ALTERNATIVE METHODS FOR GEOGRAPHIC POSITIONING OF WATER WELLS IN THE MISSISSIPPI DELTA

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INTRODUCTION

Accurate well locations are essential for management and planning of regional water resources. Well location is a required component of a Mississippi water use permit. Well locations are also used in the development of alternative water supplies and may be used in upcoming aquifer modeling efforts. Good accuracy of well locations will improve the quality of these types of projects. Recent improvements in Global Positioning Systems (G.P.S.) have made it a practical and affordable tool for water resource managers.

The latitude and longitude of well sites can be easily determined, to within a few feet, using G.P.S. The simplest way to obtain this high degree of accuracy is to place the G.P.S. antenna at the well. This is not always practical.

The following factors prompted the consideration of an alternative geographic positioning method for locating water wells:

A large number of irrigation wells are located on unpaved roads which are not passable during inclement weather.

A trend in farming practices to irrigate less acreage from a well has increased the number of wells being permitted.

There is a need to maintain a high degree of accuracy with limited resources.

YMD must meet the standards for the degree of accuracy required by other agencies.

There is a need to update the permit database in a timely fashion.

The Mississippi Delta has approximately 80% of the permitted wells in the state of Mississippi. An alternative method of geographic positioning is needed to allow for year-round determinations of the location of water wells without sacrificing accuracy.

MATERIALS AND METHODS

Four methods for obtaining well latitude and longitude were evaluated. These were:

1) G.P.S. with post processing,
2) Plotting on USGS 7.5 minute quadrangle maps,
3) Bearing and distance from a known latitude and longitude,
4) Bearing and bearing intersection from two known latitudes and longitudes.

To compare these methods, fifteen wells on the USGS Leland 7.5 minute quadrangle map were selected because they were typical of well locations throughout the Mississippi Delta and were close to a control point (Figure 1). The latitude and longitude of the control point monument were obtained from the National Geodetic Survey. The fifteen well locations, control point, and observation points were occupied, during ideal conditions, with a Trimble Pathfinder Basic Plus rover unit operating in the 3-D mode. A minimum of 180 fixes were collected on each location with a PDOP of 3.5 or less. The field data was differentially corrected and averaged using PFINDER software. The G.P.S. determined location of the control monument was differed by 1.97 feet in latitude and 0.66 feet in longitude from the published location. The G.P.S. locations were considered to be the most accurate and dependable and were used for comparing locations obtained from other methods.

The fifteen well locations, the control point, and 7 observation points were plotted as accurately as possible on the quadrangle map. Using a Topographic-Aid, the NAD1927 latitude and longitude was determined for each location, then converted to NAD1983 using CORPSCON software. These results were then compared to the G.P.S. results yielding approximately a 2 second accuracy (Table 1).

An alternative method was to locate a position on an improved road near each well and occupy the road site with a G.P.S. rover for a minimum of 180 fixes. An

azimuth to the well was obtained using a SILVA Site Master compass and converted to a true bearing. At the same time and location, a distance from the occupied point on the improved road to the well was obtained using a RANGEMATIC 1200 rangefinder (Figure 2A). The accuracy of the RANGEMATIC 1200 is ± 3.3 feet at 328, ± 30 feet at 984 feet, and ± 328 feet at 3280 feet. The distances between the wells and the observation points were obtained from the quad map and distances were used to calibrate the rangefinder. Distances of 600 feet and 2000 feet were used to calibrate the rangefinder since these distances were commonly encountered in the test. The position of the well was computed using the bearing and distance on Hayes COGO-PLOT, Version 7.23, and then was compared to the position determined by the G.P.S. rover (Table 2).

A third method evaluated used two G.P.S. located positions on an improved road and an azimuth to the well from each G.P.S. road locations (Figure 2B). A well position was calculated from a bearing-bearing intersection using Hayes COGO-PLOT, Version 7.23. These calculations were then compared to the position determined by the G.P.S. rover (Table 3).

RESULTS AND DISCUSSIONS

Results comparing locations on fifteen wells are shown on Tables 1, 2, and 3. Table 1 compares the plotted positions to the G.P.S. rover positions. An accuracy of ± 100 feet, or about 2 seconds, can be obtained by careful plotting on quadrangle maps.

Table 2 compares bearing-distance calculated positions to the G.P.S. rover positions. The bearing-distance method, as applied with this equipment, does not appear to be an acceptable method to locate wells. Location errors in excess of 1000 feet are common and are not acceptable.

The rangefinder manual indicates the rangefinder will not remain in calibration if a temperature change of ± 10°C occurs. The typical Spring day in the Delta starts at about 7°C and rises to around 21°C. The large location errors indicate that recalibration several times during this type of weather is a must. This is very time consuming and suggests that this type of range finder is not a practical tool to assist in well location determination.

Table 3 compares bearing-bearing intersection to the G.P.S. rover positions. The comparison shows less error than the bearing-distance method, but the bearing-bearing method is not as accurate as simply plotting the well on a quad map. By surveying theory, the bearing-bearing intersection method is very accurate. Considerable error is introduced into this method because bearings must be referenced to compass readings. To complicate matters, the SILVA Site Master compass is susceptible to magnetic interference from steel objects, electrical equipment, electric wrist watches, and even steel-framed spectacles. The magnetic bearings were converted to true bearings since the G.P.S. calculations are true or grid. Also, some irrigation wells in the Delta are at a great distance from the closest road which increases the location error resulting from a small bearing error. The impact of bearing errors is compounded by the fact that two magnetic bearings were used, increasing the error or difference between the calculated and the known point. This method is closer to the G.P.S. locations than the bearing-distance method.

CONCLUSION

Based on the results of the comparison of the methods evaluated in this paper, no good substitute for placing a G.P.S. at a well site was found. Errors associated with the bearing-distance and bearing-bearing methods referenced to known points are larger than careful plotting on quad maps.

Higher quality (more precise) compasses and rangefinders should improve the performance of the methods requiring their use, but could also be much slower to operate.

TABLE 1. COMPARISON OF WELL LOCATIONS PLOTTED ON QUAD MAP TO G.P.S. ROVER LOCATIONS

POINT I.D.	PLOTTED POSITION LATITUDE D M S	PLOTTED POSITION LONGITUDE D M S	G.P.S. POSITION LATITUDE D M S	G.P.S. POSITION LONGITUDE D M S	DIFFERENCE BETWEEN PLOTTED POSITION AND G.P.S. POSITION FEET NORTHING	EASTING
SAT.TRI.STA.	33 25 01	90 54 38	33 25 00.860	090 54 38.538	56.554	15.034
OBS.PT. 18B	33 25 00	90 54 37	33 24 58.973	090 54 37.317	234.826	2.707
OBS.PT. 18C	33 24 53	90 54 26	33 24 51.539	090 54 26.778	189.985	36.152
WELL 18D	33 24 53	90 54 12	33 24 52.179	090 54 12.669	125.357	26.599
OBS.PT. 19A	33 25 03	90 54 12	33 25 03.931	090 54 11.677	51.287	58.455
WELL 19B	33 25 03	90 54 24	33 25 01.138	090 54 24.613	230.576	22.397
WELL 19D	33 25 15	90 54 13	33 25 17.287	090 54 12.229	188.160	97.176
WELL 19E	33 25 14	90 54 27	33 25 13.352	090 54 28.747	107.316	117.828
WELL 19F	33 24 59	90 54 49	33 24 56.867	090 54 49.460	258.032	9.511
WELL 20A	33 24 54	90 55 02	33 24 52.640	090 55 01.207	180.499	97.174
OBS.PT. 20B	33 24 48	90 54 46	33 24 46.905	090 54 43.991	154.303	200.355
WELL 20C	33 26 22	90 54 43	33 26 22.229	090 54 39.951	20.789	289.145
WELL 20D	33 26 22	90 54 33	33 26 22.569	090 54 31.977	57.031	87.012
WELL 20F	33 26 22	90 54 23	33 26 22.135	090 54 23.273	13.773	23.060
WELL 20G	33 26 30	90 53 50	33 26 29.610	090 53 50.329	39.268	28.094
WELL 20H	33 26 23	90 53 38	33 26 21.782	090 53 39.336	122.498	113.882
WELL 20I	33 26 24	90 53 54	33 26 23.554	090 53 54.716	44.750	60.922
WELL 21A	33 25 52	90 54 22	33 25 51.051	090 54 20.581	96.581	152.735
SHED WELL	33 26 32	90 54 15	33 26 30.324	090 54 15.565	169.137	48.809
KENAF WELL	33 26 07	90 54 05	33 26 07.691	090 53 59.578	67.338	459.884
OBS.PT. 1	33 26 08	90 54 17	33 26 07.221	090 54 16.357	79.036	54.060
OBS.PT. 2	33 26 40	90 54 09	33 26 40.419	090 54 09.363	42.481	30.524
OBS.PT. 3	33 25 57	90 54 31	33 25 56.649	090 54 30.134	35.883	73.197

TABLE 2. COMPARISON OF G.P.S. ROVER LOCATIONS TO BEARING-DISTANCE LOCATIONS
*(Mississippi West Zone State Plane Coordinates In Feet)

POINT I.D.	G.P.S. COORDINATES*		BEARING-DISTANCE INTERSECTION COORDINATES*		DIFFERENCE BETWEEN G.P.S. AND BEARING-DISTANCE INTERSECTION FEET	
	NORTHING	EASTING	NORTHING	EASTING	NORTHING	EASTING
OBS. PT. 1	1431970.8310	2122320.4480				
OBS. PT. 2	1435323.0640	2122931.5280				
OBS. PT. 3	1430908.6910	2121147.0130				
OBS. PT. 18B	1425082.4130	2120505.9300				
OBS. PT. 18C	1424326.0740	2121395.1020				
OBS. PT. 19A	1425571.5660	2122682.0000				
OBS. PT. 20B	1423965.7740	2119933.4340				
WELL 21A	1430338.4010	2121953.4910	1424754.9022	2117087.9296	5583.4988	4865.5614
KENAF WELL	1432010.5570	2123742.6370	1425809.7069	2119244.0157	6200.8501	4498.6213
WELL 20C	1433498.8270	2120329.4130	1425417.8623	2119442.0206	8080.9647	887.3924
WELL 20D	1433529.4450	2121005.3240	1425871.5412	2117660.4256	7657.9038	3344.8984
WELL 20F	1433481.5040	2121742.6640	1426814.0511	2121295.0829	6667.4529	447.5811
SHED WELL	1434305.6220	2122400.3900	1427382.0963	2122846.1047	6923.5257	445.7147
WELL 2OI	1433561.9170	2124188.4480	1430260.8936	2122055.1914	3301.0234	2133.2566
WELL 20G	1434221.7810	2124538.4560	1432018.0686	2124124.3796	2203.7124	414.0764
WELL 20H	1433425.5180	2125465.7170	1434468.6811	2118079.9401	1043.1631	7385.7769
WELL 20A	1424453.5960	2118477.3490	1434229.3224	2119940.4947	9775.7264	1463.1457
WELL 19F	1424875.2730	2119475.4640	1433612.9016	2121572.1133	8737.6286	2096.6493
WELL 19B	1425295.2870	2121583.9660	1434101.6700	2124815.3400	8806.3830	3231.3740
WELL 18D	1424384.1850	2122591.4060	1434091.8271	2126394.8436	9707.6421	3803.4376
WELL 19E	1426531.7600	2121240.3780	1433657.8306	2125758.5333	7126.0706	4518.1553
WELL 19D	1426921.7890	2122642.6090	1434146.5929	2122152.8387	7224.8039	489.7703

TABLE 3. COMPARISON OF G.P.S. ROVER LOCATIONS TO BEARING-BEARING INTERSECTION LOCATIONS
* (Mississippi West Zone State Plane Coordinates in Feet)

POINT I.D.	G.P.S. COORDINATES*		BEARING-BEARING INTERSECTION COORDINATES*		DIFFERENCE BETWEEN G.P.S AND BEARING-BEARING INTERSECTION FEET	
	NORTHING	EASTING	NORTHING	EASTING	NORTHING	EASTING
OBS. PT. 1	1431970.8310	2122320.4480				
OBS. PT. 2	1435323.0640	2122931.5280				
OBS. PT. 3	1430908.6910	2121147.0130				
OBS. PT. 18B	1425082.4130	2120505.9300				
OBS. PT. 18C	1424326.0740	2121395.1020				
OBS. PT. 19A	1425571.5660	2122682.0000				
OBS. PT. 20B	1423965.7740	2119933.4340				
WELL 21A	1430338.4010	2121953.4910	1430367.4617	2121905.7885	29.0607	47.7025
KENAF WELL	1432010.5570	2123742.6370	1431994.7344	2123233.2830	15.8226	509.3540
WELL 20C	1433498.8270	2120329.4130	1433347.1453	2119983.9300	151.6817	345.4830
WELL 20D	1433529.4450	2121005.3240	1433495.1080	2120714.1952	34.3370	291.1288
WELL 20F	1433481.5040	2121742.6640	1433229.2974	2121746.9318	252.2066	4.2678
SHED WELL	1434305.6220	2122400.3900	1434194.3545	2122184.4515	111.2675	215.9385
WELL 2OI	1433561.9170	2124188.4480	1433662.1258	2124300.6998	100.2088	112.2518
WELL 20G	1434221.7810	2124538.4560	1434322.0232	2124630.9581	100.2422	92.5021
WELL 20H	1433425.5180	2125465.7170	1433653.3262	2125552.4913	227.8082	86.7743
WELL 20A	1424453.5960	2118477.3490	1424289.5129	2118766.0694	164.0831	288.7204
WELL 19F	1424875.2730	2119475.4640	1424879.7369	2119591.7173	4.4639	116.2533
WELL 19B	1425295.2870	2121583.9660	1425337.6657	2121315.4880	42.3787	268.4780
WELL 18D	1424384.1850	2122591.4060	1424474.5140	2122697.9430	90.3290	106.5370
WELL 19E	1426531.7600	2121240.3780	1426834.0781	2121304.2098	302.3181	63.8318
WELL 19D	1426921.7890	2122642.6090	1427127.3233	2122586.8458	205.5343	55.7632

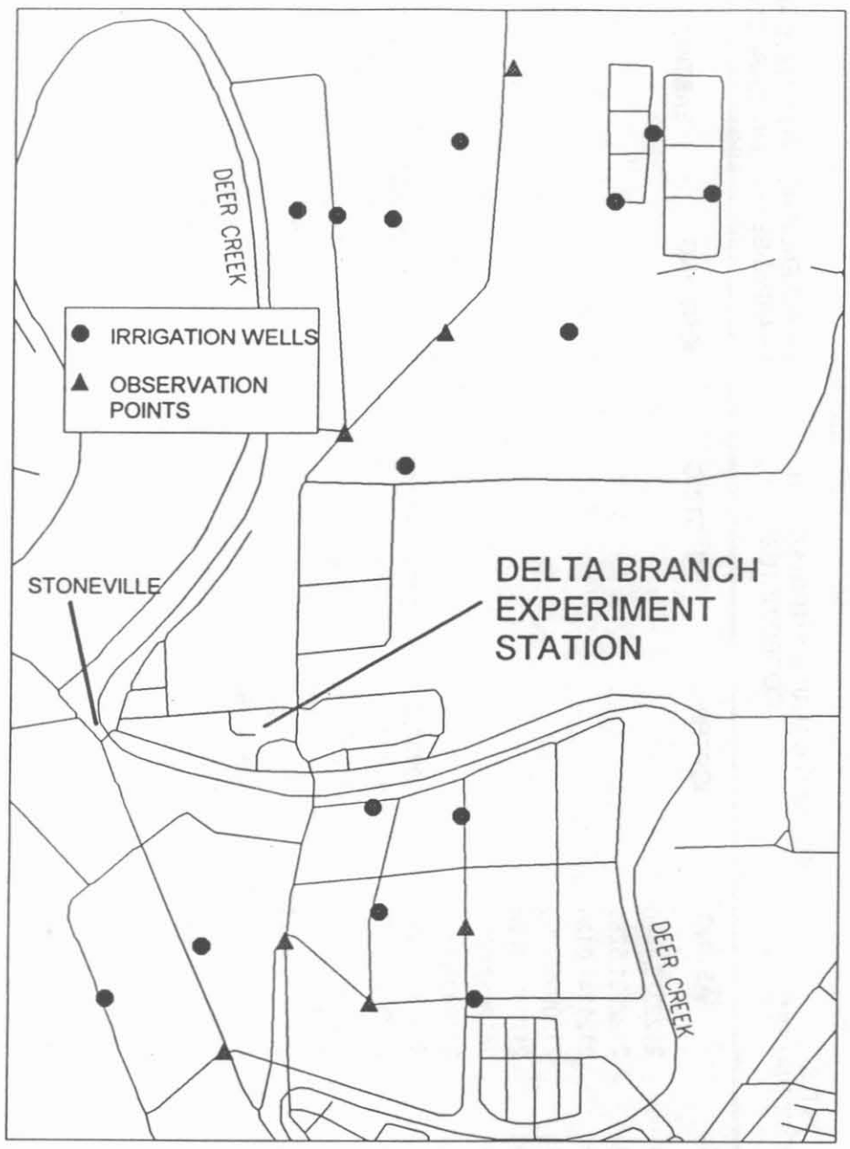

Figure 1. Site locations of study area.

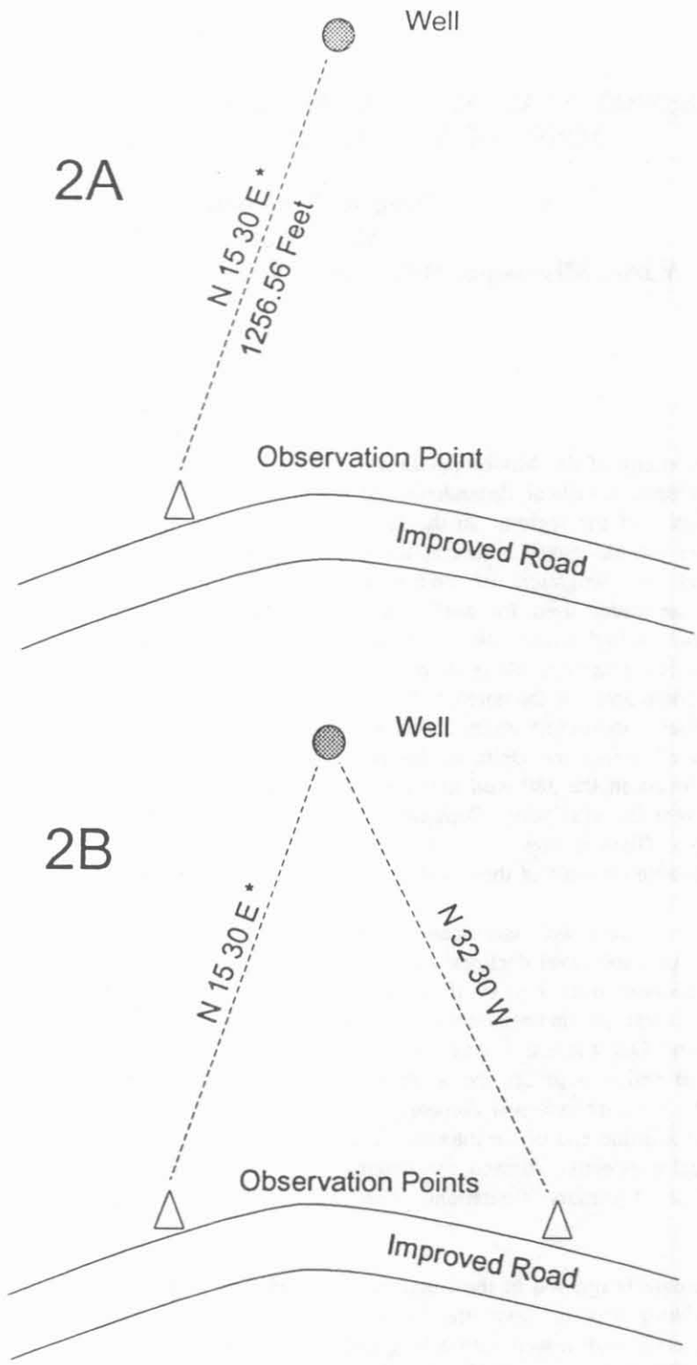

Figure 2. Alternative well locating methods. Figure 2A shows the bearing-distance method. Figure 2B shows the bearing-bearing intersection method.