1. Storm Sewer Analysis Using Gage-Adjusted Radar-Rainfall Data

Current state-of-the-art storm sewer analyses utilize detailed computer models to evaluate storm sewer performance. Model results are then used to guide or frame recommendations for best management practices, rehabilitation of existing sewers, installation of new pipelines, and/or construction of new treatment facilities, all of which can ultimately cost many millions of dollars.

Development of high quality recommendations that make the best use of public monies depends, in part, upon accurate representations of sewer system performance by the computer models. Current sewershed models enable highly detailed representation of sewershed response. Sewersheds can be defined with resolution down to individual residential lots, pipes, and inlet structures. Simulated sewer flows are then compared to flow meter measurements of sewershed response to infer storm sewer performance.

One of the big unknowns in the modeling process is measuring the distribution of rainfall over a sewershed. Traditional rainfall measurement typically involves placing several rain gages throughout the study area. Each rain gage provides estimates of rainfall at a point. Data from the gages are used to represent the volume of rain entering each portion of the sewershed then the computer models use the rainfall data to simulate sewershed performance.

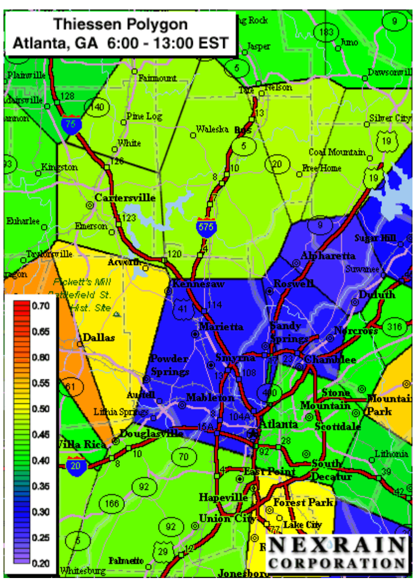

Figure 1: Example Thiessen Polygons

The tricky part of this process is that rain gages represent the rainfall at a point but computer models require a volumetric estimate of incoming rainfall. This requires an assumption on the part of the modeler on how to covert rainfall measurement at a point to a volumetric estimate. One common methodology is to use Thiessen polygons to represent the spatial distribution of rainfall. This technique assumes that the rainfall at any point in the sewershed is assigned a rainfall value equal to the value measured by the closest gage. The collection of points closest to a single gage defines a single Thiessen polygon. Figure 1 shows an example of storm total rainfall represented by Thiessen polygons. Each polygon represents an area of uniform rainfall.

The problem with representing the spatial distribution rainfall with Thiessen polygons is that the resulting distribution is a function of the geometry of the rain gage network not the geometry of the actual rainfall. Furthermore, this geometric representation is static and doesn't vary with storms.

Naturally occurring rainfall is often highly variable. Individual storms cells are typically smaller than the density of the rain gage network. As a result, locally heavy downpours are often missed by the rain gages. In fact, artificial assumptions about the spatial distribution of rainfall severely distort the true distribution and frequently place the wrong rain in wrong place at the wrong time. Volumetric errors of rainfall in excess of 50% are not uncommon. This leads directly to poor model performance or, at the very least, misleading model results which can adversely impact any recommendations that follow.

Estimates of rainfall using radar, on-the-other-hand, provide a highly detailed spatially dynamic view of the rainfall distribution. Current radars can now provide rainfall estimates down to 2 km x 2 km (~900 acres) or even 1 km x 1 km (~250 acres) in 5 to 15-minute time steps. Thus radar data provides a more valid picture of the true distribution of rainfall and significantly improved estimates of the volumetric distribution of rainfall.

Figure 2 shows two examples comparing Thiessen polygon representations of storm total rainfall with radar-based estimates of the same storms. The two graphics in Figure 2 show Thiessen polygon and radar-based representations of a storm over Austin, TX. The lower graphics represent a storm for Houston, TX. In both cases, there are large differences in the rainfall distributions. In the Austin storm, thunderstorm cells tracked along I35 going north. The radar shows the areas of heavy rainfall along I35 that were completely missed by the very dense rain gage network in Austin. (Obviously, none of the gages were on I35!)

Similar results are clear from the Houston event. The rain gage/Thiessen Polygon representation dramatically over estimated the rainfall in the southeast corner of the study area and under estimated the rainfall on the northwest side of Houston. The Thiessen polygon representation depended upon which point rain gages happened to get hit or not get hit by individual rain cells moving through the area. Again, use of the rain gage data alone would severely distort model performance and the potential recommendations that follow.

Recommendations derived from misleading rainfall information can easily lead to millions of dollars of public monies being spent on constructed works that may not actually be necessary or, conversely, the underestimation of expenditures that actually should be made.

The bottom line is that storm sewer analysis should include as much attention to measuring the rainfall input as is paid to the flow monitoring in order to achieve the best result for the client.

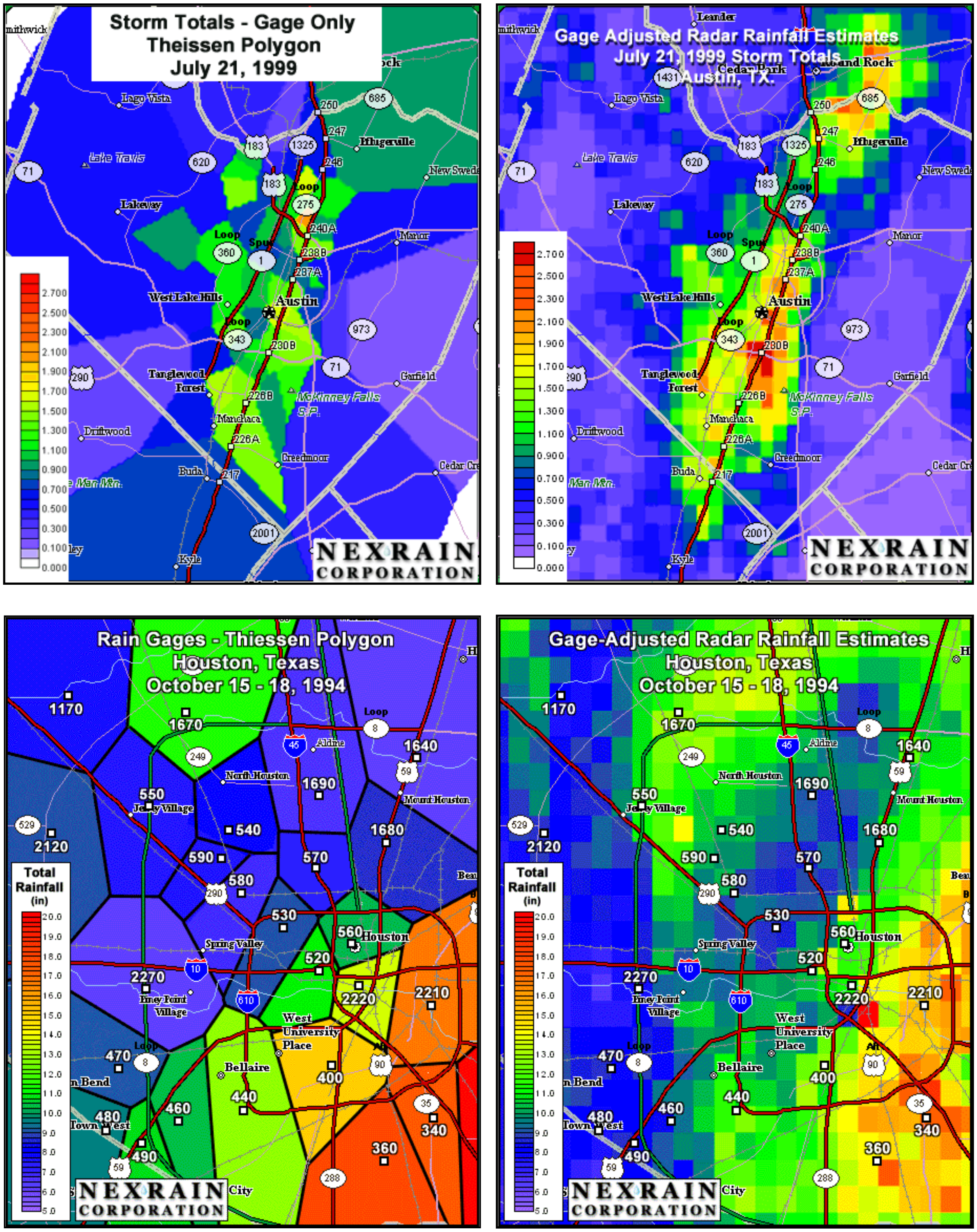

Figure 2: Comparison of storm total rainfall using Thiessen Polygons and Gage-Adjusted Radar-Rainfall

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OneRain Incorporated
1531 Skyway Drive, Unit D
Longmont, Colorado 80504, USA

+1-303-774-2033
www.onerain.com