RESULTS OF A SHALLOW SEISMIC REFRACTION SURVEY NEAR THE VILLAGE OF NORTH AURORA, ILLINOIS

Timothy H. Larson
Philip G. Orozco

Open File Series 1991-15

ILLINOIS STATE GEOLOGICAL SURVEY
Morris W. Leighton, Chief

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ABSTRACT

A shallow seismic refraction survey in southwestern Kane County, Illinois, defined the channel of a part of the buried St. Charles bedrock valley. Because a major sand and gravel aquifer, the St. Charles aquifer, is found at the base of the bedrock valley, the precise location of the buried valley is important for siting new water wells. The seismic survey found that the bedrock valley is about 1 mile farther west than previously thought, based on drill-hole data alone.

INTRODUCTION

The Village of North Aurora obtains its municipal water supply from deep aquifers. This water has a combined radium-226 and radium-228 level substantially above the maximum 5 pCi/l established by the U.S. Environmental Protection Agency (USEPA). North Aurora is considering the possibility of developing a 2-mgd supply of water from shallow drift aquifers to blend with water from their existing supply. The lower radium level in water from combined sources should be within acceptable limits (Rempe-Sharpe and Associates 1988).

Representatives of North Aurora consulted with the Illinois State Geological Survey (ISGS) to determine the most suitable location to explore for shallow aquifers. Over the past 6 years, the ISGS has conducted several similar investigations for neighboring municipalities and Kane County, and acquired a considerable database on the shallow groundwater resources of the region. In the North Aurora area, however, the database lacked detail.

This study, undertaken in cooperation with North Aurora, concentrated on an area of Kane County west of the village (fig. 1). The primary study area consists of Sections 26, 27, and 28 and 33, 34, and 35 of Blackberry Township (T39N, R7E). A major buried bedrock valley, the St. Charles bedrock valley (Curry and Seaber 1990; called the Newark Bedrock Valley in some older reports), lies beneath this area. Aquifers fill the bedrock valley in other areas of Kane County, and thus the buried bedrock valley was a target for exploration. A second study area in Sections 31, 32, and 33 of Geneva-Batavia Township (T39N, R8E) and Sections 4, 5 and 6 of Aurora Township (T38N, R8E) was initially considered as well. Preliminary results of previous investigations indicated that a small tributary to a buried bedrock valley lay beneath this second area (refer to fig. 3 in Rempe-Sharpe and Associates 1988). A detailed review of the available data eliminated this possibility, and the second site was not further considered.

This report

- reviews the existing information relative to the shallow groundwater needs of the village;
- describes seismic investigations designed to locate the buried St. Charles bedrock valley;
- makes recommendations for the siting of new shallow wells.

REVIEW OF EXISTING INFORMATION

The most recent regional information is provided by Curry and Seaber (1990). Their report on the shallow groundwater resources of Kane County not only compiles the best available data, but also defines a regional framework for more specific studies. The database developed for previous ISGS shallow groundwater investigations in Kane County (including Curry and Seaber 1990) was searched for information pertinent to North Aurora.

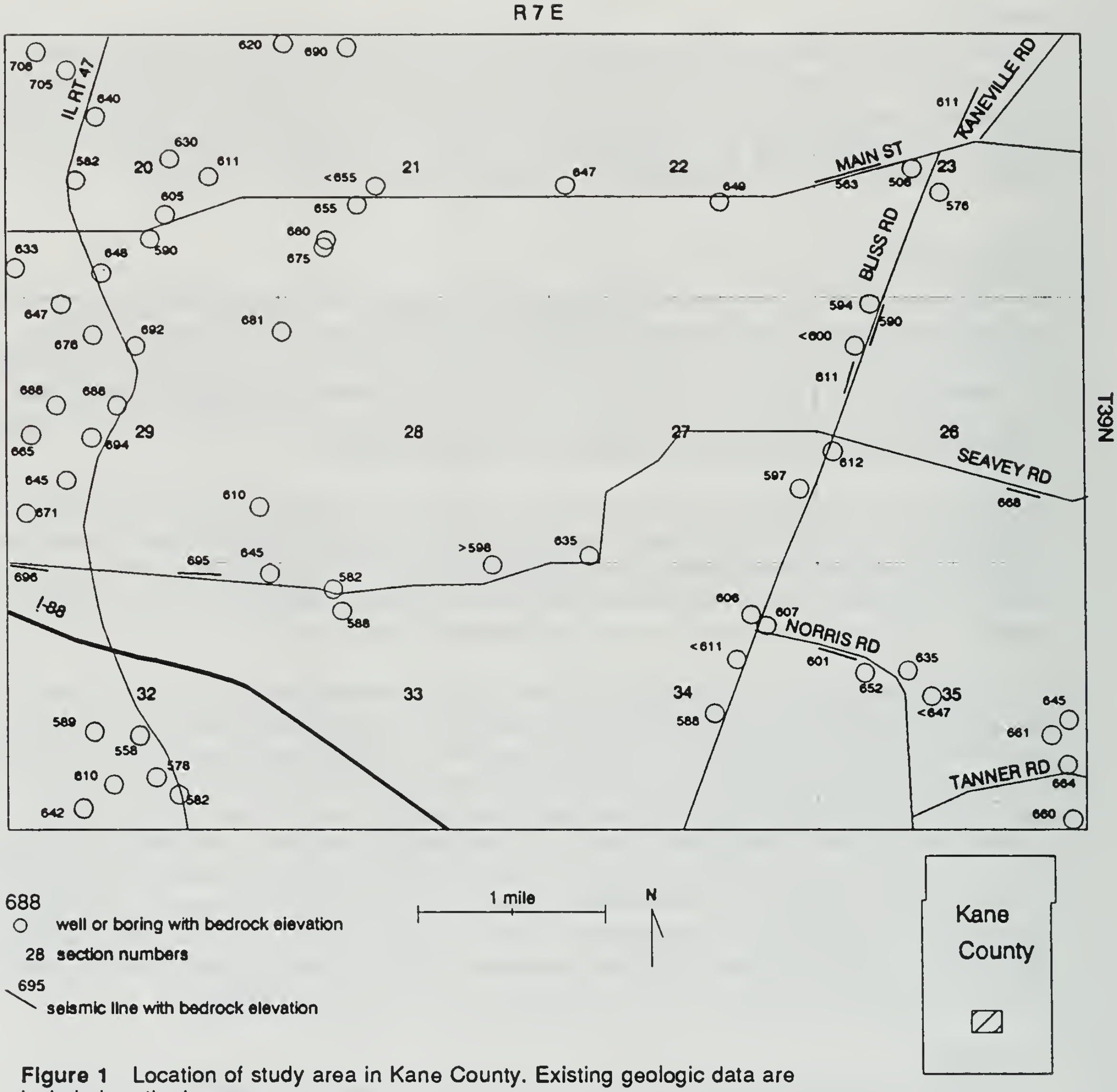

Figure 1 Location of study area in Kane County. Existing geologic data are included on the base map.

Hydrogeologic Framework

The shallow bedrock in Kane County consists of the Kankakee and Elwood Formations, Silurian in age and composed mostly of dolomite, and the Maquoketa Group, Ordovician in age and composed of shale and argillaceous dolomite (Willman et al., 1975). The shallow bedrock, which has been referred to as the shallow dolomite aquifer, is known formally as the Upper Bedrock Aquigroup (Visocky et al. 1985).

The bedrock surface, buried by Quaternary deposits (glacial till, glacial outwash, glacial lakebed materials), features hills and valleys that roughly resemble modern topography. Buried bedrock valleys often contain thick deposits of sands and gravels interpreted to be primarily of glacial or fluvial origin. Geological reasoning points to the bedrock valley systems as having the greatest potential for containing predictable and high-yielding aquifers. Bedrock valley aquifers can be recharged, not only from overlying drift, but by groundwater stored in fractures in weathered

Table 1 Informal classification of drift aquifers used in this report (after Curry and Seaber 1990).

Hydrostratigraphic unit	*General characteristics*	*Comparable stratigraphic units*
Pingree Grove aquiformation	Stratified lake deposits	Cahokia Alluvium, Grayslake Peat, and Equality Formation
Elburn aquiformation	Mostly till, some outwash	Yorkville and Malden Till Members of Wedron Formation
Kaneville aquifer member	Outwash sand and gravel	Henry Formation and outwash of Yorkville and Malden Till Members
Marengo aquitard	Thick clayey till	Tiskilwa Till Member of Wedron Formation
St. Charles aquifer	Sand and gravel in buried bedrock valleys	Outwash of Wedron Formation (Tiskilwa Till Member) and within Glasford Formation

bedrock in the valley walls and immediately below the glacial drift. Although valley-fill deposits may consist predominantly of fluvial sands and gravels that are excellent aquifer materials, they may also contain fine-grained diamicton (glacial till or debris flows) and lacustrine (lakebed) deposits that are poor aquifer materials or aquitards (Curry and Seaber 1990).

The Prairie Aquigroup (glacial or surficial deposits above the bedrock) has been informally divided into aquiformations by Curry and Seaber (1990) (table 1). Their terminology for aquifers and aquitards has been used in this report. An important hydrostratigraphic unit in the Prairie Aquigroup is the St. Charles aquifer, consisting of sand and gravel that fills several buried bedrock valleys. Of secondary importance is the Kaneville aquifer member of the Elburn aquiformation. In several locations the Kaneville aquifer member directly overlies the St. Charles aquifer; their interconnectivity results in a significantly greater resource.

Study Area

The study area lies directly over the buried St. Charles bedrock valley, which is shown by the 550-foot contour lines in figure 2. This map of the bedrock surface elevation was constructed from geologic information existing prior to completion of this study. As shown here, the eastern rim of the valley lies below Bliss Road from Main Street in the north to the southern edge of the study area, where the valley turns west-southwest. The western rim of the valley was not well defined by the existing data, but the valley was thought to be narrow in the north and wider in the south. The few wells that penetrate the St. Charles bedrock valley in this area indicate that the St. Charles aquifer is more than 50 feet thick in the deepest parts of the bedrock valley. The Kaneville aquifer member overlies the St. Charles aquifer in parts of Section 33, a situation that results in a combined thickness of the two aquifers approaching 100 feet. In places, the two aquifers are separated by 20 feet or more of the Marengo aquitard, which limits the hydraulic connection between them.

A seismic refraction survey was undertaken to locate, as precisely as possible, the western rim of the St. Charles bedrock valley. The seismic refraction method was chosen for this investigation because it provides detailed information on the depth of the bedrock at considerably less expense than drilling. The seismic refraction method cannot totally replace test drilling, but it can be used as a means of focusing attention on the most promising areas for test drilling.

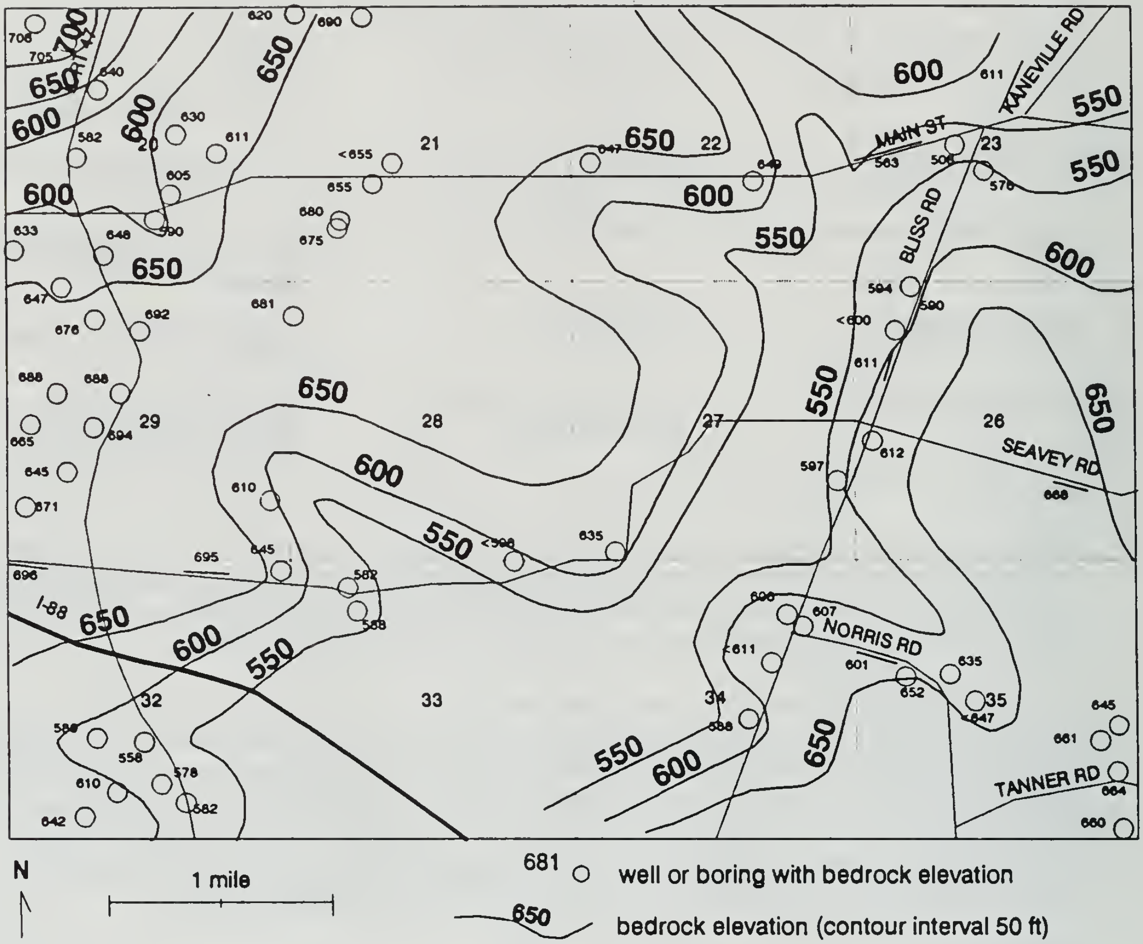

Figure 2 Bedrock surface elevations (ft above msl) based on preexisting geologic data.

DETAILED SEISMIC REFRACTION SURVEY

The locations of the seismic refraction profiles are shown in an appendix to this report and on figure 3. These sites were chosen to delineate the geometry of the buried St. Charles bedrock valley. In particular, the profiles were expected to locate the deepest portion and the western rim of the buried valley. Not only were these objectives met by the refraction profiles, but they also revealed a large area of elevated bedrock within the previously defined bedrock valley.

Methodology

Seismic refraction surveys record the seismic energy that is produced by small, controlled shots of dynamite and that returns to the ground surface after being refracted by an underground interface (i.e., bedrock surface). The recorded information is used to calculate the depth to the bedrock surface beneath the shot point. The method has been successfully employed elsewhere in northern Illinois to locate buried bedrock valleys (Gilkeson et al. 1987, Heigold 1990).

For this study, energy from shots placed every 650 to 750 feet was recorded by a set of sensors placed on the ground at 50-foot intervals between shot points. Energy was recorded from shots at each end of the sensor set to produce reversed seismic refraction profiles. The maximum energy source was a 1/3-pound charge of explosive buried in a 5-foot-deep hole.

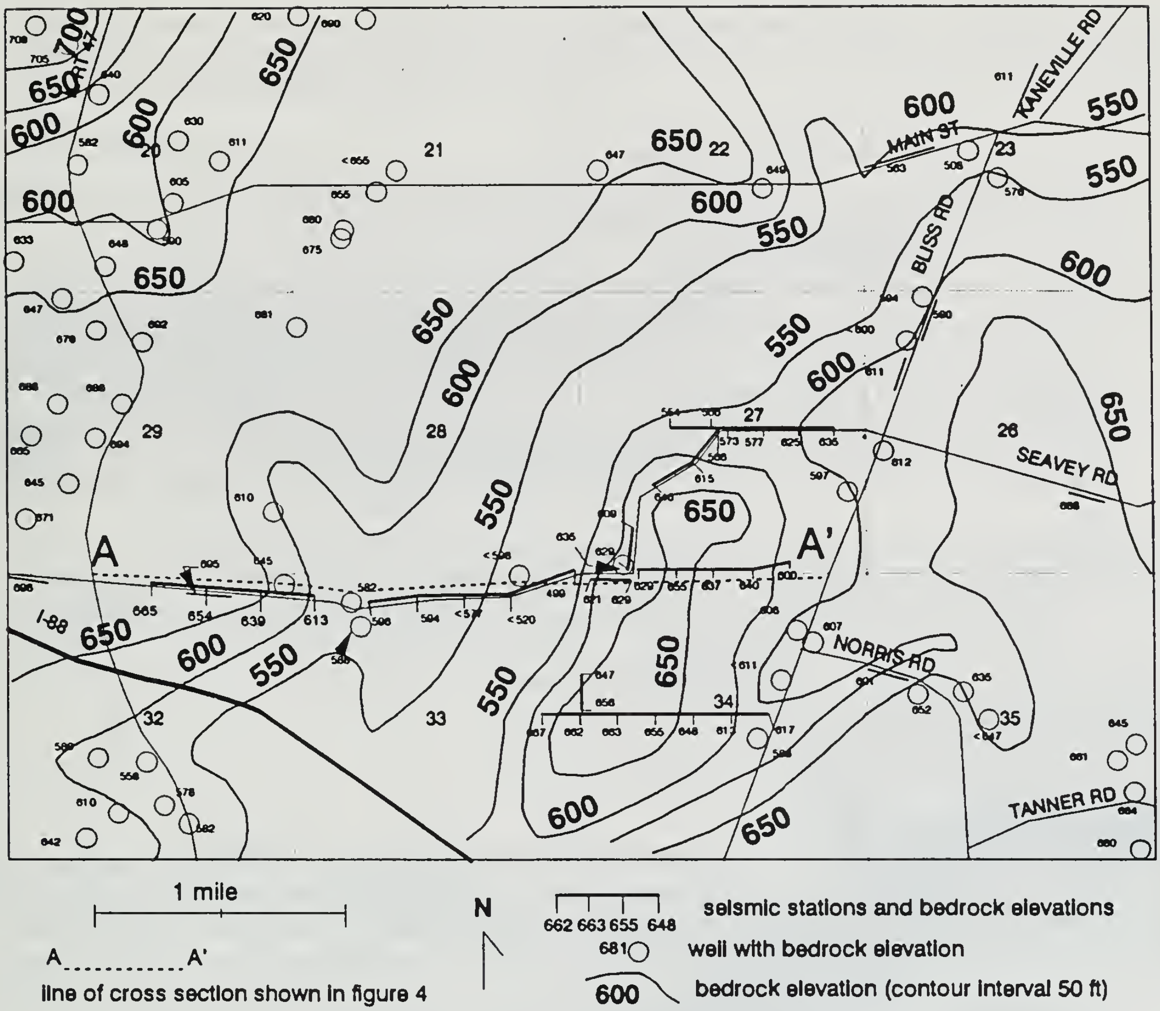

Figure 3 Bedrock surface elevations based on previous data and new seismic data. Locations of new seismic lines are included.

One major shortcoming of the seismic refraction method is that it overestimates the depth to bedrock when a thick sand and gravel layer lies beneath thick till. This situation occurs where the Marengo aquitard overlies the St. Charles aquifer within a bedrock valley; the seismic refraction method fails to detect the sand and gravel layer, apparently "hidden" beneath the till, and it provides a depth estimate that is too great. This problem can be partly overcome through the use of additional information, if available. For instance, many farm wells are finished in the top of the St. Charles aquifer but do not penetrate its entire thickness. When the elevation of the top of the sand is known, then the seismic data can be used to estimate the bottom.

Results

Twenty-seven reversed seismic refraction profiles were recorded. Results of individual reversed refraction profiles are included as an appendix to this report. Depth information from these profiles was also incorporated into the existing database to provide an updated, detailed map of the bedrock surface elevation.

Figure 3 is a revised map of the bedrock surface elevation; it incorporates the new seismic information into the existing database. The most important new feature on this map is the area

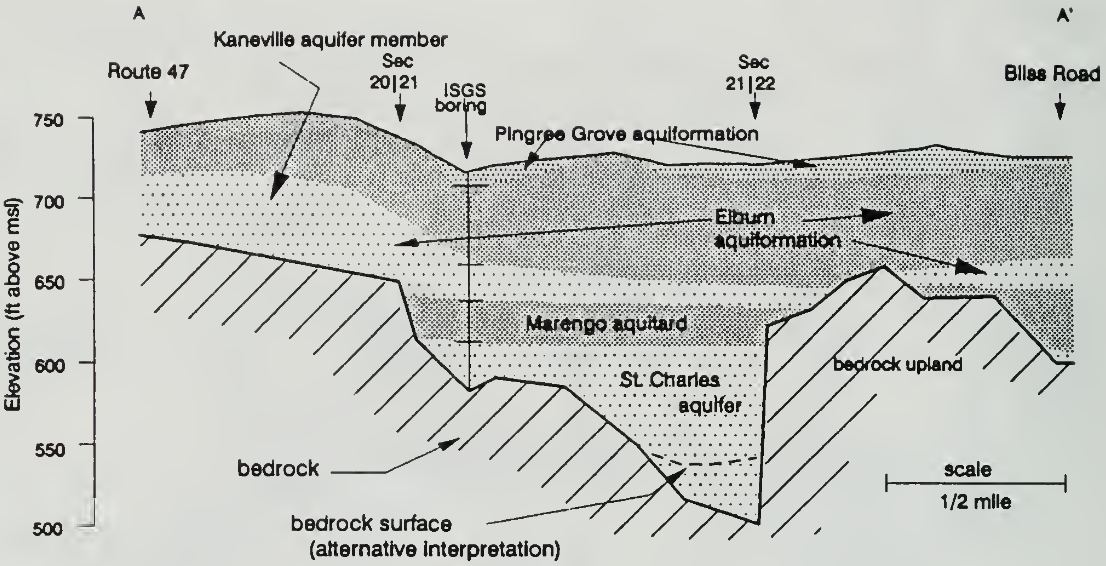

Figure 4 Cross section along Seavey Road.

of high bedrock elevation in Sections 27 and 34. This area had been previously mapped as part of the bedrock valley, but repeated seismic measurements show this area to be a buried upland. Instead of depicting a broad bedrock valley, the seismic data reveal a channel that swings west from Bliss Road, crossing Seavey Road in the southeast corner of Section 28.

The relationship between the small bedrock upland in Sections 27 and 34 and the main bedrock upland to the east and south is not clearly defined. Figure 3 shows one plausible interpretation; however, the connection could also be at the 600-foot level beneath Bliss Road. This detail is not crucial to the study because in any interpretation of the data, the groundwater potential immediately below Bliss Road is limited due to the shallow depths and narrow walls of the buried bedrock valley at this point.

The hydrogeologic relationships are shown in figure 4, a cross section east along Seavey Road from Route 47 to where it turns north in Section 34. The cross section continues east along the north edge of Section 34, ending at Bliss Road; it is based primarily on the seismic data and several farm wells. An ISGS borehole that penetrated to bedrock in the northwest corner of Section 33 provides hydrostratigraphic control. Two sand and gravel aquifers are depicted. The deeper St. Charles aquifer fills the bottom of the St. Charles bedrock valley and is separated from the shallower Kaneville aquifer member by the Marengo aquitard, a till layer 20 feet thick.

The deepest point of the buried bedrock valley (shown in figs. 3 and 4) is based on a reversed seismic profile that indicated bedrock elevations of <520 and 499 feet. If the bedrock valley is filled with sand and gravel, as interpreted in figure 4, then it is likely that the actual bedrock elevation beneath this seismic line is higher than calculated from the seismic data. Thick sand and gravel at the base of the valley results in a "hidden layer" error in the seismic data and thus results in an overestimation of the depth to the bedrock. If the top of the sand and gravel is approximately as shown in figure 4, than the actual bedrock surface may be as high as 550 feet in elevation. This interpretation of the seismic data assumes a "hidden layer" of sand and gravel having a seismic velocity of 4,000 feet per second. The two interpretations of the seismic data are shown with dotted lines on figure 4.

RECOMMENDATIONS

A simplified drawing of the main features of the bedrock topography is presented in figure 5. The 550- and 600-foot bedrock elevation contours were used to outline the buried valley and the buried bedrock upland within it.

Three locations, shown on this drawing, are recommended for test drilling. Labeled A, B, and C from north to south, they all are located within the projected limits of the main channel of the St. Charles bedrock valley. Sites B and A are located near the two deepest seismic stations, respectively. Site C is located near an existing borehole that encountered more than 50 feet of St. Charles aquifer and is within the main channel of the bedrock valley as it is projected south of the Seavey Road seismic lines.

The shallow groundwater potential in the southwestern portion of the study area, near location C, is excellent. A test well located farther north (Section 5 of Geneva-Batavia Township) but in a similar hydrogeologic setting produced 1,500 gallons per minute (gpm) with a specific

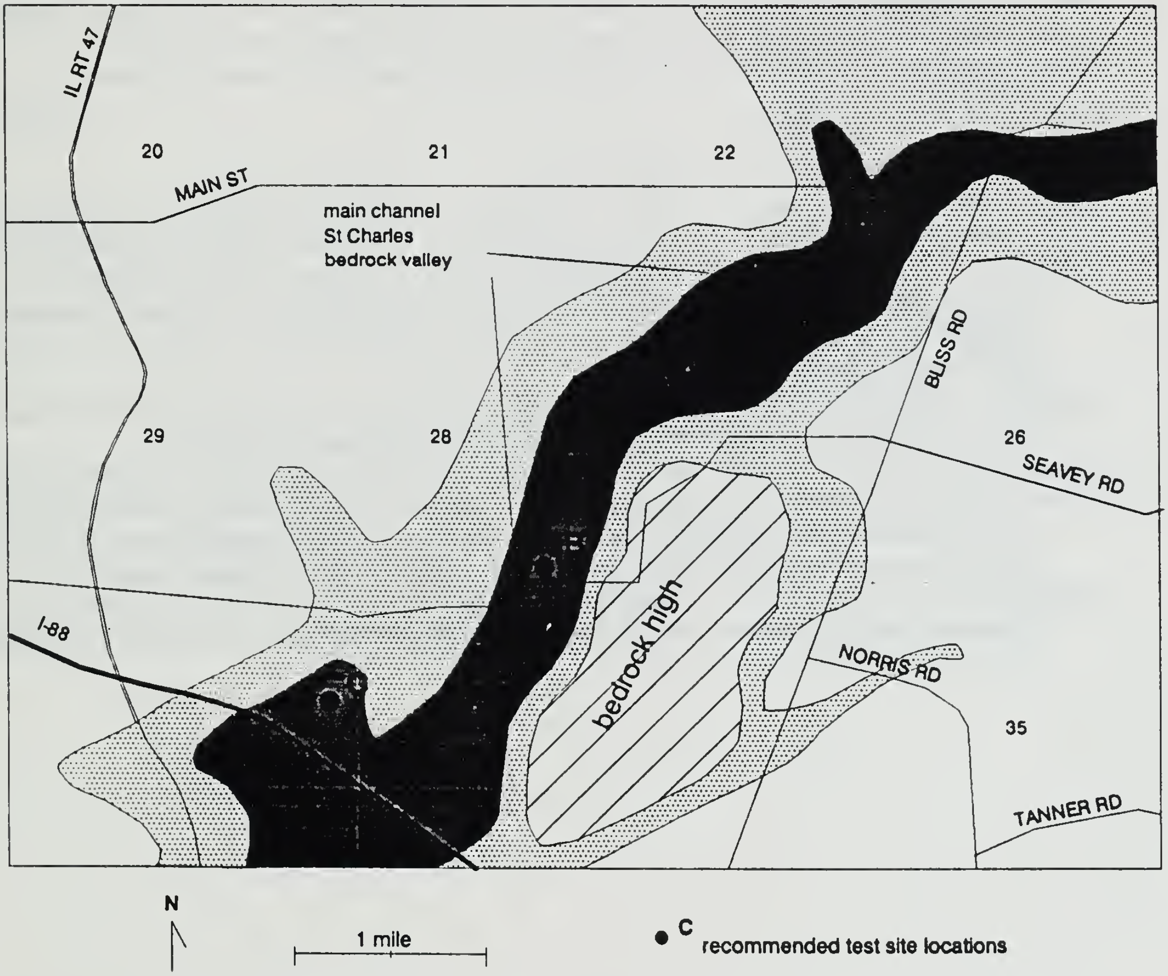

Figure 5 The main features of the St. Charles aquifer.

capacity of 66.3 gpm/ft during a pumping test in 1986 (Curry and Seaber 1990). Although the St. Charles aquifer is likely to be present within the buried St. Charles bedrock valley in the center of the area, in Section 27 near locations A and B, the apparent narrowness of the valley may limit the thickness and distribution of aquifers. Test wells located in similarly narrow reaches of the Aurora bedrock valley to the south produced 400 and 650 gpm with specific capacities of 13 and 29 gpm/ft (Curry and Seaber 1990). However, other factors that contribute to the groundwater potential make these sites favorable for test drilling. In particular, locations A and B are at or near the center of the most significant bedrock valley in the area. The specific capacities of aquifers in this bedrock valley would most likely be greater than those of aquifers in the Aurora bedrock valley, which is a tributary valley.

Although the main channel of the buried valley passes beneath the intersection of Bliss Road and Main Street, drilling in this area is not recommended. Previous drill holes in this area did not encounter significant thicknesses of the St. Charles aquifer.

ACKNOWLEDGMENTS

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APPENDIX: Results of Reversed Seismic Refraction Profiles

Refraction data were interpreted using SEISVIEW (EG&G Geometrics, 1989), an interactive computer implementation of Mota's (1959) generalized intercept interpretation method. Seismic refraction arrivals were picked from a computer display of the data and stored for later analysis. Layers were chosen from a display of the time-distance data for each profile and depth calculations were performed automatically.

Figure A-1 shows the relative location of each shot and the calculated bedrock elevation beneath the shot. Results from each profile are presented using the form as presented on page 10.

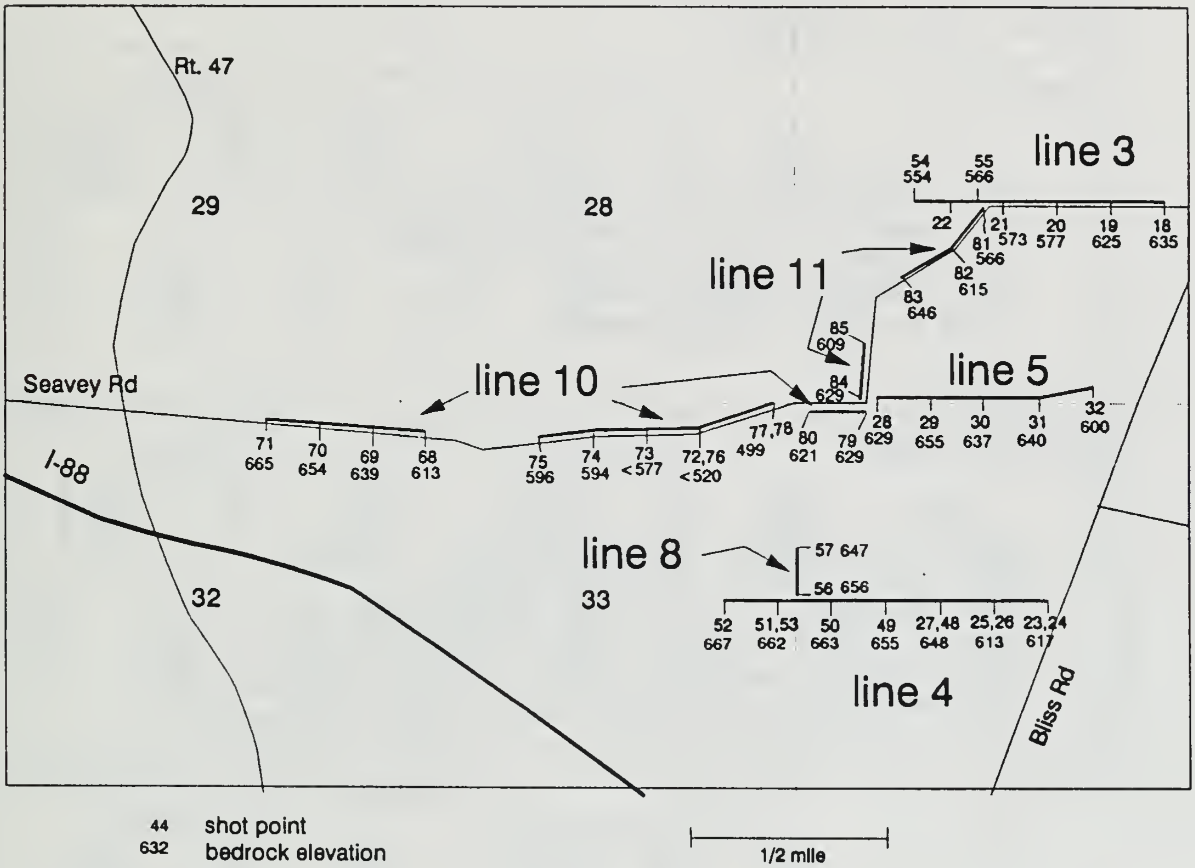

Figure A-1 Detail of seismic lines showing shot points and calculated bedrock elevations.

PROFILE ID
(First shot is FORWARD
Second shot is REVERSE)

INPUT DATA

KEY

Va = apparent velocity forward profile
Vb = apparent velocity reverse profile
Ta = intercept forward profile
Tb = intercept reverse profile
Slope = slope of line segment (1/V)

CALCULATED MODEL

KEY

Velocity = velocity in units of feet / second
Dip = dip of top of layer in degrees
Ha = thickness of layer under forward shot point
Hb = thickness of layer under reverse shot point
Da = depth to top of layer under forward shot point
Db = depth to top of layer under reverse shot point

Profile: kane 19b - 18 revised

INPUT DATA

	FORWARD PROFILE			REVERSE PROFILE		
Seg	Slope	Va	Ta(mS)	Slope	Vb	Tb(mS)
1	0.00033	3030	0.000	0.00033	3030	-0.000
2	0.00016	6064	9.390	0.00016	6061	16.500
3	0.00008	11862	36.405	0.00008	12299	38.628

CALCULATED MODEL

LAYER	VELOCITY	DIP	Ha	Hb	Da	Db
1	3030	0.00	1x16.4	28.9	0.0	0.0
2	6062	0.01	90.8	70.8	16.4	28.9
3	12076	-0.61			107.2	99.6

Profile: kane 20b - 19a

INPUT DATA

	FORWARD PROFILE			REVERSE PROFILE		
Seg	Slope	Va	Ta(mS)	Slope	Vb	Tb(mS)
1	0.00030	3333	0.000	0.00025	4000	-0.000
2	0.00015	6796	15.643	0.00014	7037	11.566
3	0.00008	12195	41.900	0.00009	11111	31.333

CALCULATED MODEL

LAYER	VELOCITY	DIP	Ha	Hb	Da	Db
1	3667	0.00	33.8	25.0	0.0	0.0
2	6914	-0.63	105.1	79.2	33.8	25.0
3	11610	2.74			138.9	104.2

Profile: kane 21b - 20a

INPUT DATA

	FORWARD PROFILE			REVERSE PROFILE		
Seg	Slope	Va	Ta(mS)	Slope	Vb	Tb(mS)
1	0.00023	4348	0.000	0.00029	3448	-0.000
2	0.00015	6711	7.744	0.00015	6654	14.686
3	0.00008	12500	44.000	0.00007	14286	51.667

CALCULATED MODEL

LAYER	VELOCITY	DIP	Ha	Hb	Da	Db
1	3898	0.00	18.6	35.2	0.0	0.0
2	6683	0.18	134.9	132.9	18.6	35.2
3	13321	-2.37			153.4	168.1

Profile: kane 55 - 54 repeat

INPUT DATA

	FORWARD PROFILE			REVERSE PROFILE		
Seg	Slope	Va	Ta(mS)	Slope	Vb	Tb(mS)
1	0.00033	3030	0.000	0.00033	3030	-0.000
2	0.00015	6772	17.156	0.00015	6801	18.514
3	0.00010	10000	47.000	0.00009	11111	49.667

CALCULATED MODEL

LAYER	VELOCITY	DIP	Ha	Hb	Da	Db
1	3030	0.00	29.0	31.3	0.0	0.0
2	6787	-0.06	127.3	132.7	29.0	31.3
3	10517	-2.43			156.4	164.1

Profile: kane 24 - 25

INPUT DATA

	FORWARD PROFILE			REVERSE PROFILE		
Seg	Slope	Va	Ta(mS)	Slope	Vb	Tb(mS)
1	0.00050	2000	-0.000	0.00050	2000	-0.000
2	0.00015	6579	28.800	0.00016	6205	27.733
3	0.00008	12411	54.533	0.00008	13158	58.933

CALCULATED MODEL

LAYER	VELOCITY	DIP	Ha	Hb	Da	Db
1	2000	0.00	30.3	29.2	0.0	0.0
2	6386	0.55	90.7	111.1	30.3	29.2
3	12758	-2.43			121.1	140.3

Profile: kane 26 - 27

INPUT DATA

	FORWARD PROFILE			REVERSE PROFILE		
Seg	Slope	Va	Ta(mS)	Slope	Vb	Tb(mS)
1	0.00050	2000	-0.000	0.00050	2000	-0.000
2	0.00015	6667	29.000	0.00018	5556	21.333
3	0.00007	13462	48.857	0.00007	13462	42.810

CALCULATED MODEL

LAYER	VELOCITY	DIP	Ha	Hb	Da	Db
1	2000	0.00	30.7	22.6	0.0	0.0
2	6058	1.82	62.9	69.6	30.7	22.6
3	13391	-4.31			93.6	92.3

Profile: kane 49b - 48a

INPUT DATA

	FORWARD PROFILE			REVERSE PROFILE		
Seg	Slope	Va	Ta(mS)	Slope	Vb	Tb(mS)
1	0.00040	2500	0.000	0.00040	2500	0.000
2	0.00015	6667	13.750	0.00012	8000	25.000
3	0.00008	12715	25.220	0.00007	14177	34.018

CALCULATED MODEL

LAYER	VELOCITY	DIP	Ha	Hb	Da	Db
1	2500	0.00	18.3	33.3	0.0	0.0
2	7269	-1.91	46.9	34.0	18.3	33.3
3	13368	2.58			65.2	67.3

Profile: kane 50b - 49a

INPUT DATA

	FORWARD PROFILE			REVERSE PROFILE		
Seg	Slope	Va	Ta(mS)	Slope	Vb	Tb(mS)
1	0.00040	2500	0.000	0.00040	2500	-0.000
2	0.00015	6667	8.750	0.00017	5714	11.250
3	0.00007	13614	20.830	0.00006	16800	30.116
4	0.00004	25000	40.250	0.00004	25000	41.250

CALCULATED MODEL

LAYER	VELOCITY	DIP	Ha	Hb	Da	Db
1	2500	0.00	12.0	15.4	0.0	0.0
2	6150	1.96	38.6	61.0	12.0	15.4
3	14914	-5.98	174.0	91.9	50.6	76.4
4	24660	2.85			224.6	168.3

Profile: kane 51b - 50a

INPUT DATA

	FORWARD PROFILE			REVERSE PROFILE		
Seg	Slope	Va	Ta(mS)	Slope	Vb	Tb(mS)
1	0.00040	2500	0.000	0.00040	2500	0.000
2	0.00013	7407	11.000	0.00015	6667	10.000
3	0.00007	14865	21.359	0.00006	15601	23.844

CALCULATED MODEL

LAYER	VELOCITY	DIP	Ha	Hb	Da	Db
1	2500	0.00	14.7	13.4	0.0	0.0
2	7016	1.15	38.6	52.6	14.7	13.4
3	15185	-3.16			53.3	66.0

Profile: kane 52ab - 51a

INPUT DATA

	FORWARD PROFILE			REVERSE PROFILE		
Seg	Slope	Va	Ta(mS)	Slope	Vb	Tb(mS)
1	0.00042	2381	0.000	0.00040	2500	-0.000
2	0.00013	7692	14.667	0.00016	6250	7.000
3	0.00007	14672	23.747	0.00007	15308	20.416

CALCULATED MODEL

LAYER	VELOCITY	DIP	Ha	Hb	Da	Db
1	2440	0.00	19.2	9.1	0.0	0.0
2	6891	2.24	32.3	50.9	19.2	9.1
3	14861	-5.46			51.4	60.0

Profile: kane 29b - 28 repeat

INPUT DATA

	FORWARD PROFILE			REVERSE PROFILE		
Seg	Slope	Va	Ta(mS)	Slope	Vb	Tb(mS)
1	0.00040	2500	0.000	0.00040	2500	0.000
2	0.00015	6667	19.167	0.00020	5000	1.667
3	0.00008	11915	32.857	0.00008	12766	29.358

CALCULATED MODEL

LAYER	VELOCITY	DIP	Ha	Hb	Da	Db
1	2500	0.00	26.7	2.3	0.0	0.0
2	5700	3.99	38.8	89.6	26.7	2.3
3	12127	-7.20			65.5	92.0

Profile: kane 30b - 29a

INPUT DATA

	FORWARD PROFILE			REVERSE PROFILE		
Seg	Slope	Va	Ta(mS)	Slope	Vb	Tb(mS)
1	0.00040	2500	-0.000	0.00040	2500	0.000
2	0.00015	6667	22.917	0.00016	6154	18.958
3	0.00008	13038	38.629	0.00008	12903	36.250

CALCULATED MODEL

LAYER	VELOCITY	DIP	Ha	Hb	Da	Db
1	2500	0.00	31.1	25.7	0.0	0.0
2	6399	0.97	52.3	59.0	31.1	25.7
3	12958	-1.67			83.4	84.8

Profile: kane 31b - 30a

INPUT DATA

	FORWARD PROFILE			REVERSE PROFILE		
Seg	Slope	Va	Ta(mS)	Slope	Vb	Tb(mS)
1	0.00040	2500	0.000	0.00040	2500	0.000
2	0.00014	7273	26.042	0.00017	5714	19.167
3	0.00006	16812	41.345	0.00005	18616	42.736

CALCULATED MODEL

LAYER	VELOCITY	DIP	Ha	Hb	Da	Db
1	2500	0.00	35.4	26.1	0.0	0.0
2	6392	2.92	45.9	76.3	35.4	26.1
3	17474	-6.19			81.3	102.4

Profile: kane 32 - 31a2

INPUT DATA

	FORWARD PROFILE			REVERSE PROFILE		
Seg	Slope	Va	Ta(mS)	Slope	Vb	Tb(mS)
1	0.00035	2857	0.000	0.00035	2857	-0.000
2	0.00014	7067	22.675	0.00017	5714	16.417
3	0.00007	15284	48.842	0.00008	12389	35.714

CALCULATED MODEL

LAYER	VELOCITY	DIP	Ha	Hb	Da	Db
1	2857	0.00	36.4	26.3	0.0	0.0
2	6310	3.08	85.2	62.9	36.4	26.3
3	13649	-1.30			121.6	89.3

LINE 8

Profile: kane 57a - 56a

INPUT DATA

	FORWARD PROFILE			REVERSE PROFILE		
Seg	Slope	Va	Ta(mS)	Slope	Vb	Tb(mS)
1	0.00040	2500	0.000	0.00040	2500	0.000
2	0.00015	6557	9.833	0.00014	7273	15.950
3	0.00006	15455	26.643	0.00007	14291	27.418

CALCULATED MODEL

LAYER	VELOCITY	DIP	Ha	Hb	Da	Db
1	2500	0.00	13.2	21.4	0.0	0.0
2	6895	-1.15	63.4	41.2	13.2	21.4
3	14805	3.57			76.6	62.6

Profile: kane 71a - 70a

INPUT DATA

	FORWARD PROFILE			REVERSE PROFILE		
Seg	Slope	Va	Ta(mS)	Slope	Vb	Tb(mS)
1	0.00040	2500	0.000	0.00040	2500	0.000
2	0.00016	6250	6.375	0.00018	5405	7.625
3	0.00006	16390	33.363	0.00007	13861	36.214

CALCULATED MODEL

LAYER	VELOCITY	DIP	Ha	Hb	Da	Db
1	2500	0.00	8.8	10.6	0.0	0.0
2	5794	1.99	82.9	87.6	8.8	10.6
3	15002	-0.93			91.7	98.1

Profile: kane 70b - 69a

INPUT DATA

	FORWARD PROFILE			REVERSE PROFILE		
Seg	Slope	Va	Ta(mS)	Slope	Vb	Tb(mS)
1	0.00040	2500	0.000	0.00040	2500	0.000
2	0.00027	3636	2.500	0.00019	5333	18.958
3	0.00006	16296	47.295	0.00007	14907	44.396

CALCULATED MODEL

LAYER	VELOCITY	DIP	Ha	Hb	Da	Db
1	2500	0.00	3.9	29.4	0.0	0.0
2	4285	-7.74	99.4	47.5	3.9	29.4
3	15230	6.74			103.3	77.0

Profile: kane 69b - 68a

INPUT DATA

	FORWARD PROFILE			REVERSE PROFILE		
Seg	Slope	Va	Ta(mS)	Slope	Vb	Tb(mS)
1	0.00040	2500	0.000	0.00040	2500	0.000
2	0.00014	7143	25.500	0.00012	8589	21.524
3	0.00004	24526	52.039	0.00006	17391	46.000

CALCULATED MODEL

LAYER	VELOCITY	DIP	Ha	Hb	Da	Db
1	2500	0.00	33.7	28.4	0.0	0.0
2	7796	-1.78	108.2	100.2	33.7	28.4
3	20059	8.31			141.9	128.6

Profile: kane 75a - 74a

INPUT DATA

	FORWARD PROFILE			REVERSE PROFILE		
Seg	Slope	Va	Ta(mS)	Slope	Vb	Tb(mS)
1	0.00040	2500	0.000	0.00040	2500	0.000
2	0.00015	6707	7.589	0.00015	6627	10.625
3	0.00008	12389	36.786	0.00008	13333	43.750

CALCULATED MODEL

LAYER	VELOCITY	DIP	Ha	Hb	Da	Db
1	2500	0.00	10.2	14.3	0.0	0.0
2	6667	0.14	112.2	126.8	10.2	14.3
3	12839	-1.56			122.4	141.2

Profile: kane 74b - 73b

INPUT DATA

	FORWARD PROFILE			REVERSE PROFILE		
Seg	Slope	Va	Ta(mS)	Slope	Vb	Tb(mS)
1	0.00040	2500	0.000	0.00040	2500	0.000
2	0.00015	6707	13.080	0.00014	7044	8.080
3	0.00008	12281	39.750	0.00008	12903	39.500

CALCULATED MODEL

LAYER	VELOCITY	DIP	Ha	Hb	Da	Db
1	2500	0.00	17.6	10.8	0.0	0.0
2	6871	-0.55	106.6	127.1	17.6	10.8
3	12583	0.29			124.1	138.0

Profile: kane 72 - 73a estimate
(Segment three slopes were not observed on the records. A minimum depth value was estimated using a segment three slope taken from KANE74B73B and placed at the end of the observed data line).

INPUT DATA

	FORWARD PROFILE			REVERSE PROFILE		
Seg	Slope	Va	Ta(mS)	Slope	Vb	Tb(mS)
1	0.00040	2500	0.000	0.00040	2500	-0.000
2	0.00014	7380	8.585	0.00014	7166	5.448
*3	0.00008	12500	43.000	0.00008	12500	43.000

*segment three is estimated

CALCULATED MODEL

LAYER	VELOCITY	DIP	Ha	Hb	Da	Db
1	2500	0.00	11.4	7.3	0.0	0.0
2	7271	0.31	152.2	166.8	11.4	7.3
*3	12498	-0.77			163.6	174.1

*Layer three velocities are estimates, depths are minimum estimates.

Profile: kane 78 - 76 repeat

INPUT DATA

	FORWARD PROFILE			REVERSE PROFILE		
Seg	Slope	Va	Ta(mS)	Slope	Vb	Tb(mS)
1	0.00040	2500	0.000	0.00040	2500	-0.000
2	0.00013	7705	16.818	0.00015	6799	9.782
3	0.00006	17857	67.400	0.00006	17500	64.048
4	0.00004	22436	77.752	0.00004	28226	82.686

CALCULATED MODEL

LAYER	VELOCITY	DIP	Ha	Hb	Da	Db
1	2500	0.00	22.4	13.0	0.0	0.0
2	7221	1.32	196.7	212.8	22.4	13.0
3	17640	-2.56	101.6	205.4	219.1	225.9
4	24713	-9.49			320.7	431.3

Profile: kane 79 - 80

INPUT DATA

	FORWARD PROFILE			REVERSE PROFILE		
Seg	Slope	Va	Ta(mS)	Slope	Vb	Tb(mS)
1	0.00040	2500	0.000	0.00040	2500	0.000
2	0.00012	8550	23.304	0.00014	7018	18.500
3	0.00007	14815	44.250	0.00008	11915	35.714

CALCULATED MODEL

LAYER	VELOCITY	DIP	Ha	Hb	Da	Db
1	2500	0.00	30.8	24.5	0.0	0.0
2	7704	1.93	95.2	78.3	30.8	24.5
3	13191	-0.81			126.0	102.8

LINE 11

Profile: kane 82b - 81

INPUT DATA

	FORWARD PROFILE			REVERSE PROFILE		
Seg	Slope	Va	Ta(mS)	Slope	Vb	Tb(mS)
1	0.00040	2500	0.000	0.00040	2500	-0.000
2	0.00015	6637	8.356	0.00015	6568	6.121
3	0.00009	11628	40.800	0.00008	12500	48.000

CALCULATED MODEL

LAYER	VELOCITY	DIP	Ha	Hb	Da	Db
1	2500	0.00	11.3	8.3	0.0	0.0
2	6603	0.12	126.2	164.0	11.3	8.3
3	12043	-1.61			137.5	172.3

Profile: kane 83a - 82a

INPUT DATA

	FORWARD PROFILE			REVERSE PROFILE		
Seg	Slope	Va	Ta(mS)	Slope	Vb	Tb(mS)
1	0.00040	2500	0.000	0.00040	2500	0.000
2	0.00016	6061	13.000	0.00021	4706	-0.625
3	0.00009	10686	32.111	0.00011	9385	25.952

CALCULATED MODEL

LAYER	VELOCITY	DIP	Ha	Hb	Da	Db
1	2500	0.00	18.5	-0.9	0.0	0.0
2	5286	3.86	55.6	83.3	18.5	-0.9
3	9930	-3.18			74.1	82.4

Profile: kane 84 - 85

INPUT DATA

	FORWARD PROFILE			REVERSE PROFILE		
Seg	Slope	Va	Ta(mS)	Slope	Vb	Tb(mS)
1	0.00040	2500	0.000	0.00040	2500	0.000
2	0.00017	5714	8.750	0.00016	6349	17.250
3	0.00009	11215	25.708	0.00007	13333	43.750

CALCULATED MODEL

LAYER	VELOCITY	DIP	Ha	Hb	Da	Db
1	2500	0.00	12.0	23.7	0.0	0.0
2	6013	-1.38	56.3	87.1	12.0	23.7
3	12179	-0.45			68.4	110.8