A Review

of Projection Methodologies

for the

Arlington County Government and Arlington Public Schools

Prepared: April 2, 2015

Introduction

Statistical Forecasting LLC and RLS Demographics Inc. ("Consultants") were contracted to review and evaluate the projection methodologies used by the Arlington County Government ("ACG") and the Arlington Public Schools ("APS"). In particular, the consultants evaluated the methodology used by ACG to forecast population counts, housing units, households, and employment, as well as the methodology used by APS to project the number of K-12 students. In addition to a thorough methodological review, the Consultants provided recommendations for improvements to the forecasting process.

To complete the review, the Consultants examined reports as provided by APS and ACG, as well as those posted on APS and ACG websites. In addition, data maintained in Excel spreadsheets, Access databases, and ArcGIS coverages, which contained the projections and associated formulas, were also analyzed. Finally, the Consultants had conference calls with appropriate staff from both agencies to discuss the methodologies used and ask follow-up questions.

Overview

APS is a PK-12 county-wide school district located in northern Virginia just outside of Washington D.C. The district's enrollment in 2014-15 is 24,529 students and has been increasing annually since 2005. In the last ten years, enrollment has grown by more than 6,000 students, which is a 33% gain. This enrollment gain reflects the increase in the total population of Arlington County, which has grown from a total of 189,453 in the 2000 Census to 207,627 reported by the 2010 Census. Census population estimates indicate that growth is continuing with a reported 2013 estimate of 224,906, a rapid increase of 8.3 percent in just three years. However, Arlington's demographic, housing, and employment picture is complicated by employment sectors that are dependent on government and military activity, rising housing costs, and commuting patterns along the primary Metro corridors. These complicating factors raise concerns about the Census Bureau's estimates, especially since they overestimated the expected 2010 Census population.

Arlington's most rapid period of growth was between 1940 and 1950 and continued to the early 1970's as the Baby Boom generation blossomed. A national economic decline in the 1970's and government contraction in the 1980's led to a population decline shown in the 1980 Census and a slow climb back to its 1970 population by 1990. Growth has been strong for the last two decades as metropolitan Washington has expanded and Arlington is an inner-most suburban area with excellent public transit systems. Arlington is highly attractive to a young and mobile population and this is reflected in the high rates of growth in the 20 to 34 age categories.

At the same time, Arlington's housing capacity is limited by the supply of suitable land for residential development. Continued growth relies on continued shifts in the type of residential development from single-family to multi-family housing. Growth in population, shifts in the type of residential development, attraction of a younger population, military movement, and shifts in employment patterns all create a complex environment for forecasting future socio-economic factors and school enrollment.

Following is a review of the methods used by 1) the Arlington County Government in the development of population, housing unit, household and employment forecasts to 2040, and 2) the Arlington Public Schools in development of enrollment projections.

Arlington County Government

County estimates and forecasts of population, households, housing units and employment are a component of the Metropolitan Washington Council of Governments (MWCOG) Regional Cooperative Forecast used in transportation planning and air quality management. The regional forecasting process can be described as a top-down/bottom-up methodology whereby regional forecasts from a third-party provider (IHS Global Insight) are reconciled with local forecasts that are based on land use, construction and approved development plans. This is not an unusual practice as many regional Metropolitan Planning Organizations use a similar approach incorporating third-party regional macro-economic forecasts as controls on employment and population. There are, of course, many variations to this conceptual model and the process used by ACG and MWCOG allows for local flexibility in the development of local estimates and forecasts.

This process does differ from a lot of traditional county planning efforts to forecast population and households which use a standard demographic cohort-component method. While the demographic methods are useful for generating population characteristics such as age, sex, and race, and understanding the interaction of fertility, mortality and migration processes, they typically do not have an explicit method of incorporating land use and development plans or constraints. Econometric models and demographic models both have strengths and weaknesses and often a combination of two approaches provides the best control of future assumptions. The ACG/MWCOG forecasting method is one hybrid of this combined approach.

1. Current Estimates

The ACG method for preparing current estimates is most definitely a bottom-up housing unit method because the estimates begin at the census block level with planning area and county totals developed by aggregating block level data. The success of such a method relies heavily on the quality of the County's housing unit database and tracking of development projects. A hands-on demonstration of the ACG system indicates that the base data, permit and project tracking systems and geographic base data are, in fact, very high quality.

The housing unit method is an acceptable methodology and is especially effective in areas with high quality data on housing development and changes. The Census Bureau will often accept population estimates based on the housing unit method as challenges to their own population based method. Conceptually, the housing unit method is straightforward but its accuracy is also heavily dependent on quality data on housing development. The starting point is typically the count of housing units from the most recent Census. Newly constructed units are added to the housing stock based upon documentation of construction while units that are demolished are subtracted from the housing stock. The updated housing stock is adjusted to a count of households (occupied housing units) by applying an occupancy rate and then population is estimated by applying an estimate of the average household size to the estimate of households.

The ACG estimating method is a housing based method that uses the 2010 Census as a benchmark and incorporates post-census development in the number of housing units through new construction, conversion and demolition.

It should be noted that this method differs substantially from the official population estimates methodology of the U.S. Census Bureau. The Census Bureau's population estimates methodology relies on resident birth and death data by county to measure the change in natural increase/decrease and estimates net-migration using administrative data from the U.S. Internal Revenue Service. Income tax returns for two tax years are matched by social security number and changes in address form the basis for county-to-county migration flows. The migration rate for all exemptions is then applied to the base population under the age of 65 to estimate net migrants at the county level.

This method tends to work well in areas with high concentrations of consistent filers. It does not work well in areas with high proportions of first-filers (those who are filing their first tax returns) and other population universes that are not fully represented in the tax files. A more detailed review of the quality of the IRS method for Arlington estimates would be necessary but given the mobility of the Arlington population, particularly in the younger ages, it is easy to consider that the Census method does not accurately capture net-migration. This is seen in the discrepancy between the Census Bureau's estimates results in the 2000's when measured against the census count for 2010. In 2009 the Census Bureau would have expected a 2010 Census population in Arlington of approximately 220,000 yet the actual census count was 207,627, a 6.2 percent error. In comparison, the ACG estimate for 2010 was 212,000 with only a 2.2 percent error.

Estimates Process

Housing Units – The 2010 Census count of housing units at the Census block level is the basis for estimating current housing. Arlington County participated in the 2010 Census Local Update of Census Address (LUCA) program and was able to provide the Census Bureau with housing unit addresses that were not included in the 2010 Master Address File. The number of these unit addresses that were accepted is unknown but the County's analysis of final block level housing unit counts indicates areas were geographic misallocations occurred and even entire buildings that were not counted correctly. Adjustments are made to the 2010 Census base to correct for these errors.

Quarterly reports from the Arlington County permit tracking system are reviewed for consistency using computer editing procedures and site visits when necessary. The **Net New Housing Units** are equal to the new unit construction minus units demolished between the 2010 Census and the current estimates date and are added to the 2010 adjusted base. The current estimate of housing units is then equal to the adjusted 2010 Census housing unit count plus the **Net New Housing Units** to the estimate date.

Households – Households are simply occupied housing units. New households are equal to the net new housing units times the occupancy rate which is derived from the 2010 Census. Occupancy rates are specific to the major planning areas and therefore capture differences in occupancy throughout the County. This reflects differences in housing type for example, between single family homes, apartments, duplexes, condos, etc. The occupancy rate based on the 2010 Census is assumed to remain constant and this is an assumption that should be

constantly monitored. A basic tenant of population and housing estimates is that errors increase as the estimate date gets the farther away from the census base. While the annual American Community Survey data has large margins of error for small area analysis, it should be used to monitor occupancy at the census tract and county levels.

Population – The population at the current estimate date is equal to the new household count times the average household size, again derived from the 2010 Census. The population on the estimate date is then simply the new population plus the 2010 Census count. Here again, the average household size is assumed to remain constant from the 2010 Census. Average household size has tended to remain fairly stable in the last two decades, however, changes in housing type composition, fertility levels and age distributions can impact future household sizes. As with housing occupancy, additional monitoring of average household size through the American Community Survey is warranted.

Estimates are also produced by age for the estimate year using the percent distribution from the 2010 Census and the Census Bureau's current population estimates program. Use of the 2010 Census or current estimate is based on the date of the estimate year. There is a lag in the Census Bureau's estimates so ACG estimates for 2011 and 2012 apply the 2010 Census distribution to the estimate total to generate age-specific estimates. For estimate years beginning in 2013, the age distribution from the Census Bureau's current estimates program is used in the same fashion to allocate the total population to 5-year age categories. There is no attempt to incorporate current birth data or apply cohort aging techniques. The method is strictly proportional allocation of the total population.

Employment – Estimating employment is a more complicated procedure and has many more data qualifications due to conceptual differences in how sources identify the employed population and differences in the data collection systems themselves. For example, the state labor department and U.S. Bureau of Labor Statistics regularly monitor employment in a number of different ways. Employment is derived from household surveys at the county level and this is a resident employment concept. As a resident concept, an employed individual is only counted once. Employment data also comes from the Quarterly Census of Employment and Wages (QCEW) which is employer based and reflects employment by workplace. As a workplace concept, an individual holding multiple jobs will be counted multiple times.

Other sources of employment data currently and previously used by ACG include the Labor Department's QCEW data, InfoUSA (a private vendor of business information) and Dun & Bradstreet (not used in the 2015 estimates). As private sources, InfoUSA and D&B each have proprietary methods for maintenance of business databases and each have limitations on the accuracy of their data. The QCEW is based on quarterly reporting by all employers and, for the universe of employers, is generally quite complete. Accuracy issues in the QCEW data stem from reporting biases related to headquarters reporting and geographic location based on reporting addresses. The reporting address does not always reflect the actual workplace location of employees. Also, the QCEW universe is employers so sole proprietors are not generally included. All of these sources are also subject to misreporting of government employment or do not include government employment at all.

As with housing units, the ACG estimates methodology starts at the block level and is highly dependent upon accurate geocoding of business locations. Much effort goes into evaluating employment coverage across the datasets and thresholds of discrepancy are established to determine needs for site visits and further research. ACG's parcel level database is also used to track commercial real estate and includes Gross Floor Area (GFA) data which is used as an alternative estimate of employment. This is particularly important in those areas with high concentrations of federal and DOD employment.

Current estimates of employment are derived from a combination of these sources and assumptions regarding: 1) number of employees per square foot when GFA is used for estimates and, 2) office vacancy rates which are generally based on CoStar data. Previous rounds of estimates used a CoStar average vacancy rate of 12 percent but current estimates utilize higher vacancy rates due to BRAC related losses and expected non-renewals in areas of redevelopment. BRAC has resulted in the loss of 17,000 direct and indirect jobs necessitating close monitoring of vacancy rates.

2. **Forecasts**

The ACG model for forecasting housing units, population, households and employment follows on the estimates methodology and depends on analysis of current residential and commercial capacity, construction projects, zoning restrictions, building permit activity and approved development plans. Ultimately, the General Land Use Plan (GLUP) adopted by the County is the driver of future change. The estimates and forecasts are produced on an annual basis (January 1, 2015 is the most current) by ACG even though the MWCOG regional forecasts process does not require annual updates. This annual process keeps the forecasts in line with the current estimates and incorporates updates to the County's GLUP. The ACG system is GIS based such that new development approvals and changes in the GLUP are incorporated at the block level and are automatically integrated into the housing unit method. Development plans and approved projects have "build dates" incorporated so future developments can be summarized for any forecast year in five-year increments. For example, an approved residential project that will bring 150 units online in 2020 will automatically feed the new construction of housing units and, depending on location, apply the assumed occupancy rate to develop a count of new households. The assumed average household size multiplied times the count of households will yield total population at the forecast date.

Forecasts are developed in a five-step process:

1) **Net New Construction** – Using the 2010 Census as a base the estimates provide the starting point for the forecasts. The development database summarizes future construction for housing units, office, retail and other square footage, and hotels rooms.

2) **Development Potential** – The General Land Use Plan (GLUP), approved site plans, development plans, sector plans and small area plans determine the development potential at specific forecast dates. This process is heavily dependent upon planning and economic development staff and their knowledge of the county. In the case of residential development, future residential construction, demolition, and redevelopment define the future year base of housing units which then determine households by applying the occupancy rate and population by applying the average household size. In the case of

commercial development, the primary use (office, retail, hotel) determines the occupancy level and square footage of net new construction. Employment per square foot is used to determine net future employment levels.

3) **Calibration** – Historic rates of absorption are used to time the occupancy of residential and commercial space. For example, a residential development is not assumed to be fully occupied as soon as it is complete. The calibration set allows for phased occupancy of both residential and commercial space.

4) **Net New Development –** At each five-year interval, net new development is determined for each category of residential and commercial development.

5) **Population and Employment –** As with the estimates methodology, future population is determined by adjusting for occupancy and average household size. Employment is determined by applying occupancy rates and the employment per square footage conversion factor.

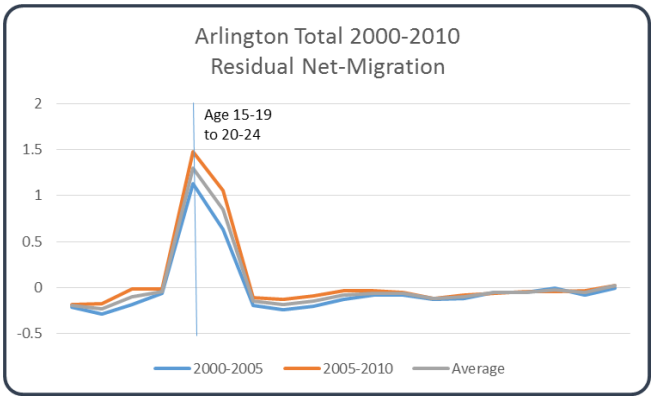
3. Alternative Demographic Forecasts

As noted earlier, the housing based forecasting method used by ACG is quite appropriate and is carried out at a block level with high quality housing and development tracking systems. It is ultimately guided by the General Land Use Plan adopted by the county. However, this method cannot generate population characteristics such as age and sex which are important components of population analysis and have direct bearing on school enrollment forecasts.

Of particular concern here is the impact of migration on characteristics of the population. The GLUP provides an important guide related to residential and commercial capacity but it does not address the changing composition of the population – particularly age characteristics. Population change in any is a function of fertility, mortality and migration.

The strength of the demographic cohort-component method is that it captures each of these processes and allows for the "aging" and migration of the population. Mortality is generally the least important process as survival rates at each age are relatively stable. Longevity continues to improve but it tends to not have immediate impacts. Fertility is more important, especially considering its link to school enrollment. Fertility rates in the U.S. have been at very low levels for decades but the timing of fertility among women of childbearing age has been delayed such that the peak years are in their late 20's and early 30's. Arlington County has a very low fertility rate of about 1.5 children per woman – well below the replacement level of 2.1. Even so, the current age pattern and level of fertility shows no sign of dramatic change in the future.

Migration on the other hand is the most volatile component of population change. One only needs to look at the recent recessionary period to understand the impact of economic crises on migration as migration rates plummeted in states of high in-migration and moderated in states of high out-migration. The figure below illustrates the importance of demographic methods and the impact of migration in Arlington County.



This migration pattern by age shows that Arlington County clearly attracts population in the late teens and early 20's at a very high rate. It also shows that in-migration drops sharply in the 30's and continues at a slight negative level throughout the age distribution. A similar pattern is seen in the 1990 to 2000 period. High in-migration of the young population is characteristic of many urban areas attracting young workers. However, in many areas this population then moves out when they start to form families and look for alternative housing arrangements.

There are generally two components to this phenomena: in college towns it's the enrollment in college that accounts for high rates of "in-migration" while in urban centers the migration is in search of employment. College populations must be accounted for separately because they distort the migration and fertility rates of the underlying population. College students are "replaced" each year as one group graduates and a new group of freshmen enter therefore the change in college population needs to be handled separately from the migration of the general population.

Analysis of Arlington's age distribution in 1990, 2000 and 2010 indicate that this young population does not age in Arlington County and therefore is more likely to behave as a special population indicative of a college town. In 1990 the 20 to 34 year old population was 31.6 percent of the total. In 2000 the same ages represented 33.9 percent and 36.2 percent in 2010. The consistency of this age group and of the cohort ages 30 to 44 in each subsequent decade support the notion that this migration bulge is related to the college population. The 2010 Census shows that Arlington's population living in group quarters (college housing) was only 610. However, American Community Survey data reports the population living in Arlington and enrolled in undergraduate and graduate colleges exceeds 20,000. Such a difference between the college group quarters population and the college enrollment points to a need for better understanding of migration and its age effects. This will have direct impacts on fertility forecasts and school enrollment.

Recommendations

This review of the ACG estimates and forecasting methodology, along with the illustration of the importance of demographic methods for a more complete understanding of the future housing and population pressures leads to the following recommendations for immediate implementation and additional study:

Immediate Implementation

1. **Methods Documentation** – ACG should consider development of comprehensive methodology documentation. There are a variety of methods statements that have been provided by ACG staff and on the website, but it is difficult to get a single, detailed description of the methods employed. The county's estimates and forecasting system is quite detailed and staff have in-depth knowledge of the data sources and interaction. Transparency of their data and methods would be improved by system documentation that identifies the process, data sources, and assumptions.

2. **Monitor ACS Housing Occupancy** – Housing occupancy rates for each planning area are based on the 2010 Census and are held constant throughout the estimates and forecast periods. The census is the best benchmark for residential housing especially for small geographic areas. However, economic conditions and development plans can alter occupancy rates. ACG should continue to monitor the American Community Survey results at the block group level but also use larger sample areas at the census tract and county level to monitor housing occupancy. Margins of error in the ACS data can be large for small areas but the data at the county and tract level can also point to trends that can help inform changes at the planning area level.

3. **Monitor ACS Average Household Size** – As with housing occupancy, the ACG methods rely on an assumption of a constant average household size for residential development. Here again, the American Community Survey data at the tract and county level should complement the use of block group data to identify trends that would inform future assumptions about change in average household size.

Additional Study and Resources

4. **Age Distribution Analysis** – The age composition of the population is an important driver of housing needs and development, yet this is an area that receives limited attention in the estimates methodology and is not incorporated in the forecast process at all. This initial review of migration by age indicates that more detailed analysis is necessary to understand both the migration and aging effects in Arlington. Reliance on the Census Bureau's age estimates is a reasonable approach for developing current estimates when close to the Census base. However, Arlington's high proportion of population in the 20 to 34 year age categories warrants detailed analysis of aging in the county. This should include historical analysis of decennial census and current estimates back to 1990 along with residual net-migration analysis to determine if this population ages in the county or is a function of the high college enrolled population.

5. **Migration Analysis Using Census Microdata** – Analysis of the American Community Survey Public Use Microdata Samples can identify migration flows (both in- and out-migrants) and the demographic characteristics of migrants. Arlington County is defined by two Public Use Microdata Areas and this would allow for some additional geographic detail within the county. The ACG should acquire the necessary processing capability and expand analysis of the microdata.

6. **Development of Cohort-Component Demographic Forecasts** – Analysis of aging and the college population points to the need for adoption of a demographic cohort-component method integrated with the existing housing based model. As noted earlier, the demographic method has no explicit controls for housing capacity and the county's housing method is probably superior for forecasting total population. However, the housing method cannot be used to generate age distributions and it can be seen from the migration patterns that Arlington County's population, and age composition, is greatly influenced by migration.

7. **Analysis of Self-Employment** – Employment estimates and forecasts are driven by office, retail and other commercial development as measured by square footage and a conversion factor used to measure average square footage per employee. The data used in the ACG method appears to adequately track current and future development. However, establishment based employment does not do a good job of measuring the self-employed, changes in multiple job holding and space sharing that is increasingly common in office employment. ACG utilizes American Community Survey data on self-employment to add the self-employed to the establishment employment base. Current ACS data seems to only account for about 20 percent of the U.S. Bureau of Economic Analysis proprietor's employment of 29,000 in 2013 so additional analysis of the self-employment component is warranted. ACG should evaluate the need to expand the employment models to monitor and incorporate proprietor's employment and the impact of office space sharing in both public and private sector employment.

8. **Integrated Economic/Demographic Modeling** – While not a requirement of the MWCOG Regional Cooperative Forecast process, the integration of an economic-demographic model and the current housing/commercial space forecast should be considered. Such integration can provide a "control" process that accounts for housing and land development and constraints in the General Land Use Plan, employment growth by economic sector, and implied population change. Employment, labor force, and population change all impact commuting patterns which are also driven by workplace employment. Currently, capacity in housing and commercial space are the controls but there is no resulting analysis of those impacts on population by age and labor force participation.

Arlington Public Schools

Enrollment Projection Methodology

APS uses the Grade Progression Ratio ("GPR") method to project future enrollments. Also known as the Cohort-Survival Ratio ("CSR") method, GPR is the preferred method to project enrollments by school demographers across the country. In essence, the method looks at historical grade-to-grade progression ratios and assumes the historical progression ratios will continue into the future, which essentially provides a linear projection of the population. Typically, GPR is most effective when a district's current trend continues into the future. In this method, a ratio is computed for each grade progression, which essentially compares the number of students in a particular grade to the number of students in the previous grade during the previous year. The ratio indicates whether the enrollment is stable, increasing, or decreasing. A grade progression ratio of one indicates stable enrollment, less than one indicates declining enrollment, while greater than one indicates increasing enrollment. If, for example, a school district had 100 fourth graders and the next year had 95 fifth graders, the survival ratio would be 0.95.

Researchers have debated the predictive ability of GPR; some claim it has a predictive validity for one to two years, others believe it is valid for less than five years, while some state it can be valid for as many as seven years. After one to two years, the projections can be inaccurate since GPR's major assumption is a linear trend, which may not hold true after a few years. GPR uses three inputs to project enrollments: historical enrollments, live births, and new housing.

1. Historical Enrollment

To compute the progression ratios, APS uses the district's September 30th historical enrollment counts. Since enrollment can vary in a district on a month-to-month basis, most districts report their enrollment on the same day each year (e.g. October 15) to maintain a level of consistency. In reviewing spreadsheets provided by the district, grade progression ratios were computed by APS for the last fourteen years to show changes in the ratios over time. To project future enrollments, APS uses an average of the last three grade progression ratios. While APS refers to it as a 3-year average ratio, in actuality it is a 4-year ratio since it takes four historical years to make three progression ratios. It is typical of school demographers to use a number of years in computing progression ratios since it removes any one-time anomalies in the enrollment data that may occur. The average progression ratios are applied to the most current enrollment to project the next year's enrollment. The process is repeated for the entire enrollment projection period, which is usually five or ten years. APS projects enrollment for a ten-year timeframe. It should be noted that a five-year projection is more reliable than a ten-year projection. If birth data are used to project kindergarten students five years later, the ten-year projection in years 6-10 relies on estimated birth counts (since the children have not yet been born) in order to project the number of kindergarten students. For this reason, elementary projections are much more susceptible to higher error rates in a ten-year projection as compared to middle or high school projections, which rely on either children that have already been born or that are currently enrolled in the district.

A "bottom-up" approach is used by APS in projecting enrollment. That is, enrollments are projected at each elementary school's attendance area (K-5) and aggregated to determine grade-by-grade elementary totals. Using appropriate feeder patterns, enrollments are then projected for each of the district's six middle schools and aggregated to determine the number of children in grades 6-8. This process is then repeated for the district's six high schools, again using existing feeder patterns.

APS completes its projections in the late fall of a school year, and then makes small modifications in the spring if enrollments on January 30 have changed significantly in a particular grade from its September 30 count. The spring revisions help the district make staffing allocations and to estimate the next year's budget.

It should be noted that pre-kindergarten students are not projected by APS since the number of students is largely dependent on funding from the Virginia Department of Education. To estimate those students, APS simply uses the pre-kindergarten count from the most recent year in its projections. APS also does not project enrollments for students in special programs, such as the Stratford Program. Instead, the Director of Facilities converses with staff in those related departments and uses the counts as provided by those departments.

2. Live Births

Birth data are used by APS to project kindergarten students five years later, which is a standard practice in the field. In many larger districts, it is also used to project the number of pre-kindergarten students either three or four years later. APS obtains Arlington live birth data from the Virginia Department of Health ("DOH"), which tabulates the number of births to women who reside in Arlington. Birth data are lagged five years behind their respective kindergarten classes to calculate a progression ratio for each birth-to-kindergarten cohort. For instance, if there were 1,000 births in 2008 and five years later (the 2013-14 school year) there were 1,100 children enrolled in kindergarten, the birth-to-kindergarten progression ratio would be 1.100.

Of all the grade progression ratios computed (birth-to-kindergarten, K to 1, 1 to 2, etc.), the birth-to-kindergarten ratio has the greatest variability since there is a five-year lag time between a child being born and when the child enters kindergarten. In that five year period, a number of things may happen. A child born in Arlington may attend APS five years later, or may attend a private or parochial school, or may move out of the school district's attendance area. On the flip side, children born in other locations other than Arlington may move into the area and attend APS. For these reasons, projecting future kindergarten counts is often difficult due to the mobility of the population under the age of 5.

Birth data are provided to APS by the DOH at the Planning Unit ("PU") level. There are more than 200 PUs in Arlington, which are slightly larger than a Census Block and can be aggregated to fit within an attendance area. APS then aggregates the number of births to determine the number of births in each elementary attendance area. In years 1-5 of a projection, APS computes kindergarten students as described above using an average of the last three birth-to-kindergarten ratios. To project kindergarten students in years 6-10, APS does not use birth-to-kindergarten progression ratios since it would need to estimate the number of births in future years, as these children have not been born. For instance, for the projections completed in the Fall 2014, years 6-10 in the projection would correspond to 2020-2024. The kindergarten classes from these

years would have been born five years prior, which is 2015-2019. Since these years are in the future, birth data would need to be estimated to project future kindergarten counts. Instead, APS does a rolling average of the last three kindergarten classes to project future kindergarten counts.

3. New Housing Units

APS receives housing pipeline data from the Department of Community Planning, Housing, and Development ("DCPHD"). Using the number of housing units in Arlington by type (detached single-family, townhouse, elevator apartment, etc.) and the number of students in each of these house types from the district's student database, student generation factors (also known as student yields) are computed at the PU level. Student generation factors are greatest for detached single-family homes and smallest for multi-family homes such as apartments, townhouses, and condominiums. Using the number of housing units that are scheduled to be built and the student generation factors, an estimate of the number of students from the new housing units can be computed. Student generation factors are also broken down by grade configuration level (K-5, 6-8, and 9-12) to determine the anticipated number of children in the elementary, middle, and high school levels. If student generation factors are not available at the PU level where the construction will occur, the county-wide student yields are used instead to project the number of anticipated children. Based on when the housing units are scheduled to be completed determines the years that the students will be added into the baseline enrollment projections. Recently-completed construction (in the last year) phases in students in Years 1 and 2, development currently under construction phases in students in Years 3-5, and approved residential developments but not yet under construction phases in students in Years 6-10. The estimated number of children is evenly-distributed both across the grade configuration level and projection years.

Internal Review of Projections

Currently, APS annually compares its projected enrollment to actual enrollments only for the first year of the projection period. For example, the district does not compute error rates for its projections computed four years ago to determine the accuracy of the projections over time, which would be a longitudinal review. If projections were computed in Fall 2013 for 2014-15 to 2023-24, only the actual enrollment in 2014-15 would be compared to the projected enrollment, which in effect, only looks at the short-term accuracy of the enrollment projection model. In the March 11, 2015 APS report summarizing the results of the enrollment projections, APS showed that in the last eleven years, the one-year projections had an error rate of +/- 2% in ten of the eleven years. However, in a survey of educational planners who complete enrollment projections, two-thirds believe that an error rate of 1% per year is acceptable[1]. Using this criterion, for a district with 10,000 students, an error rate of +/- 100 students would be acceptable in Year 1, +/- 200 students would be acceptable in Year 2, etc. For a ten-year projection, this would mean that a 10% error rate (+/- 1,000 students) would be acceptable. If this more stringent criterion were to be used instead, the enrollments projections would have had an error rate of +/- 1% in about half of the last eleven years. However, it should be noted that the *type* of

[1] Schellenberg, S. J., & Stephens, C. E. (1987). Enrollment projection: variations on a theme. Paper presented at the Annual Meeting of the American Educational Research Association, Washington D.C., (ERIC Document Reproduction Service No. ED 283 879)

school districts (fast growing, declining, or stable) was not mentioned in the survey. For a fast-growing district such as APS, with many variables that contribute to changing enrollment, a higher error rate of +/- 2% would certainly be acceptable.

Recommendations

After reviewing the APS enrollment projection methodology, it should be clearly stated the district is employing methods and using techniques that are the standard in the field of school demography. The following recommendations are not to make broad changes in the methodology, but rather to make small refinements that may lead to more accurate projections in the future. While there are scientific elements used in developing projections, it is not possible to achieve perfection in projecting enrollments due to human elements, such as migration patterns, that cannot be predicted. The recommendations, which follow below, were grouped according to two categories: Immediate Implementation and Additional Study.

Immediate Implementation

1. **Publish Annual Report** – APS should consider publishing an in-depth, annual report with a detailed narrative that shows the general population and demographic trends of Arlington using Census data, reviews historical enrollments, shows trends in live births and new housing by Planning Unit, and displays the enrollment projections with accompanying methodology.

2. **Compute Alternative Set of Projections** – APS currently computes only one set of enrollment projections. APS uses the GPR method using an average of the last three ratios to project enrollments. APS may consider performing a second set of projections, where some other variables are modified. For instance, the district might consider taking an average of the last two grade progression ratios, to reflect the current enrollment trends. Or, the second scenario might instead use weighted-average ratios, where the most recent ratios have a greater weight. In addition, the assumptions of when additional children will enter the district from new housing starts can also be modified.

3. **Perform Longitudinal Analysis of Projections** – APS annually compares its projected enrollments to actual enrollments only for the first year of the projection period. A more longitudinal review should occur, where by the enrollment projections from five to ten years ago are compared to actual enrollments to determine the effectiveness of the enrollment projection model. If the district's methodology has changed significantly over time, it would be interesting to see if those changes have led to more accurate enrollment projections.

4. **Publish Baseline and Adjusted Projections** – The projections provided to the public include additional students due to new housing. APS might consider showing both the baseline projections and the adjusted projections for new housing.

5. **Aggregate Student Generation Factors to Attendance Area** – If student generation factors are not available at the PU level where the construction will occur, APS uses

county-wide student yields to project the number of anticipated children. Instead of using county-wide yields, APS should consider aggregating the PU yields within an attendance area and use those yields to project the future number of children. In this fashion, the local information of the geographic area is not lost as it is currently when county-wide yields are used.

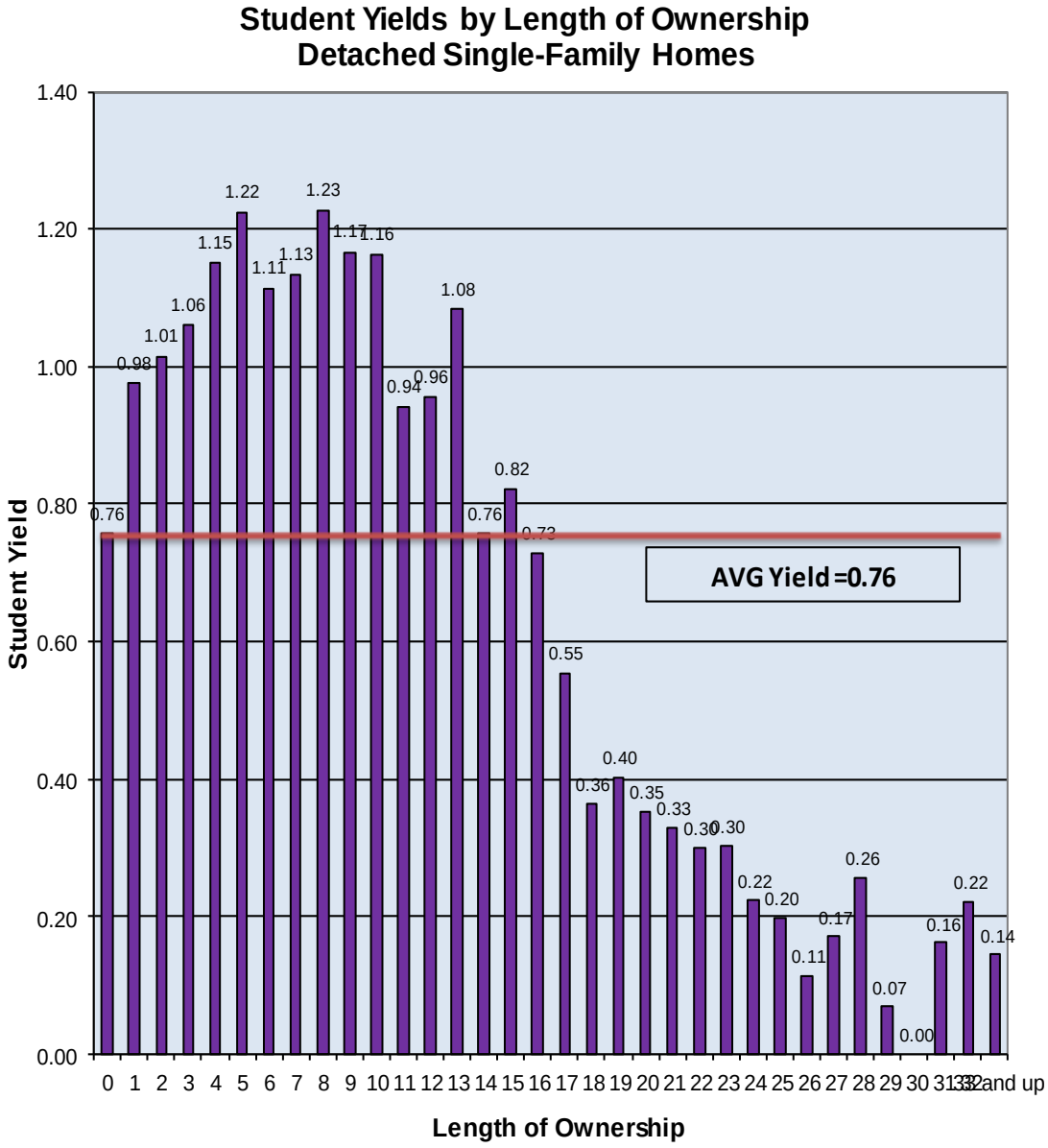
6. **Consider Past Home Construction Before Adding Students from New Home Construction** – Student generation factors from each PU level are currently being used to project the number of students from new housing, and then are added to the baseline projections based on the development timeline. It should be noted that the baseline enrollment projections utilize grade progression ratios that do take into account prior new home construction growth. Students who have moved into new housing and have enrolled in the district have been captured by the progression ratios. Therefore, the total number of children from future housing should not be added to the baseline projections in order to avoid double-counting. Instead, the *difference* between the number of children from future units and the number of children from recent historical construction in each PU should be added to the baseline counts. For instance, if 500 detached single-family homes were constructed in the last five years and generated an estimated 500 public school children, the progression ratios would have captured these students entering the district. If 700 detached single-family homes are planned in the next five years with an estimated 700 children, only the difference, 200 children, should be added to the projections since the ratios have already increased due to the children from new housing.

7. **Update APS Website** – Information describing the enrollment projection methodology found on the APS website needs to be updated. For instance, the website states that "Arlington uses the U.S. Census, reported in 10-year intervals, to conduct 10-year projections and study historical trends." APS currently does not integrate Census data into the enrollment projections, which indicates that this is an outdated statement.

Additional Study and Resources

8. **Compute Student Generation Factors by Length of Ownership** – The student generation factors (student yields) are computed by dividing the number of students in a particular housing unit type (detached single-family, townhouse, etc.) by the number of housing units of that type at the PU level. The generation factors therefore include homes owned by all age segments of the population, which lowers the overall student yield. Dr. Grip's research has shown that student yields vary with lengths of ownership. An example of student yields by length of ownership for detached single-family homes is shown below for a community in New Jersey. Long-held homes (20 or more years) will have fewer children, as they would have graduated from the district. Typically, yields gradually increase with length of ownership, peaking at around 8-10 years of ownership. Student yields at these lengths of ownership are higher than when considering average yields for the entire population. Communities with excellent school districts often have new homes that are purchased with greater frequency by families with children. In computing student yields, some school districts use the Public Use Microdata Sample ("PUMS") from the Census Bureau to obtain the number of students in recently-constructed homes in the last ten years. However, if a community has not had a

significant amount of new housing, or is too small to use the PUMS dataset since it is based on a small sample, this approach to computing student yields would not work. Instead, yields by length of ownership would be a more suitable technique for estimating children from new housing. It is recommended that APS consider computing their student generation factors based on a length of ownership model, as the yields currently being used may be underestimating the future number of children from new housing.



9. **Project Future Births in Collaboration with ACG Estimates** – Currently, APS uses a rolling average of the last three kindergarten classes to project kindergarten counts in years 6-10 of the projection period. Instead of projecting kindergarten students in this fashion, ACG can assist APS by projecting the number of women of childbearing ages (15-49) for five-year intervals (15-19, 20-24, etc.) for 2015, 2020, and 2025 using the cohort component method by using age-specific counts from the 2010 Census. Births can

then be projected by multiplying the age-specific fertility rates (based on historical birth data) by the number of women in each age class. Kindergarten counts in years 6-10 can then be computed by using average birth-to-kindergarten ratios that were used to project kindergarten students in years 1-5.

10. **Attend Professional Conferences in School Demography** – Staff from Facilities Planning should attend conferences where there are presentations by school demography experts discussing various issues in the field. Organizations such as the Population Association of America, Southern Demographic Association, and Association of American Geographers often have sessions dedicated to issues in school demography in their annual conferences.

Collaboration Between ACG and APS

Though ACG and APS have separate data sources and methods for estimates and forecasts, there is a link between the methods in that APS receives residential pipeline data from the ACG estimates process. The updated number of housing units is used with student data by housing type to compute student generation factors. However, an important area for further study and collaboration is in analysis of age distribution effects on fertility.

As discussed previously, development of a cohort-component demographic method by ACG can be used to project the number of women of childbearing ages (15-49) in Arlington for five-year intervals (15-19, 20-24, etc.). Analysis of current and historical age-specific fertility patterns, along with the integration of migration effects, will allow for the projection of births. This will allow APS to project long range (years 6-10) kindergarten counts by historical average birth-to-kindergarten ratios.