

# REPORT ON THE POSSIBILITY OF SUBSTITUTION OF COORDINATES FOR MONUMENTS IN CONTROL SURVEY PRESERVATION

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TECHNICAL REPORT NUMBER 59

**REPORT ON THE POSSIBILITY OF  
SUBSTITUTION OF COORDINATES FOR MONUMENTS  
IN CONTROL SURVEY PRESERVATION**

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November 1, 2017

## STATEMENT OF EXECUTIVE DIRECTOR

As noted in the introductory section of this report, the Commission in 1961 introduced the use of the State Plane Coordinate System within the Region for the conduct of land and engineering surveys, and as the basis for the creation of a survey control system within the Region. That system requires the remonumentation of the U.S. Public Land Survey System (USPLSS) corners within the Region and the determination of State Plane Coordinates for these corners.

The recommended survey control system not only provides the basis for the conduct of land and engineering surveys, but also provides the basis for the preparation of large scale topographic and cadastral maps. It also provides one of the foundational elements for the land information and public works management systems being created within the Region at the county and municipal levels of government.

Through the cooperative efforts of the county and municipal governments in the Region, the Commission-recommended survey control system has been completed, and the coordinate positions of the remonumented corners of the USPLSS within the Region have been determined to a high level of accuracy. This availability of coordinate values for the remonumented USPLSS has raised a question among land surveyors, public works engineers, and land information system managers as to whether or not a need still exists for the maintenance of the monuments marking the corners of USPLSS within the Region, or whether coordinates can replace the use of monumentation to perpetuate the USPLSS. The answer to this question will affect not only the preservation of the USPLSS within the Region, but the continued utility of the existing survey control network, and the certainty and stability of real property boundary corners and lines within the Region. The question, therefore, deserves careful consideration not only of the professions directly concerned, but also by landowners, developers, and elected officials—particularly such officials at the county level. Eventually, the question will have to be addressed by the courts as those institutions continue to formulate the common law.

This report is intended to help all those concerned with answering that question. Based upon the legal, technical, and miscellaneous considerations presented in this report, it may be concluded that the Commission and its constituent counties should continue to maintain the monumentation marking the stations—USPLSS corners—of the regional survey control system.

Respectfully submitted,

*Michael G. Hahn*

Michael G. Hahn  
Executive Director

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# **TECHNICAL REPORT NO. 59**

## **REPORT ON THE POSSIBILITY OF SUBSTITUTION OF COORDINATES FOR MONUMENTS IN CONTROL SURVEY PRESERVATION**

### **INTRODUCTION**

Since 1961, the Regional Planning Commission has promoted the use within Southeastern Wisconsin of a unique system of survey control as a basis for the compilation of large scale topographic and cadastral maps, as a basis for the conduct of land and engineering surveys, and as a basis for the development of county and municipal automated land information and public works management systems. The recommended survey control system requires the remonumentation of the U.S. Public Land Survey System (USPLSS) corners and the establishment of State Plane Coordinates for these corners. It also requires the establishment of an attendant bench mark for each corner monument, with an elevation established for both the monument and the attendant bench mark. Through the cooperative efforts of the Commission and its constituent counties and municipalities, the recommended survey control system has been completed within the entire seven-county Region. All of the 11,753 USPLSS corners within the Region have been remonumented, and the coordinate positions of the remonumented corners determined to a high level of accuracy. The completed survey control network provides a monumented station of known coordinate position and a bench mark of known elevation at an approximately half mile spacing throughout the entire seven-county Region.

The Commission has, since 1984, provided county surveyor services to Milwaukee County, since 1999 to Walworth County, since 2000 to Waukesha County, since 2006 to Kenosha County, and since 2012 to Ozaukee County. The county surveyor services specifically include the replacement of any monuments marking USPLSS corners that have, for any reason, been disturbed or destroyed.

Typically, about 160 corner monuments are replaced annually within the five counties concerned. This represents a loss rate of about two percent per year. The monument replacement work is provided as an integral part of a broader survey control system maintenance service. This broader service includes the maintenance of elevation bench marks attendant to the corner monuments, the maintenance of ancillary witness corners, the tie distances to the bench marks and witness corners, and the attendant documentation, in particular, the maintenance of the “Record of U.S. Public Land Survey Control Station,” forms—the so-called “dossier sheets”—and the survey control summary diagrams. An example of a typical dossier sheet and an example of a typical control survey summary diagram are appended as Figures 1 and 2. The type of monument and monument installation used by the Commission in providing county surveyor services is shown on Figure 3.

The Commission-recommended survey control system introduced the use of the State Plane Coordinate System within the Region for map preparation and for the conduct of land and engineering surveys. Even though the Federal Government created the State Plane Coordinate System in 1933, and thereafter promulgated its use nationally, the System was not used within the Region—not even by such technically sophisticated engineering organizations as

the State Highway Commission of Wisconsin—the predecessor agency to the Wisconsin Department of Transportation—until the Commission introduced the System in 1961.

The State Plane Coordinate System—together with other coordinate systems—is now routinely used within the Region in the preparation of large-scale topographic and cadastral maps, in the conduct of land and engineering surveys by both public and private practitioners, and as one of the foundational elements of the land information and public works management systems being created within the Region. The use of coordinates has been greatly facilitated by the availability in about the mid-1990s of Global Positioning System (GPS) survey technology.

In the creation of the Commission recommended survey control system, State Plane Coordinate positions are established to a specified accuracy standard for all of the USPLSS corners within the Region. Therefore, some land information system managers, some directors of public works, and some land surveyors within the Region and the State have questioned the need for the continued maintenance of the monuments marking the locations of the USPLSS corners. The Commission, for the reasons documented herein, believes that the maintenance of the monuments marking the USPLSS corners—which corners comprise the stations of the survey control system within the Region—is essential for the very existence of the System as a useful survey control system within the Region. The reasons for the Commission position may be presented under three classifications: legal considerations; technical considerations; and miscellaneous considerations.

## LEGAL CONSIDERATIONS

The ownership of real property is one of the most important rights of a citizen of a free and democratic society. The fundamental purpose of the profession of land surveying is to enable citizens to exercise this right by identifying on the surface of the earth the location and boundaries of real property ownership. Because of the importance of this fundamental purpose to society, the practice of land surveying is regulated by government. That practice, whether dealing with the retracement of existing land ownership parcels, or with the creation of new parcels, must be carried out in accordance with applicable law—both statutory and common. Among other tenets, the law requires that the practice of the profession be carried out in accordance with long standing rules of evidence and procedure. The rules of evidence include the ‘order of importance’ to be given to certain types of evidence indicative of the location of land boundary corners and lines. That order may be given as it was by a Wisconsin Court as:

The priority of calls is, first, the natural monuments to which it [the deed] refers; second, the artificial monuments the surveyor places to mark the boundaries; and, third, the courses and distances marked on the plat or survey.<sup>1</sup>

The common law in the State of Wisconsin does not currently include coordinate values in this order of importance. This order of importance of evidence is also known as the ‘order of conflicting elements’ or the ‘priority of calls,’ and is often used to resolve discrepancies between legal descriptions of property and the on-the-ground location of that property as represented by in-place monumentation.

The priority of calls in a conflicted legal description are simply a sub-set of the ‘rules of construction’ that the courts have developed over the years for the interpretation deeds and other written documents when they are internally conflicting (patently ambiguous) or, especially in the case of deeds, when they conflict with the facts on the ground (latently ambiguous). The facts on the ground, known as ‘extrinsic evidence,’ must also be considered for the correct interpretation of a deed or even dossier sheets, that, like deeds, are simply an attempt to describe the on-the-

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<sup>1</sup> *Gilbert v. Geiger*, 747 N.W.2d 188, 194 (Wisc.App.2008).

ground location of land boundaries. The Wisconsin Supreme Court discussed the importance of extrinsic evidence in the case of *Miller v. Lavelle*:

In ascertaining the true location of the streets, lots, and blocks in a city, according to the plat and survey thereof [written documents], regard is to be had (1) to the natural monuments referred to therein, and (2) to the artificial monuments placed by the surveyor to mark lines or boundaries, before resorting to the courses and distances marked on the plat or survey.

Thus, courses and distances in this classification come third in order of certainty, but it is not intended to lay down a rule of law that courses and distances shall, in all cases, overcome every other species of evidence with reference to location except natural or artificial monuments.

The rules by which the lines of such plats are to be ascertained are well settled. In the absence of natural boundaries or monuments, and of monuments or stakes set in the course of the original survey, the lines of ancient fences and long-continued occupation of adjacent lots and blocks in the same plat, if evidently intended to mark the true lines of such lots and blocks, have greater probative force than mere measurements of courses and distances.<sup>2</sup>

In other words, course and distance are not even guaranteed a third-place finish when compared to ancient fences and other indicia of long standing occupation that have greater probative value in ascertaining the location of missing monuments. In the more recent case of *Northrop v. Opperman*, the Wisconsin Supreme Court repeated and confirmed this rule of law relative to obliterated USPLSS corners and conflicting surveys depicting the true location of a section line:

The evidence of undisputed occupation and fencing in accordance with the originally surveyed line for about 30 years, not only of the piece of land in controversy, but of other parcels of land in that immediate neighborhood, raises a presumption that the line so recognized is the true line. So strong a presumption is thus raised in the present case that we do not regard it as overcome or seriously weakened by the simple fact that upon a resurvey, based upon no original monument, another line several rods distant is established.

The original location of monuments must always prevail, but that when those monuments have disappeared, they must be established by the best evidence the nature of the situation is susceptible of. The court concluded that extrinsic evidence, such as an old fence, may have so much greater probative force than more recent surveying measurements as to prevail over the latter as a matter of law.<sup>3</sup>

The rules of construction for the interpretation of deeds (and other written documents; e.g., contracts or legislation) were developed by the courts because of the inherent flaws, contradictions, and shortcomings that are imbued in the process of describing land, land boundaries, and the intent of the parties to the transaction (whatever the transaction might be) on paper. This is the reason monuments maintain the superior status that they have; they are more certain relative to the location of the boundaries that they represent than are the documents that attempt to describe them.

At best, coordinates can only be considered as a type of course and distance. When the monuments disappear over time, which they will, and enough time passes (30-years), the coordinates on those monuments will become as irrelevant as course and distance when compared to long-held occupation.

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<sup>2</sup> *Miller v. Lavelle*, 110 N.W. 421, 422 (Wisc.1907) (citations and punctuation omitted and brackets added).

<sup>3</sup>*Northrop v. Opperman*, 2011 WI 5 at P43 and P44 (Wisc. 2011) (citations and punctuation omitted).

The application of the surveying rules of evidence and proper procedures requires careful consideration and experienced judgment on the part of the surveyor. If coordinates were to replace monuments in controlling land boundaries, retracement surveying may become, in effect, a rote task that may violate private property rights and Wisconsin law.

### **Attributes of Monuments and Coordinates**

Natural and artificial monuments provide the highest degree of certainty to land boundary corner and line locations. Coordinates, courses, distances, and areas are measurements, and as such, inevitably contain systematic and random errors. Unlike courses and distances, which generally are direct measurements using well-established units of measurement, coordinates are indirect measurements which require, as a basis, the identification and proper utilization of the horizontal survey datum and related projection. Within the seven county Region, a number of such datums are in use, including the North American Datum of 1927 (NAD 27), the North American Datum of 1983 (NAD 83), seven some local datums, and some local datums. Moreover, the various datums are subject to adjustment and, therefore, may change frequently – the NAD 83 datum already having assigned a number of “epochs” resulting from adjustments, including NAD 83 (1986), NAD 83 (1991), NAD 83 (1997), NAD 83 (2007), and NAD 83 (2011). To complicate matters further, the Federal Government is proposing the creation of an entirely new datum in 2022, the North American Terrestrial Reference Frame of 2022 (NATRF 2022).

The Wisconsin Supreme Court case of *The City of Racine v. Emerson* is instructive on this point. In that case it was determined by the City Council that an earlier subdivision plat was faulty and needed to be ‘adjusted’ to, in essence, correct the datum. Essentially utilizing one monument from the original survey, the City commissioned surveyors to “fix” the plat of survey according to the new datum, and they did, setting new monuments in new locations according to the corrected plat. The resulting survey was a disaster causing the lines of all of the lots to be materially changed, and upsetting the location of fences and buildings relative to the new survey, causing the underlying lawsuit. The Wisconsin Supreme Court weighed in:

A resurvey that changes lines and distances and purports to correct inaccuracies or mistakes in the old plat is not competent evidence in the case. ...Resurveys for the lawful purpose of determining the lines of an old survey and plat are generally very unreliable as evidence of the true lines. The fact, generally known and quite apparent in the records of courts, is that two consecutive surveys by different surveyors seldom, if ever, agree; and the greater number of surveys, the greater number of differences and disagreements will occur. When two surveys disagree, the correct one cannot be determined by still another survey. It follows that resurveys are of very little use in such a case as this, except to confuse it.

Monuments set by the original survey in the ground, and names or referred to in the plat, are the highest and best evidence. If there are none such, then stakes set by the surveyor to indicate corners of lots or blocks or the lines of streets, at the time or soon thereafter, are the next best evidence. The building of a fence or building according to such stakes, while they were present, become monuments after such stakes have been removed or disappeared, and the next best evidence of the true line.<sup>4</sup>

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<sup>4</sup> *The City of Racine v. Emerson*, 55 N.W. 177, 178 (Wisc.1893).



Conspicuously absent from the discussion are course and distance (not to mention coordinates). Perhaps not to the degree as in the case of *The City of Racine*, but given the long and rich history of the Wisconsin courts favoring monuments on the ground and even fences over courses and distances, it is unlikely that courts will be readily amenable to the substitution of coordinates for monuments in land boundary determination.

### **Statutory Requirements**

Various sections of the Wisconsin Statutes deal with survey monumentation. Some sections deal specifically with monumentation of the USPLSS, others deal with monumentation for the creation of new land parcels, yet they are related to monumentation of the USPLSS. Section 60.84(1)(r) provides that a town board may contract with the County Surveyor, or any professional land surveyor, to survey some or all of the USPLSS sections in the town and to erect monuments marking the location of the corners. Presumably, the only requirement for the action is that the corners are missing monumentation. There is no specification as to what procedure should be followed in the conduct of the work. Elsewhere, the Wisconsin Statutes address, in some detail, the need for and use of survey monuments and how the monuments are to be replaced if they are missing. For example, Section 59.73 requires that bearings used in surveys must be referenced to a monumented line of given bearing. Section 59.74(1) provides for the establishment, relocation, or perpetuation of any USPLSS corner. It requires that the corners of that system be perpetuated by setting monuments. The procedure for re-establishing the monument location is left, in large part, to the fidelity of the County Surveyor.

Section 59.74(2) prohibits the proposed destruction, disturbance, or covering of USPLSS corner monuments without providing for the perpetuation of the corner through classic surveying techniques with no reference to the use of coordinate values. Section 60.84(3)(c) and (d) specify types of monuments to be set in surveys, and how to place the monuments in the ground. The Statutes consider survey monuments to be sufficiently important as to impose a fine and imprisonment for their disturbance or destruction.

Section 236.15 of the Wisconsin Statutes specifies the type and placement of monuments marking the corners and lines of new land parcels created by the preparation and filing of certified survey maps and land subdivision plats. Section 236.18 requires that if coordinates are to be shown on plats of survey—ancillary to and not in place of monuments—the certified survey or land subdivision approval authority concerned must formally adopt the datum used to define the coordinate values. Section 236.18(4)(b) provides that if coordinates are to be shown on plats, they must be tied to monumented stations of the Wisconsin Coordinate System—that is, to the State Plane Coordinate System, or to an applicable, mathematically relatable county coordinate system. Section 236.20(2)(c) requires that bearings shown on certified survey maps and land subdivision plats must be tied to the USPLSS. More specifically, Section 236.20(3)(b) requires that certified survey maps and land subdivision plats be tied by bearing and distance to the boundary line of a USPLSS quarter-section and that the boundary of the quarter-section be marked by monuments set at each end of the boundary line, that the monuments concerned be described, and that the distance and bearing between them be noted.

### **Local Requirements**

The position of the State government, with respect to the importance of survey monuments, is supported by a plethora of local—county, city, village, and town—land subdivision control ordinances. The local ordinances generally reflect State monumentation requirements, as well as, specifying good land and engineering survey practices.

### **Federal Requirements**

The position of the Federal government specifically with respect to the importance of survey monuments in the creation, maintenance, and use of the USPLSS is probably best expressed in the 2009 edition of the “*Manual of Surveying Instructions*,” prepared and published by the U.S. Department of the Interior. The *Manual* states that the law provides that the corners monumented during the implementation of the USPLSS “shall forever remain fixed in position.” The *Manual* further indicates that the courts have given great weight to monuments and their accessories

as direct evidence of the location of the corners of the system, giving far greater weight to monuments than measurements of the lengths and bearings of survey lines.

Speaking to the issue of the importance of monuments and to finding USPLSS corners as existent or obliterated, as opposed to lost (whereby measurements would have to be employed to re-establish a lost position), the Interior Board of Land Appeals, in the case of *Jacobson and Downer v. BLM (On Reconsideration)*, stated as follows:

The weight of authority is convincing that the proper standard for BLM to apply in the course of a resurvey is to consider a corner existent (or found) if such a conclusion is supported by substantial evidence.

The dissenting opinion appears to argue that the “substantial evidence” test is unprecedented. As BLM well knows, and hence its petition for reconsideration in this case, the standard enunciated here comports with the agency’s own interpretation of the Survey Manual, which it wrote, and the actual manner in which it has consistently applied the provisions of the manual throughout the years in thousands of survey decisions. The entire thrust of the Survey Manual is to recognize corners as existent, rather than lost, if at all possible. The Board’s prior decision, requiring proof beyond a reasonable doubt that a corner is existent, understandably caused a stir among survey professionals and BLM management.<sup>5</sup>

The obvious reason for accepting USPLSS corners as existent or as merely obliterated is that to refer to a corner as lost requires, under the instructions of the *Manual*, the application of measurements—that is courses and distances—to re-establish the lost position. Wisconsin Law clearly dictates, courses and distances are the last resort in re-establishing a corner position when other evidence, including (fences) are available.

The Wisconsin case of *United States v. Citko*, tried in the United States District Court for the Eastern District of Wisconsin, applying Wisconsin Law weighed in on the issues of lost corners:

Where there is no controlling federal legislation or rule of law, questions involving ownership of land are determined under state law, even where the government is a party. Therefore, the Court must turn to Wisconsin law.

Wisconsin law provides that resurveys of public lands must follow the rules established by the federal government. The federal rules to be followed are contained in the Manual of Instructions for the Survey of the Public Lands of the United States.

For a corner to be lost, it must be so completely lost that it cannot be replaced by reference to any existing data or other sources of information. The decision that a corner is lost should not be made until every means has been exercised that might aid in identifying its true original position. Even though the physical evidence of a corner may have entirely disappeared, a corner cannot be regarded as lost if its position can be recovered through the testimony of one or more witnesses who have a dependable knowledge of the original location.<sup>6</sup>

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<sup>5</sup> *Jacobson and Downer v BLM (On Reconsideration)*, 103 IBLA 83, 85, 86 (1988).

<sup>6</sup> *U.S. v. Citko*, 517 F.Supp. 233, 236, 237 (U.S.Dist.Ct.1981) (citations and punctuation omitted).

Under Wisconsin law, as under Federal law, as interpreted by the *Manual*, even parol evidence of local residents with dependable knowledge of the former location of a monument is superior to courses and distances—or coordinates—as identifying the location of a corner.

Like the State Statutes, Title 18 U.S.C. 1858 provides penalties for the alteration or removal of any USPLSS monuments. The State statutes require that the rules of evidence and procedure provided in the Manual be followed in the perpetuation of the USPLSS within the State.

## **TECHNICAL CONSIDERATIONS**

A properly set and well-designed artificial monument provides an exact and certain position for a survey corner. As a visible physical object a monument can be readily occupied by survey instruments. Survey measurements can be simply and cost-effectively made to and from monuments. Coordinates may properly serve as accessories to monuments. This categorical statement is based upon the fact that coordinates are measurements—indeed indirect measurements—and like all measurements, contain errors—both systematic and random. A monument provides the exact and certain evidence of a corner location that coordinates do not offer.

The development of Global Positioning System (GPS) survey instruments and procedures has served to promote the use of coordinates in the conduct of land and engineering surveys, as well as, in the conduct of geodetic surveys. The GPS positioning procedure is usually more convenient than the use of alternative procedures such as precise traverse surveys, although not necessarily more accurate. In this respect, it is important to understand that the procedure necessary to both obtain and to replicate coordinate positions is more complex than commonly perceived. Good professional judgement is required for the proper application of the technical procedure.

The use of GPS technology to obtain survey grade coordinates for a point requires reference to a base station of known position. Essentially, simultaneous observations of, in effect, the distances of both the survey point and the base station to the orbiting satellites permit the computation of an accurate vector connecting the survey point to the base station. This vector permits adjustment of the coordinates for the survey point, placing the survey point in relation to the base station at an accuracy that meets the desired standard. Within the Southeastern Wisconsin Region, the necessary base stations are provided by the Continuously Operating Reference Stations installed and maintained by the Wisconsin Department of Transportation. The observations and calculations involved are initially made in spherical coordinates. The conversion of the spherical coordinates to plane coordinates for use in map preparation and in the conduct of land and engineering surveys requires use of a datum and attendant projection. This identification of the proper datum and projection to use must be made correctly to avoid the introduction of significant random errors, or blunders, into the measurements and computations.

### **Sources of Error**

A number of sources of errors are involved in GPS technology surveys to obtain coordinate positions. Some of these are random and neither their presence nor magnitude can be known, and their effects remain hidden in the coordinate values produced by a survey. Some of these errors are systematic and the survey measurements can be adjusted to eliminate their effects upon the determined coordinate values. The random sources of error in GPS surveys may include: (1) the obstruction of direct “sight” lines to satellites by woodland canopy, tall structures and buildings, and electric power transmission towers and lines; (2) the number of satellites available above the horizon for observation, from a minimum of four to a desirable eight or more; (3) ionic conditions in various atmospheric layers and ionic disturbances such as solar flares; and, (4) the poor centering of instruments on points, the position and alignment of receiving antennas, and atmospheric temperature and pressure.

### **Magnitude of Error**

Commission experience indicates that under the very best conditions and procedures, the combined effects of the errors inherent in GPS measurements can be minimized to replicate a known coordinate value to within 0.1 foot. Under poor conditions and practices, the magnitude of the error may approach several feet. In addition to errors con-

tained in the measurement of coordinate positions, errors may exist in the processing of the measured data required to obtain usable plane coordinates from the measured spherical coordinates.

The magnitude of the errors to be expected in the measurement of coordinates to replicate a record coordinate position, are significantly greater than the errors involved in erecting a replacement for a monument which is to be disturbed or destroyed. Such errors in the setting of the replacement monument should not exceed 0.02 foot given proper use of carefully selected offset points and witness marks.

### **Systematic Effects of Errors**

In considering the potential magnitude of the errors contained in any GPS measurement, the cumulative effect over time on a survey control network must be understood. As monuments marking the stations in a survey control network are allowed to be lost over time, the coordinate positions could be compromised as successive generations of coordinate reiterations accumulate, and as the relative positions of the once-monumented network stations fall below desirable standards. This will eventually affect the relative location and bearings between stations in the survey control system. As already noted, Commission experience indicates that approximately 160, or about two percent of the monuments marking the regional survey control network may be expected to be lost annually. At this rate of loss the network would, as a usable entity, be destroyed within approximately 70 years. Its reestablishment would be very costly, if at all possible.

The errors inevitably contained within coordinates measured to replicate previously measured coordinates may also significantly change the bearings of a survey control network and of land and engineering surveys based upon the network. The minimum errors contained in the measurement of coordinate positions could change the survey control bearings of quarter-section lines by about eight seconds of arc, while potential maximum errors contained in the coordinate measurements could change such bearings by about seven minutes of arc. The bearings associated with surveys tied to the survey control network could also be greatly affected. For example, the bearing of a tie distance of about 500 feet from a section or quarter-section corner to a corner of the exterior boundaries of a certified survey map or a land subdivision plat could, under minimum error, be changed by about one minute of arc and, under potential maximum error, by about 34 minutes of arc. The magnitude of these discrepancies in bearings would serve to destabilize the survey control network and would present significant discrepancies in the legal descriptions of the boundaries of the newly created parcels of land tied to the survey control network.

### **Role in Datum Conversion**

In 2016, the managers of the county land information systems being created within the Region requested that the Commission undertake a conversion of the legacy horizontal survey datum in use within the Region since 1961—the North American Datum of 1927 (NAD 27)—to the newly established Federal datum—the North American Datum of 1983—and more specifically to the 2011 epoch of that datum. Washington County opted to have the conversion completed in 2018 by a resurvey of the regional survey control network as it exists within the County. The resurvey will require the occupation of all of the monumented survey control stations—USPLSS corners—within the County for the determination of the new coordinate positions of the corners by GPS measurements. Such a resurvey would not be possible without the existence of monuments marking the exact location of the stations comprising the survey control network.

The other six counties of the Region have opted to have datum conversion made by a unique procedure developed by the Commission staff. That procedure requires the occupation of a limited number of monumented survey control stations within each survey township for the conduct of GPS measurements to determine the positions of the corners on the new datum, the new coordinate values for the remaining corners in the township being then computed using the legacy measurements made in the creation of the regional survey control network. Again, the transformation procedure requires the occupation of survey control stations marked by the monuments to which the legacy measurements were made.

The Federal government has proposed the creation of another survey datum in 2022. Should the counties then desire the conversion of the legacy and 1983 datums to the 2022 datum, the position of the survey control stations as precisely marked by monuments will again be required.



## MISCELLANEOUS CONSIDERATIONS

In addition to the foregoing legal and technical considerations, some miscellaneous considerations warrant mention. Six such considerations may be cited.

### Minor Surveys

The existence of monuments marking the precise location of the USPLSS corners within the Region makes those corners readily usable by entities that may not possess, or wish to use, costly survey grade GPS instrumentation. Such users may include: some land surveyors who may determine that traverse procedures with total station instrumentation may be more accurate and cost effective in a particular situation such as the conduct of a survey to create a certified surveying map, or a land subdivision plat. Such users may also include some private sector building contractors, and some public works engineers that may prefer more conventional survey procedures for the layout—that is, the provision of line and grade—for minor works; and some farmers and other landowners who may wish to erect fences.

### Elevation Surveys

In addition to providing the basis for the conduct of horizontal positioning surveys, the Commission-recommended control survey network also provides the basis for the conduct of vertical surveys. The monumented control survey stations—USPLSS corners—act as bench marks that are a basis for the conduct of conventional differential level surveys to provide elevations of natural and constructed features of the landscape. Since they carry accurate elevations, the monuments also facilitate the use of GPS instrumentation in the conduct of elevation surveys.

A brief description of the survey procedure involved may be in order. Three spherical surfaces are involved in the use of GPS instrumentation to obtain elevations: the ellipsoid which is the basis for the geodetic datums and projections in use within the Region; the geoid which is a spherical surface that is everywhere perpendicular to the direction of gravity and which approximates mean sea level; and, the surface of the earth itself. When occupying a monumented survey control station which has an accurate elevation, a GPS instrument, in addition to determining the horizontal position of the station, determines the height of the ellipsoid at the occupied point. The difference between the determined ellipsoid height and elevation of the monumented station provides the height of the geoid at that point. By occupying, for example, the four monumented corners of a USPLSS quarter-section, the geoid height at the four corners can be determined and averaged to provide a geoid height for use within the quarter-section concerned. A GPS instrument can then be used to conduct land and engineering surveys within the quarter-section that provide accurate elevations of natural and constructed features of the landscape, the ellipsoid heights determined by the GPS instrument being converted to elevations by subtracting the now known geoid height within the quarter-section. This procedure provides an efficient means for determining both the horizontal and vertical heights of, for example, existing sanitary sewerage and stormwater drainage facilities, and to provide accurate “as-built” information for newly constructed sanitary sewers, storm sewers, water mains and other underground public works facilities. The application of this efficient procedure requires the maintenance of the monumented control survey network within the area.

### Lack of GPS

The possibility exists that the use of GPS survey procedures may be disrupted, or blocked, during periods of international tension, military threat, or actual hostilities. A monumented survey control network would always be available for use with conventional survey procedures.

Also of concern is the potential loss in the long term of the GPS system itself. The maintenance of a constellation of satellites required for GPS positioning, of the attendant organization for placing the satellites into proper orbit for continually tracking the satellites’ performance, and the software and hardware necessary for the use of the satellites in positioning, is very costly. While it may seem highly unlikely, it still may be considered possible that, in the future, society may no longer be able or willing to incur the high costs entailed. Precise GPS surveys also rely upon a usable internet. Lack of internet and/or cellular phone service would disrupt surveys using coordinates for real-time field operations.

### **Technology Changes**

The possibility also exists that another technology may at some future date replace GPS technology for use in precise positioning. One such possible technology is inertial positioning. Inertial positioning systems would not require costly orbiting satellites and attendant support services. The instrumentation would be self-contained within the various types of vehicles requiring continual positioning. Such a system might, therefore, be more cost effective than the GPS. A monumented survey control network would be essential for some other technologies; e.g., a differential inertia survey.

### **Costs**

The Commission currently provides county surveyor services to five of its constituent counties. Those services include, in addition to the preservation of the USPLSS within the county concerned, the maintenance of the vertical survey control network within the county, the preparation and maintenance of the documentation required for the preservation and use of the horizontal and vertical survey control systems, and the conduct of any special land or geodetic surveys that may be requested by the county. The work entailed in the preservation of the USPLSS includes the setting of replacement monuments for any monuments proposed to be, or actually have been disturbed or destroyed, and the conduct of attendant field surveys and office computations. The cost of the USPLSS preservation work approximates 40 to 50 percent of the annual cost of the county surveyor services provided. This cost provides within each county a survey control network that facilitates the efficient and integrated conduct of land and engineering surveys on a day-to-day basis. Moreover, the survey control network within each county provides one of the important foundational elements of the parcel-based land information and public works management systems being created and maintained by each county and by many municipalities within the Region. It is this foundational element that provides the framework for the land ownership parcel mapping required, as well as, for the mapping of other attribute data contained in the system. The cost of the county surveyor services approximates 10 to 12 percent of the annual cost of developing and maintaining the county land information systems. The cost of maintaining the foundational element—that is, the cost of maintaining the monumentation marking the corners of the USPLSS—while approximately 50 percent of the cost of the county surveyor services, approximates only six percent of the annual cost of the county land information systems. This relatively small percentage of the costs entailed not only maintains one of the foundational elements of the land information system, but also serves to maintain the survey control network within the county, a network that is, in fact, a part of the public infrastructure system of the county. Failure to routinely maintain the survey control network will ultimately commit the counties concerned to the much higher costs that would be entailed in recreating that network at some future time.

### **The Public Interest**

The preservation of the USPLSS by the maintenance of the corner monumentation—and indeed the preservation of real property boundaries in an area by the maintenance of the corner monumentation—is very much in the public interest. Monuments can be seen and experienced by people who trust in physical markers for the security of their real property holdings. Given monumented corners, they can walk the boundaries, build fences on the boundary lines, and improve their property with the understanding that their possession is witnessed by the monuments marking their property corners. Wisconsin law fully supports this view. Coordinates can do none of these things because they cannot be seen or experienced and they provide no security or assurance as to the valid on-the-ground location of real property boundaries. It is clearly in the public's interest to protect and serve the people of the State, and more specifically, the landowners within the Southeastern Wisconsin Region, by the maintenance of the monumentation marking the corners of the system, as well as, the monumentation of the real property boundary corners and lines linked to that system. When there is no means for the maintenance of the monumentation of the USPLSS corners, landowners and others needing to know the location of unmonumented corners may turn to self-help remedies for the problem. Over time, such self-help options will tend to move existing real property boundaries to new locations which will add to the uncertainty inherent in any coordinate positions of the corners involved. This may lead to future conflicts between adjacent land-owners, further taxing the legal system in remedying such conflicts. Turning away from the time-honored traditional use of monuments on the ground to the use of coordinates that are subject to error would not be in the best interest of the landowning public and would conflict with the responsibility of county and local governments to maintain existing survey monumentation.

## SUMMARY AND CONCLUSIONS

The Commission recommended survey control system, which is in place throughout the seven county planning Region, provides a monumented position for each of the USPLSS corners that constitute the stations of the survey control network. As monumented, the positions of the corners are exact and certain. It also provides a coordinate position for each station. This availability of coordinate position has raised a question as to the need for the continued maintenance of the monumentation marking the corners. The issue raised, in effect, is whether or not coordinates can substitute for monuments in identifying the location of survey corners in real property boundary surveys. Based upon the information provided in this report, some conclusions may be drawn concerning this issue. These conclusions include the following.

- Legal considerations preclude the substitution of coordinates for monuments as a means of identifying real property boundary corners and lines. The Wisconsin Statutes specifically provide for the perpetuation of the U.S. Public Land Survey System (USPLSS) by the maintenance of the monuments marking the corners of the System. The Statutes also specifically require the use of monuments to mark the corners and lines of surveys creating the boundaries of new ownership parcels, including, particularly, parcels created by certified survey maps and land subdivision plats. Moreover, the Statutes require that such plats be tied to monumented corners of the USPLSS. Case law supports these statutory provisions.
- The practice of land surveying is limited by law to licensed professionals whose work must be carried out in accordance with both statutory and case law. The historic practice of land surveying has always emphasized the need to follow rules of evidence and procedure. Surveying practice has always given great weight to monuments as evidence of the location of survey corners and boundary lines. Courses, distances, and areas while considered evidence of the location and configuration of real property boundaries, were considered inferior to monuments.
- A properly set monument provides an exact and certain location for a survey corner. Coordinates—like courses, distances, and areas—are measurements, and as such, inevitably contain random and systematic errors. Moreover, unlike courses and distances—which generally are direct measurements using well established units of measurement—coordinates are indirect measurements which require as a basis the identification and proper utilization of a horizontal survey datum and related projection. Because of the errors intrinsically present in the measurement of coordinates, surveys cannot precisely replicate positions identified only by recorded coordinates. Therefore, categorically, coordinates cannot substitute for monuments as precise and certain evidence of the location of survey corners.
- The sources of error inherent in coordinate measurements are primarily random, and, therefore, the magnitude, as well as, presence of an error cannot be known. This is an important factor contributing to the uncertainty involved in any attempted replication of record coordinate value. The magnitude of error that may be expected in a coordinate position determined using GPS technology will vary significantly, being affected by adverse conditions and imperfect procedures. The measurement errors may be expected to range from a minimum of approximately 0.1 foot under the best conditions and procedures, to several feet under poor conditions and imperfect procedures.
- The cumulative effect of the errors in coordinate measurements made over time in efforts to replicate record coordinate values will increasingly affect the relative positions of the survey control stations, destroying the integrity and usability of the increasingly deteriorating survey control network.
- At the request of its constituent counties, the Commission is currently engaged in a regionwide effort to convert the legacy horizontal datum—NAD 27—in use within the Region since 1961 to a “new” Federal Datum—NAD 83—and more specifically, NAD 83 (2011). This resurvey effort will require the occupation of the monumented survey control stations USPLSS—corners—within the Region for determination of the new coordinate positions of the corners by GPS measurements. Such effort would not be possible without the extant monumentation. The conversion of the legacy and NAD 83 (2011) data to the proposed NATRS2022 datum will again require the use of the extant monumentation within the Region.

- The existence of monuments marking the precise location of the USPLSS corners within the Region makes these corners readily usable in the conduct of minor surveys by entities that may not possess, or wish to use, costly survey grade GPS instrumentation.
- The existence of monuments, not only of known position but also of elevation, provide a basis for the use of GPS instrumentation to obtain reliable elevations for use in carrying out various engineering surveys, such as the determination of elevations in the inventory of sanitary sewerage and stormwater drainage systems, in the establishment of flood elevations, and in the provision of line and grade for construction of public works facilities, and for the determination of “as-built” elevations of such facilities.
- The possibility exists that GPS survey technology may not be available in the future. A monumented survey control network would always be available for use with conventional survey procedures.
- A potentially more cost-effective positioning technology may be developed to replace the costly GPS. A local monumented survey control network would be essential if GPS technology were replaced by some other technology.
- The cost entailed in maintaining the monuments marking the survey control network within the Region are relatively minor, constituting approximately 50 percent of the County Surveyor services provided to a county by the Commission. In turn, the cost of those services approximate 12 percent of the annual cost of developing and maintaining the county land information systems. Therefore, the cost of maintaining one of the key foundational elements of the county land information systems—that is the cost of maintaining the monumentation marking the corners of the USPLSS—approximates only six percent of the cost of maintaining the county land information systems. This relatively small proportion of the cost of maintaining a land information system provides for not only maintaining the foundational elements of the system, but also serves to maintain the survey control network that is, in fact, an important part of the public infrastructure system of the Region. Failure to routinely maintain the survey control network will ultimately commit the county concerned to the much higher costs that would be entailed in recreating the legacy system at some future time.
- The ownership of real property is one of the most important rights of a citizen of a free and democratic society. The exercise of that right requires the identification on the surface of the earth of the location and boundaries of the real property ownership concerned. Historically, that identification has been accomplished by professional land surveyors setting monuments at the corners of the real property ownership parcels concerned. Landowners long have been, and are, accustomed to relating their ownership to such monuments. Monuments can be seen and experienced by landowners who can witness the boundaries concerned, build fences on the boundary lines, and can improve their property knowing that the boundaries of their ownership is witnessed by the monuments marking the property corners. Coordinates cannot fulfill any of these functions. The importance of monuments to identifying real property boundaries was incorporated into the USPLSS. The Federal law which governed the creation, use, and preservation of the system not only required that the corners of the sections and quarter-sections be marked by monuments, but held that the monuments marked the true corner location regardless of any errors in measurement. The USPLSS provided the initial subdivision of the Federal lands for disposition. Accordingly, with but a few unusual exceptions, all real property boundaries are tied to the corners of the Federal system by distance and bearing. Wisconsin Law fully supports this view of the USPLSS, and requires that in the creation of new land parcels, the descriptions of the boundaries be tied to monumented corners of the USPLSS. The maintenance of those monuments, the certainty and stability of ownership which they provide is, therefore, very much in the public interest.

Based upon the legal, technical, and miscellaneous considerations presented in this report, it may be concluded that the Commission and its constituent counties should continue to maintain the monumentation marking the stations—USPLSS corners—of the regional survey control system.



## **APPENDIX**

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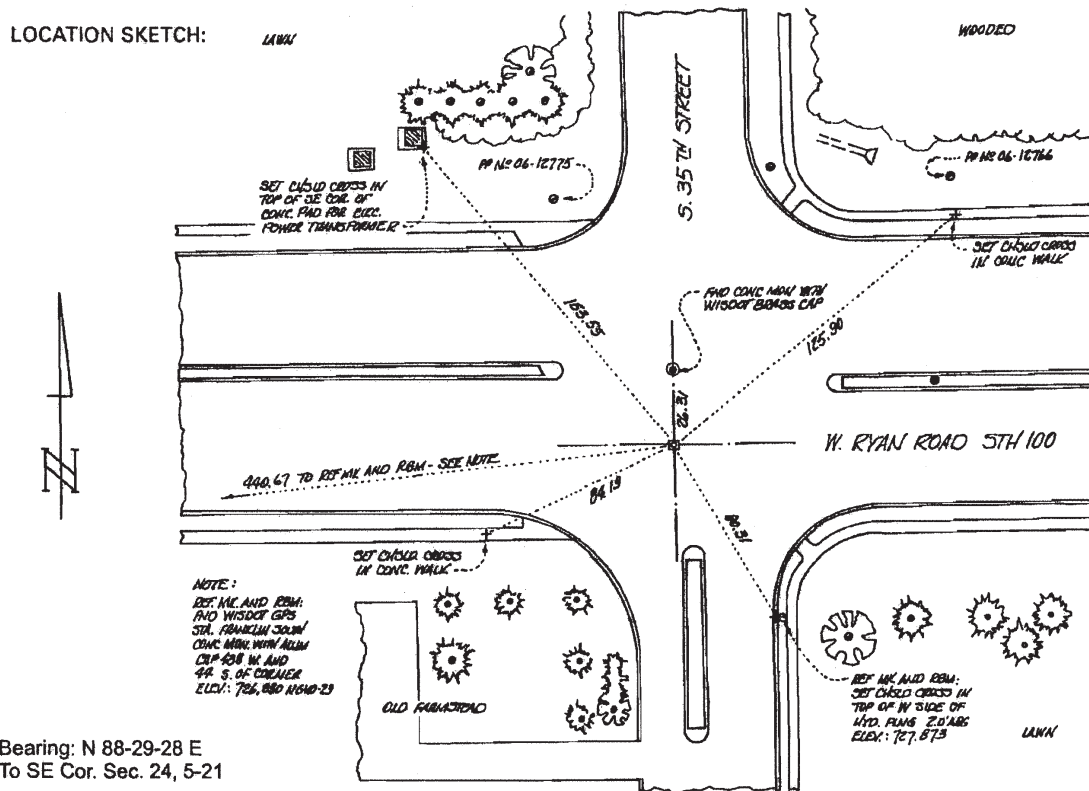
Figure 1

TYPICAL SEWRPC RECORD OF USPLSS CONTROL STATIONS

RECORD OF U.S. PUBLIC LAND SURVEY CONTROL STATION

U.S. PUBLIC LAND SURVEY CORNER <u>24</u> / <u>24</u> T <u>05</u> N, R <u>21</u> E, <u>Milwaukee</u> COUNTY, WISCONSIN	
HORIZONTAL: NORTH AMERICAN DATUM OF 1927	
VERTICAL: NATIONAL GEODETIC VERTICAL DATUM OF 1929	
HOR. CONTROL: <u>AERO-METRIC ENGINEERING, INC.</u>	<u>1993</u>
VERT. CONTROL: <u>SEWRPC</u>	<u>2007</u>
NORTHING: <u>324,725.89</u> USFT	
EASTING: <u>2,546,528.32</u> USFT	
ELEVATION: <u>728.007</u> FT	
HOR. ACCURACY: <u>3rd ORDER, CLASS I</u>	
VERT. ACCURACY: <u>2nd ORDER, CLASS II</u>	
RBM ELEV. IN SKETCH BELOW TIED TO NGVD29 DATUM. CONVERSION FROM NGVD29 <u>          </u> FT DERIVES NAVD88 HEIGHT	

LOCATION SKETCH:



Bearing: N 88-29-28 E  
To SE Cor. Sec. 24, 5-21

SURVEYOR'S AFFIDAVIT:

STATE OF WISCONSIN) SS  
MILWAUKEE COUNTY)

As Milwaukee County Surveyor, I hereby certify that following highway reconstruction, I set a concrete monument with SEWRPC brass cap to mark the location of this corner; replacing a concrete monument with cast iron plug with cross found and referenced by me as Milwaukee County Surveyor on September 11, 1992; said concrete monument with cast iron plug having been set to mark the location of this corner in 1941 by E.G. Plautz, State Highway Commission of Wisconsin Project Engineer, following highway reconstruction; replacing a cast iron plug with cross set in the then existing concrete pavement to mark the location of this corner in 1916 by a Milwaukee County Highway Department Project Engineer, following highway reconstruction; replacing an old cut limestone monument set to mark the location of this corner in 1878 by Jonathan C. Crounse, Surveyor, in the conduct of the remonumentation of the Town of Franklin; replacing in turn a wood post set to mark this corner in May 1836 by Elisha Dwelle, Deputy United States Surveyor, in the conduct of the original United States Public Land Survey; that I have referenced the same as shown hereon; and that this record is correct and complete to the best of my knowledge and belief

DATE OF SURVEY: 30 August 2007

REGISTERED LAND SURVEYOR



S - 157

FORM PREPARED BY SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION (SEWRPC)  
CERTIFICATION APPLIES ONLY TO THE LOCATION SKETCH AND SURVEYOR AFFIDAVIT

05211060

106 -

Figure 2

TYPICAL SEWRPC SIX-SECTION SURVEY CONTROL SUMMARY DIAGRAM

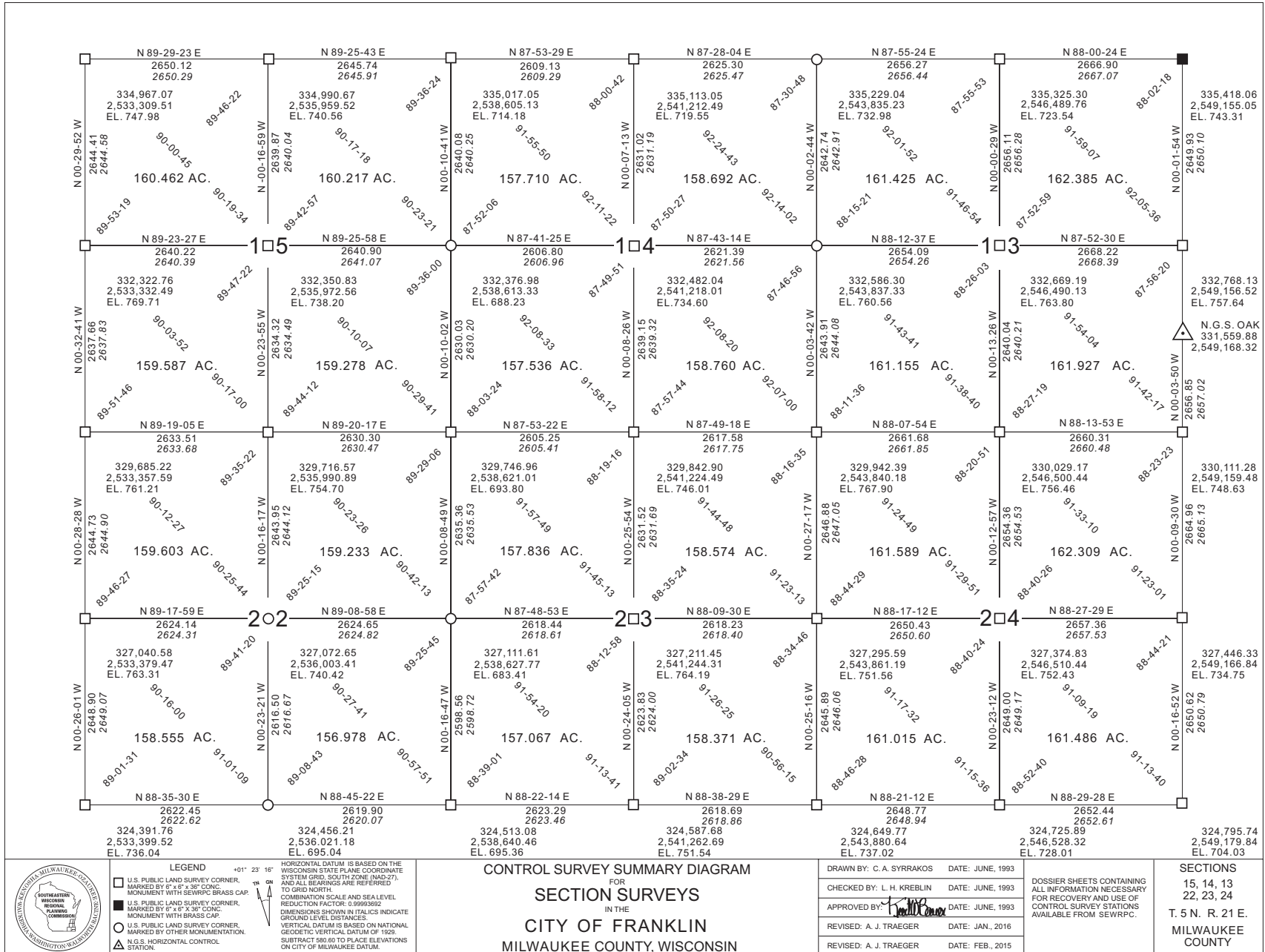
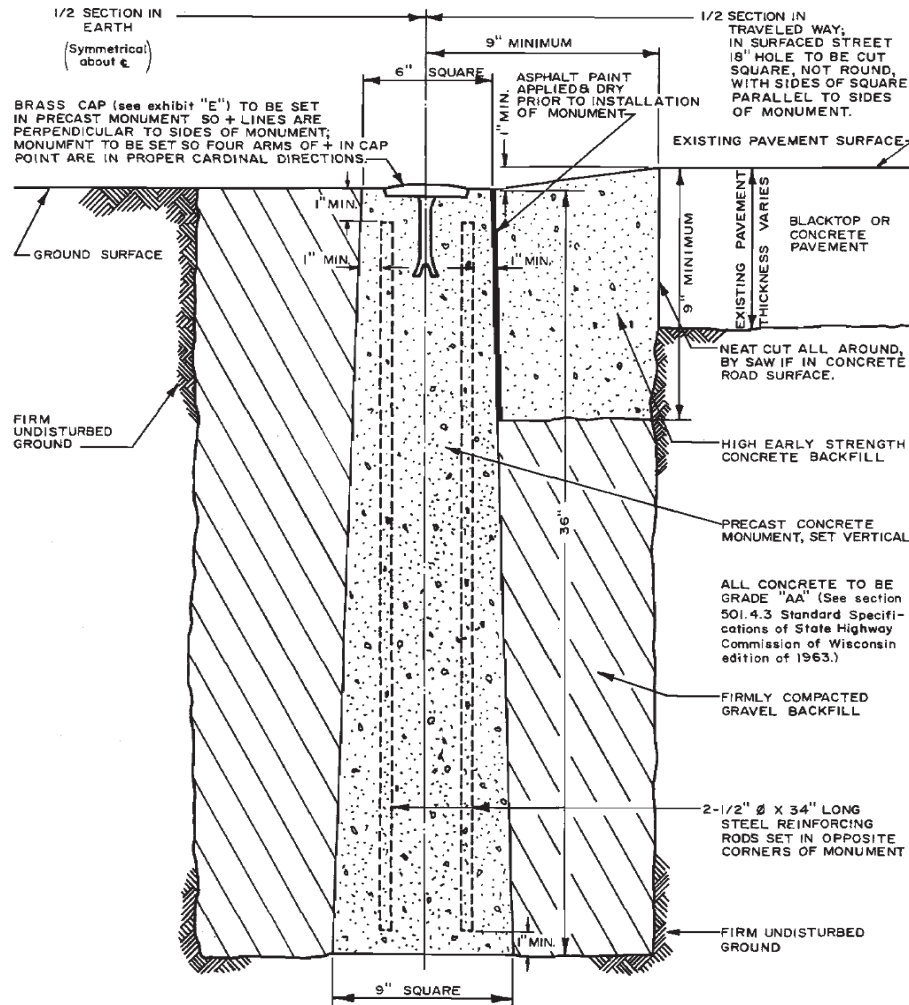


Figure 3

# SEWRPC MONUMENT AND MONUMENT INSTALLATION USED TO MARK LOCATION OF USPLSS CORNERS

## DETAIL OF MONUMENT AND MONUMENT INSTALLATION FOR SURVEY CONTROL STATIONS

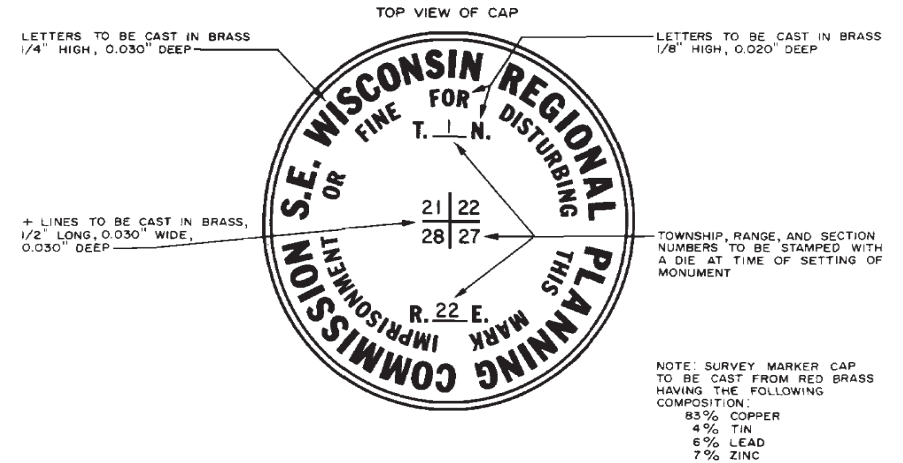


DRAWN BY: L.H.K.  
CHECKED BY: D.R.B.

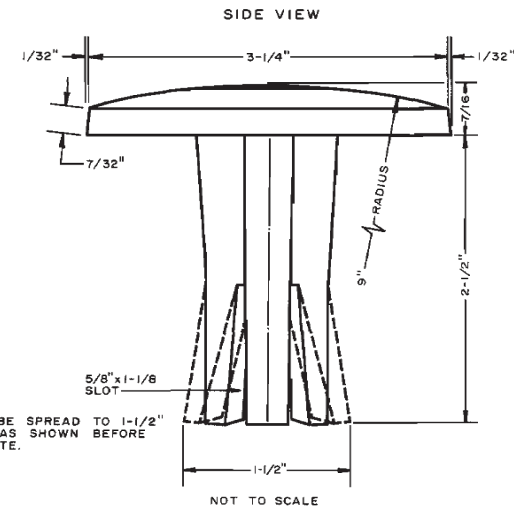
NOT TO SCALE

APPROVED BY: K.W.B.  
DATE: NOVEMBER 1967

## DETAIL OF BRASS SURVEY MARKER FOR SURVEY CONTROL STATION MONUMENTS



DRAWN BY: D.P.S.  
CHECKED BY: L.H.K.  
APPROVED BY: K.W.B.  
DATE: FEB. 22, 1966



Source: SEWRPC.