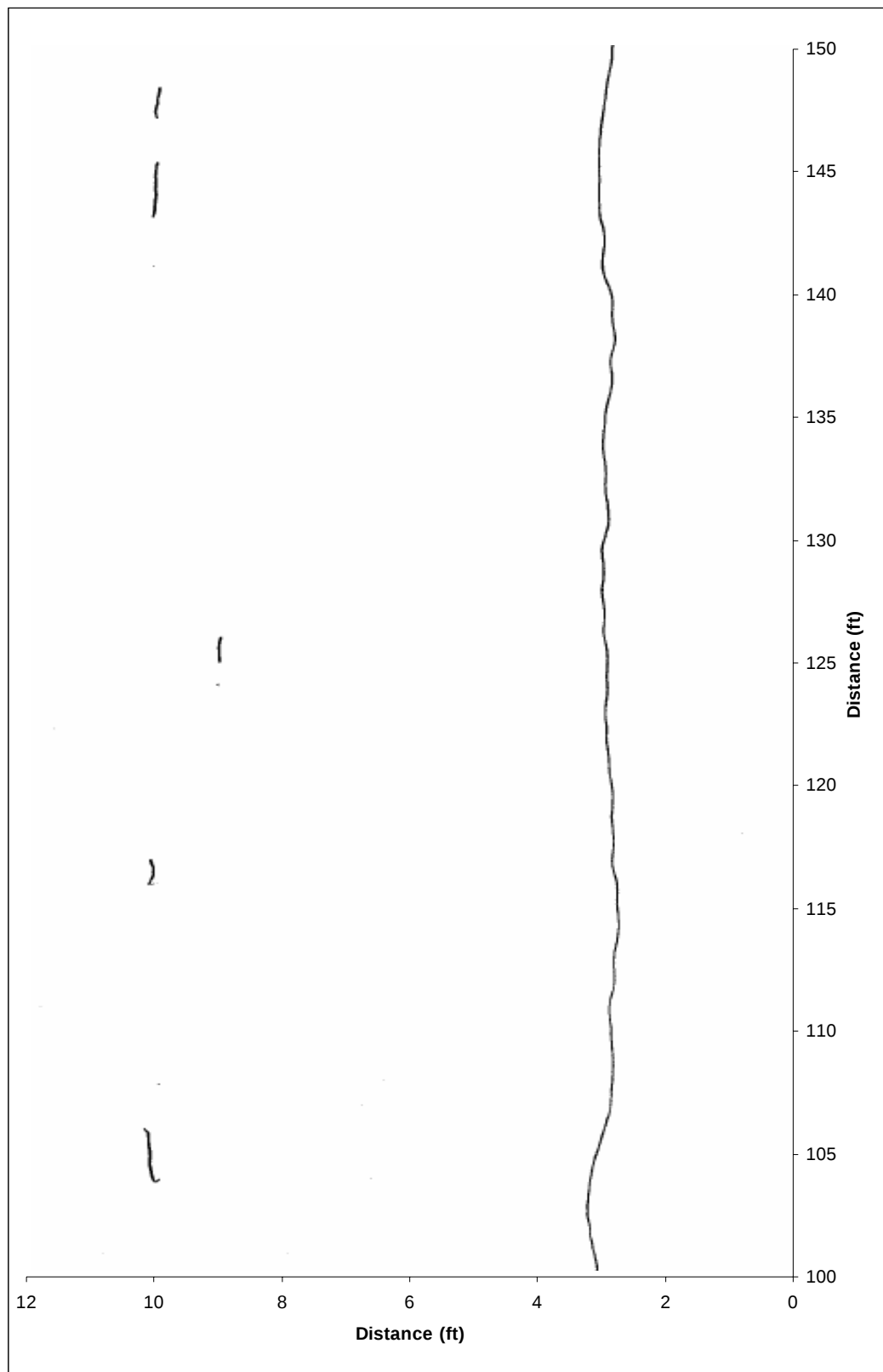


Figure 114. Robert Gray AAF Section 2 (Station 100-150 ft).

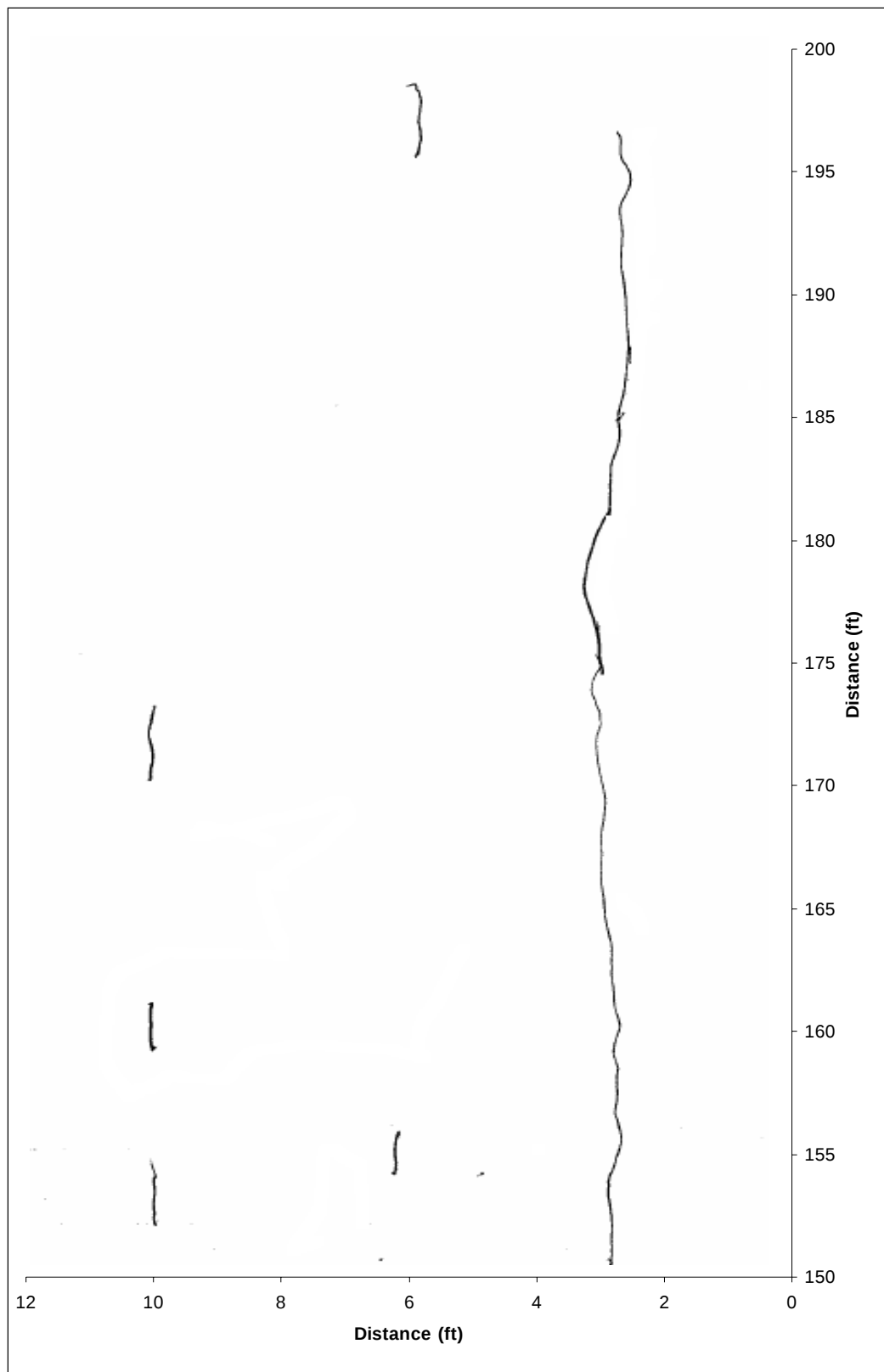


Figure 115. Robert Gray AAF Section 2 (Station 150-200 ft).

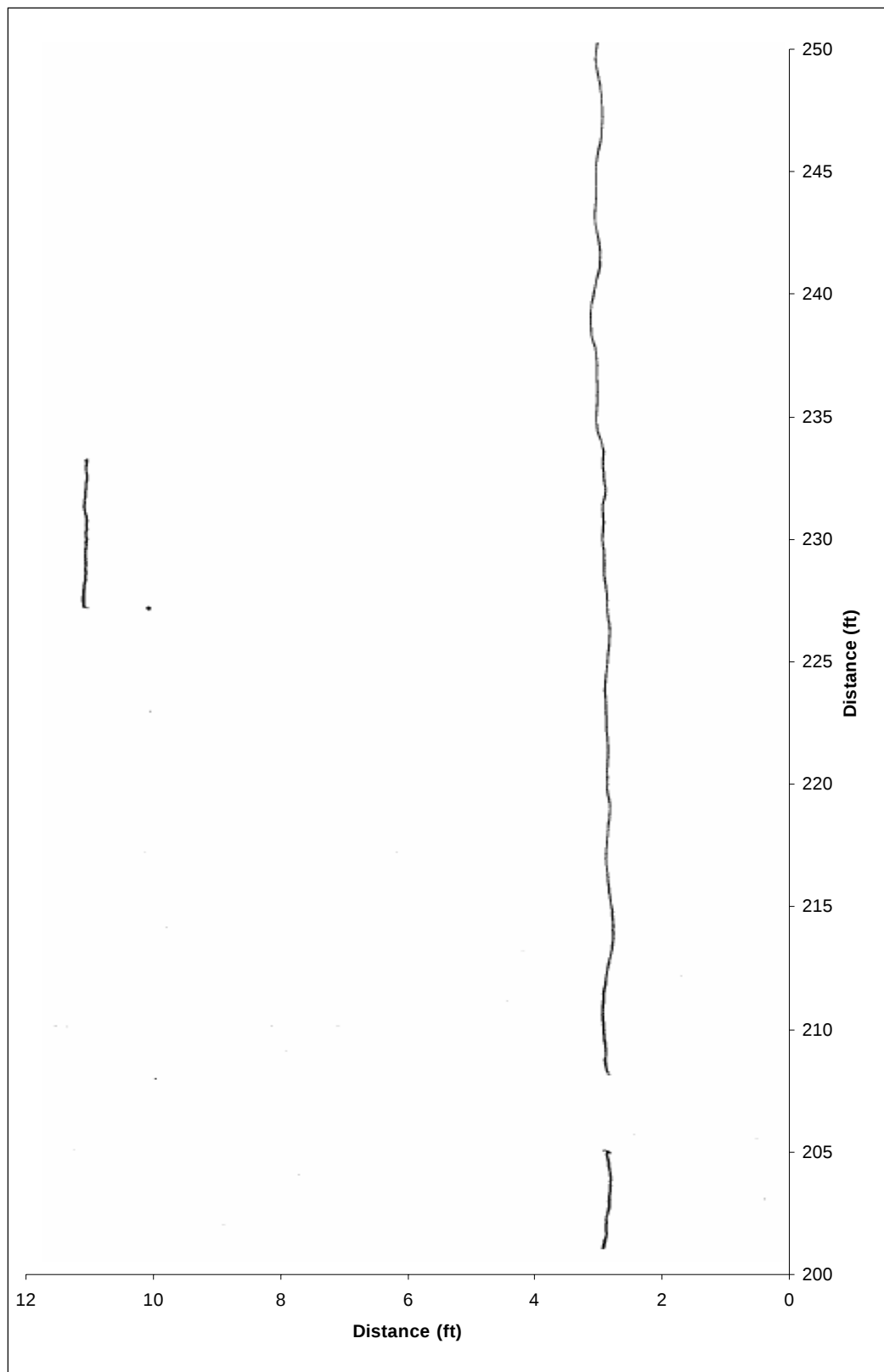


Figure 116. Robert Gray AAF Section 2 (Station 200-250 ft).

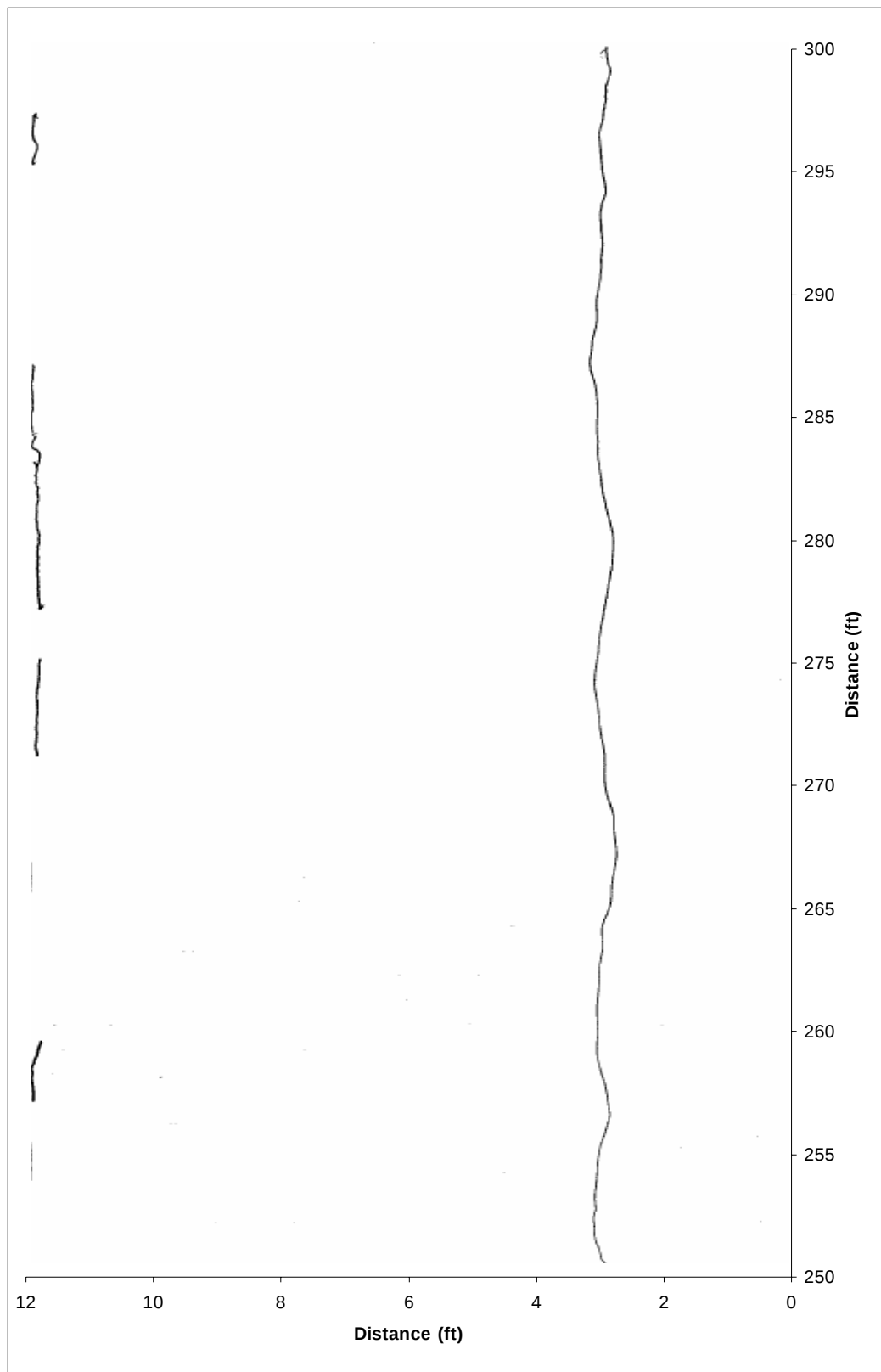


Figure 117. Robert Gray AAF Section 2 (Station 250-300 ft).

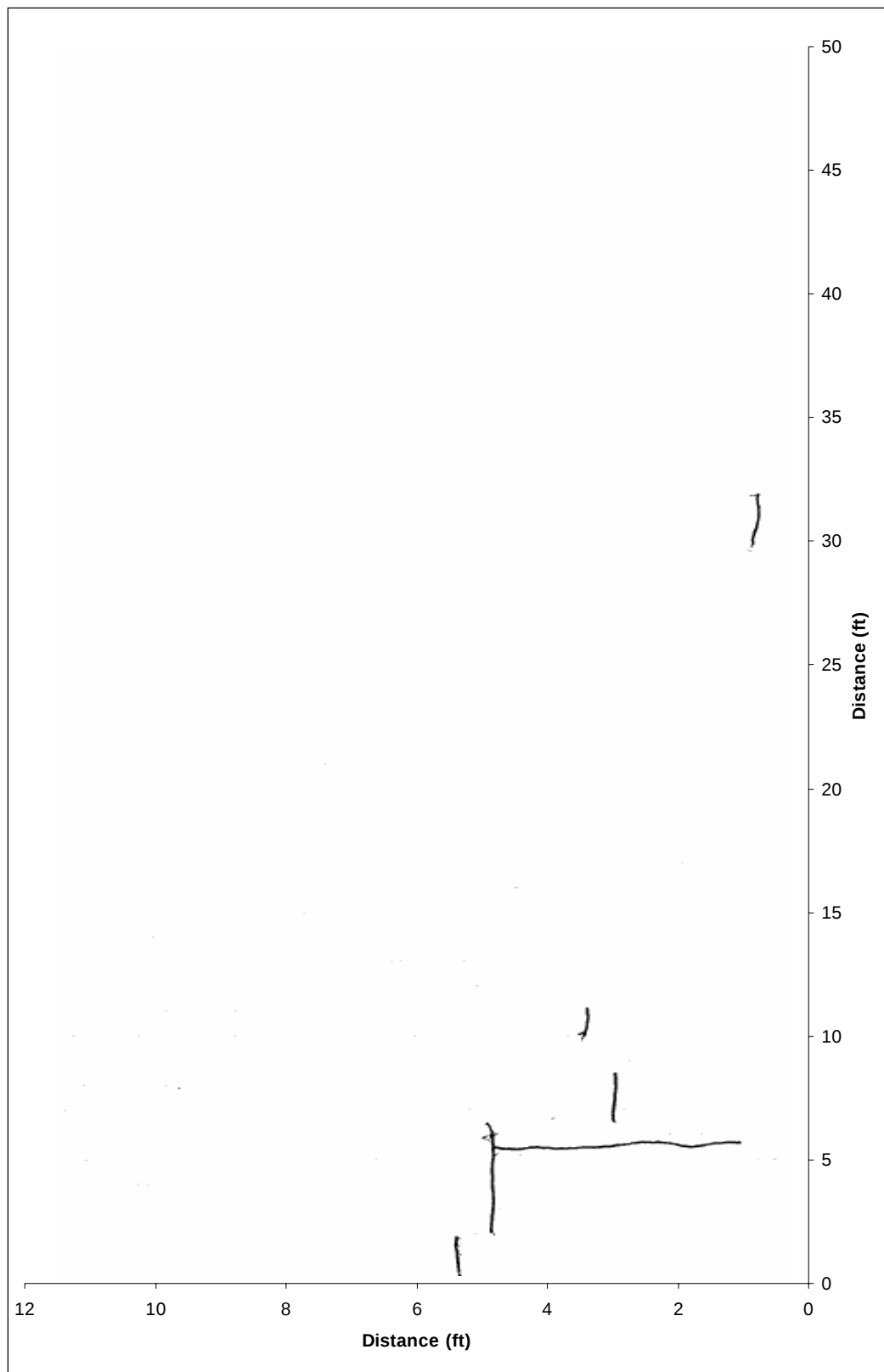


Figure 118. Robert Gray AAF Section 3 (Station 0-50 ft).

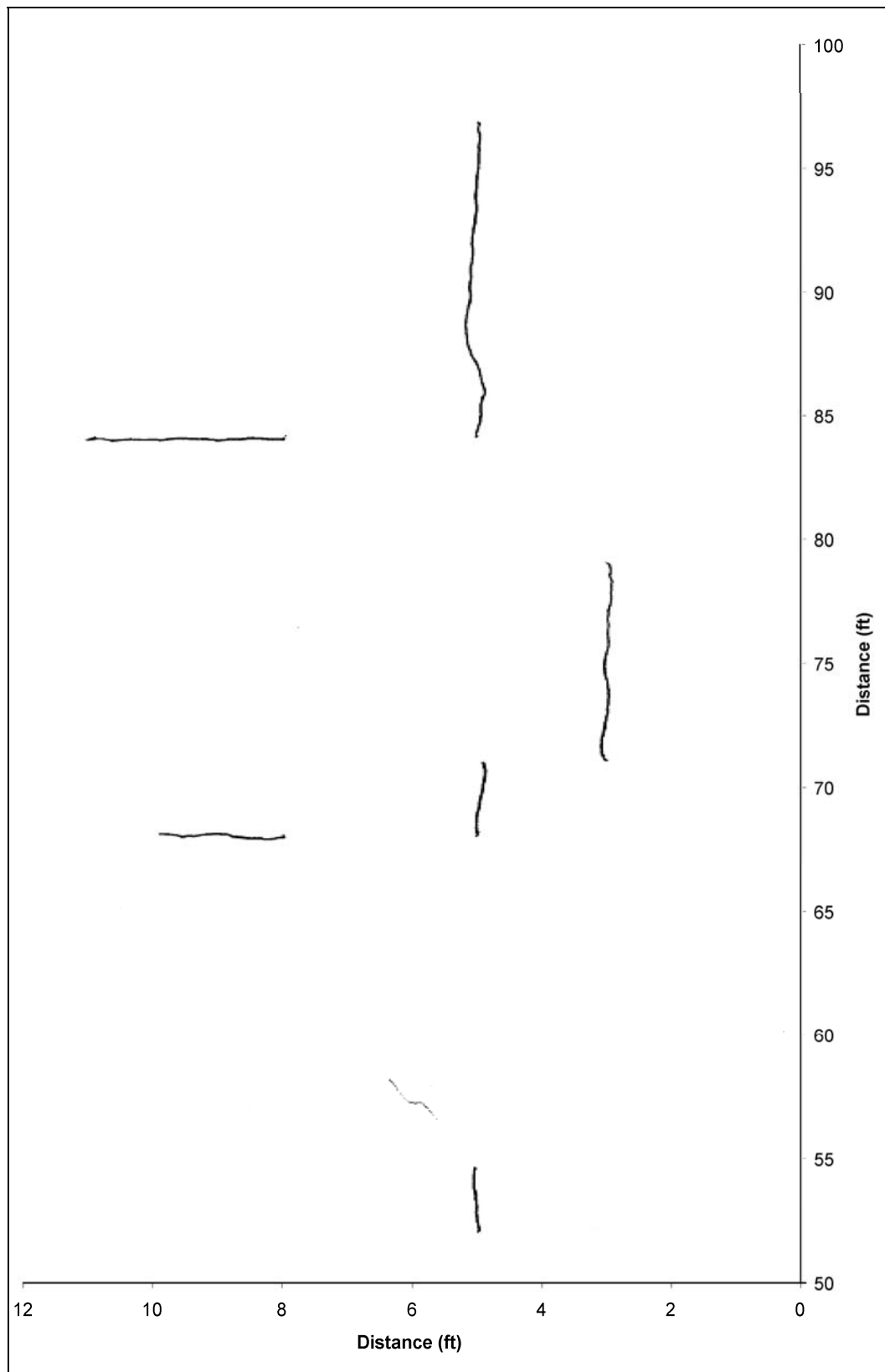


Figure 119. Robert Gray AAF Section 3 (Station 50-100 ft).

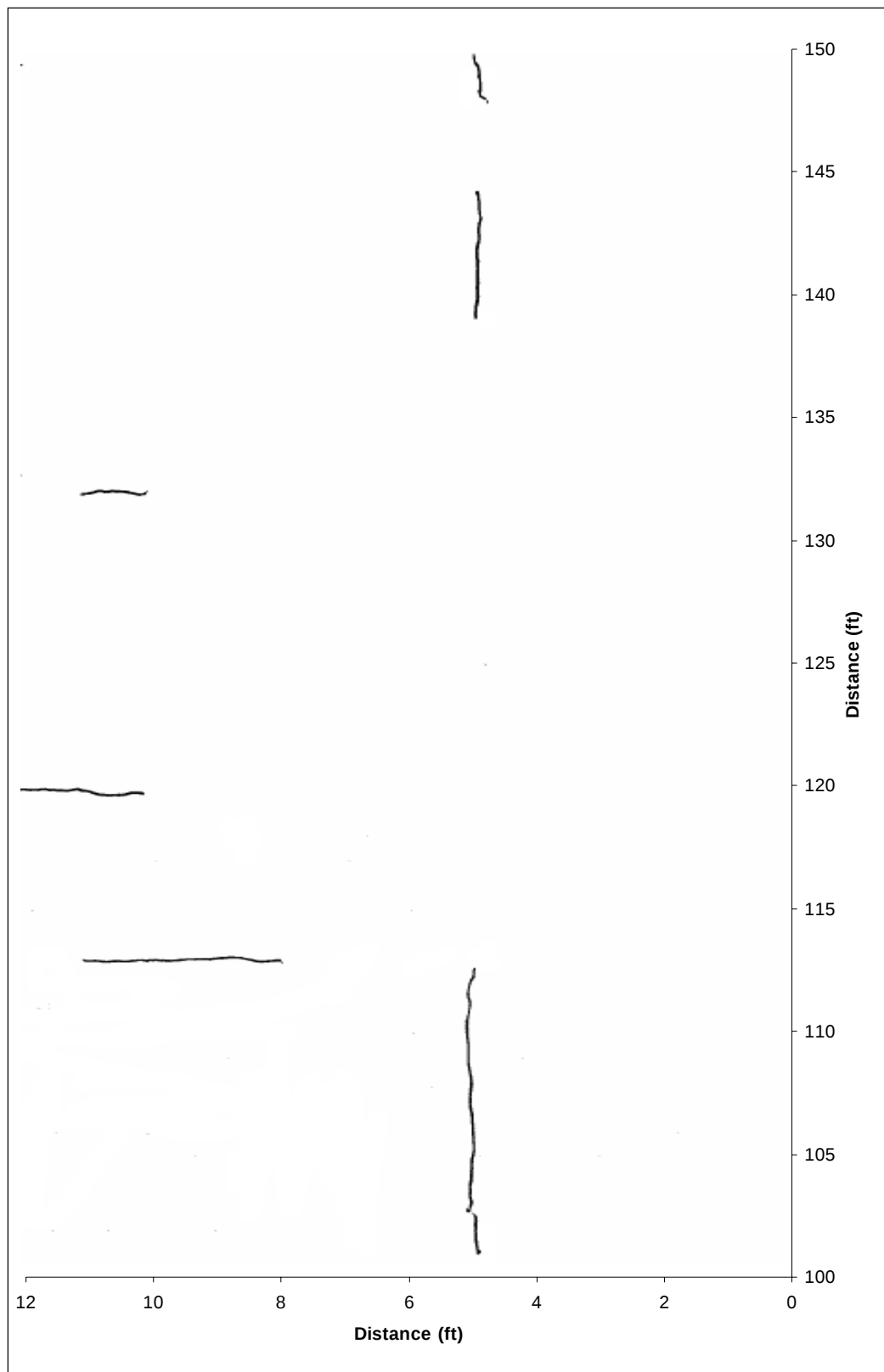


Figure 120. Robert Gray AAF Section 3 (Station 100-150 ft).

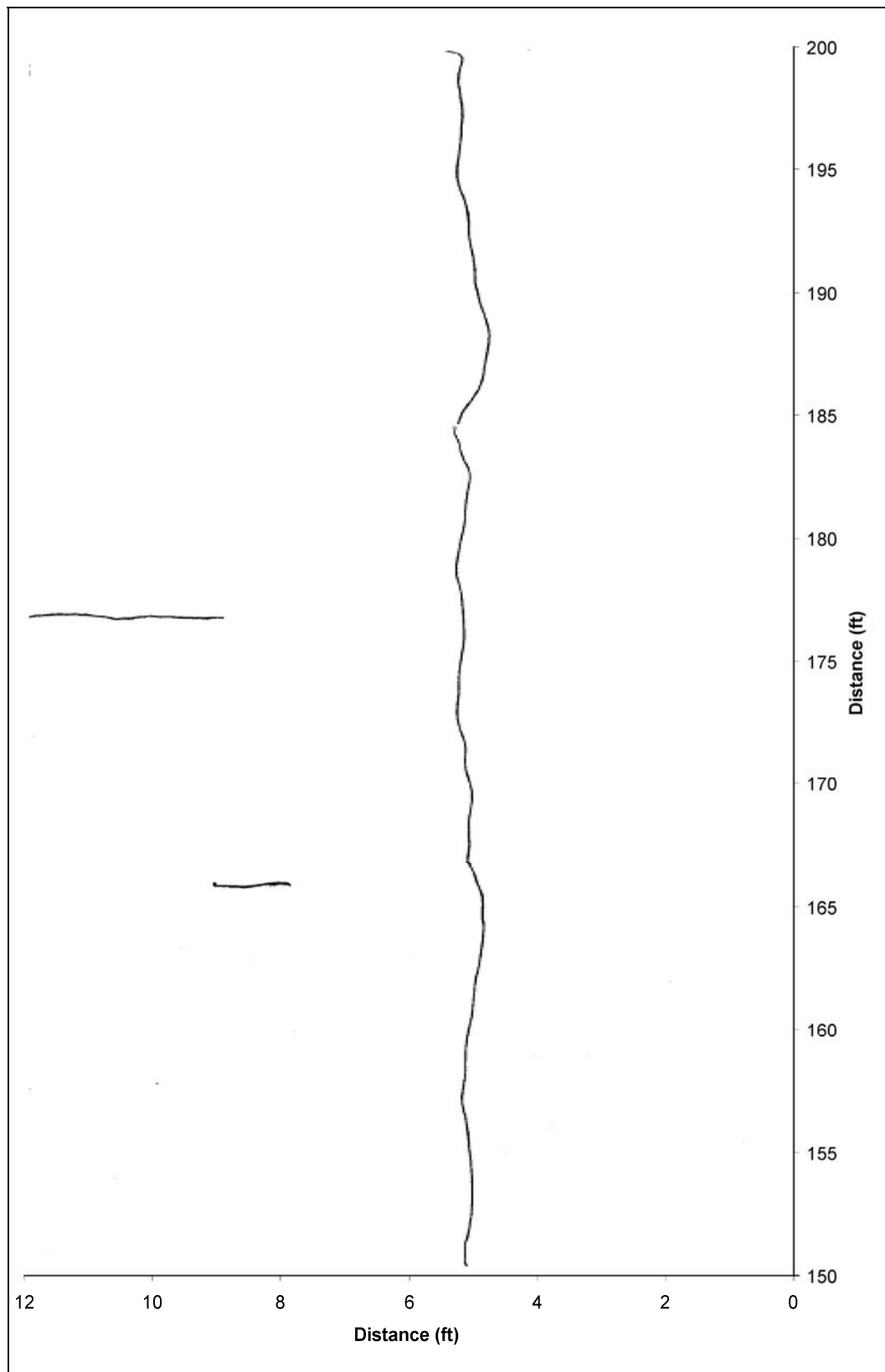


Figure 121. Robert Gray AAF Section 3 (Station 150-200 ft).

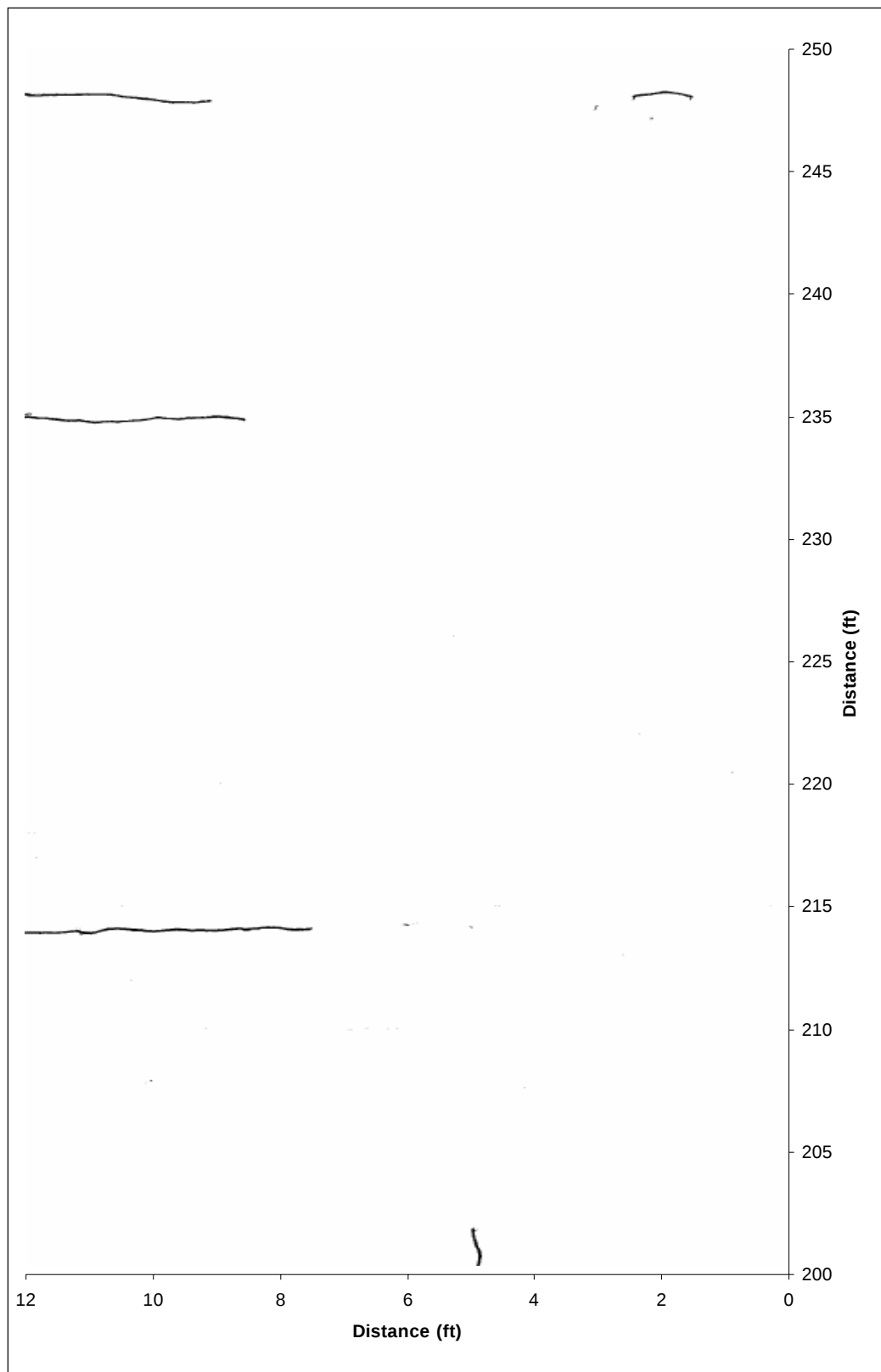


Figure 122. Robert Gray AAF Section 3 (Station 200-250 ft).

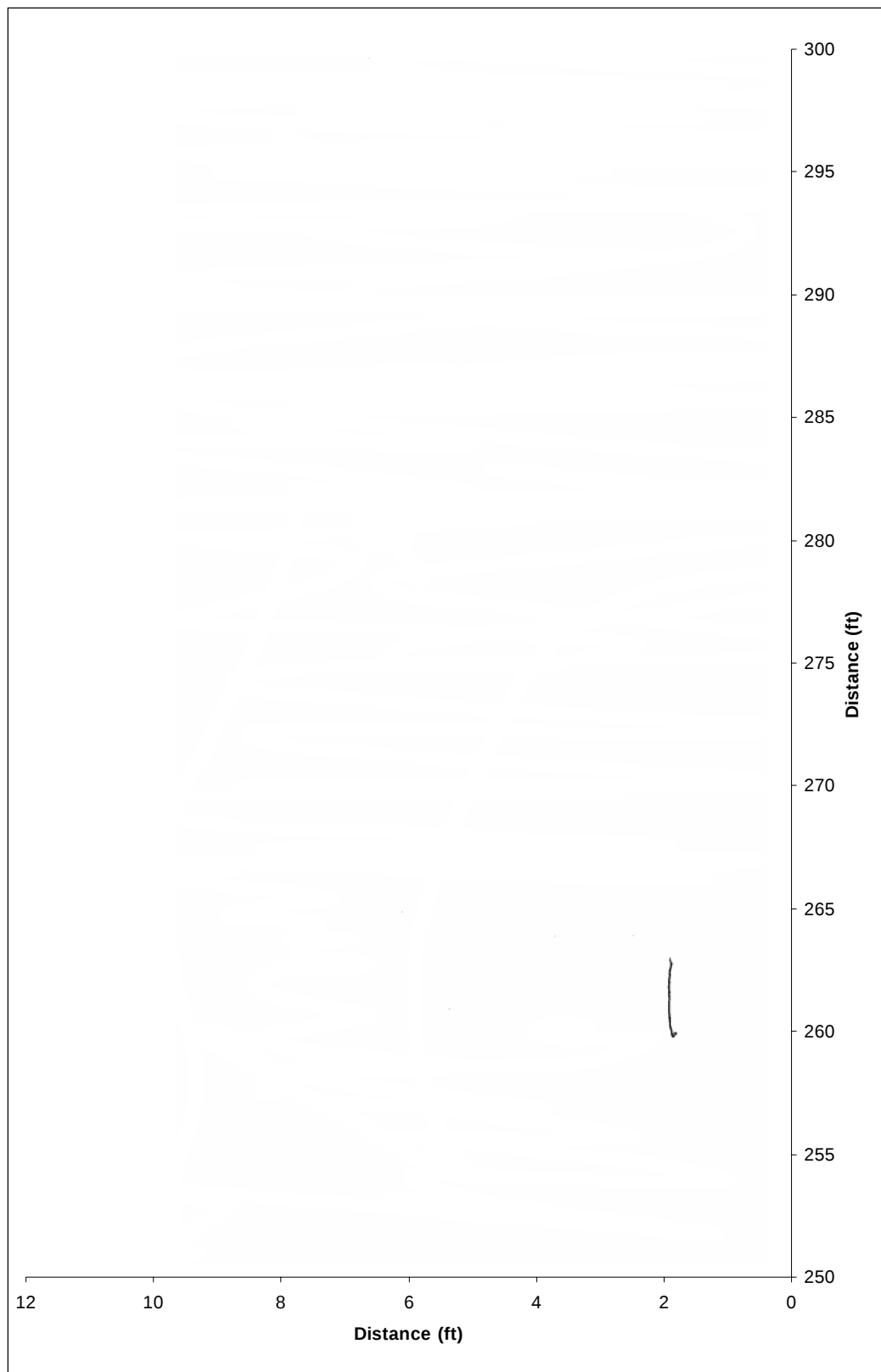


Figure 123. Robert Gray AAF Section 3 (Station 250-300 ft).

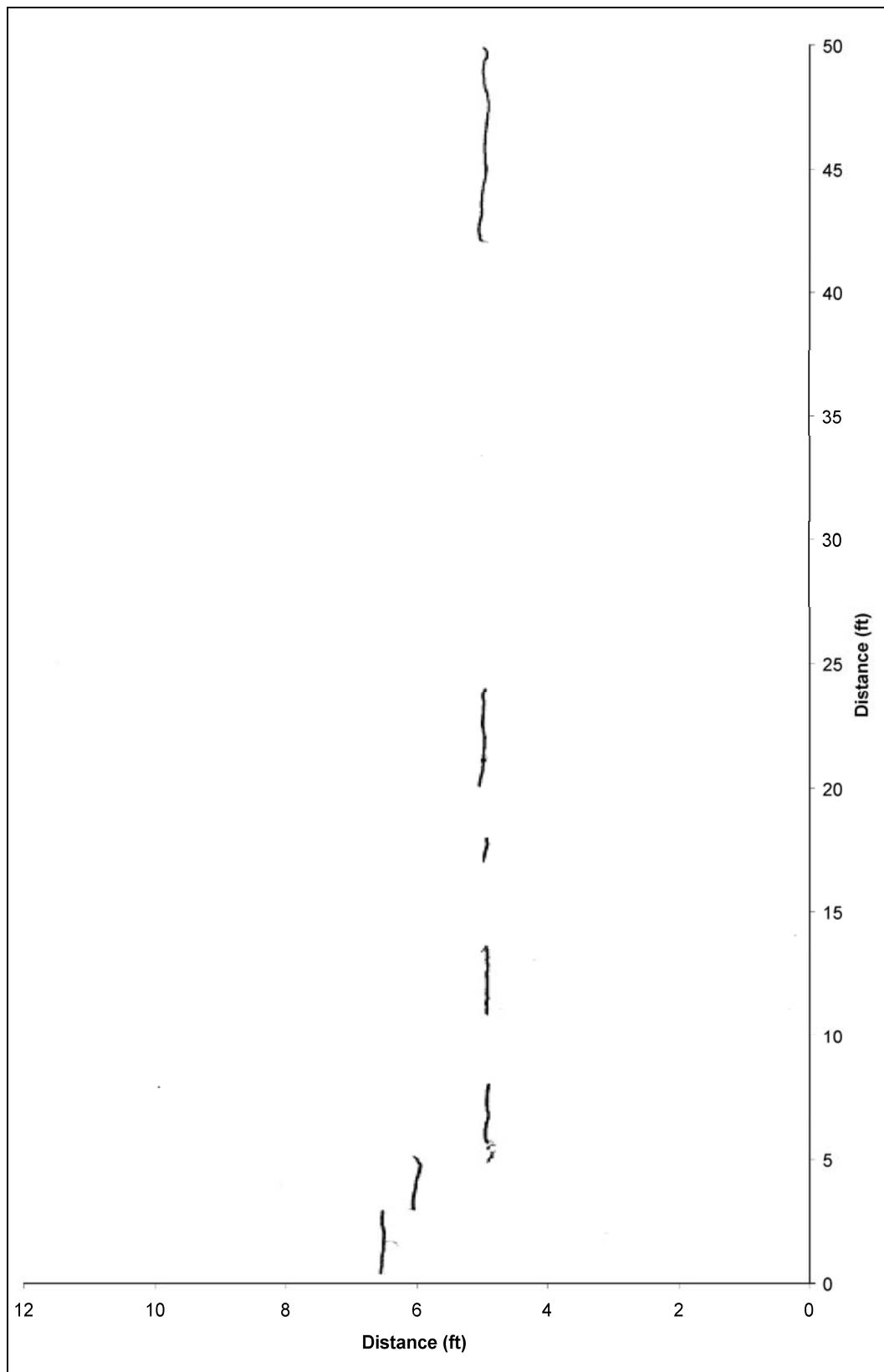


Figure 124. Robert Gray AAF Section 4 (Station 0-50 ft).

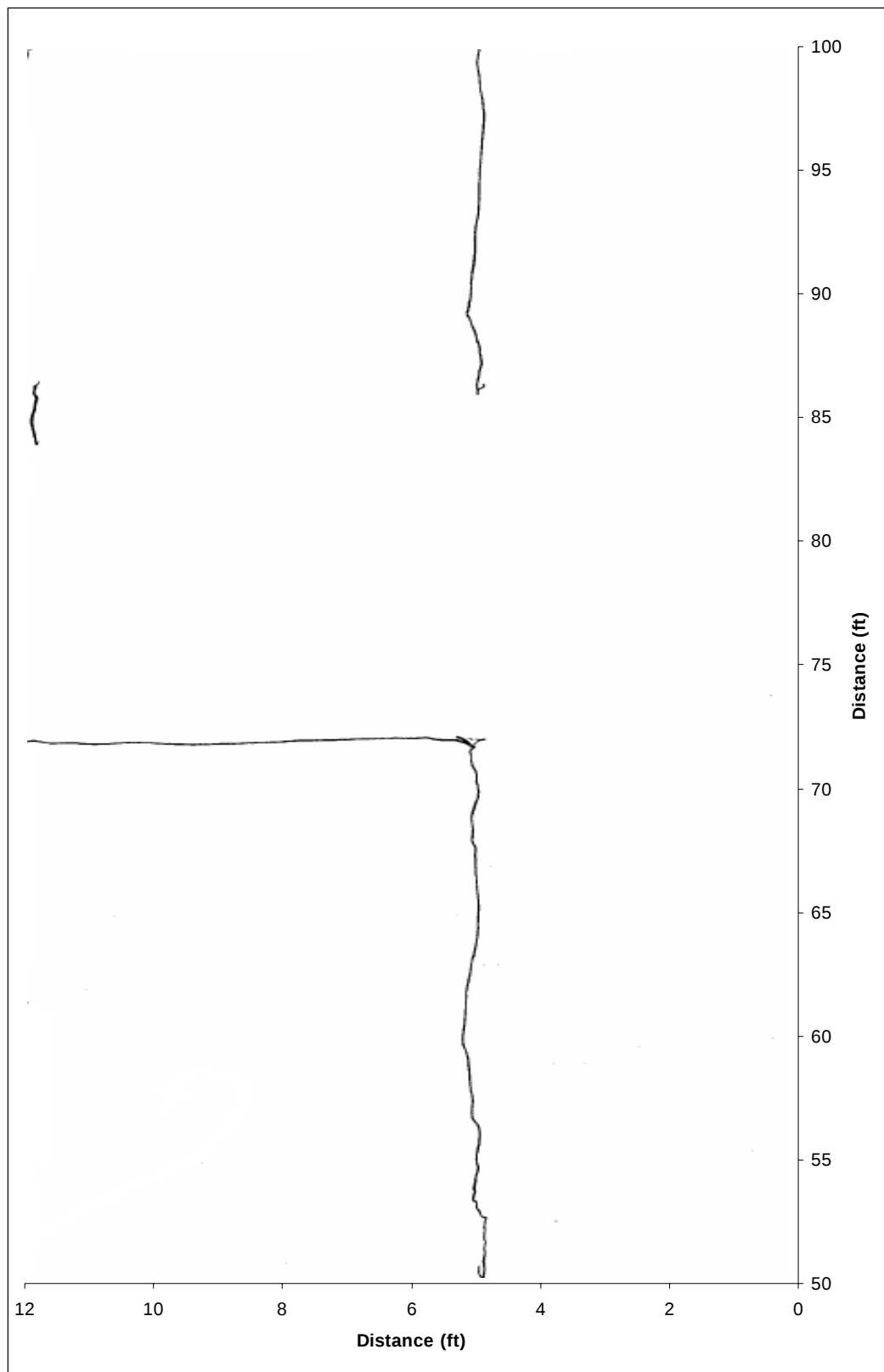


Figure 125. Robert Gray AAF Section 4 (Station 50-100 ft).

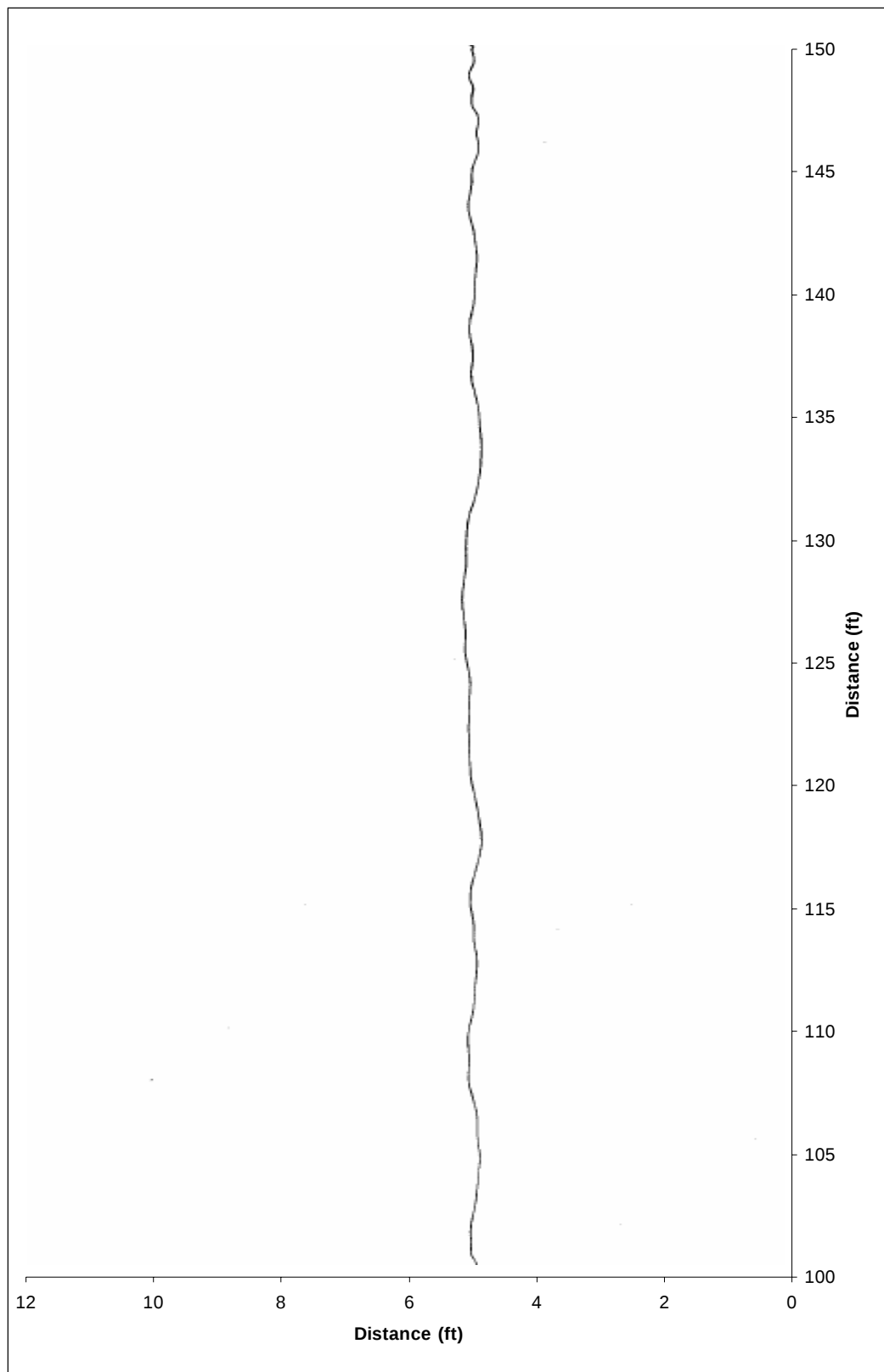


Figure 126. Robert Gray AAF Section 4 (Station 100-150 ft).

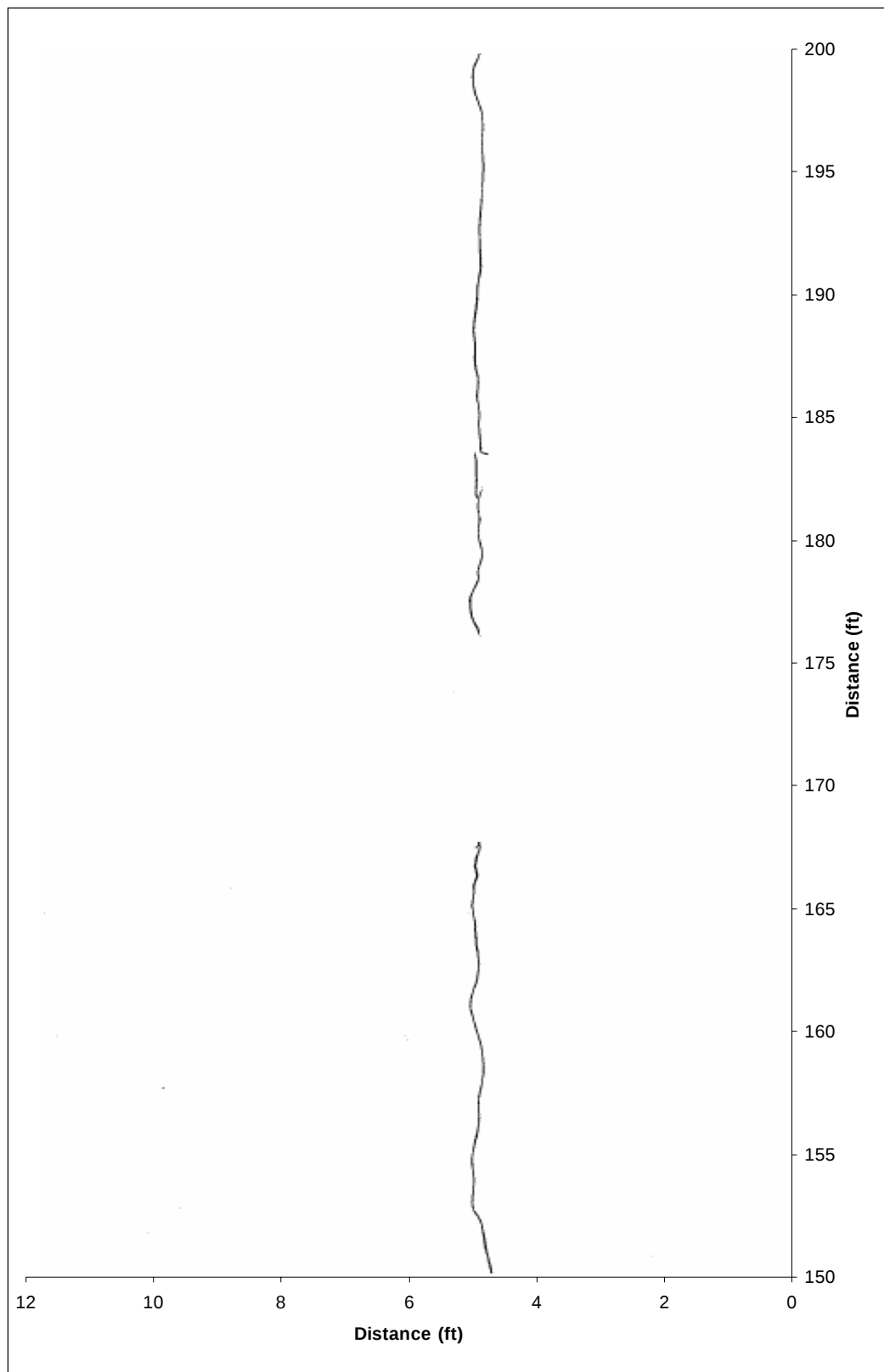


Figure 127. Robert Gray AAF Section 4 (Station 150-200 ft).

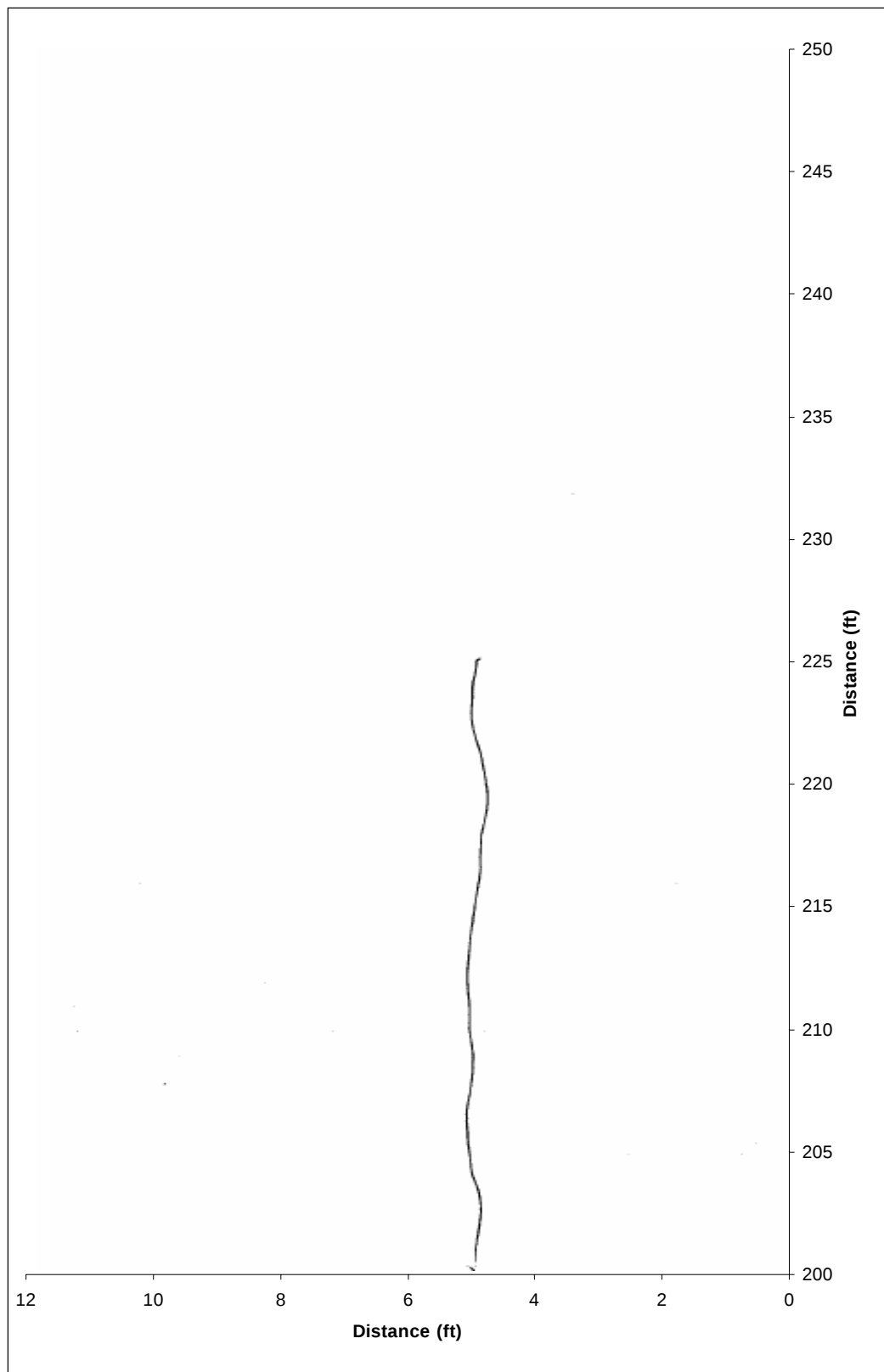


Figure 128. Robert Gray AAF Section 4 (Station 200-250 ft).

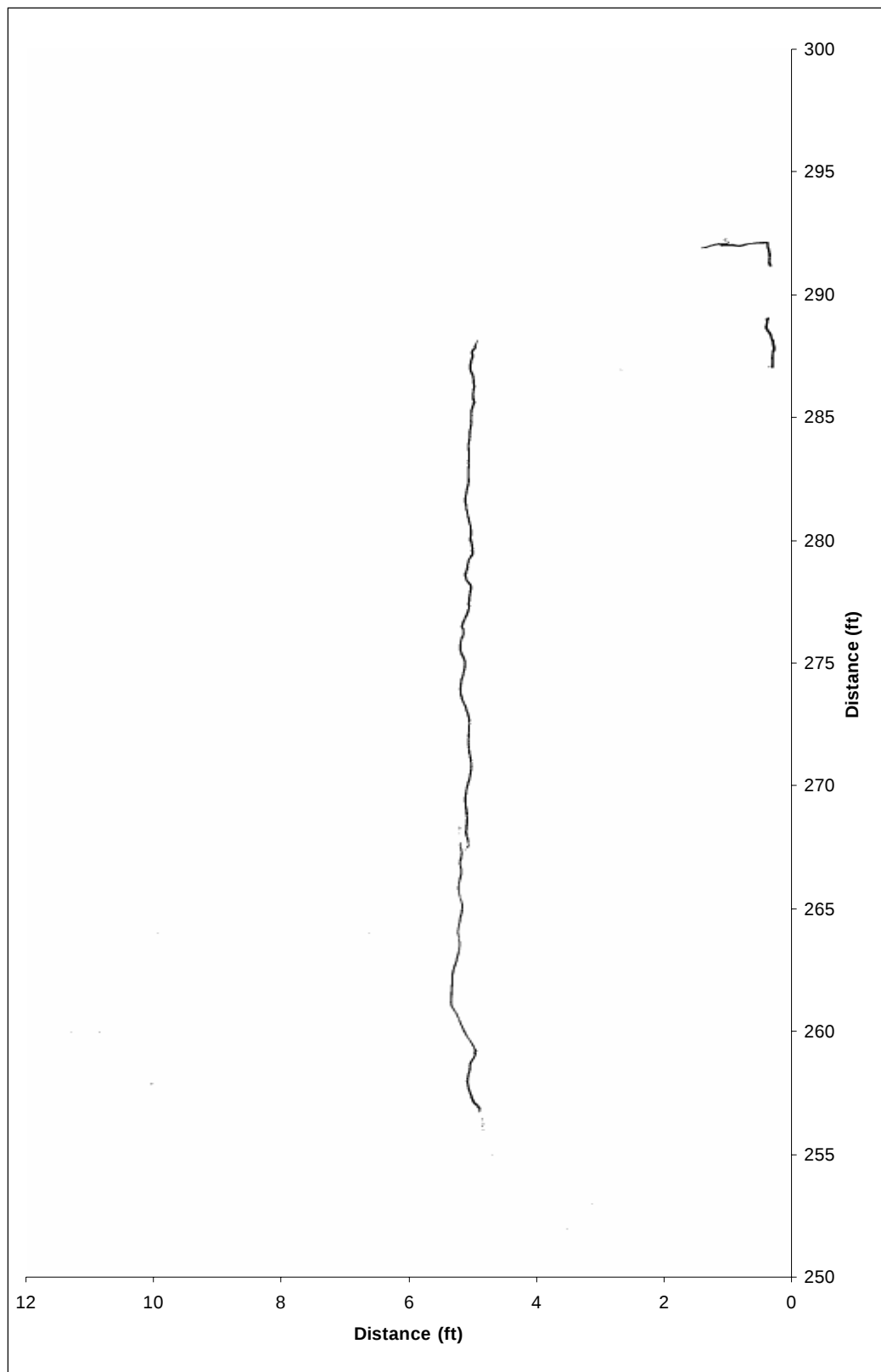


Figure 129. Robert Gray AAF Section 4 (Station 250-300 ft).

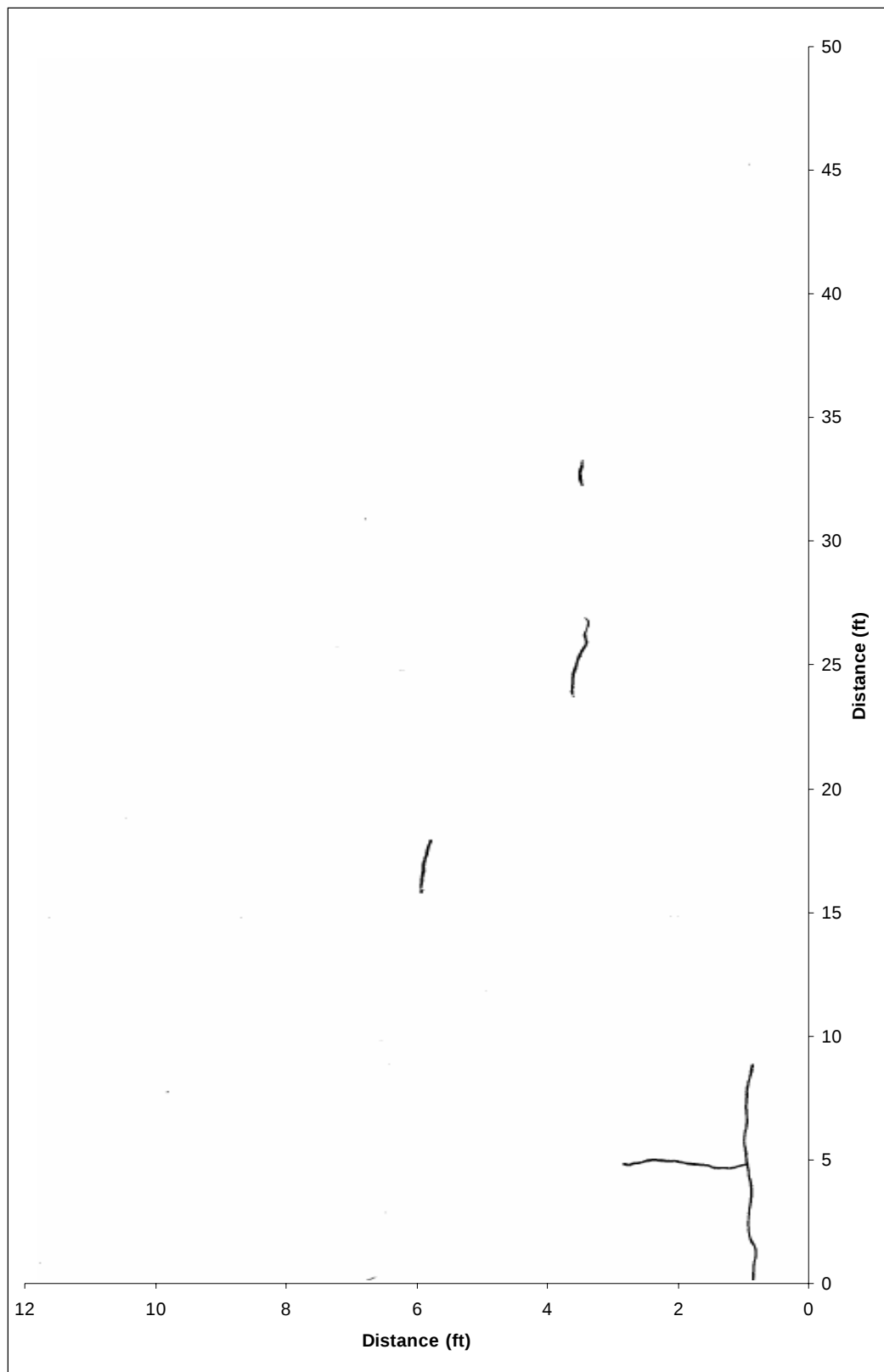


Figure 130. Robert Gray AAF Section 5 (Station 0-50 ft).

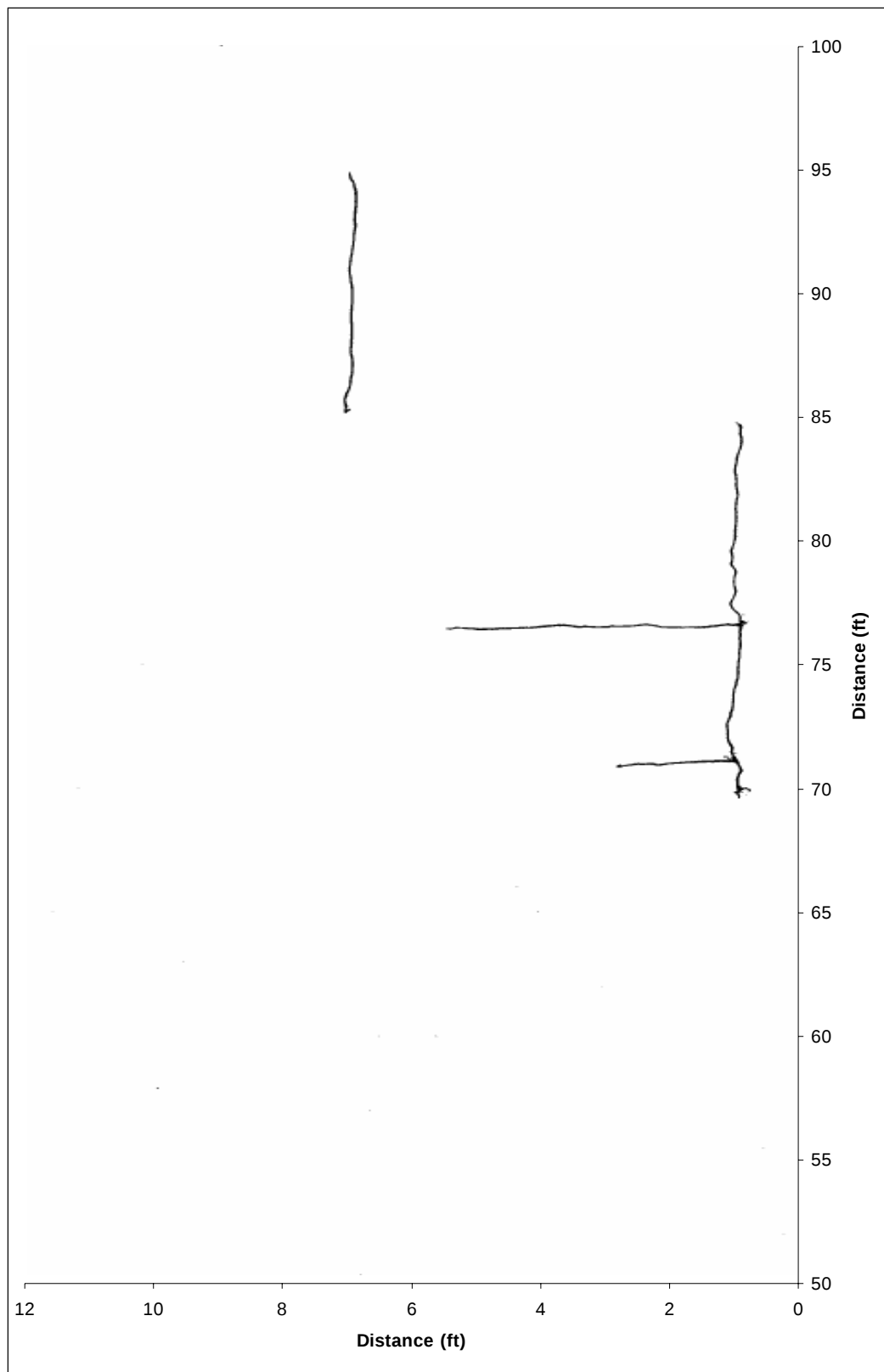


Figure 131. Robert Gray AAF Section 5 (Station 50-100 ft).

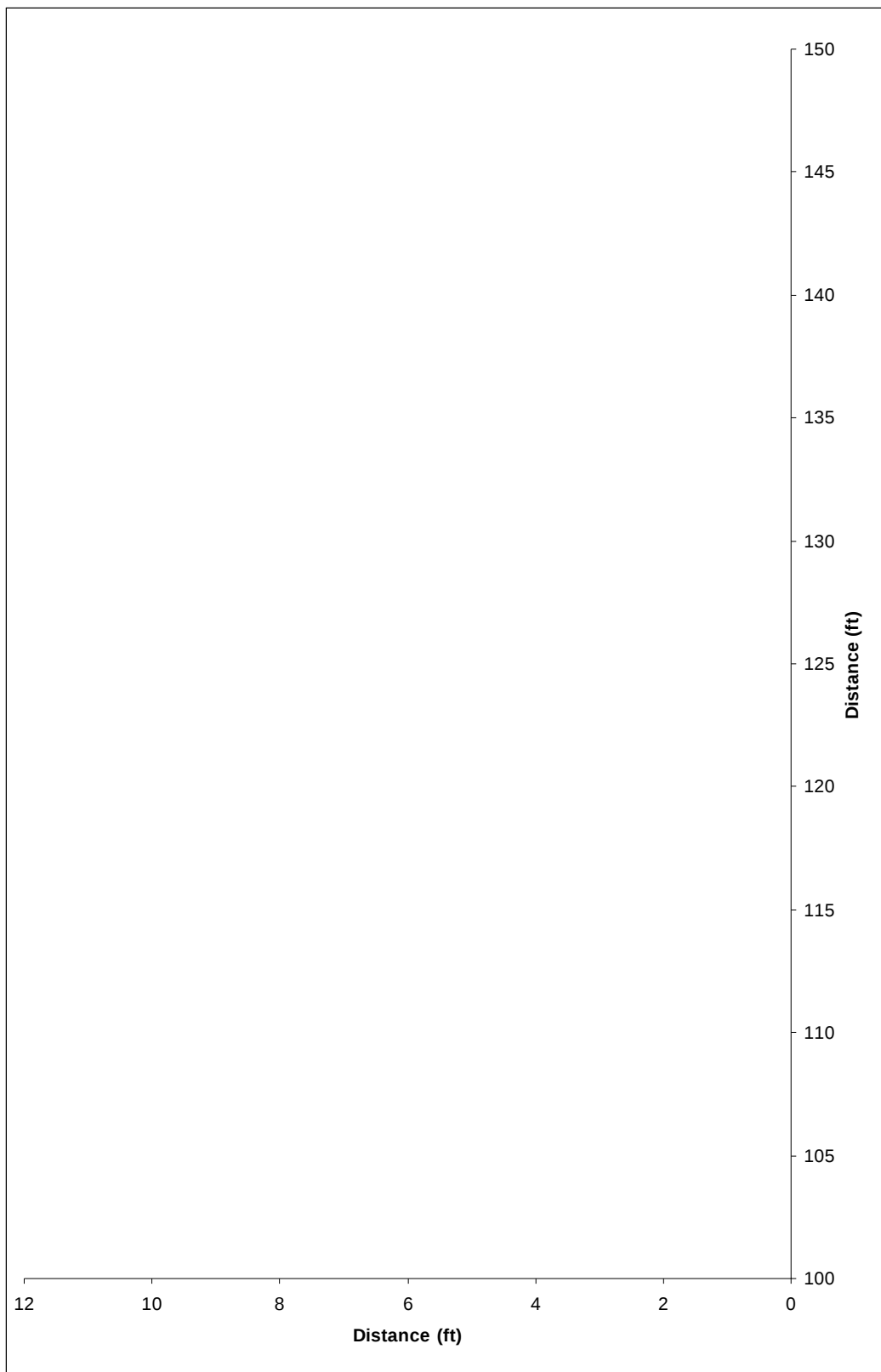


Figure 132. Robert Gray AAF Section 5 (Station 100-150 ft).

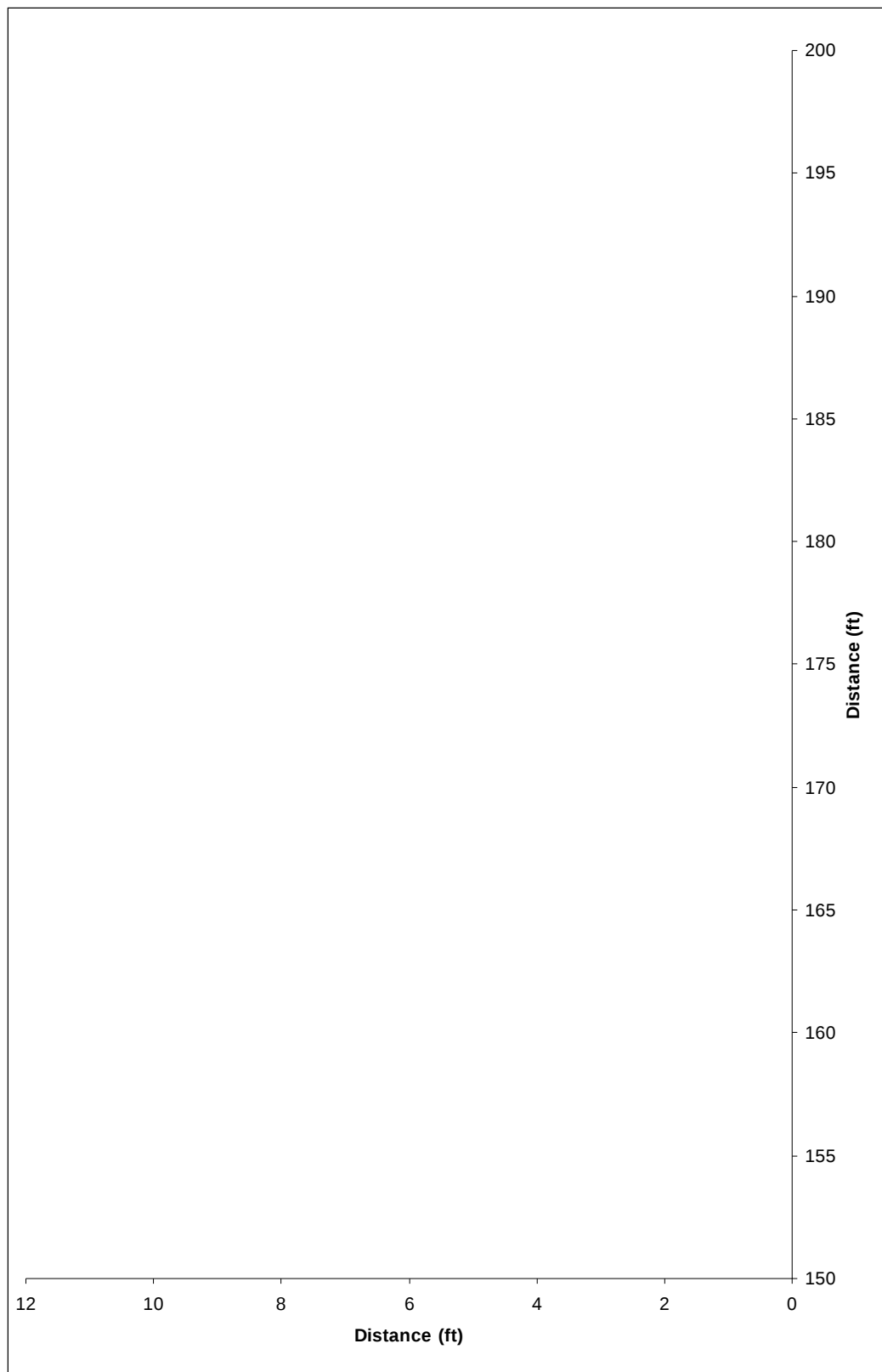


Figure 133. Robert Gray AAF Section 5 (Station 150-200 ft).

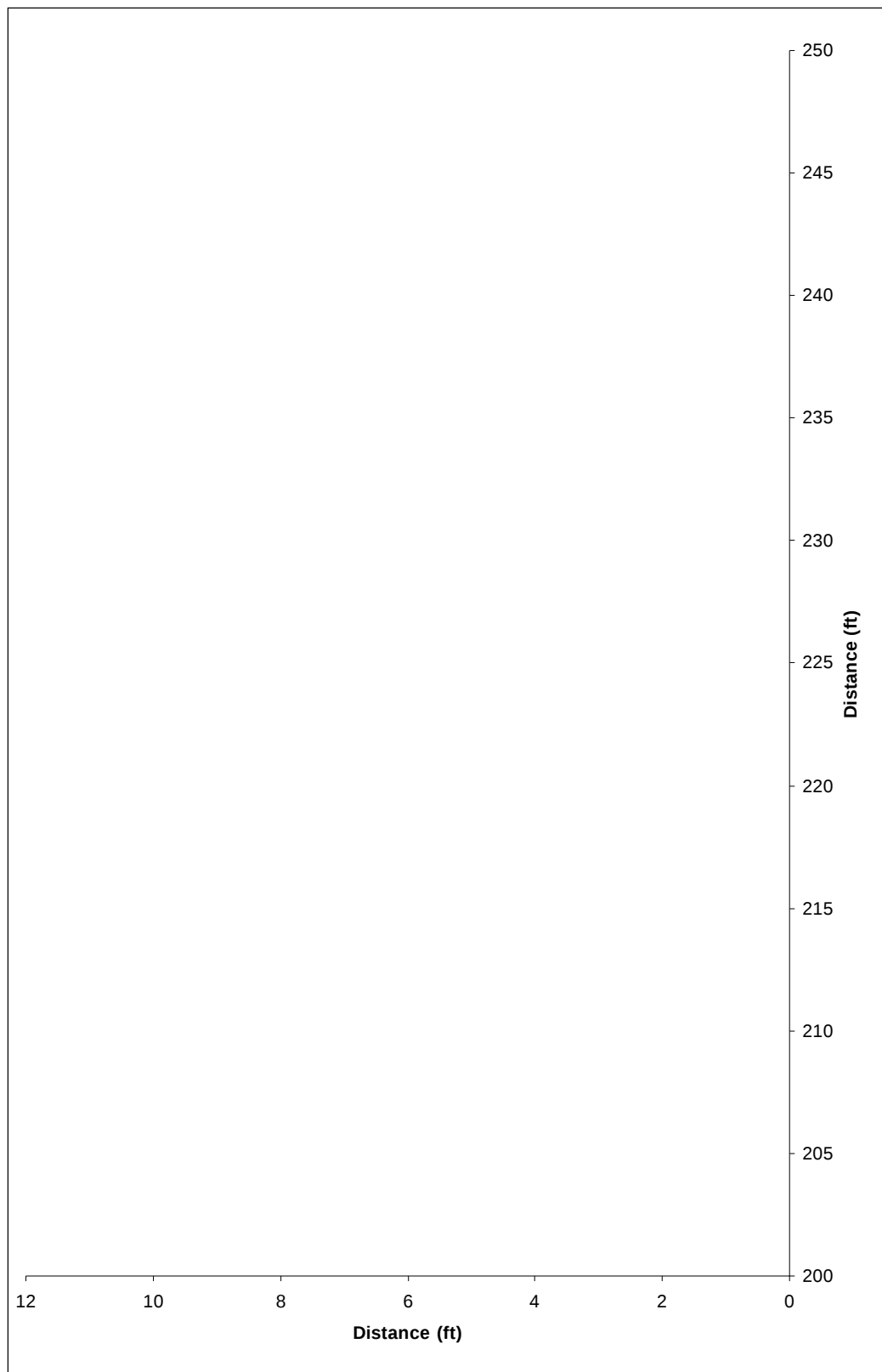


Figure 134. Robert Gray AAF Section 5 (Station 200-250 ft).

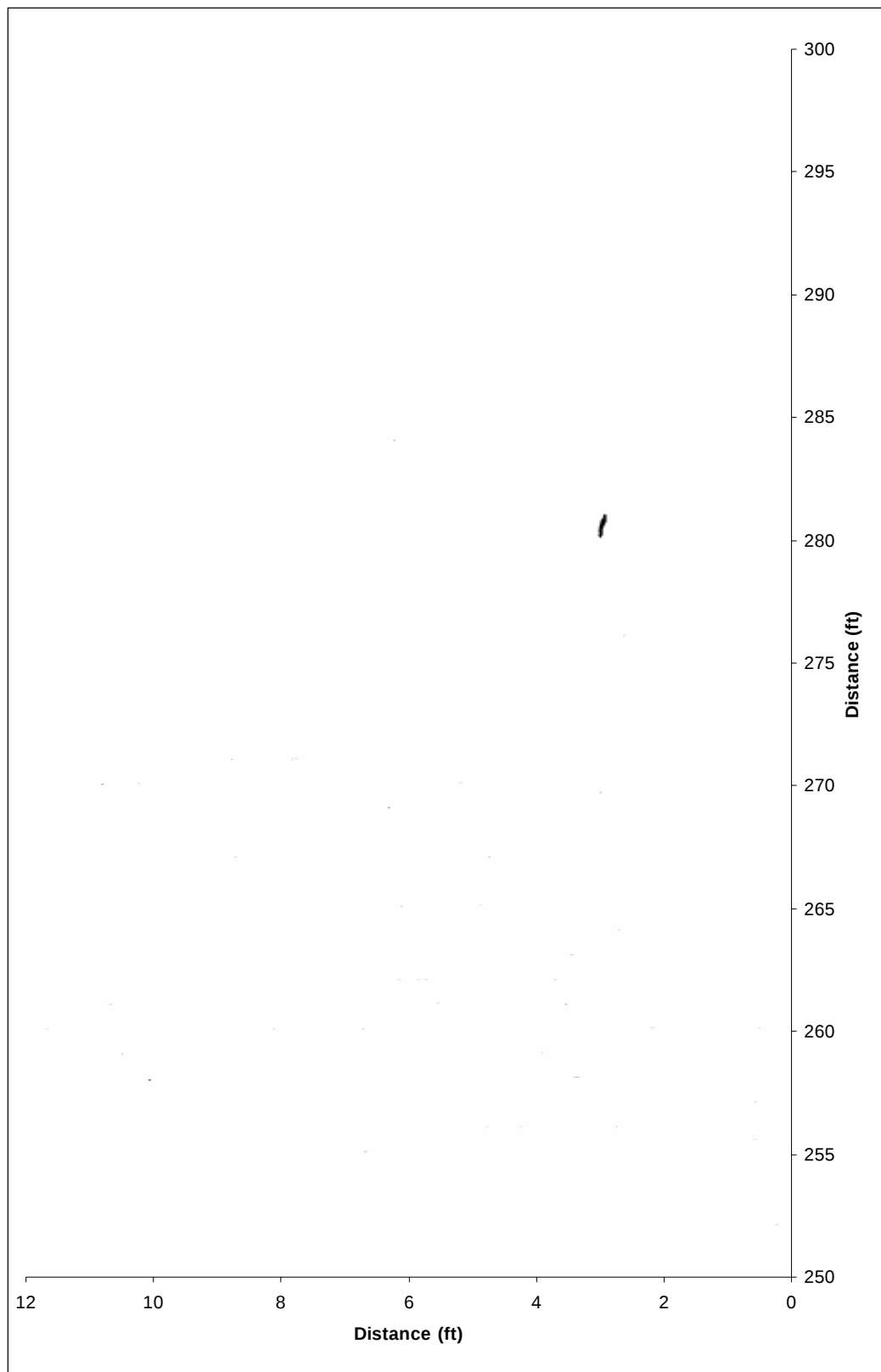


Figure 135. Robert Gray AAF Section 5 (Station 250-300 ft).

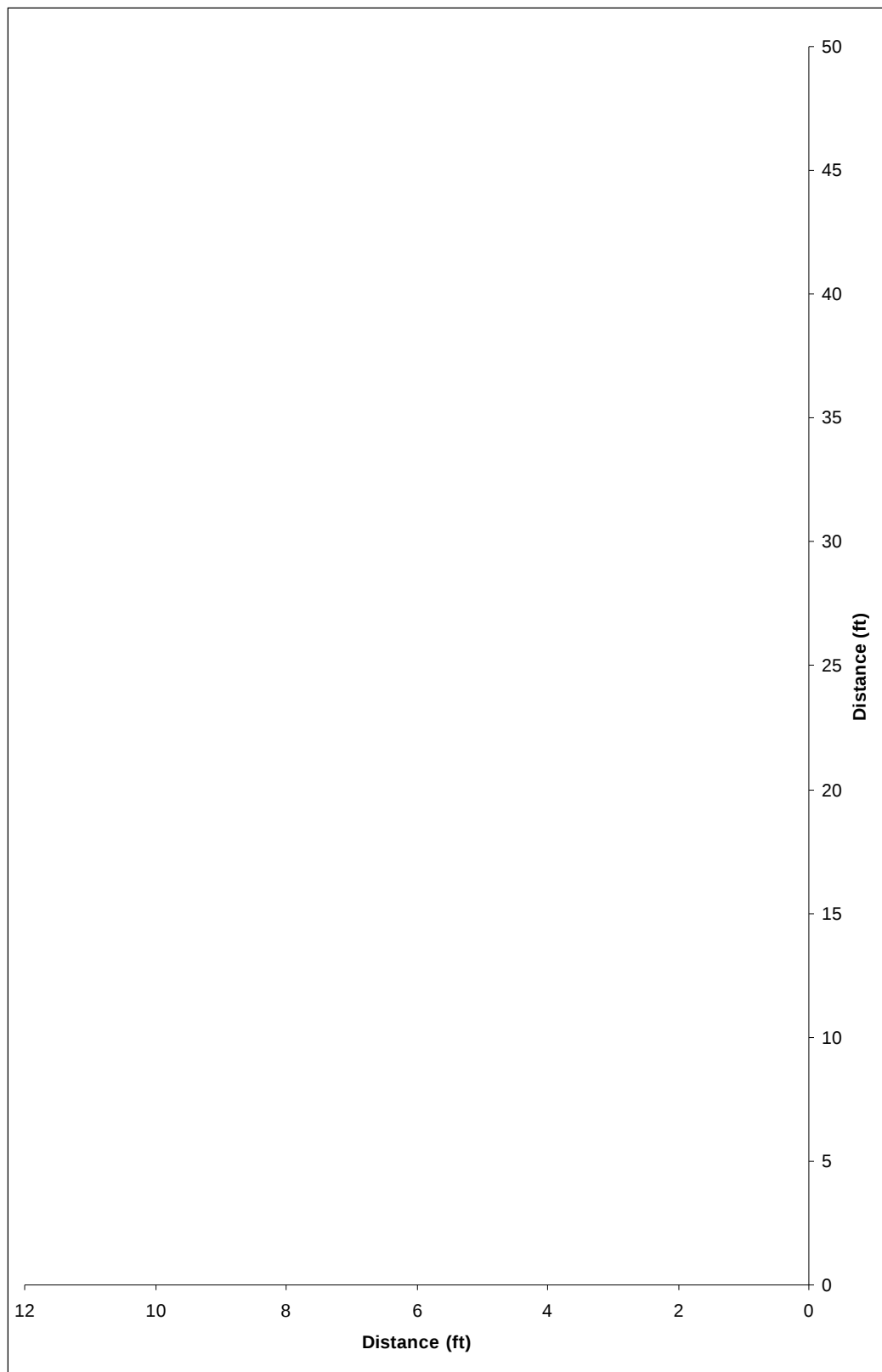


Figure 136. Robert Gray AAF Section 6 (Station 0-50 ft).

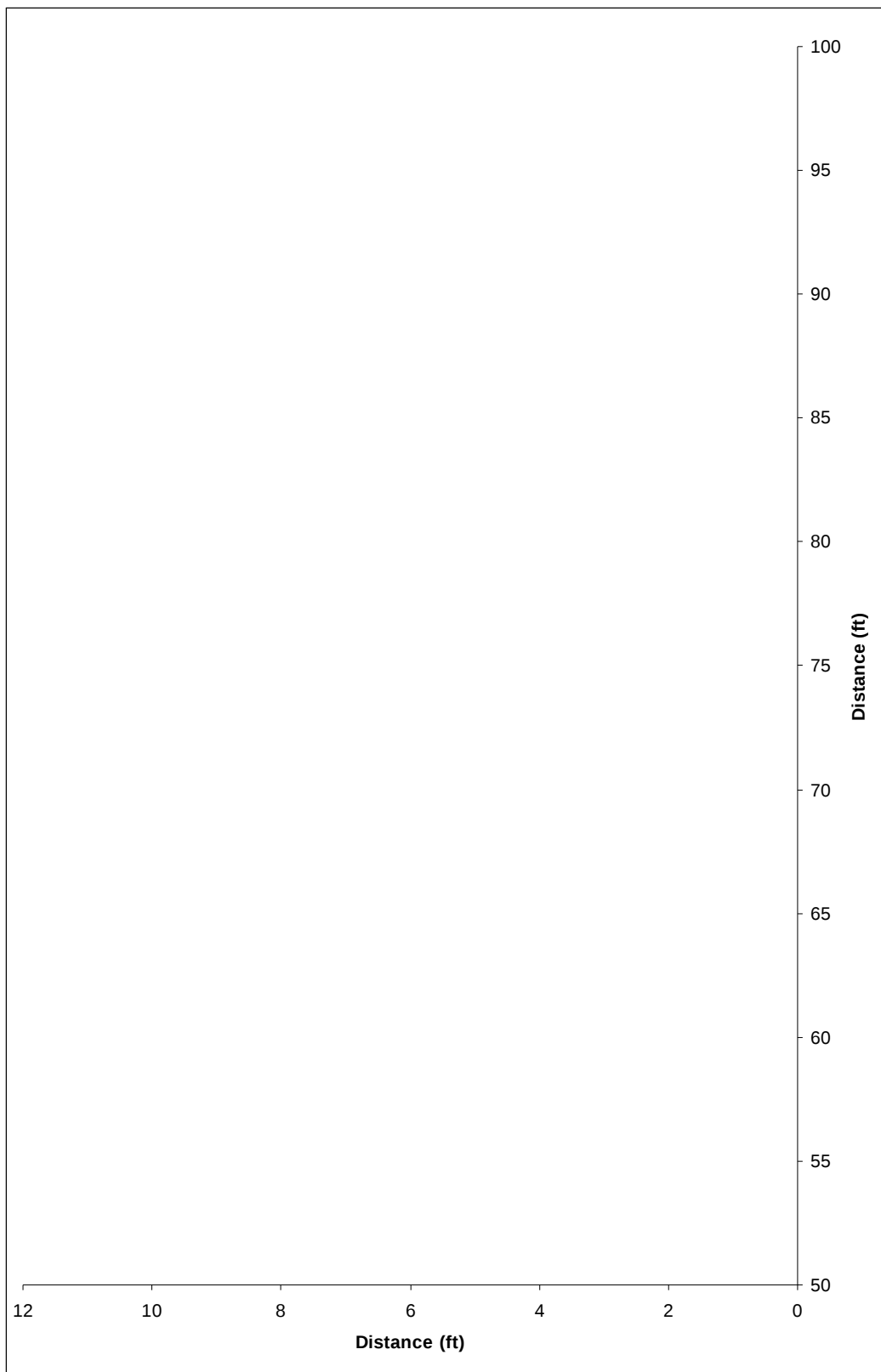


Figure 137. Robert Gray AAF Section 6 (Station 50-100 ft).

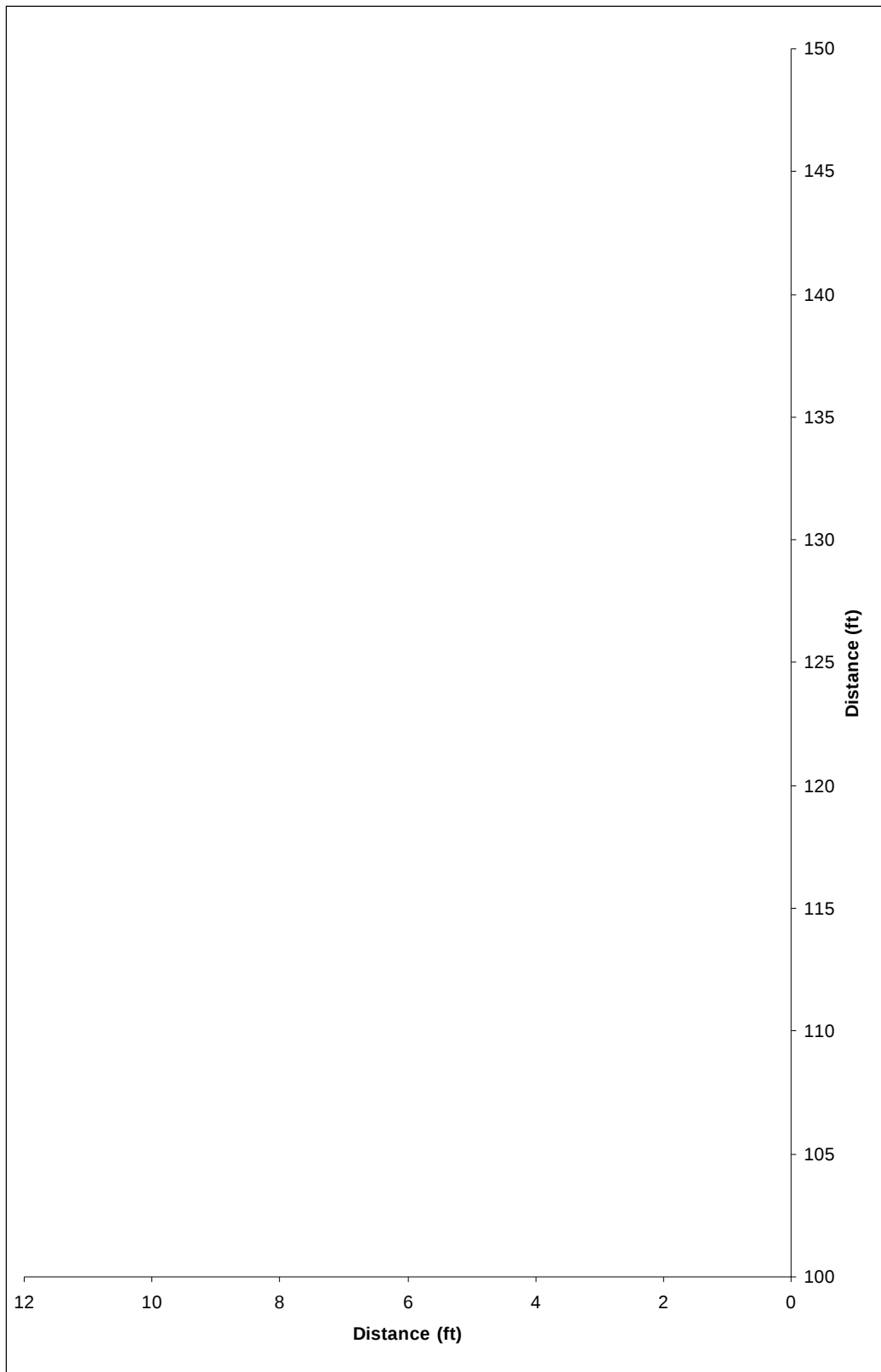


Figure 138. Robert Gray AAF Section 6 (Station 100-150 ft).

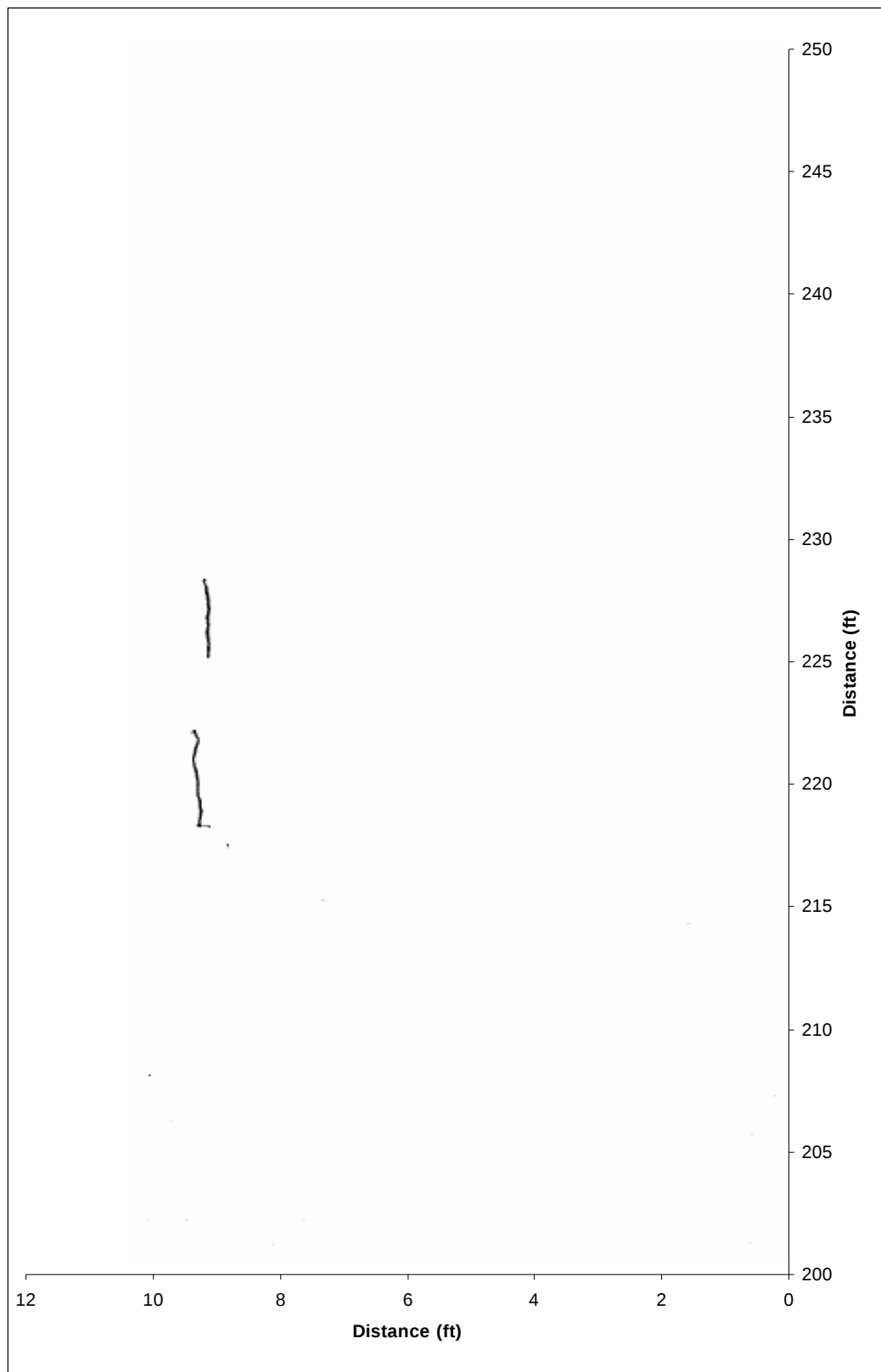


Figure 139. Robert Gray AAF Section 6 (Station 150-200 ft).

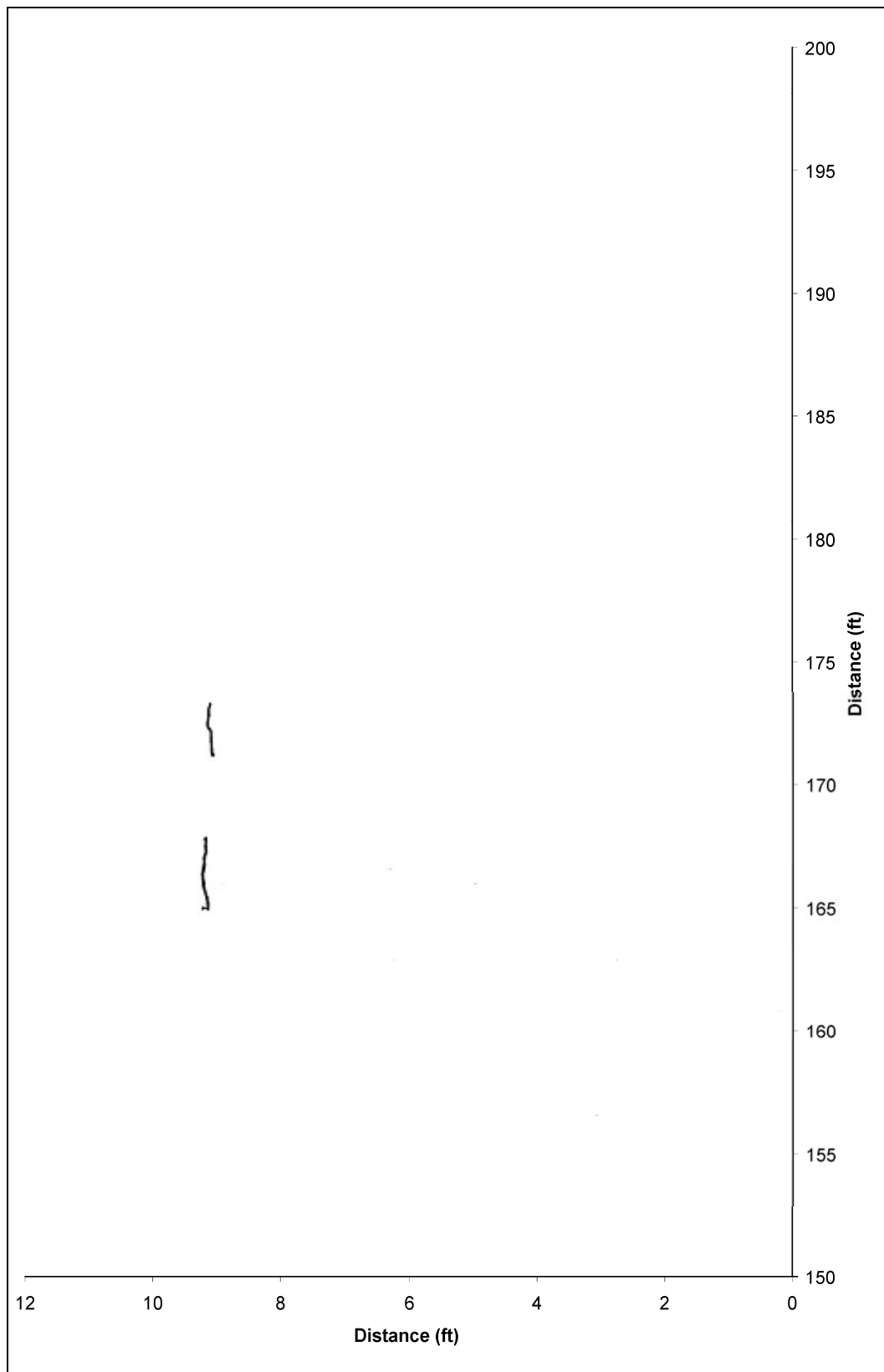


Figure 140. Robert Gray AAF Section 6 (Station 200-250 ft).

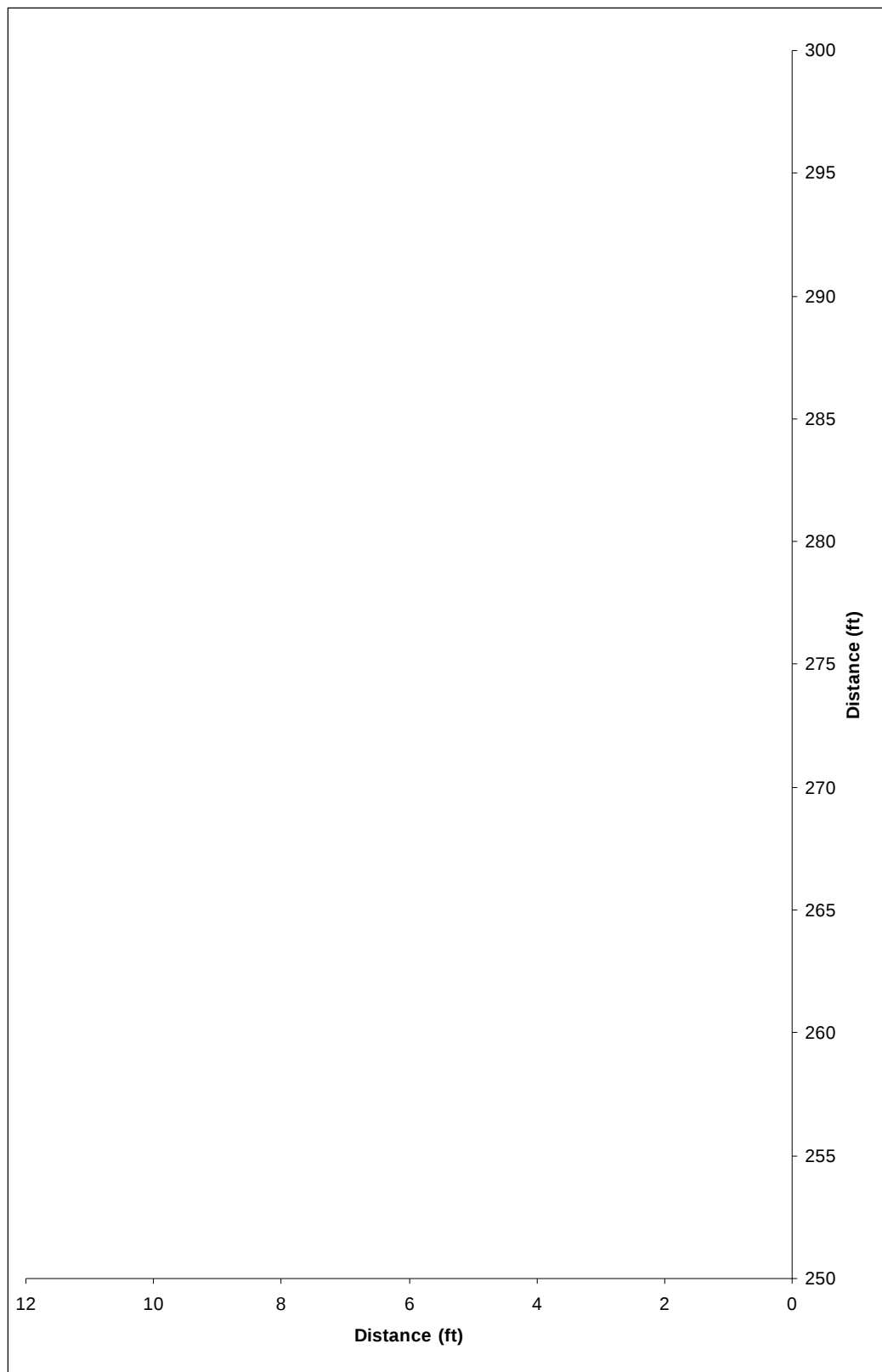


Figure 141. Robert Gray AAF Section 6 (Station 250-300 ft).

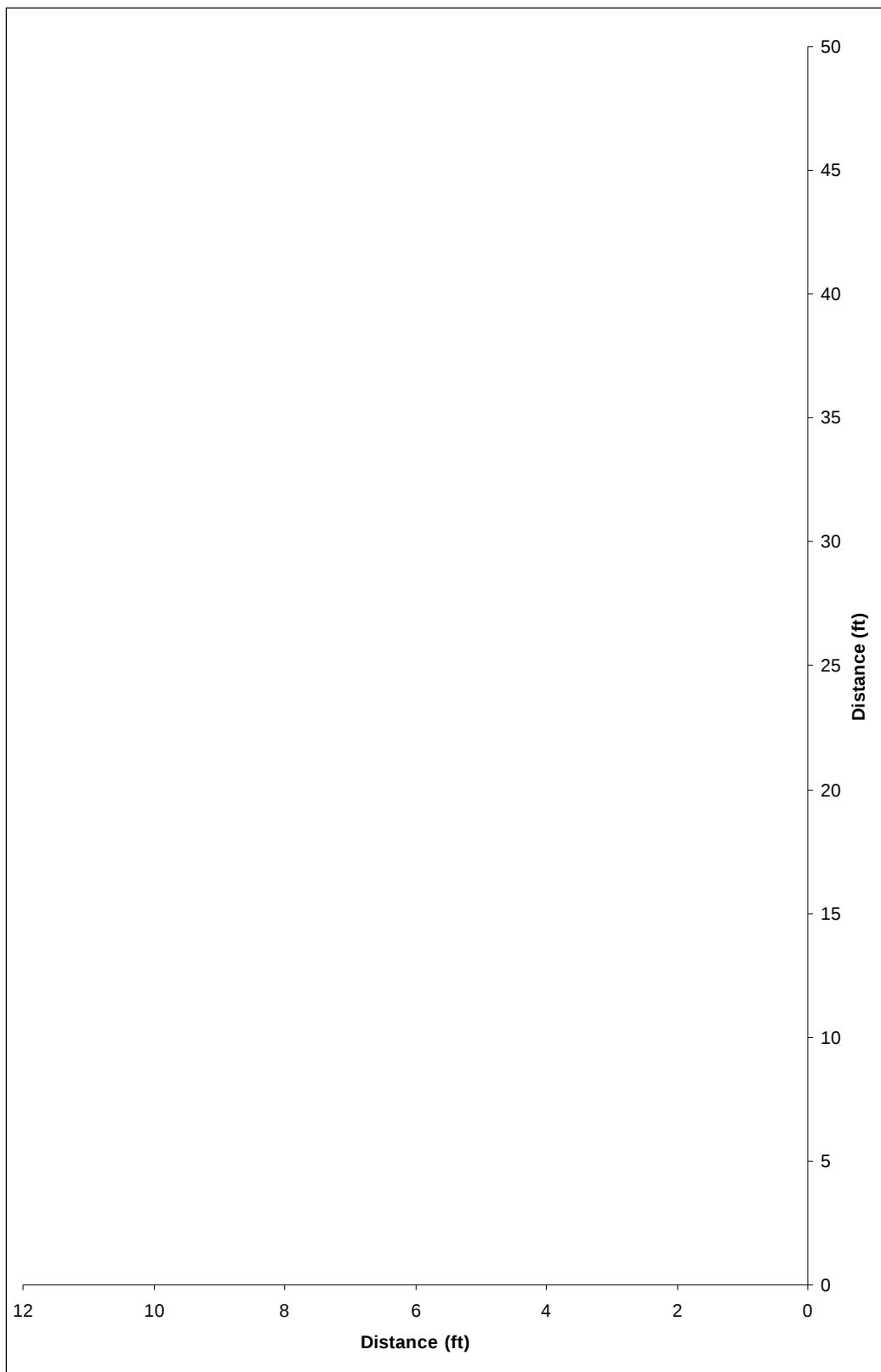


Figure 142. Robert Gray AAF Section 7 (Station 0-50 ft).

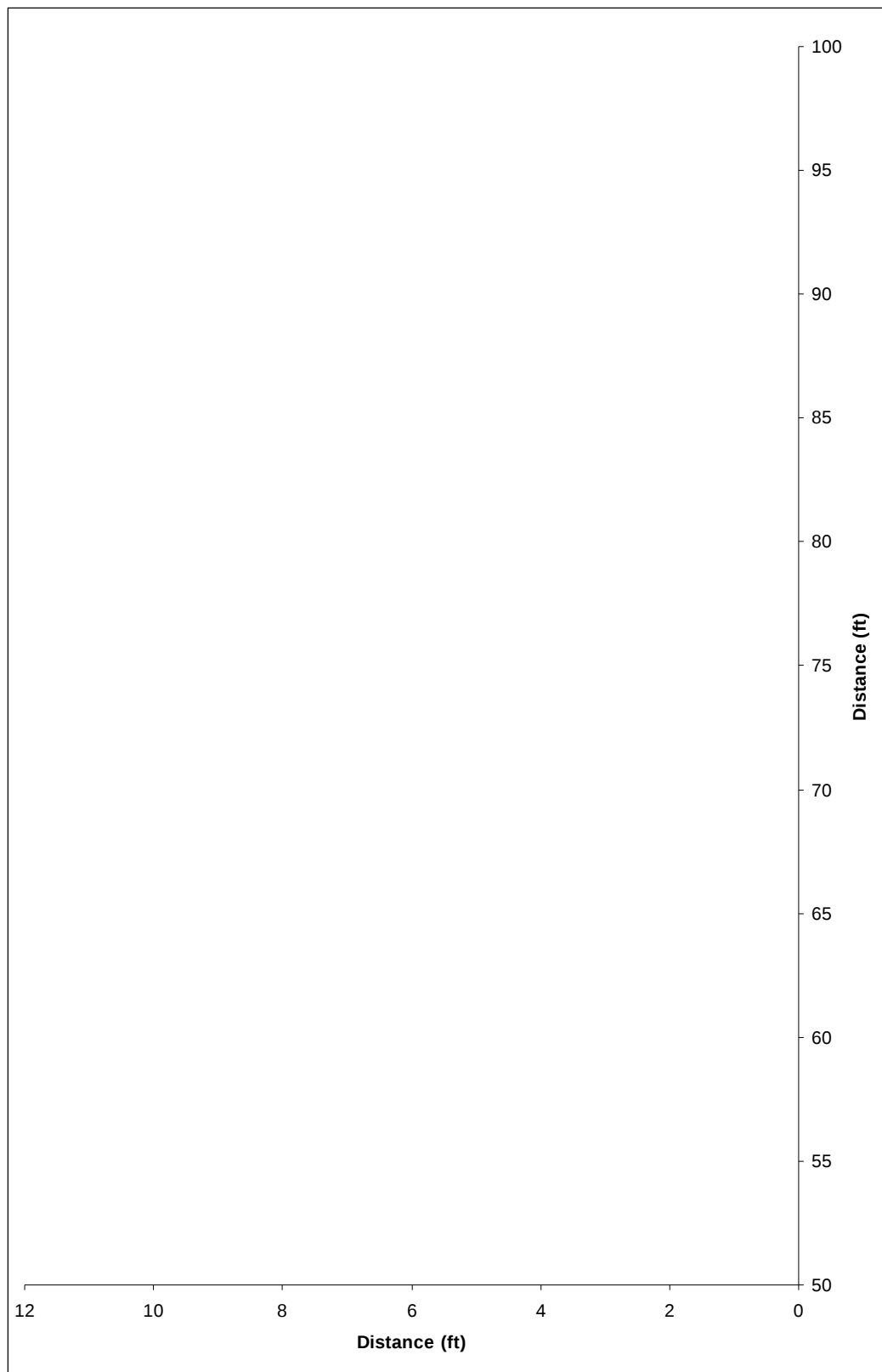


Figure 143. Robert Gray AAF Section 7 (Station 50-100 ft).

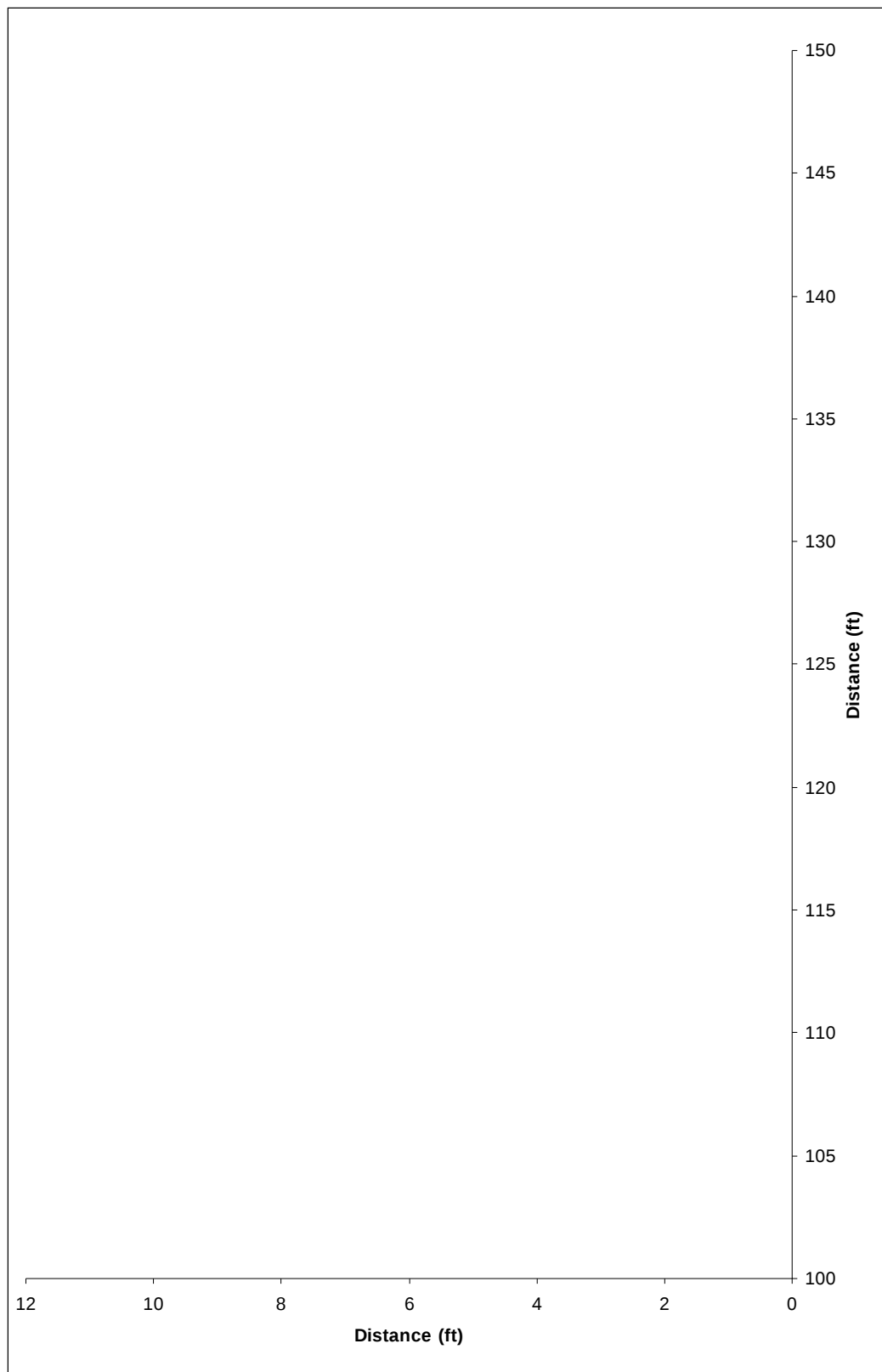


Figure 144. Robert Gray AAF Section 7 (Station 100-150 ft).

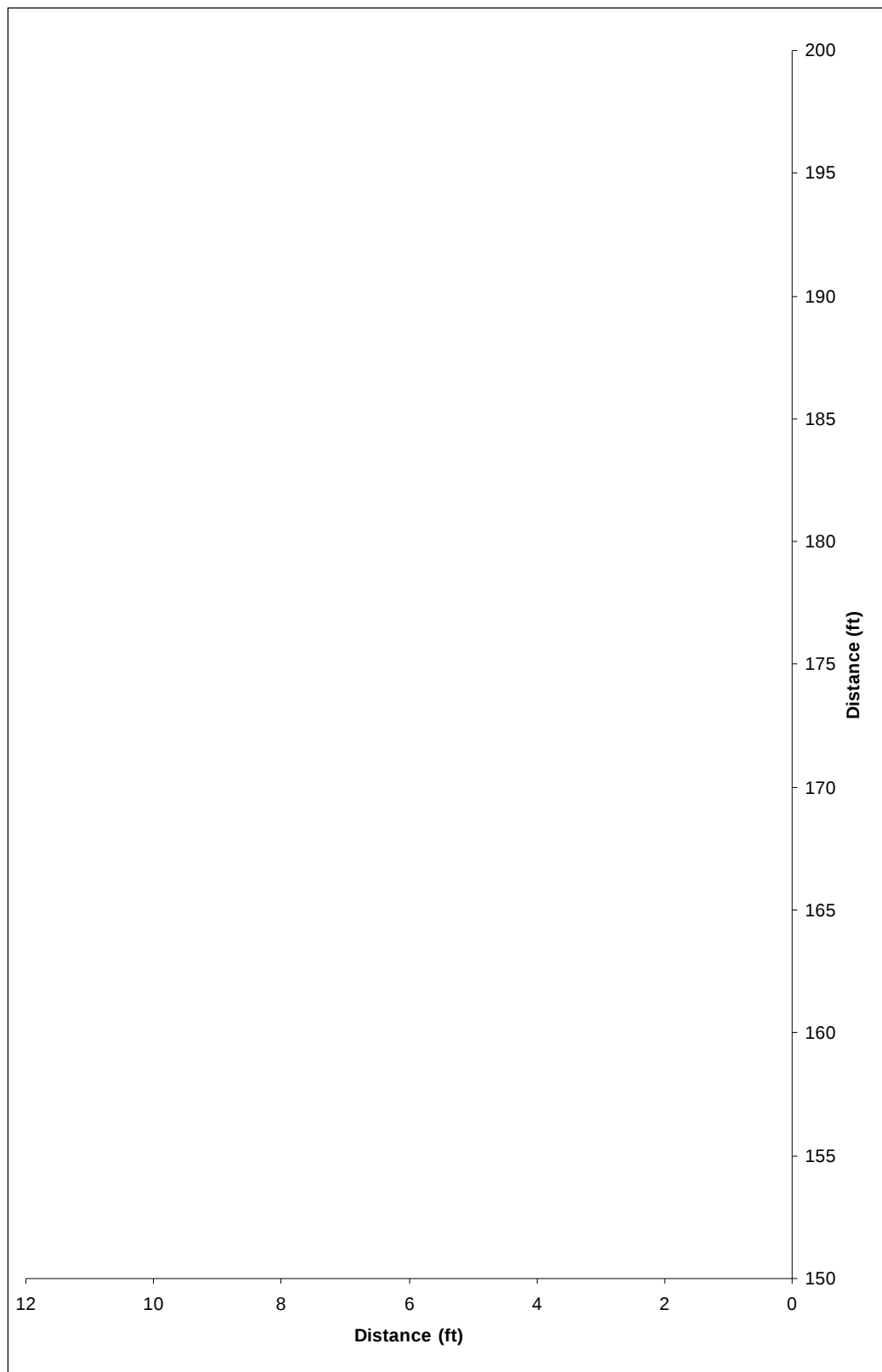


Figure 145. Robert Gray AAF Section 7 (Station 150-200 ft).

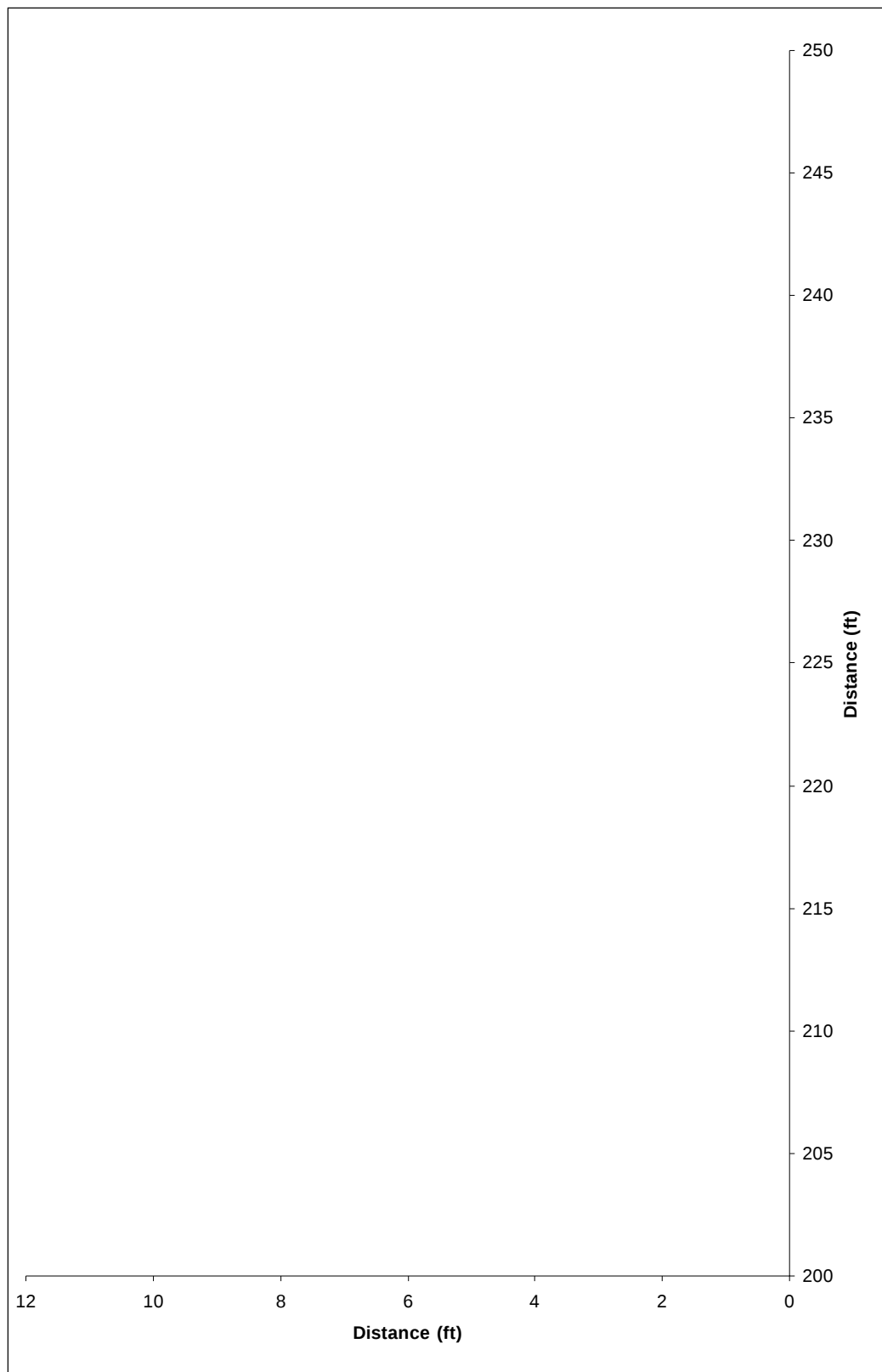


Figure 146. Robert Gray AAF Section 7 (Station 200-250 ft).

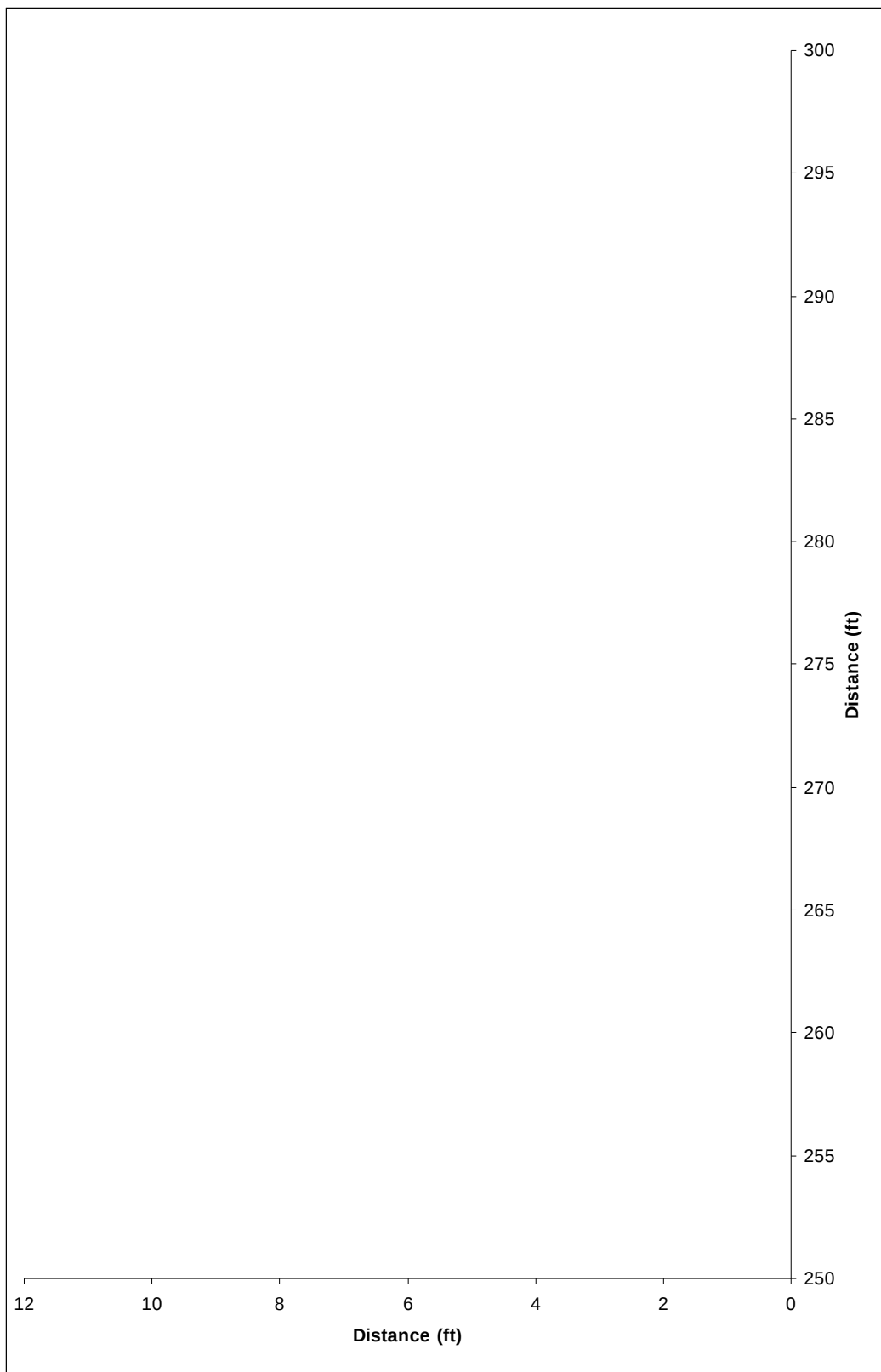


Figure 147. Robert Gray AAF Section 7 (Station 250-300 ft).

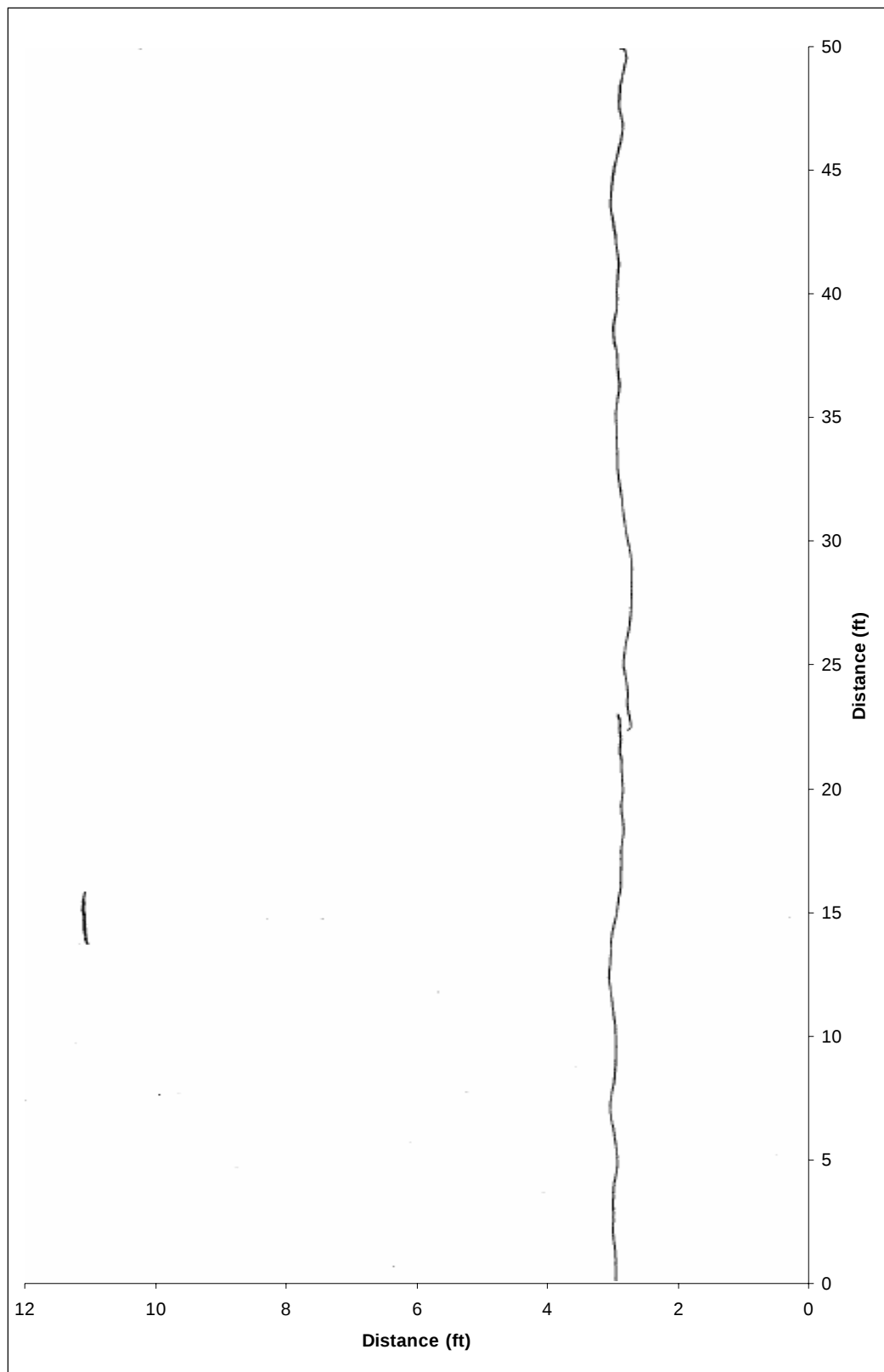


Figure 148. Robert Gray AAF Section 8 (Station 0-50 ft).

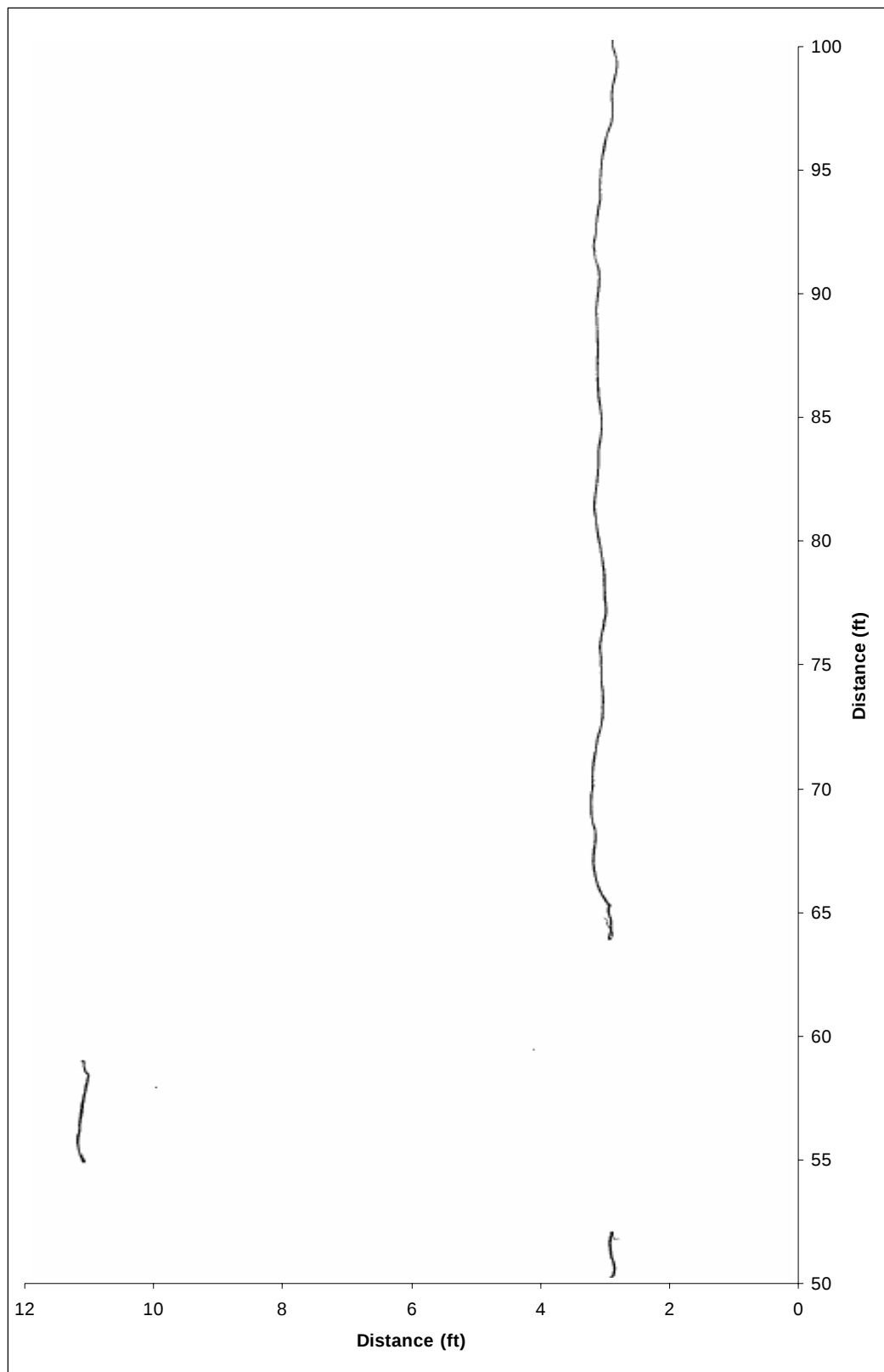


Figure 149. Robert Gray AAF Section 8 (Station 50-100 ft).

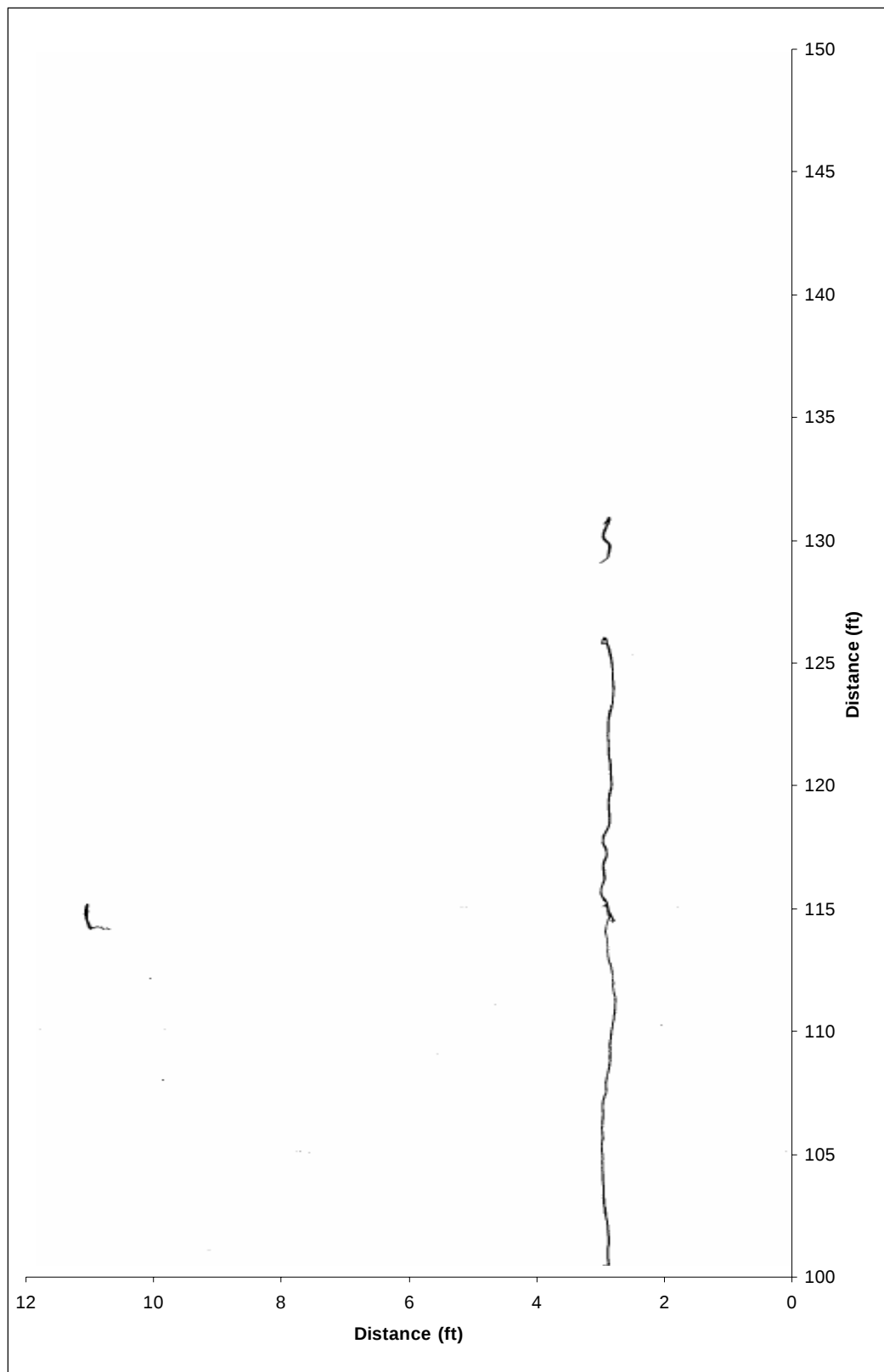


Figure 150. Robert Gray AAF Section 8 (Station 100-150 ft).

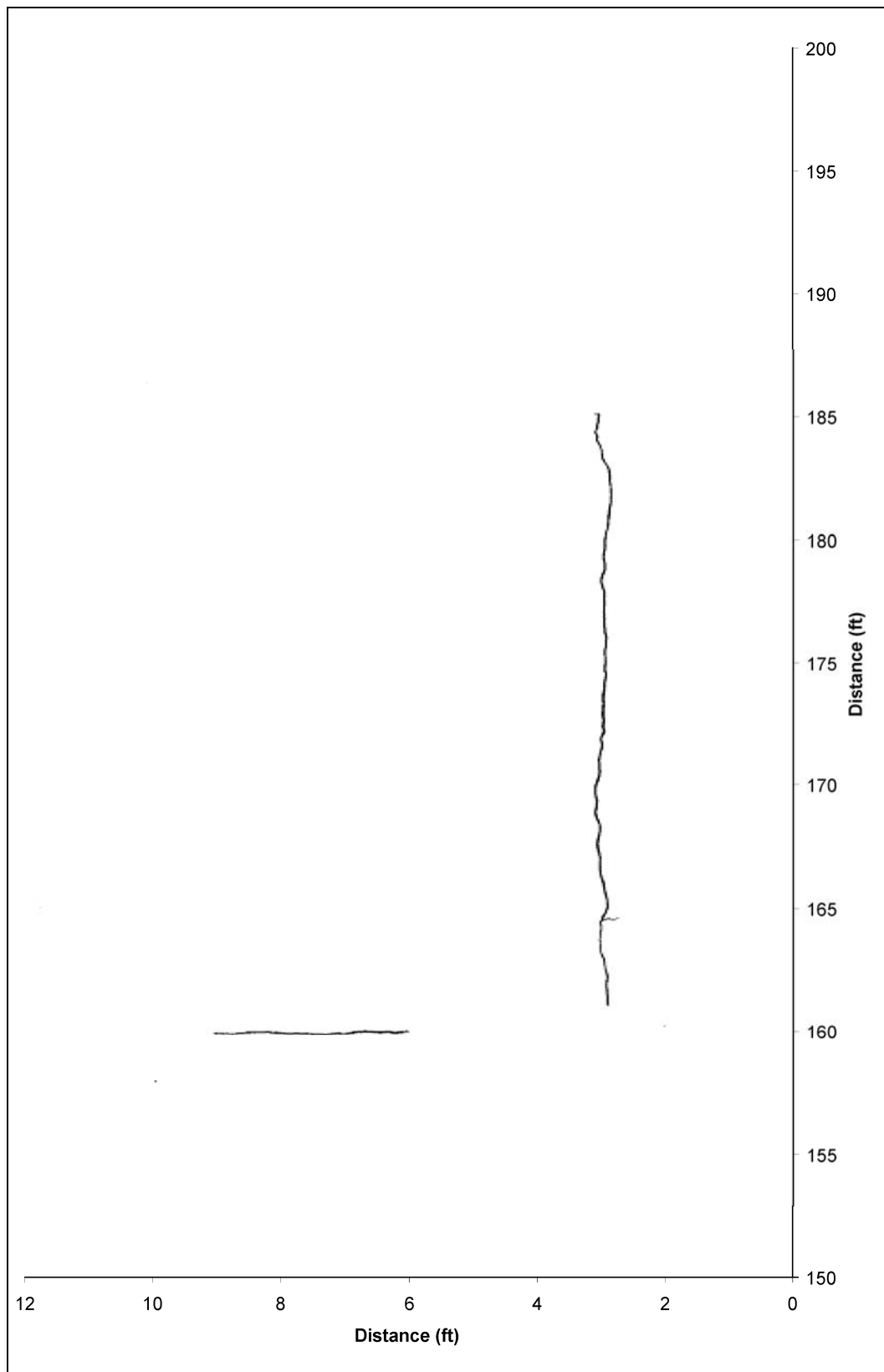


Figure 151. Robert Gray AAF Section 8 (Station 150-200 ft).

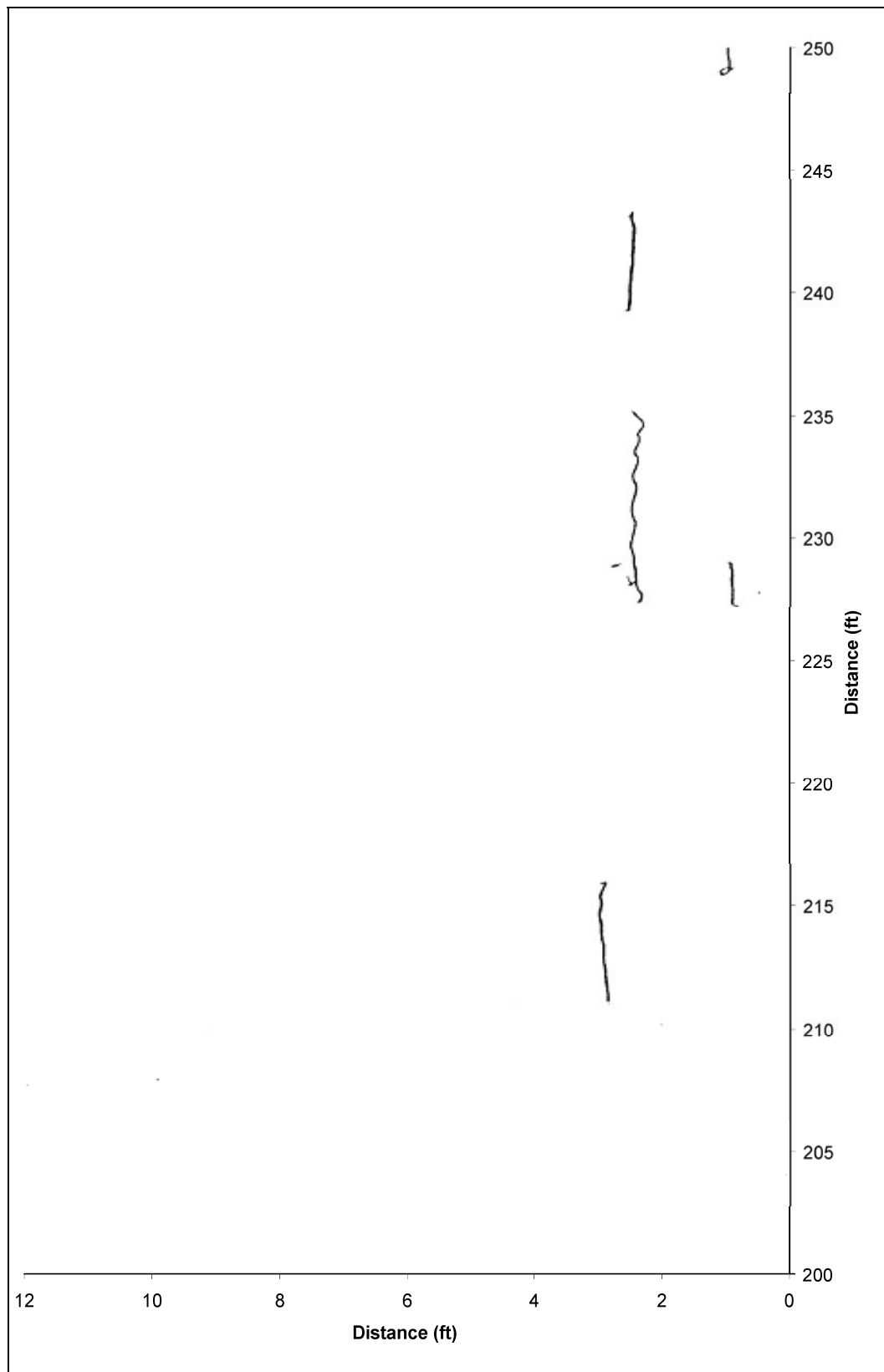


Figure 152. Robert Gray AAF Section 8 (Station 200-250 ft).

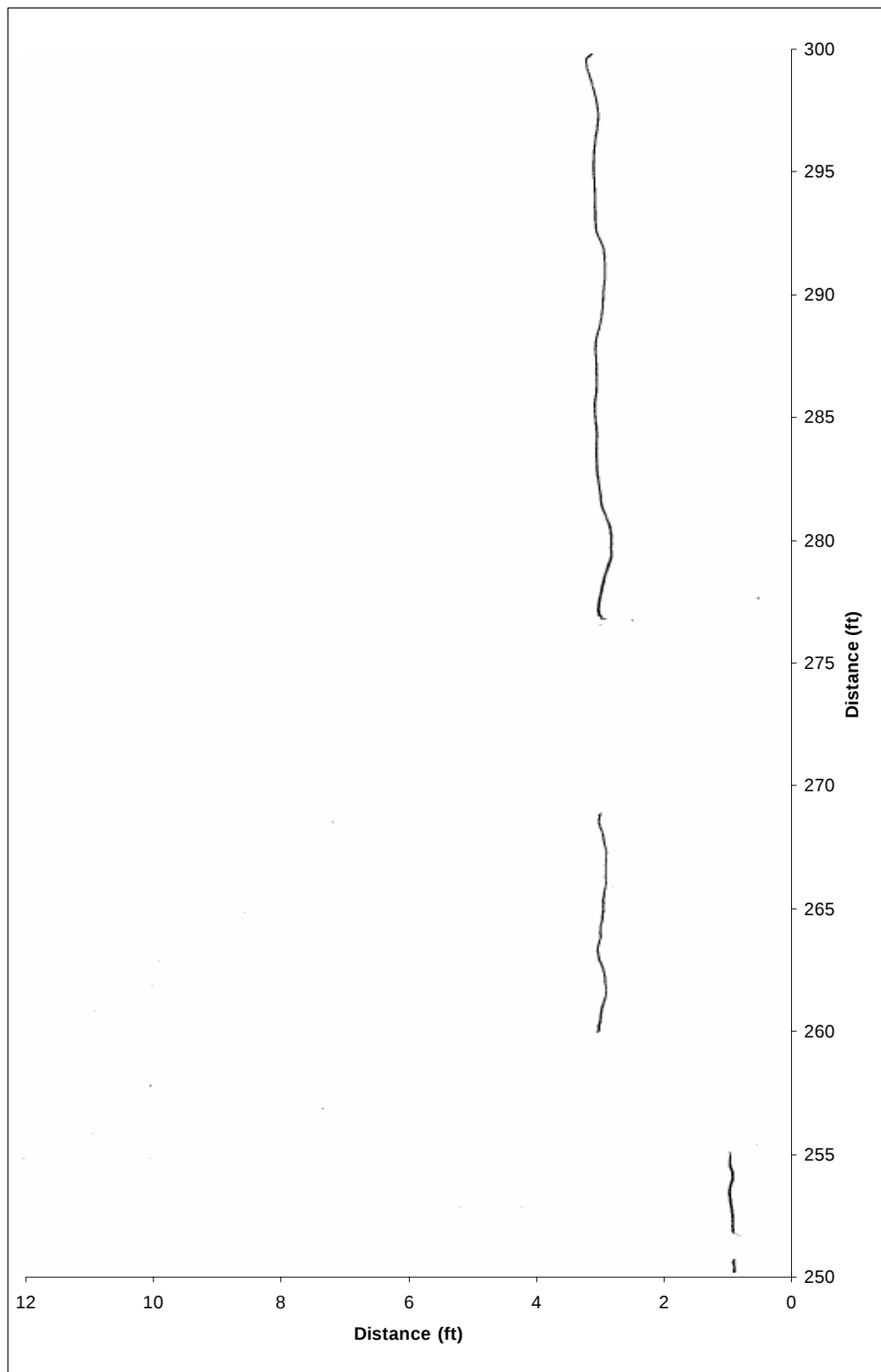


Figure 153. Robert Gray AAF Section 8 (Station 250-300 ft).

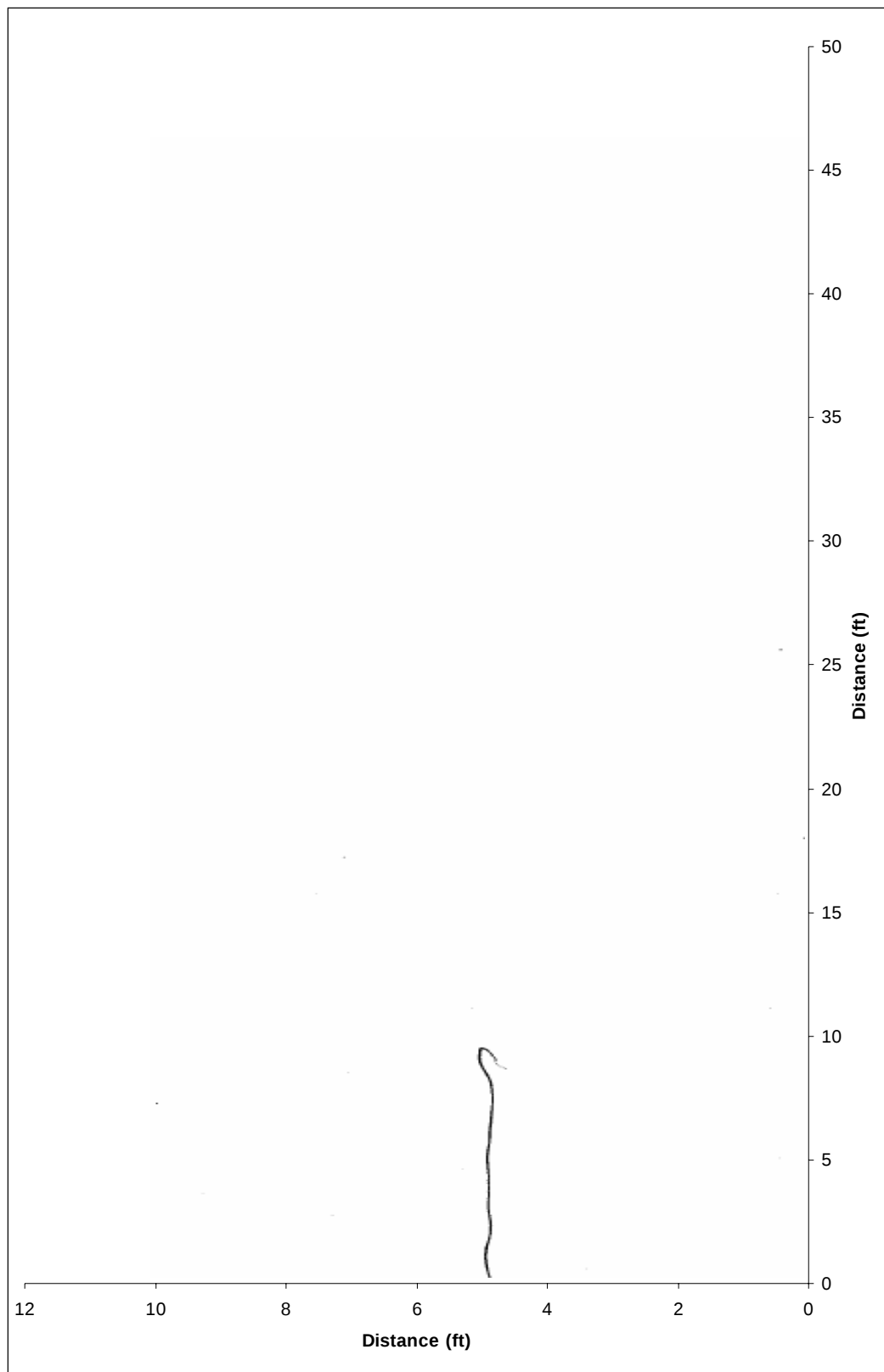


Figure 154. Robert Gray AAF Section 9 (Station 0-50 ft).

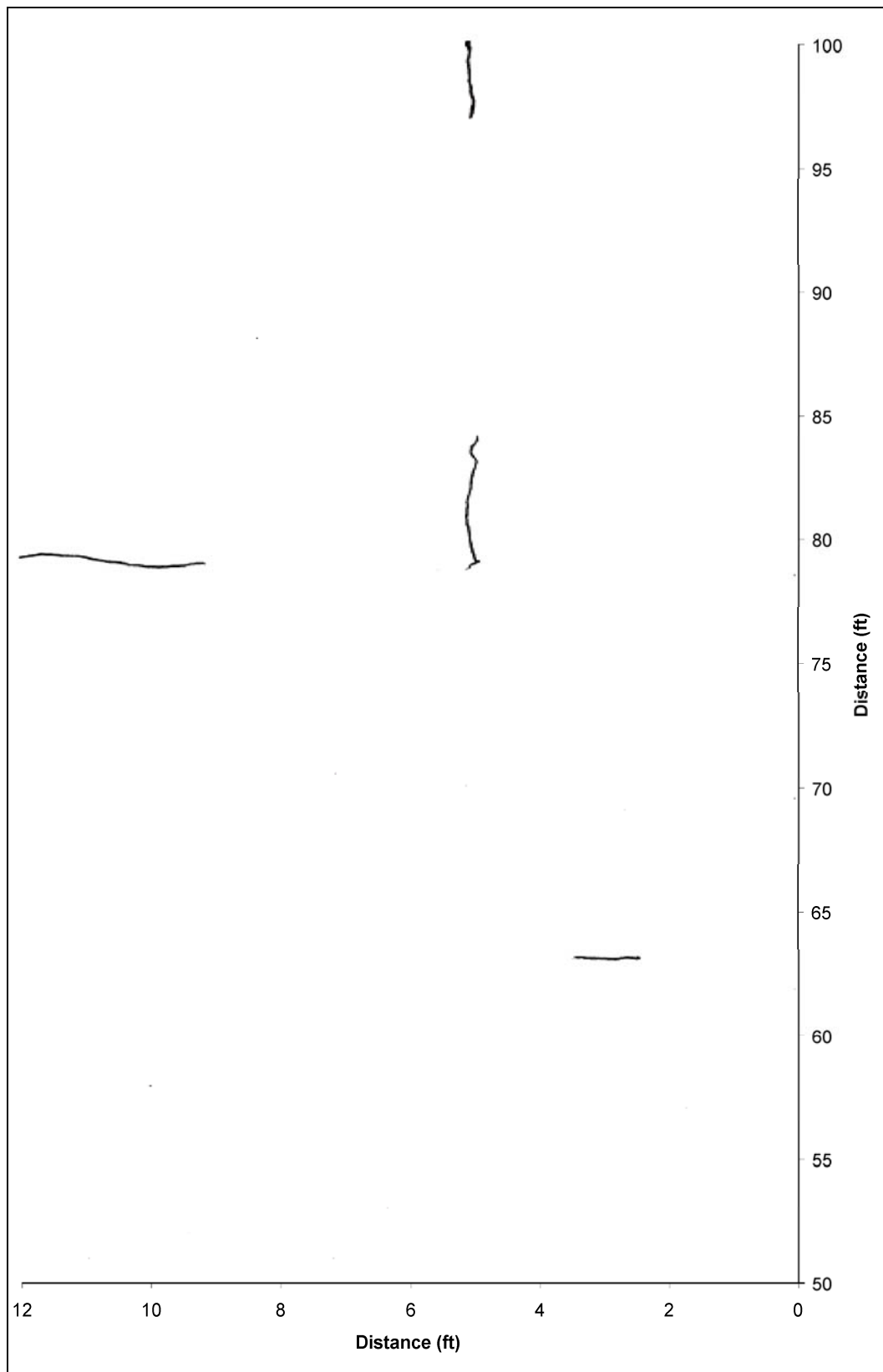


Figure 155. Robert Gray AAF Section 9 (Station 50-100 ft).

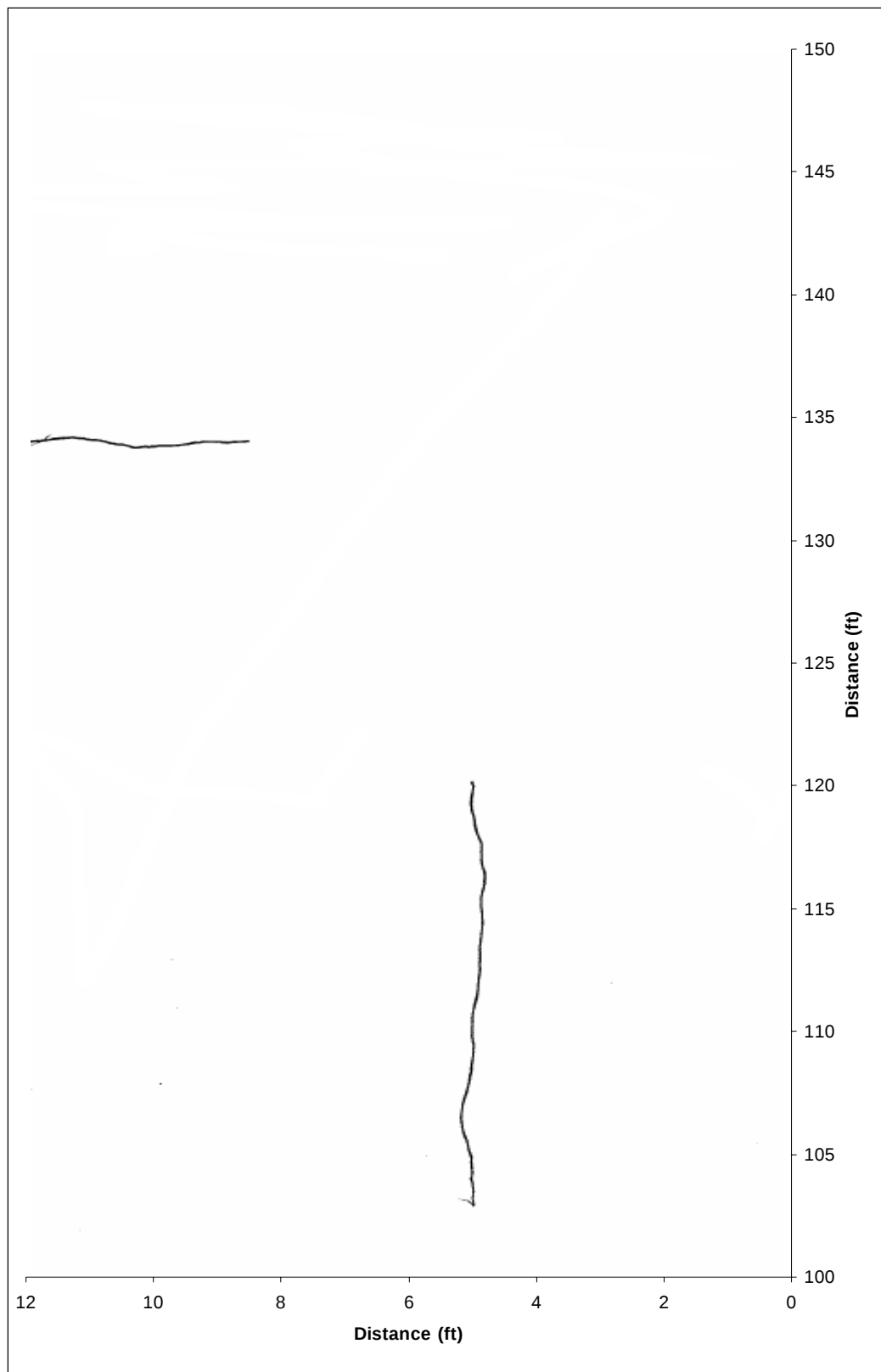


Figure 156. Robert Gray AAF Section 9 (Station 100-150 ft).

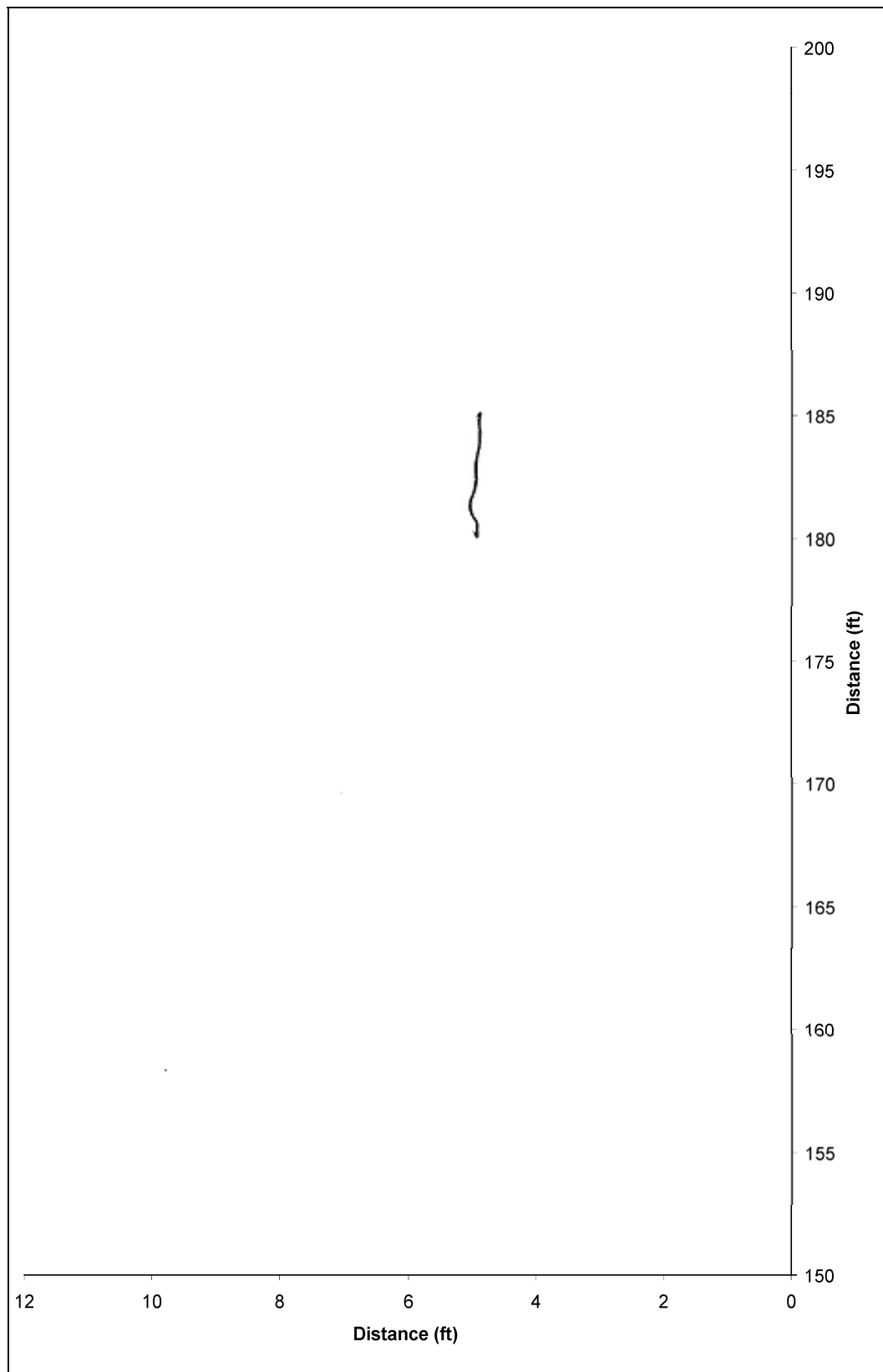


Figure 157. Robert Gray AAF Section 9 (Station 150-200 ft).

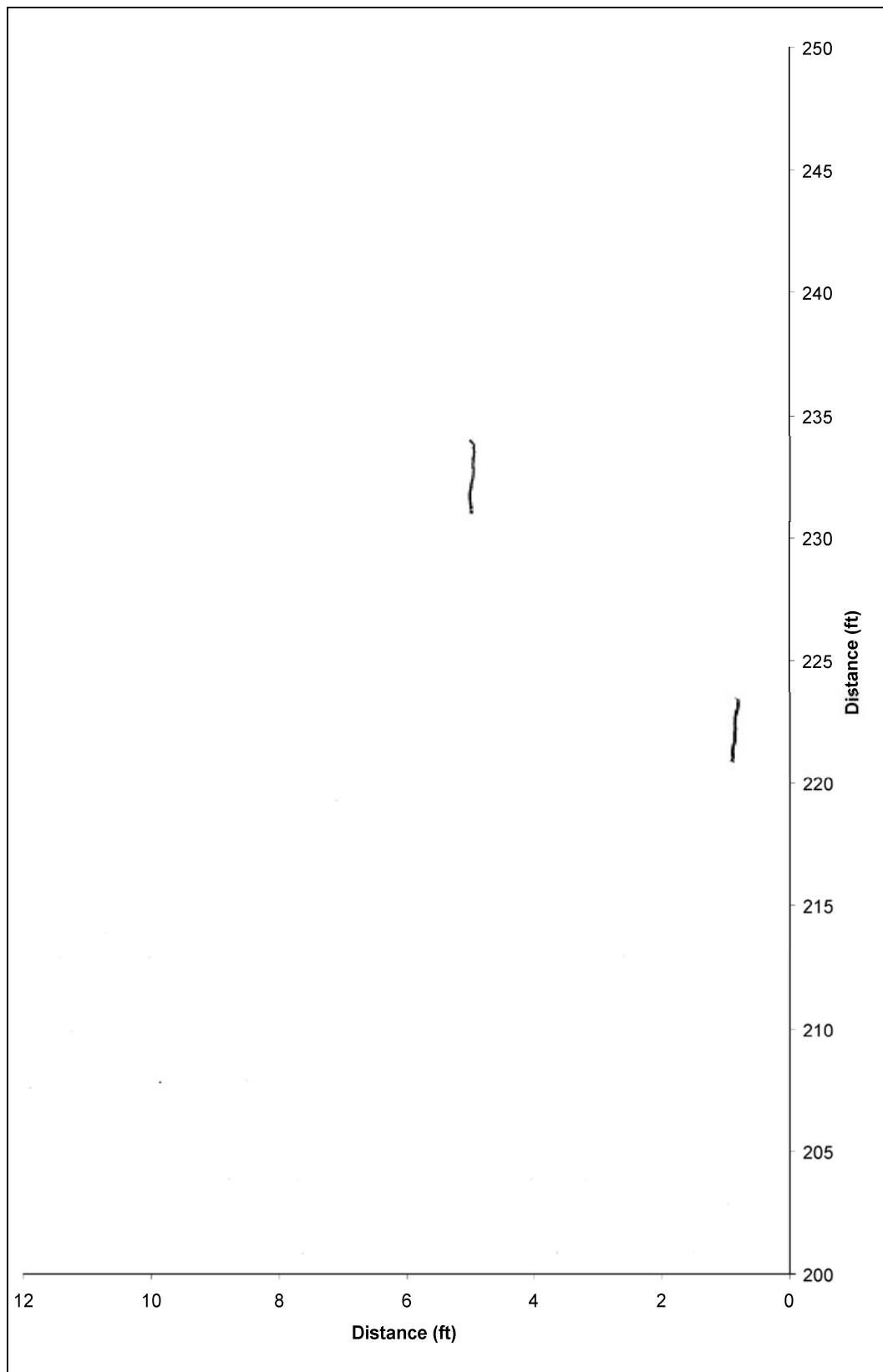


Figure 158. Robert Gray AAF Section 9 (Station 200-250 ft).

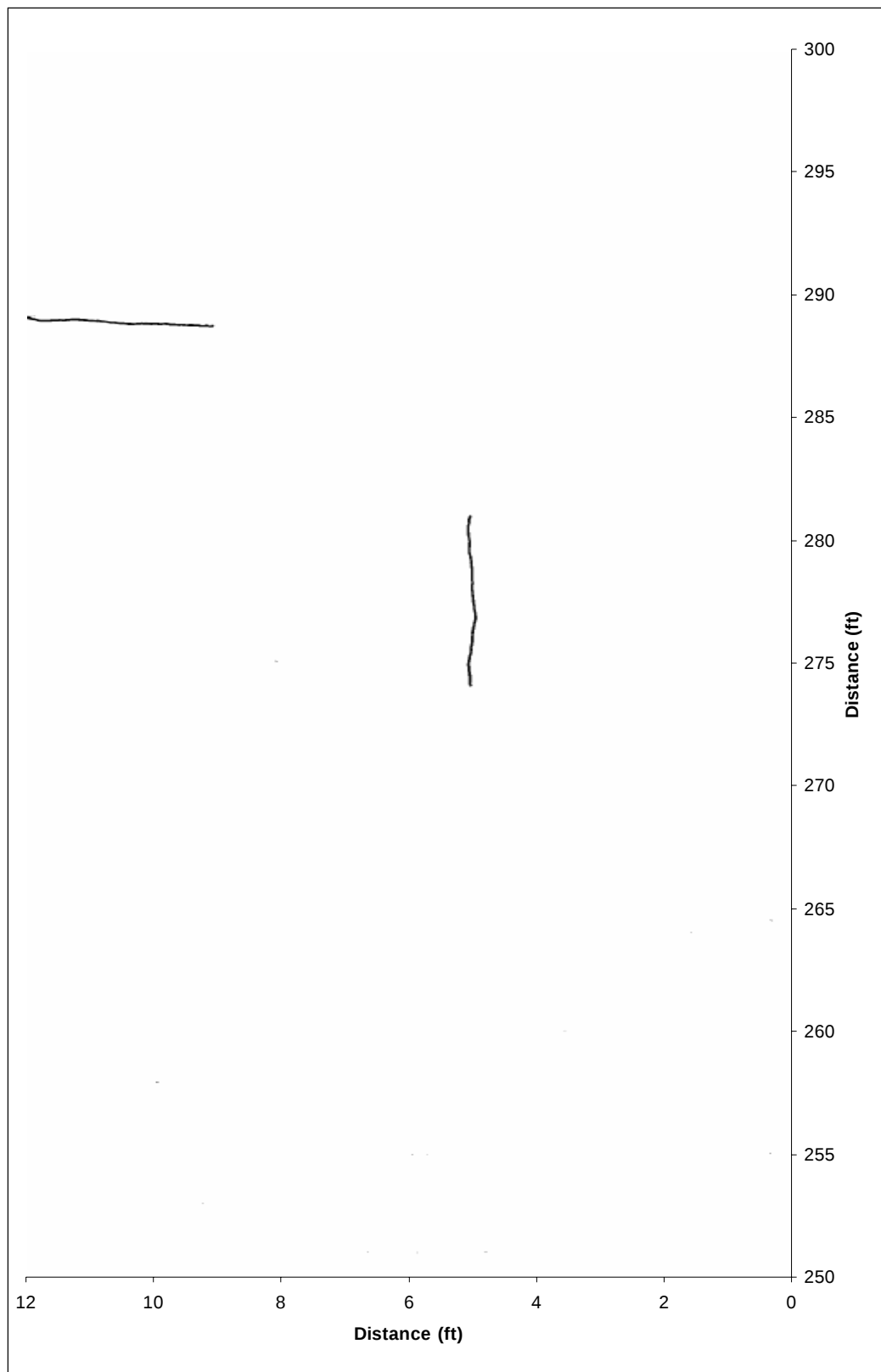


Figure 159. Robert Gray AAF Section 9 (Station 250-300 ft).

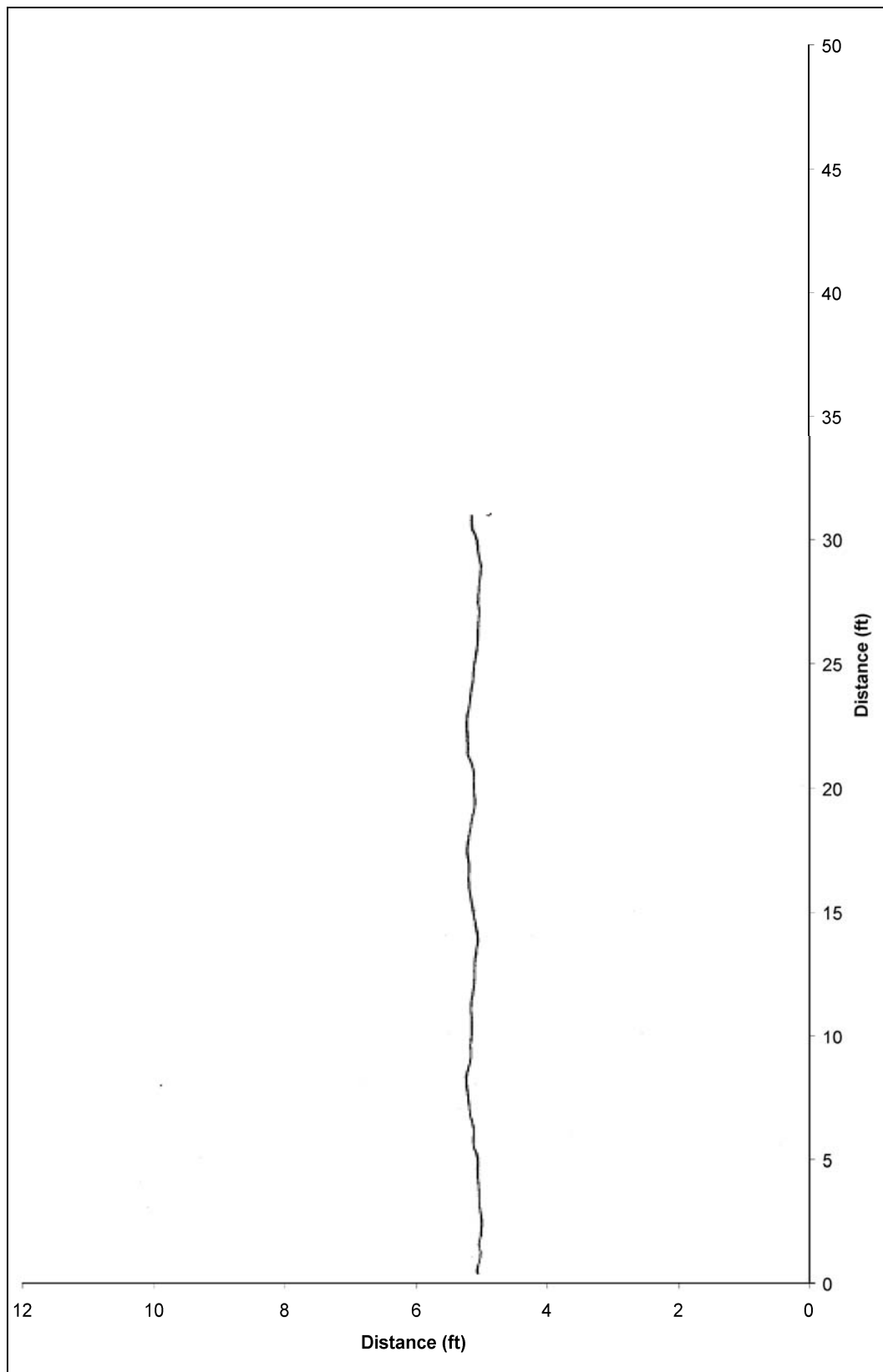


Figure 160. Robert Gray AAF Section 10 (Station 0-50 ft).

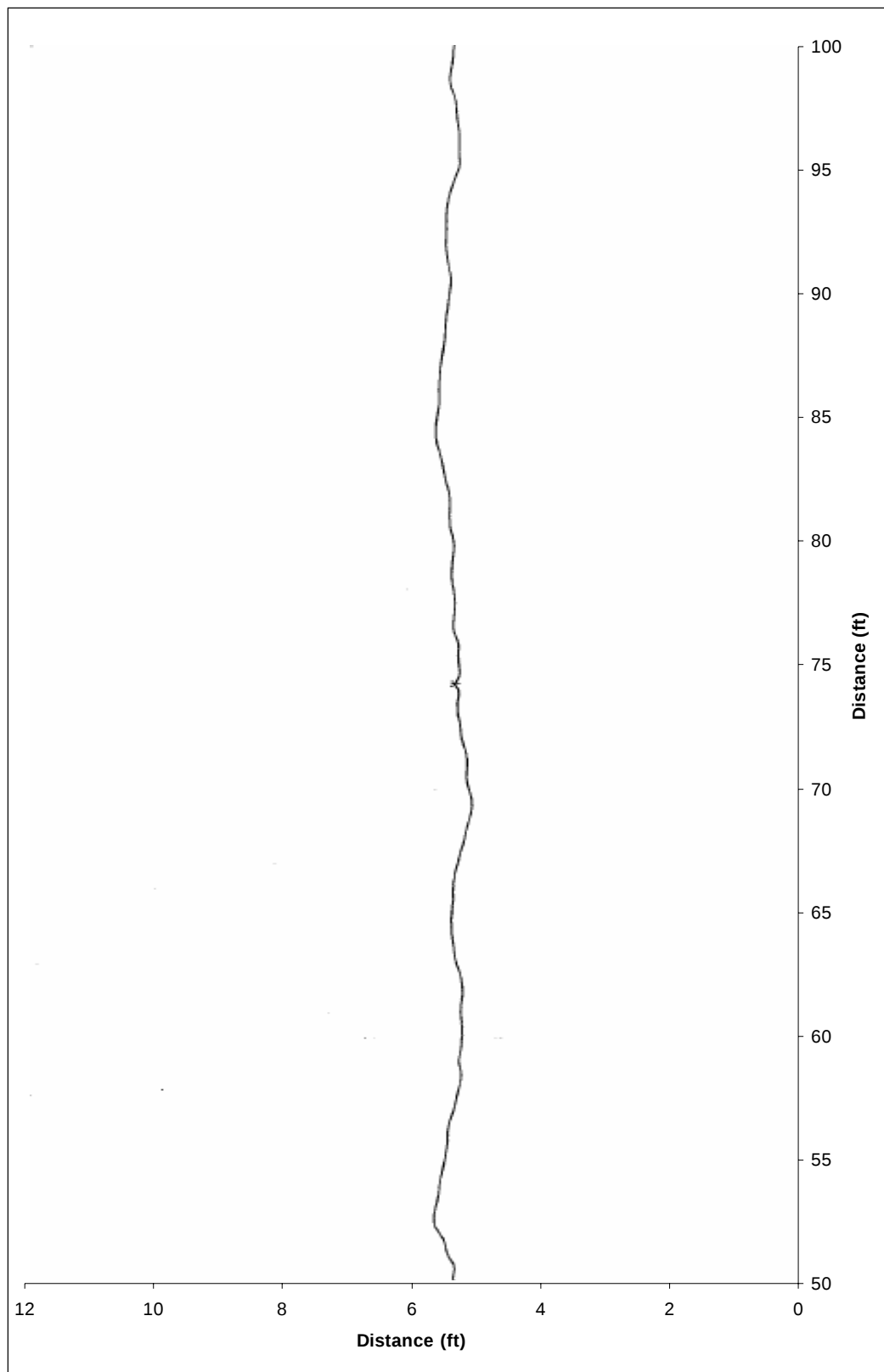


Figure 161. Robert Gray AAF Section 10 (Station 50-100 ft)

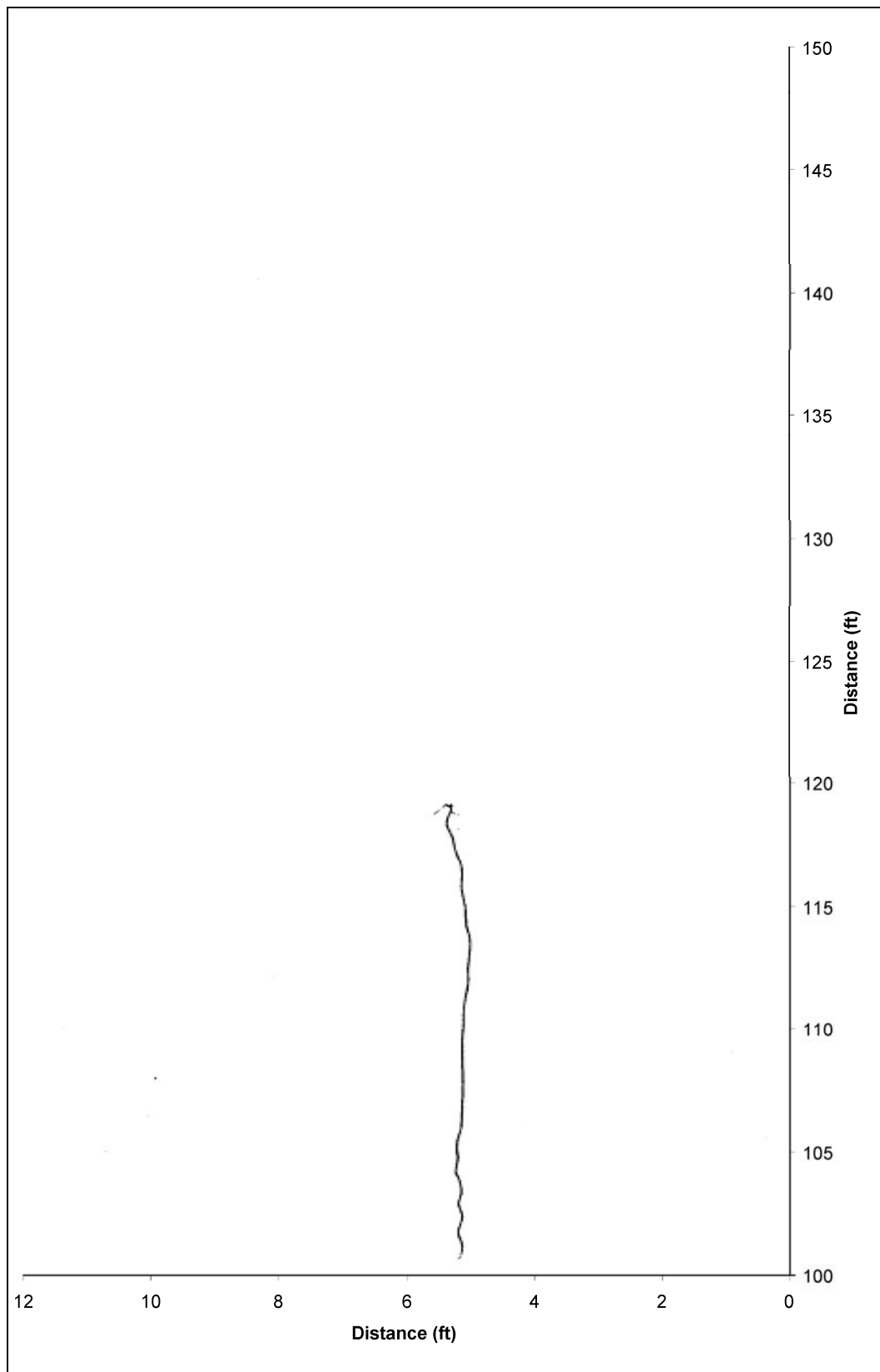


Figure 162. Robert Gray AAF Section 10 (Station 100-150 ft).

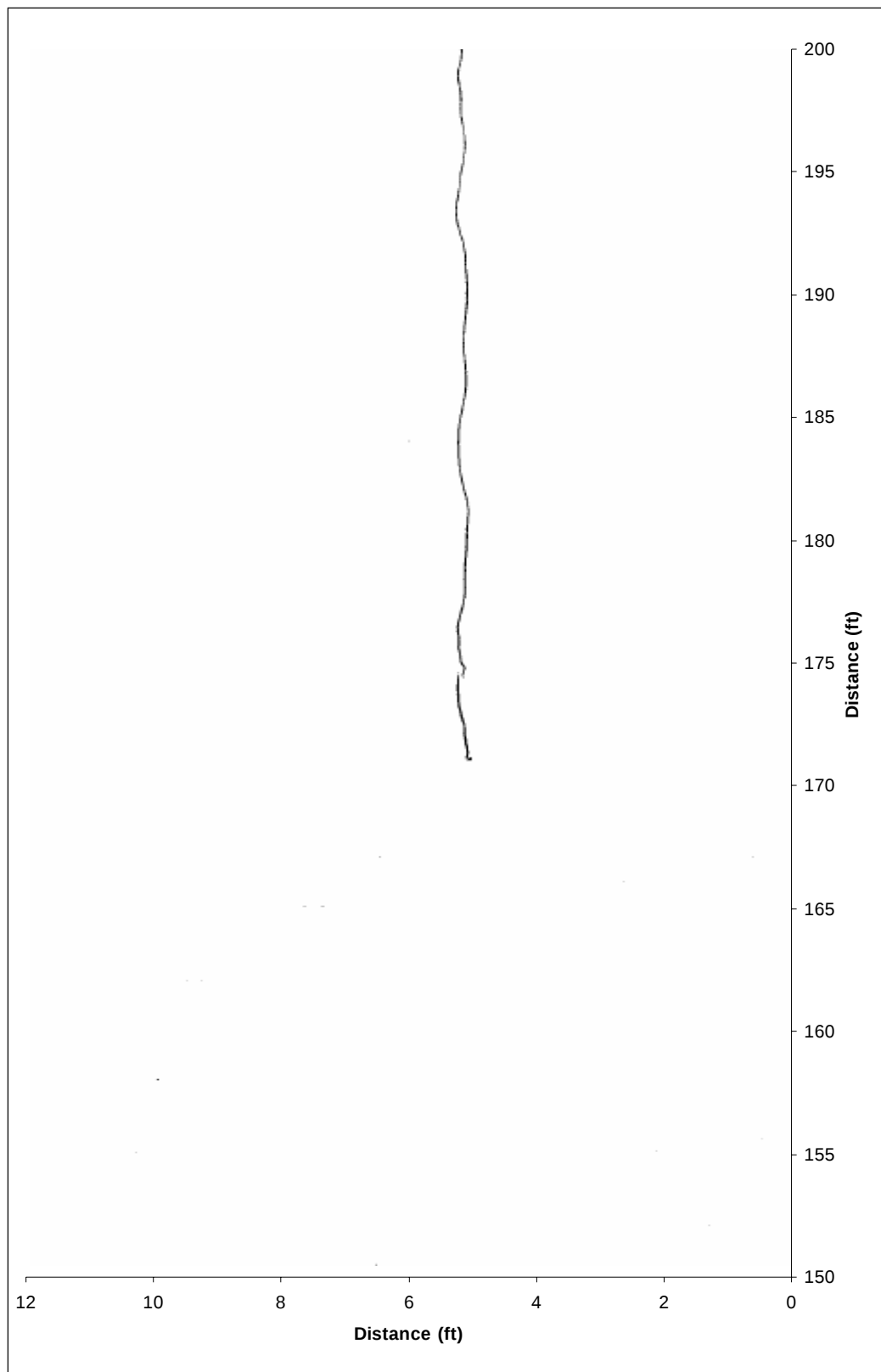


Figure 163. Robert Gray AAF Section 10 (Station 150-200 ft).

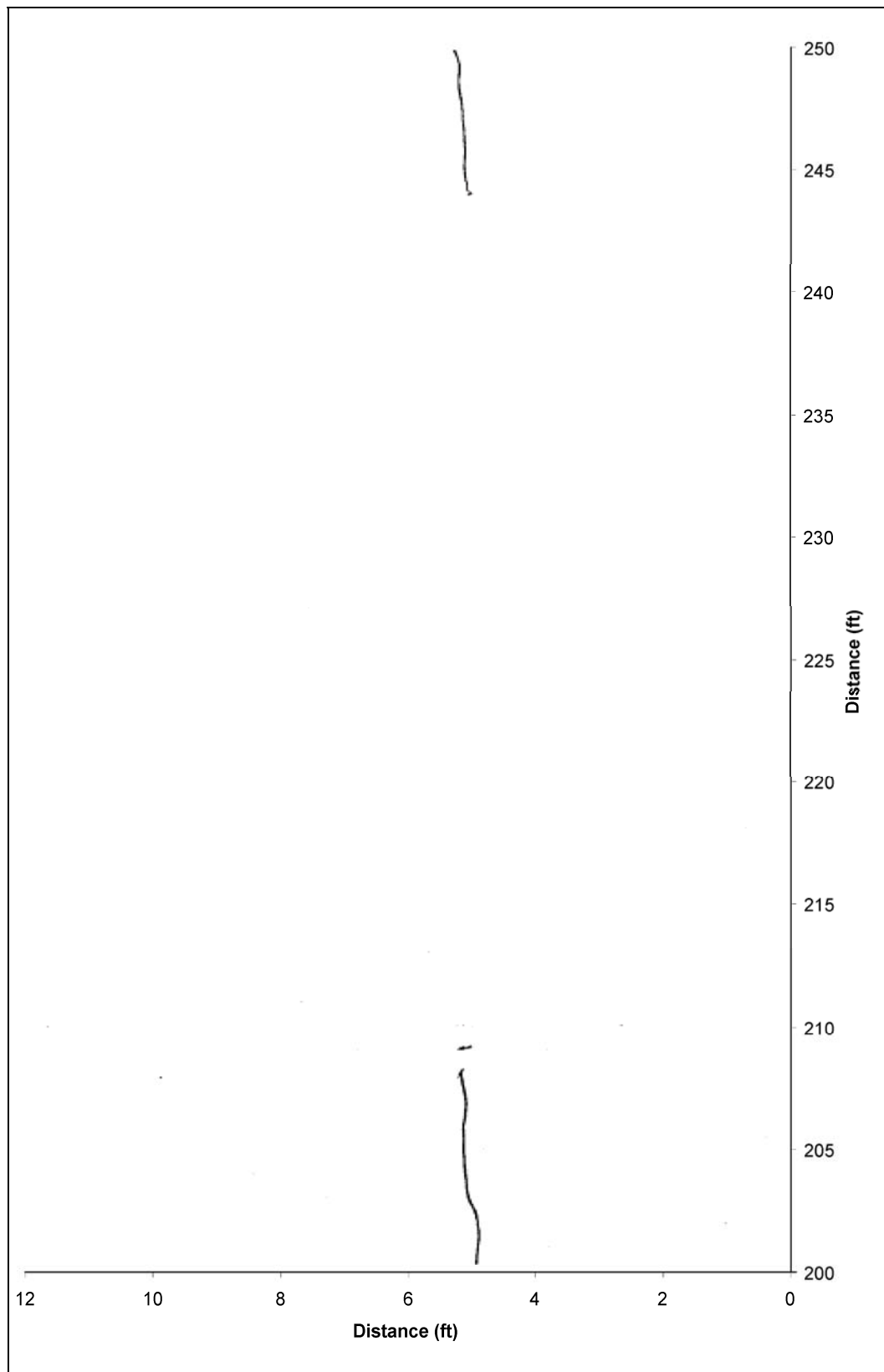


Figure 164. Robert Gray AAF Section 10 (Station 200-250 ft).

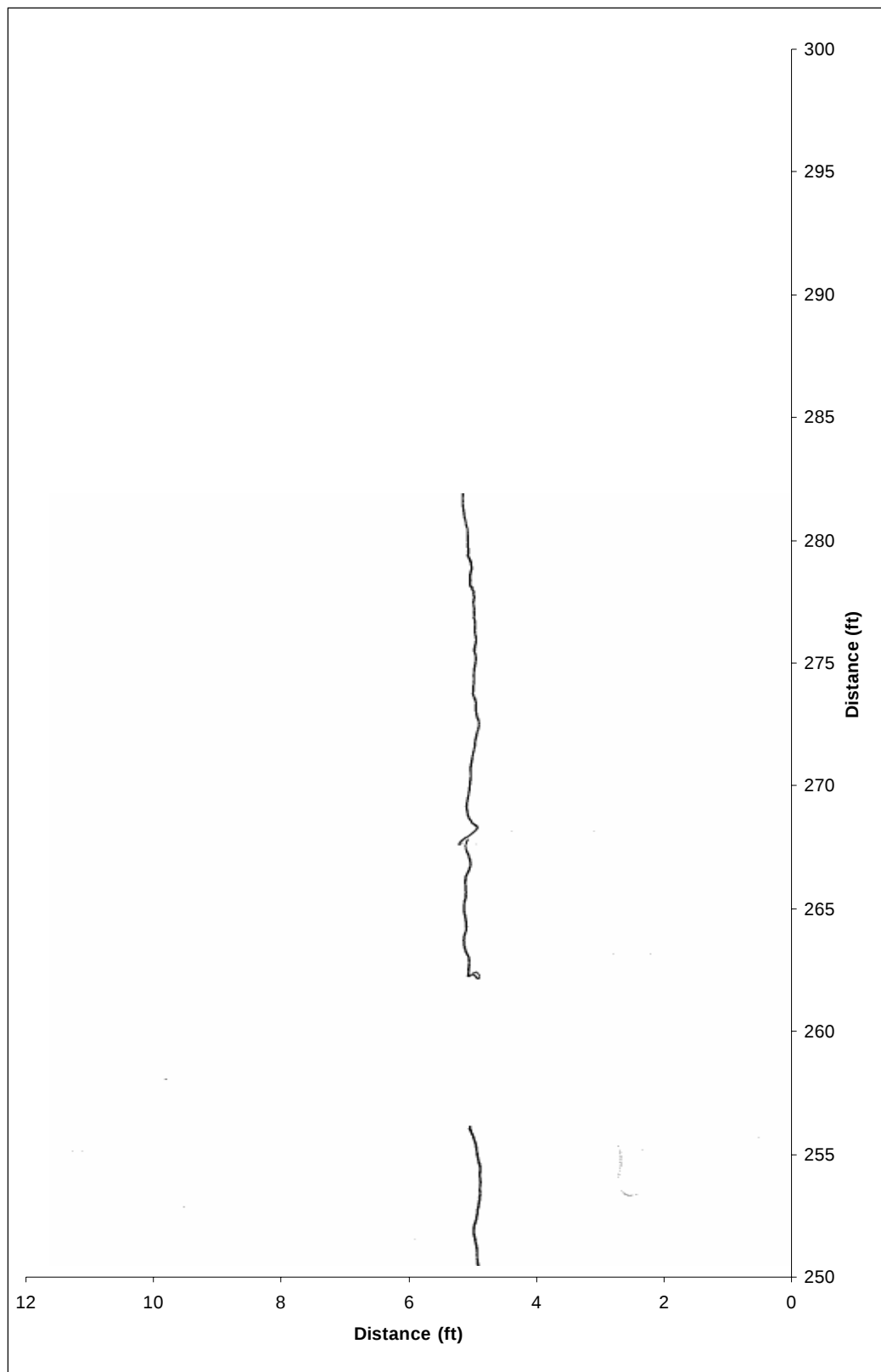


Figure 165. Robert Gray AAF Section 10 (Station 250-300 ft).

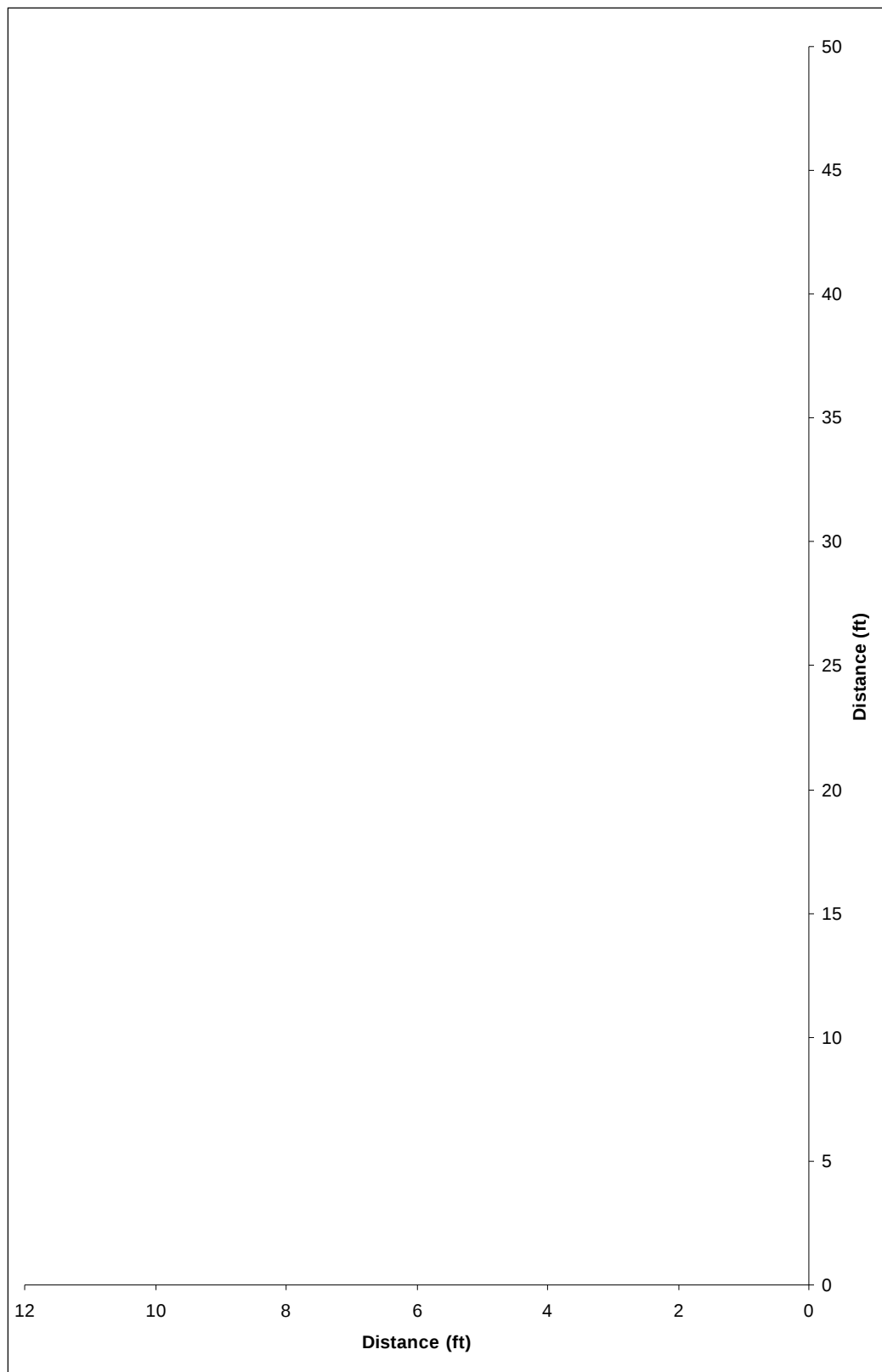


Figure 166. Robert Gray AAF Section 11 (Station 0-50 ft).

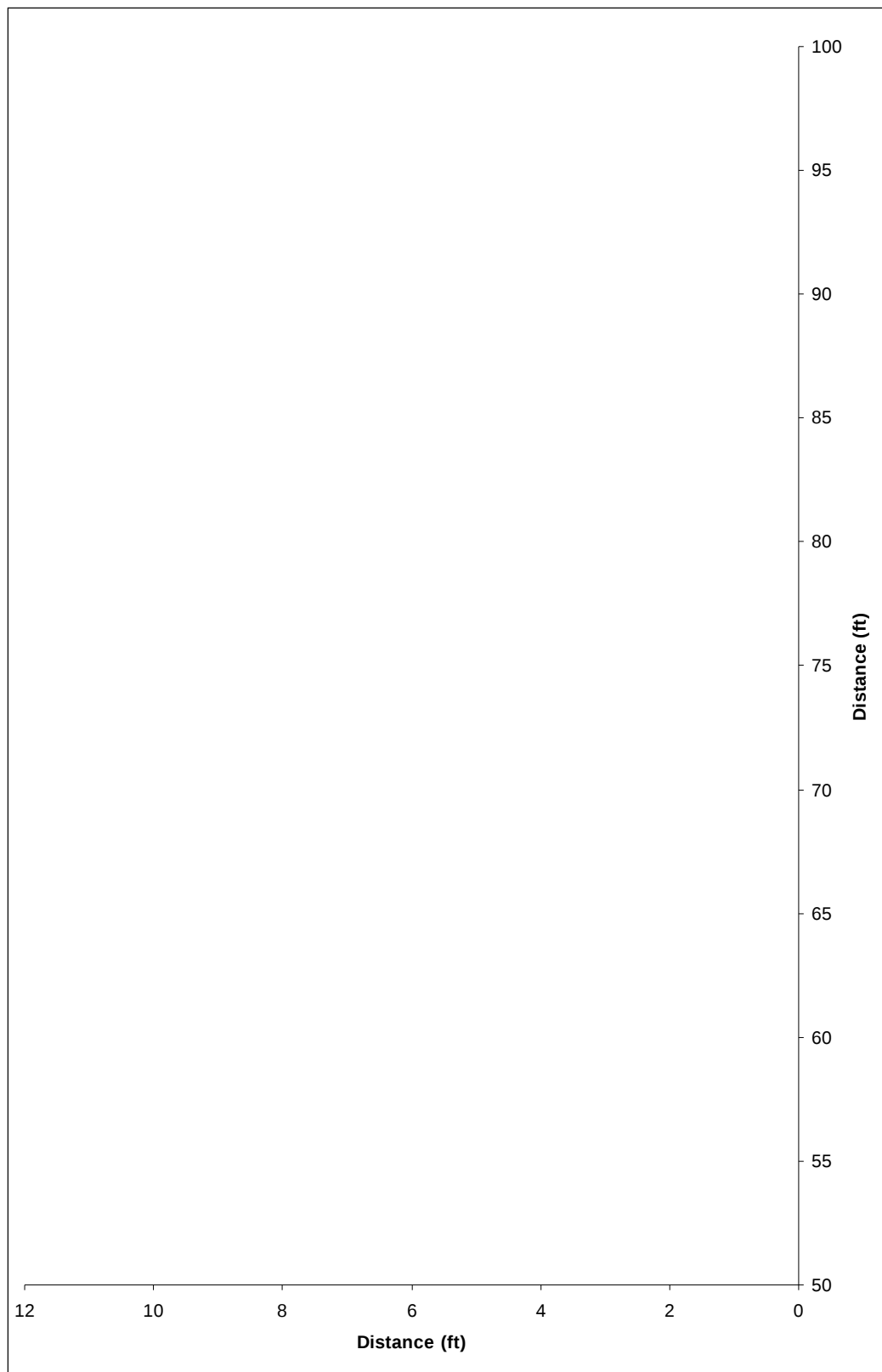


Figure 167. Robert Gray AAF Section 11 (Station 50-100 ft).

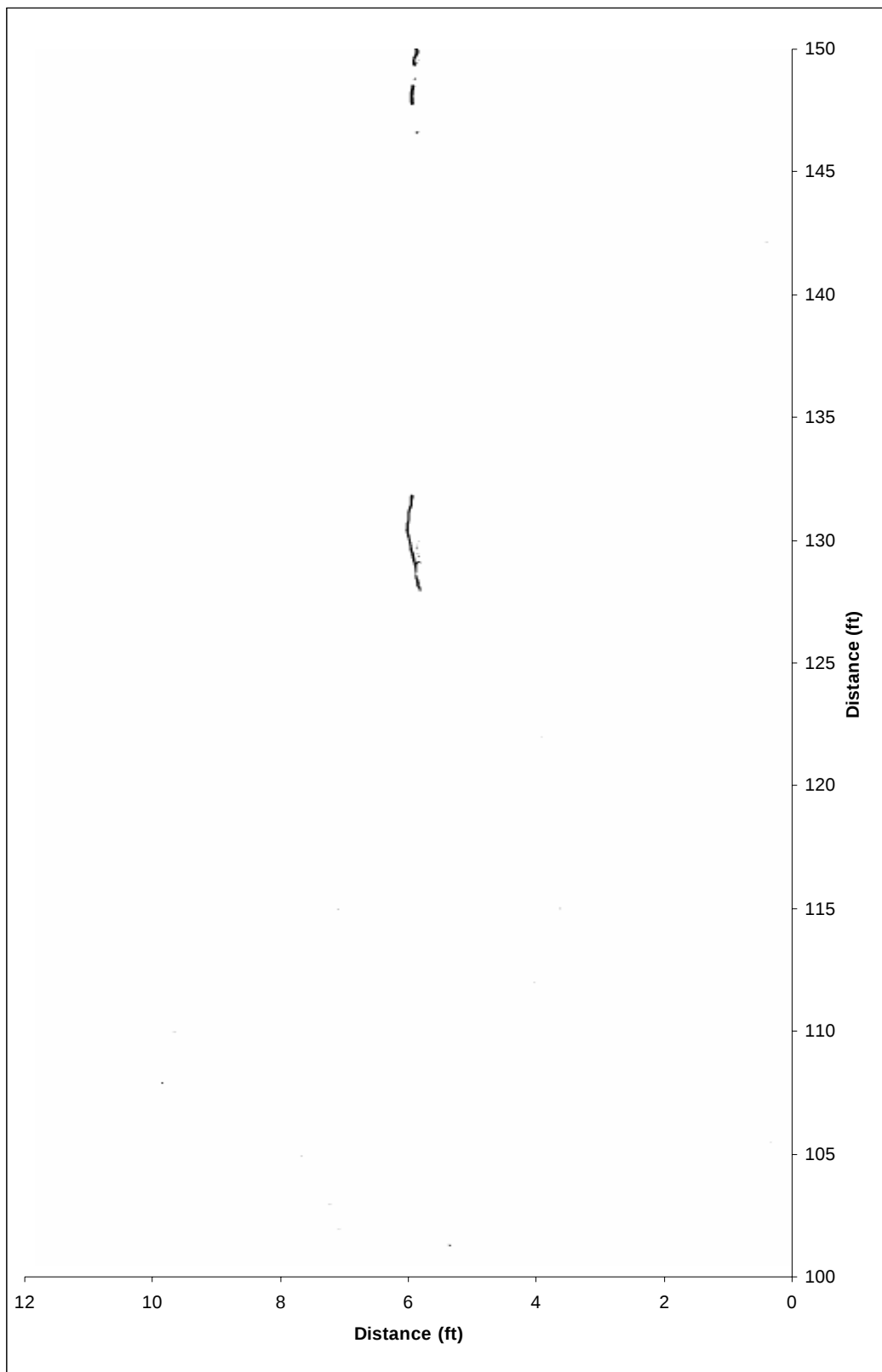


Figure 168. Robert Gray AAF Section 11 (Station 100-150 ft).

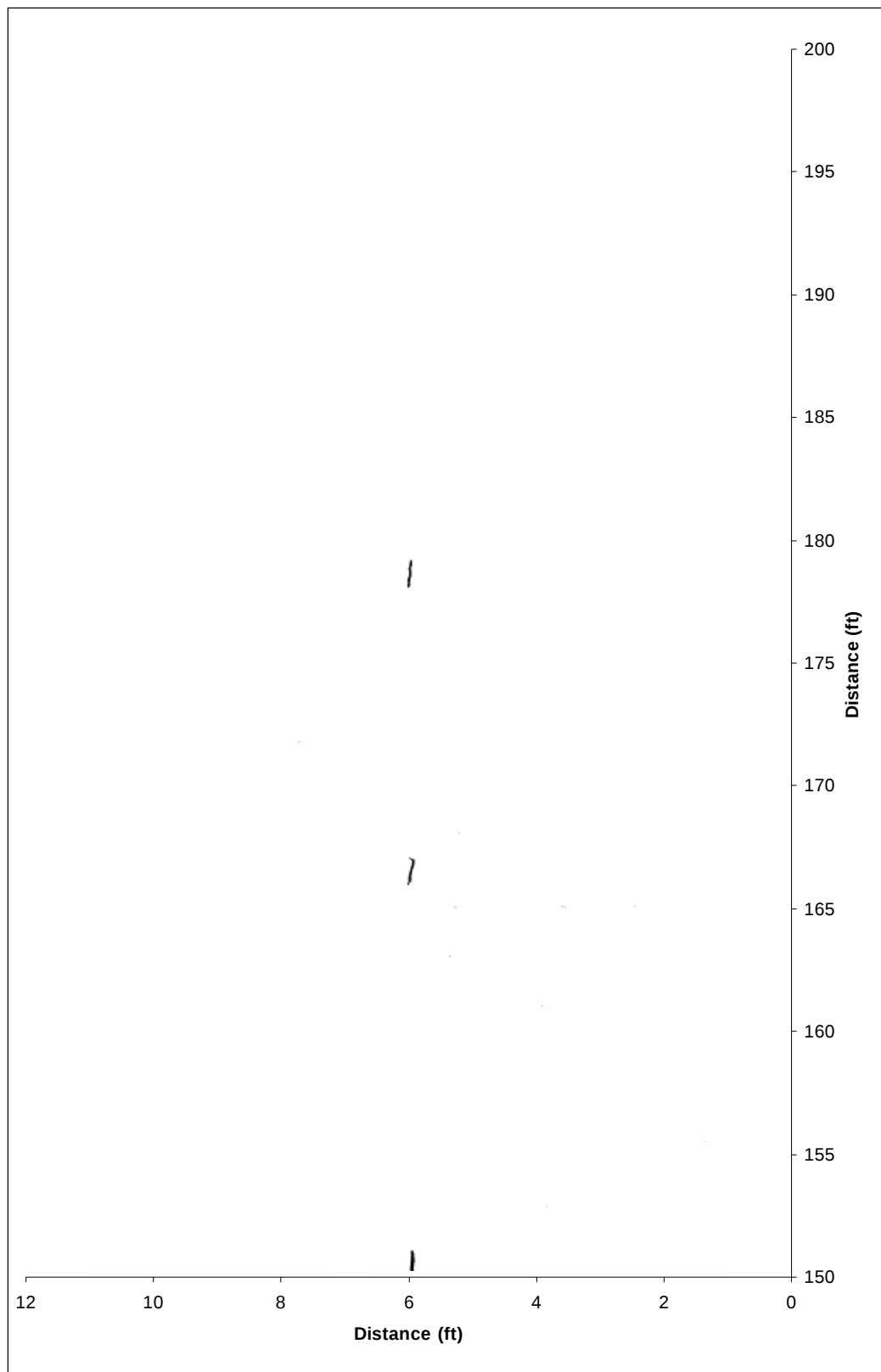


Figure 169. Robert Gray AAF Section 11 (Station 150-200 ft).

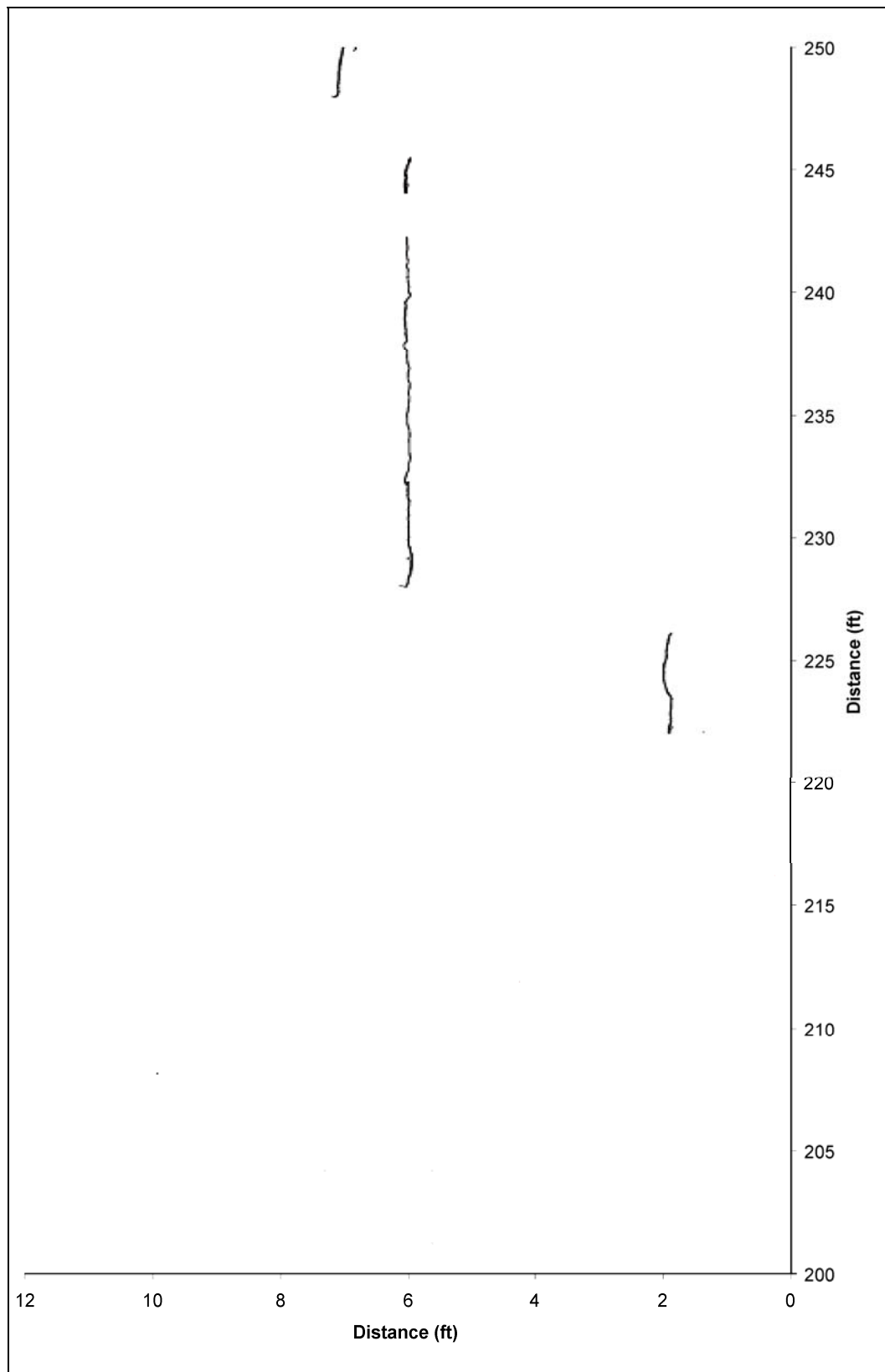


Figure 170. Robert Gray AAF Section 11 (Station 200-250 ft).



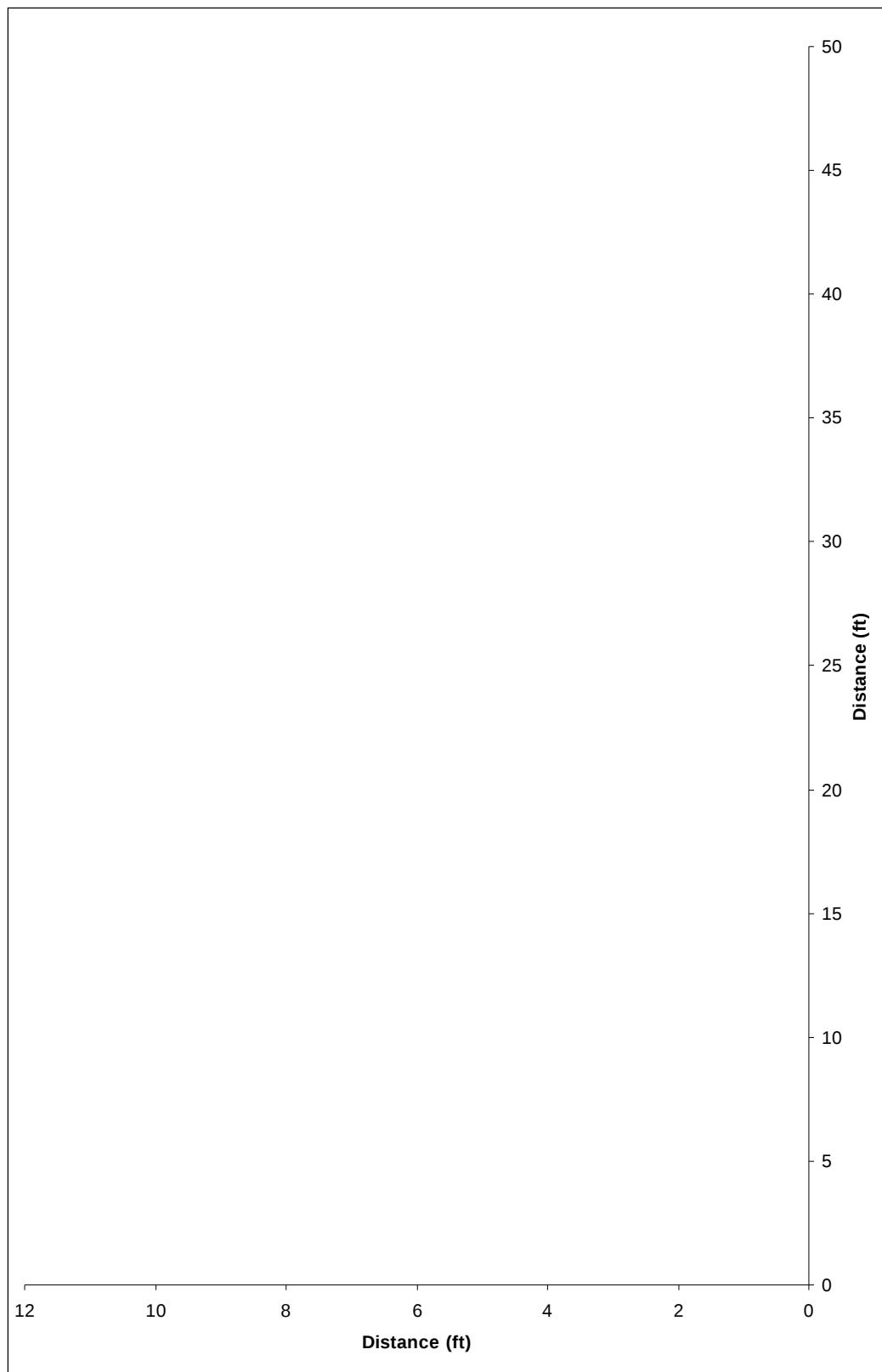


Figure 172. Robert Gray AAF Section 12 (Station 0-50 ft).

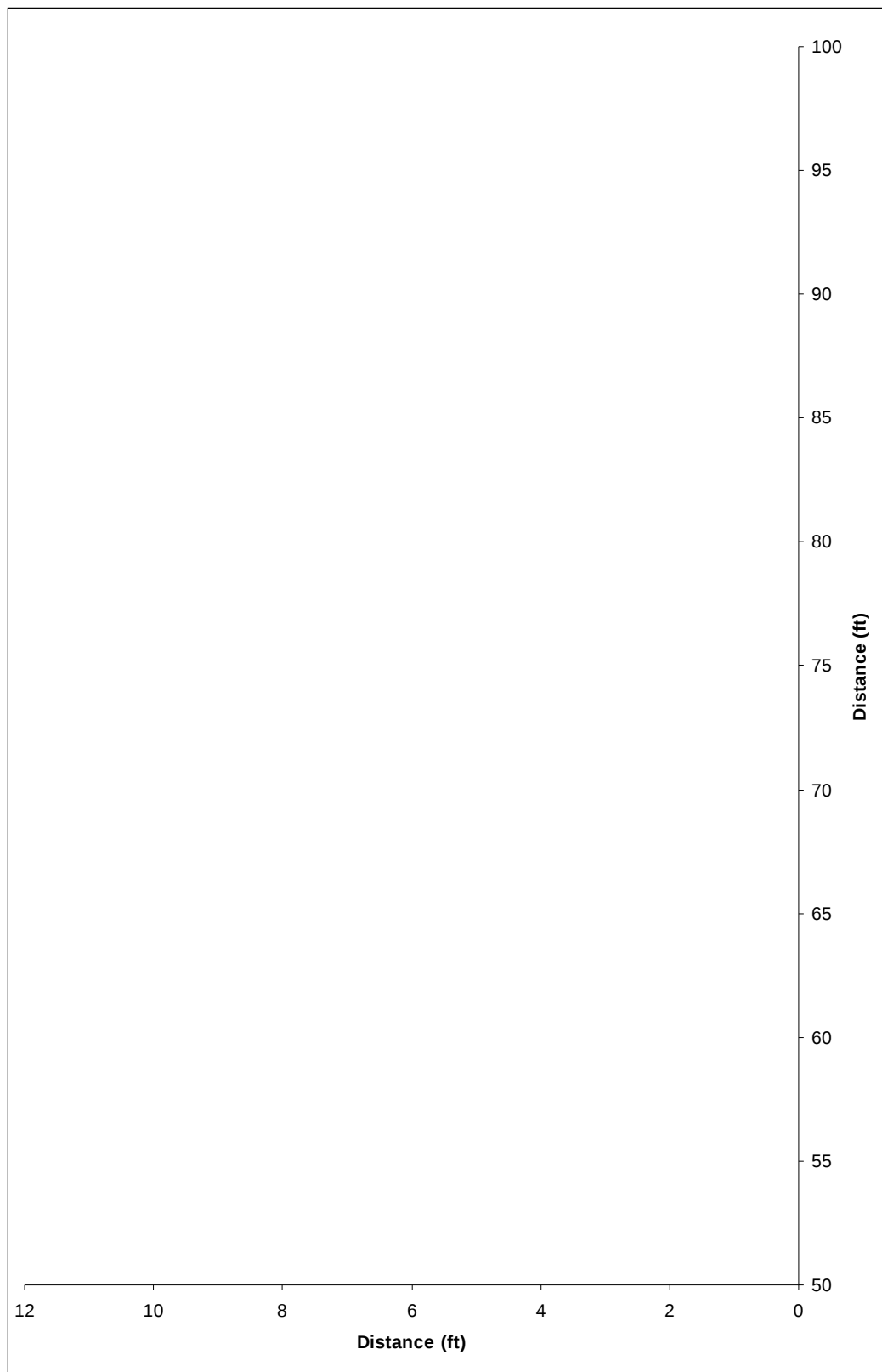


Figure 173. Robert Gray AAF Section 12 (Station 50-100 ft).

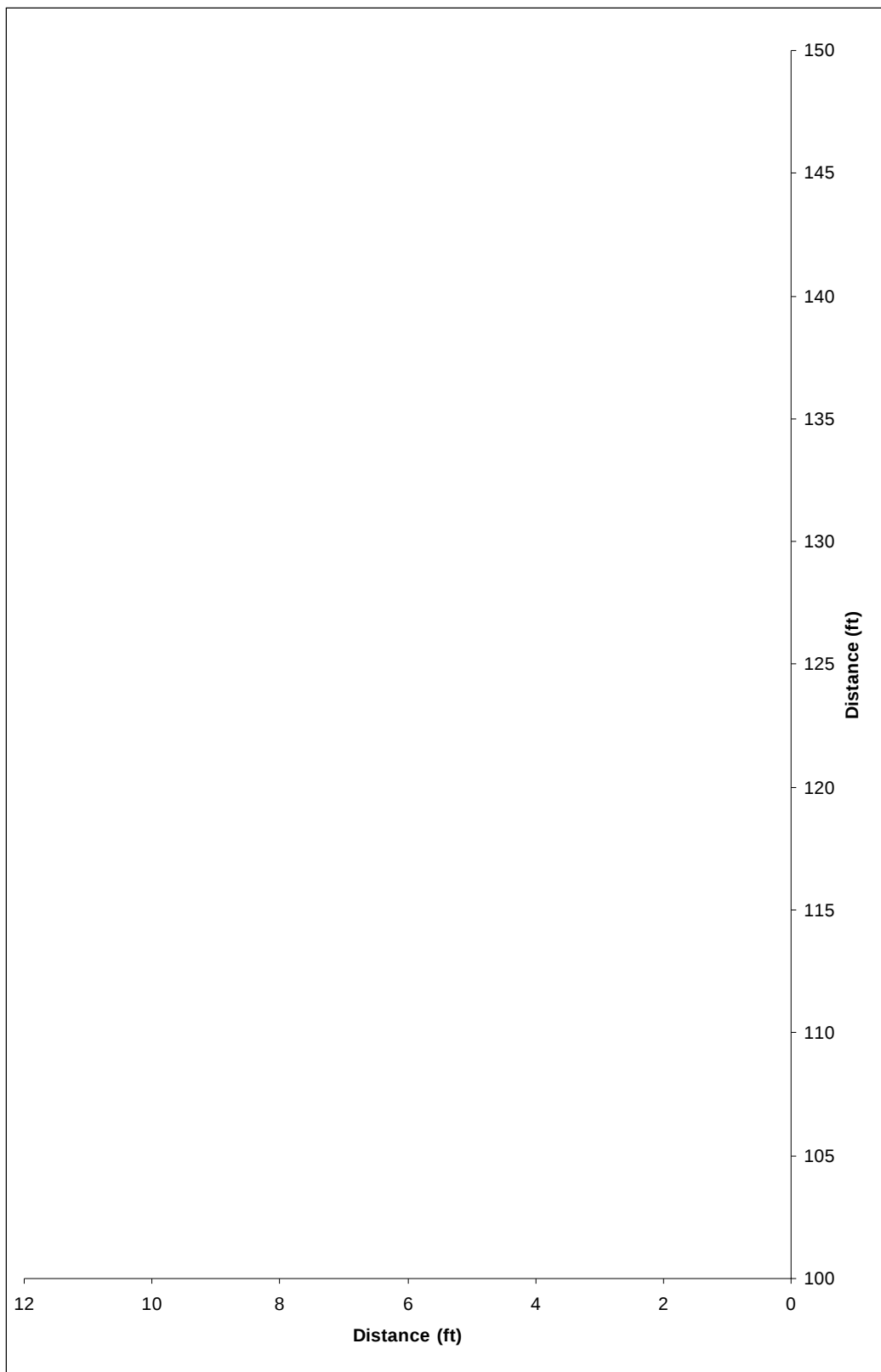


Figure 174. Robert Gray AAF Section 12 (Station 100-150 ft).

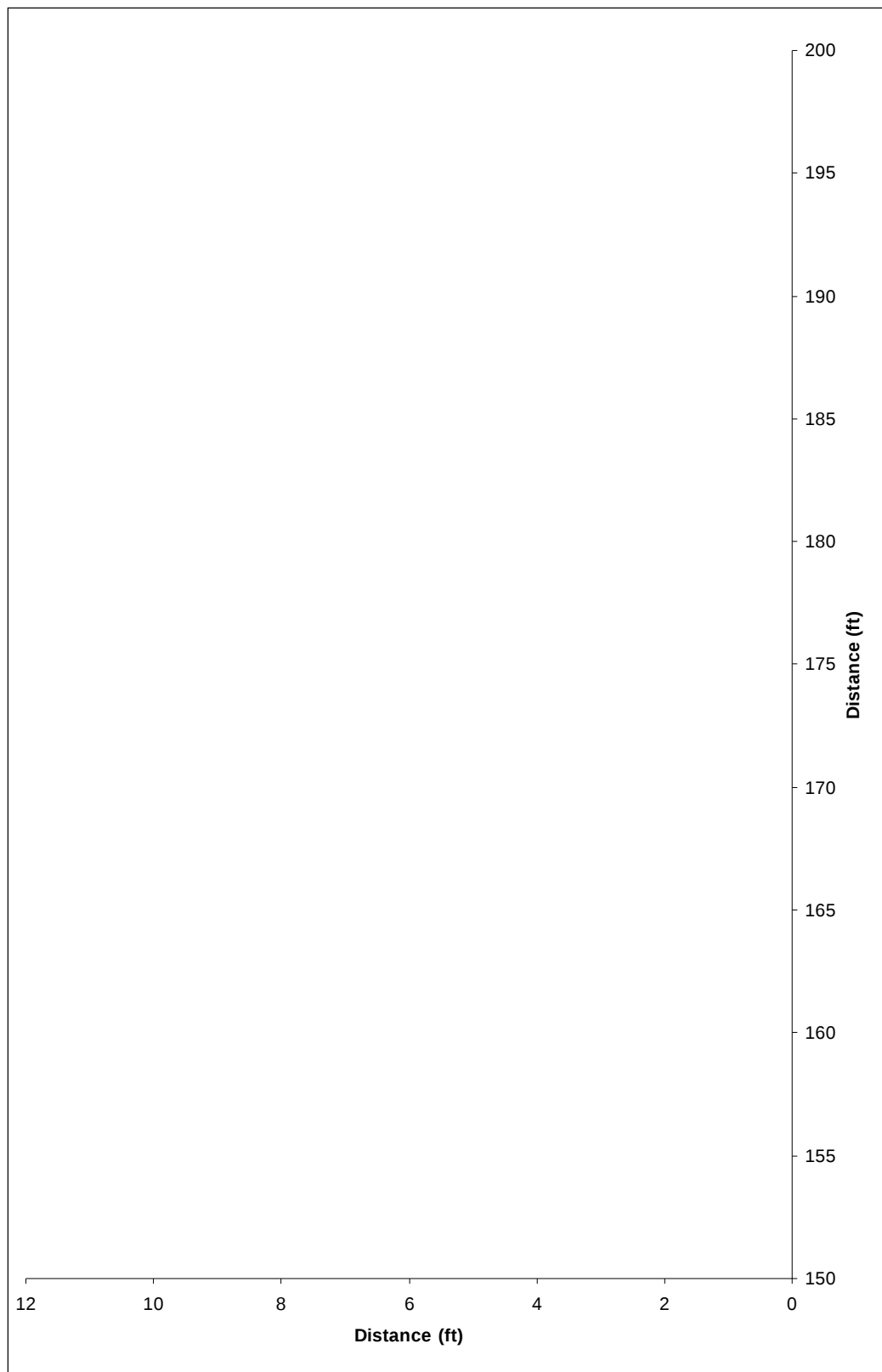


Figure 175. Robert Gray AAF Section 12 (Station 150-200 ft).

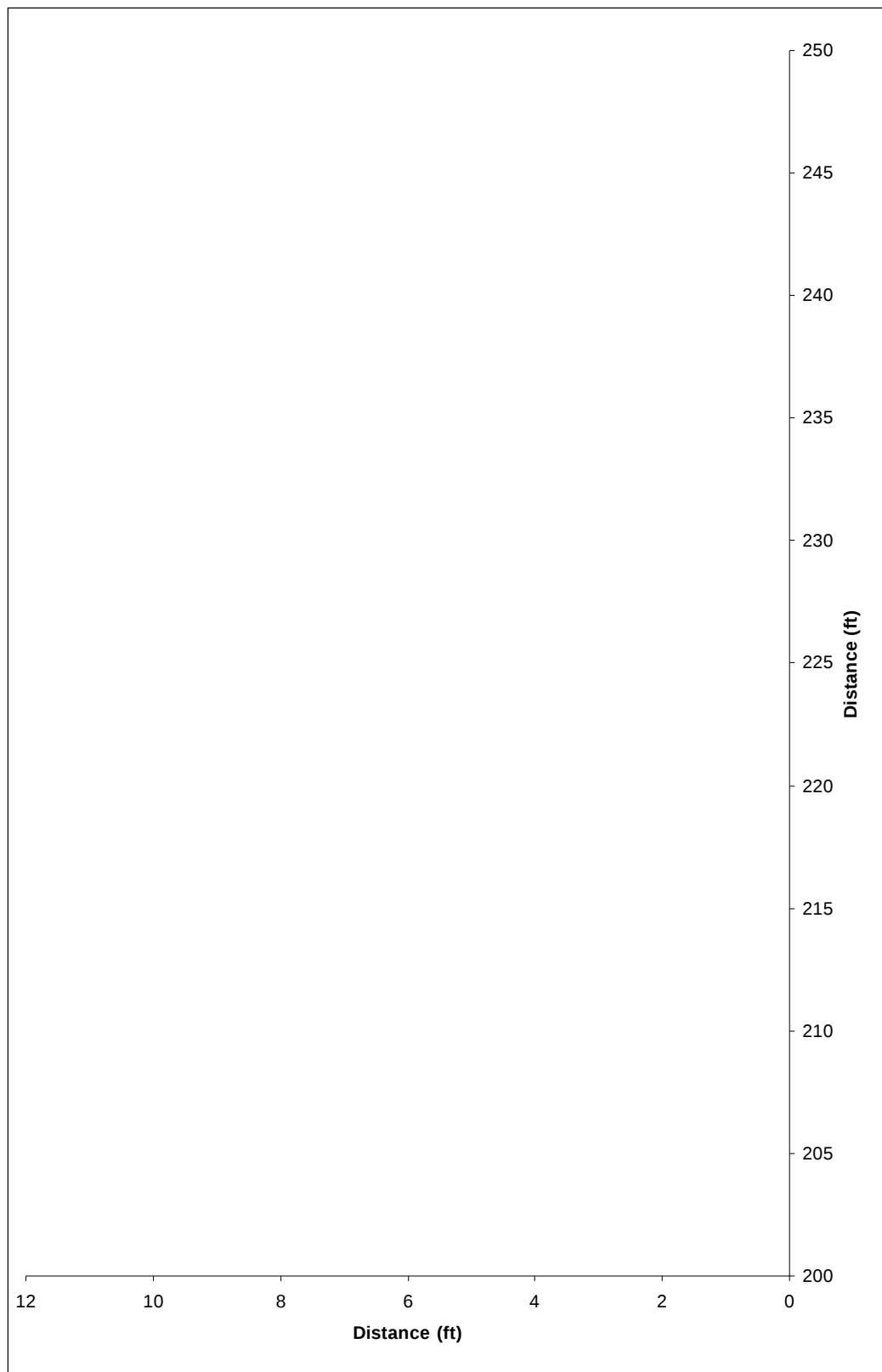


Figure 176. Robert Gray AAF Section 12 (Station 200-250 ft).

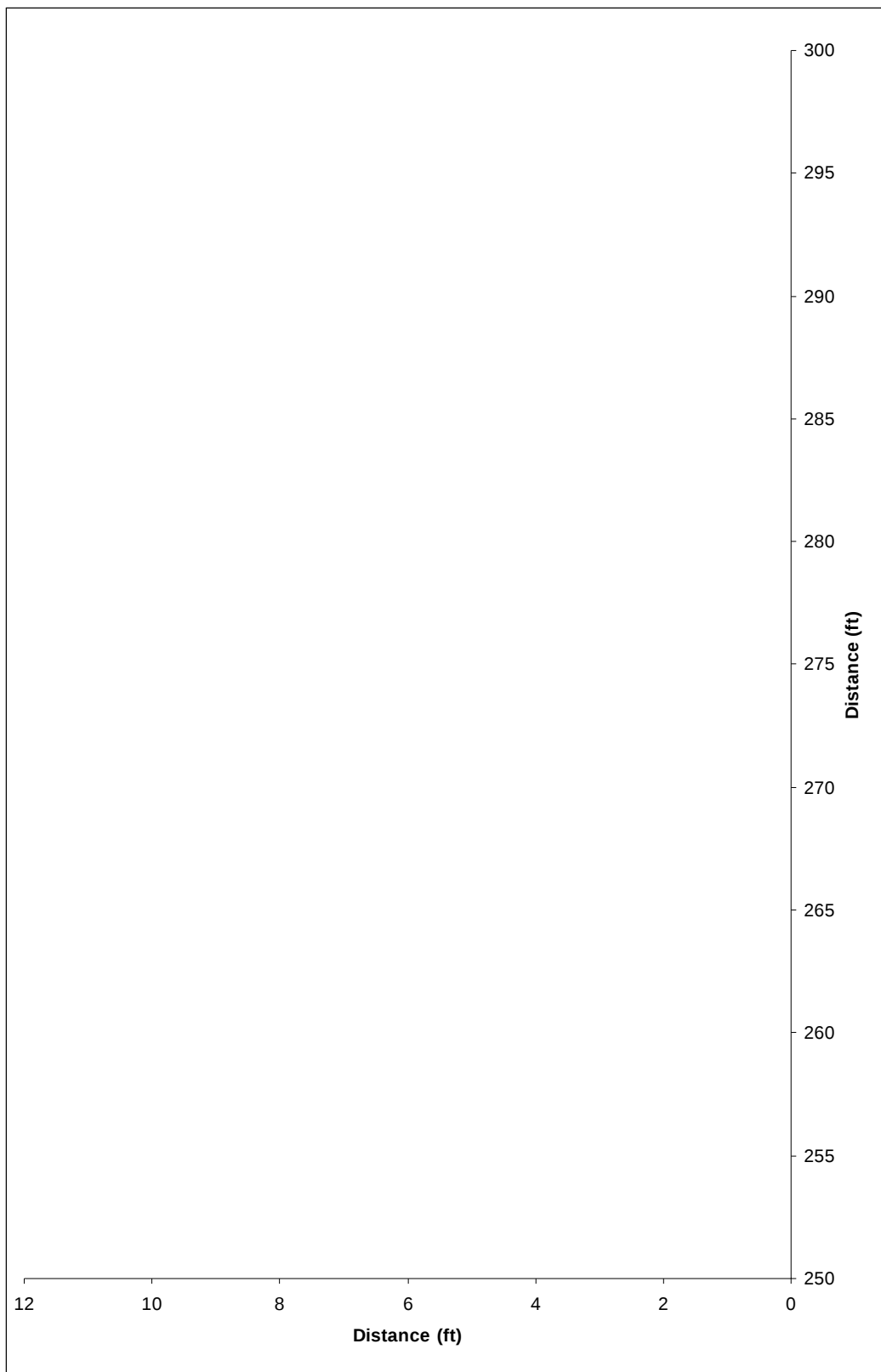


Figure 177. Robert Gray AAF Section 12 (Station 250-300 ft).

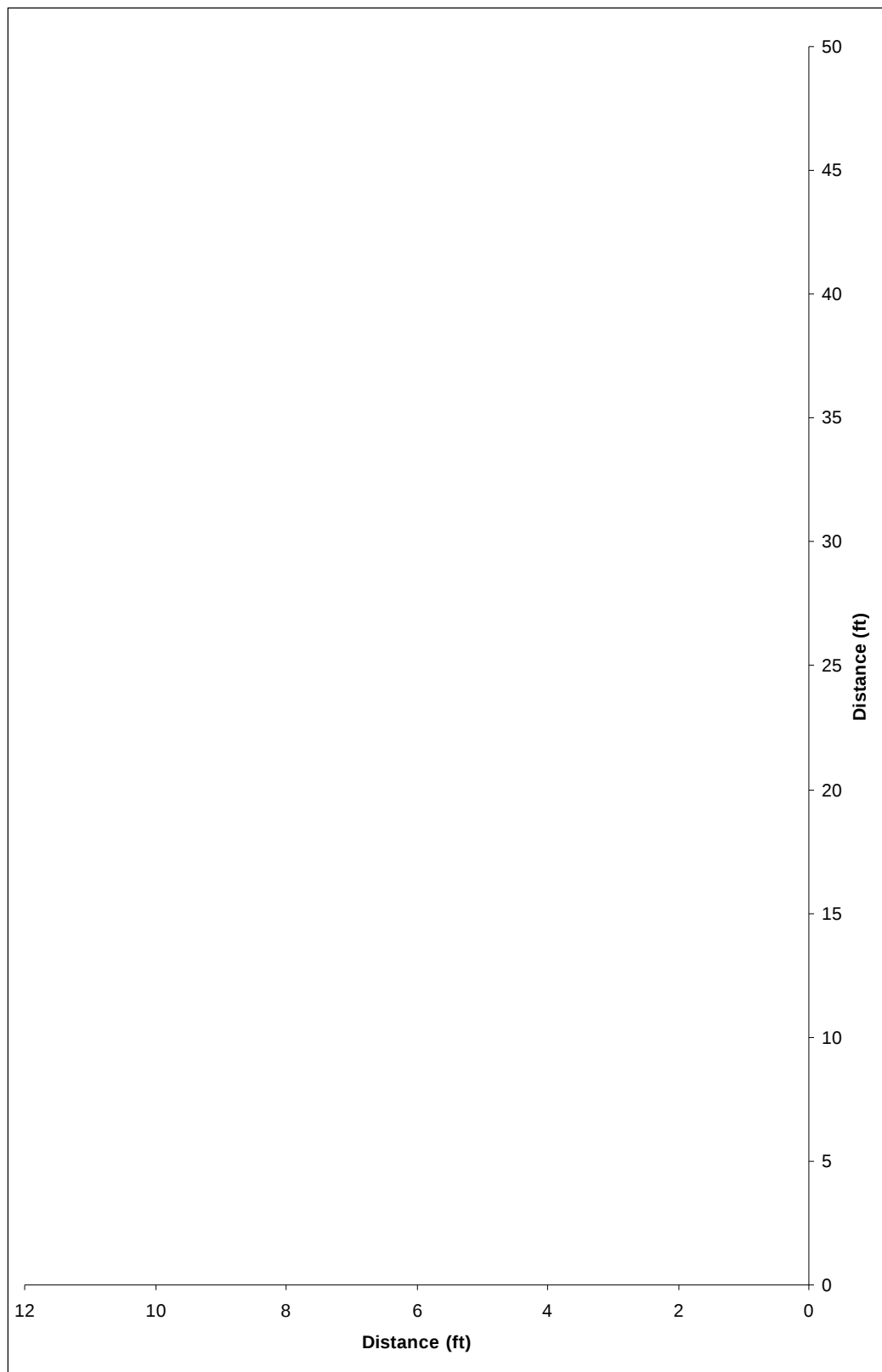


Figure 178. Robert Gray AAF Section 13 (Station 0-50 ft).

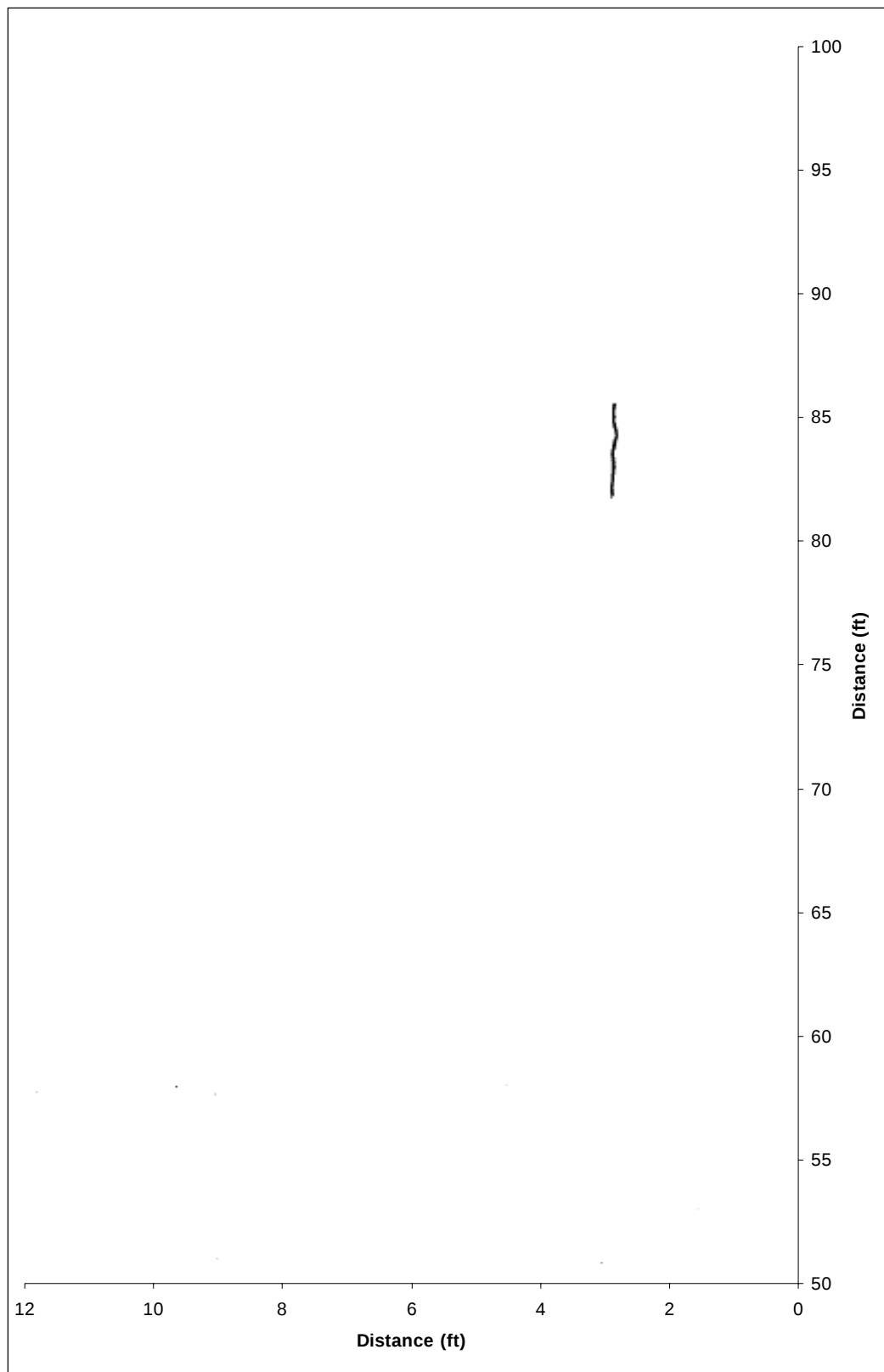


Figure 179. Robert Gray AAF Section 13 (Station 50-100 ft).

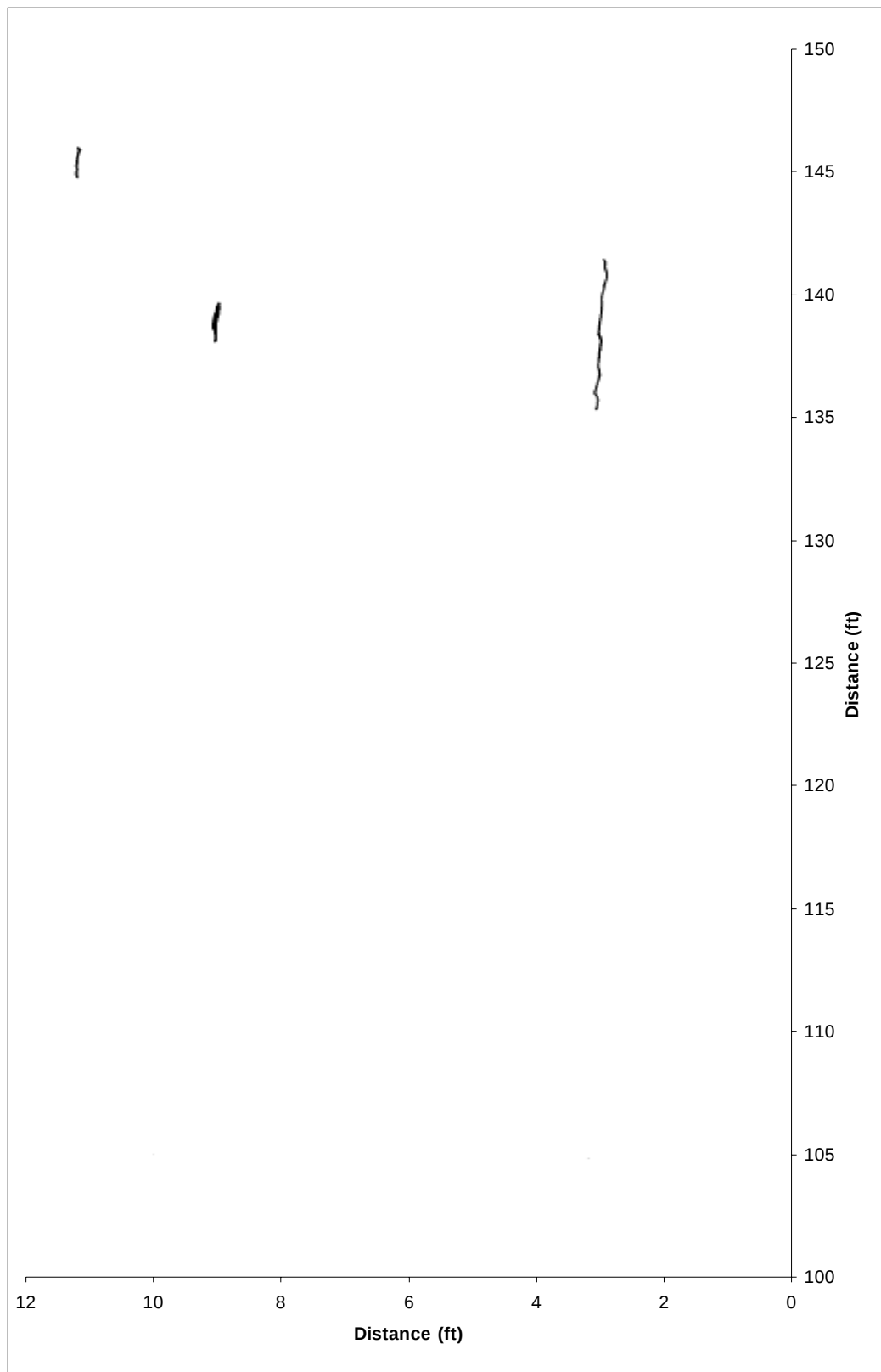


Figure 180. Robert Gray AAF Section 13 (Station 100-150 ft).

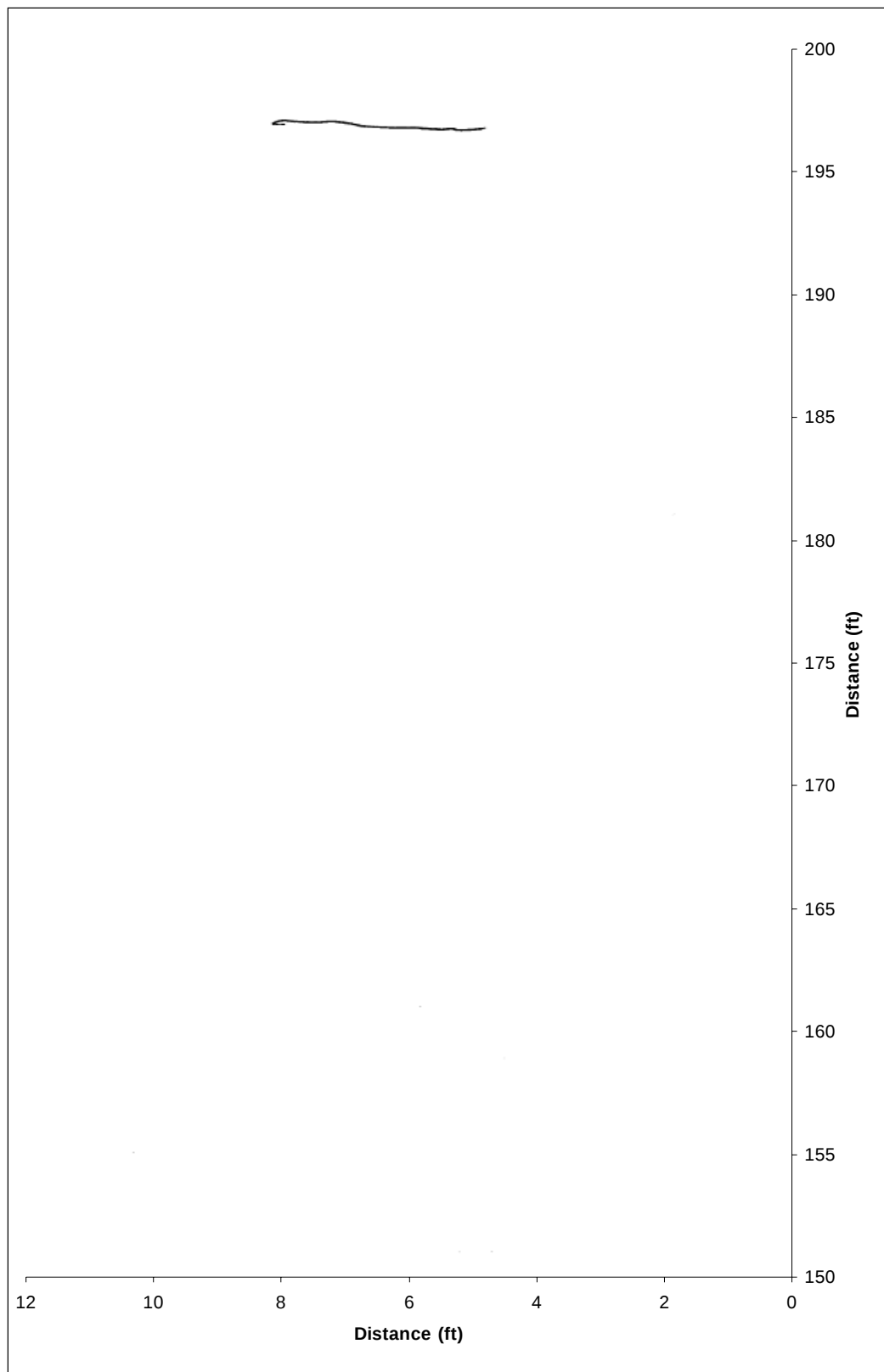


Figure 181. Robert Gray AAF Section 13 (Station 150-200 ft).

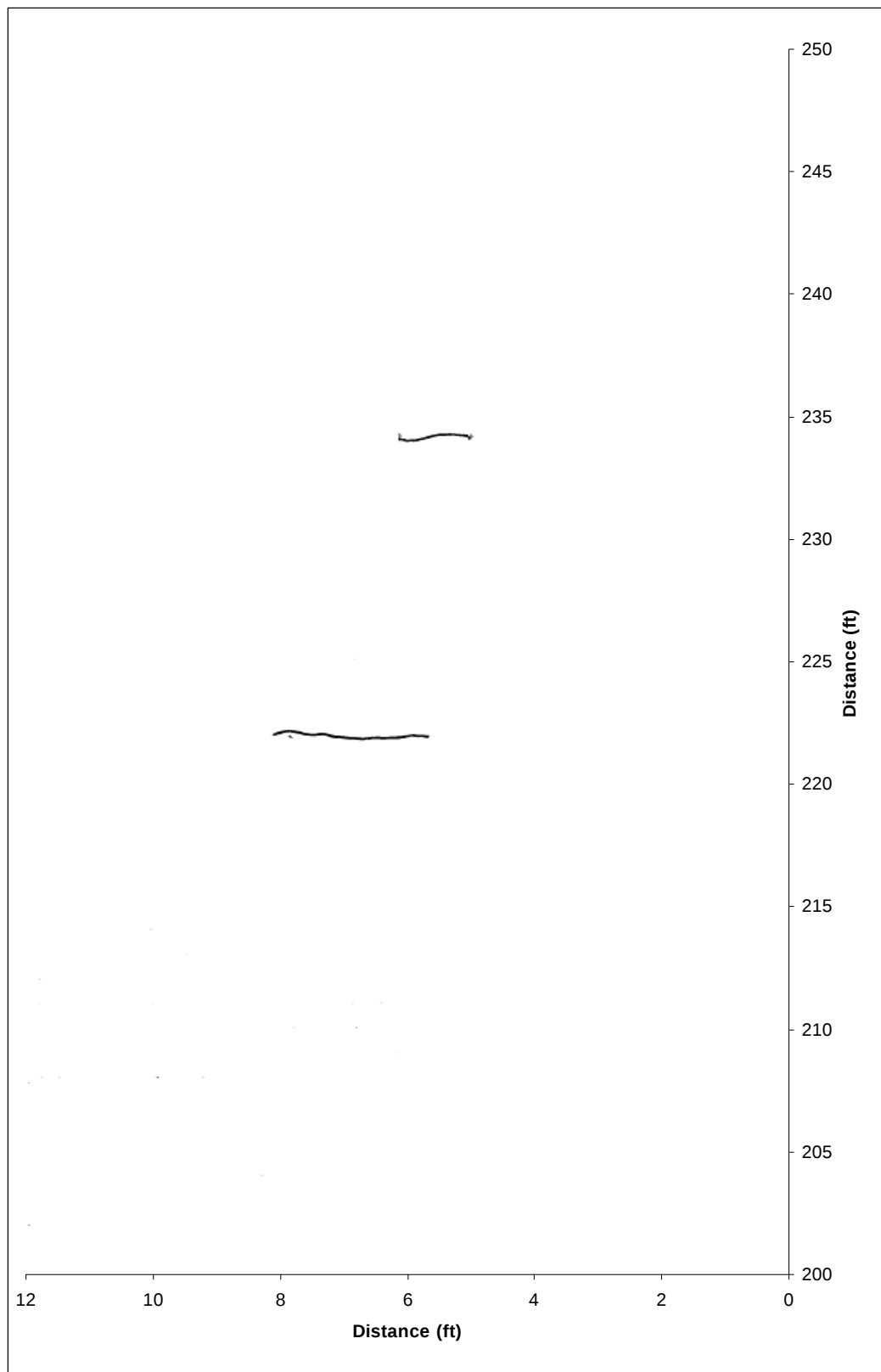


Figure 182. Robert Gray AAF Section 13 (Station 200-250 ft).

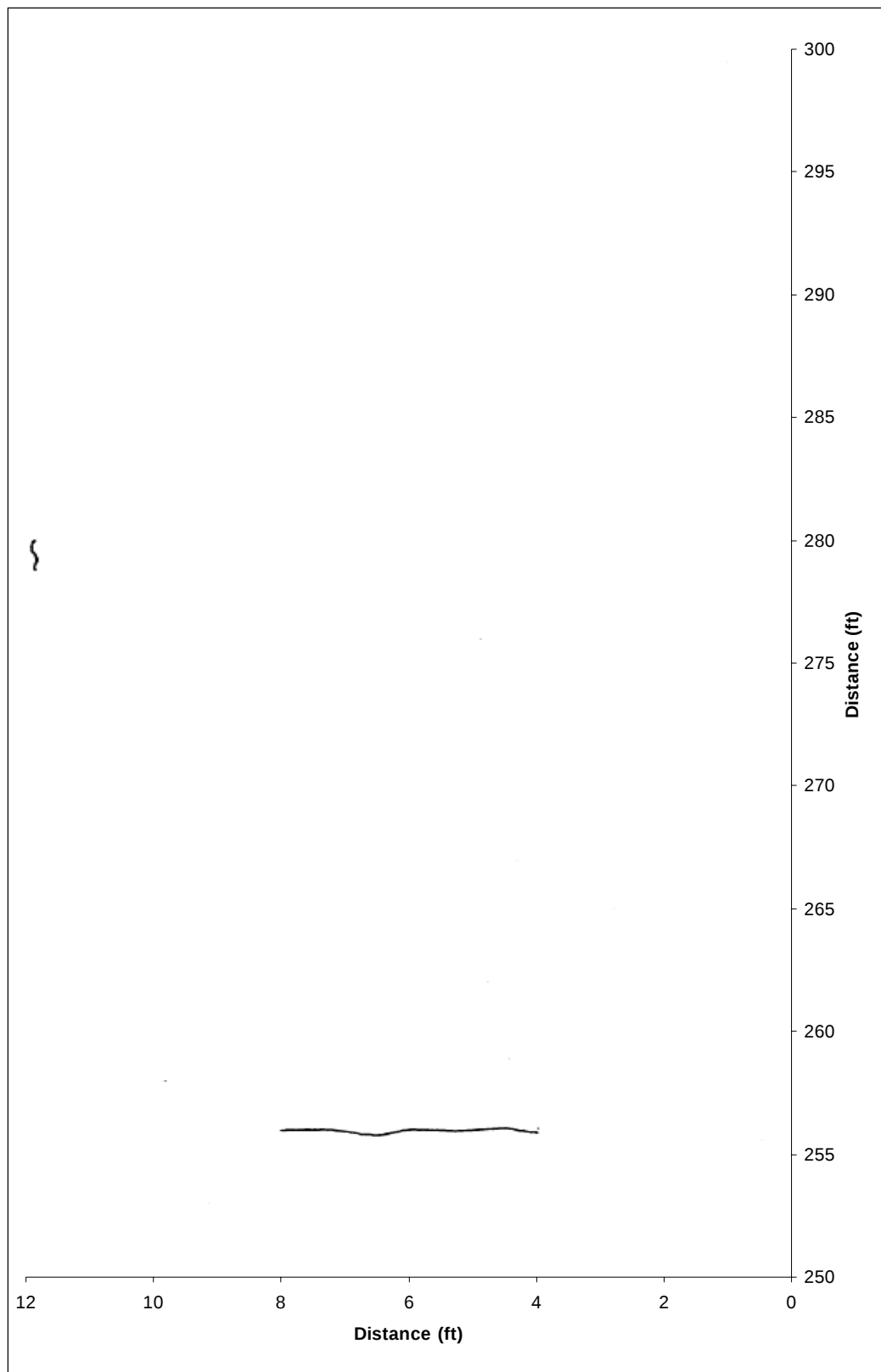


Figure 183. Robert Gray AAF Section 13 (Station 250-300 ft).

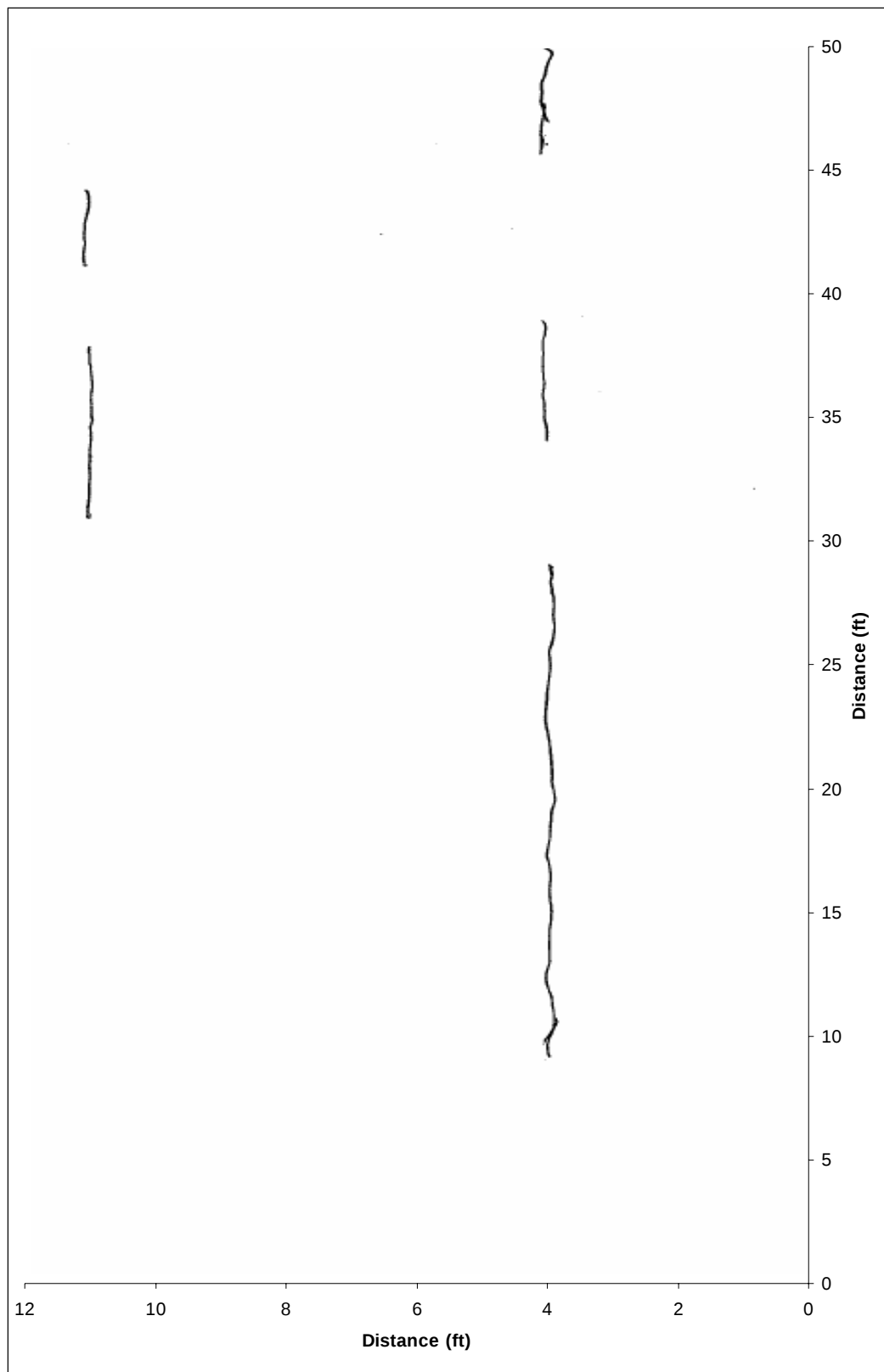


Figure 184. Robert Gray AAF Section 14 (Station 0-50 ft).

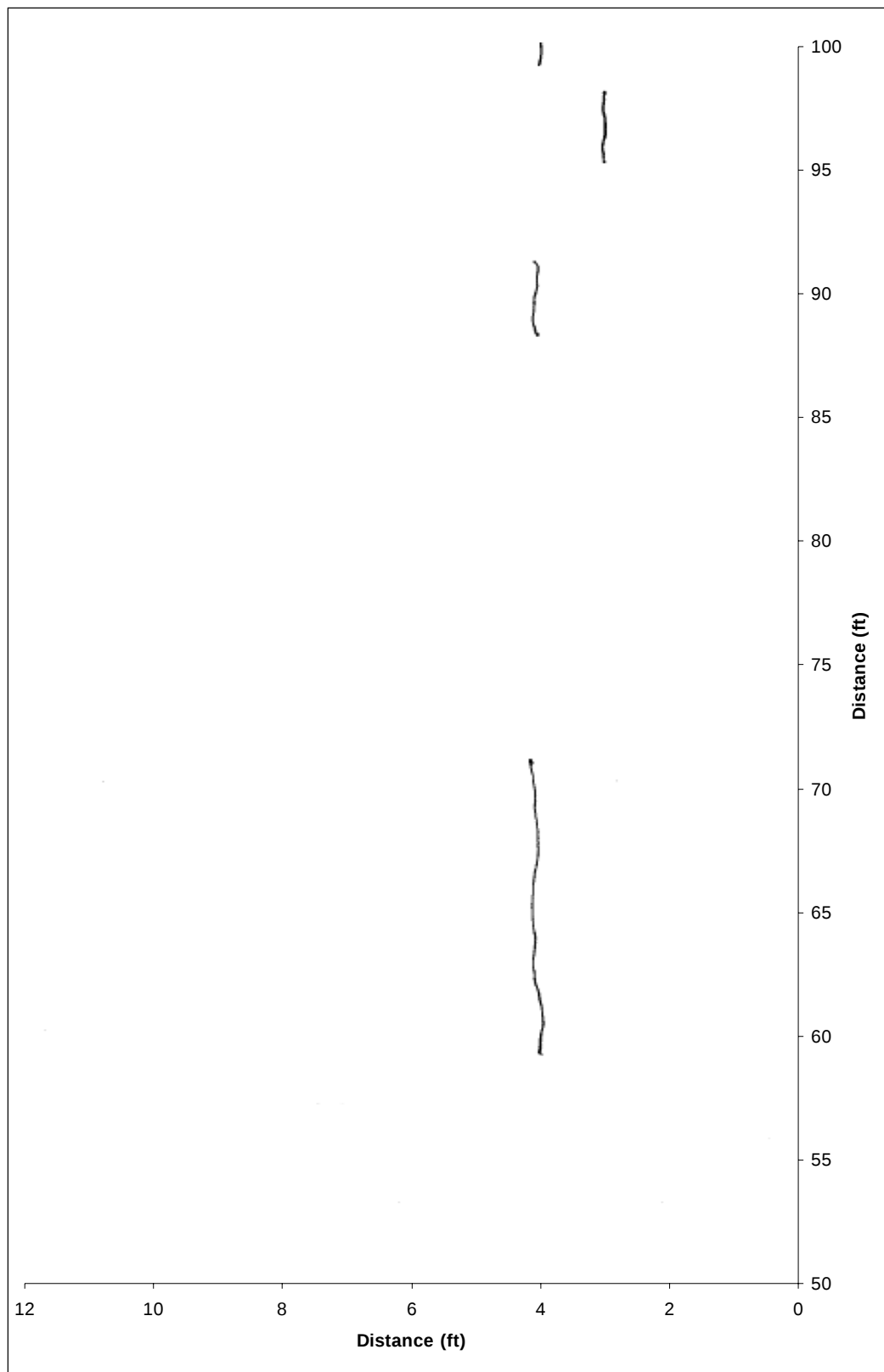


Figure 185. Robert Gray AAF Section 14 (Station 50-100 ft).

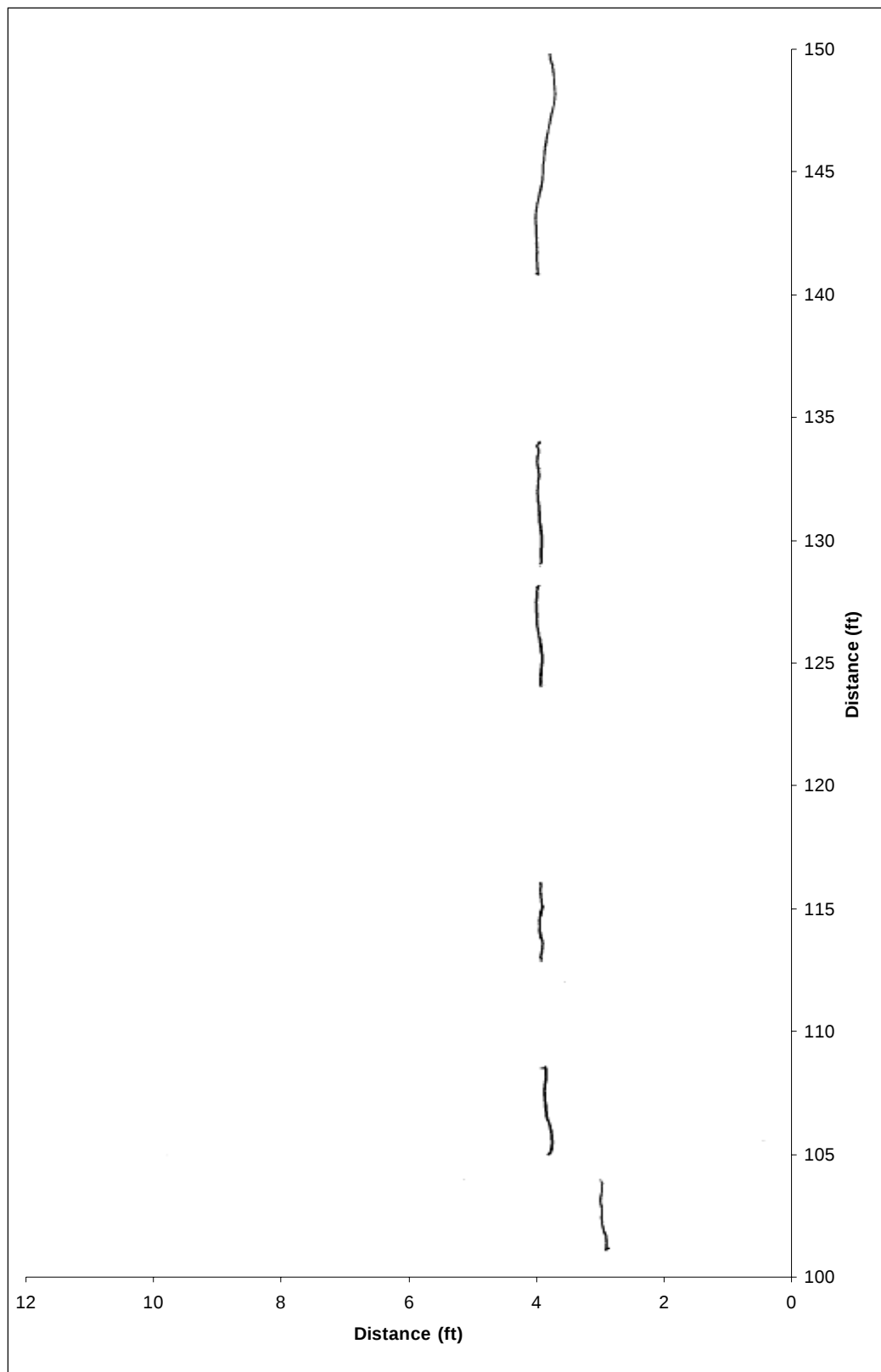


Figure 186. Robert Gray AAF Section 14 (Station 100-150 ft).

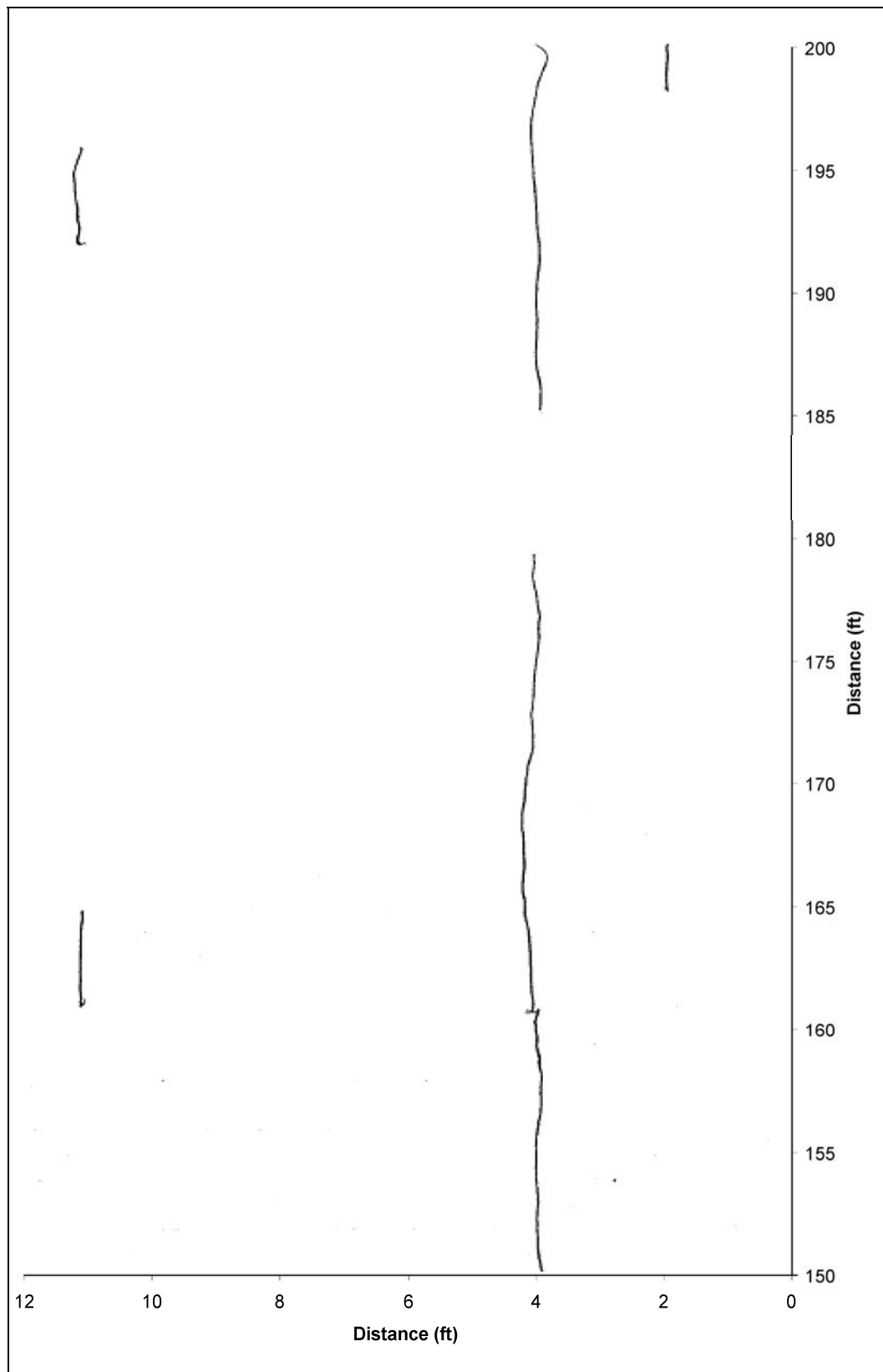


Figure 187. Robert Gray AAF Section 14 (Station 150-200 ft).

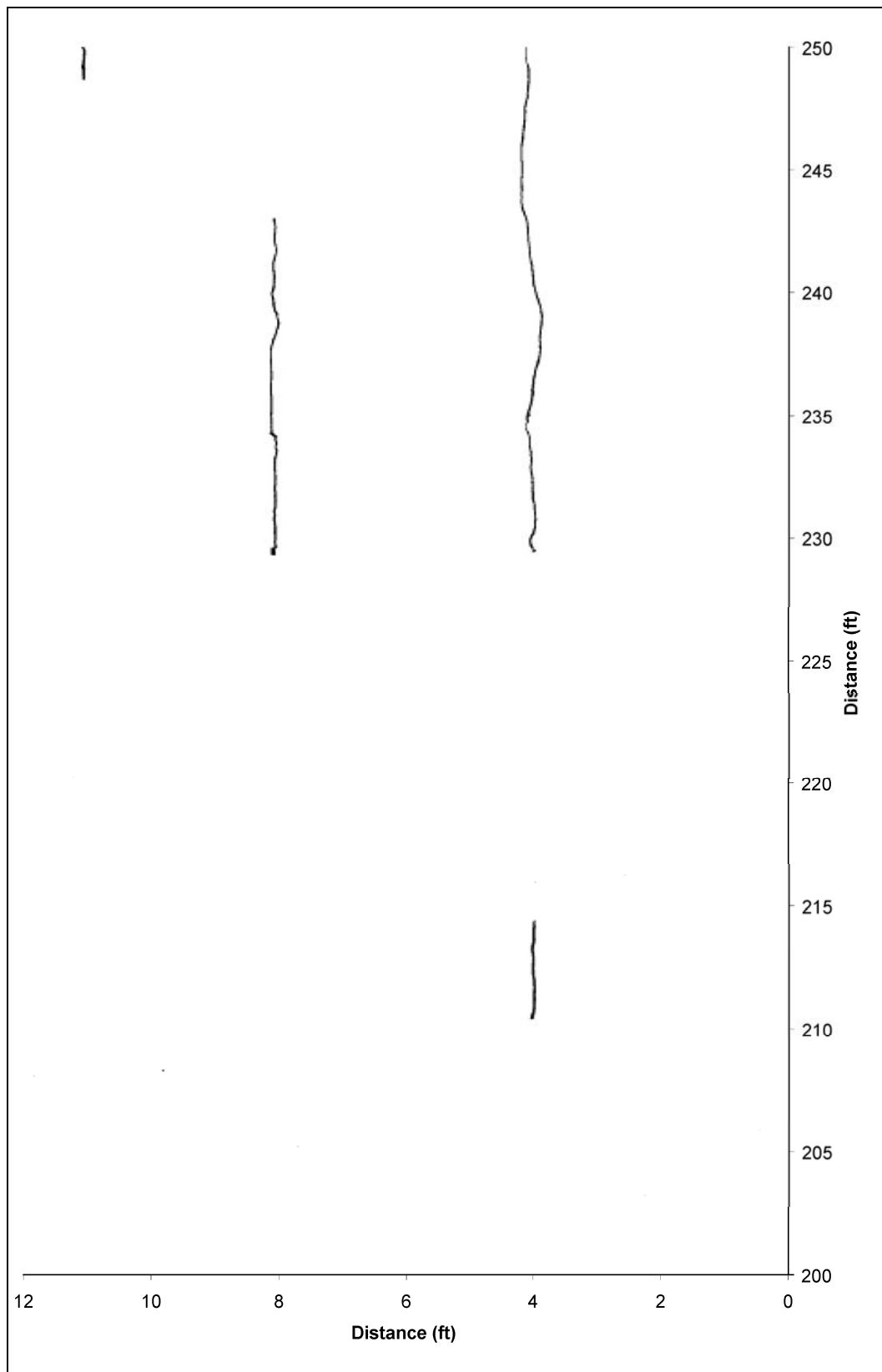


Figure 188. Robert Gray AAF Section 14 (Station 200-250 ft).

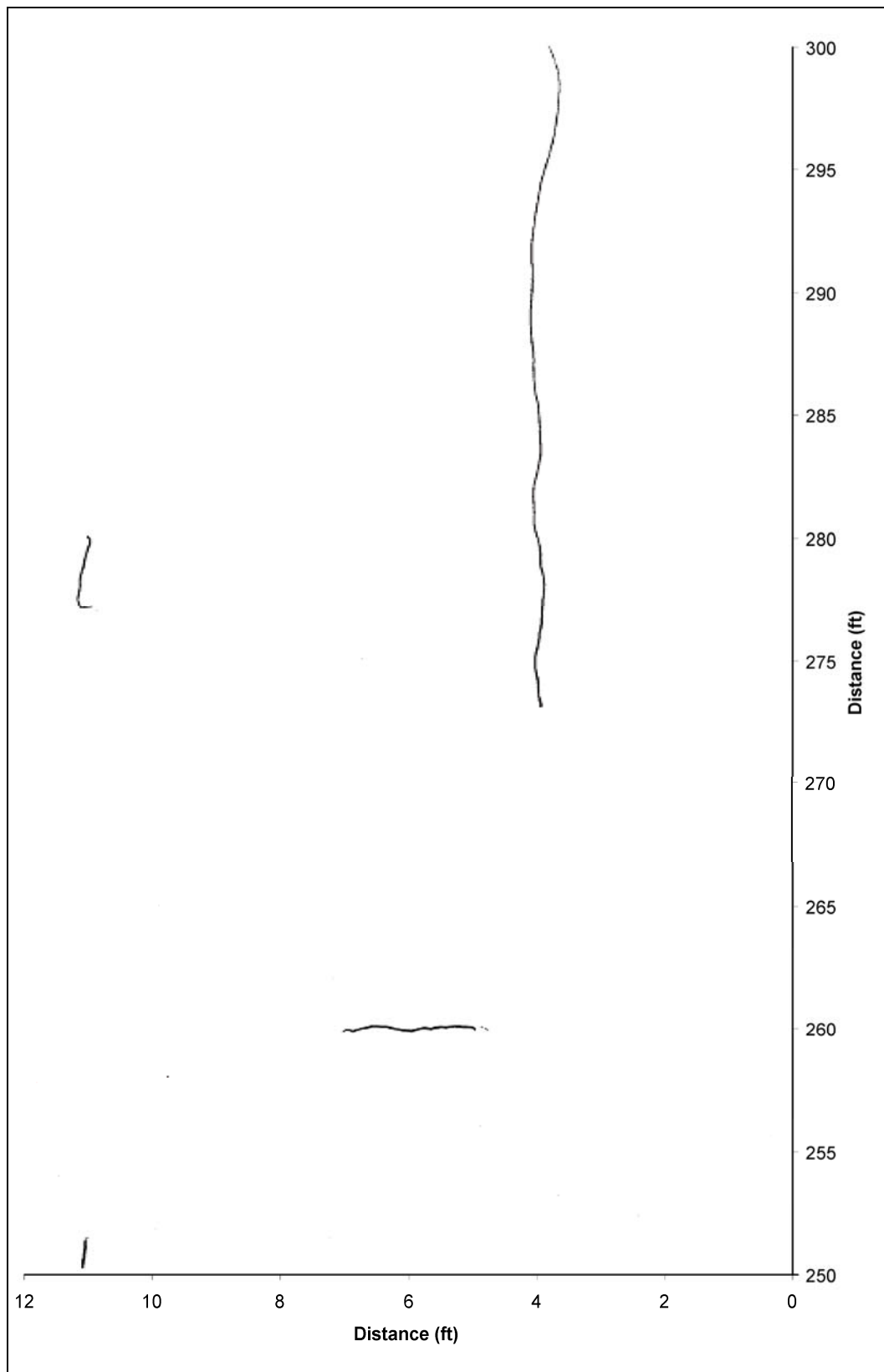


Figure 189. Robert Gray AAF Section 14 (Station 250-300 ft).

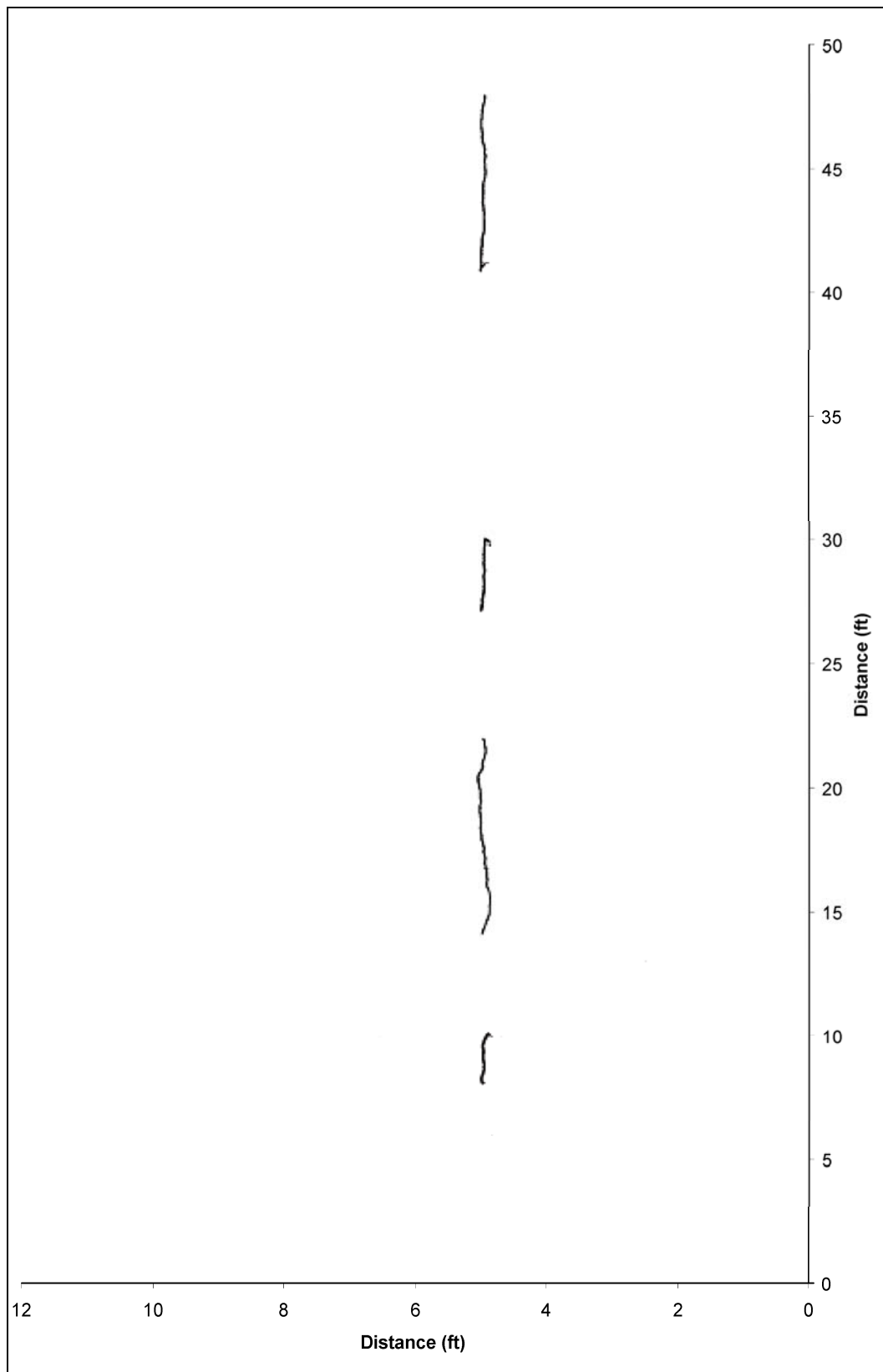


Figure 190. Robert Gray AAF Section 15 (Station 0-50 ft).

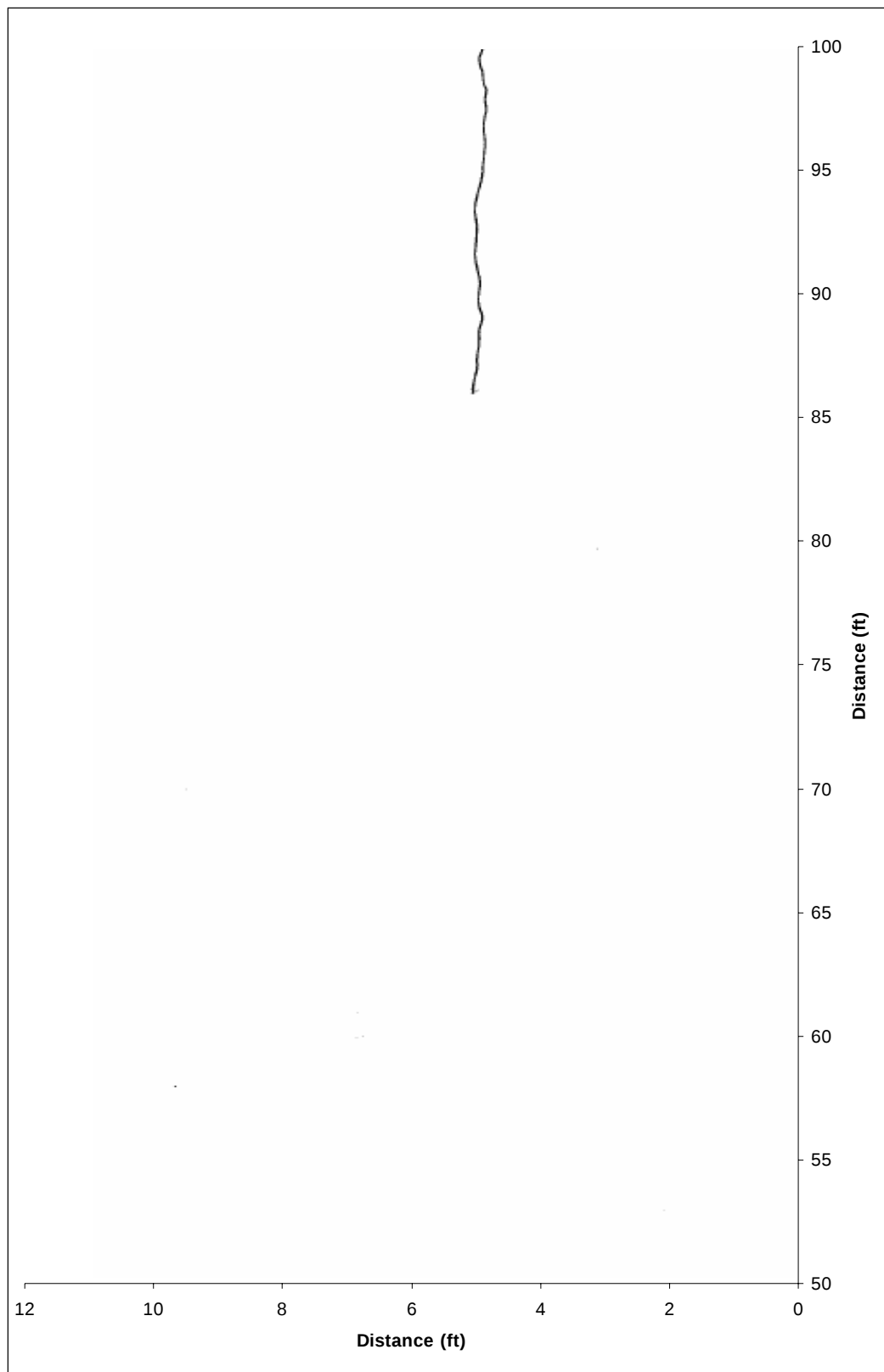


Figure 191. Robert Gray AAF Section 15 (Station 50-100 ft).

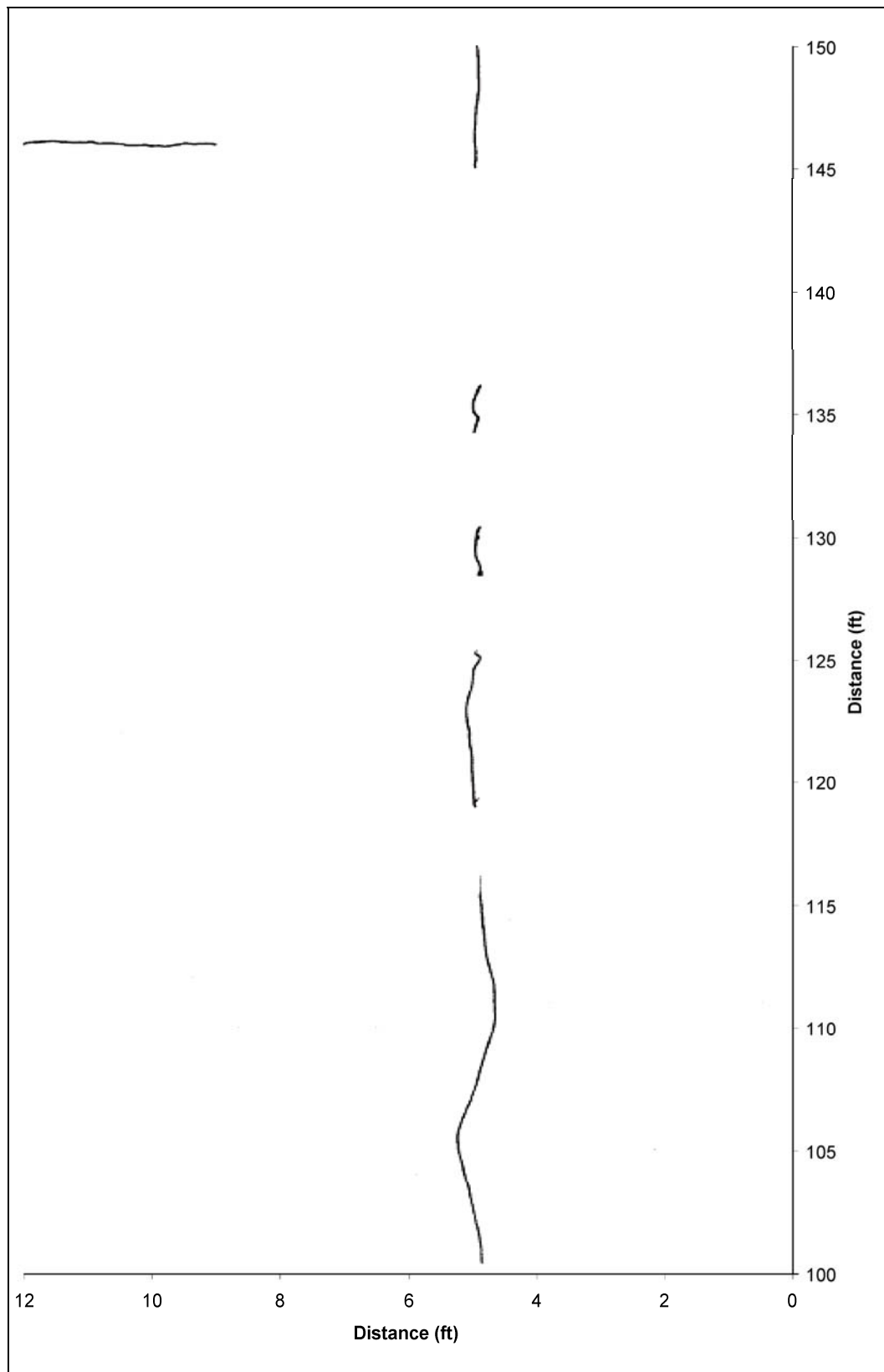


Figure 192. Robert Gray AAF Section 15 (Station 100-150 ft).

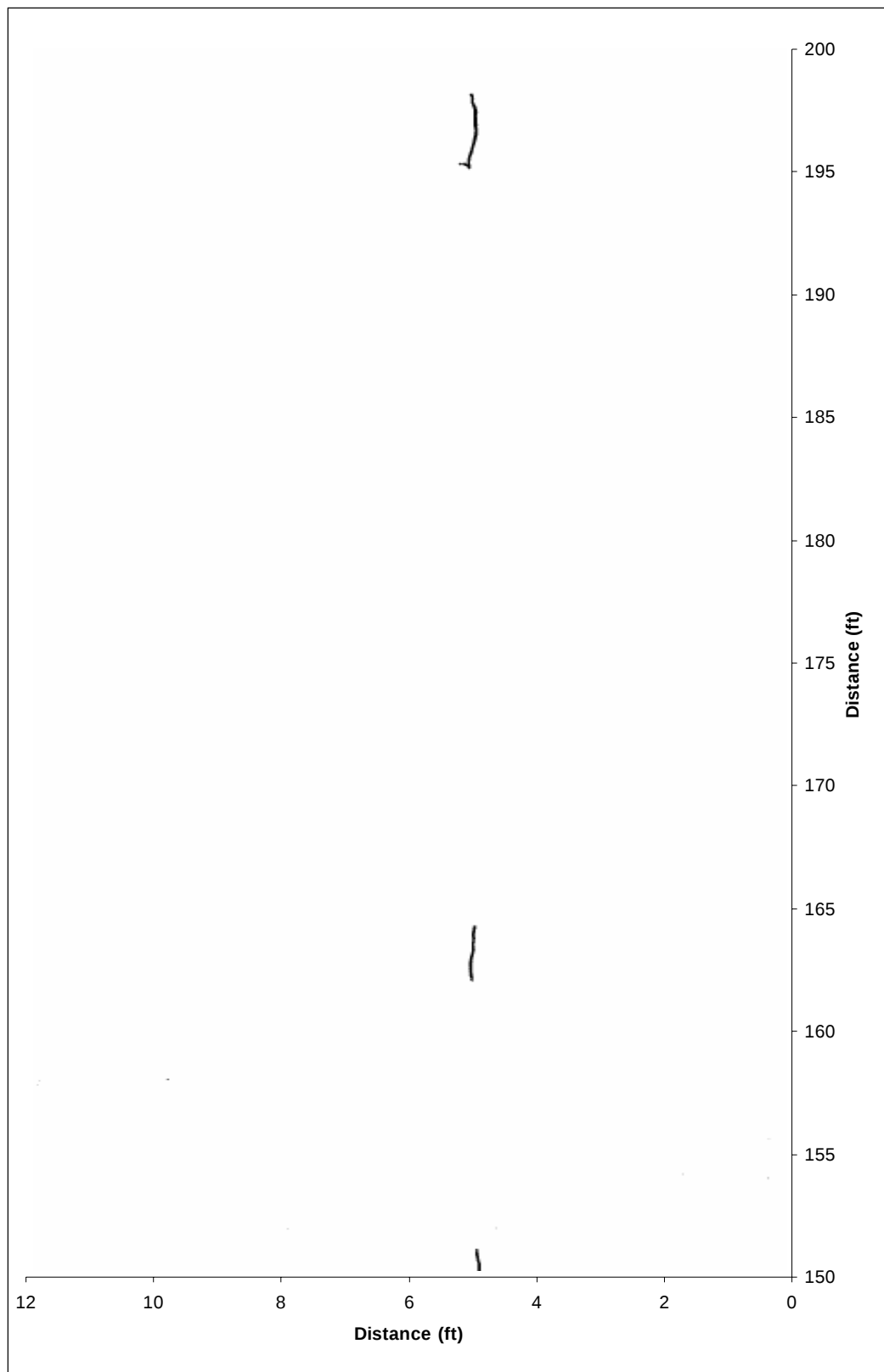


Figure 193. Robert Gray AAF Section 15 (Station 150-200 ft).

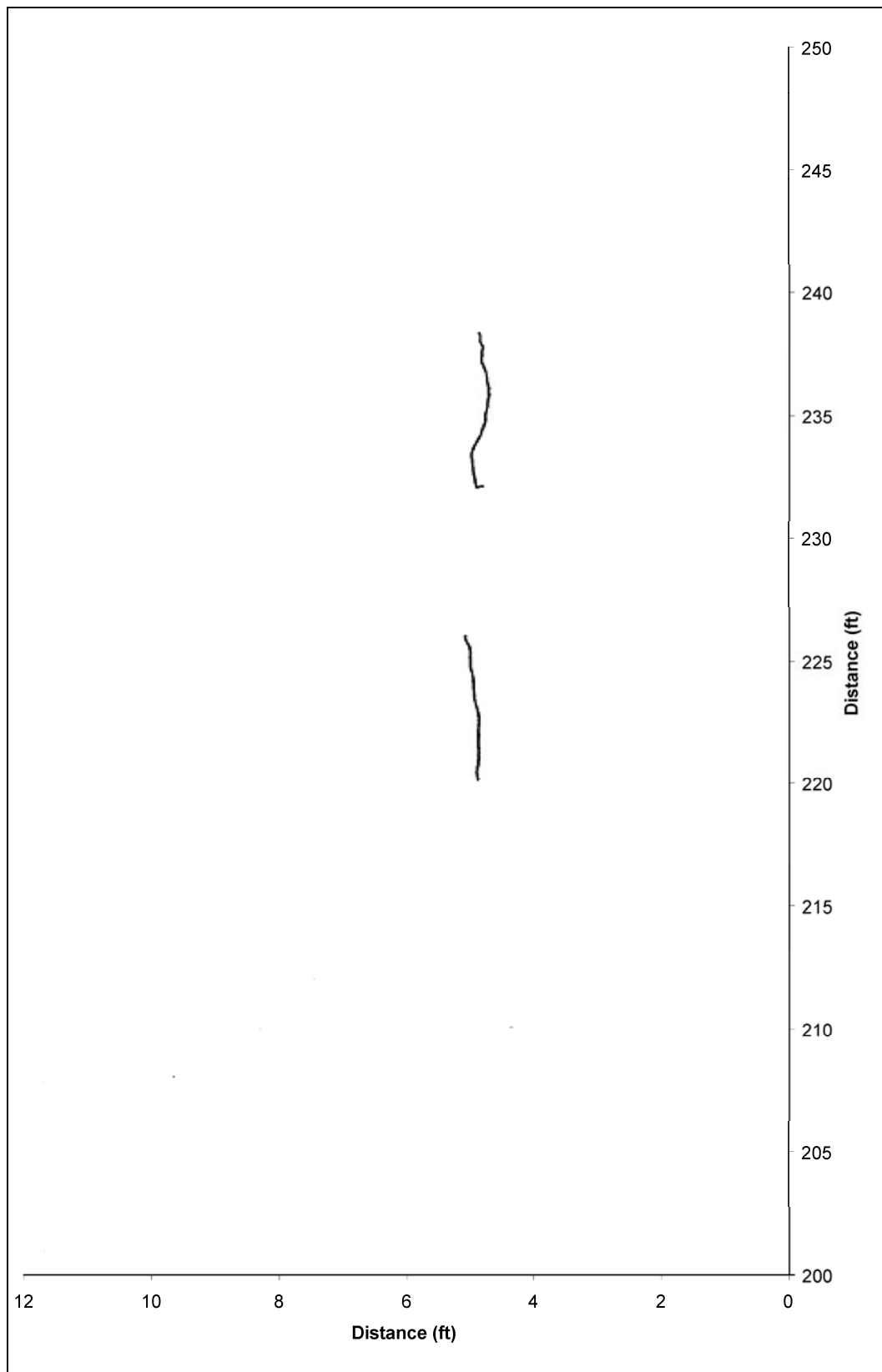


Figure 194. Robert Gray AAF Section 15 (Station 200-250 ft).

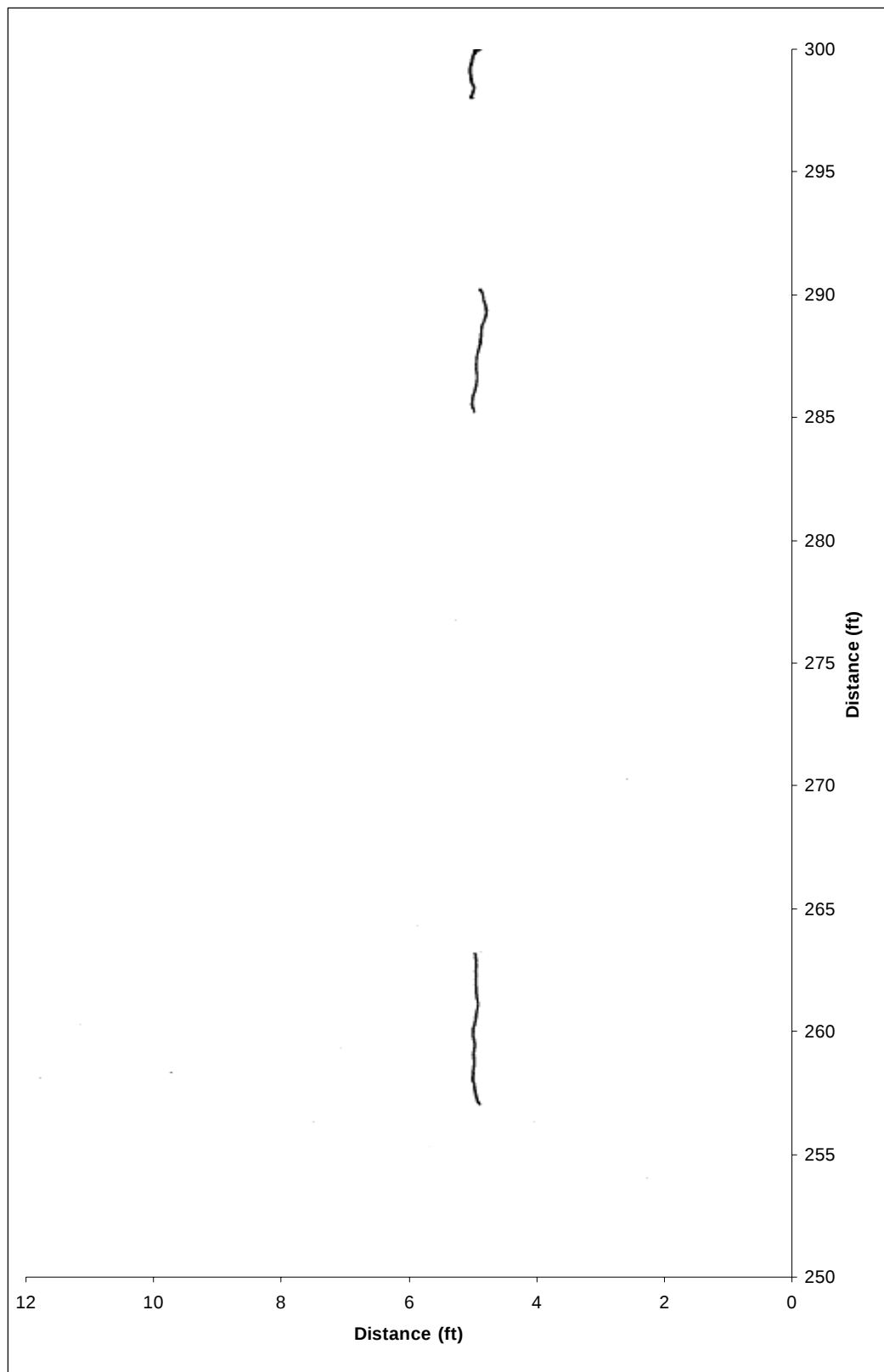


Figure 195. Robert Gray AAF Section 15 (Station 250-300 ft).

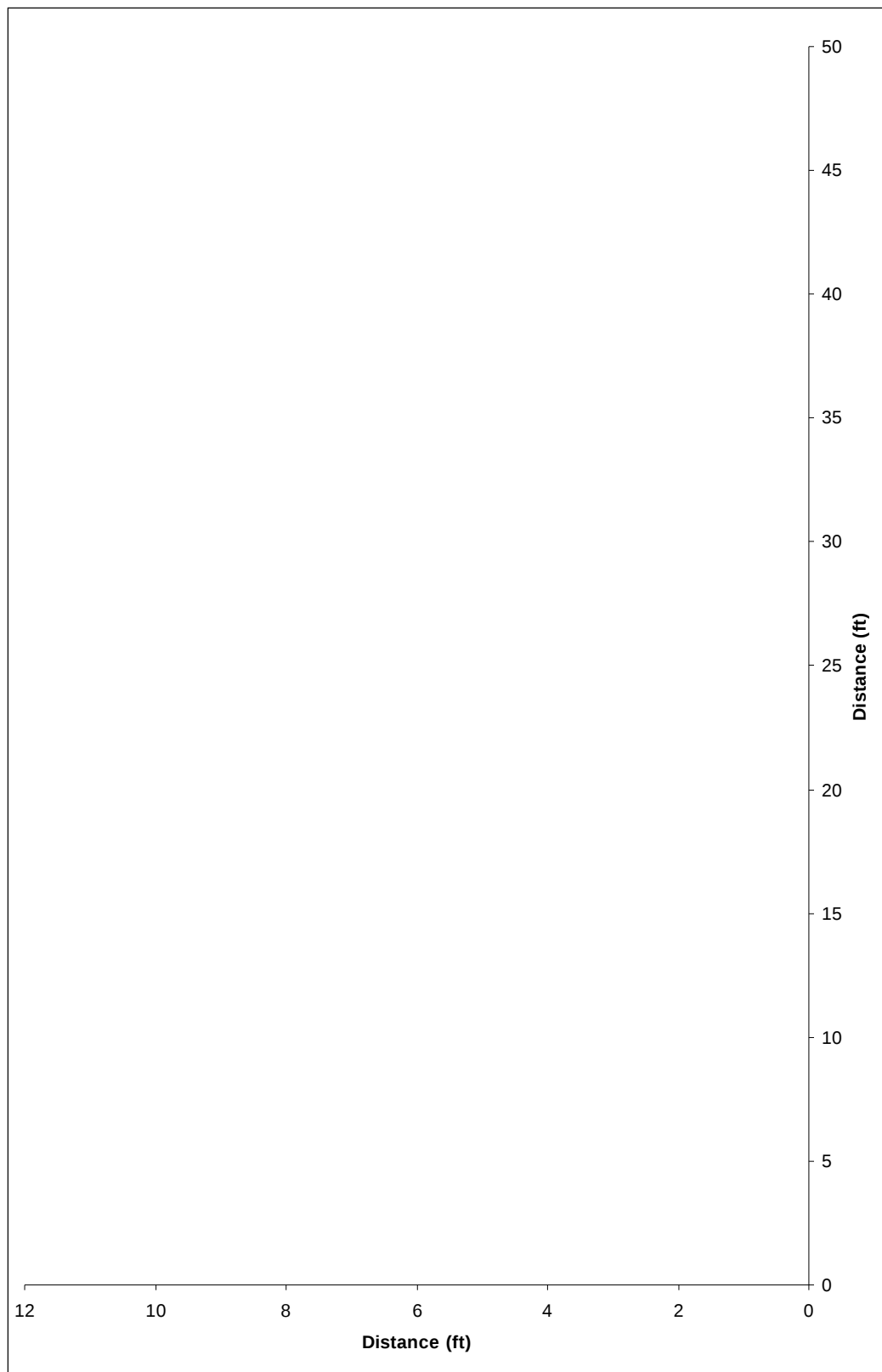


Figure 196. Robert Gray AAF Section 16 (Station 0-50 ft).

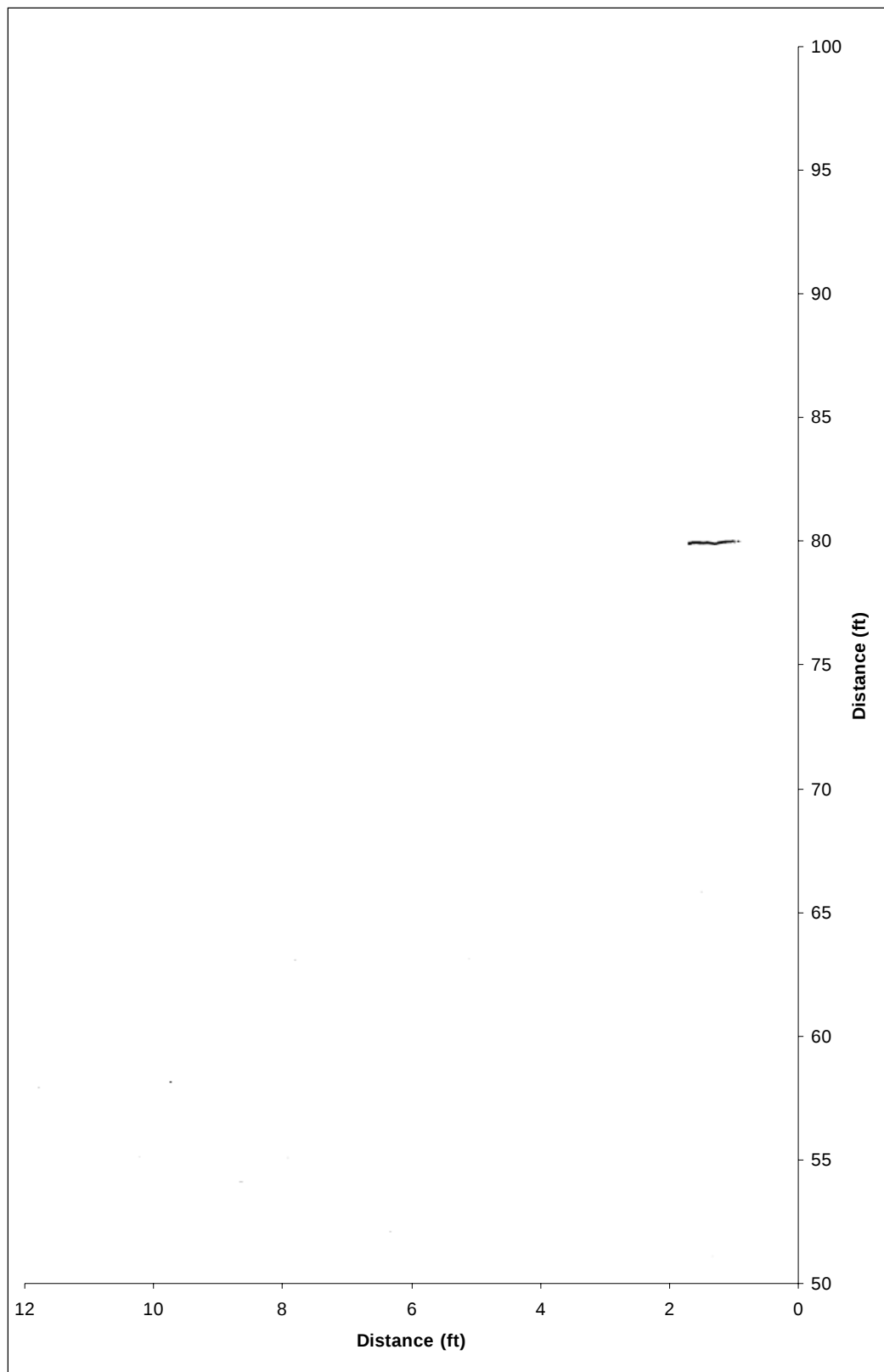


Figure 197. Robert Gray AAF Section 16 (Station 50-100 ft).

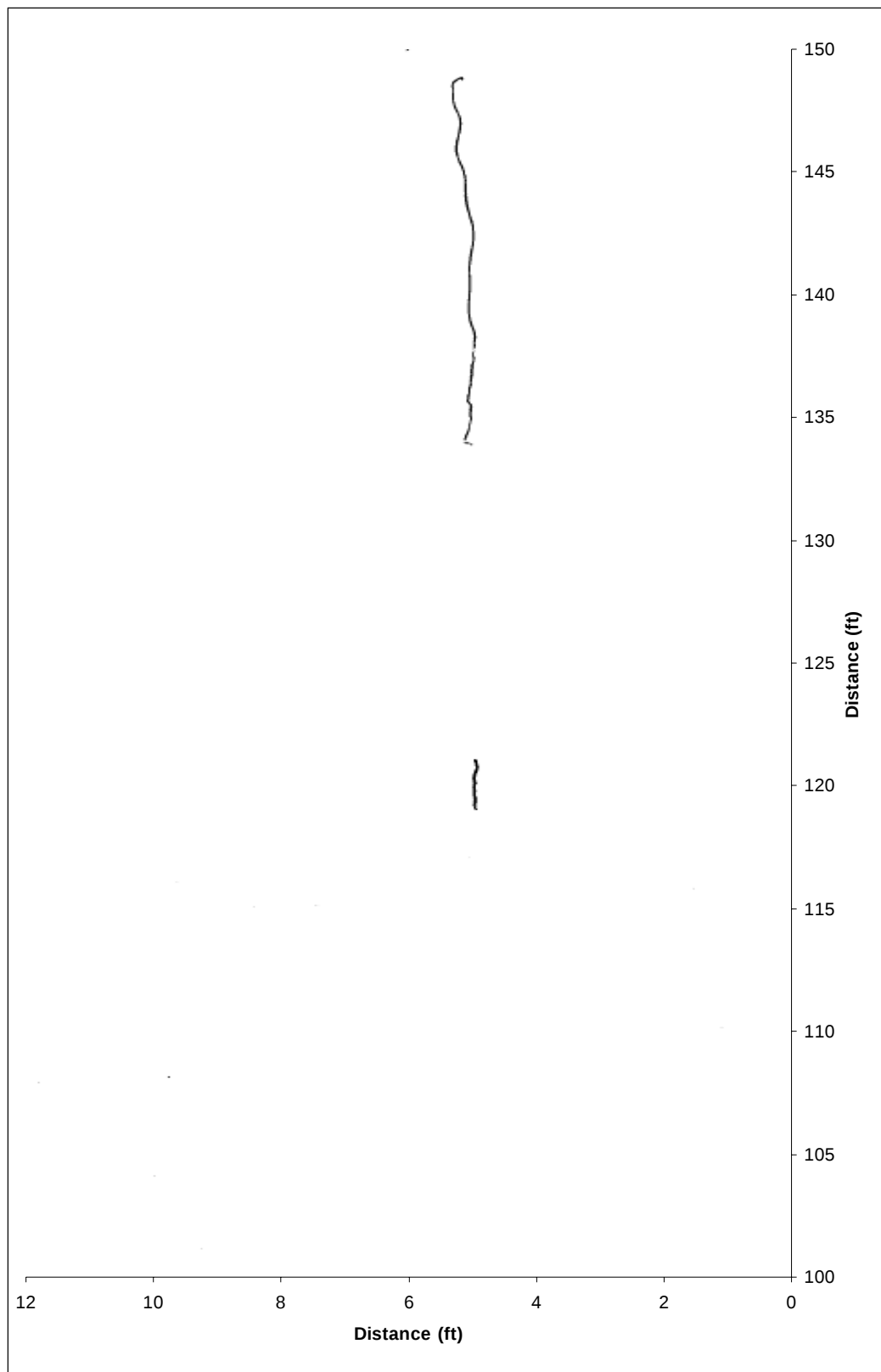


Figure 198. Robert Gray AAF Section 16 (Station 100-150 ft).

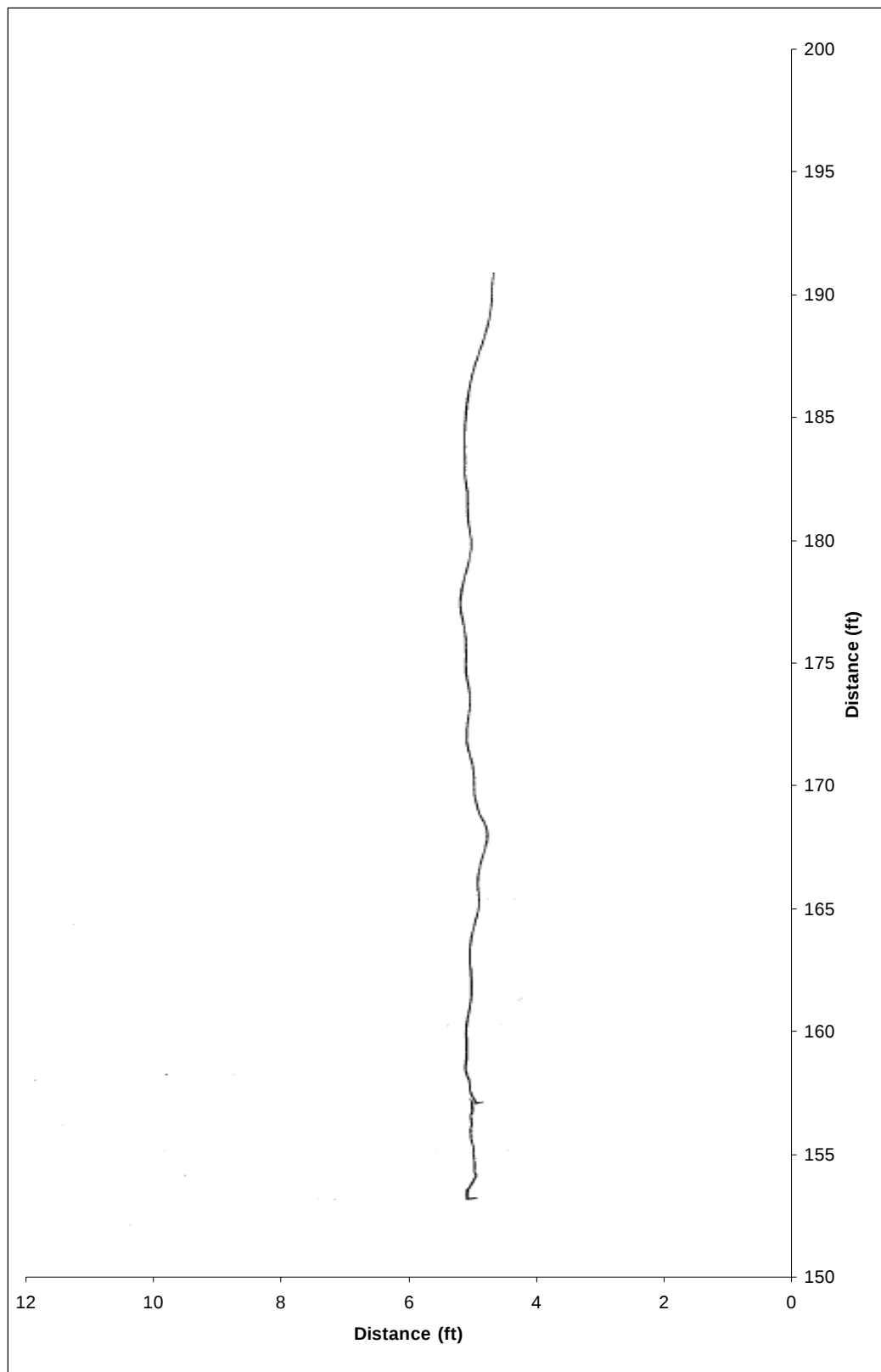


Figure 199. Robert Gray AAF Section 16 (Station 150-200 ft).

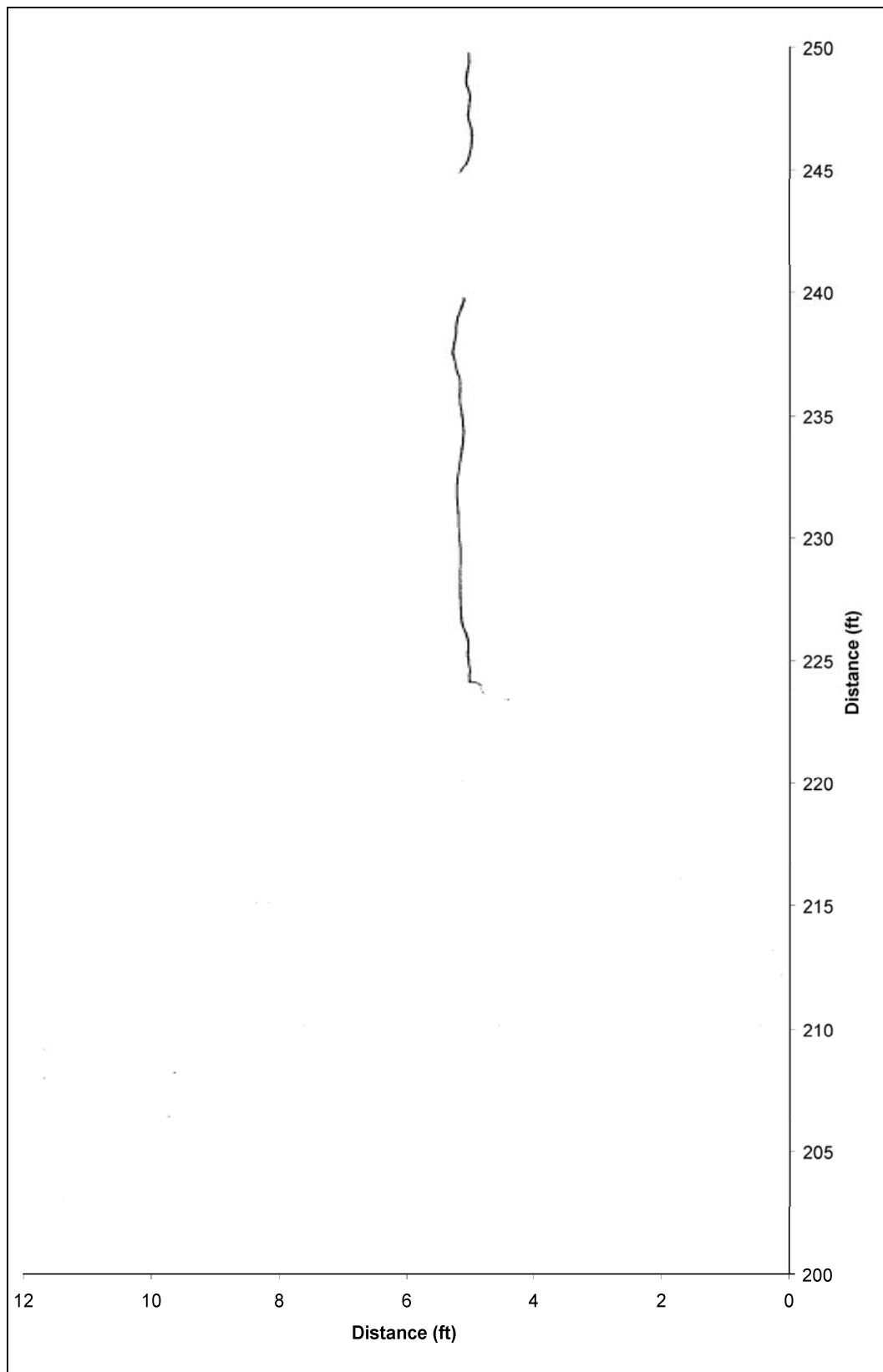


Figure 200. Robert Gray AAF Section 16 (Station 200-250 ft).

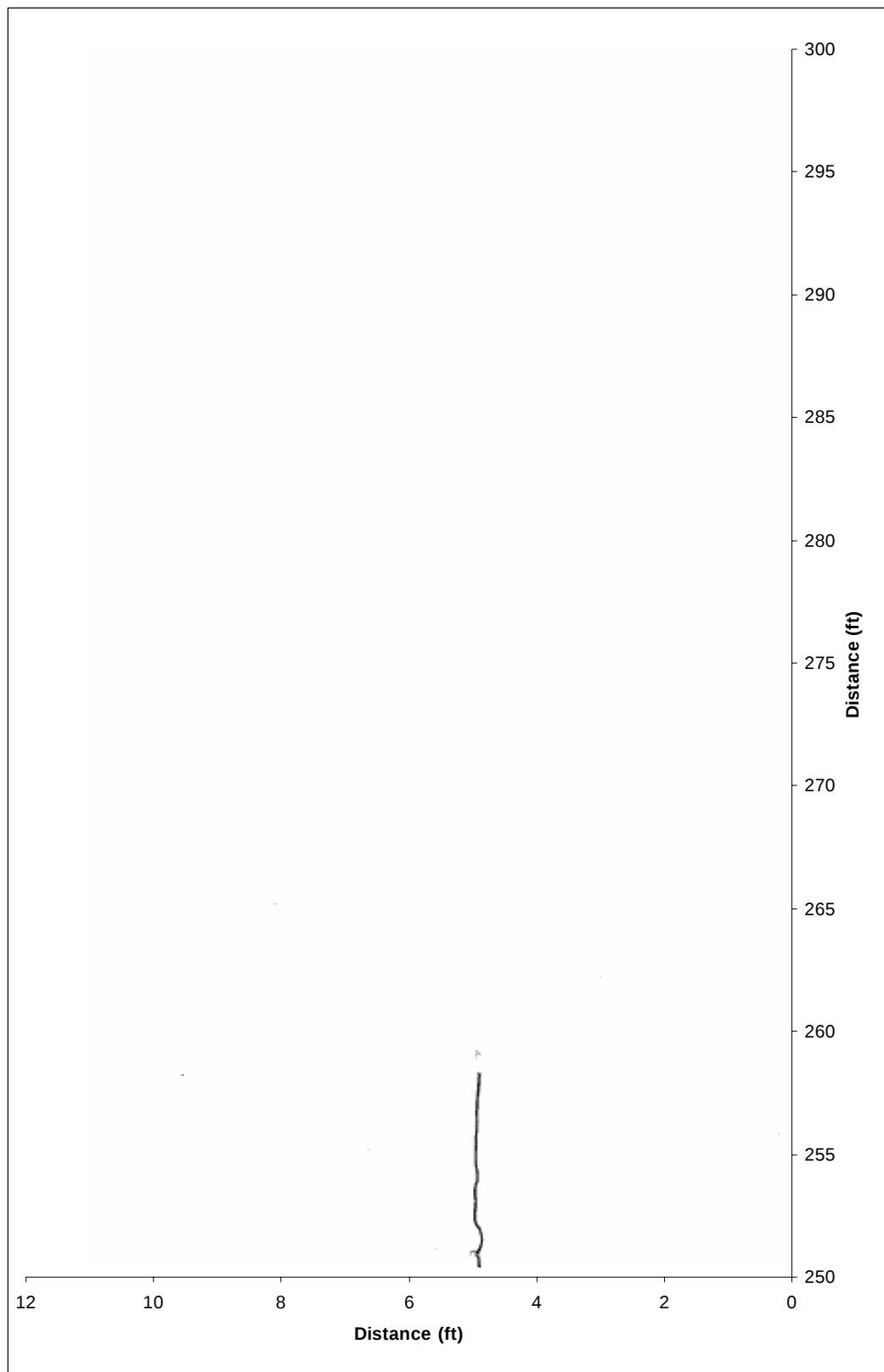


Figure 201. Robert Gray AAF Section 16 (Station 250-300 ft).

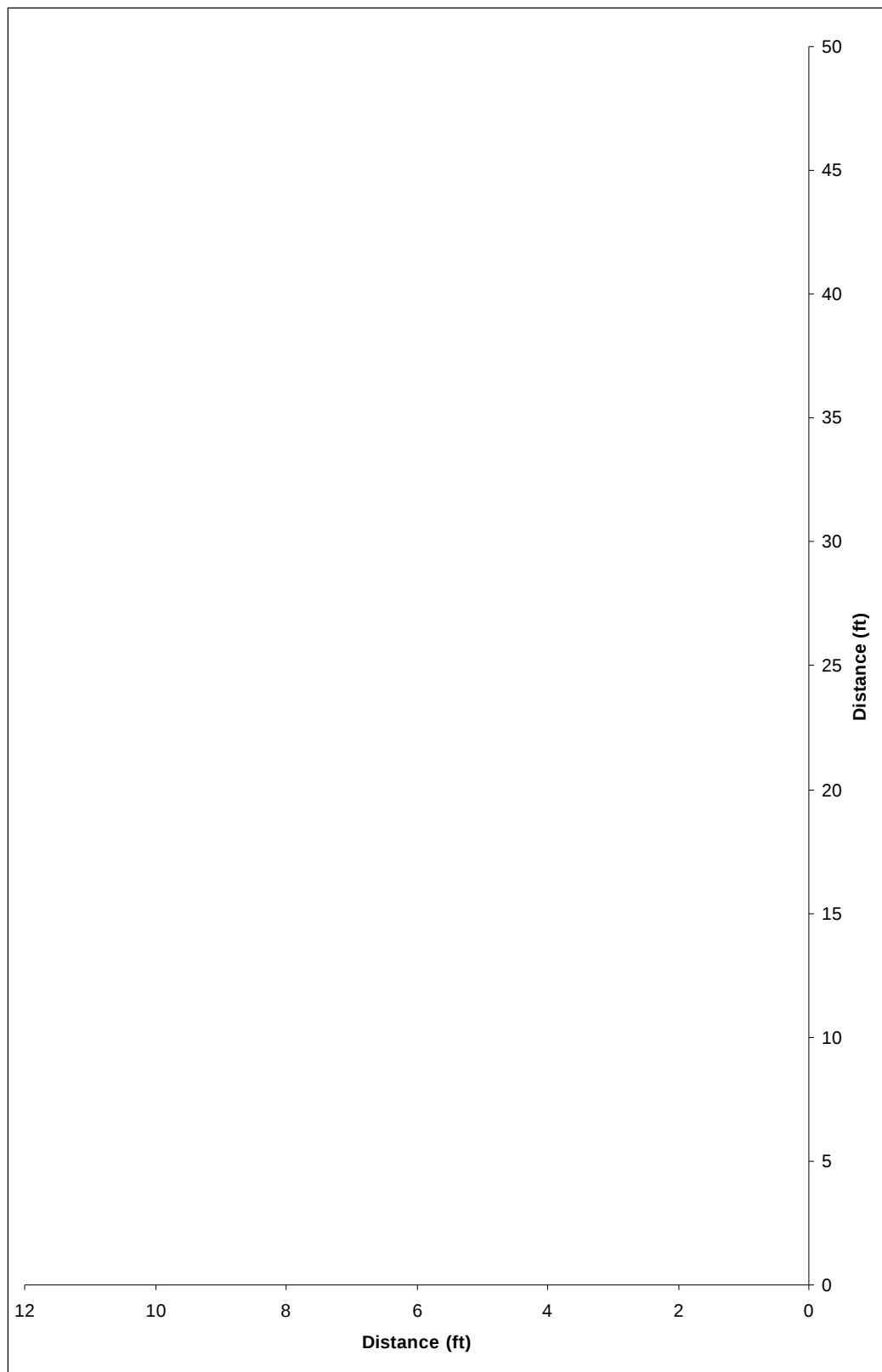


Figure 202. Robert Gray AAF Section 17 (Station 0-50 ft).

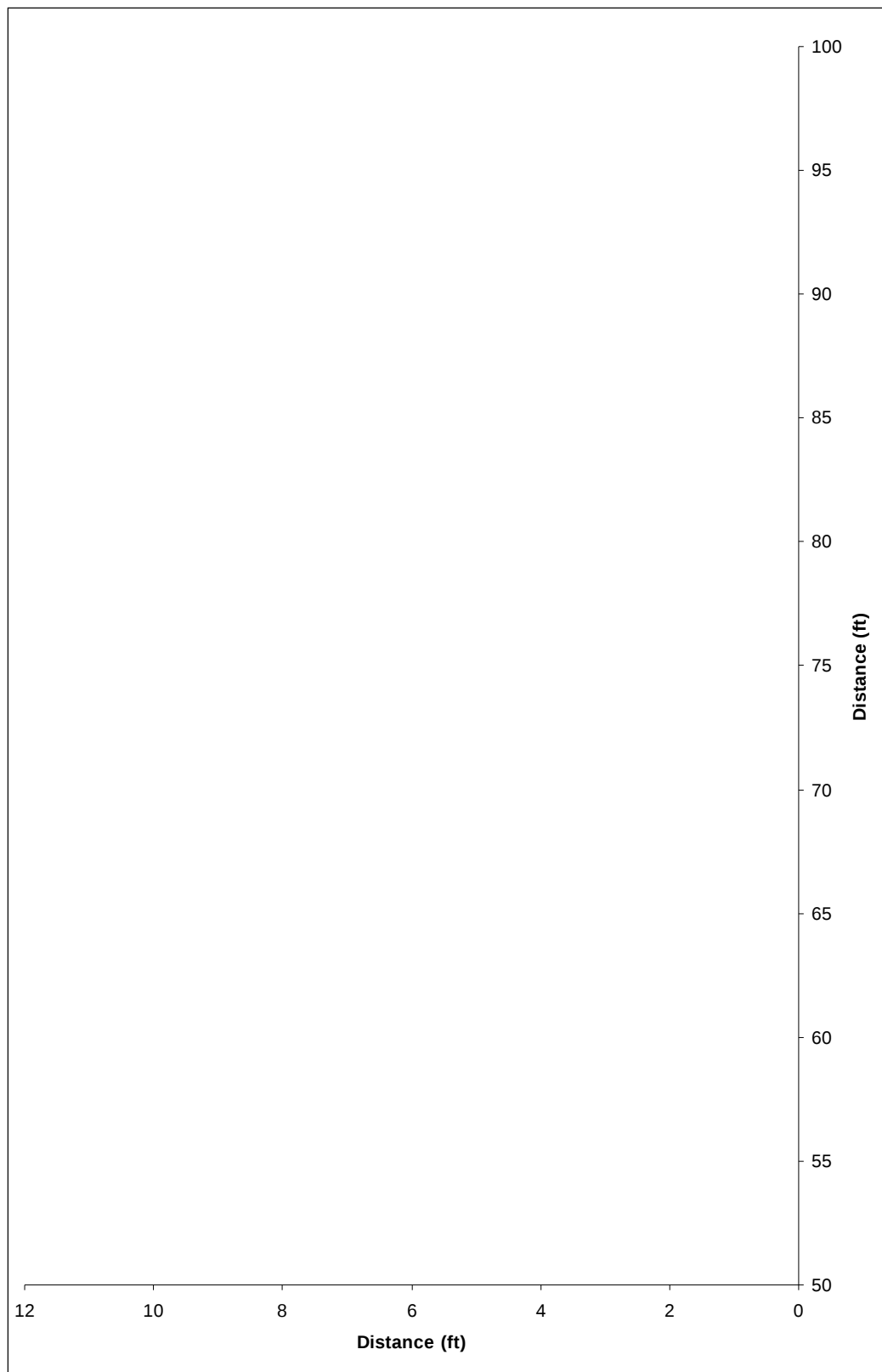


Figure 203. Robert Gray AAF Section 17 (Station 50-100 ft).

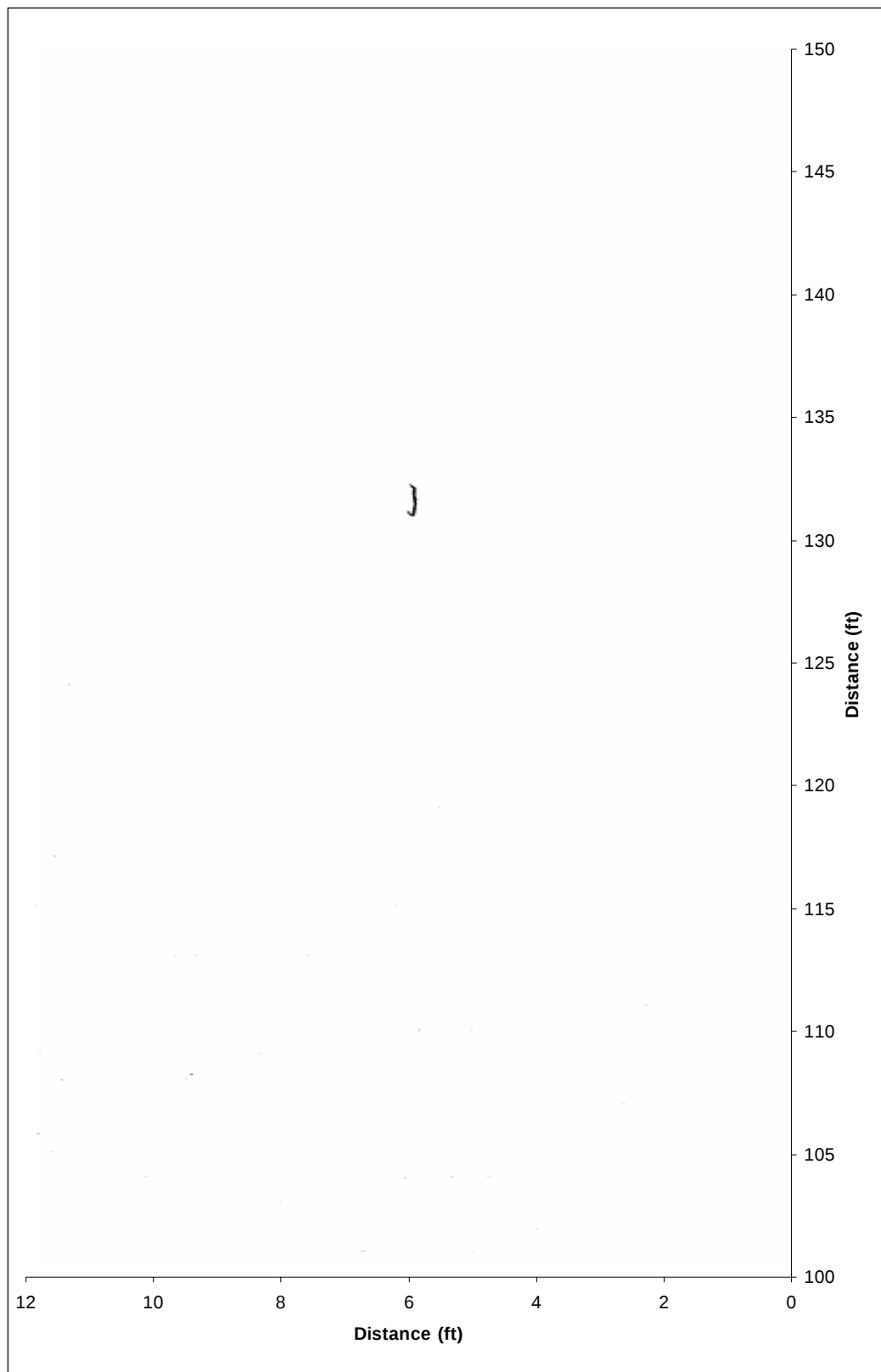


Figure 204. Robert Gray AAF Section 17 (Station 100-150 ft).

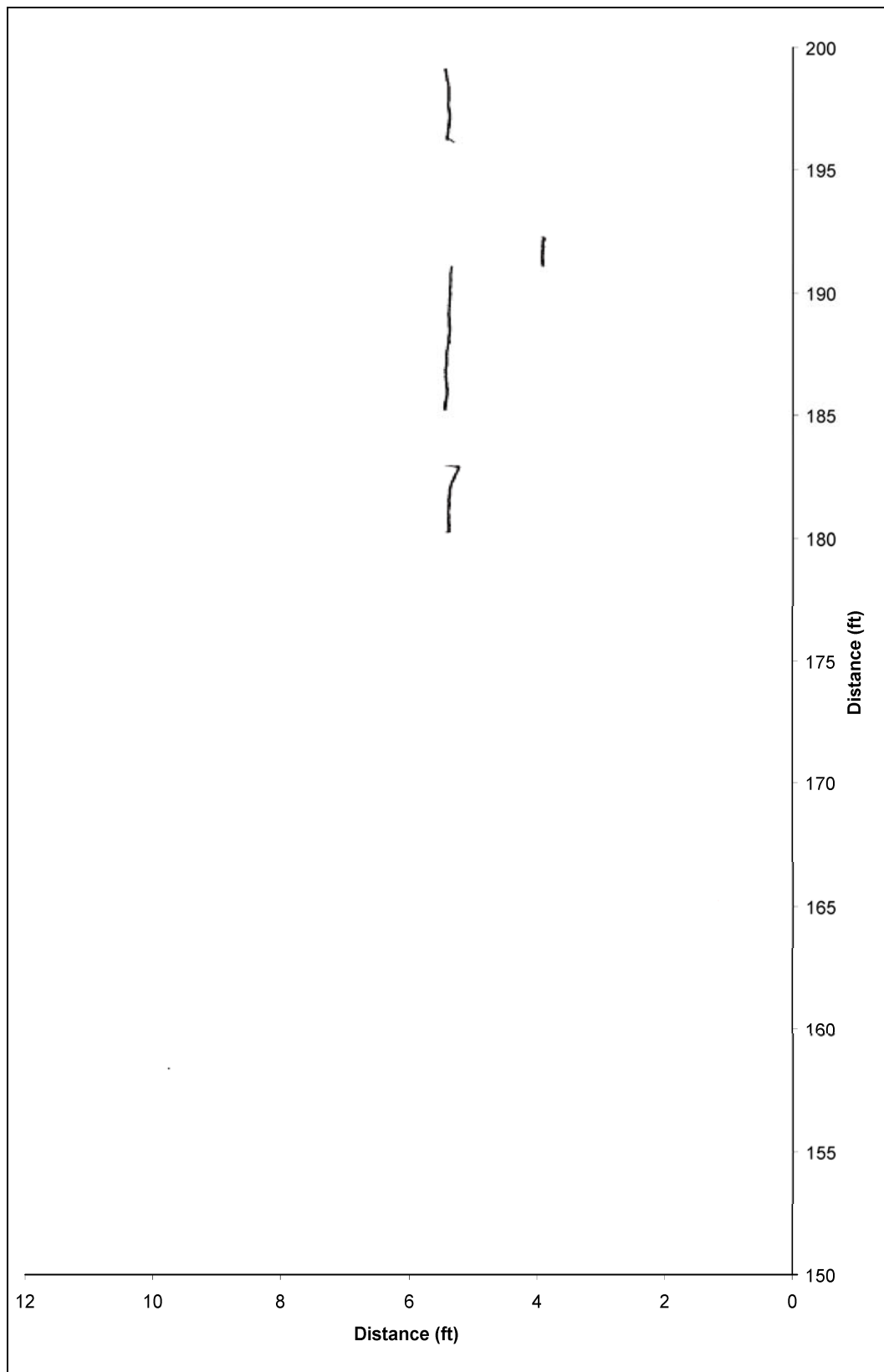


Figure 205. Robert Gray AAF Section 17 (Station 150-200 ft).

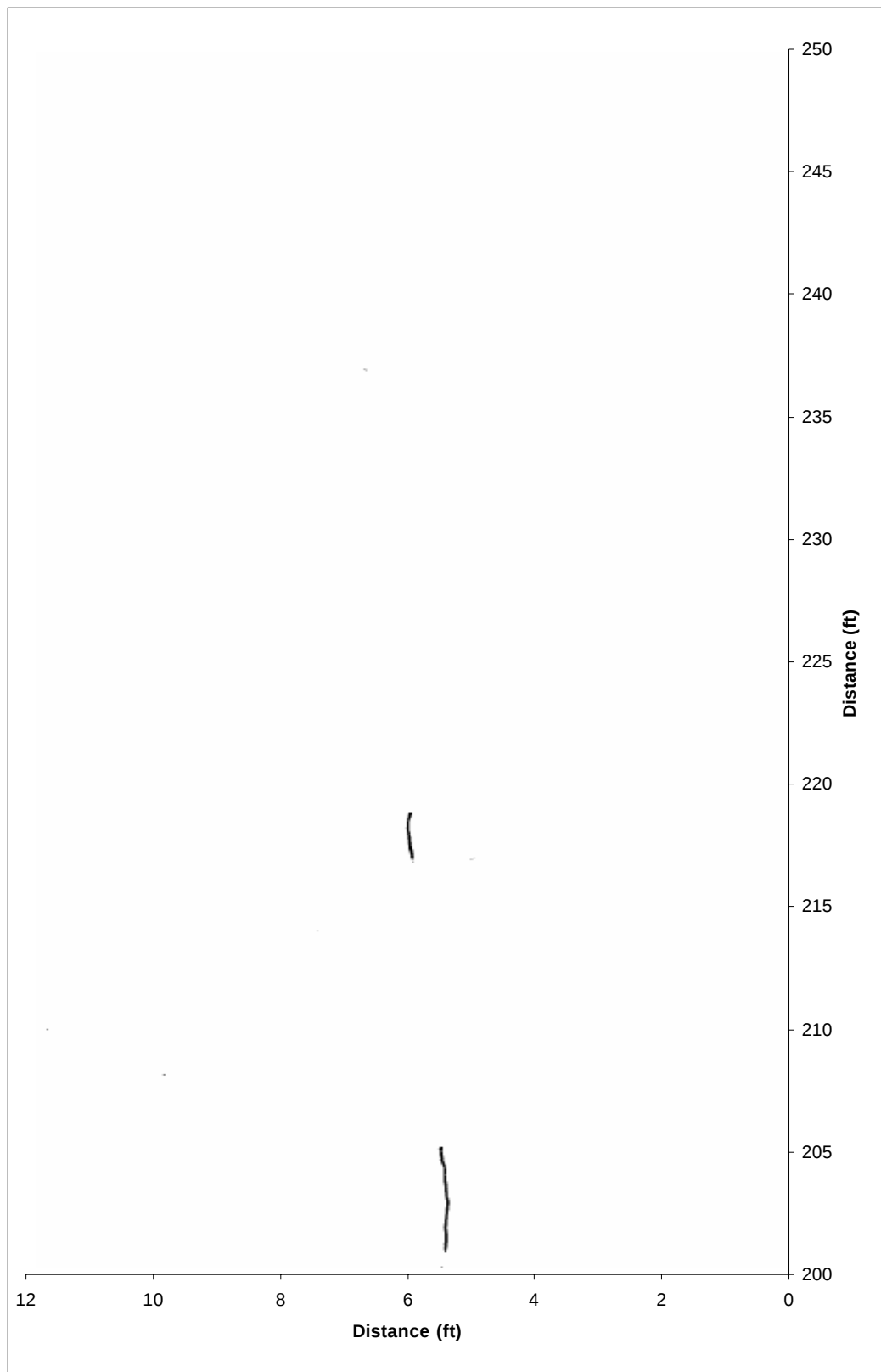


Figure 206. Robert Gray AAF Section 17 (Station 200-250 ft).

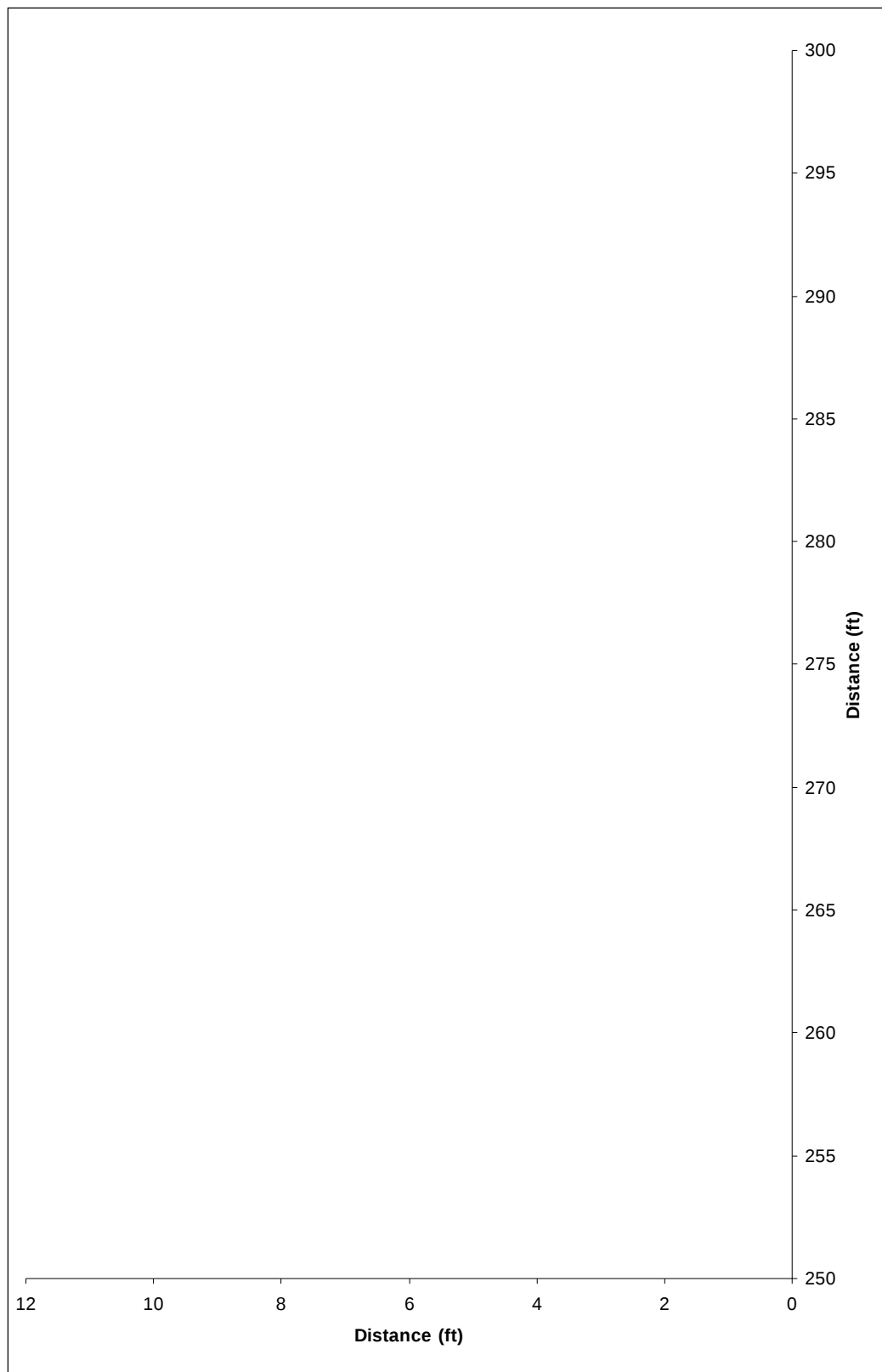


Figure 207. Robert Gray AAF Section 17 (Station 250-300 ft).

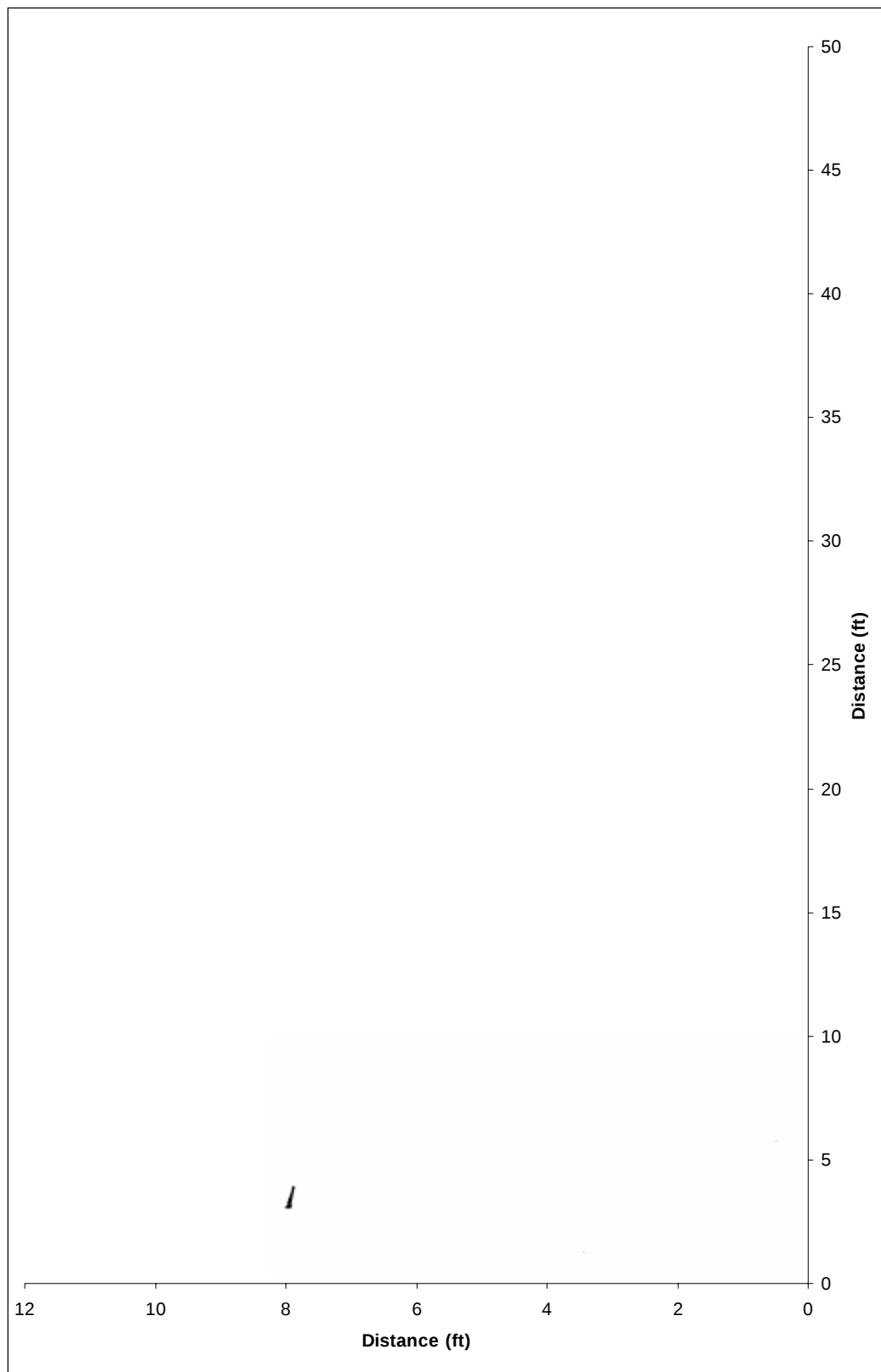


Figure 208. Robert Gray AAF Section 18 (Station 0-50 ft).

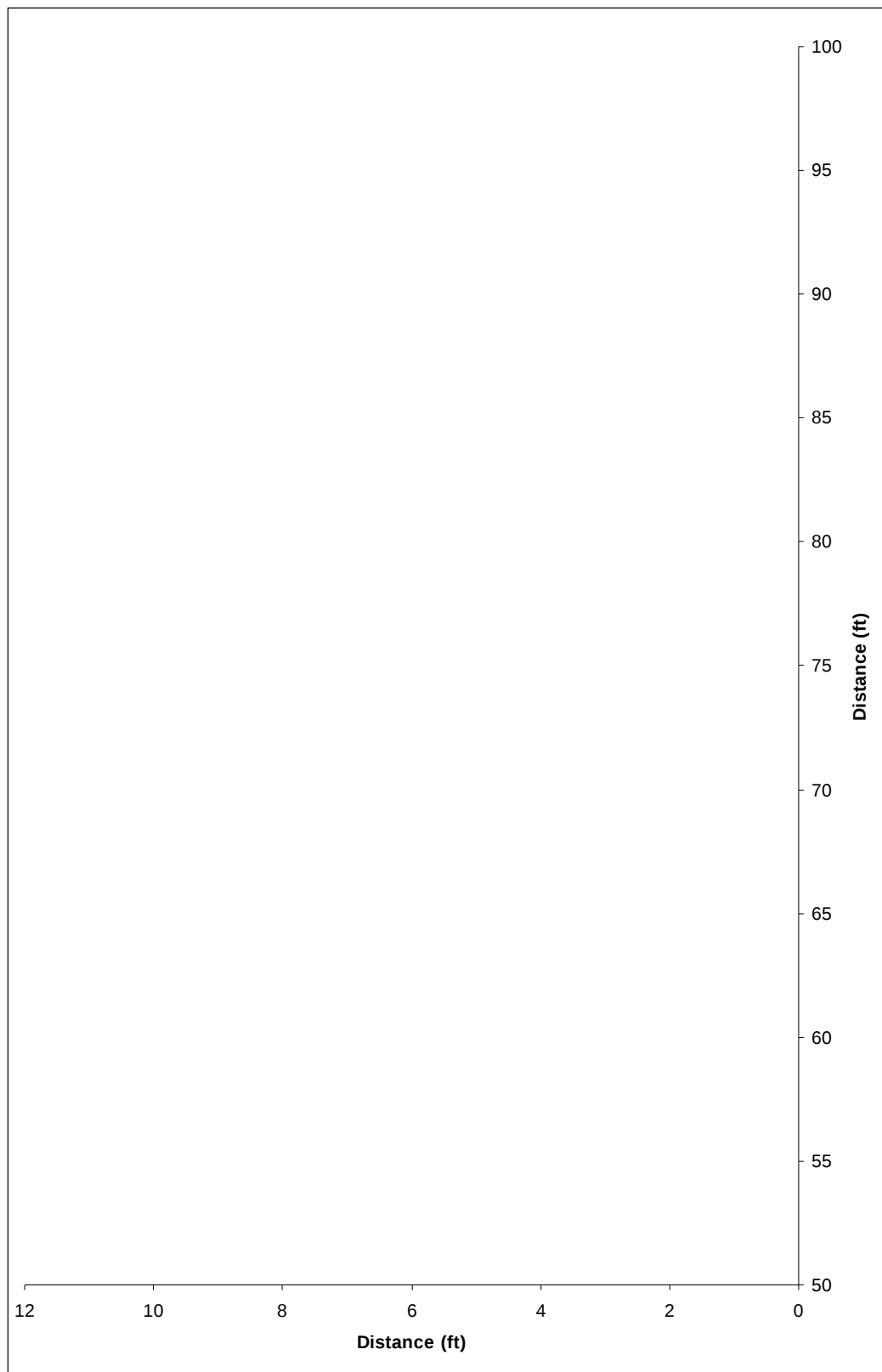


Figure 209. Robert Gray AAF Section 18 (Station 50-100 ft).

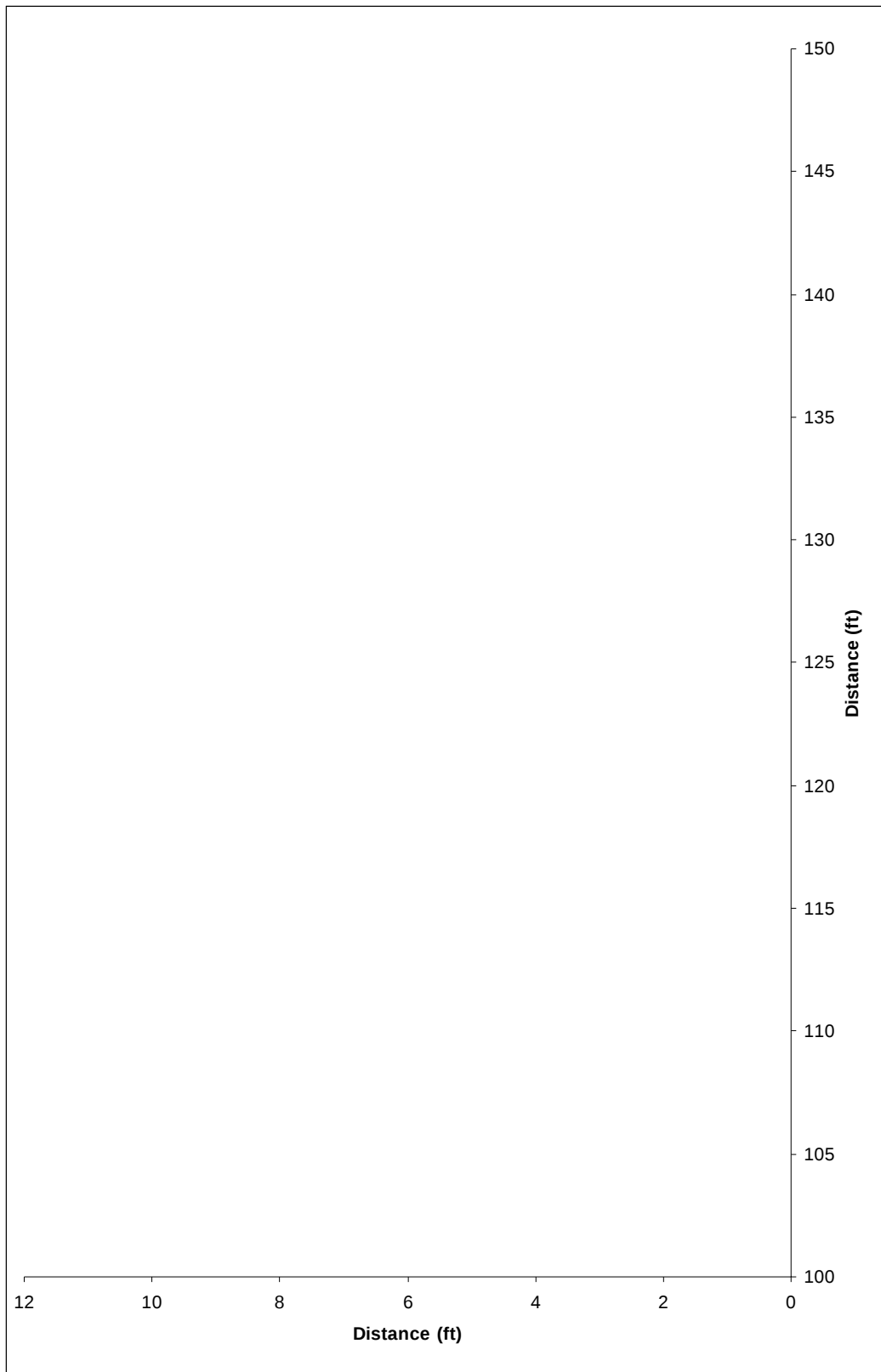


Figure 210. Robert Gray AAF Section 18 (Station 100-150 ft).

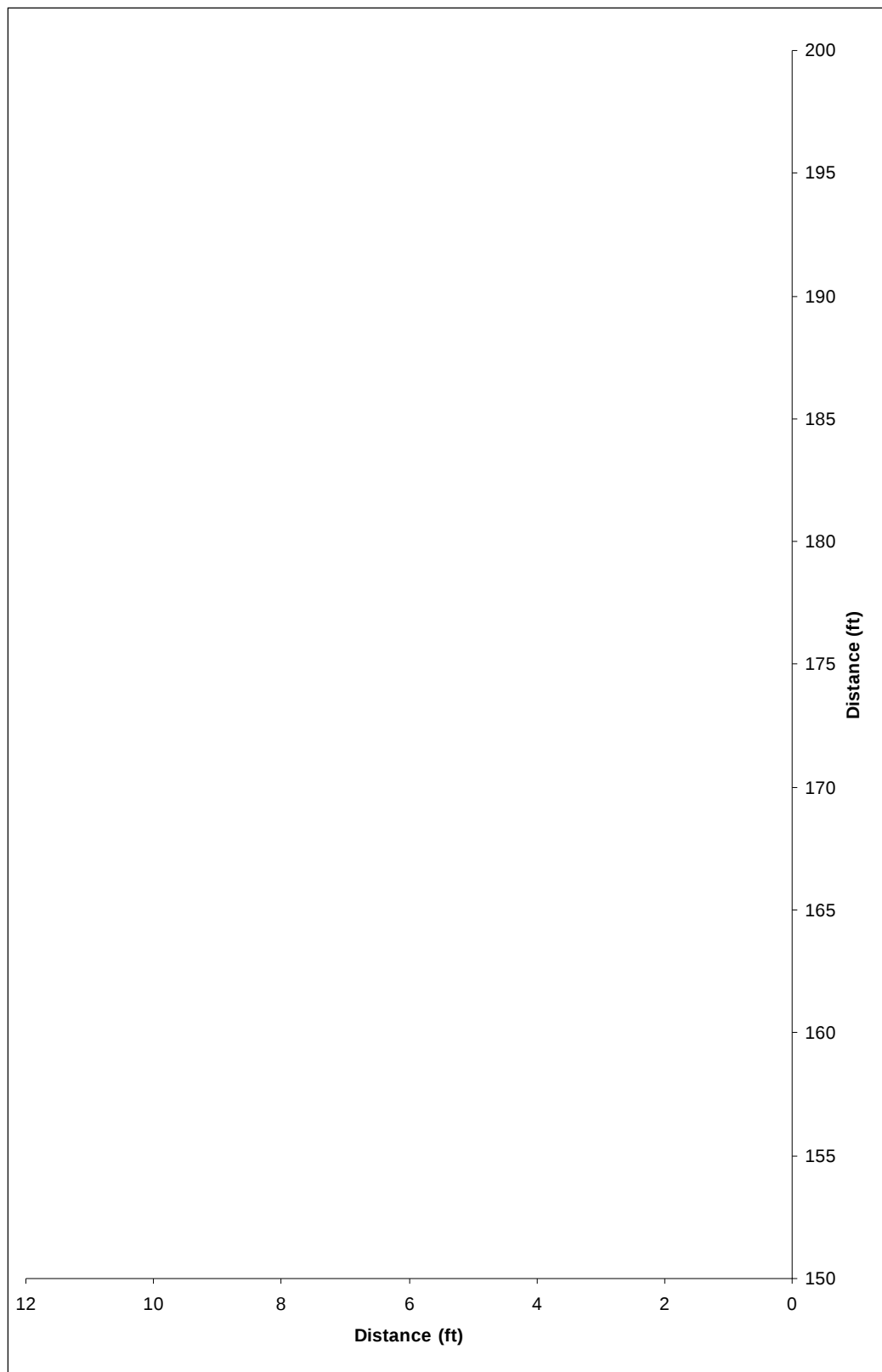


Figure 211. Robert Gray AAF Section 18 (Station 150-200 ft).

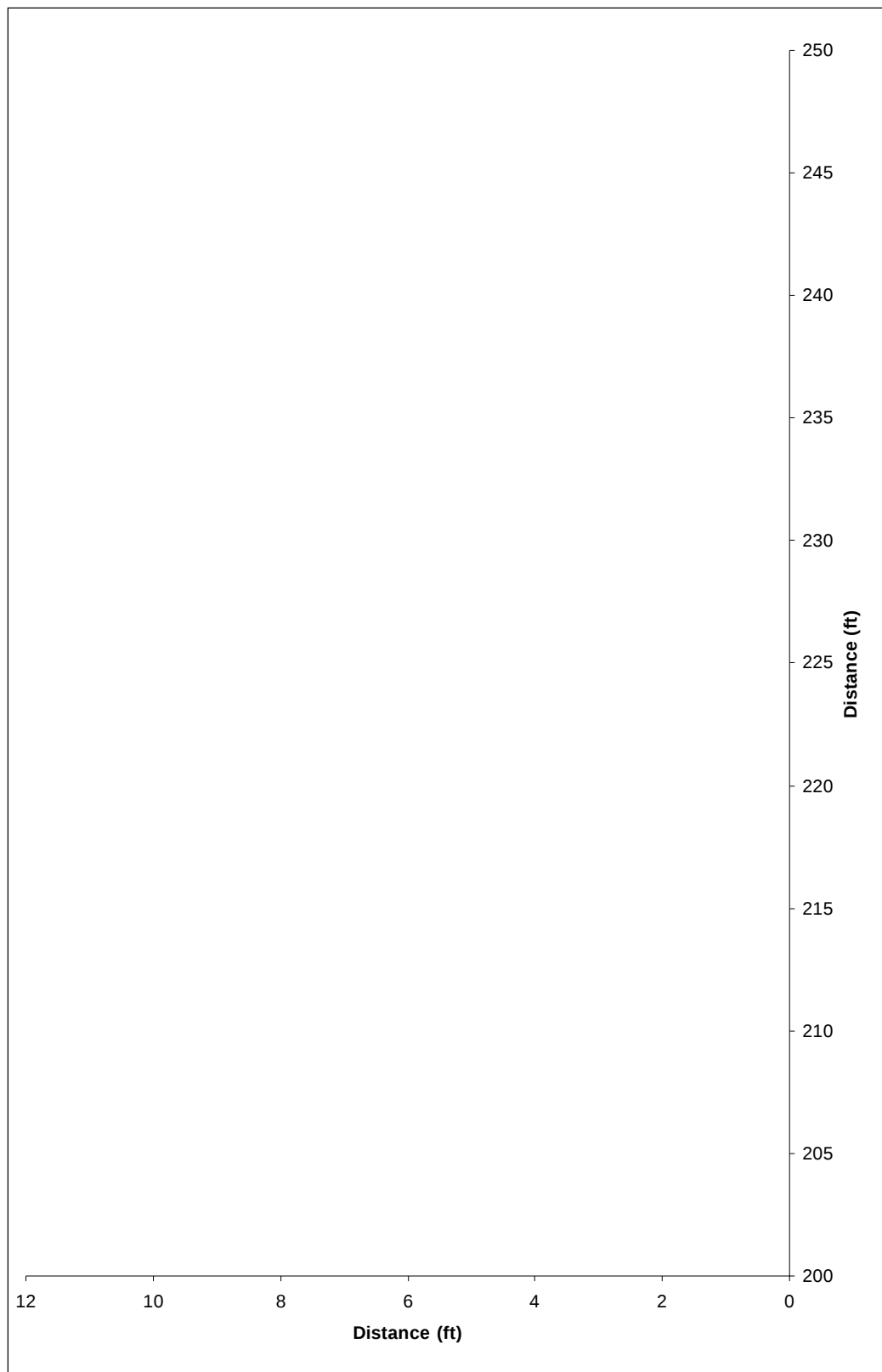


Figure 212. Robert Gray AAF Section 18 (Station 200-250 ft).

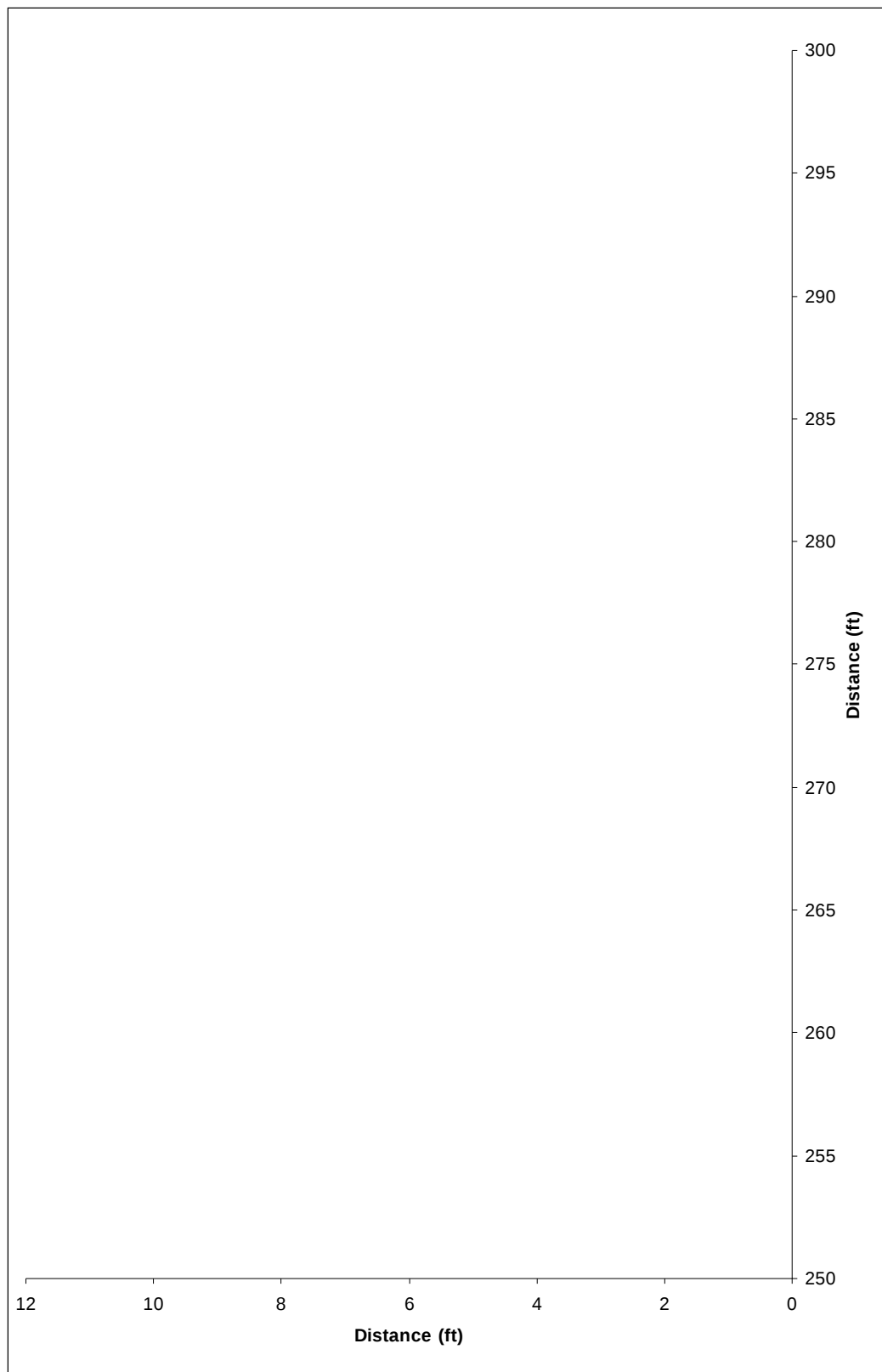


Figure 213. Robert Gray AAF Section 18 (Station 250-300 ft).

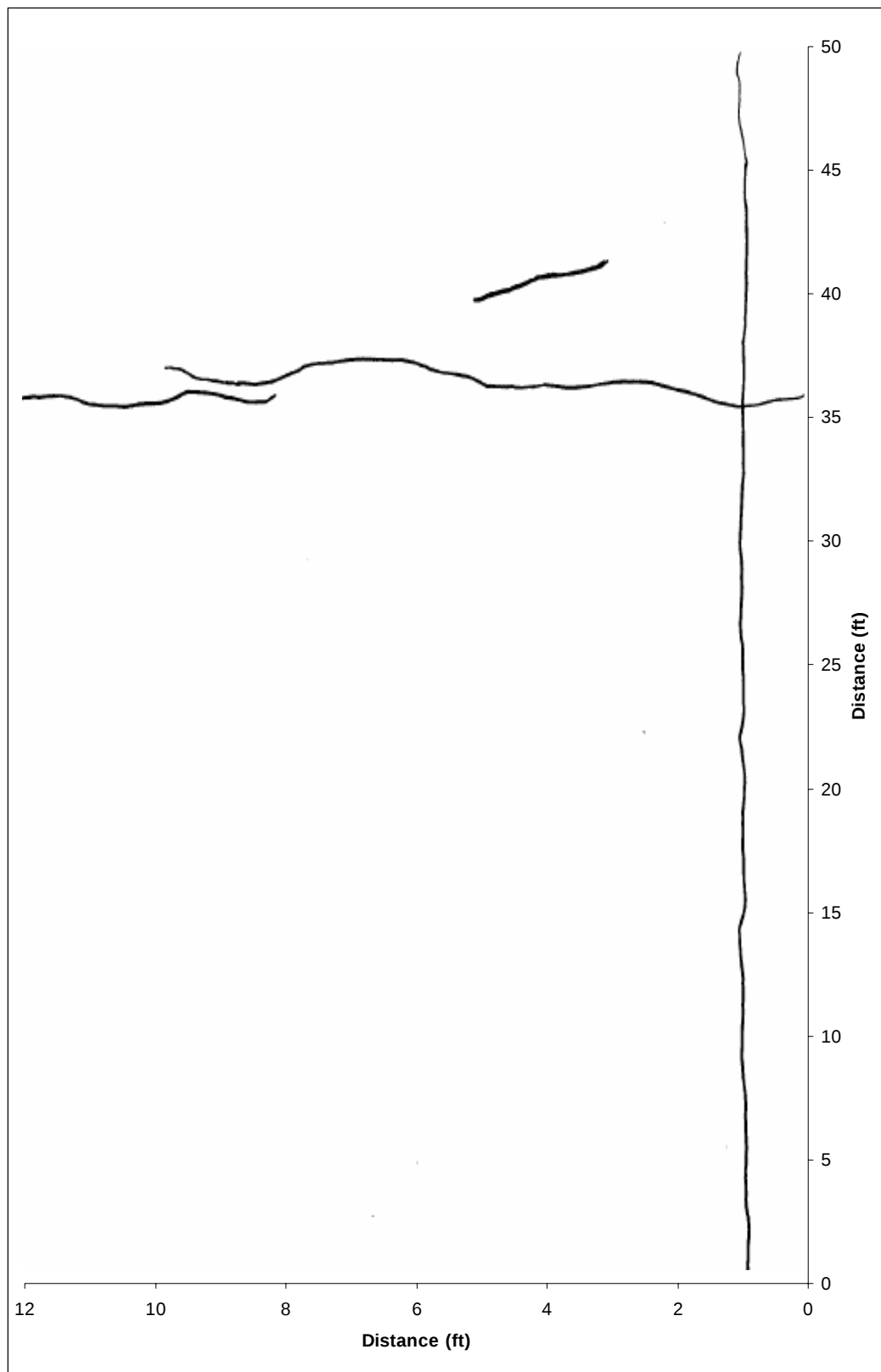


Figure 214. Wheeler-Sack AAF Section 1 (Station 0-50 ft).

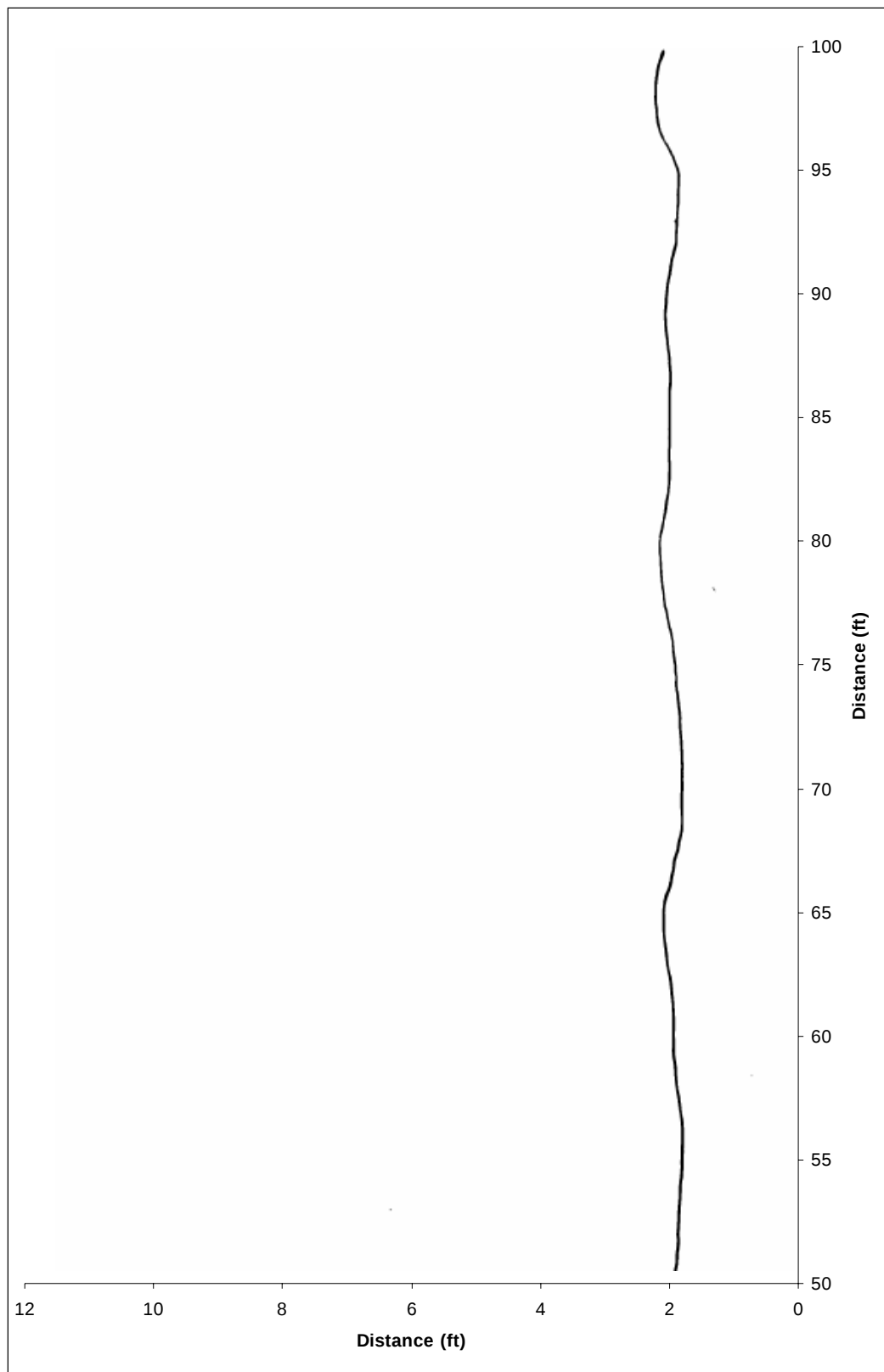


Figure 215. Wheeler-Sack AAF Section 1 (Station 50-100 ft).

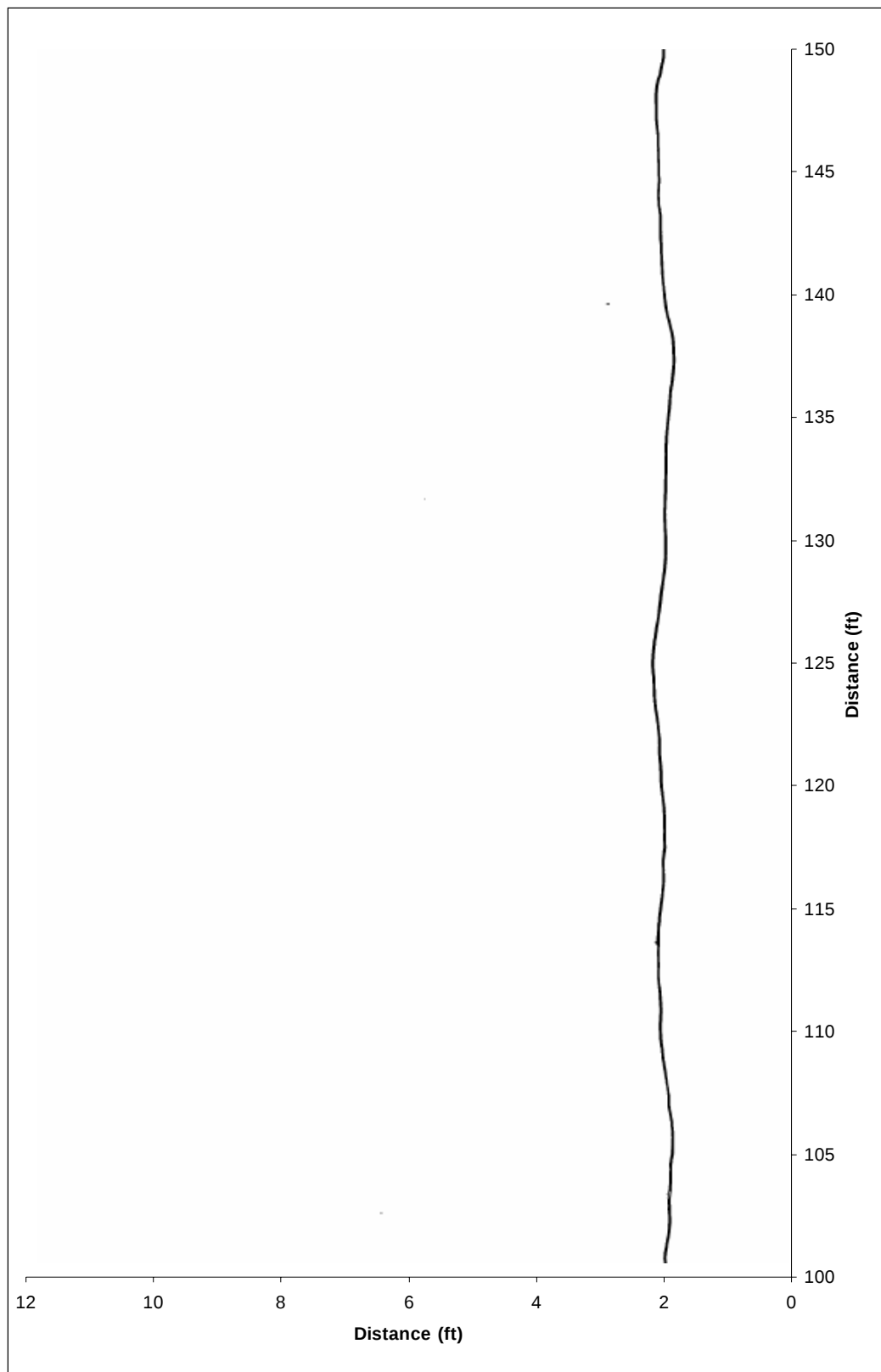


Figure 216. Wheeler-Sack AAF Section 1 (Station 100-150 ft).

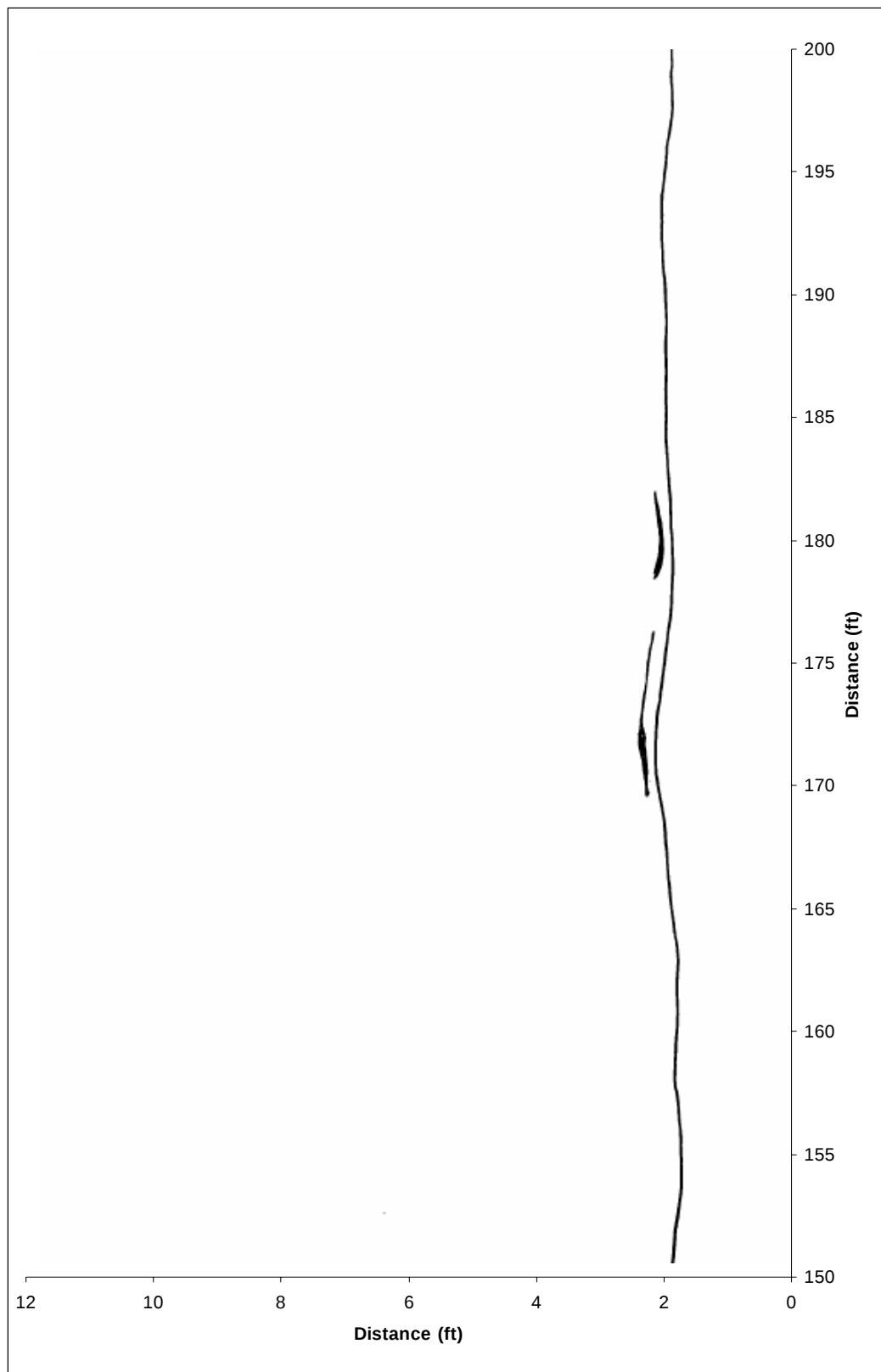


Figure 217. Wheeler-Sack AAF Section 1 (Station 150-200 ft).



Figure 218. Wheeler-Sack AAF Section 1 (Station 200-250 ft).

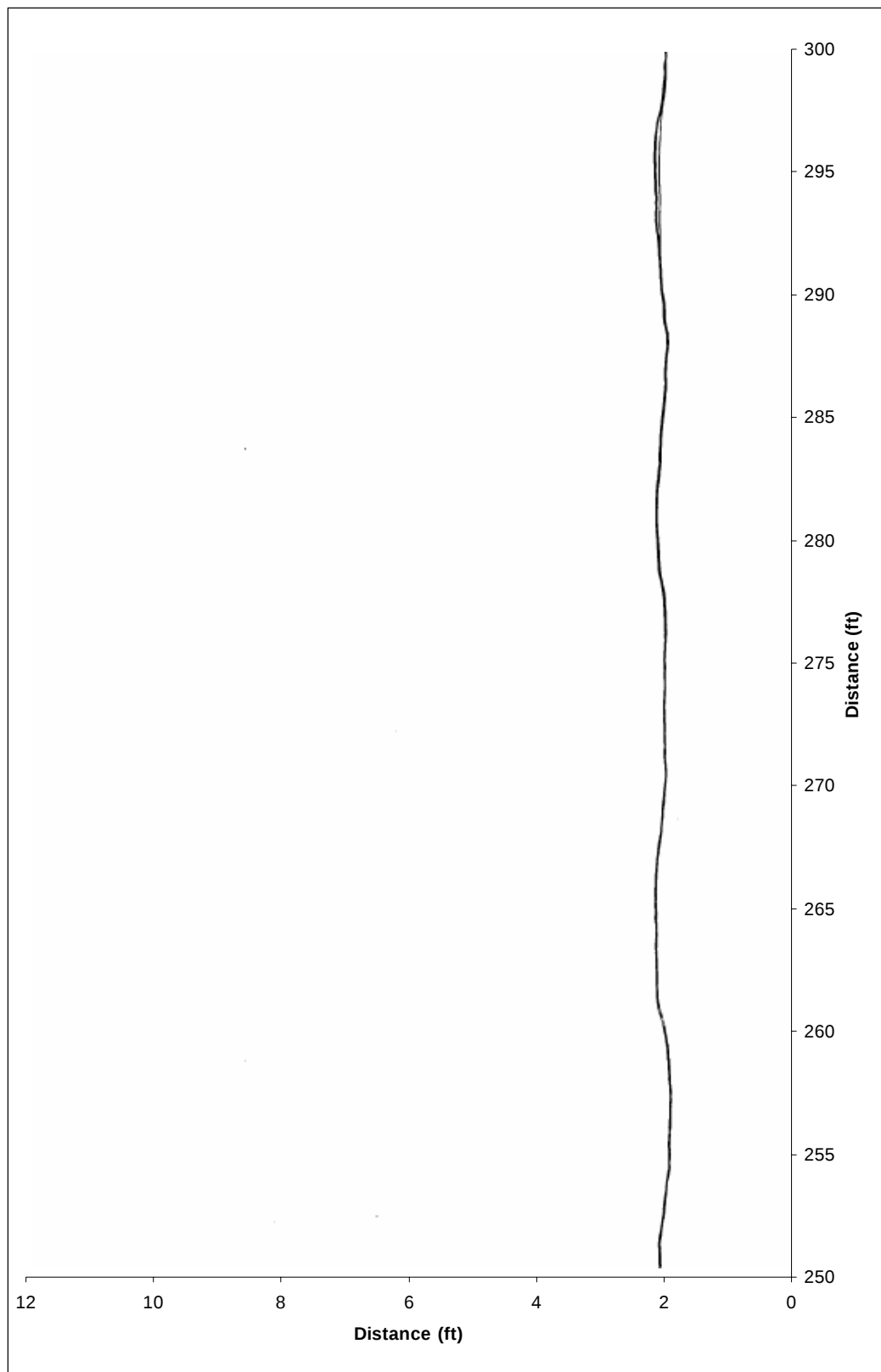


Figure 219. Wheeler-Sack AAF Section 1 (Station 250-300 ft).

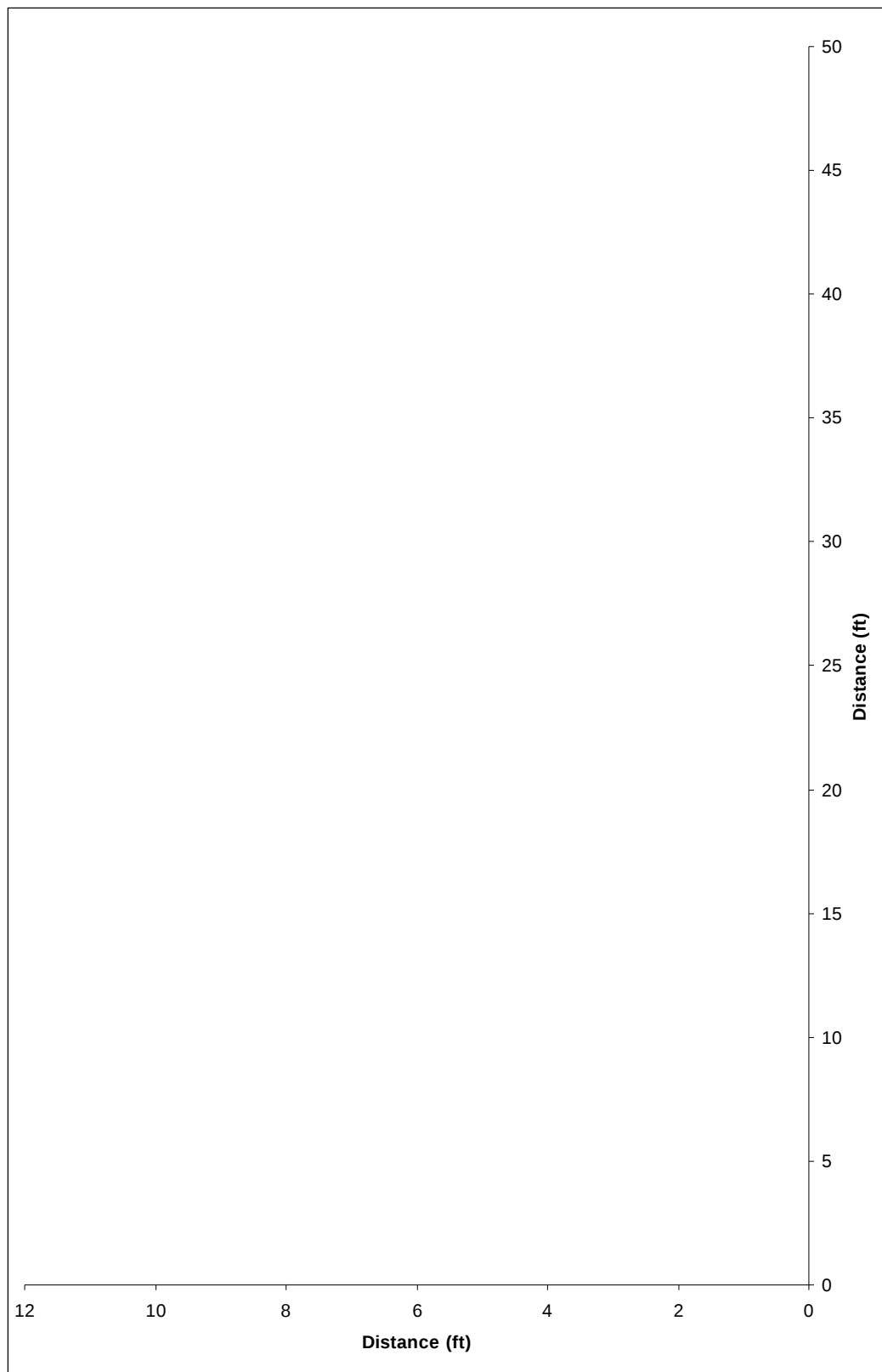


Figure 220. Wheeler-Sack AAF Section 2 (Station 0-50 ft).

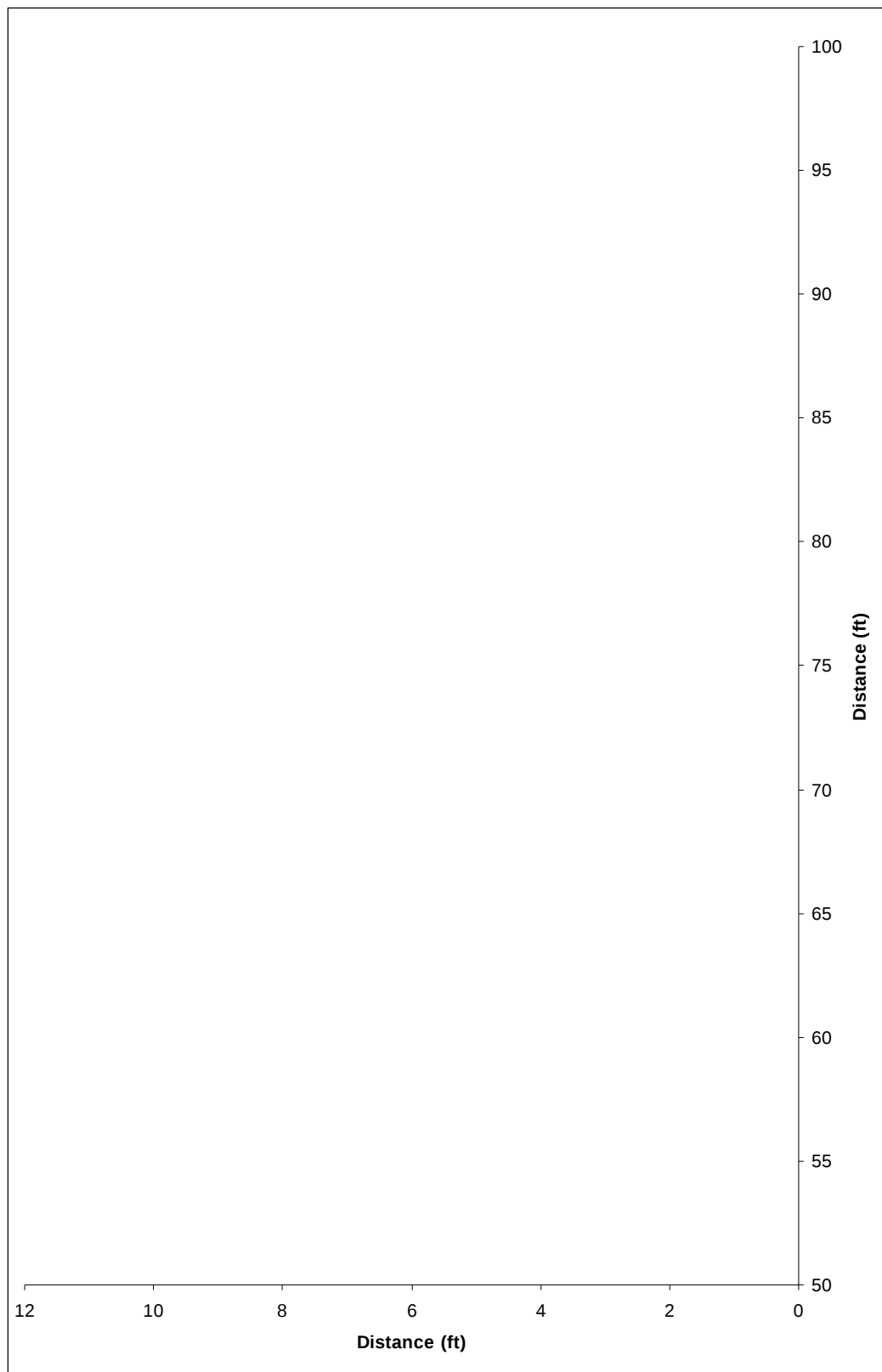


Figure 221. Wheeler-Sack AAF Section 2 (Station 50-100 ft).

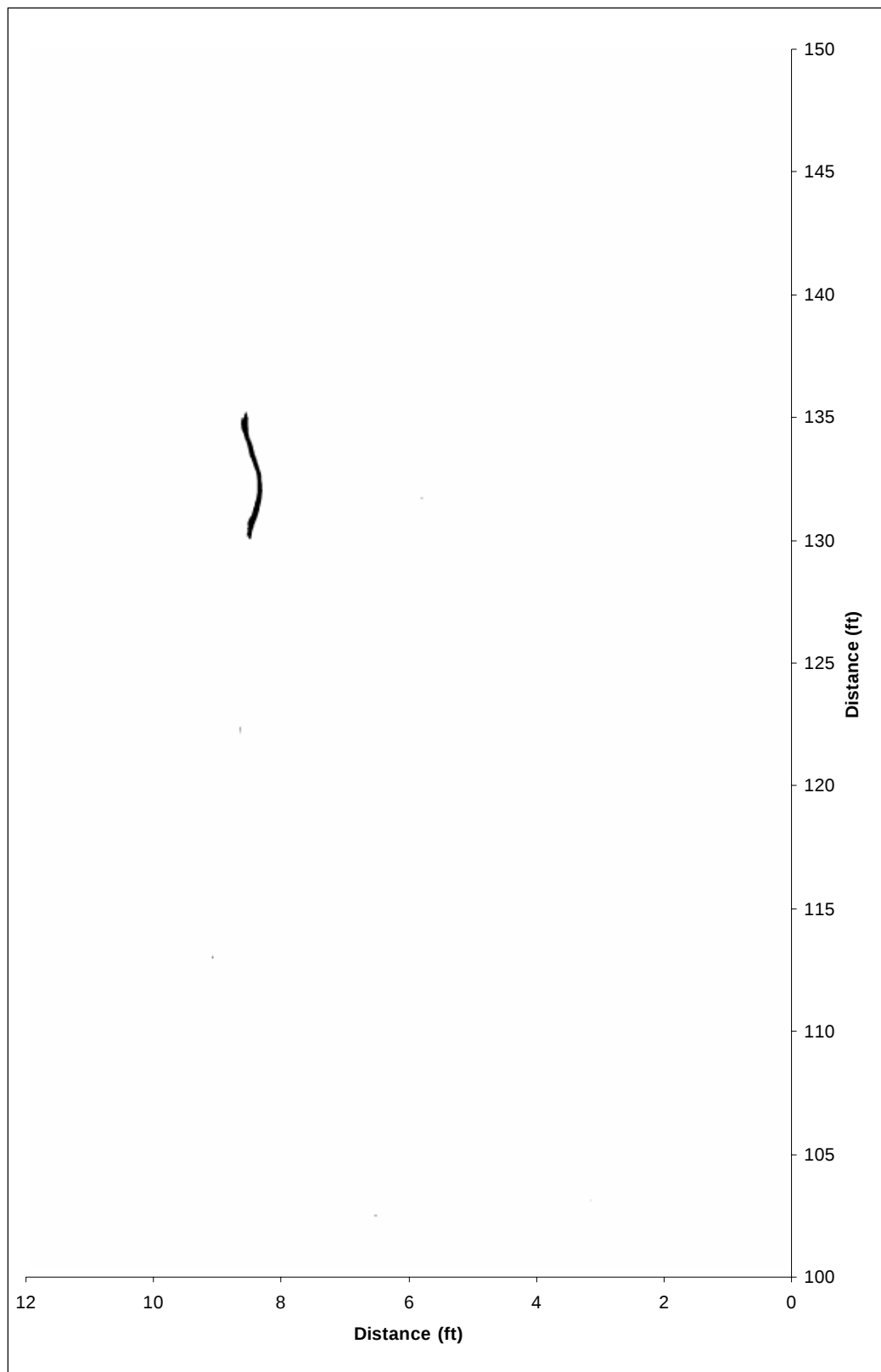


Figure 222. Wheeler-Sack AAF Section 2 (Station 100-150 ft).

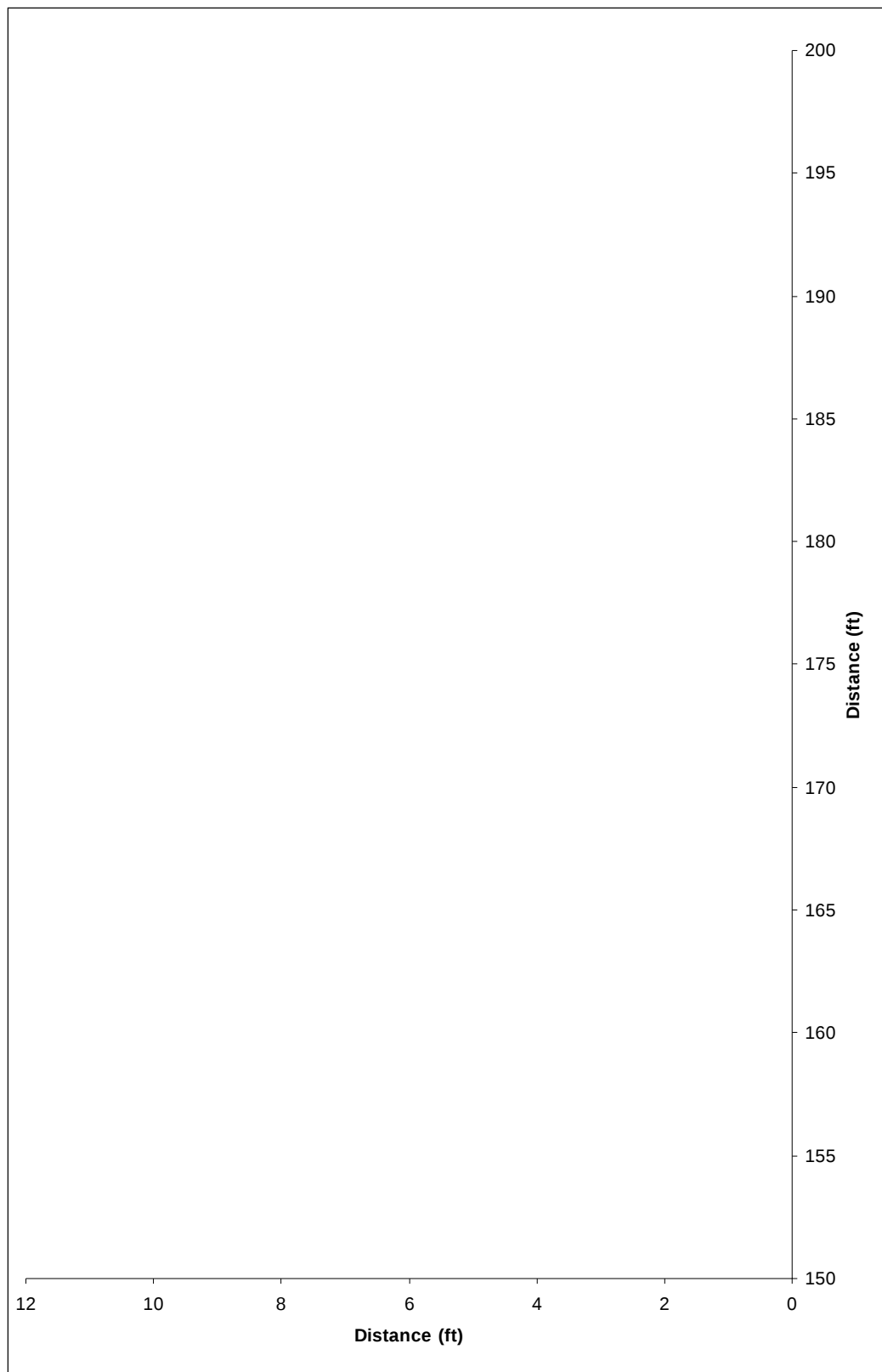


Figure 223. Wheeler-Sack AAF Section 2 (Station 150-200 ft).

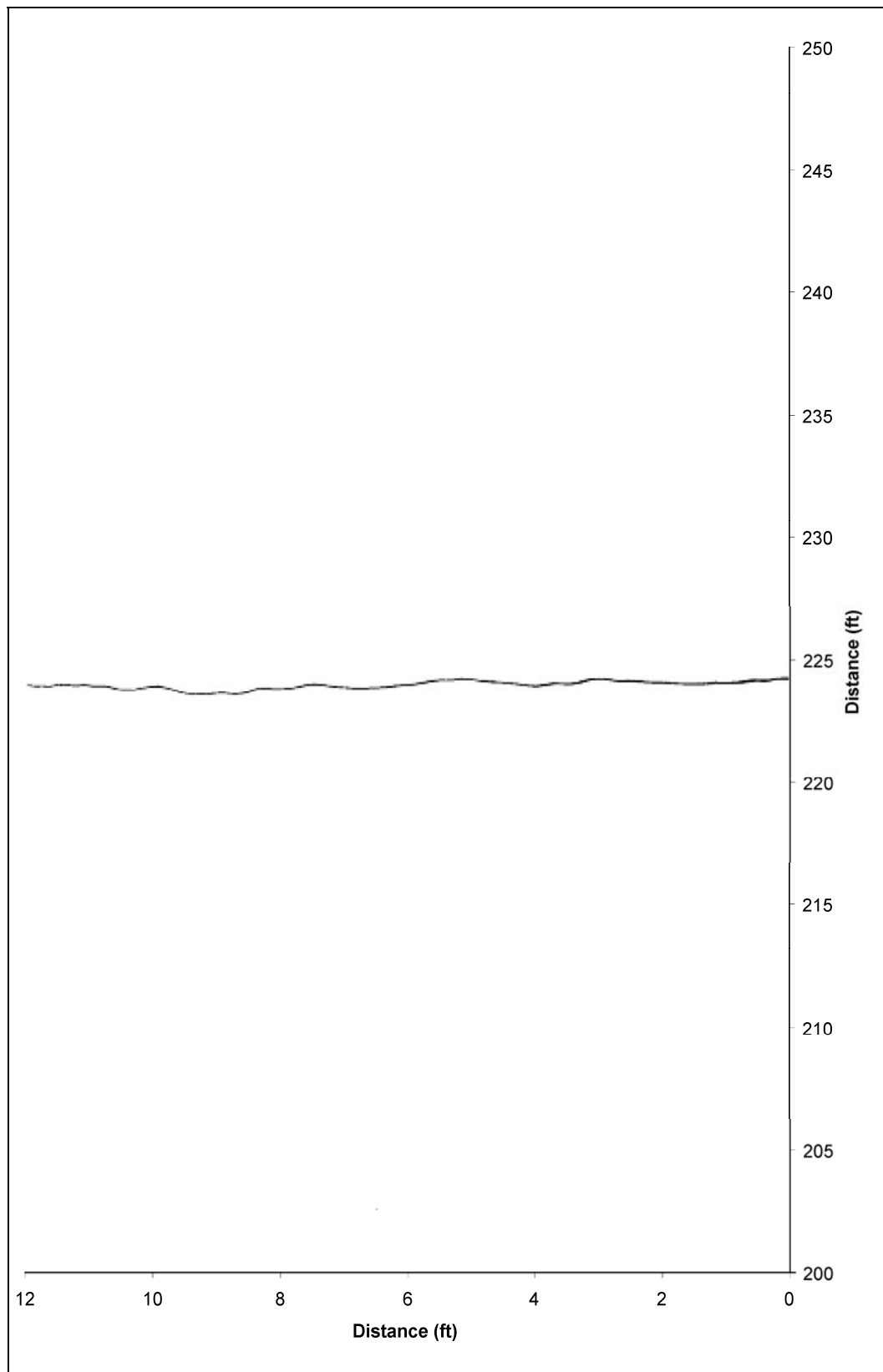


Figure 224. Wheeler-Sack AAF Section 2 (Station 200-250 ft).

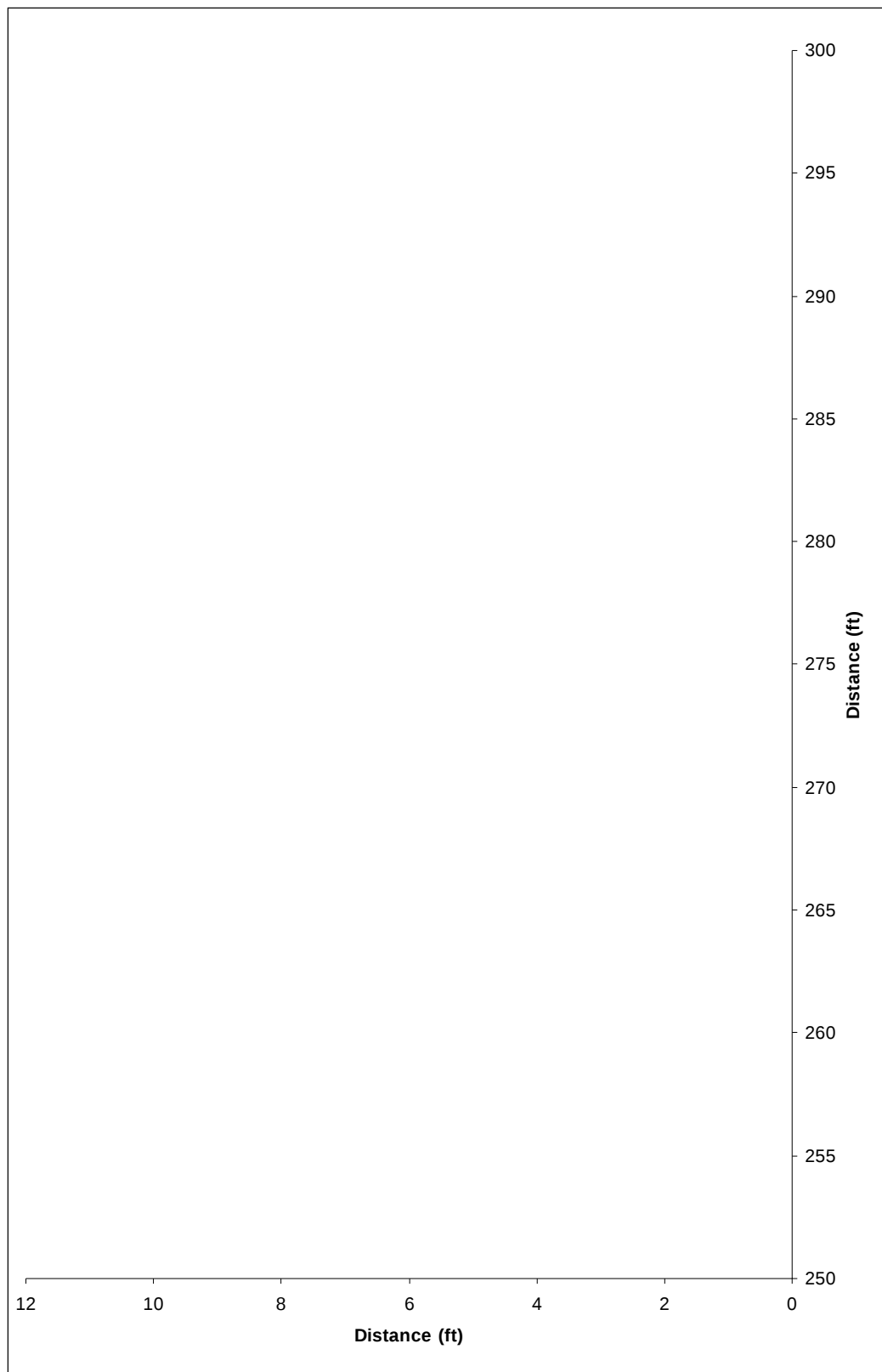


Figure 225. Wheeler-Sack AAF Section 2 (Station 250-300 ft).

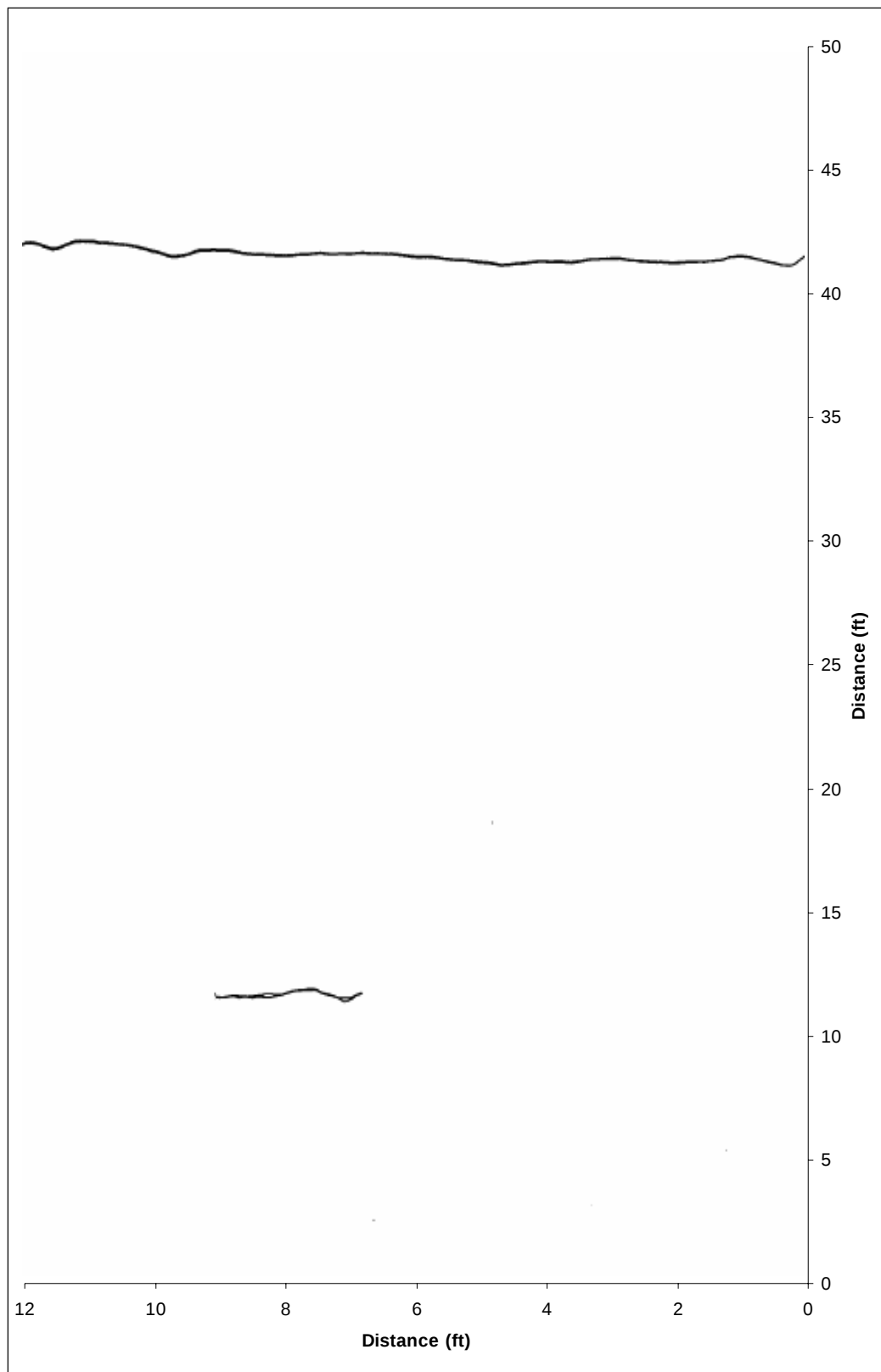


Figure 226. Wheeler-Sack AAF Section 3 (Station 0-50 ft).

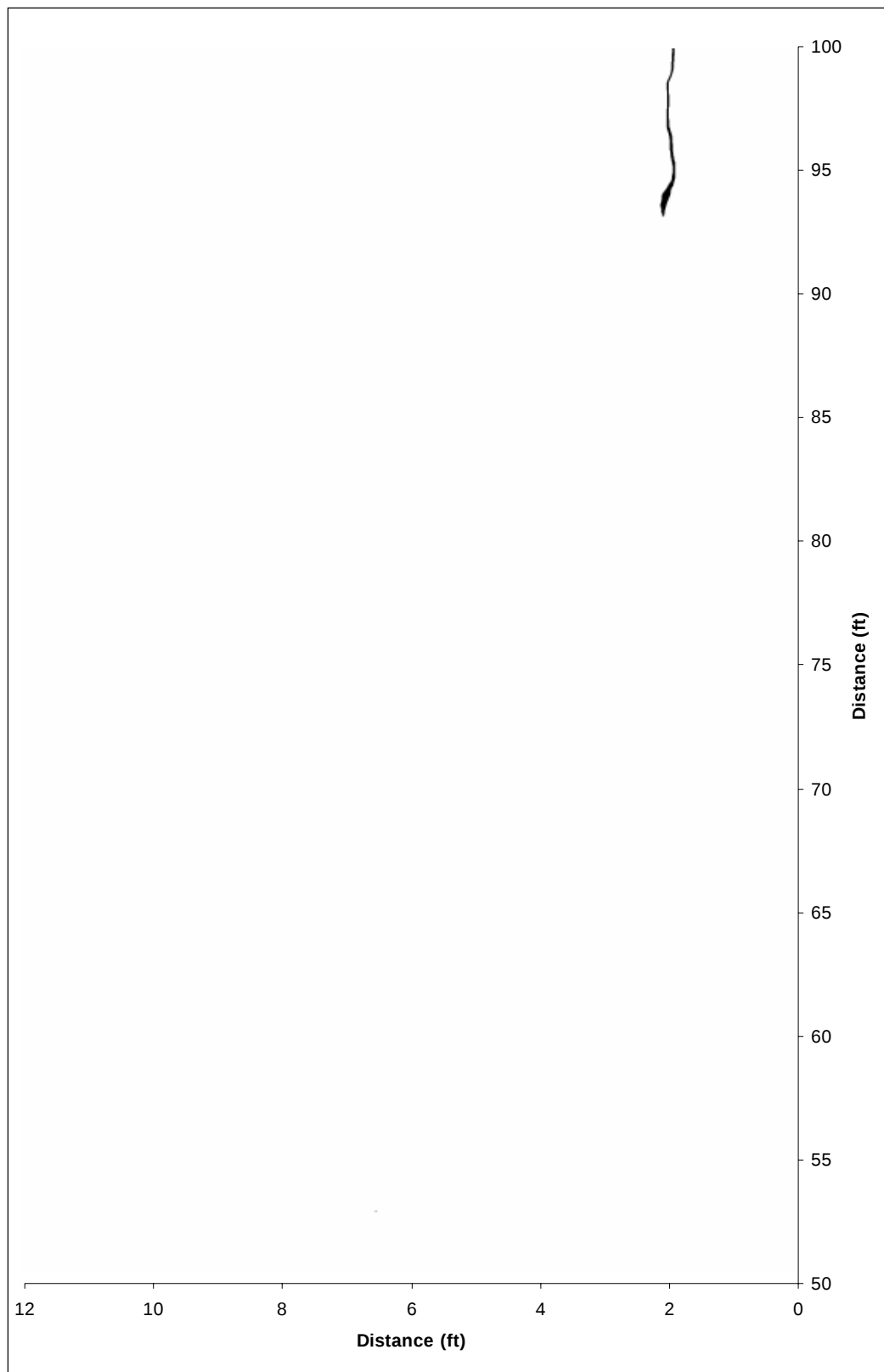


Figure 227. Wheeler-Sack AAF Section 3 (Station 50-100 ft).

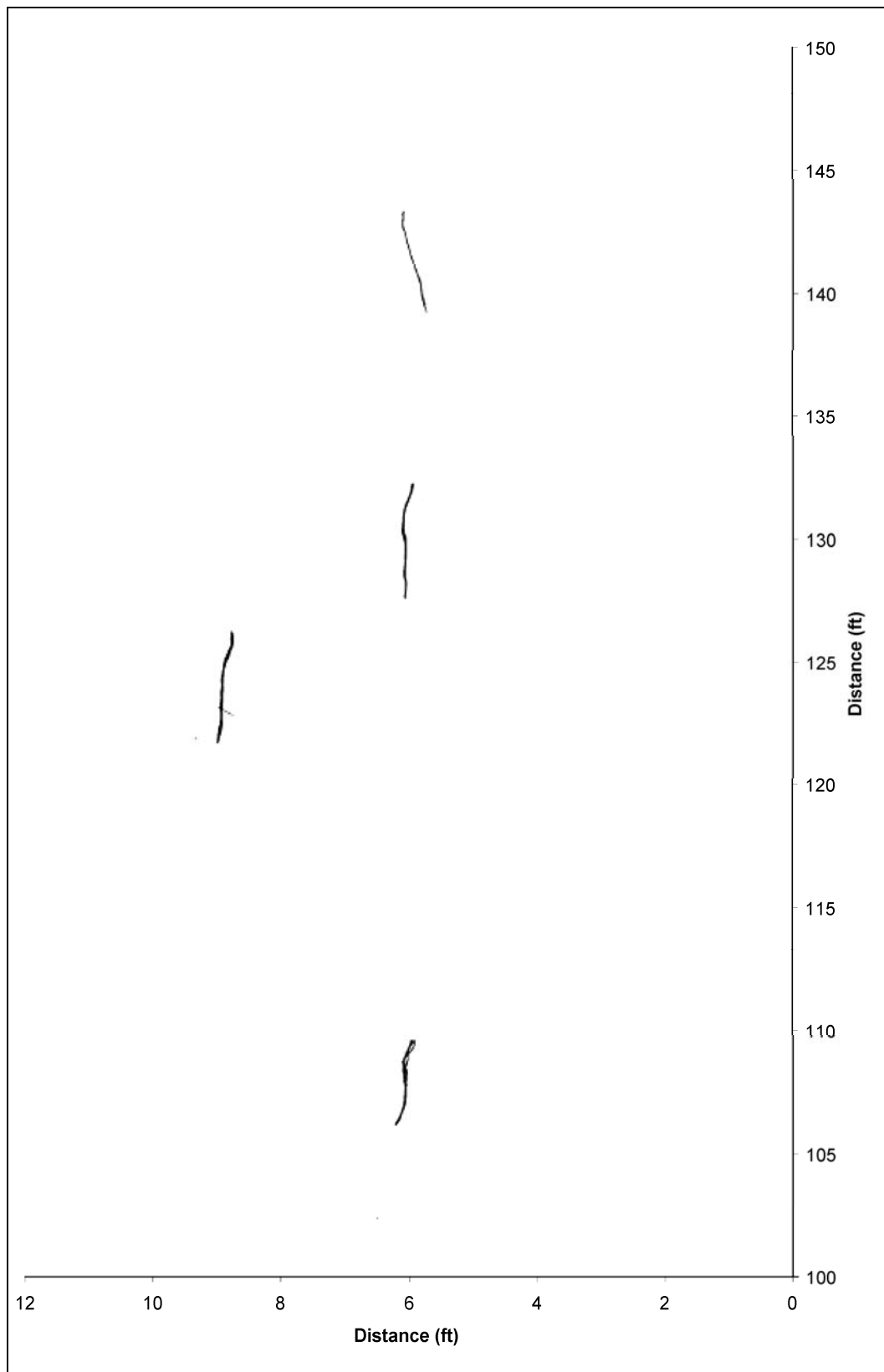


Figure 228. Wheeler-Sack AAF Section 3 (Station 100-150 ft).

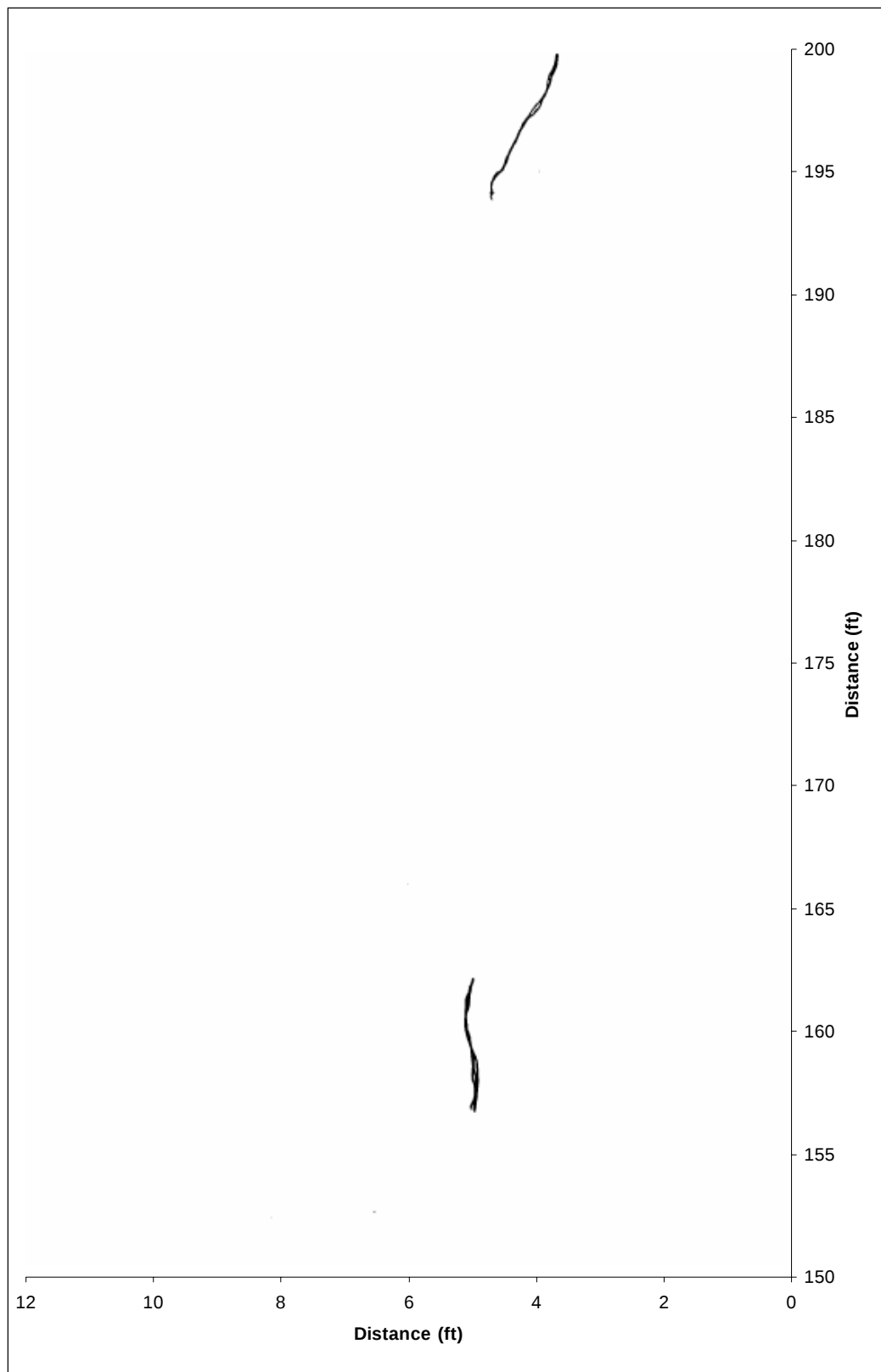


Figure 229. Wheeler-Sack AAF Section 3 (Station 150-200 ft).

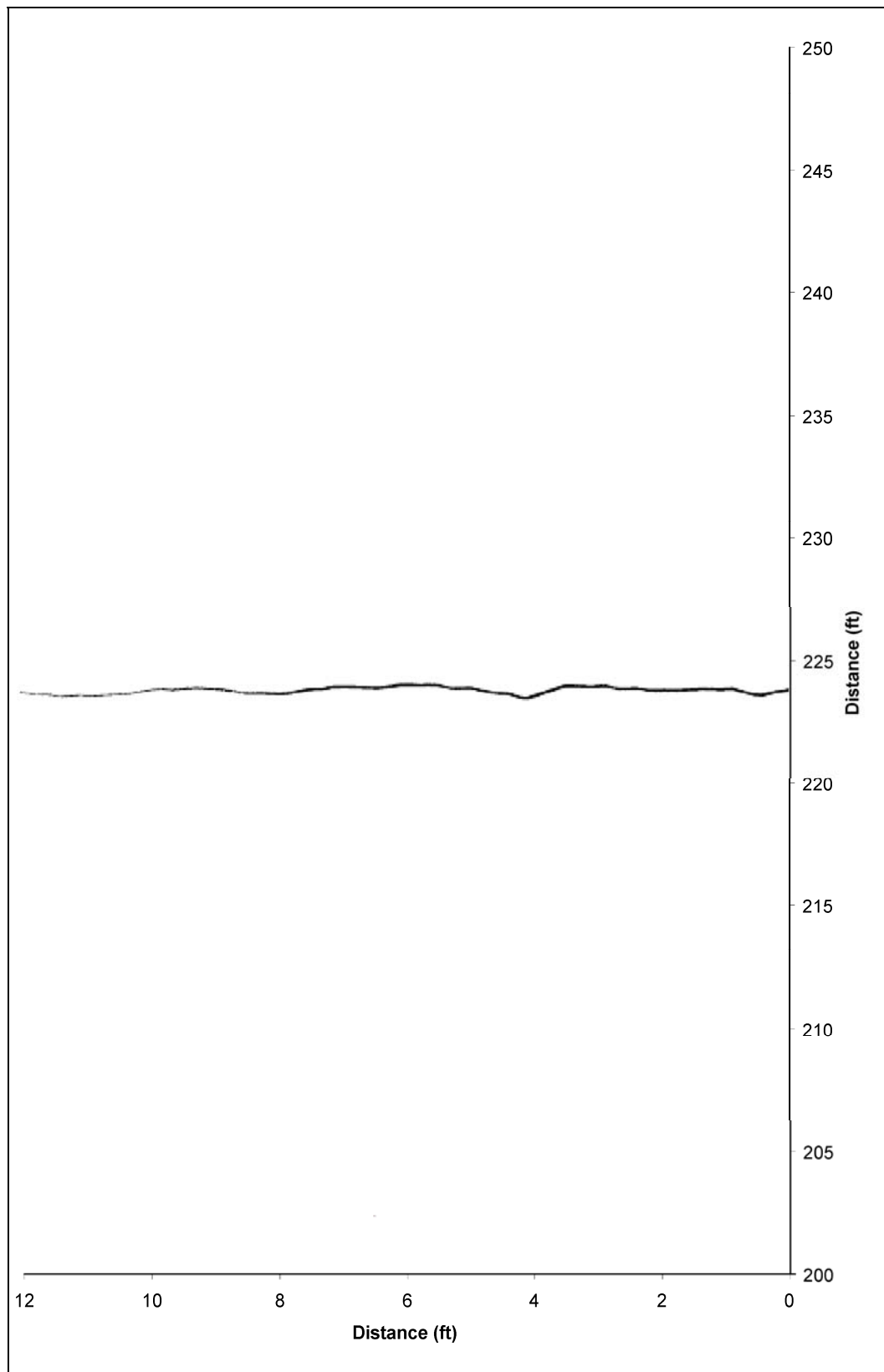


Figure 230. Wheeler-Sack AAF Section 3 (Station 200-250 ft).

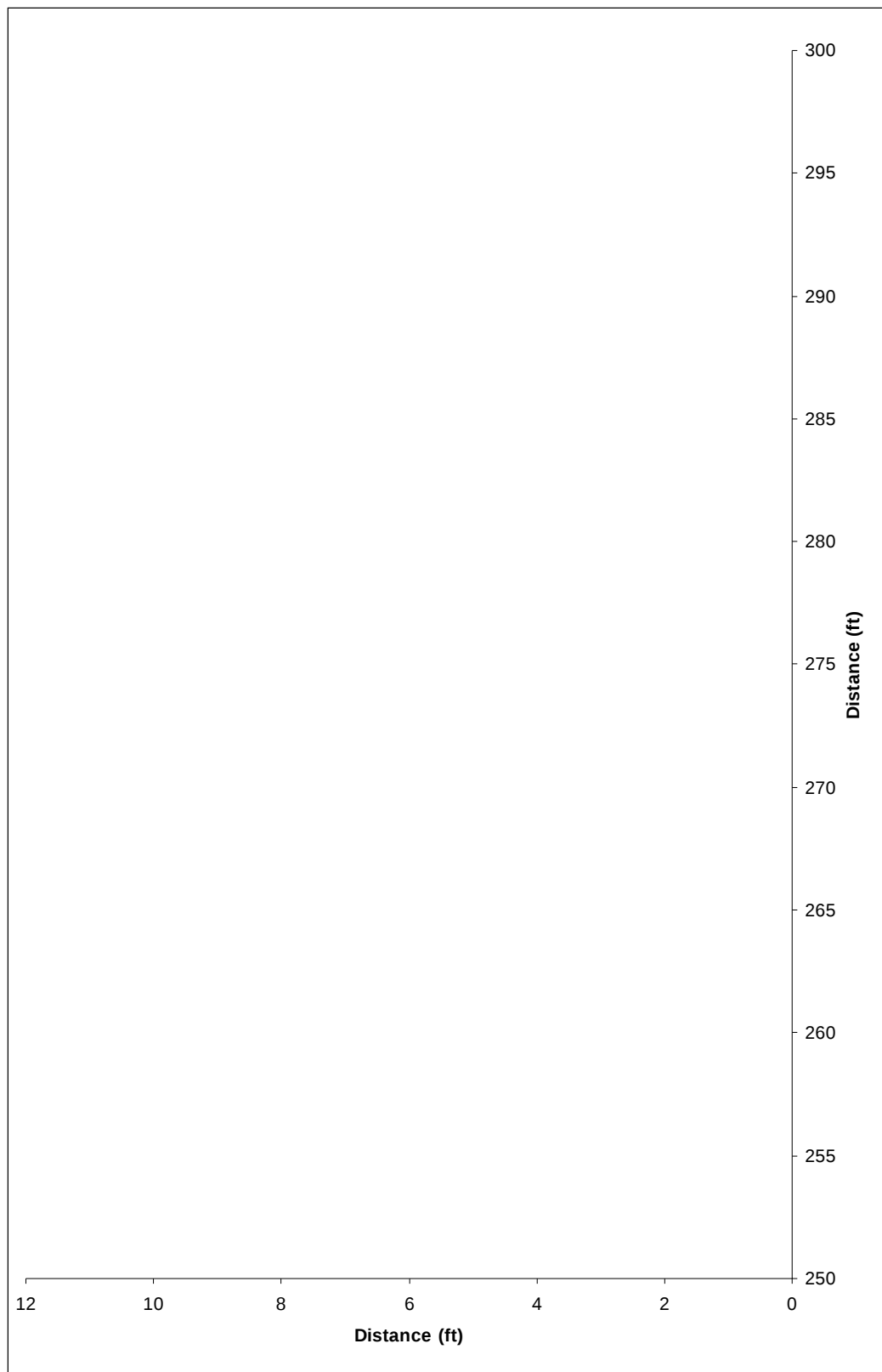


Figure 231. Wheeler-Sack AAF Section 3 (Station 250-300 ft).

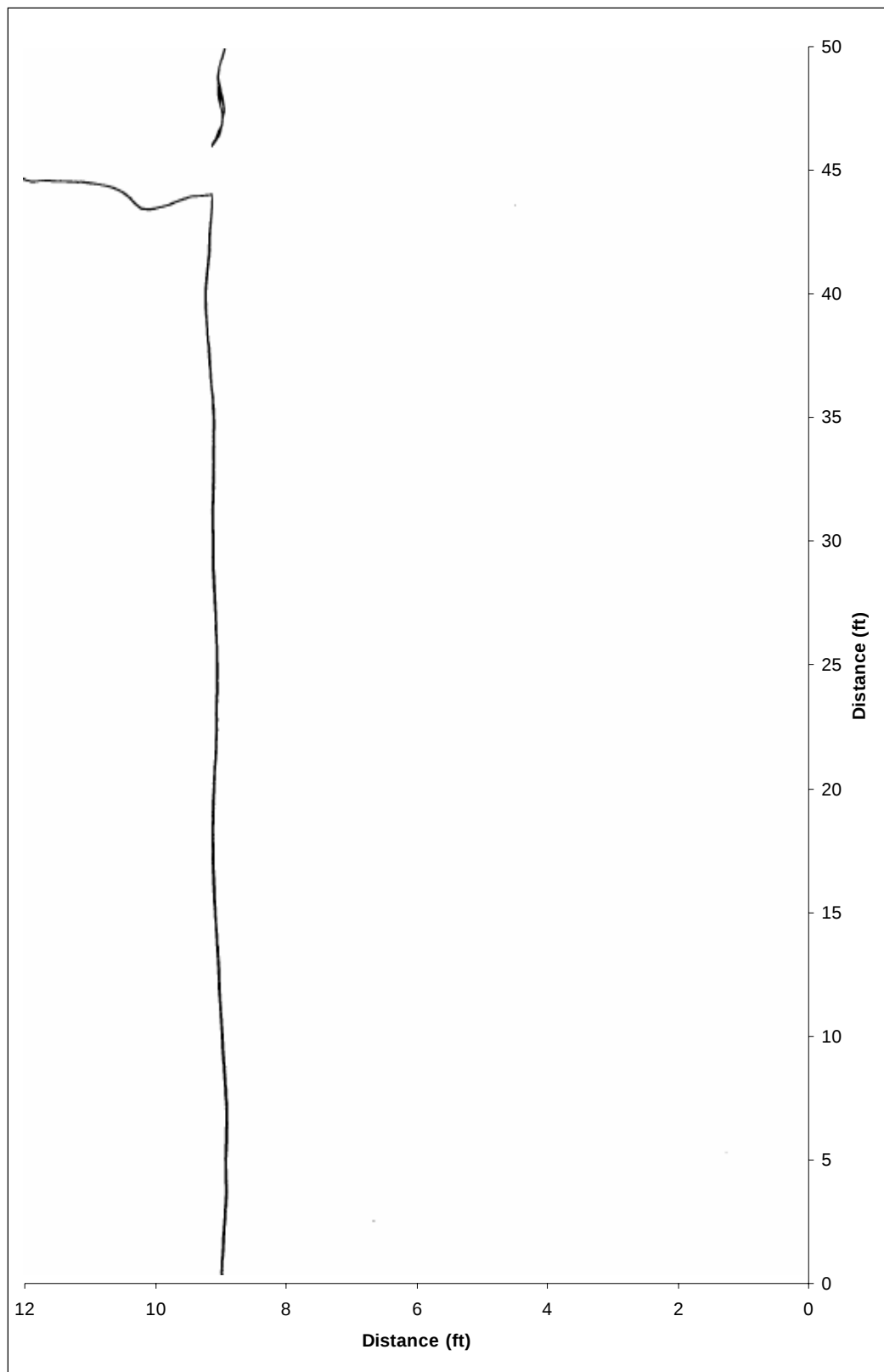


Figure 232. Wheeler-Sack AAF Section 4 (Station 0-50 ft).

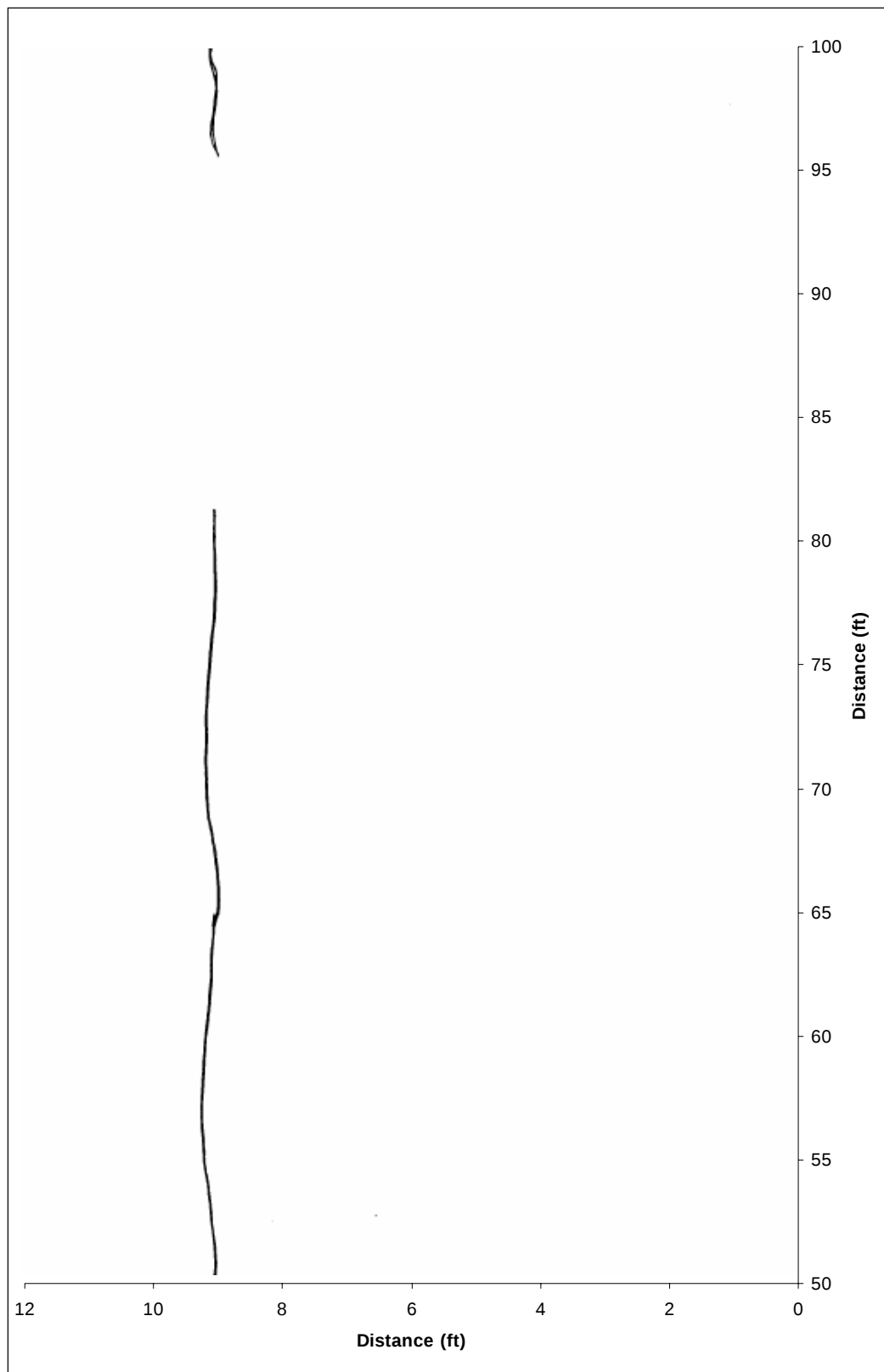


Figure 233. Wheeler-Sack AAF Section 4 (Station 50-100 ft).

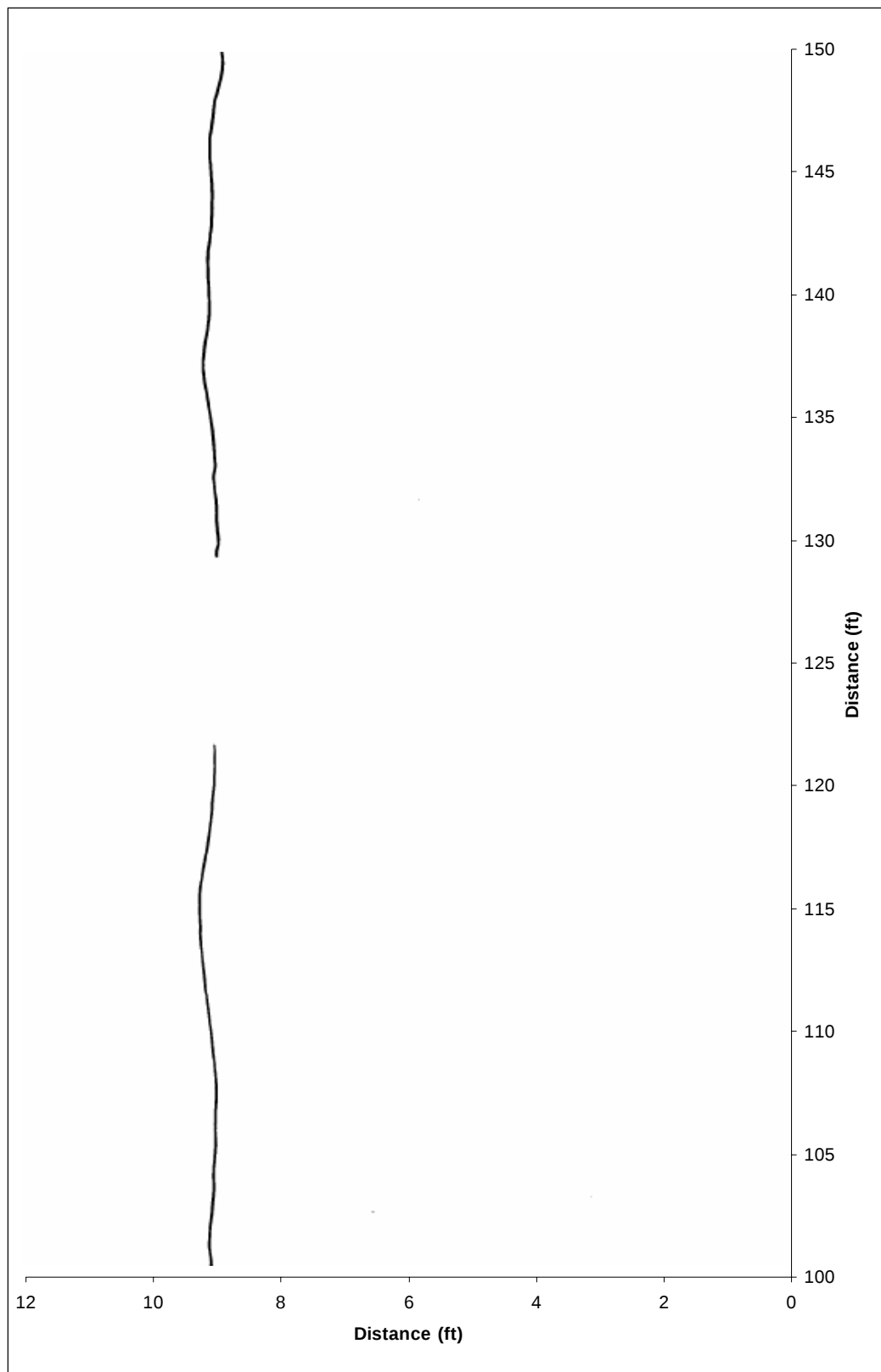


Figure 234. Wheeler-Sack AAF Section 4 (Station 100-150 ft).

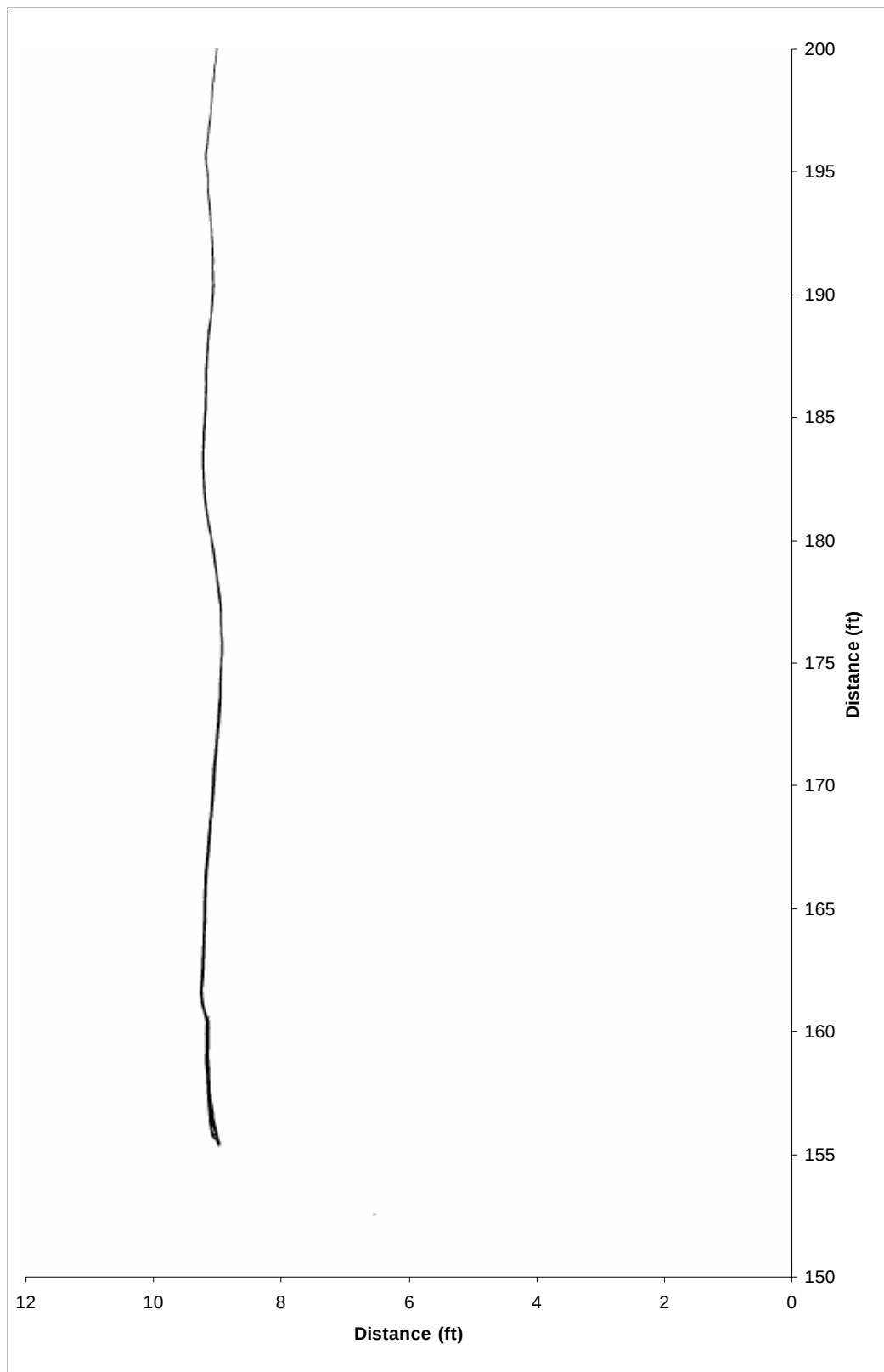


Figure 235. Wheeler-Sack AAF Section 4 (Station 150-200 ft).

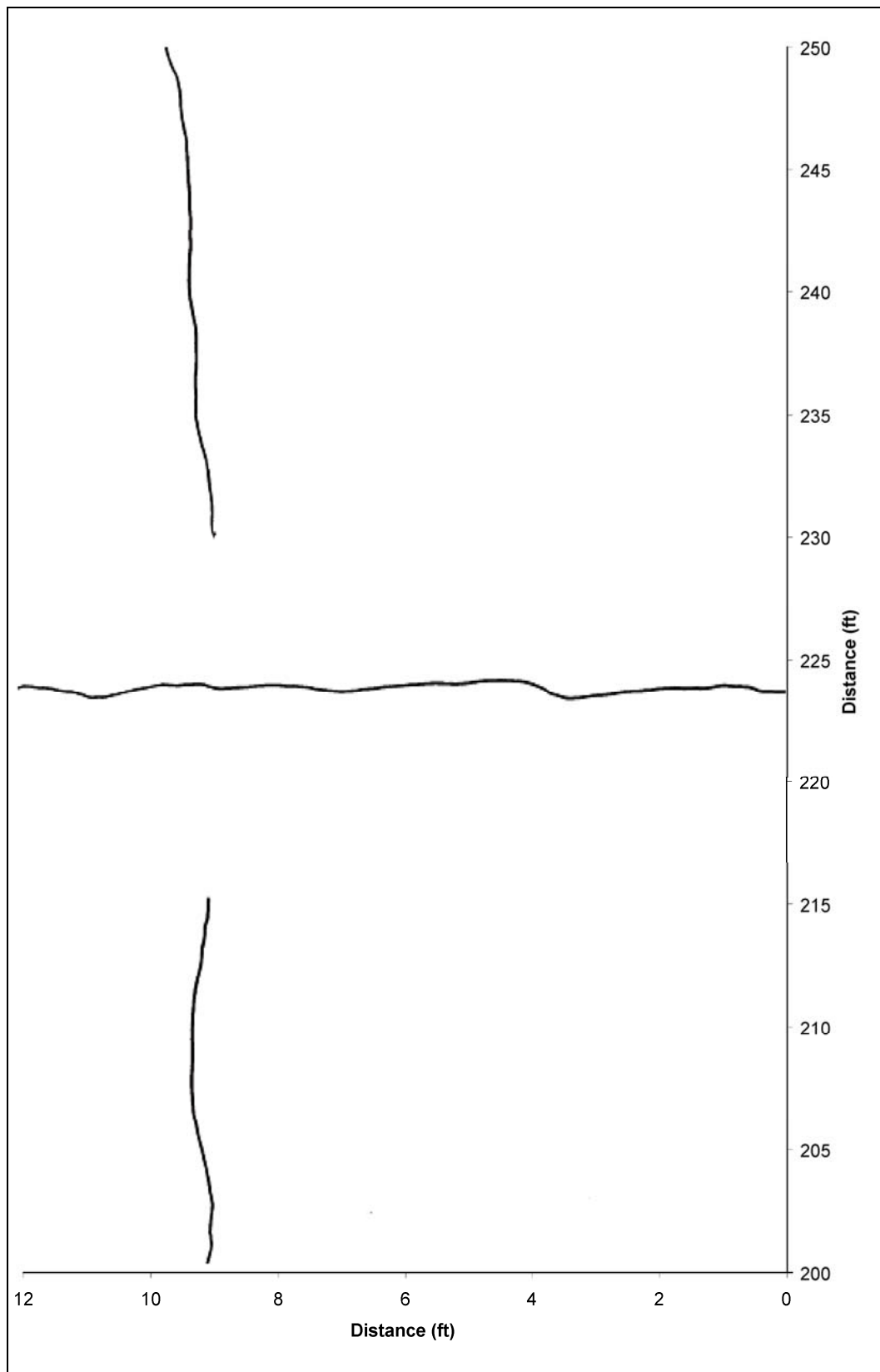


Figure 236. Wheeler-Sack AAF Section 4 (Station 200-250 ft).

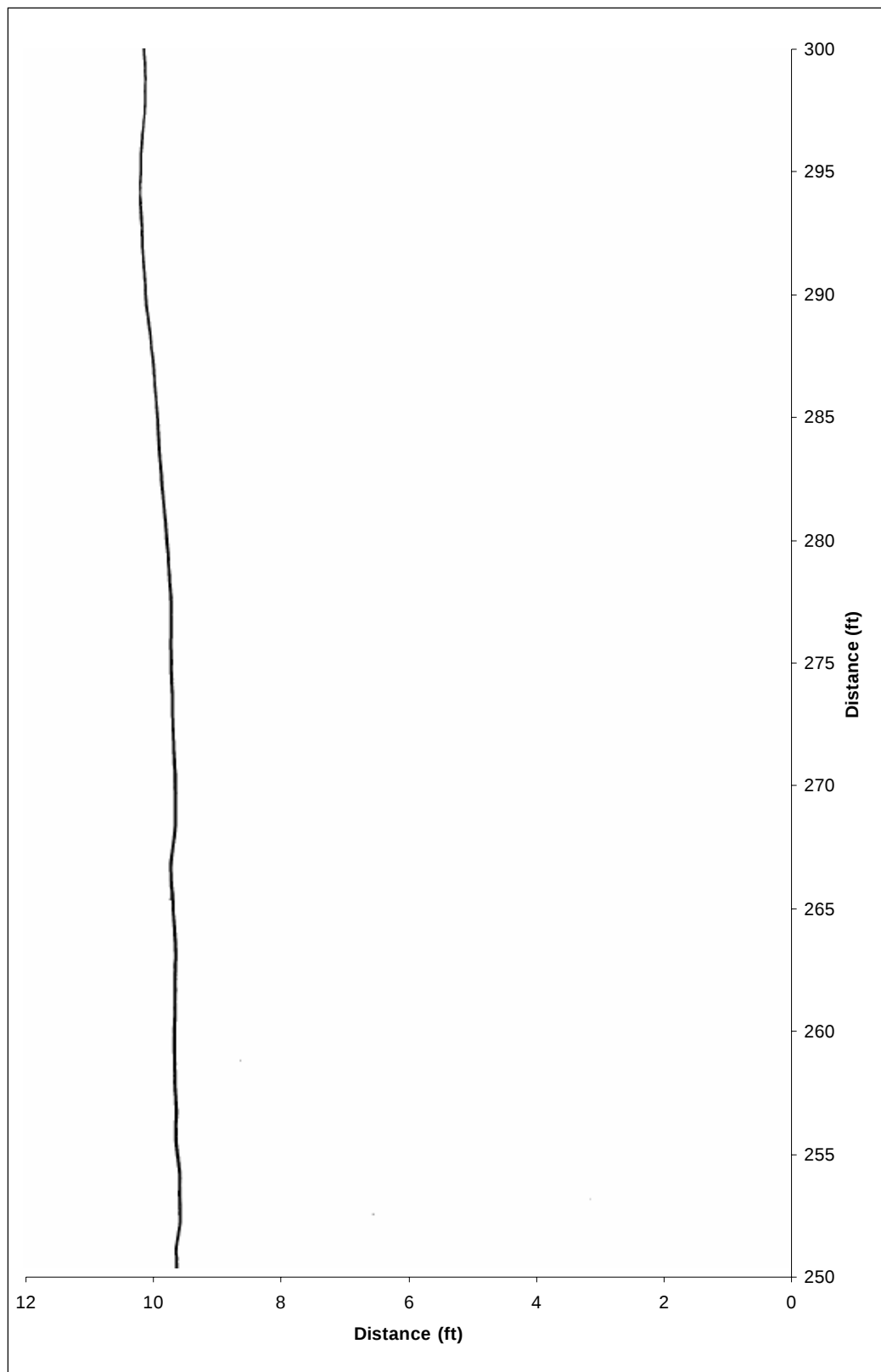


Figure 237. Wheeler-Sack AAF Section 4 (Station 250-300 ft).

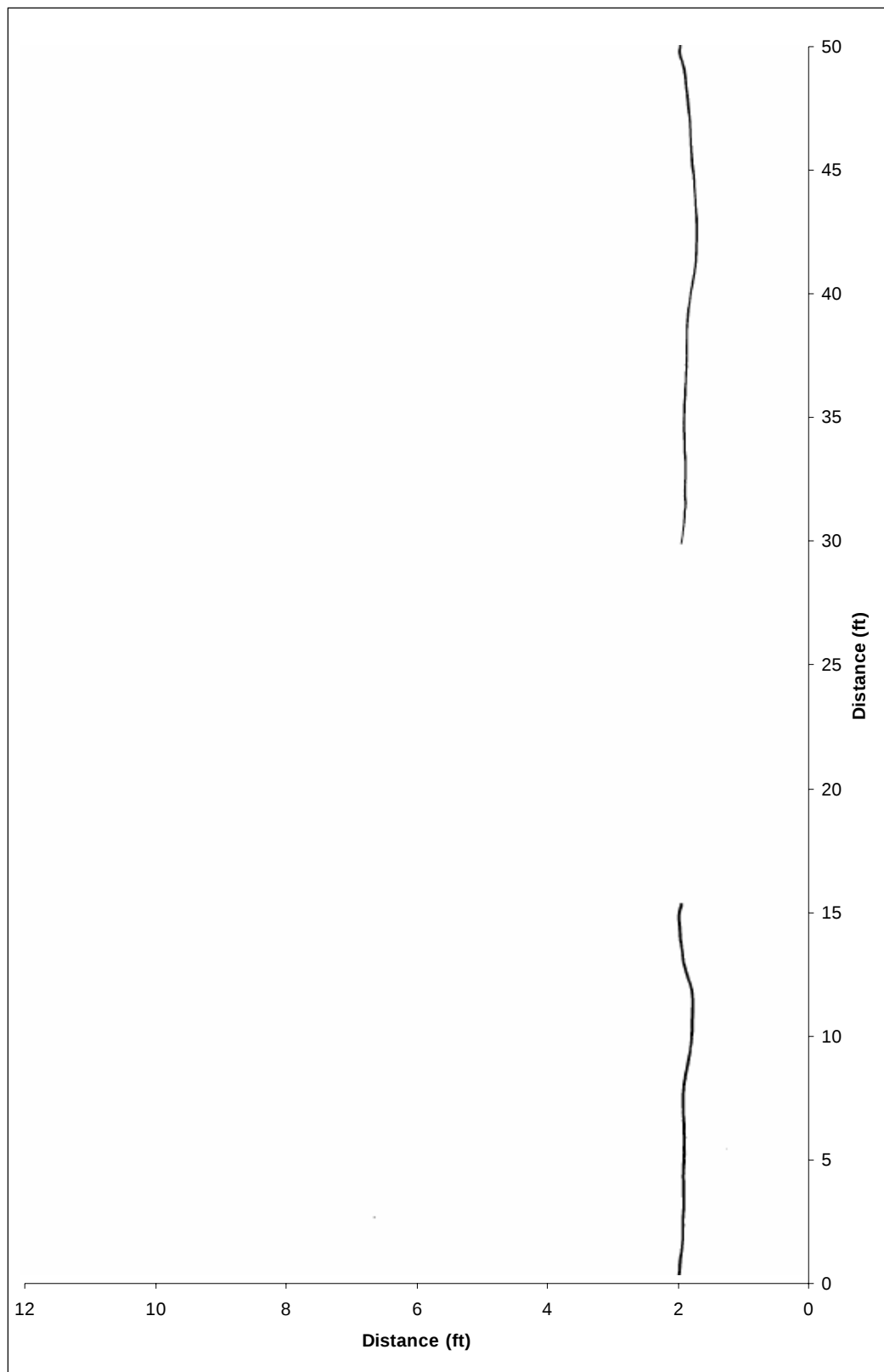


Figure 238. Wheeler-Sack AAF Section 5 (Station 0-50 ft).

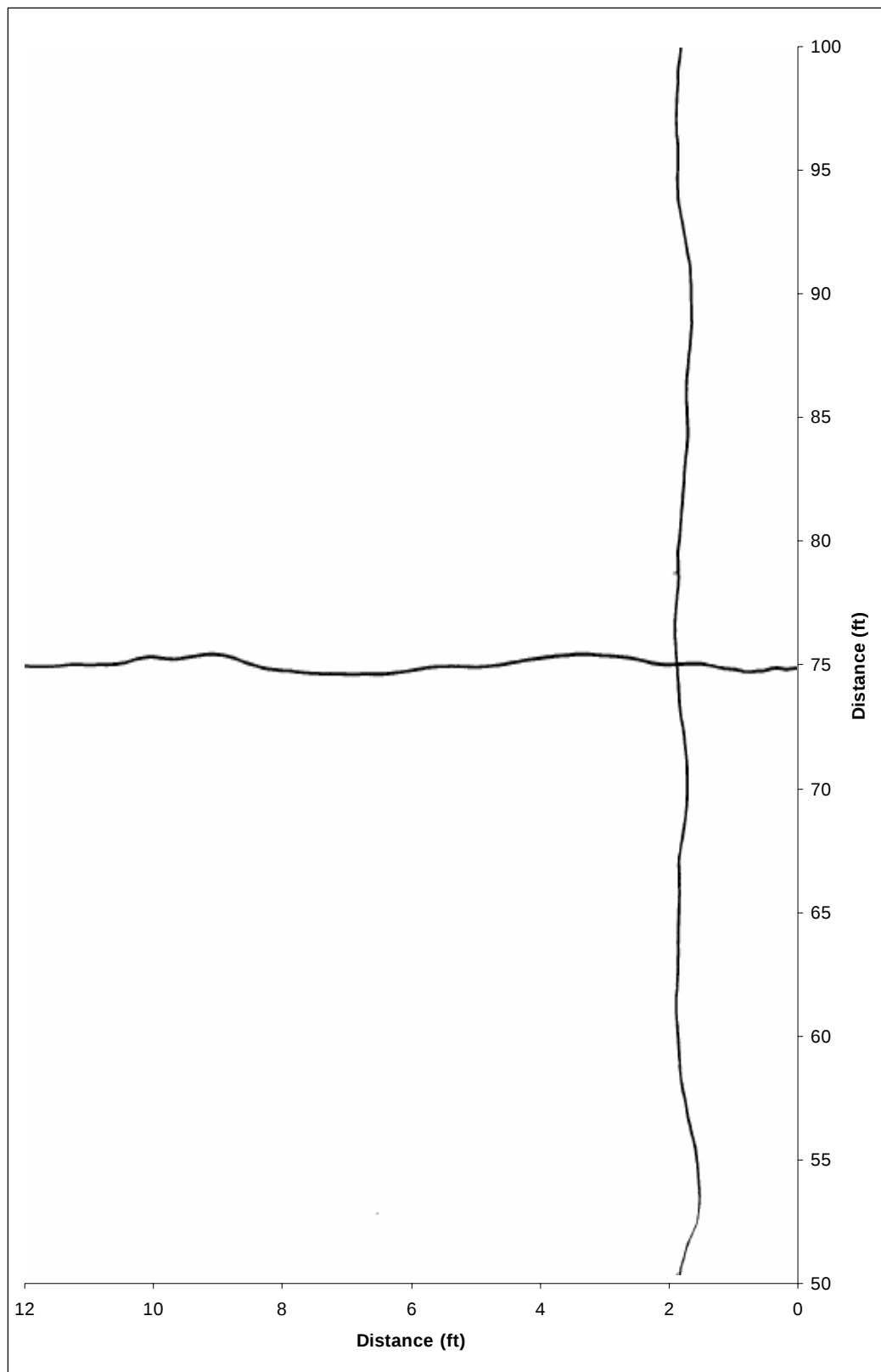


Figure 239. Wheeler-Sack AAF Section 5 (Station 50-100 ft).

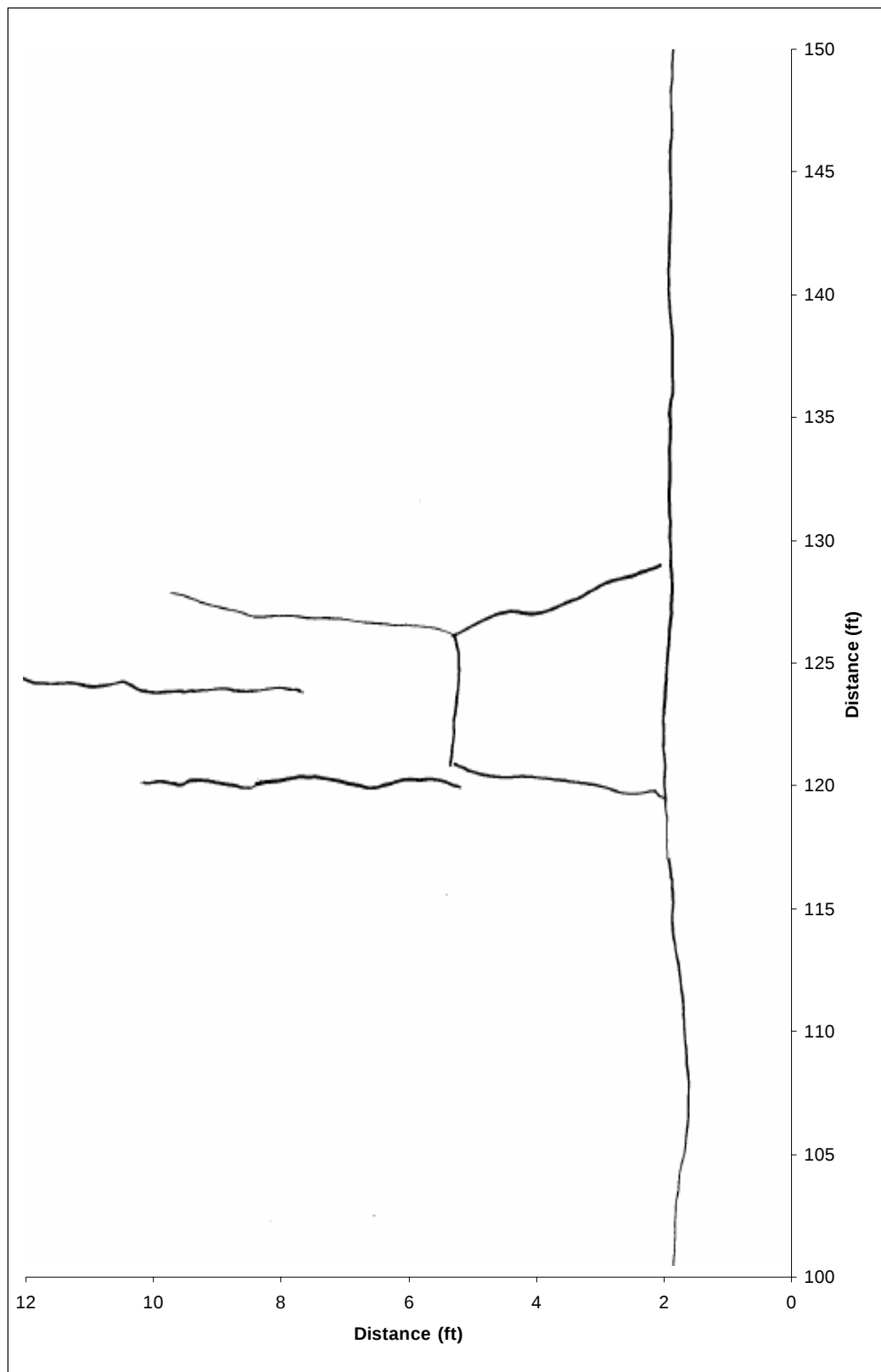


Figure 240. Wheeler-Sack AAF Section 5 (Station 100-150 ft).

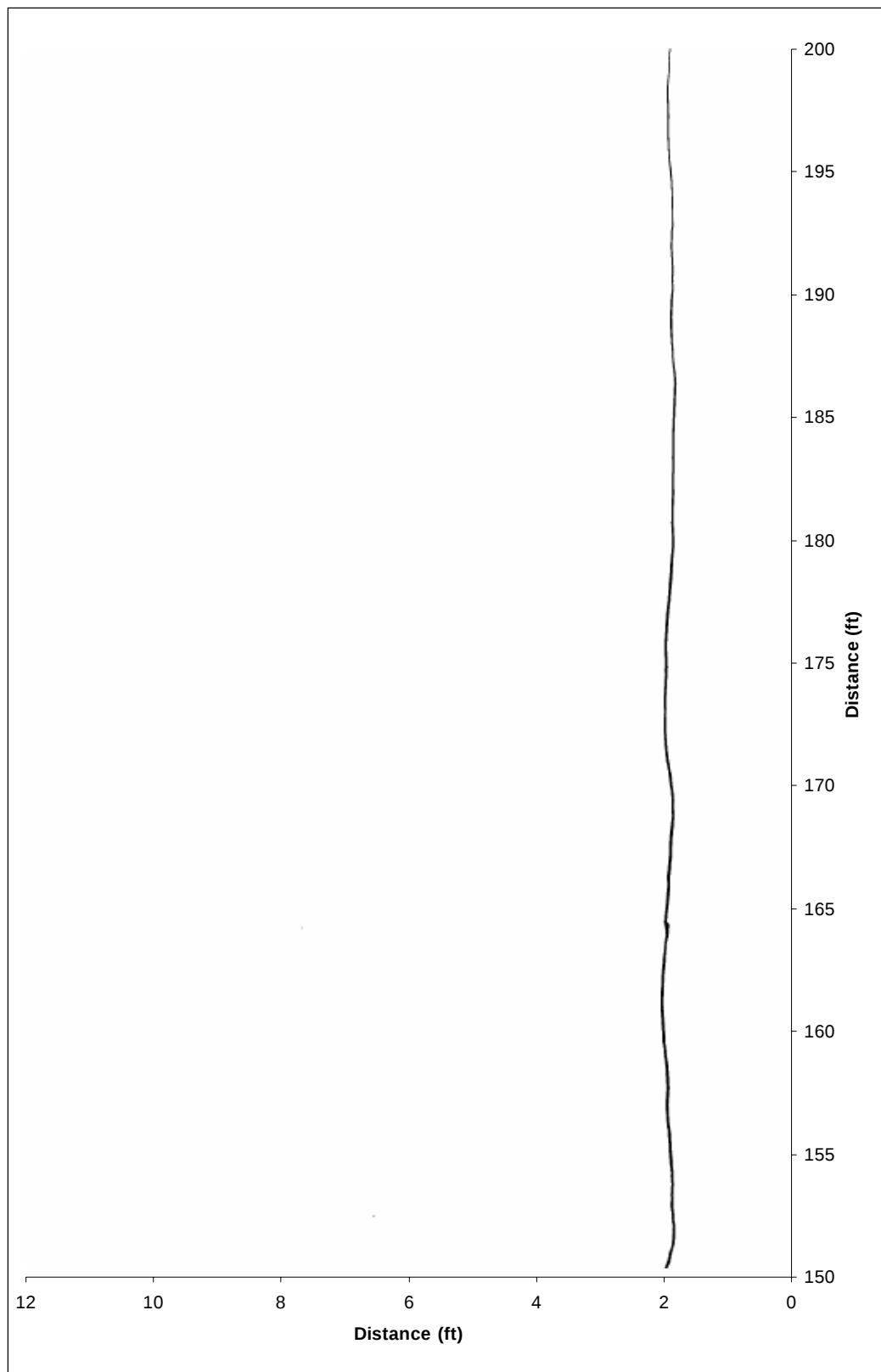


Figure 241. Wheeler-Sack AAF Section 5 (Station 150-200 ft).

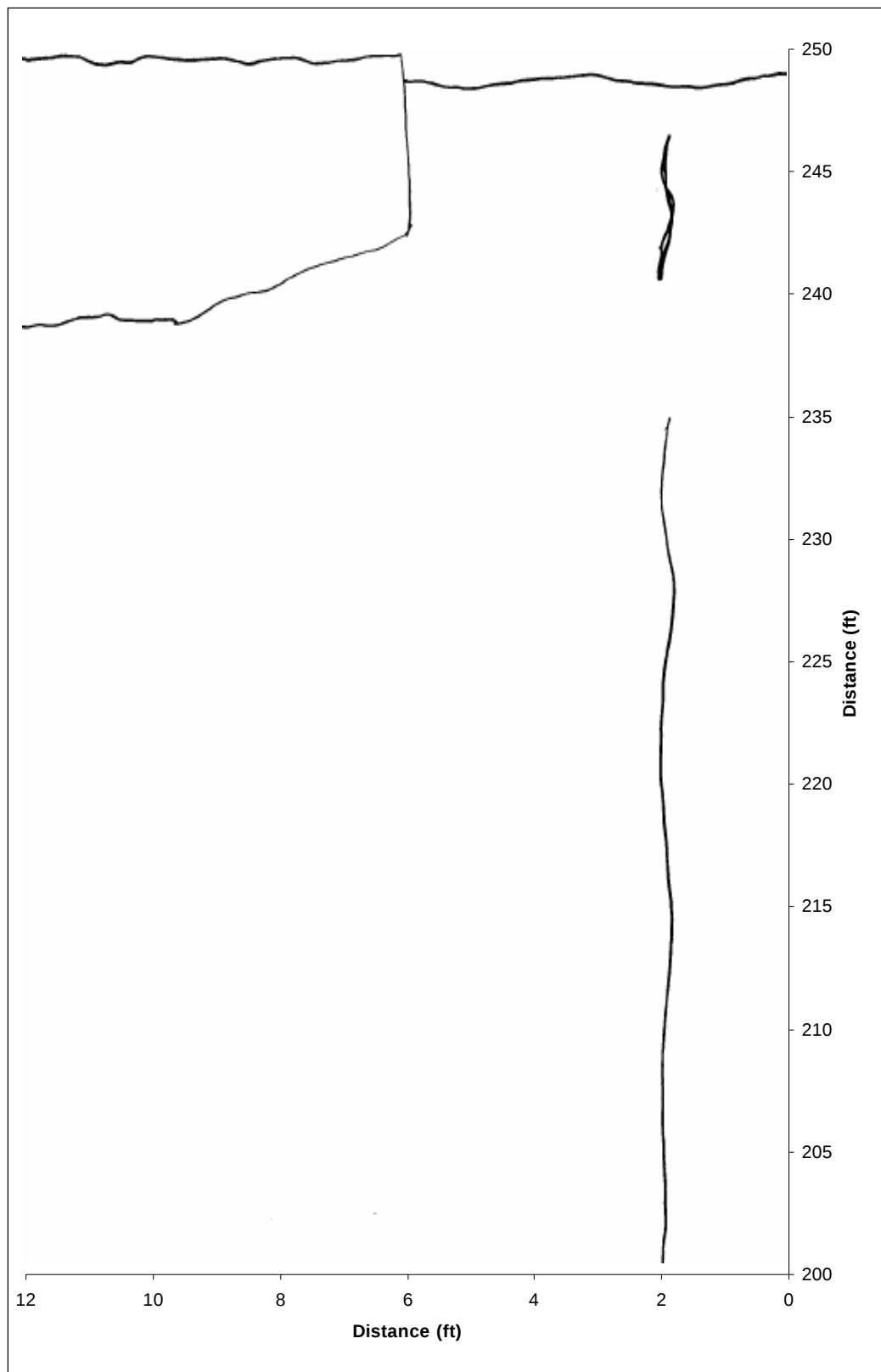


Figure 242. Wheeler-Sack AAF Section 5 (Station 200-250 ft).

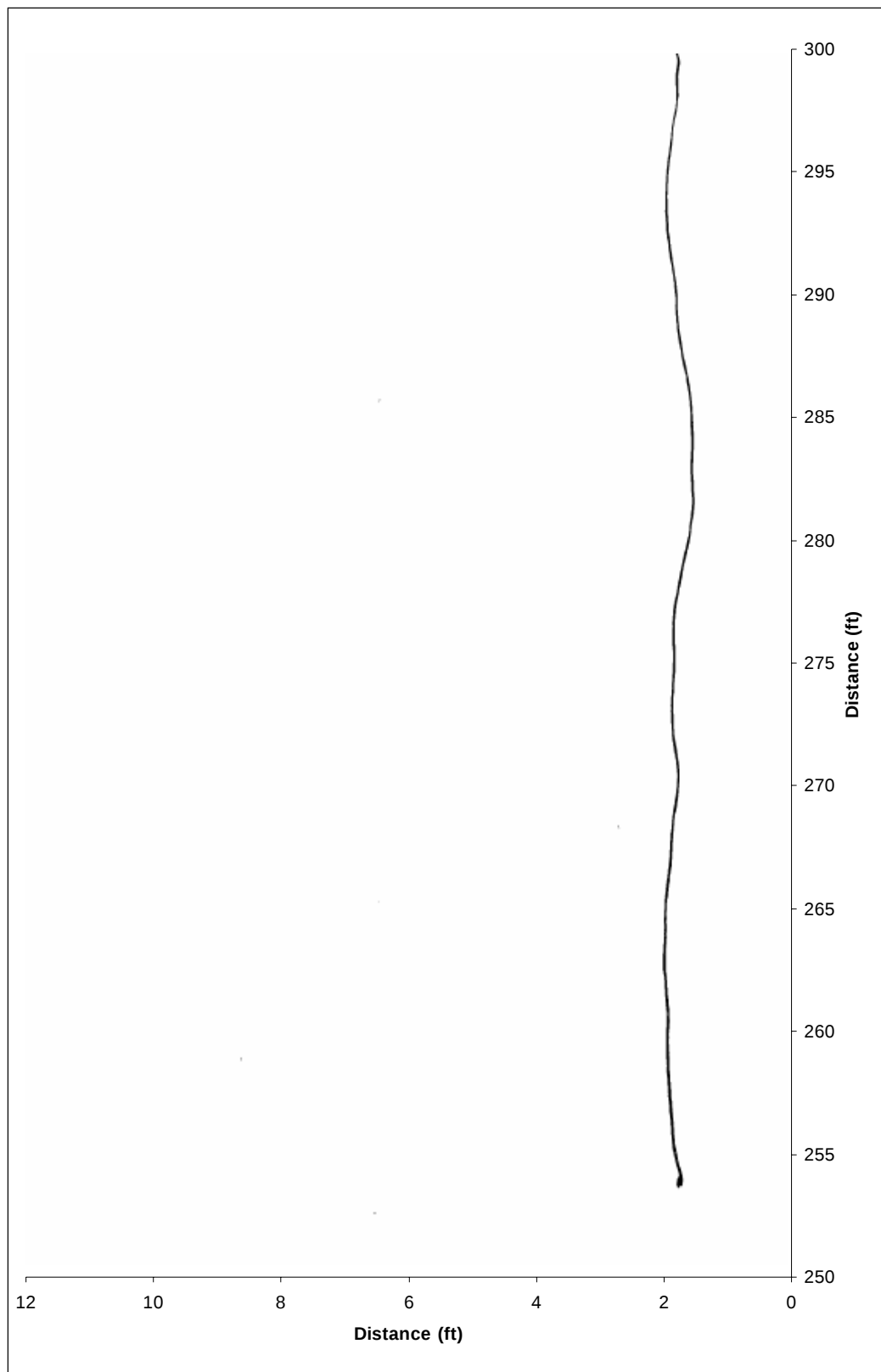


Figure 243. Wheeler-Sack AAF Section 5 (Station 250-300 ft).

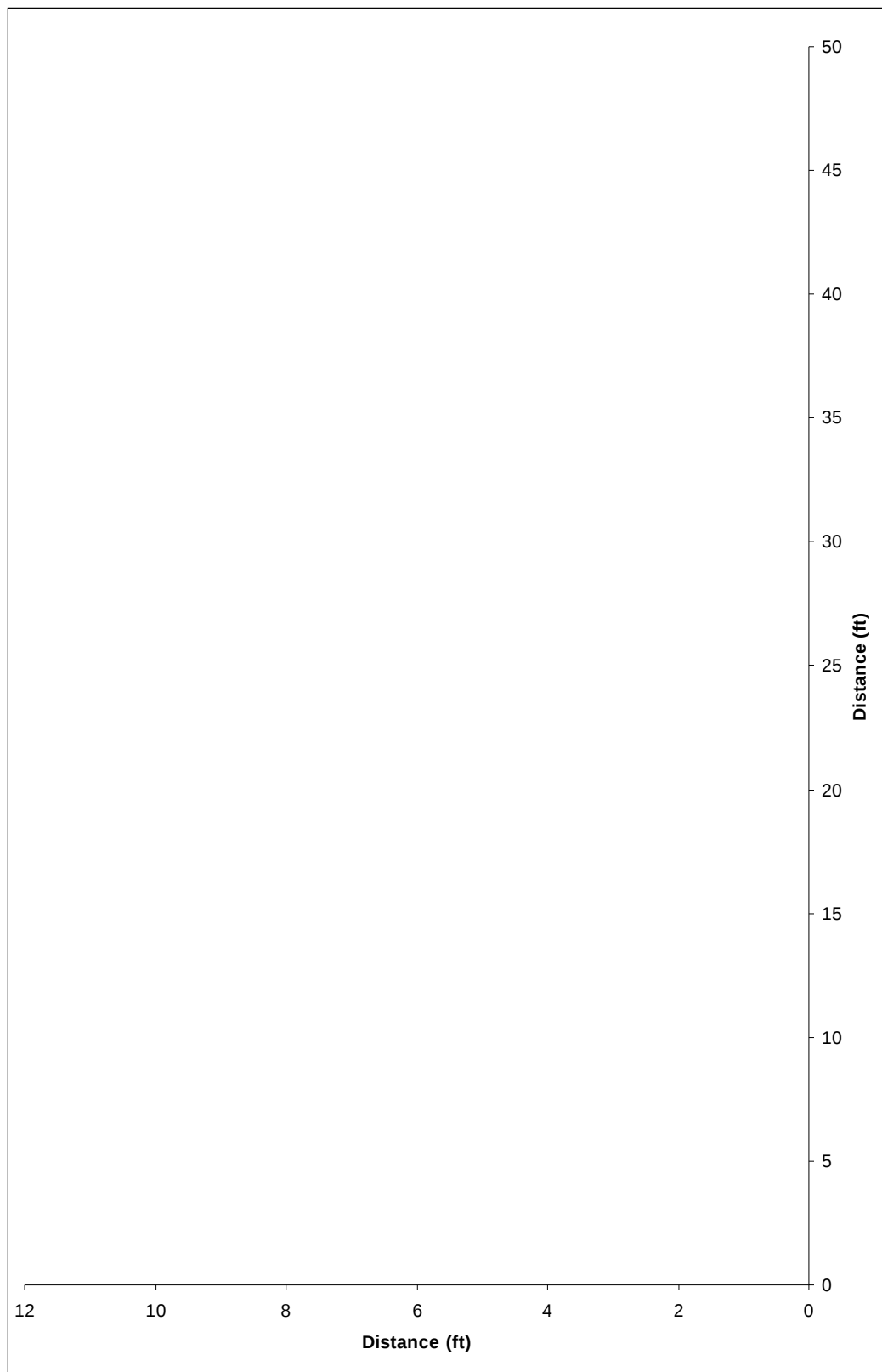


Figure 244. Wheeler-Sack AAF Section 6 (Station 0-50 ft).

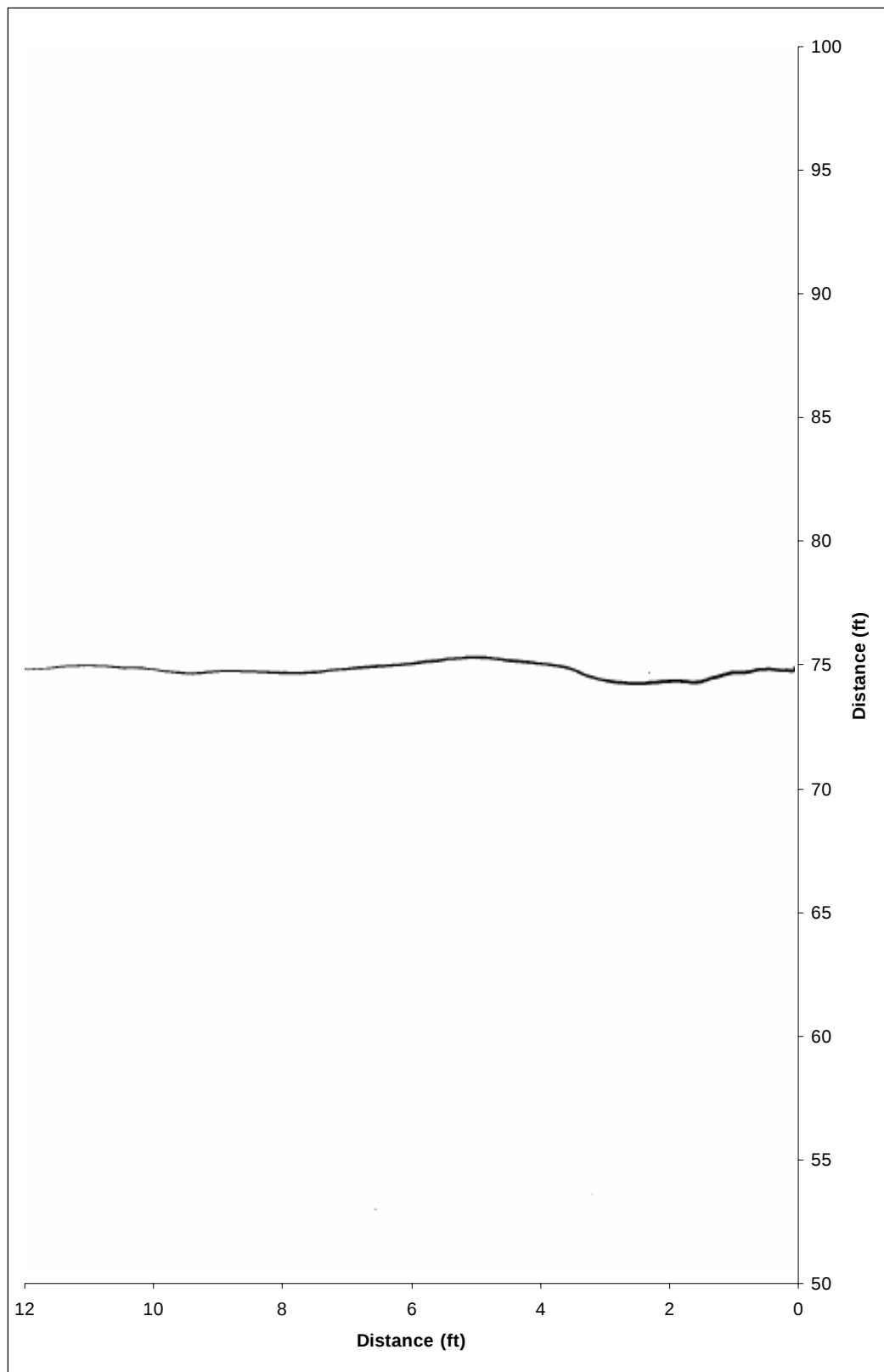


Figure 245. Wheeler-Sack AAF Section 6 (Station 50-100 ft).

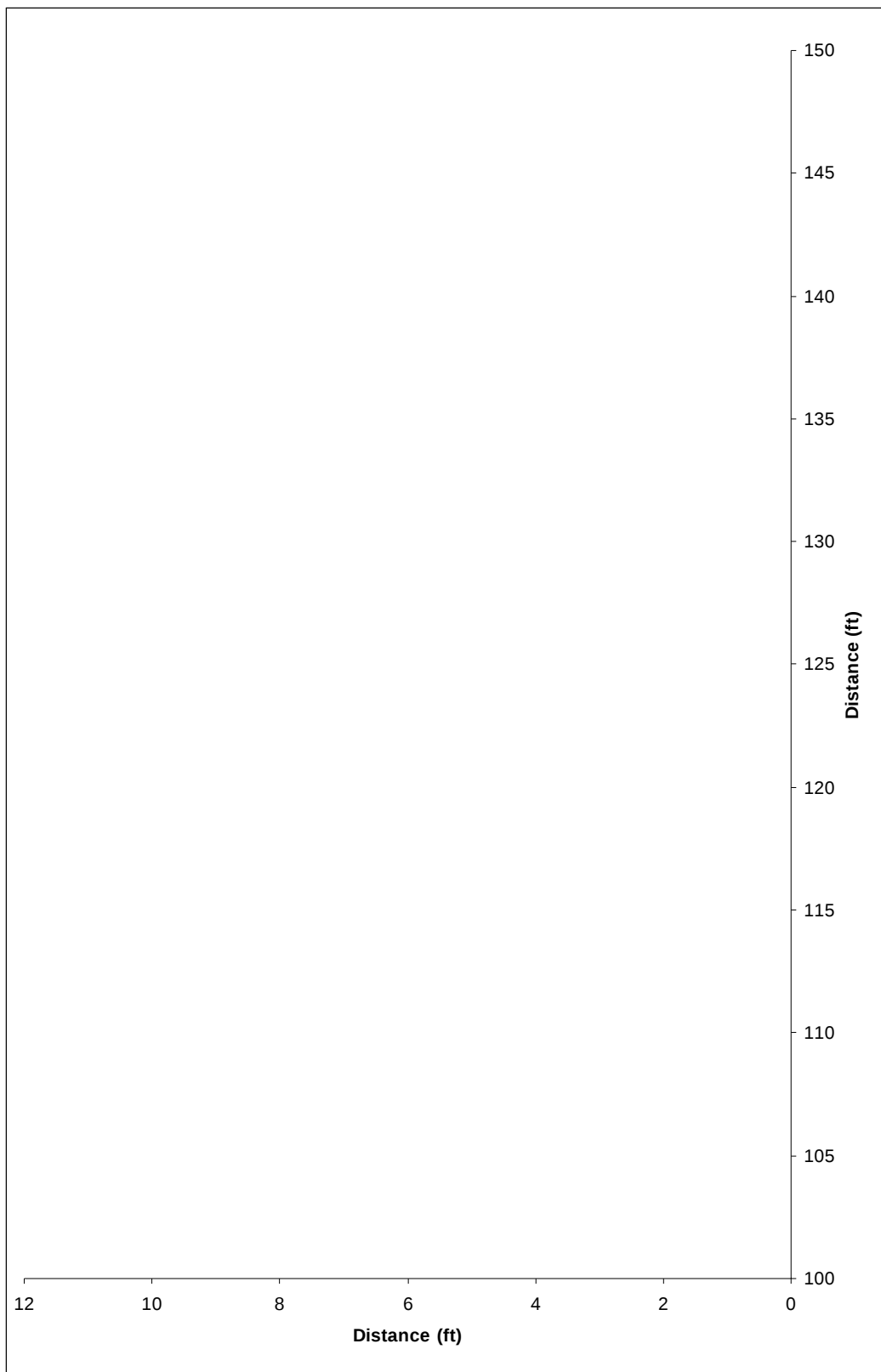


Figure 246. Wheeler-Sack AAF Section 6 (Station 100-150 ft).

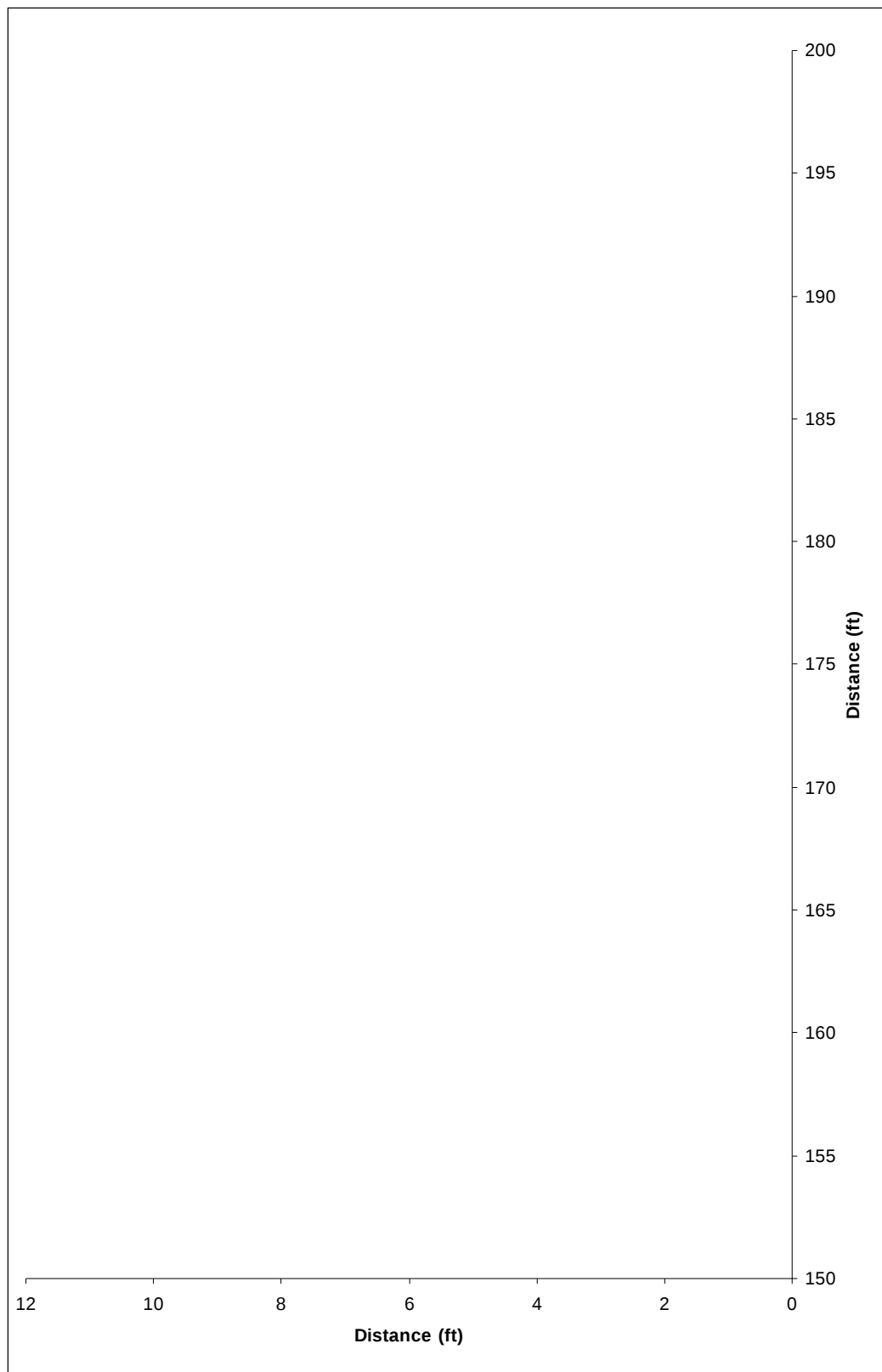


Figure 247. Wheeler-Sack AAF Section 6 (Station 150-200 ft).

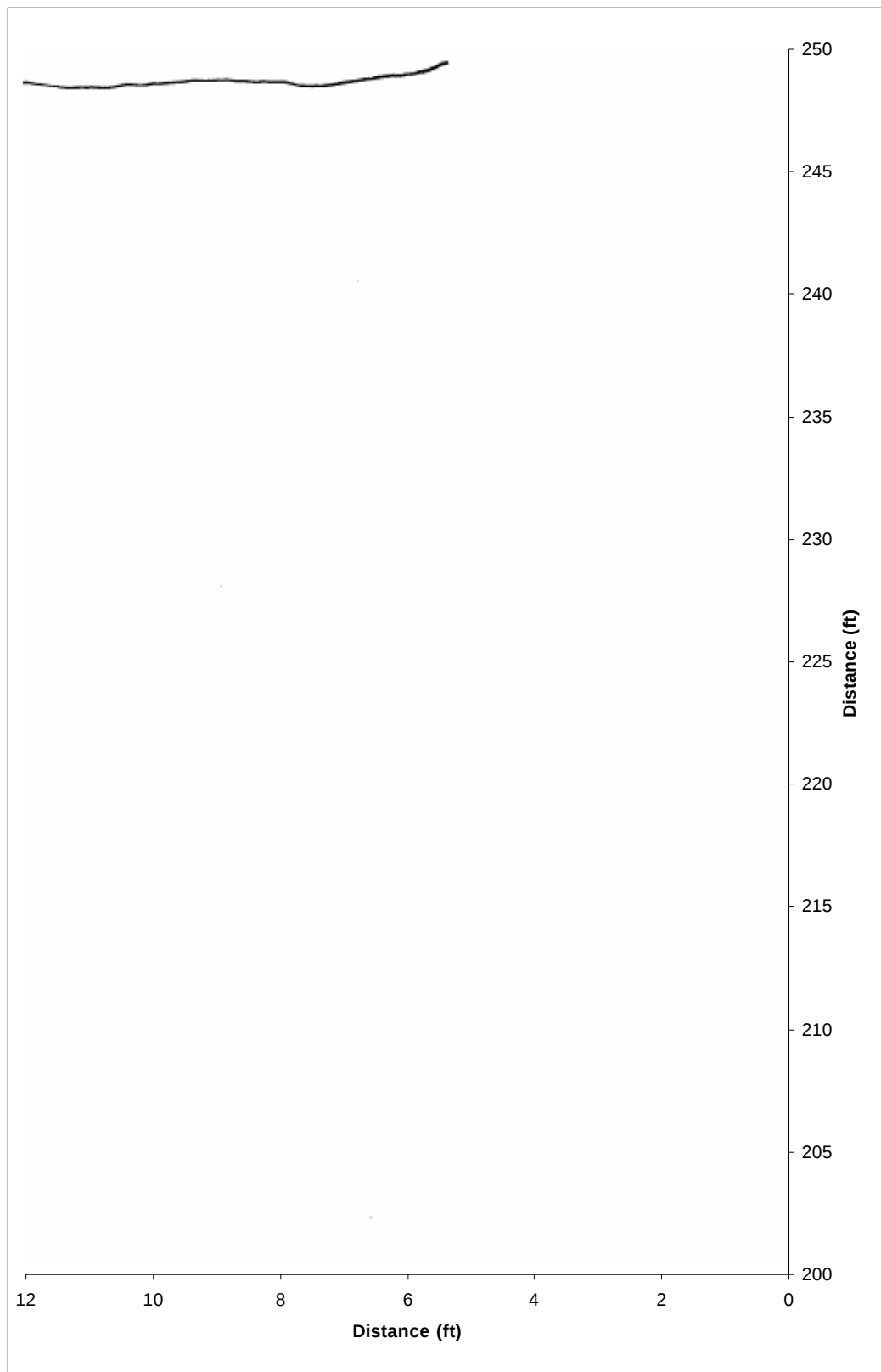


Figure 248. Wheeler-Sack AAF Section 6 (Station 200-250 ft).

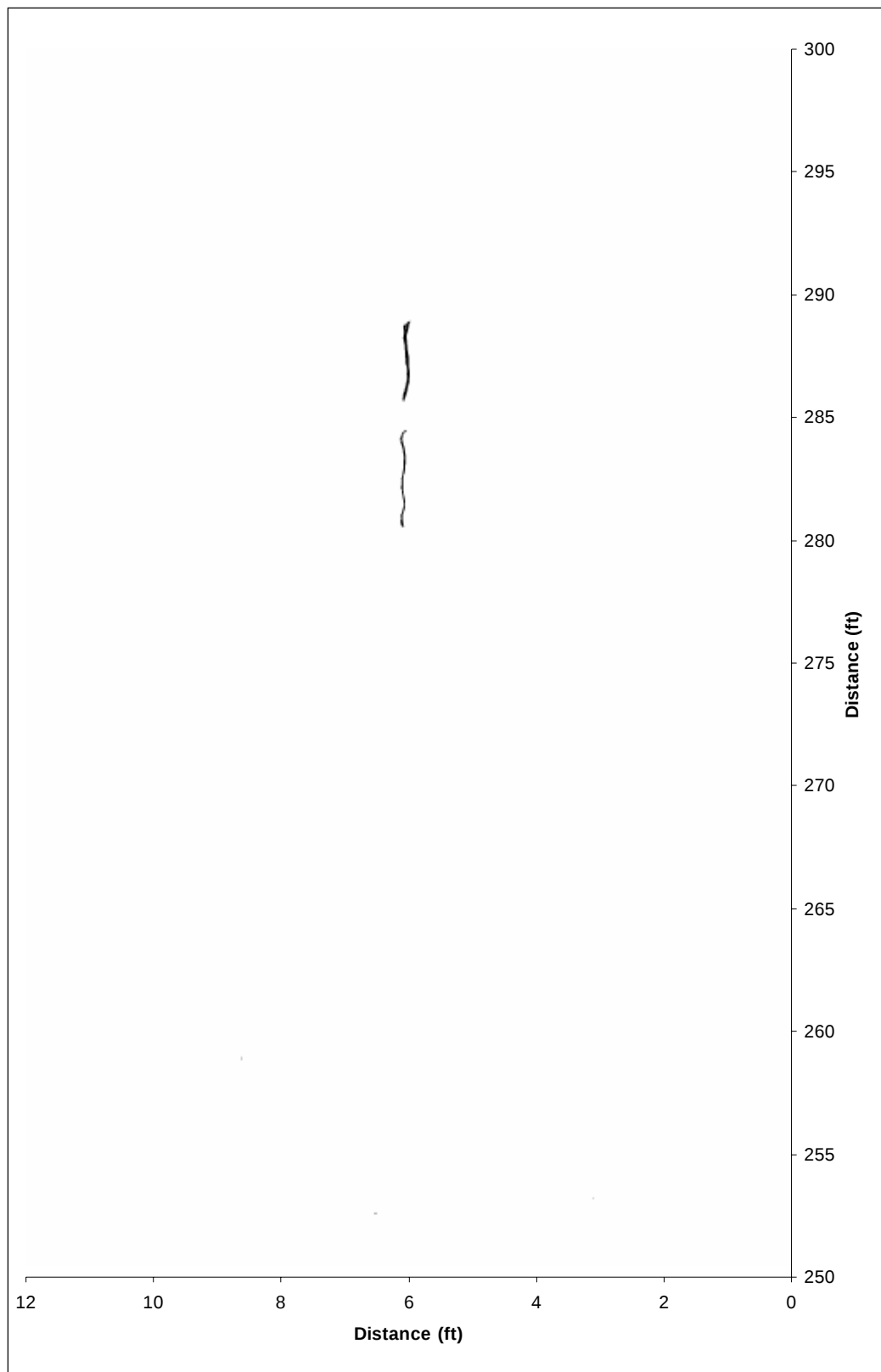


Figure 249. Wheeler-Sack AAF Section 6 (Station 250-300 ft).

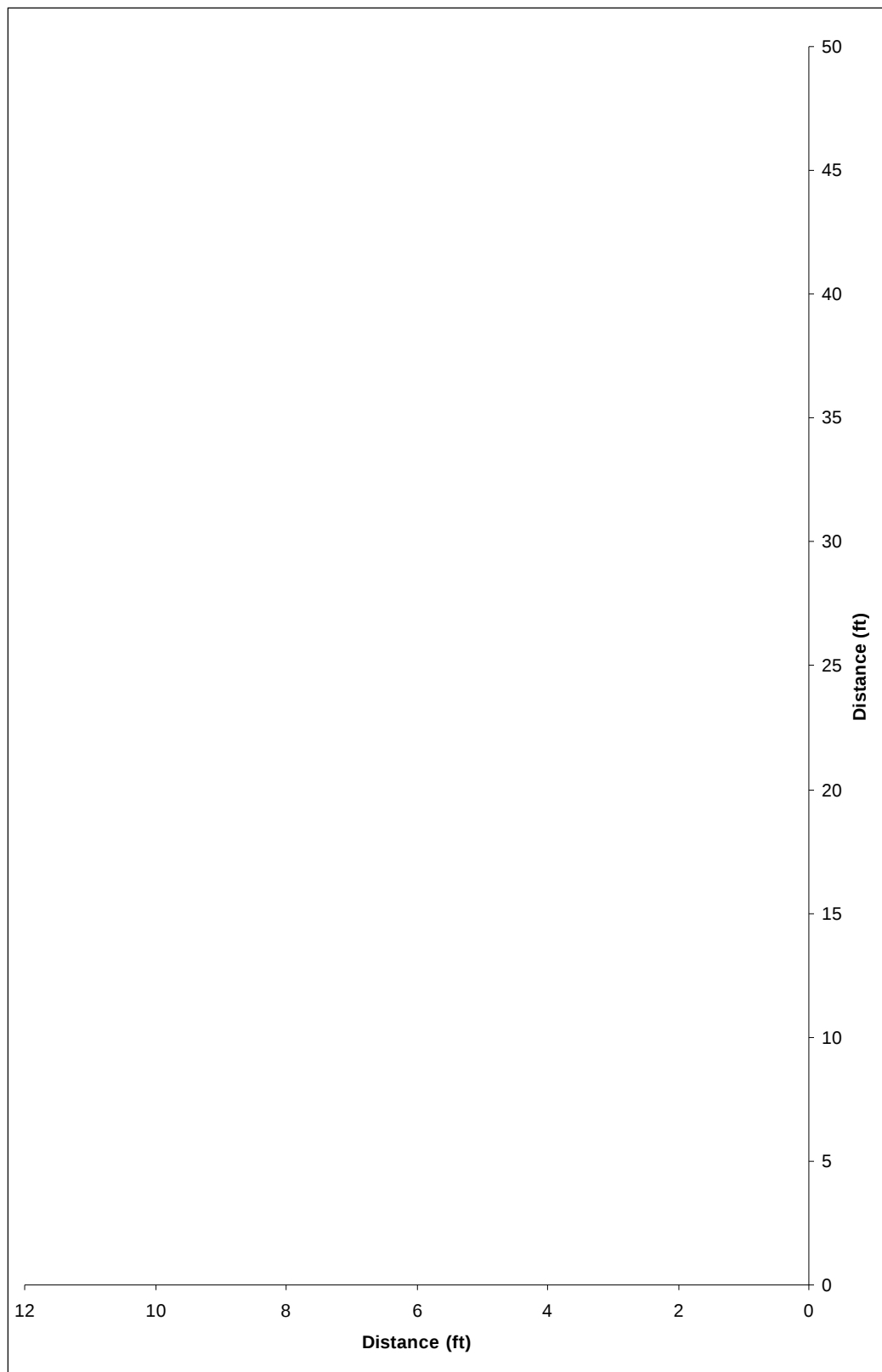


Figure 250. Wheeler-Sack AAF Section 7 (Station 0-50 ft).

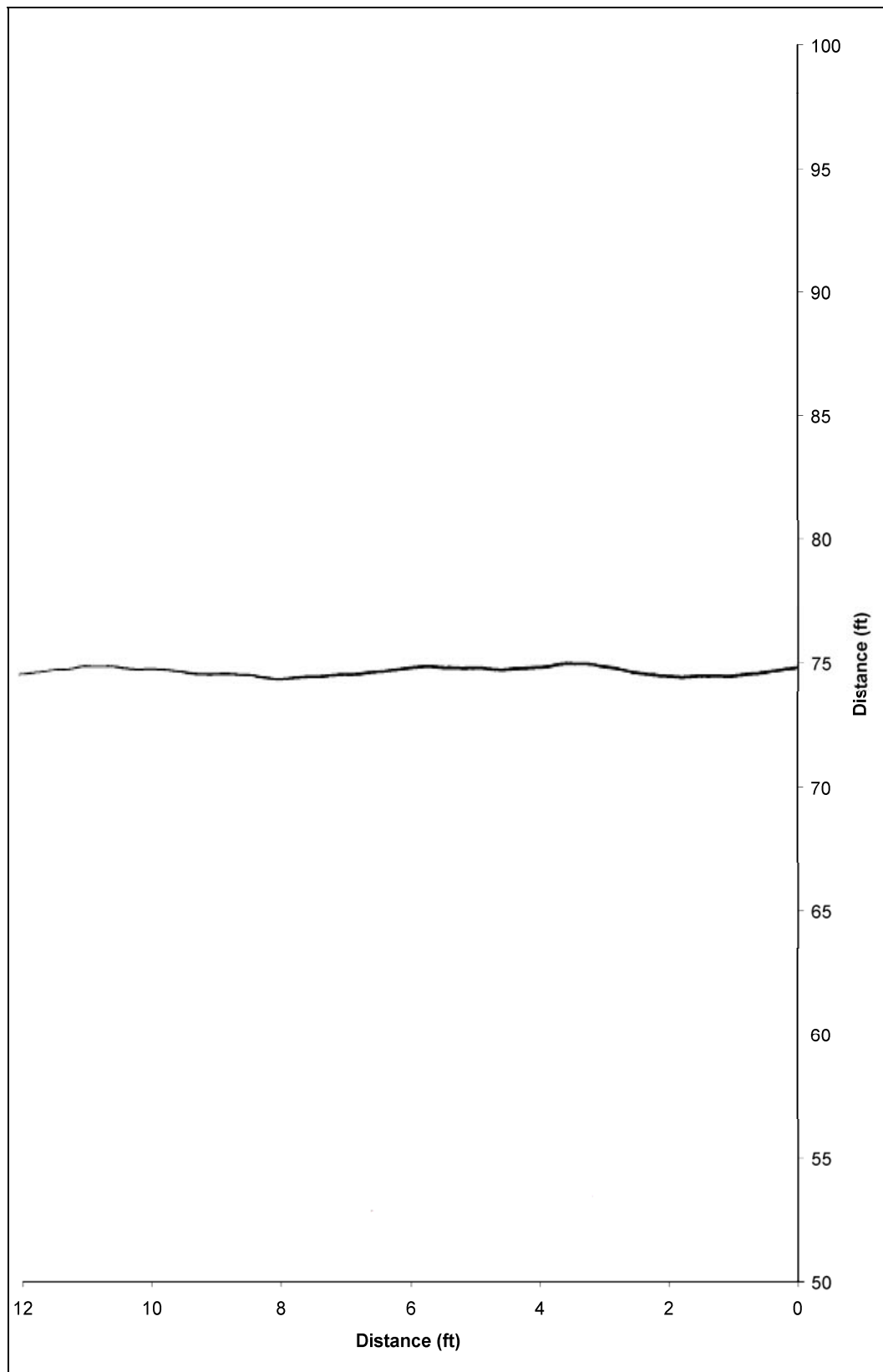


Figure 251. Wheeler-Sack AAF Section 7 (Station 50-100 ft).

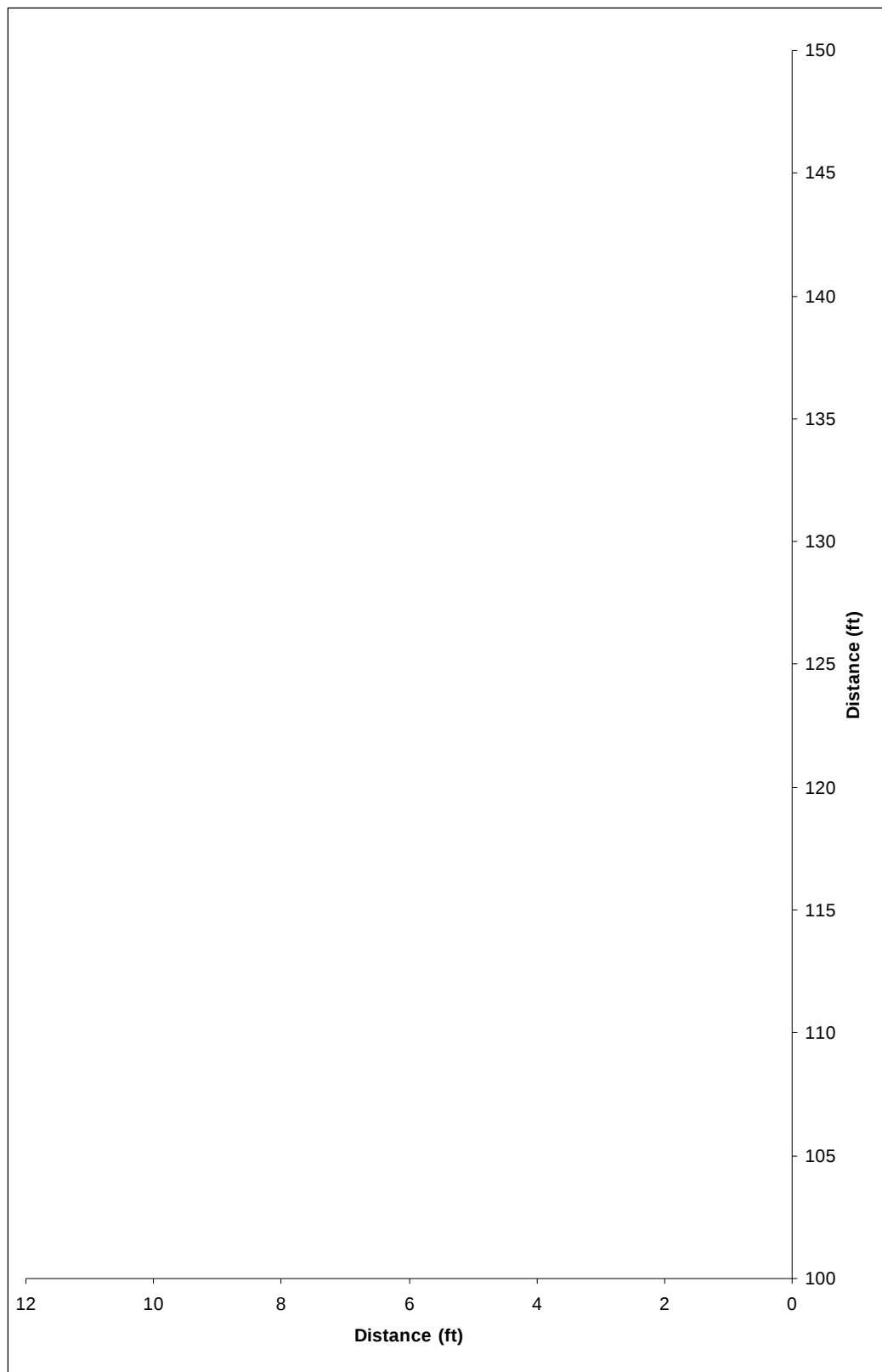


Figure 252. Wheeler-Sack AAF Section 7 (Station 100-150 ft).

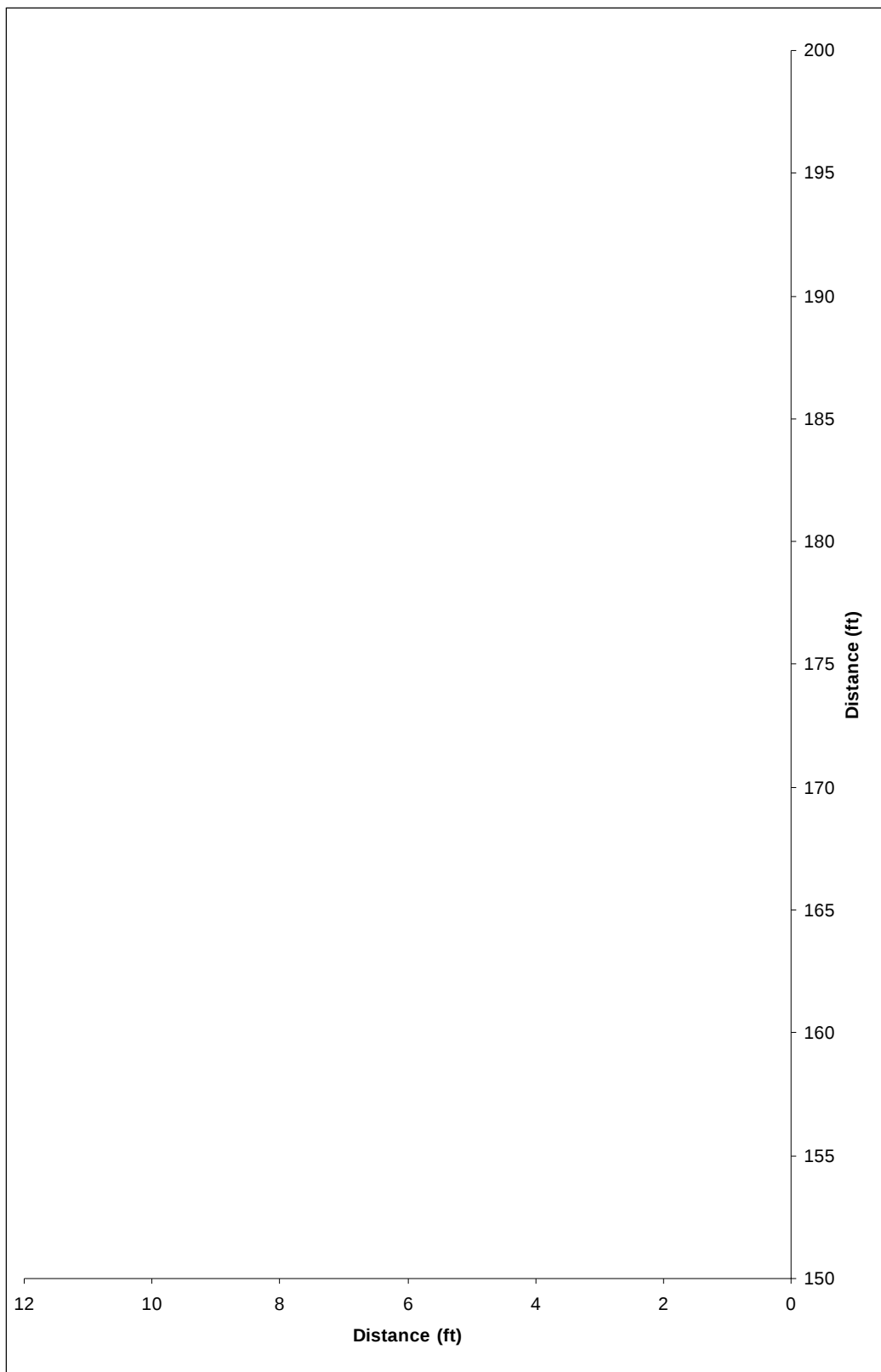


Figure 253. Wheeler-Sack AAF Section 7 (Station 150-200 ft).

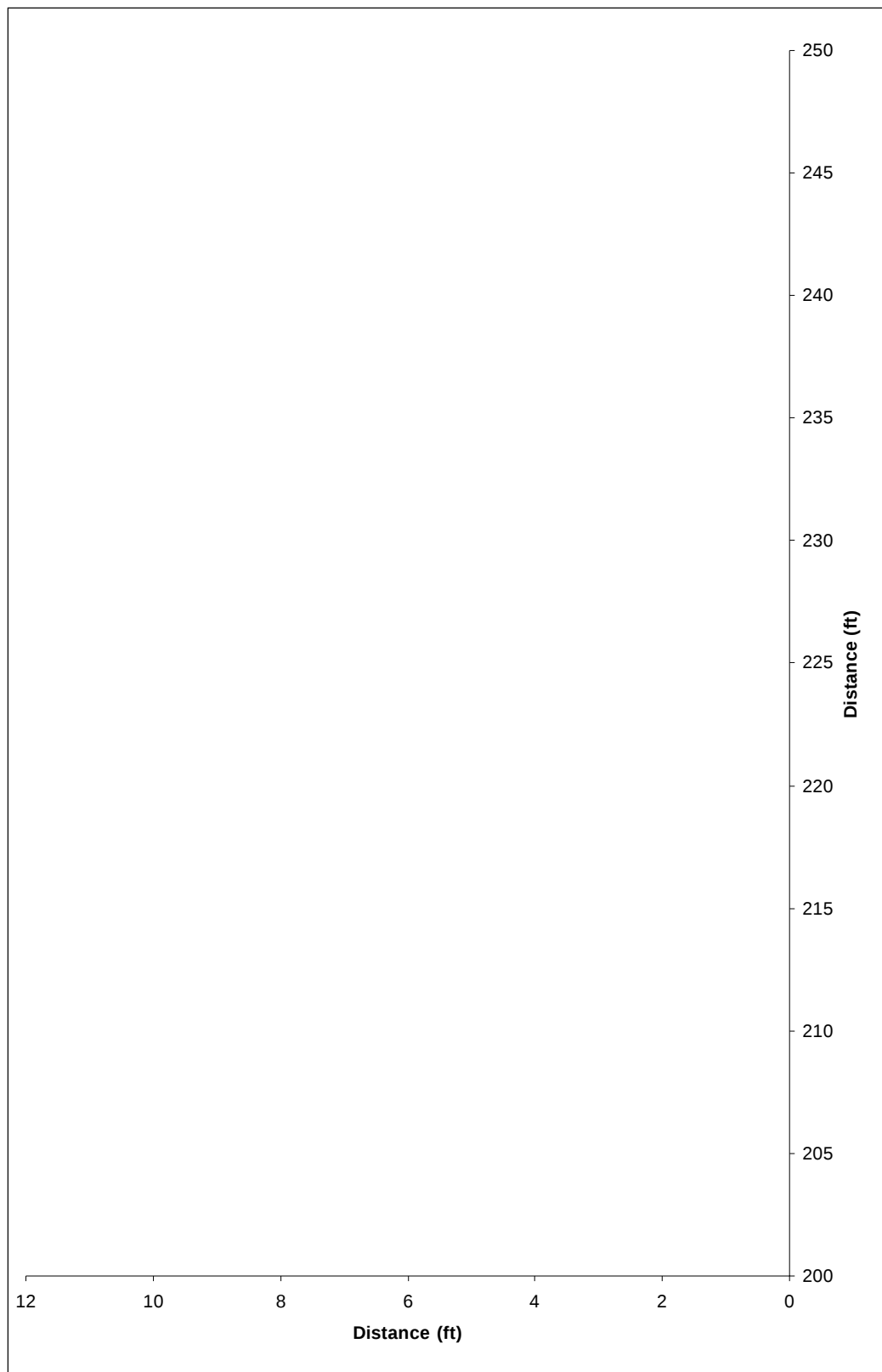


Figure 254. Wheeler-Sack AAF Section 7 (Station 200-250 ft).

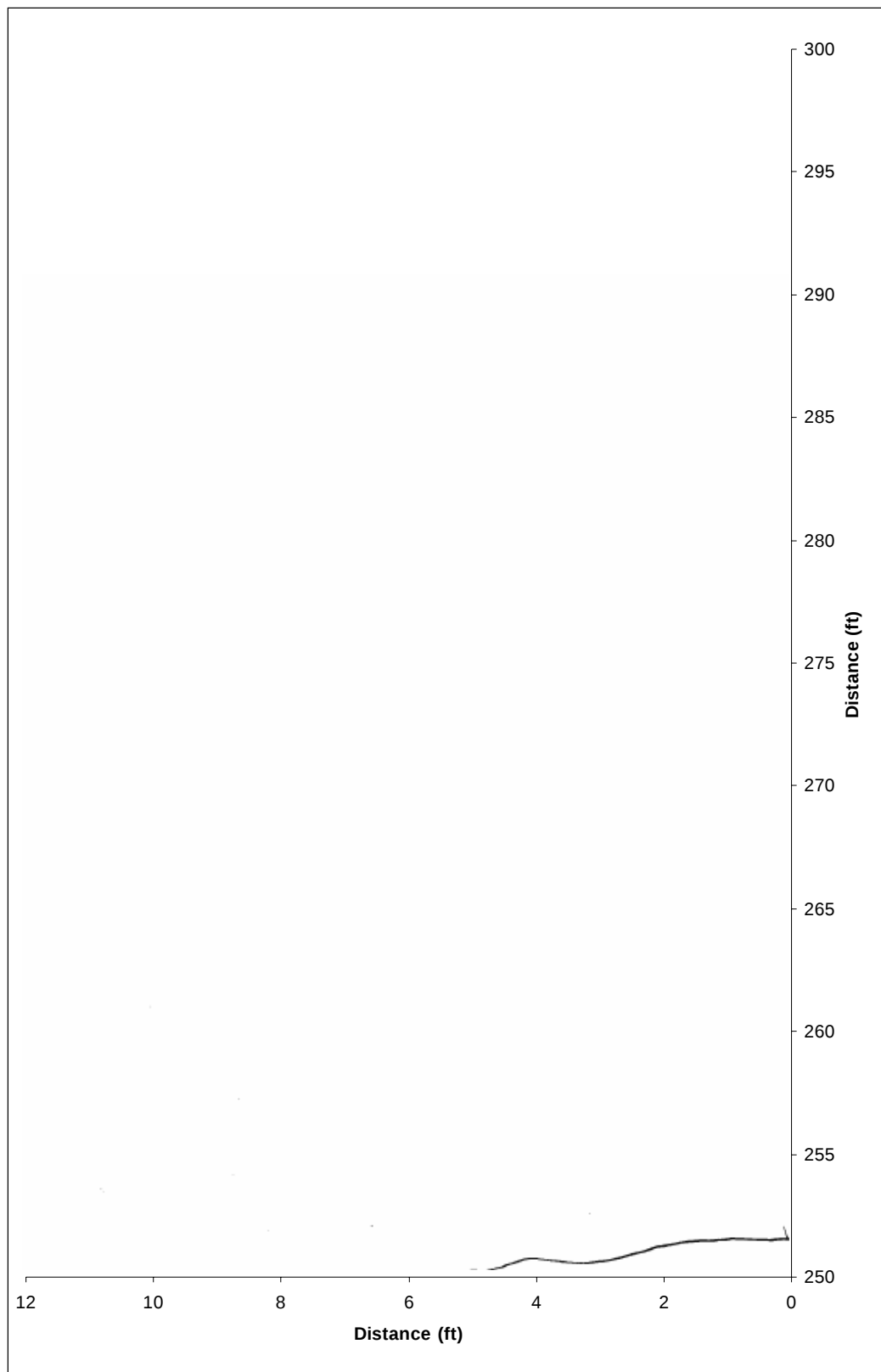


Figure 255. Wheeler-Sack AAF Section 7 (Station 250-300 ft).

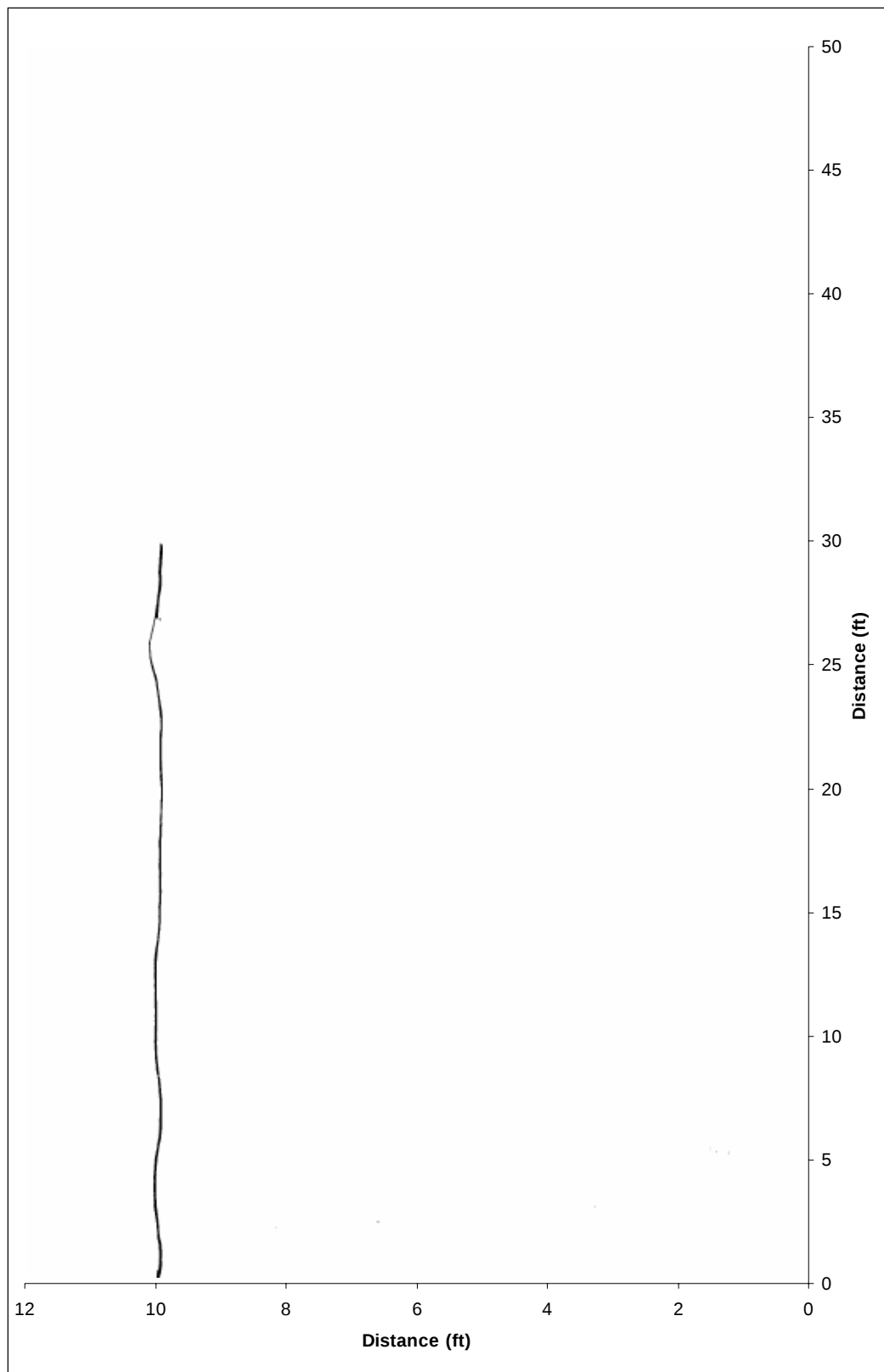


Figure 256. Wheeler-Sack AAF Section 8 (Station 0-50 ft).

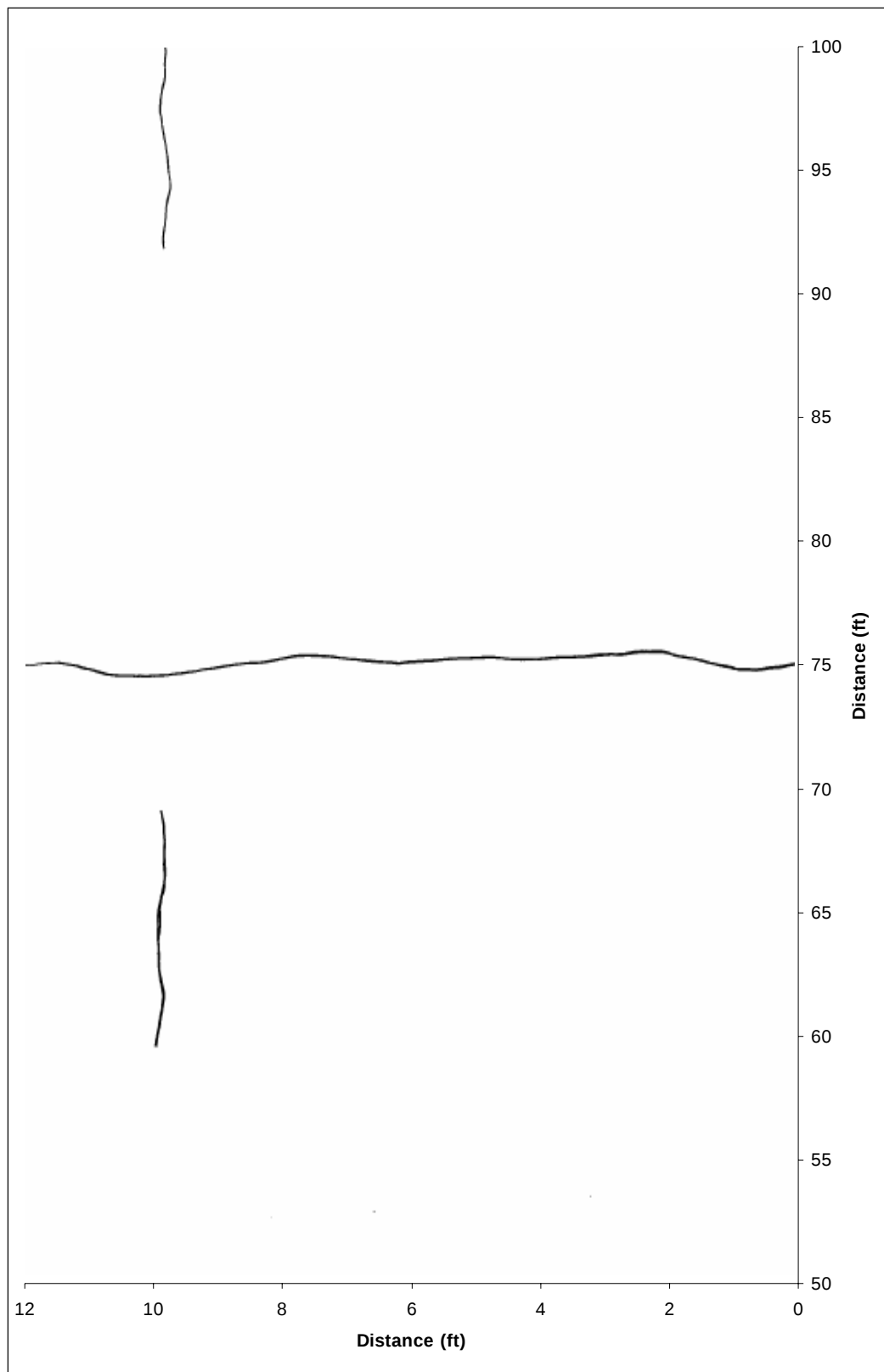


Figure 257. Wheeler-Sack AAF Section 8 (Station 50-100 ft).

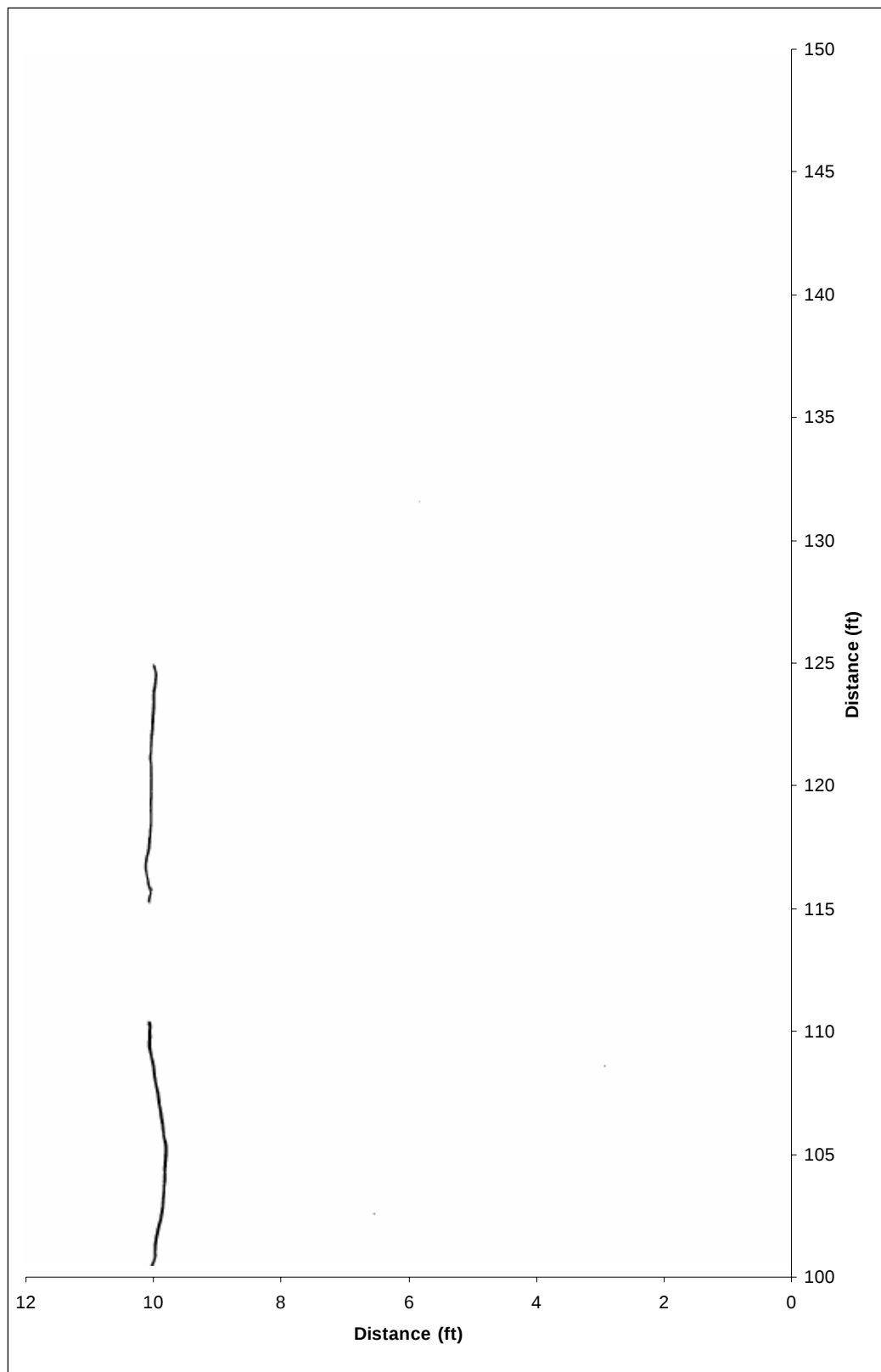


Figure 258. Wheeler-Sack AAF Section 8 (Station 100-150 ft).

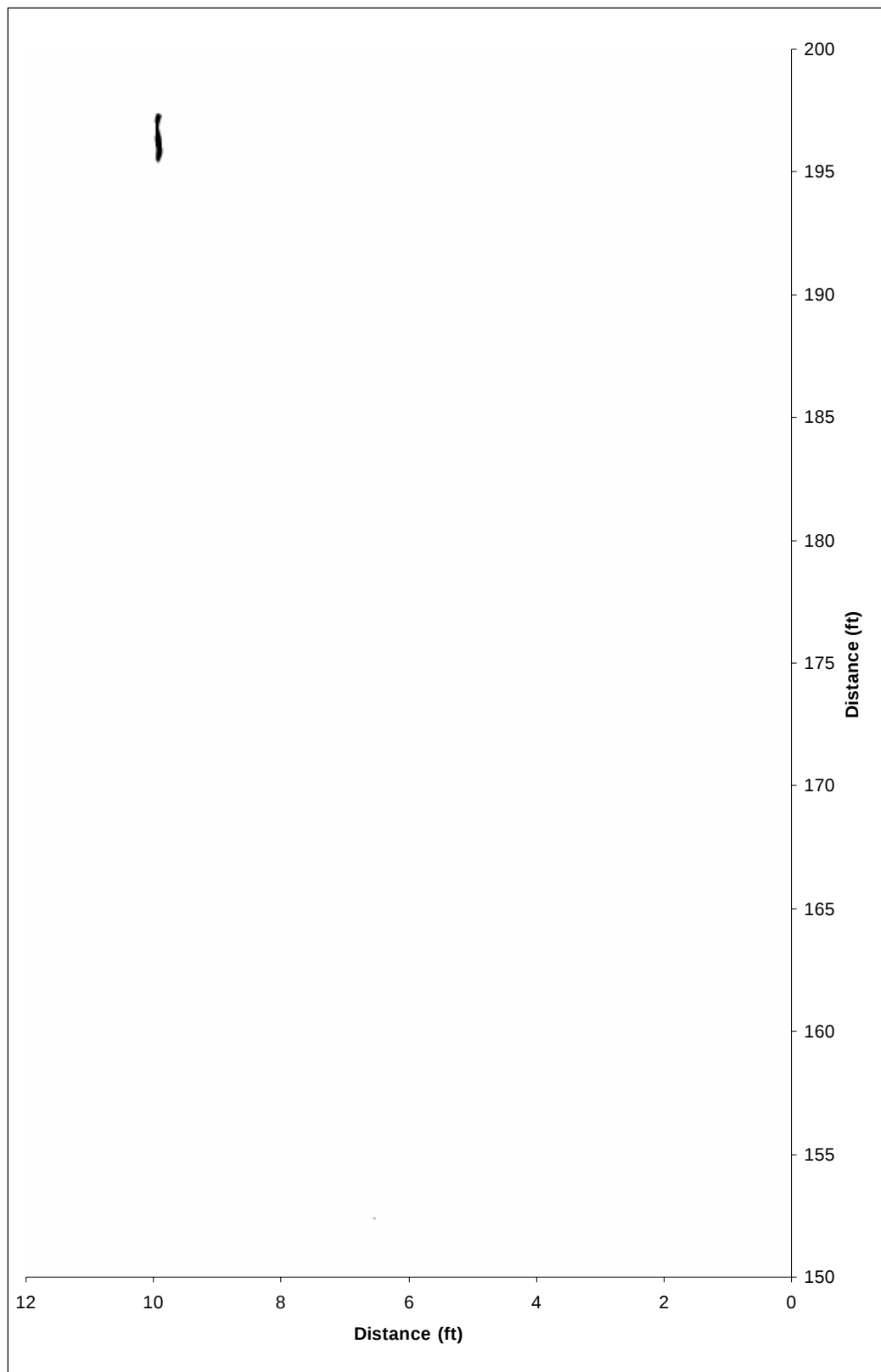


Figure 259. Wheeler-Sack AAF Section 8 (Station 150-200 ft).

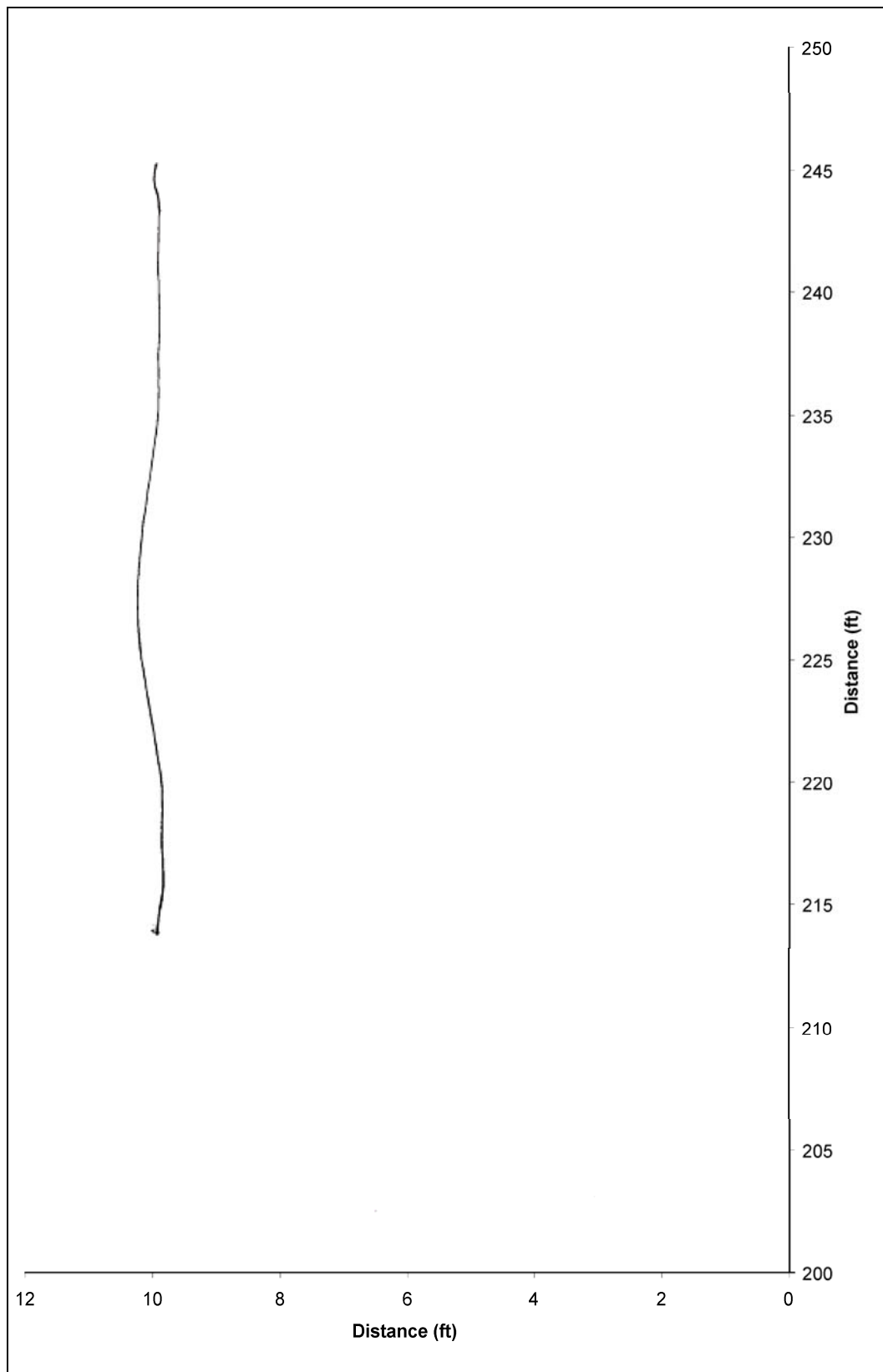


Figure 260. Wheeler-Sack AAF Section 8 (Station 200-250 ft).

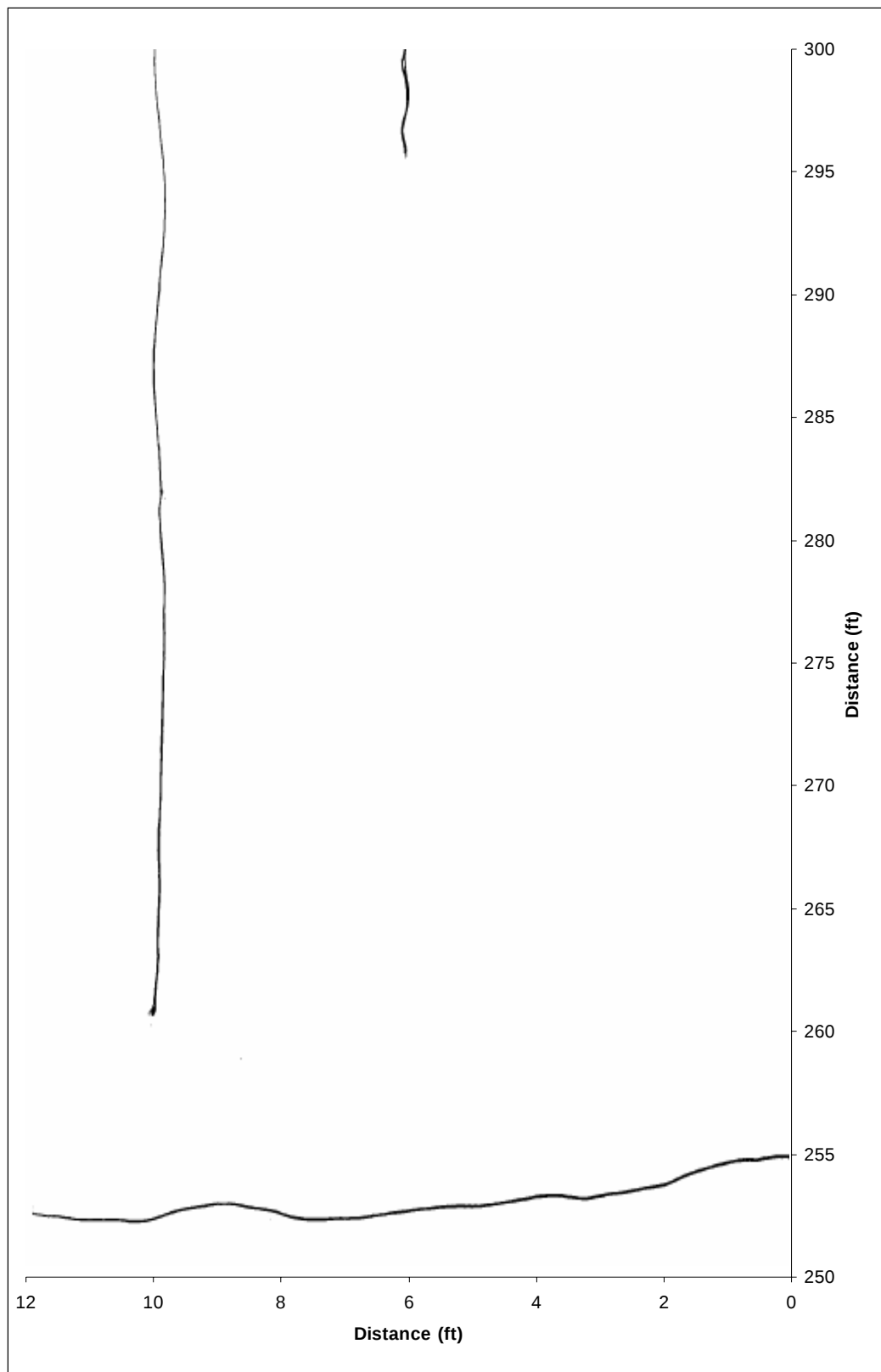


Figure 261. Wheeler-Sack AAF Section 8 (Station 250-300 ft).

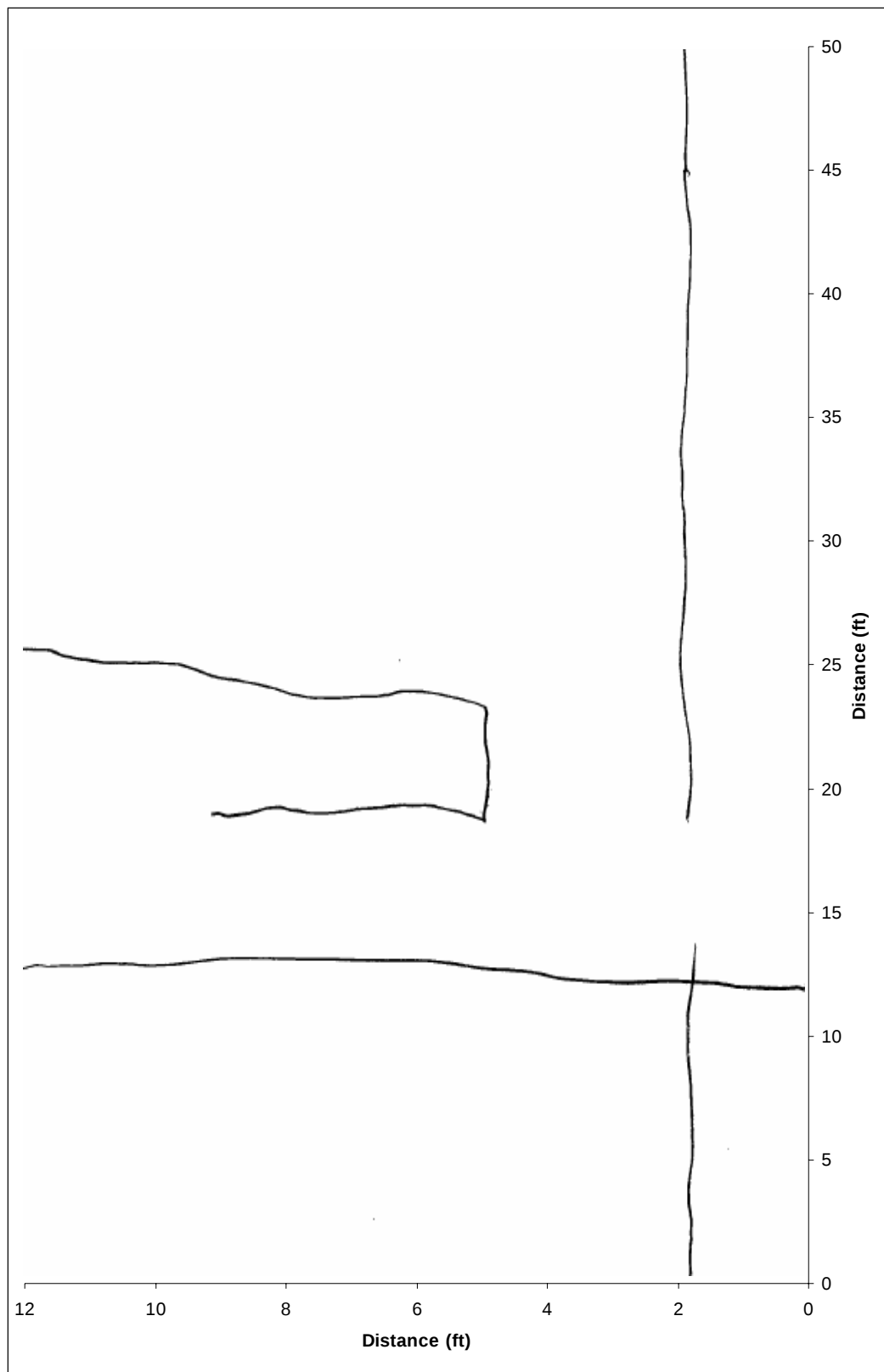


Figure 262. Wheeler-Sack AAF Section 9 (Station 0-50 ft).

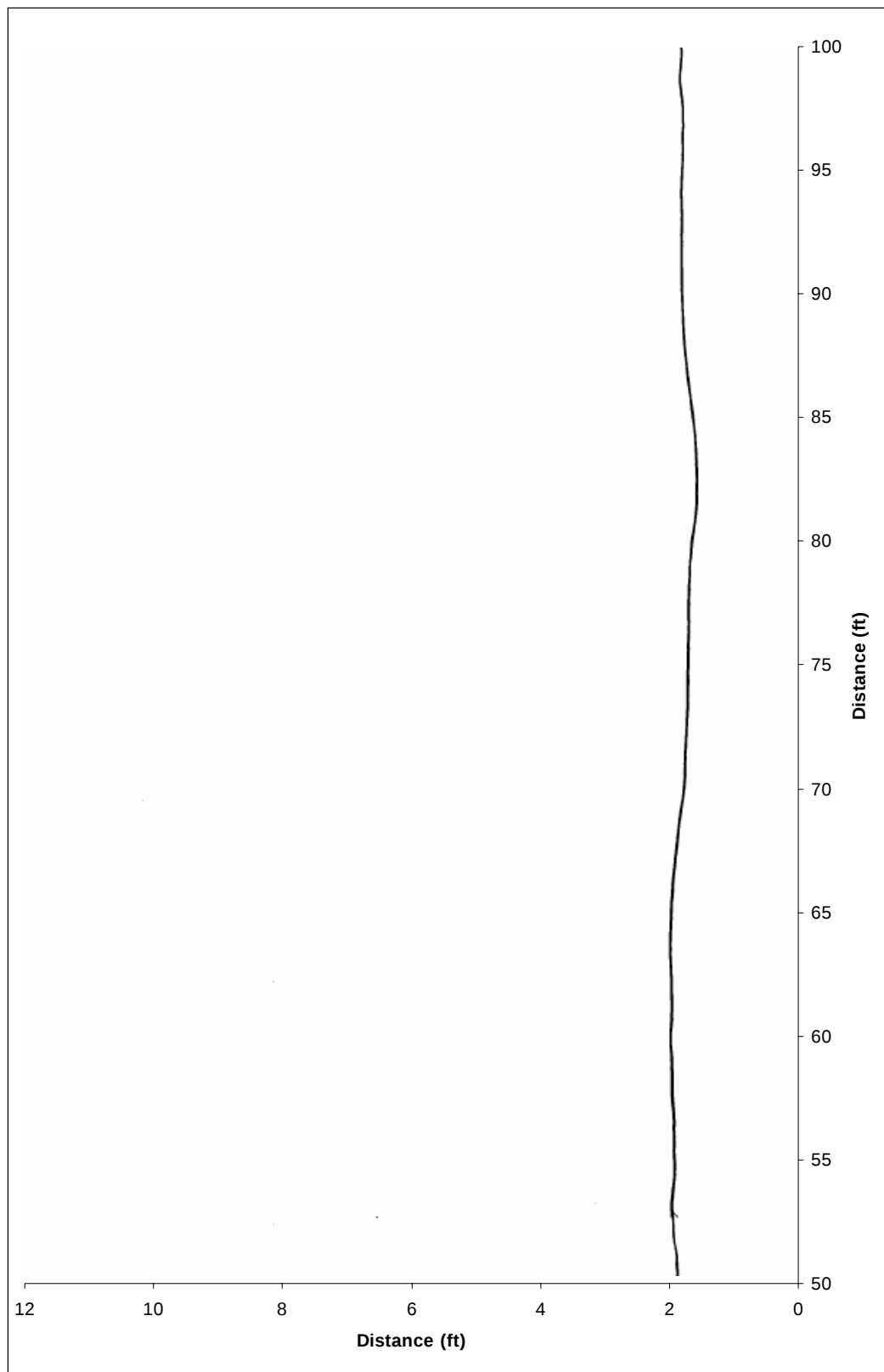


Figure 263. Wheeler-Sack AAF Section 9 (Station 50-100 ft).

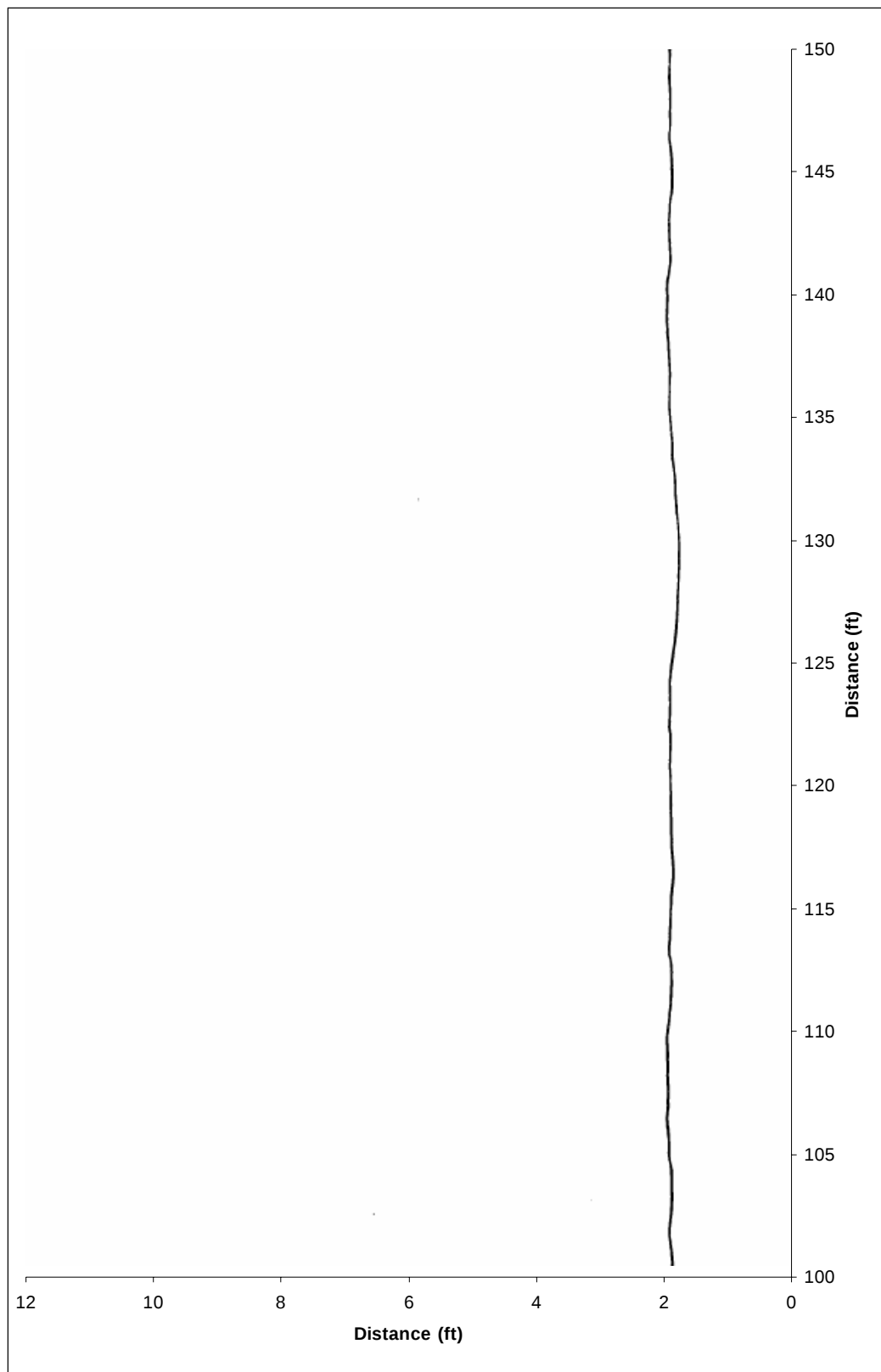


Figure 264. Wheeler-Sack AAF Section 9 (Station 100-150 ft).

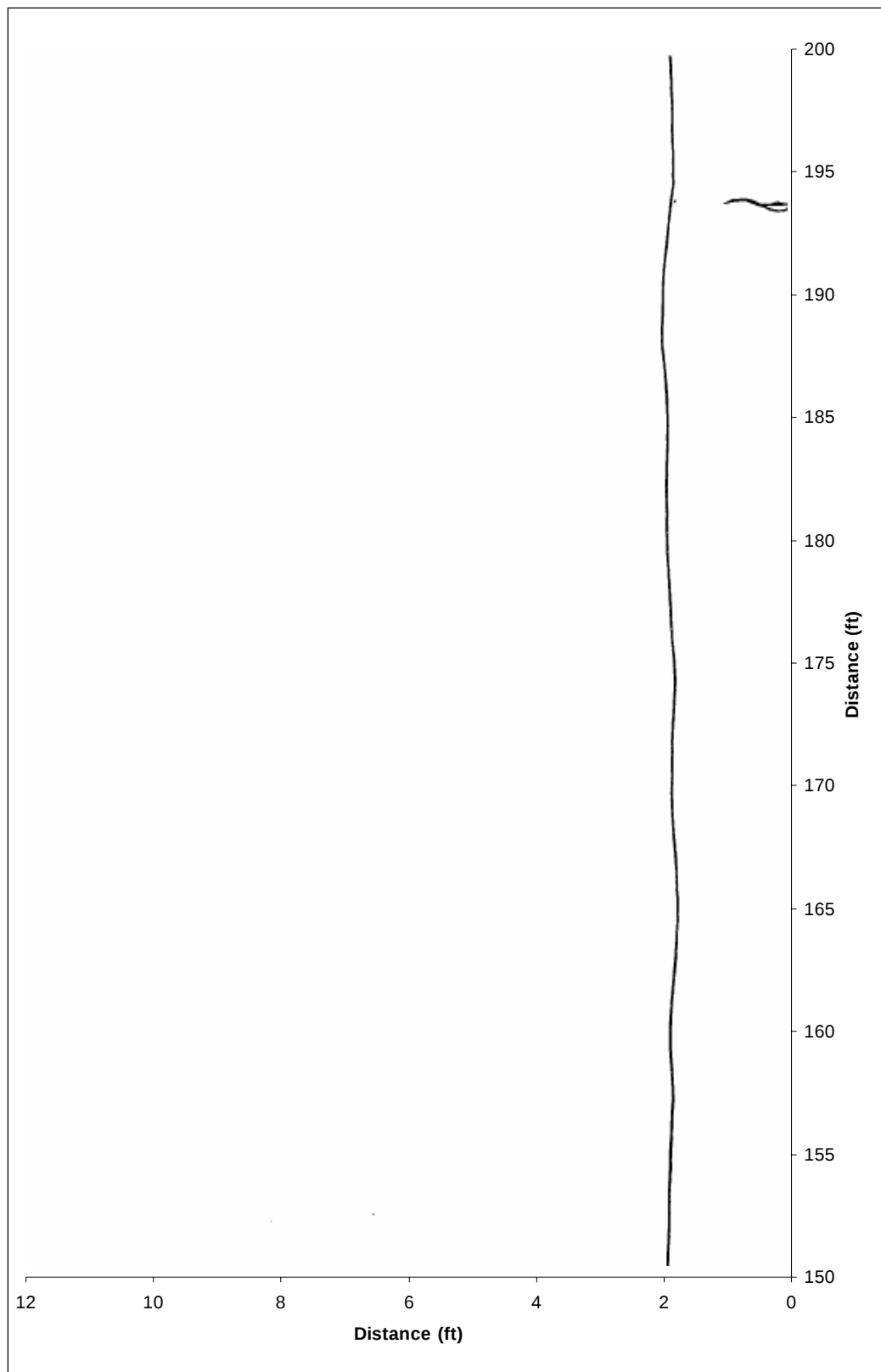


Figure 265. Wheeler-Sack AAF Section 9 (Station 150-200 ft).

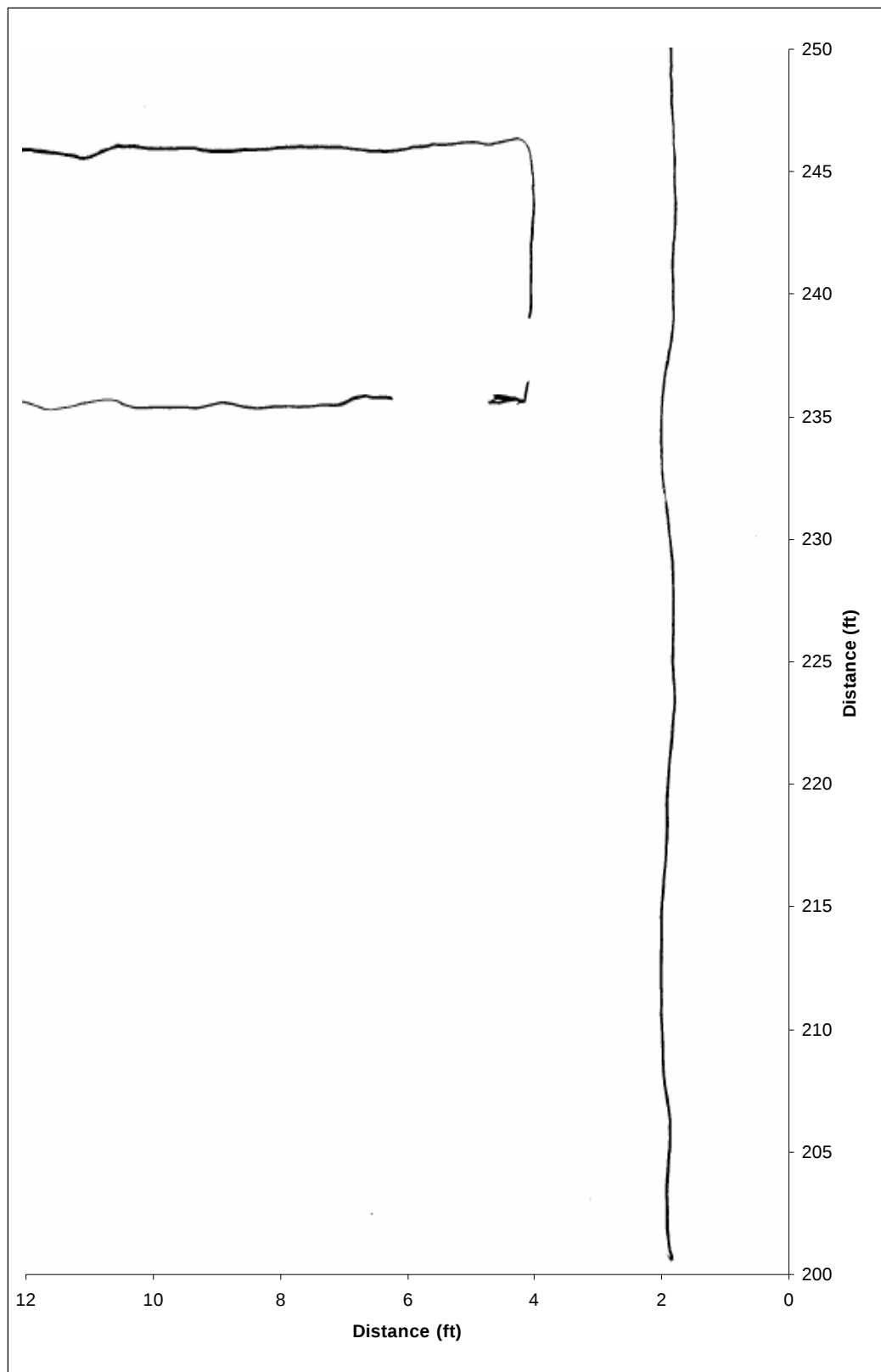


Figure 266. Wheeler-Sack AAF Section 9 (Station 200-250 ft).

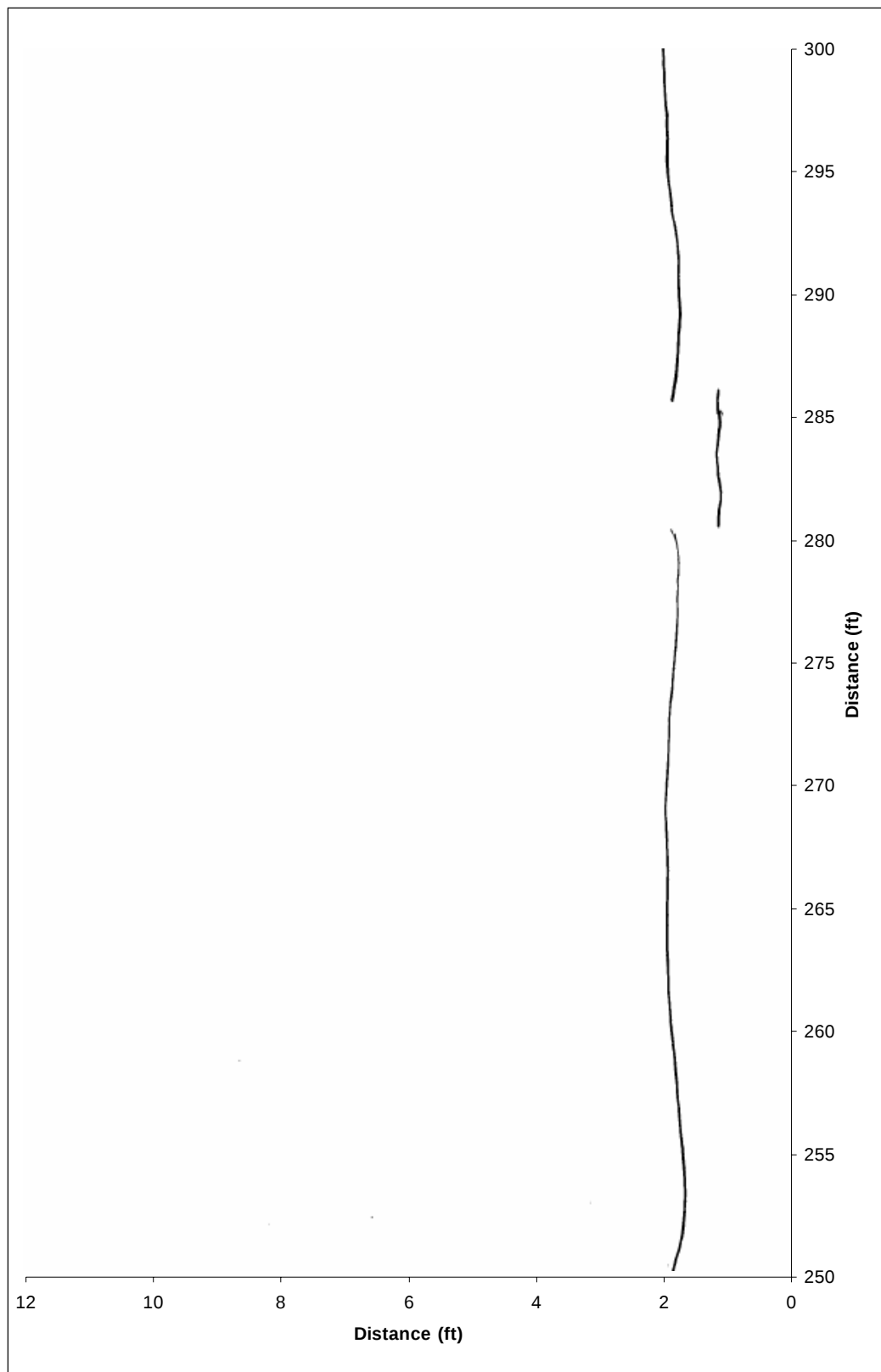


Figure 267. Wheeler-Sack AAF Section 9 (Station 250-300 ft).

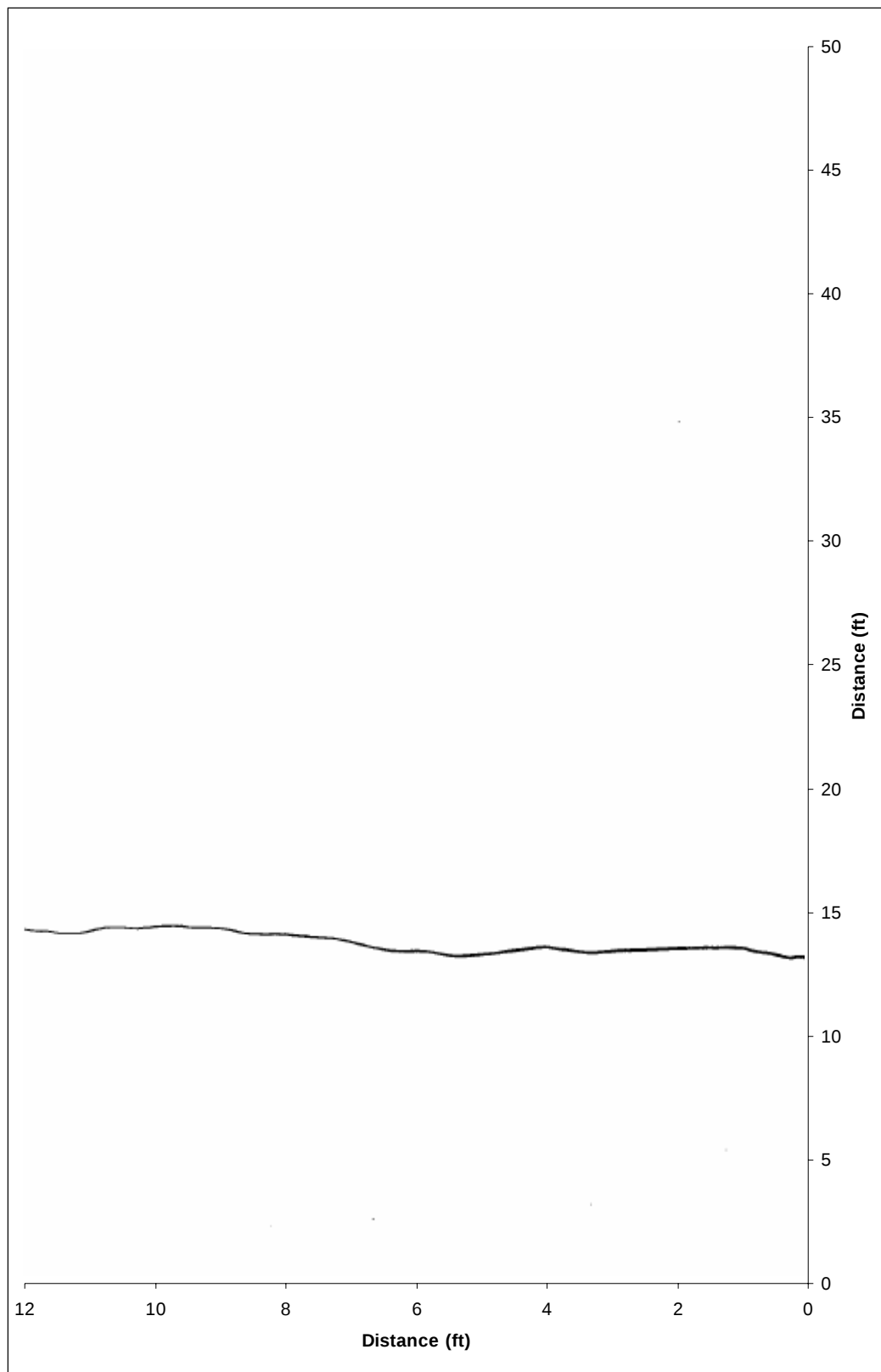


Figure 268. Wheeler-Sack AAF Section 10 (Station 0-50 ft).

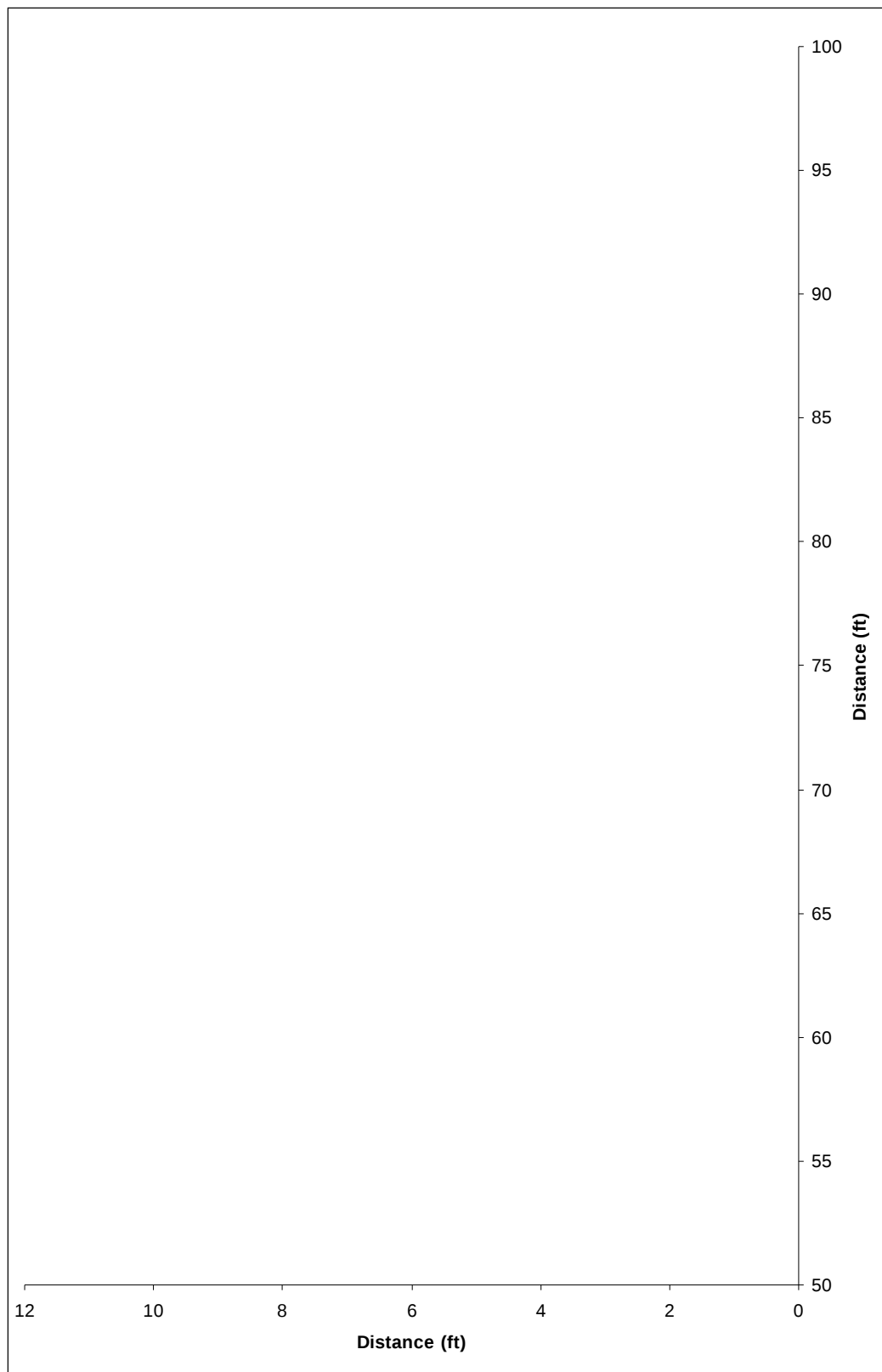


Figure 269. Wheeler-Sack AAF Section 10 (Station 50-100 ft).

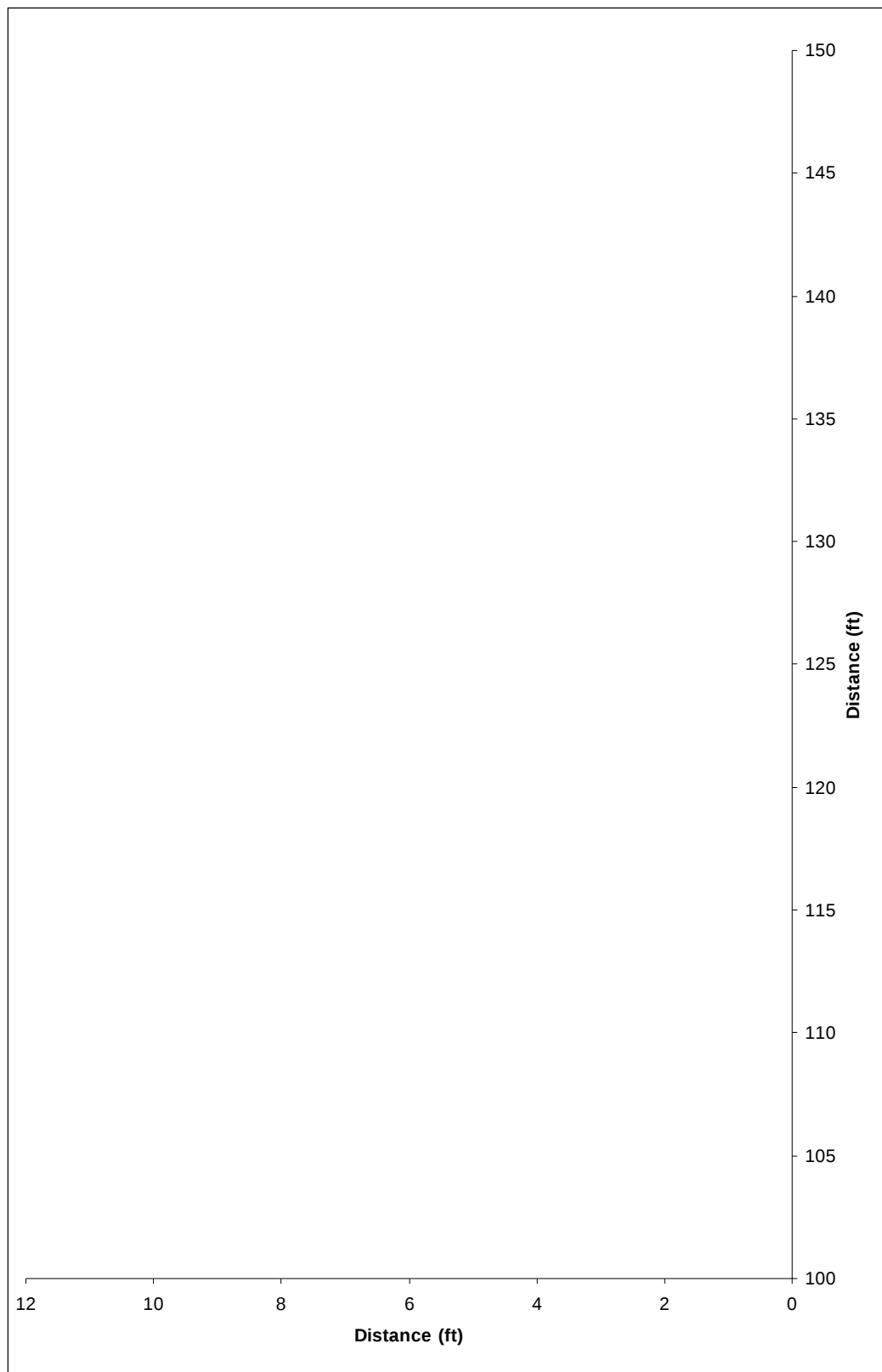


Figure 270. Wheeler-Sack AAF Section 10 (Station 100-150 ft).

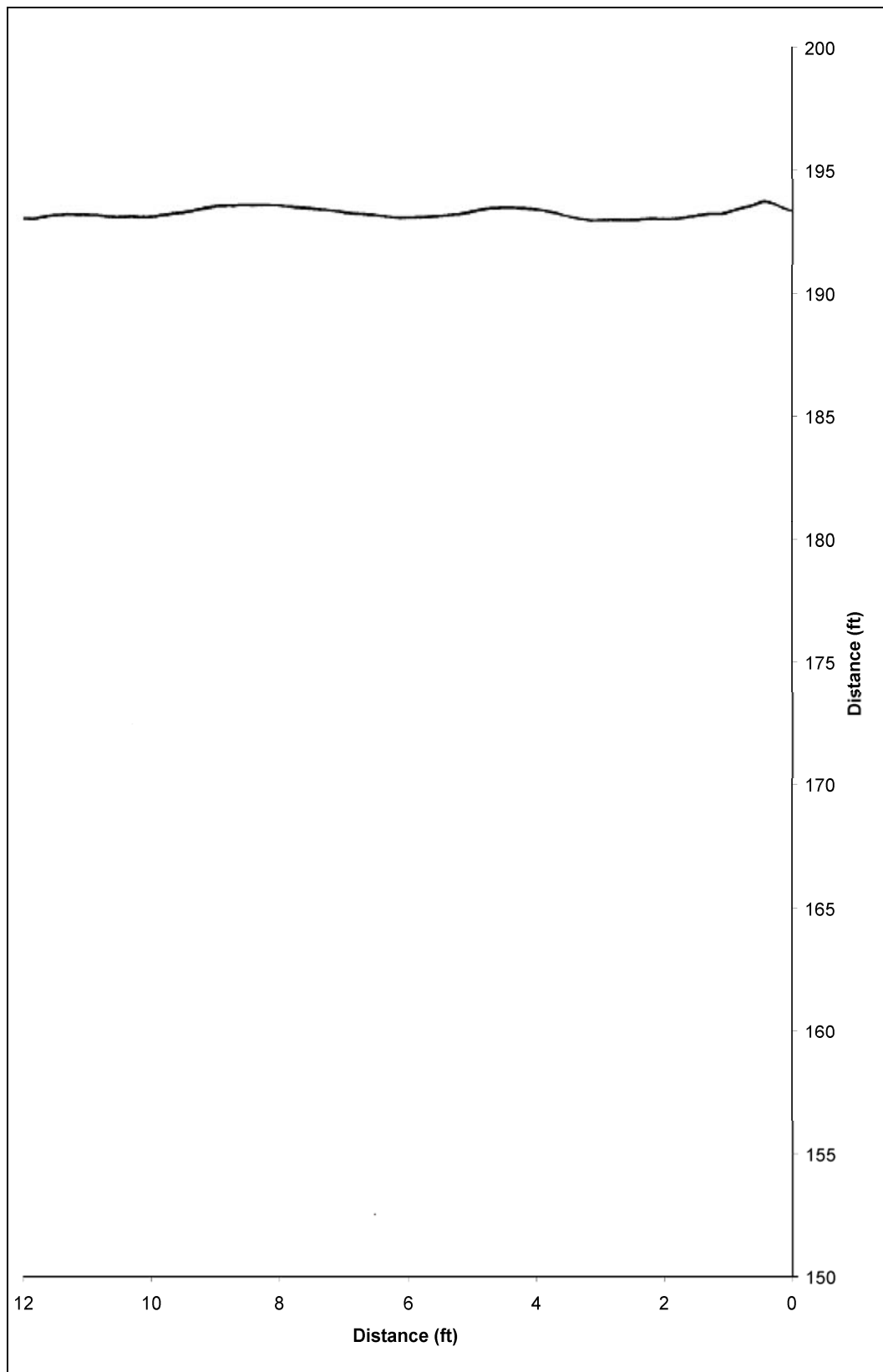


Figure 271. Wheeler-Sack AAF Section 10 (Station 150-200 ft).

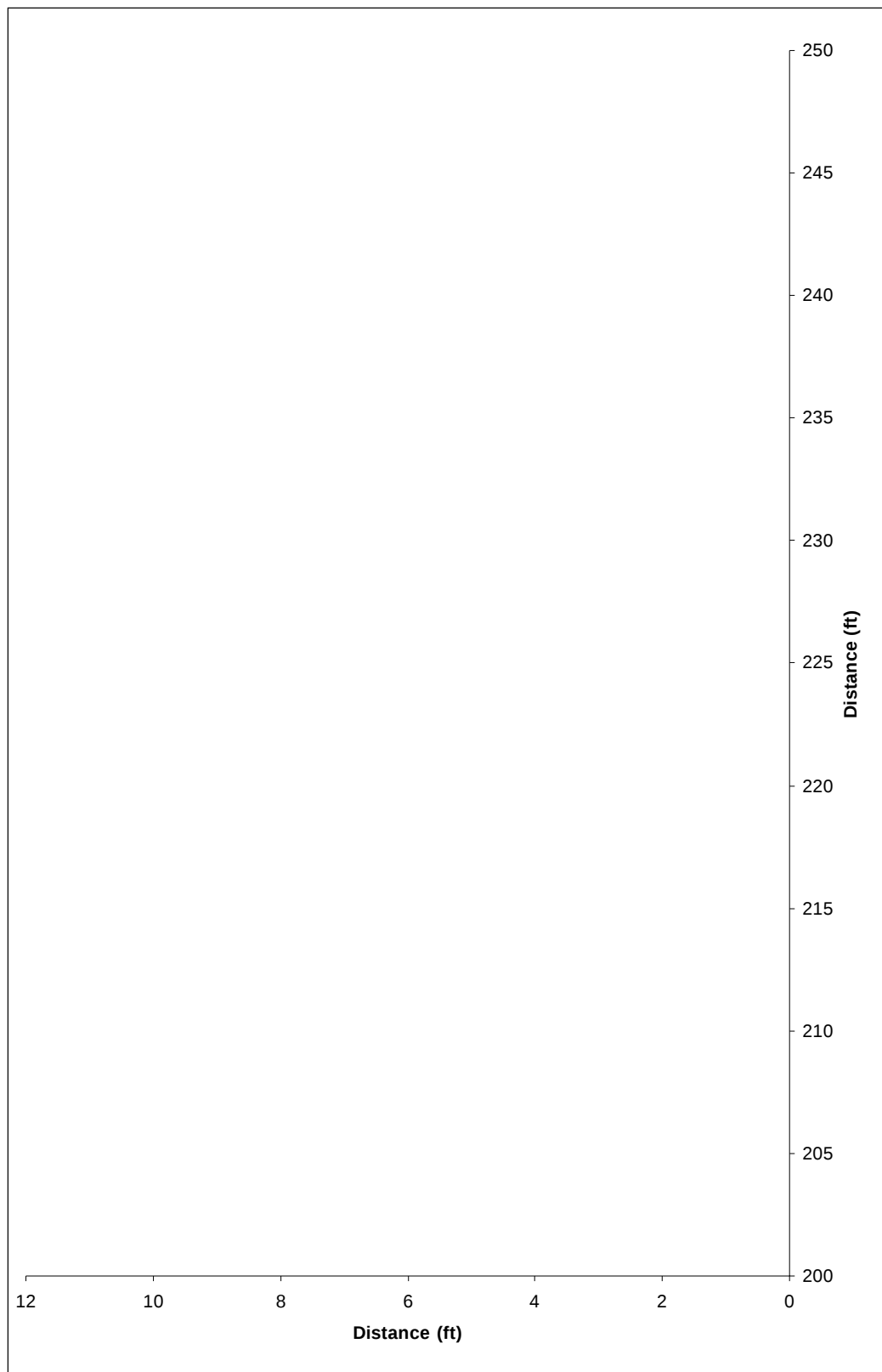


Figure 272. Wheeler-Sack AAF Section 10 (Station 200-250 ft).

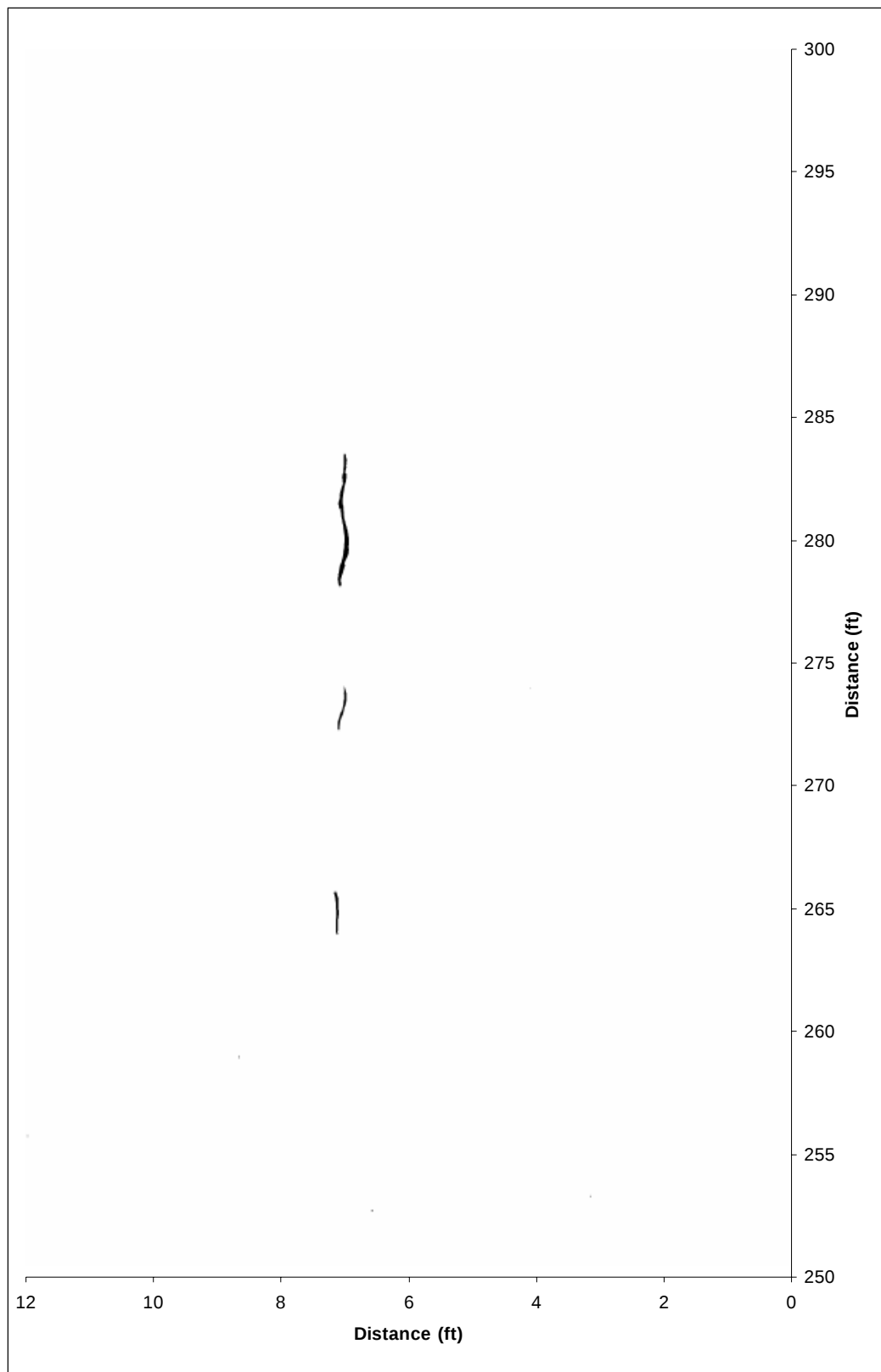


Figure 273. Wheeler-Sack AAF Section 10 (Station 250-300 ft).

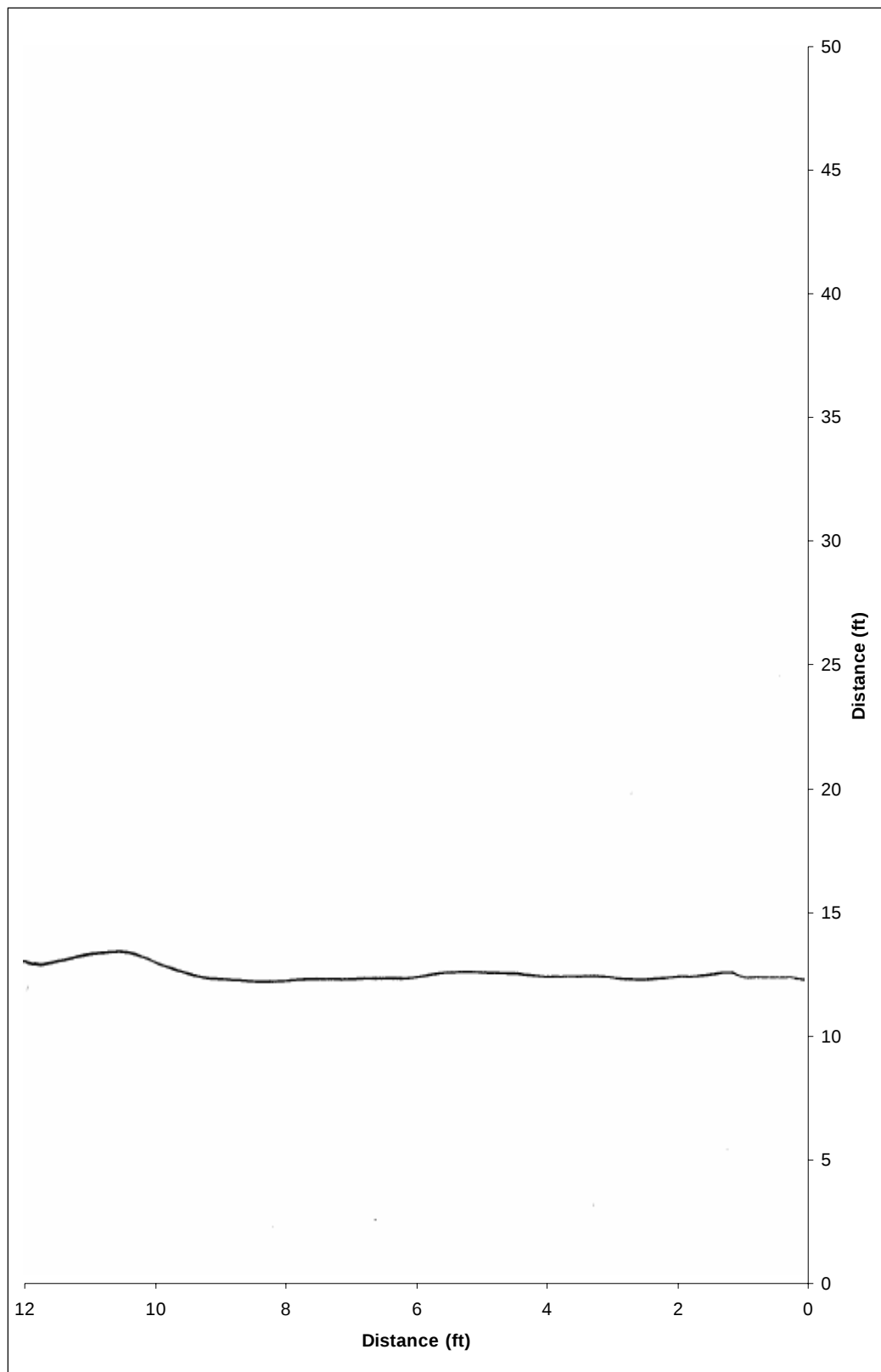


Figure 274. Wheeler-Sack AAF Section 11 (Station 0-50 ft).

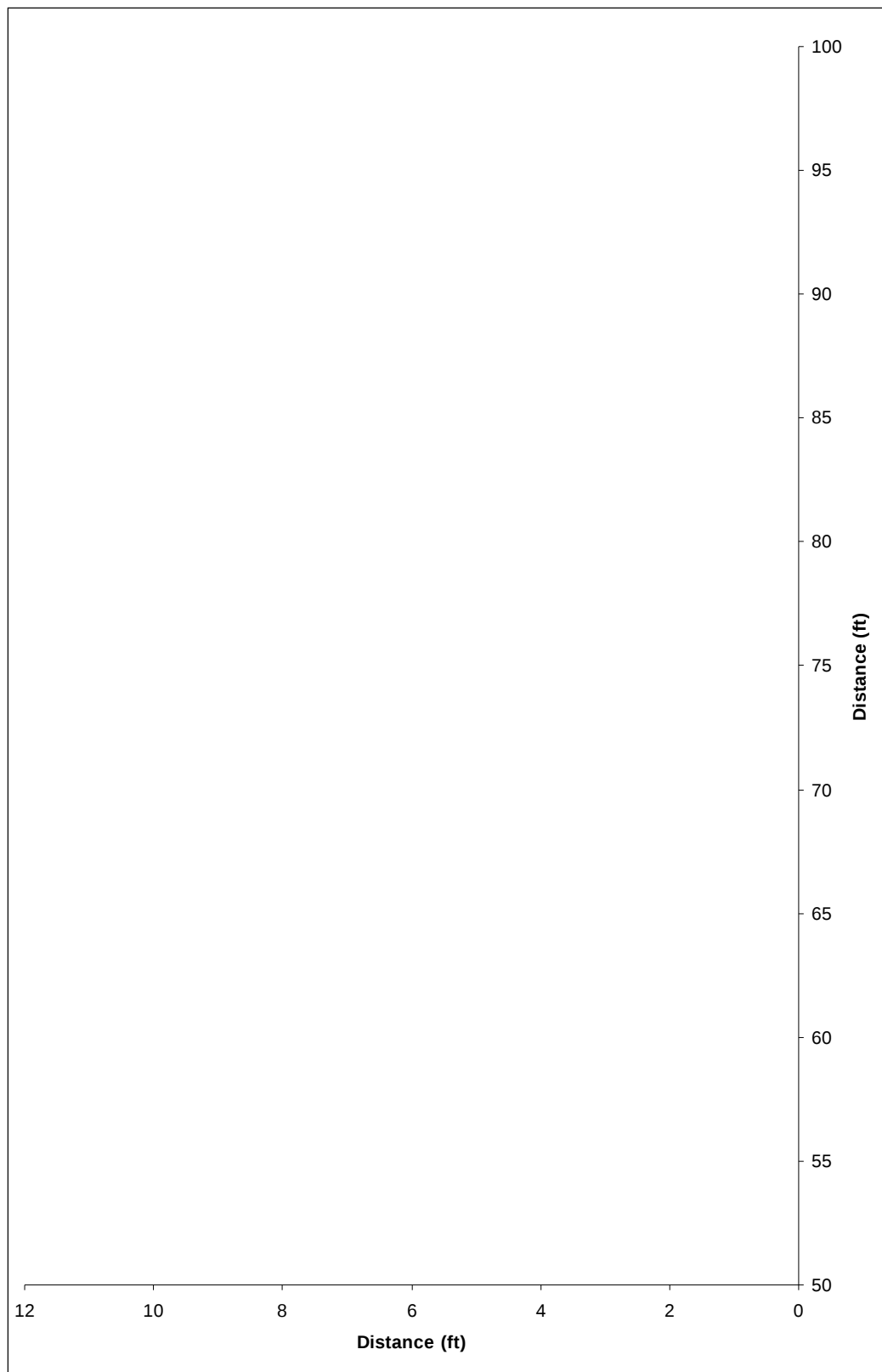


Figure 275. Wheeler-Sack AAF Section 11 (Station 50-100 ft).

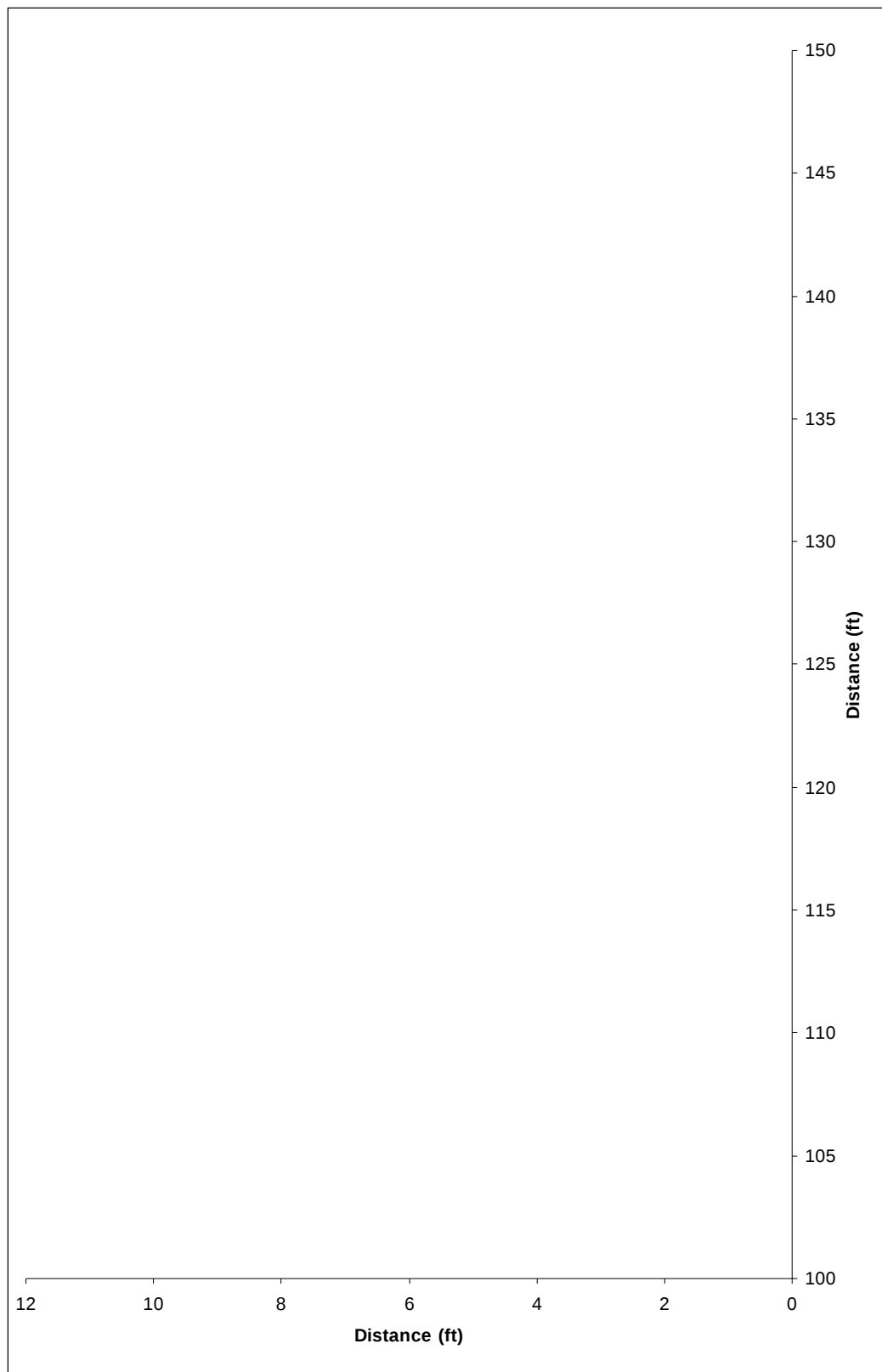


Figure 276. Wheeler-Sack AAF Section 11 (Station 100-150 ft).

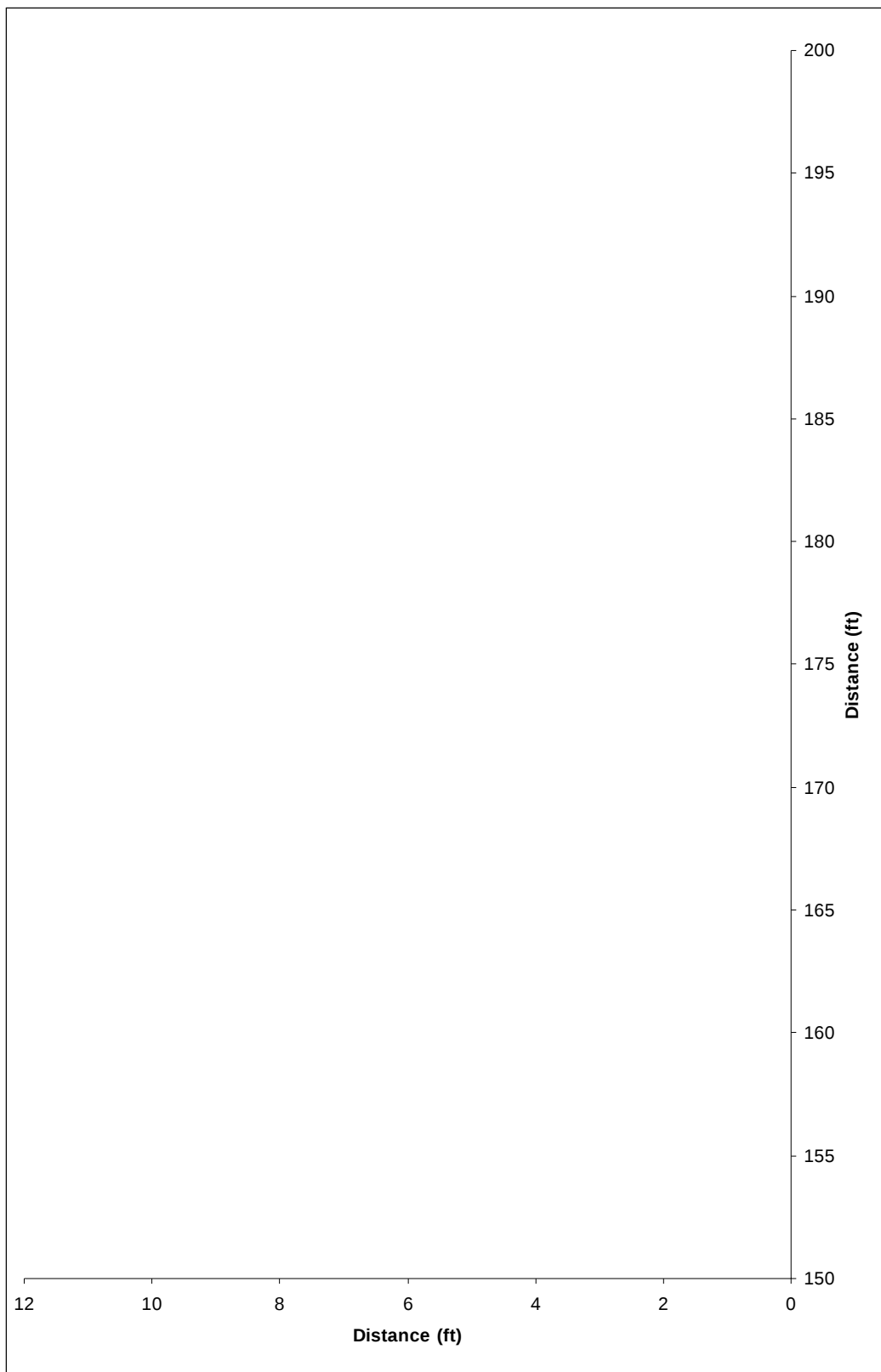


Figure 277. Wheeler-Sack AAF Section 11 (Station 150-200 ft).

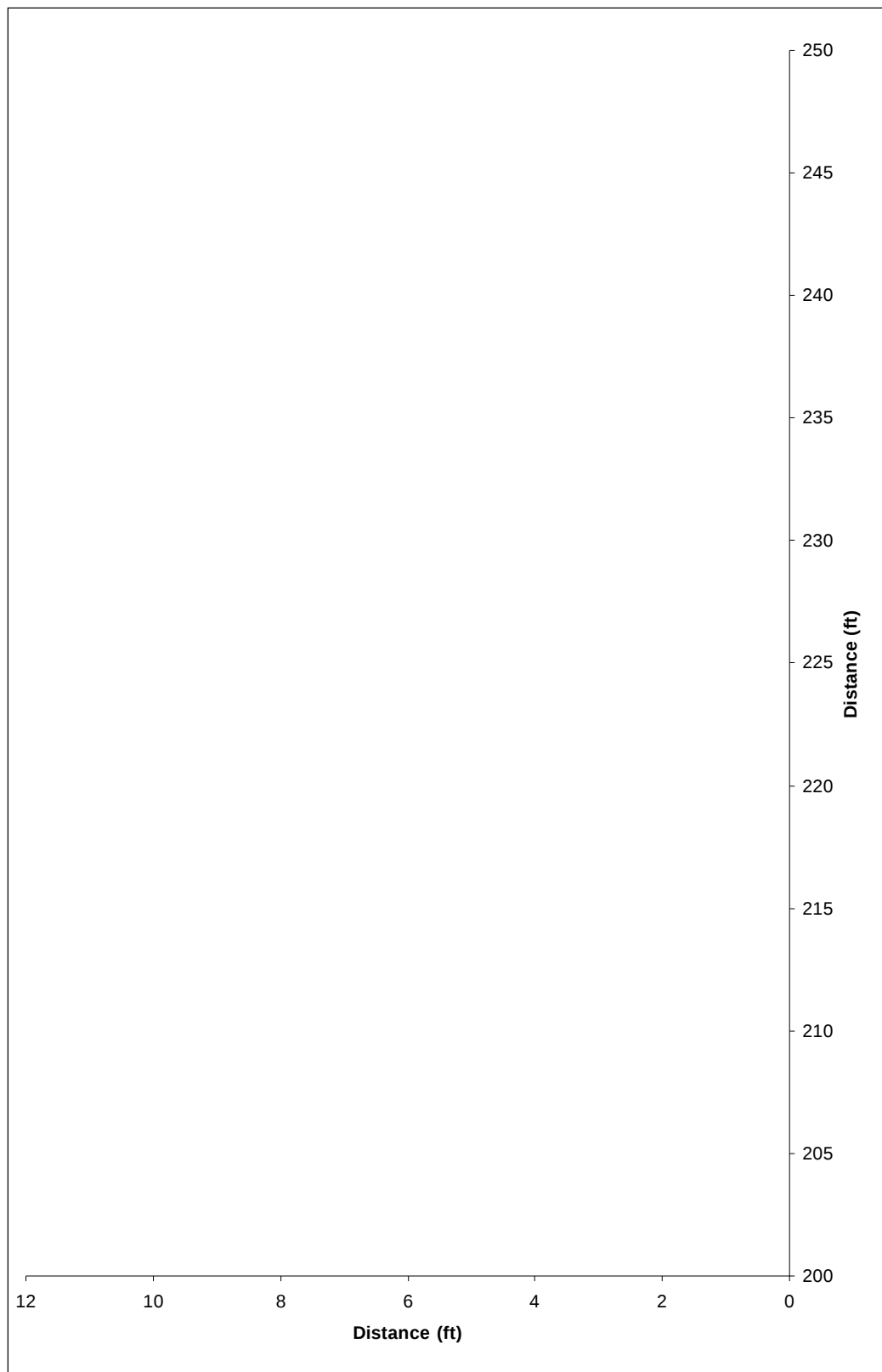


Figure 278. Wheeler-Sack AAF Section 11 (Station 200-250 ft).

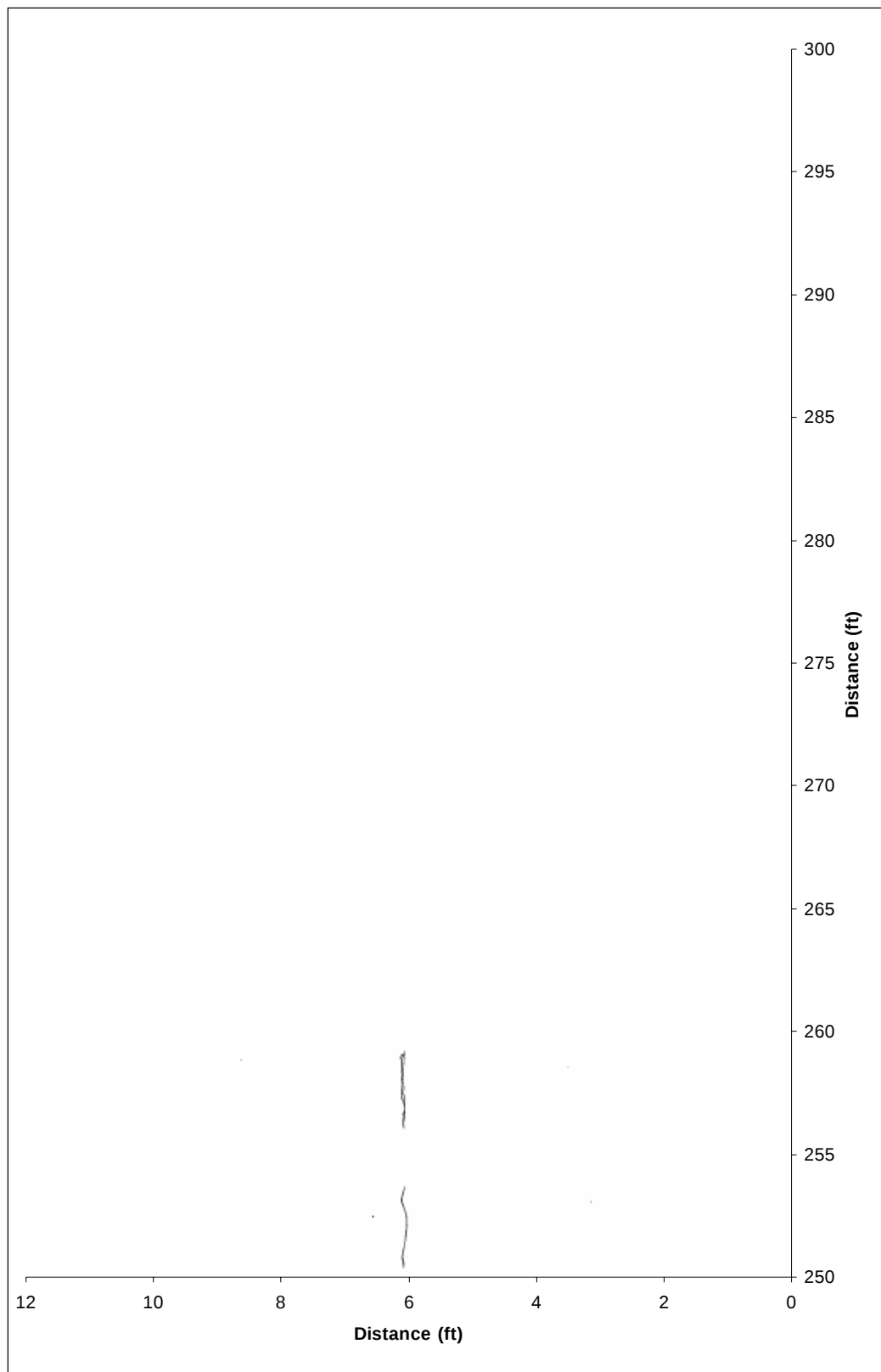


Figure 279. Wheeler-Sack AAF Section 11 (Station 250-300 ft).

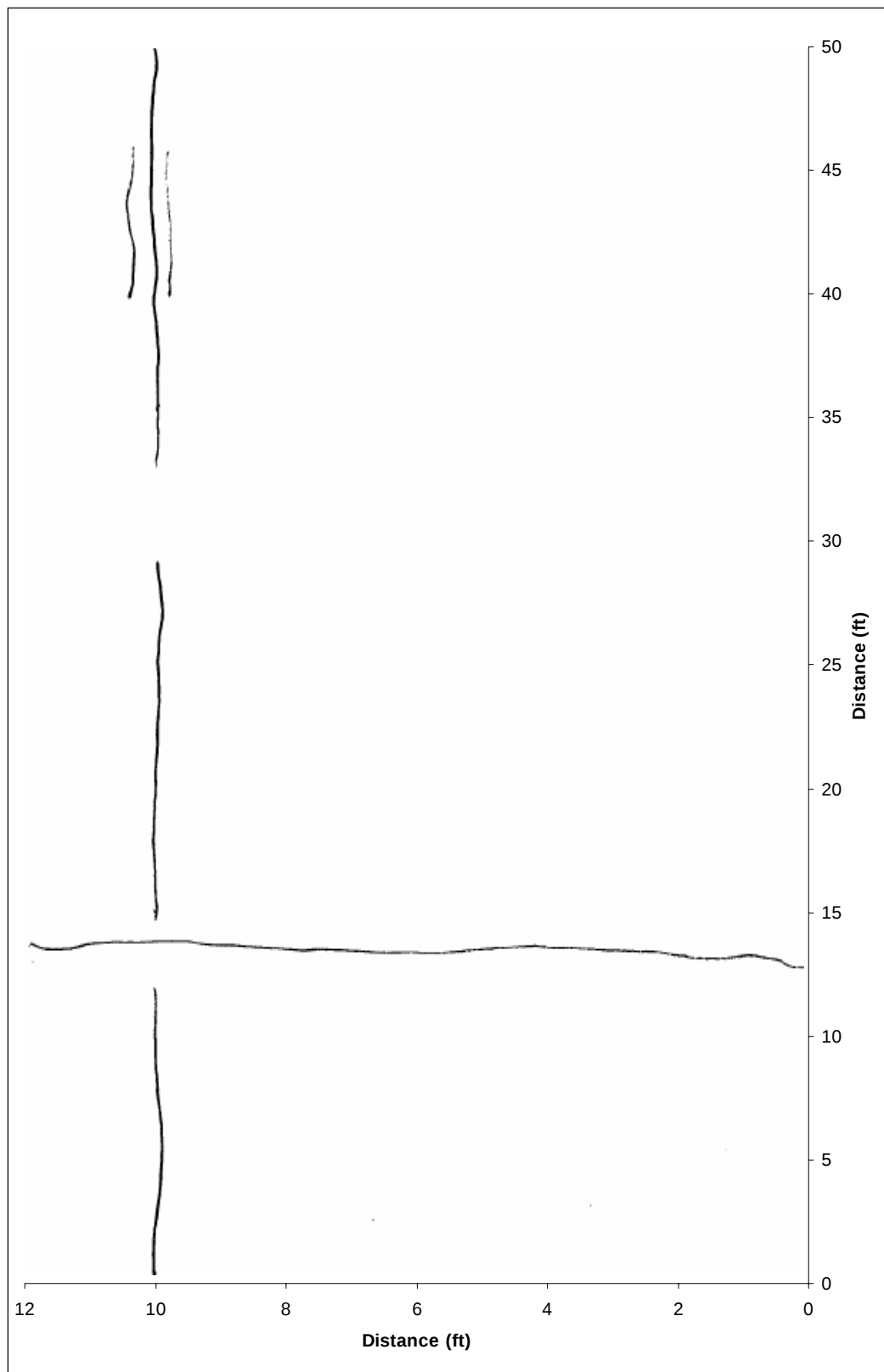


Figure 280. Wheeler-Sack AAF Section 12 (Station 0-50 ft).

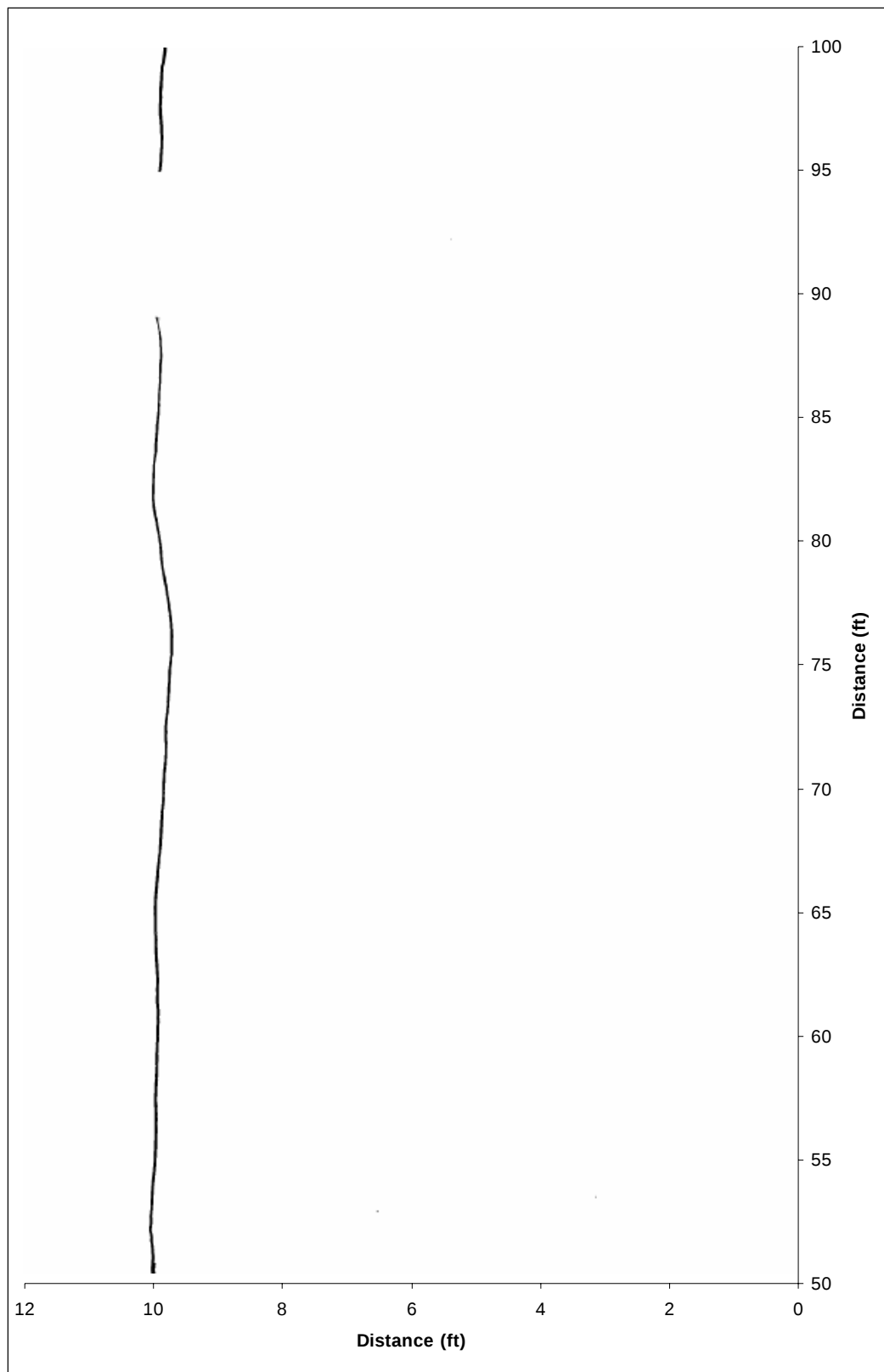


Figure 281. Wheeler-Sack AAF Section 12 (Station 50-100 ft).

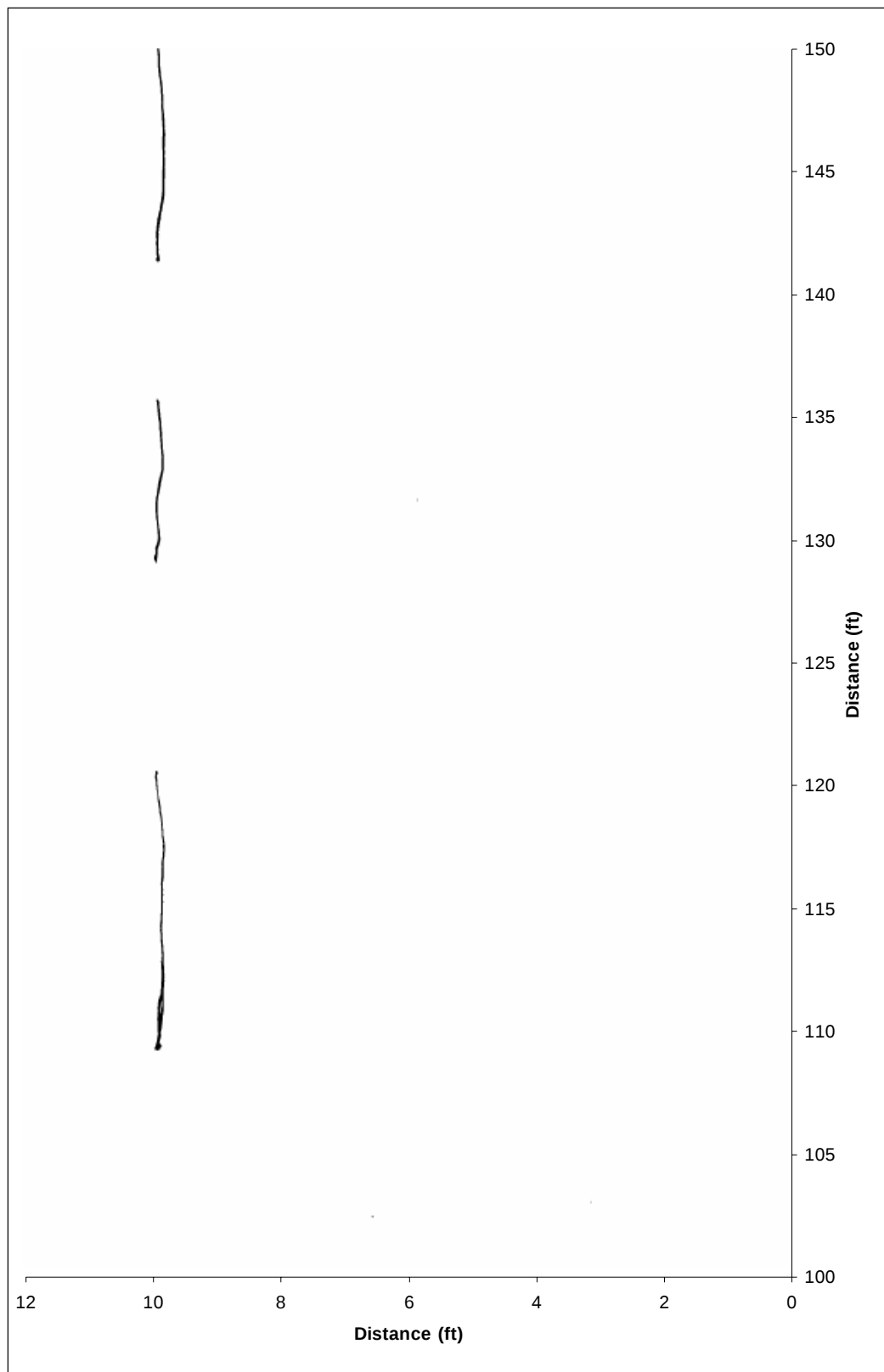


Figure 282. Wheeler-Sack AAF Section 12 (Station 100-150 ft).

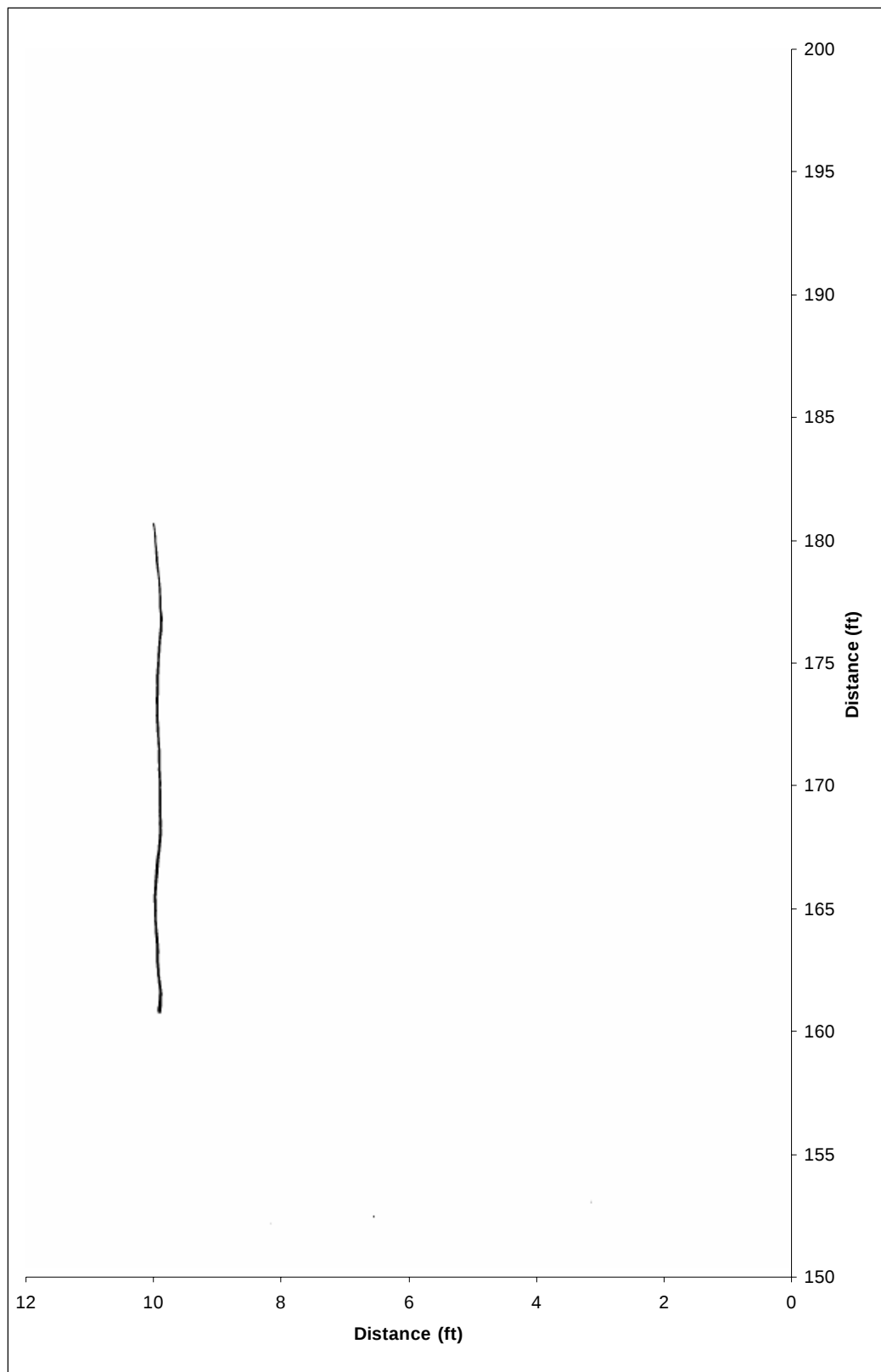


Figure 283. Wheeler-Sack AAF Section 12 (Station 150-200 ft).

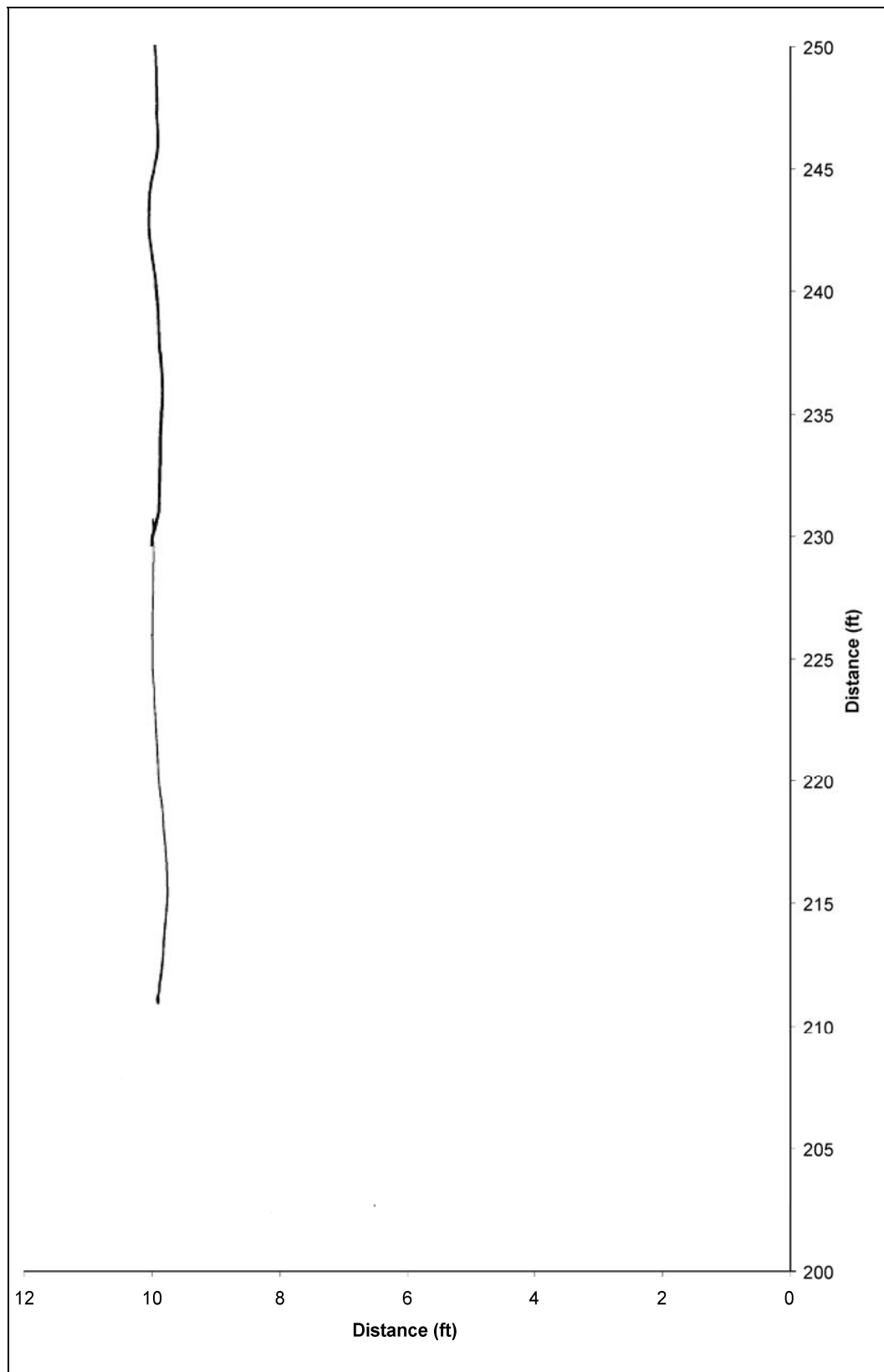


Figure 284. Wheeler-Sack AAF Section 12 (Station 200-250 ft).

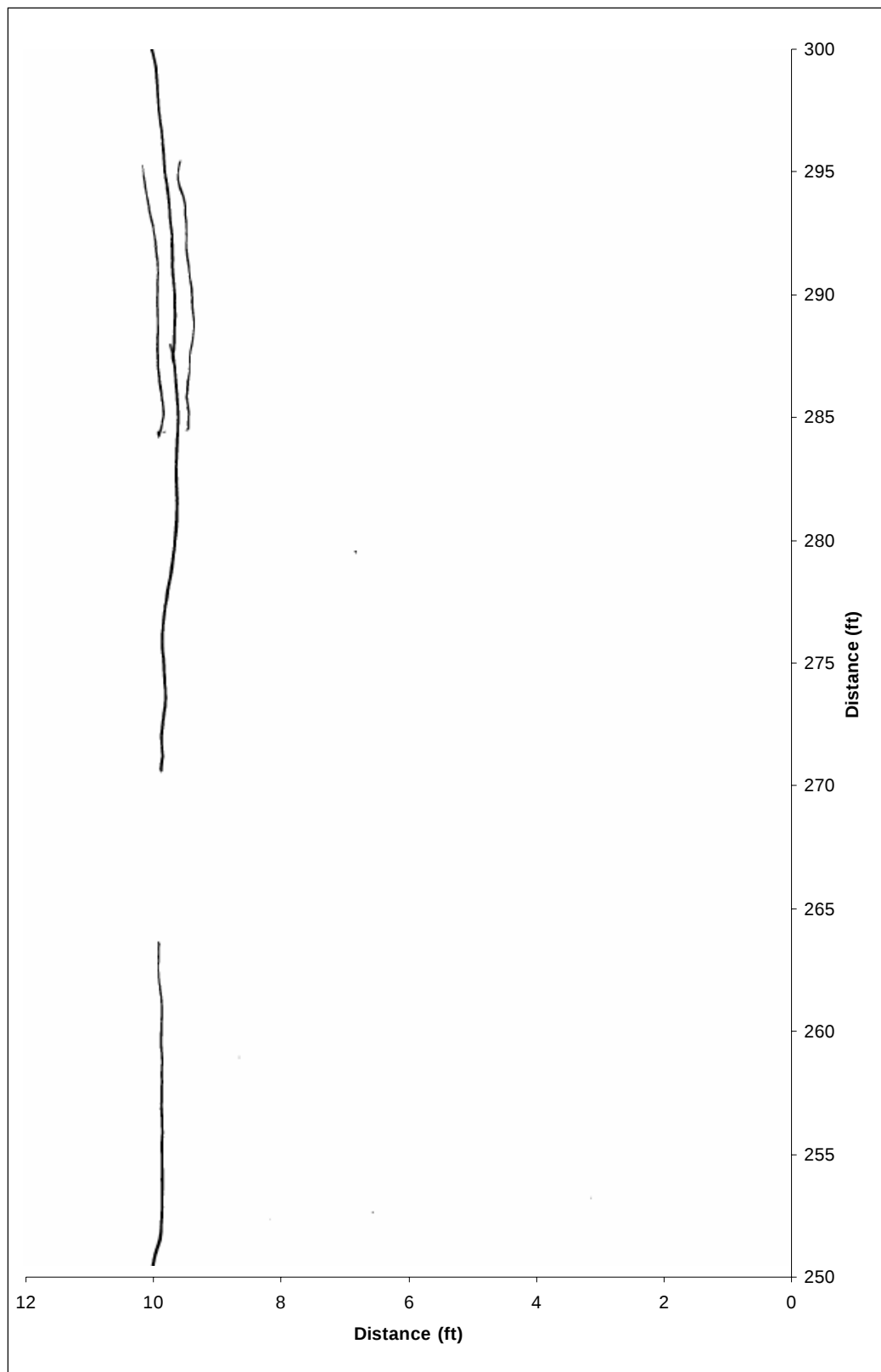


Figure 285. Wheeler-Sack AAF Section 12 (Station 250-300 ft).

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				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) John F. Rushing and Anthony J. Falls				5d. PROJECT NUMBER	
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13. SUPPLEMENTARY NOTES					
14. ABSTRACT The U.S. Army Engineer Research and Development Center recently began a research project to evaluate pavement preservation techniques for asphalt pavements on Army airfields. Three field sites were selected for testing. Field sites represented the following climatic regions: hot and wet, hot and dry, and cold. Each of the test sites was on a taxiway or parking apron pavement on an Army airfield. Commercially available products marketed for pavement preservation were placed at each site. Existing pavements were in good condition, and all exhibited only minor longitudinal or transverse cracking and limited weathering. Preliminary data were collected by evaluating pavement surface properties and by extracting pavement cores prior to placement of the surface treatment. Additional tests were performed after product placement. Annual evaluations will provide comparable data to quantify the benefit of the treatment based on its ability to reduce environmental distresses. This report provides information on the products placed at each site as well as pavement conditions before product placement.					
15. SUBJECT TERMS Asphalt surface treatments Preventive maintenance Sealers Pavement preservation techniques Rejuvenators Slurry seals					
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