What Is Causing Unusual Flooding in Back Bay?

THE ISSUE: Our monitoring data indicates there were 112 days that water levels were at or above elevation 1.3 during 2011 (reference datum NGVD88). Between 2008 and 2010 the average number of days water reached this elevation equaled just 21 days each year. This represents an increase of 91days water was at or above elevation 1.3 feet during 2011 and appears unusual. Others thought so too and we received questions and comments from residents living along Muddy Creek Road near Beggars Bridge Creek, Ocean Lakes subdivision along Asheville Bridge canal, North Bay, and Sandbridge Road. Several property owners were certain the weir was causing the increased duration and frequency of flooding during the spring and fall of 2011 while other residents replied this was normal flooding that had been observed before during their lifetime. Some mentioned it appeared to have gotten worse in the last seven to ten years.

As many know, water levels in the bay appear to rise and fall in response to wind speed and direction. Water levels usually rise when winds blow from the south and fall when winds shift around to the north. Thus, most high water events occur during the spring and summer months. Our monitoring data indicate the highest water levels occur between April and September.

In response to increased flooding during 2011 we reviewed the 2004 flood study conducted for the proposed establishment of the weirs , questioned the U.S. Fish and Wildlife Service regional hydrologist, and requested an environmental statistician analyze multiple years of data to determine if a correlation exists between wind and water levels in the bay.

PRE-WEIR FLOOD STUDY: The 2004 flood study was conducted by the U.S. Geological Survey for the Service using the City of Virginia Beach stormwater model. This model has been in use for over 20 years and was revised in 2003. The model is used to predict changes in flooding due to development or other physical changes in the watershed and was utilized in the permitting and site plans of most contemporary subdivisions and development in Virginia Beach. The model predicts flood elevations from rainfall, runoff, and hydraulic conditions that include free-surface and pressure flow, hydraulic structures, tidal conditions, and storage. The 2004 study examined the effect on the 2, 10, 25, 50, 100, and 500 year storm peak water surface elevations as a result of placing a tide gate on Asheville Bridge canal or a weir on Lake Tecumseh. The canal location was examined to determine if flooding in neighborhoods north of the tide gate could be alleviated by excluding incoming wind tides while allowing drainage out to the south to continue. The study included three “runs” or scenarios of the model; a baseline or existing condition (no weir), a weir on the canal, and a weir on Lake Tecumseh. Based upon the results the USGS hydrologists concluded,

“ The proposed structures have little effect on modeled water-surface elevations because Lake Tecumseh, an adjacent pond, and the wetlands on the southeast side of the lake provide sufficient storage for runoff. During runoff events, water flows into the lake from Canal 1 and from the system upstream of the lake. When the water level in the lake is high enough, the lake discharges

into the pond and the wetlands, which keeps the water from backing up throughout much of the system. Storage in the lake, pond, and wetlands mitigates flooding throughout the system. The effect of the lake, pond, and wetlands is to store water during the runoff event, thereby preventing flooding that would likely occur without this storage capacity."

Similar conclusions were made by the City of Virginia Beach in 2010 using the same model and a letter of support for the weirs issued by the city manager. The study is available on this Web site.

EXPECTED FLOOD LEVELS: So what are the expected flood elevations in Back Bay? Regulations and manuals contain no known references for flood frequency and duration but elevations in standard specifications for design and regulation do exist. For example section 8.2c of the City of Virginia Beach Specifications and Standards Manual states the normal water elevation of Back Bay and creeks is one foot above mean sea level. Section 8.5 states that drainage systems discharging into major canals, ditches or impoundments shall use the peak design year water surface elevation for the receiving facility unless 0.8d + the invert of the system discharge pipe is higher. The city stormwater model predicts peak water surface elevation of Asheville Bridge Creek between Lake Tecumseh and Ocean Lakes subdivision to be 2.73 feet for a 2-year storm during a tide level of 2.0 feet. For regulatory purposes the Army Corps of Engineers and Virginia Marine Resources Commission specify ordinary high water to be 1.5 feet. For comparison our monitoring data indicates the average water elevation in Back Bay, between 2000 and 2010, ranged from 1.1 to 1.6 feet. In 2011 the average was 1.75 feet for 1722 continuous measurements between June and December. Peak floods are normally 2.3 to 2.6 feet above mean sea level.

HYDROLOGIST STATEMENT: We also discussed the possibility of the weir contributing to the 2011 increase in flooding with a hydrologist. Two possibilities were discussed based upon comments by the public. One, the loss of storage from the lake caused the bay level to rise and increase flooding. The other was the loss of storage was redirecting tidal surges moving up Asheville Bridge canal to the Ocean Lakes subdivision causing increased flooding within the city's flood easement.

The hydrologist stated that it was not possible for the weirs to cause flooding in the bay, especially in the area of Beggars Bridge Creek, an area approximately 6 miles from and downstream of, the weirs. There are too many other factors responsible for flooding in this area and too great a distance between the sites for the weirs to be considered a significant cause.

The other reason was the lake represents 0.5% of the bay's flood storage on a volumetric basis. This results in a $1/100^{th}$ of a foot rise in bay levels which according to published literature would equilibrate back to baseline 9 months after the weir was established. The assumptions used in these calculations include Back Bay estuary is 25,600 acres (40 sq. mi.) with an average depth of 5 feet giving a volume of 128,000 ac-ft. Lake Tecumseh, occupying 261acres, represents 652 ac-ft being excluded by the weirs. Flood storage in the lake is unaffected by the weirs above elevation 1.0. That's when the weirs are overtopped and water can access storage provided by adjacent wetlands, the lake, and canals. The residence time of water in the bay is about 3/4ths of a year. So a 652 ac-ft storage loss spread over 25,600 acres would result in a 0.01 foot rise in

water levels or 1/100th of a foot. This is not a sufficient rise in water level to account for the flooding experienced in 2011. Our calculations are available upon request.

In the area of Ocean Lakes the hydrologist stated it was conceivable that, due to the weirs holding the lake partially full, water levels in the canal would rise faster during an incoming tide and fall faster during an outgoing tide. Once the weir was overtopped and began accepting incoming flow, water levels would rise more slowly. This occurs at approximately the same elevation that the canal banks begin overflowing. Because the weir is normally overtopped and the lake allowed to absorb flood waters the maximum or ordinary high water mark is not changed or exceeded because of the weirs.

Some considered this to mean that all the water that once flowed into the lake during an incoming tide prior to the weirs now flowed directly to Ocean Lakes and was responsible for longer floods and higher flood levels there. To test this we calculated what flood levels would be if the excluded volume of lake storage resided in the Ocean Lakes drainage easement and stormwater ponds instead. We concluded this would cause up to a six foot rise in flood levels. Because the storage of the easement is half that of the lake we calculated that flood levels would rise two feet in the easement for every foot of lake water transferred. Because flood levels have not risen anywhere close to this magnitude since the weir was established this transfer of water from one place to another is not plausible. Our calculations are available upon request.

This leaves the question of how much faster do tides potentially rise in Ocean Lakes due to the weir? To answer this we examined how fast tides rose before the weir. Prior to the weir our device recorded on average 30 floods per year, 15 of these major. One of the greatest floods recorded had a total rise of 2.8 feet (from -0.2 feet to 2.6 feet) over a period of 10.1 days at the rate of 0.01 feet per hour. After rising for 3.75 days we estimate it overtopped the banks of the canal and began flooding the Ocean Lakes drainage easement and continued to do so for another 6.35 days until reaching maximum depth. The flood lasted an additional 13.6 days before the easement began draining for a total flood period of 20 days. The lake was absorbing flood water during the overbank period leaving the first 3.75 days of the flood or 37% of the time for the weir to potentially speed up the rise of the incoming tide.

Assuming the rise in tide was doubled by the weir, an incoming tide would overtop banks in 1.9 days instead of 3.75. Given the 10 incoming tidal floods recorded in 2011 after the weir was established multiplied by 1.9 extra days per flood results in an additional 19 days of flooding in 2011. What we actually recorded was an increase of 91 days of flooding in 2011. Eighteen of those days occurred by the end of May alone. Even if the incoming tide was increased to the maximum extent possible, that is the tide rose instantaneously rather than over a period of days, one could expect a 37.5 day increase in floods (3.75 days x 10 floods) which is far less than the 91 days actually recorded. Thus, it does not appear plausible the weir was responsible for the increase in flooding during 2011 when one compares the possible increase in flooding to the actual increase in the number of days flooded. Our data is available upon request.

The report from the environmental statistician is pending. He does report there is a correlation between weather and a small 3/10ths of a foot rise in water levels but it does not appear to be weir related. Rather he believes physical changes in the watershed are responsible.

CONCLUSION: In the absence of other plausible explanations we consider increases in the frequency and duration of floods during the spring and fall of 2011 were the result of extremely active weather that produced more rain and southerly winds than recent records. According to the National Weather Service, 2011 was the second wettest year on record in Hampton Roads since record keeping began in 1881 (rainfall recorded at Norfolk International Airport). Furthermore, between April and May of 2011 there were 22% more days that winds blew from the south than in 2010 and more days of southerly wind than in any of the past 4 years. Several local residents that have lived in the bay area over the past 45 years report severe flooding does occur occasionally and flooding like that experienced in 2011 has happened before.

We recorded 112 days of flooding when the average for the previous three years had been 21 days per year. The weirs were submerged during these floods, sometimes under more than a foot of water. Hydrologists state that submerged weirs have no influence on flood level. We believe the flood studies were correct and the weirs have not raised flood elevations. All comments we received have come from residents living downstream of the weirs and residents living upstream of the weirs have not reported any issues. Logically, we would expect those living in the impounded waters behind the weirs to report flooding first and foremost if the weirs were actually causing an increase in flooding. We will continue to monitor the situation and appreciate comments and observations from residents living in the watershed.