HYDRAULIC & HYDROLOGIC FLOODPLAIN MAPPING CITY OF GRIFFIN STORMWATER UTILITY DEPARTMENT, GRIFFIN, GA

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INTRODUCTION

There are numerous examples of jurisdictions that have inadequate or non-existent flood mapping. In many instances, FEMA mapping does not extend far enough into upstream areas to serve as a management tool for a jurisdiction. Sometimes FEMA Zone A mapping, without Base Flood Elevations, has limited usefulness as a management tool. Most jurisdictions have neither the staff nor the financial resources to determine how their floodplain management responsibilities should be applied. The result is a limited understanding of the floodplain as part of a Stormwater Management Program. Knowledge of floodplain boundaries and the potential impact of flooding is a critical component of Stormwater Management. Loss of floodplains impacts not only water quantity issues, but water quality issues as well.

The City of Griffin has mapped floodplains in all major waterways, thus now having a firm analytical foundation on which to base Stormwater Management decisions.

MODELING OVERVIEW

All aspects of the modeling effort relied heavily on ArcView GIS software. ArcView, in conjunction with the HEC-GeoRas and Geoprocessing extensions, was used to process the large amount of data involved with analyses of the three watersheds.

Hydrology

Hydrologic modeling for the City of Griffin was accomplished using the Regression Equations developed by the United States Geological Survey (USGS) for the State of Georgia. Using the regression relations, the peak flows for various storm events can be estimated for urban basins. Hydrologic characteristics such as drainage area and impervious area were input into the equations to determine the peak flow rates for each drainage basin within the City.

Individual drainage basins within each of the three watersheds were divided into sub-basins. Delineation of sub-basins was based primarily on major road crossings and confluences of sub-tributaries within the watershed. Other divisions were made to account for variations in land use and existing drainage.

Soil data for each watershed were compiled from the Soil Survey of Spalding County. Soils within the City of Griffin are predominantly of the Cecil-Madison association, which is described as well drained and having a red sandy clay loam or clay loam subsoil. The majority of the soils (slightly less than 91%) included in the three watersheds are Group B soils. Group C and D soils are found mainly within the floodplains of the creeks.

Land use in the City of Griffin is defined by nine land use categories, which were adapted from TR-55. The TR-55 land use categories were expanded to represent the actual land use conditions within the City. The categories range from open space and wooded areas to commercial and industrial developments. The biggest modification of the land use data in TR-55 was in residential areas. TR-55 has six categories for residential property. However, the average lot size listed in TR-55 did not correspond well to average lot sizes in Griffin. Therefore, residential areas were broken down into eight classes based actual lot sizes and average impervious area. A runoff curve number for each hydrologic soil group was assigned for each land use category. Where necessary, runoff curve numbers were interpolated from those shown in TR-55. Average impervious areas were estimated for each category based on the data in TR-55. Table 1 shows the impervious areas and runoff curve numbers used.

Table 1. Runoff Curve Numbers by Land Use & Hydrologic Soil Group

Land Use Category	Description	Average Imperviousness	Runoff Curve Number Soil Group B	Runoff Curve Number Soil Group C	Runoff Curve Number Soil Group D
Apartments	Apartments, Townhomes	65%	85	90	92
Commercial	Shopping Centers, Offices, Institutional	85%	93	94	95
Industrial	Factories, Warehouses	72%	88	91	93
Open Space	Lawns, Natural Grassed Areas	0%	65	76	81
Open Water	Lakes and Ponds	98%	98	98	98
Park Land	Parks, Cemeteries, Recreational Areas	20%	61	74	80
Residential Class 1	0 – 0.13 acre avg. Lot Size	65%	85	90	92
Residential Class 2	0.13 – 0.25 acre avg. Lot Size	52%	80	86	90
Residential Class 3	0.25 – 0.50 acre avg. Lot Size	34%	72	81	86
Residential Class 4	0.50 – 0.75 acre avg. Lot Size	24%	70	80	85
Residential Class 5	0.75 – 1.0 acre avg. Lot Size	22%	69	79	84
Residential Class 6	1.0 – 1.5 acre avg. Lot Size	18%	67	78	83
Residential Class 7	1.5 – 2.0 acre avg. Lot Size	14%	65	77	82
Residential Class 8	2.0+ acre avg. Lot Size	5%	64	75	80
Transportation [1]	Roads & Right-of-Ways	65%	87	90	91
Wooded Space	Forests, Heavy Tree Canopy & Ground Cover	0%	60	73	78

[1] *Average Imperviousness computed based on the assumption of 30-foot average pavement width on a 50-foot avg. R/W width.*

City of Griffin Tax Parcel data was used for modeling of land use within the project area. Field checks were performed to account for recent changes in land use from that shown in the City's GIS database. Each tax parcel was assigned a runoff curve number and impervious area based on actual land use. Using the Geoprocessing extension within ArcView, the soil and land use information was combined to calculate the weighted runoff curve number and total impervious area for each sub-basin.

Hydraulics

Water surface profiles for all the tributaries were modeled using the US Army Corps of Engineers Hydrologic Engineering Center's River Analysis System (HEC-RAS). The HEC-RAS model is an open channel steady state hydraulic simulation program. It uses the standard step backwater calculations to compute changes in water surface elevation between adjacent cross sections on the basis of energy losses. HEC-RAS also has the ability to compute water surface elevations at structures such as bridges and culverts.

HEC-RAS can be set to compute the water surface profiles using a sub-critical flow regime, a super-critical flow regime, or a mixed flow regime. Although some of the streams under study exhibit super-critical flow at times (especially during the more common events such as the 2-year discharge), considering super-critical results presents concerns for engineers, such as blockage of the channel and/or structures by debris. Debris blockage is impossible to predict, but given the vegetative cover of the watersheds debris blockage can be expected. If a stream is in a super-critical flow regime, and debris blockage occurs, then the flow regime will revert to the sub-critical state resulting in an increase in the water surface elevation. Therefore, flood plain analysis and delineation used only the results from the sub-critical water surface profiles.

The physical characteristics of each stream (i.e. cross section geometry, channel geometry, reach lengths and flow paths) were processed within ArcView. Cross sections were surveyed approximately every 200 – 400 feet, as well as upstream and downstream of every major structure. When physical parameters of the tributaries had been determined, the HEC-GeoRas extension within ArcView was used to process the data in 3-D for exporting to a HEC-RAS input file.

The HEC-GeoRas geometry data was then imported into HEC-RAS for analysis. Parameters such as Manning's roughness coefficients ("n" values) and expansion/contraction coefficients were entered into the hydraulic model. Bridge and culvert data were input using data from the field survey and ineffective flow areas were defined. Water surface elevations for the 2-, 10-, 25-, 50-, and 100-year frequency floods at the first cross section of the HEC-RAS model were typically started at normal depth based on slope-area computations of convergent profiles.

MODELING RESULTS

The results from the hydrologic and hydraulic studies have been used as a tool to identify flooding problems at streams, culverts and bridges under the existing land use conditions in the City. The types of problems identified include structural flooding, non-structural flooding, areas that could potentially erode, undersized or deteriorated drainage infrastructure, and roadway overtopping by floodwaters. The results of the existing drainage system evaluation will be used to develop comprehensive stormwater management priorities. Capital Improvement Project locations were identified and prioritized based on the Level of Service (LOS) for stream crossings in the watershed.

Flood Plain Delineation

After the hydraulic modeling was complete, the water surface profile data was exported from HEC-RAS back into ArcView. Using the post-processing features of HEC-GeoRas, the flood plains for each tributary within the City were delineated and floodplain maps were created. Using the Geoprocessing extension in ArcView, buildings and parcels that lay within the floodplains were identified and mapped. Structural and non-structural flooding problems were identified as well. Using the velocities for the hydraulic analysis, streams exhibiting erosion potential were mapped.

Level of Service (LOS) Ratings

Each stream crossing structure within the corporate boundaries of the City has been assigned a LOS rating based on the return period of the event the structure conveys. A service rating of 10-years means that the 10-year event does not overtop the roadway but the 25-year event does. If a road is overtopped by the 2-year flood event, the service rating is 0-years. The degree of roadway overtopping at each discharge was also quantified.

Capital Improvement Program Recommendations

After the LOS was determined for stream crossings, the potential Capital Improvement Program (CIP) sites were evaluated and prioritized based on their current service rating. Primary consideration for selecting CIP sites is the ability for emergency service access during floods. The criteria used to select the sites are to prioritize the potential CIP's into three classes. Class 1 sites have the highest priority for future CIP's or have an immediate need for improvement based on the following factors: a high degree of roadway overtopping at frequent rain return periods; and/or a large urban areas isolated by roadway overtopping. Class 2 sites have the next level of priority for future CIP's based on the following factors: roadway overtopping at frequent to rare rain return periods; and/or urban areas isolated by roadway overtopping. Class 3 sites have lowest priority for CIP's based of the following factors: minimal roadway overtopping at rare rain return periods; and/or little if any urban areas isolated by roadway overtopping.

To assist the City in budget planning for future CIP's, preliminary cost estimates were prepared for Class 1 sites. The remedy for each Class 1 site is assumed without defining the specific improvement to the LOS or the effect on upstream or downstream flooding. When the project is programmed for improvement, a detailed evaluation of the project area will be performed to increase the LOS to current standards.

REFERENCES

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