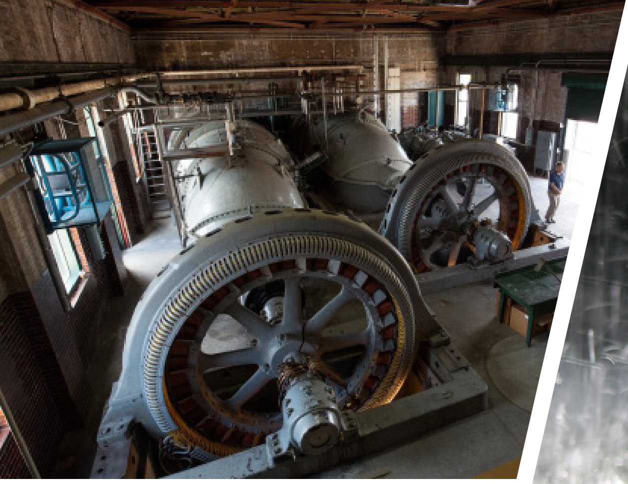


Historical/Technical Paper on S&WB Drainage System Capacity

Executive Summary

For at least the past 30 years, and probably much longer, the S&WB has stated publicly that the S&WB drainage system can handle 1-inch of rainfall in the first hour and ½-inch per hour rainfall thereafter. That criteria has recently come under scrutiny. The purpose of this paper is to discuss where that criteria came from and whether or not it accurately portrays the current capacity of the drainage system.

In general terms, the 1-inch first hour and ½-inch thereafter is not really a design criteria as much as it is a general rule of thumb that describes the drainage capacity in terms that are easy for the average citizen to understand. In reality, because of the way that the drainage system has developed and because drainage improvements are ongoing at the time of this writing, the actual capacity of the drainage system varies throughout the City from drainage basin to basin and it is constantly changing. But, the 1-inch first hour ½-inch thereafter is a conservative minimum rule of thumb and the existing drainage system is capable of handling such a rainfall throughout the city.

When a rain event occurs:

- The ground surface is not saturated and the canals and pipes of the drainage system are empty
- It takes about a ½-inch of rainfall over the basin area to saturate the soil and to fill the canals and pipes
- Each pumping station can pump at least ½-inch of rainfall in its basin per hour
- Therefore, in the first hour of a rain event, ½-inch of rainfall is absorbed by the ground and fills the canals and pipes and ½-inch of rainfall can be pumped away
- Following the first hour, the ground is saturated and only the ½-inch of rainfall that the pump station can pump is moved away from the basin

This general rule of thumb is used as a simplified way of explaining the drainage capacity to an average resident who has a limited technical background and no understanding of hydrology.

To prove how this general rule of thumb works, BCG Engineering has run the calibrated, comprehensive, computer model of the citywide drainage system using such a rainfall event as input and found no flooding.

BCG ENGINEERING & CONSULTING INC.

History

It is unclear where this rule of thumb originated. The Master Plan for Orleans Parish Drainage Improvements, prepared by Daniel, Mann, Johnson & Mendenhall (DMJM Study) in 1983 says, "As originally envisioned in 1896, the entire drainage system was designed to accommodate the runoff from a storm of one inch per hour for one hour and one-half inch per hour for four successive hours." We have reviewed the 1895 "Report of the Advisory Board on Drainage for the City of New Orleans". That report was the basis of our current drainage system. Shortly after the report was published, the Drainage Commission was created to build the drainage system described in that report. In 1903, the Drainage Commission was merged with the Sewerage and Water Board.

Our current drainage system is based on the recommendations included in the 1895 report. But, that report has no reference to a "design storm". The science of hydrology at that time was in its infancy and the concept of a "design storm" did not exist.

We suspect that the "1-inch first hour, ½-inch thereafter" rule of thumb was adopted at some point during the first half of the 20th Century. The original drainage system was only designed to drain the area between the Mississippi River and the Metairie/Gentilly ridge. As the city began to expand north of the Gentilly Ridge, there was a need to drain the swamplands in that area and the existing drainage pump stations had to be expanded to accommodate the additional flow of runoff. During this time, the Rational Method for drainage design came into common usage.

The Rational Method formula is: $Q = C\,I\,A$,

Where, Q = rainfall runoff in cubic feet per second (cfs)
C = coefficient of runoff
i = rainfall intensity in inches per hour
A = area, in acres

If you assume the worst case that 100% of the rain would runoff then 1/2-inch per hour of rainfall would equal a runoff of 0.5 cubic feet per second (cfs)/acre. Therefore, using ½-inch per hour as the design storm, the pumping capacity of the pump stations could be easily calculated as ½ the drainage area in acres. This provided a simple rule of thumb for sizing drainage pumping stations. So, we suspect that the drainage pump stations were roughly sized at ½ cfs per acre of drainage area, which equates to roughly ½-inch per hour of rainfall over the entire station's basin area. For instance, the drainage basin that Drainage Pumping Station No. 4 serves is 4,800 acres in area. The pumping capacity of DPS No. 4 is 3,720 cfs. Therefore, DPS No. 4 can accommodate more acreage than what is in its basin for a ½-inch of rainfall. All pump stations have the capacity to pump a ½-inch of rainfall based on the acreage they serve with some having more than twice the capacity due to expansions to the stations.

Table 1: Pump Station Rainfall Capacities

Station	Basin Area (Acres)	Pump Capacity (CFS)	Rainfall (in./hr.)
DPS1	5,600	5,800[1]	1.04
DPS2	1,400	2,190	1.56
DPS3	4,080	4,260[2]	1.04
DPS4	4,800	3,720	0.78
DPS5	1,465	2,260	1.54
DPS6	10,600	9,480[3]	0.89
DPS7	4,960	2,690[4]	0.54
DPS12	1,400	1,000	0.71
DPS19	4,160	3,650	0.88
N.O. East	8,920	4,320[5]	0.48
Algiers	6,800	4,650	0.68
Lower Coast	4,500	1,670	0.37

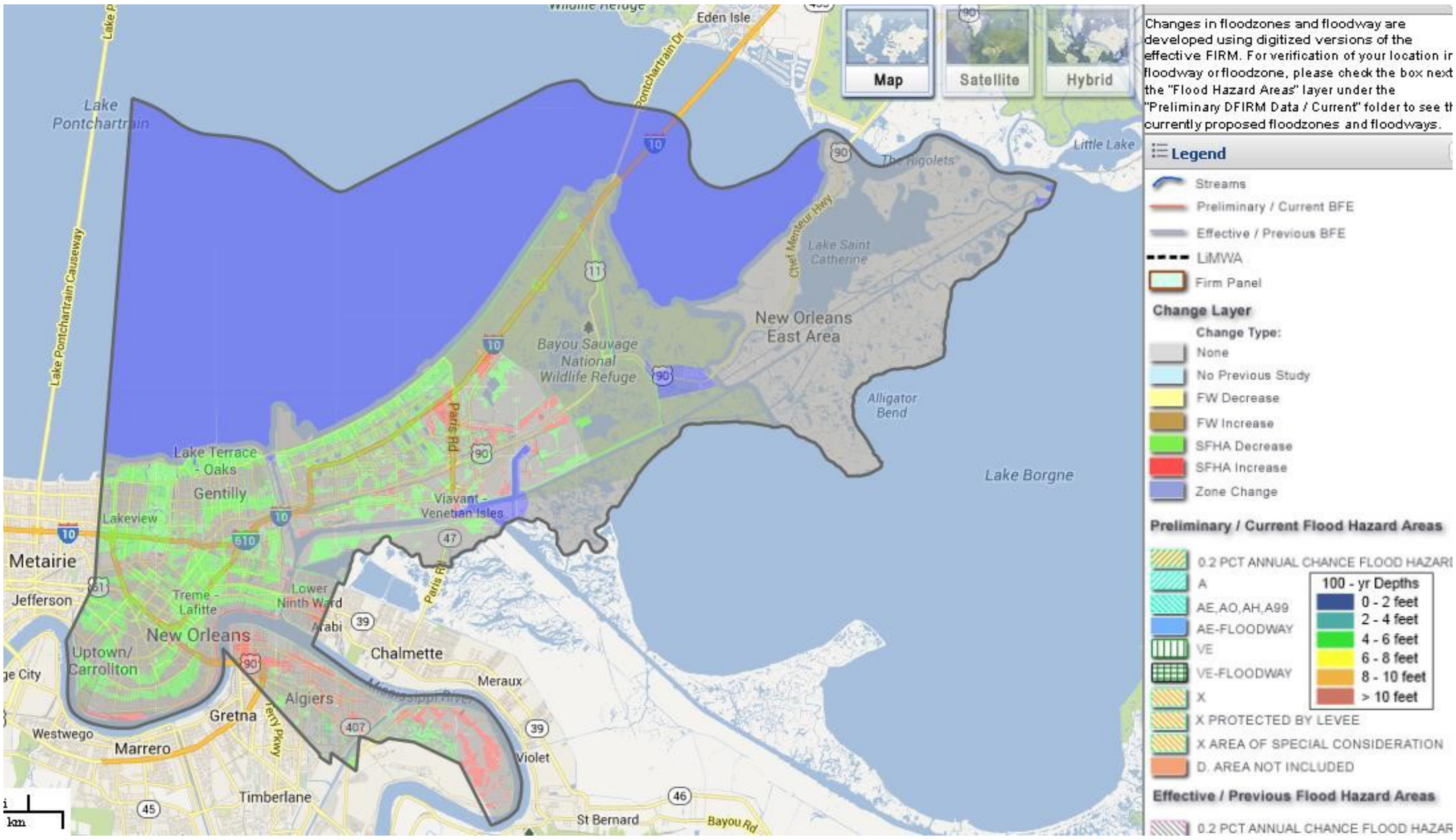
[1] Actual PS Capacity is 6,825 cfs, but that exceeds capacity of canal
[2] Assumes 1,000 acres from DPS 2 area
[3] Includes 5,600 acres from DPS 1 area and 2,500 from J.P.
[4] Includes 1,000 acres from DPS 2 area
[5] Includes PS 10, 14, 16 and Dwyer capacities

Of course, this is a very conservative design. The runoff coefficient is a factor of the surface that the rain falls on. Rain falling on grass areas may only result in 30% runoff. Rain falling on impermeable surfaces like roofs and concrete pavement may result in 80-90% runoff. In fact, the only surface that has 100% runoff is water. So, the pump stations were essentially designed to handle the runoff from ½-inch rainfall when the ground surface is totally saturated.

But, it takes time for the surface to become saturated. When, the rain begins to fall, the ground surface is not saturated and the pipes and canals are empty. So, the rule of thumb is that it takes about ½-inch of rainfall to saturate the soil and to fill the pipes and canals. Therefore, in the first hour, ½-inch of rainfall goes to filling up the system with water and a second ½-inch can be pumped out. So, that is how we believe that they came up with the 1-inch first hour, ½-inch thereafter, rule of thumb.

It is used as a simplified way of explaining the drainage capacity to an average resident who has a limited technical background and no understanding of hydrology. But, it should be noted that this rule of thumb is not the design criteria that is currently used to size the drainage system components.

Figure 1 - FEMA NFPIP Map



Current Design Criteria

The science of hydrology has developed significantly over the past 100 years. Current drainage design is based on probabilities. Obviously, it is unacceptable to have widespread flooding on a frequent basis. On the other hand, the cost of building a drainage system that can handle even the most severe rainfalls is cost prohibitive. Therefore, drainage systems are designed to balance cost against frequency of flooding.

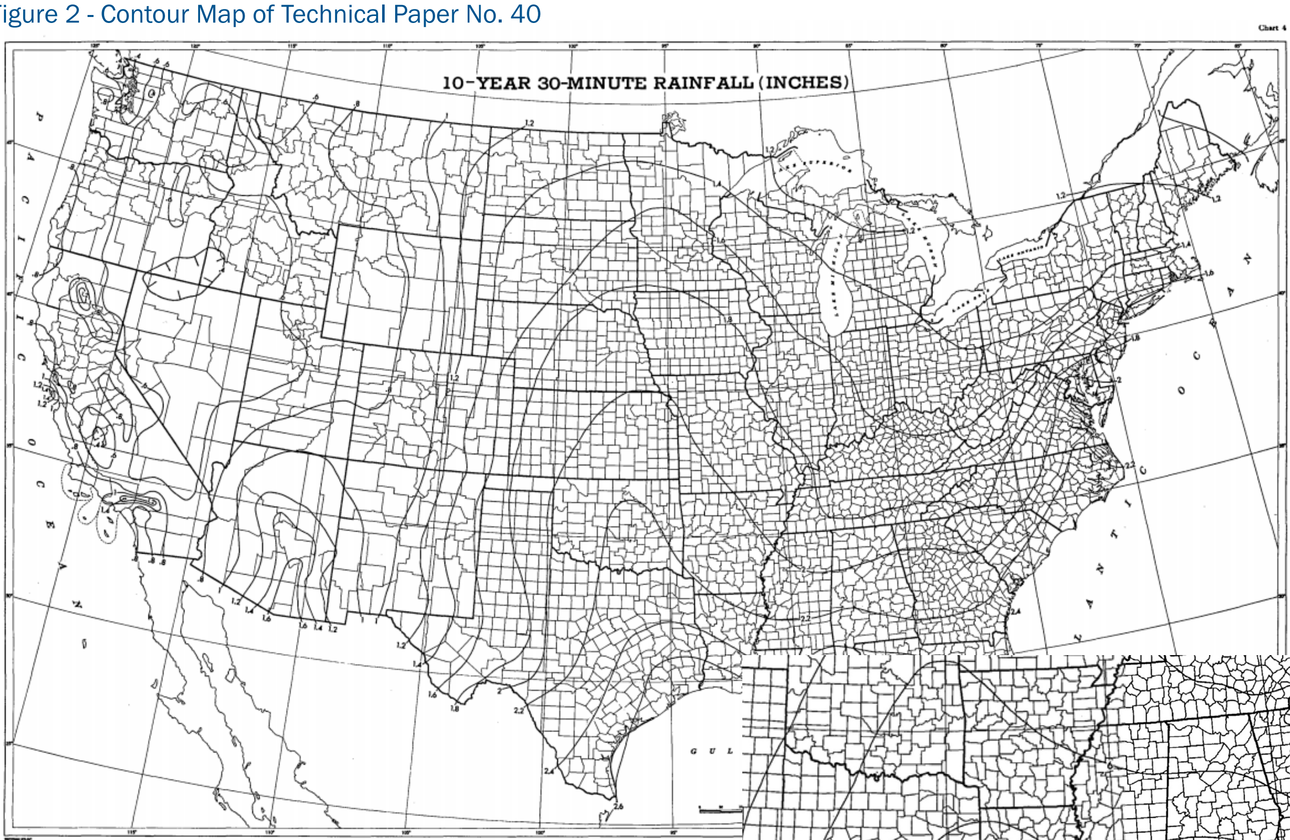
The FEMA National Flood Insurance Program is based on similar probabilities. The FEMA flood maps are based on the flooding that can be expected to occur once every 100 years. New homes must be built above the 100-year flood elevation and actuarial tables that determine flood rates assume that structures built at the Base Flood Elevation will flood once every 100 years.

Obviously, street flooding is less catastrophic than flooding of homes. Therefore, the drainage system is designed to store water in the street in an effort to prevent home flooding in a 100-year storm. New Orleans has adopted a design criteria that is similar to most other cities in the United States. New streets are designed to prevent street flooding in a 10-year storm. Therefore, the general design criteria in New Orleans is to prevent street flooding in a 10-year storm and prevent home flooding in a 100-year storm. However, it must be recognized that there are a lot of existing streets in New Orleans that were built without adequate drainage to accommodate a 10-year storm. Therefore, until all of the streets are re-constructed in New Orleans to the relatively new 10-year storm design criteria, street flooding will occur on a more frequent basis.

So, where do these storm frequencies come from? In 1961, the U.S. Department of Commerce issued Technical Paper No. 40 which provided a rainfall frequency atlas for the United States. This atlas compiled rainfall data from years of records to determine the maximum rainfall to be expected at any point in the country for rainfall durations ranging from 30 minutes to 24 hours and return periods from 1 to 100 years. This technical paper is the basis for what is commonly referred to as a 10-year or 100-year storm event.

To prepare this atlas, the Weather Bureau (now known as the National Weather Service) analyzed thousands of historical rainfall events across the country and performed a regression analysis to determine how often various rainfall intensities occurred. They then plotted those intensities on a map and then developed contours to interpolate rainfall intensities in areas where no records existed. Those contour maps are presented in Technical Paper 40.

Figure 2 - Contour Map of Technical Paper No. 40



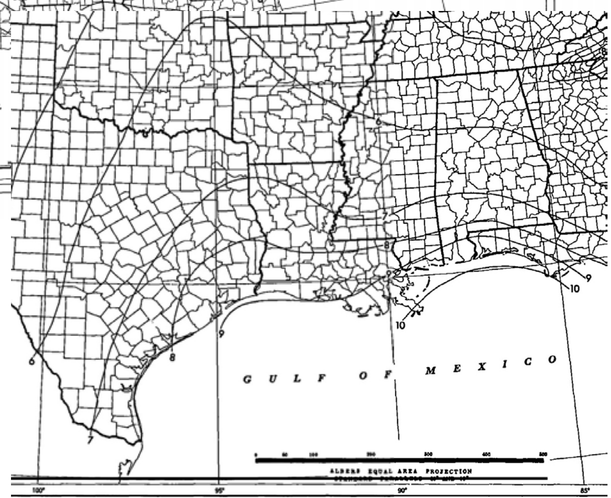


Figure 3 - Detail of Technical Map No. 40; LA Region

It is instructive to point out a couple of general points about hydrologic design that are recognized in this Technical Paper, as follows:

1. Rainfall patterns vary across the country. For instance, what is considered a 100-year storm in Chicago is essentially a 2-year storm in New Orleans.

2. A specific rain frequency is not a single rainfall intensity. The maps presented in Technical Paper 40 can be used to form a series of intensity, duration and frequency curves. Therefore, for instance, a 10-year storm event varies in rainfall intensity depending on the duration of the event.

3. Because of the variation in intensity and the time that it takes for stormwater runoff to travel from the point it falls to the structure that is being designed, the design rainfall intensity depends on the size of the drainage area. Therefore, drainage pump stations, which drain large areas, can be designed for a smaller average rainfall intensity than say a street catch basin or a small parking lot. Therefore, a rule of thumb for designing a pump station (such as the 1/2 per hour previously discussed), is not helpful when it comes to designing a structure draining a small area, such as a parking lot or a street catch basin.

When a system is designed for a specific rainfall frequency, it is assumed that the same rainfall occurs over the entire drainage area at the same time. In reality, this storm never occurs. Rainfall intensities vary over the area. This was abundantly clear in the August 5, 2017 rain event. In that event, over 9” of rainfall fell in Mid-City in a short period. But, the rainfall in New Orleans East and Uptown was significantly less than 2” over 24 hours. So, the rainfall in Mid-City was in excess of a 100-year storm, but the rainfall in New Orleans East and Uptown was not.

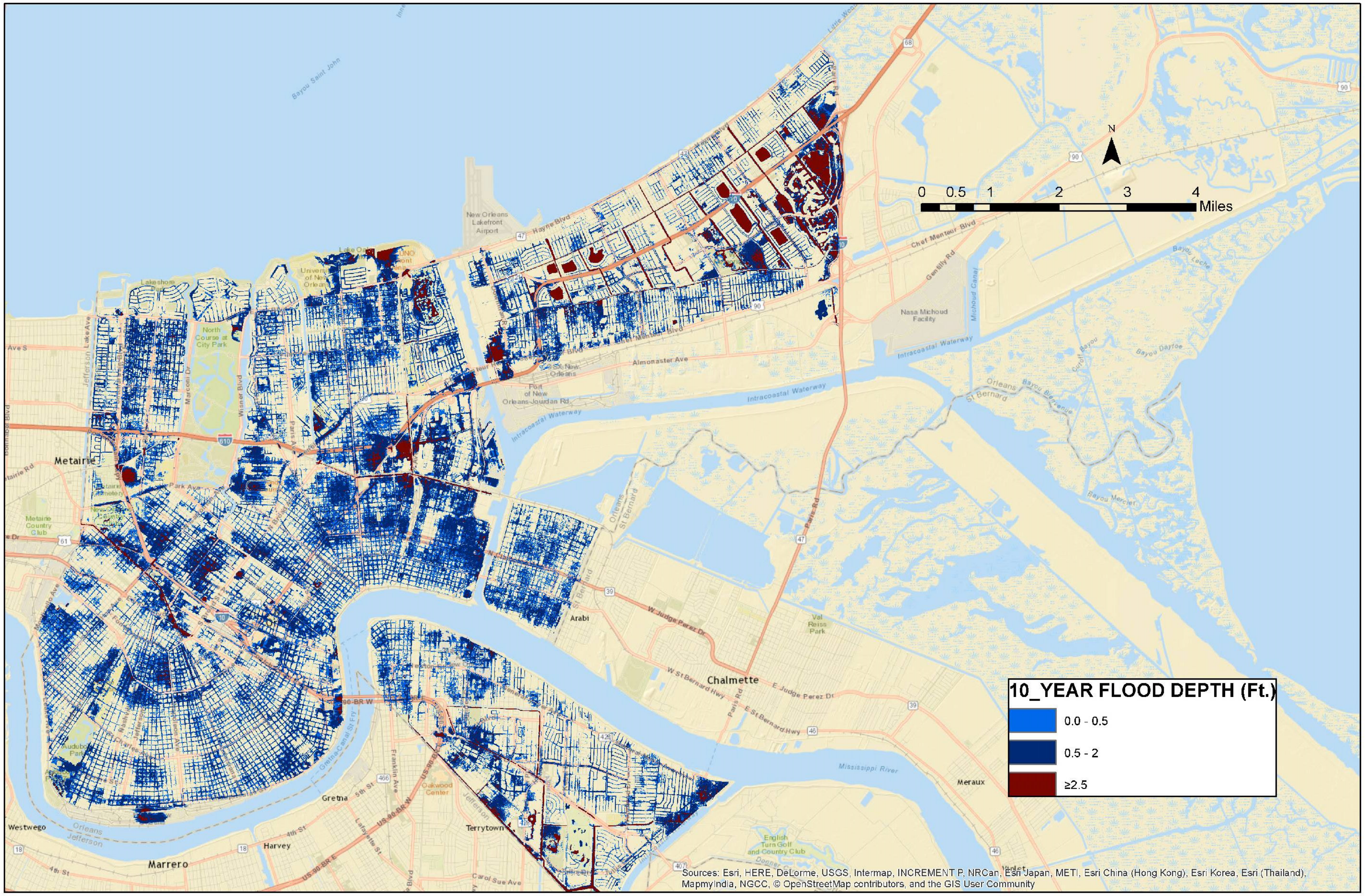


Figure 4 - 10 Year Flood Map

Conclusion

Since no one can predict where the rain will fall, the conservative approach is to design the drainage system to handle a reasonable rainfall frequency over the entire City.

Rainfall frequencies can be confusing to a lay person. They are hearing that we are having 100-year events every couple of years. But, the reality is that we may have a 100-year event in Mid-City, but not in the rest of the city. A couple of years later, we have a 100-year event in uptown, but the rainfall in Mid-City is less than a 100-year event. So, that is not really two 100-year events in a short period, it is actually single 100-year events in two different locations.
Because of the confusion, some public agencies have tried to move away from the “10-year” and “100-year” storm designations and refer to a 100-year storm as an event that has a 1% chance of happening in a year. In our opinion, the only reason this is less confusing is because the average citizen does not have a very good understanding of percentages and probability.

In conclusion, the 1-inch first hour and ½”-inch thereafter is a minimum capacity for all pumping stations and it is a general rule of thumb that describes the drainage capacity in terms that are easy for the average citizen to understand.