

**An Analysis of Probable Future Water Demand  
On the Virginia Lower Peninsula**

**August 3, 2008**

**Donald H. Phillips, Ph.D.**

**(Revised August 14, 2008)**

## Executive Summary

This document primarily addresses admitted defects in the basis for the decision granting a federal 404 permit for the proposed King William Reservoir project.

In its Final Recommended Record of Decision (FRROD) for the Proposed King William Reservoir Project, the US Army Corps of Engineers (USACE) acknowledged criticisms of a land use study which had been developed by the applicant's consultant, HDR Engineering, Inc. and “...recommended that these concerns be addressed in reviewing water use estimates...”. The land use study had been the basis for claiming that the Virginia Lower Peninsula could support the population and commercial development driving water demand in the consultants report. The concerns, which involved ignoring overlay zoning which restricts development, were not addressed in the decision document for the 404 permit for the project.

The FRROD also acknowledged that reductions in water demand due to federal standards for water appliances had not been properly taken into account. Water demand was not corrected for these standards in the decision document for the project. In both the above, and this case, the FFROD expressed the opinion that the defects in the demand projection, which should be addressed, would only be important after 2020, by which time the projections indicated that a risk of water shortages would already be occurring.

In reaching this opinion, the FFROD failed to take into account the new trend of decreasing water demand which had started in the 1990's. This effect had been discussed in Appendix E of the HDR Report and in the Final (August 2001) Report by the USACE's Institute for Water Resources. This trend had also been discussed in 1999 comments to the USACE by Michael Siegel, consultant to opponents to the reservoir project. It also failed to take the fact that washing machines have a relatively short replacement time so that the effects of the federal standard for washing machines would have a significant impact well before 2020 and that the replacement of pre-existing toilets and shower heads, would already be having a significant impact 22 years after the standard requiring them became effective.

These issues were addressed in rebuttal comments on the FFROD by the author of the present document, but the September 30, 2002 USACE Decision Memorandum acknowledged only a large number of post cards opposing the reservoir and did not address any substantive comments by anyone.

Since those comment periods, James City and York Counties, the two jurisdictions on the Virginia Lower Peninsula that have significant growth potential have produced build out analyses that do take overlay zoning and other restraints to development into account. The smaller jurisdiction of Williamsburg has also published build out information and the comprehensive plans of the two largest jurisdictions on the Peninsula, the cities of Newport News and Hampton, have acknowledged that they are very nearly completely built out.

The latter development enabled a new population projection with little room for error. The result indicates that the 2040 population of the Peninsula will be 50,000 to 220,000 persons smaller than projections from the FEIS, HDR Report, and USACE's Institute for Water Resources Final Report.

Incorporating a treatment of water demand using information on demand reductions from an American Water Works Association Research Foundation Report and US Department of Energy data, as well as more complete trend data showing that demand from large industrial and federal customers has been decreasing reveals that regional water demand in 2040 is likely to be approximately equal to that in 1984.

The results clearly indicate that the basis for the USACE decision on the 404 permit for the King William Reservoir was badly flawed and that the region would be ill advised to invest in new water supplies.

# **An Analysis of Probable Future Water Demand On the Virginia Lower Peninsula**

## **Main Report**

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## **Introduction**

The projection of future water demand in an area is not an exact science, but it is very important to decisions involving hundreds of millions of dollars in up front investment, major future expenses for maintenance and operations and major, if imperfectly understood, environmental damage.

The present study focuses on the Lower Peninsula of Virginia. This area, which is comprised of the cities of Hampton, Newport News, Poquoson and Williamsburg and James City and York Counties' was experiencing significant growth in population and water demand in the 1980's. James City County had tried to get a permit for a new reservoir at Ware Creek to provide for its anticipated future water demand, but the project was vetoed by the US Environmental Protection Agency. In 1987 the regional jurisdictions formed a Regional Raw Water Study Group, which eventually applied for a permit for a new reservoir in the Cohoke Mill Creek Valley in King William County, with water to fill the reservoir to be withdrawn from the pristine Mattaponi River. In addition to withdrawal structures in the middle of an important nursery for anadromous fish, the project would inundate hundreds of acres of wetlands, miles of fresh water streams, and intrude on a buffer area promised to the Mattaponi Indians by the Government of England (a treaty inherited by the Commonwealth of Virginia after independence from England).

The Environmental Impact Study (EIS) for the reservoir included 50 year population and water demand projections based on the population and water demand growth starting with 1990, the base year for its projections. The projections of the EIS received a lot of criticism and the US Army Corps of Engineers (USACE), which was the lead federal agency reviewing the EIS, had independent studies carried out by Planning Management Consultants Limited (PMCL) and later by an expert panel working with the USACE's Institute for Water Resources (IWR). The applicants, led by the City of Newport News,

countered with additional studies and rebuttals by consultants Research and Planning Consultants (RPC), Camp Dresser and McGee, and HDR Engineering, Inc.

The EIS 50 year projection was for a population of approximately 636,000 for the region with an average demand of 92.59 million gallons of water per day (mgd) in the year 2040, after accounting for additional water conservation measures. Most of the population and demand growth was projected to occur in the Cities of Newport News and Hampton which have the largest populations in the region. However, these Cities now acknowledge, in their respective Comprehensive Plans, that they are facing build out and that most future change will occur as the result of redevelopment and build in. The Weldon Cooper Center, which prepares the official population estimates of Cities and Counties for the Commonwealth of Virginia, estimates that the population of Newport News grew by 1% between April 1 of 2000 and July 1 of 2006, while that of Hampton shrank by 0.4% in the same period.

While the growth of the Peninsula's major cities had stalled, in the same period JCC grew by 28.3%, York County by 12.2% and bedroom communities outside the Peninsula including Gloucester County (4.9%), Isle of Wight County (13.1%), Surry County (5.5%), and the City of Chesapeake (8.7%) continued to grow. New Kent County, which lies between the Lower Peninsula and the Richmond metropolitan area grew by 26.9% in the same period.

Although regional population grew by 16% between 1990 and 2005, water demand only grew until the mid 1990's and then began dropping. Currently, regional demand is less than it was in 1990. Since 1990, both James City County (JCC) and Newport News have added wells into the Potomac aquifers and reverse osmosis units to demineralize the water from that source, significantly increasing the regional reliable supply of water.

The remainder of this document will examine the water demand trends and expectations for both population growth and water demand through 2040. This effort is abetted by the benefit of hindsight, the shorter period of the projection, and the detailed land use and build out studies of JCC and York Counties, the area jurisdictions with the greatest potential for growth in population and water demand. The results from the present study will be compared and contrasted with earlier results from the applicant's consultants and the IWR's expert panel.

## Population Projections

Population is frequently closely related to water demand. The residential demand resulting from population can be a significant demand factor. This factor may be less important in regions dominated by crop irrigation or high water use industries, but on the Peninsula, it is significant. Industrial demand has been relatively stable, if decreasing, on the Peninsula and commercial demand due to tourism seems to have matured. The remaining commercial and institutional demand (retail commerce to serve the population, hospitals and schools, etc.) should scale with population. Sometimes, the inverse approach, attempting to project commercial and industrial employment and then inferring the population required to provide the requisite employees, is taken. The latter approach has credibility, unless the area can't really accommodate the population and other activities projected. In the latter case, the population growth may predominantly occur in adjacent bedroom communities with much of the commercial and institutional growth following the population, leading to additional growth in the surrounding communities, rather than in the target area.

With the largest population jurisdictions on the Peninsula hitting build-out and with detailed build-out studies available for the two jurisdictions (JCC and York County) with significant growth potential in hand, the present study will focus on following the population to build-out and inferring commercial and institutional growth required to support the population. With very limited amounts of vacant land zoned General Industrial and with recent downward trends in large user demand, increases in heavy industry demand is not considered to be a significant factor in future water demand for the region.

### **James City County Growth Projection**

The 2003 JCC Comprehensive Plan (CP) notes that “Over the last twenty years, the average household size in James City County has steadily declined, from 2.82 persons per household in 1980 to 2.60 in 1990 and 2.47 in 2000. This trend in declining household size is expected to continue.” This trend is, at least in part, due to the fact that James City County is a favored retirement location. Some large developments which were in the planning stage when the 2003 CP was under development have age restrictions on a portion of the roughly 4,000 housing units they will provide. The average age of county residents was 41 in 2000, compared to an average age of 33.5 for the Metropolitan Statistical Area (MSA), which JCC is part of.

The JCC Planning Division projects that about 67,120 persons will live in the County in 2010. A “build-out” population can be estimated by noting that the 2003 Comprehensive Plan, which includes a primary service area (PSA) for water and sewer services) indicates that in 2002 “The County expects the balance of future growth to be within the PSA on parcels that are designated for residential development in this Comprehensive Plan. In 2002, consultants working with a committee of citizens estimated that parcels zoned for residential development inside the PSA had the potential for 13,000 to 13,800 more housing units.” Using the larger of these values and 2.4 residents per household, an additional 33,120 persons would be accommodated in the County. Adding the 2002 estimated population of 52,800 persons to this value, we obtain a build-out population of 85,920 persons.

However, the land use portion of the JCC 2003 CP indicates that land within the PSA that is currently zoned for agriculture (A1 zoning) or rural residential (R-8) could conceivably be converted to other residential zonings. If all such land were so converted, the 2003 CP indicates that the total number of housing units which could be added to the 2002 housing stock would be increased to about 20,000. This would lead to a maximum build-out population of about 100,800 assuming that the average number of persons per household does not drop below about 2.4.

It should be noted that the “Development Potential Study”, on which the JCC CP relies for information on potential development of vacant land, takes conservation and other overlay zones which would eliminate or restrict development into account.

There is reason to doubt that all of the rezoning required for the maximum development to take place will, in fact, occur. JCC started a Rural Lands Project which focused on land zoned A1 and R8 with the goals of :

- “Respect property rights;
- Reduce overall development potential and impact; and
- Encourage development patterns that protect the character of the area. “

Also “James City County protects open space in many neighborhoods through permanent conservation easements. While the property is still owned by the property owners association, the County limits activities in these areas.”; the County has a program to purchase development rights to properties it wishes to limit development of, and the private Williamsburg Land Conservancy also purchases land and development rights to land so that it will not be developed. Surveys of the citizens of JCC indicate that they strongly favor limiting growth. An example of this program is provided by the recent (April, 2008) County purchase of more than 50 acres with 36 pre-existing sewer taps within the JCSA service area.<sup>1</sup>

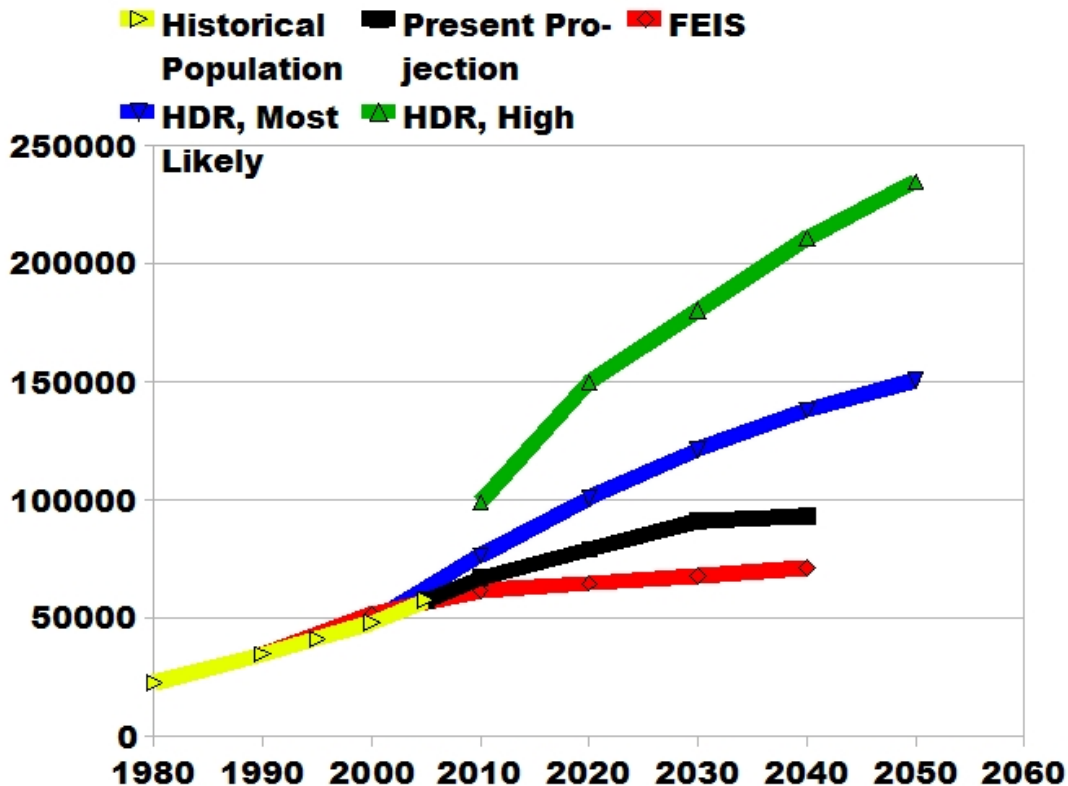
In recognition of the fact that pressures to develop more land will exist, an intermediate value for development of land not currently zoned (non-rural) residential will be adopted here. The build-out populations above will be treated as low and high estimates respectively, with the average value of 93,360 chosen as the “most probable” build-out population for JCC.

The time line for JCC population growth assumes the 2003 JCC CP value for the population in 2010. Between 2010 and 2030, it is assumed that the JCC population will grow by 12,000 persons per decade. This is at the lower end of the rates at which the JCC population grew between 1980 and 2000. This rate of growth is lower than that exhibited in recent years, but the growth experienced recently in York County suggests that the rate of growth rate may decrease as it approaches build-out. Finally, it is assumed that the growth will slow dramatically between 2030 and 2040 and hit the “most probable” build-out population in 2040.

There have been several population projections for James City County. Some of these are compared to the present in figure 1.

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1 Daily Press Article by Seth Freedland, April 24, 2008 - [dailypress.com/news/local/williamsburg/dp-local\\_jccroute5\\_0425apr25,0,5291489.story](http://dailypress.com/news/local/williamsburg/dp-local_jccroute5_0425apr25,0,5291489.story)



**Figure 1.** Comparison of the present population projection for James City County, including historical populations with those from the FEIS and two projections from the applicant's last contractor's (HDR) report.

The FEIS projection is similar to the present projection from 1990 through about 2010. After 2010, the FEIS projected growth rate is lower than the present projection until 2030 when the present projected growth rate falls as the population approaches the adopted build-out population. The FEIS projected population for 2040 was about 22,000 persons less than the present projection. The JCC Comprehensive Plan indicates that the total size of the County is 92,400 acres of which approximately 33,649 acres are tidal and non-tidal wetlands.<sup>2</sup> This leaves 58,751 acres which might potentially be developed, before subtracting floodplains, Chesapeake Bay Act protection buffers, etc.. However, according to the JCC CP, most of the soils in the County place severe limitations on the use of septic systems, so areas outside the primary service area where public sewer service is not available also has limited development potential. The HDR “high” 2050 population assumes that 77,573 acres are developed for all (residential, commercial, etc.) uses - clearly an absurd result. In 2040, the HDR high projection assumes development of 64,373 acres, which also clearly exceeds the available land. The HDR “most likely projection exceeds the build out population before 2020. By 2040, the HDR “most likely” population exceeds the build out population by about 45,000 persons, almost 50%. HDR also developed what it referred to as a “recession” or “low” population projection which is not shown here. In 2040, the HDR “low” projected population was 106,283, or almost 13,000 persons higher than the build out population assumed here on the basis of the County's land use analysis.

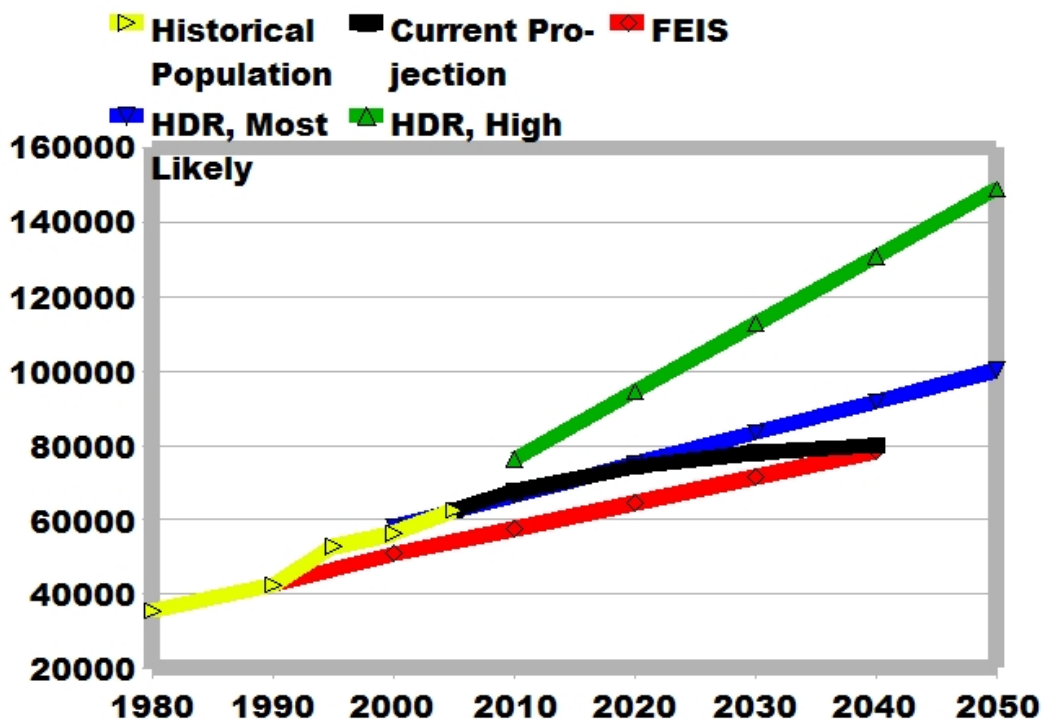
<sup>2</sup> JCC 2003 Comprehensive Plan, Environmental Section, page 1.



## York County Population Projection

The Cooper Center population estimate for York County population in 2006 is 62,729 persons and the 2005 York County Comprehensive Plan posits a 2010 population of 67,700, a 2020 population of 74,300 and a 2025 population of 76,300 persons with a build out population of about 80,000 persons. The comprehensive plan is based on a build out study and a detailed land use analysis which covers every undeveloped parcel in the County, taking protective overlay zoning into account. The Cooper Center 2006 estimate and the County planning projections through 2025 are adopted here. The County planning estimate of about 80,000 persons at build out is used for 2040 and the population for 2030 used here is based on an interpolation of the 2025 County projection and the build out population in 2040.

The current population growth projection is compared with earlier projections in figure 2 below.



**Figure 2.** Comparison of the present population projection for York County with that of the FEIS and the “most likely” and “high” projections from the HDR report.

The FEIS projection of York County population was based on a linear extension of the 1980 – 1990 growth and lies below the historical and current projection after 1990, but is a close match to the build out population in 2040. The HDR “most likely” projection is almost identical to the present projection through 2020, but because its land use study ignored limits to growth like reservoirs, watersheds, National Parks, wetlands, etc., it results in higher populations after that time. By 2040, the HDR most likely projected population is almost 20,000 persons, or 25% higher than the County's adopted build out population. The HDR projected “high” population for 2050 is about 115,000 persons, or 44% above the County's adopted build out population. This population is based on an assumption that 7,727 acres of land currently zoned conservation (National Park, wetlands, historical heritage, etc.) would be rezoned to allow residential development. This assumption is accompanied by one that an additional

1,230 acres of land zoned conservation would be rezoned for commercial, industrial, etc. uses. The York County 2005 Comprehensive Plan indicates that 10,500 acres of the land zoned conservation are reservoir areas and reservoir watershed owned by other jurisdictions and the Colonial National Park owned by the federal government. The remaining land zoned conservation is wetland or other sensitive watershed area. The HDR “most likely” projection is clearly fallacious after 2020 and the entire “high” projection is out of bounds.

### **Williamsburg Population Projection**

The City of Williamsburg includes fairly large institutional land holdings by the College of William and Mary and the Colonial Williamsburg Foundation. The City's current Comprehensive Plan does not include planning for these entities, except to note that, based on the College's Comprehensive Plan, they expect the student population housed on campus to be stable. The Colonial Williamsburg Foundation also rents a few of its properties as residences for its employees. The latter is also expected to remain stable. Since Colonial Williamsburg and the Busch Garden and other recreational attractions nearby in James City County attract a lot of visitors, the city has a lot of businesses catering to the tourist trade.

Williamsburg is approaching build out. In 2006 it had 304 acres of vacant land planned for residential development and 349 acres of vacant land planned for commercial development. According to the Comprehensive Plan, “A large portion of these vacant lands - the High Street property on Richmond Road, and the Riverside Health System property at the southeast corner of the City – are slated for development in the near future.” These developments would, together, provide for 1,535 additional housing units. Based on these development plans, the City expects growth through 2030 to exceed that projected by the Hampton Roads Development Corporation (HRDC). The City's population projections would require about 1,000 housing units in addition to those already in the planning process based on it's projected household size of 2.06 persons per household. That level of additional housing would use up the remaining vacant residential land as well as relying on some redevelopment.

The City projects a population of 16,600 in 2010 and 19,000 in 2030. By way of contrast, the HRDC projection is for 15,100 persons in 2030. The current slow down in the housing market may make it difficult to achieve the housing expansion envisioned between 2006 and 2010. Never-the-less, housing and land prices in Williamsburg are high compared to regional values, indicating that the City is a desirable place to live, so the City's optimistic projections will be accepted here, but since it appears that in order to achieve the 2030 projection all available land for residences would be used up, the population will be held constant from 2030 to 2040. The population used for 2020 will be based on an interpolation of the City's values for 2010 and 2030. The FEIS forecast a 2040 population of 17,700 and the HDR “most likely” population forecast for 2040 was 13,542. Both are lower than the current projection.

### **Poquoson Population Projection**

According to Wikipedia, “The name of the city is a [Native American](#) word which roughly translates to "great marsh" or "flat land." The term [pocosin](#), with its varied spellings, was a term used by the area's inhabitants to describe a low, marshy, woody place covered by water in the winter, but is dry in the summer.“ Because of its low elevation, significant property damage was wrought in Poquoson by the Hurricane Isabel tidal surge (actually a tropical storm when it hit Virginia). The fact that Poquoson lies

at low elevations makes population projections subject to a significant downside risk. This risk will be ignored in the subsequent discussion and projections.

Poquoson's web site does not provide a comprehensive plan or much other local planning basis for population projections. It does mention that there are a couple of new subdivisions planned. Historically, the City had grown in the 1960s and 70s and grew by an average of about 228 persons per year between 1980 and 1990 after which growth has averaged about 54 persons per year. A rate of growth of 54 persons per year will be adopted here for the period between 2006 and 2020, after which the population will be held constant. The 2040 population projected here is 12,621 compared to the FEIS value of 26,242 and an HDR "most likely" projection of a 2040 population of 14,063. The HDR 2050 "high" population was 16,895 and was based on utilization of 100% of the land (apparently including some of Poquoson's marshes and wetlands). The FEIS projection, which made no attempt to analyze limits to growth is clearly much too high.

### **Hampton Population Projection**

Hampton's population kept growing until the mid 1990's when growth slowed and then stalled in the latter 90's. Since then, its population has oscillated around a value of about 145,000 persons. Hampton's comprehensive plan (titled Hampton's Community Plan and adopted February, 2008) notes the existence of some vacant land which might be developed and it recognizes that the city is hitting build-out and that "infill, redevelopment, and revitalization will be the main source of growth and change in the city."

The Community Plan indicates that significant tidal and non-tidal wetlands, flood plains, a runway safety zone for Langley Air Force Base's runway (Air Installation Compatible Use Zone), noise impact area, etc. limits development of currently vacant land. The Air Force threatened to close Langley Air Force Base after the City allowed a theater complex to be built partially in the runway safety zone. Losing the Air Force base would put a large dent in Hampton's population as well as its economic well being.

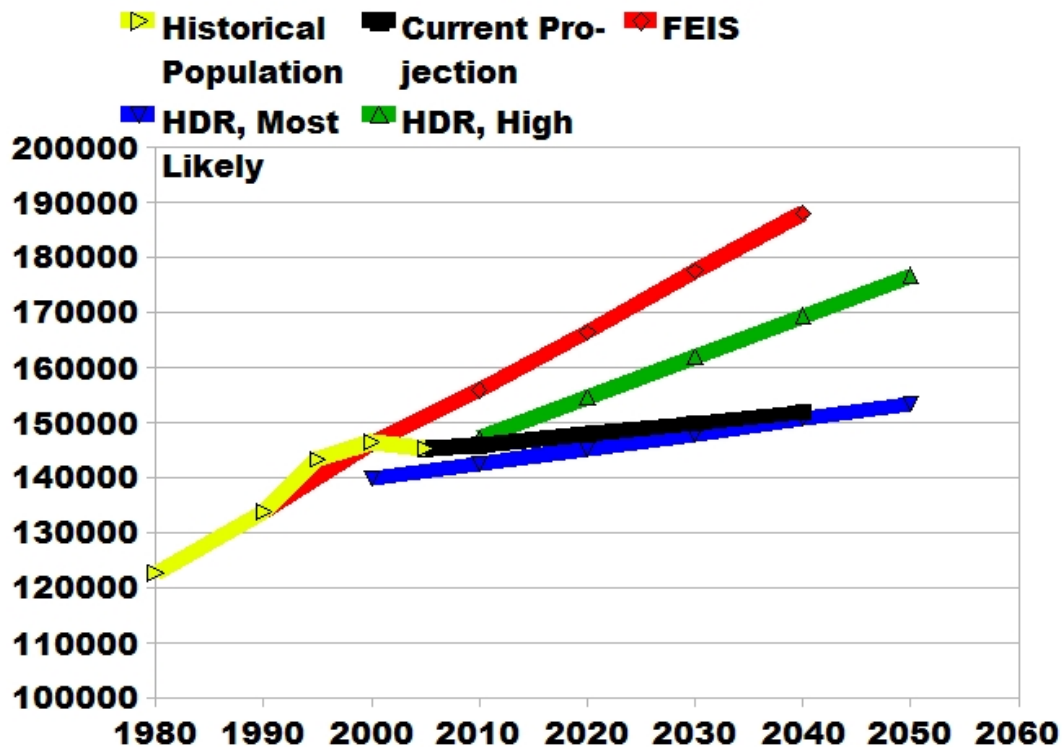
The fact that the average sales price for a single family detached house in Hampton is significantly lower than the average price for the Peninsula or for the Hampton Roads area, indicates that Hampton is not viewed a highly desirable place to live by many. According to Cooper Center estimates, the number of people who moved out of Hampton between 2000 and 2006 was slightly greater than the natural (births minus deaths) growth in the City. Hampton's General Plan recognizes this trend and states that "The future population growth rate in the city is likely to be less than in previous decades. Some areas of the city will see stable population while others may continue to see modest levels of decline in population."

For places like York, JCC, and the City of Williamsburg, which appear to be considered highly desirable places to live, it is easy to accept that remaining available land will be developed as planned and at a relatively steady pace. On the other hand, it is less straightforward to project future populations of jurisdictions which have exhibited a significant level of out migration in the recent past.

It is useful, when contemplating projections for a City which has recently been running into build-out, to consider the population change patterns of other cities which hit this point earlier in history. The cities of Norfolk and Portsmouth are nearby cities that meet this criteria. According to Cooper Center

historical census data and current population estimates, Norfolk grew to a population of 307,951 in 1970 and declined thereafter, reaching 234,219 in 2006. Portsmouth reached a population of 114,773 in 1960 and declined after that, reaching a population of 98,318 in 2006. These declines of 31 and 17 percent respectively occurred in spite of redevelopment and revitalization efforts. Norfolk and Portsmouth are not alone in this regard, most older cities are experiencing similar population declines while nearby counties and newer cities attract newcomers and continue to grow.

Rather than project a population decline in the future for Hampton, a very modest growth rate will be assumed here. Between 1995 and 2006, Hampton's estimated population grew by about 2,000 persons. That rate of growth will be used for each decade out to 2040.



**Figure 3.** Comparison of the present and earlier population projections for the city of Hampton.

The FEIS projection was a simple linear extrapolation of the growth before 1990. The FEIS 2040 population exceeds that of the present projection by more than 36,000 persons. The HDR “most likely” projection started from an assumed value below the actual 2000 census population and grows at a rate higher than that of the present projection, but the results are nearly equal in 2040. The Hampton Comprehensive Plan indicates that because of environmental and other constraints, only 9.6%, or 2812 acres, of its vacant land could ever be developed. The HDR 2050 “high” population projection of 176,784 persons is based on developing 66,270 acres of land which was vacant in 2000. Neither the FEIS or HDR “high” projections are credible.

### Newport News Population Projection

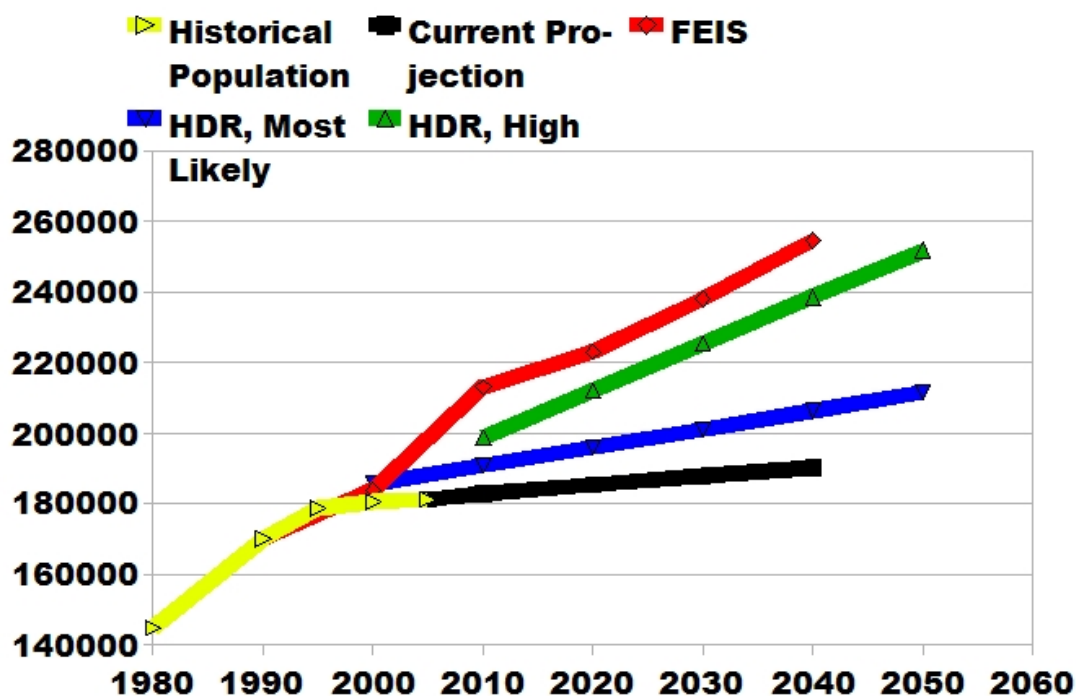
Newport News' past population growth pattern is similar to that of Hampton. US Census Bureau estimates of the (July 1) population of US towns between 1990 and 1999 indicate that Newport News' population growth stalled in 1992 (population 178,233) and oscillated in the upper 180 thousands

through 1999. The Cooper Center estimates indicate that the population oscillated in the low 180 thousands in 2000 through 2006. The difference between the US Census Bureau estimate for the 1992 population and the Cooper Center estimate of 181,840 persons in 2006 is 3,607, indicating a growth rate of about 2,500 persons per decade after population growth stalled.

Like Hampton's Community Plan, Newport News' comprehensive plan (Framework for the Future, Draft November, 2000) discusses vacant land which might be developed, but goes on to say that the City expects most future growth to occur as the result of redevelopment, build-in, etc. Discussion of overlay zoning for the reservoir protection zones around its terminal Lee Hall and Harwood's Mill reservoirs and the airport runway safety zone for the Newport News – Williamsburg regional airport, and similar limitations are missing from the discussion of the vacant lands.

The Cooper Center's estimates indicate that natural population growth slightly exceeded out-migration between 2000 and 2006 which is a minor difference from the situation with Hampton estimates. However, this difference is not enough to overcome the possibility that Newport News' population might fall like other older cities, rather than continue to grow. The Cities 2007 Annual Financial Report noted that during FY 2007, the City's population had decreased by 7,719 persons, or about 4%.<sup>3</sup>

Here, the approach will be similar to that taken with the Hampton projection. Rather than model the projection of Newport News' population on the declining population model of Norfolk, Portsmouth, and other older cities, a modest growth rate of 2500 persons per decade, equivalent to that between 1992 and 2006, will be assumed. Comparisons of earlier projections to the present projection are presented in figure 4 below.



**Figure 4.** Comparison of the historical and present projection of the population of Newport News to FEIS and HDR projections. The current projection (black line) utilizes Cooper Center official state estimates for 2005 and 2006. After the later date, the black line represents the projection discussed in the text.

<sup>3</sup> Newport News' Comprehensive Annual Financial Report for FY 2007, p 13.

The FEIS projection, which assumed very optimistic rates of growth, exceeded the 2000 census population and the population estimates in 2005. The FEIS projected population for 2040 exceeds the current projection by over 64,000, or about 34%. The HDR “most likely” projection starts at an assumed population which is greater than the 2000 census value and grows at a rate higher than the historical growth between 1995 and 2006. This HDR projection leads to a 2040 population of 206,340, a value which is about 8% higher than the current projection. The HDR high population projection for 2050 of 251,745 persons is based on the assumption of developing 100% of land that was vacant in 2000. However, according to the environmental section of the City's Comprehensive plan, the City contains significant mapped, but untabulated, acreages of non-tidal wetland, reservoir protection area, and Chesapeake Bay Protection area. The City also has 854 acres of tidal wetland which is outside of the Ft. Eustis boundary. The FEIS and HDR “high” projections are not credible. The HDR “most likely” projection is, in fact, unlikely.

### Peninsula Growth Projection

The historical and projection of population growth in each of the political jurisdictions making up the Virginia Lower Peninsula are presented in summed chart format in Figure 5. The top line of the graph represents the total projected population for the Peninsula for the period after 2005 and historical populations before that date. The Chart depicts projected growth from 471,652 in 2005 to 547,161 in 2040, a total growth of 16%. The population total line is concave upward before 1995, indicating increasing growth, and concave downward after 1995, indicating slowing growth approaching an upper limit.

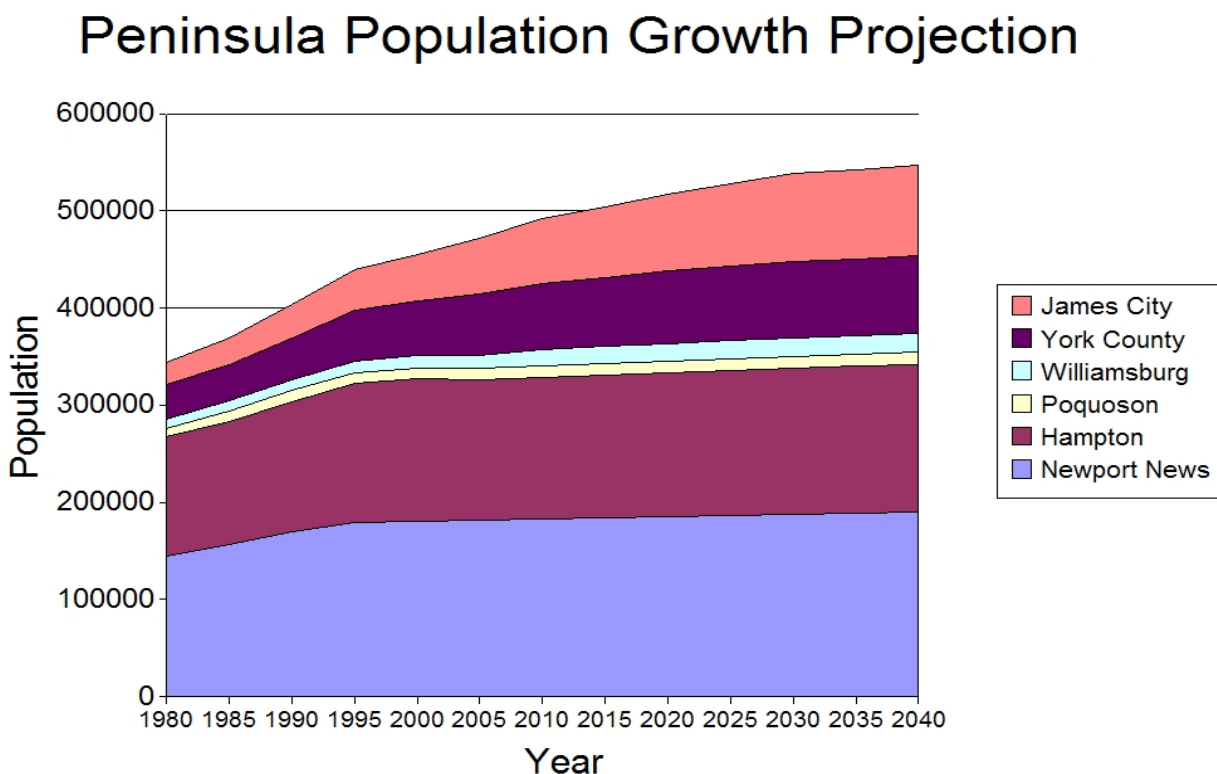


Figure 5. Population of Peninsula jurisdictions extended through the year 2040. Values up to and

including 2005 are based on US Census values and Cooper Center<sup>4</sup> estimates. Values after 2006 are projected using the methodology discussed in the text.

The 2040 populations projected here are build-out values. The major projection uncertainties in the 2040 values are that more (or less) of the land zoned for agriculture and rural residential (R8 zoning) in JCC might be converted to higher densities, leading to an increase (or decrease) of up to 7000 persons in the build-out population or that, like other older cities in the metropolitan statistical area, Hampton and Newport News might lose a significant fraction of their 2005 population, rather than growing slowly through redevelopment as projected here. There is also a significant downside risk due to the fact that large parts of Hampton, Poquoson, and the lower portion of York County are at low elevations. The area is subsiding and sea level is rising at an increasing rate. Some existing developed land in those areas may have to be abandoned in the future. The projected total population for the Peninsula in 2040 is 547,161 persons.

### **Comparison to Other Total Peninsula Population Projections**

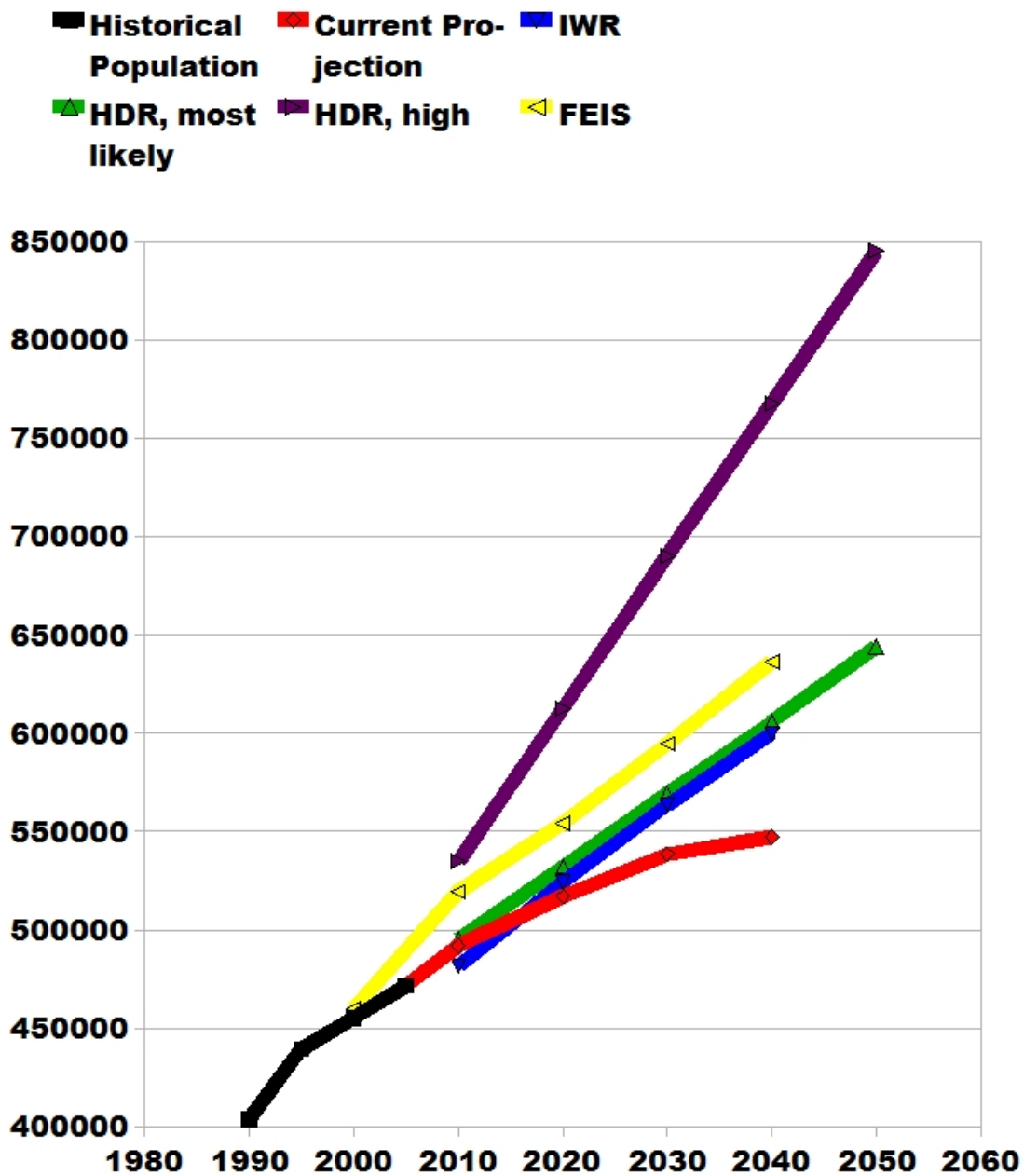
The FEIS projection resulted in a 2040 Peninsula population of 636,308. Phillip's 1997 (middle) projection in a critique of the FEIS was for a 2040 population of 531,712. The applicant's final study by HDR Engineering projected a (most likely) 2040 population of 606,751, a high population of 767,554, and a low population of 541,485.<sup>5</sup> The USACE's IWR Panel projected a total 2040 population of 600,053 with 565,670 persons being served by public water supply.<sup>6</sup> The population projections are compared in figure 6 below.

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4 The Weldon Cooper Center for Public Policy prepares the official Virginia estimates of the population of Counties, Cities and places in the State.

5 HDR Engineering, Water Needs Assessment, November, 2000, Table 3-3

6 USACE Institute for Water Resources, Revised Report, August 15, 2001, page 4 and IWR Report, October, 2000, Fig 4



**Figure 6.** Comparison of historical and the present projection of Peninsula population to those of the USACE's IWR, HDR Engineering, and the FEIS for King William Reservoir.

The IWR and HDR most likely projections are similar and are slightly below and above the present projection in 2010, but are diverging on the high population side by 2020. The differences are significant by 2030 and large by 2040. The FEIS projection is significantly high after 2010 and the HDR high projection is very high over the entire period. The HDR high population is significant because of its erroneous impact on the assessment of the probability of a water shortage, which was cited as an important factor in the USACE's decision to grant the 404 permit for the King William Reservoir.

Although the FEIS was published in 1997, its population projection relied on information available



through 1990. Its population projection was based on pre-1990 growth on the Peninsula and long term projections by local governments. The FEIS estimate for short term growth was high (2005 (interpolated) population estimate = 489,630) compared to the Cooper Center estimate of actual 2005 population of 471,652. Both the IWR and HDR estimates failed to take the limits to long term growth imposed by land use constraints into account.

The USACE's IWR population projections were based on applying projections from the US Bureau of Economic Analysis (BEA) to the smaller peninsula area. Limits to population growth due to land use constraints were not taken into account.

HDR Engineering, Inc. population projections were based on outputs from a regional economic (REMI) model for the Lower Peninsula. The use of the REMI model for a fraction of an MSA has been criticized because it assumes the results of all economic activity in an area stay in that fraction of the MSA. In reality, it is commonly found that people and the commercial activities that support them move to outlying suburban areas, especially as central areas approach build out. In the current case, migration to Gloucester and Isle of Wight Counties and the City of Chesapeake is, and will continue to occur. The final RROD acknowledged the criticism of the way the REMI model was applied (KWRFRROD, page 48), but accepted the results anyway, saying that “the discrepancies would not be significant in the next 20 years”. The discrepancies for the HDR most likely projection are not large before 2020, but grow afterwards. The HDR high projections were not only based on fallacious assumptions regarding the development of vacant lands comprising wetlands, National Parks, etc., but also resulted from two artificial injections of growth stimulation.

HDR ran three economic scenarios using REMI. The population projections are derived from the job creation output from the model. Their baseline run was a “business as usual” scenario, but with out migration and commuting ignored. They label the results of that scenario variously as “baseline” or “most probable”. In the second, “high” scenario assumed two large injections of economic activity into the Peninsula. Finally, they ran a “recession” or “low” growth scenario.

HDR utilized a land use analysis to show that the Lower Peninsula could support the populations and commercial and industrial activity projected by the REMI model. Unfortunately, HDR used only primary land zoning information and ignored limits on development imposed by overlay zoning for flood plains, wetlands, airport safety zones, reservoir protection zones, etc. Even with the shortcomings of the land use analysis, HDR recognized that Newport News and Hampton were approaching build out and could have only limited future growth. However, the HDR projections of build out populations for York County, which has a very detailed land use plan, is 186% of the County's estimate of maximum build out population. For James City County, which has a similar detailed land use plan, the HDR projected maximum population is 233% of the County's estimate if all of the service area land currently zoned A1 and R8 were rezoned to allow higher density housing. The HDR estimates of the supportable levels of commercial and other land uses were similarly inflated.

The USACE's Final Recommended Record of Decision took note of the criticisms of the lack of supporting land use studies for the IWR projection and the fatal flaws in the HDR land use analysis and stated that “IWR could not resolve this discrepancy during the RROD review period, but recommended that these concerns be addressed in reviewing water use estimates for the latter part of the forecast period. IWR commented, however, that they would expect the effects before 2020 to be less significant.”

In fact, since growth in Newport News and Hampton, the most populous portions of the Lower  
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Peninsula had already stalled because of build out and the IWR included those populations in its basis for growth, the effects of the limits to growth would be reflected in a significantly lower growth prior to 2020.

HDR's "high" population projection is particularly important because it strongly biases the statistical evaluation of the probability of water demand and water shortages used later in its report. HDR's distribution of possible population size started from a "low" population of over 550,000 and ended at a "high" population of 800,000. The peak of the distribution was around 640,000, but the area of the distribution at populations higher than the peak probability was twice the size of the portion below the peak. According to the present projection, based on detailed land use studies, the peak of the HDR distribution was high by about 100,000 persons and its high end cutoff was unreasonable by about a quarter of a million persons. Thus, for the entire population distribution used by HDR, the lower 1/3 of the distribution was "high" and the 2/3's of the distribution above the peak probability were ridiculous.

**The IWR's recommendation that the land use issues be reviewed were never followed up on.**

Although additional information supporting the fact that the land use studies were flawed was submitted with comments on the final Recommended Record of Decision, no significant comments were acknowledged in the September 30, 2002 Decision Memorandum from the USACE's North Atlantic Division. The memorandum only mentioned 3500 signed postcards in discussing comments opposed to the Reservoir. Substantiative opposing comments by Mike Siegel, the Chesapeake Bay Foundation, and others were also ignored in the 2002 Decision Memorandum.

The Final (Revised) report from the USACE's IWR was primarily a review of the applicant's HDR report. The probability of water shortages referred to in the first key factor cited in the Final USACE NAD decision document (July 29, 2005, page 6) supporting granting the 404 permit was therefore based on:

1. a flawed implementation of the REMI model to a small portion of a MSA that led to bloated predictions of population and development; and in the case of the high projection, artificial injections of growth;
2. a flawed land use study that supported much higher population and commercial development projections than supported by detailed land use studies and plans by the jurisdictions in the RRWSG area;
3. a combination of the above and other assumptions which were biased toward high water consumption and low supply led to unrealistic probabilities of water shortages which were the number one factor considered by the USACE in making its permit decision.

# Water Demand

## Introduction

Virginia's Department of Health (VDH) issues permits for water suppliers based on the amount of water that models indicate the supply could safely provide during the worst drought of record (safe yield). The worst droughts in the region were the multi-year droughts in the late 1920's through early 1930's (dust bowl drought) and a drought through the middle and late 1950's. Reductions in demand through reductions in outdoor use are not considered in determining the safe yield of a supply. If the water supply requires treatment, the permit may be limited by the treatment capacity rather than the supply's safe yield. In other cases, where there is a connection to an additional, secondary, raw water supply, the permit may be for a greater amount than the primary supply's safe yield.

The VDH also has regulations requiring that regulated supplies must start planning for expanding their capacity when their water distribution exceeds 80% of their permitted value for 3 successive months. There is, however, an exception to this requirement when evidence can be provided showing that there are limits to growth in the area served. The detailed land use plans of the Lower Peninsula demonstrates that growth in the area clearly has limits.

The public water supply on the Virginia Lower Peninsula is provided by several institutions. Newport News Waterworks is the largest of these with a customer base of about 400,000 and 126,000 customer accounts.

The City of Newport News (The City) provides potable water for all of the Cities of Newport News, Hampton, and Poquoson, most of York County, as well as a smaller portion of James City County. In addition, it provides water to most major federal installations in the area as well as one major industrial customer (Busch Brewery) in James City County.

Newport News Waterworks (NNWW) has a series of reservoirs, a permit to withdraw water to supply the reservoirs from the shallow impoundment on the Chickahominy River, treatment plants at its two terminal reservoirs, and a brackish water reverse osmosis facility with a permit to withdraw mineralized water from the Potomac aquifers. The Water Works has Virginia Department of Health (VDH) permits for production of an average of 62.7 millions gallons per day (mgd) of water.

The City has received a conditional permit from the US Army Corps of Engineers (USACE) to proceed with a project to establish a new reservoir in King William County after successfully fulfilling certain conditions, as well as permits from the Virginia Water Control Board (The City must apply for permit renewal in 2010) and from the Virginia Marine Resources Board. Part of the information for this evaluation is drawn from a prospectus for Water Revenue Bonds (Series 2007) issued to finance the proposed reservoir project in part.

The James City Service Authority (JCSA) is the second largest provider for the Peninsula. It has both a central system and distributed wells which it manages. The central system also has a reverse osmosis plant to treat mineralized water extracted from the Potomac Aquifer. It has about 17,500 customer accounts and a permitted withdrawal capacity of 7.2 mgd. The County has recently reached an agreement under which it can purchase additional water from the Newport News Waterworks.

The City of Williamsburg has a reservoir, Waller Mill, and associated treatment plant as well as a permit to withdraw water from a well. In addition to residents and businesses in the City, including the College of William and Mary and the Colonial Williamsburg facilities, the system provides water for some nearby parts of James City and York Counties, as well as the federal facility at Camp Peary. The total permitted capacity for Williamsburg's water supply is 6.15 mgd. The City has at times purchased raw water from NNWW and is negotiating a long term agreement with Newport News.

There are some small community suppliers and York County also has a small public supply. Other residences and businesses outside of the areas served by the JCSA, York County, and the small private purveyors utilize private wells for their water supply. These small supplies will not be taken into account in the ensuing analysis. Since the demand from the residents utilizing these supplies will be included in the analysis, this represents an element of conservatism.

Previously, the Big Bethel Reservoir was operated by the US Army and supplied some federal installations in the area. The former Big Bethel customers have been served by Newport News since the federal facility was shut down in 2003. It had a permitted supply of 4 mgd with a safe yield for the reservoir of 1.9 mgd. The facility was transferred to the Air Force after the Army's Fort Monroe was slated for closure. Big Bethel has interconnections with NNWW and at least its raw water is presumably available to public supply in the event of a drought more severe than historical droughts of record.

One federal facility on the Peninsula, the Navy's supply center at Cheatham Annex has maintained its own water treatment plant with supply from Jones' Pond Reservoir. Cheatham Annex has recently ended production and is currently also purchasing water from Newport News.

The total permitted (safe yield) supply for the lower Peninsula is tabulated in Table 1.

Water Supplier	Permitted Supply (Safe Yield) - mgd
Newport News	62.7
James City County	7.2
Williamsburg	6.2
All Other	0
Total	76.1

**Table 1.** Total VDH permitted supply for the Virginia Lower Peninsula. The cumulative supply of the smaller systems has not been tabulated.

### **NNWW Large Customers**

As the areas largest water purveyor, Newport News provides water to most area large water users. These customers include those like the Anheuser Busch Brewery and Busch Gardens which are located in James City County and large users in York County. As a part of its representations, Newport News's prospectus for the Series 2007 Water Revenue Bonds discusses NNWW's 10 largest customers for treated water. Large water users (in 1990) had also been discussed in the January, 1997 Final Environmental Impact Statement (FEIS) for the proposed reservoir project (FEIS Table 2 -7). Table 2

compares the information in the prospectus and the FEIS. The FEIS presented water consumption data in terms of millions of gallons per day (mgd), while the prospectus used hundreds of cubic feet per year. The prospectus data has been converted to mgd in Table 2.

Customer	1990 Consumption, mgd	2006 Consumption, mgd
Anheuser Busch, Inc. (Brewery)	5.1	4.93
Giant, Inc. (Formerly Amoco then BP) (Refinery – now Western)	1.066	1.57
Northrop Grumman Newport News (Shipbuilding)	2.403	1.45
GRMO, Fort Eustis (US Army)	1.3 (Note 1)	1.29
Langley Air Force Base	1.234	0.63
Busch Gardens (Amusement Park)		0.59
Fort Monroe (US Army)	0.587	0.26 (Note 2)
Virginia Electric Power	0.566	0.53
Naval Weapons Station (US Navy)	0.657	0.48
Great Atlantic Management Corp. (Apartments)		0.47
Hampton University		0.37

**Table 2.** Newport News Water Works Service Area (and Big Bethel) large customer water consumption in 1990 and 2006. Note 1. Ft. Eustis 1990 consumption taken from Newport News federal consumption, EIS Table 2-13 (by way of comparison, DEQ lists Ft. Eustis calendar 1989 consumption as 1.44 mgd). Note 2. Fort Monroe 2006 consumption was taken from Virginia Department of Health spreadsheet and has not been reduced to account for unaccounted for water, which is included in the VDH data.

The striking feature of Table 1 is that large users that appear in both columns, with the exception of the refinery at Yorktown, have decreased consumption since 1990. For Customers that appear in both the 1990 and 2006 columns, consumption decreased from 11.63 mgd in 1990 to 9.85 mgd in 2006.

The FY 2006 water use listed for the refinery at Yorktown is problematic. The refinery experienced a significant fire in November 2005. It took eleven hours to eradicate the fire and water for fighting the fire may have been from metered sources. The refinery did not return to full operation for several months. The refinery is utilizing 0.5 mgd of filtered effluent from the Hampton Roads Sanitation District treatment plant at Yorktown and is reportedly discussing increasing that water reuse to 1 mgd.

There may be a small artifact in the data with respect to the Busch Brewery which has significantly increased its production capacity since 1990. Although the FEIS Table included users with average consumption as low as 0.042 mgd, the Busch amusement park, which opened in 1976, was not in the FEIS Table. The amusement park has grown significantly and has acquired Water World, a water sports amusement park which has also grown significantly. It is possible that the two Busch accounts were lumped together in 1990, although Busch Gardens consumption would have been much smaller then. The Great Atlantic (apartments) and Hampton University entries in the prospectus list are probably due, in large part, to consolidation of a number of smaller accounts which existed in 1990.

Although the 2007 Water Revenue Bond Prospectus mentions the fact that the Busch Brewery has undergone a major renovation which includes aspects of the facilities that could impact water consumption, it does not discuss the implications with respect to future water sales. A [viriniabusiness.com](http://viriniabusiness.com) (Feb 27, 2008) article mentions the fact that the renovations allowed employment to be reduced, but did not address input factors like water consumption, which are usually also reduced when efficiency is improved.

The absence of the Army's Ft. Eustis water use from the FEIS Table 2-7 is inexplicable since the installation existed with a large staff well before 1990. The water use at the Army's Fort Monroe was in the 1990 Table, but had dropped below the large user threshold in the prospectus. Fort Monroe is slated to be closed by 2011 as a result of the 2005 Base Realignment and Closure (BRAC) cycle. Part of Fort Monroe's current functions will be transferred to Ft. Eustis with the remainder going to Ft. Knox, in Kentucky.

It should be noted that the FEIS list was of all Peninsula large customers, not just those served by Newport News Waterworks. Some military facilities were formerly supplied by water from the Army's Big Bethel reservoir and treatment plant, which was closed several years before the Prospectus was prepared.

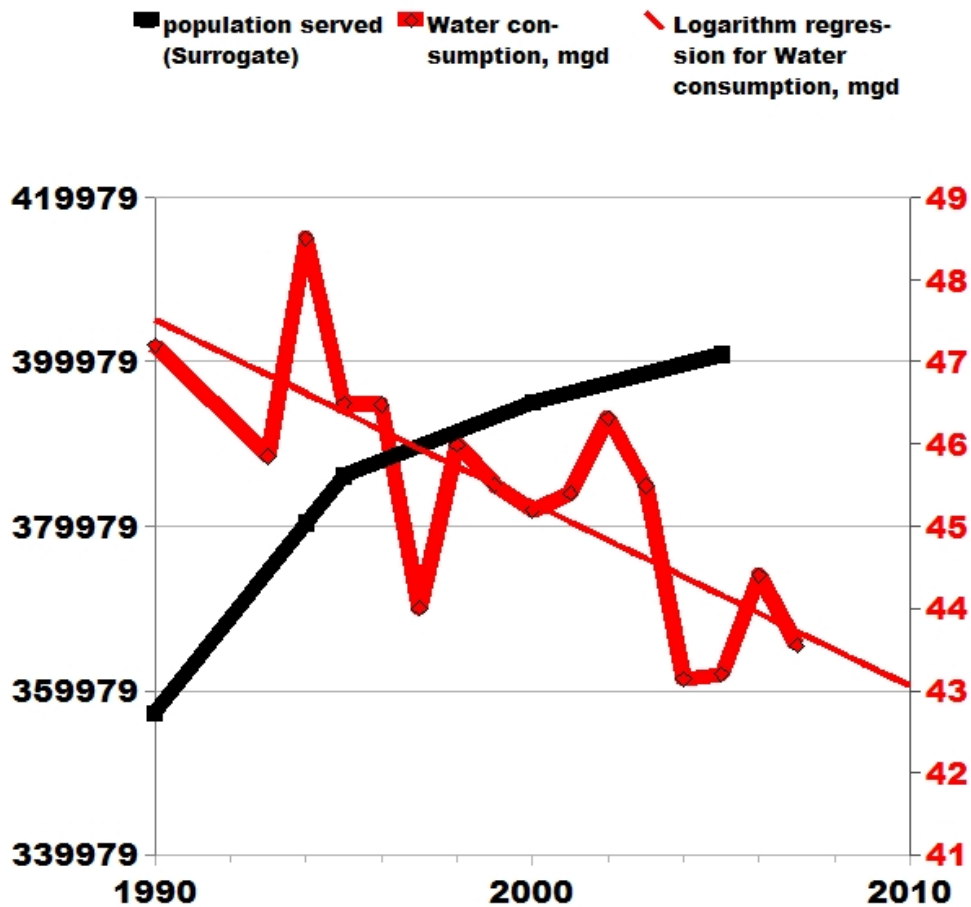
Overall, Table 2 indicates that Newport News has a fairly stable list of large customers, but that many of those customers have been able to reduce their water consumption over time. This trend of decreasing water use by large customers is expected to continue.

### **Historical Population and Water Consumption Trends for NNWW**

Before proceeding to consider historical and water future demands for the entire Lower Peninsula, it is useful to examine the historical trends for service area population and water consumption for the dominant water supplier in the region, NNWW. It would be difficult to determine the details of the populations served by NNWW in James City and York Counties over time, since all of the major purveyors and small independent systems, as well as that of York County, serve some people in those Counties. Instead, the populations of the Cities of Newport News, Hampton, and Poquoson will be used along with the entire population of York County. The small portion of James City Counties population which is served by Newport News will be ignored in this surrogate for NNWW population served. Comparing the population served in 2005, according to Newport News' bond 2007 water revenue bonds prospectus, to that (401,474) calculated for the surrogate using Weldon – Cooper Center population estimates indicates that the surrogate population is about 1% low. However, the prospectus for Series A and Series B 2008 general obligation bonds (page A-5) states that the estimated population served “of *nearly* 400,000” (italics added). Thus, the surrogate population served appears accurate for the current population served.

Since the fraction of the population in various jurisdictions has been increasing the surrogate population is expected to overestimate the population served early in the 1990 to 2040 study period. Examination of 1990 population served data from Table 2-15 of the FEIS indicates that the population served was about 340, 000 rather than the 357,000 estimated using the surrogate defined here.

The historical growth trend of this surrogate population and the change in water consumption between 1990 and 2007 are exhibited in Figure 7.



**Figure 7.** Surrogate population served for NNWW (black, left axis) and water consumption in mgd (red, right axis). The thin red line (right axis) is a trend line for the water consumption data. Here, water consumption refers to metered sales of water and does not include unaccounted for water or transferred water. Water consumption prior to 2003 includes water from Big Bethel for customers currently served by NNWW.

The result, that water consumption would decrease dramatically, even as population continued to grow is counterintuitive. The decreases in large user consumption documented in Table 2, along with similar decreases by smaller industrial, institutional and commercial users, is undoubtedly responsible for most of the decrease in consumption in the mid to late 90's. The decrease in the NNWW's water sales for 2005 through 2007, would have been larger if the Army's Big Bethel water supply had continued to supply water for Fort Monroe, Langley Air Force Base, and NASA's Langley Research Center. Big Bethel's production in FY 2001, the last full year for which VDH data indicates production was 1.21 mgd.

The continuing decrease indicates that the new federal standards for ultra low flush toilets and low flow shower heads, which went into effect at the end of 1997 are already having an impact on residential, as well as commercial water consumption. A 1999 American Water Works Association Research Foundation (AWWARF) report on residential water use found that actual savings due this standard were 10.5 gallons per capita day (gpcd) for the ultra low flush toilets and 4.5 gpcd for low flow shower heads. Toilets are assumed to have an average replacement life of 50 years. Using a conservative 1.75% per year for the initial replacement rate leads to an estimate that between the ends of 1997 and

2006, 15.75% of the pre 1997 toilets would have been replaced. If the assumption that shower heads were replaced at the same rate is adopted, water appliance replacement in homes serving people living in pre-1997 homes would have generated an estimated 0.93 mgd water saving by the end of 2006. The (future) replacement of the remaining pre-1997 toilets and shower heads will result in an estimate of 3.49 mgd of additional water savings for NNWW to be realized in the future.

The USACE's Institute for Water Resources (IWR) Final (revised) report "An Evaluation of the Risk of Water Shortages in the Lower Peninsula, Virginia" August 15, 2001 used 65.3 gpcd for the total residential water use per day in 1999 - 2000. Reducing the indoor use by 15 gallons per day would result in a 50.3 gpcd total water demand for new residences.

There have been other factors contributing to the reduced demand. No account has been taken of the fact that the 1997 federal standard also covered sink faucets, but they are undoubtedly also contributing to reduced demand. The IWR value for total residential water demand per day was based on the mixture of low density single family residences and higher density housing types typical of the Peninsula in 1999. As the cities in the NNWW service area have approached build-out, they have begun switching to more mixed use and higher density housing for new growth, leading to lower per capita residential water demand, primarily because of decreased outdoor water use. In addition, the fraction of single family housing which is less than 5 years of age has decreased in the NNWW service area. New houses have new lawns which require significant irrigation until the lawns become well established. As the residential developments age, the outdoor residential demand decreases. These demand reducing factors would require analysis beyond the scope of these comments in order to quantify their impact, but there is little doubt that they are contributing.

The water savings in the industrial, commercial, and institutional sectors have more than offset the growth in demand in those sectors and the remainder of the residential demand growth. This trend of decreasing demand is not new. In 1999 Mike Siegel of Public and Environmental Financial Associates reported that comparison of information in the NNWW Water Rate Study for FY 2000 and that in the FEIS indicated that combined NNWW industrial, commercial, and institutional demand had decreased by about 1.3 mgd over the 9 year period, federal demand had fallen by about 0.7 mgd, and residential demand had increased by only 0.3 mgd. Overall demand decreased by 3.6% in spite of significant increases in population and commercial and institutional employment during the period.<sup>7</sup> The fact that water demand had started falling in the 1990's was also discussed in Appendix E of the HDR Report and in the IWR Final Report (page 20). However, the trend of falling demand was not investigated and no action was taken to incorporate it in the analysis of either of the latter reports.

It is not possible to estimate the amount of water demand reduction which may occur in the future due to increased efficiency in the industrial, commercial, and institutional sectors, but only to note that the trend of reduced water consumption for existing customers is likely to continue. The fact that the cost of water from NNWW has increased, and is projected to continue to increase, faster than the rate of inflation provides a strong incentive for that sector to continue to invest in water use efficiencies. Also, residential consumption is not immune from "price elasticity" of demand.

A new factor which will further reduce residential demand in the future is the 2007 standard (10CFR 430 rule) requiring more water efficient clothes washers. The Department of Energy Federal Register (Volume 65, number 194, page 59552) discussion of the proposed rule included an estimate that, on

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<sup>7</sup> Mike Siegel comments to the Norfolk District of the US Army Corps of Engineers, August 13, 1999.



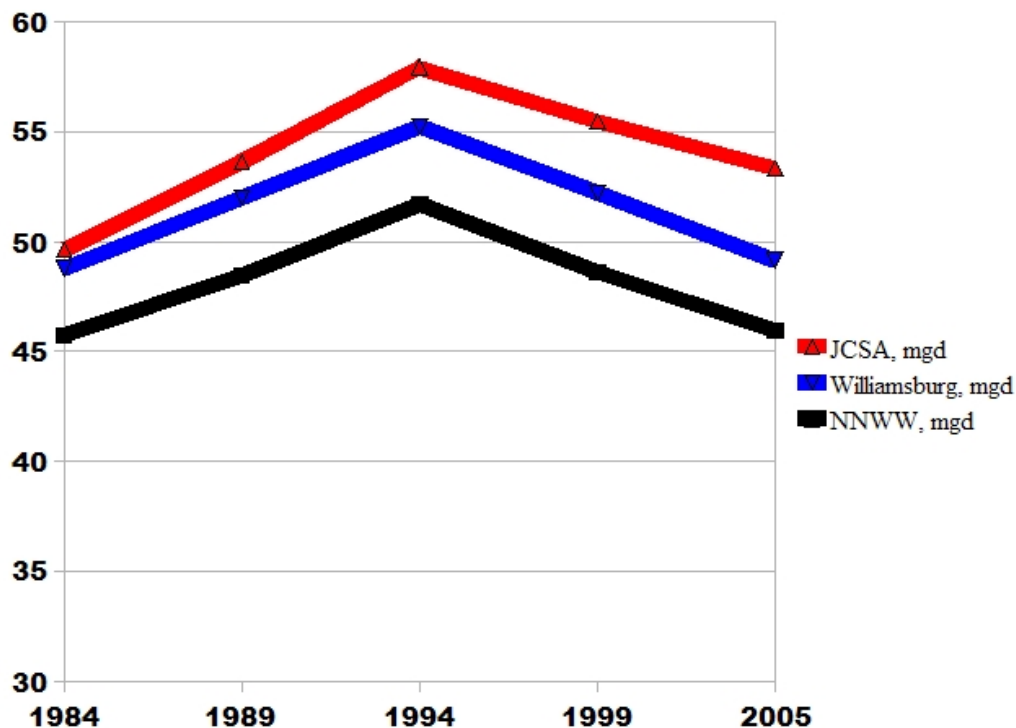
average, the new washers would reduce water consumption for washing clothes by 18 gallons per load. The 1999 AWWARF report mentioned above provides data on clothes washing water use that allows the savings per capita per day to be estimated to be about 8 gallons, or slightly more than half of the combined toilet and shower head savings. The new standard would also lead to a further reduction of the total residential demand to 42.3 gpcd for population and new residences added after 2007.

The considerations above provide a basis for understanding the decrease in water consumption in the NNWW service area, even as population increases.

It is probable that over the period of this projection additional water saving technologies, such as distributed tankless hot water heaters, will come into widespread use. This probability will not be taken into account in this evaluation.

Before going on to examine growth in water demand in the entire Lower Peninsula, it is desirable to change to a discussion of water supplied. This includes unaccounted for water (UAW), estimated as 6% of the water use. Eventually we will want to compare water use projections to safe yield and UAW is a part of the supply. In addition, water historically supplied by Big Bethel in the past will be lumped with that from Newport News which currently serves the former Big Bethel customers. Also, water shown as transferred from NNWW to federal customers and raw water transferred from its Lee Hall Reservoir to Newport News' Deer Run Golf Course are included.

Historical water use for NNWW, JCSA, and Williamsburg are exhibited in stacked graphical form in Figure 8.



**Figure 8.** Historical water use from the three major Lower Peninsula Purveyors. Water values include estimated UAW, Big Bethel production and transfers to the Newport News Deer Run golf course in the Newport News quantities as described in the text. Data is taken from the FEIS for the King William Reservoir, NNWW Rate Studies, the Virginia Department of Health, and the Virginia Department of

## Environmental Quality.

The results exhibit the decrease in water use from NNWW after the mid 90's and almost constant use of water from Williamsburg. The use from the JCSA, in contrast, increases significantly over the period. The big difference is the high rate of growth of James City County. Its population more than doubled in the period and it didn't have a base of large users or other consumption types with decreasing demand which could offset demand increases of the magnitude imposed by its population growth.

In spite of the growth in JCC demand, overall water use from these purveyors on the Peninsula decreased over the period following the mid 90s, while its population increased significantly.

## Projection Methodology

The task of projecting future water consumption for the Lower Peninsula is ameliorated by the fact that detailed land use plans impose tight restrictions on the build-out population. Also, only a very limited amount of unoccupied land is zoned for general industry so there is little likelihood of a major increase in industrial consumption. The largest unoccupied site zoned general industrial is a 600 acre brown field site last occupied by BASF. Approximately 100 acres of that site are designated as a superfund site that has not yet been cleaned up. Although rumors about potential buyers surface occasionally, negotiations have not gone past the "interest" stage.<sup>8</sup>

- 1. Planning Period** – The current projections are carried through 2040. Since all of the jurisdictions on the Lower Peninsula are projected to have reached build out populations by that time, extension for longer periods would make little difference. Minor increases in total population achieved by higher density redevelopment is likely to be offset by unused offset due to the 1997 federal standards (see below).
- 2. Population Served** – In the following it will be assumed that the total population growth will be served by public water supply. This is not expected to be accurate since there are no plans to provide public water to some areas of James City and York Counties, the areas of the Lower Peninsula that are expected to experience the most growth. However, the Planning Departments of both Counties expect that most future growth will occur in areas served by public water. The USACE's IWR assumed less than 100% of the total population would be served by public water in 2040. The 100% of total population growth value used here serves as an element of conservatism.
- 3. Water use Coefficients** – Large User/industrial and federal water consumption will be assumed to remain constant. In order to get an approximate per capita water use value without heavy industry and federal consumption but including commercial, institutional and light industry (CIL) demand, the 11.73 mgd used by large users (excluding Hampton University and Apartments – uses directly related to population) in 2006 (Table 1) was subtracted from the rounded off 2006 average demand and the result was divided by the 2006 population served. The value obtained, 79.68 gpcd is significantly higher than a value of 71 gpcd for Newport News published by the Hampton Roads Sanitation District (HRSD) in 2003. HRSD stated that "Recent data indicates a decreasing potable water consumption in most local jurisdictions ranging from approximately 53 gpcd in Virginia Beach to 71 gpcd in Newport News."<sup>9</sup> In order to remain consistent, the larger value obtained by the present estimate of residential and

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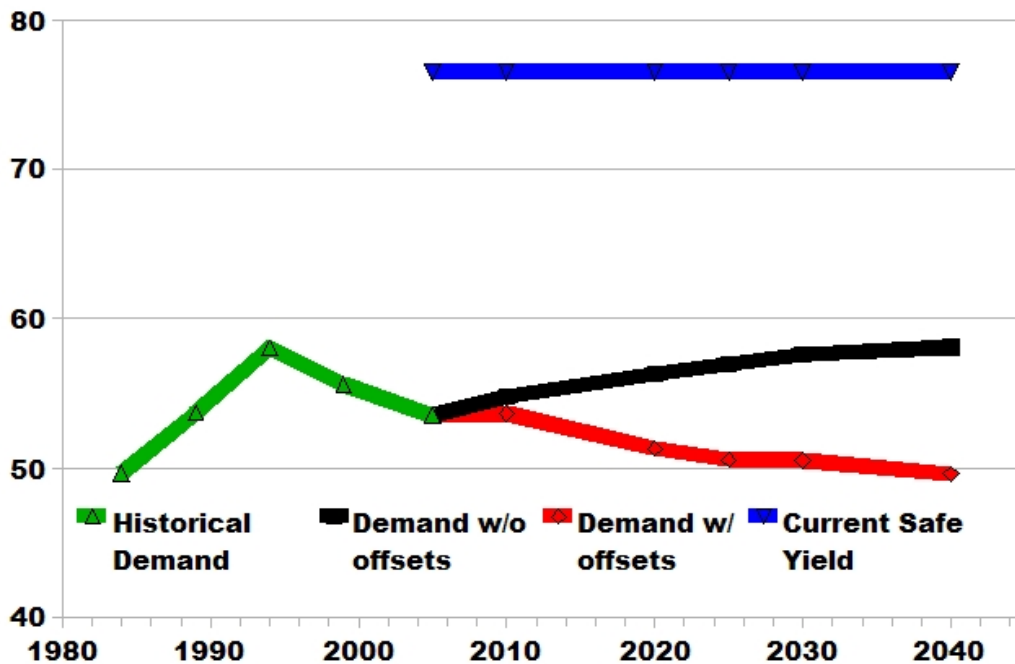
<sup>8</sup> Virginia Gazette article by Courtney Langley, April 30, 2008.

<sup>9</sup> HRSD Development Plan 2000, Locality Version, May 2003, page 7.

CIL per capita daily use for the NNWW service area will be used in the water consumption projections below. Although the conventional designations of industrial, CIL, and residential consumption categories is used here, the actual partitioning of the water use here corresponds to large user consumption; small (commercial, institutional, light industry, and residential) user consumption. The value of 79.68 gpcd is reduced for added population by the 15 gpcd to account for ULF toilets and low flow showers in new residences prescribed by the 1997 federal standard and by 8 gpcd to account for the 2007 federal standard for washing machines. The resulting value of 56.68 gpcd will be multiplied by population growth to determine increases in consumption by the residential and CIL sectors.

4. **Unaccounted for Water (UAW)** – A value of 6% of production was used in the FEIS for water used in and prior to 1990. The FEIS and the Regional Raw Water Study Group's contractors have consistently argued for the use of the value of 10% in projecting future need. The actual difference between water pumped to distribution by NNWW and metered sales is generally less than 6%, although it occasionally exceeds that value. This reviewer can not see planning to waste more water as a justification for new water sources. A UAW value of 6% will be used in projections here. Demand increments due to added population will be divided by 0.94 to account for the losses represented by UAW.
5. **Demand Offsets Due to Replacement of Preexisting Fixtures With Models Compliant with Federal Standards** – For convenience, replacement of toilets and shower heads which existed before the 1997 federal standard became effective are treated together. Toilets may be replaced because of remodeling, unavailability of repair parts, unrepairable breakage, or simply to reduce water consumption. Shower heads may be replaced as part of remodeling or modernization, because of corrosion, because of mineral deposits blocking orifices, or to reduce water consumption. It is assumed that, initially, 1.75% of these fixtures will be replaced each year through the year 2023. It is assumed that between 2023 and 2033 the fixtures will be replaced at a rate of 2% per year and that between 2033 and 2040 they will be replaced at a rate of 2.25% per year. That will leave an assumed 15.75% of these fixtures in service to be replaced after 2040. Since these devices serve the water consuming population, the percentages above are applied to the estimated Peninsula population of 443,500 persons in 1997. Clothes washing machines are assumed to have a 14 year life and it is assumed that they will be replaced at a rate of 7% per year between 2009 and 2023. That percentage is applied to the Weldon Cooper Center provisional estimate of Peninsula population of 478,455 in 2007.
6. **Projection Forward** – The Peninsula water consumption in 2005 is used as a starting point. That consumption already has existing large user, CIL, federal, and residential use built in. Two projections are actually carried out. In the first, the added CIL and residential water demand (including UAW) due to the change in population is added to the prior period usage for each projection period. This is the projected consumption without accounting for replacement of preexisting fixtures due to federal standards. In the second projection, the water demand offsets due to replacement of fixtures is subtracted after the new population demand increment is added.

The combined historical water use for the Peninsula, along with projections of demand with and without offsets due to replacement of toilets, shower heads, and clothes washing machines is exhibited in figure 4 below. The current permitted total supply (safe yield) is also exhibited for reference.



**Figure 9.** Historical and projected water use on the Peninsula, along with current safe yield (all in mgd). Historical use by the Naval Supply Center at Cheatham Annex is included in the data, along with all water use included in figure 8.

Figure 9 illustrates the demand growth that would occur with the residential, and associated CIL, growth due to the population growth projected above without taking the impact of federal standards on existing residences into account, along with the demand to be expected when those standards are taken into account. In the first five years of projected demand, the demand offsets due to replacement of toilets and shower heads (and one year of clothes washing machine replacement) just neutralizes the growth of demand due to population increase. Between 2010 and 2023, the demand offset due to clothes washing machine replacement results in a significant demand reduction. After 2030 the combination of lower population growth and toilet replacement demand offset result in additional demand reduction. As a result, the Peninsula's projected demand in 2040 is approximately the same as it was in 1984.

The demand reductions due to federal standards projected here are dramatic. The USACE's Recommended Record of Decision acknowledged criticisms of the failure of the applicant's consultant to adequately take the clothes washing machine standard into account, but argued that the effects would only be important later in the forecast period (for some reason, the USACE's IWR reports focused only on the short term possibility of a water shortage). The report stated:

*IWR agrees this is a new development that will save more water than predicted by HDR (or IWR in previous reports). Its largest effect will occur later in the forecast period because people will continue to use existing machines until they must be replaced with the water efficient ones.*

In fact, the new washing machine standard alone is projected to reduce demand of population housed in new residences significantly (8 gpcd) and lead to offsets to demand of 3.2 mgd by 2020. The combined effect of the 1997 standard for toilets and shower heads and the 2007 standard for clothes washing machines is to reduce per capita daily demand for residents in new housing by 23 gpcd and

provides 5 mgd in demand offsets due to replacement of pre-existing fixtures by 2020. The total offsets from both sources through 2040 total 13.4 mgd.

It is worth noting that the current results indicate that the probability of a water shortage should further decrease after 2010, rather than increase as predicted in the FEIS, HDR Report, and IWR Final (revised) Report.

In fact, even if the Peninsula experienced an increase of federal water requirements of 3 mgd, an increase in industrial/large user demand of 5 mgd (equivalent to another Busch Brewery), and somehow crowded in another 30,000 people (~ 1.7 mgd of residential and CIL/small user demand), the total 2040 demand would still be under 60 mgd.

***Thus, both the applicant's final contracted projections, the IWR projections, and the USACE's North Atlantic Division's resulting decision on the need for the reservoir project were fatally flawed as a result of the failure to adequately account for federal standards affecting water use and limits imposed on population growth imposed by overlay land use zoning.***

## Appendix A

# Further Comments on the HDR and Final IWR Reports

## HDR Population Projections

The USACE's Institute for Water Resources' special study of March 1, 2001 (page 34) indicated that a principal conclusion was that “the forecasts prepared in the HDR report depend primarily on projections of population.”

Earlier, the IWR report (page 16) had noted that the population increment between 1999 and 2000 was anomalous in that it was over 3 times as large as the annual increments in following years. Although the IWR report does not address the reason for this anomaly, it is clear that it occurs as a result of the transition from the base study, which used population estimates from Regional Economics Modeling, Inc. to a model based on available housing units *with an assumption of a zero percent vacancy rate.*

The housing studies for York and James City Counties emphasize the importance in accounting for vacancies in predicting populations. The vacancy rate in James City County, which has some vacation homes was 8.5% in 2000. Williamsburg had a 6.7% rate and Hampton and Newport news were both at 6% vacancy rates in 2000, while those in York County and Poquoson were lower at 3.4% and 3.1%. Assuming a 6% overall vacancy rate and HDR's “most likely” number of housing units, the HDR population projection for 2040 would have been 36,000 persons lower with attendant reductions in water demand for the residents and businesses supporting them.

Alternatively, and actually in accordance with the procedure of first using the REMI model to determine the number of employees needed to support the economic activity predicted and then seeing if the available land could support the implied population, the amount of land that would have been required to support the 2040 projected populations would have been 6% higher. Since the land utilization in the HDR projections already exceeds that available under real world conditions, this makes the HDR study even less credible.

Other factors ignored in the HDR report, like the current utilization of land zoned residential for nonresidential uses that are likely to remain in place, makes the HDR report even less tenable. For instance, the York Build Out Study lists examples of a farm with a permanent development easement, Williamsburg Country Club and golf course, a gun club with outdoor ranges for high power rifles and skeet shooting, three parks, and the Peninsula Mulch Company as current uses of land zoned residential.

Other important limitations are that the minimum lot size in York RC land is 3 acres, for privately held land in an reservoir protection zone has a minimum lot size of 5 acres and, Chesapeake Bay Protection Area buffers and steep slopes increase minimum lot sizes in other instances. The York Build Out Study lists 5 subdivision proposals which have developable areas which range from 91 to 56% of their total area and which average having 77% of the land developable. The latter factors will cause housing densities in various categories to decrease as build out is approached instead of increasing as assumed in the HDR report.

In carrying out assessments of risk of water shortages both HDR and IWR used water supply values that are significantly less than current than listed as the permitted capacity for Peninsula water purveyors by the Virginia Department of Health. The total of these values from Table 1 in the body of this assessment is 76.1 mgd while IWR used 60.5 mgd and HDR used only 56.5 mgd. Even these underestimated amounts were subjected to downside uncertainty in the risk analysis.

The Final Recommended Record of Decision on the King William Reservoir project acknowledged that residential rates in the HDR report and IWR analyses were flawed because federal standards for more efficient washing machines were not considered in the analysis. In addition, replacement of toilets, shower heads, etc. in homes existing before 1997 was not adequately accounted for.

The “most likely” single family and multifamily indoor use rates for 2000 in Table 11 in the Final IWR Report are virtually identical to the values given by the American Water Works Association Research Foundation (AWWARF) 1999 study “Residential End Uses of Water”, which presents values prior to widespread adoption of ultra low flow toilets and new Energy Star washing machines. By 2040, all residences and commercial built after December 1997 and most (84% under assumptions in the current study) of those existing before 1997 will have ultra low flow toilets and low flow shower heads and all residences will have the new, efficient washing machines. Based on the AWWARF findings on water savings due to toilet replacement and the US Energy Department washing machine water efficiency, the “most likely” residential indoor water use for 2040 should have decreased by about 21 gallons per person per day using the IWR 2040 population estimate in the weighted average for toilets and shower heads. Instead, it was reduced by only 6.4 gpcd in the IWR Table 11 and similar values used by HDR.

HDR, in its Appendix E, mentioned the normal residential water use rates from the 1999 AWWARF report, but failed to mention the degree of water savings found when ultra low flow toilets and new shower heads were installed. The AWWARF report was not referenced in the Final IWR Report.

In the risk assessment, residential rates were further inflated on the high end, resulting in a risk biased in favor of future water shortages.

The March 1, 2001 IWR Report notes that the HDR report includes “growth in commercial water demand assumes growth in commercial acreage that exceeds both the growth in population and the growth in commercial employment. If...the commercial demand in 2040 would be 2.05 mgd lower.”

Overall, the HDR report is biased toward populations and business development that can not be accommodated by the land available, excessive water consumption rates, and underestimated water supply. The IWR report merely confirms the HDR biased results in most respects. It did not do an independent land use evaluation of supportable growth.