Integrated Asset Management and Conditions Analysis for Building Collections: A *Case Study of the Houston Zoo*

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Abstract

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There is a natural connection between deteriorating assets, animal health, and ultimately, guest satisfaction in zoological gardens. Understanding this correlation is a requirement for long-term success that begins with a comprehensive look at the conditions and finances associated with the zoo's built asset portfolio. However, asset management is not always a foremost focus at zoos across the United States or abroad. The question that arises from this fact is if a zoo cannot manage the maintenance and condition of its facility to the degree that it impacts the health of the animals and presents hazardous situations for its guests, should it be afforded the privilege of caring for and displaying animals at all? With the privilege of being the caretaker of animals, who cannot advocate for their own lives, comes a variety of responsibilities, one of which is managing built assets.

This thesis looks at the development of a prototype software-based tool that facilitates the gathering and analysis of necessary financial and maintenance data for assets in order to enable zoos to meet the challenges of superior asset management, which includes conditions analysis. The objective of the research is to investigate the types of data that need to be captured to support analysis of investment and expenditure strategies, while at the same time provides a framework for a comprehensive maintenance program. Together, the two fuse into the creation of an asset management program that will benefit the built assets, the guests, and most importantly the living, breathing animal residents.

To accomplish this, two software programs are used: Microsoft Access 2000, for database creation and data collection, and ESRI's ArcView GIS 3.2, for visually connecting with data. Stored information may be accessed and studied with tools available in the database software or alternately by using the visual interface software that allows users to work with data via an interactive plan of the zoo. The user for the prototype design is the Houston Zoo located in Houston, Texas, but the framework of the database and system may be applied to any zoo or other similar scale organization. Implementation of this tool has the ability to help any zoo that currently has no program or a directionless program develop a system that will lead to success. However, this must be done without losing site of the amazing power that zoos have to sustain animal life and inspire visitors to take action in saving habitats and animal species around the world.

Thesis Advisor: John B. Miller

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Acknowledgements

Although the main focus of this thesis, asset management, was a new topic for me the drive behind it was not. I have always been passionate about animal welfare from the first time I was old enough to realize that the animals at our local zoo were essentially trapped in horrendous habitats, which made them depressed and weary. The passion to design better, healthier habitats guided me to study architecture as an undergraduate and complete a Master's of Architecture that focused on habitat design in February of 2000. It was also this passion that led me back to school soon after to pursue an education in civil engineering and I feel, to find an advisor whose research could be taken in a different direction and applied to zoos. This thesis bridges the gap between the design of a structure and the effort that it takes to maintain that structure so it may function as intended, throughout its life.

I have continued to learn during the course of this degree and this research process, but the knowledge that I gained during this time was not the result of a self-directed effort. There were many people who have provided support during the time that I spent in the Department of Civil Engineering and I would like to thank a few now.

Thank you to my family and friends who continued to support me during this second master's degree.

Thank you to my advisor, John B. Miller, who helped me understand the function and responsibilities that zoos inherently have in the public sphere and that meeting these challenges is not an impossible task, if the right approach is taken.

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Introduction

Although zoological gardens have the power to pull animal species back from the brink of extinction, many are having difficultly managing their own assets. Collections management of capital assets is not a main focus at zoos across the United States or abroad. Consequently, a zoo may have a state of the art facility for primates, while lions are housed in crumbling concrete enclosures, and guests have to dodge cracks in pathway pavement. If a zoo is unable to manage the maintenance and condition of its facility to the extent that it negatively impacts the health of the animals and presents a danger to its guests, the question that needs to be asked is if the zoo should be afforded the privilege of caring for and displaying animals to the public at all? With the privilege of being the caretaker of animals, who cannot advocate for their own lives, comes a variety of responsibilities, one of which is managing built assets.

There is an inherent connection between deteriorating assets, animal health and ultimately guest satisfaction. The zoo, its funding agencies, and even its guests do not always make this connection however. The correlation is a requirement for long-term success that begins with a comprehensive understanding of the conditions and finances associated with the zoo's built asset portfolio. This in turn must begin with an initial shift in attitude that built structures are investments that must be maintained, not one-time construction projects that deteriorate until they are useless and must be rebuilt. Furthermore, asset management requires more than just creating an annual maintenance budget and fixing things when they malfunction. Rather, it requires an understanding of annual expenditures on a detailed level that has the flexibility to identify spending by individual exhibit, type of repair, and even separates the costs for labor versus the costs for materials.

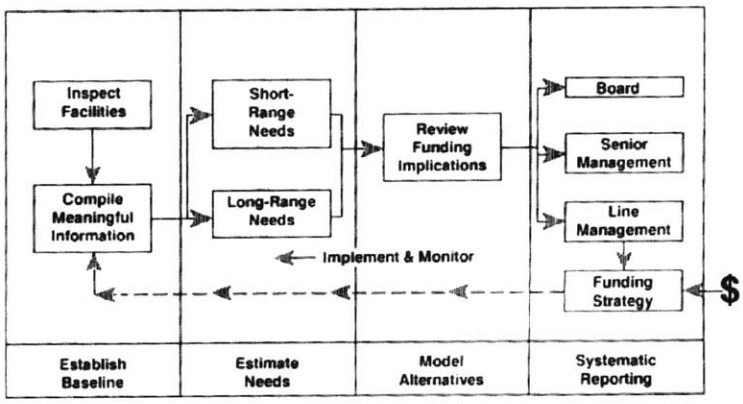


Figure 1 *Overview of the Facilities Portfolio Management Model*

Figure 1 is a model for facilities portfolio management.[1] It demonstrates that a successful management program is a continuous cycle of inspecting, estimating, analyzing, and reporting.[2] A management program cannot be a stagnant entity that is looked at once a year. Instead, it must be fluid and constantly reevaluating itself to ensure that it is meeting its goals and in that the goals of the organization.

The lack of transparency in a zoo's financial position both historically and currently often makes it hard to raise and borrow funding. A zoo must demonstrate where the money is going in order to express the need for additional funding. It is a cycle of proving that they do not have adequate resources to do the job, in order to prove what resources they need to do the job correctly. Part of this process includes having a preventative maintenance program that quantifies all routine repairs along with their cost and projects major replacements and renovations. Although most zoos have some system for tracking maintenance, the problem is that the information on repairs and renovation is most often separate from the data on maintenance, which is kept apart from the budgetary requirements of the overall zoo. There needs to be a unification of information, not a further separation. An additional issue adding to this dilemma is frequently the information that is captured is not enough to provide a complete picture. In order for a zoo to run effectively, information from notification to completion of an activity must be combined in a way that interrelates the data and can clearly demonstrate how funding is allocated to projects in the past and present so that decisions may be made for the future. As well, having this data in one place will help in the planning for maintenance and construction activities, in addition to supporting decision makers who strategically plan future expenditures and funding requirements.

The final part of this process includes condition assessments of built assets. A zoo must have conditions data from the past in order to compare with current and future data. The old adage of "You have to know where you've been in order to know where you are going," certainly applies here. Conditions assessments are a necessary tool to understand the current state of the collection in comparison with it a year ago, or even a decade ago, in order to judge the success or failure of the maintenance program and to identify if current levels of funding are adequate and being distributed in the best interest of the collection. Finally, conditions data may be used to identify the most urgent maintenance and repair projects, thus providing aid to the decision making process of where to allocate funding and other resources.

With all of these processes in place zoos will have all of the tools needed to understand their collections to best maintain and manage them. This will in turn lead to safe habitats for the animal residents and the visitors who come to learn about them.

Thesis Objectives

This research looks at the development of a prototype software-based tool that facilitates the gathering and analysis of necessary financial and maintenance data for assets in order to enable zoos to meet the challenges of superior asset management, including conditions analysis. The objective of the research process was not to create a flawless software tool, but rather to investigate the types of data that need to be captured to support analysis of investment and expenditure strategies, while at the same time provides a framework for a comprehensive maintenance program. Together, the two fuse into the creation of an asset management program that will benefit the assets, the guests and most importantly the living, breathing animal residents. The software tool that results supports the overall research goals and should be looked at as a useable prototype that has the ability to be modified to suit the needs of individual zoological gardens.

The software tool allows for information on maintenance and construction expenditures to be captured and saved in an electronic format. The information gathered is stored in a comprehensive database and over time will provide an inclusive history of expenditures, maintenance activities, and asset conditions. Once entered into the database, the information may be accessed and studied with tools available in the database software or alternately by using a

visual interface software package that references assets via an interactive plan of the zoo. This process is explained in detail later in the thesis. The user for the prototype design is the Houston Zoo located in Houston, Texas, but the framework of the database and system may be applied to any zoo or other similar scale organization.

Once established and implemented at a zoo, the software tool has the ability to provide the following things:

- ✧ Extract and breakdown finances to a useful level of detail
- ✧ Organize and optimize maintenance procedures
- ✧ Decision-making and strategic planning tool
- ✧ Conditions assessment and tracking
- ✧ Comply with GASB Statement 34 requirements.

In addition to the main intentions for the tool there are a number of other resulting benefits, a few of the most significant are listed here:

- ✧ Scheduling tool for facilities department
- ✧ Facilitate creation/extension of a preventative maintenance program
- ✧ Aid CFOs to determine staffing levels to perform activities internally versus outsourcing tasks to contractors.
- ✧ Accountability in planning and spending
- ✧ Aid zoos in the AZA accreditation process
- ✧ Modernization of the process via the use of computer based programs.

Fundamentals

The thesis examines the research process and explains the design, development, and analysis capabilities of the software tool. The tool is composed of two major software components and the development was guided in part by requirements of the Government Accounting and Standards Board, (GASB) as well as requirements for the conditions analysis tracking, both of which are covered in detail later. In addition, the research project ongoing in the Department of Civil Engineering at MIT, from which this thesis originates, is discussed.

Database requirements for accounting and tracking of maintenance activities is guided by recent standards released by the Government Accounting and Standards Board (GASB), in which cities are required to adhere to in the coming years. The majority of zoos are city run entities. As such, eventually many of them will be required to report their annual financial plans in the same

manner that cities do or in the least, they will be responsible to report this information to their city board in the same fashion. With this in mind, the GASB standards are a logical structure to guide the development of the accounting and maintenance activity areas of the database.

In order to analyze the condition of assets in an objective manner both in the present and future, the basic formula created by The National Association of College and University Business Officers (NACUBO), which compares monetary figures of current maintenance backlog and asset replacement value, is used. The resulting ratio is called a Facility Conditions Index and is used to define the current state of a building or of the entire collection. It too provides a valid guideline as to what information the database needs to capture.

The initial idea for this thesis developed from similar research being done at MIT with the City of Winchester, Massachusetts. It is important to note that the development of the tool took the focus in a slightly different direction with increased attention on the built structure, not infrastructure components, as in the city model. Nevertheless, it is useful to examine the Winchester project to see how concepts in this research may apply to infrastructure, but mainly are applicable to built structures and site elements.

Winchester, Massachusetts

Currently research is being done in the Civil Engineering Department at MIT, under Professor John B. Miller, working with the city of Winchester. The research centers on creating a tool to help cities follow the new standards of GASB, in particular Statement 34, which deals with the accounting practices relating to maintenance activities for city assets.

Briefly, Winchester is located in eastern Massachusetts, just outside of the city of Boston. It was settled in 1630 and encompasses 6.49 square miles of land.[3] The population has grown steadily over the years and is currently around 22,300 residents. A five member Board of Selectmen and a single Town Manager heads the city government.[4] Winchester was once an industrial town full of mills and factories.[5] In the late 1800's the town's businessmen began to develop suburban areas that attracted large numbers of new residents of similar stature to the growing town. Today a large majority of the homes built during this time still stand along with a considerable amount of the town's infrastructure.

Winchester, like other cities across the US, does not have an adequate system in place to monitor its infrastructure assets. Consequently elements like sewer systems, roads, and public spaces are deteriorating before the resident's eyes. This is not unlike the issues that plague zoos. Winchester is in need of a system that captures the repair issues and can then demonstrate the resulting need for funding. Without clear data on the funding required to meet specific standards taxpayers will not agree to expend their money to a program that they feel is failing them daily. These facts were part of the catalyst that sparked Professor Miller to begin research in this area.

With the aid of research assistants from MIT, Professor Miller is currently developing a tool that divides the assets of the city into six areas: water, sewer, streets, drainage, public buildings, and open spaces. The tool will aid the city in tracking, modeling, and planning for long term maintenance activities performed in the six areas in accordance with the standards of GASB Statement 34. The goal of the tool is to not only help Winchester comply with the standards set out in Statement 34, but to also coordinate maintenance and capital programs with the towns other financial and social responsibilities while fostering accountability in city infrastructure decision making. Through the use of Windows based software programs that take advantage of GIS capabilities, the tool tracks conditions and maintenance data that may then be used to calculate budgets and inform decisions, as well as produce work orders for maintenance and capital activities to be done.

It is important to understand the fundamentals of the Winchester project as this thesis uses some of the very basic database framework and logic from the Winchester tool, but realigns and adjusts it to encompass and address the specific needs of a zoological garden.

GASB

The Governmental Accounting Standards Board (GASB) is a nonprofit organization that was established in 1984 by the Financial Accounting Foundation. The goal of the foundation is to establish a set of standards of financial accounting and reporting for state and local government entities.[6] GASB's mission is to:

> . . .establish and improve standards of state and local governmental accounting and financial reporting that will result in useful information for users of financial reports and guide and educate the public, including issuers, auditors and users of those financial reports.

The role of GASB is important as it works to create level platforms for financial reporting that may be easily understood by the general public. The public may use the financial information presented by the government entities as basis for investment, credit and legislative and regulatory decisions.[7]

Through research conducted within the organization, as well as with input from external sources, GASB seeks to keep itself up-to-date on the current industry reporting needs. By issuing and updating reporting standards GASB is seeking to accomplish its mission on a daily basis. The most discussed recent standard issued by GASB is Statement 34, "Basic Financial Statements-and Management's Discussion and Analysis-for State and Local Governments." Statement 34 was issued on June 15, 1999 with the objective, "to enhance the understandability and usefulness of the general purpose external financial reports of the state and local governments to the citizenry, legislative and oversight bodies, and investors and creditors."[8] Through Statement 34 and others, GASB is trying to force governments to be accountable in the reporting of finances so that these financial reports maybe used for decision making in economic, social, and political spheres.[9]

Statement 34 requires that at minimum, financial reports should include the Management's Discussion and Analysis (MD&A), which provides an overview of the reporting body's financial activities along with its Basic Financial Statements. Within the Basic Financial Statements are three subsets: Government-wide Financial Statements, Fund Financial Statements, and Notes to the Financial Statements. In addition the government must submit all Required Supplementary Information (RSI). Below is a diagram included in Statement 34 that depicts the relationship of these requirements.[10]

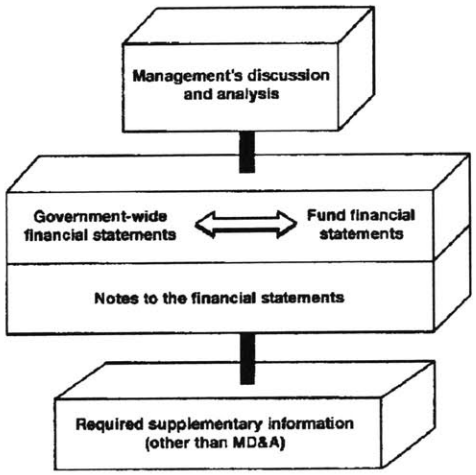


Figure 2 *Minimum Requirements for General Purpose External Financial Statements*

In addition to the reporting standards, the statement essentially requires that state, local, and municipal governments calculate the original cost of infrastructure constructed or improved in the past 20 years and put this information in their annual financial reports.[11] All future infrastructure investments are to be accounted for and tracked in the same manner. This not only sets a standard for each individual government entity, but it also creates a benchmark for comparison of government entities with each other. The final requirement is that costs associated with using the assets are also calculated and reported.

In financial terms, Statement 34 allows for two types of financial reporting, standard or modified. The standard approach uses the standard accounting practices for depreciation of fixed assets. That is, assets must be grouped into classes and depreciated annually over their estimated useful life. If a government is not using the modified approach then GASB suggests that all capital assets be depreciated unless they are inexhaustible, such as land or land improvements.[12] The most common formula that GASB uses to measure depreciation expense is:

$$\frac{\text{Net Cost of Depreciable Assets (historical cost – estimated salvage value)}}{\text{Estimated Useful Life.}}$$[13]

Equation 1 *GASB Depreciation Expense Equation*

The modified approach, on the other hand, does not require that assets be depreciated in the traditional manner, as long as the government meets two requirements. First, the government must have a systematic approach to managing the assets, which minimally requires:[14, 15]

1. A current inventory of eligible assets
2. Condition assessments of the asset inventory using a reproducible assessment procedure
3. Estimating the actual cost to maintain and preserve the assets.

Second, the government must demonstrate through documentation that the assets in question are being preserved at a minimum condition level that is established and disclosed by the government.[16] The condition assessments must be performed at a minimum, every three years and must be of a consistent manner. If an asset meets these requirements then any expenditure made for that asset should be expensed in the period incurred.[17] Any expenditures that are considered as an improvement or addition must be capitalized. Finally, an asset loses its ability to be accounted for under the modified approach if the three most recent conditions assessments demonstrate that it is no longer being preserved at the established condition level disclosed by the government prior to using the modified reporting procedures. At this point, the asset must be depreciated in the following years.

The rational behind the modified approach first established during GASB's public comment process for Statement 34, was that although specific public infrastructure may exhaust their useful life, this period of depreciation is either very long or difficult to estimate. Moreover, the functions performed by these facilities are perennial; that is water supply, schools, streets, and bridges are a never-ending responsibility of governments therefore the standard approach does not match the needs when accounting for these assets.

In Statement 34, GASB loosely defines three categories that activities and their expenditures should fall under. They are: Maintenance, Preservation, and Additions & Improvements. A *Maintenance Activity* is one that allows an asset to continue to be used during its original established useful life. A *Preservation Activity* is one that extends the useful life of an asset beyond the original useful life. Finally, an *Additions & Improvement Activity* results in an increase in capacity or efficiency of the asset, thus essentially creating a new useful life for that portion of the asset.

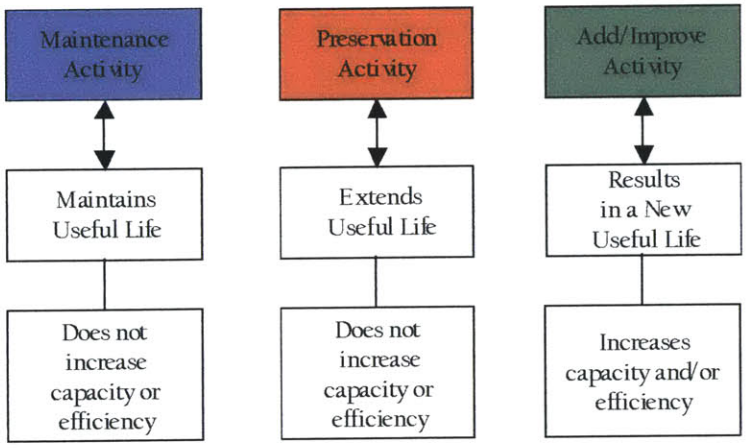


Figure 3 *GASB Categories and Definitions*

The benefit of Statement 34 to the residents of towns like Winchester, Massachusetts for example is increased accountability by local and state governments that demonstrates their efforts to not only expand assets, but also most importantly maintain and preserve them for continued future use. In addition to the general public, local organizations such as public hospitals, state universities, municipal parks and city zoos are also influenced by the new standards set forth. Clearly, Statement 34 recognizes the importance of preservation of infrastructure as assets and expenditures in them as investments, not as one-time construction projects that are then left to manage and maintain themselves.[18] By following the new standards of Statement 34, governments will demonstrate to the public their efforts in preserving their collective assets.

Institutions like zoos, hospitals or universities, do not have to immediately follow the new GASB guidelines because they do not directly report to GASB and therefore are not required to follow the guidelines they set forth. However, benefits to following Statement 34 can be realized by these organizations as well. Poor maintenance accountability is a problem faced in many organizations that may be alleviated by utilizing the standards set for in Statement 34. In addition, these entities will have to report this information to their cities and states, which will then presumably have to take that data and convert it to GASB standards. It is advantageous to the cities that these city run or city funded organizations transition their record keeping systems to emulate that of the local cities. This will reduce the added time and effort that it would take to

transfer their reports to GASB standard reports since these assets have to be reported in this fashion by the cities eventually as they are categorized as an asset.

Although there are differences in the way that buildings are used in zoos versus in cities, since the required condition level is determined by the individual reporting body, using GASB standards won't pose a problem for zoos. Each zoo may determine the condition level at which they will maintain their collections. Therefore differences in function and use between city properties and zoos will not be an issue.

In particular for the Houston Zoo, the state of Texas will be required to implement GASB 34 and 35 in fiscal year 2002. The state has established a website to help state agencies prepare for the transition.[19] It therefore even more prudent for the Houston Zoo to adapt such methods as it is considered an asset of the state and will probably continue to be considered such after the privatization occurs.

AZA

Where cities and states report to GASB, zoos and aquariums report to the American Zoo and Aquarium Association (AZA). AZA is a non-profit organization that was founded in 1924. The primary focus of the organization is to promote advancement of zoos and aquariums in the areas of conservation, education, science, and recreation.[20] AZA grants accreditation to those zoos and aquariums that meet certain standards set forth by AZA. The accreditation procedure includes a detailed review and inspection process covering all aspects of an institution's operation including the animal collection, veterinary care, physical facilities, safety, security, finance, staff, governing authority, support organization, involvement in education, conservation, and research, and adherence to AZA policies.[21] A zoo does not have to be a member of the AZA, though most are and the accreditation has essentially become an industry standard.

In order to receive accreditation, a zoo must demonstrate that its facilities as well as its financial accounting standards are up to a certain level prescribed by the AZA. As the accreditation process occurs every five years, a zoo must maintain the conditions of its facilities, as well as its finances during this period or risk not being renewed. Although this process might appear to be well organized, upon examining the standards for facility conditions included in *Appendix 1*, it is clear that the requirements are rather basic and do not begin to define the

physical condition that the buildings must be in. The lack of attention to maintenance issues in the AZA appears to be a common issue. In fact, due to this lack of focus on construction and maintenance issues, in 1994 members of facilities departments of thirty zoos and aquariums joined together to form the Aquarium and Zoo Facilities Association (AZFA).[22] The AZFA seeks to encourage communication between organizations on facility related topics. Its mission is to, "Improve the standards of effectiveness and efficiency among zoo and aquarium construction and maintenance staff."[23] Hopefully the AZA will recognize the importance of such issues in the near future and do more to aid zoos and aquariums in maintaining excellent condition levels throughout their facilities. It would be best if the relationship between conditions, animal health, and visitor satisfaction is made within the AZA first and then disseminated to its members through publications and programs.

The financial requirements set forth by the AZA guidelines are more detailed than those for facilities. The tool created in this thesis will aid a zoo in meeting the financial requirements set forth by the AZA, which mandates certain annual reports including an operations budget detailing income as well as expenditures. In addition, a capital improvements and maintenance program for the upcoming five year term must be included in the report. It is important to note that the maintenance program is looking at all areas of the zoo including pathways, parking lots, and general buildings, not just animal enclosures.[24] This tool allows a zoo to track all of these areas and more if desired. The accreditation report does not require certain reporting standards however, therefore those required by GASB will work well and can be incorporated with the AZA requirements easily and will only raise the level of the reporting, not encumber it.

Brief History of Zoos

Shaped by political and environmental forces since their creation, zoos have undergone drastic changes in size, appearance and focus. In order to understand the function and daily requirements of a zoo and the need for an asset management strategy, like the one proposed in this thesis, it is necessary to present a brief history of the development of zoos and menageries.[25]

The earliest known collection of animals was documented on a stone tablet, which described a collection of animals from the Sumerian city of Ur; it dated back to 2300 BC.[26] Records of collections of animals kept in Egypt date back to 1500 BC.[27] Also, in China the Zhou Dynasty that existed from 1027-221 B.C. kept animals in the "Garden of Intelligence" and in

Roman times there are many accounts of collections of animals kept for the fights that took place in the Coliseum up until 476 AD.[28] Centuries later, kings and conquerors throughout the East kept animals as symbols of power and victory.

Early in the 18th century, animals were still collected and displayed by European royalty as an example of power and wealth. The conditions they lived in were poor to say the least, and the overall design of the cages, most commonly a concrete slab with iron bars, was to facilitate the view of the spectators with no concern for the animals' daily living requirements. These menageries, as they were then termed, were infamous for their poor living conditions and care.

Although menageries became popular destinations, the conditions under which the animals lived remained unchanged. Typical examples of animal housing continued to be barred cages with no place for the animals to retreat from view. Although easy to maintain, animals did not need a building to survive in, but a habitat to live in.

During the 19th century three major events sparked changes in the menagerie and led to the development of the zoological garden. First, the idea of a city was emerging. As many people, industries, and businesses were crowding together in cities, space problems arose and the need to preserve parkland for human recreation and health came to the forefront.[29] The survival of the natural world became an increasing concern, and a hunger for a scientific understanding of wildlife developed.[30] The menagerie moved to parkland, and animals, though still in barred cages, were being displayed alongside plants.[31]

Second, British naturalist, Charles Darwin wrote his book, The Origin of Species by Means of Natural Selection. Theories that arose from this book, termed Darwinism, led to an explosion of interest in natural history, zoology and the study of living beings.[32]

Finally, in this century came the founding of the Zoological Society of London, which aided in the opening of the first real zoo, Regent's Park, in 1826. Although the zoo existed as a menagerie since the early 1700s, sometimes housing its animal collection in the Tower of London, it quickly took shape on its own and was the first zoo with a mission to collect animals for study, not just for entertainment.[33] The animals in the collection were housed in taxonomic lines, demonstrating very scientific approach of the zoo.

The rest of the century led to the emergence of numerous zoological parks in Europe as well as in the United States. It was clear zoological parks were becoming an integral part of life, similar in scope to museums. They offered the visitor a place to escape the hectic style and congestion of the city, while having the ability to relax and enjoy the natural setting of a park. Unfortunately, these parks did not afford the same experiences to the animals. This was due in part to a lack of concern, but more importantly due to the lack of knowledge of how to care for exotic animals. "Animal management, largely by trial and error, was not adequate by today's standards," Linda Koebner writes in Zoo Book.[34] It was often the case that only the trappers and a few others at the zoo had ever seen the animals in their natural habitats. No one took the time to study behaviors or what daily life in the wild consisted of. Zookeepers were forced to guess as to what these needs were.

Animals were often housed alone, even though they might be highly social and live in groups in the wild. Cages were small, barren concrete slabs surrounded by bars. There were no rocks to sit or scratch on, no trees to provide shade, no running water to drink or play in. Needless to say, boredom was common amongst the animals. The only highlights of the day were being fed and possibly being moved so the cage could be cleaned.[35] Again, although the concrete slab buildings were easy to maintain, they provided little enrichment for the animal or stimulus for the visitor.

A revolutionary change in the way animals were displayed came in 1907 with the opening of the Stellingen Zoo. The man who envisioned the design was German animal collector, Carl Hagenbeck. Although Hagenbeck originally was an animal dealer for menageries and circuses, he "dreamed of creating a spacious zoological park where he might display animals in settings that resembled their natural habitats."[36] Exhibits in the Stellingen Zoo had no bars or concrete slabs, but rather were rolling green landscapes that contained many animals and species. Artificial mountains and invisible moats separated predators from prey, while visually keeping them together. One final change was that the animals were displayed according their continent of origin, not taxonomic group. This display technique helped to educate the visitor as to which species were to be found together in the wild and also helped explain, for example, the similarities that animals from the Artic had which differed from animals from Africa.

Regrettably, due to the radical nature of the ideas and the expense involved with constructing and maintaining exhibits of this type of design, much of the motivation provided by

this zoo was quickly lost. The barred and tiled cages with concrete slabs continued, as exhibits turned into architecture showcases with the animals as mere props in the concrete landscape. Trends in zoo design were still not coming from research on animal requirements in the wild, but rather from the current movements in architecture. Jon Charles Coe, of CLR design, summed up the principles of zoo design in the mid 20th century well when he said:

> The hallmark of high-style Modernism of the fifties in zoos was that it was an architectural expression with animals in it. They were beautiful forms and shapes that had almost nothing to do with the animal's behavior.[37]

A classic example of this is seen in the penguin exhibit at the London Zoo. Here a double helix ramp serves as the center focal point of the otherwise boring concrete oval that houses the artic birds. Although the ramp requires little maintenance and is easily cleaned with a spray of a hose, one hardly gains any knowledge about the species or their habitat from this design.

For numerous reasons, change slowly started to occur in the 1960s and later a more aware public was spurred on by the media and such shows as Wild Kingdom, which discussed the fight of animals in the wild from extinction.[38] The TV images of animals running free in open plains were not what visitors were seeing when they went to the zoo. Pressure to make changes in the appearance of the exhibits grew, as visitors were opposed to seeing animals in the isolation of the current conditions. In addition, the problem of depleting natural habitats only continued to grow, and it became clear that zoos were going to be the link to help save endangered species from extinction. Awareness continued to increase in 1973 with the passing of the Endangered Species Act, which attracted attention from the media and was kept in the public eye by animal rights groups.[39]

In 1978, a major revolution occurred in Seattle, Washington. The Woodland Park Zoo under director David Hancocks opened a new gorilla habitat designed by Dennis Paulson, Grant Jones, FASLA, and Jon Coe, FASLA. The design shocked the zoo community, amazed the public, and effectively put the zoo design world on a new track. The exhibit brought a miniature piece of Africa to Seattle and gave the visitor a sense of stumbling upon the gorillas in the wild. In addition, it benefited its inhabitants greatly.

Still in use today, the gorillas are displayed in a troop and live in a habitat that resembles their natural one. The habitat helps to foster natural behaviors such as foraging for food,

wrestling for dominance, and even breeding. The "neurotic behavior" the gorillas were displaying while living in the old exhibit disappeared.[40] The new exhibit shows the public not only the wonder of wild animals in a fascinating landscape but also the importance of the gorillas' connection to their natural habitat. This type of design strategy is referred to as "landscape immersion," a term created by Jones, Coe, Hancocks and Paulson in the 70s, which is still used today.[41]

Anne Powell explained why this immersion exhibit was seen as such a great departure from the traditional zoo design as it,

> . . .reflected a pronounced shift in philosophy from the homocentric view – the zoo as a display of human power over nature-to the biocentric view-zoo as an educational medium that strives to explain the interrelationships between animals and the natural world.[42]

This shift in attitude is still stressed today in exhibits and is even more important as it is a key in the conservation race that continues. Unless we can understand our place on the earth, as part of something larger than humankind, we cannot fully understand the importance of conservation of all living things from animals to plants. The 1978 gorilla exhibit was a crucial turning point that led to increased responsibilities of zoos and organizations surrounding the conservation of animals and plants.

It is clear that during the last two to three decades, zoos have taken on a much higher and more significant level of responsibility. Be they called zoos, nature centers, "animal kingdoms," "bioparks," or conservation parks, the messages they send must be in the same vein. Zoos are not only places of recreation but are also serving as the modern Noah's Ark, as well as educators and promoters of animal welfare and habitat conservation. It is for these reasons as well as other economic reasons that zoos must strive to maintain their facilities and not allow them to deteriorate. It is not an option, but a requirement. Not only do the animals suffer in poorly maintained facilities, but the visitors suffer as well. Zoos with decaying buildings and crumbling sidewalks do not appeal to the general public. This reduces their attendance and thus reduces funding that the zoo would have received through entrance fees and other purchases made while at the zoo. In addition, donors are less likely to give money to a zoo that cannot prove they are responsible enough to manage their facilities. The necessity for zoos to treat their assets like investments and manage them with proper maintenance to preserve or improve their conditions is

imperative if they are going to survive and be able to offer healthy homes for animals to prosper in and visitors to enjoy.

History of the Houston Zoo[43]

Mission of the Houston Zoo:
Nurture the wonder of the diversity and interdependence of life.

Figure 4 *Entrance to the New Children's Zoo at the Houston Zoo*

The Houston Zoo was officially founded in 1920, when the U.S. government gave a single bison to the city of Houston as part of its effort to thin bison herds in national parks throughout the country. This bison, named Earl, was soon joined by a deer to keep him company. In 1922 the "Zoo" was moved to a central location in the city's Hermann Park. A small piece of land was fenced in with wooden cages that held a variety of animals that were once exotic pets of city residents and some circus animals. A year later the Zoo acquired a keeper and soon after with some local help began purchasing additional animals for the Zoo.

In 1925 the Houston Zoo had grown to thirty acres and the following year the first real facilities were constructed for monkeys and birds. Over the next 75 years the Zoo continued to grow, building by building, exhibit by exhibit, and today houses over 5,000 animals of 700 different species on 55 acres of land. Annually over 1.5 million people visit the zoo, which makes it the most visited zoo in all of Texas and the southwest.

Finances

The Houston Zoo is supported financially by three major sources. First, the city gives an annual subsidy to the zoo. This is not enough to cover the basic expenses, which include such things as the salaries of the Zoo's personnel and animal feed bills. The Zoological Society of

Houston and Zoo Friends of Houston, Inc. provide the two additional sources of financial support that help meet financial needs. The Zoological Society operates the annual membership program, as well the concessions and gift stands throughout the Zoo. Profit from these areas goes back into the zoo. Finally, Zoo Friends focus their efforts on fund raising from the public and private sectors for new animal purchases and exhibit construction. The actions of these two organizations free the Houston Zoo staff to focus on care of the animals and the facilities. The Zoo does charge visitors an entrance fee, which would be a source of funding. However, the city currently retains all revenue from gate sales so additional sources of funding are required.

Privatization

The Houston Zoo is currently undergoing a process that will enable the zoo staff to better control the activities and decision-making surrounding the zoo. Although not a true privatization, as the city of Houston will still maintain ultimate ownership, the new plan will remove the city from the responsibilities over the daily running of the zoo.[44] Through the formation of corporations and nonprofit organizations, operations control will be relinquished by the city and given to a newly created Houston Zoo staff corporation.

The process begins with the formation of a Local Government Corporation (LGC) by the City of Houston that will lease the zoo from the city. The LCG will act as the public partner in process and will hire Houston Zoo, Inc. (HZI), a non-profit organization, to operate the facility. The city charter states that it cannot enter into leases with private entities so the LGC is a necessary middleman. The LGC will not be an operating entity, however it will have a board of directors that will interact with the board of directors from the HZI. Its main and only real function will be to hold the lease and in doing so, enforce that the operator, HZI, uphold the operations contract.

The city will pay the HZI to run zoo functions in the form of a management fee. The fee will not cover all of the funds that are needed, but it will essentially be equal to the annual subsidy that is currently received from the city. These actions limit the liability of the city for operations. Currently the zoo operates under the control of the Zoological Society of Houston, which is a 501(3) non-profit corporation. With the privatization of the Zoo, this corporation will dissolve and the HZI will take over management, but maintain the Zoo's non-profit status. It is unclear when the final contracts will be signed to complete the process. Delays have occurred

due to political issues surrounding the Mayor's runoff election. However, these political issues are not expected to affect current plans for the Zoo.

2000 - 2001 Zoo Statistics

In order to understand where annual funding goes, it would be useful to examine the complete annual budget. However, according to the assistant director, Gail Johnson, the Houston Zoological Society does not share budget information with the public. She was able to provide some figures for the 2001 budget, which are in the following table:

Total Combined Budget for 2001	**$17,000,000**
Personnel Costs	$8,500,000
Facilities	$750,000
Grounds Maintenance	$600,000
Marketing	$485,000

Table 1 *Houston Zoo Budget Disclosed for 2001*

It is difficult to draw any conclusions with these figures as they only represent 61% of the budget. Suggesting anything about funding allotment or other trends would be misleading without knowing the breakdown for the full seventeen million dollar budget. In addition, the description of what activities and other items fall under each of the categories is not defined anywhere. Therefore, it is unknown what the $750,000 was used for in Facilities or what the $600,000 covered in Grounds Maintenance. Finally, the assistant director noted that individual costs of such things as renovating buildings or designing new exhibits are not accounted for in specific categories which suggests that the annual budget is very segmented. These facts demonstrate the concern over transparency of spending. Why are the figures not shared with the public or at least other zoos? The zoo industry is not a competitive market where zoos vie for attendance by luring visitors away from other zoos. An environment of sharing needs to be fostered more intense than it currently is. Internally for the Houston Zoo, perhaps they need to examine all expenses in terms of how they fit into and relate to each other in general categories before they are filtered down into their own specific line items.

Current Conditions

Figure 5 *Pheasant Run Exhibit*

There are over 100 structures on Zoo property that include: buildings, cages, and open enclosures, such as the Pheasant Run Exhibit pictured above. Many original buildings, constructed as early as the 1940s, still remain and are used today. The buildings do not share overall appearance traits, as they were constructed piece by piece as the zoo expanded over the years. See *Appendix 2* for additional photos of the zoo.[45] Visitors traverse the Zoo on pathways of varying sizes and material composition that includes, reinforced concrete, granite pavers, brick pavers, scored concrete, patterned concrete and loose gravel.[46] Numerous fencing types from wood to bamboo and wire mesh to concrete are also visible to Zoo guests. In addition, there are a significant amount of landscaping elements present including trees, shrubs and planted beds. This helps the Zoo blend into the neighboring Hermann Park which sits to the north, but despite these elements, there isn't an overall feel that the Zoo takes on which can be felt or seen in looking at the buildings and moving through the exhibits.

It is felt that due to the somewhat confused nature of what group has ultimate responsibility and control, issues of funding, and lack of personnel has led to deterioration of the

Zoo's assets. The hope is that with the formation of the LGC and HZI and with the use of a conditions and maintenance tracking system, such as this one, the Houston Zoo will be able to tackle its maintenance backlog and proceed with its new master plan, shown below.

Figure 6 *Houston Zoo Proposed Master Plan*

Facility Management Procedures

Mr. Fred Maier is the current Senior Superintendent of Facilities and Grounds. He has been with the Houston Zoo for over twenty years and has an extensive knowledge of the collections and landscaping. However, he is the only one with this comprehensive knowledge. This is a dangerous situation for obvious reasons. Although the facilities department currently stores some information on computer, there is no network that enables the information to be shared among multiple members of the staff. In addition, the Zoo does not employ any program that stores information on past maintenance items, expenses, and future items that allows for easy access and analysis of the data. This is a detriment to the facilities department and zoo as a whole. They are in need of a computer network throughout the Zoo and a process for tracking work to be done as the current method is not only time consuming, but also inefficient. The current process for completing a repair activity by a member of the zoo staff is the following[47]:

1. An animal keeper notices an issue and notifies the exhibit curator. Approval to report the item is given or denied.

2. The keeper fills out a three-part form, submits it to the facilities department and retains a copy for their records.

3. A member of the facilities department enters the item into the computer and keeps a copy of the original form. A work order is then generated and the final copy of the form is sent to the maintenance department where the appropriate tradesman is assigned the item.

4. Once the item is completed the tradesman fills out the time the job took and what materials were used and then sends the form back to the facilities department.

5. A member of the facilities department enters the new information and closes the work order in the computer.

6. A weekly report is produced of the items.

A great deal of this process is done on paper. Therefore simply moving it to an electronic format will result in increased efficiency. In addition, maintenance data can be combined with financial data and then be easily access for analysis. Clearly the Zoo needs a direction to move towards to be able to meet the challenges that face them and most zoos in their position. The prototype tool developed in this thesis has the capabilities to do just that.

The Software Tool

Motivation for Design

Once again, the connection between failing infrastructure conditions, animal health, and guest satisfaction is not one that many make easily, including those that run zoos. The truth of the matter is that all are inextricably linked and the lack of general understanding of this fact is a detriment to facility funding and conditions management. To further this, without substantial data that proves a zoos requirement for funding for reactionary and preventative maintenance along with needs for preservation and improvement funding it is difficult for zoos to attain the needed financial support. Simply stating, "we need more money" is not enough.

Complicating the situation further is the fact that many zoos still have not moved to computers to track maintenance activities and expenditures. Their work order and data storage systems still exist primarily in paper form. Besides the clear inefficiency of this type of system, with data missing or in hard to use formats it is difficult for well-informed decisions on funding, spending, major projects and other needs for the future to be made, as analysis on the data does not yield a complete representation. This thesis proposes a solution to aid the decision making process while tracking data that may then be used by multiple departments for analysis purposes. There is one major component involved in the solution, a comprehensive, referential database. The database is designed to capture all relevant data regarding maintenance, preservation and improvement activities from the description of the problem to the final cost and time to complete. The benefits of having this information have already been discussed and are not in question; rather it is the ability for zoos to create or purchase such a tool on their own and then implement it that has and continues to be the issue for many.

The benefits of the database tool are numerous. First, it will benefit the finance department as each activity is captured and may be assigned a cost in terms of labor and materials. All of the data is sortable and can be used to analyze past and current conditions and expenses. Therefore, the analysis will serve as a way to accurately predict future expenditures and needs for budget making purposes or in order to acquire funding from outside sources. Second, the tool will assist the facilities department as work orders may be generated, tracked, assigned, and closed all in one place. Lost work orders and small projects that typically get

pushed to the bottom of the pile will no longer be a problem since once a work order is entered, it is in the database forever and may be tracked and located in a variety of ways. Finally, if a zoo captures all of the activities that relate to maintenance, even minor ones such as replacing filters or changing light bulbs, they can create a comprehensive preventative maintenance program. Armed with a preventative maintenance program zoos will be better equipped to be proactive in their scheduling and completion of routine activities and as a result, assets will not deteriorate at the same rate. Such a program will help end the general "fix it only when it breaks" theory that many zoos are forced to operate under due to lack of funding or just a lack of knowledge.

All of these benefits are possible with the use of the tool, however it is important to reiterate that the ultimate goal of this thesis is not to create a perfect and completely comprehensive software tool. The thesis is not based in the computer science department, but in the civil engineering department and it would take more than a single person and a few months to research, design, test, and build a software program. Rather, the thesis creates a tool that is a representative extension of the ongoing research in infrastructure management in the Civil Engineering department at MIT. As discussed earlier, software tools do exist that focus on maintenance and asset management, however in their quest to be used in multiple industries, they fall short of the needs of zoos and aquariums. This suggests that either the software manufactures need to focus energy on modifying their existing product to meet the specific needs of zoos and aquariums or continue without change, suggesting that this market is not one that they want to compete in. In either case, the fact that such tools exist that deal with asset management validates the work that has gone into this thesis proving that that there is a demand for a software tool to mange assets for zoos.

The tool created in this thesis uses readily available programs with a user-friendly environment which creates the potential for zoos to implement this tool now. It will allow them to begin tracking data with a small learning curve and expense, which are both significant issues that at the onset of the research needed to have solutions. The how to section of this thesis is enough to allow zoos to begin using the programs and capturing their data. With this in mind, the following sections explain how the design of the tool progressed, the two software programs involved, and finally demonstrates how to use the tool along with a section that defines all of the variables used in the database.

Design Process

As stated, one objective for the tool is to work with software programs that already exist and are readily available. To accomplish this goal the two programs used are Microsoft Access 2000, for database creation and data collection, and ESRI's ArcView GIS 3.2, for visually connecting with data via an interactive plan. Although MS Access 2000 is essentially the only tool needed to manage the database, ArcView GIS 3.2 has capabilities that allow the user to interact with the data via the easily recognizable zoo plan. In addition, when queries are run on the data in ArcView GIS 3.2, the results can be displayed on the map providing excellent visual reference or in a table format, which may then be exported and used in other programs if desired.

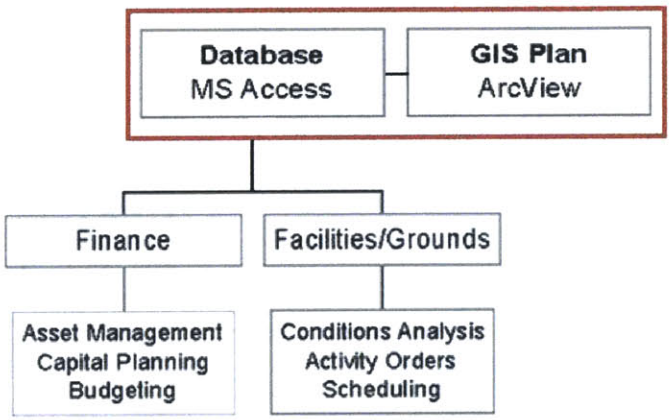


Figure 7 *Software Tool Components and Relation to Zoo Departments*

The figure above shows that in addition to the database component, the tool also uses GIS technology to make storing, accessing and analyzing data easier and more complete. This module provides a visual interface with the data that offers benefits of its own in terms of it day to day use and for data presentation purposes. This part of the tool will be explained in more depth later.

Database Design

The first step in creating this tool was to design a framework for the relational database. In order to do this a clear understanding of what the needs were in terms of GASB's Statement 34, as well as in terms of what data was needed to aid zoos had to determined. A skeleton for the database design was created and then that design underwent a process of modification during the

research. In order to meet the needs of GASB, the basic design of the database started with the model prepared by Professor John B. Miller for testing in Winchester, Massachusetts. That design was then modified and adjusted to meet the needs of a zoo, which are different in some ways from that of a city. The Winchester test database contains over 50 tables. Therefore, Figure 6 shows only a portion of the relationship layout for the database. Figure 7 shows the entire layout for the Houston Zoo test database, which is composed of 21 tables. A larger version of the zoo database is attached as *Appendix 3*.

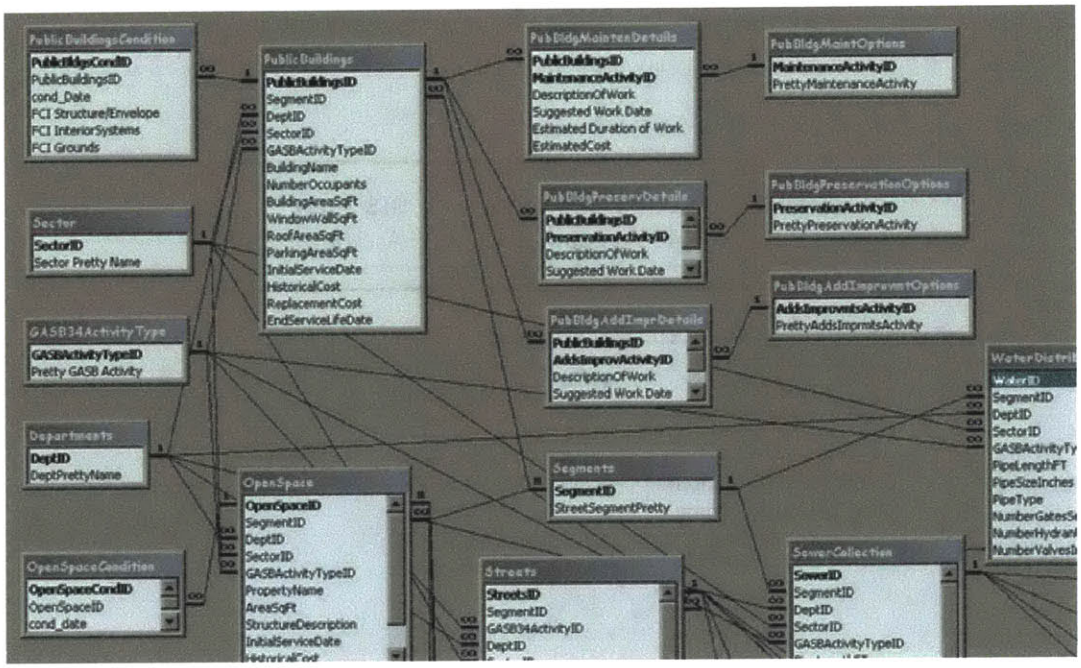


Figure 8 *Portion of the Winchester Test Database Relationships*

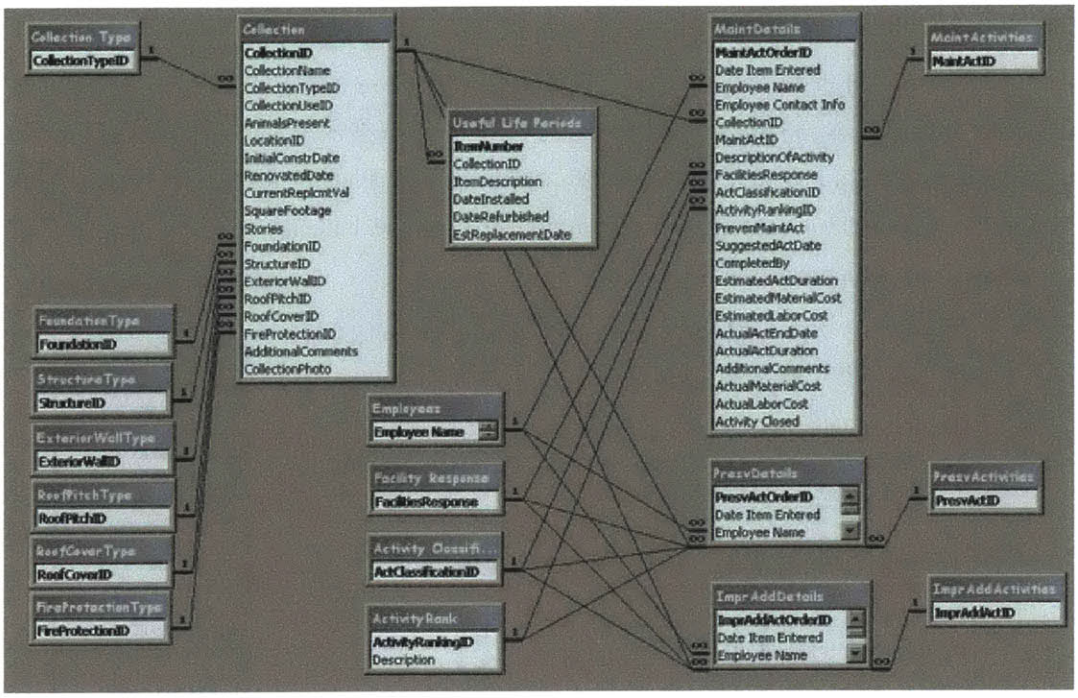


Figure 9 *Houston Zoo Test Database Relationships*

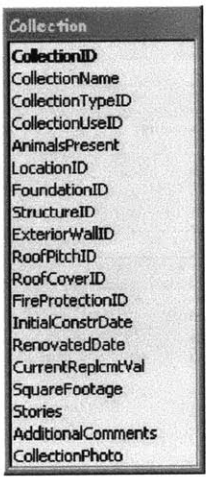
The tables in the Houston Zoo database are connected via "one-to-many" relationships, which is one of the three options used in Access. This type of relationship allows multiple collection items such as the Bear Dens and the Gorilla Habitat to have the same description where applicable, such as the fact that they are both slab-on-grade structures and have pitched, built-up roofs. Without this type of relationship the database would be unnecessarily large or would not be able to accommodate similar attributes of different buildings.

The information gathered by each of the main tables is described below. First the general idea of what information the table seeks to capture is described, and then each column/field is defined. If the column is a reference for a look-up table that is noted. A look-up table is a way of limiting the choices for a column to a predetermined set. The look-up table may be added to if desired, but its use prevents users from entering random data in that column. In addition, the Primary Key which is the column that contains a unique identification for each record in each table is noted after the column name by an asterisk "*." For definitions of the tables not included here, see *Appendix 4*.

Database Table Descriptions

The first and perhaps most important table is ***Collection***. This table stores information about the structures on zoo property or the assets of the zoo. In it each building, cage, enclosure, and barn is assigned a unique number and the commonly used name for the building may also be added. This table also captures general information on the building that includes, date of construction, location, replacement value, and function.

CollectionID* – Contains the unique number for each collection item in the zoo.



CollectionName – Name used at the zoo for the collection item. Some collection items did not have a specific name associated with them. They are left as "Unknown."

CollectionTypeID – Describes whether the collection item is a building, enclosure, pool, yard, or site work element. It references a look up table, *Collection Type*, that limits the description to a set of six choices.

CollectionUseID- Describes if the collection is accessible by Zoo Staff only or Zoo Staff and the public. It references the look up table, *Collection Use*.

AnimalLifeID – Lists whether animal life is present in the collection item or not.

LocationID – The zoo is divided into five areas: North, South, East, West, and Central. This column notes which section the collection item is in.

The following six columns capture information about the characteristics of each collection item. Each column references a look up table for the descriptions. The tables were designed this way to make the data easier to analyze by limiting subjective descriptions of the collections. The descriptions for the six tables were modified from ones used by the standards of the Uniformat and RS Means categorizing descriptions. They are meant to be somewhat general, but with enough detail as to provide an accurate description of each asset.

FoundationID – Describes the foundation type of the collection item.

StructureID – Describes the main type of material used for the structural system of the collection item.

ExteriorWallID – Describes the material of the exterior wall system.

RoofPitchID – Lists if the roof is pitched, flat, or a combination of the two.

RoofCoverID – Describes the type of roofing material or system used to enclose the building.

FireProtectionID – Identifies the type of fire protection system used in the item.

Often a building is not composed of just one material. In order to deal with situations where combinations of materials are common, such as with CIP or CMU walls the description chosen is representative of the majority of the feature. For example, if an exterior wall is composed of 65% CMU and 35% CIP then the wall is considered to be CMU for the purposes of this database. If an unusual combination occurs the option for "Other" is included as a choice. In addition there is a column, "Additional Comments" in the Collection item's record in case further explanation needs to be made.

InitialConstrDate – Initial date of construction of the collection item.

RenovatedDate – Date the item was renovated, if at all.

CurrentReplcmtVal – Current replacement value of the collection item.

SquareFootage – Lists the area of the item in units of square feet.
Stories – Lists number of stories.

AdditionalComments – Column to enter any additional information on the item if necessary.

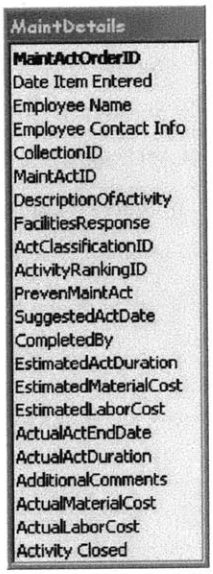
CollectionPhoto – Provides a link to a photo of the item if desired.

It is important to note that the term *collection* implies more that just a typical building. It could be a cage, an exterior enclosure, or it could be a landscaping element. For this small scale, under 100 collection item records, it made sense to keep everything together. For larger zoos, the database might be structured differently and for example have separate tables for buildings, landscaping elements, and site work elements. Also, the database accounts for the fact that certain things might not be known about a building. Therefore where a value of "0" or "Unknown" appears it means that these attributes are not known for the asset.

The next three tables, **MaintDetails, PresvDetails**, and **ImprAddDetails** capture details about the actual activities that need to be completed at the zoo. The tables are similar in all columns except two. The first column is the primary key for each table and the second is the column that lists the activity choices. The tables are designed so that anyone at the zoo may enter an activity. In fact, while capturing vital information for the asset management program, these

tables can function to produce work orders, or as they are called here, Activity Orders. All three names of the tables are listed before the definition when they contain columns that are different.

MaintActOrderID*/ PresvActOrderID*/ ImprAddActOrderID* – This column is an auto number that creates a unique number for each activity entered. The user does not enter this as it is created automatically by the program.



Date Item Entered – This is the date the item is entered on. It should be the same date the problem is noticed or the decision to go ahead with a major project is made.

Employee Name – Name of the employee who noticed the problem or who is entering the data. This column is linked to a look up table that contains the names of all zoo employees to make data entry easier. Names of the staff members at the Houston Zoo were not entered into this table, but rather just a few in order to demonstrate the concept.

Employee Contact Info – Phone number or email address for the employee who noticed the problem so she/he may be contacted for further information on the activity.

CollectionID – Number for the collection item. This is a foreign key that references the numbers from the table **Collection**.

MaintActID/ PresvActID/ ImprAddActID – These columns list the possible choices of activities. They all reference look up tables that contain the descriptions.

Each look up table, **MaintActivities**, **PresvActivities**, and **ImprAddActivities** contains a set of two to seven activity descriptions for the user the pick from. For example in the maintenance table the activities to choose from include: Clean, Paint, Regrade, Repair/Fix, Routine Inspection, Routine Testing, and Routine Treatment. The sets were created to help group activities into finite categories that will aid facilities staffing and financial analysis.

DescriptionOfActivity – Area for detailed description of the problem or reason for completing the activity.

All of the columns above contain data that may be entered by any member of zoo staff. The following columns capture data that is specific to the facilities department and the finance department. A member of the facilities department should enter data for the following columns.

FacilitiesResponse – Lists whether the activity is accepted, rejected or should be investigated further.

ActClassificationID – Categorizes the activity into one of four areas that describes whether the action is affecting something non-structural, structural, a service, or a site item.

The purpose of categorizing an activity into one of these four areas is to provide more specific analysis of expenditures. Often the decision that a zoo will be trying to make is whether to outsource an activity or use staff labor to complete the activity. The finances director may sort the expenditures based on these categories, which will provide knowledge on the amount of money spent in each category. This information can aid decisions on what skills facilities repair personnel need to have, if new staff members need to be added with specific talents in areas with the majority of expenditures, or if outsourcing of some of these areas would be the best use of funding to tackle the activities. The four main categories to describe the activities are: Collection Structural, Collection Non-Structural, Collection Services, and Zoo Site/Grounds. Below are the areas that fall under each category:

Structural	**Non-Structural**	**Services**	**Zoo Site/Grounds**
Foundation	Window	HVAC	Drainage/Sewer
Column Structure	Exterior Door	Fire Protection	Site Irrigation
Beam Structure	Exterior Stairs	Electrical Service	Pavement
Floor Structure	Interior Floor Finish	Electrical Lighting	Pathway/Sidewalk
Wall Structure	Partition Wall	Plumbing Inflow	Plazas
Roof Structure	Interior Door	Plumbing Outflow	Fencing/Curbs
Exterior Wall	Ceiling Finish	Elevators	Retaining Wall
Roof Covering	Interior Stairs		Artificial Rock Form
	Furnishings		Pools/Moats
	Equipment		Ground Cover/Plant

Table 2 Activity Classifications and Attributes

ActivityRankingID – Choice of one to five that determines the urgency of the activity, with one being the most urgent and five being the least. This column references a look up table, **ActivityRank**.

The exact definitions for each ranking are just suggestions. Each zoo should ultimately determine these, as they know what will best serve their purposes. They might only want to have three categories such as urgent, semi-urgent, and non-urgent.

PrevenMaintAct – Check box that determines if the activity should be included as a preventative maintenance item in the future.

SuggestedActDate – Estimated date the activity will be completed by.

EstimatedActDuration – Estimate in man-hours for the length of time that the activity will take to complete.

EstimatedMaterialCost – Estimated cost for materials to complete the activity, if any.

EstimatedLaborCost – Estimate of the cost of labor to complete the activity.

CompletedBy – Lists the facilities employees that the activity is tasked to, to complete. If the activity is to be done by an outside contractor, "outsourced" should be chosen.

If the zoo desires, the *CompletedBy* column can be linked to a look up table for facilities employees only, which may contain such information as: areas skilled in, skill level, scheduled vacations, and hours per week that are worked. These pieces of data will give the facilities manager the most information that she/he needs to set the schedule of work for the upcoming time period. In addition, the look up table may contain information on salary, broken down by hour, to aid the labor cost estimates. For privacy purposes certain columns can be protected by password so that only specific staff members may access them.

The combination of the remaining five columns can help to determine if the activity should be outsourced or should be completed by staff, in-house. In addition, they are where the finance department will retrieve their cost data for all completed work. These fields were left blank in the actual database, as the data can only be inputted once the activities are complete.

ActualActEndDate – Date the activity was completed.

ActualMaterialCost – Cost for the materials used, if any.

ActualLaborCost – Cost for labor used in completing the activity.

ActualActDuration – Duration in man-hours that it took to complete the activity.

AdditionalComments – Area where follow up comments or any comment about the activity may be made.

A close examination of the structure of the database reveals that this is not the most efficient design, as all but two fields are repeated in the three tables for maintenance, preservation and add/improve activities. It was designed this way however to reduce the decisions the user will have to make while inputting data and therefore lower the chance of user error. Although the three GASB distinctions for activity types are valid and useful for accounting purposes, every user of the tool will not and should not necessarily have a 100% understanding of what activities

fall under each category. During the research for this thesis, general activity types for each of the categories were established by looking at the actual activities that are done at the Houston Zoo and then creating general categories that the specific activities may be classified under. In the database, by separating the maintenance, preservation, and improvement/addition activities into three tables it is almost a guarantee that the user will enter the activity in the correct GASB table and therefore an accurate picture of where expenditures are being allocated can be calculated. This is because the actual activities are separated into the three tables and a user will not be able to choose a maintenance activity such as "Routine Treatment" and classify it as a preservation activity since it is a maintenance activity and is not listed under preservation activities. The goal is to have each activity be categorized correctly into one of the three GASB choices at a 100% level of accuracy within the given framework. Due to the fact that MS Access 2000 does not allow for "if-then" statements, which would allow the user to first pick the activity description and have the GASB activity selected automatically, the database must be designed in this fashion for the sake of accuracy in data classification.

The final major table is called **Useful Life Periods**. This table stores information on significant pieces of equipment and collection elements that will need to be replaced or refurbished. It tracks the end date of the useful life, or life span, of the item so that the zoo can budget for the cost associate with its replacement or refurbishment and the facilities department can schedule the staff associated with such major activities.

ItemNumber* - This is a number given to the equipment or element.

CollectionID – Identifies within which collection item the equipment or element is located. This column is linked to the ***Collection*** table.

ItemDescription – Description of the item.

Items that can be tracked in this table include, heating units, A/C units, exhaust fans, boilers, electric circuitry, fire suppression systems, roof enclosures, exterior wall cladding, and any other items that would require significant funding to replace.

DateInstalled – Date the item was initially installed.

DateRefurbished – Date the item was refurbished, if any. This should extend the lifespan of the item and would presumable affect the following column.

EstReplacementDate – Date the item would need to be replaced or refurbished, according to its lifespan calculation.

Although items may continue to be useful after their lifespan passes, they also often malfunction prior to that date. Therefore it is up to the facilities and finance departments to note the replacement dates and work on a strategy to make sure there is adequate funding for the replacement of the item in advance of the replacement date. In addition, before the facilities department might make a major, costly repair on a item they should consult its replacement date to see if it would be more cost efficient to simply replace or refurbish the item rather than just fixing a portion of it.

All 21 tables that compose the database were mentioned in this section. The most important tables were discussed in detail, including definitions for the columns. For a description of the other tables along with a definition of each column, see *Appendix 4*.

Visualization Design

The second major component of the tool is the ArcView GIS 3.2 program, which utilizes GIS technology to enable the user to interact with an electronic plan of the zoo. This facilitates analysis of the data stored in the database and even allows for the updating of the database to be done in this program rather than in Access. The next section is a brief description of GIS and its capabilities followed by a description of how the plan for the zoo was converted from AutoCAD into a useable file in ArcView.

Geographic Information Systems

In its most basic definition, a Geographic Information System (GIS) is a way to visualize, manipulate, analyze, and display spatial data.[48] The data can come in two forms, raster or vector. Raster data is a grid of information that contains a location and a value, such as an aerial photograph or a satellite image. Vector data, on the other hand, may contain points, lines or polygons, which have links to attributes such as type, age, or length.[49] The attribute information comes from databases that are linked to the data sources. The result is a spatial map that visually displays the information.

A GIS could bring together data on population density along with information on public school locations to help a local government find the best site for a new elementary school. A GIS

could also be used to identify patterns such as areas of high pollution, street intersections with the most accidents, or cities with the lowest voter turnout. Finally a GIS could be used, as it is in this thesis, to track infrastructure maintenance activities and thus be used as a decision making tool for among other things, investing funds and creating annual budgets for maintenance, preservation and additions.

Using software programs that combine the information in a database with a two dimensional map, such as Arc View, users have the ability to interact with the data and find out specific information by using *queries*. Queries are essentially questions asked of the database to extract specific data. The answers to the queries are displayed both in the maps and can also be displayed in table format, providing the most clarity. The section *Querying the Database in MS Access 2000 and ArcView GIS 3.2* shows step-by-step how to use Arc View specifically for displaying and manipulating the data for the Houston Zoo. After reading this section the benefits of linking the Access database with the zoo plan in ArcView will be clear.

AutoCAD Conversion

In order to have a plan of the zoo that the user may work with in ArcView GIS 3.2, it first had to be created in a CAD program, such as Auto CAD. The plan of the zoo that users interact with in ArcView was imported from the program AutoCAD. Morris Architects in Houston, Texas did the plan in preparation for the new master plan that the Zoo is implementing. (See Figure 6 for the master plan drawing.) Although having a plan to begin with was helpful, significant work was done to clean up the drawing so that it could be used in this project. There were multiple layers that represented the same thing, but slightly askew from one and other. There were lines upon lines, often up to four sets of the same line stacked upon each other. This added to the size of the drawing and if left unchanged would have negatively impacted the use of the plan in ArcView. In addition, the drawing seemed to be incomplete in areas as paths ended in the middle of nowhere, buildings were missing sides, landscaping beds looked like small cages, and often buildings were indiscernible from site elements. The legend included with the plan was incomplete and in some cases incorrect. The layering system used was a confused mix of names and numbers, which did not follow any apparent logic. Using aerial photos and a caricature map of the Zoo, assumptions on building footprints and exhibit boundaries were made.[50] Once the drawing was simplified, each collection item was given a unique identifying number that was entered into the database along with the item name, if known. The outlines for the collection

items were then converted into closed polygon shapes and all assigned to one layer called *Collection* and ultimately saved into a CAD file by itself.

After the plan was completed in AutoCAD it had to be imported into ArcView and then converted into a shapefile. Ideally, this should have been able to be completed in two steps, however there were some significant issues that had to be dealt with in order to get the plan to its current state. The first step was to create a new *Project* in ArcView. A project is the file that stores some information, but primarily points the program to retrieve specific data files used. When data is imported into ArcView, the program simply stores the link to find the information on the computer, it does not make the data part of the project. After this is done, information may be brought into the project as a *Theme*. A theme contains a layer of information and may be turned on or off to display the data in the project window. The number of themes created is up to the user and should be based on how the user wants to display and use the data. Next, ArcView has an extension for working with CAD plans called, *CAD Reader*. With this extension turned on, the CAD plan was brought into its own theme using the *Import* command. From there, the plan needed to be converted to a *shapefile*. In this form each of the 98 collection items are treated as individual units. This is an important step to enable the link with the Access database and the Houston Zoo plan. Unfortunately, this is where numerous problems were encountered.

The makers of ArcView GIS 3.2 state that using CAD plans in the program may be done with ease, however this thesis shows the opposite. Although it was easy to bring the CAD plan into ArcView and look at it, converting it into a modifiable shapefile was not. Presumably if all of the shapes or polygons that are in the CAD plan are clean, meaning that they are completely closed around all edges, one would only have to select the theme the plan is in and choose the command, *Covert to Shapefile*. In this case, all that did was make the entire plan a shapefile, not the individual collection items themselves. This was not an acceptable solution, as each item must be able to be studied individually. In order to circumvent the inability of ArcView to do this, the aid of the Information Technology Department at MIT was used and resulted in a shapefile that met the goals of the project. The following steps were taken to correct the problems of using the CAD plan in Arc View.

To begin, the AutoCAD plan was simplified down to contain only four layers of information, one for the collection item outlines, one for the pathways, one for the alphanumeric grid system and one for an outside box that set the boundaries of the map. The last layer had to

be added in order to set the extents for the view. Next, three separate CAD plans were created each containing only the outline, pathway or grid layer and the box to maintain the extents of the drawing.

From there each drawing was imported into ArcView as a theme. The drawing that contained the collection item outlines was converted into a shapefile and taken into ArcInfo. The command "Shapearc" was run on the file to create an Arcinfo format or a coverage. The coverage was then built as a polygon coverage using the "Clean" command and finally the "Arcshape" command was run to return the current file to shapefile format.[51]

These steps appeared to convert the file into a clean shapefile with individual collection items. However, the collection items could not be modified or moved, which had to be done as some difficulties were encountered with the coordinate systems of the various themes. Upon examination of the shapefile it appeared that there was something wrong with the file structure. To correct this, the shapefile was imported, via the "Import Shapefile" function into a GIS file editing program, CartaLinx, to try and recreate a correct file structure. This program automatically builds topology when it imports a file. Once the building process was complete, the file was exported back into the shapefile format.[52] The resulting file was imported into ArcView using the "Add Theme" command and was thankfully editable. The exact themes that were added to the Houston Zoo project are discussed in the section, *Viewing Data in ArcView GIS 3.2*. In addition the link between the Access database and the ArcView project are discussed.

Populating the Database

In order to verify that the database design was efficient, it had to be populated with data and then tested by running analysis on the data. As stated earlier, the records that the zoo has on its structures and activities is scattered and in paper format. In the past few years however, the zoo has commissioned numerous organizations to do audits on current conditions and suggest actions to rectify the current issues. In April of 2001, the Dallas based company, Building Solutions Inc. finished a facility audit on 65 of the buildings on zoo property. The audit identifies maintenance issues for each building and suggests actions for the next three years. It appears to be rather thorough, to the point where removing debris from a drain with a value of $5 is included as repair item along with major system replacements with values of over $90,000. However, no information was provided on the estimated length of time that a repair would take or the

suggested date that the repair should be completed by. Repairs were categorized with an importance level of one, two, or three which then corresponded to getting the repair completed in the year 2001, 2002, or 2003. Within the audit, activities are first categorized by building and second categorized by area of repair that is specific to the Building Solutions Audit (BSA) such as, structural, exterior, roofing, mechanical, electrical, and code/fire protection.

There are 732 repair activities suggested in the BSA. In a June meeting with the Assistant Director and Senior Superintendent of Facilities and Grounds of the Houston Zoo, it was suggested that these activities be used to populate this test database as collection of information was going to be difficult for the zoo personnel to complete in a timely fashion and it appeared that they didn't have the capabilities to do so. Therefore, once the database design was complete, each activity from the BSA that met the criteria for entry into the database was categorized by building and then entered as a *Maintenance*, *Preservation* or *Improve/Add Activity*. It is important to note that the BSA only looked at 65 buildings whereas there are over 100 on the property. In the database all buildings, enclosures, cages, exhibits, parking lots, and major landscaping elements are accounted for with at least a unique number and name if possible. Filling in the remaining collection data is up to the Houston Zoo. Since the records are already established, once data is filled in it will be able to be accessed through the Arc View program and will not require the Zoo to make any changes to the AutoCAD plan or database.

For the purpose of populating the thesis database with useful information so that its analysis properties could be demonstrated, a few assumptions were made. First, using just the year for the "suggested activity date" in the database was not acceptable. If the tool is to function as a scheduling device, exact dates for activities to begin or end on must be inputted into the file. Therefore, for each year, 2001, 2002, and 2003, the beginning of the forth quarter, October 1st was used for "Suggested Activity Date." The "Estimated Activity Costs" provided by Building Solutions were used as in their calculations they provided for a three percent inflation rate.

According to GASB regulations individual organizations have the ability to choose the monetary threshold above which activities will be counted. The logic is that for some organizations a $5 activity might be the smallest level that needs to be accounted for while, at another organization a $1,000 activity might be the cut off. This database is designed so that any activity from $1 and higher may be accounted for with the idea that the zoo might want to record small denomination tasks such as light bulb replacement and ceiling tile replacement to

understand what percentage of the annual budget is spent on minor repairs and also to create a comprehensive preventative maintenance program, which includes many smaller tasks. Although these tasks are minor, if left undone they can create significant problems for systems and buildings. As noted, the Building Solutions Audit for the Houston Zoo included tasks that ranged from $5 to $90,000, however, activities under $100 were not added to this database, as only a few existed in the entire BSA. If the audit is truly indicative of the items to be done at the Houston Zoo it would stand to reason that there should be many more of these minor activities. There seems to be a disconnect in the analysis to only have the few that it contains without others of similar scale.

This tool will be most beneficial after a few years of data is collected. Then patterns will be seen, preventative maintenance can be extracted from other items, and predictions can be made. Therefore it is important that zoos begin to collect their own authentic data as soon as possible. In addition, the BSA does not assign a dollar value to activities that can be completed by in-house staff. It is unclear if the dollar amount of the repair includes material costs and/or labor costs, therefore for the purpose of this analysis all costs were assigned to materials.

Once all 732 suggested activities were sorted through and accepted or rejected, a total of 487 activity records were added to the database. Analysis was therefore completed using these records.

How to Use The Tool

Now that the construction of the database and GIS link have been explained along with the specifics of the tables in the database, the use of the two programs must be covered. Therefore in this section, data entry in the Access database will be explained along with the use of the ArcView tool. Finally, analyzing data with the use of queries will be explained for use in both the Access and ArcView programs.

Data Entry in MS Access 2000

Entering Data Directly into a Table

Information may be entered into an MS Access 2000 database in two ways, either by entering it directly into the table or with the use of an Access Form. Entering a collection item into the **Collection** table will be used to demonstrate both ways. In order to enter data directly into the table one starts by opening the table called **Collection**. Once open information may either be edited by going to a specific cell and changing the data in it or by going to the bottom of the table and entering data in a new row. For demonstration purposes the last item entered, Collection Item 98, The Desert Prairie Building, will be used to explain the process.

The first step is entering the *CollectionID* number; in this case that is 98. As noted earlier, this number must be unique as it is the only way to identify the collection items throughout the database. The second column asks for the name of the collection item, in this case "Desert Prairie Building" is filled in. In Access there are two ways to enter data within each cell. The information to be entered is either up to the user and might have minor constraints such as: information must be entered in as a dollar amount, or in a specific date/time format, or the entry simply must be a number, as it is in this first cell. If the data is entered in incorrectly, an error window will be displayed directing the user to enter the data correctly. The other way that data may be entered is through a drop down box that is fed information via a lookup table.

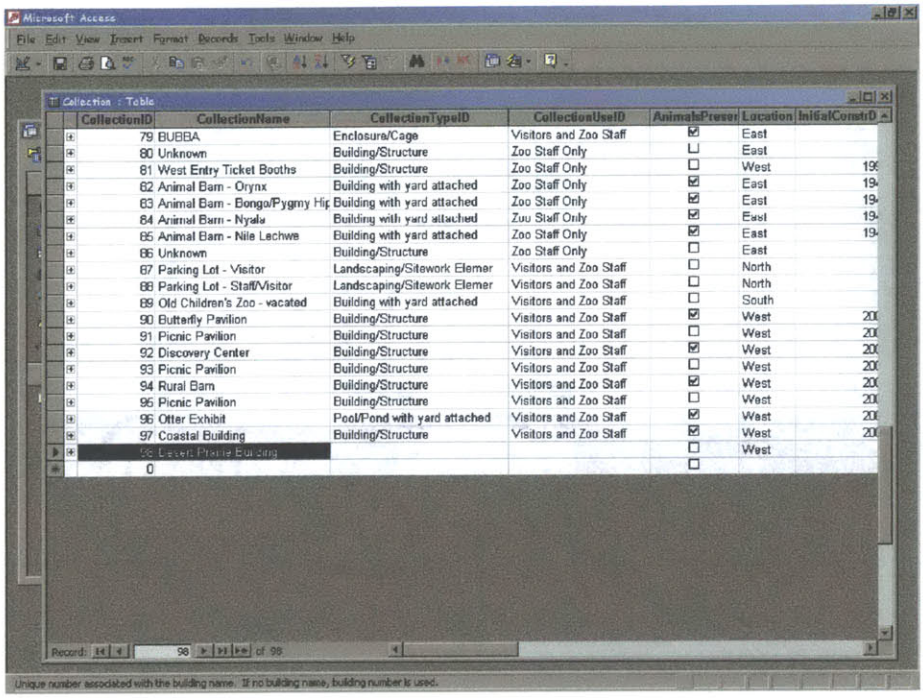


Figure 10 *Collection Table – Step 1*

The first column of this type is *CollectionTypeID*. When a user moves the cursor into this cell the gray box on the right side of the cell appears and when clicked, it displays the possible choices in a dropdown menu box. Once selected the choice appears in the cell. Using lookup tables as part of a database design is effective if multiple users will be entering information, therefore the use of predetermined data will reduce entry errors or in the case where the data to be entered needs to be restricted, perhaps for analysis purposes, and limiting the choices is desired. If by looking at the column name the user does not know what information is to be entered into to cell, a description of the column is shown at the bottom left side of the Access window. This information is entered in the "Description" section of the table design view window and is useful to clarify the data to be entered in that column cell. After *LocationID* is entered, the next five columns contain information relating to the construction dates, cost, and some basic item information that is not easily entered using a lookup table. These are good examples of data that should be entered by the user not with dropdown menus.

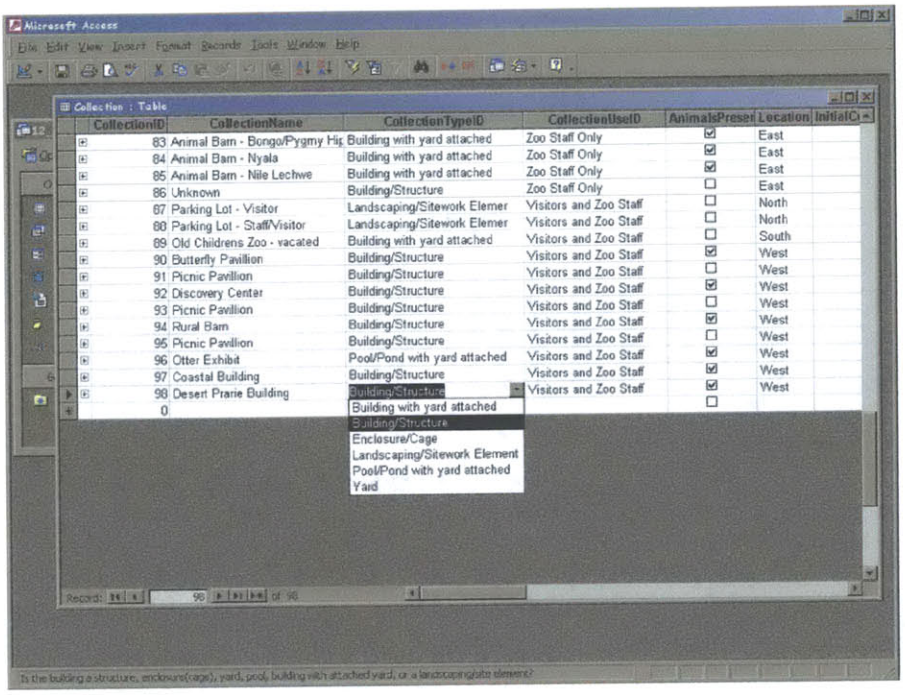


Figure 11 *Collection Table – Step 2*

The next six columns capture the characteristics of the collection item and each reference lookup tables for their choices. Next, the *AdditionalComments* column provides space for written comments on anything relating to the item and therefore allows for a lot of information to be stored. This column is a "memo" type, which in Access means that there is no limit on the length of data that can be entered. In fact, multiple sentences may be entered into it. The last column, *CollectionPhoto*, is where a link to a photo of the collection item may be entered. The photo is not seen in table view, but the link is shown.

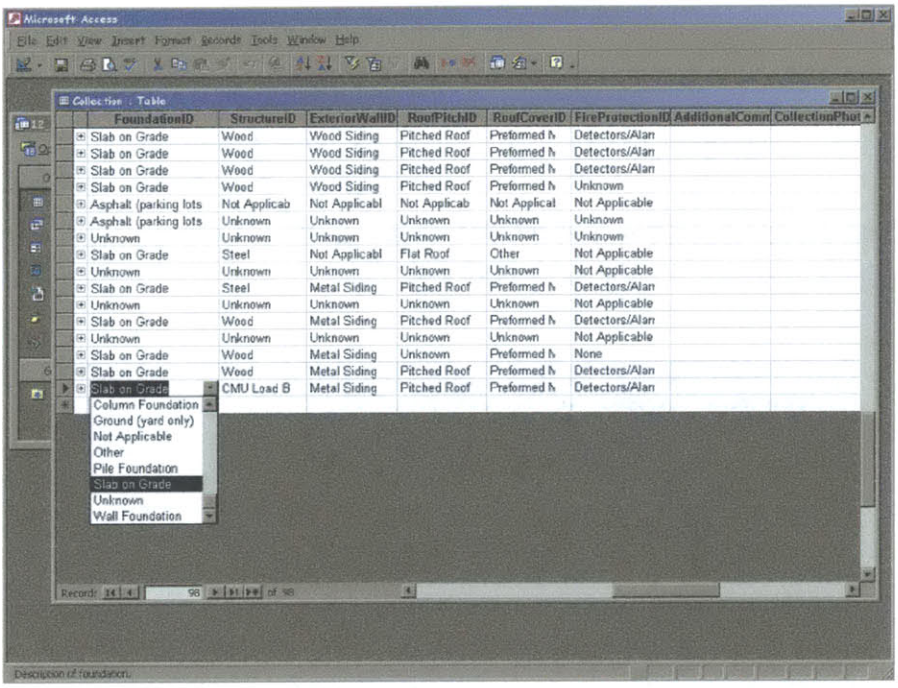


Figure 12 Collection Table – Step 3

Some columns contain information that is not required, such as construction dates or square footage, but other columns are required such as *CollectionID* and *LocationID*. If an item is required and not entered, an information window will appear directing the user to enter the information before moving to the next column.

Although entering data in table format is useful if comparisons with previous entries need to be made, there are limitations of using this view. For example, the last two columns are good examples as to why one would want to enter and view data in a form, rather than in table format. In order to see all of the information stored in the *AdditionalComments* column, the column width would have to be increased to the full length of the comment. This is not very efficient and only increases the overall length of the table. In addition, if a photo is linked to the record, it will never been seen in this view. The following section describes the use of a form to enter data using the same table, **Collection**, and the same record, Desert Prairie Building, for continuity.

Entering Data Using an MS Access 2000 Form

MS Access 2000 has an interface for entering and viewing data called a form. When data is entered into a form it is actually being entered into an existing table. Form layouts may be designed or created using the Form Wizard provided by Access. The following is the form layout for the **Collection** table. Although initially created using the Wizard, the layout was altered later to make data entry efficient.

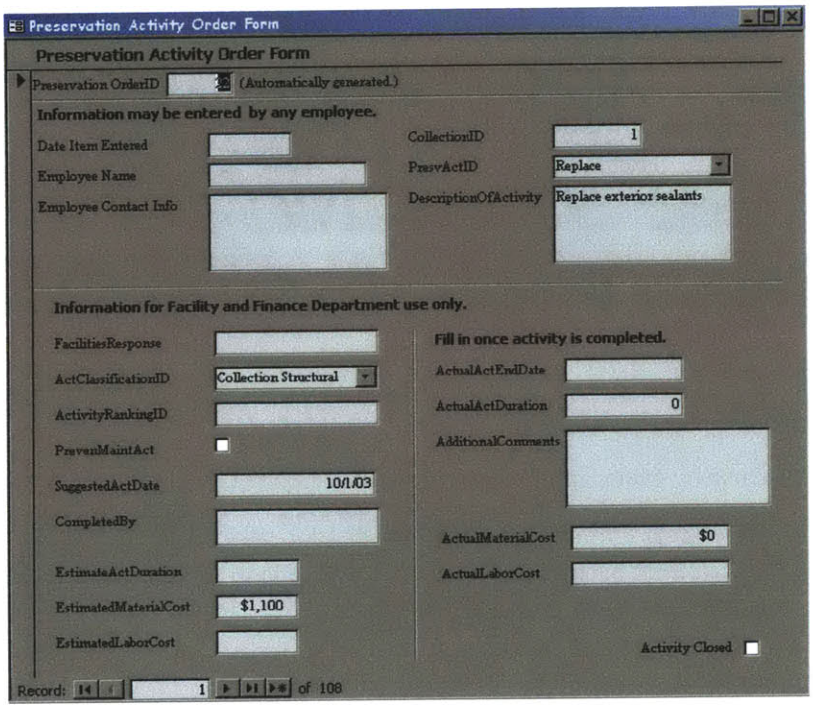


Figure 13 *Preservation Activity Order Form for Collection Item 1*

In form view all of the same columns appear as they do in the table view. It is possible to not have certain columns appear in the form as long as they are not required to in order to complete a record. For example, the columns *RenovateDate*, *SquareFootage*, or *Stories* could be left out, as they are not required in order for the record to be complete. This is a useful option, but in the case of the **Collection** table all columns are included in the form.

Collection Item Information Form is the name of the form that enters and recalls data from the table called **Collection**. Entering data into this form is not much different than entering data into the **Collection** table view, except for the way in which the data is presented. In a form,

the information displayed is for one record only. One moves from one record to another with the use of the buttons at the bottom of the form window. Entering data occurs in the same way either with the user entering the specific information or by choosing a selection from a drop down box. The same data entry restrictions that were present in the table are present in the form, such as entering data as a date or dollar amount.

Despite the numerous similarities, there are a few benefits of using a form to enter data instead of a table. In a form, all data is displayed on the screen. Recall that in the table view since the column headings were listed horizontally, one had to scroll the length of three screens to see all of the information for one record. In a form, all of the information is displayed on the screen at once. In addition, if there were additional comments or a photo for a collection item, these would be displayed on the screen in their entirety. Finally, using a form makes data entry efficient and easy to understand for the user. Rather than being daunted by the numerous records that appear in table view a user has the ability to look at one record at a time and the incidences of simply data entry errors are reduced.

In the Houston Zoo database there are total of 21 tables and four forms. The form **Collection Item Information** has already been discussed. The other three forms are used for entering maintenance, preservation, and improvement/addition activity data. Below is the form, **Maintenance Activity Order Form**. This form is used for entering data into the table, **MaintDetails**. This form is designed to allow multiple zoo staff members the ability to enter data into it. It is divided into two main parts. The first part allows any staff member to enter an activity into the table. For example, if a keeper sees that the hinge of a door in an exhibit is coming loose he may enter this into the database, or if the manager of finances sees that there is a leak in her ceiling she can enter it into the database, or if the assistant director wants to request that the carpeting in her office be replaced she can enter it herself. Direct access to these forms eliminates having staff members leaving messages, sending emails, or filling out unnecessary paper work and sending it to someone in the facilities department, who then would have to enter the item into the database themselves.

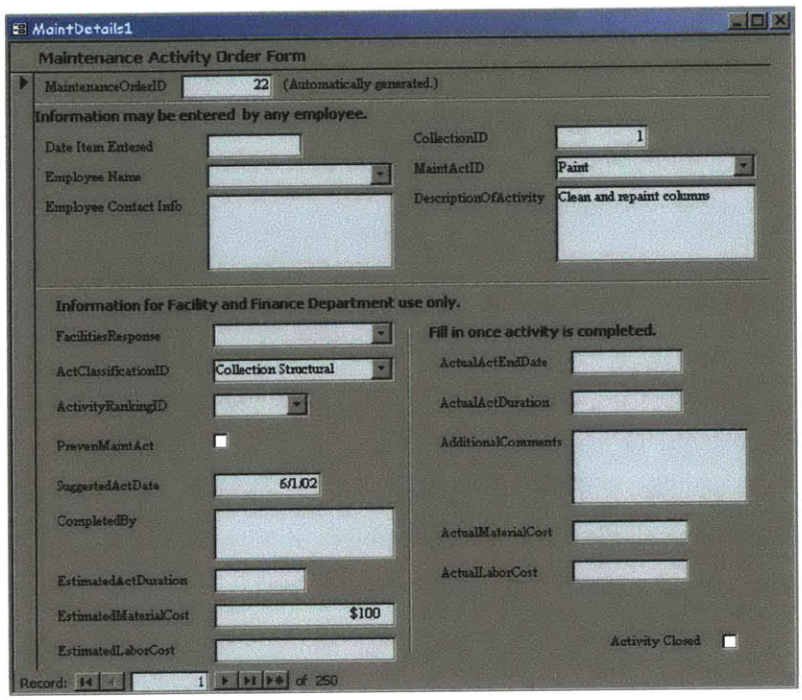


Figure 14 *Maintenance Activity Order Form*

The staff member who makes the report is responsible for entering in only six pieces of information. First, they fill in the date they are making the request on followed by their name and contact information so they may be contacted for further questions on the activity if necessary. Next, they need to enter in the numerical ID of the collection item where the problem exists. The last two items describe the activity with the appropriate predetermined list of *Maintenance, Preservation,* or *Improve/Add Activity IDs* and a description in the staff member's own words as to what the request is. In order to assure that the staff member is categorizing the activity under the correct GASB category, the activity forms for the three types are separate. The staff member will know that they are using the correct form when they find the description of the activity they are reporting under the *MaintActID, PresvActID* or *ImprAddActID* columns located in the respective Activity Order form. As noted, if Access had the capability of "if-then" statements the three forms could be combined into one as the tables they reference would be combined into one, however since this is not possible the use of three forms is necessary. After the staff member enters these six items they are done. The *ActivityOrderID* is automatically entered and is the primary key of the table. Every activity will be assigned an ID so it may be tracked from start to finish.

The second part of the form is to be used by the facility and finance departments at a zoo. It has two sections, one captures information about the activity for scheduling and programming purposes and the other captures the cost data on the item for budgeting purposes. This part of the form is not required for the record to be created, therefore once the activity is entered by a staff member, the remaining portion may remain blank until it is processed by a member of the facilities department. Since the information is entered in a form, the staff member who enters in the initial activity will not be overwhelmed by the information to be entered into the record and will not be confused as to what she/he needs to enter as it is clearly labeled on the form. Typically a staff member would enter maintenance activities and perhaps some preservation activities. However, when planning larger projects, improvement/addition activities, using the same format will provide the same benefits to the facility department for scheduling and programming and will provide the finance department with the information it requires for budgeting. In these cases the staff member who is noted for entering the item might be the head of facilities or perhaps the director of the zoo so it is clear when reviewing open items where the activity request started. Now that the use of the database tool is clear, the next section will detail how the GIS tool is used.

Viewing Data in ArcView GIS 3.2

ArcView GIS 3.2 is a program that allows users to interact with a map of the zoo that is connected to the database. The following section will describe the ArcView user interface along with some of the features that were specifically added for this project.

To open the Houston Zoo file in ArcView GIS 3.2, first the program is started. The initial window that opens asks for the project filename to be opened. The project called "HoustonZooAV" is picked. Once this opens the next window asks to link the appropriate database. "HoustonZooDB" is chosen and the program opens with two main windows, the project window called "HoustonZooAV.apr" and the view window called "Zoo Plan." The project window shows the various items that relate to the Houston Zoo project. The view window displays the map of the zoo, created from the AutoCAD plan, along with other layers of information. These are called themes. In this project there are three themes, *Zoo Collection*, *Pathways,* and *Grid.* Themes may be turned on or off by checking the box in the upper left-hand corner of the dialog box. When displaying information or running queries, it might be beneficial to have unused themes turned off. The *Zoo Collection* theme contains only the outline of the

ninety-eight collection items. The theme, *Pathways*, contains lines that delineate pathways as well as other site elements that aid in a visual understanding of the zoo and the collection items. The last theme, *Grid*, is the alphanumeric layout for determining where a pathway or sidewalk is that is in need of repair.[53] The grid uses a spacing of 100' x 100' across the entire plan. Letters run east to west along the top and numbers run north to south along the left side. Used together they identify small areas of the Zoo, which can be used to easily locate a damaged area of pathway or pavement.

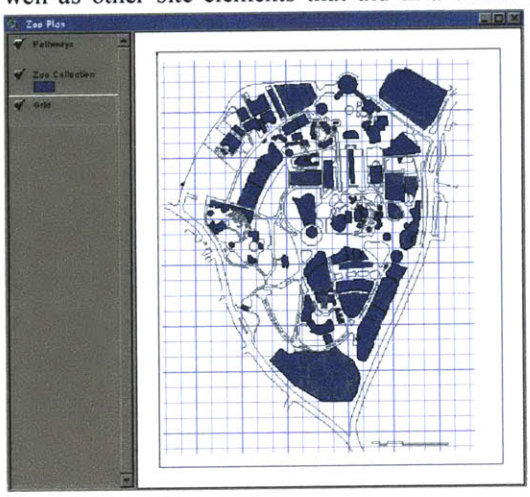


Figure 15 *Grid Theme Layer*

In Arc View the project window shows all of the views, tables, charts, layouts and scripts that are specific to the project. Only the categories: views, tables, and scripts are used in this project. As stated, there is only one view, *Zoo Plan*. This view contains all three themes. Each theme has a table that is associated with it; by default this table contains a number of columns that describe things such as the shape, perimeter, area, and id. The table stores this information and generates what is actually seen in the theme. The table for Zoo Collection is used to link the HoustonZooDB database to the ArcView program. In order to do this though a new column, *CollectionID*, had to be added to the Zoo Collection table. In order to do this, while in the table the command "Start Editing" was used to add a new field/column. This column contains the exact same data that is contained in the HoustonZooDB's **Collection** table, *CollectionID*. This field was necessary so that the two tables can be joined based on this unique identifier, thus essentially joining all of the information in the HoustonZooDB database to the HoustonZooAV project.

Scripts

A series of scripts were written to join the two tables and perform a few other functions in ArcView. Scripts are essentially code that directs the ArcView program to complete specific actions. Avenue is the programming language used to write scripts in ArcView GIS 3.2 version 3.2. Most of the scripts written for the Houston Zoo project are assigned a button in the view

window interface so that the user may easily run them. The following section describes the scripts and there function within the ArcView project.

A total of six scripts are used in the HoustonZooAV project. Each has a different function related to associating the Access database with the ArcView project. They are:

- Start Up
- Login to Access
- Load All Tables
  - Load Initial Access Tables
- Join Collection to Shape Table
- GASB Choice
- Logout of Access

The function of each script is described below. The actual code for each script may be found in *Appendix 5*.

Start Up is a simple script that names the title bar of the ArcView window to Houston Zoo. It is linked to the project start up functions and therefore is automatically executed when the project HoustonZooAV is launched. The other six scripts are executed by clicking a button located in the program window, when the theme window, Zoo Plan, is active.

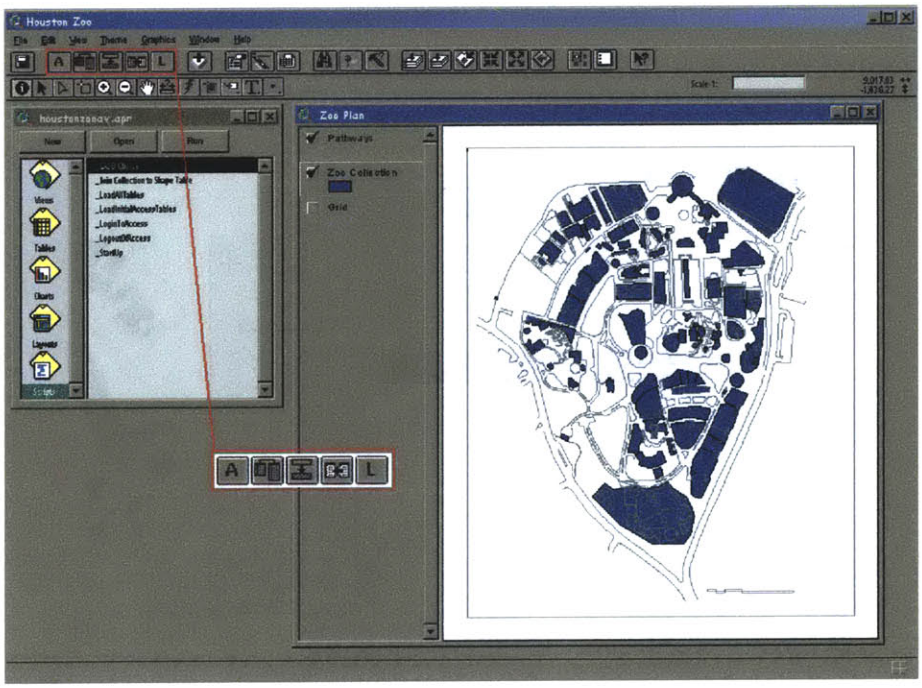


Figure 16 *ArcView GIS 3.2 Window Displaying Script Buttons*

Login to Access and *Logout of Access* are almost self-explanatory as the first script opens a link to MS Access 2000 so that other scripts that join Access tables may be run and the second script closes the connection to the Access program before the user finishes using the ArcView program. Both of these commands are executed with a button in the interface window. The "A" button is to login and the "L" button is to logout.

Load All Tables and *Load Initial Access Tables* work together as the *Load All Tables* script directs the *Load Initial Access Tables* script to run. The function of the two scripts is to load the four Access tables: **Collection**, **MaintDetails**, **PresvDetails**, and **ImprAddDetails**, into the ArcView project. These tables need to be called into the ArcView program first so that the information they contain may be joined to the theme table for Zoo Collection and then data viewed collection item, by collection item.

Join Collection to Shape Table does exactly that. This script joins the Access table, **Collection**, to the ArcView theme table Zoo Collection. At this point users may use the information tool to list data on each collection item.

GASB Choice is a script that first executes a dialog box that asks the user to select one of the three GASB activity types to analyze, maintenance, preservation, improve/add, or all three activity types.

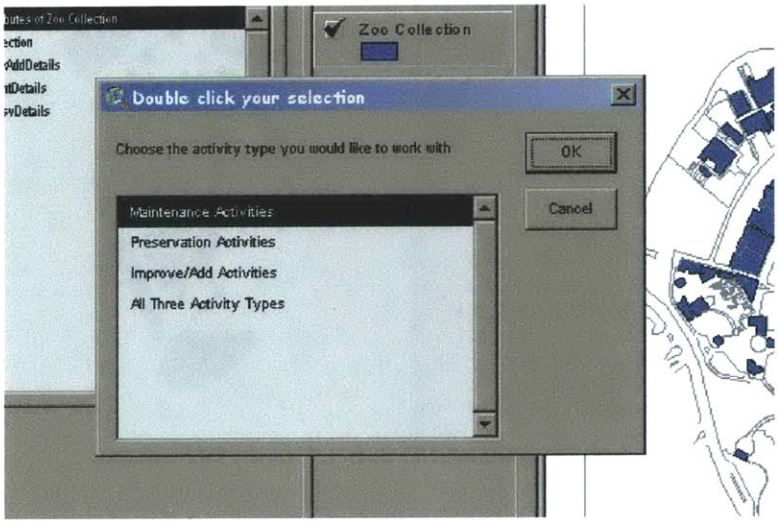


Figure 17 *Dialog Box for "GASB Choice" Script*

Once the user chooses the activity to analyze, the script joins the appropriate Access table, **MaintDetails**, **PresvDetails**, **ImprAddDetails**, or all three to the *Zoo Collection* theme table, which already has the Access table **Collection** joined to it. From this point the user is free to run queries or just to use the information tool to view the activity data stored for each collection item. In addition to using the information tool, queries may be run on the data in the joined tables.

Querying the Database in MS Access and ArcView

It is possible to run queries, in either MS Access 2000 or ArcView GIS 3.2, which extract specific data to analyze. There are some differences however in the types of analysis that is done in Access versus in ArcView. This section reviews how to design and run a query, discusses the types of queries that are most efficient and prudent to use in both programs, and briefly describes the queries that are already built in the Access database for the Houston Zoo project.

Running Queries in MS Access 2000

In MS Access 2000, a query is used to analyze or simply view information stored in tables in a database. Information may be viewed within a single table or pulled from numerous tables in a single database. In order to create a query, either the Query Wizard feature is used or the query is created in the design view window, shown below.

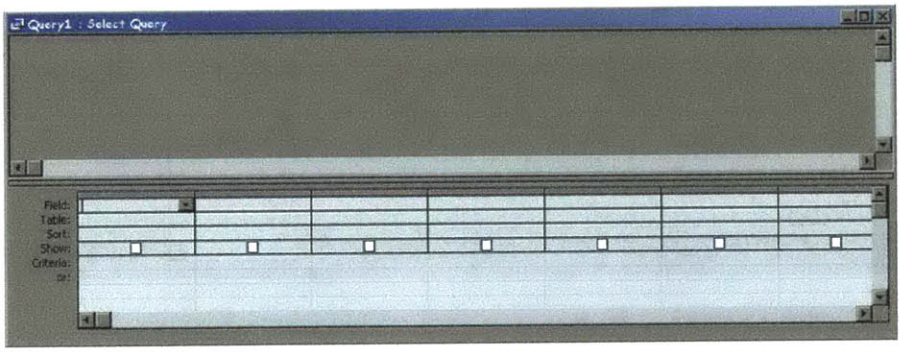


Figure 18 Blank Query Window in MS Access 2000

The first step in creating a query is to add the table or tables that will be analyzed. For this example, the goal is to create a query that lists by collection item, the cost for labor and materials of all maintenance activities to be done from 2001 – 2003.

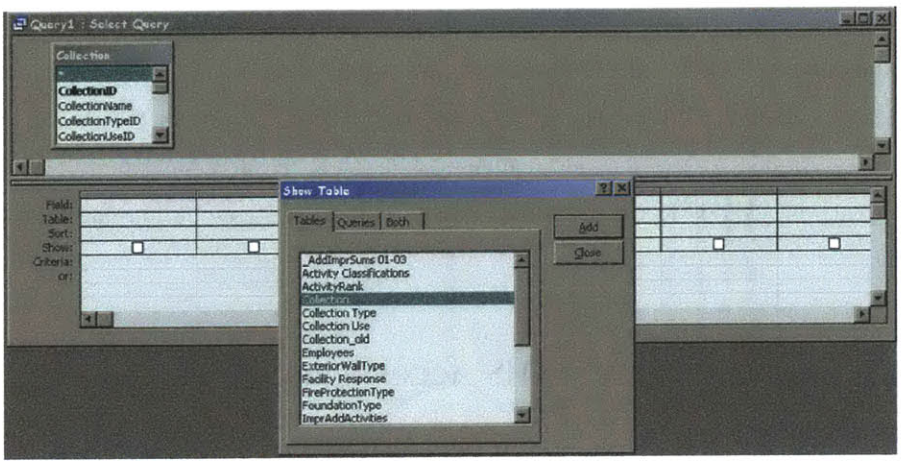


Figure 19 Dialog Box to Add a Table to the Query

The two tables that contain the information sought are added, **Collection** and **MaintDetails**. Next the fields/columns of information are added to the design and the "Total" function for each column is chosen. Once this is complete the query is ready to be run and calculated. Note that if only maintenance activities for the year 2001 were to be extracted then under the column for Suggested Activity Date the criteria cell should be set to equal 2001 with the following expression "=10/1/01".

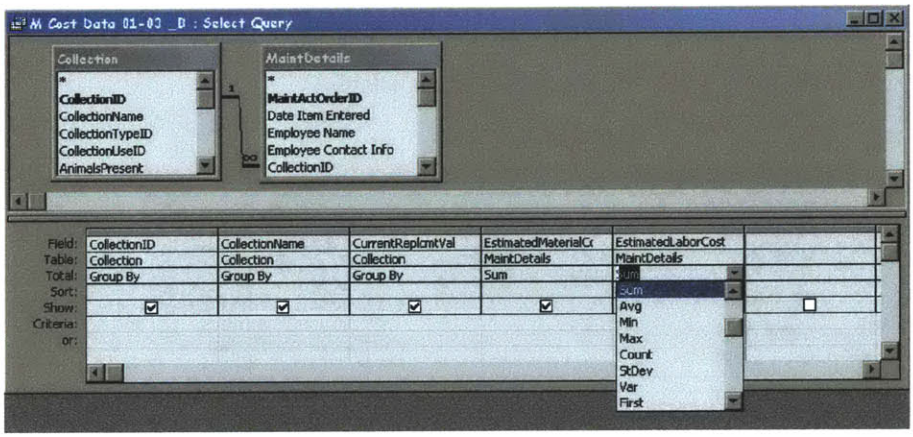


Figure 20 Final Step in Designing the Query

The query is then run and the following table is produced. It contains the sum of the material costs and labor costs for all maintenance activities to completed from 2001 – 2003, sorted by each collection item. It also contains the replacement cost for each item so that further calculations may be made using this value. This table is related specifically to the query. The query can

either be saved and used in other queries, just as a table is, or it may be made into a table and joined to the other tables in the database relationships window.

M Cost Data 01-03 B : Select Query

CollectionID	CollectionName	CurrentReplcmt	SumOfEstimatedMaterialCost	SumOfEstimatedLaborC
1	Administration/Aquarium	$2,375,000	$14,600.00	
2	Quarantine Building	$375,000	$1,500.00	
3	Denton Cooley Animal Hospital	$1,750,000	$9,563.00	
4	MYRA	$1,250,000	$1,500.00	
5	Hay Storgage Building	$70,000	$700.00	
6	Society Warehouse	$1,473,000	$19,360.00	
8	Zoo Commissary	$1,350,000	$15,450.00	
9	Exhibits Building Warehouse	$2,152,250	$16,254.00	
10	Maintenance Building	$2,152,250	$7,100.00	
11	McCaw Cafeteria	$594,250	$1,900.00	
12	Main Gift Shop/Society Admin	$2,550,000	$1,400.00	
17	ACE	$675,000	$5,100.00	
19	OEF	$25	$21,000.00	
27	Sea Lion Exhibit	$2,500,000	$3,000.00	
28	Koala Building	$600,000	$2,125.00	
29	Small Mammal House	$2,600,000	$104,088.00	
30	Brown Education Center	$3,750,000	$77,050.00	
37	Main Ticket Booths	$50,000	$2,400.00	
39	Reptile House	$2,600,000	$11,050.00	
41	Giraffe Exhibit	$300,000	$4,350.00	
42	Chinese Alligators	$122,000	$750.00	
43	Ice Cream Stand	$100,000	$1,100.00	
45	Tropical Bird House	$2,350,000	$33,100.00	

Record: 1 of 46

Figure 21 Query Results

In this project 18 queries were designed to demonstrate how the given data might be analyzed. Reviewing the design of each is not necessary. Rather, each query is listed below with a brief description of its purpose.

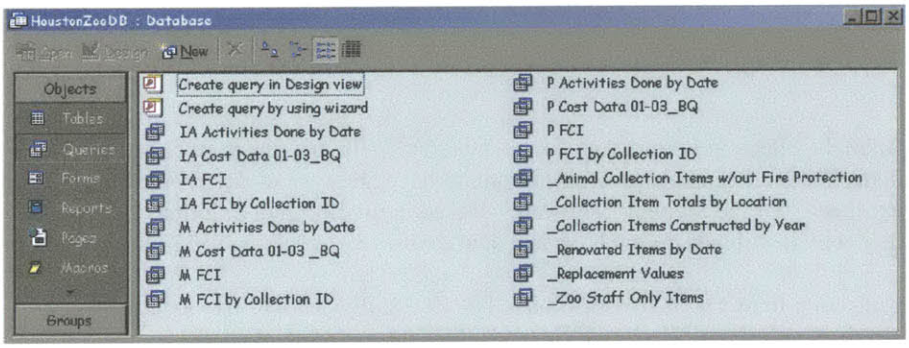


Figure 22 Queries Run on the Test Database in MS Access 2000

For each of the GASB categories four queries were run. Each query serves the same purpose in the three categories, Maintenance, Preservation, and Improve/Add. The names of each query are listed below, followed by the general description of the purpose of the query.

M Cost Data 01-03_BQ / P Cost Data 01-03_BQ / IA Cost Data 01-03_BQ – This query is a building query as it extracts the necessary data to find the FCI for each GASB category, which is done in the next query. Discussion of the FCI value is explained later. Three columns of data are extracted: *CollectionID*, *CollectionName*, and *CurrentReplcmtVal*. It then sums the total estimated costs for materials and for labor for each collection item for the years 2001-2003. It may be modified to only extract data for specific years as the FCI only tracks activities that are backlogged, not to be completed.

M FCI / P FCI / IA FCI - Using the results of the previous query, this query sums activity backlogs and divides them by the sum of the replacement values for all respective collection items yielding the FCI value.[54]

M FCI by Collection ID / P FCI by Collection ID / IA FCI by Collection ID – This is a parameter query that finds the FCI for an individual collection item. When the query is run, a dialog box opens that asks the user to enter the *CollectionID* for the item to be analyzed. The resulting table shows the *CollectionID, CollectionName,* and *CurrentReplcmtVal* along with the sum of material and labor costs for that item. The last column calculates the FCI for the item. This query also uses information from the first query, and therefore the specific time period to be examined should be specified in that query, not this one.

M Activities Done by Date / P Activities Done by Date / IA Activities Done by Date – This query lists all activities for each collection item that must be completed by a specified date. The current date is set to 10/1/01, but may be modified in the design view.

The following queries were created to calculate specific data about the zoo. They are listed alphabetically in the query window and will be described in the same order here. Their results are discussed in a later section, *General Analysis Results*.

Animal Collection Items w/out Fire Protection[55] – In this query all collection items that have animals present, but do not have any type of fire protection are extracted. Of the 56 items that were covered in the Building Solutions Audit, 21 that contain animals do not have any source of fire protection.

Collection Item Totals by Location – The Zoo is divided into five locations: North, South, East, West, and Central. This query counts the total number of collection items in each area of the zoo. It should be noted that the South part of the zoo contains only the Old Children's Zoo, which although contains a number of unused buildings, was treated as one item in the database.

Collection Items Constructed by Year – The count of collection items constructed in each year is listed in this query. Unknown values are have a year equal to "0" and are excluded.

Renovated Items by Date - Renovated collection items are listed by name followed by the year in which they were renovated in this query.

Replacement Values – This query lists current replacement values for collection items followed by the total of items that may be replaced for the specified amount.

Zoo Staff Only Items – This query contains only one column that lists the collection items that are accessible only by members of the Houston Zoo staff.

Running Queries in ArcView GIS 3.2

In ArcView GIS 3.2 queries are designed in a similar fashion, however their purpose is often different. The benefit of having a connection with the information stored in the MS Access 2000 database is that queries can be run on that data and results can be displayed visually in ArcView. Therefore with this in mind, running a query in ArcView that extracts cost totals for all collection items might not be the best use. However, running a query that displays where the most expensive activities are scheduled or a query that shows where activities need to take place by a given data would better use the visual capabilities of the program. In ArcView, unlike in Access, queries cannot be saved. Rather, the tables that are created in a query may be exported to another program or built and run again.

To design a query in ArcView the theme window entitled *Zoo Plan* must be open and the theme *Zoo Collection* needs to be active. Under the theme menu is the command Query. Selecting this command opens the query dialog box shown on the following page.

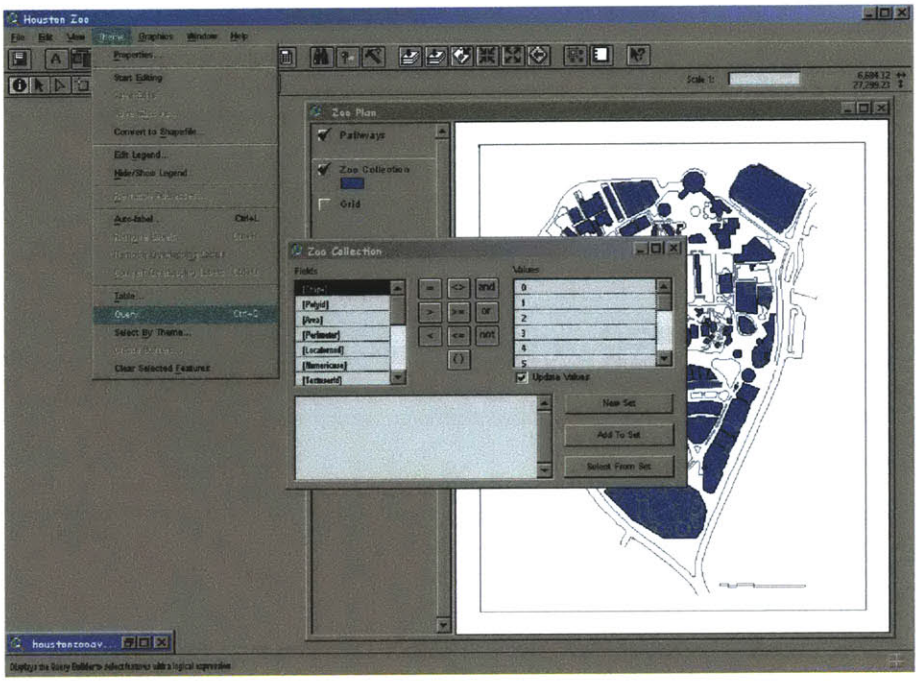


Figure 23 Blank Query Window in ArcView GIS 3.2

To design the query, columns from the table are selected from the choices on the left and operations are shown in the middle. Values for every column in a theme table are shown in the window on the right. The principles of construction for a query in ArcView are the same as for those in Access. In this case, the query is asking for all collection items constructed before 1960. Once the expression is built the command "New Set" is chosen and all collection items constructed before 1960 are displayed in yellow.

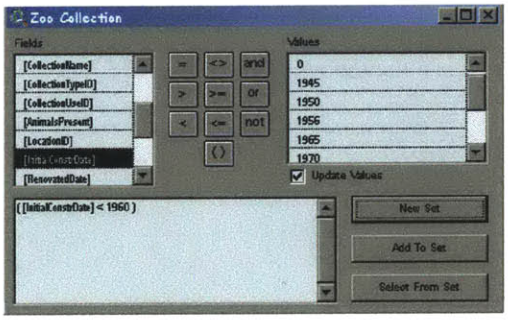


Figure 24 Finished Query

In addition to the visual display, if the theme table is opened all rows containing collection items constructed prior to 1960 are highlighted in yellow. They can then be moved to the top of the table using the *Promote* command allowing them to be analyzed together.

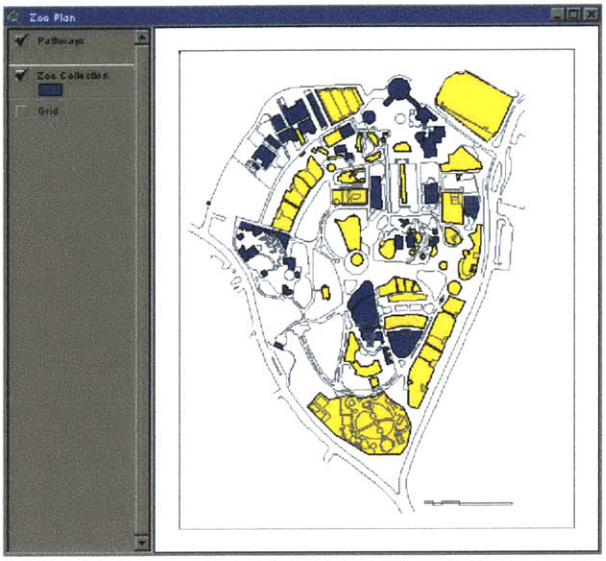
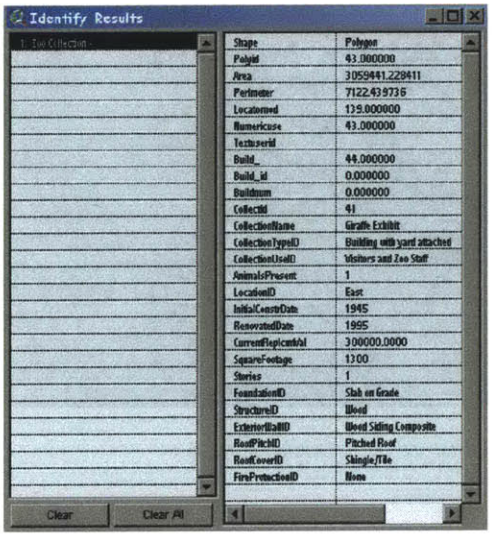


Figure 25 Query Results

Another benefit to ArcView is the information tool. This tool selects an item from the theme and displays all of the information stored about it in a separate window. Therefore if information about only a few items is desired this tool can be used to easily display it. For example, the image below shows all of the information in the table on the Giraffe Habitat, after the attribute table for Zoo Collection was joined to the **Collection** table from Access.



Shape	Polygon
Polyid	43.000000
Area	3059441.229411
Perimeter	7122.439736
Locationid	139.000000
Numericuse	43.000000
Textuserid	
Build_	44.000000
Build_id	0.000000
Buildnum	0.000000
Collectid	41
CollectionName	Giraffe Exhibit
CollectionTypeID	Building with yard attached
CollectionUseID	Visitors and Zoo Staff
AnimalsPresent	1
LocationID	East
InitialConstrDate	1945
RenovatedDate	1995
CurrentReplcmtVal	300000.0000
SquareFootage	1200
Stories	1
FoundationID	Slab on Grade
StructureID	Wood
ExteriorWallID	Wood Siding Composite
RoofPitchID	Pitched Roof
RoofCoverID	Shingle/Tile
FireProtectionID	None

Figure 26 Information Tool Results Table for the Giraffe Exhibit

Using the Information Tool is a quick and easy way to find information on items using the map as reference. The same information could be found by running a query in Access, but this way is much faster and does not require setting up a query for each collection item to be examined.

Extension of The Tool

Clearly the information exchange in ArcView has tremendous possibilities. The three themes used in this prototype convey significant amounts of information however, other layers of data can be added to increase the detail of information provided and extend the function of the tool past its current capabilities. For example, an aerial photo, such as the one below, may be added as a theme to be layered under the outline of the Zoo map to provide information about tree canopies or other landscaping elements.

Figure 27 *Aerial Photo of Houston Zoo with Overlay of Pathways*

In addition, another AutoCAD map that focuses solely on the botanical elements of the Zoo might be added along with a detailed database that describes plant species, age, and care instruction. Another potential addition to the ArcView project is a utility map and plumbing map.

Accurate utility and pipe maps would not only be a benefit as they would contain technical information about shutoff valves and electrical stations, but they would also be a benefit when any construction that required digging or rerouting of infrastructure was done. In fact, technology currently exists that allows surveying of collections, such as plant life or utilities, with the use of GPS (Geographic Positioning System) that will allow for onsite surveys to be completed and then data uploaded and ultimately viewed in this program. Although a bit more work needs to happen to fine-tune the exact GPS positioning capabilities, very soon creating such themes as the ones discussed here at the zoo itself, rather than at a computer station, will be possible. When differing data types like the ones discussed are layered upon each other they provide an enormous amount of beneficial information and as such should be investigated further.

Conditions Assessment

Through the use of queries, information in the database may be examined in both programs. There are numerous goals that users have for running queries and sorting data to find out about their zoo depending on what department they are from. Taken as a whole however, the ultimate goals are to improve the overall condition of the zoo through repairs, renovations, and new construction. The following is a system that creates a basic ratio to compare the conditions of an entire facility or just an exhibit by comparing the backlog of activities to be completed with the current replacement value of the item or items.

Effective asset management requires a way to quickly and accurately understand the conditions of the assets in the collection. There are numerous approaches that have been developed to categorize the condition of an asset, be it a bridge, sewer system, or a group of buildings. For example, Lee and Atkan created a deterioration model that works on a scale of one to four that helped them quantify the conditions of office buildings in Detroit, Michigan.[56] While Madanat and Mishalani developed a Multinomial Logit Model for studying highway pavement that determines whether the action for the section being studied is to do nothing, perform routine maintenance, or resurface the area.[57] Although most studies such as these have developed a scaling system that works for each specific situation, none of these systems can be efficiently used to evaluate the condition of a zoo. In order to establish and track the conditions of zoo assets in concert with financial requirements, a different approach must be taken such as the use of a Facility Condition Index.

Facilities Condition Index

The National Association of College and University Business Officers (NACUBO) created a ratio called the "Facilities Condition Index" or FCI. NACUBO is a nonprofit organization comprised of administrative and financial officers representing over 2,100 colleges and universities in the United States. Their mission is to "promote sound management and financial practices at colleges and universities."[58] In 1991, recognizing the fact that there was a $60 billion facility renewal and replacement backlog, 1/3 of which was of an urgent status, NACUBO developed the FCI.[59] The index compares the sum of maintenance backlogs with current replacement value.

$$\textit{Facility Condition Index} = \frac{\textit{Cost of Deficiencies(\$)}}{\textit{Current Replacement Value (\$)}}$$

Equation 2 *Facility Condition Index Equation*

In the ratio, the numerator, *Cost of Deficiencies*, is the sum of existing maintenance and repair deficiencies and the denominator, *Current Replacement Value*, is the replacement value for the entire building or set of buildings being examined. The index can be used to study individual buildings or be summed to examine a group of facilities. It is important to understand that the FCI does not include any future maintenance or construction costs, only backlogs. In addition, the index does not account for the differing urgencies of the deficiencies. In looking at the output values, it is necessary to keep such variables in mind before making decisions on funding allocation or other actions.

Although input variables are in dollars, the index is dimensionless; this yields a very basic, yet valid indication of the condition of a facility or group of facilities. There are no subjective components to the index therefore it may be used as a benchmark for future comparison against past facility conditions, as well as a way to compare the facilities of multiple organizations with each other. NACUBO suggests that the ranges of the index output may be classified into three basic categories:

FCI Range	Condition Rating
Under .05	Good
.05 - .10	Fair
Over .10	Poor

Table 3 *FCI Ranges and Conditions Ratings*

NACUBO based these ratings on results of comprehensive conditions inspections and discussions with facilities personnel.[60] Despite that effort, the ratings are noticeably subjective and organizations using the index should use these ranges as a guideline only until they are able to suggest ranges based on their own facility specific data and requirements.

As noted earlier, the FCI does not account for the priority of deficiencies. For example in a zoo, the new gorilla habitat might need its window seals repaired to prevent further water damage of the floor and night houses, while in the older giraffe exhibit, the walls might need to be repainted. Although the gorilla habitat might be in better overall condition, as it is new, the window repair is essential to prevent damage, while a new coat of paint can wait in the giraffe exhibit. If one only looks at the cost of the repair in relation to the entire collection item, the priority of repair might be missed. Although contrary to NACUBO's belief, the importance of the individual repairs must be referred to before decisions on which activities will be done are made. This is where the secondary classification of Activity Ranking, located in the **MaintDetails, PresvDetails**, and **ImprAddDetails** tables will be of assistance. With the use of a ranking classification, such as a number system from one to five that notes the urgency of an activity, the zoo has the ability to prioritize the work that needs to get done. NACUBO suggests that the use of the FCI as a benchmark to be lowered is the best way to manage collections. This is a valid idea and should guide the spirit of the asset management program. However, the inclusion of a secondary ranking system allows for some judgment based on the actual condition deficiencies to be used. The section, *Conditions Analysis Results*, will demonstrate how this ratio is used in practice with the information used in the Houston Zoo database.

Ultimately, there is no one formula that will make all financial decisions for an organization. At some point, managers will have to interact with the data and make the final decisions. The purpose of this thesis is not to try and create a system in which no humans are needed, but rather to serve as a tool to aid in decision making that removes many of the base subjective decisions by providing data upon which to make informed decisions. The beauty of this tool is that it allows the users to gather and modify the data in a detailed or broad fashion, as they see fit, so that it may benefit each individual organization as best as possible. Although each zoo has the ability to use differing modifiers to aid decision making, if all zoos begin to use the basic FCI, then benchmarks for the zoo industry will be created. This will result in an overall industry benefit as comparisons can be made in non-subjective terms. For this reason alone, it is important for all zoos that don't currently track data electronically to begin soon. They are

collectively working for the betterment of animal life and preservation of the Earth and as a community, zoos can help themselves to grow and succeed by working together and sharing information freely.

Analyzing Data

General Conclusions about the Houston Zoo

Once design was complete, the database was populated. As stated, the source of the data used was the facilities audit done by the Texas based firm, Building Solutions, Inc. Although this data is not ideal as it is not complete, it does however allow the analysis process to be demonstrated both in the Access and in the ArcView programs. By examining the results of queries run on the data a general picture of the zoo is given and the manner in which the data is analyzed is demonstrated.

Overall, 98 collection items were entered into the database. Of the 98, sufficient information regarding general condition, size, construction, and activity requirements was gathered for 56 items. Although general analysis on the zoo was done using all of the data, the 56 items were used to complete the financial analysis and FCI calculations. A list of the 56 items used is included in *Appendix 6*. The conclusions drawn on the zoo are based on only 57% of the possible data and therefore should not be looked upon as definitive data. In order for a through analysis to be done, members of the Houston Zoo staff should audit the remaining items, finish populating the database, confirm the data already entered, and then follow those steps with analysis. The use of the available data however, allows for demonstration of the tool created in this thesis and as such has produced viable results.

General Analysis Results

In the year 2000 the Houston Zoo reported the following data to the AZA. It is informative to compare some statistics with that of other zoos to gain an understanding of the relative scale of the Houston Zoo. For the year 2000, the Zoo reported an annual operating budget of $13 million. This was well above the average of non-profit public zoos, which was around $4.7 million.[61] However, it was in line with the other zoos of its size and popularity. Last year 1,450,000 people visited the Houston Zoo of which 1,125,000 paid to enter. 70% of the guests were repeat visitors and about 20% were coming from areas outside of the usual visitor

area. Attendance at all zoos last year was just over 66 million. A total of 134,699,712 people visited all zoos, aquariums, wild animal parks and combination parks in 2000. This is a tremendous amount of visitors and the totals increase yearly.

General analysis on the data inputted in the database was done to determine further background information on the zoo. All figures were calculated using queries in the Access program. Results show some fundamental statistics about the Zoo. To begin, the average age of the 56 buildings is 23.8 years old. The chart below shows collection item construction by year.

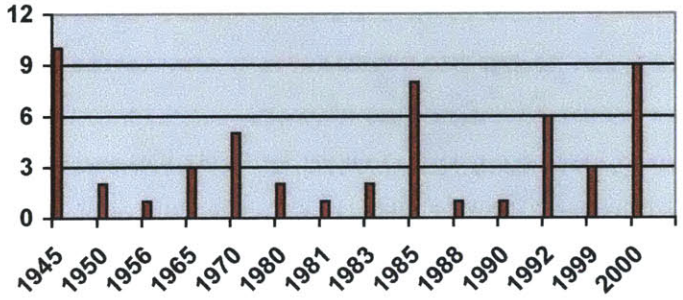


Figure 28 Collection Items Constructed by Year

Three major areas of growth are clear in looking at the construction timeline below. The first period occurred about twenty years after the Zoo moved to its current location in Hermann Park. The next period of growth came during the 1980s and early 1990s. The last period of significant growth came in the year 2000 when nine collection items were constructed.

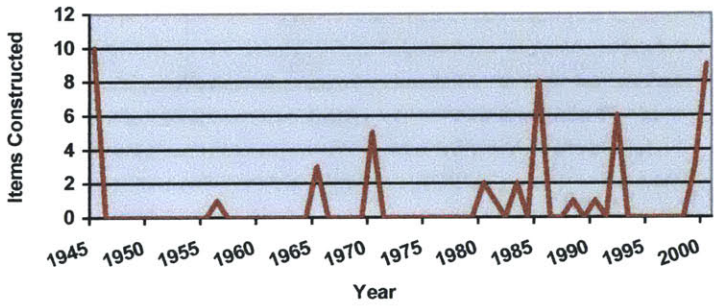


Figure 29 Construction Timeline

The north and central areas of the Zoo contain the majority of collection items. Note that the main entrance to the Zoo is located in the north, with a smaller entrance recently added in the west.

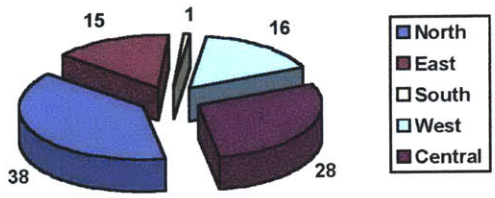


Figure 30 Collection Items by Location

Only nine items have been renovated during the eighty plus years that the Zoo has been in operation. Most items were renovated thirty to forty years after their initial construction date and all but two are accessible by the public. The table below lists the collection name and respective dates.

COLLECTION NAME	CONSTRUCTION DATE	RENOVATED DATE
Administration/Aquarium	1980	1996
BUBBA	unknown	1990
Elephant Barn 1	1950	1996
Elephant Barn 2	1950	1996
Giraffe Exhibit	1945	1995
McCaw Cafeteria	1980	2000
Reptile House	1965	1986
Sea Lion Exhibit	1956	1988
Small Mammal House	1965	1992

Table 4 Collection Item Renovation Dates

Conditions Analysis Results

The Facility Condition Index (FCI) was calculated for the zoo individually for the three GASB areas, as well as for the entire collection. The results, shown below, display the increasing FCI value if no funding is used to complete any outstanding activities. Further discussion follows showing the resulting FCI values when differing funding amounts are used to complete activities.

FCI CALCULATIONS	2001	2002	2003	2001 - 2002	2001 - 2003
Maintenance Backlog	262,957.00	140,820.00	110,563.00	403,777.00	514,340.00
Replacement Cost for 56 Items	41,209,025.00	41,209,025.00	41,209,025.00	41,209,025.00	41,209,025.00
Maintenance FCI	0.006	0.003	0.003	0.010	0.012
Preservation Backlog	744,604.00	400,690.00	386,784.00	1,145,294.00	1,532,078.00
Replacement Cost for 56 Items	41,209,025.00	41,209,025.00	41,209,025.00	41,209,025.00	41,209,025.00
Preservation FCI	0.018	0.010	0.009	0.028	0.037
Improve Add Backlog	37,650.00	580,700.00	300,270.00	618,350.00	918,620.00
Replacement Cost for 56 Items	41,209,025.00	41,209,025.00	41,209,025.00	41,209,025.00	41,209,025.00
Improve Add FCI	0.001	0.014	0.007	0.015	0.022
Total Activities Backlog	1,045,211.00	1,122,210.00	797,617.00	2,167,421.00	2,965,038.00
Replacement Cost for 56 Items	41,209,025.00	41,209,025.00	41,209,025.00	41,209,025.00	41,209,025.00
FCI for 56 Collection Items	0.025	0.027	0.019	0.053	0.072

Table 5 FCI Calculations

The table shows the breakdown of FCI values by year and GASB activity classification. The last three rows of the table contain the FCI values for the sum of all three GASB classifications. In any of the three years of data from 2001 – 2003 the FCI value for individual components falls within the range considered "Good" by NACUBO, whether looked at as individual categories or taken as a total. This suggests that the 56 collection items are actually in excellent condition based on the system used by Building Solutions Inc. for reporting the deficiencies to be corrected in their audit. As stated earlier, the average age of the items is only 23.8 years, with the oldest item constructed in 1945 and the newest constructed in 2000.

If no funding is allocated to the outstanding activities in 2001 the FCI will be .025. This also falls within the "Good" category and the Zoo might choose to do nothing this year and allocate facilities funding to another area with higher need for that year. If funding is not allocated in 2002 however the FCI jumps to .053, dropping the condition of the assets into the "Fair" classification. And finally, if no activities are completed in 2003 the FCI will then be at least .072, still within the "Fair" classification, but closer to the "Poor" classification and certainly resulting in worse asset conditions overall.

Even with this limited data, the benefit of having the ability to calculate the FCI and then run funding scenarios against the benchmark values is an excellent tool. The ability to see how reducing or increasing funding for activities affects the FCI is an excellent objective way to make financial decisions. The fact that urgency of activities cannot be accounted for in the FCI is not a

concern as each zoo may decide on a way to control this either by using a secondary ranking, such as the one used in this database, or another method that will allow for the most urgent projects to be completed within the confines of the annual budget.

The goal of using the FCI method may vary from zoo to zoo as one may want the FCI to be less than .01 while another might simply seek to maintain a level below .05. The breakdown of the FCI results into the standard categories of Good, Fair, and Poor is not the key to the method. Rather, setting the required levels internally and working with benchmarks will help individual zoos make sound asset management decisions. In addition, using the FCI values provides an objective way to demonstrate the need for funding be it from the government, corporations, or from members of the community. In order to calculate the FCI not only does a zoo need to understand what activities need to be completed, but it also has to understand what the costs would be to replace each item in its collection. This requires an in-depth understanding of the zoo's assets to first determine what it considers an asset and then what the replacement costs are for each item in the collection. In addition, it requires that each asset be analyzed for deficiencies. With this knowledge the condition and finances of the zoo become more transparent not only to zoo staff, but to external bodies and will allow zoos to clarify financial needs internally and clearly convey them externally. Accountability for the condition of the zoo and the welfare of the species that live within it may be assigned. As stated earlier, if a zoo is not able to manage the maintenance and condition of its facility to the extent that it negatively impacts the health of the animals and presents a danger to its guests it should not be afforded the privilege of caring for and displaying animals. If implemented, the tool created in this thesis will lead zoos to a clearer understanding of what its assets are and what is required to maintain them.

Objective of Use - Revisited

Once again, the objective of this tool is not to define the level of detail with which each zoo will record maintenance, preservation, and improvement activities. Rather, the goal is to create a tool that has the ability to capture each activity, no matter how minor, or to capture activities at a more broad level as defined by each organization. The ability to use the tool to do either has been demonstrated and the benefits that capturing and manipulating this data for maintenance of the facility, planning, and budgeting for the future is clear. The ultimate success of the tool relies on the ability of the zoo to integrate it with current practices or in some cases to

drastically refine current procedures to align with the functions of the tool. The system is in place for success, it is now up to each organization to implement it and follow through.

Applications of The Tool at the Houston Zoo

Implementing The Tool

At the Houston Zoo, applying this tool will benefit two major areas. The first is the pubic arena where decisions on long term budgeting and planning will be made. Use of the Access component of the tool will provide clear statistics, while using the ArcView component of the tool will yield images, both of which will aid the public and government officials in understanding the budgetary requirements and the overall goals that the Zoo has for its future growth. The effects of lack of funding can be clearly addressed in short-term and long-term conditions, thus displaying direct benefits and deficits of current plans.

Second, the tool will aid internal operations as the Access database component has the capabilities to streamline facility procedures with the use of the activity work order forms and scheduling functions. In addition, the capabilities of both software programs to analyze data with queries will help finance personnel create a capital project budget that reflects the needs of the Zoo to grow and expand.

Implementation of the tool is at the discretion of zoo staff. As indicated in previous sections, additional work will have to be done to input data and clarify the necessary assumptions that were made in order to maintain the speed of research and allow for design and construction of the tool.

Main Goals for the Houston Zoo

The Houston Zoo is currently undergoing a process of privatization that staff members hope will simplify decision-making by transferring the power to make decisions for the zoo on a day-to-day basis, as well as for future planning, to current staff members, not members of the city government who do not have the same level of knowledge of the Zoo. If they choose to implement this tool it will help them capture the necessary data to not only aid the facilities department in scheduling and creating a comprehensive maintenance program, but also benefit capital budget planning and financing. They will need to check the current data in the database, as assumptions had to be made, as well as decide if the information provided in the Building

Solutions Audit is useful to their overall goals and objectives. They might decided that at this point it would make sense to do an internal conditions and financial survey using this tool as the basis for data collection. In the least, the hope is that this tool will benefit the zoo in providing a successful model for conditions analysis and asset management.

Requirements for The Tool to be Established Elsewhere

The goal for the thesis is to create a tool that may be used at any zoo. In order to establish this tool at other organizations however there are a few items that will make construction easier and more efficient, and will therefore produce an accurate and thorough tool for asset management and conditions analysis.

At minimum each zoo should strive to capture maintenance, preservation and improvement/addition data electronically into a database. In order to do this they will need:

- A listing of all collection items with names and unique ID numbers
- A plan of the zoo with each item clearly drawn and labeled (this plan may be done by hand or in CAD)

If a zoo wants to take advantage of all of the capabilities of the tool they need to have the following items before construction of the database begins:

- A complete CAD plan of entire zoo with collection items and pathways
- An accurate and current facility audit of zoo including
  - Collection item data (i.e. - area, stories, attributes, date constructed)
  - Financial data (i.e. – replacement cost, activity costs)
  - Maintenance, Preservation and Improvement Activities to be completed
  - Preventative Maintenance Schedule (if one exists)
- Accurate infrastructure surveys (i.e. - electrical, plumbing, sewer)
- Table of current staff including their titles, departments, and contact information
- Any additional information that is required for the database to function as desired by each individual zoo

These items will make establishing a new database less complicated and will yield a functioning and accurate tool for each zoo. Without them, issues such as the ones discussed in the section, *Data Collection Problems*, may be encountered. These issues limit the potential of the database and visualization tool unless accurate data is sought and input in the database and CAD plan.

Conclusions

Throughout the research, design, construction, and testing phases of the thesis, much was learned not only about asset management requirements and the needs of zoos, but also about the software programs and the necessities to use them efficiently. Some of the issues faced are shared below and then the final thoughts about the research and future of the tool complete the section.

Data Collection Issues

During the research and data collection process of the thesis significant challenges were faced with missing or incomplete data, conflicting data, and other issues. The following sections detail the issues faced and then makes suggestions for the future.

To begin, a majority of the most important data is not stored on computer at the Houston Zoo, but rather the Senior Superintendent of Facilities and Grounds, Fred Maier, manages the difficult task of keeping all of that information in his head. Having only a single person who has significant knowledge about a zoo is clearly dangerous and most likely difficult for that individual. It also made trying to capture data about the Zoo for the thesis difficult. The Houston Zoo is in need of a program that tracks data in electronic format that allows multiple staff members to access it.

In addition, the Zoo has not created a system for capturing data on their own. Instead, they have a number of audits that were done covering things such as infrastructure and conditions. The audits studied the different areas of the Zoo and each suggested a plan for rectifying current issues. The problem with the audits is that each firm that performed one had their own analysis system and a great majority of the final documents seemed to provide extraneous information to make the report seem larger than it was. In addition, as the audit findings did not build upon one and other, but rather suggested the Zoo move in different directions, their results were never incorporated by into any plans for the future. Furthermore, within the audits there were issues with the way in which the final information was presented. A specific example is the audit that is used in this thesis completed by the firm Building Solutions, Inc.

The audit by Building Solutions, Inc. looks at a number of buildings on the property, analyzes current conditions, and makes suggestions for things that should be done to improve the current state of each building. The suggestions cover everything from replacing an old ceiling tile to totally demolishing a building. Although the information is presented in a clear form, much of the information is redundant and in some cases not clear. For example, in the Tropical Bird House there are two items, 629 and 632, that both pertain to repairing wall cracks. The two line items are worded only slightly differently and are listed as repair items in two different years. It is unclear what cracks need to be repaired in which year and why the two would not be fixed at the same time. If audit suggestions are to be taken seriously, they need to be deciphered by zoo staff members, not only by the firm that created the audit otherwise the problems are often ignored.

Perhaps, if auditors work with the known values that are used in this database their ability to note a problem and what needs to be fixed can be clearer. If they know how their data on conditions and suggested repairs will be entered into a database then they will understand how to best describe the activities. Although most of the information that is presented in the Building Solutions audit is useful, it is presented multiple times and in different formats making the final audit a huge document that required multiple binders to contain the information. The final size is too large to be useful in its entirety, as one can get lost wading though some of the repetitive information. Also, since the firm uses its own spreadsheet software program, rather than a compatible program such as excel, to display collection items and activites the only way to look at the information is on paper. If everyone can use the database program, then the repetition of data would not be necessary. However in order to combine pieces of data, such as collection item with cost or collection item with the activity, requires entirely different printouts. This decreases the usability of the audit even further.

Another issue that was confronted during the creation of the tool was the horrendous condition of the cad plan of the zoo. The plan given by Morris Architects was not discernable on its own, even with the legend that was provided. In addition, while doing a cursory review of the plan with Mr. Maier of the Houston Zoo via the telephone, multiple mistakes were found in labeling and location of exhibits. The plan was incomplete and had over 300 layers, many of which were duplicates. In order to have a plan that was useable in the thesis the entire drawing was cleaned up and reduced to only four layers. In cleaning up the drawing some assumptions

were made about building footprints and exhibits that should not have had to be made. Thankfully, none of the assumptions affect the manner in which the tool is used, or the results of the numerical analysis. If time permitted the best course of action would have been to commission another Master Plan in of the zoo or to do internal onsite surveying.

Hindsight Issues

A major issue that surfaced numerous times was the somewhat limited ability of the MS Access 2000 program. Although it is very user friendly, it lacks some capabilities that would increase the efficiency of the database design and subsequent use of the tool. In addition, a stronger database tool would make extension of the database to include additional functions easier.

One other major issue that complicated the process was the difficulty of communicating with staff members at the zoo. Although much information was gathered during the initial visit to the Zoo in June of 2001, follow up was necessary. There was a significant delay in getting questions answered and finding the correct entities to seek information from. This resulted in assumptions that had to be made in order for the research and thesis to move forward. This was unfortunate, but the effectiveness of the resulting software tool and thesis conclusions were not hampered in this process.

Further Applications

Zoos are not the only organizations that face issues with asset management. Programs for funding allocation and decision-making are needed in numerous areas. Fortunately the same strategy used in this thesis is applicable in other situations. In fact, just as the tool created in the thesis may be used in other zoos or aquariums, it may also be applied to other similar scaled functions such as universities, office complexes, resorts, or even museums. Universities may be the most likely candidate and will find this tool helpful since as of 1991, universities and colleges are facing a sixty billion dollar facility renewal and replacement backlog. Of that, one third of the activities are in need of urgent attention.[62] The foundation and structure for the database would be similar in all of these applications, while other areas maybe modified or added to make the tool applicable to numerous other circumstances. In addition the potential for the tool to apply to

these areas is there, since it is constructed using widely available software and the design can easily handle the addition of other functionalities.

Final Thoughts

Due to human destruction of natural habitats there are fewer and fewer places for free animals to call home on the Earth. Therefore, zoos are a requirement to sustain these precious lives while serving as places of education and research. They have the ability to bring positive thoughts and encounters with animals from places far away to the cities we live in. They have the power to expose the major problem of habitat depletion that is not only detrimental to the animal population, but whose negative consequences affect humans as well. But they lose all of this power if their animal habitats do not support these goals.[63] Ultimately, each zoo needs to work towards realizing the connection between asset management, animal welfare, and zoo livelihood. If a zoo is unable to manage the condition of its facility to the degree that it impacts the health of its animals and is unsafe for its guests, it should not be allowed to house and display animals. In addition, local governments should not be afforded the privilege of using the zoo as a tourist attraction if they do not provide adequate funding to maintain the quality of life for the animals, staff, and guests. If these fundamental ideas are not already part of the model for the zoo and city, this shift in thinking needs to occur first.

This research process resulted in a thesis that communicates the issues surrounding asset management programs specifically related to zoos, the effects if nothing is done to change current practices, and also produced a functioning prototype software tool that responds to the present needs of zoos. Implementation of this tool has the ability to help any zoo that currently has no program or a directionless program develop a system that will lead to success. Meaningful use of the tool is dependant on the amount of data stored. It cannot be an accurate predictor for financial needs and preventative maintenance without historical data. Thus the focus is for all zoos to begin storing data in an electronic database form so that, in the least, they begin to track their annual expenses. Zoos will be able to build upon this tool as members of staff, local government, and the community realize the impacts of having historical data in a useful format that can be peeled back and examined at a more detailed level than current budgeting practices allow. The possibilities are enormous and the positive impacts should serve as motivation for each zoo to focus on their facilities programs now.

Although this research has accomplished the goals it set out, this paper and resulting software tool should not be thought of as an ending, but a marker of where to continue the research, investigation, and development.

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Appendices

Appendix 1 - 2002 AZA Guide to Accreditation of Zoological Parks and Aquariums

The following two pages are excerpts from the 2002 guide to accreditation for zoos and aquariums. They address the specific requirements that must be followed for the areas of *Finance* and *Physical Facilities*.

SUPPORT ORGANIZATION

- The terms establishing the working relationship between an institution and its support organization must be in writing and adhered to in practice. [SO-1, SO-4]

- A support organization must share the institution's goals and objectives. [SO-2]

  Explanation: A support organization which has goals inconsistent with those of the institution may jeopardize the institution's work.

- The support organization must recognize the CEO/Director's overall responsibility for the management of the institution. [SO-4, SO-5]

FINANCE

- An institution, regardless of whether operating on a profit or nonprofit basis, must provide sufficient evidence of its financial stability by submitting complete financial reports, including an operating budget indicating that the financial support from the governing authority and/or support organization meets the needs of the institution. [F-1, F-2, F-4]

  Explanation: Proof of financial support includes the submission of an operating budget reflecting sources of income, as well as expenses. It should also include contingency plans in the event that significant decreases in support are anticipated. In the case of financial reports other than audited statements, the Primary Reviewer or the Commission shall determine what constitutes *sufficient evidence*.

- Insurance coverage, via independent carrier or internal means, must be provided for visitors, staff, volunteers/docents, and physical facilities. [F-5]

- An institution should provide evidence of a capital improvements and maintenance program for the next five years and indicate sources of funding. [F-6, *F-7*, F-9, *PF-8, PF-17, PF-18*]

  Explanation: Capital improvements include renovations, maintenance of buildings/grounds/exhibits, new construction, and demolition of outdated structures. The Commission and its Visiting Committees review all components of an institution, including walkways, driveways, and buildings—not just animal enclosures.

PHYSICAL FACILITIES

General Considerations:

While the Commission is interested in the institution's future plans, accreditation will be based upon its operations and facilities at the time of the Visiting Committee inspection.

All United States institutions should be adjusting their facilities toward compliance with the Americans with Disabilities Act.

- Good housekeeping must be regularly practiced. [PF-4, *PF-9, PF-15, PF-16, PF-19, AC-21, AC-22, VC-13*]

  Explanation: Rodent control, proper drainage, clutter in work areas, and other housekeeping activities require continuous attention. Animal food must not be stored in the same area as animal drugs, nor with food for humans. Cadavers awaiting necropsy must be stored in a dedicated storage area.

- An institution must have holding facilities for the quarantine of newly arrived animals and isolation facilities for the treatment of sick/injured animals.

- Quarantine, hospital, and isolation areas must be in compliance with standards/guidelines adopted by the AZA (see pages 35 - 41). The hospital facilities should have x-ray equipment or have access to x-ray services. Written, formal procedures for quarantine must be available to all staff working with quarantined animals. [PF-5]

- If not in separate buildings, animal food preparation areas must be physically separated from other functions such as the animal hospital (including animal treatment, isolation, holding, deceased animal storage) and employee lounges. Animal food preparations must meet all local, state/provincial, and federal regulations. [PF-5, VC-17]

- Life-support systems for the animal collection, including but not limited to heating, cooling, aeration, and filtration, must be equipped with a warning mechanism, and emergency backup systems must be available. All mechanical equipment should be under a preventative maintenance program as evidenced through a record-keeping system. Special equipment should be maintained under a maintenance agreement, or a training record should show that staff members are trained for specified maintenance of special equipment. [PF-6, *PF-10, PF-11, PF-23*, SS-19]

  Explanation: Facilities such as aquariums, tropical rainforest buildings, or other exhibits which rely on climate control for life-sustaining conditions must have emergency backup systems and a mechanism for warning if those systems are malfunctioning.

- Alarms for fire, security, and other safety alerts must be in place and in working order. Routine maintenance records should be kept detailing safety checks of the equipment. [PF-6, SS-8, SS-12, SS-13, SS-14, SS-15, *SS-17*, SS-19]

- Lighting must be sufficient in all indoor facilities, including night houses, so that maintenance can be accomplished and animals can be observed. A means for emergency lighting must be available. Lighting in public areas should be sufficient for the safe maneuvering of the visiting public. [*PF-11*]

- A written policy for the handling of toxic/hazardous materials must be available to all staff working with those materials. Material Safety Data Sheets (MSDS) must be located in areas for easy access by employees, and employees must be trained in the proper handling of toxic/hazardous materials. [*PF-14*, SS-8, SS-16, SS-18]

- All walkways must be kept in good repair. [*PF-17*]

- All animal enclosures (exhibits, holding areas, hospital, and quarantine/isolation) must be of a size and complexity sufficient to provide for the animal's physical, social, and psychological well-being; and exhibit enclosures must include provisions for the behavioral enrichment of the animals. [*PF-23, PF-24, AC-25, AC-26, AC-29*]

Appendix 2 – Additional Photos From the Houston Zoo

The Houston Zoo provided the following photos. They were taken by staff members and provided for use in this paper. The two photos included in the section, *Current Conditions* were also provided by the Zoo.

Figure 31 *Bali Mynas Exhibit*

Figure 32 ***Flamingo Exhibit***

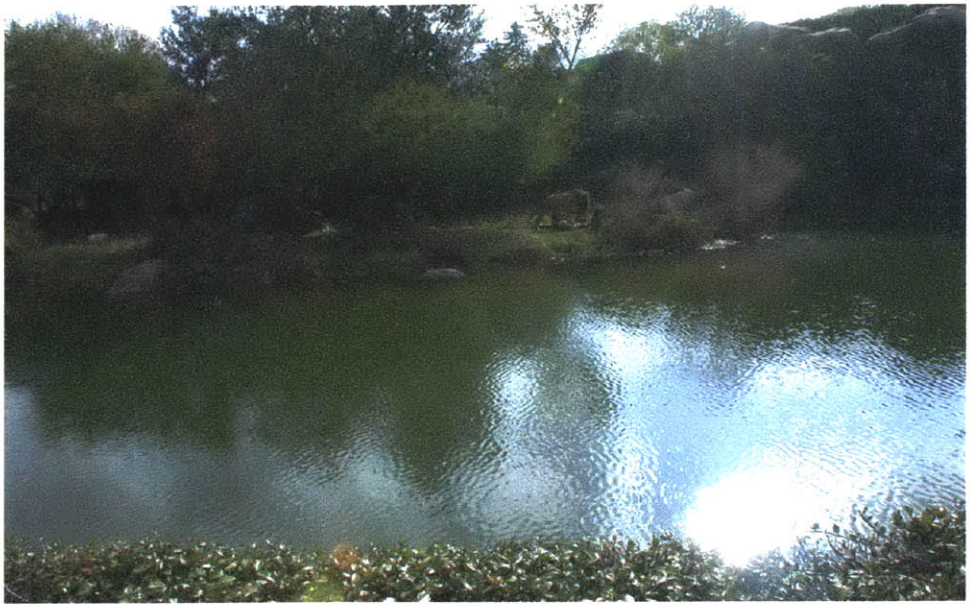


Figure 33 *View From The Lion Exhibit*

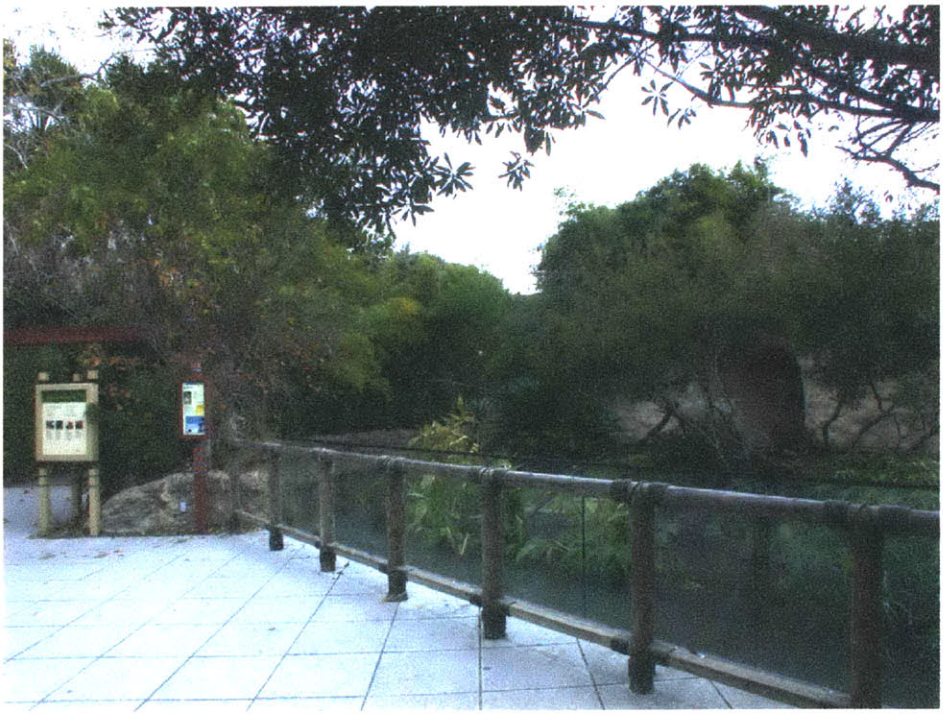


Figure 34 *Ring Tail Lemur Exhibit*

Appendix 3 – Houston Zoo Test Database Relationships

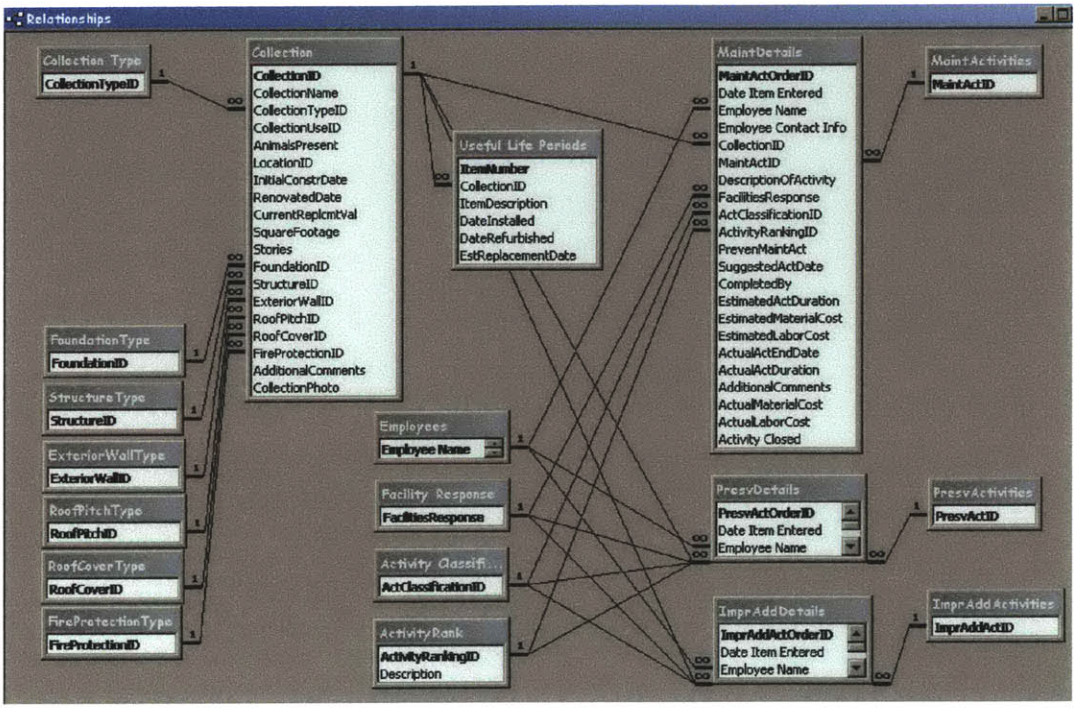


Figure 35 Houston Zoo Test Database Relationship Window

Appendix 4 - Additional Table Descriptions

The following descriptions are for the tables that were not discussed in the section *Database Table Descriptions*. Column titles are noted in italics and the contents are bulleted below them. In most cases the tables serve as look-up tables for the major tables in the database.

Collection Type

This table is connected to the table **Collection.** It describes the construction type of the collection item. There is only one column in the table. Each row in the column describes a possible construction type found in the zoo.

CollectionTypeID
- Building with yard attached
- Building/Structure
- Enclosure/Cage
- Landscaping/Sitework Element
- Pool/Pond with yard attached
- Yard

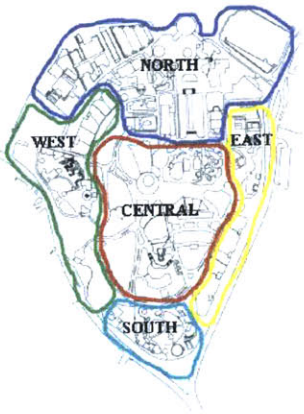
Collection Use

This table describes whether the collection item is for use of zoo staff only in the case of maintenance buildings or animal night houses or is the building is accessible to visitors to the zoo. It is connected via its only column, *CollectionUseID*, to the table **Collection**.

CollectionUseID
- Visitors and Zoo Staff
- Zoo Staff Only

Location

The Houston Zoo staff created a simple way of identifying regions of the zoo, by dividing it into five areas, North, South, East, West and Central. The image below shows the regions. This look-up table is connected to the table **Collection** and is specific to the Houston Zoo, but a table with similar function could be designed easily for any zoo.



LocationID

- N
- S
- E
- W
- C

Figure 36 *Internal Zoo Location Plan*

The following six tables help to describe elements of each collection item. They are all related to the **Collection** table. Together they provide a general idea about each item. The structure for each table is a single column with numerous rows. In each column the following rows appear: Other, Unknown, and Not Applicable. Although an effort was made to provide classifications that were general enough to describe any collection item, but specific enough as to provide a good idea of the collection, there are bound to be some conditions that cannot be categorized in these terms, therefore the user should select Other. If the description is not known then the user should select Unknown and if the table does not apply to the collection item type then Not Applicable should be chosen.

Foundation Type
FoundationID

- Slab on Grade
- Column Foundation
- Pile Foundation
- Wall Foundation
- Asphalt – This row applies to parking lots only.
- Ground – This row applies to collection items that are only yards.
- Other
- Unknown
- Not Applicable

Structure Type
StructureID

- C.I.P. Concrete

- CMU Load Bearing
- Precast Concrete
- Steel
- Wood
- Other
- Unknown
- Not Applicable

Exterior Wall Type
ExteriorWallID
- Block Face Composite
- Brick Face Composite
- C.I.P. Concrete
- Concrete Block/CMU
- Metal Siding Composite
- Precast Concrete
- Stone Veneer
- Vynal Siding Composite
- Wood Siding Composite
- Exhibit Enclosure Wall
- Wire Mesh/Chain Link – Used only to describe the collection item type "Enclosure/Cage."
- Other
- Unknown
- Not Applicable

Roof Pitch Type
RoofPitchID
- Flat Roof
- Pitched Roof
- Combination
- Other
- Unknown
- Not Applicable

Roof Cover Type
RoofCoverID
- Built-up
- Preformed Metal
- Shingle/Tile
- Single Ply Membrane
- Other
- Unknown
- Not Applicable

Fire Protection Type
FireProtectionID
- Detectors/Alarm – No Sprinklers
- Fire Sprinkler Systems, Dry

- Fire Sprinkler Systems, Wet
- Other
- None
- Unknown
- Not Applicable

The following tables are each referenced to the tables **MaintDetails**, **PresvDetails**, and **ImprAddDetails**. They provide data for the Activity Order Forms.

Employees

This table stores information on Zoo Employees. The column, *Employee Name*, is referenced in the detail tables. It provides the name of the employee in the Activity Work Order so that if a record needs to be clarified the name and department of the employee is listed via this table. Phone/email contact information is entered directly into the Details table via the applicable Activity Work Order Form. This table only has two test entries to demonstrate how it functions. If used, zoo staff should complete the table.

Employee Name
Employee Zoo ID
Title
Department

Facility Response

Since any employee has the ability to add an activity, it is possible that activities may be entered twice or might not an issue as was thought at the time of entry. Therefore, the maintenance department needs to check the activities entered and then decide whether to go ahead with them, reject them, or investigate them further. This table contains the response of the facilities department.

FacilitiesResponse
- Approve
- Reject
- Investigate

Neither **Employees** nor **Facility Response** are required tables. The idea of creating an Activity Work Order was explored in this thesis as a way of making the facilities department more efficient by combing the description of the activity to be done with information on cost and time. This does not have to be followed and other zoos might want to approach it differently. By

combining these together, however, the asset management plan is more efficient and comprehensive.

Activity Classifications

In order to aid financial planning, the *ActClassificationID* further defines the activity into four different categories.

ActClassificationID
- Collection Structural
- Collection Non-Structural
- Collection Services
- Zoo Site/Grounds

Activity Rank

The Activity Rank table is used to note the urgency of a repair. This table does not have to be used, however the Facility Condition Index values might not be sufficient to determine which activities should be completed first, given a fixed budget. Although using the FCI values is a comprehensive strategy, the use of the activity rank will capture, and then be able to identify, activities that were done in an emergency and didn't have a chance to become part of the maintenance backlog. A numbering system from one to five is used to demonstrate the table. The descriptions are also just used for example. The zoo should change them once their management program is established.

ActivityRankingID
- 1
- 2
- 3
- 4
- 5

Description
- Emergency
- Urgent
- Priority
- Non Urgent
- Long Term

The last three tables identify specific types of activities under the three GASB categories. The activity ID types may be modified by a zoo to fit individual program needs. They were

adapted from the standards of the Uniformat and RS Means categorizing descriptions. They are meant to be somewhat general, but with enough detail as to provide an accurate description of each asset. Each table is referenced to its corresponding Details table.

Maintenance Activities
MaintActID

- Clean
- Paint
- Regrade
- Repair/Fix
- Routine Inspection
- Routine Testing
- Routine Treatment

Preservation Activities
PresvActID

- Refurbish
- Replace

ImprAdd Activities
ImprAddActID

- Construct/Build
- Demolish
- Extend
- Improve
- Install

Appendix 5 - ArcView GIS 3.2 Scripts

The code for each of the scripts written in the ArcView GIS 3.2 program is below. The scripts are written using the coding language Avenue. In Avenue comments on the scripts may be written in the same window with the code, without affecting the program. These lines of text begin with a single apostrophe and are not read by the program when the scripts are executed. For a complete description see the section, *Scripts*.

Start Up

```
'Names the title bar on the Arc View window.

Av.SetName("Houston Zoo")

return nil
```

Login to Access

```
' Logs into Microsoft Access

_theCon = SQLCon.Find("MS Access Database")

return nil
```

Load All Tables

```
'Runs the other script called _LoadInitialAccessTables

av.run("_LoadInitialAccessTables", {"Collection"})
av.run("_LoadInitialAccessTables", {"MaintDetails"})
av.run("_LoadInitialAccessTables", {"PresvDetails"})
av.run("_LoadInitialAccessTables", {"ImprAddDetails"})

return nil
```

Load Initial Access Tables

```
'Runs from _LoadAllTables.
'Selects the table and loads it.
'Cannot run on its own. Needs to be run from _LoadAllTables
```

```
theTable = Self.Get(0)

theProject = Av.GetProject
table1 = theProject.FindDoc(theTable)
if (table1 <> nil) then
 theProject.RemoveDoc(table1)
end

selects = "select * from "+theTable
theVTab = VTab.MakeSQL(_theCon,selects)
locateTable = Table.Make(theVTab)
theProject.AddDoc(locateTable)
locateTable.SetName(theTable)

return nil
```

Join Collection to Shape Table

```
'Joins the Access DB with the ArcView table via "Collection ID"

theView = Av.GetActiveDoc
theProject = Av.GetProject
theTable = theProject.FindDoc("Attributes of Zoo Collection")
if (theTable = nil) then
 msgbox.info("Add the attribute table before running join","warning")
 return nil
end

TheVTab = theTable.GetVTab
theVTab.UnJoinAll
theToField = theVTab.FindField("CollectID")
' theFromVTab = theProject.FindDoc(theChoice).GetVTab - use this if multiple tables from the start, like Winchester
theFromVTab = theProject.FindDoc("collection").GetVTab
theFromField = theFromVTab.FindField("CollectionID")

if (theFromField = nil) then
msgbox.info("the From Field Was Not Found","warning")
return nil
end

theVTab.Join(theToField, theFromVTab, theFromField)
```

GASB Choice

```
'Gives user choice of what GASB activity to load and work with, then loads the chosen table(s)

theListofTables = {"Maintenance Activities", "Preservation Activities", "Improve/Add Activities", "All Three Activity Types"}
```

```
theChoice = MsgBox.ListAsString(theListofTables, "Choose the activity type you would like to work with", "Double click your selection")
if (theChoice = nil) then
 msgbox.info("You did not make a selection (choice)", "warning")
 return nil
end

if (theChoice = "Maintenance Activities") then
 theJoinedTable = {"MaintDetails"}
 numTables = 1
end

if (theChoice = "Preservation Activities") then
 theJoinedTable = {"PresvDetails"}
 numTables = 1
end

if (theChoice = "Improve/Add Activities") then
 theJoinedTable = {"ImprAddDetails"}
 numTables = 1
end

if (theChoice = "All Three Activity Types") then
 theJoinedTable = {"MaintDetails", "PresvDetails", "ImprAddDetails"}
 numTables = 3
end


theView = Av.GetActiveDoc
theProject = Av.GetProject
theTable = theProject.FindDoc("Attributes of Zoo Collection")

for each i in theJoinedTable
 TheVTab = theTable.GetVTab
 theToField = theVTab.FindField("CollectID")
 MsgBox.Info(i.AsString,"")
 theFromVTab = theProject.FindDoc(i.AsString).GetVTab
 theFromField = theFromVTab.FindField("CollectionID")
 theVTab.Join(theToField, theFromVTab, theFromField)
end

return nil
```

Logout of Access

```
' Logout of Microsoft Access

_theCon.LogOut

return nil
```

Appendix 6 - 56 Collection Items Used in Calculations and Analysis

1	Administration/Aquarium
2	Quarantine Building
3	Denton Cooley Animal Hospital
4	MYRA
5	Hay Storage Building
6	Society Warehouse
8	Zoo Commissary
9	Exhibits Building Warehouse
10	Maintenance Building
11	McCaw Cafeteria
12	Main Gift Shop/Society Admin
17	ACE
19	OEF
20	Pink Pigeon House
27	Sea Lion Exhibit
28	Koala Building
29	Small Mammal House
30	Brown Education Center
32	Animal Barn - Zebra/Crane
33	Animal Barn - Kudu/Gazelle
34	Animal Barn - Kudu/Camel
35	Pheasant Run
37	Main Ticket Booths
39	Reptile House
41	Giraffe Exhibit
42	Chinese Alligators
43	Ice Cream Stand
45	Tropical Bird House
46	Tapir Barn
48	Tamarin/Titi Night House
51	Orangutan Night House
52	Central Night House
54	Pattas Night House
56	Mangabey Night House
62	Elephant Barn 1
63	Elephant Barn 2
65	Duck Lake Concessions

67	Lion Exhibit
68	Lion Exhibit Tunnel
72	Small Cats Exhibit
74	Bear Dens
75	Rhino Exhibit
76	Gorilla Exhibit
78	Bengal Tiger Exhibit
79	BUBBA
81	West Entry Ticket Booths
82	Animal Barn - Orynx
83	Animal Barn - Bongo/Pygmy Hippo
84	Animal Barn - Nyala
85	Animal Barn - Nile Lechwe
90	Butterfly Pavilion
92	Discovery Center
94	Rural Barn
96	Otter Exhibit
97	Coastal Building
98	Desert Prairie Building

Table 6 56 Collection Items Used for Analysis

Endnotes

[1] Rush, Sean C. Managing the Facilities Portfolio: A Practical Approach to Institutional Facility Renewal and Deferred Maintenance. Washington, DC, NACUBO, 1991: pg 6.
[2] Rush, Sean C. Managing the Facilities Portfolio: A Practical Approach to Institutional Facility Renewal and Deferred Maintenance. Washington, DC, NACUBO, 1991: pg 6.
[3] www.winchestermas.org
[4] www.winchestermas.org
[5] www.winchestermas.org/history.html
[6] www.gasb.com/facts
[7] www.gasb.com/facts
[8] Basic Financial Statements-and Management's Discussion and Analysis-for State and Local Governments, GASB, June 1999. p. 1
[9] Basic Financial Statements-and Management's Discussion and Analysis-for State and Local Governments, GASB, June 1999. p. 2
[10] Basic Financial Statements-and Management's Discussion and Analysis-for State and Local Governments, GASB, June 1999. p. 6
[11] Primer: GASB 34, US Department of Transportation, November 2000. p 5
[12] Basic Financial Statements-and Management's Discussion and Analysis-for State and Local Governments, GASB, June 1999. p. 21
[13] Basic Financial Statements-and Management's Discussion and Analysis-for State and Local Governments, GASB, June 1999. p. 22
[14] Primer: GASB 34, US Department of Transportation, November 2000. p 8
[15] Basic Financial Statements-and Management's Discussion and Analysis-for State and Local Governments, GASB, June 1999. p. 23
[16] Basic Financial Statements-and Management's Discussion and Analysis-for State and Local Governments, GASB, June 1999. p. 23
[17] Basic Financial Statements-and Management's Discussion and Analysis-for State and Local Governments, GASB, June 1999. p. 25
[18] Primer: GASB 34, US Department of Transportation, November 2000. p 9
[19] The website is http://www.window.state.tx.us/comptrol/san/gasb/gasb34_intro.html
[20] www.aza.org/AboutAZA/
[21] www.aza.org/AboutAZA/
[22] www.azfa.org/about.html
[23] www.azfa.org/about.html
[24] Guide to Accreditation of Zoological Parks and Aquariums, AZA, 2002. p. 27
[25] An excerpt from the Master's Thesis, Designing for Those Without Voices, Jacquelynn Henke, 2000.
[26] Koebner, Linda. Zoo Book: the evolution of wildlife conservation centers. (New York, NY: Tom Doherty Associates, Inc. 1994.) 55.
[27] Koebner, Linda. Zoo Book: the evolution of wildlife conservation centers. (New York, NY: Tom Doherty Associates, Inc. 1994.) 58.
[28] Koebner, Linda. Zoo Book: the evolution of wildlife conservation centers. (New York, NY: Tom Doherty Associates, Inc. 1994.) 58.
[29] Koebner, Linda. Zoo Book: the evolution of wildlife conservation centers. (New York, NY: Tom Doherty Associates, Inc. 1994.) 60.
[30] Arrandale, Tom. "A New Breed of Zoo." Sierra. November/December 1990, 26.
[31] Arrandale, Tom. "A New Breed of Zoo." Sierra. November/December 1990, 27.
[32] Koebner, Linda. Zoo Book: the evolution of wildlife conservation centers. (New York, NY: Tom Doherty Associates, Inc. 1994.) 61.
[33] Koebner, Linda. Zoo Book: the evolution of wildlife conservation centers. (New York, NY: Tom Doherty Associates, Inc. 1994.) 59, 61.

[34] Koebner, Linda. Zoo Book: the evolution of wildlife conservation centers. (New York, NY: Tom Doherty Associates, Inc. 1994.) 68.
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[36]Robinson, Michael H., David Challinor. Zoo Animals. (New York, NY: Macmillan. 1995.) 19.
[37] Vider, Elsie. "Environmental Theater . . . the new zoo." Metropolis. June 1990, 45.
[38] Robinson, Michael H., David Challinor. Zoo Animals. (New York, NY: Macmillan. 1995.) 20.
[39] Powell, Anne E. "Gardens of Eden." Landscape Architecture. April 1997, 85.
[40] Powell, Anne E. "Gardens of Eden." Landscape Architecture. April 1997, 87.
[41] Powell, Anne E. "Gardens of Eden." Landscape Architecture. April 1997, 83.
[42] Powell, Anne E. "Gardens of Eden." Landscape Architecture. April 1997, 83.
[43] www.houstonzoo.rg/infoset.htm
[44] This thesis uses the term Privatization as defined by John B. Miller in his book, Principles of Public and Private Infrastructure Delivery. See page 35 for the complete definition.
[45] All photos provided by Gail Johnson of the Houston Zoo.
[46] Building Solutions Audit, Section 2.1, *Site*.
[47] Procedure as given by Mr. Fred Maier, Senior Superintendent of Facilities and Grounds at the Houston Zoo
[48] www.gis.com.whatisgis/index.html, power point presentation, slide 7.
[49] www.gis.com.whatisgis/index.html, power point presentation, slide 10.
[50] It should be noted that as the AutoCAD map provided was incomplete and significant difficultly was encountered in trying to communicate with members of the Houston Zoo staff, many assumptions about the boundaries of the collection items and their function had to be made in order to insure continued progress with the thesis. Therefore the accuracy of the collection item boundaries along with names is not guaranteed. 100% accuracy was not the goal for the tool once communication became difficult; rather the creation of a functional tool that has the ability to be modified was the goal and ultimately the end result.
[51] The ArcInfo steps were done with the help of Mr. Daniel Sheehan of MIT's Information Services Department.
[52] The CartaLinx steps were done with the help of Ms. Sarah Williams, the GIS Librarian at MIT.
[53] The zoo is divided into five sections: north, south, east, west and central. Along with a unique identifying number, each building is secondarily described using its location in the zoo. Initially, the same approach was going to be used to describe areas of pathways using the building closest to the path to be the first descriptor and then have an additional descriptor to pinpoint the location, however since the plan provided was incomplete in terms of the pathway system and as stated, was difficult to understand, another approach had to be taken. Therefore, in order to locate an area of pathway that needs to be repaired a grid system was created.
[54] As noted earlier, there are no values for labor costs; therefore the sum of the activity backlog is for material costs only. See the section, Facility Conditions Index, for the equation to calculate the value.
[55] Note that checkboxes are Boolean items where a check=yes = 1=true and an empty check box=no = 0=false. This is a computer language standard and when running a query that uses a checkbox, such as this one, true and false values need to be used to specify the condition.
[56] Lee, Jin H. and Atkan, Haluk M., Infrastructure Condition Assessment: Art, Science, and Practice. Ed Misuru Saito. Boston, MA: ASCE, 1997. p. 1-10.
[57] Madanat, Samer and Mashalani, Rabi, Modeling Highway Pavement Maintenance Effectiveness. Infrastructure Condition Assessment: Art, Science, and Practice. Ed Misuru Saito. Boston, MA: ASCE, 1997. p. 151 – 160.
[58] www.nacubo.org
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[61]members.aza.org/departments/RC/SurveyResearchDocs/

[62] Rush, Sean C. Managing the Facilities Portfolio: A Practical Approach to Institutional Facility Renewal and Deferred Maintenance. Washington, DC, NACUBO, 1991: pg 1.
[63] An excerpt from the Master's Thesis, Designing for Those Without Voices, Jacquelynn Henke, 2000.