**QA/QC to Validate Position and Attribute Accuracy for Stormwater Inventory**

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## Abstract

Over the past several years, municipalities mostly cities and counties have embarked on developing various GIS based stormwater inventory. This development is driven primarily by State and National regulations such as the EPA National Pollutant Discharge Elimination System (NPDES) and the Governmental Accounting Standards Board Statement 34 (GASB34). A review of most RFP's in the market reveals that most municipalities want the data on the ArcGIS platform and also want the data to a positional accuracy of ± 1 meter or submeter. This paper discusses a QA/QC procedure developed to validate position and attribute accuracy of a GPS based data collected by a private firm for a county's stormwater infrastructure inventory program. The paper discusses methodologies, results type of equipment needed to validate position accuracy. Finally, the paper discusses some critical ambiguities that can render the entire QA/QC plan valueless.

## 1.0 Introduction

Storm water inventory on a GIS platform has become a common project for many municipalities. Various government regulations such as the (EPA) National Pollutant Discharge Elimination System (NPDES) and the Governmental Accounting Standards Board Statement 34 (GASB34) are the driving force behind these projects. While some agencies are going the extra mile to request survey grade horizontal accuracy, most of the projects in the system require only a sub meter accuracy meaning a ± 1 meter. For most agencies requiring sub meter accuracy, vertical positions ( elevation of the structures) are not needed for obvious reasons. This paper is based on a project conducted to verify the attribute and horizontal accuracies of a county's contract with an outside consultant.

The project had two main objectives: 1) to perform field verification of structural attributes collected by a consultants to capture any structural descriptive discrepancies including key structure attributes such as type (catch basin, headwall, drop inlet, etc), shape, and structure condition (good, poor, fair) and 2) to determine the position accuracy of the structures.

## 2.0 Methodology

Two equipments were used for this survey: 1) a Trimble Geo XH equipped with ESRI Arcpad software was used mainly to conduct the attribute verification survey and 2) a survey quality GPS, the Leica 1200 RTK GPS unit was used to validate the positional accuracy of the surveyed points. In all a total; of 1737 points were used for both the attribute validation and position validation surveys. The total number of points surveyed was based on a 10 percent rule that was mandated by the client. By using an internet based random number generator, 10 percent of the total points to be validated were determined and selected for the QAQC process. These random points were geocoded and uploaded to the GPS units for filed survey. Each point was visited once and in cases where the selected point was not found, a new point was selected in the field as a compensating point. Of the 1737 points used for the survey, 1320 structures were field surveyed for attribute verification and 417 were surveyed with Geodetic quality GPS for accuracy comparison. Even though 1320 points were randomly selected to verify the three attributes of type, shape and condition, , only 1097 of the field collected structure were used. Structures such as junction boxes and intersection were removed from the original dataset due to the subjective nature of their location and hence the tendency for the results to be bias should they be included in the study.

## 3.0 Data Analysis

### 3.1 Attribute Data Analysis

Three attributes were collected for each structure. These attributes were the type of the structure, the shape of the structure and the condition of the structure. While the type and shape were easy to call, classification of the structures condition was very subjective. For all the three attributes, a simple analysis was done to determine the discrepancy between the consultants observation and our observation. Table 1 presents a summary of the attribute analysis done. As seen from the table, the consultants and our filed surveyors disagree on 11% of the conditional assessment. Since the structural conditional assessment is very subjective and also changes over time, it will be difficult to avoid discrepancies. In addition, since the entire data collection was done by multiple technicians, there is bound to be discrepancies due to the fact that data was collected at different time periods. Similarly, the type and the shape as seen from the table are 3.4% and 1.7 % respectively.

**Table 1: Attribute Analysis Summary**

| Total Structures : 1097 | | |
|---|---|---|
| | Number | Percent |
| Type of Discrepancy: | | |
| Condition | 123 | 11.2% |
| Shape | 19 | 1.7% |
| Type | 37 | 3.4% |

### 3.2 Position Accuracy Analysis.

This section discusses the relative accuracy of the points (X, Y) determined by the consultants. As stated earlier, determining the positional accuracy of the points was done using a survey grade GPS unit. It should be noted that the mapping grade GPS units that are quoted as sub-meter can still be off by as much as 5 meters (based on our filed data). Determining the positional accuracy of two surveys using the same methods may create some positional ambiguities that may result in wrong and bias conclusions. A measure of accuracy is a measure of how close a measured quantity is to the true value. Since the true value can never be determined, the closest to the truth is used as the measure of the true value. Thus a measure of the positional accuracy of a point taken with a map grade GPS cannot be done with similar equipment with the same degree of accuracy. To determine the actual positional accuracy of the points therefore, we decided to use survey grade GPS equipment that is accurate to a fraction of a foot. The Lieca 1200 GPS RTK unit with a horizontal position accuracy of ± 0.03 feet was used for a portion of the survey. To remove any bias conclusions from the analysis, points whose positions are very subjective were removed from the analysis. Structures such as junction boxes, intersections and control structures were removed. Twenty two (22) points were removed from the analysis. The table and chart below represent the analysis and results of this sub task. As seen from Table 2, using the RTP positions as the base points, about 42% of all points surveyed were outside the 1 meter threshold mark. Table 1 below shows some of the sample data used. The last column of table 1 was computed as

$$\delta = \sqrt{(x_c - x)^2 + (y_c - y)^2}$$

where $(x, y)$ represents the survey grade position and $(x_c, y_c)$ represents the mapping grade points determined by the consultants. δ represents the relative distance between the mapping grade point position and the geodetic quality point position. Note that the smaller the deviation, the closer the two surveys are to each other (which is a measure of how accurate the original survey was).

**Table 2: Position Accuracy Assessment**

| Performance Measure | Qty | % |
|---|---|---|
| Less Than 1m | 230 | 58.2 |
| Greater than 1 meter | 165 | 41.8 |
| Total Sample used | 395 | 100.0 |

**Table 3: Sample Position Analysis Data and Computations**

| | | Their Coordinate | | Our Coordinate | | Deviation |
|---|---|---|---|---|---|---|
| Point # | Type | Northing | Easting | Northing | Easting | (meters) |
| 1 | CB | 1345127.682 | 2270748.833 | 1345124.082 | 2270748.766 | 1.1 |
| 2 | CB | 1345186.518 | 2271193.887 | 1345185.573 | 2271190.052 | 1.2 |
| 3 | FL | 1345446.12 | 2272156.682 | 1345442.74 | 2272158.063 | 1.1 |
| 4 | DI | 1345182.757 | 2270587.149 | 1345173.972 | 2270586.182 | 2.7 |
| 5 | CB | 1343151.354 | 2270626.294 | 1343147.489 | 2270624.54 | 1.3 |
| 6 | HW | 1341983.086 | 2271427.042 | 1342009.742 | 2271454.471 | 11.6 |
| 7 | CB | 1342082.204 | 2271807.593 | 1342072.686 | 2271807.795 | 2.9 |
| 8 | CB | 1343134.417 | 2271861.876 | 1343131.189 | 2271860.022 | 1.1 |
| 9 | HW | 1343776.604 | 2272033.656 | 1343776.376 | 2272039.387 | 1.7 |
| 10 | CB | 1344378.335 | 2272092.216 | 1344372.796 | 2272092.069 | 1.7 |
| 11 | CB | 1344747.634 | 2266414.114 | 1344745.932 | 2266423.056 | 2.8 |
| 12 | CB | 1345298.829 | 2265006.014 | 1345294.527 | 2265007.632 | 1.4 |
| 13 | DI | 1343619.102 | 2264992.249 | 1343612.408 | 2264990.341 | 2.1 |
| 14 | DI | 1343427.202 | 2265114.486 | 1343424.289 | 2265111.588 | 1.2 |
| 15 | FL | 1342616.362 | 2265052.94 | 1342613.936 | 2265060.723 | 2.5 |
| 16 | FL | 1344056.55 | 2266529.274 | 1344054.003 | 2266516.505 | 4.0 |
| 17 | DI | 1344380.45 | 2268893.757 | 1344377.148 | 2268894.139 | 1.0 |
| 18 | FL | 1345082.744 | 2268078.888 | 1345079.516 | 2268069.708 | 3.0 |
| 19 | HW | 1345154.986 | 2266499.605 | 1345161.428 | 2266500.116 | 2.0 |
| 20 | DI | 1343046.934 | 2269129.411 | 1343049.33 | 2269138.781 | 2.9 |

## 4.0 Conclusion.

From the analyses and discussions above, it is evident attribute accuracy determination is very subjective and also temporal in nature. Also a mapping grade GPS survey that requires a 1 meter margin of error may not be achievable even at the 70 percent level. While mapping grade GPS units provide smooth and quick project transition times, one has to be careful asking for this degree of accuracy. In a recent RFP by a municipal government on stormwater inventory data collection, it was stated that the horizontal accuracy requirement was ±3 meters. This value was actually confirmed at a pre proposal meeting. It appears most of these agencies do not fully understand the accuracy implications of the data collection process. It is very important that for such projects, agencies employ the services of people with the technical skills to provide the best results for their projects. For most mapping municipality projects ± 1 meter accuracy specification will do just fine except that one should also understand the level of confidence at which this number is achievable. This will form the basis for a better and agreeable QA\QC planning. The study also revealed that for a robust and reliable QA\QC process, it is important that the original survey points are marked (the position where GPS observation are taken). It can surely be argued that the difference in positions between the two surveys can be attributed to the different positions of the rod during the two surveys. Of course one assumes that the center point of the structure will be used (for structures whose center can be well defined) for all survey by all parties. This is not always the case and can lead to erroneous and ambiguous conclusion including those made in this paper. It is therefore being concluded here that, while the position comparison gave the consultant about 60% of their points falling within the required ±1 meter threshold, it is also possible that the position of the two rods of the two surveys contributes significantly to the 40% points falling outside the required threshold.