ENGINEERING REPORT

ON

TAX DAY STORM
(APRIL 15-16, 2007)

REQUESTED BY:
CRANFORD TOWNSHIP COUNCIL

PREPARED BY
Township of Cranford
Engineering Department
Room 100 – Municipal Building
8 Springfield Avenue
Cranford, NJ 07016

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EXHIBITS

1.0 INTRODUCTION:

At the request of the Township of Cranford Council, the Engineering Department was asked to prepare a report that evaluates the April 15 through 16, 2007, northeaster that inundated our community leaving 66 homes flooded above their first floors, 427 homes with flooded basements, and over 2.3 million dollars in public property damage and municipal costs.

This report will present the data that the Engineering Department collected from this storm, a storm that we like to call the "Tax Day Storm." We will compare this storm to the new FEMA reports and maps showing the estimated 100 year, or 1% annual flood, storm. We will also compare this storm to the "Floyd" storm in 1999. We will present some observations about the storm and how it impacted our stormwater facilities and community. Base on all our data recovered we will discuss some observations, make recommendations, and come to some conclusions.

It is important for you to know that river hydraulics are dynamic and are complicated. Rivers, like the Rahway River, will act differently for any given storm event, because the river is always changing in character. Bank erosion and debris, like fallen trees and the ever-changing sediment, change the flow-rate, or velocity, of a river. (There are many different velocities in a river at any given point during a storm. The main portion of the river, between the two normal banks, usually generate higher water flow velocities then the flows in the over-banks areas, or floodplain, of the river. The flood plain can extend hundreds of feet in width beyond the normal banks of the river.)

In addition, every storm event is different. It may rain 10 inches in one area and not rain two miles away in another area. The rain may come down hard and quickly in one area and not in another area. Tracking the highly intense areas of a storm and a storms timing is still an educated witchcraft. This "Tax Day Storm" proved to be one of those difficult storms for tracking the area of heavy rainfall.

Based on the above understanding of river and storm event dynamics, the Township of Cranford Office of Emergency Management (OEM) did their best in trying to identify the nature of the storm, and how it was going to impact our community. They prepared their operations based on the best available data at the time.

Although the Township had major flooding damage, the blessing in all this is that no one was killed or injured, and that the community came together and supported each other in their tragic event. Neighbors were helping other neighbors with cleaning up, neighbors provided temporary housing for neighbors that could not stay in their homes because they were un-safe, and the surrounding communities provided public work department support machinery and personnel in the cleanup efforts.

2.0 OBSERVATIONS:

2.1 LOCATION: The Rahway River and its tributaries drain about 31 square miles of land into the Township of Cranford. This is about 20,000 acres of stormwater runoff that comes from other communities and drains through Cranford. The Rahway River Drainage Basin begins as high up as West Orange. There are five communities in Essex County and eight communities in Union County that drain their stormwater through Cranford.

2.2 STORM HISTORY:

2.2.1 Timing: Heavy rains began to fall across New Jersey during the early morning hours on Sunday April 15, 2007. National weather forecasts were predicting a major northeastern storm event to impact New Jersey and surrounding states as far back as April 12. On Saturday April 14, at 1:30 PM "Accu Weather" reported exclusively for the Cranford Police Department a" heavy rain/high wind advisory," and that the storm would reach our area by 5:00 AM Sunday. (See Exhibit A "Accu Weather Report")

Based on this information, the Township Department of Public Works opened all the gates located at our two dams around 7:00 PM Saturday evening, before the rain event started.

The USGS 01394500 Rahway River Gage Station near Springfield showed that the depth of water started increasing around 4:00 AM, the next morning, Sunday, April 15th. (See Exhibit B "Springfield Gage Height Table") Finally, this gage station indicated that the major intense portion of the storm ended around 11:30 PM when the gage showed peak height. It was also observed in the field at the Mobile Commend Center that the rains started to subside around the same time.

2.2.2 Tract of Storm: The storm developed over Texas on April 13, and move off the coast of Virginia on late Sunday, April 15. The storm then moved slowly northward reaching the New York City area early Monday Morning April 16. The heaviest rainfall tract of this storm went through the center of New Jersey. (See Exhibit C, "Map of Tract of Heaviest Precipitation of Storm," taken from a USGS report entitled "Summary of April 15-18, 2007 Flooding in New Jersey.") Based on the precipitation total from IFLOWS rain gages in northern New Jersey, as represented on a map in the same above referenced USGS report, the tract of the heaviest rain, shown in inches, came through Cranford. (See Exhibit D, "Precipitation Total in North Jersey")

2.2.3 Precipitation: Even though the National Weather Service indicated that precipitation totals averaged between 5 to 7 inches across most of the state, this thin tract of heavy rain dumped 9.1 inches over the Irvington area, and 7.87 inches in the New Brunswick area. On either side of this tract in the Union County Area, a low of 2.87 inches was recorded in Millburn area and very little rain was deposited in the Woodbridge area, as can be seen from this Exhibit D map. Even the local newspaper, The Star Ledger, reported that a cumulative 10.27 inches of rain fell in Newark, and stated that other areas got as little as April showers. (See Exhibit E "Cumulative Rainfall Yesterday in Newark") Based on this precipitation information, Cranford may have gotten over 8 inches of rain in less then a 24-hour period. There were areas in Cranford that had flooding that normally do not have flooding. For example, it was reported that Casio Brook system, located to the west of the river, flooded so high that the entire roadway that parallels the brook, Casio Avenue, was a raging river, not seen by the residents in the area before.

2.3 GAGE STATION OBSERVATIONS: As stated earlier, the USGS 01394500 Rahway River Gage Station near Springfield (Springfield Gage) showed that the depth of water started increasing around 4:00 AM, (See Exhibit B "Gage Height Table") the approximate start of the storm in our area. By 11:30 AM the gage read 5.18 feet (5.2' is when protocol requires the DPW to start to mobilize the pumps), and the mobilization of the pumps started. By this time, the Police Department had already started reading the staff gage at the Balmiere Parkway Footbridge every 30 minutes. (See Exhibit F "Balmiere Parkway Gage Reading")

Both gages were rising at a consistent rate until 6:00 PM, when the Springfield Gage actually started descending. The calculated flow rate at the gage station was 2,790 CFS. Based on the history of gage data of past major storms, this flow rate would be far below what the dikes would be breached at. (See Exhibit G " Gage Comparison of Past Major Storm Events") However, two hours later, the Springfield Gage starting showing a surge in rainfall intensity. The increase in water height at this gage was doubling every 15 minutes. Around this same time, the Police Department could not get to the gage at Balmiere Parkway because the depth of water cut them off.

This sudden surge in water required the OEM to meet. Although the Springfield Gage still indicated that the flows would still be below what the dikes would breach at, observation of the weather maps, the surge in gage readings, a gage reading of 67.1 feet (an increase of 1.2 feet in an hour) at Balmiere Parkway(recovered by the DPW accessing by a front-end loader,) and the fact that the local areas outside the flows of the river were showing a surge in flooding, the OEM called for a mandatory evacuation. By 11:30 PM and Springfield Gage peaked at 9.35 feet, 4,690 CFS.

Even this peak, based upon the Exhibit G " Gage Comparison of Past Major Storm Events" readings, showed that the Balmiere Parkway gage should only be reading 67.6 feet around 5:00 AM to 6:00 AM the next day. This would have placed the

flood elevation at the bridge a half of foot below the top of dike at its lowest point. However, this was not the case. By 10:45 PM the dikes started to breach. By 11:00 PM the entire dike system along Riverside Drive breached. By 5:00 AM the next day the flood elevation peaked at the Balmiere Parkway gage. The high water mark reading was 69.3 feet at the footbridge, over 1.1 feet higher then the dike in that area.

2.4 PEAK FLOOD ELEVATIONS: By 5:00 AM Monday morning, just after the River peaked in the north side of town, the Engineering Department started tagging all the high water marks that they could find. Over 61 high water marks were located and surveyed for vertical control. Marks were set before and after bridges, in areas of roadway flooding, along building lines that showed debris staining, and at other structures like utility poles that showed staining at high water marks. These new high water elevations were analyzed and placed in a chart comparing them with the 1999 Floyd storm, and the new FEMA flood map 1% or 100 year Rahway River profiles. (See Exhibit H "Peak Flood Elevation Comparisons", column titled "April 15-16, 2007, for 34 of the high water elevations along the Rahway River)

2.5 HOW THIS STORM COMPARED TO FLOYD AND FEMA: From the flood elevation data recovered in the field, as shown on Exhibit H, the Engineering Department plotted the profile of the Tax Day Storm and Floyd over the new FEMA profiles. (See Exhibit I 'Flood Profiles"). Both the chart (Exhibit H) and the Flood Profiles (Exhibit I) show that this April 15, 2007 Tax Day Storm was lower then the 1999 hurricane Floyd storm. The variation went from as small as 0.25 feet to as large as 1.15 feet. In the area of the dikes, the variation was much tighter and only averaged 0.5 feet. From South Avenue, and going downstream, both Floyd and the Tax Day Storms were higher then the FEMA projected 100-year storm. From South Avenue, and going upstream, Floyd was pretty much the same height as the FEMA 100 year event projection. Only in the area between Springfield Avenue Bridge located near Hampton Road and the Belmiere Parkway Footbridge did both the Floyd and Tax Day Storms surpass the FEMA 100 year storm projections. Beginning from the footbridge all the way to Lenape Park Detention Basin the Tax Day Storm was just under the 100-year FEMA flood elevation projections, However this storm was much higher then the FEMA 50-year flood elevation projections.

2.6 HOW THIS STORM COMPARED TO FUTURE DIKE IMPROVEMENTS: A preliminary report prepared by Hatch Mott MacDonald (HMM) on February 9, 2006, targeted the 50-year storm as the storm event that would start to over top the existing dikes. This 50-year storm event is based on the latest flood insurance study FEMA reports. The HMM report hypotheses is that the existing 50-year storm event would be a good starting point for evaluating the impact of phases 1,2 and 5 on the dikes.

The Northeast Quadrant projects, phases 1, 2, & 5 called for the design of storm water express piping systems that take the rainwater runoff from our upper reaches of our local drainage systems and "express" it, (by-passing the local under-designed drainage systems) and get it into the river before it floods the downstream areas. These phases also included pumping stations that will pipe the rainwater runoff, (runoff that our local stormwater piping systems collect,) and pump the water over the dikes. This would eliminate the major flooding of the communities behind the dikes for up to a 50-year storm event.

Basically, HMM took all the water that spills over the dikes, the water that was stored among the homes and in the roadways during the 50-year storm event, and placed it back in the main river between the dikes. They then ran this change through their computer generated hydraulic model of the Rahway River, and observed what happens to the changes in the flows and depths. They called this their "project storm event." (Note, with phases 1, 2 & 5 in-place, and the dikes remaining at existing height, there would be no change in the flood elevations for storms greater than the 50-year event, because the dike would be breached anyway, flooding the area.)

Table #2 of the HMM report is the outcome of this hydraulic river flow model run. It shows the difference between the existing water surface elevations of the 50-year storm event and the target storm event in the area of the dikes. (See Exhibit J " Estimated Existing And Proposed Water Surface Elevations") This chart does not compare the existing dike elevation with the 50-year storm elevations. However, it does show, from the Balmiere Footbridge downstream passed N. Union Avenue, that there is an increase in the river height averaging 0.5 feet higher then the existing 50-year, if that storm was contained within the dikes. Upstream there is an average increase of 0.7 feet. By plotting this information on Exhibit I " Flood Profiles", "plat 120P," the FEMA profiles, it shows that the "Tax Day" storm would have still breached the dikes if they were brought up to the "Target Storm Event."

The problem with using this "Target Storm Event" is that it impacts downstream of Springfield Avenue by raising the water surface elevation approximately 0.5 feet, and there will be an increase in water surface elevation upstream of approximately 0.7 feet in the area of Kenilworth Boulevard, impacting the residents in the vicinity of Lenape Park.

As stated in the HMM report, before the dike could be raised to this height, there would have to be some additional mitigation, like by-passing the additional stormwater flows past the downstream residents and possibly holding back more water in Lenape Park Basin for the upstream residents. A more detailed report is now underway by HMM. This final HMM report may show us that the dikes will have to be lower or higher. In any event, they will not be able to be as high as needed to protect the residents from this community from the 100-year flood event, without mitigation along the upstream and downstream communities. This would require New Jersey Department of Environmental Protection and US Army Corp participation.

2.7 IMPACT OF STORM ON INFRASTRUCTURE:

These following items only address physical damage to infrastructure that is presently known and obvious. There will be underground piping system damage that most likely occurred, but has not been specifically identified. We also are not addressing personnel man-hours spent or machinery lost, nor the cost and time spent on picking up and removing the damaged property and debris generated by this storm.

2.7.1 Dike System: The storm had a major impact on our dike system. Because this storm breached the dikes at all locations, there was erosion of the top of the dikes and the downstream slope of the dikes. In some areas it was severe. Approximately 4000 feet of dike will have to be rehabilitated. The Engineering Department is looking to repair the dikes back to their original designed sections and heights. In addition, to reduce future erosion and repairs on the dikes, the Engineering Department is looking to armor the top and downstream slope of the dikes with some high strength interlocking grass paver design that would reduce any future erosion that occurs when the dikes are breached. The top of the dikes would still act as a pathway because we would propose ¾" gravel for the pathway. We hope that the County would be able to help fund the pathway portion.

2.7.2 Footbridges: The other major impact that this storm had was on one of our footbridges, entitled the High Street/ Baldwin Court Footbridge. This footbridge is one of the major routes for the students of Livingston Avenue and Hillside Avenue Schools. With this bridge out some of these grammar school age students have to walk almost a mile through busy intersections to get to Walnut Avenue School and more then a mile to get to Hillside Avenue School.

This bridge was severely bowed and yanked from its abutment walls leaving gaps in the pins that hold this bridge to the wall, and bending the steel and bolts that support the pre-manufactured bridge together. The Engineering Department is currently in contact with a consultant to prepare plans for a new bridge.

2.7.3 Public Buildings: Two public buildings had major damage from this storm. The Municipal Court Room and Judge Chambers, located in the Municipal Building, had over 8" of water in it. The Canoe Club building had over 24" of water damage. The Municipal Court Room and Judge Chambers repairs have been completed, and the Canoe Club building damage estimate has been provided for insurance coverage.

2.7.4 Dams: The Hansel Dam at Sperry Park has had some minor damage. Although this damage does not presently threaten the failure of this dam, it should be repair as soon as possible before is gets worse. We anticipate that the DPW work forces will repair this dam. Both our dams have had cracks around the old gates that now need to be monitored more, and repaired in the near future. And both dams need wing wall repairs due to this storm.

2.7.5 Roadways: Our roadway surface has had damage in the form of surface pavement being lifted and removed along the dikes areas, and in the flooded areas where emergency vehicles and operations extended, roadways were cracked, and cut up.

2.7.6 Storm and Sanitary Systems: Because most of our storm and sanitary sewer system infrastructure is underground, we can not identify many of their failures due to this storm, other then what we can easily see; like headwall under-mining and displacement, or manhole cracking.

2.8 IMPACT OF STORM ON NEW STORMWATER SYSTEMS: There was no appreciable damage to our new stormwater express storm sewer system other then some minor erosion at one of the new outlet structures and that has been fixed. The Phase #1 system worked properly. The new "flex" floodgates did close.

2.8.1 Local System Backup: What happened in the area of this new system was anticipated, because of the magnitude of this storm event. The local Glenwood stormwater-piping system did surcharge quickly because the system was not designed to take the volume of rain that fell in such short time. We may have had over 8 inches of rain, possibly reaching up to the 100-year storm event in this area. Those inlets, specifically the yard inlets that are lower then the street inlets, will and did bubble or spray out water, because of the volume and head pressure of the water trying to go down stream of it.

2.8.2 New Swale Protection: The new swales located between Oak Lane and Herning Avenue did not overflow. However, the old existing stormwater-piping system that runs along the back yards of the residents of Herning Avenue did surcharge quickly, because the piping system was not designed to take the volume of rain that fell in this area in such a short time.

The path of the rainwater runoff, from the wooded areas and adjoining community of Kenilworth, was the same path that ran into the back yards of some of the homes along Herning Avenue before the improvements were made, with the exception of the runoff in the immediate vicinity of the swale. This runoff went directly into the swales by-passing the Herning Avenue yards.

However, the path that this water takes after it gets into the back yards may have changed. At this time the Engineering Department is looking into providing an additional yard inlet in the area of the flooding to more quickly dissipate the flooding in those low lying areas outside the wetlands, but inside their yards. With the new landscaping in the swale easement at Stone Street, and new landscaping walls constructed by one of the residents, the over-land flow of runoff may be partly restricted, holding back more water then it originally did. In addition, the pipe located in the area will be video taped to see if there has been a failure of some sort.

3.0 CONCLUSION:

3.1 UNIQUE STORM: The Tax Day Storm was different than most of the storms in the past records. The heaviest volume of rain in the immediate area tracked through Cranford, but did not come through Millburn located upstream of Cranford, nor Clark and Woodbridge located to the southeast. This may account for the Springfield Gage readings being so low when the river at Cranford was already breaching the dikes.

In addition, the volume of rain that fell so quickly in the area immediately west and northeast of town created flooding uncommon to the area. Heavy rain from the Echo Lake area, and from Kenilworth may have filled the Lenape Basin faster then the Springfield gage indicated, because this gage is upstream of these areas. This may account for the Lenape Park Detention Basin emergency spillway breaching long before the Springfield Gage got to that depth.

3.2 STORM CLASSIFICATION: Based on the 61 peak flood elevations recovered by the Engineering Department, the 2007 Tax Day Storm did not peak as high as the 1999 Floyd Storm. However, in the south end of the Township this storm did peak beyond the FEMA 100-year probability storm. Only in the area between the Balmiere Footbridge and the Lenape Basin did this Tax Day Storm not surpass the FEMA 100-year projected storm, but it was much higher then the FEMA 50 year projected storm. By observing the placement of the peak height of this storm on the FEMA Flood maps, it would appear that this storm in the north end of the township would be between the 80 and 100-year event.

3.3 BREACHING OF THE DIKES: Breaching of the dikes occurred earlier then the Springfield and Balmiere Footbridge gages indicated. This was most likely do to the focused effect of the heavier rains, as stated earlier. In addition, when we analyzed this storms' peak flood elevation with the projected height of the dikes as hypothesize in the Northeast Quadrant Phase 3 and 4 preliminary report, prepared by Hatch Mott MacDonald, we found that this storm would have breached the projected hypothetical dike height.

3.4 PHASE #1 OPERATION: Based on the high water marks found on the headwalls, and swales located in the woods behind the Herning Avenue residents, the Phase #1 system functioned according to design. The flooding in the yards of the residents located on Herning Avenue were not do to this new drainage system. The flooding was do to the high volume of local rainwater runoff, and possibly minor blockage of the area where this flooding would spill over into the roadway.

4.0 RECOMMENDATIONS:

4.1 ADDITIONAL GAGE STATIONS: Because of human error in miss-reading the gage station at the Balmiere Footbridge, and the safety of the police officers reading this gage when the flood waters in the street rise quickly, a "phone-in" gage station, similar to the Springfield gage station should be placed in this area. In addition, the same type of gage station should be placed inside of the Lenape Park Detention Basin to catch those flows that enter the river system downstream of the Springfield gage. This would provide us with a little more advanced notice of sudden surges in flooding due to the breaching of the Lenape emergency grass and concrete spillways.

4.2 IMMEDIATE REPAIRS: The entire dike system was breached. The water ripped the top off the dikes in some areas and gutted the downstream, (or roadside) dike slopes in many other areas. Just placing dirt back into these areas will not stop this erosion from happening in the future. Next time the erosion may be greater, possibly causing complete dike failure. Until we complete phases 3 and 4, we recommend that the top and side of the dikes be armored with some high strength interlocking grass paver design that would prevent this erosion. So, the next time the dikes are breached, we will not have a possible failure do to erosion, or have to make such expensive repairs.

4.3 COMPLETION OF ALL FIVE PHASES: All five phase of our stormwater management program should be completed. There were now six times that the dikes were breached since 1968. (See EXHIBIT G) Each time we put our citizens, police, fire and public works people at risk. In addition, hundred's of thousands of dollars is lost in machinery usage, man-hours, and material costs due to an event like the Tax Day Storm. Until Federal help is available, in the form of US Army Corp support, and a 100-year design is implemented for the entire river system, we should try to reduce those number of occurrences that the dikes breach.

4.4 ARMY CORP REGIONAL DESIGN: History shows, from other US Corp projects, that the US Army Corp will take many years to study, design, and construct a 100-year protection for this river system. We have to encourage action now, so that we may be able to have protection in less then ten years.

4.5 OTHER OPTIONS: The federal flood insurance program is being hit hard across the country in the last few years because of the unprecedented major storm, hurricanes, and flooding. FEMA will be looking for other options to mitigate the damage costs of these storms. They do not want to pay over and over again for the same damage. The following are areas where they will be looking to reduce these re-occurring costs:

4.5.1 By-Outs: We should encourage residents that get the major flooding damage to sell their properties and turn their properties into "Green-Acres." We should encourage our government to provide fair compensation for this cost.

4.5.2 Raise Homes: The first floors of many homes could be raised to get them a foot above the 100-year flood plain, thus reducing the damage costs significantly. We should encourage our government to provide fair compensation for this work.

4.6 RAHWAY RIVER AUTHORITY: If we are going to spend ten's of millions of dollars in protecting our community from flooding we must also take seriously the idea of controlling the stormwater runoff that enters our community. A regional Rahway River Authority will help everyone in controlling all development from increasing our stormwater runoff, and it may even help to clean up our river.

EXHIBITS