Reducing Drinking Water Demand in the Hunt-Annaquatucket-Pettaquamscutt Basin

By

Michael Ryan Clark

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EXECUTIVE SUMMARY

Current levels of potable water use in the summer months, June through August, in the Hunt-Annaquatucket-Pettasquascut basin (HAP) are unsustainable. Three water suppliers withdraw water from the HAP: the Town of North Kingstown (NK), the Kent County Water Authority (KCWA), and the Quonset Development Corporation (QDC). NK withdrawals water from ten wells, three in the Hunt subbasin, four in the Annaquatucket subbasin, and three in the Pettaquamscutt subbasin. NK's primary end users are residential (87%), followed by commercial (11%). KCWA withdrawals water from the HAP at its East Greenwich Well (EG Well), located in the Hunt subbasin. The EG Well serves mainly residential customers. The QDC withdraws water from three wells, all located in the Hunt subbasin, and supplies water mainly to commercial and industrial customers located at the Quonset Business Park. Summer demand in the North Kingstown and KCWA systems rises from a winter average of approximately 3.5 million gallons per day (MGD) to a summer average of approximately 7 MGD, straining distribution systems and the ecological constraints of the watershed. Though population in North Kingstown has increased by 12% since 1990, water demand, has increased by 26%. Additionally, from 1990 to 2007, per capita water use has increased by 17%, from 106 to 124 GPCD. According to a recent buildout analysis, average water demand is forecast to double, from an ADD of 3.5 to 7 MGD (though it must be noted that this estimate is based on town-wide consumption, not the water service area).

This increasing demand is resulting in adverse environmental effects and may result in adverse economic effects. In August 2005, during a time of little rainfall and high demand, the flow in the Hunt River fell below historical average daily minimum flows; in some locations, flows stopped altogether. Though not related to the HAP, the KCWA, struggling to meet high demands, could not guarantee water to the pharmaceutical giant Amgen. More critically, the Quonset Business Park, envisioned as the state's future economic hub, is dependent on water from QDC wells in the Hunt. Additionally, the increasing demand in straining distribution system infrastructure: in August 2005, peak day demand in NK reached 8.3 MGD, a mere 0.2 MGD under system capacity. The Rhode Island Department of Environmental Management (DEM) has proposed allowable withdrawal standards that use a percentage of historic low flows to estimate the volume of water that may be withdrawn from a stream without adversely affecting aquatic wildlife.

Managing the 'summer surge' – the increase in summer demand – has therefore become key to sustaining the region's environment (aquatic habitat, and flora and fauna dependent on floodplains) and ensuring the economic future of the state. The 'summer surge' is largely the result of outdoor irrigation, as argued in Chapter 3.

Seeing this as a critical issue, in 2008 the Rhode Island Water Resources Board (WRB) gave top priority to the implementation of a HAP pilot program, to initiate the design of a state level demand management and allocation program. The purpose is to implement short and long term demand management strategies, measure the extent to which these strategies will reduce demand, create an allocation program for what remains, and, finally, to create a replicable demand management and allocation

program applicable to the remaining watersheds in the state. Short term strategies will be focused on limiting outdoor residential water use – these include temporal irrigation restrictions and conservation rates to dissuade excessive outdoor water use and improving leak detection capabilities. Long term strategies include the implementation of smart irrigation technology, such as soil moisture sensors (SMSs), the implementation of land use planning strategies more closely linked to water availability, and the implementation of strategies targeting indoor water use efficiency, such as appliance retrofits.

In this thesis, quantify the amount of the summer surge attributable to landscape irrigation, and then estimate the potential reductions associated with the implementation of once/week irrigation restrictions and soil moisture sensors (SMSs). Finally, I analyze the current distribution of radio read automatic read meters in the North Kingstown water distribution system to assess if they will provide sufficient data to measure the impacts of the implementation of irrigation restrictions and SMSs, as well as to measure the efficiency of in-ground irrigation systems currently equipped with rain sensors. In addition, based on my analyses, I make further recommendations for reducing water demand and minimizing the need to develop additional water supply.

, In Chapter 1 I establish a baseline water use analysis using annual report data for years 2005, 2006, and 2007 for the three water suppliers in the HAP, and thirty years of monthly pumping data from North Kingstown. The results indicate that the ADD at KCWA's EG Well, in the Hunt, ranges from 0.64 MGD during the winter to 1.33 MGD and the GPCD ranges from 74 to 140, with an annual average of 107. In short, demand nearly doubles during the summer. In North Kingstown, the ADD for the years 2005- 2007 ranges from 3.7 MGD during the winter to 7 MGD in the summer, and the

GPCD ranges from 90 to 175 GPCD, with an annual average of 124. In the QDC water distribution system, the ADD ranges from 0.5 to 0.9 MGD. The average annual GPCD in the HAP, 114, exceeds the state's annual average GPCD, 97, by 18%. This indicates that there is room to reduce excessive water consumption in the HAP.

I then compared the existing withdrawals by subbasin to DEM's proposed allowable withdrawals and discovered that the Hunt and Annaquatucket subbasins would not comply. Withdrawals in the Hunt and Annaquatucket subbasins exceed DEM's proposed allowable withdrawals by 2.29 and 0.86 MGD, respectively. Withdrawals in the Pettaquamscutt fall 0.68 MGD below the proposed withdrawals. The net result is that the HAP would exceed the proposed allowable withdrawals by 2.47 MGD. Lastly, I estimate the summer surge ratio (summer ADD to winter ADD ratio) and the average daily summer surge volume in each subbasin. The findings indicate that the summer surge ratio in the Hunt is 1.78, 2.15 in the Annaquatucket, and 1.75 in the Pettaquamscutt; the average daily summer surge volume is 1.87, 1.05, and 0.22 MGD, respectively. Therefore, the total average daily 'summer surge' volume in the HAP is 3.14 MGD.

In Chapter 2, I analyze one year (2007) of quarterly water use data for a residential subdivision in North Kingstown, Rhode Island. This subdivision was chosen because the ninety-five (95) homes located there are equipped with deduct meters, which measure outdoor water use. This allows for an analysis of how much indoor and outdoor water use contribute to the 'summer surge'. Using aerial photography and on-line property assessors data, it also facilitates an analysis that quantifies volume of water demand per a pre-determine area of irrigable space, herein defined as any area that is not

improved. The results of this analysis indicate that 75% of the summer surge is attributable to an increase in outdoor water use; 25% is attributable to an increase in indoor water use. The results also indicate that more water was used outdoors than was needed for irrigation purposes: during the course of the summer of 2007, 3.5 MG of water was used outdoors in excess of irrigation requirements, assuming 1"/week.

In Chapter 2, I also analyze water use data in two multifamily developments (condos) in North Kingstown that are equipped with dedicated irrigation meters. This allows a comparison of the water use between single family and multifamily development. The results indicate that single family homes use 4.5 times more water than the multifamily developments. The results indicate that the outdoor water demand in the single family subdivision exceeded that of the multifamily developments by nearly eight times: on average, water usage in the subdivision was 4.3 gallons per square foot of irrigable space, while in the multifamily it was 0.5 gallons per square foot. Further, single family homes require 14.5 gallons of water per $1 in annual property tax revenue that the town receives, while the multifamily units required 7.7. Lastly, the average annual property tax revenue at the subdivision is $15,514 per acre, as compared to $1.16m per acre at the multifamily units. This analysis provides an economic and environmental rationale for the densification of residential development, a potential long term demand management strategy. It also suggests that outdoor water use in single family homes is likely inefficient, and should therefore be the target of demand management strategies in the short term.

In Chapter 3, I analyze monthly pumping data for the Town Franklin, Massachusetts, which, in 2000, implemented permanent once/week irrigation restrictions.

The results have been significant: the summer water use has decreased by 32 GPCD (30%), the winter water use by 12.5 GPCD, and the average annual water use by 21 GPCD (26%). I apply these reductions to NK to estimate the potential water savings based on Franklin's experience. Prior to this, I determine that the two towns have very similar land use and end user profiles using GIS. The results indicate that, during the summer, NK could reduce water demand by 0.85 MGD and and KCWA by up to 0.3 MGD. The findings indicate that irrigation restrictions alone will likely not allow compliance with DEM's proposed allowable withdrawals.

In Chapter 4, I quantity the potential demand reductions associated with the installation of soil moisture sensors in the KCWA EG Well and NK service areas. Based on a literature review, I quantify the volume of potential demand reductions at three tiers of water savings: 25%, 37.5% and 50% reductions in irrigation demand. These reductions translate to a total water demand reductions of 0.34, 0.51, and 0.59 MGD, respectively, in the EG Well and NK service areas. The results suggest that SMSs alone will not allow for compliance with DEM's proposed allowable withdrawals.

In Chapter 5, I seek to answer the primary question related to the implementation of the HAP pilot: are the existing radio read AMR's sufficient to provide a representative measurement of the potential reductions associated with the implementation of demand management strategies? A total of 2,283 ARMs are currently installed in the North Kingstown water supply system, approximately 23% of the 9,277 total metered service connections 2,215 (97%) of the existing AMR installations are installed on residential accounts. The analysis indicates that 23% the top 20% consumers are equipped with AMRs. This indicates that the distribution of AMR's is sufficiently

representative of the whole system. Furthermore, a comparison between the 2007 quarterly water use data for the existing AMRs and the system wide water use data for the same year indicates that the annual quarterly use differs by an average of +/- 7%, likely well within the bounds of the margin of error for predicting demand impacts at the distribution system level. Additionally, a GIS map of all of the AMR locations was prepared, which can provide a tool for designing meter reading routes.

I make eleven (11) recommendations related to the implementation of the HAP pilot and demand management strategies, as summarized below.

- The WRB and its partners should implement the HAP pilot, as it is a necessary step in the development of a state level demand management and allocation program.

- Weekly water use data should be collected from AMR meters during the pilot, for numerous reasons: weekly demand data will allow an analysis to test the sensitivity between demand and rainfall, allow for the testing of an improved leak detection system, and provide nearly real time data that can be used for public display and education, especially when connected to rainfall and streamflow data, and provide fine-grained data on water use responses to various demand management strategies. Also, weekly meter reading may provide a tool for enforcement of irrigation restrictions and SMSs when they are implemented.

- Demand management initiatives that target outdoor water use in the highest using residential accounts should be the focus of the pilot, at least in the short term, as they have the largest potential for immediate reductions.

- In addition to targeting outdoor water use, reducing leakage/non-account water should be a focus of the pilot as a short term demand management strategy by using more frequent meter data as a tool to identify potential leaks using anomalous water demand as a surrogate.

- The pilot should include the development of long term demand management strategies/ordinances that aim to better link land use and water availability and reduce indoor water use. A recent build out analysis in North Kingstown indicates that current water availability is likely insufficient to support current growth patterns and analyses suggest that irrigation restrictions and SMSs alone are not likely sufficient to achieve compliance with DEM's proposed allowable withdrawals.

- During the pilot, if all of the AMR meters are not read, it is recommended that a subset of the highest residential accounts that are currently equipped with AMR be used for data collection, particularly for strategies related to outdoor water use, including irrigation restrictions and SMSs. In particular, the list of 167 of the top 8% of residential accounts that are currently equipped with AMRs should be a focus of data collection and demand management initiatives.

- A portion of the $80k currently available from the WRB to potential fund the pilot should be used to purchase the required radio read meter equipment and, if possible, additional AMRs installations.

- It is recommended that a clear, multiphase scope of work/work plan be created for the pilot using the existing scope of work written by Jon Reiner, Principal Planner for the Town of North Kingstown, as a template for year one.

- It is recommended that the weekly AMR data, along with economic (current bill summary)and environmental data (streamflow) be posted to the Internet and made accessible by homes equipped with AMR's. This public display of data using the latest technology (radio read meters and the Internet) has the potential to provide the information needed to educate homeowners on their nearly real time water use and its impacts.

- It is recommended that future ARMs retrofits in North Kingstown be prioritized based on demand, rather than age necessarily. Implementation on highest users first will allow the town to acquire real time feedback on its highest using customers and, if applicable, implement appropriate demand management strategies targeted at these households.

- Lastly, as part of the pilot, short term demand reductions goals should be determined and stated publicly. For example, the 2005- 2008 WSSMP data, along with the AMR data from 2009, can be used as a baseline to establish reductions goals. Reduction goals may be gradual – 5% in 2010, 10% in 2011, and so on. Perhaps the first goal is reaching the current state annual average of 97 GPCD by a pre-determined date, say, 2015. This would allow 5 years to implement the plan and allow for a 5 year review of the plan.