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AIR FORCE INTEGRATED SOLID WASTE MANAGEMENT PROCUREMENT ANALYSIS

June 2018

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ANALYSIS**

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ABSTRACT

Across a majority of Air Force installations in the Continental United States (CONUS), there appear to be large variations in prices paid for Integrated Solid Waste Management (ISWM) contracted services, with little understanding as to why this variation occurs. To effectively analyze these ISWM contract price variations, we compared the Price Per Ton (PPT) of disposed solid waste paid by a sample of Air Force installations, to the PPT paid by co-located municipalities. We developed a methodology to test the hypothesis that the Air Force paid, on average, a greater PPT than their respective co-located municipalities. In addition to this hypothesis, we implemented multivariate linear regression modeling to determine any applicable ISWM cost drivers to help explain price variations. This research resulted in two findings: we were unable to determine that, on average, and at an appropriate level of confidence, that the Air Force pays more than respective municipalities, and that there are two significant cost drivers of Air Force ISWM PPT—number of containers used and the distance to landfills. We recommend the standardization of Air Force ISWM cost data to industry standards, and utilization of category management and strategic sourcing with ISWM contracts.

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LIST OF ACRONYMS AND ABBREVIATIONS

ACF	Arruda-Clark-Fuchs
AFB	Air Force base
AF-COLS	Air Force Common Output Level Standards
AFCEC	Air Force Civil Engineer Center
AFICA	Air Force Installation Contracting Agency
BMO	building maintenance and operations
BMO SB	building maintenance and operations small business
CBIS	Contracting Business Intelligence Service
CIR	category intelligence report
CLIN	contract line item number
CMLC	Category Management Leadership Council
CONUS	continental United States
DoD	Department of Defense
DPAP	Defense Procurement and Acquisition Policy
DWSS	DoD-wide services sourcing
EPA	Environmental Protection Agency
FAR	Federal Acquisition Regulation
FFP	firm fixed price
FSSI	Federal Strategic Sourcing Initiative
FY	fiscal year
GSA	General Services Administration
ISWM	integrated solid waste management
MA-IDIQ	multiple-award, indefinite delivery, indefinite quantity
NDAA	national defense authorization act
NPS	Naval Postgraduate School
OMB	Office of Management and Budget
OFPP	Office of Federal Procurement Policy

PPT	price per ton
SME	subject matter experts
Sub-AMP	sub-activity management plan
USD (AT&L)	Under Secretary of Defense for Acquisition, Technology and Logistics

EXECUTIVE SUMMARY

Across all United States Air Force installations in the Continental United States (CONUS), there appear to be large differences in prices paid for Integrated Solid Waste Management (ISWM) contracted services, with little understanding as to why they occur. The purpose of the research is to provide the Air Force with a tangible metric, such as average price per ton (PPT) of disposed solid waste, which can be compared against Air Force installation PPT as well as their co-located municipalities. These collected and standardized local city prices can then be compared to Air Force prices and used to determine whether the Air Force, on average, overpays for ISWM services. A comparison between both the local municipalities and Air Force installations will further assist Air Force contracting organizations in determining whether the prices paid are fair and reasonable when compared to the Air Force average and when compared to each individual installation's municipality.

This research used ISWM contract data from the Air Force Installation Contracting Agency (AFICA) to calculate a PPT ISWM cost of each Air Force base. Also, we used data collected from 20 municipalities to calculate the PPT ISWM cost for each local municipality. To effectively analyze ISWM contract price variances for solid waste disposal services between Air Force installations and between Air Force installations and their surrounding local municipalities, we used hypothesis testing to compare the difference in means across Air Force bases and local municipalities, as well as multivariate linear regressions to identify potential correlates of the cost drivers.

We found that there were only two significant cost drivers correlated with Air Force PPT: Air Force base number of containers, and Air Force base distance to landfills. We found that as the Air Force base number of containers increased, the unit Air Force PPT costs correspondingly decreased. Alternatively, as the Air Force base distance-to-landfill cost driver increased, the unit Air Force PPT costs also increased. Also, we did not find, on average and at conventional levels of statistical confidence, that CONUS Air Force bases pay a higher PPT than their respective municipalities. Though we were unable to reject the null hypothesis using conservative conversion estimates, we were able to identify

multiple Air Force bases that pay a significantly higher PPT than their respective municipalities. The Air Force installations with over twice the PPT costs of their local municipality are: Patrick Air Force Base, Peterson Air Force Base, Schriever Air Force Base, The United States Air Force Academy, Kirtland Air Force Base, Columbus Air Force Base, and McConnell Air Force Base.

Additionally, we were able to identify multiple Air Force bases that pay a significantly lower PPT than their respective municipalities. The Air Force installations with less than half the PPT costs of their local municipality are: Davis-Monthan Air Force Base, F.E. Warren Air Force Base, Naval Air Station Joint Reserve Base Fort Worth, Fairchild Air Force Base, and Edwards Air Force Base.

There are additional areas requiring further research. First, the Air Force needs to conduct further research on the installations with over twice the PPT costs of their local municipalities at the contract line item number (CLIN) level. The main cost drivers at each Air Force installation need to be identified in order to evaluate negative trends. Additionally, the Air Force should review the five contracts with less than half the PPT costs of their local municipality to identify best practices that can be utilized by all. Also, two areas we believe might explain the higher prices paid by the Air Force are the cost of regulation and additional security requirements placed on ISWM service. The additional federal laws and regulations placed on government ISWM programs and government contracts in general might explain the price differences between the local municipalities and Air Force bases. These two theories require more research to validate this theory and help identify the true cost of federal regulations.

Finally, based on our findings, we recommend the following:

1. Standardize the CLIN cost structure in ISWM contracts across all Air Force installations to be in accordance with industry standards.
2. Require Air Force ISWM contracting officers to compare local municipality costs and all Air Force installation costs during market research.
3. Require that each installation's contracting officer provide detailed CLIN-level data and a calculated PPT into a repository that is accessible to all, to

better accommodate contracting officers during the market research process.

4. Perform a deep dive into the contracts of previously identified outliers to find the cost drivers creating such large variations. The deep dive will aid AFICA in developing comprehensive lessons learned and best practices that can be incorporated into future contracts to save scarce governmental funds.
5. Utilize category management and strategic sourcing with ISWM contracts. ISWM contracts are a prime candidate to benefit from category management and strategic sourcing considering the large price variances across each installation. Consolidating ISWM services into a regional contract will allow the Air Force to assign experts in the ISWM market to manage ISWM service contracts.

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I. INTRODUCTION

A. BACKGROUND

Across all United States Air Force installations in the Continental United States (CONUS), there appear to be large differences in prices paid for Integrated Solid Waste Management (ISWM) contracted services, with little understanding as to why they occur. In regard to ISWM services, we believe that there should be few differences in the level of service provided to Air Force installations compared to their respective municipalities. As a result, there is an expectation that both organizations would have similar, if not identical ISWM contract costs. Further understanding of ISWM contracts procedure is imperative because its associated costs are significant: “Air Force ISWM spend from Fiscal Year (FY) 2010–FY 2014 constitutes \$281M of AF installation spend” (Brady et al., 2016, p. 6). This project develops the methodology to compare ISWM price differences between Air Force installations, local municipalities, and their associated cost drivers.

B. PURPOSE OF RESEARCH

This research will attempt to provide a means to identify efficiencies or inefficiencies in the procurement of ISWM services, which require substantial annual funding obligations. Our purpose is to improve future acquisitions of ISWM services and safeguard scarce government resources. Our team wants to deliver information to the Air Force that will aid them in ensuring ISWM services are provided by contractors at best value to the government. We want to provide the Air Force with a tangible metric, such as average price per ton (PPT) of disposed solid waste, which can be compared against Air Force installation PPT as well as their co-located municipalities. These collected and standardized local city prices can then be compared to Air Force prices and used to determine whether the Air Force on average overpays for ISWM services. A comparison between both the local municipalities and Air Force installations will further assist Air Force contracting organizations in determining whether or not the prices paid are fair and reasonable when compared to the Air Force average and when compared to the individual installations’ municipality.

C. RESEARCH QUESTIONS

The goal of this research is to answer the following questions:

1. Using AFICA pricing data, what is driving the price variation (unit price) across CONUS Air Force installations for solid waste disposal services?
2. Using municipality pricing data, how do municipality unit prices compare to Air Force unit prices?
3. Using local cost of living indices, do local consumer price indices account for the variation in prices paid for solid waste disposal services?

D. METHODOLOGY

This research used ISWM contract data from the Air Force Installation Contracting Agency (AFICA). AFICA provided us with the most recent Sub-Activity Management Plan (Sub-AMP) data which included number of bins, tons of solid waste, and the annual contract price of solid waste services at each Air Force installation. From those figures, we calculated a PPT ISWM cost of each Air Force Installation. In order to compare Air Force PPT costs, we surveyed a sample of municipalities co-located with the population of CONUS Air Force Installations. The results of this survey allowed us to determine municipality PPT costs. The standard rates provided by AFICA and cost data provided by local municipalities co-located with Air Force installations were used in this study. To effectively analyze ISWM contract price variances for solid waste disposal services between Air Force installations, and between Air Force installations and their surrounding local municipalities, we utilized hypothesis testing about the difference between two population means, as well as multivariate linear regression modelling to identify applicable cost drivers.

The first and most important model we applied to the dataset was a hypothesis test to estimate whether the difference between the two population means was statistically significant. In the hypothesis test, we determined the null hypothesis, or the current assumption, would state that there should be no difference between the population of Air Force and municipality PPT ISWM costs. Whereas, the alternative hypothesis, or the opposite of the assumption, would state that there is a difference between the populations of Air Force and municipality PPT ISWM costs and that the Air Force costs are higher. To

test this hypothesis, we utilized the normalized cost dataset, using the PPT mean of the Air Force sample and the PPT mean of the municipality sample as point estimators of the means of each sample's respective population. Following the development of the hypothesis, we established significance tests using three separate levels of significance to assess the potential of rejecting the null hypothesis when it may, in fact, be true.

To identify systematic patterns effecting price variation for ISWM contracted services, we used multivariate linear regression modelling of Air Force installation ISWM costs against several independent variables. We chose the following independent variables: state's Cost of Living Index, Consumer Price Index, County Average Weekly Wages, Air Force Base Population, County Population Density, Distance to Landfill, and a number of containers utilized. We decided these variables had the highest probability of explaining the differences in solid waste disposal prices across the U.S. Chapter III, Methodology, provides an in-depth look at the selection process for local municipalities and the application of statistical analysis and models.

E. BENEFITS OF RESEARCH

The goal of our research is to provide findings and recommendations that could be used by contracting officers as tools to optimize Air Force cost savings and efficiencies in ISWM procurement. Understanding these differences in ISWM costs across Air Force installations may help the Department of Defense (DoD) reduce service contract costs and allow reallocation of funds to better support the warfighter. The research will also aid in determining whether or not ISWM services are provided to the government at best value.

F. LIMITATIONS OF RESEARCH

There are no databases that provide local government pricing information for ISWM services contracts. As a result, we had to request pricing information from each local municipality individually. The number of samples available for analysis was dependent on each city's cooperation and willingness to aid in our research. As you will see in Chapter IV, Findings, this proved to be more of an issue than originally anticipated. Once we collected ISWM data through AFICA and municipality responses, we identified another major limitation of our research, finding that the quantitative data relating to ISWM

unit costs between the Air Force and municipalities were in the form of separate units of measure. Both the Air Force and municipality raw data would have to be normalized to compare apples-to-apples unit cost, specifically PPT. Chapter III, Methodology, will further explain how we converted and normalized the data.

G. ORGANIZATION OF REPORT

In this report, we conduct a Literature Review that provides a better understanding of the evolution of purchasing to supply management, which then evolved to strategic sourcing and category management. We also examine previous studies on DoD ISWM service contracts and the contribution of our work to this literature. Next, the report reviews the methodology utilized in our research, including the process used to collect ISWM cost data from Air Force installations and local municipalities. The methodology chapter discusses why and how we normalized the collected data to make a direct comparison between local municipalities and Air Force installations. Additionally, we explain the hypothesis test and regression analysis performed by our team. Following methodology, we provide a detailed report of our findings. The findings include qualitative analysis based on responses from local municipalities, and provide quantitative results and analysis of our hypothesis test and regression models. Finally, the last chapter provides our conclusions and recommendations, as well as areas requiring further research.

H. SUMMARY

In this chapter, we provided a brief introduction to the background of ISWM service contracts, the purpose of our research, focused research questions, methodology, benefits of the research, limitations of the research, and organization of our report. The next chapter provides a literature review, which includes a synopsis of previous ISWM contract studies and the evolution of the procurement process.

II. LITERATURE REVIEW

A. INTRODUCTION

The purpose of this research is to compare Integrated Solid Waste Management (ISWM) price differences between Air Force installations, local municipalities, and their associated cost drivers. The comparison of price differences and the identification of cost drivers are activities involved in supply management, strategic sourcing, and category management. Thus, our literature review begins with a discussion of the evolution of purchasing to supply management, then to strategic sourcing and category management in the federal government's acquisition process of services. Additionally, we examine previous studies conducted on ISWM service.

B. PURCHASING AND SUPPLY MANAGEMENT

Up until 2002, purchasing and procurement of services in the Department of Defense (DoD) was historically a "passive, administrative, and reactive process" with a transaction-oriented outlook (Rendon, 2005, p. 8). This is the norm until "Sections 801 through 803 of the National Defense Authorization Act (NDAA) for Fiscal Year 2002, Pub. L. 107-107, establishe[d] a series of requirements impacting the acquisition of services" (Aldridge, 2002). In accordance with section 801(d) of NDAA FY 2002, the "Review of Department of Defense (DoD) Acquisition of Services" document was issued by Under Secretary of Defense for Acquisition, Technology and Logistics (USD AT&L) on May 2002, with guidance on the new review structure and the process for the acquisition of services (Aldridge, 2002). Edward Aldridge Jr., then Under Secretary of Defense for AT&L, wrote in the "Acquisition of Services" memorandum:

Through this guidance and other forthcoming guidance, it is my intent to move DoD to a more strategic and integrated approach to the acquisition of services that recognizes the importance of service acquisitions to the Department and the need to treat acquisition of services as seriously as we do the acquisition of hardware (2002).

The changes to acquisition procedures, policies, and practices, in addition to resource constraints, pushed the DoD to implement and adopt the transformation of the

“procurement process to reflect an integrated strategic supply management perspective” which the commercial sector had been experiencing with great success (Rendon, 2005, pp. 13–14). Supply management is a “proactive, strategic, [and] boundary-spanning function” with a strategic-oriented outlook to purchasing and procurement (Rendon, 2005, p.8). Supply management “embraces the other supply chain management function of material management, logistics, and physical distribution” (Rendon, 2005, p. 8). According to Rendon (2005), the concept of supply management focuses on:

- supply management’s strategic contributions to organizational objectives[.]
- [being] integrated with selected suppliers, working as one team toward mutual goals[.]
- value-adding outputs such as quality, total ownership cost, time to market, technology, and continuity of supply[, and]
- the [breakdown] of functional walls with the use of cross-functional teams, the development and management of supply chains and supply alliances, the use of electronic procurement systems, and the adoption of strategic sourcing approaches. (p. 9)

C. STRATEGIC SOURCING

Strategic sourcing is a business procurement process that top leading companies utilize to capitalize on economies of scale and leverage their buying power. As the saying goes, a dollar saved in purchasing is a dollar earned in profit. Rendon (2005) concurs that “[s]trategic sourcing is probably the most significant aspect characterizing an organization’s transformation to supply management” (p. 9). Commodity sourcing is an element of strategic sourcing where:

“Commodities” is used solely to refer to categories or groups of services or supplies. The success of commodity strategy is based on maximizing the cost reduction advantages of leveraging combined buying power for volume discounts, using market experts to formulate a sourcing strategy, and

finally, forming strong relationships with preferred suppliers. (Rendon, 2005, p. 9)

In 2004, DoD established pilot programs in support of the DoD-Wide Services Sourcing (DWSS) Program implemented by the Defense Procurement and Acquisition Policy (DPAP) Office as part of DoD's procurement transformation "to reflect an integrated strategic supply management perspective" (Rendon, 2005, p.14). The DoD hopes to achieve the following objectives through the DWSS Program:

- Develop department-wide cross-functional acquisition strategies in order to improve total cost ownership for acquired services,
- Address improvements in meeting socio-economic goals through the use of strategic sourcing,
- Leverage commercial best practices in order to streamline and standardize DoD acquisition business processes, and
- Improve overall skills of DoD acquisition staff through the utilization of commercial tools and processes (Rendon, 2005, p. 14)

As noted by DPAP (2018), who is responsible for all pricing, contracting, and procurement policy matters in DoD:

Strategic Sourcing is a key practice within the Category Management framework. It is the collaborative and structured process of critically analyzing an organization's spending and using this information to make business decisions. Strategic Sourcing involves the establishment or modification of acquisition vehicles to better address Federal Government procurement needs and more effectively leverage spend, market position, market knowledge (e.g., price benchmarks), and capabilities (e.g., IT integration) in contract terms and conditions. This process helps agencies optimize performance, minimize price, increase achievement of socio-economic acquisition goals, evaluate total life cycle management costs, improve vendor access to business opportunities, and otherwise increase the value of each dollar spent.

Strategic sourcing became a government-wide initiative when the Office of Management and Budget (OMB) produced a 2005 memorandum instructing all federal

agencies to control spending by implementing strategic sourcing for reasonable contracts (U.S. Government Accountability Office [GAO], 2014, p. 5). According to GSA (n.d.), to support OMB's mandate, GSA and U.S. Department of Treasury partnered up and launched the Federal Sourcing Initiative (FSSI). According to GAO (2014), the Office of Federal Procurement Policy (OFPP) is overall responsible for FSSI while the Category Management Leadership Council (CMLC) governs the FSSI. The FSSI Program Management Office, located within the GSA, provides regular status reports to OFPP (GAO, 2014). As noted by GSA (2018b), the primary goals of FSSI are to:

- Strategically source across federal agencies;
- Establish mechanisms to increase total cost savings, value, and socioeconomic participation;
- Collaborate with industry to develop optimal solutions;
- Share best practices; and
- Create a strategic sourcing community of practice.

One of the current FSSI commodity solutions that support our research is the Building Maintenance and Operations (BMO) vehicle which provides “comprehensive and flexible solution covering all high demand [facility-related] services” (GSA, 2018a). BMO and BMO SB “is an open market, multiple-award, indefinite delivery, indefinite quantity (MA-IDIQ), government-wide contract vehicle supporting the strategic sourcing initiative to reduce costs and drive efficient purchasing by federal agencies” (GSA, 2018a). There are 16 service categories included in the BMO and Building Maintenance and Operations Small Business (BMO SB) commodity solution. The service category we were interested in and proved beneficial to our research was the Waste Management and Recycling Services category.

BMO and BMO SB utilize a zonal approach to create reasonable size regions to encourage small businesses to participate in a full and open competition solicitation (GSA, 2018a). As shown in Figure 1, Phase I and II zones have contracts in place with small

businesses, while Phase III represents the proposed future zones for BMO/BMO SB. One of the requirements for all awarded contractors is the capability to provide coverage for the entirety of the zone(s) they are awarded (GSA, 2017). The difference between Phase I/Zone1I (\$15B) and Phase II/Zones 2–6 (\$27B) is the maximum dollar ceiling for each task order (GSA, 2017).

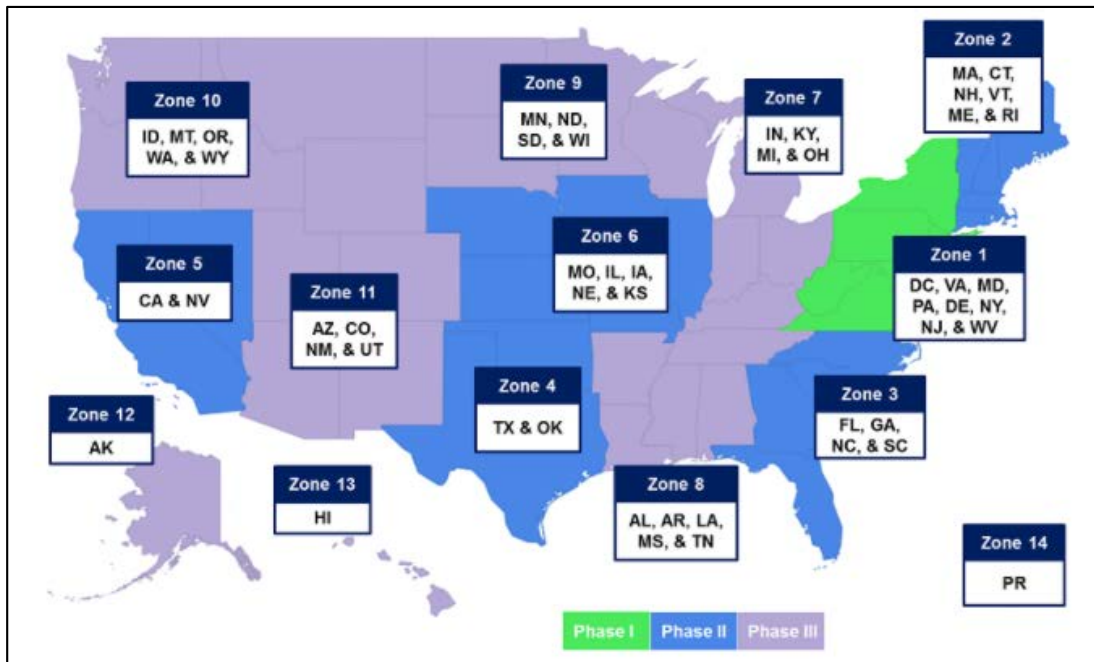


Figure 1. Current and Future Phases and Zones for BMO/BMO SB. Source: GSA (2018a).

D. CATEGORY MANAGEMENT

Category Management is a business procurement strategy where companies will buy more effectively and save significant sums of money by purchasing like items in a single transaction or contract (Webb, 2015). Fortune 500 companies and the United Kingdom's government have been using this acquisition approach since it leads to smarter decisions, better purchasing options, and saves dollars (Rung and Sharpe, 2015; Sharpe, 2014).

Category management became a top priority for DoD in December 2014 when the Office of Federal Procurement Policy (OFPP) issued the “Transforming the Marketplace: Simplifying Federal Procurement to Improve Performance, Drive Innovation, and Increase Savings” memorandum to federal agencies. This strategy is part of OFPP’s continuous effort to “further streamline and manage the Federal Government’s vast goods and services more like a single enterprise—leading to big savings, better efficiencies, and improved performance” (Rung, 2016). OFPP, in the OMB, is responsible for providing “overall direction for government-wide procurement policies, regulations and procedures and to promote economy, efficiency, and effectiveness in the acquisition processes” (Office of Management and Budget [OMB], n.d.). As noted by DPAP (2018):

Category management is an approach the Federal Government is applying to buy smarter and more like a single enterprise. Category management enables the government to eliminate redundancies, increase efficiency, and deliver more value and savings from the government’s acquisition programs. It involves: Identifying core areas of spend; Collectively developing heightened levels of expertise; Leveraging shared best practices; and, Providing acquisition, supply and demand management solutions.

The governance structure for category management are Category Management Leadership Council (CMLC), Category Managers, Category Team, Sub-Category Team, and finally the Commodity Team. The CMLC, chaired by OFPP administrator, is the governing board for category management initiatives and provides government-wide directions on category management strategy and initiatives (Category Management, n.d.; Gibson and Field, 2018). The Gibson and Field (2018) powerpoint presentation lists the role and responsibilities of the different teams,

- The Category Managers are “government experts in the 10 categories—[and are responsible for] develop[ing] the government-wide strategy to drive improved performance and act as change agents for the category” (slide 3).
- The Category Team is “responsible for the development and execution of category strategies for a specific category (e.g., IT)” (slide 3).

- The Sub-Category Team is “responsible for the development and execution of category-specific sub-strategies (e.g., IT software within the IT category)” (slide 3).
- The Commodity Team is the “traditional strategic sourcing working group formed when the category management process identifies the need for a new acquisition solution” (slide 3).

E. PREVIOUS STUDIES

The purpose of this research is to compare ISWM price differences between Air Force installations, local municipalities, and their associated cost drivers. Our focus is to study the cost drivers that affect the price Air Force installations pay, compared to the price co-located municipalities pay, for ISWM services. Past studies focused on the Air Force’s internal procurement process and did not look into how other agencies procure ISWM services.

As part of the Category Management pilot project effort, the Air Force produced a Category Intelligence Report (CIR) for ISWM. The CIR is a “detailed analysis that includes a category overview, data analysis, market analysis, competitive analysis (gap analysis) and cost improvement recommendation” (Brady et al., 2016, p.6). To “build actionable business intelligence,” the pilot team first reviews the Air Force’s ISWM requirements, then conducted data analysis, market analysis, and competitive analysis, and finally provides recommendations. The CIR describes the different sections of the report and what was the purpose of that section:

- ISWM Requirements–“Was developed by ISWM Subject Matter Experts (SMEs) and describes the Air Force Common Output Level Standards (AF COLS) for ISWM services and the associated Sub-Activity Management Plan (Sub-AMP) data instrumental in understanding the Air Force management of ISWM” (Brady et al., 2016, p. 8).
- “Data analysis–This section was build using a combination of Air Force contracting data (from systems like Contracting Business Intelligence

Service (CBIS) and the Sub-AMP functional data. This section identifies the total Air Force spend on ISWM to include insights into the Air Force's support of socio-economic categories (e.g., Small Business, 8A, Source America, etc.)" (Brady et al., 2016, p. 9).

- "Market analysis—This section was developed using industry research tools such as IBISWorld, interviews with ISWM service providers, interviews with similar buyers of ISWM services, and interviews with Air Force installations. In this section, best practices and technologies are identified that may be helpful in reducing the Air Force's ISWM costs (Brady et al., 2016, p. 9).
- "Competitive analysis—This section was developed using the Air Force's Sub-AMP reporting data and utilized key market cost driver information to establish Air Force benchmarks for costs per ton. In addition, the benchmarks were used to perform a comparative analysis and to identify cost performance gaps. Gaps were sorted largest to smallest specifically to identify opportunities where cost savings measures can be taken" (Brady et al., 2016, p. 9).
- "Recommendations—This section outlines the pilot team's recommendations for the Air Force to take action to begin to close the cost performance gaps. These recommendations were developed through several brainstorming sessions with the AFCEC SMEs and leveraged information learned throughout the process" (Brady et al., 2016, pp. 9).

The CIR focused on Air Force and market industry to identify cost performance gaps and ways to reduce the Air Force's ISWM costs, but it did not investigate whether or not the Air Force installations and their local municipalities are paying the same price for ISWM services. Our research focuses on Air Force installations and their local municipalities to determine whether the Air Force is paying below, same, or above the local municipal ISWM service cost. The goal of the research is to identify the price drivers

causing the difference and provide recommendations to improve ISWM procurement processes.

The waste management literature also includes studies on whether or not the Federal Acquisition Regulation (FAR), specifically FAR part 6, and performance affects the price. The FAR governs the federal government's acquisition process and FAR part 6, Competition Requirement, lists all the rules and regulations applicable for the different types of competition available in the procurement process. Apte, Landale, Rendon, and Salmerón conducted a study:

On the procurement of integrated solid waste management (ISWM) within the Air Force to identify the relationship between service-related price drivers, contract-related price drivers, price, and contractor performance...focus is to study the effect that price drivers (both service and contract) have on contract price and contractor performance. (Apte, Landale, Rendon, and Salmerón, 2017, p. 2)

This study tested seven hypotheses, using sequential multiple regression, the Wilcoxon Rank Sum Test, and ordered logistic regression. Their findings indicate that the number of containers has the most significant effect on price while small business set-asides did not significantly affect the Price Per Ton or Price Per Container. Small business set-asides will not matter since the award of ISWM services are “subject to the lowest cost technically acceptable source selection method, where price is the main determinant of award” (Apte, Landale, Rendon, and Salmerón, 2017, p. 23). This research helped dispel the misconception that small business set-asides are the reason DoD pay more for services and let us focus on other price drivers, such as distance to landfill, consumer price index, Air Force base population, etc.

Finally, Arruda and Clark (2017) conducted a study on category management of common, recurring service contracts, e.g., ISWM, to demonstrate how category management would result in cost savings with a focus on strategic sourcing. The study explored available sources and method (clustering continuum, commercial business mapping software, etc.) to determine the best approach to the acquisition of ISWM services. They developed the Arruda-Clark-Fuchs (ACF) methodology “to account for all the complexities of a given service requirement” as the regular clustering methodology was

not able to account “the inherently complex nature of services” (Arruda and Clark, 2017, p. 37). The ACF method consists of four steps, which will help the acquisition teams strategically source ISWM services. Arruda and Clark (2017) describe the four steps as:

1. Identify DoD requiring activities for a given service
2. Identify cost-driver market intelligence relevant to developing clusters
3. Integrate cost-driver market intelligence into commercial mapping software
4. Use cost-driver market intelligence to determine optimal cluster size. (p. 21)

Arruda and Clark’s research goal was to provide “versatile, commercial-off-the-shelf software that provides the capability to map DoD requiring activities and cluster them [...] the intent was to provide a flexible solution to category management teams that offered the benefit of continuous improvement through software upgrades[...]” (Arruda and Clark, 2017, p. 37). Arruda and Clark (2017) attempted to use ISWM services to validate their ACF methodology, focusing within the Los Angeles area, but the research was inclusive since they did not have sufficient data to quantify possible savings.

F. SUMMARY

In this chapter, we presented a literature review on the evolution of purchasing to supply management, then to strategic sourcing and category management, and previous studies of ISWM. Understanding the evolution of DoD’s acquisition process will provide the foundation for what the federal government is striving toward concerning the acquisition of services, as well as examining previous studies, will show how our research differs. As previously stated, the purpose of this research is to compare ISWM price differences between Air Force installations, local municipalities, and their associated cost drivers. The following chapter is a discussion of our research methodology.

III. METHODOLOGY

A. INTRODUCTION

Across all Air Force installations in the Continental United States (CONUS), there appear to be large differences in prices paid for Integrated Solid Waste Management (ISWM) contracted services. There is little understanding as to why this variation occurs. To identify systematic patterns, we use regression analysis on Air Force installations ISWM costs against several independent variables. We chose the following independent variables: state's cost of living index, consumer price index, county average weekly wages, Air Force base population, county population density, distance to landfill, and a number of containers utilized. We decided these variables had the highest probability of explaining the differences in solid waste disposal prices across the U.S.

With the large variation across Air Force installations, there is concern that variation may also exist between the installations and local municipalities. Identifying variation between local municipalities and Air Force installations will aid us in identifying if prices paid by the Air Force are fair and reasonable. The prices paid for ISWM services by a local municipality, and the adjacent Air Force base, should be the same, considering they have similar market conditions. Both local municipalities and Air Force bases are government organizations with similar requirements based on the size of the organizations. Identified price variations will provide a better understanding of why some installations are paying higher prices than others. We analyzed ISWM contract price variances for solid waste disposal services between Air Force installations and their surrounding local municipalities through t-tests of the difference in population mean between the two.

We also felt it was beneficial to capture qualitative data on how municipalities contract and manage ISWM services to understand industry standards, and to better identify trends in the local government. A thorough understanding of contracting methods and cost structures, utilized by local municipalities, could assist us and provide the Air Force with additional recommendations to improve ISWM contracting.

B. COST DATA COLLECTION

We contacted the Air Force Installation Contracting Agency (AFICA) to inquire if necessary pricing information on ISWM service contracts was available. Fortunately, AFICA already collects data on installation contracts from each Air Force base. AFICA provided us with the most recent Sub-Activity Management Plan (Sub-AMP) data which included number of bins, tons of solid waste, and the annual contract price of solid waste services at each installation. From those figures, we calculated the Price Per Ton (PPT) at each Air Force Installation.

Following the collection of relevant Air Force pricing data, the next step was to gather pricing data from local municipalities. We chose local municipalities based on two parameters: the city must be within 30 miles of the Air Force installation, and must be a part of the same county. These parameters are necessary to ensure both the Air Force installation and local municipality have the same market conditions. It also ensures both the installation and municipality have the capability of using the same commercial vendors for solid waste disposal.

Before contacting the selected municipalities, we contacted the City of Monterey Public Works Office to gain further insight into how city governments contract solid waste disposal. We met with the Sustainability Coordinator for the City of Monterey and gained insight into the contracting vehicles used by city governments. From that meeting, we learned there are four general ways that city governments contract solid waste services. These four ways include franchise agreements, city-owned solid waste haulers, three to five-year term contracts, and finally, open market with operating permits. Also, we discovered that the Naval Postgraduate School contracts solid waste services on a Firm Fixed Price (FFP), with a surcharge fee, through the City of Monterey. Finally, the City of Monterey informed us that it bases its rates on collection bin size and frequency of collections per week. As a result of this meeting, the team was able to create five standardized questions to ask selected municipalities. The five questions are as follows:

1. What type of contract does your city use for solid waste disposal?
2. What are the negotiated rates for solid waste collection at city-owned buildings (e.g., per bin size and frequency of collection)?

3. What are your published prices for commercial business rates for solid waste collection (e.g., per bin size and frequency of collection)?
4. Is the local Air Force installation's solid waste contract managed by your city? What are the Air Force base's rates? Are the Air Force base's rates the same as the negotiated rates for the city? What is the surcharge rate applied to the Air Force for the city to manage its solid waste contract?
5. Are there standing city regulations requiring the local Air Force installation utilize the same hauler that is already contracted with the city?

These qualitative responses are important to the research in the following capacity. The responses from question (1) will help to understand the solid waste contracting vehicles used by city governments, identify the most common methods used, and see if there are best practices that the Air Force can leverage. The responses from question (2) and (3) will provide us with the prices paid by local municipalities that will aid in data analysis and comparisons with Air Force installations. The responses from question (4) will aid us in identifying if the city manages the contract similar to the City of Monterey, positing that prices should be identical. This question will also provide a potential reason for variation in prices due to additional surcharges. Finally, question (5) will help to rule out any regulations that might prevent Air Force installations from contracting with the same solid waste hauler utilized by the city.

Once we established these questions, we submitted a standardized email to the 63 municipalities, see Appendix A. The team decided it was best first to contact each city's government office by phone and identify the Solid Waste Contract Administrator, introduce ourselves, and briefly explain our study in accordance with the standardized format. Following our initial introduction over the phone, we then followed up with the standardized email.

C. NORMALIZATION OF COST DATA

Once we collected ISWM data through AFICA and municipality responses, we found that the quantitative data relating to ISWM unit costs between the Air Force and municipalities were in the form of separate units of measure. AFICA tracked Air Force ISWM costs through total contract costs per installation. These costs were typically annualized by straight line costing for a contract which ranged from three to five years per

installation. As Air Force ISWM costs were typically recorded as the total cost of a contract per year, this created difficulties when trying to normalize and compare the total cost of contract from a respective municipality. The ISWM data received from municipalities were not in a total cost format or annualized terms. Instead, municipality data was in unit cost, as in price per cubic yard and frequency of collection, which corresponded with the size of waste container offered by either the municipality or solid waste contracted company.

For us to compare the cost of solid waste for the Air Force in relation to the municipality for which it was co-located, we concluded that costs would have to be converted to a unit cost, specifically PPT. Both the Air Force and municipality raw data would have to be normalized to compare apples-to-apples unit costs.

We found that Air Force raw data provided by AFICA, specifically the total annualized contract price of each installation, could be divided by the annual number of tons of solid waste disposed. This would give the team a PPT unit of measure with which to compare to municipality unit costs. However, municipality unit costs were provided as cost per cubic yard, where cubic yard containers came in sizes: two cubic yards, four cubic yards, six cubic yards, and eight cubic yards. Additionally, the prices of each size container provided by the municipality or solid waste contracted company varied by the frequency of scheduled solid waste collection per week. Standard frequency of collection provided by the municipality or solid waste contracted company typically ranged from one to five times per week. Table 1 is an example of municipality solid waste unit costs. The price data format provided by Albuquerque, NM was typical of price data received by other municipalities and is only included as an example of the price sheets collected.

Table 1. Municipality Solid Waste Price Sheet.

Albuquerque, NM		1X	2X	3X	4X	5X	6X	7X
	2yd	\$56.52	\$107.68	\$158.84	\$210.01	\$261.17	\$312.33	N/A
	4yd	\$83.99	\$161.84	\$239.70	\$317.55	\$395.41	\$473.26	N/A
	6yd	\$112.92	\$217.47	\$322.01	\$426.56	\$531.10	\$635.65	N/A
	8yd	\$145.85	\$277.08	\$408.32	\$539.56	\$670.79	\$802.03	N/A

Normalizing municipality cost data to Air Force costs of PPT created two separate challenges. The first and most salient challenge was converting municipality costs of price per cubic yards, a measure of volume, into Air Force costs of PPT, which is a measure of weight. To convert cubic yards to tons, we had to find data relating to the average weight of one cubic yard of solid waste.

The United States Environmental Protection Agency's (EPA) Office of Resource Conservation and Recovery published standard volume-to-weight conversion factors for use by state and local governments in comparing recycling efforts between municipalities, regions, and states ((Environmental Protection Agency [EPA], n.d.). These conversion factors included the standard weight per cubic yard of un-compacted, residential, institutional, and commercial solid waste, with an estimated weight of 300 to 600 pounds (EPA, n.d.). Using this estimated range the team chose to use the more conservative estimate, in relation to our hypothesis, of 300 pounds per cubic yard of un-compacted solid waste as opposed to 600 pounds.

After we converted volume based municipal price data into weight-based price data, we compared Air Force solid waste costs with municipal solid waste costs. Though unit costs were in the same unit of measure, the team had to decide what frequency of municipal container collection per week they would choose to convert. Using the same conservative principals in choosing 300 pounds per cubic yard, the team chose the highest cost per unit according to the frequency. On average, the cost of emptying solid waste was the highest per unit at the frequency of once per week. For instance, additional collections per week would inevitably raise the total cost of emptying each cubic yard container; however, subsequent collections per week lowered the cost of each collection at a marginally steep learning curve. Therefore, the marginal cost continually diminished as the frequency of collection increased.

After converting the municipality price data to frequencies of once per week, the team found that the majority of municipality responses contained price data for a two cubic yard container, emptied once per week, which provided the largest data set from the sample of which to compare to Air Force unit price. The municipality responses that failed to provide price data for two cubic yard containers at a frequency of once per week, or prices

that were in the form of other units of measure, were excluded from the sample data set in the comparison of Air Force and municipality costs.

With municipality price data converted to PPT, we compared PPT of each Air Force installation with their corresponding municipality. The finalization of data normalization allowed for us to compare 20 paired observations of Air Force PPT vice municipality PPT. Table 2 shows the normalized data set comparing PPT.

Table 2. Converted Air Force and Municipality Price Per Ton (PPT).

Observation	Element Names	Variables	
		AF Price per Ton (PPT)	Municipality Converted PPT
1	Davis-Monthan AFB	\$ 78.19	\$ 316.67
2	Patrick AFB	\$ 298.83	\$ 116.47
3	Peterson AFB	\$ 288.59	\$ 73.77
4	Schriever AFB	\$ 284.62	\$ 73.77
5	USAFA	\$ 192.09	\$ 73.77
6	Luke AFB	\$ 199.37	\$ 116.10
7	Malmstrom AFB	\$ 213.88	\$ 136.30
8	Kirtland AFB	\$ 448.26	\$ 188.40
9	Dyess AFB	\$ 41.52	\$ 67.07
10	Goodfellow AFB	\$ 429.80	\$ 265.13
11	F E Warren AFB	\$ 62.33	\$ 385.33
12	Columbus AFB	\$ 855.95	\$ 166.67
13	Whiteman AFB	\$ 125.87	\$ 200.00
14	Buckley AFB	\$ 91.41	\$ 140.00
15	McConnell AFB	\$ 270.36	\$ 120.00
16	March AFB	\$ 165.16	\$ 306.87
17	NAS JRB Ft. Worth	\$ 55.74	\$ 138.27
18	Fairchild AFB	\$ 187.46	\$ 611.87
19	Homestead ARB	\$ 359.25	\$ 244.27
20	Edwards AFB	\$ 75.83	\$ 311.00

After normalizing the cost data set, we establish various statistical point estimates and measures of variability for both Air Force and municipal cost data, specifically the mean, median, mode, range, variance, standard deviation, and coefficient of variation. This statistical analysis allowed the application of various models to the cost data in an attempt to develop an analysis and understanding of the variance in Air Force and municipality solid waste costs.

D. HYPOTHESIS TEST AND MODELING

The first and most important model we applied to the dataset was a hypothesis test to estimate whether the difference between the two population means is statistically significant. Our research is concerned with the population of Air Force installations within CONUS, and the PPT ISWM cost of each installation. The second population is the municipality co-located with its respective Air Force installation and their solid waste management cost of PPT. In the hypothesis test, we determined the null hypothesis, or the current assumption, would state that there should be no difference between the population of Air Force and municipality PPT ISWM costs. Whereas, the alternative hypothesis, or the opposite of the assumption, would state that there is a difference between the population of Air Force and municipality PPT ISWM costs and that the Air Force costs are higher. The hypothesis could also be written as $H_0: M_1 - M_2 = 0$; $H_a: M_1 - M_2 \neq 0$; where M_1 is equal to the Air Force ISWM PPT population mean, and M_2 is equal to the municipality ISWM PPT population mean.

To test this hypothesis, we utilized the normalized cost dataset, using the mean of the Air Force sample and the mean of the municipality sample as point estimators of the means of each sample's respective population. Following the development of the hypothesis, we established significance tests using three separate levels of significance to assess the potential of rejecting the null hypothesis when it may, in fact, be true. To test the hypothesis, we would use the t-distribution as the test statistic to compare to the levels of significance, as the mean of both Air Force and municipality costs of PPT are unknown and our sample size, or n , being less than 30. Using Microsoft Excel's data analysis package, we computed the test statistic, specifically running the "t-Test: Two Sample Assuming Unequal Variances," analysis tool. Comparing the test statistic to the one-tailed critical value would allow us to determine if the null hypothesis could be rejected at each level of significance.

Following the primary hypothesis test, the next step would be to apply regression analysis to determine applicable cost drivers to the Air Force ISWM PPT. The cost drivers to be analyzed can be broken down into cost of living related independent variables such as the state cost of living index, consumer price index, and average weekly wage. Secondly,

population-based independent variables such as the Air Force base population and the county population density. Finally, cost drivers can be categorized as Air Force base number of containers, and the Air Force bases' distance to landfills. With the exception of the number of containers variable, which was derived from AFICA provided data, all other variables were available through open source government and private websites.

E. SUMMARY

In this chapter, we were able to hone in on the driving forces behind perceived price variations for the Air Force ISWM contracted services through the use of hypothesis testing and regression modelling. Comparing cost data provided by AFICA with cost data gathered and normalized from municipalities will allow us to determine if Air Force ISWM costs vary significantly from respective municipality ISWM costs. With normalized cost data, we can now feasibly compare ISWM unit costs of a sample of 20 paired observations with Air Force ISWM unit costs, using point estimators of the means of each sample's respective population. The results of this hypothesis test, as well as the analysis of ISWM cost drivers will help provide the basis for any ISWM procurement recommendations we make to Air Force contracting leaders.

IV. FINDINGS

A. QUALITATIVE RESULTS

1. Local Municipality Response Distribution

We contacted 69 cities across the continental United States that would be used to compare Integrated Solid Waste Management (ISWM) prices to adjacent Air Force bases. Each city was contacted multiple times by phone and email over the course of three months. By the end of the three months, 31 of the 69 cities responded to our inquiries, which equates to a 45% response rate.

The distribution of responses per region was high, with one exception. The southern and southwest regions have a response rate of 60% (19 of 32 bases). Midwestern states also had similar response rates, which equated to 64% (9 of 14 bases). The region with the biggest gap in responses, based on the concentration of Air Force bases, is the Northeast. The Northeastern states have a total of nine Air Force installations, and not one of them responded to inquiries. Despite three months of trying to get responses, we still came up with a 0% response rate. Figure 2 shows the response distribution and the red dots mark the cities that responded.



Figure 2. Distribution of Local Municipality Responses.

2. Qualitative Responses

There were three qualitative questions asked of each local municipality. The three questions were as follows:

1. What type of contract does your city use for solid waste disposal?
2. Is the local Air Force installation's solid waste contract managed by your city? What are the Air Force base's rates? Are the Air Force base's rates the same as the negotiated rates for the city? What is the surcharge rate applied to the Air Force for the city to manage its solid waste contract?
3. Are there standing city regulations requiring the local Air Force installation utilize the same hauler that is already contracted with the city?

The results from question (1) provided five different ways that local municipalities manage their solid waste disposal services. Three of the 31 cities, 10%, manage their ISWM with a 3-year term contract. Five of the 31 cities, 16%, manage their ISWM with a 5-year contract. Twelve of 31 cities, 39%, manage their ISWM services and do not contract out. Seven of 31 cities, 22%, manage their ISWM with a franchise agreement. Finally, four of 31, 13%, offer an open market for ISWM. The cities that allow an open market manage the solid waste vendors through an annual permit issued by the city. If there are too many

complaints against a vendor, and those complaints are validated by the city government, then the vendor's permit to operate within city limits are revoked.

The responses from question (2) showed that only one of 31 cities, 3%, managed or contracted ISWM services with the Air Force installations. The most surprising was the negative responses with cities who managed their own solid waste program. Only one local municipality which falls under this category services the Air Force installation, based on responses from the local governments. The other Air Force installations contract with an outside contractor.

The responses from question (3) showed zero city regulations requiring Air Force bases to use the same solid waste haulers as the local municipality. This is also evident from the responses received from question (2). Table 3 shows the responses to our three qualitative questions by the local municipality and their corresponding Air Force Base.

Table 3. Qualitative Local Municipality Responses.

AF Installation	What type of contract does your city use for solid waste disposal?	Is the local Air Force installation's solid waste contract managed by your city? What are the Air Force base's rates? Are the Air Force base's rates the same as the negotiated rates for the city? What is the surcharge rate applied to the Air Force for the city to manage its solid waste contract?	Are there standing city regulations requiring the local Air Force installation utilize the same hauler that is already contracted with the city?
Davis-Monthan AFB	3yr Term	No	No
Whiteman	3yr Term	No	No
Buckley AFB	3yr Term	No	No
Peterson AFB	5yr Term	No	No
Schriever AFB	5yr Term	No	No
USAFA	5yr Term	No	No
Dyess AFB	5yr Term	No	No
Goodfellow AFB	5yr Term	No	No
Vandenberg AFB CA	City Owned	No	No
Tyndall AFB	City Owned	No	No
Seymour Johnson AFB	City Owned	No	No
Malmstrom AFB	City Owned	No	No
Kirtland AFB	City Owned	No	No
F E Warren AFB	City Owned	No	No
Sheppard AFB	City Owned	No	No
Fairchild AFB	City Owned	No	No
Dobbins ARB	City Owned	No	No
Columbus AFB	City Owned	Yes	No
Homestead ARB	City Owned	No	No
Scott AFB	City Owned	No	No
Patrick AFB	Franchise Agreement	No	No
March AFB	Franchise Agreement	No	No
Offutt AFB	Franchise Agreement	No	No
NAS JRB Ft. Worth	Franchise Agreement	No	No
Edwards, AFB	Franchise Agreement	No	No
MacDill AFB	Franchise Agreement	No	No
Beale AFB	Franchise Agreement	No	No
Luke AFB	Open Market	No	No
McConnell AFB	Open Market	No	No
Keesler AFB	Open Market	No	No
Grissom	Open Market	No	No

B. QUANTITATIVE RESULTS

As outlined in Chapter III, there is large variation in prices paid for ISWM contracted services across all Air Force installations in CONUS. In an attempt to verify if these differences across installations are significant, we conducted a hypothesis t-test to see at what significance we could say the Air Force was paying more than their respective local municipality for ISWM costs. We were able to derive 20 paired observations from the original 31 responses from municipalities. Three of the 11 municipalities were not able

or unwilling to provide cost data due to proprietary relationships with their ISWM contractors. Five of the 11 municipalities could not provide sufficient ISWM cost data to allow us to normalize ISWM Price Per Ton (PPT). The remaining three municipalities did provide sufficient cost data, however, AFICA did not provide sufficient cost data for co-located Air Force installations. Through the analysis of the sample of 20 Air Force installations and their paired municipality, we found the averages of ISWM PPT costs, determining that the Air Force average was indeed higher than the municipality average. Table 4 shows the various measures of location and variability compared to the Air Force and municipalities.

Table 4. Comparison of Air Force and Municipality PPT Measures of Location and Variability.

<u>Measures of Location / Variability</u>	<u>AF Price per Ton (PPT)</u>	<u>City Price per Ton (PPT)</u>
Mean	236.23	202.59
Median	195.73	153.33
Mode	None	73.77
Range	814.44	544.80
Variance	36189.48	18211.09
Standard Deviation	190.24	134.95
Coefficient of Variation (%)	80.53	66.61

The sample mean of the 20 municipality and Air Force PPT observations were \$202.59 and \$239.23 respectively. Additionally, the coefficients of variation, which indicates how large the standard deviations are in relations to each mean, were 66.6% for municipalities and 80.5% for the Air Force. The magnitude of the coefficient of variation for each PPT shows the large variation of prices for each observation using a standard normal distribution. Though it might be tempting to compare the sample means of both Air Force and municipality, concluding that the Air Force PPT is on average higher than municipality PPT, a hypothesis test was required to see if these sample results could be applied to each respective population.

Our null hypothesis stated that there should be no difference in Air Force and municipality PPT. The alternate hypothesis stated that there is a difference between Air

Force and municipality PPT and that Air Force PPT is indeed higher. This hypothesis is written as $H_0: M1-M2 = 0$; $H_a: M1-M2 \neq 0$; where $M1$ is equal to the Air Force ISWM PPT population mean, and $M2$ is equal to the municipality ISWM PPT population mean. Using the 20 sample results, we ran the “t-Test: Two Sample Assuming Unequal Variances” analysis tool from Microsoft Excel’s data analysis package, using an alpha of 0.1 or 90% level of confidence. Table 5 shows the results of this t-test.

Table 5. t-Test: Two-Sample Assuming Unequal Variances ($\alpha=.1$).

	<i>AF \$Price per Ton (\$PPT)</i>	<i>City Converted \$PPT</i>
Mean	236.2258112	202.585
Variance	36189.47791	18211.08754
Observations	20	20
Hypothesized Mean Difference	0	
df	34	
t Stat	0.645029758	
P(T<=t) one-tail	0.261618448	
t Critical one-tail	1.306951587	
P(T<=t) two-tail	0.523236896	
t Critical two-tail	1.690924255	

Using the critical value approach, we compared the “T-stat” value of 0.6450 with the “t critical one-tail” value of 1.3069. As the “t critical one-tail” value is greater than the “t Stat” value, the null hypothesis cannot be rejected at the 90% level of significance. Stated alternately, we cannot say that nine out of 10 times there would be a difference between the means. We conducted subsequent hypothesis tests at lower levels of confidence, and it was not until a test at the 70% level of confidence, did the t-test produce a result where the null hypothesis could be rejected. Table 6 shows the results of the t-test using an alpha of 0.3, or 70% level of confidence.

Table 6. t-Test: Two-Sample Assuming Unequal Variances ($\alpha=.3$).

	<i>AF \$Price per Ton (\$PPT)</i>	<i>City Converted \$PPT</i>
Mean	236.2258112	202.585
Variance	36189.47791	18211.08754
Observations	20	20
Hypothesized Mean Difference	0	
df	34	
t Stat	0.645029758	
P(T<=t) one-tail	0.261618448	
t Critical one-tail	0.529353194	
P(T<=t) two-tail	0.523236896	
t Critical two-tail	1.052484878	

It is generally accepted that when evaluating the results of a hypothesis test with an alpha greater than 0.1, or lower than 90% level of confidence, it is non-standard to reject a null hypothesis with such a low level of certainty. Alternatively, to reject the null hypothesis would mean a 30% chance of us committing a type I error or rejecting the null hypothesis when it is in fact true. Combining this practice and the fact that we gathered only a sample of 20 observations, we could not conclude that on average, the Air Force was paying a higher PPT than their co-located municipality.

After gathering the findings of our original hypothesis test, we conducted sensitivity analysis to determine if the volume-to-weight conversion factors used in calculating the municipality PPT had a significant effect on the municipality PPT average. We used the non-conservative upper estimate of 600 pounds for the standard weight per cubic yard of un-compacted, residential, institutional, and commercial solid waste to determine municipal PPT. Replacing the estimate of 300 pounds with 600 pounds had a significant effect on the municipality PPT average, inevitably halving the original sample mean of \$202.59 to \$101.29. We ran a t-test using the new municipality sample mean and determined that using a non-conservative volume-to-weight conversion factor of 600 pounds, we could reject the null hypothesis with a 99% level of confidence. Table 7 shows the results of this test.

Table 7. Sensitivity Analysis.

	<i>AF \$Price per Ton (\$PPT)</i>	<i>City Converted \$PPT</i>
Mean	236.2258112	101.2925
Variance	36189.47791	4552.771885
Observations	20	20
Hypothesized Mean Difference	0	
df	24	
t Stat	2.989590276	
P(T<=t) one-tail	0.003180527	
t Critical one-tail	1.317835934	
P(T<=t) two-tail	0.006361053	
t Critical two-tail	1.71088208	

Though we could not conclude that Air Force costs were higher on average using conservative volume-to-weight conversion factors, we were able to compare individual PPT variances between each observed Air Force and municipality dataset. We compared individual price variances in an attempt to identify outliers of any paired dataset. Figure 3 shows a graphical comparison of PPT for each Air Force installation and local municipality paired dataset.

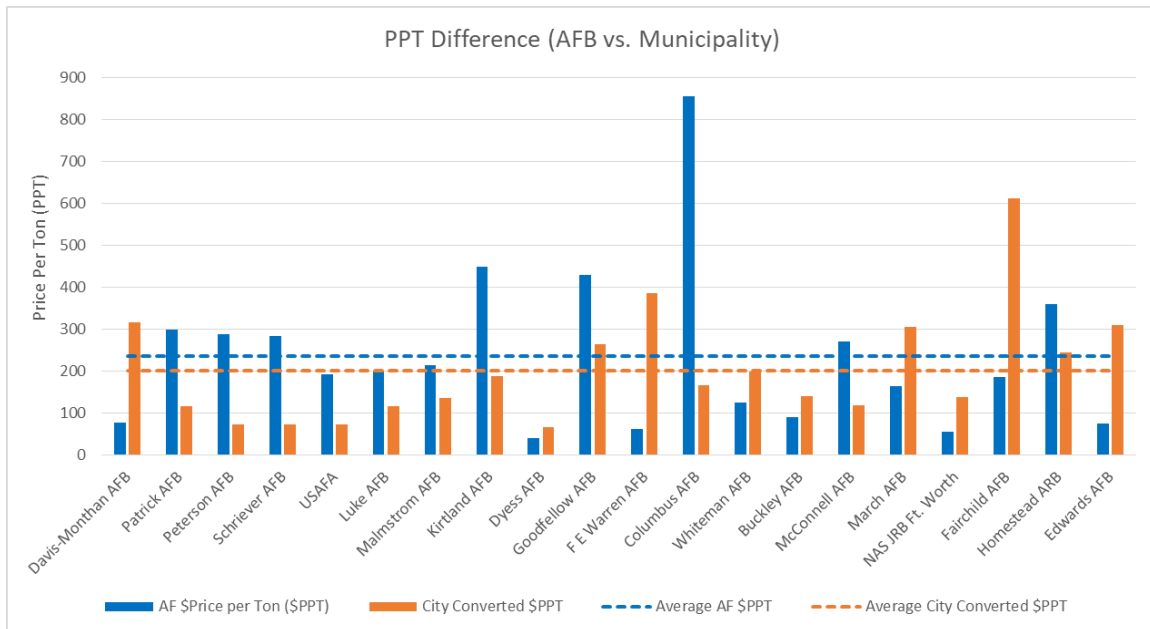


Figure 3. Comparison of Paired Air Force and Municipality PPT.

Of the 20 observations, we found that the Air Force PPT was higher than municipality PPT 11 times, 55%. Seven of the 11 times, 63%, the Air Force PPT was over twice that of the municipality PPT. The highest Air Force PPT and coincidentally the greatest disparity between Air Force and municipality costs occur with Columbus Air Force Base (AFB) and the city of Columbus, Mississippi, at a PPT of \$855.95 and \$166.67, respectively. This difference is significant as Columbus AFB PPT is over five times that of the city of Columbus. The Air Force installations with over twice the PPT costs of their local municipality are:

- Patrick Air Force Base
- Peterson Air Force Base
- Schriever Air Force Base
- The United States Air Force Academy
- Kirtland Air Force Base
- Columbus Air Force Base
- McConnell Air Force Base

Of the nine times the municipality PPT was higher than the Air Force PPT, the municipality PPT was over twice that of the Air Force PPT a total of five times, 55%. The highest municipality PPT in the sample was Spokane, Washington at \$611.87, over three times the PPT of Fairchild AFB. However, the greatest disparity between municipality and Air Force costs, when the municipality PPT is greater than the Air Force PPT, was in the city of Cheyenne, Wyoming and F.E. Warren AFB, at a PPT of \$385.33 and \$62.33, respectively. This variance is significant as F.E. Warren AFB PPT is less than one-sixth that of the city of Cheyenne. The Air Force installations with less than half the PPT costs of their local municipality are:

- Davis-Monthan Air Force Base
- F.E. Warren Air Force Base

- Naval Air Station Joint Reserve Base Fort Worth
- Fairchild Air Force Base
- Edwards Air Force Base

C. ANALYSIS OF COST DRIVERS

Following the analysis of individual differences in each paired case, we conducted simple linear regression models, comparing potentially applicable cost driver independent variables, as described in chapter III, to the Air Force ISWM PPT dependent variable. These cost drivers were: state cost of living index, consumer price index, county average weekly wage, Air Force base population, county population density, Air Force base number of containers, and Air Force base distance to landfill. These seven independent variables were individually compared to the Air Force ISWM PPT to determine the overall significance, or F-test, and secondly the coefficient of determination, or r^2 , to determine the regression relationship between the independent and dependent variables. What about the individual coefficients on the independent variables?

Using an alpha of 0.2, we first determined which independent variables or cost drivers were significant using Microsoft Excel's regression data analysis tool. We found that of the seven cost drivers, five of the seven were insignificant. These five insignificant independent variables were: state cost of living index, consumer price index, county average weekly wage, Air Force Base population, and county population density. We determined that two of the seven cost drivers were significant, the independent variable of Air Force Base number of containers and Air Force Base distance to landfill.

The cost driver of Air Force Base distance to landfill was the most significant independent variable, producing a significance F-test of 0.1224. The coefficient of determination was 0.0510, meaning that the regression relationship is present yet weak, where 5.1% of the variability in the Air Force ISWM PPT can be explained by the linear relationship between Air Force Base distance to landfill and Air Force ISWM PPT. Table 8 shows the regression analysis tool's summary output of Air Force Base distance to landfill independent variable and Air Force ISWM PPT dependent variable. Figure 4 shows

a scatter diagram which fits a linear trendline showing the estimated regression equation of Air Force Base distance to landfill independent variable and Air Force ISWM PPT dependent variable.

Table 8. Regression Summary Output: Air Force Base Distance to Landfill.

Regression Statistics								
Multiple R	0.226020644							
R Square	0.051085332							
Adjusted R Square	0.030456752							
Standard Error	156.4943286							
Observations	48							
ANOVA								
	df	SS	MS	F	Significance F			
Regression	1	60649.06294	60649.06	2.476434744	0.122417534			
Residual	46	1126561.845	24490.47					
Total	47	1187210.908						
	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 70.0%	Upper 70.0%
Intercept	216.3241378	40.78511255	5.303998	3.14847E-06	134.2279643	298.4203114	173.5711385	259.0771372
Distance to Landfill	5.052440255	3.210611393	1.573669	0.122417534	-1.410185288	11.5150658	1.686916458	8.417964052

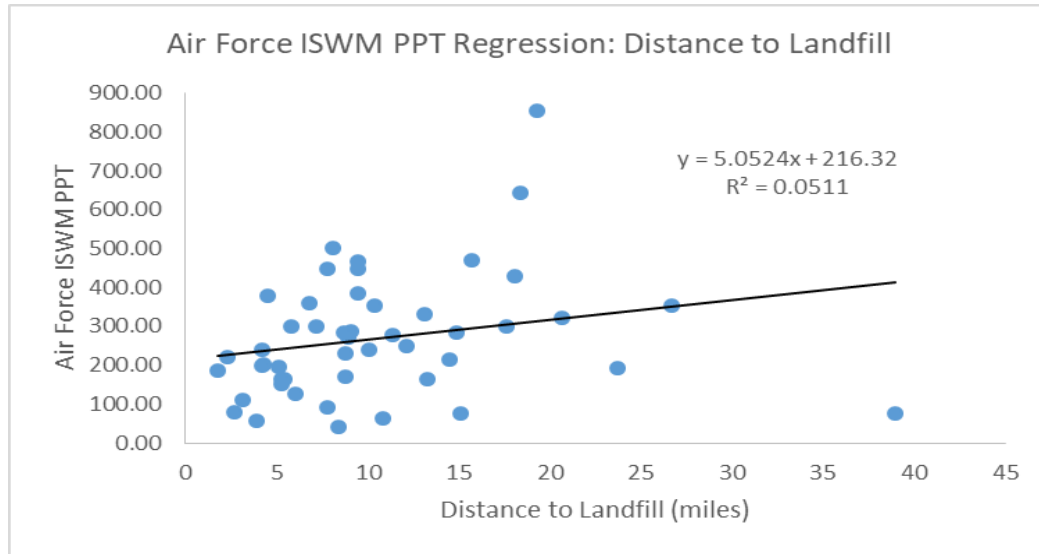


Figure 4. Regression Scatter Plot: Air Force Base Distance to Landfill.

The cost driver of Air Force Base number of containers was the second most significant independent variable, producing a significance F-test of 0.1974. The coefficient

of determination was 0.0392, meaning that the regression relationship is present yet weak, where 3.9% of the variability in the Air Force ISWM PPT can be explained by the linear relationship between Air Force Base number of containers and Air Force ISWM PPT. Table 9 shows the regression analysis tool's summary output of Air Force Base number of containers independent variable and Air Force ISWM PPT dependent variable. Figure 5 shows a scatter diagram that fits a linear trendline showing the estimated regression equation of Air Force Base number of containers independent variable and Air Force ISWM PPT dependent variable.

Table 9. Regression Summary Output: Air Force Base Number of Containers.

<i>Regression Statistics</i>								
Multiple R	0.198066391							
R Square	0.039230295							
Adjusted R Square	0.016354826							
Standard Error	157.4243617							
Observations	44							
ANOVA								
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>			
Regression	1	42500.6378	42500.64	1.71495	0.197463015			
Residual	42	1040862.046	24782.43					
Total	43	1083362.684						
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 70.0%</i>	<i>Upper 70.0%</i>
Intercept	313.8234481	37.64085151	8.33731	1.9E-10	237.8611344	389.7857618	274.323533	353.3233631
# of Containers	-0.230548863	0.176050476	-1.30956	0.197463	-0.585833107	0.12473538	-0.415294387	-0.045803339

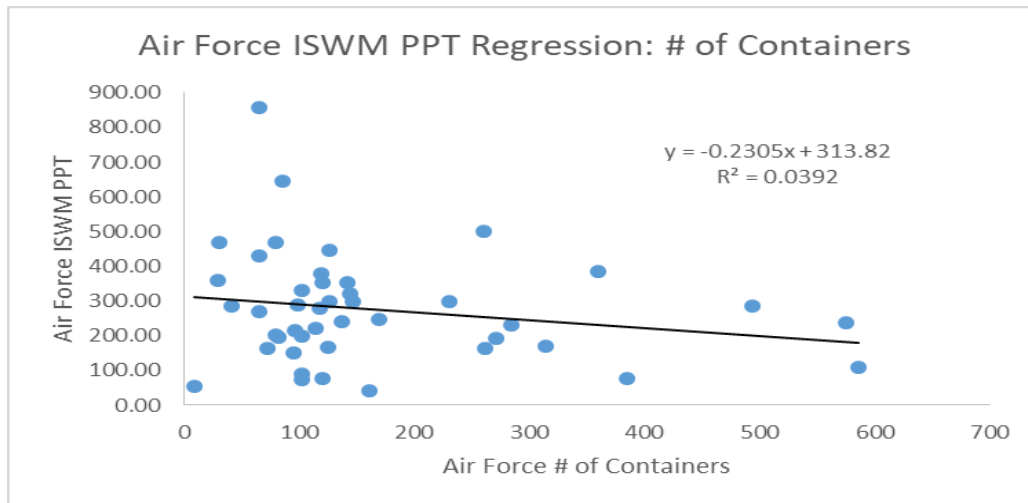


Figure 5. Regression Scatter Plot: Air Force Base Number of Containers.

In addition to analyzing the regression relationship between Air Force ISWM PPT and the Air Force Bases' number of containers, we analyzed the individual price variations of installations with more than 75 containers and the price variations of less than 75 containers. We found that 13 of the 20 bases had more than 75 containers and the remaining seven had less than 75 containers. We found that the average Air Force ISWM PPT of bases with more than 75 containers was significantly less than the PPT of bases with less than 75 containers. Figure 6 and 7 show the comparison of paired Air Force and municipality PPT for bases with less than and greater than 75 containers. Air Force Bases with greater than 75 containers had an average PPT of \$177.20, significantly less than \$345.84, the average PPT of bases with less than 75 containers. Additionally, the average PPT of Air Force Bases with greater than 75 containers was less than the average municipality PPT of \$210.52 shown in Figure 7.

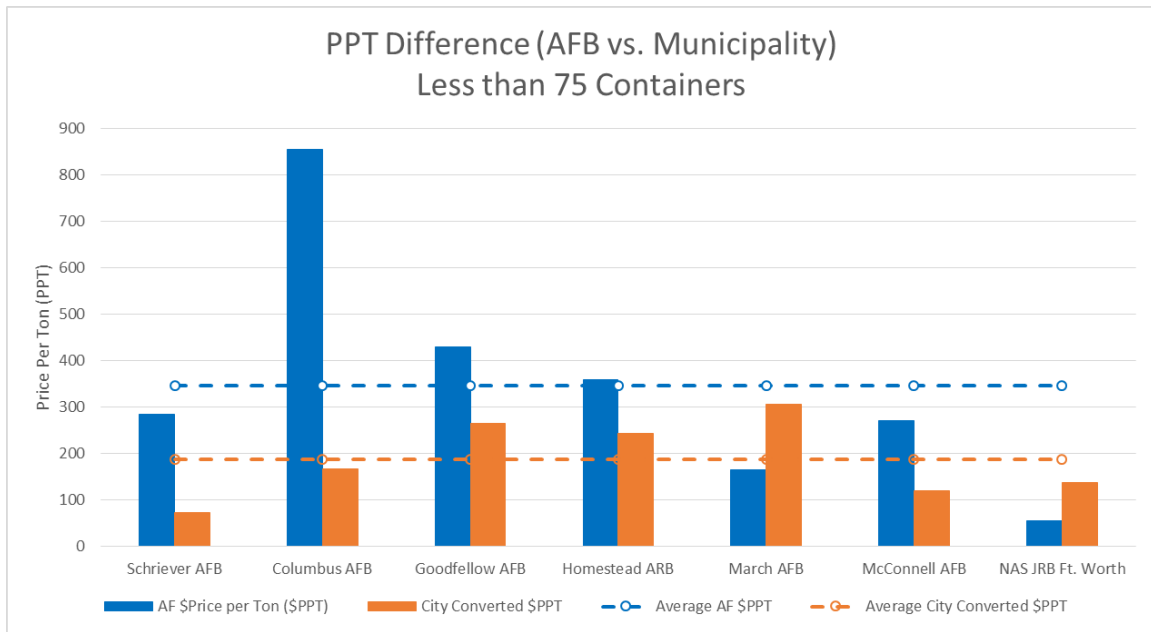


Figure 6. Comparison of Paired Air Force and Municipality PPT: Less than 75 Containers.

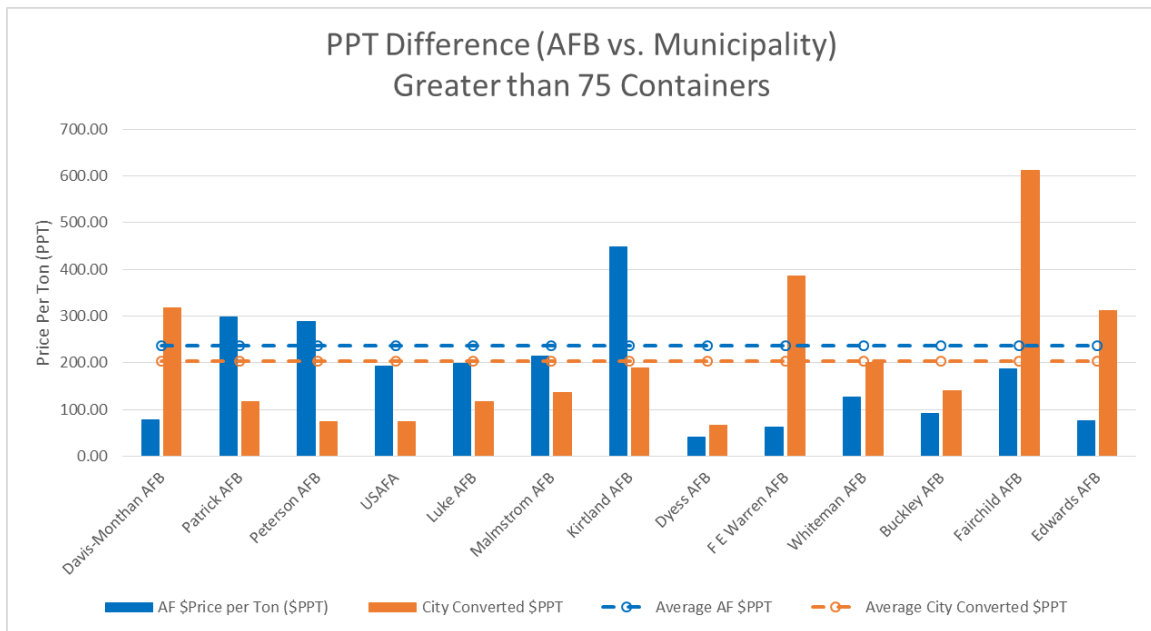


Figure 7. Comparison of Paired Air Force and Municipality PPT: Greater than 75 Containers.

D. SUMMARY

In summary, we were unable to determine, that on average and at an appropriate level of confidence, that the total population of CONUS Air Force Bases pay a greater PPT than respective municipalities. Though we were unable to reject the null hypothesis using conservative conversion estimates, we were able to identify multiple Air Force Bases which pay a significantly greater PPT than their respective municipality. Additionally, we found that there were only two significant cost drivers with a regression relationship with Air Force PPT: Air Force Base number of containers, and the Air Force Bases' distance to landfills.

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V. CONCLUSION AND RECOMMENDATIONS

A. SUMMARY

Our project tries to understand the large differences in prices paid for ISWM contracted services. To effectively analyze ISWM contract price variances for solid waste disposal services between Air Force installations, and between Air Force installations and their surrounding local municipalities, we utilized hypothesis testing about the difference between two population means and multivariate linear regression modeling. Using these statistical models, we were unable to determine, that on average and at an appropriate level of confidence, the total population of CONUS Air Force bases pay a greater Price Per Ton (PPT) than respective municipalities. However, we were able to identify multiple Air Force installations that had significant enough price differences that require further analysis and scrutiny. Also, by utilizing the regression model, we were able to identify two significant cost drivers: Air Force base number of containers and the Air Force bases' distance to landfills.

B. CONCLUSION

The purpose of the research was to provide a means to identify efficiencies or inefficiencies in the procurement of ISWM services, which require substantial annual funding obligations. Also, our purpose was to improve future acquisitions of ISWM services the further safeguard scarce government resources. Our team wanted to deliver information to the Air Force which would aid them in ensuring ISWM services were provided by contractors at best value to the government. We wanted to provide the Air Force with a tangible metric, such as average PPT of disposed solid waste, which could be compared against Air Force installation PPT as well as their co-located municipalities. These collected and standardized local city prices were compared to Air Force prices and used to determine whether the Air Force on average overpays for ISWM services. A comparison between both the local municipalities and Air Force installations further assists Air Force contracting organizations in determining whether or not the prices paid are fair

and reasonable when compared to the Air Force average and when compared to the individual installations' municipality.

We can now answer the three original questions presented at the beginning of our research in order to provide Air Force with a clearer understanding of the ISWM market and cost drivers.

1. Using AFICA pricing data, what is driving the price variation (unit price) across CONUS Air Force installations for solid waste disposal services?

We determined there were two significant cost drivers, the independent variable of Air Force Base number of containers and Air Force Base distance to landfill. Though these cost drivers were significant, when combined, less than 10% of the variability in Air Force ISWM PPT can be explained by the linear relationship between these two independent variables.

2. Using municipality pricing data, how do municipality unit prices compare to Air Force unit prices?

We were unable to determine, that on average and at an appropriate level of confidence, that the total population of CONUS Air Force Bases pay a greater PPT than respective municipalities. Though we were unable to reject the null hypothesis using conservative conversion estimates, we were able to identify multiple Air Force Bases which pay a significantly greater PPT than their respective municipality

3. Using local cost of living indices, do local consumer price indices account for the variation in prices paid for solid waste disposal services?

We found that consumer price indices were insignificant variables in explaining variations in prices paid. The regression data analysis tool allows us to confidently conclude that there is no relationship between consumer price indices and prices paid for ISWM services.

C. RECOMMENDATIONS

The first recommendation is to standardize the CLIN cost structure in ISWM contracts across all Air Force installations to be in accordance with industry standards.

While researching with AFICA to obtain the cost breakdown per installation, it became apparent that each installation formats their CLINs differently. This, in turn, would become problematic because of the difficulty in comparing each installation's costs, line-by-line, to successfully compare installation prices to one another. As previously discussed, this forced us to normalize the sample dataset by calculating the overall PPT for each Air Force base.

Every local municipality provided their cost breakdown in terms of bin size, number of bins, and frequency of pick-up, which is the industry standard. Due to the disparity in the reporting of costs of the installations, we had to normalize the local municipality data to compare them to Air Force bases, converting the local municipality costs to PPT. The format the Naval Postgraduate School (NPS) uses for ISWM services is the best example of what we are proposing. We refer to this cost structure as the "Monterey Model." Appendix B is a copy of NPS's most recent contract with the city of Monterey. The costs are broken down by container size, number of containers, and number of pick-ups per week.

The additional steps required to normalize the data to make direct comparisons, begs the question of how the Air Force can properly conduct market research when their cost structure is not directly comparable with the industry standards. Having the ability to compare with other organizations, like local governments, will aid in determining if proposed prices are fair and reasonable. Also, contracting officers are unable to compare their proposed costs with other installations which aid in determining fair and reasonable prices.

The second recommendation is that Air Force ISWM contracting officers be required to compare local municipality costs and all Air Force installation costs during market research. As previously discussed, multiple bases have substantially higher PPT costs than their local municipalities and other Air Force bases. Conducting market research with local governments and other installations will help contracting officers avoid accepting substantially higher prices, as well as decrease the large variability of prices between installations. This research will also provide a means of rebuttal to offerors during negotiations because they now have more information available to negotiate lower prices.

Finally, this process will decrease installation contracting officers' reliance on historical prices paid.

The third recommendation is that each installation's contracting officer report detailed CLIN level data and a calculated PPT into a repository that is accessible to all in order to better accommodate contracting officers during the market research process. We understand that there is already a collection process, however, the current inputs are not detailed enough to enable adequate market research. The repository will be an avenue that helps not only contracting officers but also their chain of command in identifying potential cost drivers. This also gives the chain of command the ability to hold each installation accountable and able to quickly identify outliers.

The fourth recommendation is for AFICA to deep dive into the contracts of previously identified outliers to find the cost drivers creating such large variations. This is a necessary step because we could not identify variables with strong regression relationships to explain the large variation in prices. The deep dive will aid AFICA in developing comprehensive lessons learned and best practices that can be incorporated into future contracts to save scarce governmental funds.

Finally, our fifth recommendation is to utilize category management and strategic sourcing with ISWM contracts. "Category management is an effective business practice for reducing duplication in contracting, better leveraging the government's buying power, and promoting the use of best in class solutions government-wide" (Category Management [CM], 2016, p. 69860). Also, category management "provides a pathway for agencies to move away from managing purchases and prices individually across thousands of procurement units and towards managing entire categories of common spend with collaborative decision-making" (CM, 2016). ISWM contracts are a prime candidate to benefit from category management and strategic sourcing considering the large variances across each installation. Consolidating ISWM services into a regional contract will allow the Air Force to assign experts in the ISWM market to manage ISWM service contracts. Also, this solution will help reduce unit costs through increasing the size of the contract, reduce duplicating administrative costs, and better manage requirements per installation (CM, 2016). Much of the success of category management will come from consolidating

services and standardizing the requirements at each installation based on their size and actual usage. Consolidation of each installation's services will help eliminate unnecessary requirements and give the Air Force the ability to select the right size of service required.

Strategic sourcing will further reduce unit costs, volume of services per installation, and improve operating efficiencies through a critical analysis of an organization's spending (Dieges, 2013). Also, strategic sourcing provides a means of continuous monitoring of ISWM contracts and helps contracting teams to "adjust their strategy to include for efficiencies and greater savings" (Dieges, 2013). As explained by Hartmann, Landale, and Rendon, "category management and strategic sourcing require extensive market research—a much more comprehensive examination and understanding of the markets for common products and services than the federal government has ever performed in the past" (R. Rendon, email to author, July 13, 2017, p.2). By implementing these two concepts, the other recommendations provided by us will be satisfied, thus creating a more efficient and cost-effective contracting process for ISWM services.

D. AREAS REQUIRING FURTHER RESEARCH

In order to explain why CONUS Air Force bases pay a greater PPT than respective municipalities, the Air Force installations with over twice the PPT costs of their local municipality need to be further scrutinized at the contract line item number (CLIN) level. The main cost drivers at each Air Force installation need to be identified in order to evaluate negative trends may be driving up costs. We limited our research to analyze the overall PPT. We did not analyze costs at the CLIN level, nor did we poll the government contracting officers of each ISWM contract to better understand each installation's ISWM contracting process. A detailed level of scrutiny with the ISWM contracts of the seven Air Force installations identified in the findings chapter as having the highest levels of variance, is a vital step to further understand the price differences.

Two areas we believe might explain the higher prices paid by the Air Force are the cost of regulation and additional security requirements placed on ISWM service. The additional federal laws and regulations placed on government ISWM programs and government contracts in general might explain the price differences between the local

municipalities and Air Force bases. These two theories require more research to validate this theory and help identify what the true cost of federal regulations are. Unfortunately, this will not fully explain why the seven Air Force bases identified have the highest level of variance, because the cost of regulation and security should be similar across all CONUS Air Force bases. However, this assumption would establish a baseline of expected costs. Once these baseline regulation and security costs are identified, researchers would be better equipped to pinpoint the additional costs that are outside the expected range.

Based on our research and limited data, we could not theorize why there are five Air Force installations with less than half the PPT costs of their local municipality. However, the Air Force should review each of those five contracts with a detailed level of examination and talk to the respective government contracting officers. Some questions the Air Force should focus on answering are as follows:

1. How did the contracting officer conduct market research?
2. Are there special contract provisions that are providing cost savings?
3. Is there anything unique that the contracting officer did during the planning or development phase?
4. Which CLINs are significantly lower than other Air Force installations?
5. Are their contracts in accordance with industry standards?

These questions will aid the Air Force in developing lessons learned and implement best practices across all installations.

APPENDIX A. EMAIL TO MUNICIPALITIES

Dear XXXX,

My name is Lieutenant Commander XXXX, I am a student at the Naval Postgraduate School conducting research on solid waste contract costs. Our research team is comparing and contrasting the costs of solid waste disposal between Air Force bases and their neighboring cities. We hope this will help military leadership in deciding the types of service contracts they should pursue across bases.

To that end, my team and I are inquiring as to how municipalities manage their solid waste contracts in an effort to use them as a model to improve Air Force contract processes.

I am hoping that you can answer a few quick questions in support of our research for the military and the federal government.

- What type of contract does your city use for solid waste disposal?
- What are the negotiated rates for solid waste collection at city owned buildings (e.g., per bin size and frequency of collection)?
- What are your published prices for commercial business rates for solid waste collection (e.g., per bin size and frequency of collection)?
- Is the local Air Force installation's solid waste contract managed by your city? What are the Air Force base's rates? Are the Air Force base's rates the same as the negotiated rates for the city? What is the surcharge rate applied to the Air Force for the city to manage its solid waste contract?
- Are there standing city regulations requiring the local Air Force installation utilize the same hauler that is already contracted with the city?

The information you provide will be treated as confidential. Our report will be sanitized of any city, Air Force installation, or commercial hauler names. After the report is complete, we would be happy to share our findings with you.

Thank you very much for your time and support, your vital contribution to our research will help improve Department of Defense contract processes.

Sincerely,

XXXX

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APPENDIX B. EXAMPLE OF “MONTEREY MODEL” LINE ITEM NUMBERS

According to Ted Terrasas (email to author, October 12, 2017), the below table is an example of the “Monterey Model.”

ATTACHMENT J-0200000-04 EXHIBIT LINE ITEM NUMBERS SOLICITATION/CONTRACT # N62473-14-C-2811 EXHIBIT A - CLIN 9000–AWARD PRICING Base Period 1 May 2014 through 30 April 2015 ELINs A001 through A005 Sub ELINs A001AA through A005AA								
ELIN/ Sub Elin	Bldg No.	Building Name	Size (CY)	QTY	Pickups Per Week	Buyer	Monthly Cost	Cost Per Year
A001 - Main Campus, NSAM								
A001AA	208	Gymnasium	4	1	2 M/F	NSAM	\$549.43	\$6,593.20
A001AB	220	Herrmann Hall	20 comp	1	On-Call NTE 30/ yr	NSAM	Variable*	\$17,999.10
A001AC	232	Spanagel Hall	6	2	2 T/TH	NSAM	\$1,612.25	\$19,347.05
A001AD	236	Boiler Plant	4	1	3 M/W/F	NSAM	\$811.26	\$9,735.14
A001AE	246	Watkins Hall	4	1	3 M/W/F	NSAM	\$811.26	\$9,735.14
A001AF	259	CCMR	4	1	1 F	NSAM	\$289.92	\$3,478.99
A001AG	302	Glasgow Hall	20 comp	1	On-Call NTE 14/ yr	NSAM	Variable*	\$8,399.58
A001AH	330	Ingersol Hall	6	1	3 M/W/F	NSAM	\$1,229.87	\$14,758.38
A001AI	339	Knox Library	6	1	3 M/W/F	NSAM	\$1,229.87	\$14,758.38
A001AJ	426	Public Works (General)	30 db	1	On-Call NTE 52/ yr	NSAM	Variable*	\$24,449.33
A001AK	426	Public Works (Green Waste)	20 db	1	On-Call NTE 60/ yr	NSAM	Variable*	\$10,720.08
A001AL	426	Public Works (Floater)	20 db	1	On-Call NTE 12/ yr	NSAM	Variable*	\$ 4,288.16
A001AM	438	Environmental Storage	2	1	2 W/F	NSAM	\$287.93	\$ 3,455.17
A001AN	Misc	Incidentals	NTE			NSAM	Variable* NTE \$1500	\$Est \$1,500.00

SUBTOTAL ELIN A001								\$149,217.70
A002–LRA								
A002AA	191	Snack Bar	3	1	2 M/F	NSAM	\$418.60	\$5,023.24
A002AB	214	Astro Area	3		1 F	NSAM	\$235.47	\$2,825.68
A002AC	217	Jet Lab	3	1	2 M/F	NSAM	\$418.60	\$5,023.24
A002AD	425	Maint. Shop	3	1	1 F	NSAM	\$235.47	\$2,825.68
A002AE	230	RV Parking Lot	3	1	2 M/F	NSAM	\$418.60	\$5,023.24
SUBTOTAL ELIN A002								\$20,721.08
A003–LMV								
A003AA	334	Navy Lodge	6	2	3 M/W/F	NSAM	\$ 2,444.82	\$29,337.84
A003AB	439	CDC	4	1	3 M/W/F	NSAM	\$ 811.26	\$ 9,735.14
A003AC	444	Teen Center	3	1	1 F	NSAM	\$ 235.47	\$ 2,825.68
SUBTOTAL ELIN A003								\$41,898.66

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